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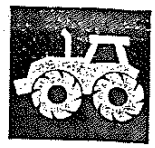




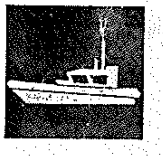


'A' Series Workshop Manual

Types: AA1, AC1, AD1 and AD2

INTRODUCTION

The purpose of this manual is to give information, operating, maintenance and repair procedures for the AA1, AC1 (Series 2), AD1 and AD2 engines.

This manual deals with engines built after 1st January 1986. Comprehensive information for earlier AA1 engines can be found in Workshop Manual P027-08228

The manual is designed primarily for use by qualified technicians with electrical and mechanical experience.

This 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 then this work should not be attempted.

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

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

The specification details given apply to a range of engines and not to any one particular engine. In cases of difficulty the user should consult the local Lister-Petter Distributor or Dealer 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, 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 the Lister-Petter organisation 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 and the guarantee will be invalidated.

When purchasing parts or giving instructions for repairs users should, in their own interests, always specify Genuine Lister-Petter Parts and quote the Description of the Part and the Engine Serial Number.

Associated Publications

Operators Handbook
- English P027-08183
- French P027-08183/fre
- Spanish P027-08183/spa

Master Parts Manual P027-08028

Technical Handbook P027-09212

Various technical/sales leaflets are available; please contact your Lister-Petter Distributor or Dealer for details.

Data on CD Rom

The Master Parts Manual, Technical Bulletins issued since June 1988 and parts information is available on CD Rom.
Please contact Lister-Petter for details.

Training

Comprehensive training in the correct operation, service and overhaul procedures of engines is available at the Lister-Petter International Product Training Centre. Please contact Lister-Petter for details.

If Problems Occur

If problems occur with your engine, or any of the Lister-Petter approved accessories fitted to it, your local Lister-Petter Distributor should be consulted.

There are Lister-Petter Distributors in most countries of the world and details for these can be obtained from any one of the companies listed on the back cover.

How to Use this Workshop Manual

Each section title is given at the top of the relevant pages and a full cross reference 'Index' appears at the back of the manual.

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

At times it may be necessary to refer to other parts of the section, or to a different section, for more specific or detailed information.

Caution and Warning Symbols

When an 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 manual.

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

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SAFETY PRECAUTIONS

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

⚠ WARNING

Starting any diesel engine can be dangerous in the hands of inexperienced people. Engine operators must be instructed in the correct procedures before attempting to start any engine.

Before Starting Precautions

- Ensure the engine is free to turn without obstruction, is securely mounted, there is a generous supply of cooling and combustion air available and all guards are in position.
- Check that the lubricating oil level is correct.
  The oil sump must be filled to the 'full' or 'max' mark on the dipstick; do not overfill.
- Check that the fuel supply is adequate and the system is primed.
- Where possible, disengage the driven equipment while starting.
- Keep the body and loose clothing away from all moving parts, and hot surfaces, while the engine is being started or it is running.

Alternator Precautions

The following points must be strictly observed when charge windings are fitted otherwise serious damage can be done.

- Never remove any electrical cable while the battery is connected in the circuit.
- Only disconnect the battery with the engine stopped and 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 and transistors.
- Never connect a battery into the system without checking that the voltage and polarity are correct.
- Never flash any connection to check the current flow.
- Never experiment with any adjustments or repairs to the system.
- The battery and charge windings must be disconnected before commencing any electric welding when a pole strap is directly or indirectly connected to the engine.

⚠ WARNING

Starting engines that are fitted with charge windings which have been disconnected from the battery will cause irreparable damage unless the stator leads from the rectifier/regulator have been removed.

Starter Battery Precautions

- Do not smoke near the batteries.
- Keep sparks and flames away from the batteries.
- Batteries contain sulphuric acid - if the acid has been splashed on the skin, eyes or clothes flush it away with copious amounts of fresh water and seek medical aid.
- Keep the top of the battery well ventilated during charging.
- Disconnect the battery negative (earth) lead first and reconnect last.
- Switch off the battery charger before disconnecting the charger leads.
- Never 'flash' connections to check current flow or experiment with adjustments or repairs to the system.
- Ensure that the battery is correctly connected, fully charged and serviceable.

Precautions for Filters and Elements

- Particular attention is drawn to the instructions given later in this section for replacing filters.
- 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

Fuel and new or used lubricating oil may cause skin irritation.

⚠ WARNING

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 gases if they are burnt.

Fuel System Precautions

- When priming or checking the fuel injection 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 injection 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.
  This procedure will ensure that there is no leakage from these joints.
- It is most important that all fuel joints are tight and leak proof.
- Always fill the fuel tank through a fine strainer, preferably at the end of the engine work period.
  If any sediment is stirred up during the process this has time to settle before the engine is used again, this will minimise the risk of condensation contaminating the fuel.
  If cans are used, avoid tipping out the last few drops.
- Funnels are very difficult to keep clean in dusty conditions.
  Wash them before and after use and wrap them up when not required, or fill the tank direct from a small mouthed screw capped fuel can.

⚠ WARNING

Care must be taken to ensure that no unprotected part of the body comes into contact with high pressure fuel oil at any time.

Lifting Precautions

- Ensure the lifting equipment to be used has the correct capacity to lift the engine.
- The lifting eye fitted to the engine is only suitable for lifting the engine and accessory assemblies originally fitted by Lister-Petter.

Waste Contamination

⚠ WARNING

Care must be taken to ensure that waste fuel, oil, filter elements and acid, where applicable, are disposed of in accordance with local regulations to prevent contamination.

Section 1 General Information

Technical Data

		AA1	AC1	AD1	AD2
Injection		Air cell	Direct		
Rotation - looking on flywheel		See Section 6			
Bore - nominal (not to be used for machining tolerances)	mm	69.85	76.20	80.00	
	in	2.75	3.00	3.15	
Stroke	mm	57.15	66.675	73.0	
	in	2.25	2.625	2.874	
Piston area	cm^2	38.32	45.60	50.265	100.53
	in^2	5.940	7.069	7.791	15.582
Cylinder capacity - total	l	0.219	0.304	0.367	0.734
	cm^3	219	304	367	734
	in^3	13.4	18.55	22.392	44.784
Compression ratio		17:1	18.5:1	18.8:1	
Mean piston speed at 3600r/min	m/sec	6.85	8.00	8.76	
	ft/min	1350	1575	1724	
Maximum permissible crankshaft end thrust	kg	54.0			
	lb	120.0			
Mechanical efficiency		59%	71%	72%	
Brake thermal efficiency		25%	33%	33.5%	
Oil sump capacity - with engine level See Note	l	1.9	2.7	2.7	3.7
	pt	3.33	4.75	4.75	6.5
	US qt	1.95	2.85	2.85	3.9
Capacity between dipstick marks See Note	l	0.65			1.2
	pt	1.2			2.1
	US qt	0.7			1.3
Lubricating oil pressure - mininmum at idling with engine hot	bar	0.8			
	lbf/in^2	12.0			
Lubricating oil pressure - mean	bar	2.8 - 4.0			
	lbf/in^2	40 - 60			
Pressure relief valve setting	bar	3.0 - 3.3			
	lbf/in^2	43 - 48			
Fuel tank capacity - engine mounted	l	3.8	5.0		
	pt	6.5	8.7		
	US qt	3.9	52		
Fuel injector setting	bar	183	200		
Intake restriction before derating	mm Hg	20.5			
	in H_2O	11.0			
Exhaust back pressure before derating	mm Hg	18.7			
	in H_2O	10.0			
Minimum idling speed	r/min	1200	1000		

Note:
AC1 Build 05 has the same capacity figures as AA1

Basic Installation Details

These instructions are of a general nature and further information and installation drawings are available from Lister-Petter.

DISTORTION

The engine should be bolted down to a rigid bed to ensure there is no excessive distortion. Customers installing engines in their own equipment must ensure that no strain is imposed on the engine feet either by distortion during installation where the feet are not correctly shimmed or by deflection of the structure during operation.

It is recommended that the units are bolted onto machined surfaces that are free from burrs, paints or other contaminants. Before tightening the holding down bolts a check for gaps between the unit mounting and the bed must be carried out. If any gap exceeds 0.125mm (0.005in) shims must be used to fill the gap.

ALIGNMENT

Accurate alignment is necessary between the engine drive shaft and the driven unit even with a flexible coupling fitted. Poor alignment shortens coupling life, causes bearing wear and produces excessive vibration.

Two principal types of misalignment can occur and they are shown in Figure 1, although there could be a combination of both.

a. Parallel
b. Angular

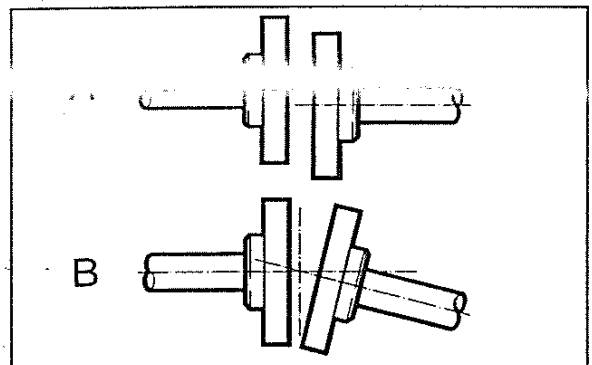

Figure 1. Misalignment:
A Parallel
B Angular

Parallel Misalignment

When the shaft of the driven unit is parallel to, but not in line with, the engine drive shaft.

Angular Misalignment

When the axis of the two shafts meet at the correct point but the shafts are at an angle to each other. To check the alignment the following procedure should be carried out:-

1. Fit the coupling halves to their respective engine drive shaft and the driven unit shaft.
2. Position and secure the engine and driven unit on the base frame so that the coupling halves are apart by the same amount as the thickness of the coupling middle section.
3. Check the parallel alignment by laying a straight edge across the coupling flanges at several positions around the circumference. An alternative method using a dial indicator can be used.
4. Using a suitable measuring tool check the angular alignment by measuring the gap between the coupling halves at several positions around the circumference of the couplings.
5. If the measurements made are more than 0.127mm (0.005in) adjust the parallel alignment by placing shims under the supports of the units as necessary and the conical alignment by adjusting position of the driven unit on its frame.
6. Fit and secure the middle flexible section of the coupling making sure that no strain is applied to it.
7. Tighten the grub screws or bolts securing the couplings to the shafts.

Warning:

Care must be taken to ensure that when couplings are secured the end floats of the engine and the driven unit shafts are as specified.

COOLING

The engines are cooled by air and must be installed where a generous supply of fresh air is assured which is not re-circulated or restricted.
A fan impeller is secured to the flywheel and the air is drawn into the impeller and discharged through trunking and shrouding to the fins of the cylinder and cylinder head.

THE EXHAUST SYSTEM

Small, light, non-tubular exhaust silencers can be mounted direct onto the manifold or on very light and short extensions which must be no more than 152mm (6in) long. Heavy silencers must be remotely mounted and connected by flexible pipe or hose, with no solid extensions between the manifolds and the flexible element. The silencer outlet pipe must face away from the engine and care must be taken to ensure that all joints are gas tight.

In general the exhaust pipe run should be kept short and straight with a silencer or expansion chamber fitted as near as possible to the engine. The tail pipe beyond the silencer should be about 10 times the pipe diameter in length. When long tail pipes have to be fitted the bore of the pipe must be increased as shown in the accompanying table. When the larger diameter pipes are fitted they should be fitted from the manifold or cylinder head onward.

Pipe Length	Pipe Bore
0 - 4.5m (0 - 15ft)	44.5mm (1.75in)
4.5 - 7.5m (15 - 25ft)	50.8mm (2.0in)
7.5 - 18.8m (25 - 65ft)	63.5mm (2.5in)
18.8 - 39.1m (65 - 130ft)	76.2mm (3.0in)

A back pressure of 18.7mmHg (10.0in H_2O) must not be exceeded without de-rating.

Bends should have a radius of not less than 4 diameters at the centre line of the pipe. When reckoning the total effective length of the pipe an allowance of 0.3m(1ft) of the total centre line length must be made for each bend in the system. If the bends are sharper than 4 diameters the allowance must be increased to 0.6m (2ft) per bend. Where pipes must be led upwards from the engine a suitable drain cock, or drain tap with cock, should be fitted at the lowest point to prevent the condensate running into the engine.
It is important to ensure that exhaust gasses are not sucked by the air cleaner or flywheel cooling fan.

Example:
In an exhaust system which measures 4.5m (15ft) the pipe bore diameter would be 44.5mm (1.75in), but if there were five simple bends in the system the total effective length would be 4.5 + 1.5 = 6.0m (15 + 5 = 20ft) and the pipe size would have to be increased to 50.8mm (2.0in).

POWER RATING AND DERATING

Declarations of power given for Lister-Petter diesel engines are in accordance with ISO 3046/1:1986, which is exactly comparable with BS 5514 Part 1:1987 and DIN 6271.

Ambient Temperature

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

The engines are able to run satisfactorily at ambient temperatures up to 25°C (77°F) without derating. Above this temperature the rated brake horsepower must be reduced in accordance with the relevant ISO, BS or DIN Standards.

The maximum ambient temperature at which an engine should be operated is 52°C (125°F); if an engine is required to run at a higher temperature Lister-Petter must be consulted.

Humidity

There are very few sites in the world that would require a de-rating in excess of 6% for humidity.

Altitude

The approximate relationship between barometric pressure and altitude above sea level up to 2440m (8000ft) is as follows:-

Barometric pressure (mmHg)
= 760 - (0.08 x Altitude)m

Barometric pressure (inHg)
= 30 - (0.001 x Altitude)ft

CARE OF YOUR NEW ENGINE

Before leaving the works each engine is carefully tested and inspected but after being put into service, further settling of some joints will occur and the valve gear will bed down.

It is important that a new or overhauled engine receives regular attention, particularly during the first 500 hours.

Long periods of light or 'no load' running early in the engine's life may lead to cylinder bore glazing and high oil consumption.

Initial Attention

To ensure that the top cups of the push rods are full of oil and the valve springs are lubricated, pour lubricating oil over the valve gear.

It is recommended that the following receive attention after the engine has run 25 hours and again after 250 hours running.

a. Check and tighten nuts, bolts and unions paying particular attention to the fuel system.

b. Change the lubricating oil for the first time after 25 hours and then every 250 hours.

c. Adjust the tappet clearances.

Operating 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" inside the front cover and be instructed in the use of the engine control and the correct starting procedures.

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

AA ENGINES

Cold Starting Below 15°C (59°F)

1. Withdraw the plunger (A) and fill the cup with the same type of lubricating oil as used in the engine.
2. Replace the plunger to inject the oil just before starting.

Repeat the above procedure if the temperature is below 0°C (32°F).

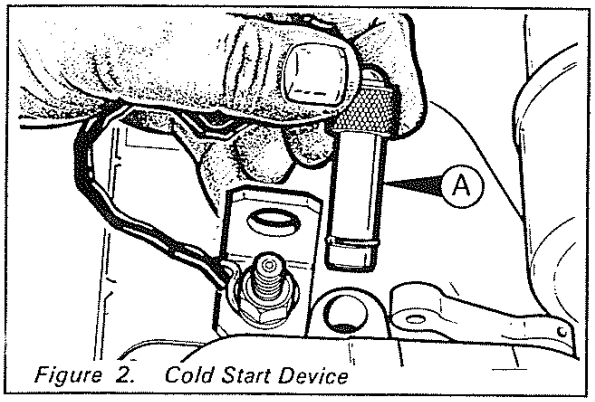

Figure 2. Cold Start Device

Rope Start

Rope starting is not recommended at temperatures below -4°C (25°F).

1. Before attempting to start the engine read the "Safety Precautions" inside the front cover.
2. Move the decompressor lever towards its stop and hold it in this position.
3. Move the engine control to the RUN position.
4. If a variable speed control is fitted:-
   a. Move the speed control lever towards the fast position.
   b. Push down and release the overload stop lever which is located on the fuel pump side of the engine.
5. Move the decompressor lever downwards.
6. Turn the starting pulley against rotation until resistance is felt.
7. On a cold engine bounce the pulley vigorously against the resistance until the injector operates several times.
8. Wind the rope two turns around the pulley in the direction of rotation.
9. Pull the rope sharply until it unwinds from the pulley.
10. If a variable speed control is fitted reduce the speed as required.

Warning:
Do not wind the rope around the hand or wrist.

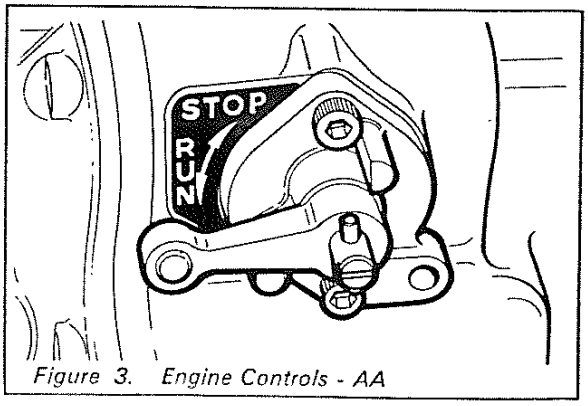

Figure 3. Engine Controls - AA

Hand Starting

1. Before attempting to start the engine read the "Safety Precautions" inside the front cover.
2. Move the decompressor lever towards its stop and hold in this position.
3. Move the engine control to the RUN position.
4. If a variable speed control is fitted:-
   a. Move the speed control lever towards the fast position.
   b. Push down and release the overload stop lever which is located on the fuel pump side of the engine.
5. Crank the engine really fast and when sufficient speed is obtained, move the decompressor lever down and continue to crank until the engine fires, retain a firm grip on the starting handle and remove it from the engine.
6. When a speed control is fitted, reduce the speed as required.

Stopping the Engine

Move the engine control to STOP and wait until the engine comes to rest.

Warning:
Never stop the engine by using the decompressor lever or valve damage may occur.

AC and AD ENGINES

Hand Starting

1. Before attempting to start the engine read the "Safety Precautions" inside the front cover.
2. Move the decompressor lever towards its stop and hold it in this position.
3. If a variable speed control is fitted move the lever towards the fast position.
4. Move the engine control anti-clockwise to the RUN position.
5. Crank the engine really fast and when sufficient speed is obtained, release the decompressor lever and continue to crank until the engine fires, retain a firm grip on the starting handle and remove it from the engine.
6. When a speed control is fitted, reduce the speed as required.

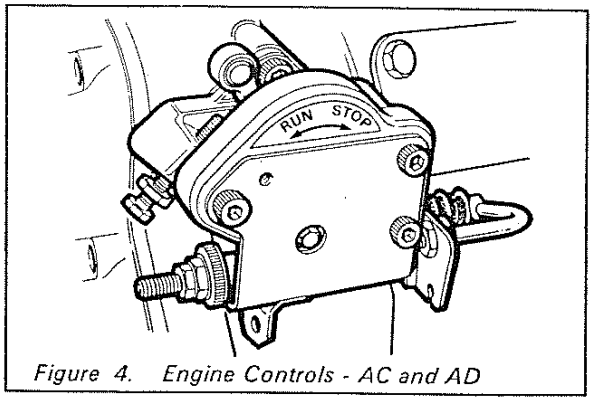

Figure 4. Engine Controls - AC and AD

Rope Start

Rope starting is not recommended at temperatures below -10°C (14°F).

1. Before attempting to start the engine read the "Safety Precautions" inside the front cover.
2. Move the decompressor lever towards its stop and hold it in this position.
3. Move the engine control anti-clockwise to the RUN position.
4. If a variable speed control is fitted move the lever towards the fast position.
5. Release the decompressor lever.
6. Turn the starting pulley against rotation until resistance is felt.

7. On a cold engine bounce the pulley vigorously against the resistance until the injector operates several times.
8. Wind the rope two turns around the pulley in the direction of rotation.
9. Pull the rope sharply until it unwinds from the pulley.
10. If a variable speed control is fitted reduce the speed as required.

Warning:
Do not wind the rope around the hand or wrist.

Electric Starting with Key Start

1. Before attempting to start the engine read the "Safety Precautions" inside the front cover.
2. If a variable speed control is fitted move the lever towards the fast position.
3. Move the engine control anti-clockwise to the RUN position.
4. Turn the starter key clockwise and release immediately the engine fires.
   Do not operate the start key for more than 20 seconds at a time.
5. If a variable speed control is fitted reduce the speed as required.

Electric Starting with Heater Plug

1. Before attempting to start the engine read the "Safety Precautions" inside the front cover.
2. If a variable speed control is fitted move the lever towards the fast position.
3. Move the engine control anti-clockwise to the RUN position.
4. Turn the starter key in a clockwise direction and hold it there for 20 seconds.
5. Turn the key clockwise and hold it in the next clockwise position until the engine fires.
   Do not operate the start key for more than 20 seconds at a time.
6. If a variable speed control is fitted reduce the speed as required.

Stopping the Engine

Move the engine control to STOP and wait until the engine comes to rest.
After the engine has stopped ensure the electric start key, if fitted, is switched off.

Warning:
Never stop the engine by using the decompressor lever or valve damage may occur.

Routine Maintenance

Following the initial attention the normal Routine Maintenance, as specified on the following page, must be carried out.
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 sound engineering practice to tighten bolts or nuts holding cylinder heads, sumps, covers, and doors diagonally. This will ensure the component is pulled down square, resulting in less chance of oil seepage from the joint.

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 2000 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.

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 seals and care must be taken to prevent damaging the new seal when it passes over shafts.

Before fitting a new oil seal it is important that the recess in the seal is filled with Shell Alvania R2 Grease; this is a Lithium Grease to NLG1 No 2 consistency. In the event of non-availability of the grease immerse the seal in engine lubricating oil at ambient temperature for 24 hours.

All nuts, bolts, setscrews and studs with damaged threads must always 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.

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.

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.

Warnings:

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.

Damage will be caused to the flywheel fan if it is used to turn the crankshaft.

CRANKCASE VACUUM

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

Regardless of the type of air cleaner used, the vacuum with a clean air cleaner must not be less than the minimum figures given in the table below. The vacuum is measured with a manometer at the lubricating oil filler/dipstick hole with the engine running at any speed. To use a manometer it will be necessary to modify a filler cap by removing the dipstick section and replacing it with a suitable union to accommodate the manometer pipe.

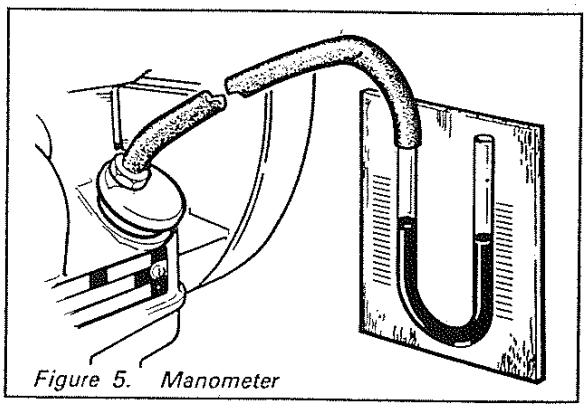

Figure 5. Manometer

In engines in good condition the vacuum increases slightly with engine speed but not proportionally, a fluctuating vacuum may indicate faulty oil seals, valves, or piston blow-by troubles.

Crankcase pressure can cause serious oil leaks, and often occurs in engines which need overhauling.

All Engines	mm WG	50.8 - 203.2
	in WG	2.0 - 8.0

Maintenance Schedule

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

Every 125 Hours

The previous and the following items.
Clean the air cleaner under moderately dusty conditions.
Check for fuel and lubricating oil leaks.
Check the serviceability of the battery.

Every 250 Hours

The previous and the following items.
Check all external nuts, bolts and unions for tightness.
Check and adjust the valve clearances with the engine cold.
Check and adjust the decompressor setting.
Renew the oil filter element.
On all engines except AC1 Build 05, drain the sump and refill with new oil of the correct type and specification.
Clean the carbon deposit from the exhaust system.
Clean the fuel tank cap air vent.
Test and clean the fuel injector and fit with a new washer.
Remove the hand start sprag clutch assembly, clean and inspect the oil seals and bearing. Refit the assembly and lubricate it.

Every 500 Hours
The previous and the following items.
On all AC1 Build 05 engines drain the sump and refill with new oil of the correct type and specification.
Renew the air cleaner element.

Every 1000 Hours

The previous and the following items.
Drain and flush the fuel tank.
Change the fuel filter element.
Clean the cylinder and cylinder head fins under dusty conditions.
Ensure that all guards are firmly attached and not damaged.
Decarbonise if the engine power has deteriorated.

Every 5000 Hours

The previous items and give the engine a major overhaul, if necessary.

Starting, Running and Injector Faults

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

Difficult Starting
Incorrect grade of fuel or oil.
No fuel in tank.
Choked fuel filter.
Air lock in the fuel system.
Faulty injector or fuel pump.
Stop/start lever in the wrong position.
Retarded injection.
Injector loose in the cylinder head.
Leaking or sticking valves.
Sticking piston rings.
Worn cylinder.
Incorrect decompressor clearance.
Load not disconnected.
Battery not serviceable.
Faulty, dirty or loose electrical connections.
Turning the crankshaft the wrong way.
Faulty starter motor or solenoid.
Engine seized.
Faulty heater plug.
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 clearance between the piston and cylinder head.
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 oil.
Unsuitable lubricating oil.
Continuous idling.
Defective injector spraying.

