
Perkins 4000 Series 4016-E61TRS

16 cylinder, turbocharged,
gas engines

WORKSHOP MANUAL

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General information

Introduction

The 4016-E61TRS Series engine is a 16 cylinder turbocharged gas engine designed by Perkins Engines Company Limited, a world leader in the design and manufacture of high-performance gas engines.

Perkins approved assembly and quality standards, together with the latest technology, have been applied to the manufacture of the engine to give reliable and economic power.

The general information included in the User's Handbook Publication TSL4230 (Sections 1 to 9) has not been repeated in this Workshop Manual, the two publications should be used together as specific references to the User's Handbook are made for certain operations.

For information and maintenance procedures on the engines electronic management system refer to the EMS Diagnostic Manual Publication TSL4233.

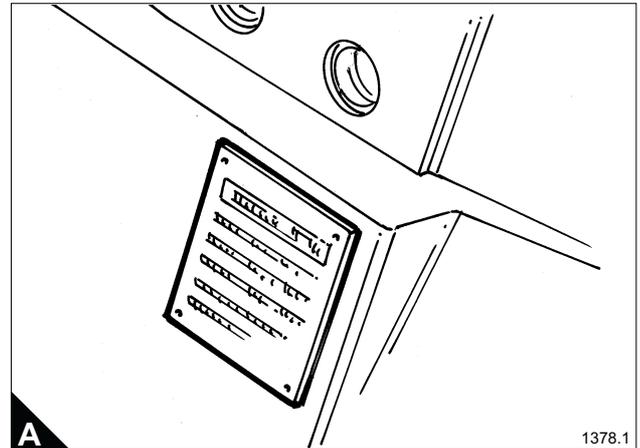
The manuals enable the operator to carry out routine servicing of the engine. Before undertaking any service work the appropriate section should be read in full and completely understood.

Users are respectfully advised that, in the interests of safety, it is their responsibility to employ competent persons to operate, maintain and service the engine.

Special tools are required to perform certain overhaul operations and a list is given on page 113, Section 23.

Reference to the relevant special tools is also made at the beginning of each operation. Operators who are not equipped to undertake major repairs are urged to consult their Perkins distributor.

Torque settings on page 29 and Wear and renewal limits on page 30, Section 11 for specific components are also provided. Reference should be made to these where indicated in the manual.



In addition to the general safety precautions, danger to both operator and engine are highlighted in the engine manuals with the caption.

Warning! This indicates that there is a possible danger to the person (or the person and engine).

Caution: This indicates that there is a possible danger to the engine.

Note: Is used where the information is important, but there is not a danger.

The information contained in this manual is based on that available at time of going to print. In line with Perkins Engines Company Limited policy of continual development and improvement that information may change at any time without notice. The engine user should ensure that he has the latest information before starting work.

The engine type and serial number must be given when requesting information from Perkins Engines Company Limited or a Perkins Distributor.

Note: The plate carrying the engine type and serial number is fixed to the crankcase above the flywheel housing on cylinder no. 8 'A' Bank (A).

Engine description

4016-E61TRS Engine specification

16 Cylinder, 60° 'V' form, 4-stroke gas engine, water cooled, displacing 61.1 litres.

Dry exhaust manifolds with single turbocharger, and a water-cooled two-stage charge air cooler with separate water cooling circuits.

Electronic management system of ignition timing and knock-detection, closed-loop control of lean burn combustion with NO_x emissions maintained to 250mg/Nm³, 500mg/Nm³ or other setting as desired.

Safety precautions

General

For safe and reliable operation of the engine it is essential that these safety precautions, and those Warnings and Cautions given throughout the handbook, are observed, and where necessary the special tools indicated are used.

All safety precautions should be read and understood before operating or servicing the engine.

Improper operation or maintenance procedures are dangerous and could result in accidents, injury or death.

The operator should check before beginning an operation that all the basic safety precautions have been carried out to avoid accidents occurring.

You must also refer to the local regulations in the country of use. Some items only apply to specific applications.

Ensure that guards are fitted

- over exposed rotating parts.
- over exposed hot surfaces.
- over exposed air intakes.
- over exposed belts.
- over live electrical terminals (high and low tension).

Ensure that appropriate protection equipment is worn at all times

- always wear protective gloves when:
 - using inhibitors.
 - using anti-freeze.
 - removing the pressure cap from the cooling system.
 - when changing the lubricating oil/filter.
 - when changing the electrolyte in the battery.
- always wear ear protection when working in an enclosed engine room.
- always wear goggles when using an air pressure line.
- always wear protective boots when working on the engine.
- always wear protective headgear when working on or underneath the engine.

Ensure that no smoking or naked flames are lit

- when checking battery electrolyte.
- when working in the engine room.
- when operating or servicing the engine.

Oil pipes

- ensure that all pipes are regularly checked for leaks.
- always apply suitable barrier cream to hands before any work is carried out.

Gas/air pipes

- always check for gas/air mixture leaks.

Electrical equipment

- always check that electrical equipment is earthed to local safety standards.
- always disconnect the electrical supply to the jacket water heater (if fitted) before working on the engine.
- take care to avoid any risk of electric shock.
- never re-adjust the settings of electronic equipment without reference to the appropriate Manual.

Freezing or heating components

always use protective gloves and use the correct handling equipment.

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Exhaust system

- check the system for leaks.
- ensure that the engine room is correctly ventilated.
- check that all the guards are fitted.
- check that the pipework allows the exhaust gas to escape upwards.
- check that the pipework is supported.

Stopping the engine

- Ensure that the engine is stopped before performing any of the following operations:
 - changing the lubricating oil.
 - filling or topping up cooling system.
 - beginning any repair work on the engine.
 - adjusting belts (where fitted).
 - adjusting bridge pieces / valve clearance.
 - changing spark plugs.
 - changing air, or oil filters.
 - tightening any fixing bolts.

Flammable fluids

- ensure that these are never stored near the engine.
- ensure that they are never used near a naked light.

Clothing

- do not wear loose clothing, ties, jewellery, etc.
- always wear steel toe cap shoes/boots.
- always wear appropriate head, eye and ear protection.
- always wear suitable overalls.
- always replace a spillage contaminated overall immediately.

Lifting heavy components

- always use the correct lifting equipment.
- never work alone.
- always wear a helmet, if the weight is above head height.

De-scaling solution

- always wear both hand and eye protection when handling.
- always wear overalls and appropriate footwear.

