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RAILWAY TRACTION DEPARTMENT, DERBY, ENGLAND

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ROLLS-ROYCE TRANSMITTALS

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TELEGRAMS: "ROYCAR, SHREWSBURY"

ROLLS-ROYCE LIMITED

SENTINEL WORKS
SHREWSBURY

TELEPHONE: SHREWSBURY 2011

OIL ENGINE DIVISION

Bk/Sd

March 1959

RAILWAY DIESEL POWER EQUIPMENT MAINTENANCE MANUAL

T.S.D. PUBLICATION 866

TRANSMITTAL LETTER NO.1

Incorporate:

Reason for change:

Chapter 5, Section 15B, pages 1 & 2

Initial Issue. Double Starter Protection Unit

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TRANSMITTAL LETTER No.2

Incorporate:

Torque Converter pages 1 and 2 to replace old pages 1 and 2

Final Drive, Section 1 title page to) To define railcars fitted with precede Section 1, page 1

Final Drive, Section 2 title page and Self-Change Service Manual pages 1 to 27 to follow Section 1

Reason for change:

To include sectioned view of DFR converter

Walker reversing gearbox

New section R.F. 28 Forward and Reverse Final Drive Unit

Record incorporation on, Lists of Transmittals



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TRANSMITTAL LETTER No.3

Incorporate:

Leader page and new section Fluidrive publication ER.412 to follow existing Section 10 FLUID DRIVE COUPLING Reason for change:

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TRANSMITTAL LETTER No.4

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Controls, Section 2, foldout illustration and text pages to follow Section 1 Reason for change:

Initial issue. Miscible control system for Bedford - St. Pancras Railcars E.51591 to E.51650 and M.51731 to M.51780

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TRANSMITTAL LETTER No. 5

Incorporate:

Engine, Section 17A, Fuel pump test schedule for Series 821 engines, to follow existing test schedule for Series 803 and 823 engines at end of section

Engine, Section 18E, Instruction manuals for Serck-Behr hydrostatic fan drive (P.697) and sectional radiators (P.682) to follow page 2 of Section 18D Reason for change:

Initial issue to cover Midland Pullman DeLuxe Trains

Initial issue to cover Midland Pullman DeLuxe Trains

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Incorporate:

Reason for change:

Engine, Section 25B. Air

Compressor - Westinghouse.

To follow existing Section

25A

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TRANSMITTAL LETTER No. 7

Incorporate new and revised material in Engine part of manual.

- 1. Remove existing Contents Page and insert revised page
- Remove and destroy the existing Sections 1A, 2, 6, 7, 8, 9, 11, 13A, 13B and 14
- 3. Insert the new Sections 2, 3, 4A, 5, 6, 7, 8, 9, 11, 13A, 13B 13C and 14 in that order to follow General Instructions, page 2
- 4. Insert new Section 16 to follow Section 15B, page 2
- Remove existing Section 17A, pages 1 to 30 and insert new pages 1 to 40. Retain existing governor and fuel pump test schedules
- Remove existing Sections 18A and 18C, and insert new sections.
 Retain Sections 18D and 18E
- 7. Remove existing Section 19A and insert new section
- 8. Remove existing Section 28 and insert new section.
- Discard Chapter 4, Fault Diagnosis and Appendix 1, Fit and Clearances

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ROLLS-ROYCE

RAILWAY DIESEL POWER EQUIPMENT

MAINTENANCE

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T.S.D. PUBLICATION 866 · 1958

ROLLS-ROYCE RAILWAY TRACTION DEPARTMENT · DERBY · ENGLAND

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ENGINE

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ENGINE DATA

RATED POWER AND	SPEEL)									
6-cylinder Series 138	3A and	138B				447	1995		180 b.	h.p. at 1,	800 r.p.m.
8-cylinder Series 82	:3				-+	14.4				O. The state of th	880 r.p.m.
BORE	***			2.2			1+1	4.0	5.125	in. (130	175 mm.)
STROKE			9.60				- 4	747	6.0	000 in. (1	52.4 mm.)
TOTAL SWEPT VOLU	IME										
6-cylinder	2000-020							7.	42 64	n in (12	.17 litres)
8-cylinder		7.0 2.4									6.2 litres)
COMPRESSION RATIO	0										
Supercharged											14 to 1
Unsupercharged			956	27	(55)	11	7.59	(7.71)	221	10	16 to 1
VALVE TIMING	100 100					15.5%		(2.3)	- 1	3.5	
Inlet valve opens	£3			25		1.27	0.00	++	12	lea hefo	re T.D.C.
Inlet valve closes		3		18	220	100	940				er B.D.C.
Exhaust valve opens			11	25	200	200	227	44		100	re B.D.C.
Exhaust valve closes			Same I					7.19		523	T.D.C.
(600)	1		1	-7_		117	- 1		1.0	Jeg. and	1.0.0.
VALVE TAPPET CLES	ARANCI	E (em	gine ho	ot or co	ld)	2.	_/	2.	<u> </u>	1)	0.010 in.
FUEL INJECTION TIME	MING	ff		**		14.47	A	s stam	ped on	engine n	ameplate
FIRING ORDER											
6-cylinder	75		11.0	22	200	23				1-4	. 2, 6, 3, 5
8-cylinder			20	77					456		, 8, 3, 7, 4
DIRECTION OF ROT	ATION		23	++	1000	(Clockwi	ise, vie	wed fro		of engine
WEIGHT OF UNIT AS	HELL	ON	MOL	NTING	e						-
) HELL		MOL	, III,	s (ary	,					
Supercharged 6-cylinder with fluid	couplin	g		4.4	-+	-	(44)			2,9301	o. approx.
Unsupercharged											100
6-cylinder with fluid	couplin	g.		***	++-				14740	2.81411	o. approx.
8-cylinder with torqu				87	***		0.00	1000	440		o. approx.
			F	UEL:	SYST	EM					
FUEL	22	0	-	23	**	35	10	33	13	See table	e, page 3
PRESSURE	G .		22	53			**		-+	10 t	o 12 p.s.i.
INJECTION PUMP			11	**						ed mech	anical or
					an-sp	ecd ny	draulic	gover	nor		

FUEL INJECT	ORS										
Opening pro	essure		(14.4)	24040	++		ep 10000			175 a	tmosphere
Injector asse	embly	1111		14040	000			100	100	**	OD.4752
Nozzle holde		18.00	5440	***	0.750						.96S.684M
Nozzle	7.5		55.74	0.00	4.4						50S.6130A
FUEL FILTER	ELEMENTS		44	217	C	D.267	2, C.A.V.	paper	expen	dable N	o. 7111/44
		LUI	BRICA	ATING	G O	IL S	YSTEM				
APPROVED O	ու	111	7/7	\leftrightarrow	9	**	***	* 1	*1	See tab	le, page 3
CAPACITY											
6-cylinder	914 KA	100	(17) 8:0	22	1.4	57	5.7	7.5	Imperi	al gallo	ns approx.
8-cylinder	11.	33	10	20		3.55		12.5	Imperi	al gallo	ns approx.
PRESSURE (at	working con	lition	18)								
Maximum	01.00		10.0				199			1.4	60 p.s.i.
Normal		11:4	88	266	14.0	266	7.63	72	1.4	30	to 50 p.s.i.
Minimum	33		+ +	144	4.4	1144	0.4		24		to 15 p.s.i.
FILTERS	(e)	15.5	1215	44	Full	flow w	ith expend	iable e	lement	s No. A	C.1530942
)						010.100.79.000				
7	77		7	1-	1	10		η,			1.7.
	Cl,		coc	LINO	SY	STE	M (1		,	IJ.
RECOMMENDE	D COOLANT			(1404-)	(4.4)	-	**		0	See tabl	e, page 3
CAPACITY											
6-cylinder (Me	tro-Cammell	Raile	ars)		120	20		141	mperi	al gallon	s approx.
8-cylinder, inc	duding torqu						Viola	1200		Banor	э прргол.
exchanger	11 77	4.4	**		4.0	+ +	1.4	181	Imperi	al gallor	s approx.
CLEANING AGE	INT ,,	ate:	0.000	50.0	5900	1000	4.0		100	See tabl	e, page 3
THERMOSTAT	100		194	22	4.0	OE.I	5981. Smi	ths' X			restrictor
RADIATOR	ee:	- 1	++	141							
FAN	10: 02:		4.0	(909)	0.0	1.4	1101120	ntat w	nn sep	arate ne	ader tank
6-cylinder											
0 0 1		15	**	2.0	**	255					aft driven
ocyanaer	in m	1.50			(8)	(***)	2	y in. di	a., 8 bl	ades, sh	aft driven
		FI	ECTD	ICAL	FO	UTDA	(ENT				
			ao i N	- Corth	LQ	CIFA	MENT				
STARTER MOT	OR	4.4	9.47	-+		Simms	624 SGI	RE 51/	7 or C.	A.V. U	624/21M
TACHOMETER	GENERATOR	3									
6-cylinder		200		0.00	*2	20	Smiths'	M' typ	e, code	No. M	DG 12/5
8-cylinder							Smithe'				DC 1615

Smiths' 'M' type, code No. MDG 16/5

8-cylinder

AUXILIARY EQUIPMENT

AIR COMPRESSOR

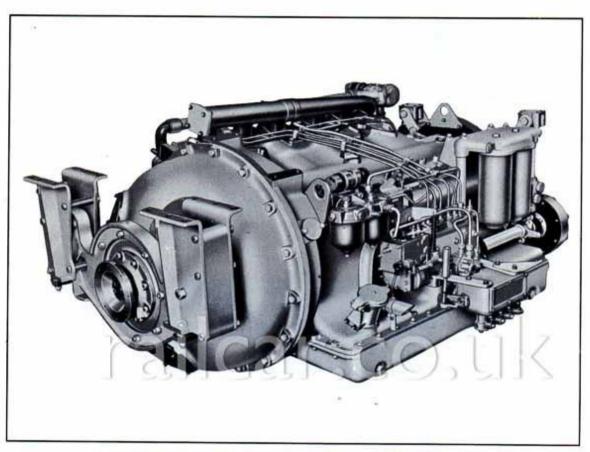
6-cylinder	4.4	++	++	++		0.0	Clayton-Dewandre type 238/2. Belt-driven
8-cylinder	+ 4	++	++	÷:	0.0	-+	Westinghouse type E15. Gear-driven

COOLANT, FUEL AND LUBRICANTS

MATERIAL.	MANUFACTURER	RECOMMENDED BRAND OR SPECIFICATION				
Coolant	=	B.R. No. 621, Cat. No. 7/4580 D.T.D.779 and clean water				
Cooling system cleaning agent	I.C.I. Ltd.	Lissapol N				
Coolant pump and compressor drive jockey pulley bearing grease	Shell	Retinax A or equivalent				
Engine lubricating oil	DEF.2101B, or U.S. Specif the ambient temperature S.A.E.10 in lower ambient	certificated to British Specification cification MIL-L-2104A. Use S.A.E.30 are is above 20 deg.F. (-7 deg.C.), and that temperatures. If the grade of fuel S.2869 Class 'A', Supplement 2 or 3				
Fuel oil	B,S. 2869 Class 'A'	211/2				
Fluidrive traction coupling						
Fluid Rear bearing grease	Shell Shell	Tellus 29 oil or equivalent Retinax A or equivalent				
Hardy Spicer						
Fan drive shaft oil	=	S.A.E.250				
Auxiliary gearbox shaft oil	-	S.A.E.250				
Final drive cardan shaft grease		Lithium base grease with 3% E.P. additive				
Radiator fan bearing grease	Shell	Retinax A or equivalent				
Starter motor (Simms)						
Ball bearing grease	Shell	Retinax A or equivalent				
Pinion grease		D.T.D.783				
Starter motor (C.A.V.)						
Drive end bearing oil		S.A.E.20				
Pinion grease	Shell	Retinax A or equivalent				
Tachometer generator ball						

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8-cylinder railcar engine with torque converter



6-cylinder railcar engine with fluid-drive coupling

CHAP. 1

CHAPTER 1.. GENERAL DESCRIPTION

INTRODUCTION

The Rolls-Royce high-speed compression ignition engine operates on the four-stroke cycle with mechanical fuel injection. The normal direction of rotation is clockwise viewed from the front of the engine, but may be anti-clockwise rotation for special requirements.

Although basically similar, engines are fitted with wet or dry sump lubrication and are either supercharged or unsupercharged. Other differences are confined to the type of accessories fitted and their location on the engine to suit installation requirements.

The crankcase is so designed that the exhaust system, filters and other externally mounted units can be fitted on either the left or the right-hand side of the engine. Looking on the flywheel, the normal left-hand engine has the fuel pump and other accessories on the right-hand side and with a right-hand engine on the left-hand side.

The coolant pump, the dynamo and the air compressor are driven by 'Vee' belts from a pulley on the front of the crankshaft. On supercharged engines the drive for the air compressor is taken from a pulley on the supercharger driving shaft. The driving pulleys incorporate a means for hand-turning the engine for maintenance purposes.

ENGINE FEATURES

The vertical in-line cylinders and crankcase form a single iron casting, fitted with easily replaceable flanged wet liners. The liner flanges are slightly proud of the block face, and are nipped by the gasket between the cylinder head and block to provide a top seal, the lower end of each liner being sealed by two rubber rings.

The main bearing housings are supported by deep webs and the more heavily loaded centre and end bearings are additionally supported by transverse bolts.



Fig. 2 Unsupercharged wet sump engine

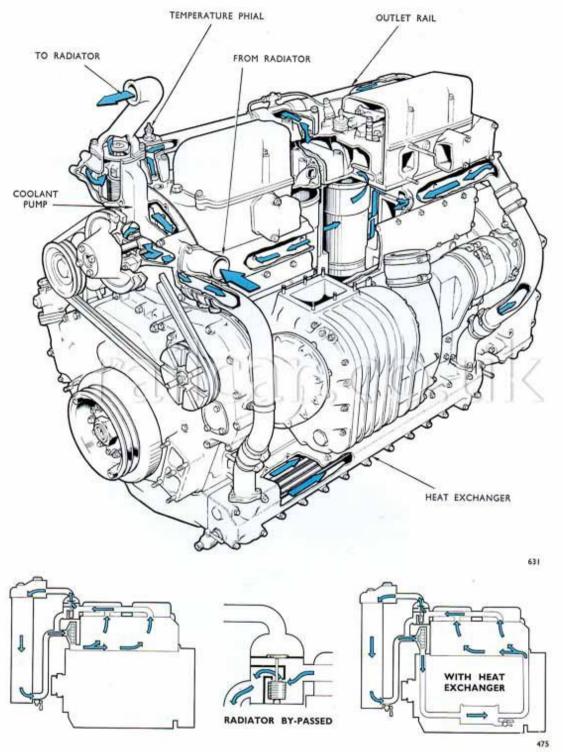


Fig. 3 Cooling system



The crankshaft is nitride hardened and has at the front end an externally mounted viscous damper, which reduces the crankshaft oscillations at all speeds. A pinion on the crankshaft drives the timing gears from which are driven the fuel injection pump and the camshaft.

Main and connecting rod bearings are of the prefinished, steel-backed shell type, with lead-indium bearing surfaces.

Each of the light alloy pistons is fitted with three compression and one oil scraper ring and is recessed in the crown to form a combustion chamber. The variation in compression ratio between the unsupercharged and supercharged engines is controlled by the capacity of the combustion chambers.

The overhead valves have stellited seat faces and stem tips, and are operated by a single internal camshaft through tappets, push rods and rocker assemblies. The two-piece cylinder head is provided with rocker covers for access to the valve gear.

INDUCTION AND EXHAUST SYSTEMS

Air is ducted to the engine inlet manifold through large capacity oil bath cleaners or, on marine engines, through a combined oil-wetted cleaner and absorption silencer.

The positive displacement supercharger raises the pressure in the induction manifold by 8 lb. per sq. in. at an engine speed of 1,800 r.p.m.

The supercharger consists of two coupled lobed rotors which rotate in opposite directions inside a sealed rotor casing. The interior of the casing is in the form of two intersecting cylindrical bores; air is drawn into the casing through an inlet port and is carried round between the rotor lobes and the casing to the outlet port where the intermeshing action of the rotors force the air out to the inlet manifold for distribution to the cylinders.

On supercharged marine engines, a charge cooler interposed between the supercharger outlet and the engine inlet manifold, reduces the air temperature resulting from supercharger compression by heat extraction from the air to the sea-water circulating through the cooler tubes.

The exhaust manifold on marine engines is jacketted and circulated with engine coolant, to assist silencing and keep the engine-room temperature as low as possible.

On coupled power units, pyrometers fitted in the exhaust system provide an indication for engine synchronization by comparing the measurement of the exhaust gas temperatures.

COOLING SYSTEM

For most applications the cooling system is pressurized to raise the boiling point of the coolant.

A pressure-vacuum relief valve, located on the header tank of the coolant heat exchanger, operates as a springloaded safety valve to vent pressure in excess of 10 lb. per sq. in. (0.70 kg. per sq. cm.), and to admit air when the pressure in the system falls to less than 1 lb. per sq. in. below atmospheric pressure. The coolant is circulated around the engine by a belt-driven centrifugal pump, the heat of combustion imparted to the coolant being dissipated by the radiator, or by a sea-water circulated heat exchanger on marine engines.

Coolant is drawn from the radiator by the pump and is delivered to the engine either directly into the inlet gallery or through an oil heat exchanger, which serves as a heating or cooling medium for the lubricating oil, thence around the cylinders and cylinder heads, and back to the header tank of the radiator.

A thermostat is incorporated in the system to give rapid 'warming up' and to maintain the coolant at the correct working temperature under all conditions. This it does by isolating the radiator as long as the coolant is below a pre-determined value, and by gradually increasing the flow of coolant through the radiator as the temperature rises, until, after a given rise of temperature, the full cooling capacity of the radiator is used.

The heat exchanger of the marine engine is circulated with sea-water by a centrifugal pump, directly driven by a friction coupling attached to the crankshaft damper.

The self-priming pump draws sea-water through its injection valve and delivers it through the tubes of the heat exchanger, thence to the exhaust silencer and is discharged overboard with the exhaust gases. A second delivery from the pump circulates sea-water through the charge cooler and gearbox oil cooler.

Whilst water can be used as the engine coolant, a correctly inhibited anti-freeze mixture is recommended for use all the year round, as this not only provides protection against frost, but prevents corrosion within the cooling system.

LUBRICATION SYSTEM

Engine lubrication for vertical engines is either by the dry or wet sump system, but for both systems the distribution of oil to the moving parts of the engine is identical.

The normal wet sump system has a gear type pressure pump, located on the front main bearing cap and forming part of the gallery pipe assembly. The pump draws oil from the sump well and delivers it through full-flow filters to the engine main feed gallery. The pack type heat exchanger used for this system is interposed between the pump and the filters.

For the dry sump system, one pressure and two scavenge pumps are used. The scavenge pumps clear the front and rear sump wells and their operation is unaffected by inclination of the engine up to 40 deg. in any direction. Oil is transferred from the sump wells to a reservoir from which it is circulated by the pressure

pump, passing first through an in-built oil heat exchanger and a bank of full-flow filters and thence to the engine main feed gallery.

For horizontal engines, a semi-dry sump lubrication system is used, the pump assembly consisting of one scavenge and one pressure pump unit.

Oil is drawn from an external drains chamber by the scavenge unit and discharged into the sump from where it is drawn by the pressure unit and delivered to the engine main feed gallery.

The oil is distributed by the main feed gallery to the main and crankpin bearings and through longitudinal drillings in the connecting rods to the gudgeon pin bearings and cylinder walls. A separate feed from the gallery delivers oil at high pressure to the camshaft bearings and thence through a restrictor to supply low pressure oil to the hubs of the timing gears.

Oil to the rocker assemblies is fed through a drilling in the crankcase, to a pipe assembly in the tappet recess where the flow divides and is directed to each rocker shaft through a drilling in one of the holding down studs of each cylinder head. Spill from the rockers lubricate the ends of the valve stems, the push rod ball ends and the tappets.

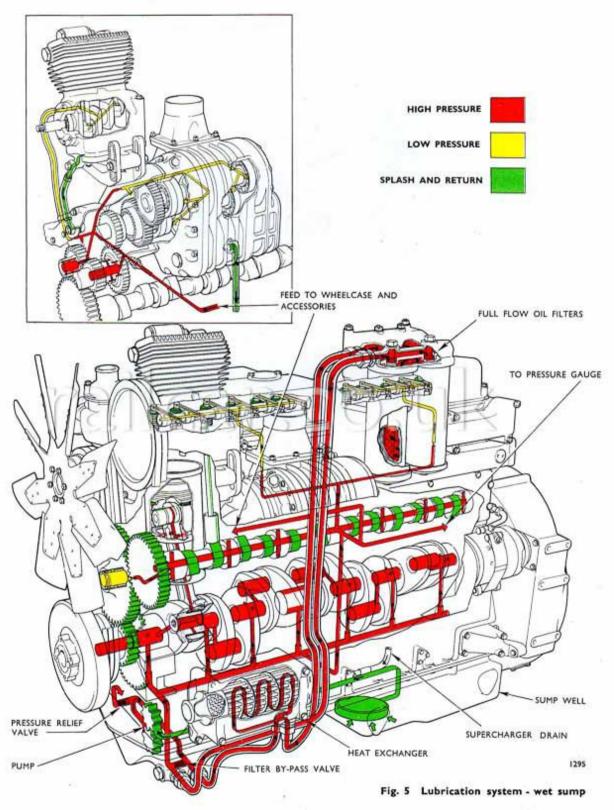
The relief valve unit contains pressure-relief and filter by-pass valves which, apart from spring loadings, are identical. These loadings are such that the pressure-relief valve opens when the oil pressure rises above 60 lb. per sq. in. (4.2 kg. per sq. cm.) and the filter by-pass valve opens if the pressure drop across the bank of filters exceeds 10 lb. per sq. in. (0.7 kg. per sq. cm.). This obviates oil starvation of the engine in the event of the filters becoming choked.

On some wet sump installations, the housing for the relief valves is cast into the front end of the sump, the base having a thickened section to provide a front support for the engine.

The pressure filters are fitted in-line to a header bracket secured to the side of the crankcase and connected by external pipes to the relief valve unit. Filtration is achieved by forcing the oil through paper elements within the cylindrical containers, any foreign matter being trapped by the paper. These elements cannot be cleaned; they are renewed at the appropriate servicing period.

The function of the heat exchanger is to bring the oil rapidly to its most efficient working temperature and to maintain it at that temperature under all conditions, thereby reducing wear and obtaining maximum efficiency from the engine.

Engine breathing from the crankcase is through an elbow fitted to the tappet cover. A gauge filter secured to the elbow outlet minimizes the ejection of oil.



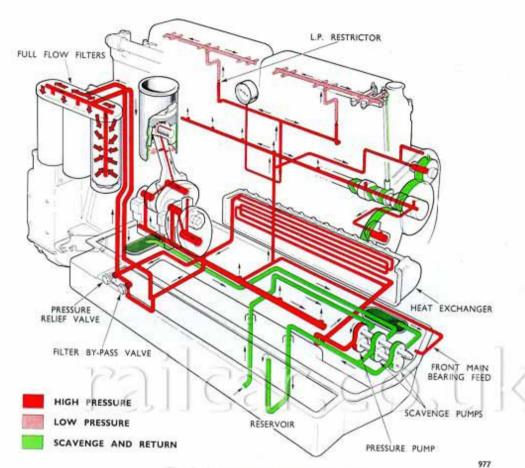


Fig. 6 Lubrication system - dry sump

Warning of low oil pressure is provided by a pressure sensitive switch which operates on both a rising and falling pressure, thus an indication of correct functioning is given each time the engine is started if the switch is used in conjunction with an audible warning device.

When the switch is used in conjunction with a solenoid for stopping the engine, the circuit embodies an isolating switch to break the current to the solenoid when starting the engine.

On some engines oil is piped from the engine to lubricate the fuel injection pump and so reduce wear on the pump camshaft. A restrictor located in the engine crankcase, meters oil to the pump sump, from where it overflows into the governor housing and thence to the engine sump.

FUEL SYSTEM

Fuel supply to the engine is maintained by a piston type lift pump located on the injection pump casing and operated by a cam on the injection pump camshaft. The fuel is drawn from the supply tank through a primary filter and is forced through a bank of secondary filters arranged in-line on a common header bracket bolted to the engine crankcase.

To prevent excessive pressure rise on the inlet side of the filters, a constant pressure valve is incorporated which limits the inlet pressure to 15 lb. per sq. in. (1.05 kg. per sq. cm.); any fuel overflow from this valve is carried by a spill line back to the supply tank.

After passing through the external filters the fuel flows to the injection pump, where it passes through an internal filter to the pumping element intake gallery.

Where an open fuel drain from the injection pump is prohibited due to fire risk, the lift pump embodies a scavenge pump which discharges any surplus fuel oil into the spill line, thence to the supply tank.

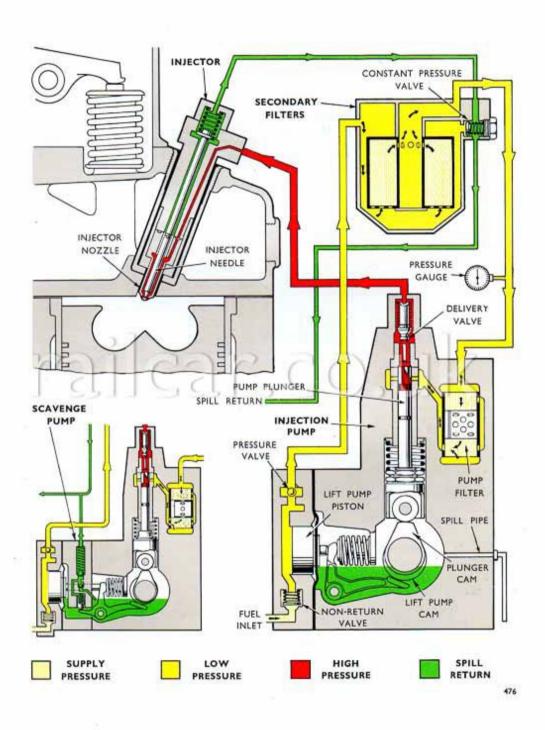


Fig. 7 Fuel system

The fuel injection pump is driven at half engine speed and consists of constant-stroke pumping elements in a common casing, each element supplying fuel to its respective engine cylinder. The plungers of the pumping elements force an accurately measured quantity of fuel into each cylinder and this is atomised in its passage through the nozzle of the injector.

The quantity of fuel injected into the cylinders and, therefore, the power of the engine is varied by means of a control rack which rotates the pump plungers simultaneously through the same angle, thus increasing or decreasing the quantity of fuel delivered to each cylinder by the same amount.

An adjustable stop, by which movement of the rack may be restricted, can be set at any desired point to control the maximum fuel delivery. To start the engine from cold in low ambient temperatures, an excess fuel device is fitted to the injection pump. By operating a push button, the fuel control rack is allowed to override the maximum fuel stop setting, thus permitting a greater amount of fuel to be injected. When the engine runs up to maximum speed, the device is automatically released by the action of the governor; the maximum fuel supply to the engine is then governed by the maximum fuel stop.

When the engine is running, the fuel delivered to the engine is determined by a chosen setting of the speed control lever, and thereafter is varied by the governor to maintain the desired engine speed. The governor may be mechanically or hydraulically operated, and effects control at all engine speeds.

A lever operated stop control on the pump rotates the pump plungers to the 'no-delivery' position, thus stopping the engine due to fuel starvation. On some

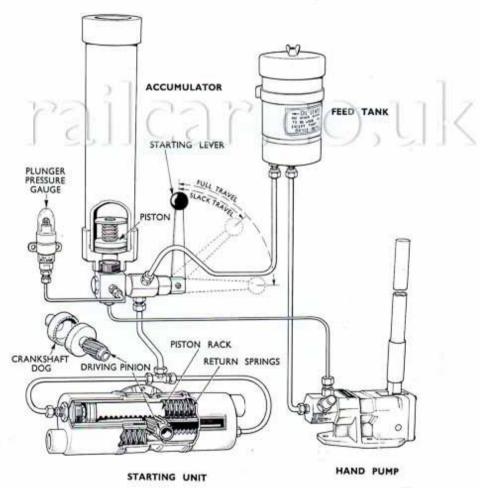
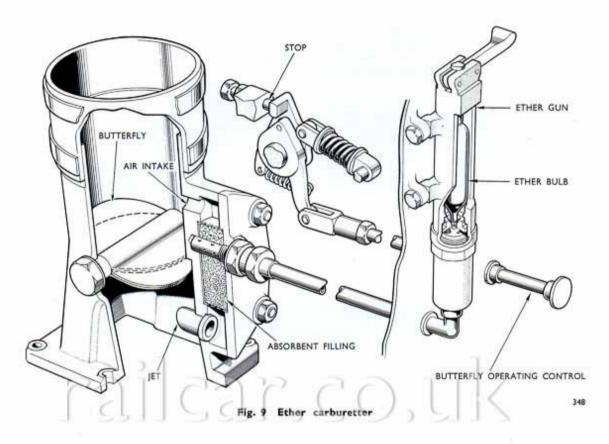


Fig. 8 Bryce Berger starting system



installations, the pump stop control is operated by a solenoid which is energised by a push switch for normal stopping, and automatically in an emergency by oil pressure, coolant and air temperature switches.

ELECTRICAL UNITS AND STARTING

The 24-volt starter motor and dynamo are standard equipment. The starter motor is of the 'axial' type, and with normal batteries and S.A.E. 30 oil, will start the engine satisfactorily at temperatures down to -8 deg.C.

The dynamo fitted is according to the electric power requirements of the installation.

On some installations, where electrical equipment is undesirable, starting is effected by a Bryce Berger 'Handraulic' starter, and for starting in extremely low ambient temperatures, certain engines have an air started fitted.

The Berger starter consists of four main components, a piston accumulator and relay valve, an oil reservoir, a hand pump and the starting unit.

The starting unit is secured to the front end of the engine and comprises two opposed cylinders, each containing a piston-rack which engage with a pinion. The pinion is integral with a toothed dog which engages with a corresponding dog on the engine crankshaft.

On operating the starting lever, the energy stored in the high pressure air in the accumulator is transmitted through the medium of the hydraulic fluid to the starting unit.

The starting lever operates a two-stage valve, the first admitting sufficient pressure to the starting unit to engage it with the crankshaft. During the second stage, when the dogs are engaged fully, oil at high pressure is admitted to the unit cylinders and the crankshaft is rotated at high speed.

When the engine starts, the dogs are automatically disengaged and, on release of the starting lever, the piston-racks return to their original positions under the influence of return springs; the oil being discharged into the feed tank for pumping up to the accumulator for further starts.

Ether starting carburetter

Starting in extremely low ambient temperatures is assisted by an ether carburetter embodied in the induction system. The carburetter consists of a duct which carried a reservoir containing a cotton wool filling. The duct is fitted with a butterfly throttle and an air passage in the side of the duct above the butterfly leads air into the reservoir.

A second passage is provided from the reservoir into the duct on the engine side of the butterfly, and an external pipe to the reservoir allows the cotton wool to be charged with ether.

When the engine is cranked with the butterfly closed, the pressure drop across the reservoir causes a mixture of ether and air to be drawn into the cylinders. On the engine commencing to fire, the butterfly is slightly opened and air flow down a passage milled in the duct beneath the butterfly maintains the depression at the jet so that ether vapour continues to be drawn from the reservoir.

When even running is established, the butterfly throttle is opened fully and the ether carburetter ceases to operate.

ENGINE INSTRUMENTS

The engine is fitted with a tachometer drive and the necessary pressure and temperature gauge connections: The engine service counter provides an accurate means of determining the correct time for servicing.

AIR COMPRESSOR

The air compressor is an in-line twin cylinder unit with either a liquid or air cooled head. Filtered air is drawn from the engine intake manifold and for a liquid cooled head, the engine coolant is utilized.

There are no separate filters to service as the compressor is also lubricated from the engine lubrication system.



GENERAL INSTRUCTIONS

The general instructions given below cover essential common procedure, which should be kept in mind when dismantling or assembling an engine.

When an engine component or accessory is removed precautions must be taken to prevent dirt entering any exposed apertures. Before removal operations are commenced, clean the area in the vicinity of the component to be removed and immediately after removal blank off all pipes and adequately cover all openings.

Cleanliness cannot be too greatly emphasized particularly in respect of the fuel system and every precaution must be taken to keep dirt out of working parts during assembly. Pipes should be washed and blown through immediately before they are fitted.

Clean all parts thoroughly after they have been removed and inspect them. Be sure that all lubricating passages and oil holes are clear and cover all serviceable parts to keep them clean until they are installed. Special attention should be paid to ball and roller bearings to keep out dirt. After washing and inspection they should be dipped in light oil and wrapped in clean paper.

Special service tools are provided for specific jobs and they should be used, when recommended, to save time and prevent damage to parts. The application of these tools is illustrated throughout the manual.

Never break a hose connection by prizing the hose off with a screwdriver, as this practice causes damage to the pipe or adapter and ultimately a leaking joint. The recommended method is to cut through the hose with a sharp knife and afterwards cut the ends from the pipe or adapter. Whenever a hose connection is broken a new hose should always be fitted. If any difficulty is encountered when fitting a new rubber, it may be lubricated with water, glycol or French chalk, but never use oil or grease as this is injurious to the rubber.

It is false economy to use doubtful gaskets or seals such as rubber rings. Rubber rings should always be renewed whenever they are disturbed.

Used split-pins, locking plates and tab-washers must never be refitted, they should be scrapped. The correct method of fitting split-pins and locking plates is shown in fig. 1; split-pins should be a good fit in the hole with one leg turned over the



Fig. 1 Right and wrong methods of locking

Revised February 1957

top of the nut and the other down the flat. Locking plates should be fitted with one end of the plate bent sharply around the edge of the part and the other end sharply against the flat of the nut.

When self-locking nuts are removed they should be scrapped and new nuts fitted. When a new selflocking nut is fitted, at least one full thread of the bolt should protrude through the nut when it is fully tightened.

When installing oil seals, first pack the seal with 'Vaseline' and be careful not to cut the rubber on shoulders or sharp edges and unless otherwise specified always fit the seal with the wiping edge inwards to the bearing. When refitting the various assemblies, it is important that nuts are tightened to the correct torque loadings when these are specified, otherwise failures of studs, bolts and joints may result due to uneven tightening of the nuts. For joints such as the cylinder head, the tightening should be done evenly, in stages and in the sequence recommended so that a uniform pressure is maintained across the joint. The torque wrench GA.238 is recommended, having a range of 35 to 225 lb. ft. (4.8 to 31.1 kg.-m.).

Unserviceable units should be returned for reconditioning with the same parts attached as the replacement unit and with all apertures blanked off and joint faces protected. When necessary, units should be treated internally against corrosion.



T.S.D. 803 SEC.2

SECTION 2 ... STORAGE AND TRANSIT

STORAGE

Before an engine is placed in storage it must be adequately protected against internal and external corrosion. The anti-corrosion treatment necessary will depend on the anticipated length of the storage period, the climatic conditions in which storage will take place, and on whether the engine is to be stored in a packing case or installed in a vehicle. Suitable anti-frost precautions will also be necessary when an installed engine is to be stored under climatic conditions in which temperatures below 0 deg.C. (32 deg.F.) are likely to occur.

No internal or external anti-corrosion treatment is necessary when an engine is to stand for periods of up to seven days.

When an engine is placed in temporary storage for a period of up to one month no external treatment is necessary, but to prevent internal deterioration the engine must be either hand turned at least two revolutions once every seven days if it is not installed in a vehicle, or run until normal oil and coolant temperatures are reached once every seven days if it is installed.

Before being placed in storage for a period longer than one month, an installed engine must be internally inhibited and subjected to external protective treatment. A non-installed engine must be either internally inhibited and subjected to external protective treatment, or internally inhibited and enclosed in a sealed exhausted polythene bag containing silica gel desiccant. The latter method is recommended, particularly when an engine is to be stored under humid climatic conditions. The external protective treatment must be repeated after every twelve months of storage on an installed engine and on a non-installed engine which is not stored in a polythene bag.

Vapour phase inhibitor (V.P.I.)

Protection of certain parts of the engine is simplified by the use of V.P.I. 260 powder, which produces a vapour which combines with any water vapour present to render it non-corrosive. When used in sealed induction and exhaust manifolds the air will remain saturated with this protective vapour until the powder becomes dissipated, when a new quantity should be used. A powder gun similar in type to those used by horticulturists should be used for injecting the powder.

V.P.I. 260 powder is obtainable from Shell Chemicals Ltd., Distributors, 112, The Strand, London, W.C.2.

STORAGE PROCEDURE

INSTALLED ENGINES

The following instructions apply to engines which are to be stored in the vehicles in which they are installed.

Cooling system

Whenever possible the vehicle should be stored with the cooling system completely filled, i.e. with no air space left above the coolant in the radiator header tank.

If the cooling system is already filled with a mixture of approved inhibited ethylene glycol and water when a vehicle is received for storage, test the specific gravity and the acidity of the coolant as described in Section 18A. If the tests are satisfactory, and the strength of the mixture is adequate for the lowest temperature likely to be encountered during the storage period, the coolant should be left in the system. If the tests are unsatisfactory, drain the system and refill with fresh

coolant mixture of an adequate strength and to the same formulation as that drained from the system.

If a vehicle is received for storage with the cooling system filled with a mixture of approved inhibitor and water, the existing coolant should be left in the system provided that temperatures below 0 deg.C. (32 deg.F.) will not be encountered during the storage period. If freezing temperatures are likely to occur the inhibited water must be drained and the system refilled with an approved inhibited ethylene glycol/water mixture of adequate strength and to the same formulation as the drained inhibitor.

If a vehicle is received for storage with the cooling system filled with untreated water, and if temperatures below 0 deg.C. (32 deg.F.) will not be encountered during storage, pour into the water an approved inhibitor. If freezing temperatures are likely to occur during the storage period the water must be drained and the system filled with a mixture of approved inhibited ethylene glycol and water.

See Section 18A for particulars of inhibited coolant and filling instructions.

If for any reason a vehicle must be stored with the cooling system drained, add soluble oil to the existing coolant before the engine is run for inhibiting purposes, and drain the system on completion of the final run. A list of recommended soluble oils and mixture strengths is given in 'Engine Data'.

Internal inhibiting

Start the engine and run it until normal working temperatures are reached. Stop the engine and drain all the lubricating oil from the sump while the engine is still hot. Refit the sump drain plug or plugs and fill with clean engine lubricating oil to the 'MAX' mark on the dipstick. Remove the oil filters from the filter header bracket, pour off the oil, renew the elements, refill with clean engine lubricating oil, and refit the filters to the header bracket. The lubricating oil to be used should be that recommended for service operation of the engine.

Remove the oil level and filler plugs from the fuel injection pump and governor casing, syphon out the oil, refill with clean engine lubricating oil and refit the plugs.

Connect the fuel lift pump to a supply of inhibiting fuel oil. A list of recommended inhibiting fuel oils is given in 'Engine Data'.

Start the engine and run at 800 to 1,000 r.p.m. under no load for 30 minutes to ensure complete circulation of the clean engine lubricating oil throughout the engine.

Stop the engine and allow it to cool. Drain the lubricating oil if necessary to comply with local storage orders or transportation regulations, otherwise the oil should be left in the engine sump and in the fuel pump and governor.

If the engine has been finally run with soluble oil in the coolant, drain the cooling system. In all other cases top up the system so as to completely fill the radiator header tank.

Blank off the radiator pressure-vacuum valve outlet or radiator overflow pipe, as applicable.

Remove the starter motor and hand turn the engine through at least eight revolutions to ensure that an oil film is left on the cylinder bores above the pistons. At the same time paint the teeth of the flywheel starter ring with an approved protective oil through the timing aperture. A list of approved protective oils is given in 'Engine Data'.

Disconnect the inhibiting fuel oil supply to the fuel lift pump and reconnect the pump inlet to the vehicle fuel supply pipe.

Seal the fuel pump governor casing breather with waterproof adhesive tape and secure the speed control lever in the 'no fuel' position. Fit blanking caps to the fuel pump drains.

On supercharged engines remove the plug from the centre of the induction manifold, inject one gramme of V.P.I. 260 powder into the manifold, and refit the plug. Disconnect the hose at the supercharger inlet, inject one gramme of V.P.I. 260 powder into the supercharger, and remake the hose connection.

On unsupercharged engines disconnect the hose at the inlet branch on the induction manifold, inject two grammes of V.P.I. 260 powder in the manifold, and remake the hose connection.

Disconnect the exhaust pipe at the manifold joint, inject two grammes of V.P.I. 260 powder into the exhaust manifold, and blank off the outlet port in the manifold with an end cover OE.4011. Do not reconnect the exhaust pipe to the manifold.

External protective treatment

Paint the pinion and splined shaft of the starter motor with an approved protective oil. Refit the motor to the engine.

Remove the driving belts from the dynamo pulley. Wrap the dynamo, starter motor and tachometer generator 'in situ' in moisture-proof wrapping and seal the wrappings with waterproof tape.

If the engine is fitted with wet-type air cleaners, remove the pre-cleaners from the air cleaners and blank off the exposed air inlets. Seal with waterproof tape.

If the engine is fitted with dry-type air cleaners, seal the air inlet holes in the base of the containers with moisture-proof adhesive tape.

Remove the crankcase breather filter and blank off the breather pipe with the plug OE.4150.

Wrap the pre-cleaners and the breather filter in moisture-proof wrappings and seal the wrappings with waterproof tape.

Treat all rubber pipes, hose connections and belts with French chalk.

Clean the engine externally and remove any signs of corrosion. Liberally coat the control linkage with low temperature grease and paint all external machined and unpainted surfaces with a recommended protective oil.

Labelling of stored engines

Attach labels in prominent positions on the engine and in the driving cab of the vehicle, stating:

- Whether the cooling system is empty or full, and whether or not soluble oil has been used in the cooling system. If soluble oil has been used, stress the need for cleaning out the system with 'Lissapol N' or 'Texofor F', as described in Section 18A, before refilling the system with an approved coolant.
- The brand and formulation of the inhibited ethylene glycol or water inhibitor which is in the cooling system if it has not been drained, or which was used in the system prior to draining if the system is empty.
- Whether or not the engine oil sump, injection pump and governor have been drained of engine lubricating oil.
- 4. That the exhaust manifold has been blanked and is disconnected from the exhaust pipe. The label should also indicate that the speed control lever is secured in the 'no fuel' position.
- The date (in full) on which the engine was inhibited. This information is necessary for re-inhibiting record purposes.

NON-INSTALLED ENGINES

The procedure for inhibiting a non-installed engine is substantially the same as that for an installed engine. The engine running can be carried out immediately after the acceptance test, thus dispensing with the initial running before changing the lubricating oil. Soluble oil in an approved strength should be used in the coolant for the inhibiting run.

If the engine is to be stored in a polythene bag, no external protective treatment is necessary. If a polythene bag is not being used, paint the splined bore of the clutch driven plate, the clutch release lever plate, the engine mounting faces and the joint face of the clutch housing with an

approved protective oil. Avoid the use of a spray gun in the vicinity of the clutch as the protective oil is detrimental to the clutch linings. When electrical components such as ammeters, voltmeters and switches are fitted, all terminals should be coated with petroleum jelly or lanolin.

Place a label on the engine stating that soluble oil was used in the cooling system before it was drained, and indicating whether or not the engine sump, fuel pump sump and governor casing were drained prior to storage. The date (in full) on which the engine was inhibited must be clearly indicated for re-inhibiting record purposes if the engine is not to be stored in a polythene bag.

Sealing an engine in a polythene storage bag

Inhibit the engine internally as described in the storage procedure for installed engines. No external protective treatment is necessary, but all hose connections, pipe ends, breathers and other orifices must be blanked.

Place the base of a suitably sized polythene bag over the base of the engine crate, taking care not to tear the plastic on the engine securing bolts, and roll the slack sides of the bag around the base of the crate. Cut holes in the base of the bag just sufficiently large to accommodate the engine securing bolts, and fit suitable felt pads over the bolts and bag so that the engine bearers will not rest on the polythene. Polythene storage bags are obtainable from W. Griffiths and Son, N.A. Clare Street, Cardiff.

Lower the engine carefully on to the securing bolts, and fit and tighten the securing nuts.

Distribute eight one-pound (0.45 kg.) bags of silica gel basic desiccant in secure positions around the engine, and hang a safety indicator colour change humidity card in a prominent position on the engine. Suitable bags of desiccant are obtainable from Joseph Crossfield and Sons Limited, Warrington, England.

Pack any accompanying parts such as engine breather and air pre-cleaners and a bag of desiccant in a suitable moisture-proof container and place the container on the base of the polythene bag. Scatter a liberal quantity of V.P.I. 260 powder (about seven handfulls) over the base of the bag, and dust the injection pump with an additional handful of the powder.

Bring up the sides of the bag around the engine until the top edges meet. Seal the open top end of the bag by the simultaneous application of heat and pressure, leaving a slot about 2 in. long unsealed for the insertion of an air exhauster tube. Suitable 'Pyramid' electrical sealing equipment can be obtained from A. H. Bland (Engineers) Ltd., Hayes, Middlesex.

Insert a tube connected to a suitable air exhausting pump into the slot in the top of the bag and slowly exhaust the air until the bag collapses around the engine. Remove the pipe and seal the slot without allowing air to re-enter the bag.

Lower the lid of the crate over the engine and secure it to the base. The lid of the crate should be lined with two-ply moisture-proof toughened paper.

The lid of the crate should be removed and the safety indicator checked weekly during the first three weeks of storage and thereafter at three-monthly intervals. The indicator is easily visible through the polythene. Should the colour change from blue ('safe') to red ('unsafe') the probable cause will be a split in the polythene bag, in which case the desiccant should be changed and the bag repaired, re-exhausted and re-sealed. Should the indicator then not change to blue the engine must be removed from the bag, inspected, cleaned, re-inhibited and re-packed in a new bag.

PREPARING A STORED ENGINE FOR RUNNING

The following instructions give the procedure for preparing an installed inhibited engine for running. Non-installed engines need not be prepared for running until after they have been installed, after which the procedure prior to running is the same as that described for an installed engine.

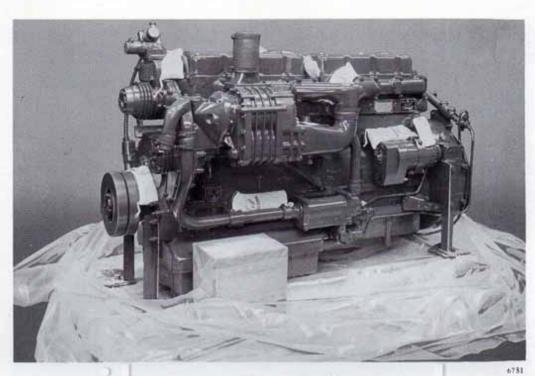


Fig. 1 Engine prepared for sealing in polythene storage bag



Fig. 2 Sealing the polythene storage bag

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Fig. 3 Storage bag exhausted and sealed

Remove the blanking cap from the radiator pressure-vacuum valve or overflow pipe. By reference to the storage label attached to the engine, ascertain the contents of the cooling system and if necessary top up as required with an approved ethylene glycol solution or inhibited water to the same formulation as that already in the system.

If the engine has been stored with the cooling system drained, thoroughly clean the system as described in Section 18A to remove all traces of soluble oil before filling with an approved coolant.

By reference to the storage label, ascertain whether the engine sump, fuel injection pump sump and governor casing were drained prior to storage. If necessary, fill the injection pump sump and the governor casing, if mechanical type, with engine lubricating oil. See Operator's Handbook for specific instructions. Remove the sealing tape from the governor breather and unlock the speed control lever. Remove the blanking caps from the fuel pump drains.

Fill the engine sump with the recommended lubricating oil up to the 'MAX' mark on the dipstick.

Remove the blanking plug from the outlet port of the exhaust manifold and connect up the manifold to the vehicle exhaust pipe.

If the engine is fitted with wet-type air cleaners remove the air cleaner oil baths, ensure that they are filled with clean engine lubricating oil up to the pressed rib around the bath, and refit the baths to the cleaners. Remove the sealing tape from the air inlets, wash the pre-cleaners in petrol and fit them over the air inlets.

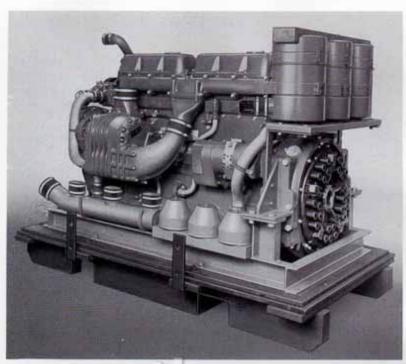




Fig. 4 Typical method of packing for transportation

at Printed Bullingland.

If the engine is fitted with dry-type air cleaners, remove the sealing tape from the base of the containers.

Remove the plug from the end of the crankcase breather pipe and fit the breather.

Remove the moisture-proof wrappings from the dynamo, starter motor and tachometer generator. Refit the dynamo driving belts and adjust to the correct tension.

Start the engine and run at moderate r.p.m. under no load for about 20 minutes.

TRANSIT OVERLAND

Before an engine is transported by road it should be internally inhibited against corrosion, and all hose connections, pipe ends, breathers and other orifices on the engine and the open ends of all accompanying loose parts fitted with suitable blanks. Crating of the engine is not necessary for a short journey, but it must be adequately covered with tarpaulin to exclude dust and moisture.

TRANSIT OVERSEAS

Installed engine

Before being shipped overseas an engine installed in a vehicle must be internally inhibited and externally protected against corrosion, as described in the storage procedure for an installed engine.

When a vehicle is driven to the docks under its own power the inhibiting must not be carried out until the services of the engine have been finally dispensed with.

It is preferable that the inhibited ethylene glycol mixture or inhibited water be left in the cooling system, but it may be drained off if necessary to comply with shipping regulations, in which case soluble oil in an approved strength must be added to the coolant prior to the final run before the system is drained. A label to this effect must be attached to the engine.

Remove the crankcase breather filter and seal the end of the breather pipe with the plug OE.4150.

Wrap the crankcase breather and the air precleaners and pack them with any other loose parts accompanying the vehicle.

Non-installed engine

Before being shipped overseas an engine which is not installed in a vehicle must be inhibited internally as described in the storage procedure for a non-installed engine. The engine and accompanying loose parts must then be sealed in an exhausted polythene bag and crated as described in 'Sealing an engine in a polythene bag'. The crate should be lined with two-ply moisture proof toughened paper.

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SYMPTOM OR CONDITION	POSSIBLE CAUSE	ACTION	REFER TO
1. FAILURE TO START Starter will not turn engine	Discharged battery, faulty starter circuit, defective starter motor Starter pinion will not engage	Check voltage at starter motor terminals. If satisfactory, change starter motor. If no voltage, check battery, battery connections and starter switch Turn engine by hand and try again. Change starter motor if fault persists	Section 27A or B
	Loss of air pressure (air starter) Leaking pipe joints (handraulic starter)	Check for loose connections and faulty non-return valve in air system Repair leaks	Section 27E Section 27D
Engine will not fire (even after excess fuel device has been operated)	No fuel at injectors Air in fuel system Fuel filters choked Water mixed with fuel Fuel pump timing incorrect Air cleaners choked Faulty lift pump	Check tank level and fuel cock Prime fuel system Bleed fuel system Change engine filter elements Empty fuel filter bowls Reset timing Clean air cleaners Change lift pump	Operator's H/book Operator's H/book Operator's H/book Operator's H/book Section 17A or B Section 4A or B Operator's H/book
2. FAILURE TO PICK UP	Faulty fuel supply Faulty fuel lift pump Air cleaners choked Faulty fuel injectors	Check pipe unions and bleed fuel system Change lift pump Clean air cleaners Change injectors	Operator's H/bool Operator's H/bool Section 4A or B Section 17A or B
3. MISFIRING	Air in fuel system Fractured injector feed pipe Faulty injector Incorrect tappet clearances Faulty fuel injection pump	Bleed fuel system Change pipe Loosen feed pipe to each injector in turn and note engine response Check tappet clearances Change injection pump	Operator's H/bool Operator's H/bool Operator's H/bool Section 5 Section 17 A or B
4. OIL PRESSURE LOW (Relatively sudden pressure drop as opposed to progres- sive drop due to worn bearings)	Low oil level Faulty oil pressure gauge Oil filters choked Faulty relief valve Oil temperature high	Check and fill up Try another gauge Change filter elements Examine and clean pressure relief valve See item 5	Operator's H/book Operator's H/book Section 19A, B or 0

SYMPTOM OR CONDITION	POSSIBLE CAUSE	ACTION	REFER TO
5. OVERHEATING	Loss of coolant	Check coolant level and inspect for leaks	Section 18A
	Choked air passages and		MARK TEST TO
	radiator matrix	Clean air passages and matrix	-
	Fouled coolant system	Drain, clean and refill system with	2
	1	correct coolant	Section 18A
	Incorrect fan belt tension Faulty thermostat	Adjust tension	Section 26A
	Fuel injection pump timing	Change thermostat	Section 18A or C
	incorrect	Reset timing	Section 17A or B
	Low oil level	Check and fill up	Operator's H/book
6. FUEL PRESSURE LOW	Fuel filters choked	Change filter elements	Operator's H/boo
or real randomin non	Faulty fuel constant pres-	Examine and clean constant pres-	Operator's 11/000
	sure valve	sure valve	Section 17A or B
	Leaks in fuel suction line	Check for loose connections	
	Faulty fuel lift pump	Change lift pump	Operator's H/boo
	Faulty pressure gauge	Try another gauge	-
7. POWER LOW	Low fuel pressure	See item 6	+
135	Fuel injection pump timing incorrect	Reservation 7	days and an
(''	Faulty injectors	Reset timing Change injectors	Section 17A or B
	Air filters choked	Clean air filters	Section 4A
	Insufficient tappet clear-	Cicali an inters	Section 474
	ances	Adjust tappets	Section 5
	Cylinder head or inlet,	Renew gaskets or joint packings	A MARKETT CASA I L. I.
	manifold joints leaking	as necessary	Section 5
	Sheared supercharger drive or seized rotors	Remove supercharger air intake	
	or seized rotors	and check drive. If confirmed, change supercharger	Section 28
		change supercharger	Section 28
8. BLACK SMOKE FROM	Over-fuelling	If max. fuel stop seal has been	Cultivities (CVI)
EXHAUST	CONTRACTOR OF THE CONTRACTOR O	broken, change pump	Section 17A or B
	Sheared supercharger drive or seized rotors	Remove supercharger air intake and check drive	
	Faulty injectors	Change injectors	Section 17A or B
	Fuel injection pump timing	Bo injestora	Section 1774 OF B
	incorrect	Reset timing	Section 17A or B
	Air filters choked	Clean air filters	Section 4A or B

T.S.D. 803 SEC, 4A

SECTION 4A . . AIR CLEANERS

Two types of air cleaners are used, the dry and the wet.

The dry type has a removable one-piece pleated paper element in a perforated metal container.

The wet type has a detachable oil bath, a single or two-piece woven wire element and a louvred air intake or, alternatively, a centrifuge pre-cleaner intake; for certain applications the pre-cleaner is fitted with a dust jar.

CLEANING

Dry type

Unscrew the captive knurled nut, remove the lid, lift out the element, and examine it for tears and deterioration.

If a supply of clean, dry compressed air is available, apply a low pressure jet to the inside of the element to blow off the dust in an outward direction. If there is any doubt as to the cleanliness or dryness of the air supply, or if a compressed air supply is not available, clean the element by lightly tapping it. While the latter method is not as thorough as cleaning with com-



Fig. 2 Blowing out the element

pressed air, the element will still operate satisfactorily, but more frequent cleaning may be required:

torily, but more frequent cleaning may be required: The element must on no account be washed or immersed in any liquid.

Replace the element, taking care not to damage the small rubber seal, refit the lid and tighten the knurled nut.



Fig. 1 Dry type cleaner - exploded



The efficiency of the cleaner is not unduly affected by the accumulation of dust, but the resultant restriction of the airflow will eventually affect engine performance. For this reason regular cleaning is important.

When cleaning of the element appears to be ineffective, a new element must be fitted.

Wet type

Release the toggle clips and lower the bath from the body. Remove the oil baffle plate (if fitted) and discard the used oil; wash the bath and the baffle in paraffin or petrol.

If the element is of the two-piece type, withdraw the removable section and wash it in paraffin or petrol; blow off with compressed air. Wash off any dirt from the fixed element and from the inside of the centre tube; blow out thoroughly with compressed air.

Remove the pre-cleaner (if fitted) and clean likewise.

Replace all parts and fill the bath with clean engine oil up to the level of the pressed rib, or the baffle ledge when a baffle is fitted.

Refit the bath to the body and ensure that the toggle clips are secure.

Note: If the cleaner is not to be put back into immediate service, the woven wire element should be immersed or well sprayed with oil to prevent rusting.

T.S.D. 803 SEC

SECTION 5 .. CYLINDER HEAD

SETTING THE TAPPETS

For either a hot or cold engine set the clearance between the top of the valve stems and the rocker pads at 0.010 in. (0.254 mm.) for both inlet and exhaust valves, ensuring that the tappet corresponding to the valve being adjusted is on the base circle of its cam.

Adjust in firing order and in the sequence shown in the table below. This ensures that all adjustments can be made with the minimum amount of turning, e.g. when adjusting the tappets of the 4-cylinder engine, turn the engine in the direction of rotation until No. 4 valves are 'rocking' i.e. the inlet valve just commencing to open and the exhaust valve about to close, then adjust No. 1 cylinder tappets to 0.010 in. (0.254 mm.) using the spanner OE.3310. Insert a 0.010 in. feeler gauge between the rocker pad and the top of the valve stem and

turn the adjusting screw until the feeler is just nipped, then tighten the locknut and check again. Follow on in the sequence shown in the table.



Fig. 1 Setting the tappets

TAPPET ADJUSTING SEQUENCE 4-CYLINDER ENGINE 6-CYLINDER ENGINE 8-CYLINDER ENGINE Tappets Valves rocking Tappets Valves rocking Tappets Valves rocking 8 6 1 3 2 3 2 5 7 3 2 4 5



Fig. 2 Changing valve springs

CHANGING VALVE SPRINGS

If necessary, valve springs can be removed without removing the cylinder head, providing that the appropriate piston is at the top of its stroke. Turn the engine by hand in the normal direction of rotation until the INLET valve of the cylinder concerned is just opening. The piston will then be approximately at T.D.C.

Remove the rocker mechanism.

Screw the spring compressing tool, GA.25, into the appropriate rocker bracket bolt hole, compress the springs and check that the valve head is in contact with the piston crown. If necessary turn the engine a little more at the same time keeping the valve springs compressed so that movement of the valve by the piston can be seen. Remove the collets, rubber sealing ring and top washer, taking care that they do not fall down the push rod holes, and withdraw the outer and inner springs. Examine the top washer for wear on the spring land and, if grooved, fit a new washer.

Fit the new inner and outer springs and top washer. With the spring compressing tool GA.25, compress the springs and fit a new rubber sealing ring to the valve stem.

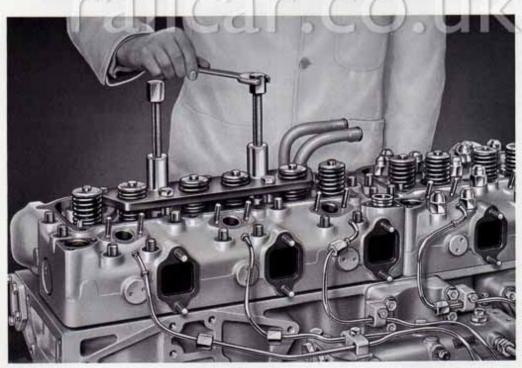


Fig. 3 Breaking cylinder head joint

Insert the collets in the top plate and release the springs. Refit the valve rocker mechanism and check the tappet clearances as described under 'Setting the Tappets.'

REMOVING THE CYLINDER HEAD

Drain the coolant system.

Release the securing set-bolts and remove the two rocker covers.

Remove the temperature phial from the pocket in the coolant outlet rail and lift the phial and capillary clear of the cylinder heads.

Release the set-bolts securing the rocker shaft brackets a turn at a time until all the rockers are free, remove the bolts and lift off the valve rocker mechanism.

Remove the push rods.

Disconnect the exhaust pipe from the manifold, release the flange nuts at each of the exhaust ports and remove the manifold.

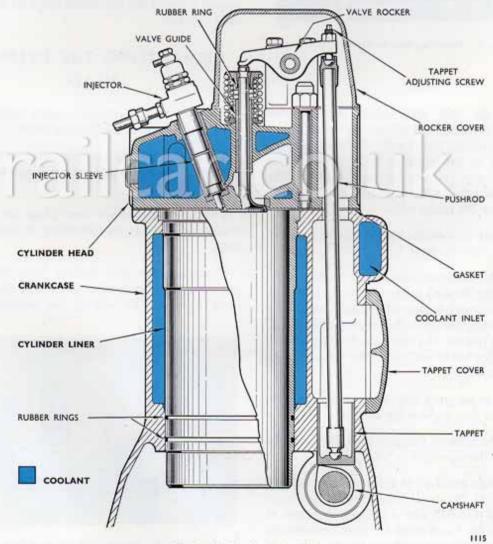


Fig. 4 Section through cylinder

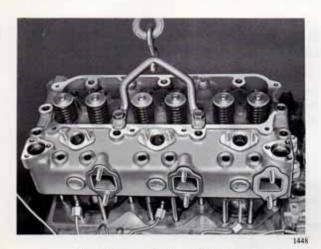


Fig. 5 Removing the cylinder head

Remove the fuel spill pipes between the injectors by releasing the unions on the injectors and on the coolant outlet rail. Release the fuel supply pipes at the injectors by unscrewing the union nuts, and release the pipe between the coolant outlet rail and the forward fuel filter at the connection on the outlet rail.

Fit blanking caps to the ends of the fuel supply pipes and to the injectors.

Release the coolant outlet rail at the hose connection on the coolant pump of a vertical engine and for a horizontal engine release and remove the setbolts securing the rail to the thermostat housing. Release and remove the setbolts securing the rail to the cylinder heads and withdraw the rail in an upward direction.

Release the securing nuts and remove the fuel injectors. Fit dust caps to the nozzles.

Release the setbolts securing the inlet manifold and remove the manifold.

Unscrew and remove the cylinder head holding down nuts, fit the tool GA.273 (for 6-cylinder engines) and GA.330 (for 8-cylinder engines) as illustrated in fig. 3 and break the joint between the cylinder head and the crankcase block.

If the cylinder heads are secured by setbolts it will not be necessary to use the tool to break the joint between the cylinder head and the crankcase block.

Remove the tool, and fit the lifting bar GA.13 (for 6-cylinder engines) and GA.331 (for 8-cylinder engines) as illustrated in fig. 5, securing it to the head with two bolts. Lift the head from the engine. The tool GA.13 may also be used for lifting the cylinder heads of 4-cylinder engines, if $\frac{3}{8}$ in. dia. bolts are substituted for the $\frac{7}{16}$ in. dia. ones, and the bolts are screwed into two convenient tapped holes in the machined faces for the rocker shaft brackets.

DISMANTLING THE CYLINDER HEAD

Remove the coolant rail transfer bobbins from the cylinder head using the tool GA.9.

Using the spring compressing tool GA.25, remove all the valves and springs from the cylinder head.

Examine the coolant core plugs for signs of leaking and rectify by tightening or fitting a new plug.

If coolant has been leaking from the swaged joint between the injector sleeve and the cylinder head bore at the top of the sleeve, it may



Fig. 6 Removing the transfer bobbins

be stopped by using the expander tool GA.291 for the screwed-in type sleeve, and GA.305 for the rolled-in type sleeve.

If these tools are not available, lightly peen the top of the sleeve into the head, using a ball-pane hammer directed against the top edge of the sleeve chamfer and afterwards spreading the metal on the top face to leave a flat surface.

Check that the joints are satisfactory on the first run after assembly.

Examine the injector sleeves for carbon deposit and if necessary, recondition the sleeve bores and seatings using the reaming kit GA.88.

The reamer GA.304 and holder GA.307 are provided for cleaning up the small bore of the sleeve and a cutter GA.299 and holder GA.23 for refacing the injector seating. The amount of metal which can be removed from the seating is limited and great care should be taken to remove only sufficient to provide a true seating; the depth of the seating, measured from the face of the cylinder head, must not be more than 3.54 in. (90 mm.).

If the injector sleeve is being reconditioned without removing the cylinder head from the engine the reamer and cutter should be liberally smeared with grease to prevent any cuttings falling into the cylinder.

VALVE SPRINGS

Thoroughly clean and check that the inner edge of the end coils of the springs are chamfered so that the edge will not cut into the radius on the top washer.

Check the springs for free length by comparing them with a new spring and check the squareness of the spring ends. Where possible the spring loadings should be checked using the dead weight method.

The length of an inner spring should not be less than 1.500 inches (38 mm.) when subjected to a load of 53 lb. (24 kg.). The length of an outer spring should not be less than 1.6875 inches (43 mm.) when subjected to a load of 95 lb. (43 kg.).

VALVES

The valve stems are 'Stellite' tipped and the seat faces coated with 'Stellite' to prolong valve life. All valves are etched with their cylinder number on the valve stem adjacent to the collet groove.

With the introduction of the sodium filled exhaust valve, means of identification became necessary.

This valve can be identified by a small 'Vee' groove round the top of the valve stem.

Clean the heads of the valves by means of a carbon removing solution or fine emery cloth, until a bright, smooth surface is obtained. Carefully examine each valve head for cracks, the faces for pitting and the stems for scoring.

When examining the valve head for cracks use a X15 magnifying glass or, if this is not available, a normal X5 pocket glass.

Cracks originate from the radius between the outer diameter and the end face of the head as illustrated.

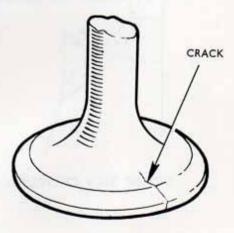


Fig. 7 Typical crack

Valves which are found to be cracked must be scrapped, and those which appear to be satisfactory under visual examination should be further tested by the acetone/chalk method to ensure that no minute cracks exist.

The acetone/chalk test consists of immersing the valves in a bath containing a mixture of 75 per cent kerosine and 25 per cent lard oil (by volume), which has been heated to a temperature of 185 to 194 deg.F. (85 to 90 deg.C.). After approximately 20 minutes in the bath, remove the valves and dry them in sawdust. When completely dry, dip each valve in a solution consisting of 4/5 pint acetone, \(\frac{1}{2}\) pint French chalk and \(\frac{1}{4}\) teaspoon of 'Waxalene' red dye O.S. Inspect the valve when the solution is dry; cracks will be indicated by white stains.

Any valve which shows the slightest sign of a crack should be scrapped and a new valve fitted. 'Waxalene' dry is manufactured by I.C.I. Limited.

An alternative method of crack testing is by the 'Ardrox' 996 dye penetrant process. This is a simple inexpensive method requiring no special equipment, and the materials with instructions for their use can be obtained from Brent Chemical Products Ltd., Commerce Road, Brentford, Middlesex, England.

If the exhaust valves are sodium filled, test the heads for 'dishing' with a straightedge and a feeler gauge. When the gap between the straightedge and the centre of the valve head exceeds 0.005 in. the valve must be rejected. Sodium-filled exhaust valves have a circumferential identification groove round the top of the stem.

Slight pitting on a valve face can be remedied by regrinding the face at 45 deg. but if the face is deeply pitted or the stem scored, the valve is unserviceable.

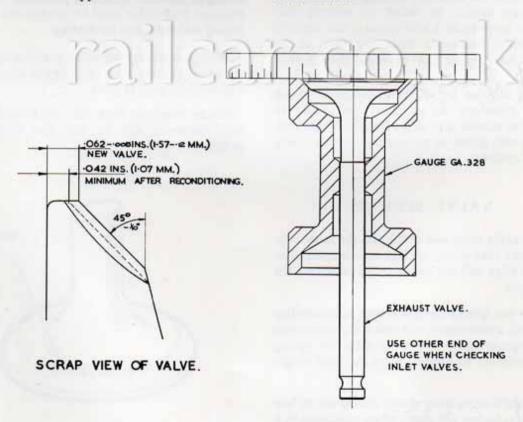


Fig. 8 Testing gauge for inlet and exhaust valves

When regrinding the inlet and exhaust valve faces, the testing gauge GA.328 (fig. 8) should be used to assess the amount of Stellite which may safely be removed.

If the head of the valve is below the top of the gauge when checked, this indicates that the valve has been ground beyond the permissible limits and should be discarded.

Check the valves for seating, keeping each valve to its correct position, and, if necessary, lap them in. When lapping, do not rotate the valve but turn it in a small arc, then lift and repeat in another position.

If after reconditioning a valve face, the head of the valve is more than 0.025 in. (0.635 mm.) below the face of the cylinder head, a new valve should be fitted.

For reconditioning of the valve seatings refer to 'Valve Seat Inserts'.

VALVE GUIDES

Clean the bores of the valve guides and check the clearance between the valve stem and its guide bore. Check the lower ends of the valve guides for belling. Belling must not exceed 0.006 in. (0.152 mm.) for the inlet valve guide, and 0.008 in. (0.203 mm.) for the exhaust valve guide.

The stem clearance for an inlet valve should not be more than 0.006 in. (0.152 mm.) and for an exhaust valve not more than 0.008 in. (0.203 mm.). If the clearance is more check with a new valve and if still excessive, fit new valve guides.

Replacement of valve guides

To remove a guide, press or drive the guide from the cylinder head, using a suitable drift on the inner face of the guide.

A new guide has an interference of 0.0015 to 0.0025 in. (0.039 to 0.063 mm.) between the outside diameter of the guide and the cylinder head bore, and the bore of the guide is 0.006 in. (0.152 mm.) undersize to allow for final reaming in position.

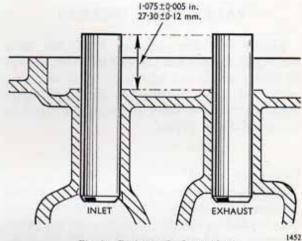


Fig. 9 Position of valve guides

Although it is strongly recommended to fit new valve guides by shrinking them with liquid air, the following alternative method can be employed when liquid air is not available.

Lightly tap a new guide into the cylinder head bore, chamfered end first, and drive it into position, using a hardwood drift. The guide should protrude 1.075 in. (27.3 mm.) above the roof of the cylinder head as illustrated, and the spacing collar GA.203 should be used to ensure that the guide is driven into its correct position. After fitting a guide, machine ream the bore to a finished size of 0.5000 to 0.5005 in. (12.700 to 12.713 mm.). Use the special reamer GA.122 driven at a chuck speed of between 80 and 110 r.p.m. and keep it well fed with cutting lubricant. After reaming check the guide bore with the plug gauge GG.1; the 'GO' part of the gauge is extra long for checking the straightness of the bore.

After replacement of valve guides, the valve seatings must be refaced.

It will be found that some cylinder heads are stamped with OER.37 adjacent to the part number; this indicates that valve guides of a larger outside diameter have been fitted. The part number of the valve guide is OE.5585, and that of the bottom washer OE.5556. No special instructions, over and above those already given, are necessary for removing and replacing these valve guides.

VALVE SEAT INSERTS

Ensure that the cylinder head has been thoroughly cleaned and examine the valve seatings for pitting, cracks and valve bedding. If necessary, reface the valve seatings as described under 'Refacing the valve seats' and relap the valves as instructed under 'Valves'.

Fitting new inserts

Unserviceable valve seat inserts can be removed with the tool GA.128. The tool is provided with two expanding spigots GA.255 for use when removing an exhaust insert and GA.254 for an inlet insert. For early engines fitted with smaller diameter valves the valve inserts can be removed with the tool GA.128 using the expanding spigots GA.129 for exhaust, and GA.130 for inlet inserts.

Alternatively, inserts can be removed by cutting through the insert with an end milling cutter. A \(\frac{3}{3} \) in. (9.525 mm.) cutter is suitable for this operation and care should be taken when nearing the outside diameter of the insert not to completely break through and cut the cylinder head bore. Just before breaking through, the insert will collapse and can be removed easily.

A new insert has an interference of 0.002 to 0.0035 in. (0.0508 to 0.0889 mm.) between the outside diameter of the insert and the cylinder head counterbore and it is recommended they should be fitted by shrinking them in liquid air if this is available. Alternatively the following procedure can be adopted.

First heat the cylinder head either in boiling water for at least half-an-hour, or in a temperature controlled oven to 200 deg.F. (93 deg.C.) then as quickly as possible draw in the insert with the tool GA.263 for an exhaust valve insert and GA.262 for an inlet valve insert. If the insert is being fitted without the valve guide in position, use the sleeve GA.142 to hold the tool concentric in the cylinder head bore.

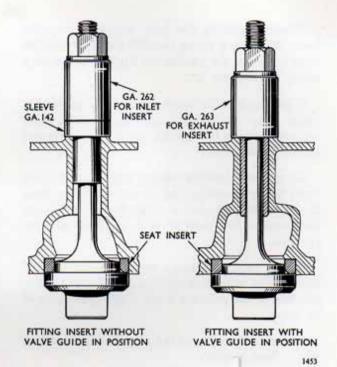


Fig. 10 Valve seat replacement

Care must be taken to keep the insert square to the cylinder head bore. A tilted insert must not be corrected; it should be removed and a new one fitted, after cleaning any proud metal from the cylinder head counterbore.

At the final stage of drawing in, tap the centre bolt of the tool as the nut is tightened and, after removing the tool, check with a feeler gauge that the insert is fully home.

When a number of inserts are being fitted, it will normally be necessary to reheat the head after fitting two inserts.

It will be found that some cylinder heads are stamped with OER.50 adjacent to the part number, this indicates that valve seat inserts of a larger outside diameter have been fitted. The part numbers of the inserts are OE.7854 inlet and OE.7853 exhaust. No special instructions, over and above those already given, are necessary for removing and replacing these inserts.

Refacing the valve seats

When refacing the valve seats a Hall's portable valve seat grinding machine and a 2½ in. (53.975 mm.) dia. 45 deg. stone, grade A80-L5-V30, are recommended. A pilot GA.127 is available for use with this machine.

When refacing, the stone should only be allowed to touch the surface of the valve seat and as the stone cuts, sparks will be seen issuing from the point of contact, and the wheel should not be lowered further until these disappear. The seat must be continually inspected and as soon as a complete ring of bright metal is obtained, grinding must cease. Test the seat by blueing or pencil marks across the face of a new valve and check

that the head of the valve does not stand proud of the face of the cylinder head. When a new insert and valve are fitted, the depth of the valve head below the face of the cylinder head should not be more than 0.010 in. (0.254 mm.). The permissible worn depth is 0.025 in. (0.635 mm.).

VALVE ROCKER MECHANISM

Release and remove the rocker shaft locating screws from their brackets. Spring the circlip off the rear end of the rocker shaft and remove the washer. Slide the brackets, valve rockers, springs and front retaining washer off the shaft. Remove the front spring circlip from the shaft. Unscrew and remove the rocker shaft blanking plugs.



Fig. 11 Exploded view of rocker mechanism

Thoroughly clean all components and visually inspect them for wear. Stone down any ridges on the rocker pads. Examine the bushes for scoring and replace any that are scored or if the clearance between the shaft and the bush exceeds 0.005 in. (0.127 mm.). When fitting new bushes to the rockers, ensure that the oil holes line up. The split in the bush should be on the horizontal centre line of the rocker arm towards the pad end of the arm.

Rocker shafts for vertical and horizontal engines are not interchangeable due to the difference in location of the rocker oil feed holes in the two shafts.

To prevent incorrect assembly, all horizontal engine rocker shafts can be identified by a Veesection groove cut across the face at each end of the shaft.

To reassemble the rocker mechanism, screw in the shaft blanking plugs and fit a new spring circlip to the groove at the front end of the shaft. Slide on the front retaining washer followed by a rocker, bracket, rocker and spring in that order. Fit the rear retaining washer and a new circlip to the rear end of the shaft.

Hold the rocker shaft bracket which locates the rocker shaft and rotate the shaft until the locating hole in the shaft is in line with the hole in the bracket, then screw in the locating screw. Turn up the tabwasher.

The rocker shaft locating screw for a 4-cylinder engine is in the rear bracket, and for a 6-cylinder engine in the centre bracket. The 8-cylinder engine has two locating screws, one in the front bracket and the other in the rear bracket.

Check the push rods for loose end pieces by 'ringing' them. Rods with one or both end pieces loose are unservicable and should be replaced.

ASSEMBLING THE CYLINDER HEAD

Smear a valve stem with clean engine oil and insert it in its valve guide, fit the bottom spring washer, inner and outer valve spring and top spring washer. Screw the spring compressing tool, GA.25, into the appropriate rocker bracket bolt hole, compress the springs, fit a new rubber sealing ring to the valve stem and insert the split collets in the top spring washer, ensuring that the collets are in the valve stem groove as the spring is released.

Carry out this procedure until all valves and springs are fitted.

Fit new sealing rings to the coolant rail transfer bobbins and fit the bobbins.

REFITTING THE CYLINDER HEAD

Ensure that the mating surfaces between the cylinder head and the crankcase are perfectly clean. It is most important to clean all carbon from the top faces of the liner flanges, and this should be carried out until bright metal is obtained over the whole of the top faces of each liner flange and spigot. Any carbon deposit on the liner bores should not be removed.

Refit the coolant bobbins with new rubber sealings rings on the bobbins.

Fit the corrugated steel gaskets to the crankcase face with the corrugations uppermost to the cylinder heads and ensure that they are correctly located by the dowels.

If a copper/asbestos gasket is being replaced by a corrugated steel one, particular care must be taken to locate the new gasket correctly, as no dowels will exist for this purpose. In these circumstances, the spigot diameters of the liner flanges are used for locating the gasket, and the important point to note is that the edges of the liner bores in the gasket are not trapped between the top face of the liner spigots and the cylinder head.

Lift the cylinder heads and lower into position.

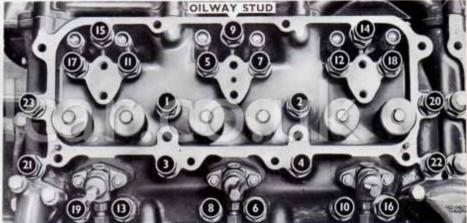
Fit the cylinder head holding down nuts and tighten in the sequence shown in fig. 12 to a torque loading of 80 lb. ft. (11.06 kg.-m.) for the oilway studs and 130 lb. ft. (17.973 kg.-m.) for the remaining studs.



4-cylinder

00





1454



8-cylinder

Fig. 12 Cylinder head tightening sequence

If the setbolts are fitted, reference should be made to fig. 12 for their correct position as follows:

4-cylinder engines

Fit the short setbolts OE.10488 in positions numbered 10, 4, 5 and 7.

Fit the long setbolts OE.10487 in positions numbered 14, 1, 11, 12, 2, 13, 8, 6, 3, 9 and 16.

6-cylinder engines

Fit the short setbolts OE.10488 in positions numbered 19, 13, 8, 6, 10 and 16.

Fit the long setbolts OE.10487 in positions numbered 15, 14, 17, 11, 5, 7, 12, 18, 23, 1, 2, 20, 21, 3, 4 and 22.

8-cylinder engines

Fit the short setbolts OE.10488 in positions numbered 19, 18, 10, 3, 6, 7, 23 and 24.

Fit the long setbolts OE.10487 in positions numbered 12, 9, 20, 17, 11, 4, 5, 8, 22, 25, 29, 13, 1, 16, 27, 30, 14, 2, 15 and 28.

Where a lifting eye or oil filter bracket is fitted on the cylinder head, the extra long setbolts OE.10486 should be fitted.

Using the sequence shown in fig. 12, torque load the oilway stud capnuts to 80 lb. ft. (11.06 kg.-m.) and all setbolts to 130 lb. ft. (17.973 kg.-m.).

Place new joint washers on the faces of the inlet ports and secure the inlet manifold with the setbolts.

Fit the coolant rail and connect it to the coolant pump, using a new rubber hose. For the horizontal engine connect the rail to the thermostat housing. Fit and tighten the setbolts securing the rail to the cylinder heads.

Fit the fuel injectors into the sleeves in the cylinder head (no joint washers are required) and tighten the securing nuts evenly, half-a-turn at a time, using the special spanner Part No. OE.3311, until the injectors are firmly secured. It is most important to use this spanner, as overtightening of the nuts will cause damage to the cylinder head. If a torque spanner is used, the loading of the nuts must not exceed 8.5 lb. ft. (1.175 kg.-m.).

When fitting the fuel supply pipes to the injectors, ensure that the pipe nipple fits squarely into the union connection on the injector, before screwing on the union nut. Do not overtighten the nuts.

Fit the pipe between the connections on the coolant outlet rail and the fuel filter bracket and tighten the securing nuts.

Fit the fuel spill pipes between the injectors as shown in fig. 13 and tighten the banjo bolts, replacing unserviceable copper washers.

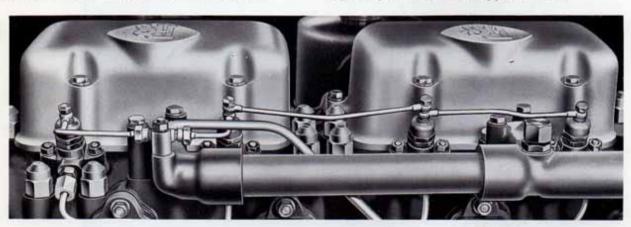


Fig. 13 Location of spill pipes

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Fit new joint washers to the exhaust ports of normally aspirated and supercharged engines. Do NOT fit joint washers on turbocharged engines. Fit the exhaust manifold

Fit the push rods and position the two rocker shaft assemblies on the cylinder heads. Fit the double locking washers to the pedestals; fit the setbolts and tighten them a turn at a time to draw the assemblies down evenly.

Set the tappet clearances as previously described in this section.

Before fitting the rocker covers, pour a pint of clean engine lubricating oil evenly over each set of rockers.

Place the rocker covers in position, using new jointing washers, and tighten the securing setbolts after fitting the temperature phial capillary tube clips under the appropriate bolt heads.

Refill the engine with coolant and examine all connections for leaks.

SPECIAL TOOLS

PART NO.	DESCRIPTION
OE.3310	Spanner, tappet
GA.25	Compressor, valve spring
AD.30	Socket spanner, cylinder head nuts and setbolts
GA.238	Torque wrench, 35 to 225 lb. ft. for use with AD.30
GA.273	Tool for breaking cylinder head joint - 6-cylinder engine
GA.330	Tool for breaking cylinder head joint — 8-cylinder engine
GA.13	Lifting beam, cylinder head — 6-cylinder engine
GA.331	Lifting beam, cylinder head — 8-cylinder engine
GA.9	Withdrawing tool, coolant transfer bobbin
J.53366	Assembling stand, cylinder head (drawings available)
GA.128	Extractor, valve seat insert
GA.254	Expanding spigot, valve seat insert — large inlet valve
GA.255	Expanding spigot, valve seat insert — large exhaust valve
GA.130	Expanding spigot, valve seat insert — small inlet valve
GA.129	Expanding spigot, valve seat insert — small exhaust valve
GA.263	Inserting tool, valve seat insert — large inlet valve
GA.262	Inserting tool, valve seat insert — large exhaust valve
GA.141	Inserting tool, valve seat insert — small inlet valve
GA.140	Inserting tool, valve seat insert — small exhaust valve
GA.142	Sleeve for use with GA.140, 141, 262 and 263 when valve guide is not fitted in cylinder head
K.53372	Valve seat insert grinder (proprietary)
GA.127	Pilot, valve seat insert grinding stone
GA.328	Gauge, inlet and exhaust valve face
GG.1	Plug gauge, valve guide

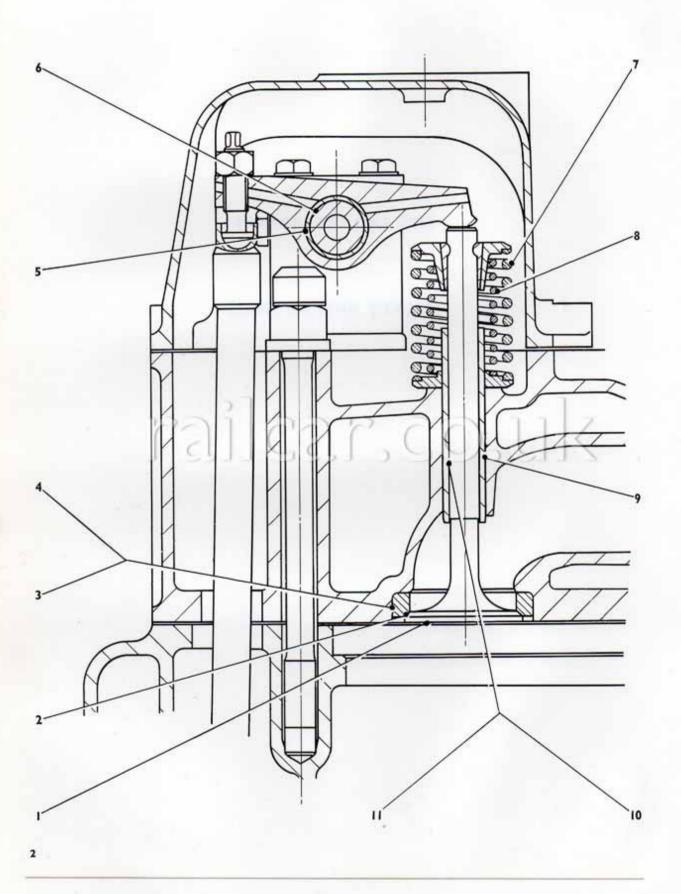
GA.122	Reamer, valve guide
GA.203	Spacing collar, valve guide
OE.3311	Spanner, injector securing nuts
GA.305	Expanding tool, rolled-in injector sleeve
GA.291	Expanding tool, screwed-in injector sleeve
GA.88	Kit, injector sleeve reaming and cutting tools and holders
GA.299	Cutter for refacing seating in injector sleeve
GA.23	Holder for GA.299
GA.304	Reamer for cleaning up small bore of injector sleeve
GA.307	Holder for GA.304
J.53371	Assembling jig, valve rocker shaft (drawings available)

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FITS AND CLEARANCES

VALVES AND FITTINGS

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No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
	VALVE HEAD IN SEATING				-	
1	Clearance of valve head below face of cylinder head		Zero to		0.025	
	race of cylinder head		0.010		0.025	
100	VALVE INSERTS	******				
2	Angle of valve seat	45 deg.				
3	Inlet valve inserts in					
20	cylinder head					
	Cylinder head - bore	2.437 to	Interfer.			
	1217 12	2.348	0.002 to		Interfer.	
	Valve insert - dia.	2.440 to	0.004		0.001 min.	
4	Exhaust valve inserts in	2.441				
4	cylinder head					
	Cylinder head – bore	2,437 to	Interfer.			
	Toyana near bote	2.348	0.002 to		Interfer.	
	Valve insert - dia.	2.440 to	0.004		0.001 min.	
	**************************************	2.441			1	
	ROCKER ARMS					
5	Bushes in rocker arms Rocker arms – bore	1 02105	Total			
	Rocker arms – bore	1.03125 to 1.03175	Interfer. 0.00375 to			
	Bushes - dia.	1.03175 1.034 to	0.00375 to		9.3	2
		1.035	0.00223	()		1/
6	Rocker arms on shaft		20		5	
	Bushes - bore	0.87425 to	1		1 11	7 7
	(Figure 197)	0.87575	0.00075 to		autosau	
	Shaft - dia,	0.873 to	0.00275		0.005	
	VALVE SPRINGS	0.8735				
7	Outer springs					
50	Load when compressed					
	to 1.688	100 lb. to		95 lb, min.		
		114 lb.				
		N. Carre				
	Free length	3.425				
8	Inner springs					
	Load when compressed					
	to 1.500	56 lb. to		53 lb. min.		
		64 lb.		and accommodated		
	Free length	3.000				
		DESTRUCTION OF THE PARTY OF THE				
	VALVE GUIDES					
9	Valve guides in cylinder head					
	Cylinder head – bore	0.750 to	Interfer.		3 5	
	Volumental and	0.7505	0.0025 to		Interfer.	
	Valve guides – dia.	0.752 to 0.7525	0.0015		0.001 min.	
		0.1323				

No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
10	VALVES IN VALVE GUIDES Inlet valves in guides Valve guide – bore Valve stem – dia,	0.500 to 0.5005 0.498 to 0.4985	0.0015 to 0.0025			Belling at lower end of guide bore must not ex- ceed 0.014 on diameter.
11	Exhaust valves in guides Valve guide – bore Solid valve stem-dia.	0.500 to 0.5005 0.4965 to 0.497	0.003 to 0.004			Belling at lower end of guide bore must not ex- ceed 0.010 on diameter.
	Hollow valve stem-dia.	0.4945 to 0.495	.005 to .006			Sodium filled valve
	2001	2-	0.72			1112
	[2]	<u> </u>) [, C		, UK

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SECTION 6 . . PISTONS AND RINGS

The pistons are of light alloy, the head of each being machined out to form an open fuel combustion chamber.

Fully floating gudgeon pins are retained by circlips sprung into grooves in the piston boss bores and each piston has three compression rings and a grooved oil scraper ring fitted above the gudgeon pin.

A delayed action scraper ring is fitted in the groove in the piston skirt below the gudgeon pin on engines for installation in all road vehicles other than self-propelled track-laying types.

The first noticeable sign of worn piston rings and cylinder liners is increased oil consumption.

Extreme wear may result in loss of power and difficulty in starting, due to poor compression.

Whenever field servicing pistons are fitted they must be changed at the next complete overhaul of the engine.

REMOVAL

Drain the coolant and oil systems, and fit the engine to a turnover stand.

Remove the cylinder heads as described in Section 5.

Turn the engine upside down and remove the sump.



Fig. 1 Piston and rings

For the horizontal engine it will also be necessary to remove the sump adapter plate from the crankcase, and to allow this the following components must first be removed:—

Tachometer generator and adapter.

Lubricating oil pump, see Section 19C.

Lubricating oil filters and header bracket.

Lubricating oil relief valve assembly.

Fuel filters and header bracket.

Fuel injection pump and driving shaft.

Crankcase breather assembly.

Turn the engine crankshaft until the piston to be removed is at the bottom of its stroke and turn the engine until the cylinders are horizontal.

Remove the connecting rod big-end bearings as described in Section 8.

Push the connecting rod and piston assembly outwards until the complete assembly can be withdrawn from the top of the engine.

Remove the circlip from each end of the gudgeon pin bore using 'Seeger' pliers. To remove the gudgeon pin from the piston first heat the piston in oil or water and lightly tap out the gudgeon pin using a soft metal drift. It is most important to keep a gudgeon pin to its respective piston and to ensure this, the gudgeon pin should be located in the piston immediately after the connecting rod is removed.

Remove the piston rings, using the pliers GA.78.

INSPECTION

Two types of pistons are used; the toroidal cavity and the straight walled cavity.

Inspect the combustion chamber of the piston for cracks, particularly round the edge of the toroidal cavity and in the piston boss bore. Cracks from the edge of the toroidal cavity are permissible if they are not more than $\frac{3}{4}$ in. (19 mm.) long.

Ensure that the piston ring grooves are square and smooth, and check that the groove widths conform to the following dimensions completely round each groove.

RING GROOVE	DIME	Charles et	PERMISSIBLE WORN DIMENSION		
	in.	mm.	in.	mm.	
1st gas ring	0.1295	3.289	0.1360	3.454	
2nd & 3rd gas rings	0.1290	3.275	0.1350	3,429	
Top scraper ring	0.2540	6.452	0.2600	6.604	
Bottom scraper ring	0.2340	5.944	0.2400	6.096	

Test the gudgeon pin for cracks by electromagnetic detection. The gudgeon pin should be a hard push fit in the piston when both the piston and pin are at a temperature of 68 deg.F. (20 deg.C.). Pistons and gudgeon pins are selectively assembled by the manufacturers to obtain the correct fit, therefore, if a pin is found to be loose a new piston assembly should be fitted.

Inspect the piston rings for signs of wear and scoring, and with the rings fitted to the piston, check that the side clearance between each ring and its groove is not more than 0.012 in. (0.3048 mm.).

The clearances when new are:-

1st gas rings 0.0045 to 0.0065 in (0.114 to

0.165 mm.)

Remaining rings 0.004 to 0.006 in. (0.102 to

0.152 mm.).

Check each ring separately in a new liner and ensure that the ring gap is not greater than 0.060 in. (1.52 mm.). Gap clearances outside these dimensions entail the fitting of new rings. New standard rings are correctly gapped before despatch and are as follows:—

Top chrome ring 0.028 to 0.032 in. (0.8112 to

1.014 mm.).

Remaining rings 0.022 to 0.026 in. (0.5588 to

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All piston rings are etched with their Part No. thus:—

Top chrome ring 'Welchrome' OE.8310-1

2nd & 3rd gas ring OE.372 'TOP'

Top scraper ring OE.373 Bottom scraper ring OE.21229

Where new rings are necessary the cylinder liners should be examined for wear and if they are within the worn limits given in Section 7, remove any ridge at the top of the ring travel.

ASSEMBLING AND REFITTING

Fit the rings to the piston using the special pliers GA.78 to expand the rings. One face of the second and third gas ring is marked 'TOP' adjacent to the gap and it is most important that these rings are fitted with the correct face uppermost. If a used second or third ring is being refitted the identification mark may be worn off and in these circumstances the ring should be fitted according to the bedding on the outer face. This face is tapered towards the top and will show a bright band on the bottom half. The remaining rings can be fitted with either face uppermost.

To assemble the piston to the connecting rod, first warm the piston in hot water then insert the gudgeon pin, retaining it in position with a circlip at each end of the piston boss bore. The piston number is stamped on the gudgeon pin boss and the piston should be fitted to its rod as follows:—

Left-hand and horizontal engines

Valve recesses on piston same side as correlation number on rod.

Right-hand engine

Valve recesses on piston opposite correlation number on rod.

Turn the engine so that the cylinders lie horizontal and smear the bore of each cylinder with clean engine oil.

Ensure that each piston and connecting rod assembly is fitted in its correct position; pistons and connecting rods are numbered to correspond with the cylinders.

Ensure also that each assembly is fitted to the crankshaft the correct way round.

Left-hand, right-hand and horizontal engines Valve recesses on piston towards the camshaft.

Stagger the ring gaps and, using the sleeve GA.12, as illustrated, push the piston and connecting rod assembly into the liner. The connecting rod should be held clear of the side of the liner while the piston is being inserted. Refit the connecting rod bearing.

If a new piston is to be fitted, special attention must be paid to the clearance between the piston crown and the joint face of the cylinder block. This clearance is controlled by the height of the top face of the piston from the centre of the gudgeon pin bore; the nominal dimension is 3.900 in. (99.06 mm.) with a limit of minus 0.005 in. (0.127 mm.). The actual amount (in 1/1000 in.) that the dimension varies from the nominal, is stamped on the top face of the piston, opposite the valve recesses and also on the underside of the gudgeon pin boss. A piston marked 'N' is exactly 3,900 in. (99.06 mm.).

Select a piston with the same marking as the old one, or if necessary machine the top face of a piston to give the correct height and, after fitting it to the engine, check the clearance with the piston on T.D.C. Obtain the correct T.D.C. position by means of a dial test indicator gauge registering from the cylinder block face, then check the clearance with a suitable inspection block positioned in line with the gudgeon pin and the dial

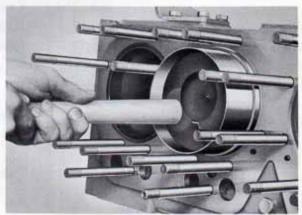


Fig. 2 Fitting a piston and connecting rod assembly

test gauge fixture GA.65, as illustrated. The clearance must not be less than 0.005 in. (0.127 mm.) and not more than 0.010 in. (0.254 mm.) below the joint face.

When a new connecting rod is fitted, the clearance may not be within the above limits, in which case a piston as near the nominal length as possible should be selected and, if necessary, the top face of it machined to give the required clearance. It is not necessary to deepen the valve recesses.

When satisfactory refit all parts removed for access. Fill up with lubricating oil and coolant.

RUNNING IN

Whenever new piston assemblies, rings or cylinder liners are fitted the engine must be run-in as follows:—

- 1. Run the engine at idling speed for \frac{1}{2} hour.
- Run the engine at half speed with no load for

 in hour.
- Run the engine at approximately ¹/₄ speed on light load for 2 hours.

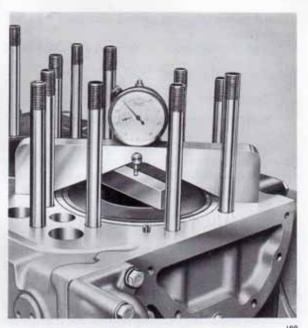


Fig. 3 Checking the piston crown clearance

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 Run the engine at full engine speed on light load for 2 hours.

These periods may be impractical to maintain in all cases, but at least 3 hours running should be accumulated before operating at full speed.

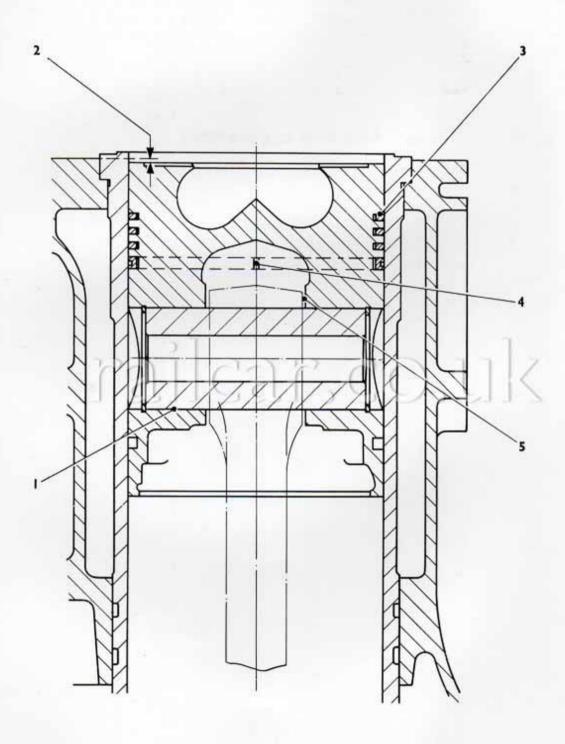
SPECIAL TOOLS

PART NO.	DESCRIPTION
	Circlip pliers, internal (proprietary)
GA.12	Compressing sleeve, piston rings
GA.65	Bridge and block, piston clearance
GA.78	Pliers, piston ring
GA.269	Facing fixture, piston

FITS AND CLEARANCES

PISTONS

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No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE NEW	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
1	GUDGEON PIN IN PISTON Piston – bore	2.000 to 2.00025	Interfer, 0.00025 to			
	Gudgeon pin – dia.	2.000 to 2.00025	0.00025 Clearance			
2	PISTON CROWN CLEARANCE AT T.D.C. Crown of piston below crankcase face		0.005 min.			
	PISTON RINGS		0.010 max.		100	
3	Side clearance between rings and grooves					
	Top ring		0.0045 to 0.0065		0.012	
	Remaining rings		0.004 to 0.006		0.010	
4	Ring gaps measured with					
	rings in position in new liner Top ring		0.028 to 0.032		0.060	
	Remaining rings	173	0.022 to	-	0.060	2
5	CONNECTING ROD IN PISTON Side clearance		0.026 0.075 to	0	ارکا د	15
			0.082			
			1000			

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SECTION 7 . . CYLINDER LINERS

The liner flanges are slightly proud of the block joint face and are nipped by the cylinder head gasket to form the top seal. The lower end of each liner is sealed by two rubber rings.

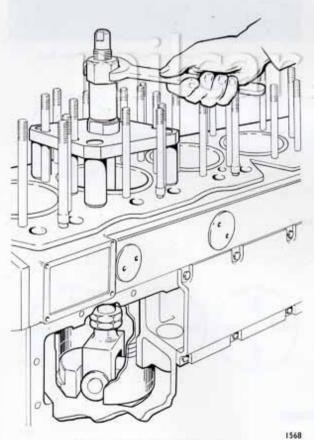


Fig. 1 Removing a cylinder liner

REMOVAL

Fit the engine to a turnover stand and drain the oil.

Remove the cylinder heads. Invert the engine and remove the sump. Turn the engine on its side and turn the crankshaft until the piston of the liner to be removed is at B.D.C. Remove the piston and connecting rod assembly.

