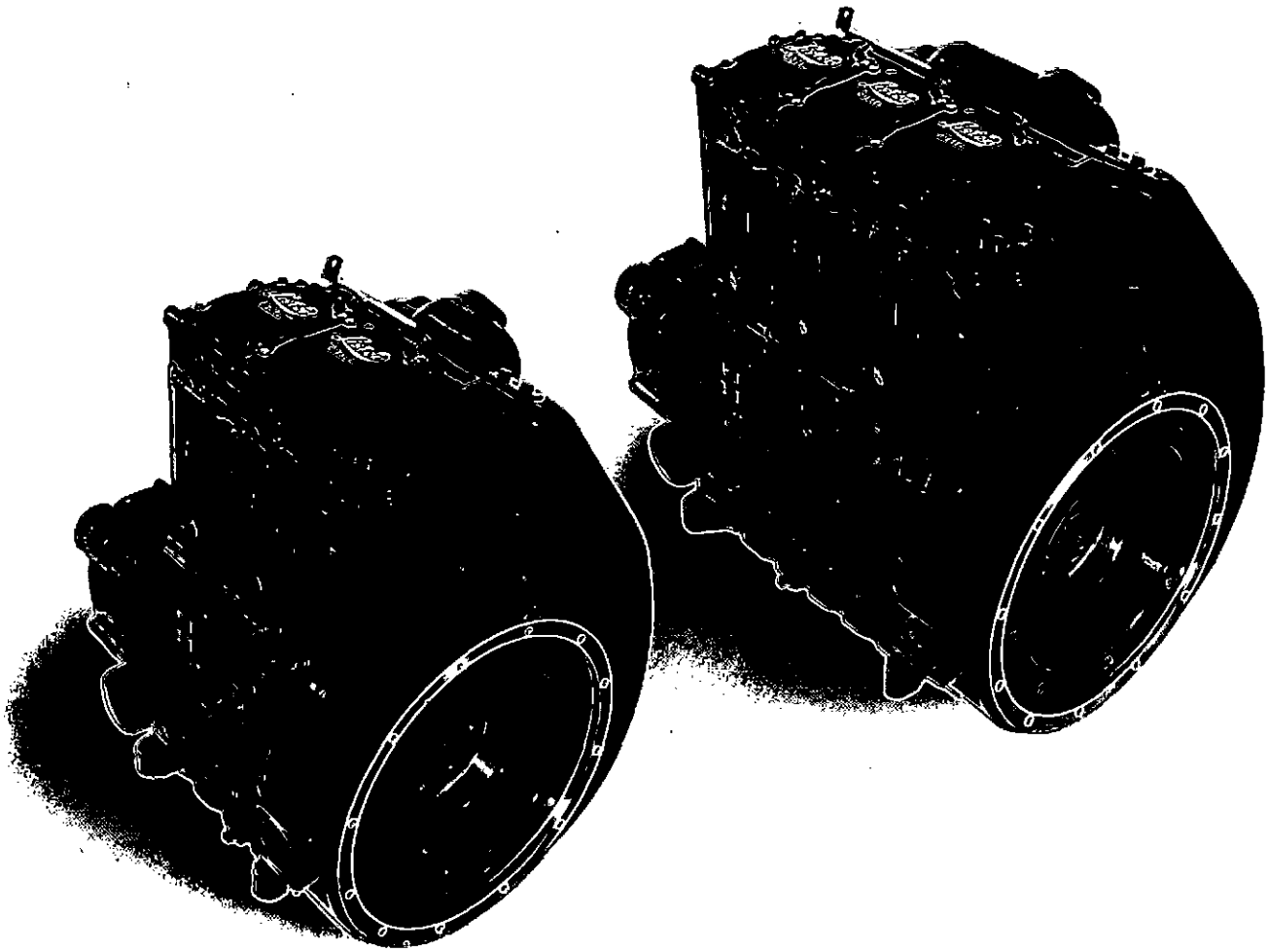
Lister
DIESELS

TS range



Workshop Manual

SAFETY PRECAUTIONS

GENERAL

- Ensure the engine is securely mounted.
- Ensure that a generous supply of fresh air is available to the engine house.
- Ensure that the engine is clean.
- Ensure that all necessary safety guards are fitted.
- Never place the hands or any other part of the body near rotating parts of the engine such as fan impeller or flywheel.
- Never allow any unprotected skin to come into contact with high pressure fuel oil, for example when testing fuel injection equipment.
- Thoroughly clean any diesel fuel oil from the skin as soon as practicable after contact.
- Always rectify any fuel oil or lubricating oil leaks as soon as practicable.
- Always clean up any fuel oil or lubricating oil or lubricating oil spillage lying near the engine.
- The lifting plates and eyes supplied by RAL are designed to carry the engine plus RAL accessories. They must not be used to lift complete assemblies such as a complete power plant.

STARTING

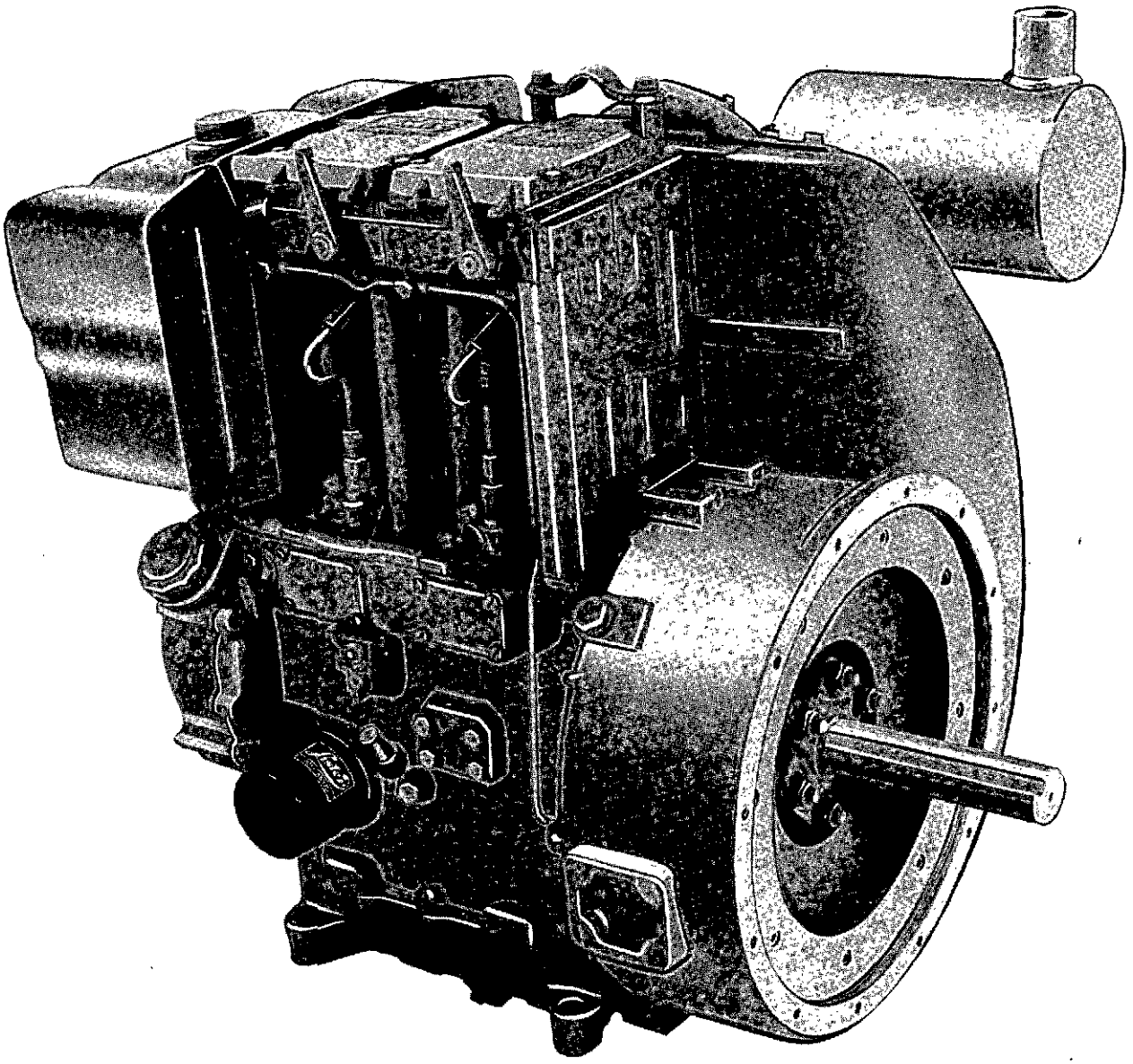
- Always ensure that oil levels (including gear boxes), coolant levels and fuel oil levels are correct prior to starting.
- Ensure that the engine is free to turn without obstruction.
- Use the **CORRECT** Lister handle. Ensure there are no burrs, paint or dirt on starting shaft and lightly oil before fitting handle. Do not attempt to start an engine if the starting handle is damaged and always check the arrow on the handle boss for direction of rotation.
- ON ST, HL and HR/W engines, a clutch pin (pawl) on the starting handle engages with a keyway on the starting shaft. After fitting handle, turn in opposite direction to that required to start the engine in order to check that the clutch pin will disengage from the keyway, and does not bind on the starting shaft, before attempting to start the engine.
- Do not allow the starting handle to rotate on the running shaft when the engine is firing.
- Hand starting any diesel engine can be dangerous in the hands of inexperienced people. Engine operators must be instructed in correct procedures before attempting to start an engine, if these conditions cannot be met electric starting should be used.

PUBLICATION 2006
SECOND EDITION

Lister DIESELS

TS 2 and 3 Cylinder Diesel Engines

Workshop Manual



TS2 AIR COOLED DIESEL ENGINE
with earlier styled fuel tank

TS 2 and 3 Cylinder Diesel Engines

FOR
INDUSTRIAL
MARINE AUXILIARY
AND
MARINE PROPULSION
APPLICATIONS

Publications for TS2/3

Workshop Manual
Industrial and Marine — Book 2006

Operators Handbooks
Industrial Engines — Book 2010

Parts List
Industrial — Book 1983PL

Note: Every engine supplied by R. A. Lister is consigned with the appropriate Handbook and Parts List.

ENQUIRIES

Industrial Engines — R. A. Lister and Co. Ltd.

DURSLEY, GLOUCESTERSHIRE, GL11 4HS, ENGLAND

Telephone: DURSLEY (0453) 4141. Telex: 43261

Telegrams & Cables: Machinery, Dursley.

Marine Auxiliary and Marine Propulsion — Hawker Siddeley Marine Ltd.

GOODRIDGE AVENUE, BRISTOL ROAD, GLOUCESTER, GL2 6XX, ENGLAND

Telephone: GLOUCESTER (0452) 21401 Telex: 43330

Generating Sets supplied by Lister — Hawker Siddeley Power Plant Ltd.

THRUPP, GLOUCESTERSHIRE, GL5 2BW, ENGLAND

Telephone: BRIMSCOMBE (0453-88) 5166 Telex: 43559

OR YOUR NEAREST LISTER DISTRIBUTOR

FOREWORD

This manual covers the operation and servicing of Lister TS2/3 Engines.

The Manual is divided into sections as listed in the Index which are arranged to show the complete strip and assembly sequence for each component part of the engine and its accessories. All the salient external features of the basic engine can be identified by reference to the photographs on pages 51 to 53.

TS engines are manufactured in a range of standard Builds, each incorporating certain features to allow engines to be adapted for various applications by the addition of a range of easily fitted accessories. Appendices at the end of the book give a brief description, speed setting etc. for each Build, and a comprehensive list of coded accessories. Appendix C lists a complete strip and rebuild procedure together with cross references for more detailed information.

The use of genuine Lister replacement parts will assure the correct material, dimension and high standard of quality associated with the original engine components. When ordering replacement parts, always quote the engine serial number which will be found on the right hand side top corner of the cowling as seen when facing the manifold side of the engine.

The information, specifications, and illustrations in this publication are correct at the time of going to print. Our policy is one of continued development and we reserve the right to amend any of the information contained in this book without prior notice.

IMPORTANT

When purchasing parts or giving instructions for repairs customers should in their own interests, always specify:

Genuine Lister Parts

Parts that have not been supplied by the Lister organisation cannot be relied upon for correct material, dimensions or finish.

R. A. LISTER & CO. LTD. cannot therefore, be responsible for any damage arising from the use of such parts and the guarantee will be invalidated.

In your own interest, therefore, specify:

GENUINE LISTER PARTS

INDEX

INDEX

RATING DEFINITIONS

All declarations of power are conditional upon the use of the correct grades of fuel and lubricating oil as specified by R. A. Lister & Co. Ltd., and correct maintenance at the prescribed intervals.

1. BS5514 CONTINUOUS RATING is the net output in kW (hp) which the engine is capable of delivering continuously at a stated crankshaft speed under conditions of 750mm Hg. (29.5 in Hg) barometric pressure, 60% relative humidity and 27°C (81°F) air inlet temperature.

The engine is capable of providing an overload output 10% in excess of the BS continuous rating, at the same speed, for one hour in any period of twelve hours consecutive running.

2. BS649 CONTINUOUS RATING is the net output in kW (hp) which the engine is capable of delivering continuously at a stated crankshaft speed under conditions of 749mm Hg. (29.5 in Hg) barometric pressure, 50% relative humidity and 29.4°C (85°F) air inlet temperature.

The engine is capable of providing an overload output 10% in excess of the BS continuous rating, at the same speed, for one hour in any period of twelve hours consecutive running.

3. DIN 6270NB (DIN 'B') RATING is the output in CV (kW) which the engine is capable of delivering continuously for a period of one hour within a 6 hour period of fluctuating low load operation, under conditions of 736 mm Hg (29 in Hg) barometric pressure, 60% relative humidity and 20°C (68°F) air inlet temperature. No overload is permitted.

4. MAXIMUM GROSS RATING is the kW (hp) which the engine develops on the dynamometer without driving any power consuming accessories or auxiliaries. The use of this rating is not covered by the terms of the guarantee.

5. HEAVY DUTY OPERATION When the engine is required to operate under conditions involving poor maintenance or long periods of unattended running, at a high load factor, particularly in conjunction with high air inlet temperatures, the engine should be limited to the BS5514 rating at 2500 rev/min with no overload capacity. Typical application, irrigation pumping.

6. THE OVERLOAD CONDITION TO BS5514/649 AND THE DIN 'B' RATING APPLY ONLY TO A FULLY RUN-IN ENGINE. THIS IS NORMALLY ATTAINED AFTER A PERIOD OF ABOUT 50 HOURS RUNNING, but, if specially negotiated, engines can be supplied delivering these powers ex works.

7. The BS and DIN definitions given are approximate abbreviations and are not binding. For full details reference must be made to the relevant specifications.

8. DE-RATING

(a) For non-standard site conditions, reference should be made to the relevant BS and DIN standards.

(b) Accessories reduce the rated engine power as follows:-

- (i) Speed increase or reduction gears, marine or industrial — 5% .
- (ii) Marine reverse gears — 10%
- (iii) Belt drives — 5%
- (iv) Hydraulic transmissions — on request
- (v) See Section 8 for power absorbed by flywheel mounted alternator.

GUARANTEE. Under the terms of the guarantee, the rating selected must be appropriate to the operational conditions of the engine.

Section One
GENERAL INFORMATION

TECHNICAL DATA TS2 — AIR COOLED ENGINE

Engine

Type	Four stroke, vertical two cylinder, direct injection Diesel engine.
Bore and Stroke	95.25 mm. x 88.9 mm. (3.75 in. x 3.5 in.)
Cylinder Capacity (2 cyls.)	1.27 litres (77.3 in.^{3})

POWER OUTPUTS		
Rev/Min	**hp/kW (to BS649 or BS5514) continuous**	**kW/CV (to DIN 6270N$_B$) Intermittent**
1500	12.00/ 8.95	9.84/13.38
1800	14.70/10.96	12.06/16.40
2000	16.50/12.30	13.53/18.40
2500	20.18/15.05	16.56/22.51
2600	20.70/15.44	16.98/23.09
3000	22.00/16.41	18.05/24.54

B.M.E.P.	5.77 bar (83.66 lbf/in.^{2}) at 1800 rev/min.
Weight (Basic engine)	149 kg. (328 lb.) approx.

No. 1 Cylinder is at opposite end to Flywheel.

Lubricating System

Oil Pressure—normal	2.0 bar (29 lbf/in.^{2}) at 1500 rev/min.
—minimum	0.7 bar (10 lbf/in.^{2}) at 1000 rev/min.
Oil Pump	Self regulating plunger pump.
Oil Filter	Screw on cartridge type.
Oil Consumption	Less than 0.75% of full load fuel consumption.
Sump Capacity (engine level)	4.30 litre 7.60 imp. pints 4.60 U.S. quarts.

Fuel System

Fuel Pumps	Bryce Berger (2)
Fuel Filter	Cartridge or bowl and element type
Injectors	Bryce Berger (2)
Injector Pressure	190 Atmospheres
Fuel Consumption (approx.) g/kWh lb/hp h (at full load subject to 5% B.S. tolerance)	266-0.437 at 3000 rev/min 259-0.426 at 2600 rev/min 257-0.423 at 2500 rev/min 248-0.408 at 2000 rev/min 244-0.401 at 1800 rev/min 241-0.396 at 1500 rev/min

BS5514 is the equivalent of ISO-3046

Fuel Consumption

The fuel consumption figures apply to fully run-in, non derated, bare engines without power absorbing optional accessories, transmissions or marine gearboxes, etc.

Rotation is anti-clockwise looking on flywheel

TECHNICAL DATA TS3 – AIR COOLED ENGINE

Engine

Type	Four stroke, vertical three cylinder, direct injection Diesel engine.
Bore and Stroke	95.25 mm. x 88.9 mm. (3.75 in. x 3.5 in.)
Cylinder Capacity (3 cyls.)	1.90 litres (116.0 in.^{3})

POWER OUTPUTS		
Rev/Min	**hp/kW (to BS649 or BS5514) continuous**	**kW/CV (to DIN 6270N$_B$) Intermittent**
1500	18.00/13.42	14.76/20.08
1800	22.05/16.44	18.09/24.59
2000	24.75/18.46	20.30/27.61
2500	30.27/22.57	24.83/33.76
2600	31.05/23.15	25.47/34.63
3000	33.00/24.61	27.07/36.81

B.M.E.P.	5.77 bar (83.66 lbf/in.^{2}) at 1800 rev/min.
Weight (Basic engine)	208 kg. (459 lb.) approx.
Firing Order	1—2—3

No. 1 Cylinder is at opposite end to Flywheel.

Lubricating System

Oil Pressure—normal	2.0 bar (29 lbf/in.^{2}) at 1500 rev/min.
—minimum	0.7 bar (10 lbf/in.^{2}) at 1000 rev/min.
Oil Pump	Self regulating plunger pump.
Oil Filter	Screw on cartridge type.
Oil Consumption	Less than 0.75% of full load fuel consumption.
Sump Capacity (engine level)	6.50 litre 11.40 imp. pints 6.80 U.S. quarts.

Fuel System

Fuel Pumps	Bryce Berger (3)
Fuel Filter	Cartridge or bowl and element type
Injectors	Bryce Berger (3)
Injector Pressure	190 Atmospheres
Fuel Consumption (approx.)	266-0.437 at 3000 rev/min
g/kWh lb/hp h	259-0.426 at 2600 rev/min
(at full load subject to 5% B.S.	257-0.423 at 2500 rev/min
tolerance)	248-0.408 at 2000 rev/min
	244-0.401 at 1800 rev/min
	241-0.396 at 1500 rev/min

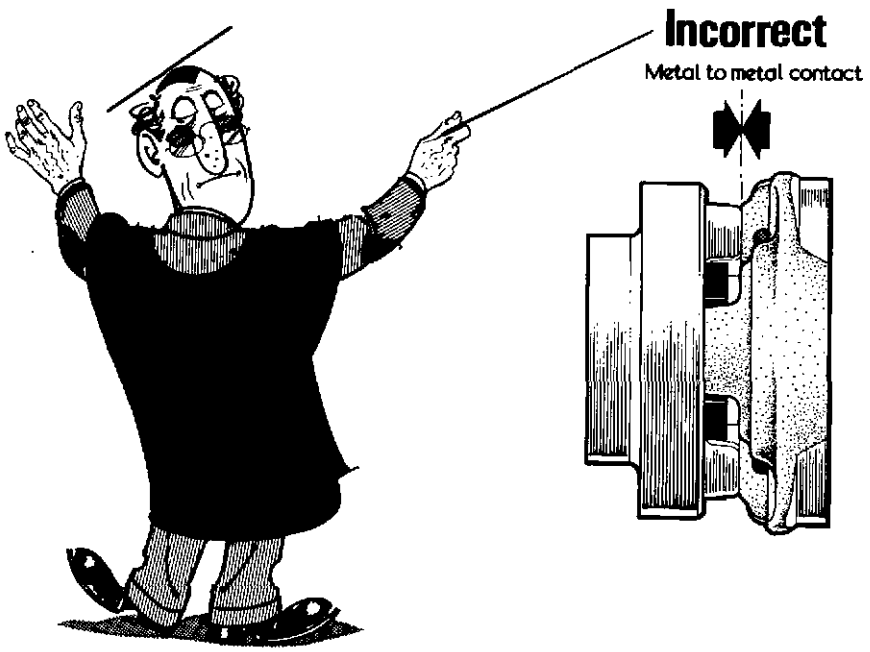
BS5514 is the equivalent of ISO-3046

Fuel Consumption

The fuel consumption figures apply to fully run-in, non derated, bare engines without power absorbing optional accessories, transmissions or marine gearboxes, etc.

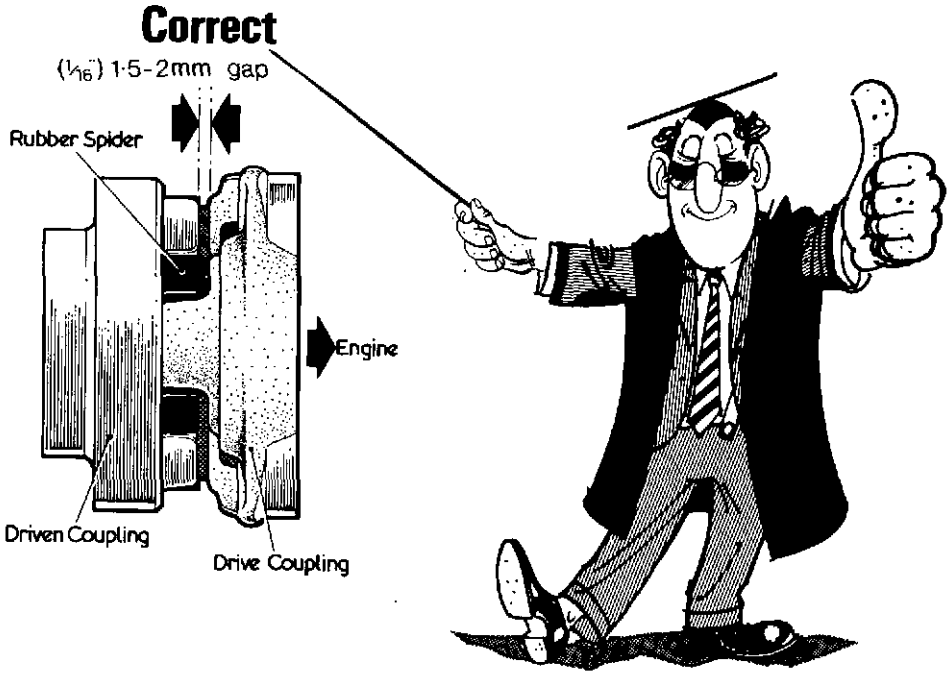
Rotation is anti-clockwise looking on flywheel

FENNER COUPLING HRC (See Sect. 5)



① Fit drive coupling to engine.
② Fit rubber spider to drive coupling.
③ Fit driven coupling to driven equipment shaft.
④ Offer up driven equipment and adjust driven coupling to ensure there is a minimum clearance of ($\frac{1}{16}$") 1·5mm between the couplings. See diagrams.

REMEMBER–END FLOAT IS ESSENTIAL TO AVOID SEIZURE



INSTALLATION INFORMATION—INDUSTRIAL ENGINES

The engine should be bolted down to a rigid bed to ensure there is no excessive vibration and installed where a generous supply of fresh air is assured. (see COOLING AIR CONSIDERATIONS)

DISTORTION

Customers installing engines in their own equipment must ensure that no strain is imposed on the engine feet either by distortion during installation (feet not correctly shimmed) or by deflection of the structure during operation.

COOLING

The engine is cooled by air. Arrangements must be made to ensure the cooling air is not re-circulated or restricted.

A fan impeller is secured to the flywheel. Air is drawn into the impeller and discharged through trunking and shrouding to the fins of the cylinder, cylinder head and crankcase.

HAND STARTING

TS engines can be started from the camshaft.

BELT DRIVE

Driving belts must be run as close to the engine as possible to avoid undue strain on the bearings.

EXHAUST SYSTEM

In general the exhaust pipe run should be kept as short and straight as possible. A silencer, or expansion chamber, should be fitted near the engine. The tail pipe beyond the silencer should be about 30 times the pipe diameter in length. When long tail pipes have to be fitted the bore of the pipe must be increased as shown in the accompanying table. When the larger diameter pipes are fitted they should be fitted from the silencer onward.

A back pressure of about 1½ lbf/in.^{2} (40in. water gauge) (3in. mercury) at the point where the exhaust pipe joins the manifold must not be exceeded.

Bends should have a radius of not less than 4 diameters at the centre line of the pipe. When reckoning the total effective length of the pipe an allowance of 1 foot to the total centre line length must be made for each bend in the system. If the bends are sharper than 4 diameters then the allowance must be increased to 2 feet per bend.

Where pipes must be led upwards from the engine a suitable drain cock, or drain tap with cock, should be fitted at the lowest point to prevent the condensate running into the engine.

Normal Pipe B		Maximum total length of exhaust pipe TS2/TS3	
in	mm	ft.	m.
1¾	44.5	15	4.5
2	50.8	25	7.5
2½	63.5	62	18.8
3	76.2	129	39.1

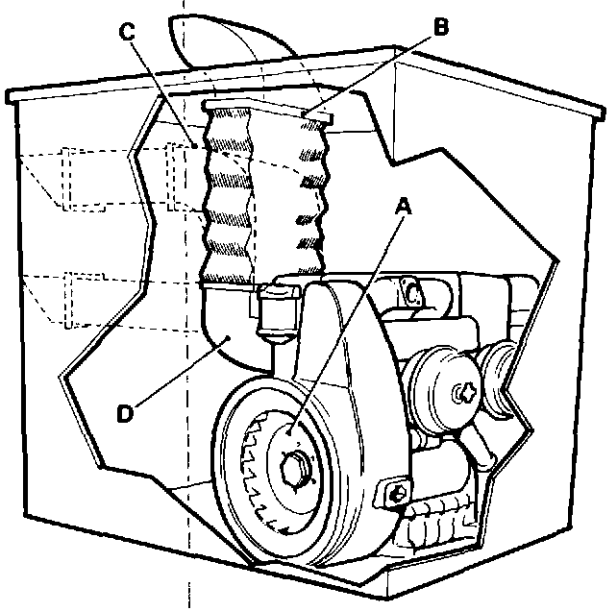
Example:— In an exhaust system which measures 15 feet, 1¾in. (44.5 mm) pipe would be required for TS2 but, if there were five simple bends in the system then the total effective length would be 15 + 5 = 20 ft. (4.5 ÷ 1.5 = 6.0 m) and the pipe size would have to be increased to 2in. (50.8 mm).

TEMPERATURES

From the aspect of engine performance, the temperature of the air entering the engine is the only criterion of ambient temperature. The power developed by the engine depends on the temperature of the combustion air, measured at the air manifold inlet (or the air cleaner), and the temperature of the cooling air as measured at the fan inlet. The higher of these two temperatures is taken as being the "Ambient Temperature" as far as engine ratings are concerned.

The engines are able to run satisfactorily at Ambient temperatures up to 29.4°C (85°F) without derating. Above this temperature the rated brake horsepower must be reduced by 1% for every 2.78°C (5°F). The maximum temperature is 52°C (125°F), and if it is desired to run at higher temperatures, R. A. Lister & Co. Ltd., or their Distributors must be consulted.

COOLING AIR CONSIDERATIONS



Diag. 1 Method of leading out the hot cooling air in small enclosed compartments.

A It is absolutely essential that the hot cooling air discharge does not find its way to the cooling inlet and become recirculated.

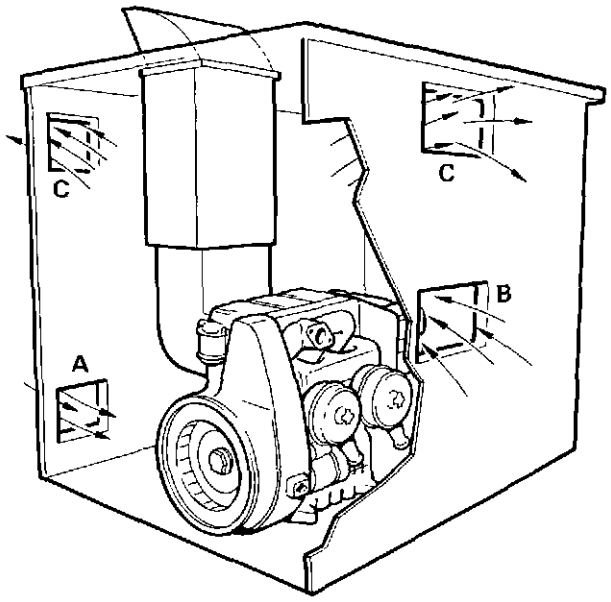
B Flexible trunking of canvas, rubberized canvas or heat resisting rubber.

C One of these alternative methods must be used if engine is flexibly mounted.

D Ducting should be fully detachable for servicing and priming fuel pump and the trunking must be attached so that it does not impair the quick removal of the ducting.

The extension of the ducting, the trunking and the cowl are to be supplied by the customer. For lengths up to 1.5 m. (5 ft.) the minimum inside area to be:—
333 cm.^{2} (51 in.^{2}) for TS2
526 cm.^{2} (81 in.^{2}) for TS3

For 1.525 m. to 3.05 m. (5-10 ft.) multiply by 1.4.
For 3.05 m. to 7.625 m. (10-25 ft.) multiply by 2.25.
For 7.625 m. to 15.25 m. (25-50 ft.) multiply by 3.5.

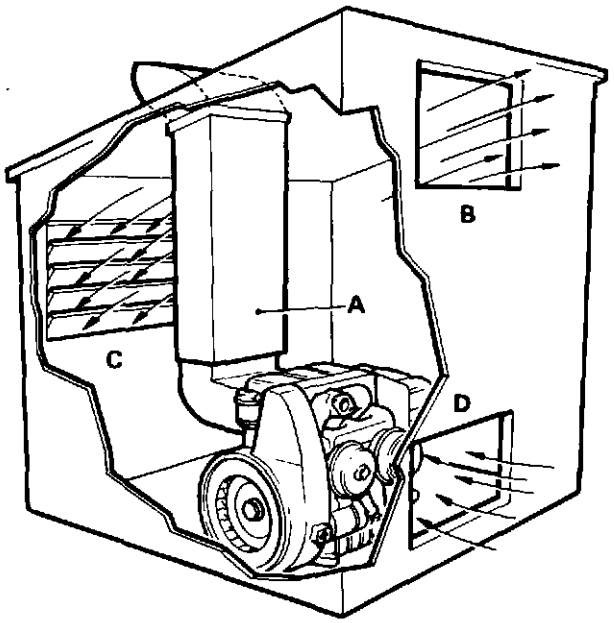


Diag. 2 Notes on Air Intakes

A One of the cooling air intake holes must be near the bottom of engine room to bring cool air in and also to strike the engine sump to assist cooling the lubricating oil.

B Another intake hole must be opposite the air filter to ensure a good supply of cool combustion air.

C One or two cooling air intake holes must be near the top of the engine room to prevent an accumulation of hot air above the engine. Generally it is not desirable to place an air intake hole opposite the engine cooling fan, because the rest of the engine room will not be ventilated (except where the ambient temperature exceeds 49°C (120°F) when it is essential for the engine to be as cool as possible under these conditions).



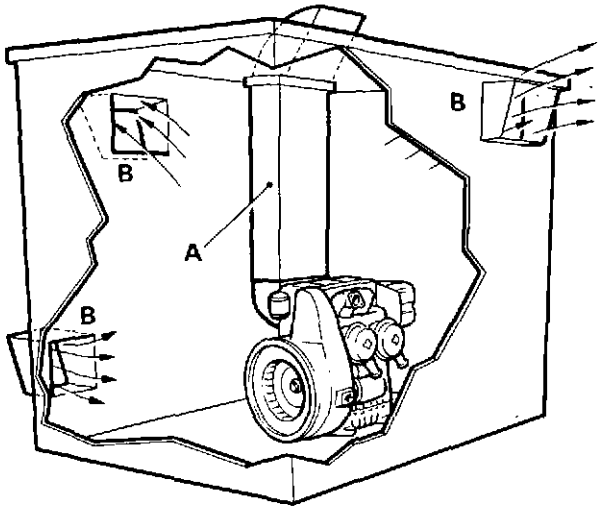
Diag. 3 Installation in moderate size engine house. 3.05 m. x 1.83 m. (10 ft. x 6 ft.)

A Engine ducting, trunking and cowl to be used in tropical climates, and also in other climates *when a cool engine house is required.*

B Window 62 x 62 cm. (2 ft. x 2 ft.) near the roof and opposite the main window capable of being fully opened.

C Large window opposite the engine air outlet, capable of being fully opened (or if louvred, slots to be 102 mm. (4") apart).

D Window 62 x 62 cm. (2 ft. x 2 ft.) near the floor and opposite main window or in the wall nearest the engine fuel filter, capable of being fully opened.



Diag. 4 Installation in confined space where air intake holes have to be as small as possible.

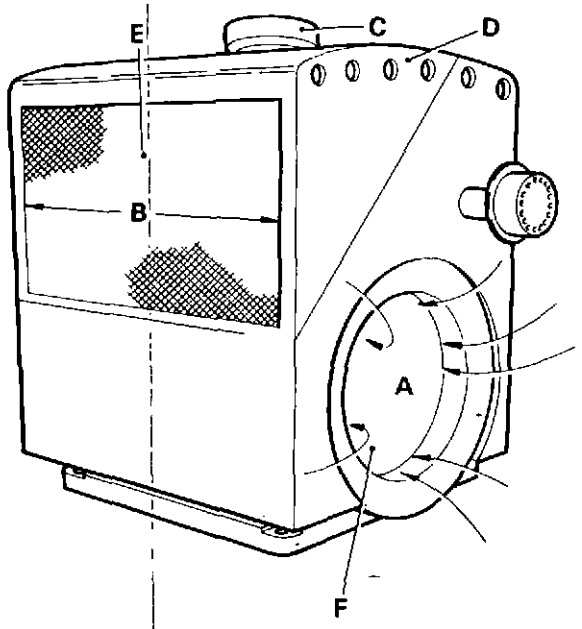
A Area of trunk and cowl to be as given in Diag. 1.

B Air intake holes to be in positions shown and all the same size to ensure even air distribution.

For area of intakes consult with RAL.

NOTE: The air supply to the engine room must be at least 30% greater than the air required for cooling (see page 12), to allow for combustion air consumption.

WARNING: THE EXHAUST SYSTEM MUST ALWAYS BE TAKEN TO THE OUTSIDE OF THE ENGINE ROOM.



Diag. 5 Engine installed in a housing which itself is in the open with unobstructed air all round. (2 and 3 cylinder engines only).

A 381 mm. (15 in.) minimum diameter hole opposite flywheel air intake.

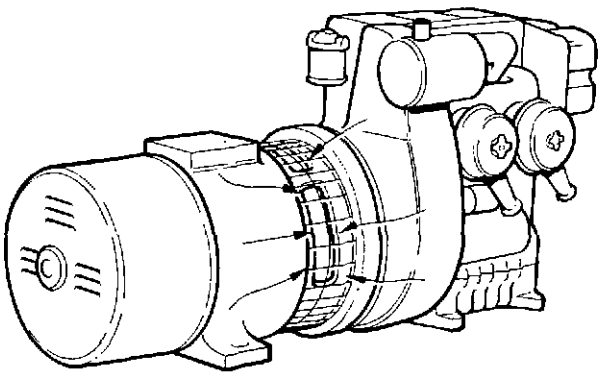
B 533.4 mm. (21 in.) for two cylinder engine: 660.4 mm. (26 in.) for three cylinder engine.

C Combustion air intake brought outside.

D At least 6 ventilating holes each end 25.4 mm. (1 in.) dia.

E Open mesh grille opposite hot air side of engine. Free area through grille, 450 cm.^{2} (70 in.^{2}) (minimum) for two cylinder engine; 970 cm.^{2} (105 in.^{2}) (minimum) for three cylinder engine.

F Flywheel air intake to be against this end.



Diag. 6 Engine close coupled to a driven machine

A typical air intake area in the adaptor is 288cm.^{2} (44.6in.^{2})

Larger areas are preferred. The coupling or clutch driving member at the flywheel end must not obstruct the air flow to the fan, and the areas above must be maintained at this point and through to the fan.

Note: Information on alignment and air flow through louvres or grille can be found on pages 15 and 16.

CRANKCASE VACUUM

The value depends to some extent on the type and size of air cleaner fitted to the engine.

Regardless of the type of air cleaner used, the vacuum with a clean air cleaner must not be less than the minimum figures given in the table below measured at the dipstick adaptor hole at any speed after the engine has run 1½ hours from new.

ENGINE	VACUUM mm W.G.	
	Minimum	Average
TS2	25	45
TS3	30	75

Vacuums as high as 150 mm W.G. are sometimes recorded.

In engines in good condition the vacuum increases slightly with engine speed but not gradually. A fluctuating vacuum may indicate faulty oil seals or valves, or piston blow-by troubles. Crankcase pressure can cause serious oil leaks, and often occurs in engines which need overhauling.

COOLING AIR FLOWS AND PRESSURES

The following figures are only provisional. They vary for individual engines, and are affected by the method of measurement used.

	Air Flows Through Cylinders and Heads, m^3/s Air Pressures, mm WG			
	TS2		**TS3**	
rev/ min	**m^3/s**	**mm WG**	**m^3/s**	**mm WG**
1500	0.11	30	0.16	30
1800	0.13	43	0.20	43
2000	0.15	53	0.22	53
2500	0.18	83	0.27	83
3000	0.22	120	0.33	120

Add 15% to the air flows for the air bleed through the oil cooling fins on the crankcase. The pressures are those required to induce the total air flow including bleed.

To convert mm WG to ins WG multiply by .039.

INSTALLATION INFORMATION—MARINE ENGINES

GENERAL

Before arranging your installation it is imperative that careful consideration be given to the general layout of the machinery, and to the cooling of the engine; the guidance notes on the arrangement drawings must be followed.

Careful consideration should be given to ensure accessibility and ease of maintenance, any housing must be constructed so that the sides and forward portion can be dismantled for servicing without disturbing the controls or instruments. The housing should not be connected directly to the engine bearers but fastened to a coaming on the deck or cockpit floor.

COOLING

Unless an adequate supply of air is allowed to circulate around the engine and means are taken to prevent the same air re-circulating, the engine will lose power due to overheating.

Provision is made on the engine to take the customer's air outlet ducting. Sizes of air inlets and outlets as specified are minimum and must not be obstructed in any way. If wooden slats, or wire mesh having not less than 6.35mm x 6.35mm (¼'' x ¼'') mesh between the wires, are fitted as protective measures over openings, the area of the openings must be increased to compensate for same, thus maintaining the net specified area.

It is recommended that the portion of ducting which attaches to the outlet port on the engine should be made of fire resistant material and be made readily detachable. When engines are flexibly mounted due allowance must be made in the length of ducting between engine and fixed ducting.

An unrestricted flow of cold air to the engine fan must be maintained, inlets for cooling air should be designed to give not less, and preferably more, than the sectional area specified.

To ensure efficient engine operation the combustion air cleaner must receive an adequate supply of cold air. To ensure this the cleaner may, if found necessary, be removed from the engine and fitted in a protected position on deck or at engine bearer level, the connection between engine and cleaner being by flexible pipe.

Where hot air is led away by trunking, this hot air can be utilised to heat accommodation and ventilate cupboards, etc., but the recirculation of this air back to the engine compartment must be prevented and, further shutters or similar fittings used to control the air to the accommodation must operate in the heating trunk — not in the engine discharge trunking.

Heat radiated from the engine must be expelled from the engine case or compartment. Where an engine is installed in a case, a series of one inch diameter holes near the top will give adequate top ventilation. When fitted in a compartment, cowl ventilators opening just below the top of the compartment, will dispel the heat; extractor fans installed in the ventilators will obviously improve this arrangement.

EXHAUST SYSTEM

Pipes should slope gradually away from the engine down to the outlet on ship's side or transom and be kept as straight and short as possible, the minimum radius in any bend being not less than 4 times the pipe bore. Adjacent wood structure must be protected from exhaust heat by adequate clearance and lagging.

If it is found necessary to fit a swan neck in the exhaust pipe to prevent the ingress of water, a small .793mm (1/32'') diameter hole must be drilled in the top of same to break the vacuum and a drain plug or cock should be fitted at the lowest point in the pipe.

CASINGS OR COMPARTMENTS

These can be constructed of 9.53mm (⅜'') bonded marine plywood to BSS 1080 on substantial framing and have portable panels secured by cuphead screws for ease of servicing. The noise level can be effectively reduced by lining the box or compartment with resin impregnated glass fibre type 425 secured in position by 0.5mm (25 gauge) perforated zinc plate having 51-2.38mm (3/32'') dia. holes per square inch. Glass fibre can be obtained in varying thicknesses but for

pleasure craft or vessels operating in confined waters a thickness of 50.8mm (2") is recommended.

Where large openings in the casing cannot be avoided, the noise level can be further reduced by fitting plywood baffle plates faced with glass fibre and perforated zinc but it is essential that the area between the casing and the baffle is not below the specified requirement.

ENGINE MOUNTING (Diag. 7)

To provide a rigid bed free from alignment troubles it is essential in the case of wooden hulls to ensure that the engine bearers extend as far forward and aft as possible, and are made of well seasoned wood of liberal size so arranged that they are an integral part of the ship's hull. In addition a steel plate should be placed along the top of the bearer the length of the engine base to prevent the engine feet biting into the bearers. Bearers must be adequately supported by athwartship members secured to the hull structure. See also page 17.

Since NO PROVISION is made in the engine design to take END THRUST, a thrust block must be provided for all propulsion installations.

Most proprietary gearboxes are provided with thrust bearings, if in doubt check manufacturers instructions.

On propulsion units when a flexible coupling is fitted, a plummer block must be fitted to the tailshaft if the stern tube forward bearing is more than 228.6mm (9") from the edge of the tailshaft coupling.

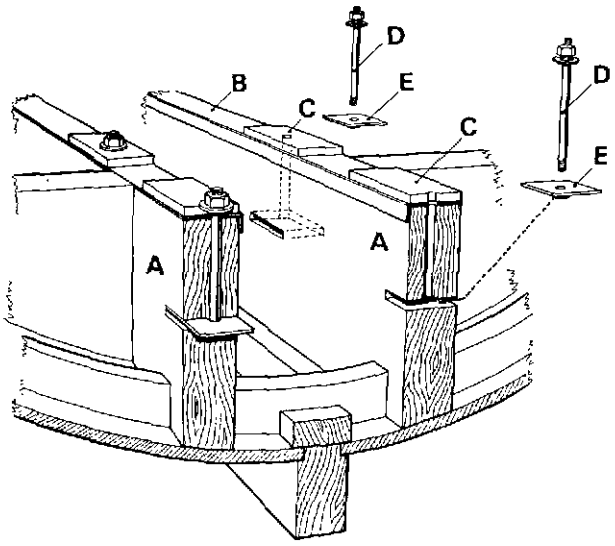
Propellers must run in adequate apertures and never behind heavy square ended body posts. These should be tapered off to an inclusive angle of about 40°. The distance between the outboard gland and the propeller boss should not be greater than the diameter of the shaft.

FLEXIBLE MOUNTINGS

Allowance must be made for the engine to clear bearers by at least 12.7mm (½"), and to clear any casing, including air ducts or deflectors which might be fitted, by 25.4mm (1") to allow for engine movement.

INCLINATION

The maximum angle of inclination at which engines may be run is 15° flywheel up or down.



A—Engine Bearers.
B—Soleplate.
C—Chocks.
D—Holding Down Bolt.
E—Nut welded to steel plate.

Diag. 7 Installation in a wooden vessel

ROTATION

Engine rotation is anti-clockwise when looking on flywheel end of engine. When reverse/reduction gear is fitted rotation of the output coupling is anti-clockwise.

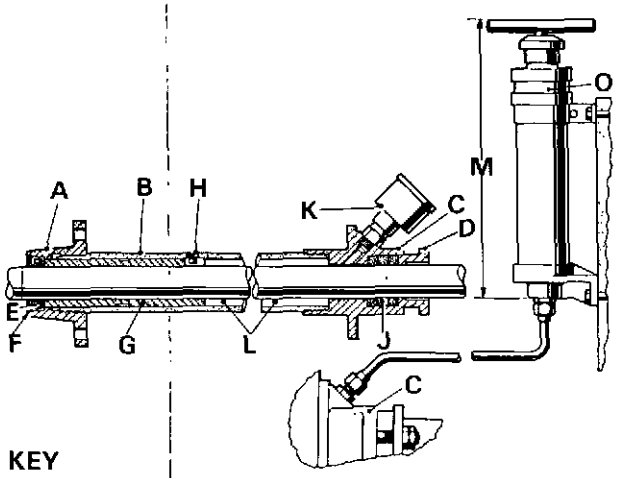
TEMPERATURES

From the aspect of engine performance, the temperature of the air entering the engine is the only criterion of ambient temperature. The power developed by the engine depends on the temperature of the combustion air, measured at the air manifold inlet (or the air cleaner), and the temperature of the cooling air measured at the fan inlet. The higher of these two temperatures is taken as being the "Ambient Temperature" as far as engine ratings are concerned.

The engines are able to run satisfactorily at Ambient temperatures (as defined above) up to 29.4°C (85°F) without derating. Above this temperature, the rated brake horsepower must be reduced by 1 per cent for every 2.78°C (5°F). The maximum temperature is 52°C (125°F), and if it is desired to run at higher temperature Hawker Siddeley Marine, or their Distributors must be consulted.

STERNGEAR (Diag. 8)

Packing glands should allow free rotation of the tailshaft. Stern tubes should be filled with grease before inserting shaft. Before launching, run engine to ensure that packing glands do not overheat. If necessary slacken back gland. Long lengths of unsupported shafting must be avoided by the use of plummer blocks.



KEY

A—Tail Housing.
B—Stern Tube.
C—For'd Bracket.
D—For'd Gland.
E—Water and Sand Seal.
F—Spring Ring.
G—Aft Bearing.
H—Locating Screw.
J—Packing.
K—Stauffer Grease Cup.
L—Annular Grease Space.
M—Grease Gun Height: Empty 304.8mm (12''), Full 495.3mm (19½'').
O—Grease Gun—0.426 litre (3/4 pt.) cap—optional.

Diag. 8 Stern Gear

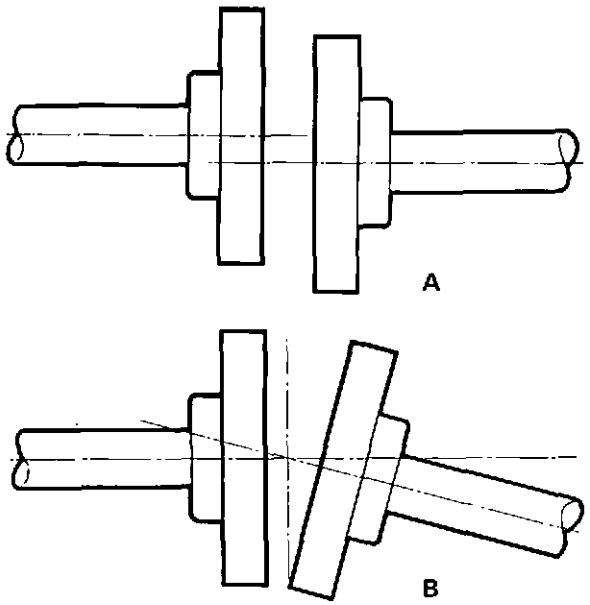
IMPORTANT

The sterntube MUST be filled with a suitable grease, such as Vickers "NEOX DT" immediately after installation. To ensure complete filling of the tube it is imperative that a grease gun be used for the initial filling. For service, regular attention to the grease cup provided should be sufficient to make up any loss incurred.

ALIGNMENT

It is often thought that little attention need be paid to accurate alignment when a "flexible coupling" is fitted between the engine and driven unit but such optimism is seldom justified in practice. Irrespective of the type of coupling used, the coupling life will be longer, the chance of coupling or shaft failure will be greatly reduced, and vibration of the combined set will be minimised if proper attention is paid to the alignment problem.

Two principal types of misalignment can occur — parallel misalignment and conical misalignment, or there can be a combination of these two.



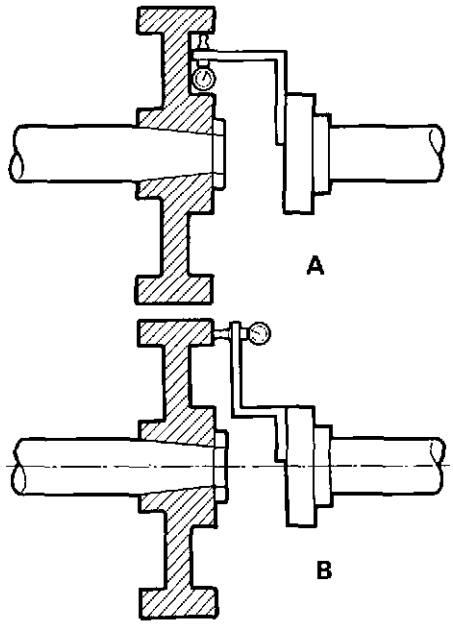
Diag. 9 Misalignment

(a) **Parallel Misalignment (A)**— when the shaft of the driven unit is parallel to, but not in line with, the engine output shaft.

(b) **Conical Misalignment (B)**— when the axes of the two shafts meet at the correct point, but the shafts are not parallel to each other.

CHECKING FOR MISALIGNMENT (Diag. 10)

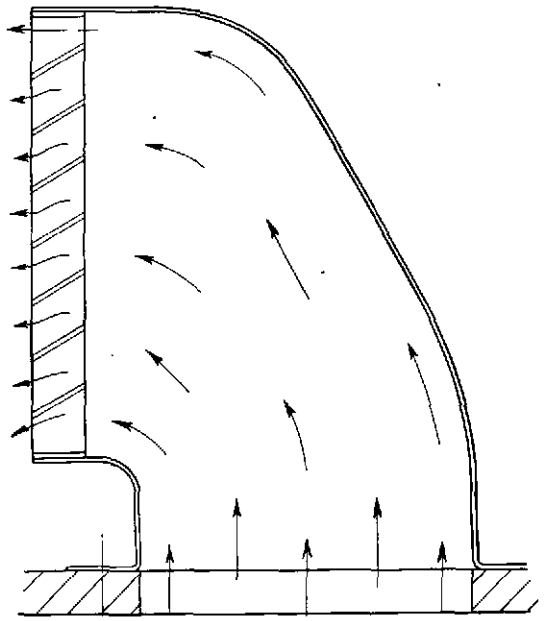
Each type of misalignment is checked individually by having a bracket or clock gauge rigidly bolted to the flange of the driven unit, when suitable, and rotating through 360° to check the clearance to (A) the inside (or outside) of the flywheel rim for parallel misalignment, and (B) the clearance to the flywheel face for conical misalignment. Readings should not vary by more than 0.127mm (0.005") throughout one revolution.



Diag. 10 Checking Alignment

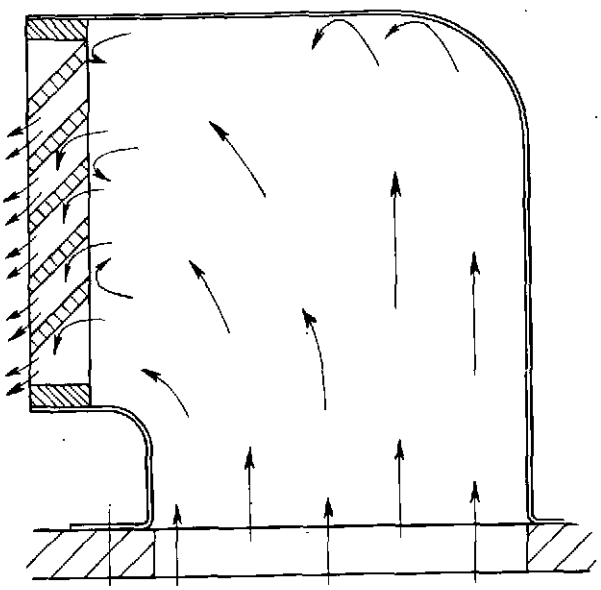
AIR FLOW

Grilles, wire mesh or louvres placed in the air stream are obstructions and allowance must be made for them. The free flow area of these must be calculated to ensure that it is at least 25 per cent greater than that specified for the inlet and outlet passages.



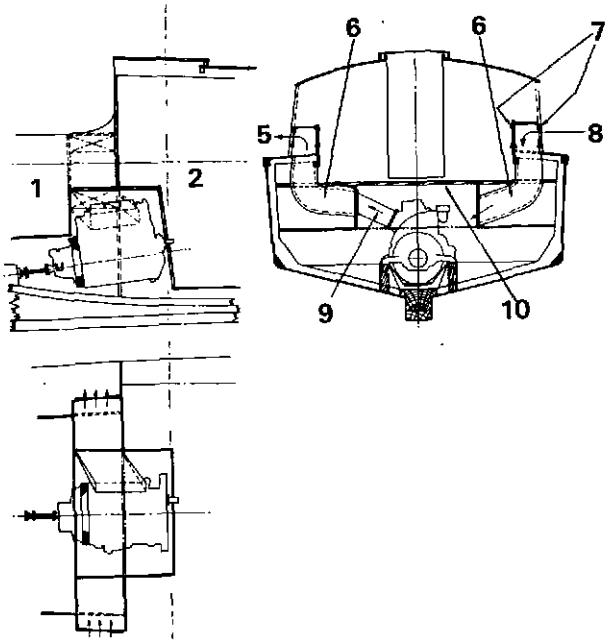
CORRECT —
Area through louvres or grille is at least 25 per cent greater than area of ducting.

Diag. 11 Cowl

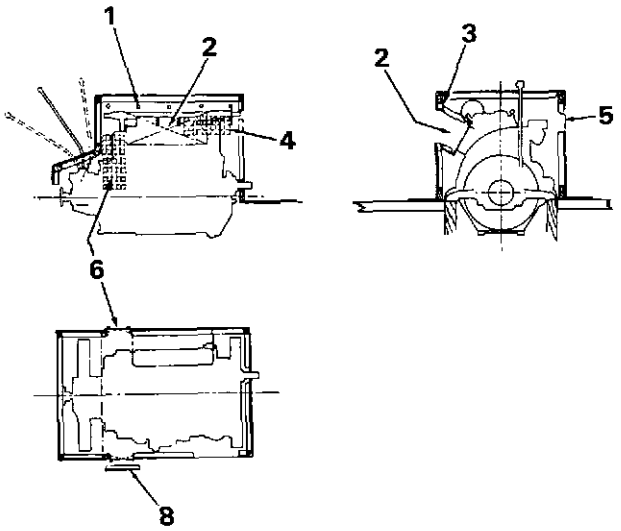


WRONG —
Louvres or grille obstructs air flow. Area through louvres is smaller than area of ducting.

Diag. 12 Cowl



Diag. 13 Installation below deck



Diag. 14 Installation in open boat

Key to Diag. 13

1—Cockpit.
2—Cabin.
5—Outlet.
6—Inlet & Outlet Trunks lined internally with 25.4mm (1'')thick fibre glass faced with perforated zinc.
7—In bad weather shutters may be fitted to outboard inlets and inboard inlets used, P & S.
8—Inlet.
9—Portable Ducting of plywood or heavy canvas expanding from engine duct size to area of duct given in table.
10—Hot air to be vented from top of engine to atmosphere.

Key to Diag. 14

1—25.4mm (1'') dia. holes near top to expel radiated heat.
2—Hot air outlet duct of sheet steel lined with 25.4mm (1'') fibre glass. Minimum area of duct to be as given in table.
3—Outlet duct to be a close fit but not secured to engine box.
4—Combustion Air Inlet.
5—Combustion Air Inlet covered with wire mesh.
6—Air Inlet each side giving a total unobstructed area as shown in table.
8—To further reduce the noise, plywood baffles faced with fibre glass may be fitted in way of inlets, but inlet area between baffle and box must not be less than that specified.

Note — Engine Box may be constructed of 9.53mm (3/8'') resin bonded marine plywood to BSS 1088 on substantial framing. To reduce the noise level, the inside of the box can be lined with resin impregnated fibre-glass of a minimum thickness of 25.4mm (1'') 50.8mm (2'' thick preferred).

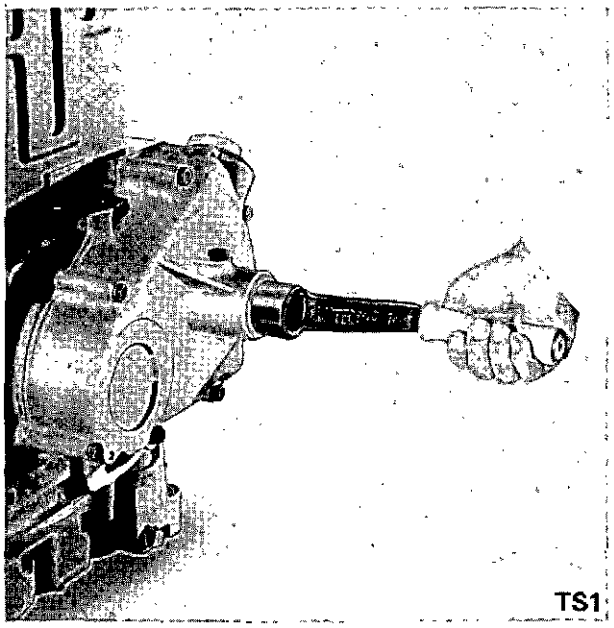


Fig. 1 Hand Starting

OPERATING INSTRUCTIONS

To Start the Engine (Fig. 1) — Hand Starting

(a) *Check the fuel and lubricating oil levels.*

(b) Ensure that the fuel and oil systems are primed.

(c) If the engine is fitted with a fuel lift pump, prime the fuel filter by using the priming lever on the lift pump.

(d) Check the engine control is in the start position. (Clockwise position).

(e) Move the decompressor levers over towards the flywheel.
Note: On engines fitted with speed control, set the lever to the 'Fast' position.

(f) **Important: Lightly oil the inside of the starting handle and fit the handle to the camshaft, first ensuring that the starting handle is the correct one and is fully serviceable. (See inside front cover for safety precautions when starting diesel engines by hand).**

(g) Turn the engine slowly from 3 to 20 turns on the camshaft according to the temperature *and period of standing unused, in order to* prime the combustion chambers and the lubricating oil system.

(h) Turn the engine in the correct rotation and *when maximum cranking speed is reached* operate decompressors. Continue to crank until the engine fires. Retain grip on the starting handle and then remove the handle from the shaft.
WARNING: IT IS DANGEROUS TO ALLOW THE HANDLE TO ROTATE ON THE RUNNING SHAFT.

(j) *If fitted, reduce speed control as desired.*

Note: If an engine fitted with Automatic excess fuel *stops other than by the operation of the engine* control, the control must be turned to the 'STOP' position and then released in order to select excess fuel.

To Start Engine (Electric Starting with Key Switch)

Carry out Items (a) to (d) as hand starting, set speed control if fitted.

(e) *Turn switch in clockwise direction until the* engine fires.
Note: After the engine has been stopped ensure the switch is turned to the off position to prevent the warning light remaining on.

To Start Engine (Electric Starting with Starter Button)

Carry out Items (a) to (d) as hand starting, set speed control if fitted.

(e) Press starter button and release immediately the engine fires.
If fitted reduce speed control as desired.

Note: Further information and wiring diagrams for *electric starting systems.can be found in Section 8.*

COLD STARTING (Below – 10°C)

A cup and plunger may be fitted on the combustion air intake port of each cylinder on TS engines. To operate withdraw plungers and fill one third of the cups with the same type of lubricating oil as used in the engine. Replace plungers and inject the oil before starting. The device must not be used more than three times in succession. When hand starting, turn the engine through 20 revolutions with the fuel on after injecting the oil before attempting to start.