Waste disposal

- do not leave oil covered cloths on or near the engine.
- do not leave loose items on or near the engine.
- always provide a fireproof container for oil contaminated cloths.

Note: Most accidents are caused by failure to observe basic safety precautions and can be avoided by recognising potentially dangerous situations before an accident occurs. Whilst there are many potential hazards that can occur during the operation of the engine which cannot be always be anticipated, and thus a warning cannot be included to cover every possible circumstance that might involve a potential hazard, by following these basic principles the risk can be minimised.

Dangers from used engine oils

Prolonged and repeated contact with mineral oil will result in the removal of natural oils from the skin, leading to dryness, irritation and dermatitis. The oil also contains potentially harmful contaminants which may result in skin cancer.

Adequate means of skin protection and washing facilities should be readily available.

The following is a list of 'Health Protection Precautions', suggested to minimise the risk of contamination.

- 1 Avoid prolonged and repeated contact with used engine oils.
- 2 Wear protective clothing, including impervious gloves where applicable.
- 3 Do not put oily rags into pockets.
- 4 Avoid contaminating clothes, particularly underwear, with oil.
- 5 Overalls must be cleaned regularly. Discard unwashable clothing and oil impregnated footwear.
- 6 First aid treatment should be obtained immediately for open cuts and wounds.
- 7 Apply barrier creams before each period of work to aid the removal of mineral oil from the skin.
- 8 Wash with soap and hot water, or alternatively use a skin cleanser and a nail brush, to ensure that all oil is removed from the skin. Preparations containing lanolin will help replace the natural skin oils which have been removed.
- 9 Do NOT use petrol, kerosene, diesel fuel, thinners or solvents for washing the skin.
- 10 If skin disorder appears, medical advice must be taken.
- 11 Degrease components before handling if practicable.
- 12 Where there is the possibility of a risk to the eyes, goggles or a face shield should be worn. An eye wash facility should be readily available.

Environmental protection

There is legislation to protect the environment from the incorrect disposal of used lubricating oil. To ensure that the environment is protected, consult your Local Authority who can give advice.

Danger from 'fluorosilicone' (trade name Viton) 'O' ring seals

All of the engines 'O' ring seals are made from fluorosilicone material

It is a safe material under normal conditions of operation, but if it is burned the extremely dangerous hydrofluoric acid is produced.

If it is necessary to come into contact with the components which have been burnt, follow the precautions below:

- Allow the components to cool.
- Use Neoprene gloves and a face mask.
- Wash the contaminated area with a calcium hydroxide solution and then with clean water.
- Disposal of gloves and components which are contaminated, must be in accordance with local regulations.

If there is contamination of the skin or eyes, wash the affected area with a continuous supply of clean water.

Obtain immediate medical attention.

Practical information for cleaning components

Use suitable gloves for protection when components are degreased.

It is important that the work area is kept clean and that the components are protected from dirt and debris. Ensure that dirt does not contaminate the fuel system.

Before a component is removed from the engine, clean around the component and ensure that all openings, disconnected hoses and pipes are sealed.

Remove, clean and inspect each component carefully. If it useable, put it in a clean dry place until needed. Ball and roller bearings must be cleaned thoroughly and inspected. If the bearings are usable, they must be flushed in low viscosity oil and protected with clean paper until needed.

Before the components are assembled, ensure that the area is free from dust and dirt as possible. Inspect each component immediately before it is fitted, wash all pipes and ports, and pass dry compressed air through them before connections are made.

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Lubricating oil recommendations

Only one oil is recommended for the 4016-E61TRS engine, that is MOBIL PEGASUS 805.

Quantity of oil

Sump capacity on the dipstick

- Maximum257 litres
- Minimum 147 litres
- Total system286 litres

Oil change period

For normal operation change the oil after the first 500 hours, then sample the oil every 250 hours to establish a contamination trend. This should give an oil change period of 2,000 hours.

Oil samples should be taken from the mean level in the engine sump never from the sump drain plug. Should there be a lubricating oil supply problem or a high sulphur content in the gas, Perkins Engines Company Ltd should be contacted.

Oil contamination to be regarded as critical parameters

Viscosity at 100°C	16.5 cSt maximum
Insolubles	1.5 maximum
Total Acid Number (TAN)	less than 4 times the TAN value for new oil.
Total Base Number (TBN)	50% less than new oil value.
Total Base Number (TBN) and Total Acid Number (TAN) must not cross over.	
Nitration	25 maximum
Oxidation	25 maximum
Water	0.2% maximum
Iron	Less than 20 ppm*
Copper	Less than 40 ppm*

Coolant specification

50% inhibited ethylene glycol or 50% inhibited propylene glycol and 50% clean fresh water. For combined heat and power systems and where there is no likelihood of ambient temperature below 10°, then clean 'soft' water may be used, treated with 1% by volume of Perkins inhibitor in the cooling system. The inhibitor is available in bottles under Perkins Part No. OE 45350 (1 litre).

Maintenance of coolant

Warning! *Always stop the engine and allow the pressurised system to cool before removing the filler cap. Avoid skin contact with the coolant mixture.*

The coolant mixture should be changed at 8,000 hours or 12 months and checked at 2,000 hour intervals for the correct alkalinity level, the pH should not be above 7.5.

Note: A hydrometer only shows the proportion of ethylene glycol. This is not a measure of protection against corrosion.

Warning! *Failure to follow the above recommendations may result in engine damage and will invalidate the engine warranty.*

10

Gas specification

A new engine will be set to operate on clean natural gas conforming to the British natural gas specifications having a lower calorific value of 34.71 MJ/Sm³ (930 BTU/Sft³).

The difference between high calorific value (HCV) and low calorific (LCV) is that (HCV) is the total amount of heat given off by the gas during combustion and the (LCV) is the high calorific value less the amount of heat used to vaporize the water content of the gas. Since the amount of heat lost in vaporizing the water is different for different gases, the lower calorific value of the gas is chosen as the basis for fuel consumption data. There must be no liquid hydrocarbon fractions in the gas.

Limiting values for British Gas	
Methane number must exceed	75
Combustible constituents must exceed	95%
Calorific value (LCV) to exceed	34 MJ/Nm ³ (912 BTU/Sft ³)
Ethane	4.5%
Hydrogen content not to exceed	0.1%
Propane must not exceed	1.0%
Isobutane content not to exceed	0.2%
Normal butane not to exceed	0.2%
Normal pentane and higher fractions (hexane, heptane, etc). The summation must not exceed:	0.02%
Gas pressure at inlet to regulators	15 mbar (1.5 kPa)
Gas pressure not to exceed without additional pressure regulators	50 mbar (5 kPa)
Hydrogen sulphide not to exceed	0.01% or 100 ppm

Note: The rating may be reduced if lower calorific value of the fuel is lower than 34.71 MJ/Nm³ (930 BTU/Sft³). Also pressure must be constant to maintain emissions and stability. If any of the above parameters are not met, Perkins Engines Company Ltd should be consulted for advice.