The method of removing the above items is given in the relevant Sections.

Turn the engine to its normal position and cover the crankshaft and bearings so that sediment from the coolant passages does not enter the oilways.

Remove the cylinder liner using the withdrawal tool GA.4A as illustrated in fig. 1.

The liners should at all times be handled with extreme care as even a small impact such as a liner falling over will cause a crack.

INSPECTION

Thoroughly clean the liners. Remove all traces of carbon from the top face and all traces of 'Wellseal' jointing compound from the underside of the flanges.

Examine the top face of the flanges for signs of fretting. Reject all liners on which fretting has taken place. Measure the liner bores. Reject all liners that are worn by more than 0.006 in. (0.147 mm.) on diameter at the top of the ring travel.

Test the liners for cracks, preferably by the electro-magnetic method. If the necessary equipment for this test is not available, the 'Ardrox' 996 dye penetrant process is recommended in preference to chalk testing.

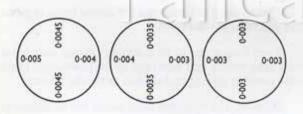
Clean the cylinder head joint faces and examine them for signs of fretting.

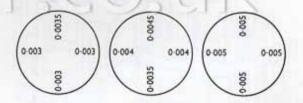
Clean all traces of deposit from the upper and lower bores in the crankcase, taking care to remove deposit only, and not metal. Ensure that the leadin chamfer at the top of each lower bore is clean. Clean the crankcase top joint face and the seats for the liner flanges. Examine the top joint face for signs of fretting.

Measure the distance from the crankcase top joint face to the liner seat at four diametrically opposite points around each liner bore, using a

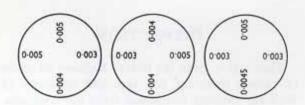


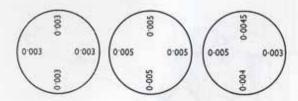
Fig. 2 Measuring distance from crankcase face





ACCEPTABLE





UNACCEPTABLE

Fig. 3 Acceptable and unacceptable protrusions

micrometer depth gauge as illustrated in fig. 2. It should be between 0.495 and 0.496 in. (12.573 and 12.598 mm.).

If fretting has taken place on the cylinder head or crankcase joint faces, or if the depth of the liner seats from the crankcase joint face is not within the limits stated, the cylinder heads and/or crankcase must be reclaimed. When this is necessary operators are advised to consult their local Rolls-Royce dealer, who has full particulars of the procedure and the necessary equipment for carrying out this work.

Test the liners for freedom in the crankcase bores. Each liner should fit into position quite freely without sealing rings. If tightness is encountered it may be caused by corrosion or distortion of the crankcase bores, and should be corrected by careful scraping.

REFITTING

Fit the liners in the crankcase without sealing rings.

Measure the protrusion of each liner with a clock gauge (dial test indicator) based on the crankcase top joint face, at four points around the flange of each liner. Tabulate the readings as illustrated in fig. 3. The protrusion of each liner must be between 0.003 and 0.005 in. (0.0762 and 0.127 mm.), and must not vary by more than 0.001 in. (0.0254 mm.) around each flange. Variations in protrusion at the adjacent points of any two liners under any one cylinder head must not exceed 0.001 in. (0.0254 mm.),

Lightly etch the appropriate cylinder number on each liner flange at a point adjacent to the relative coolant transfer port in the crankcase joint face.



Fig. 4 Replacing a cylinder liner

Remove each liner in turn and fit rubber sealing rings in the grooves at the base, lightly smear the rings with clean engine oil, apply a thin coating of 'Wellseal' compound to the underside of the flange, and lower the liner carefully into the crankcase. Ensure by reference to the position of the etched mark on the flange that the liner has been refitted in the same position relative to the crankcase, and press it home with the tool GA.3, as illustrated in fig. 4.

Refit all parts removed for access. Examine the pistons for serviceability when rebuilding the engine. New compression and scraper rings must always be fitted.

Whenever new liners have been fitted the engine should be run in as instructed for pistons and rings in Section 6.

SPECIAL TOOLS

PART NO. DESCRIPTION

GA.3 Cylinder liner inserting tool

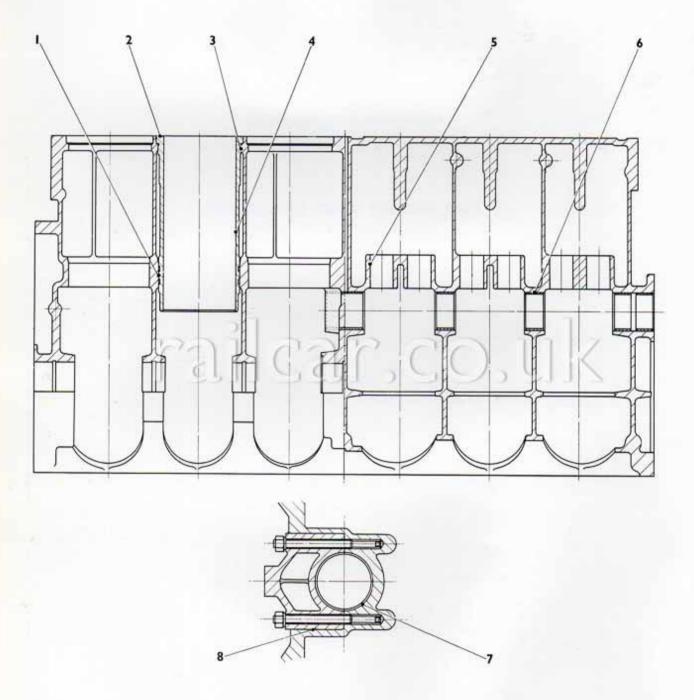
GA.4A Cylinder liner withdrawing tool

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CRANKCASE AND CYLINDERS

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No. ON DIAGRAM	DESCRIPTION	DIMENSIONS NEW	CLEARANCE NEW	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
1	CYLINDER LINERS IN CRANKCASE Liner skirt in crankcase Crankcase – lower bore	5.676 to 5.677	0.003 to			
2	Liner skirt - dia. Projection of liners above	5.672 to 5.673	0.005			
	crankcase face Crankcase counterbore – depth	0.495 to	Proud			
	Liner flange - depth	0.496 0:499 to 0.500	0,003 to 0,005 Proud			
3	Liners in crankcase		AND COURT			
	Crankcase – upper bore Liners – dia.	5.778 to 5.779 5.775 to	0.002 to 0.004			
	CYLINDER LINERS OUT OF	5,776	0.004			
4	CRANKCASE Liners – bore	5.125 to 5.126		5.131 max.		Wear on cylinder bore must not exceed 0.006
	3 7	31,100				on diameter.
5	TAPPETS IN CRANKCASE Crankcase – bore Tappets – dia,	1.625 to 1.626 1.6235 to	0.001 to 0.0025	0	0.003	<
	CAMSHAFT BEARINGS IN CRANKCASE	1.624				
6	Crankcase – bore Camshaft bushes – dia.	2.5995 to 2.6005 2.603 to	Interfer. 0.0055 to 0.0025			
	MAIN BEARING HOUSING	2.605	0.0025			
7	IN CRANKCASE Bearing housing bore	4.100 to 4.101				Reclaim damaged bores as instructed in Service
8	BEARING BLOCKS IN CRANKCASE					Bulletin No. OEB,149,
0	Front, rear, intermediate and centre Bearing block location – width	6.625 to 6.626	Interfer. 0.0005 to			
	Bearing block - width	6.625 to 6.6255	0.001 Clearance			

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SECTION 8 . . CONNECTING RODS AND BEARINGS

The connecting rods are 'forged-to-size' and the big ends are fitted with bearings of the pre-finished steel back shell type with lead-bronze bearing surfaces. The rods are drilled longitudinally for pressure lubrication to the gudgeon pin bearings with small cross drillings for cylinder wall lubrication. The rods are numbered from the front of the engine and correspond to the cylinder numbers.

REMOVAL

The connecting rods can only be removed with the pistons from the top of the cylinders, as described in Section 6. This is not necessary for inspection or replacement of the bearings, which can be removed in the following manner:

Mount the engine in a turnover stand, and invert the engine.

Remove all parts necessary for access as described in Section 6 and turn the crankshaft until the bearing to be dismantled is at B.D.C.

Turn the engine until the cylinders are horizontal. Bend down the locking plate tabs,



Fig. 1 Connecting rod and bearings

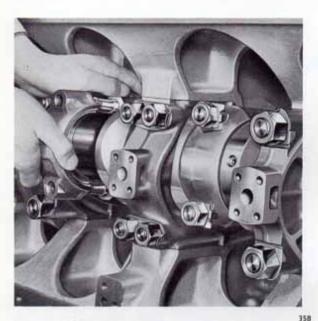


Fig. 2 Removing a connecting rod bearing

remove the nuts from the bearing bolts and withdraw the cap half together with the lower half bearing shell, as illustrated in fig. 2.

Push the rod up slightly to free the upper half bearing from the crankpin, release the shell from the rod and turn it round the crankpin until it can be withdrawn.

INSPECTION

As the bearing halves are interchangeable it is not necessary to reject the complete bearing when one half only is unserviceable.

Examine the bearing surface of the shell halves for cracked plating, scores and embedded foreign matter.

Bearings should be rejected if the lead-indium is cracked or if there are more than three deep scores in the bearing surface. They should also be rejected if there is a heavy impregnation with foreign matter even if the lead plating is unbroken.

Any shells with the lead-indium plating worn off, exposing the lead-bronze intermediate layer, for more than one fifth of the bearing area should be changed. Check the connecting rods for alignment of the big and small ends. The error of parallelism should not be more than 0.001 in. per inch of mandrel (0.025 mm. per 25.4 mm. of mandrel).

Under no circumstances should mal-alignment be corrected by bending a connecting rod.

If a new connecting rod is to be fitted, a rod of the same weight group as that of the old one should be selected. Where a rod of the same weight group is not available, a rod from the nearest available weight group should be fitted.

Rods are arranged in weight groups, each being identified by a letter stamped on the lobe of the bolt trap on the same side of the rod as the correlation marks.

The weight groups are as follows:

Group A 7 lb. 10 oz. to 7 lb. 14 oz. (3.4587 kg. to 3.5722 kg.)

Group B 7 lb. 14 oz. to 8 lb. 2 oz. (3.5722 kg. to 3.6857 kg.)

Group C 81b. 2 oz. to 8 lb. 6 oz. (3.6857 kg. to 3.7992 kg.)

Group D 8 lb. 6 oz. to 8 lb. 10 oz. (3.7992 kg. to 3.9127 kg.)

Group E 8 lb. 10 oz. to 8 lb. 14 oz. (3.9127 kg. to 4.0262 kg.)

Group F 8 lb. 14 oz. to 9 lb. 2 oz. (4.0262 kg. to 4.1387 kg.)

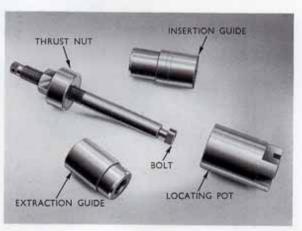


Fig. 3 Tool assembly GA.285

Check the bore of the gudgeon pin bushes. The bore of a bush when new is 2.0015 to 2.002 in. (50.83 to 50.85 mm.) dia., and the clearance between pin and bush is 0.00125 to 0.002 in. (0.03 to 0.05 mm.). The worn clearance should not be more than 0.0025 in. (0.063 mm.).

Very little wear will normally be found in the bush bores and only if they are scored should it be necessary to fit new bushes.

Replacement of gudgeon pin bushes

A gudgeon pin bush can be replaced with the tool assembly GA.285 which consists of an extraction guide, bolt, ball bearing thrust nut, insertion guide, and locating pot.

The bore of a new bush is machined to the finished size, therefore no machining operation is necessary.

Removing the old bush

Grip the locating pot in a bench vice.

Position the extraction guide in the bore of the gudgeon pin bush, and position the connecting rod small end on the locating pot with the guide uppermost.

Grease the bolt thread with a heavy-bodied grease, then take the bolt with the thrust nut on the screw and insert it through the guide and connecting rod small-end bore, and into the slot in the bottom of the locating pot. A half turn locks the bolt in the slot.

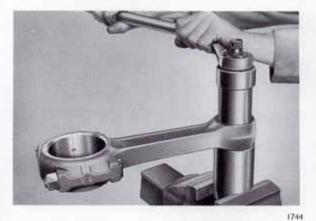


Fig. 4 Removing the old bush

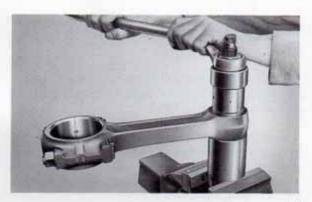


Fig. 5 Fitting a new bush

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Tighten the thrust nut down to nip the assembly.

With a long ring spanner, continue tightening the thrust nut, at the same time supporting the connecting rod until the bush is pressed from the rod small end into the bore of the locating pot.

Unlock the bolt and withdraw the extraction assembly and connecting rod from the locating pot, and remove the unserviceable bush.

Any signs of pick-up on the unserviceable bush will indicate the possibility of small metal shavings being left in the crescent of the small-end bore, these should be cleared away and the bore blown out with compressed air.

Fitting a new bush

Place the insertion guide in the small-end bore of the connecting rod.

Position the new bush on the upper end of the insertion guide so that the large chamfer on the bush is to the rod; at the same time ensure that the bush joint is facing the same direction as the tenon slots on the joint line in the big-end bore of the connecting rod, with the centre hole of the three holes in the bush at the bottom of the smallend bore and on the vertical centre line of the rod.

Screw the thrust nut back to the end of the bolt thread and grease the thread.

Position the connecting rod small-end bore over the locating pot with the guide and bush assembled, and insert the bolt through the guide and connecting rod small-end bore, and into the slot in the bottom of the locating pot. A half-turn locks the bolt in the slot.

Tighten the thrust nut down to nip the assembly, and check that the positioning of the gudgeon pin bush has not been altered.

It is important that before inserting the new bush, the connecting rod small-end bore, the insertion guide, and the new bush are greased with 'Keenol' (a zinc-based Lanolin). If oil is used, scoring of the bush will result.

With a long ring spanner, tighten the thrust nut, at the same time supporting the connecting rod, until the bush has been inserted into the small-end bore. This will be indicated by a sharp click as the guide drops into the locating pot.

Slack back the thrust nut, unlock the bolt and withdraw the insertion assembly and connecting rod from the locating pot.

Finally check that all oilways and passages in the connecting rod are clear.

REFITTING

Piston and connecting rods are numbered from front to rear of the engine to correspond with the cylinders. Ensure that the piston is fitted the correct way round; the valve recesses on the piston and the correlation marks on the connecting rod must be on the right-hand side when viewed from the front of the engine.



Fig. 6 Measuring a big end bolt for stretch

For the horizontal engine the valve recesses and correlation marks should be on the underside of the rod when the engine is in the installed position.

When refitting a bearing ensure that the tang on each shell half is located in the rod or cap slot.

For each bearing in turn, finger-tighten the nuts and measure the length of the bolts with a micrometer, then gradually tighten the two bolts alternately until they are stretched 0.009 to 0.010 in. (0.228 to 0.254 mm.), and lock the nuts.

Refit all parts removed for access.

SPECIAL TOOLS

PART NO.

DESCRIPTION

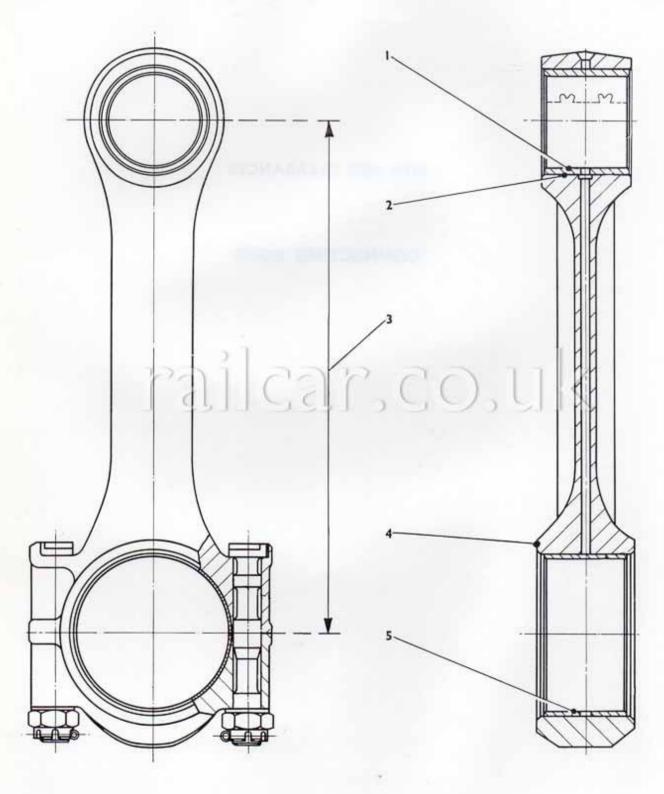
GA.285

Standard 4 to 5 in. micrometer (proprietary)
Extracting and inserting tool, gudgeon pin bushes

FITS AND CLEARANCES

CONNECTING RODS

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No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE NEW	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
1	SMALL END Gudgeon pin in bush Bush – bore Gudgeon pin – dia.	2.0015 to 2.002 2.000 to	0.00125 to 0.002		0.0025	
2	Bush in small end Small end – bore Bush – dia,	2.00025 2.250 to 2.2505 2.252 to 2.2535	Interfer, 0.0035 to 0.0015			
3	ERRORS IN ALIGNMENT Errors in alignment between big and small ends per inch of mandrel Parallelism			0.001		
	BIG END					
4	End float		0.003 to 0.008		0.012	
5	Running clearance	1r	0.0025 to 0.004	0	0.008	<

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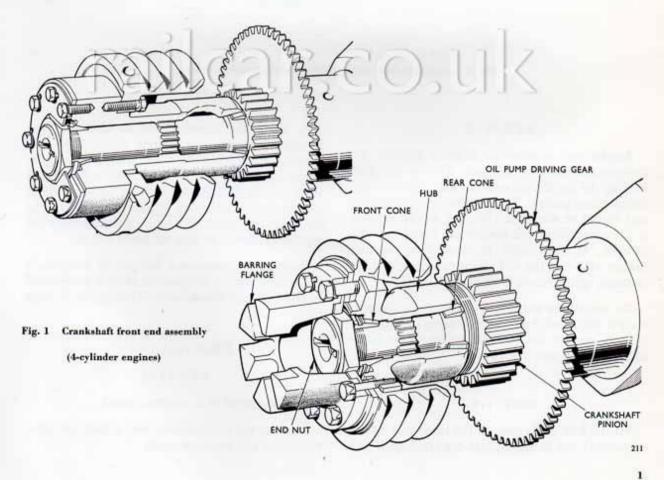
SECTION 9 .. CRANKSHAFT AND BEARINGS

CRANKSHAFT FRONT END ASSEMBLY

The crankshaft front end assembly consists of a hub, front and rear cones and a crankshaft nut. Secured to the hub flange by setbolts is the fan or compressor pulley. This arrangement, as shown in fig. 1, is fitted to the 4-cylinder engine.

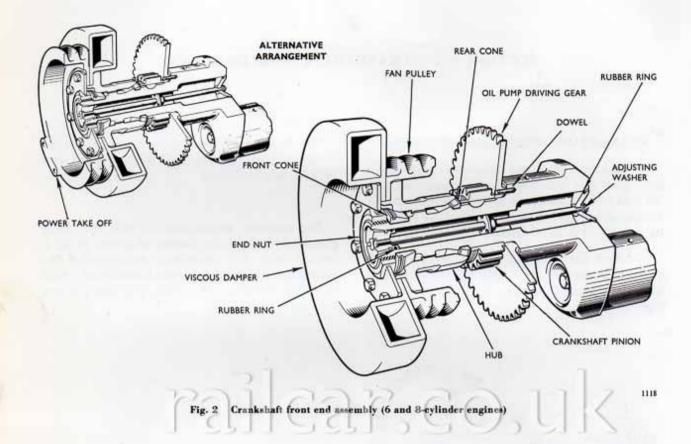
For the 6 and 8-cylinder vertical and horizontal engines the assembly is similar, but with the addition of a crankshaft damper of the silicone viscous type, see fig. 2. The function of the damper is to reduce the oscillations and vibrations of the crankshaft over the full running range.

The common arrangement is with the pulley positioned behind the damper as shown in fig. 2, but to cater for installation requirements the alternative arrangement shown is employed, which in addition to the pulley drive, provides a power take-off.



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Section 9



REMOVAL

Release and remove the setbolts securing the damper and pulley to the hub. Detach the plate locking the crankshaft end nut and withdraw the damper and pulley. The damper is a heavy unit and should be removed with care, as any damage to the outer casing will destroy the function of the damper. It is advisable to support the damper before removing the setbolts, especially when the common arrangement is being dealt with.

To remove the hub which supports the damper, slacken the crankshaft end nut, using the spanner GA.18; remove the nut and withdraw the front hub cone, hub and rear cone.

REFITTING

Fit the hub and cones to the front end of the crankshaft and fit and tighten the crankshaft end nut, using the spanner GA.18 and a heavy hammer. Ascertain a correct position for the locking plate before the pulley and damper is replaced by moving the plate from flat to flat around the nut until the holes in the plate and hub are in line; it may be necessary to turn the plate over to find a true position, but on no account must the nut be slackened so that the plate will fit.

Position the pulley and damper on the hub, fit the locking plate in the position already determined and secure with the setbolts. Turn up the locking tabs.

CRANKSHAFT

REMOVAL

Fit the engine to a turnover stand.

Remove the transmission unit, torsion damper, wheelcase and cylinder heads.

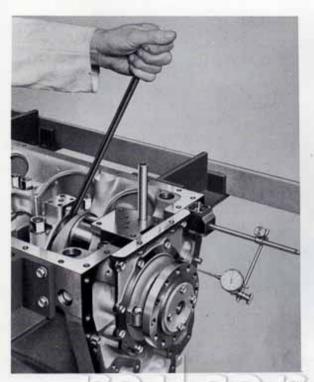


Fig. 3 Checking the crankshaft end float

For marine engines remove the sea-water pump, coolant heat exchanger and pedestal.

Turn the engine upside down and remove the sump and the lower half of the flywheel housing. If a single-piece flywheel housing is fitted, remove the flywheel and the housing.

For the horizontal engine remove the lubricating oil pump, crankcase adapter plate and the main oil gallery pipe.

For the vertical engine remove the oil pump gallery pipe assembly.

Turn the engine until the cylinders are horizontal and remove the piston and connecting rod assemblies.

The method of removing the above assemblies is given in the relevant sections

Turn the engine again into the inverted position and check the end float of the crankshaft by barring the shaft and measuring the movement by means of a dial indicator, as illustrated. Record the figure obtained.

Remove the two setbolts securing together the halves of the oil seal cover at the rear of the crankcase; it is not necessary to remove the bolts securing the bottom half of the cover to the bearing cap.

Remove the six lateral bolts which screw into the cap halves of the front, centre and rear bearing caps. Bend down the tabs of the locking washers and remove the nuts and washers from the main bearing studs.

Withdraw the main bearing caps, using the extractor GA.2, as illustrated, and detach the lower half bearing shells and the thrust washers from the centre bearing cap.



Fig. 4 Removing main bearing cap

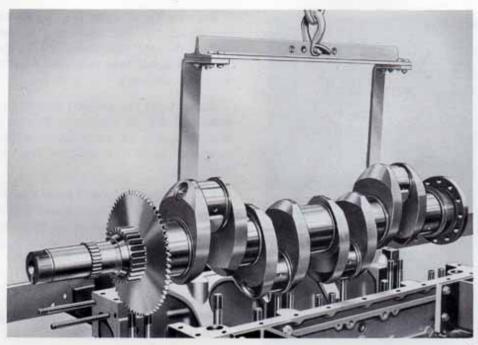


Fig. 5 | Lifting the crankshaft (4-cylinder engine)

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Lift the crankshaft, using the slinging beam GA.261, as illustrated, and lower the assembly into a suitable support fixture.

Collect the upper half thrust washers and bearing shells.

DISMANTLING

If a clutch shaft bearing is fitted, unscrew the setbolts securing the retaining plate, remove the plate and withdraw the bearing, using the tool GA.11, as illustrated.

Withdraw the driving pinion from the front end of the shaft using the tool GA.17, extract the two keys and remove the oil pump driving gear by tapping it off the dowels. Collect the dowels.

For the 8-cylinder engine, and engines having the crankshaft pinion and oil pump driving gear shrunk-on, no attempt should be made to remove it, except when the crankshaft requires re-nitriding. Withdraw the plugs from the crankwebs in the following manner:

Drive the plug into the recess sufficient to release the spring ring, and extract the ring.

Pour a small quantity of light oil into the recess behind the plug, through the journal oilway. Screw the tool GA.171 into the tapped hole in the end of the plug and rotate the plug, at the same time withdrawing it.

INSPECTION

Thoroughly clean all parts, particularly the oilways and the bores of the crankpin and journals.

Check the crankshaft journals and crankpins for diameter and ovality. When new, the journals are 3.8995 to 3.900 in. diameter and the crankpins 3.2490 to 3.2495 in. with running clearances of 0.0035 to 0.0055 in. (0.089 to 0.140 mm.) and 0.0025 to 0.004 in. (0.063 to 0.102 mm.) respectively. For the 8-cylinder engine crankshaft with 5 in. journals, the journals when new are 4.9995 to 5.000 in. diameter.

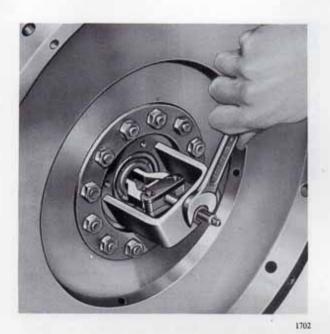


Fig. 6 Removing the clutch shaft bearing

If the ovality on either journals or crankpin exceeds 0.003 in. (0.0762 mm.), or if they are scored, a new or reconditioned crankshaft should be fitted.

Examine the bearing surfaces of the shell bearings for cracked or worn plating, scored and embedded foreign matter. Bearings should be rejected if the lead-indium is cracked or if there are more than three deep scores in the bearing surface. They should also be rejected if there is a heavy impregnation with foreign matter, even if the plating is unbroken.

Examine the lead plating on the bearing shells; any shells which have the plating worn off, exposing the lead-bronze surface for more than \frac{1}{3} of the bearing area should be changed.

For highly stressed parts, such as the crankshaft and driving gears, electro-magnetic crack detection is recommended.

Examine the teeth of the oil pump driving gear and the driving pinion for the timing gears. Loss of tooth profile is not in itself serious, and only if this is combined with an extensive area of breakup on the teeth need the gear be rejected.

Check the crankshaft for 'bow' by supporting it in 'Vee' blocks at the front and rear journals, and using a dial indicator, check the amount of 'bow' at the centre journal. The 'bow' must be progressive over the length of the crankshaft, and not between adjacent journals.

ASSEMBLING

With the crankshaft in the support stand, fit the sealing plugs, first ensuring that the bores and oilways are perfectly clean.

Fit new rubber rings to the sealing plugs and smear the rings with engine oil to facilitate assembly. Press each plug into the crankweb bore as far as it will go, insert the spring ring and pull the plug back against the ring with the tool GA.171.

Fit the oil pump driving gear with the chamfered side of the bore towards the shoulder on the shaft, ensuring that the dowels are fitted. Fit the keys for the driving pinion, and fit the pinion on the shaft with the centre punch mark on the face of the pinion in line with the punch mark on the end of the shaft.

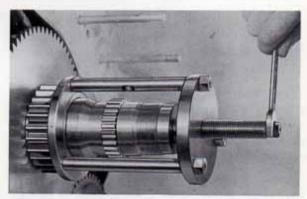


Fig. 7 Withdrawing the crankshaft pinion

If provision is made for a clutch shaft ball bearing, fit it in the counterbore at the rear end of the crankshaft and secure it with the retaining plate, interposing a new gasket between the plate and the shaft. Pack the bearing with Shell 'Retinax A' grease.

REFITTING

If a reground crankshaft is to be fitted, carefully check the journals and crankpins for size. The journal size will be found etched on the periphery of the crankshaft flange, e.g. the marking - 10J will indicate that the journals have been reground 0.010 in. (0.254 mm.) undersize on the diameter. The crankpin size will be found etched on the adjacent crankwebs, e.g. the marking - 10P will indicate that the crankpins have been reground 0.010 in. (0.254 mm.) undersize on the diameter.

If the crankcase is of the non-standard type it can be identified by the marking OER.111 and/or OER.105 stamped in the following positions:

- (a) On the centre bearing cap web at the camshaft side of the crankcase, and also adjacent to the crankcase serial number on the opposite side of the crankcase.
- (b) On the engine modification plate.

Oversize main bearings with standard bores, and oversize bearings with undersize bores are available and are identified by their numbers etched on the back of the shell.

Fit the upper half bearing shells into the crankcase, smear the bearing surfaces with clean engine oil and carefully lower the crankshaft into position.

The end float of the crankshaft on a new assembly is between 0.005 and 0.013 in. (0.127 and 0.330 mm.). Fit new thrust washers if the figure recorded during dismantling was more than 0.020 in. (0.508 mm.).

If the crankcase main bearing housings have been rebored, new thrust washers 0.013 in. (0.3202 mm.) oversize should be fitted.



Fig. 8 Fitting the upper half thrust washer

Feed the upper half thrust washers into the recess at each side of the centre bearing housing with the bronze face towards the crankweb.

Assemble the lower half bearing shells in the bearing caps, ensure that the cap dowels are fitted to the centre bearing cap, and press the caps into position with the tool GA.2. The caps are numbered from the front of the engine and these numbers must coincide with the corresponding numbers on the crankcase. Before fitting the centre cap, place the lower half thrust washers against each side of the cap with a little grease smeared on the face to retain them in position.

For the 6-cylinder engine, fit new wooden sealing dowels in the holes between the crankcase and the rear bearing cap. After first fitting the dowels, leave them for a few minutes to allow any air trapped in the bottom of the holes to escape, then drive them fully home and saw off the surplus wood.

Fit new locking plates and tighten the nuts to the following torque loadings:

With the exception of engines whose crankcases are stamped for 200 lb. ft. (27.6510 kg.-m.) and 160 lb. ft. (22.1208 kg.-m.) torque loadings, the loadings are 150 lb. ft. (20.7383 kg.-m.) for the intermediate bearings and 120 lb. ft. (16.5906 kg.-m.) for the front, centre and rear bearings.

A 3 in. (76.2 mm.) extension spanner GA.21 is supplied for torque tightening the outer nuts of the front and rear bearings of the 6-cylinder engines. The effect of adding this extension is to increase the leverage of the torque spanner by approximately one-seventh and this must be allowed for on the spanner setting. When using this spanner, tighten to 105 lb. ft. (14.5168 kg.-m.) to give an actual loading of 120 lb. ft. (16.5906 kg.-m.) and to 140 lb. ft. (19.3557 kg.-m.) to give an actual loading of 160 lb. ft. (22.1208 kg.-m.).

When fitting the front and rear journal bearing caps nip the nuts evenly. Then torque load the two outer nuts of the front and rear bearing studs first before loading the inner studs. This must be done to prevent oil leaks at the front and rear bearings.

For the 8-cylinder engine crankshaft with 5 in. journals, the torque loading for the front, centre and rear bearings is 200 lb. ft. (27.651 kg.-m.), and for the intermediate bearings 320 lb. ft. (44.2416 kg.-m.).

Fit the lateral bolts and tighten the nuts to a torque loading of 45 lb. ft. (6.22 kg.-m.).

Before locking the capauts, turn the crankshaft to ensure that it is free, and recheck the end float of the shaft. Fit the connecting rod bearings and the two setbolts to the crankshaft rear oil seal housing.

Fit the main oil gallery pipe to the lower halves of the crankshaft journal caps. Prime the lubricating oil system.

Refit all parts removed for access.

Whenever new bearings are fitted, operate the engine at half-speed on light load for at least 30 minutes.

Points to note

The nuts of the front, centre and rear bearing caps should be tightened evenly to prevent tilting the caps. Special attention must be paid to tightening down the front and rear caps of the 6-cylinder engine, as previously described in this Section.

The lateral bolts must be tightened after the main bearing caps.

Reclamation of worn crankshafts

Operators who wish to reclaim a worn crankshaft are advised to consult their local Rolls-Royce dealer, who has full particulars of the procedure and the necessary equipment for carrying out this work.

SPECIAL TOOLS

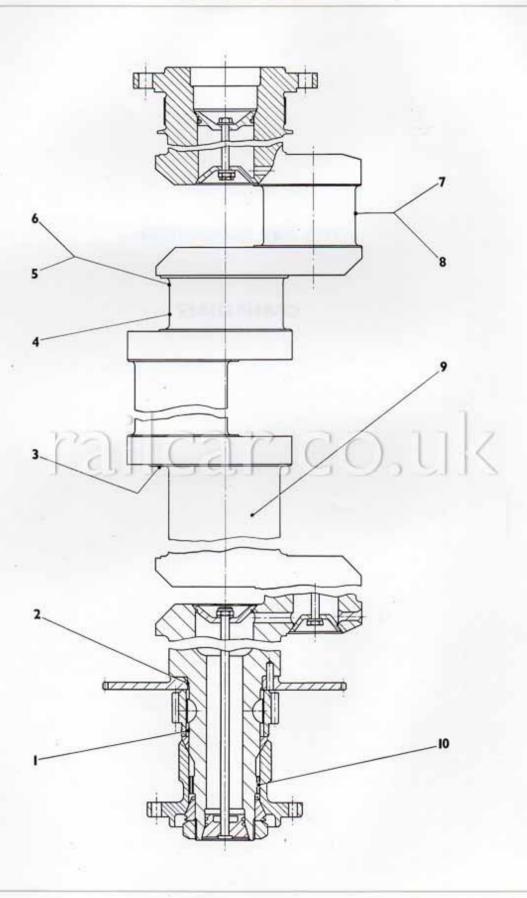
PART NO.	DESCRIPTION
GA.17	Extractor, crankshaft pinion
GA.18	Slogging spanner, crankshaft nut
GA.2/M1	Inserting and extracting tool, main bearing caps
GA.261	Slinging beam, crankshaft
GA.11 \	Extractors, clutch shaft spigot bearings
GA.245	Extractors, clutch shart spigot bearings
GA.171	Extractor, crankshaft oil plug
J.47789	Lifting beam, crankshaft and flywheel (drawings available)
J.53367	Assembling stand, crankshaft (drawings available)

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FITS AND CLEARANCES

CRANKSHAFT

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No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE NEW	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
1	CRANKSHAFT PINION ON CRANKSHAFT Pinion – bore	2.500 to				
	Crankshaft – dia.	2.5005 2.499 to 2.4995	0.0005 to 0.0015			
2	OIL PUMP DRIVE GEAR ON CRANKSHAFT					
	Gear - bore Crankshaft - dia.	2.625 to 2.6255 2.624 to	0.0005 to 0.0015			
3	CRANKSHAFT END FLOAT	2.6245				
	Centre journals – length Centre bearing – width over	3.175 to 3.177	0.005 to	di.	0.020	
	thrust washers	3.164 to 3.170	0.013		0.020	
4	CRANKSHAFT JOURNALS Standard size – dia.	3.8995 to		-		
	5 in. journals - dia.	3.900 5.000 to 4.9995				
5	Ovality]] [, C	0,003	, U	K
6	Journals in main bearings Running clearance		0.0035 to 0.0055			Lead surface must not be worn off more than 1/5 of bearing surface area.
7	CRANKPINS Standard size - dia.	3,249 to 3,2495				ocaring surface area.
8	Ovality	2000		0.003		
9	CRANKSHAFT BOW Bow at centre journal when supported by end journals in Vee blocks					
	4-cylinder engine			0.008		Total indicator reading
	6-cylinder engine			0.010		0.016, 0.020 and 0.030 respectively.
2020	8-cylinder engine			0.015		
10	VISCOUS DAMPER HUB Hub on crankshaft Backlash between splines		0.0003 to 0.003		0.006	

T.S.D. 803 SEC.

SECTION II . . FLYWHEEL

The flywheel is spigot-mounted on the crankshaft and is secured by dowels and set-bolts, as illustrated. An offset dowel hole ensures that the flywheel can be fitted in only one position on the crankshaft, thus maintaining the correct position of the timing marks.

maintaining the correct position of the timing marks.

On earlier engines, the flywheel is secured by 12 fitting bolts as shown on the alternative arrangement.

The flywheel may have to be changed due to a badly scored driving face, or the starter ring gear teeth may be badly worn, in which case a new gear ring can be fitted.

REMOVAL

Set-bolt and dowel fixing

Remove the engine from the vehicle, fit it to a turnover stand and detach the lower half of the flywheel housing.

Remove the clutch as described in Section 12.

Attach the lifting plate GA.16 to the flywheel and support it with a suitable hoist.

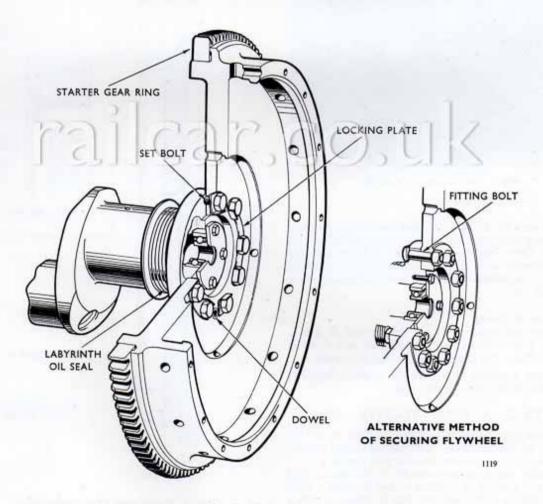


Fig. I Flywheel assembly



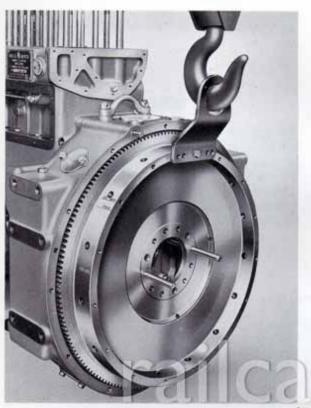


Fig. 2 Removing the flywheel

Turn back the locking tabs and remove the set-bolts and locking plates, and extract the dowels, using the tool GA.87. Insert the two guide bars GA.256 into the two horizontal set-bolt holes, ease the flywheel off its spigot, and withdraw it from the flywheel housing along the guide bars.

Fitting-bolt fixing

Remove the engine from the vehicle and fit it to a turnover stand. Remove the crankshaft and flywheel assembly from the engine as described in Section 9.

It is not necessary to remove the flywheel from the crankshaft to fit a new starter ring.

FITTING A NEW STARTER RING

If a new gear ring is to be fitted, machine or cut the old ring off the flywheel. Carefully clean and remove all burrs from the flywheel and the new gear ring.

Heat the ring to a temperature of 175 deg.C. (347 deg.F.) and place it in position on the flywheel. With a feeler gauge, check that the ring is seating correctly all round the flywheel.

RECLAIMING THE FRICTION FACE

After prolonged service, the severity of scoring on the clutch friction face of the flywheel may be such that reclaiming of the face is necessary.

It is recommended that only when the depth of the scoring exceeds 0.025 in. (0.635 mm.) below the general level of the face should it be reclaimed.

As the friction face will be work hardened, it will be necessary to reclaim the face by grinding, and the metal removed should only be sufficient to restore a smooth surface.

Having completed this operation, check the depth of the reground friction face from the outer face of the flywheel, and machine the outer face to restore this

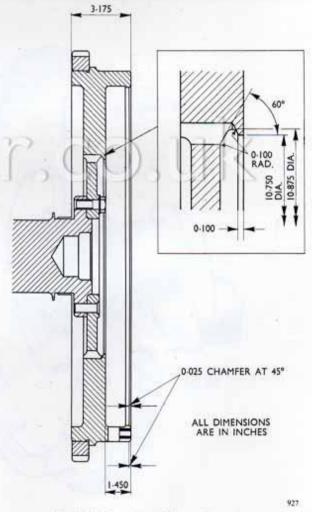


Fig. 3 Dimensions after reclamation

dimension to 1.450 in. (36.83 mm.). Also restore the 0.050 in. (0.127 mm.) 45 deg. chamfer at the outer edge of the clutch spigot bore.

After machining, the overall width should not be less than 3.175 in. (80.64 mm.) except for early flywheel assemblies OE.2157 and OE.4147, which should only be reduced to a width of 3.200 in. (81.28 mm.).

No further reclamation should be carried out which reduces the overall width of the flywheel to less than these dimensions.

A further machining operation will be necessary when the width of the land on the inner diameter of the friction face to the commencement of the undercut is less than 0.030 in. (0.0762 mm.). If necessary, this land should be restored to a width of 0.100 in. (2.540 mm.) by re-machining the undercut.

REFITTING

Insert the guide bars GA.256 in the two horizontal set-bolt holes in the crankshaft flange. Lift the flywheel using the lifting plate GA.16, and locate it on the guide bars, ensuring that the off-set dowel holes are in line, and press the flywheel on to its spigot

Fit the dowels, withdraw the guide bars and fit the locking plates. Tighten the setbolts to a torque loading of 65 to 70 lb. ft. (8.9866 to 9.6776 kg. m.). and turn up the locking tabs. When refitting a flywheel secured by fitting-bolts, position the flywheel on the crankshaft flange spigot, ensuring that the off-set bolt holes in the flywheel and the crankshaft flange are in line. Insert the fitting-bolts, fit new nuts and lock them by centre punching the ends of the bolts in four places. The bolt heads are chamfered on one edge and they must be fitted with this edge to the radius on the crankshaft flange.

If the flywheel friction face has been reclaimed, the flywheel must be secured to the crankshaft with bolts OE.4770 and lock-nuts UF.4556, in order to maintain clearance for the clutch friction plate rivets when the clutch lining is worn.

SPECIAL TOOLS

PART NO.	DESCRIPTION			
GA.16	Lifting plate, flywheel			
GA.87	Extractor, flywheel dowels			
GA.256	Guide bars, flywheel			

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T.S.D. 803 SEC. 13A

SECTION 13A .. WHEELCASE AND TIMING GEARS

VERTICAL ENGINES

The wheelcase provides mountings for the auxiliary drive, supercharger drive and service counter and a means of distributing to them the drive from the engine crankshaft.

The timing gears consist of a crankshaft pinion driving an idler gear, from which is driven the camshaft and the fuel injection pump. The supercharger, when fitted, is driven by a small idler gear through a spring drive.

The camshaft and auxiliary gears are timed to the crankshaft by mating the marked teeth as described in Section 13C.

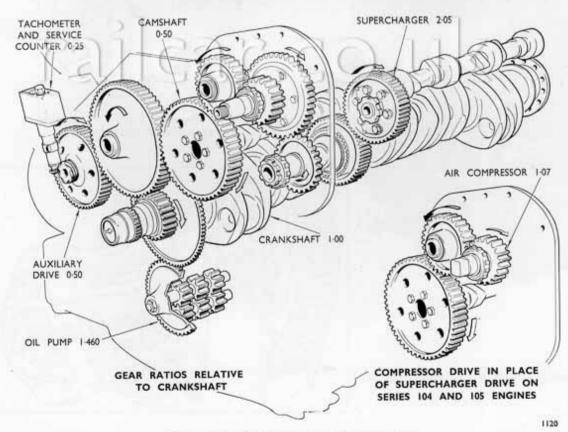


Fig. 1 Gear train diagram-supercharged engines

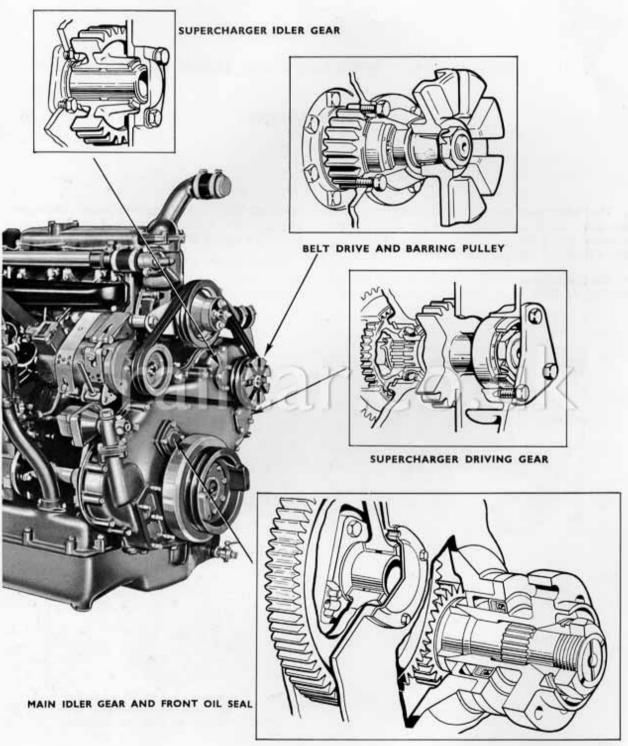


Fig. 2 Wheelcase details-supercharged engines

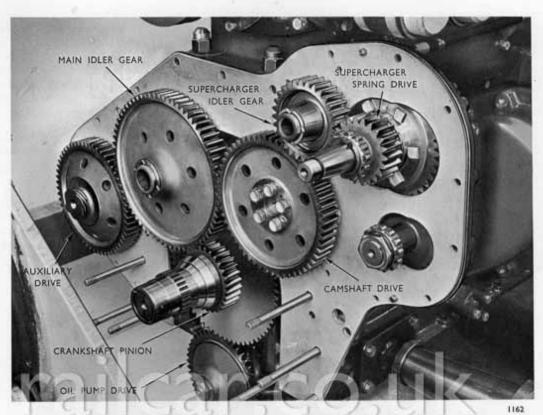


Fig. 3 Wheelcase gears-low mounted supercharger

The coolant pump and dynamo are belt driven from a pulley on the supercharger driving shaft, or directly from a pulley on the crankshaft. On normally aspirated engines the coolant pump, dynamo and the air compressor are usually belt driven from a pulley on the front end of the crankshaft.

REMOVAL

Remove the cooling fan.

Release and remove the driving belts, and remove the torsion damper, crankshaft pulley, dynamo and service counter complete with its driving shaft. Remove the torsion damper and crankshaft pulley as described in Section 9.

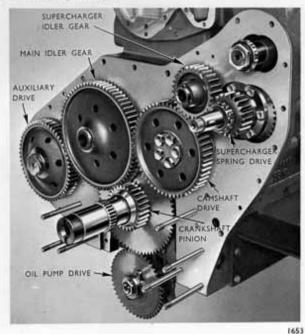


Fig. 4 Wheelcase gears-high mounted supercharger

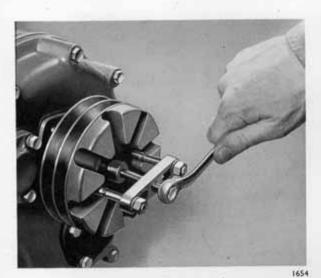


Fig. 5 Removing the barring pulley supercharged engines

On supercharged engines, release and remove the nut securing the barring pulley to the supercharger drive shaft and withdraw the pulley using the tool GA.7. Extract the key from the shaft to prevent damage to the oil seal when the casing is withdrawn. Remove the supercharger driving gear end cover from the face of the wheelcase.

On normally aspirated engines that have a low mounted belt-driven air compressor, remove the driving pulley from the compressor drive shaft.

The idler gear end covers are jointed with 'Heldite' compound and should not be disturbed.

Remove the set-bolts securing the sump to the wheelcase and slacken off the remaining set-bolts sufficiently to free the sump and joint gasket from the wheelcase flange.

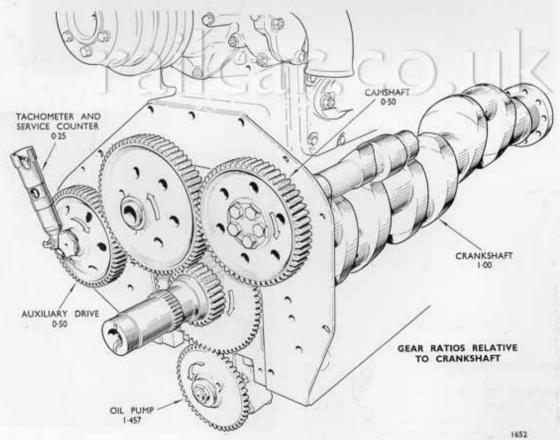
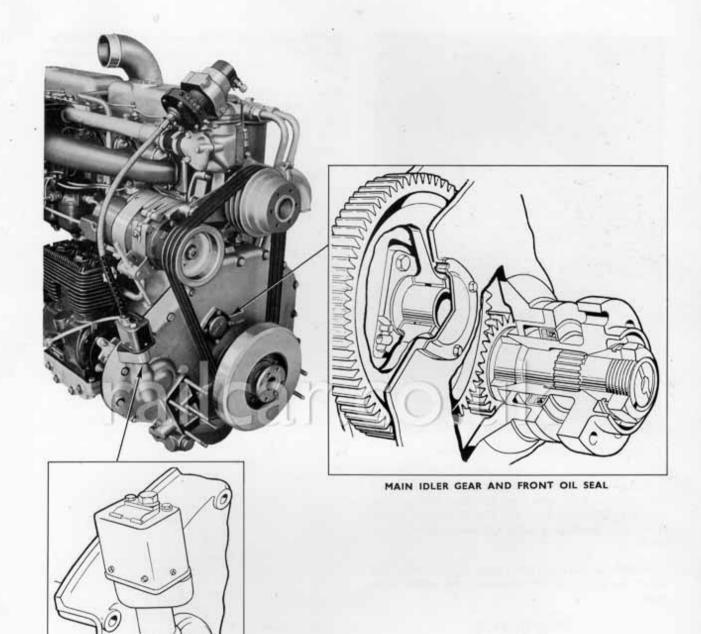


Fig. 6 Gear train diagram-normally aspirated engines



SERVICE COUNTER DRIVE

THRUST BUTTON

Fig. 7 Wheelease details-normally aspirated engines

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Section 13A

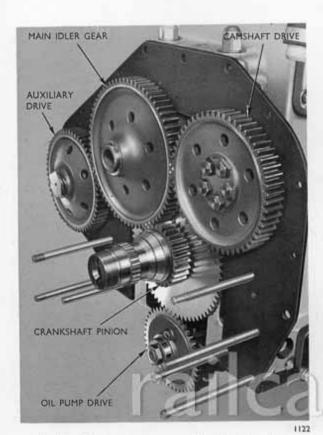


Fig. 8 Wheelcase gears-normally aspirated engines

Remove the bolts securing the wheelcase to the backplate and the nuts from the close-fitting bolts, and carefully withdraw the casing until it is free from the close-fitting bolts and the engine bearer studs.

Withdraw the main idler gear from its hub. If a supercharger is fitted withdraw the small idler gear.

INSPECTION

Examine the teeth of the timing gears for wear. Loss of tooth profile is not in itself serious and only if this is combined with an extensive area of break-up on the teeth, should a gear be rejected.

Where the necessary equipment is available the gears should be electro-magnetically crack tested.

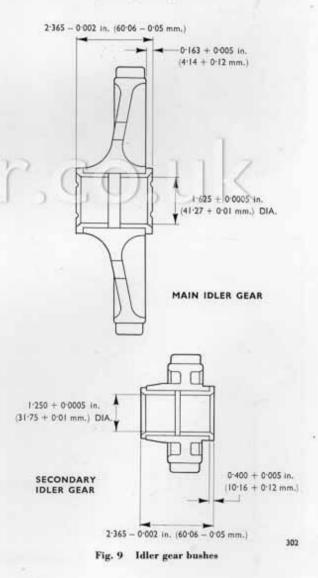
Examine the bushes of the main idler and secondary idler gears. If the clearance between the bushes and their hubs is more than 0.005 in. (0.127 mm.), the bushes should be drifted from the gears, and new bushes fitted.

Renewing idler gear bushes

To fit new bushes it is strongly recommended that they be shrunk with liquid air. After fitting a bush it must be machined so that the bore is concentric with the gear teeth.

The recommended procedure is as follows:-

Set up the gear on the faceplate of a lathe with a temporary fixing.



Using a clock indicator and with a 0.3125 in. (7.9 mm.) diameter roller positioned between the gear teeth at four equally spaced positions around the gear, set the gear so that the clock reading over the roller is the same in all four positions.

Secure the gear to the faceplate with clamping plates and remove the centre fixing.

Diamond bore the bushes and face the bush flanges to the dimensions given in fig. 9.

After machining the bushes, thoroughly clean out the bore and ensure that no loose metal is lodged in the space between the bushes.

Fit new oil seals, pre-packed with Vaseline, to the front end of the crankshaft and the supercharger spring driveshaft. The crankshaft oil seal is an interference fit in the housing and the tool GA.264 is supplied for pressing in a new seal.

After prolonged running it may be found that the wiping edge of the crankshaft front end oil seal has worn a groove in the surface of the pulley hub, and consequently the fitting of a new seal to locate in its original position will not be effective.

In these circumstances the new seal should be positioned in its housing at a distance of 0.110 in. (2.8 mm.) from the front end face of the housing, ensuring that the seal is kept square to the housing bore whilst being pressed in.



Fig. 10 Typical timing marks

When a second groove has been worn in the hub, a new seal should be pressed in to the full depth of the housing.

Check the tachometer drive thrust button for wear. If the face of the button is worn flat a new button should be fitted. The button has a shank diameter of 0.375 in. (9.525 mm.) and is a press fit in the wheelcase.

To remove a worn button, drive it from the housing with a suitable drift located in the hole in the underside of the casing.

REFITTING

The timing marks for both left and right-hand build engines are described in Section 13C.

Position the crankshaft pinion and the auxiliary drive and camshaft gears, so that the timing marks are coincident when the main idler gear is fitted.

Check the backlash of each gear at not less than four equally spaced positions around the gear.

If new gears are fitted, the backlash should be between 0.004 and 0.010 in. (0.101 and 0.254 mm.) for all gears.

If the backlash is not within these limits, the main idler gear hub should be repositioned and oversize dowels fitted.

To reposition the main idler gear hub:-

Detach the gear hub from the crankcase and extract the dowels. Refit the hub, leaving out the dowels. Position it to give the required backlash and tighten the set-bolts. Recheck the backlash and open out the dowel holes to 0.343 in. (8.73 mm.), using the special kit of tools GA.102. The tool kit contains a reaming jig GA.103, a roughing reamer GA.104, a finishing reamer GA.105, and a recessing tool GA.106.

After reaming the holes, remove the hub from the crankcase and open out the counterbore at the hub dowel holes with the recessing tool GA.106.

Fit oversize dowels OE.4692 and locking rings OE.2296 and refit the hub to the crankcase.

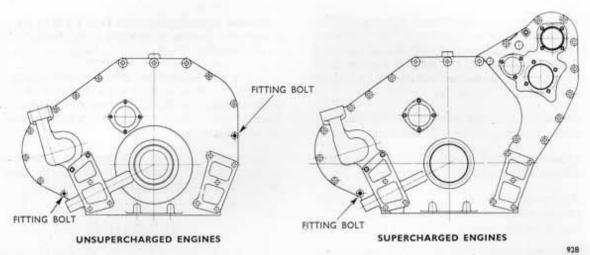


Fig. 11 Position of close-fitting bolts

On supercharged engines fit a close-fitting bolt in the bottom hole of the backplate on the same side of the engine as the fuel injection pump, with the bolt head to the backplate. On normally aspirated engines fit the two close-fitting bolts, one each side, in the bottom holes of the backplate as illustrated in fig. 11. Fit a new gasket at the joint between the wheelcase and the backplate.

Refit the wheelcase in the reverse order to dismantling, ensuring that the supercharger bearings, if fitted, are correctly located before tightening the flange bolts. When fitting the supercharger driving gear cover, do not omit the distance piece behind the cover.

Fit the crankshaft front end assembly as described in Section 9, and refit the service counter and its drive shaft to the wheelcase.

AUXILIARY DRIVE

The auxiliary drive is driven from the crankshaft through a train of gears in the wheelcase and drives the fuel injection pump at half engine speed. Details of the drive are shown in fig. 12.

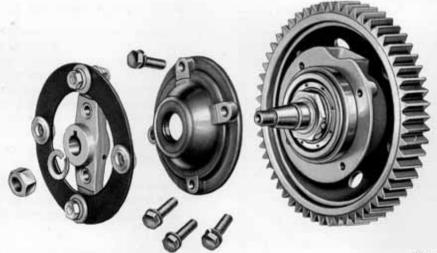


Fig. 12 Exploded view of auxiliary drive

REMOVAL

Driven end assembly

Turn the engine in the direction of rotation until the timing marks on the engine flywheel and the fuel injection pump flywheel are in line with their pointers; avoid turning the engine or injection pump until the drive is refitted.

Detach the injection pump drive shaft or yoke by removing the bolts securing the drive shaft or yoke flanges to the front and rear spring plate assemblies and withdraw the drive shaft or yoke.

Driving end assembly

Remove the wheelcase.

Detach the spring plate from the driving coupling and remove the nut from the rear end of the driving shaft.

Withdraw the coupling, using the withdrawing tool GA.7, and extract the key from the shaft.

Remove the four set-bolts securing the oil seal housing and the driving gear assembly to the wheelcase backplate. Withdraw the oil seal housing from the driving shaft, taking care not to damage the seal, and tap the gear assembly forward out of the backplate.

To dismantle the gear assembly, release and remove the nut locking the gear shaft in the bearing housing and withdraw the gear and shaft from the housing. If the inner race and rollers of the front bearing are not withdrawn with the shaft, they should be taken out so that the space between the bearings can be washed out. It is not necessary to remove the rear bearing or outer race of the front bearing unless new bearings are to be fitted.

REFITTING

When refitting the gear assembly care should be taken to ensure that the gear is timed with the crankshaft gear by mating the marked teeth.

Fit a new seal and a new gasket at the joint between the oil seal housing and the backplate, and always fit new self-locking nuts to the bolts securing the driving shaft or yoke. The bolts securing the driving shaft or yoke to the auxiliary drive coupling should be fitted with their heads to the wheelcase backplate, and should be inserted in the coupling holes before the coupling is assembled on the gear drive shaft.

To ensure positive locking, at least one full thread of the bolts should protrude through the self-locking nuts.

After assembly, check the fuel pump timing.

SERVICE COUNTER AND TACHOMETER DRIVE

The service counter is located on the right-hand side of the wheelcase and usually registers one unit for every 90,000 revolutions of the crankshaft, which is equivalent to one hour's running at 1,500 r.p.m.

For some installations the counter is adjusted to register one unit for every 75,000 revolutions of the engine crankshaft, which is equivalent to one hour at 1,250 r.p.m.



Fig. 13 Removing the service counter

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Fig. 14 Removing the service counter drive

A vertical shaft driven from the auxiliary drive gear turns the counter and in addition provides a tachometer drive at quarter engine speed.

To remove the service counter, remove the setbolts securing the counter to its mounting face on the wheelcase and detach the counter. The driving shaft assembly can then be withdrawn from the wheelcase, as illustrated in fig. 14.

When reassembling the drive, pack the space between the shaft and housing and smear the driving gear with low melting point grease (Wakefield's 'Castrolease Heavy' is recommended).

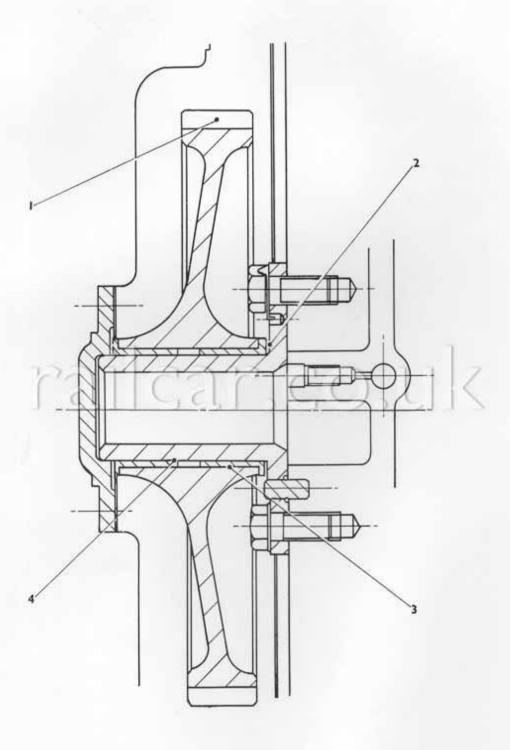
SPECIAL TOOLS

PART NO.	DESCRIPTION	
GA.7	Extractor, supercharger driveshaft barring pulley and auxiliary driveshaft coupling	<
GA.102	Reaming and recessing kit, main idler gear hub dowel holes	
GA.264	Inserting tool, crankshaft oil seal	

FITS AND CLEARANCES

MAIN IDLER GEAR

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No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE NEW	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
1	IDLER GEAR BACKLASH Backlash between idler gear and crankshaft pinion, idler gear and auxiliary drive gear, and idler gear and camshaft drive gear		0.005 to		0.012	
2	IDLER GEAR AND SHAFT Idler gear end float		0.010 0.005 to 0.030		0.045	
3	Bushes in idler gear Gear – bore	1.8125 to 1.813	Interfer. 0.0035 to			See Service Bulletin
4	Bushes – dia. Idler gear on shaft Bushes – bore	1.8155 to 1.816	0.0025			O.E.B. 196.
	Shaft - dia,	1.6255 1.6235 to 1.624	0.001 to 0.002		0.004	
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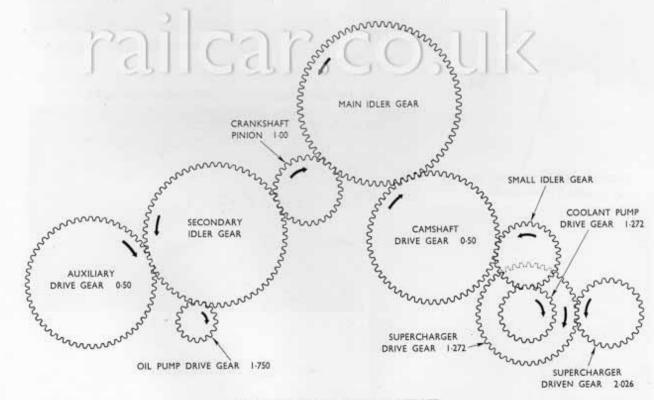
SECTION 13B WHEELCASE AND TIMING GEARS

HORIZONTAL ENGINES

The wheelcase of the horizontal engine is similar to that of the vertical engine, but with an additional idler gear.

The timing gears consist of a crankshaft pinion driving a main and a secondary idler gear. From the main idler gear is driven the camshaft, coolant pump and, if fitted, the supercharger. From the secondary idler gear is driven the lubricating oil pump, tachometer generator, fuel injection pump and service counter.

The camshaft and auxiliary gears are timed to the crankshaft by mating the marked teeth.

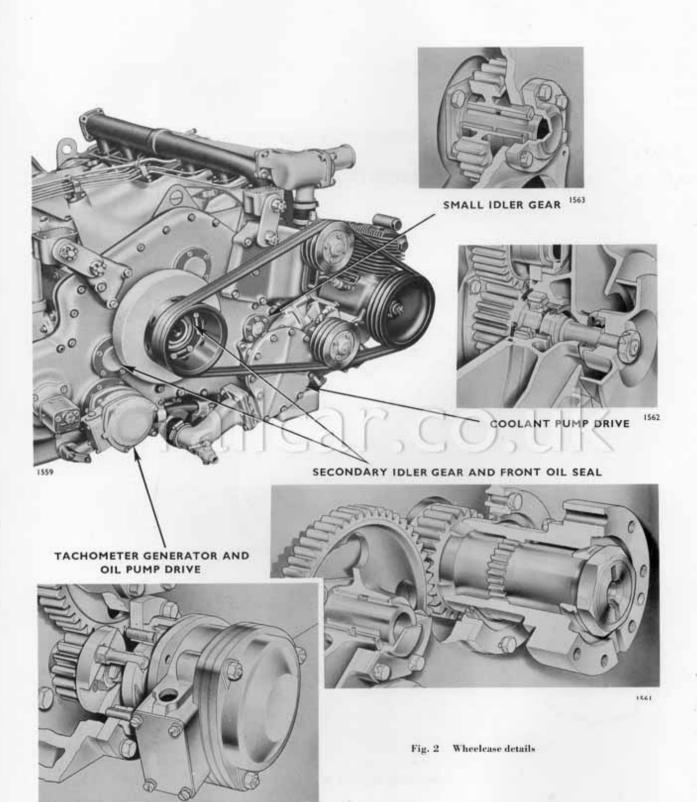


GEAR RATIOS RELATIVE TO CRANKSHAFT

Fig. 1 Gear train diagram

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Section 13B



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REMOVAL

Support the engine in a turnover stand.

For normally aspirated engines release and remove the compressor driving belts, fixed belt pulley, crankshaft pulley and air compressor.

Remove the engine front suspension brackets, torsion damper, service counter, tachometer generator and coolant pump. For normally aspirated engines remove the compressor mounting bracket.

Release and remove the crankshaft front end nut and withdraw the split cone and torsion damper hub.

Release and remove the suction pipe from the wheelcase drain chamber and then release and remove the drain chamber.

Release and remove the nuts and bolts securing the wheelcase to the backplate and the nuts of the close fitting bolts. Carefully withdraw the wheelcase until it is free from the close fitting bolts. Remove the idler gear end covers from the wheelcase. Turn back the locking tab and release and remove the nut securing the tachometer generator drive to the drive end of the lubricating oil pump shaft. Withdraw the tachometer drive from the shaft and collect the dowel.

Withdraw the main, secondary and small idler gears from their hubs.

INSPECTION

Inspection of the wheelcase details is identical with that detailed in Section 13A, and the instructions given for renewing the idler gear bushes, and repositioning the crankshaft oil seal, should be followed.

REFITTING

The timing marks are described in Section 13C. Position the crankshaft pinion and the auxiliary drive and camshaft gears so that the timing marks are coincident when the main and secondary idler gears are fitted. Fit the small idler gear.

Check the backlash of each gear at not less than four equally spaced positions around the gear. The

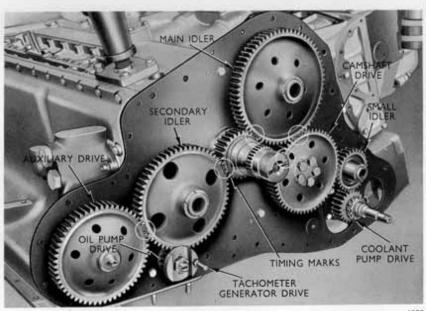


Fig. 3 Wheelcase gears and timing marks

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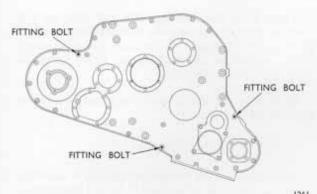


Fig. 4 Position of close fitting bolts

backlash should be between 0.004 and 0.010 in. (0.101 and 0.254 mm.) for all gears.

If the backlash is not within these limits, the main and secondary gear hubs should be repositioned and oversize dowels fitted, as described in Section 13A.

Fit the dowel to the lubricating oil pump drive gear, and fit and secure the tachometer drive to the drive end of the oil pump shaft. Turn up the locking tab.

Fit the close fitting bolts to the wheelcase backplate in the position shown in fig. 4, with the bolt heads to the backplate.

Fit a new gasket at the joint between the wheelcase and the backplate, refit the wheelcase in the reverse order to dismantling and tighten the bolts.

Fit the wheelcase drain chamber to the wheelcase, interposing a new gasket between the joint faces, and tighten the securing set-bolts.

Fit the suction pipe between the engine sump and the drain chamber and secure the supporting clip. If a supercharger is fitted, connect the supercharger drain adapter to the wheelcase drain chamber. Pack the crankshaft front oil seal with Vaseline and fit the oil seal and housing assembly to the wheelcase.

Fit the cone, torsion damper hub and split cone to the front end of the crankshaft, and fit and tighten the crankshaft end nut using the spanner GA.18 and a heavy hammer.

If new idler gear bushes have been fitted it is advisable to check the end float of the gears.

Interpose a piece of lead wire 0.0625 in. (1.5875 mm.) diameter between the flange of the idler gear bush and the face of the end cover. Tighten the setbolts securing the end cover, then release and remove the set-bolts and cover, and carefully remove the lead wire. With the aid of a micrometer measure the thickness of the wire, the measurement obtained will be the end float of the gear being checked.

The end float of the idler gears should be:-

Main idler	0.017 to 0.041 in. (0.4318 to 1.0414 mm.)
Secondary idler	0.022 to 0.036 in. (0.5588 to 0.9144 mm.)
Small idler	0.017 to 0.038 in. (0.4318 to 0.9652 mm.)

Smear the idler gear end covers and wheelcase joint faces with 'Heldite', fit the end covers to the wheelcase and tighten the securing set-bolts. Turn up the locking tabs.

Before fitting the torsion damper and pulley, ascertain the correct position of the locking plate as described in Section 13A.

Refit all parts removed for access and adjust the tension of the compressor belts to give a total deflection of one inch at a position equidistant between the driving pulley and the compressor pulley.

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SECTION 13C . . TIMING PROCEDURE - ALL ENGINES

The timing of all engines is by marked teeth on the timing gears.

Three types of timing marks are provided: single centre-punch marks for use when timing left-hand build vertical engines (fig. 1); twin centre-punch marks for use when timing right-hand build vertical engines (fig. 2); and a combination of single centre-punch marks and single 'X' stampings for timing horizontal engines (fig. 3).

Timing left-hand build vertical engines

Position the crankshaft pinion, auxiliary drive gear and camshaft gear so that the tooth on each of these gears which is marked with a single centre-punch mark will mesh with the similarly marked teeth on the idler gear when that component is fitted.

Timing right-hand build vertical engines

Position the crankshaft pinion, auxiliary drive gear and camshaft gear so that the tooth on each of these gears which is marked with twin centrepunch marks will mesh with the similarly marked teeth on the idler gear when that component is fitted.

Timing horizontal engines

Position the crankshaft pinion so that the tooth which bears an 'X' stamping will mesh up with the similarly stamped teeth on the secondary idler gear, then fit the auxiliary drive gear so that the tooth bearing a single centre-punch mark will mesh with the similarly marked teeth on the secondary idler gear when that component is fitted.

Position the crankshaft pinion and the camshaft gear so that the tooth on each gear which is marked with a single centre-punch mark will mesh with the similarly marked teeth on the main idler gear when that component is fitted.

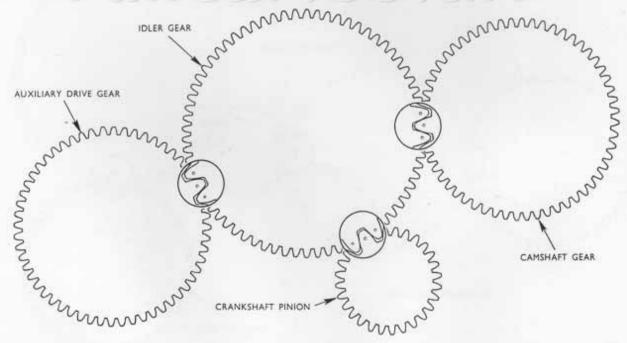
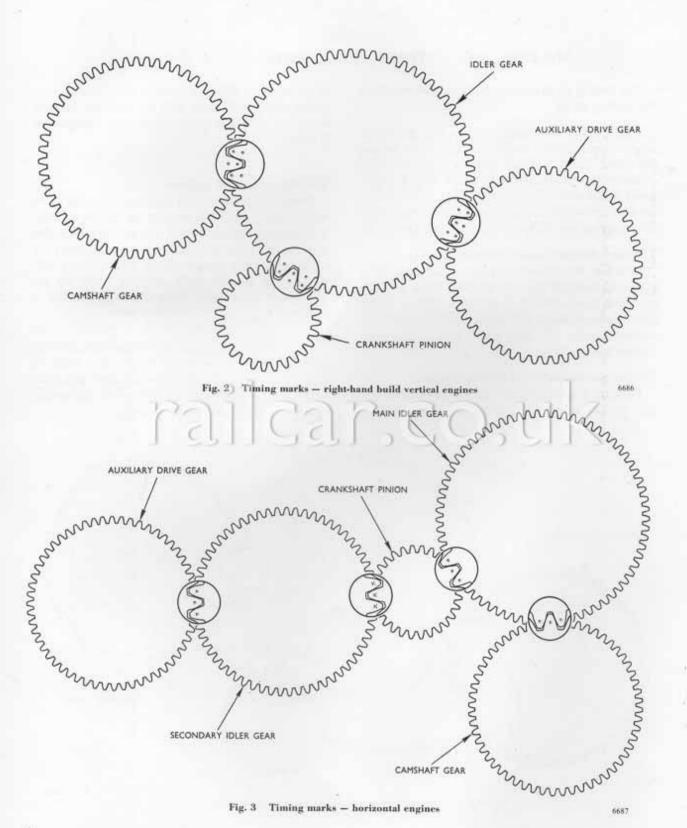


Fig. 1 Timing marks - left-hand build vertical engine

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SECTION 14 .. CAMSHAFT

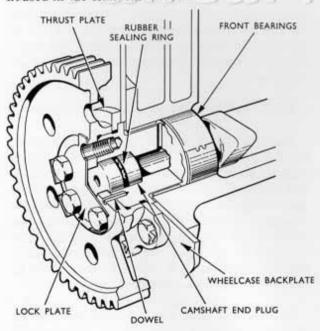
The camshaft is driven at half engine speed by the crankshaft pinion, through the main idler gear which is mounted in the wheelcase. The driving gear is secured to the camshaft by five setbolts, one of which is offset to ensure that the gear can be fitted to the shaft in one position only. It is also dowelled to the shaft to prevent misplacement due to oscillations of the timing gears. Mating teeth on the crankshaft pinion, main idler gear and camshaft driving gear are marked to facilitate valve timing during assembling.

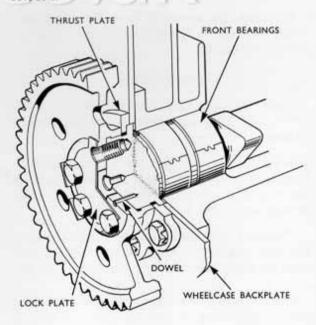
The cams are forged integrally with the shaft, and actuate the inlet and exhaust valves through tappets, push rods and overhead rocker mechanism. The large diameter journals are carried in plain lead-bronze bearings which are housed in the crankcase webs.

A hollow camshaft is fitted to the 6-cylinder engine, the bore being sealed at both ends by plugs. Oil from the main engine lubricating system flows through a drilling in the crankcase to lubricate the camshaft centre journal bearings, and thence via a drilling in the camshaft centre journal to the hollow shaft bore, from which further drillings in the journals convey oil to the remainder of the bearings.

A solid camshaft is fitted to both the 4 and 8cylinder engines, each journal bearing being separately lubricated from the crankshaft main bearings through drillings in the crankcase webs.

The end float of the camshaft in the crankcase is governed by a phosphor-bronze thrust plate which is secured to the wheelcase backplate by setbolts.





6 - CYLINDER ENGINES

4 and 8 - CYLINDER ENGINES

Fig. 1 Camshaft front end details

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REMOVAL

Remove the valve rocker mechanism (as described in Section 5), the wheelcase (Section 13A or 13B), and the sump (Section 19A, 19B or 19C). On supercharged engines remove the supercharger and supercharger drive, as described in Section 28; on normally aspirated engines remove the belt-driven air compressor, as described in Section 25A, and remove the air compressor mounting bracket.

Remove the cover from the tappet recess and remove the push rods and tappets.

Measure and record the end float of the camshaft. This information will be required during inspection and reassembling.

Remove the setbolts securing the driving gear to the camshaft; remove the main idler gear, and gently prise off the camshaft gear. Remove the five locating dowels.

Remove the setbolts securing the phosphorbronze thrust plate to the wheelcase backplate and detach the thrust plate.

Withdraw the camshaft from the crankcase, taking care not to damage the journal bearings during the operation.

INSPECTION

Clean the camshaft, camshaft driving gear, thrust plate, tappets, push rods and all securing setbolts.

6-cylinder engines: Remove the sealing plugs from both ends of the hollow camshaft, flush out the bore and oilways with paraffin, and blow through with compressed air.

Clean the camshaft bearings in the crankcase and flush out the crankcase oilway drillings with clean paraffin. Blow through with compressed air.

Carry out an electro-magnetic crack detection test on the camshaft and the camshaft driving gear. Demagnetize the shaft and gear on completion of the test. Examine the teeth of the driving gear for wear and damage. Examine the cams for wear and damage. Blend out any scores or other slight damage which will not affect the cam profiles. The maximum cam lift on a new shaft is 0.390 in. (9.906 mm.); the lift on a worn cam must not be less than 0.375 in. (9.525 mm.).

Examine the journals for wear, scores and other damage, and the bearings for wear, scores and 'break-up'. Blend out any scores or other slight damage found on the journals. New camshaft journals are 2.4365 to 2.4360 in. diameter, and new bearings are 2.4395 to 2.4420 in. diameter, giving a running clearance of 0.003 to 0.006 in. (0.076 to 0.152 mm.). The clearance on worn assemblies must not exceed 0.010 in. (0.254 mm.).

6-cylinder engines: Fit a new sealing ring to the camshaft front end plug and a new locking washer to the rear end plug, and fit the plugs to seal the camshaft bore. Tighten the rear plug and bend up the locking tabs.

Examine the thrust plate for wear on the thrust faces. The end float of the camshaft is governed by the thickness of this plate between the thrust faces; if the figure recorded during the removal of the camshaft was more than 0.016 in. (0.406 mm.), the plate must be renewed, irrespective of its condition.

Examine all securing setbolts for serviceability.

Examine the tappets for wear and damage, and blend out any scores found on their walls. Subject each tappet to an electro-magnetic crack detection test; demagnetize each tappet on completion of its test. Clean the bores of the tappet housings in the crankcase, blend out any scores, and test the clearance of each tappet in its housing. The clearance on new components is 0.001 to 0.0025 in. (0.025 to 0.062 mm.); it must not exceed 0.003 in. (0.076 mm.) on worn assemblies.

Examine the push rods for distortion and for wear and damage of the end pieces. Test for loose end pieces by 'ringing' the rods; reject any on which one or both end pieces are loose.

REFITTING

Ensure that the camshaft bearings are clean and that the oilways are free of restrictions. Liberally smear the bearings and the camshaft journals with clean engine lubricating oil.

Insert the camshaft into position in the crankcase, rotating the shaft as it passes through the bearings.

Fit the phosphor-bronze thrust plate with the counterbore towards the inside (plain face outermost). Tighten and lock the securing setbolts and pour an adequate quantity of clean engine lubricating oil over the thrust surfaces of the plate.

Liberally smear the cams with clean engine lubricating oil.

Position the driving gear on the shaft and fit the dowels, locking plate and setbolts. Tighten the setbolts and bend up the locking tabs.

Recheck the end float of the camshaft in the crankcase. The end float on new assemblies is 0.004 to 0.008 in. (0101 to 0.203 mm.); it must not exceed 0.016 in. (0.406 mm.) on worn assemblies.

Fit the idler gear to the wheelcase, with the crankshaft pinion and camshaft driving gear so positioned that the timing marks on the gear train teeth coincide. See Section 13A and 13B. Pour an adequate quantity of clean engine lubricating oil over the teeth of the driving gears.

Refit all parts removed for access, and adjust the valve tappet clearances, as described in Section 5.

CAMSHAFT BEARINGS

Plain lead-bronze camshaft bearings are fitted, the front camshaft journal, i.e. the journal immediately behind the camshaft driving gear, and the centre journal being carried in double bearings and the remainder in single bearings.

A total of seven bearings are fitted to 4-cylinder crankcases, two each in the front and centre housings and one each in the remaining three housings; nine to 6-cylinder crankcases, two each in the front and centre housings and one each in the remaining five housings; eleven to 8-cylinder crankcases, two each in the front and centre housings and one each in the remaining seven housings. The rear end of the rear bearing housing in each case is sealed by a plug and sealing ring assembly which is retained in the crankcase by the flywheel housing.

Special service crankcase assemblies for 4 and 8-cylinder engines are supplied with two bearings fitted in both end housings; this is to enable the assemblies to be used on either left-hand or righthand engines as required. When such an assembly is used for the first time, the surplus end bearing, i.e. the outer of the two bearings in the housing at the flywheel end of the crankcase, must be sealed with the special blanking plug OE.2488. During subsequent renewal of the camshaft bearings, the surplus bearing should not be refitted; in its place the blanking plug OE.3947 should be fitted to seal the rear end of the bearing housing. Care must be taken when fitting the plug OE.2488 in the surplus rear bearing of service assemblies to ensure that the sealing ring is not torn as the plug is pushed into the bearing. Sealing ring KB.16630 must be used with plug OE.2488, and sealing ring KB.14533 with plug OE.3947.

The bearings are a press fit in their housings in the crankcase. They are supplied with their bores finished to size and do not therefore require reaming after fitting. They are externally chamfered at one end to give a 'lead-in' during the fitting operation; care must therefore be taken during this operation to position the chamfered end of each bearing to its housing.

Camshaft bearings will not normally require renewal between complete engine overhauls. Since their renewals during such overhauls will be carried out when the crankcase has been stripped to the bare state, and as the design of the crankcase is such that it can be used on either left-hand or right-hand engines, the front bearing housing, i.e. the housing behind the camshaft driving gear, should be suitably marked before the bearings are removed. This will ensure that two bearings are fitted to the correct end housing during the refitting of new bearings.

The following combined extraction and insertion tool assemblies are available for renewal of the camshaft bearings:

4-cylinder engines: tool No. GA.260 6-cylinder engines: tool No. GA1./M.1 8-cylinder engines: tool No. GA.329

To ensure that the bearings are correctly located in their housings relative to their oilway drillings in the crankcase during their insertion, the plain, guide, master and thrust bushes of the tool assemblies used on 4 and 8-cylinder engines are keyed to their mandrels, the flanges of the thrust bushes are drilled for positive location on the crankcase, and a locating pin is incorporated on each plain, guide, and master bush to mate with the slot which is machined in one end of each camshaft bearing.

Two thrust bushes are included in each of the three tool assemblies. In both the 4 and 6-cylinder engine tool assemblies the bushes are of different diameters, one having a diameter of 2.439 in. for insertion in the camshaft end bearing and the other a diameter of 2.599 in. for insertion in the camshaft end bearing housing. In the 8-cylinder engine tool assembly both bushes are 2.439 in diameter, and a packing bush is included in the assembly to increase this diameter to 2.599 in. when required. Two master bushes are also included in each kit, one having a spigot diameter of 2.439 in. and the other of 2.599 in. diameter.

The flanges of the thrust bushes in the 4 and 8-cylinder engine tool assemblies are drilled to enable the bushes to be secured to the end faces of the crankcase by setbolts, the disposition of the holes on one bush being such that it can be bolted to the front end of the crankcase only, and on the other such that it can be bolted to the rear end of the crankcase only, thus ensuring alignment of the oil holes in the bearings and housings during fitting operations. The flanges of the thrust bushes of the 6-cylinder engine tool assembly are not

drilled for setbolts, as the oil feed to the camshaft bearings on this engine is such that alignment of oil holes is not required.

REMOVAL

If the bearings are being removed during a complete overhaul of the engine, the crankcase will already have been stripped to the bare state as described in Section 15. In this case the front end bearing housing, i.e. the housing in which the camshaft journal is supported in two bearings, must be suitably marked for identification during refitting of the bearings, and the sealing plug must then be removed from the other end housing. If the crankcase is a special service type incorporating a surplus bearing in the rear end housing, the front bearing housing must be suitably marked and the sealing plug removed from the surplus bearing.

If the bearings are to be removed other than during a complete overhaul, remove the camshaft as previously described in this section, and in addition:

Detach the injection pump drive shaft or yoke, as described in Section 13A.

Supercharged vertical engines: Remove the supercharger idler gear.

Horizontal engines: Remove the oil pump (Section 19C), and the small and secondary idler gears (Section 13B).

Remove the dynamo adjuster eye bolt fulcrum bolt from the wheelcase backplate (where applicable).

Remove the wheelcase backplate complete with the auxiliary drive gear.

Remove the flywheel housing from the rear of the crankcase and extract the sealing plug from the rear camshaft bearing housing, or from the surplus bearing if the crankcase is of the special service type.

The removal of the camshaft bearings from their housings is carried out in two operations; in

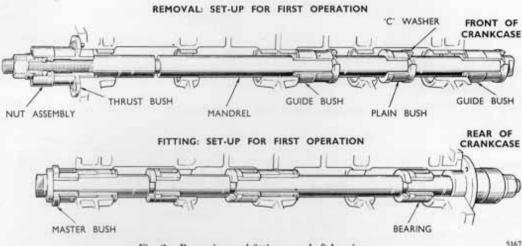


Fig. 2 Removing and fitting camshaft bearings — 4-cylinder engine

the first the bearings are removed from the front, centre and front intermediate housings, and in the second the bearings are removed from the remainder of the housings in the rear half of the crankcase.

Fit the appropriate flanged thrust bush of the special tool incorporating the large spigot diameter to the rear camshaft bearing housing. On 8-cylinder engines use the appropriate thrust bush to suit the rear end of the crankcase, and increase the spigot diameter by using the packing bush. Four and 8-cylinder engines: Secure the thrust bush to the crankcase with four setbolts.

Insert the plain, unthreaded end of the mandrel through the thrust bush and pass it through the rear half camshaft bearings. Place a guide bush on the mandrel immediately after it emerges from the centre bearing, with its short spigot towards the bearing. Place a plain bush on the mandrel after it has passed through each front intermediate bearing, with the large spigot diameter towards each bearing. Place a second guide bush on the mandrel after it has passed through the front bearing, with its short spigot to the bearing. Insert 'C' washers in the mandrel grooves behind each bush, and at the same time locate the guide bushes in the centre and rear bearings.

Screw the nut assembly on to the threaded end of the mandrel, and tighten until the bearings are withdrawn from the crankcase. Remove the tool and extracted bearings. Remove the thrust bush from the rear bearing housing.

Extract the rear bearings in the same manner, but with the mandrel in the reverse end-to-end position, and using the thrust bush with the larger spigot diameter in the front bearing housing. On 8-cylinder engines use the appropriate thrust bush to suit the front end of the crankcase, and increase the spigot diameter by using the packing bush provided.

FITTING

4 and 6-cylinder engines

Ensure that the bearing housings are clean and free from burrs, and that all oilway drillings are clear.

Place a new bearing on each of the plain bushes and the appropriate master bush of the inserting tool. On 4-cylinder engines locate the bearings on the bushes by mating the peg on each bush with the slot in the end of each bearing.

Fit the appropriate thrust bush with the larger spigot diameter to the rear camshaft bearing housing. On 4-cylinder engines secure the bush to the crankcase with setbolts.

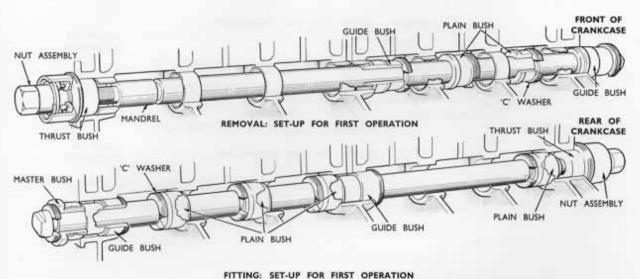


Fig. 3 Removing and fitting camshaft bearings — 6-cylinder engine

5168

Insert the plain, unthreaded end of the mandrel through the thrust bush, and fit a plain bush and bearing assembly to the mandrel as it emerges from the rear bearing housing. Fit a guide bush before it enters the centre housing and a plain bush and bearing assembly as it emerges from the housing. Place a plain bush and bearing assembly on the mandrel as it emerges from each subsequent housing except the front. Before it enters the last (front) bearing housing fit a guide bush to the mandrel, and as it emerges fit a master bush and bearing assembly.

Position the guide bushes in the centre and front bearing housings. Ensure that all bearings are fitted with the chamfer to the bearing housing and insert the 'C' washers in the mandrel slots behind the bushes.

Screw the nut assembly on to the threaded end of the mandrel and continue tightening until the flange of the master bush abuts the crankcase end face, when the bearings will be fully inserted in their housings.

Ease off the nut assembly on the threaded end of the mandrel, remove the 'C' washers, withdraw the mandrel from the crankcase and collect the bushes. Remove the thrust bush from the rear end of the crankcase.

Fit the appropriate thrust bush with the smaller spigot diameter to the front camshaft bearing. On 4-cylinder engines secure the bush to the crankcase with setbolts.

Insert the plain, unthreaded end of the mandrel through the thrust bush and fit a plain bush and bearing assembly as it emerges from the bearing housing. Fit a guide bush to the mandrel before it enters the centre bearing, with its smaller diameter to the bearing. Place a plain bush and bearing assembly on the mandrel as it emerges from the centre and each rear bearing housing except the last. Before the mandrel enters the last bearing, fit a guide bush with the smaller diameter to the bearing; after it has passed through fit the master flanged bush with the larger spigot diameter.

Position the guide bushes in the centre and rear bearings. Ensure that all the bearings are fitted with the chamfer to the bearing housing and insert the 'C' washers in the mandrel slots behind each bush and bearing assembly.

Screw the nut assembly on to the threaded end of the mandrel and continue tightening until the flange of the master bush abuts the crankcase end face, when the bearings will be fully inserted. Ease off the nut assembly on the threaded end of the mandrel, remove the 'C' washers, withdraw the mandrel and collect the bushes. Remove the thrust bush from the front bearing.

On 4-cylinder engines examine each bearing to ensure that its oil hole is accurately lined up with its oil feed drilling in the crankcase web.

Fit a new sealing ring to the rear bearing housing sealing plug and fit the plug in the housing. Ensure that the rear face of the plug does not stand proud of the rear face of the crankcase.

If the engine is not undergoing complete overhaul, reassemble to the engine all parts removed for access, and adjust the tappet clearances as described in Section 5.

8-cylinder engines

Ensure that the bearing housings are clean and free from burrs, and that all oilway drillings are clear.

Place a new bearing on each of the plain bushes and the appropriate master bush of the inserting tool, and locate each bearing on its bush by mating the peg on the bush with the slot in the end of the bearing.

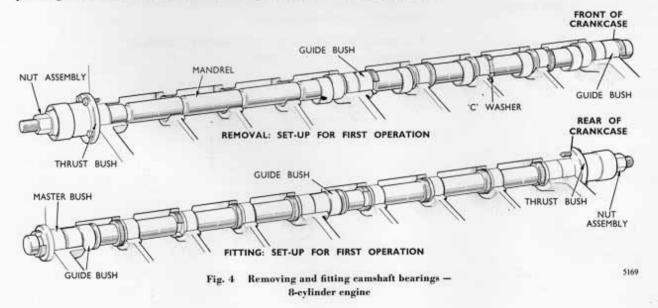
Fit the appropriate flanged thrust bush and packing bush to the rear camshaft bearing housing, and secure the bush to the rear crankcase face with setbolts.

Insert the plain, unthreaded end of the mandrel through the thrust bush, and fit a plain bush and bearing assembly to the mandrel as it emerges from the rear bearing housing and the three rear intermediate housings. Fit a guide bush before it enters the centre housing and a plain bush and bearing assembly as it emerges from the centre housing and the three front intermediate housings. Before it enters the last (front) bearing housing fit a guide bush to the mandrel, and as it emerges fit a master bush and bearing assembly.

Position the guide bushes in the centre and front bearing housings, and insert the 'C' washers in the mandrel slots behind the bushes.

Screw the nut assembly on to the threaded end of the mandrel and continue tightening until the flange of the master bush abuts the front face of the crankcase, when the bearings will be fully inserted in their housings.

Ease off the nut assembly on the threaded end of the mandrel, remove the 'C' washers, withdraw the mandrel from the crankcase and collect the bushes. Remove the thrust bush from the rear bearing housing.



Fit the appropriate thrust bush to the front camshaft bearing and secure the bush to the front face of the crankcase with setbolts.

Insert the plain, unthreaded end of the mandrel through the thrust bush and fit a plain bush and bearing asembly as it emerges from the bearing housing. Fit a guide bush to the mandrel before it enters the centre bearing, with its smaller diameter to the bearing. Place a plain bush and bearing assembly on the mandrel as it emerges from the centre bearing housing. Before it enters the last (rear) bearing fit a guide bush with the smaller diameter to the bearing; after it has passed through fit the master flanged bush with the larger spigot diameter.

Position the guide bushes in the centre and rear bearings and insert 'C' washers in the mandrel slots behind each bush and bearing assembly.

Screw the nut assembly on to the threaded end of the mandrel and continue tightening until the flange of the master bush abuts the crankcase end face, when the bearings will be fully inserted. Ease off the nut assembly on the threaded end of the mandrel, remove the 'C' washers, withdraw the mandrel and collect the bushes. Remove the thrust bush from the front bearing.

Examine each bearing to ensure that its oil hole is accurately lined up with its oil feed drilling in the crankcase web.

Fit a new sealing ring to the rear bearing housing sealing plug and fit the plug in the housing. Ensure that the rear face of the plug does not stand proud of the rear face of the crankcase.

If the engine is not undergoing complete overhaul, reassemble to the engine all parts removed for access, and adjust the tappet clearances as described in Section 5.

SPECIAL TOOLS

** *	WA FWY	21.00
P 4	15.1	NO.
		110

DESCRIPTION

GA.260

Extracting and inserting tool assembly, camshaft bearings - 4-cylinder engine

GA.1/M.1

GA.329

Extracting and inserting tool assembly, camshaft bearings - 6-cylinder engine

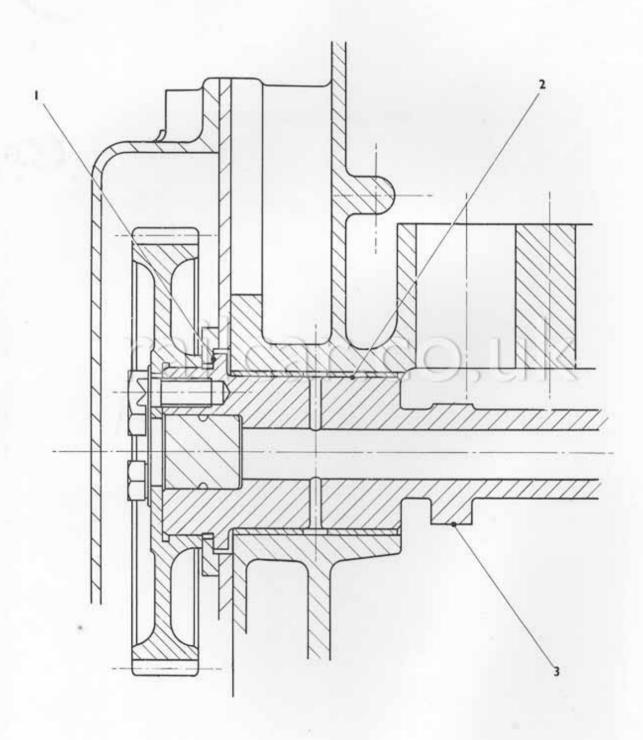
Extracting and inserting tool assembly, camshaft

bearings - 8-cylinder engine

FITS AND CLEARANCES

CAMSHAFT

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No. ON DIAGRAM	DESCRIPTION	DIMENSIONS NEW	CLEARANCE NEW	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
1	CAMSHAFT AND BEARINGS Camshaft end float		0.004 to 0.008		0.016	
2	Camshaft in bearings Bearings – bore Camshaft – dia.	2.4395 to 2.442 2.436 to 2.4365	0.003 to 0.006		0.010	
3	CAMS Cam lift	0.390 max.		0.375 min.		
	paila		7			
	rallca	J	ر د	9:		
						. *

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SECTION 15A . TACHOMETER GENERATOR

Smiths Series M

DESCRIPTION

The Smiths Series 'M' generator is spigot-mounted on the wheelcase of each six and eight-cylinder horizontal railcar engine, and is driven from the wheelcase auxiliary drive gear to provide the operating current for the engine speed indicator which is mounted on the instrument panel in the railcar driving cab.

This generator is of the single phase, variable frequency, A.C. type, in which the stationary windings are carried on a laminated stator surrounding the twelve-pole permanent magnet rotor, which is mounted on the driving shaft. This arrangement eliminates the use of brushes, sliprings and all moving contacts and, in conjunction with grease-packed, heavy, deep-tracked ball bearings, ensures satisfactory functioning over long periods with the minimum of maintenance.

Provision has been made by the manufacturers for the attachment, when required, of an engine service counter to the generator end cover, so that both the generator and the service counter can be driven from the same take-off point on the engine. On engines which do not incorporate this type of service counter mounting, the counter is fitted to the wheelcase as a separate attachment. On eightcylinder railcar engines the counter is mounted on the generator, and both are driven by the auxiliary drive gear. On some early six-cylinder railcar engines the generator is driven by the oil pump and the service counter by the auxiliary drive gear; on others the service counter is driven by the camshaft. On later six-cylinder engines the generator is driven by the auxiliary drive gear, and the service counter, if separately fitted, is driven by the camshaft. The service counter registers one unit for every 90,000 revolutions of the engine crankshaft, which is equivalent to one hour's running of the engine at 1,500 r.p.m.

The engine speed indicating instruments in the driving cabs are of the moving coil type with built-in rectifiers, and are calibrated to suit the particular application. The number of instruments operated from any one generator must therefore never be altered unless suitably calibrated instru-

ments are substituted throughout, otherwise inaccurate indications of engine speeds will result from the alteration of the load on the generator.

MAINTENANCE

The only attention normally required is periodic examination for damage and contamination.

During their initial assembly the bearings of the generator are packed with a suitable grease, and the pivots of the instruments are adequately lubricated; this supply should last for many years of running at moderate ambient temperatures, and no additional lubrication is therefore required in normal service.

Checking the complete equipment

Remove the generator from its mounting on the engine wheelcase and set it up on a variable-speed drive fitted with a time-controlled stroboscope, accurate to within $\pm 0.1\%$. Remove the engine speed indicator instruments from the driving cabs and connect them to the generator so that the loading of the generator during testing is identical to that existing in normal service.

Run the generator at the speed indicated on the instrument label for full scale and check the instrument readings. If the readings are inaccurate, or if they vary between instruments, substitute an instrument of known accuracy, and having the same code, for one of the original instruments, and repeat the test. If the reading on the new instrument is similar to one or both of the original instruments and still records inaccurately, it can be assumed that the fault is in the generator. If a variation exists between the readings of the original instruments, the inaccurate gauge can be detected by comparison of readings with the accurate substitution gauge.

Repair of faulty equipment must only be undertaken by experienced instrument mechanics with the necessary special equipment for accurate mechanical and magnetic adjustment.

Test the wiring to the instruments in the railcar for insulation. This value must exceed 20 megohms at 500 volts D.C.

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SECTION 15B . DOUBLE STARTER PROTECTION UNIT Smiths TRB.5/2

The Smiths double starter protection unit is incorporated to prevent damage to the starter pinion and gear ring by rendering the starter inoperative when the engine has fired. This is achieved by a system of relays energized by the tacho-generator to break the circuit to the starter motor.

Note: Throughout these instructions the complete assembly is referred to as the 'relay unit' and the actual relay, identifiable by the transparent cover, is referred to as the 'calibrated relay'.

Insulation test precautions

The generator, indicator, relay unit and associated equipment must be disconnected when the main insulation test of the railcar wiring is carried out unless a low output tester, such as a 'D.C. Megger' (manufactured by Evershed and Vignoles Ltd.) is used.

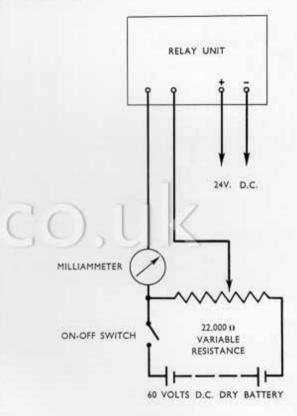
Check the insulation between the cable conductors and to earth at 500 volts D.C. when the insulation resistance must not be less than 20 megohms. Is is advisable to mark terminals in any junction boxes and jumper connections to distinguish the measuring circuit from control circuits and thus avoid accidental damage to the equipment by routine insulation tests using high power testers. The maximum loop resistance between the generator and the relay unit must not exceed 3 ohms.