Late injection of fuel.
Too much side play on valve rockers.
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 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.
Incorrect tappet clearance.
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.
The fuel system is not primed.
Insufficient fuel.
Injection retarded.
Governor out of adjustment.
The wrong type of governor weights or spring 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 head or cylinder barrel blocked with dirt.
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.
Injector 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.

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.
Blocked nozzle hole.
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.
The nozzle hole is blocked.
The needle is sticking or damaged.
The seats are distorted, hammered, scratched or eroded.

Section 2 - The Basic Engine

This section deals with all 'A' range engines built after 1st January 1986 and is therefore not specific to any one type or build of engine.

Every effort must be made to maintain the engine in a clean condition and all fuel 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.

Tables showing the recommended Jointing Compounds, Spanner Torques and Service Tools can be found at the end of this section.

Warning:
Damage will be caused to the flywheel fan if it is used to turn the crankshaft.

ASSEMBLY LUBRICATION

When assembling the engine, use new engine lubricating oil to lubricate the following items prior to fitting.

- All main bearings.
- The connecting rod bearings.
- Cam followers, camshaft bearings, valve rocker bores and the valve push rod cups.
- The gear train.
- Pour a small quantity of oil through the oil pump plate.
- Lightly oil all other moving parts and fastener threads.
- The pistons with rings and connecting rods assembled, must be sprayed with oil just before fitting into the cylinder; ensure no oil is in the combustion chamber or inside the piston.
- Lubricate oil seal lips.

THE ROPE START ASSEMBLY - GEAR END

The rope start facility is not fitted to AD2 engines.

Dismantling the Rope Start

1. Open the guard (A).
2. Pull the pulley (B) off of the shaft (C).
3. Remove the four setcrews and the guard (A).
4. Remove the four setscrews securing the adaptor plate (D) and remove it.

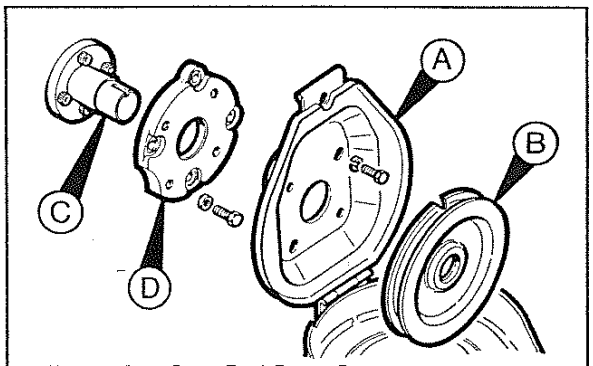

Figure 6. Gear End Rope Start

Assembling the Rope Start

1. Replace the adaptor plate and the four setscrews.
2. Replace the guard and pulley.

THE ROPE START ASSEMBLY - FLYWHEEL END

The rope start facility is not fitted to AD2 engines.

Dismantling the Rope Start

1. Open the guard (A).
2. Remove the three capscrews and the pulley (B) from the flywheel.

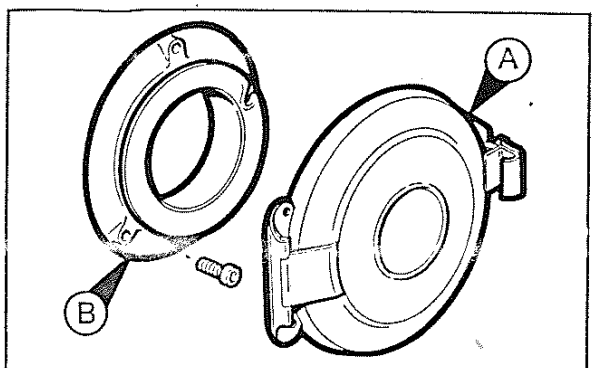

Figure 7. Flywheel Rope Start

Assembling the Rope Start

1. Replace the flywheel pulley.
2. Replace the guard.

THE GEAR END HAND START

This start facility is not fitted to AD2 engines.

Dismantling the Gear End Start

1. Remove the three retaining screws and washers from the gearwheel guard (A) and remove it.
2. Remove the retaining circlip (B) and the gearwheel (C).
3. Remove the three setscrews and washers securing the backplate (D) and mounting bracket (E) to the adaptor (F).
4. Remove the pinion assembly (G) from the extension shaft (H).
5. Drain the lubricating oil from the shaft.
6. Remove the extension shaft.
7. Clean and examine all parts for wear and damage.

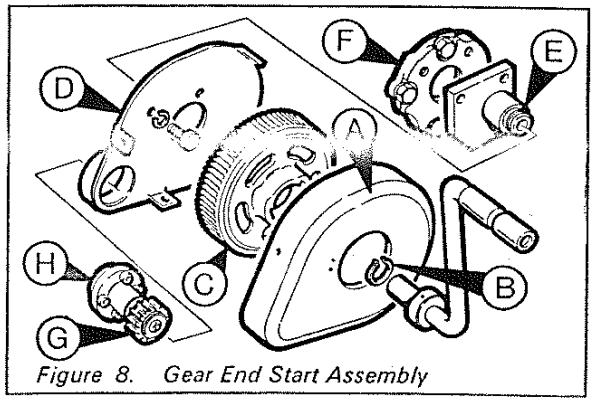

Figure 8. Gear End Start Assembly

Assembling the Gear End Start

1. Fit the extension shaft and torque load the four retaining screws to 19.0Nm (14.0lbf ft).
2. Fit the backplate (E) and mounting plate (D).
3. Slide the clutch and pinion assembly (G) onto the extension shaft (H).
   Ensure that the clutch grips when it is rotated anti-clockwise viewed from the shaft end.
4. Remove the setscrew from the end of the shaft and using a syringe fill the small oil reservoir in the shaft with 7cc of SAE 20W/20 lubricating oil.
5. Replace the setscrew and torque load it to 8.0Nm (6.0lbf ft).
   Lock the setscrew using Loctite 87AV.
6. Lightly lubricate the gearwheel bush, fit the gearwheel and circlip.
7. Replace the guard.

THE FLYWHEEL END HAND START

This start facility is not fitted to AD2 engines.

Dismantling the Flywheel End Start

1. Remove the four screws securing the starting gear guard (A) and remove it.
2. Remove the retaining circlip (B) and the gearwheel (C).
3. Remove the four set screws and washers retaining the mounting plate assembly (D) to the engine bell housing and Withdraw the assembly.
4. Lock the flywheel to prevent it turning.
5. Remove the pinion assembly (E) and the shaft (F) from the flywheel.
6. Drain the lubricating oil from the shaft.
7. Remove the extension shaft.
8. Clean and examine all parts for wear and damage.

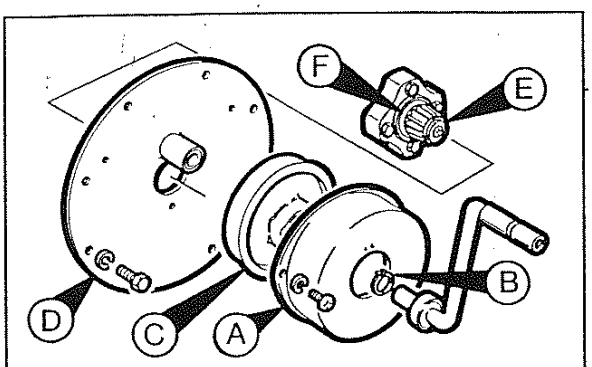

Figure 9. Flywheel End Start Assembly

Assembling the Flywheel End Start

1. Fit the extension shaft (F) and torque load the four retaining screws to 34.0Nm (25.0lbf ft).
2. Slide the clutch and pinion assembly (E) onto the extension shaft (F).
   Ensure that the clutch grips when it is rotated clockwise viewed from the shaft end.
3. Fit the mounting plate (D).
4. Remove the setscrew from the end of the shaft and using a syringe fill the small oil reservoir in the shaft with 7cc of SAE 20W/20 lubricating oil.
5. Replace the setscrew and torque load it to 8.0Nm (6.0lbf ft).
   Lock the setscrew using Loctite 87AV.
6. Lightly lubricate the gearwheel bush, fit the gearwheel and circlip.
7. Replace the guard.

THE REDUCTION GEARBOX

Three reduction gearboxes (6:1, 4:1 and 2:1) are available for each type of engine.
A 6:1 gearbox is illustrated and the following instructions are common for all gearboxes; specific parts for each type are shown in the Parts List:-

AA..... 027-08097
AC..... 027-08098
AD1 027-08099
AD2 027-08100

Dismantling the Gearbox

1. Remove the oil drain plug (A) from the reduction gear housing and drain the oil.
2. Remove the bearing housing (B) from the gear case (C).
3. Remove the gear case complete with the power take-off shaft (D) and the driven gearwheel (E).
   Take care to retain the end float shims (F).
4. Remove the eight capscrews and remove the gearcase from the crankcase.
5. Remove the four nuts and washers (capscrews on 2:1 ratio) securing the driving gearwheel (G).
6. Clean and examine all parts for wear and damage.

Warning:
If the taper roller bearing is being removed the housing should be placed in boiling water before attempting to remove or fit the bearing tracks.
After a few minutes sufficient expansion will have taken place, to ease removal or replacement.

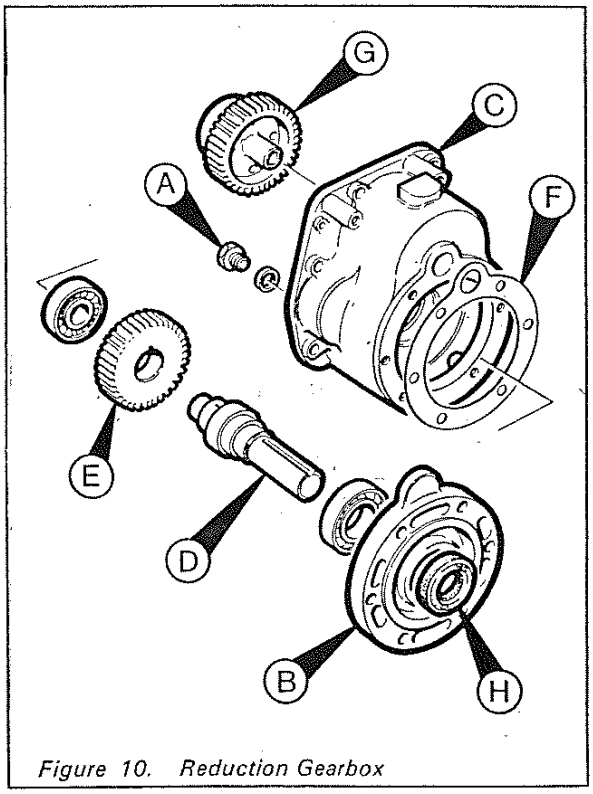

Figure 10. Reduction Gearbox

Assembling the Gearbox

1. Fit a new oil seal (H) ensuring that it is fitted squarely with its outer face flush with the bearing housing (B).
2. Secure the driving gearwheel (G) to the camshaft with the four nuts and washers (capscrews on 2:1 ratio).
3. Replace the gearcase and secure it with eight capscrews.

4. Assemble the bearing housing (B) over the power take-off shaft assembly (D); protect the oil seal by using a sleeve.

5. Replace the endfloat shims (F).
Initially it is advisable to fit sufficient shims to give excessive endfloat and then correct back; see the 'Warning'.

6. Fit the bearing housing and shaft assembly to the gearcase (C).

7. Using a dial test indicator check the endfloat of the power take-off shaft.
The 0.05-0.127mm (0.002-0.005in) endfloat is adjustable by adding or removing 0.05, 0.127, 0.178 or 0.508mm (0.002, 0.005, 0.007 or 0.020in) shims.

8. Tighten the bearing housing bolts.

Warning:
If the bearing housing (B) is tightened down with insufficient shims (no endfloat) it could result in a cracked housing or gearcase.

THE AIR CLEANER

A dry or oil bath air cleaner is fitted to the air inlet manifold adaptor by two studs and nuts and the crankcase breather pipe is attached to the manifold adaptor by a spring clip.

Dry Air Cleaner

1. Unscrew the nut (A), or release the clips, (A) and lift off the snout or cover (B).

2. Remove the element (C) from the cleaner body.

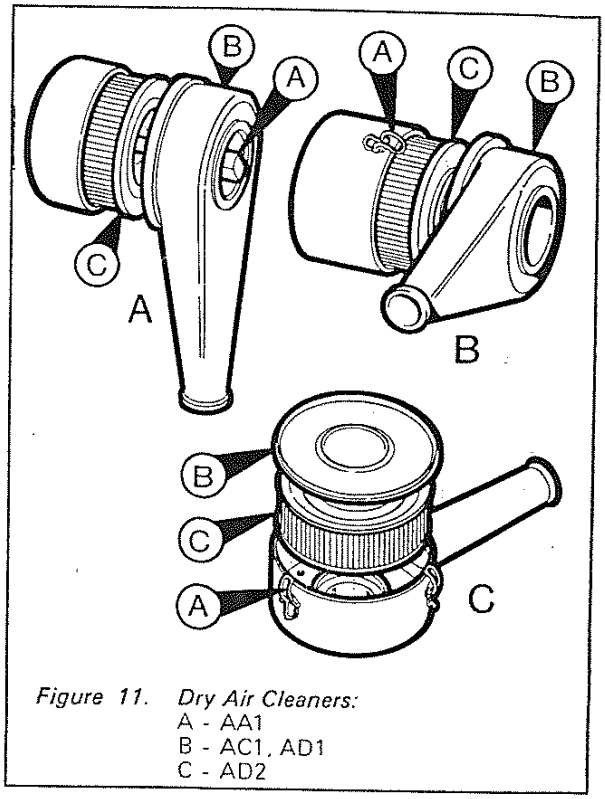

Figure 11. *Dry Air Cleaners:*
A - AA1
B - AC1, AD1
C - AD2

3. Clean the cleaner body and snout of all dust.

4. Fit a new element and joint if necessary.

5. Replace the cover or snout.
On AC and AD1 engines replace the snout with the inlet lying horizontal across the air cowling.
On AA engines the snout faces downwards.

Oil Bath Air Cleaner

An oil bath air cleaner is not available for AD2 engines.

1. Remove the bottom section from the cleaner.

2. Dispose of the old oil from it.

3. Wash all internal parts with clean kerosene and allow to drain.

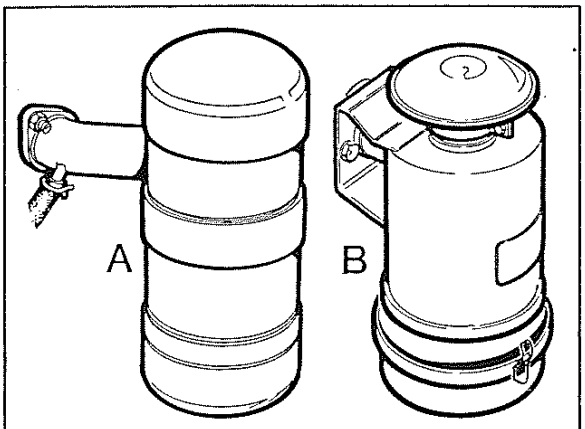

Figure 12. Oil Bath Air Cleaner:
A - AA
B - AC, AD

4. Fill the lower section with new engine lubricating oil to the mark.

5. Replace the lower section.

THE LIFTING EYE

To remove the lifting eye remove the cylinder head nut securing it.

THE MANIFOLDS

The inlet and exhaust manifolds are secured to the cylinder head by studs and nuts.
Before the inlet manifold can be removed the crankcase breather pipe must be disconnected from it by squeezing the spring clip tails together and pulling the pipe off.

REMOVING THE FUEL TANK

Some tanks are fitted with studs and nuts while others have bolts and spacers.

1. Drain the tank.

2. Remove the fuel pipes from the tank.

3. Remove the retaining bolts and lift the tank from the engine.

THE AIR COWLING

Three sides of the engine are encased in a one-piece air cowl to direct cooling air from the flywheel fan around the cylinder.

Removing the Air Cowling

1. Drain the fuel tank.

2. Remove the fuel pipes.

3. Remove the fuel tank.

4. Remove the two securing nuts and the lifting eye.

5. Remove the screw/s from behind the fuel tank on AC and AD engines.

6. Lift off the cowling.

Refitting the Air Cowling

1. Replace the cowling over the cylinder head studs.

2. Replace the screw/s behind the fuel tank.

3. Replace the fuel tank.

4. Tighten the two retaining nuts.

5. Replace the fuel pipes.

THE CRANKCASE BREATHER

The breather assembly is fitted to the top of the crankcase and is connected to the inlet manifold by a rubber pipe secured at both ends by spring wire clips.

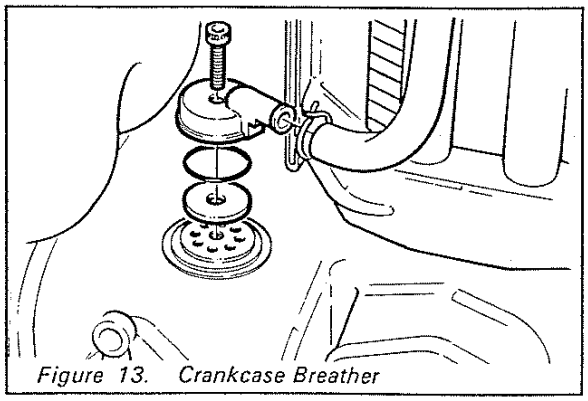

Figure 13. Crankcase Breather

THE FUEL INJECTOR

AA engines are air cell injection therefore the AA injector and injector sealing washer are not interchangeable with those fitted to AC and AD engines which have direct injection.

The following paragraphs are included only to describe the dismantling and assembly procedures, comprehensive instructions can be found in Section 4.

Removing the Injector - AA

1. Remove the air cleaner and fuel tank.
2. Remove the air cowling; not fitted to AA1 Build 05.
3. Slacken and remove the pump to injector fuel pipe (A); hold the fuel pump delivery valve holder with a spanner to prevent it turning.
4. Disconnect the leak-off pipe (B) from the injector.
5. Remove the two injector holding down nuts (C).
6. Remove the injector (D) and the sealing washer (E).

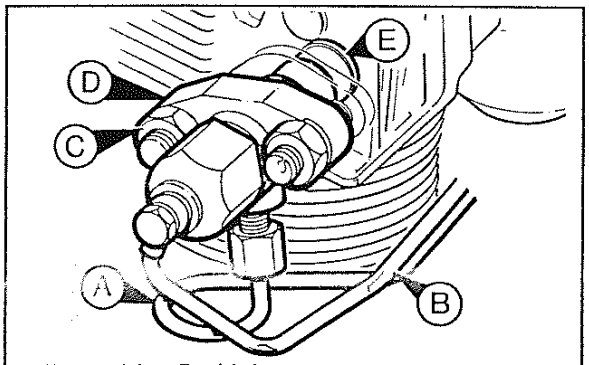

Figure 14. Fuel Injector

7. If the injector cannot easily be removed use the Service Tool 317-50027 and Adaptor 317-50095.

Replacing the Injector - AA

1. Ensure the seatings in the cylinder head are clean and smooth.
2. Fit the sealing washer to the injector. Build 05 engines are fitted with a copper washer and all others have a sealing washer which must be fitted with the dimple facing towards the injector.
3. Replace the injector into the cylinder head.
4. Replace the retaining nuts leaving the injector loose.
5. Replace the fuel pump to injector pipe and tighten the unions finger tight.
6. Tighten the unions a **further half turn with a spanner.**
7. Torque load the injector nuts to 18.0Nm (13.0lbf ft).
8. Replace the leak-off pipe.
9. Replace the cowling, lifting eye, air cleaner and the fuel tank.
10. After the initial run following an injector replacement re-torque the two retaining nuts.

Note:
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.

Removing the Injector - AC, AD

1. Slacken and remove the pump to injector fuel pipe (A); hold the fuel pump delivery valve holder with a spanner to prevent it turning.
2. Disconnect the leak-off pipe (B) from the injector.
3. Remove the two injector holding down nuts (C).
4. Lift off the injector clamp (D).
5. Lift out the injector (E) and the sealing washer (F).

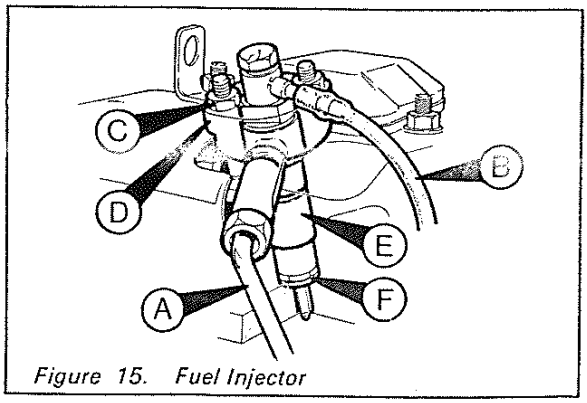

Figure 15. Fuel Injector

6. If the injector cannot easily be removed use the Service Tool 317-50027 and Adaptor 317-50095.

Replacing the Injector - AC, AD

1. Ensure the seatings in the cylinder head are clean and smooth.
2. Fit the sealing washer onto the injector with the dimple facing towards the injector.
3. Replace the injector into the cylinder head.
4. Place the injector clamp over the injector with the cut out section facing outwards.
5. Replace the two clamp nuts leaving them finger tight.
6. Replace the fuel pump to injector pipe and tighten the unions finger tight.
7. Tighten the unions a **further half turn with a spanner.**
8. Torque load the injector nuts to 3.0Nm (6.0lbf ft).
9. Replace the leak-off pipe.
10. After the initial run following an injector replacement re-torque the two clamp nuts.

Note:
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.

Injector Removal Tool

1. Remove the fuel pipes from the injector.
2. Screw the adaptor (A) into the leak-off hole of the injector.

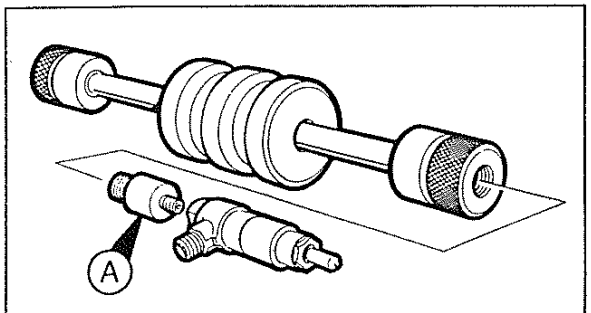

Figure 16. Injector Removal Tool

3. Fit the slide hammer to the adaptor.
4. Hold the slide hammer firmly and slide the sleeve from end to end and 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.
Excessive force must not be used.

THE FUEL INJECTION PUMP

The pump is fitted onto the crankcase at the gear end and is operated directly from the camshaft.

AA, AC and AD1 have similar physical characteristics but only AC and AD1 fuel pumps are interchangeable.

AA, AC and AD1 timing shims are interchangeable.

The following paragraphs are included only to describe the dismantling and assembly procedures, comprehensive instructions can be found in Section 4.

Removing the Pump

1. Remove the tank.
2. Remove the air cowling if necessary.
3. Slacken and remove the pump inlet (A) and delivery (B) pipes; hold the fuel pump delivery valve holder with a spanner to prevent it turning.

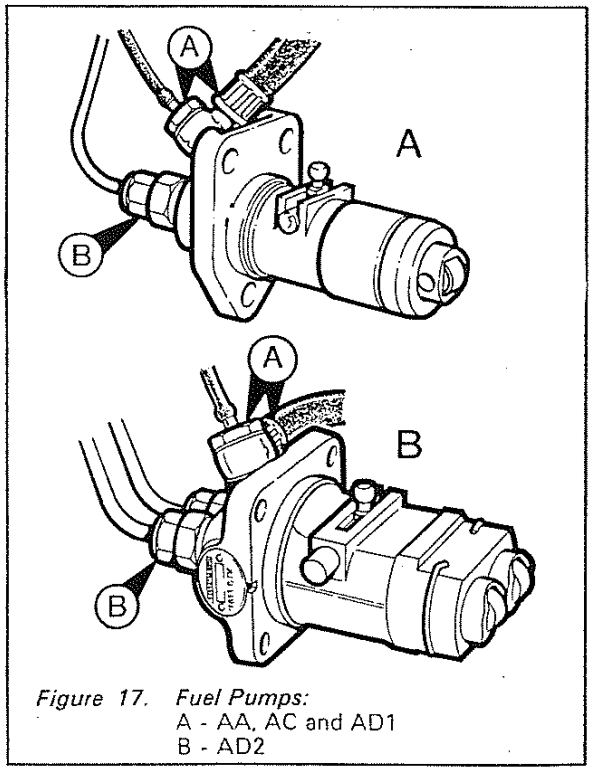

Figure 17. Fuel Pumps:
A - AA, AC and AD1
B - AD2

4. Turn the engine to TDC on the exhaust stroke.

5. Remove the pump retaining nuts.

6. Refer to Figure 18 and align the fuel pump rack ball (C) with the cut-out (D) in the crankcase by positioning, and holding, the engine control lever approximately 10° before the vertical position.

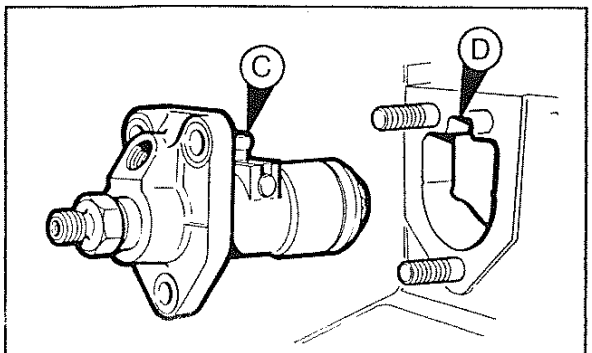

Figure 18. Removing the Fuel Pump

7. Remove the fuel pump and retain the timing shims.

Warning:
Do not use force or a screwdriver to remove the pump.
If difficulty is experienced, remove the gear end cover and position the fuel pump rack ball to clear the cut-out.