Gas safety regulations

There are legal requirements that within the U.K. gas fittings and equipment must be installed only by competent persons and in accordance with the Institution of Gas Engineers Procedures IGE UP2. Outside the U.K. anyone undertaking work on the engine or associated with the engine and its gas equipment in particular should check with local and national regulations to ensure compliance.

Preventive maintenance

Maintenance checks

The maintenance procedures are suitable for an engine working under average conditions. If your engine is working under particularly dirty or dusty conditions, more frequent servicing will be necessary particularly in respect of the lubricating oil and air cleaners. Correct and regular maintenance will help prolong engine life.

Warning! *Make quite certain that the engine cannot be started before undertaking any maintenance.*

10

Maintenance procedures

Using Manuals

User's Handbook (Publication TSL4230).....	UH
Diagnostic Manual (Publication TSL4233).....	DM
Workshop Manual (Publication TSL4235)	WM

Also refer to Maintenance Schedule on page 22.

First 500 hour – A service

Description	Manual
Check EMS logged events and record	DM
Check EMS logged diagnostic codes, record and rectify	
Oil & filter change. Clean piston cooling jet oil strainer plug	UH
Equalise bridge pieces and set valve clearance	UH
Spark plugs clean and re-gap	UH

B service – 2,000, 6,000, 18,000 and 22,000 hours

Description	Manual
Check EMS logged events and record	DM
Check EMS logged diagnostic codes, record and rectify	
Oil & filter change. Recommend oil sampling required Clean piston cooling jet oil strainer plug	UH
Equalise bridge pieces and set valve clearance	UH
Spark plugs check, clean and re-gap	UH
Breather element – replace	UH
Air filter – replace (Subject to environmental conditions)	UH
Calibrate oxygen sensor, - Replace oxygen sensor	UH - DM

C service – 4,000 and 20,000 hours

Description	Manual
Check EMS logged events and record	DM
Check EMS logged diagnostic codes, record and rectify	
Oil & filter change. Recommend oil sampling required Clean piston cooling jet oil strainer plug	UH
Equalise bridge pieces and set valve clearance	UH
Spark plugs check, clean and re-gap	UH
Breather element – replace	UH
Air filter – replace (Subject to environmental conditions)	UH
Calibrate oxygen sensor, - Replace oxygen sensor	UH - DM
Check emissions. (Adjust if required)	DM

Using Manuals

User's Handbook (Publication TSL4230)	UH
Diagnostic Manual (Publication TSL4233)	DM
Workshop Manual (Publication TSL4235)	WM

Also refer to Maintenance Schedule on page 22.

D service – 8,000 and 24,000 hours

Description	Manual
Check EMS logged events and record	DM
Check EMS logged diagnostic codes, record and rectify	
Oil & filter change. Recommend oil sampling required Clean piston cooling jet oil strainer plug	UH
Equalise bridge pieces and set valve clearance	UH
Spark plugs check, clean and re-gap	UH
Breather element – replace	UH
Air filter – replace (Subject to environmental conditions)	UH
Cylinder head – Check valve recession using tool	UH
Charge cooler – Clean & regasket	WM
Test sensors & protection systems yearly	DM
Check coolant antifreeze/inhibitor strength yearly	UH
Calibrate oxygen sensor, - Replace oxygen sensor	UH - DM
Calibrate turbine inlet temperature interface module	DM
Check emissions. (Adjust if required)	DM
Magnetic pick ups – clean & adjust	WM
Check & calibrate ignition timing	DM

E service – 10,000, 14,000, 26,000 and 30,000 hours

Description	Manual
Check EMS logged events and record	DM
Check EMS logged diagnostic codes, record and rectify	
Oil & filter change. Recommend oil sampling required Clean piston cooling jet oil strainer plug	UH
Equalise bridge pieces and set valve clearance	UH
Spark plugs check, clean and re-gap	UH
Breather element – replace	UH
Air filter – replace (Subject to environmental conditions)	UH
Cylinder head – Check valve recession using tool	UH
Calibrate oxygen sensor, - Replace oxygen sensor	UH - DM

10

Using Manuals

User's Handbook (Publication TSL4230).....	UH
Diagnostic Manual (Publication TSL4233).....	DM
Workshop Manual (Publication TSL4235)	WM

Also refer to Maintenance Schedule on page 22.

F service – 12,000 and 28,000 hours

Description	Manual
Check EMS logged events and record	DM
Check EMS logged diagnostic codes, record and rectify	
Oil & filter change. Recommend oil sampling required Clean piston cooling jet oil strainer plug	UH
Equalise bridge pieces and set valve clearance	UH
Spark plugs check, clean and re-gap	UH
Breather element – replace	UH
Air filter – replace (Subject to environmental conditions)	UH
Cylinder head – Check valve recession using tool	UH
Calibrate oxygen sensor, - Replace oxygen sensor	UH - DM
Check emissions. (Adjust if necessary)	DM

G service – 16,000 hours

Description	Manual
Check EMS logged events and record	DM
Check EMS logged diagnostic codes, record and rectify	
Oil & filter change. Recommend oil sampling required Clean piston cooling jet oil strainer plug	UH
Equalise bridge pieces and set valve clearance	UH
Spark plugs check, clean and re-gap	WM
Breather element – replace	WM
Air filter – replace (Subject to environmental conditions)	WM
Change cylinder heads	WM
Charge cooler - clean and regasket	WM
Test sensors and protection systems yearly	DM
Check coolant antifreeze/inhibitor strength yearly	UH
Calibrate oxygen sensor, - Replace oxygen sensor	UH - DM
Calibrate turbine inlet temperature interface module	DM
Check emissions. (Adjust if required)	DM
Oil cooler assembly - overhaul	WM
Turbocharger - replace	WM
Clean gas mixer (see air filter change)	UH
Magnetic pick ups – clean & adjust	WM
Check & calibrate ignition timing	DM
Inspect ignition coils	UH
TV dampers - replace	WM

Using Manuals

User's Handbook (Publication TSL4230)	UH
Diagnostic Manual (Publication TSL4233)	DM
Workshop Manual (Publication TSL4235)	WM

Also refer to Maintenance Schedule on page 22.