SERVICE MAINTENANCE

This equipment should require no attention in service other than a weekly check on the correct functioning of the relay unit.

Relay unit test

Disconnect the leads from the relay unit terminals and connect a 60 volt battery, a variable resistance and a milliammeter to the relay unit as shown in the following diagram, also connect a 24 volt D.C. supply to the positive and negative terminals.



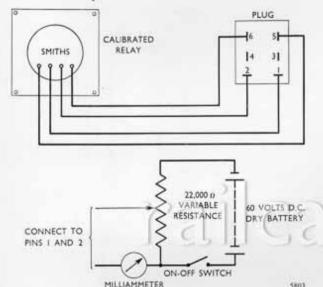
5802

Switch on and increase the voltage until the calibrated relay trips, and note the reading on the milliammeter. It should trip at approximately 10 M.A. It should be noted that this is a D.C. test and does not ensure the accuracy of the unit which normally works from a varying frequency A.C. voltage. Once the relay has operated it is inadvisable to take the current any higher as damage may be caused to the rectifier or condenser. The relay will not be de-energized until the current has fallen by about 50% of the tripping value.

5803

Calibrated relay test

If the functioning of the calibrated relay is suspected, this item can be checked by disconnecting the plug from the socket and connecting the battery and variable resistance to the plug, as shown in the diagram below. When the calibrated relay is fitted with the rectangular type of plug with locking clips, the moving coil leads are connected to pins 1 and 2, and the contacts are connected to pins 5 and 6.



Switch on the battery at the minimum voltage. Increase the voltage by adjusting the variable resistance. The current required to close the contacts (in milliamps) can be obtained from the suffix to the code number on the top plate of the relay, e.g. TRB.622/10 has a setting of 10 M.A.

A faulty calibrated relay can be removed from the mounting board by removing the plug from the socket and turning each of the four screw fasteners a quarter turn to the left. The calibrated relay can then be pulled off the board and a replacement fitted, ensuring that the name 'SMITHS' on the cover is the right way up. Turn the screw fasteners a quarter turn to the right, and connect the plug and socket.

Check the complete equipment as detailed previously.

Defective calibrated relays should be returned to the manufacturers for overhaul or repair. Under no circumstances should the transparent cover be removed while the relay is in position as it contains a powerful magnetic system which is capable of attracting ferrous particles from the surroundings which would seriously impair the correct functioning of the unit.

T.S.D. 803 SEC. 16

SECTION 16 . . TESTING THE ENGINE AFTER REBUILD

Test bed

A suitable test bed layout is shown in fig. 1. The main features are a dynamometer for applying varying loads to the engine, a control panel, and fuel, coolant and electrical services.

Preparing the engine for test

When an engine is received from the assembly shop all pipe ends will be blanked off. The blanks should not be removed until immediately before making each joint. When making a hose connection, remove the new hose and blank from the pipe and fit a slave hose. The new hoses and blanks should be refitted to the engine on completion of the test running.

Remove the clutch, if fitted, from the engine flywheel, and fit in its place a suitable self-aligning coupling to connect the engine to the dynamometer.

Fit the front and rear bearer brackets to the engine facings.

Lift the engine, using the universal slinging beam OR.1466, and lower it into position on the test bed. Some form of anti-vibration mounting is essential; at the least, rubber pads should be interposed between the bearer brackets and the bearers.

Fit the engine air cleaners and connect up the exhaust manifold to the test bed exhaust system. Connect up the dynamometer to the self-aligning coupling.

When all installation connections have been made, carry out a final inspection to ensure that tools and other loose articles have not been left on the engine, and prepare the engine for starting as follows:

If the engine is to be put into immediate use after testing, or if it is to be stored in a vehicle with the cooling system filled, fill the cooling system with a mixture of clean water and recommended inhibitor. If the engine is to be stored with the cooling system empty, fill the system with a mixture of clean water and soluble oil. A list of recommended inhibitors and soluble oils, with proportions, is given in Section 18A and 'Engine Data' respectively.

Fill the lubricating oil system up to the 'MAX' mark on the dipstick. See 'Engine Data' for recommended oil and approximate engine capacities. Remove the oil filter canisters, fill them with clean engine oil, and refit them to the filter header bracket.

C.A.V., fuel injection pump

Remove the filler plug from the side of the pump and pour 4 pint (142 c.c.), 4 pint (189 c.c.) or ½ pint (284 c.c.) of clean engine lubricating oil into the cambox of the 4, 6 or 8-cylinder pump respectively, and refit the plug. Surplus oil will run from the vent pipe or pipes when the cambox is full. If the fuel pump has a mechanical governor, fill the governor casing with clean engine lubricating oil; approximately ¼ pint (142 c.c.) of oil will fill the casing. Early pumps have a level plug at the rear of the governor casing which must be slackened off to prevent over-filling; later pumps have a coiled pipe which automatically drains any surplus oil from the casing.

Simms fuel injection pump (engine oil lubricated)

Disconnect the oil feed pipe at the union on the pump casing, and disconnect and blank off the oil drain at the governor casing. Remove the filler plug from the governor casing and pour in clean engine lubricating oil until it runs from the disconnected feed union on the pump casing. Reconnect the oil feed and drain pipes and the filler plug.

Turn on the fuel supply cock and prime the fuel system by means of the hand priming lever on the fuel lift pump. Open the vent valves on top of the injection pump casing and the fuel filters, and operate the priming lever until the flow of fuel through the vents is continuous and free of bubbles. Open and close the vents several times to ensure that all air is bled from the system. Tighten the vents securely on completion of the operation.

Running-in

Start the engine and allow it to run at set slowrunning. Ensure that a steady oil pressure is registering on the oil pressure gauge, and examine the engine for fuel, lubricating oil and coolant leaks. Stop the engine and top up the oil and coolant systems.

Proceed with a two-hour running-in period as detailed in the following tables:

Engines up to 1,500 r.p.m.

Sauce of the		
R.P.M.	Dynamometer brake load	Duration minutes
1,000	Minimum	10
1,200	Minimum	10
1,400	Minimum	10
1,500	Minimum	15
1,500	50% full load	30
1,500	75% full load	30
1,500	Full load	15

-Engines over 1,500 r.p.m. and up to 1,800 r.p.m.

R.P.M.	Dynamometer brake load	Duration minutes
1,000	Minimum	10
1,200	Minimum	5
1,400	Minimum	10
1,600	Minimum	10
1,800	Minimum	10
1,800	50% full load	30
1,800	75% full load	30
1,800	Full load	15

Engines over 1,800 r.p.m. and up to 2,100 r.p.m.

R.P.M.	Dynamometer brake load	Duration minutes
1,000	Minimum	10
1,200	Minimum	5
1,400	Minimum	5
1,600	Minimum	5
1,800	Minimum	10
2,100	Minimum	10
2,100	50% full load	30
2,100	75% full load	30
2,100	Full load	15

Oil pressure

The minimum acceptable oil pressure at maximum governed r.p.m. and 60 deg.C. (140 deg.F.) oil temperature is as follows:

(140 deg.F.) oil temperatur	e is as follows:
4-cylinder engines 6-cylinder engines Gauge connected to oil	45 p.s.i. (3.2 kg. per sq. cm.)
distributor block on crankcase	
Normally aspirated	45 p.s.i. (3.2 kg. per sq. cm.)
Supercharged and turbocharged	35 p.s.i. (2.5 kg. per sq. cm.)
Gauge connected to filter header bracket	55 p.s.i. (3.9 kg. per sq. cm.)
8-cylinder engines	55 p.s.i (3.9 kg. per sq. cm.)
Fuel pressure The fuel pressure at eng follows:	1 10000

Not less than 10 to 12 p.s.i. (0.703 to 0.843 kg. per

sq. cm.)

Engines fitted with C.A.V. pumps

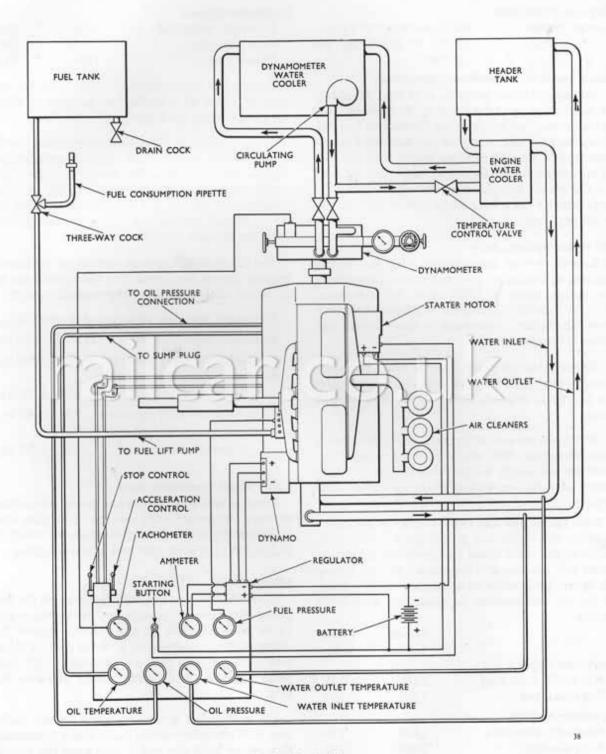


Fig. 1 Test bed layout

Engines fitted with Simms pumps

Not less than 5 to 8 p.s.i. (0.351 to 0.562 kg. per sq. cm.)

Boost pressure (supercharged engines)

Although a boost pressure of at least 14 in. Hg. at maximum governed r.p.m. is desired, this pressure may not be obtained during the first few hours running after a new or reconditioned supercharger has been fitted to an engine. The output of the supercharger improves with running, and for this reason acceptance of the engine should be governed by the power check rather than by the boost pressure.

Oil consumption cheek

Record the oil temperature with the engine running at maximum governed r.p.m., then reduce the engine speed to 1,000 r.p.m. for 2 minutes. Run for a further 2 minutes at idling speed, then stop the engine. Adherence to these speeds and times is important.

Remove the oil drain plug or plugs from the sump, drain the engine oil into clean containers for exactly 15 minutes, then refit the drain plug or plugs.

Weigh the oil and containers, pour the oil back into the engine, then weigh the empty containers. Subtract the empty weight from the gross weight and record the net weight of the oil put into the engine.

Start the engine and run for exactly two hours at either the speed and power given in the table below or the rated speed and power of the engine under test, whichever is the lower. Do not exceed the figures given when testing higher rated engines, as the oil consumption is calculated at B.S.649 ratings.

Speed r.p.m.	Power b.h.p.
1,800	113
1,800	140
1,800	170
1,800	210
1,800	235
	1,800 1,800 1,800 1,800

8-cylinder engines		
Normally aspirated	1,800	225
Supercharged	1,800	280
Turbocharged	1,800	315

Reduce the engine speed to 1,000 r.p.m. for two minutes. Run for a further two minutes at idling speed, then stop the engine.

Weigh the empty clean containers, drain the oil for exactly 15 minutes, then weigh the oil and containers. Subtract the empty weight from the gross weight and record the net weight of the oil. The difference in the two net weights will indicate the oil consumed during the two-hour test period. Pour the oil back into the engine.

The oil consumed by both vertical and horizontal engines during the 2-hour test run should not be in excess of the following approximate figures:

4-cylinder, normally aspirated	1 1 lb. (0.4536 kg.)
4-cylinder, supercharged	1½ 1b. (0.6804 kg.)
6-cylinder, normally aspirated	11 lb. (0.6804 kg.)
6-cylinder, supercharged and turbocharged	21 lb. (1.02 kg.)
8-cylinder, normally aspirated	2 lb. (0.907 kg.)
8-cylinder, supercharged and turbocharged	3 lb. (1.361 kg.)

Valve tappet clearance check

Remove the rocker covers and test the clearances between the rocker pads and the valve stem tips. If necessary, adjust the clearances to 0.010 in. (0.254 mm.) for both inlet and exhaust tappets.

Idling check

Close the rack control until the lever on the fuel pump abuts the idling stop, and check the engine r.p.m. with no load on the brake. Adjust the idling stop as necessary to give the correct injection pump idling r.p.m. as stamped on the data plate attached to the pump. Lock and seal the stop.

On mechanical governors screw in the buffer stop until the slow-running speed starts to increase, then screw back the buffer stop until the engine slows down to normal idling. Lock the buffer stop. Test the slow-running setting by accelerating the engine and shutting down quickly, when the engine should recover and idle steadily. If the engine stops, or the idling speed is too fast, readjust the idling stop on hydraulic governors, or the idling and buffer stops on mechanical governors, until recovery and idling are satisfactory.

Power cheek

Run the engine at 1,000 r.p.m. until normal oil and coolant temperatures are attained.

Open up to full rack, i.e. until the control lever abuts the maximum speed stop, and check the b.h.p. This should be within the minimum and maximum power rating figures for the particular engine under test. If necessary, screw the fuel stop outwards (anti-clockwise) to increase the power or inwards (clockwise) to decrease it.

Alteration of the fuel stop setting may affect the speed of the engine. If, as a result of the last adjustment, a reduction of engine speed becomes necessary, care must be taken not to alter the maximum speed stop to such an extent that governor interference at maximum governed speed occurs. When the maximum speed stop is correctly set the governor should start to operate at approximately 20 r.p.m. above the maximum governed speed at maximum power.

When satisfactory stop settings have been obtained, seal the fuel stop.

Maximum speed check

Open up to full rack with no load on the brake, and check the governor cut-out. The speed must not be greater than the figures given for the particular engine under test.

Power rating, torque, maximum governed speed and specific fuel consumption

Detailed information on the power rating, torque, maximum governed speed and specific fuel consumption for any particular engine or engine series can be obtained from the Service Department, Rolls-Royce Limited, Oil Engine Division, Shrewsbury, England.

Final inspection

Run the engine at approximately 500 r.p.m. and check for fuel, oil and coolant leaks.

Stop the engine, allow it to cool and carry out a physical check on external nuts and setbolts for signs of looseness.

Inhibiting

If the engine is not to be put into use within one month of the test it should be inhibited against corrosion as described in Section 2.

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T.S.D. 803 SEC, 17A

SECTION 17A .. FUEL SYSTEM - C.A.V.

FUEL INJECTION PUMP

The servicing instructions for the C.A.V. fuel pump and governors which are included in this Section should be used for general guidance only. Detailed instructions applicable to the fuel injection pump fitted to any particular engine can be obtained from the Service Department of Rolls-Royce Oil Engine Division.

CORRIGENDA

FUEL PRESSURE

The constant pressure valve is now set to maintain a fuel lift pump delivery pressure of 10 to 12 p.s.i. (0.7 to 0.85 kg. per sq. cm.). Page 1, column 1, paragraph 1, and page 3, column 1, paragraph 2, should be amended accordingly.

INJECTOR HOLDING PLATE

The diameter of the two pins on the fuel injector holding plate illustrated in fig. 21, page 16, should be altered to read 0.300 in. instead of 0.500 in.

INJECTOR SLEEVE TOOLS

The injector sleeve cutter and reamer described on page 20 and illustrated in fig. 27 now carry the following Part No.:

3.6	GA.299
3.2	GA.304
* * *	GA.23
	GA.307
	• •

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SECTION 17A .. FUEL SYSTEM—C.A.V.

Fuel is delivered by the lift pump through three engine mounted filters to the injection pump. A constant pressure valve incorporated in the triple filter assembly maintains an inlet pressure of 15 lb. per sq. in. (1.0546 kg. per sq. cm.) and a pressure gauge connected to the filter outlet serves to indicate the condition of the filter elements and the lift pump.

On the injection side of the system, the fuel injection pump delivers the fuel to the injectors, which control the injection pressure and atomize the fuel delivered to the cylinders. Overflow from the injectors and the constant pressure valve is carried by a spill line back to the fuel supply tank.

FUEL FILTERS

The triple fuel filters are arranged in-line on a common header, which is secured to the engine crankcase by four set-bolts.

At overhaul of the engine, remove the complete assembly from the crankcase so that the fuel passages in the header can be thoroughly washed out. Renew all rubber sealing rings and the filter elements. At the joint between the filter body and the header, the sealing rubber should be fixed in the header with a suitable adhesive such as 'Hermatite' and this must be applied to the bottom of the recess only.

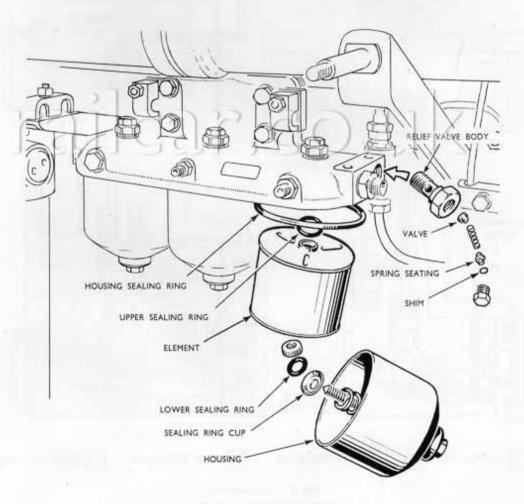


Fig. I. Fuel filter details

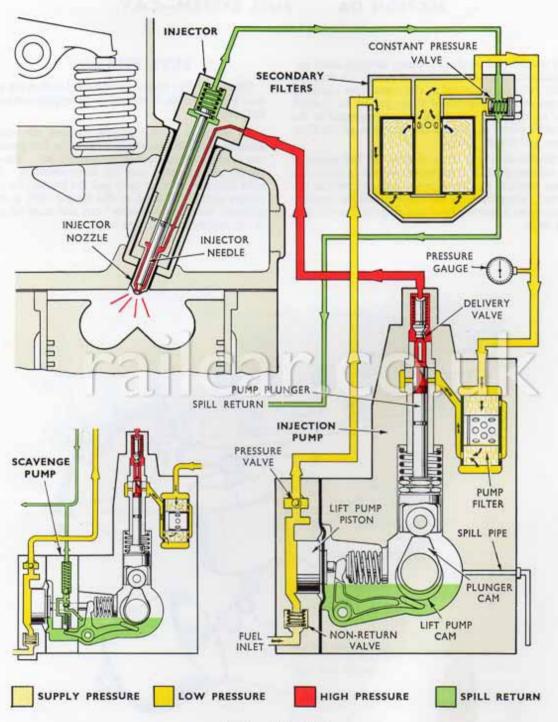
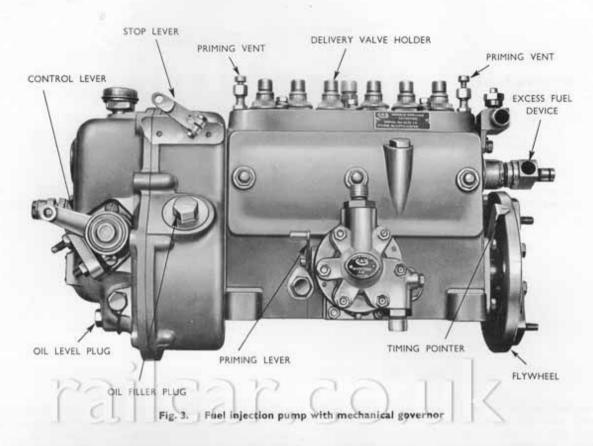


Fig. 2. Fuel system



Unscrew the constant pressure valve from the header, dismantle the unit and examine and clean the parts.

After the filter assembly has been rebuilt, carry out an air under water pressure test at 15 lb. per sq. in. (1.0546 kg. per sq. cm.) and check for leaks. The constant pressure valve should open just above this pressure but will invariably leak at a much lower pressure. The spring loading on the valve can be adjusted by changing the shim behind the spring seat.

FUEL INJECTION PUMP

The C.A.V. injection pump is basically the same for all engines but variations do occur which affect the overhaul procedure. In particular the 'ND' type pump has a different calibration control mechanism from the 'NE' type pump as shown in fig. 10. Other differences are confined to the location of external features for mechanical or hydraulic governor application.

REMOVAL

Turn the engine until the timing mark on the fuel pump flywheel is in line with the pointer on the pump casing and the engine flywheel timing mark INJ.1 is in line with its pointer then remove the two bolts securing the driving shaft flange to the pump flange. Avoid turning the engine until the fuel pump is refitted.

Detach the control rod or rods and tie them up clear of the pump.

Disconnect the injector pipes and the feed and spill pipes from their unions on the pump. Remove the feed pipe between the lift pump and the filters and fit dust caps to all unions.

Remove the air vent and sump drain pipes from their banjo connections on the pump and replace the vent valves to prevent ingress of dirt.

Remove the bolts securing the pump to its platform on the engine, and withdraw the pump.

DISMANTLING

Preliminary information

When dismantling or rebuilding the pump absolute cleanliness is essential. The work bench should be covered with zinc or some other material that can be kept free from dust, and clean paraffin should be available for washing parts as they are removed.

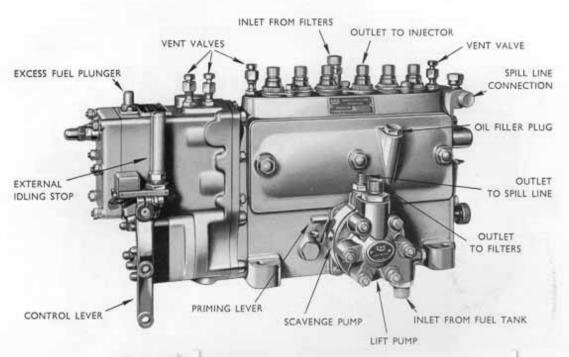


Fig. 4. Fuel injection pump with hydraulic governor

Parts such as the element barrel and plunger, and delivery valve and seating, have been carefully paired together with very fine clearances and must not be interchanged. Furthermore, the parts should be arranged in order so that they can be reassembled in the same position as before. To facilitate this, a tray with six numbered compartments should be available.

Remove the two set-bolts securing the governor guide bush and plate, see fig. 6; it will be necessary to restrict the camshaft at the coupling end, to prevent it from turning, while the bolts are loosened. Remove the swivel pin retaining the link pin to the governor links and withdraw the linkage.

Lift pump

Remove the nuts securing the lift pump to the casing and remove the pump. If a lift and scavenge pump assembly is fitted, unscrew the scavenge pump suction pipe from the joint face of the injection pump. Overhaul instructions for the lift pump are given later in this section.

Governor-mechanical

Remove the two screws securing the control lever assembly to the governor casing and withdraw the assembly. Detach the cap nut at each end of the link swivel pin and push out the pin. The casing cover is now free from the linkage and can be detached after removing the securing screws.

Remove the clevis pin securing the control rod link to the control rod.

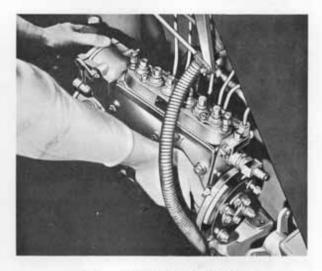


Fig. 5. Removing the fuel pump

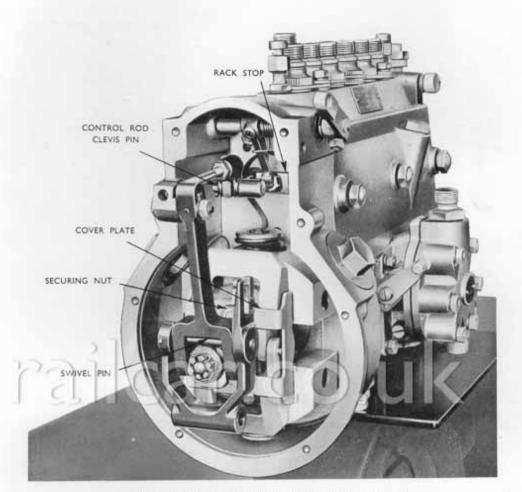


Fig. 6. Disconnection points (mechanical governor)

Remove the slotted nut from the governor end of the camshaft using the key Part No. ET.112, fit the withdrawal tool Part No. ET.008, withdraw the governor assembly from the shaft and remove the key.

Governor-hydraulic

Remove the six nuts securing the governor end cover and detach the cover.

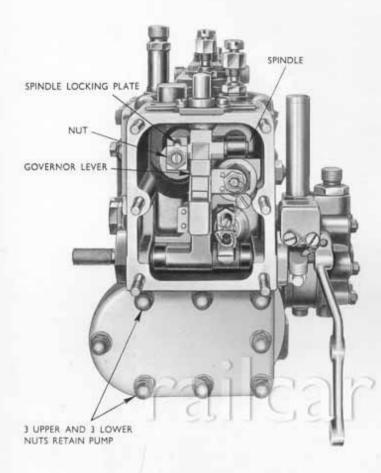
Remove the three top and three bottom domed nuts securing the gear pump to the lower part of the governor casing and withdraw the pump. The two central horizontally opposed nuts should not be removed as they secure together the pump components. Detach the gasket and remove the two hollow dowels.

Remove the nut and locking plate from the spindle block (fig. 7), push the spindle through the block and allow the connecting link to swing clear. Push the spindle in the opposite direction until the governor lever is free to swing clear.

Unscrew the internal retaining nut (fig. 7) using the key spanner Part No. ET.730 and remove the nut. Remove the external retaining nuts, carefully withdraw the governor assembly and lay it on its back so that the operating pistons will not fall out.

Remove the muff coupling from the camshaft using the special spanner Part No. ET.693 and the extractor Part No. ET.695.

Detach the control link from the control rod, first withdrawing the stud in the pump casing adjacent to the link so that the clevis pin can be withdrawn.



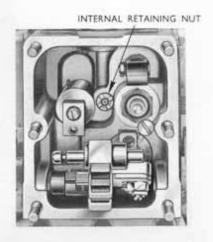


Fig. 7. Disconnection points (hydraulic governor)



Fig. 8. Removing the governor

Camshaft

Remove the inspection cover from the front of the pump.

Turn the camshaft by hand to raise each cam in turn to top dead centre and insert a tappet lifter Part No. ET.648-9 under each spring plate.

Remove the coupling from the camshaft using the extractor Part No. GA.7 and extract the key.

Check and record the end float of the camshaft using the C.A.V. tool Part No. ET.634. Release the bearing end plate at the coupling end of the pump casing and remove the plate by gently tapping the opposite end of the camshaft, keeping the end plate square and avoiding damage to the joint face.

The camshaft can now be withdrawn from the open end of the cambox. Note the position of the notch on the end of the camshaft before withdrawing; this marks the end to end position of the camshaft to give the correct firing order.

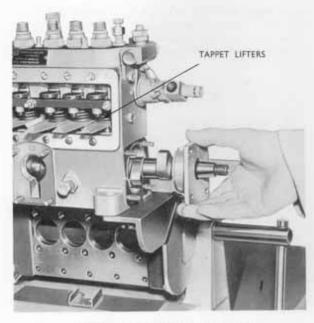


Fig. 9. Removing the camshaft

The inner races of the bearings are pressed on to the shaft and they can be removed with the extractor Part No. ET.026A. The outer race is pressed into the bearing end plate and can be removed with the extractor Part No. ET.026B. The oil seal is a push fit in its location and, if serviceable, should not be removed.

Remove the screws securing the baseplate to the body of the pump and remove the plate.

Pumping assemblies

Release the plates locking the delivery valve holders. Remove each holder in turn, using the serrated box spanner Part No. ET.661. The valve spring, spring guide and delivery valve should be placed in their separate compartments in the tray and the valve seatings added as they are lifted out.

- 'ND' type pumps. Release the calibrating bar by removing the three securing nuts and lift the bar off the studs.
- 'NE' type pumps. The clamping screws locking the control quadrants should not be disturbed unless new parts are to be fitted.

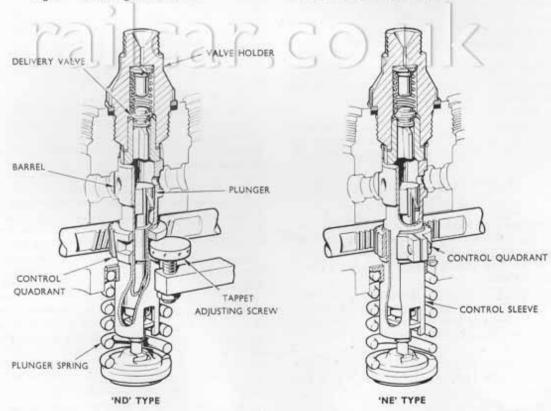


Fig. 10. Pumping assemblies

Slacken off the tappet locating screws sufficient to release the tappets. Force up each tappet in turn with the forceps Part No. ET.428A, withdraw the tappet lifter and allow the tappet to come away slowly under control. The tappet, phasing washer, lower spring plate and the plunger can now be removed. Take particular care to avoid any damage to the plunger. The plunger spring, upper spring plate and the control quadrant should next be removed and the parts of each assembly placed in their compartment in the tray.

Slacken off the barrel locking screws sufficient to release the barrels and push out each barrel from the bottom, using a fibre or copper rod. Immediately each barrel is taken out fit the plunger in the barrel to protect it from damage.

Control rod-mechanical governor

Remove the control rod stop block from the governor end of the pump casing, remove the maximum fuel stop and withdraw the rod endwise.

Control rod-hydraulic governor

Remove the control rod stop from the drive end of the pump and withdraw the rod endwise.

To remove the control rod bushes, unscrew the locking collars using the special key Part No. ET.658; the bushes are a press fit in the pump housing and should be removed with the extractor Part No. ET.668.

Pump filter

Remove the bolts and nuts securing the filter cover to the pump housing and lift off the cover together with the filter packs. Discard the packs.

The fuel gallery closing plugs should not normally be removed but if it is required to rejoint these plugs, the special key Part No. ET.003 should be used for removal and refitting.

INSPECTION

Check the camshaft bearing rollers and tracks for corrosion pitting. Where the pits are deep or tend to form a continuous line across the bearing track, or if they are caused by the break out of slag particles, the bearing should be rejected.

Visually inspect all pumping line details, particularly the delivery valves and seatings and the barrels and plungers. No attempt must be made to correct a faulty plunger or delivery valve; they should be replaced with new parts.

Check the lobes of the camshaft for wear and fit a new shaft if wear is noticeable on the leading edge of the cam lobes.

The end float of the camshaft is adjusted by means of shims located on the shaft behind the bearing inner races. This end float should be maintained at 0·10 to 0·15 mm. (0·004 to 0·006 in.) and if the figure recorded at dismantling is not within these limits, alter the shims to give the correct end float, equalising the shims at each end of the shaft.

ASSEMBLING

The greatest cleanliness must be exercised in every assembly operation. Each part should be thoroughly washed in clean paraffin, and dipped in clean light oil immediately before assembling. Cloth should not be used on working parts.

Pumping assemblies

Secure the pump housing to the assembly base plate Part No. ET.650.

Insert the element barrels from above, check that the slot for the locking screw is in line with the screw hole in the housing and tighten the locking screws; a sealing washer is not required behind the screw heads.

Slide in the control rod and fit the control rod stop. Lay the pump on its back.

'ND' type pumps. Push the control rod to the left until it abuts the stop and place the quadrants on the barrels with their teeth towards the front of the pump. Keeping the control rod hard against the stop, rotate the quadrants in turn in an anti-clockwise direction with a slight upward pressure until they find their mating teeth on the control rod. Check that the full control rod travel can be obtained.

'NE' type pumps. Set the control rod in mid position so that the centre punch marks on each end of the rod are the same distance from each side of the pump housing. Fit the control sleeve assemblies, positioning the quadrants so that the gaps in the clamp jaws are uppermost. If a new sleeve or quadrant has been fitted, position the quadrant so that the gap in the clamp jaws is in line with the marked slot in the sleeve and tighten the clamping screw. After fitting each quadrant, pull the control rod from end to end to ensure that the teeth are meshing correctly, and that full travel can be obtained

Insert the upper spring plate and the plunger spring of each pumping element. Carefully insert the plungers into their respective barrels with the bottom spring plate hooked to each plunger head, and the tappet with the phasing washer held in position on the plate by a smear of grease. Locate the plunger toe in the quadrant slot and push the tappet home with the forceps Part No. ET.428A. With the tappet still pushed home insert the tappet lifters, turn the tappet so that its slot is in line with the locking screw and tighten the screw; a sealing washer is not required behind the screw head.

The marked toe of an element plunger on the 'ND' pump should be uppermost when the control rod is in

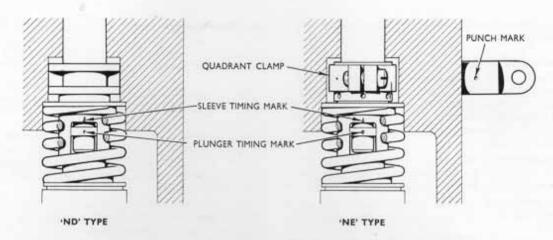


Fig. 11. Element timing marks

mid position, and for a 'NE' pump the marked toe should be in-line with the mark on the control sleeve (fig. 11).

Camshaft

Ascertain the correct end to end position of the camshaft, either by the notched end or by a check of the campositions in relation to the firing order. The cams should rise in the order of 1, 4, 2, 6, 3, 5 from the flywheel to governor end. Fit the shaft and the bearing end plates using the protection cap Part No. ET.684 to prevent damage to the oil seals.

Turn the shaft in the direction of rotation and check for freedom and firing order.

Check the end float; this should be 0-10 to 0-15 mm. (0-004 to 0-006 in.). If necessary, adjust by means of the shims located behind the bearing inner races, equalising the shims at each end.

"ND" type pumps. Fit the calibrating bar and adjust the position of all quadrants so that their peripheral slots engage the disc heads of the calibrating screws.

Remove the tappet lifters and check that the control rod moves freely, at the same time turning the camshaft at least one complete revolution.

Move the pump into an upright position and place a delivery valve and seat on top of an element barrel, with a new steel joint ring above the seat flange. Position the valve spring on the head of the valve, then insert the spring guide in the upper end of the spring. Fit a new low pressure sealing ring into the pump recess followed by a steel slip washer above the ring and screw the holder into place, taking care that the valve spring and guide are not displaced.

Repeat for each delivery valve and tighten the holders to a torque loading of 34 to 37 lb. ft. (4.7 to 5.1 kg.-m.). Check the control rod for freedom and travel and, if satisfactory, refit the baseplate. On pumps with a mechanical governor, refit the maximum fuel stop.

Pump filter

Fit new filter pads to their support spigots and place these in position on the filter cover. Place the perforated plate in the filter recess with the perforations at the bottom and a gasket interposed between the plate and the face of the recess. Check the cover gasket for serviceability, renew if necessary and fit the cover assembly, ensuring that the filter pads are located on their spigots as the cover is placed in position.

Lift pump

Fit the lift pump using a new jointing washer. If the assembly has a scavenge pump, first fit the suction pipe and ensure that the adapter is screwed fully home and is not proud of the joint face. It is most important that the correct jointing washer is used with the lift and scavenge pump assembly otherwise the suction hole will be blanked off.

Governor-mechanical

Fit the key to the governor end of the camshaft and assemble the governor on the shaft with a spring washer behind the securing nut. Tighten the nut to a torque loading of 40 lb. ft. (5.53 kg.-m.).

Offer the linkage up to the governor with the guide bush and cover plate placed on the link pin. Insert the link pin in the governor centre piece and fit the swivel pin through the holes in the governor links and the link pin. Secure the guide bush and cover plate with two set-bolts, using new tab washers to lock the bolts.

Connect the control rod link to the control rod and fit a new split-pin. Secure the cover to the governor casing and fit the link swivel pin and the control lever assembly.

Governor-hydraulic

Fit the key to the governor end of the camshaft and assemble the muff coupling on the shaft, with a spring washer behind the securing nut, and tighten the nut to a torque loading of 40 lb. ft. (5.53 kg.-m.). Fit the ring dowel over the muff coupling and into the counter bore in the sandwich plate.

Couple the connecting link to the control rod with the head of the clevis pin on the inside, and fit the split-pin. Refit the stud for the internal governor retaining nut.

Fit the governor using a new jointing washer and use the key spanner Part No. ET.730 for tightening the internal nut.

Connect the control rod link to the governor lever and fit the tab washer and nut to lock the spindle.

Fit the pump and the governor end cover with new jointing washers between the mating faces. Ensure that the gear pump dog is correctly engaged with the loose coupling before tightening the securing nuts.

PUMP ADJUSTING

To ensure regular and accurate metering and injection of the fuel the setting of the pump elements must be done with care and precision. The adjustments consist of two operations, phasing and calibration. Phasing ensures that the injections occur at equal angular intervals of camshaft rotation, and calibration ensures that the amount of fuel injected into each cylinder will be equal.

Phasing

Mount the pump on a test machine which has a suitable angular scale of degrees marked on the driving member. A suitable machine manufactured by L. Hartridge & Co., Buckingham, is illustrated in fig. 12.

Couple the pump to a fuel oil supply with a head of about 2 feet and vent all air from the pump.

Shut off the oil supply.

Move the control lever to bring the control rod to mid position and secure the lever.

Remove No. 1 delivery valve holder and delivery valve complete.

With the plunger at the top of its stroke, check the amount the top face of the plunger is below the element barrel. This head clearance should be 0.50 mm. (0.02 in.) and can be measured with the clearance gauge Part No. ET.715 or a dial gauge.

If the gauge ET.715 is used, screw it into the position normally occupied by No. 1 delivery valve and holder until it is hard on the face of the element barrel. With the centre pin of the gauge resting on the top face of the plunger, adjust, by means of phasing shims, so that the small cross pin is level with the centre land on the top of the gauge body. The top and bottom lands on the gauge are intended as a guide and represent plunger head clearances of 0.35 mm. and 0.65 mm. (0.013 to 0.025 in.) respectively.

Phasing washers are supplied in thicknesses from 0.7 mm. to 1.4 mm. (0.027 to 0.055 in.), in steps of 0.1 mm. (0.004 in.). To change the washer, turn the camshaft to top dead centre (T.D.C.). Insert the tappet lifter and rotate the camshaft 180 deg., then with the extractor Part No. ET.712 press in the spring catch through the small hole in the tappet to release the bottom spring plate from the tappet.

The washer can now be lifted from the tappet recess with the hook Part No. ET.654 and the new washer guided into place with the same tool.

Having changed the washer, turn the camshaft back slowly towards T.D.C. until the top of the tappet touches the spring catch. Press in the catch and at the same time turn the camshaft to T.D.C., when the spring catch should click into the hole in the tappet. Remove the tappet lifter.

Replace the delivery valve seat, joint rings and holder, leaving out the valve, spring and spring guide. Fit a

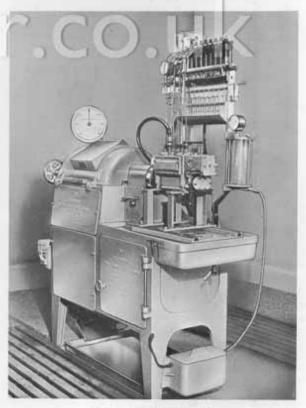


Fig. 12. Typical test rig

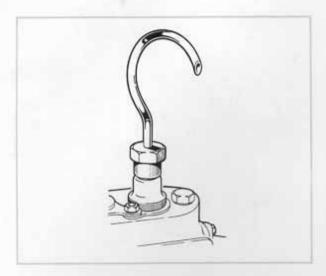


Fig. 13. Fuel spill pipe

spill pipe to the valve holder as illustrated in fig. 13 and turn on the oil.

Turn the pump by hand in the direction of rotation until No. 1 plunger is starting to lift and fuel flows from the spill pipe; as the plunger closes the barrel ports, the flow of fuel will gradually diminish. Turn the pump slowly in the final stages until fuel ceases to flow from the pipe and note the angular reading on the scale. This is the point of spill cut-off. Turn off the oil supply.

Wash the delivery valve, spring and spring guide in paraffin and replace them. The camshaft is now set at the point on No. 1 to which all adjustments are correlated and the remaining elements must be set as follows. For each element in turn remove the delivery valve, spring and spring guide, fit the spill pipe and turn on the oil supply.

Check the angular reading of the spill cut-off and adjust this point by changing the phasing washer to the correct relationship with No. 1, i.e. 60 deg. advance in the order 4, 2, 6, 3, 5. All elements should be within 0.5 deg. overall error.

The cam rate at spill cut-off point is approximately 0.22 mm. (0.009 in.) per degree. Thus 0.1 mm. (0.004 in.) change in washer thickness will move the spill point by just less than 0.5 degree pump shaft angle.

Remove each delivery valve holder and seat in turn and check the plunger head clearances as previously described. These readings must all be 0.5 ± 0.15 mm. $(0.020\pm.006\,\text{in.})$. Replace the delivery valve assemblies after ensuring that they are perfectly clean. Tighten the holders to a torque loading of 40 lb. ft. (5.53 kg.-m.) and fit the holder locking plates and dust caps.

Calibration

The instructions for calibration given in the following paragraphs cover the procedure to be adopted for all pumps. Speeds and fuelling will vary according to the power rating of the engine and reference should be made to the relevant schedule at the end of this section, which tabulates the speed and fuel delivery settings for each engine series.

Mount the pump on the test rig and couple the suction and delivery pipes to the lift pump. Remove the dust caps from the main feed connection and the delivery holders and connect their respective pipes.

If the pump has a mechanical governor, remove the oil filler plug from the governor casing, slacken off the

GOVR	SERIAL	PE NL 4	1987 1487 Chanice			1.0	MAX.	UEL A	5-6 CC M-5 CC 186 R.P.M. 225 R.P.M. 460 R.P.M. UT 1.100 R.P.M.		
PUMP R P M	-11	2	3	4	5	6	7	8	RACK	REMARKS	
600	4.1	14.0	140	d. a	14-0	the fe			Maximum		
3ee	13-1	13-2	13-3	13-+	15-5	13-4					
900	14-4	14.0	tle le	14.5	ile#	14.5					
920	A-te	pla-8	4.1	sir 5	14.2	14.3					
940	15- 2	101	15.2	13 0	13.0	15-1					
180	3.4	3.6	3.5	5.7	3.6	3-6			Minimum	Jolling Check Excess Fuel Check	
lore	14.5								Maximum	Excess Fool Check	
1,100	the s										

Fig. 14. Typical test card

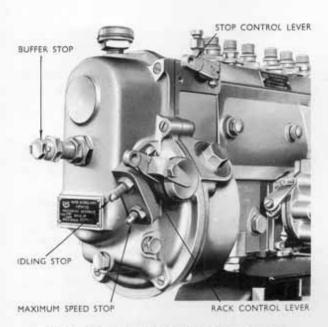


Fig. 15. Control points (mechanical governor)

level plug, and pour 1 pint (142 cc.) of clean engine oil into the casing.

Remove the pump inspection cover, and lubricate the exposed parts of the pumping elements, also pour 1 pint clean engine oil into the pump sump.

If the pump is 'ND' type and new parts have been fitted, adjust all calibrating screws to approximately the middle of their adjustment range.

Partly unscrew the maximum fuel stop.

Check the level of fuel in the tank, turn on the fuel and prime the filter and the pump.

Fuel setting

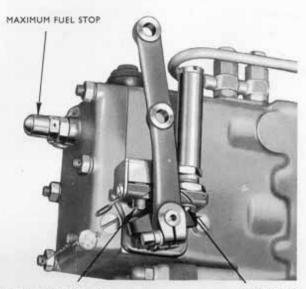
Start the rig, run at 300 r.p.m. and vent the system, then open up to the speed given in the appropriate schedule with full rack. Check the delivery and adjust the maximum fuel stop to give an average of the delivery figure quoted in the schedule. On the Hartridge rig the delivery will be for 100 injections e.g., the pump for the 101 Series engine should be set to deliver between 14.5 and 14.7 cc. and corresponds to the schedule figure of 145 to 147 cu. mm. per injection.

Screw the fuel stop in (clockwise) to decrease the fuel and out to increase it.

Balance the output of the elements by means of the calibrating screws or quadrant sleeves, according to whether the pump is 'ND' or 'NE' type.

' ND ' Pump with mechanical governor.

Slacken the lock-nut and with the tommy bar ET.712 turn the calibrating screw clockwise to



MAXIMUM SPEED STOP

DLING STOP

Fig. 16. Control points (hydraulic governor)

increase the amount of fuel or anti-clockwise to decrease it.

NE' Pump with mechanical governor

Slacken the control quadrant clamping screw and turn the control sleeve anti-clockwise to increase the amount of fuel or clockwise to decrease it.

' ND' or ' NE' Pumps with hydraulic governor

Turn the calibrating screw or control sleeve in the opposite direction to that given for the pumps with a mechanical governor to obtain the same result. The reason for this is that the rack of a hydraulically governed pump moves in the opposite direction to that of the mechanically governed pump.

Take and record delivery readings at the fuel check speeds given in the schedule.

Maximum speed setting

When a balanced delivery for all elements has been achieved slowly increase the pump speed to the 1st maximum speed r.p.m. given in the relevant schedule and set the maximum speed stop. The fuel quantities should show a slight increase over the previous maximum fuel check. At the 2nd r.p.m. fuelling should have decreased, indicating that the governor is commencing to cut the fuel. If necessary, adjust the maximum speed stop to give these conditions, and when satisfactory increase the pump speed to the maximum 'run-out' r.p.m. at which injection should cease.

Idling

To set idling, release the control level to its idling position, screw out the idling stop and, if the pump has a mechanical governor, remove the buffer stop. Run the pump at 225 r.p.m. and adjust the idling stop so that fuel commences to drip from the nozzle pipes.

Lower the r.p.m. to 180, check the delivery at this speed and if necessary re-adjust the stop to give a delivery of 3.6 to 4.0 cc. Screw in the stop (clockwise) to increase the fuel delivery and out to decrease it. A small amount of idling stop movement will considerably alter the fuel delivery.

Increase the pump speed to 300 r.p.m.; the governor should then cut off the injection of fuel. Slowly decrease the r.p.m. until the pump again commences to deliver fuel; this should occur at approximately 220 r.p.m. and at 180 r.p.m. there should be full delivery, i.e. 3-6 to 4-0 cc.

Refit the buffer stop.

Excess fuel device check

Press in the excess fuel plunger and secure the control lever at full rack position.

Run the pump at 100 r.p.m. and check the delivery. This should be approximately 5 cc. more than the maximum fuel figure. Increase the pump speed to 1,100

r.p.m. to trip the excess fuel device and check that fuel is now being delivered at the maximum fuel figure; this ensures that the control rod has moved to the normal full rack position.

Stop control check

With the pump running at 100 r.p.m., operate the stop control, and check that the pump ceases to deliver fuel.

Internal foul check

Run the pump at 1,400 r.p.m. and check that no internal foul occurs.

On completion of the test, remove the pump from the rig and immediately blank all connections with the approved dust caps.

REFITTING

Refitting the pump to the engine is the reverse of removal.

Couple the driving shaft to the pump coupling with the timing mark on the pump flywheel in line with the pointer and check that the INJ.1 marking on the engine flywheel is directly in line with the pointer on the flywheel housing. Before finally tightening the coupling bolts, turn the crankshaft backwards a little and then bring it



Fig. 17. Timing marks

forward again to take up the backlash in the timing gears and recheck the timing.

The injector pipes should be washed through with paraffin before they are fitted. The dust caps should not be removed from the pump connections until immediately before the pipes are fitted.

FUEL LIFT PUMP

The fuel lift pump is of the piston type and incorporates a hand operating lever for the purpose of priming the fuel system. The diaphragms incorporated in the pump assembly prevent fuel oil leaking back into the injection pump.

Where an open fuel drain from the injection pump is prohibited due to fire risk, the lift pump assembly incorporates a scavenge pump which discharges any surplus fuel oil into the spill line.

DISMANTLING

Remove the nuts securing the cover assembly to the pump body and withdraw the cover.

Cover assembly

Unscrew the delivery valve body from the top of the cover and collect the ball valve. The valve seat should only be removed if a new seat is to be fitted.

Unscrew the suction valve body and remove the valve disc and spring.

Body assembly

Remove the priming and operating lever assemblies and withdraw the piston and diaphragms, taking care not to damage the diaphragms as they are withdrawn from the studs. Withdraw the scavenge pump (if fitted).

Scavenge pump

Unscrew the pipe union from the top of the pump body and extract the delivery valve spring and ball valve. Remove the suction ball valve locking screw and extract the ball from the delivery valve drilling.

Remove the plug from the bottom of the body and extract the suction plunger, plunger return spring and spring seating disc.

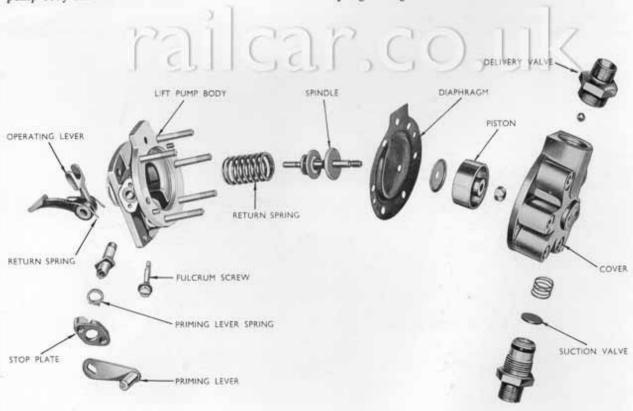


Fig. 18. Exploded view of lift pump (without scavenge pump)

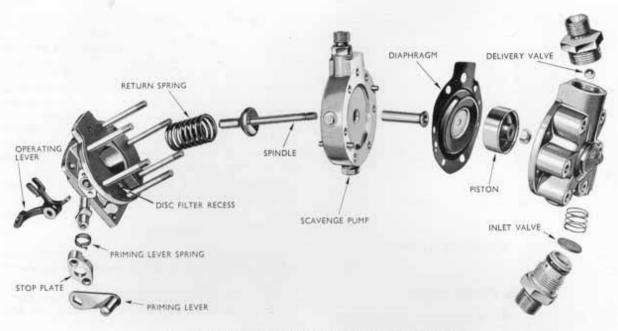


Fig. 19. Exploded view of lift pump (with scavenge pump)

GNSPECTION

Visually inspect the diaphragms for any break or puncture. A report of excessive spill from the injection pump drain indicates a puncture of the diaphragms.

Check the delivery ball valve and the suction disc valve for pitting. Examine the seatings for indentations and renew any faulty parts.

Check the scavenge pump suction pipe bore for obstruction. If necessary, renew the rubber extension tube and clean out the bore of the adapter.

Due to a high delivery pressure the 'Tufnol' pad on the operating lever has been found to wear badly and a new lever with a steel pad has been introduced. If the pump has not already been modified in this respect, the new lever should be fitted.

ASSEMBLING

Refit all parts in the order illustrated, with special attention to cleanliness. If the assembly incorporates a scavenge pump, ensure that the small disc filter is in position in the flange face of the body and fit a new joint washer between the mating faces.

When assembled, check the operation of the piston with the priming lever.

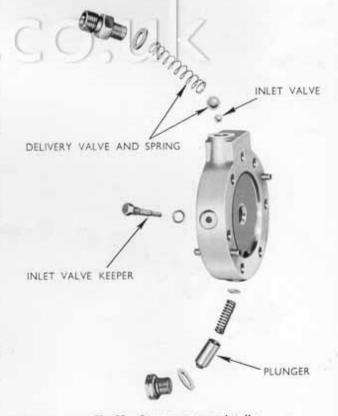


Fig. 20. Scavenge pump details

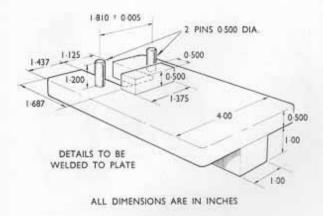


Fig. 21. Injector holding plate

FUEL INJECTORS

The fuel injector consists of a nozzle of the 'closed' type and a nozzle holder.

The nozzle has two parts, the nozzle valve and nozzle body which are paired to form a replaceable unit. The valve is accurately lapped into the upper bore of the body to the closest fit within which it will work freely. The lower end of the valve is reduced in diameter to form the valve face.

The nozzle holder incorporates a spring loaded spindle to hold the valve on its seat and a compression screw for adjustment of the spring loading. The lower end face of the holder forms a face-to-face joint with the nozzle body.

REMOVAL

Before removing an injector, the area of the cylinder head in the vicinity of the injector sleeve must be cleaned very carefully with a brush dipped in paraffin.

Disconnect the fuel delivery pipe and the spill pipe at their connections on the injector and remove the two flange nuts; the injector can then be withdrawn from the cylinder head. Due to carbon build up it may be necessary to prise the injector out and in such cases a small lever should be used under the injector flange, at the same time tapping the flange with a hide mallet.

Immediately after removing an injector fit dust caps to the inlet and spill connections and the nozzle tip.

DISMANTLING

Support the injector in a holding plate with the nozzle pointing downwards. A suitable holding plate is shown in fig. 21.

Unscrew the end cap nut, the adjusting screw locknut and the adjusting screw, then remove the spring and nozzle valve spindle.

Reverse the nozzle holder, unscrew the nozzle cap nut and extract the nozzle.

INSPECTION AND CLEANING

All tools quoted in the following instructions refer to the C.A.V. cleaning outfit Part No. ET.141.

Examine the nozzle for carbon deposit and check that the valve is free in the bore of the nozzle. Immerse the unit in petrol and allow it to soak to assist cleaning. The nozzle valve must always be mated to its original nozzle

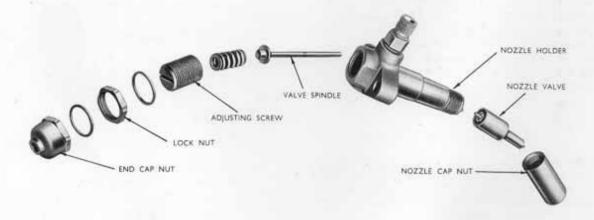


Fig. 22. Exploded view of injector

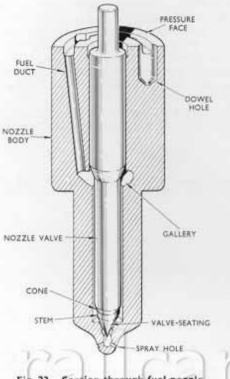


Fig. 23. Section through fuel nozzle

and for this reason it is recommended that injectors should be dismantled one at a time.

Examine the nozzle valve face for scratches and discoloration. If the valve face is 'blued' due to overheating, both nozzle body and valve must be rejected and a new nozzle fitted.

Clean the nozzle body with the brass wire brush Part No. ET.068 and free all residue from the oil channel and oilways.

Scrape all carbon from the valve seating with the soft brass scraper Part No. ET.070 and, using the body groove scraper Part No. ET.071, remove any carbon from the gallery shown in fig. 23.

Prick out the spray holes with a wire needle held in the probing tool part No. ET.120, making sure that the end of the needle which has been ground to a 'D' shape is used.

Examine the pressure surfaces shown in fig. 23. They must be without scratches or dull patches and absolutely clean, as they form a high pressure joint between the holder and the nozzle.

Assemble the nozzle body into the flushing tool Part No. ET.137 and attach it to the nozzle setting rig Part No. ET.122 PA. Flush through in the reverse way to normal flow, with the joint face of the nozzle body facing downwards to avoid dirt or carbon being pocketed in the body recesses.

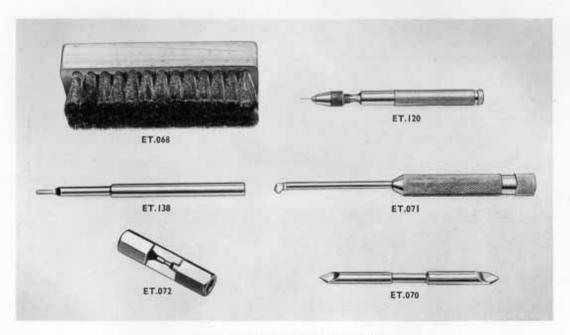


Fig. 24. C.A.V. cleaning outfit ET.141

Brush the valve face and stem of the nozzle valve with the brass wire brush as shown in fig. 26, wash in clean paraffin and insert the valve in the body immediately after flushing it through.

Remove the nozzle from the flushing tool.

Thoroughly wash all parts of the nozzle holder.

ASSEMBLING

Mount the nozzle on the holder pressure face, ensuring that the joint faces are clean and the dowels engaged. Screw on the cap nut and tighten it firmly but not excessively. Assemble the nozzle valve spindle, spring and adjusting screw in the nozzle holder, in the order shown in fig. 22. The shim and the spring should be inserted in the bore of the adjusting screw before fitting the screw, and a joint washer placed on each side of the lock-nut. Screw in the adjusting screw to approximately the same position it occupied before dismantling, but do not tighten the the lock-nut or the end cap at this stage.

If the injector is not to be tested immediately, fit dust caps to the fuel inlet and spill connections and the nozzle.

TESTING THE NOZZLE

For testing and setting a small number of injectors the hand machine Part No. ET.122 PA manufactured by

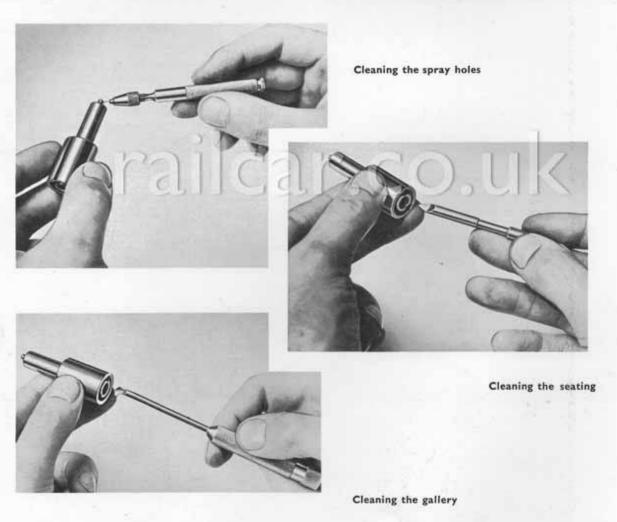


Fig. 25. Cleaning the nozzle

C.A.V. is satisfactory. If a large quantity of injectors is to be dealt with, a motorised tester such as the STANDARD NOZZLE TESTER manufactured by L. Hartridge Ltd., is recommended. The following instructions refer to the hand machine.

Fit the injector to the testing machine and remove the end cap.

With the gauge check valve closed, smoothly operate the hand lever several times to expel all air from the system.

Back leakage check

Open the pressure gauge check valve and pump up a pressure of 160 to 165 atmospheres, if necessary adjusting the tension on the valve spring to prevent the valve opening. Allow the pressure to fall naturally and check the time taken for the pressure to fall from 150 to 100 atmospheres; this must not be less than six seconds.

A more rapid drop indicates leakage between the lapped portion of the valve and body and, assuming all connections are tight, renders the nozzle unfit for use.

When carrying out this test observe that no leakage occurs between the holder and the nozzle cap nut. Leakage at this point indicates a faulty joint between the pressure faces of the nozzle holder and the nozzle body and may be due to dirt between the faces or a loose cap nut. The cap nut must not be overtightened in an effort to cure the leakage, as overtightening will distort the nozzle.

Pressure setting

Slowly move the hand lever downwards and carefully watch the pressure gauge for the highest recorded pressure before the needle 'flicks,' indicating the opening of the valve. Set this pressure to 175 atmospheres by turning the adjusting screw clockwise to increase the pressure or vice versa to decrease the pressure. When satisfactory, tighten the locknut, refit the end cap and recheck the pressure.

Wipe the nozzle tip dry, build up the pressure to 165 atmospheres and hold, it for 10 seconds. Carefully examine the nozzle for any seepage of fuel from the spray holes; the tip must be perfectly dry at this pressure. Close the gauge check valve and operate the hand lever smartly at about 1½ strokes per second for a total of 15 to 20 strokes, then examine the nozzle tip. The tip must be perfectly dry and there must be no tendency for blobs of fuel to collect or drip.

Atomization check

With the gauge check valve closed, operate the hand lever smartly at about 1½ strokes per second and observe that there are four equal sprays fully atomized without any visible core or jets of unvaporized fuel.

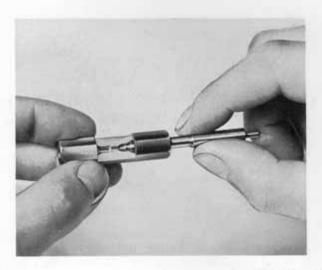
WARNING: DO NOT allow the hand to contact the spray as the pressure will cause fuel oil to penetrate the skin.

Jets without spray indicate a sticking nozzle valve or dirt under the valve seat.

On completion of the lest, remove the injector from the rig and immediately fit all dust covers.

REFITTING

Before refitting an injector, examine the copper sleeve in the cylinder head for carbon deposit and check the seating at the bottom of the sleeve for signs of ' blowing.'



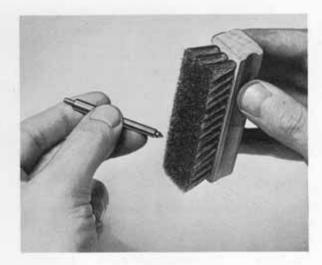


Fig. 26. Cleaning the nozzle valve



Fig. 27. Reconditioning injector sleeve

A reamer Part No. GA.22 is provided for cleaning up the small bore of the sleeve and a cutter Part No. GA.23 for refacing the injector seating. The amount of metal which can be removed from the seating is limited and great care should be taken to remove only sufficient to provide a true seating. The depth of the seating, measured from the face of the cylinder head, must not be more tnan 3.54 in. (90 mm.) after refacing.

If the injector sleeve is being reconditioned without removing the cylinder head from the engine the reamer and cutter should be liberally smeared with grease to prevent any cuttings falling into the cylinder.

Place the injector in the sleeve in the cylinder head (a joint washer is not required) and tighten the securing nuts evenly, half-a-turn at a time using the special short spanner Part No. OE.3311, until the injector is firmly secured. It is most important to use this spanner as overtightening of the nuts will cause damage to the cylinder head. The torque loading of the nuts must not exceed 8·5 lb. ft. (1·175 kg.-m.).

Connect the fuel delivery pipe and the spill pipe to the injector, with a copper jointing washer each side of the spill pipe banjo.

MECHANICAL GOVERNOR Type LVW (A) 3M

The principle of this governor is that any speed between idling and maximum can be pre-set by means of an operating lever and automatically maintained by a flyweight governing device,

The governor maintains any pre-set speed irrespective of load by regulating the quantity of fuel delivered by the injection pump. Its fundamental characteristic is the subdividing of the governing device into the actual governor with flyweights and linkage, and an operating lever with a equalizing spring as a selective medium for any desired speed.

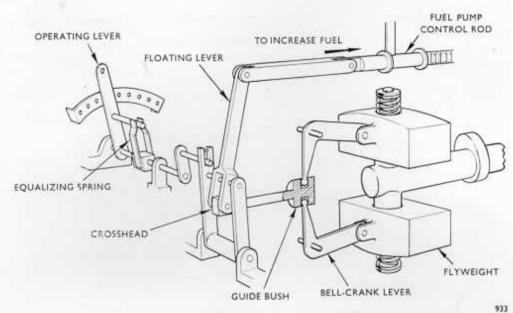


Fig. 28. Schematic arrangement of mechanical governor

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CONSTRUCTION

The governor comprises two spring-loaded flyweights operating on a fixing sleeve which is mounted as an extension to the injection pump camshaft. Bell-crank levers connected to each flyweight and pivoted on the fixing sleeve, engage with a link pin which is supported at one end in a guide bush secured to the fixing sleeve. A crosshead attached to the other end of the link pin is engaged by one end of a floating lever which pivots just above the crosshead on a cross-pin; a link connects the other end of the floating lever with the injection pump control rod. The cross-pin is pivoted between two arms of a saddle lever the axis of which is a cross-shaft secured in the base of the governor casing. One arm of the saddle lever is slotted, and a crankpin on the operating shaft lever engages in the slot. The operating lever is spring coupled to the operating shaft on the outside of the governor casing.

The flyweights are formed with a centre cavity to house the governor springs and with two opposed extensions to accommodate the actuating pins of the bell-crank levers. Two springs assembled concentrically in each flyweight cavity, retain the flyweights on a pillar. The springs are secured, under pressure, at the outer end of the pillar by a spring plate and adjusting nut. At the other end, the outer spring bears on a friction washer at the bottom of the flyweight cavity, but the inner spring bears on a spring plate which butts against a shoulder on the spring pillar. A locking device secures the adjusting nuts at each half-turn of the nuts.

DISMANTLING

Governor housing

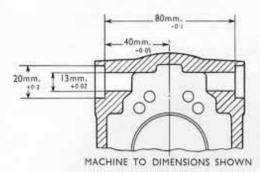
Remove the four screws and the two nuts securing the governor housing to the injection pump and detach the housing. An 'inertia' type screwdriver will be required to slacken the screws.

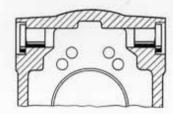
Governor

Unscrew the spring adjusting nut and withdraw the outer spring plate, springs and inner spring plate from each weight cavity. The small locking spring and locating washer will be withdrawn with the inner plate.

INSPECTION

Wash all parts in clean paraffin and examine the links, link pins, crosshead and crosshead bearing for wear. Check for wear on the faces of the spring plates and 934





FIT BUSHES OD. 3694 AND REAM 8mm. +0015 DIA.

Fig. 29 Reconditioning stop control

friction washers. Renew all parts that are worn excessively.

Examine the governor springs for squareness of the spring ends and check that the coils are not worn.

If a letter 'A' is not included in the type symbol on the governor name plate, phosphor bronze bearings are not fitted for the stop control shaft, and the holes in the casing will most likely be worn. In these circumstances, the casing should be machined to the dimensions shown in fig. 29 and bushes OD.3694 fitted. Ream the bushes in line to 8 mm. diameter and when reassembling the stop shaft in the casing fit 'Gaco' oil seals OD.3532. The washers and clips removed at dismantling can be used again for retaining the seals. Stamp a letter 'A' over the existing symbol on the governor name plate to indicate that the modification has been embodied.

Check for wear in the control lever assembly by rotating the lever whilst restricting the crankpin on the other end of the shaft. If lost motion is found to be present, a new assembly should be fitted.

ASSEMBLING

Governor element

Place the friction washer and inner spring plate over the pillar in one of the flyweight recesses, with the longer boss outermost, then fit the small abutment washer and nut tension spring over the smaller diameter of the pillar. Place the inner and outer governor springs in position, fit the outer spring plate and screw on the adjusting nut. Repeat for the other flyweight.

As a temporary setting for the adjusting nuts, screw them on until the outer faces of the nuts are flush with the ends of the pillars. The nuts must be in identical positions on their pillars to give the same spring tension on each flyweight.

Governor linkage and housing

Refit the governor housing to the injection pump using a new joint packing and ensure that the packing is correctly positioned. Use an 'inertia' type screwdriver for tightening the screws, and lock the screws by peening the casing metal into the screwdriver slots.

Replace any clevis pins removed from the linkage and fit new split-pins.

Refit the governor element and the linkage to the pump as detailed under 'Injection Pump.'

ADJUSTMENT

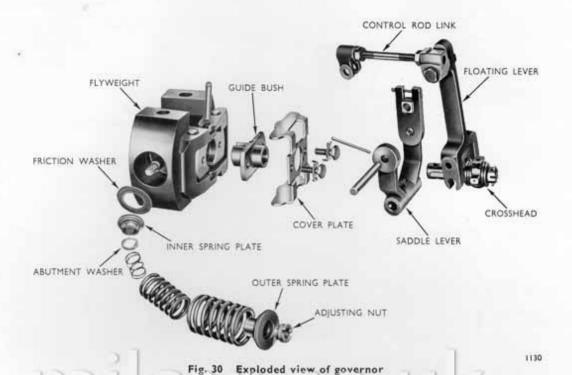
Governor link assembly

Under normal circumstances the governor link assembly, connecting the floating lever to the fuel injection pump control rod, should not be dismantled, but if a new floating lever or element is fitted, re-adjustment of the link will be necessary and should be carried out in the following manner:—

Detach the screwed rod from the floating lever and the end link, remove and discard the nut locking plates and reassemble with new plates.

Adjust the length to 76 mm. between centres, fig. 31, but do not lock the nuts at this stage.

Fit the governor cover and the control lever assembly. Detach the excess fuel device from the other end of the pump, to expose the end of the control rod. Set the control lever by adjustment of the idling stop screw so that the centre of the pick-up hole in the lever is 93 mm. above the base of the pump. This corresponds to a control lever position of 18 degrees above the horizontal.



Remove the buffer stop, then press the control rod into the stop position and measure the travel. This must be between 9.5 and 10.5 mm. and if necessary corrected by further adjustment of the control rod link. When a satisfactory adjustment has been established bend the lockwasher tabs over the control link locknuts and refit the excess fuel device. Refit the buffer stop; this is adjusted during engine test run-

Flyweight springs

ning.

If, after very long use, the speed range of the governor needs adjustment, this can be done within narrow limits by the spring tension nuts. Adjustment of the nuts alter the maximum speed more than idling speed and for this reason a limited adjustment of the maximum speed can be made without affecting the idling speed.

For access to each spring adjusting nut, remove the plug from the side of the governor casing and turn the pump camshaft until the nut is opposite the plug opening.

Using the C.A.V. key wrench ET.065, turn the nuts a half turn clockwise or anti-clockwise, to increase or decrease the speed range. Only at each half turn does the nut engage in its locking device.

The total nut adjustment is 3 mm., and on no account must a nut face be more than 0.5 mm. proud of the end of the pillar.

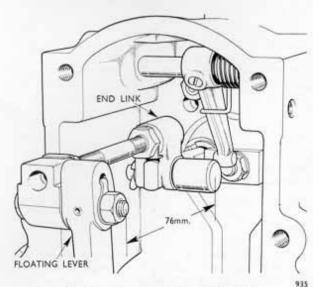
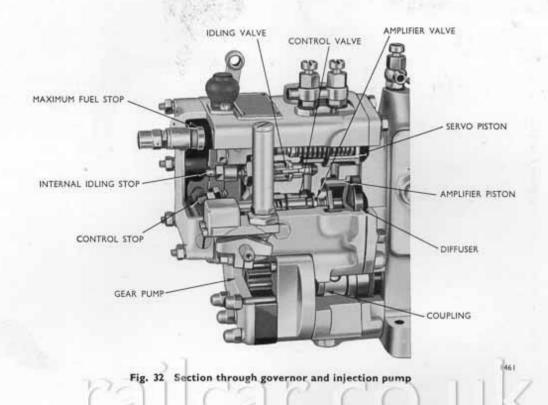


Fig. 31 Governor link adjustment



HYDRAULIC GOVERNOR

C.A.V. Type 'H'

The principle of this governor is that any speed between idling and maximum can be pre-set by means of an operating lever and automatically maintained by a hydraulic governing device. The governor maintains any pre-set speed irrespective of load by regulating the quantity of fuel delivered by the injection pump.

DESCRIPTION

The governor comprises a gear pump driven by a muff coupling on the rear end of the camshaft and an hydraulic system embodied in the governor casing.

Fuel oil flows to the gear pump from the fuel gallery of the injection pump and is delivered at pressure through a diffuser to the amplifier chamber, from which the fuel oil escapes through the orifice in the amplifier piston. The pressure drop through the orifice will set up an endwise thrust on the amplifier piston, depending upon the amount of fuel oil flowing, i.e., upon the gear pump speed which is half engine speed. The fuel oil after passing through the amplifier piston is led to the servo piston, where it acts on the servo piston against the servo piston spring. The servo piston is coupled to the governor lever and the injection pump control rod, therefore, movement of the piston will in turn move the injection pump control rod towards the 'open' position and so increase the pump delivery. The maximum pressure generated at this point is controlled by the high pressure relief valve, and excess of pressure is released to the inlet connection of the gear pump.

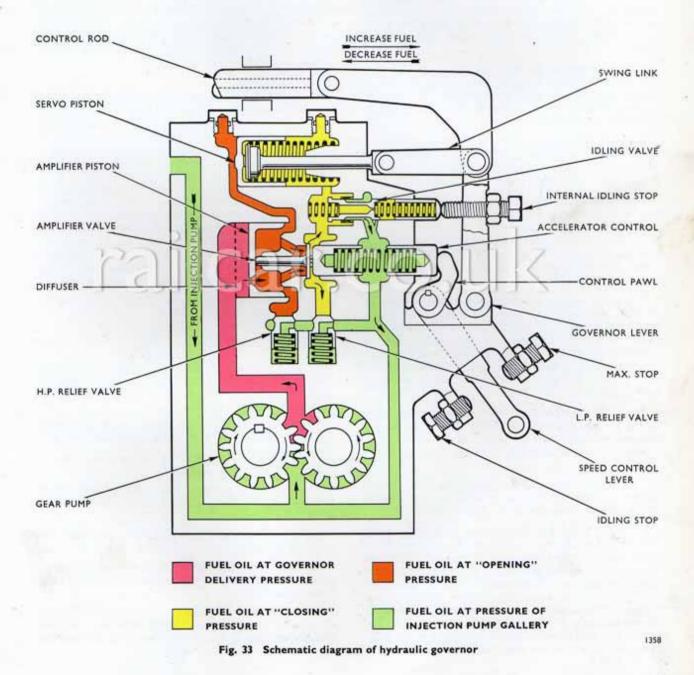
The thrust on the amplifier piston referred to previously, causes the piston to bear against the stem of the amplifier valve, tending to open this valve, which is resisted by the load on the accelerator control valve spring.

The control valve spring loading is varied by a pawl which is keyed to the control shaft, and operated by the speed control lever.

Depressing the speed control lever forces the outer plunger towards the inner plunger, thus compressing the control valve spring to increase the load on the amplifier valve. The amplifier valve will then open at a pressure dependent upon the setting of the speed control lever. The fuel oil which flows through the amplifier valve is led to the inside of the servo piston, and acts to assist the servo piston spring in opposing the 'opening pressure' and brings the servo piston to a state of balance, depending on the difference between the 'opening pressure' and 'closing pressure.'

The 'closing pressure' is controlled by the low pressure relief valve which returns excess fuel oil to the inlet side of the gear pump.

In communication with the 'closing pressure' system is the idling valve. This valve can allow fuel oil to



escape to the gear pump inlet through slots in the idling valve body which are opened or closed by a collar on the valve piston, and gives greater sensitivity under idling conditions than can be given by the amplifier alone.

Idling

The governor lever is pivoted at its lower end on the control shaft, and coupled at its upper end to the servo piston and injection pump control rod. At an intermediate point on the governor lever is fitted an adjusting screw, against which the idling valve outer plunger bears.

The two plungers of the idling valve assembly are held apart by the outer spring, while the inner spring is placed between the inner plunger and the governor housing, holding both plungers towards the governor lever and the adjusting screw.

A small orifice through the inner plunger allows fuel oil at 'closing pressure' to fill the space between the plungers, but restricts the passage of fuel oil in or out of this space, i.e., a dash pot action is obtained.

For rapid movement of the control rod, governor lever and outer plunger, such as are usual under 'idling' conditions, the restriction causes the fuel oil to be trapped between the two plungers and so they move as one solid plunger. This gives the idling valve a high momentary rate, such as is suitable to maintain steady idling.

For slow movements and permanent changes of position, the fuel oil pressures on either side of the orifice can equalize themselves, due to the steady flow of fuel oil through the orifice. In this case, there is no hydraulic unbalance, the minor plunger will take up a position which depends not only on the position of the outer plunger but also the rate of the inner and outer springs, since their loads must be equalized.

The outer spring has one half the rate of the inner spring. Thus a permanent change of position of the outer plunger will cause the inner plunger to change its position by one third of the movement of the outer plunger.

This reduces the effective permanent rate of the governor, so that for any change of load or resistance at idling, the resultant change of idling r.p.m. is small.

Returning to the flow through the idling valve, it will be seen that a movement of the control rod and idling valve plunger towards the open position will allow the idling valve to move outwards, so that the inner plunger closes off the slots. This restricts the flow of fuel oil through the valve, raises the 'closing pressure' and brings the servo piston and control rod back towards the closed position. Thus the valve tends to hold the control rod, and also the engine speed, at a steady position depending upon the adjustment. The actual speed of the engine, from idling to top speed, is selected by the position of the control pawl, as determined by the speed control lever.

The governor will adjust the fuel supply to bring the engine speed to the selected value, subject to the limitation imposed by the maximum power available.

The idling valve adjusting screw, referred to as being carried midway on the governor lever, is used to adjust the sensitivity of the governor at idling. It is adjusted at the makers factory to an optimum position, and should not be moved except by a properly trained person.

Excess fuel device

To start the engine from cold, more fuel will be required than for normal running, and to allow for this, provision is made for the control rack to over-ride the maximum fuel stop setting. Before the engine is started, a plunger situated in the governor housing is operated; this moves the stop block, which normally abuts the fuel stop screw when the control rack is in the maximum fuel position, and permits extended motion of the rack, thus allowing rotation of the pump plungers beyond the pre-set maximum position. On starting the engine, the control rack moves the stop block carrier against the maximum fuel stop and trips the stop-block retaining spring. When the engine runs up to maximum speed, the operation of the governor withdraws the rack, and the stop-block returns to its normal position.

The fuel supply to the engine is then governed by the setting of the maximum fuel stop.

DISMANTLING

Remove the servo piston, sleeve and sealing ring and the diffuser amplifier, piston and sleeve from the governor housing. Use the tool ET.713 for extracting the sleeves.

Compress the servo spring by means of the spring plate and remove the circlip, spring plate and spring.

Unscrew the amplifier valve seat and withdraw it together with the amplifier valve.

Slacken off the clamping screw of the speed control lever and remove the lever from the end of the control shaft.

Slacken off the clamping screw of the stop pawl and remove the pawl from the end of the control shaft.

Remove the grub screw from the control pawl, unscrew the four screws and remove the control shaft bearing brackets.

Withdraw the control shaft, which leaves behind the distance pieces, control pawl and control lever. Extract the distance pieces and control pawl from the governor casing. Remove the governor lever together with the servo piston rod, remove the control plungers and spring,

Remove the outer idling valve plunger and spring, unscrew the gland nut and, using the tool ET.693, withdraw the idling valve body complete with inner idling valve, spring and joint washer.

Unscrew the locking screw and, using the extracting tool ET.692, extract the control plunger sleeve complete with sealing rings.

Remove the high and low pressure relief valve assemblies from the governor housing. It is not advisable to dismantle these valves, but if it becomes necessary, they can be dismantled by unscrewing the plugs. Care, however, should be exercised when taking out these plugs, as they take the pressure of the springs.

The relief valve assemblies must be kept in their respective groups, because, although alike in some points they are definitely not interchangeable. Any shims found in these valves must be kept exactly as found for re-assembly.

Should it be necessary to remove the servo piston spring seat, use the tool ET.707.

Should it be necessary to remove the governor sandwich plate from the pump, first insert the tappet holders ET.648 and 649 under the pump tappets, then release the camshaft nut, and with the extracting tool ET.695, withdraw the driving dog.

Unscrew the eight nuts securing the sandwich plate, and with a rawhide mallet, tap the sandwich plate carefully away from the pump body.

ASSEMBLING THE GOVERNOR

Assemble the sandwich plate to the pump body, taking care that the gasket is in good condition, and secure in position with the washers and nuts.

Fit the driving dog and tighten the nut securely.

Connect the control link to the injection pump control rod by means of the screw and fit the retaining collar and split-pin.

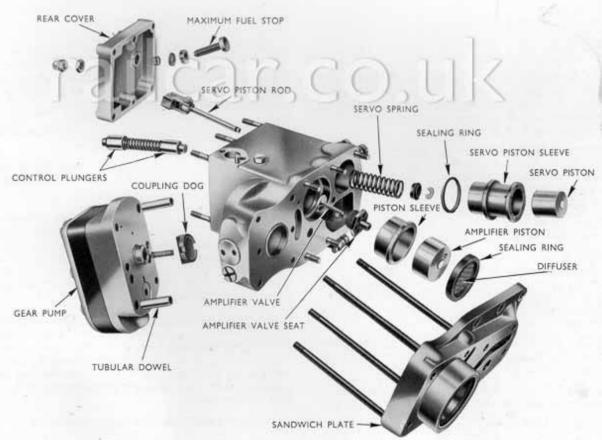


Fig. 34 Exploded view of hydraulic governor

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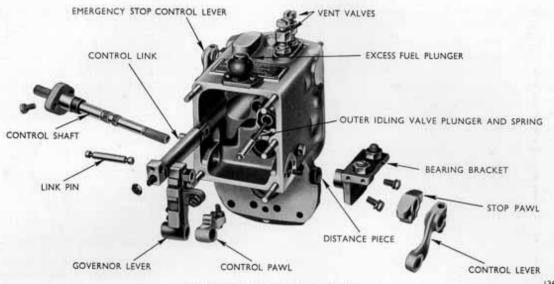


Fig. 35 Governor control details

Fit the control valve sleeve ensuring that three new sealing rings are fitted correctly in the grooves in the governor housing, care being taken that the transverse hole is in line with the locking screw hole in the housing. Screw in the locking screw and tighten.

Insert the inner idling valve and spring into the valve body and fit the assembly in the governor housing. Insert the sealing ring and washer, and screw home the gland nut securely. Check the idling valve for freedom after tightening the gland nut.

Insert the amplifier valve into its seat and screw the assembly into the governor housing.

Fit the servo piston rod with the governor lever attached. Insert the servo spring into the servo sleeve from the opposite end and fit the spring plate in the end of the spring. Compress the spring and fit the circlip ensuring that it is home in the groove of the servo piston rod.

Fit the control plungers with the spring interposed between the plungers, and fit the outer idling valve plunger and spring.

Assemble a new sealing ring on the servo piston sleeve and fit the sleeve into the governor housing.

Insert the servo piston.

Insert the amplifier piston sleeve into the governor housing, and fit the amplifier piston and the diffuser. Locate the governor housing on the studs of the sandwich plate, after ensuring that the gasket is in good condition and correctly positioned.

Tighten the nuts securing the governor housing to the sandwich plate, carefully and evenly.

With a small screwdriver, screw the control rod spindle through the connecting link and when sufficient thread protrudes, replace the locking tab and nut.

Fit the control shaft bearings to the governor housing. Fit the control shaft with the distance pieces, governor lever and control pawl, see fig. 35. Centralize the shaft, and position the control pawl on the shaft splines and lock with the grub screw. Fit new oil seals to the control shaft bearings and fit the stop pawl and control lever to the shaft.

Engage the gear pump coupling dog in position on the camshaft, assemble the spring into the driving spindle of the gear pump, then place the tubular dowels on the studs and fit the gear pump to the governor with a gasket between the joint faces, at the same time turning the pump camshaft until the coupling dog registers with the gear pump spindle.

Replace the acorn nuts and tighten down evenly.

Testing and adjustment of the governor should be carried out before fitting the rear cover.

TESTING THE HYDRAULIC GOVERNOR

The injection pump must be calibrated and phased before these tests can be carried out.

Test equipment

For testing the governor, the fuel pump rig should be equipped with pressure gauges for setting the high and low pressure relief valves. These gauges should be situated between 18 and 24 inches (45.72 and 60.96cm.) above their connections on the governor; any appreciable alteration in this height will affect the pressures obtained in the governor for given gauge readings. The pressure gauges should be connected to the governor by flexible pipes of synthetic rubber, 3 feet long with \(\frac{1}{4}\) inch gas connections and adapters ET.704.

Restrictor valves should be fitted to the pressure gauges to prevent violent gauge fluctuations.

A governor test schedule giving the settings for the governor of each engine Series, will be found immediately after page 30 of this Section.

Testing

Mount the pump and governor assembly on the Hartridge test machine fitted with standard calibrating injectors and a pressure filter. Connect the pump delivery pipes to the standard test injectors, and connect the suction pipes to the diaphragm feed pump to draw test oil.

Remove the rear cover from the governor and remove the guard plates from the external fuel and speed stops.

Remove the vent valves from the top of the governor casing and fit the adapters ET.704 in their places.

Connect a zero to 80 lb. per sq. in, pressure gauge to the vent valve adapter nearest the pump and a zero to 30 lb. per sq. in, gauge to the vent valve adapter furthest from the pump.

Turn on the test oil and vent the pump gallery, also thoroughly vent the governor by running the machine at 100 r.p.m. with the vent valves open and by operating the control lever sharply several times. Close the vent valves and stop the machine.

Remove the internal and external speed stop screws and screw back the idling speed stop. Fully unscrew the idling valve adjusting screw.

Relief valve setting

Run the machine at 100 r.p.m. with the external control lever at the full rack position. All the gear pump delivery is now passing through the H.P. relief valve.

Observe the pressure on the high pressure gauge and, if necessary, stop the rig and adjust to the required pressure, given in column 6 of the governor test schedule, by altering the shims in the counterbore of the valve cap. Finally check that the valve has a minimum lift of 1 mm. (0.039 in.)

Run the machine at 100 r.p.m. with the governor control lever in the lowest speed position and close the idling circuit by using the tool ET.696 to pull open fully the governor lever. All the gear pump delivery is now passing through the L.P. relief valve.

Observe the pressure on the low pressure gauge and, if necessary, stop the rig and adjust to the required pressure given in column 6 of test schedule, by altering

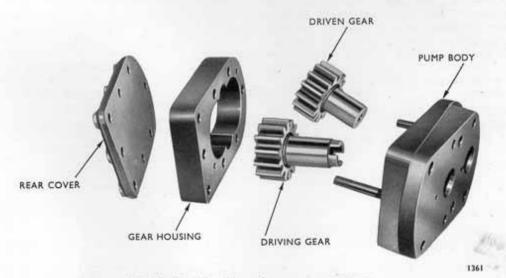


Fig. 36 Exploded view of governor gear pump

the shims in the counterbore of the valve cap. Finally check that the valve has a minimum lift of 1mm. (0.039 in.).

Remove the H.P. gauge and replace the vent valve.

Governor link adjustment

Run the machine at 1,000 r.p.m. with the control lever in the lowest speed position and check that the internal governor lever goes to the fully closed position. Adjust the control rod link screw to give a trace of fuel delivery from the injectors, then give the screw 1 to 1½ turns to cut off the fuel delivery, and tighten the locknut.

Idling setting

Run the pump at the correct speed for idling setting, see column 7 of test schedule, with both the idling and idling valve stop screws in the fully unscrewed position.

Screw in the idling stop until the pump commences to inject fuel, then screw in the idling valve stop screw and bring the servo closing pressure on the 0 to 30 lb. per sq. in. gauge to the correct setting.

Adjust the idling stop to give the correct idling delivery, see column 9 in test schedule, this will probably alter the servo closing pressure and further adjustment of the idling valve stop screw will be necessary.

By simultaneous adjustment of both stops, the correct pressure and idling fuelling can be obtained. The threads on the idling stop screw should now be just showing through the bracket. Check that the idling pawl is on the correct serration.

Remove the L.P. gauge and replace the vent.

Maximum speed setting

Run the machine at the r.p.m. given in the relevant pump test schedule, with the control lever in the maximum speed position. Set the internal maximum speed stop so that the governor is just commencing to cut off fuel, and lock the stop. With the control lever still in the maximum speed position, set the external maximum speed stop just in contact with the stop pawl and lock this stop.

With the control lever in the maximum speed position, raise and lower the machine speed slowly between 800 r.p.m. and 1,100 r.p.m. Check that the fuel cut-off

commences at the 2nd r.p.m. given under Maximum Speed Setting in the relevant pump schedule and is completely cut-off at the 3rd speed given.

Run the machine at 500 r.p.m. and set the control lever so that the pump is delivering 6 cc. of fuel. The governor is now set in the 'load governing' range. Raise the machine speed slowly and check that fuel delivery ceases at 750 r.p.m. This is done to check the point of change-over from 'load governing' to 'speed governing.'

Run the machine at 180 r.p.m. with the control lever in the idling position. Raise the speed slowly and check that, once the pump delivery has been cut-off, it does not recommence at any point up to 1,200 r.p.m.

Run the machine at various speeds between idling and maximum speed r.p.m. and check at each speed that the pump rack responds smoothly to steady movement of the control lever. Stop the machine.

Fit the governor cover and gasket in place on the governor housing,

Run the machine at 50 r.p.m.

Depress the excess fuel device button, and move the control lever quickly to the maximum speed position. Check that the control rod reaches the excess fuel position and trips off the excess fuel device within 3 turns of the camshaft. Check that the excess travel of the control rod is not less than 3.5 mm.

Adjust the emergency stopping lever on the governor casing and check that:—

- (a) The control lever will not move off its stop when the pump control rod is pushed on to the normal maximum fuel stop.
- (b) The control lever will move slightly off its idling stop when the pump control rod is pushed to the excess fuel position.
- (c) It is possible to push the pump control rod into contact with its stop plate by pulling back the control lever and compressing the idling stop plunger.

Ensure that all covers, nuts and bolts are tight and secure.

GOVERNOR TEST SCHEDULE

				_		_	_	_	10		_			_	_	_
16	Remarks		INTERNAL SPEED	STOP SHOULD BE	M 8 0 8 D 8 D 8 D 8 D 8 D 8 D 8 D 8 D 8 D		HIGHER THAN THE	QUOTED EXTERNAL	SPEED, STOP SETTING	IN COLUMN II						
12	If tested with	lift pump	YES	YES	7.65	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
14	Dead travel setting	from trace of fuel turns	1 to 15	2-1 ot 1-5	1 to 1-5	1 10 15	1 10 1.5	1 to 1-5	1 to 1-5	1 to 15	1 to 15	5-1 on 1-2	1 to 15	1 to 1·5	1 00 1-5	1 to 1.5
22		hysteresis r.p.m.	20 to 30	20 to 30	20 to 30	20 to 30	20 to 30	20 to 30	20 to 30	20 to 30	20 to 30	20 to 30	20 to 30	20 to 30	20 to 30	20 to 30
12	Governor overrun on test	rig to no fuel r.p.m.	8	150	150	150	150	150	150	150	150	150	150	8	150	150
=	Governor 'cue In' r.p.m.		1,020 1,040	1.020 1.040	1,020 1,040	1,020 1,040	1.020 1,040	1,020 1,040	1,020 1,040	900, 920	900, 920	970.990	1,020, 1,040	1,020 1,040	1,020 1,040	1.020 1.040
0.	Max. fuelling per 100 shots std. nozzles at 600 r.p.m.		11.2	11.3	13-0	12-0	11/2	13.0	12.0	15.6	15.6	10.2	11.0	311-0	12.0	12:0
•	Idling fuelling per	100 shots	+	*	176	*	*	7	*	+	+	+		4		+
	Idling	pressure p.s.i.	30	30	30	30	30	30	30	30	30	30	30	30	30	30
	Idling	rg.m.	180	180	180	061	81	180	180	100	081	991	180	180	180	180
	alve ; at	LP.	37 to 39	37 to 39	37 to 39	37 to 39	37 to 39	37 to 39	37 to 39	37 to 39	37 to 39	37 to 39	37 to 39	37 to 39	37 to 39	37 to 39
•	Relief valve setting at 100 r.p.m.	H.P.	60 to 62	60 to 62	60 to 62	60 to 62	60 to 62	60 to 62	60 to 62	60 to 62	60 to 62	60 to 62	60 to 62	60 10 62	60 to 62	60 to 62
un.	Governor	Governor		LHF 23MC LHF 22MC	LHF 22MC	LHF 22MC	LHF 23MC	LHF 22MC	THE 22MC	LHF 33MC	LHF 23MC	RHF 20MC	RHF 20MC	RHF 20MC	RHF 20MC	KHF 20MC
	Unit		U	U	0	Ç	U	U	o	O	v	v	υ	U	U	U
4	Pump		z	z	z	z	z	z	N	N	z	z	z	Z	z	z
-	π, π,		2.100	2,100	2,100	2.100	2.100	2,100	2,100	1,800	1,800	2,000	2,100	2,100	2,100	2,100
	B.H.P.		184	18	210	300	184	210	300	190	190	170	184	184	200	300
	Series No.		102	102A	1028	1020	1020	102E	102#	113	V(I)	115	122	122 A	(228	122C
÷	Engine		C6. NFL	C6. NFL	C6. NFL	C6. NFL	C6. NFL	C6. NFL	C6. NFR	C6. SFLM	C6. SFLM	C6. NFR	C6 NFR	C& NFR	CA. NIR.	C& NFR

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MASTER TEST SCHEDULES

It is not practicable to include in this manual a separate test schedule for every type of C.A.V. fuel injection pump, governor and lift pump assembly fitted to the numerous engines which constitute the Rolls-Royce range, since the components in each assembly vary in both design and application to such an extent that a large number of combinations exists, and since the fuel delivery settings of otherwise similar pumps vary to suit specific engine power ratings.

For this reason seven master test schedules only are given, covering the following groups of applications:

- Pumps with mechanical all-speed governors fitted to vehicle and earth-moving equipment engines.
- Pumps with mechanical all-speed governors with torque control fitted to vehicle and earth-moving equipment engines.
- Pumps with mechanical two-speed governors with rigid drive fitted to vehicle and earthmoving equipment engines.
- Pumps with hydraulic all-speed governors fitted to vehicle and earth-moving equipment engines.
- Pumps with hydraulic two-speed governors fitted to vehicle engines.
- Pumps with mechanical all-speed governors fitted to electric generating set engines.

Pumps with hydraulic all-speed governors fitted to marine engines.

All C.A.V. fuel injection pumps fitted to engines built since September, 1957, carry a Rolls-Royce data plate. To use the appropriate master test schedule, refer to this data plate for the normal fuel delivery and the maximum and idling speed settings for the pump under test.

Before a master test schedule can be used for testing a pump which was supplied prior to September, 1957, it will first be necessary to obtain the fuelling and governed speed settings from the Service Department of Rolls-Royce Limited, Oil Engine Division.

The 'Rig Figure' which will be obtained during the maximum speed setting will normally be in excess of the 'Normal Delivery' figure, except in the case of pumps fitted to engines with maximum governed speeds below 1,200 r.p.m., when the 'Rig Figure' will be less than the 'Normal Delivery'.

The Rolls-Royce part number for the complete pump assembly, as given on the Rolls-Royce data plate, or the part numbers given on the individual plates attached to the injection pump body, governor casing and lift pump on assemblies not fitted with a Rolls-Royce data plate, together with the number of the engine from which the pump was removed (if known), must always be quoted in all communications addressed to Rolls-Royce Limited concerning fuel pump settings and adjustments.

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MASTER TEST SCHEDULE No. 1

INJECTION PUMP: C.A.V. WITH MECHANICAL ALL - SPEED GOVERNOR ENGINE APPLICATION: VEHICLE AND EARTH-MOVING EQUIPMENT

Pump r. p. m.	Average fuel delivery		Control lever setting	Remarks
Pump r.p.m.	cc. per 100 strokes	Tolerance		
ALIBRATION CHECK				
PUMPS WITH 10 MM. DIA.	ELEMENTS			
	control rod opening and calibrate to the	following tolera	ncest	
300	10.5 to 11.9		Maximum	Maximum spread between any two elements not exceed 0.6 cc. per 100 strokes.
600	11.2 to 12.4		Maximum	Maximum spread between any two elements not t exceed 0, 6 cc. per 100 strokes
900	11.7 to 13.3		Maximum	Maximum spread between any two elements not exceed 0.7 cc. per 100 strokes
Set fuel nome to 7 mm. co	ontrol rod opening and calibrate to the fo	Illowing toleran	ne er	
200	2.5 to 3.7	diowing toteran	Maximum	Mantager annual Saturday and the observations of
200	2.5 (0.5.7		Maximum	Maximum spread between any two elements not t exceed 0.8 cc. per 100 strokes
PUMPS WITH 0 MM. DIA		Acces to the		
Colored and the property of th	control rod opening and calibrate to the t	following tolerar	ncest	
300	13.0 to 14.4		Maximum	Maximum spread between any two elements not t exceed 0.8 cc. per 100 strokes
600	13.9 to 15.1		Maximum	Maximum spread between any two elements not exceed 0.7 cc. per 100 strokes
900	14.3 to 15.7		Maximum	Maximum spread between any two elements not sexceed 0.8 cc. per 100 strokes
Set fuel nume to 7 mm. or	petral rod opening and calibrate to the fo	llowing tolerand	nest.	
200	1.2 to 2.2	1 7	Maximum	Maximum spread between any two elements not exceed 0.5 cc. per 100 strokes
FUEL SETTING	Normal delivery	± 0,10 cc.	Maximum	Set maximum fuel stop
Max. gov. speed	Rig figure	± 0.15 cc.	Maximum	
MAXIMUM SPEED SETTING				
Max. gov. speed + 20	Pull delivery		Maximum	Set maximum speed stop
Max. gov. speed + 40	Fuel delivery reduced		Maximum	Governor commencing to cut fuel
Max. gov. speed + 10%	NII		Maximum	Complete fuel cut-off
IDLING SETTING				
180	3. 6 to 4. 0		Minimum	Set idling stop
330	Nii		Minimum	Complete fuel cut-off
EXCESS FUEL CHECK				
100	Rig figure	± 0.50 cc.	Maximum	
20189	Rig figure at 100 r.p.m. + 6cc. (9) mm. dia. elem.}		NAME OF THE OWNER O	See the Second Second Control of the
100	Rig figure at 100 r.p.m. +8cc. (10) mm. dia.elem.)		Maximum	After pressing excess fuel plunger
Max. no load speed	Nil	5-70000-00	Maximum	To disengage excess fuel device
600	Normal delivery	± 0.10 ec.	Maximum	Disengagement check
INTERNAL FOUL CHECK				
1,400	Nil		Maximum	Run up to this speed and check that no internal fo occurs.
PER DESCRIPTION OF THE PER PER PER PER PER PER PER PER PER PE				

Essential features of test rig

Hartridge BDN 12S D12 nozzles in BK. B50 nozzle holders set at 175 atmospheres.

High pressure pipes must be 6 mm. outside diameter and have a bore of 2 mm.

Fuel system to incorporate lift pump of unit on test, connected through a filter to the injection pump, with the relief valve set to give 13 to 15 p. s. i. on the inlet side of the filter. Pressure drop across the filter not to exceed 2 p. s. i.

MASTER TEST SCHEDULE NO. 2

INJECTION PUMP: C.A.V. WITH MECHANICAL ALL-SPEED GOVERNOR

WITH TORQUE CONTROL

ENGINE APPLICATION: VEHICLE AND EARTH-MOVING EQUIPMENT

Pump r.p.m.	Average fuel delivery		Control lever	Remarks
rump repense	cc. per 100 strokes	Tolerance	setting	No. all the second seco
ALIBRATION CHECK				
PUMPS WITH 10 MM, DIA	FLEMENTS			
	control rod opening and calibrate to the	following tolors	neart.	
300	10.5 to 11.9	portowing toocta	Maximum	Maximum spread between any two elements not to
300	10.0 to 11.9		ASSOCIATION	exceed 0.6 cc. per 100 strokes
600	11.2 to 12.4		Maximum	Maximum spread between any two elements not to exceed 0, 6 cc. per 100 strokes
900	11.7 to 13.3		Maximum	Maximum spread between any two elements not to exceed 0.7 cc. per 100 strokes
Set fuel numn to 7 mm. r	control rod opening and calibrate to the f	ollowine toleran	cest	
200	2.5 to 3.7		Maximum	Maximum spread between any two elements not to
200	4.7.00 4.1			exceed 0.8 cc. per 100 strokes
PUMPS WITH 9 MM. DIA.	ELEMENTS			
Set fuel pump to 13 mm.	control rod opening and calibrate to the	following tolera	ncest	
300	13.0 to 14.4		Maximum	Maximum spread between any two elements not to exceed 0.8 cc. per 100 strokes
600	13.9 to 15.1		Maximum	Maximum spread between any two elements not to exceed 0.7 cc. per 100 strokes
900	14.3 to 15.7		Maximum	Maximum spread between any two elements not to exceed 0.8 cc. per 100 strokes
200	control rod opening and calibrate to the f	b contract	Maximum	Maximum spread between any two elements not to exceed 0.6 cc. per 100 strokes
FUEL SETTING				
	Normal delivery	2-0.15 cc.	Maximum	Set maximum fuel stop
Max. gov. speed		# 0.1 cc.		Adjust this fuel delivery by means of adjustment
600	Normal delivery for max. torque	+ 9.1 00.	Maximum	governor timing lever
MAXIMUM SPEED SETTIN	G G			
Max. gov. speed + 20	Full delivery		Maximum	Set maximum speed stop
Max. gov. speed + 40	Fuel delivery reduced		Maximum	Governor commencing to cut fuel
Max. gov. speed + 10%	Nil		Maximum	Complete fuel cut-off
IDLING SETTING				
180	3.6 to 4.0		Minimum	Set idling stop
330	Nii		Minimum	Complete fuel cut-off
EXCESS FUEL CHECK				
100	Rig figure	± 0.5 cc.	Maximum	
(2794)	Rig fig. at 100 r.p.m. + 6 cc. (9	10000		
100	mm. dia. elem.) Rig fig. at 100 r.p.m. + 8 cc. (10		Maximum	After pressing excess fuel plunger
	mm. dia. elem.) Nil		Maximum	To disengage excess fuel device
Max. no load speed 600	Normal delivery for max. torque	± 0.1 ec.	Maximum	Disengagement check
INTERNAL FOUL CHECK	Nil		Maximum	Run up to this speed and check that no internal
INTERNAL FOUL CHECK 1,400	NII			foul occurs.
	NII			foul occurs.

