LISTER PETTER®

YOUR CRITICAL COMPONENT







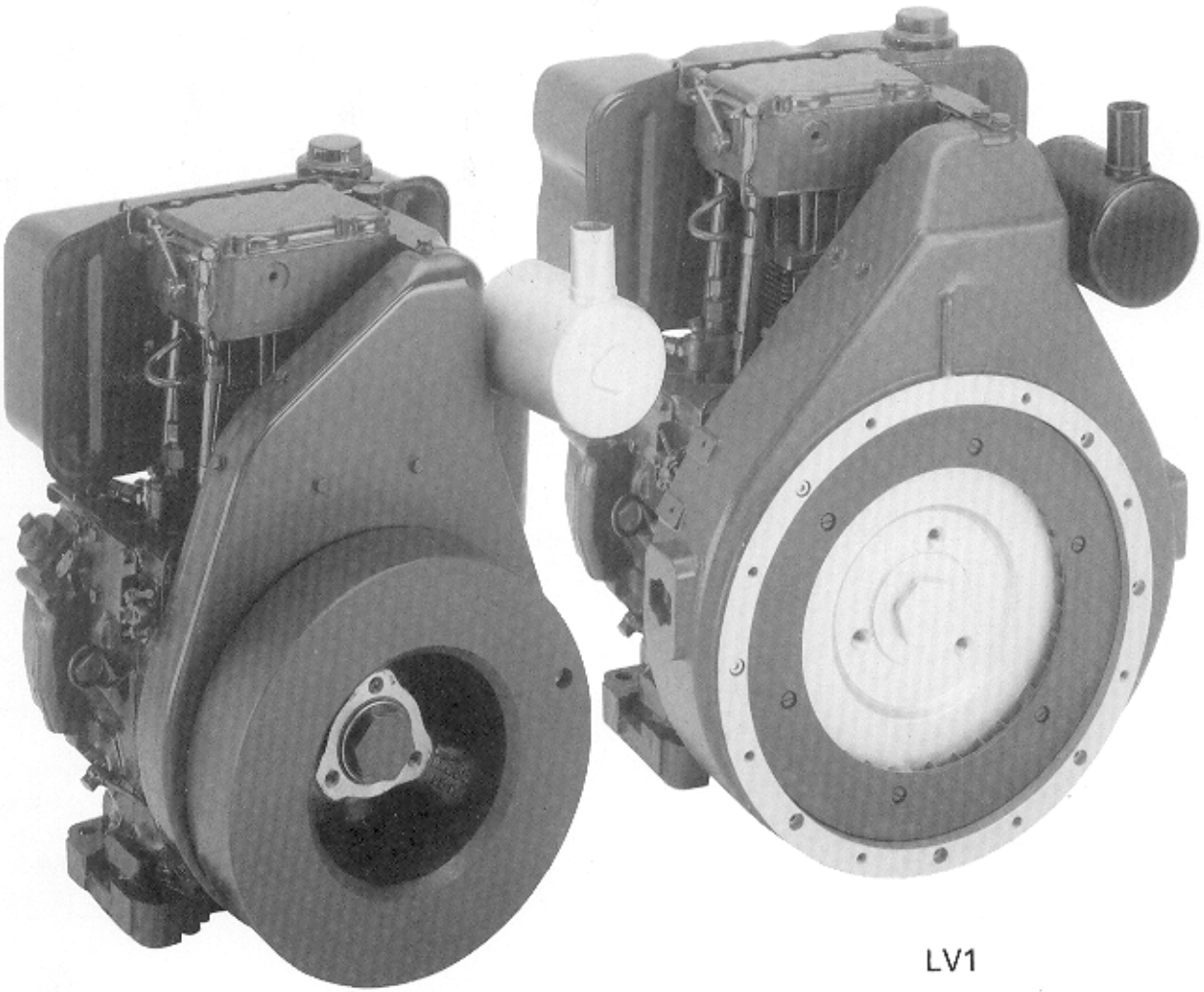
'L' Series Workshop Manual

Types: LT1, LT2, LV1 and LV2

Publication 027-09207 Edition 3

Published in August 1999 by Lister-Petter Technical Publications
Printed in the United Kingdom
Lister-Petter Limited, Dursley GL11 4HS, England

Publication 027-09207



LV1

LT1

LT and LV Workshop Manual

Introduction

The manual has been compiled in loose leaf form and when further alterations are made the individually affected pages will be up-issued and made available for insertion in the manual in place of those they supersede.

The purpose of this manual is to give information, operating, maintenance and repair procedures for one and two cylinder versions of Lister-Petter LT and LV engines.
It is designed primarily for use by qualified technicians with electrical and mechanical experience.

The specification details apply to a range of engines and not to any one particular engine, in cases of difficulty the user should consult the local, approved Diesel Centre or Distributor for further advice and technical assistance.

The information, specifications, illustrations, instructions and statements contained within this publication are given with our best intentions and are believed to be correct at the time of going to press.

Our policy is one of continued development and we reserve the right to amend any technical information with or without prior notice.

Whilst every effort is made to ensure the accuracy of the particulars contained within this publication neither the Manufacturer, Distributor or Dealer shall in any circumstances be held liable for any inaccuracy or the consequences thereof.

The information given is subject to the Company's current Conditions of Tender and Sale, and is for the assistance of users and is based upon results obtained from tests carried out at the place of manufacture. This Company does not guarantee that the same results will be obtained elsewhere under different conditions.

Parts that have not been approved by this Company cannot be relied upon for correct material, dimensions or finish. This Company cannot therefore, be responsible for any damage arising from the use of such parts. When purchasing parts or giving instructions for repairs users should, in their own interests, always specify Genuine Parts and quote the Part Number, Description of Part and the Engine Serial Number.

When a diesel engine is operating or being overhauled there are a number of associated practices which may lead to personal injury or product damage.
Your attention is drawn to the symbols shown and described below which are applied throughout this publication.

⚠ CAUTION

This caution symbol draws attention to special instructions or procedures which, if not correctly followed, may result in damage to or destruction of equipment.

⚠ WARNING

This warning symbol draws attention to special instructions or procedures which, if not strictly observed, may result in personal injury.

⚠ WARNING

A WARNING SYMBOL WITH THIS TYPE OF TEXT DRAWS ATTENTION TO SPECIAL INSTRUCTIONS OR PROCEDURES WHICH, IF NOT STRICTLY OBSERVED, MAY RESULT IN SEVERE PERSONAL INJURY, OR LOSS OF LIFE.

Note.
A note is used to draw your attention to additional or important information.

Manual Contents

SECTION 1 - GENERAL INFORMATION 5

SECTION 2 - THE BASIC ENGINE 23

SECTION 3 - THE LUBRICATION SYSTEM 67

SECTION 4 - THE FUEL SYSTEM 75

SECTION 5 - THE GOVERNOR 89

SECTION 6 - THE ELECTRICAL SYSTEM 97

SECTION 7 - CONVERSION FACTORS AND FORMULAE 115

INDEX 121

PAGE ISSUE RECORD 125

Section 1 - General Information

Contents

Safety Precautions 6
ISO 8999 Symbols 8
Builds - LT 9
Builds - LV 10
Technical Data 11
Operating Instructions 12
Routine Maintenance 15
Routine Maintenance Periods 16
Starting and Running Faults 16
Injector Faults 18
Jointing Compounds 19
Routine Maintenance Parts 20
Service Tools 21
Spanner Torques 22

SAFETY PRECAUTIONS

The following safety precautions are of a general nature more specific precautions appear where they are relevant.

General Precautions

⚠ CAUTION

Some engines may be fitted with seals or 'O' rings manufactured from VITON or a similar material.
When exposed to abnormally high temperatures, in excess of 400°C (752°F), an extremely corrosive acid is produced which cannot be removed from the skin.
If signs of decomposition are evident, or if in doubt, always wear disposable heavy duty gloves.

⚠ WARNING

Some components on the engine and transmission, such as gaskets and clutch discs or brake bands, may contain asbestos.

- Ensure the engine is securely mounted.
- Ensure that there is a generous supply of cooling and combustion air available.
- Keep the engine and surrounding area clean.
- Keep all safety guards in position.
- Keep the body and clothing clear of all moving or hot parts.
- Never allow any part of the body to come into contact with high pressure fuel oil; for example when testing fuel injection equipment.
- Thoroughly clean any lubricating oil or fuel from the skin as soon as is practicable after contact.
- Rectify all fuel and oil leaks as soon as is practicable and clean any spillages when they occur.
- Engine lifting points are designed to lift the engine only and must never be used to lift the complete plant.
- Isolate the battery before commencing any work on the engine.

Battery and Charging Precautions

⚠ WARNING

Batteries contain sulphuric acid which can cause severe burns and produce explosive gasses.
If the acid has been splashed on the skin, eyes or clothes flush with copious amounts of fresh water and seek immediate medical aid.

⚠ CAUTION

When charging the starter battery by means of an external source the charge winding regulator/rectifier must be disconnected from the starter battery.
Failure to do this will result in discharge of the starter battery and damage to the regulator/rectifier.

- Do not smoke near the battery.
- Keep sparks and flames away from the battery.
- Keep the top of the battery well ventilated during external charging.
- When removing or fitting a battery disconnect the earth lead first and reconnect it last.
- Switch off the battery charger before disconnecting the charge leads.
- Never 'flash' connections to check current flow.
- Never use a damaged or unserviceable battery.
- Keep children and animals well away from all batteries.
- Never remove any electrical cable while the battery is connected in the circuit.
- Only disconnect the battery with the engine stopped and with all switches in the off position.
- Always ensure that cables are fitted to their correct terminals.
  A short circuit or reversal of polarity will ruin diodes, transistors and the regulator.
- Never connect a battery into the system without checking that the voltage and polarity are correct.
- Never experiment with any adjustments or repairs to the system.
- The battery and charging system must be disconnected before commencing any electric welding when a pole strap is directly or indirectly connected to the engine.
- To prevent irreparable damage to the charge winding rectifier/regulator unit never attempt to start the engine when the system has been disconnected from the battery.

Precautions for Filters and Elements

- The materials used in the manufacture and treatment of some filters and elements may cause irritation or discomfort if they come into contact with the eyes or mouth and they may give off toxic gasses if they are burnt.
- Used liquid filters and elements contain some of the filtered liquid and should be handled and disposed of with care.
- After handling new or used elements the users hands should be thoroughly washed, particularly before eating.

⚠ WARNING

Prolonged or repeated contact with diesel fuel and used engine oil may cause serious skin disorders.
Apply a good quality barrier cream to the hands and forearms and wash hands and arms thoroughly on completion of the work or before eating.

Fuel System Precautions

- 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 union has been disturbed.
- 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 of the pump calibration marks.
- When refitting the fuel pipe from the pump to injector the connection to the injector must be tightened before the connection to the fuel pump.
- 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 the engine work period.

Starting Precautions

Starting any diesel engine can be dangerous in the hands of inexperienced people. Instructions for starting and stopping the engine can be found in the Operators Handbook.

Before attempting to start any engine the operator should:

- Read the Operators Handbook.
- Understand and have been instructed in the use of the engine controls and their functions.
- Be conversant with, and understand the correct starting procedure.
- Ensure the engine is free to turn without obstruction.
- Maintain an adequate supply of combustion and cooling air.
- Ensure the air cleaner is firmly attached.
- Check that the fuel and lubricating oil levels are correct and correctly primed.
- Check the electric start battery, if fitted, is correctly connected and fully charged.

When hand starting:

- Ensure the correct starting handle which has been designed for the engine is used.
- Always clean and lightly oil that part of the handle which fits onto the engine before attempting to start the engine.
- Hold the handle firmly with the thumb *on top of the grip and not around it.*
- After fitting the handle, and before attempting to start the engine, check that it does not bind on the starting dog.

⚠ WARNING

When the engine is firing it is dangerous to allow the handle to rotate on the running shaft.

Safety Symbols

This section identifies the ISO 8999 symbols currently used by Lister-Petter.

Stop control (on engine)

Rotational speed control

Diesel fuel fill

Engine oil fill

Linear speed control

Anti-clockwise rotation

Clockwise rotation

Engine oil level

Lifting eye - engine only

Rotational speed control

Electrical hazards

General hot surface warning

Read the handbook

Elapsed hours

Tachometer

Oil pressure

On

Off

Battery charging condition

Engine cranking

Pre-heat

BUILDS

Where the build number is preceded by a 9 this indicates that the engine is either of a non-standard configuration, or contains non-standard parts or accessories.

When new parts are required for such a build it is suggested that reference be made to Lister-Petter to determine the exact engine specification and which parts are non-standard.

LT1 Builds

Build	Speed	Speed Set r/min	Governor Range r/min	Rotation
01	Variable	2500	1000-2500	
02	Variable	1000	1000-1600	
03	Variable	3000	1000-3000	
04	Variable	1500	1000-1600	
05	Fixed	3000	2400-3000	
06	Fixed	3000	2400-3000	
07	Variable	3000	1000-3000	
08	Fixed	3600	2400-3600	
09	Variable	3000	1000-3000	Clockwise
10	Variable	1000	1000-1500	Clockwise
11	Variable	1500	1000-1500	Clockwise
12	Constant	3000	3000	Clockwise
13	Variable	3000	1000-3000	Clockwise
14	Variable	3000	1000-3000	Clockwise
15	Constant	3600	3600	Clockwise
17	Variable	3000	1000-3000	Clockwise
18	Constant	3600	3600	Anti-clockwise
19	Variable	3000	1000-3000	Anti-clockwise
20	Variable	1500	1000-1500	Clockwise
23	Variable	2000	1000-3000	Anti-clockwise
25	Variable	3000	1000-3000	Anti-clockwise
26	Variable	2000	1000-3000	Anti-clockwise
30	Variable	2200	1000-3000	Anti-clockwise
31	Variable	3000	1000-3600	Clockwise
32	Constant	1000	1000-1500	Clockwise

LV1 Builds

Build	Speed	12v Charge Windings	Speed Set r/min	Governor Range r/min	Starting	Rotation
01	Variable	No	2000	1000-3000	Hand	Anti-clockwise
02	Variable	No	3000	1000-3000	Hand	Anti-clockwise
03	Variable	Yes	3000	1000-3000	Electric	Anti-clockwise
04	Constant	No	3600	3600	Electric	Anti-clockwise
05	Constant	Yes	3600	3600	Electric	Anti-clockwise
06	Constant	No	1800	1800	Electric	Anti-clockwise
07	Variable	No	2000	1000-3000	Hand	Anti-clockwise
08	Variable	No	3000	1000-3000	Hand	Anti-clockwise
09	Variable	No	1000	1000-1500	Hand	Clockwise

LV2 Builds

Build	Speed	12v Charge Windings	Speed Set r/min	Governor Range r/min	Starting	Rotation
01	Variable	No	3000	1500-3000	Hand	Anti-clockwise
02	Variable	Yes	3000	1500-3000	Electric	Anti-clockwise
03	Constant	No	3000	3000	Hand	Anti-clockwise
04	Constant	Yes	3000	3000	Electric	Anti-clockwise
05	Constant	Yes	3600	3600	Electric	Anti-clockwise
06	Constant	No	1800	1800	Electric	Anti-clockwise
07	Variable	Yes	3000	1500-3000	Electric	Anti-clockwise
08	Variable	Yes	3000	1500-3000	Electric	Anti-clockwise

Technical Data

		LT1	LT2	LV1	LV2
Injection		Direct			
Rotation - looking on flywheel		See Note			
Bore	mm in	82,55 3,25		85,73 3,375	
Stroke	mm in	76,20 3,00		82,55 3,25	
Cylinder Capacity - total	litre in³	0,4078 24,89	0,8156 49,78	0,4765 29,08	0,953 58,15
Compression Ratio		16,4:1		16,2:1	
Mean Piston Speed at 3000r/min	m/sec ft/min	7,62 1499		8,25 1625	
Oil Sump Capacity (engine level)	l pt U.S. qt	1,3 2,3 1,4	3,6 6,3 3,8	1,3 2,3 1,4	3,6 6,3 3,8
Lubricating Oil Pressure - minimum	bar lbf/in²	0,4 5,8			
Capacity Between Dipstick Marks	l pt U.S. qt	0,2 0,35 0,21	0,5 0,88 0,53	0,2 0,35 0,21	0,5 0,88 0,53
Fuel Tank Capacity (engine mounted)	l pt U.S. qt	5,0/8,25 8,8/14,5 5,28/8,7		13,5 23,7 14,2	
Maximum Permissible Crankshaft End Thrust	kg lb	68,0 149,9			
Injector Setting	bar atmos	195-205 192-200			
Number of Flywheel Gear Ring Teeth		108			

Note:
LT1/LV1 - Anti-clockwise and clockwise depending on Build
LT2/LV2 - Anti-clockwise only

Crankcase Vacuum

	Minimum [1]	Average
mm WG in WG	25,0 1,0	50,0-75,0 2,0-3,0

Note:
[1] LT1 engines running at 1000r/min may have a vacuum as low as 5,0mm WG (0,2in WG).

OPERATING INSTRUCTIONS

The following information is of a general nature and should be read in conjunction with, or substituted by, the equipment manufacturers instructions.

⚠ WARNING

Starting any diesel engine can be dangerous in the hands of inexperienced people.
Before attempting to start any engine the operator should read the "Safety Precautions" on page 6 and be instructed in the use of the engine controls and the correct starting procedures.

⚠ CAUTION

ETHER BASED COLD START AIDS IN AEROSOL CANS MUST NOT BE USED UNDER ANY CIRCUMSTANCES.
Systems may be fitted to allow a measured quantity to be injected into the inlet manifold, but these must be used in accordance with the manufacturers instructions.

⚠ WARNING

EXHAUST GASSES CONTAIN CARBON MONOXIDE WHICH IS A COLOURLESS, ODOURLESS AND POISONOUS GAS THAT CAN CAUSE UNCONSCIOUSNESS AND DEATH.

Cold Weather Starting Aid

This device, if fitted, consists of a cup and plunger fitted into the combustion air intake port and is used to aid starting at temperatures below -10°C (14°F).

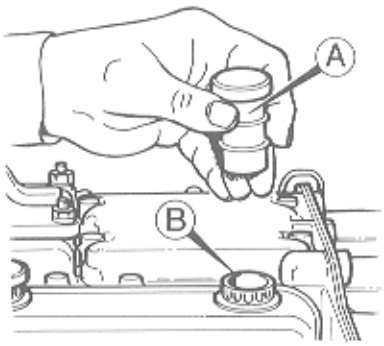


Figure 1. Cold Start

1. With the fuel on turn the engine for up to 20 revolutions to prime the fuel system.
2. Withdraw the plunger and fill one third of the cup with the same type of lubricating oil as used in the engine.
3. Replace the plunger and push it down firmly to inject the oil just before starting.

⚠ CAUTION

The device must not be used more than three times in succession during the same attempt to start the engine.

Automatic Excess Fuel Device - LV2

LV2 engines are fitted with an automatic excess fuel device which becomes operative, ready for the next start, when the engine is stopped. As the engine runs up to speed the excess fuel device will automatically reset to the normal running position.

Note:

If the engine stops other than by the operation of the engine control, the control must be turned anti-clockwise to the 'STOP' position and released before the device will operate for the next start.

Engine Control

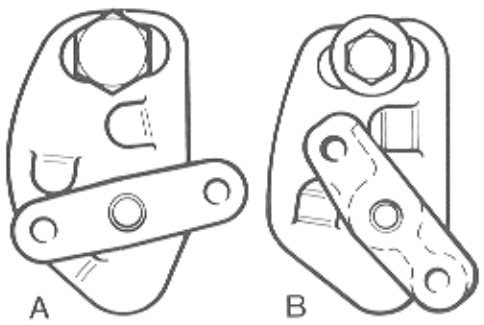


Figure 2. Engine Control:
A - Manual Excess Fuel
B - Automatic Excess Fuel

Starting Handle

A non-limited kick-back handle (A) or limited kick-back handle (B) system may be fitted to the engine. The two handles are not interchangeable and care must be taken to ensure the correct type is retained with the engine.

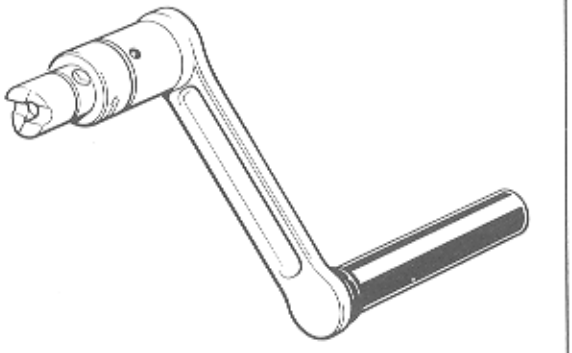


Figure 3. Starting Handles

Hand Starting - non-limited kickback

1. On engines not fitted with an automatic excess fuel device select the excess fuel position by gently pulling the engine control lever outward over the middle catch and turning it fully clockwise.
2. If a variable speed control is fitted move it towards the full speed position.
3. Move the decompressor lever towards the flywheel.
4. Operate the cold weather starting aid if the ambient temperature is below -10°C (14°F).
5. Lightly oil the end of the starting shaft and fit a correct and fully serviceable starting handle.
6. If the cold weather starting aid was not used turn the engine slowly, for up to 20 revolutions, to prime the combustion chamber and the lubricating oil system. Hold the handle firmly with the thumb ***on top*** of the grip and not around it.
7. Retain a firm grip on the starting handle and crank the engine really fast and when sufficient speed is obtained, move the decompressor lever towards the gear end continue to crank until the engine fires, remove the starting handle from the shaft.
8. On engines not fitted with an automatic excess fuel device turn the engine control lever anti-clockwise to the run position.
9. If a speed control is fitted reduce the engine speed as required.

Hand Starting - limited kick-back

1. On engines not fitted with an automatic excess fuel device select the excess fuel position by gently pulling the engine control lever outward over the middle catch and turning it fully clockwise.
2. If a variable speed control is fitted move it towards the full speed position.
3. Move the decompressor lever towards the flywheel.
4. Operate the cold weather starting aid if the ambient temperature is below -10°C (14°F).
5. Insert the handle into the starting housing.
6. Slowly rotate it in the direction of cranking until the handle fully engages.
7. If the cold weather starting aid was not used turn the engine slowly, for up to 20 revolutions, to prime the combustion chamber and the lubricating oil system.
8. Retain a firm grip on the starting handle and crank the engine really fast and when sufficient speed is obtained, move the decompressor lever towards the gear end continue to crank until the engine fires, remove the starting handle from the shaft.
9. On engines not fitted with an automatic excess fuel device turn the engine control lever anti-clockwise to the run position.
10. If a speed control is fitted reduce the engine speed as required.

Electric Starting - Starter Button

1. On engines not fitted with an automatic excess fuel device select the excess fuel position by gently pulling the engine control lever outward over the middle catch and turning it fully clockwise.
2. If a variable speed control is fitted move it towards the full speed position.
3. Ensure that the decompressor lever is towards the gear end.
4. Operate the cold weather starting aid if the ambient temperature is below -10°C (14°F).
5. Press the starter button and release it immediately the engine fires.
6. On engines not fitted with an automatic excess fuel device turn the engine control lever anti-clockwise to the run position.
7. If a speed control is fitted reduce the engine speed as required.

Electric Starting - Keyswitch

1. On engines not fitted with an automatic excess fuel device select the excess fuel position by gently pulling the engine control lever outward over the middle catch and turning it fully clockwise.
2. If a variable speed control is fitted move it towards the full speed position.
3. Ensure that the decompressor lever is towards the gear end.
4. Operate the cold weather starting aid if the ambient temperature is below -10°C (14°F).
5. Turn the keyswitch clockwise and hold it in position '3' until the engine fires.
6. Release the keyswitch.
7. On engines not fitted with an automatic excess fuel device turn the engine control lever anti-clockwise to the run position.
8. If a speed control is fitted reduce the engine speed as required.

Stopping the Engine

1. Turn the engine control lever fully anti-clockwise and hold it in the stop position until the engine comes to rest.
2. After the engine has stopped ensure the keyswitch, if fitted, is turned anti-clockwise to the 'OFF' position.

⚠ CAUTION

The engine cannot be stopped by turning the keyswitch to the 'OFF' position unless a fuel control solenoid is fitted.

To prevent possible valve damage the engine must not be stopped by using the decompressor.

ROUTINE MAINTENANCE

The routine servicing and maintenance periods given are based on average operating conditions. Under very dusty conditions air cleaners, lubricating oil and fuel filters will require more frequent attention. Decarbonising may be required more frequently when engines are running on light loads for long periods.

General Instructions

It is strongly recommended that bolts or nuts holding cylinder heads, covers, and doors are tightened diagonally.

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 and/or bolts from connecting rods and cylinder heads should be renewed.

Decarbonising the engine is usually carried out at 6000 hours unless the engine shows signs of loss of compression or blow-by past the pistons.

When re-assembling an engine it is always advisable to apply a small quantity of new lubricating oil to all moving parts. After any maintenance work on the engine has been completed the lubricating oil and fuel levels must be checked and all safety guards replaced before starting.

Wear protective overalls, and keep items of loose clothing clear of all hot and moving parts. Use protective barrier cream when necessary.

Wherever possible clean components and the surrounding area before they are removed or dismantled. Take particular care to exclude all dirt and debris from the fuel injection equipment while it is being serviced.

Some joints are fitted dry and others with jointing compound; a list of compounds is given towards the end of 'Section 2'. Before re-assembly all traces of the old joint and compound must be removed. Take extreme care to exclude dirt from all jointing surfaces and jointing compound from all tapped holes unless otherwise specified.

It is recommended that all oil seals are replaced once they have been removed from their original position. Seals must be fitted square in the housing and all lip seals must be fitted with the lip facing the lubricant to be retained. A service tool should be used to install the seals and care must be taken to prevent damaging the new seal when it passes over shafts.

All nuts, bolts, setscrews and studs with damaged threads must be replaced. Using a tap or die to repair damaged threads may impair the strength and closeness of fit of the threads and is not recommended.

Do not allow grease or oil to enter a blind threaded hole as the hydraulic action present when the bolt or stud is screwed in could split or stress the housing.

To check or re-torque a bolt or nut it is slackened a quarter of a turn and then re-tightened to the specified value.

A steel ISO metric bolt, setscrew or nut can be identified by the letter 'M' either on the head or one of the hexagon flats. The strength grade will also be marked on the top or one flat.

On nuts with identification marks on one face the frictional area of that surface will be reduced therefore the nut should be fitted with the unmarked face towards the component.

Repair and maintenance work can only be carried out if the necessary hand and service tools are available. When the user has insufficient tools, experience or ability to carry out adjustments, maintenance and repairs this work should not be attempted.

Service tools are designed to aid the dismantling and assembly procedures and their use will prevent possible unnecessary damage to components. It is recommended that service tools are always used; some operations cannot be safely carried out without the aid of the relevant tool.

Under no circumstances should makeshift tools or equipment be used as their use may adversely affect safe working procedures and engine operation.

Where accurate measurements or torque values are required they can only be made using calibrated instruments.

It is recommended the individual steps contained in the various maintenance or repair operations are followed in the sequence in which they appear.

⚠ CAUTION

Before carrying out any maintenance work on an engine it is advisable to remove the battery and, to avoid possible damage, the battery and charging system must be disconnected before commencing any electric welding when a pole strap is directly or indirectly connected to the engine.

Routine Maintenance Periods

Daily
Check the fuel and lubricating oil levels.
Check for oil and fuel leaks.
Clean or replace the air cleaner element under very dusty conditions.
Every 125 Hours
The above and the following items.
Check the condition of the battery, if fitted.
Clean or replace the air cleaner element under moderately dusty conditions.
Every 250 Hours
The above and the following items.
Drain the sump and refill with new oil of the correct type and viscosity as given in the Operators Handbook.
Check the valve clearances.
Clean or replace the injectors if the exhaust is dirty.
Renew the fuel filter element if the fuel being used is not perfectly clean.
Every 500 Hours
The above and the following items.
Replace the air cleaner element.
Examine the exhaust and induction systems for leaks, damage or restrictions.
Renew the fuel filter element.
Check the battery charge winding system; refer to 'Section 6'.
Every 1000 Hours
The above and the following items.
Decarbonise if the engine performance has deteriorated.
Clean the cylinder barrel and head fins.
Clean the restrictor banjo union at the cylinder head end of the oil feed pipe.
Every 2000 Hours
The above and drain, flush and refill the fuel tank.

Starting and Running Faults

This section can only be included as a guide and any rectification to the engine should be carried out in accordance with Lister-Petter instructions.

Difficult Starting
Incorrect grade of fuel or oil.
No fuel in tank.
Choked fuel or oil filter.
Air lock in the fuel system.
Injector nozzle valve stuck open.
Fuel pump delivery valve scored.
Sticking fuel pump rack.
Stop/start lever in the wrong position.
Retarded injection.
Injector loose in the cylinder head.
Leaking valves.
Sticking piston rings.
Exhaust valve sticking.
Worn cylinder.
Incorrect decompressor clearance.
Load not disconnected.
Battery not serviceable.
Faulty or loose electrical connections.
Knocking
Valve, probably exhaust, sticking in the guide and touching the piston.
Worn connecting rod bush or bearing.
Worn gudgeon pin or small end bearing.
Insufficient cylinder head clearance.
Injection too early.
Flywheel coupling or pulley loose.
Excessive camshaft or crankshaft end float.
Excessive carbon deposits on the pistons.
Excessive clearance between the piston and cylinder.
Engine loose on its mountings.
Wrong type of fuel.
Flywheel loose.
Excessive Carbon Deposits
Choked air filter.
Choked exhaust system.
Unsuitable fuel or lubricating oil.
Continuous idling.

Defective injector spraying.
Late injection of fuel.
Low load running.
Low temperature running.
Dark Blue Smoke
Piston rings worn.
Cylinder bore worn.
Faint Blue Smoke
Light load.
White Smoke
Water in the fuel supply.
Black Smoke
Overload.
Choked air filter.
Inlet air temperature too high.
Defective injector spraying.
Unsuitable fuel oil or water in fuel.
Engine Stops
Lack of fuel.
Air or water in the fuel system.
Choked fuel filter.
Blocked injector nozzle.
Excessive overload.
Overheating.
Loss of compression.
Loss of oil.
Loss of electrical supply to the fuel control solenoid, if fitted.
Automatic shutdown, if protective devices are fitted.
Loss of Power
Loss of compression.
Choked air filter.
Choked exhaust system.
Defective fuel pump or injector.
Choked fuel filter.
Failure to Attain Normal Speed
Attempting to start the engine on full load.
Air in the fuel system.
Insufficient fuel.
Injection retarded.
Governor out of adjustment.
The wrong type of governor weights for the speed expected.

Loss of Oil Pressure
Low oil level in the sump.
Choked oil pump.
Badly worn crankshaft or big end bearings.
Oil pump failed.
Oil diluted with fuel.
Unsuitable lubricating oil (too thin).
Overheating
Cooling air being recirculated.
Cooling air inlet obstructed.
Cooling air outlet obstructed.
Driven unit cooling air also used to cool engine.
Fins of the cylinder barrel or head blocked.
Running on excessive overload.
Lubricating oil level too low or too high.
Injection timing faulty.
Low Compression
Injector loose on its seat.
Injector washer scored.
Piston ring gaps in line.
Inlet or exhaust valve not seating.
Cylinder head gasket leaking.
Hunting
Tight spots on governor linkage.
Fuel pump rack not free.
Air in the fuel system.
Faulty injector.
High Oil Consumption
Valve guides worn.
Piston rings worn.
Cylinder bore worn.
Loss of Crankcase Vacuum
Worn piston rings.
Worn cylinder barrel bore.
Worn oil seals.
Too much oil in the sump.
Oil filler cap not seating.
Leaking Oil Seals
Too much oil in the sump.
Loss of crankcase vacuum.

Injector Faults

This section can only be included as a guide and any rectification to the injector should be carried out in accordance with the local Lister-Petter Distributor's instructions.

If injector testing or cleaning equipment is not available the injector should be replaced with a new or reconditioned one.

Excessive Leak-off (back leakage)
Needle slack or worn.
Cap nut not tight.
Dust or dirt between the nozzle and holder faces.
Incorrect Opening Pressure
The adjuster may have worked loose and moved.
The needle may be dirty or seized.
Nozzle holes blocked.
The adjuster spring has broken.
Nozzle Wet.
The needle is sticking or tight.
Carbon deposits on the nozzle or needle seats.
The seats are distorted, hammered, scratched or eroded.
The Injector Does Not 'Chatter' When Injecting
The needle is tight or sticking.
Leaking seats.
The cap nut is distorted.
The injector may be set at a very low breaking pressure.
Dirt on the nozzle or holder faces.
Distorted Spray
Carbon on the needle.
One or more holes are blocked.
The needle is sticking or damaged.
The seats are distorted, hammered, scratched or eroded.

Jointing Compounds

Some engines will have been assembled with jointing compounds that have been superseded. Providing all traces of the old compound and joint are removed the later specified compounds can be used.

Cylinder Head Cover Assemble the joint dry with all surfaces clean and dry.
Fuel Pump Door Assemble the joint dry with all surfaces clean and dry.
Gear End Cover Assemble the joint dry with all surfaces clean and dry.
Sump Assemble the joint dry with all surfaces clean and dry.
Bottom of Cylinders Coat the cylinder on the jointing face with Wellseal, stick the joint to it and coat the joint.
Crankshaft Bearing Housing Shims Coat the housing face with Wellseal. Fit an aluminium joint and coat it. Continue this process until the correct end float is obtained. Torque the housing bolts and re-torque after ten minutes.
Valve Guides Coat the outside diameters of the guides with Wellseal before fitting. Do not use grease or any other substance.
Camshaft Expansion Plug Apply a small amount of Loctite 270 to the recess.
Oil Sump Drain Plug Coat the threads with Hylomar PL32/M, Loctite 572 or Hylogrip 760.
Oil Seals (not lip type) Apply a little Hylomar PL32/M to the outside diameter of the seal.
Cylinder Head Gasket and Shims Smear a very small amount of High Melting Point Grease where the shims seat, the side of the recess, both sides of each shim and the gasket.
Valve Rocker Stub Shafts Coat the sealing groove nearest to the bolt hole with Wellseal.

Cylinder Head Nuts and the Top Threads of the Cylinder Head Studs Coat the threads at the top of the stud and the area of the top plate in contact with the nut with Hylomar PL32/M.
Fuel Lift Pump or Blanking Plate Assemble the joint dry with all surfaces clean and dry.
Crankcase Breather Pipe Press the knurled tube end into the top plate and coat 15mm of the tube which is to enter the cylinder head with Hylomar PL32/M. Assemble the top plate to the cylinder head and ensure no compound fouls the tube.
Crankshaft Bucket Plug Coat the plug periphery with Loctite 572, Three Bond 1110B or Hylogrip 760.
End Cover Bush - TS/TR Coat the outside diameter of the bush before assembly with Loctite 601 or Three Bond 1303.
Crankshaft Oil Hole Sealing Plug Coat the plug threads with Loctite 572 or Hylogrip 760.
Push Rod Tube Seals Lightly coat the bore of the seal with grease to aid assembly.
Balance Plate Screws Coat the threads with Loctite 270.
Polypropylene Flywheel Fan Coat the setscrews in Loctite 270.

Routine Maintenance Parts

		LT	LV
Fuel tank filter element	5,0 litres 8,25 litres	201-13118 330573	201-13118 330573
Air cleaner element		See Note [1]	See Note [1]
Decarbonising joint set		657-25997	657-29460
Overhaul joint set		657-28573	657-29440
Connecting rod bearing		601-50420	601-50420
Connecting rod bolt		601-40090	601-40090
Connecting rod nut		272-00151	271-00151
Main bearing	Gear end Flywheel end	601-30060 601-30061	601-30060 601-30061
Piston ring set		601-50400	601-54490
Inlet valve		601-30361	601-30361
Exhaust valve		601-30372	601-30372
Injector and nozzle		See Note [2]	See Note [2]
Fuel pump		See Note [3]	See Note [3]

Note:

[1] Refer to any Lister-Petter Diesel Centre.
[2] Refer to "Injector Part Numbers" on page 85.
[3] Refer to "Fuel Pump Identification - LT" on page 82.

Service Tools

This table gives the Service Tools that are currently available for particular servicing operations on LT and LV engines.
Some early tools have been superseded but can, in many cases, still be used on current engines.

Due to continued development and improvement it is quite possible that any tool purchased may not completely resemble that described or illustrated in other Sections, however the principle for using it will remain the same.

All the Service Tools listed in the table can be ordered by the Part Number and Description following the same procedure as for ordering other Lister-Petter spares.

Tool	Description of Tool
393235	Main bearing tool
317-50078	Adaptor - for use with 393235
317-50020	LT Gear end oil seal Tool (19mm shaft)
317-50023	Crankshaft extension fixture
317-50025	Crankshaft pinion extractor
317-50027	Slide hammer
317-50028	Stub shaft adaptor - for use with 317-50027
317-50029	Valve spring compressor
319155	Valve spring compressor
317-50033	Valve guide removal and replacement tool
317-50034	Adaptor - for use with 317-50033
317-50037	LV Depth stop - for use with 317-50034
317-50040	LT Depth stop - for use with 317-50034
317-50042	Valve seat and recess cutter kit
317-50047	Flywheel removal and replacement mandrel
317-50050	Socket for flywheel screw - 46mm
317-50051	Adaptor for use with 317-50050
317-50057	LV flywheel locking tool
317-50063	gear end cover oil seal tool (22mm shaft)
317-50094	Valve clearance gauge
317-50096	Injector removal tool - for use with 317-50027

Spanner Torques
The tolerance for all torque setting is +5% -0 and for practical purposes the figures have been rounded to the nearest 0,5 of a unit.