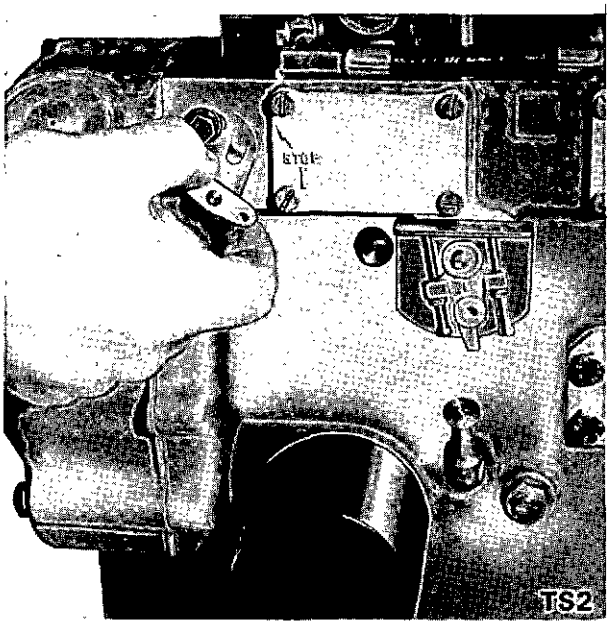


Fig. 3 Stopping Engine

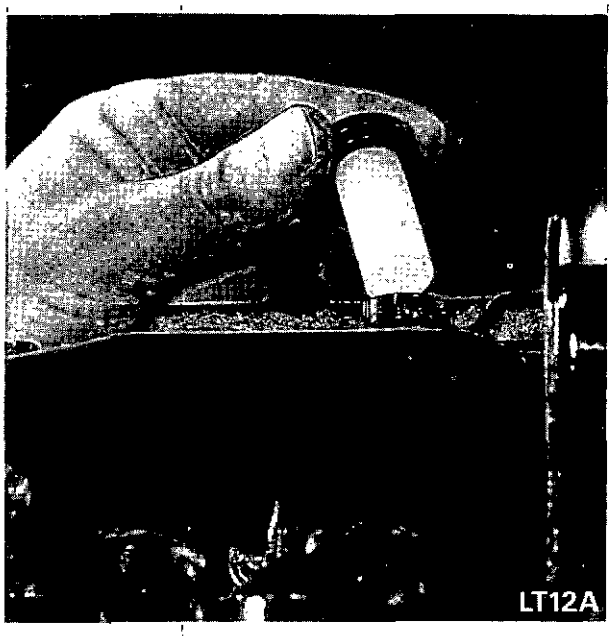


Fig. 2 Oil Priming Cup

TO STOP ENGINE

Turn the stopping lever anti-clockwise until the engine stops. When remote control is fitted, move the lever to the STOP position.

WARNING: AFTER PROLONGED RUNNING THE STOPPING CONTROL MAY WELL BE HOT, USE SUITABLE PROTECTION FOR THE HANDS WHILST OPERATING THE CONTROL. ON LATER ENGINES A PLASTIC COVERED CONTROL IS FITTED. (See Fig. 3a).

VARIABLE SPEED CONTROL

On all engines, in place of the standard fixed speed control, a variable speed control can be fitted with a range of 750 rev/min to maximum rev/min, however the standard slow running speed is 900 rev/min.

NOTE: NEVER STOP ENGINES WITH THE DECOMPRESSORS OR VALVE DAMAGE MAY OCCUR.

CARE OF YOUR NEW ENGINE

Before leaving the maker's works, each engine is carefully tested and inspected; this includes full load running, followed by detailed examination and tightening of all nuts and unions.

When the engine is put into service, further settling of some joints will occur and the valve gear will bed down. For these reasons, if the best results are to be obtained from the engine, it is important that it should receive regular attention, particularly during the first 500 hours of its life. The same applies to an engine which has been completely overhauled.

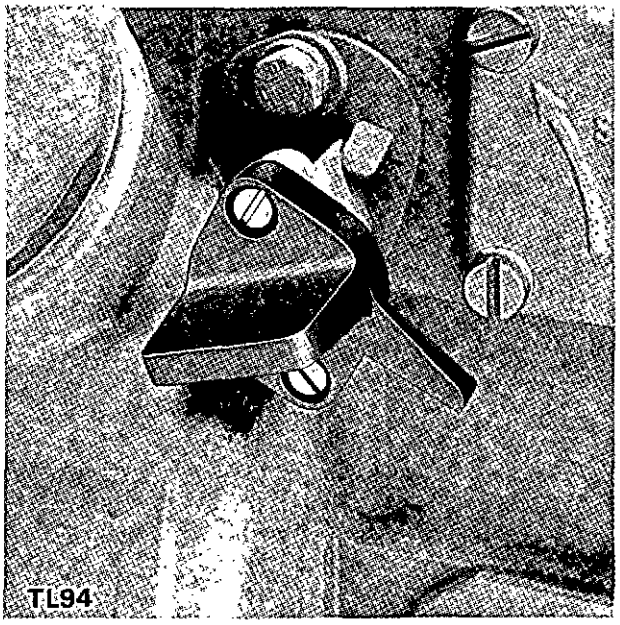


Fig. 3a Plastic covered stopping control.

INITIAL ATTENTION

Ensure that the top cups of the push rods are full of oil and that the valve springs are liberally lubricated.

It is recommended that the following are attended to after the engine has run 25 hours and again after the engine has run 250 hours.

1. Adjust tappet clearances (See page 64)
2. Check, and tighten the nuts on the following joints: end cover, cylinder head covers, fuel pipes, lubricating and fuel oil pipe joints.

In addition to the above the following should also be carried out:

a. Change the lubricating oil for the first time after 100 hours. Thereafter every 250 hours.
b. Clean the engine and keep it clean.
c. Observe the exhaust at the normal full load. The exhaust must be free from soot. A black exhaust means that the engine is overloaded or that the injection equipment is out of order. Do not allow the engine to run with a dirty exhaust whilst investigating the cause as this may well result in a breakdown.

ROUTINE MAINTENANCE

Following the initial attention, the normal routine maintenance must be carried out as defined on page 21.

LUBRICATING OIL

Always use oils of the correct viscosity and type Heavy Duty diesel engine detergent lubricating oils. (See Section 2).

This will ensure easy starting, lowest fuel consumption, minimum wear and longest periods between major overhauls.

ROUTINE MAINTENANCE

Daily:

Check the fuel level or supply.
Check the level and condition of the lubricating oil.
Clean the air cleaner under very dusty conditions.

Every 125 Hours:

Clean the air cleaner under moderately dusty conditions.
Renew the element if necessary.
Check for oil and fuel leaks — tighten nuts and fittings if necessary.
The oil should be changed in engines running at any speed, if it is thick and black.

Every 250 Hours:

Drain the lubricating oil and refill with the correct grade and type.
Renew the lubricating oil filter element.
Renew the fuel filter element if the fuel used is not perfectly clean.
Clean the fuel injector nozzle if the exhaust is dirty.

Every 500 Hours:

Renew the fuel filter element.

Every 1000 Hours:

Decarbonise if the engine shows loss of compression, or blow-by past the piston. Do not disturb otherwise.
Adjust the valve clearances.
Check that all external nuts, bolts and unions are tight.
Clean engine and cure fuel, lubricating oil and air leaks.
Ensure that the air cleaner connections are tight and air tight.
Ensure that any guards fitted are firmly attached and not damaged.

Every 2000 Hours:

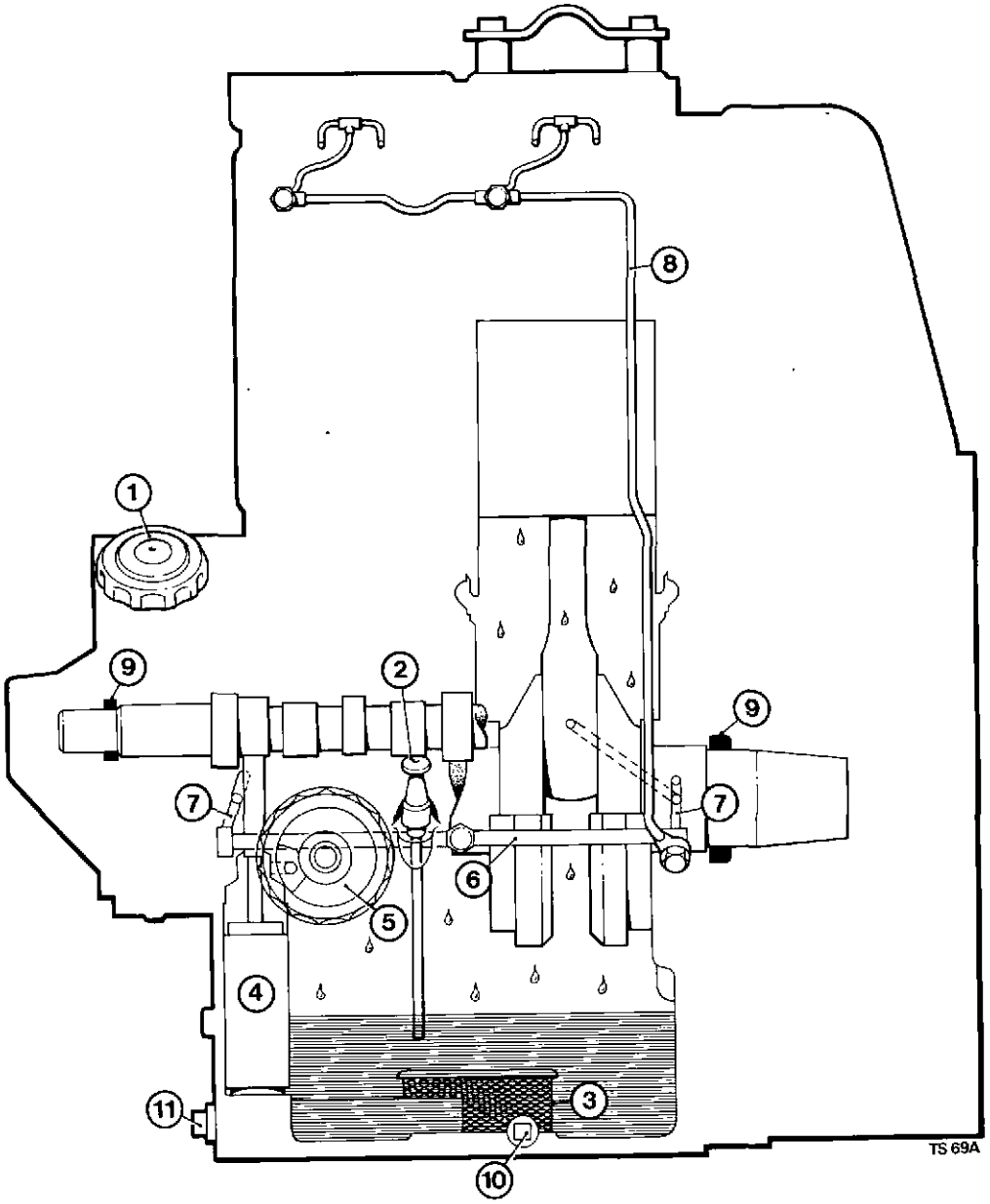
Decarbonise.
Drain and clean the fuel tank if necessary.
Check for free working of the governor and all its adjustments including speed and stopping controls.
Check the fuel pump timing.
Clean or replace the fuel injector nozzles and adjust the pressure settings.
Clean the inlet manifold and exhaust system.
Examine the fan for damage.
Clean the cylinder and cylinder head finning.
Check the lubricating oil pressure.
Renew the air cleaner element.

Every 6000 Hours:

Give the engine a major overhaul, if necessary.

A reasonable amount of time spent in checking over the details as described above is the user's best insurance against loss of valuable time and costly repairs.

Section Two
LUBRICATING SYSTEM



1. Oil Filler Cap
2. Dipstick
3. Strainer
4. Oil Pump
5. Lubricating Oil Filter
6. Oil Gallery
7. Oil Pipe/Drilling to Main Bearings
8. Oil Pipe to Valve Gear
9. Oil Seals
10. Drain Plugs (2)
11. Blanking Plug

Fig. 4 Lubricating Oil System

SPECIFICATION

1. The Temperatures mentioned in the table are the ambient temperatures at the time when the engine is started. However if the running ambient temperatures are much higher than the starting temperatures, a compromise must be struck and a higher viscosity oil used, providing starting is satisfactory; multigrade oils overcome the problems provided they have a suitable specification. See paragraphs 2 and 3.
2. Naturally aspirated diesel engines must be run on H.D. Diesel lubricating oils to specifications equal to or better than DEF2101D or MIL-L-2104B or MIL-L-46152 A/B or API CC. Straight mineral oils are not suitable, neither are oils of less detergency than specified.
3. API CD, Series III or MIL-L-2104C/D oils must be used in all turbocharged engines.
4. For naturally aspirated engines running at a high load factor particularly in conjunction with high ambient temperatures, oils to API CD, Series III, or MIL-L-2104C/D are recommended. They must also be used if the sulphur content of the fuel exceeds 0.5%.

   The use of these oils in new, or re-conditioned, naturally aspirated engines may inhibit running-in, and give rise to cylinder bore glazing in engines operating on low duty cycles. They should, therefore, not be used for the first fill in such engines, but may be used to advantage after the first 250 hours.
5. For long-running naturally aspirated engines, oils as specified in para 2 should be used for both engine test and the recommended 250 hour commissioning run. Thereafter, API CD, Series III or MIL-L-2104C/D oils are considered beneficial for dry sump and **essential** for top up systems.

   Turbocharged engines must be run on oils as specified in para. 3 at all times.
6. The oil should be suitable for oil changes every 250 hours without undue oxidisation, with sump temperatures reaching 150°C in tropical climates under extremely severe applications, and 120°C under normal applications.
7. Marine gearboxes of Lister manufacture with separate lubrication from the engine, and all marine reduction gears of Lister manufacture, must use "Mild type EP gear lubricants" or "Multi-purpose gear lubricants" (as used in the majority of motor car differentials).

VISCOSITY

The viscosity of the lubricating oil must be as follows:

Starting Temperatures			Monograde Oils	Multigrade Oils
	°C	°F		
Below	−15	5	SAE 5W	5W/20
Between	−15	5	SAE 10W	10W/30
and	4	39		
Between	4	39	SAE 20/20W	15W/40
and	30	86		
Above	30	86	SAE 30	15W/40 20W/40

DESCRIPTION (Fig. 4)

A cast iron lubricating oil sump is bolted to the base of the crankcase. Two drain plugs are fitted, one either side of an oil strainer. An oil filler cap is located at the top of the end cover and a dipstick is fitted in the crankcase on the fuel pump side.

A self regulating oil pump, operated by a push rod from the camshaft, is located in a drilling in the base of the crankcase. The pump is retained in position by the sump. An external pipeline is taken from the crankcase oil gallery line and supplies oil to the cylinder head for the rocker lever bushes.

OPERATION

Oil in the sump is drawn into the self-regulating oil pump through the oil strainer. Pressure oil is then delivered by the pump through a drilling in the crankcase to the hole nearest the outside of the cartridge type oil filter base. Filtered pressure oil passes through the centre of the filter and into the oil gallery, and from the oil gallery is delivered to the crankshaft gear end bearing via a pipe, and via drillings to the crankshaft centre bearings and the bearing in the main bearing housing. An external pipe supplies pressure oil to the rocker lever bushes.

The big end bearings are pressure fed through internal drillings in the crankshaft from the supply to the main bearings. Splash oil lubricates the gears, governor, camshaft and the underside of the pistons.

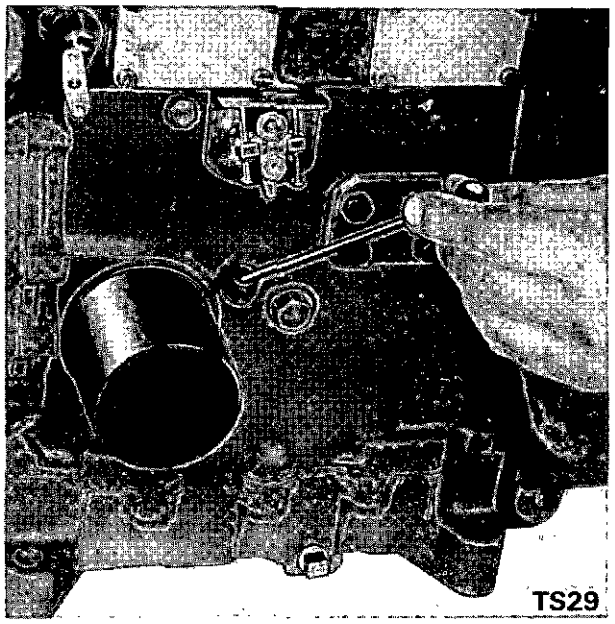


Fig. 5 Checking Oil Level

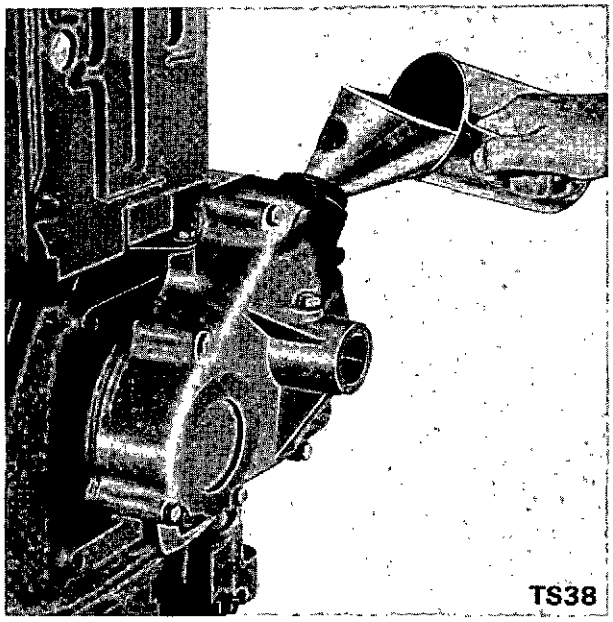


Fig. 6 Filling with Lubricating Oil

The lubricating oil pump is self regulating and the minimum pressure is 0.7 bar (10 lbf/in^2) at 1000 rev/min (See technical data for normal oil pressures). The oil supply capacity is 4.3 litres (7.6 pts.) for the two cylinder engine and 6.5 litres (11.4 pts.) for the three cylinder engine, and is filled through the oil filler neck in the end cover to the full mark on the dipstick. The distance between the high and low marks represent approximately 0.5 litre (0.88 pt.) on the TS2 and 0.72 litre (1.27pt) on the TS3 engine.

BEFORE STARTING OR AFTER OVERHAUL

Fill the engine crankcase through the oil filler to the mark "max" on the dipstick. Top up when the engine has been stopped after the initial run.

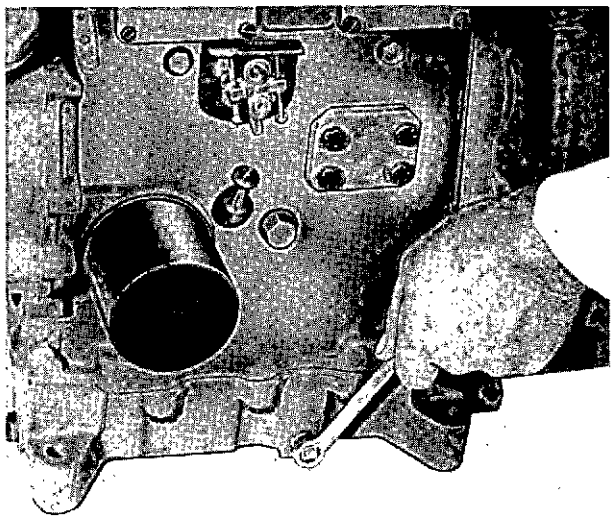


Fig. 7 Draining Lubricating Oil

There is a second drain plug at the gear end of the engine. The plug between the two drain plugs is the blanking plug for the oil pump drilling (Fig. 114).

OIL FILTER (Fig. 8)

The standard full flow oil filter is a screw on cartridge type located on the crankcase. A band gripping tool is required to remove the filter from the engine. When fitting a new filter, the face of the rubber joint must be lightly greased to facilitate assembly and removal. The filter must be screwed until the rubber joint makes contact with the crankcase facing and then screwed on clockwise 1/2 to 3/4 of a turn.

Only genuine Lister spare filters must be used, these have the correct by-pass valve pressure to match the self regulating oil pump, high temperature joints, adequate filter paper characteristics and a rigid case. The fact that a proprietary filter may have the same external dimensions and thread as the genuine one is no guarantee that it cannot cause a serious lubricating oil failure.

HIGH OIL CONSUMPTION

TS engines use very little oil, but the consumption can increase if the valve guides are worn, or if the breather in the rocker compartment is not functioning correctly. This can be caused by excess oil in the rocker compartment due to excess piston blow by, incorrect parts, or worn rocker bushes and shafts.

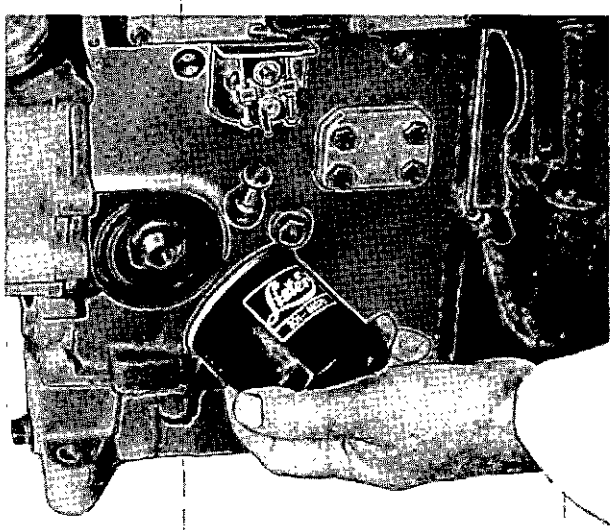
Note: Remote mounted oil filters are available for all engines.

LUBRICATING OIL STRAINER (Fig. 9)

Engines are fitted with a coarse lubricating oil strainer on the suction side of the oil pump. Rags must not be used to wipe the inside of the engine during overhauls because the fluff might easily clog the oil strainer.

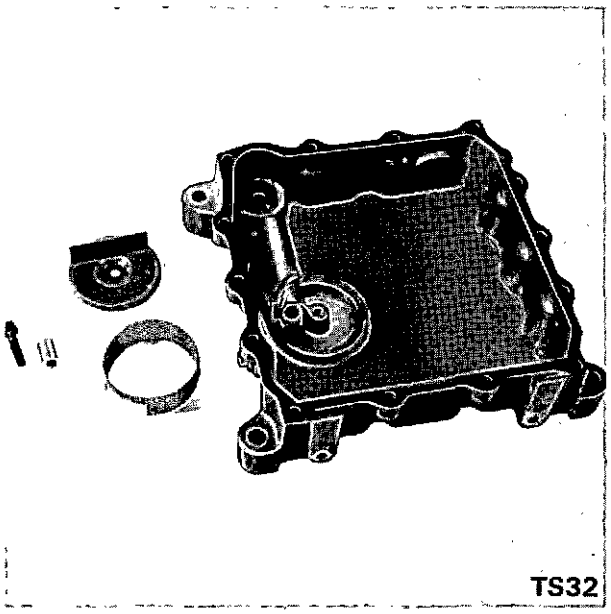
Access to the strainer is gained by removing the sump. To dismantle the strainer first remove the centre setscrew, be careful to replace the distance piece under the top plate on re-assembly.

The anti-surge plate must be fitted parallel to the crankcase web.



TS36

Fig. 8 Changing Oil Filter



TS32

Fig. 9 Oil Strainer

SUMP AND LUBRICATING OIL PUMP
(See also Section 4 Page 70)

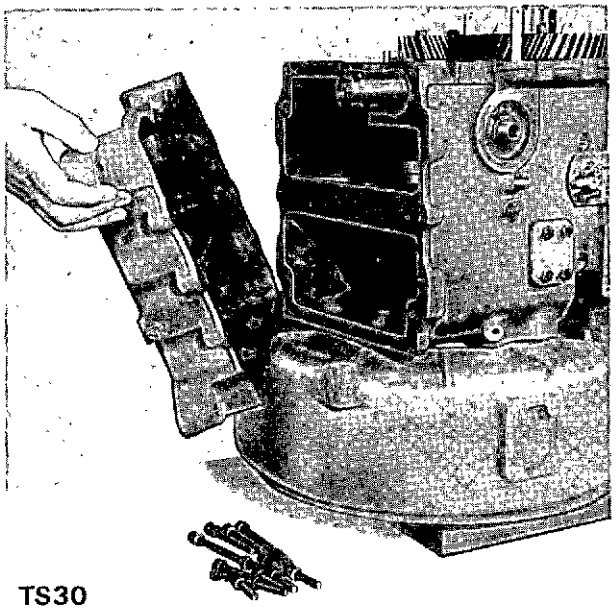
To Remove:

(a) Remove plugs from the sump and drain the oil into a suitable receptacle.
(b) Remove the sump bolts and spring washers. The oil pump will move the sump away from the crankcase as the bolts are removed.
(c) Remove the sump taking care not to damage the oil pump or sump joint. (Fig. 10).
(d) Remove oil pump and then remove oil pump push rod (if necessary) by using long nosed pliers. (Figs. 11 & 12).
(e) Dismantle oil pump making careful note of component positions (See Fig. 13).
Make particular note of the two different sized ball valves.

Note: The fanshroud is attached to the sump with two bolts. (See page 78 for precautions to be observed when fitting).

Servicing:

Clean all components and replace any worn or damaged parts. Clean sump and crankcase faces and fit a new joint, coating the sump face with Wellseal and stick the joint to it.



TS30

Fig. 10 Removing Oil Sump

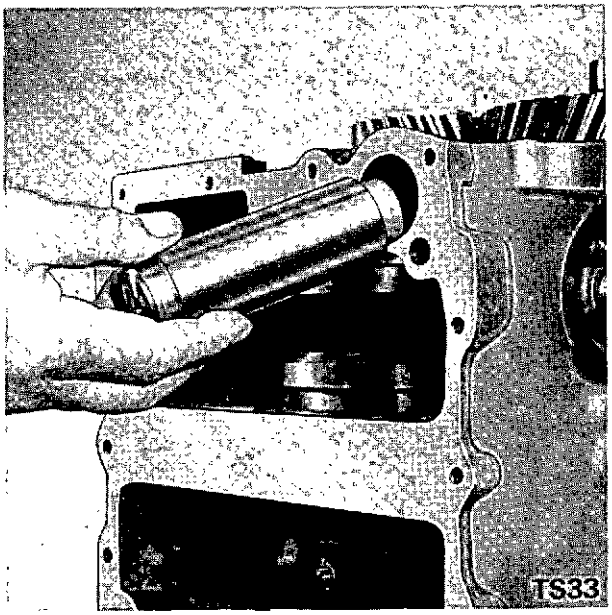


Fig. 11 Removing Oil Pump

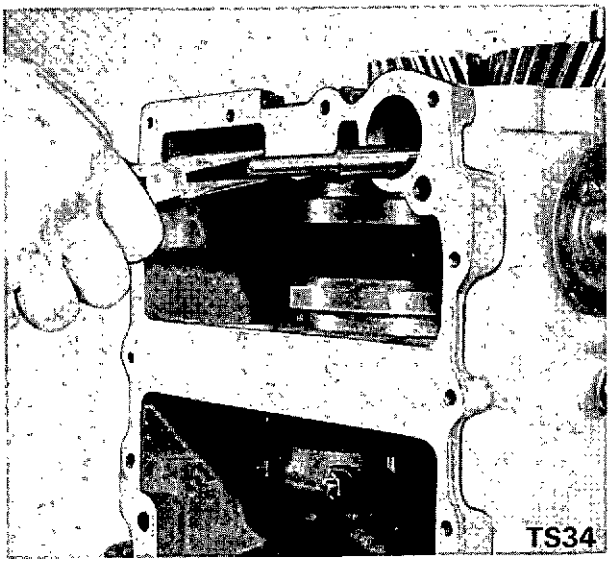


Fig. 12 Removing Oil Pump Push Rod

It should be noted that rods of different lengths are used, therefore always ensure that the correct replacement rod is fitted by checking its length.

To Refit:

(a) Check that the oil pump is correctly assembled and working freely by compressing between the palms of the hands.
(b) Replace oil pump push rod with the larger diameter towards the camshaft.
(c) Replace oil pump with plunger leading.
(d) Fit sump with recessed corner adjacent to the oil pump. Torque load sump bolts to 27.12 Nm. (20.0 lbf.ft).
(e) Coat the threads of the drain plugs with Hylomar PL32/M and refit.
(f) Fill sump to the correct level with the correct grade of lubricating oil.

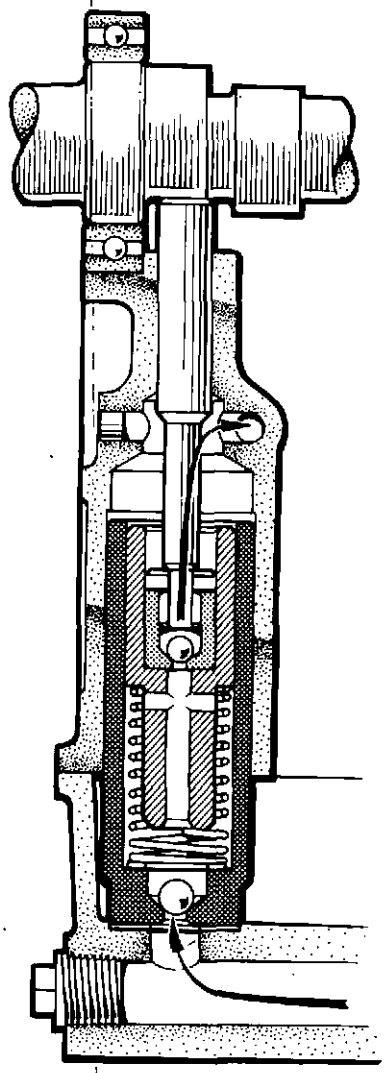


Fig. 13 Oil Pump (diagrammatic)

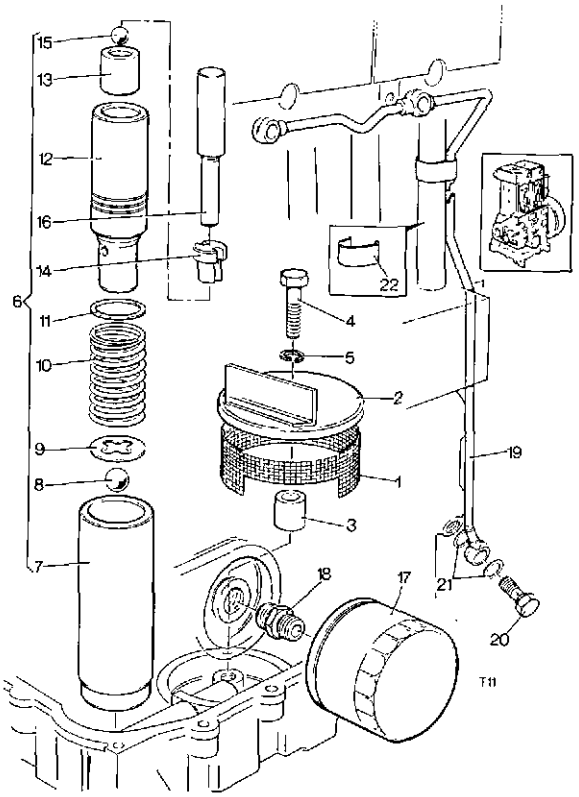


Fig. 14 Lubricating Oil System

STRAINER

1 Mesh
2 Cap Asembly
3 Distance Piece
4 Bolt—M8 x 1.25-6g x 35mm
5 Spring Washer

OIL PUMP & FILTER

6 Oil Pump Assembly Comprises
7 Cylinder
8 Lower Ball Valve
9 Retaining Plate
10 Spring
11 Plunger Washer
12 Plunger
13 Plunger Valve Seat Insert
14 Plunger Cap
15 Upper Ball Valve
16 Push Rod
17 Filter
18 Connector

LUBRICATING OIL PIPE

19 Lubricating Oil Pipe
20 Swivel Union Plug
21 Copper Washer
22 Clip

Oil Feed to Cylinder Heads (Fig. 15)

An external pipe secured by 3 or 4 swivel union plugs carries lubricating oil from the crankcase oil manifold to the valve rockers. The pipe is retained in position by two spring clips attached to an exhaust push rod sealing tube.

OIL SEALS (See also Section 4 and 7)

A lip type oil seal is fitted to the crankcase end of the end cover starting shaft tube and either a rotary type oil seal, lip seal, or a screw type oil seal is fitted to the main bearing housing.

Rotary Type Oil Seal (Fig. 16)
(Early engines only)

(See also Section 4 and 7)

The rotary type oil seal may be fitted to the main bearing housing and consists of a rotating impeller which is an interference fit on the crankshaft, and has an oil sealing thread machined on the outside diameter. Next and outwards from the face of the impeller a felt ring is fitted, which acts as a dust seal, and is held in place by a stationary retaining cap. The retaining cap is an interference fit in the bearing housing.

Special tools* are required to assemble the unit in order to achieve the correct spacing between the impeller and the inner edge of the retaining cap, and to ensure the components are square to the crankshaft. The impeller must not touch the retaining cap otherwise damage will result. Special care must be taken when fitting the impeller not to damage the oil sealing thread, or oil leaks will result.

When refitting the impeller ensure there is adequate interference with the crankshaft, otherwise the impeller will not rotate with the crankshaft when it expands with engine heat. If necessary change the impeller.

* See Section 7 concerning special tools.

Note: If a rotary oil seal requires changing on earlier engines it can be replaced by an alternative seal. Every care should be taken to keep the crankshaft free from scratching or scoring to ensure that a good seal is maintained.

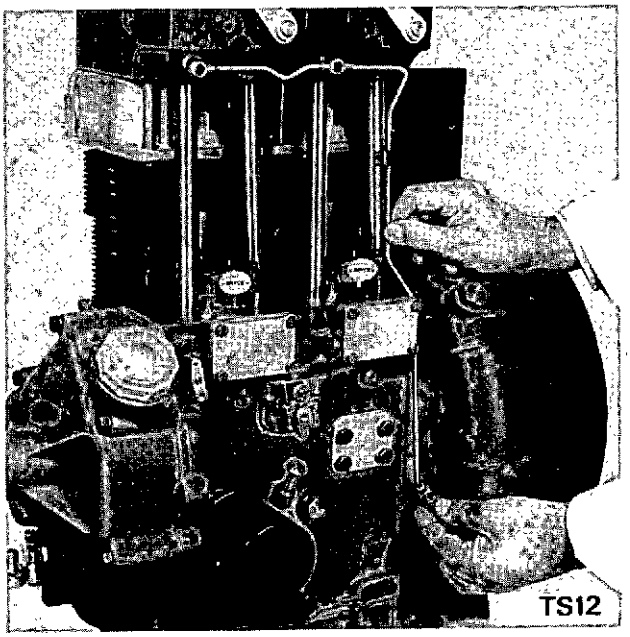


Fig. 15 Removing Oil Feed Pipe to Cylinder Head

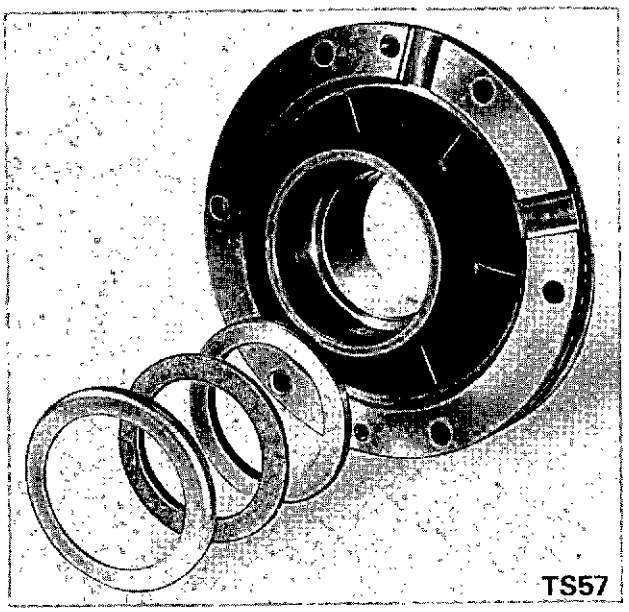


Fig. 16 Rotary Type Oil Seal

Lip Type Oil Seals

(See also Section 4 and 7).

The lip seals used must be the approved type supplied by R. A. Lister as genuine spares. Ordinary rubber seals may quickly harden in use, rapidly wear the shaft, or not even seal on original fitment.

A lip type seal will definitely not seal if the shaft is scratched or bruised, and a scratch means minute marks or lines barely visible to the naked eye. No such scratching or bruising must exist within 5 mm either side of the path of the lip of the seal. A finely and accurately ground shaft without chatter marks and with a surface finish of 0.4 microns Ra (16 micro inches CLA) maximum is adequate. It is essential to check that no damage has taken place during transit or servicing.

Emery cloth of any grade used on a sealing shaft will damage it; and if the grade has not been extremely fine, it is probable that the damage cannot be remedied. It is even recommended that the reverse side of emery cloth should not be used because of the probability of grains of emery becoming dislodged.

Very fine scratches should be corrected by polishing the working surface with a wet mixture of metal polish and **optical** aluminium oxide powder, failing this domestic scouring powder may be used.

To rub the shaft, a strip of rag some 300mm long by 50mm wide should be folded lengthwise and made into 10mm belt. Wet the belt with the abrasive mixture, wrap once right around the shaft and use with a reciprocating motion.

Screw Type Oil Seal (Fig. 16a)

The crankcase may be sealed at the crankshaft by a screw type oil seal (A) and a felt ring (B). The screw seal must be concentric with the shaft, the maximum permissible variation of gap being 0.075 mm. (0.003''). A ring type oil thrower (C) is fitted over the crankshaft at the flywheel end and must be fitted before the main bearing housing.

When an oil seal is replaced, the outside diameter of the seal should have a little Hylomar PL32M applied. When fitting a new crankshaft felt seal, coat the inside of the grooves with Wellseal before inserting felt. Ensure the felt is not distorted during fitting, and lightly oil before fitting assembly to the crankshaft.

Ensure that the correct seal assembly is fitted for the direction of the engine rotation. An arrow marked on the seal shows the direction of rotation.

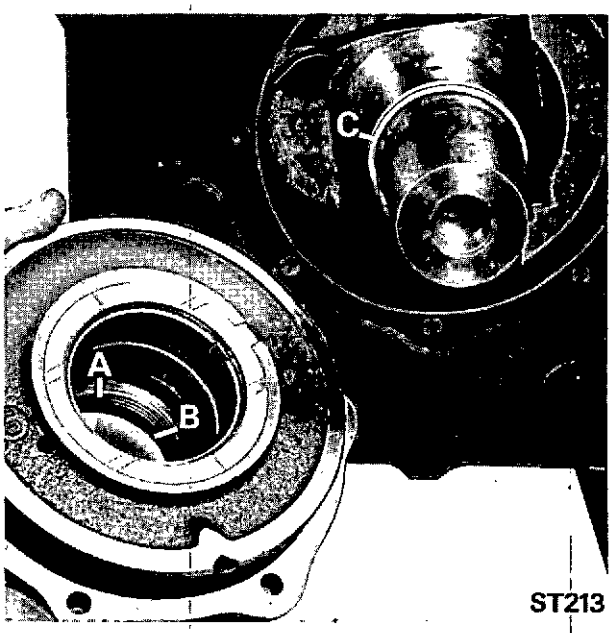


Fig.16a Screw Type Oil Seal

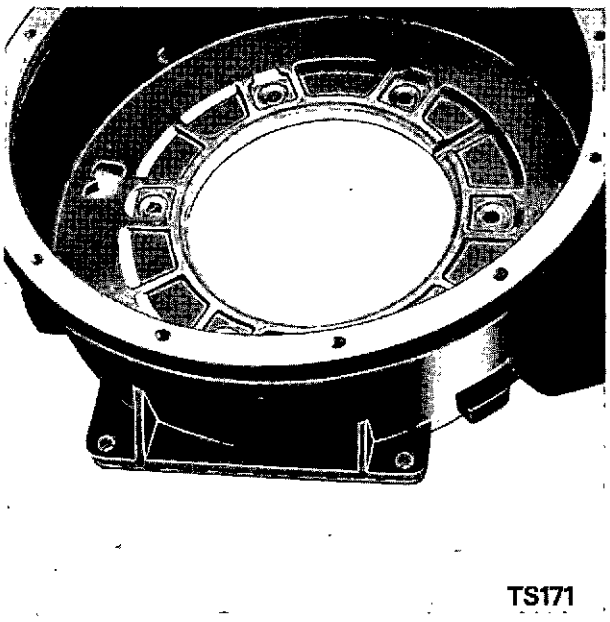


Fig. 16b Showing where Fanshroud is secured to Sump

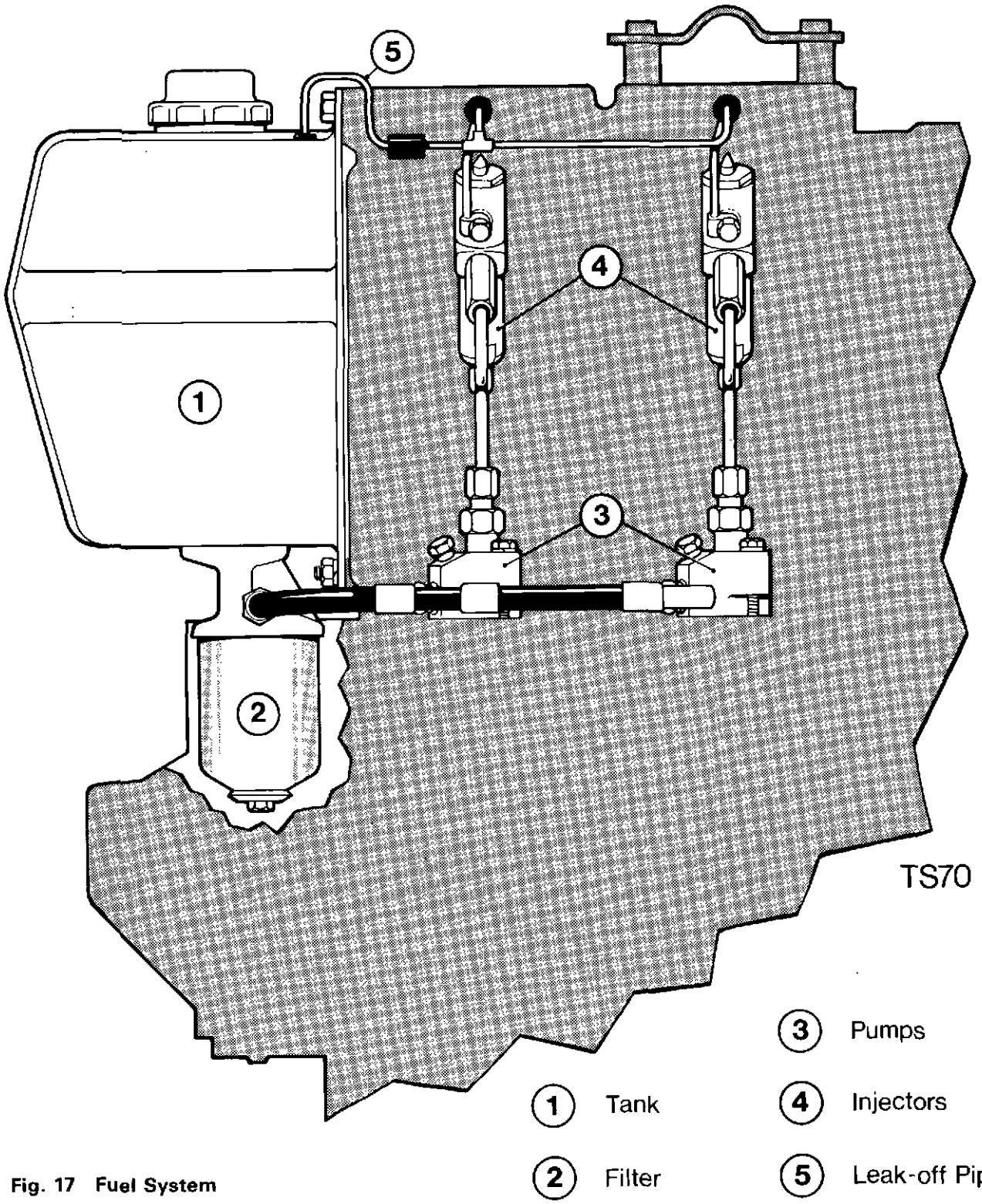


Fig. 17 Fuel System

With a self venting fuel system the fuel feed pipe will be found fitted to the bleed screw point (see item B Fig. 30).

SPECIFICATION

It has not been found practicable to recommend any particular fuel for universal use, but the fuel must be a distillate and not a residual oil or a blend thereof.

It should have a Specification conforming to British Standard No. 2869: 1970, Class A1 or A2.

Fuels to USA Specifications ASTM D-975-77 Grades No. 1-D and No. 2-D are also acceptable.

SPECIFICATION LIMITS

Item	Class A1	Class A2
Viscosity, Kinematic at 37.8°C		
centistokes, Min.	1.6	1.6
centistokes, Max.	6.0	6.0
Cetane number, min.	50	45
Carbon residue Conradson on 10% residue, % by weight max.	0.2	0.2
Distillation, recovery at 357°C% by volume, min.	90	90
Flash point, closed, Pensky-Martens, min.	55°C	55°C
Water content, % by volume, max.	0.05	0.05
Sediment % by weight, max.	0.01	0.01
Ash % by weight, max.	0.01	0.01
Sulphur Content % by weight, max.	0.5	1.0
Copper corrosion test, max.	1	1
Cloud point °C, maximum Summer	0	0
Winter	−7	−7

In some cases Summer grade oil is unsuitable for use in Winter because it becomes cloudy and rapidly clogs the fuel filters on the engine.

In general the fuel must be free from foreign matter and water otherwise excessive wear may take place, particularly in the fuel injection system. Certain fuels are unsuitable owing to the excessive temperatures, pressures, deposits and corrosion resulting from their use.

The user is cautioned that although the engine may run satisfactorily for a short time on some fuels, excessive wear and damage will ultimately be suffered by the engine and its life materially shortened. For these reasons this company can accept no responsibility for such damage or wear caused by the use of unsuitable or dirty fuels.

When in doubt as to the suitability of a fuel oil, the local dealer should be consulted.

Clean fuel is of the utmost importance in ensuring reliable performance.

Vaporising oils are unsuitable as fuel for Lister diesel engines.

DESCRIPTION (Fig. 17)

The fuel system comprises a fuel tank, fuel filter and a fuel pump and injector for each cylinder. The fuel tank is normally engine mounted but may be of a variety to be mounted elsewhere. The engine mounted fuel tank on the TS engines has an integral fuel filter of the element and bowl variety which has a single attachment bolt through the base of the bowl to the adaptor, other engines have a cartridge type fuel filter fitted to the flywheel end of the engine. Both types of fuel filter are fitted with bleed screws. From the filter fuel flows to the fuel pumps through flexible pipes. The fuel pumps feed high pressure fuel to the injectors which are held in position in the cylinders by a clamp. Leak off pipes carry leak off fuel back to the tank.

A camshaft operated fuel lift pump may be fitted to the crankcase between the fuel supply and the fuel filter.

SERVICING—GENERAL

When priming or checking the fuel pump timing, care must be taken to wipe spilled fuel from the outside of the engine.

Always fit a NEW joint when a joint has been broken.

Special care must be taken to see that there is no leakage from the joints of the fuel pipe connection to the pump.

When tightening or loosening the fuel pump delivery connections, use two spanners to prevent the pump from twisting on its seating and causing misalignment and possibly jamming of the fuel pump rack.

When refitting the fuel pipe from pump to injector the connection to the injector must be tightened before the connection to the fuel pump. This procedure will ensure that there is no leakage from these joints. It is most important that all fuel joints are tight and leakproof.

Always fill the fuel tank through a fine strainer, preferably at the end of a run. If any sediment is stirred up during the process this has time to settle before the engine is used again. If cans are used, avoid tipping out the last few drops.

Funnels are very difficult to keep clean in dusty conditions. Wash them before and after use and wrap them up when not required, or fill service tank direct from a small mouthed screw capped can such as a 2 gallon fuel can.

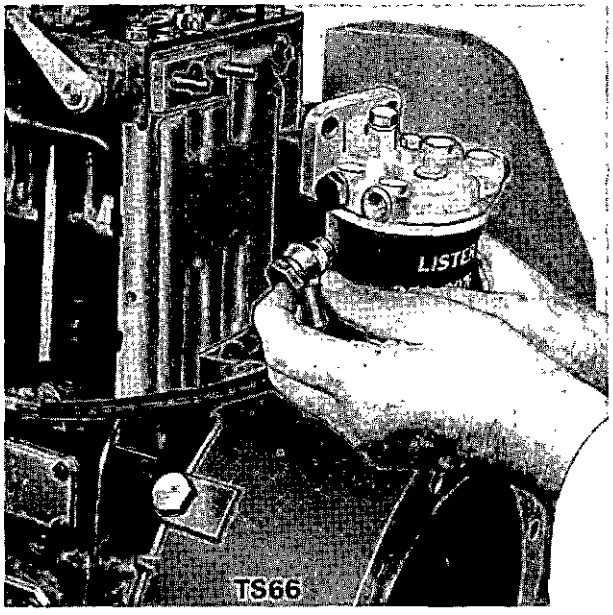


Fig. 18 Removing Fuel Filter (without Engine Mounted Fuel Tank).

REMOVING THE FUEL TANK AND FILTER

(a) Drain tank.
(b) Disconnect the fuel pipe at fuel pumps or fuel tank.
(c) Remove leak off pipe from top of tank (push fit).
(d) Remove the two nuts securing the base of the tank to the air shield and end cover bracket.
(e) Remove the three bolts securing the top of the tank to cylinder head cover and air cowl bracket.

Refitting is carried out in reverse order; after refitting, fill tank and vent system through bleed screw on filter and pump.(Fig. 30).

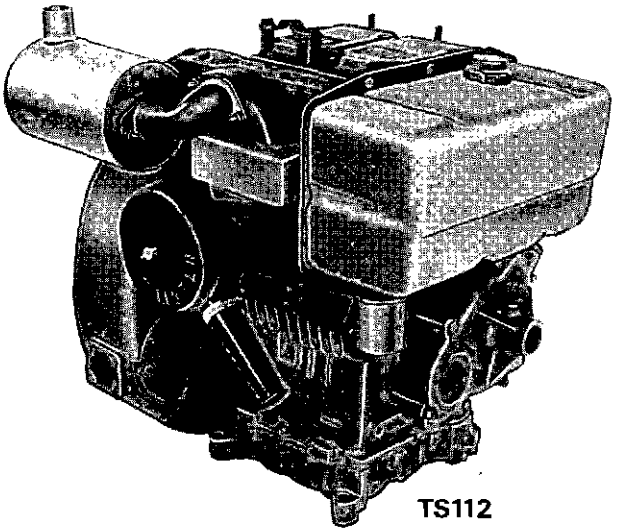


Fig. 19 Fuel Tank and Filter (earlier style tank).

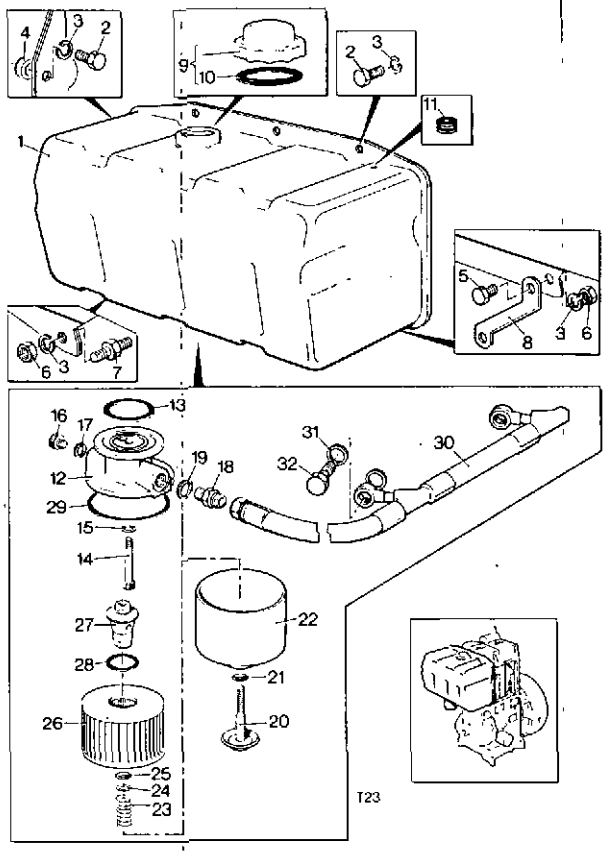


Fig. 20 FUEL TANK—13 Litre

1 Fuel Tank
2 Setscrew—M8 x 1.25-6g x 25mm
3 Spring Washer
4 Spacer
5 Setscrew—M8 x 1.25-6g x 20mm
6 Nut—M8 x 1.25-6H
7 Stud
8 Stay
9 Filler Cap Includes
10 Joint
11 Grommet
12 Adaptor
13 Washer
14 Cap Screw—M6 x 1.0-6g x 50mm
15 Washer
16 Bleed Screw
17 Washer
18 Union
19 Joint

— Fuel Filter Assembly Comprises
20 Bolt
21 Sealing Ring
22 Bowl
23 Spring
24 Spring Locating Washer
25 Sealing Ring
26 Element
27 Adaptor
28 Sealing Ring
29 Sealing Ring
30 Pipe Assembly
31 Copper Washer
32 Swivel Union Plug

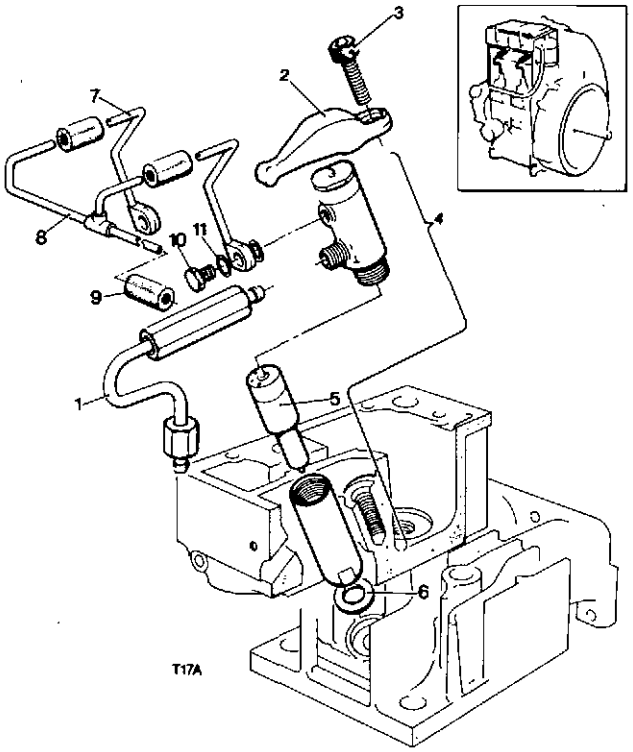


Fig. 21 FUEL SYSTEM—Injector

1 Pump to Injector Pipe
2 Injector Clamp
3 Cap Screw
4 Fuel Injector
5 Nozzle
6 Fuel Injector Washer
7 Leak Off Pipe
8 Leak Off Pipe
9 Rubber Connector
10 Swivel Union Plug
11 Copper Washer

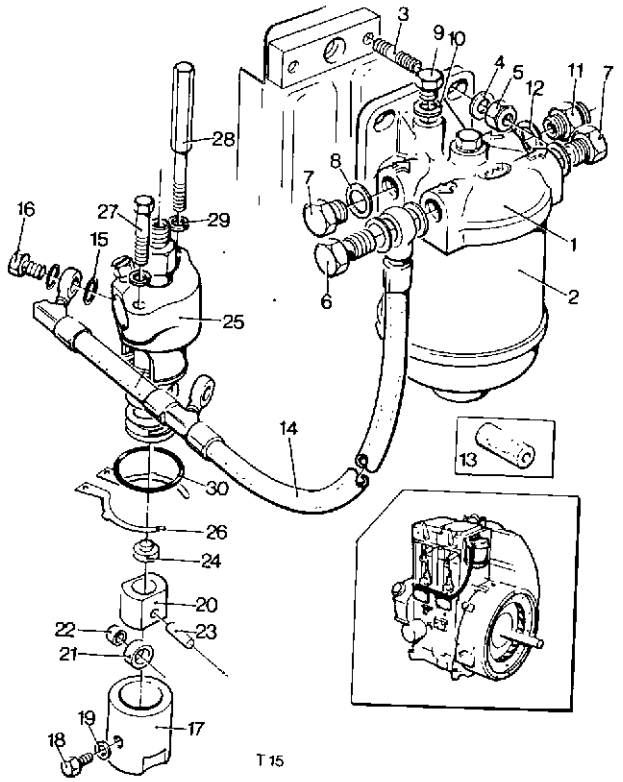


Fig. 22 Fuel System—Filter & Pump

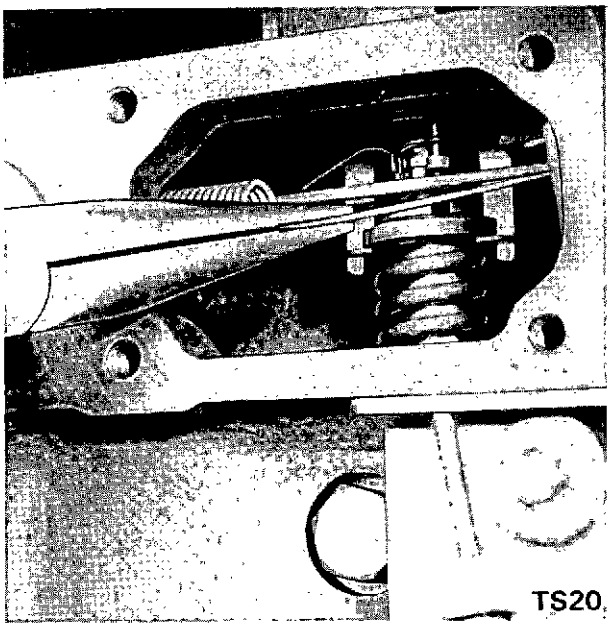


Fig. 23 Removing Speeder Spring with Fuel Pump Door Removed.

FUEL SYSTEM—Filter & Pump

1 Fuel Filter Includes
2 Element Kit
3 Stud—M8 x 1.25-6g x 30mm
4 Plain Washer
5 Self Locking Nut—M8 x 1.25-6H
6 Swivel Union Plug
7 Blanking Plug
8 Copper Washer
9 Vent Plug
10 Copper Washer
11 Union
12 Copper Washer
13 Leak Off Pipe Rubber Connection
14 Fuel Pipe
15 Copper Washer
16 Swivel Union Plug
17 Fuel Pump Tappet Guide
18 Locating Screw
19 Copper Washer
20 Fuel Pump Tappet
21 Fuel Pump Tappet Roller
22 Fuel Pump Tappet Bush
23 Fuel Pump Tappet Pin
24 Fuel Pump Tappet Insert
25 Fuel Pump Includes
— Element
— Delivery Valve
26 Shim—0.127mm. (0.005")
— Shim—0.508mm. (0.020")
27 Bolt—Front—M6 x 1.0-6g x 40mm
28 Bolt—Rear—special
29 Spring Washer
30 'O' ring

FUEL PUMP

The Bryce Berger Fuel Pumps are located at the side of the engine between the push rods and are secured to the crankcase by two bolts. At the base of the pump split shims are fitted to obtain accurate timing.

Removing Fuel Pump

(a) Drain fuel.
(b) Disconnect fuel feed pipes at pumps.
(c) Remove fuel pipes—pump to injector (Fig. 25).

Note: During removal hold fuel pump delivery valve holder with spanner to stop it turning.

(d) Remove fuel pump inspection doors.
(e) Disconnect governor link and pump interconnecting link at pumps (it will assist access if speeder spring is first disconnected from spindle on right hand side) (Fig. 23). Set operating lever on pump to central position.
(f) Remove fuel pump holding down bolts. Lift out pumps taking care to retain adjusting shims below the pump body (Fig. 24).