Essential features of test rig

Hartridge BDN 12S D12 nozzles in Bk. B50 nozzle holders set at 175 atmospheres.

High pressure pipes must be 6 mm. outside diameter and have a bore of 2 mm.

Puel system to incorporate lift pump of unit on test, connected through a filter to the injection pump, with the relief valve set to give 13 to 15 p. s. l. on the inlet side of the filter. Pressure drop across the filter not to exceed 2 p. s. l.

MASTER TEST SCHEDULE NO. 3

INJECTION PUMP: C.A.V. WITH MECHANICAL TWO-SPEED GOVERNOR

ENGINE APPLICATION: VEHICLE AND EARTH MOVING EQUIPMENT

Thomas are an area	Average fuel delivery		Control lever	Remarks	
Pump r.p.m.	cc. per 100 strokes	Tolerance	setting	pemarks	
ALIBRATION CHECK					
PUMPS WITH 10 MM. DIA	PIEMENTS				
	control rod opening and calibrate to the	following tolera:	ncest		
300	10.5 to 11.9		Maximum	Maximum spread between any two elements not to exceed 0.6 cc. per 100 strokes	
600	11. 2 to 12. 4		Maximum	Maximum spread between any two elements not to exceed 0. 6 cc. per 100 strokes.	
900	11.7 to 13.3		Maximum	Maximum spread between any two elements not to exceed 0.7 cc. per 100 strokes	
	and and an extension and an inches to the	following to long		Annah Charles Control of the Control	
ACCURATION AND ADDRESS OF THE PARTY OF THE P	control rod opening and calibrate to the	tollowing toleran		Management of the second between the state of the second sect to appear	
200	2.5 to 3.7		Maximum	Maximum spread between any two elements not to excee exceed 0.8 cc. per 100 strokes	
PUMPS WITH 9 MM. DIA.	ELEMENTS				
Set fuel pump to 13 mm.	control rod opening and calibrate to the	following tolera	ncest		
300	13.0 to 14.4		Maximum	Maximum spread between any two elements not to exceed 0.8 cc. per 100 strokes	
600	13.9 to 15.1		Maximum	Maximum spread between any two elements not to exceed 0.7 cc. per 100 strokes	
900	14.3 to 15.7		Maximum	Maximum spread between any two elements not to exceed 0.8 cc. per 100 strokes	
		Edition for the Control			
To be a second of the second o	ontroi rod opening and calibrate to the	lollowing toleran		Maximum sprend between any two elements not to	
200	1.102.2	1 (Maximum	exceed 0.6 cc. per 100 strokes	
FUEL SETTING	- LCL	11 5 5	7.1		
600	Normal delivery + 2 cc.	1.500	Maximum	Set on control lever stop	
600	Normal delivery	± 0.10 cc.	Maximum Maximum	Set on rack stop	
Max. gov. speed	Rig figure	± 0.15 cc.	MAXIMUM		
MAXIMUM SPEED SETTIN	G				
Max. gov. speed + 20	Full delivery		Maximum	Check that governor does not cut fuel before this speed. Adjust on governor springs if necessary	
Max. gov. speed + 40	Puel delivery reduced		Maximum	Governor commencing to cut fuel	
Max. gov. speed + 10%	NII		Maximum	Complete fuel cut-off	
IDLING SETTING					
180	3,6 to 4.0		Minimum	Set idling stop	
330	Nii		Minimum	Complete fuel cut-off	
EXCESS FUEL CHECK					
100	Rig figure		Maximum		
11.575.0	(Rig fig. at 100 r.p.m. + 6 cc. (9) (mm. dia. elem.)		E STATE	the state of the s	
	Rig.fig. at 100 r.p.m. + 8 cc. (10 mm. dia.eiem.)		Maximum	After pressing excess fuel plunger	
Max. no load speed	Nil		Maximum	To disengage excess fuel device	
600	Normal delivery		Maximum	Disengagement check	
INTERNAL FOUL CHECK	to the		9.007	Ped ACRES SERVICE AND	
1,400	Nil		Maximum	Run up to this speed and check that no internal foul occurs	
STOP CONTROL CHECK			N. P. Carrier		
100	Nil		Maximum	Check that stop control will completely cut fuel	

Essential features of test rig

Hartridge BDN 125 D12 nozzles in BK. B50 nozzle holders set at 175 atmospheres.

High pressure pipes must be 6 mm. outside diameter and have a bore of 2 mm.

Fuel system to incorporate lift pump of unit on test, connected through a filter to the injection pump, with the relief valve set to give 13 to 15 p. s. i. on the inject side of the filter. Pressure drop across the filter not to exceed 2 p. s. i.

MASTER TEST SCHEDULE No. 4

INJECTION PUMP: C.A.V. WITH HYDRAULIC ALL-SPEED GOVERNOR. ENGINE APPLICATION: VEHICLE AND EARTH-MOVING EQUIPMENT

Pump r.p.m.	Average fuel delivery		Control lever	Bassadar
	cc. per 100 strokes	Tolerance	setting	Remarks
CALIBRATION CHECK				
PUMPS WITH 10 MM. DL	PIPMPNPA			
			15 P. 17	
300	control rod opening and calibrate to the f	following tolera	WINESES .	
300	10,5 to 11.0		Maximum	Maximum spread between any two elements not to exceed 0.6 cc. per 100 strokes
600	11. 2 to 12. 4		Maximum	Maximum spread between any two elements not to exceed 0, 6 cc. per 100 strokes
900	11.7 to 13.3		Maximum	Maximum spread between any two elements not to exceed 0.7 cc. per 100 strokes
Set fuel pump to 7 mm. c	control rod opening and calibrate to the foll	owing tolerance	197	
200	2.5 to 3.7	1	Maximum	· · · · · · · · · · · · · · · · · · ·
	3.000		Min Asimum	Maximum spread between any two elements not to exceed 0.8 cc. per 100 strokes
PUMPS WITH 9 MM. DIA.	ELEMENTS			
Set fuel pump to 13 mm.	control rod opening and calibrate to the f	ollowing tolera	See SE	
300	13.0 to 14.4	The second of th	Maximum	Maximum spread between any two elements not to
600	13.9 to 15.1		Maximum	exceed 0.8 cc. per 100 strokes
5.0			S. C. S.	Maximum spread between any two elements not to exceed 0.7 cc. per 100 strokes
900	14. 3 to 15. 7		Maximum	Maximum spread between any two elements not to exceed 0.8 cc. per 100 strokes
Set fuel pump to 7 mm.	control rod opening and calibrate to the fo	Howing toleran	Next:	- 14 TO
200	1 1.2 to 2/2	2 -	Margmum	Maximum spread between any two elements not to
600				exceed 0, 6 dr. per 100 strokes
SENSED DO C			. 6	The second secon
FUEL SETTING				
600	Normal delivery	±0.10 cc	Maximum	Set maximum fuel stop
Max gov. speed - 30	Rig figure	=0.15 cc.	Maximum	
MAXIMUM SPEED SETTI	NG.			
Max. gov. speed	Full delivery	±0.15 ec.	Maximum	Set internal max, speed stop just contacting stop fa
Max. gov. speed + 20	Fuel delivery reduced	-71,845,554	Maximum	Governor commencing to cut fuel
Max. gov. speed + 150	No delivery		Maximum	The Tarried Management of the Control of the Contro
max. gov. speed + 130	no delivery		MAXIMUM	Complete fuel cut-off. Set external max. speed stop to commence cutting fuel 30 p. r. p. m. earlier
				Constant Constant Contract
IDLING SETTING				
180	3.6 to 4.0		Minimum	Set idling stop
330	Nil		Minimum	Complete fuel cut-off
EXCESS FUEL CHECK	No. 10			
100	Rig figure		Maximum	
	(Rig fig. at 100 r.p.m. + 6 cc. (9)			
100	(mm. dia.elem.)		Maximum	After pressing excess fuel plunger
	Rig fig. at 100 r.p.m. + 8 cc. (10 { mm. dia. elem.)			A DOCUMENT OF THE PROPERTY OF THE PROPERTY OF THE
Max. no load speed	Nil		Maximum	To disengage excess fuel device
600	Normal delivery		Maximum	
000	Normal delivery		maximum.	Disengagement check
STOP CONTROL CHECK	-774			

Essential features of test rig

Hartridge BDN 12S D12 nozzles in BK. B50 nozzle holders set at 175 atmospheres

High pressure pipes must be 6 mm. outside diameter and have a bore of 2 mm.

Fuel system to incorporate lift pump of unit on test, connected through a filter to the injection pump, with the relief valve set to give 13 to 15 p. s.i. on the inlet side of the filter. Pressure drop across the filter not to exceed 2 p. s.i.

MASTER TEST SCHEDULE NO. 5

INJECTION PUMP: C.A.V. WITH HYDRAULIC TWO-SPEED GOVERNOR ENGINE APPLICATION: VEHICLE

-	Average fuel delive	ry	Control lever	Remarks
Pump r.p.m.	cc. per 100 strokes	Tolerance	setting	
CALIBRATION CHECK				
PUMPS WITH 10 MM. DIA	ELEMENTS			
	. control rod opening and calibrate to	the following toler	ancest	
300	10.5 to 11.9		Maximum	Maximum spread between any two elements not to exceed 0.6 cc. per 100 strokes
600	11.2 to 12.4		Maximum	Maximum spread between any two elements not to exceed 0. 6 cc. per 100 strokes
900	11.7 to 13.3		Maximum	Maximum spread between any two elements not to exceed 0.7 cc. per 100 strokes
Set fuel pump to 7 mm.	control rod opening and calibrate to	the following tolers	noes:	
200	2.5 to 3.7		Maximum	Maximum spread between any two elements not to exceed 0.8 cc. per 100 strokes
PUMPS WITH 9 MM. DIA.	ELEMENTS			
Set fuel pump to 13 mm	. control rod opening and calibrate to	the following toler	ancest	
300	13.0 to 14.4		Maximum	Maximum spread between any two elements not to exceed 0.8 cc. per 100 strokes
600	13.9 to 15.1		Maximum	Maximum spread between any two elements not to exceed 0.7 cc. per 100 strokes
900	14.3 to 15.7		Maximum	Maximum spread between any two elements not to exceed 0.8 cc. per 100 strokes
Set feel remove to 7 min	control rod opening and calibrate to	the following tolors	Const.	3 3 3
200	1.2 to 2.2	0 0	Maximum	Maximum spread between any two elements not to exceed 0.6 cc. per 190 strokes
- C	101	1)	1	3 5 1
FUEL SETTING	Named dellares	±0.10 cc.	Maximum	Set max. fuel stop at rear of governor
600 Max. gov. speed	Normal delivery Rig figure	± 0.15 cc.	Maximum	Set max. tuet stop at rear of governor
	100 - 100 A	8-5-20-53/63/4	Medital Action	
MAXIMUM SPEED SETTIN	G	7579-025	0.000000	
Max. gov. speed	Full delivery	± 0.15 cc.	Maximum	Set internal max. speed stop just contacting stop face
Max. gov. speed + 20	Fuel delivery reduced		Maximum	Governor commencing to cut fuel
Max. gov. speed + 150	NII		Maximum	Complete fuel cut-off Set external max. speed stop to commence cutting for 30 p.r.p.m. earlier
IDLING SETTING	****		0.132000	
180	3. 6 to 4. 0		Minimum	Set idling stop
330	Nii		Minimum	Complete fuel cut-off
EXCESS FUEL CHECK				
100	Rig figure	± 0.5 cc.	Maximum	
	(Rig fig. at 100 r.p.m. + 6 cc. (9 mm. dia. elem.)	}	TOOKSAMA	104417 (10400 11410 11700 1146 1146 1147 410 1147
100	Rig fig. at 100 r.p.m. + 8 cc. (10 mm. dia.elem.)	}	Maximum	After pressing excess fuel plunger
Max. no load speed + 50	Nil		Maximum	To disengage excess fuel device
600	Normal delivery			Disengagement check

Essential features of test rig-

Hartridge BDN 125 D12 nozzles in Bk. B50 nozzle holders set at 175 atmospheres. High pressure pipes must be 6 mm. outside diameter and have a bore of 2 mm.

Fuel system to incorporate lift pump of unit on test, connected through a filter to the injection pump, with the relief valve set to give 13 to 15 p.s. 1. on the inlet side of the filter. Pressure drop across the filter not to exceed 2 p.s. 1.

MASTER TEST SCHEDULE No. 6

INJECTION PUMP: C.A.V. WITH MECHANICAL ALL-SPEED GOVERNOR

ENGINE APPLICATION: ELECTRIC GENERATING SET

Pump r.p.m.	Average fuel delivery		Control lever	Remarks	
Pump r-p-m-	cc. per 100 strokes	Tolerance	setting		
CALIBRATION CHECK					
PUMPS WITH 10 MM. DIA.	ELEMENTS				
	control rod opening and calibrate to t	he following tole	rances:		
200	10.5 to 11.9		Maximum	Maximum spread between any two elements not to exceed 0.6 cc. per 100 strokes	
600	11.2 to 12.4		Maximum	Maximum apread between any two elements not be exceed 0.6 cc. per 100 strokes	
900	11.7 to 13.3		Maximum	Maximum spread between any two elements not be exceed 0.7 cc. per 100 strokes	
		C-1111-1			
set fact pump to 7 mm. c	ontrol rod opening and calibrate to th 2.5 to 3.7	e tottowing toter.	Maximum	Maximum spread between any two elements not be exceed 0.8 cc. per 100 strokes	
PUMPS WITH 9 MM. DIA.		Acces to the			
Set fuel pump to 13 mm.	control rod opening and calibrate to t	he following tole			
300	13.0 to 14.4		Maximum	Maximum spread between any two elements not t exceed 0.8 cc. per 100 strokes	
600	13.9 to 15.1		Maximum	Maximum spread between any two elements not t exceed 0.7 cc. per 100 strokes	
900	14.3 to 15.7		Maximum	Maximum spread between any two elements not t exceed 0.8 cc. per 100 strokes	
Set fuel pump to 7 mm. c	ontrol rod opening and calibrate to th	e following toler:	ATTHEORY CANCELLY TO THE	SECRETARIAN DE PARA DIVIDADA DE ANTONIO DE ANTONIO	
200	1.2 to 2.2		Maximum	Maximum spread between any two elements not t exceed 0.6 cc. per 100 strokes	
FUEL SETTING	(1) 7	1 6			
600	Normal delivery	1 0.1 bc.	Maximum	Set maximum fuel stop	
Max. gov. speed	Aig ligure	2 0.15 ec.	Maximum	3 213 2	
MAXIMUM SPEED SETTIN	G			E = 200	
Max. gov. speed	Full delivery	2 0.15 cc	0.000 (0.000, 0.000)	Set max. speed stop	
Max. gov. speed + 10	Fuel delivery reduced		Maximum	Governor commencing to cut fuel	
Max. gov. speed + 4%	No delivery		Maximum	Complete fuel cut-off	
IDLING SETTING	407 (407) (77)		Minimum	Set idling stop to lowest speed at which springs	
Lowest idling speed	Rig figure		Minimum	will govern	
Lowest idling speed + 150	NII		Minimum	Complete fuel cut-off	
EXCESS FUEL CHECK		20.000	22329		
100	Rig figure	± 0.5 cc.	Maximum		
100	Rig fig. at 100 r.p.m. + 6 cc. (9 mm. dia. elem.)		Maximum	After pressing excess fuel plunger	
	Rig fig. at 100 r.p.m. + 8 cc. (10 mm. dia. elem.)		3,0-52,1-74401		
Max. no load speed	NII		Maximum	To disengage excess fuel device	
600	Normal delivery		Maximum	Disengagement check	
INTERNAL FOUL CHECK			2000 ACT TO A		
1,400	NII		Maximum	Run up to this speed and check that no internal foul occurs	
STOP CONTROL CHECK				76- 127/10- A743-734-111-72764-1-4-6-75W	
100	NII		Maximum	Check that stop control will completely cut fuel	

Essential features of test rig

Hartridge BDN 12S D12 nozzles in BK.B50 nozzle holders set at 175 atmospheres.

High pressure pipes must be 6 mm. outside diameter and have a bore of 2 mm.

Fuel system to incorporate lift pump of unit on test, connected through a filter to the injection pump, with the relief valve set to give 13 to 15 p.s.i. on the inlet side of the filter. Pressure drop across the filter not to exceed 2 p.s.i.

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T.S.D. 803 SEC, 17A

MASTER TEST SCHEDULE No. 7

INJECTION PUMP: C.A.V. WITH HYDRAULIC ALL-SPEED GOVERNOR ENGINE APPLICATION: MARINE

Pump r.p.m.	Average fuel delivery	Y	Control lever	Remarks	
2 amp 11 primi	cc. per 100 strokes	Tolerance	setting	Atmarks	
CALIBRATION CHECK					
PUMPS WITH 10 MM. DI	ALELEMENTS				
Set fuel pump to 10 mm.		ollowing tolera	ncest		
300	10.5 to 11.9	1010110110	Maximum	Maximum spread between any two elements not to exceed 0.6 cc. per 100 strokes	
600	11.2 to 12.4		Maximum	Maximum spread between any two elements not to exceed 0.6 cc. per 100 strokes	
900	11.7 to 13.3		Maximum	Maximum spread between any two elements not to exceed 0.7 cc. per 100 strokes	
Set fuel pump to 7 mm.	control rod opening and calibrate to the fo	llowing toleran	ces		
200	2.5 to 3.7	A STATE OF THE PARTY OF THE PAR	Maximum	Maximum spread between any two elements not to	
	21.5.10.01.1		Cittoring.	exceed 0.8 cc. per 100 strokes	
PUMPS WITH 9 MM. DIA.	ELEMENTS			CONTROL CONTROL CONTROL CONTROL CONTROL	
Set fuel pump to 13 mm.	control rod opening and calibrate to the f	ollowing tolera	nces:	THE STATE OF THE S	
300	13.0 to 14.4		Maximum	Maximum spread between any two elements not to exceed 0.8 cc. per 100 strokes	
600	13.9 to 15.1		Maximum	Maximum spread between any two elements not to exceed 0.7 cc. per 100 strokes	
900	14.3 to 15.7		Maximum	Maximum spread between any two elements not to exceed 0.8 cc. per 100 strokes	
200	1.2 10 2.2	3	Maximum	Maximum apread between any two elements not to exceed 0, 6 cc. per 100 strokes	
FUEL SETTING		The second second			
600	Normal delivery	± 0.1 cc.	Maximum	Set maximum fuel stop	
Max. gov. speed	Rig figure	1 0.15 ec.	Maximum		
MAXIMUM SPEED SETTIN	NG				
Max. gov. speed + 30	Full delivery	± 0.15 cc.	Maximum	Set internal max, speed stop just contacting stop face	
Max. gov. speed + 50	Fuel delivery reduced		Maximum	Governor commencing to cut fuel	
Max. gov. speed + 150	No delivery		Maximum	Complete fuel cut-off Set external max. speed stop to commence cutting fue 30 p. r.p.m. earlier	
IDLING SETTING					
180	3. 6 to 4. 0		Minimum	Set idling stop	
330	NII		Minimum	Complete fuel cut-off	
EXCESS FUEL CHECK					
100	Rig figure	10.5 cc.	Maximum		
100	(Rig figure at 100 r.p.m. + 6 cc. (9) mm. dia. elem.)		Maximum	After pressing excess fuel plunger	
	Rig figure at 100 r.p.m. + 8 cc. (10 { mm. dia. elem.)				
Max. no load speed	Nil		Maximum	To disengage excess fuel device	
	Normal delivery		Maximum	Disengagement check	
600	Normal delivery		500 C 10 T		
STOP CONTROL CHECK	Normal delivery		I WENTERS		

Essential features of test rig

Hartridge BDN 125 D12 nozzles in BK. B50 nozzle holders set at 175 atmospheres. High pressure pipes must be 6 mm. outside diameter and have a bore of 2 mm. Fuel system to incorporate lift pump of unit on test, connected through a filter to the injection pump, with the relief valve set to give 13 to 15 p. s. i. on the inlet side of the filter. Pressure drop across the filter not to exceed 2 p. s. i.

SPECIAL TOOLS

	Si	PECIAL TOOLS
ROLLS-ROYCE PART NO.	C.A.V. PART NO.	DESCRIPTION
GA.7		Extractor, injection pump coupling
GA.304		Reamer, fuel injector sleeve in cylinder head
GA.307		Holder for GA.304
GA.299		Cutter, fuel injector sleeve in cylinder head
GA.23		Holder for GA.299
GA.24		Box for GA.23, 299, 304 and 307
OE.3311		Spanner, fuel injector securing nuts
OD.5162	ET.003	Spanner, fuel gallery closing plug
OD.5163	ET.008	Extractor, mechanical governor assembly
OD.5927	ET.011	Key, coupling
OD.5164	ET.026A	Extractor, camshaft bearing inner race
OD.5165	ET.026B	Extractor, camshaft bearing outer race
OD.5166	ET.028A	Forceps, tappet
OD.7974	ET.065	Spanner, mechanical governor spring nuts
OD.5167	ET.068	Wire brush, injector cleaning
OD.5168	ET.070	Scraper, injector valve seat
OD.5169	ET,071	Scraper, injector body
OD.5170	ET.072	Tool, injector nozzle valve cleaning
OD,5925	ET.078	Tool, nipple forming
OD.5171	ET.112	Spanner, mechanical governor nut
OD.5172	ET.116	Spanner, injector nozzle cap nut
OD.5173	ET.117	Spanner, injector nozzle spring cap nut
OD.5174	ET.119	Spanner, compression screw
OD.5175	ET.120	Probing tool, fuel injector
OD.5176	ET.121	Spanner, nozzle holder cap nut
OD.5177	ET.122PA	Outfit, injector nozzle setting
OD.5178	ET.137	Tool, injector flushing
OD.5179	ET.141	Kit, injector cleaning
OD.5218	ET.142	Container, petrol
OD.5290	ET.411	Needle for use with OD.5180
OD.5291	ET.412	Needle for use with OD.5180
OD.5292	ET.413	Needle for use with OD.5180
OD.5293	ET.414	Needle for use with OD.5180
OD.5180	ET.426	Broaching tool, injector nozzle spray holes
OD.5219	ET.428A	Forceps, tappet (superseded by ET.859)
OD.5924	ET.432	Seat lap, feed pump
OD.5930	ET.533	Cleaning kit
OD.5181	ET.537	Bench plate, injector
OD.5182	ET.562	Guide, control rod bush reamer

ROLLS-ROYCE PART NO.	C.A.V. PART NO.	DESCRIPTION
OD.5183	ET.562A	Guide, control rod bush reamer
OD.5184	ET.563	Reamer, control rod bush
OD.7050	ET.634	Gauge, camshaft end float
OD.5185	ET.648	Holder, tappet, R.H.
OD.5186	ET.649	Holder, tappet, L.H.
OD.5187	ET.650	Base plate
OD.5188	ET.652	Spanner, closing plug
OD.5189	ET.654	Hook, phasing washer
OD.5190	ET.655	Spanner, delivery valve holder
OD.5191	ET.658	Key, hydraulic governor control rod bush locking collar
OD.5192	ET.661	Spanner, splined socket
OD.5193	ET.668	Extractor, hydraulic governor control rod bush
OD.5194	ET.684	Cap, protection
OD.7975	ET.692	Extractor, hydraulic governor control plunger sleeve
OD.5918	ET.693	Extractor, hydraulic governor muff coupling nut and idling valve body
OD.5917	ET.695	Extractor, hydraulic governor muff coupling
OD.7976	ET.696	Tool, hydraulic governor lever
OD.5195	ET.700	Spanner, special
OD.5196	ET.702	Spanner, special
OD.5928	ET.703	Base plate, governor
OD.7977	ET.704	Adapter, hydraulic governor test equipment
OD.7732	ET.707	Key, servo piston rod bush
OD.7731	ET.709	Tap, relief valve housing threads
OD.7692	ET.710	Spanner, governor housing nuts
OD.5197	ET.712	Bar and extractor
OD.7978	ET.713	Extractor, hydraulic governor sleeve
OD.5926	ET.714	Gauge, phasing shims
OD.5198	ET.715	Gauge, plunger clearance
OD.5220	ET.716	Extractor, delivery valve seating
OD.5199	ET.717	Support, pump holding
OD.5200	ET.718	Cutter, facing
OD.5201	ET.719	Extractor, plunger
OD.5919	ET.730	Spanner, hydraulic governor internal retaining nut
OD.5920	ET.731	Spanner, closing plug
OD.5923	ET.733	Test ring
OD.5929	ET.743	Seat lap
OD.5921	ET.825	Test fixture, amplifier valve
OD.5922	ET.832	Test fixture, relief valve
OD.5219	ET.859	Forceps, tappet

TEST SCHEDULE

C.A.V. Hydraulic Governor LHF30MC

for Series 823 C8.NFLH Engines Rated 238 b.h.p. at 1,880 r.p.m.

Relief valve setting at 1,00	0 p.r	.p.m.				
H.P. valve			(2.2)	111	1615	59 to 63 p.s.i.
L.P. valve	*101	*1*	7555	10.0	++-	35 to 37 p.s.i.
Idling speed setting	+ +	114		4.9	2.	180 p.r.p.m.
Idling closing pressure	227					30 ± ½ p.s.i.
Idling fuel setting	500	+1+1	1.5		to 4.	c.c. per 100 strokes
Maximum fuel setting at	600	p.r.p.n		12.5	to 12.7	c.c. per 100 strokes
Governor 'cut-in' speed	1.	7.	2	6	V	910 to 930 p.r.p.m.
Complete 'cut-off' speed		***		(100	1,040 p.r.p.m.
Maximum hysteresis		137	11	-	100	20 p.r.p.m.
Feed pump pressure	71	2.0	8.4	22		13 to 15 p.s.i.

TEST SCHEDULE

C.A.V. Fuel Pump for Series 138A and 138B Engines

Engine power rating 180 b.h.p. at 1,800 r.p.m.

Pump r.p.m.	Pump r.p.m. Average fuel delivery cu. mm. per stroke		Remarks
Fuel setting			
600	138 to 142	Maximum	Set on control lever stop
600	115 to 117	Maximum	Set on rack stop. Spread between elements not to exceed 6 cu. mm.
940	123 to 126	Maximum	Spread between elements not to exceed 7 cu. mm.
Maximum speed setti	ing		
940	123 to 126	Maximum	Check that governor does not cur fuel before this speed. Adjust governor spring load as necessary
960	Delivery reduced	Maximum	W 25
1,020	Nil	Maximum	Complete fuel cut off
Idling setting			
180	36 to 40	Minimum	Set idling stop
330	NII)	Minimum	Complete fuel cut off
Excess fuel check	461	403	
100	164 approx.	Maximum	Obtained by operating excess device
1,020	Nil	Maximum	To disengage excess device
600	115 to 117	Maximum	To check that excess device is disengaged
Stop control check			TO SHOW THE
100	Nil	Maximum	Check that stop control will com- pletely cut fuel
Internal foul check			
1,400	Nil	Maximum	Run up to this speed to check that no internal foul occurs

Essential features of test rig

Hartridge BDN 12S D12 nozzles in BK B50 nozzle holders set at 175 atmospheres.

High pressure pipes must be 6 mm. outside diameter and have a bore of 2 mm.

Fuel system to incorporate lift pump of unit on test, connected through a filter to the injection pump, with the relief valve set to give 15 lb. per sq. in. on the inlet side of the filter. Pressure drop across the filter not to exceed 2 lb. per sq. in.

TEST SCHEDULE

C.A.V. Fuel Pump for Series 803 and 823 Engines

Engine power rating 238 b.h.p. at 1,880 r.p.m.

Pump r.p.m.	p r.p.m. Average fuel delivery cu. mm. per stroke		Remarks
Fuel setting			
600	125 to 127	Maximum	Set maximum fuel stop. Spread between any two elements not to exceed 6 cu. mm.
910	129 to 132	Maximum	Spread between any two elements not to exceed 7 cu. mm.
Maximum speed sett	ing		
940	130 to 133	Maximum	Set internal maximum speed stor just contacting stop face. Se external maximum speed stop to commence cutting fuel 30 p.r.p.m lower
960	less than 130	Maximum	
1,030	Nil	Maximum	Complete cut off
Idling speed setting)		
140	36 to 40	Minimum	Set Idling stop
330	Nil	Minimum	Complete out off
Excess fuel check	11 5 5 5 1		SITZ
100	170 approx.	Maximum	Obtained by operating excess fuel device
1,030	Nil	Maximum	To disengage excess fuel device
600	125 to 127	Maximum	To check that the excess fuel device is disengaged
Stop control check			
100	Nil	Maximum	Check that stop control will completely cut fuel

Essential features of test rig

Hartridge BDN 12S D12 nozzles in BK B50 nozzle holders set at 175 atmospheres.

High pressure pipes must be 6 mm. outside diameter and have a bore of 2 mm.

Fuel system to incorporate lift pump of unit on test, connected through a filter to the injection pump, with the relief valve set to give 15 lb. per sq. in. on the inlet side of the filter. Pressure drop across the filter not to exceed 2 lb. per sq. in.

TEST SCHEDULE

C.A.V. Fuel Pump NNR8F100/176M for C8NFLH Series 821 Engines

Engine Power Rating 190 b.h.p. at 1,500 r.p.m.

Governor LVWB24M(228-750)

Pump r.p.m. Average fuel delivery cu. cm. per stroke		Control lever setting	Remarks	
Fuel setting				
600	12.5 to 12.7	Maximum	Set maximum fuel stop. Spread	
750	12.8	Maximum	between any two elements not to exceed 0.6 cu. cm.	
Maximum speed setting	g			
750	12.6 to 12.9	Maximum	Set maximum speed stop	
760	Less than 12.6	Maximum	Governor commencing to cut fuel	
780	Nil	Maximum	Complete fuel cut off	
Idling setting	3.7			
Set at lowest	1 3 3 33	20	7 7 2 0	
speed that		(()		
will govern	-	Minimum	Set idling stop	
Set speed plus 150	Nil	Minimum	Complete fuel cut off	
pius 150	4544	Minimum	Complete fuel cut on	
Excess fuel check				
100	18.2	Maximum	After operating excess fuel plunge	
830	Nil	Maximum	To disengage excess fuel device	
600	12.6	Maximum	Disengagement check	
Internal foul check				
1400	_	Maximum	Run up to this speed and check that no internal foul occurs	
Stop control check				
100	_	Maximum	Check stop control will completely cut fuel	

Essential features of test rig

Hartridge BDN12SD12 nozzles in BKB50 nozzle holders set at 175 atmospheres.

High pressure pipes must be 6 mm. outside diameter and have a bore of 2 mm.

Fuel pump to incorporate lift pump of unit on test, connected through a filter to the injection pump, with the relief valve set to give 15 p.s.i. on the inlet side of the filter. Pressure drop across the filter not to exceed 2 p.s.i.

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L.S.D. 803 SEC, 18A

SECTION 18A . . COOLING SYSTEM

VERTICAL ENGINE

DESCRIPTION

Coolant is drawn from the bottom of the radiator by a belt-driven centrifugal pump and is delivered to the engine coolant inlet gallery either directly or via a heat exchanger which serves as a heating or cooling medium for the engine lubricating oil. After circulating around the liners in the crankcase and through the coolant passages in the cylinder head, the coolant is returned to the radiator header tank.

A thermostat is fitted in the cooling system to give rapid initial warming-up and thereafter to assist in maintaining the coolant at its correct working temperature under all conditions. It is located in the top of the coolant pump casing, and operates by blocking the flow of coolant from the cylinder heads to the radiator as long as the temperature is below a predetermined minimum, and then permitting the flow to gradually increase as the temperature of the coolant rises until, after a predetermined maximum temperature is reached, the full cooling capacity of the radiator is used.

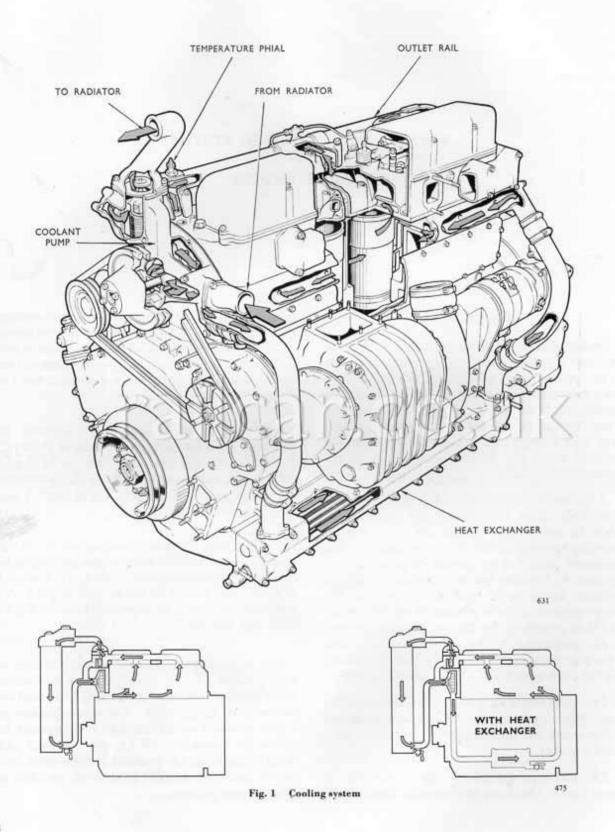
Two types of blocking thermostats are available: one type incorporates temperature-sensitive bellows, and the other temperature-sensitive waxfilled capsules.

The wax-type thermostat fig. 3, consists of three valves which are individually operated by three wax-filled capsules. Coil compression springs are incorporated to ensure positive closing action of the valves when the coolant falls below a predetermined temperature. It should be noted that when a wax thermostat is used a sleeve is fitted in the thermostat housing.

Bellows-type thermostats are available as 'summer' units which begin to open at 72 deg.C. (161.6 deg.F.) and are open fully at 85 deg.C. (185 deg.F.), and as 'winter' units with corresponding temperatures of 80 deg.C. (176 deg.F.) and 95 deg.C. (203 deg.F.).

The wax-type thermostat is designed for all the year round use. Of the three valves one begins to open at a temperature of 77 deg.C. (171 deg.F.) and the other two at 82 deg.C. (180 deg.F.). All valves are fully open at between 93 and 96 deg.C. (200 and 205 deg.F.).

For many applications the cooling system is pressurized to raise the boiling point of the coolant and a pressure-vacuum relief valve is located on the radiator header tank. The valve operates as a spring-loaded safety valve to vent pressure in excess of 10 p.s.i. (0.70 kg. per sq. cm.) and to admit air when the pressure in the system falls to less than 1 p.s.i. (0.07 kg. per sq. cm.) below atmospheric pressure.



COOLANT

Neglect of the cooling system will lead to serious damage due to 'sludging', corrosion and acidic attack. To prevent this it is essential that the following instructions are strictly complied with.

The use of plain uninhibited water as a coolant is not recommended, as it may promote rusting within the cooling system. If at any time its temporary use is unavoidable, 2 per cent Shell Dromus B soluble oil or 0.5 per cent Regent Caltex soluble oil C should be added.

When operating conditions are such that protection against freezing of the coolant is not required, the use of an approved inhibitor in clean water will provide protection against corrosion of the cooling system.

When protection against moderate frost is required a coolant mixture consisting of 30 per

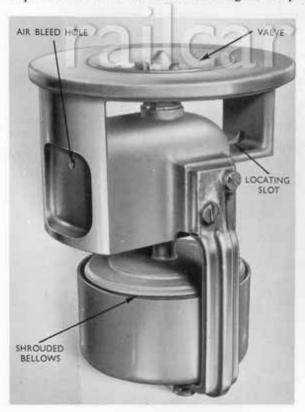


Fig. 2 Bellows type thermostat

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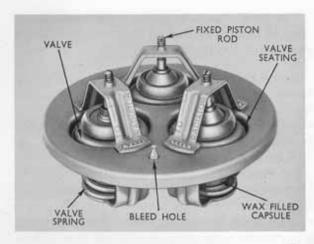


Fig. 3 Wax thermostat

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cent approved inhibited ethylene glycol and 70 per cent clean water should be used. In addition to providing protection against corrosion, this mixture prevents 'mushing' and allows full pump circulation down to 4 deg.F. (-16 deg.C.) and does not freeze solid until -28 deg.F. (-33 deg.C.).

In temperatures between 4 and -15 deg.F. (-16 and -27 deg.C.), a coolant mixture consisting of 55 per cent approved inhibited ethylene glycol and 45 per cent clean water must be used, and in temperatures between -15 and -40 deg.F. (-27 and -40 deg.C.) the strength must be increased to 60 per cent approved inhibited ethylene glycol and 40 per cent clean water. These concentrations are required to ensure complete fluidity of the coolant which is necessary for the satisfactory operation of the coolant heaters at these temperatures.

In temperatures between -40 and -65 deg.F. (-40 and -54 deg.C.), a coolant mixture consisting of 20 per cent β Methoxy — Methoxy Ethanol, 45 per cent approved inhibited ethylene glycol and 35 per cent clean water is recommended.

Before inhibited ethylene glycol solution or inhibited water is used in a cooling system in which either plain water or water and soluble oil has previously been used, the system must be thoroughly cleaned with 'Lissapol N' or 'Texofor F' as described under 'Cleaning the coolant system'.

The level of coolant in the radiator should be checked frequently, and all hose connections and joints examined for leaks.

Except for making up losses due to evaporation in unpressurized systems, cooling systems containing either ethylene glycol solution or inhibited water must not be 'topped up' with plain water, as the mixture in the system will thereby be weakened. A mixture of either ethylene glycol and clean water or inhibitor and clean water, as appropriate, to the same formulation and of the same proportions as the coolant already in the system, must always be used. Ethylene glycol preparations or inhibitors to different formulations must never be mixed.

When an inhibited ethylene glycol solution is used as a coolant it is most important that it is kept at the recommended strength; for this reason frequent specific gravity tests should be made. To carry out the test, draw approximately one pint (568 c.c.) of coolant from the system immediately after the engine has been stopped, while the coolant is still at a normal operating temperature and before any solids in the coolant have settled. Measure the specific gravity and temperature with a suitable hydrometer and thermometer. The correct specific gravity at various temperatures, with limits of mixture strength, is given in fig. 4.

The coolant must be changed every six months. This is necessary because anti-corrosion inhibitors dissipate gradually during service. Periodical changing of the coolant also ensures that the pH value, which is a measure of the acidity or alkalinity of the coolant, will be automatically maintained at a neutral value, except in a few isolated places where the water is particularly unsuitable for use in cooling systems, in which case

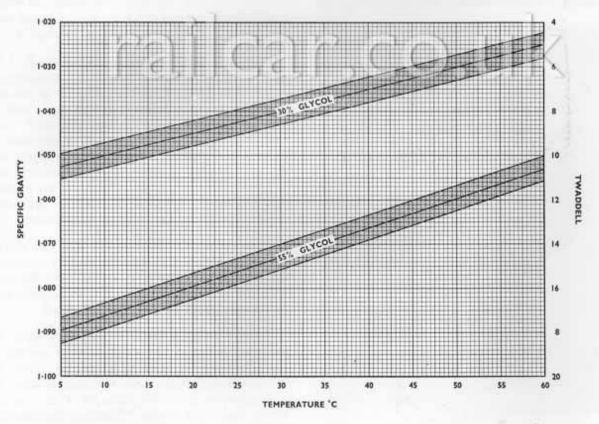


Fig. 4 Specific gravity at various temperatures

the acidity of the coolant should be frequently tested by the use of indicator papers, or the services of a public analyst called upon for a more detailed periodical analysis.

Whenever the coolant is changed the system must always be flushed through with clean water before refilling. If a change is made from inhibited ethylene glycol solution to inhibited water, the same inhibitor formulation must be used.

RECOMMENDED ANTI-FREEZE PREPARATIONS

The following proprietary brands of inhibited ethylene glycol anti-freeze are approved for use in the cooling systems of Rolls-Royce diesel engines:

Trade Name

Manufacturer

SPECIFICATION D.T.D. 779

'Boots Anti-Freeze'	Boots Limited, Nottingham		
'Silkolene 779'	Daltons Limited, Belper, Derby		
'Dragonfly'	R. D. Nicholls Limited, Sheffield		
'Vitafreeze'	Vigzol Oil Company Limited, 10 Eastney Street, Greenwich, London, S.E.10		
'Snowdrift'	Snowdrift Lubricants Limited Eccleston Street, London, S.W.1		
'Lautol'	James Light and Son Limited, 20 Hermitage Wall, London, E.1		
'Antifreeze'	Midland Paint and Oil Company Limited, 26 Marshgate Lane, London, E.15		
'SBS/779'	Smith Bros. and Co. (Chemicals) Limited Marshgate Lane, Stratford, London, E.15		
'Femol Blue'	Fletcher Miller Limited, Alma Mills, Hyde, Cheshire		
'Polar Blue'	Germ Lubricants Limited, Bloom Street, Salford, Manchester 3		
'Syncol'	Synthite Limited, West Bromwich		
'Thermidor'	Petrofina (G.B.) Limited, 25 Victoria Street (South Block), London, S.W.1		
'Petromor'	Manchester Oil Refinery Limited, 76 Jermyn Street, London, S.W.1		

SODIUM BENZOATE/SODIUM NITRITE

'Esso Antifreeze'	Esso Petroleum Limited, 36 Queen Anne's Gate, London, S.W.1		
'Golden Film'	Morris and Co. (Shrewsbury) Limited, Welsh Bridge, Shrewsbury		
'Speedwell'	Speedwell Lubricants Limited, Speedwell House, Earls Court Road, London, S.W.5		
'SBS/BN'	Smith Brothers and Company (Chemicals) Limited, Marshgate Lane, Stratford, London, E.15		
'Chemico Formula 79'	County Chemicals Limited, Chemico Works, Shirley, Solihull, Warwickshire		

T	ra	de	e	N	a	m	e

Manufacturer

'Femol W'	Fletcher Miller Limited, Alma Mills, Hyde, Cheshire		
'Sternol'	Sternol Limited, Royal London House, Finsbury Square, London, EC.2		

SODIUM TETRABORATE

'SBS/DLX	Smith Brothers and Co. (Chemicals) Ltd., Marshgate Lane, Stratford, London, E.15		
'Petromor'	Manchester Oil Refinery Limited, 76 Jermyn Street, London, S.W.1		
'Femol Red'	Fletcher Miller Limited, Alma Mills, Hyde, Cheshire		
'Permazone'	Mobil Oil Company Limited, Caxton House, Westminster, London, S.W.1		
'Polar Green'	Germ Lubricants Limited, Bloom Street, Salford, Manchester 3		
'Kilfrost'	Kilfrost Limited, Drayton House, Gordon Street, London, W.C.1		
'Foyl D'	Falcon Oil Company, Praed Road, Trafford Park, Manchester 17		
'Zerocol'	Liberty Oils Limited, 1 York Street, Twickenham, Middlesex		

RECOMMENDED INHIBITORS

The following proprietary brands of inhibitor are approved for use when water is used in the cooling system of Rolls-Royce diesel engines:

Trade Name	Manufacturer	Recommended proportions
	SPECIFICATION D.T.D. 779	
'SQ.36'	Marston Lubricants Limited, Rockferry, Birkenhead	3 fluid oz. per Imp. gallon of water (19 c.c. per litre)
	SODIUM BENZOATE/SODIUM NIT	RITE
'Golden Film Rust-Gard'	Morris and Co. (Shrewsbury) Limited, Welsh Bridge, Shrewsbury	½ pint to each 7½ pints of water (67 c.c. to each litre)
'Sobenite 10'	W. J. Bush Company Limited, Ash Grove, Hackney, London, E.8	2 to 2½ oz. per Imp. gallon of water (13 to 16 gr. per litre)
'Silkolene 829'	Dalton and Co. Limited, Belper, Derby	2 oz. per Imp. gallon of water (13 gr. per litre)

Trade Name

Manufacturer

Recommended proportions

SODIUM TETRABORATE

'Inhibitabs'

Smith Bros. and Company (Chemicals) Limited, Marshgate Lane, Stratford, London, E.15 1½ to 1½ oz. per Imp. gallon of water (8 to 10 gr. per litre). Tablets to be predissolved

Note: When ordering anti-freeze preparations or corrosion inhibitors it is advisable to stipulate the formulation as well as the trade name, e.g. "'Petromor' D.T.D. 779" or "'Petromor', Sodium Tetraborate". This will avoid any possibility of inadvertently mixing formulations in a cooling system when two or more formulations are obtainable under any particular trade name.

FILLING THE COOLING SYSTEM

It is essential that the ingredients which constitute the coolant are thoroughly mixed before being introduced into the system. To do this, ascertain the capacity of the particular system to be filled, pour into a suitable clean mixing tank sufficient clean water and approved inhibited ethylene glycol or inhibitor to obtain the required quantity in the recommended proportions, and stir until the coolant is thoroughly mixed. When bulk quantities of pre-mixed coolant are held against future requirements, always stir the coolant thoroughly immediately before drawing off the amount required for any particular filling or topping-up operation.

Close the drain cocks on the radiator and on the crankcase or oil-to-coolant heat exchanger.

Open the radiator filler cap and pour in coolant through a fine mesh filter until it is approximately 3 in. below the filler neck. Close the filler cap.

After filling it is advisable to run the engine for a short period at between 800 and 1,000 r.p.m. to circulate the coolant quickly and sweep out any air pockets in the system. Stop the engine before the coolant temperature exceeds 104 deg.F. (40 deg.C.).

Open the radiator filler cap and check the coolant level. If necessary, add coolant to restore the level, and close the filler cap.

At temperatures in excess of 149 deg.F. (65 deg.C.) a pressure exists in the system, and it is unsafe to open the filler cap.

DRAINING THE COOLING SYSTEM

Before draining the system, start the engine and warm up to a coolant temperature of not more than 122 deg.F. (50 deg.C.). Stop the engine, open the radiator filler cap and the drain cocks, and drain as quickly as possible while the sediment is still in suspension.

If a liquid-cooled air compressor is fitted, remove the drain plug from the compressor head.

If in cold weather the system is drained instead of an anti-freeze mixture being used, a notice stating that the cooling system is empty must be placed in a prominent position, to prevent the engine being started before filling the system. The head of the air compressor must be drained if an anti-freeze mixture is not used.

CLEANING THE COOLING SYSTEM

For periodic cleaning of the cooling system, flush through with copious quantities of clean water until it runs clean from the drain cocks.

If the system is badly contaminated, 'Lissapol N' or 'Texofor F' are recommended as the most satisfactory cleaning agents. A solution strength of 1 per cent or 45 c.c. of 'Lissapol N', or 0.25 per cent or 12 c.c. of 'Texofor F', to every gallon of coolant in the system has been found the most effective and should be applied in the following manner:

Open the radiator filler cap, check that the coolant level is low enough for the purpose and pour into the existing coolant in the system sufficient 'Lissapol N' or 'Texofor F' to obtain the recommended concentration. Close the filler cap.

Start the engine and warm up to a coolant temperature of 140 deg.F. (60 deg.C.). Open up to 1,800 r.p.m. and run for 10 minutes, then stop the engine and drain the system as soon as the coolant temperature falls to 122 deg.F. (50 deg.C.).

Refill the system with clean water, allowing a gallon or more to run to waste before closing the drain cocks. Start the engine and run at 1,800 r.p.m. for 5 minutes, then stop the engine and drain the system.

COOLANT PUMP

Two types of pumps are fitted to vertical engines to suit varying installation requirements. Both pumps are basically similar, the differences being confined to the length of the rotor shafts, the shape of the bearing housings, the disposition of the ball and roller bearings in the bearing housing, and the type of oil seal fitted in the front of the bearing housings.



Fig. 5 Removing the coolant pump

Where the dismantling and assembling of the two types of pumps varies slightly, they are dealt with separately under 'Dismantling' and 'Assembling'.

REMOVAL

Drain the system down to an adequate level.

Release the tension in the pump driving belts by slackening off the adjusting screw on the dynamo mounting and remove the belts.

Remove the cooling fan.

Slacken off, but do not remove, the bolt securing the dynamo to the mounting plate and release the hose connection between the coolant outlet rail and the pump.

Remove the setbolts securing the pump outlet branch pipe and break the joint.

Release the top hose connection on the pipe between the pump and the radiator.

Remove the setbolts securing the pump assembly to the cylinder block, and withdraw the assembly.

DISMANTLING

Release the securing nuts and bolts and remove the backplate from the pump assembly.

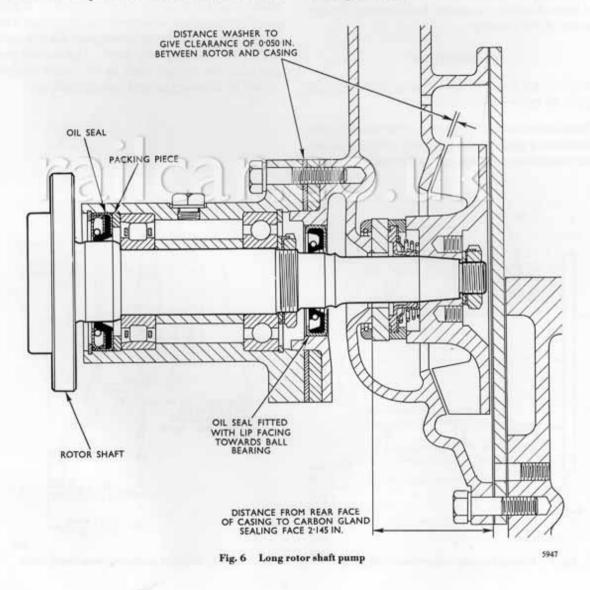
Remove the setbolts and washers or nuts and washers securing the driving pulley to the pump, and withdraw the pulley.

Unscrew the nut securing the rotor to the shaft, withdraw the locking washer and keywasher, and extract the rotor assembly, using the tool GA.7. Remove the circlip from the forward end of the

rotor assembly and withdraw the carbon gland ring, rubber seal and housing, spring and rubber seal retaining ring, in that order, from the rotor.

Remove the six setbolts securing the bearing housing to the pump casing and withdraw the bearing housing, adjusting washer and the dynamo mounting plate. Withdraw the oil seal.

Unscrew the locknut from the rotor shaft and remove the tabwasher and keywasher. Extract the bearing retaining circlip from the rear of the bearing housing.



9

Withdraw the rotor shaft through the front of the bearing housing.

Long rotor shaft pump, fig. 6

Extract the circlip from the front of the bearing housing and withdraw the front oil seal, oil seal packing piece, roller bearing and distance piece through the front of the housing. Withdraw the ball bearing through the rear of the housing.

Short rotor shaft pump, fig. 7

Withdraw the front oil seal through the front of the bearing housing, and the roller bearing, inner and outer distance pieces and ball bearing through the rear of the housing.

INSPECTION

Thoroughly clean all the pump components and inspect all items for serviceability.

Test the rotor shaft ball and roller bearings for freedom and smooth action; if any rough spots are detected the bearings should be renewed.

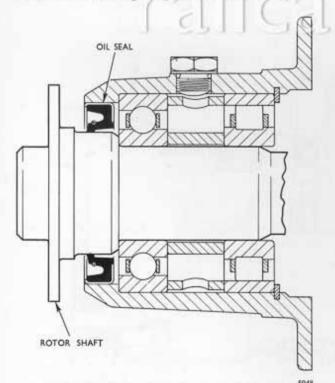


Fig. 7 Bearing housing - short rotor shaft pump

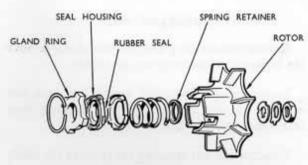


Fig. 8 Rotor assembly exploded

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Examine the carbon ring driving slots on the pump rotor for wear on the driving edges; if necessary, file the edges to remove any shoulders which might prevent the carbon ring from seating on the sealing face in the pump body. The carbon gland ring and the rubber seals in the rotor assembly should be renewed at each pump overhaul.

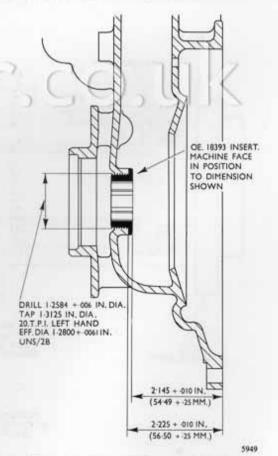


Fig. 9 Detail of machining when fitting insert

Examine the gland sealing face in the pump body for scoring and uneven wear. If either or both of these defects are found, a phosphor-bronze insert OE.18393 must be fitted to the pump body, as described in 'Fitting the sealing face insert'. If, during subsequent overhauls, the face of the insert is found to be worn or scored, the defective insert should be removed and a new insert fitted. Whenever an insert is renewed the face of the new insert must always be finish machined in position to obtain a dimension of 2.145 in. (54.49 mm.) between the joint face of the pump casing and the face of the insert.

Fitting the sealing face insert

Machine the pump casing to the dimensions shown in fig. 9, ensuring that the face is square with the newly machined thread. Screw in the insert OE.18393, using a length of hexagon bar in the hole in the insert. Machine the face of the insert to give a dimension of 2.145 in. (54.49 mm.) between the joint face of the casing and the face of the insert, taking care that the face is square to the bore.

For subsequent reclamation of the gland scaling face, fit a new insert in place of the old one and machine to the dimensions given in the preceding paragraph.

ASSEMBLING

Long rotor shaft pump

Fit the roller bearing, packing piece and oil seal, in that order, to the front of the bearing housing, and secure with the circlip in the groove in the front of the housing. The oil seal must be fitted with the lip facing outwards. Pack the bearing housing half full with Shell Retinax 'A' grease and fit the distance piece and ball bearing through the rear of the housing, and secure the bearing in position with the circlip in the groove in the rear of the housing.

Short rotor shaft pump

Fit the ball bearing and the inner and outer distance pieces through the rear of the bearing housing and ensure that the outer race of the ball bearing abuts the shoulder in the front of the housing. Pack the bearing housing half full with Shell Retinax 'A' grease, and fit the roller bearing and retaining circlip. Fit the oil seal in the front of the housing with the lip facing outwards.

Note: On no account should a grease nipple be fitted in place of the bearing housing sealing plug. Greasing between overhauls is unnecessary and can cause damage to the oil seals.

Assemble the rotor shaft to the bearing housing and fit the keywasher, tabwasher and retaining nut. Tighten and lock the nut.

Fit the oil seal in the front of the pump casing, with the lip facing *outwards*, i.e. towards the ball bearing when the bearing housing is fitted.

Fit the dynamo mounting plate, adjusting washer and bearing housing to the pump casing and secure with the setbolts and spring washers. Ensure that the chamfer of the dynamo mounting plate is to the housing radius.

Assemble the rotor in the order shown in fig. 8, and fit the rotor, keywasher, tabwasher and retaining nut to the shaft. Tighten the nut, but do not lock it at this stage.

Measure the clearance between the front of the rotor blades and the pump casing; it must be 0.050 in. (1.27 mm.). If necessary, re-adjust by varying the thickness of the adjusting washer fitted between the bearing housing and the dynamo plate. Adjusting washers are supplied 0.060, 0.065, 0.070 and 0.075 in. (1.524, 1.651, 1.778 and 1.905 mm.) thick. Lock the rotor retaining nut when the correct clearance has been obtained.

Fit the backplate to the pump casing, using a new joint washer, and secure with the retaining bolts, nuts and spring washers.

Fit the driving pulley to the front of the pump shaft.

REFITTING

Fit the pump assembly to the cylinder block, using a new joint washer, and secure with the setbolts and spring washers. Refit all parts removed during the removal of the pump, using new joint washers and rubber hose connections throughout. Adjust the driving belts to give a total deflection of 1 in. at a central point on the longest length of belt.

COOLANT THERMOSTAT

REMOVAL

Drain the coolant down to an adequate level.

For access, remove the coolant outlet branch pipe from the top of the coolant pump by removing the four setbolts at the flange joint on the top of the pump casing and the hose connection at the inlet to the radiator.

Withdraw the thermostat from the casing, using the extractor GA.15 if the thermostat is of the bellows type. Withdraw the sleeve which is fitted in the coolant pump body when a wax-type thermostat is fitted.

Neither the bellows type nor the wax type thermostat can be dismantled or adjusted.

INSPECTION

Thoroughly clean the thermostat, using a solution of 1 per cent 'Lissapol N', i.e. 45 c.c. 'Lissapol N' per gallon of water, or 0.25 per cent 'Texofor F' i.e. 12 c.c. of 'Texofor F' per gallon of water.

Carry out a visual examination, ensuring that the valve faces and either the bellows or capsules and springs are in good condition. If the blocking valve or valves are in the open position the unit is unserviceable and must be renewed.

Suspend the assembly and a thermometer of known accuracy in water and gradually heat the water, stirring it to maintain a uniform temperature throughout. Check that the blocking valve or valves operate at the following temperatures:

	deg.C.	de	g.F.
Bellows thermostat ('Sumi	mer 'type)		
Opening temperature	72 ± 2	161.6	$5 \pm 3 +$
Fully open temperature	85 ± 2	185	± 3½
Bellows thermostat ('Winte	er' type)		
Opening temperature	80 ± 2	176	± 34
Fully open temperature	95 ± 2	203	± 3½
Wax thermostat			
Opening temperature			
Leading valve	77 ± 1	171	± 2
Trailing valves	82 ± 1	180	± 2
Fully open temperature			
All valves	94.5 ±1½	202.5	5 ± 3

If a thermostat fails to function correctly a new unit must be fitted.

Ensure that the bleed hole in the thermostat, and in the sleeve which is fitted with the wax type thermostat, is unobstructed.

REFITTING

Refitting is the reverse of removal. Ensure that the locating screw in the coolant pump body registers with the locating slot in the bellows type thermostat or with the slot in the sleeve which is fitted underneath the wax type.

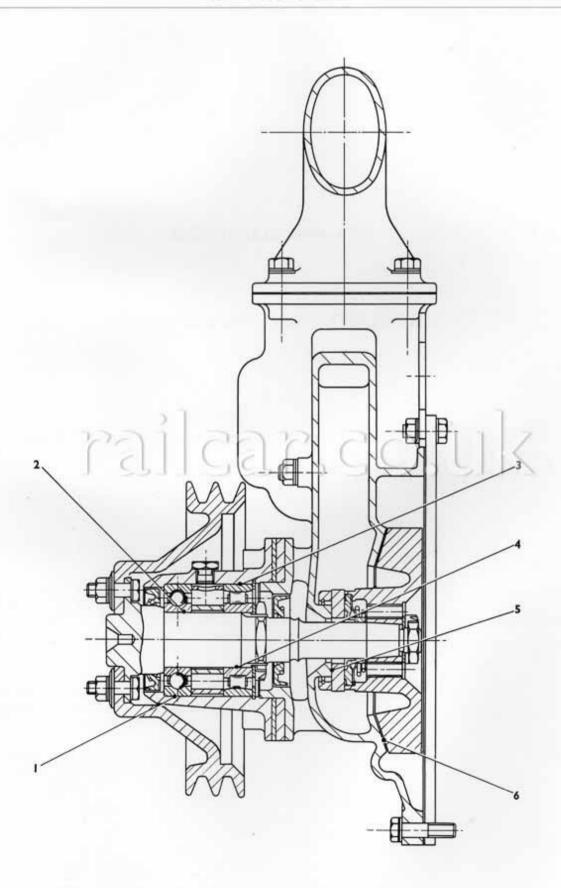
SPECIAL TOOLS

PART No.	DESCRIPTION
GA.7	Extractor, rotor assembly
GA.15	Extractor, thermostat
GA.38	D.E. box spanner, coolant
	pump rotor shaft
_	Hydrometer (proprietary)
-	Thermometer (proprietary)

FITS AND CLEARANCES

COOLANT PUMP - Vertical engines

railcar,co,uk



No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE NEW	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
1	ROTOR SHAFT BALL BEARING Bearing in housing Housing – bore Bearing – dia,	2.44075 to 2.44125 2.4405 to	Interfer. 0.00025 to 0.00075			
2	Bearing on shaft Bearing – bore Shaft – dia. ROTOR SHAFT ROLLER	2.441 1.1806 to 1.1811 1.18085 to 1.1811	Interfer. 0.0005 to 0.00025 Clearance			
3	BEARING Bearing in housing Housing – bore Bearing – dia.	2.44075 to 2.44125 2.4405 to 2.441	Interfer. 0.00025 to 0.00075 Clearance			
4	Bearing on shaft Bearing – bore Shaft – dia.	1.1806 to 1.1811 1.18085 to 1.181	Interfer. 0.0005 to 0.00025 Clearance			7
5	DEPTH OF GLAND FACE FROM CASING FACE	2.145 to 2.155	9	2.225 to 2.235	Ş.I.	Fit insert to reclaim face; Sec. 18A.
6	ROTOR AND CASING Clearance between rotor and casing		0.050			Adjust by shims to give this clearance.
					<u>.</u>	

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T.S.D. 803 SEC. 180

SECTION 18C . . COOLING SYSTEM

HORIZONTAL ENGINES

COOLANT

With the exception of the gear driven coolant pump and the thermostat location, the cooling system of the six or eight-cylinder horizontal engines is the same as for the vertical engines, and the instructions given in Section 18A for coolant, the filling, cleaning and draining of the system, should be followed.

COOLANT PUMP

REMOVAL

Drain the coolant system.

On normally aspirated engines where a compressor is fitted and is belt driven from a pulley on the crankshaft front end, slacken the driving belt adjuster and remove the belts. Release and remove the fixed belt pulley from the air compressor mounting bracket.

Release the hose connection on the branch pipe between the coolant thermostat and the pump, and release and remove the pipe.

Release and remove the hose connection between the radiator outlet and the pump, and the connection between the pump and the heat exchanger.

Release and remove the set-bolts securing the coolant pump front cover and remove the cover.

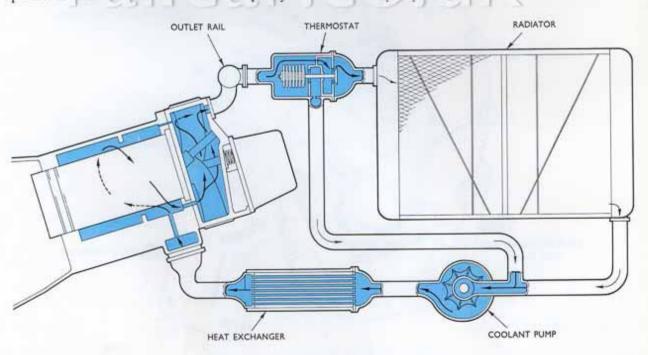


Fig. 1 Cooling system

Turn back the locking tab and unscrew the nut securing the rotor to the shaft. With the tool GA.7 withdraw the rotor from the shaft and extract the Woodruff key. Withdraw the front coolant seal from the rotor.

Withdraw the adjusting washer and carbon ring from the shaft.

Release and remove the four nuts and washers securing the coolant pump, and withdraw the pump casing from the wheelcase.

Withdraw the rear oil seal from the pump casing.

INSPECTION

Thoroughly clean all the pump components and inspect all items. Examine the rotor shaft roller bearing for freedom and smooth action, if any rough spots are present after being thoroughly washed out the bearing should be changed.

Examine the gland sealing face in the pump body for uneven wear and scoring, and if necess ary reclaim the face.

Reclaiming gland sealing face

For the first reconditioning, machining of the original face will normally restore the sealing face, but if the face is badly worn or has been previously machined an insert should be fitted.

Reclaiming the original sealing face

Open out the pump casing bore to the dimension given in Part 1 of the illustration and machine the sealing face until a smooth flat surface is obtained. Check the dimensions between the joint face of the casing and the newly machined sealing face; if this is more than 1.970 in. (50.038 mm.) an insert must be fitted as described in the following paragraphs.

Fitting the insert

Machine the pump casing to the dimensions shown in Part 2 of the illustration, ensuring that the

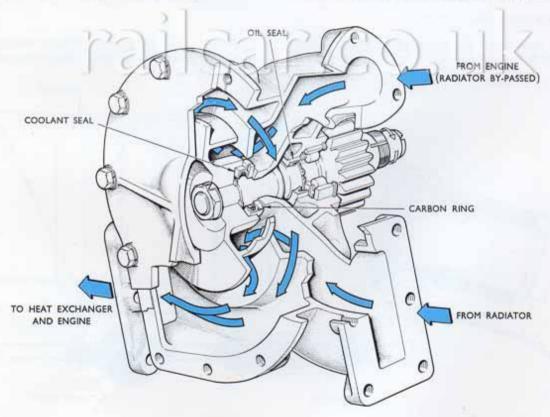


Fig. 2 Section through pump showing coolant flow

face is square with the newly machined thread. Screw in the insert OE.22854 using a length of hexagon bar in the insert hole.

Machine the face of the insert to give a dimension of 1.900 in. (48.26 mm.) between the joint face of the casing and the insert face, taking particular care that the sealing face is square to the bore.

Reclaiming of sealing face when insert is fitted

Machine the sealing face until a smooth, flat surface is obtained. Check the dimensions between the joint face of the casing and the newly machined sealing face; if this is more than 1.970 in. (50.038 mm.) the insert must be renewed.

Before assembling the pump, check the carbon ring driving slots in the pump rotor for wear on the driving edges, if present, file the edges to remove any shoulder which may prevent the carbon ring from seating on the sealing face.

ASSEMBLING AND REFITTING

Press a new rear oil seal into its housing in the rear of the pump casing.

Smear the joint face of the wheelcase and the rear of the pump casing with 'Heldite' and fit and secure the pump casing to the wheelcase.

Fit a new front coolant seal and carbon ring assembly to the rotor shaft. Smear the mating faces of the rotor and seal housing with 'Wellseal' or similar sealing compound.

Position the rotor clearance adjusting washer on the rotor shaft and fit the Woodruff key to the shaft. Fit the rotor to the shaft and fit and tighten the retaining nut. Check the clearance between the rotor and the pump casing which should be from 0.040 to 0.060 in. (1.016 to 1.524 mm.). Adjusting washers are available from 0.070 to 0.100 in. (0.762 to 2.540 mm.) in steps of 0.005 in. (0.127 mm.).

After adjusting the rotor clearance, remove the rotor nut and fit the locking washer, refit and tighten the nut and turn up the locking tab.

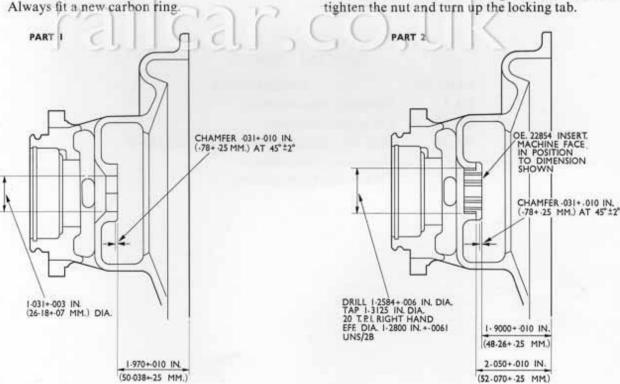


Fig. 3 Reclaiming the coolant pump gland face

Fit the front cover to the pump casing interposing a new 'Klingerit' joint between the joint faces, and tighten the securing set-bolts.

Fit and secure a new hose rubber at the connections between the radiator outlet and the pump, and the pump outlet and the heat exchanger.

Fit the branch pipe connecting the pump to the thermostat, to the pump, and fit and secure a new hose at the thermostat connection.

Refit all parts removed for access.

Ensure that all coolant drain cocks are in the 'off' position and refill the system with coolant.

COOLANT THERMOSTAT

The coolant thermostat is a separate unit located at the outlet end of the coolant rail and consists of a blocking valve operated by temperature sensitive bellows.

REMOVAL

Drain the coolant down to an adequate level.

For access, remove the coolant outlet branch pipe from the thermostat casing by removing the four set-bolts at the flange joint of the thermostat casing, and the hose connection at the inlet to the radiator.

Fit the extractor GA.15 and withdraw the thermostat.

The thermostat assembly cannot be dismantled or adjusted.

INSPECTION

Clean, inspect and test the thermostat as described in Section 18A.

If a thermostat fails to function correctly a new unit must be fitted.

REFITTING

Refitting is the reverse of removal. Ensure that the locating screw in the thermostat casing registers with the slot in the thermostat.

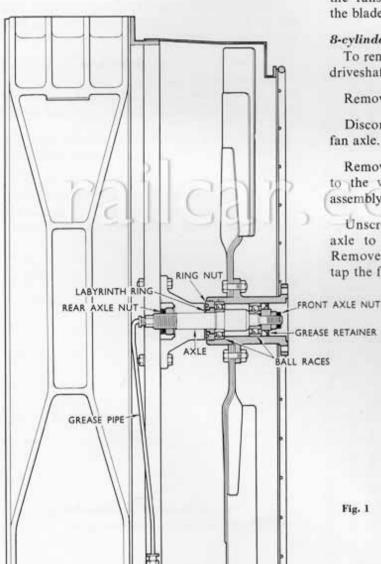
SPECIAL TOOLS

PART NO.	DESCRIPTION
GA.7	Extractor, rotor assembly
GA.15	Extractor, thermostat
GA.38	D.E. box spanner, coolant pump rotor shaft
222	Hydrometer (proprietary)
-	Thermometer (proprietary)

SECTION 18D . RADIATOR AND FAN

The interior condition of the radiator should not deteriorate if the specified coolant is used.

If, however, contamination is suspected, the radiator and cooling system should be cleaned by the method given under 'Cleaning the Cooling System', Section 18A.



Fan

The two ball races in the fan hub are lubricated from a single grease nipple situated underneath the fan cowling. Use Shell Retinax A grease or its equivalent.

The mounting of the fan hub differs slightly on the 6 and 8-cylinder power units; in other respects the fans are the same except for the size of the blades.

8-cylinder power units

To remove the fan, disconnect the Hardy-Spicer driveshaft from the fan hub, and tie the shaft clear.

Remove the fan guard.

Disconnect the grease pipe at its union on the fan axle.

Remove the bolts securing the fan axle housing to the vertical support, and withdraw the fan assembly.

Unscrew the grease pipe adapter from the fan axle to prevent the adapter being damaged. Remove the rear (large) axle nut, then carefully tap the fan axle out of its housing.

Fig. 1 Section through radiator and fan showing fan hub details for 8-cylinder engine

6-cylinder power units

To remove the fan, first disconnect and remove the Hardy-Spicer driveshaft, then detach the fan and cowl assembly from the radiator block.

Remove the fan guard from the cowl.

0

0

GREASE PIPE

RING NUT

Remove the grease pipe, and then unscrew the grease pipe adapter from the fan axle to prevent the adapter being damaged.

Remove the rear (large) nut from the fan axle. The fan assembly may then be detached from its housing by carefully tapping the axle through the housing while supporting the weight of the fan.

After removal of the fan assembly from the radiator the procedure given in the following paragraphs for dismantling the fan hub is the same for both the 6 and 8-cylinder power units.

Remove the fan blade assembly.

Using a suitable peg spanner, unscrew and remove the ringnut from the rear of the hub, then remove the labyrinth ring.

Remove the front nut from the axle, and also the grease seal distance piece. The axle, together with the rear bearing, can then be tapped out of the hub. Remove the rear bearing from the axle.

Withdraw the front bearing, together with the grease retainer, from the hub; this completes the dismantling.

When reassembling, fit a new grease retainer, and also examine the outer surface of the distance piece as this forms a land for the seal; renew if grooved.

LABYRINTH RING FRONT AXLE NUT REAR AXLE NUT GREASE RETAINER BALL RACES 0

4902

Fig. 2 Section through radiator and fan showing fan hub details for 6-cylinder engine

FOR HYDROSTATIC FAN DRIVE CAICAC.CO.UK

SERCK RADIATORS LIMITED
WARWICK ROAD, BIRMINGHAM 11.

Section

1 General Description, Operation, Individual Components.

Section

Installation.

Section

3 Commissioning.

Section

4 Servicing—Leakage Tests, Service Check, Removal and Replacement of Thermostat Element, Flexible Hoses.

SERCK TECHNICAL ADVISORY SERVICE

A record is kept of every unit and when information or spares are required, it is only necessary to quote the serial number on the nameplate. A service and repair organisation is available for maintenance, cleaning and overhaul of Serck equipment at short notice.

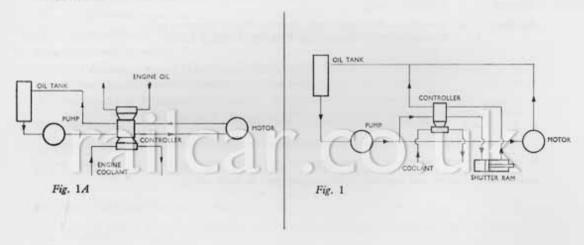
The Serck policy is one of continuous improvement and the Company reserve the right to modify the equipment described in this manual without prior notice.

Telephone: VICtoria 4353 Telex 33-141 Telegrams: SERCKRAD

GENERAL DESCRIPTION

The drive consists of a fixed displacement hydraulic pump driven from a suitable power take-off and coupled hydraulically to a fixed displacement hydraulic motor on which the fan is mounted. A controller, sensitive to the coolant temperature, governs the speed of the hydraulic motor through bypass regulation of the hydraulic fluid. The fourth component is an oil tank containing the hydraulic fluid and housing magnetic filters.

This is the basic system. There are several variants available. These may include radiator shutters operated by hydraulic rams which are connected to the hydraulic circuit (Fig. 1), or a twin controller actuated by two cooling fluids (Fig. 1A). Various sizes of controllers are available to suit the particular application.



OPERATION

Basic System

On starting, the hydraulic pump begins to rotate and the hydraulic fluid is wholly by-passed through the controller so that the fan motor does not rotate. When the coolant approaches the pre-selected temperature a thermostatic element in the controller actuates the hydraulic by-pass valve, allowing some of the fluid to pass to the fan motor, which starts to rotate. The speed of the fan increases until there is sufficient cooling to maintain the coolant at the pre-selected temperature. As the load on the engine is increased, so the fan runs at a correspondingly greater speed, always controlling the coolant at the desired value.

System with Shutter Ram

Shutters fitted to the radiators can easily be operated from the hydraulic system. The pressure from the hydraulic circuit is led to a hydraulic ram which operates the shutters. These are arranged to open at the bottom end of the fan speed curve just as the fan starts to rotate. Correspondingly, they are closed again just as the fan stops rotating. The radiator shutters close when no cooling is required and help to maintain temperature stability in the system.

System with Twin Controller

When there are two fluids to be cooled in the radiator equipment and only one fan to provide the cooling air, a twin controller can be incorporated.

In a twin controller the position of the valve is controlled simultaneously by the temperature of two separate fluids (e.g., engine jacket water and lubricating oil). The position of the valve and hence the speed of the fan depends upon which thermostatic element is extended farthest and thus the air flow is controlled by whichever fluid is nearest to its maximum design temperature at any particular instant. This system can be fitted with shutter ram control.

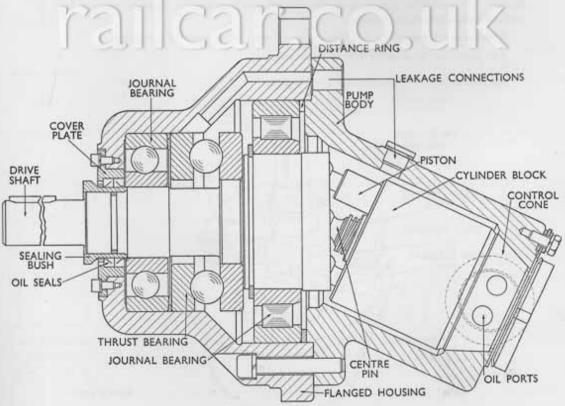
INDIVIDUAL COMPONENTS

(1) Axial Plunger Pumps and Motors

A standard range of these units is available, Fig. 2 shows a cross-section through a typical unit. In general it is preferable for the pump and motor units to run in opposite directions. The standard direction of rotation is MR/PL (motor right, pump left). The direction of rotation can be reversed; however, this involves an adjustment in the position of the valve plate while the unit is running and should only be carried out by a Serck Service Engineer.

On all installations where the pump is direct driven, a flexible coupling should be fitted. When the drive is by V-belt no other flexible member is required. To damp out vibration and noise, flexible rubber hoses are usually fitted to pump connections.

The axial piston pump/motor units have parallel shafts with fitted key. A collar on the inner end of the driving shaft locates the axial position of the driving or driven members and it is important that the coupling, pulley or fan should abut against this collar. On the S/12 unit which has a taper shaft this does not apply. Fans, pulleys, couplings etc., are secured by means of a set bolt which screws into a tapped hole in the end of each shaft. Pulleys, fans or couplings should be pressed and not driven onto the shaft.



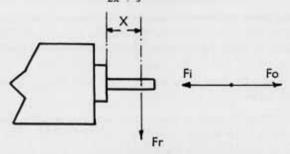
Axial Plunger Pump or Motor

Fig. 2

The table and sketch below illustrate the permissible forces on these shafts :-

Type	Inwar	ds Forces	Outwa	rds Forces	Dista	ance x		al Forces stance x
	Fi lb	Fi kg	Fo lb	Fo kg	in.	mm.	Fr lb	Fr kg
12 & S/12	175	79.38	85	38.55	0.75	19.05	185	83.91
16	350	158.76	175	79.38	1.0	25.40	415	188.24
20	505	229.06	260	117.99	1.25	31.75	630	286.56
25	780	353.80	395	179.18	1.50	38.10	935	424.11
32	1280	580.60	640	291.10	2.00	50.80	1590	711.22

For a radial force acting at a distance greater than x, the permissible force is reduced in the proportion $\frac{2x}{2x+s}$ where s is the increase in distance.



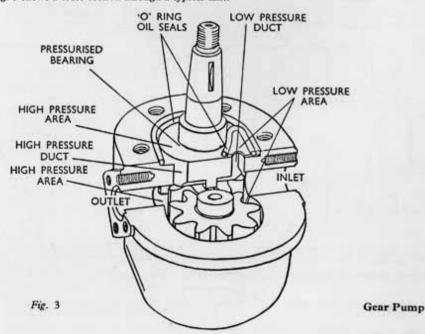
The axial piston units have a leakage connection. This connection is taken to the appropriate fittings on the fluid tank.

(2) Gear Pumps

In certain cases gear pumps are used. The bearings of the gear pumps are self-adjusting for wear and self-lubricating. Any side thrust transmitted through the drive will affect the balance of the bearings and the direct drive either through a chain or "oldham" type coupling, is therefore most suitable. If a belt drive must be used, the belt pull should oppose the hydraulic bearings loads to prevent undue wear of the bearings.

Rotation of the gear pump is not reversible and must be specified when ordering. The pump may be mounted directly to an engine.

Fig. 3 shows a cross-section through a typical unit.



(3) Controllers

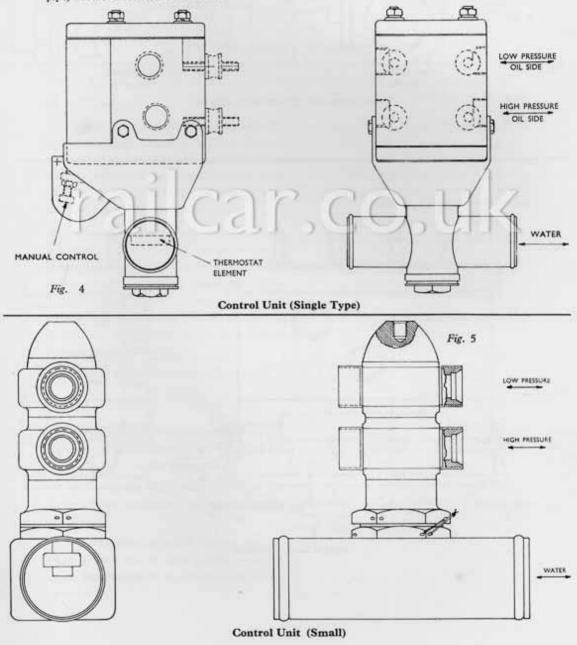
These are available in various types and sizes to suit the application as shown in Figs. 4, 5, 6, 7 and 8. The control temperature stated on the nameplate is the one at which the by-pass is fully shut, the fan thus running at maximum speed.

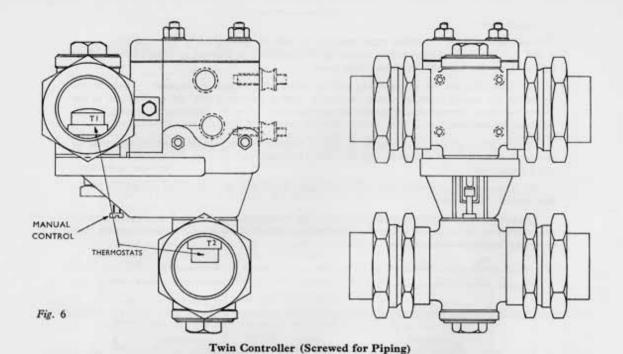
The controllers are set at our works and no adjustments should be necessary. However, the controllers are usually provided with a number of spacing washers 1 mm. thick. Removal of one washer will lower the control temperature by approximately 2 deg. F. Insertion of an extra washer will have the opposite effect.

Alternatively, a similar adjustment of the control temperature can be carried out by shortening the pin in the element if it is desired to raise the control temperature. To lower the control temperature, use a longer pin.

We strongly advise, however, that any adjustments which may be required be carried out by our own Service Engineers.

The coolant, the temperature of which is sensed by the controllers, must wash the thermal element and, depending on the type of fitting of the controller, it can either be put in a by-pass or on the main pipe, whichever is most convenient.

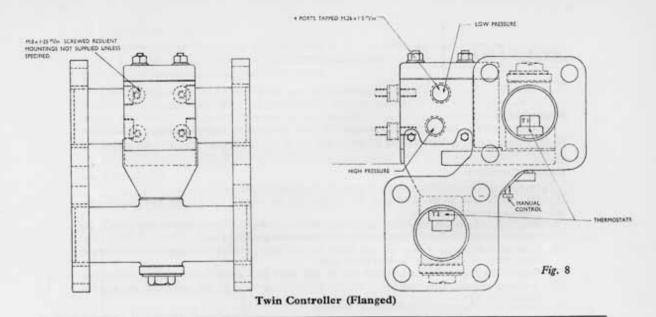




MANUAL
CONTROL
No. 1

THERMOSTATS
EV

Control Unit (Flanged)



(4) Oil Tanks

The tank should be a little above the pump inlet with a smooth pipe connection between. It is not essential that the tank should be high in the circuit but if it is very low all the hydraulic fluid will drain into it on close down and sufficient capacity must be allowed to prevent an over-flow.

A name plate on the tank will specify the recommended grade of oil for use in the system. Normally Shell Tellus 33, Esso Teresso 52 (British Railways Specification R.14) or any of the other hydraulic oils of similar viscosity, such as BP Energol Hydraulic 100 may be used. Heavy duty mineral, acid free lubricating oils of SAE.20-30 viscosity can also be employed.

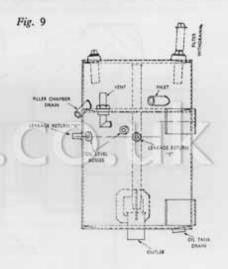
A typical oil tank is shown in Fig. 9.

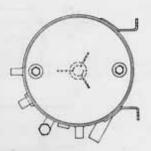
General

If the installation is subject to vibration, it is desirable that flexible rubber hoses be put into the hydraulic circuit at appropriate places.

Before despatch each hydraulic drive is run under working conditions, the procedure being as follows:

The temperature at which the fan starts to rotate is noted and the unit is then run at full speed. During the runs all components and joints are checked.





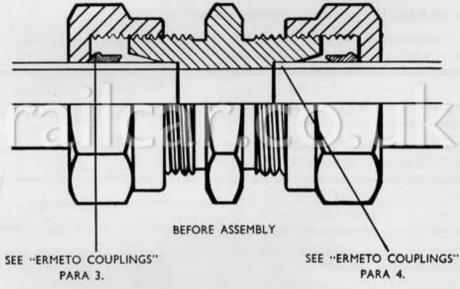
Important

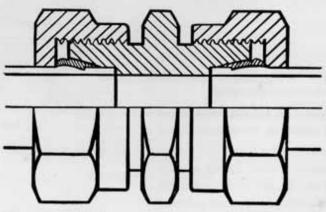
It is essential that care be taken to maintain all items scrupulously clean throughout. The ingress of any foreign matter will impair the efficiency and life of the equipment. All units are despatched in sealed condition and these seals should only be removed immediately prior to installation.

Ermeto Couplings

Ermeto couplings are fitted to ends of pipes by the following process:-

- (1) Cut end of tube square to its axis, file cut face flat and remove burrs inside and outside tube.
- (2) Lubricate all parts with oil.
- (3) Slide nut and Ermetic ring over end of tube with the collar end of the ring facing towards the nut and the thin end of the ring towards the cone of the coupling body.
- (4) Grip the coupling body in a vice and insert the tube into the body, ensuring that the tube end butts firmly on the step at the base of the cone.
- (5) Position the ring in the cone, engage the nut and screw up till pipe is just gripped by the ring.
- (6) Screw up strongly with a spanner: the nut should be given 11-11 full turns after the ring has gripped the pipe.
 Dismantle the coupling and clean tube as below.
- (8) Remake the joint on site by inserting the tube into the body, engaging the nut and tightening strongly, using two spanners, one on the body and the other on the nut.





AFTER ASSEMBLY FIG. 10 ERMETO COUPLINGS

Cleaning of Steel Pipes

After all cutting, bending, fitting of couplings, etc., has been completed:

- (1) Remove all burrs and swarf.
- (2) Degrease.
- (3) Rinse in water.
- (4) Pickle in 15% hydrochloric acid solution.
- (5) Neutralize in sodium carbonate solution.
- (6) Rinse in water.
- (7) Bonderize or equivalent.
- (8) Rinse in water.
- (9) Dry with warm air.
- (10) Flush with hydraulic oil.
- (11) If not fitted into circuit immediately, seal ends with adhesive tape.

When the system is finally erected, cleanliness must be observed and if there is any doubt as to whether dirt may have got into any of the pipes, or if they have been stored, the following simplified cleaning process may be used, provided no further cutting or heating of the pipe has taken place:

- (1) Flush with clean paraffin.
- (2) Dry with warm air.
- (3) Flush with hydraulic oil.
- (4) If not fitted into circuit immediately, seal ends.

section

:3

COMMISSIONING

After complete assembly of the fan control system, the following operations must be carried out when commissioning the set:

- 1. Remove the oil tank filler cap and open the high level cock.
- Fill the tank with clean, filtered oil of the grade indicated on the tank to the level of the high level cock. Close the high level cock and replace the filler cap.
- 3. Run the pump at its normal working speed. Certain types of controllers are not fitted with a manual control screw; in that case the fan will have to be rotated by heating of the thermostatic element near to its control temperature. Otherwise carry out the procedure as below: Release the locking nut on the controller over-ride screw and, using a screw driver, screw this until the fan is rotating slowly. There is some lost motion on the screw and this must be taken up before rotation of the fan will commence.
- 4. Fully retract the manual over-ride screw and top up the tank with oil as in (1) and (2).
- Screw in the over-ride screw to its normal limit. This will cause the fan to rotate at full speed.
 Leave in this state for thirty minutes. Meanwhile, examine the system for leaks and, if necessary, tighten joints.
- 6. Fully retract the manual over-ride screw and lock by means of the locking nut in this position.
- Shut down the pump.
- 8. Remove, clean and refit the magnetic filter in the oil tank as follows:
 - (a) According to the type of filter fitted, either unscrew by central hexagon boss or remove nuts holding the filter flange.
 - (b) Remove filter and clamp fixing flange lightly in vice.
 - (e) Remove filter cage either by unscrewing hexagon nut at base or by undoing knurled nut, if necessary inserting a 5/16in. (7.93 mm.) tommy-bar in the holes provided in the nut for that purpose.
 - (d) Withdraw the cage from the central bar magnet.
 - (e) Wash the cage in clean paraffin and wipe the bar magnet with a clean cloth to reomve any particles adhering to it.
 - (f) Re-assemble the cage onto the bar magnet and screw down.
 - (g) Refit the filter into the tank.

NOTE.—Care must be taken that the bar magnet is not accidentally dropped, nor should it come into contact with either steel or iron objects, as this would reduce its effectiveness.

Before despatch each hydraulic drive is run under working conditions according to the following procedure:

The temperature at which the fan starts to rotate is noted, and the unit is then run at full speed for a period. During the run, all components and joints are checked.

section

4

SERVICING
LEAKAGE TESTS, SERVICE CHECK
REMOVAL AND REPLACEMENT OF THERMOSTAT
ELEMENT
FLEXIBLE HOSES

SERVICING

It is essential that care be taken to maintain all items scrupulously clean throughout. The ingress of any foreign matter will impair the efficiency and life of the equipment.

- Inspect the oil level in the tank weekly and top up to the level of high level cock if necessary.
 If the oil level is appreciably down, inspect the system for leaks and tighten couplings, etc., if required.
- (2) Remove, clean and refit the magnetic filter two weeks after commissioning and thereafter quarterly or at every change of oil. This must be done with the set shut down.
- (3) Drain the hydraulic system through the drain holes at the bottom of the tank and refill with clean filtered oil of the specified type after the following periods:

Locomotives and railcars-Every 30,000 miles.

Shunting locomotives and stationery sets-Every 2,000 running hours.

- (a) Remove the oil tank filler cap and open the high level cock.
- (b) Fill the tank with clean, filtered oil of the grade indicated on the tank to the level of the high level cock. Close the high level cock and replace the filler cap.
- (c) Run the pump at its normal working speed. Certain types of controllers are not fitted with a manual control screw; in that case the fan will have to be rotated by heating of the thermostat near to its control temperature. Otherwise carry out procedure as below: Release the locking nut on the controller over-ride screw and using a screwdriver screw until the fan is rotating slowly. There is some lost motion on the screw and this must be taken up before rotation of the fan will commence.
- (d) Fully retract the over-ride screw and top up in the tank with oil as in (a) and (b).
- (4) Replace all flexible hoses and thermostatic elements every two years; ensure replacements are of the right type and size. When replacing hoses, cut Ermeto ring on standpipe end of old flexible hose, remove nut so that it may be re-used with the new flexible hose if desired.
- (5) After a considerable time in service replacement of oil seals on pumps and motor units may be required. Oil seals can be replaced by removing the cover plate. Replace scaling bush if worn.

Leakage Tests

Every twelve months during the course of the life of the equipment a leakage test should be applied to measure possible wear of the pump and motor units, the procedure being as follows:—

- (1) Fit pressure gauge in the pump outlet pipe at the appropriate fitting provided for that purpose.
- (2) Run the set under manual control until the oil reaches normal working temperature of 122 deg. F. (50 deg, C.) and adjust pressure in the system to 1425 p.s.i. (100 atm.) approximately, or run the set at maximum pressure if this is below 1425 p.s.i.

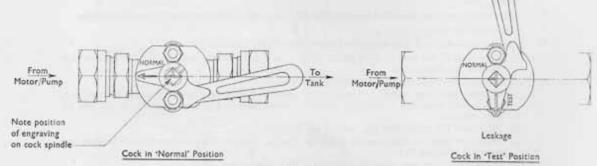


Fig. 11

- (3) Turn tap in leakage line into appropriate position and measure leakage flow for one minute. If no leakage cocks are fitted, disconnect leakage pipe at convenient point and proceed as above.
- (4) Check oil level in tank and repeat test for motor at the same temperature and pressure as in (2) above.
- (5) To obtain the maximum leakage allowed, multiply figure shown in Table 1 below by factor F for the oil being used, obtained from Table 2.
- (6) Ensure that leakage cock is returned to normal after testing.

TABLE 1

TABLE 2

Size of Unit	Max. Leakage		
	Litres	Galls.	
12 16 20 25 32 40 50	1.0 1.8 2.4 4.5 6.5 12.5 18.0	.22 .40 .53 .99 1.43 2.75 3.96	

Factor F	Oil Grade
1.0 1.76 1.01 0.61 0.61 1.35 1.5 1.0	Teresso 52 SAE 10W SAE 20W SAE 30W Shell Talpa 30 Turbo 29 Tellus 29 Tellus 33 R.14

After several years the leakage on the pump will exceed that on the motor. If it is still below the permissible maximum, the units can be interchanged. This will give several years more satisfactory service.

If leakage exceeds the permitted maximum value, the unit must be returned to Serck Radiators Limited or an accredited agent.

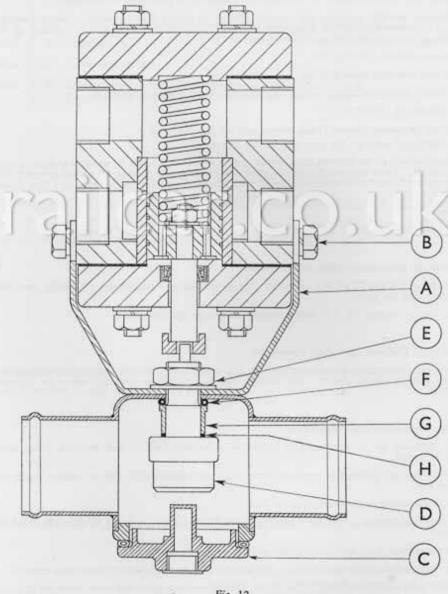


Fig. 12

Service Check

If the drive appears to be operating incorrectly the following procedure must be adopted:

- (1) Check oil level in tank; if down, check for leaks.
- (2) (a) Run pump at correct running speed.
 - (b) Screw down manual over-ride screw on controller to its full extent.
 - (c) Fan should now run at its rated speed.
 - (d) If shutters are fitted check they are open.
 - (e) If fan does not rotate check that pump spindle is turning.
 - (f) Check for rotation, if incorrect check pipework; reversal of motor connections reverses rotation.
- (3) If the mechanical side of the drive is satisfactory then check thermostat element:
 - (a) Run prime mover at normal running speed.
 - (b) Allow temperature of controlling fluid to increase to that rated on controller.
 - (c) The fan should now rotate.

Removal and Replacement of Thermostat Element in Standard Controllers

Wherever possible operators are strongly advised to return the controller to Serck Radiators Limited for replacement of the thermostat element. The following procedure is included for the guidance of operators outside the United Kingdom.

To Remove Element (see Fig. 12)

- (1) Screw over-ride screw fully in.
- (2) Detach thermostat carrier A from controller by removing four set screws B.
- (3) Unlock and remove cap G.
- (4) Hold thermostat element D and remove lock nut E. (Note.—In some models there may be two lock nuts.)
- (5) On the neck of the element are a copper sealing washer F, a collar G, and one or more spacing rings H. These rings can be used to adjust the operating temperature by a small amount. The rings are 1 mm. thick, removal of one ring lowering the operating temperature by 1 deg. C., and vice versa.

To assemble

(6) Replace spacing rings, collar and sealing washer on the element and fit into carrier.

Removal of Element in Twin Controllers

To remove element T2 on twin controller (Fig. 6) proceed as described above for single controller, after removal of the carrier.

To remove element T1 it is only necessary to remove the lock nuts.

Removal of Element on Large Controller

To remove elements on large controller (Fig. 7) remove controller from pipe line and undo carrier retaining nuts to detach carrier. The element can be changed as described above for standard controllers.

Flexible Hoses-Storage Conditions

The following are the recommended conditions under which rubber and synthetic rubber hoses should be stored:

- Store flat and relieved of unnatural stress, e.g., not tightly coiled, and no weight should rest on them.
- (2) Correct sealing caps should always be fitted.
- (3) Store in a cool atmosphere, not exceeding 80 deg. F. (27 deg. C.), in which air should be circulated freely.
- (4) Protect from direct sunlight and store away from electric motors.
- (5) Prevent contact with oils, solvents or any substance likely to be harmful to the hose material.

Under these conditions, flexible pipes can be stored for periods up to four years, but if the period of storage has exceeded two years they should be pressure-tested before installation.

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FOR SECTIONAL RADIATORS

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CONTENTS

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DESCRIPTION

The heat transfer surface comprises a number of standard interchangeable and easily removable sections made from brass or copper tubes threaded through and bonded to brass or copper fin plates.

The section headers are of two types:

- (1) B type in which the attachment to the manifolds is by means of two bolts.
- (2) C type where the sections are clamped in pairs to the manifolds.

In the larger units the sections are arranged in two banks and/or two tiers. An inspection panel is provided in the fan cowl of double bank radiators to facilitate inspection and removal of the inner bank of sections.

The steel manifolds have welded-in divisions to ensure that the oil and water flow through the sections at the correct velocities. Inlet and outlet connections are arranged to suit engine makers' requirements.

Steel side plates support the radiator panel.

The axial flow type fan impeller may be mounted in a bearing held by four tubular arms attached to the steel fan plate. The fan may be driven by means of a chain drive, or through V belts from the engine or from a separate motor. A jockey pulley may be fitted for adjustment of fan belt tension. Alternatively a direct motor drive or the Serck-Behr hydrostatic fan drive may be used. In the case of locomotive radiators the fan may be mounted on the engine bulkhead or in the roof of the locomotive with air ducting to the radiator panel or panels.

Combined filler plug/air cocks are fitted in both the oil and the water compartments of the top manifold, whilst in the water compartment is fitted a double-acting spring-loaded pressure release valve. This prevents the building up of excessive pressure due to overheating and also reduces any depression which may form when the engine is shut down, thus protecting the radiator against abnormal stresses. Drain plugs are provided in the bottom manifold.

Manually, mechanically or thermostatically operated shutters may be fitted to control air flow through the radiator.

OPERATING NOTES

Aerated water promotes corrosion and may eventually lead to tube failure by impingement attack. Keep air from the systems by maintaining pump glands and pipe connections quite leakproof and by bleeding air from the top manifolds at regular intervals.

Drain the water side in extremely cold weather when the radiator is to be left inoperative, particularly in exposed locations, otherwise keep both oil and water sides completely full at all times. Leaving a radiator partly filled with water encourages corrosion.

In closed circuit water systems of this type, water losses, if any, should be very small and the formation of hardness scale easy to avoid. Use of suitable chemical or oil emulsion inhibitors provides full insurance against corrosion and scale if the manufacturer's instructions are closely followed. Distilled or naturally soft water should be used wherever possible.

Oil and water temperatures and the pressure loss across the radiator indicates the condition of the cooling surfaces. Thus a gradual rise in the radiator outlet temperature under normal operating conditions may indicate that the surfaces are becoming progressively fouled by deposits of insulative dirt or scale. If the temperature rise is accompanied by increasing pressure loss, then fouling will be on the insides of the tubes and headers; if not, then the fins and tubes on the outside may be obstructed. In both cases, cleaning is indicated.

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CLEANING

Air Side

In dusty situations, particularly where oil fumes or spilling are encountered, it is possible for the radiator sections to become very dirty. A low pressure steam jet will remove most deposits, but in very stubborn cases it is advisable to wash or hose down the sections using a reliable detergent, such as Shell's Teepol in hot water.

Water Side

Little guidance is necessary, since this side should not normally become fouled. If, due to leaky joints for instance, indiscriminate topping-up with hard water has been carried out for some time, the system may become restricted by hardness scale. This will cause higher running temperatures which, in turn, accelerate scale deposition. In such a case it is advisable to descale the entire cooling system.

To descale the radiator alone, suitable acid solvents should be used such as Houseman & Thompson's H.T.L. "A" solution or inhibited hydrochloric (muriatic) acid. Whatever solvent is used, the manufacturer's instructions should be closely followed.

The procedure is as follows:

- Drain the water system and disconnect and blank off the pipe connections to the engine.
- Prepare a 4% solution of inhibited acid solvent and fresh water, more than sufficient to fill the sections to be descaled. Add the acid to the water, never vice versa.
- Allow several minutes for mixing, then heat the solution to 120 deg. F. (maximum).
- Run the solution slowly into the radiator via the filler cap or a branch in the top manifold. Effervescence will occur; when it ceases, fill the radiator completely with the heated solvent.
- Allow to stand for several minutes, then drain the solvent back into the original container through a branch in the bottom manifold, or the drain plug.
- Examine the interior of the headers on the sections. If scale remains repeat the
 process outlined above with the solvent strength increased to 8%. Finally drain
 to waste.