Location	Nm	lbf ft
Governor link adjusting screw	3,0	2,0
Polypropylene flywheel fan	4,0	3,0
Injector leak-off banjo screw	6,0	4,5
Cold start oil cup taper thread	8,0/14,5	6,0/10,5
Fuel filter to tank cap screw Valve rocker adjusting screw Manifold lower level nuts Fuel pump holding bolts	9,0	6,5
Cylinder head cover bolts	11,0	8,0
Fuel filter adaptor (steel into aluminium)	19,0	14,0
Main bearing dowel locating plug	20,5	15,0
Injector clamp screw Crankshaft balance plate nuts Manifold higher level nuts	21,0	15,5
Connecting rod nuts	24,5	18,0
Main bearing housing screws Sump retaining bolts Injector top plug	27,0	20,0
Injector pipe nuts	28,5	21,0
Cylinder head nuts Fuel tank internal filter	40,5	35,0
Fuel pump delivery valve holder	41,0	30,0
Gear end crankshaft drives	138,5	102,0
Flywheel retaining screw	196,5	145,0

Section 2 - The Basic Engine

Contents

Air Cleaner 25
Exhaust Silencer 26
Air Cowling and Shields 27
Cylinder Head Cover 28
Crankcase Breather 28
Fuel Injector 29
Cylinder Head 30
Valve Clearance 31
Decompressor 32
Stub Shafts 33
Valve Rocker Bush 34
Valves 34
Valve Guides 35
Valve Seats 37
Gear End Cover 38
End Cover Oil Seal 39
Governor and Fuel Pump 40
Fuel Pump Tappet 41
Oil Sump 41
Camshaft 43
Camshaft Bushes 45
Cylinder Barrel 47
Piston 49
Flywheel 50
Fanshroud 51
Main Bearing Housing 52
Crankshaft Extension 53
Crankshaft 54
Crankshaft Main Bearings 57
Engine Control 59
Speed Adjustment 61
Decarbonising 62
Laying-up 62
Dimensions of Wearing Parts 63

DISMANTLING AN ENGINE

Every effort must be made to maintain the engine in a clean condition and oil leaks must be dealt with when they occur.

With a new or overhauled engine the joints settle during the first few hours running and their tightness must be subsequently checked.

When the engine is being dismantled all items must be identified and retained in their respective cylinder orientation and all related components must be treated similarly.

The instructions given in this section deal with individual components and it may be necessary to remove others before the relevant instructions can be carried out.

Before beginning any work on the engine:-

- Disconnect or isolate any non-electric starting systems.
- Disconnect and remove the battery.
- Drain the fuel and oil.
- Disconnect all services.
- Remove any accessories or components that may be susceptible to damage when the engine is turned out of its normal plane.
- Cap pipes and orifices as items are dismantled to prevent the ingress of foreign matter.

⚠ CAUTION

Damage may be caused to the polypropylene flywheel fan if it is used to turn the crankshaft other than by hand.

REBUILDING AN ENGINE

Because of the various engine configurations, and installations in which the engine can be fitted, it is not possible to give detailed instruction for each one.

Torque values are given in "Spanner Torques" on page 22.

Tables showing the permissible acceptable wear limits can be found at the end of this section.

When assembling the engine, use normal engine lubricating oil to spray all moving parts during assembly and all bearings and bushes must be well lubricated during assembly.

Renew all joints, gaskets, connecting rod bolts and nuts and the cylinder head bolts.

THE DRY AIR CLEANER

Medium duty cleaners are available for LT and LV and there is a heavy duty cleaner for LV2 engines. On some builds the air cleaner is fitted with an air restrictor.

The Air Cleaner - Build 32

1. Slacken the clip (A).
2. Remove the cleaner (B) from the manifold (C).

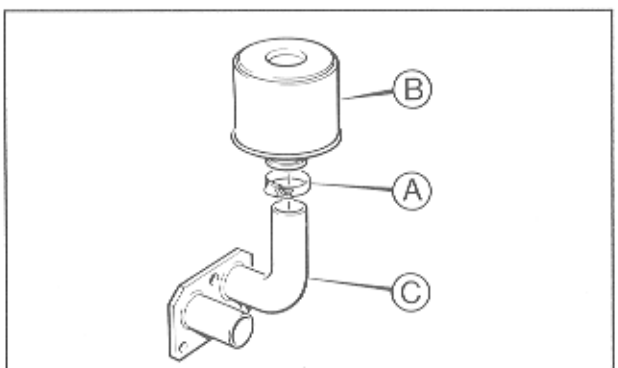


Figure 4. Air Cleaner - Build 32

3. Fit a new cleaner assembly.

LT/LV1 Medium Duty

1. Remove the cover (A) by removing the centre bolt.

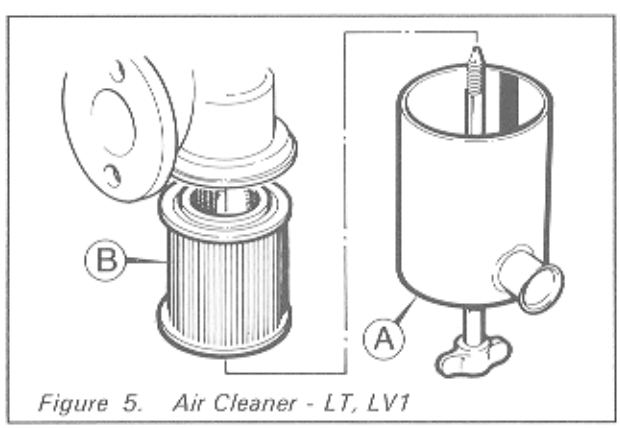


Figure 5. Air Cleaner - LT, LV1

2. Remove the old element (B) and fit a new one.

LT/LV2 Medium Duty

1. Slacken the clip and remove the snout (A).
2. Remove the cover (B) by unscrewing the centre nut.

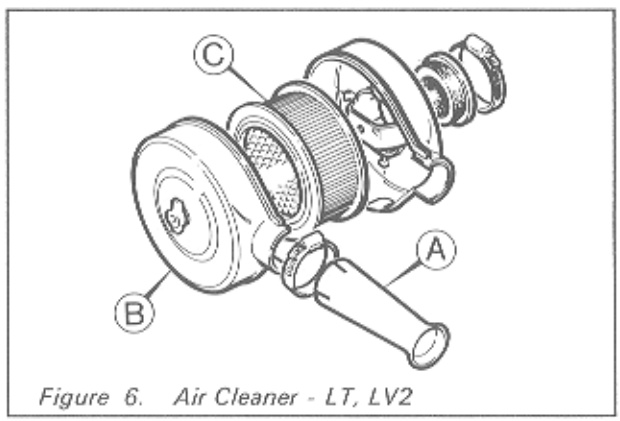


Figure 6. Air Cleaner - LT, LV2

3. Remove the old element (C) and fit a new one.

LV2 Heavy Duty

1. Remove the inlet cap (A).
2. Slacken the two strap (B) screws sufficiently until the end cap (C) can be removed.
3. Remove the element (D).

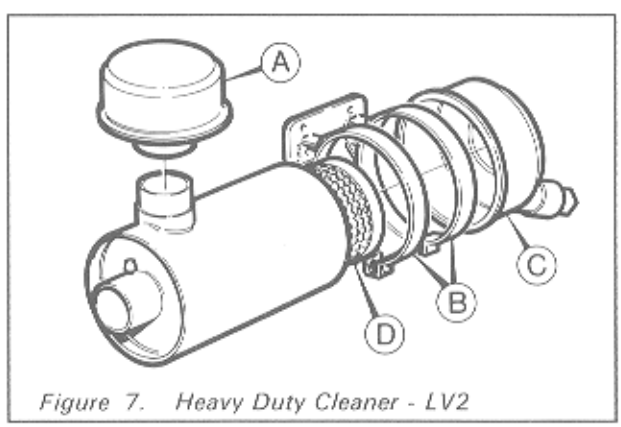


Figure 7. Heavy Duty Cleaner - LV2

4. Carefully direct a low pressure compressed air jet inside the element.
5. Place a suitable light into the element and check for damage.
6. Replace the element, end cap and the top cap.

THE EXHAUST SILENCER

The Lister-Petter engine mounted silencers are not interchangeable and when they are fitted care must be taken to ensure the outlet is pointing upwards or horizontal; a heavy duty silencer is available for LV2 engines.

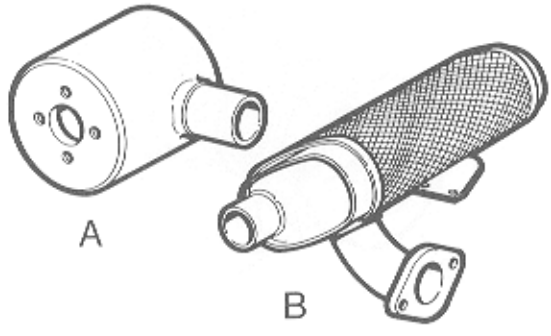


Figure 8. Silencers:
A - LT1,2 and LV1
B - LV2 Heavy Duty

⚠ CAUTION

Care must be taken to ensure exhaust gasses are not allowed to enter the air cleaner or flywheel cooling air fan.

THE MANIFOLDS

All single cylinder engines have a single combined inlet and exhaust manifold, LT2 and LV2 manifolds are individual, and in all cases the manifolds are mounted on studs with torque loaded nuts.

Removing and Fitting the Manifolds

1. Remove the exhaust silencer and air cleaner.
2. Remove the retaining nuts and lift the manifolds off.

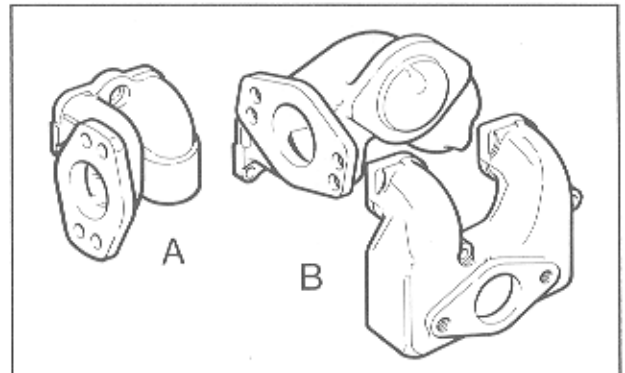


Figure 9. Manifolds:
A - LT/LV1
B - LT/LV2

3. Remove the gaskets and fit new ones.
4. Replace the manifolds and nuts.
   LT/LV2 engines have two spacer washers fitted to the studs securing the top of the exhaust and the bottom of the inlet manifolds.
5. Torque load the nuts:-
   Top nuts - 21,0Nm (15,5lbf ft)
   Lower nuts - 9,0Nm (6,5lbf ft)

THE FUEL TANK

Three sizes of engine mounted fuel tank are available and comprehensive information is given in "The Fuel Tank" on page 77.

THE AIR COWLING AND SHIELDS

The sheet metal air cowling, with the side shields, directs cooling air from the flywheel fan around the cylinders, heads and on LV engines, with the aid of a deflector plate, over the crankcase.

LT/LV2 engines are fitted with a plate, held in position by a spring clip, between the cylinders.

Build 32 engines are designed to operate at 1000r/min and are not fitted with a fanshroud, air cowling or side shield.

On some engines a cold start device is fitted through the top of the cowling.

⚠ CAUTION

To prevent overheating and possible seizure, due to incorrect positioning of the cowling and shields, extreme care must be taken to ensure their respective positions are noted; refer to Figure 10.

Removing the Cowling

1. If a cold start device is fitted unscrew and remove it.
2. Remove the manifolds.
3. Remove the two bolts securing the cowling to the flywheel housing.
4. Lift off the cowling.

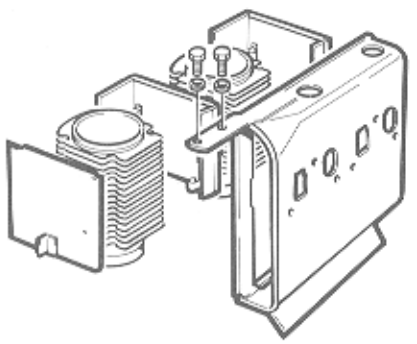


Figure 10. Air Cowling and Shields

Removing the Shields

1. Remove the cylinder heads or heads.
2. Slide the shields off the cylinder barrel studs.

THE LIFTING EYE

The lifting eye plate is fitted to the top of a cylinder head cover on studs and spacers and is only fitted as standard on LT/LV2 engines.

⚠ CAUTION

The lifting eye must only be used to lift the engine, under no circumstances must it be used to lift a complete plant.

THE CYLINDER HEAD COVER

The valve rocker oil feed pipe is connected to the alloy cover by a union and the cover gives access to the crankcase breather, decompressor, injector and valve tappets.

When the oil pipe union is replaced two new copper washers must be fitted. Before fitting a new union refer to "Cylinder Head Oil Feed" in 'Section 3'.

Removing the Cylinder Head Cover

1. On LT/LV2 engines remove the lifting eye plate.
2. If a fuel tank is fitted remove the leak-off pipe from the top of it and remove the three bolts holding the tank to the cover.
3. Remove the four cover setscrews and lift the cover off.

Fitting the Cylinder Head Cover

1. Check the cover joint for damage and if necessary fit a new dry joint.
2. Check that the felt seal over the breather pipe on the cylinder head is in place and not damaged.
3. Move the decompressor lever to the vertical position and place the cover in position taking care to ensure the leak-off pipe is correctly located.
4. On LT/LV1 engines replace the four cover setscrews.
   On LT/LV2 engines replace the lifting eye plate spacers and nuts.
   Torque the cover setscrews to 11,0Nm (8,0lbf ft).
5. Replace the fuel tank top mounting bolts.
6. Replace the fuel leak-off pipe into the top of the tank.
7. Replace the valve rocker oil feed pipe union with new copper washers; ensure only one washer each side of the union is fitted.

THE CRANKCASE BREATHER

A crankcase breather pipe in the top of the cylinder head is connected to the inlet port and a breather box which is attached to the underside of the cylinder head cover by a countersunk screw.

Care must be taken to ensure the screw is kept tight, the rocker box joint and the breather pipe felt seal are in good condition.

Removing and Refitting the Breather Box

1. Remove the cylinder head cover (A).
2. Unscrew the countersunk screw (B).
3. Lift off the box (C) and the joint (D).
4. Clean the box and cover.

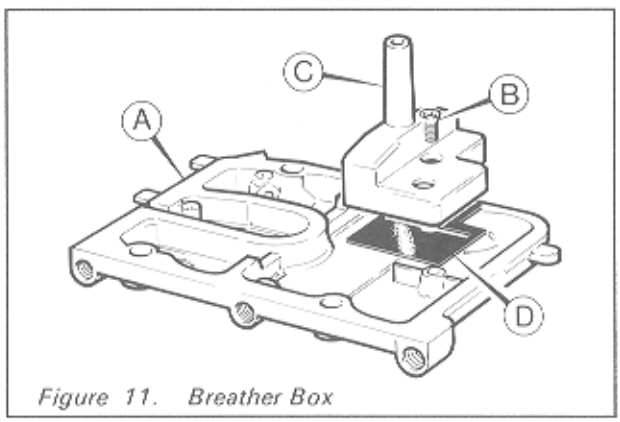


Figure 11. Breather Box

5. Replace the joint or fit a new one if necessary; ensure the joint is the correct way round.
6. Replace the box ensuring it is parallel with the side of the cover and the joint is not damaged.
7. Replace and tighten the countersunk screw.
8. Replace the cylinder head cover and torque the setscrews to 11,0Nm (8,0lbf ft).

THE FUEL INJECTOR

The injector and fuel system are fully covered in "Section 4", the following instructions are included only to describe the dismantling and assembly procedures.

The current injector washers are bonded metal-fibre and the earlier copper type can be replaced by the new type.

Removing an Injector

1. Remove the cylinder head cover.
2. Remove the fuel feed pipe between the fuel pump and injector; hold the fuel pump delivery valve holder with a spanner to stop it turning.
3. Remove the leak-off pipe from the top of the fuel tank.
4. If only one LT/LV2 injector is being removed separate the leak-off pipe from the union.
5. Remove the Allen screw and the injector clamp.
   The clamp is located in position by a hole in the side of the cylinder head assembly.
6. Lift out the injector, leak-off and sealing washer.

Using the Injector Removal Tool

1. Remove the fuel pipes from the injector.
2. Remove the injector clamp.
3. Place the injector removal tool (A) over the injector and ensure the hole with the insert is fitted over the fuel inlet hole of the injector.

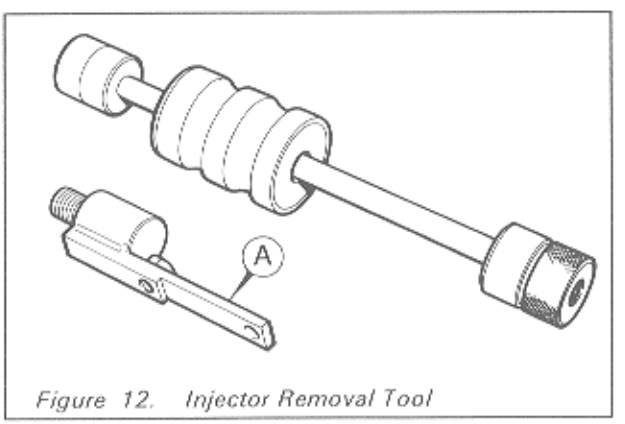


Figure 12. Injector Removal Tool

4. Fit the slide hammer to the tool.
5. Use the slide hammer to remove the injector.

⚠ WARNING

Care must be taken to ensure that any part of the hand is not likely to become trapped between the two parts of the tool while it is being used.

Replacing an Injector

1. Ensure the seating in the cylinder head is clean and smooth.
2. Lightly smear a very small amount of high melting point grease to one side of a new copper injector sealing washer or the metal side of the metal-fibre washer.
3. Place the washer over the injector nozzle, greased side first.
4. Replace the injector into the cylinder head.
5. Replace the clamp bar leaving the Allen screw finger tight.
6. Replace the fuel pump to injector pipe - do not tighten.
7. Renew the copper washers each side of the leak-off pipe swivel union - do not tighten.
8. Replace the leak-off pipe into the fuel tank.
9. Torque load the injector clamp bar to 21,0Nm (15,5lbf ft).
10. Torque load all pipe nuts and unions.
    Injector Pipe Nuts - 28,5Nm (21,0lbf ft).
    Leak-off pipe union - 6,1Nm (4,5lbf ft).
11. Replace the cylinder head cover and torque the setscrews to 11,0Nm (8,0lbf ft).
12. After the initial run following an injector replacement re-torque the injector clamp screw.

Note:

It is recommended that all fuel equipment washers are renewed on assembly and therefore a suitable supply should be stocked.

⚠ CAUTION

If the injector sealing washer has been used more than once it will become compressed and may adversely affect combustion. Care should be taken to ensure two washers are not fitted.

THE CYLINDER HEAD

The cylinder head assembly comprises of two parts held together by the valve guides. The top plate is cast iron and contains the valve gear, breather tube and the decompressor lever. The lower part is aluminium alloy and is fitted with the valve seats.

Removing the Cylinder Head

1. Remove the fuel tank if necessary.
2. Remove the the valve rocker oil feed pipe unions at the head and crankcase ends.
3. Remove the cylinder head cover.
4. Unclip the two spring clips holding the pipe to the exhaust push rod tube and remove the pipe.
5. Slacken the fuel injector pipe unions at both ends; hold the fuel pump delivery valve union with a spanner to prevent it turning.
6. Remove the fuel injector clamp.
7. Lift out the injector and leak-off pipe complete.
8. Remove the inlet and exhaust manifold.
9. Remove the air cowling.
10. On LT/LV2 engines mark the heads to identify them if both are being removed.
11. Slacken the four cylinder head nuts diagonally and evenly and remove them.
12. Lift off the cylinder head and retain the head clearance shims with it.
13. If further dismantling is anticipated remove and number the push rods and tubes.
14. If further dismantling is not anticipated place a suitable tube, secured by a hand tightened head nut, over one cylinder barrel stud to prevent the cylinder moving if the crankshaft is turned.

Checking the Cylinder Head Clearance

1. Smear a very small amount of high melting point grease in the recess on the head where the shims seat and also the side of the recess.
2. Lightly grease both sides of each shim in turn and place them in the recess.
3. Place the gasket in the recess on top of the shims.

   The gasket must be placed next to the cylinder and a minimum number of 0,076mm shims must be used which must be placed between the gasket and the 0,254mm shims.
4. From two 50mm x 1,6mm (2,00 x 0,063in) pieces of lead wire or soft, but not multicore, solder form two 'U' shaped symmetrical loops.
5. Twist the open tails of each loop to form four or five coils.
6. Refer to Figure 13, and using a very small amount of high melting point grease place the two pieces of wire (A) on the piston crown (B) at either side of the gudgeon pin axis and 90° to the centre line. They should just touch the cylinder bore.
   Care must be taken to ensure the wires are not placed over any markings on the piston.

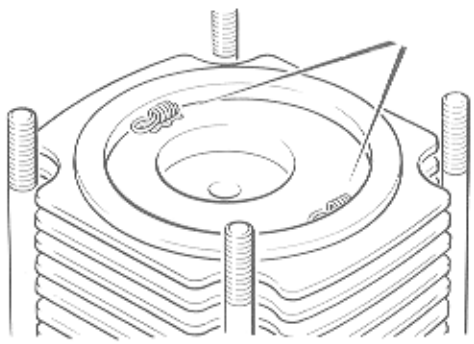


Figure 13. Checking the Cylinder Head Clearance

7. Replace the cylinder head.
8. Replace and tighten the cylinder head nuts, diagonally, to a torque loading of 40,7Nm (30,0 lbf ft).
9. Turn the piston twice past T.D.C.
10. Remove the cylinder head and measure the thickness of the lead, this should be:-
    LT - 0,71-0,79mm (0,028-0,031in).
    LV - 0,84-0,91mm (0,033-0,036in).
11. If this measurement is not correct it can be adjusted by adding or removing 0,076mm or 0,254mm (0,003 or 0,010in) thick shims placed between the cylinder head and the gasket.

Fitting the Cylinder Head

The top threads of the studs and the area of the top plate in contact with the nuts should be lightly coated with Hylomar PL32/M.
Cylinder head nuts should be fitted with the grade symbol facing upwards to ensure a good seal between the nut and the top plate.

It is recommended that cylinder head nuts are replaced on every occasion they are removed, if not, ***they must be replaced every fourth time.***

1. Examine the push rod tube rubber seals; renew if necessary.
2. Replace the push rod seals in the cylinder head.
3. Replace the push rod seals in the crankcase.
4. Lightly grease both ends of the push rod tubes and replace them in the crankcase taking care to ensure they are centralised in the seals.
5. Replace the push rods in their original positions.
6. Replace the cylinder head.
   Great care must be taken not to trap the shims on the cylinder spigot.
7. Replace the head nuts finger tight only.
   The LT/LV2 manifold flanges of both cylinder heads must be lined up with a straight edge and any gap along the straight edge must not exceed 0.2mm (0,008in).
   Alternatively fit a manifold before tightening down the cylinder heads.
8. Tighten down the cylinder head, ensuring the push rod tubes are located in the seals, and tighten the head nuts finger tight.
9. Tighten all nuts diagonally and evenly to a torque of 40,7Nm (30,0 lbf ft).
10. Check and adjust the decompressor.
11. Check and adjust the valve rocker clearances.
12. Replace the injector and the injector clamp.
13. Replace the cylinder head cover and lifting eye.
14. Replace the air cowling.
15. Replace the manifolds with new joints.
16. Replace the valve rocker lubricating oil feed pipe and the oil swivel plug to the cylinder head and crankcase; fit new washers.

VALVE CLEARANCE

The valve clearance must be measured and adjusted when the engine is cold and it is important that the clearances are maintained correct to prevent serious damage to the valve gear. With new engines, or engines which have just been overhauled, the valve gear beds down rapidly during the first 500 hours running. It is essential that the clearance is checked every 25 hours until it is found to remain constant then the period between adjustments may be increased to every 1000 hours.

Engines up to 3000r/min

		mm	in
Inlet and Exhaust	GO	0,10	0,004
	NOT GO	0,15	0,006

Engines above 3001r/min

		mm	in
Inlet	GO	0,05	0,002
	NOT GO	0,10	0,004
Exhaust	GO	0,13	0,005
	NOT GO	0,18	0,007

Adjusting the Valve Clearance

1. Ensure the decompressor is clear of the exhaust valve rocker.
2. With the cylinder head cover removed, turn the engine until the piston is at the TDC position on the firing stroke - both valves will be closed.
3. Hold the adjusting screw (A) with a screwdriver and slacken the locknut (B).

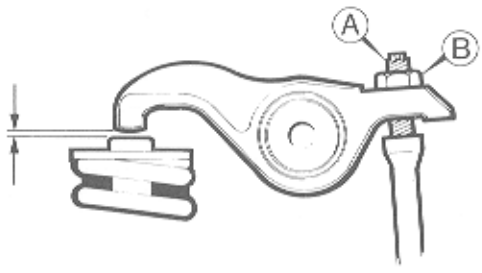


Figure 14. Adjusting the Valve Clearance

4. Turn the screw until the correct clearance has been obtained.
5. Torque the locknut, while continuing to hold the adjusting screw, to 9,0Nm (6,5lbf ft).
6. Re-check to ensure the clearance is correct.
7. Repeat the entire procedure for the each valve.

THE DECOMPRESSOR

The decompressor locates on the exhaust valve and when the cylinder head cover is being replaced care must be taken to ensure the lever is vertical.

The decompressor lever should only be adjusted with the valve clearance correctly set.

Decompressor Adjustment

1. Remove the cylinder head cover.
2. Turn the engine until the piston is at the TDC position on the firing stroke.
3. Turn the decompressor lever (A) towards the gear end.

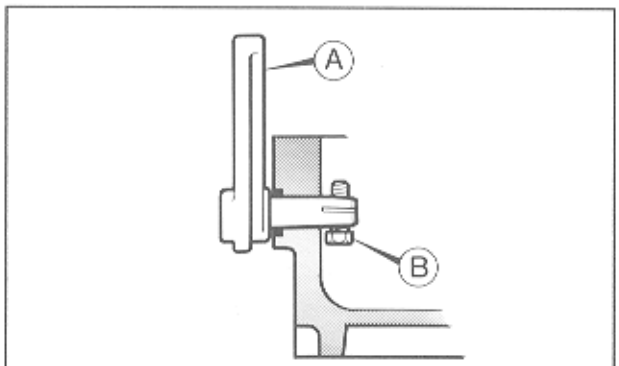


Figure 15. Setting the Decompressor Lever

4. Turn the adjusting screw (B) clockwise until the exhaust valve begins to move downwards when the lever is operated.
5. Turn the adjusting screw one further turn clockwise.
6. With the decompressor lever vertical replace the cover.

Removing the Decompressor

1. Remove the cylinder head cover.
2. Ensure the exhaust vale is fully open.
3. Remove the adjusting screw, soring and washer.
4. Withdraw the decompressor lever from the cylinder head.
5. Ensure the 'O' ring remains on the lever shaft.

THE STUB SHAFTS

The removal of the stub shafts is necessary when it is required to examine or change the valves, valve seats, rocker arms or rocker arm bushes.

Removing Stub Shafts

Depending on which stub shaft is being removed will determine if it is necessary to remove the cylinder head.

1. Remove the cylinder head, if necessary, and place it in a soft jawed vice.
2. Screw the adaptor (A) into the stub shaft.
3. Fit the slide hammer (B) to the adaptor.
4. Grip the slide hammer in one hand and strike the sleeve of the tool furthest from the cylinder head with the slide hammer until the stub shaft has been removed.
5. Lift out the valve rocker arm.

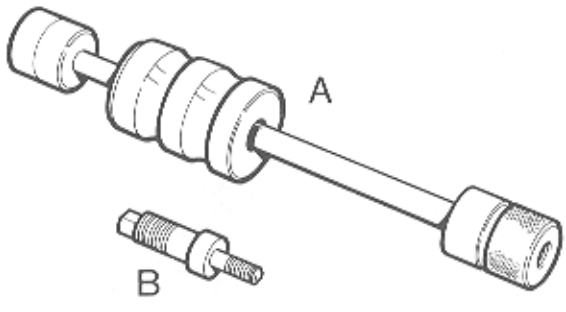


Figure 16. Stub Shaft Tool:
A - Adaptor
B - Slide hammer

Fitting a Stub Shaft

When refitting, the mark 'TOP' on the outside face of the stub shaft must be positioned towards the top of the cylinder head.

1. Fit the small end of the adaptor (A) into the screw thread of the stub shaft; ensure 'TOP' will be correctly positioned.
2. Place the cylinder head on its side on a bench and place the rocker into position for refitting the stub shaft.
3. Fit the slide hammer tool onto the adaptor.
4. Align the stub shaft with the stub shaft hole.
5. Grasp the slide hammer with one hand while positioning the rocker arm with the other and refit the stub shaft by striking the end of the tool nearest the cylinder head with the slide hammer.

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

After fitting, the stub shaft and cylinder head stud holes must be perfectly aligned.

⚠ WARNING

Care must be taken to ensure that any part of the hand is not likely to become trapped between the two parts of the tool while it is being used.

THE VALVE ROCKER BUSH

The bush can be removed and replaced with the aid of a suitable press. Extreme care must be taken to ensure the oil holes (A) in the new bush and the top of the rocker arm are exactly aligned.

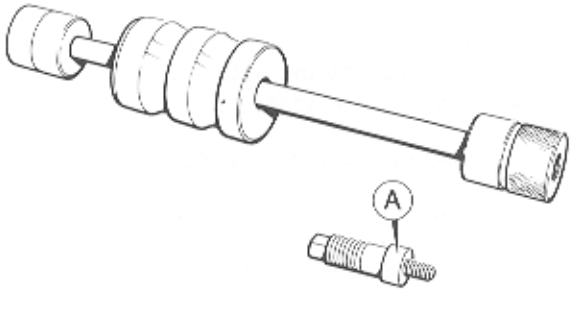


Figure 17. Valve Rocker Bush

THE VALVES

Two Service Tools are available for compressing the valve spring; both are described and either can be used.

It will be found easier to remove the valves with the rocker arms removed.

Removing a Valve - using Tool 317-50029

1. Remove the cylinder head.
2. Remove the stub shaft and valve rocker arm.
3. Remove the decompressor lever if the exhaust valve is being removed.
4. Lay the cylinder head upright on a bench and place a circular block of wood under the head of the valve.
5. Fit the adaptor (A) into the cylinder head cover holding down screw hole.
6. Screw the pivot (B) into the adaptor (A).
7. Adjust the width of the bridge (C) to suit the valve spring carrier and locate it over the valve spring carrier.

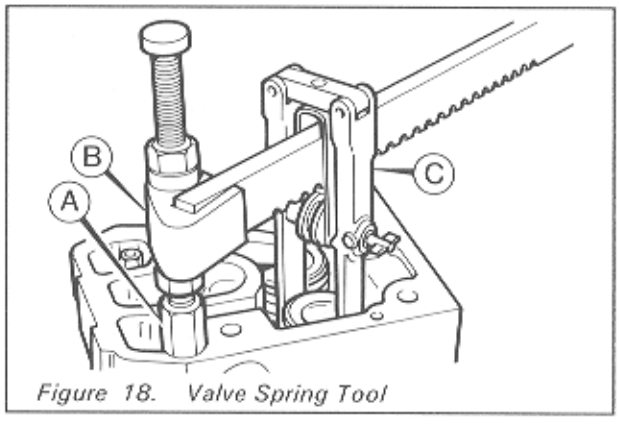


Figure 18. Valve Spring Tool

8. Push down on the free end of the lever until the collets can be removed.
9. Gently release the lever and remove the carrier, valve stem shield, valve spring and oil seal from the valve stem.
10. Turn the cylinder head over and remove the valve.

Fitting a Valve

Assemble in the reverse order ensuring the collets are securely in position with their tops slightly sunk in the valve spring carrier.

Take care to ensure the valve stem oil seal is correctly fitted.

Removing a Valve - using Tool 319155

1. Remove the cylinder head.
2. Remove the stub shaft and valve rocker arm.
3. Remove the decompressor lever if the exhaust valve is being removed.
4. Remove the valve rocker assembly.
5. Lay the cylinder head upright on a bench and place a circular block of wood under the head of the valve to be removed.
6. Place the adaptor (A) onto the valve spring carrier with the two indentations facing outwards.
7. Fit the tool (B) into the two adaptor indentations.

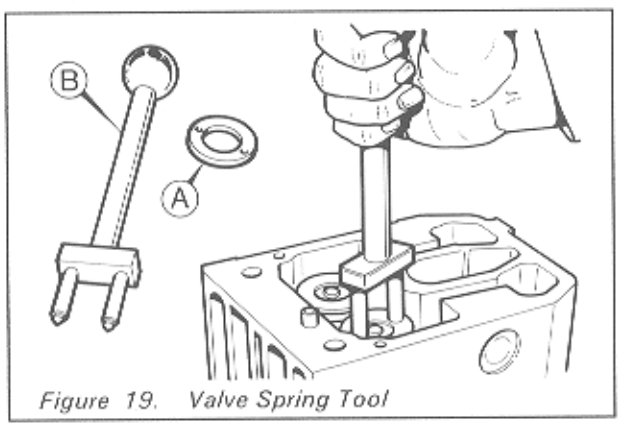


Figure 19. Valve Spring Tool

8. Push down on the tool until the collets can be removed.
9. Gently release the tool and remove the carrier, valve stem shield, valve spring and oil seal from the valve stem.
10. Turn the cylinder head over and remove the valve.

Fitting a Valve

Assemble the valve in the reverse order ensuring the collets are securely in position with their tops slightly sunk in the valve spring carrier.

Take care to ensure the valve stem oil seal is correctly fitted.

VALVE GUIDES

The valve guides are marked 'IN TOP' and 'EX TOP' (inlet or exhaust valve guide, top position) and are a press fit into the two halves of the cylinder head assembly.

A valve stem seal, 'O' sealing ring and plate are fitted to the inlet guide.

After coating the outside of the valve guides with Wellseal they should be pressed into their correct positions with the markings uppermost and pointing towards the opposite guide.

Valve Guide Protrusions

When the guides are refitted they must project above the top plate by the dimensions shown in the table. The dimensions will be correct if the service tool and depth stops are correctly used.

		Protrusion
LT Inlet and Exhaust	mm	12,35-12,60
	in	0,486-0,496
LV Inlet	mm	10,15-10,40
	in	0,400-0,409
LV Exhaust	mm	13,15-13,40
	in	0,518-0,528

Removing Valve Guides

1. Remove the cylinder head.
2. Remove the valve.
3. Remove the inlet valve guide oil seal.
4. Preferably place the cylinder head on its side in a soft jawed vice.
5. Screw the correct mandrel (B) into the tool (D).
6. Place the sleeve (C) onto the tool.
7. Fit the bevelled adaptor (E) into the sleeve (C) and locate the bevel into the valve seat.
8. Locate the mandrel through the guide.
9. Screw the small threaded sleeve (A) onto the mandrel.
10. Holding the sliding handle firmly to prevent rotation, turn the double handled lever clockwise until the guide is withdrawn through the head.
    If it is found difficult to start moving the guide a sharp tap with a copper hammer should break the seal

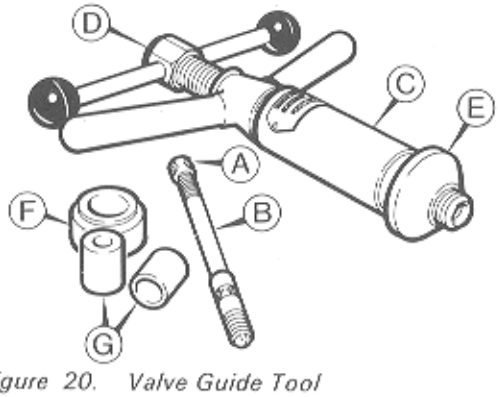


Figure 20. Valve Guide Tool

Fitting Valve Guides

Before refitting coat the outside diameters of the guide with Wellseal.

1. Fit the correct mandrel into the valve guide hole from the valve rocker end.
2. Place the valve guide over the mandrel in the top plate.
3. Place the correct depth stop (G) over the mandrel and screw on the threaded sleeve (A).
4. Fit the tool complete with the bevelled adaptor (E) onto the mandrel.
5. Hold the sliding handle firmly, to prevent it rotating, and turn the double handled lever clockwise until the depth stop prevents any further movement.
   At this point the guide will protrude the correct distance above the cylinder head as given in the previous table.
6. Fit a new inlet valve guide oil seal.

THE VALVE SEATS

The valve seats are cast iron inserts which are pressed into position to ensure they bed on the bottom of the recess in the cylinder head. Before pressing in the inserts the head should be heated to a maximum of 120°C (248°F) and the insert chilled in solid CO_2 (dry ice).

Valve Seat Widths

Valve		Width
Inlet	mm	1,65-2,29
	in	0,065-0,090
Exhaust	mm	1,65-2,01
	in	0,065-0,079

Valve Depths

The valves are pre-finished and no lapping or further processing is required and the seats are precision ground to allow the valves to lay below the combustion surface of the head by the figures given below.

Valve		Depth
Inlet	mm	1,00-1,31
	in	0,039-0,051
Exhaust	mm	1,10-1,41
	in	0,043-0,055

Note:
On early engines the inlet valve depth was 0,84-1,15mm (0,033-0,045in), this has been superseded by the above figures and the early seat width must be ground to the new dimensions.

Valve Seat and Recess Cutting

1. Fit the correct adjustable mandrel (A) into the valve guide and turn the adjuster until the flutes just bind onto the guide.
2. Select the necessary cutting tool (B) and assemble it to the handle (C).
3. Place the cutter over the mandrel and adjust the three individual blades by using the Allen Key (D).

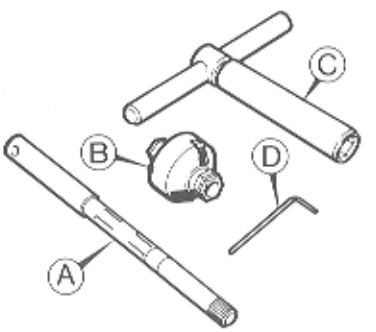


Figure 21. Valve Seat/Recess Tool

4. Rotate the tool in a clockwise direction until the valve seat or recess finish is satisfactory. Care must be taken to ensure an even, gentle downward pressure is applied when using the cutter to prevent the removal of too much metal.