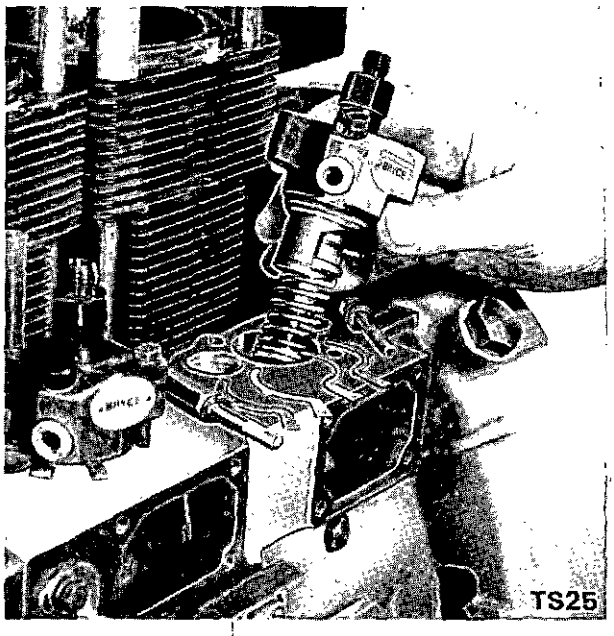


Fig. 24 Removing Fuel Pump.

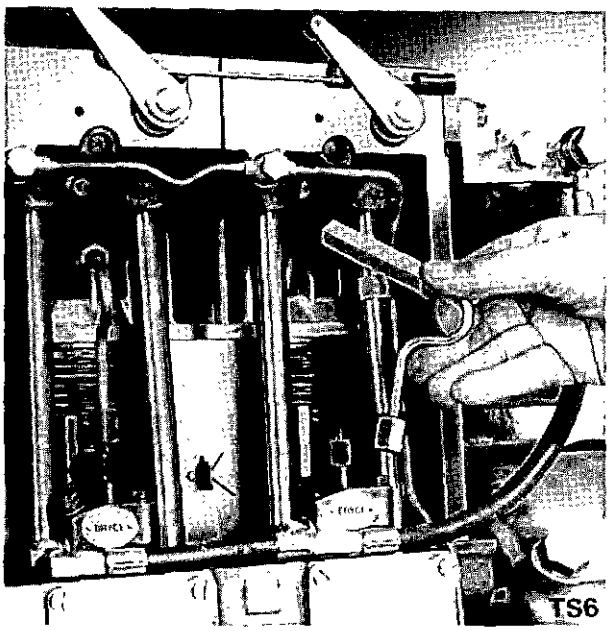


Fig. 25 Removing Fuel Pipe between Fuel Pump and Injector.

Servicing

It is recommended that the work of servicing the fuel pump is carried out by accredited Service Depots. For operators wishing to carry out their own maintenance, refer to Bryce Berger Publication F158. See Parts List for genuine Lister parts.

Refitting Fuel Pump

(a) Position fuel pumps and shims and fit retaining bolts — largest head bolt nearest the cylinder. Bolts should be tightened to a torque of 8.82 Nm. (6.5 lbf.ft.).
(b) Connect governor link and pump interconnecting link to pumps (re-connect speeder spring if removed).
(c) Check governor setting.
(d) Apply Wellseal to fuel pump inspection door jointing face and stick joint to it; fit doors.
(e) Refit fuel feed pipes and pipes from pump to injector; prime fuel system.
(f) Check spill timing and adjust with shims as necessary.

Care should be taken to prevent shims fouling the oil seal on the base of the pumps.

FUEL PUMP TIMING

(a) Check the control is in the start position.

(b) Turn the flywheel to the firing position for the correct cylinder by lining up the timing mark on the flywheel with the arrow head in the window at the rear of the fanshroud (Fig. 27). Ensure that both valves on the cylinder being timed are closed.

(c) Disconnect the fuel injector pipe at the pump and injector.

(d) Remove the delivery valve holder (A), delivery valve (C) and spring assembly (B). If fuel flows from the pump, turn the crankshaft in the direction of rotation until the flow ceases.

(e) Replace the delivery valve holder without the valve and spring.

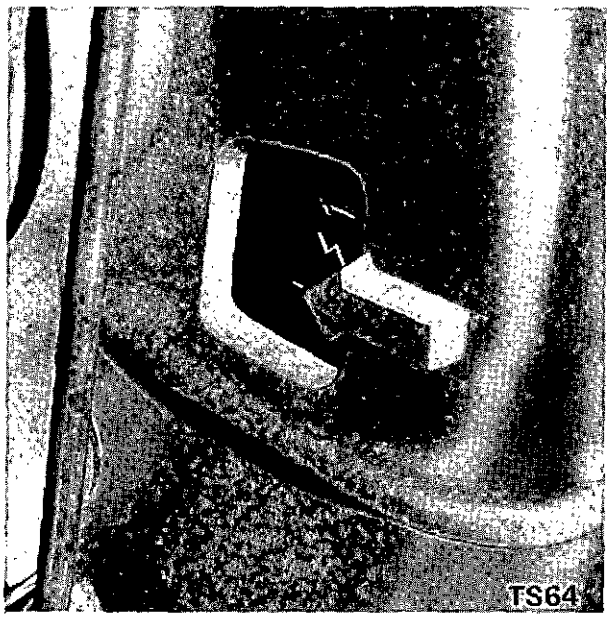


Fig. 27 Timing Marks

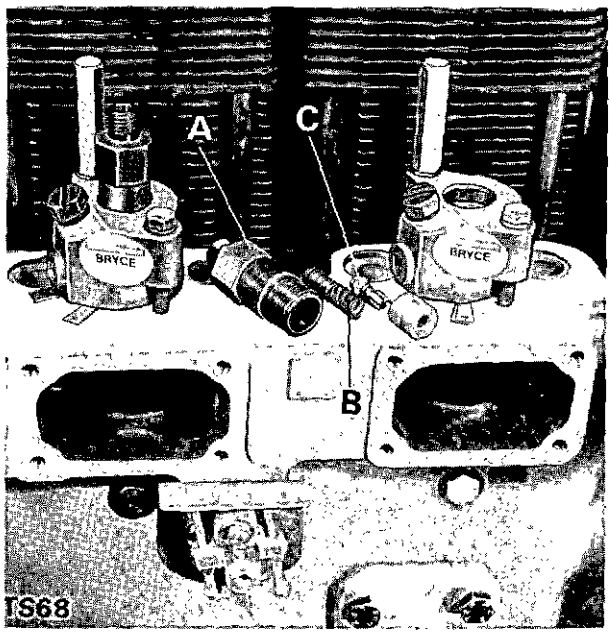


Fig. 26 Fuel Pump Delivery Valve and Spring

IMPORTANT:
Apart from the attention given to the fuel pump delivery valve and seat, if applicable, and the changing of defective injector nozzles, ALL other work on the fuel injection system must be carried out by an accredited Service Depot.

(f) Ensure a fuel supply and then turn the crankshaft against the direction of rotation until fuel commences to flow. Then turn the crankshaft slowly in the direction of rotation until the flow ceases. Blow the fuel from the top of the holder to ensure that the flow has ceased. At this position the firing mark on the flywheel should be in line with the arrow head in the window. If it is not adjust the shims below the pump body. Shims 0.127mm (0.005"), 0.254mm (0.010"), 0.508mm (0.020") and 0.762mm (0.030") thick are normally inserted below the fuel pump. When timing is correct replace delivery valve and spring.

(g) Turn the flywheel to the firing position for the next cylinder and repeat until all pumps are timed.

REMOVE SHIMS TO ADVANCE
ADD SHIMS TO RETARD

FUEL FILTER

The fuel filter is an essential part of a diesel engine. The engine must never be run without a fuel filter element. The element should be renewed every 500 hours, more frequently if for any reason the fuel is known to be dirty. To remove, drain the fuel tank and unscrew the bolt to the filter assembly. As applicable either change the cartridge element or clean the filter bowl and fit new element. Always renew all joints and seals before reassembly. When the filter has been correctly reassembled fill the fuel tank and prime the fuel system.

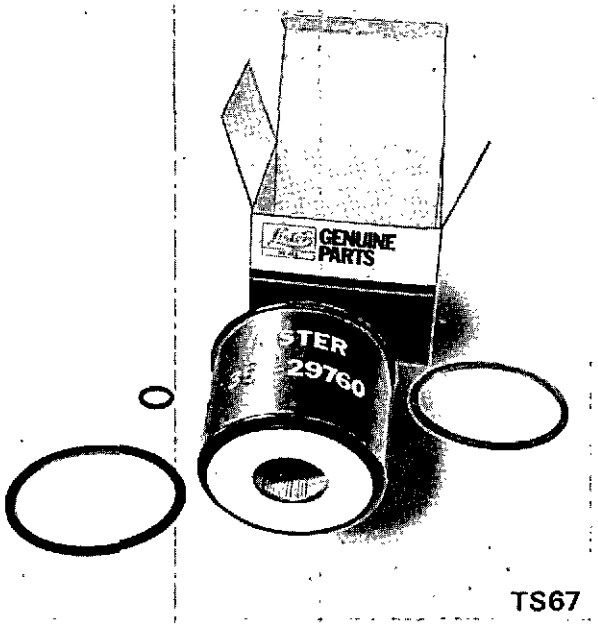


Fig. 28 Fuel Filter Element Kit

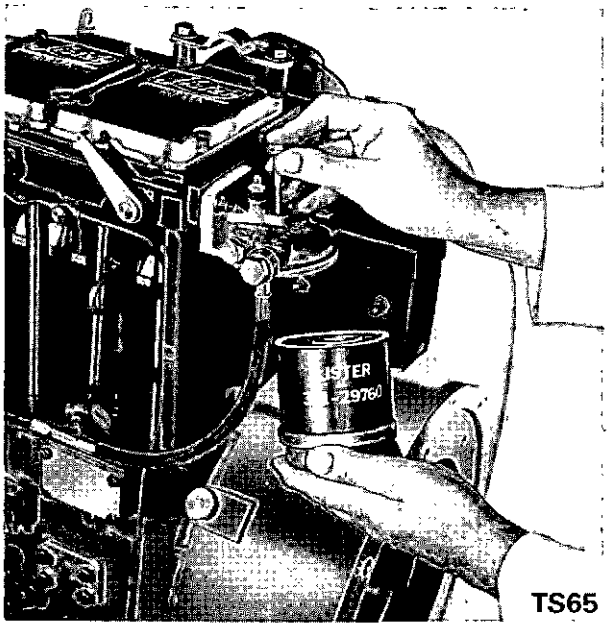


Fig. 29 Fuel Filter Element Replacement

PRIMING FUEL SYSTEM (Fig. 30)

(a) Fill the fuel tank with correct fuel oil.
(b) Vent the fuel filter through the bleed screw A until a full air free flow of fuel is obtained.
(c) Vent the fuel at the pumps through the bleed screw B starting with the pump nearest to the fuel tank.

If the fuel system is self venting the fuel supply pipe will be connected to bleed screw B position and no priming will be required.

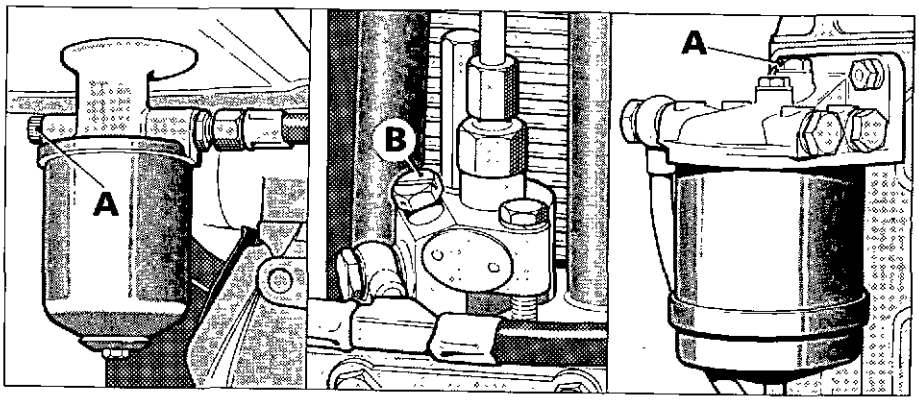


Fig. 30 Priming Fuel System

FUEL INJECTOR

To Remove:—

(a) Remove cylinder head covers. (See Section 4).
(b) Remove fuel feed pipes from fuel pump and injector.

Note: During removal hold fuel pump delivery valve holder with spanner to stop it turning.

(c) Remove leak-off pipe from tank.
(d) Unscrew holding down Allen screws and remove clamps; clamps are located in position by a hole in the side of the cylinder head assembly. (Fig. 32).
(e) Remove injector and washers. The injector is set to 200 atmospheres. (Fig. 31).

Full instructions for testing injector can be found on next pages.

Refitting is carried out in reverse order. Renew the copper washer and torque the swivel union securing leak off pipe to injector to 4.07Nm (3.0 lbf.ft); injector clamp screw torque is 21.02 Nm (15.5 lbf.ft). After the initial run following an injector replacement re-torque the injector clamp screw.

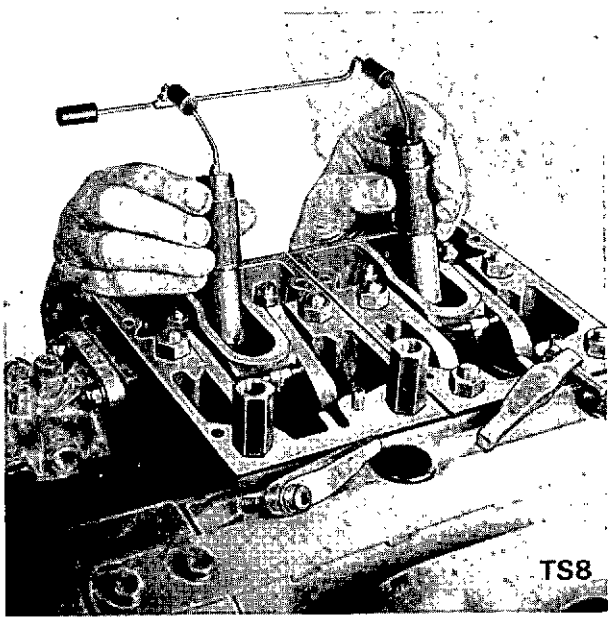


Fig. 31 Injectors

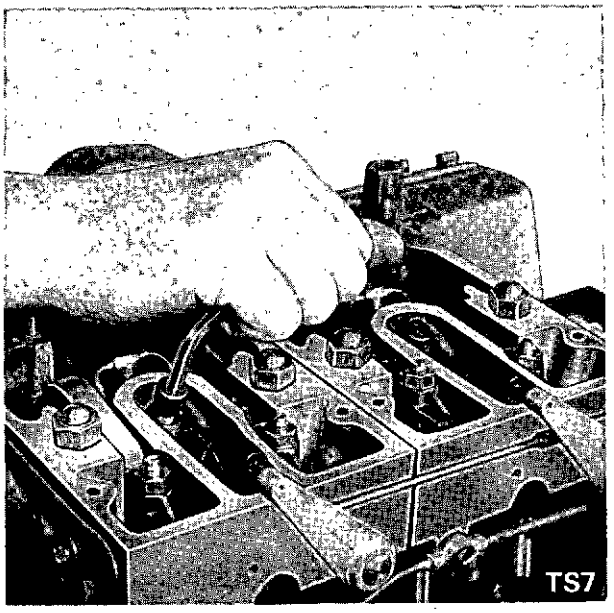


Fig. 32 Removing Injector Clamp

FUEL INJECTOR

The injection equipment, and the pipes and unions between the fuel filter and the fuel pump, and between the fuel pump and the injector must be absolutely clean; one particle of dirt can easily block one hole in the nozzle and produce a dirty exhaust. Every care is taken before the engine leaves the Works to ensure that this equipment is scrupulously clean, and after the engine is run in on test these injectors are checked and replaced if necessary, as sometimes particles of dirt get dislodged from the system when all the equipment is new. Therefore it is recommended that great care be taken not to introduce dirt into the system in any subsequent dismantling after the engine leaves the Works. This applies to the fuel pump, the fuel injector and all the pipes and unions between the fuel filter and the fuel pump and between the fuel pump and the injector.

FUEL INJECTOR—TESTING INSTRUCTIONS

The injector nozzle has four spray holes each **0.25 mm diameter.** The setting pressure of the injector spring is **200 atmospheres:** this allows for settling to the normal pressure of 190 atmospheres.

To ascertain if the injector spray is in good condition, the injector is removed from the engine and reconnected to the fuel injection pump externally with the injector pipe fitted in the reverse position so that the spray can be observed. After connecting the injector, check engine control is in the starting position, turn the engine at about 60 rev/min **camshaft** speed and observe the sprays in the usual way – **ensure spray is directed away from the operator.**

All sprays should have the same appearance and the same length of penetration in the air. If one spray is shorter or weaker than the others this means that the corresponding hole is partially blocked and best results will not be obtained.

If one hole is totally blocked or the nozzle dribbles it must be replaced or sent to be cleaned and reclaimed by an accredited Service Depot.

If the nozzle only is replaced, the injector spring pressure must be reset and this cannot be done without a special test rig consisting of a hand operated fuel pump and a pressure gauge. This rig is normally carried by Service Engineers but if it is not available it becomes necessary to replace the complete injector by a new or a serviced one which has a clean nozzle and has been properly set to the correct pressure: in this case the complete faulty injector should be sent to an accredited service depot for reconditioning.

The back leakage measured with a hand pump and gauge must be such that the time for the setting pressure to drop from 170 to 140 atmospheres must be within **6 to 27 seconds at 15.5°C (60°F) calibration fluid temperature. See page 48 for comprehension table.**

Tighten the injector top plug to 27.12 Nm (20 lbf.ft.)

SERVICING FUEL INJECTORS

Examine oil seal ring for damage or cuts, replace if necessary.

Ensure the seatings in the cylinder head are clean and smooth.

Fit new joint.

CLEANING FUEL INJECTORS/PUMPS

A thoroughly cleaned container holding a supply of clean, fresh fuel oil should be available for washing dismantled parts. Components should be assembled wet although it is permissible to use non-fluffing paper during cleaning processes. Never use paraffin and never use woven cloths. The components of each individual injector/pump should be kept together during dismantling.

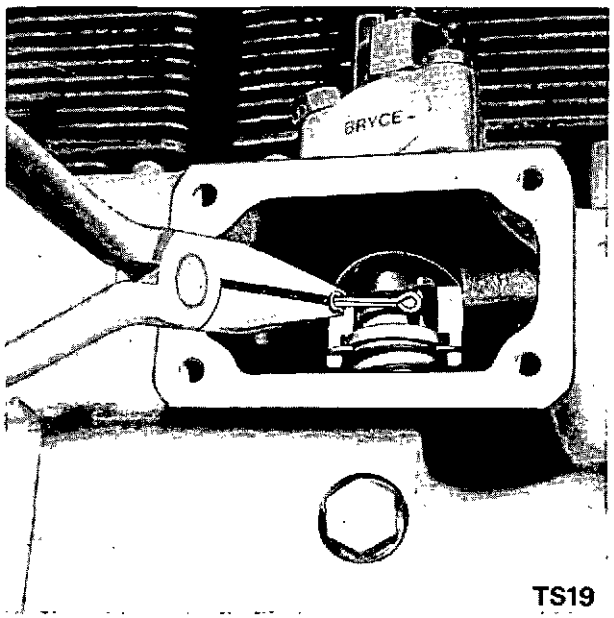


Fig. 33 Disconnecting Fuel Pump

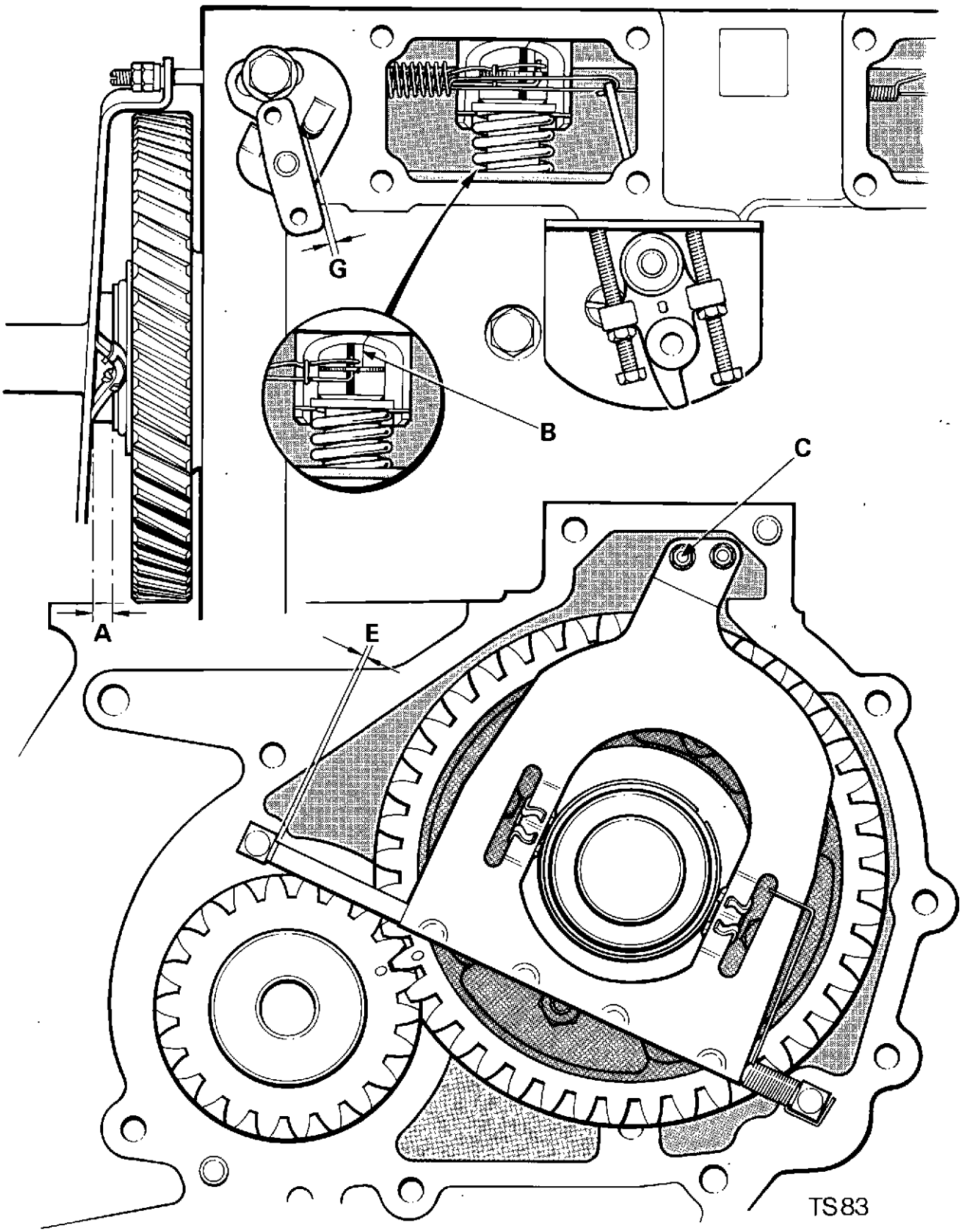


Fig. 34 Fuel Pump and Governor Setting

CHANGING GOVERNOR WEIGHTS AND GOVERNOR SPEEDER SPRING

NOTE: A complete list of weights and springs for each build is given on page 43.

(a) Remove fuel pump inspection door and end cover (see Section 4).
(b) Disconnect speeder spring from spindle.(Fig. 23).
(c) Remove speeder spring from governor lever and fit new spring.
(d) Turn the engine until one of the two or four governor weight retainer set screws is accessible. Remove setscrew and retainer plate.
(e) Turn the engine until the adjacent retainer plate is accessible. Remove setscrew and retainer plate (Fig. 35).
(f) Remove governor weight.
(g) Repeat for remaining governor weights.
(h) Fit new governor weights, retainer plates and setscrews. Torque load the setscrews to 8.82 Nm (6.5 lbf.ft.)
(j) Check fuel pump and governor setting.

Note: Care must be taken when refitting the retainer plates. If the plate is tilted the weights may foul the plate.

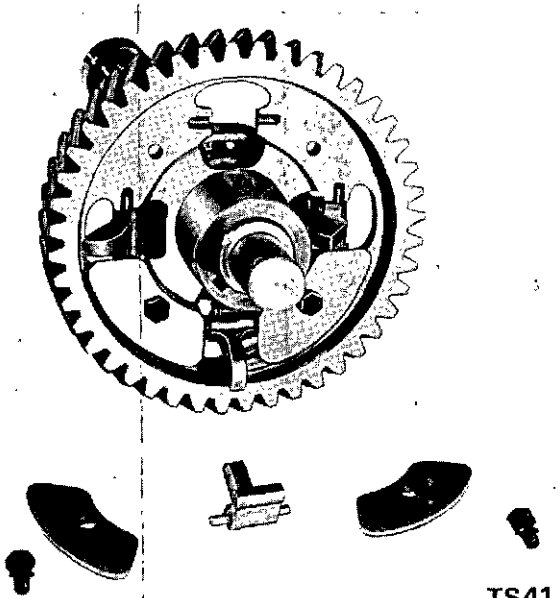


Fig. 35 Changing Governor Weights. (earlier engines)

FUEL PUMP AND GOVERNOR SETTING (Fig. 34 & 44a)

To adjust or check the settings, it is necessary to remove the fuel pump inspection doors and the end cover. The auto excess fuel device (Fig. 42) should be in the START position and the end of the camshaft gently tapped towards the flywheel in order to take up any end play.

(a) Adjustment 'E' should be checked and if necessary shims added or removed to obtain a clearance of between 0.12mm (0.005") and 0.25mm (0.010") (Fig. 36).
Set the distance 'A' (Fig. 38) between the end of the thrust sleeve and the shoulder on the camshaft gear hub to 5.0mm (0.197") by marking a scribed line 5.0mm from the shoulder and then moving the thrust sleeve forward to line up with the scribed mark. Check that the calibration mark 'B' on No. 1 fuel pump is in line with the mark on the centre of the fuel pump body whilst distance 'A' is maintained. Adjust by altering the effective length of the governor link through the locknuts 'C'. Ensure chamfered spacer is seated when making this adjustment. The length of the link between the fuel pumps is then adjusted so that the calibration marks (B) on all pumps are in line simultaneously.* To adjust the length of each link it has to be disconnected from its pump and rotated to suit.
*For later engines see page 48 under FUEL PUMP SETTINGS (Later Engines).
(b) Check the auto excess fuel device is in the 'RUN' position as follows:-
(i) Turn the engine control to the 'STOP' position and release.
(ii) Move the governor lever away from the camshaft until the excess fuel device clicks into the 'RUN' position.
With a feeler gauge of the correct thickness (see table values of 'G') inserted as shown in Fig. 37, loosen the control plate retaining screw and rotate the plate until the fuel pump calibration marks line up. Retighten retaining screw.

After all settings have been carried out, ensure the fuel pump rack and all moving parts move freely.

NOTE: The torsion or return spring fitted to the lower right hand side of the governor lever (Fig. 34) is no longer fitted to constant speed models.

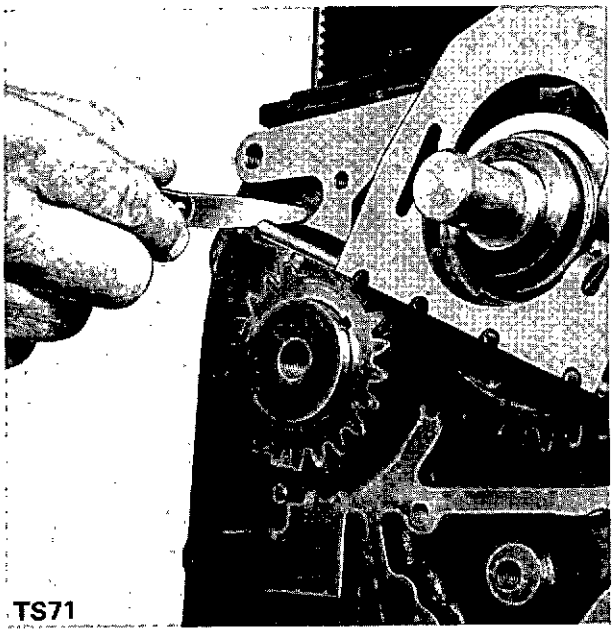


Fig. 36 Setting 'E' Adjustment.

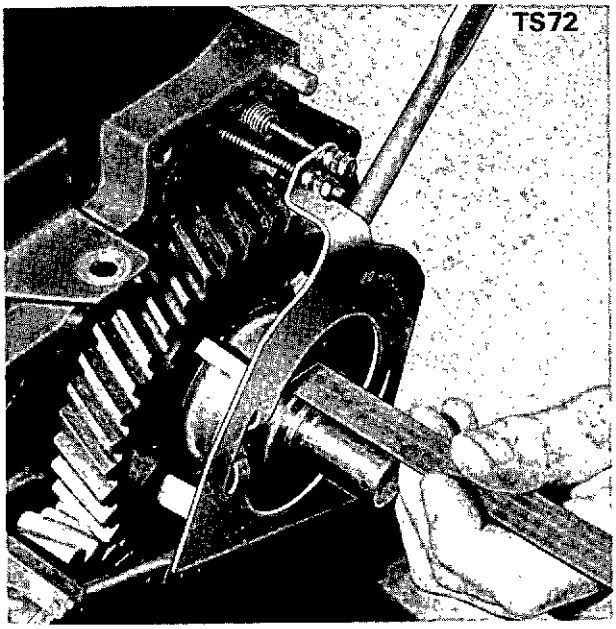


Fig. 38 Setting 'A' Adjustment.

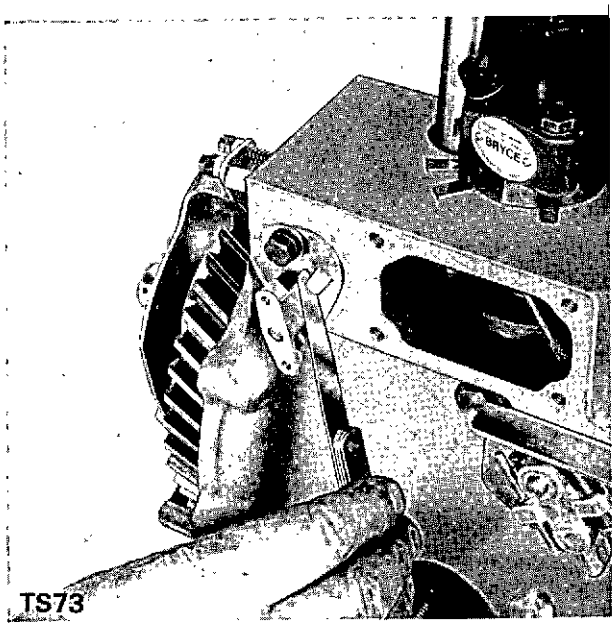


Fig. 37 Setting 'G' Adjustment.

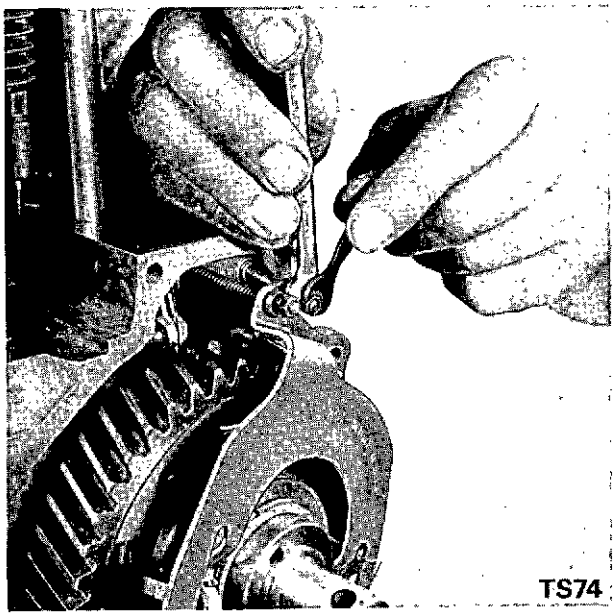
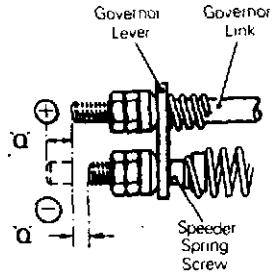


Fig. 39 Setting 'Q' Adjustment.

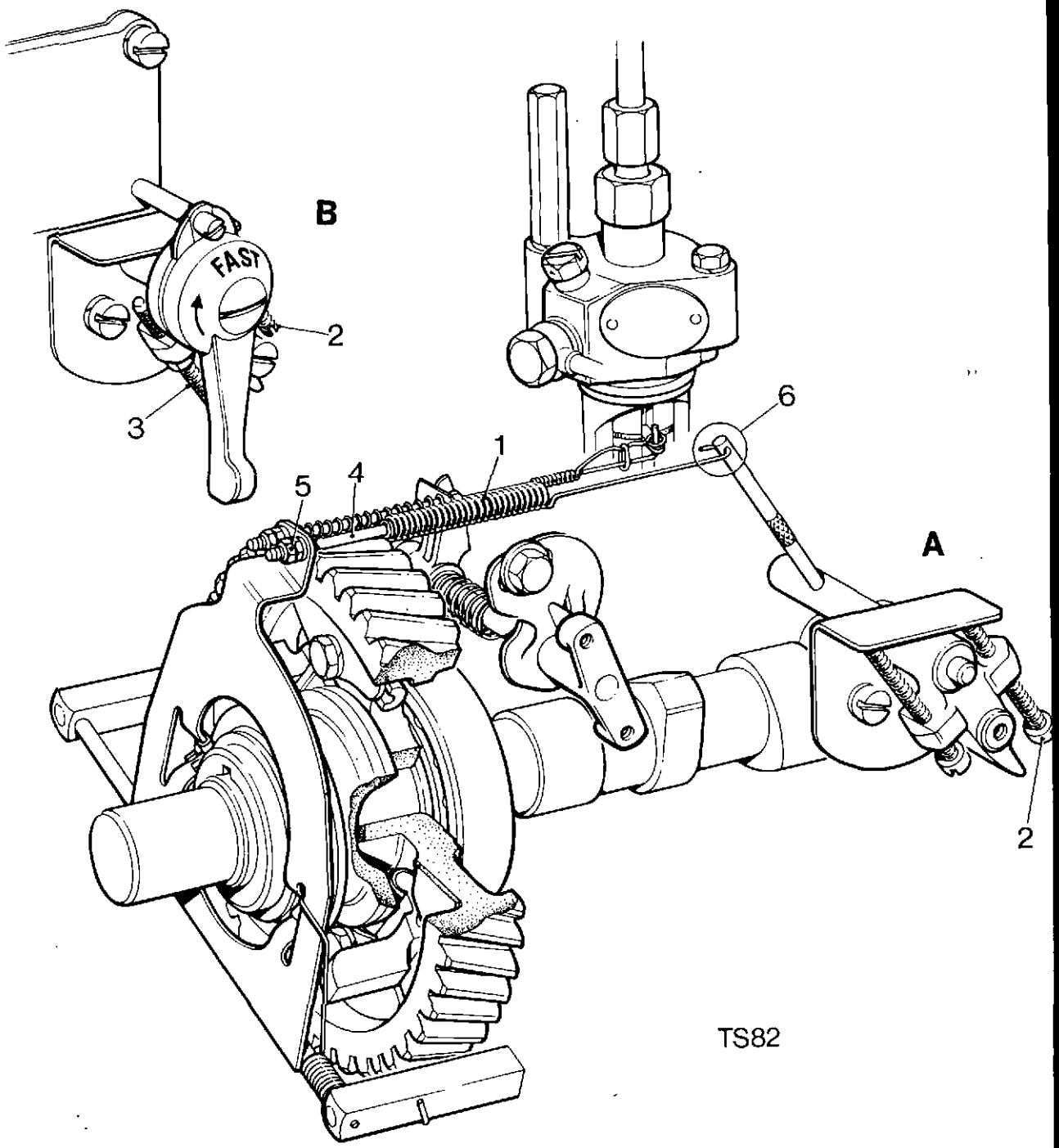
TS 2/3 GOVERNOR WEIGHT/SPRING COMBINATION & GOVERNOR PERFORMANCE

COMBINATION CODE See note 1	BUILD NUMBERS		Rev/min RANGES AND % GOVERNING				Q. Adjustment
	TS2	TS3	FULL LOAD RANGE WITHIN BS5514 PART 4 CLASS A1 (5%)	FULL LOAD RANGE WITHIN BS5514 PART 4 CLASS B1 (10%)	FULL LOAD RANGE OUTSIDE 10%	IDLING PRODN LIMITS	
18W2	01, 02, 03, 04, 05, 06, 07,	01, 02, 03, 04, 05, 06, 07,	2700 3000	1950 3000	1300 1949 (2)	850 950	Q = 0
13Y4	10, 11,	10, 11,	1700 1800	—	—	—	Q = 0
13B4	08, 09,	08, 09,	1400 1800 (2)	1250 1800 (2)	—	—	Q = 0
13Y2	12, 13,	12, 13,	2050 3000	1300 3000 (2)	—	—	Q = 0

Notes:—

1. Governor combination code:- First figure = weight code; letter = spring colour code (W = white, B = black, Y = yellow); end figure = number of weights.

2. Minimum permissible Full load speed = 1500 rev/min.



A. Constant Speed Control
B. Variable Speed Control

Fig. 40 Governor Speed Adjustment

GOVERNOR SPEED ADJUSTMENT (Fig. 40)

The speeder spring (1) is tensioned by the speed control lever. The lever has a right hand side adjusting screw (2) which increases the speed when it is turned clockwise in constant speed engines but, in variable speed engines, it is used to control the lowest speed or the idling speed.

To adjust the idling speed in a variable speed engine, the screw is unscrewed by turning anti-clockwise until it has no further effect on reducing engine speed; the governor will then be controlled by the torsion spring and the engine is likely to 'hunt'. The screw is then turned clockwise until the 'hunting' just stops—if the lowest idling speed is required—or continued to be turned clockwise until the desired idling speed is obtained. The locknut must then be tightened.

The left hand screw (3) on the lever, is used to limit the maximum speed on variable speed engines; when the screw is turned clockwise, the maximum speed is reduced and vice versa. This screw has no function in constant speed engines without a speed control lever or remote speed control.

The range of tensioning of the speeder spring and therefore the speed range is controlled by the movement of the speed control lever and the effective length of the screw (4) which is secured by the nut and locknut (5). The adjustment of the screw is gauged by the position of its end in relation to the end of the fuel pump link. This is known as the 'Q' setting. The measurement can be (See Fig. 41) either negative or positive. The values of 'Q' are quoted on page 43.

Note: It is advisable to grease the speed control adjusting screw before painting the engine.

IDLING SPEEDS

Engines with variable speed governors are to be set to idle at 900 rev/min.

FUEL PUMP TIMING CHART

Rev/min	Deg. BTDC
1500	20°
1800	20°
Variable speeds up to and including 3000	23°

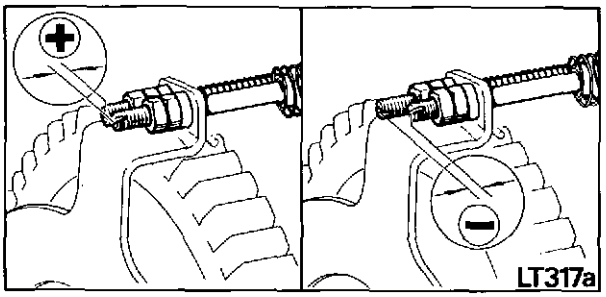


Fig. 41 Projection of Speeder Spring Screw

Note: *It is important that the speeder spring is* hooked properly through the hole in the spindle—see item 6 on Fig. 40.

AUTOMATIC DEVICE GIVING EXCESS FUEL FOR STARTING (Fig. 44)

The engine is fitted with an auto excess fuel device (Fig. 42) fitted with a spring loaded cam (1) which together with the movement of the lever (2) varies the distance between the centre line of No. 1 fuel pump and the edge of the governor linkage abutment (3). The three positions available are 'ENGINE STOP'. 'EXCESS FUEL FOR STARTING' and 'ENGINE RUN'.

The two main features of the device are:

(a) The resetting of the cam during the stopping operation which is effected by turning the engine control fully anti-clockwise so that on release 'EXCESS FUEL FOR STARTING' will automatically be selected.

(b) If the engine is not overloaded, as soon as the governor reaches the on speed position the cam turns under the force of its spring so that the engine power output is limited to the rated power plus overload if allowed by the rating specification.

STOPPING THE ENGINE

To stop the engine the engine control is turned fully anti-clockwise and held there until the engine stops.

Note: If an engine fitted with Automatic excess fuel stops other than by the operation of the engine control, the control must be turned to the 'STOP' position and then released in order to select excess fuel.

PREVENTION OF FUEL LEAKS

The following should be properly tightened and checked during service at frequent intervals:

(a) The joints or unions of the fuel pipe(s) leading from the fuel tank.
(b) The two unions of the fuel lift pump (if fitted).
(c) The fuel filter inlet (if external) and outlet unions and vent screws.
(d) The fuel pump element locating screw which must be screwed dead tight.
(e) The fuel pump inlet and outlet unions.
(f) The fuel pump vent screw.
(g) The fuel injector leak off and inlet union.
(h) The fuel pump holding down screws.
(j) The fuel injector clamp screw.

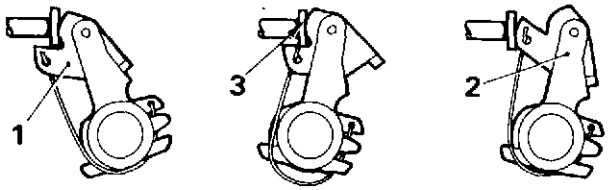


Fig. 42 Auto Excess Fuel Device (earlier engines)

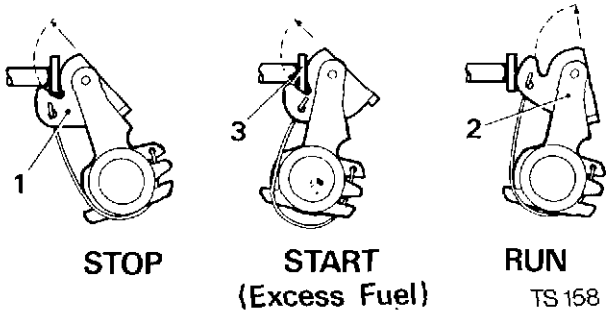


Fig. 42a Auto Excess Fuel Device (later engines)

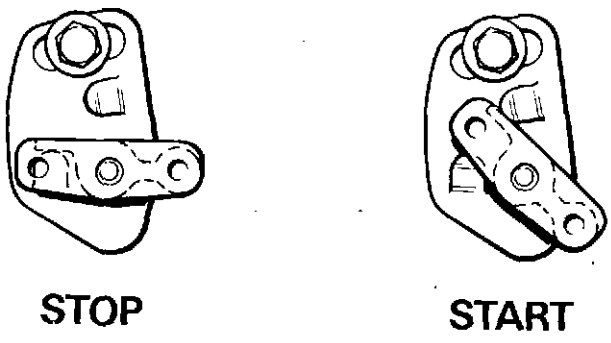


Fig. 43 Engine Control

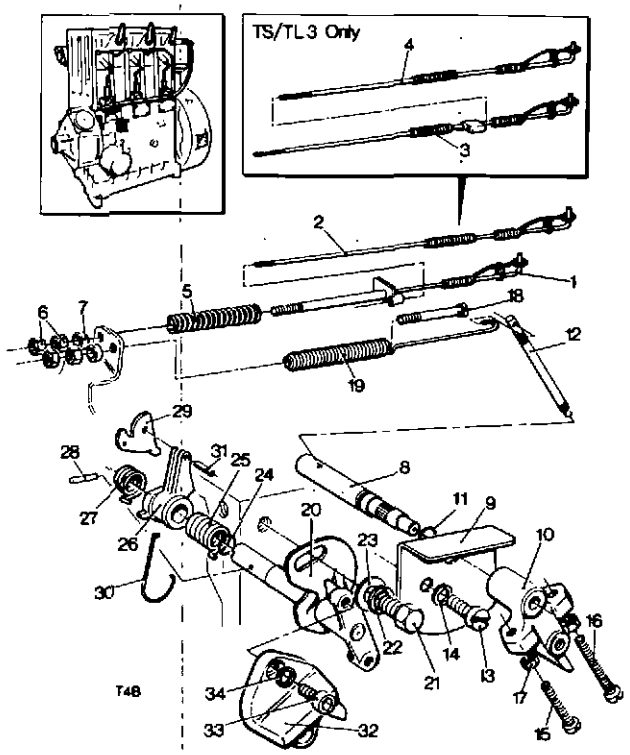


Fig. 44 Governor Linkage (earlier engines), Automatic Excess Fuel Control and Speed Control (See Figs. 44a and 44b)

GOVERNOR LINKAGE

1 Governor Link Assembly
— Fuel Pump Link Assembly
2 —TS2—Between 1 & 2 cylinders
3 —TS3—Between 1 & 2 cylinders
4 —Between 2 & 3 cylinders
5 Governor Lever Spring
6 Nut
7 Swivel Spacer
— Speed Control Lever & Bracket Assembly Comprises
8 Spindle
9 Bracket
10 Lever
11 'O' Ring
12 Pin
13 Cheese Head Screw
14 Spring Washer
15 Cheese Head Adjusting Screw—Short
16 Cheese Head Adjusting Screw—Long
17 Nut—M4 x 0.7-6H
18 Speeder Spring Adjusting Screw
19 Speeder Spring
20 Control Knob, Spindle & Plate Assembly (engine control)
21 Setscrew—M6 x 1.0–6g x 12mm
22 Spring Washer
23 Plain Washer
24 'O' Ring
25 Stopping Control Spring
26 Lever
27 Spring
28 Dowel
29 Cam
30 Cam Spring
31 Pin
(26–31: Automatic Excess Fuel Control)
32 Stop Control Knob
33 Cheese Headed Screw —M4 x 0.7-6g x 10 mm
34 Spring Washer

G SETTINGS

These are given in the table below in mm and (inches) for various speeds and two torque ratings (10% overload and no overload). For intermediate speeds use the value for the nearest highest speed.

An engine set to 100% load will develop its rated H.P. continuously including 10% overload for a period not exceeding one hour in any period of 12 hours consecutive running.

TS 2 and 3	Speed rev/min			
	1500	1800	2500	3000
10% overload	0.6 (0.024)	0.6 (0.024)	0.8 (0.032)	1.00 (0.039)
No overload	—	—	0.35 (0.014)	0.50 (0.020)

Removal of Engine Control and Automatic Excess Fuel Lever (Fig. 44)

(a) Remove excess fuel spring.
(b) Move automatic excess fuel lever along shaft.
(c) Remove dowel pin.
(d) Remove stopping control spring from location on excess fuel lever.
(e) Remove excess fuel lever and cam whilst withdrawing stopping lever, spindle and plate assembly.

Refitting Engine Control and Automatic Excess Fuel Lever

(a) Renew 'O' ring if necessary.
(b) Replace control knob, spindle and plate assembly whilst sliding automatic excess fuel lever over the spindle and against the stopping control spring.
(c) Relocate stopping control spring on excess fuel lever.
(d) Holding automatic excess fuel lever away from the hole replace dowel.
(e) Replace excess fuel spring.

Nozzle Leak Back

Calibration fluid temperature		Back leakage time (secs) 170 to 140 Atms pressure drop
°C	°F	
6	43	7.5—34
8	47	7 —33
10	50	7 —31
12	54	6.5—29
14	57	6.5—28
15.5	60	6 —27
18	64	5.5—25.5
20	68	5.5—24
22	72	5 —23
24	75	4.5—22
26	79	4.5—21
28	82	4 —20
30	86	4 —19.5

Method: Hand Pump.

FUEL PUMP SETTING (Later Engines) (Fig. 44b)

The length of the link between the fuel pumps is then adjusted so that the calibration marks (B) on all pumps are in line simultaneously. To adjust the length of each link it has to be disconnected from its pump. With shackle (D) still connected, slacken off locking sleeve (E) and rotate governor link (C) until the required length is obtained — fuel pump calibration marks are in line simultaneously. Tighten locking sleeve (E) on to shackle (D).

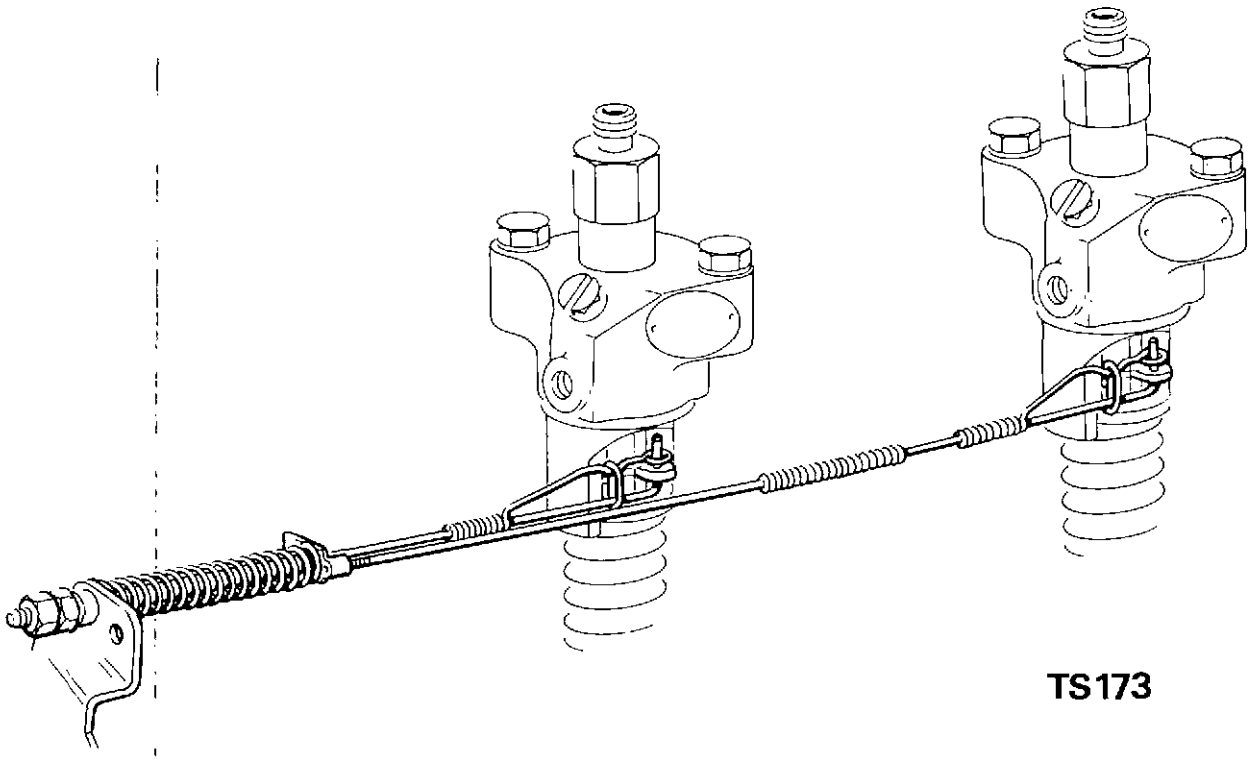


Fig. 44a Governor Linkage (earlier engines)

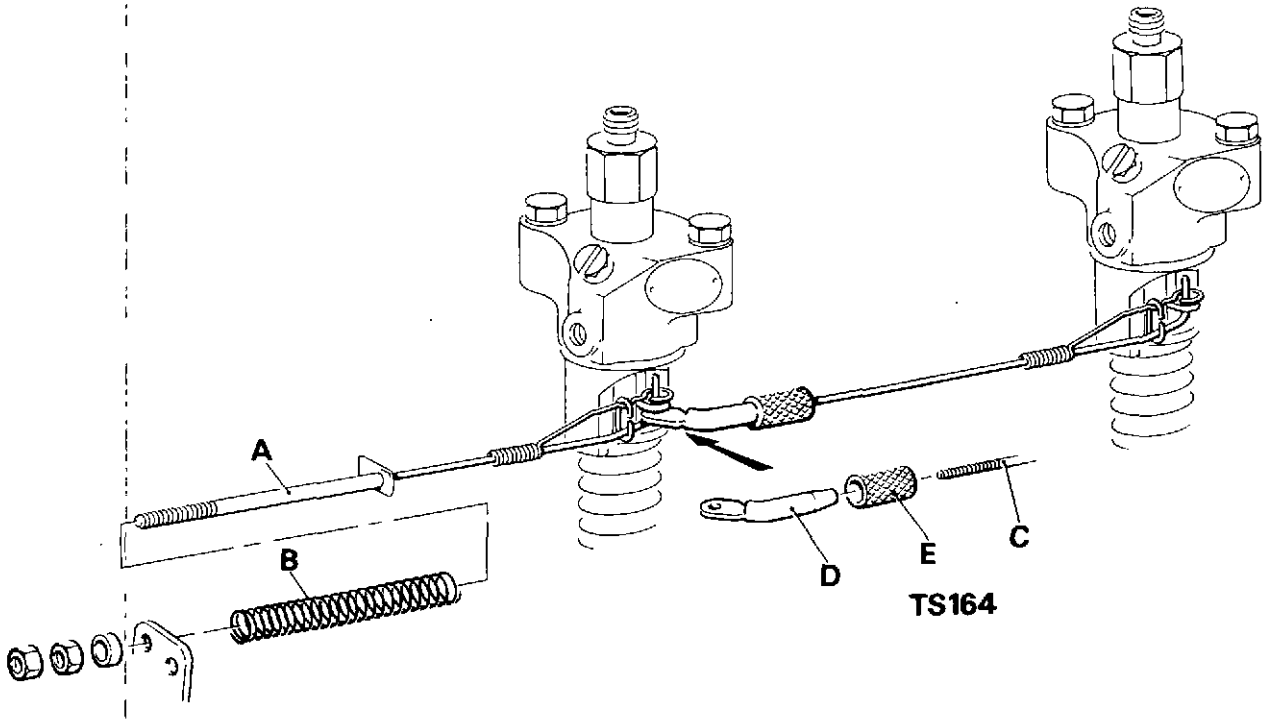


Fig. 44b Governor Linkage (later engines)

A. Governor Link (No. 1 pump)
B. Governor Lever Spring
C. Governor Link (No. 2 and 3 pump)
D. Shackle
E. Locking Sleeve

The method of retention of the governor weight pins in machined slots in the gearwheel has been superseded by the introduction of sintered keeper plates with cast slots to position the pins.