NOTE: Where facilities are not good it may be more convenient to remove the individual sections and descale each separately, following the general procedure outlined above. If this is done steps should be taken to remove any scale from the relevant compartments of the manifolds also.

- 7. Fill the mixing container with fresh water, heat to boiling point then add common washing soda crystals at the following strength: 1 lb, soda to 5 gallons water. Fill the radiator with this solution, then drain it back into the container.
- Flush the radiator in this manner several times, finally leaving the radiator quite full for at least an hour. Drain to waste and wash out the radiator with hot, fresh water.
- 9. Before putting the radiator into service again, fill with water and apply a test pressure of 40 lb. per square inch. Examine carefully for any leaks which may have been revealed by descaling. If possible the rubber joint rings for each water section should be renewed after descaling.

Oil Side

A number of suitable degreasants exist and while some entail the use of special equipment, there are now available efficient solvents in concentrated liquid, crystal or powder form, ready for mixing with water. These are non-toxic and free from fire risk, besides being easy to handle, transport and store. Houseman & Thompson's H.D. Degreasant has been tested and found entirely satisfactory, it may be obtained easily through a world wide distributive organisation. Whatever solvent is used the makers' instructions should be closely followed.

Methods of degreasing include:

- Filling the radiator with solution of the correct strength then injecting steam at pressures not exceeding 10 lb. per square inch through a connection on the bottom manifold.
- Circulating the solution (preferably heated) through the radiator using a portable pump and tank.
- Removing individual sections and immersing them in a separate tank of solvent.
 Agitation by air or steam injection will speed up the cleaning process. It is important that the solvent should flow through the tubes. Remember also to wash out the relevant compartments in the manifolds.

REPAIRS

In the event of damage causing leakage from a section, the section should be removed and suitable blanking plates and packing fitted as a temporary measure.

It is always advisable to carry sections as spares, particularly in not readily accessible regions where operating conditions are arduous.

When calling for spares, please quote the serial number on the radiator name plate.

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SECTION 19A . . LUBRICATION SYSTEM

DRY AND SEMI-DRY SUMP ENGINES

DESCRIPTION

The dry sump system employs one pressure and two scavenge oil pumps. The scavenge pumps return the oil from the front and rear sump wells into a separate oil reservoir in the sump casting, from which it is drawn by the pressure pump and circulated round the engine.

The semi-dry sump system employs one pressure and one scavenge pump, the scavenge pump emptying the rear sump well into the front well, from which it is drawn by the pressure pump and circulated round the engine.

Scavenging in the dry sump system is unaffected by inclinations of the engine up to 40 degrees in a fore and aft direction and up to 20 degrees sideways, and in the semi-dry system up to 35 degrees in a fore and aft direction and 15 degrees sideways. Gear-type scavenge and pressure pumps are used throughout.

Oil is pumped by the pressure pump through an in-built oil-to-coolant heat exchanger on dry sump engines, or a pack-type oil-to-coolant heat exchanger (if fitted) on semi-dry sump engines, and thence through a bank of full-flow filters to the engine main oil feed gallery.

The function of the oil-to-coolant heat exchanger is to bring the oil to its working temperature as rapidly as possible, and to maintain it at that temperature under all working conditions, the necessity for a heat exchanger depending on climatic conditions, engine rating and arrangement of installation.

The externally-mounted in-line filters are fitted to a header bracket secured to the side of the crankcase, and are connected by external pipes to the relief valve unit. Filtration is achieved by forcing the oil through expendable paper elements housed in cylindrical containers. These elements cannot be cleaned; they must be renewed at the appropriate servicing period.

The relief valve unit contains a pressure relief valve and a filter by-pass valve which, apart from their spring loadings, are identical. The spring loading of the pressure relief valve is such that the valve opens when the oil pressure rises above the maximum recommended for any particular engine, as stated in 'Engine Data'. The spring loading of the filter by-pass valve is such that the valve opens if the pressure drop across the filters exceeds 15 p.s.i. (1.054 kg. per sq. cm.), thereby preventing

oil starvation in the event of the full-flow filters becoming choked.

The oil which is delivered under pressure to the crankshaft from the main oil feed gallery lubricates the main and big-end bearings, and is conveyed along drillings in the connecting rods to lubricate the gudgeon pin bearings and the cylinder walls.

On 6-cylinder engines the camshaft bearings are fed through the hollow camshaft by a direct supply from the main oil feed gallery to the camshaft centre journal, and a restricted low pressure feed is taken from this supply to lubricate the valve rocker shafts. On 4 and 8-cylinder engines, in which a solid camshaft is employed, each camshaft bearing is fed from the adjacent main bearing journal via drillings in the crankcase, the end bearing feeds providing the low pressure supply to the valve, rocker shafts. A drilling in one of the holding-down studs of each cylinder head is used in all engines to convey the rocker shaft oil from the crankcase to the cylinder head. Spill oil from the rocker shaft bearings lubricates the ends of the valve stems, the push rod ball ends, and the

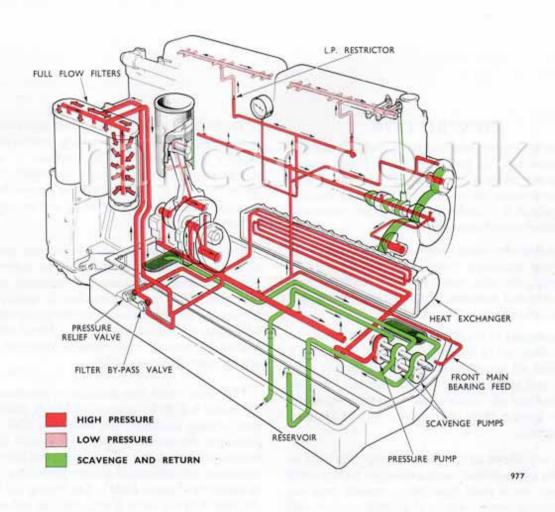


Fig. 1 Lubrication system - dry sump engine

tappets. Additional bleeds from the camshaft tapping lubricate the air compressor, supercharger and supercharger driving gears, when fitted.

When an engine-oil lubricated fuel injection pump is fitted to an engine the feed tapping is taken through a restrictor from the main idler gear supply at the front of the crankcase.

CHANGING THE OIL

Drain the oil system immediately after stopping the engine while the oil is still warm.

Remove the drain plug or plugs from the bottom of the sump and after all oil has drained from the engine refit the drain plugs.

Use the oil recommended, see 'Engine Data'; fill through the stand pipe until the oil level in the sump is up to the 'MAX' mark on the dipstick.

Remove the oil filters, pour out the oil, and fit new elements, see 'Filters'. Fill the filter canisters with lubricating oil and refit them to the header bracket.

Run the engine for 1 minute to circulate the oil and re-check the level.

FILTERS

To renew the filter elements, unscrew the capnut securing each filter to the header bracket and remove the filters.

Withdraw the filter elements, clean out the canisters and fit new elements and sealing rings, and ensure that the bottom sealing ring, spring, and washer are correctly fitted. The elements removed cannot be cleaned and should be discarded with the old sealing rings.

Fill the filter canisters with clean lubricating oil immediately before refitting them to the header bracket. Always fit a new sealing ring in each header bracket recess and ensure that a new sealing ring is in position on the top of each filter element.

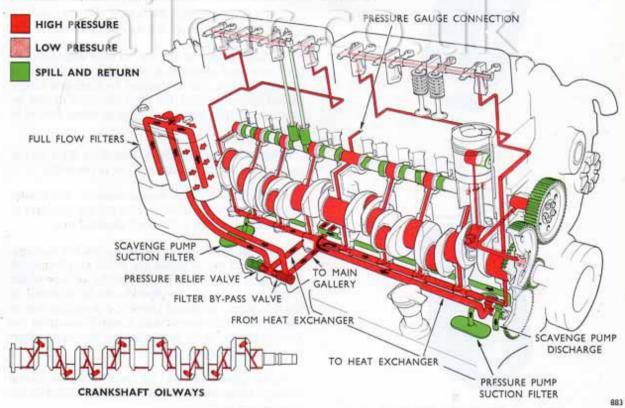
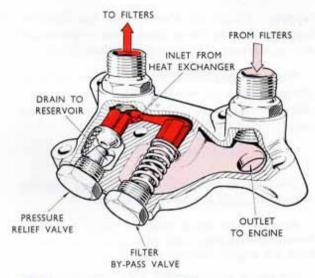


Fig. 2 Lubrication system - semi-dry sump engine

Note: Two types of oil filter assemblies are in service: the earlier long-bowl assembly with corrugated paper elements fitted to engines manufactured before August 1958, and the short-bowl assembly with multiple-disc paper elements fitted to all engines manufactured after August 1958, and to engines manufactured before August 1958 which have been modified to incorporate the improved type filter assembly. On no account should components from one type of filter assembly be



Fig. 3 Oil filter details (short bowl)



INLET PRESSURE

OUTLET PRESSURE

Fig. 4 Oil flow through relief valves - dry sump engine

used with the other, as unfiltered oil will be circulated through the system if short-bowl elements are fitted in long-bowl filters.

The change period for the oil filter elements has been arranged to coincide with that for the oil. If for any reason the oil cannot be changed at the period recommended, the filter elements should be renewed at that period and again when the oil is changed.

When first running the engine after filter servicing inspect the filter canister joints for leaks.

At overhaul of the engine remove the header bracket from the engine so that the oil passages in the bracket can be effectively cleaned out.

Examine the inlet and outlet pipes for damage. Where rigid metal pipes are fitted small smooth dents may be ignored but where the surface of the metal has been cut the pipe should be replaced. If flexible pipes are fitted check for deterioration of the rubber outer cover and visually examine the bore of the pipes for restriction by directing a light down the pipe bore.

Rigid pipes should be washed and blown through immediately before they are refitted to the engine.

RELIEF VALVES

Twin relief valves are contained in a common casing. The valves and springs are identical, the difference in loading being obtained by varying the depth of the valve seatings from the end faces of the casing.

One valve maintains the oil pressure at 40 to 60 lb. per sq. in. (2.8 to 4.2 kg. per sq. cm.), and the other provides a safety by-pass at 15 lb. per sq. in. (1.054 kg. per sq. cm.) in event of the filters becoming choked. The unit is mounted on the rear of the oil reservoir cover for the dry sump engine, and for the semi-dry sump engine on the engine sump below the oil filters, the valve at the rear of the unit being the pressure relief valve and that at the front the filter by-pass.

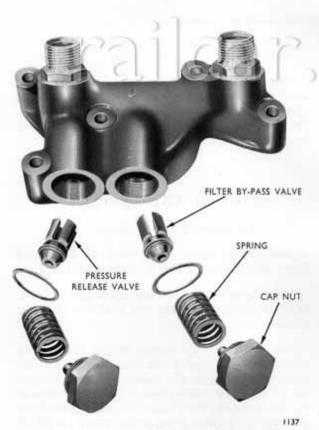


Fig. 5 Exploded view of relief valve - dry sump engine

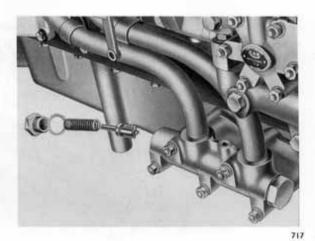


Fig. 6 Oil pressure relief valve - semi-dry sump engine

If a valve is believed to be faulty, remove the end cap and spring from the relief valve unit, and extract the valve using the special tool GA.14 or a 2 B.A. screw of sufficient length to reach the tapped hole in the valve head. Examine the valve and seating for dirt or foreign matter. In the unlikely event of the valve seating being badly indented, the complete unit should be changed; in most cases, however, any trouble can be rectified by cleaning.

At overhaul dismantle the unit and examine the valves and seats for indentations. Check the free length of the valve springs by comparing them with a new spring or preferably check the spring loadings at their compressed length to the figures given in the following table:—

ENGINE	VALVE	COMPLEN	LOAD			
		in.	mm.	11:	, oz.	kg.
DRY SUMP	Pressure relief	0.972	24.688	24	14	11,283
	Filter by-pass	1.286	32.664	8	13.5	4.012
	Pressure relief	1.650	41.91	26	8	12.02
SEMI-DRY SUMP	Filter by-pass	2.320	58.928	6	10	3.007
	Heat exchanger by-pass	2,320	58.928	6	10	3.007

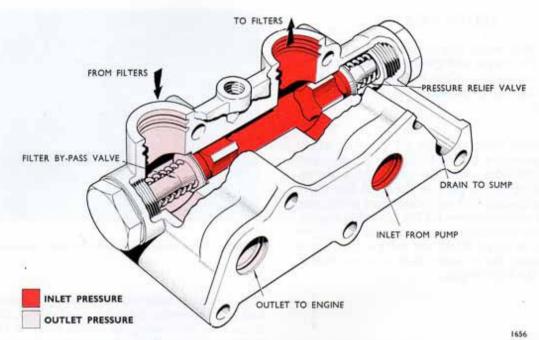


Fig. 7 Oil flow through relief valves - semi-dry sump engine

Before re-assembling the unit thoroughly clean all parts. Fit new sealing washers under the valve retaining caps. After assembly, check the opening

pressure of the valves in the following manner:-

Seal off the inlet and outlet ports of the unit and by means of a 3-way connection and a hand pressure pump, apply an oil pressure through the filter delivery and return unions of the unit. The pressure relief valve should lift at 60 lb. per sq. in. (4.2 kg. per sq. cm.) and allow oil to flow from the by-pass port.

Uncover the outlet port and seal off the inlet and by-pass ports. Remove the 3-way connection and apply an oil pressure through the filter delivery connection. The by-pass valve should lift at 15 lb. per sq. in. (1.054 kg. per sq. cm.) and allow oil to flow through the outlet port.

If a valve leaks before the lift pressure is reached, examine the valve and seating, and if these are satisfactory, fit a new spring. When refitting the unit to the engine, use a new jointing washer for the semi-dry sump engine and ensure that new rubber sealing rings are fitted to the inlet and outlet pipes at their connections to the relief valve unit.

SUMP

REMOVAL AND REFITTING

Drain the engine cooling system.

Remove the drain plugs from the sump and drain the oil from the engine. Refit the drain plugs.

If the installation does not allow access to the sump, remove the engine and fit it to a turnover stand.

For the dry-sump engine release the coolant inlet and outlet pipes to the heat exchanger at the hose connections on the coolant adapters. Release the oil inlet and outlet pipes to the relief valves at the unions on the valve assembly. Release the front and rear air balance pipes at the unions on the oil reservoir.

Withdraw the dipstick from its holder.

For the semi-dry sump engine remove the oil filters from the header bracket, disconnect the inlet and outlet pipes between the header bracket and the relief valve assembly, and withdraw the pipes from the relief valve casing.

Turn the engine upside down.

For the semi-dry sump engine remove the base plate from the sump front oil well.

Remove the set-bolts securing the sump to the crankcase and break the joint using $\frac{1}{8}$ in. dia. UNF set-bolts in the starting holes at each corner of the sump flange, and withdraw the sump evenly.

· Remove the oil transfer bobbins.

For the dry sump engine remove the nuts securing the heat exchanger coolant jacket and withdraw the jacket from the studs. Remove the six nuts securing the two oil transfer brackets to the sump, and withdraw the heat exchanger oil pipes and bracket assembly from the studs. Withdraw the brackets from the ends of the pipes.

Remove the oil tiller pipe assembly and unscrew the dipstick holder.

For the semi-dry sump engine release and remove the oil relief valve assembly, the heat exchanger oil transfer bend, and withdraw the transverse oil pipes from the sump.

Inspect all parts for corrosion and wear and renew the rubber sealing rings on the ends of the heat exchanger oil pipes, sump transverse pipes and on the oil transfer bobbins.

Clean all items thoroughly and ensure that the oil passages in the sump are clear.

Assembling is the reversal of dismantling. Use new joint washers on all the mating surfaces.



Fig. 8 Sump and heat exchanger - dry sump engine

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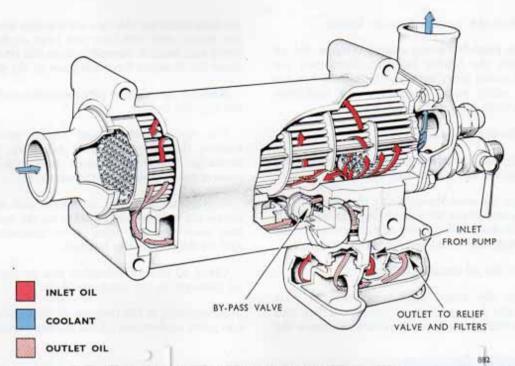


Fig. 9 Cut-away view of heat exchanger-semi-dry sump engine

When refitting the sump, position the transfer bobbins in the holes in the main gallery pipe bracket, and for the semi-dry sump ensure that the transfer bobbins are positioned in the heat exchanger oil transfer bracket.

Fit a new joint washer and offer the sump up to the crankcase, locating it with the 4 sump guide bars GA.257 before pressing into position.

Remove the 4 guide bars and secure the sump with the set-bolts.

For the semi-dry sump fit and secure the base plate to the sump front oil well.

Refit all parts removed for access.

OIL PUMP AND FITTINGS

The oil pump, gallery and suction pipe assembly are bolted to the cap halves of the main bearings. The pipes are sealed at their connections by rubber sealing rings located in grooves in the pump and bracket bores.

REMOVAL

Drain the oil and remove the sump.

Remove the bolts securing the pump assembly and the pump inlet and outlet pipes to the engine main bearing caps.

For the dry sump engine release the front main bearing feed pipe at the union on the pipe between the rear oil intake and the pump.

The complete assembly can then be lifted off the engine.

DISMANTLING

Withdraw the oil inlet, outlet and main oil gallery pipes from the pump. At complete overhaul of the engine, the piping assembly should be dismantled so that the rubber sealing rings can be renewed.

Unscrew the nut securing the oil pump driving gear to the pump shaft, withdraw the gear, and extract the key.

Dry sump pump

Release the four retaining bolts and withdraw the front intake and strainer assembly from the pump.

Release the four bolts on the opposite side of the pump to the strainer assembly and withdraw the oil outlet branch.

Mark the pump casing to ensure correct assembly on rebuild.

Unscrew and remove the pump assembly retaining bolts and withdraw the pump gears and dividing plates, marking the two scavenge pump driven gears so that they can be replaced in the same order in which they were removed.

Semi-dry sump pump

Release and remove the forward suction strainer from the rear of the pump, and the rear suction elbow from the left hand side of the pump.

Mark the pump casing to ensure correct assembly on rebuild.

Unscrew and remove the set-bolts securing the pump casings together, then carefully split the assembly and withdraw the drive shaft, gears, floating bushes and dividing plate. Care must be taken to keep the loose gears and bushes to their respective pumps.

INSPECTION

Clean all the components thoroughly, ensuring that the gauze strainers are free from sludge.

Check the teeth of all gears for wear and damage. Loss of tooth profile is not in itself serious and only if this is combined with an extensive area of break-up on the teeth, should a gear be rejected.

Where the necessary equipment is available the gears should be electro-magnetically crack tested.

Check the end float and diametral clearance of each pair of gears in the casing and check the backlash of the gears.

If the wear on either pair of gears increases the backlash to more than 0.015 in. (0.381 mm.) new gears should be fitted.

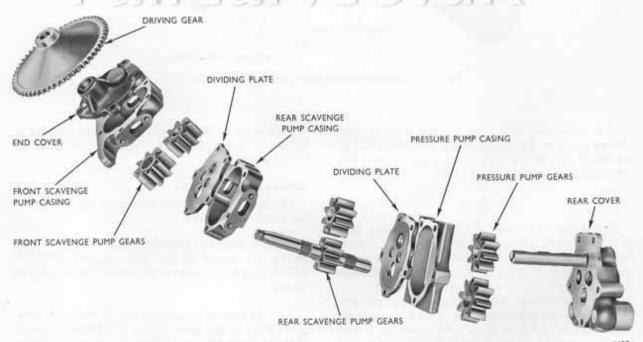


Fig. 10 Exploded view of oil pump - dry sump engine

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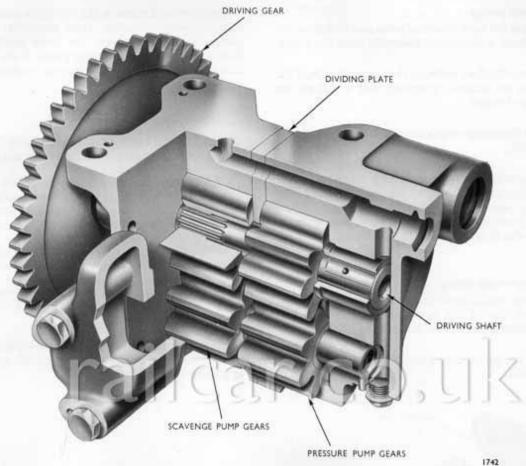


Fig. 11 Section through oil pump - semi-dry sump engine

The diametral clearance of the driving and driven gears in the casing when new is 0.0075 to 0.0086 in. (0.1905 to 0.2184 mm.) and should not be more than 0.015 in. (0.381 mm.).

The axial clearance of the gears when new is 0.0055 to 0.006 in. (0.1397 to 0.1524 mm.). Scoring on the dividing plates can be lapped out providing the thickness of a plate after lapping is not less than 0.248 in. (6.3 mm.) for the dry sump pump, and 0.240 in. (6.096 mm.) for the semi-dry pump. Wear on the face of the plate is permissible to a depth of 0.005 in. (0.127 mm.) providing any scoring present is not more than 0.010in. (2.54 mm.) wide.

The faces of the plate must be kept parallel to within a total indicator reading of 0.001 in. (0.0254 mm.).

Bushes and gearshafts

Check the driving shaft bushes in the end covers for wear and scoring.

If the bushes in the end covers of the dry sump pump are scored or the bores exceed 0.7535 in. (19.14 mm.) new end cover assemblies should be fitted.

For the semi-dry sump pump, fit new end cover assemblies if the bore of the front bush exceeds 0.7535 in. (19.14 mm.) and the rear bush 0.878 in. (22.3 mm.).

Check the floating bushes and the bores of the driven gears.

If the gear bores are badly scored the gears should be renewed.

If the outside diameter of the floating bushes is less than 0.90125 in. (22.8971 mm.) or if the bores are worn so that the clearance between the gear-shaft and the bush exceeds 0.0025 in. (0.0635 mm.), or if the bushes are badly scored they should be renewed.

Check the splines on the driving gearshaft and in the driving gears for wear, by trying each gear into its correct position on the shaft. If any appreciable slackness exists, try the gear on a new shaft and also a new gear on the old shaft, to determine the serviceability of each component. The backlash of either component tried in this manner should not be more than 0.005 in. (0.127 mm.) measured on a P.C.D. of 0.80 in. (20.32 mm.).

Alternatively the shaft splines can be checked over 0.046 in. (1.1684 mm.) wires. The diameter over the wires should not be less than 0.8570 in. (21.77 mm.).

Check the diameter of the plain portions of the gearshaft which locate in the bushes of the end covers.

If the diameter of the dry sump pump gearshaft has worn to less than 0.745 in. (18.92 mm.) a new gearshaft should be fitted.

For the semi-dry sump pump, if the diameter of the front bush location has worn to less than 0.745 in. (18.92 mm.), or 0.870 in. (22.1 mm.) for the rear bush location, a new gearshaft should be fitted.

New end cover assemblies should be fitted if the bores locating the driven gear shaft are worn. If the driven gear shaft is worn so that its diameter is less than 0.65425 in. (16.61795 mm.), fit a new cover assembly.

Check the internal machined surfaces of the pump casings for scoring and, if badly scored the casings should be renewed. Light scoring not exceeding a depth of 0.005 in. (0.127 mm.) is permissible.

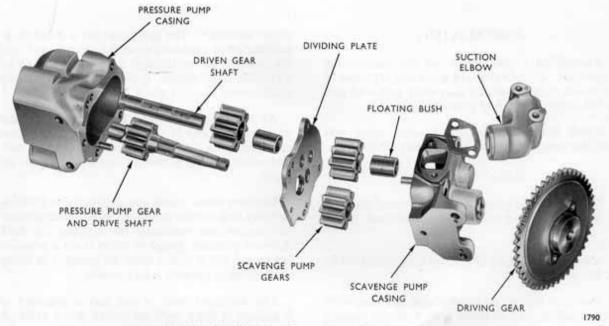
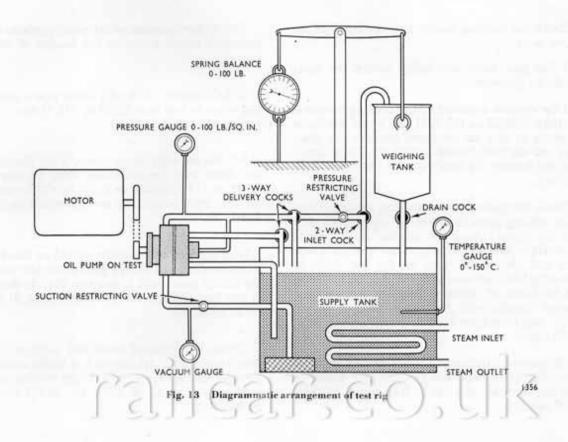


Fig. 12 Exploded view of pump - semi-dry sump engine



ASSEMBLING

Assembling is the reverse of the dismantling procedure. Ensure that the gears are replaced in the same order in which they were removed and in the same end to end position.

Check that all bolts are correctly locked and that the pump gears will rotate freely by hand.

RIG TESTING

The assembled pump should be tested on a rig to prove its correct working after overhaul.

Rig

A suitable test rig is illustrated diagrammatically in fig. 13.

The open topped oil supply tank has a capacity of 15 gallons and is fitted with a steam heating coil; an alternative method of heating can be used where necessary. The pump on test is fitted to an adapter plate mounted over the supply tank and the pump is driven through a flexible coupling by a variable speed motor capable of producing pump shaft speeds of 1,010 and 2,790 r.p.m.

All suction and delivery pipes are 1 inch bore with 3-way cocks in the delivery circuits so that each pumping unit can be tested independently. For adjustment of pressures, restricting valves are fitted.

The instrument panel has gauges for registering delivery and suction pressures and oil temperature. To ensure true readings, the tapping for each delivery pressure gauge is taken from a position between 2 and 6 inches from the pump. The pump shaft speed is set with a tachometer.

The weighing tank which has a capacity of 8 gallons is fitted with an outlet sluice valve. A special inlet valve is fitted for quick action.

Test procedure

Fill the supply tank approximately \(\frac{1}{4} \) full with S.A.E.30 engine lubricating oil, specific gravity 0.845.

Mount the pump to be tested on the adapter plate, secure the suction and delivery branch connections, and fit the assembly into position over the supply tank. Couple the suction and delivery pipes to the branch connections, and fit the flexible coupling between the pump shaft and the rig driving shaft.

Check that the delivery cocks and the weighing tank inlet cock are open to the supply tank and that the delivery restricting valve is fully open.

Open fully the suction valves, then slowly open the steam to the heating coil in the supply tank.

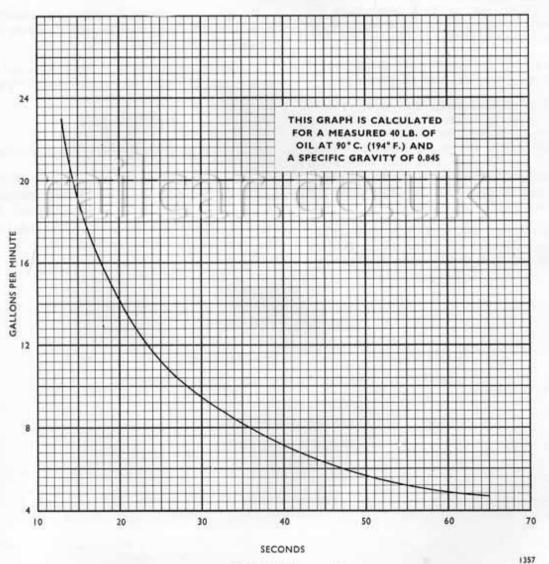


Fig. 14 Delivery graph

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No. of the last

Start the rig and run at approximately 1,000 r.p.m. until a steady oil temperature of 90 deg. C. (194 deg.F.) is attained, then set the pump shaft speed to exactly 1,010 r.p.m. or 2,790 r.p.m. and check the delivery at each speed in the following manner:—

- Turn the 3-way cock in the delivery line so that the cock is closed to the supply tank and open to the delivery header.
- 2. Adjust the suction restricting valve to give a suction pressure of -5 lb. per sq. in. (-0.3515 kg. per sq. cm.), and adjust the delivery restricting valve to give a pressure of 60 lb. per sq. in. (4.2184 kg. per sq. cm.).
- 3. Recheck the pump shaft speed, reset if necessary and again check the pressures.
- 4. Turn the weighing tank inlet cock to admit oil to the weighing tank and, with a stop watch, check the time it takes to add 40 lb. (18.144 kg.) to the spring balance reading. Switch the weighing tank inlet cock to its original position immediately after the check, and open the outlet cock to drain the oil back into the supply tank.
- Turn the 3-way cock in the delivery line so that the cock is closed to the delivery header and open to the supply tank, and close

the weighing tank outlet cock when all oil has drained from the tank.

Record the stop watch reading for each weighing on a suitable test card.

After checking the pump at each speed, carefully examine the pump for leaks before stopping the rig.

The delivery in gallons per minute from the stop watch readings, can be obtained from the graph in fig. 14.

The minimum delivery at 1,010 r.p.m. should not be less than 5.4 galls, for the pressure pump and 7.6 galls, for the scavenge pump.

The minimum delivery at 2,790 r.p.m. should not be less than 12.7 galls. for the pressure pump and 16.4 galls. for the scavenge pump.

REFITTING

Refitting is the reverse of the removal procedure.

Test the backlash between the crankshaft gear and the oil pump driving gear with the crankcase in its normal running position and not inverted. The minimum backlash is 0.002 in. (0.0508 mm.) and the maximum worn backlash is 0.015 in. (0.381 mm.).

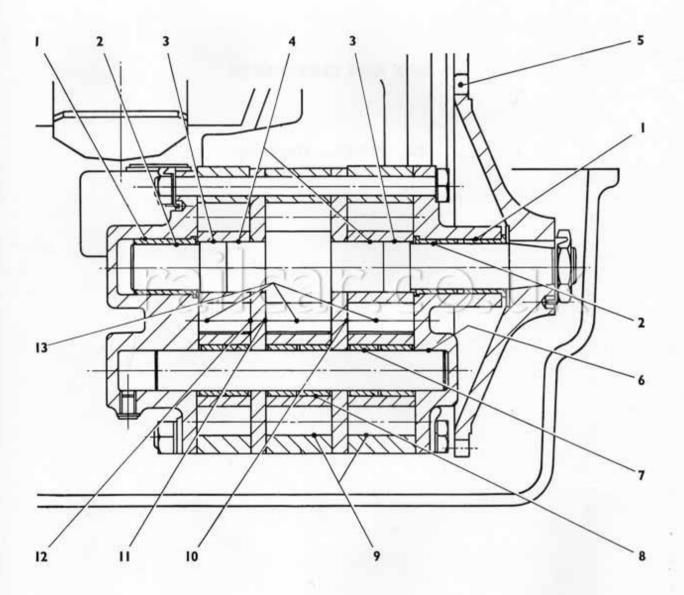
SPECIAL TOOLS

PART NO.	DESCRIPTION
J.53365	Stand, sump assembly (drawings available)
GA.14	Extractor, oil relief valves
GA.257	Guide bars, sump assembly

FITS AND CLEARANCES

OIL PUMP - Dry sump

railcar, co, uk



		35000	NEW	DIMENSIONS	CLEARANCE	
	DRIVING GEARSHAFT IN FRONT AND REAR COVERS					
1	Bushes in end covers					
	End covers - bore	0.875 to	Interfer.		Interfer.	
		0.8755	0.0015 to		0.0005	
	Bushes – dia,	0,876 to	0.0005			
20		0.8765				
2	Gearshaft in bushes	0.000		0.7535		
	Bushes – bore	0.750 to 0.7505	0.0015 to	0.7555		
	Shaft - dia.	0.748 to	0.0025	0.745	0,005	
	Share - tha.	0.7485	0.0023	0.143	0.005	
	DRIVING GEARS ON	0.1.103				
	DRIVING GEARSHAFT					
3	Gears on gearshaft serrations					
	Backlash measured on					
	pitch circle of gear teeth				0.015	
34	142111111111111111111111111111111111111					
4	Gears on plain portion of					
	gearshaft Gear – plain bore	0.843 to				
	Gear - plain bore	0.8435	0.0005 to			
	Gearshaft - plain dia.	0.84225 to	0.00125			
	Generalit - plant da.	0.8425	0.00123			
	CRANKSHAFT GEAR AND	770		-	30.30	2
	OIL PUMP DRIVE GEAR					16
5	Backlash		4 60		0.015	
	DRIVEN GEARSHAFT IN	200	/			1 2
	FRONT COVER					
6	Front cover - bore	0.656 to				
	127-3172 0.1	0.6565	0.0005 to		Springer	
	Gearshaft – dia.	0.65525 to	0.00125		0.0025	
	DRIVEN GEARS ON DRIVEN	0.6555				
	GEARSHAFT					
7	Gearshaft in gear bushes					
(A)	Bushes – bore	0.65625 to				
		0.65675	0.00075 to			
	Gearshaft – dia.	0.65525 to	0.0015		0.0025	
	DESHIPMINE STATES	0.6555	1100714		(2007)57	
8	Bushes in driven gears					
	Gears – bore	0.90625 to	0.001	0.91025		
	B L	0.90675	0.001 to	0.00105	0.005	
	Bushes – día,	0.905 to 0.90525	0.00175	0.90125	0.005	25
	DIAMETRAL CLEARANCE OF	0.90323				
	DRIVING AND DRIVEN					
	GEARS IN CASING					
9	Casing - bore	2.0545 to		2.0625		
-00	VICE 30013-600-3900 1933	2.0555	0.0075 to	200000000000000000000000000000000000000	Pitestone	
	Gears – dia,	2.046 to	0.0095	2.039	0.015	
		2.047				
					100	

DESCRIPTION	DIMENSIONS NEW	CLEARANCE	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
AXIAL CLEARANCE OF DRIVING AND DRIVEN GEARS IN CASING Front scavenge gears axial					
Casing – width Gears – width	1.0495 to 1.050 1.0445 to	0.0045 to 0.0055			Maximum permissible depth of wear on sand- wich plates 0.005.
Rear scavenge gears axial clearance	1.045				
Casing – width Gears – width	1.0495 to 1.050 1.0445 to	0,0045 to 0,0055			Maximum permissible depth of wear on sand- wich plates 0.005.
Pressure gears axial clearance Casing – width	0.8495 to 0.850	0.0045 to			Maximum permissible depth of wear on sand-
Gears – width BACKLASH BETWEEN	0.8445 to 0.845	0.0055			wich plates 0.005.
PUMP GEARS		0.004 to 0.010		0.015	1
- 7311	Ca	lF	C	0,	UK-
		5			
					1100
			-		
	AXIAL CLEARANCE OF DRIVING AND DRIVEN GEARS IN CASING Front scavenge gears axial clearance Casing – width Gears – width Rear scavenge gears axial clearance Casing – width Gears – width Pressure gears axial clearance Casing – width Gears – width BACKLASH BETWEEN	AXIAL CLEARANCE OF DRIVING AND DRIVEN GEARS IN CASING Front scavenge gears axial clearance Casing – width Rear scavenge gears axial clearance Casing – width Gears – width Pressure gears axial clearance Casing – width Gears – width AGEARS — width BACKLASH BETWEEN PUMP GEARS AXIAL CLEARANCE OF DRIVING 1.0495 to 1.045 to 1.045 1.0	AXIAL CLEARANCE OF DRIVING AND DRIVEN GEARS IN CASING Front scavenge gears axial clearance Casing – width Rear scavenge gears axial clearance Casing – width Gears – width Pressure gears axial clearance Casing – width Gears – width Gears – width BACKLASH BETWEEN PUMP GEARS NEW NEW NEW NEW NEW NEW NEW N	AXIAL CLEARANCE OF DRIVING AND DRIVEN GEARS IN CASING Front scavenge gears axial clearance Casing – width Gears –	AXIAL CLEARANCE OF DRIVING AND DRIVEN GEARS IN CASING Front scavenge gears axial clearance Casing – width 1.045 to 1.045 to 1.045 to 1.050 0.0055 1.045 to 1.045 to 1.050 0.0055 1.045 to 1.050 0.0055 1.045 to 0.0055 1.045 t

SECTION 19C . . LUBRICATION SYSTEM

HORIZONTAL ENGINES

Lubrication of the horizontal engine is by the wet sump system. The engine sump and wheelcase drain chamber having a capacity of approximately 7.5 Imperial gallons (32.0 litres) for the six-cylinder engine and 12.5 Imperial gallons (56.8 litres) for the eight-cylinder engine.

The pump assembly is of the twin-gear type, incorporating a pressure and scavenge pump. The pump is mounted on the rear of the wheelcase backplate and is driven from the wheelcase gear train. A transfer pipe and bracket conveys oil from No. 2 main bearing oil gallery pipe bracket to the rear ends of the hollow driving and driven oil pump shafts and thence by drillings to the pump bearings.

Oil is drawn by the pressure pump, through a submerged suction filter in the centre of the engine sump and is delivered at high pressure through the heat exchanger via an oil transfer bobbin and inlet duct cast integral with the sump. After circulating the heat exchanger the oil flows along the outlet duct in the sump and through a transfer pipe to the oil relief valve housing.

From the oil relief valve housing the oil flows up the oil delivery pipe to the header bracket of the full-flow filters mounted on the upper face of the engine crankcase, oil in excess of the maximum working pressure of 60 lb. per sq. in. (4.2 kg. per sq. cm.) will pass through the oil pressure relief valve and return to the sump. If there is a pressure difference in excess of 15 lb. per sq. in. across the full-flow filters then the by-pass valve will open and allow the oil to travel up the by-pass tube to the oil outlet side of the filter header bracket and so by-pass the filters. From the outlet side of the filter header bracket the oil flows down the delivery pipe to an elbow fitted to the crankcase adapter plate,

and via an oil transfer bobbin through the adapter plate to the main oil gallery pipe assembly, fitted to the cap halves of the main bearings. Oil from the crankpins flows through longitudinal drillings in the connecting rods to the gudgeon pins. Cross drillings in the connecting rods lubricate the cylinder walls.

A transfer pipe and bracket delivers oil from No. 4 main bearing oil gallery pipe bracket to a drilling in the crankcase the extremity of which divides into three separate feeds, one to the hollow camshaft, one to the oil distributor block and the other to the tappet chest where the flow divides and is directed to each rocker shaft, through a drilling in one of the holding down studs of each cylinder head.

The tappets and cams are lubricated by spill oil draining from the rocker mechanism.

The oil distributor block mounted on the underside of the engine crankcase provides an attachment for a pressure gauge, a supply to the wheelcase and the supercharger or compressor if fitted. Provision is made for the fitting of an oil pressure warning switch if required.

In the event of the heat exchanger becoming blocked, a by-pass valve built into the oil feed and delivery passages for the heat exchanger in the engine sump is set to operate at 20 lb. per sq. in. allowing the oil to pass direct to the relief valve housing.

Spill oil draining from the engine returns to the sump, whilst the spill oil from the wheelcase drains into the wheelcase drain chamber from which it is drawn by the scavenge pump and delivered into the engine sump.

FILTERS

The servicing of the full-flow oil filters is the same as described for the vertical engines in Section 19A.

RELIEF VALVES

The housing for the relief valves is secured to crankcase adapter plate and connected by a drilling and internal pipe to the delivery side of the oil pressure pump.

Detail parts of each valve assembly are identical and differ only in the loading which is obtained by varying the depth of the valve seating from the machined locating faces for the retaining caps.

The relief valve stems are drilled and tapped 2 BA, to facilitate the removal of the valves.

When the valves are removed for servicing, inspect the faces of the valves and seats for indentations. Light scoring and indentation of the valve seatings may be faced out by lapping; valves that are deeply grooved must be renewed.

Indented valve seatings may be restored by lightly cutting the seating with a suitable flat faced cutter to restore the knife edge seating, which should be smoothed off by inserting a $\frac{7}{8}$ in (22.225 mm.) dia. steel ball bearing and tapping it with a light hammer.

The dimensions from the valve seat faces to the machined locating faces of the valve retaining caps are:—

High pressure valve 1.462 in. (37.089 mm.). Filter by-pass valve 2.132 in. (53.42 mm.).

When refacing a relief valve seating, only the minimum amount of metal should be removed, and

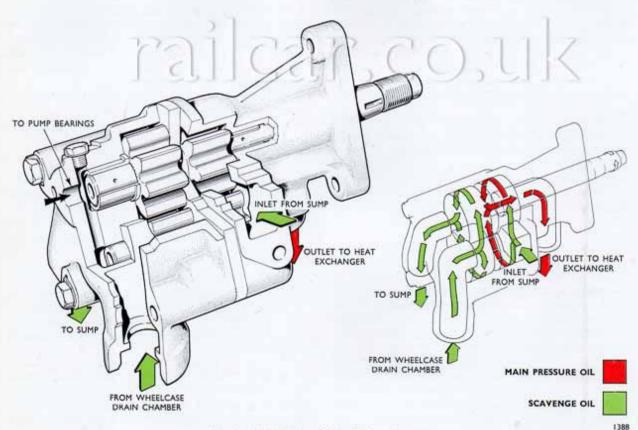


Fig. 1 Oil flow through lubrication oil pump

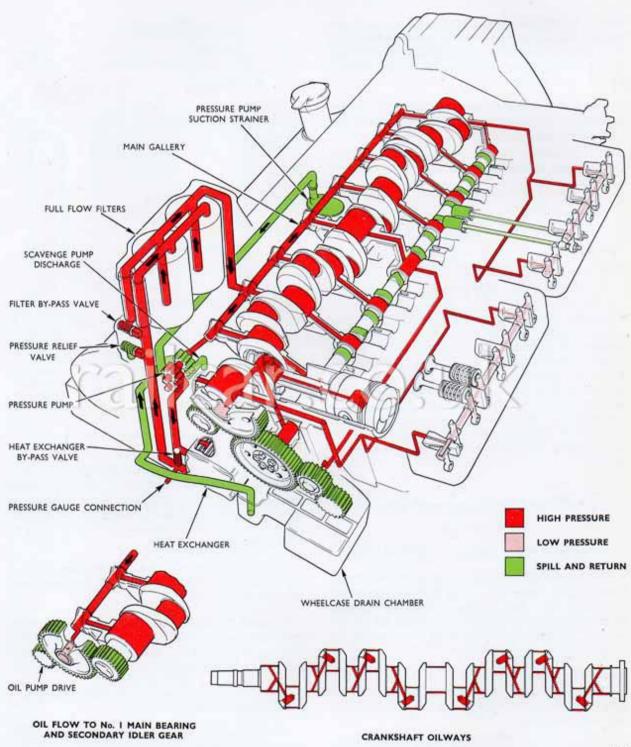


Fig. 2 Lubrication system — 8-cylinder engine

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shim adjusting washers equal in thickness to the metal removed from the seating must be inserted in the recess of the valve retaining cap, between the spring and the cap, to maintain the correct loading on the valve spring.

Check the springs for wear, squareness, and for free length, and loading to the figures given in the following table.

SETTING	COMPRESSED LENGTH	LOAD	
60 lb./sq. in.	1.650 in.	26.5 lb.	
(4.2 kg./sq. cm.)	(41.91 mm.)	(12.02 kg.)	
15 lb./sq. in.	2.320 in.	6.63 lb.	
(1.0546 kg./sq. cm.)	(58.928 mm.)	(3.0078 kg.)	

REFITTING

Ensure that the joint faces of the crankcase adapter plate and the relief valve housing are perfectly clean and free from burrs. Fit new sealing rings to the ends of the oil inlet and by-pass pipes, and fit the pipes to the relief valve housing. Insert the free ends of the inlet and by-pass pipes into the oil filter header bracket and secure the relief valve assembly to the crankcase adapter plate with the four set-bolts and spring washers, having first interposed a new joint washer between the joint faces.

SUMP AND WHEELCASE DRAIN CHAMBER

WHEELCASE DRAIN CHAMBER

The wheelcase drain chamber is secured to the bottom of the wheelcase by set-bolts and is further supported by a bracket. The chamber forms a reservoir for spill oil draining from the wheelcase and also for spill oil draining from the supercharger and compressor when fitted.

Removal and refitting

Remove the drain plug and drain the oil from the drain chamber, preferably when the engine is hot, then refit the plug.

Release and remove the scavenge oil pipe from between the drain chamber and the engine sump.

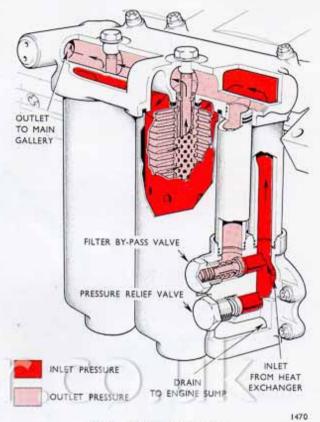


Fig. 3 Oil flow through filters

Release and remove the nuts and spring washers securing the drain chamber to the supporting bracket. If the supercharger is fitted release and remove the two set-bolts securing the oil transfer adapter to the drain chamber and ease the adapter off its joint face.

Release and remove the eight set-bolts securing the drain chamber to the wheelcase, and withdraw the chamber.

Remove the set-bolts securing the drain chamber inspection plates and remove the plates. Thoroughly clean out the drain chamber with paraffin and examine for cracks or other damage.

Refit the inspection plates interposing new gaskets between the joint faces.

Refitting of the wheelcase drain chamber is the reversal of removal. Always ensure that new sealing rings and joint washers are fitted.

ENGINE SUMP

The sump has internal ductings for conveying oil to the scavenge pump and from the pressure pump to the heat exchanger, and has a machined face for the fitting of the pack-type heat exchanger at the front end, the whole forming a single casting secured to the crankcase by set-bolts. The capacity of the 6-cylinder sump is approximately 7.5 Imperial gallons (32.095 litres) and 12.5 Imperial gallons (56.825 litres) for the 8-cylinder engine sump.

Removal and refitting

Drain the oil from the sump by removing the three drain plugs.

Disconnect the scavenge oil pipe between the sump and the wheelcase drain chamber and remove the pipe. Release the coolant hose clips on the coolant connection between the coolant pump outlet elbow and the heat-exchanger and break the joint. Release and remove the setbolts securing the coolant outlet elbow, and remove the elbow and connection. Release the rear coolant connection hose clips and rubber connections and remove the pipe between the coolant delivery rail and the cylinder block.

Remove the set-bolts securing the sump to the crankcase adapter plate and break the joint using $\frac{3}{8}$ in. UNF, set-bolts in the starting holes at each corner of the sump. Withdraw the sump evenly until the transfer bobbins connecting the oil pump to the sump oil ducts are free.

Release and remove the heat exchanger coolant outlet hose connection.

Remove the six set-bolts securing the heat exchanger to the sump and detach the heat exchanger.

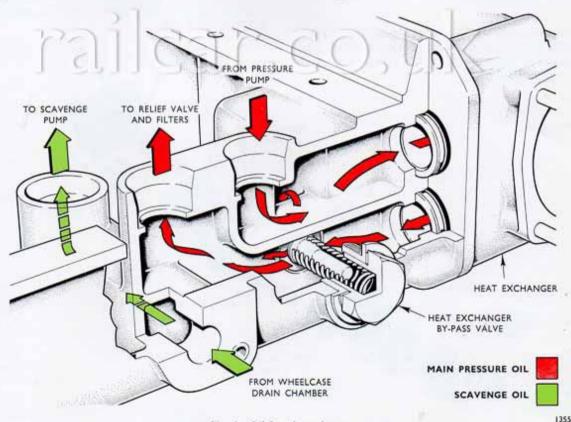


Fig. 4 Oil flow through sump

Inspection

Thoroughly clean all parts in paraffin and ensure that all sump internal passages are clear.

Inspect all parts for corrosion.

Refitting

When refitting the sump, fit new sealing rubbers to all transfer bobbins and position them in the holes in the sump.

Fit the four sump guide bars GA.257, one at each corner of the crankcase adapter flange and fit a new joint gasket. Offer the sump up to the adapter plate flange and locate it with the guide bars before pressing the sump into position. Secure the sump with the set-bolts, then replace the guide bars with the remaining set-bolts and finally tighten all the set-bolts.

Fit the heat exchanger to the sump and secure it with the six set-bolts.

Refit the coolant elbow to the coolant pump and remake and secure all coolant connections between the coolant sump and the coolant inlet branch on the engine crankcase.

OIL PUMP

Removal

Drain the oil from the engine sump and remove the sump.

Release and remove the two set-bolts securing the suction strainer bracket to the crankcase adapter plate, and withdraw the strainer, bracket and pipe assembly from the oil pump.

Release and remove the two set-bolts securing the transfer bracket to the pump and withdraw the transfer pipe and bracket from No. 2 main bearing gallery pipe bracket.

Release and remove the tachometer generator and adapter from the wheelcase.

Release and remove the locknut and tabwasher from the end of the pump drive shaft and withdraw the tachometer drive plate assembly and dowel. With the aid of tool GA.279 withdraw the gear from the taper on the pump drive shaft, and extract the Woodruff key.

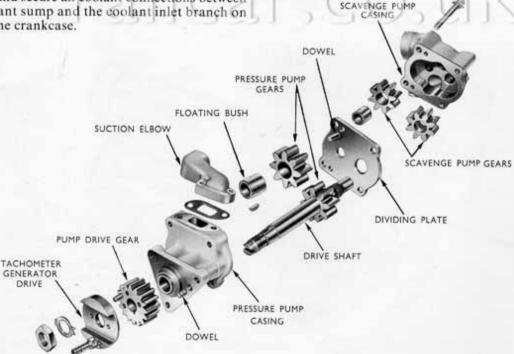


Fig. 5 Exploded view of lubrication oil pump

Turn the engine until one of the set-bolts securing the oil pump to the wheelcase backplate is visible through one of the lightening holes in the idler gear flange. Turn back the locking tabs, release and remove the set-bolts at the same time supporting the oil pump.

Withdraw the oil pump assembly from the wheelcase backplate, and extract the dowel.

Dismantling

Before dismantling the pump, suitably mark the pump casings and the dividing plate to ensure correct positioning of the dividing plate when re-assembling.

Turn back the tabs of the locking washers and release and remove the four set-bolts which secure the pump casings together.

Suitably support the pump assembly in a soft jawed vice with the rear pump uppermost.

Carefully withdraw the pump casing, exposing the scavenge pump gears. Withdraw the driving pump gear from the splined pump drive shaft, and the driven gear and bush from the fixed driven shaft.

Withdraw the dowels and the centre dividing plate from the pressure pump casing.

Withdraw the pressure pump driven gear and bush, and then withdraw the pump drive shaft which is machined integral with the pump driving gear.

The driven gear shaft is secured into the pressure pump casing by means of a locking peg and should not be removed.

Inspection

Thoroughly clean all the components, taking care to keep the loose gears and bushes to their respective pumps.

Gears, bushes and gearshafts

Check the teeth of all gears for wear and damage. Loss of tooth profile is not in itself serious and only if this is combined with an extensive area of break-up on the teeth, should a gear be rejected. Where the necessary equipment is available the gears should be electro-magnetically crack tested.

If the wear on the teeth of either pair of gears increases the backlash to more than 0.015 in. (0.3710 mm.) new gears should be fitted.

Check the fit of the scavenge pump driving gear on the splines of the pump driving shaft for wear. If any appreciable slackness exists, try the gear on a new shaft and also a new gear on the old shaft, to determine the serviceability of each component. The backlash of either component tried in this manner should not be more than 0.005 in. (0.127 mm.).

The diametral clearance of the driving and driven gears in their casings when new is 0.0075 to 0.0086 in. (0.1905 to 0.2135 mm.) and should not be more than 0.015 in. (0.3810 mm.).

The axial clearance of the gears when new is 0.005 to 0.0065 in. (0.1270 to 0.1651 mm.). Wear on the dividing plate is permissible up to a depth of 0.005 in. (0.127 mm.) and the permissible worn thickness of the plate is 0.235 in. (6.029 mm.). Check the driving shaft bush in the scavenge pump casing, if the bush is scored or the internal diameter exceeds 0.7555 in. (19.1897 mm.) then a new pump casing should be fitted.

Check the driving shaft bushes in the pressure pump casing, if the brushes are scored or the internal diameters exceed 0.8805 in. (22.3647 mm.) a new pressure pump casing should be fitted.

If the pump drive shaft is worn to a diameter of less than 0.868 in. (22.0472 mm.) at the drive end or less than 0.743 in. (18.8722 mm.) at the rear end, a new shaft should be fitted.

Check the floating bushes and the bores of the driven gears. If the gear bores are badly scored the gears should be renewed. If the outside diameter of the bushes is less than 0.900 in. (22.860 mm.) or if the inside diameter is worn so that the clearance of the bushes on the driven gear shaft exceeds 0.0025 in. (0.0635 mm.), or if the bushes are badly scored they should be changed.

If the driven gear shaft is worn to a diameter of less than 0.65175 in. (16.5544 mm.) the shaft and pressure pump casing assembly should be changed.

Check the internal machined surfaces of the two pump casings for scoring and if badly scored the casings should be renewed. Light scoring not exceeding a depth of 0.005 in. (0.127 mm.) is permissible.

Scoring on the dividing plate can be lapped out providing the thickness of the plate is not reduced below 0.235 in. (6.029 mm.).

The faces of the plate after lapping must be parallel to within a total indicator reading of 0.001 in. (0.0254 mm.).

Assembling

Assembling and refitting are the reverse of the removal procedure. Ensure that the pump driven gears are replaced in the same order in which they were removed and in the same end to end position. Ensure that the correlation marks are in-line thus ensuring that the dividing plate has been fitted the correct way round.

Check that all bolts are correctly locked and that the pump gears will rotate freely by hand.

Rig testing

The pump assembly should be tested on a suitable rig to prove its correct working after overhaul.

Test rig

A suitable test rig is illustrated diagrammatically in fig. 6

The open topped oil supply tank has a capacity of 15 gallons and is fitted with a steam heating coil; an alternative method of heating can be used where necessary. The pump on test is fitted to an adapter plate mounted over the supply tank and the pump is driven through a flexible coupling by a variable speed motor, capable of producing pump shaft speed of 1.010 and 2.790 r.p.m.

All suction and delivery pipes are 1 inch bore with 3-way cocks in the delivery circuits so that each pumping unit can be tested independently. For adjustment of pressures, restricting valves are fitted.

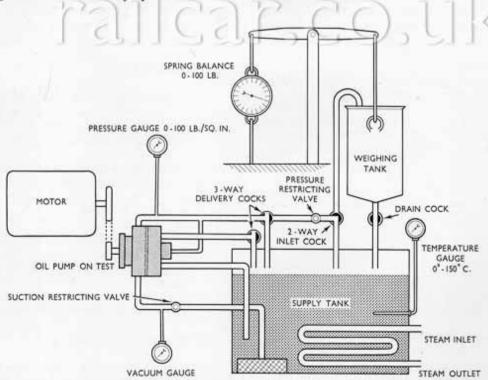


Fig. 6 Diagrammatic arrangement of test rig

The instrument panel has gauges for registering delivery and suction pressures and oil temperature. To ensure true readings, the tapping for each delivery pressure gauge is taken from a position between 2 and 6 inches from the pump. The pump shaft speed is set with a hand tachometer.

The weighing tank has a capacity of 8 gallons. A special inlet cock is fitted for quick action, and an outlet sluice valve.

Test procedure

Fill the supply tank approximately 4 full with

S.A.E. 30 engine lubricating oil specific gravity 0.890 at 60 deg.F.

Mount the pump to be tested on the adapter plate, and then fit the oil transfer bracket to the rear end of the pump. Fit the assembly into position on the rig. Couple up the suction and delivery pipes to the branch connections on the pump and the rig, and also the oil feed branch pipe from the pressure delivery pipe to the oil transfer bracket. Fit the flexible coupling between the pump shaft and the rig driving shaft.

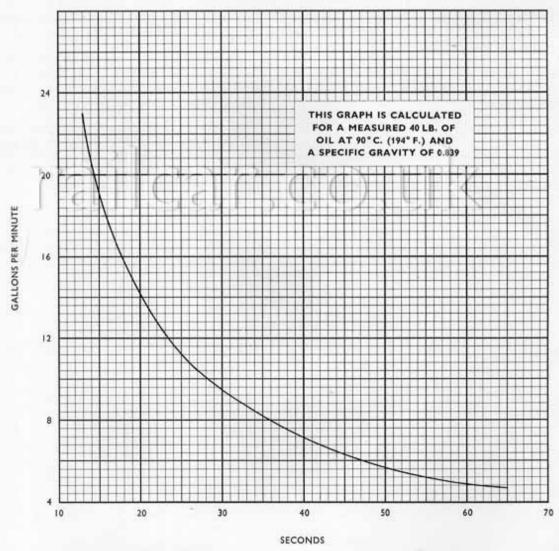


Fig. 7 Delivery graph

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Check that the delivery cocks and the weighing tank inlet cock are open to the supply tank, and that the delivery restricting valve is fully open.

Open fully the suction valves, then slowly open the steam to the heating coil in the supply tank.

Start the rig and run at approximately 1,000 r.p.m. until a steady oil temperature of 90 deg.C. (194 deg.F.) is attained, then set the pump shaft speed to exactly 1,000 or 2,700 r.p.m. and check the delivery of the pressure pump at each speed in the following manner:—

Turn the 3-way cock in the delivery line so that the cock is closed to the supply tank and open to the delivery header.

Adjust the suction restricting valve to give a suction pressure of -5 lb. per sq. in. (-0.3515 kg. per sq. cm.) and the delivery restricting valve to give a pressure of 60 lb. per sq. in. (4.2184 kg. per sq. cm.).

Recheck the pump shaft speed, reset if necessary and again check the pressures. Turn the weighing tank inlet cock to admit oil to the weighing tank and, with a stop watch, check the time it takes to add 40 lb. (18,144 kg.) to the spring balance reading. Switch the weighing tank inlet cock to its original position immediately after the check, and open the outlet cock to drain the oil back into the supply tank.

Turn the 3-way cock in the delivery line so that the cock is closed to the delivery header and open to the supply tank, and close the weighing tank outlet cock when all has drained from the tank.

Record the stop watch reading for each weighing on a suitable test card.

After checking the pressure pump at each speed, observe that the delivery of oil by the scavenge pump is satisfactory and carefully examine the pump for leaks before stopping the rig.

The delivery in gallons per minute from the stop watch readings can be obtained from the graph in fig. 7. The minimum delivery at 1,000 r.p.m. must not be less than 6 galls, per min. and at 2,700 r.p.m. not less than 17 galls, per min.

SECTION 23B . . AUXILIARY GEARBOX

The auxiliary gearbox is mounted independently of the engine in certain railcar installations to provide the drives for a radiator fan, an air compressor, an exhauster, and an electrical generator. It is positioned in front of the engine and is driven by the crankshaft hub through a disc-type flexible coupling and a Hardy-Spicer coupling. Flexibility of mounting is achieved by the use of Metalastik bushes on the gearbox bearer plates.

The main drive shaft is carried in the two-piece cast-iron gearbox casing by a ball bearing at its driven end and a roller bearing at the opposite (belt driving pulley) end. A coupling flange is keyed to a taper at the driven end of the shaft to receive the drive from the Hardy-Spicer coupling, and a double belt pulley is keyed to a taper at the

opposite end to drive the exhauster at 0.625 times engine speed. A four-belt pulley is bolted to the double belt pulley to drive a generator pulley at 2.8 times engine speed. An oil seal is fitted at each end of the shaft to retain the gearbox lubricating oil. A spiral bevel gearwheel which is bolted and dowelled to the shaft inboard of the ball bearing, meshes with and drives a spiral bevel pinion keyed to a taper on the fan drive shaft.

The fan drive shaft is carried by a roller bearing at its driven end and a ball bearing at its driving end. A coupling flange is keyed to a taper on the shaft at its driving end to accommodate a Hardy-Spicer coupling, which in turn drives the hub of the separately mounted radiator fan. An oil seal is fitted at the driving end of the shaft to retain the

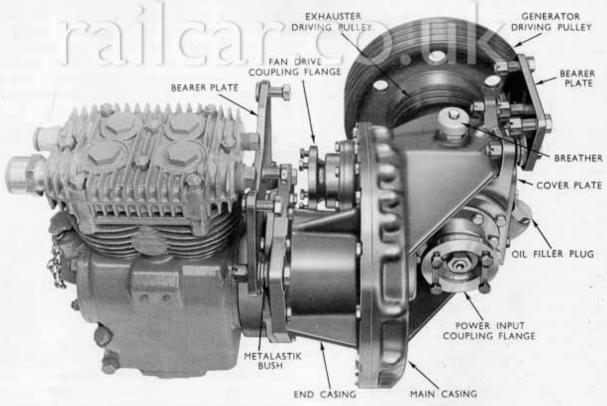


Fig. 1 Auxiliary gearbox with air compressor attached

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gearbox lubricating oil. A spiral bevel pinion keyed to a taper at the driven end of the shaft meshes with and is driven by the bevel gearwheel bolted to the main drive shaft. The fan is driven at 1.075 times engine speed. A helical pinion integral with the shaft meshes with and drives a helical gear which is integral with the compressor drive shaft.

The compressor drive shaft is carried by a roller bearing at its driven end and a ball bearing at its driving end, and is driven at 0.533 times engine speed through the reduction gear, as described in the preceding paragraph. An internally splined coupling keyed to a taper at the driving end of the shaft transmits the drive to the air compressor through an externally splined coupling keyed to a taper on the air compressor crankshaft. A machined face is provided on the gearbox casing to permit direct mounting of the air compressor.

The spiral bevel gears are supplied in matched pairs, with marked locating teeth to ensure correct meshing during the assembling of the gearbox. Their backlash is governed by the thickness of two packing pieces, one of which is fitted between the gearbox casing and the housing for the main drive shaft ball bearing, and the other between the gearbox casing and the housing for the fan drive shaft ball bearing. A detachable cover plate on the gearbox casing provides access for examination of the gears in situ.

The bearings and gears are splash lubricated by oil which is contained in the base of the casing, the level of which is governed during filling by the position of the filling plug on the casing. A drain plug is fitted to the base of the casing. The approximate oil capacity is 1\frac{1}{4} pints; it is essential that only Castrol 'Hi-Press' oil (or an approved equivalent) is used.

A breather is fitted to the top of the casing to maintain atmospheric pressure in the gearbox.

REMOVAL

Clean the exterior of the gearbox casing. Remove the drain plug from the base of the casing, drain and refit the drain plug. Manipulate the belt adjusting devices on the separately mounted generator and exhauster until maximum slackness of the driving belts is achieved. Remove the belts.

Support the weight of the Hardy-Spicer main drive coupling and remove the setbolts securing it to the flange on the gearbox main drive shaft and the setbolt securing it to the adapters on the flexible coupling on the engine crankshaft hub. Remove the Hardy-Spicer coupling.

Support the weight of the Hardy-Spicer fan drive coupling and remove the setbolts securing it to the flange on the fan drive shaft and the setbolts securing it to the hub of the radiator fan. Remove the Hardy-Spicer coupling.

Remove the split-pins from the slotted nuts on the bolts securing the bearer plate to the railcar frame member at the main drive shaft end of the gearbox, and remove the locking wire from the drilled heads of the setbolts securing the bearer plate to the railcar frame member at the compressor end of the gearbox. Support the weight of the gearbox and air compressor assembly on a suitable jack, and remove the bolts and setbolts from the bearer plates and frame member. Lower the assembly clear of the railcar and transport it to a suitable workbench.

Discard all locking plates, split-pins and locking wire removed during the above operation.

DISMANTLING

Remove the two bearer plates and their Metalastik bushes, and clean the exterior of the gearbox with paraffin.

Remove the setbolts and bolts securing the air compressor to the gearbox, and remove the air compressor, complete with male splined coupling.

Remove the setbolts securing the generator driving belt pulley to the exhauster driving belt pulley and remove the pulley. Remove the nut securing the exhauster driving belt pulley to the keyed taper on the main drive shaft; remove the pulley and collect the key.



Fig. 2 Testing backlash of spiral bevel gears

Remove the setbolts securing the oil seal housing to the casing (exposed by the removal of the belt driving pulley assembly), and remove the oil seal housing complete with oil seal.

Remove the nut securing the coupling flange to the keyed taper at the driven end of the main drive shaft; remove the coupling flange and collect the key. Remove the setbolts securing the oil seal housing to the bearing housing and remove the oil seal housing complete with oil seal.

Remove the nut securing the coupling flange to the keyed taper at the driving end of the fan driveshaft; remove the coupling flange and collect the key. Remove the setbolts securing the oil seal housing and bearing housing to the end casing, and remove the oil seal housing complete with oil seal. Temporarily refit the setbolts, suitably washered to compensate for the thickness of the oil seal housing flange, to retain the bearing housing in position on the end casing.

Remove the nut securing the female splined coupling to the keyed taper on the driving end of the compressor drive shaft; remove the coupling and collect the key. Remove the setbolts securing the cover plate to the end of the main casing and remove the cover plate. Clean the joint face on the main casing, and on it mount a dial test indicator so positioned that the button of the instrument contacts the teeth of the main drive shaft spiral bevel gearwheel. Gag the fan drive shaft and test the backlash of the spiral bevel gears by rocking the main drive shaft gear (fig. 2). Take backlash readings through at least four revolutions of the main drive shaft, at 90 deg. intervals; record the readings for reference during inspection and reassembling.

Remove the nut securing the inner race of the ball bearing to the driven end of the main drive shaft. To gag the shafts against rotation during this operation and other similar operations during dismantling, insert a \(\frac{5}{8} \) in. diameter steel rod through the hole in the end casing and into one of the holes in the compressor drive shaft helical gearwheel (fig. 3).

Remove the setbolts securing the bearing housing to the main casing and remove the housing and

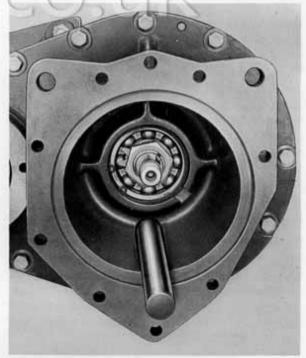


Fig. 3 Method of gagging shafts against rotation

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bearing assembly; collect the packing piece interposed between the bearing housing and the main casing. Withdraw the main drive shaft, complete with spiral bevel gearwheel and the inner race and rollers of the bearing, from the main casing.

Remove the nut securing the spiral bevel pinion to the keyed taper at the driven end of the fan drive shaft; remove the pinion and collect the key. Two tapped holes are provided on the bevel pinion for extraction purposes.

Remove the nut securing the inner race of the ball bearing to the driving end of the fan drive shaft. Remove the setbolts and withdraw the bearing housing, complete with ball bearing, from the end casing. Two $\frac{5}{16}$ in. tappings are provided for withdrawal purposes. Collect the packing piece interposed between the bearing housing and the end casing. Remove the ball bearing from the bearing housing.

Remove the nut securing the inner race of the ball bearing to the driving end of the compressor drive shaft.

Remove the setbolts securing the end casing to the main casing, and remove the end casing complete with the compressor drive shaft, its ball bearing, and the inner race and rollers of its roller bearing. Remove the compressor drive shaft from the end casing. Extract from their grooves the spring rings retaining the outer race of the ball bearing in the end casing, the outer race of the roller bearing in the main casing, and the inner race and rollers of the roller bearing on the shaft. Extract the ball bearing, the outer race of the roller bearing, and the inner race and rollers. Assemble the roller bearing.

Withdraw the fan drive shaft, complete with the inner race and rollers of its bearing, from the main casing. Extract from their grooves the spring rings retaining the inner race of the roller bearing on the shaft and the outer race in the main casing; remove the inner race and rollers from the shaft and the outer race from the main casing, and assemble the bearing.

From its groove in the driving end of the main drive shaft extract the spring ring securing the inner race of the roller bearing, and remove the inner race and rollers from the shaft. Remove the outer race from the main casing and assemble the bearing. Remove the ball bearing from the bearing housing.

Remove the setbolts securing the spiral bevel gearwheel to the main drive shaft; remove the gearwheel and extract the dowels.

Discard all keywashers, tabwashers and locking plates removed during dismantling.

INSPECTION

Clean all parts in paraffin and dry off with compressed air.

Ensure that all joint faces are undamaged and perfectly clean. Examine all securing setbolts for serviceability.

Examine the casing for external damage and test for cracks by either a chalk test or the 'Ardrox' 996 dye penetration process. The 'Ardrox' process is a simple, inexpensive method requiring no special equipment, and the materials, with instructions for their use, can be obtained from Brent Chemical Products Ltd., Commerce Road, Brentford, Middlesex.

Carry out an electro-magnetic crack detection test on all shafts and gearwheels; demagnetize each component on completion of its test. Examine all shaft tapers and gear and coupling flange bores for signs of fretting, and all shaft threads for signs of damage.

Examine the teeth of all gears for wear and damage. Loss of tooth profile is not in itself serious, and only if this is combined with an extensive area of break-up on the teeth or accompanied by excessive backlash should a gear be rejected.

Examine all keys and keyways for wear and damage. Blend out any withdrawal marks on the keys and check the fit of each key in its keyway.

Examine all ball and roller bearings for cracks and for pitting of the races, balls or rollers, and test for excessive end float and radial play. Spin each bearing and check for freedom and smooth action; reject any bearings having rough spots. Examine the races for signs of spinning on their shaft or in their housings.

Examine all spring rings for damage and distortion.

Examine the oil seals for serviceability; ensure that there are no signs of the seals seizing on the coupling flanges or on the main drive shaft. Do not remove the seals from their housings unless they show obvious signs of unserviceability. Ensure that the coupling flanges and the main drive shaft are not grooved where they contact the oil seals.

Test the fit of the male and female splines of the air compressor couplings for excessive clearance.

Examine the belt driving pulleys for damage, and the belts for damage, wear and deterioration.

Examine the Metalastik mounting bushes for bonding and deterioration, the bearer plates for damage, and the bearer bolts for signs of fretting.

Examine the Hardy-Spicer couplings and their coupling flanges for damage and wear, and the flexible coupling on the engine crankshaft hub for damage and deterioration.

ASSEMBLING

Ensure that the housings in the main casing for the outer races of the fan drive shaft and compressor drive shaft roller bearings are clean and free from burrs. Fit the races in the housings; ensure that they are driven fully home, and secure them in position by fitting a spring ring in the groove in each housing. Fit the inner races and rollers of the bearings to the driven ends of the shafts, i.e. the unthreaded end of the compressor drive shaft and the single threaded end of the fan drive shaft; ensure that the races abut the shaft flanges, and secure each assembly by fitting a spring ring in the groove in each shaft.

Support the main casing on the workbench so that the joint face is uppermost and truly horizontal. Smear the outer race of the fan drive shaft roller bearing with Castrol 'Hi-Press' oil (or an approved equivalent) and offer up the fan drive shaft (fig. 4) to the casing, ensuring that the rollers of the bearing enter the outer race squarely. Do not use force during this operation.

Ensure that the compressor drive shaft ball bearing housing in the end casing is clean and free from burrs. Fit the bearing in the housing; ensure that it is driven fully home and secure it in

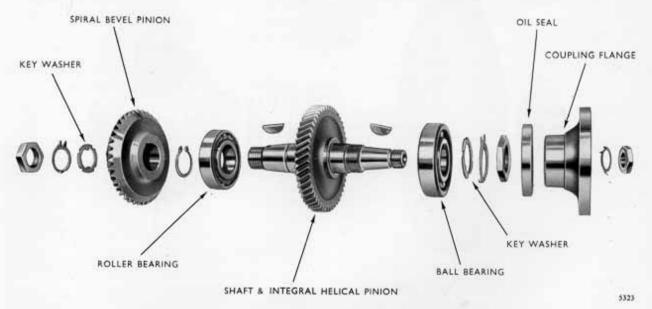


Fig. 4 Fan drive shaft exploded

position by fitting a spring ring in the groove in the housing. Pour a small quantity of oil over the balls and spin the bearing to distribute the oil.

Support the end casing on the workbench so that the joint face is uppermost and truly horizontal, and offer up the compressor drive shaft (fig. 5) to the end casing, ensuring that the shaft enters the inner race of the bearing squarely. Drive the shaft fully home in the bearing.

New main casing only. Ream the three dowel holes and fit the dowels as follows:

Temporarily assemble the end casing to the main casing without a joint washer. Spin the compressor drive shaft to test for freedom of rotation, tighten the casing joint securing setbolts and retest for freedom. Ream the three dowel holes in the main casing, locating a ½ in. reamer through the finished dowel holes in the end casing. Remove the end casing together with the compressor drive shaft from the main casing, and extract the swarf from the reamed holes by means of a magnetic rod. Do not use compressed air for this operation, or swarf may be blown into the bearings or on to the internal

surfaces of the casing. Fit a spring ring in the groove of each of the three dowels required, and fit the dowels in the reamed holes in the main casing.

With the main casing still supported on the workbench with the joint face horizontal and uppermost, lightly smear the joint face with grease and position a joint washer on the face so that its holes coincide accurately with the setbolt holes. Smear the outer race of the compressor drive shaft roller bearing with oil and fit the end casing, with the compressor drive shaft, to the main casing. Fit the securing setbolts and spring washers, and tighten firmly. Test the compressor drive shaft for free rotation.

Mount the assembly in a build stand capable of permitting the gearbox to be positioned at any required angle. A suitable build stand is a modified 'Hydraclamp', manufactured by All Precision Engineering Co. Limited, Horsham, Sussex.

Ensure that the fan drive shaft ball bearing housing is clean and free from burrs, and fit the bearing in the housing. Pour a small quantity of oil into the bearing and spin it to distribute the oil.

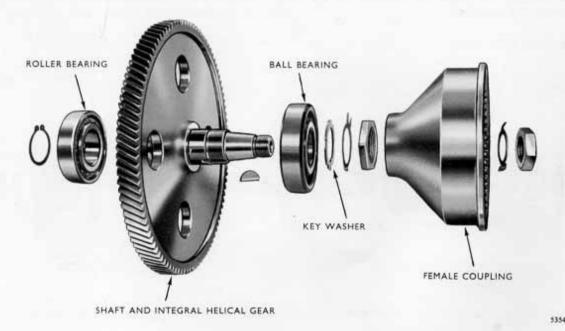


Fig. 5 Compressor drive shaft exploded

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If the backlash of the spiral bevel gears recorded during dismantling was between 0.010 and 0.012 in., and no new parts have been fitted during the overhaul of the gearbox, refit the original fan drive shaft packing piece, the bearing housing and bearing assembly, and the oil seal housing, to the end casing. Secure them with setbolts and spring washers, interposing a joint washer between each unit. If the backlash recorded during dismantling exceeded 0.012 in., or if new parts have been fitted during the overhaul of the gearbox, fit a trial packing piece ground to a thickness of 0.148 in., and temporarily assemble the packing piece, bearing housing and oil seal housing to the end casing without joint washers. In place of the two joint washers normally fitted on either-side of the packing piece, temporarily insert three equispaced 0.008 in. feeler gauges between the packing piece and the end casing before tightening the setbolts.

Fit the keywasher, tabwasher and ball bearing retaining nut to the fan drive shaft. Tighten the nut but leave it unlocked at this stage. To gag the main, compressor, and fan drive shafts during this and other similar operations, insert a § in. diameter steel rod through the hole in the end casing and into one of the holes in the compressor drive shaft helical gearwheel (see fig. 3).

Fit the key in the keyway in the taper at the driven end of the fan drive shaft, and fit the bevel pinion to the shaft. Fit the keywasher, tabwasher and retaining nut; tighten and lock the nut.

Ensure that the main drive shaft roller bearing housing in the main casing is clean and free from burrs, and fit the race in the housing. Ensure that it is driven fully home and smear its bearing surface with oil. Fit the oil seal housing to the main casing, with a joint washer interposed between the casing and the housing, and secure with setbolts and spring washers.

Fit the three spiral bevel gear locating dowels to the main drive shaft and fit the spiral bevel gear to the shaft. Fit the locking plates and bevel gear retaining setbolts; tighten and lock the setbolts. Fit the inner race and rollers to the driving end of the shaft. Ensure that the inner race abuts the flange on the shaft and secure it in position by fitting a spring ring in the groove in the shaft.

Offer up the main drive shaft (fig. 6) to the main casing, ensuring that the rollers enter the outer race of the roller bearing squarely and that the marked locating teeth of the spiral bevel gears are correctly meshed.

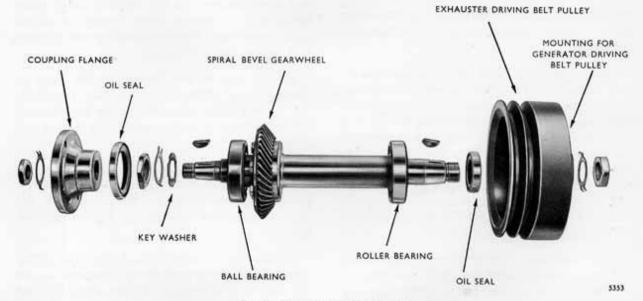


Fig. 6 Main-drive shaft exploded

Ensure that the housing for the main drive shaft ball bearing is clean and free from burrs, and fit the bearing in the housing; ensure that it is driven fully home. Pour a small quantity of oil over the cage of balls and spin the bearing to distribute the oil.

If the backlash of the spiral bevel gears recorded during dismantling was between 0.010 and 0.012 in., and no new parts have been fitted during the overhaul of the gearbox, refit the original main drive shaft packing piece and the bearing housing (with ball bearing) to the main casing, interposing joint washers between the units, and secure with setbolts and spring washers. If the backlash recorded during dismantling exceeded 0.012 in., or if new parts have been fitted during the overhaul of the gearbox, fit a trial packing piece ground to a thickness of 0.148 in., and temporarily assemble the bearing housing assembly to the main casing without joint washers, allowing for their combined thickness by inserting three equispaced 0.008 in. feeler gauges between the packing piece and the main casing before tightening the setbolts.

Examine the spiral bevel gears to ensure that the meshing of the marked locating teeth has not been disturbed during the last operation.

Fit the keywasher, tabwasher and bearing retaining nut to the driven end of the main drive shaft. Tighten the nut, but leave it unlocked at this stage.

Examine the spiral bevel gears to ensure that the teeth of the wheel and pinion are meshing over their complete sections. Mount a dial test indicator rigidly on the gearbox casing so that the button of the instrument contacts the teeth of the main drive shaft gear. Gag the fan drive shaft and test the backlash by rocking the main drive shaft gear. It must be between 0.010 and 0.012 in. This test must be carried out through at least four revolutions of the main drive shaft, at 90 deg. intervals (see fig. 2).

If the backlash is not within the stated limits, slacken the setbolts and re-tighten and test with varying thickness of feeler gauges inserted in place of the 0.008 in. feelers at each housing until the correct backlash is obtained. Then remove the packing pieces and feeler gauges and fit standard packing pieces ground to a thickness determined by subtracting 0.008 in. from the combined thickness of the trial packing piece and the feeler gauges.

Joint washers must be interposed between the units on final assembly.

Carry out a final backlash test through four revolutions of the main drive shaft. Remove the dial test indicator and lock the nuts on the driven end of the main drive shaft and the driving end of the fan drive shaft. Fit the oil seal housing to the main drive shaft ball bearing housing, with a joint washer interposed, and secure with setbolts and spring washers.

Fit the key to the keyway in the taper at the driven end of the main drive shaft, and the oil seals in the oil seal housings at both ends of the shaft. Fit the coupling flange to the keyed taper at the driven end of the shaft, taking care not to damage the oil seal during the operation. Fit the tabwasher and securing nut; tighten and lock the nut.

Fit the key to the keyway in the taper at the driving end of the fan drive shaft and the oil seal in its housing. Fit the coupling flange to the keyed taper, taking care not to damage the oil seal in the operation. Fit the tabwasher and securing nut; tighten and lock the nut.

Fit the key to the keyway in the taper at the pulley end of the main drive shaft, and fit the belt driving pulley assembly to the keyed taper. Fit the tabwasher and securing nut; tighten and lock the nut.

Fit the key to the keyway in the taper at the driving end of the compressor drive shaft. Fit the male splined coupling to the keyed taper. Fit the tabwasher and securing nut; tighten and lock the nut.

Remove the assembly from the build stand and support it on the workbench with the joint face for the cover plate uppermost. Lightly smear the joint face with grease and position the joint washer on

ENGINE

the face so that its holes coincide accurately with the setbolt holes. Fit the cover plate and secure it to the main casing with setbolts and spring washers.

Using new joint washers, fit the breather and the oil drain plug to the main casing and the oil filler plug to the cover plate.

Ensure that the female splined coupling is firmly secured to the crankshaft of the air compressor, and that its securing nut is correctly split-pinned. Support the gearbox assembly on the workbench so that the breather is uppermost and the mounting flange for the air compressor is vertical. Smear the mounting face lightly with grease and position the joint washer so that its holes coincide accurately with the bolt holes in the face. Offer up the compressor to the gearbox, at the same time lining up the splines of the couplings. Secure the compressor to the gearbox casing, using as applicable bolts or setbolts and spring washers.

Fit the two gearbox bearer plates to the gearbox casings, with the hard Metalastik bushes at the compressor end of the casing and the soft Metalastik bushes at the main drive shaft end of the casing. Tighten and split-pin the bearer bolt nuts.

REFITTING

By means of a suitable jack, raise the gearbox and compressor assembly until the bolt holes in the bearer plates are in line with the holes in the railcar frame members. Fit and tighten the bearer plate setbolts and bolts; split-pin the slotted nuts and wire-lock the setbolts with 22 S.W.G. (0.028 in. dia.) mild steel wire.

Offer up the Hardy-Spicer main drive coupling to the flange on the gearbox main drive shaft and the adapters on the flexible coupling on the engine crankshaft hub. Fit the securing setbolts and locking plates; tighten and lock the setbolts.

Offer up the Hardy-Spicer fan drive coupling to the flange on the gearbox fan drive shaft and the fan hub. Fit the securing setbolts and locking plates; tighten and lock the setbolts.

Connect and tighten the air inlet and outlet unions on the cylinder head of the air compressor.

Fit the generator and exhauster driving belts, and manipulate the belt adjusting devices on the generator and exhauster until the correct belt tension is obtained on each set of belts, i.e. one inch total deflection at the central points on the longest stretches of belts between pulleys. If new belts have been fitted, test the deflection after the first day's running and readjust as required.

Ensure that the oil drain plug is tight in the casing boss and fill the gearbox with Castrol 'Hi-Press' oil (or an approved equivalent) up to the filler plug level. Refit the filler plug and tighten securely.

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T.S.D. 803 CHAP. 5 SEC. 25A

SECTION 25A . . AIR COMPRESSOR-CLAYTON DEWANDRE

The air compressor is an in-line twin cylinder unit with either a liquid or air cooled cylinder head. For most installations the compressor is belt driven from a grooved pulley on the front end of the engine crankshaft.

Compressors are pressure lubricated by engine oil fed from the engine lubrication system. The oil is conveyed to the compressor crankshaft centre journal through a communicating member and lubricates the crankpin bearings by means of an oilway in the crankshaft. Gudgeon pin bearings, cylinder walls and the crankshaft ball and roller bearings are lubricated by splash.

If the compressor is fitted with a bevel gear fan drive, the oil flows from the compressor crankcase to the bevel gearcase, through the perforated ballrace retaining plate, to lubricate the gears by splash. A gearcase drain pipe returns the oil to the engine sump.

Filtered air is drawn from the engine intake manifold and for a liquid cooled cylinder head the engine coolant is utilized.

REMOVAL

If the head is liquid cooled, drain the engine cooling system until the level of coolant is below the compressor head, and disconnect and remove the coolant pipes. Disconnect the air inlet and outlet pipes, and the lubricating pipes from the compressor.

Belt driven compressor

Slacken off the driving belt adjuster sufficient to release the belts. Remove the driving belts, and the bolts securing the compressor to the baseplate and lift the compressor from the engine.

Shaft driven compressor (tandem with fuel pump)

Turn the engine in direction of rotation until the timing marks on the engine and fuel pump flywheels are in line and, if possible, avoid turning the engine or fuel pump until the compressor is refitted; this will obviate the necessity of resetting the fuel pump timing.

Release and remove the bolts securing the spring plate assembly to the drive coupling on each end of the compressor crankshaft. Remove the set-bolts securing the compressor to its mounting bracket, and lift off the compressor.

Blank all apertures exposed by removal.

DISMANTLING

Remove the cylinder head complete.

Withdraw the driving pulley or driving couplings from the crankshaft, extract the key or keys but do not remove the drive end cover at this stage.

Section revised March 1957

Remove the connecting rod caps and withdraw

the pistons and connecting rods through the top of the cylinder bores. Mark each connecting rod and

cap before removal to ensure correct assembly on

Detach the base plate and the oil supply inlet flange. Unbolt and remove the oil communicating member from the centre journal of the crankshaft.

rebuild. DELIVERY VALVE CAP AIR INLET MANIFOLD Remove the set-bolts from the front end cover. ALVE DISC Screw two set-bolts, with approximately twice the length of thread of the ones removed, into the starting holes provided, and withdraw the end cover. Tap the crankshaft, together with its bearings, away from the drive end cover and remove the cover. The bearings should not be removed from the INLET VALVE DISC crankshaft unless they are unserviceable. PCGA.283-3 compressor with bevel gear fan drive Remove the driving pulley, cylinder head, base VALVE KEEPER plate, oil communicating member, connecting rods and pistons as previously described in this section. Release and remove the gearcase rear end cover. Release and remove the nut securing the flange coupling to the fan driving shaft and withdraw the flange from the shaft. Extract the key. Release and remove the end cap from the pinion end of the fan driving shaft, and release and remove the nut from the shaft. LUBRICATING OIL DRIVING PULLEY LUBRICATING OIL COMMUNICATING MEMBER INLET FLANGE DRIVING END COVER REAR END

Fig. 1 Exploded view of air compressor

OIL SEAL

Release and remove the set-bolts securing the end cap and seal housing.

Support the fan drive bevel pinion and with the aid of a hollow drift, drive the fan driving shaft, end cap and seal housing assembly through the roller bearing and bevel pinion. Withdraw the assembly from the gear casing. Collect the bevel pinion and shims, and extract the key from the shaft.

Support the fan driving shaft on the outer race of the ball bearing, and using a hollow drift drive the shaft out of the race and the seal housing. Collect the adjusting washer and ballrace. Withdraw the oil seal from its housing.

Release and remove the nut securing the bevel gear to the crankshaft.

Remove the set-bolts from the compressor drive end cover. Screw two set-bolts, with approximately twice the length of thread of the ones removed, into the starting holes provided and withdraw the end cover. Withdraw the oil seal sleeve from the drive end of the crankshaft.

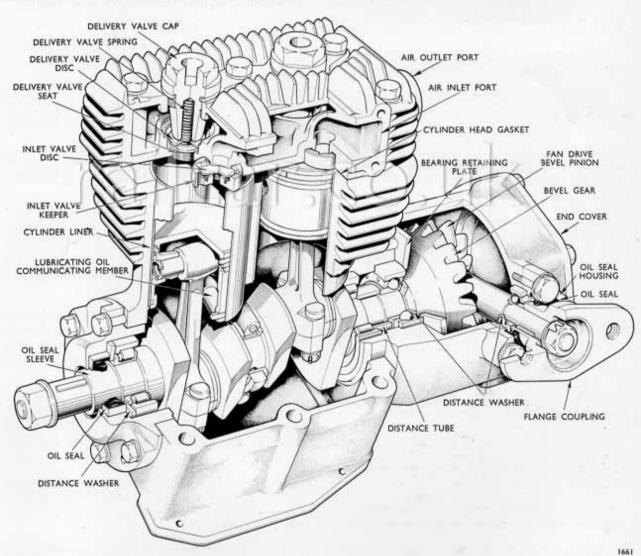


Fig. 2 - Section through compressor and gearbox

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Tap the crankshaft, together with its bearings, away from the bevel gear casing, and withdraw the shaft from the compressor crankcase. Collect the bevel gear, adjusting washer and distance piece.

Mark the bevel gearcase and bearing retaining plate to ensure correct assembly on rebuild.

Release and remove the six set-bolts securing the bearing retaining plate, and the bevel gearcasing to the compressor crankcase, remove the plate and withdraw the gearcasing.

Turn the gearcasing on to its rear end and with a suitable drift, tap the ball bearing from its housing in the casing.

The bearings should not be removed from the crankshaft unless they are unserviceable.

To dismantle the cylinder head, remove the inlet manifold, delivery valve cap, springs and disc valves.

Unscrew the inlet valve keepers of a 15 cu. ft. capacity compressor using the tool GA.81, and withdraw the valve discs and springs.

For the 10 cu. ft. capacity compressor extract the inlet valve keepers using the tool GA.265, and withdraw the valve discs and springs.

The delivery valve seats can be removed by using the tool GA.86.

If the valves and the delivery valve springs show any sign of wear they should be renewed. It is advisable to always fit new inlet valve springs.

INSPECTION

Remove all deposit from the cylinder head and thoroughly clean all air and cooling passages.

Check the ball and roller bearings for freedom and smooth action, any bearings having rough spots after being thoroughly washed out should be changed.

Examine the bevel gear and bevel pinion for plucking. Slight plucking should be stoned out.

Check the cylinder bores for wear and refer to the table for limits of wear and service action.

WEAR IN BORE (on dia.)	ACTION
Up to 0.005 in. (0.127 mm.)	Fit new standard rings
0.005 to 0.010 in. (0.127 to 0.254 mm.)	Bore to + 0.010 in. (0.254 mm.) and fit 0.010 in. (0.254 mm.) oversize pistons and rings
0.010 to 0.015 in. (0.254 to 0.381 mm.)	Fit new 0.010 in. (0.254 mm.) oversize rings
Over 0.015 in. (0.381 mm.)	Fit new liners and new standard pistons and rings

Cylinder bores when new are as follows:-

Compressors with a nominal capacity of 10 cu. ft. per min. are 2.625 in. (66.675 mm.) diameter.

Compressors with a nominal capacity of 15 cu. ft. per min. are 2.812 in. (71.424 mm.) diameter.

Check the gap of each compression and scraper ring with the ring positioned in the bore of the cylinder. Any ring which has a gap of more than 0.012 in. (0.304 mm.) should be discarded and a new ring fitted. New rings should have a gap of 0.003 to 0.007 in. (0.076 to 0.179 mm.).

Ensure that the rings grooves in the piston are square and smooth and, with the rings fitted to the piston, check the side clearance between the rings and the rings grooves. This should not be more than 0.005 in. (0.127 mm.).

Examine the white metal of the connecting rod bearings and the bearing of the oil communicating member. If the metal is cracked or badly scored, a new or replacement rod or member should be fitted.

Check the clearance between the gudgeon pin and the gudgeon pin bush. If the clearance is more than 0.0015 in. (0.0381 mm.), fit a new or replacement connecting rod.

Check the connecting rods for parallelism and twist. In the event of a connecting rod bearing being remetalled, the length between the bore centres of 4.127 to 4.123 in. (104.825 to 104.724 mm.) for the 10 cu. ft. capacity type, and 4.752 to 4.747 in. (120.700 to 120.573 mm.) for the 15 cu. ft. capacity type must be maintained.

Fitting new cylinder liners

To remove a worn liner heat the cylinder block in oil to a temperature of 180 deg.C. (356 deg.F.), the liner should then fall from the block as it is lifted out of the oil.

To fit a new liner, first heat the cylinder block in boiling water, then press in the liner until its bottom edge is located on the shoulder in the cylinder block bore. After fitting, grind the edge of the liner flush with the top face of the cylinder block, and grind and lap the liner bore to the finished dimension previously given for new compressors.

ASSEMBLING AND REFITTING

When assembling the unit use new jointing washers and a new cylinder head gasket. If new cylinder liners have been fitted, fit new standard pistons and rings.

Assemble the compressor in the sequence given in the following paragraphs.

Fit the distance tube to the drive end of the crankshaft, ensure that the distance washer is located in the drive end cover, and fit the cover to the roller bearing which is in position on the crankshaft. Fit the crankshaft into the crankcase and secure the drive end cover, taking care not to damage the oil seal.

Fit and secure the rear end cover.

PCGA.283-3 compressor with bevel gear fan drive

Fit the ball bearing to its housing in the bevel gearcasing.

Fit the oil seal sleeve to the drive end of the crankshaft, ensure that the distance washer is located in the drive end cover, and fit the cover to the roller bearing which is in position on the crankshaft. Position a new joint washer on the drive end face of the compressor crankcase. Fit the crankshaft into the crankcase and secure the drive end cover taking care not to damage the oil seal.

Fit the distance tube to the gearcase end of the crankshaft. Fit a new joint washer to the spigotted end of the bevel gearcase, and fit the gearcase to the compressor crankcase. Ensure that the ball bearing is home in its housing and the correlation marks are in line on the casings. Fit the bearing retaining plate, and secure the plate and gearcase to the compressor crankcase with the correlation marks on the plate and gearcase in line. Lock the set-bolts.

Position the distance washer to abut the inner race of the ball bearing and fit the key and bevel gear to the crankshaft.

Fit the tabwasher, secure the bevel gear with the nut, and turn up the tabwasher.

Fit the key and the bevel pinion to the fan driving shaft.

Position the driving shaft in the bevel gearcasing, and position the adjusting shims to abut the bevel pinion. Fit the roller bearing to the shaft and the bevel gearcasing. Fit the keywasher, the tabwasher, and fit and tighten the nut securing the bearing race to the shaft. Lock the nut.

Fit the end cap and secure with the three set-bolts.

Position the distance washer at the flange end of the driving shaft and fit the ball bearing to the shaft and casing.

Fit a new oil seal to the end cap, and fit the end cap to the gearcasing. Lock with the three set-bolts.

Position the driving flange on the shaft ensuring that the key has been fitted to the shaft and taking care not to damage the oil seal. Position the keywasher and tabwasher on the shaft, and secure the flange to the shaft with the nut. Turn up the locking tab.

Fit the bevel gearcase end plate, interposing a new joint washer between the mating faces. Smear the crankpins with clean lubricating oil, fit a new oil seal to the oil communicating member, and fit the member to the crankshaft ensuring that the correlation marks are coincident. Tighten and split-pin the nuts.

Insert the lubricating oil inlet flange into the crankcase at the same time lining up the oil communicating member with the bore of the inlet flange, and secure with the two set-bolts.

Insert the connecting rod and piston assemblies into the crankcase from the top of the cylinder bores, ensuring that they are in their correct end to end position and the correct way round.

Fit the bearing cap halves ensuring the correlation marks are coincident. Tighten and split-pin the nuts.

Fit the driving pulley to the crankshaft ensuring that the Woodruff key is fitted correctly. Tighten and split-pin the nut.

Assemble the cylinder head, fitting new inlet and delivery valve springs and discs if necessary. The delivery valve springs are slightly flared at one end, and it is most important that this end is entered first into the valve cap bore. Use a screwing action to fit the springs, and ensure that they are inserted to the full depth of the bore; if they are not fully inserted, overheating of the cylinder head may result, with rapid deterioration of the valves and springs.

Check that the springs are bottoming in the bore by compressing them solid with the easily made

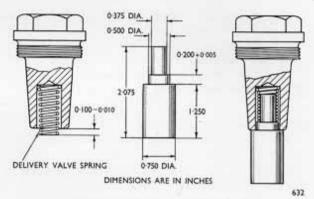


Fig. 3 Fitting delivery valve springs

tool illustrated; the shoulder of the tool will make contact with the end faces on the caps if the springs are correctly fitted.

Take care also that the inlet springs are correctly located and that the valve keepers are fully home, so that each keeper is flush with the cylinder head face.

Fit the inlet manifold to the head and secure the head to the cylinder block, interposing a new gasket between the joint faces.

Refitting the compressor to the engine is the reverse of the removal procedure.

After fitting the belts, adjust the tension to give a total deflection of one inch at a position midway between the driving pulley and the compressor pulley.

SECTION 25B . . AIR COMPRESSOR — WESTINGHOUSE

The air compressor is an in-line, twin-cylinder, gear-driven unit with a detachable air-cooled cylinder head. The head incorporates two pairs of suction and delivery valves, one pair for each cylinder. The valves are of the plate disc-type held on their respective seats by one coil spring.

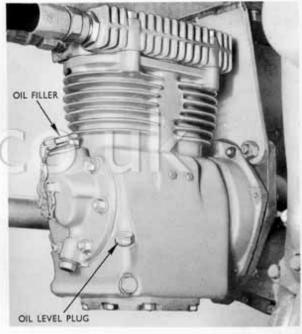
Lubrication of the cylinder bores and gudgeon pins is by surplus oil thrown from the big-end bearings which are pressure fed, along with the main bearings, by a gear-type pump. The pump is situated in the base of the compressor and is driven by a helical gear mounted centrally on the crankshaft.

Except for the periodic examination and topping-up of the oil level (fig. 1), no maintenance is normally required between overhaul periods.

If the compressor fails to function correctly and there is no leakage in other parts of the air system, the valves should be removed and examined.

Servicing the valves

Unscrew the valve caps from the cylinder head and remove the valve discs and springs. Clean off all carbon deposits. Examine the valve discs and springs for pitting and distortion, and renew if necessary.



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Fig. 1 Air compressor, showing oil filler and oil level plug

Examine the valve seats. Lightly pitted seats should be lapped with fine grinding paste. Badly pitted seats should be refaced with a cutter, removing only the minimum amount of metal. After refacing a suction valve seat, check the dimension 'X' (fig. 2) which should be retained between 0.283 and 0.289 in. by skimming face 'M' of the suction valve cap. Similarly, the delivery

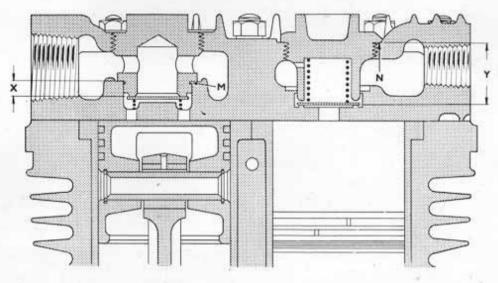


Fig. 2 Suction valve and delivery valve

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valve dimension 'Y' should be retained between 1.215 and 1.221 in. by skimming the cylinder head face 'N'.

Remove swarf and blow out with compressed air. Carefully clean all parts before reassembling, and do not use any lubricant or jointing compound when fitting valves and caps. Check the cylinder head nuts and pipe connections for tightness.

For further maintenance instructions refer to the appropriate Westinghouse publication.

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SECTION 27A .. STARTER MOTOR

SIMMS TYPE 624 SGRE.44 6

The starter is a 24 volt series motor with a wave wound armature of heavy section in series with four field windings. The drive is transmitted through a spring clutch which assists engagement and disengagement of the pinion.

Engagement with the engine flywheel is effected by an axial movement of the pinion against a return spring, the movement being obtained through push rods and a shock spring operated by a solenoid.

REMOVAL

Remove the leads from the motor, and unscrew the keep strap bolt.

Take the weight of the motor, remove the nut and bolt from the motor retaining clamp bracket, and withdraw the motor.

DISMANTLING

Remove the commutator end cover, solenoid end plate and the solenoid coils.

Release all connections to the solenoid unit and re-

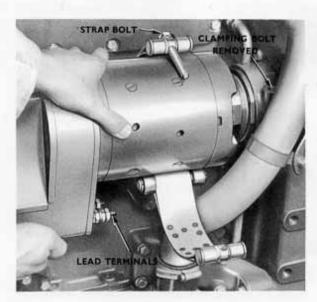


Fig. 1. Removing the starter motor.

move the three screws securing the solenoid frame.

Remove the switch securing nut and dowel screw.

Lift the trip lever at the same time withdrawing the switch and solenoid from the motor.

Lift all brushes off the commutator and wedge them in their boxes by means of the brush springs.

Slacken the screw in the commutator end shaft nut and remove the nut.

Remove the retaining pin and spring plug from the end of the splined shaft using the tool Part No. L.77485 and withdraw the pinion return spring.