⚠ CAUTION
The valve guide will be damaged if the mandrel is adjusted too much when it is located in the guide.

THE GEAR END COVER

The light alloy end cover is located on two dowels and is secured to the crankcase by six setscrews and washers and carries the oil filler neck.

Various end covers, depending on engine and build, are available and these are shown in the Parts List.

One of the engine mounted fuel tank brackets is secured by the top right hand side end cover setscrew.

The cover oil seals are of the lip variety and on LV engines a plain bush is fitted in the cover boss to support the starting handle when it is used. A joint is fitted between the end cover and the crankcase face.

The oil seal tool, 317-50098, should be used to protect the oil seal when the end cover is either removed or replaced. The same tool can also be used to remove and replace the seal in the end cover.

⚠ CAUTION

Early engines were fitted with a paper gear end cover joint which can be replaced with the later thicker type provided the camshaft end float is checked and adjusted as necessary.

Removing the End Cover - LT

1. Sufficiently slacken the Allen screw (A) in the starting dog (B) and slide the dog off the shaft.

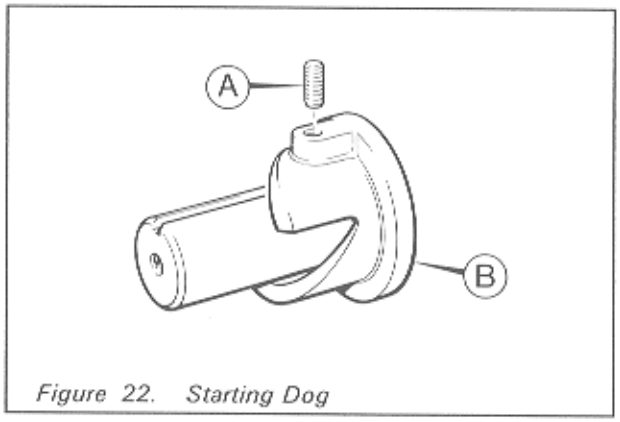


Figure 22. Starting Dog

2. Remove the starting dog key from the shaft keyway.
3. Fit the Service Tool into the end cover to protect the seal.
4. Remove the retaining bolts.
   On engines fitted with a hydraulic pump an extra end cover retaining bolt is fitted behind the pump mounting flange and it must be removed before attempting to remove the end cover.
5. Remove the end cover.
6. Clean all traces of the old joint from the crankcase and cover.
7. If necessary push out the oil seal by using the oil seal tool or a suitable plug press.

Removing the End Cover - LV

1. Remove the plastic dustcap in the end cover boss.

On early engines

a. Turn the crankshaft until the spring pin (A) of the starting handle catch pin (B), in the camshaft is visible through the hole in the cover boss.

b. Tap out the pin (A) with a suitable punch.

c. Turn the engine through 90° and drift out the starting handle catch pin (B).

On later engines

d. Remove the grub screw (A) from the end of the camshaft.

e. Drift out the pin (B).

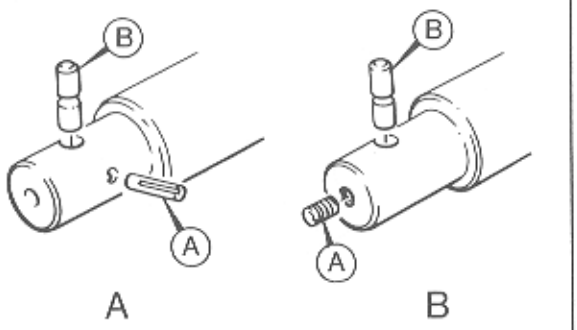


Figure 23. Starting Handle Pin:
A - Early Engines
B - Later Engines

2. Insert the oil seal tool into the end cover to protect the seal.

3. Remove the retaining bolts.
On engines fitted with a hydraulic pump an extra end cover retaining bolt is fitted behind the pump mounting flange and it must be removed before attempting to remove the end cover.

4. Remove the end cover.

5. Clean all traces of the old joint from the crankcase and cover.

6. If necessary push out the oil seal by using the oil seal tool or a suitable plug press.

Fitting the End Cover - LT, LV

1. With the crankcase and end cover joint faces clean and dry fit a new joint.

2. Fit the oil seal tool into the outside of the oil seal.

3. Replace the end cover, taking care to ensure the new joint is not damaged and the cover is correctly fitted over the dowels.

4. On LT engines replace the starting dog key, dog and tighten the Allen screw.

5. On LV engines replace the catch pin and spring pin or grub screw.

6. Check the camshaft end float as described in "Checking Camshaft End Float" on page 44.

THE END COVER OIL SEAL

1. Place a new seal into the outside neck of the end cover, lip side first, and position it squarely on the shoulder of the seal boss.

2. Using the oil seal tool, 317-50093, press the seal into position within the oil seal housing boss until it is flush with the inside face of the boss.
In an emergency, if the tool is not available, a suitable hard wood plug could be used.

3. Push the seal tool into the seal from the cover outside face.

4. Oil the sealing lip before fitting the end cover.

THE GOVERNOR AND FUEL PUMP

The fuel system is fully covered in "Section 4" and the governor in "Section 5" and the following paragraphs are included only to describe the dismantling and assembly procedures.

Dismantling the Governor and Fuel Pump

1. Remove the gear end cover.
2. Remove the fuel pump inspection door/s.
3. Disconnect the fuel pump and governor linkage at the fuel pump using long nosed pliers.
4. Slacken off the speed control screw and then disconnect the speeder spring.
5. Remove both fulcrum pins from the pivot support blocks using a 1.5mm rod, punch or a suitable piece of stiff wire. Take great care not to lose the shims.
6. Remove the governor lever assembly complete with the speeder spring and fuel pump linkage.
7. Remove the governor sleeve assembly.
8. Lift out the fuel pump/s, taking care not to lose the timing shims.

Assembling the Governor and Fuel Pumps

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

a. The fulcrum pins are drilled at one end only and these holes must be fitted at the outer end.

b. Ensure the governor sleeve is fitted the correct way if it is not the Nylatron type.

c. The speed control spring is correctly hooked into its spigot.

d. The small return spring, which is only fitted to variable speed engines, must be fitted to the fuel pump side end of the lever assembly with the short tail wound backwards and held captive under the pivot support block.

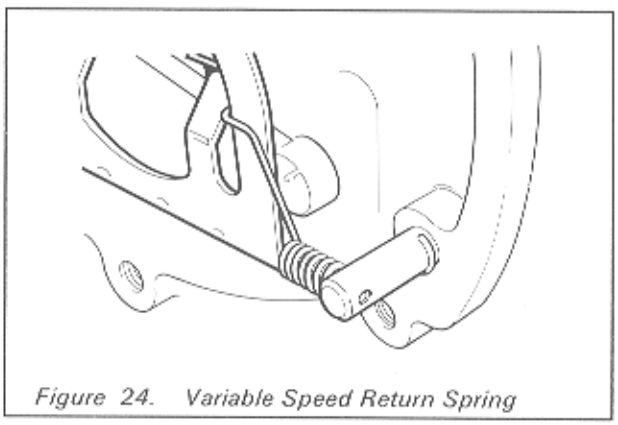


Figure 24. Variable Speed Return Spring

e. Check that the governor lever assembly is perfectly free to move.

f. All shims are replaced as dismantled - subject to checking pump spill timing and adjustments.

REMOVING A FUEL PUMP TAPPET

1. With the fuel pump removed use long nosed pliers to remove the tappet insert (A) from the top of the tappet assembly (B).
2. Lift out the fuel pump tappet assembly from the guide (C).
3. Remove the guide locating bolt (D) from the fuel pump side of the crankcase.
4. Remove the tappet guide.

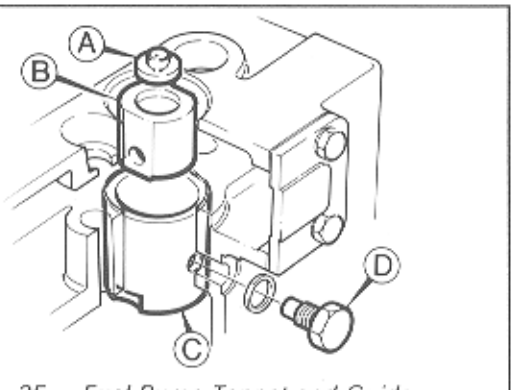


Figure 25. Fuel Pump Tappet and Guide

Replacing a Fuel Pump Tappet

1. Replace the guide into the crankcase taking extreme care to ensure the end with the two flats enters first and the locating holes in the crankcase and guide are correctly aligned.
2. Replace the guide locating bolt and a new copper washer.
3. Replace the tappet.
4. Replace the tappet insert with the smaller section on the outside.

⚠ CAUTION

Failure to fit a correct new washer to the guide locating bolt may allow the bolt to touch the tappet and prevent it operating.

THE OIL SUMP

The sump is manufactured from cast iron and is secured to the crankcase by fourteen bolts and spring washers; the four corner bolts are longer than the remainder. The integral engine mounting bolt drillings are located on each corner of the sump.

An oil strainer is fitted inside the sump on LT/LV2 engines.

⚠ CAUTION

With the sump removed and the flywheel housing still in position the engine cannot be turned the correct way up, and remain stable, without a suitable piece of wood the same depth as the sump is fitted under the crankcase.

Draining and Filling the Sump

1. If possible run the engine immediately before draining the oil.
2. Place a suitable container under the drain plug.
3. Remove the plug.
4. Clean and coat the threads of the drain plug with Hylomar PL32/M, Loctite 572 or Hylogrip 760.
5. Replace the drain plug; do not overtighten it.
6. Fill the engine crankcase through the oil filler to the top mark on the dipstick - do not overfill.
7. Start the engine and run it for a few minutes to circulate the oil and check the drain plug does not leak.
8. Stop the engine and allow time for the oil to settle and re-check the level on the dipstick.
9. Add more oil if necessary.

Removing the Sump

1. Remove the drain plug from the sump and drain the oil into a suitable receptacle.
2. Remove the oil dipstick.
   A polypropylene handled dipstick is currently fitted; refer to "The Oil Dipstick" in "Section 3".
3. Stand the engine on its flywheel using a suitable piece of wood or similar material on which to rest the flywheel; this will enable the engine to be rotated and ease subsequent dismantling.
4. Remove the sump bolts.
   As the bolts are removed from the sump the oil pump will move it away from the crankcase.
5. Remove the sump taking care not to damage the oil pump.

Replacing the Sump

1. Using a new joint, replace the sump with the recess corner adjacent to the oil pump.
2. On LT/LV2 engines replace the four long corner bolts finger tight.
3. Replace the remaining bolts and torque all the bolts to 27,0Nm (20,0lbf ft).
4. Coat the threads of the drain plug with Hylomar PL32/M or Three Bond 1110B and replace it; do not overtighten.
5. Fill the sump to the correct level with the correct grade and type of lubricating oil.

THE LUBRICATING OIL STRAINER - LT/LV2

The sumps are fitted with a coarse lubricating oil strainer on the suction side of the oil pump and access to it is gained by removing the sump.

The strainer can be dismantled by removing the centre setscrew, lifting off the top cap and lifting out the strainer mesh.

Care must be taken to ensure that rags are not used to wipe the inside of the crankcase during overhauls to eliminate the possibility of fluff entering the strainer and causing a restricted oil flow.

Note - Early Engines:
On re-assembly take care to replace the distance piece under the top plate and ensure that the anti-surge plate on the strainer is parallel to the crankcase web.

THE LUBRICATING OIL PUMP

Access to the self-regulating oil pump is only possible with the sump removed.
Some components of the LT and LV pumps are not interchangeable; refer to the relevant Parts List for further details.

Instructions for removing the oil pump are given in "The Lubricating Oil Pump" on page 72.

THE CAMSHAFT

The steel camshaft is carried in plain bearings in the crankcase at both the flywheel end 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 and carries the governor weights.

Cams on the camshaft operate the valve tappets, oil pump, fuel pumps and the fuel lift pump.

Details regarding the governor weights are detailed in "Section 5".

Removing the Camshaft

1. Remove the cylinder head, push rods and tubes.
2. Remove the sump.
3. Remove the oil pump.
4. Remove the end cover.
5. Remove the governor sleeve, lever and linkage.
6. Remove the fuel pump/s, pump tappet(s) and guide(s).
7. If the engine is in its normal plane hold the cam followers clear of the camshaft using suitable clips or magnets.
8. Gently ease the camshaft out of the crankcase keeping it square at all times.
9. Remove the cam followers.

Inspection of the Camshaft

a. Examine the camshaft bush for scars or wear.

b. Examine the ball race bearing for wear and freedom of movement.

c. Check the camshaft gearwheel and crankshaft pinion teeth for wear.

d. Ensure the cams are not chipped or damaged.

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

f. Examine the oil seal in the end cover for damage or wear.

Note:

On and after the following engine numbers helical toothed crank and camshaft pinion gears have been fitted, therefore the early straight spur toothed gears can only be replaced as a pair.

36 01614 LT1
36 00450 LV1
36 00232 LV2

Replacing the Camshaft

1. Replace the cam followers and secure them in their highest positions.
2. Carefully replace the camshaft into the crankcase keeping it square at all times; take care to line up the 'O' timing marks on the crankshaft and camshaft gears exactly.

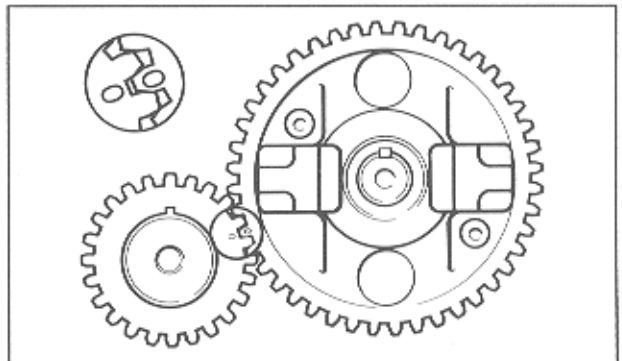


Figure 26. Timing Marks

3. Release the cam followers.
4. Replace the oil pump and sump.
5. Replace the fuel pump and governor.
6. Replace the gear end cover.
7. Replace the cylinder head.

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 float of 0,08-0,2mm (0,003-0,008in) which is measured with a clock gauge with the end cover fitted.

1. Using a rod through the oil filler hole push the camshaft fully towards the flywheel.
2. Position a clock gauge and zero the pointer.
3. Push the camshaft gearwheel towards the gear end by inserting a suitably cranked rod through the fuel pump inspection door: the movement recorded on the gauge is the end float.

The shims available are 0,13mm, 0,25mm, 0,38mm, 0,51mm 0,63mm and 0,76mm (0,005, 0,010, 0,015, 0,020, 0,025 and 0,030in) thickness but only one shim of the necessary thickness must be used.

⚠ CAUTION

Excessive camshaft end play affects the governing and can cause uneven firing.

Early engines were fitted with a paper gear end cover shim which can be replaced with the later thicker type provided the camshaft end float is checked and adjusted as necessary.

THE CAMSHAFT GEARWHEEL

Removing the Camshaft Gearwheel

1. Drift pin (A) into the camshaft (B) until it clears the gearwheel (C).
2. Press off the gearwheel sufficiently to allow a thin metal washer to be placed between the bearing (D) and the gearwheel to prevent dirt entering the bearing.
3. Continue to press off the gear.
4. Remove The Woodruff key (E).
5. Drift pin (A) out of the camshaft (B) using a small drift.

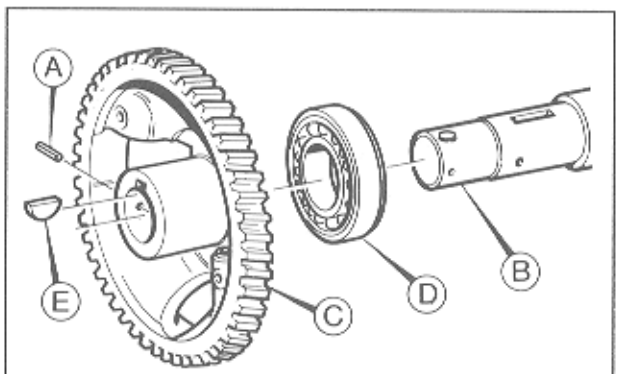


Figure 27. Camshaft Gearwheel

Fitting the Camshaft Gearwheel

On re-assembly a new dowel pin must be carefully pressed in to 1mm below the diameter of the gearwheel hub and any sharp edges around the hole must be removed - any burrs will affect the operation of the governor thrust sleeve. Fit the camshaft gearwheel in the reverse order to dismantling ensuring the thin flat washer is removed and that the gearwheel abuts against the shoulder (F).

⚠ CAUTION

Ensure no pressure is applied to the outer ring of the gear at any time.

Changing the Camshaft Ball Race

1. Remove the retaining pin from the gearwheel hub.
2. Support the camshaft assembly on the hub of the ball race and push the camshaft through the gearwheel and bearing.
3. Press the new bearing on to the camshaft.
4. Fit a new key to the camshaft.
5. Press on the gearwheel.
6. Refit the retaining pin.

CAMSHAFT BUSHES

A new bush should be immersed in clean engine lubricating oil for four hours before fitting. A small identification dot is on one outside edge of the bush and on assembly this dot must be towards the top of the crankcase.
It is recommended that bushes are replaced as a set.

To gain access to the flywheel end expansion plug and bush it will be necessary to remove the flywheel, fanshroud and main bearing housing.

Camshaft Bush Tool 393235

The legend numbers referred to in the illustration and text are also marked on the individual tool items.

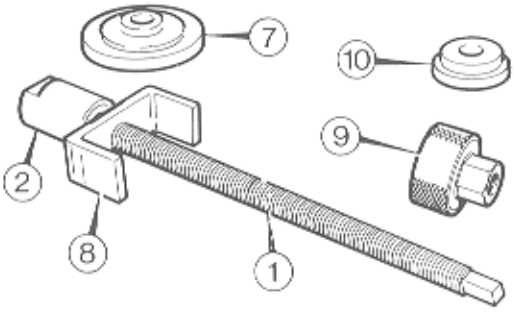


Figure 28. Camshaft Bush Tool

Flywheel End Bush Removal

1. Remove the flywheel end main bearing housing.
2. Fit the nut (2) onto the screw (1).
3. Fit the small dolly into the bush from inside the crankcase.
4. Place the screw through the dolly from the gear end.
5. Assemble the bridge (8) and thrust nut (9) to the screw
6. Using the correct size of spanner tighten the thrust nut until the bush is removed.
7. Remove the tool.

Flywheel End Bush Replacement

1. Fit the new lubricated bush to the small dolly.
2. With the dot on the bush at the top, place the dolly and bush into the crankcase from the inside and line up the bush with its location.
3. Fit the nut (2) onto the screw (1).
4. Place the screw through the dolly from the gear end.
5. Place the guide (10) over the screw to align the bush in the housing.
6. Fit the bridge (8) and thrust nut (9).
7. Using the correct size of spanner and checking the tool and bush alignment very carefully, tighten the thrust nut until the bush is central across its housing.
8. Remove the tool.

Centre Bush Removal

1. Fit the nut (2) onto the screw (1).
2. Fit the large dolly into the bush.
3. Place the screw through the dolly from the end giving the maximum protrusion of the screw outside the crankcase.
4. Fit the bridge (8), or the depth plate (7).
5. Fit the thrust nut (9) to the screw.
6. Using the correct size of spanner tighten the thrust nut until the bush is removed.
7. Remove the tool.

Centre Bush Replacement

1. Fit the new lubricated bush to the large dolly.
2. Fit the nut (2) onto the screw (1).
3. With the dot on the bush at the top, place the dolly and bush into the centre web housing and align the bush by using guide the (10).
4. Place the screw through the dolly and place the guide (10) over the screw to align the bush in the housing.
5. Assemble the bridge (8), or the depth plate (7).
6. Fit the thrust nut (9) to the screw.
7. Using the correct size of spanner and checking the tool and bush alignment very carefully, tighten the thrust nut until the bush is central across its housing.
8. Remove the tool.

THE CYLINDER BARREL

Before removing any cylinder barrel it should be marked to ensure it is returned to its original position.

It is possible to remove the cylinder barrel, after the head has been removed, without the need to remove the sump provided the piston is in the TDC position.

The following instructions apply in cases of additional dismantling.

Removing the Cylinder Barrel

1. Stand the engine on its flywheel on a suitable piece of wood so that the crankcase can be turned.
2. Remove the cylinder head and sump.
3. Place a retaining tube, secured by a hand tight cylinder head nut, over one stud of the cylinder to prevent the cylinder rising when the crankshaft is turned.
4. With the engine standing on the flywheel rotate the engine until the connecting rod big end is at the bottom of the throw.
5. Remove the big end bearing cap.
6. To protect the crankshaft journal fit a tube over each connecting rod bolt and secure them with a hand tight nut.
7. Rotate the engine until the piston is at TDC.
8. Remove the tube securing the barrel.
9. Lift off the barrel, piston and connecting rod complete.
10. Remove the tubes from the big ends.
11. Replace the big end bearing cap.
12. Remove the piston from the cylinder barrel.
13. Thoroughly clean the cylinder barrel and check for scoring and wear.
14. Repeat the above procedure for LV2 engines.

Fitting the Cylinder Barrel

1. Fit the piston to the connecting rod with the wording 'MANIFOLD SIDE' on the piston to the same side as the identification marks on the connecting rod big end.
2. Insert the gudgeon pin and circlips.
3. Fit the piston rings in the order as detailed in "The Piston" on page 49.
4. Stagger the piston ring gaps and fit the piston into the cylinder barrel while compressing the piston rings.
5. If necessary, fit new big end bearing shells ensuring they are correctly located in both the connecting rod and cap.
6. Coat the bottom jointing face surface of the cylinder barrel with Wellseal, stick a new joint to it and coat the joint with Hylomar.
7. Stand the engine on its flywheel on a suitable piece of wood so that the crankcase can be turned.
8. Turn the crankcase until the crankshaft crankpin is at TDC.
9. To protect the crankshaft journal from possible damage fit a tube over each connecting rod bolt and secure them with a hand tight nut.
10. With the radiused fins towards the camshaft and manifold sides of the engine, and 'MANIFOLD SIDE' on the piston correctly positioned, lower the cylinder, piston and connecting rod into position.

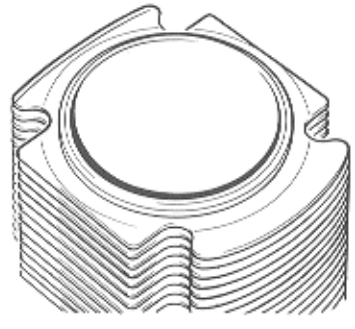


Figure 29. Cylinder Barrel Radiused Fins

11. Slide the air shields into position taking extreme care to ensure they are in their original positions as shown in Figure 10 on page 27.
12. Push down on the piston and turn the crankcase until the connecting rod big end is at BDC.

13. Remove the protection tube.

14. Fit the bearing cap, ensuring the identification marks on the cap and connecting rod are on the same side, and torque load the nuts to 24,4Nm (18,0lbf ft). It is recommended that the connecting rod bolts and nuts are replaced at every major overhaul.

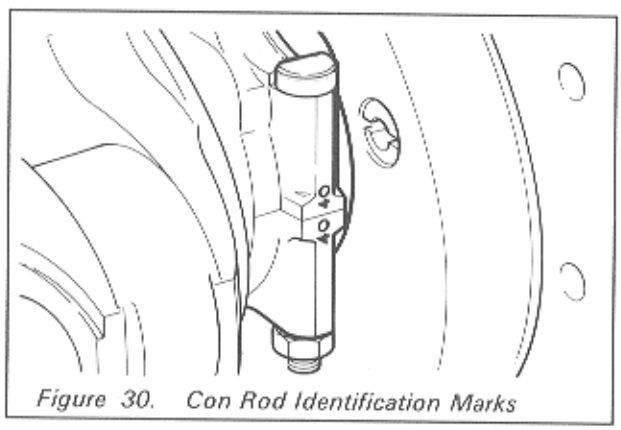


Figure 30. Con Rod Identification Marks

⚠ CAUTION

Care must be taken to ensure the connecting rod bolt head is correctly positioned with the head flat against the shoulder on the rod as shown in Figure 31.

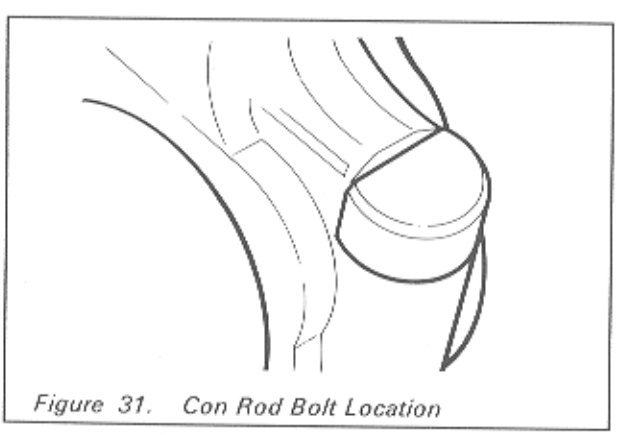


Figure 31. Con Rod Bolt Location

CLEANING THE COOLING FINS

The cylinder and cylinder head fins must be kept reasonably clean otherwise seizure of various components can occur because of overheating. Cleaning frequency depends on the nature and concentration of the substances contained in the cooling air; fluff, hair, vegetable fibre, and other such items have a greater clogging effect than dry dust. The fins should always be cleaned when the engine is decarbonised but can also be cleaned, when necessary, by removing the manifold and air cowl and raking the dust off the fins with a hooked piece of wire.

THE PISTON

The piston is manufactured from low expansion alloy and has a machined recessed combustion chamber in the crown. LT pistons are fitted with four rings and LV pistons have three rings.

The gudgeon pin is retained by two circlips and runs in a bush in the small end of the connecting rod.

Removing a Piston

1. Remove the cylinder barrel together with the piston.
2. Withdraw the piston from the barrel.
3. Release the circlip from one end of the gudgeon pin.
4. Push out the gudgeon pin.
   If the pin is tight, place the piston in hot water until it can be removed; it may be necessary to protect the hands.
5. Using a standard piston ring expander remove the piston rings.

Inspection and Servicing

1. Clean the piston removing all traces of carbon from the crown, ring grooves and oil holes.
2. Check all the piston rings for wear; refer to "Dimensions of Wearing Parts" on page 63.

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 Ring

Two compression rings are fitted to the LT piston and one on the LV. They have 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.

Oil Control Ring

One conformable type, with a spring expander, is fitted above the gudgeon pin and a slotted scraper ring is fitted below the gudgeon pin on LT pistons. On LV pistons only one ring is fitted above the gudgeon pin.

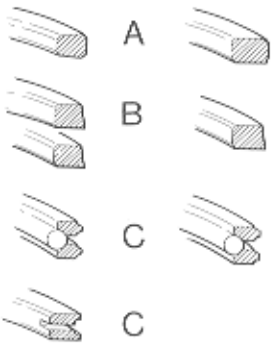


Figure 32. Piston Rings:
A - Firing Ring
B - Compression Ring
C - Oil Control Ring

Fitting a Piston

1. Fit the piston to the connecting rod with the wording 'MANIFOLD SIDE' on the piston to the same side as the identification marks on the connecting rod big end.
2. Insert the gudgeon pin and circlips.
3. Using a standard piston ring expander replace the piston rings in their correct order.
4. Distribute the piston ring gaps around the piston circumference so that the gaps are not in line.
5. Lightly lubricate the piston and rings with new engine oil.
6. Using a suitable piston ring clamp compress the rings and fit the piston and connecting rod assembly into the cylinder barrel.

THE CONNECTING ROD

The forged steel connecting rod is connected to the crankpin by a conventional big end bearing, the cap being held in position by two bolts and nuts.

The two halves of the big end bearing are steel backed copper lead and are precision finished and should not be scraped or touched up in any way. A new small end bush must be pressed in ensuring the oil holes align.

The gudgeon pin is a clearance fit in the small end bush.

Removing the Connecting Rod

Detailed instructions for removing and fitting the connecting rod are given in "The Cylinder Barrel" on page 47.

Inspection and Servicing

a. Clean the connecting rod and examine for bending and twisting.

b. Examine the small end bush for wear.

c. 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.

THE FLYWHEEL

The type of flywheel fitted depends on the engine, application and build.

The cooling air fan is fitted to either the outside or inside face and is polypropylene or cast depending on the type of flywheel fitted.

The flywheel is keyed on to the crankshaft and held in position with a setscrew torque loaded to 196,0Nm (145,0lbf ft).

All flywheels have tapped holes for attaching couplings, shaft extensions, pulleys etc. The tolerance for bore and face run-out must be within 0,25mm (0,010in) TIR.

On builds fitted with a flywheel charge winding system the magnetic rotor is pressed into the rear face of the flywheel.

To prevent damaging the stator, which is fitted to the main bearing housing, the free length of studs or bolts entering the flywheel must not exceed 20,0mm (0,79in).

⚠ WARNING

Some flywheels weigh a considerable amount therefore it is important to bear this point in mind when supporting, removing, moving or replacing it.

Removing the Flywheel

⚠ CAUTION

Before attempting to remove the flywheel setscrew determine the rotation of the engine.

1. Remove the starter motor, if fitted.

2. On LV engines fit the flywheel locking tool (A) into the tapped hole in the fanshroud. On LT engines, or if the flywheel locking tool is not available, wedge the crankshaft with a suitable piece of wood to prevent it turning.

3. Slacken the flywheel retaining setscrew two turns with a 46mm socket spanner.

4. Fit the flywheel puller tool (B) by screwing the three bolts through the plate 'B' holes into the flywheel.

5. Lightly oil or grease the tool centre bolt and screw it into the plate sufficiently to loosen the flywheel.

6. Remove the puller and locking tools.

7. Remove the flywheel setscrew and fit the flywheel mandrel (C) to prevent damaging the stator and for personal safety.

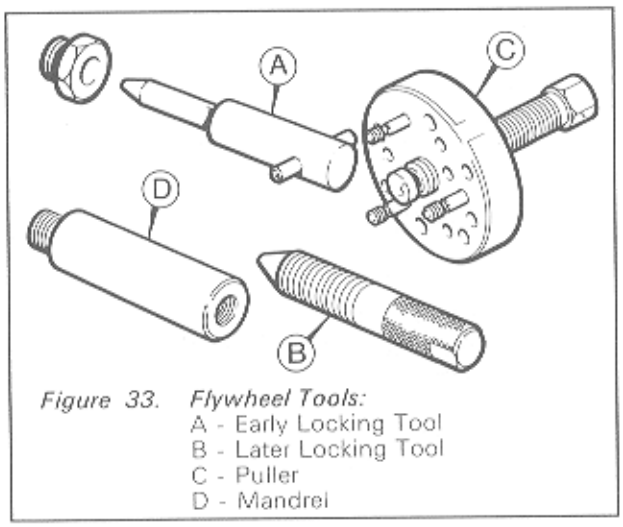


Figure 33. Flywheel Tools:
A - Early Locking Tool
B - Later Locking Tool
C - Puller
D - Mandrel

8. Support the flywheel at all times and, keeping it square, slide it over the mandrel and lift it off.

9. Remove the Woodruff key from the crankshaft.

Fitting the Flywheel

The shaft and the bore of the flywheel must be perfectly clean and should be smeared with clean lubricating oil before assembly.

1. Fit a new Woodruff key to the crankshaft.

2. Fit the flywheel mandrel to prevent damaging the stator and for personal safety.

3. Support the flywheel at all times and, keeping it square, slide it over the mandrel and onto the crankshaft.

4. Check that the key has remained in position in the shaft.

5. Remove the mandrel.

6. Replace the retaining setscrew finger tight.

7. Either fit the flywheel locking tool or wedge the crankshaft with a suitable piece of wood to prevent it turning.

8. Torque the setscrew to 196,0Nm (145,0lbf ft).

9. Remove the locking tool.

THE FANSHROUD

An aluminium or sheet metal fanshroud is fitted to all engines, except Build 32, and the type fitted is dependant on the engine type and build.

The fanshroud is secured to the crankcase with five setscrews and washers; cast fanshrouds are fitted with lockwashers.

Removing the Fanshroud

1. Remove the flywheel.

If flywheel charge windings are fitted:

a. Remove the two nuts and then remove the Synchro system rectifier/regulator cover.

b. Carefully noting the position of the electrical cables, disconnect all four cables.

c. Remove the two nuts, washers and distance pieces and remove the rectifier/regulator unit from the fanshroud.

d. Remove the cable clip securing the cable inside the fanshroud.

e. Remove the six screws securing the stator and as it is removed gently ease the cable through the fanshroud.

2. On engines with an aluminium fanshroud ease back the six tab washers.

3. Remove the six retaining bolts.

4. Lift off the air restrictor, if fitted, and the fanshroud.

Fitting the Fanshroud

Refitting is carried out in the reverse order and it is recommended that new tabwashers are fitted and correctly locked after the bolts have been torque loaded to 27,0Nm (20,0lbf ft).

THE MAIN BEARING HOUSING

The main bearing housing is secured to the crankcase at the flywheel end and has an oil drain which must be located at the bottom of the housing when it is refitted. Shims are fitted between the housing and the crankcase to maintain the crankshaft end float. An oil seal is fitted to the centre bore of the housing and an 'O' ring is fitted in the side of the bearing housing to provide a seal between the housing and bearing oil feed drilling in the crankcase.

If the crankshaft is moved with the main bearing housing removed the 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 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 while removing the housing turn the engine until the piston, No. 1 piston on LT/LV2 engines, is at the BDC position.

Removing the Main Bearing Housing

1. Remove the flywheel.
2. Remove the stator, if fitted.
3. Remove the six bolts securing the main bearing housing.
4. Remove the bearing housing.
   If the housing is tight:
   a. On LT/LV2 engines remove the centre bearing dowel bolt and the dowel using a fuel pump retaining bolt; refer to the 'Warning'
      Leave the bolt in the dowel until it is refitted to ensure the dowel is fitted the correct way round.
   b. On all engines use two M8 setscrews through the threaded holes provided in the housing and jack it off.
      To avoid possible damage do not use a screwdriver.
5. Drift out the oil seal taking care not to damage the bearings.

⚠ CAUTION

Failure to remove the centre bearing dowel may result in it becoming distorted making it very difficult to remove at a later stage.

Fitting the Main Bearing Housing

1. Lightly grease the steel back of the thrust washers and position them in the housing, ensure they are correctly located and the copper face will be towards the crankshaft.
2. With the oil seal removed from the main bearing housing refit the housing.
3. Replace the housing, shims, stator and restrictor plate, if fitted, and torque the bolts to 27.1Nm (20.0lbf ft).
4. Check the crankshaft endfloat as described in "Checking Crankshaft Endfloat" on page 56.
5. Replace the oil seal using the Service Tool.
6. Replace the centre bearing locating dowel with the tapped end facing outwards.
7. Check the wire end of the centre bearing locating dowel bolt for distortion.

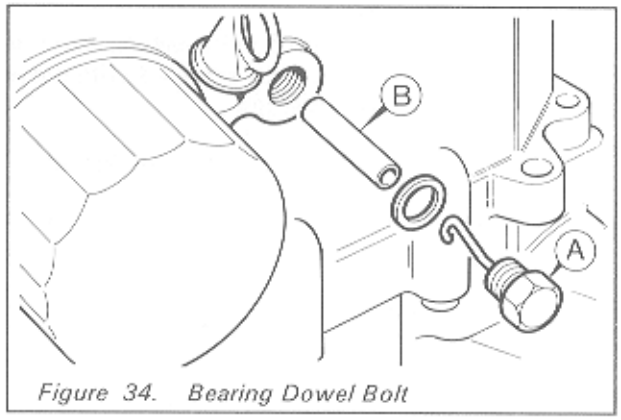


Figure 34. Bearing Dowel Bolt

8. Replace the bearing dowel bolt.

THE MAIN BEARING OIL SEAL

1. Lubricate the sealing lip with clean engine oil.
2. Place the new seal squarely into the housing; do not use any jointing compound.
3. Drive in the seal until it is flush with the bearing housing outside face.

GEAR END CRANKSHAFT EXTENSION

One of four types of gear end extension shafts may be fitted:

a. SAE No 6 shaft.
b. SAE No 9 shaft.
c. Non SAE shaft A.
d. Non SAE No 4.

The shaft must be correctly torque loaded to 138,0Nm (102,0lbf ft).

Crankshaft Extension Spanner 317-50023

The tool is used when it is not possible to torque direct at the gear end with the flywheel locked.

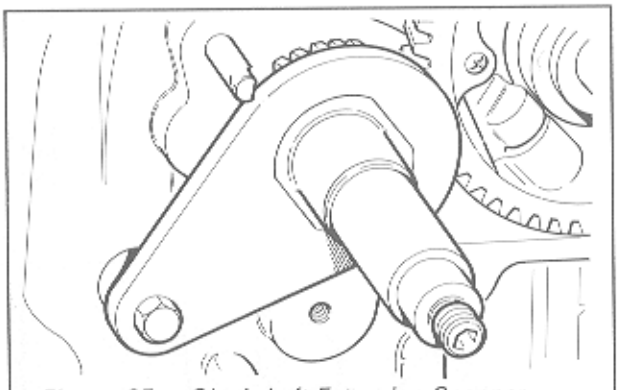


Figure 35. Crankshaft Extension Spanner

1. Fit the tool onto the extension shaft and screw the bolt through the boss into the crankcase.
2. With the engine decompressed turn the flywheel using a 46mm socket fitted on the flywheel setscrew.
3. Remove the tool.
4. Fit the flywheel locking tool.
5. Re-torque the flywheel setscrew to 197,0Nm (145,0lbf ft).