H service – 32,000 hours

Description	Manual
Check EMS logged events and record	DM
Check EMS logged diagnostic codes, record and rectify	
Oil & filter change. Recommend oil sampling required Clean piston cooling jet oil strainer plug	UH
Equalise bridge pieces and set valve clearance	UH
Spark plugs check, clean and re-gap	UH
Breather element – replace	UH
Air filter – replace (Subject to environmental conditions)	UH
Change cylinder heads	WM
Change cylinder head bolts - replace after 2 uses or 32,000 hrs	WM
Charge cooler - clean and regasket	WM
Test sensors and protection systems yearly	DM
Check coolant antifreeze/inhibitor strength yearly	WM
Calibrate oxygen sensor, - Replace oxygen sensor	UH - DM
Calibrate turbine inlet temperature interface module	WM - DM
Check emissions. (Adjust if required)	DM
Oil cooler assembly - overhaul	WM
Turbocharger - replace	WM
Clean gas mixer (see air filter change)	UH
Magnetic pick ups – clean & adjust	WM
Check & calibrate ignition timing	DM
Governor actuator – change throttle valve	WM
Fuel valve / tecjet - replace	WM
Butterfly valve – overhaul	WM
Inspect ignition coils	UH
Pistons, rings and liners – replace	WM
Big end bearings & bolts – replace	WM
Small end bearings – inspect & replace if necessary	WM
Camshaft, camshaft bushes & cam-follower assembly – replace	WM
Starter motors - replace	WM
Front and rear crankshaft oil seals – inspect & replace if necessary	WM
Pushrods – check for wear & straightness	WM
Valve train gear – clean & inspect	WM
TV dampers - replace	WM

Activity	A	B	C	B	D	E	F	E	G	B	C	B	D	E	F	E	H
	Engine running hours																
	500	2000	4000	6000	8000	10000	12000	14000	16000	18000	20000	22000	24000	26000	28000	30000	32000
Check EMS logged events and record	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Check EMS logged diagnostic codes, record and rectify	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Oil & filter change. Recommend oil sampling required at every 250 hrs initially to establish trends	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Rocker box cover joints - replace	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Check, log & adjust tappets/bridge pieces	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Spark plugs - clean, re-gap & new washer, Change = O	X	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O
Breather element - replace		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Air filter - replace (Subject to environmental conditions)		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cylinder head - check using valve recession tool					X	X	X	X					X	X	X	X	
Cylinder head - change (Life = 14,000--16,000)									X								X
Cylinder head bolts - replace after 2 uses or 32,000 hrs Whichever occurs first																	X
Charge cooler - clean & regasket					X				X				X				X
Test sensors & protection systems yearly or 8000 hrs					X				X				X				X
Check coolant antifreeze/inhibitor strength yearly or 8000 hrs					X				X				X				X
Calibrate oxygen sensor = X, replace oxygen sensor = O		X	X	X	O	X	X	X	O	X	X	X	O	X	X	X	O
Calibrate turbine inlet temperature interface module					X				X				X				X
Check emissions - adjust if necessary			X		X		X		X		X		X		X		X
Oil cooler assy - overhaul									X								X
Turbocharger - replace									X								X
Clean and inspect gas mixer									X								X
Magnetic pick ups - clean & adjust					X				X				X				X
Check & calibrate ignition timing					X				X				X				X
Governor actuator - change throttle valve																	X
Fuel valve / Tecjet - replace																	X
Butterfly valve - overhaul																	X
Inspect ignition coils									X								X
Pistons, rings and liners - replace																	X
Big end bearings & bolts - replace																	X
Small end bearings - inspect & replace if necessary																	X
Camshaft, camshaft bushes & camfollower assy - replace																	X
Starter motors - replace																	X
Front & rear oil seals - inspect & replace if necessary																	X
Pushrods - check for wear & straightness																	X
Valve train gear - clean & inspect																	X
TV Dampers - replace									X								X
Exhaust manifold - replace																	X

Notes:

- All sensors should last the life of the engine.
- Maintenance schedule from 32,000 hrs to 64,000 hrs same as 2,000 to 32,000.
- At 64,000 hrs operation consult Perkins Engine Company Limited reference major overhaul - swing engine / service exchange engine components such as oil pump, main bearings, knock sensors, EMS, ignition coils will require overhauling / replacing.

This schedule is for guidance purposes only and is to assist in calculating whole life cost, figures based on project objectives, parts consumption's are not warranted.

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F-95913 Roissy - CDG Cedex, France.
Telephone: 0033 (01) 49-90-7168
Fax: 0033 (01) 49-90-7190

Germany

Perkins Motoren GmbH,
Saalaeckerstrasse 4,
D-63801 Kleinostheim,
Germany.
Telephone: 0049 6027 5010
Fax: 0049 6027 501130

Italy

Motori Perkins S.p.A.,
Via Socrate 8,
22070 Casnate con Bernate (Como), Italy.
Telephone: 0039 (0) 31 564633/564625
Fax: 0039 (0) 31 565480/564145/396001

Singapore

Perkins Engines (Far East) Pte Ltd,
39 Tuas Avenue 13,
Singapore 638999.
Telephone: (65) 861 1318
Fax: (65) 861 6252

United Kingdom

Perkins Engines Company Ltd,
Eastfield, Peterborough, PE1 5NA,
England.
Telephone: 0044 (0) 1733 583000
Telex: 32501 Perken G
Fax: 0044 (0) 1733 582240

Perkins Engines Company Limited,
Tixall Road, Stafford, ST16 3UB,
England.
Telephone: 0044 (0) 1785 223141
Fax: 0044 (0) 1785 215110

Perkins Engines Company Limited,
Lancaster Road, Shrewsbury, SY1 3NX,
England.
Telephone: 0044 (0) 1743 212000
Fax: 0044 (0) 1743 212700

United States of America

Perkins Engines Inc,
26200 Town Centre Drive,
Suite 280, Novi,
Michigan 48375,
USA
Telephone: 001 248 374 3100
Fax: 001 248 374 3100

Perkins Engines Latin America Inc,
999 Ponce de Leon Boulevard, Suite 710,
Coral Gables, Florida 33134,
U.S.A.
Telephone: 001 305 442 7413
Telex: 32501 Perken G
Fax: 001 305 442 7419

In addition to the above companies, there are Perkins distributors in most countries. Perkins Engines Company Limited, Peterborough or one of the above companies can provide details.