Move the push rod forward to release the cross-key and remove the cross-key from the pinion. The key should be gently driven out through the slot in the pinion, using the punches LA.77487, LA.77488 and LA.77489 in that order, see fig. 2.

Slide the pinion off the shaft, unscrew the two nuts on the tie rods, and remove the driving end plate, taking care to retain the thrust washer.

Slide the splined shaft and clutch from the main armature shaft; this will expose the driving keys. Remove and retain the keys.

Tilt the motor with the commutator end downwards and remove the push rods and buffer spring.

Withdraw the armature from the driving end. Release the field coil leads at their connections on the brush gear and detach the commutator end plate and brush gear. Care should be taken not to bend or twist the field coil leads. To dismantle the clutch, hold the clutch spring and withdraw the splined shaft at the same time turning it in the normal direction of rotation. Next remove the sleeve at the opposite end by the same process.

INSPECTION

Inspection will be mainly confined to cleanliness and general wear.

It will be found in service that the commutator assumes a polished surface with a dark brown colour. This should not be cleaned off, but any particles of dust from the brushes can be blown away or removed with a clean petrol soaked cloth. Examine the binding bands for signs of loose and thrown solder.

If the commutator is badly worn, it should be set up in a lathe and skimmed. It is important that after skimming the commutator surface is concentric with

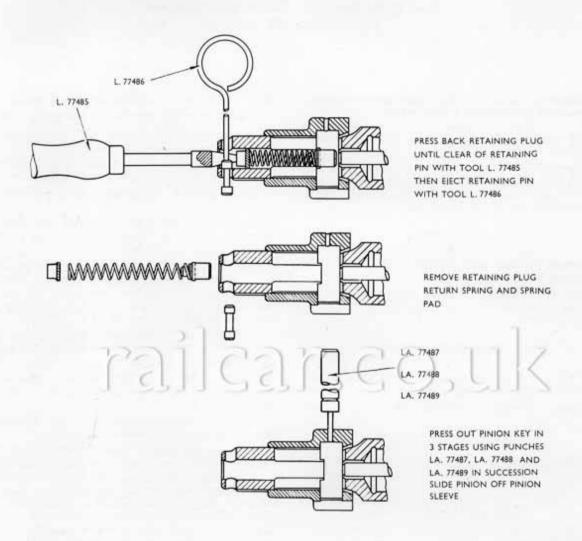


Fig. 2. Removing the drive pinion.

the bearing diameters. Only a very light cut should be taken and the tool should be sufficiently keen to leave a smooth surface. A high polish can be obtained with Grade 000 glass paper.

After skimming, undercut the mica insulations with a hacksaw blade ground down to the thickness of the mica. The mica should be cut to a depth of 0.8 mm. (0.032 in.) care being taken to ensure that no mica is left level with, or projecting above the copper segments.

Check that the field coils are clean and free from dust and moisture and that the rigid strip leads are clean, well soldered and show no signs of abrasion.

Ensure that the brushes slide freely in their boxes and that the springs seat squarely on top of the brushes. All screws should be tight and connections clean and well soldered.

Examine the contacts for burning and check the switch for freedom.

Check the main clutch spring and push rod buffer spring for frettage and compression, and all bushes, ball races, splines and keys for general wear.

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ASSEMBLING

Before assembly, the clutch spring should be packed with graphite grease. Other parts should be lubricated with Intava 659 high temperature grease.

Mount the commutator end plate assembly on to the carcase and remake the main field connections.

Lift all the brushes and wedge them in their respective boxes by means of the springs.

Slide the armature into the carcase. Replace and tighten the end nut and lock it by means of the screw, then release the brushes.

Re-assemble the spring release clutch and fit it to the armature shaft, having first ascertained that the three bushes and keys are in position.

Replace the driving end plate and check the armature end float. The end float should be between 0·1 mm. (0·004 in.) and 0·2 mm. (0·008 in.) and can be adjusted by changing the thrust washer.

Fit the switch assembly.

Assemble the push rods and spring in the bore of the armature shaft starting from the commutator end and in the order shown in fig.4.

Refit the solenoid frame, coils and the solenoid plate. Make all connections to the switch terminals and coils.

Replace the pinion, fit the cross-key and return spring, ensuring that the key is located between the end of the push rod and the spring, with the slot in the key towards the spring.

Compress the spring and fit the retaining plug and pin.

With the punch LA.77487 check that the key is securely locked by the spring.

TESTING

Switch

Measure the length which the plunger projects beyond the solenoid end plate when the pinion is in the disengaged position. Energise the switch coil only, to close the switch on the stop. Slowly push the plunger inwards until the switch trips on to the second contact and measure the amount the plunger now projects. The difference in measurement to that taken when the pinion is disengaged, gives the full travel before the power is applied and should be 19 to 20 mm. (0.74 to 0.78 in.). Should the switch trip at less than 19 mm. (0.74 in.) the length of the pushrod must be reduced by grinding down the end. If the switch trips at more than 20 mm. (0.78 in.) a new pushrod should be fitted.

Armature

When a short circuit in the winding is suspected the armature may be tested by means of a 'growler'. If during this test a hacksaw blade is rested on the core laminations whilst the armature is rotated, a short circuit will be indicated when the blade is attracted to the core.

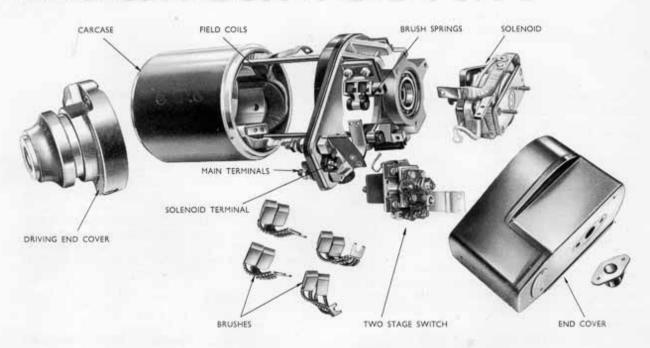


Fig. 3. Exploded view of housing assembly.

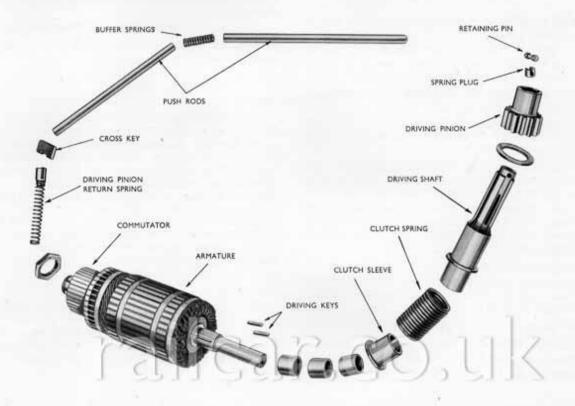


Fig. 4. Exploded view of armature assembly.

Test the armature coils for continuity by passing current from a battery through the armature via two brushes at 90 deg. on the commutator and noting on a millivolt meter the voltage drop between every adjacent pair of segments. A variable resistance must be incorporated in the circuit to limit the voltage on the armature to approximately 2 volts. Rotate the armature; the indicated voltage drop should be substantially the same for any pair of segments. A low reading or none at all will indicate a partially short circuited coil or commutator segment, while a high reading will mean a high resistance in the coil circuit, probably a badly soldered joint.

A mains voltage test lamp may be employed to test the armature winding and commutator insulation. If the lamp lights when it is connected between the commutator and the shaft, a short circuit to earth is indicated.

Field coils, solenoid and switch coils

A mains voltage test lamp connected between windings

and the frame of the starter, will indicate any short circuit to earth.

Field coils

Tests for internal short circuits should be made by checking the resistance of individual coils. The tests should be carried out with the coils in the carcase, and may be effected by baring short sections of the interconnectors and passing heavy currents through individual coils to the appropriate brush boxes or main terminals. When a current of 100 amperes is passed through a coil, the voltage drop across the coil should be 0.54 volts at a coil resistance of 0.0054 ohms.

REFITTING

The procedure for installing the starter motor is the reverse of that given for its removal.

SECTION 27B .. STARTER MOTOR

C.A.V. TYPE U624-1

The starter is a 24 volt motor with a wave wound armature in series parallel with four field windings.

The armature has an axial movement in its bearings and when extended, engages the teeth of the starter pinion with the gear ring of the engine flywheel.

An overload device prevents damage due to engine back-fire, and consists of a simple 'Bendix' and spring loaded clutch arrangement, which has a slipping torque of about three times the lock torque of the starter, but below the shearing strength of the pinion teeth.

REMOVAL

Remove the leads from the motor, and unscrew the keep strap turn-buckle. Open the keep straps and withdraw the starter.

RENEWING A DAMAGED PINION

The pinion can be removed without dismantling the starter provided care is exercised, the stages of removal

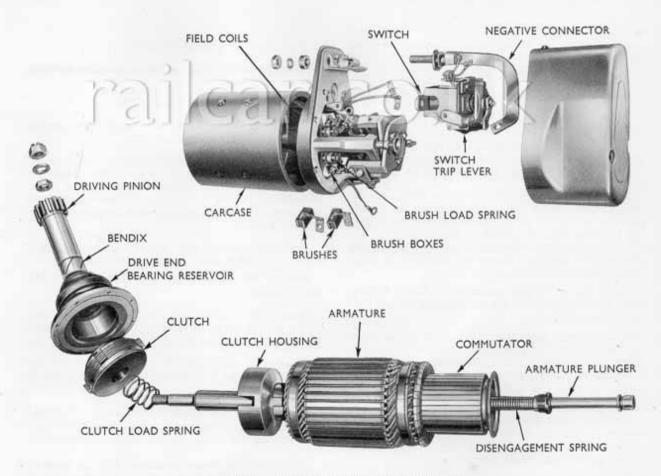


Fig. I. Exploded view of starter motor.

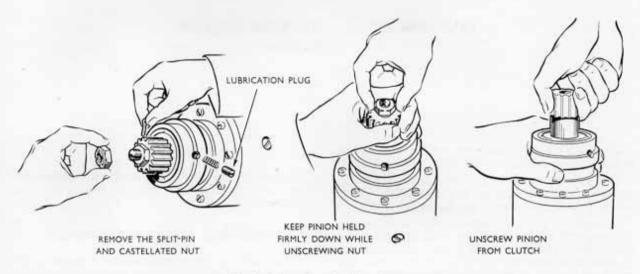


Fig. 2. Removing the drive pinion.

are illustrated in fig. 2, and should be carried out in the following sequence:—

Remove the starter from the engine.

Remove the lubrication plug and spring.

Remove the split-pin and the castellated nut from the driving shaft.

Stand the starter on its end with the pinion uppermost, loosen the thin shaft nut, hold the pinion firmly down against the spring pressure, and take off the nut.

Without releasing the pressure of the spring, turn the pinion slowly in the opposite direction to the normal direction of rotation of the starter and gradually release the pressure until the pinion is unscrewed from the clutch and free to be removed. It is essential that this operation is executed slowly and carefully to avoid disturbing the clutch plates.

Before fitting the new pinion check that it has the same number of teeth as the old one, and that the Part No. is the same.

Smear a small quantity of 'Retinax A' grease round the pinion bore. Carefully insert the pinion into the endshield until it meets with resistance then turn slowly in the direction of rotation, until a forward movement is felt, indicating that the pinion has engaged with the clutch plates.

Push the pinion into the endshield to its full extent against the pressure of the spring, hold in position and screw the thin nut on the drive shaft. Screw on the castellated nut, and insert the split-pin.

Replace the spring and locking plug.

DISMANTLING

To dismantle the starter motor for complete overhaul, proceed as follows:—

Remove the commutator end cover.

Remove the nut from the end of the armature plunger with the aid of the special tool 842X.

Lift all the brushes and wedge them in their boxes by means of the brush springs. The brushes should not be removed from the holders unless they are to be renewed, or require re-bedding. If they are removed they should be marked to ensure they are refitted in their correct positions.

Disconnect the leads from the main and auxiliary field coils to the switch and commutator end shield.

Remove the commutator end shield and brush gear complete.

Remove the screw securing the positive terminal connector and the nut securing the solenoid switch terminal to the commutator end shield.

Remove the main negative terminal nuts, and the screw securing the negative strip terminal connector to the brush holder.

Remove the fixing screws and remove the switch and negative connector, taking care not to break the connection between the switch and the negative connector.

If the switch is unserviceable and is being removed for renewal, unsolder the connection from the negative connector, and remove the switch complete, without removing the negative connector.

Remove the screws securing the driving end shield to the starter motor carcase, tap the end shield with a hide faced mallet and gently slide out the end shield and armature complete.

Remove the split-pin and the thin and castellated nuts from the armature shaft, withdraw the pinion and driving end shield together, and take out the pinion spring.

Remove the clutch assembly from the clutch housing. There should be five of each brass and steel plates. Care should be taken not to damage the springs between the clutch sleeve and the first friction plate.

To remove the armature spring and plunger, unscrew the nut securing the end plunger in the armature bore by means of the special tool 332W and take out the plunger.

INSPECTION

Inspection will be mainly confined to cleanliness and general wear.

It will be found in service that the commutator assumes a polished surface with a dark brown colour. This should not be cleaned off, but any particles of dust from the brushes can be blown away or removed with a clean petrol soaked cloth. Examine the binding bands for signs of loose and thrown solder.

If the commutator is badly worn it should be set up in a lathe and skimmed. It is important that after skimming the commutator is concentric with the bearing diameters. Only a very light cut should be taken and the tool should be sufficiently keen to leave a smooth surface. A high polish can be obtained with Grade 000 glass paper.

After skimming undercut the mica insulations with a hacksaw blade ground down to the thickness of the mica. The mica should be cut to a depth of 0.8 mm. (0.032 in.) care being taken to ensure that no mica is left level with, or projecting above the copper segments.

No attempt should be made to machine the armature core, or to true a distorted armature shaft.

Inspect the bearing bush inside the armature plunger spring cavity at the commutator end. The bush should be replaced if a 21.57 mm.(0.8491 in.) plug gauge can be entered into the bearing. As a special tool is required to replace this bearing, the complete armature must be renewed if the bearing is worn beyond the specified limit.

Check that the field coils are clean and free from dust and moisture and that the leads are clean, well soldered and show no signs of abrasion.

Ensure that the brushes slide freely in their boxes and that the springs seat squarely on top of the brushes. All screws should be tight and connections clean and well

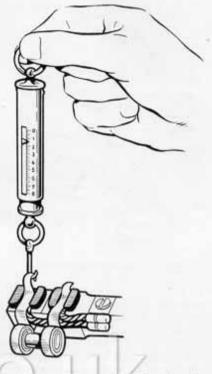


Fig. 3. Checking tension of brush springs.

soldered. Check the pressure of the springs with a spring balance. This should be 18 to 24 ozs., the method of checking is illustrated in fig. 3.

Check both the armature shaft bearings for wear. The bearings are accurately machined after fixing in the end shields, and should therefore only be replaced as a complete assembly with their end shields. No attempt should be made to replace or reclaim the bearings only.

Examine the clutch plates and springs and check the teeth of the driving gear and clutch 'Bendix' gear for wear

Inspect the tripping disc and switch trigger for wear, and the solenoid contacts for burning.

TESTING PRIOR TO RE-BUILDING

Armature

When a short circuit in the winding is suspected the armature may be tested by means of a 'growler.' If during this test a hacksaw blade is rested on the core laminations whilst the armature is rotated, a short circuit will be indicated when the blade is attracted to the core.

Test the armature coils for continuity by passing current from a battery through the armature via two brushes at 90 deg. on the commutator and noting on a

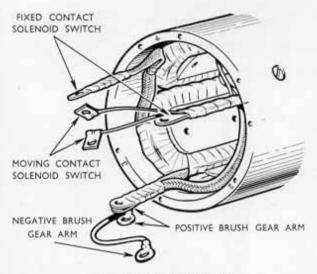


Fig. 4. Starter motor leads.

millivolt meter the voltage drop between every adjacent pair of segments. A variable resistance must be incorporated in the circuit to limit the voltage on the armature to approximately 2 volts. Rotate the armature; the indicated voltage drop should be substantially the same for any pair of segments. A low reading or none at all will indicate a partially short circuited coil or commutator segment. A high reading will mean a high resistance in the coil circuit, probably due to a badly soldered joint.

A mains voltage test lamp may be employed to test the armature winding and commutator insulation. If the lamp lights when it is connected between the commutator and the shaft, a short circuit to earth will be indicated.

Field coils and switch coils

A mains voltage test lamp connected between the windings and the frame of the starter, will indicate any short circuit to earth.

Field coils

Test for internal short circuits should be made by

checking the resistance of individual coils. The tests should be carried out with the coils in the carcase, and may be effected by baring short sections of the interconnectors and passing heavy currents through individual coils to the appropriate brush boxes or main terminals. When a current of 100 amperes is passed through a coil, the voltage drop across the coil should be 0.23 volts at a coil resistance of 0.0023 ohms.

ASSEMBLING

Assembling is the reverse of dismantling. The following points should be noted in particular:—

Make sure the clutch has been assembled correctly.

When assembling the armature to the starter carcase, take care not to damage or bend the switch trip lever.

Ensure the leads from the field are connected to their correct points.

The driving end bearing reservoir only requires refilling with lubricant at overhaul. Pour 12 cc. (approx. 3 teaspoonfulls) of S.A.E.—20 grade oil through the plug hole provided.

REFITTING

Before refitting the starter to the engine, a test may be made to check the operation of the starter by connecting a 24 volt battery to the main terminals. The battery positive must go to the starter positive and the battery negative to the starter negative. Connect a lead from the terminal solenoid on the starter through a small push switch to the positive battery terminal. Insert a strip of paper between the moving contact and the second contact in the solenoid switch.

Operate the push switch; the starter should revolve in the direction as stamped on the starter label, looking on the pinion end. The pinion should travel forward for a distance of approximately 1 inch, where it will remain as long as the push switch is operated.

Remove the piece of paper, operate the switch again for a brief period only to see that the starter functions as previously but at a higher speed.

Refit the starter to the engine.

SECTION 28 ... SUPERCHARGER AND SUPERCHARGER DRIVE

SUPERCHARGER

The supercharger is a positive displacement blower of the Roots type and consists of two parallel intermeshing rotor assemblies geared together to rotate in opposite directions inside a rotor casing. The unit components are illustrated in fig. 8.

The superchargers for the 4, 6 and 8-cylinder engines are identical and differ only in the length of the rotors and lubrication systems.

Lubrication

The universal oil feed system is used on the L300 Mk. 2 supercharger fitted to the 4-cylinder vertical engine, and on the L450 Mk. 55 fitted to the horizontal engine.

Oil tapped from the main engine lubrication system is piped to a connection on the supercharger drive housing. From the connection the oil flows through drillings in the drive housing casing to two jets, one which delivers the oil into the bore of the compounder shaft to lubricate the spring drive assembly, and the other to lubricate the supercharger gears.

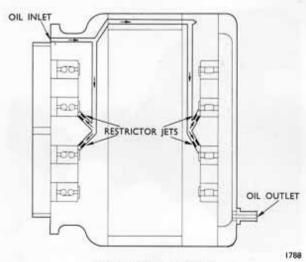


Fig. 1 Universal oil feed

From the main drilling the oil passes through a restrictor in the spring drive housing; oil is then directed through the supercharger mounting flange to a longitudinal drilling in the drive end plate, rotor casing, and intermediate plate of the supercharger. From this drilling oil is conveyed by two further drillings and is delivered to the bearings through restrictors located in each bearing housing.

For the six and eight-cylinder vertical engines fitted with high or low mounted superchargers, the lubrication of the supercharger drive is essentially the same as that previously described, but the lubrication of the supercharger differs.

Oil directed from the drive housing flows into a longitudinal drilling in the drive end plate, here the flow divides and is directed through two restrictors, one large and one small.

The small restrictor directs oil to the uppermost front bearing housing, and to the lower bearing via a VEE drilling between the two housings.

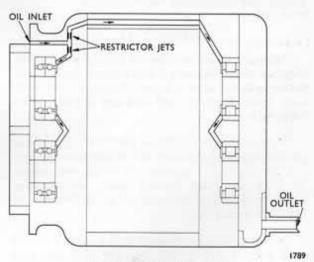


Fig. 2 Alternative oil feed

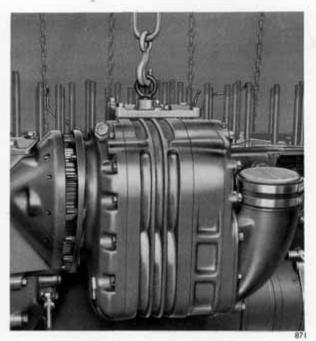


Fig. 3 Removing the supercharger

Oil passing through the large restrictor flows through a longitudinal drilling in the rotor casing and a drilling in the intermediate plate, lubricating the two rear bearings in a similar manner to that of the front bearings.

The universal lubrication system will be incorporated in all future superchargers.

REMOVAL

Release and remove the oil drain pipe. For the horizontal engine, release and remove the set-bolts securing the oil drain transfer adapter to the wheelcase drain chamber, and ease the adapter off its joint face.

Release the worm clips at the hose connections on the supercharger inlet and outlet branches and cut through the rubbers to break the joints. Remove the inlet branch, using the spanner OE.3391 to slacken the nuts, and fit the lifting plate OE.3126 in its place.

Support the supercharger with a hoist. Release and remove the steady bracket and the nuts securing the supercharger to the drive housing. Carefully break the flange joint at the same time fully supporting the weight of the unit until it is free from the drive coupling and dowels.

Blank off all apertures exposed by removal of the unit and fit the special blanking plate OE.3394 to the supercharger drive flange.

DISMANTLING

Remove the nuts and washers securing the rear end plate to the intermediate plate and withdraw the plate.

Check the end float of the rotors, the radial movement of each rotor at both ends, and the tip clearance of the rotors in the casing. Check the backlash between the drive and driven gears. The method of carrying out these checks is given later when rebuilding the supercharger.

Record the figures obtained.

Lock the rotors with the rubber wedge 5725/O between the rotors and remove the nuts securing the drive and driven gears. Mark the drive coupling and the driving gears to ensure correct assembly on rebuild. Remove the nuts from the bolts securing the coupling to the driving gear and remove the coupling. Withdraw the drive and driven gears using the extractor 5725/S, first removing three of the driven gear hub bolts for location of the extractor bolts.

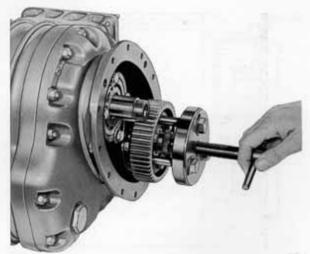


Fig. 4 Removing the driven gear

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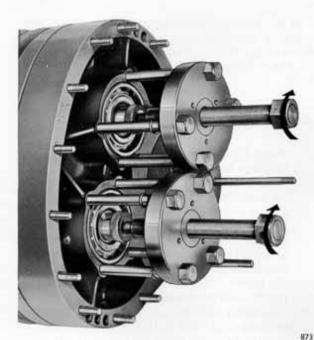


Fig. 5 Removing the rear intermediate plate

Remove the nuts from the rear end of the rotor shafts.

Remove the Allen screws securing the intermediate plate to the casing and unlock and remove the bearing retaining screws. Fit the protection plugs 5725/P into the rear ends of the shafts and withdraw the intermediate plate from the shafts evenly, using the extractors 5725/W, as illustrated.

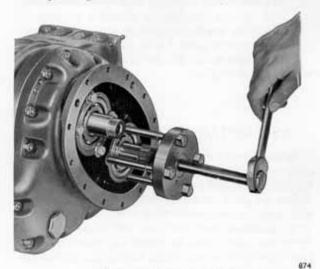


Fig. 6 Pressing out a rotor

Remove the two roller bearing inner races and scrolls from the intermediate plate. The bearing outer races can be withdrawn with the tool 5725/V. Extract the dowels from the plate using the extractor 5725/K.

Remove the bearing retaining screws from the drive end plate and remove the keys from the shafts.

Press out each rotor separately using the extractor 5725/W and a shaft protection plug.

Withdraw the labyrinth seals from the ends of the rotor shafts using the tools 5725/T and 5725/S, only if the labyrinth seals are damaged.



Fig. 7 Removing bearing outer race

Remove the nuts and washers securing the drive end plate to the rotor case, and separate the plate from the case.

Extract the double ball bearings and the scrolls from the drive end plate. The inner half of each bearing outer race can be withdrawn with the tool 5725/V. The parts of each bearing should be tied together immediately after they have been removed and the assembly marked to identify it with its housing.

Remove'the lubricating oil restrictors.

INSPECTION

All parts of the supercharger should be degreased and thoroughly cleaned before inspection. Ensure that all oil passages are clear and that the restrictors are free from blockage. Steel parts should be lightly oiled immediately after cleaning.

Rotor case and rotors

Examine the rotor case bores for scoring, picking up, or other damage. Small score marks, caused by dust particles or other foreign matter may be removed by careful scraping, provided the score marks are not more than 0.025 in. (0.635 mm.) deep. Examine the rotor case for cracks and damaged or loose studs.

Inspect the rotor lobes for cracks, scoring and other damage; small burrs may be carefully 'dressed' out locally to remove any proud metal, taking care that the anti-corrosive treatment is disturbed as little as possible.

Intermediate and drive end plate assemblies

Inspect the plates for damage and check that the joint faces are true. If there are signs of bearing 'spinning,' check that the bearing when assembled in the housing is proud of the end plate, so that it will be nipped by the retaining washers.

Examine the ball bearings for cracks and pitting and for excessive end float and radial play.

If the gear backlash before dismantling was more than 0.006 in. (0.1524 mm.) and the bearings are found to be serviceable, excessive wear on the teeth is indicated and can only be corrected by fitting new gears.

Blend out any withdrawal marks on the keys and check the fit of the keys in the shafts and the gear keyways.

Check that the labyrinth seals are not damaged or loose on the rotor shafts and that the scroll seals will be a push fit when refitted.

Examine the drive coupling for cracks, pitting and excessive wear between the teeth of the male and female couplings. Examine the securing bolt holes for wear.

If the securing bolt holes in the driving gear and coupling are worn new securing bolts should be fitted to the unused alternate holes in the gear and coupling. Then remove the bolts from the worn holes.

If the driving coupling is unserviceable fit a new coupling as follows:—

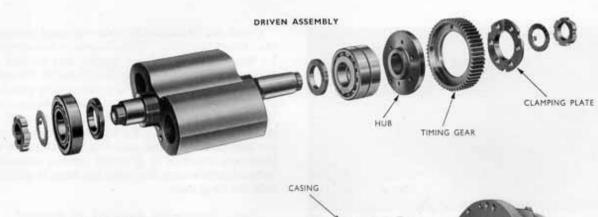
Assemble the new coupling to the driving gear, holding them in light contact with three 1 B.A. bolts in alternate holes. Mount the assembly on an arbor centred from the driving gear bore, and insert three magnetic rollers 0.151 in. (3.8354 mm.) diameter at equal intervals in the splines of the coupling. Rotate the assembly and, using a dial test indicator gauge, check for concentricity of the coupling over the rollers. Adjust the coupling by tapping gently until the coupling is as near as possible concentric with the gear; eccentricity must not be more than 0.005 in. (0.127 mm.).

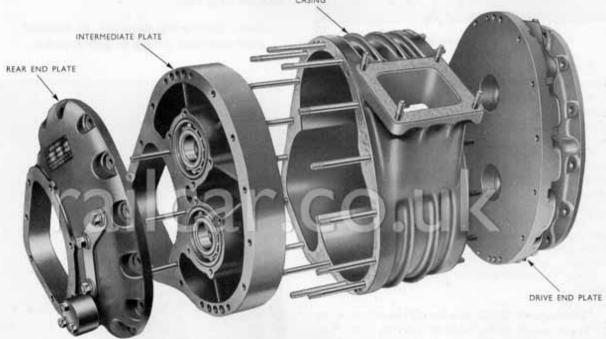
Tighten the three 1 B.A. securing bolts and make a further check to ensure that the coupling has not moved, then ream the three open holes in the coupling to 0.25 in. (6.35 mm.) diameter. Use the reamer GA.268 and take care to keep the reamer square with the holes to avoid removal of metal from the gear holes.

Fit three new securing bolts in the newly reamed holes, together with new tabwashers and tighten the nuts to a torque loading of 100 lb. in. but do not lock the nuts at this stage. Remove the three 1 B.A. bolts and ream the remaining holes. Fit the circlip to the rear hub of the drive gear.

ASSEMBLING AND REFITTING

When rebuilding the supercharger strict cleanliness must be observed, and oilways and oil restrictors should be blown through immediately before the parts are assembled. If the original races and seals are serviceable they must be reassembled in the positions they occupied before dismantling. Particular care must be taken to assemble each bearing with its correct races. Correlation marks are etched on each race.





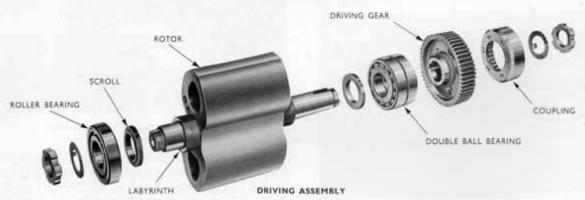


Fig. 8 Exploded view of supercharger

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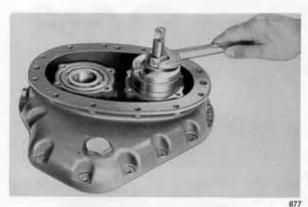


Fig. 9 Fitting the ball bearings

Fit the scroll seals into their respective bores in the drive end intermediate plate. Ensure that a scroll 17914 is fitted into the driving shaft bore and a scroll 17913 into the driven shaft bore, otherwise their action will be reversed.

Press in the ball races with the tool 5725/U ensuring that the races are correctly paired and positioned and fit the retaining set-bolts and washers.

Press the outer races of the roller bearings into the intermediate plate and secure them with setbolts and washers.

Fit a labyrinth seal to each end of the rotor shafts.

Pull the rotor shafts into the ball bearings in the drive end plate, using the insertion tool 5725/R as illustrated. Remove the tool and fit and tighten the securing nuts but do not lock the nuts at this stage.



Fig. 10 Fitting rotors to drive end plate

Check the clearances between the rotor lobes and the face of the plate. This clearance is controlled by the thickness of the scrolls and should be between 0.005 and 0.007 in. (0.127 and 0.178 mm.). Excessive clearance can be corrected by grinding off an amount equal to the excess clearance from the stepped face of one, or both, of the scrolls as required. If the clearance is below the limit, remove the appropriate scroll and fit a new scroll of the thickness required to give the correct clearance, When a satisfactory clearance has been established lock the rotor nuts.

Note: Rotors are supplied in matched pairs and must always be kept together.



Fig. 11 Fitting the roller bearings

Fit the dowels into the drive end of the rotor casing and assemble the drive end plate and rotors to the casing with a 0.010 in. (0.254 mm.) gasket between the joint faces. Temporarily secure the plate with four evenly spaced nuts and washers.

With the rear end of the casing uppermost, check the clearances between the ends of the rotor lobes and the face of the casing by means of a straightedge and feeler gauges. Add gaskets of suitable thickness to the end face of the casing to give a clearance of 0.008 to 0.010 in. (0.203 to 0.254 mm.).

Fit the dowels into the rear end of the casing and fit the intermediate plate in position with the selected gaskets between the joint faces.

Fit a scroll 17914 on to the driven shaft and a scroll 17913 on to the driving shaft, with the plain face of the scrolls inwards to abut the labyrinths.

Assemble the inner races and rollers of the bearings on their respective shaft and press them home using the tool 5725/R as illustrated in fig. 11.

Temporarily secure the intermediate plate to the casing with the two Allen screws, then secure the rear end plate to the intermediate plate with four nuts and washers evenly spaced.

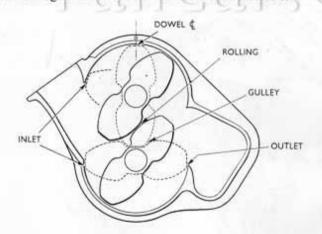
Check the tip clearances between the rotors and the casing at the inlet and outlet side and refer to fig. 12 for permissible clearances. The clearance should not vary by more than 0.002in. (0.0508mm.) at all points along the length of the rotors.

If the clearances are not equal at all points, remove the dowels from each of the end plates, and tap the plates with a hide mallet to centralize the rotors. When the clearances are correct, tighten the securing nuts and fit oversize dowels VS.357 to the drive end and VS.358 to the rear end. Use the oversize reamer 5725/N.

When reaming, use a liberal quantity of paraffin as a cutting medium, otherwise an oversize hole will be the result. After reaming, clean out all swarf and blow out with compressed air.

Check the assembled rear end clearance between the rotor lobes and the inner face of the intermediate plate; this should be between 0.008 and 0.010 in. (0.203 and 0.254 mm.) as previously established. If further adjustment is required remove or add gaskets. Remake the joints, fitting all the nuts securing the drive end plate and the four Allen screws retaining the intermediate plate to the rotor casing.

Re-check the tip clearance and end clearances.



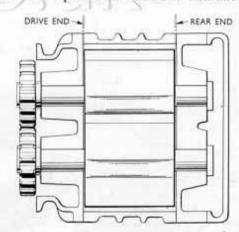


TABLE OF CLEARANCES

(Inches)

REAR END	0.008 to 0.010	OUTLET	0-005 to 0-007		
DRIVE END	0:005 to 0:007	ROLLING	SEE ROTOR TIMING		
INLET	0:011 to 0:013	GULLEY	0-0080 to 0-0105		
DOWEL ¢	0.008 to 0.010	GEAR BACKLASH	0 0005 to 0 0060		

Fig. 12 Supercharger clearances

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Fit the nuts to the rear ends of the rotor shafts with new tabwashers, lock the rotors with the rubber wedge 5725/O and tighten the nuts, but do not lock them at this stage.

Wirelock all the bearing retaining bolts at both ends of the supercharger.

Fit the three coupling bolts in alternate holes in the driving gear hub, and retain them with the circlip sprung into the groove in the gear hub. Assemble the coupling to the gear but do not lock the nuts at this stage.

Fit the keys in the drive and driven shafts and assemble the gears and the drive coupling to the shafts using new tab-washers, but do not lock the nuts.

Check the backlash of the gears using a dial indicator; this must not be less than 0.0005 in. (0.0127 mm.) or more than 0.006 in. (0.1524 mm.) at any position of the gears.

Timing the rotors

Timing of the rotors is carried out by checking the rolling clearance at each side of each rotor lobe i.e. in four positions. It is most important that these clearances are set accurately otherwise failure of the supercharger will occur.

Proceed as follows:-

Remove the six set-bolts and the locking plates securing the holding flange to the driven gear hub. Remove the dowel and refit three of the bolts in alternate holes with plain washers.

Check the backlash of the gears in eight equally spaced positions and record the maximum figures obtained.

Insert a feeler gauge between the rotor lobes, of a thickness equal to the maximum gear backlash figure plus 0.007 in. (0.178 mm.) and, with one rotor restricted, move the other rotor until the feeler gauge is just nipped, tighten the set-bolts, turn the rotors and check the clearance at the other side of the same rotor lobe.

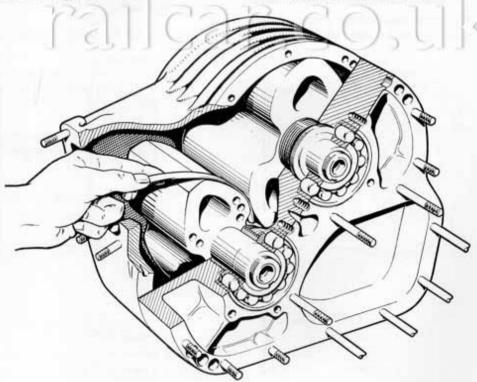


Fig. 13 Cheeking the rolling clearance

The clearance at each side of the lobe must be equal to within 0.002 in. (0.0508 mm.) and if necessary the gear hub should be reset to give this condition.

The minimum rotor clearance measured by feelers minus the maximum gear backlash must not be less than 0.007 in. (0.178 mm.).

Turn the rotors and check the clearances at each side of the opposite lobe; these should be substantially the same as before.

When satisfactory, withdraw the driven gear assembly with the tool 5725/S, so that the gear can be re-dowelled.

Position the special centre punch 5725/D in the scallop in the holding flange at 120 deg. from the existing dowel hole and mark the position of the new hole.

Drill the new hole $\frac{14}{64}$ in. (5.953 mm.) diameter and ream with a standard $\frac{1}{4}$ in. (6.35 mm.) diameter parallel reamer. Clean out the hole and fit a new dowel with the groove end towards the holding flange.

Remove the three hub bolts and plain washers, fit new locking plates and fit and tighten the six bolts.

Lock the rotors and refit the gear to the shaft.

Recheck the clearance and bend up the tabs of the locking washers.

Check the gulley clearance by rolling a 0.008 in. (0.2032 mm.) feeler gauge between the rotors, until they are in the position shown in fig. 13; the feeler gauge should be free along the full length of the rotor.

Check the drive coupling for concentricity. If the total clock reading is not more than 0.005 in. (0.127 mm.), the assembly is satisfactory. Tighten the coupling securing bolt nuts to a torque loading of 100 lb. in. and lock the nuts.

Lock the four shaft end nuts and fit the rear end plate using a new joint gasket.

Refitting the supercharger to the engine is the reverse of removal.

After fitting a new or overhauled supercharger, the engine should be run at idling speed for one hour.

SUPERCHARGER DRIVE

The supercharger drive is a self-contained gear unit, taking its drive from the crankshaft through the wheelcase gears. It consists of a compound gear incorporating a spring drive and a driven gear which has a splined coupling to engage with the supercharger.

REMOVAL

Remove the wheelcase and supercharger. The removal of the wheelcase is recommended as only by this means can the drive be refitted satisfactorily.

Disconnect and remove the oil feed pipe.

Remove the set-bolts securing the drive housing to the wheelcase backplate and carefully withdraw the unit from the dowels.

DISMANTLING

Release and remove the nut securing the driving coupling to the driving shaft and withdraw the coupling and shaft from the housing. The bearing is an interference fit in the housing and is retained by a circlip.

Remove the set-bolts securing the compound gear assembly in the housing and withdraw the assembly, taking care not to damage the oil jet.

To dismantle the compound gear assembly, commence from the rear removing the locknut, the lock and keywasher, bearing and bearing housing and the thrust washer in that order. Remove the bolts securing the retaining plate to the spring drive gear, remove the plate, extract the springs and spring bearers, and withdraw the spring carrier and compound gearshaft from the spring drive gear.

INSPECTION

Check all bearings for freedom and smooth action, any bearings having rough spots after they have been thoroughly washed out should be changed.



Fig. 14 Position of leaf springs for fitting

Examine the gear teeth for plucking, Slight plucking should be carefully stoned out.

Ensure that the oilways to the bushes of the spring drive are clear.

Examine the leaf springs and replace any that are cracked or broken.

ASSEMBLING AND REFITTING

Position the front thrust washer on the compound gear gearshaft so that it abuts the rear face of the gear.

Fit the spring carrier to the spring drive gear with the correlation marks coincident and temporarily secure it with the six square headed bolts and nuts.

Insert the compound gearshaft in the spring drive gear and carrier, and support the shaft in a vertical position on its front end.

Smear the spring bearers lightly with grease and place them in position within the spring carrier.

For each spring pack in turn, place a spring in the spring carrier against the bearers. Arrange the remaining five leaf springs in the form of a wedge,

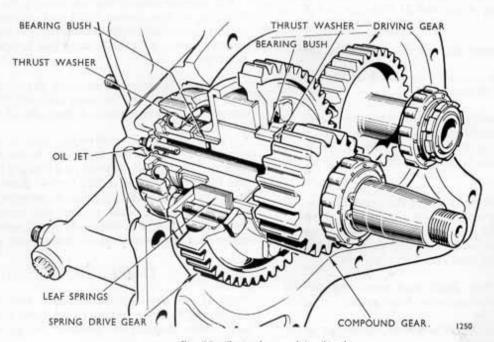


Fig. 15 Supercharger drive details

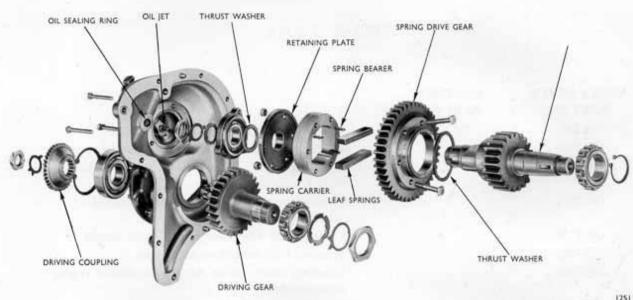


Fig. 16 Exploded view of supercharger drive

as illustrated, and press them into the gap between the spring already positioned and the shaft.

Remove the nuts from the six bolts securing the spring carrier and fit the retaining plate with its correlation mark in line with those on the spring carrier and spring drive gear. Fit the tabwashers, tighten the nuts and turn up the locking tabs.

Fit the rear thrust washer on the compound gearshaft so that it abuts the rear bearing of the spring drive gear, followed by the rear housing and ball race, keywasher, lockwasher and locknut. Tighten the locknut and turn up the locking tab.

Fit the front roller race to the front end of the compound gearshaft and secure it with the circlip.

The end float of the spring drive gear is controlled by the thrust washers which abut the front and rear flanges of the spring drive gear bushes. When fully assembled the end float should be 0.002 to 0.008 in. (0.0508 to 0.2032 mm.).

Fit the driving gear rear ball race in the supercharger drive housing and secure it with the spring circlip. Fit the roller race to the front end of the driving gearshaft followed by the keywasher, lockwasher and locknut. Tighten the locknut and turn up the locking tab.

Fit the driving gearshaft to the rear ball race already positioned in the supercharger drive housing and fit the driving coupling followed by the locking washer and locknut. Tighten the locknut and turn up the locking tab.

Fit the compound gearshaft and spring drive assembly to the supercharger drive housing, ensuring that the rear ball race housing is correctly located in the drive housing, fit and tighten the three securing set-bolts and turn up the locking tab of the inner set-bolt.

Fit a new oil seal washer to the supercharger drive housing.

Refit the supercharger drive to the engine backplate interposing a new gasket between the joint faces and ensure that the dowels are correctly located in the backplate.

Refit all parts removed for access.

SPECIAL TOOLS

ROLLS-ROYCE PART NO.	GODFREY PART NO.	DESCRIPTION
GA.268		Reamer, bolt holes in coupling
OE.2948		Lifting plate, 6 and 8-cylinder engine superchargers
OE.2949		Blanking cover, drive flange, 6 and 8-cylinder engine superchargers
OE.2951		Blanking cover, inlet port, low-mounted supercharger
OE.3126		Lifting plate, 4-cylinder engine supercharger
OE.3391		Spanner, inlet branch securing nuts
OE.3394		Blanking cover, drive flange, 4-cylinder engine supercharger
OE.3881		Blanking cover, inlet port, high-mounted supercharger
OE.7771-A	5725/A	Stud box, 5 in. UNF
OE.7772	5725/B	Stud box, in. UNF
OE.7773	5725/C	Distance piece
OE.7774	5725/D	Centre punch
OE.7775	5725/E	Collar (for use with OE.7789)
OE.7776	5725/F	Spanner, double jaw
OE.7778	5725/H	Slot spanner
OE.7779	5725/I	Allen key
OE.7780	5725/K	Extractor, dowels
OE.7781	5725/L	Pliers
OE.7782	5725/M	Feeler gauge
OE.7783	5725/N	Reamer, end plate oversize dowels
OE.7784	5725/O	Rubber wedge, supercharger rotors
OE.7785	5725/P	Protection plugs, rear ends of shafts
OE.7786	5725/R	Inserting tool, rotor shafts and roller races
OE.7787	5725/S	Extractor, driving and driven gears
OE.7788	5725/T	Extractor, labyrinth seals
OE.7789	5725/U	Inserting tool, ball bearings
OE.7790	5725/V	Extractor, bearing outer races
OE.7791	5725/W	Extractor, intermediate plate and rotors
OE.7792	5725/X	Dolly, ball bearing
OE.7793	5725/Y	Dolly, ball and roller bearings
OE.7794	5729/M	Lifter, key

APPENDIX 1

LIST OF SCHEDULES

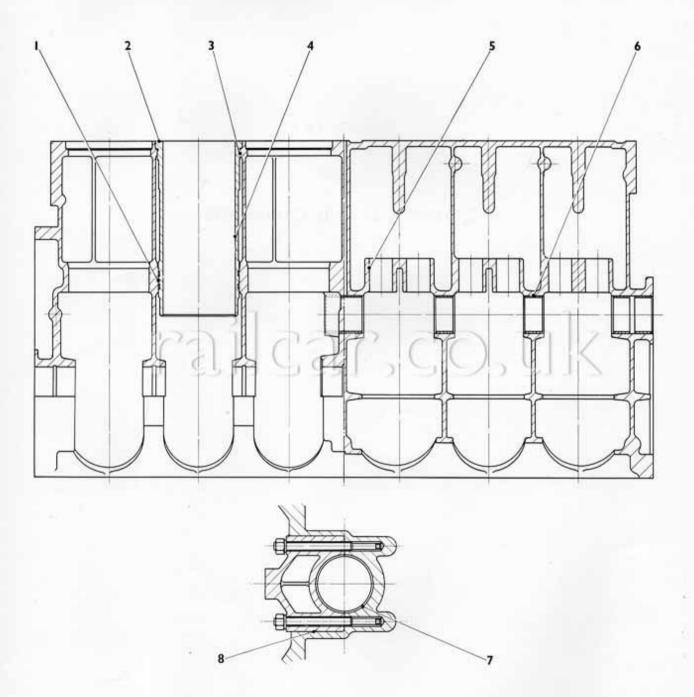
Camshaft			14.4			6
Connecting rods						3
Coolant pump						10
Crankcase and cylinders		**				1
Crankshaft	79.75		٠.	74	+37	2
Main idler gear		(()		7
Oil pump—dry sump					·	8
Oil pump—wet sump		**				9
Pistons		* * *	**			4
Valves and fittings						5

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SCHEDULE I

CRANKCASE AND CYLINDERS

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No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE	PERMISSIBLE WORN DIMENSIONS	WORN CLEARANCE	REMARKS
	CYLINDER LINERS IN CRANKCASE					
1	Liner skirt in crankcase Crankcase – lower bore	5.676 to 5.677	0.003 to			
9%	Liner skirt - dia.	5.672 to 5.673	0.005			
2	Projection of liners above crankcase face Crankcase counterbore –	114 2004 3				
	depth	0.493 to 0.495	Proud 0.007 to		7	
	Liner flange - depth	0.498 to 0.500	0.003 Proud			
3	Liners in crankcase					
	Crankcase - upper bore	5.778 to 5.779	0.002 to			
	Liners - dia,	5.775 to 5.776	0.004			
	CYLINDER LINERS OUT OF CRANKCASE	Complete State of the State of		7 TT 1 - 2-20 COTTO - 100 CO		
4	Liners - bore	5.125 to 5.126		5,131 max.		Wear on cylinder bore must not exceed 0.006 on diameter.
	TAPPETS IN CRANKCASE	7	6	(on distincter.
5	Crankcase – bore	1.625 to				
11272	T #2	1.626 1.6235 to	0.001 to 0.0025		0.003	7.7
	Tappets – dia.	1.624	0.0023		0.003	
	CAMSHAFT BEARINGS IN CRANKCASE					
6	Crankcase – bore	2,5995 to 2,6005	Interfer. 0.0055 to			
	Camshaft bushes - dia.	2.603 to 2.605	0.0025			
	MAIN BEARING HOUSING IN CRANKCASE					
7	Bearing housing bore	4.100 to 4.101				Reclaim damaged bores as instructed in Service
	BEARING BLOCKS IN CRANKCASE					Bulletin No. OEB.149.
8	Front, rear, intermediate and centre					
	Bearing block location – width	6.625 to 6.626	Interfer. 0.0005 to			
	Bearing block - width	6.625 to 6.6255	0.001 Clearance			

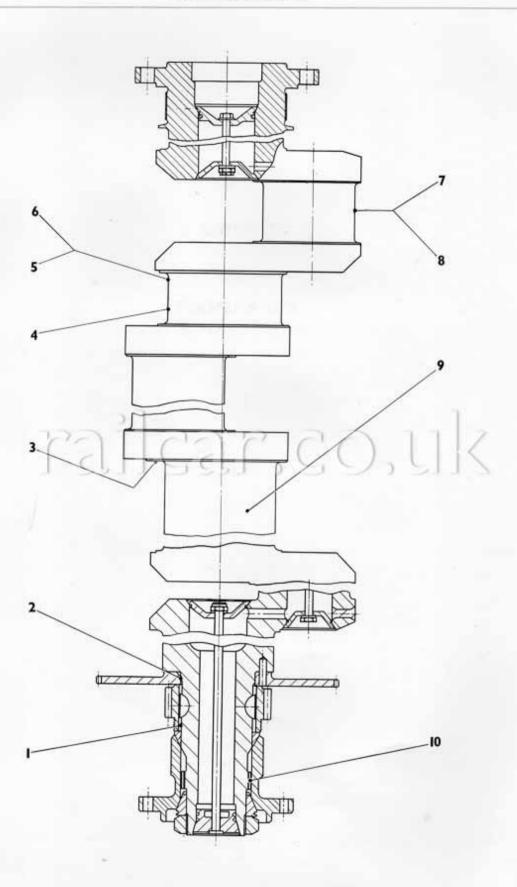
T.S.D. 803 - APPENDIX

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SCHEDULE 2

CRANKSHAFT

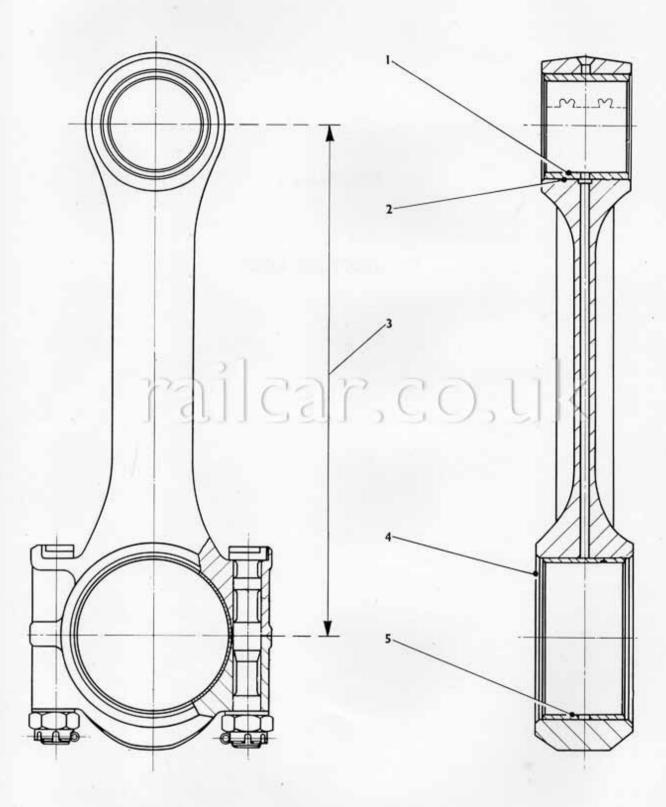
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No. ON DIAGRAM	DESCRIPTION	DIMENSIONS NEW	CLEARANCE NEW	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
1	CKANKSHAFT PINION ON CRANKSHAFT					
	Pinion – bore	2.500 to				
	Crankshaft - dia.	2,5005 2,499 to 2,4995	0.0005 to 0.0015	100		
2	OIL PUMP DRIVE GEAR ON CRANKSHAFT	2.699				
	Gear – bore	2.625 to	225322			
	Crankshaft - dia.	2.6255 2.624 to 2.6245	0.0005 to 0.0015		7/-1	
3	CRANKSHAFT END FLOAT	2.0215				
	Centre journals - length	3.175 to 3.177	0.005		740000000	
	Centre bearing - width over thrust washers	3.164 to 3.170	to 0.013		0.020	
	CRANKSHAFT JOURNALS					
4	Standard size - dia.	3.8995 to 3.900				
5	Ovality			0.003	200	Regrind to minus 0.010 or 0.020.
6	Journals in main bearings Running clearance		0,0035 to	0		Lead surface must not be
			0.0055			worn off more than 1/5 of bearing surface area.
616	CRANKPINS	processor in				bearing surface area.
7	Standard size - dia.	3.249 to 3.2495				
8	Ovality			0.003		Regrind to minus 0.010 or 0.020.
9	CRANKSHAFT BOW Bow at centre journal when supported by end journals in Vee blocks					
	4-clyinder engine			0.008		Total indicator reading
	6-cylinder engine			0.010		0.016, 0.020 and 0.030 respectively.
	8-cylinder engine			0.015		
10	VISCOUS DAMPER HUB Hub on crankshaft					
- "	Backlash between splines		0.0003 to 0.003		0.006	

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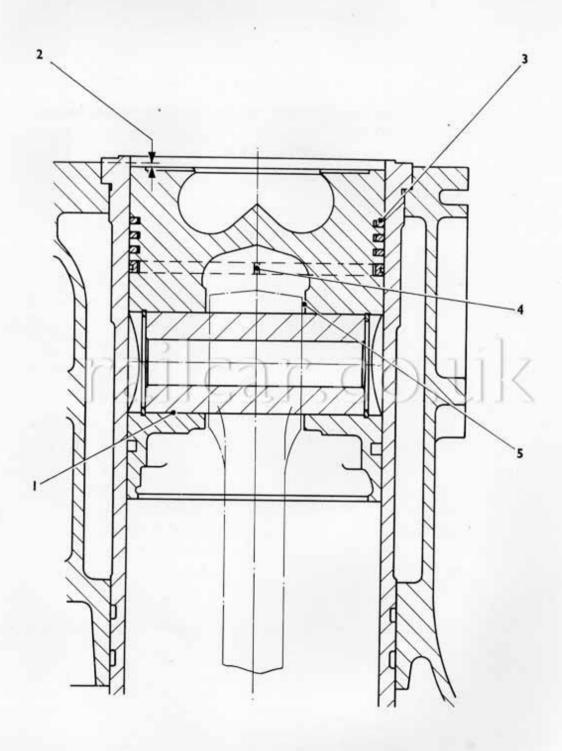
CONNECTING RODS



2

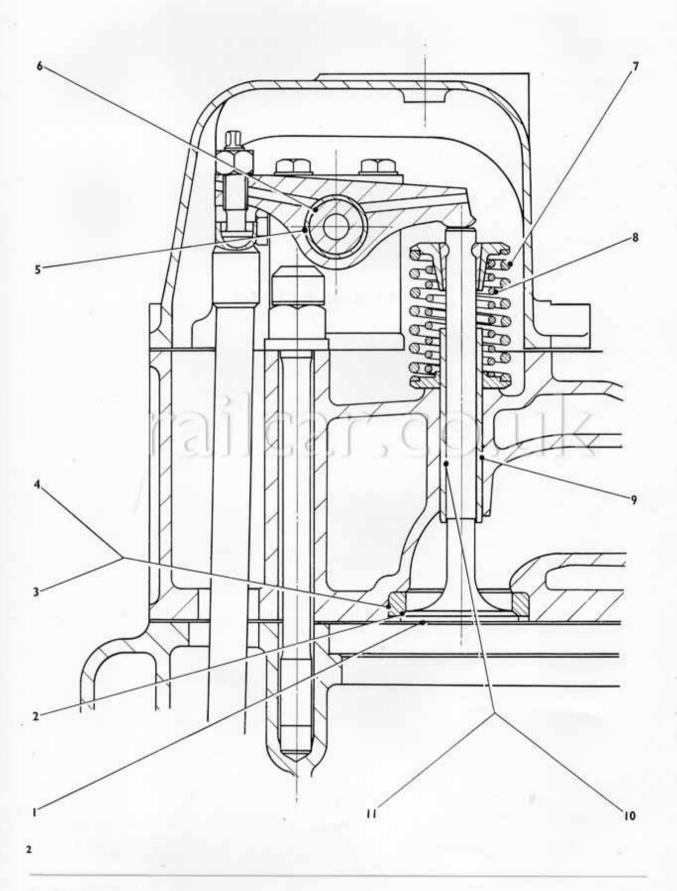
No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE NEW	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
1	SMALL END Gudgeon pin in bush Bush – bore Gudgeon pin – dia.	2.0015 to 2.002 2.000 to 2.00025	0.00125 to 0.002		0.0025	See Service Bulletin
2	Bush in small end Small end – bore Bush – dia,	2.250 to 2.2505 2.252 to 2.2535	Interfer. 0.0035 to 0.0015			O.E.B.156. See Service Bulletin O.E.B.156.
3	ERRORS IN ALIGNMENT Errors in alignment between big and small ends per inch of mandrel Parallelism	2,2333		0.001		O.R.B.130.
4	BIG END BEARING BUSH ON CRANKPIN End float		0.003 to 0.008		0.012	
5	Running clearance	37	0.0025 to 0.004	0	0,008]<
	91					

PISTONS



No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
1	GUDGEON PIN IN PISTON	gwassense				
	Piston – bore	2.000 to	Interfer. 0.00025 to			
	Gudgeon pin - dia.	2.00025 2.000 to	0.00025 to			
	Guageon pin - dia:	2.00025	Clearance			
2	PISTON CROWN					
(5)	CLEARANCE AT T.D.C.					
	Crown of piston below					
	crankcase face		0.005 min. 0.010 max.			
144	PISTON RINGS		0.010			
3	Side clearance between					
	rings and grooves Top ring		0,0045 to		0.012	
	Top ring		0.0065		0.012	
	Remaining rings		0.004 to		0.010	
			0.006		10000	
4	Ring gaps measured with					
	rings in position in new liner Top ring		0.028 to		0.060	
	100 11118		0.032			
	2					
	Remaining rings	7	0.022 to 0.026	(0.060	1
5	CONNECTING ROD IN		0.020	()		
75	PISTON	221			1 21	7 7
	Side clearance		0.075 to 0.082			
			0.002			
100						
	0					
					9	
	59					

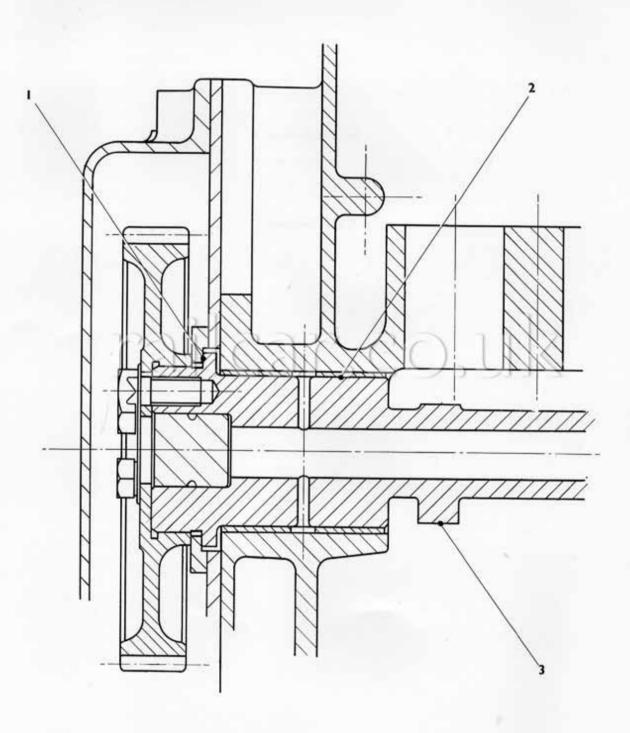
VALVES AND FITTINGS



No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE NEW	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
1	VALVE HEAD IN SEATING Clearance of valve head below face of cylinder head VALVE INSERTS		Zero to 0.010		0.025	
2	Angle of valve seat	45 deg.				
3	Inlet valve inserts in cylinder head Cylinder head – bore	2.3115 to 2.3125	Interfer. 0.0035 to		Interfer.	
	Valve insert - dia.	2.3145 to 2.315	0.002		0,001 min.	
4	Exhaust valve inserts in cylinder head Cylinder head – bore Valve insert – dia.	2.3115 to 2.3125 2.3145 to 2.315	Interfer, 0.0035 to 0.002		Interfer. 0.001 min.	
	ROCKER ARMS	2,315				
5	Bushes in rocker arms Rocker arms – bore	1.03125 to 1.03175	Interfer, 0.00375 to			
6	Bushes – dia. Rocker arms on shaft	1,034 to 1,035	0.00225			1
	Bushes - bore Shaft - dia,	0.87425 to 0.87575 0.873 to 0.8735	0.00075 to 0.00275		0.005	7
7	VALVE SPRINGS Outer springs Load when compressed to 1,688	100 lb. to 114 lb.		95 lb. min.		
×	Free length	3.425				
8	Inner springs Load when compressed to 1,500	56 lb. to 64 lb.		53 lb. min.		
	Free length	3.000				
9	VALVE GUIDES Valve guides in cylinder head Cylinder head – bore Valve guides – dia,	0.750 to 0.7505 0.752 to 0.7525	Interfer. 0.0025 to 0.0015		Interfer. 0.001 min.	

No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
10	VALVES IN VALVE GUIDES Inlet valves in guides Valve guide – bore Valve stem – dia,	0.500 to 0.5005 0.498 to 0.4985	0.0015 to 0.0025	1		Belling at lower end of guide bore must not ex- ceed 0.014 on diameter.
11	Exhaust valves in guides Valve guide – bore Valve stem – dia,	0.500 to 0.5005 0.4965 to 0.497	0.003 to 0.004			Belling at lower end of guide bore must not ex- ceed 0.010 on diameter.
	· vail	2		, C		11/2
	rail	ي ر		5 9		7115
		100				

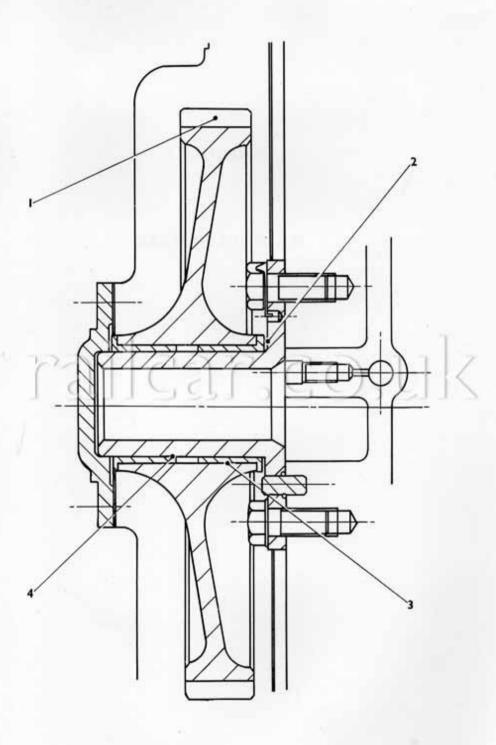
CAMSHAFT



No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE NEW	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
1	CAMSHAFT AND BEARINGS Camshaft end float		0.004 to 0.008		0.016	
2	Camshaft in bearings Bearings – bore Camshaft – dia.	2.4395 to 2.442 2.436 to 2.4365	0.003 to 0.006		0.010	
3	CAMS Cam lift	0.390 max.		0.375 min,		
	railca	ar	, C	0	U	K
	Ly.					

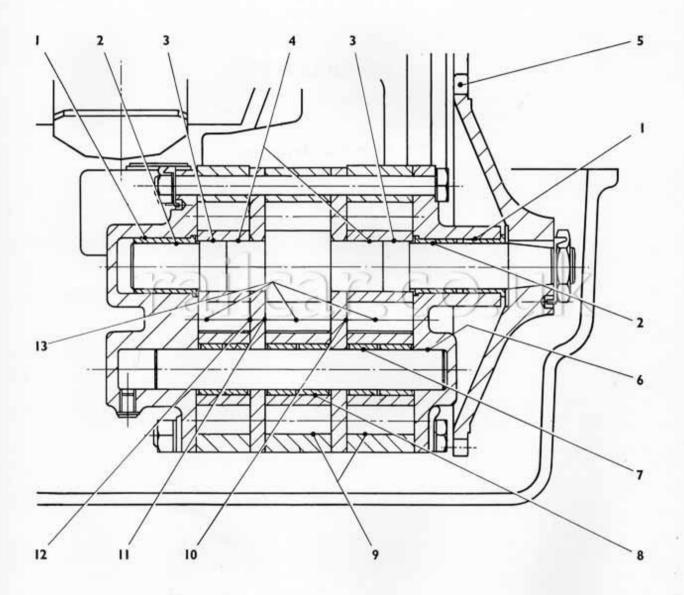
T.S.D. 803 - APPENDIX I

MAIN IDLER GEAR



IDLER GEAR BACKLASH Backlash between idler gear and carabshaft pinion, idler gear and carabshaft drive gear, and idler gear and carabshaft drive gear, and idler gear and carabshaft drive gear. 0.005 to 0.010	No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE NEW	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
Camshaft drive gear	1	Backlash between idler gear and crankshaft pinion, idler gear and auxiliary drive					
2 Idler gear end float 0.005 to 0.025 3 Bushes in idler gear Gear – bore 1.8125 to 1.813		camshaft drive gear		III THE RECOGNICATION		0.012	
Gear – bore 1.8125 to 1.813 0.0035 to 1.815 to 1.8155 to 1.816 4 Idler gear on shaft Bushes – bore 1.625 to 1.6255 0.001 to 1.6235 to 1.6235 to 1.624 See Service Bulli O.E.B. 196.	2					0.030	
Bushes – dia. 1.813 1.8155 to 1.8155 to 1.816 4 Idler gear on shaft Bushes – bore 1.625 to 1.6255 1.6235 to 1.6235 to 1.624 See Service Bulli O.E.B. 196. See Service Bulli O.E.B. 196.	3		1 8125 to	Interfer			
4 Idler gear on shaft Bushes – bore 1.625 to 1.6255 0.001 to 1.6235 to 1.6235 to 1.6235 to 1.624 0.002		35.50 (2.535)	1.813 1.8155 to	0.0035 to			See Service Bulletin O.E.B. 196.
Shaft – dia. 1.6235 to 0.002 0.004	4	Idler gear on shaft Bushes – bore	1.625 to	0.001 to			
railcar, coluk		Shaft – dia.	1.6235 to			0.004	
	-	mailas	12	- 2	0	111	7
		1 51115		50	9		17
		7-1					
	- 2						
		×					

OIL PUMP - Dry sump



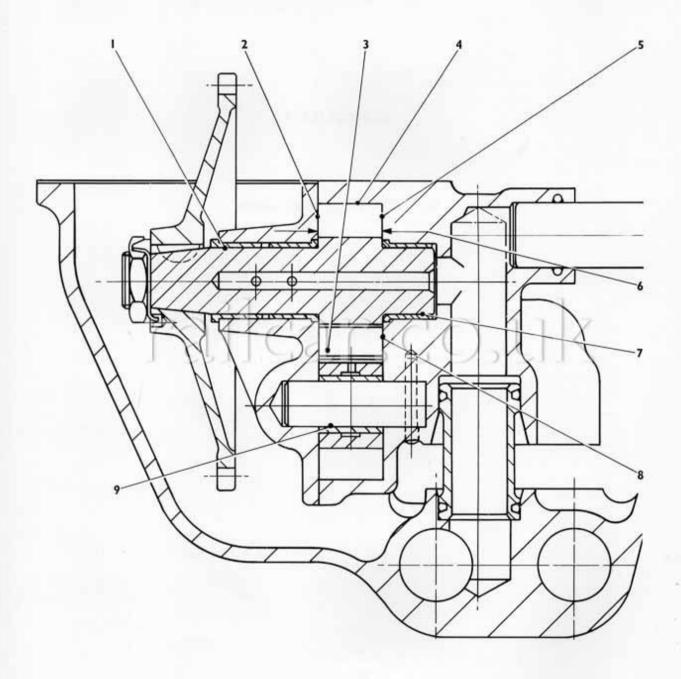
DRIVING GEARSHAFT IN FRONT AND REAR COVERS	No. ON IAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
Bushes - dia. 0.876 to 0.8765 0.0005 0.8765 0.8765 0.8765 0.8765 0.0005 0.7535 0.0015 to 0.7505 0.7505 0.0015 to 0.7505 0.0025 0.745 0.005 0.7485 0.0025 0.745 0.005 0.7485 0.0025 0.745 0.005 0.7485 0.0025 0.745 0.005 0.7485 0.0025 0.745 0.005 0.7485 0.005 0.7485 0.005 0.7485 0.005 0.7485 0.005	1	FRONT AND REAR COVERS Bushes in end covers	0.875 to	Interfer.		Interfer.	
Cases Case		District An III At	0.8755 0.876 to	0.000.000.000.000.000		0.000 Sept. Sept. 1	
Shaft - dia. 0.748 to 0.0025 0.745 0.005	2		0.750 to		0.7535		
DRIVING GEARSHAFT Gears on gearshaft serrations Backlash measured on pitch circle of gear teeth			0.748 to		0.745	0.005	
Backlash measured on pitch circle of gear teeth	3	DRIVING GEARSHAFT	- 87				
Gear - plain bore		Backlash measured on				0.010 max.	
Gearshaft - plain dia.	4	gearshaft					
CRANKSHAFT GEAR AND OIL PUMP DRIVE GEAR Backlash DRIVEN GEARSHAFT IN FRONT COVER Front cover – bore Gearshaft – dia. DRIVEN GEARS ON DRIVEN GEARSHAFT GEARSHAFT Gearshaft in gear bushes Bushes – bore Gearshaft – dia. DRIVEN GEARS ON DRIVEN GEARSHAFT O.0025 D.00025		AND A CONTRACT OF STREET	0.8435 0.84225 to	D. Carlotte and Ca			
DRIVEN GEARSHAFT IN FRONT COVER Front cover – bore Gearshaft – dia. DRIVEN GEARS ON DRIVEN GEARS ON DRIVEN GEARSHAFT Gearshaft in gear bushes Bushes – bore Gearshaft – dia. DRIVEN GEARS ON DRIVEN GEARSHAFT Gearshaft in gear bushes Bushes – bore O.65525 to O.65525 to O.65525 Bushes in driven gears Gears – bore DIAMETRAL CLEARANCE OF DRIVING AND DRIVEN GEARS IN CASING Casing – bore DIAMETRAL CLEARANCE OF DRIVING AND DRIVEN GEARS IN CASING Casing – bore Casing – bore D.6555 O.00075 to O.0015 O.00175 O.00175 O.00175 O.0015 O.00555 O.0075 to O.			0.8425	0	0	771	7
Front cover - bore 0.656 to 0.6565 0.0005 to 0.0025	5	DRIVEN GEARSHAFT IN	577	00	9	0.015	7
DRIVEN GEARS ON DRIVEN GEARSHAFT Gearshaft in gear bushes Bushes – bore O.65625 to O.65675 O.00075 to O.6555 8 Bushes in driven gears Gears – bore O.90625 to O.90625 to O.90625 O.90125 O.00175 O.90125 O.00175 O.00	6		2002.113.024.0	0.0005 to			
GEARSHAFT Gearshaft in gear bushes Bushes – bore Gearshaft – dia, Gearshaft – dia, Gearshaft – dia, O.65525 to O.6555 Bushes in driven gears Gears – bore O.90625 to O.90675 O.90125 DIAMETRAL CLEARANCE OF DRIVING AND DRIVEN GEARS IN CASING GEARS IN CASING GEARS – dia. Gears – dia. Gears – dia. GEARS – dia. O.00075 to O.001 to O.90125 O.005 O.00175 O.00175 O.0015 O.00		CONTRACTOR OF THE CONTRACTOR O	100 March 100 Com 100 Com	0.00125		0.0025	
Gearshaft - dia, 0.65675 0.00075 to 0.0025	7	GEARSHAFT Gearshaft in gear bushes	20120015				
8 Bushes in driven gears Gears – bore Bushes – dia, 0.90625 to 0.90675 0.001 to 0.90125 0.90125 0.90125 0.005 DIAMETRAL CLEARANCE OF DRIVING AND DRIVEN GEARS IN CASING Casing – bore Casing – bore Casing – dia. 2.0545 to 2.0555 0.0075 to 0.90125 0.90125 0.90125 0.005		25 16-16 000	0.65675	INCHEST CONTRACTOR OF THE STATE	-	0,0025	
Bushes – dia. 0,90675 0.001 to 0,90125 0.005 DIAMETRAL CLEARANCE OF DRIVING AND DRIVEN GEARS IN CASING Casing – bore 2.0545 to 2.0555 0.0075 to Gears – dia. 2.046 to 0.0095 2.039 0.0155	8		110 (222)		0.01025		
DIAMETRAL CLEARANCE OF DRIVING AND DRIVEN GEARS IN CASING 9 Casing – bore 2.0545 to 2.0555 0.0075 to 2.0555 0.0095 2.039 0.0155			0.90675			0,005	
9 Casing – bore 2.0545 to 2.0625 2.0555 0.0075 to 2.039 0.0155		DRIVING AND DRIVEN	0.90525			35.45	
	9	Casing – bore	2.0555				
		Gears - dia.	T0000000000000000000000000000000000000	0.0095	2.039	0.0155	

No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
10	AXIAL CLEARANCE OF DRIVING AND DRIVEN GEARS IN CASING Front scavenge gears axial clearance Casing – width	1.0495 to 1.050 1.0445 to 1.045	0,0045 to 0,0055			Maximum permissible depth of wear on sand- wich plates 0.005.
11	Rear scavenge gears axial clearance Casing – width Gears – width	1.0495 to 1.050 1.0445 to 1.045	0.0045 to 0.0055			Maximum permissible depth of wear on sand- wich plates 0.005.
12	Pressure gears axial clearance Casing – width Gears – width	0.8495 to 0.850 0.8445 to 0.845	0.0045 to 0.0055			Maximum permissible depth of wear on sand- wich plates 0.005.
13	BACKLASH BETWEEN PUMP GEARS		0.004 to 0.010		0.015	
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SCHEDULE 9

OIL PUMP - Wet sump

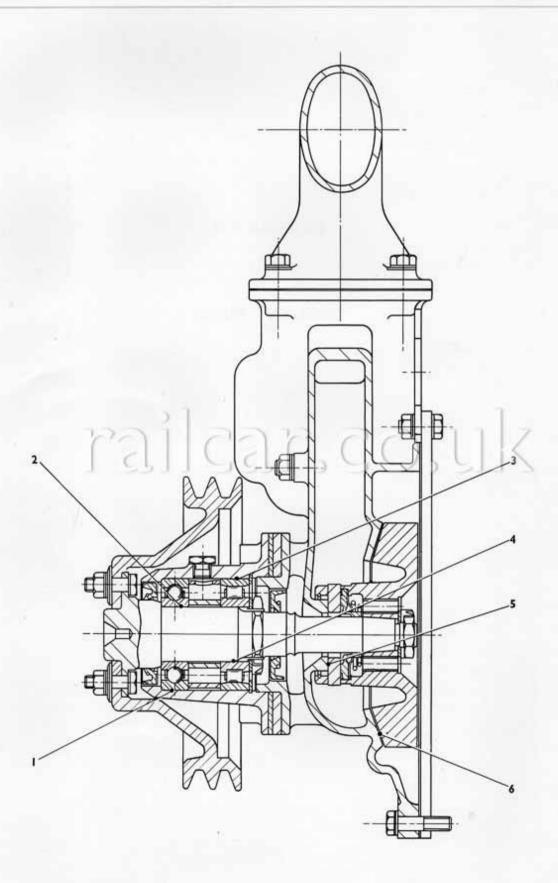


No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORN CLEARANCE	REMARKS
	DRIVING GEARSHAFT IN FRONT COVER					
1	Gearshaft in bush Bush – bore Gearshaft – dia.	0.875 to 0.8755 0.873 to	0.0015 to 0.0025		0.005	
2	SCORING ON FRONT COVER Thickness of cover	0.8735 1.340 to		1.330		Relap minus 0.010 maxi-
	DRIVING AND DRIVEN	1.350				mum.
3	GEARS Backlash	-	0.004 to 0.008		0.015	
4	Diametral clearance		0.003 to 0.005		0.008	
5	End float		0.004 to 0.0055		0.006	
6	Gear thickness	0.8455 to 0.846				
7	DRIVING GEARSHAFT IN RHAR CASING Gearshaft in bush Bush – bore	0,875 to 0.8755	0.0015 to	0	U	K
	Gearshaft – dia.	0.873 to 0.8735	0.0025		0.005	
8	REAR CASING INNER FACE Scoring					Scoring must not exceed 0.0015 deep and 0.010 wide.
9	DRIVEN GEAR ON SHAFT Shaft in bush Bush – bore	0.626 to				wite.
	Shaft - dia,	0.6265 0.624 to 0.6245	0.0015 to 0.0025		0.005	
					6	

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COOLANT PUMP

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No. ON DIAGRAM	DESCRIPTION	DIMENSIONS	CLEARANCE NEW	PERMISSIBLE WORN DIMENSIONS	PERMISSIBLE WORH CLEARANCE	REMARKS
	ROTOR SHAFT BALL BEARING					
1	Bearing in housing	H-D-T-T-T-T-T-T-T-T-T-T-T-T-T-T-T-T-T-T-	-12 54			
	Housing - bore	2.44075 to	Interfer.			
		2.44125	0.00025 to			
	Bearing – dia,	2.4405 to	0.00075			
		2.441	Clearance			
2	Bearing on shaft				150	
	Bearing - bore	1.1806 to	Interfer.			
	Shaft - dia.	1.1811 1.18085 to	0.0005 to 0.00025			
	Shart - dia.	1.18085 to	Clearance			
		1.1011	Clearance			
	ROTOR SHAFT ROLLER					
8 1	BEARING					
3	Bearing in housing	2012/06/2015	200000000000000000000000000000000000000			
	Housing – bore	2.44075 to	Interfer.			
	Bearing - dia.	2.44125 2.4405 to	0.00025 to 0.00075			
	Bearing - dia.	2.441	Clearance			
4	Bearing on shaft	2.441	Cicarance			
-	Bearing - bore	1.1806 to	Interfer.			
		1.1811	0.0005 to			7
	Shaft - dia,	1.18085 to	0.00025			
	201 0	1.1811	Clearance	1	1 1	7
5	DEPTH OF GLAND FACE			()		1 <
-	FROM CASING FACE)) 5	
	4-cylinder engine	2.075 to		2.145 to)
	The state of the s	2,085		2.155		
	6-cylinder engine	2,075 to		2.145		The factor of the factor
	o-cynnder engine	2.085		2.145 to 2.155		Fit insert to reclaim face Chap. 5, Sec. 18A.
		2.003		2.155		Chap. 5, Sec. 18A.
	8-cylinder engine	1.900 to		1.970 to		
1	o-cylinder engine	1.910		1.980		
		11,710		1.500		,
6	ROTOR AND CASING					
	Clearance between rotor		0.050			1740 17 1741 17
	and casing		0.050			Adjust by shims to give
						this clearance.
- 1						
						2
						7
					7	
					100	

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SECTION 10 . . FLUID DRIVE COUPLING VULCAN-SINCLAIR

The Fluid Coupling is operated with a constant quantity of oil, and its slip characteristic in relation to the load is determined by its hydraulic design and by the speed of the driving shaft.

It ensures a light load start of the engine, since the torque transmitted is progressively built up from zero at the instant of starting, and increases as the square of the input speed up to the moment that the driven shaft starts to rotate; as the output shaft accelerates, the slip of the coupling rapidly decreases until, at normal full speed it is of the order of a few per cent.

The coupling is filled with Shell Tellus 29 oil so that the level of oil when cold is up to the filling plug hole when this is set at an angle of 55 deg. from the T.D.C. or vertical position; the coupling will then function correctly provided this level is maintained. The capacity of the coupling with the filling plug hole set as describe previously is 5.75 Imperial gallons (26 litres) approximately.

A fusible plug is incorporated in the 'fluidrive' impeller housing, this provides a safeguard to the fluid coupling in the event of prolonged stalling or excessive loading. The plug contains a fusible alloy which melts at a temperature of approximately 360 deg.F. (182.2 deg.C.), and permits the oil to escape from the coupling allowing it to run free.

REMOVAL

Release and remove the rear engine mounting brackets from the fluid coupling bell housing. Release and remove the nut securing the output flange to the shaft, and withdraw the flange.

Extract the key from the output shaft.

Support the bell housing with a hoist and remove the set-bolts securing the bell housing to the flywheel housing.

Withdraw the bell housing and thrust race assembly from the output shaft of the fluid coupling.

Turn the engine until one of the two filling plugs on the drive casing is at B.D.C. Support the fluid coupling with a hoist, and remove the nuts securing the driving disc. Withdraw the coupling from the driving disc.

Whilst the coupling is suspended, remove the bottom plug and drain the oil from the coupling into a container. Ease the top plug to speed the flow of oil. Tilt the coupling to ensure that all oil is drained from the casing.

It is not necessary to remove the driving disc which can be examined in position for defects.

DISMANTLING

Suitably mark the flange of the impeller and casing to ensure correct assembly when rebuilding the coupling.

Release and remove the set-bolts securing the centre spigot to the impeller and withdraw the spigot and the roller bearing.

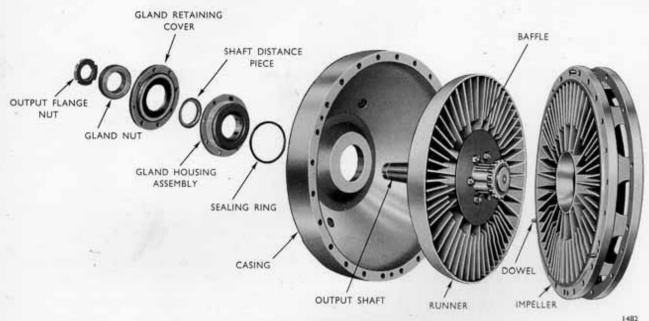


Fig. 1 Exploded view of Fluid Drive

Release and remove the bolts securing the impeller and casing, and with a hoist lift the impeller away from the casing. Withdraw the three locating dowels from the casing.

Turn the casing and runner assembly over so that the output shaft is uppermost.

Unlock the gland nut by lifting the metal out of the hole in the shaft with a screwdriver.

Using the ring peg spanner Pt. No.11711, release and remove the gland nut from the output shaft.

Release and remove the six set-bolts securing the gland retaining cover to the casing, and withdraw the cover.

Withdraw the diaphragm gland, shaft distance piece, sealing ring, casing distance piece, and sealring in that order from the gland housing.

Using two of the gland bolts in the starting holes of the gland housing, withdraw the gland housing and ball bearing from the casing. Remove the bearing housing sealing ring.

Withdraw the ball bearing from the gland housing.

Lift the casing off the runner and output shaft.

Turn the runner over with the baffle uppermost. Remove the spring circlip, and withdraw the inner race of the roller bearing from the shaft. Suitably mark the baffle, output shaft and runner to ensure correct assembly on rebuild. Release and remove the six bolts securing the runner and baffle to the shaft, and remove the baffle. Withdraw the shaft from the runner.

INSPECTION

Thoroughly clean all parts and visually examine them for damage.

Check all bearings for freedom and smooth action, any bearings having rough spots after they have been thoroughly washed out should be changed.

Examine the metal details of the diaphragm gland, which should be in a bright polished condition, if distorted or deteriorated the diaphragm should be renewed. If the sealing face of the gland nut is worn, a new gland nut should be fitted.

Renew all sealing rings.

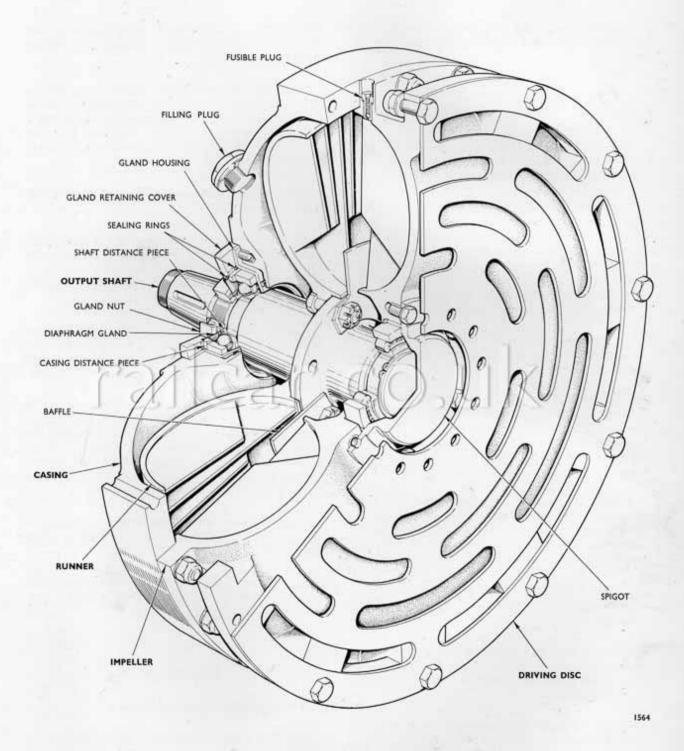


Fig. 2 Section through Fluid Drive

Examine the fusible plug for serviceability and always fit a new fibre washer when refitting the plug.

ASSEMBLING

Before commencing assembly, see that all parts are clean and free from dust or dirt, particularly the joint faces of the impeller and casing.

Assemble the runner and baffle on the output shaft, ensuring that the correlation marks are in line and secure them to the shaft with the six bolts. Lock the nuts with new split-pins. Press the inner race of the roller bearing on the shaft, and fit the securing circlip. Stand the unit on a bench with the bearing projecting through a hole in the bench and the output extension of the shaft pointing upwards.

Fit the casing over the shaft and support it in approximately its correct position relative to the runner.

Lightly smear the gland housing sealing ring with grease and position it in its recess at the bottom of the casing counter bore, and assemble the gland housing into the bore of the casing. Fit the ball bearing to the output shaft and into the gland housing.

Fit one of the diaphragm joint sealing rings in the groove of the casing distance piece, then slightly stretch and fit the second sealing ring to the periphery of the distance piece. Position the distance piece on the outer race of the ball bearing.

Place the shaft distance piece on the shaft with the wide face of the piece abutting the ball bearing inner race.

Position the gland diaphragm with the corrugation uppermost, and fit and secure the gland retaining cover with the set-bolts and shakeproof washers.

Apply red lead to the thread of the gland nut, and after checking the insert face for cleanliness, fit the nut to the shaft and screw it hard up to the distance piece. Finally tighten with the spanner Pt.No.11711. Lock the nut by punching part of the extended rim of the nut into the hole in the output shaft.

Insert the outer race of the roller bearing into the centre spigot housing. Fit the centre spigot housing into the impeller ensuring that the sealing ring is positioned against the impeller abutment face, and secure the housing with the set-bolts and shake-proof washers.

Position the impeller assembly on the bench with the vanes upwards.

Check that the joint faces of the impeller and casing are thoroughly clean, and fit a thin paper joint lightly smeared with 'Wellseal' or equivalent jointing compound to the joint face of the impeller casing.

Lift the casing and runner assembly and lower on to the impeller until the bearing rollers engage with the outer race in the spigot housing and the spigot on the impeller is close to the register in the casing.

Check that the correlation marks across the flange of the impeller and casing are in line. Lower off, and fit the three locating dowels. Secure the dowels by peening over the metal surrounding the dowel holes. Fit and secure the bolts which secure the casing assembly to the impeller and check that there is a plain washer under each nut.

Check that the fusible plug is fitted and secure in the impeller casing and that the filling plugs are fitted.

The special ring spanner Pt.No.11711 can be obtained from Fluidrive Engineering Co. Ltd., Isleworth, Middlesex.

REFITTING

Refitting is the reverse of removal.

After all components have been fitted to the engine remove one of the top inspection covers of the bell housing, and turn the engine until one of

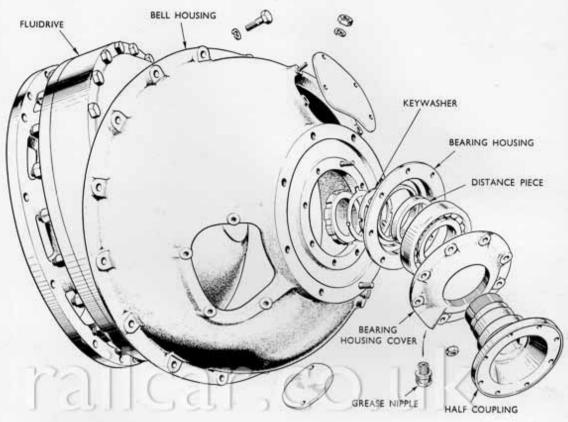


Fig. 3 Fluidrive coupling with bell housing

5534

the filling plugs in the casing is at 55 degrees to T.D.C. Remove the plug and fill the coupling through a suitable strainer with 5.75 Imperial gallons (26.139 litres) of Shell Tellus 29 oil up to the filling plug hole when the coupling is cold. Refit and tighten the filling plug.

Refit the inspection cover to the bell housing.

Points to note

During assembly, where self-locking nuts are used all nuts should be replaced by new ones.

Ensure that the key is fitted to the output shaft before the half coupling is fitted, and that the coupling nut is securely tightened and locked to the shaft. railcar.co.uk

FLUIDRIVE STEEL-CASED TRACTION COUPLINGS

SIZE 500 and SIZE 550

Railcars E51541 to E51560, E51809 to E51848 and M51681 to M51730

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Instruction Book for

VULCAN - SINCLAIR

FLUID COUPLINGS, Type STC,

Sizes 500 & 550

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&	Alignment	,

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&	Maintenance	-

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& Drawings	11

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FLUIDRIVE ENGINEERING Co LTD. ISLEWORTH, MIDDX. & BRACKNELL, BERKS.

IMPORTANT

These instructions have been prepared primarily for the mechanics who will be responsible for the erection, operation and maintenance of the Fluid Coupling, and it is MOST IMPORTANT that the book is handed to the men actually concerned.

Further copies can be supplied, if required, at 3s. 6d. each.

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VULCAN - SINCLAIR STEP-CIRCUIT FLUID COUPLING Type STC, Sizes 500 and 550

This fluid coupling is of the steel-cased 'traction' type, incorporating a 'stepped reservoir' working circuit and its construction is shown in typical sectional arrangement drawing M. 26625.

The main components are :-

INPUT side : Runner casing, impeller casing

and impeller.

OUTPUT side : Runner and shaft.

The two halves of the casing are steel pressings and the impeller and runner are aluminium alloy castings. The runner shaft is carried in ball and roller bearings in the steel casings and there is no mechanical connection between the impeller and the runner.

The coupling is filled with thin mineral oil and, when running, the impeller acts as a centrifugal pump transmitting power by the kinetic energy of the oil, which circulates in the form of a vortex in the working circuit, to the runner, which acts as a turbine.

A feature of the stepped reservoir working circuit is that when the output shaft tends to stall or is stalled, part of the oil circulating in the working circuit is discharged into the central reservoir space, thus reducing the effective quantity of oil in the working circuit and giving a correspondingly low stalling torque.

The gland has been designed for very long life and comprises a steel diaphragm with a floating ring of sintered graphite bronze between hardened steel faces.

Characteristics

Starting

The steel traction coupling enables the engine to develop maximum torque when accelerating the load from a standstill. The smoothest possible take-up of the drive is obtained simply by accelerating the engine. The torque at the output shaft builds up as the speed of the engine increases, until the driven shaft starts to rotate. The slip then rapidly decreases, and over the normal working speed range it is of the order of a few per cent. only, and therefore the efficiency is high.

Stalling

With the traction coupling it is not possible for the engine to be stalled by overload. Overloading the coupling merely results in the speed of the engine being pulled down until the coupling is stalled at 100% slip, and the full torque of the engine remains applied to the driven machine.

The torque at the output shaft is always the same as the engine torque and as soon as the overload is removed, normal speed working is resumed.

Mounting

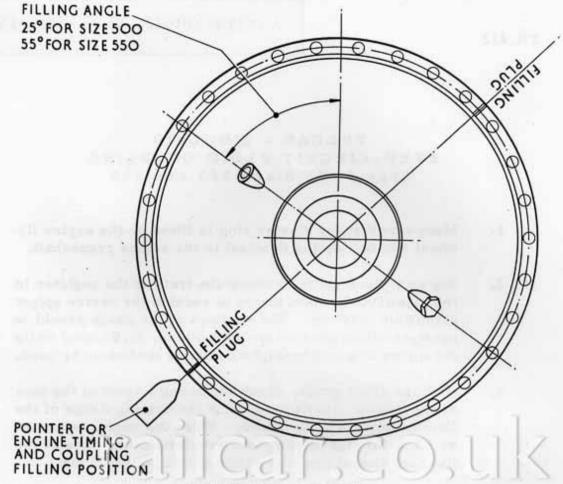
The fluid coupling is bolted directly to the engine flywheel and is centred in the flywheel by means of the centre spigot which engages with a register provided in the flywheel. A flexible coupling is provided on the runner shaft of the fluid coupling to connect it to the driven machine. The runner shaft has a taper end to receive the driven half of this flexible coupling.

Screw threads

The bolts and nuts used on these fluid couplings are to British Standard 1768 - 1951 and have Unified threads.

VULCAN - SINCLAIR STEP-CIRCUIT FLUID COUPLING Type STC, Sizes 500 and 550

- Make sure that the starter ring is fitted on the engine flywheel and bolt up the flywheel to the engine crankshaft.
- Rig up a clock gauge to check the truth of the register in the bore of the flywheel that is to receive the centre spigot of the fluid coupling. The readings of the gauge should be constant within plus or minus 0.002 in. (0.05 mm) while the engine is turned through a complete revolution by hand.
- With the clock gauge, check the running truth of the face of the engine flywheel to which the driving flange of the fluid coupling will be bolted. When the engine is turned by hand through a complete revolution, the face of the flywheel should run true within 0.002 in. (0.05 mm).
- Take off the light steel shroud which is fitted to the driving flange of the fluid coupling to protect it during transport. Smear grease on the centre spigot of the fluid coupling. Lift the coupling into position and enter the centre spigot into the register in the engine flywheel or crankshaft adaptor. Bolt the driving flange of the fluid coupling to the flywheel, tightening up the nuts securely, and locking them by means provided.
- 5. Check the truth of the mounting of the fluid coupling on the engine flywheel by setting the clock gauge to bear on the diameter of shaft 4 close to the shaft nut 9. When the engine is turned by hand the clock gauge should read within plus or minus 0.002 in. (0.05 mm) over a complete revolution.
- 6. Fit the key to the taper end of shaft 4 and put the driven half of the flexible coupling on the shaft. Secure the halfcoupling with shaft end plate 46 and setbolts 67, which should be tightened up hard to draw the half-coupling firmly on to the shaft. Lock the setbolts by wiring their heads together.



FILLING DIAGRAM

VULCAN - SINCLAIR STEP-CIRCUIT FLUID COUPLING Type STC, Sizes 500 and 550

OPERATION

Filling.

Before putting the fluid coupling into service, it requires to be filled with thin mineral oil of low viscosity and the use of SHELL TELLUS OIL 29 is recommended.

Great care should be taken to ensure that oil of a different grade is never added to that already in the coupling and that a mixture of oils is never used.

To fill the coupling, one of the filling plugs 22 or 42 is set at an angle from the vertical as shown in the filling diagram opposite. To enable the coupling to be set at the correct angle, the flange of the impeller casing is marked "FILLING PLUG" in two diametrically opposite positions. When one of these positions is brought opposite the timing pointer, the filling plug must then be removed and cold oil poured in to fill up to the plug hole. Setting the coupling in the angular position ensures that the correct quantity of oil is put in.

NOTE: It is essential that the plug hole is set to the required angle before the oil is poured in. The coupling must not be filled with the plug hole set on the vertical centre line and then turned to the angular setting after filling, as owing to the internal design of the coupling, the excess oil will not overflow.

Replace the filling plug with its joint washer 44 and tighten securely.

The approximate quantities of oil for the two sizes of steel traction coupling are as follows:

SIZE	500	550
gallons	3 1/2	4
litres	16	18

These quantities are given for guidance only as the coupling must always be filled up to the plug hole when set in the correct angular position.

Fusible plug

A fusible plug 43 is incorporated in one of the filling plugs (ref. 42). Should this plug fuse, due to prolonged stalling of the fluid coupling, the oil in the coupling will be thrown out and the drive will be disconnected. The plug will fuse at a temperature of 430° F. (220° C.).

The fusible plug should be replaced and the coupling must be refilled with oil as described above.

MAINTENANCE

Checking tightness of bolts

After the fluid coupling has been in service for a few weeks, check that the bolts in the driving flange, casing bolts 14, gland set bolts 28 and the bolts in the output flexible coupling are tight.

Checking filling

Periodically, with the coupling cold, set one of the filling plug marks on the casing flange against the timing pointer and remove the upper filling plug, to check that the oil level is correct. If necessary, add oil to make up the level. The same grade of oil as that used for filling the coupling must be used for "topping-up".

Gland shim

The shim 71 is fitted to provide for taking-up any wear of the gland parts which may occur over very long periods of service, say of several years. Removal of the shim will restore the tension of the gland diaphragm after wear has taken place. To carry out this work on the gland, there is no need to empty the oil from the coupling, which should be laid on the bench, resting on the input flange on the runner casing 3. Any pressure in the coupling should be released by taking out one of the filling plugs.

DISMANTLING

- Unbolt the flexible coupling on the runner shaft and move away the driven machine,
- Take the weight of the fluid coupling and remove the nuts from the driving studs. Move the fluid coupling away from the flywheel to disengage the centre spigot and the studs, and then lift it clear.
- 3. Support the coupling on the bench with the input flange upwards. Take out filling plugs 22 and 42 to drain the oil from the coupling into suitable containers. Then turn the coupling over and support it with the input flange downwards.
- 4. Take out setbolts 67 from the end of the runner shaft, remove shaft end plate 46 and draw off the half of the flexible coupling. Take out the key.

Carefully straighten the peened-over skirt of the shaft nut 9 and remove the nut and floating ring 72.

Unscrew setbolts 28 and take off retaining plate 7, diaphragmassembly 8, '0' ring 74, springs 75, bearing distance 10, '0' ring 73, shaft distance piece 11 and shim 71.

 Turn the coupling over and support it with packing under the impeller casing 40.

Remove capscrews 14 and Nyloc nuts 49 from the casing flange and tap out the two dowels 66.

Break the joint and lift away runner casing 3 with the outer race of the roller bearing 5. The inner race and rollers of bearing 5 will remain on the shaft 4.

6. Turn over the remaining assembly again and put supports under the flange of the impeller casing 40 so that the end of the shaft carrying the roller bearing is 1 in. to 1½ in. (25 to 40 mm) clear of the bench. Tap the upper end of the shaft using a hard wood block to drive the shaft 4 through the ball bearing 6. When the bearing is clear of its seating on the shaft, lift the impeller/impeller casing assembly away from the shaft and runner.

7. Lay the impeller assembly on the bench vanes downwards. After removing the four capscrews 64, the impeller may be separated from the impeller casing 40. Note the two dowels 58 between the casing and the impeller.

ASSEMBLY

Assembly of the fluid coupling must be done in a clean place and care taken that all parts are thoroughly clean before assembling. Use only clean rags to wipe the parts, cotton waste is unsuitable. A clear space should be chosen for the work which is carried out in three stages. The sectional arrangement drawing should be studied carefully at each stage,

1. Runner and shaft assembly

Bolt the runner 2 to the flange on shaft 4, using bolts 16 with plain washers against the aluminium alloy runner. The bolts must be put through the six equally spaced holes. The other two holes, diametrically opposite to each other, are air vents. Lock the slotted nuts 51 with new splitpins.

Impeller assembly

Place the impeller 1 on the bench vanes downwards. Fit new '0' rings 61 and 62 into their recesses in the impeller. Lower impeller casing 40 over the impeller with the fixing holes in line. Put in the four capscrews 64 loosely. Tap in the two impeller dowels 58 and finally tighten the screws 64.

Press ball bearing 6 into the bore of the impeller casing. Assemble bearing distance piece 10, springs 75, new '0' ring 74, diaphragm assembly 8 and retaining plate 7 in place in the bore of the impeller casing and secure with setbolts 28 with shake-proof washers 52 under their heads.

3. Complete assembly

Turn over the impeller assembly to bring the vanes upwards and support the impeller casing on packing of suitable height to give a clearance below for the shaft when assembled. Lower the runner and shaft assembly over the impeller, guiding the end of the shaft through the bore of ball bearing 6, and bring the shoulder of the shaft up to the inner race of the bearing. Then turn the assembly over.