If the Service Tool is not available apply the 138,0Nm (102,0lbf ft) torque to the flywheel setscrew with the engine decompressed and then with the flywheel locked re-torque the flywheel setscrew to 197,0Nm (145,0lbf ft).

Fitting a Gear End Shaft

1. Screw the shaft onto the crankshaft handtight.
2. Fit the crankshaft extension tool, 317-50023, as shown in Figure 36.

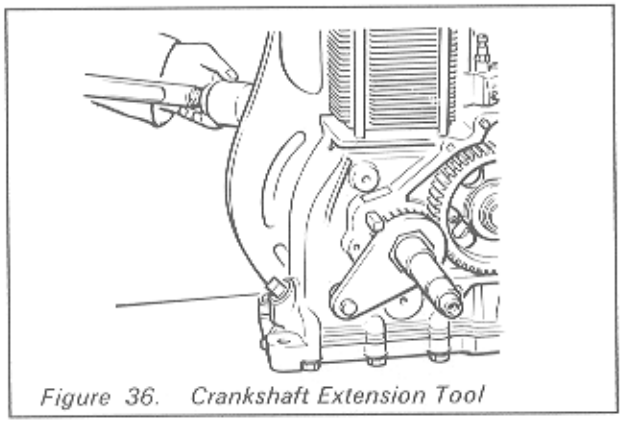


Figure 36. Crankshaft Extension Tool

3. Move the decompressor lever towards the flywheel end.
4. Tighten the extension by turning the flywheel nut to a torque of 138,0Nm (101,0lbf ft).

THE CRANKSHAFT

The steel forging crankshaft is carried in steel backed copper faced main bearings which are located in the crankcase at the gear end, the flywheel end and the central web/s of the crankcase. End thrust is taken on steel backed copper faced split thrust washers fitted at the gear end of the crankcase and in the flywheel end main bearing housing.

An interference fit pinion is keyed onto the end of the crankshaft and engages with the camshaft gear.

On and after the following engine numbers helical toothed crank and camshaft pinion gears have been fitted. The early and LT2 straight spur toothed gears can only be replaced as a pair.

36 01614 LT1
36 00450 LV1
36 00232 LV2

LV crankshafts are fitted with balance weight plates held in position with two countersunk screws and nuts torque loaded to 21,0Nm (15,5lbf ft).

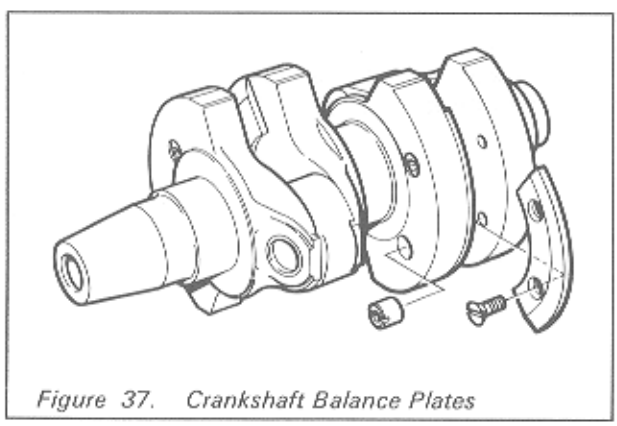


Figure 37. Crankshaft Balance Plates

Removing the Crankshaft

1. Remove the cylinder barrel/s, main bearing housing and sump.

On LT/LV2 engines

a. Remove the centre bearing locating dowel bolt (A).

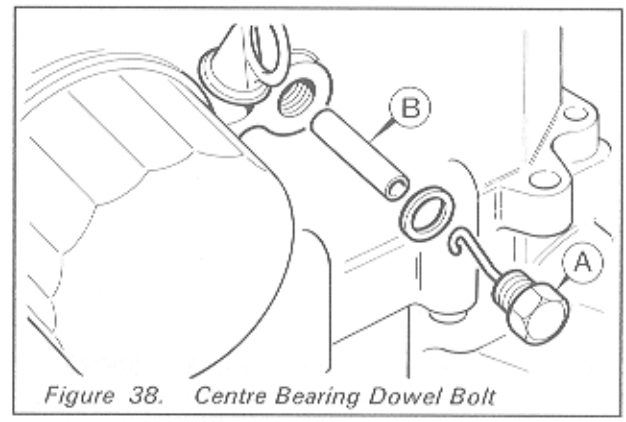


Figure 38. Centre Bearing Dowel Bolt

b. Using a fuel pump securing bolt remove the centre bearing dowel (B). Leave the bolt in the dowel until it is refitted to ensure the dowel is fitted the correct way round.

2. Fit the Service Tool 317-50025 to the pinion gear, lightly oil or grease the centre bolt and tighten it until the crankshaft is pushed through the pinion gear.

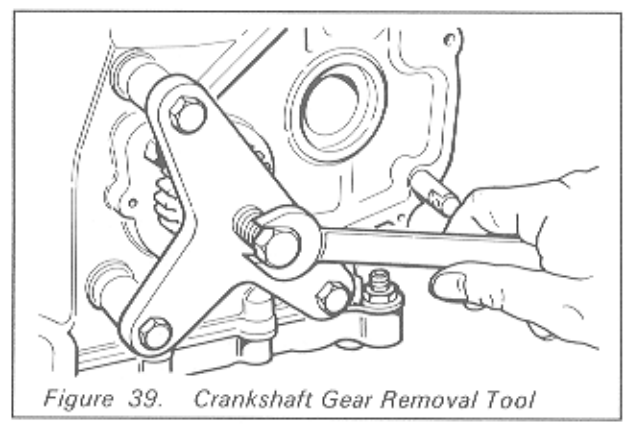


Figure 39. Crankshaft Gear Removal Tool

3. Remove the pinion gear Woodruff key if necessary.

4. Keeping the crankshaft square at all times gently withdraw it through the flywheel end of the crankcase.

5. Remove the two socket screws and dismantle the centre bearing housing on LT/LV2 crankshafts.

6. Remove the gear end thrust washers.

Servicing the Crankshaft

a. Inspect the main bearings for scoring or wear and if necessary they can be removed and replaced as described in "Crankshaft Main Bearings" on page 57.

b. If the connecting rod 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.

c. Check the clearance between the crankshaft and journals, the main bearings and crankpins and also the connecting rod bearings.

d. Renew the split thrust washers if they are damaged or worn.

Fitting the Crankshaft

1. If necessary fit new bearing shells to the main bearing housing, centre bearing housing and the gear end crankcase main bearing.

On LT/LV2 engines

2. Re-assemble the centre main bearing housing around the crankshaft ensuring the socket screws are torque loaded to 27,0Nm (20,0lbf ft).
Ensure 'Flywheel End' on the housing halves is correctly located before assembly.

3. Apply grease to the steel side of the thrust washers and place them in the gear end of the crankcase with the tab correctly located and the copper face towards the crankshaft.

4. Offer up the crankshaft, lining up the centre bearing to ensure the dowel hole is in the correct position.

5. With the fuel pump bolt inserted in the centre bearing dowel, insert the dowel through the crankcase wall and into the centre bearing housing; ensure the dowel has gone fully home and that is not fitted into the bearing housing capscrew head hole.

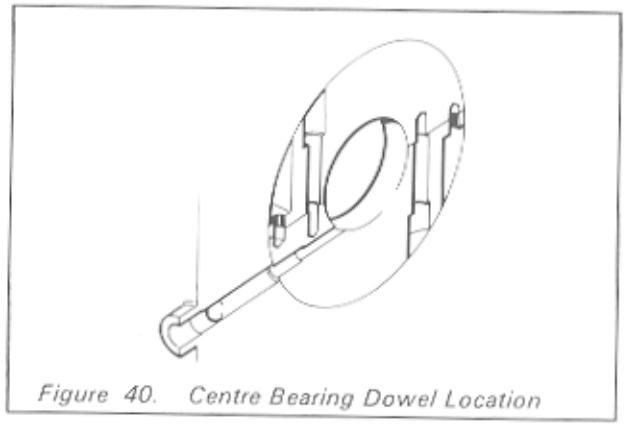


Figure 40. Centre Bearing Dowel Location

6. Remove the fuel pump bolt from the dowel.

7. Check the wire end of the centre bearing locating dowel bolt for distortion.

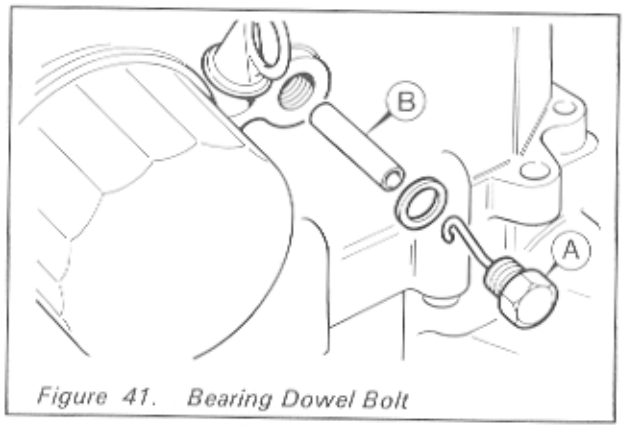


Figure 41. Bearing Dowel Bolt

8. Replace the dowel bolt.

On LT/LV1 engines

9. Apply grease to the steel side of the thrust washers and place them in the gear end of the crankcase with the tab correctly located and the copper face towards the crankshaft.

10. Replace the crankshaft through the flywheel end of the crankcase.

On all engines

11. Coat both sides of each bearing housing shim with Wellseal and fit them to the housing.

12. With the oil seal removed from the main bearing housing refit the housing, stator and restrictor plate if fitted and torque the bolts to 27,1Nm (20,0lbf ft). After the bearing housing has been replaced and the housing bolts torqued they must be re-torqued ten minutes later.

13. Check the crankshaft endfloat as described in "Checking Crankshaft Endfloat" on page 56.

14. Replace the oil lip seal.

15. Check that the crankshaft is free to rotate.

16. Fit the Woodruff key at the gear end.

17. Heat the crankshaft pinion to straw yellow and fit it to the crankshaft without delay ensuring the 'O' mark is facing outwards.
Insufficient heat or delay in fitting could well cause the pinion to become jammed on the crankshaft, whereas overheating may cause softening of the pinion.

18. Check the crankshaft end float.

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

CHECKING CRANKSHAFT ENDFLOAT

1. Set a dial test indicator so that the actuating plunger makes contact with the flywheel end face of the crankshaft.

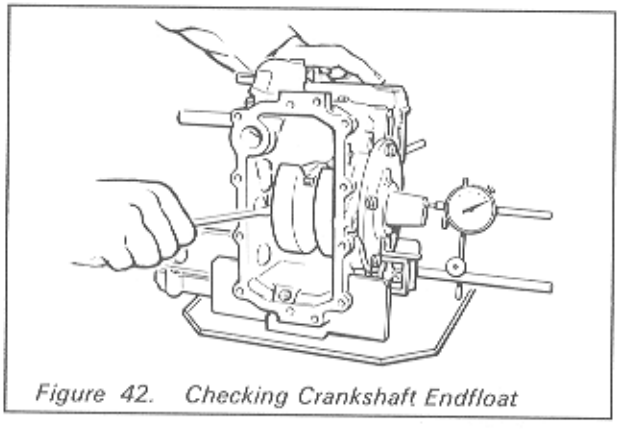


Figure 42. Checking Crankshaft Endfloat

2. Push the crankshaft firmly towards the gear end of the engine and zero the indicator.

3. Push the crankshaft firmly towards the flywheel end of the engine and check the end float, this should be:-
   LT/LV1 - 0,178-0,245mm (0,007-0,010in).
   LT/LV2 - 0,229-0,305mm (0,009-0,012in).

4. If the end float is incorrect it can be adjusted by the addition or removal of 0,076mm, 0,127mm or 0,254mm (0,003, 0,005, 0,010in) shims from the back of the bearing housing.
   After the bearing housing has been removed and replaced the housing bolts must be torqued to 27,0Nm (20,0lbf ft) and re-torqued ten minutes later.

Note:
Early LT engines were fitted with paper and 0,076mm (0,003in) metal shims which can be replaced with those given above provided the crankshaft endfloat is re-checked.

CHECKING BEARING CLEARANCE

1. Place a piece of the correct size Plastigauge approximately 6,35mm (0,25in) off-centre across the full width of one bearing shell.

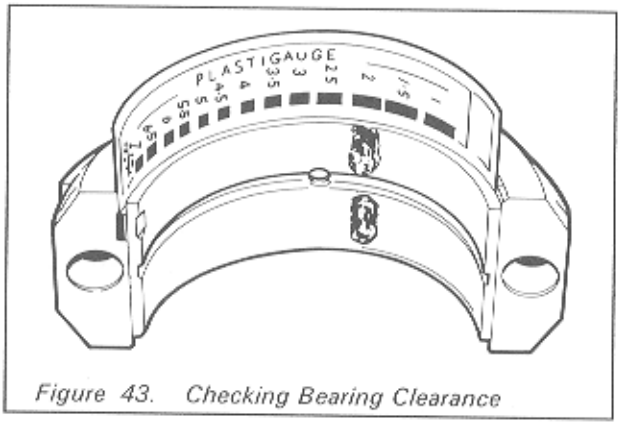


Figure 43. Checking Bearing Clearance

2. Replace the bearing and torque the bolts or nuts.

3. Remove the bearing shell and use the scale to check the width of the flattened Plastigauge.
   The width at the widest point establishes the minimum clearance and at the narrowest point the maximum clearance.
   The difference between the two readings is the journal to bearing clearance; refer to "Dimensions of Wearing Parts" on page 63.

⚠ CAUTION
The crankshaft must not be turned when the Plastigauge is in place, and all traces of it must be removed before final assembly of the bearing.

CRANKSHAFT MAIN BEARINGS

The legend numbers referred to in the illustration and text are also marked on the individual tool items.

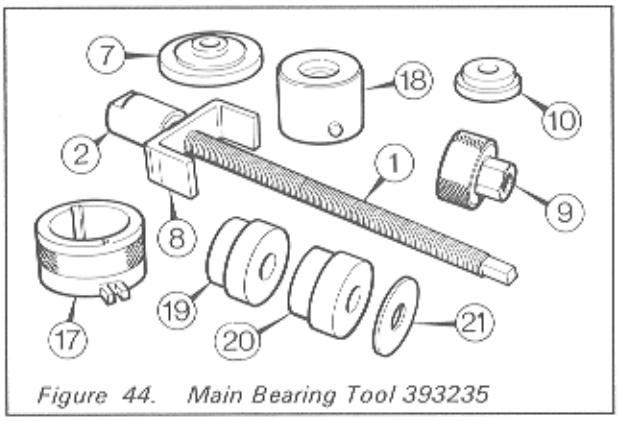


Figure 44. Main Bearing Tool 393235

Removing the Gear End Bearing

1. Fit the nut (2) onto the screw (1).
2. Place both dollies (19, 20) onto the screw with the tapered ends outwards and the large dolly (20) next to the nut (2).
3. Insert the assembly into the main bearing from inside the crankcase.
4. Fit the bridge (8) followed by the thrust nut (9) onto the screw (1).
5. Locate the bridge against the outside of the crankcase
6. Using the correct size of spanner tighten the thrust nut (9) until the main bearing shells are removed from the crankcase.

Fitting the Gear End Bearing

1. Remove the thrust washers from the crankcase.
2. Fit the nut (2) onto the screw (1).
3. Fit the depth plate (7) with the face marked 'G' next to the nut.
4. Place both halves of the new bearing into the sleeve (17) from the end opposite the locating spigot.
   Align the ends of the new bearings with the line on the sleeve and ensure the bearing oil hole is correctly lined up with the 'O' mark on the sleeve face.
5. Place the large dolly (20) with the taper outwards into the spigot end of the sleeve.
6. Fit the driver (18) into the other end of the sleeve, ensuring the guide dowel is positively located in the slot in the sleeve.
7. Place the sleeve assembly onto the screw assembly.
8. Fit the assembly into the crankcase from the inside making sure the sleeve spigot is positively located in the slot in the crankcase.
9. Place the bridge (8) and thrust nut (9) to the screw.
10. Using the correct size of spanner tighten the thrust nut (9) until the depth plate is tight to the sleeve.
    When the plate is tight to the sleeve the bearing shells are correctly located in the crankcase.
11. Remove the tool taking care to prevent it dropping onto the new bearing.
12. Check that the oil holes in the crankcase and bearings align.

Removing the Flywheel End Bearing

1. Remove the thrust washers and the oil seal from the bearing housing.
2. Fit the nut (2) onto the screw (1).
3. Hold the nut firmly across its flats in a vice.
4. Place both dollies (19, 20) onto the screw with the tapered ends outwards and the large dolly (20) next to the nut (2).
5. Fit the bearing housing on the screw with the thrust face uppermost.
6. Fit the bridge (8) followed by the thrust nut (9) onto the screw (1).
7. Using the correct size of spanner tighten the thrust nut (9) until the main bearing shells are removed from the bearing housing.
8. Remove the tool.

Fitting the Flywheel End Bearing

1. Fit the nut (2) onto the screw (1).
2. Hold the nut firmly across its flats in a vice.
3. Place both halves of the new bearing into the sleeve (17) from the end opposite the locating spigot.
   Ensure the tag on the top half of the new bearings faces outwards and is correctly located in the slot in the sleeve.
4. Place the large dolly (20) with the taper outwards into the spigot end of the sleeve (17).

THE ENGINE CONTROL ASSEMBLY

On current engines a polypropylene knob is fitted to the engine control lever. The control lever, plate (G) and spindle (F) shown in Figure 45 are only supplied as an assembly.

Removing the Automatic Excess Fuel Assembly

1. Remove the gear end cover.
2. Remove No.1 cylinder fuel pump inspection door.
3. Move the automatic excess fuel lever (B) along the shaft towards the outside of the crankcase and hold it in this position.
4. Remove the small dowel pin (C).
5. Remove the spring (D) from its location on the excess fuel lever.
6. Remove the excess fuel lever assembly (B) and spring (E) while withdrawing the control lever (F) and plate assembly (G).

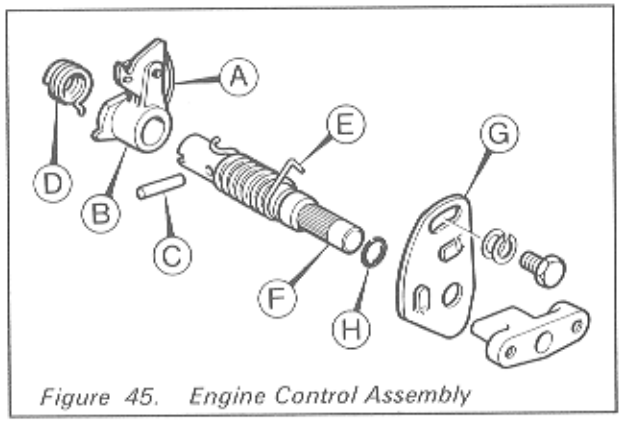


Figure 45. Engine Control Assembly

Fitting the Automatic Excess Fuel Assembly

1. Examine and renew the 'O' ring (H) if necessary.
2. Replace the cam spring (A), if removed, to the lever assembly (B).
3. Replace the control lever (F) and plate assembly (G) through the crankcase into the spring (E) and the excess fuel lever assembly (B)
4. Relocate the spring (D) on the excess fuel lever.
5. Move the automatic excess fuel lever (B) along the shaft towards the outside of the crankcase and hold it in this position.
6. Replace the dowel (C).
7. Replace the gear end cover.
8. Replace No.1 cylinder fuel pump inspection door.

Removing the Manual Excess Fuel Assembly

1. Remove the gear end cover.
2. Remove the fuel pump inspection door.
3. Move the automatic excess fuel lever (A) along the shaft towards the outside of the crankcase and hold it in this position.
4. Remove the nut and washer (B).
5. Remove the lever (A).
6. Remove the spring (C) from its location on the excess fuel lever.
7. Withdrawing the plate (C) and control lever assembly (D).

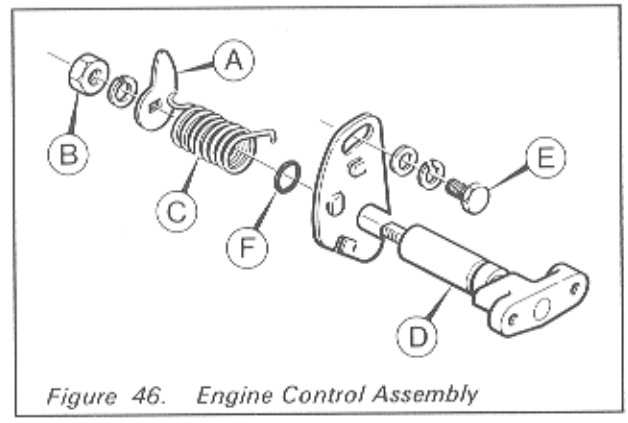


Figure 46. Engine Control Assembly

Fitting the Manual Excess Fuel Assembly

1. Examine and renew the 'O' ring (F) if necessary.
2. Replace the control lever assembly and plate.
3. Replace the spring (C) onto the control lever assembly.
4. Replace the lever (A) and nut.
5. Relocate the spring (C) on the lever.
6. Replace the gear end cover.
7. Replace the fuel pump inspection door.

THE SPEED CONTROL LEVER

On current engines a polypropylene knob is fitted to the external engine control lever.

The lever is fitted to the internal spindle on splines and to ensure the speed control is correctly re-fitted care must be taken to ensure the angle is 89°-91° when the speeder spring spigot is upright. When the lever is assembled it must be free to rotate.

The speeder spring locating hole in the spindle must be positioned as shown in Figure 47.

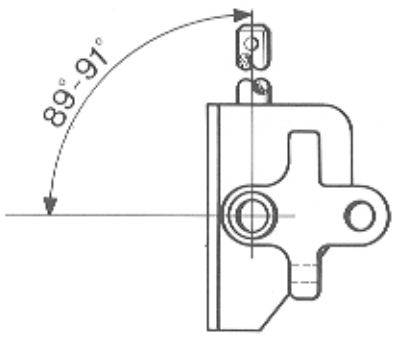


Figure 47. Speed Control Assembly

SPEED ADJUSTMENT

The speed of the engine is controlled by the tension of the speeder spring which is internally attached to the speed control. The control has two adjustable screws which are adjusted and locked to give the rated full on-load or variable speed as determined by the engine build.

Variable Speed Adjustment

The speed control can be operated either by a cable or rod and the idling speed must be set in accordance with "Governing Ranges to BS5514 - LT" on page 89 or "Governing Ranges to BS5514 - LV" on page 90.

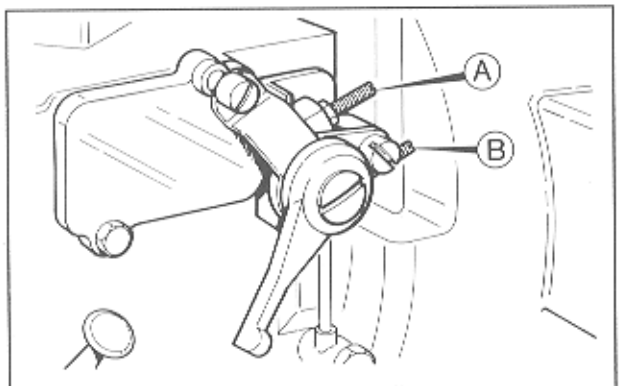


Figure 48. Variable Speed Adjustment

1. Move the speed control lever to the slow speed position.
2. Turn the uppermost adjusting screw (A) anti-clockwise until it has no further effect on reducing the engine speed: the engine may now be hunting.
3. Gradually turn the screw clockwise until the correct idling speed is obtained.
4. Tighten the locknut.
5. Move the speed control lever to the full speed position.
   If the speed is not correct turn the lower adjusting screw (B) clockwise to reduce the speed and anti-clockwise to increase it.

Fixed Speed Adjustment

The two screws are adjusted and locked against the speed control lever to give the full on-load speed. The uppermost adjusting screw (A) increases the speed when it is turned clockwise after the lower screw has been slackened clear.

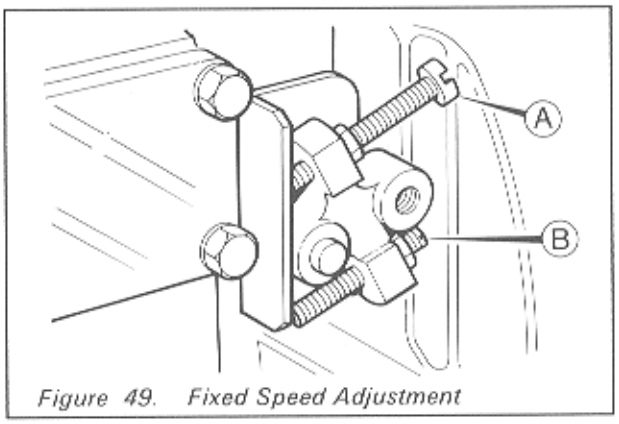


Figure 49. Fixed Speed Adjustment

DECARBONISING

Decarbonising should be carried out if the engine shows loss of compression or blow-by past the piston.

Thoroughly clean and examine the following items for damage or wear and renew any defective parts as necessary.

a. Piston.

b. Piston rings, piston grooves and oil holes.

c. Piston combustion chamber.

d. Valve ports, valves, valve seats and valve guides.

e. Exhaust manifold, piping and silencer.

f. Fins on the cylinder barrel and cylinder head.

Joint Sets

LT1	Decarbonising	657-25999
	Overhaul	657-28576
LT2	Decarbonising	657-29022
	Overhaul	657-29032
LV1	Decarbonising	657-29461
	Overhaul	657-29443
LV2	Decarbonising	657-29471
	Overhaul	657-29453

LAYING-UP PROCEDURE

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

a. Replace the fuel in the tank with a small supply of calibration fluid or equivalent.

b. Drain the lubricating oil from the sump and refill with new oil.

c. Run the engine for a period to circulate the oil through the system and to ensure the calibration fluid is passed through the fuel pumps and injectors.

d. Stop the engine and drain the 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.

e. Seal all openings on the engine with tape.

f. Remove the batteries, when applicable, and store fully charged with the terminals coated with petroleum jelly.

g. Grease all external bright metal parts and the speed control linkage.

h. Tie labels on the engine clearly stating what steps have been taken to inhibit the engine during storage.

If the above items are not carried out the engine should be run on full load for approximately 45 minutes once a month.

⚠ CAUTION

As a direct result of combustion the lubricating oil will contain harmful acids and therefore it should not be left in the sump if it is known that the engine will not be used for extended periods.

DIMENSIONS OF WEARING PARTS

The information is given as a guide to the extent by which components may 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 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 and materials. If labour costs are high it may pay to replace parts before the maximum wear condition is reached to avoid further work before the next scheduled overhaul.

Cylinder Bore Wear

The maximum advisable piston to cylinder clearance given is the clearance between the bottom of the piston skirt, across the faces, and the cylinder bore measured in the region of travel of the piston skirt. The clearance is ***not to be measured at the top of the bore.***

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

Piston/Cylinder Clearance - LT Engines

The initial dimensions given for piston to cylinder clearance and piston ring gaps are those for engines up to and including 2500r/min. Engines at higher speeds are fitted with cylinder barrels giving an additional 0,025mm (0,001in) piston to cylinder clearance. These barrels are identified by a vee-shaped nick in the top fin.

Therefore, for all engines above 2500r/min, the maximum piston to cylinder clearances given are to be increased by 0,05mm (0,002in) and all maximum ring gaps increased by 0,16mm (0,0063in).

Piston Ring Gaps

The initial dimensions given for piston ring gaps assume the use of a gauge having a bore exactly equal to the nominal cylinder bore. The gaps given in the table under 'Initial Clearance' are those to be anticipated when checking rings in a new bore. For every 0,02mm (0,001in) by which the actual bore size exceeds the dimension given, the ring gap will increase by approximately 0,08mm (0,003in).

Firing Ring Groove Width

The width may be measured with a new ring.

The side clearance is:-

LT - 0-0,06mm (0-0,0024in)
LV - 0-0,05mm (0-0,002in)

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 0,1mm (0,0039in).

Normally special gauges are required to measure the groove.

Oversize and 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 the relevant part numbers.

The variations from the standard dimensions are:-

0,254mm (0,010in)
0,508mm (0,020in)
0,762mm (0,030in)
1,016mm (0,040in)

Non-standard sizes are marked, by the amount they are under or oversize, as a suffix to the part numbers which can be found in the following locations:-

a. Piston Rings - stamped on the face of the ring.

b. Pistons - stamped on the top surface.

c. Bearings - stamped on the steel outside surface of the bearing.

Component	Initial Dimension		Initial Clearance		Maximum Clearance	
	mm	in	mm	in	mm	in
LT Cylinder bore (1 and 2) (Up to 2500r/min)	82.575 82.550	3.251 3.250	0.177	0.007		
LT Piston diameter at bottom of skirt across thrust face	82.423 82.398	3.245 3.244	0.127	0.005	0.22	0.0087
LV Cylinder bore (1)	85.750 85.775	3.376 3.377	0.233	0.0092	0.28	0.011
LV Piston diameter at bottom of skirt across thrust face	85.567 85.542	3.3688 3.3678	0.183	0.0072		
Firing ring gap - LT (2 and 3)	0.300 0.500	0.012 0.020	0.300 0.575	0.012 0.023	0.72	0.028
Firing ring width and groove width (4)						
Firing ring gap - LV (3)	0.30 0.50	0.0118 0.0197	0.38 0.66	0.015 0.026	0.81	0.0319
Firing ring width and groove width (4)						
Compression ring gap - LT (2 and 3)	0.200 0.400	0.008 0.016	0.200 0.475	0.008 0.019	0.67	0.026
Compression ring gap - LV (3)	0.20 0.40	0.0079 0.0157	0.28 0.56	0.011 0.022	0.76	0.0299
Compression ring width	1.984 1.959	0.078 0.077	0.051	0.002	0.14	0.006
Compression ring groove width	2.060 2.035	0.081 0.080	0.101	0.004		
Oil scraper ring gap - LT (2 and 3)	0.200 0.400	0.008 0.016	0.200 0.475	0.008 0.019	0.67	0.026
Oil scraper ring gap - LV (3)	0.20 0.40	0.0079 0.0157	0.28 0.56	0.011 0.022	0.76	0.0299
Oil scraper ring width	3.967 3.942	0.156 0.155	0.051	0.002	0.14	0.006
Oil scraper ring groove width	4.043 4.018	0.159 0.158	0.101	0.004		
Small end bearing bore	28.623 28.611	1.1269 1.1264	0.0556	0.0022	0.064	0.0025
Gudgeon pin diameter	28.5725 28.5674	1.1249 1.1247	0.0385	0.0015		
Big end bore (in rod)	57.696 57.683	2.2715 2.2710				
Bearing shell thickness (5)	1.835 1.826	0.0722 0.0719	0.067 0.023	0.0026 0.0009	0.090	0.0035
Crankpin diameter	53.990 53.977	2.1256 2.1251				
Main bearing housing bore	57.696 57.671	2.2715 2.2705				
Bearing shell thickness (5)	1.835 1.826	0.0722, 0.0719	0.089 0.034	0.0035 0.0013	0.120	0.0047
Crankshaft journal diameter	53.967 53.955	2.1247 2.1242				
Thrust bearing thickness - LT/LV1 (6)	2.360 2.310	0.093 0.091	0.103 0.230	0.0051 0.0091	0.230	0.0091
Thrust bearing thickness - LV2 (6)	2.310	0.0909	0.305 0.229	0.012 0.009	0.30	0.0118

Component	Initial Dimension		Initial Clearance		Maximum Clearance	
	mm	in	mm	in	mm	in
Camshaft bearing - gear end (7)			0,010 0,020	0,0004 0,0008		
Camshaft journal diameter	30,007 29,997	1,1792 1,1788				
Camshaft centre bush bore - LT/LV2 (8)	37,013	1,4572	0,071 0,058	0,0028 0,0023	0,11	0,0043
Camshaft journal diameter - LT/LV2	36,955 36,942	1,4549 1,4544				
Camshaft bush bore - flywheel end (9)	25,4	1,00	0,051 0,038	0,0020 0,0015	0,090	0,0035
Camshaft journal diameter	25,362 25,349	0,9985 0,9980				
Camshaft gear wheel clearance width	37,43 36,90	1,4736 1,4528	0,080	0,0031		
Camshaft wheel width	36,82 36,77	1,4496 1,4476	0,200	0,0079	0,200	0,0079
Fuel pump tappet diameter	24,987 25,030	0,9837 0,9828	0,068	0,0027		
Fuel pump tappet guide bore	25,03 25,00	0,9854 0,9843	0,013	0,0005	0,080	0,0031
Oil pump - LT/LV1 Push rod diameter	9,50 9,48	0,3740 0,3732	0,065	0,0026		
Push rod crankcase bore	9,545 9,525	0,3758 0,3750	0,025	0,0010	0,090	0,0035
Pump plunger diameter	19,025 19,000	0,7490 0,7480	0,075	0,003		
Pump cylinder diameter	19,075 19,050	0,7510 0,7500	0,025	0,001	0,100	0,0039
Oil pump - LT/LV2 Push rod diameter	11,50 9,48	0,4528 0,3732	0,065	0,0026		
Push rod crankcase bore	9,545 9,525	0,3758 0,3750	0,025	0,0010	0,090	0,0035
Pump Plunger Diameter	19,025 19,000	0,7490 0,7480	0,075	0,003		
Pump cylinder diameter	19,075 19,050	0,7510 0,7500	0,025	0,001	0,100	0,0039
Valve spring free length - LT	45,50 43,70	1,7913 1,7205				
Valve spring free length - LV	48,00	1,90				
Inlet valve guide bore	7,915 7,895	0,3116 0,3108	0,059	0,0023	0,070	0,0028
Valve stem diameter	7,869 7,856	0,3098 0,3093	0,026 0,076	0,0010 0,0030	0,090	0,0035
Exhaust valve guide bore	7,932 7,912	0,3123 0,3115	0,043	0,0017		
Valve rocker bore	22,339 22,326	0,8795 0,8790	0,084	0,0033	0,100	0,0039
Valve rocker shaft diameter	22,263 22,255	0,8765 0,8762	0,063	0,0025		
Backlash between gears			0,220 0,035	0,0087 0,0014	0,290	0,0114

Notes:

1. See "Cylinder Bore Wear" on page 63.
2. See "Piston/Cylinder Clearance - LT Engines" on page 63.
3. See "Piston Ring Gaps" on page 63.
4. See "Firing Ring Groove Width" on page 63.
5. Theoretical clearance, in practice this may be 0,005mm (0,00019in) more.
6. Replace the thrust washers if their thickness is less than 2,20mm (0,087in).
7. Replace the bearing if it feel rough when it is rotated.
8. The centre bush is inserted with a 37,013mm (1,4572in) diameter fitting plug. Once inserted, a gauge of 37,0mm (1,4567in) diameter must freely enter the bore.
9. The flywheel end bush is inserted with a 25,413mm (1,0005in) diameter fitting plug. Once inserted, a gauge of 25,4mm (1,0in) diameter must freely enter the bore.
10. Replace if the free length is 42,4mm (1,669in) or less.

Section 3 - The Lubrication System

Contents

General Description 68
Oil Pressure 69
Oil Capacity 69
Oil Filter 69
Oil Dipstick 70
Oil Sump 70
Oil Strainer 71
Oil Pump 72
Cylinder Head Oil Feed 72
Oil Seals 73

GENERAL DESCRIPTION OF THE SYSTEM

A cast iron lubricating oil sump is bolted to the base of the crankcase and has a drain plug on the fuel pump side.

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

Oil in the sump is drawn into the self-regulating oil pump, through the oil strainer and filter on LT/LV2 engines, into the oil gallery and is delivered to the crankshaft main bearings.

The connecting rod big end bearings are pressure fed through internal drillings in the crankshaft and splash oil lubricates the gears, governor, camshaft and the underside of the pistons.

A low oil pressure switch and equipment for long running installations are available as accessories.

OIL SPECIFICATION

The Oil Specification is given in the Operators Handbook.

⚠ WARNING

Before commencing any work on the lubrication system refer to the relevant sections of the "Safety Precautions" on page 6.

OIL PRESSURE

Minimum - 0,4bar (5,8lbf in²).

OIL SUMP CAPACITY

	litres	pints	US quarts
LT/LV1	1,3	2,3	1,4
LT/LV2	3,6	6,3	3,8

Capacity Between Dipstick Marks

	litres	pints	US quarts
LT/LV1	0,20	0,35	0,21
LT/LV2	0,50	0,88	0,53

HIGH OIL CONSUMPTION

The oil consumption can increase dramatically if the valve guides are worn, or if the breather in the rocker compartment is not functioning correctly.

Excess oil in the rocker compartment due to excessive piston blow-by or worn rocker bushes and shafts can cause incorrect functioning of the breather.

THE OIL FILTER - LT/LV2

The standard full flow oil filter is a spin-on cartridge type located on the side of the crankcase.

Lister-Petter approved filters should be used as 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 will not fail in service.

Changing the Oil Filter

A readily available strap wrench is required to remove the filter from the engine but must not be used to fit a replacement.

1. Using a suitable strap wrench, unscrew and remove the filter canister.
2. Thoroughly clean the oil filter housing face.
3. Apply a small amount of clean engine oil to the oil filter sealing gasket.
4. Screw on the new oil filter canister, by hand, until the sealing gasket is just touching the filter head and tighten a further half turn.
5. Run the engine and check for any oil leaks.
6. Stop the engine, allow the oil to settle and top up as necessary.

THE OIL DIPSTICK

Nylon handled dipsticks have been introduced from the following engine numbers:-

36 04429 LT1
36 00665 LV1
36 00661 LV2

The new type are not fitted with a crankcase adaptor and an existing adaptor must not be removed to allow the new type of dipstick to be used as the adaptor bore has no lead-in chamfer. If the adaptor is removed damage to the O-Ring may result leading to loss of crankcase vacuum and ingress of dirt.