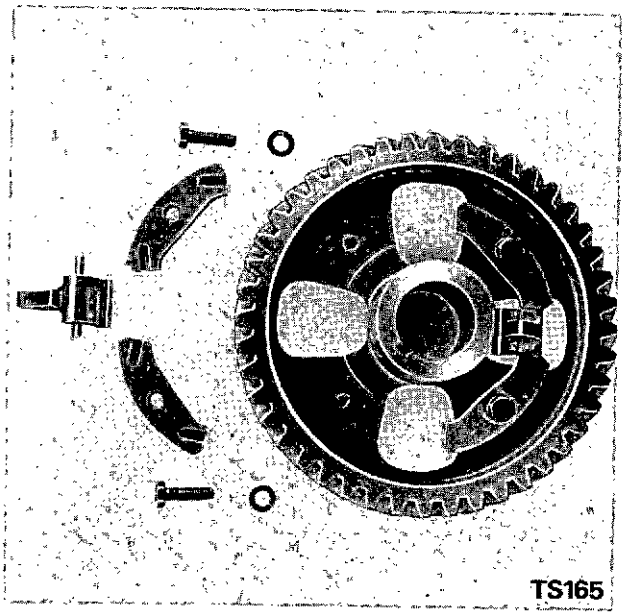


Fig. 44c Governor Weights (later engines)

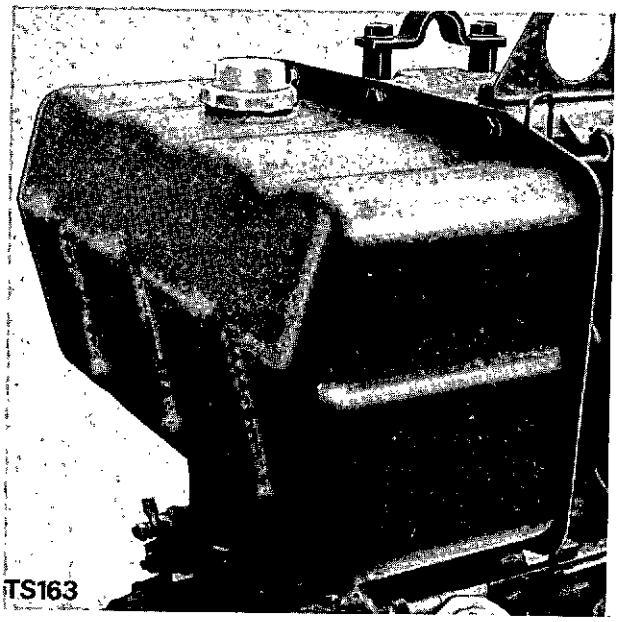


Fig. 44d. Fuel Tank (later style)

Section Four
ENGINE

TS2 Engine — Without Engine Mounted Fuel Tank

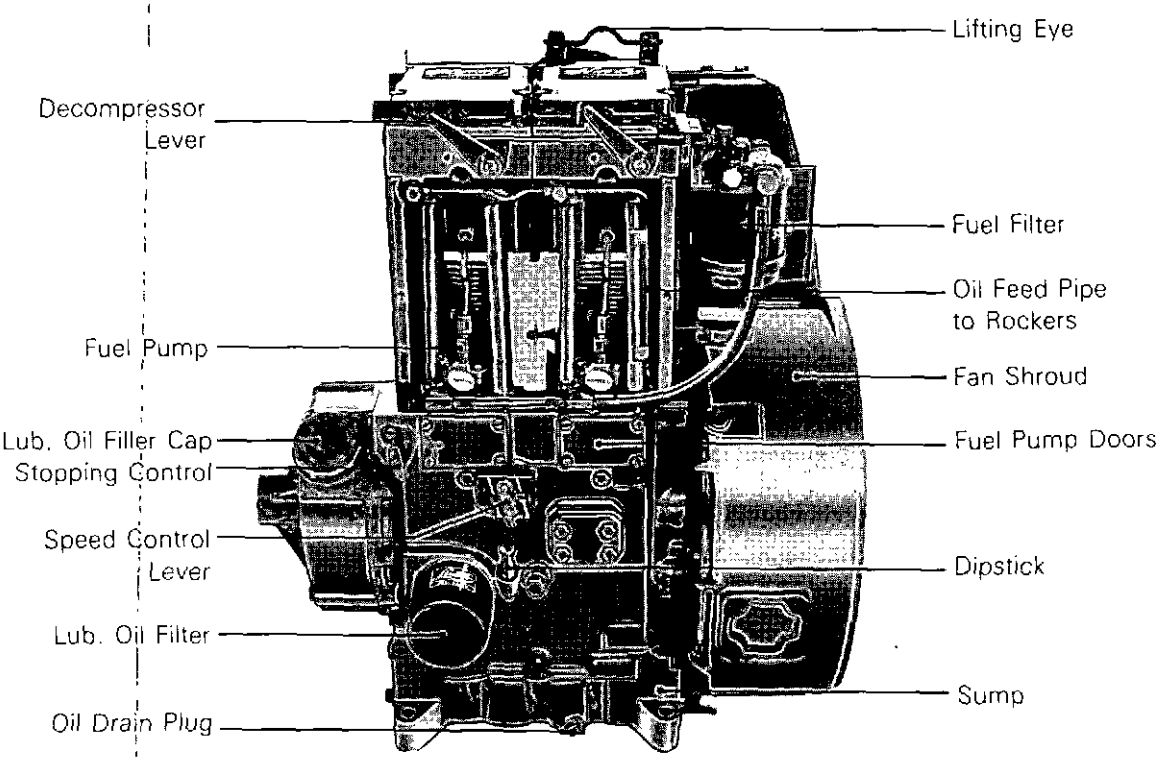


Fig. 45 Main Features — Fuel Pump Side

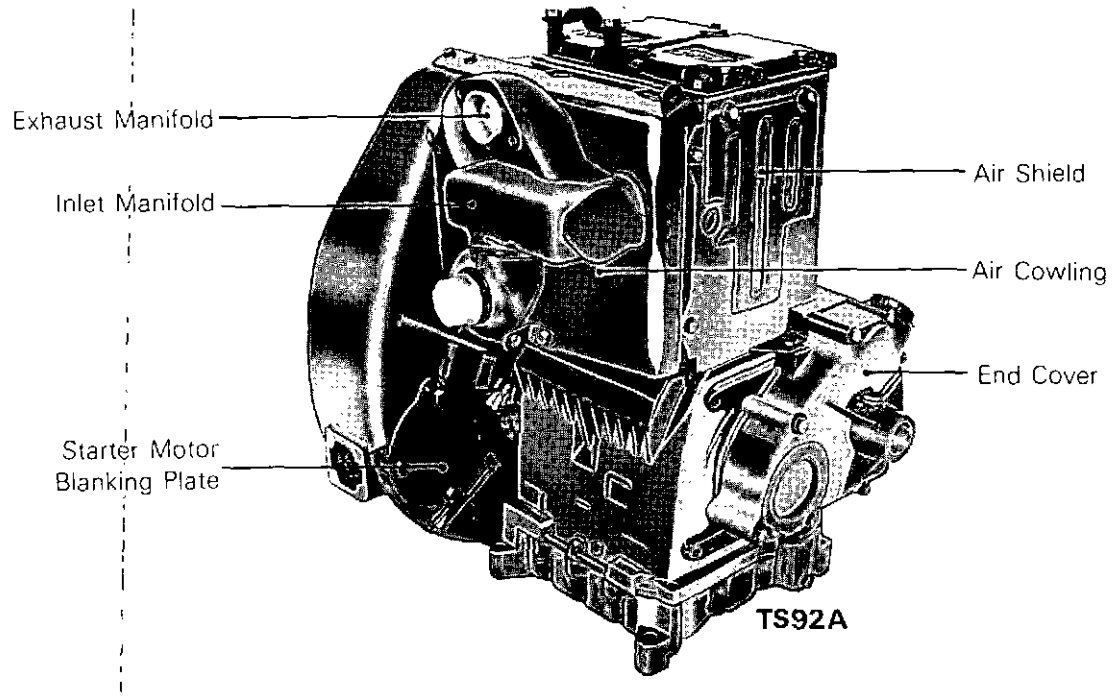


Fig. 46 Main Features — Manifold Side

TS2 Engine — With Early Version Engine Mounted Fuel Tank

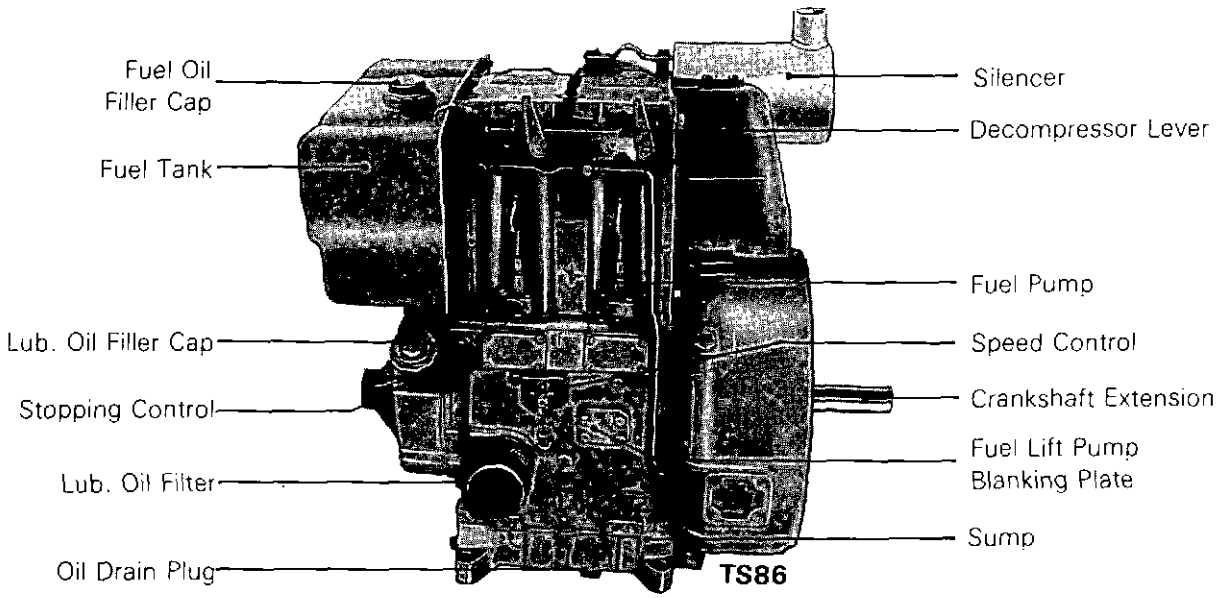


Fig. 47 Main Features — Fuel Pump Side

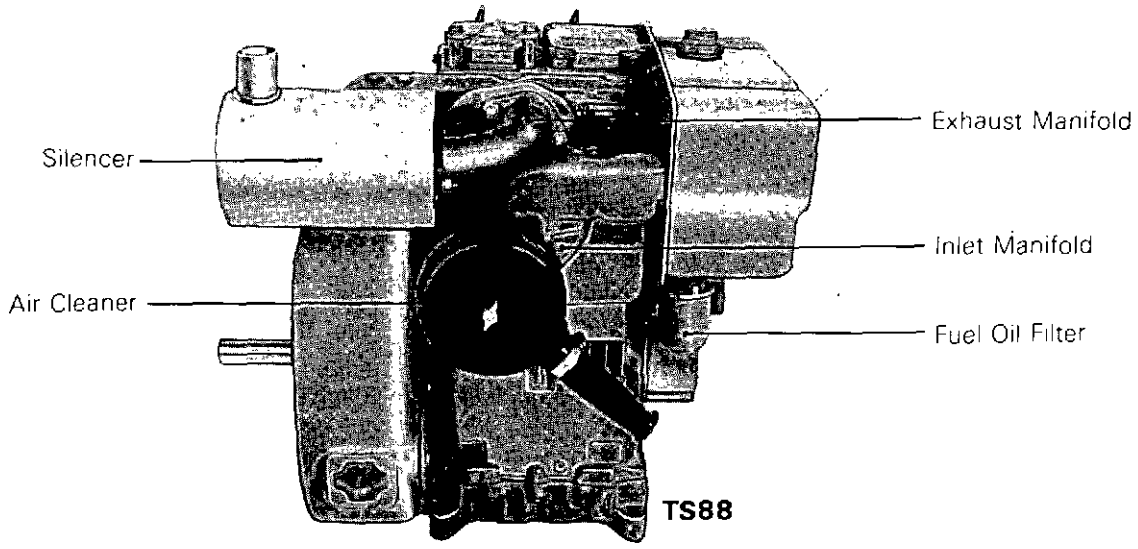


Fig. 48 Main Features — Manifold Side

TS3 Engine — Without Engine Mounted Fuel Tank

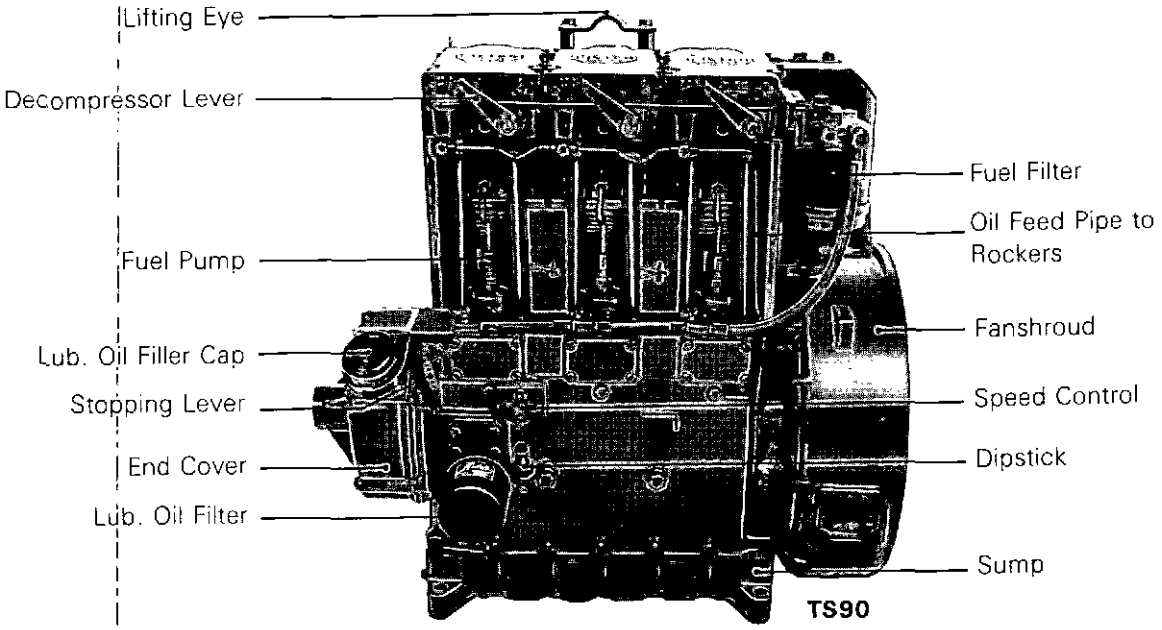


Fig. 49 Main Features — Fuel Pump Side

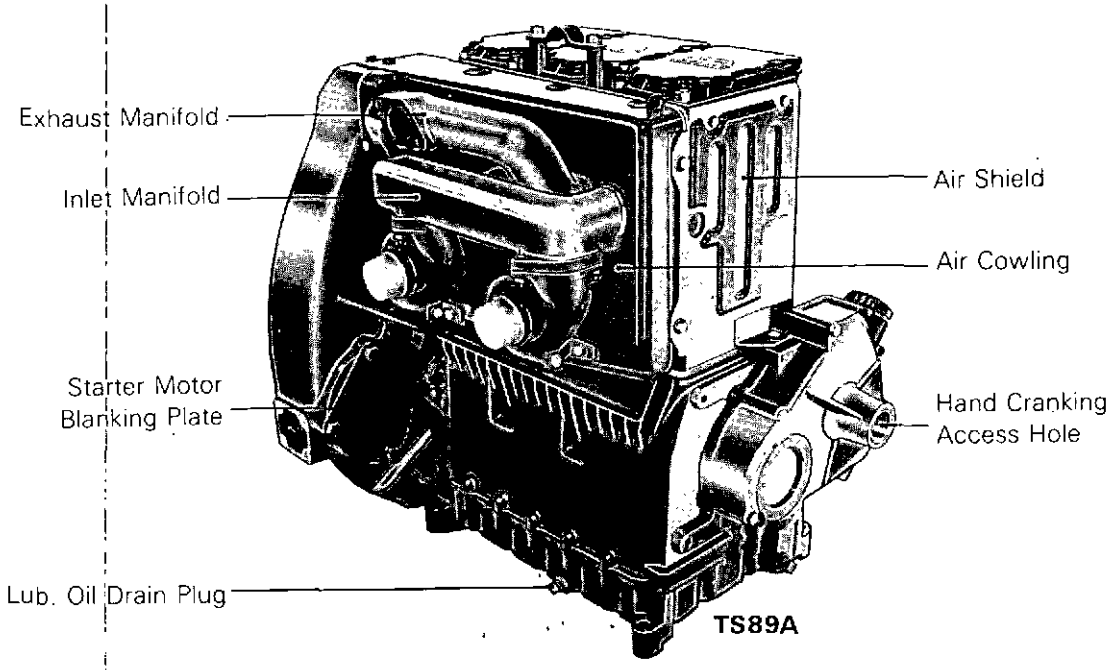


Fig. 50 Main Features — Manifold Side

INTRODUCTION

Every effort must be made to maintain the engine in a clean condition and oil leaks must be dealt with as soon as they occur. With a new or overhauled engine the joints settle during the first few hours running and their tightness must be subsequently checked. A table showing recommended jointing compounds and how to use them can be found on page 87.

LUBRICATION ON ASSEMBLY

When assembling the engine, use normal engine lubricating oil of the correct performance and viscosity.

All bearing surfaces must be well lubricated including the valve stems and the cups of the push rods.

New camshaft bushes should be immersed in clean engine oil for four hours before fitting.

The pistons with rings and connecting rods assembled, must be submerged in oil just before fitting into the cylinder. After submersion drain both ways so that no liquid oil is left in the combustion chamber or inside the piston.

CYLINDER HEAD COVER AND LIFTING EYE

The light alloy cylinder head cover, which is bolted to the top of the cylinder head, gives access to the breather box, decompressors, injector and valve gear. The top of the engine mounted fuel tank is secured to the side of the cover at the gear end by two setscrews. The lifting eye is adjacent to the cover.

Removing Lifting Eye (Fig. 51)

(1) Remove the two setscrews and washers securing the lifting eye to the pillar nuts securing the cylinder head.
(2) Remove lifting eye.

Refitting the Lifting Eye

To refit the lifting eye reverse the procedure.

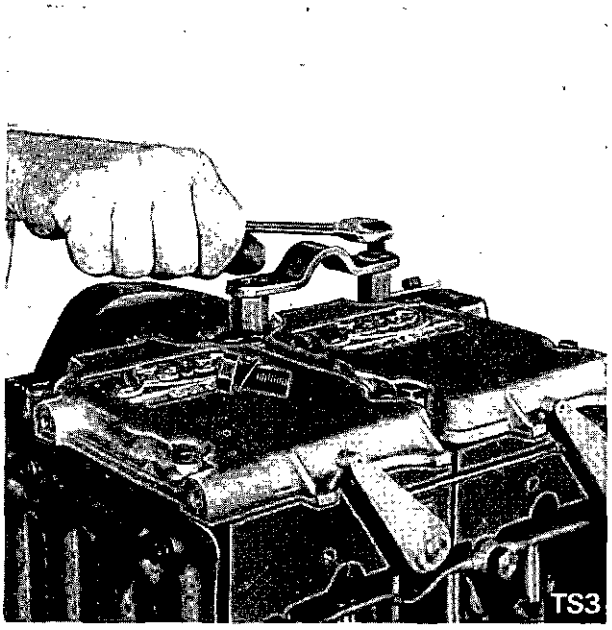


Fig. 51 Removing Lifting Eye

Note: When re-assembling an engine it is always advisable to renew nuts and bolts that have been taken from high stress locations, in particular nuts/bolts from connecting rod big ends and cylinder heads should be renewed.

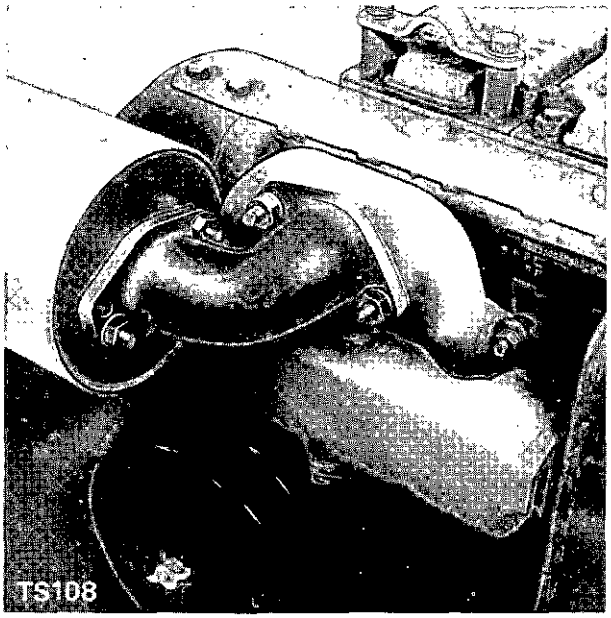


Fig. 52 Silencer Attachments

AIR CLEANER, MANIFOLD AND SILENCER

Air Cleaner (Fig. 53)

The standard air cleaner is fitted to the air manifold adaptor by a jubilee clip. Access to the paper element is gained by undoing the cruciform headed screw in the centre of the main body of the filter casing. If the element is found to be dirty it should be renewed. (For heavy duty air cleaner see silencer).

Silencer

Bolted to the side of the exhaust manifold is the standard exhaust silencer which has provision for fitting a tail pipe or a lightweight extension. The outlet of the silencer must face away from the engine unless it is connected to a tail pipe.

It is important to ensure exhaust gases are not sucked in by the air cleaner or the cooling fan, otherwise choking will occur.

Small light non-tubular exhaust silencers, and ordinary small air cleaners may be mounted direct on to the manifolds, or on very short and light *extensions which must be no more than 152mm* (6'') long.

Heavy exhaust silencers and air cleaners must be remotely mounted, or mounted on the engine using special brackets. Connections should be by means of flexible pipe or hose with no solid extensions between the manifold adaptors and the flexible element. All joints must be gas or air tight.

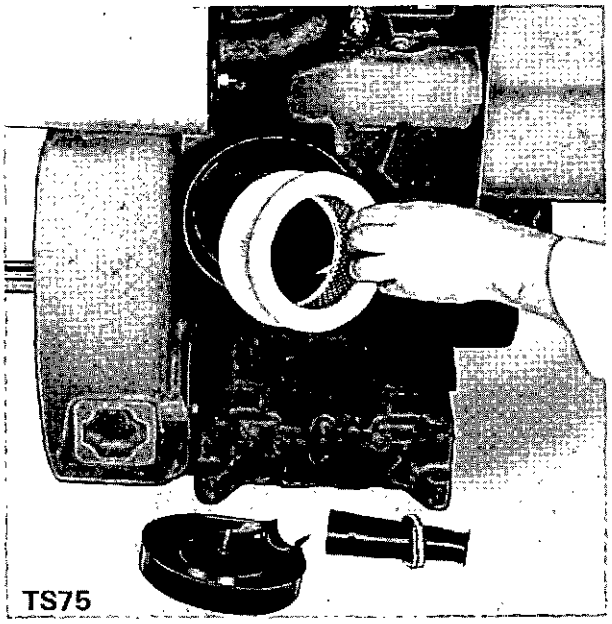


Fig. 53 Changing the Air Cleaner Element

Manifolds (Fig. 55)

The exhaust manifold is made of cast iron and the inlet manifold of light alloy. They are secured to the cylinder heads on studs. The brass nuts are torque loaded as follows;

(a) Top nuts 21.02 Nm. (15.5lbf.ft)
(b) Bottom nuts 8.82 Nm. (6.5 lbf.ft.)

Removal of Manifolds (Fig. 54)

(a) Remove air cleaner and silencer.
(b) Remove brass nuts, spring washers and distance pieces.
(c) Remove setscrew securing inlet manifold to air cowling.
(d) Remove manifolds and gaskets.
(e) Unscrew and remove cold start pots (if fitted).

Refitting of Manifolds

To refit the manifolds reverse the above procedure.

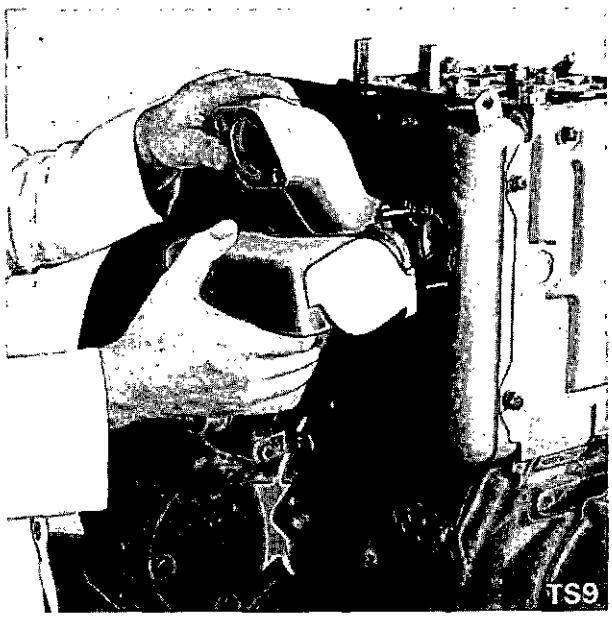


Fig. 54 Removal of Manifolds

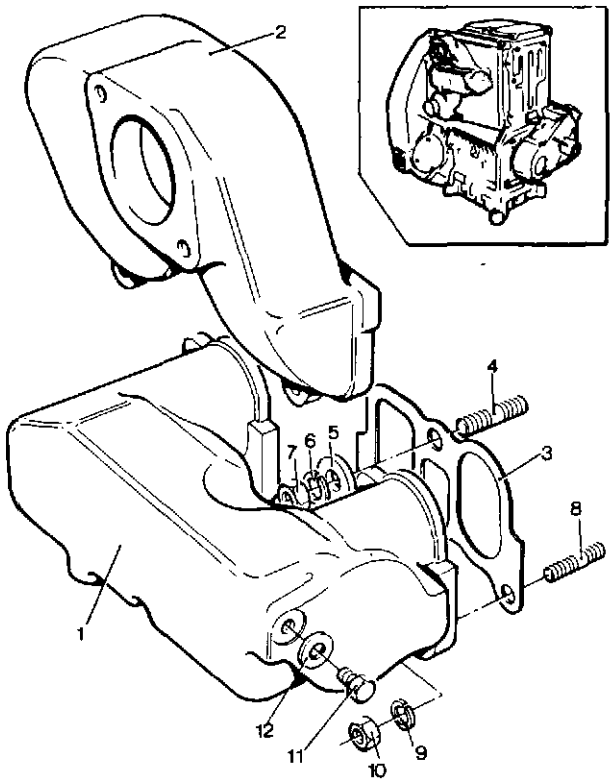


Fig. 55 Manifolds

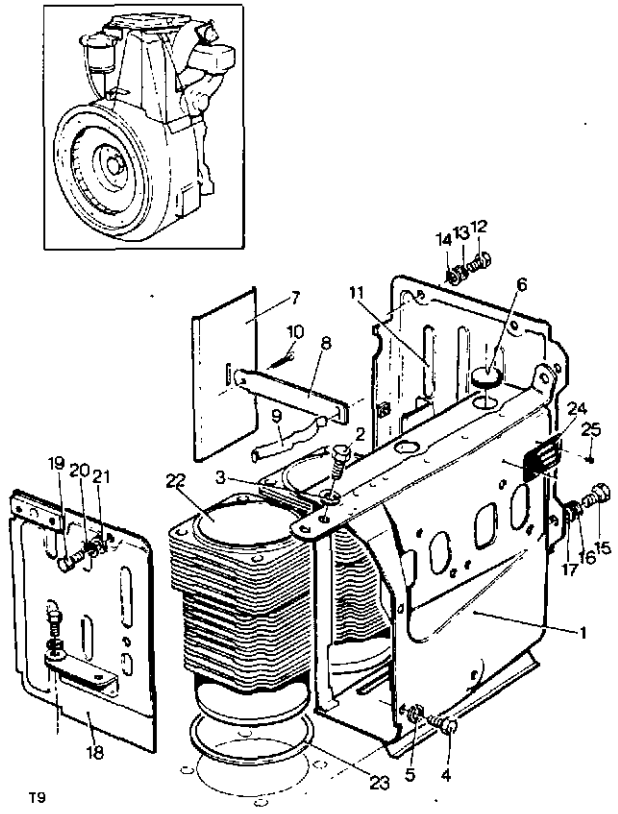


Fig. 56 Air Cowling and Baffles

MANIFOLDS

1 Inlet Manifold
2 Exhaust Manifold
3 Joint
4 Manifold Top Stud—M8 x 1.25-6g x 40mm
5 Clamping Washer
6 Spring Washer
7 Brass Nut—M8 x 1.25-6H
8 Manifold Bottom Stud—M8 x 1.0-6g x 35mm
9 Spring Washer
10 Special Nut
11 Setscrew—M8 x 1.25-6g x 8 mm
12 Washer

AIR COWLING & BAFFLES

1 Air Cowling Assembly
2 Strap To Fanshroud Setscrew —M8 x 1.25-6g x 20mm
3 Spring Washer
4 Cowling To Fanshroud Setscrew —M6 x 1.0-6g x 8mm
5 Spring Washer
6 Grommet
7 Air Baffle
8 Tie
9 Spring Clip
10 Split Pin

SIDE SHIELDS

11 Gear End Side Shield Assembly
12 Setscrew—M6 x 1.0-6g x 12mm
13 Spring Washer
14 Plain Washer
15 Setscrew—M8 x 1.25-6g x 16mm
16 Spring Washer
17 Plain Washer
18 Flywheel End Side Shield Assembly
19 Setscrew—M6 x 1.0-6g x 12mm
20 Spring Washer
21 Plain Washer

CYLINDER BARREL

22 Cylinder Barrel
23 Joint

ENGINE NUMBER PLATE

24 Engine Number Plate
25 Self Tapping Screw

AIR COWLING AND SIDE SHIELDS

Three sides of the engine are encased in an air cowl and two side shields, which together with the air baffle(s) direct cooling air from the flywheel fan around the cylinders. If cold start pots fitted remove before removing air cowling.

Removal of Air Cowling and Side Shields (Fig. 57 & 58)

(a) Drain fuel oil and remove engine mounted fuel tank (if fitted), complete with fuel filter (see Section 2).

(b) Remove gear end air shield by removing setscrews, spring washers and plain washers in top plate and air cowling.

(c) With manifolds removed, take off air cowl by removing setscrew in fanshroud and setscrews, spring and plain washers in cowl.

(d) If a fuel filter is fitted to the flywheel end shield, isolate or drain fuel before disconnecting fuel feed to fuel pumps and remove two nuts and spring washers securing the fuel filter.

(e) Remove setscrews, spring washers and plain washers securing flywheel end shield to top plate (note the setscrew in the middle of the filter mounting block) and remove shield.

Air Baffles

Air baffles can be removed for cylinder fin cleaning by removing the split pin with the cylinder head still fitted.

Refitting of Air Cowling and Side Shields

To refit the air cowlings and side shields reverse the above procedure.

Tolerances

The cooling air sheet metal work and ducting must fit together within 0.8 mm (0.032") maximum, except in places where a cast irregular profile is followed, where the gap may be 2.0 mm (0.080") maximum.

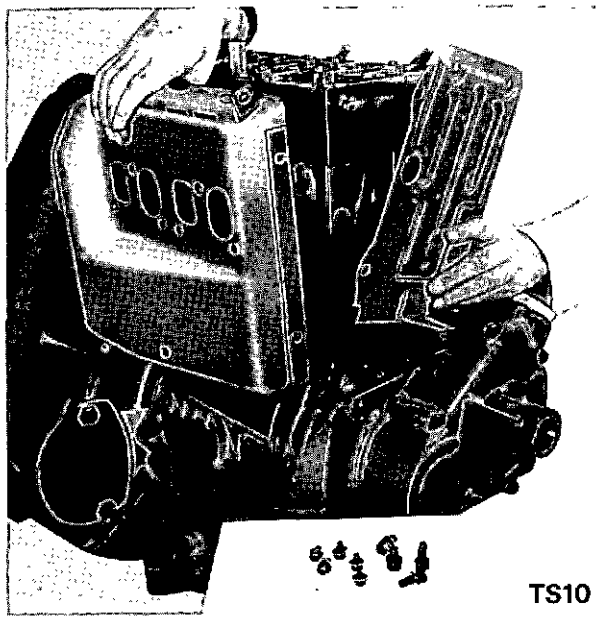


Fig. 57 Removing Gear End Air Shield and Air Cowling.

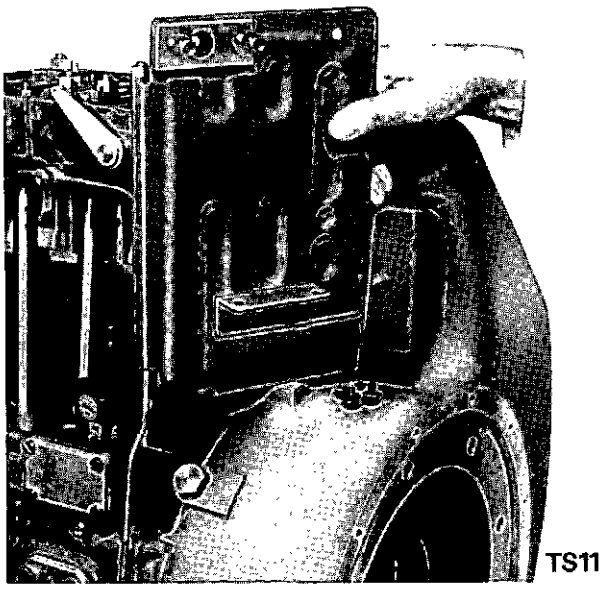


Fig. 58 Removing Flywheel End Air Shield.

Removal and Refitting of Fuel Injector

See Section 3.

Note: It is recommended that all copper washers are renewed on assembly and therefore a suitable supply should be stocked. In the case of the injector copper washer any undue 'squashing' of the washer when used more than once will adversely affect combustion. For the same reason care should be taken not to fit two washers.

CYLINDER HEAD (Fig. 61 & 62)

The cylinder head assembly comprises two main parts. The top half (top plate) is cast iron and contains the valve gear, breather tube and on certain builds the decompressor lever. The lower half (cylinder head) is aluminium alloy into which are fitted the valve seat inserts. The valve guides are a press fit and hold the two halves together.

Removing Cylinder Head Cover (Fig. 59 & 60)

(a) Remove four setscrews and copper washers securing the cover.
(b) Remove the cover being careful not to damage the joint or fuel leak off pipe. Take care not to lose the felt washer fitted over the cylinder head breather tube.

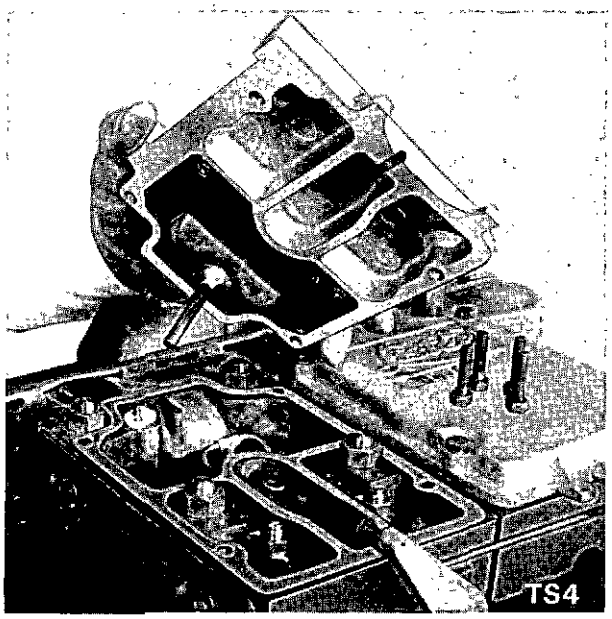


Fig. 59 Removing Cylinder Head Cover

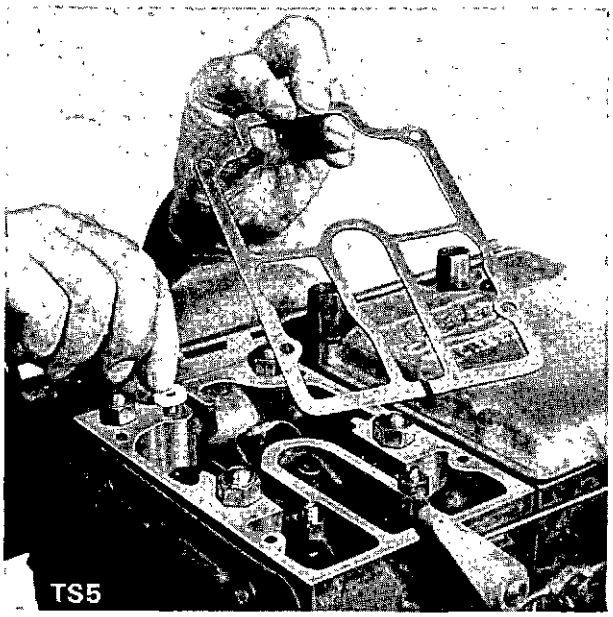


Fig. 60 Cylinder Head Cover Joint and Felt Washer

Breather (Fig. 59)

A breather plate locates over the breather tube and forms an oil separator box in the cylinder head cover. The oil separator box connects with the inlet port via a copper pipe brazed to the breather plate. The breather plate has a metal to metal contact with the cylinder head cover and is secured with three self tapping screws.

A felt washer is fitted around the top of the tube between the cylinder head and breather plate.

The breather tube forms an interference fit in the cylinder head.

Refitting the Cylinder Head Cover

(a) Ensure the breather plate is securely retained in position and that the felt washer is fitted around the breather tube.
(b) Apply Hylomar PL32M to cover jointing face and stick the joint to it.
(c) Replace cylinder head cover ensuring the decompressor lever (if fitted) is located between the two stops and that the leak off pipe is located snugly in the recess provided.
(d) Fit four setscrews and copper washers.

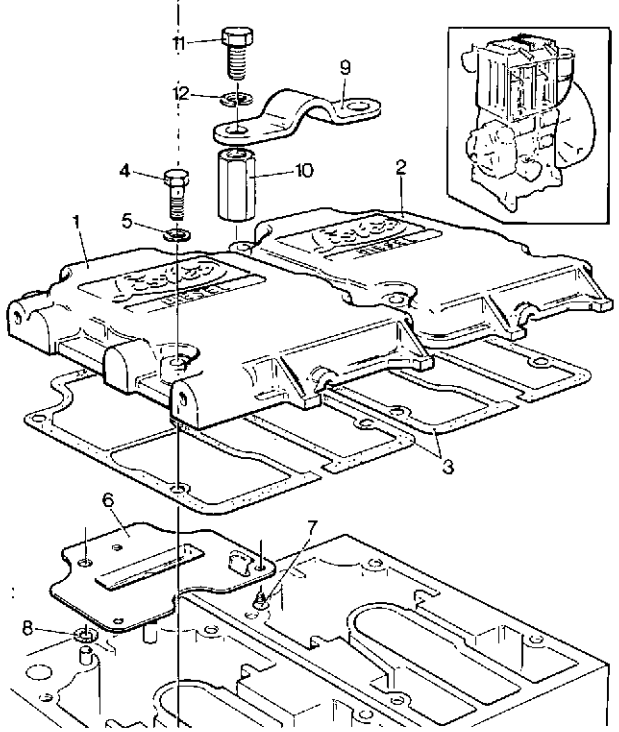


Fig. 61 Cylinder Head Cover & Lifting Plate

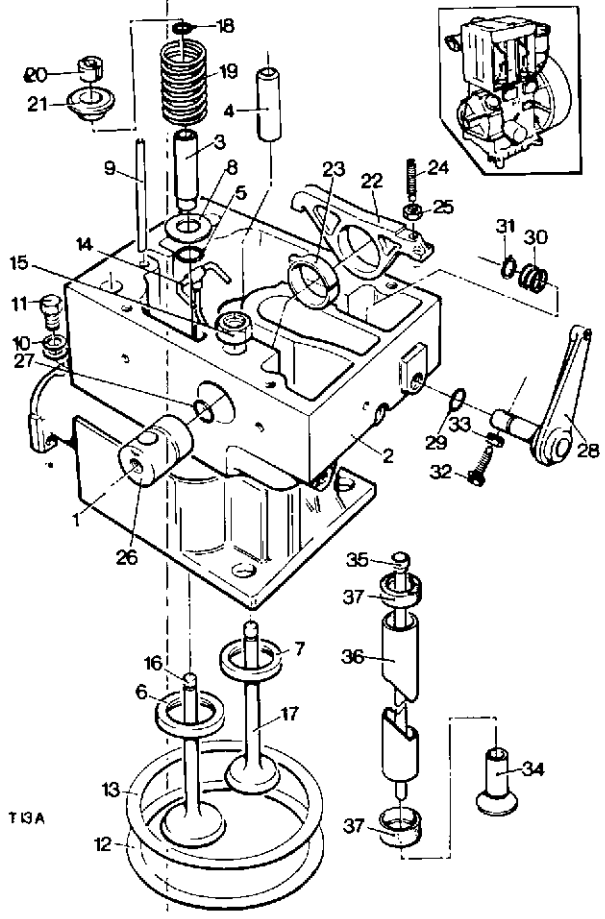


Fig. 62 Cylinder Head

CYLINDER HEAD COVER

1 Cylinder Head Cover—Gear End
2 —Centre/Flywheel End
3 Joint
4 Bolt—M6 x 1.0-6g x 25mm
5 Copper Washer
6 Breather Plate
7 Self Tapping Screw—M4 x 0.7-6g x 10mm
8 Breather Plate Sealing Ring
9 Lifting Eye
10 Pillar Nut
11 Setscrew—7/16"UNF x 1"
12 Spring Washer

CYLINDER HEAD

1 Cylinder Head
2 Top Plate
3 Inlet Valve Guide
4 Exhaust Valve Guide
5 'O' Ring—Inlet Valve
6 Inlet Valve Insert
7 Exhaust Valve Insert
8 Bottom Spring Carrier—Inlet Valve
9 Breather Tube
10 Copper Washer
11 Setscrew—M8 x 1.25-6g x 8mm
12 Cylinder Head Gasket
13 Cylinder Head Shim
14 Lubricating Oil Pipe
15 Cylinder Head Nut
16 Inlet Valve
17 Exhaust Valve
18 Inlet Valve Stem Sealing Ring
19 Spring
20 Cotter/Collet
21 Top Spring Carrier
22 Valve Rocker Lever
23 Bush
24 Adjusting Screw
25 Nut—M8 x 1.25-6H
26 Stub Shaft
27 'O' Ring
28 Decompressor Lever Assembly
29 Oil Seal
30 Spring
31 Circlip
32 Screw
33 Nut—M6 x 1.0-6H
34 Tappet
35 Push rod
36 Sealing Tube
37 Rubber Cup.

Removal of Cylinder Heads

(a) Remove rocker lubricating oil feed pipe by removing plugs from cylinder head and crankcase, note copper washer on either side of each banjo union (Fig. 15).

(b) Remove cylinder head securing nuts, four per head including two lifting eye pillar nuts (Fig. 63).

(c) Mark cylinder heads (No. 1, 2 and 3—No. 1 is the gearcase end) and carefully remove (Fig. 64).

(d) Ensure shims and gaskets from each cylinder are placed with respective cylinder heads for correct re-assembly.

(e) Remove air baffle/s taking careful note of position for re-assembly.
Note: with the cylinder head in position the air baffle/s may be removed by removing the split pin.

(f) Remove push rod covers and push rods and place with cylinder heads if further dismantling anticipated (Fig. 66).

(g) Place a suitable length of tube over one holding down stud of each cylinder, and secure by placing a cylinder head nut finger tight to prevent movement of the barrels when the crankshaft is turned (Fig. 65).

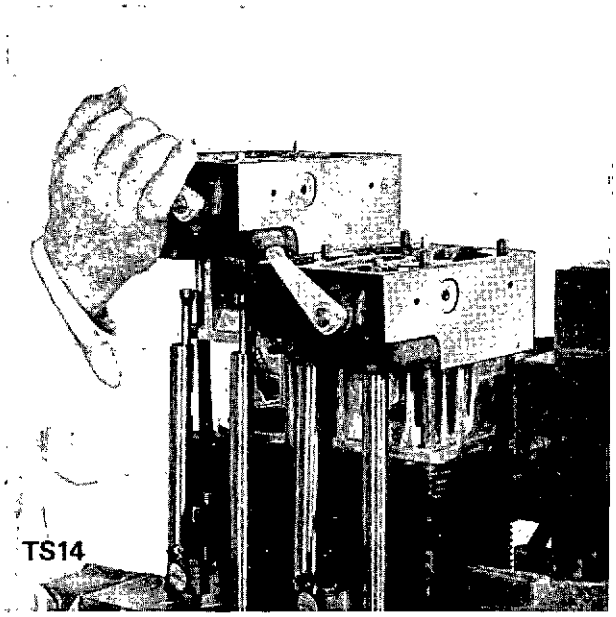


Fig. 64 Removing Cylinder Head.

Note: All cylinder head studs should be dipped in Shell Ensis Fluid MD (formerly Fluid 260) and air dried before fitting.

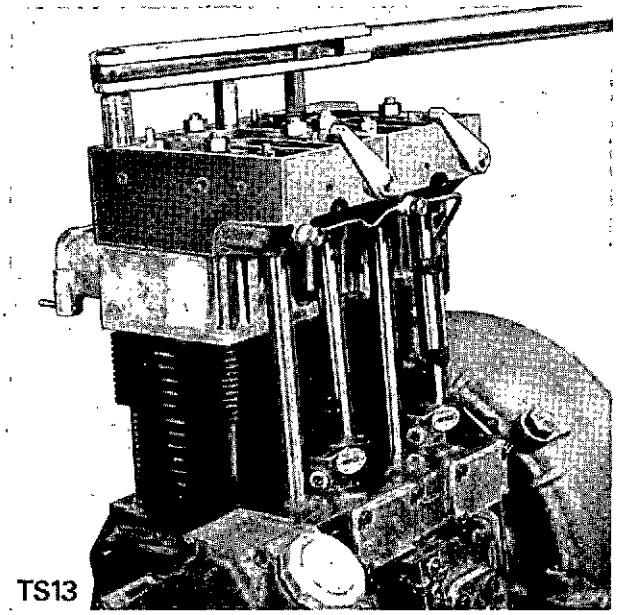


Fig. 63 Removing Cylinder Head Nuts.

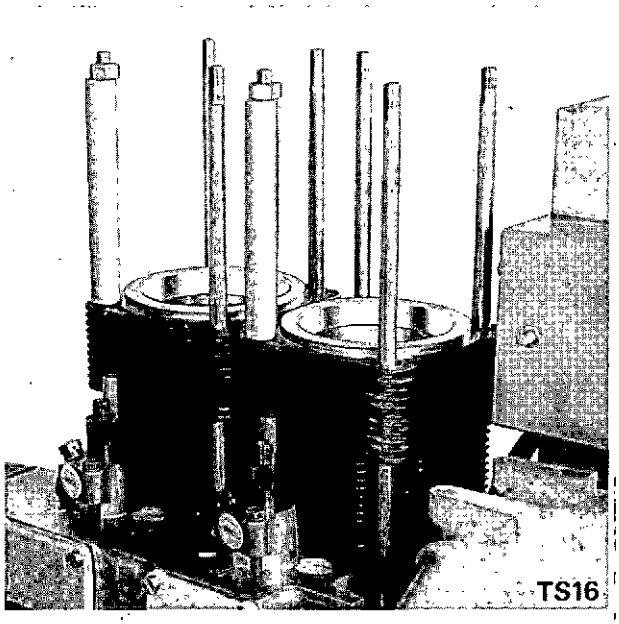


Fig. 65 Holding Down Tubes.

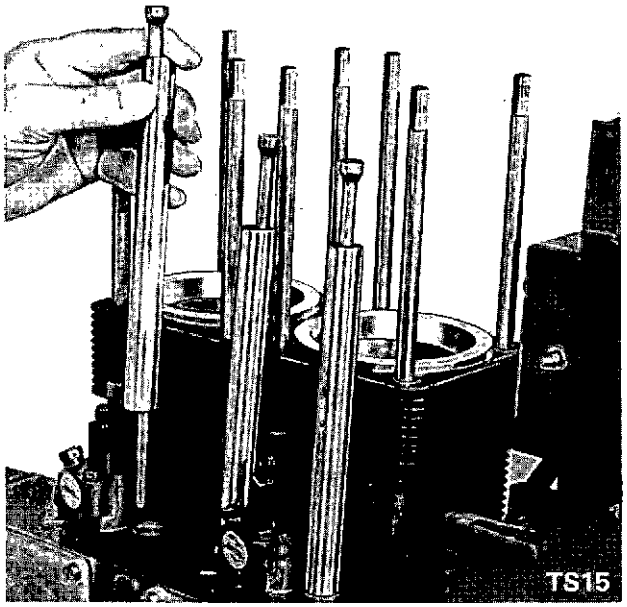


Fig. 66 Removing Push Rod and Tubes.

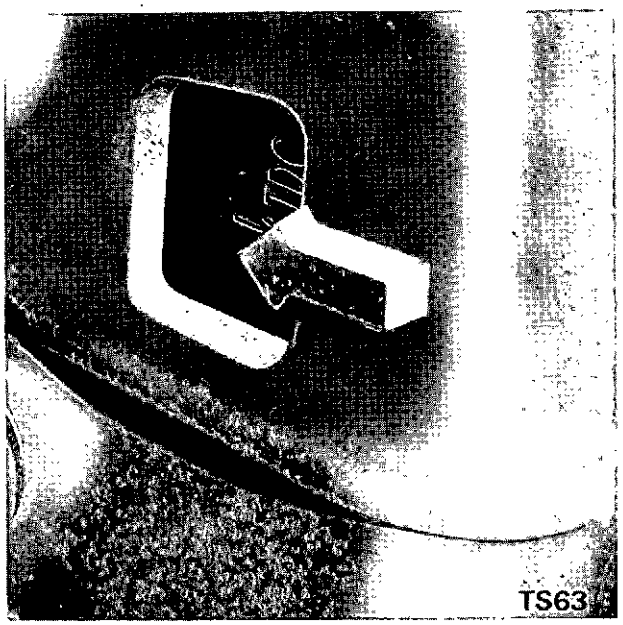


Fig. 67 Flywheel T.D.C. Mark

Cylinder Head

1 Breather tube felt sealing washer
2 Cylinder head
3 Stub shaft
4 Decompressor lever
5 Tappet adjusting screw
6 Rocker feed lubricating oil pipe
7 Valve assembly
8 Top plate

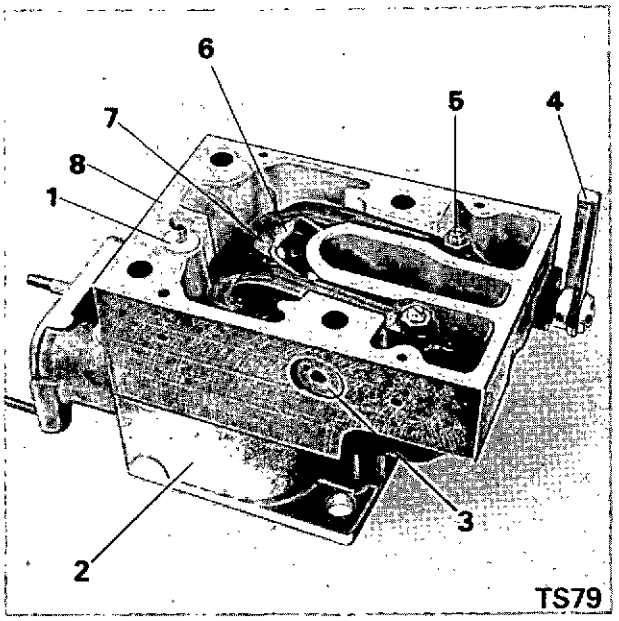


Fig. 68 Cylinder Head

Valves and Valve Guides

The valve guides are a press fit into the two halves of the cylinder head assembly. A rubber ring and a retaining plate are located around the top of the inlet guide. The rubber sealing ring must be inserted in the top plate recess prior to pressing in the inlet valve guide to prevent damage to the ring because there is no lead chamfer to the recess.

The valve guides are marked 'IN TOP' and 'EX TOP' and is short for 'Inlet top' and 'Exhaust top' respectively. After coating the outside of the valve guides with 'Wellseal' they should be pressed into their correct drilling with the markings uppermost and pointing towards the opposite guide, a special tool* is needed to obtain the correct projection of the valve guides above the top plate surface and this *should be:*

Exhaust Valve Guide
17.40/17.90 mm (0.685/0.704 ins.)

Inlet Valve Guide
12.40/12.90mm (0.488/0.507ins.).

After assembly a gauge 8.707 mm (0.343 ins.) dia. must pass through the exhaust valve guide otherwise the guide must be reamed square 8.707/8.727 mm (0.343/0.3436 ins.) dia.

Valve Seatings

The seats in the heads are cast iron inserts which are pressed in ensuring that they bed on the bottom of the recesses in the cylinder head. Before pressing the inserts the head should be heated to 120°C maximum, and the inserts chilled in solid CO_2 (dry ice).

The seats are precision ground so that the inlet valves lay sunk 1.02/1.27 mm. (0.040/0.050 ins.) and the exhaust 0.89/1.14 mm. (0.035/0.045 ins.) below the combustion surface of the head. The width of the inlet seatings must be 1.65/2.29 mm. (0.065/0.090 ins.) and the exhaust 1.35/1.78 mm. (0.053/0.070 ins.) and if necessary metal must be ground or cut from the top of the insert or recess. The valves are prefinished and no lapping or further processing is required.

Valve Rocker Stub Shafts

The removal of these items is only necessary where it is required to examine or change the rocker arms, bushes or stub shafts.

The stubs are tapped M8 x 1.25 pitch and can be withdrawn by a special tool* or by improvising an extractor with a steel tube and penny washer in conjunction with an M8 x 1.25 pitch setscrew and distance piece. Prior to fitting check oil holes are clear, fit 'O' ring to the recess on the inside face of the stub shaft, **and coat the sealing groove with Wellseal.** When refitting, the mark 'TOP' on the outside face of the stub should be positioned accordingly. Ideally the stub shaft should be pressed home. It is imperative that the stub shaft hole and internal hole of the rocker arm bush are perfectly *aligned. If no special tool is available small G clamps* or a second pair of hands will be required.

*See Section 7 for special service tool.

WARNING: When refitting stub shafts take care not to dislodge the 'O' ring on the inside face recess.

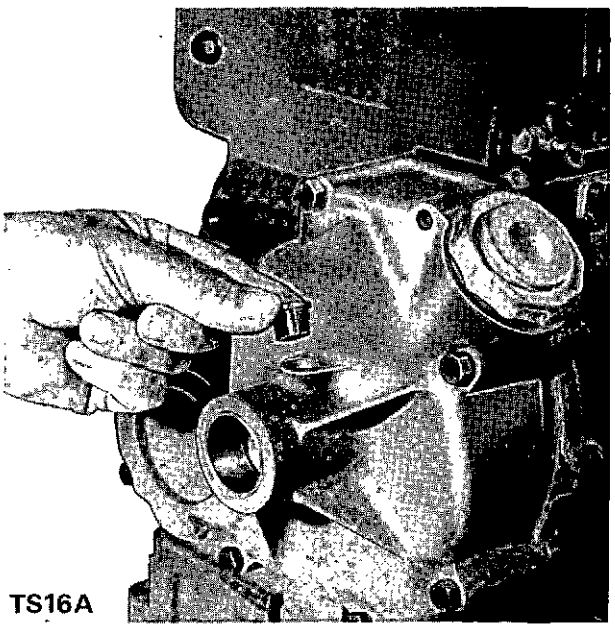


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Fig. 69 Removing Plastic Cap

Valves and Valve Springs

Prior to removing valves and valve springs remove the decompressor lever (if fitted) as follows. Remove split pin or circlip, washer, spring and adjusting screw and withdraw the decompressor lever (Fig. 74).

(a) Lay head upright on the bench and place a circular block of wood under the heads of the *valves*.
(b) Depress valve spring carrier* (Fig. 70).
(c) Remove valve stem collets.
(d) Remove valve spring carrier, valve spring, and inlet valve stem sealing ring.
(e) Remove valve (Fig. 71).

Assemble in reverse order and when refitting, ensure collets are securely in position with tops of collets slightly sunk in the valve spring carrier.

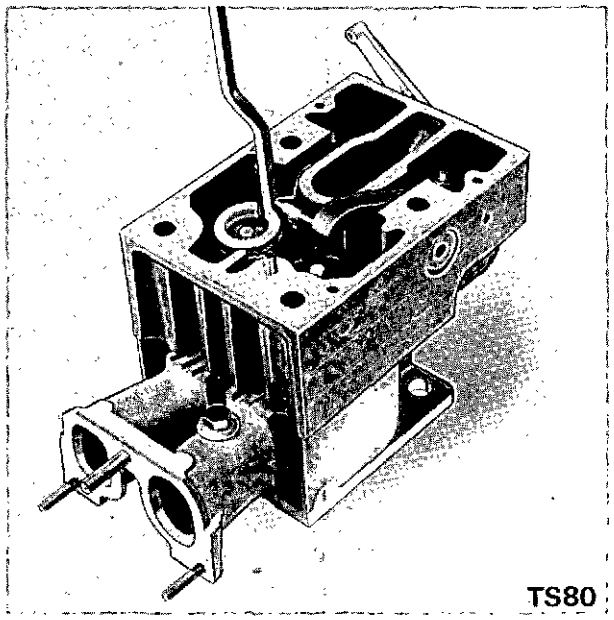

Fig. 70 Removing Valves and Springs

Refitting the Cylinder Head

Examine the gasket and shims and renew if necessary. Fit the necessary shims — see Checking Cylinder Head Clearance — nearest the head followed by the gasket. Smear high melting point grease in the recess on the head where the shims seat and also the side of the recess. Smear grease on each shim in turn and place it in the recess. Finally smear grease on the thick gasket and place it in the recess on top of the shims. The top of the cylinder is not coated and in all cases use the grease sparingly.

The sequence for fitting the head is the reverse to removal. The cylinder head nuts, top threads of the studs and the area of the top plate in contact with the nuts should be lightly coated with Wellseal; cylinder head nuts should always be fitted with the grade symbol facing upwards to ensure a good seal between the nut and the top plate.

Push rods should be lined up correctly and push rod guides centralised in their rubber rings. Great care must be taken not to trap the shims on the cylinder spigot. The inlet and exhaust flanges of all cylinder heads must be lined up with a straight edge and any gap along the straight edge must not exceed 0.2 mm. (0.008 ins.). Alternatively fit a manifold before tightening down the cylinder heads.

When tightening down the cylinder head, ensure all nuts are tightened evenly and torque loaded to 67.8 Nm. (50 lbf/ft.). After refitting the cylinder head reset valve rocker clearances and readjust the decompressor (if fitted). It is essential that the cylinder head nuts are tightened before securing the injector.

*See Section 7 for special service tool for removal of valve springs.

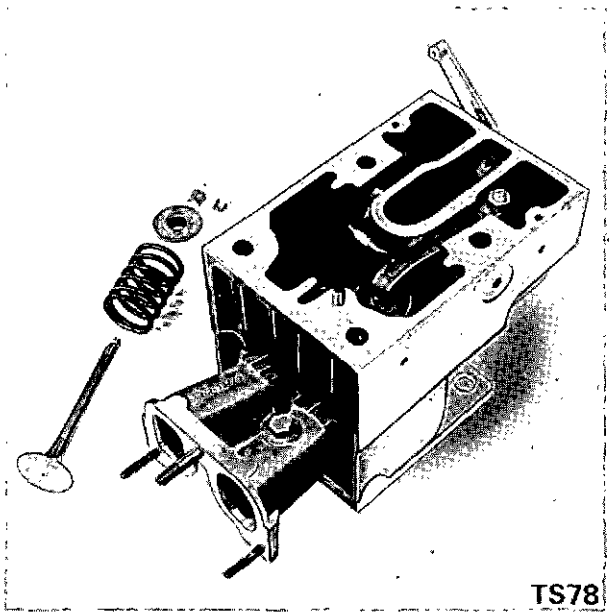

Fig. 71 Valve and Spring Dismantled

Checking Cylinder Head Clearance (Fig. 72)

Place two pieces of lead wire 1.2 mm. (0.048 ins.) thick on the cylinder head, clear of valve recesses and the combustion chamber in the top of the piston; retain in position with grease. Space the lead wire widely and as near as possible in line with the gudgeon pin. Tighten down the cylinder head to the correct torque loading and turn the piston twice past T.D.C. Remove the cylinder head and measure the thickness of the lead. This should be between 0.889 and 0.965 mm. (0.035/0.038 ins.) and can be adjusted by shims 0.076 mm. (0.003 ins.) or 0.254 mm. (0.010 ins.) thick placed between the cylinder head and the gasket. The gasket must be placed next to the cylinder and a minimum number of 0.076 mm. thick shims must be used and these must be placed between the gasket and the 0.254 mm. shims.

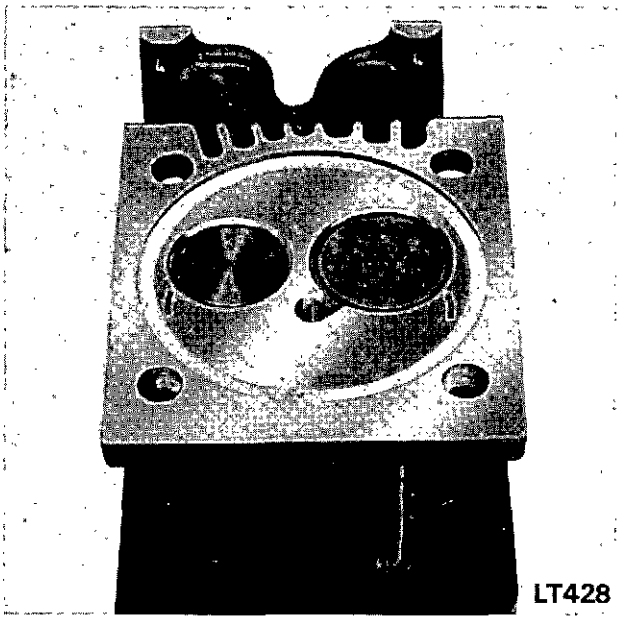

Fig. 72 Checking Cylinder Head Clearance.

To Adjust Valve to Rocker Clearance (Fig. 73)

The valve to rocker clearances with the corresponding cylinder set at T.D.C. firing stroke and with the engine cold are:-

Engine	Valve to Rocker	Clearance mm. (ins)
	GO	NOT GO
Inlet	0.15mm (0.006")	0.20mm (0.008")
Exhaust	0.15mm (0.006")	0.20mm (0.008")

(a) With the cylinder head cover removed, turn the engine until the piston is on the TDC position of the firing stroke (both valves closed).

(b) Restrain the adjusting screw with a screwdriver and slacken the locknut. Turn the screw until the correct clearance has been obtained.

(c) Tighten the locknut whilst continuing to restrain the adjusting screw, and re-check to ensure the clearance is correct.

Repeat the procedure for both valves in all cylinders. The adjusting screw locknut should be torque loaded to 21.02Nm. (15.5 lbf.ft.).

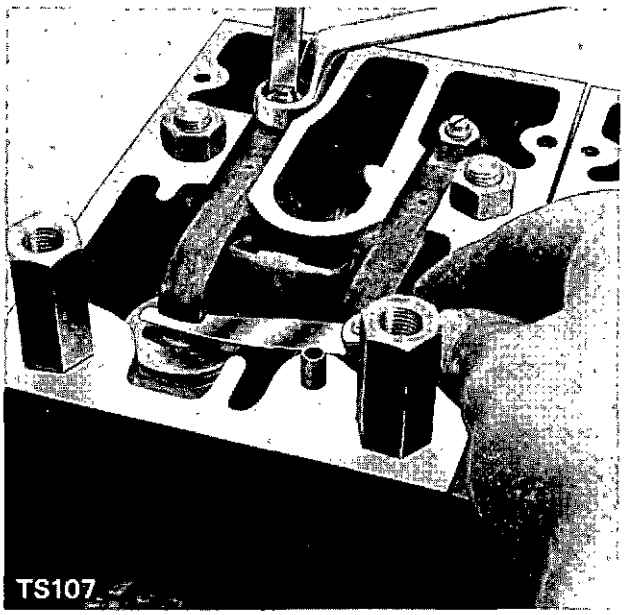

Fig. 73 Adjusting Valve Clearance.

Valve to Rocker Clearance

It is important that the valve clearances are maintained correctly, otherwise serious damage to the valve gear can result. With new engines or engines which have just been overhauled, the valve gear beds down rapidly during the first 500 hours running and for this reason it is essential that the valve to rocker clearance is checked at 25 hours, and at every 250 hours until it is found that the clearances remain constant. The periods between adjustments may then be increased to 1000 hours.

Decompressor (if fitted)

The decompressor lever is spring loaded towards the cylinder head and is located by a plain washer and a split pin or circlip fitted through the decompressor shaft. A seal fitted on the outside of the cylinder head prevents oil seepage along the spindle. When builds are not fitted with a decompressor the drilling in the cylinder head is plugged with a dowel.

Adjusting the Decompressor (Fig. 75)

(a) With the cylinder head cover removed turn the engine until the piston is on the TDC position of the firing stroke (both valves closed).

(b) Loosen the adjuster locknut and turn the adjustment screw until the valve rocker just begins to depress the valve.