11

Specifications

Basic technical data

Number of cylinders.....	16
Cylinder arrangement	60° Vee
Cycle.....	4 stroke, spark ignition
Induction system.....	Turbocharged
Compression ratio	12:1
Bore	160 mm
Stroke	190 mm
Cubic capacity	61,123 litres
Direction of rotation	Anti-clockwise viewed on flywheel
Firing order	1 ^A , 1 ^B , 3 ^A , 3 ^B , 7 ^A , 7 ^B , 5 ^A , 5 ^B , 8 ^A , 8 ^B , 6 ^A , 6 ^B , 2 ^A , 2 ^B , 4 ^A , 4 ^B
Estimated total weight (dry)	5500 kg

Ratings

Electrical ratings are based on average alternator efficiency and are for guidance only (1.0 power factor being used).

Operating point

Engine speed.....	1500 rpm
Ignition timing	24° BTDC
Mixture cooler water temp	40 °C
Cooling water exit temp	<98 °C
Exhaust emissions:.....	1/2 TA-Luft (NOx)
.....	TA-Luft (NOx)

Fuel data

Fuel type.....	Natural Gas (UK)
Lower calorific value	34,710 kJ/Sm ³ (45,671 kJ/kg)
Density.....	0.76 kg/Sm ³
Stoich. air requirement	16 kg/kg
Minimum methane number	75

Performance

Note: All data based on operation to ISO 3046/1, BS 5514 DIN 6271 standard reference conditions.

Test conditions

Air temperature.....	25°C
Barometric pressure	100 kPa
Relative humidity	30%

General installation

Designation	Units	Continuous baseload rating	
		50 Hz; 1500 rpm	
		¹ / ₂ TA-Luft (NOx)	TA-Luft (NOx)
Gross engine power	KW	1042	1042
BMEP gross	Bar	13.7	13.7
Combustion air flow	m ³ /min	82.7	79.8
Exhaust gas temperature max (after turbo)	°C	496	495
Exhaust gas flow (max)	m ³ /min	220	212
Overall electrical efficiency	%	38.2	39.2
Mean piston speed	m/s	9.5	9.5
Charge coolant flow	l/s	10	10
Nominal excess air factor (Lambda)	λ	1.80	1.75
Typical Gen Set 25°C (100 kPa) Electrical Output (unit 1.0pf)	kW	1008	1008
Assumed alternator efficiency	%	96.8	96.8

Energy balance

Continuous baseload rating	Units	1500 rpm ¹ / ₂ TA-Luft NOx	%	1500 rpm TA-Luft NOx	%
Energy in fuel (Fuel heat of combustion)	kW	2638	100	2574	100
Energy in power output (Net) (Engine shaft power)	kW	1042	39.5	1042	40.5
Energy to exhaust cooled to 120°C	kW	693	26.3	665	25.8
Energy to coolant (jacket, oil and 1st circuit of c/c)	kW	577	21.9	584	22.7
Sum of useable heat	kW	1270	48.1	1249	48.5
Sum of useable energy	kW	2312	87.6	2291	89.0
Energy to radiation (surface radiation and other losses)	kW	83	3.1	46	1.8
Energy to charge cooler 2nd circuit	kW	71	2.7	68	2.6
Waste energy from exhaust gas	kW	172	6.5	169	6.6

Note: Not to be used for CHP design purposes. (Indicative figures only). Consult Perkins Engines Co. Ltd. Assumes complete combustion.

Cooling system

Recommended coolant:

50% inhibited ethylene glycol or 50% inhibited propylene glycol and 50% clean fresh water. For combined heat and power systems and where there is no likelihood of ambient temperature below 10°, then clean 'soft' water may be used, treated with 1% by volume of Perkins inhibitor in the cooling system. The inhibitor is available in bottles under Perkins Part No. OE 45350 (1 litre)

Maximum jacket water pressure in crankcase 1.7 bar

Jacket water data	Units	1500 rpm
Coolant flow	m ³ /h	54
Coolant exit temperature (max)	°C	98
Coolant entry temperature	°C	84

Charge cooling water data (2nd circuit)	Units	1500 rpm
Coolant flow	m ³ /h	36
Coolant entry temperature (max)	°C	40

Charge cooler Plate and fin on engine

Coolant pump..... not fitted

Maximum static pressure head on coolant inlet above engine crank centre line..... 7m

Coolant immersion heater capacity..... 4 kW (2 off)

Lubrication system

Recommended lubricating oil:

For Natural Gas fuel applications Mobil Pegasus 805

Lubricating oil capacity:

Total system 286 litres

Sump maximum 257 litres

Sump minimum 147 litres

Lubricating oil temperature maximum to bearings 105°

Lubricating oil pressure:

at 85°C temperature to bearing gallery 4.5 bar

Oil consumption	Units	1500 rpm
After RUNNING-IN *	g/kW.hr	0.3
Oil flow rate from pump	l/s	7.8

* Typical after 250 hours

Sump drain plug tapping size G1

Oil pump gear driven

Normal operating angles:

Fore and aft 5°

Side tilt 22°

Fuel systemRecommended fuel Natural Gas LHV at 34.71 MJ/m³

Gas supplies must be filtered to the same standard as the engine intake air, i.e. Maximum particle size not to exceed 5 microns.

Gas supply pressure 5 kPa to 10 kPa at full rated flow conditions

Carburettor type Woodward Tecjet 50

Installation of gas supply and shut off valves to be in accordance with local regulations.