The dipsticks have identification numbers stamped on the blade.

62 - All LT1 except Build 30
63 - LV2
64 - LT1 Build 30

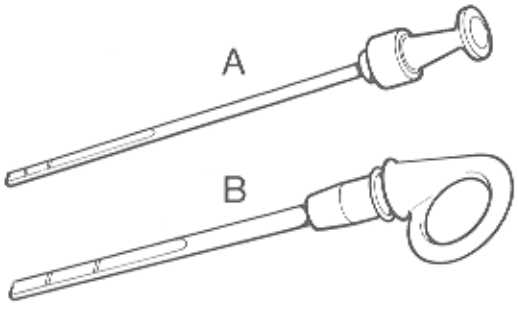


Figure 50. Dipsticks:
A - Early Engines
B - Later Engines

THE OIL SUMP

Draining and Filling the Sump

1. If possible run the engine immediately before draining the oil.
2. Place a suitable container under the drain plug.
3. Remove the plug.

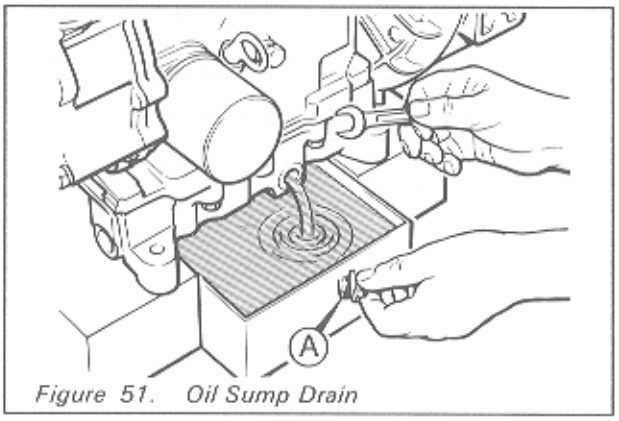


Figure 51. Oil Sump Drain

1. Clean and coat the threads of the drain plug with Hylomar PL32/M, Loctite 572 or Hylogrip 760.
2. Replace the drain plug; do not overtighten it.
3. Fill the sump through the filler on the fuel pump side of the gear end cover to the top mark on the dipstick with the correct grade and type of lubricating oil.
   Early LT1 engines were not fitted with a dipstick therefore the sump is filled until oil overflows from the filler.
4. Start the engine and run it for a few minutes to circulate the oil and check the drain plug does not leak.
5. Stop the engine and allow time for the oil to settle and re-check the level on the dipstick.
6. Add more oil if necessary.

Removing the Sump

1. Remove the drain plug from the sump and drain the oil into a suitable receptacle.

2. Remove the oil dipstick.
   A polypropylene handled dipstick is currently fitted; refer to "The Oil Dipstick" on page 70.

3. Stand the engine on its flywheel using a suitable piece of wood or similar material on which to rest the flywheel; this will enable the engine to be rotated and ease subsequent dismantling.

4. Remove the ten, fourteen on LT/LV2 engines, sump bolts.
   As the bolts are removed from the sump the oil pump will move it away from the crankcase.

5. Remove the sump taking care not to damage the oil pump.

Replacing the Oil Sump

1. Using a new joint, replace the sump with the recess corner adjacent to the oil pump.

2. On LT/LV2 engines replace the four long corner bolts finger tight.

3. Replace and torque the remaining sump bolts to 27,0Nm (20,0lbf ft).

4. Coat the threads of the drain plug with Hylomar PL32/M or Three Bond 1110B and replace it; do not overtighten.

5. Fill the sump to the correct level with the correct grade and type of lubricating oil.

THE LUBRICATING OIL STRAINER - LT/LV2

LT/LV2 sumps are fitted with a coarse lubricating oil strainer on the suction side of the oil pump and access to it is gained by removing the sump.

The strainer can be dismantled by removing the centre setscrew, lifting off the top cap and lifting out the strainer mesh.

Care must be taken to ensure that rags are not used to wipe the inside of the crankcase during overhauls to eliminate the possibility of fluff entering the strainer and causing a restricted oil flow.

Note - Early Engines:
On re-assembly take care to replace the distance piece under the top plate and ensure that the anti-surge plate on the strainer is parallel to the crankcase web.

THE LUBRICATING OIL PUMP

Access to the self-regulating oil pump is only possible with the sump removed.
Some components of the LT and LV pumps are not interchangeable; refer to the Parts List for further details.

Removing the Pump

1. Drain the oil and remove the dipstick and sump.
2. Remove the oil pump.
3. Using long nosed pliers remove the oil pump push rod from the crankcase.
4. Dismantle the oil pump making a careful note of the component positions and the two different sized ball valves.

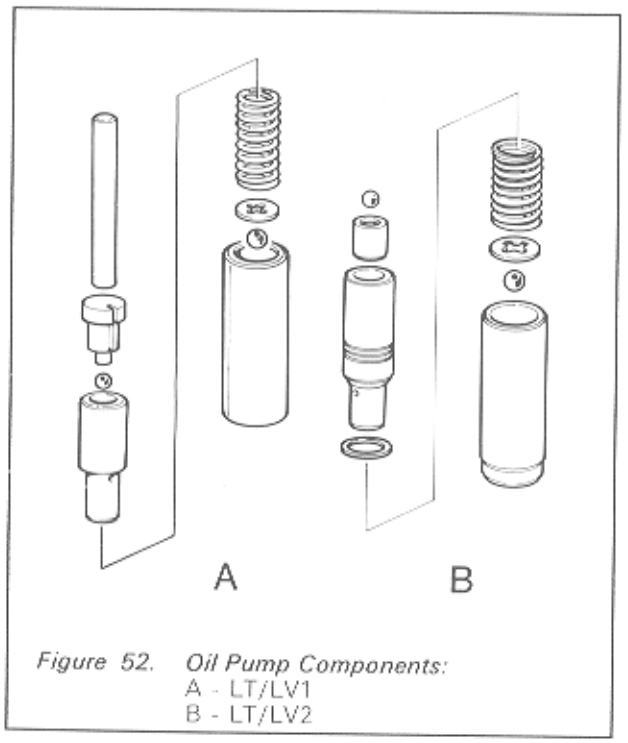


Figure 52. Oil Pump Components:
A - LT/LV1
B - LT/LV2

Refitting the Oil Pump

1. Check that the oil pump is correctly assembled.
2. Check that the pump is working freely by compressing it between the palms of the hands.
3. Replace the oil pump push rod into the crankcase as far as it will go.
4. Replace the oil pump with the plunger end towards the push rod.
5. Replace the sump, drain plug and the dipstick and refill the sump with oil.

CYLINDER HEAD OIL FEED

An external pipe secured by 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 the exhaust push rod tube nearest the flywheel.

The top union is stamped with an identification letter on the head various letters have been used and the table below gives those currently used.

	Build	Letter
LT1	10, 11, 20, 27	F
	All Other Builds	C
LV1	09	F
	All Other Builds	C
LT/LV2	All Builds	C

Cleaning the Oil Feed Union

The top union must be cleaned every 1000 hours.

1. Remove the union.
2. Carefully remove all traces of dirt from inside and in the small delivery hole of the union and the top of the feed pipe.
3. Replace the union and fit two new copper washers.

OIL SEALS

Lip seals are currently fitted to all LT and LV engines; very early LT engines were fitted with rotary seals.

A lip type oil seal is fitted to the gear end cover and either a rotary, lip or a screw type is fitted to the main bearing housing.

Lip Type

Lister-Petter approved lip seals are fitted without any jointing compound being applied. Ordinary rubber seals may quickly harden in use, rapidly wearing the shaft, or not even seal on fitting.

A lip type seal will not seal if the shaft is scratched or bruised within 5mm (0,20in) 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 advisable and it is essential to check the shaft for damage.

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 400mm long by 50mm wide should be folded lengthwise and made into a 10mm belt. Wet the belt with the abrasive mixture, wrap once right around the shaft and use it with a reciprocating motion.

⚠ CAUTION

Emery cloth of any grade must not be used in the area of the seal lip.

Lip Seal Tools

Before fitting the new seal the lip must be lubricated with new engine oil.

When the tool is being used the seal is pushed in as far as the tool will allow or until the seal is flush with the housing.

The End Cover Oil Seal

1. Place a new seal into the outside neck of the end cover, lip side first, and position it squarely on the shoulder of the seal boss.
2. Using the oil seal tool, 317-50093, press the seal into position within the oil seal housing boss until it is flush with the inside face of the boss.
   In an emergency, if the tool is not available, a suitable hard wood plug could be used.
3. Push the seal tool into the seal from the cover outside face.
4. Oil the sealing lip before fitting the end cover.

Rotary Seal

Special tools are required to assemble the seal 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. The rotary type oil seal, fitted to the main bearing housing, consists of three components.

a. A rotating impeller which is an interference fit on the crankshaft, and has an oil sealing thread machined on the outside diameter.

b. A felt ring, held in place by a stationary retaining cap, which acts as a dust seal.

c. A retaining cap which is an interference fit in the bearing housing.

If a rotary oil seal requires changing on very early engines it can be replaced by the current lip type.

Section 4 - The Fuel System

Contents

General Description 76
Excess Fuel Device 76
Fuel Tank Capacity 77
Fuel Filter 77
Priming the Fuel System 78
Fuel Lift Pump 79
Fuel Pump 79
Spill Timing 83
Fuel Injector 85

GENERAL DESCRIPTION OF THE SYSTEM

The fuel system comprises a fuel filter, pump and injector for each cylinder. Engines not fitted with a fuel tank have a cartridge type fuel filter fitted to the gear end of the engine.

From the filter fuel flows through flexible pipes to the fuel pumps and the high pressure fuel is fed to the injectors which are held in position in the cylinders by a clamp. Leak-off pipes carry fuel back to the tank and this fuel must never be fed directly into the injection pumps.

A self bleed fuel system is available and a camshaft operated fuel lift pump can be fitted to LT/LV2 engines.

⚠ WARNING

Before commencing any work on the fuel system refer to the relevant sections of the "Safety Precautions" on page 6.

FUEL SPECIFICATION

The Fuel Specification is given in the Operators Handbook.

THE EXCESS FUEL DEVICE

The automatic excess device is not fitted to LT or some LV1 engines. Figure 53shows the engine control plate for manual and automatic devices.

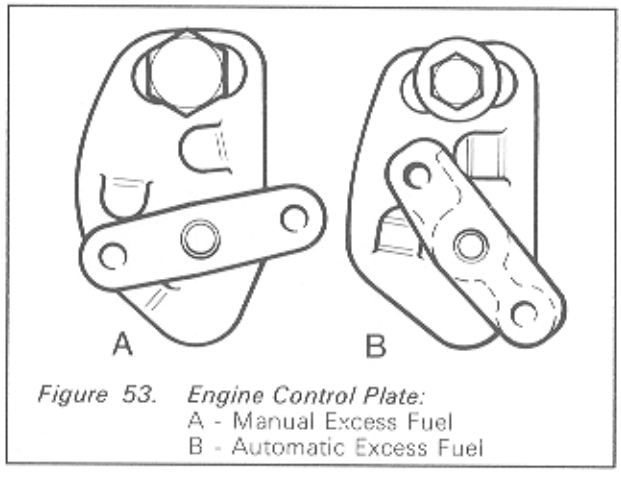


Figure 53. Engine Control Plate:
A - Manual Excess Fuel
B - Automatic Excess Fuel

Manual Excess Fuel Device

The excess fuel position is selected by pulling the engine control lever outwards over the middle catch and turning it clockwise. When the engine has started and run up to speed the control must be turned anti-clockwise back to its original position.

Automatic Excess Fuel Device

The automatic excess fuel device resets ready for the next start when the engine is stopped by using the engine control.

If the engine stops other than by the operation of the engine control, the control must be turned to the stop position and then released to select excess fuel.

The resetting of the cam during the stopping operation is effected by turning the engine control fully anti-clockwise so that on release the excess fuel position will automatically be selected. If the engine is not overloaded, when 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.

Before removing the excess fuel device refer to "The Engine Control Assembly" on page 59.

THE FUEL TANK

Various sizes of engine mounted fuel tanks are available and in all cases the pressed steel tanks are fitted to the gear end of the engine.

	LT1	LT2	LV1,2
l	5,0/8,25	13,5	13,5
pt	8,8/14,5	23,75	23,75
US qt	5,28/8,7	14,2	14,2

Removing the Fuel Tank

1. Drain the fuel from the tank into a clean receptacle.
2. Disconnect the fuel pipe at either the fuel pumps or fuel tank.
3. Pull out the leak-off pipe from top of the tank.
4. Remove the bolts securing the top of the tank to the air shield and the bracket from the tank to the end cover.

Maintenance

Every 2000 hours remove any sediment from the tank and flush it with clean kerosene and allow it to drain.

Fitting the Fuel Tank

1. Support the tank and replace the bolts securing the top of the tank to the cylinder head cover and air cowl bracket.
2. Replace the bracket securing the base of the tank to the the end cover bracket.
3. Re-connect the fuel pipe at either the fuel pumps or fuel tank.
4. Push the leak-off pipe into the top of the tank.
5. Refill the fuel tank.
6. Bleed the system if it is not self-bleed.

THE FUEL FILTER

One of three types of filter will be fitted depending on the size of tank or if no tank is fitted.

The filter is an essential part of a diesel engine and the engine must never be run without a fuel filter element. The element should be renewed every 500 hours, or more frequently if for any reason the fuel is known to be dirty.

5,0 litre Tank Filter

1. Remove the fuel pipe from the filter and drain the tank.
2. Remove the bolt (A) from the filter body.
3. Remove the element (B) from the bowl and discard it.
4. Discard the joints (C) and (D).
5. Fit new joints.

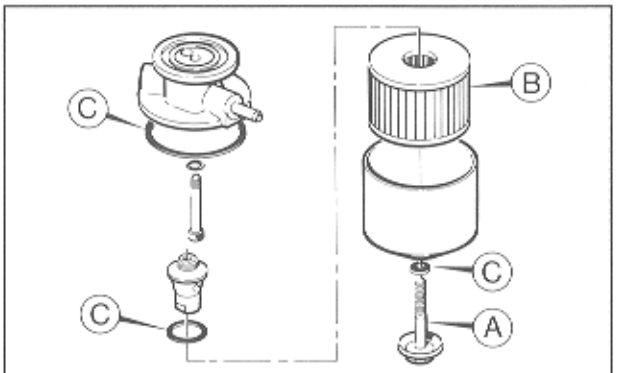


Figure 54. Fuel Tank Filter

6. Fit a new element and replace the bowl and bolt.
7. Prime the fuel system if it is not self-venting.

8,25/13,5 litre Tank Filter

1. Remove the fuel pipe from the tank and drain the tank.
2. Unscrew the plug (A) from the tank and remove the plug and element from the bottom of the tank.
3. Unscrew the element (B) from the plug and discard it.
4. Discard the joint (C).

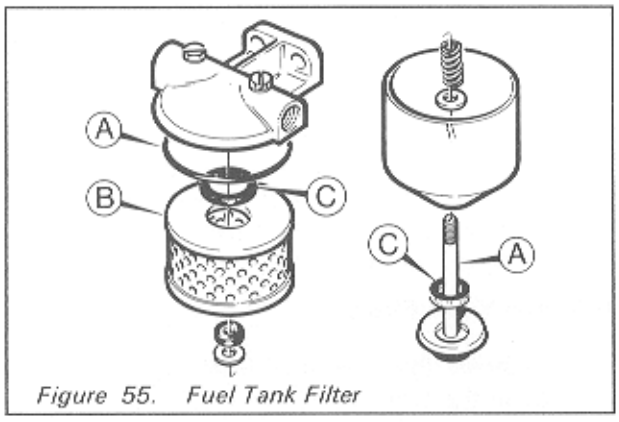


Figure 55. Fuel Tank Filter

5. Fit a new joint.
6. Screw the new element onto the plug; ***use the nut section of the element only.***
7. Screw the plug and element into the bottom of the tank and torque load it to 41.0Nm (30.0lbf ft).
8. Replace the fuel pipe.
9. Fill the fuel tank.
10. Prime the fuel system if it is not self-venting.

Remote Filter

1. Remove the bolt (A) from the element bowl.
2. Remove the element (B) and discard it.
3. Discard the three joints (C).

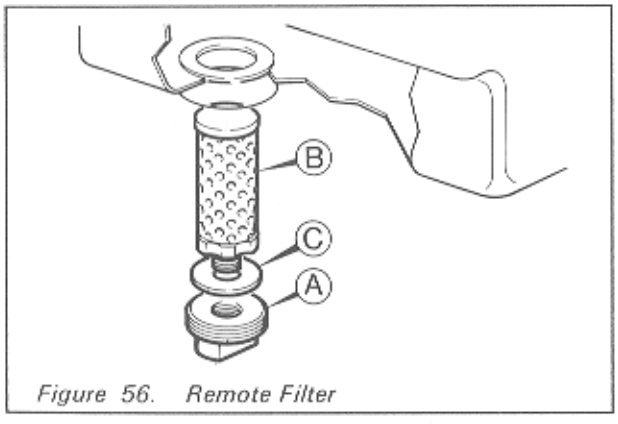


Figure 56. Remote Filter

4. Fit three new joints.
5. Place the new element onto the adaptor.
6. Replace the element bowl and bolt.
7. Fill the fuel tank.
8. Prime the fuel system if it is not self-venting.

PRIMING THE FUEL SYSTEM

If the fuel system is self venting it should not be necessary to prime the system.

1. Fill the tank with fuel.
2. Vent the fuel filter through the bleed screw (A) until a full air free flow of fuel is obtained.

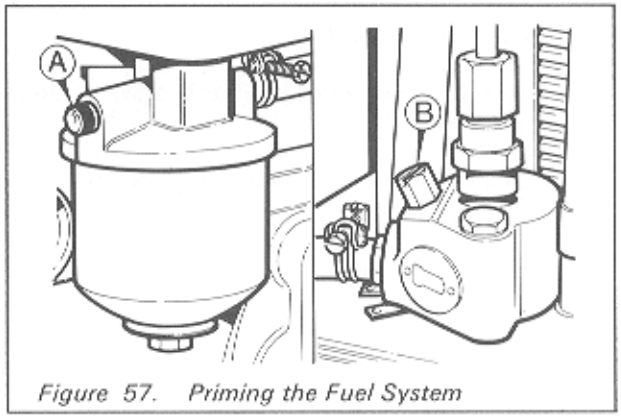


Figure 57. Priming the Fuel System

3. Vent the fuel at each pump in turn through the bleed screw (B) starting with the pump nearest to the fuel tank.

THE FUEL LIFT PUMP

A lift pump is available for LT/LV2 engines and is fitted to the fuel pump side of the crankcase.

Three types of lift pump have been fitted and these are shown in Figure 58.

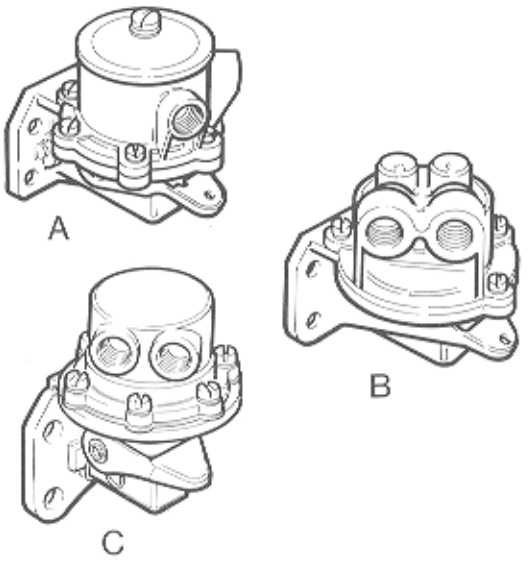


Figure 58. Fuel Lift Pumps:
A - AC Delco
B - Pienne
C - Corona

THE FUEL INJECTION PUMP

The individual fuel pumps are located at the side of the engine between the push rods and are secured to the crankcase by two bolts. Early LT engines were fitted with a long headed bolt fitted to the inside hole in the pump mounting flange.

It is important to ensure the fuel pumps on LT/LV2 engines are both the same type and have the same delivery characteristics.

Details for the fuel pumps can be found in "Fuel Pump Identification - LT" on page 82 or "Fuel Pump Identification - LV" on page 82.

Timing Shims

Timing shims, which are fitted between the pump and crankcase, are available in the following sizes:-

0,127mm (0,005in)	0,508mm (0,020in)
0,254mm (0,010in)	0,762mm (0,030in)

Removing a Fuel Pump

1. Drain the fuel tank or isolate the fuel supply.
2. Disconnect the fuel inlet pipe (A) at the pump.
3. Remove the pipe (B) from the pump to injector taking care to hold the fuel pump delivery valve holder (C) with a spanner to prevent it turning.

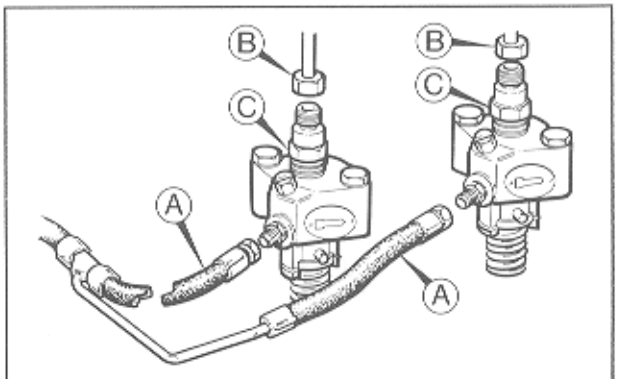


Figure 59. Fuel Pump Pipes

4. Remove the fuel pump inspection door (D) from the crankcase.

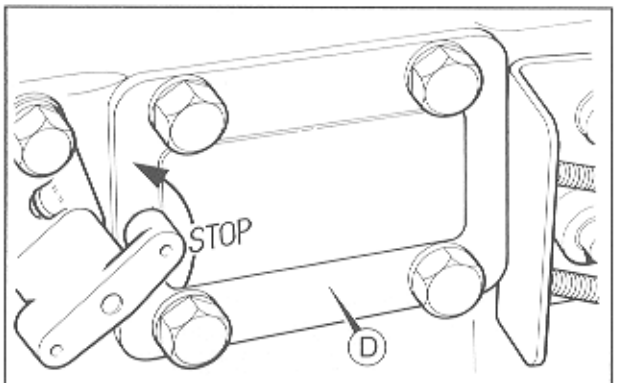


Figure 60. Inspection Door

5. Release the spring tension of the speeder spring by unscrewing the speed adjusting screw (E) on the side of the crankcase.

6. Using long nose pliers disconnect the speeder spring (F) from its spigot (G). It may be necessary to turn the spigot until the hole axis is parallel to the camshaft before removing the spring.

7. Disconnect the governor and pump interconnecting linkage at the pump.

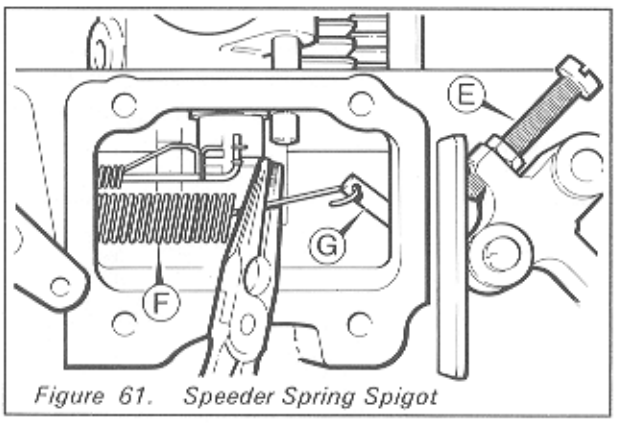


Figure 61. Speeder Spring Spigot

8. Move the rack operating lever on the pump to the central position.

9. Remove the fuel pump holding down bolts.

10. Gently lift out the pump taking care to retain the timing shims which are between the pump flange and crankcase.

⚠ CAUTION
If both LT/LV2 pumps are being removed care must be taken to retain the timing shims with their respective pump.

Fuel Pump Maintenance

It is recommended that the work of servicing the fuel pump is carried out by accredited Service Depots.

Fitting the Fuel Pump

1. Check the rubber 'O' ring on the pump body for damage.
2. Place the pump into the crankcase and fit the two holding down bolts finger tight only until the pumps are slightly above the face of the crankcase.
   Early LT engines were fitted with a long headed bolt fitted to the inside hole in the pump mounting flange.
3. Replace the timing shims between the pump and crankcase, taking care to ensure that the same size of shims are on each side of the pump. Place the thickest shims next to the crankcase to minimise the possibility of damaging the oil seal ring around the pump body by the shims as it enters the crankcase.
4. Evenly tighten the retaining bolts to a torque of 9,0Nm (6,5lbf ft).
5. Connect the governor link and LT/LV2 pump interconnecting linkage to the pump as shown in Figure 62.
6. Connect the speeder spring to the spigot.
   If the spigot was turned when the pump was removed it must be turned until the hole axis is at 90° to the camshaft before refitting the spring.
7. Check the governor setting - refer to "Setting the Governor" on page 90.
8. Fit a new joint to the fuel pump inspection door and replace the door.
9. Replace and torque the fuel pipes.
   Injector Pipe Nuts - 28,5Nm (21,0lbf ft)
   Injector Leak-off Banjo - 6,0Nm (4,5lbf ft)
10. Prime the fuel system if it is not self-bleeding.
11. Check the spill timing.

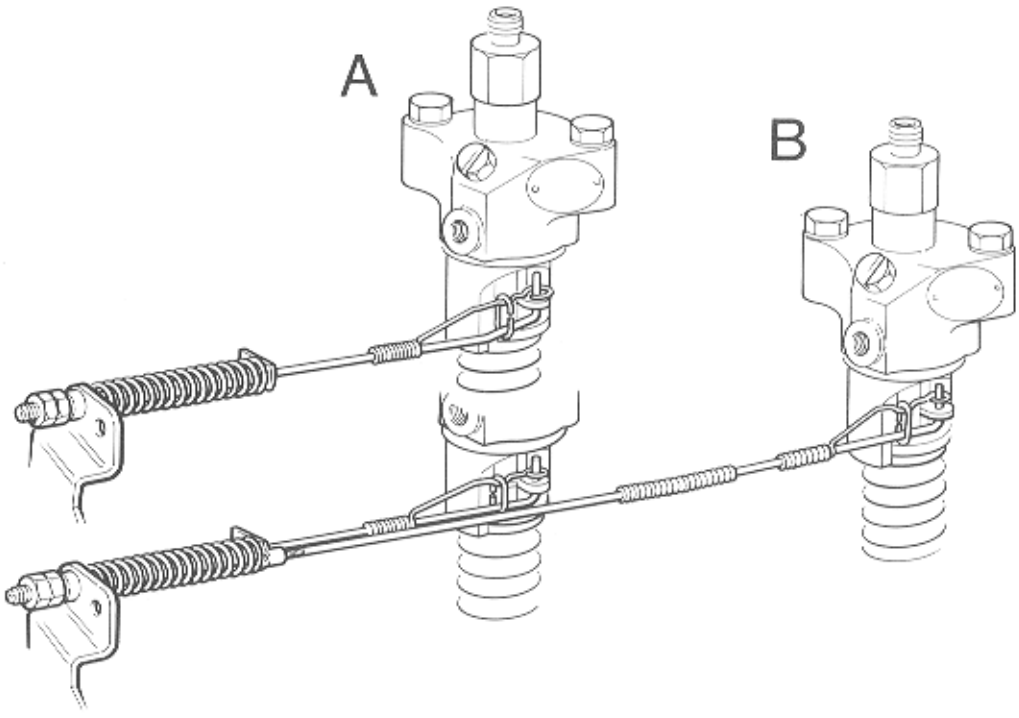


Figure 62. Fuel Pump Governor Linkage:
A - LT/LV1
B - LT/LV2

Fuel Pump Identification - LT

	Lucas Bryce	OMAP	Lucas Dizel
Brand mark	Lucas, Lucas Bryce or Bryce Berger		Lucas
Brand mark location	D	A and B	D or A
Type mark	FA0AN065E0741	Part number only	See Note [1]
Type mark location	D	A and B	C
Assembly part number - see Note [3]	601-21714	601-21715	601-21716
Element part number	660-14500	660-14500	660-14500
Delivery valve part number	660-14270	660-14271	660-14270

Fuel Pump Identification - LV

	Lucas Bryce	OMAP	Lucas Dizel
Brand mark	Lucas, Lucas Bryce or Bryce Berger		Lucas
Brand mark location	D	A and B	D or A
Type mark	FA0AN075E0782	Part number only	See Note [2]
Type mark location	D	A and B	C
Assembly part number - see Note [3]	601-40650	601-40651	601-40652
Element part number	660-14260	660-14260	660-14260
Delivery valve part number	660-14270	660-14271	660-14270

Notes for Both Tables

[1] 'T' and/or marking as Lucas Bryce at D.
[2] 'V' and/or marking as Lucas Bryce at D.
[3] The pumps are interchangeable with each other within the same engine type.

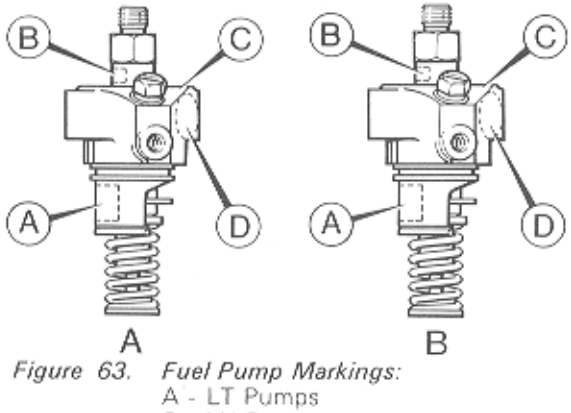


Figure 63. Fuel Pump Markings:
A - LT Pumps
B - LV Pumps

FUEL PUMP SPILL TIMING

Fuel pump components are manufactured to exacting limits and care must be taken to ensure they are returned to their respective pumps if more than one pump is dismantled at a time.

Spill timing can be checked by the conventional method or by using the fuel pump timing gauge, 317-50518, without the need to dismantle the pump; both methods are described.

Spill Timing

1. Isolate the fuel supply.
2. Remove the fuel pipe from the pump to the injector.
3. Unscrew the fuel pump delivery union body (A) and remove it.
4. Lift out the delivery valve spring seat (B) and spring (C).
5. Carefully lift out the delivery valve (D) taking care not to disturb the valve seat.
6. Place these components in a suitable container of clean fuel.

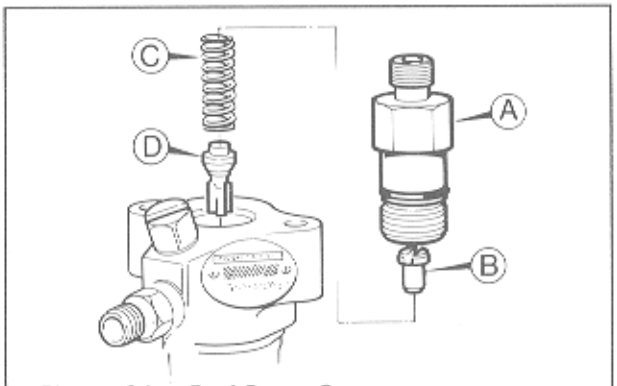


Figure 64. Fuel Pump Components

7. Replace the delivery union body (A).
8. Fit a suitable spill pipe.
9. Select the excess fuel position.
   The LV2 excess fuel position is automatically set when the engine control lever is moved from the stop to the run position.
10. Turn the flywheel, in the direction of rotation, until the piston for the cylinder being timed is at 'FP' on the compression stroke.
    The flywheel timing mark 'FP', which can be seen through an aperture in the fanshroud or on the periphery of the flywheel, should align with the arrow on the fanshroud.
11. Connect the fuel supply and bleed the fuel filter and pump.
12. Carefully turn the flywheel ***against rotation*** until fuel is flowing from the spill pipe.
13. Turn the flywheel very slowly in the ***direction of rotation*** until the fuel flow from the spill pipe just stops dripping this is known as the Spill Point.
14. Check the flywheel timing mark.
15. If the flywheel mark is not correct the shims under the fuel pump must be adjusted.

If the timing is:-

Advanced - Add Shims
Retarded - Remove Shims.

Approximately 1° of flywheel movement can be obtained by adding or removing one 0,127mm (0,005in) shim.

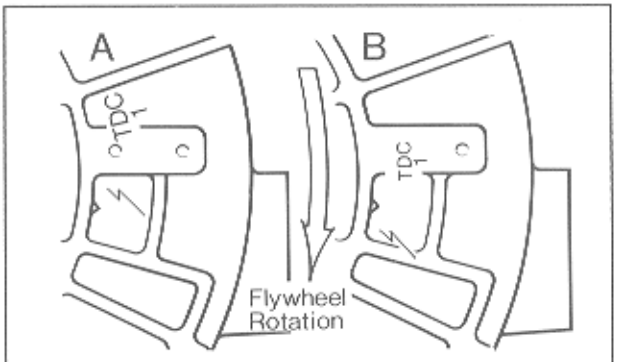


Figure 65. Flywheel Timing Marks:
A - Advanced
B - Retarded

16. Re-check the timing.
17. When the correct timing has been obtained remove the spill pipe and delivery union body.
18. Replace the delivery valve, delivery valve spring and spring seat.
19. Refit the delivery valve holder and torque load it to 41,0Nm (30,0lbf ft).
20. On LT/LV2 engines check that the fuel pump calibration marks are still aligned, and repeat the procedure for the second fuel pump.
21. Connect all fuel pipes.
22. Bleed the entire fuel system.

Fuel Pump Timing Gauge 317-50518

1. Assemble the pipe (A) to the gauge ensuring that the pipe nuts are tight.
2. Remove the fuel pipe from the pump to the injector.
3. Connect the gauge and pipe to the fuel pump delivery valve union.

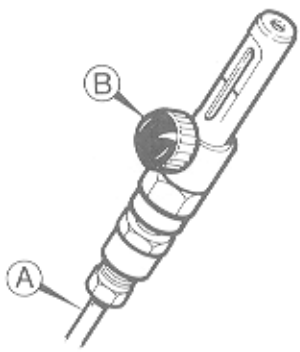


Figure 66. Fuel Pump Timing Gauge

4. Bleed the filter and pump.
5. Select the excess fuel position.
   The LV2 excess fuel position is automatically set when the engine control lever is moved from the stop to the run position.
6. Turn the flywheel, ***in the direction of rotation,*** to prime the gauge and continue to turn it until the flywheel 'FP' timing mark is in line with the arrow.
   The flywheel timing mark 'FP', which can be seen through an aperture in the fanshroud or on the periphery of the flywheel, should align with the arrow on the fanshroud.
7. Turn the flywheel ***against rotation*** for 51,0mm (2,00in).
8. Slowly release the gauge knob (B) until the fuel level is in line with the calibration mark on the gauge sight glass.
9. Turn the engine in the ***direction of rotation*** extremely slowly until the fuel in the sight glass ***just*** moves.
10. Check the flywheel 'FP' timing mark and adjust the fuel pump timing shims as necessary.

Fuel Pump Timing Tables

LT1 Builds 01 - 08

Full Load r/min	°BTDC
Up to 2500	24°
2501 and above	27°

LT1 - all Other Builds

Full Load r/min	°BTDC
1000	22°
1001 - 1500	26°
1501 - 3000	28°
3001 - 3600	30°

LT2

Full Load r/min	°BTDC
1500 - 3000	28°
3001 - 3600	30°

LV1

Full Load r/min	°BTDC
1500	22°
1501 - 1800	24°
1801 - 3000	26°
3001 - 3600	30°

LV2

Full Load r/min	°BTDC
1500 - 1800	24°
1801 - 3000	26°
3001 - 3600	30°

THE FUEL INJECTOR

The fuel injection equipment and all of the pipes and unions between the fuel filter and the injector must be absolutely clean. A minute particle of dirt can easily block one hole in the injector nozzle and this will give rise to a dirty exhaust and starting and running problems.

Injector Part Numbers

	Lucas Bryce	OMAP	Lucas Dizel
Complete	601-36120	601-56170	601-36120
Nozzle	601-37020	601-56190	601-37020

Removing an Injector

1. Remove the cylinder head cover.
2. Remove the fuel pipe between the fuel pump and injector; hold the fuel pump delivery valve holder with a spanner to prevent it turning.
3. Remove the leak-off pipe from the tank.
4. Unscrew the Allen screw and remove the injector clamp; the clamp is located in position by a hole in the side of the cylinder head assembly.
5. Remove the injector, leak-off and sealing washer.

Injector Removal Tool

1. Remove the fuel pipes from the injector.
2. Remove the injector clamp.
3. Place the injector removal tool (A) over the injector and ensure the hole with the insert is fitted over the fuel inlet hole of the injector.
4. Fit the slide hammer to the tool.
5. Use the slide hammer to remove the injector.

⚠ WARNING

Care must be taken to ensure that any part of the hand is not likely to become trapped between the two parts of the tool while it is being used.

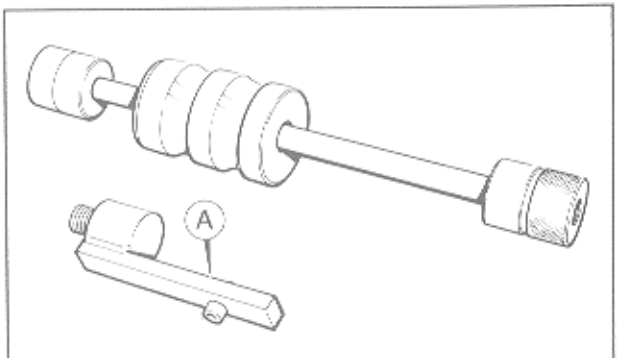


Figure 67. Injector Removal Tool

Fitting an Injector

1. Ensure the seating in the cylinder head is clean and smooth.
2. Lightly smear a very small amount of high melting point grease to one side of a new copper injector sealing washer or the metal side of the metal-fibre washer.
3. Place the washer over the injector nozzle, greased side first.
4. Replace the leak-off pipe to the injector with new copper washers each side of the swivel union.
5. Replace the injector.
6. Replace the clamp and leave the Allen screw finger tight.
7. Replace the fuel pump to injector pipe - do not tighten.
8. Replace the leak-off pipe into the fuel tank.
9. Torque the clamp screw to 21,0Nm (15,5lbf ft).
10. Torque all fuel pipe nuts to 28.5Nm (21,0lbf ft) and the leak-off pipe swivel union to 6,0Nm (4,5lbf ft).
11. Replace the cylinder head cover.