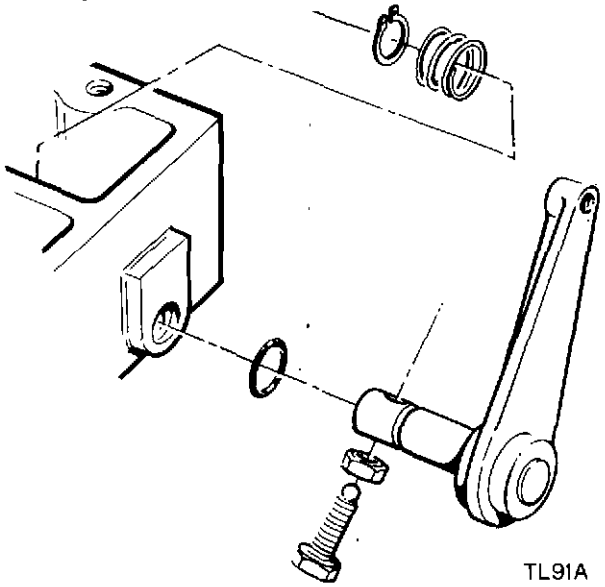

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Fig. 74 Decompressor Lever Dismantled (later engines)

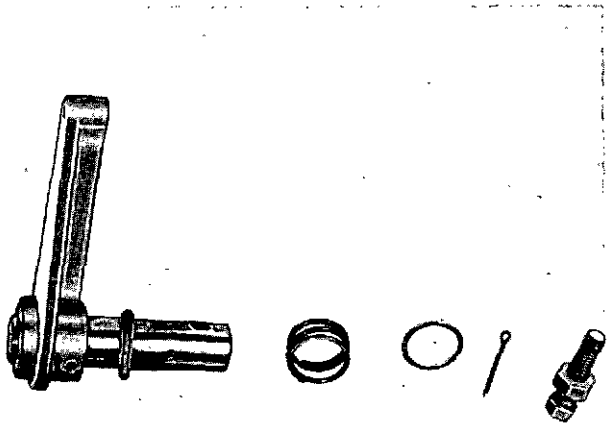

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Fig. 74 Decompressor Lever Dismantled (earlier engines)

(c) Turn the adjustment screw down a further turn clockwise and lock in position. The adjusting screw nut should be torque loaded to 8.82 Nm. (6.5 lbf.ft.).

Repeat the procedure for all cylinders.

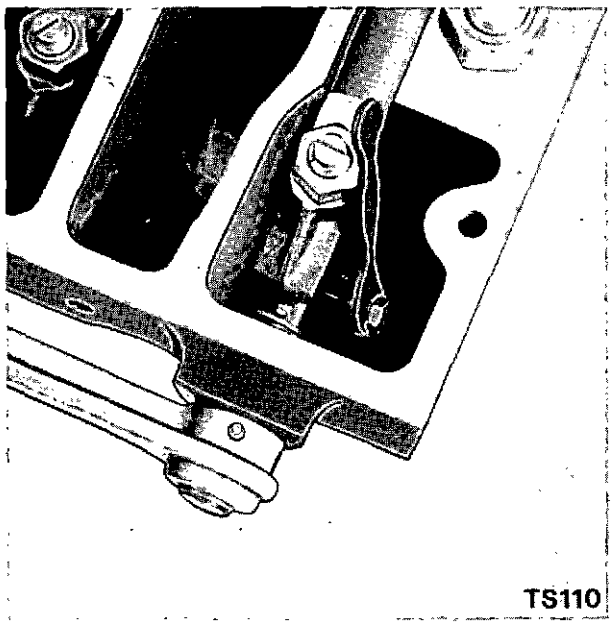

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Fig. 75 Decompressor Adjustment

END COVER—Gear End (standard)

End Cover Assembly Comprises
1 End Cover
2 Oil Filler
3 Strainer Plate
4 Bush
5 Expansion Plug
6 End Cover Joint
7 Oil Filler Cap Includes
8 Joint
9 Bolt—M8 x 1.25-6g x 70mm
10 Copper Washer
11 Dowel
12 Camshaft Oil Seal
13 Black Nylon Cap
14 Camshaft Thrust Washer
15 Shim—0.13mm, —0.25mm, —0.38mm } Between Thrust Washer & Camshaft Gearwheel Hub

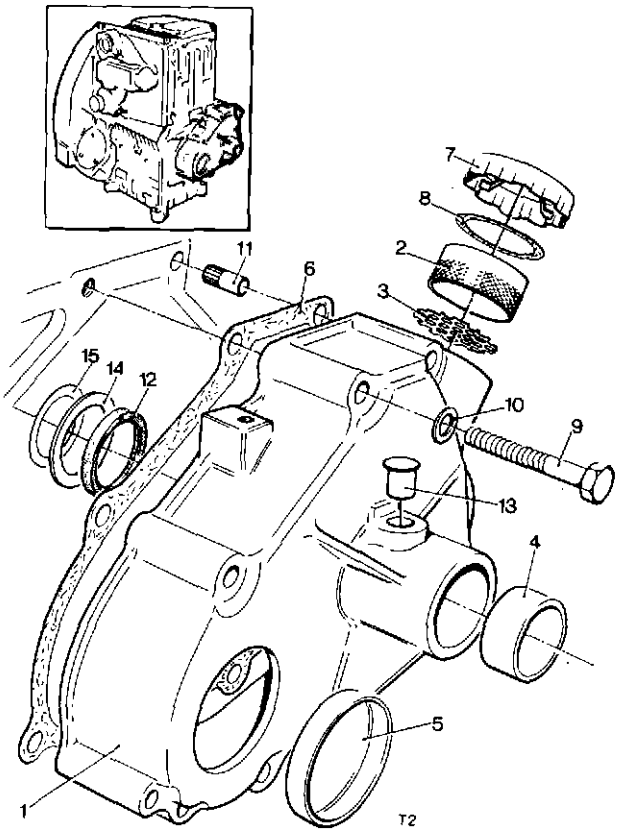


Fig. 76 End Cover

END COVER—Gear End (Build 05)

End Cover Assembly Comprises
1 End Cover
2 Oil Filler
3 Strainer Plate
4 Joint—End Cover
5 Oil Seal
6 Oil Filler Cap Includes
7 Joint
8 Bolt—M8 x 1.25-6g x 70mm
9 Copper Washer
10 Dowel
11 Camshaft Thrust Washer
12 Shim—0.13mm, — —0.25mm, — —0.38mm } Between Thrust Washer & Camshaft Gearwheel Hub
13 Setscrew —7/16"UNC X 7/8" } Removed hydraulic pump etc. is fitted
14 Washer

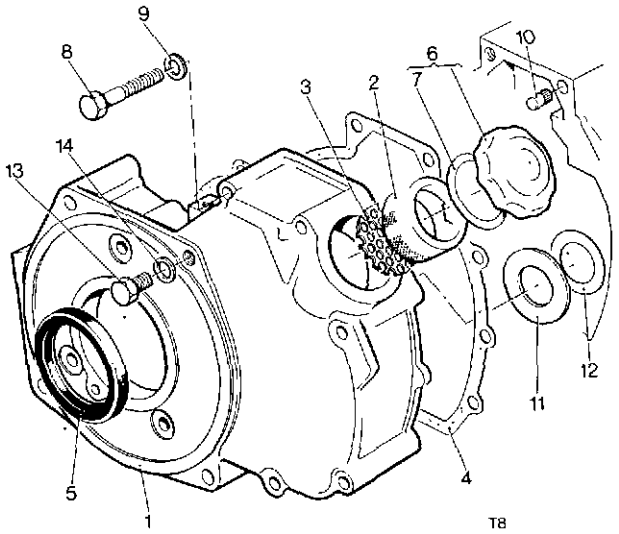


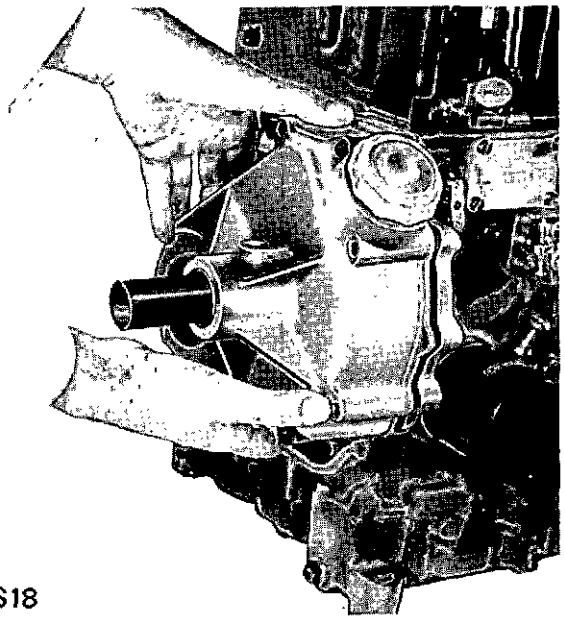
Fig. 76a End Cover

END COVER

The light alloy end cover is located on two dowels and is secured to the crankcase by seven setscrews and copper washers. A paper joint is fitted between the end cover and the crankcase face. The end cover contains an oil filler neck and filler cap, and a bucket plug is secured in position with Hylomar PL32M over the crankshaft pinion. The camshaft oil seal is of the *lip variety and a plain* bush fitted to the outside of the end cover sleeve is to support the starting handle when in use.

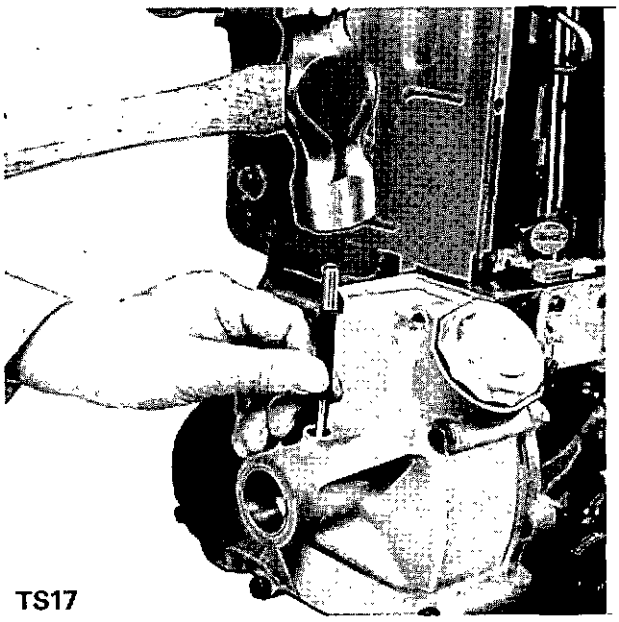
Removing End Cover

(a) Remove plastic dustcap in end cover projecting sleeve (Fig. 69).
(b) Turn the engine until the spring pin of the crank handle catch pin is visible through the hole in the end cover, tap out the pin with a suitable punch.
(c) Turn the engine through 90° and drift out the crank handle catch pin (Fig. 78).
(d) Insert end cover oil seal tool (Fig. 77).
(e) Remove seven setscrews and copper washers.
(f) Remove end cover taking care not to damage the paper joint.
(g) Remove thrust washer and end float shim. (Fig. 76)



TS18

Fig. 77 Removing End Cover



TS17

Fig. 78 Removing Crank handle catch pin

Also see page 94 for hydraulic adaptor and *end cover.*

Fitting Oil Seal

(a) Place the lip seal through the neck of the end cover lip side first and position squarely on the shoulder of the seal boss.
(b) *Using the end cover oil seal tool (See Section 7)* or in emergency a suitable plug, preferably hard wood, press the oil seal into position within the oil seal housing boss until it is flush with the inside face of the boss.

Removing Oil Seal

Using the end cover oil seal tool or a suitable plug press the oil seal out through the end cover.

Refitting End Cover

Fit end cover oil seal tool and then fit the end cover in the reverse order, carrying out a camshaft end float check as described below, and on final assembly coat the end cover face with Wellseal. Seal the paper joint to the end cover face of the joint before offering up to the engine.

Checking Camshaft End Float

The end float is adjusted with a metal shim between the camshaft thrust washer and the camshaft gearwheel hub, to an end play of 0.08/0.2 mm. (0.003/0.008 ins.) measured with a clock gauge. The shims available are 0.13 mm. (0.005 ins.), 0.25 mm. (0.010 ins.), and 0.38 mm. (0.015 ins.) thickness. Only one shim of appropriate thickness must be used. Excessive camshaft end play affects the governing and can cause uneven firing.

In engines where the camshaft is not extended externally, the end play of the camshaft is measured through the top right hand tapped hole of the SAE flange in the gear cover. Using a rod through this hole, the camshaft gearwheel is pushed fully inwards, and then a clock gauge is fixed in position with an extension inserted through the hole, after which the camshaft gearwheel is pushed towards the timing case by inserting a cranked rod through the fuel pump linkage inspection door. The movement recorded on the gauge is the end play.

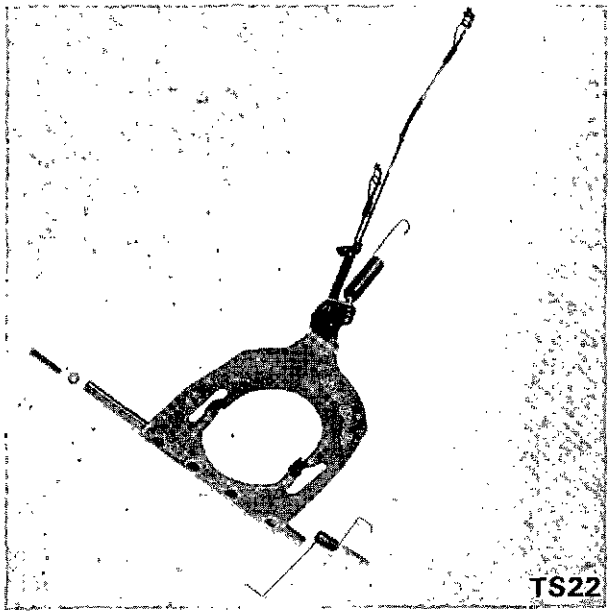


Fig. 79 Governor Lever Assembly Removed (See Fig. 44b for later engines)

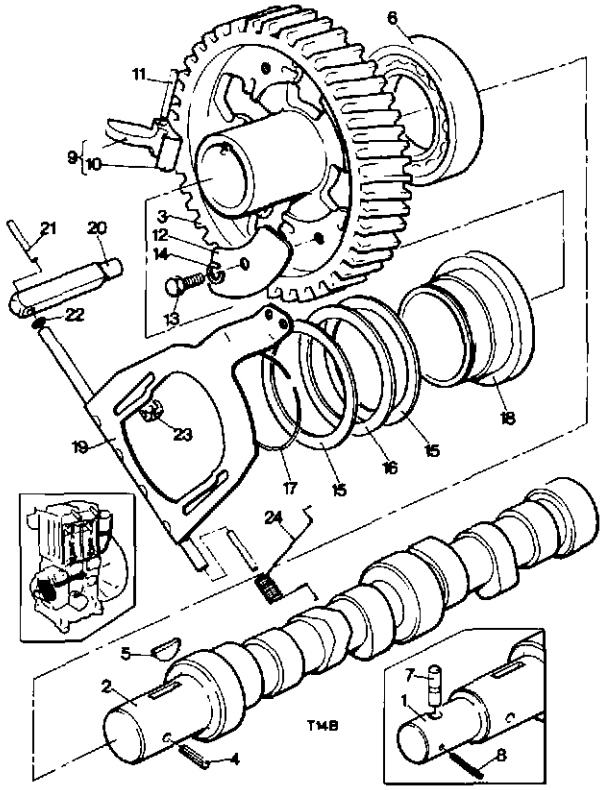


Fig. 80 Camshaft & Governor

CAMSHAFT & GOVERNOR

Camshaft Assembly Comprises

1 Camshaft
2 Not TS engines
3 Gearwheel (earlier engines)
4 Dowel Pin
5 Key
6 Ball Bearing
7 Catch Pin
8 Spring Pin
9 Governor Weight assembly Includes
10 Shoe
11 Governor Weight pin
12 Governor Weight Retainer (earlier engines)
13 Setscrew—M6 x 1.0-6g x 12mm
14 Spring Washer
15 Thrust Washer
16 Thrust Pad
17 Spring Ring
18 Governor Sleeve Assembly
19 Governor Lever Assembly
20 Governor Lever Pivot Support Block
21 Pin
22 Shim
23 Governor Lever Shoe
24 Return Spring —Variable Speed Engines Only

GOVERNOR AND FUEL PUMPS

The governor and fuel system is fully covered in Section 3 and the following paragraphs are included only to describe the dismantling and assembly procedures in normal sequences.

Dismantling of Governor and Fuel Pumps

(a) Remove fuel pump inspection doors noting that No. 1 cylinder is marked 'Stop'
(b) Disconnect fuel pump and governor link at the fuel pumps by using long nosed pliers (Fig. 33)
(c) Slacken off the speed control screw and then *disconnect speeder spring. (Fig. 23)*
(d) Remove fulcrum pins from the pivot support block (Fig. 83), using a magnet, a 1.5mm rod or punch, or a suitable piece of copper or soft iron locking wire. Take great care not to lose the shim(s).
(e) Remove governor lever assembly complete *with speeder spring and fuel pump* interconnect lever. (Fig. 79)
(f) Remove governor sleeve assembly. (Fig. 81)
(g) Taking care not to lose shims, remove securing bolts and remove fuel pumps (Fig. 24)

Assembling Governor and Fuel Pumps

Assemble the governor and fuel pumps in the reverse order to dismantling, taking care to note the following points:

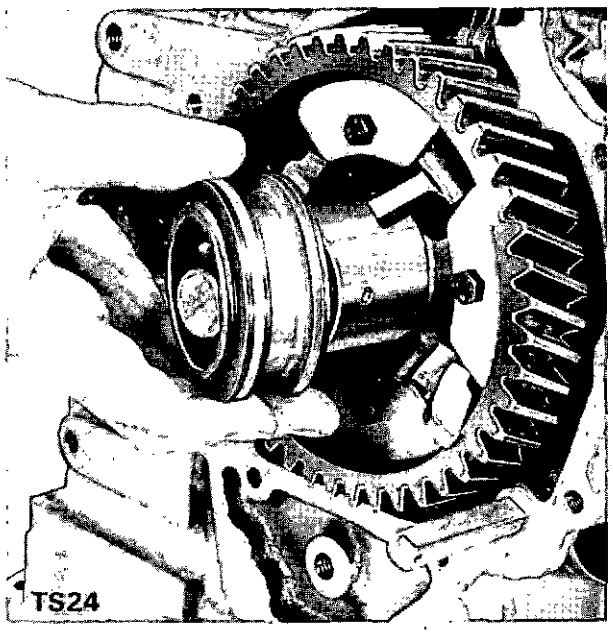


Fig. 81 Fitting Governor Sleeve

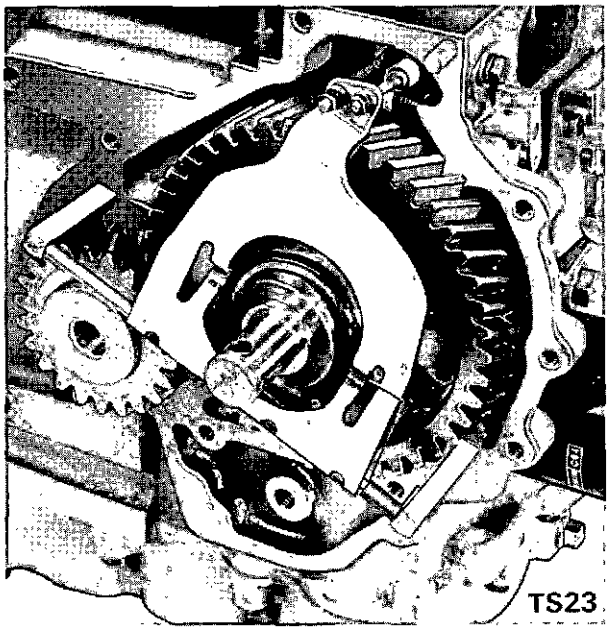


Fig. 82 Governor Lever Fully Assembled (variable speed engine)

(a) The fulcrum pins are drilled at one end only and these must be fitted at the outer end.
(b) The correct way round for fitting the governor sleeve. (Fig. 81)
(c) *The correct way to fit the speed control spring* hook (Fig. 40)
(d) Refit all shims as dismantled — subject to checking timings and adjustments.

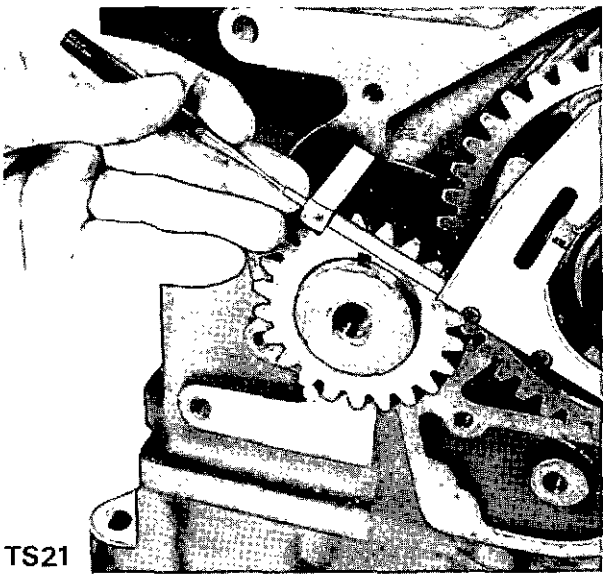


Fig. 83 Removing Fulcrum Pins

FUEL PUMP TAPPETS

Removing Fuel Pump Tappets

(a) Using long nosed pliers remove tappet insert and fuel pump tappet assembly (Fig. 84)
(b) Remove guide locating screw, noting special end that fits into the drilling in the fuel pump tappet guide (Fig. 85)
(c) Remove fuel pump tappet guide noting correct way for refitment (Fig. 86)

Refitting Fuel Pump Tappets

Refit fuel pump tappets in the reverse order being careful to fit the copper washer to the guide locating screw otherwise the fuel tappet may well jam in the guide.

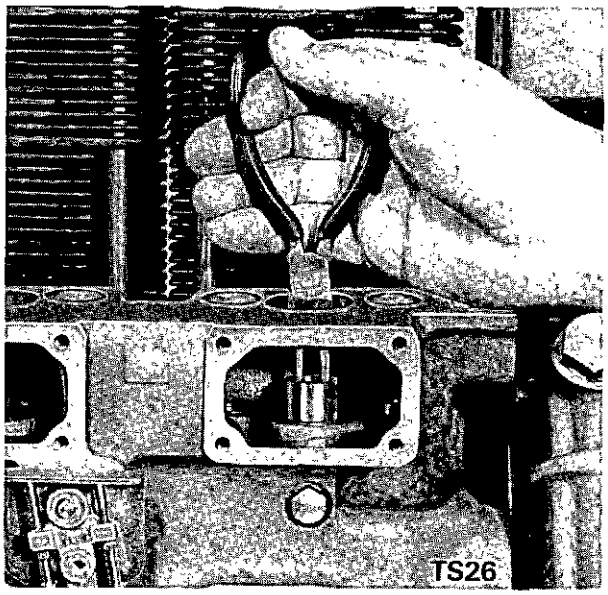


Fig. 84 Removing Fuel Pump Tappet

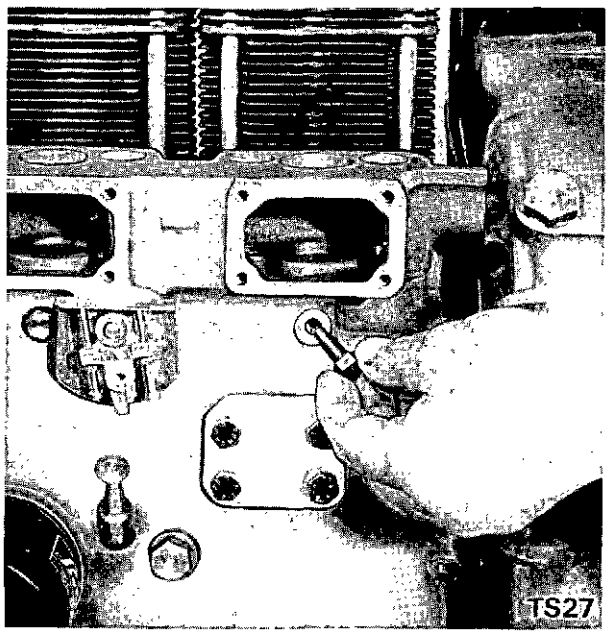


Fig. 85 Removing Fuel Pump Tappet Guide Screw

OIL SUMP AND OIL PUMP

(See also Sect. 2 for description and illustrations)

The sump is cast and is secured to the crankcase by bolts and spring washers, the four corner bolts are longer than the remainder. On each corner of the sump is a lug with drillings that permit the bolting down of the engine.

An oil strainer is fitted to the inside of the sump and a drilling in the casting carries oil from the sump through the strainer to the oil pump. An anti surge plate fitted to the oil strainer lays alongside the crankcase web when the sump is fitted.

Removing Sump and Oil Pump

(a) Remove dipstick (Fig. 5)
(b) Stand engine on flywheel.

NOTE: If possible use a suitable piece of wood or similar material on which to rest the flywheel but keeping it clear of the flywheel housing. This will enable the engine to be rotated and ease subsequent dismantling.

(c) Remove the sump bolts and spring washers. Remember the fanshroud is attached to the sump by two bolts.

WARNING: As the sump bolts are being released the oil pump will extend under spring pressure and move the sump away from the crankcase. Care must be taken that the pump does not come away with the sump.

(d) Remove sump taking care not to damage the oil pump or sump joint. (Fig. 10)
(e) Dismantle the oil strainer in sump by removing the centre securing bolt noting the distance piece in the centre (Fig. 9)
(f) Remove oil pump assembly and then remove the oil pump push rod with long nosed pliers. (Figs. 11 & 12)

Refitting Sump and Oil Pump

Refit the sump and oil pump in the reverse order. Coat the sump jointing face with Wellseal and stick the joint to it. If possible ensure the sump bolts are torque loaded to 27.12Nm. (20.0 lbf/ft) at this time because it will be difficult to torque these bolts when the engine is turned on to its feet.

OIL PUMP AND OIL FILTER

(See also Section 2 for description and illustrations)

Dismantling Oil Pump and Removal of Oil Filter

(a) Dismantle oil pump (if necessary) making careful note of component positions. Make particular notice of the two different sized ball valves (Fig. 13)

(b) *Spin off oil filter and renew if necessary.*

Assembly of Oil Pump and Refitting of Oil Filter

Assemble the oil pump and fit oil filter in sequence.

CAMSHAFT

The steel camshaft is carried in plain bearings in the crankcase at the flywheel end of the engine and in the centre web(s). A ball bearing attached to the camshaft and fitted behind the camshaft gear provides the bearing for the gear end. (See Section 7 for changing plain bearings).

Cams on the shaft operate valve tappets, self regulating oil pump, fuel pumps and fuel lift pump (if fitted).

The camshaft gear carries the governor weights (See Section 3 for illustrations and changing instructions).

Checking camshaft end float is covered in this *section under end cover.*

Removal of Camshaft and Cam Followers

With the end cover removed:

(a) Push the cam followers clear of the camshaft if the engine is standing on the flywheel but if standing on the sump then hold the cam followers clear of the camshaft by the use of clothes pegs or magnets.

(b) Gently ease the camshaft out of the crankcase. (Fig. 87)

(c) Remove or change governor weights if required (See Section 3).

(d) Remove cam followers (Fig. 90)

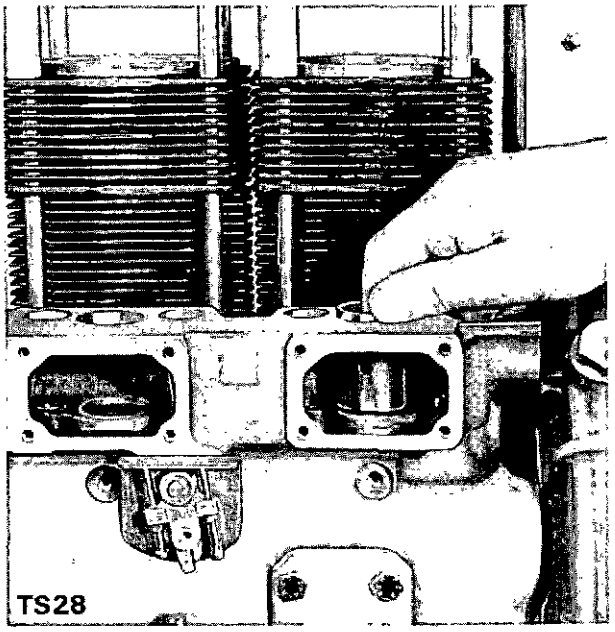


Fig. 86 Removing Fuel Pump Tappet Guide

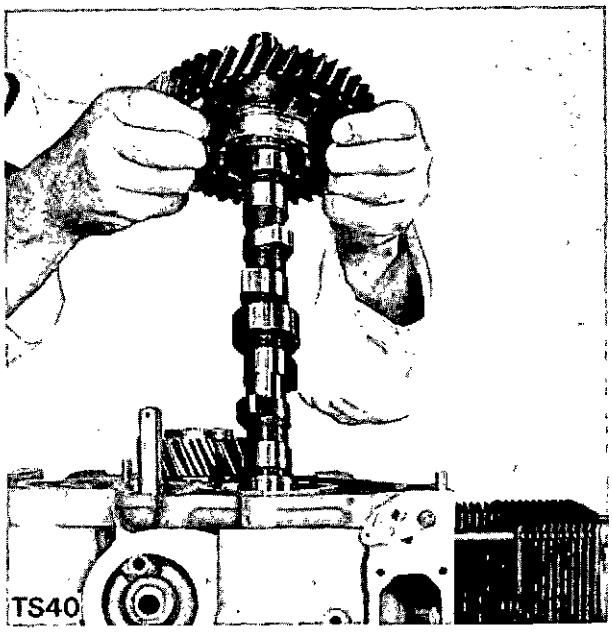


Fig. 87 Removing Camshaft

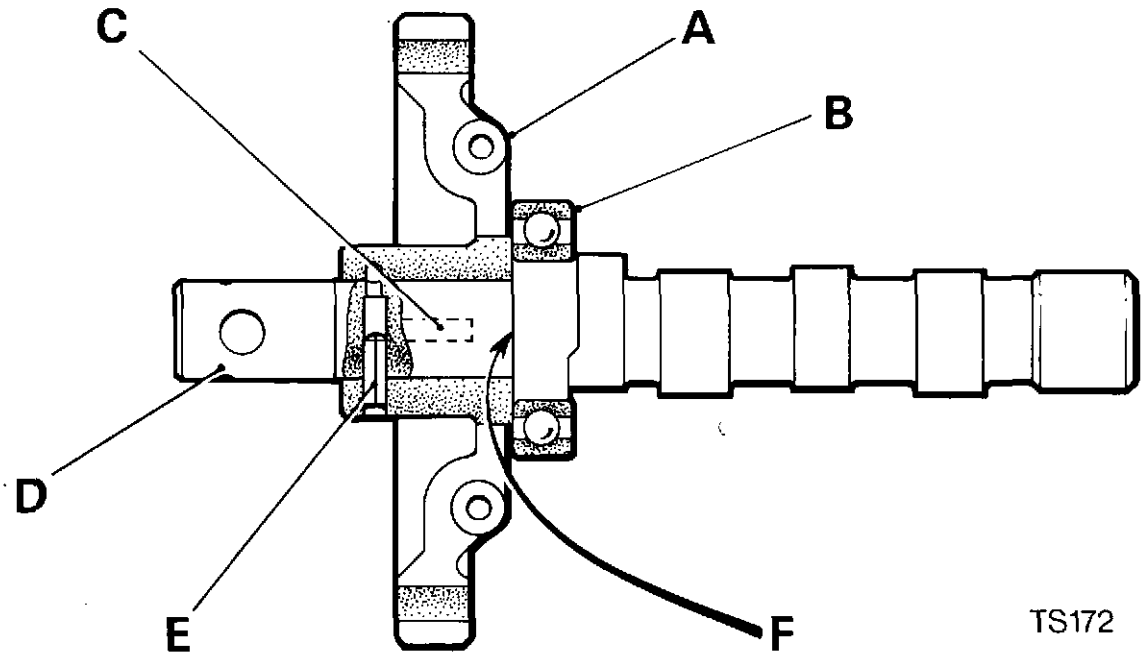


Fig. 88 Removing Camshaft Gearwheel.

Removing Camshaft Gearwheel

ENSURE NO PRESSURE IS APPLIED TO THE OUTER RING OF THE GEAR AT ANYTIME.

(a) Drift pin (E) into the camshaft until it stops against the step.
(b) Press off gearwheel (A) sufficiently to allow a thin metal 'C' washer to be placed between the bearing (B) and the gearwheel to prevent dirt entering the bearing.
(c) Continue to press off the bearing.
(d) Remove Woodruffe key (C).
(e) Drift pin (E) out of camshaft using a smaller drift.

Fitting Camshaft Gearwheel

Fit camshaft gearwheel in the reverse order ensuring the 'C' washer is removed and that the gearwheel abuts shoulder (F).

On re-assembly the dowel pin must be carefully pressed in to 1mm below the diameter of the gearwheel hub and the sharp edges of the hole removed.

Any burrs will affect the operation of the governor thrust sleeve.

Changing Camshaft Ball Race Bearing (Fig. 88)

(a) Remove retaining pin from hub of gearwheel.
(b) Support camshaft assembly on hub of ball race and push camshaft through gearwheel (keyed) and bearing.
(c) To refit, push new bearing on to camshaft and applying pressure to gearwheel hub, push on gearwheel and key.
(d) Refit retaining pin.

Inspection (see Table of Clearances, page 112)

Examine camshaft bush for scars or wear.

Examine ball race bearing for wear and freedom of movement.

Check the camshaft gearwheel and crankshaft pinion teeth for wear.

Ensure cams are not chipped or damaged.

Check the tappets for scars or damage to the contact face.

Examine oil seal in end cover for damage or wear.

Changing Camshaft Bush

A new bush should be immersed in engine lubricating oil for four hours before fitting.

To gain access to the expansion plug and bush it will be necessary to remove the flywheel, fan shroud, main bearing housing and alternator adaptor—see pages 77 - 79.

(a) Remove expansion plug.
(b) Using service tool extract bush (see Section 7).
(c) Fit new bush with thinnest part of bearing wall towards the top (marked 'O').
(d) Apply a little Hylomar PL32/M in the recess to the crankcase and fit new expansion plug.
(e) Refit main bearing housing alternator adaptor, fan shroud and flywheel.

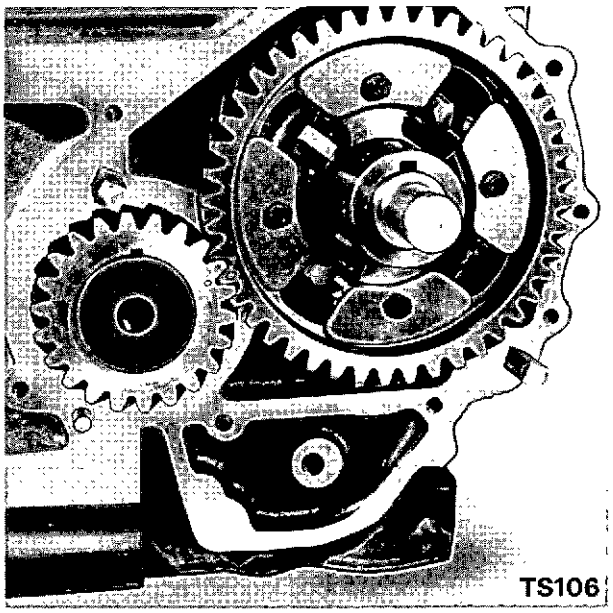


Fig. 89 Camshaft Timing.

Refitting Camshaft and Cam Followers

Refit the camshaft and cam followers in the reverse order, taking care to fit the cam followers before the camshaft and line up the 'O' markings on the crankshaft pinion and camshaft gear (Fig. 89)

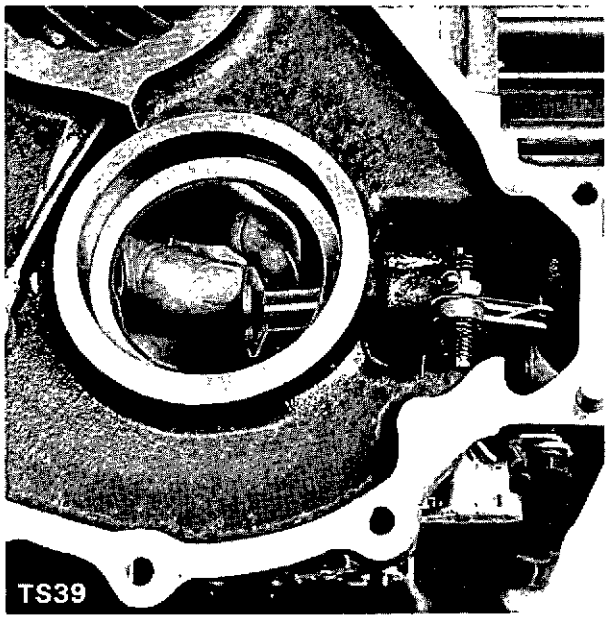


Fig. 90 Removing Cam Followers

CYLINDER PISTON, PISTON RINGS AND CONNECTING ROD (Fig. 91)

Piston and Gudgeon Pin

The piston is made of low expansion alloy with a machine recessed combustion chamber in the crown. The gudgeon pin is a clearance fit in the piston and is retained by two circlips. It runs in a copper faced steel backed bush in the small end of the connecting rod.

Piston Rings

Five piston rings are fitted:—

Firing Ring

A barrel lapped chrome ring is situated at the top of the piston and is tapered on the sides to prevent sticking in the groove.

Compression Rings

Two compression rings are fitted. Each has a tapered face in contact with the barrel. One surface on each is marked TOP and the rings must be fitted the correct way up.

Scraper Rings

One conformable type — with spring expander — is fitted above and a slotted scraper ring fitted below the gudgeon pin.

Connecting Rod and Big End Bearing

The forged steel connecting rod is connected to the crankpin by a conventional big end bearing, the cap held in position by two bolts and nuts. The two halves of the big end bearing are steel backed copper lead. They are precision finished and should not be scraped or touched up in any way.

Servicing (see page 112, Table of Clearances)

Thoroughly clean the barrel and check for scoring and wear.

Clean the piston, remove all carbon from both upper and underside of head, ring grooves and oil holes.

Check all piston rings in the cylinder barrel for correct gap clearance.

Clean connecting rod and examine for bending and twisting — examine small end bush for wear.

If the big end has been dismantled because of metal failure, the oil passages in the crankshaft must also be examined for obstruction and fragments of metal.

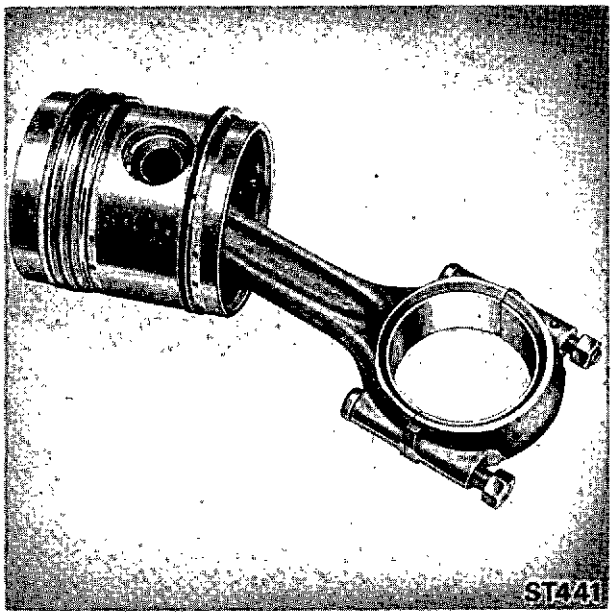


Fig. 91 Piston and Connecting Rod.

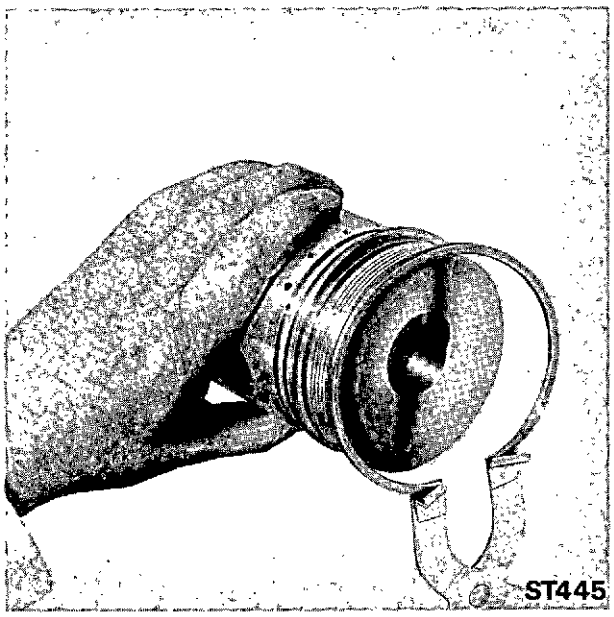


Fig. 92 Fitting Piston Rings using standard ring expander.

Removing Cylinders, Pistons, and Connecting Rods

(a) Ensure barrels located by tube (see removal of cylinder head).

(b) Rotate engine on the flywheel so that one big end is at the bottom of the throw, unscrew two securing nuts and remove big end cap. (Fig. 93). Fit thread protector if available.

(c) Rotate engine so as the same piston is at the TDC position, mark the cylinder for position and number.

(d) Remove the tube securing the barrel. Remove barrel, piston and connecting rod complete, (Fig. 94) noting copper joint between barrel and crankcase and position of nick in top fin of barrel.

(e) Replace big end cap and bearing matching raised dots.

(f) Repeat for the other cylinders.

NOTE: If further dismantling is anticipated remove crankshaft balance weights by removing Allen screws in the weights (Fig. 95). These weights are locked by peening and the lock must be reinstated on assembly. The balance weights retaining screws must be torque loaded to 67.8 Nm. (50 lbf.ft.)

(g) Withdraw piston from barrel.

(h) Gudgeon pin may be removed by releasing one circlip and pushing out pin.

(j) Using a standard ring expander, remove piston rings.

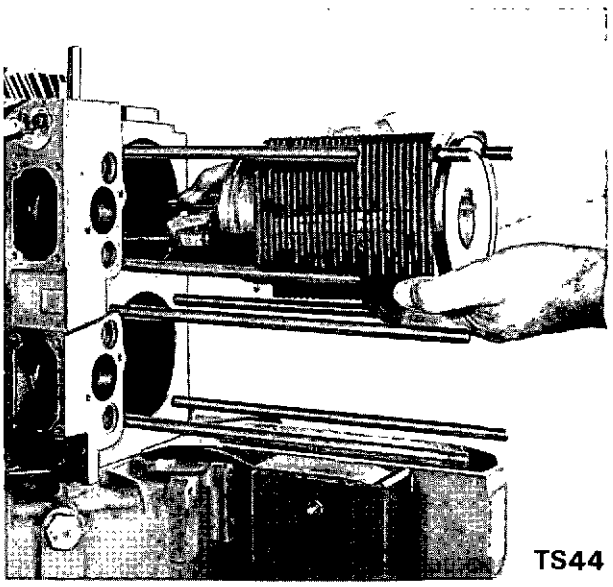


Fig. 94 Removing Cylinder, Piston and Connecting Rod

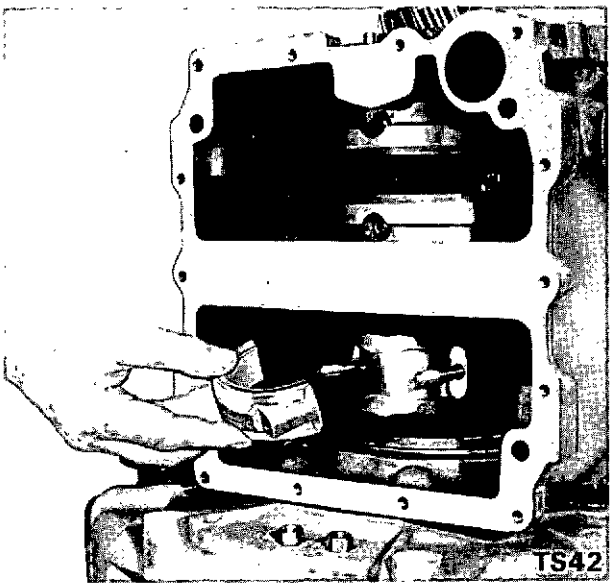


Fig. 93 Removing Big End Caps

NOTE: The cylinder holding down stud centres are narrower on the camshaft side of the engine.

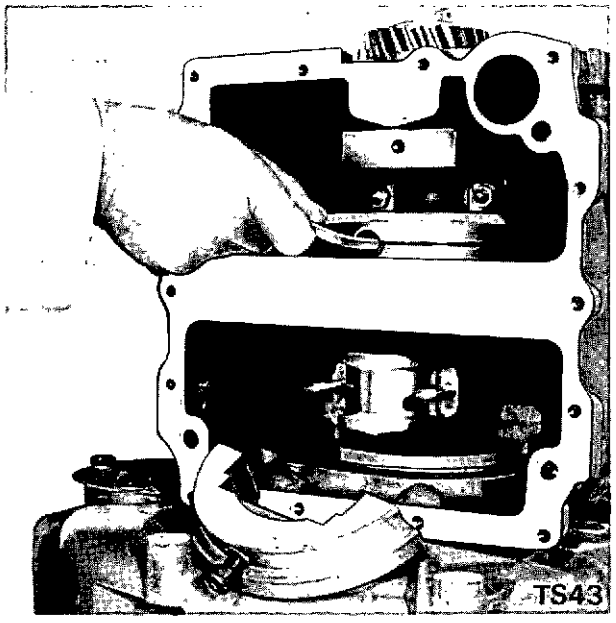


Fig. 95 Removing Balance Weights

Refitting Piston, Connecting Rod and Barrel:

(a) Fit piston to connecting rod with the wording CAMSHAFT SIDE on piston to the same side as raised dots on connecting rod. Insert gudgeon pin and circlips.
(b) Fit piston rings as detailed on page 74 (Fig. 92)
(c) Stagger piston ring gaps and fit piston into barrel whilst compressing piston rings.
(d) Ensure bearing shells are correctly located in connecting rod and cap.
(e) Fit joint to bottom of the cylinder using Hylomar PL32/M.
(f) Position crankshaft with crankpin to T.D.C.
(g) With the nicks in the same position as when dismantled, the deeper fins towards the camshaft and manifold side of the engine, and 'CAMSHAFT SIDE' on the piston correctly positioned, lower the cylinder, piston and connecting rod assembly into position.
(h) Push down on piston and turn crankshaft until access is gained to connecting rod bolts; fit cap with bearing shell and torque nuts to 43.4 Nm (32 lbf.ft).
(j) Repeat for remaining cylinders.

NOTE: Ensure connecting rod bolt head is correctly positioned with the flat against the rod.

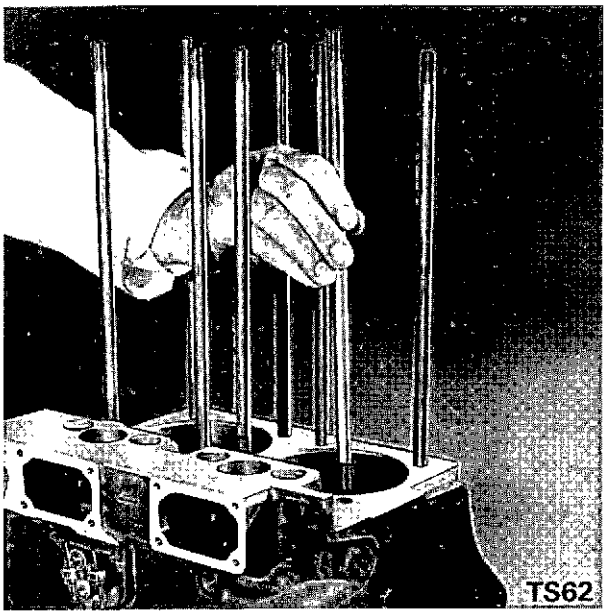


Fig. 96 Removing Cylinder Holding Down Studs

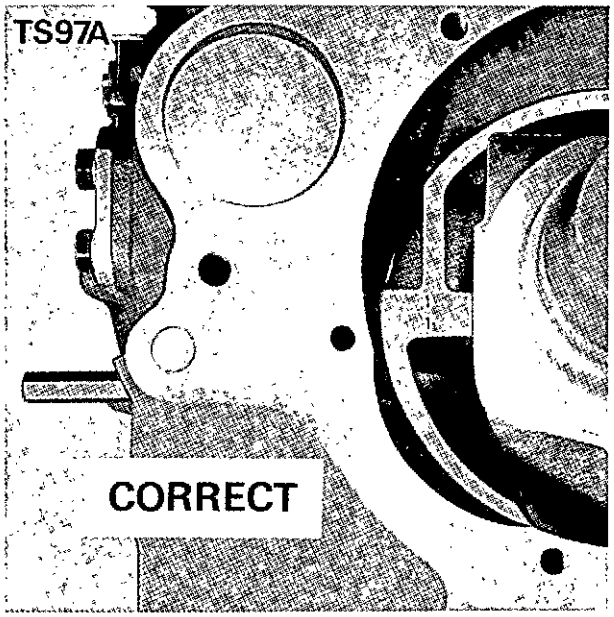


Fig. 97 Centre Bearing Housing secured correctly.

NOTE: Individual cylinders may be removed with the piston and connecting rod in situ if desired.

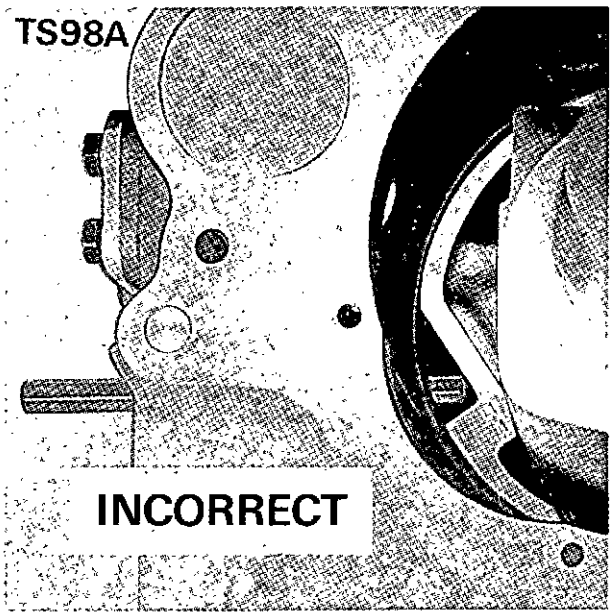


Fig. 98 Centre Bearing Housing secured incorrectly.

FLYWHEEL AND FANSHROUD

The fanshroud is cast with an SAE 4 flange. The flywheel rotates within the fanshroud aperture and the type of flywheel depends on engine speed and application. Part numbers complete with ordering instructions can be found in the appropriate engine Parts List. Should it be required to change the application of an engine R. A. Lister or their main distributors should be consulted.

FLYWHEEL

The cast iron flywheel (without gear ring or fan) weighs 54 kg (119 lbs) and the SG iron flywheel weighs 57 kg (126 lbs). It is important to bear this point in mind when removing or replacing a flywheel. All flywheels are fitted with ring gears for electric starting and the fan is fitted to the outside face of the wheel. The fan may be made of polypropelene or iron depending on application.

The flywheel is keyed on to the crankshaft and held in position with a setscrew. When fitted the rim of the flywheel must run true within 0.13 mm TIR.

A stator for the charging system is positioned within the magnetic ring rotor which is pressed into the rear face of the flywheel. Etched markings show the firing (Z) points and the TDC positions for each cylinder (Fig. 106). These markings can be viewed through an aperture in the rear of the fanshroud (Fig. 27 & 67).

Removing Flywheel

(a) Remove any accessories including starter motor if fitted.

(b) If the engine is standing on its flywheel return it to its normal position, if necessary using wooden supports to keep the fanshroud clear of the ground or bench or temporarily refit sump.

(c) If a flywheel locking tool is not available wedge the crankshaft with a suitable piece of wood to prevent the crankshaft turning, and slacken the flywheel setscrew with a 65mm socket spanner. (Fig. 100).

(d) With the slackened flywheel retaining setscrew in position loosen the flywheel using the flywheel extractor tool. (See Section 7).

(e) After removing the extractor tool and flywheel securing setscrew fit a removing mandrel. (See Section 7) to prevent damage to the alternator stator and for personnel safety.

(f) Remove flywheel and Woodruffe key. (Fig. 146).

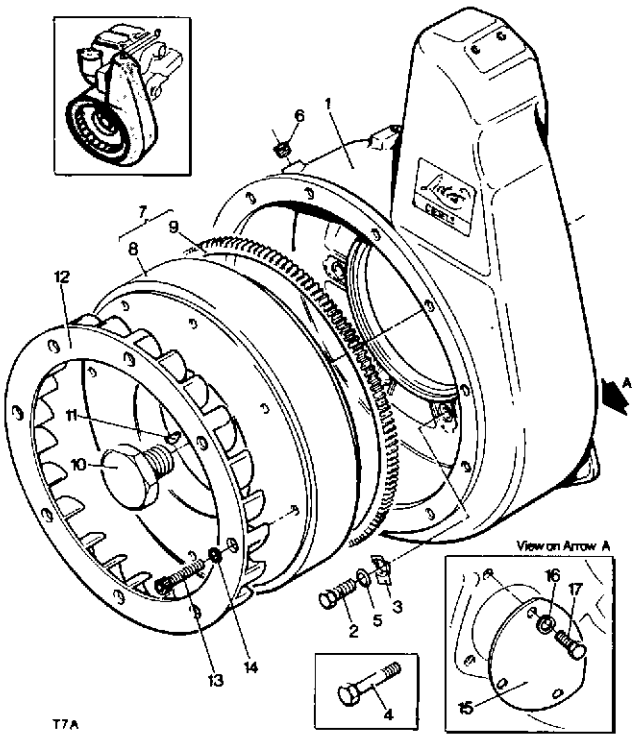


Fig. 99 Fanshroud & Flywheel.

FANSHROUD & FLYWHEEL

1 Fanshroud
2 Setscrew-M10 x 1.5-6g x 25mm
3 Locking Washer
4 Bolt—M10 x 1.5-6g x 55mm (fits into Sump)
5 Disc Spring Washer
6 Blanking Plug
7 Flywheel Assembly Comprises
8 Flywheel
9 Gear Ring
10 Retaining Screw
11 Key
12 Fan—TS2
13 Capscrew—M8 x 1.25-6g x 35mm
14 Lockwasher
15 Starter Motor Blanking Plate
16 Spring Washer
17 Setscrew—M10 x 1.5-6g x 16mm

NOTE: In an emergency the flywheel can be loosened by carefully striking the loosened flywheel retaining setscrew with copper hammer.

Refitting The Flywheel

Refitting is carried out in the reverse order, once again using the mandrel to prevent damage to the alternator stator. The tapered shaft and the coned bore of the flywheel must be perfectly clean and should be smeared with clean lubricating oil before assembly.

After removing the mandrel, fit and torque securing setscrew to 474.7 Nm(350 lbf ft.).

If a torque spanner is not available the screw may be tightened with an offset ring spanner about 460mm (18") long, which must be hit round with a 3.0 Kg (7lb) hammer used single handed.

Removing Stator and Fanshroud

(a) Remove two nuts and washers and then remove rectifier/regulator cover.
(b) Carefully noting position of electrical cables, disconnect all four cables (Figs. 101 & 155).
(c) Remove two nuts, washers and distance pieces and remove rectifier/regulator unit from fanshroud. On some engines this item may well be fitted behind the fanshroud.
(d) Remove cable clip securing cable inside fanshroud.
(e) Remove six screws securing stator and remove, easing cable through the fanshroud (Fig. 102).
(f) Ease tab washers and remove six securing bolts and then remove the fanshroud (Fig. 103).

Note: The fanshroud is secured to the sump by two bolts.

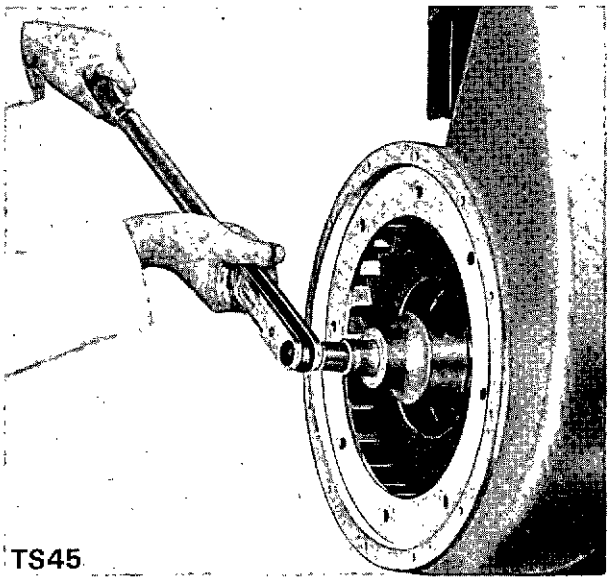


Fig. 100 Undoing Flywheel Setscrew

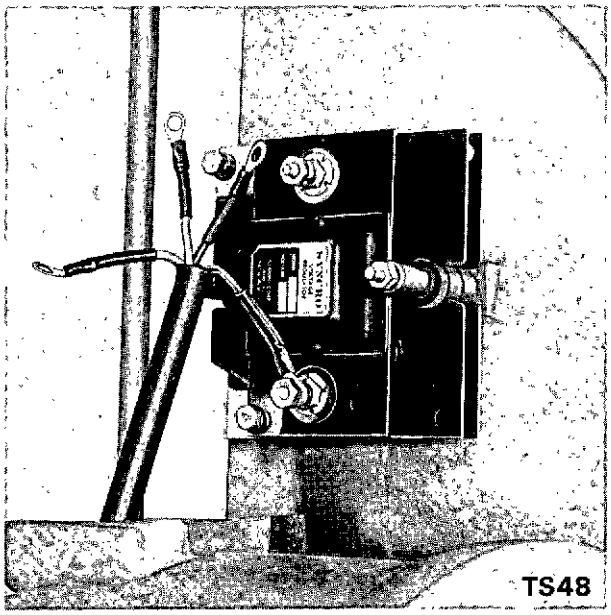


Fig. 101 Removing Cables from Rectifier/ Regulator

Refitting Fanshroud and Stator

Refitting is carried out in the reverse order. To prevent putting excessive strain on the alloy fanshroud it is advisable to slightly loosen the sump bolts before fitting the fanshroud. It is recommended that new tabwashers are fitted whenever possible and correctly locked.

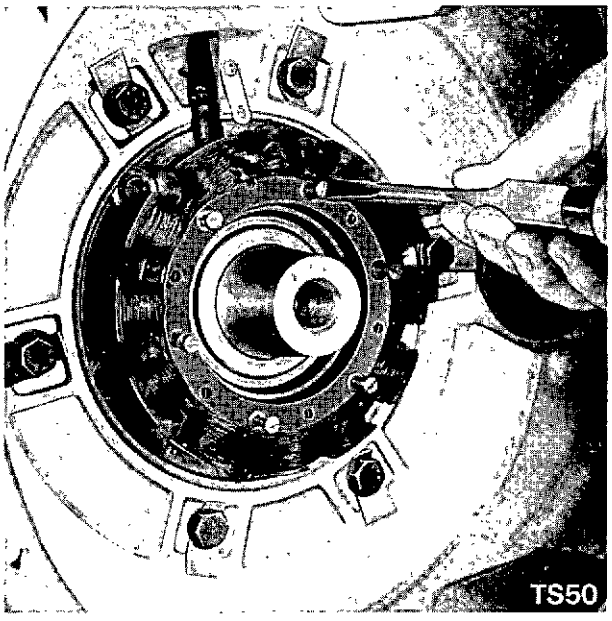


Fig. 102 Removing Alternator Stator

MAIN BEARING HOUSING, CRANKSHAFT AND MAIN BEARINGS

The crankshaft is a steel casting and is carried in steel backed main bearings which are located in the crankcase at the gear end and in a housing at the flywheel end (Fig. 114). Additional centre main bearings are fitted to the central web/s of the crankcase. End thrust is taken on steel backed copper faced split thrust washers (Fig. 111).

The main bearings are in two halves and are not interchangeable; the top half has an oil groove and an oil hole which must be correctly located. A pinion is keyed on to the end of the crankshaft and engages with the camshaft wheel (Fig. 89).

The main bearing housing is secured to the crankcase at the flywheel end. The housing includes an oil drain hole which must be located at the bottom when refitting, an oil seal fitted to the centre bore, and on the side of the housing an 'O' ring provides a seal between the oil drilling in the crankcase and the flywheel end main bearing. On engines fitted with charging equipment the stator is secured to the main bearing housing with cheese headed screws which are fitted through the alternator adaptor (Fig. 104). Shims of metal and paper material are fitted between the main bearing housing and the crankcase to provide crankshaft end float adjustment (Fig. 116).

Removal of Main Bearing Housing and Alternator Adaptor

NOTE: Remove centre bearing locating dowel securing screw (Fig. 107), then using fuel pump securing bolt (with long head) remove centre bearing dowel (Fig. 108). Failure to do this will result in the distortion of the dowel. Leave fuel pump bolt in dowel until refitted to ensure dowel is fitted the correct way round.