Put shim 71 against the inner race of ball bearing 6, followed by shaft distance piece 11, new '0' ring 73 and floating ring 72. It is essential that the lapped gland faces are perfectly clean and a final wipe with dry newspaper will be found effective.

Screw on shaft nut 9 and tighten up hard. Lock the nut by peening a part of the thin skirt into the hole in the shaft.

Fit the key of the half flexible coupling to the taper end of the runner shaft. The half-coupling is secured by retaining plate 46 and two setscrews 67. After tightening the screws firmly to draw the half-coupling securely on to its taper, lock the screw heads by wiring together.

Again turn the assembly over. Examine the casing joint to make sure that it is in good condition. If in doubt, fit a new one of Phiberoid 0.010 in. (0.25 mm) in thickness.

Lower the runner casing 3 over the runner, making sure that the outer race of roller bearing 5 in the casing passes over the rollers of the inner race on the shaft, and bringing the dowel holes into line. Tap in the two casing dowels 66. Bolt the casings together with capscrews 14 and Nyloc nuts 49, tightening these evenly.

Screw in the two filling plugs 22 and 42, making sure that the bonded seals 44 are in good condition and are in place.

On some couplings, a drain plug 158, is fitted in one of the bosses on impeller casing 40. See that this, together with its bonded seal 159, is in place.

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DARTS LIST & DRAWINGS

Ref. No.	Name of Part	No. off					
1	Impeller	1					
. 2	Runner	1					
3	Runner casing	1					
4	Shaft	1					
5	Roller bearing	1					
6	Ball bearing	1					
7	Retaining plate	1					
8	Diaphragm assembly	1					
9	Shaft nut	1					
10	Bearing distance piece	1					
11	Shaft distance piece	1					
14	Capscrew	40 or 30					
16	Runner bolt	6					
22	Filling plug (solid)	1					
28	Gland setbolt	12					
40	Impeller casing	1					
42	Filling plug for fusible plug	1					
43	Fusible plug	1					
44	Bonded seal	1					
45	Washer for 43	1					
46	Shaft end plate	1					
49	Nyloc nut for 14	40 or 30					
50	Plain washer	6					
51	Slotted nut	6					
52	Shakeproof washer	12					
58	Dowel, impeller casing/impeller	2					
61	'0' ring						
62	'0' ring						
64	Capscrew 4						

Ref. No.	Name of Part	No. of
65	Setbolt for 78	3
66	Casing dowel	2
67	Setbolt for 46	2
71	Gland shim	1
72	Graphite bronze floating ring	1
73	. '0' ring	1
74	'0' ring	1
75	Spring	1
78	Bearing retaining plate	1
158	Drain plug	1
159	Bonded seal for 158	1

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VULCAN - SINCLAIR STEP - CIRCUIT FLUID COUPLING Type STC, Sizes 500 and 550

- Refer to the sectional arrangement drawing and parts list, to find the reference number of the part required.
- Find the serial number of the fluid coupling for which the spare part is needed. This is stamped on the coupling, usually on the nameplate.

It might read for example:- C. 13955/58815

 Quote the reference number and serial number in your order, as in this typical example:-

Two bonded seals ref. 44 for coupling C. 13955/58815.

FLUIDRIVE ENGINEERING CO. LTD.

Head Office:

FLUIDRIVE WORKS, WORTON ROAD, ISLEWORTH, MIDDX, ENGLAND.

Northern Office: 8, Cumberland Road, LEEDS, 6.

Telephone: Leeds 55861

Telephone : ISLeworth 1121

Telegrams: Hydynamic Isleworth TELEX

TELEX No : 24107

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DIMENSIONS of BALL & ROLLER BEARINGS

SIZE	500	550
BALL BEARING		
Ref. No. 6		
bore	65	85
o/dia	120	150
width	23	28
ROLLER BEARIN	G	
Ref. No. 5		(a steel, by
bore	60	80
o/dia	110	140
width	22	26

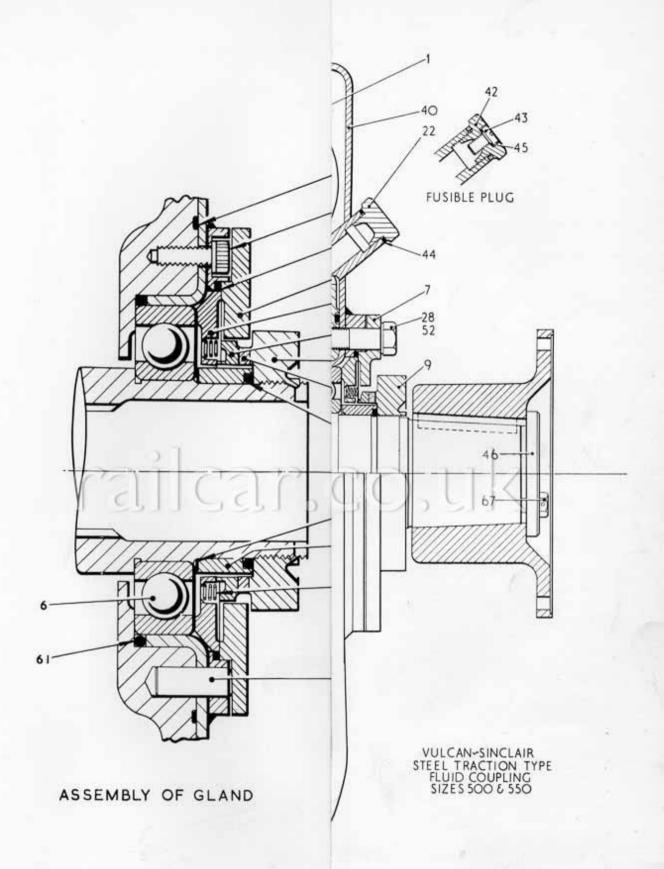
dimensions in mm

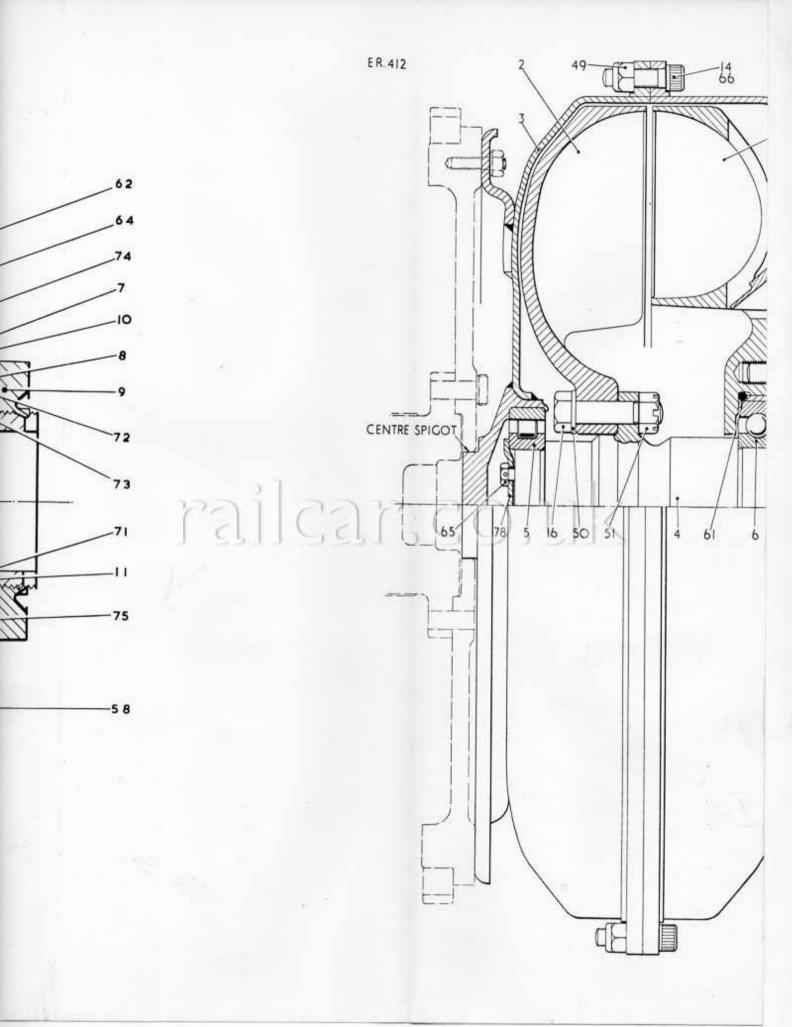
DIMENSIONS of '0' RINGS

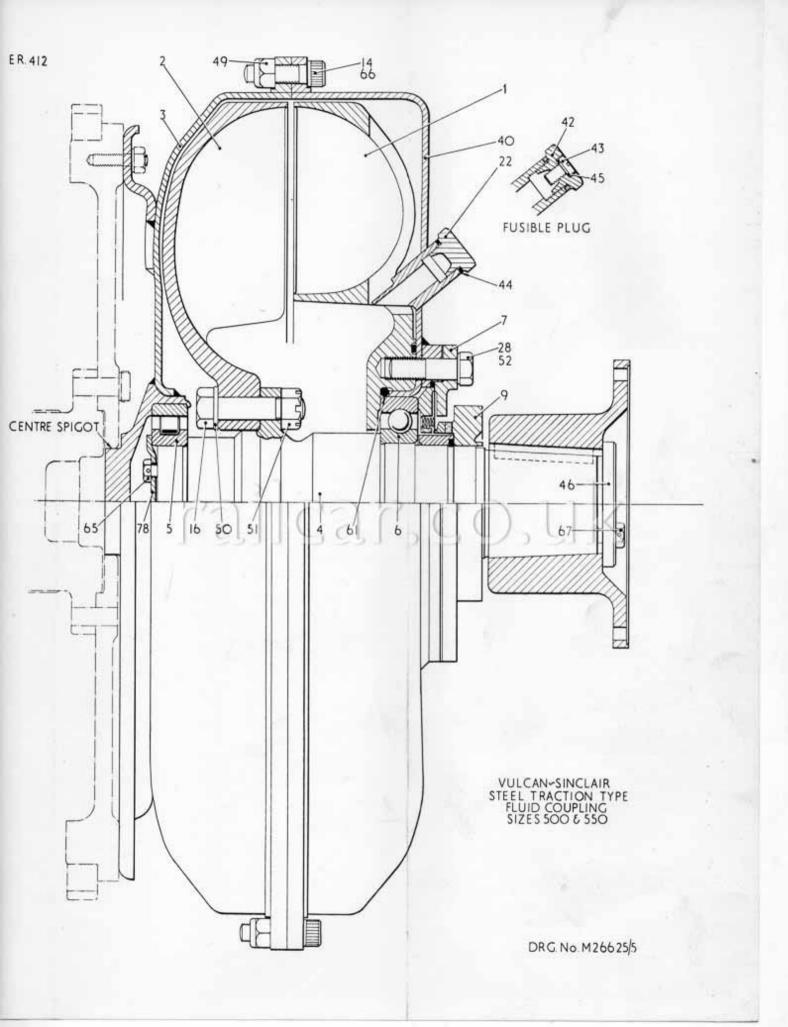
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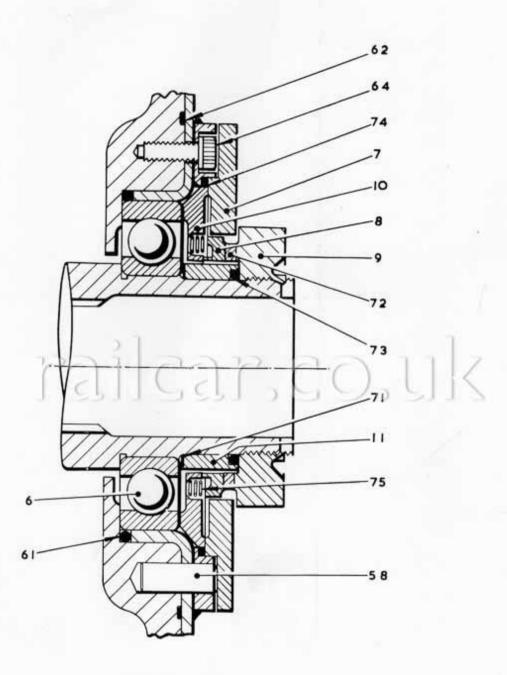
'0' ring		500	550
	ef. No. 61	4.5/8	5.7/8
336	ection	0.139	0.139
	ef. No. 62		
i/	dia	7	8.1/2
8	ection	0.139	0.139
R	ef. No. 73	E.C.C.	Ta windar
i/	'dia	2.1/2	3.1/4
8	ection	0.139	0.139
R	ef. No. 74		
i	dia	5	6.1/2
8	ection	0.139	0.139

dimensions in inches









ASSEMBLY OF GLAND

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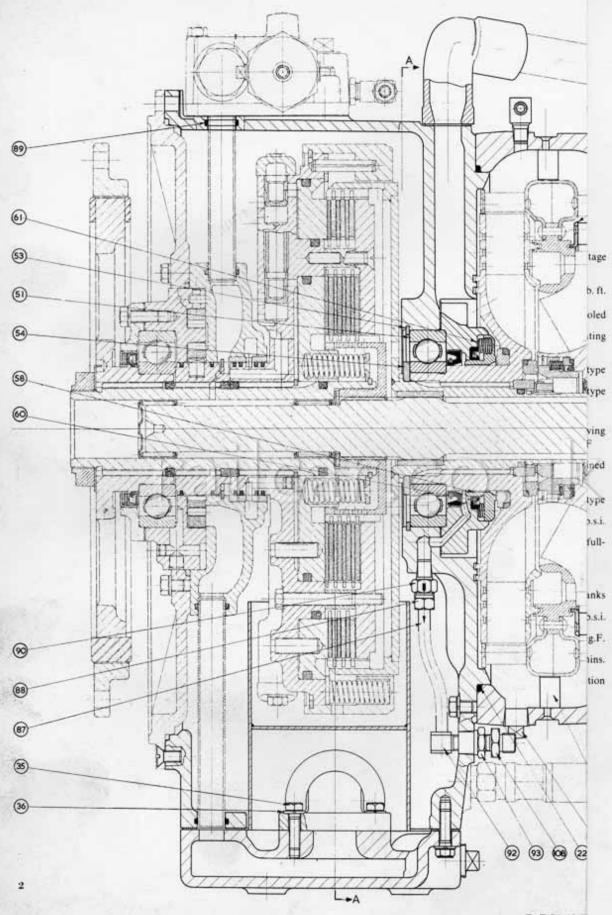
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TORQUE CONVERTER - DFR SERIES 10,000

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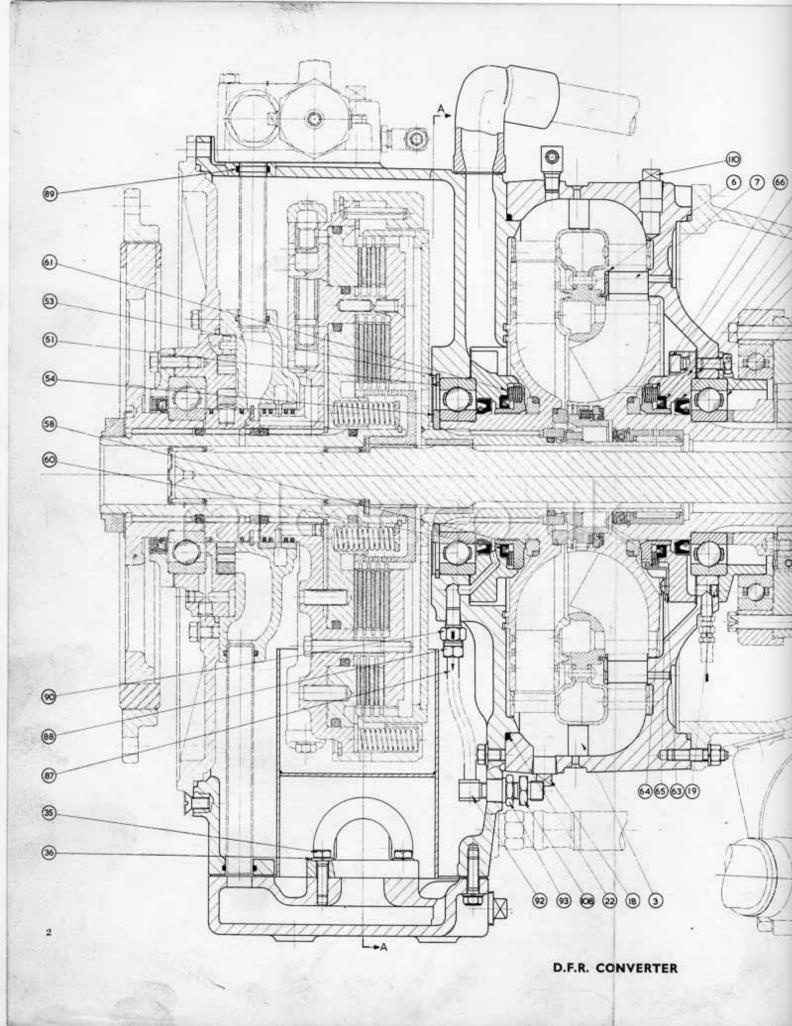


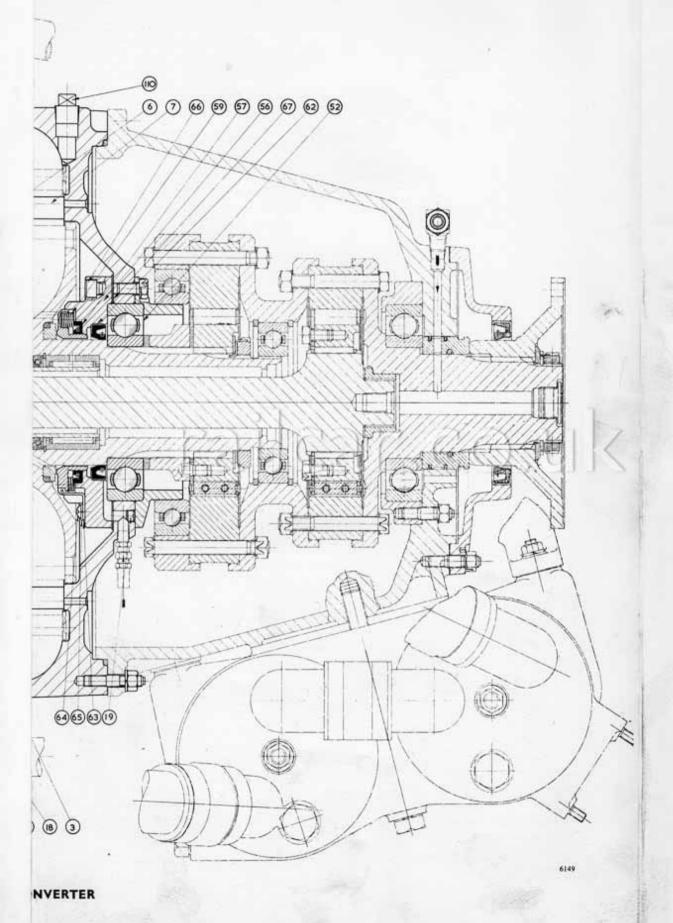
D.F.R. CO

TORQUE CONVERTER DATA

Type	25	13	ä	ji.	DFR.10,000, Ms.500, hydro-kinetic, three-stage torque converter, with direct drive
Specific torque (Mi)	7.0	~	7.7	500 lb. ft.
Clutches	10	7.7	W	111	Multi-plate, oil cooled
Clutch operation	Ħ		H	ž.	Hydraulic by oil pressure from clutch lubricating oil pump
Freewheels		7.7	11	11	Cam and roller type
Control valve		++		1.0	Air-operated sliding piston type
LUBRICATING OIL	SYSTE	М			
Oil Specification	7	ři.		ř.	Automatic Transmission Fluid Type 'A' having Armour Qualification number prefix AQ/ATF
Capacity	33	7	3	.7	4) Imperial gallons (filled through a combined filler, breather and dipstick assembly)
Pump		1	8	h	Around-the-shaft gear type
Working pressure	maximu	m)	12	T.F.	150 p.s.i.
Filters	14			150	Submerged internal gauze type and external full-flow type with expendable element
CONVERTER FLUID	SYSTI	EM			
Fluid		2.5		1.1	Diesel engine fuel oil from main fuel tanks
Base pressure	1.55	9	11	17	45 to 65 p.s.i.
Normal operating	tempera	lure	11	11	Not exceeding 220 deg.F.
Maximum operatin	g tempe	rature	55		250 deg.F. for limited periods up to 3 mins.
Cooling	44				Twin pack-type heat exchanger in conjunction with engine coolant system

Seal drain tanks with graduated sight glass are fitted only to Railcars E50000, E50988 to E51007 and E51154 to E51173





TORQUE CONVERTER - DFR SERIES 10,000

DESCRIPTION

The DFR torque converter is a hydraulic power transmission unit embodying a three-stage torque converter element together with hydraulically operated clutches which permit engagement of either direct or converter drive. A freewheel device comes into operation during direct drive allowing the turbine blades to remain stationary, thus eliminating power losses which would otherwise be occasioned by the churning of the converter fluid. A second freewheel comes into operation during the 'over-run', allowing the railcar to coast whilst the engine is idling.

The engine power is transmitted through a set of clutch plates to the converter impeller which drives, through the medium of the converter fluid, a three-stage turbine wheel. Stator blades situated between the turbine blade stages redirect the converter fluid on to the succeeding turbine blades and provide the reaction component necessary for torque multiplication. The engine torque is multiplied to a maximum of five to one when the converter output shaft is stalled, decreasing to unity as the output speed increases.

A clutch is provided to engage direct drive when the converter has attained unity torque ratio.

The clutches are operated by oil pumped from the clutch sump and directed by the control valve either to a piston which engages the outer set of concentrically mounted clutch plates through which the converter impeller is driven, or to a piston which engages the inner set of clutch plates for direct drive. Neither set of clutch plates is engaged when the control valve is in the neutral position.

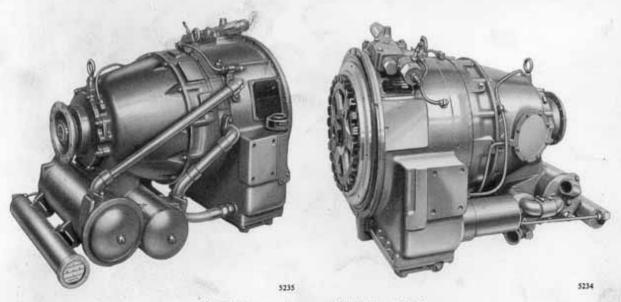


Fig. 1 Torque Converter DFR Series 10,000

railcar, co, uk

T.S.D. 866/B1890

RUNNING MAINTENANCE

HYDRAULIC CLUTCH SYSTEM

Lubrication

Fill the sump through the combined dipstick and breather orifice up to the level of the FULL mark on the dipstick (fig. 2); the following method of filling is recommended.

Fill to level.

Run engine for 5 minutes.

Stop engine and wait for minimum period of 5 minutes.

Top up as required.

Use only Automatic Transmission Fluid Type 'A' having an Armour Qualification Number prefixed by AQ/ATF.

When replenishing the oil, allow the power unit to stand for not less than 20 minutes before making the check. Checking the oil level immediately after the power unit has been running will give a false reading.

Take care not to overfill as this may cause clutch-slip. Should the oil level be found too high after topping up, drain the level down to the FULL mark by easing one of the sump drain plugs. Ensure that the plug is retightened after draining.



Fig. 2 Checking lubricating oil level



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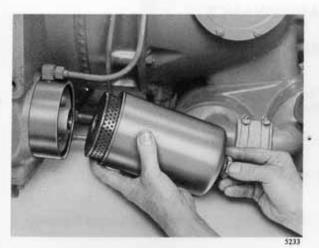
Fig. 3 Draining lubricating oil

External lubricating oil filter

To renew the element in the horizontally fitted full flow filter, drain off the lubricating oil by removing a drain plug.from the converter clutch sump (fig. 3).

Unscrew the centre bolt securing the filter assembly and remove the bowl from the clutch housing (fig. 4); discard the used element.

Clean out the filter bowl, fit a new element and reassemble the unit to the housing with a new sealing ring; ensure that the ring is correctly seated.



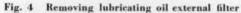




Fig. 5 Removing clutch sump cover

Refill the sump with the correct oil as specified under Lubrication; check for leaks after a short period of running.

Renew the element at the recommended period.

Note: A used element must never be cleaned for further use,

Sump filter

To clean the internal sump filter, drain the lubricating oil and remove the sump cover from the clutch housing (fig. 5).

Take care when lowering the cover, as a quantity of oil is retained in the clutch carrier oil tray; this oil must also be discarded.

Remove the oil tray from the sump cover, then unscrew the filter unit from the elbow in the cover (fig. 6).

Remove the small cotter pin from the locking nut, and dismantle the filter unit. Thoroughly clean the components in clean diesel fuel and blow off with compressed air. Reassemble the filter, fitting new rubber sealing washers if necessary (fig. 7).

Wash out the sump cover and the oil tray, then reassemble, using a new gasket for the sump cover joint. Refill the sump as described under Lubrication.

Note: Ensure that the oil tray is refitted to the sump cover the correct way, otherwise it will foul the clutch carrier when the engine is restarted (see fig. 47).

Clutch dump valves

There are four dump valves situated at 90 degrees in the clutch carrier assembly, each clutch having two valves at 180 degree positions.

The valves work under pressure of oil from the clutch pump, thereby closing the two oil outlet ports for their relative clutch while that particular clutch is in operation.

When the drive changes from one to the other, either from converter drive to direct drive or vice versa, the oil pressure to the clutch becoming inoperative is relieved, and the dump valves immediately slide outwards in their bores due to centrifugal force, and in so doing uncover the oil outlet ports, allowing the oil in the clutch system to empty into the sump.

If sticking dump valves are suspected, drain the lubricating oil and remove the sump cover.

Rotate the clutch carrier to gain access to each valve.

Unscrew the setbolts securing the retaining plate, remove the plate, and then withdraw the valve from the housing (fig. 8).

One pair of valves for the converter drive is accessible immediately after removing the retaining plates. The other pair for the direct drive are located behind distance sleeves. Use a suitable wooden plug to facilitate the removal and replacement of the dump valves.

Oil pump

Oil pressure is provided by an internal around-the-shaft gear-type pump, driven directly off the power input shaft. No servicing of the pump is required, but if a faulty pump is suspected, remove the torque converter from the engine and fit a new pump assembly.



Fig. 6 Removing sump internal filter

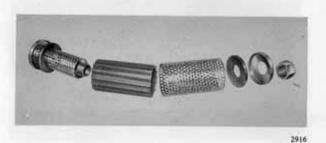


Fig. 7 Internal filter components



Fig. 8 Removing dump valve

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CONTROL VALVE ASSEMBLY

To remove the control valve assembly, disconnect the air pipes and the oil pipes at their unions on the control valve assembly.

Unscrew and remove the five setbolts securing the assembly, then lift the assembly from the clutch housing (fig. 9).

Fit a new joint washer when reassembling.

Relief valve

To inspect the relief valve, unscrew and remove the valve cap, then withdraw the outer spring, inner spring, spring-pin and valve from the housing (fig. 10).

Ensure that the valve and the valve bore are perfectly clean, and that the valve moves freely in its bore. Check the springs for distortion and for free length against a new spring.

When reassembling, ensure that the copper washer is bedding correctly; renew the washer if faulty.

Air valve cylinder

To remove, unscrew and detach the cylinder from the control valve assembly.



Fig. 9 Removing control valve assembly



Fig. 10 Relief valve components

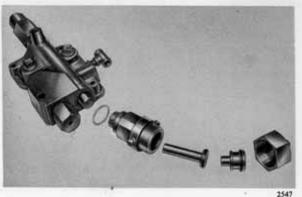


Fig. 11 Air valve cylinder components

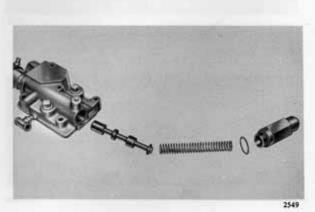


Fig. 12 Control valve piston components

To inspect, remove the capnut and withdraw the pistons complete with 'O' rings from the cylinder (fig. 11).

Ensure that the pistons are clean, and that they work freely in their respective bores. Check that the 'O' rings are seating correctly; renew the rings if defective.

When reassembling, ensure that the copper washers are bedding correctly; renew if faulty.

Control valve piston assembly

To inspect, unscrew and remove the spring carrier capnut from the control valve housing (fig. 12).

Ensure that the valve and its bore in the housing are clean, and that the valve slides freely in the housing.

Check the return spring for distortion and for free length against a new spring.

When reassembling, ensure that the copper washer is bedding correctly; renew if faulty.

CONVERTER FLUID SYSTEM

Fluid for the torque converter is diesel fuel oil from the main fuel reservoir, with the feed outlet positioned at a lower level than the feed to the engine fuel system.

Both feed lines should have internal screens which should be cleaned periodically.

Charging pump

The converter is automatically charged with fuel oil by a small gear-type pump mounted on the engine wheelcase and driven from the engine oil pump shaft. A pressure relief valve situated on the front face of the pump prevents the feed to the converter exceeding 65 p.s.i.

No servicing of the pump is normally required.

If a faulty relief valve is suspected, unscrew the retaining plug on the crankshaft side of the pump and withdraw the spring, spring-pin and valve from the pump housing (fig. 13).

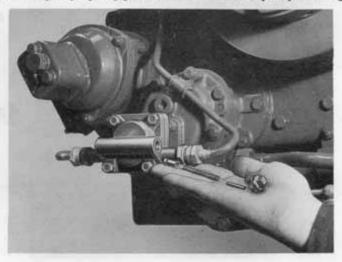


Fig. 13 Charging pump relief valve ,

Ensure that the valve and the bore are perfectly clean. Examine the spring for distortion, and check that both the valve and the spring are free in the bore.

To renew a faulty pump, disconnect the fuel oil pipe lines to the pump and remove the pipe support clip from the pump drive cover.

Remove the pump drive cover complete with the charging pump, taking care not to damage the joint face, and withdraw the driving gear which is keyed and pressed on to the pump shaft. This will allow the defective pump to be removed from the pump drive cover and the new pump fitted in its place, interposing a new joint washer.

Remove the pump end cover and, supporting the exposed shaft end on a suitable metal block, fit the key and press the driving gear on to the pump shaft until the shaft end is flush with the face of the gear boss.

Place the drive cover and pump assembly in position on the drive casing, interposing a new joint washer. Remove the inspection plug and examine the meshing of the driving gears. Adjust if necessary by moving the driving gear on the pump shaft until a full-width tooth engagement is achieved. Refit the inspection plug.

Bolt the drive cover in position. Refit the end cover, ensuring that the rubber 'O' ring is in place. Reconnect and tighten the fuel oil pipe lines.

Main fluid filter

To renew the main filter element, turn off the stopcock at the fuel tank, unscrew the centre securing bolt on the header bracket and remove the bowl assembly (fig. 14), then withdraw and discard the filter element.

Clean out the bowl, fit a new filter element and refit the bowl assembly to the header bracket, using a new sealing ring.

Turn on the stopcock and check for leaks after a short period of running.

Note: A used element must never be cleaned for further use.



Fig. 14 Removing main filter bowl







Fig. 16 Orifice filter components

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Orifice filter

To clean the orifice filter, disconnect both unions securing the filter unit to the torque converter fuel oil return line, release the securing clip, and remove the filter unit (fig. 15).

Dismantle the filter unit, blow out the edge-type element with compressed air and ensure that the small orifice in the cap is perfectly clear. No attempt must be made to increase the size of the bleed orifice.

Reassemble the filter unit and ensure that the two copper washers are correctly positioned (fig. 16).

Refit the filter unit to the fuel oil return line, run the engine for a short period to obtain circulation of the fuel oil, and check the base pressure on the converter fluid gauge.

Normal running pressure is approximately 45 to 65 p.s.i.

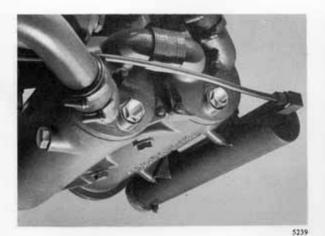
HEAT EXCHANGER ASSEMBLY

The torque converter fluid (fuel oil) is cooled by the engine coolant circulating through a twin pack heat exchanger mounted under the converter. Circulation of the fluid is maintained by the pressure difference of the fluid across the converter impeller. A temperature gauge in the local control box indicates the fluid temperature. Normal operating temperature should not exceed 220 deg.F. Maximum operating temperature for a limited period of 3 minutes is 250 deg.F. and an automatic switch in the control box shuts down the engine when the fluid reaches this temperature.

After prolonged operation the tubes of the cooling packs may become choked; this will allow the fluid temperature to increase, and may also affect the temperature of the lubricating oil, thereby causing low lubricating oil pressure.

To carry out inspection for contamination of the heat exchanger tube packs, drain off the fluid by removing the plug from the centre of the lower pack.

Drain off the coolant, first by means of the engine drain cock, then finally to obtain complete drainage by removing the two drain plugs from the heat exchanger end caps (fig. 17).



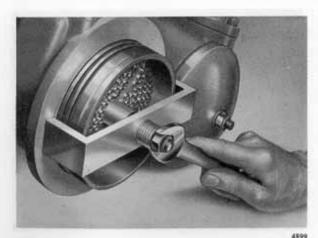


Fig. 17 Heat exchanger drain points

Fig. 18 Removing heat exchanger tube pack

Unscrew the centre nuts securing the four end caps and remove the caps.

The tube packs can then be inspected, and if necessary flushed through.

When reassembling, renew the rubber sealing rings for the end caps and for the centre stud.

Refill the cooling system, run the engine at approximately \(\frac{1}{4}\) throttle for a minimum of 5 minutes to circulate the fluid.

Stop the engine and check coolant level, top up as necessary.

Run the engine for a further short period at ½ throttle and check converter fluid base pressure which should read 45 to 65 p.s.i.

Note: Should it be necessary to remove the tube-packs from their casings, first remove the end caps, then using a suitable withdrawing tool, pull the packs in one direction just sufficient to take off the two rubber sealing rings from the exposed end of each tube-pack (fig. 18). After removing the sealing rings from the exposed ends, carefully pull the tube-packs from the casings in the opposite direction.

To replace the tube packs, reverse the above order and fit new seals. Take great care when entering the tube-packs into the casing as the rubber rings can easily be damaged, which would result in the converter fluid mixing with the coolant.

Points to note

The large rubber 'O' rings are of two kinds, and although they are physically interchangeable, they must only be used in their correct relative positions, thus:

Fit the rings marked with a RED SPOT in pairs in the grooves around the periphery of the tube stack end plates.

Fit the rings marked with a YELLOW SPOT singly in the recess in each end cap.

When refitting the tube stacks place the dowelled faces towards the end caps which carry the inlet and outlet connections, turning the tube stacks to align the dowels with the locating holes.

OVERHAUL

TOOLS

The following special tools will be required to dismantle and reassemble the torque converter:

D : 11 1 12 1

LC.1905	Drive spider locking plate
LC.1904	Extractor screw \(\frac{3}{8}\) in. UNC. \(\times 3\)\(\frac{1}{4}\) in. (3 off)
UE.5845	Nut 3 in. UNC. (3 off)
LC.2844	Output flange nut spanner
UA.210	Extractor screw § in. UNF. × 1½ in. (2 off)
LC.1916	Holding tool (turbine hub)
LC.1908	Ring spanner (turbine hub nut)
LC.1914	Oil pump extractor
LC.1915	Oil pump extractor adapter
LC.2007	Oil pump press adapter
LC.1906	Clutch assembly lifting tool
LC.1909	Holding and lifting tool (impeller and turbine wheel)
LC.1911	Clutch piston extractor (2 off)
LC.1910	Clutch spring compressor
LC.1913	Circlip removing pliers
LC.1907	Impeller nut spanner
LC.2593	Freewheel roller snare
LC.2079	Drive spider assembly tool

DISMANTLING TO MAJOR GROUPS

Disconnect all pipes between the converter and the diesel engine, and drain all lubricating oil and converter fluid from the converter.

Support the converter on suitable lifting gear of one ton minimum capacity, using slings attached to the two lifting eyes, and remove the bolts securing the converter to the diesel engine.

Move the converter gently straight back from the engine, taking care not to damage the drive spider, and unlock the tabwasher under the spider retaining nut. Attach the drive spider locking plate LC.1905 to the front flange of the converter, using two extractor screws LC.1904 and nuts UE.5845 to prevent rotation of the spider (fig. 19). Unscrew the centre hexagon nut, and remove and discard the tabwasher. Insert three extractor screws LC.1904 into the $\frac{3}{8}$ in. UNC. tapped holes in the spokes of the drive spider, and tighten the screws in turn to withdraw the spider from its shaft (fig. 20).

Remove the drive spider locking plate and place the converter on two hardwood blocks, each approximately $6 \text{ in.} \times 6 \text{ in.} \times 24 \text{ in.}$, with the output drive and freewheel housing uppermost. The arrangement of the blocks can be seen in fig. 21.

Disconnect all pipes between the heat exchanger and the torque converter, and remove the heat exchanger by unscrewing the two § in. setscrews.

Remove the inspection plate on the side of the freewheel housing, discarding the fibre joint.



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Fig. 19 Drive spider locking plate in position

Fig. 20 Withdrawing drive spider

Unlock the tabwasher under the output flange locknut, unscrew the locknut, using the output flange nut spanner LC.2844, and discard the tabwasher. Remove the keywasher and the plain washer, and withdraw the output flange from the output shaft. Unscrew the eight nuts securing the end cover, and discard the tabwashers. Insert the two extractor screws UA.210 in the UNF, tapped holes, and tighten the screws alternately to remove the end cover. Discard the joint. A further six nuts securing the bearing housing studs will now be exposed; unlock and remove these nuts and discard the tabwashers.

Remove the output sealing ring housing by pulling it firmly along the output shaft.

Disconnect the large external flexible pipe between the clutch housing and the freewheel housing at the union nut on the clutch easing. Disconnect the internal flexible oil feed pipe to the turbine housing bearing. Access to this pipe is obtained through the aperture exposed by the removal of the inspection plate.

Remove the twelve \(\frac{3}{8}\) in. UNF. nuts and spring washers securing the freewheel and turbine housings, and with a suitable sling attached to the lifting eye on one side and round the elbow connection on the other side, lift the freewheel housing off the turbine housing (fig. 21).

Remove the nuts from the twelve bolts securing the halves of the rearward freewheel, and withdraw the output shaft complete with bearing, bearing housing, and internal bush. Remove the bolts and discard the tabwashers. Carefully remove the freewheel outer race which will allow the eleven freewheel rollers to fall out of the cage. These must be collected, together with the twenty-two springs and followers, counted and stored in a separate marked container.

Insert one of the $\frac{5}{8}$ in. heat exchanger setscrews into the tapped hole in the end of the direct drive shaft to lift the shaft out. If it is desired to remove the freewheel cam and cage assembly from the direct drive shaft, remove the snap rings which locate the cam and slide it off the end of the shaft.

To remove the forward freewheel casing, place two levers diametrically opposite to each other under two of the bolts securing the halves of the forward freewheel and, using two small blocks of wood as fulcrum points, lever the freewheel casing away from the turbine housing (fig. 22). The eleven rollers, twenty-two followers and springs will fall out of the lower freewheel cage, and these must be collected, counted and stored in a separate marked container pending reassembly.

The two halves of the forward freewheel can be parted by removing the twelve securing bolts, thus releasing the freewheel outer race. If subsequent inspection indicates renewal, the bearing between the freewheels located in the freewheel casing can be pressed out after removing the internal circlips.

To remove the freewheel cage and cam, unlock the tabwasher, insert the holding tool LC.1916, and unscrew the central nut, using ring spanner LC.1908 (fig. 23). Remove the nut, tabwasher and plain washer, withdraw the freewheel cage assembly, the spacer and the freewheel adjusting washer.

If it is desired to remove the majority of the freewheel assembly without dismantling, this may be achieved by the following method:

Remove the output flange, end cover, output sealing ring housing and freewheel housing as previously described. Reassemble the output flange to the output shaft, and secure with its nut partially tightened. Attach a suitable sling to the output flange, and the whole of the freewheel assembly, with the exception of the forward freewheel cage, cam and rollers, can be lifted off intact (fig. 24).





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Fig. 22 Removing forward freewheel casing

Fig. 21 Lifting freewheel housing off turbine housing



Fig. 23 Removing freewheel forward cage and cam



Fig. 24 Removing freewheel assembly

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Some resistance to this lift may be expected as both the between-freewheels bearing and the forward freewheel bearing are moved from their seatings simultaneously (fig. 25).

At this stage the converter unit should be inverted and placed on the hardwood blocks so that the input end is uppermost.

Remove the three countersunk-head screws securing the outer flange of the front plate to the clutch housing. Remove the eight $\frac{3}{8}$ in. UNC, setscrews securing the inner flange of the front plate to the distribution housing, together with the two short $\frac{3}{8}$ in. UNC, setscrews used to blank the extractor screw holes. The ten copper washers located under the setscrew heads should be removed and discarded.

Fit two extractor screws LC.1904 in the UNC, tapped holes, and lift off the front plate by tightening evenly (fig. 26). Remove and discard the sealing joints on the inner and outer flanges.

Unscrew the unions at each end of the external short pipe between the impeller bearing oil feed adapter on the clutch housing and the T-piece on the side of the control valve assembly, and remove the pipe.

Remove the five $\frac{1}{8}$ in. UNC, setscrews securing the control valve assembly to the clutch housing, noting the relative positions of the two long and three short bolts. Lift off the control valve assembly and discard the joint.

Unscrew the eighteen \(\frac{1}{8} \) in. UNC. setscrews and spring washers securing the sump cover to the clutch housing, lift away the sump cover and discard the joint.

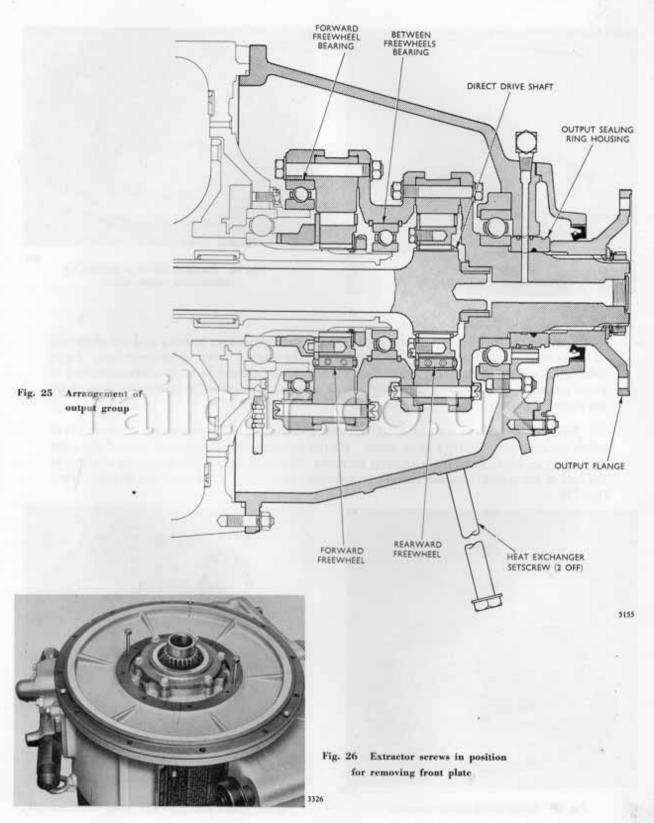






Fig. 28 Extractor screws in position for withdrawing clutch carrier

Fig. 27 Withdrawing oil pump and distribution housing

Remove the four short transfer tubes between the distribution housing and the underside of the control valve facing, and the single longer tube leading to the sump cover face. These tubes are located in rubber 'O' rings at each end and care should be taken whilst removing to avoid raising burrs which would damage the 'O' rings on reassembly. Remove and discard the ten rubber 'O' rings.

Remove four of the six $\frac{3}{8}$ in. UNC. setscrews retaining the oil pump seal carrier plate to allow the extractor LC.1914 to be fitted. Fit the extractor and secure with four of the eight $1\frac{1}{4}$ in. by $\frac{1}{8}$ in. UNC. front plate securing setscrews. The adapter LC.1915 should be attached to the end of the central screwed ram of the extractor and located in the end of the input sleeve (fig. 27).



Fig. 29 Lifting clutch carrier assembly

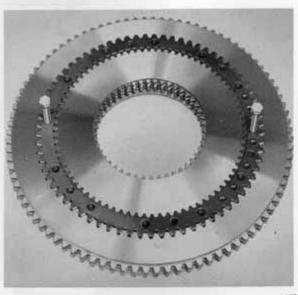


Fig. 30 Clutch plate pack with lifting screws attached

Screw down the extractor handle and draw off the oil pump and distribution housing assembly complete. Remove the tool and refit the four \(\frac{1}{8} \) in. UNC. setscrews.

Remove and discard the three 'O' rings from their annular grooves around the splined input sleeve. One of the 'O' rings is located midway along the shaft and is usually sheared whilst withdrawing the housing assembly, the other two being positioned side by side at the lower end of the splines.

Remove the twelve $\frac{3}{8}$ in. UNF, setscrews securing the clutch carrier to the backing plate and driving ring assembly. Fit two extractor screws LC.1904 in the UNC, tapped holes provided in the recesses of the clutch carrier (fig. 28), and by tightening the screws evenly, draw the clutch carrier assembly off its dowels. Assemble the lifting tool LC.1906 to the input sleeve, securing it with the drive spider nut, and lift out the clutch carrier assembly complete (fig. 29). Remove the thrust washer from the face of the clutch hub.

Insert two of the twelve 3½ in. by ½ in. UNC. setscrews, used to secure the clutch carrier assembly, through the holes in the clutch driving ring, and into the tapped holes in the backing plate. By grasping both setscrew heads firmly and lifting evenly, the complete clutch plate pack can be drawn out of the impeller driving wheel (fig. 30). Remove the direct drive clutch hub.

Remove the external oil filter canister complete and discard the element and sealing ring.

Remove the oil feed pipes from the base of the oil filter leading to the freewheel housing and to the turbine bearing, and detach the external seal drain outlet pipe if fitted. Unscrew the three \(\frac{3}{3}\) in. UNC, setscrews securing the filter base to the clutch housing, remove the filter base and discard the joint.

Remove the twenty-four \{\frac{1}{2}\) in. UNF, self-locking nuts from the studs securing the clutch housing to the turbine housing. Remove also the two \{\frac{1}{2}\) in. UNC, blanking setscrews from the tapped holes provided in the clutch housing, and insert two extractor screws LC.1904.

Screw down the extractor screws evenly to separate the clutch and turbine housings (fig. 31) and, finally, lift the clutch housing off the turbine housing, using a sling in conjunction with tool LC.1909 attached to the clutch housing front face (fig. 32). Remove and discard the sealing joint between the housings.

The converter is now dismantled to major groups.



Fig. 31 Using extractor screws to separate clutch and turbine housing



Fig. 32 Attachment of sling for lifting clutch housing

DISMANTLING OF INDIVIDUAL MAJOR GROUPS

Control valve group

Unscrew the spring carrier and remove the return spring and control valve piston from the valve body. Unscrew the relief valve cap from the valve body and withdraw the spring pin, inner and outer relief valve springs and the relief valve piston.

Holding the air cylinder body firmly, unscrew the air cylinder cap and withdraw the converter drive and direct drive pistons. Then remove the air cylinder body from the valve body. Discard the four copper washers and the 'O' rings from both air pistons.

Sump cover group

Remove the four \(\frac{3}{8} \) in. UNC. setscrews securing the oil tray to the sump cover, and lift off the oil tray. This reveals the main lubricating oil intake filter, which can be removed by unscrewing the large hexagon nut locked to its end plate (fig. 33).

The magnetic plug should also be removed from one end of the sump cover.

Oil pump and distribution housing group

Unscrew the six \{\frac{3}{8}\) in. UNC. socket-head capscrews securing the distribution housing to the oil pump housing, noting the relative positions of the two short and four long screws, and separate the two subassemblies.

The circlip in the bore of the distribution housing should not be disturbed unless renewal is necessary.

Carefully mark the faces of the pump gear rings to ensure that on reassembly the original faces are uppermost.

Lift the pump drive hub complete with the inner pump gear ring out of the pump housing. Remove the two piston-ring-type oil sealing rings from the pump drive hub and withdraw the inner pump gear ring and its driving key. The outer pump gear ring can be lifted out of the housing.

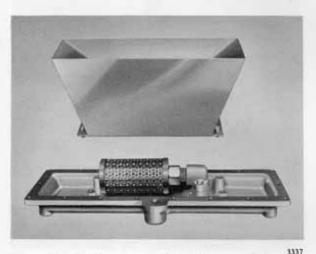


Fig. 33 Sump cover with oil tray removed

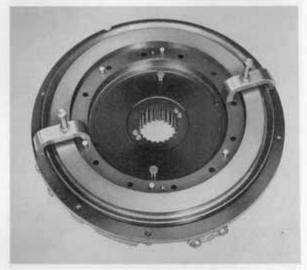


Fig. 34 Piston extractors in position

Remove the six \(\frac{3}{8} \) in. UNC, setscrews securing the pump oil seal carrier to the oil pump housing, and discard the joint on the seal carrier face. Push out and discard the oil seal.

The oil pump ball bearing should only be removed from the pump housing when renewal is necessary.

Clutch carrier group

To facilitate reassembly of the converter drive and direct drive pistons, a very light diametral scriber mark should be made across the face of the two pistons and the raised surface between them. It is important that this scriber mark is not heavily impressed and can be smoothed off after reassembly.

Drive out the assembly of the input sleeve and direct drive piston, using a soft-faced mallet on the front end of the input sleeve.

Support the clutch carrier on blocks with the aluminium spring carrier ring uppermost, and slacken the six \(\frac{3}{8}\) in. UNF, securing setscrews evenly in rotation until all spring pressure is released. Finally, remove the setscrews, the carrier ring, the twenty-two springs, the circular spring support plate and the six distance pieces.

Invert the clutch carrier and remove the four piston-ring-type oil sealing rings from the clutch carrier hub.

To extract the four dump valves, unscrew the two \{\}\ in. UNC. setscrews securing each dump valve cap. The two diametrically opposed direct-drive dump valves have distance tubes located under their caps and seated within the two longer radial passages in the clutch carrier. The converter drive dump valves are contained in the two shorter passages.

Attach two piston withdrawal tools LC.1911 to the converter drive piston, using two extractor screws LC.1904 and nuts UE.5845 in the tapped holes provided in the piston face (fig. 34). Tighten the nuts evenly to withdraw the converter drive piston from its recess in the clutch carrier. The piston is a close fit in the carrier recess and care should be taken to ensure that the piston does not tilt as it is lifted.

Remove and discard the rubber 'O' rings from the grooves in the periphery of the piston and the inner wall of the piston recess.

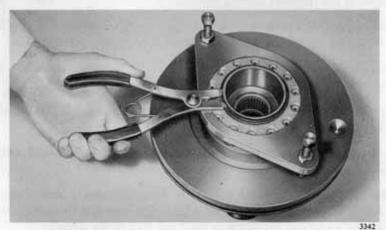


Fig. 35 Dismantling direct-drive piston and input sleeve

The piston locating dowels in the two concentric piston recesses should only be removed from the clutch carrier if they require renewal.

To dismantle the assembly of the direct drive piston and the input sleeve, assemble the spring compressing tool LC.1910 to the two tapped holes in the direct drive piston face, using two extractor screws LC.1904 and nuts UE.5845 (fig. 35). Compress the springs by tightening the two nuts evenly, and remove the retaining circlip, using the circlip pliers LC.1913.

Release the spring pressure by slackening the nuts, dismantle the tool and remove the spring retaining plate, fourteen springs and the direct-drive piston (fig. 36). Remove and discard the 'O' rings from the outer periphery of the piston and the input sleeve. The needle roller bearings should only be removed from the bore of the input sleeve if they require renewal.

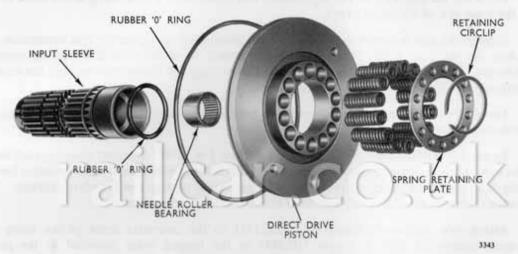


Fig. 36 Exploded view of direct-drive piston and input sleeve components

Clutch housing and impeller group

Rest the clutch housing on wooden blocks on the sump cover face, and assemble the impeller driving wheel holding tool LC.1909 to the front face of the clutch housing, with the tool dowels located in the impeller driving wheel face.

Remove and discard the centre seal carbon ring and its rubber seating ring from the recess in the impeller face, and unlock the tabwasher under the impeller retaining nut.

Using the impeller nut spanner LC.1907, remove the nut, the tabwasher, and the spacer from the driving wheel hub, and remove the holding tool LC.1909.

Drive the impeller driving wheel out of the impeller, using a soft-faced mallet on the end of the hub, remove the flat washer and discard the 'O' ring.

The Oilite bush in the front end of the driving wheel hub should only be removed if renewal is necessary.

The impeller can now be pressed out of its bearing under a suitable press, using the adapter LC.1915 in the front end of the impeller bore. Remove and discard the carbon seal ring and its rubber seating ring from the recess in the front face of the impeller.

With a 5 in. A/F Allen key, remove the six socket-head capscrews from the impeller seal housing on the rear face of the clutch housing, and lift off the seal assembly complete. Remove and discard the joint from the mating face.

Note: A main fluid seal replacement kit includes an assembled and pressure-tested seal housing unit. There is no need to dismantle the old unit.

The impeller main bearing should only be removed if subsequent inspection indicates that it should be renewed.

Turbine housing group

Stand the turbine housing on wooden blocks with the output (freewheel) end uppermost.

Insert the adapter LC.1915 into the rear end of the turbine hub and press out the turbine wheel under a suitable press. Remove and discard the carbon seal ring and its rubber seating ring from the recess in the rear face of the turbine.

Invert the turbine housing to rest on its rear face, and with a \$\frac{5}{16}\$ in. A/F Allen key unscrew the six socket-head capscrews from the turbine seal housing and lift off the seal assembly complete. Remove and discard the joint from the mating face.

Note: A main fluid seal replacement kit includes an assembled and pressure-tested seal housing unit. There is no necessity to dismantle the old unit.

To dismantle the centre seal unit from the front of the turbine hub, first remove the retaining circlip from the bore of the recess in the turbine hub, then lift out the nose piece, followed by the locating keys, the six springs and the seal pressure plate. Extract and discard the rubber garter seal element from the bottom of the turbine hub recess.

Remove and discard the rubber garter seal from the inner bore of the turbine hub. The needle roller bearing in the bore of the turbine hub should not be disturbed unless renewal is necessary.

The turbine main bearing remaining in the turbine housing should also only be removed if subsequent inspection indicates that it should be renewed.

INSPECTION

After dismantling and prior to examination, all parts should be carefully cleaned, preferably with diesel fuel.

Examination of the components is detailed in the following pages under five main headings, viz. General Parts, Clutch Housing and Input Group, Converter Group, Freewheel and Output Group, and Control Valve Group.

General parts

Examine all nuts, washers, setscrews and screw threads for damage. Flexible pipes should be checked for deterioration or swelling of the rubber covering. The latter would indicate failure of the inner member.

Joints, 'O' rings and garter-type oil seals should be renewed during assembly.

All ball bearings should be examined carefully for cage wear or damage and for evidence of races having turned in their housings, or on shafts. Bearings should be renewed if inspection shows pitting, corrosion or cracking of balls or tracks, or if axial movement between inner and outer races is excessive.

Clutch housing and input group

Inspect the drive spider for broken, cracked or damaged lugs on its outer diameter, and check that it is a light press fit on the input sleeve. Renew the drive spider if any discrepancies are observed.

The oil seal diameter should be checked for ridging. Any surface irregularity may be removed by regrinding and lapping to a diameter of not less than 3.990 in.

The rubber driving blocks do not need renewing unless damaged or deteriorated.

The pump gear teeth should be checked for pitting and wear. Minor damage can be rectified by stoning.

The axial clearance of the pump gears between the pump body and the distribution housing, when new, is 0.002 in. to 0.0035 in. This clearance should not exceed 0.005 in. when the pump components are reassembled. Should any damage marks exist in the gear recesses of the pump body or distribution housing they may be removed by stoning, but it is important that the axial clearance given above is maintained.

The pump body and distribution housing should be renewed if wear or damage caused by the piston-ring-type seals exists in the oil seal bores. Examine the piston-ring-type oil seals for breakage and wear. The butt clearance of the seals should be 0.005 in. to 0.015 in. when installed in their respective bores (refer to fig. 45 in 'Assembling').

The clutch carrier assembly and the pump drive hub when new are a press fit on the input sleeve, and if the wear on the splines is such that they become less than a light drive fit, the worn component should be renewed. Inspect the driving gear keyhole in the pump hub for elongation. Ensure that the oil feed holes are clear.

An inspection of the direct drive shaft bearing surfaces will generally reveal whether needle rollers within the input shaft are worn. The position of the needle roller bearings should be checked (refer to fig. 43 in 'Assembling'). The direct drive shaft splines should be inspected for wear and corrosion. The clutch hub is initially a light push fit on the direct drive splines.

The clutch splines on the hub, impeller driving ring and clutch driving ring should be examined for damage or indentation caused by the clutch plates. If the damage on any component is such that the smooth operation of the clutch plates is impaired the component should be renewed. Inspect the impeller driving ring needle roller bearing surface for brinelling. Should damage be evident, renew the driving ring and the needle roller bearing inside the turbine wheel. If the garter-spring-type oil seal surface is worn the impeller driving ring should be replaced. The thrust washer which fits over the direct drive shaft between the clutch hub and the input sleeve should be checked for scoring. The face groove must be clean and free from metallic debris.

Check the thirty-six clutch springs for damage and pitting. The load required to compress new springs to their installed length of 1.810 in. should lie between 81.7 and 90.3 lb. Renew springs if pitting or damage exists or if the load falls below 77 lb. at the installed length.

The steel converter drive and direct drive clutch plates are slightly 'dished' when new. If this 'dishing' becomes excessive, i.e. more than 0.020 in. for converter drive plates and 0.010 in. for direct drive plates, renew the plates. The bronze plates should be flat and if 'dishing' exists at all, or if the plates are worn to a level approaching the bottom of the oil retaining grooves, they should be renewed.

The dump valves should be examined for scoring. Minor scoring only may be removed by stoning, severe scoring will necessitate renewal of the damaged pieces.

Examine the clutch housing generally for damage and cracks. Check all joint faces and flanges for burrs and chafing, which may be rectified by stoning. Examine the five oil transfer tubes for scoring which may damage the 'O' rings and impair sealing on reassembly.

Converter group

Any slight damage noted on the impeller blading can be rectified by careful stoning and blending, but a new impeller assembly should be fitted if loose or distorted blades are observed.

The garter-type oil seal rubbing surface on the impeller hub must be examined for grooving or other damage. Restoration of the seal surface can be achieved either by light emery taping, or in bad cases, by regrinding to a diameter of not less than 3.990 in. A high surface finish is necessary and the oil seal must be renewed when reassembling.

The splines within the impeller hub should be examined for damage and wear.

Examine the housing generally for damage or cracks. Check all joint faces and flanges for burrs and rectify by stoning.

Examine the first-stage stator blades for looseness in the casing outer periphery and for damage. If slight, any damage may be rectified by stoning but the housing should be renewed if severe damage or loose blades are observed.

The second-stage stator blades are riveted into a preassembled unit, the latter being riveted to the rear face of the housing. Again, slight damage may be stoned, but severe damage or loose blades or blade assemblies will require renewal of the housing.

Inspect the bore of the housing which accepts the turbine main bearing for any wear which may have been caused by rotation of the bearing outer race.

The first and second-stage blades of the turbine are carried in circular sub-frames which are in turn riveted to an annular centre carrier. The third-stage blades are located between this carrier and the turbine hub, the blade trunnions being used to rivet the assembly together.

Blades in all turbine stages must be carefully checked for security, and the turbine wheel assembly renewed if any loose blades are noted. Minor blade damage can be rectified by stoning, but replacement blades are not supplied as spare parts and no attempt should be made to renew individual blades that are loose or damaged. Examine the garter-type oil seal rubbing surface on the turbine hub for grooving or other damage. The seal surface can be restored by light emery taping or regrinding to a diameter of not less than 3.990 in. A high surface finish is essential. The oil seal will be automatically renewed as part of the replacement main fluid seal assembly.

Freewheel and output group

Inspect the wear pattern on each cam of the two freewheel hubs. A normal wear pattern appears as a slightly worn area near the centre of each cam, which is the freewheeling position. The loaded area should appear bright and extend towards the high side of the cam. When this area approaches the top of the cam the hub must be renewed.

Inspect the freewheel cages for wear and cracks, and ensure that the spring-loaded roller followers slide freely in their sockets. Check the follower springs for squareness, and check the free length against a new spring. If any freewheel rollers are pitted, cracked, or chipped, the complete set of eleven rollers should be renewed. Inspect each freewheel outer race bore for wear and cracking.

Examine the freewheel casing and housing for cracks and damage, and check all joint faces and flanges for burrs which should be removed by stoning.

Check the output shaft seal housing for damage and wear in the bore.

The piston-ring-type oil seals should be examined for wear and breakage. The butt clearance of the seals should be between 0.005 in. and 0.015 in. when the seals are installed in the freewheel housing (refer to fig. 45 in 'Assembling').

ASSEMBLING

Cleanliness

Successful functioning and long life of the torque converter can be seriously impaired by dirt. Strict attention must therefore be paid to the cleanliness of all components during reassembly.

* The sequence of operations for reassembly of the torque converter is in general the reverse of the dismantling sequence previously described.

ASSEMBLY OF INDIVIDUAL MAJOR GROUPS

Turbine housing group

If a new turbine main bearing is to be fitted, it should be pressed in under a suitable press, ensuring that the load is applied to the outer race of the bearing only. Ensure that the bearing is entered squarely into its bore and is pressed fully home. Lightly oil the bearing.

Place a new seal housing joint in position on the seal assembly mating face within the turbine housing, ensuring correct alignment of the holes in the joint with those in the casing (fig. 37). Place a new main fluid seal housing assembly in position, again noting correct alignment of the holes, and secure with the six $\frac{3}{8}$ in. UNF. \times $\frac{3}{4}$ in. socket-head capscrews, tightening evenly, using a $\frac{5}{16}$ in. A/F Allen key.

If the needle roller bearing in the bore of the turbine hub has been removed, fit a new bearing, using a suitable press, ensuring that the bearing outer race enters squarely and is pressed fully home against the internal shoulder. Secure the needle roller bearing with its retaining circlip.

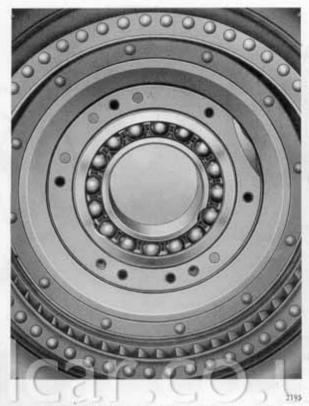


Fig. 37 Seal housing joint washer in position

Press in a new turbine hub inner oil seal with its lip facing towards the needle roller bearing and lightly oil both rollers and seal.

Fit a new carbon seal ring and its rubber seating, supplied with each main fluid seal replacement kit, to the recess in the rear face of the turbine wheel. It is important that these seal parts are from the same seal kit as those fitted to the turbine housing, since the complete seal assembly is pressure tested as a unit before packing.

Using a clean cloth, wipe the sealing face of the carbon ring on the turbine wheel and the ground face of the seal assembly in the turbine housing. These faces should be spotlessly clean and unmarked if the minimum of seal leakage is to be achieved.

Install the turbine wheel into the turbine main bearing under a suitable press, applying the load to the recess in the turbine hub adjacent to the inner oil seal and supporting the main bearing on its inner race. This operation must be carried out with care to ensure that the outer rim of the turbine wheel does not foul the turbine housing stator blades.

When the turbine wheel has been pressed fully into the main bearing, spin the turbine slowly to check that it is quite free and, using feeler blades, check that the gap between the stator blade tips and turbine rim is constant over the whole circumference. A light tap with a plastic mallet on the turbine face at a point diametrically opposite to the point of foul may be necessary to ensure true running of the turbine.

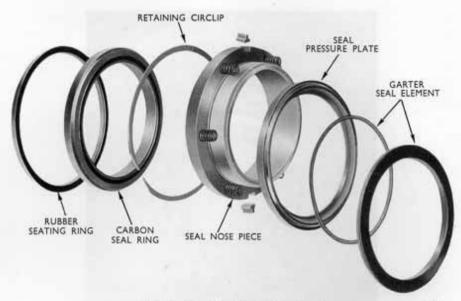


Fig. 38 Centre fluid seal components

Centre fluid seal assembly

The centre seal assembly should first be built up by placing the six springs in their recesses in the seal nose piece, followed by the seal pressure plate with its flat surface towards the springs, finally placing the garter seal element on the end of the nose piece (fig. 38).

The centre seal assembly should then be entered as a unit into the bore of the turbine hub, using hand pressure on the nose piece until the garter seal element is fully seated in the bottom of the recess.

Rotate the nose piece of the seal gently to align the keyways and insert the two keys, then fit the retaining circlip, ensuring that it seats squarely in its groove. Depress the seal nose piece with the hand to check freedom of movement against the pressure of the six springs.

Clutch housing and impeller group

If a new impeller main bearing is to be fitted, place the main bearing circlip in its groove in the bore of the impeller bearing housing, ensuring that it is fully seated. The bearing should then be pressed in under a suitable press, applying the load to the outer race of the bearing only. Ensure that the bearing is entered squarely into its bore and is pressed fully home against the circlip. Lightly oil the bearing.

Stand the clutch housing on wooden blocks with the impeller seal housing face uppermost, and place a new seal housing joint in position, ensuring correct alignment of the holes in the joint with those in the casing. Place a new main fluid seal housing assembly in position, again noting correct alignment of the holes (fig. 39), and secure with the six $\frac{3}{8}$ in. UNF. $\times \frac{3}{4}$ in. sockethead capscrews, tightening evenly with a $\frac{5}{16}$ in. A/F Allen key.

Fit a new carbon seal ring and its rubber seating, supplied with each main fluid seal replacement kit, to the recess in the rear face of the turbine wheel. It is important that these seal parts are from the same seal kit as those fitted to the turbine housing, since the complete seal assembly is pressure tested as a unit before packing.

Using a clean cloth, wipe the sealing face of the carbon ring on the impeller and the ground face of the seal assembly in the turbine housing. These faces should be spotlessly clean and unmarked if the minimum of seal leakage is to be achieved.

Press the impeller assembly into the impeller main bearing under a suitable press, supporting the main bearing under the inner race only, and applying the load to the raised inner rim around the centre fluid seal recess.

Spin the impeller slowly to ensure that the labyrinth lands on the front face of the impeller are not fouling their mating grooves in the rear face of the clutch casing.

Lift the clutch housing assembly to stand upright on its sump facing on wooden blocks, and attach the lubricating oil filter base to its facing on the rear face of the clutch housing, using a new joint and securing with three $\frac{3}{8}$ in. UNC. \times $1\frac{1}{4}$ in. setscrews and spring washers.

Fit the two internal oil feed pipes leading from the clutch casing wall to the filter base and from the filter base to the centre of the housing beneath the impeller main bearing. Also fit the single seal drain pipe leading from the centre of the housing to the elbow mounted in the rear of the clutch casing face (fig. 40).

If the Oilite bush in the centre of the impeller driving wheel hub has been removed, press in a new bush, then place the flat washer, with its chamfered edge towards the impeller driving wheel, over the hub to seat in its recess. Insert the impeller driving wheel hub into the impeller bore splines and tap home with a soft-faced mallet.

Attach the impeller driving wheel holding tool LC.1909 to the front face of the clutch housing, with the tool dowels located in the impeller driving wheel face.

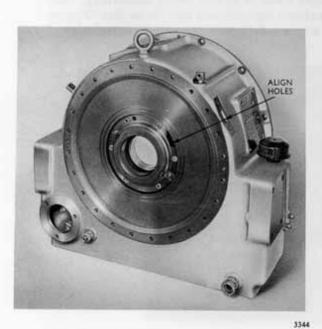


Fig. 39 Main fluid seal assembly in position



Fig. 40 Arrangement of pipes within clutch casing

Lightly oil a new rubber 'O' ring and fit it to the groove in the rear end of the impeller driving wheel hub, then insert the spacer over the 'O' ring and inside the end of the impeller hub, with its chamfered edge to the front, i.e. towards the impeller driving wheel.

Fit the tabwasher and the impeller nut and tighten, using the impeller nut spanner LC.1907. Lock the tabwasher, ensuring that the nut is tightened further to bring a tab coincident with one of the three slots in the nut and never loosened off.

To avoid damage, the carbon ring component of the centre fluid seal should not be fitted at this stage, but should be kept in its carton until the assembly of the complete converter.

Clutch carrier group

Insert the four dump valves in their radial passages on the front face of the clutch carrier, with the solid ends of the valves towards the centre. The two direct-drive dump valves in the longer passages should be followed by the two distance tubes. Fit the four dump valve caps securing each cap with two $\frac{3}{2}$ in. UNC. \times 1 in, setscrews and washers (fig. 41).

If any of the four clutch piston locating dowels have been removed, drive new dowels into position, ensuring that they are perfectly square with the face of the clutch carrier and that no burrs or rough edges exist on the dowels. As a check on satisfactory alignment of the dowels it is advisable to place each clutch piston, without any 'O' rings fitted, in position on its dowels and to ensure that complete freedom of axial movement exists, afterwards removing the pistons.

Insert the new rubber 'O' rings in their grooves in the inner wall of the converter drive piston recess and around the periphery of the converter drive piston, lightly oiling both 'O' rings.

Screw two extractor screws LC.1904 into the tapped holes in the face of the converter drive piston and install the piston carefully into its recess in the clutch carrier, aligning it on its locating dowels by means of the light scriber mark made on its face during dismantling. Care must be taken to ensure that the piston enters perfectly squarely and that the rubber 'O' rings remain fully seated in their grooves. Light taps with a soft-faced mallet will assist the entry of the piston.

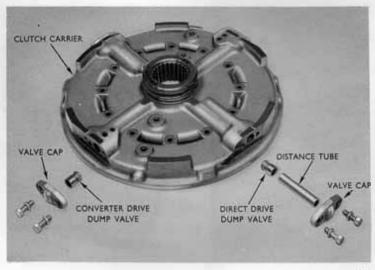


Fig. 41 Dump valve components

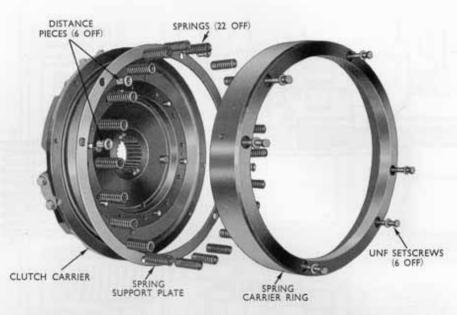


Fig. 42 Clutch carrier components

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Insert the six $\frac{1}{8}$ in. UNC. \times $2\frac{3}{8}$ in. setscrews and plain washers into the aluminium spring carrier ring and, with the spring recesses uppermost, position the twenty-two converter clutch springs in the carrier ring. Fit the six distance pieces over the setscrews with their shouldered ends towards the carrier ring, then rest the circular spring support ring on the springs with its six holes aligned with the six distance pieces (fig. 42).

Compress the springs slightly by gripping the circular support ring against the spring carrier ring and invert the assembly on to the clutch carrier. Any distance pieces which become dislodged can be re-inserted before screwing the six \{\frac{1}{2}\) in. UNC, setscrews into the clutch carrier.

Tighten the six setscrews one turn at a time in rotation to avoid distortion until the clutch carrier is drawn fully into the spring carrier ring.

If the needle roller bearing assemblies have been removed from the bore of the input sleeve, new bearings should be inserted, the open-ended bearing at the rear end of the sleeve being fitted first, and the closed-end bearing being inserted at the forward end of the sleeve with its closed end to the front. The position of these bearings in the sleeve is shown in fig. 43.

Fit one of the input sleeve circlips to the groove situated at the commencement of the runout of the splines, using the circlip pliers LC.1913, followed by a new rubber 'O' ring in the groove on the plain portion of the sleeve, lightly oiling the 'O' ring.

With the clutch carrier mounted rear face uppermost, press the input sleeve into the splined bore of the clutch carrier, ensuring that the circlip abuts against the clutch carrier face.

Fit a new direct-drive piston rubber 'O' ring (9½ in. dia.) to the groove in the periphery of the direct-drive piston and lightly oil the surface of the 'O' ring. Carefully insert the direct-drive piston into its recess in the clutch carrier, passing it over the rear protruding end of the input sleeve and aligning it on its locating dowels by means of the light scriber mark made on its face during dismantling. Care must be taken to ensure that the piston enters squarely and that the rubber 'O' ring on its periphery remains fully seated in its groove.

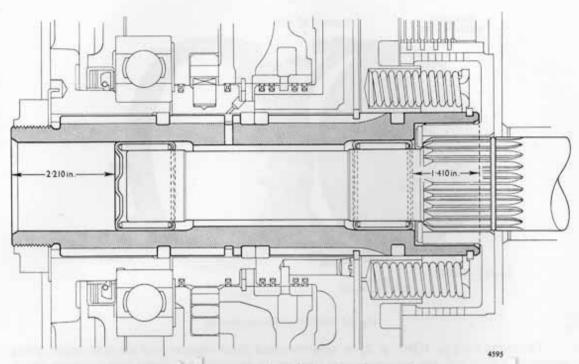


Fig. 43 Position of needle roller bearings in input sleeve

Place the fourteen direct-drive clutch springs in their individual recesses in the direct-drive piston face, followed by the spring retaining plate. Attach the spring compressing tool LC.1910 to the direct-drive piston face, using two extractor screws LC.1904, and two extractor nuts UE.5845. Compress the springs by tightening the nuts on the extractor screws evenly until the circlip groove on the protruding end of the input sleeve is clear of the spring retaining plate (fig. 44).

Fit the circlip securely in its groove, using the circlip pliers LC.1913, then remove the spring compressing tool and the extractor screws.

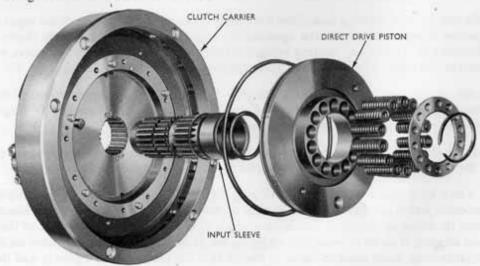
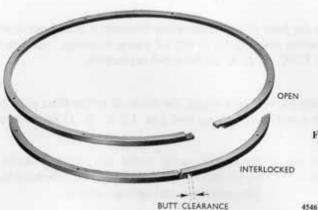


Fig. 44 Exploded view of input sleeve and direct-drive piston assembly





Piston-ring-type oil sealing ring

Oil pump and distribution housing group

If the oil pump ball bearing has been removed from the pump housing, press a new ball bearing into the bore of the housing under a suitable press, applying the load to the outer race of the bearing only. Lightly oil the bearing.

Fit a new oil seal to the oil pump seal carrier with its wiping lip towards the rear, and secure to the front face of the pump housing, using a new joint and the six 3 in. UNC. × 1 in. setscrews and spring washers.

The two piston-ring-type oil sealing rings should now be checked in the bore of the pump housing. When the ends of the rings are correctly interlocked, the butt clearance should be between 0.005 in. and 0.015 in. (fig. 45).

Remove the two rings and fit one into one of the two external grooves on the pump drive hub, interlocking the ends. Place the pump gear driving key in position and fit the inner pump gear ring over the pump drive hub so that the smaller projecting diameter on the end face of the hub and the mark on the face of the pump gear, made during dismantling, are uppermost. Fit the second piston-ring-type oil sealing ring into the remaining groove on the pump drive hub, interlocking the ends.

Install the subassembly of the pump drive hub and the inner pump gear into the pump housing together with the outer pump gear, ensuring that the marks made on the face of both gears and the smaller projecting diameter on the end of the drive hub are facing rearward, i.e. away from the pump ball bearing (fig. 46).

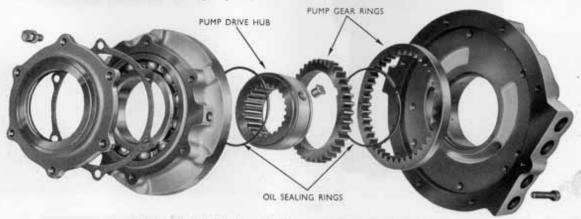


Fig. 46 Exploded view of oil pump and distribution housing

Fit the circlip to its groove in the bore of the distribution housing, if it had previously been disturbed, then lower the distribution housing on to the oil pump housing. Secure the two $\frac{3}{8}$ in. UNC. \times $1\frac{1}{4}$ in. and four $\frac{3}{8}$ in. UNC. \times $1\frac{1}{4}$ in. socket-head capscrews.

Sump cover group

Fit the magnetic plug to the sump cover, and attach the main oil intake filter with its elbow to the facing on the inside of the sump cover, using two $\frac{3}{8}$ in. UNC. \times $1\frac{1}{4}$ in. setscrews and spring washers.

When fitting the oil tray to the inside of the sump cover, the offset position of the two attachment holes at each end of the tray should be carefully noted by reference to fig. 47. Secure the oil tray with four $\frac{1}{8}$ in. UNC. $\times \frac{3}{4}$ in. setscrews and spring washers.

Control valve group

Fit new rubber 'O' rings to the converter and direct-drive air pistons, lightly oil the 'O' rings, and insert the pistons in the bore of the air cylinder body (fig. 48). Using new copper washers, first screw the air cylinder body into the control valve body, then screw the cylinder cap on to the end of the cylinder body.

Place the relief valve piston, closed end first, in its bore in the control valve body, followed by the inner and outer relief valve springs and the spring pin. Screw down the relief valve cap, using a new copper washer (fig. 49).



Fig. 47 Correct position of oil tray on sump cover

Fig. 49 Relief valve components

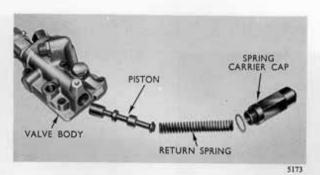


Fig. 50 Control valve piston components

Insert the control valve piston in its bore in the control valve body, referring to fig. 50 to ensure that the larger end is entered first, followed by the return spring and, finally, screw on the hexagon-bodied spring carrier cap, using a new copper washer.

Final tightening of all three caps can be left until the control valve body assembly is fitted to the torque converter.

FINAL ASSEMBLY

Stand the turbine housing assembly on wooden blocks with the turbine wheel uppermost, and fit a new sealing joint ring to the spigot recess in the upper edge of the turbine housing.

Fit a new centre seal carbon ring together with its rubber seating ring, supplied as part of the centre seal replacement kit already fitted to the turbine, to the recess in the centre of the impeller. With a clean cloth, wipe the sealing faces of both components of the centre seal unit, ensuring that they are spotlessly cleaned and unmarked.

Attach the impeller driving wheel holding tool LC.1909 to the front face of the clutch housing with the tool dowels located in the impeller driving wheel face and, using a rope sling as shown in fig. 32, suspend the clutch housing assembly over the turbine housing. Lower the clutch housing gently, ensuring that the lower end of the impeller driving wheel hub enters the needle roller bearing in the turbine hub bore.

Fit the twenty-four $\frac{3}{8}$ in. UNF, self-locking nuts securing the two housings together and tighten evenly in rotation, then fit the two $\frac{3}{8}$ in. $\times \frac{1}{2}$ in. blanking setscrews and spring washers to the two tapped extractor holes situated between the securing studs.

Check that the clutch driving ring is securely attached to its backing plate with the three countersunk-head screws, then place the assembly in the impeller driving wheel.

Fit the direct-drive clutch plates to the inner splined recess, placing a bronze plate in position first and then alternately fitting steel and bronze plates. The four bronze plates engage the direct-drive hub splines and the four steel plates engage the teeth in the clutch driving ring. The steel plates only are slightly 'dished' and the direction of the 'dishing' is unimportant.

Place the converter drive clutch plates in a similar manner in the outer splined recess, again commencing with a bronze plate against the backing plate, and following alternately with steel and bronze plates.



Fig. 51 Lowering clutch carrier assembly into position

Fig. 52 Oil supply tubes in position

Place the thrust washer over the end of the direct-drive shaft on to the centre portion of the clutch hub with the grooved face uppermost.

To locate the clutch pack and its driving ring accurately prior to lowering the clutch carrier assembly into position, it is advisable to procure two locating studs, \(\frac{1}{8}\) in. diameter and approximately 3\(\frac{1}{2}\) in. long, screwed \(\frac{3}{8}\) in. UNF, for 1 in. at one end and having a screwdriver slot at the other end. One of these studs should be screwed into the tapped hole in the clutch ring adjacent to the dowel hole marked OFFSET, and the other into the tapped hole diametrically opposite.

Check the four piston-ring-type oil sealing rings for correct gap by fitting in the bore of the distribution housing body. When correctly interlocked, the butt clearance should be between 0.005 in. and 0.015 in. (fig. 45). If satisfactory, the four rings should now be fitted to their grooves in the boss on the front face of the clutch carrier.

Before fitting the clutch carrier assembly to the converter, the oil pump and distribution housing assembly should be pressed on to the input sleeve. First fit two new rubber 'O' rings side by side in the wide groove in the input sleeve adjacent to the edge of the clutch carrier boss, and lightly oil the surfaces of the rings.

Mount the clutch carrier assembly, open end downwards, on a suitable press and place the oil pump and distribution housing assembly over the end of the input sleeve, engaging the splines in the bore of the pump drive hub. Using the oil pump press adapter LC.2007, inserted in the upper end of the oil pump housing, press the oil pump and distribution housing assembly down the input sleeve. As the lower edge of the distribution housing approaches the boss of the clutch carrier, each of the four piston-ring-type oil sealing rings require careful checking to ensure that they enter the bore of the distribution housing correctly. Continue pressing until the oil pump driving hub abuts firmly against the end of the clutch carrier boss.

It is inadvisable to attempt to press the oil pump and distribution housing assembly on to the input sleeve by applying the pressure directly to the oil pump seal carrier face. The load must be applied to the pump driving hub, using the correct press adapter LC.2007.

Assemble the lifting tool LC.1906 to the end of the input sleeve, securing it with the drive spider nut, and lower the complete assembly of the clutch carrier and the oil pump and distribution housing into position (fig. 51). Rotate the clutch carrier until its offset dowel is aligned with the offset dowel hole in the clutch driving ring and allow the carrier to pass down over the temporary locating studs previously fitted.

When the clutch carrier assembly is in position, remove the two temporary locating studs, and fit the twelve $\frac{3}{8}$ in. UNF. \times $3\frac{1}{4}$ in. setscrews, rotating the distribution housing as necessary to allow the setscrew heads to pass. Tighten the setscrews evenly in rotation.

Fit new rubber 'O' rings in the four ports in the distribution housing which connect with the control valve assembly, and in the inlet port from the sump facing. Also fit new rubber 'O' rings in the four ports in the clutch casing under the control valve facing and the single port adjacent to the sump facing.

Lightly oil the rubber 'O' rings and push the four short tubes into position from the outside of the control valve facing, and enter the single longer tube from the sump facing (fig. 52).

Fit new sealing rings to the outer flange of the front plate and to the outer diameter of the pump housing, and place the clutch housing front plate in position. Secure with three countersunk-head screws to the clutch housing and eight $\frac{1}{2}$ in. UNC. \times $1\frac{1}{4}$ in. setscrews and eight new copper washers to the oil pump housing. Fit the two $\frac{1}{8}$ in. UNC. \times $\frac{1}{2}$ in. blanking setscrews, again using two new copper washers.

Using a new joint, attach the sump cover to the clutch casing with the eighteen $\frac{1}{8}$ in. UNC. \times 1½ in. setscrews and spring washers.

Place a new control valve joint in position and attach the control valve assembly to the clutch casing, using two $\frac{3}{8}$ in. UNC. \times $3\frac{1}{4}$ in. and three $\frac{3}{8}$ in. UNC. \times 2 in. setscrews and spring washers. Assemble the oil feed pipe from the T-piece on the side of the control valve body to the impeller bearing oil feed adapter on the clutch housing.

Finally tighten the relief valve, air cylinder and control valve piston caps on the control valve assembly.

Invert the converter to stand on the wooden blocks with the output (freewheel) end uppermost.

Place the freewheel adjusting washer in position on the turbine main bearing, followed by the spacer and the freewheel cam and cage assembly (fig. 53). Place the plain washer, new tabwasher and nut in position, and using the holding tool LC.1916 and ring spanner LC.1908, tighten the nut and lock the tabwasher.

Insert the twelve bolts with new tabwashers into the freewheel bearing housing and, holding the bolts in place by means of a length of cord tightened round the threads of the ring of bolts, press the bearing housing and bearing into position. Remove the length of cord.

Assemble the twenty-two springs and followers and the eleven rollers into the freewheel cage, securing them with the snare LC.2593 (fig. 54). A rubber band encircling the freewheel cage will assist in this operation; remove the rubber band when the snare is in position.

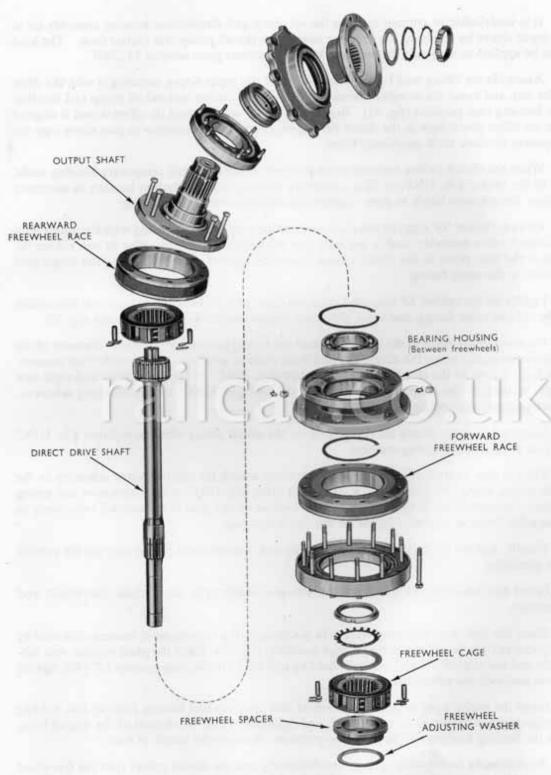


Fig. 53 Exploded view of freewheel assembly

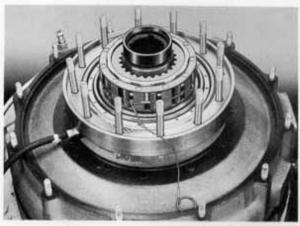


Fig. 54 Freewheel roller snare in position

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Press the eleven rollers back against their springs so that the rollers are at the bottom of the cams, and fit the forward freewheel outer race with the locating arrow pointing towards the input (forward) end. Release and withdraw the snare when the outer race is half-way along the rollers (fig. 55).

Fit the housing carrying the between-freewheels bearing, locating the peripheral holes on the bolts already in position; fit new tabwashers, replace the nuts, tighten and lock in position.

Insert the direct-drive shaft complete with its freewheel cage assembly, taking care not to damage the input sleeve needle roller bearings inside the converter.

Fit the rearward freewheel springs, followers, rollers and outer race as previously described for the forward freewheel.

Insert the bush in the output shaft and assemble it to the upper freewheel. Bolt the freewheel halves together, using new tabwashers under the bolt heads and nuts; tighten and lock.

Press the bearing and bearing housing on to the output shaft if these items have been previously removed.

Fit a new cork joint to the spigot of the freewheel housing, and support the housing with a suitable sling attached to the lifting eye on one side and round the elbow connection on the other side, as shown in fig. 21. Carefully lower the housing into position, taking care not to trap the flexible pipe, and, by inserting a hand into the inspection aperture, guide the studs of the upper bearing housing through the corresponding holes in the end of the freewheel housing.



Fig. 55 Fitting freewheel outer race



Fig. 56 Drive spider assembly tool in position

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Fit the twelve nuts and spring washers to secure the freewheel housing to the turbine housing, tightening the nuts progressively in diametrically opposite pairs.

Fit the six nuts and new tabwashers to the upper bearing housing studs, tighten and lock.

Fit a new internal sealing ring to the output sealing ring housing, and press the housing into position, ensuring that the piston-ring-type oil sealing rings are correctly located and interlocked.

Fit a new joint to the end cover and press into position, securing it with the eight nuts and locking with new tabwashers.

Press the output flange into position, fit the central washer, the keywasher, a new tabwasher and the nut. Tighten and lock, using the output flange nut spanner LC.2844.

Connect the internal flexible pipe to its elbow inside the freewheel housing, renew the inspection cover joint, and refit the inspection cover.

Refit the heat exchanger to the freewheel housing, using new tabwashers on the two setscrews.

Fit a new oil filter element and sealing ring to the external oil filter canister and attach it to the filter base on the clutch casing.

Reconnect all external pipes.

Support the converter by its lifting eyes on suitable lifting gear in the horizontal position.

Fit a new rubber 'O' ring over the protruding splines of the input sleeve, pushing it along until it is seated in its groove adjacent to the pump drive hub. Place the input drive spider in position on the input sleeve, and tap lightly until the threads of the sleeve are visible. Attach the drive spider locking plate LC.1905 to the front flange, using two extractor screws LC.1904 and two nuts UE.5845. Press the drive spider home, using the assembly tool LC.2079 and the drive spider locking nut (fig. 56). Remove the assembly tool, fit a new tabwasher, refit the nut, and tighten securely. Lock the tabwasher and remove the drive spider locking plate.

The converter is now ready to be refitted to the diesel engine, after which it can be refilled with the correct lubricating oil and converter fluid.

FAULT DIAGNOSIS

SYMPTOM OR CONDITION	POSSIBLE CAUSE	ACTION	REFER TO
1. Poor performance	Engine not delivering full power	Apply handbrake securely and scotch driving wheels. Select 'Drive', run engine up to full throttle and check engine speed	_
		If engine does not reach the designed pull-down speed at full throttle, the engine is not developing its full rated power. Engine pull-down speed (stall torque speed) is 1,495 r.p.m.	-
		Check engine for loss of power, refer to 'Engine Fault Diagnosis'	_
	Incorrect fluid in torque converter	Check grade of fuel oil	2
	Low base pressure	Check direct reading on base pressure gauge with engine running at half throttle. Base pres- sure should read between 45 and 65 p.s.i.	2
100	Inadequate fluid supply	Check converter fluid pipe lines and filters for leaks or restrictions	
	Faulty charging pump relief valve	Check relief valve	9
	Faulty pressure gauge	Try another gauge	_
	Faulty fluid seals	Check that converter main fluid seal leakage rate is not excessive. If quantity exceeds 4 pints for every 12-hour running period, remove con- verter from installation and renew seals	_
	High base pressure	If base pressure rises above 65 p.s.i., check relief valve in charging pump for tightness or seizure	9
2. Overheating of converter	Inadequate cooling	Converter fluid temperature must not con- tinuously exceed 220 deg.F. Check converter heat exchanger and engine cooling system in general for restrictions	_
	Air in fluid system	Check whole of converter fluid system for source of air inlet. Stop engine and make further check; an air leak in the feed line will not always show itself when engine is running. Remove and clean orifice filter	
	Low base pressure		11
	Mechanical tightness in train transmission	Refer to 'Low base pressure' in item 1 Check for any tightness or overheating in train transmission which may cause overloading of engine and converter	
	Seized freewheel (causing con- verter turbine to churn when direct drive is engaged)	Remove converter, dismantle freewheel unit, and renew defective components	-

SYMPTOM OR CONDITION	POSSIBLE CAUSE	ACTION	REFER TO
. Clutches failing to engage	Low clutch operating pressure	Check pressure on gauge. Maximum pressure should be 150 p.s.i.	· ·
	Lubricating oil relief valve stuck in control valve body	Remove and clean relief valve	8
	Clogged oil sump filter	Remove sump cover and clean filter	6
	Sticking dump valves	Remove sump cover, rotate clutch carrier, remove dump valves, and check for free movement. Each clutch has two dump valves	6
	Defective clutch pump	Remove converter and renew pump	-
	Defective 'O' rings on hydraulic clutch pistons	Remove converter from installation. Dismantle clutch pistons and renew 'O' rings	: - :
4. No converter drive or direct drive	Faulty control valve	Check correct operation of control valve	_
	Refer to other possible causes under item 3	2.2011	1-
	Distorted clutch plates caused by overheating	Remove and dismantle converter. Renew defective clutch plates	7

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SECTION 1 . . DRIVE SHAFTS - HARDY SPICER

The Hardy Spicer drive shafts for the fan, auxiliary gearbox and final drive are of orthodox design.

Regular lubrication of the needle roller bearings and sliding joints is important.

The drive shaft for the fans and the engine auxiliary gearbox should be lubricated with oil SAE.250.

The final drive propeller (cardan) shafts should be lubricated with a lithium base grease containing a minimum of 3 per cent Extreme Pressure additive.

DISMANTLING

Snap ring type - fan and auxiliary gearbox shafts

To remove the sliding joint from the splined shaft, unscrew the knurled dust cap and pull back the cork washer.

Remove any dirt and paint from around the snap rings.

Carefully remove the snap rings from their grooves, using suitable pliers. A tight ring may be eased by tapping the end of the bearing race to relieve the pressure on the ring.

To remove a bearing, hold the joint squarely and tap the upper yoke lug sharply with a soft-faced hammer (fig. 1); the bearing should then emerge from the lug being tapped, after which it can be withdrawn with the fingers (fig. 2) or, if tight, carefully driven out from the inside with a small drift (fig. 3).

Remove the opposite bearing by repeating the operation. The two halves of the joint can then be separated.

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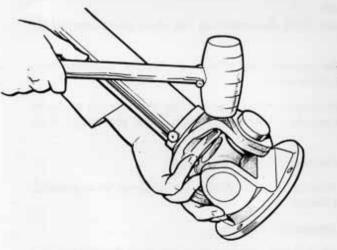


Fig. 1 Tapping yoke to remove bearing race

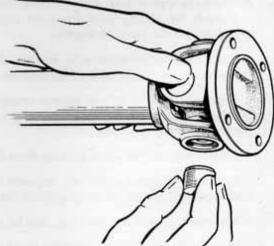
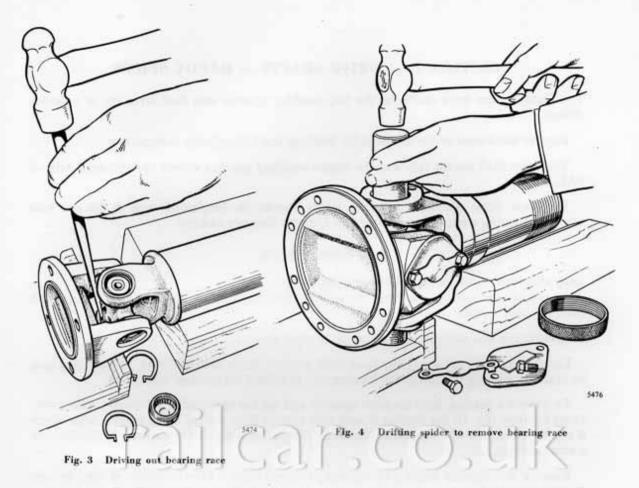


Fig. 2 Bearing race removed



Remove the spider from the yoke to which it is still attached by supporting the two exposed spider trunnions on wooden blocks and withdrawing the two bearing races still in position by the same procedure.

Bearing cap type - final drive cardan shaft

Detach the sliding joint from the main shaft by removing the dust cover completely and pulling back the cork washer.

Bend back the lockplate tabs, unscrew the setscrews and remove the bearing retaining caps; this exposes the blank ends of the bearing outer races.

Using a soft metal drift of slightly smaller diameter than the race (fig. 4), drive out the lower bearing by tapping the upper bearing inwards as far as possible, until the spider fouls the bottom lug of the yoke.

Finally, tap out the lower bearing from the inside, using a small drift,

Invert the joint and remove the opposite bearing by again driving the spider as far as possible, and then tapping out the bearing from the inside.

The two halves of the joint can then be separated.

Remove the spider from the yoke to which it is still attached by supporting the two exposed spider trunnions on wooden blocks and driving out the remaining two bearings as described in the preceding paragraphs.

INSPECTION

Clean the components before inspection.

The parts most likely to show signs of wear after long service are the bearing races and the spider journals. Should looseness in the fit, load markings, or distortion be observed, renew the complete unit. Worn needle bearings used with a new spider journal, or new needle bearings used with a worn spider journal, will wear more rapidly, making another renewal necessary in a short time.

It is essential that the bearing races are a light drive fit in the yoke trunnions.

In the event of wear having taken place in the yoke cross holes, the holes will show ovality and the yoke must be renewed.

In the case of wear of the cross holes in a fixed yoke, yoke and tube or yoke and shaft assembly, the complete assembly should be renewed in each case.

Other parts likely to show signs of wear are the splined sleeve yoke and the splined stub. A total of 0.004 in. circumferential movement, measured on the outside diameter of the spline, should not be exceeded. Should the splined stub shaft require renewing, this must be dealt with in the same way as the fixed yoke, i.e. a replacement tubular shaft assembly fitted.

ASSEMBLING

Insert the spider into the yoke with new gaskets and retainers in position on the spider trunnions. Where the spider lubricating nipple is at an angle, position the spider so that the lubricator points towards the drive shaft.

Carefully tap each bearing into position, using a soft round drift slightly smaller in diameter than the yoke holes.

On the snap ring type, drive in the bearings until the snap rings just fit into the grooves.

On the bearing cap type, drive in the bearings until they are flush with the outer surface of the yokes with the slots in the top of the races in line with the bearing cap screw holes.

Fit the bearing caps and ensure that the keys on the inner side of the caps engage the slots in the top of the races. Tighten the screws securely, and bend over the tabs of the lockplates.

If a joint appears to bind, tap lightly with a wooden mallet, which will relieve any pressure of the bearings on the end of the journal.

When replacing the sliding joint on the shaft, ensure that the arrow on the splined sleeve yoke is in line with the arrow on the splined stub shaft. This is important as the trunnions of both joints must be in line.

After assembly, lubricate the bearings and sliding sleeve with the specified lubricant.

To prevent excessive pressure of grease bursting the trunnion gaskets, the spiders on the joints of the main propeller (cardan) shaft are fitted with a pressure relief valve situated in the centre of the spider. Grease exuding from this point indicates that the trunnion bearings are fully lubricated.

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FINAL DRIVE

SECTION 1 .. WALKER REVERSING GEARBOX

Railcars E50000, E50988 to E51007 and E51154 to E51173

SECTION 1 . . WALKER REVERSING GEARBOX

DESCRIPTION

The engine power is transmitted to the driving wheels through the reversing final drive gearbox.

A spiral bevel gear on the end of the input shaft engages two facing contra-rotating bevel gears on the clutch shaft. Either of these two bevel gears can be made to drive the clutch shaft by engaging a sliding dog-clutch, thus determining the direction of rotation.

The clutch shaft is in turn connected to the driving axle by two helical gear pinions arranged as a reduction gear.

Forward or reverse gear is selected by the sliding dog clutch, the position of which is controlled pneumatically from the driver's cab, or manually by a lever on the gearbox. The lever can be pinned in the neutral position.

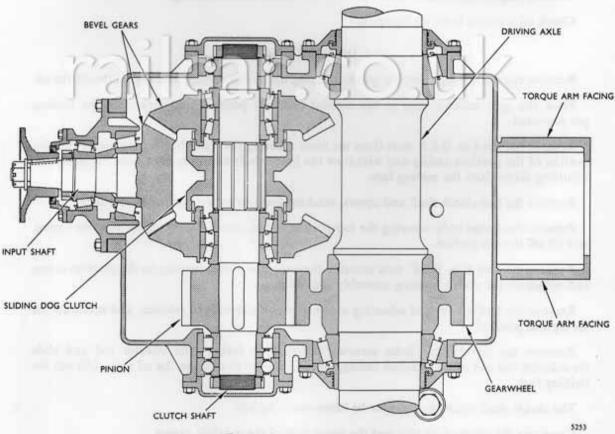


Fig. 1 Cross section of gearbox

LUBRICATION

Recommended oil . . A first quality Extreme Pressure gear lubricant of S.A.E. 90 viscosity. Capacity Approximately 8 Imperial gallons.