Fuel consumption gross	kJ/kWs	
Designation	¹ / ₂ TA-Luft	TA-Luft
	1500 rpm	1500 rpm
Continuous baseload rating	2.53	2.47

Designation		¹ / ₂ TA-Luft	TA-Luft
Mass flow data	Units	1500 rpm	1500 rpm
Fuel	kg/h	201	198

Designation		¹ / ₂ TA-Luft	TA-Luft
Volume flow data (100kPa)	Units	1500 rpm	1500 rpm
Fuel (15°C)	m ³ /h	265	261

Induction system

Emissions data with combustion air temperature of 25°C at continuous baseload rating

Designation		¹ / ₂ TA-Luft (NO _x)	TA-Luft (NO _x)
Speed		1500 rpm	1500 rpm
Oxygen (O ₂)	%	9.35	9.13
* Oxides of nitrogen (NO _x)	mg/Nm ³	250	500
* Carbon monoxide (CO)	mg/Nm ³	790	765

* Figures corrected to 5% O₂ in the exhaust stream

Designation		¹ / ₂ TA-Luft	TA-Luft
Mass flow data	Units	1500 rpm	1500 rpm
Combustion air	kg/h	5760	5544

Exhaust system

Exhaust outlet size 210 mm (Internal)

Designation		¹ / ₂ TA-Luft	TA-Luft
Exhaust data	Units	1500 rpm	1500 rpm
Exhaust gas flow (wet)	kg/h	5961	5742
Exhaust gas temperature	°C	496	495
Lambda	λ	1.80	1.75

Electrical system

Starter motor 24 volts

Starter motor power 16.4 kW

Number of teeth on flywheel 156

Number of teeth on starter motor 12

Minimum cranking speed 120 rpm

Pull in current of starter motor solenoid 26.8 amps at 24 volts

Hold in current of starter motor solenoid 9 amps at 24 volts

Engine management system

Full electronic Engine Management System controlling:

Speed governing

Air / Fuel ratio

Start / Stop sequence

Anti-knock

Engine protection and diagnostics

Ignition system

Primary voltage 24 volts

Polarity Negative earth

Ignition coils 1 per cylinder

Spark plug type 18 mm

Spark plug gap 0.4 mm

Ignition timing 24° BTDC

Torque settings

Cylinder head group

		lbf.ft	Nm
Cylinder head bolt **	M24	530	720
Rocker shaft capscrew/nut	M16	90	120
Rocker adjuster nuts inlet/exhaust	M12	35	50
Bridge piece adjuster nuts	M10	25	35
Rocker box bolts	M10	35	50
Air manifold bolt	M10	35	50
Exhaust manifold bolts	M10	50	70
Turbo to ex manifold	M20	250	340

Note: ** = Cylinder head bolts to be lubricated under the heads, under the washers and on the threads with PBC (Poly-Butyl-Cuprysil) grease. All other threads only to be lubricated with clean engine oil.

Crankcase and crankshaft groups

Main bearing bolt *, see Section 16, page 75	M24	580	786
Lateral capscrews, see Section 16, page 75	M16	124	168
Bolts sump to crankcase	M10	40	54
Connecting rod bolts	M16	210	285
Inspection covers	M10	35	50
Viscous damper bolts and retaining plate	M16	250	340
Flywheel bolts	M16	250	340
Balance weight bolts	M16	250	340
Piston cooling jet screws	M10	20	27
Flywheel housing bolts	M10	35	50
Lifting bracket Durlock screws	M10	50	70

Lubricating oil pump

Bolts, pump housing to gearcase plate	M10	35	50
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Camshaft group

Camshaft gear bolt	M12	110	150
Camshaft thrust plate bolt	M10	35	50
Camshaft follower housing bolt	M10	35	50
Idler gear hub bolts	M10	35	50

Note: * = Bolt and threads must be lubricated with clean engine oil.

General torque loadings

M5	5	7
M6	9	12
M8	21	28
M10	41	56
M12	72	98

Wear and renewal limits

Key

Column 1

Description of components

Column 2

Designed size of components

Column 3

This column gives the limiting wear dimension of a component outside of which it must be renewed, or as in the case of the crankshaft, must be reground to the next underside dimension.

Column 4

Designed working clearance between mating parts.

Column 5

If during a major or top overhaul period it is necessary to refit worn components, the maximum clearance between the mating parts must not exceed the figure given in this column if a further 10000 hours running is required, or in the case of a top overhaul, a further 3000 hours.

If the clearance between mating parts exceeds this figure, a satisfactory running clearance may be obtained by a combination of a new part mated with a corresponding component worn to the limiting dimensions as stated in Column 3. Generally, however, the mating of components already worn to the maximum with new components is not recommended.

Column 1	Column 2	Column 3	Column 4	Column 5
DESCRIPTION	Design Dimensions mm (in)	Limiting Dimensions mm (in)	Design Clearance mm (in)	Max Worn Clearance mm (in)
Piston Ring Gap	0.75 (0.030) 0.5 (0.020)	0.75 (0.030)	NA	1.27 (0.050)
Piston Ring Gap - Second	0.75 (0.030) 0.5 (0.020)	0.75 (0.030)	NA	1.27 (0.050)
Piston Ring Gap - Oil Control	0.75 (0.030) 0.5 (0.020)	0.75 (0.030)	NA	1.275 (0.050)
Ring Groove Width	3.590 (0.141) 3.565 (0.140)	NA	NA	0.20 (0.008)
Ring Groove Width - Second	3.565 (0.140) 3.540 (0.139)	NA	NA	0.18 (0.007)
Ring Groove Width - Oil Control	6.065 (0.2388) 6.040 (0.2378)	NA	NA	0.18 (0.007)
Cylinder Liner Bore	160.025 (6.300) 160.000 (6.299)	160.15 (6.305)	NA	160.15 (6.305)
Gudgeon Pin Diameter	63.500 (2.500) 63.492 (2.4997)	NA	0.084 (0.0033)	0.15 (0.0059)
Small End Bush Bore (fitted)	63.576 (2.503) 63.550 (2.502)	NA	0.058 (0.0022)	
Crankshaft Main Journal Diameter	140.02 (5.5125) 140.00 (5.5112)	139.849 (5.506)	0.170 (0.0067) 0.093 (0.0037)	0.240 (0.010)
Inlet and Exhaust Valve Stem Diameter	11.0236 (0.4340) 11.0109 (0.4335)	NA	0.109 (0.0043)	0.20 (0.006)
Inlet and Exhaust Valve Guide Diameter	11.120 (0.4378) 11.090 (0.4366)	NA	0.066 (0.0026)	
Valve Spring Fitted Length	42.54 (1.675)	Minimum Load at Fitted Length = 400N (90.616 lb)		
Valve Gear Dimensions	Rocker Arms (Bore)		Rocker Shaft (OD)	
Cam Lobe Dimensions				
Camshaft Journal Diameter	91.925 (3.619) 91.898 (3.618)	NA	0.233 (0.0091)	0.254 (0.010)
Camshaft Bearing Bore	92.131 (3.627) 92.093 (3.6257)		0.168 (0.0066)	