Cleaning the Injector

- A thoroughly cleaned container holding a supply of clean, fresh fuel oil should be available for washing dismantled parts.
- The components of each individual injector should be kept together at all times.
- Never use paraffin or woven cloths; it is permissible to use non-fluffing paper during the cleaning process.
- Components should be assembled wet.

Setting the Injector

To ascertain if the injector is in good condition, it is removed from the engine and connected to a fuel injector test rig similar to the one shown in Figure 68.

The injector must be set in accordance with the figures given in "Injector Settings" on page 87.

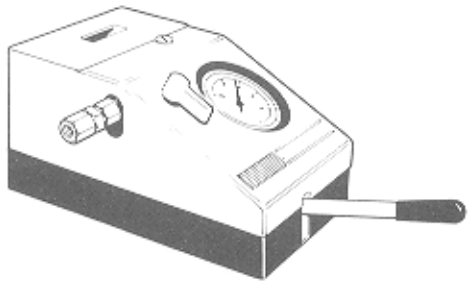


Figure 68. Injector Tester

If a rig is not available it becomes necessary to replace the complete injector by a new or serviced one which has a clean nozzle and has been correctly set.

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. When a new nozzle is fitted the injector must be reset on a test rig. After testing and resetting the injector top plug must be torque loaded to 27,0Nm (20,0lbf ft).

⚠ WARNING

ON NO ACCOUNT ALLOW ANY UNPROTECTED SKIN TO COME INTO CONTACT WITH THE INJECTOR SPRAY AS THE FUEL MAY ENTER THE BLOOD STREAM WITH FATAL RESULTS.

Injector Back Leakage

The back leakage time for the setting pressure to drop from 172 to 142bars (170-140atms) must be within 6 to 27 seconds at 15,5°C (60°F) calibration fluid temperature.

Various temperature and time bands are given in the table and if the time taken is outside the relevant band the injector should be serviced or replaced.

⚠ CAUTION

The following figures do not apply to the pintle type injector nozzles fitted to LT1 Builds 1-8.

Back Leakage Values

Calibration Fuel Temperature		Back Leakage Time Band in Seconds
°C	°F	
6,0	42,8	7,5 - 34,0
8,0	46,4	7,0 - 33,0
10,0	50,0	7,0 - 31,0
12,0	53,6	6,5 - 29,0
14,0	57,2	6,5 - 28,0
15,5	60,0	6,0 - 27,0
18,0	64,4	5,5 - 26,5
20,0	68,0	5,5 - 24,0
22,0	71,6	5,0 - 23,0
24,0	75,2	4,5 - 22,0
26,0	78,8	4,5 - 21,0
28,0	82,4	4,0 - 20,0
30,0	86,0	4,0 - 19,5

Injector Settings

		bar	atmos
LT1	Builds 1-8	162	160
	All other Builds	192-205	189-200
LT2	All Builds	192-205	189-200
LV1,2	All Builds	192-205	189-200

Section 5 - The Governor

Contents

Governing Ranges - LT 90
Governing Ranges - LV 91
Governor Modifications 91
Governor 'E' Setting 92
Governor 'A' Setting 92
Speeder Spring 'P' Setting 93
Speeder Spring 'Q' Setting 94
Governor 'G' Setting 94
Governor 'D' Setting 95
Governor Weights 96

LT GOVERNING RANGES TO BS5514

Before using these tables refer to "Governor Modifications" on page 91.

LT1 - Builds 1-8

	Full Load r/min Ranges			
Build	**Within 4½%**	**Within 8%**	**Outside 8%**	**Idling Limit**
01	-	2000-2500	1000-1999	900-1000
03 06 07	-	2200-3000	1000-2199	900-1000
05 08	2800-3600	2400-3600	-	2200-2300
02 04	-	1200-1600	1000-1199	900-1000

LT1 - all Other Builds

	Full Load r/min Ranges			
Build	**Class A1 - 5%**	**Class B1 - 10%**	**Outside 10%**	**Idling Limit**
10 11 20 27 32	-	1200-1500	1000 [a]-1199	900-1000
09 13 14 16 17 19 21 22 23 25 26 28 29 30	-	2500-3000	1000 [b]-2499	1050-1150
30		2500-3000		
12	2900-3300	2700-2899	-	
15 18 24	3200-3600	2700-3199	2100 [c]-2699	

Notes:

[a] Full load range outside 14%.
[b] Full load range outside 50%.
[c] Full load range outside 12%.

LT2

	Full Load r/min Ranges			
Build	**Class A1 - 5%**	**Class B1 - 10%**	**Outside 10%**	**Idling Limit**
6	1750-200	1550-1749	-	1650-1750
01 02 07	-	2500-3000	1000 [a]-2499	1050-1150
03 04	2900-3300	2700-2899	-	2600-2700
05	3200-3600	2700-3199	2100 [b]-2699	2200-2300

Notes:

[a] Full load range outside 50%.
[b] Full load range outside 12%.

LV GOVERNING RANGES TO BS5514

Before using these tables refer to "Governor Modifications".

LV1

	Full Load r/min Ranges				
Build	**Class A1 - 5%**	**Class A2 - 8%**	**Class B1 - 10%**	**Class B2 - 15%**	**Idling Limit**
01 02 03 07 08	-	-	2300-3000	1900-2299	1050-1150
04 05	3100-3600	2300-3099	2200-2299	-	2200-2300
06	1600-2000	1500-1599	-	-	1650-1750
09	-	-	900-1200	-	900-1000

LV2

	Full Load r/min Ranges				
Build	**Class A1 - 5%**	**Class A2 - 8%**	**Class B1 - 10%**	**Class B2 - 15%**	**Idling Limit**
01 02 07 08	-	-	2300-3000	1900-2299	1050-1150
03 04	2500-3300	-	-	-	2600-2700
05	3100-3600	2300-3099	2200-2299	-	2200-2300
06	1600-2000	1500-1599	-	-	1650-1750

GOVERNOR MODIFICATIONS

In later text dealing with the governor these changes will be referred to as being applicable to 'Early Engines' or 'Later Engines'.

Governor Thrust Sleeve

There have been alterations to the governor thrust sleeve assembly and the two types are not totally interchangeable.

A one-piece 'Nylatron' sleeve has been introduced to replace the original sleeve assembly. The new type is interchangeable with the original if the:-

a. Governor lever shoes are removed.
b. Governor weight shoes are removed.
c. Governor sleeve setting 'A' is set at 8.25mm (0.325in).

The above change was introduced on and after the following engine serial numbers.

36 02475 LT1
36 00497 LV1
36 00381 LV2

Governor Pivot Support

Re-designed support blocks and return springs are now fitted with the springs not being interchangeable, if the pivot blocks are changed the return springs must also be changed.

The above change was introduced on and after the following engine serial numbers.

36 00322 LT1
36 00041 LV1
36 00061 LV2

SETTING THE GOVERNOR

Before attempting to set any governor refer to "Governor Modifications" and "Governing Ranges".

To adjust or check the settings, it is necessary to remove the fuel pump inspection door/s and the end cover. The engine control must be in the start position and the end of the camshaft gently tapped towards the flywheel to take up any end play.

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

⚠ CAUTION

Extreme care must be taken to ensure that the governor is correctly set for engine type and build.

Governor 'E' Setting

1. Adjustment 'E', as shown in Figure 69, should be checked and if necessary shims added or removed to obtain a clearance of 0,12-0,25mm (0,005-0,010in).

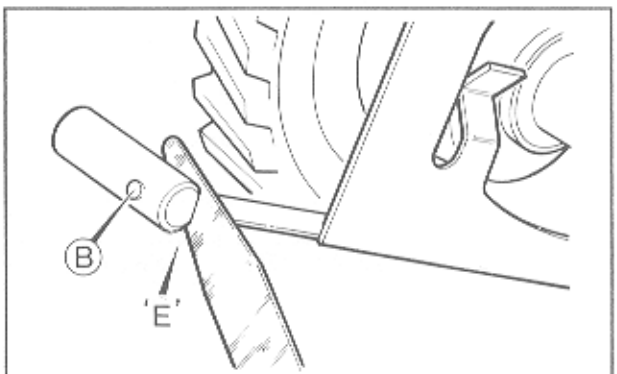


Figure 69. Governor 'E' Setting

The pivot pins (B) can be withdrawn with a small diameter piece of stiff wire, they are drilled at one end only therefore extreme care must be taken on re-assembly to ensure they are fitted with the holes facing outwards. Take care to retain the endfloat shims.

2. Check that the governor lever assembly is perfectly free to move.

3. The small return spring, which is only fitted to variable speed engines, is fitted to the fuel pump side end of the lever assembly and the short tail is wound backwards and held captive under the pivot support block.

Governor 'A' Setting

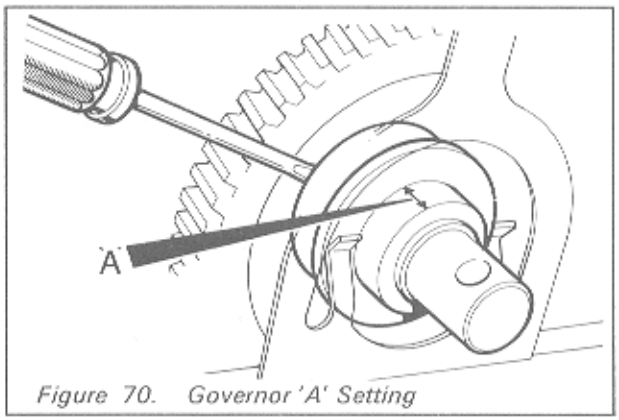


Figure 70. Governor 'A' Setting

1. Set the distance 'A', between the end of the thrust sleeve and the shoulder on the camshaft gear hub, to 5,0mm (0,197in) on early engines and 8,25mm (0,325in) on later engines by marking a scribed line the required distance from the shoulder and then moving the thrust sleeve forward to this scribed mark.
With care, an engineers screwdriver can be fitted behind the governor lever assembly to hold it in the correct position while the next stages are carried out.

On LT/LV1 engines:

2. Check that the calibration mark (X) on the fuel pump is in line with the mark on the centre of the fuel pump body, as shown in Figure 71, while the distance 'A', as given in Item 1., is maintained.

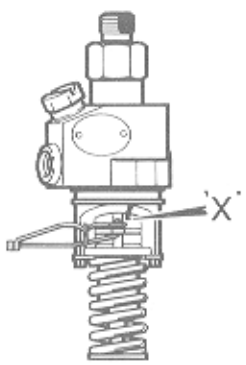


Figure 71. Fuel Pump Calibration Marks

3. If the two calibration marks are not in line they can be adjusted by altering the effective length of the governor link through the two locknuts on the outside of the governor lever.
Ensure the chamfered spacer is seated when making this adjustment.

4. Replace the linkage to the pump.

5. Release the governor lever assembly and check that all parts of the governor move freely.

On LT/LV2 engines:

6. Disconnect No.2 fuel pump linkage from No.1 pump by:-

   a. Sliding the oval split ring towards the gear end.

   b. Lifting the spring tail from the end of the governor link.

   c. Removing the governor link from the fuel pump rack.

7. Check that the calibration mark (X) on No.1 fuel pump is in line with the mark on the centre of the fuel pump body while the distance 'A', as given in Item 1. on page 92, is maintained.

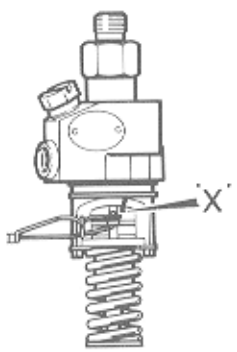


Figure 72. Fuel Pump Calibration Marks

8. If the two calibration marks are not in line they can be adjusted by altering the effective length of the governor link through the two locknuts on the outside of the governor lever.
   Ensure the chamfered spacer is seated when making this adjustment.

9. Replace the linkage to No.1 pump.

10. The length of the link from No.1 to No.2 fuel pump is then adjusted by removing the linkage from No. 2 pump and rotating the link as necessary until the calibration marks (X) on both pumps are in line simultaneously while the distance 'A', as given in Item 1. on page 92, is maintained.

11. Release the governor lever assembly and check that all parts of the governor move freely.

Speeder Spring 'P' Setting

⚠ CAUTION

The 'P' setting is only used on LT1 Builds 01-08 and is the length of screw thread protruding through the speeder spring adjuster nuts.

1. Gently move the governor plate forward sufficiently to ensure the chamfered spacer behind the locknuts on the speeder spring linkage is seated.

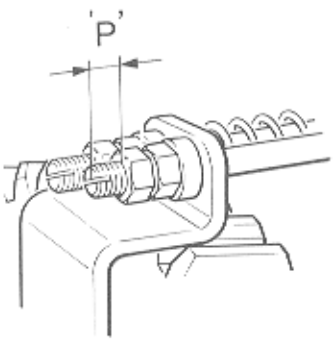


Figure 73. Governor 'P' Setting

2. Adjust the two locknuts on the speeder spring link until the end of the link is as given in the table below.

	Build	mm	in
LT1	01	5,5	0,22
	02 04	5,0	0,20
	03 06 07	1,5	0,06
	05 08	8,0	0,31

Speeder Spring 'Q' Setting

1. Gently move the governor plate forward sufficiently to ensure the chamfered spacers behind the locknuts on the speeder spring and governor linkages are seated.

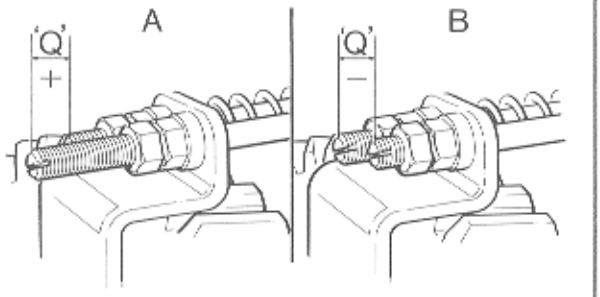


Figure 74. Governor 'Q' Setting

2. Adjust the two locknuts on the speeder spring link until the ends of both links are as given in the table below.

	Build	mm	in
LT1	10 11 20 27 32	-0.5	-0.020
	09 13 14 16 17 19 21 22 23 25 26 28 29 30 31	-1.5	0.059
	12 15 18 24	+2.5	+0.98
LT2	01 02 07	+1.5	+0.060
	03 04 05	+2.5	+0.10
	06	0	0
LV1	01 02 03 07 08	-1.5	-0.06
	04, 05	+2.5	+0.10
	06 09	0	0
LV2	01 02 07 08	-1.5	-0.06
	03 04 05	+2.5	+0.10
	06 09	0	0

Governor 'G' Setting

The 'G' setting is used to ensure that the fuel pumps deliver the correct amount of fuel as dictated by the engine and build number.

The various settings are given in the "Governor 'G' Setting Table" on page 95. For intermediate speeds not given the setting for the nearest higher speed must be used.

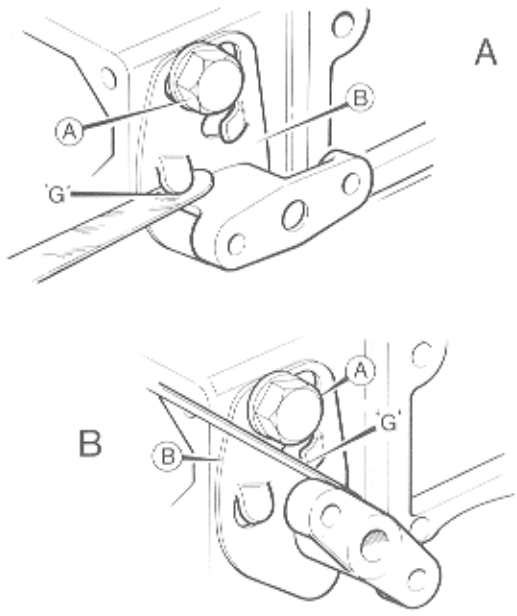


Figure 75. Governor 'G' Setting:
A - Automatic excess fuel device
B - Non-automatic excess fuel device

1. Turn the engine control to the run position.
2. With a feeler gauge of the correct thickness for the engine and build inserted between the control lever and the lever stop loosen the control plate retaining screw (A) and rotate the plate (B) until the fuel pump calibration marks are aligned.
3. Tighten the plate retaining screw.

⚠ CAUTION

Extreme care must be taken when inserting the feeler gauge or rotating the plate to ensure that the governor does not move into the start position.

Governor 'G' Setting Table

	Build	mm	in
LT1	01 03 05	0,5	0,020
	02 04	0,7	0,028
	06 07 18 24	0,3	0,012
	08	0,4	0,016
	09 12 16 23 26 28	1,2	0,047
	10 15 27	1,0	0,040
	11 20	0,6	0,024
	13 14 17 19 21 22 25 29 30 31	0,5	0,020
	32	0	0
LT2	01 02 07	0,5	0,020
	03 04	1,2	0,047
	05	1,0	0,040
	06	0,7	0,028
LV1	01 06 07	1,0	0,040
	02 03 08	0,6	0,024
	04 05	0,8	0,032
	09	0	0
LV2	01 02 06 07 08	0,6	0,024
	03 04	1,2	0,047
	05	1,0	0,040

Governor 'D' Setting

This setting is only used on engines not fitted with an automatic excess fuel device.

The excess fuel setting 'D' is the distance between the governor lever stop and the crankcase. With the fuel pump calibration marks aligned the distance should be 6,0-8,0mm (0,24-0,31in). If this is not correct the wire is carefully bent until it is.

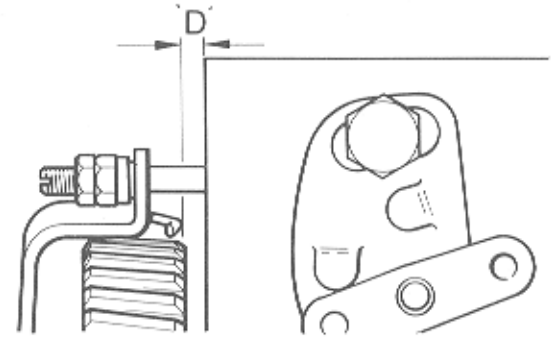


Figure 76. Governor 'D' Setting

THE GOVERNOR WEIGHTS

The sintered governor weights are located on pins pushed into the camshaft gearwheel held in position by self-tapping screws.

From the following engine numbers the governor weight shoes were no longer fitted.

36 02475 LT1
36 00497 LV1
36 00381 LV2

Changing Governor Weights

1. Remove the gear end cover.
2. Remove the fuel pump inspection door/s.
3. Remove the governor lever and sleeve assemblies.
4. Turn the engine until one of the governor weights is in the 1-o'clock position.
5. Very carefully move the camshaft out a maximum of 6,0mm (0,24in).
   Moving the camshaft out more than this will allow the oil pump plunger to move away from its cam and become wedged on the camshaft.
6. Remove the self-locking screw (A) and washer.
7. Push out the pivot (B) just sufficiently to extract the governor weight (C).
8. Fit the new weight.

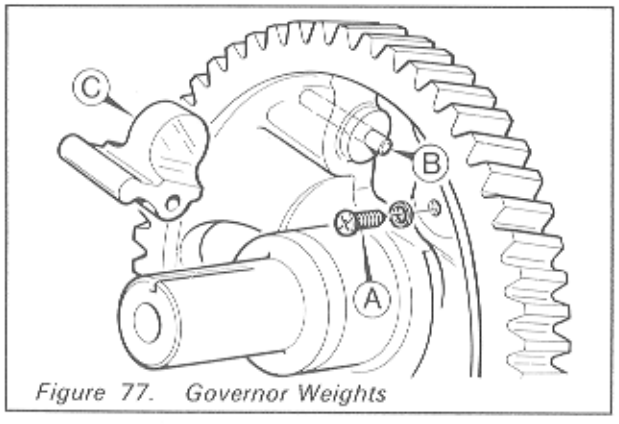


Figure 77. Governor Weights

9. Repeat the above procedure for the second governor weight.
10. Remove the speeder spring from the governor lever assembly.
11. Fit a new speeder spring, if necessary.
12. Replace the governor lever and sleeve assemblies, the the fuel pump inspection door/s and the end cover.

Weights and Speeder Springs

	Build	Code
LT1	01	W G
	02 04	D B
	03 06 07	G G
	05	J Y
	09 13 14 16 17 19 21 22 23 25 26 28 29 31	T U
	10 11 20 27 32	D B
	12	U N
	15 18 24	J N
	30	B U
LT2	01 02 07	T U
	03 04	U N
	05	J N
	06	A O
LV1	01 02 03 07 08	T U
	04 05	J N
	06	A O
	09	B B
	15 18 24	J N
LV2	01 02 07 08	T U
	03 04	U N
	05	J N
	06	A O

Code:

The first letter is the governor weight identification and the second is the speeder spring identification colour.

B - Black; U - Blue; N - Brown; O - Orange; Y - Yellow

Section 6 - The Electrical System

Contents

Polarity 98
Electrical Equipment Identification 98
Cold Cranking Battery Requirement 98
Battery Connections 99
Starter Motor 99
Flywheel Charge Windings 100
Schematic Wiring Diagrams 107

⚠ CAUTION
Before commencing any work on the electrical system refer to the relevant sections of the "Safety Precautions" on page 6.

Polarity
All electric start engines have a negative earth system and a 12 Volt flywheel mounted charging system is available dependant on Build.

ELECTRICAL EQUIPMENT IDENTIFICATION

The following details are not applicable to LT1 Builds 01 - 08.

	Voltage	Part Number	Rating	Pull-in Amps	Hold-on Amps
Starter motor					
LT,LV1	12	602-37110			
LT,LV2	12	602-37092	1,4kW		
Stator					
LT,LV1	12	601-39900			
LV2	12	601-36640			
Rectifier/Regulator					
LT,LV1	12	601-38210			
LV2	12	601-36900			
Impulse transmitter	12	607-10035			
Starter solenoid	12	351-31480	200A at 12V	4,8	
Fuel control solenoid	12	601-41430	9lbs at 25mm	3,0	0,7
Oil pressure switch[1,2]	12/24	757-15720	5A at 12/24V		
Relay	12	382-07974	20A NO 30A NC	0,16 0,16	
Keyswitch	12/24	757-16570			

Notes:
[1] Insulated return with single pole double throw contacts.
[2] Operates at 0,138-0,344bar (2,0-5,0lbf in²) on falling pressure.

COLD CRANKING BATTERY PERFORMANCE RATING

	System Volts	Ambient Temperature Range			
		Above 27°C Above 80°F	26° to 1°C 79° to 34°F	0° to -8°C 32° to 18°F	-9° to -18°C 16° to -1°F
LT1	12	50A	70A	110A	See Note [a]
LT2	12	88A	112A	157A	260A
LV1	12	57A	75A	120A	See Note [a]
LV2	12	90A	120A	170A	295A

Notes:
[a] These engines may be successfully hand-started down to -15°C (5°F) but the current inertia type starter motor is not reliable below -8°C (18°F).

The cold cranking battery performance rating figures given are in accordance with BS3911: Part 2 and IEC95-1. They relate to the cranking current required from a fully charged starter battery when tested at -18°C (0°F) and not the current available from the battery at the engine operating ambient temperature stated.
To use the table:-

1. Select the system voltage and ambient temperature range.
2. Read off the value in Amps.
3. Refer to a battery catalogue for the battery required.

BATTERY CONNECTIONS

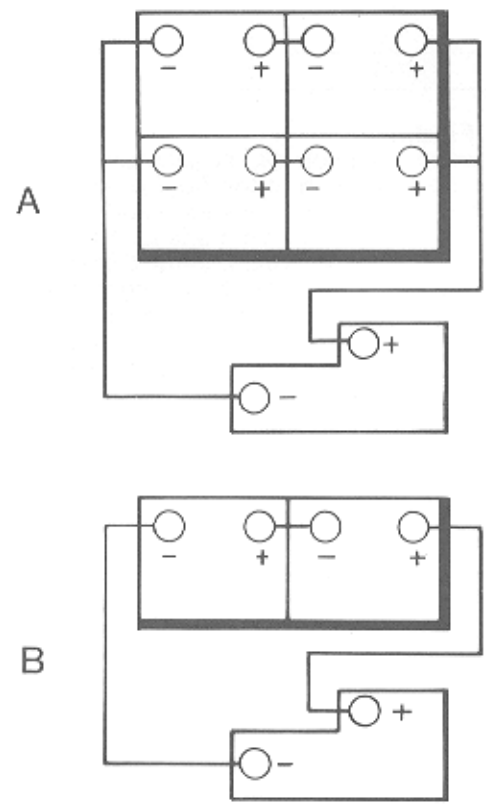


Figure 78. *Battery Connections:*
A - 12 Volt system using four 6V batteries connected in series-parallel.
B - 12 Volt system using two 6V batteries connected in series.

THE STARTER MOTOR

Starter motors are designed to overcome the high compression and inherent drag of the moving parts of the engine before it fires. To reduce battery drain during starting it is advisable to temporarily remove or reduce any load on the engine to lessen the inherent drag of the driven equipment.

To reduce the load on the starter motor the engine should, if possible, be turned for several revolutions decompressed before operating the starter.

Before attempting to remove the starter ensure that the battery has been disconnected.

Pre-engaged Starter

The pre-engaged starter pinion moves into full engagement with the flywheel gear ring before full cranking torque develops. A built-in safety device ensures the pinion gear will eventually engage should tooth-to-tooth abutment occur and a clutch prevents the armature from excessive rotation if the pinion remains in mesh after the engine has started.

Starter Motor Connections

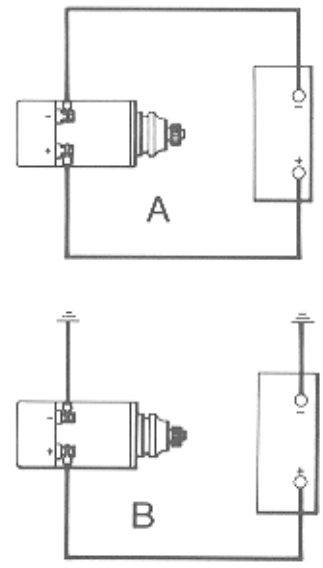


Figure 79. *Starter Motor Connections:*
A - Insulated Return Starter
B - Earth Return Starter

FLYWHEEL CHARGE WINDINGS

One of two types of charge windings may be fitted to the engine.

1. Syncro.
2. Nicsa.

⚠ CAUTION

The Syncro and Nicsa charge winding components are not interchangeable.

The flywheel charge winding system comprises of three components; stator, rotor and regulator.

The rotor, in the form of permanent magnets, is attached to the back of the flywheel.

The stator consists of coils of copper wire wound onto a laminated iron core which is attached to the main bearing housing.

The stator output leads pass through the flywheel housing to the regulator unit which is attached to the outside of the housing. Should any of the output cables be attached to the wrong terminal the regulator unit will be permanently damaged when the battery is connected into the circuit.

Battery Charge Indicator Light

Some engines may be fitted with an impulse transmitter and warning light to provide an indication of when the system is faulty. The transmitter is fitted between the rectifier/regulator and the battery, during periods of running the indicator light will remain unlit unless there is a fault in the charging system. The battery charge indicator light will always be lit 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. The charge rate drops below 4 Amps at idling speed.

SYNCRO CHARGE WINDINGS

Maximum Output - Voltage held at 13 Volts

r/min	Amps
1000	8,0
1500	12,5
2000	15,0
3000	17,0

Fault Finding

The most common faults associated with this system are dealt with in the flow charts.

In cases where no electric start is possible reference should firstly be made to 'Starter Motor, Battery and Charge System Fault Diagnosis Flow Chart', proceeding through to other charts if a charge system fault becomes evident.

In cases where a specific charging fault is known to exist refer directly to the relevant flow chart.

The necessary instruments and connection diagram to carry out the tests are given in "Nicsa Charge Windings" on page 103.

Stator Winding Resistance at 20°C (68°F)

	Resistance
LT/LV1 Black to Yellow	0,496 - 0,744
LT/LV1 Red to Yellow	1,28 - 1,92
LT/LV2 Black to Black	0,22 - 0,33
LT/LV2 Red to Red	2,00 - 3,00

Stator Winding AC Open Circuit Voltages at 20°C (68°F)

The values given are True rms AC volts

LT/LV1

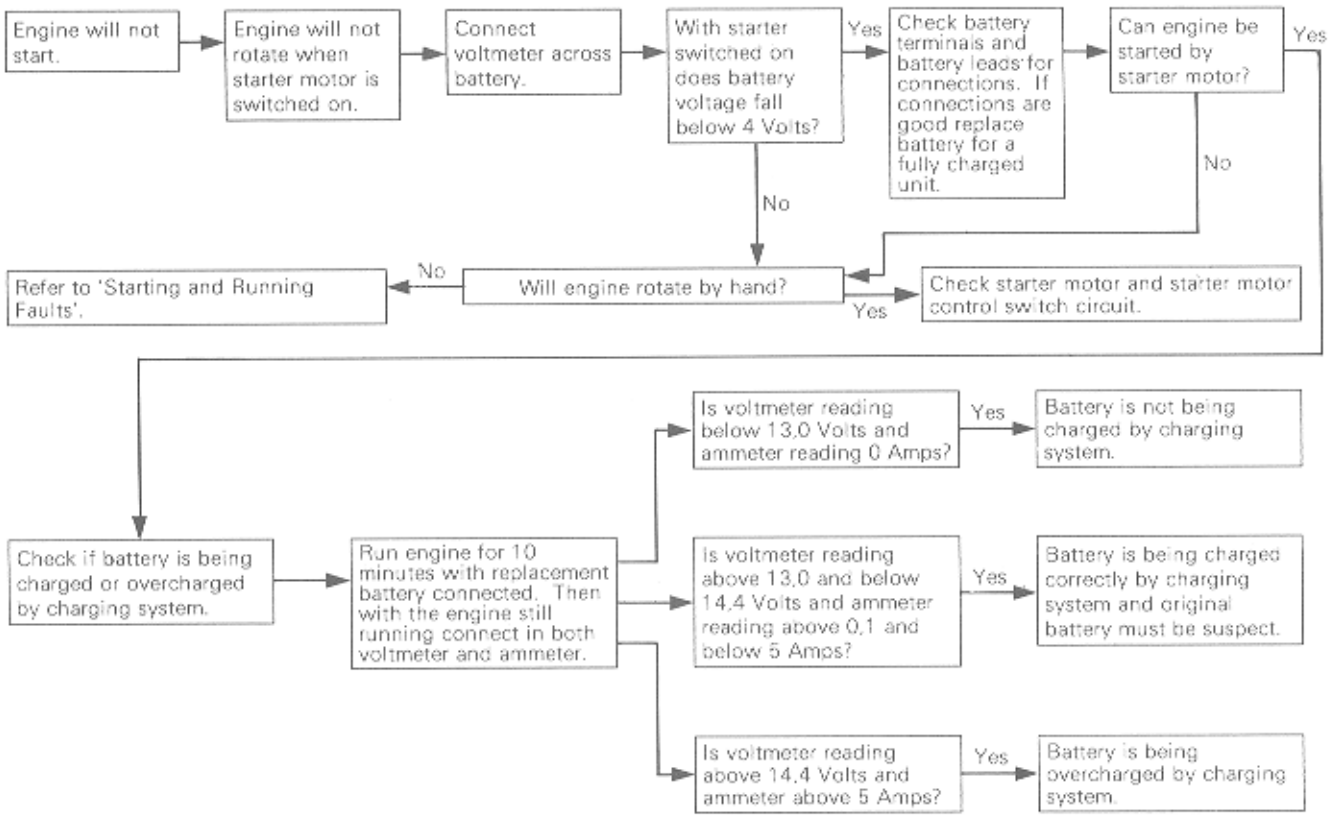
r/min	Black to Yellow	Red to Yellow
1000	11 - 17	31 - 47
1500	16 - 25	46 - 69
2000	22 - 33	61 - 92
2500	27 - 40	75 - 113
3000	32 - 48	90 - 134
3600	38 - 57	106 - 160

LT/LV2

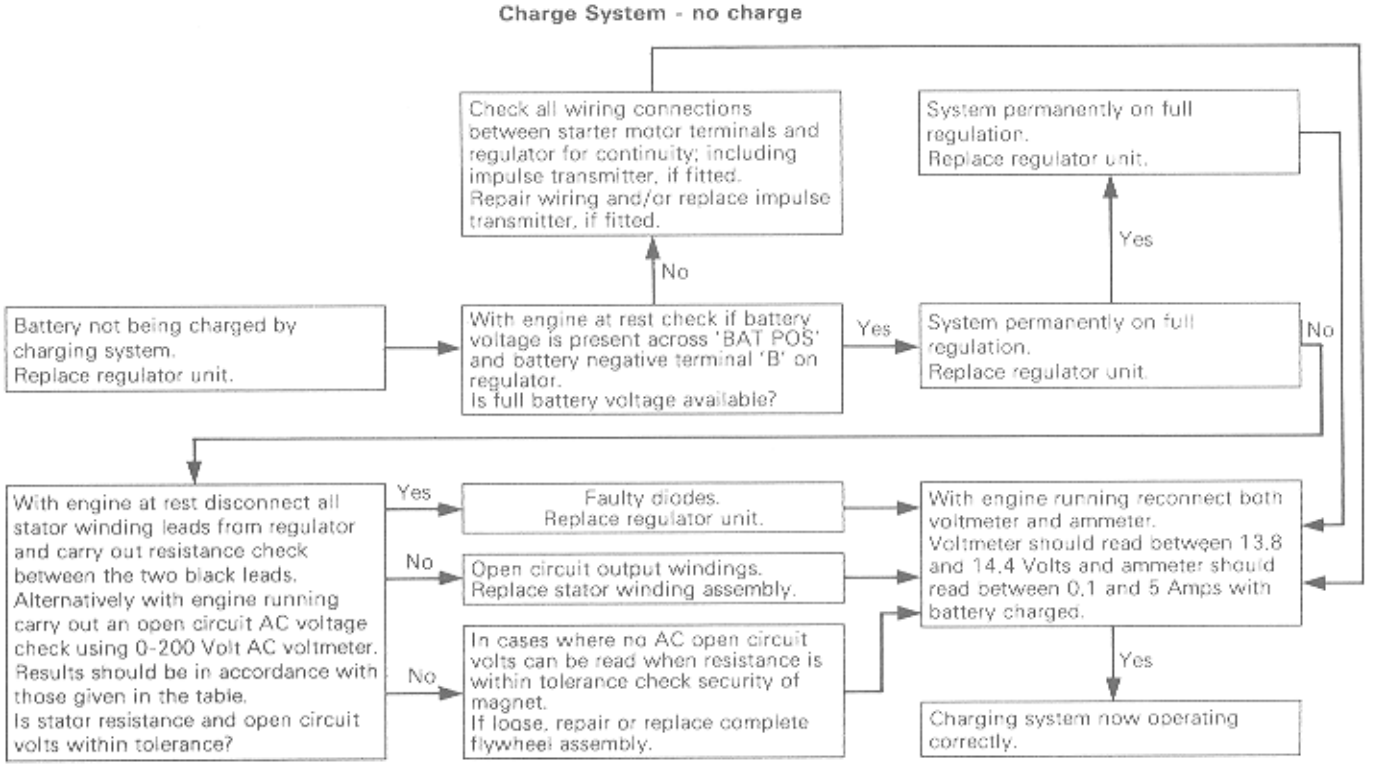
r/min	Black to Black	Red to Red
1000	16 - 24	42 - 63
1500	23 - 35	62 - 93
2000	31 - 46	81 - 121
2500	37 - 56	99 - 149
3000	45 - 68	121 - 181

Syncro Fault Finding Flow Charts

Starter Motor, Battery and Charge System

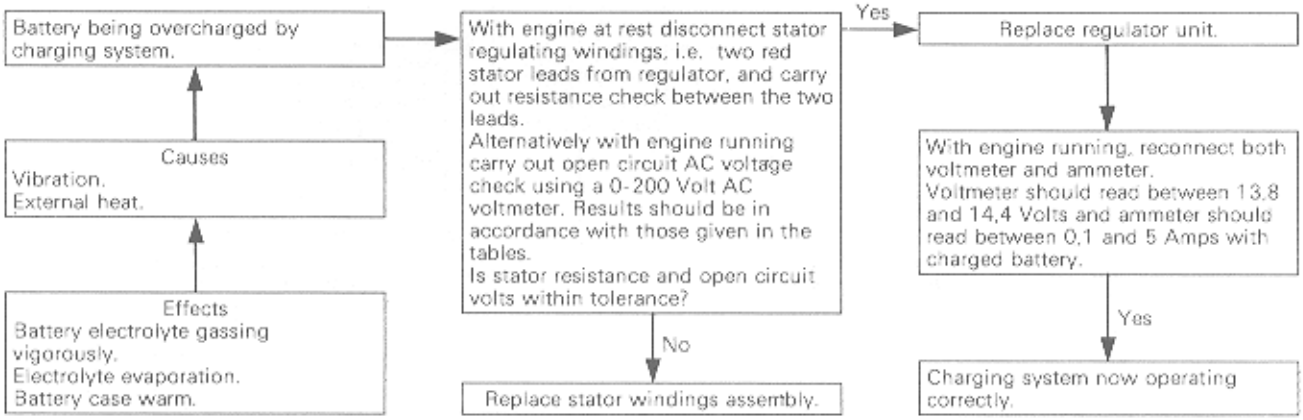


Charge System - no charge

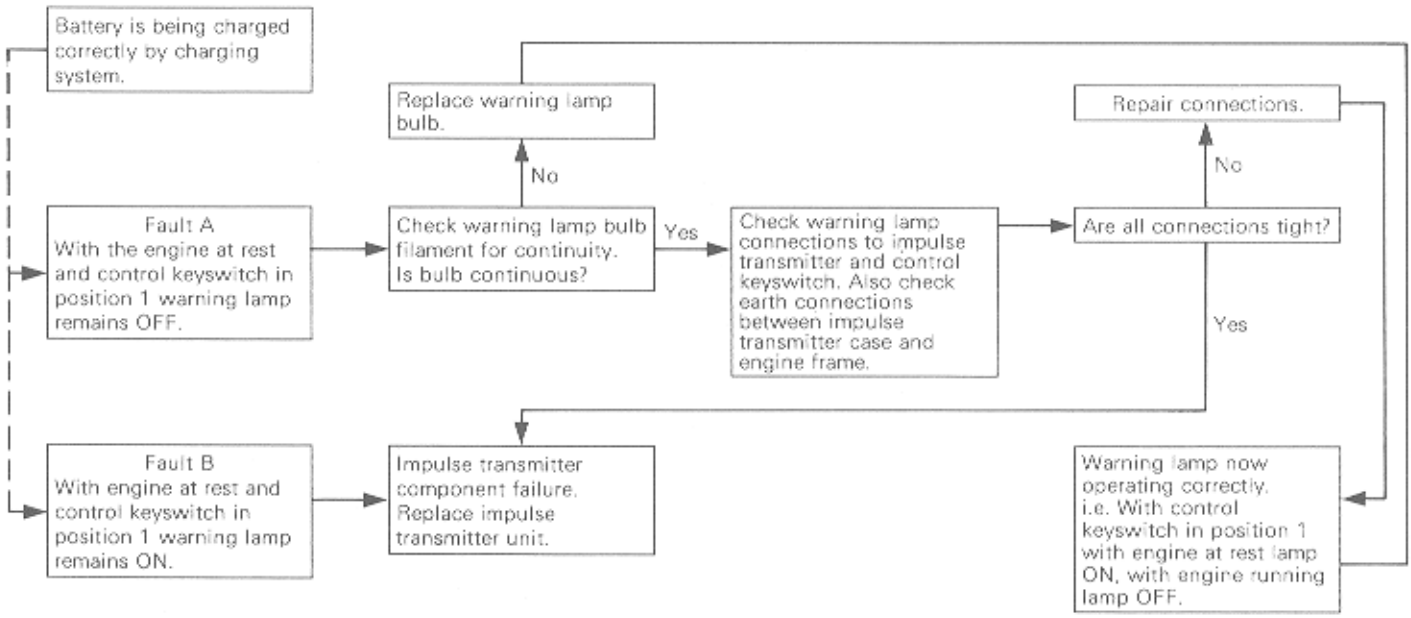


Syncro Fault Finding Flow Charts

Charge System Overcharging



Charge System Warning Lamp Malfunction



NICSA CHARGE WINDINGS

Output Charge Rate - Voltage held at 12,5 Volts

r/min	Amps
1000	5,3 - 7,0
1500	10,0 - 11,5
2000	13,0 - 14,5
2500	15,0 - 16,5

Fault Finding

The most common faults associated with this system are dealt with in the flow charts.