Replacing the Fuel Pump

1. Turn the engine to TDC on the exhaust stroke.

2. Place the pump timing shims over the pump mounting studs.

3. Position the governor lever fork in line with the cut-out in the crankcase by moving, and holding, the engine control lever approximately 10° before the vertical position.

4. Replace the fuel pump taking care to ensure the fuel pump rack ball is fully engaged in the governor lever.

5. Replace and tighten the pump retaining nuts.

6. Time the pump as described in Section 4.

7. Replace the fuel pump to injector pipe and tighten the unions finger tight.

8. Tighten the unions a **further half turn with a spanner.**

[illegible] lifting eye, air cleaner and the fuel tank.

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

THE OIL SUMP

The sump is secured to the crankcase by eight, ten on AD2 engines, capscrews and the integral engine mounting bolt drillings are located on each corner of it. Two drain plugs are fitted.

Removing and Refitting the Sump

1. Lift out the dipstick.

2. Drain the oil.

3. Stand the engine on its flywheel.

4. Remove the capscrews diagonally.

5. Lift off the sump and joint.

6. Clean and dry the crankcase and sump mating surfaces.

7. Fit the joint and sump onto the crankcase.

8. Replace the capscrews finger tight.

9. Torque load the capscrews, diagonally, to 12.0Nm (9.0lbf ft).

10. Stand the engine the correct way up and refill the sump with new oil.

THE CYLINDER HEAD COVER

The light alloy cylinder head cover, which is bolted to the top of the cylinder head, gives access to the decompressor and valve gear.

Removing the Cylinder Head Cover

1. Remove the two setscrews securing the cover.

2. Lift off the cover being careful not to damage the joint.

Refitting the Cylinder Head Cover

1. Clean the cover and cylinder head joint area.

2. Place a new joint on the cylinder head.

3. Replace the cylinder head cover and two setscrews.

THE CYLINDER HEAD

The finned cylinder head is a one-piece alloy casting and carries the valves, valve guides, decompressor and the injector.

The AA cylinder head is fitted with an air cell and oil priming device and is therefore not interchangeable with AC or AD heads.

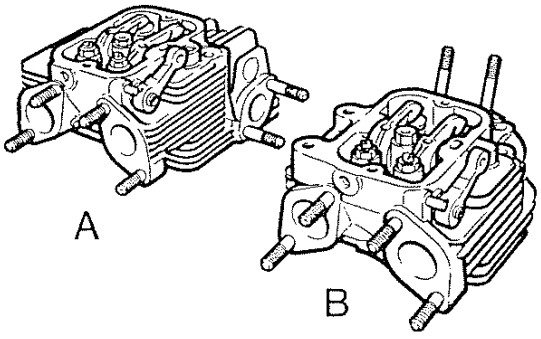

Figure 19. Cylinder Head:
A - AA
B - AC and AD

Removing the Cylinder Head

1. Remove the exhaust and inlet manifolds.
2. Remove the air cowling.
3. Remove the fuel pipes.
4. Remove the crankcase to cylinder head oil pipe.
5. Remove the cylinder head cover.
6. Remove the injector.
7. Gradually slacken the cylinder head retaining nuts in the sequence shown in Figure 20.

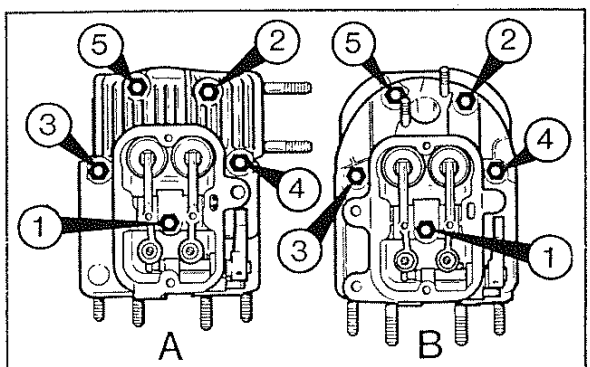

Figure 20. Cylinder Head Nuts:
A - AA
B - AC and AD

8. Remove the five nuts and washers.
9. Lift off the valve rocker assembly.
10. Mark the position of the push rods to identify their location on re-assembly and lift them out.
11. Lift off the cylinder head.
12. Remove the push rod tubes.
13. Place a suitable length of tube, over one cylinder head holding down stud and secure by fitting a cylinder head nut finger tight. This will prevent movement of the barrel if the crankshaft is turned.

Fitting the Cylinder Head

When the cylinder head is being replaced it is recommended that a new cylinder head gasket, rocker support 'O' ring seal and push rod seals are fitted.

1. Fit a new cylinder head gasket onto the top of the barrel.
2. Replace the push rod tubes using new seals.
3. Carefully fit the cylinder head over the studs.
4. Lightly lubricate the push rods with new engine oil and place them in their original positions.
5. Fit a new valve rocker support 'O' ring seal, the rocker support and the valve rockers.
6. Replace and gradually tighten the cylinder head retaining nuts, in the sequence shown in Figure 20, until they are finger tight.
   While tightening the nut holding the rocker support ensure that the support is correctly located over the locating pin in the cylinder head.
   a. Before tightening AD2 cylinder head nuts the manifold flanges of both cylinder heads must be lined up, either with a straight edge or by fitting a manifold.
      If the straight edge method is used any gap the edge of the straight edge must not exceed 0.2mm (0.008ins).
7. Tighten each nut a quarter of a turn at a time, in the correct sequence as shown in Figure 20, to a torque loading of 27.0Nm (20.0lbf ft).

Notes:

After 20 running hours the torque loading of the cylinder head must be checked by slackening each nut, in turn and following the correct sequence, a quarter of a turn and re-torqued to 27.0Nm (20.0lbf ft).

After the nuts have been torqued check and adjust the valve clearances.

CHECKING CYLINDER HEAD CLEARANCE

1. Remove the cylinder head and push rods.
2. Turn the crankshaft until the piston is 6.35mm (0.25in) before TDC.
3. Using a very small amount of high melting point grease place three pieces of lead wire 1.2mm (0.048in) thick equidistant on the cylinder head as shown in Figure 21.

   Extra care should be taken to ensure they are not placed over the valve heads or combustion chamber.

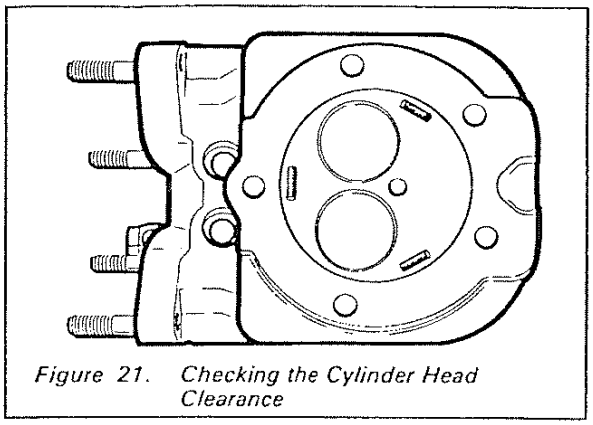

Figure 21. Checking the Cylinder Head Clearance

4. Replace the cylinder head gasket.
   On AA engines the raised sections of the gasket must be fitted facing the cylinder barrel.
5. Replace the cylinder head and torque the bolts to 27.0Nm (20.0lbf ft) following the sequence given in Figure 20 on page 20..
6. Turn the piston past TDC.
7. Remove the cylinder head and measure the thickness of the lead; this should be as specified below.

	Bu	mm	in
AA	05	0.46-0.56	0.018-0.022
	All others	0.56-0.66	0.022-0.026
AC	05, 55	0.46-0.58	0.018-0.023
	53	0.56-0.66	0.022-0.026
	All others	0.56-0.69	0.022-0.027
AD	All Builds	0.56-0.76	0.022-0.026

If the clearance is not correct it can be adjusted by adding or removing different thickness of shim placed between the cylinder barrel and crankcase.

mm	0.076	0.127	0.254	0.381	0.508
in	0.003	0.005	0.010	0.015	0.020

8. Replace the push rods and cylinder head.

THE AIR CELL - AA

The air cell (A) is only fitted to AA1 engines and can be removed after removing the plug (B). On refitting the plug Achesons anti-scuffing graphited grease is used.

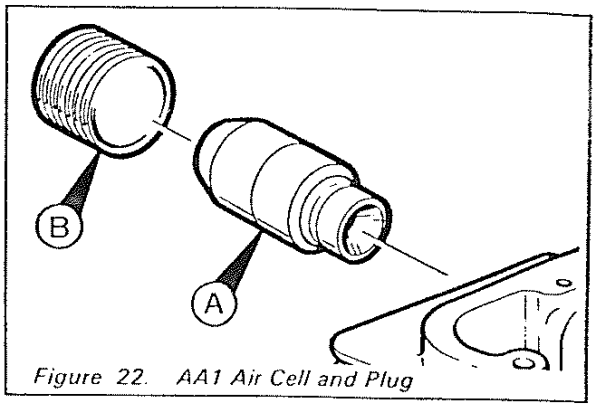

Figure 22. AA1 Air Cell and Plug

THE VALVES

Removing the Valves

1. Remove the cylinder head
2. Remove the valve rocker assembly.
3. Lay the cylinder head upright on a bench and place a circular block of hardwood under the head of the valve to be removed.
4. Place the adaptor (A) onto the valve spring carrier with the two indentations facing outwards.

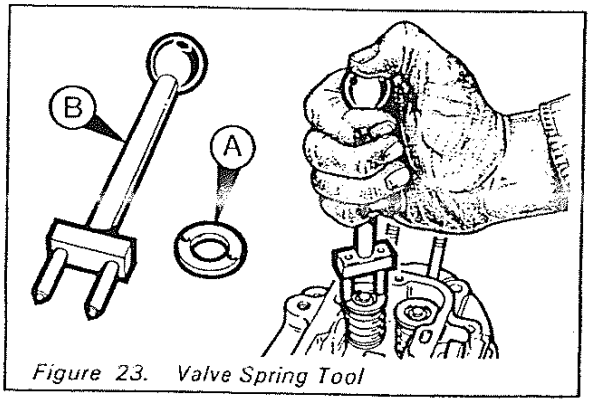

Figure 23. Valve Spring Tool

5. Fit the tool (B) into the two adaptor indentations.
6. Push down on the tool until the collets can be removed.
7. Gently release the tool and remove the carrier, valve spring and the inlet valve stem sealing ring.
8. Turn the cylinder head over and remove the valve.

Refitting the Valves

AA1 Build 05 engines are fitted with an inlet valve stem oil seal and an exhaust valve stem 'O' ring.

1. Assemble the valves in the reverse order ensuring the collets are securely in position with their tops sunk in the valve spring carrier.
2. Replace the valve rocker assembly.
3. Replace the cylinder head and check the valve clearance.
4. Replace the valve rocker cover.

VALVE GUIDES

The valve guides are a press fit into the cylinder head and an oil seal is fitted onto the top of the inlet valve guide.

Removing Valve Guides

1. Remove the cylinder head.
2. Remove the valves.
3. Remove the inlet guide oil seal.
4. Place the head in hot water for a few minutes.
5. Place the head on its side in a soft jawed vice leaving access to the guide from the underside.
6. Fit the narrow end of the Service Tool 390263 into the guide from the valve seat side and use a hammer to remove the guide.
   It is recommended that suitable precautions are taken to prevent the guide causing personal injury when it comes away from the head.

Refitting Valve Guides

1. Place the head in hot water for a few minutes.
2. Stand the cylinder head the correct way up, preferably on a bench.
3. Place the new guide squarely into the guide hole.
4. Using a suitable press, carefully press the guide into the head until it protrudes 12.2mm (0.48in) above the surface of the head.
5. Fit a new inlet valve guide oil seal.

Warning:
Valve guides obtained from Lister-Petter are pre-reamed and require no further attention.

VALVE SEAT INSERTS

The valve seats are cast iron inserts which are pressed into position in the cylinder head. Oversize inserts, 360049, are available.

The valve depth from the cylinder head face must be as specified below.

If the seats are badly pitted and require cutting back to such an extent that the depth exceeds the maximum tolerance oversize inserts must be fitted.

Valve Depth from Cylinder Head Face

		New	Not to Exceed
AA	mm	0.63 - 1.06	1.27
	in	0.025 - 0.042	0.050
AC, AD	mm	0.25 - 0.65	0.84
	in	0.010 - 0.025	0.033

Fitting New Valve Inserts

1. Remove the cylinder head.
2. Remove the old inserts.
3. Machine the inlet and exhaust valve insert bores to 32.004-32.029mm (1.260-1.261ins) to a cylinder head depth of 4.750-4.801mm (0.187-0.189in).
   The insert bores should be radiused to suit the chamfered lead on the insert.
4. Heat the cylinder head to 150°C (302°F) and with the insert at ambient temperature press it into position with the chamfered end first.
5. Machine the valve seats to 32/, before grinding in the valves, and they must be concentric with the guide bores to within 0.005mm (0.002in) TIR.
6. Grind in the valves as described in "Valve Grinding".

Valve Seat and Recess Cutting

The correct valve seat angle will be maintained if the procedure below, using Service Tool 317-50042, is followed.

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).

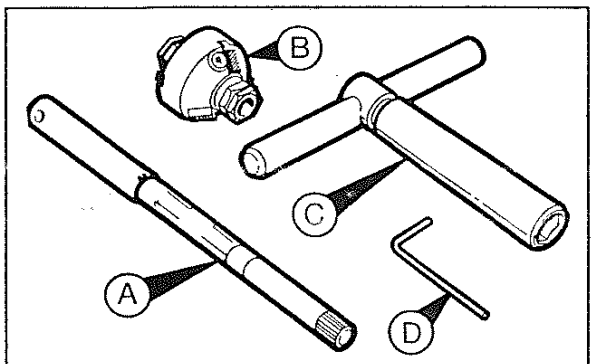

Figure 24. Valve Seat and Recess Tool

4. Rotate the tool in a clockwise direction until the valve seat or recess finish is satisfactory.

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

Valve Grinding

1. Lightly lubricate the valve stem with new engine oil.
2. Place a very small quantity of grinding paste evenly around the valve face and insert the valve in the correct valve guide.
3. [illegible] and rotate it backwards and forwards as on its seating, exerting a gentle but firm pressure.
   Periodically lift the valve from its seating and rotate it through approximately 120°.
4. Continue grinding until the faces of the valve and its seating have a clean, even matt-surfaced appearance.
5. [illegible] removed.
6. Replace the valves and rotate them backwards and forwards a few times and remove them.
   If the valves have been correctly ground a thin polished line will appear all round the mating surfaces.
7. Check the dimensions as given in "Valve Depth from Cylinder Head Face" on page 22 and if they are outside the tolerance new inserts must be fitted.

VALVE CLEARANCE

The valve clearance, 0.1mm (0.004in), must be measured and adjusted when the engine is cold.
It is important that the clearance is 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 and it is essential that the clearance is checked every 25 hours until it is found that the clearances remain constant. The periods between checks may then be increased to 250 hours.

Adjusting the Valve Clearance

Due to the close confines of the rocker box and difficulty in obtaining an accurate adjustment with a standard feeler gauge it is recommended that the Service Tool 317-50094 is used.

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

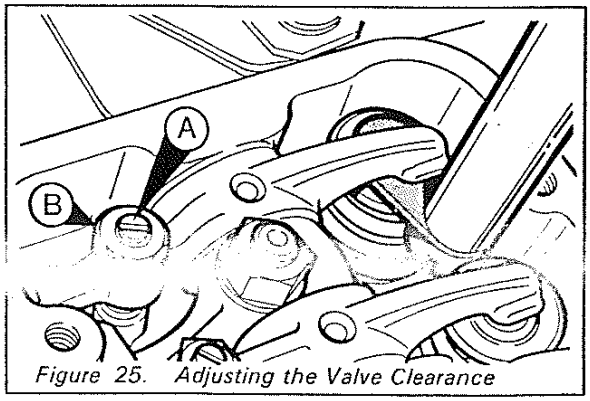

Figure 25. Adjusting the Valve Clearance

4. Turn the screw until the correct clearance of 0.1mm (0.004in) has been obtained.
5. Torque load the locknut, while continuing to hold the adjusting screw, to 12.0Nm (9.0lbf ft).

6. Re-check to ensure the clearance is correct.

7. Repeat the procedure for the second valve.

8. On AD2 engines turn the engine until the piston is at TDC on the firing stroke for the second cylinder and repeat the above procedure.

THE DECOMPRESSOR

The decompressor operates on the exhaust valve and an 'O' ring seal fitted to the spindle inside the cylinder head, prevents oil seepage.

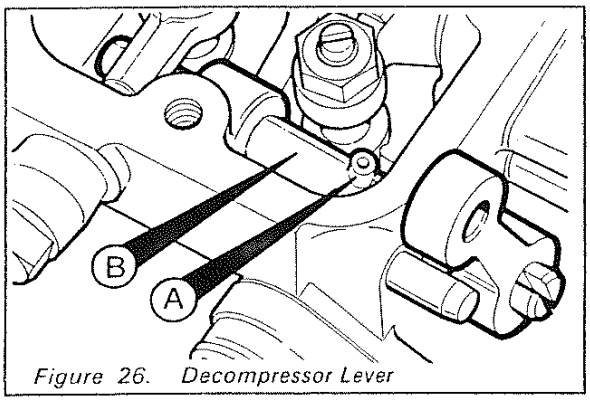

Figure 26. Decompressor Lever

Removing the Decompressor

1 Remove the cylinder head cover.

2. Use a suitable punch and hammer to push the roll pin (A) through the spindle (B); care must be taken to ensure the pin does not foul on the cylinder head casting.

3. Withdraw the decompressor lever from the cylinder head.

Decompressor Adjustment

The decompressor lever must only be adjusted after the valve clearance has been correctly set.

1. With the cylinder head cover removed turn the engine until the piston is at TDC position on the firing stroke.

2. Hold the decompressor lever (A) in the vertical position.

3. Turn the spindle clockwise by using a screwdriver in slot (B) until the valve rocker no longer moves, this will set the decompressor.
   After this setting has been made moving the decompressor lever to the stop will then give the correct amount of valve opening.

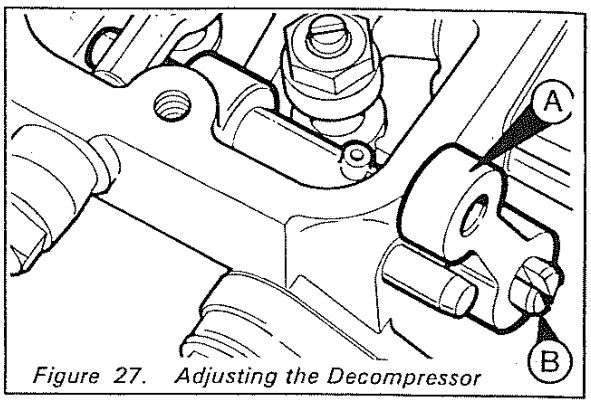

Figure 27. Adjusting the Decompressor

4. Replace the cylinder head cover.

5. On AD2 engines turn the engine until the piston is at TDC on the firing stroke for the second cylinder and repeat the above procedure.

THE CYLINDER BARREL

The cylinder barrel can be removed with out the need to remove the piston and connecting rod assembly.

Removing the Barrel Only

1. Remove the cylinder head.

2. Turn the piston to TDC.

3. Lift off the cylinder barrel.

4. Check the cylinder bore wear, if this has reached the maximum of 0.15mm (0.010 in), refer to "Dimensions of Wearing Parts and Clearances" on page 37, the cylinder must be rebored and an oversize piston and rings fitted.
   The cylinder should be bored and honed to the size listed in the relevant table.

Refitting the Cylinder Barrel Only

1. Replace the cylinder head clearance shims onto the crankcase.

2. Turn the piston to TDC.

3. Distribute the piston ring gaps around the piston circumference so that the gaps are not in line.

4. Lightly lubricate the cylinder bore, piston and piston rings with new engine oil.

5. Using a suitable piston ring clamp compress the rings and fit the cylinder over the cylinder studs and piston.

Removing the Barrel and Piston Assembly

1. Remove the cylinder head.
2. Lift out the sump dipstick.
3. Drain the oil from the sump.
4. Turn the engine onto its flywheel.
5. Remove the sump retaining capscrews and remove the sump and gasket.
6. Turn the piston to a suitable position to give access to the connecting rod big end bearing cap bolt.
7. Remove the big end bolt and the bearing cap.
8. Turn the piston to TDC.
9. Lift off the cylinder barrel complete with the piston and connecting rod.
10. Retain the cylinder head clearance shims which are fitted between the cylinder barrel and crankcase.
11. Replace the bearing cap onto the connecting rod.
12. Withdraw the piston and connecting rod assembly from the cylinder barrel.
13. Check the cylinder bore wear, if this has reached the maximum of 0.15mm (0.010 in), refer to "Dimensions of Wearing Parts and Clearances" on page 37, the cylinder must be rebored and an oversize piston and rings fitted.
    The cylinder should be bored and honed to the size listed in the relevant table.

CYLINDER REBORE DIMENSIONS

AA

		Bore Size
Standard	mm in	69.850-69.875 2.750-2.751
Oversize 0.508mm (0.020in)	mm in	70.358-70.388 2.770-2.771
Oversize 1.016mm (0.040in)	mm in	70.866-70.891 2.790-2.791

AC

		Bore Size
Standard	mm in	76.20-76.23 3.000-3.001
Oversize 0.508mm (0.020in)	mm in	76.71-76.73 3.020-3.021
Oversize 1.016mm (0.040in)	mm in	77.22-77.24 3.040-3.041

AD

		Bore Size
Standard	mm in	80.00 3.1496
Oversize 0.508mm (0.020in)	mm in	80.51 3.1696
Oversize 1.016mm (0.040in)	mm in	81.02 3.1896

Cylinder Bore Glazing

When the engine has been fully run in, the bore will have a highly polished and very hard surface, if new piston rings are fitted without the cylinder being rebored, the new rings will not bed satisfactorily. Under these conditions the hard polished bore must be lightly roughened using a medium grade carborundum cloth radially by hand sufficient only to produce a matt surface on the bore. Alternatively, a suitable sized de-glazing tool or the rotary bush type with silicone-carbide tips may be used.

After this treatment extreme care must be taken to ensure the cylinder is thoroughly washed in kerosene to remove all traces of carborundum.

Refitting the Cylinder Barrel

1. With the engine on its flywheel turn the crankshaft crankpin to TDC.
2. Fit the piston to the connecting rod after immersing the piston in hot water to allow the gudgeon pin to slide freely.
3. Secure the gudgeon pin by replacing the circlips; ensure the circlips are correctly fitted in their grooves.
4. Distribute the piston ring gaps around the piston circumference so that the gaps are not in line.
5. Lightly lubricate the crankshaft crankpin, cylinder bore, piston and piston 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.
7. Replace the cylinder head clearance shims between the cylinder barrel and crankcase.
8. Place the cylinder over the cylinder studs.
9. Assemble the connecting rod to the crankshaft and ensure:-
   a. The numbers on the connecting rod are towards the camshaft side of the engine.

b. The connecting rod is assembled to the crankshaft journal the bearing cap faces away from the camshaft.

10. Turn the crankshaft and at the same time push down on the top of the piston until it is in a suitable position to give access to the connecting rod big end bearing.

11. Fit the connecting rod cap ensuring that the numbers on the cap and rod assembly are correctly matched and are on the same side.

12. Tighten the big end bolt to a torque of 34Nm (25 lbf ft).

Note:
Care must be taken to ensue the correct type of connecting rod cap bolts, as shown in Figure 28, are fitted and it is recommended that they are replaced on every occasion they are removed. if not, ***they must be replaced every fourth time.***

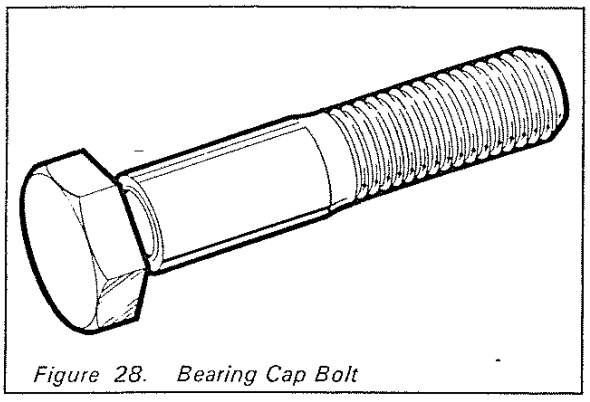

Figure 28. Bearing Cap Bolt

THE PISTON

The piston is manufactured from low expansion alloy and is fitted with a firing ring, compression ring and one oil ring. The gudgeon pin is retained by two circlips and runs in a bush in the small end of the connecting rod.
'A' range pistons and rings are not interchangeable, although AC and AD pistons have similar physical characteristics.