(a) Remove six bolts securing main bearing housing and remove alternator adaptor (Fig. 104).
(b) Using two M6 setscrews through threaded holes provided jack off main bearing housing (Fig. 109).
(c) Drift out main bearing housing rotary oil seal (See Section 7).

NOTE: Items (b) and (c) not applicable if screw or lip type seals fitted.

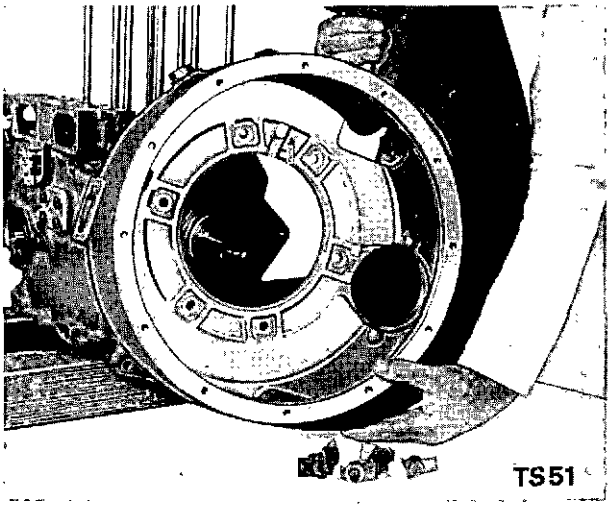


Fig. 103 Removing Fanshroud

WARNING: If the crankshaft is moved towards the flywheel end the crankshaft thrust washer at the gear end could become detached from its recess. This can be avoided by removing the gear end cover and placing two suitably thin strips of metal between the crankshaft pinion and the crankcase. To prevent the thrust washer at the flywheel end becoming detached from the Main Bearing Housing whilst jacking off the housing turn the engine until the No. 1 cylinder piston is at the BDC position.

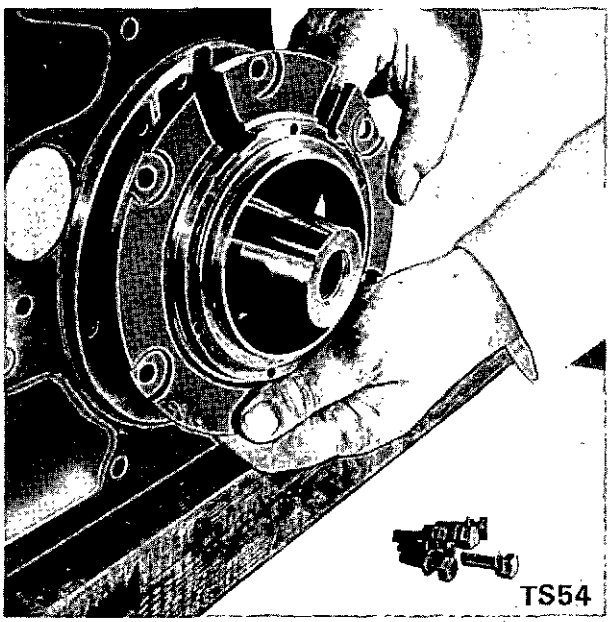


Fig. 104 Removing Alternator Adaptor

CRANKSHAFT

Crankshaft Assembly Comprises
1 Crankshaft
2 Socket Grubscrews M6 x 1.0-6g x 6mm
3 Balance Weight
4 Balance Weights Screw
5 Pinion
6 Key
— Thrust Washer Comprises
7 —Top Half
7A —Bottom Half

CONNECTING ROD & PISTON

— Connecting Rod Assembly Comprises
8 Connecting Rod
9 Bolt
10 Nut—3/8"UNF
11 Bush—Small End
— Big End Bearing Comprises
12 —Top Half
12A —Bottom Half
— Piston Assembly Comprises
13 Piston
14 Gudgeon Pin
15 Circlip
— Piston Ring Set Comprises
16 Piston Ring—Top Taper
17 —Compression
18 —Scraper—Top
19 —Bottom

CENTRE BEARING HOUSING

— Centre Bearing Housing Comprises
20 —Top Half
20A —Bottom Half
21 Dowel
22 Cap Screw
— Centre Bearing Comprises
23 —Top Half
23A —Bottom Half
24 Locating Dowel
25 Locating Dowel Plug Assembly
26 Copper Washer

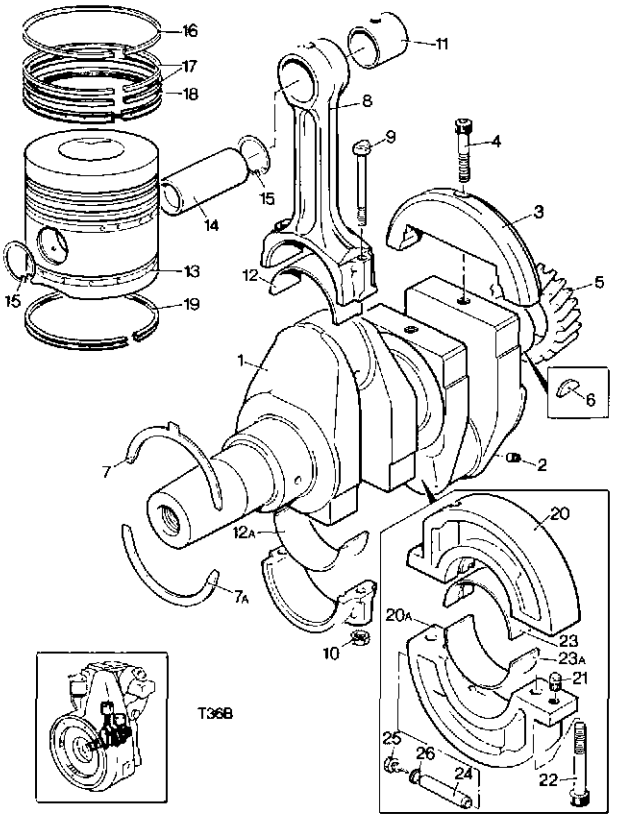
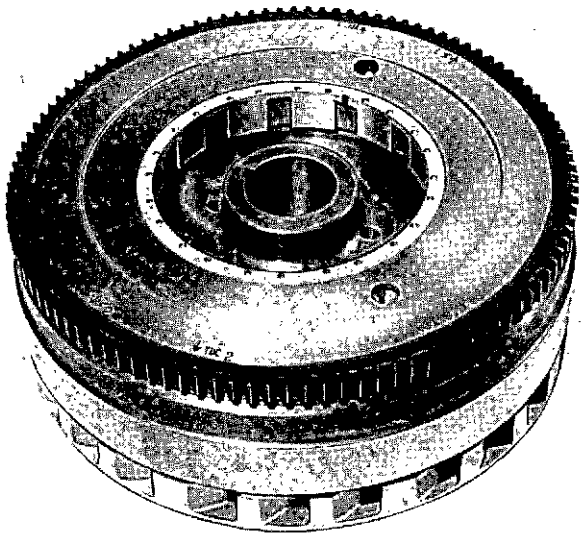


Fig. 105 Crankshaft, Connecting Rod, Piston and Centre Bearing Housing



TS61

Fig. 106 Flywheel Showing Timing Marks

Refitting of Main Bearing Housing and Checking Crankshaft End Float

(a) *Ensure the thrust washer is correctly positioned* in the main bearing housing, Use grease to secure the washer and ensure that the copper face is towards the crankshaft.

(b) With the oil seal removed from the main bearing housing refit the housing ensuring that the metal shims are interspaced with paper shims to ensure an oil tight joint (Fig. 116).

NOTE: When refitting the main bearing housing ensure that the oil supply holes line up and the grooved bearing is fitted at the top.

(c) Secure the housing with four bolts, equally spaced.

(d) Set a dial test indicator so that the actuating plunger makes contact with the flywheel end face of the crankshaft (Fig. 115).

(e) Push the crankshaft firmly towards the gear end of the engine and zero the indicator.

(f) Push the crankshaft firmly towards the flywheel end of the engine and check an end float of 0.229/0.305mm (0.009''/0.012'').

(g) If the end float is incorrect adjust by the addition or removal of metal shims. These shims are available in 0.076mm (0.003''), 0.127mm (0.005'') and 0.254mm (0.010'') thickness. The shims are cemented as listed in 'Jointing Compounds'.

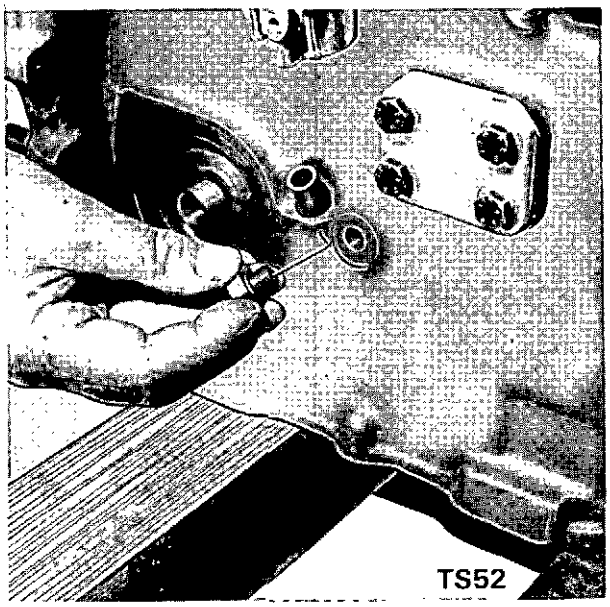


Fig. 107 Removing Centre Bearing Locating Dowel Securing Screw.

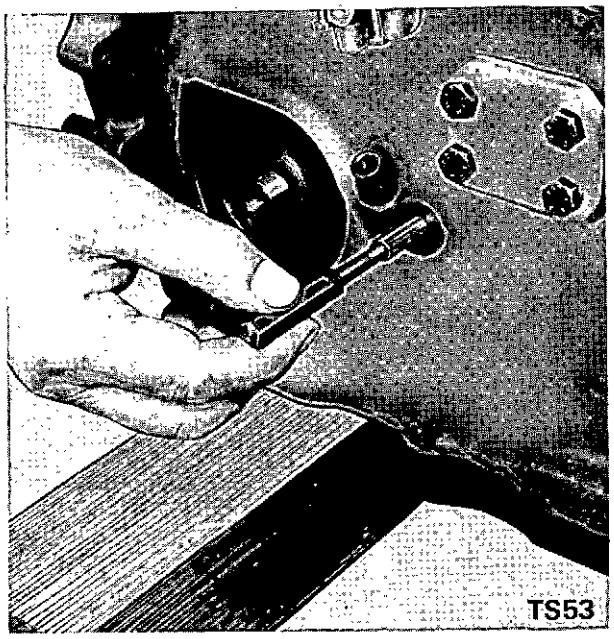


Fig. 108 Removing Centre Bearing Locating Dowel.

(h) Remove four bolts temporarily securing the main bearing housing, offer up the alternator adaptor and replace six bolts and spring washers to a torque of 27.12Nm (20.0 lbf.ft.). Re-torque after 10 minutes.

(j) Ensure the centre bearing dowel is removed and refit rotary oil seal (See Section 7). (Early engines only).

NOTE: Striking the crankshaft may displace the thrustwashers.

NOTE: Balance weights must be removed before attempting to withdraw crankshaft.

Removal of Crankshaft

(a) Using extractor (See Section 7) remove crankshaft pinion and Woodruffe key.

(b) Once again ensuring the centre bearing dowel/s is removed, lightly mark the position of the centre bearing in relation to the crankcase and then withdraw the crankshaft.

(c) Remove the two socket screws and dismantle the centre bearing housing/s.

(d) Remove gear end thrust washers.

Servicing

Inspect the main bearings for scoring or wear, replace bearings if necessary (See Section 7).

If the big end has been dismantled because of failure of the bearing, the oil passages in the crankshaft must also be examined for obstruction and fragments of metal.

Check the clearance between crankshaft journals and main bearings and crankpin and connecting rod bearing, see Table of Clearances, page 112. Examine crankshaft for scoring or wear. If a standard set of bearings will not fit with the required clearance, regrind crankshaft and fit oversize bearings,

Renew split thrust washers if damaged or worn.

To Refit Crankshaft

(a) If required fit new bearing shells to the main bearing housing, centre bearing housing/s and the gear end crankcase main bearing. The grooved bearing shell must be to the top and the oil holes must be lined up.

(b) Reassemble centre main bearing housing/s around the crankshaft ensuring the socket screws are dead tight. Note the mark 'Flywheel End' on the housing halves before assembly, and assemble accordingly. (Fig. 113).

(c) Apply grease to the steel side and fit the thrust washer to the gear end with the tab correctly located and the copper face towards the crankshaft.

Note: Take special care when passing the crankshaft through gear end bearing as it is quite easy to score the bearing shell with the crankshaft.

(d) Offer up the crankshaft, lining up the centre bearing marks to ensure the dowel hole(s) is/are in the correct position.

(e) With the long fuel pump bolt inserted in the centre bearing dowel, insert through the crankcase wall and into the centre bearing housing. Ensure the dowel has gone fully home and that the dowel is not abutting the main bearing housing shoulder. (See Figs. 97 & 98).

(f) Leave fuel pump bolt in dowel.

(g) Refit crankshaft balance weights correctly and torque load the Allen screws to 57.0 Nm (42lbf ft.) and then lock by peening with a centre punch. The balance weights must be fitted with the part numbers facing each other.

(h) Fit the main bearing housing (see page 81).

(j) Check the crankshaft is free to rotate.

(k) Fit Woodruffe key and then heat the crankshaft pinion to straw yellow and fit to the crankshaft without delay with the 'O' mark facing outwards. Insufficient heat or delay in fitting could well cause the pinion to become jammed on the crankshaft, whereas overheating will cause discolouration of the pinion.

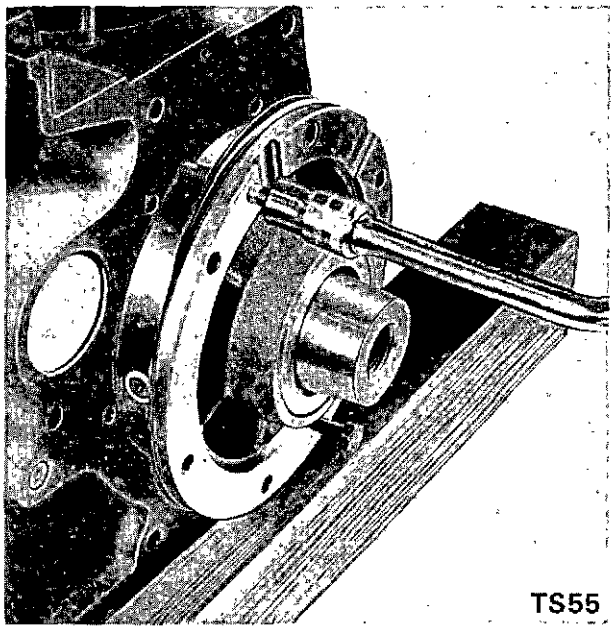


Fig. 109 Jacking off Main Bearing Housing

Crankshaft Drives at Gear End

These must be correctly tightened to the torque given on page 86. Where it is not possible to torque direct at the gear end with the flywheel locked, it will be necessary to lock the drive at the gear end with a special tool (See Sect. 7) and apply torque to the flywheel setscrew with the engine decompressed. Following this the flywheel locking tool should be fitted (See Sect. 7) and the flywheel setscrew re-torqued to the correct value.

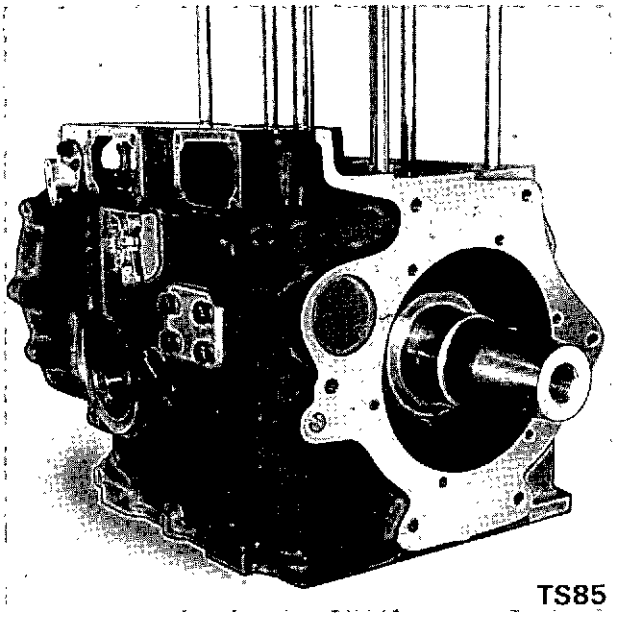


Fig. 110 Crankcase with Main Bearing Housing Removed

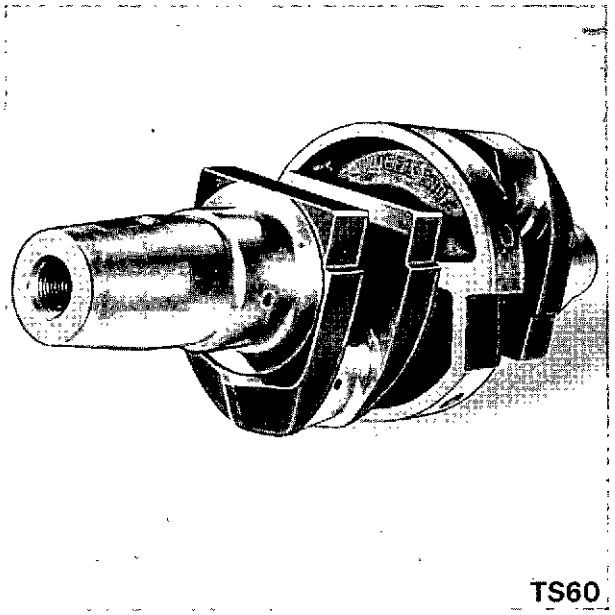


Fig. 112 Crankshaft with Centre Bearing Housing Fitted

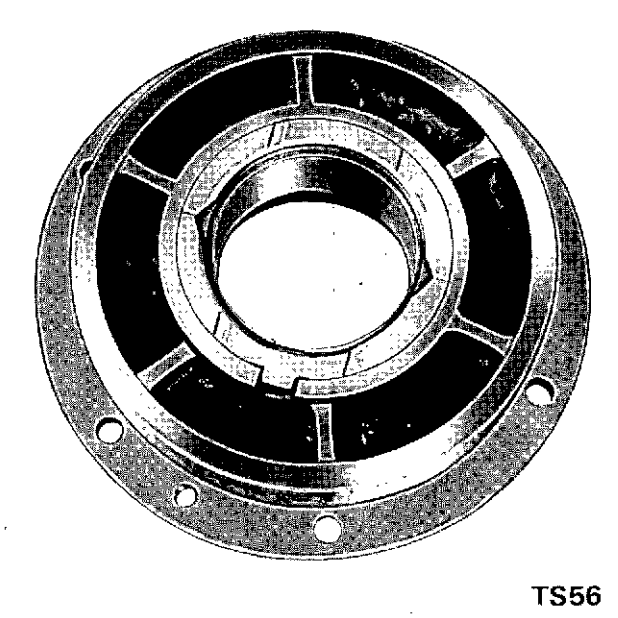


Fig. 111 Main Bearing Housing Showing Thrust Washers

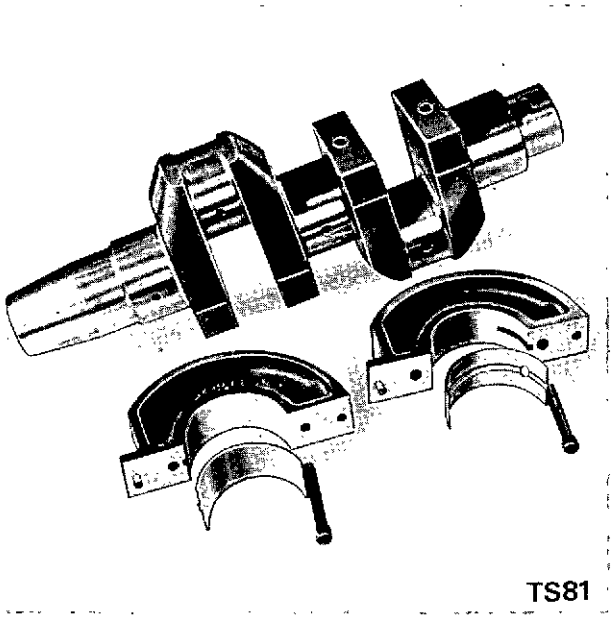


Fig. 113 Crankshaft with Centre Bearing Housing Dismantled

CRANKCASE, SUMP & FITTINGS

1 Crankcase
– Main Bearing Comprises
2 —Top Half
2a —Bottom Half
3 Flywheel End Expansion Plug
4 Flywheel End Bush—Camshaft
5 Centre Bush
6 Cylinder Head Stud
7 Oil Hole Plug—Gear End
8 Oil Gallery Plug—Flywheel End
9 'O' Ring
10 Dipstick Adaptor
11 Dipstick Includes
12 'O' Ring
13 Lubricating Oil Pipe
— Fuel Pump Inspection Door
14 —Gear End
15 —Flywheel End/Centre
16 Joint
17 Copper Washer
18 Cheese Head Screw—M6 x 1.0-6g x 12mm
19 Fuel Lift Pump Blanking Plate
20 Joint
21 Copper Washer
22 Screw—M8 x 1.25-6g x 14mm
23 Governor Lever Pivot Support Block
24 Sump
25 Joint
26 Long Bolt—M8 x 1.25-6g x 75mm
27 Short Bolt—M8 x 1.25-6g x 35mm
28 Spring Washer
29 Drain Tapered Plug—3/8''BSP
30 Sump Oil Hole Tapered Plug—1/2''BSP
31 Washer

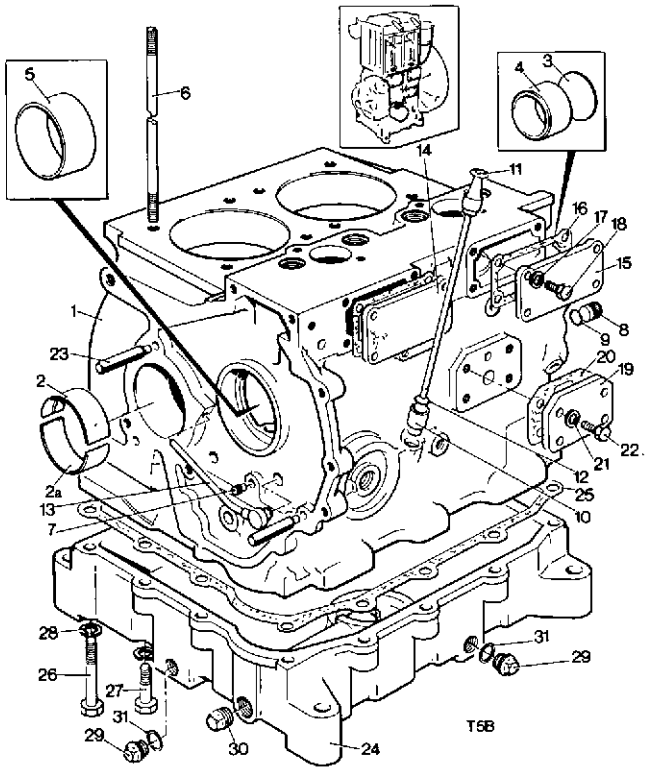


Fig. 114 Crankcase Sump & Fittings

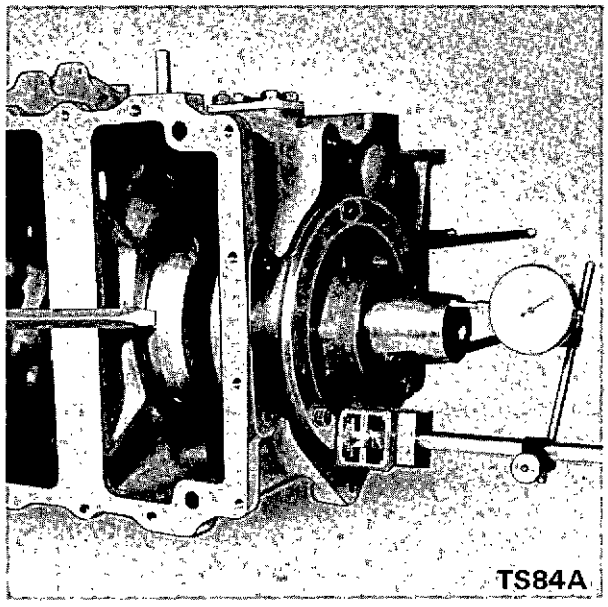


Fig. 115 Checking Crankshaft End Float

DECARBONISING

Decarbonising should be carried out after 2000 hours running or if the engine shows loss of compression or blow-by past the piston. To gain access, remove the cylinder barrel, piston and rings.

Thoroughly clean and examine for damage or wear:—

1. Piston.
2. Piston rings and grooves.
3. Combustion chamber in the top of the piston.
4. Valve ports, valves and valve seats.
5. Exhaust manifold, piping and silencer.
6. Fins on cylinder, cylinder head and injector.
7. Regrind the valves.

Renew any defective parts as necessary, re-assemble as detailed on previous pages.

CLEANING COOLING FINS

The cylinder, and cylinder head must be kept reasonably clean if the engine runs at high loads and speeds, otherwise seizure of various components can occur due to overheating.

Cleaning frequency depends on the nature and concentration of the substances contained in the cooling air. For example, fluff, hair, vegetable fibre, etc., have a greater clogging effect than dry dust.

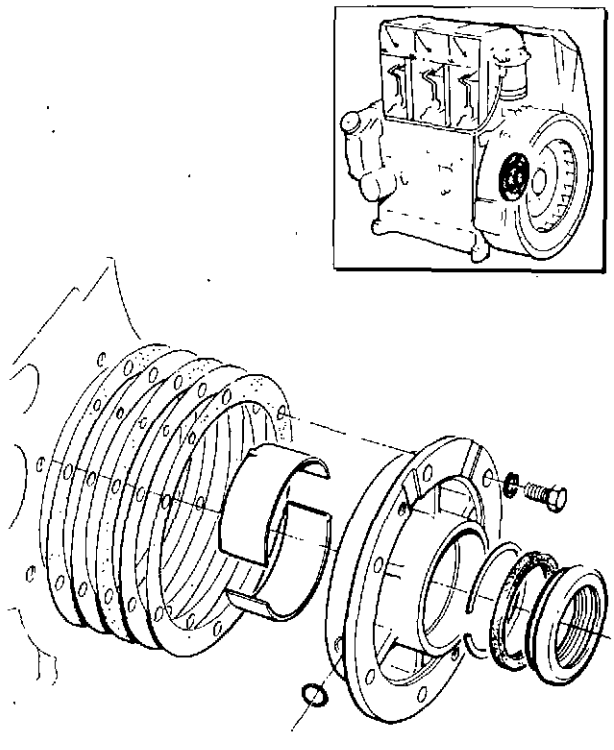
The fins should always be cleaned when the engine is decarbonised but can also be cleaned by removing the manifold and air cowl and raking the dust off the fins with a hooked piece of wire.

LAYING-UP PROCEDURE

The following routine should be carried out when it is known that the engine will not be required for some months:—

1. Replace fuel in tank with a small supply of calibration fluid or equivalent.
2. Drain lubricating oil from sump and refill with Shell Ensis 20 or equivalent.
3. Run the engine for a period to circulate the Ensis oil through the system and to ensure the calibration fluid is passed through the fuel pumps and injectors.
4. Stop the engine and drain off the Ensis lubricating oil from the sump, after which the crankshaft should NOT be turned until the engine is again required for service. The calibration fluid should be left in the fuel system.
5. Seal all openings on the engine with tape.
6. Remove batteries, when applicable, and store fully charged with the terminals coated with Vaseline (petroleum jelly).
7. Grease all external bright parts and control linkage, etc.
8. Tie labels on the engine clearly stating what steps have been taken to inhibit the engine during storage, as above.

If the above is not carried out then the engine should be run about 45 minutes once a month—preferably on load.



TS122A

Fig. 116 Main Bearing Housing showing Main Bearing, Oil Seals, Metal and Paper Shims.

SPANNER TORQUES (TOLERANCE PLUS 5% MINUS 0)

Thread Size	Torque		Location
	Nm	lbf. ft.	
M4 x 0.7	2.98	2.2	Governor Link Adjusting Nuts
M6 x 1.0	8.82	6.5	Decompressor Screw Nut Fuel Filter to Tank Cap Screw Manifold Lower Nuts Fuel Pump Holding Down Bolts Governor Weight Securing Screw
M6 x 1.0	4.07	3	Injector Leak Off Banjo Screw
M8 x 1.0	21.02	15.5	Injector Clamp Screw
M8 x 1.25	21.02	15.5	Valve Rocker Adjusting Screw Nuts Manifold Higher Nuts
M8 x 1.25	27.12	20.0	Main Bearing Housing Screws Sump Retaining Screws
M8 x 1.25	7.9/14.4	5.8/10.6	Oil Starter Adaptor Taper Thread
M10 x 1.25	57.0	42	Balance Weights Retaining Screws
M12 x 1.75	78.66	58	General
M12 x 1.5	28.48	21	Injector Pipe Nuts
M16 x 1.5	362.13	267	Gear End Crankshaft Drives
M18 x 2.5	271.26	200	General
M18 x 1.5	54.25	40	Fuel Pump Delivery Valve Holder
M20 x 2.5	393.32	290	General
M20 x 1.25	27.12	20	Injector Top Plug
M24 x 2.0	474.70	350	Flywheel Retaining Screw
1/4''UNF	11.53	8.5	General
5/16''UNF	20.34	15	General
3/8''UNF	43.40	32	Connecting Rod Nuts
7/16''UNF	67.80	50	General
7/16''UNF	67.80	50	Cylinder Head Holding Down Nuts
1/2''UNF	92.22	68	General
9/16''UNF	135.63	100	General
5/8''UNF	203.45	150	General
1/8"BSP	20.34	15	Main Bearing Dowel Locating Plug

Section Four
JOINTING COMPOUNDS

JOINT DESCRIPTION	JOINTING COMPOUND TO BE USED	INSTRUCTIONS FOR APPLYING COMPOUND
Cylinder Head Cover	Hylomar PL32/M	Coat the cylinder head cover jointing face and stick the joint to it.
Bottom of cylinders	Hylomar PL32/M	Coat the cylinder on the jointing face, stick the joint to it and coat the joint.
Gear Case Cover	Wellseal	Coat the cover jointing face, stick the joint to it, and coat the joint.
Valve Guides	Wellseal	Coat the outside diameters of the guides before fitting. Do not use grease or other substance.
Camshaft Expansion Plug in Crankcase	Hylomar PL32/M	Apply a little compound to the recess in the crankcase before driving in the plug.
Taper Sump Drain Plug	Hylomar PL32/M	Coat the threads.
Taper Plugs other than those mentioned above	P.T.F.E. Thread	Bind the thread with the tape before screwing the plug.
Rotary Type Seals	Hylomar PL32/M	Apply a little compound to the outside diameter of the seal external cover.
Cylinder Shims and Gaskets	High melting point grease	Smear grease in the recess on the head where the joints seat and the side of the recess. Smear grease on each shim in turn and place it in the recess. Place it in the recess on top of the shims. Finally smear grease on the thick gasket. The top of the cylinder is not coated. Use the grease sparingly.
Screw Type Oil Seal	Hylomer PL32/M, Wellseal	Lightly coat the outside diameter of the seal with PL32/M and coat the inside of the grooves with Wellseal.

JOINTING COMPOUNDS

JOINT DESCRIPTION	JOINTING COMPOUND TO BE USED	INSTRUCTIONS FOR APPLYING COMPOUND
Sump Joint	Wellseal	Coat the sump jointing face and stick the joint to it and coat joint.
Valve Rocker Stubs to Top Plate	Wellseal	Coat the sealing groove nearest to the bolt hole.
Fuel Pump Control Door to Crankcase	Wellseal	Coat the door jointing face and stick the joint to it and coat joint.
Crankshaft Bearing Housing Shims	Wellseal	Coat the bearing housing face, place a paper shim over it and coat it; place a steel shim over it and coat it; continue this process using alternative paper and steel shims, always finishing with a paper shim.
Cylinder Head Nuts and **Top** Threads of Cyl. Head Studs	Wellseal	Dip nuts and coat the stud threads and the area of the top plate in contact with the nut.
Fuel Lift Pump to Crankcase. If pump is fitted	Wellseal	Coat the pump face, place the joint over it and coat the joint.
Breather Tube to Aluminium cylinder head	Hylomar PL32/M Loctite 601	Coat the knurls with Loctite and push the tube through the Top Plate. Before the tube reaches the hole in the Cylinder Head, coat approx. 15 mm of the lower end with Hylomar. Do not block the bore of the tube.

Section Five
ACCESSORIES

INTRODUCTION

This section contains information on some of the accessories which may be fitted to TS engines. An Appendix at the end of the book gives a comprehensive list of all the accessories that are currently available.

Code letters, with ordering instructions, may be obtained from the appropriate engine parts list and each accessory is consigned with a drawing and fitting instructions where applicable.

Information on electric starting equipment with wiring diagrams can be found in Section 8.

AIR CLEANERS

The correct fitting and maintenance of air cleaners cannot be over-emphasised. The air cleaner must be fitted to ensure no possibility of air entering the engine except through the cleaner. Loose or incorrect fittings will leave gaps through which dust will be drawn. Servicing periods will vary according to the conditions under which the engine is run, see Routine Maintenance.

Lister Dry Air Cleaner (Fig. 117)

The Lister dry air cleaner, which may be fitted to all TS engines, is removed by loosening the clip to the manifold and lifting off the assembly. Remove the top half by releasing the centre bolt and lift out the element. Check that the rubber adaptor and clip are in good condition and clean the inside of the assembly. The paper element should be changed if found to be damaged or dirty. When refitting; ensure the two halves of assembly is securely attached to the engine air intake.

FOAM ELEMENT AIR CLEANER

A foam element may be used on the TS engine in place of the Lister dry element. The foam element should be treated before initial fitting and subsequently cleaned as follows:

1. Remove the inner and outer perforated reinforcements.
2. *Wash the element in a mixture of fuel oil and* 5% lubricating oil and wring dry.
3. Fit the reinforcements back ensuring that approximately 6 mm (1/4") of foam element protrudes from beyond the reinforcements on both ends for sealing purposes.

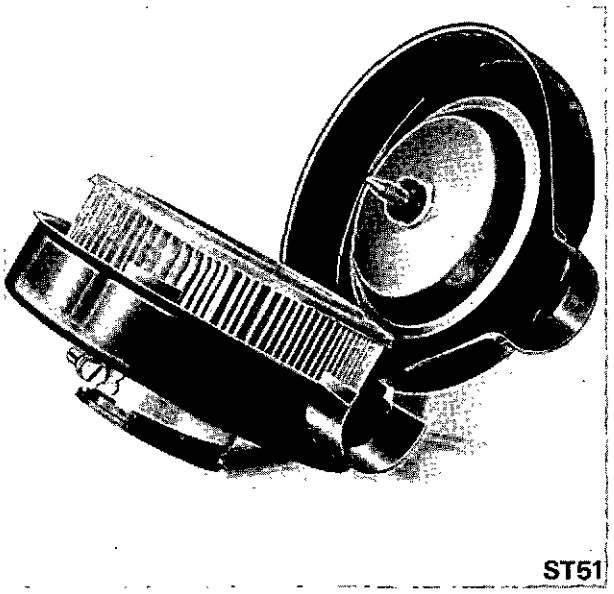


Fig. 117 Lister Dry Cleaner

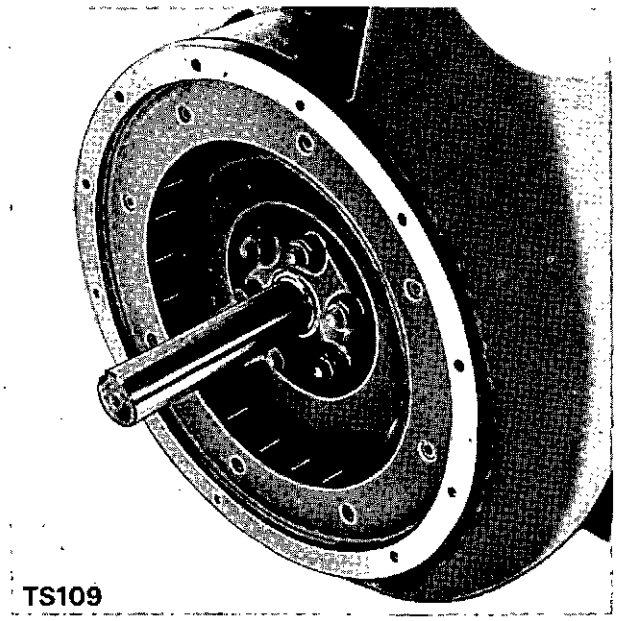


Fig. 118 Flywheel Shaft Extension

FLYWHEEL SHAFT EXTENSIONS (Fig. 118)

A six hole type of shaft extension may be fitted to the flywheel. When fitting a shaft extension ensure all nuts are tightened evenly and there are no burrs on keyway. Nuts should be tightened to 67.8Nm (50 lbf.ft.).

Cyclopac Air Cleaner (Fig. 119)

The dust cap on the end of the cleaner should be emptied daily.

To service cleaner, remove element and clean the outside with a soft brush or by tapping. If compressed air is available this can be used by blowing from the inside of the element only. Maximum pressure 100 lbf.in.^{2}. If air is blown on to the outside of the element it will force the dust through the element leaving holes and it will then be useless. These elements are renewable but if carefully maintained they can be reused. To check if the element is still serviceable, clean and then insert an unshaded light inside the element in a darkened room. The light will show through any small holes which may be in the element and this will indicate that the element is no longer serviceable. A new element must then be used.

Clean the element container thoroughly, refit the element and ensure that all joints are in good condition and well made. Refit the complete unit to the engine and again ensure that all the fittings are tight and that there are no gaps through which the unfiltered air can be drawn.

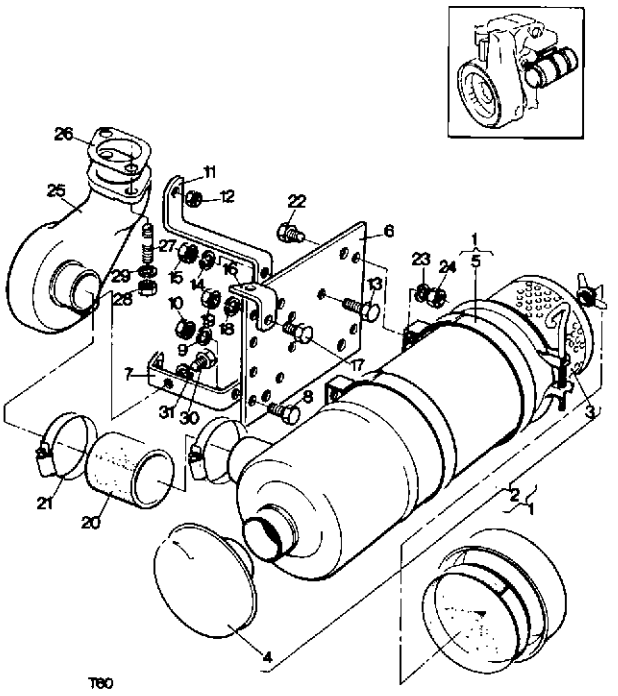


Fig. 119 Cyclopac Air Cleaner

CYCLOPAC AIR CLEANER—5 1/4" Heavy Duty

1 Air Cleaner Assembly Comprises
2 Air Cleaner which Includes
3 Element
4 Inlet Cap
5 Mounting Band
6 Mounting Plate
7 Bracket
8 Setscrew—M8 x 1.25-6g x 16mm
9 Spring Washer
10 Nut—M8 x 1.25-6H
11 Bracket
12 Nut—M6 x 1.0-6H—Replaces Manifold Nut
13 Setscrew—M8 x 1.25-6g x 20mm
14 Spring Washer
15 Nut—M8 x 1.25-6H
16 Bracket
17 Setscrew—M8 x 1.25-6g x 16mm
18 Spring Washer
19 Nut—M8 x 1.25-6H
20 Hose
21 Clip
22 Setscrew—M8 x 1.25-6g x 16mm
23 Spring Washer
24 Nut—M8 x 1.25-6H
25 Adaptor
26 Joint
27 Stud—M8 x 1.25-6g x 30mm
28 Nut—M8 x 1.25-6H
29 Spring Washer
30 Setscrew—M8 x 1.25-6g x 16mm
31 Spring Washer

Fig. 120 Typical Ether Start Kit

FENNER COUPLING HRC (Fig. 122)

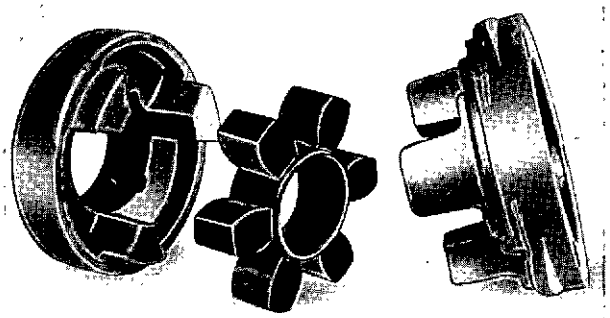
The Fenner Coupling HRC consists of three parts;

(a) Drive Coupling
(b) Rubber Spider
(c) Driven Coupling

The drive coupling is attached to the flywheel with three M12 bolts and spring washers. The bolts should be torque loaded 78.66Nm (58 lbf ft). The rubber spider fits over the driving spigots of the drive coupling and the driven coupling.

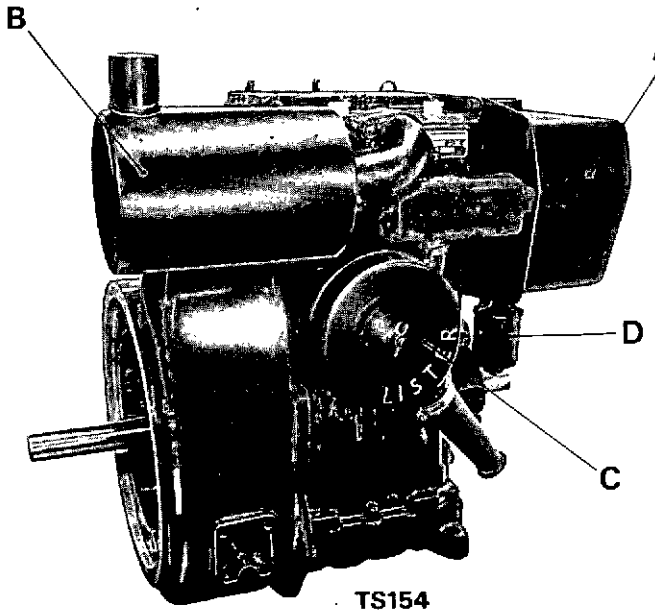
The final drive is either taken direct from the driven coupling via a key and keyway, or via a taper lock bush which is locked into the bore of the driven coupling by two hexagon grub screws. This bush reduces the bore to the required diameter and the final drive is then by key and keyway.

Caution: When offering up driven equipment ensure that metal to metal contact within the coupling is avoided. (See page 7)



TS134

Fig. 122 Fenner Coupling—HRC



TS154

Fig. 121 Common Accessories fitted to the engine.

COMMON ACCESSORIES FITTED TO ENGINE

A. 13.5 litre Engine Mounted Fuel Tank.
B. Exhaust Silencer.
C. Medium Duty Air Cleaner.
D. Fuel Filter (Part of engine mounted fuel tank).

SAE ADAPTORS (Fig. 124)
The following fanshroud adaptors may be fitted:
SAE4 to 5
SAE4 to 4

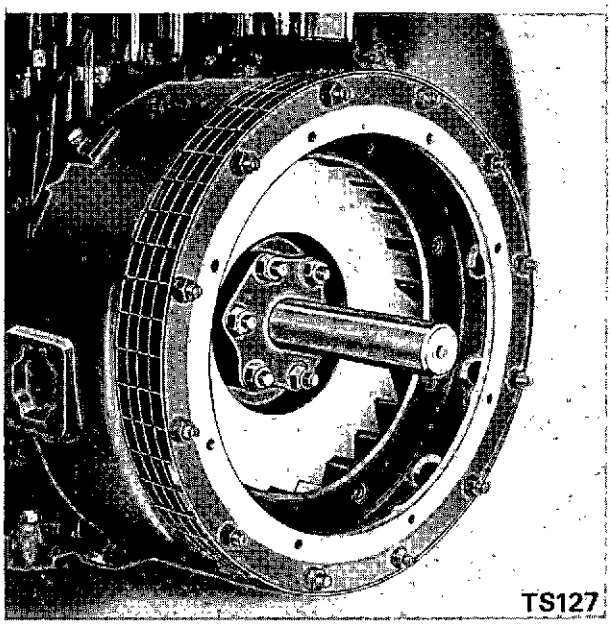


Fig. 124 SAE Adaptor

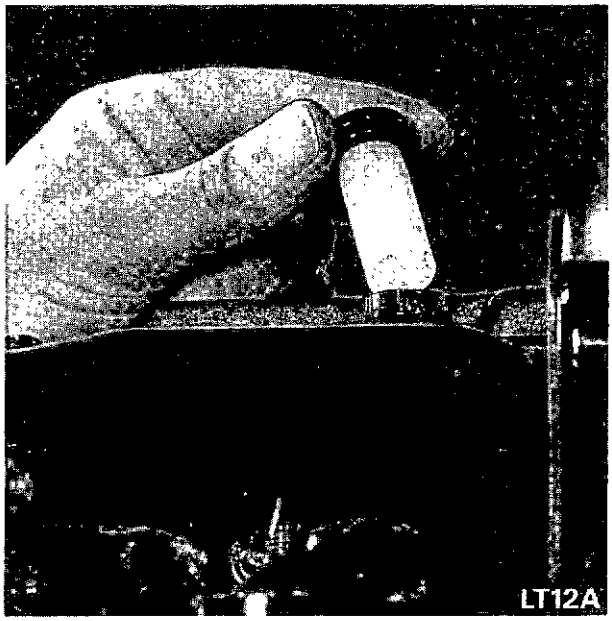


Fig. 123 Cold Starting Oil Cups

COLD STARTING (Fig. 123)
Cold starting oil cups may be fitted to the TS engine side cowl by removing a solid grommet for each cup, and TS engines may be fitted with remote mounted ether start (see Fig. 120).

HOURMETER (Fig. 125)
A vibration type hourmeter is available and may be fitted to the top of the cylinder head cover.

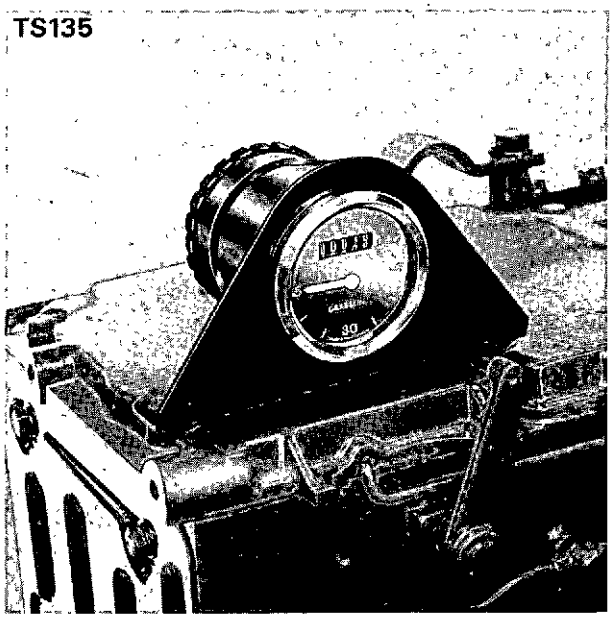


Fig. 125 Hourmeter

AIR OUTLET DUCT ADAPTOR (Fig. 127)

The outlet duct adaptor is secured by brackets to the top plates with setscrews and washers, and also to the side cowl. A solid grommet on the side face of the adaptor may be removed to permit entry for any cable or pipe that may be required.

When ducting or trunking is to be fitted to the adaptor, COOLING AIR CONSIDERATIONS in Section One should be considered.

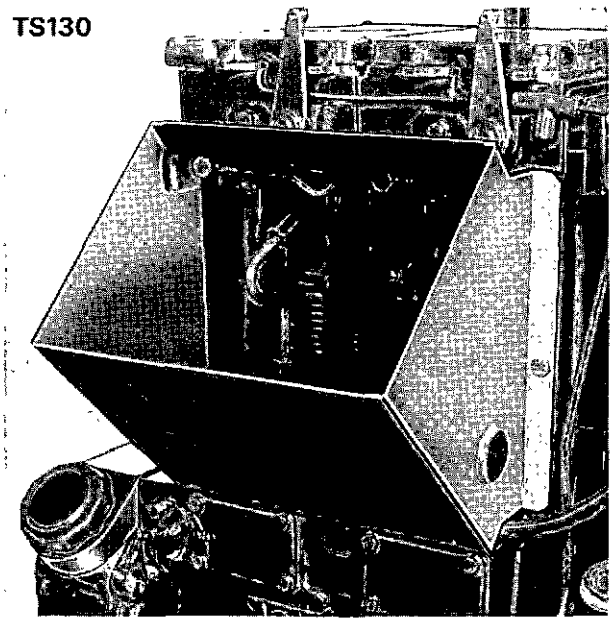


Fig. 127 Air Outlet Duct Adaptor

FUEL LIFT PUMP (Fig. 126)

A fuel lift pump (when required) is fitted to the fuel pump side of the crankcase and is operated by a tappet from the camshaft.

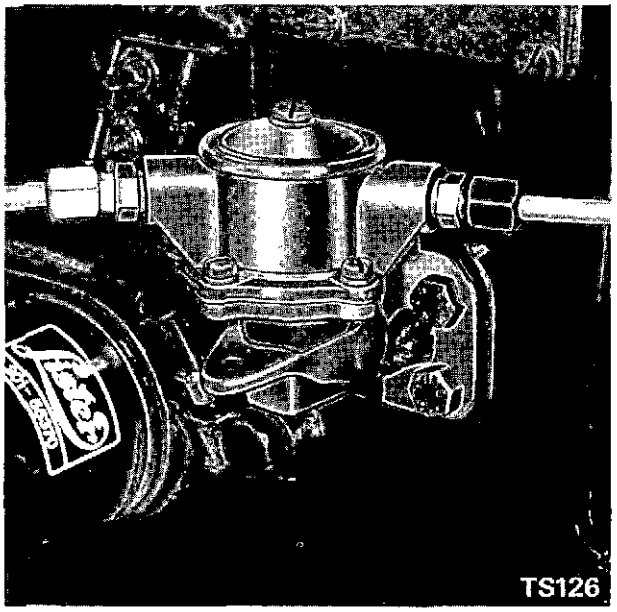


Fig. 126 Fuel Lift Pump

Fitting Fuel Lift Pump

1. Remove the four setscrews and spring washers from the blanking plate and remove.
2. Fit pushrod into large hole until it abuts the operating cam.
3. Turn engine until the push rod is at its outermost point of travel.
4. Check that the push rod protrudes from the machined face of the crankcase by 4.1-4.8mm.
5. Turn the engine until the pushrod is retracted and fit the fuel lift pump, ensuring that a joint is fitted between the pump and crankcase face.
6. Torque setscrews to 2.15 kgf m (15.5 lbf ft).

   Note: If the push rod extension is incorrect an adjustment can be made by fitting a second joint between the pump and crankcase, but the pump must never be fitted without a joint.

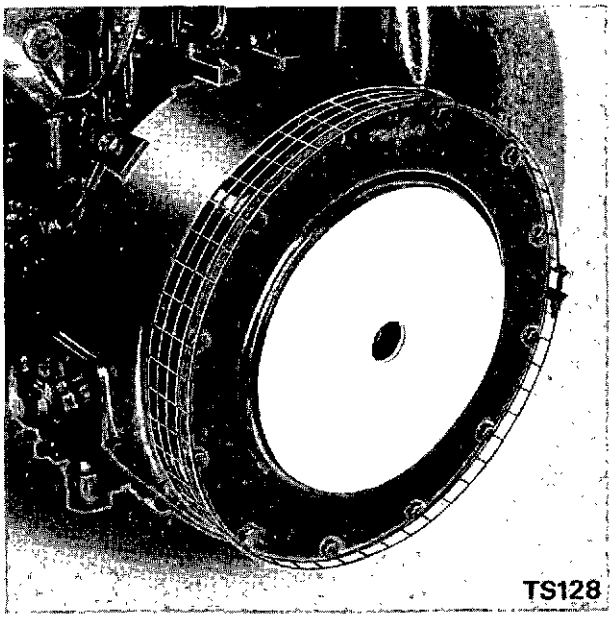


Fig. 128 Hydraulic Pump Adaptor—Flywheel End.

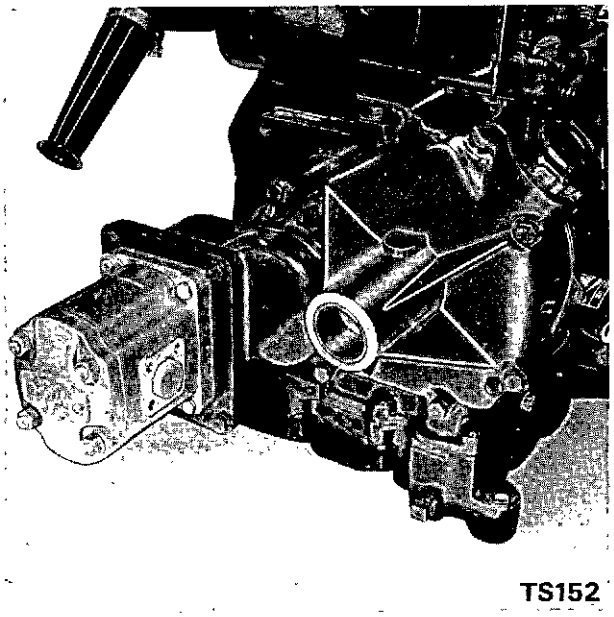


Fig. 129 Hydraulic Pump Adaptor—Gear End.

Hydraulic Pump Drives

By using suitable adaptors (see accessory codes) an hydraulic pump may be driven from either the flywheel end or gear end of the engine, however R A Lister & Co do not supply the hydraulic pumps.

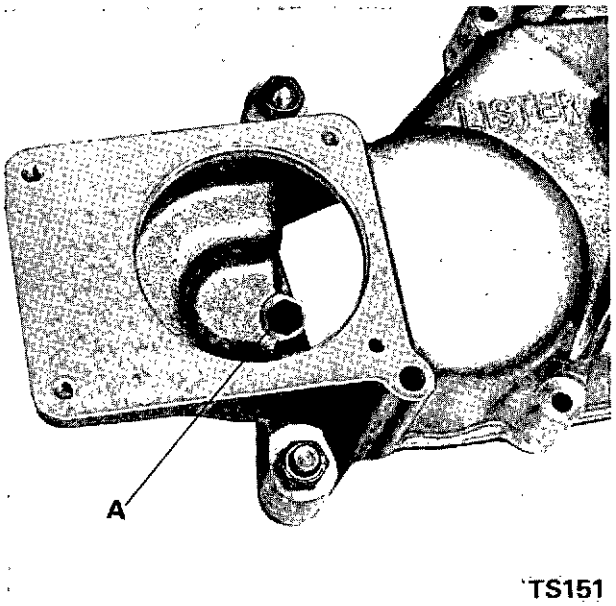


Fig. 130 Hydraulic End Cover Attachment

When removing hydraulic drive end cover always ensure that the setscrew 'A' is removed before attempting to remove the end cover from the engine.

Section Six
FAULT DIAGNOSIS

FAULT	PROBABLE CAUSE	RECTIFICATION	PAGE REFERENCE TL
Engine difficult to Turn (Decompressed)	Lubricating oil too heavy	Drain sump and refill with correct oil	23
	Incorrect decompressor clearance	Re-adjust	65
	Load not disconnected from engine	Investigate	—
Engine Difficult to Start	Lack of fuel	Fill tank and bleed system	37
	Air in fuel system	Check and tighten all connections and bleed system	37
	Defective fuel pump	Overhaul or replace	Sect 3
	Faulty injector	Test or replace	39
	Low compression	See 'Low Compression'	—
	Stopping control incorrectly positioned	Set in correct starting position	46
	Air cleaner or exhaust blocked	Clean	—
Failure to Obtain Normal Speed	Engine started under overload	Reduce load on engine until normal speed obtained	—
	Fuel system not primed	Bleed and prime	37
	Injection retarded	Retime fuel pump	36
Loss of Power	Incorrect fuel	Drain and refill tank with correct fuel	31
	Choked air cleaner	Change element	89/90
	Choked fuel filter	Change	37
	Fuel injector not functioning properly	Test injector, replace if necessary	39
	Fuel pump not operating correctly	Replace	35
	Incorrect tappet clearance	Adjust	65
	Choked exhaust	Remove restriction	—
Erratic or Uneven Running	Air in fuel system	Check all fuel lines and connectors, bleed system	37
	Incorrect fuel pump timing	Retime	36
	Faulty injector	Test and/or replace	39

FAULT	PROBABLE CAUSE	RECTIFICATION	PAGE REFERENCE TS
Knocking	Incorrect timing.	Retime fuel pump.	36
	Air in fuel system	Check connections and bleed system.	37
	Incorrect fuel.	Change.	31
	Worn bearings.	Replace.	Sect. 7
	Insufficient clearance between piston and cylinder head.	Adjust.	64
	Flywheel loose.	Tighten.	78
	Excessive carbon deposit on piston.	Remove carbon.	85
	Engine loose on its mountings.	Tighten.	—
	Valve sticking in guide.	*Clean stems and guides.*	63
	Slack bearing.	Fit new bearing if crankshaft is not worn.	31
Low Compression	Injector loose on its seat.	Check clamp is secure.	38
	Piston rings worn or broken.	Fit new rings.	74
	Leaking inlet or exhaust valves.	Regrind valve and seat.	—
	Cylinder head gasket leaking.	Check head is correctly torque loaded, replace gasket if necessary.	60
Low oil pressure	Insufficient oil.	Maintain correct oil level.	—
	Oil seals leaking.	Check and change defective seal.	Sect 3
	Worn bearings.	Change.	Sect 7
	Fractured pipe.	Change.	—
	Oil pump defective.	Change.	26
	Oil diluted.	*Drain and refill with* correct oil.	23
	Strainer choked.	Remove and clean.	25
	Oil pump plunger and valves worn or dirty.	Clean and renew as necessary.	25
Smoky Exhaust (BLACK)	Engine running on overload.	Check auto excess fuel control.	46
	Air cleaner choked.	Renew element.	89
	Injector nozzle dirty.	Clean or replace.	38
	Incorrect fuel.	Drain and refill with correct fuel.	31

FAULT	PROBABLE CAUSE	RECTIFICATION	PAGE REFERENCE TS
Smoky Exhaust (BLUE)	Piston rings worn.	Renew.	74
	Cylinder bore worn.	Rebore and fit oversize rings.	74
Engine Stops	Insufficient fuel	Fill tank and bleed system.	37
	Loss of compression	See "Low Compression"	—
	Dirt in injector or fuel system.	Investigate and clear.	—
	Air in fuel system.	Bleed system.	37
	Water in fuel system.	Drain, flush, fill with correct fuel and bleed system.	37
High Oil Consumption	Valve guides worn	Change guides or fit new cylinder head	60
Engine Overheating	Cooling air recirculating	Check that cooling air inlet and outlet are not obstructed.	Sect 1
	Air cleaner or exhaust choked.	Clean.	89
	Injection retarded.	Retime fuel pump.	36
	Insufficient lubricating oil.	Check level.	—
	Engine overloaded.	Reduce load.	—

Section Seven
SPECIAL SERVICE TOOLS

INTRODUCTION

Spanners are supplied with each engine. This section describes the special service tools that are available for particular servicing operations on these engines.