In cases where no electric start is possible reference should firstly be made to 'Starter Motor, Battery and Charge System Fault Diagnosis Flow Chart', proceeding through to other charts if a charge system fault becomes evident.

In cases where a specific charging fault is known to exist refer directly to the relevant flow chart.

The following instruments are necessary to carry out the tests:

1. 0-20A moving coil ammeter.
2. 0-20V moving coil voltmeter or a DC multimeter.
3. 0-200V moving iron voltmeter or an AC multimeter.
4. 0-5 Ohm meter or multimeter.

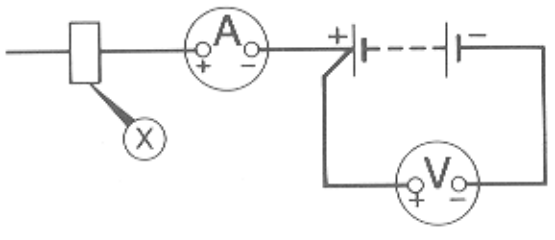


Figure 80. Test Instrument Connection Diagram:
X - Removed B+ Battery Terminal

Stator Winding Resistance at 20°C (68°F)

Leads	Resistance
Yellow to Yellow	0,45-0,55
Red to Yellow	0,225-0,275

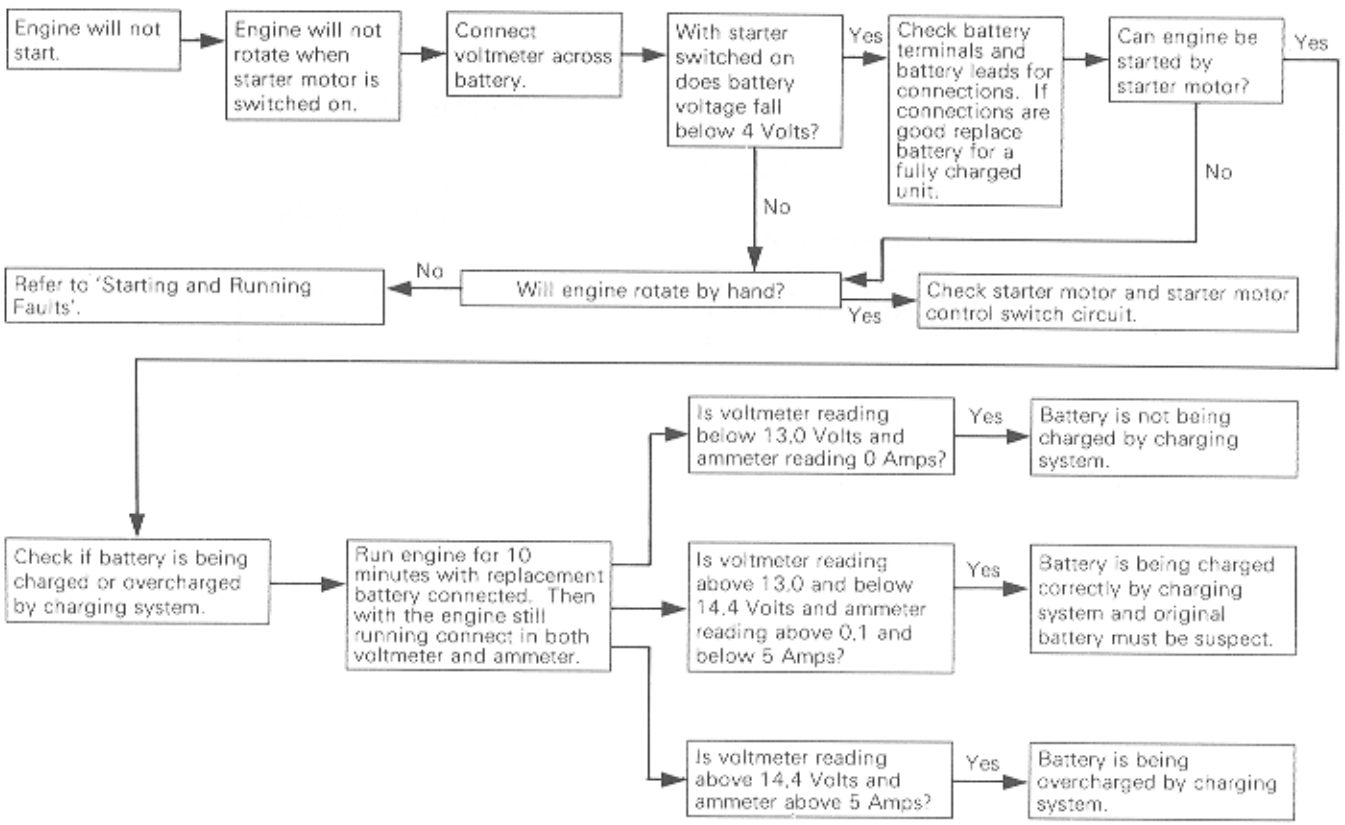
Stator Winding AC Open Circuit Voltages at 20°C (68°F)

The values given are True rms AC volts

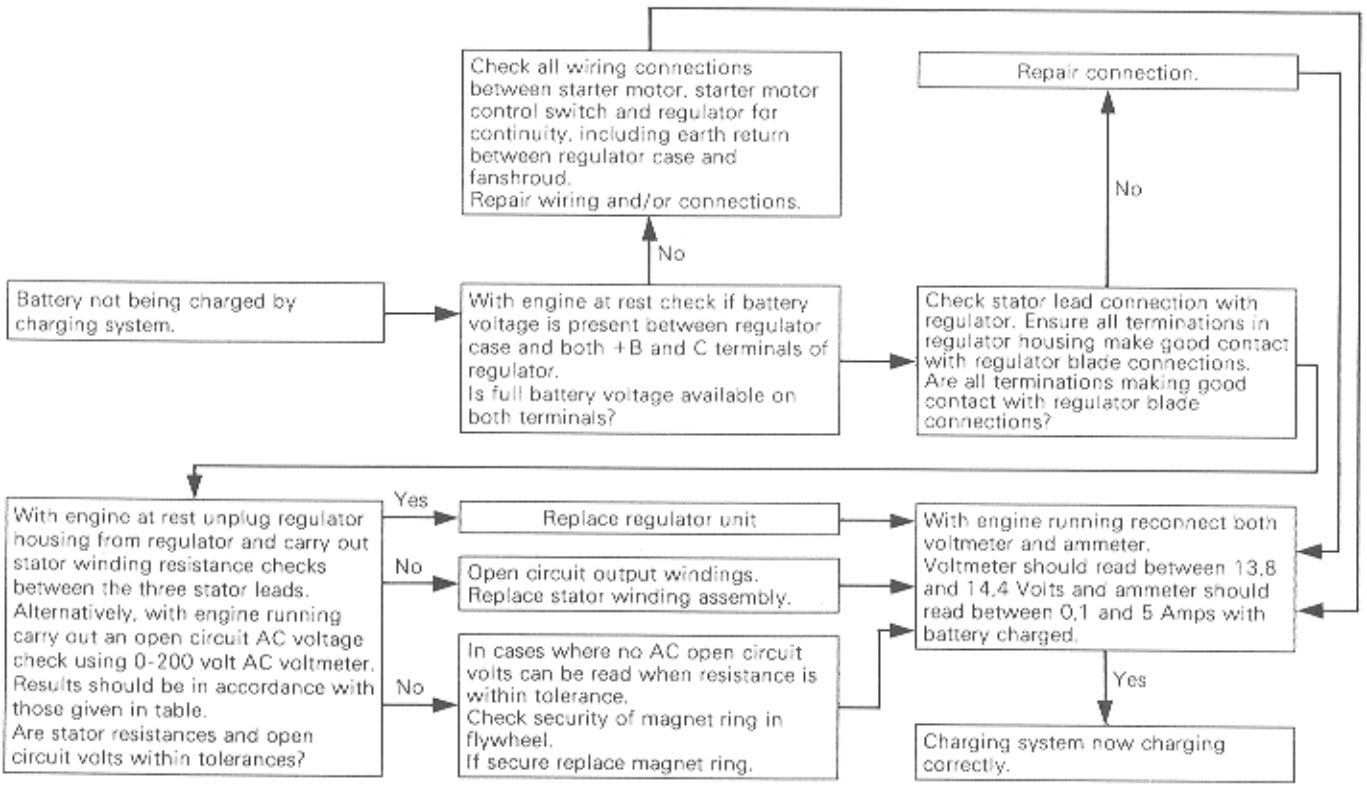
r/min	Yellow to Yellow	Red to Yellow
1000	30 - 34	13 - 17
1500	43 - 49	21 - 24
2000	53 - 62	26 - 32
2500	69 - 77	33 - 39

Nicsa Fault Finding Flow Charts

Starter Motor, Battery and Charge System

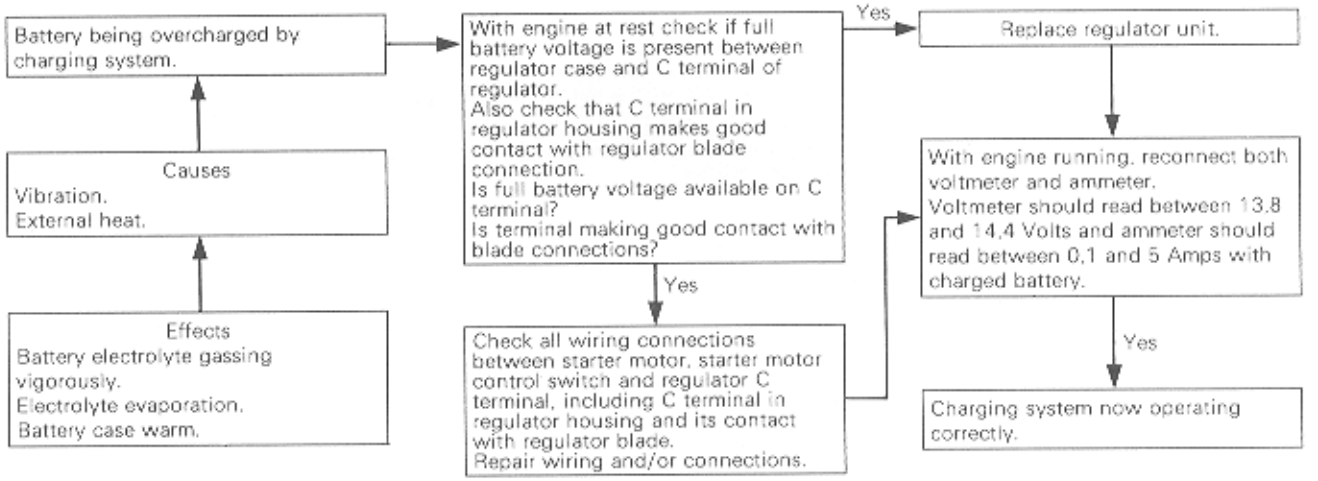


Charge System - no charge

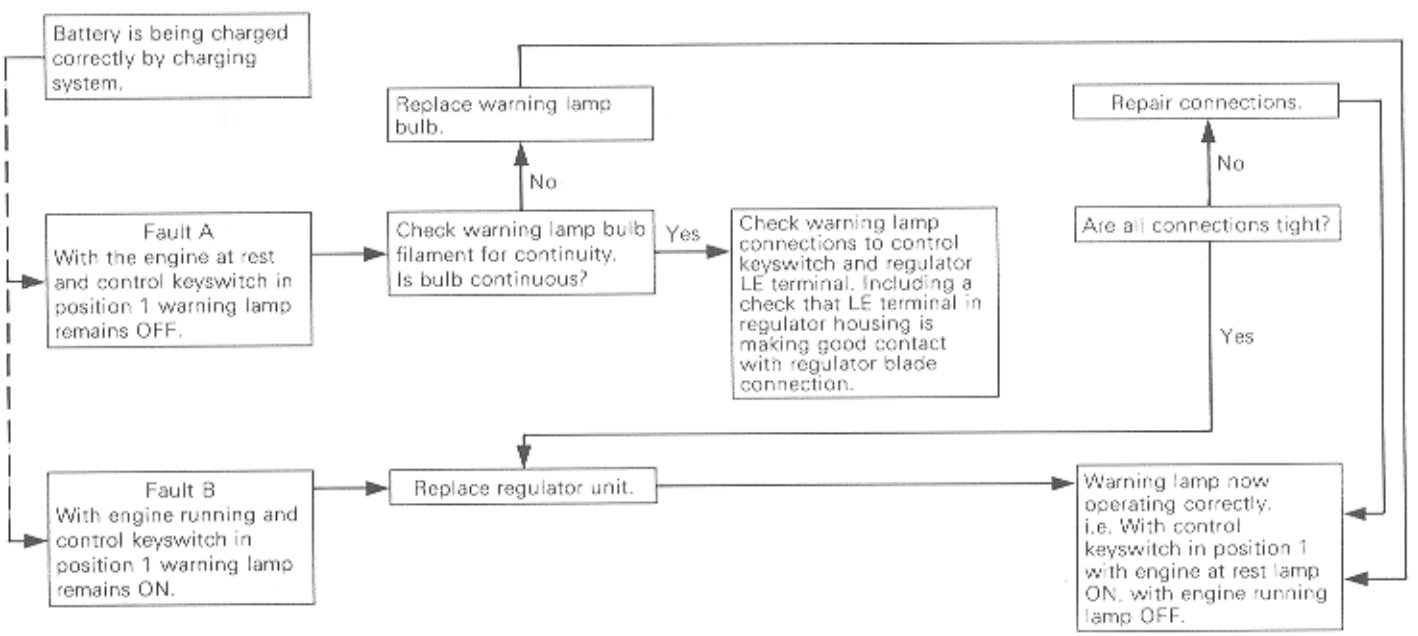


Nicsa Fault Finding Flow Charts

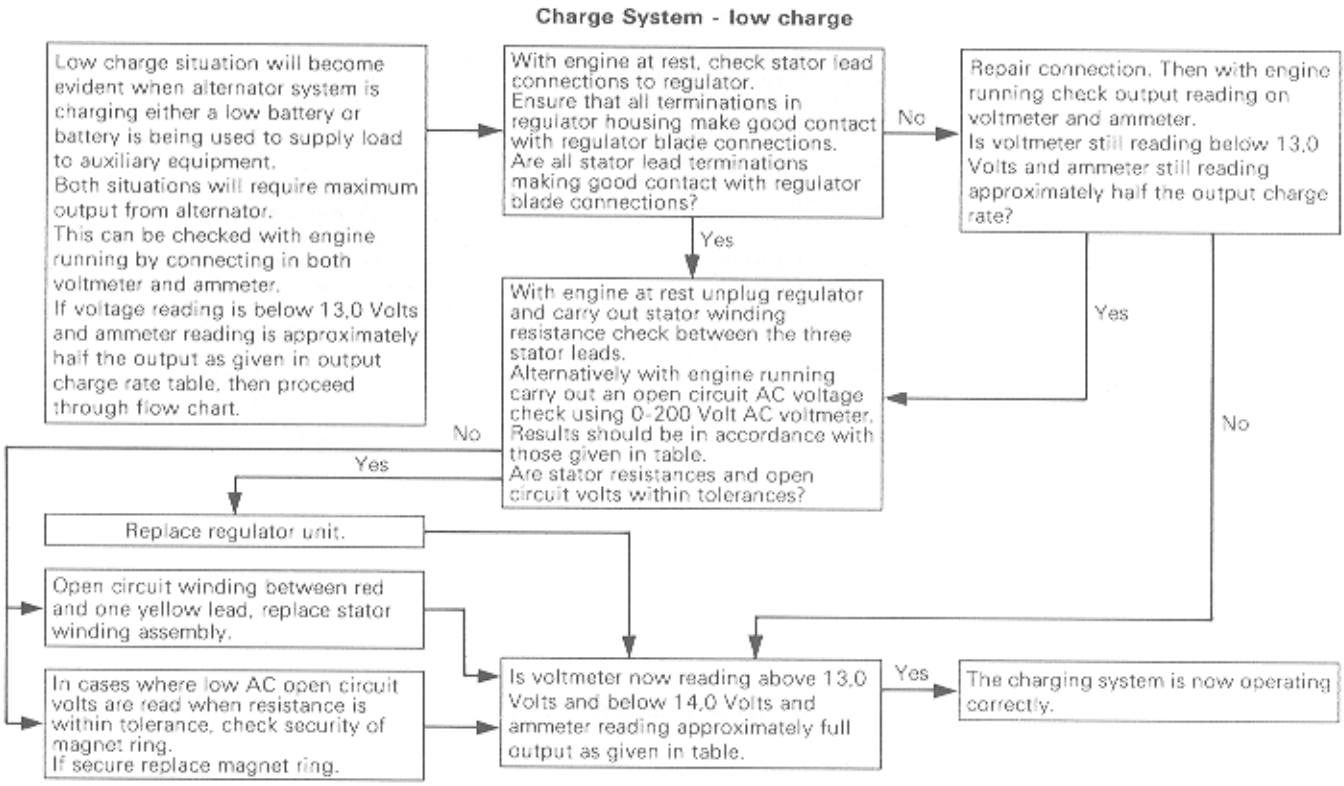
Charge System Overcharging



Charge System Warning Lamp Malfunction



Nicsa Fault Finding Flow Chart



WIRING DIAGRAMS

All cables must be P.V.C. insulated automobile cable to BS6862. The cable sizes given relate to the cables between the control panel, or loose components, and the engine being a maximum length of 1,5 metres and the cables between the battery and engine being a maximum length of 0,94 metre.

In cases where Nicsa Charge Windings are used without a starter motor the cable size given relates to the cable between the regulator and battery being a minimum length of 0,5 metre.

The small numbered boxes shown attached to some cables are cable identification numbers.

Key to All Diagrams

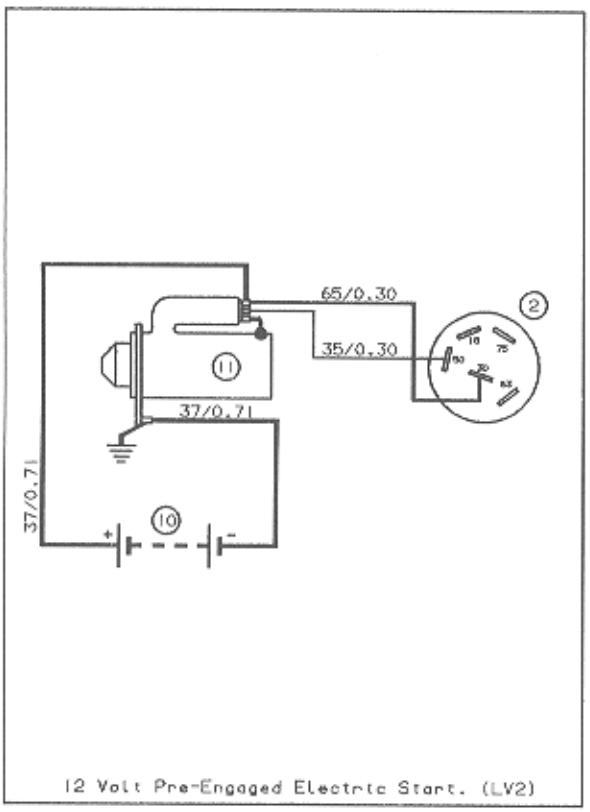
1. Flywheel Alternator Stator.
2. Control Keyswitch.
3. Engine Temperature Switch.
4. Fuel Control Solenoid Circuit Breaker.
5. Fuel Control Solenoid.
6. Battery Charge Indicator.
7. Oil Pressure Override Pushbutton.
8. Oil Pressure Switch.
9. Regulator.
10. Starter Battery.
11. Starter Motor.
12. Control Switch (5A rating) - not supplied.
13. Warning Lamp.
14. Protective Switch Relay.
15. Starter Solenoid.
16. Plug (16b) and Socket (16a).
    All terminal arrangements are as viewed from the rear.

Cable Colour Code for All Diagrams

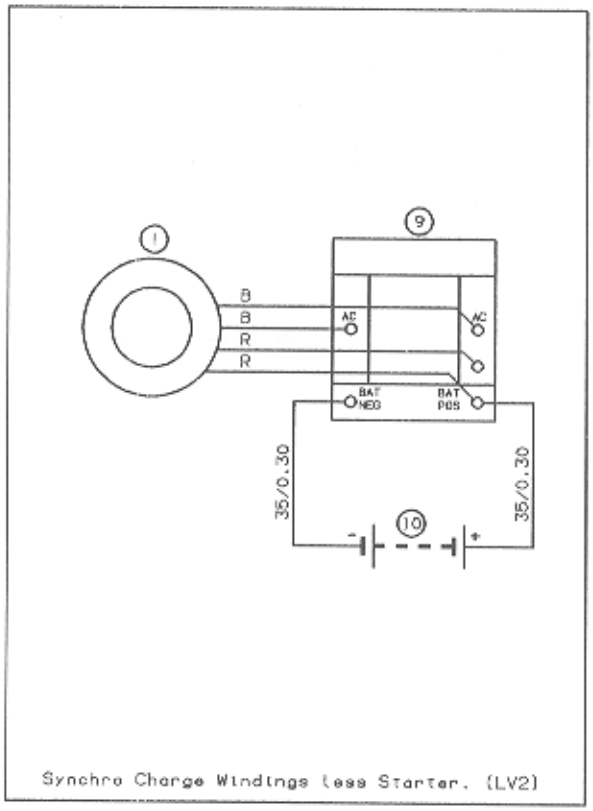
R = Red
R (Small) = Red (Small)
R (Large) = Red (Large)
Y = Yellow
B = Black

Rectifier/Regulator Terminals

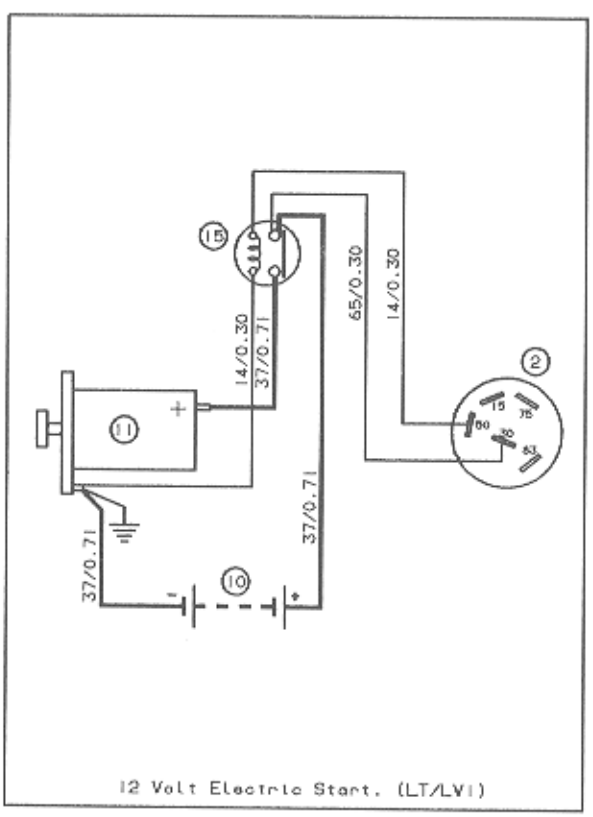
BAT POS = Battery +
BAT NEG = Battery -



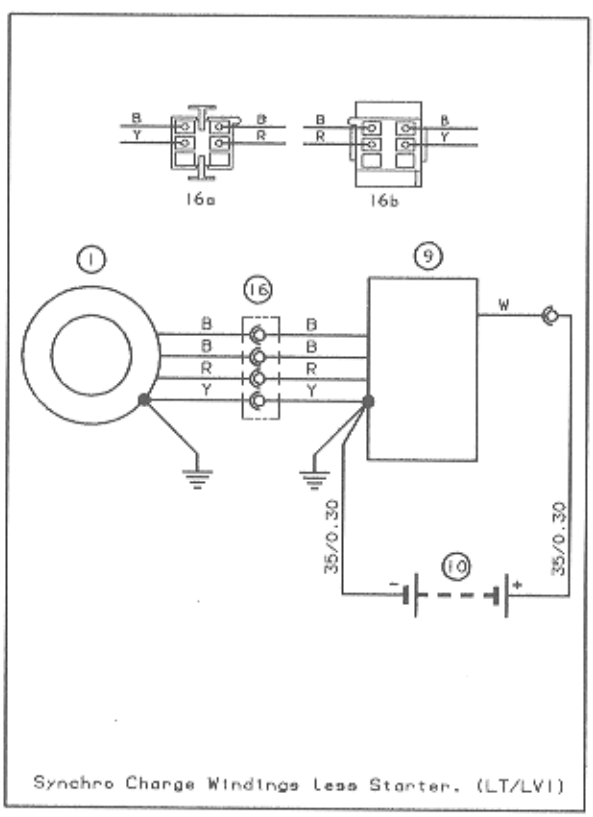
12 Volt Pre-Engaged Electric Start. (LV2)



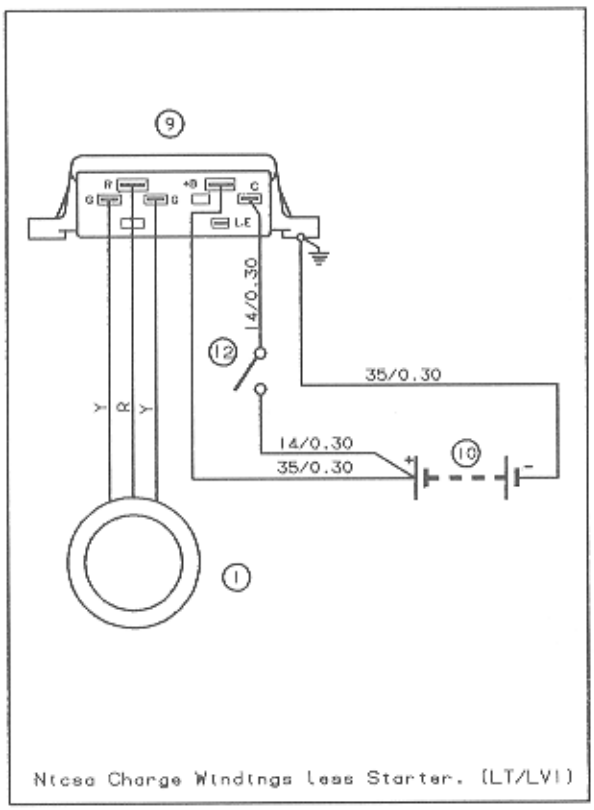
Synchro Charge Windings less Starter. (LV2)



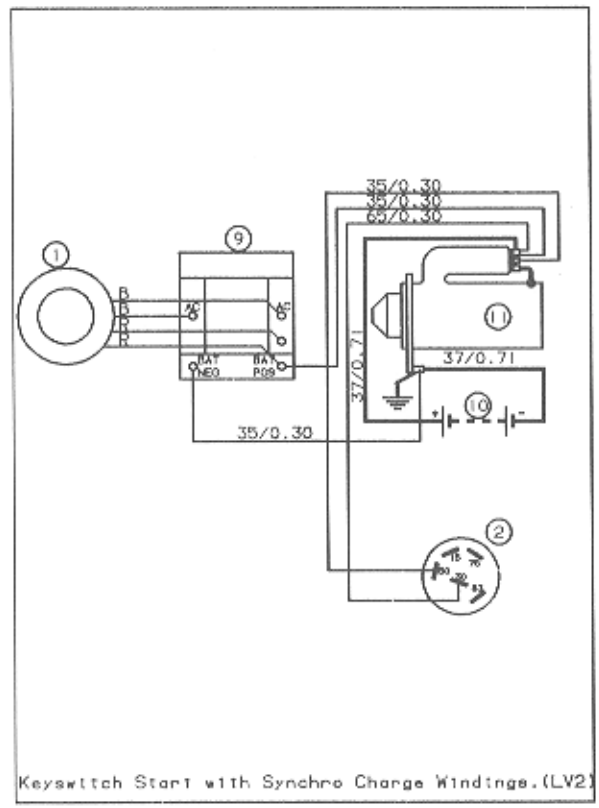
12 Volt Electric Start. (LT/LVI)



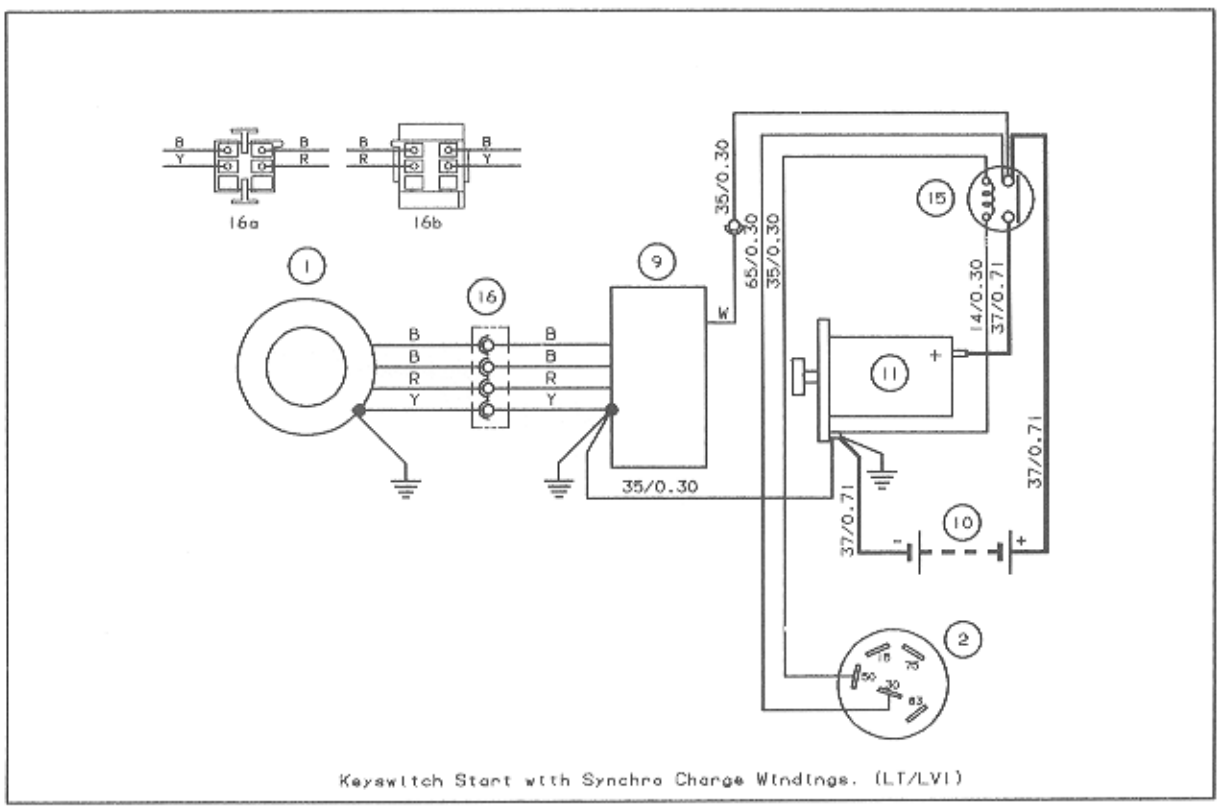
Synchro Charge Windings less Starter. (LT/LVI)



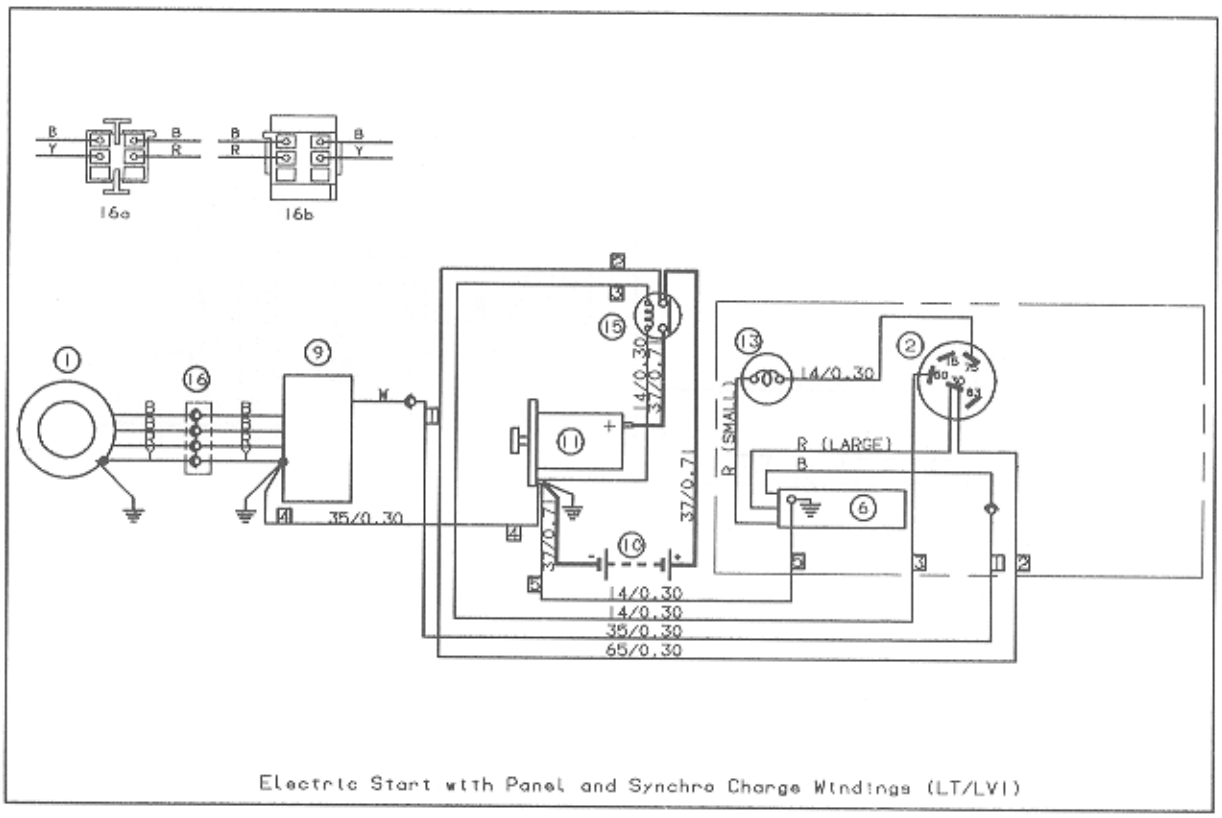
Ntcsa Charge Wtndtngs Less Starter. (LT/LVI)