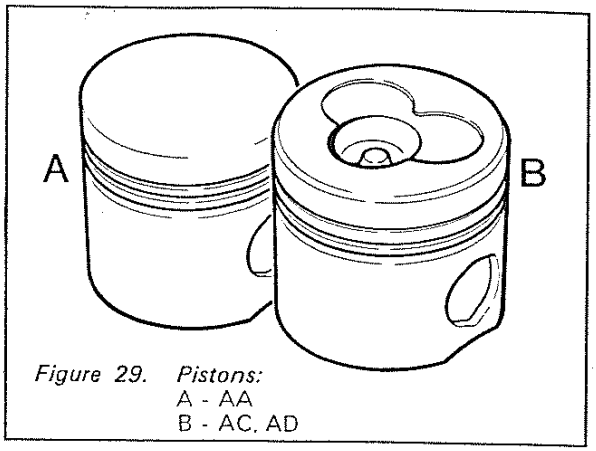

Figure 29. Pistons:
A - AA
B - AC, AD

Removing the Piston

1. Remove the cylinder barrel.

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 suitable piston ring expander remove the piston rings.

Inspection and Servicing

The dimensions to be expected can be found in "Dimensions of Wearing Parts and Clearances" on page 37.

1. Clean the piston and remove all traces of carbon from both the upper and underside of the head, ring grooves and the oil holes. Insert the piston into the cylinder barrel with the crown towards the bottom end of the bore and about 13mm (0.05in) from the bottom edge.

2. Insert the rings one at a time, pushing each ring hard up against the piston crown to ensure that it is level in the cylinder bore.

3. Withdraw the piston sufficiently to allow the gap to be measured with a feeler gauge.

4. Place each ring in its correct piston ring groove and check the side clearances.

Refitting the Piston

1. Assemble the piston to the connecting rod ensuring that when the piston and connecting rod are in the engine the offset combustion chamber will be opposite the push rods.

2. Insert the gudgeon pin and circlips.

3. Using a standard piston ring expander replace the piston rings in the order shown in Figure 30.

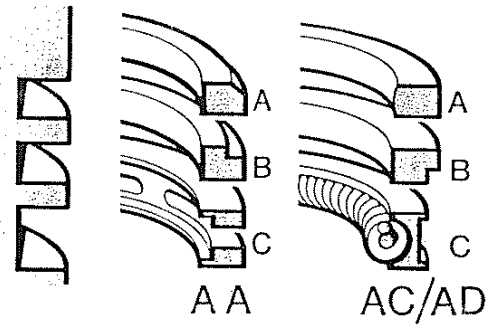

Figure 30. *Piston Rings:*
A - Firing Ring
B - Compression Ring
C - Oil Control Ring

4. Distribute the piston ring gaps around the piston circumference so that the gaps are not in line.

5. Lightly lubricate the piston and piston 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.

THE CONNECTING ROD

The connecting rod is connected to the crankpin by a conventional big end bearing, the cap being held in position by two bolts. Care must be taken to ensure the correct type of connecting rod cap bolts, as shown in Figure 28 on page 26, are fitted and it is recommended that they are replaced on every occasion they are removed, if not, ***they must be replaced every fourth time.***

When the connecting rod is assembled to the crankshaft journal the bearing cap must face away from the camshaft and the numbers on the connecting rod and cap are towards the camshaft side of the engine.

Small End Bush

When fitting a small end bush extreme care must be taken to ensure that the oil feed hole coincides with the hole in the connecting rod and the bush enters squarely.

Large End Bearings

New bearings are machined to give the required fit when in position and should not be scraped or bedded in, neither should shims of any description be fitted. When fitting bearing shells ensure that the connecting rod bore and the outside of the shells and their split face are clean.

Connecting rods and caps are stamped with an assembly serial number and care must be taken to ensure that these numbers match and on assembly are on the same side.

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 all of the oil passages must be examined for obstruction and fragments of metal.

d. Check the bearing shell clearance as described in "Checking Bearing Clearance" on page 31.

THE FLYWHEEL

The flywheel rotates within the fanshroud aperture and is fitted with the engine cooling air fan on the crankcase side. All flywheels have tapped holes for attaching couplings, shaft extensions, pulleys etc.

AC and AD engines may be fitted with a flywheel mounted battery charging system and a starter motor ring gear; refer to Section 6.

The flywheel is keyed on to the crankshaft and held in position with a tab washer and nut and the tolerance for bore and face run-out must be within 0.13mm (0.005in) TIR.

Warning:
The weight of the flywheel must be taken into account when removing, handling or replacing it.

Removing the Flywheel

1. Remove any fittings from the bell housing and flywheel.

2. Prevent the flywheel from turning by inserting a suitable steel rod through the timing hole in the bell housing into the hole in the flywheel periphery.

3. Bend back the tab washer on the flywheel retaining nut.

4. Use a 1⅞ AF socket and slacken the flywheel nut several turns.
5. Remove the flywheel locking device.
6. Fit the Service Tool 393175, with suitable setscrews through the 'C' holes, onto the flywheel.

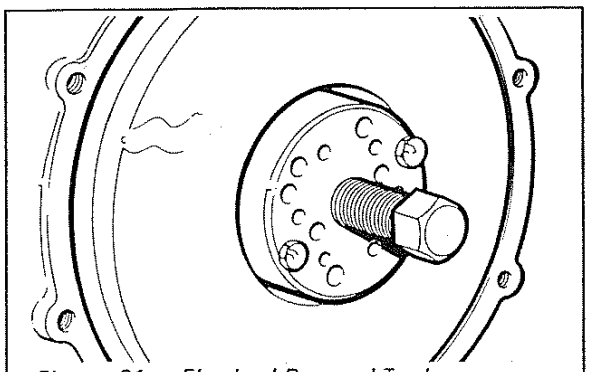

Figure 31. Flywheel Removal Tool

7. Lightly oil the tool centre bolt and tighten it until the flywheel is loosened from the crankshaft.
8. Remove the tool.
9. Remove the retaining nut and tabwasher.
10. Screw two suitable bolts into the flywheel and use these to carefully slide the flywheel off the crankshaft and out of the housing taking care not to damage the cooling fan or the charging equipment if it is fitted.

Fitting the Flywheel

1. Fit the flywheel key into the crankshaft.
2. Lightly oil the crankshaft and flywheel bore.
3. Align the flywheel keyway with the key on the shaft and push the flywheel on the shaft as far as possible.
4. Prevent the crankshaft from turning.
5. Fit a new tabwasher.
6. Fit the retaining nut and tighten it to a torque loading of 210Nm (155lbf ft).
7. Bend up the tabwasher over one of the retaining nut flats.
8. Remove the flywheel locking device.

Note for Build 50:
After fitting the flywheel the depth of the outer periphery of the flywheel from the housing face must be less than 13.9mm (0.547in).

THE GEAR END COVER

The end cover is secured to the crankcase by eight socket head capscrews and two dowels. The end cover joint must be fitted dry and it is recommended that a new joint is fitted when the end cover is replaced.

Warning:
Do not use a screwdriver, or similar tool, between the cover and crankcase to lever the cover off.

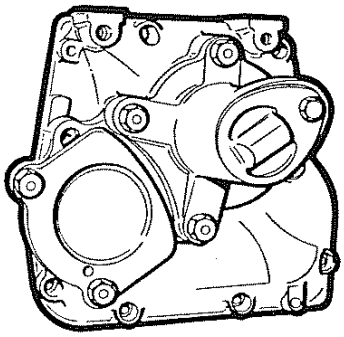

Figure 32. Gear End Cover

End Cover Oil Seal

Before fitting a new oil seal it is important that the recess in the seal is filled with Shell Alvania R2 Grease. This is a Lithium Grease to NLG1 No 2 consistency. In the event of non-availability of the grease soak the seal in engine lubricating oil at ambient temperature for 24 hours.

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 Service Tool 393211 press the seal into position within the oil seal housing boss until it is flush with the outside face of the cover.
   In an emergency, if the tool is not available a suitable plug, preferably hard wood, can be used.

THE GEAR TRAIN

The gear end cover must be removed to gain access to the gear train and the oil pressure relief valve.

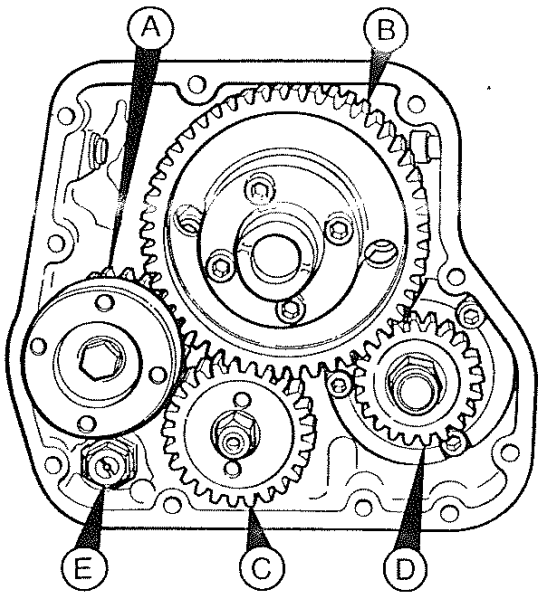

Figure 33. Gear Train:
A - Crankshaft Gear
B - Camshaft Gear
C - Oil Pump Gear
D - Governor Gear
E - Oil Pressure Relief Valve

THE CRANKSHAFT

The crankshaft is a steel forging and is carried in steel backed copper faced main bearings which are located in the crankcase at the gear end and flywheel ends.

End thrust is taken on steel backed copper faced thrust washers fitted at the gear end of the crankcase and in the flywheel end main bearing housing.

Extreme care must be taken to ensure that the crankshaft float is correctly maintained when driven units are connected.

The main bearings are the [illegible] type and have an oil feed hole hole which must be correctly located.

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

Removing the Crankshaft

1. Remove the extension shaft on the crankshaft gearwheel, if fitted.
2. Remove the cylinder head(s).
3. Remove the gear end cover.
4. Lock the flywheel to prevent it turning and remove the crankshaft pinion gear retaining bolt (A), plate (B) and the 'O' ring (C).

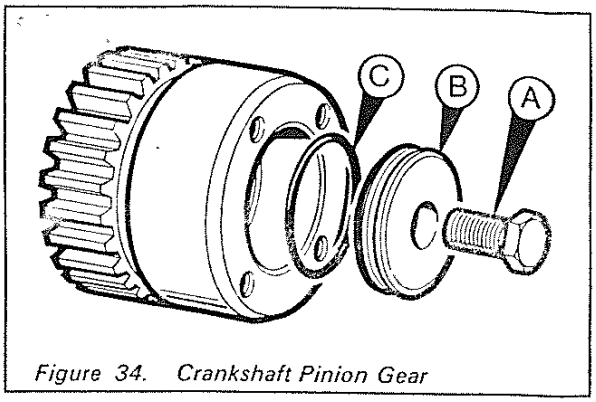

Figure 34. Crankshaft Pinion Gear

The plate (B) can be lifted out by using two suitable Allen keys placed into the bolt hole as shown in Figure 35.

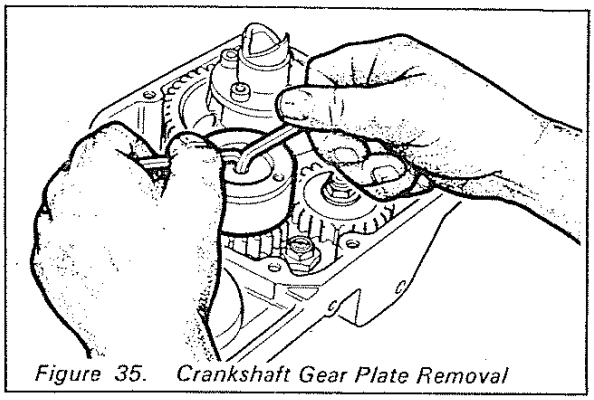

Figure 35. Crankshaft Gear Plate Removal

5. Fit the Service Tool 393175 onto the pinion gear using two suitable setscrews through the 'B' marked holes.
6. Lightly oil and tighten the centre bolt of the tool until the pinion is drawn off the crankshaft.

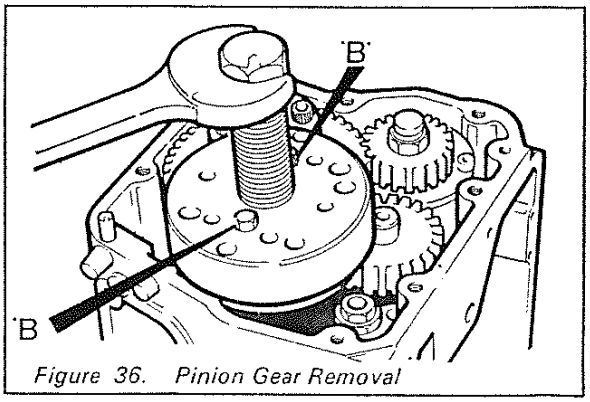

Figure 36. Pinion Gear Removal

7. Remove the flywheel and key.
8. Drain and remove the sump.

On AD2 engines remove the oil suction pipe and strainer; see "The Oil Pump Strainer" on page 42.

9. Remove the cylinder barrel(s), piston(s) and connecting rod(s).

10. If flywheel charge windings are fitted remove the screws securing the stator, adaptor and the cable clamp. Feed the cable through the flywheel housing before removing the stator and adaptor.

11. On AD2 engines remove the two bolts that hold the intermediate main bearing housing in position, note the position of the two bearing halves and remove them.

12. Remove the six nuts and washers retaining the flywheel end main bearing housing and guard.

13. Remove the flywheel guard and housing assembly.

14. Carefully remove the crankshaft through the flywheel end of the crankcase.

15. If necessary remove the crankshaft thrust washer from inside the gear end of the crankcase.

Inspection and Servicing

a. Inspect the main bearings for scoring or wear. If necessary the bearings can be removed and replaced as described in "Crankshaft Main Bearings" on page 32.
If the connecting rod big end has been dismantled because of failure of the bearing, all of the oil passages must also be examined for obstruction and fragments of metal.

b. Check the crankshaft to bearing clearances.

c. Examine all bearing surfaces for scoring and wear.

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

e. If necessary the crankshaft must be reground to the diameter shown in the relevant table and undersize bearings fitted.

CRANKSHAFT REGRIND DIMENSIONS

AA and AC

		Journal and Crankpin
Standard	mm	41.275-41.262
	in	1.6250-1.6245
Undersize 0.254mm	mm	41.021-41.008
(0.010in)	in	1.6150-1.6145
Undersize 1.508mm	mm	40.767-40.754
(0.020in)	in	1.6050-1.6045

AD

		Crankpin Journal
Standard	mm	44.450-44.425
	in	1.750-1.749
Undersize 0.254mm	mm	44.20
(0.010in)	in	1.740
Undersize 1.508mm	mm	43.94
(0.020in)	in	1.730

		Main Journal
Standard	mm	41.262-41.275
	in	1.6245-1.6250
Undersize 0.254mm	mm	41.008-41.021
(0.010in)	in	1.6145-1.6150
Undersize 1.508mm	mm	40.754-40.767
(0.020in)	in	1.6045-1.6050

Refitting the Crankshaft

1. If necessary fit new main bearings.

2. If new bearings are not being fitted ensure that the journal bearing surfaces and oil holes are clear.

3. Place a small quantity of new engine oil in the gear end bearing and on the crankshaft journals.

4. Fit the gear end thrust washer in the crankcase, making sure that the grooved side is facing away from the crankcase.

5. Carefully replace the crankshaft through the flywheel end of the crankcase into the gear end bearing taking care not to damage the bearing surface.

6. On AD2 engines, replace the top half of the intermediate main bearing and housing, ensure that the oilway cross hole is towards the flywheel end of the engine, and line up the matching numbers on both halves of the bearing housing and fit the bottom half. Fit the intermediate bearing bolts and washers and torque load the bolts to 41.0Nm (30.0lbf ft).

7. Fit the flywheel end thrust washer into the flywheel end main bearing housing, making sure that the grooved side is facing away from the housing.

8. Coat the flywheel end main bearing housing studs with Loctite Driloc 711.

9. Fit a new joint to the main bearing housing and using Service Tool 317-50101 to prevent damaging the oil seal on the keyway edges replace the housing.

10. Torque load the six nuts diagonally to 23.0Nm (17.0lbf ft).

11. Check that the crankshaft is free to rotate.

12. Check the crankshaft endfloat by using a feeler gauge inserted between the thrust washer face and the crankshaft or by using a dial gauge.
The endfloat should be 0.102-0.635mm (0.004-0.025in).

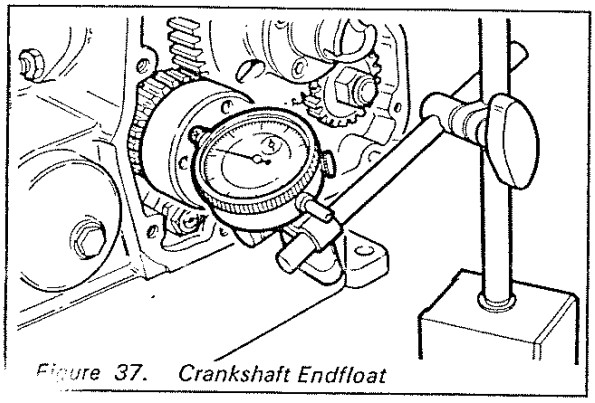

Figure 37. Crankshaft Endfloat

13. Fit the Woodruff key at the gear end.

14. Heat the crankshaft pinion gear to straw yellow and fit it to the crankshaft without delay.
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.

15. Replace the plate (B), without the 'O' ring (C), and the retaining bolt (A) torque loaded to 37.5Nm (27.5lbf ft).

16. When the pinion gear has cooled sufficiently remove the plate (B).

17. Fit a new 'O' ring (C) to the plate (B).

18. Replace the plate by pushing it into position; resistance will be felt due to the new 'O' ring.

19. Replace the bolt and torque load it to 37.5Nm (27.5lbf ft).

Note:
Items (A), (B) and (C) in 15. above are illustrated in Figure 34 on page 29.

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.

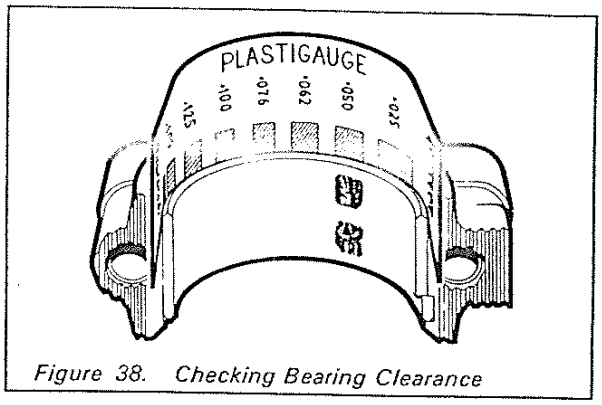

Figure 38. Checking Bearing Clearance

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 and Clearances" on page 38.

Notes:
Care must be taken to ensure the crankshaft is not 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.

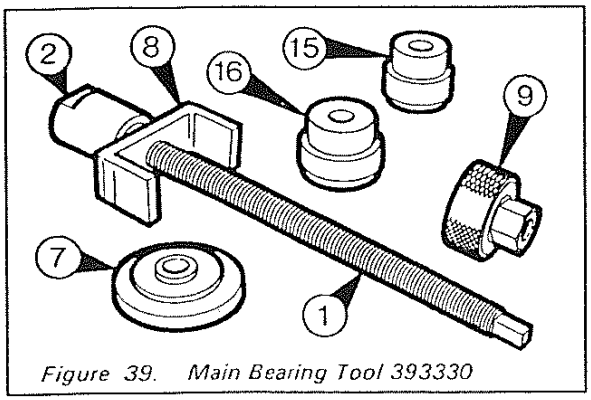

Figure 39. Main Bearing Tool 393330

Gear End Main Bearing Removal

1. Fit the nut (2) onto the screw (1).
2. Place the small dolly (15) onto the screw with the flanged end next to the nut (2).
3. Loosely fit the flywheel end bearing housing.
4. Insert the assembly through the bearing from the gear end.
5. Fit the depth plate (7) and the thrust nut (9) to the screw.
6. Using the correct size of spanner, and pulling against the flywheel bearing housing, tighten the thrust nut (9) until the bearing is removed from the crankcase.

Gear End Main Bearing Replacement

1. Fit the nut (2) onto the screw (1).
2. Place the small dolly (15) onto the screw with the flanged end next to the nut (2).
3. Place the new bearing onto the dolly (15) and fit the large dolly (16) into the bearing.
4. Loosely fit the flywheel end bearing housing.
5. Fit the screw assembly from the gear end ensuring the bearing oil hole is correctly lined up with the slot in the crankcase.
6. Using the depth plate (7), thrust nut (9) and the correct size of spanner tighten the thrust nut (9) until the bearing is almost flush with the crankcase thrust face.
7. Remove the tool taking care to prevent it dropping onto the new bearing.
8. Check the oil holes in the crankcase and bearing align.

Flywheel End Main Bearing Removal

1. Fit the nut (2) onto the screw (1).
2. Hold the nut firmly across its flats in a vice.
3. Place the small dolly (15) onto the screw (1) with the flanged end next to the nut (2).
4. Remove the oil seal.
5. Fit the bearing housing, thrust face uppermost, onto the screw.
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 bearing is removed.

Flywheel End Main Bearing Replacement

1. Fit the nut (2) onto the screw (1).
2. Hold the nut firmly across its flats in a vice.
3. Place the small dolly (15) onto the screw (1) with the flanged end next to the nut (2).
4. Place the new bearing onto the dolly (15) and fit the large dolly (16) into the bearing.
5. Using the bridge (8), thrust nut (9) and the correct size of spanner tighten the thrust nut (9) until the bearing inner edge is almost flush with the housing thrust face.
6. Remove the tool taking care to prevent it dropping onto the new bearing.
7. Check the oil holes in the crankcase and bearing align.

FLYWHEEL END OIL SEAL

When fitting the flywheel end oil seal, ensure that it is fitted squarely in the housing before pressing, or driving, in the seal. The seal face must be flush with the outer face of the bearing housing.

Before fitting anew oil seal it is important that the recess in the seal is filled with Shell Alvania R2 Grease; this is a Lithium Grease to NLG1 No.2 consistency. In the non-availability of the grease immerse the seal in new engine lubricating oil at ambient temperature for 24 hours.

THE CAMSHAFT

The steel camshaft is carried in bearings in the crankcase at the flywheel and gear ends end and in the centre web. A thrust plate is fitted behind the camshaft gear and the gearwheel is keyed and an interference fit.

The rotary oil pump is driven by the camshaft gearwheel and cams on the camshaft operate the valve tappets and fuel pump.

Removing the Camshaft

1. Lift out the dipstick.
2. Drain the oil from the sump
3. Drain and remove the fuel tank.
4. On AC and AD engines remove the fuel lift pump and plunger if a pump is fitted.
5. Remove the fuel pump.
6. Remove the fuel injector.
7. Remove any accessories fitted to the gear end cover.
8. Remove the gear end cover.
9. Remove the cylinder head cover, the valve rockers and push rods; note the position of the pushrods.
10. Stand the engine on its flywheel end.
11. Remove the oil sump.
12. Remove the two camshaft thrust plate retaining screws; these are accessible through holes in the gearwheel as shown in Figure 40.

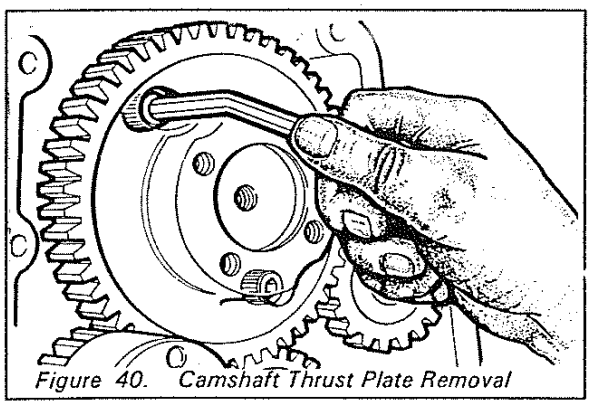

Figure 40. Camshaft Thrust Plate Removal

13. Remove the crankshaft pinion gear.
14. Push the cam followers away from the camshaft as far as possible.
15. Carefully withdraw the camshaft from the gear end of the engine.
16. Remove the cam followers noting their positions.

Inspection and Maintenance

a. Check the cam lobes and cam followers for wear or damage.

b. Check the camshaft core plug for leaks.

c. Before fitting the camshaft check the camshaft bearings and thrust plate for damage or wear.

d. Check the camshaft and crankshaft pinions teeth for wear.

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

Camshaft Bushes

New bushes should be immersed in clean engine oil before fitting and it is recommended that they are replaced as a set.

1. Remove the camshaft.
2. Use a suitable brass drift to remove the bushes.
3. Ensure the crankcase bush bore is clean and not damaged.
4. Using a suitable dolly or hardwood block drive in the new bushes.

Camshaft Core Plug

1. Drive out the old plug.
2. Coat the periphery of the new plug with Hylomar PL14.
3. Fit the plug from the inside of the crankcase with the cup bottom entering first.

Camshaft Pinion Gear

It is recommended that the gear is heated, preferably using an oil bath, before attempting to fit it to the camshaft. If an alternative source of heat is used ensure that the pinion is not overheated as this may affect the hardness.

Removing the Camshaft Pinion

1. Remove the extension shaft, pinion, or starter dog.
2. Remove the gear retaining setscrew (A) and washer.
3. Using a suitable press remove the gearwheel (B) from the shaft.
4. Remove the thrust plate (C).