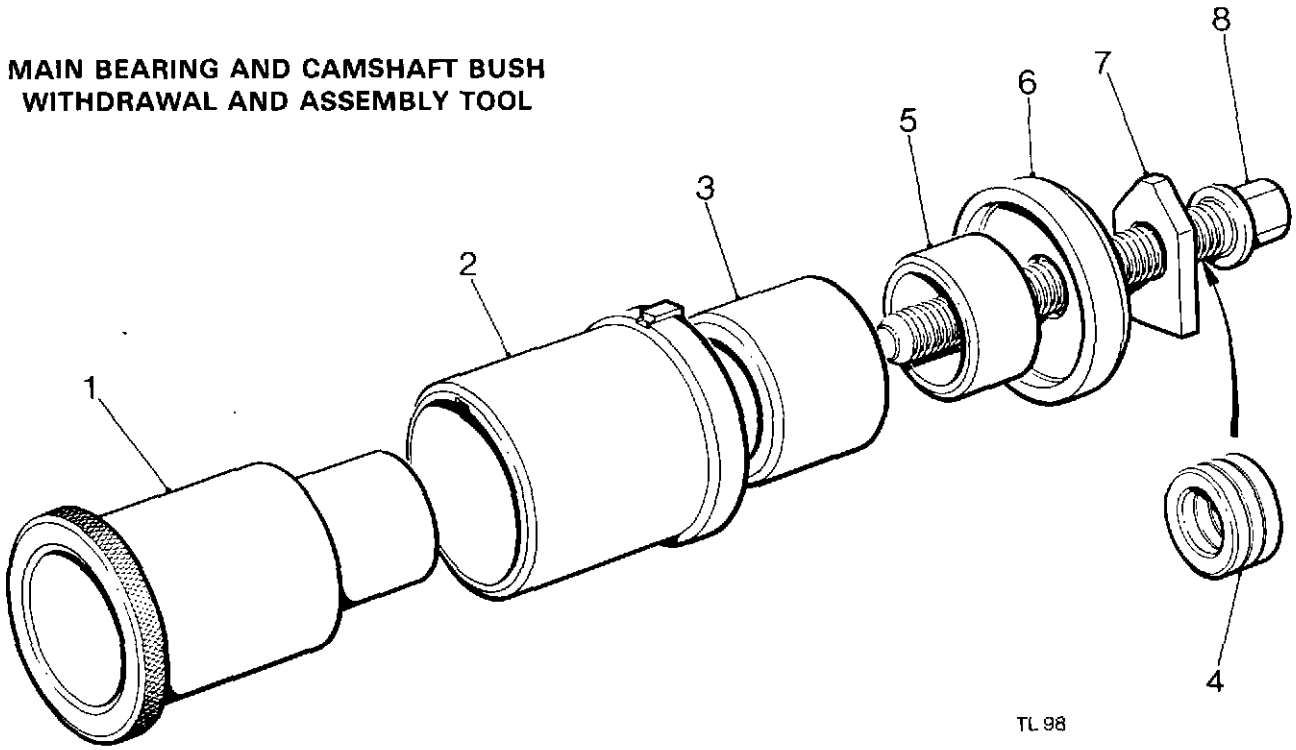
Due to constant development and improvement it is quite possible that any tool purchased may not completely resemble that described or illustrated in *this section of the book, however the principle* will remain the same.

NOTES:

The use of a large amount of force is not *required to fit or remove plain bearings,* particularly camshaft bearings.

The fitting of a ball race bearing (approx. 19mm/3/4" internal dia.) under the head of the bolt of the bearing tool will ease the effort required to turn the bolt.

MAIN BEARING AND CAMSHAFT BUSH WITHDRAWAL AND ASSEMBLY TOOL



1. **Plug**
2. **Sleeve**
3. **Bearing Locating Ring**
4. **Ball Bearing (not part of tool)**
5. **Washer**
6. **Spacer**
7. **Plate**
8. **Bolt**

Fig. 131 Components of Main Bearing and Camshaft Bush Tool

Removing Main Bearing (Fig. 133)

(a) Fit correct bearing location ring (3) on to plug (1).
Note: Four bearing rings are available for standard and undersize bearings.
(b) Insert plug with bearing ring into main bearing shells until bearing ring is located completely in the bearing shells.
(c) Fit sleeve (2) inside crankcase with the locating lug positioned in the thrust washer locating groove in crankcase.
(d) Push bolt (8) through ball bearing (if available) and through centre of spacer (6) with recessed face of spacer nearest the head of bolt.
(e) Fit bolt from inside crankcase through sleeve and screw into plug.
(f) Maintain a grip on knurled flange of plug and tighten bolt until main bearing shells are pushed fully into sleeve of tool.

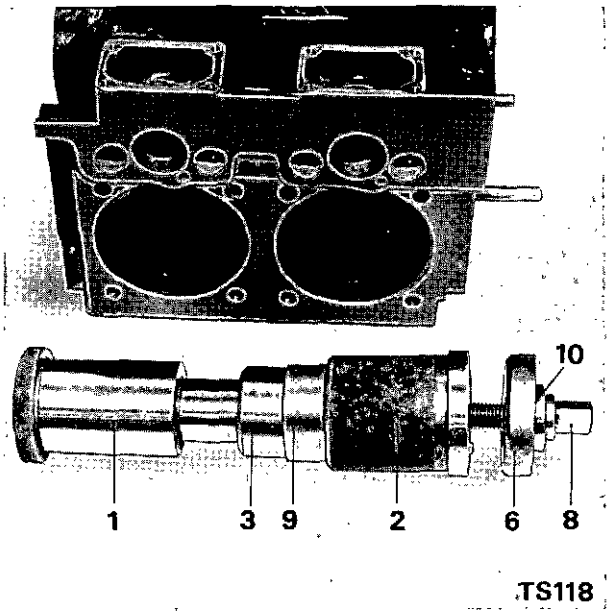


Fig. 132 Fitting Gear End Main Bearing (rigged for demonstration purposes).

Note: The spacer (6) which was designed for the ST engine has insufficient depth to allow the bearings to be pulled fully home, therefore place 3/8'' distance pieces between the spacer (6) and the crankcase face. Use Bearing tool sleeve (2) 317-00594 with the existing ST tool for engines with the larger thrust washers.

NOTE: The top gear end main bearing shell has an oil groove but no locating lug, and when fitting, care must be taken to ensure location of the shells (See Item 2 Fig. 114). Otherwise oil restriction or starvation may occur.

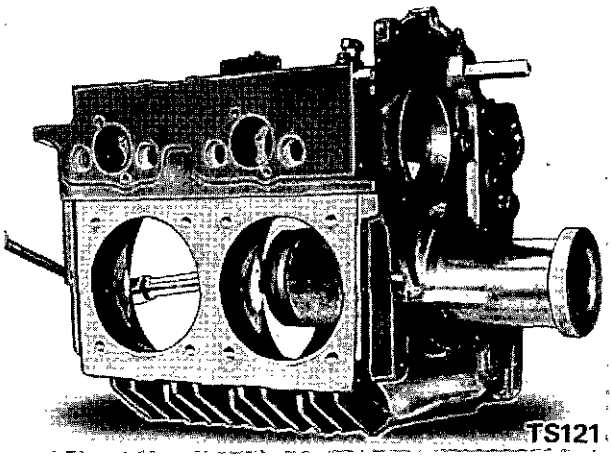


Fig. 133 Removing Gear End Main Bearing

Fitting Main Bearing (Fig. 132)

(a) Position sleeve (2) with locating lug facing downwards on a flat surface. Slide the two halves of the new bearing (9) into the top of the sleeve together.
(b) Fit correct bearing locating ring (3) on to plug (1).
Note: Four bearing rings are available for standard and undersize bearings.
(c) Fit plug into sleeve with bearing ring located completely in the bearing shells,
(d) Place assembly into crankcase with locating lug on sleeve positioned in slot in crankcase.
(e) Place ball race bearing (10) (if available) on to bolt (8) followed by spacer (6) with plain face towards bolt head.
(f) Push bolt into crankcase, locate spacer squarely against outside of crankcase; screw bolt into plug.
(g) Tighten bolt until bearing shells are drawn into position. (See note).

Main Bearing Housing

The removal and fitting of bearing shells in the main bearing housing is carried out by the same method. The bearing housing should be held securely in a vice or refitted to the engine.

The oil seal assembly should first be pushed out from the centre of the housing; new oil seal refitting instructions for earlier engines can be found on page 103.

The top half of the plain bearing in the main bearing housing has a locating tongue which must be fitted into the groove of the fitting sleeve (item 2 Fig. 131) to ensure the tongue locates into its recess in the main bearing housing, when fully fitted.

Intermediate Main Bearings

Instructions for the removal and fitting of intermediate main bearing(s) can be found on page 82.

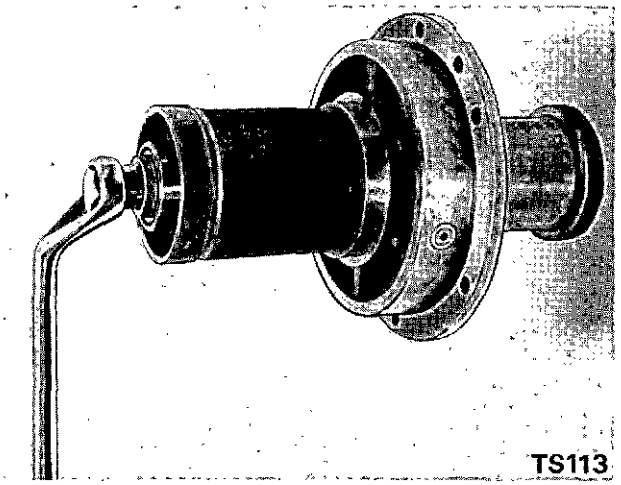


Fig. 135 Removing Main Bearing from Housing (rigged for demonstration purposes)

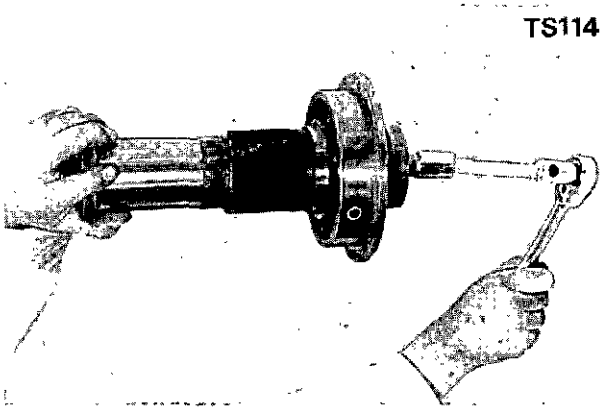


Fig. 134 Fitting Main Bearing to Housing (rigged for demonstration purposes)

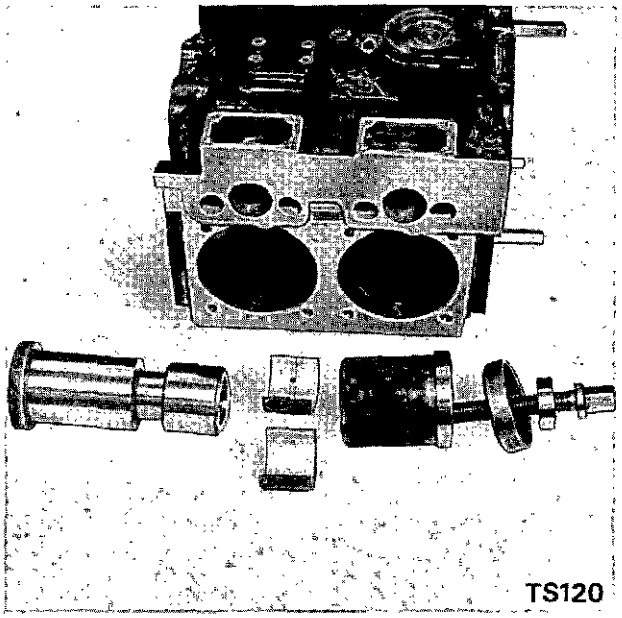


Fig. 136 Fitting Main Bearing (tool exploded)

Removal of Centre Camshaft Bush (Fig. 138)

(a) Place sleeve over plug with locating lug towards plug head.

(b) Place sleeve and plug into gear end camshaft bush hole. The chamfer on the sleeve will assist in aligning the tool.

(c) Insert bolt through flywheel end camshaft bearing hole, place washer over bolt with flat face towards bolt head, and screw into plug until washer abuts the centre camshaft bush.

(d) Checking carefully for tool alignment tighten bolt, pushing the washer and bush through the centre web of the crankcase.

(e) Remove complete tool and bush.
Note: The washer must be the same diameter as the centre bearing bush.

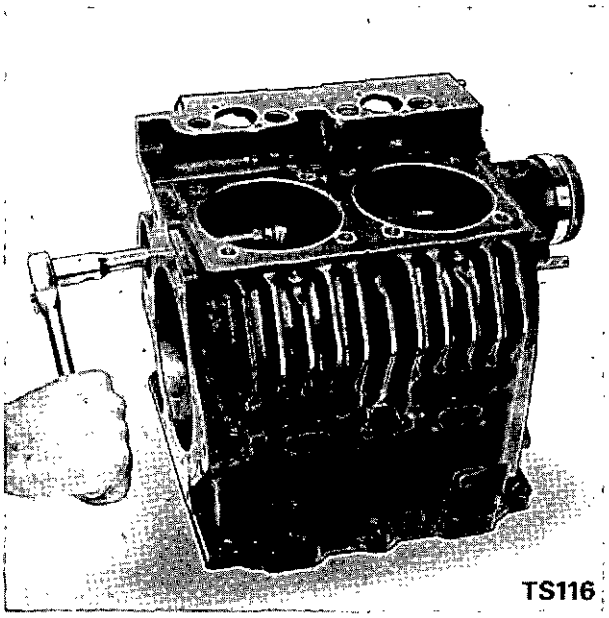


Fig. 138 Removing Centre Camshaft Bush.

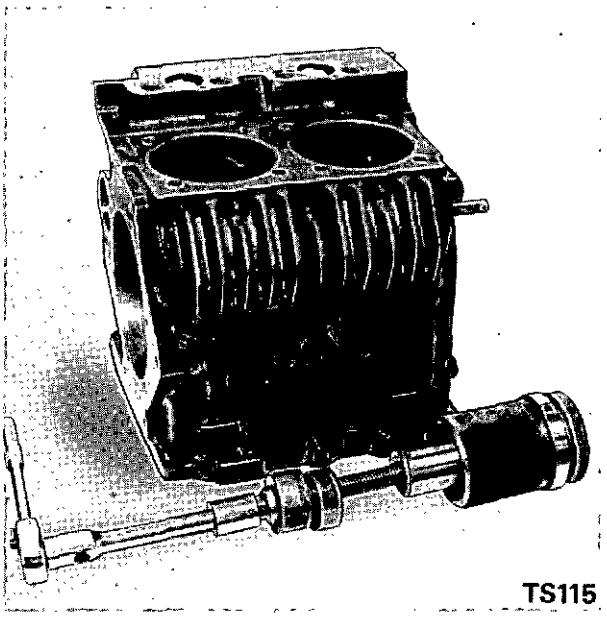


Fig. 137 Fitting Centre Camshaft Bush (rigged for demonstration purposes).

Fitting Centre Camshaft Bush (Fig. 137)

(a) Place sleeve over plug with locating lug towards plug head.

(b) Place sleeve and plug into gear end camshaft bush hole. The chamfer on the sleeve will assist in aligning the tool.

(c) Insert bolt through flywheel end camshaft hole, place washer and bush over bolt with flat face towards bolt head, and screw into plug until bush and washer abuts centre camshaft bearing hole.

(d) Checking tool and bush alignment very carefully, gently screw bolt until centre bearing is fully located in centre web bearing housing.

(e) Remove complete tool.

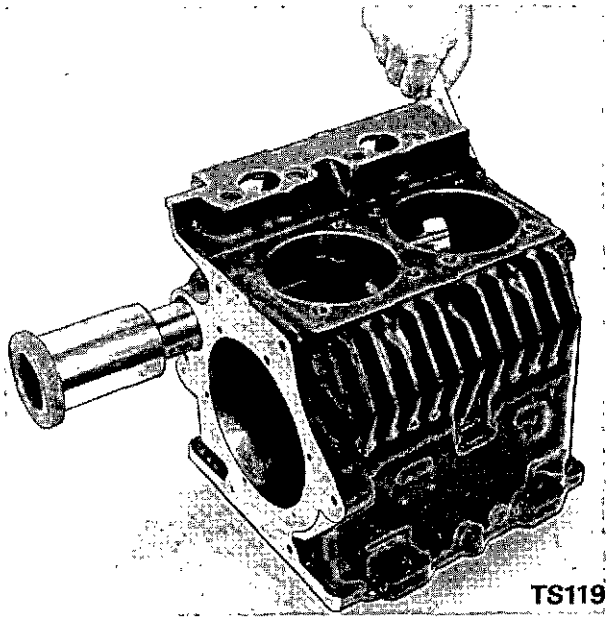


Fig. 139 Removing Flywheel End Camshaft Bush.

Removal of Flywheel End Camshaft Bush (Fig. 139)

(a) Place plug against bush.
(b) Insert bolt with plate through gear end camshaft bearing housing and screw into plug.
(c) Place plate in correct position on centre web and tighten bolt.
(d) Ensure tool correctly lined up, tighten bolt until bush is fully removed.
(e) Unscrew plug and remove tool and bush.

Fitting Flywheel End Camshaft Bush (Fig. 140)

(a) Start bush by gently tapping bush into hole using copper or hide faced hammer.
(b) Place plug against bush.
(c) Insert bolt with plate through gear end camshaft bearing hole and screw into plug.
(d) Place plate into correct position on centre web and tighten bolt.
(e) Ensure tool is correctly lined up, tighten bolt until bush is correctly located.
(f) Unscrew plug and remove tool.

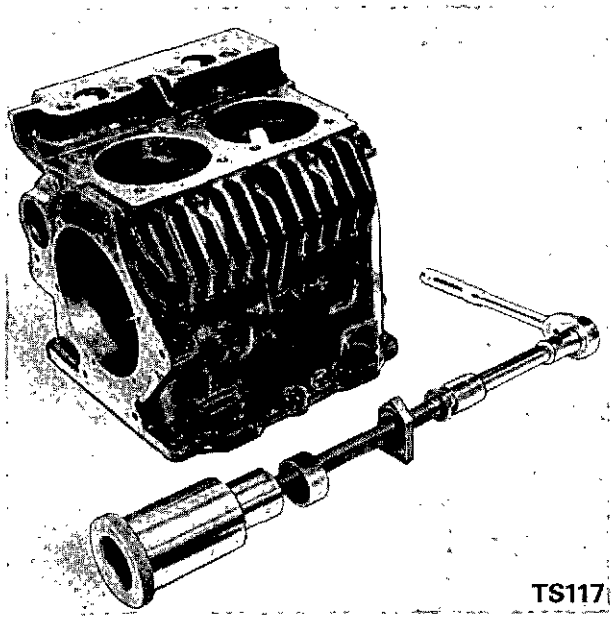


Fig.140 Fitting Flywheel End Camshaft Bush (rigged for demonstration purposes).

ROTARY OIL SEAL (Early engines only)
To Remove (See also Section 4)

1. Remove flywheel.
2. Remove Main Bearing Housing retaining bolts and alternator stator. Fit two M6 setscrews into the two tapped holes in the Main Bearing Housing.
3. Jack off the housing taking care to retain any shims which may be fitted.
4. Drift the complete seal assembly out of the housing taking care not to damage the main bearing shells.

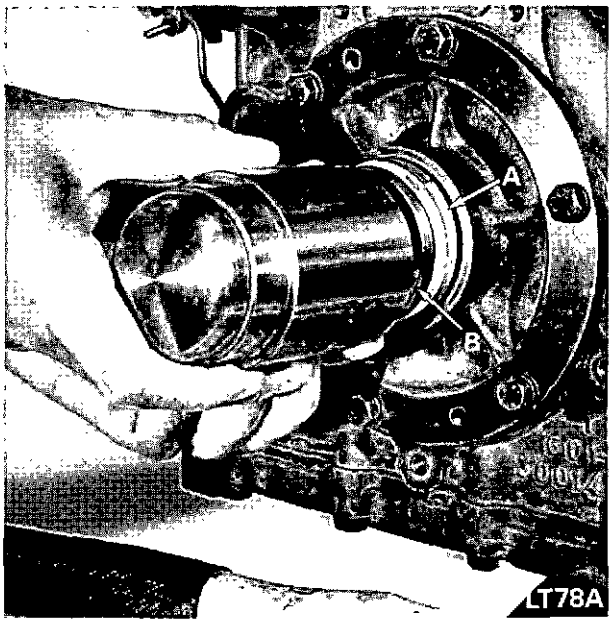


Fig. 141 Fitting Felt and Seal Cover.

Fitting New Oil Seal (See also Section 4)

1. With centre bearing dowel removed fit Main Bearing Housing and check the crankshaft end float.
2. Fit mushroom headed guide tool into the end of the crankshaft.
3. Check that the impeller A is for the correct rotation and fit over the shaft with direction arrow visible. Fit spacer B and using tool illustrated in Fig. 141, drive the impeller onto the shaft.
4. Lightly lubricate the felt and fit inside the seal cover.
5. Fit assembly C (felt and cover) into the centre of the bearing housing until flush with end face using the tool shown in Fig. 143.

Note: the use of this tool ensures the correct clearance of 0.05 to 0.50 mm between the impeller and the felt seal cover.

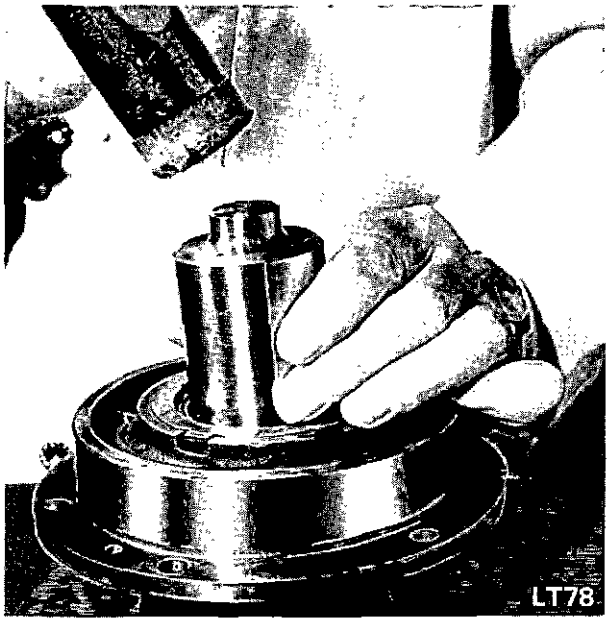


Fig. 142 Removing Oil Seal

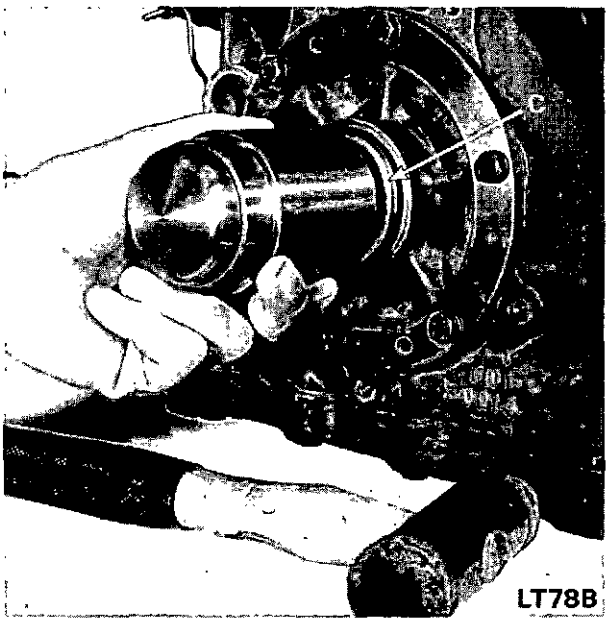
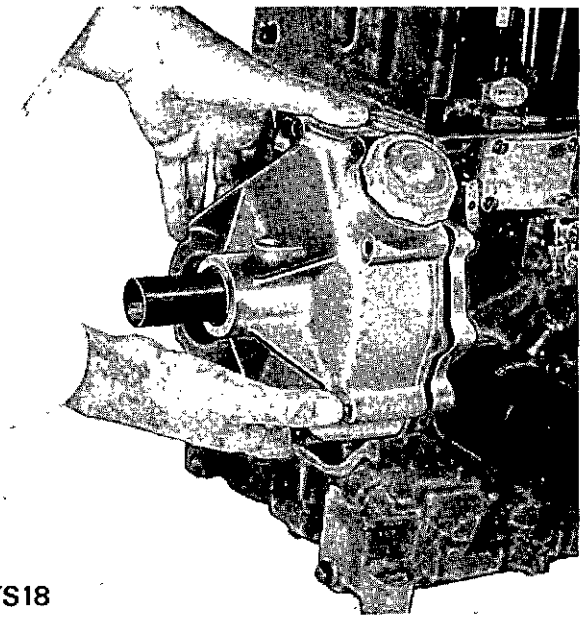


Fig. 143 Fitting Oil Seal Impeller

WARNING: If the crankshaft is moved towards the flywheel end the crankshaft thrust washer at the gear end could become detached from its recess. This can be avoided by removing the gear end cover and placing two suitable strips *of metal (1.5mm thick) between the crankshaft* pinion and the crankcase. To prevent the thrust washer at the flywheel end becoming detached *from the Main Bearing Housing whilst jacking* off the housing turn the engine until the No. 1 cylinder is at the BDC position.



TS18

Fig. 144 End Cover Oil Seal Tool

Loosening Flywheel from Crankshaft (See also Section 4)

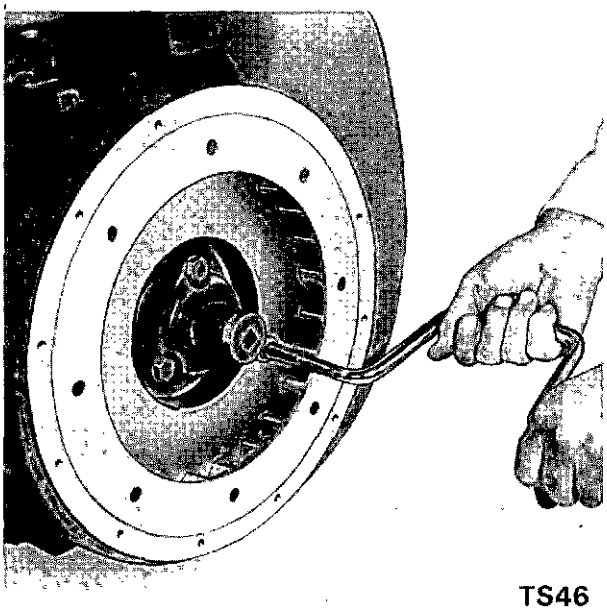
1. Lock the flywheel.
2. Loosen flywheel retaining setscrew by two turns (approx.)
3. Fit the flywheel loosening tool (Fig. 145).
4. Turn the three bolts progressively and in sequence until the flywheel is loosened on the shaft.
5. Remove the extractor tool.

Note: If the flywheel extractor tool has a centre bolt, secure the tool with the three circumference bolts, then screw up the centre bolt.

Note: If a flywheel extractor tool is not available *a flywheel end extension shaft may be used* with equal success.

End Cover Oil Seal Tool (See also Section 4)

To protect the lip seal fitted to the crankcase end of the starting handle sleeve of the end cover introduce the oil seal tool through the lips of the seal and then remove or replace the end cover as required. Remove the tool after use. The tool may also be used to replace the seal in the end cover.



TS46

Fig. 145 Flywheel Loosening Tool

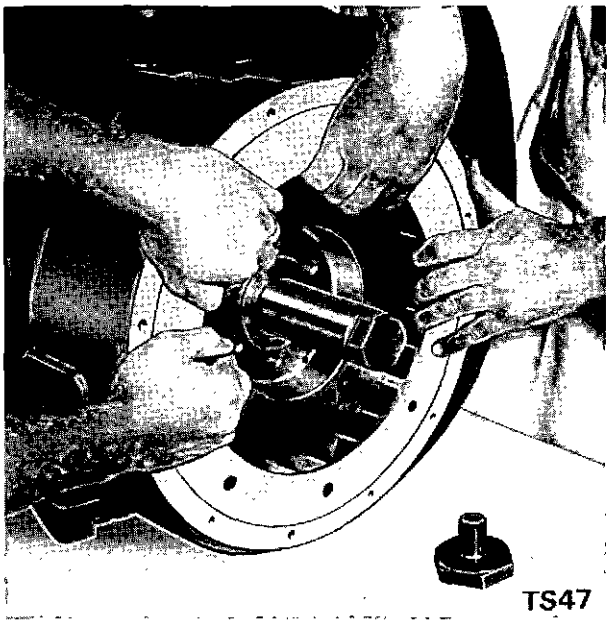


Fig. 146 Removing Flywheel

Flywheel Removal Mandrel (Fig. 146)
After loosening flywheel (as already described) remove flywheel retaining setscrew and replace with mandrel. This will enable the flywheel to be removed without damaging the stator and will help prevent injury to the hands.

Remove Crankshaft Pinion Gear (Fig. 147)

1. With end cover removed loosen central screw of the pinion removal tool.
2. Place pad (not visible) into the crankshaft.
3. Place removal tool in position over the pinion and screw up central screw to just hold the pad.
4. Fit and tighten the three securing bolts into the pinion.
5. Screw in central screw until the pinion has been removed.
6. Remove crankshaft key.

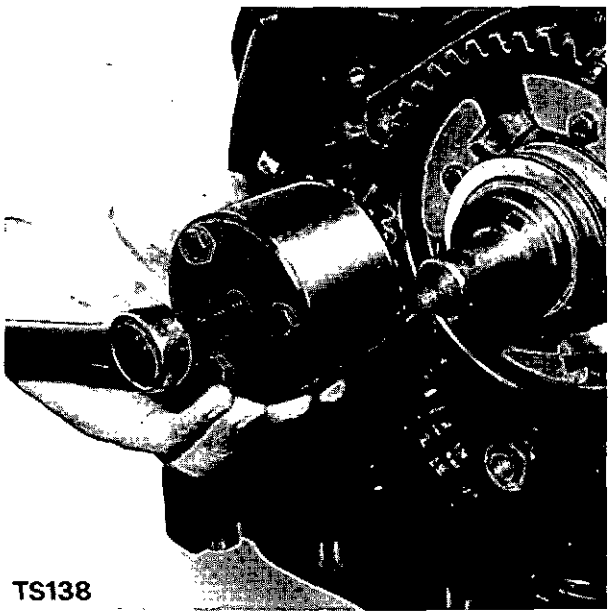


Fig. 147 Removing Crankshaft Pinion Gear

FLYWHEEL LOCKING TOOL (Fig. 149)

1. *Remove perception head blanking plug.*
2. Screw brass adaptor into perception head hole.
3. Drop flywheel locking tool into starter ring gear teeth through the adaptor centre hole.

Note: Always ensure the flywheel locking tool is removed after use and blanking plug replaced.

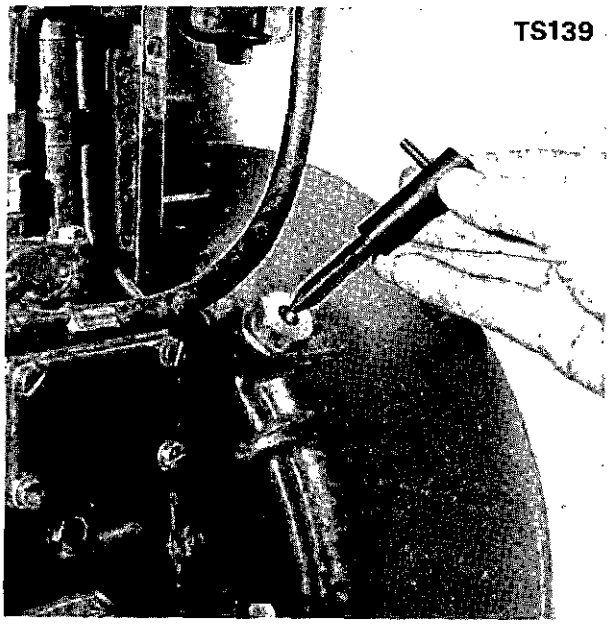


Fig. 149 Flywheel Locking Tool

STUB SHAFT TOOL (Fig. 148)

To remove stub shaft

1. Screw small end of adaptor into the screw thread of the stub shaft and tighten.
2. Preferably place the cylinder head into a vice, and screw slide hammer tool on to adaptor.
3. Grip slide hammer in one hand and strike the sleeve in the required direction until the stub shaft has been removed.
4. *Remove rocker arm.*

To refit stub shaft

1. See Section 4 'Valve Rocker Stub Shafts' before attempting to refit stub shafts.
2. *Fit small end of adaptor into the screw thread of the stub shaft and tighten.*
3. Place cylinder on its side on a bench and *place the rocker arm into position for refitting* stub shaft.
4. Fit slide hammer tool on to adaptor and (see Sect. 4) correctly fit stub shaft into stub shaft hole.
5. Grasp slide hammer with one hand whilst positioning rocker arm with the other and refit stub shaft by striking the end of the tool nearest the cylinder head with the slide hammer.

Note: If the rocker lever bush is not correctly lined up and is preventing the stub shaft being refitted gently strike either end of the tool with the slide hammer whilst repositioning the rocker arm.

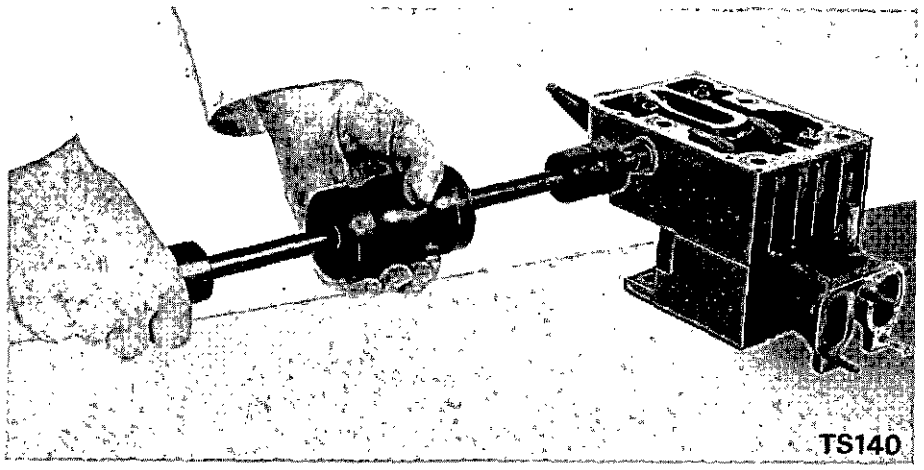


Fig. 148 Stub Shaft Tool

VALVE GUIDE TOOL (Fig. 150)

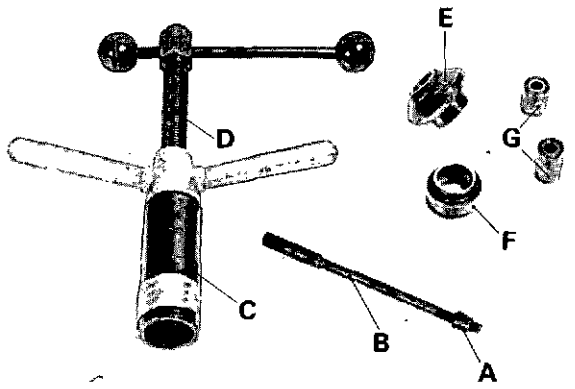
To remove valve guides

1. Preferably place cylinder head on its side in a vice.
2. Place sleeve over the tool and locate spacer (if required) into sleeve.
3. Place mandrel into tool and insert mandrel through guide.
4. Screw on threaded sleeve.

Note: If it is intended to withdraw the guides from the valve seat end, the tapered adaptor must be fitted into the sleeve and located into the valve seat.

5. Holding the sliding handle firmly to prevent rotation, turn the double handled lever clockwise until the guide is withdrawn through the head.

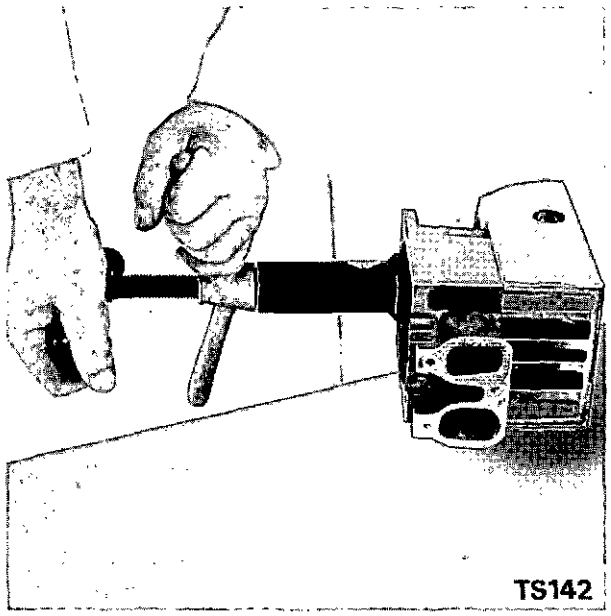
Note: If the valve guides are difficult to start on removal, a sharp tap with a copper hammer should break the seal.



TS141

Fig. 150b Valve Guide Tool

A. Threaded Sleeve
B. Mandrel
C. Sleeve
D. Extractor/Fitting Tool
E. Bevelled Adaptor
F. Spacer
G. Depth Stops



TS142

Fig. 150a Fitting Valve Guide

To fit valve guides

1. Fit mandrel into valve guide hole from the cylinder head end.
2. Place valve guide over mandrel in the top plate.
3. Place depth stop over mandrel and screw on mandrel sleeve.
4. Fit tool complete with tapered adaptor onto mandrel.
5. Holding the sliding handle firmly to prevent rotation, turn the double handled lever clockwise until the depth stop prevents any further movement.

Note: At this point the guide will protrude the correct distance above the cylinder head (See Sect. 4).

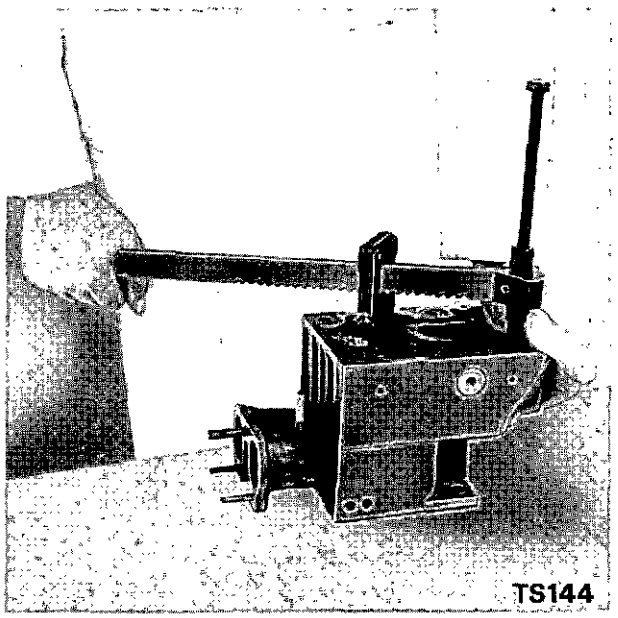


Fig. 151 Valve Spring Removal Tool

VALVE SPRING REMOVAL TOOL (Fig. 151)

1. Fit adaptor into cylinder head cover holding down screw hole.
2. Screw pivot into adaptor.
3. Adjust width of bridge piece to suit valve spring carrier and locate.
4. Push down on lever until collets can be removed/replaced.

Note: It is easier to remove the valves with the rocker arms removed.

VALVE SEAT AND RECESS CUTTING TOOL (Fig. 152)

1. Fit correct adjustable mandrel into valve guide and ensure snug fit.
2. Select correct cutting tool and assemble to 'T' handle.
3. Fit over mandrel and adjust individual blades to correct diameter and rotate in a clockwise direction until valve seat/recess is satisfactory. (See 'Table of Clearances for limitations).

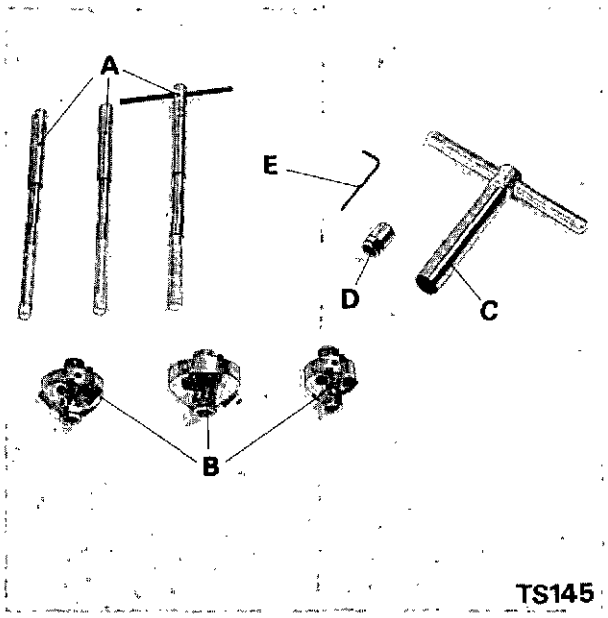


Fig. 152 Valve Seat and Recess Cutting Tool — Exploded

A. Adjustable Mandrels
B. Cutting Tools
C. T. Handle
D. Adaptor
E. Allen Key

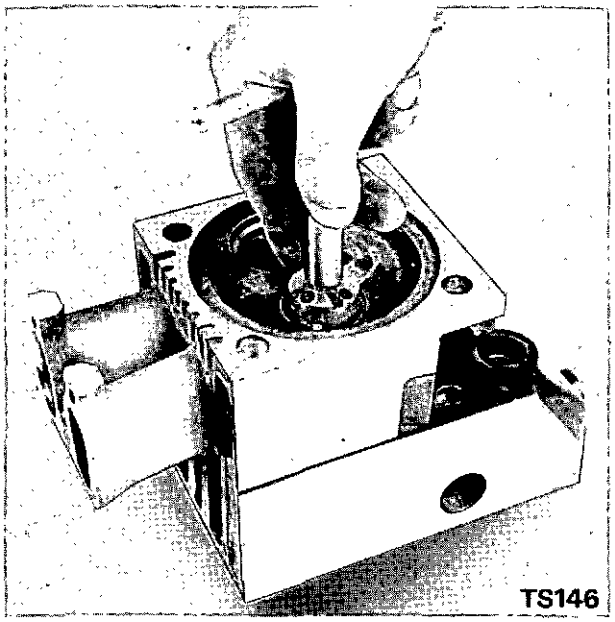


Fig. 152a Valve Seat and Recess Cutting Tool

OVERSIZE/UNDERSIZE ITEMS

Oversize pistons and piston rings, and undersize big end and main bearing shells are available. Reference should be made to an up to date Parts List for accurate numbers. The variations from standard dimensions are as follows:—

0.010'' (0.254mm), 0.020'' (0.508mm), 0.030'' (0.762mm), 0.040'' (1.016mm)

RAL does not undertake the reboring of cylinders or the regrinding of crankshafts.

Non-standard sizes are marked as a suffix to the part number and in the following locations:—

a. Piston rings—+0.010'', stamped on the face of the ring.

b. Pistons—201-80157 0.010'', stamped on the top surface.

c. Bearings—202-80600 US 0.010'', stamped on the steel outside surface of the bearing.

When cylinders are rebored the lower skirt should be etched or painted with the amount of over-size.

The standard initial dimensions are given in the 'Table of Clearances.'

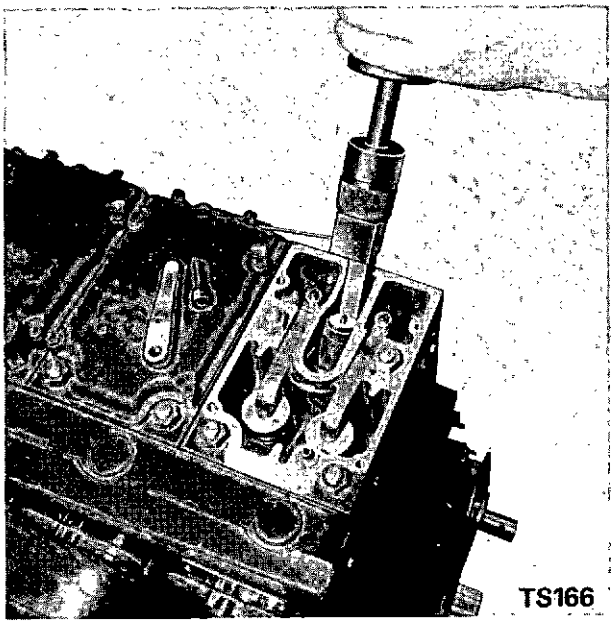


Fig. 152b Slide Hammer with Injector Removal Tool

Injector Removal Tool

Remove the screw from its storage hole. Place the injector removal tool over the injector and insert screw through the hole in the tool and into the fuel inlet hole in the injector. Now fit the slide hammer to the tool to assist in the removal of the injector.

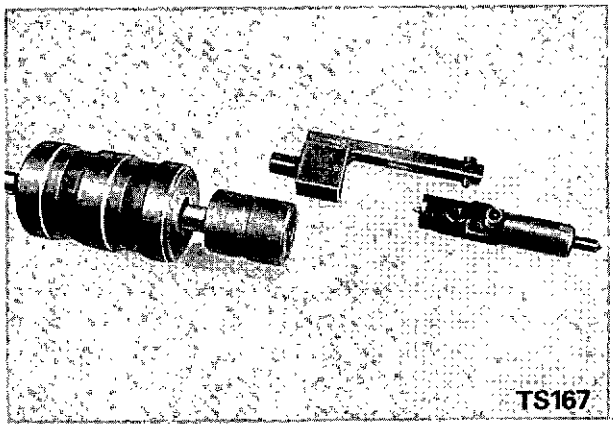


Fig. 152c Slide Hammer and Injector Removal Tool exploded.

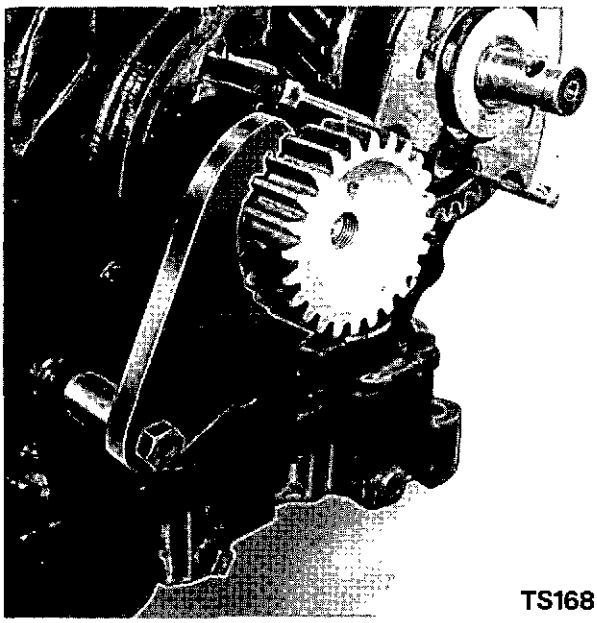


Fig. 152d Tool for Torque Loading Gear End Drive

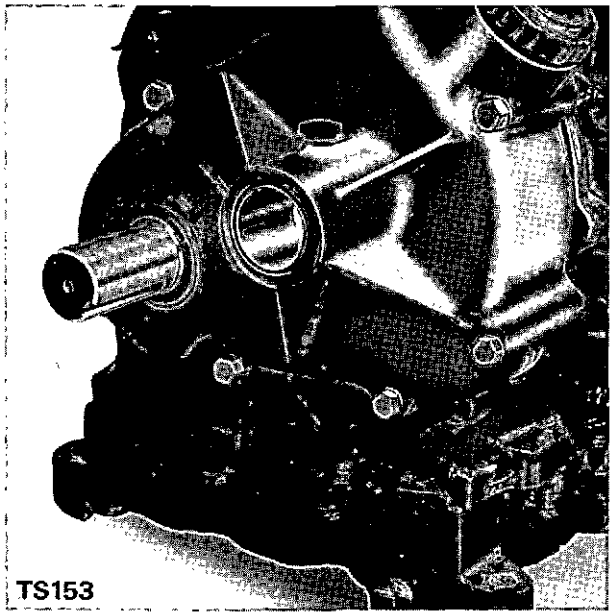


Fig. 152e Crankshaft Extension

See Page 82 Crankshaft Drives at Gear End.

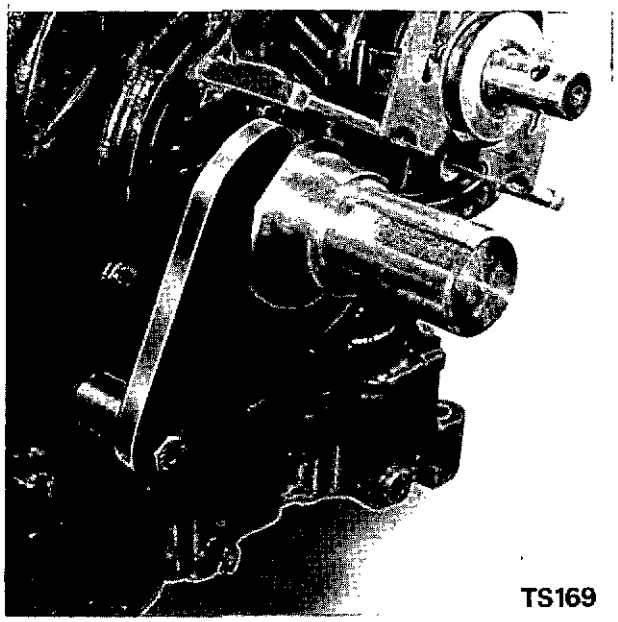


Fig.152f Tool for Torque Loading Gear End Crankshaft Extension

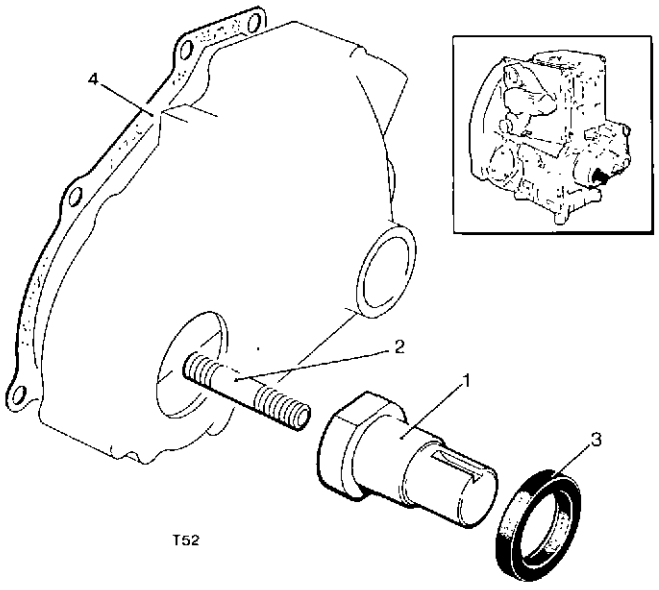


Fig. 152g Crankshaft Extension

1. Crankshaft Extension.
2. Special Stud.
3. Oil Seal.
4. End Cover Joint.

Table of Clearances and Dimensions of Wearing Parts

TS 2/3 ENGINES — DIMENSIONS OF WEARING PARTS

ENGINE WEAR. The following information is given as a guide to the extent by which components may reasonably be expected to wear, without appreciable loss of performance. To maintain the engine in good running order it is therefore recommended that when the "maximum advisable clearance" figure is reached, one or more components affecting the clearance be replaced.

The wear to be allowed in parts refitted to an engine depends on the life required to the next overhaul and the relative cost of labour to materials. If labour costs are high it may pay to replace parts before the maximum wear condition is reached, in order to avoid further work before the next scheduled overhaul.

COMPONENT	INITIAL DIMENSION		INITIAL CLEARANCE		MAXIMUM ADVISABLE CLEARANCE	
	mm	in.	mm	in.	mm	in.
Cylinder bore (See Note 1)	95.30 95.27	3.752 3.751				
			0.262 0.211	0.0103 0.0083	0.35	0.0138
Piston dia at bottom of skirt — across thrust face	95.065 95.039	3.743 3.742				
Fire Ring Gap	0.55 0.35	0.0217 0.0138	0.70 0.41	0.0276 0.0161	0.98	0.0386
Compression ring gap	0.40 0.20	0.0157 0.0079	0.55 0.26	0.0217 0.0102	0.85	0.0335
Scraper ring gap	0.50 0.30	0.0197 0.0118	0.65 0.36	0.0256 0.0142	0.85	0.0335

NOTE 1: The maximum advisable piston to cylinder clearance given above is the clearance between the bottom of the piston skirt (across thrust faces) and the cylinder bore measured in the region of travel of that part of the piston, i.e. NOT at the top of the bore.

NOTE 2: Initial dimensions given for piston ring gaps assume the use of a gauge exactly equal to the nominal cylinder bore. The gaps given under "initial clearance" are those to be anticipated when checking rings in a new bore. For every 0.01mm by which the actual bore size exceeds the "as new" dimension, the ring gap will increase by approximately 0.03mm.

COMPONENT	INITIAL DIMENSION		INITIAL CLEARANCE		MAXIMUM ADVISABLE CLEARANCE	
	mm	in.	mm	in.	mm	in.
Fire ring width Groove width	This may be measured with a new ring. The side clearance is from 0 to 0.06mm (0 to 0.0024in.) when the face of the ring is level with the top land of the piston. In an acceptable worn groove this clearance could be up to 0.100mm (0.0039in.). Normally special gauges are required to measure the groove.					
Compression ring width	2.380 2.355	0.093 0.092	0.18	0.0071	0.23	0.0091
Groove width	2.527 2.502	0.099 0.098	0.13	0.0051		
Scraper ring width	4.763 4.737	0.188 0.186	0.10	0.0039	0.15	0.0059
Groove width	4.838 4.813	0.190 0.189	0.05	0.0020		
Small End Bearings diameter	33.381 33.393	1.3142 1.3417	0.0606	0.0024	0.085	0.0033
Gudgeon Pin dia	33.3375 33.3324	1.3125 1.3122	0.0435	0.0017		
Big End Bore (in rod)	67.221 67.208	2.6464 2.6459				
Bearing shell thickness	1.826 1.835	0.0719 0.0722	0.08 0.04	0.0031 0.0016	0.14	0.0055
Crankpin dia	63.500 63.487	2.5000 2.4995				

TS 2/3 ENGINES — DIMENSIONS OF WEARING PARTS

COMPONENT	INITIAL DIMENSION		INITIAL CLEARANCE		MAXIMUM ADVISABLE CLEARANCE	
	mm	in.	mm	in.	mm	in.
Main bearing housing bore	67.221 67.195	2.646 2.645				
Bearing shell thickness	1.835 1.826	0.0722 0.0719	0.09 0.04	0.0035 0.0016	0.16	0.0063
Crankshaft journal diameter	63.50 63.47	2.5000 2.4988				
Thrust bearing thickness	2.36 2.31	0.092 0.090	0.229 0.305	0.009 0.012	0.305	0.012
			CRANKSHAFT END FLOAT — ADJUSTABLE			
Camshaft bush bore gear end (inner & outer) & centre	44.56 44.53	1.7543 1.7531	0.23 0.18	0.009 0.007	0.28	0.011
Camshaft journal diameter	44.35 44.34	1.7461 1.7457				
Camshaft bush bore flywheel end	44.51 44.49	1.7524 1.7516	0.15	0.0059	0.23	0.009
Camshaft journal diameter	44.35 44.34	1.7461 1.7457	0.14	0.0055		
NOTE: A mandrel of 44.4170mm (1.7487 in.) diameter and the length of the crankcase must just pass through all camshaft bearings, but a mandrel of 44.4055 (1.7482 in.) diameter must fall through freely when the crankcase is inclined at an angle of 45°.						
Camshaft bush length, gear end (inner)	27.91 27.66	1.0988 1.0980				
Camshaft bush length gear end (outer)	40.61 40.36	1.5988 1.5890	0.51 0.13	0.020 0.005	0.63	0.0248
Camshaft gear hub width	26.99 26.94	1.062 1.060	END FLOAT		END FLOAT	

TS 2/3 ENGINES — DIMENSIONS OF WEARING PARTS

COMPONENT	INITIAL DIMENSION		INITIAL CLEARANCE		MAXIMUM ADVISABLE CLEARANCE	
	mm	in.	mm	in.	mm	in.
Fuel pump tappet diameter Tappet guide bore	24.593 24.568 24.632 24.606	0.968 0.967 0.9698 0.9687	0.06 0.01	0.0024 0.0004	0.10	0.0039
Oil pump tappet diameter Crankcase bore	15.850 15.830 15.900 15.875	0.6240 0.6232 0.626 0.625	0.070 0.025	0.0028 0.0010	0.12	0.0047
Oil pump plunger diameter Oil Pump Cylinder diameter	29.960 29.935 30.000 30.033	1.179 1.178 1.1811 1.1824	0.098 0.04	0.0039 0.0016	0.13	0.0051
Valve spring free length	52 approx	2 approx	—	—	3% SET	
Valve guide bore (inlet & exhaust)* Valve stem dia	8.751 8.731 8.663 8.650	0.3445 0.3437 0.3411 o.3406	0.10 0.07	0.0039 0.0028	0.13	0.0051
Valve rocker bush bore Valve rocker shaft diameter	25.462 25.475 25.444 25.436	1.0024 1.0030 1.0017 1.0014	0:039 0.018	0.0015 0.0007	0.07	0.0028
Backlash between gears	— —		0.13 0.02	0,0051 0.0008	0.20	0.0079

* EXHAUST GUIDES ARE COUNTERBORED

Section Eight
ELECTRICAL EQUIPMENT

ELECTRIC STARTING/CHARGING SYSTEM (Figs. 153-155)

A 12/24V electric starting system may be fitted to TS engines. The 12V charging system consists of a flywheel alternator which supplies electrical power to a 12V battery. 24V starting systems do not have a charging system.

Charging System

The 12V alternator stator is attached to the alternator adaptor by setscrews which is in turn attached to the main bearing housing. The 12V stator is positioned within the magnetic ring rotor, which is a press fit into the rear centre of the flywheel and fixed with Loctite 601. Colour coded leads pass through the fanshroud and are connected to the rectifier/regulator unit. The rectifier/regulator is usually fitted to the fanshroud and is secured by two setscrews and safety washers.

Wiring Diagrams

Wiring diagrams for both starting and charging systems are to be found in this section.

Warning

When running engine with alternator system disconnected from battery, disconnect stator leads from rectifier/regulator and tape up separately.

Battery Charge Indicator Light

The battery charge indicator light will always be switched on to indicate a charging fault. The light will also be switched on with a fully serviceable system under the following circumstances:

(a) If the charge rate drops below 2 amps at normal engine speed and the battery is fully charged.
(b) When the charge rate drops below 4 amps at idling engine speed.

ELECTRIC STARTING INCORPORATING LUCAS ALTERNATORS

The following points must be strictly observed when an alternator is fitted otherwise serious damage can be done.

(a) NEVER disconnect the battery whilst the alternator is running.
(b) NEVER disconnect a lead unless the alternator is stopped and all switches are in the "OFF" position.
(c) ALWAYS ensure that leads are fitted to their correct terminals. A short circuit or reversal of polarity will ruin the diodes or transistors.
(d) NEVER connect a battery into the system without checking that voltage and polarity are correct.
(e) NEVER "flash" the connections to check current flow.
(f) NEVER experiment with adjustment or repairs to the system.

SERVICING ELECTRIC STARTING/ CHARGING SYSTEMS

A battery charge indicator will indicate the state of the charging circuit by operating a red light. The light will go out when the charging circuit is operating satisfactorily, and will come on in the event of a fault in the system. The charging circuit uses solid state components which should give trouble free service. No periodic servicing is required on any part of the system other than keeping the rectifier/regulator unit clean, failure to do this may cause overheating of the unit. In the unlikely event of any running troubles clean the wiring connectors and check for broken or frayed wire. If the fault persists the easiest repair technique is to replace individual units, starting with rectifier/regulator, until the fault has been remedied. NOTE: If a problem develops in the battery charge indicator, it can be bypassed without affecting the performance of the system.

The DC resistance of the starter windings should be as follows:

(a) Black to black 0.275 ohms ±20%
(b) Red to red 2.50 ohms ±20%

Cold Cranking Battery Performance Table
(See BS3911:1982)

This table defines the recommended minimum cold cranking performance required from lead acid batteries, when tested at an ambient temperature of −18°C (0°F). For temperatures below −18°C (0°F), high discharge, low resistance Arctic or Alkaline batteries must be used.

Refer to the table and select engine type, system voltage and ambient temperature band. Read off value in amps. e.g. a TS2 with a 12V system at −6°C (21.2°F) would require a battery with a minimum cold cranking rating of 239A. Should that same engine have a 24V system it would require a minimum rating of 210A.

ENGINE TYPE	SYSTEM VOLTAGE	ENGINE OPERATING AMBIENT TEMPERATURE				
		°C	27 min	26 to 1	0 to −8	−9 to −18
		°F	81 min	79 to 34	32 to 18	16 to 0
TS2	12		104A	151A	239A	400A
	24		118A	158A	210A	372A
TS3	12		125A	181A	258A	415A
	24		139A	170A	239A	393A

Starter Motor Cranking Current
Current Requirements (See BS3911: 1982)

This table defines the current required by the engine starter motor to crank an engine at the stated temperature.