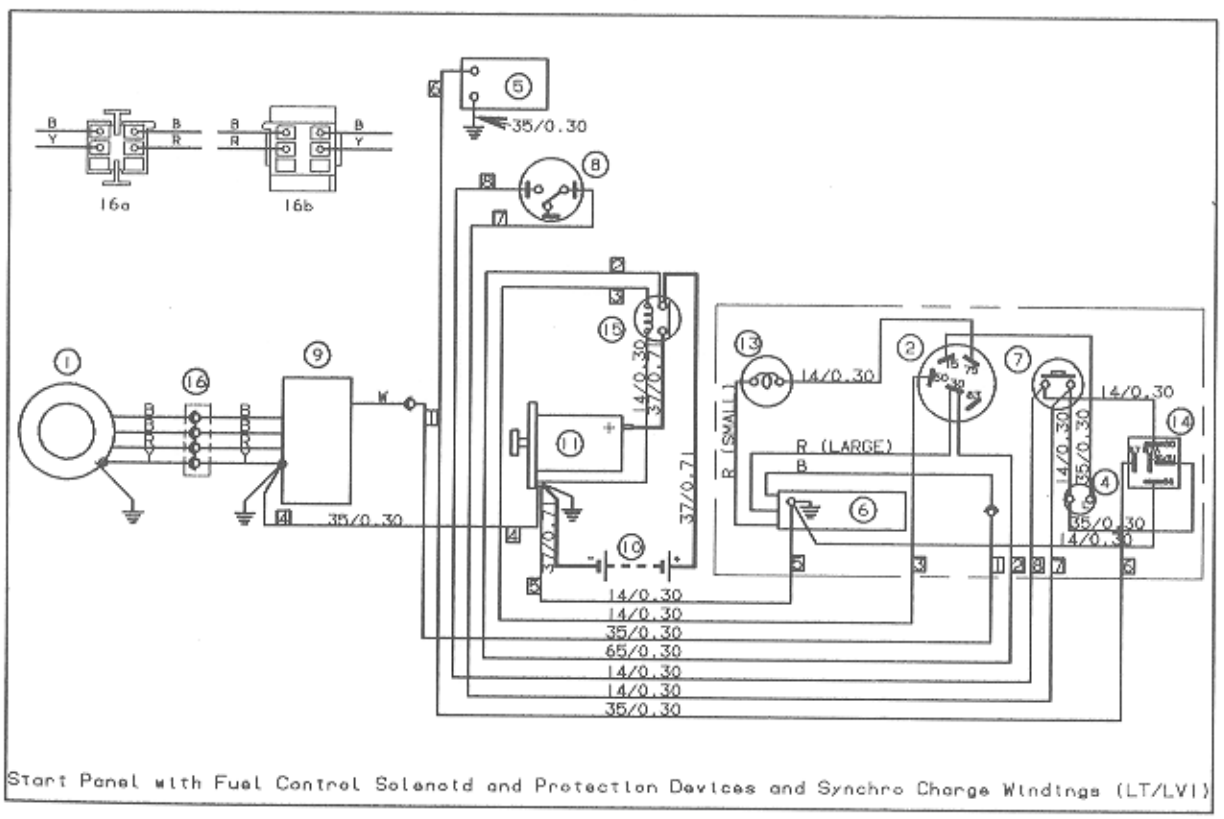
Keyswttch Start wtth Synchro Charge Wtndtngs.(LV2)



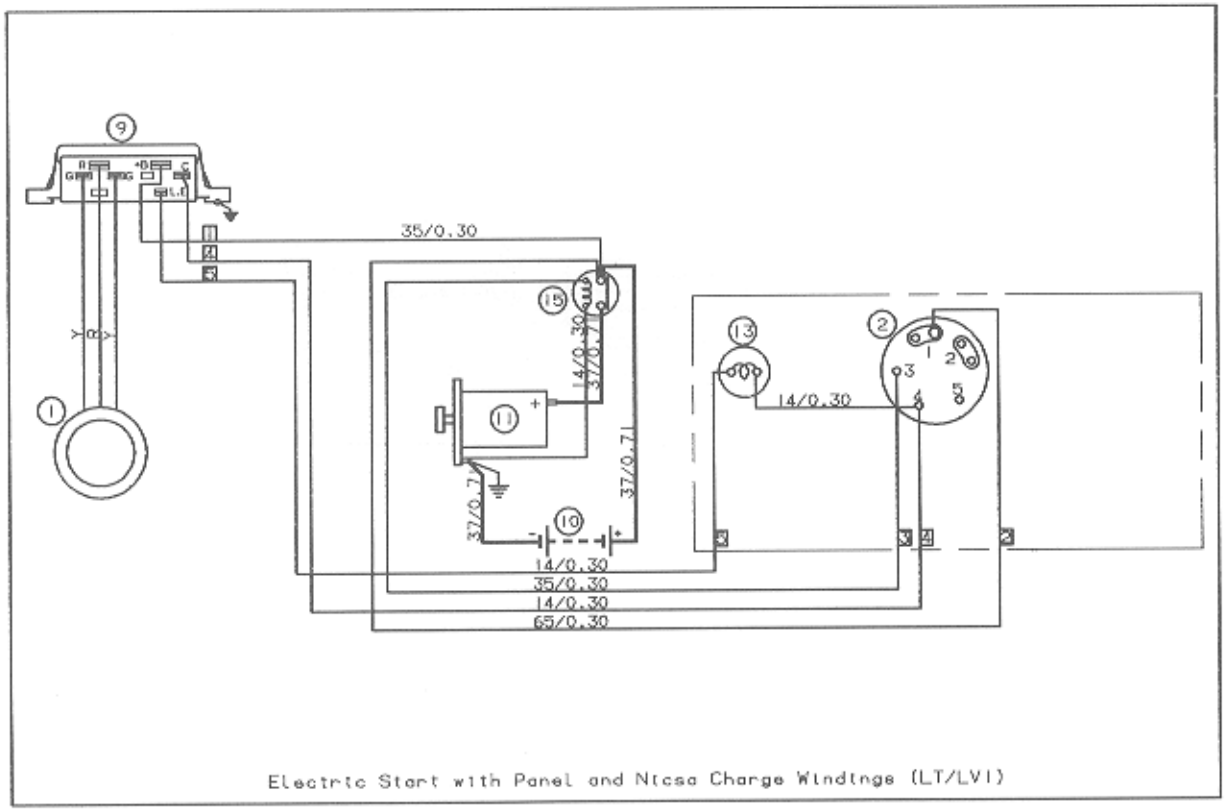
Keyswttch Start wtth Synchro Charge Wtndtngs. (LT/LVI)



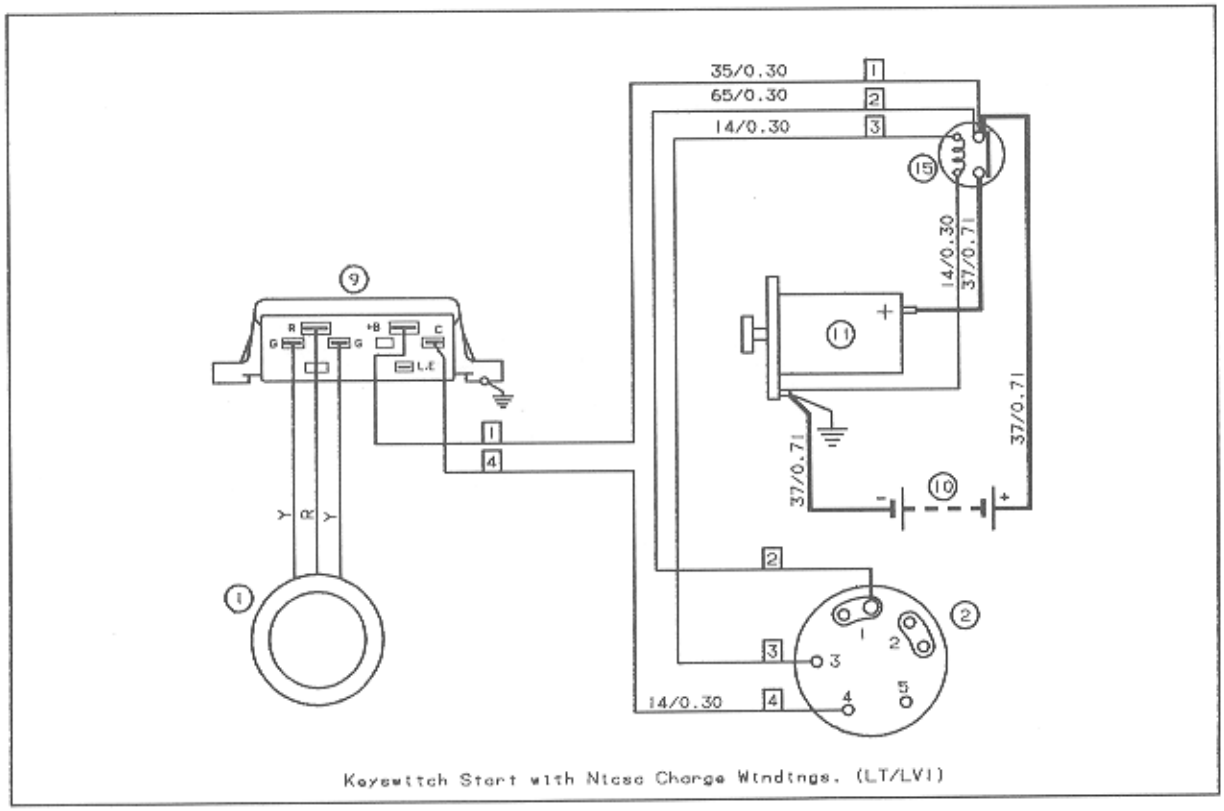
Electric Start with Panel and Synchro Charge Windings (LT/LVI)



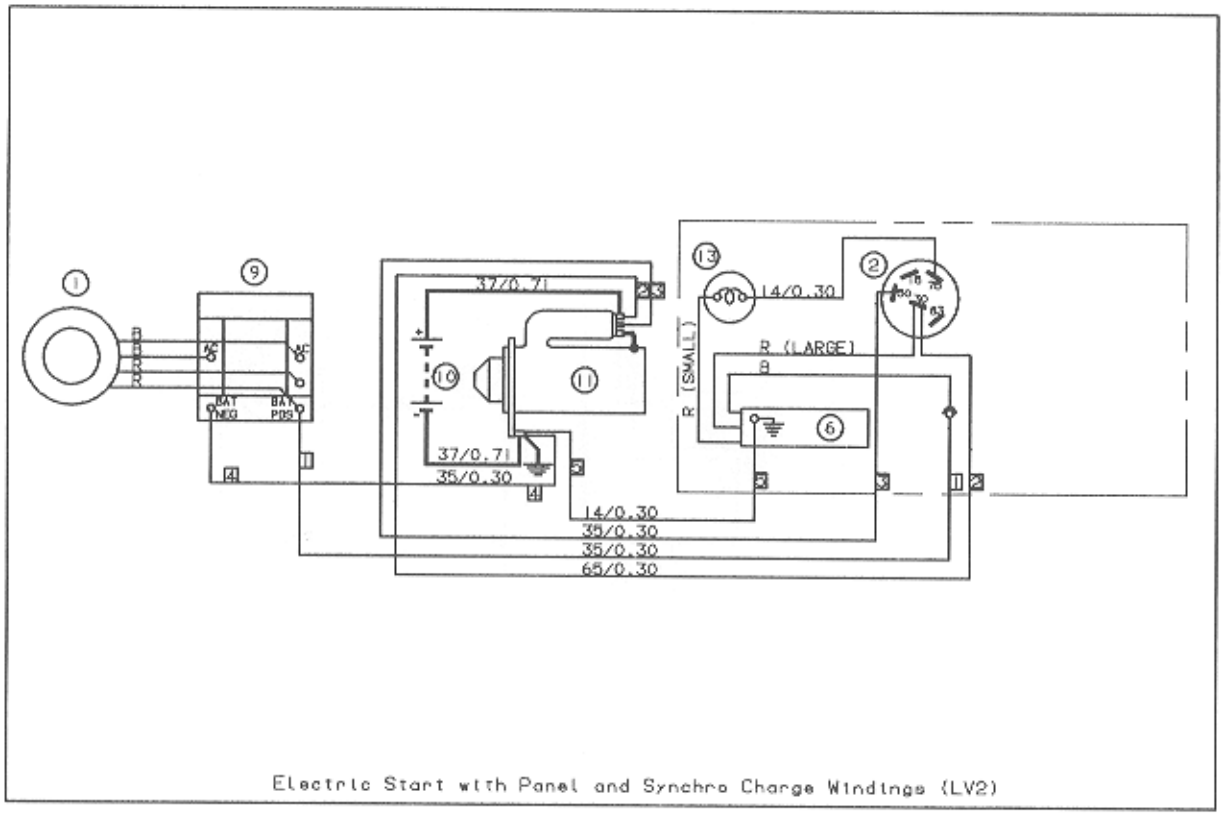
Start Panel with Fuel Control Solenoid and Protection Devices and Synchro Charge Windings (LT/LVI)



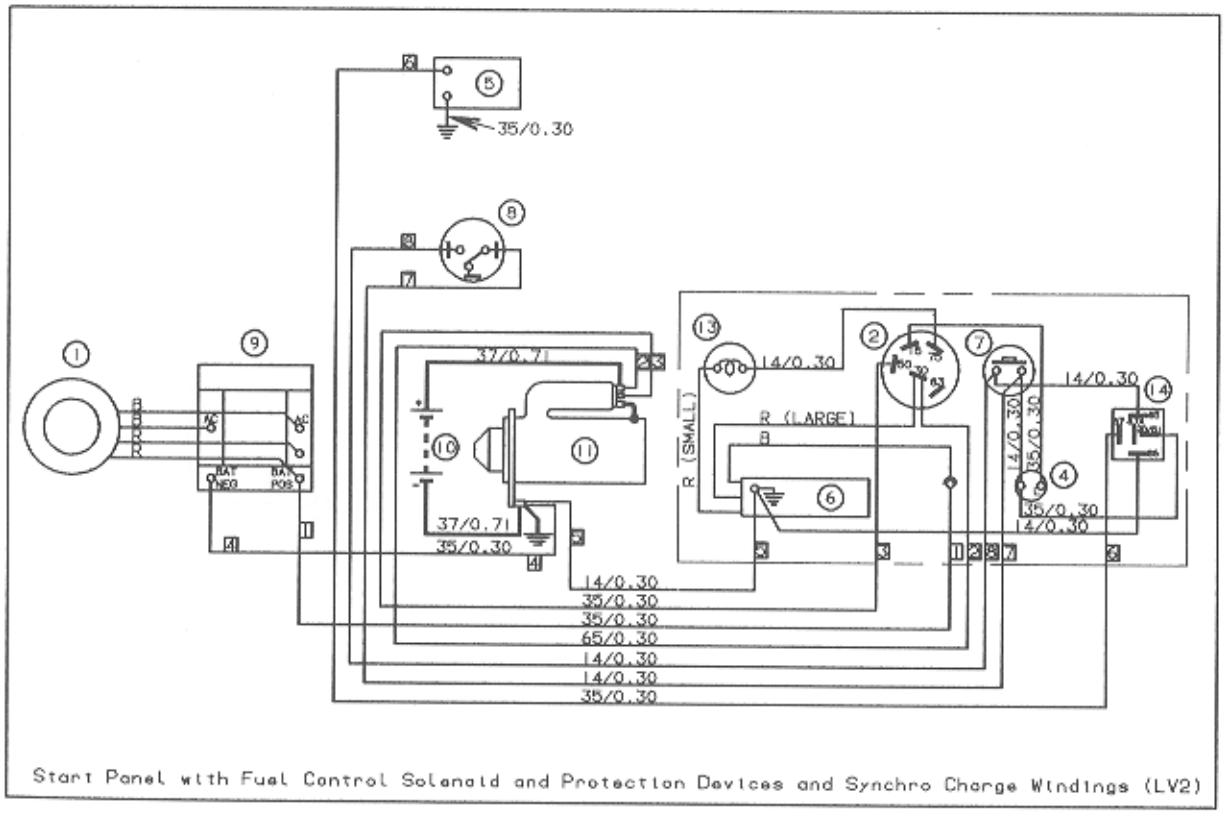
Electric Start with Panel and Nicsa Charge Windings (LT/LV1)



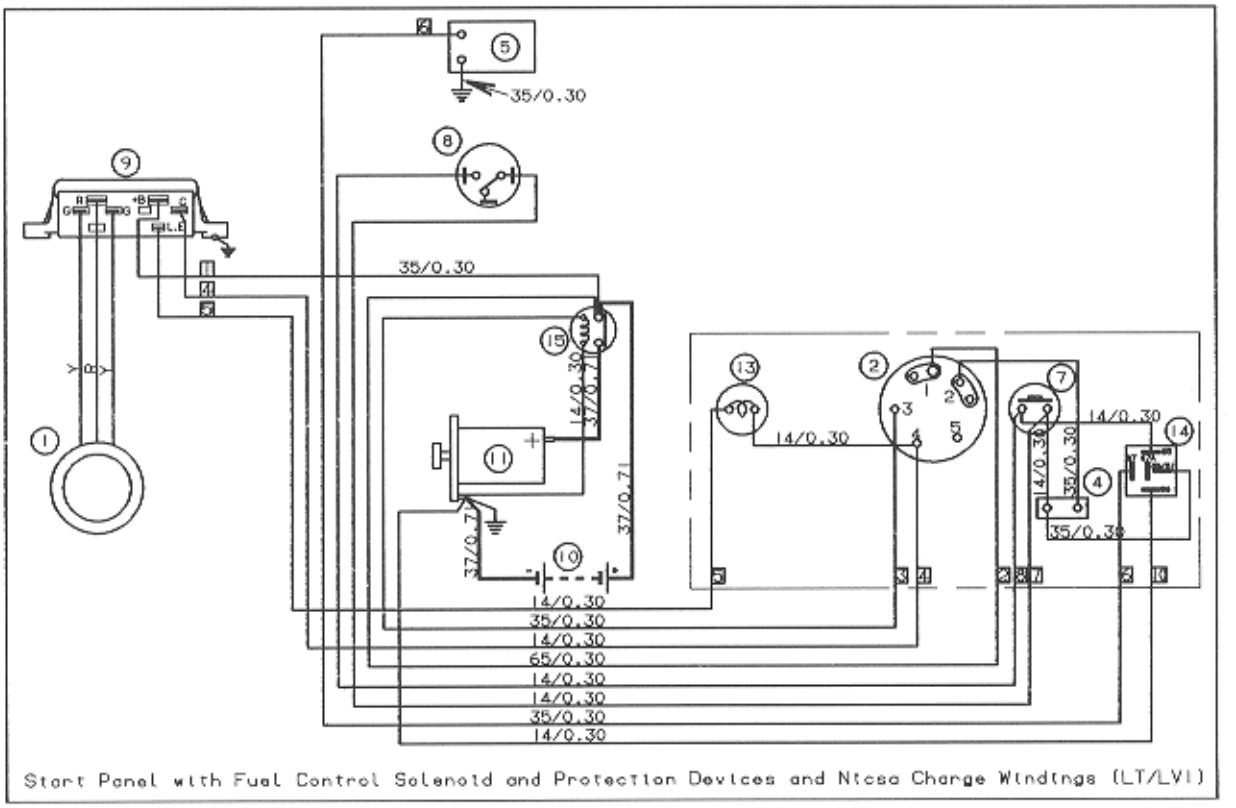
Keyswitch Start with Nicsa Charge Windings. (LT/LV1)



Electric Start with Panel and Synchro Charge Windings (LV2)



Start Panel with Fuel Control Solenoid and Protection Devices and Synchro Charge Windings (LV2)



Start Panel with Fuel Control Solenoid and Protection Devices and Ntcsa Charge Windings (LT/LVI)

Section 7 - Conversion Factors and Formulae

Contents

Length 116
Liquid Capacity 116
Volume 116
Linear Velocity 116
Rate of Flow 117
Pressure 117
Torque 118
Force 118
Energy 118
Power 118
Specific Fuel Consumption 119
Temperature 119
Metric Prefixes 119
Calorific Value of Fuel 119
Air Density 119
Formulae 120

Conversion Factors

The conversion tables in this section have been derived from BS350.

LENGTH

	metre	inch	foot	yard
	m	in	ft	yd
1 metre =		39,3701	3,2808	1,0936
1 inch =	0,0254		0,0833	0,0278
1 foot =	0,3048	12,0000		0,3333
1 yard =	0,9144	36,0000	3,0000	

1 in = 25,4mm
1mm = 0,03937in

LIQUID CAPACITY

	litre	UK pint[1]	UK gallon[2]	US pint
	l	pt	gal	pt
1 litre =		1,7598	0,2199	2,1134
1 UK pint =	0,5683		0,1250	1,2009
1 UK gallon =	4,5464	8,0000		9,6076
1 US pint =	0,4732	0,8327	0,1041	

[1] Also known as the Imperial pint.
[2] Also known as the Imperial gallon.

1 UK gallon = 1,2009 US gallon
1 US gallon = 0,8326 UK gallon

VOLUME

	cubic metre	litre	cubic inch	cubic foot
	m^3	l	in^3	ft^3
1 cubic metre =		1000,0	61023,8	35,3147
1 litre =	0,0010		61,0238	0,0353
1 cubic inch =	$1,6387 \times 10^{-5}$	0,0164		$5,7870 \times 10^{-4}$
1 cubic foot =	0,0283	28,3168	1728,0	

$1 dm^3 = 1l$,
$1 in^3 = 16,3871 cm^3$

LINEAR VELOCITY

	metre per second	foot per second	foot per minute	inch per second
	m/s	ft/s	ft/m	in/s
1 metre/second =		3,2808	196,850	39,3701
1 foot/second =	0,3048		60,0000	12,0000
1 foot/minute =	0,0051	0,0167		0,2000
1 inch/second =	0,0254	0,0833	5,0000	

RATE OF FLOW - MASS

	kilogram per second	kilogram per hour	pound per second	pound per hour
	kg/s	kg/h	lb/s	lb/h
1 kilogram/second =		3600,0	2,2046	7936,6
1 kilogram/hour =	$2,7777 \times 10^{-4}$		$6,1239 \times 10^{-4}$	2,2046
1 pound/second =	0,4535	1632,9		3600,0
1 pound/hour =	$1,2599 \times 10^{-4}$	0,4535	$2,7777 \times 10^{-4}$	

RATE OF FLOW - VOLUME

	cubic metre per second	litre per second	cubic foot per second	UK gallon per second
	m^3/sec	l/s	ft^3/s	gal/s
1 cubic metre/second =		1000,0	35,3147	219,969
1 litre/second =	0,0010		0,0353	0,2200
1 cubic foot/second =	0,0283	28,3168		6,2288
1 UK gallon/sec =	$4,5460 \times 10^{-3}$	4,5461	0,1605	

1 UK gallon = 1,2009 US gallon

PRESSURE - Table 1

	newton per square millimetre	kilogram-force per square centimetre	pound-force per square inch	pound-force per square foot
	N/mm^2	kgf/cm^2	lbf/in^2	lbf/ft^2
1 N/mm^2 =		10,1972	145,038	20885,4
1 kgf/cm^2 =	$9,8066 \times 10^{-2}$		14,2233	2048,16
1 lbf/in^2 =	$6,8947 \times 10^{-3}$	0,0703		144,00
1 lbf/ft^2 =	$4,7880 \times 10^{-5}$	$4,8824 \times 10^{-4}$	$6,9444 \times 10^{-3}$	

1Pa (Pascal) = $1 N/m^2$

PRESSURE - Table 2

	bar	atmosphere	kilogram-force per square centimetre	pound-force per square inch
	bar	atm	kgf/cm^2	lbf/in^2
1 bar =		0,9869	1,0197	14,5038
1 atmosphere =	1,0132		1,0332	14,6959
1 kgf/cm^2 =	0,9807	0,9678		14,2233
1 lbf/in =	0,0689	0,0680	0,0703	

PRESSURE - Table 3

	inch of water	foot of water	millimetre of mercury	inch of mercury
	in H_2O	ft H_2O	mmHg	inHg
1 inch of water =		0,0833	1,8683	0,0735
1 foot of water =	12,0000		22,4198	0,8827
1 mm of mercury =	0,5352	0,0446		0,0394
1 inch of mercury =	13,5951	1,1329	25,4000	

1 in H_2O = 0,00248bar

TORQUE (Moment of Force)

	newton metre	kilogram-force metre	pound-force foot	pound-force inch
	Nm	kgf m	lbf ft	lbf in
1 Newton metre =		0,1020	0,7376	8,8507
1 kilogram-force metre =	9,8066		7,2330	86,7962
1 pound-force foot =	1,3558	0,1382		12,0000
1 pound-force inch =	0,1130	0,0115	0,0833	

The kilogram-force is known as the kilopond (kp) in Germany. 1kgf m = 1kp m

FORCE (Mass x Acceleration)

	newton	kilogram-force	pound-force	poundal
	N	kgf	lbf	pdl
1 Newton =		0,1019	0,2248	7,2330
1 kilogram-force =	9,8066		2,2046	70,9316
1 pound force =	4,4482	0,4536		32,1740
1 poundal =	0,1382	0,0141	0,0311	

The kilogram-force is known as the kilopond (kp) in Germany. 1kgf = 1kp
1pdl = 1lb ft/s^2
1N = 1kg m/s^2

ENERGY - Table 1

	kilowatt hour	kilogram-force metre	foot pound-force	horsepower hour
	kWh	kgf m	ft lbf	hp h
1 kWh =		$3,6709 \times 10^5$	$2,6552 \times 10^6$	1,3410
1 kgf m =	$2,7240 \times 10^{-6}$		7,2330	$3,6530 \times 10^{-6}$
1 ft lbf =	$3,7661 \times 10^{-7}$	0,1382		5,0505
1 hp h =	0,7457	$2,7374 \times 10^5$	$1,98 \times 10^6$	

ENERGY - Table 2

	joule	horsepower hour	calorie	British thermal unit
	J	hp h	cal	Btu
1 Joule =		$3,7250 \times 10^{-7}$	0,2388	$9,4781 \times 10^{-4}$
1 horsepower hour =	$2,6845 \times 10^6$		641186	2544,43
1 calorie =	4,1868	$1,5596 \times 10^{-6}$		$3,9683 \times 10^{-3}$
1 British thermal unit =	1055,06	$3,9301 \times 10^{-4}$	251,996	

POWER - Table 1

	kilowatt	metric horsepower	brake horsepower	British thermal unit per hour
	kW	CV	bhp	Btu/h
1 kW =		1,3596	1,3410	3412,14
1 CV =	0,7355		0,9863	2509,63
1 bhp =	0,7457	1,0139		2544,43
1 Btu/h =	0,00029	$3,9846 \times 10^{-4}$	$3,9301 \times 10^{-4}$	

The metric horsepower is more commonly known as the Cheval Vapeur (CV). (1CV = 1CH = 1PS)

POWER - Table 2

		watt	kilocalorie per hour	British thermal unit per hour	
		W	kcal/h	Btu/h	
1 Watt	=		0,8598	3,4121	
1 kcal/h	=	1,1630		3,9683	
1 Btu/h	=	0,2930	0,2519		

SPECIFIC FUEL CONSUMPTION

		pounds per horsepower hour	pounds per Cheval Vapeur hour	grams per kilowatt hour	grams per Cheval Vapeur hour
		lb/hp h	lb/CV h	g/kW h	g/CV h
1 lb/hp h	=		0,9862	608,27	447,33
1 lb/CV h	=	1,0140		616,80	453,59
1 g/kW h	=	$1,6440 \times 10^{-3}$	$1,621 \times 10^{-3}$		0,7354
1 g/CV h	=	$2,235 \times 10^{-3}$	$2,205 \times 10^{-3}$	1,3600	

The Cheval Vapeur (CV) is also known as the metric horsepower. (1CV = 1CH = 1PS)
1lb = 453,592g

TEMPERATURE

The temperature unit in most practical use in many countries is the degree Celsius (°C), however the terms Centigrade (°C) and Fahrenheit (°F) are still in use. The Fahrenheit scale is not formally defined but it is generally recognised that the temperature difference of 1°F is equal to five ninths of the temperature difference of one degree °C.

$$1°F = \frac{9}{5}\ °C + 32$$

$$1°C = \frac{5}{9}\ (°F - 32)$$

The refinements of temperature scales are abstruse, but for most practical purposes the following relationships apply. For the same temperature, if t and Ø represent the temperature on the Fahrenheit or Celsius scales, similarly r and T the Rankine (absolute Fahrenheit °R) and Kelvin (absolute Celsius K) temperatures, respectively, then

$$Ø = \frac{5}{9}\ (t - 32)$$

$$T = \frac{5}{9}\ (t + 459,67)$$

$$r = t + 459,67$$

The temperature at the triple point of water,(where water, ice and water vapour are in equilibrium) is very slightly removed from the temperature of the melting point of ice at atmospheric pressure (the ice point).

METRIC PREFIXES

Prefix	Symbol	Factor by which the Unit is Multiplied.
tera	T	1 000 000 000 000
giga	G	1 000 000 000
mega	M	1 000 000
kilo	k	1 000
hecto	h	100
deca	da	10
deci	d	0,1
centi	c	0,01
milli	m	0,001
micro	u	0,000 001
nano	n	0,000 000 001
pico	p	0,000 000 000 001
femto	f	0,000 000 000 000 001
atto	a	0,000 000 000 000 000 001

CALORIFIC VALUE OF FUEL

kJ/kg - 42800
Btu/lb- 18400

AIR DENSITY

= 1,205kg/m³ = 0,0752lb/ft³

Formulae

BMEP

Bar = $\frac{kW \times 60000 \times 20000}{\text{Cylinders} \times r/min \times \text{bore area } (mm^2) \times \text{stroke } (mm)}$

$lbf/in^2 = \frac{bhp \times 792000}{\text{Cylinders} \times r/min \times \text{bore area } (in^2) \times \text{stroke } (in)}$

Torque

$Nm = \frac{kW \times 9549}{r/min} \times OL$

$lbf\ ft = \frac{bhp \times 5252}{r/min} \times OL$

OL = Overload
No overload = 1,0
10% overload = 1,1

Fuel Consumption

$l/h = \frac{g/kWh \times kW}{840} \times L$

$pt/h = \frac{lb/bhp\ h \times bhp}{1,05} \times L$

L = Load (naturally aspirated engines)
100% = 1,0 50% = 0,58
75% = 0,78 25% = 0,40
L = Load (turbocharged engines)
100% = 1,0 50% = 0,55
75% = 0,76 25% = 0,38
A Specific Gravity of 0.84 is assumed.

Oil Consumption

$l/24h = \frac{g/kWh \times kW}{4922}$

$pt/24h = \frac{lb/bhp\ h \times bhp}{0,15}$

A Specific Gravity of 0,886 is assumed

Piston Speed

$m/sec = \frac{\text{stroke (mm)} \times r/min}{30000}$

$ft/min = \frac{\text{stroke (in)} \times r/min}{6}$

Mechanical Efficiency

$\% = \frac{bhp}{ihp} \times 100$

Cyclic Irregularity

$\frac{\text{max flywheel speed - min flywheel speed}}{\text{mean flywheel speed}}$

Power

$kW = \frac{r/min \times Torque(Nm)}{9549}$

$bhp = \frac{r/min \times Torque(lb\ ft)}{5252}$

Continuous Power

1bhp = 1,014CV = 0,746kW
1kW = 1,340bhp = 1,359CV
1CV = 0,986bhp = 0,736kW

Intermittent Power

1,1bhp = 1,115CV = 0,821kW
1,1kW = 1,474bhp = 1,495CV
1,1CV = 1,085bhp = 0,810kW

Index

A

Air Cleaner 25
Air Cowling 27
Air Density 119
Automatic Excess Fuel Assembly 59
Automatic Excess Fuel Device 12, 76

B

Back Leakage 87
Battery Connections 99
Battery Performance 98
Bearing Clearance 56
Breather 28
Builds 9, 10
Bumping Clearance 30

C

Camshaft 43
Camshaft Ball Race 44
Camshaft Bushes 45
Camshaft Endfloat 44
Camshaft Gearwheel 44
Charge Windings 100
Charge Windings - Nicsa 103
Charge Windings - Syncro 100
Cleaning the Cooling Fins 48
Cleaning the Injector 86
Cold Cranking Battery Performance 98
Cold Weather Start Aid 12
Connecting Rod 50
Conversions 116
- Calorific Value of Fuel 119
- Energy - Table 1 118
- Energy - Table 2 118
- Force (Mass x Acceleration) 118
- Length 116
- Linear Velocity 116
- Liquid Capacity 116
- Metric Prefixes 119
- Power - Table 1 118
- Power - Table 2 119
- Pressure - Table 1 117
- Pressure - Table 2 117
- Rate of Flow - Mass 117
- Rate of Flow - Volume 117
- Specific Fuel Consumption 119
- Temperature 119
- Torque (Moment of Force) 118
- Volume 116

Crankcase Breather 28
Crankcase Vacuum 11
Crankshaft 54
Crankshaft Endfloat 56
Crankshaft Extension 53
Crankshaft Main Bearings 57
Cylinder Barrel 47
Cylinder Head 30
Cylinder Head Clearance 30
Cylinder Head Cover 28
Cylinder Head Oil Feed 72

D

Decarbonising 62
Decarbonising Joint Sets 62
Decompressor 32
Dimensions of Wearing Parts 63
Dipstick 70

E

Electrical Equipment 98
Electrical Wiring Diagrams 107-113
End Cover 38
End Cover Oil Seal 39, 73
Endfloat - Camshaft 44
Endfloat - Crankshaft 56
Engine Control Assembly 59
Excess Fuel Assembly 59
Excess Fuel Device 12, 76

F

Fanshroud 51
Faults 16
Flywheel 50
Flywheel Charge Windings 100
Flywheel Housing 51
Formulae 120
Fuel Filter 77
Fuel Injection Pump 79
Fuel Injector 29, 85
Fuel Injector Back Leakage 87
Fuel Lift Pump 79
Fuel Pump Identification 82
Fuel Pump Spill Timing 83, 84
Fuel Pump Tappet 41
Fuel Pump Timing Tables 84
Fuel System 75
Fuel Tank 77

G

Gear End Cover 38
Gear End Drives 53
Governor 89
Governor 'A' Setting 92
Governor 'D' Setting 95
Governor 'E' Setting 92
Governor 'G' Setting 94
Governor 'P' Setting 93
Governor 'Q' Setting 94
Governor and Fuel Pump 40
Governor Modifications 91

Governor Setting 91
Governor Weights 96

H

Head 30
Head Clearance 30
High Oil Consumption 69

I

Injection Pump 79
Injector 29, 85
Injector Back Leakage 87
Injector Cleaning 86
Injector Faults 18
Injector Part Numbers 85
Injector Removal Tool 29, 85
Injector Setting 86
Injector Settings 87

J

Joint Sets 62
Jointing Compounds 19

L

Laying-up Procedure 62
Lift Pump 79
Lifting Eye 27

M

Main Bearing Housing 52
Main Bearings 57
Manifolds 26
Manual Excess Fuel Assembly 59
Modifications to the Governor 91

N

Nicsa Fault Flow Charts 104-106

O

Oil Dipstick 70
Oil Filter 69
Oil Pressure 69
Oil Pump 42, 72
Oil Seal 39, 73
Oil Seals 73
Oil Strainer 42, 71
Oil Sump 41, 70
Oil Sump Capacity 69
Operating Instructions 12
Overhaul Joint Sets 62
Oversize and Undersize Items 63

P

Piston 49
Piston Rings 49
Polarity 98
Priming the Fuel System 78
Pump Spill Timing 83, 84
Pump Timing Tables 84

R

Rocker Stub Shafts 33
Routine Maintenance 15
Routine Maintenance Parts 20
Running Faults 16

S

Safety Precautions 6
Safety Symbols 8
Seat and Recess Cutting 37
Service Tools 21
Setting the Governor 91
Spanner Torques 22
Speed Adjustment 61
Speed Control Lever 60
Speeder Spring Code 96
Spill Timing 83, 84
Starting and Running Faults 16
Starting Handle 13
Stator 51
Stub Shafts 33
Sump 41, 70
Sump Capacity 69
Syncro Fault Flow Chart 101, 102

T

Technical Data 11
Timing Tables 84
Timing the Fuel Pump 83, 84
Tolerances and Clearances 63
Tools 21
Torques 22

U

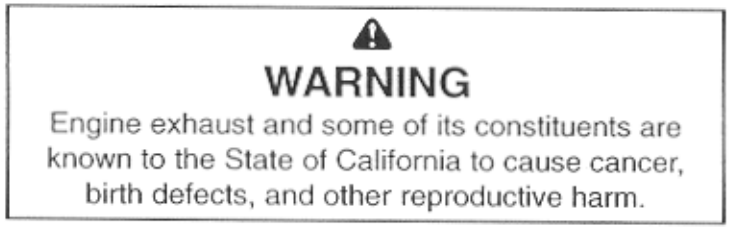
Undersize and Oversize Items 63

V

Vacuum	11
Valve Clearance	31
Valve Depths	37
Valve Guide Protrusions	35
Valve Guides	35
Valve Rocker Bush	34
Valve Rocker Stub Shafts	33
Valve Seat Cutting	37
Valve Seat Widths	37
Valve Seats	37
Valves	34

W

Wearing Parts	63
Wiring Diagrams	107-113


WARNING
Engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

Lister-Petter Limited
Dursley
Gloucestershire
GL11 4HS
England

Tel: +44 (0)1453 544141
Fax: +44 (0)1453 546732
E-mail: sales@lister-petter.co.uk
http://www.lister-petter.co.uk

Lister-Petter Inc.
815 E. 56 Highway
Olathe
Kansas 66061
USA

Tel: +1 913 764-3512
Fax: +1 913 764-5493
E-mail: lpinfo@lister-petter.com
http://www.lister-petter.com

Lister-Petter France
1, Avenue de L'escouvrier
Zone d'Activités
95842 Sarcelles Cédex
France

Tel: +33 (0)1 39330420
Fax: +33 (0)1 34195760
E-mail: frlister@aol.com

LISTER PETTER®