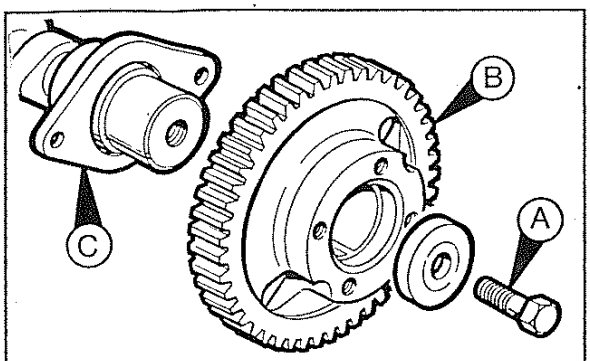

Figure 41. Camshaft and Pinion

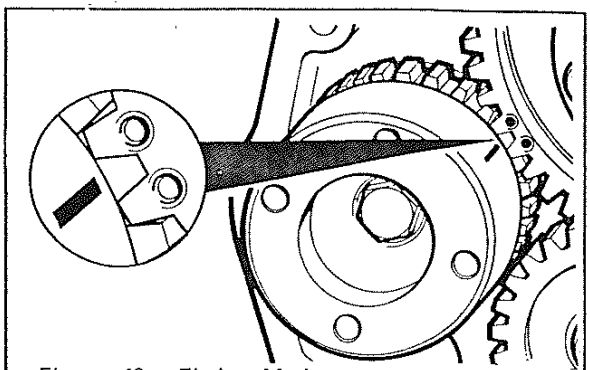
Figure 42. Timing Marks

Refitting the Camshaft Pinion

1. Place the thrust plate onto the camshaft.
2. Fit the Woodruff key at the gear end.
3. Heat the camshaft pinion gear to straw yellow and fit it to the camshaft without delay.
   Insufficient heat or delay in fitting could well cause the pinion to become jammed on the camshaft, whereas overheating may cause softening of the pinion.
4. When the pinion gear has cooled sufficiently fit the plate and the retaining setscrew which should be torque loaded to 37.5Nm (27.5lbf ft).

Refitting the Camshaft

1. With the engine standing on its flywheel place the camshaft followers in their original positions and push them as far as they will go into the crankcase.
2. Lightly oil the camshaft and bearings with new engine oil.
3. Carefully replace the camshaft through the gear end of the crankcase.
   If the crankshaft gear is fitted ensure that the timing marks on both gearwheels are correct as shown in Figure 42.
4. Turn the camshaft as necessary to align the thrust plate mounting holes with the holes in the pinion gear.
5. Replace and tighten the two thrust plate retaining capscrews.
6. Check the camshaft end float using a dial indicator as shown in Figure 43; this should be 0.127-0.305mm (0.005-0.012in) and is not adjustable.

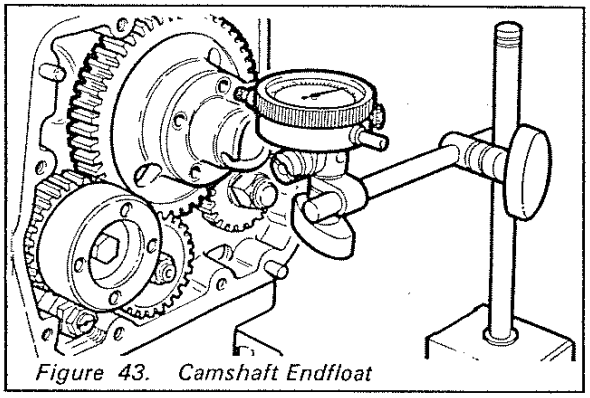
Figure 43. Camshaft Endfloat

7. Replace the crankshaft pinion gear.
8. Replace the gear end cover.
9. Refit the sump using a new gasket and stand the engine on its base.
10. Fit the push rods in their noted positions and assemble the valve rocker support and rocker arms.
11. Check the valve clearances and decompressor adjustment.
12. Replace the injector, fuel pump, tank and all fuel pipes.
13. Fill the sump with the correct type and grade of lubricating oil.
14. Fit any starting arrangements or accessories.

THE GOVERNOR

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

Removing the Governor

1. Lift out the dipstick.
2. Drain the oil from the sump.
3. Drain and remove the fuel tank, if fitted.
4. Remove the gear end cover.
5. If necessary remove the governor pinion gear retaining nut and pull off the pinion.
6. Remove the three capscrews retaining the governor.
7. Turn the crankshaft sufficiently to ensure one of the 'flats' on the assembly will clear the camshaft pinion gear teeth.
8. Lift out the governor assembly.

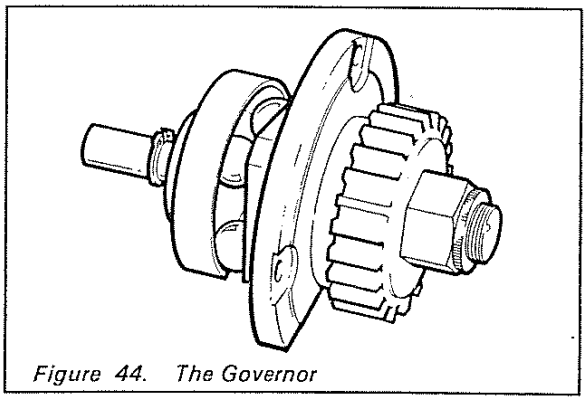

Figure 44. The Governor

Servicing the Governor Assembly

1. Clean the assembly in kerosene.
2. Check the governor balls and sliding cone for wear or damage.
3. Hold the assembly horizontal, by the housing, in one hand and spin the pinion gear with the other hand.
   As the pinion revolves the governor cone assembly should be forced towards the circlip.
   If there are tight-spots or damage the complete assembly should be replaced.

Refitting the Governor

1. Fit the governor assembly in position and tighten the three capscrews.
2. Replace the key in the governor shaft.
3. Align the key and keyway and fit the gearwheel and nut.

THE GOVERNOR LINKAGE

The governor linkage is covered in Section 4.

DECARBONISING

Decarbonising should be carried out after 2000 hours running or 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.

1. Piston.
2. Piston rings, grooves and oil holes.
3. Valve ports, valves and valve seats.
4. Exhaust manifold, piping and silencer.
5. Fins on the cylinder, cylinder head and injector.
6. Regrind the valves and seats.

CLEANING THE COOLING FINS

The cylinder barrel and 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 air cowl and raking the dust off the fins with a hooked piece of wire.

LAYING-UP PROCEDURE

The following routine should be carried out when it is known that the engine will not be required for some months, if they are not carried out the engine should be run on full load for approximately 45 minutes once a month

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.

Warning:
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.

JOINTING COMPOUNDS

Some engines may 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.

Flywheel End Bearing Housing Studs Coat the studs with Loctite Driloc 711.
Fuel Injection Pump Studs Coat the studs with Loctite Driloc 711.
Oilway Plugs - except crankcase plugs Fit the plug with Stag 'A' type jointing compound.
Oil Filler Collar Coat with Loctite 87AV Red Compound.
Valve Rocker Box Oilway Plug Coat with Hylomar PL32.
All Compressed Asbestos Fibre Gaskets Assemble clean and dry.
Air Cell Retaining Plug Assemble using Achesons anti-scuffing graphited grease.
Oil Seals Fill the seal recess and smear the crankshaft sealing area with Shell Alvania 2 grease.
Camshaft Core Plug Coat the periphery of the plug with Hylomar PL14.
Cylinder Head Gaskets Assemble dry.
Cylinder Head Clearance Shims Assemble dry.

SERVICE TOOLS

This table gives the service tools that are available for particular servicing operations..

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

All the tools listed can be ordered by quoting the part number and description following the same procedure as for ordering other Lister-Petter spares.

Part Number	Description of Tool
390263	Valve quide remover
393155	Valve spring compressor
393171	Jacking screw; included with 393175
393175	Gear and flywheel puller kit
393211	Oil seal sleeve
393212	Speed adjusting tool
392333	Main bearing adaptor
303330	Main bearing removal and replacement tool
317-50027	Slide hammer
317-50042	Valve seat and recess cutting tool
[illegible]	with 317-500[illegible]
317-50094	Valve clearance gauge
317-50095	Injector removal adaptor; use with 317-50027
317-50101	Flywheel end crankshaft oil seal tool
317-50517	Fuel injector test rig
517-50518	Fuel pump timing gauge

DIMENSIONS OF WEARING PARTS AND CLEARANCES

Component	Initial Dimension		Initial Clearance		Maximum Clearance	
	mm	in	mm	in	mm	in
AA - All Builds						
Cylinder Bore	69.850 69.875	2.7500 2.7510	0.150 0.099	0.0059 0.0039	0.403	0.0159
Piston Diameter - bottom of skirt across thrust face	69.751 69.726	2.7461 2.7451				
Piston Ring Gap	0.279 0.406	0.0110 0.0160	0.279 0.483	0.0110 0.0190	1.19	0.047
Firing and Compression Ring Width	1.984 1.958	0.0781 0.0771	0.038 0.089	0.0015 0.0035	0.114	0.0045
Firing and Compression Ring Groove Width	2.022 2.047	0.0796 0.0806				
Oil Ring Width	3.967 3.942	0.1562 0.1552	0.041 0.091	0.0016 0.0036	0.119	0.0047
Oil Ring Groove Width	4.008 4.034	0.1578 0.1588				
AC - All Builds						
Cylinder Bore	76.200 76.225	3.0000 3.0010	0.142 0.097	0.0056 0.0038	0.395	0.0156
Piston Diameter - bottom of skirt across thrust face	76.103 76.083	2.9962 2.9954				
Firing and Compression Ring Gap	0.305 0.432	0.012 0.017	0.305 0.508	0.012 0.020	1.321	0.052
Oil Ring Gap	0.229 0.356	0.009 0.014	0.305 0.432	0.012 0.017	1.245	0.049
Firing Ring Width	1.750 1.737	0.0689 0.0684	0.064 0.245	0.0025 0.0100	0.330	0.0130
Firing Ring Groove Width	1.814 1.991	0.0714 0.0784				
Compression Ring Width	1.984 1.958	0.0781 0.0771	0.038 0.089	0.0015 0.0035	0.117	0.0046
Compression Ring Groove Width	2.022 2.047	0.0796 0.0806				
Oil Ring Width	3.970 3.945	0.1563 0.1553	0.038 0.089	0.0015 0.0035	0.097	0.0038
Oil Ring Groove Width	4.008 4.034	0.1578 0.1588				
AD - All Builds						
Cylinder Bore	80.000 80.025	3.1496 3.1506	0.145 0.095	0.0057 0.0037	0.395	0.0156
Piston Diameter - bottom of skirt across thrust face	79.905 79.880	3.1459 3.1449				
Firing Ring Gap	0.305 0.432	0.012 0.017	0.305 0.511	0.012 0.020	1.300	0.051
Compression Ring Gap	0.304 0.432	0.012 0.017	0.304 0.511	0.012 0.020	1.300	0.051
Oil Ring Gap	0.240 0.490	0.009 0.019	0.240 0.569	0.012 0.022	1.354	0.053
Firing Ring Width	1.753 1.740	0.0690 0.0685	0.114 0.152	0.0045 0.0060	0.198	0.0078
Firing Ring Groove Width	1.867 1.892	0.0735 0.0745				
Compression Ring Width	1.984 1.958	0.0781 0.0771	0.101 0.153	0.0040 0.0060	0.199	0.0078
Compression Ring Groove Width	2.085 2.111	0.0821 0.0831				
Oil Ring Width	3.970 3.945	0.1563 0.1553	0.060 0.110	0.0024 0.0043	0.143	0.0056
Oil Ring Groove Width	4.030 4.055	0.1587 0.1596				

Component	Initial Dimension		Initial Clearance		Maximum Clearance	
	mm	in	mm	in	mm	in
Small End Bearing Diameter - AA, AC	22.231 22.244	0.87525 0.87575	0.025 0.005	0.0010 0.0003	0.035	0.0014
Gudgeon Pin Diameter - AA, AC	22.225 22.220	0.87575 0.8748				
Small End Bearing Diameter - AD	22.244 22.257	0.8750 0.87626	0.034 0.016	0.0013 0.0006	0.050	0.0020
Gudgeon Pin Diameter - AD	22.228 22.223	0.8751 0.8749				
Big End Bore (in rod) - AA, AC	44.983 44.971	1.7710 1.7705	0.076 0.033	0.0030 0.0013	0.112	0.0044
Bearing Shell Thickness - AA, AC	1.8313 1.8225	0.07210 0.07175				
Crankpin Diameter - AA, AC	41.275 41.262	1.6250 1.6245				
Big End Bore (in rod) - AD	47.142 47.130	1.8560 1.8555	0.076 0.028	0.0030 0.0011	0.112	0.0044
Bearing Shell Thickness - AD	1.327 1.321	0.0522 0.0520				
Crankpin Diameter - AD	44.450 44.425	1.7500 1.7490				
Main Bearings - Bore Diameter (when pressed in housing	41.338 41.308	1.6275 1.6263	0.076 0.033	0.0030 0.0013	0.112	0.0044
Crankshaft Journals - Diameter	41.275 41.262	1.6250 1.6245				
Thrust Bearing/Crankshaft Endfloat	2.362 2.311	0.0930 0.0910	0.102 Endfloat	0.004 Endfloat	0.635 Endfloat	0.025 Endfloat
Camshaft Bush Bore Diameter - Flywheel End (when pressed in housing)	25.464 25.390	1.0025 0.9996	0.102 0.015	0.0040 0.0006	0.150	0.0059
Camshaft Journal - Flywheel End	25.375 25.362	0.9990 0.9985				
Camshaft Bush Bore Diameter - Intermediate and Gear End (when pressed in housing)	34.996 34.910	1.3778 1.3744	0.112 0.010	0.0044 0.0004	0.165	0.0065
Camshaft Journal - Intermediate and Gear End	34.900 34.884	1.3740 1.3734				
Camshaft Assembly - Endfloat	0.127 0.305	0.0050 0.0120			0.335	0.013
Oil Pump - Rotor End Clearance			0.025 0.064	0.0010 0.0025	0.127	0.005
Oil Pump - Rotor Form Clearance			0.051 0.127	0.0020 0.0050	0.203	0.008
Oil Pump - Shaft/Bore Clearance			0.038 0.076	0.0015 0.0030	0.127	0.005
Valve Spring - approximate free length	38.00	1.5				
Valve Guide Bore	7.201 7.226	0.2835 0.2845	0.081 0.041	0.0032 0.0016	0.103	0.0041
Valve Stem Diameter	7.160 7.145	0.2819 0.2813				
Valve Rocker Arm Bore	15.870 15.900	0.6248 0.6260	0.071 0.025	0.0028 0.0010	0.103	0.0041
Valve Rocker Shaft Diameter	15.845 15.830	0.6238 0.6232				
Backlash Between Gears			0.06 0.10	0.002 0.004	0.18	0.007

SPANNER TORQUE SETTINGS

Location	Nm	lbf ft
Breather Base to Crankcase	5.0	4.0
Leak-off Banjo Bolt	7.0-8.0	5.0-6.0
Fuel Injector Stud Nut - AC, AD	8.0	6.0
Lubricating Oil Pump Screw	10.0-12.0	7.0-9.0
Solenoid Bracket Button Head Screw - AA	11.0	8.0
Gear Cover Cap Screw Sump Cap Screw	12.0	9.0
Oil Gallery Plug Lubricating Oil Filter Centre Bolt	14.0	10.0
Gear End Adaptor Housing Retaining Bolts	17.0/23.0	13.0/17.0
Fuel Injector Stud Nut - AA Fuel Injection Pump Nuts	18.0	13.0
Crankshaft Extension Shaft Screw Camshaft Extension Shaft Screw Starting Handle Shaft Retaining Screw - AC, AD	19.0	14.0
Crankshaft Cheek Weight Screw - AD	22.0	16.0
Rear Main Bearing Housing Nuts	23.0	17.0
Cylinder Head Nut - AA, AC	27.0	20.0
Cylinder Head Nut - AD	30.0	22.0
Connecting Rod Large End Bolt Starting Pinion Cap Screws - AD2	34.0	25.0
Camshaft Gearwheel Retaining Screw Crankshaft Gearwheel Retaining Screw Flywheel End Extension Shaft Bolt Starting Handle Shaft Retaining Screw - AD2	36.0	27.0
Fuel Pump Delivery Union Intermediate Bearing Housing Bolt - AD2	41.0	30.0
Air Cell Plug - AA	95.0	70.0
Flywheel Nut	210.0	155.0

Section 3 - The Lubrication System

OIL SPECIFICATION

The Oil Specification is given in the Operators Handbook - 027-08183.

DESCRIPTION AND OPERATION

A rotary type lubricating oil pump is mounted inside the gear end cover and is driven by a gear from the camshaft pinion.

The lubricating oil can be drained by removing one of two drain plugs located at the bottom of the sump.

The oil is drawn through a strainer in the sump to the rotary pump, through a pressure relief valve to the filter. From the filter it is distributed by oilways to the crankshaft main bearings and an external pipe feeds oil through a restrictor to the valve rockers. The connecting rod small end bearings and the camshaft are splash lubricated.

A combined oil filler and dipstick is located in the crankcase on the manifold side of the engine.

LUBRICATING OIL PRESSURE

The oil pressure must be checked after an engine overhaul or if the oil system has been disturbed.

1. Remove the blanking plug from below the valve rocker oil supply pipe union; this is located on the opposite side of the crankcase to the manifolds.
2. Fit a ⅛inch BSP union, capillary pipe and pressure gauge.
3. Start the engine and check that the pressure builds up.
4. Run the engine at its normal operating speed and check the pressure.

The mean pressure should be:-
2.8-4.0Bar (40-60lbf/in²

The minimum pressure at idling should not be less than:-
0.8bar (12lbf/in²).

OIL SUMP CAPACITY

	litres	pints	US quarts
AA1	1.9	3.25	2.0
AC1	2.7	4.8	2.9
AD1	2.7	4.8	2.9
AD2	3.7	6.5	3.9

THE OIL SUMP

The sump is secured to the crankcase by capscrews and the integral engine mounting bolt drillings are located on each corner of it and two drain plugs are fitted.

Draining the Sump

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

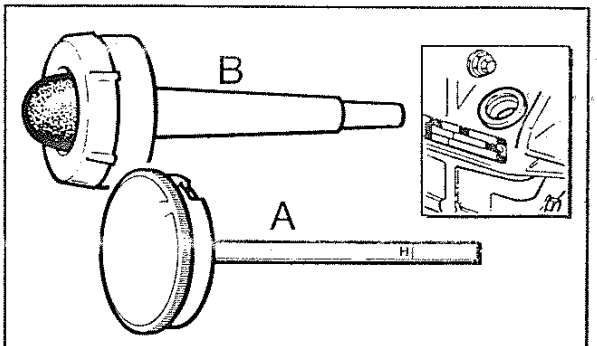

Figure 44. Oil Filler and Dipstick:
A - AA
B - AC and AD

Filling the Sump

1. Replace the drain plug taking care not to over tighten it.
2. Fill the engine crankcase through the oil filler to the top of the narrow section on the AA dipstick and to the 'H' mark on AC and AD engines.

3. Start the engine and run it for a few minutes to circulate the oil and check the drain plug does not leak.
4. Stop the engine and allow time for the oil to settle and re-check the level on the dipstick.
5. Add more oil if necessary.

Removing and Refitting the Sump

1. Drain the oil.
2. Stand the engine on its flywheel.
3. Remove the capscrews diagonally.
4. Lift off the sump and joint.
5. Clean and dry the crankcase and sump mating surfaces.
6. Fit the joint and sump onto the crankcase.
7. Replace the capscrews finger tight.
8. Torque load the capscrews, diagonally, to 12.0Nm (9.0lbf ft).
9. Stand the engine on the sump and refill with new oil to the specification given above.

THE OIL PUMP

The rotary oil pump is mounted on the crankcase inside the gear end cover and is driven from the camshaft pinion gear.

The oil pressure relief valve is set at 3.0-3.3bar (43-48lbf ft²).

Removing the Oil Pump

1. Lift out the dipstick.
2. Drain the oil sump.
3. Remove the fuel tank.
4. Remove the eight capscrews securing the end cover and remove it.
5. Loosen the nut retaining the oil pump gearwheel.
6. Remove the camshaft.
7. Remove the oil pump gearwheel retaining nut and pull off the gearwheel.
8. Remove the three capscrews and washers securing the pump and withdraw the pump assembly.

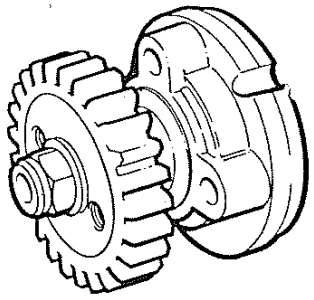

Figure 45. Oil Pump

9. Clean the crankcase pump orifices.
10. Clean the pump in kerosene and allow it to drain.
11. Check the rotors for wear; if they are worn the complete pump assembly must be replaced.
    The clearances can be found in "Dimensions of Wearing Parts" in Section 2.

Refitting the Pump

1. Before fitting the pump to the engine pour a small quantity of new engine oil into the pump through the inlet and delivery ports.
2. Align the pump assembly with the offset capscrew thread holes.
3. Fit the three capscrews and washers and torque load them to 13.6Nm (10.0lbf ft.).
4. Align the shaft key and the pump gearwheel and fit the pump gearwheel.
5. Replace the nut and washer retaining the gearwheel.
6. Tighten the pump gear retaining nut.
7. Replace the camshaft.
8. Fit a new joint and replace the gear end cover.

THE OIL PUMP STRAINER

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

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.

Cleaning the Strainer - AA, AC, AD1

1. Lift out the dipstick.
2. Drain and remove the sump.
3. Remove the centre bolt (A), strainer clip (B) and lift out the strainer (C).

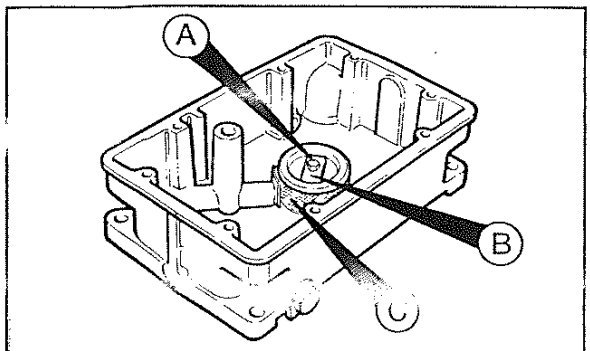

Figure 46. Oil Strainer - AA, AC, AD1

4. Clean the strainer using clean kerosene and allow it to drain.
5. Locate the strainer in the sump making sure it is correctly seated.
6. Fit the strainer clip and centre bolt, making sure that the concave side of the clip holds the strainer.
7. Renew the sump gasket and fit the sump.

Cleaning the Strainer - AD2

1. Drain and remove the sump.
2. Remove the two bolts (A) from the crankcase.
3. Remove the strainer assembly (B) and the flange gasket (C).

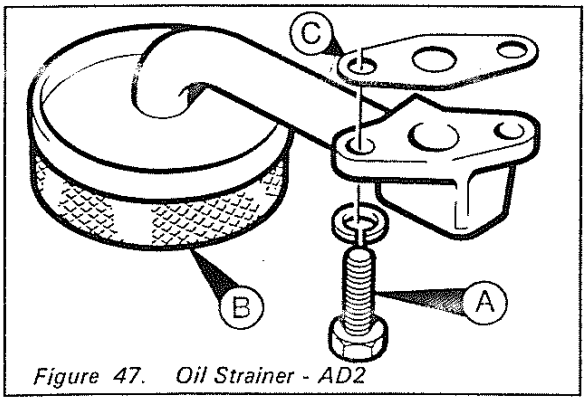

Figure 47. Oil Strainer - AD2

4. Clean the strainer using clean kerosene and allow it to drain.
5. Fit a new flange gasket.
6. Locate the strainer flange and replace the two retaining bolts taking care to tighten them evenly.
7. Renew the sump gasket and fit the sump.

THE OIL PRESSURE RELIEF VALVE

A pre-set ball type oil pressure relief valve is fitted at the side of the pump and should not require adjustment. If it is dismantled extreme care must be taken to check the number of turns necessary to remove the adjusting screw, so that it can be returned to its original position on assembly.

The position of the relief valve is shown in Figure 33 on page 29.

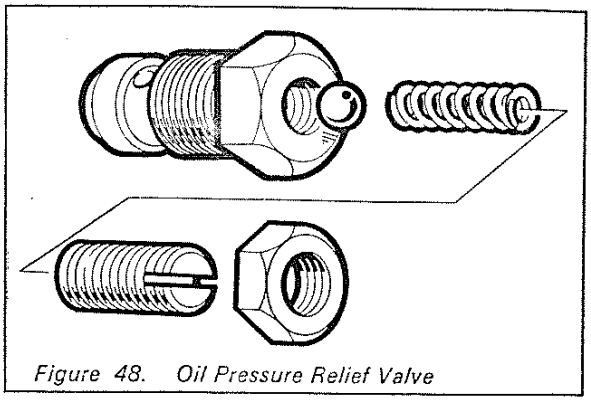

Figure 48. Oil Pressure Relief Valve

THE OIL FILTER

The oil filter is mounted inside the crankcase at the gear end and consists of a detachable cover containing the element which is secured by a centre bolt into the crankcase.