ENGINE TYPE	SYSTEM VOLTAGE	ENGINE OPERATING AMBIENT TEMPERATURE				
		°C	27 min	26 to 1	0 to −8	−9 to −18
		°F	81 min	79 to 34	32 to 18	16 to 0
TS2	12		1504A	200A	250A	280A
	24		170A	210A	220A	290A
TS3	12		180A	1240A	270A	290A
	24		200A	225A	250A	275

RECOMMENDED BATTERY CAPACITIES

10Hr rate 67 AH } Advisory only.
20Hr rate 75 AH } See cold cranking performance chart

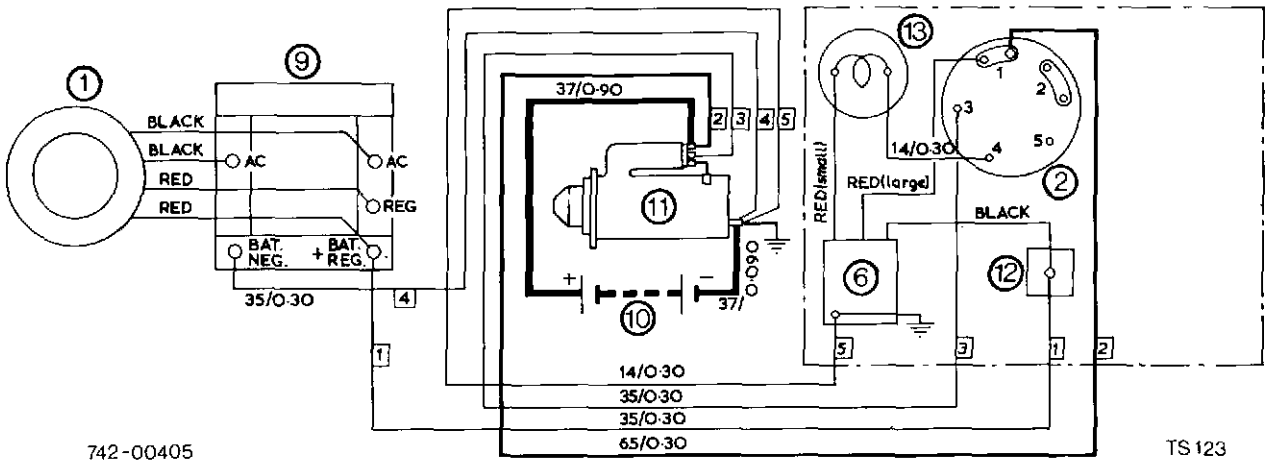


Fig. 153 **Basic Electric Start**

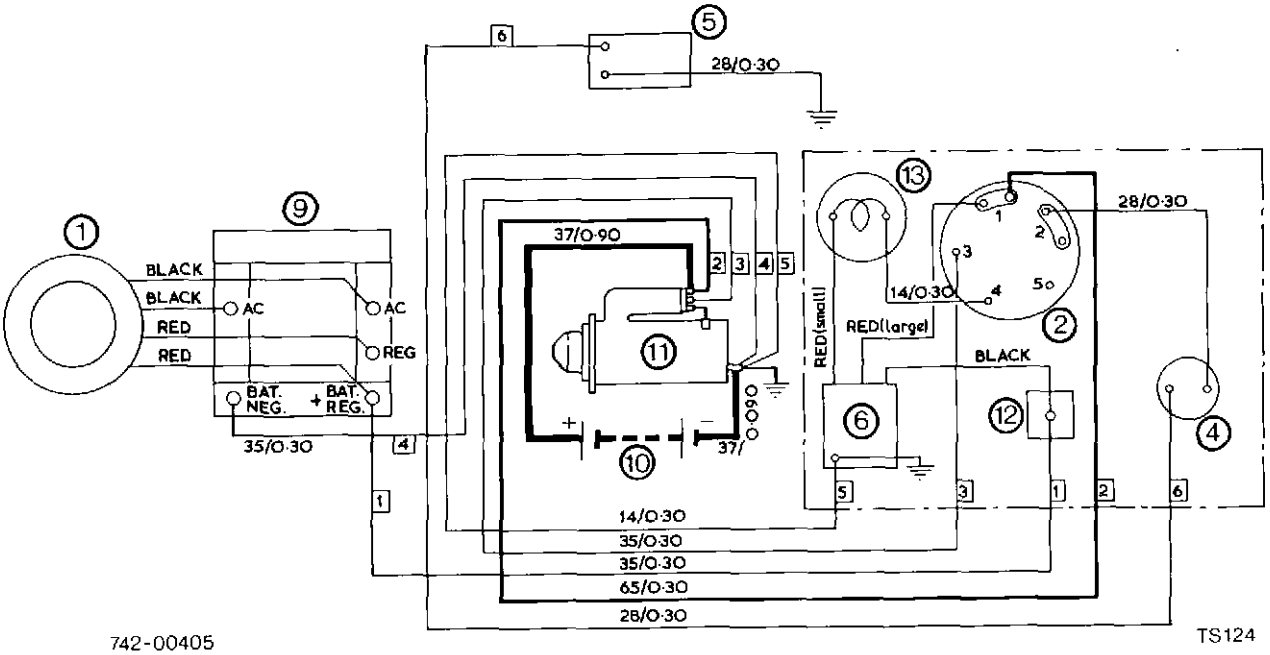


Fig. 154 **Electric Start with Fuel Control Solenoid**

INDEX OF COMPONENTS

1. Flywheel Alternator Stator.
2. Control Keyswitch.
4. Fuel Control Solenoid Circuit Fuse.
5. Fuel Control Solenoid.
6. Battery Charge Indicator.
9. Rectifier/Regulator.
10. Starter Battery.
11. Starter Motor.
12. Terminal Block (Applicable to control panel only).
13. Warning Lamp.

NOTES:

1. All cables to be P.V.C. insulated automobile cable to B.S.6862. Cable sizes given relate to cables between loose control panel or loose components and engine being a maximum length of 1.5 metres, and cables between battery and engine being a maximum length of 0.94 metres.
2. [1] This denotes cable identification number.

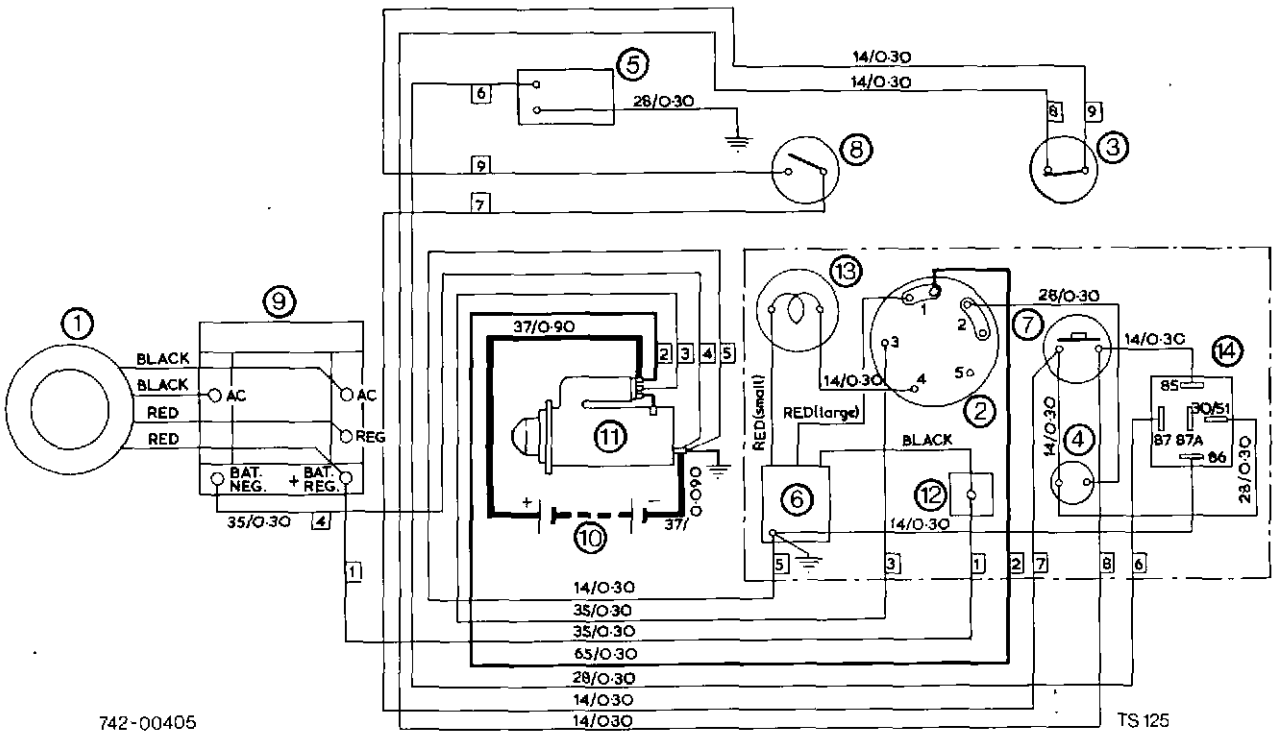


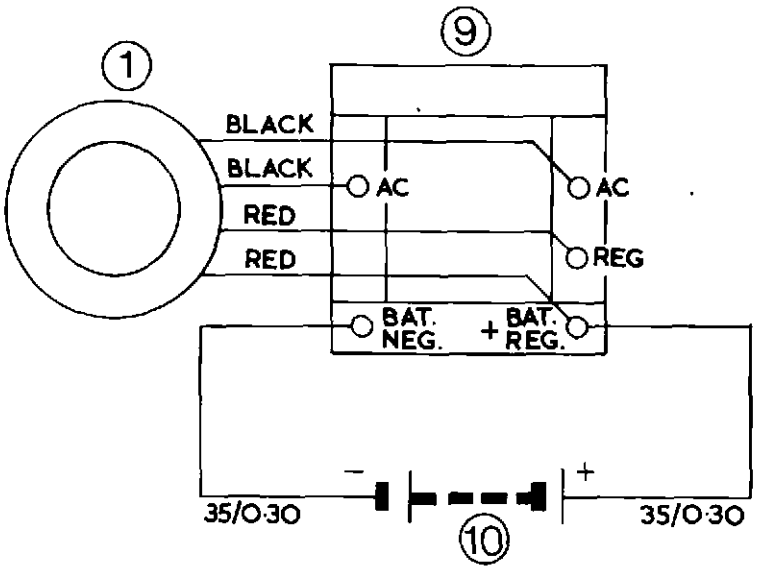
Fig. 155 Electric Start with Fuel Control Solenoid and Protective Switches

INDEX OF COMPONENTS

1. Flywheel Alternator Stator.
2. Control Keyswitch.
3. Engine Temperature Switch.
4. Fuel Control Solenoid Circuit Fuse.
5. Fuel Control Solenoid.
6. Battery Charge Indicator.
7. Oil Pressure Override Pushbutton.
8. Oil Pressure Switch.
9. Rectifier/Regulator.
10. Starter Battery.
11. Starter Motor.
12. Terminal Block (Applicable to control panel only).
13. Warning Lamp.
14. Protective Switch Relay.

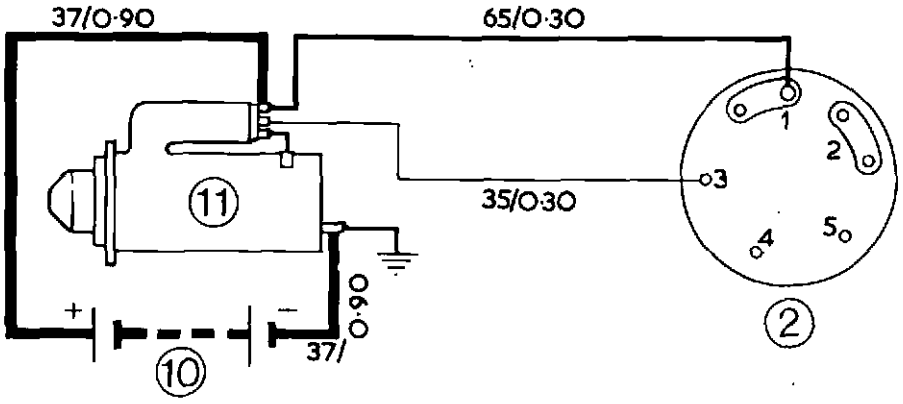
NOTES:

1. All cables to be P.V.C. insulated automobile cable to B.S.6862. Cable sizes given relate to cables between loose control panel or loose components and engine being a maximum length of 1.5 metres, and cables between battery and engine being a maximum length of 0.94 metres.
2. [1] This denotes cable identification number.
3. If item 3 is used as an air temperature switch it must be wired in irradiated p.v.c. cable (suitable for temperatures up to 120°C/248°F).



742-00406 TS159

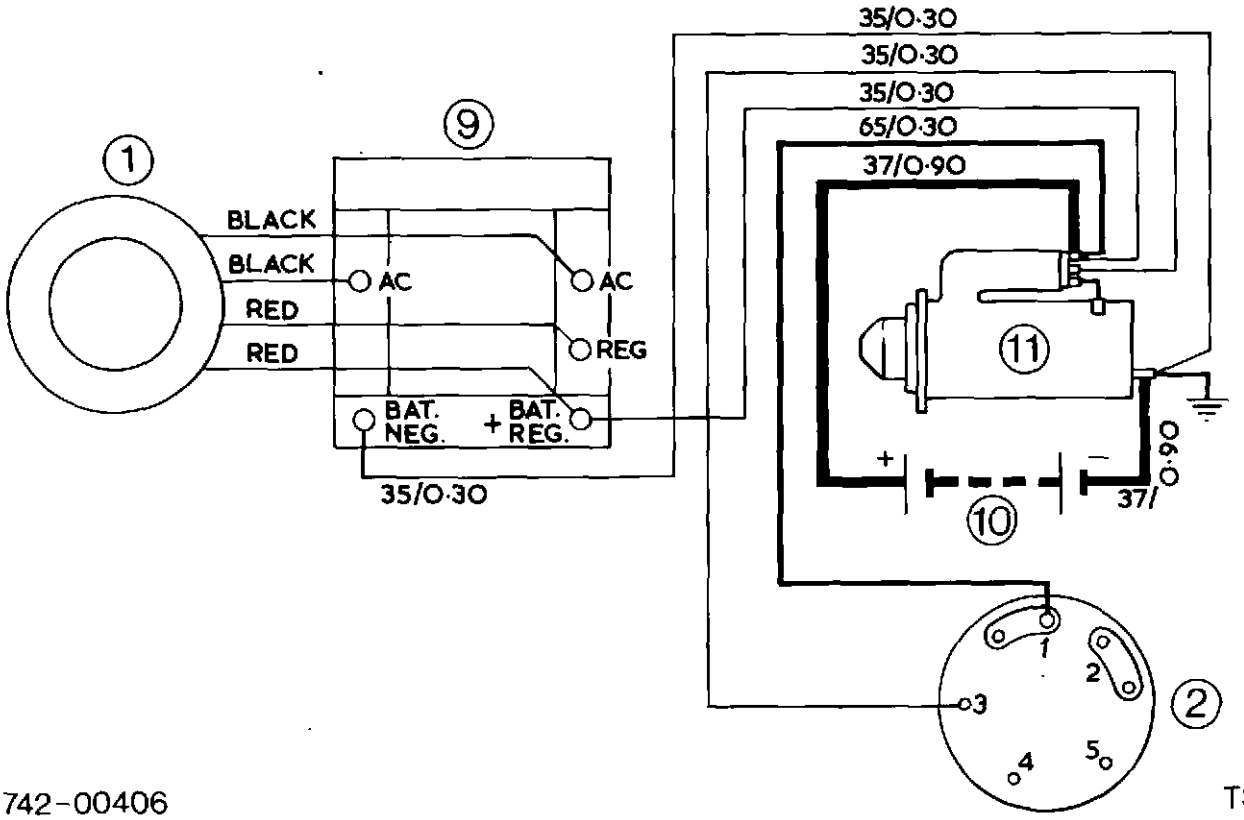
Fig. 155a **Charge Windings less Starter Motor**



742-00406 TS160

Lucas 2M 113 Starter Motor (12 volt) and Keyswitch

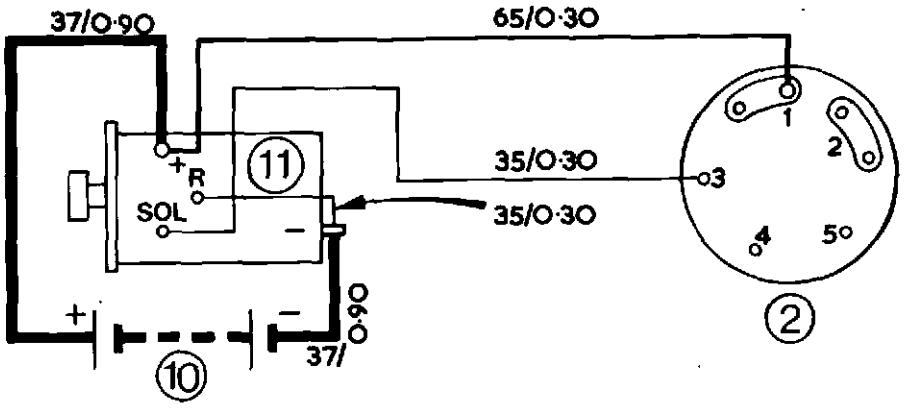
Fig. 155b



742-00406 TS161

Charge Windings,12 volt Starter Motor and Keyswitch

Fig. 155c



742-00406 TS162

CAV. CA45 Starter Motor (24volt) and Keyswitch

Fig. 155d

COMMISSIONING AND FITTING OF BATTERIES

Storage

Dry batteries should be stored in a cool, dry place and protected from the floor by a wooden pallet or suitable thick cardboard sheet.

FILLING A DRY CHARGED BATTERY

1. Check for physical damage.
2. Remove the vent plugs and break any seals (if present) taking care not to damage the separators.
3. Fill the cells to 6-12mm (¼ - ½ in.) above the top of the separators, at a temperature of 16° - 32°C (60° - 90°F), with pure sulphuric acid of standard B.S.3031 and a specific gravity of:
   (a) Temperate climates. 1260 S.G.
   (b) Tropical climates 1220 S.G.
4. Allow the battery to soak for 30 minutes, then adjust the acid level (see para. 3 above).
5. **ANY FURTHER TOPPING UP SHOULD BE CARRIED OUT WITH CLEAN DISTILLED WATER ONLY.**

COMMISSIONING CHARGE

1. Commence commissioning charge ideally 1 hour after filling with acid, (but not less then 30 minutes and not more than 8 hours).
2. Charge at the bench charge rate (see battery manufacturers catalogue). If it is not possible to charge at the bench charge rate then charge for a longer period of time at a lower current to achieve the same ampere hour input.
3. Ensure that the battery temperature does not rise above 43°C (110°F).
4. Ensure that the vents are in position during charging.
5. Check the levels and top up with **DISTILLED WATER** (if necessary) and replace vents.

FITTING WITHOUT CHARGE

1. It is not recommended but if it is essential that the battery be fitted without a commissioning charge, the specific gravity fall in all cells should be less than 30 points, that is with a normal specific gravity of 1260, the minimum acceptable hydrometer reading would be 1230.
2. The engine to which the battery has been fitted must be run immediately for approximately 1 hour to ensure adequate charging of the battery.

Fitting the Batteries to Engines

1. Check that the batteries are fully charged and have correct acid levels, ensure the vents are firmly in position and that the batteries are dry and clean.
2. **CHECK THAT THE TERMINAL POLARITIES ARE CORRECT,** as even momentary reversal of connections can cause damage to the engine electrical system.
3. When the batteries are mounted in a tray or frame, tighten the battery clamp(s) or holding down bolts firmly, but be careful not to overtighten.
4. Connect the battery cables on to the battery terminals, ensuring that the earth lead is connected last. Cover connectors and terminals with petroleum jelly and replace any protective covers.
5. On 24 Volt systems connect the two 12 Volt batteries as shown below.

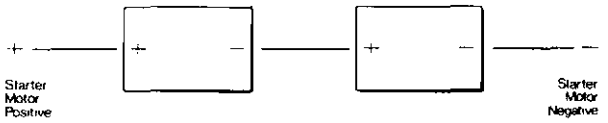


Fig. 155e Series Connection for Batteries.

SAFETY PRECAUTIONS

1. Do not smoke near the batteries.
2. Keep sparks and flames away from the batteries.
3. Batteries contain sulphuric acid — if the skin or eyes have been splashed flush with water.
4. Keep the top of the battery well ventilated when charging.
5. Disconnect earth lead first and re-connect last.
6. Switch off charge before disonnecting any charge leads.
7. Never 'flash' connections to check current flow.
8. Never experiment with adjustments or repairs to the system.
9. Never use a damaged battery.
10. KEEP CHILDREN WELL AWAY FROM THE ENGINE.

FLYWHEEL

1 Flywheel Assembly Comprises
2 *Flywheel*
3 Gear Ring
4 Rotor

STATOR

5 Adaptor
6 Setscrew—M8 x 1.25-6g x 25mm
7 Spring Washer
8 Stator
9 *Cheese Head—Screw—0.19"UNF x 1 3/4"*
10 Spring Washer
11 Stator Cable—Strap
12 Taptite Screw

RECTIFIER & REGULATOR

13 Rectifier & Regulator Cover
14 Stud
15 Nut
16 *Spring Washer*
17 Plain Washer
18 Rectifier & Regulator
19 Brass Terminal Bolt—0.19"UNC x 1/2"
20 Spring Washer
21 Plain Washer
22 Terminal

KEY SWITCH

1 Keyswitch
2 Connector
3 Cover
4 Connector
5 Cover

BATTERY CHARGE INDICATOR

— Battery Charge Indicator Assembly Comprises
6 Battery Charge Indicator
7 Lamp Holder
8 Connector
9 Cover
10 Connector
11 Cover
12 *Cable*
13 Lens
14 Bulb—12v 100mA

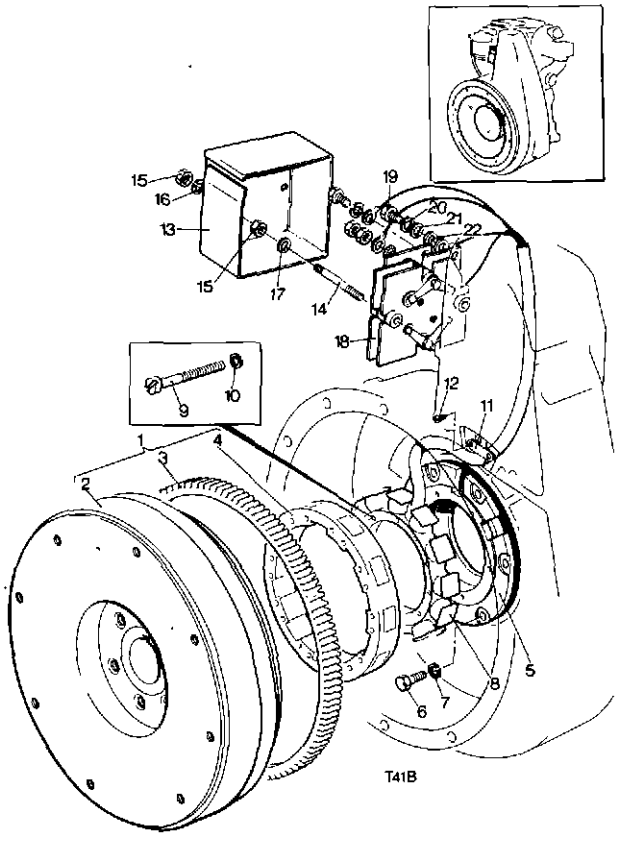


Fig. 156 Flywheel, Stator Rectifier and Regulator

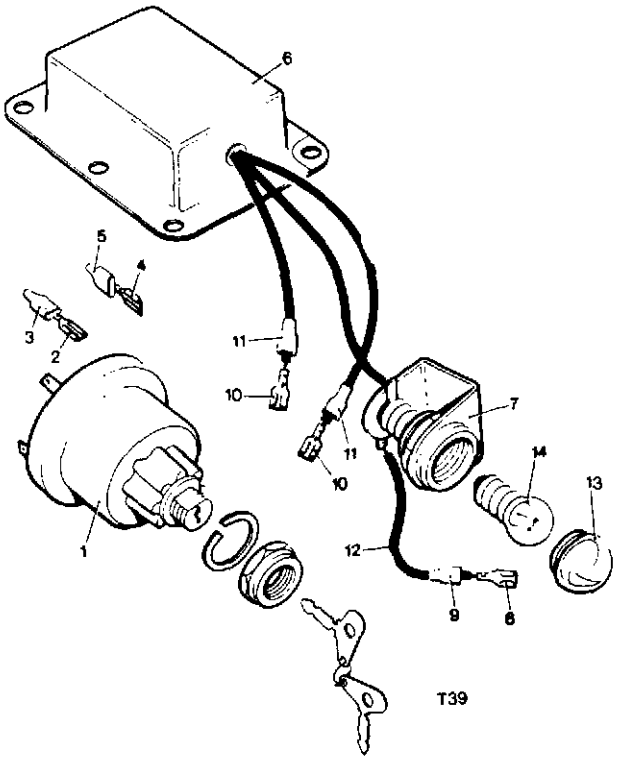


Fig. 157 Key Switch, Battery Charge Indicator and Lamp

STARTER CONTROL PANEL

Starter Control Panel
Assembly Comprises

1	Control Panel
—	Battery Charge Indicator & Lampholder Assembly Comprises
2	Battery Charge Indicator
3	Lamp Holder
4	Connector
5	Insulating Cover
6	Cable
7	Connector
8	Insulating Cover
9	Key Switch
10	Helvin Button
11	Terminal Block
12	Screw
13	Nut
14	Washer
15	Spring Washer
16	Screw
17	Spring Washer
18	Nut
19	Washer
20	Nameplate
21	Self Tapping Screw
22	Label
23	Label
24	Lens
25	Bulb—12v x 100mA
26	Screw—2BA x 3/8''
27	Plated Nut—2BA
28	Rear Cover
29	Terminal
30	Connector
31	Insulation Cover
32	Insulation Cover
33	Connector

Supplied Loose

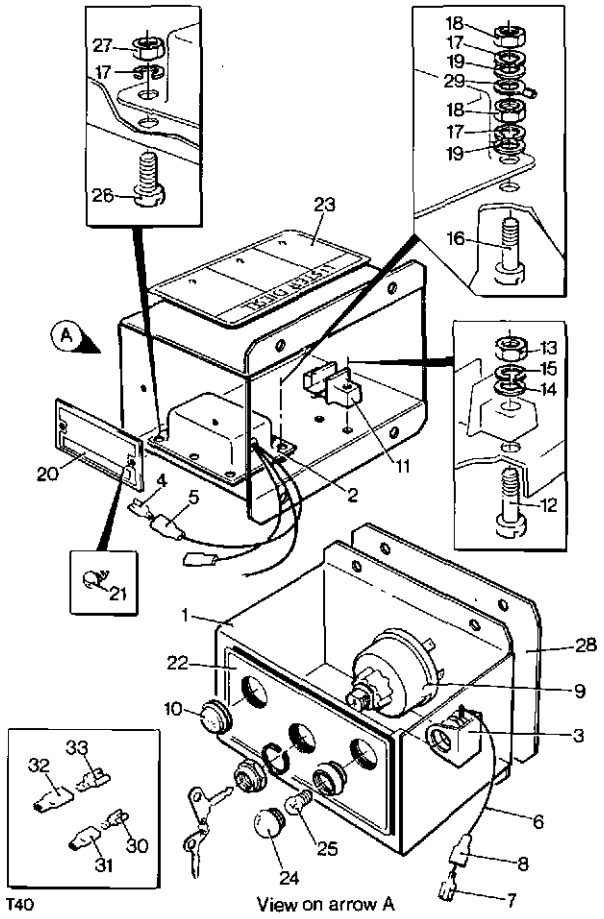


Fig. 158 Starter Control Panel

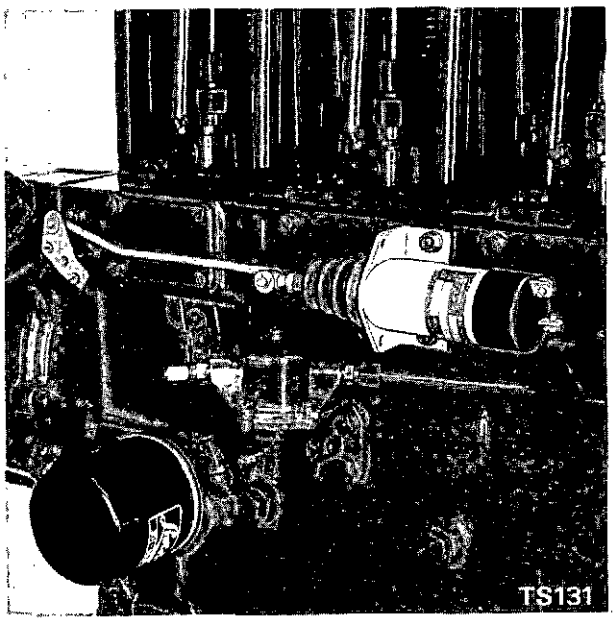


Fig. 159 Fuel Control Solenoid (energised to run)

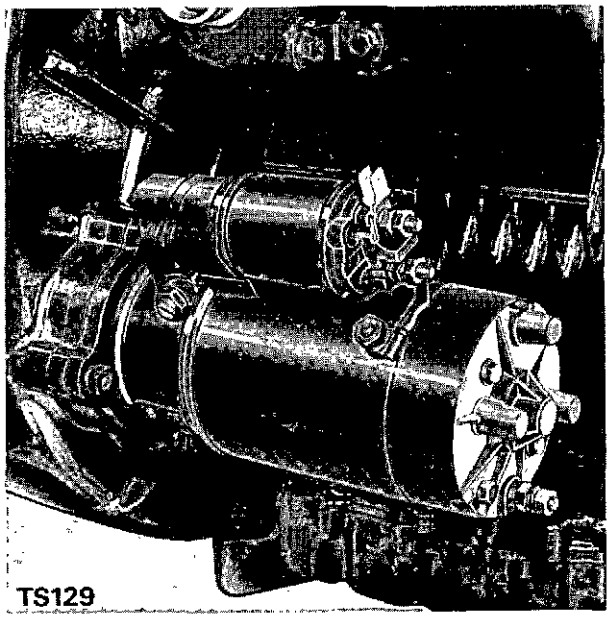


Fig. 161 12V Starter Motor

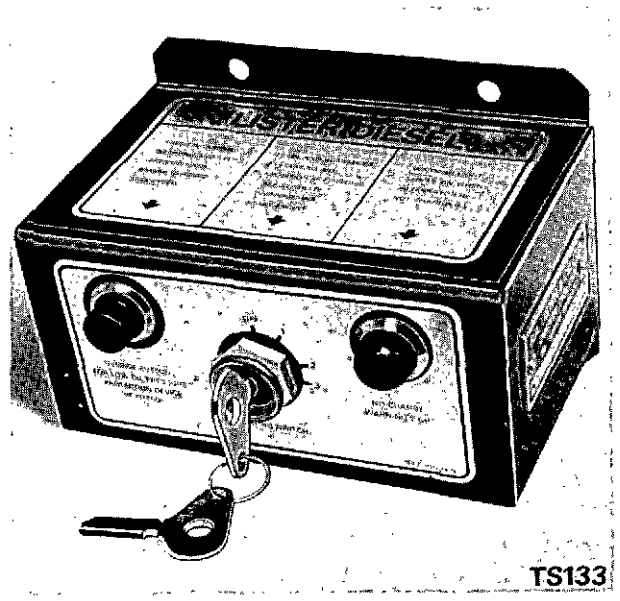


Fig. 160 Key Switch

KEYSWITCH

The keyswitch is contained in a box together with a press button and warning light. The starter switch has four selections — 'Off' and position '1' are positive selections, whilst positions '2' and '3' are spring loaded back to position '1'. The selections are as follows:—

'Off'' — Electrical isolation.

'1' — Activates warning light which will come on when alternator is not charging.

'2' — Activates starting aid (not used).

'3' — *Start engine.*

Note: when the engine has been stopped the warning light will stay on until the keyswitch is selected to the 'Off' position.

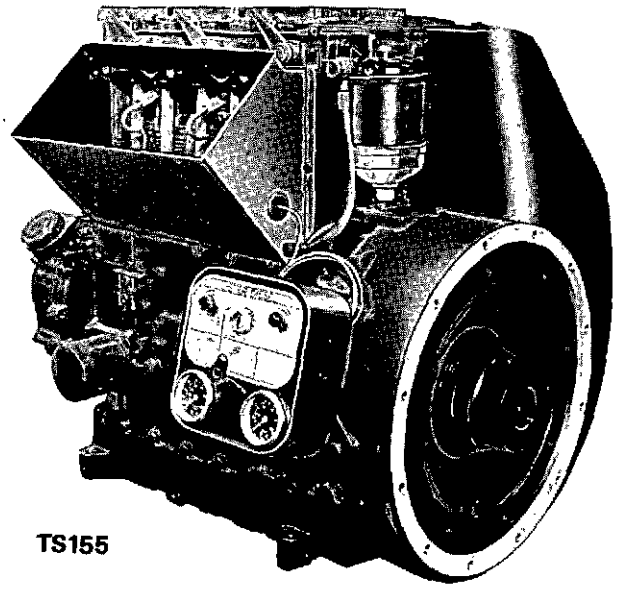
The override button is pressed on 'start up' to override the low oil pressure protection device (if fitted). Release the button when the engine is 'on speed'.

Power Absorbed by Flywheel Mounted Charging Alternators

1. The alternator has a 17 amp capacity, and charging at 1 amp or less absorbs:-
   0.3 hp at 2500 r/min or lower speeds.
   0.6 hp at 3000 r/min

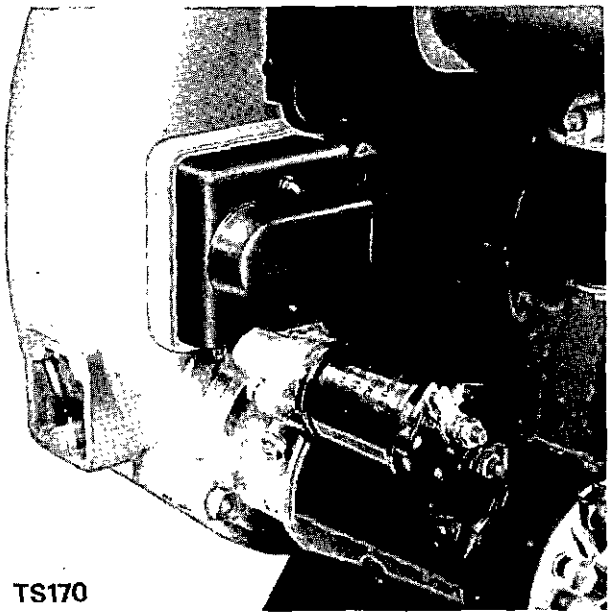
2. When the alternator is charging at more than 1 amp, an additional deduction in power is to be made at the rate of 0.1 hp per 50 watts electrical load.

3. Example:-
   TS engine, running at 3000 r/min and charging at 6 amps:-
   Base power absorbed at 1 amp = 0.6 hp (see para 1)
   Power absorbed for remaining 5 amps
   0.1 x 5 amps x 12 volts/50 = 0.12 hp
   Total power to be deducted = 0.72 hp



TS155

Fig. 160a Electric Start Panel plus two gauges (Also see agglometer)



TS170

Fig. 160b Rectifier casing as fitted to later engines.

APPENDIX A
TS2/3 BUILDS

BUILDS *Minimum permissible full load speed 1500 rev/min

BUILD No. 01
General purpose model-close coupled with hand starting, variable speed governor.
Fuel pumps set to 'No Overload'
Governor set at 2500 rev/min
Governor range 1300-1949* (outside 10% governing limits)
To BS5514 1950-3000 (within 10% governing limits)

BUILD No. 02
General purpose model-close coupled with hand starting, variable speed governor.
Charge windings in the flywheel. Fuel pumps set to 'No Overload'.
Governor set to 2500 rev/min
Governor range 1300-1949* (outside 10% governing limits)
To BS5514 1950-3000 (within 10% governing limits)

BUILD No. 03
General purpose model-close coupled with hand starting, variable speed governor.
High speed flywheel. Fuel pumps set to 'No Overload'.
Governor set to 3000 rev/min.
Governor range 1300-1949* (outside 10% governing limits)
To BS5514 1950-3000 (within 10% governing limits)

BUILD No. 04
General purpose model-close couplied with hand starting, variable speed governor.
High speed flywheel. Charge windings in flywheel. Fuel pump set to 'No Overload'.
Governor set to 3000 rev/min.
Governor range 1300-1949* (outside 10% governing limits)
To BS5514 1950-3000 (within 10% governing limits)

BUILD No. 05
Full power hydraulic take-off from end cover.
Electric starting, variable speed governor.
Governor set to 2500 rev/min.
Governor range 1300-1949* (outside 10% governing limits)
To BS5514 1950-3000 (inside 10% governing limits)

BUILD No. 06
Hydraulic pump drive model-close coupled with hand starting, variable speed governor. End cover to suit hydraulic pump.
Governor set to 2500 rev/min.
Governor range 1300-1949* (outside 10% governing limits)
To BS5514 1950-3000 (inside 10% governing limits)

BUILD No. 07
Hydraulic pump drive model-close coupled with hand starting, variable speed governor. End cover to suit hydraulic pump. Charge windings in the flywheel.
Governor set to 2500 rev/min.
Governor range 1300-1949* (outside 10% governing limits)
To BS5514 1950-3000 (inside 10% governing limits)

BUILDS — Contd. *Minimum permissible full load speed 1500 rev/min

BUILD No. 08
50 Hz Gen Set build-close couplied with hand starting. TS2 fitted with heavy fan.
Class A1 governing.
Governor set to 1500 rev/min
Governor range to BS5514 1400-1800* (within 5% governing limits)

BUILD No. 09
50 Hz Gen. Set build-close coupled with hand starting. TS2 fitted with heavy fan.
Charge windings in the flywheel. Class A1 governing.
Governor set to 1500 rev/min.
Governor range to BS5514 1400-1800* (within 5% governing limits).

BUILD No.10
60 Hz Gen. Set build-close coupled with hand starting. Class A1 governing.
Governor set to 1800 rev/min.
Governor range to BS5514 1700-1800* (within 5% governing limits).

BUILD No. 11
60 Hz Gen. Set build-close coupled with hand starting. Charge windings in the flywheel. Class A1 governing.
Governor set to 1800 rev/min.
Governor range to BS5514 1700-1800* (within 5% governing limits).

BUILD No. 12
50 Hz Gen. Set build-close coupled with hand starting. High speed flywheel. Class A1 governing.
Governor set to 3000 rev/min.
Governor range to BS5514 2050-3000 (within 5% governing limits)

BUILD No. 13
50 Hz Gen. Set build-close coupled with hand starting. High speed flywheel. Charge windings in the flywheel. Class A1 governing.
Governor set at 3000 rev/min.
Governor range to BS5514 2050-3000 (within 5% governing limits)

APPENDIX B
TS2/3 ACCESSORIES

CODE	DESCRIPTION	TS2	TS3
	A. AIR CLEANERS		
AA	Medium duty—Dry Type	★	★
AB	—*Foam element*	★	★
AC	Heavy duty—5 1/4" (133mm)	★	—
AD	—6 1/2" (165mm) (Above 1800 rev/min TS2)	★	★
AE	—Gear end mounted (includes Pre-cleaner) Requires AX	★	★
AF	—5 1/4" (133mm)—Loose c/w 1m hose and	★	—
AG	—6 1/2" (165mm)—Loose engine adaptor	★	★
AI	*Medium duty—Gear end mounted*	★	★
	Adaptor for remote air cleaner		
AO	—Spigot dia. 1 7/8" (47.6mm)	★	—
AP	—Spigot dia. 2 1/4" (57.1mm)	★	★
AR	*Inlet manifold adaptor*—Use with AX	★	★
AX	Inlet manifold—with gear end inlet	★	★
AY	—with gear end inlet and tapped boss	★	★
AZ	—with tapped boss	★	★
	B. DRIVES		
	Flywheel End		
BA	Shaft extension—40mm (1.57") dia	★	★
BC	—Unmachined 50mm (2")	★	★
BE	*Overcentre clutch PTO* —7 1/2" (190mm) to SAE J621d—SAE4	★	★
BG	Automotive clutch PTO—8" (203mm)—SAE5	★	—
BH	—9" (229mm)—SAE4	★	★
BJ	*Reduction gear*—2:1	★	★
BK	—3:1	★	★
	Fenner HRC Coupling		
BL	—Undrilled	★	★
BM	—Without taper lock bush—with reverse taper	★	★
BO	—Less taper lock bush	★	★
BP	—32mm (1.25")	★	★
BQ	—35mm (1.38") *Supplied with*	★	★
BR	—38mm (1.50") taper lock bush	★	★
BS	—42mm (1.65")	★	★
BT	—48mm (1.89")—Bored and keyed no taper lock	★	★
	Gear End		
BW*	Shaft extension—40mm (1.57") dia	★	★

* Accessories not available in "Loose" form or for fitting by customers

CODE	DESCRIPTION	TS2	TS3
	C. CLOSE COUPLING ADAPTORS		
CA	Adaptor—SAE4/5—(51mm wide) (2") wide	★	★
CB	—SAE4/4—(51mm wide) (2") wide	★	★
CC	—SAE4/4—(80mm wide) (3.15") wide	★	★
CE	—Multi purpose unmachined	★	★
	Automotive clutch Fittings (use with CA or CB)		
CH	—for 8" (203mm) dia. clutch plate	★	—
CI	—for 9" (229mm) dia. clutch plate	★	★
	Overcentre Clutch drive members		
CL	—For 7 1/2" (190mm) Overcentre Anderton } Use with	★	★
CN	—For 7 1/2" (190mm) Overcentre Twin Disc } CA/CB	★	★
	D. COOLING SYSTEMS		
DA	Air duct adaptor—Outlet at 45°	★	★
	E. STARTING SYSTEMS		
EA	Starting handle—Standard	★	—
EB	—Long grip	★	★
EC	—Gear end hydraulics	★	—
ED	—Long grip gear end hydraulics	★	★
EE†	—Gear end hydraulic	★	—
EF†	—Long grip gear end hydraulics	★	★
EJ	Coupled decompressors	★	★
EK	Starter motor—12V } Pre-engaged with spacer	★	★
EL	—24V } Pre-engaged with spacer	★	★
EM	Starter motor distance piece—12.75mm (0.5")—Lucas	★	★
EN	—30.5mm (1.2")—Delco	★	★
EP	A115/36 Alternator (Build 05 only)	★	★
EU	Cold start aids—Oil cups	★	★
EV	—Ether start (use with AY/AZ)	★	★
EW*	—Lubricating oil sump heater	★	★
	F. FUEL SUPPLY EQUIPMENT		
FB	Fuel Tank—Engine mounted—13.5 litre	★	★
FD	—Loose —25 litre	★	★
FE	Fuel lift pump	★	★
FF	Fuel Agglomerator	★	★
FG	Self venting fuel system to suit std filter	★	★
FH	Steel fuel pipes	★	★
	G. GUARDS		
GC	Alternator drive guard for EP (Build 05 only)	★	★

* Accessories not available in "Loose" form or for fitting by customers.

† Supplied in kit form for customer assembly.

CODE	DESCRIPTION		TS2	TS3
	H. HYDRAULIC PUMP ADAPTORS			
	Gear End			
	Adaptor for			
HA	—Pump 2P3000 (4 bolt)	Build 05 only	★	★
HB	—Pump 2P3000 (2 bolt)	Build 05 only	★	★
HC	—Pump 1P3000 (4 bolt)	Build 05 only	★	★
HD	—Pilot bored	Build 05 only	★	★
HF	—Pump 1P3000 (4 bolt)		★	★
HG	—Pump 2P3000 (4 bolt)		★	★
	Adaptor for			
HH	—Dowty 1P3000 4 bolt flange and tapershaft drive		★	★
HJ	—SAE A 2 bolt flange and parallel shaft drive		★	★
HK	—Dowty 2P3000 4 bolt flange and tapershaft drive		★	★
HL	—SAE B 2 bolt flange and parallel shaft drive		★	★
HM	—Pilot bored adaptor and coupling		★	★
	J. PROTECTION DEVICES AND SOLENOIDS			
JB	Sensor—Cylinder head temperature (not with FB)		★	★
JC	—Cooling air temperature		★	★
JD	—Low lubricating oil pressure		★	★
	Solenoid			
JE	—12V (energised to run)		★	★
JF	—12V to allow for 2 speed control		★	★
JH	—24V (energised to run)		★	★
	K. CONTROLS			
KA	Variable speed control—Cable and lever		★	★
KB	—Engine mounted		★	★
KC	Variable speed control adaptor less cable and lever		★	★
KD	Remote stop control—cable and lever		★	★
KE*	Linkage for electronic governor pick up			
	—(Governor not supplied by RAL)		★	★
	L. LUBRICATION EQUIPMENT			
LA*	Long running system (see below)		★	★
LB	Remote location of oil filter		★	★
LC	Extended oil filler and dipstick		★	★
LG	Oil pressure distribution block—Flexible fuel pipe		★	★
LH*	Long running equipment—wet sump—use with LJ/EW		★	★
LJ*	Long running—wet sump		★	★

NB If JB, JC and/or JD needs wiring to WA; WC or WD must be called for.
LA is supplied with all connections, but not with tank or piping.

*Accessories not available in "loose" form or for fitting by customer.

CODE	DESCRIPTION	TS2	TS3
	F. EXHAUST EQUIPMENT		
NA	Silencer—Standard	★	★
NB	—Heavy duty engine mounted (only with AX, AI, AY)	★	★
NC	—Heavy duty remote fitted	★	★
ND	Spark arrestor (use with NC)	★	★
NE	Flexible exhaust pipe—1m long	★	★
NF	Exhaust flange—1 1/2" BSP connection	★	★
NG	Manifold adaptor for vertical discharge	★	★
NH	Exhaust silencer bend—90°	★	★
NJ	Forward sweep exhaust bend	★	★
	P. GAUGES		
PA**	Panel and mounting—for 2 gauge } Less	★	★
PB**	—for 3 gauge } gauges	★	★
PC	Gauge—12V ammeter	★	★
PE	—Oil pressure } requires	★	★
PF	—Air temperature } PA, PB, PH, WA	★	★
PG	—Running hour recorder—12V/24V }	★	★
PH**	Electrical Tachometer and panel		
	—with provision for 2 additional gauges	★	★
PK	Running hour recorder—vibration	★	★
	Q. MOUNTINGS		
QA	Holding down bolts	★	★
	R. RECOMMENDED SPARES		
	Refer to Parts & Service		
	S. SUNDRIES		
SA	Paint finish—Primer	★	★
SB	—Lister Green	★	★
SD	Transfers: English, French, Norwegian, Spanish, Italian, Dutch, German, Portuguese	★	★
	Parts Book: English only	★	★
SE	Manuals: Operators Handbook: English, French, Spanish	★	★
SF	Manuals: Workshop maintenance	★	★
SG	Packing—Road base	★	★
SH	—Export (not available UK customers)	★	★
SJ	Tool kit	★	★
SK	Packing—Export skid base	★	★
	W. WIRING LOOMS AND LOOSE ELECTRICAL ACCESSORIES		
WA	Electric start panel —12V engine mounted and wired to starter/regulator with provision for 2 additional gauges (see PC to PG incl)	★	★
WC	Wiring loom—For cylinder head temp and oil pressure switches	★	★
WD	—For cooling air temp and oil pressure switches	★	★
	LOOSE ELECTRICAL ACCESSORIES		
WK	Starter Keyswitch	★	★
WL	Battery Charge indicator	★	★
WM	Remote electric start panel—12V	★	★
WN	Charge indicator for EP (Build 05 only)	★	★
WO	Battery leads		

**Customer to specify which gauge/s from options PC to PG incl. are required.

APPENDIX C
ENGINE STRIP AND REBUILD SEQUENCE

This appendix is included purely as an aide memoire and is in no way intended as an instruction.

DISMANTLING AND ASSEMBLY INSTRUCTIONS FOR TS ENGINES

Drain all fuel and oil from the engine and disconnect all services. Remove air filter, silencer and fuel tank (if fitted).

1. Remove the bolts from the lifting eye and lift it off (see Page 54).
2. Remove the cylinder head covers (see Page 58).
3. Slacken both ends of the fuel pipes from the pumps to the injectors and remove the pipes (see Page 35).
4. Remove the injector clamp (see Page 38).
5. Remove the injector and leak off pipes. Note that a washer is fitted over the nozzle of each injector (see Page 38).
6. Remove the inlet and exhaust manifolds and the two gaskets (see Page 55).
7. Unscrew and remove the cold start pots, if these are fitted (see 19 & 92).
8. Ensure the fuel pipe from the filter to the pumps is removed (see Page 32). Remove fuel lift pump if fitted. (See Page 93).
9. Remove the fuel filter if engine mounted (see Page 57).
10. Remove the gear end side shield, the air cowling and the flywheel end side shield (see Page 57).
11. Remove the valve rocker oil feed pipe and unions from the crankcase and cylinder heads (see Page 28).
12. Remove the four cylinder head nuts from No. 1 cylinder (see Page 60).
13. Lift off the cylinder head and place it on its side on a bench. Remove the gasket and shims if these have remained on the top of the cylinder barrel (see Page 60).
14. Remove the push rods and tubes. (see Page 61).
15. Fit a retaining tube over one cylinder head stud and secure it with a hand tight nut. This will prevent the cylinder from rising if the crankshaft is turned. (see Page 60).
16. Repeat Nos. 12-15 for No. 2/3 cylinder. Remove air baffles. (See Page 57).
17. After removing plastic cap in the end cover turn the crankshaft until the locking pin of the starter dowel is visible through the hole in the end cover. Use a suitable drift to tap the pin out. (see Page 66).
18. Drift out the starting handle dowel (see Page 67).
19. Fit the special tool and remove the end cover (see Page 67 & 104).
20. Remove the thrust washer and shim from the camshaft (see Page 66).
21. Remove all fuel pump inspection doors. (see Page 69).
22. Disconnect the governor link from all fuel pump racks. (see Page 69).
23. Remove the two fulcrum pins from the governor lever assembly pivot supports. Retain the loose spring and shims. (see Page 69).
24. Using long nosed pliers, remove the speeder spring from its control. (see Page 34).
25. Remove the governor lever assembly complete. (see Page 68).
26. Remove the governor sleeve assembly from the camshaft. (see Page 69).
27. Remove the fuel pumps taking care to retain the shims with the correct pump (see Page 35).
28. Remove the fuel pump tappet and cap using long nosed pliers. (see Page 70).
29. Remove the fuel pump tappet guide locating bolts from the side of the crankcase. (see Page 70).
30. Remove the fuel pump tappet guide noting which way it is fitted. (see Page 71).
31. Remove the oil dipstick. (see Page 24).
32. Stand the engine on its flywheel using a suitable piece of timber between the recessed flywheel and the plinth.
33. Remove the sump. (see Page 26).
34. Remove the oil pump and oil pump push rod. (see Page 26).
35. If necessary dismantle the oil pump. (see Page 27).
36. Ensure the push rod cam followers are at their highest positions to clear the camshaft.
37. Keeping the camshaft square gently ease it out of the crankcase. (see Page 71).
38. Rotate the crankcase until No. 1 piston is at BDC.
39. Remove No. 1 connecting rod bearing cap. (see Page 75).
40. Rotate the crankcase until No. 1 piston is at TDC.

41. Remove the retaining tube and gently lift off the cylinder barrel, piston and connecting rod as one unit. (see Page 75).
42. Replace the bearing cap on to the connecting rod.
43. Repeat items 38-42 for No. 2/3 cylinder.
44. Remove the Allen screws and crankshaft balance weights (see Page 75).
45. Remove the cam followers. (see Page 73).
46. Replace the sump holding it with four bolts (one on each side).
47. Turn the engine to its normal position.
48. Unscrew the flywheel retaining bolt two turns using a 65mm socket. (see Page 77).
49. Use the special tool and break the tapered seal between the flywheel and the crankshaft, in an emergency tap the flywheel retaining bolt with a copper hammer. (see Page 104).
50. Use a crane if available and with the hook in one of the flywheel fins just take the strain.
51. Remove the flywheel retaining bolt and fit mandrel in its place. (see Page 105).
52. Keeping the flywheel square ease the flywheel out from the housing and place it in a safe position.
53. Remove the rectifier cover. (see Page 78).
54. Mark the four rectifier cables for identification and remove them from their respective positions. (see Page 78 & 116).
55. Remove the rectifier from the flywheel housing. (see Page 78).
56. Remove the cable clip from inside the housing.
57. Remove the stator gently easing the cable through the housing as this is being done. (see Page 78).
58. Remove the fanshroud. (see Page 79).
59. Use a brass drift to remove the flywheel key.
60. Remove the intermediate bearing retaining bolts from the side of the crankcase. (see Page 81).
61. Remove the intermediate bearing dowels by screwing a long headed fuel pump bolt into the dowel and withdrawing it. The bolt should be left in the dowel to identify the correct assembly procedure as the dowel is threaded on one end only. (see Page 81).
62. Remove the alternator adaptor plate. (see Page 79).
63. Screw two M6 bolts into the two holes in the main bearing housing to jack it off the crankshaft. (see Page 82).
64. Use the special tool to remove the crankshaft gear. (see Page 105).
65. Gently remove the crankshaft from the crankcase. (see Page 81).
66. Remove the split thrust washers from inside the crankcase at the gear end and from the main bearing housing. (see Page 83).

RE-ASSEMBLY

All spanner torques and jointing compounds are given on pages 86-88.

Replace all joints and gaskets. Spray all moving parts with oil during assembly.

1. Turn the crankcase on to its manifold side using a suitable piece of wood to support it.
2. Remove the sump (if fitted). (see Page 26).
3. Grease the steel backs of the split thrust washers and refit them into the gear end of the crankcase and the main bearing housing. (see Page 81 & 82).
4. Replace the crankshaft taking care to ensure the bearing locating dowel hole is in line with the hole in the crankcase before the bearing enters its housing. If, on final assembly, the holes are not in line use a brass drift to rotate the bearing housing. Check exact alignment by using a tapered rod. (see Page 82).
5. Replace the intermediate bearing dowel with a bolt fitted to ensure the threaded section is facing outwards. (see Page 82).
6. Refit the crankshaft balance weights in their correct order with the larger flanges (and part numbers) facing each other. (see Page 82).
7. Replace the crankshaft end float shims on to the main bearing housing and refit the housing. (see Page 81, 85 and 88).
8. Secure the housing with two bolts 180° apart.
9. Check, and adjust if necessary, the crankshaft end float. (see Page 81).
10. Remove the two bearing housing bolts.
11. Replace the alternator adaptor making sure the slot on the face is towards the top of the crankcase. (see Page 79).
12. Remove the centre bearing dowel. (see Page 81).
13. Replace the oil seal in the bearing housing. (see Page 103 if rotary oil seal).
14. Replace the centre bearing dowel and the dowel retaining bolt. (see Page 76).
15. Replace the flywheel key.
16. Check that the key is in position on the crankshaft. Heat the crankshaft pinion gear and ensure the "O" timing mark is facing outwards when the gear is refitted to the crankshaft. (see Page 82).
17. Replace the sump with four bolts (one each side). (see Page 27).
18. Turn the crankcase the correct way up.
19. Replace the fanshroud. (see Page 78).
20. Replace the stator. (see Page 78).
21. Replace the cable clip.
22. Turn the crankshaft until the flywheel key is at TDC and fit mandrel. (see Page 105).
23. Rub chalk over the flywheel timing marks to aid identification during later procedures.
24. Use a crane (if available) to replace the flywheel ensuring that it is offered up dead square. (see Page 78).
25. Remove mandrel and replace the flywheel bolt. Check that the key is still in position and turn the flywheel to check for free movement.
26. Replace the rectifier, cables and cover. The two large cutouts in the cover are towards the bottom of the rectifier. (see Page 78).
27. Stand the engine on its flywheel using a suitable piece of timber between the recessed flywheel and the plinth.
28. Remove the sump. (see Page 27).
29. Replace the push rod cam followers, a tool with a rubber suction pad (as used to grind in valves) can be used to advantage. (see Page 73).
30. Gently replace the camshaft, keeping it square at all times, and ensure that the "O" timing marks on the camshaft and crankcase gears coincide exactly with each other on final assembly. (see Page 73).
31. Replace the fuel pump tappet guides, the end with the two flats enters the crankcase first. Replace the bolt making sure a copper washer is fitted under the bolt head. (see Page 70).
32. Using the flywheel as a pivot rotate the crankcase to TDC No. 1 cylinder crankshaft throw.
33. Replace No. 1 cylinder, connecting rod and piston. (see Page 76).

34. Fit a retaining tube on to one of the cylinder studs and secure it with a hand tightened nut. (see Page 60).
35. Push down on the top of the piston as the crankcase is turned until the piston is at BDC.
36. Fit the connecting rod bearing cap. (see Page 76).
37. Rotate the crankcase to check for free movement and return to TDC No. 2 cylinder.
38. Repeat items 33-37 for No. 2/3 cylinders.
39. Replace the oil pump push rod and then the pump. (see Page 27).
40. Replace the sump ensuring oil strainer fitted correctly. (see Page 27).
41. Turn the engine the normal way up and replace the oil dipstick. (see Page 24).
42. Replace the fuel pump tappets and tappet caps. (see Page 71).
43. Refit the air baffles with the spring clip facing the manifold side. (see Page 57).
44. Replace the fuel pumps and shims, the long headed bolt is fitted nearest to the cylinder barrels. (see Page 35).
45. Replace the governor sleeve assembly with the spring ring facing outwards. It will be necessary to open the governor weights to ensure the assembly is pushed fully on to the shaft. (see Page 69).
46. Replace the governor lever assembly and both fulcrum pins. (see Page 69).
47. Measure and adjust as necessary, the end play between pivot and lever assembly. (see Page 41 'E' adjustment).
48. Connect the governor interconnecting lever to the fuel pump racks. (see Page 35).
49. Adjust the fuel pump racks. (see Page 41).
50. Reconnect the speeder spring to its control. (see Page 34).
51. Check the governor lever and rack for correct operation. (see Page 41).
52. Set the governor. (see Page 41).
53. Replace the camshaft end float shim and then the camshaft thrust washer. (see Page 66).
54. Replace the end cover using the special tool to protect the oil seal. Check camshaft end float. (see Page 67).
55. Refit the starting dowel and pin. (see Page 67).
56. Remove the retaining tube from No. 1 cylinder.
57. Replace the cylinder head and diagonally torque the nuts. (see Page 63).
58. Check cylinder head clearance. (see Page 64).
59. With the cylinder head removed, replace the push rods and tubes. A very small amount of grease added to the tube sealing rubbers will ease the fitting of the heads. (see Page 61).
60. Replace the cylinder head complete with gasket and shims making sure it is fully seated and then replace the nuts hand tight only. (see Page 63).
61. Repeat items 56-60 for No. 2/3 cylinders.
62. Replace a manifold with one nut on each cylinder head. This will ensure the heads are correctly aligned. (see Page 63).
63. Torque the cylinder head nuts. (see Page 63).
64. Remove the manifold.
65. Spill time the fuel pumps. (see Page 36).
66. Replace the side shields at the gear and flywheel ends. (see Page 57).
67. Replace the air cowling with the gaskets on the outside of the cowling. (see Page 56).
68. Replace both manifolds using the thick spacer on the top studs between both manifolds. (see Page 55).
69. Replace the valve rocker oil feed pipe to the heads and crankcase. (see Page 28).
70. Turn the engine to TDC No. 1 cylinder firing stroke and set the inlet and exhaust valve clearances. (see Page 64).
71. With the engine still at TDC No. 1 firing stroke set the decompressors. (see Page 65).
72. Repeat items 70 & 71 for No. 2/3 cylinders.
73. Check and reset (if necessary) the fuel injector settings. (see Page 39).
74. Replace the injectors and leak off pipes complete. Ensure the washer is fitted at the nozzle end. (see Page 38).
75. Replace the fuel pump to injector pipes leaving the nuts finger tight. (see Page 35).
76. Replace the injector clamp. (see Page 38).
77. Replace the fuel pump inspection doors. (see Page 69).
78. Replace the cylinder head covers. (see Page 58).
79. Replace the lifting eye. (see Page 54).
80. Refit air filter, silencer and fuel tank, reconnect services and replenish fuel and oil supplies.

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