Column 1	Column 2	Column 3	Column 4	Column 5
Camshaft End Float	NA	NA	0.25 (0.010) 0.10 (0.004)	0.30 (0.012)
Exhaust and Inlet Cam Height	78.905 (3.1065) 78.855 (3.1045)	77.795 (3.0628)	NA	NA
Idler Gear End Float	NA	NA	0.254 (0.010) 0.152 (0.006)	0.30 (0.012)
Idler Gear to Camshaft Gear	NA	NA	0.45 (0.018) 0.125 (0.005)	0.63 (0.025)
Idler, Camshaft and Oil Pump	NA	NA	0.38 (0.015) 0.13 (0.005)	0.50 (0.020)
Main Bearing Bore Diameter	140.170 (5.5185) 140.113 (5.5160)	See Crankshaft Main Journal diameter and clearances		
Undersize Bearings	0.254 (0.010) 0.508 (0.020)			
Crankpin Diameter	118.013 (4.6462) 117.993 (4.6454)	Min. Diameter 117.932 (4.643)	0.127 (0.005) 0.073 (0.0029)	0.203 (0.008)
Big End Bearing Bore	118.127 (4.651) 118.086 (4.649)	See Crankpin diameter and clearances		
Undersize Bearings	0.254 (0.010) 0.508 (0.020)			
Crankshaft End Float	NA	NA	0.51 (0.020) 0.13 (0.005)	0.55 (0.022)

12

Cylinder head assemblies

Note: In the event of failure, valve recession reaching an unacceptable limit (see section 4, page 22 User's Handbook) or if the engine is undergoing a major overhaul. Service exchange cylinder heads will be supplied by your Perkins agent. The specialised equipment to recondition cylinder heads is only available at Perkins Engines.

To remove air cleaner, pipework, tec-jet, ISM unit, ignition wiring rail and sensor wiring rail

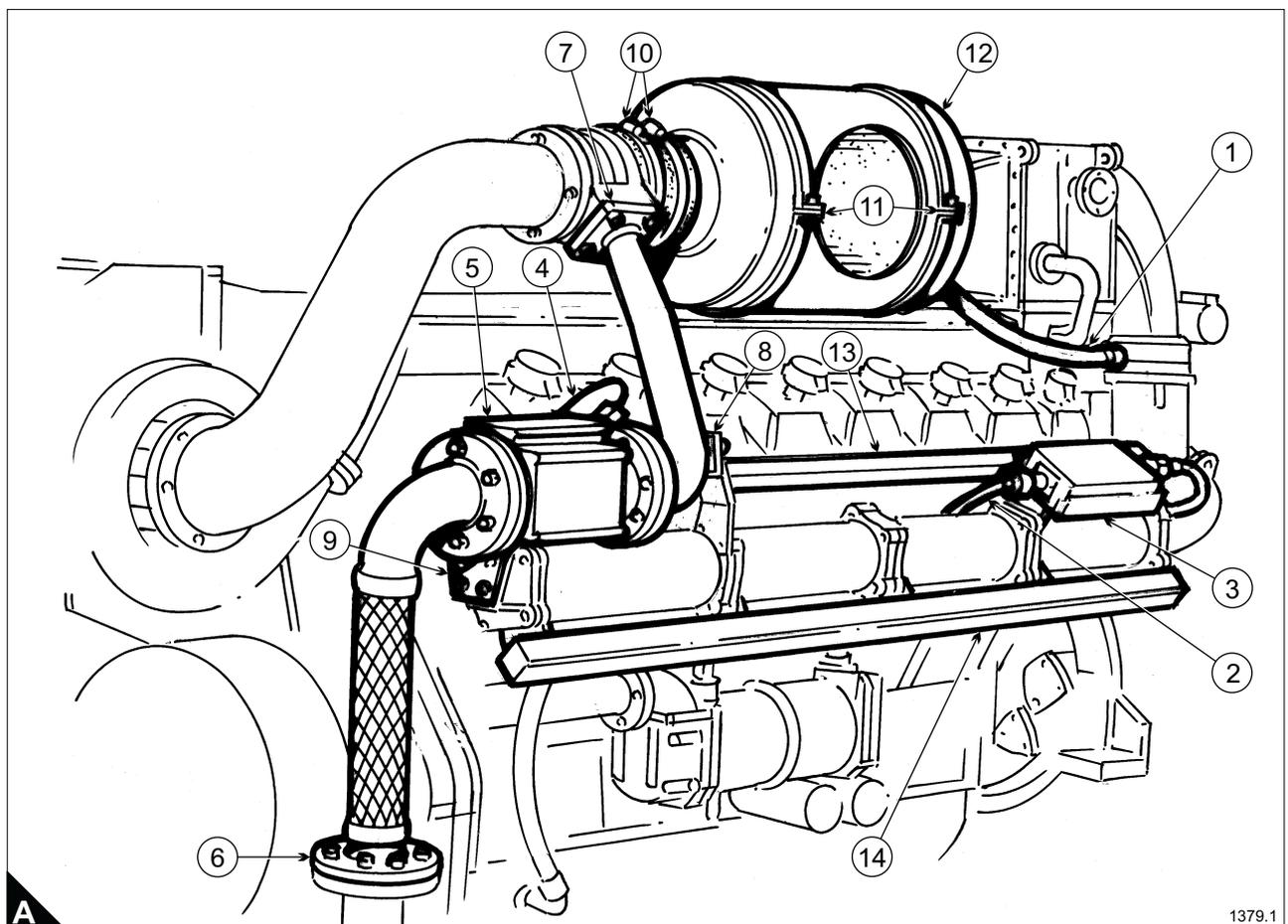
12-1

Warning! Turn off the gas and isolate the engine.

- 1 Disconnect the breather outlet pipe (A1) 'A' and 'B' bank.
- 2 Disconnect the two multi-pin plugs (A2) from the ISTM unit 'B' bank only.
- 3 Take out the mounting bracket bolts and remove the ITSM unit (A3).

- 4 Disconnect the multi-pin plug (bayonet type) (A4) from the tec-jet unit (A5).
- 5 Take out the retaining bolts (A6) from the bottom flange of the flexible gas feed pipe to the tec-jet.
- 6 Remove the retaining nuts (A7) from the tec-jet gas feed pipe.
- 7 Remove the retaining bolts (A8) from the gas feed pipe support bracket.
- 8 Remove the retaining bolts (A9) from the tec-jet support bracket, then lift the tec-jet off the engine.
- 9 Slacken the hose clips (A10) remove the retaining bolts (A11) then remove the air cleaner (A12) from its support bracket.