Removing the Filter

1. Unscrew the centre bolt (A) and withdraw the filter cover (B) and the element (C).
2. Clean the cover and chamber.

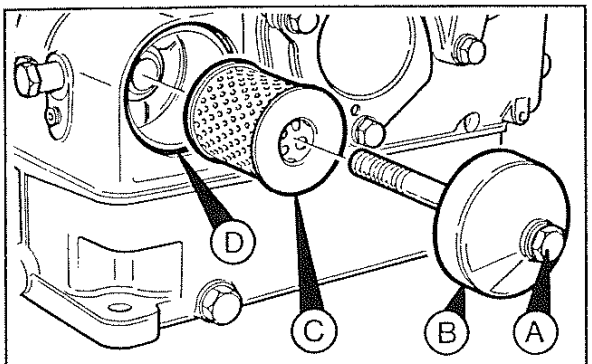

Figure 49. Oil Filter

Refitting the Filter

No attempt must be made to clean the filter element.

1. If necessary fit a new seal (D).
2. Fit a new element into the crankcase and replace the cover.
3. Tighten the centre bolt to a maximum torque loading of 13.6Nm (10.0lbf ft.).

THE CYLINDER HEAD OIL FEED

An external pipe, secured by ⅛inch swivel union plugs torque loaded to 14.0Nm (10.0lbf ft), carries lubricating oil from the internal oil gallery to the cylinder head valve rockers.

THE OIL SEALS

Warning:
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.

A lip type oil seal is fitted to the gear end cover and the main bearing housing. The fitting of lip type oil seals is described in "End Cover Oil Seal" on page 28.

The lip seals used must be the approved type as supplied by Lister-Petter and are fitted without any jointing compound being applied. Ordinary rubber seals may quickly harden in use, rapidly wear 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 that no damage has taken place during transit or servicing. Emery cloth of any grade must not be used in the area of the lip. 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.

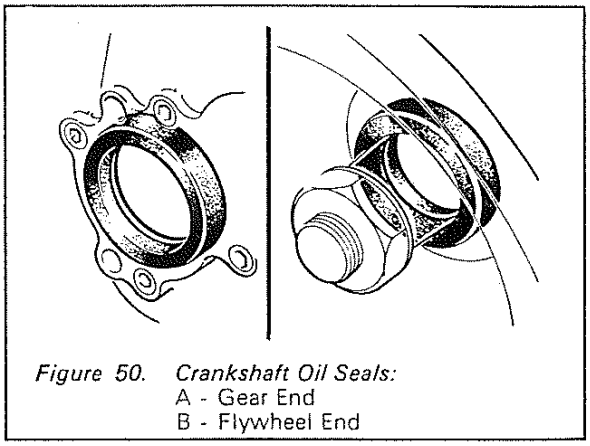

Figure 50. Crankshaft Oil Seals:
A - Gear End
B - Flywheel End

Flywheel End Oil Seal

When fitting the flywheel end oil seal ensure that it is fitted squarely in the housing before pressing or driving in the seal. The seal face must be flush with the outer face of the bearing housing.

Note:
Before fitting a new oil seal it is important that the recess in the seal is filled with Shell Alvania R2 Grease. This is a Lithium Grease to NLG1 No 2 consistency. In the event of non-availability of the grease soak the seal in engine lubricating oil at ambient temperature for 24 hours.

Section 4 - The Fuel System and Governor

The Fuel System

FUEL SPECIFICATION

The Fuel Specification is given in the Operators Handbook - 027-08183.

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 pipe connections use two spanners to prevent slackening the pump delivery valve union.
- 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. This procedure will ensure that there is no leakage from these joints.
- It is most important that all fuel joints are tight and leakproof.
- Always fill the fuel tank through a fine strainer, preferably at the end of the engine work period. If any sediment is stirred up during the process this has time to settle before the engine is used again. If cans are used, avoid tipping out the last few drops.
- Funnels are very difficult to keep clean in dusty conditions. Wash them before and after use and wrap them up when not required, or fill the tank direct from a small mouthed screw capped fuel can.

TYPE OF INJECTION

AA - Air Cell
AC and AD - Direct

DESCRIPTION AND OPERATION

The fuel injection equipment is manufactured to very fine limits and requires extreme care and absolute cleanliness in handling. All orifices on any part of the fuel system that is removed from an engine must be sealed, failing this the item should be placed in a clean container containing clean fuel.

The fuel system comprises a fuel tank, fuel filter and a fuel injection pump and injector. Fuel is supplied from the tank via a filter to the pump through a flexible pipe and by a rigid pipe from the pump to the injector. The leak-off from the injector is fed through an external pipe back to the tank or to the inlet side of the filter when the system is fitted with a remote tank.

FUEL INJECTION EQUIPMENT

The fuel injection equipment fitted to the engines is identified in the relevant Parts List
AA1 - 027-08097.
AC1 - 027-08096
AD1 - 027-08099
AD2 - 027-08100

THE FUEL TANK

Engine mounted tanks are fitted at the gear end of the engine and will be supported on studs and nuts or bolts and spacers.
Three fuel tanks are available:-
3.8 and 5.1litres with an internal filter.
9.0litres with a gauze strainer in the filler and remote mounted filter.

Removing the Fuel Tank

1. Drain the tank.
2. Remove all of the fuel pipes.
3. Remove the top and bottom bolts and lift the tank from the engine.
4. Remove the sediment from the tank, if necessary flush with clean kerosene and allow it to drain.
5. Check the tank and mounting lugs for damage.
6. If necessary change the 3.8 or 5.1litre tank filter element.

THE FUEL FILTER

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 250 hours, or more frequently if for any reason the fuel is known to be dirty.

Tank Mounted Filter

Care should be taken to ensure the jubilee clip fitted to polypropylene fuel tanks is not slackened or removed.

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).

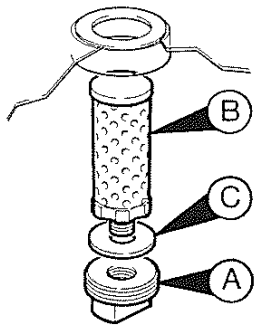

Figure 51. Tank Mounted Filter

5. Fit a new joint over the element screw spigot.
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.
8. Replace the fuel pipe.
9. Fill the fuel tank and prime the fuel system.

Remote Mounted Filter

1. Unscrew and remove the retaining bolt (A) from the element bowl.
2. Remove the element (B) and discard it.
3. Discard the four joints.
4. Clean the element bowl.

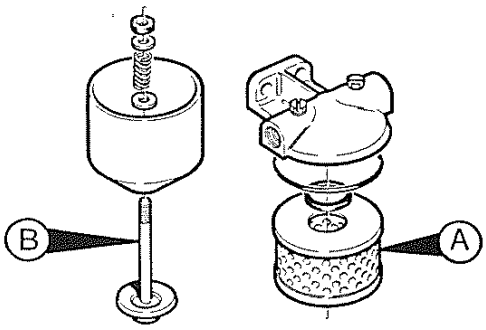

Figure 52. Remote Filter

5. Fit a new joint to the element adaptor, the retaining bolt, the filter head and below the element.
6. Place the new element onto the adaptor.
7. Replace the element bowl and retaining bolt.
8. Fill the fuel tank and prime the filter.

PRIMING THE FUEL SYSTEM

Most A Range Engines are fitted with a self-venting fuel system as standard.

Priming the Remote Filter

1. Slacken both vent screws (A) on top of the remote filter.

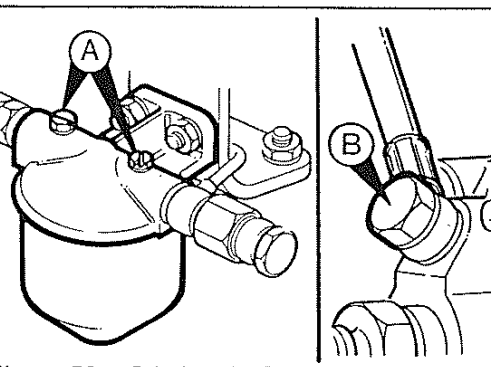

Figure 53. Priming the Remote Filter

2. When no further air bubbles are escaping close both vents starting with the one nearest the fuel tank.

Priming the Fuel Pump

1. Prime the filter.
2. Move the engine control lever to the 'RUN' position.
3. Slacken the vent screw (B) on the pump inlet pipe union.

4. When no further air bubbles are escaping close the vent.

5. Crank the engine until the injector is heard to 'squeak'.

THE FUEL INJECTOR

AA engines are indirect injection therefore the AA injector and are not interchangeable with those fitted to AC and AD engines which have indirect injection.

The injector breaking pressure can only be set on a test rig and if this is not available the injector should be replaced with a new or reconditioned one.

Removing the Injector - AA

1. Remove the air cleaner and fuel tank.

2. Remove the air cowling.

3. Slacken and remove the pump to injector fuel pipe (A); hold the fuel pump delivery valve holder with a spanner to prevent it turning.

4. Disconnect the leak-off pipe (B) from the injector.

5. Remove the two injector holding down nuts (C).

6. Remove the injector (D) and the sealing washer (E).

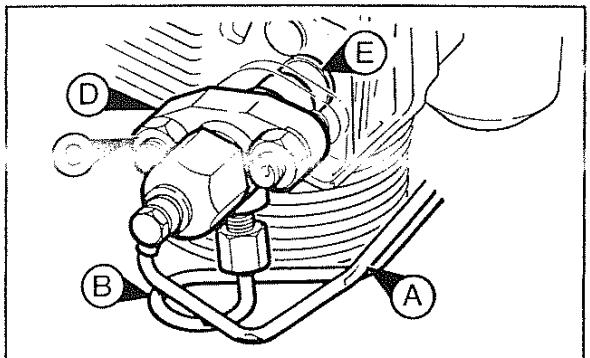

Figure 54. Fuel Injector

7. If the injector cannot easily be removed use the Service Tool 317-50027 and Adaptor 317-50095.

Replacing the Injector - AA

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

2. Fit the sealing washer to the injector. Build 05 engines are fitted with a copper washer and all others have a sealing washer which must be fitted with the dimple facing towards the injector.

3. Replace the injector into the cylinder head.

4. Replace the retaining nuts leaving the injector loose.

5. Replace the fuel pump to injector pipe and tighten the unions finger tight.

6. Tighten the unions a **further half turn with a spanner.**

7. Torque load the injector nuts to 8.0Nm (6.0lbf ft).

8. Replace the leak-off pipe.

9. Replace the cowling, lifting eye, air cleaner and the fuel tank.

10. After the initial run following an injector replacement re-torque the two retaining nuts.

Note:
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.

Removing the Injector - AC, AD

1. Slacken and remove the pump to injector fuel pipe (A); hold the fuel pump delivery valve holder with a spanner to prevent it turning.

2. Disconnect the leak-off pipe (B) from the injector.

3. Remove the two injector holding down nuts (C).

4. Lift off the injector clamp (D).

5. Lift out the injector (E) and the sealing washer (F).

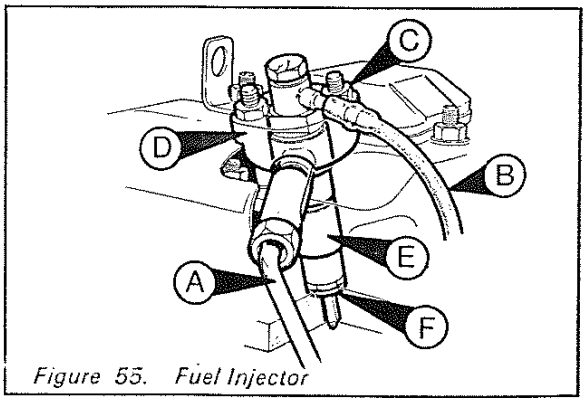

Figure 55. Fuel Injector

6. If the injector cannot easily be removed use the Service Tool 317-50027 and Adaptor 317-50095.

Replacing the Injector - AC, AD

1. Ensure the seatings in the cylinder head are clean and smooth.
2. Fit the sealing washer onto the injector with the dimple facing towards the injector.
3. Replace the injector into the cylinder head.
4. Place the injector clamp over the injector with the cut out section facing outwards.
5. Replace the two clamp nuts leaving them finger tight.
6. Replace the fuel pump to injector pipe and tighten the unions finger tight.
7. Tighten the unions a **further half turn with a spanner.**
8. Torque load the injector nuts to 18.0Nm (13.0lbf ft).
9. Replace the leak-off pipe.
10. After the initial run following an injector replacement re-torque the two clamp nuts.

Note:
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.

Injector Removal Tool

1. Remove the fuel pipes from the injector.
2. Screw the adaptor (A) into the leak-off hole of the injector.

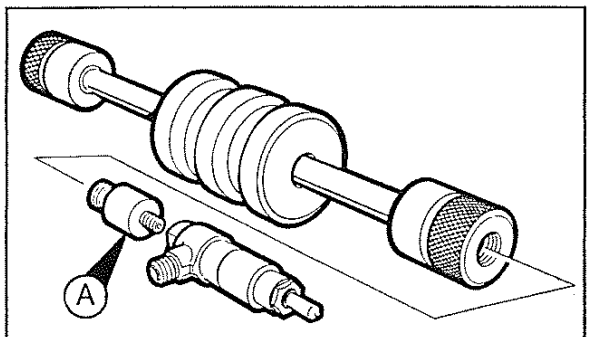

Figure 56. Injector Removal Tool

3. Fit the slide hammer to the adaptor.
4. Hold the slide hammer firmly and slide the sleeve from end to end and 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.
Excessive force must not be used.

CLEANING AND SETTING THE INJECTOR

- A thoroughly cleaned container holding a supply of clean, fresh fuel oil should be available for washing dismantled parts.
- Never use paraffin or woven cloths; it is permissible to use non-fluffing paper during the cleaning process.
  The 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 57.

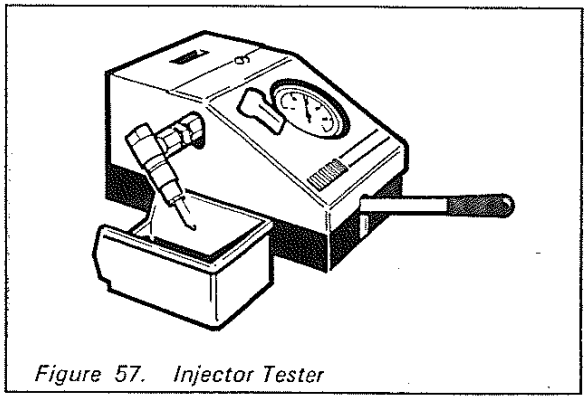
Figure 57. Injector Tester

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.

When a new nozzle is fitted the injector must be reset on a test rig. and after testing and resetting the top plug must be torque loaded to 27.1Nm (20lbf ft).
The settings are:-
AA - 183bar (180atms).
AC, AD - 200bar (197atms).

Note:
A list of injector faults can be found in Section 1.

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.

Back Leakage Values

Calibration Fuel Temperature		Back Leakage
°C	°F	Time Band in Seconds
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

THE FUEL INJECTION PUMP

The fuel pump is fitted onto the crankcase at the gear end and is operated directly from the camshaft.

AA, AC and AD1 have similar physical characteristics but only AC and AD1 fuel pumps are interchangeable.

AA, AC and AD1 timing shims are interchangeable.

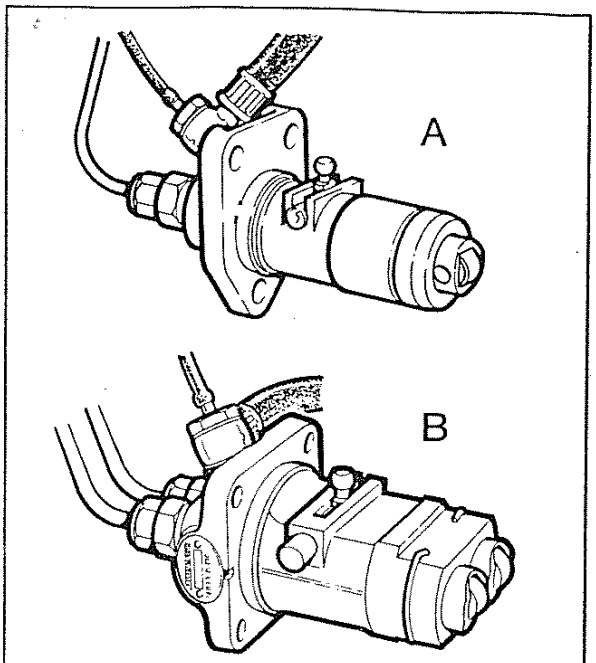

Figure 58. Fuel Pumps:
A - AA, AC, AD1
B - AD2

Removing the Pump

1. Drain and remove the fuel tank.
2. Remove the air cowling.
3. Slacken and remove the pump inlet (A) and delivery (B) pipes; hold the fuel pump delivery valve holder with a spanner to prevent it turning.

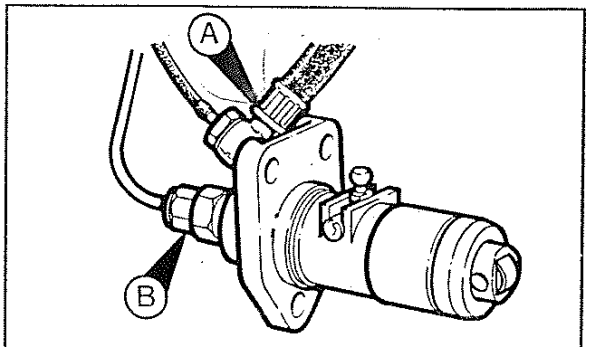

Figure 59. Removing the Fuel Pump

4. Remove the valve rocker oil pipe.
5. Turn the engine to TDC on the exhaust stroke.
6. Remove the three pump retaining nuts.
7. Refer to Figure 60 on page 50 and align the fuel pump rack ball (C) with the cut-out (D)

in the crankcase by positioning, and holding, the engine control lever approximately 10° before the vertical position.

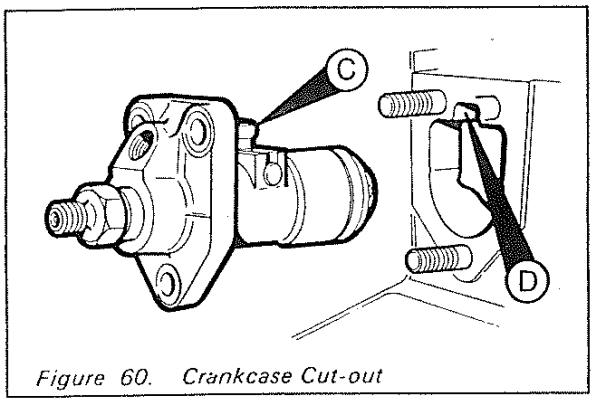

Figure 60. Crankcase Cut-out

8. Carefully lift out the fuel pump and retain the timing shims.

Warning:
Do not use force to remove the pump.
If difficulty is experienced, remove the gear end cover and position the fuel pump rack ball to clear the cut-out.

Replacing the Fuel Pump

1. Turn the engine to TDC on the exhaust stroke.
2. Position the governor lever fork (A) in line with the cut-out in the crankcase by moving, and holding, the engine control lever approximately 10° before the vertical position.

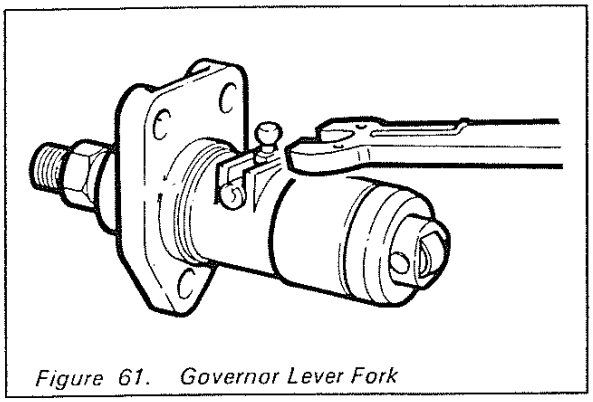

Figure 61. Governor Lever Fork

3. Place the pump timing shims over the pump mounting studs.
4. Replace the fuel pump taking care to ensure the fuel pump rack ball (B) is fully engaged in the governor lever fork (A).
5. Replace and tighten the pump retaining nuts.
6. Replace the fuel pump to injector pipe and tighten the unions finger tight.
7. Tighten the unions a **further half turn with a spanner.**
8. Replace the valve rocker oil feed pipe.
9. Time the pump as described in "Fuel Pump Spill Timing" on page 51
10. Replace the cowling, lifting eye, air cleaner and the fuel tank.

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

Dismantling the Pump

Fuel injection pumps are calibrated by the pump manufacturer and only the delivery side of the pump must be dismantled.

Warning:
If adequate workshop facilities or skills are not available it is advisable not to attempt to service a faulty pump, it is recommended that a replacement pump is fitted.

1. Ensure that the work area is clean.
2. Clean the exterior of the pump.
3. Unscrew the delivery valve holder (A) and remove it.
4. Lift out the delivery valve spring seat (B) and spring (C).
5. Remove the 'O' ring seal (D) and the copper seal (E).
6. Carefully lift out the delivery valve (F) taking care not to disturb the valve seat.
7. Place the pump components in a suitable container of clean fuel.

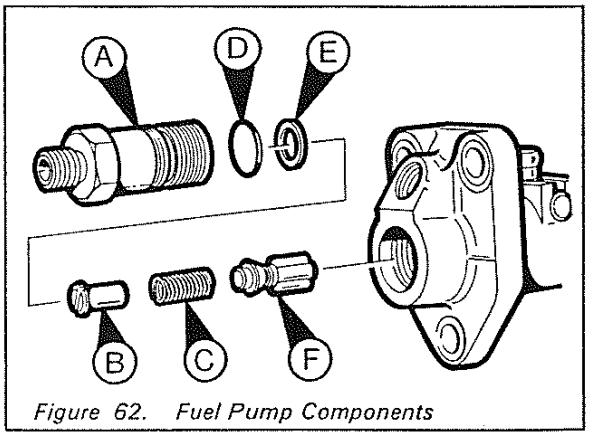

Figure 62. Fuel Pump Components

8. Check the valve and seat for damage and renew if faulty.

9. Check the 'O' ring and copper seal for damage.

Assembling the Pump

Before assembly ensure that all component parts are clean and wetted with clean fuel.

1. Replace the delivery valve into the seat.
2. Replace the high pressure seal (E).
3. Replace the delivery valve spring (C) and spring seat (B).
4. Fit the 'O' ring seal onto the delivery valve holder and ensure it is correctly located.
5. Replace the delivery valve holder and torque load it to 41.0Nm (30.0lbf ft).

FUEL PUMP SPILL TIMING

The conventional method and the fuel pump timing gauge, 317-50518, can both be used to check the timing and both methods are described.

Spill Timing

1. Isolate the fuel supply.
2. Remove the fuel pipe from the pump to the injector.
3. Remove the fuel pump delivery valve holder (A).
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.

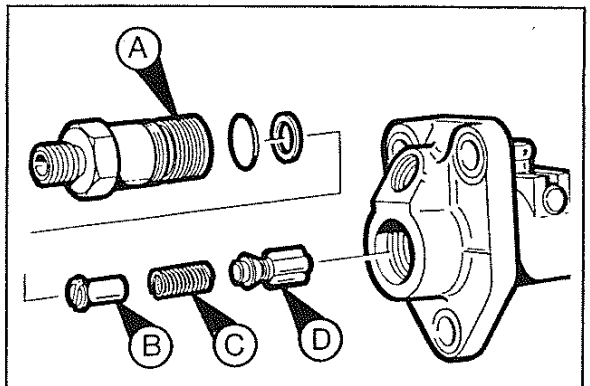

Figure 63. Fuel Pump Components

7. [illegible] (A).
8. Fit a suitable spill pipe.
9. Select the correct engine control lever position:-

   a. On fixed speed and two speed engines running at speeds above 3000r/min and all variable speed engines, move the control lever towards the STOP position and fix it at approximately 10° before the vertical position.
   Move the speed control to the full speed position on all variable speed builds.
   Do not operate the overload stop lever.

   b. On fixed speed and two speed engines running below 3000r/min move the control lever to the RUN position.

10. Turn the flywheel, in the direction of rotation, until the flywheel is a quarter turn before TDC on the compression stroke.
11. Connect the fuel supply and bleed the fuel filter.
12. Carefully 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'.
13. Check the flywheel timing mark; refer to the "Fuel Pump Timing Figures" for the relevant engine speed value.
    The flywheel timing angle mark can be seen through an aperture in the fanshroud and should align with the mark on the fanshroud.
14. If the flywheel timing mark is not correct, see Figure 64, the shims under the fuel pump must be adjusted.

If the timing is:-

Advanced (° too large) - Add Shims

Retarded (° too small) - Remove Shims.

Approximately 1° of flywheel movement can be obtained by adding or removing one 0.127mm (0.005in) shim.

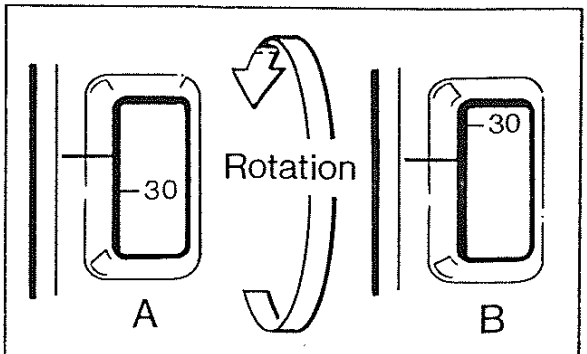

Figure 64. 30° Flywheel Timing Mark:

B - Retarded

15. Re-check the timing.
16. When the correct timing has been obtained remove the spill pipe and delivery valve holder.
17. Replace the delivery valve, delivery valve spring and spring seat.
18. Refit the delivery valve holder and torque load it to 41.0Nm (30.0lbf ft).
19. Connect all the fuel pipes.
20. Bleed the entire fuel system.