The first oil filling must be made at the top filler orifice above the clutch shaft. This ensures the filling of the oil tray under the spiral bevel gears before the oil overflows to fill the sump to the indicator elbow level.

Subsequent oil fillings and replenishings are to be made through the oil level indicator elbow.

RUNNING MAINTENANCE

Weekly or every 2,500 miles

Check the oil level and top up as necessary.

Monthly or every 10,000 miles

Drain the oil and refill with the recommended oil.

Remove the dust covers on the reversing lever toggle mechanism, visually inspect for damage, and relubricate before replacing the dust covers.

Visually inspect the exterior of the gearbox for cracks and oil leakage.

Check all securing bolts for tightness.

DISMANTLING

Remove the drain plug from the gearbox easing under the driving axle and drain off the oil.

Place the gear selector arm in the neutral (central) position and lock with the locking pin provided.

Remove the ten ½ in. B.S.F. nuts from the studs securing the input bearing housing to the top portion of the gearbox casing and withdraw the input shaft assembly complete. Remove the adjusting shims from the mating face.

Remove the two clutch shaft end covers, marking them to ensure correct replacement.

Remove the flange bolts securing the top portion to the centre portion of the gearbox casing, and lift off the top portion.

Remove the four 3 in. B.S.F. nuts securing the indicator switch housing to the gearbox casing and withdraw the switch housing assembly complete.

Remove the locking nut and adjusting screw from the selector rod retainer, and withdraw the spring and plunger.

Remove the two locking bolts securing the striking fork to the selector rod and slide the selector rod out of the gearbox casing, taking care not to damage the oil seal. Lift out the striking fork.

The clutch shaft assembly can now be lifted out complete.

Clean out the internal oil tray and the lower half of the gearbox casing.

INSPECTION

Ensure absolute cleanliness by washing all parts in diesel fuel or clean paraffin.

Do not remove the bearings and gears from the shafts unless subsequent inspection indicates that they should be renewed.

Input shaft and clutch shaft

Examine the ball and roller bearings for excessive wear, cracked and chipped races, broken balls and rollers, damaged cages, and for evidence of races having turned in their housings or on shafts.

Check the bevel gears and the pinion teeth for cracks and chipping.

Check that the sliding clutch moves freely on its splines and that the engaging dogs are not damaged.

Driving axle

Remove the end covers and examine the labyrinth oil seals for damage and scoring. Ensure that the end covers do not foul the oil flingers on the shaft.

Inspect the roller bearings for cracked or damaged races, chipped or broken rollers and damaged cages.

Examine the helical gear teeth for cracks and chipping.

Replace the end covers and check the end float on the driving axle, which should be between 0.006 and 0.008 in. Any excess movement can be taken up by the removal of a shim or shims from the endplate mating faces.

Gear selector

Ensure that the gear selector rod slides freely in its bushes,

Examine the two keys for excessive wear and check that they are a good fit and not loose in the keyways (fig. 2).

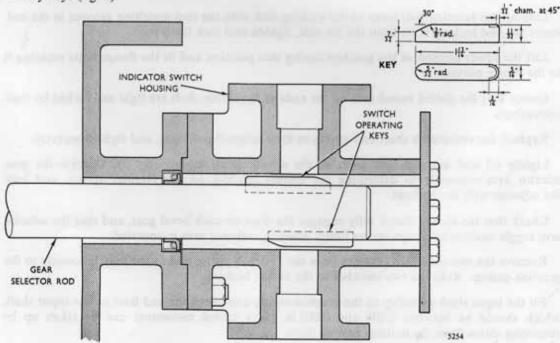


Fig. 2 Indicator switch housing and selector rod

Examine the oil seal for any signs of oil leakage, and renew if necessary on assembly.

Check that the selector rod retainer plunger slides freely in its socket, and ensure that the spring is free from corrosion and not distorted.

Examine the striking fork for cracks and damage, and if it shows excessive wear on the working surfaces it should be renewed.

External mechanisms

For maintenance instructions on the diaphragm chambers and the indicator switches refer to the appropriate Westinghouse publication.

Remove the dust covers and examine the toggle mechanism on the reversing lever for damage and wear on the pivot pins and bushes. Renew where necessary. Ensure that the spring and the moving parts are free from corrosion and relubricated before the dust covers are replaced.

ASSEMBLING

Lower the clutch shaft assembly into position, engaging the pinion teeth and locating the shaft roller bearing against the housing at the pinion end.

Ensure that the gear selector arm is pinned in the neutral (central) position and place the striking fork in position on the sliding clutch, locating the aperature at the top of the fork over the rounded end of the selector lever.

Carefully slide the selector rod through the oil seal in the switch housing aperture on the side of the gearbox casing and guide the rod through the striking fork into the bearing bush on the opposite side.

Line up the locating bolt holes in the striking fork with the two matching grooves in the rod, insert the two locking bolts from the far side, tighten and lock the nuts.

Lift the upper portion of the gearbox casing into position and fit the flange bolts securing it to the centre portion.

Ensure that the slotted round nuts on the ends of the clutch shaft are tight and locked by their tabwashers.

Replace the two clutch shaft end covers in their original positions, and tighten securely.

Lightly oil and assemble the parts of the selector rod retainer (fig. 3). Operate the gear selector arm manually to determine the correct loading on the retainer spring, and lock the adjuster with the locknut.

Check that the sliding clutch fully engages the dogs on each bevel gear, and that the selector arm toggle mechanism snaps across firmly when the selector arm is operated.

Remove the two indicator switches from the switch housing and fit the switch housing to the gearbox casing. Refit the two switches to the switch housing.

Fit the input shaft assembly to the gearbox casing and check the end float on the input shaft, which should be between 0.006 and 0.008 in. Any excess movement can be taken up by removing shims from the housing mating faces.

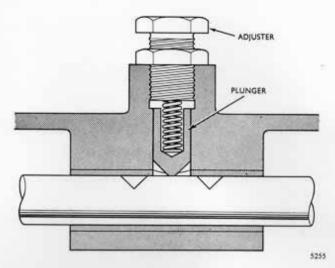


Fig. 3 Selector rod retainer assembly

Refit the drain plug to the gearbox casing under the driving axle and remove the oil level plug cap from the elbow adjacent to the driving axle.

Remove the oil filler cap from the top of the upper portion of the gearbox casing and pour in a first quality Extreme Pressure gear lubricant of S.A.E. 90 viscosity until the oil level reaches the top of the elbow adjacent to the driving axle.

Refit the oil level plug cap and the oil filler cap.

FINAL DRIVE

SECTION 2 .. S.C.G. TYPE RF.28

Railcars E51591 to E51650 and M51681 to M51780

TYPE R.F.28 FORWARD & REVERSE FINAL DRIVE UNIT



SELF-CHANGING GEARS LIMITED LYTHALLS LANE COVENTRY ENGLAND

TELEPHONE: COVENTRY 89081

TELEGRAMS: SELF-CHANGE, COVENTRY

TYPE R.F.28 REVERSING UNIT

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Fig. 11. Casing and Covers ...

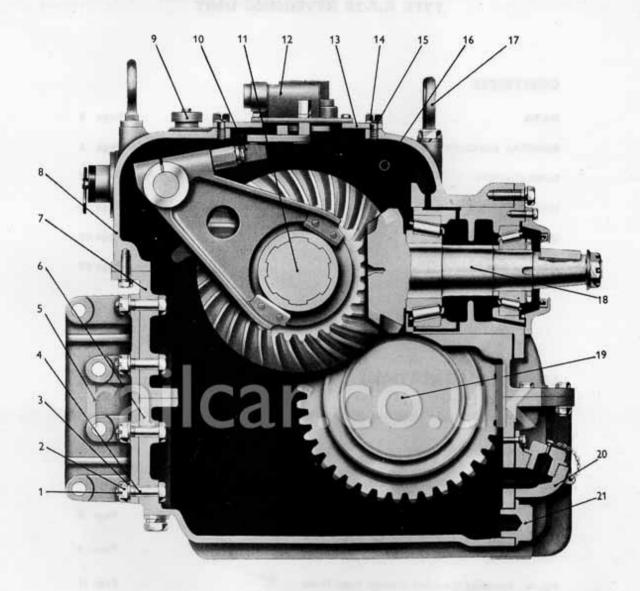


Fig. 1. VERTICAL SECTION ALONG AXIS OF INPUT SHAFT

- 1 Split Pin
- 2 Slotted Nut
- 3 Plain Washer
- 4 Bolt
- 5 Torque Arm Bracket
- 6 Gearcase (Bottom Portion)
- 7 Gearcase (Intermediate Portion)
- 8 Gearcase (Top Portion)
- 9 Breather Body
- 10 Switch Operating Bracket
- 11 Assembly of Top Shaft
- 12 Indicator Switch
- 13 Inspection Cover
- 14 Bolt

- 15 Spring Washer
- 16 Oil Distribution Pipe
- 17 Eyebolt
- 18 Assembly of Input Bevel
- 19 Assembly of Axle
- 20 Filler Spout
- 21 Drain Plug

GEARBOX — DATA (TYPE R.F.28)

TYPE

R.F.28 Railcar Reverse and Final Drive Unit.

MAX. INPUT TORQUE

3,000 ft. lbs.

RATIO

2:6.1 (other ratios available).

LUBRICATION

One Hobourn-Eaton Bi-directional type pump.

OPERATION

Pneumatic 60/75 lbs. per sq. in.

WEIGHT

10 cwt. less axle.

GEARBOX - GENERAL DESCRIPTION

This unit is specially designed for heavy duty rail traction purposes, and provides full reverse, enabling the vehicle to be driven in either direction at all speeds provided by the gearbox.

The casing is a steel casting made in three portions which are suitably dowelled to maintain accurate alignment. The forward and reverse gearing consists of a spiral bevel pinion (made integral with input shaft) meshed with two bevel wheels which are mounted on the top shaft and is carried in the top portion of the unit. The bevel wheels are free on the top shaft, the centre portion of which is splined carrying a sliding dog. This is engaged with either one or the other of the bevel wheels, depending upon the direction of drive required. A direction detector switch is incorporated to give positive indication that the sliding dog is fully engaged.

The bevel wheels are carried on adequately proportioned bearings which ensure accurate positioning. The top shaft pinion is keyed on the top shaft and is in constant mesh with a driving spur gear mounted on the axle. Taper and roller bearings are provided throughout the unit.

SELECTOR MECHANISM (See Fig. 5)

The selector mechanism consists of a fork which fits into a groove in the sliding dog. The top end of the fork is fastened by means of set bolts (14) to a selector bar (15), which is moved to the required position by air pressure moving one of the two pistons (20) at each end of the selector bar (15). The bar is held in position by air pressure on the piston (20).

A neutral detent is provided in the selector bar (15) which should always be engaged by means of the manually operated neutral lock if the vehicle is being towed.

Should the main air supply fail at any time when forward or reverse is engaged, remove the top cover of the unit and with a suitable lever move the selector bar (15) into the neutral position, ensuring that the locking plunger (9) in the neutral lock mechanism is positively engaged before moving the vehicle.

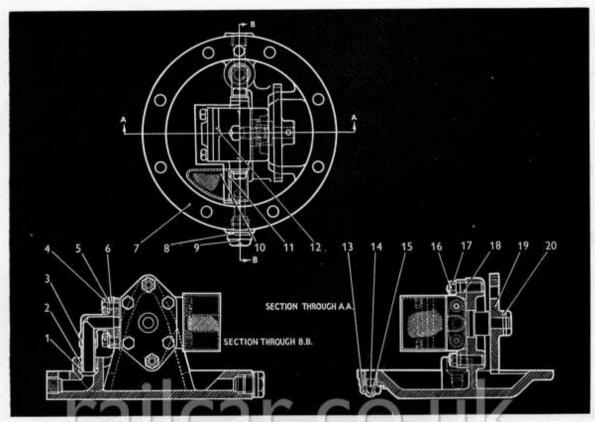


Fig. 2. OIL PUMP ASSEMBLY

- 1 'O' Ring for Bush
- 2 Bush
- 3 Oil Delivery Pipe
- 4 Bolt
- 5 Washer
- 6 Oil Pump Elbow
- 7 Oil Pump Bracket
- 8 Drain Plug Washer
- 9 Drain Plug
- 10 Oil Filter
- 11 Mounting Plate
- 12 Oil Pump
- 13 Nut
- 14 Washer
- 15 Stud
- 16 Split Pin
- 17 Slotted Nut
- 18 Stud
- 19 Pump Gear
- 20 Taper Pin

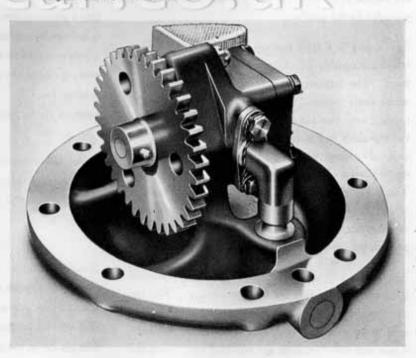


Fig. 3. VIEW OF OIL PUMP AND BASE PLATE

LUBRICATION

(See Figs. 2 and 6)

The lubrication of the whole of the unit is carried out by a rotary type bi-directional pump situated in the bottom portion of the case. The pump is driven by means of a gear (Fig. 2, Item 19) which engages with a driving gear on the axle (Fig. 6, Item 34). The oil is pumped from the sump and is fed into an oil distribution pipe situated in the top portion of the casing. The oil distribution pipe has drilled holes so placed as to deliver oil jets onto the bevel gears, at the same time lubricating the bearings by means of oil ways in the casings and covers.

The base lubricant should be 100% mineral oil of high quality possessing a high resistance to oxidation and a natural viscosity index of not less than 90.

When tested by I.P. 114/55T the increase in acidity of the oil must not be greater than 0·1 milligramme KOH/gramme, the total acidity after oxidation must not exceed 0·2 milligramme KOH/gramme.

In order to meet this clause and ensure satisfactory operation in service it is advised that oxidation inhibitors are included in the formulation.

The oil must also contain additives against corrosion and preferably in addition it should contain additives against frothing and must be consistent with the requirements of a high quality turbine lubricant.

The viscosity of the lubricant shall also conform to the following requirements.

- 1000 PART -		CLIMATE	
Redwood No. 1	Arctic	Temperate	Tropical
Viscosity at 140°F	120-210	200-280	277-330

OIL CHANGES

First change 1,000 then every 30,000 miles. This applies also to reconditioned gearboxes. Oil capacity 5 galls.

OIL PUMP (See Fig. 2)

The oil pump is of the rotary type and because of its simple and robust construction it can be depended on to give trouble free service. Only if difficulty is experienced with maintaining the oil pressure should the pump be dismantled, and the parts inspected for excessive wear and damage. Parts of the reversible pump are not interchangeable, and therefore should the pump fail an entirely new replacement pump should be fitted.

REMOVAL OF OIL PUMP (See Fig. 2)

Drain the oil from the sump. Remove the nuts (13), spring washers (14), and withdraw oil pump assembly from the gearcase. Tap clear the tapered pin (20) and withdraw the pump gear (19). Remove pump elbow (6), oil filter (10), split pin (16), and slotted nuts (17). Remove the oil pump (12) from oil pump bracket (7).

REPLACEMENT OF OIL PUMP (See Fig. 2)

Fit the new oil pump (12) in position on the oil pump bracket (7), secure with slotted nuts (17) and split pins (16). Using bolts (4), secure in position the oil filter (10), and pump elbow (6), locking the bolts (4) with a suitable wire. Press home the pump gear (19), and secure with tapered pin (20). Replace the pump assembly into the bottom portion of the gearcase securing with spring washers (14) and nuts (13).

MAINTENANCE & ADJUSTMENT

(See Fig. 5)

The oil level of the unit should be checked weekly by removing plug from oil filler spout and topped up if necessary. External oil pipes should be examined periodically for leaks.

An occasional examination should be carried out on the air pistons (20). Examine the piston seals (1) and replace if worn or cracked. Normally the selector mechanism, pistons, selector bar, etc., can be removed and replaced without effecting the clearances of the sliding dog, but the following check can be made to ensure the correct clearances before replacing the cylinders. This clearance is measured between the air cylinder (3) and cylinder cap (22). To adjust the selector bar (15) to give correct engagement of the sliding dog, slide the dog shifting fork assembly (13) together with sliding dog into engagement as far as possible, and

whilst retaining them in this position, fit an air cylinder cap (22) piston (20) together with adjuster screw (18).

The adjuster screw is held by locknut (17), and split pin (19). Check that there is then a clearance of ·015"/·020" between the air cylinder (3) and cylinder cap (22). The cylinder cap can then be fitted. Repeat the operation on the other side to check that the same clearance exists there also.

When new piston seals are being fitted or the pistons are removed for examination, cylinder liners, seals and pistons should be oiled before being replaced, preferably with 'OILDAG' Achesens's Colloidal Graphite. If the gearbox has been standing without use for some time, the pistons should be withdrawn and parts oiled as described above.



Fig. 4. VIEW OF OIL PUMP LOCATED IN BOTTOM PORTION OF GEARCASE

5 Bottom Portion of Gearcase

¹ Intermediate Portion of Gearcase 2 Hollow Dowel

³ Oil Pump 4 End Cover

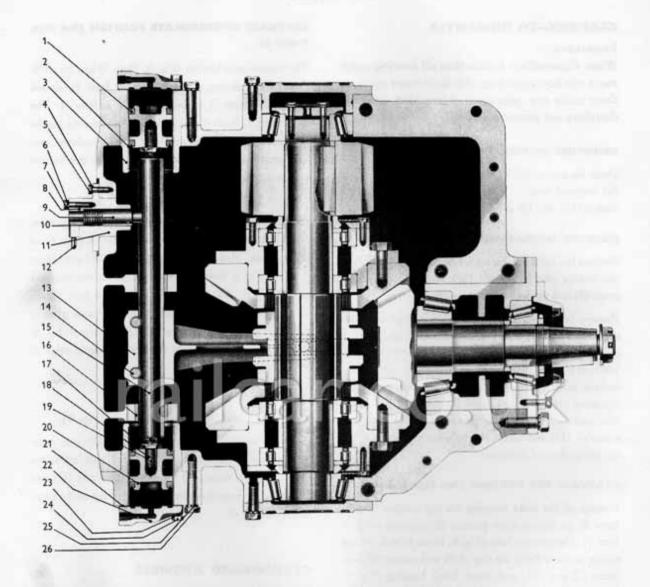


Fig. 5. SELECTOR MECHANISM

- Piston Seal
- 2 Air Cylinder Liner
- Air Cylinder
- 4 Spring Washer
- 5 Bolt
- 6 Spring Washer
- 7 Bolt 8 Locking Plunger Guide
- 9 Locking Plunger

- 10 Locking Plunger Spring
- 11 Neutral Lock Sleeve
- 12 Locking Plunger Handle
- 13 Dog Shifting Fork
- 14 Bolt
- 15 Selector Bar
- 16 Selector Bar Bush
- 17 Locknut
- 18 Adjuster Screw

- 19 Split Pin
- 20 Piston
- 21 Gasket
- 22 Cylinder Cap
- 23 Spring Washer
- 24 Bolt
- 25 Spring Washer
- 26 Bolt

OVERHAUL

GEARBOX-TO DISMANTLE

Important.

When dismantling ensure that all bearing outer races are kept paired up with their inner races, as these parts are selectively assembled and are therefore not interchangeable.

REMOVING INSPECTION COVER (See Fig. 1)

Drain the sump, disconnect oil pipe unions, and remove the external pipes. Remove bolts (14), and spring washer (15), and lift away the inspection cover (13).

SELECTOR MECHANISM (See Fig. 5)

Remove the bolts (7), spring washers (6), and withdraw the locking plunger handle (12), spring (10), plunger guide (8) and the locking plunger (9).

Remove bolts (26), spring washers (25), and withdraw the air cylinder (3) with cylinder caps (22), gaskets (21), pistons (20), together with the adjuster screws (18), locknuts (17), split pins (19), and seals (1). Release the locking wire, remove bolts and withdraw the switch operating bracket (Fig. 1, Item 10). Release the locking wire and remove the bolts (14) from dog shifting fork assembly (13) and withdraw the selector bar (15) from the top portion of gearcase.

GEARCASE TOP PORTION (See Figs 1, 5 and 6)

Remove all the bolts securing the top portion (Fig. 1, Item 8) to intermediate portion of gearcase (Fig. 1, Item 7). Remove the bolts (Fig. 6, Items 14 and 24) and spring washers from the top shaft end covers (Fig. 6, Items 22 and 45), and input bevel housing (Fig. 6, Item 1). Three bolts should be left in the bottom of the top shaft end covers, secured in position to retain the shims and outer races, whilst the top portion of gearcase (Fig. 1, Item 8) complete with the oil distribution pipe is lifted away. Remove the dog shifting fork assembly (Fig. 5, Item 13), top shaft (Fig. 6, Item 21), and input bevel housing assembly (Fig. 6, Item 1). Remove the remaining bolts from the end covers (Fig. 6, Items 22 and 45), keeping shims, and outer races together. It is not advisable to dismantle these assemblies as they have been carefully adjusted to give correct clearances for the bearings and bevels.

GEARCASE INTERMEDIATE PORTION (See Figs. 1 and 6)

The torque arm bracket (Fig. 1, Item 5) can be withdrawn by removing split pin (Fig. 1, Item 1), slotted nut (Fig. 1, Item 2), and washers (Fig. 1, Item 3). The bolts (Fig. 1, Item 4) are a drive fit and should not be removed. Remove the nuts and spring washers from oil pump assembly and withdraw it from the bottom portion of the gearcase.

Withdraw all the bolts securing the intermediate portion (Fig. 1, Item 7) to bottom portion (Fig. 1, Item 6) of the gearcase. Remove bolts (Fig. 6, Item 41) and spring washers (Fig. 6, Item 40) from the bearing thrust plates (Fig. 6, Item 30). Two bolts should be kept lightly secured in position on the bottom of each thrust plate to retain the shims (Fig. 6, Item 31) and outer races (Fig. 6, Item 32) in position, whilst the intermediate portion of casing is lifted away.

GEARCASE BOTTOM PORTION (See Fig. 6)

Take the weight of the axle assembly (37) and completely remove thrust plates (30), keeping axle half shims (31) and outer races (32) together. The axle (37) can now be lifted away from the bottom portion of the gearcase (See Fig. 7).

GEARBOX-TO ASSEMBLE

First thoroughly clean all parts and make sure that all oil ways and channels are clear. **Note.** Before fitting, all joint faces should be first cleaned and then coated with a suitable jointing compound.

GEARCASE BOTTOM PORTION (See Fig. 6)

Replace the axle assembly (37) into the bottom portion of case (See Fig. 7). Re-fix bearing thrust plates (30) on to the bottom portion of gearcase, and so retaining in position axle taper roller bearings (32).

- 1 Input Bevel I
- 2 Input Bevel I
- 3 Oil Seal Hou
- 4 Oil Seal
- 5 Washer-Loc 6 Washer-Nut
- 7 Split Pin
- 8 Nut
- 9 Key
- 10 Locking Ring
- 11 Bearing
- 13 Spring Wash
- 14 Bolt
- 15 Spring Wash
- 16 Shims
- 17 Distance Piec
- 18 Bearing
- 19 Bolt
- 21 Top Shaft
- 22 End Cover
- 23 Oil Thrower
- 24 Bolt
- 25 Spring Washi
- 26 Bearing
- 27 Bearing
- 28 Distance Piec
- 29 Bearing
- 30 Thrust Plate
- 31 Half Shim
- 32 Bearing
- 33 Spacing Piece
- 34 Pump Driving
- 35 Sliding Dog

- 39 Oil Thrower
- 40 Spring Washe
- 41 Bolt
- 42 Oil Collector
- 43 Oil Thrower
- 44 Shims
- 45 End Cover
- 46 Bearing Retai
- 47 Bolt
- 48 Key
- **Driving Pinio**
- 50 Bevel Hub
- 51 Bevel Wheel

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49 Driving Pinion 50 Bevel Hub 51 Bevel Wheel

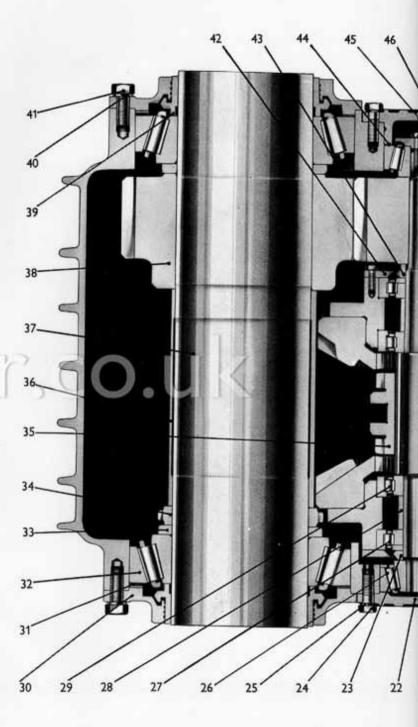


Fig. 6. SECTIONAL ELEVATI

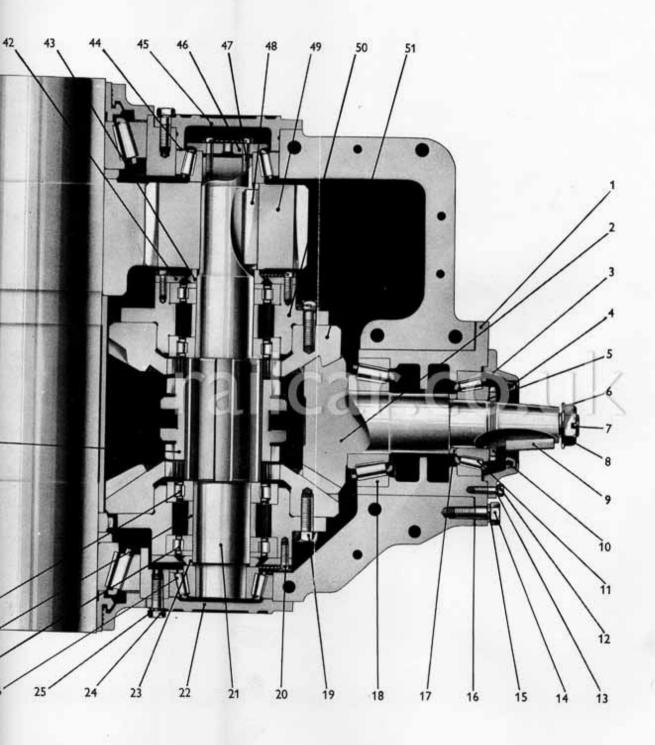
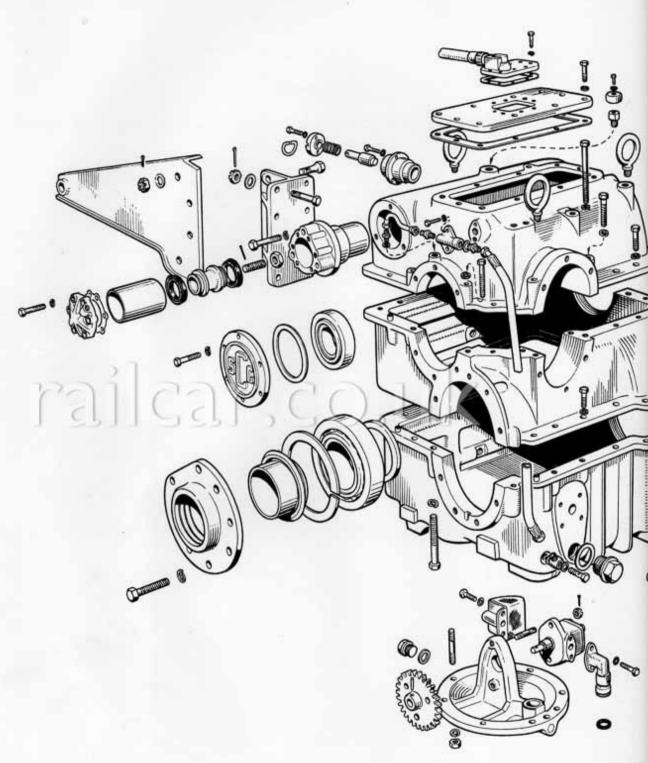


Fig. 6. SECTIONAL ELEVATION THROUGH FINAL DRIVE



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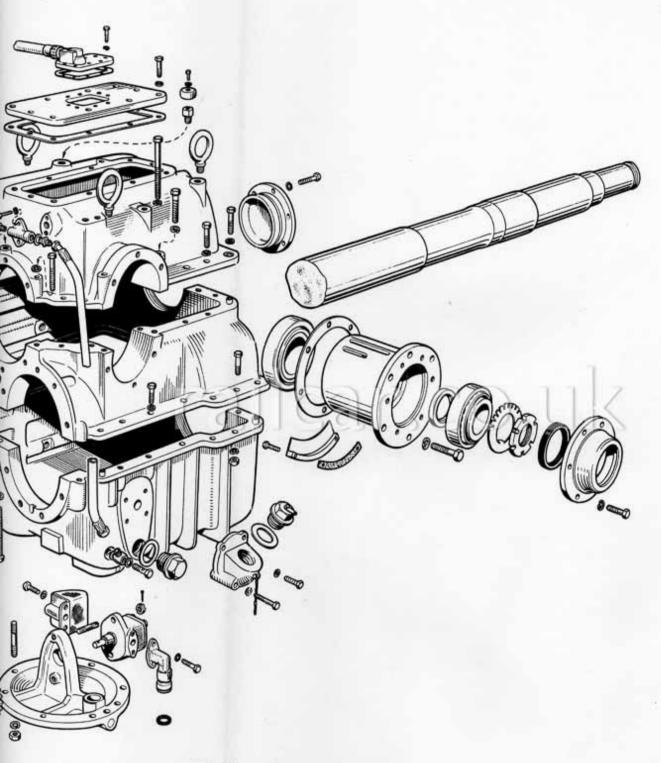


FIG. II. CASING AND COVERS

GEARCASE INTERMEDIATE PORTION (See Figs. 1, 2 and 6)

Re-fit the intermediate portion of the gearcase (Fig. 1, Item 7) on to the bottom portion, locating with the hollow dowels. The axle half shims (Fig. 6, Item 31) can now be replaced, and the bearing thrust plates (Fig. 6, Item 30) secured in position, first ensuring that there is a '004/5" end float on the axle assembly. Re-fit the oil pump assembly (See Fig. 2) into the bottom portion of the gearcase and secure in position, ensuring that there is backlash between the pump driving gear (Fig. 6, Item 34), and the pump gear (Fig. 2, Item 19).

Replace the torque arm bracket (Fig. 1, Item 5) ensuring that it is perfectly square in relation to the machined surface of the intermediate portion of the gearcase. The top shaft assembly end cover (Fig. 6, Item 22) and (Fig. 6, Item 45) can now be replaced on to the intermediate portion of gearcase, and lightly secured in position with three bolts (Fig. 6, Item 24).

The top shaft and input bevel assemblies can now be replaced in the casing.

Replace the top shaft assembly in position ensuring that there is a '004/5" end float.

The input shaft can now be replaced, and the shimming checked by measuring the dimension between the face of the input bevel pinion (Fig. 6, Item 2) to the O/Dia. of the sliding dog (Fig. 6, Item 35) which should be '887". Locate the dog shifting fork into position on the top shaft.

GEARCASE TOP PORTION (See Figs. 1, 5 and 6)

Replace the top portion of gearcase (Fig. 1, Item 8) ensuring that the dog shifting fork assembly (Fig. 5, Item 13) is in its approximate working position, with the dog shifting fork pads which are located in the grooves

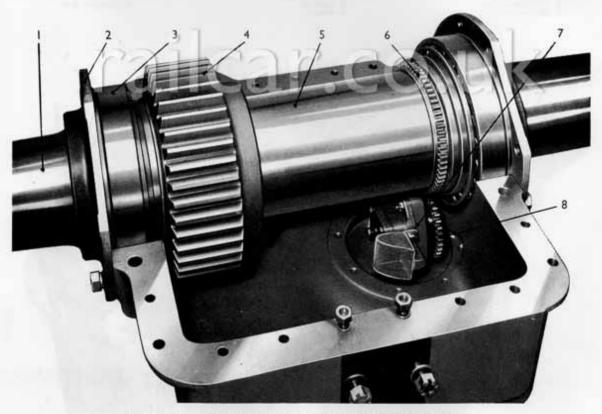


Fig. 7. VIEW OF AXLE MOUNTED IN BOTTOM PORTION OF GEARCASE

¹ Axle 2 Thrust Plate 3 Bearing

⁴ Axle Gear 5 Axle Sleev 6 Oil Pump

⁷ Pump Gear Driver 8 Pump Gear Driver

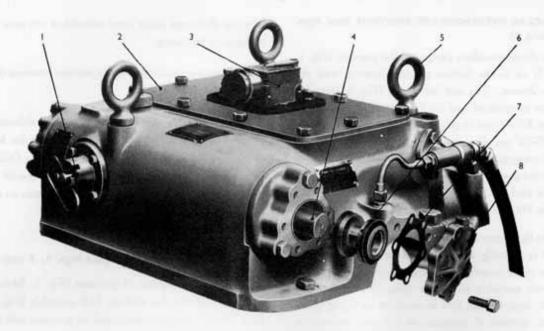


Fig. 8. VIEW OF TOP PORTION OF CASE AND PISTON

- Neutral Lock
 Inspection Cover
 Direction Indicator Switch
- 4 Selector Bar 5 Eyebolt 6 Piston

7 Gasket 8 Cylinder Cap

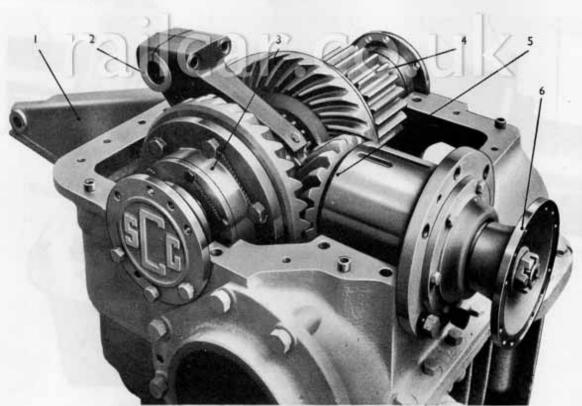


FIg. 9. VIEW OF INPUT BEVEL AND TOP SHAFT SHOWING LOCATION OF DOG SHIFTING FORK

1 Torque Arm 2 Dog Shifting Fork

- 3 Top Shaft Assembly 4 Driving Pinion
- 5 Input Bevel Assembly 6 Input Coupling

in the sliding dog (Fig. 6, Item 35) on the top shaft assembly. Locate top portion with the hollow dowels, replace bolts and secure in position.

Finally secure into position the top shaft end covers and input bevel housing and note that the letters S. C. G. on all end covers are kept in an upright position, as this ensures that the lubrication ports in the cases and covers are in alignment.

SELECTOR MECHANISM (See Fig. 5)

Slide the selector bar (15) into position in the top portion of the gearcase, and secure it to the dog shifting fork assembly (13) with the bolts (14). Locking the bolts with a suitable wire, replace the switch operating bracket (Fig. 1, Item 10) on to the dog shifting fork bolts, securing with bolts and spring washer, and locking bolts with a suitable wire.

Replace the air cylinders (3) with cylinder caps (22), gaskets (21), pistons (20) together with the adjuster screws (18), locknuts (17), split pins (19), and seals (1), securing in position with bolts (26) spring washers (25). Replace the locking plunger (9), locking plunger handle (12), spring (10), and plunger guide (8), securing with bolts (7) and spring washers (6).

TO REPLACE TOP COVER (See Fig. 1)

Replace the inspection cover (13) complete with indicator switch (12) on to the top portion of the gearcase, ensuring that the arm on the indicator switch is correctly located in the switch operating bracket (10). Secure with bolts (14), and spring washer (15).

Replace the external oil pipes and fill up the unit with the correct grade of oil, ensuring that the drain plug (21) has been replaced.

The sump will be at correct capacity when oil overflows from the filler spout (20).

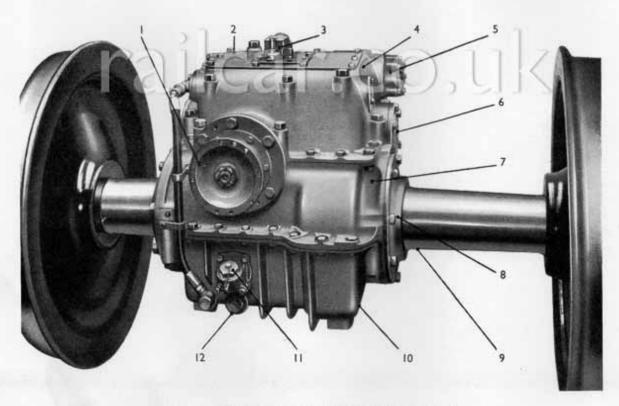


Fig. 10. VIEW OF COMPLETE UNIT MOUNTED ON AXLE

- Input Coupling Inspection Cover Indicator Switch

- Air Cylinder End Covers Intermediate Portion Gearcase Thrust Plate
- Axle Bottom Portion of Gearcase Filler Spout Drain Plug

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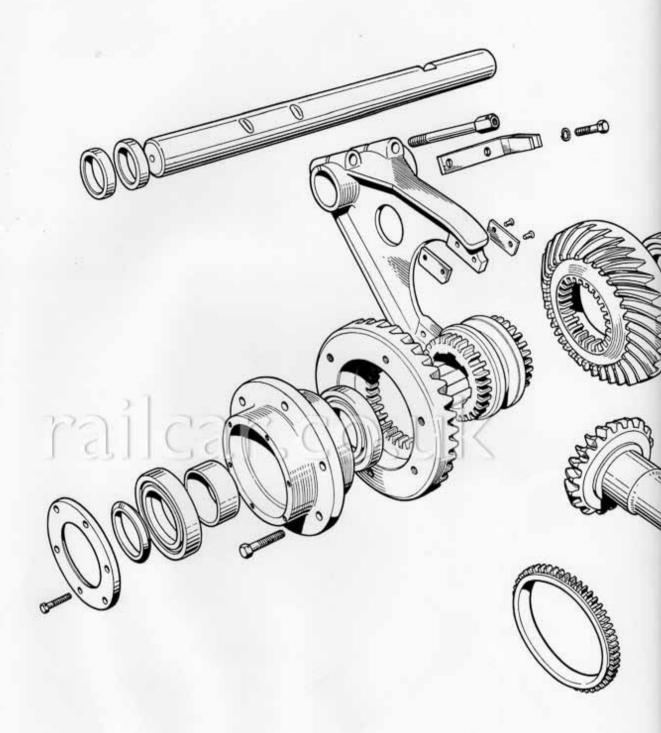
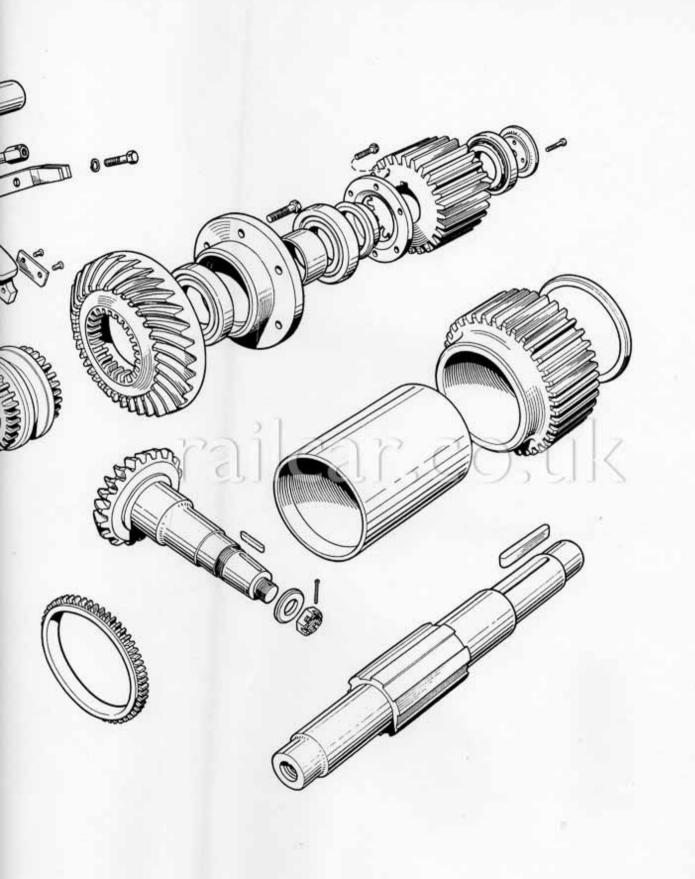


FIG. 12. GEARS.



R.F.28 PARTS LIST

Fig. 6. (Sectional Elevation Through Final Drive)

Ref. No.	Part No.	Total Make plan	D	escripti	ion					No. o
1	31599	Input bevel housing				1		244		1
2	31549	Input bevel pinion	***	***					***	1
	31611	Oil scoop					***			1
	31612	Gasket-oil scoop								1
	30422	2 B.A. bolt (oil scoop t	to input	housi	ng)		***		***	2
	30620	1" B.S.F. plug	***							1
3	31601	Oil seal housing			***			***		1
4	26302	Oil Seal				Par	t of be	evel in		1
5	32124	Washer-locking ring						ssy. 37		1
5 6 7	11339	Washer—nut	***	***	***		item			1
7	19069	Split pin				10.000				1
8	11338	Nut	-			-				1
9	11943	Key-coupling flange	1.	/	1. /	11			/	1
10	32123	Locking ring				1)			1	1
11	16725	Taper roller bearing		1.	-1	1	1.	57.1	1	1
12	16354	2" B.S.F. bolt) Oil se	al hou						6
13	17330	a" dia. spring washer								6
14	30081	§" B.S.F. bolt			housing			***		6
15	17334	\$" dia. spring washer	to cas				***		***	6
16	31594	Shims ·002"	,	6	1.000	6.0	***		***	"
	31595 31596	Shims ·005" Input ho	using to	casing			***	***	***	As re
17	31600	Distance piece) Par	t of be	evel inpu	it				1
18	26852	Taper roller bearing	Chou	using a	ssy. 376	5	***			1 1
	37427	Input coupling) Acc	V 438	4					1
	37395	Sleeve for input coupli	ng No	t supp	lied sep	arately				l i
19	31609	Set bolt) Part	of top	shaft			12
20	22534	3" B.S.F. bolt (collecto	r ring to	o hub)	see it	ems 35	. 27.	12. 46		12
21	37204	Top shaft								1
22	37242	End cover (top shaft)				***			***	i i
23	37243	Oil thrower (part of to			4365)					1 1
24	22689		\ E			***				12
25	17332	1 dia. spring washer	}				***			12
26	16724	Taper roller bearing							9.10	2
27	29999		Part of	ton sh	aft	***				2
28	31565		assy. 43				100		****	2
29	29998	Roller bearing				***	***	***	•••	1 5
30	37253	Bearing, thrust plate-		***	***	***	***	***	***	2 2 4
31	37258	Axle, half shim)	-4.716		***	***	***	***	***	1 4
32	16717	Taper roller bearing			***	***	***	***		2
33	37313		17//19		***	***	***	***	***	2
34	37244	Pump driving gear		***	***	***	***	***	***	1
34	3/277	I dilip di tvilig gear)	***	***		***	***	***	***	1

ef. No.	Part No.				1	Descripti	on					No. off
35	31551	Slidin	g dog (pa	rt of tor	shaft	assv. 4	365)			***		1
36	37248	Sleeve	for axle)				1
37	2, 210	Axle	€ See Sp	ecial No	otes at	end of	***					1
38		Gear	Parts	List		***	***		Axle as			1
39	37254	Oil th	rower			***			4366/2			2
40	17334	₹" dia	, spring w	rasher								16
41	30081	₹" B.S	.F. bolt	***	f to ca	sing					***	16
42	31560	Oil co	lector ri	ng] [Part of	top sha	aft		***			2
43	31561	Oil th	rower	·}	assy. 4	365	***	***	***	***	***	1
44	31585 31586	Shim	·002" ·005" To	p shaft	end co	vers			***		•••	As req
45	31587 31567	Shim	·020" J over top :	hafe								1
46	31559	Bearing Co	ng retaine	r plate			:::)				1
47	31563	2" R S	.F. bolt (etaining					Part of			
48	31604	Key (driving pi	nion)	5 Piace			}	assy. 43			1 1 1 1
49	31001	Drivin	ng pinion						Special	Notes	at	1
50	31572	Bevel	hub	***			***		end of	Parts L	ist	1
51	31550	Bevel	wheel					}				1
	0.000	20.0.										
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Fig. 1. (Vertical Section along Axis of Input Shaft)

	Part No.	Description	No.
1	17964	$\frac{5}{32}$ " dia. x 2" long split pin (torque arm bracket to casing)	8
2	17300	§" B.S.F. slotted nut (torque arm bracket to casing)	8
3	25286	a" dia. plain washer (torque arm bracket to casing)	8
4	41050	§" B.S.F. bolt (torque arm bracket to casing)	8
5	37322	Torque arm bracket	1
77.75	39697	Torque arm	1
- 1	38812	3" B.S.F. bolt (special) Torque arm to	1
	17301	3 B.S.F. slotted nut 5 bracket	
	19069	Split pin 5 dia. x 2" long	1
	25287	3" dia. plain washer (Torque arm to bracket)	1 1
6	39815	Gearcase (bottom portion) (Part of assy. A5569)	
100	10873/2	1" B.S.F. bolt	1
	11378/2	1 B.S.F. bolt	
	16284	⅓" B.S.F. bolt	
	37319	3" B.S.F. bolt	1 3
	41186	3" B.S.F. bolt Intermediate to bottom casing	3
	17332	1 dia spring washer	1
	19033	1 dia. D.C. spring washer	1 7
	17335	3" dia. spring washer	1
	24994	‡" dia. plain washer	
22	17947	# B.S.F. plain nut	
7	39816	Gearcase (Intermediate portion) Part of assy	
8	39817	Gearcase (Top portion) A5569	
	10873/2	1 B.S.F. bolt	
	11378/2	# B.S.F. bolt	1
	16284	4" B.S.F. bölt 1 5 5 4 3 5 5 5 5 5	1
	37318	3" B.S.F. bolt	
	37319	3" B.S.F. bolt Intermediate to top casing	
	37320	3" B.S.F. bolt	1
	17332	½" dia. spring washer	1
	19033	1 dia. spring washer	
	17335	3" dia. spring washer	
	17947	# B.S.F. bolt Switch operating bracket	
	12666		
9	17330		
7	30083	4400	
	30084 17531	tract i'l	
	17329	C# dia sautan washan	
10	42570	Switch operating bracket	
	4365	Assy, of top shaft, see Fig. 6	
11	7303	Assy. of top strait, see rig. o	

lef. No.	Part No.	Description	0. 0
12	A5561	Direction indicator switch	1
11.00	41248	Gasket for direction indicator switch	1
	A5562	Direction indicator cable and plug unit	1
13	42569	Inspection cover plate	1
	41213	Inspection cover plate gasket	1
-	32602	Cover plate	1
	41199	Hollow dowel	8
	17824	Name plate	1
	32619	Interlock indicator plate	1
	17337	Drive screw No. 4 v 5 "	16
2	41196	Direction Indicator plate	2
	17531	5" R S F holt Indicator switch to	8
	17329	5" dia spring washer (inspection cover	8
14	19584	1" B S F holt Inspection source place	10
15	17332	1" dia spring washer (to casing	10
16	41042	\$\frac{1}{4}" \text{ dia. spring washer \text{ to casing \text{colored} Assy. \qu	
	37324	Oil feed albow joint (ASSS)	1
17	30076	Oil feed elbow joint \$\int A5558 \\ \dots \dots \\ \dots	1
18	3765	The state of the s	3
19	4366/2	Assy, of bever input nousing—See Fig. 6	1
20	37255	Assy. of axle—See Fig. 6	1
20	14254	Oil filler spout	1
		3" B.S.F. bolt	1 2 2
	32612 37256	§ B.S.F. bolt bottom casing	
		Gasket for oil filler	1
	17330	a dia. spring washer (oil filler to bottom casing)	4
	30078	Oil filler plug	1
	30079	Rivet	1
	11415	Drain plug and filler plug washer	2
	30077	Oil filler plug chain	1
21	11414	Drain plug	1

Fig. 5. (Selector Mechanism)

Ref. No.	Part No.		Descrip	ition					No
1	11716	Piston seal	***	***					
27/1	17330	₹" dia. spring washer	\ Oil fe	ed elbow	joints				1.5
	10873/1	# B.S.F. bolt	} to cas	ing					
2	37251	Liner for air cylinder			***		***		- 1
3	37250	Forward and reverse air	r cylinder						
4 5 6 7 8 9	17329	충" dia, spring washer	Neutr	al lock sl		***			- 4
5	14377	· 등" B.S.F. hex. headed l	bolt \				***		
6	17329	🚣" dia, spring washer	\ Locki	ng plunge	er guid	е			200
7	22694	16" B.S.F. hex. headed I	oolt I to sle	eve		***		***	2
8	22572	Guide for locking plung	er	***		***		***	
9	31558								1
10	18510	Spring for locking plung	ger	***			***	***	
11	41043	Sleeve for neutral lock							1
12	18509	Handle for locking plun		***		***			1
	31667	Rivet pad to dog shiftin		***		***	***		4
	31557	Pad dog shifting fork		A 47					4
13	31555	Dog shifting fork)			***			1
14	41047	Bolt for selector fork			***	***	***	***	7
15	41041	Selector bar							1
16	37314	Bush for selector bar	*** ***	***		***	***	***	
17	19621	3" B.S.F. hex. locknut							1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
18	37257	Adjuster screw							7
19	19069	Split pin, 32" dia. x 2" lo	ong			***			
20	37252	Piston					***	***	- 3
21	31436	Gasket for air cylinder			2		10	12	- 5
22	29618	Cylinder cap							- 5
23	17330	dia. spring washer) Air cv	linder ca	0.70		1	7.	12
24	15276/4	# B.S.F. hex. headed bo	olt (air cv	inder			- 111		12
25	17332	1" dia. spring washer	Airc	linder to	***	***	***	***	1
26	21851	1" B.S.F. hex. headed be	olt (casing	mider to		***	***	****	è
20	21031	2 D.S.I. HEX. HEADED DO	one) casing	***	***	***	***	***	
							1		

Fig. 2. (Oil Pump)

	Part No.			1	Descript	tion					No.
1	26279	'O' ring for bush	١	***	***	***	****				
2	35088	Bush	***	***	***		***	***	***	***	1
3	32601	Oil delivery pipe				***	***	***		***	121
2 3 4 5 6 7 8 9	33311	a B.S.F. bolt			and Elb	ow to	oil	***	***	***	4
5	15608	a" dia. plain wash	her J	52 1 5 W 5 P	***	***	***	***	***	***	
6	29637	Elbow for oil pur	mp	***	***	***	***	***	***		1
6	37316	Bracket for oil p	ump	***	***	***	***	***	***	***	1
8	17343	Drain plug washe	er L			***	***	***	***	***	1
10	17342	1" B.S.P. drain pl	-		Nier		***	0:1		***	1
11	32603 32604	Oil filter		}	NOT SU	pplied			mp assy		
12	3143	Oil filter mounti Hobourn-Eaton	ing piat	blo ou	separa	tely		4367	***	***	
13	18753	#" B.S.F. nuts				***	***	***	***	***	
14	17332	½" spring washer		***	***	***	***	***	***	***	8
15	10100/13	# B.S.F. studs	***	***	***	***	***	***	***	•••	1 6
16	17362	Split pin 3 × 1	L' long	5	***	***	***	***	***	***	
17	37317	7 B.S.F. slotted	nut		l num	p brack	01	***	***	***	8 8 1 1 1
18	33310	76 B.S.F. stud	1100	ات				***	****	***	1
19	29639	Pump gear		,	***	160	***	***	***	***	1
20	33309	Taper pin			***	***	***	***	***	***	1
	33307	Locking wire		***	***	***	***	***		***	
		Totaling	100	***	***	998	****		***	***	
	1 6	1115	61)	9		15	51	1/	
	1 6	5119	E.J.) '	9		5	5.1		
		5119	C.I.	J) '	<u>_</u> , '			<u> </u>		
		5119	<u> </u>		> '	<u>_</u> , '		5			
		5119	<u> </u>		2				5.1		
		5119	<u> </u>		2						
		5119	<u> </u>								
		5119	915								
			<u> </u>								
			<u> </u>								
			95								

Oil Pipe and Fittings

Ref. No.	Part No.			D	escrip	tion					No. o
	36045	Banjo bolt									1
	36043	Banio union	***	***				***			1
	34881	Dowty sealing	washer,	¾" B.S.P		***	***	***	***		2
	37326	Pipe clip Dowty sealing				•••	***	***	***	***	2
	37878	Dowty sealing	washer,	± B.S.P		***	***	***	***	***	2
	37399	Union (% x ½" Aeroquip end f	B.S.P.)			***	***	***	***	***	1
	36004/5 36007/4	Aeroquip end f	itting (Si	35°)	[A	1371/1	Oil Bur	nn	***	- 1
	36053/4	Aeroquip hose	recing (33 1	*** [to galle	ery pip	e Pui		***	1
	37331	Oil pipe (3" o/e	d))							1
	19050	Union nut (3"							bearing		2
	19049	Union nipple (***					2 4
- 1	34875	Dowty sealing	washer		***	***	***		***		4
	36402/3	Union (2" B.S.F	?.)	***	111	222	***				4
	37324	Oil feed elbow	joint		***	***	***	***	***	***	1
1.0	17342 41049	Plug, ½" B.S.P.				***		***	***	***	1
	19050	Oil pipe (% o/o	RSPI				Gallery	nine to	o bearin		2
	19049	Union nipple (danery	hihe r		· 6	2 2
- 3	1,01,	Omon implie (8 0.0	,	***	***		****	****		
				SPECI	AL	NOTE	S				
		PARTS	WHIC	H DIFF	ER	FOR E	ACH	GEARE	OX		
		When ore	dering th		npon	ents Ur	nit No.				
		When ore	dering th	nese con gearbox	npon mus	ents Ur t be qu	nit No. ioted.	and Li			
		When or	dering th of § XLE	nese con gearbox	npon mus	ents Ur t be qu (See Fig	nit No. loted. g. 6, Ite	and Li			
		When ore	dering th of § XLE XLE GE	nese con gearbox AR	npon mus	ents Ur t be qu (See Fig (See Fig	nit No. noted, g. 6, Ite g. 6, Ite	and Li m 37) m 38)			
		When ore	dering th of § XLE	nese con gearbox AR	npon mus	ents Ur t be qu (See Fig	nit No. noted, g. 6, Ite g. 6, Ite	and Li m 37) m 38)			
		When ore	dering th of § XLE XLE GE	nese con gearbox AR	npon mus	ents Ur t be qu (See Fig (See Fig	nit No. noted, g. 6, Ite g. 6, Ite	and Li m 37) m 38)			

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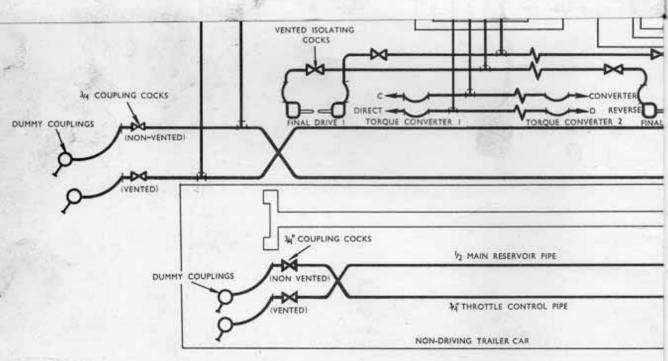
SECTION 1 .. CONTROL SYSTEM

Railcars No. E50988 to E51007 and E51154 to E51173

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T.S.D. 866/B1890 CONTROLS

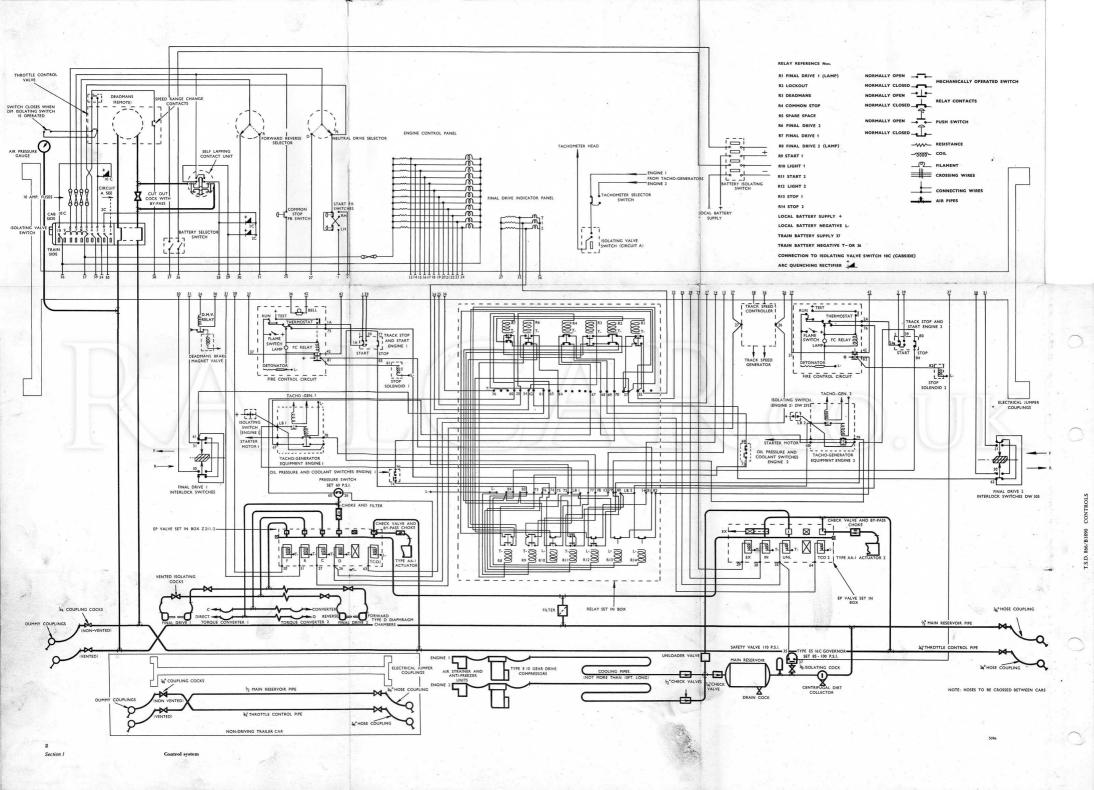
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Section 1

Control system



SECTION 1 .. CONTROL SYSTEM

Railcars No. E50988 to E51007 and E51154 to E51173

Each power car is driven by two Rolls-Royce C8.NFLH oil engines, through a transmission system consisting of two Rolls-Royce DFR 10,000 Ms 500 torque converters and two 'Walker Brothers' reversing final drives of 2.88:1 ratio mounted on the axle bogies. The torque converter has a torque ratio of 5:1 at stall, varying gradually with reduction of load to 1:1 when it is automatically changed to a solid direct drive.

The railcars are designed to run in multiples of three cars, comprising power car—trailer—power car, up to a maximum of nine cars. Thus the maximum number of engine-converter units per train is twelve. Each power car has a driving cab at one end. The trailer is without cab and carries through wiring and piping to other power cars.

Driver control of engines and transmissions of the railcar set is carried out by electrical and pneumatic means, rack control being fully graduable. Automatic safeguards are provided should fault conditions arise. A description follows of the circuitry and operation of this control system.

Battery switches

A switch on the underframe connects the battery of that car with all local positive and negative leads. A selector switch in the cab, operated by Yale-type key, connects these local wires to the respective train positive and negative wires 37 and 36. Thus any battery can be chosen to energize the train wire system.

Isolating valve switch

This switch is fitted in the cab and is operated by a removable handle so that only one switch per train set is energized at one time. It is a combined pneumatic and electrical switch. In the off position, the pneumatic portion shuts off both the main reservoir pipe and the rack control pipe, isolating the self-lapping contact unit and the rack controller in that cab.

Electrically, train wires 37, 36, 39 and 34 respectively for positive, negative, start and deadmans, are isolated from the cab wiring system. Engine speed indicator heads are also isolated through this switch. Fused positive wires lead from it to the neutral-drive selector (wire S8), the self-lapping contact unit and common stop (wire S7), the forward-reverse selector (wire S6) and the deadmans switches (wire S5).

Engine isolating switch

One of these is provided per engine and is mounted on the underframe. It isolates the whole of the engine running circuit from its local positive feed and can thus be used to prevent a faulty engine from being started or run.

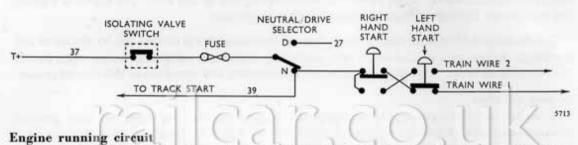
Fire control circuit

This is a 'Graviner' control box. Before an engine can be started it must be switched into circuit. In case of overheating or presence of flame, a positive feed is applied to wire 81 energizing the stop solenoid and thus stopping the engine. A warning bell and fire extinguisher are also brought into operation.

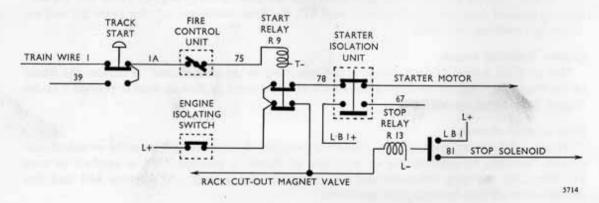
Engine control panel

This incorporates twelve blue lamps and three push buttons. On switching on the battery isolating and selector switches energizing wires 37 and 36, lights in all cabs corresponding to engines on the train set will glow brightly, any remaining lights for which there are not equivalent engines will glow dimly. On engines being started, the corresponding lights will dim. Should a fault occur in an engine, causing a shut-down, this will be indicated by the light concerned glowing brightly. A light being extinguished can only be caused by a faulty bulb filament. The lamp covers are rotateable to decrease the intensity of the light, so that the driver will not be distracted when night driving. As all train lights are in circuit, no 'light test button' is required.

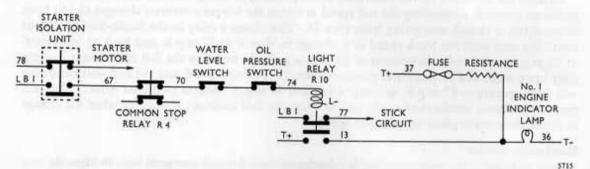
Of the three push buttons, one is the common stop button which, when depressed, will stop all engines in the train set simultaneously, and the others are start buttons, one starting all engines down the left side of the train and the other all engines down the right side. These two buttons are interconnected, so that if both should be pressed at the same time, no current will flow and thus batteries will be protected from the strain of starting two engines at once.



On starting a L.H. engine, from the cab via wire 1, or locally via wire 39, then wire 1A is energized. This passes to the fire control box, which energizes wire 75 leading to the start relay R9 which closes its contacts. Local positive current from the engine isolating switch is then taken through wire 78 to the starter isolation box. The second pair of contacts of this relay pass current via wire 83 to the rack cut-out magnet valve and to the stop relay R13, de-energizing the stop solenoid. The isolation box contains a Smiths variable relay actuated by the engine tacho-generator, cutting in when engine speed reaches 250 r.p.m., together with a secondary relay. Wire 78 passes via the normally closed contacts of this relay to the starter motor solenoid, thus starting the engine. The second pair of contacts of this relay are normally open, preventing passage of current from the local positive wire.



On reaching 250 r.p.m., the secondary tacho-relay breaks the supply of current to the start solenoid and at the same time passes a signal to wire 67, through the common stop contact to wire 70 and the oil pressure and coolant level switches. If the engine has started, sufficient oil pressure will be present to close the pressure switch and energize wire 74 and light relay R10. This opens a pair of contacts to break the train positive wire 37 leading to light wire 13 and thus cause the light to dim as soon as the engine has started, reached 250 r.p.m. and has indicated oil pressure. The other pair of contacts on this relay close, joining the local positive wire to wire 77. This passes current via the local stop button to wire 83 which allows R13 to remain energized and thus the engine to continue running.



Low oil pressure or coolant level will cause an engine immediately to stop, by breaking the circuit to relay R10. Pressure on either the common stop button in the cab or the relevant local stop button will also break this circuit and stop the engine. Pressure on the common stop button should be maintained until the brightening of the engine lights shows that engines have stopped.

Rack control circuit

Engine speed is varied by opening and closing the rack which controls the metering of fuel by the injector pumps. This is done via an all-speed governor, itself controlled by a pneumatically operated actuating cylinder. Air pressure to all actuators in a train is carried by a continuous rack control pipe. The pressure in this pipe is varied, and thus speed of all engines is controlled by means of a manually operated control valve at the driver's desk. This valve is infinitely variable between idle and full rack positions.

When the rack control valve in the cab is operated to increase engine speed, air is fed from the main reservoir pipes to the rack control pipe. The pressure in the latter is raised and immediately moves the inlet piston of the self-lapping contact until, towards the centre, it closes the inlet electrical contacts. This passes positive supply current from the isolating switch terminal SC7 to train wire 28, which causes inlet valves of all electro-pneumatic magnet valve units in the train to operate. These admit main reservoir air to the rack control pipe at each car of the train set. At the same time, air bleeds between inlet and exhaust pistons of the self-lapping contact unit, via the by-pass choke. When pressure in the rack control pipe has been equalized these pistons will centralize, breaking electrical contact with wire 28 and stopping further ingress of air to this pipe.

On moving the rack control handle towards the closed position, pressure in the control pipe is reduced. A similar function to the above then takes place at the contact unit, the exhaust piston of which is moved towards the centre, energizing wire 29 and thus operating all exhaust valves of the magnet valve units. These connect the rack control pipe to exhaust at each power car.

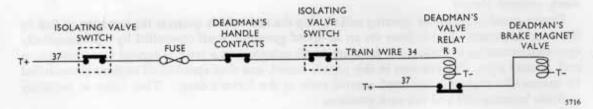
When a lower pressure has been obtained throughout the control pipe to give the desired reduction in engine speed, the equalization of pressure at the contact unit will once again cause its contacts to open, breaking the circuit and de-energizing the magnet valve units.

Engine speed is thus able to be varied continuously and rapidly throughout a train, whatever its length. An electrical failure in this system can be overcome by opening the by-pass cock in the leading cab to the full through position. This will give pneumatic operation of all engines direct from the rack controller.

Detents are provided on the controller corresponding to idling and full rack. Between these positions a switch, controlling the rail speed at which the torque converter changes to and from direct drive, is closed, energizing train wire 38. This closes a relay in the Smith-Stone lock-out controller and fixes the track speed of a change to 'direct' at 37 m.p.h. and back to 'converter' at 30 m.p.h. A handle movement of 10 deg. is possible between the full rack detent and the fully open stop, and in this latter position, wire 38 is de-energized and the lock-out controller will then operate at 47 m.p.h. to direct drive and 40 m.p.h. back to converter drive. This will permit maximum acceleration of the railcar. Greater fuel economy is possible when the change to direct drive takes place at the lower speed.

Deadmans circuit

Also included in the rack controller is a deadmans switch which energizes wire 34 when the control handle is depressed. This closes relays operating deadmans brake magnet valves in each car of the train. This circuit, once broken by releasing the control handle, can only be remade at the controller by first returning the handle to the idle position. A push-button-type remote deadmans switch is provided on the right of the cab and another set of contacts with the same function is incorporated in the deadmans emergency isolation switch, to allow engines to be driven at speeds above idling when this switch is operated.



Rectifiers

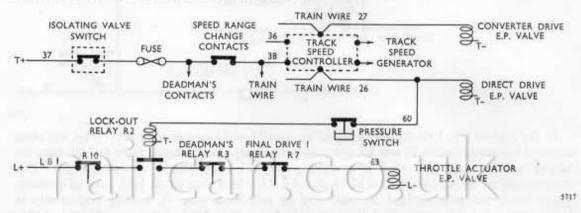
Small are quenching rectifiers are included on circuits 28, 29 and S3 to protect the contacts of the self-lapping contact unit and the deadmans switches.

Drive selection, including 'automatic lock-out' operation

This is carried out in the cab by means of a two-position selector switch, giving 'neutral' or 'drive'. In the neutral position, positive supply from the cab isolation switch is passed via wire SC4 to the common start buttons in the same cab, and via wire S4 to the isolation switch and thence to train wire 39 and the local start buttons along the train.

In the drive position all starter buttons are isolated, thus engines can only be started with the drive selector in neutral. In drive, a signal is passed through train wire 27 to all converter drive magnet valves. These cause main air pressure to be applied to the hydraulic drive cylinder of each converter. Converter oil pressure then actuates the associated clutch plates which engage hydraulic drive.

Wire 27 also energizes the Smith-Stone lock-out controller in readiness for its operation. At 37 or 47 m.p.h., dependent on rack control handle position as previously described, the lock-out controller connects wire 27 to wire 26. This being a train wire, will synchronize the application of all direct drives. Immediately, a signal is given via wire 26 leading to wire 60, through a normally closed pressure switch, relay R2 is energized and this breaks the feed to the rack cut-out magnet valves, bringing engines to idle; direct drive magnet valves are also energized, feeding air via choke to the direct-drive cylinder of each converter. As this requires approximately 40 p.s.i. to operate the clutches engaging direct drive, there is a slight delay whilst this pressure builds up. The switch in the circuit to relay R2 will open when this pressure has increased to 60 p.s.i., re-energizing the rack magnet valves and bringing the engines up to the new speed required for a solid drive to the axles. Thus, completely automatically, a sequence of events occurs: (1) engines drop to idle, (2) direct drive is engaged, (3) engines speed up. This ensures a smooth transition from hydraulic to direct drive.



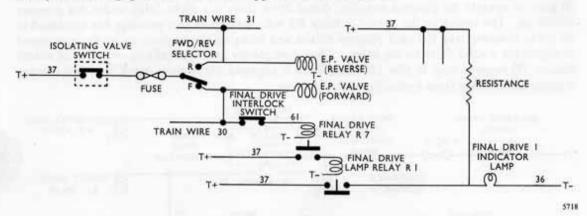
The hydraulic drive magnet valve remains energized even when the transmission is in direct drive, but the hydraulic cylinder on the converter is overridden by the direct cylinder. Thus, when a return to hydraulic drive is signalled by the lock-out controller, breaking wire 26 and de-energizing the direct magnet valve, hydraulic drive is immediately re-engaged. The engine does not drop to idle but increases speed to that required for torque converter operation.

Forward/reverse selection

An electrical selector switch with 'forward' and 'reverse' positions only and incorporating a mechanical baulk to prevent inadvertent operation, is situated in the driving cab. Positive current is fed to it from terminal S6 of the isolating switch and this is passed to train wire 30 in 'forward' or 31 in 'reverse' positions. The corresponding magnet valve on each power car of the train is then energized, allowing air to pass to the associated diaphragm chambers of each final drive gearbox, thus selecting the required direction. The magnet valves concerned are continuously energized so that air pressure at the diaphragms is always present, maintaining positive engagement.

A final drive indicator panel is also included in the cab. This consists of three blue lights, which give warning in the same way as the engine lights. They glow dimly when direction has been correctly engaged at the final drive boxes, and brightly in the case of faulty engagement. These lamps are marked respectively T, 1 and 2. The 'T' lamp refers to all final drives in the train and '1' and '2' lamps refer to the first and second final drive units of the power car in which the lamps are situated.

Two direction indicator switches are coupled to the sliding dog actuator shafts of each final drive. With dogs fully engaged in forward or reverse, the main contacts of the respective switch are closed and its back contacts open. In any intermediate position main contacts of both switches are open and the back contacts closed. A signal will only pass to wire 61 or 62, for final drive 1 or 2 respectively, if the indicator switch operated is that appertaining to the direction selected in the cab. No signal will pass if dogs remain in an 'end on end' position or if they remain engaged in the direction opposite to that selected.



In the case of No. 1 final drive, a signal on wire 61 will energize relay R7. This will close contacts connecting wires 83 and 63, energizing the rack cut-out magnet valve and allowing the engine rack to be opened. Also, on energizing relay R7, a second pair of contacts open. This disconnects the train positive wire 37, from relay R1, which then opens both pairs of contacts. These break the positive feed to train wire 32 and local wire 71, leading respectively to the indicator lights for train final drives and the No. 1 final drive of that car. This local light will thus change from bright to dim as the only feed to it is now via a resistance. Similarly with No. 2 final drive, when in the correct direction, No. 2 engine rack is allowed to open and No. 2 local light will dim. When all final drives of a train are in the correct direction, train wire 32 will no longer give a signal and the final drive train light will also dim.

If, on selecting a change of direction, the train light does not dim immediately as some final drive dogs may have moved 'end on end', then these can be made to mesh correctly by the engagement of 'drive' for a few seconds with the rack controller at idle. This engagement of hydraulic drive will apply sufficient torque to the final drive input to move the bevel gear and allow the dogs to mesh. Until any final drive is correctly engaged its associated engine cannot be raised above idle speed, its indicator light in the local cab and train lights in all cabs will glow bright. By examining all cab lights the faulty final drive can be easily traced.

A lever with toggle action is provided on the reversing gearbox. This ensures that the final drive dogs do not slowly disengage with slow build-up of air but move smartly when air pressure overcomes the toggle spring. If air pressure should subsequently be lost, this toggle action will keep the final drive dogs in the selected position. By manual movement of the lever it is possible to pin any final drive in neutral, forward or reverse.

Electrical control boxes

The 13 electrical relays required for the various purposes already described are housed in one relay box mounted on the side of the underframe. There are two electro-pneumatic magnet valve boxes similarly mounted. One contains valves controlling forward-reverse, converter drive,

direct drive, and first engine rack idle. The other contains the rack pipe repeater valve unit, and valves controlling the unloaders and second engine rack idle.

These relays and magnet valves pick up at 8 volts and are continuously rated at 30 volts. Thus they will operate from a train wire under extreme conditions of voltage drop, yet under high charging conditions the windings will not overheat.

The Smiths starter isolation equipment for both engines is located in a single box on the underframe, as is the Smith-Stone lock-out controller. This latter item connects to the normal speedo-generator via the wheel adjustment box. The bare wire in this box is cut as the loading of the controller unit is equivalent to that of a second speedometer head.

Two local gauge panels, one associated with each engine, are situated on the underframe side. They each contain pressure gauges for engine oil, converter clutch oil and converter fluid, and a converter fluid temperature gauge.

Also at each side of the frame is a box containing one start and one stop button controlling the engine at that side.

Compressor equipment

A Type E10 compressor is mounted on each engine auxiliary gearbox and air from each is drawn through air strainers and anti-freezers, compressed and passed to the main reservoir of the car. A $\frac{1}{2}$ in. check valve behind each compressor prevents air loss through an idle compressor if one engine is stopped. A $\frac{3}{4}$ in. check valve prevents air loss from the main reservoir when compressors are unloaded.

Compressors unload when pressure in the train line reaches 100 p.s.i. An electrical governor closes its contacts at this pressure, connecting train positive wire 37 to train wire 35. This energizes the unloader magnet valve, which passes air to the unloader and connects the compressor supply to atmosphere. Wire 35 connects all governors on the train, thus all compressors unload simultaneously when the first governor operates. When main air pipe pressure has reduced to 85 p.s.i. the last governor to open will break the electrical signal to wire 35 and all unloader magnet valves are de-energized. Unloaders then cause all compressors to be re-connected to their main reservoirs.

In the case of a faulty governor failing to open, so that compressors continue to unload below 85 p.s.i., the governor can be isolated by closing the associated isolation cock. At each main reservoir is a safety valve which will operate at 110 p.s.i., preventing any excessive pressure build-up if a fault should occur. This safety valve can be tested by isolating the main air reservoir of the car in question by closing the coupling cocks and also the governor isolating cock to prevent the compressors unloading.

A dirt collector is situated in the line between each reservoir and the main air pipe. This and the drain cock of the main reservoir should be opened at stated intervals to allow accumulations to drain off.

MAINTENANCE

Instructions for the maintenance of the control equipment manufactured by the Westinghouse Brake and Signal Co. are given in their catalogue M38/7.

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SECTION 2 . . CONTROL SYSTEM FOR BEDFORD - ST. PANCRAS RAILCARS MISCIBLE WITH 'BLUE SQUARE' STOCK

Railcars No. E51591 to E51650 and M51731 to M51780

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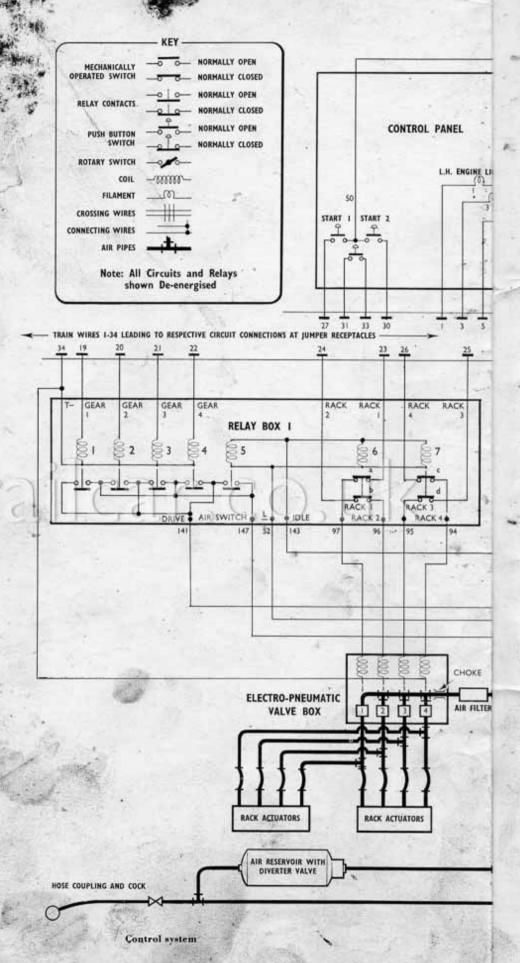


dni

J	UMPER RECEPTACLE	2
1	ENGINE STOP	31
2	DEADMAN'S	32
3	TRAIN + VE	33
4	TRAIN - YE	-34

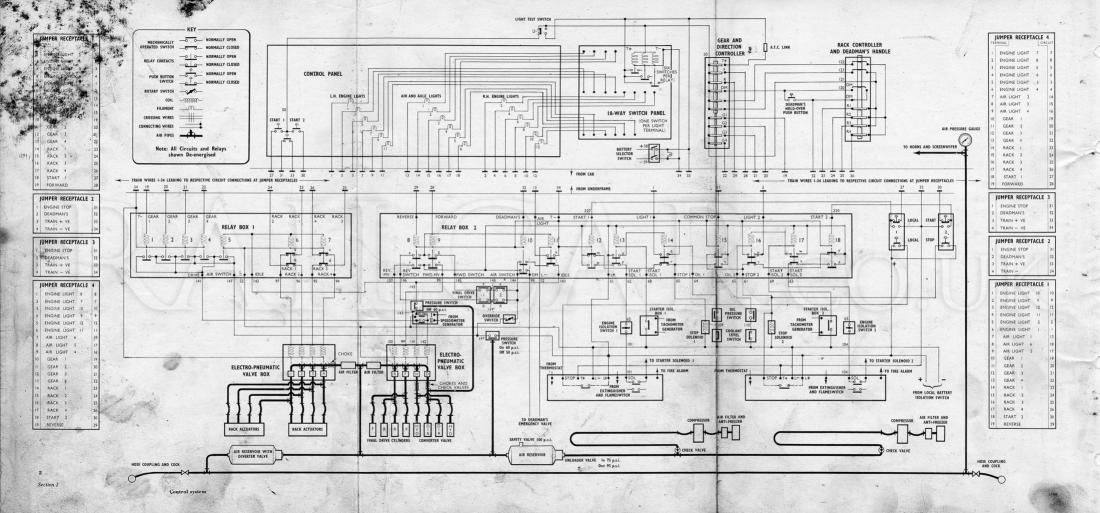
1	JUMPER RECEPTACLE	3
1	ENGINE STOP	31
21	DEADMAN'S	12
3	TRAIN + VE	33
4	TRAIN - VE	34

1	UMPER RECEPTACLE	4
1	ENGINE LIGHT 8	8
2	ENGINE LIGHT 7	7
1	ENGINE LIGHT 10	10
4	ENGINE LIGHT 9 "	9
5	ENGINE LIGHT 12	12
6	ENGINE LIGHT II	11
7	AIR LIGHT 6	18
В	AIR LIGHT 5	17
9	AIR LIGHT 4	16
10	GEAR I	19
11	GEAR 2	20
12	GEAR 3	21
13	GEAR 4	22
14	RACK I	23
15	RACK 2	24
16	RACK 3	25
17	RACK 4	26
18	START 2	30
19	REVERSE	29



2

Section 2



SECTION 2 . . CONTROL SYSTEM FOR BEDFORD-ST. PANCRAS RAILCARS MISCIBLE WITH 'BLUE SQUARE' STOCK

Railcars No. E51591 to E51650 and M51731 to M51780

The railcar is powered by two Rolls-Royce C8NFLH oil engines each of 239 gross horsepower. The transmission consists of two Rolls-Royce DFR 10000 series torque converters in unit with the engines and two S.C.G. RF 28 reversing final drive boxes mounted on the axle bogies. The torque converter has a torque ratio at stall of approximately 5:1 reducing gradually with decrease in load and increase of car speed to 1:1, when the drive is automatically coupled direct to the engine.

The cars are designed to run in multiples of 4, comprising power car—trailer—trailer—power car, with a maximum of 12 cars and 12 engine-converter units. Power cars have a cab at one end only, whilst trailer cars have no cab. The Rolls-Royce-powered cars are miscible with all other 'blue square' stock and can be run in conjunction with B.U.T.-powered cars of this type.

A description of the controls and circuitry required for the operation of this system is as follows:

Engine and transmission control is carried out electro-pneumatically, rack control being of the four-stage type and transmission control being by a combined controller to select forward/everse, and neutral/converter drive, or the equivalent gear positions required for mechanical transmission cars. Automatic safeguards are provided within the system.

Battery switches

A key-operated switch in each cab selects which battery shall be used to energize the train wires by connecting the local positive and negative wire 58 and 59 to the respective train wires 33 and 34. Normally this would be the battery of the leading car. A frame side mounted master switch connects positive leads 51, 58 and 53 and negative leads 52, 59 and 55 to the battery.

Gear and direction controller

This includes a mechanism which isolates the train positive wire 33 from the control equipment of that cab, unless the loose handle is inserted and 'forward' or 'reverse' direction is chosen. Insertion of this handle connects the train positive wire 33 to forward 28 or reverse 29, wire 120 leading to the deadmans switches and wires 122 and 123 for rack operation. The drive handle connects drive wire 121 to train gear wire 19, 20, 21 or 22 as the handle is rotated to the respective positions 1, 2, 3 or D. A mechanical baulk in the controller prevents the operation of the drive handle until the forward/reverse handle has been inserted and moved to either F or R position. Similarly, direction cannot be chosen unless the drive handle is in the neutral position.

Rack controller and deadmans handle

This is operated in two stages. On depressing the handle, three sets of contacts are made, connecting wires 120, 122 and 123 from the gear controller to the deadmans train wire 32, and the two positive feeds to the rack switch respectively. On rotating the handle, positions 1, 2 and 3 and full rack are progressively engaged, energizing wires 23, 24, 25 and 26 respectively. Interconnection of the switches causes, in addition, the engagement of the rack position lower than that selected, i.e. at full rack, position 3 is also energized; at 3, position 2 is also energized, and

at 2, position 1 is energized. If pressure on the handle is removed, it will spring up, releasing a cam which breaks the connection to deadmans wire 32 and the rack positive wire. This causes all engines to return to idling and after five to seven seconds delay the vacuum brake will also be applied. To reset this handle, it must first be moved back to the 'engine idle' position and then depressed.

Deadmans hold-over push button

This is incorporated in the circuit from the gear controller to train wire 32. It provides a means of over-riding the deadmans brake valve, preventing its operation if the driver should require to go to the opposite side of his cab.

Engine control panel

This incorporates 12 engine running lights, 6 air and axle indicator lights, 2 start buttons and a common stop button. Engine lights shine when the corresponding engines are running and circuits 1 to 12 are completed. Similarly, each air and axle light will be lit when both final drives of that power car are in the selected direction and the car air pressure has reached the required figure, the respective circuit 13 to 18 being completed. Lamp covers are rotatable to decrease the intensity of light when required. One start button starts all left-hand engines by connecting wire 50 to train wire 27 and the other all right-hand engines by connecting wire 50 to train wire 30. The stop button stops all engines by connecting train wires 33 and 31.

Relay switch panel

This incorporates three 6-pole relays and provides a means of isolating all control panel lights other than those of the cab from which the train is being driven. Wire 50 from the drive controller energizes the panel in this cab alone and passes positive current from wire 33 to the control panel lights.

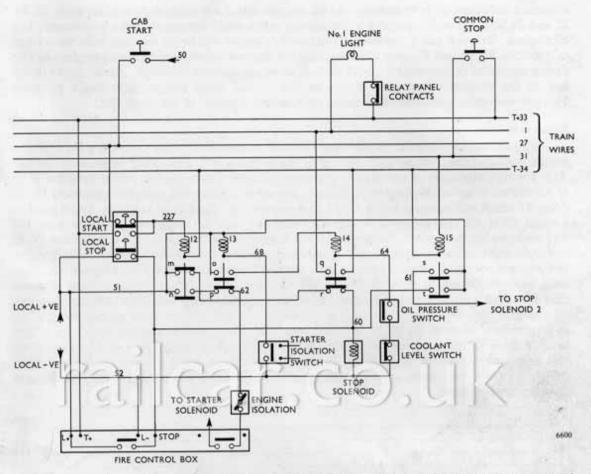
Test switch

This can be used to over-ride the relay panel in other cabs than that under driver control and allows engine and axle lights to shine in the cab concerned. Start and stop buttons, however, remain isolated.

Engine running circuit

The left-hand engine of the leading car can be started via the cab push switch, energizing train wire 27, or at the local underframe switch energizing wire 227. The cab switch will not operate whilst the local button is being pressed. Wire 227 passes to relay box 2 where it will energize relay 12. Contacts 'n' close and current from local positive wire 51 flows via contacts 'p' of relay 13 to wire 62. This passes to the engine isolation switch and thence, via the fire control box, to the starter solenoid, thus starting the engine. On the engine starting, and reaching 250 r.p.m., current via wires 36 and 37 from the engine-driven tacho-generator closes the contacts of the calibrated relay in the Smiths starter isolation box, thus completing the circuit through relay 13 via wire 68. This relay then opens contact 'p' which breaks the supply of current to the starter solenoid. At the same time, its contacts 'o' close. Sufficient engine oil pressure should now be present to close the pressure switch. Current will pass via relay 14 and wire 64 to this switch, through the coolant level switch via wire 109 and to negative wire 52. This, by closing contacts 'q', completes a circuit via wire 1 to train negative 34 and causes engine No. I light to shine at the cab control panel. When a start button is pressed, contacts 'm' open and the circuit via wire 60 to the engine shut-down solenoid is broken. This allows the engine to be started and over-rides the effect of an open oil pressure switch. If the oil pressure switch does not close after starting, the engine will stop when the start button is released.

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In normal running, engine shut-down would follow loss of oil pressure or low level of engine coolant as opening of either of these switches will break the circuit from relay 14 to negative and close contacts 'r'. This completes the circuit through wire 60 to the shut-down solenoid and stops the engine. Contacts 'q' of this relay will open and put out the engine panel light concerned. A right-hand engine would similarly be started or shut down, via relays 16, 17 and 18.

Normal stopping of engines can be carried out from the cab by pressing the common stop button. This, by joining train wires 33 and 31, energizes relay 15, closing contacts 's' and 't' which pass local positive current to wires 60 and 61. These in turn energize solenoids stopping both engines of all cars. Pressure on the button should be maintained until all engine lights are extinguished. A local stop button at each engine side will, when pressed, also pass current to wire 60 or 61 and stop the adjacent engine.

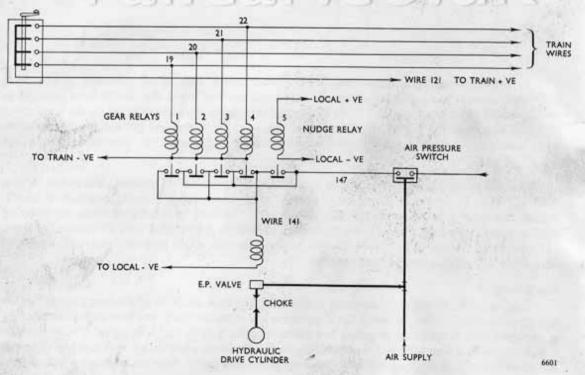
Rack control

Engine speed is varied by opening and closing the rack controlling the metering of fuel by the injection pump. An all-speed CAV governor operates this rack and is in turn controlled by a pneumatically actuated lever giving five positions, idle, $\frac{1}{4}$, $\frac{3}{4}$, and fully open. The pneumatic actuator contains four valves, corresponding to the positions of opening, and compressed air is fed to each from its respective electro-pneumatic magnet valve. One set of magnet valves con-

trols rack actuators on both engines. As all magnet valves are energized via train wires 23, 24, 25 and 26 from the rack controller in the driving cab, a simultaneous response is obtained from all engines. Relays 6 and 7, opening contacts a, b, c and d, will break the feed from these wires to wires 94, 95, 96 and 97, thus de-energizing the magnet valves and returning engines to idle during operation of converter lock-out or final drive engagement interlock. An air choke in the line to the magnet valves gives a one to two-second delay before racks begin to open. This prevents jerky operation of the train, from sudden opening of the controller.

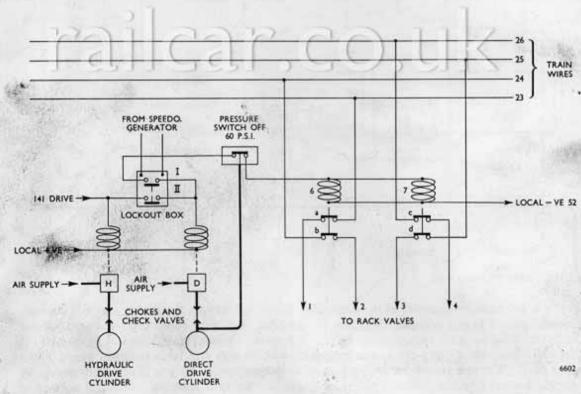
Drive selection

This is carried out from the drive and direction controller in the cab. On a Rolls-Royce torque converter car, moving from neutral to any position, 1, 2, 3 or D will select drive, though with a train consisting of this type of car alone, it is only necessary to select position N or D for neutral or drive. Moving the selector to any drive position will energize train wires 19, 20, 21 or 22 which will energize relays 1, 2, 3 or 4 respectively, closing the contacts. Local positive current from the air pressure switch via wire 147 will be connected to drive wire 141 and energize the 'hydraulic' electro-pneumatic magnet valve. This applies air pressure to the hydraulic drive cylinder of the converter; oil pressure then actuates the associated clutch plates and engages converter drive. As the air pressure switch is included in the electrical circuit, drive cannot be selected unless 50 to 60 p.s.i. air pressure is available. When a train consists of mixed cars with both hydraulic and mechanical drive, then the controller would be operated as with a 'mechanical' car. Position 1, 2, 3 or D would select 1st, 2nd, 3rd or direct gear at the gearbox as respective train wires 19, 20, 21 or 22 are energized. Drive will be engaged on converter cars in all of these positions. As engine speed is not proportional to transmission speed on converter cars an engine tachometer is not fitted. In order to inform the driver when to change gear when driving a mixed train from such a car, the speedometer is marked in segments corresponding to gear change positions.



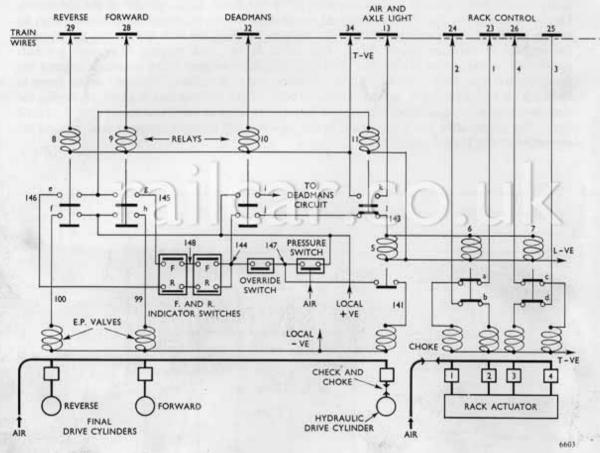
Automatic lockout to direct drive

At 46 m.p.h., when the converter torque ratio has reached 1:1, a change to direct drive should be made. This is accomplished automatically without any action by the driver. The signal that this speed is reached is given by a Smith-Stone lockout box. This receives current from the speedo-generator which also controls the speedometer head in the driving cab. At 46 m.p.h. a calibrated relay closes its contacts and in turn closes the double contacts of the lockout box drive relay. These had previously been opened when 'drive' was first engaged. Current flows via contacts 'I' through the closed contacts of the lockout pressure switch and energizes wire 143 and relays 5, 6 and 7. Relay 5 has no effect as drive is already engaged. Relays 6 and 7 open their contacts which break the feed to all four rack magnet valves and bring both engines immediately to idle. Closing contacts II energizes the 'direct drive' magnet valve, which after a three-second delay through a choke, applies air to the direct drive cylinder of the converters. This in turn operates the clutches engaging direct drive. When the pressure has further built up to 60 p.s.i., the pressure switch will open its contacts, breaking the feed to wire 143 and allowing the engines to increase above idling. The choke in the rack magnet valve unit prevents the sudden re-imposition of full rack. The hydraulic drive magnet valve remains energized but the respective operating cylinders at the converters are over-ridden. When the speed drops to 39 m.p.h., a signal from the second calibrated relay of the lockout box is given, re-closing the contacts of its drive relay, de-energizing the direct drive magnet valve and re-engaging hydraulic drive. The engine does not drop to idle in this case but will increase speed to that required for operation of the torque converter.



Forward/reverse selector

When direction is selected by operation of the selector in the cab, positive current is passed to train wire 28 (forward) or 29 (reverse), energizing relay 9 or 8. If, for example, forward is selected, relay contacts g and h are closed. Positive current feeds through contact h to wire 99, energizing the 'forward' magnet valve. This passes compressed air to the 'forward' air cylinder of the two final drives of the car. As the gears move into mesh, the final drive indicator switches will close their 'forward' contacts and if sufficient air pressure is present to close the pressure switch contacts, a circuit will be made via wires 147, 144, 148 and 145 through contacts g of relay 9 and energize relay 11. Contacts k of this relay close, completing a circuit through wire 13, causing the air and axle light to shine. Thus, indication of engagement is only shown when both final drives of a car are in the direction selected and 50 to 60 p.s.i. air pressure is present.



On selection of direction at the controller, the gear dogs of a final drive may occasionally assume an end to end position. Selection of converter drive with engines idling would provide sufficient drag to cause engagement of these dog teeth. However, this cannot be carried out manually from the driving cab as mechanical cars which may also be in the train would be put into gear. For this reason an application of torque converter drive is effected automatically should correct direction initially fail to be engaged. Drive is returned to neutral as soon as correct engagement has been made. The sequence is carried out as follows. If dogs are end on end, the contacts of the indicator switch will remain open. Thus the circuit through wire 145 or 146 to relay 11 cannot be made and contacts 'l' remain closed. If the deadmans handle

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is depressed, closing contacts 'i' of relay 10, then, with the air pressure switch closed, a circuit is completed through wires 144 and 143 to energize relays 5, 6 and 7. Relays 6 and 7 break wires 23, 24, 25 and 26 which ensures that the engines of that car remain at idle, whilst relay 5 closes its contacts, joining wire 141 to 147 and energizing the 'hydraulic' magnet valve. After a three-second delay given by a one-way choke in the line to the converter cylinders, hydraulic drive is engaged. This will cause sufficient drag to take the final drive dogs into engagement. The indicator switch will then close and relays 5, 6 and 7 will be de-energized. Hydraulic drive will be immediately disengaged and after approximately two seconds delay, engine racks can again be opened. Thus, drive can only be engaged with engines at idle and with the driver in the cab depressing the deadmans handle.

Engine and final drive isolation and over-ride switches

A faulty battery, engine or final drive, will necessitate isolation of engines and final drives concerned. Isolation of the engine starter circuit is carried out by opening the switch at the engine side and breaking the circuits through wires 62 to 101 or 63 to 104 for engine 1 or 2 respectively.

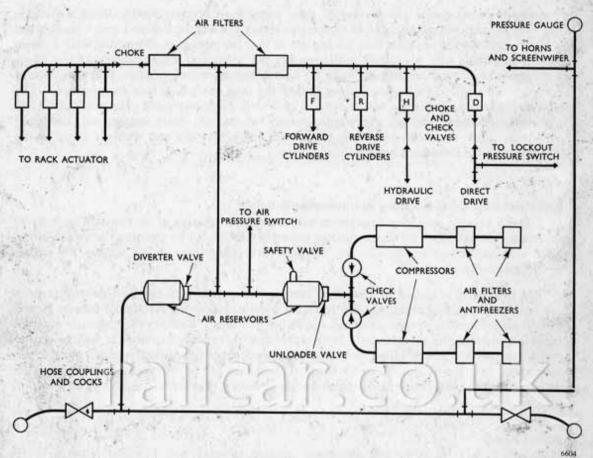
The final drive is locked in neutral by turning the neutral lock handle a quarter turn by means of the special tool available. The reversing lever in the driving cab should then be moved slowly from forward to reverse and back a number of times. Sufficient air pressure must be available to actuate the air cylinder. With either final drive locked in neutral, neither engine can be speeded up above idling until the emergency over-ride switch on the underframe is turned to the OFF position. This cuts the feed from wire 147 to 144, de-energizing relays 5, 6 and 7 and allowing the non-isolated engine and final drive of the car to continue to be used.

Control boxes

Relays 1 to 7 for drive and idling are situated in relay box 1, whilst relays 8 to 18 for forward, reverse, deadmans, engine starting and stopping are situated in relay box 2. One electro-pneumatic magnet valve box contains the four rack valves and the other contains the forward, reverse, hydraulic drive and direct drive valves. These relays and magnet valves are continuously rated to 30 volts yet will pick up at 9 volts. The Smiths-Stone lockout box, also underframe mounted, is connected to the speedometer generator via the wheel adjustment box. The bridge wire in the latter should be cut. The Smiths starter isolation boxes are frame mounted separately for each engine. A 'Graviner' fire control box is provided for each power unit, and in case of severe overheating or presence of flame, the engine concerned will be stopped by energizing its stop solenoid via wire 60 or 61. A warning bell and fire extinguisher also come into operation. An engine cannot be started unless this box is switched on.

Air equipment

Compressed air for control operation is provided by two 10 cu. ft. air compressors on each car. These are mounted on the engine auxiliary gearboxes and air is drawn by them through air strainers and anti-freezers. Air loss back through an idle compressor is prevented by a check valve in its air line. The compressed air is passed to the primary reservoir via a mechanical unloader valve which is set to relieve the compressors of their load on reaching a pressure of 95 p.s.i. and allows charging to recommence at 75 p.s.i. A safety valve is provided on the reservoir and is set at 105 p.s.i.



From this reservoir, air is passed to an air pressure switch which closes at 60 p.s.i. and reopens at 50 p.s.i. This prevents the air and axle light from shining and converter drive from being engaged until its contacts are closed. Air also passes via individual filters to the two electro-pneumatic magnet valve boxes. Air pressure to other cars and to the horns and windscreen wipers is made available through a larger secondary reservoir. A diverter valve attached to this reservoir prevents air passing to it until 50 p.s.i. has been built up in the primary system, which allows sufficient air for cab control of engine racks to be made available more quickly when starting without air.

In the event of an unloader sticking in the open position, air would not be drained from the system as a non-return valve is incorporated, preventing escape of air from the reservoir.

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