FUEL PUMP SPILL 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.

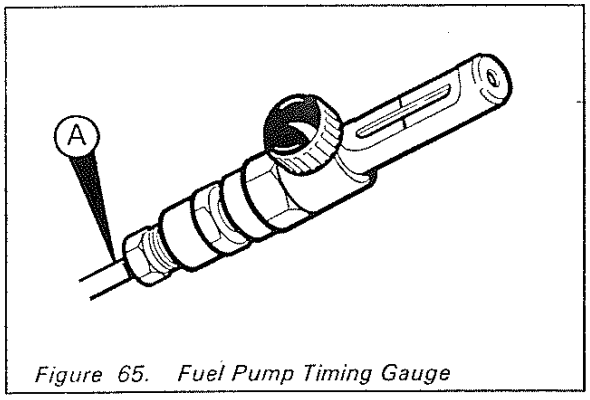

Figure 65. Fuel Pump Timing Gauge

4. Bleed the filter and pump.
5. Select the correct engine control lever position:-
   a. On fixed speed and two speed engines running at speeds above 3000r/min and all variable speed engines, move the control lever towards the STOP position and fix it at approximately 10° before the vertical position.
   Move the speed control to the full speed position on all variable speed builds.
   Do not operate the overload stop lever.
   b. On fixed speed and two speed engines running below 3000r/min move the control lever to the RUN position.
6. Turn the engine in the direction of rotation on the compression stroke to the relevant flywheel timing mark, as given in "Fuel Pump Timing Figures".
   The flywheel timing mark can be seen through an aperture in the fanshroud and should align with the mark on the fanshroud.
7. If the flywheel timing mark is not correct, see Figure 64 on page 51, the shims under the fuel pump must be adjusted.

If the timing is:-

Advanced (° too large) - Add Shims

Retarded (° too small) - Remove Shims.

Approximately 1° of flywheel movement can be obtained by adding or removing one 0.127mm (0.005in) shim.

8. Re-check the timing.
9. When the correct timing has been obtained remove gauge.

FUEL PUMP TIMING FIGURES

AA

	r/min	°BTDC
Fixed speed	Build 05 1500	27° (see Note)
	1500-2200	24°
	2205-3300	27°
	3305-3600	30°
Variable speed		33°

Note:
27° timing and 1mm injection pipe bore were incorporated from engine 38 00546 AA1

AC

	r/min	°BTDC
Fixed speed	1000	22°
	1500-3000	20°
	'Q' Build 3000	18°
	3600	24°
	Build 53 3600	33°
Variable speed	3000	20°
	3600	24°

AD1

	r/min	°BTDC
Fixed speed	1500-3000	20°
	3600	26°
Variable speed		22°

AD2

	r/min	°BTDC
Fixed speed	1500-3000	22°
	3300	[illegible]
Variable speed		22°
Idler control	3600	26° (see Note)

Note:
Two speed or idler control engines must be timed as a fixed speed engine at the higher rated speed.

SPEEDER SPRING IDENTIFICATION

AA

Build	Speeder Spring	Spring Colour
01, 12, 15	344967	Light orange one end
03	268189	Aluminium and blue bands
05	268194	Aluminium and yellow bands
06, 17	314554	Light orange and blue bands
09	314552	Yellow and brown bands

AC

Build	Speeder Spring	Spring Colour
01, 02, 04, 20, 21, 22, 50, 101	344967	Light orange one end
03, 55, 100	314553	Light orange and brown bands
05, 103, 104, 105	374700	Red on both ends
06, 07, 08, 23, 24, 25, 53, 66, 67, 68	314554	Light orange and blue bands
09, 10, 11, 26, 27	314552	Yellow and brown bands

AD1

Build	Speeder Spring	Spring Colour
01, 02, 04, 13, 52	363488	One orange and one yellow end
05	268199	No markings
06, 07, 08, [illegible] 68, 77, 82, 100, 101 When a two speed control is fitted	344967	Orange on one end

AD2

Build	Speeder Spring	Spring Colour
21, 22, 30	268189	Aluminium and blue bands
24, 25	314553	Light orange and brown bands
28, 29	314554	Light orange and blue bands
51	344933	Brilliant green one end

The Governor

Governor Performance - AA

r/min	Transient Speed r/min		Off Load	Idling		BS5514
	Load On (min)	Load Off (max)	r/min (max)	r/min	Speed	Class
1500	1230	1770	1650		Fixed	B_1
1800	1476	2124	1980		Fixed	B_1
2100	1722	2478	2130		Fixed	B_1
2500	2050	2950	2750		Fixed	B_1
3000	2550	3480	3240		Fixed	A_2
3600	3060	4140	3888		Fixed	A_2
3000	2460	3540	3300	1000-1200	Variable	B_1
3600	2852	4248	3960	1000-1200	Variable	B_2
1500	1180	2250	1980	1000-1200	Idler/2 Speed	
1800	1200	2400	2200	1000-1200	Idler/2 Speed	
2100	1602	2598	2432	1000-1200	Idler/2 Speed	
2500	2065	2935	2790	1000-1200	Idler/2 Speed	
3000	2460	3540	3300	1000-1200	Idler/2 Speed	B_1
3600	2952	4248	3960	1000-1200	Idler/2 Speed	B_1

Governing Ranges - AA

Build	Speed	Full Load Range r/min	Speed Set r/min
01	Variable	1500-3600	3600
05	Fixed	1500	1500
06	Fixed	3000	3000
09	Fixed	3600	3600
12	Variable	1500-3000	3000
15	Variable	1500-2500	2500

Note:
Build 05 is not fitted with a cylinder barrel air cowling and is suitable for traffic light sets etc.

Governor Performance - AC

r/min	Transient Speed r/min		Off Load	Idling		BS5514
	Load On (min)	Load Off (max)	r/min (max)	r/min	Speed	Class
1500	1230	1770	1650		Fixed	B_1
1800	1476	2124	1980		Fixed	B_1
2100	1722	2478	2130		Fixed	B_1
2500	2050	2950	2750		Fixed	B_1
3000	2550	3480	3240		Fixed	A_2
3600	3060	4140	3888		Fixed	A_2
3000	2460	3540	3300	1000-1200	Variable	B_1
3600	2852	4248	3960	1000-1200	Variable	B_2
1500	1180	2250	1980	1000-1200	Idler/2 Speed	
1800	1200	2400	2200	1000-1200	Idler/2 Speed	
2100	1602	2598	2432	1000-1200	Idler/2 Speed	
2500	2065	2935	2790	1000-1200	Idler/2 Speed	
3000	2460	3540	3300	1000-1200	Idler/2 Speed	B_1
3600	2952	4248	3960	1000-1200	Idler/2 Speed	B_1

Governing Ranges - AC

Build	Speed	Full Load Range r/min	Speed Set r/min
01, 02, 04, 20 21, 22	Variable	1500-3600	3600
03	Fixed	2100	2100
06, 07, 08, 23, 24, 25	Fixed	3000	3000
09, 10, 11, 26 27	Fixed	3600	3600

Note:
Builds 01-11 are Clockwise rotation
Builds 20-27 are Anti-clockwise Rotation

Governor Performance - AD1

r/min	Transient Speed r/min		Off Load r/min (max)	Idling r/min	Speed	BS5514 Class
	Load On (min)	Load Off (max)				
1500	1275	1725	1620		Fixed	A_2
1800	1530	2070	1944		Fixed	A_2
2100	1785	2415	2268		Fixed	A_2
2500	2125	2875	2700		Fixed	A_2
3000	2550	3480	3240		Fixed	A_2
3600	3060	4140	3888		Fixed	A_2
3000	2460	3540	3300	1000-1200	Variable	B_1
3600	2952	4248	3960	1000-1200	Variable	B_2
1500	1180	2250	1980	1000-1200	Idler Control	
1800	1200	2400	2200	1000-1200	Idler Control	
2100	1602	2598	2432	1000-1200	Idler Control	
2500	2065	2935	2790	1000-1200	Idler Control	
3000	2460	3540	3300	1000-1200	Idler Control	B_1
3600	2952	4248	3960	1000-1200	Idler Control	B_1

Governing Ranges - AD1

Build	Speed	Full Load Range r/min	Speed Set r/min
01, 02, 04, 13	Variable	1500-3600	3600
05	Fixed	1500	1500
06, 07, 08, 14	Fixed	3000	3000
09, 10, 11	Fixed	3600	3600

Governor Performance - AD2

r/min	Transient Speed r/min		Off Load	Idling		BS5514
	Load On (min)	Load Off (max)	r/min (max)	r/min	Speed	Class
1500	1275	1725	1620		Fixed	A_2
1800	1530	2070	1944		Fixed	A_2
2100	1785	2415	2268		Fixed	A_2
2500	2125	2875	2700		Fixed	A_2
3000	2550	3480	3240		Fixed	A_2
3600	3060	4140	3888		Fixed	A_2
3000	2460	3540	3300	1000-1200	Variable	B_1
3600	2952	4248	3960	1000-1200	Variable	B_2
1500	1180	2250	1980	1000-1200	Idler Control	
1800	1200	2400	2200	1000-1200	Idler Control	
2100	1602	2598	2432	1000-1200	Idler Control	
2500	2065	2935	2790	1000-1200	Idler Control	
3000	2460	3540	3300	1000-1200	Idler Control	B_1
3600	2952	4248	3960	1000-1200	Idler Control	B_1

Governing Ranges - AD2

Build	Speed	Full Load Range r/min	Speed Set r/min
21, 22, 30	Variable	1500-3600	3600
24, 25	Fixed	3000	3000
28, 29	Fixed	3600	3600

OPERATION OF THE GOVERNOR

The governor maintains a constant predetermined engine speed, irrespective of load conditions, and prevents the maximum permitted speed being exceeded.

The governor system consists of steel balls housed in a cage which, with the application of centrifugal force operates a sliding cone. The movement of the cone is transmitted via a bracket, shaft and lever to the fuel pump where it controls the amount of fuel delivered to the fuel injector.

As the governor rotates, centrifugal force causes the steel balls to be thrown outwards moving the cone along the governor spindle, this in turn moves the governor bracket which is connected by a down shaft to the fuel pump rack operating lever. The centrifugal forces acting on the governor bracket are balanced by an adjustable speeder spring which is located behind the governor bracket. The engine speed can be set, within a narrow range, by adjusting the pressure of the speeder spring. Adjustment outside this range can be achieved by fitting an alternative speeder spring.

Initially the spring brings the fuel pump rack into the starting position and as the engine starts and runs up to speed a balanced position between the centrifugal force of the governor assembly and the spring tension is achieved; the fuel supplied holds the engine at a steady speed. An increase in load reduces the speed and consequently the centrifugal force decreases allowing the fuel pump rack to open further to increase the fuel delivery. The engine speed recovers and a balance of forces is again achieved. Conversely if the load is removed the action is reversed and the fuel delivery is reduced.

Removing the Governor

1. Lift out the dipstick.
2. Drain the oil from the sump.
3. Drain and remove the fuel tank, if fitted.
4. Remove the gear end cover.
5. If necessary remove the governor pinion gear retaining nut and pull off the pinion.
6. Remove the three capscrews retaining the governor.

7. Turn the crankshaft sufficiently to ensure one of the 'flats' on the assembly will clear the camshaft pinion gear teeth as shown in Figure 66 on page 58.

8. Lift out the governor assembly.

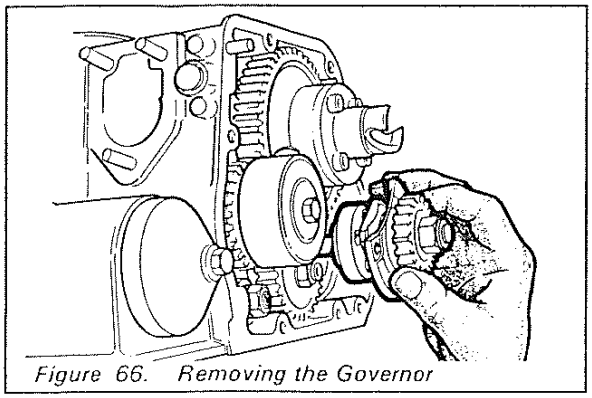

Figure 66. Removing the Governor

Servicing the Governor Assembly

1. Clean the assembly in kerosene.

2. Check the governor balls and sliding cone for wear or damage.

3. Hold the assembly horizontal, by the housing, in one hand and spin the pinion gear with the other hand.
   As the pinion revolves the governor cone assembly should be forced towards the circlip.
   If there are tight-spots or damage the complete assembly should be replaced.

Refitting the Governor

1. Fit the governor assembly in position and tighten the three capscrews.

2. Replace the key in the governor shaft.

3. Align the key and keyway and fit the gearwheel and nut.

THE GOVERNOR LINKAGE

Removing the Linkage

1. Remove the governor assembly: it is not necessary to remove the governor gearwheel unless it is required to carry out maintenance on the governor assembly.

2. Remove the camshaft.

3. Unscrew the governor speeder spring adjuster (A) and remove the speeder spring (B).

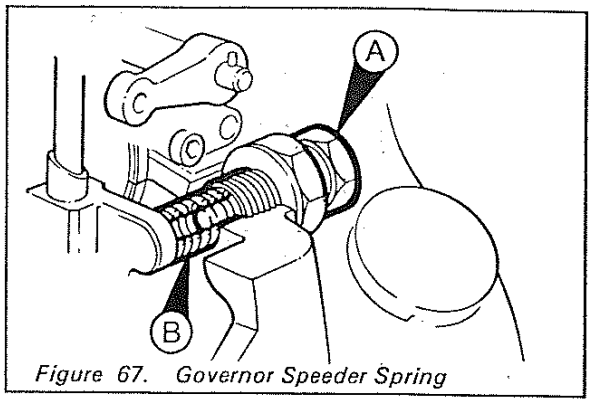

Figure 67. Governor Speeder Spring

4. Remove the two capscrews retaining the engine control lever assembly and remove the assembly.

5. Slacken the governor bracket capscrew (C) and remove the bracket (D).

6. Remove the breather assembly (E) from the top of the crankcase.

7. Remove the fuel pump operating lever (F) by lifting the shaft (G) and placing a suitable hard wood block at the base as shown.

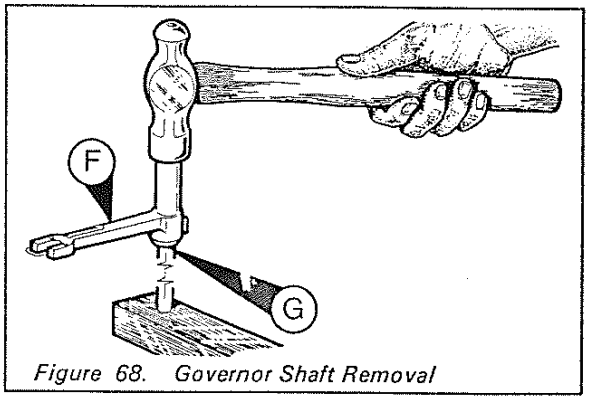

Figure 68. Governor Shaft Removal

Use a suitable tubular drift over the top of the operating lever (F) and shaft (G) to drive the operating lever downwards allowing the shaft to pass up through the lever.
It will be necessary to increase the thickness of the hard wood block in stages until the shaft is clear of the lever.

8. Clean all the components in kerosene and check for damage and wear.

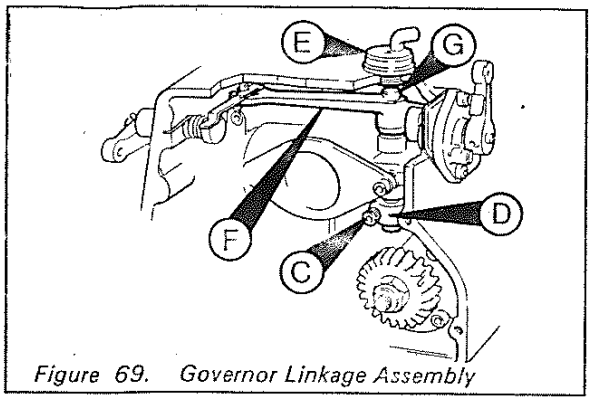

Figure 69. Governor Linkage Assembly

Fitting the Governor Linkage

1. Position the fuel pump operating lever (F) in the crankcase and gently tap the operating shaft (G) into the lever as far as it will go.
2. Fit the governor bracket (D).
3. Fit the governor bracket spacer (H) between the legs of the bracket.
4. Fit and tighten the securing screw (C) sufficiently to ensure that the bracket is retained; ensure the spacer (H) is correctly located with the square section against the shaft.

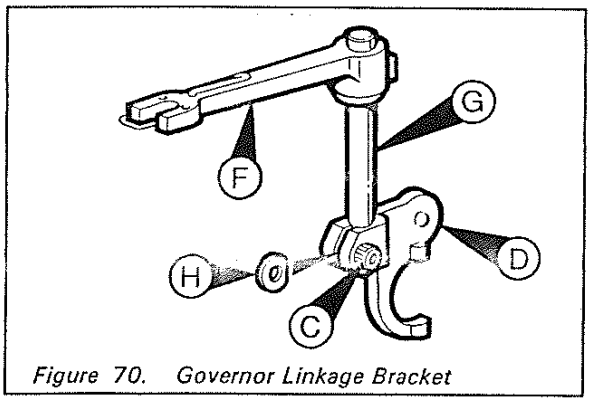

Figure 70. Governor Linkage Bracket

5. Fit the governor assembly and fully tighten the three securing capscrews.
6. Replace the spreader spring (B) and adjuster

Setting the Governor Linkage

The governor linkage can only be set with the fuel pump in position.
If a variable or two speed control is fitted it must be set in the maximum speed position.
The governor bracket should be hard against the governor, with its sliding cone and rotating housing together.

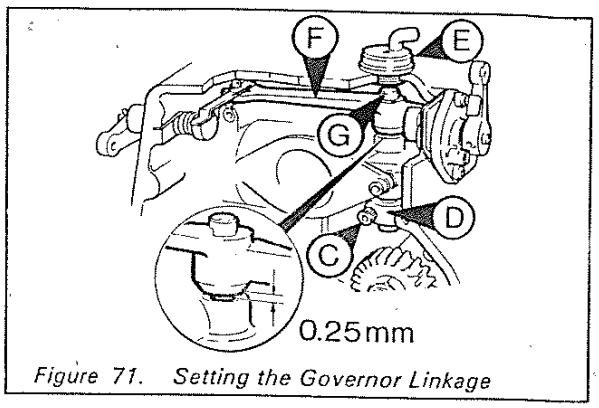

Figure 71. Setting the Governor Linkage

1. Slacken the governor bracket capscrew (C).
2. Operate the overload stop, if fitted.
3. Push the fuel pump operating lever (F) in as far as possible
4. Move the governor bracket up or down the shaft as necessary to ensure the distance between the pump operating lever and the top of the governor shaft bush is 0.25mm (0.010in).
5. Tighten the governor bracket capscrew.
6. Fit the engine control lever assembly and tighten the retaining capscrews.
7. Replace the breather assembly (E).
8. Replace the camshaft.
9. Replace the gear end cover.
10. Fill the sump with the correct grade and type of lubricating oil.
11. Fit the fuel tank and connect the fuel pipes.

THE OVERLOAD STOP

Warning:
The overload stop is set when the engine is manufactured and it should not be disturbed.

oving the Ove

1. Remove the pin (C) securing the overload lever (D) and remove the lever.
2. Withdraw the spindle and spring from inside the crankcase.
3. Replace the affected items.
4. Reset the overload stop.

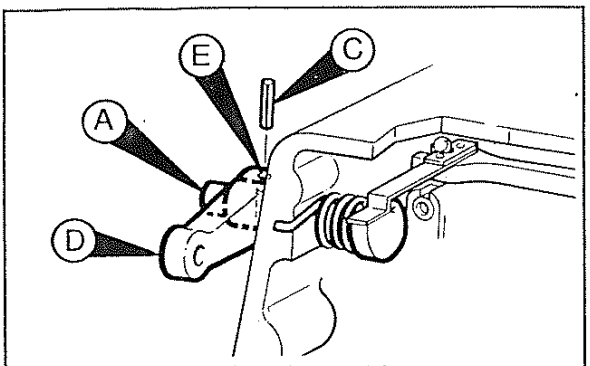

Figure 72. Overload Stop - AA

Setting the Overload Stop - AA

To initially set the overload stop turn the spindle (A) to align the pin (C) with the hole (E) in the lever (D) as shown in Figure 72.

Removing the Overload Stop - AC, AD

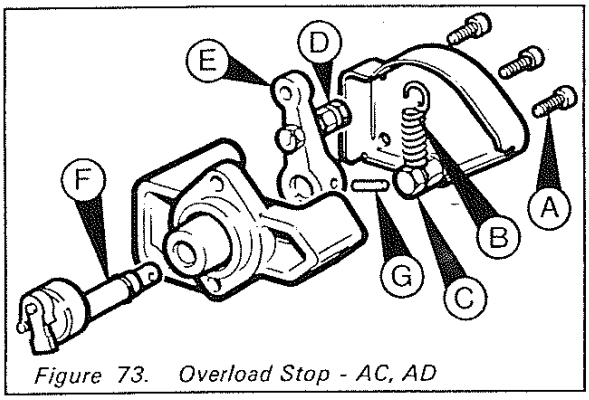

Figure 73. Overload Stop - AC, AD

1. Remove the three cover (A) retaining bolts.
2. Move the cover sufficiently to gain access to the spring (B).
3. Unhook the spring (B) from the grooved nut (C), on the inside of the cover, or from the grooved nut (D) on the lever (E).
4. Remove the cover.
5. Remove the lever (E) from the shaft (F) after removing the pin (G).

CHECKING THE OVERLOAD STOP SETTING

When the overload stop is set correctly the exhaust should be a barely visible haze.

To check the overload stop setting the engine has to be accelerated from idle to full speed as quickly as possible, with no load, and the level of exhaust smoke checked.

Fixed Speed Engines

1. Move the engine control lever towards the "STOP" position to decrease the engine speed.
2. Obtain an idle speed and allow it to stabilise for a few seconds.
3. Move the lever sharply to the "RUN" position to accelerate the engine.
4. Slowly turn the overload stop spindle anti-clockwise in small amounts until black smoke is emitted from the exhaust when the engine is accelerated; it may be necessary to repeat the procedure several times until this is achieved.
5. When black smoke is emitted from the exhaust slowly turn the spindle clockwise by small amounts and accelerate the engine and check the smoke.
6. Repeat the procedure, turning the spindle by a small amount at a time, until the black smoke just clears and a barely visible haze is emitted.

Variable Speed Engines

1. Run the engine on load until it reaches its normal working temperature.
2. Remove the load from the engine.
3. Adjust the speed control to give full rated speed.
4. Obtain an idle speed and allow it to stabilise for a few seconds.
5. Accelerate the engine to full speed using the speed control.
6. Turn the overload stop spindle anti-clockwise in small amounts until black smoke is emitted from the exhaust when the engine is accelerated; it may be necessary to repeat this several times until this is achieved.
7. When black smoke is emitted from the exhaust turn the spindle clockwise by a small amount at a time until the black smoke just clears and a barely visible haze is emitted.

THE SPEED CONTROL

The centrifugal forces on the governor balls are transmitted to the fuel pump rack. These forces, which vary with the speed of the engine are balanced by an adjustable speeder spring to allow a set range of speed. However, if the setting is disturbed or a different speed is required within

the set range, adjustments can be carried out as detailed in the following paragraphs.
Using the Service Tool 393212 will facilitate adjustment.

ADJUSTING THE ENGINE SPEED

Fixed Speed

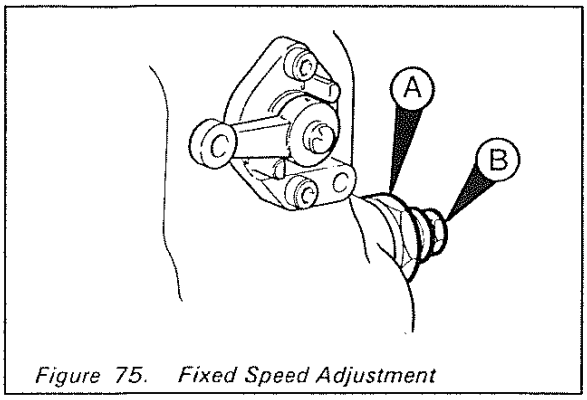

Figure 75. Fixed Speed Adjustment

1. Slacken the locknut (A).
2. Screw in the adjuster (B) to increase the speed or out to decrease it.
3. Tighten the locknut.

Two Speed Control

1. Move the nuts (A) to the end of the control rod (B).
2. Move the control block (C) to the idling position; upwards from the position shown in Figure 76.

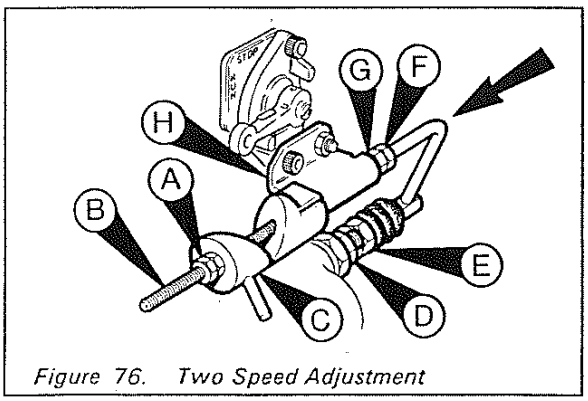

Figure 76. Two Speed Adjustment

3. Slacken the locknut (D) and adjust the idling speed to approximately 1200r/min by screwing in the adjuster (E) to increase speed, or out to decrease it.
4. Tighten the locknut (D).
5. Slacken the locknut (F).
6. Move the control rod (B) in the direction of the arrow so that the nut (G) is hard against the bracket (H).
7. Maintain the nut (G) hard against the bracket and adjust the full speed by turning the nut anti-clockwise to increase speed or clockwise to decrease it.
   The speed should be set at 8% above the rated speed.
8. Tighten the locknut (F).
9. Move the control block (C) to the full speed position; the position shown in Figure 76.
10. Turn the nuts (A) clockwise until nut (G) is lightly touching the bracket (H) and lock the nuts (A).

Variable Speed Control

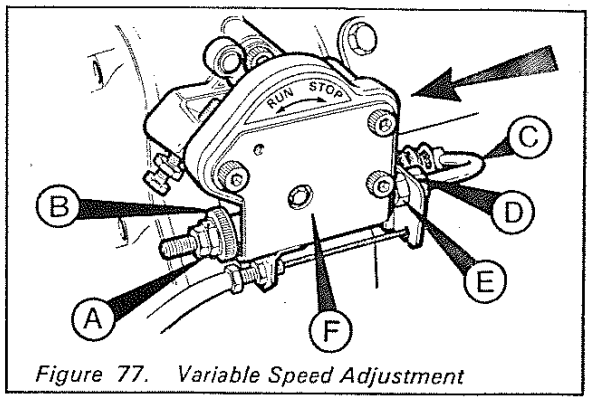

Figure 77. Variable Speed Adjustment

1. If the speed control is cable operated disconnect the cable from the bracket.
2. Move the lock nuts (A) to the end of the control rod (C).
3. Adjust the idling speed to 1200r/min by screwing in the adjuster (B) to increase the speed or out to decrease it.
4. Lock the adjusting nut (B) with the locknuts (A); see "Note".
5. Slacken the lock nut (D).
6. Move the control rod (C) in the direction of the arrow so that the nut (E) is hard against the bracket (F).
7. Maintain the nut (E) hard against the bracket and adjust the full speed by turning the nut (E) anti-clockwise to increase the speed or clockwise to decrease it.
   The speed should be set at 8% above the rated speed.

8. Position the nut (E) against the bracket (F) and tighten the locknut (D).

9. Fit and adjust the control cable so that it is capable of moving the control rod from the minimum speed to the full speed position.

Note:
If the minimum speed required is above the idling speed turn the adjusting nut (B) towards the bracket (F) until the required speed is obtained and lock the adjusting nut in position.

Section 5 - The Electrical System

A 12 volt negative earth starter motor and flywheel mounted charging system is available for AC and AD engines.

ELECTRICAL EQUIPMENT IDENTIFICATION

	Voltage	Part Number	Rating	Pull-in Amps	Hold-on Amps
Starter Motor[1]					
AC[2] AD1	12	407056	0.9kW	40.0 max	11.0 max
AC[3]	12	407046	0.9kW	40.0 max	11.0 max
AD2	12	275156	0.9kW	40.0 max	11.0 max
Stator	2	299887	15Amps		
Rectifier/Regulator	12	360567	15Amps		
Fuel Control Solenoid	12	362666	9lbs at 25mm		
	24	362367	9lbs at 25mm		
Oil Pressure Switch[4]	12/24	329-15110	5Amps		
Heater Plug[5]	12	327523	375watts		
	12	363102	600watts		

Notes:

1 The Amp ratings refer to trhe starter solenoid.
2 Clockwise Builds - see Section 6.
3 Anti-clockwise Builds - see Section 6.
4 Insulated return with single pole double throw contacts. Operates at 0.138-0.344 bar (2.0-5.0 lb/in²) on falling pressure.
5 AD2 has two heater plugs rated at 600watts each.

BATTERIES

	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 0°F
AC1	12	70A	85A	115A	190A
AD1	12	75A	90A	125A	200A
AD2	12	80A	105A	152A	255A

Notes:

The cold cranking battery performance rating figures given relate to the cranking current required from a 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:-

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

LEAD ACID BATTERIES

By means of the electric starter motor the batteries stored energy is converted to the cranking effort necessary to start the engine. The output voltage of batteries will decrease slowly as they are discharged. The number of ampere-hours of current that a battery will deliver is dependant on its temperature (lower temperatures slow the chemical reactions and decrease the amount of available energy) and upon the rate at which it is discharged. A battery will deliver considerably more total energy if it is discharged at low current over a long period of time rather than rapidly at high currents.

Battery Specific Gravity

The specific gravity of a battery should be tested using a hydrometer to determine the state of charge; the figures given are at 15°C (59°F).

1100-1120 Discharged.
1190-1210 Half charged.
1270-1290 Fully charged.

BATTERY SAFETY PRECAUTIONS

- Do not smoke near the batteries.
- Keep sparks and flames away from the batteries.
- Batteries contain sulphuric acid - if the acid has been splashed on the skin, eyes or clothes flush it away with copious amounts of fresh water and seek medical aid.
- Keep the top of the battery well ventilated during 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 experiment with adjustments or repairs to the system.
- Never use a damaged or unserviceable battery.
- Keep children and animals well away.
- Before running an engine with the charging system disconnected from the battery, the stator leads from the rectifier/regulator unit must be removed and the ends taped individually.
- Disconnect the battery or alternator before commencing any electric welding when a pole strap is directly or indirectly connected to the engine.

OPERATION OF BATTERIES IN LOW TEMPERATURES

There is little danger of the acid freezing in a battery which is operating under normal conditions. Even in an appreciably discharged state of 1.130 at 15°C, the acid electrolyte would not freeze until about -13°C, whilst in the fully charged state of 1.280 at 25°C, the temperature would have to fall as low as -68°C before freezing occurred.

However, some extra care should be taken during a cold spell. Water near to freezing point should not be used for topping up and it is advisable to top up immediately before the battery is to be charged to ensure that the acid and water are thoroughly mixed. The energy demanded on the battery is heavier during cold weather than at normal temperatures. At the same time, an inherent characteristic of storage is that their electrical output is reduced at low temperatures. A battery which will function satisfactorily in Summer may fail to start the engine in Winter. These considerations make it all the more important to see that the battery is fully charged and properly maintained during cold weather.

OPERATION OF BATTERIES IN HIGH TEMPERATURES

When a battery is operating frequently in situations or climates where air temperatures frequently exceed 32°C, (90°F), it is advisable to work the battery with a lower specific gravity acid than that ordinarily employed. This helps to offset the adverse effects of high temperature on battery life. "Low gravity" acid having a specific gravity 50 points lower than normal is used (1220 to 1240 at the end of charge as compared with 1270 to 1290 for normal gravity acid).

The desirable maximum temperature at any time is 52°C (125°F). If this temperature is frequently exceeded the life of the battery will tend to be shortened.

LOW TEMPERATURE APPLICATIONS

For temperatures below -18°C (0°F) high discharge, low resistance Arctic or Alkaline batteries must be used. These batteries are outside the scope of this section and advice on correct selection should be sought direct from the battery manufacturer.

As the ambient temperature decreases, additional cold start equipment becomes necessary to ensure satisfactory starting.

Heavy Duty or Type 'B' Batteries to BS3911:1982 are recommended for all applications.

BATTERY CHARGING

Battery charging is by means of flywheel mounted charge windings, see "Flywheel Charge Windings" on page 65, or a remote mounted charger.

Too little charging can be indicated by the specific gravity being frequently below 1230.

Too much charging is indicated by the specific gravity of the acid being generally at the fully charged value of 1270 to 1290 and by unusually frequent topping-up being necessary.

Bench Charge

This term applies to any charge given at the recommended current which takes place with the battery removed from the engine. Bench charges may be necessary due to some fault in the electrical system allowing the battery to become discharged. Direct current only can be used for charging a battery and a bench charge should be carried out as follows:-

1. Check that the level of the electrolyte in each cell is covering the separators or separator guard. Top up with pure water if the levels are low.
2. Ensure that the vent chamber vent plugs are in place and the venting holes are free to permit the escape of gasses.
3. Connect the positive lead of the charging source to the positive terminal of the battery (marked with a "+" or "P") and the negative lead to the negative terminal of the battery.
4. Commence charging and adjust the current to the recommended value.
5. Continue the charge until all cells are gassing freely and the specific gravities of each cell have reached a maximum as shown by three consecutive hourly readings remaining constant. At this point the specific gravity should be within plus or minus 10 points of the recommended fully charged gravity when corrected for temperature. If they are not, expert advice should be obtained.
6. Check the acid level. If it is necessary to add water to the battery the charge should be continued for a short period to thoroughly mix the water with the acid in the cells.
7. Switch off and disconnect the charger from the battery.
8. Clean and dry the battery top.

Fast Charging

Fast Chargers are capable of charging a battery in a relatively short time but they are not usually intended for complete recharging of the battery and should be used with discretion by an experienced person with approved equipment. Fast charging should only be considered as an emergency measure to charge the battery to a state such that it will operate the electrical equipment of the set. The charging arrangements on the set can then complete the charge in the normal way.

CONNECTING BATTERIES

It is most important to ensure that the starter battery or batteries are correctly connected and all connections are tight with the earth lead being connected last.

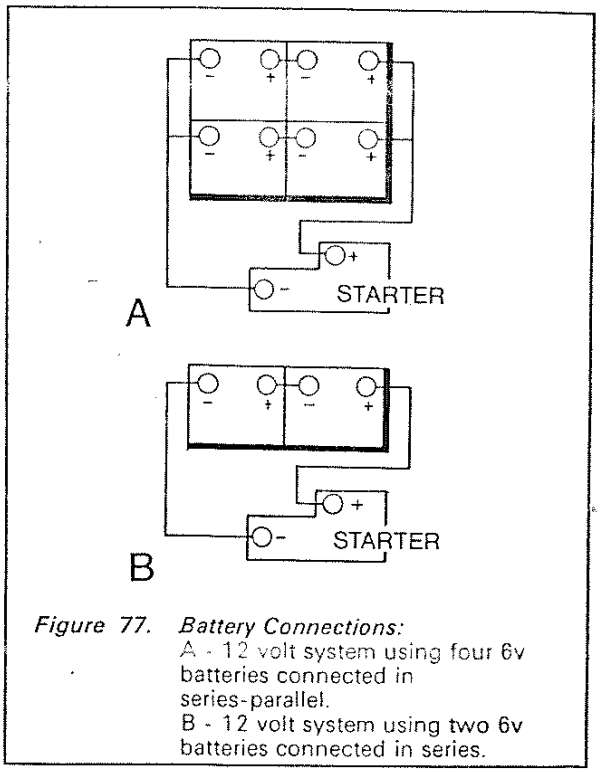

Figure 77. Battery Connections:
A - 12 volt system using four 6v batteries connected in series-parallel.
B - 12 volt system using two 6v batteries connected in series.

FLYWHEEL CHARGE WINDINGS

The system can only be fitted to AC and AD engines and comprises three components; stator, rotor and regulator/rectifier.

The rotor, in the form of permanent magnets, is pressed into 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 leads pass through the flywheel housing to the rectifier/regulator unit

which is attached to the outside of the housing. Should any of the output cables be attached to the wrong terminal the rectifier/regulator unit will be permanently damaged when the battery is connected into the circuit.

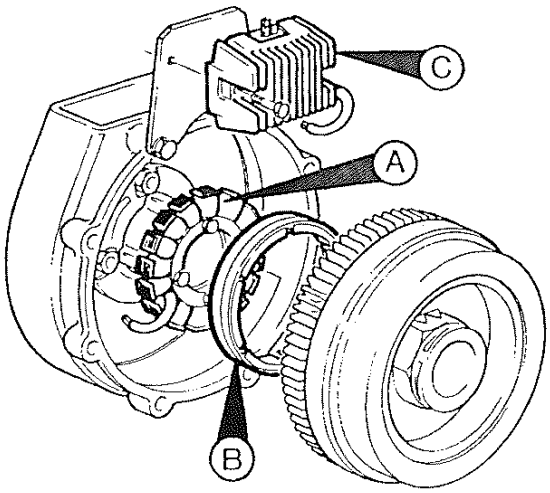

Figure 78. Charge Winding Components:
A - Stator
B - Rotor
C - Rectifier/Regulator

Maximum Charging Output at 12.6 Volts

r/min	Amps
1200	1.4
1500	2.8
1800	5.0
2000	6.2
2500	8.6
3000	10.9
3600	12.9

Servicing

The charging circuit uses solid state components which should give trouble free service. No periodic servicing is required on any part of the system other than keeping the rectifier/regulator clean as failure to do this may cause overheating of the unit.

In the event of any running troubles, clean the wiring connections and check for broken or frayed wires.

Check that the earth between the rectifier/regulator and the engine is satisfactory. If the fault persists and test equipment is not available the easiest repair technique is to replace individual items, starting with the rectifier/regulator unit, until the fault has been remedied.

If a problem develops in the battery charging indicator, it can be by-passed without affecting the performance of the system.

Fault Finding

The most common faults associated with this type of battery charging system are:

a. Not charging - evident by a low or flat battery.

b. Overcharging - evident by high electrolyte gassing levels in the battery cells.

Before proceeding with fault finding it is recommended that a 0-20A moving coil ammeter is connected in the battery positive line. This will give an indication as to what is actually happening in the output circuit when the engine is running.

No Charge

1. Check all the wiring connections between the rectifier/regulator and the battery for continuity.
2. With the engine at rest, check that the full battery voltage is available at the rectifier/regulator terminals.
3. If the battery voltage is correct run the engine at full rated speed and check B+ to Earth. If the voltage is above 14v add a load to reduce it to below 13.8v.
4. Remove the load and if the voltage increases the system is satisfactory.
5. If the voltage does not increase, remove the rectifier/regulator plug and test for AC voltage.
   a. If the AC voltage is zero or well below 1v per 100r/min replace the stator.
   b. If the AC voltage is approximately 1v per 100r/min replace the rectifier/regulator.

Overcharging

With the engine running at full speed and with a fully charged battery (14v) connected, the alternator output current should reduce to a value between 1 and 2 amps.

1. Check all the wiring connections between the rectifier/regulator and the battery for continuity.
2. With the engine at rest, check that the full battery voltage is available at the rectifier/regulator terminals.
3. If the battery voltage is correct run the engine at full rated speed and check B+ to Earth.
   a. If the voltage is above 14.4v replace the rectifier/regulator.
   b. If the voltage is under 14.4v the system is probably satisfactory.

NICSA CHARGE WINDINGS

The Nicsa charge winding components are not interchangeable with the earlier type.

Fault Finding

The following instruments are necessary to carry out 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.

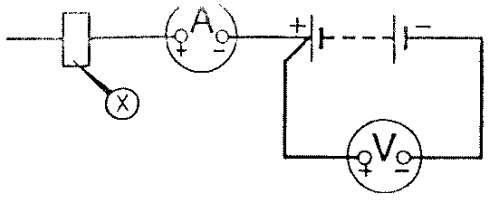

Figure 78A. Test Instrument Connection Diagram:
X - Removed B+ Battery Terminal

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

Leads	Resistance
Yellow to Yellow leads	0.45 - 0.47
Red to one Yellow lead	0.239 - 0.249
Red to other Yellow lead	0.239 - 0.249

Stator Winding AC Open Circuit Voltage

r/min	Yellow to Yellow	Red to Yellow
1000	16 - 22	8 - 11
1500	24 - 32	12 - 16
2000	34 - 42	17 - 21
2500	42 - 52	21 - 26
3000	50 - 60	25 - 30

Output Charge Rate - voltage held at 12.5V

r/min	Amps
1000	0.75 - 2.25
1500	4.25 - 5.75
2000	7.75 - 9.25
2500	10.50 - 12.00
3000	12.25 - 13.75

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 temporally remove, or reduce, any load on the engine to lessen the 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.

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.

A clutch prevents the armature from excessive rotation if the pinion remains in mesh after the engine has started.

SCHEMATIC WIRING DIAGRAM

All cables must be 21/0.30, except the battery to starter which are 37/0.90, P.V.C insulated automobile cable to BS6862.

The cable sizes given relate to the cables between the key switch and the engine being a maximum length of 1.0metre, and the cables between the battery and engine being a maximum length of 0.94metre.

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

The heater plugs (C) are optional accessories and only one heater is fitted to AC and AD1 engines.

The plug (D) and socket (E) are only fitted when a wiring loom is supplied.

Key to Wiring Diagram

A. Flywheel Alternator Stator.
B. Control Keyswitch
C. Heater Plugs
D. Plug
E. Socket
F. Regulator
G. Starter Motor.
H. Starter Battery.

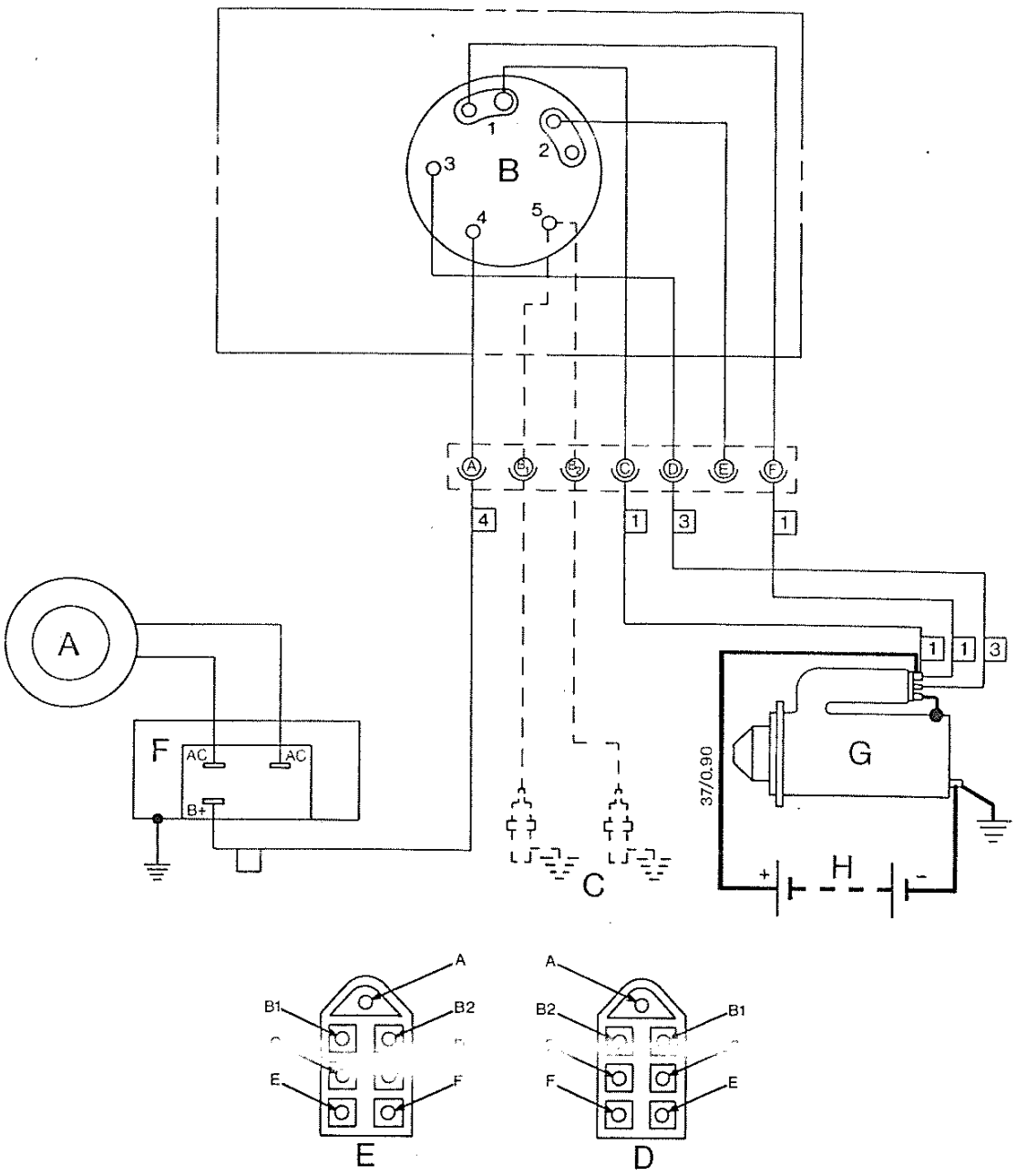

Figure 79. Schematic Wiring Diagram - 273098

Section 6 - Engine Builds and Accessories

AA1

Build	Speed	Speed Set r/min	Governor Range r/min	Special Features
01	Variable	3600	1500-3600	
05	Constant	1500	1500	Suitable for traffic light sets
06	Constant	3000	3000	
09	Constant	3600	3600	
12	Variable	3000	1500-3000	
15	Variable	2500	1500-2500	

Note:
All Builds have clockwise rotation.

AC1

Build	Speed	Charge Windings	Speed Set r/min	Governor Range r/min	Rotation	Ring Gear
01	Variable	No	3600	1500-3600	Clockwise	No
02	Variable	No	3600	1500-3600	Clockwise	Yes
03	Constant	No	2100	2100	Clockwise	Yes
04	Variable	Yes	3600	1500-3600	Clockwise	Yes
06	Constant	No	3000	3000	Clockwise	No
07	Constant	No	3000	3000	Clockwise	Yes
08	Constant	Yes	3000	3000	Clockwise	Yes
09	Constant	No	3600	3600	Clockwise	No
10	Constant	No	3600	3600	Clockwise	Yes
11	Constant	Yes	3600	3600	Anti-clock	Yes
20	Variable	No	3600	1500-3600	Anti-clock	No
21	Variable	No	3600	1500-3600	Anti-clock	Yes
22	Variable	Yes	3600	1500-3600	Anti-clock	Yes
23	Constant	No	3000	3000	Anti-clock	No
24	Constant	No	3000	3000	Anti-clock	Yes
25	Constant	Yes	3000	3000	Anti-clock	Yes
26	Constant	No	3600	3600	Anti-clock	Yes
27	Constant	Yes	3600	3600	Anti-clock	Yes
66	Constant	No	3000	3000	Clockise	No
67	Constant	No	3000	3000	Clockwise	Yes
68	Constant	Yes	3000	3000	Clockwise	Yes

Note:
Builds 66, 67 and 68 are Low Noise (Q) Builds

AD1

Build	Speed	Charge Windings	Speed Set r/min	Governor Range r/min	Ring Gear	Special Features
01	Variable	No	3600	1500-3600	No	Gear end start only
02	Variable	No	3600	1500-3600	Yes	Flywheel start only
04	Variable	Yes	3600	1500-3600	Yes	
05	Constant	No	1500	1500	No	Gear end start only
06	Constant	No	3000	3000	No	Gear end start only
07	Constant	NO	3000	3000	Yes	Gear end start only
08	Constant	Yes	3000	3000	Yes	
09	Constant	No	3600	3600	Yes	Gear end start only
10	Constant	No	3600	3600	Yes	Flywheel start only
11	Constant	Yes	3600	3600	Yes	
13	Variable	Yes	3600	1500-3600	Yes	Flywheel start only
66	Constant	No	3000	3000	No	Gear end start only
67	Constant	No	3000	3000	Yes	Gear end start only
68	Constant	Yes	3000	3000	Yes	Gear end start only

Note:
All Builds have clockwise rotation.
Builds 66, 67 and 68 are Low Noise (Q) Builds

AD2

Build	Speed	Charge Windings	Speed Set r/min	Governor Range r/min	Ring Gear	Special Features
21	Variable	No	3600	1500-3600	Yes	
22	Variable	Yes	3600	1500-3600	Yes	Gear end drive facilities
24	Constant	No	3000	3000	Yes	Low noise build
25	Constant	Yes	3000	3000	Yes	Low noise build
28	Constant	No	3600	3600	Yes	
29	Constant	Yes	3600	3600	Yes	
30	Variable	No	3600	1500-3600	Yes	

Note:
All Builds have anti-clockwise rotation.

Accessories

This section contains general information on some of the accessories which may be fitted to AA, AC and AD engines, some of those shown may not be compatible for all engines. A comprehensive list of all the accessories that are currently available can be obtained from either the appropriate engine Parts List or any Lister-Petter Distributor. Each accessory is despatched with a drawing and fitting instructions where applicable.

AIR CLEANERS (A)
Engine mounted:-
- Medium duty dry.
- Heavy duty oil bath.

DRIVES (B)
Half speed drive.
Full speed drive.
Parallel shafts.
Generator shafts.
Pump shafts.
Reduction gearbox - 6:1, 4:1, 2:1.

STARTING EQUIPMENT (E)
Starting handle - 3.5:1, 4:1, 2:1, 3:1 (AD2 only)
Rope start
Heater plug Keyswitch

FUEL SUPPLY EQUIPMENT (F)
Engine mounted - 3.8, 5.1, 9.1litre

GUARDS (G)

PROTECTION EQUIPMENT
Low oil pressure switch
Fuel control solenoid

CONTROLS (K)
Variable speed control - cable/lever operated.
Remote stop control - cable operated.

EXHAUST EQUIPMENT (N)
"Pepperpot".
Acoustic.

RECOMMENDED SPARES

SUNDRIES (S)
Technical Publications:-
- Parts List.
- Workshop Manual.
- Operators Handbook.

Tool Kit.

Technical Library

http://engine.od.ua