Continued



1379.1

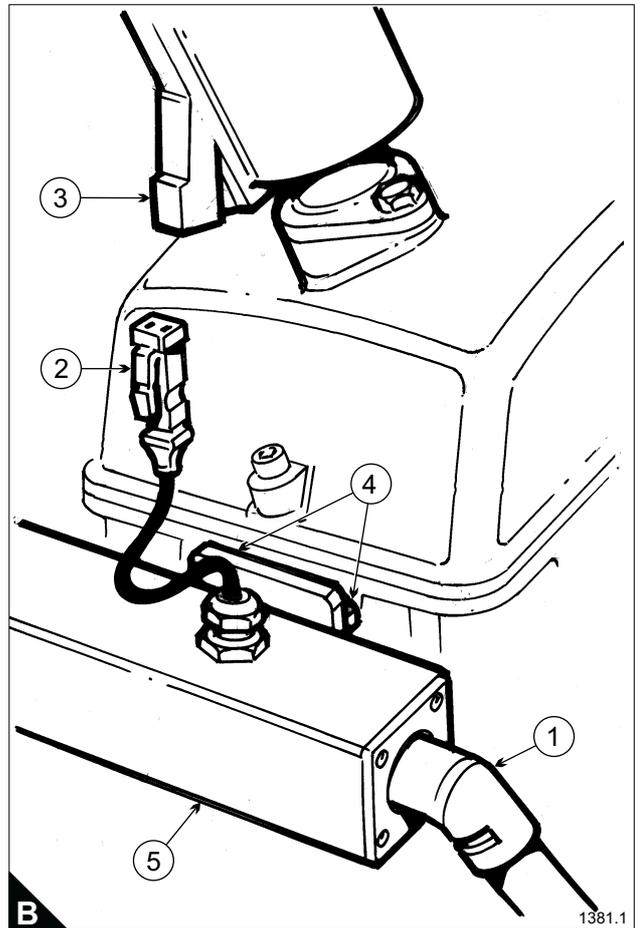
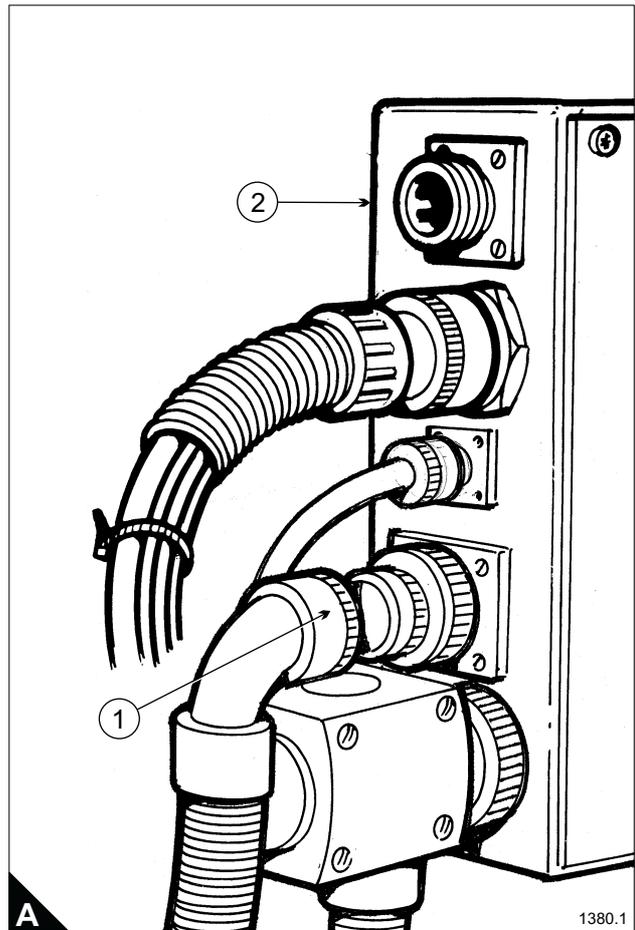
12

10 Disconnect the ignition power cable multi-pin plug (A1) from the EMS unit (A2) 'A' and 'B' bank.

Warning! Do not attempt to disconnect the ignition power cable elbow fitting (B1).

11 Disconnect the power feed plug (B2) from each ignition coil (B3) 'A' and 'B' bank.

12 Remove the retaining bolts (B4) from the three ignition support rail brackets (B5) lift off the ignition rail (B5) - (A13) on page 33.



13 Disconnect the sensor system cable multi-pin plug (A1) from the EMS unit (A2) 'A' and 'B' bank.

14 Disconnect the sensor connections between the engine and the sensor rail 'A' and 'B' bank (A14) on page 33.

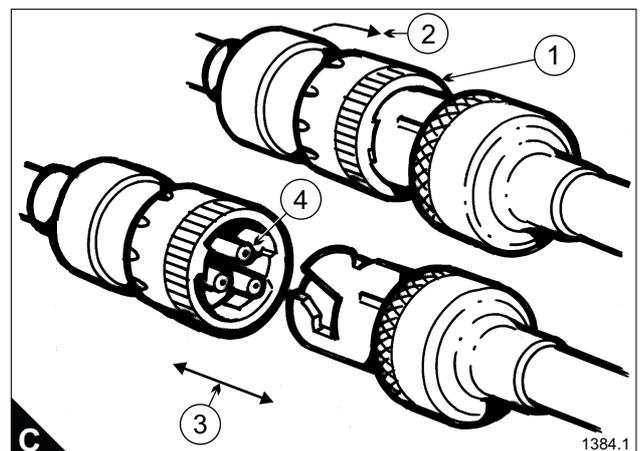
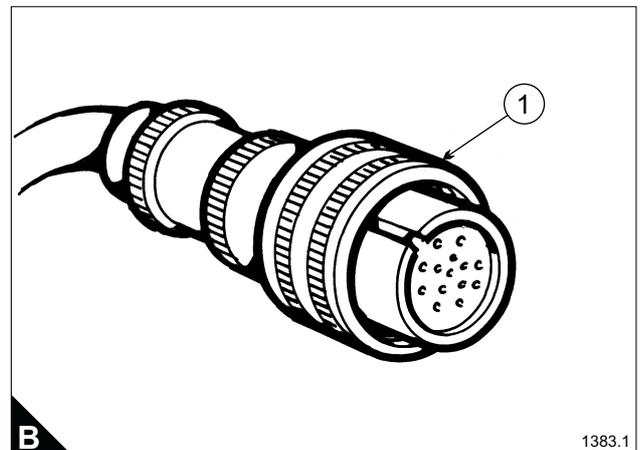
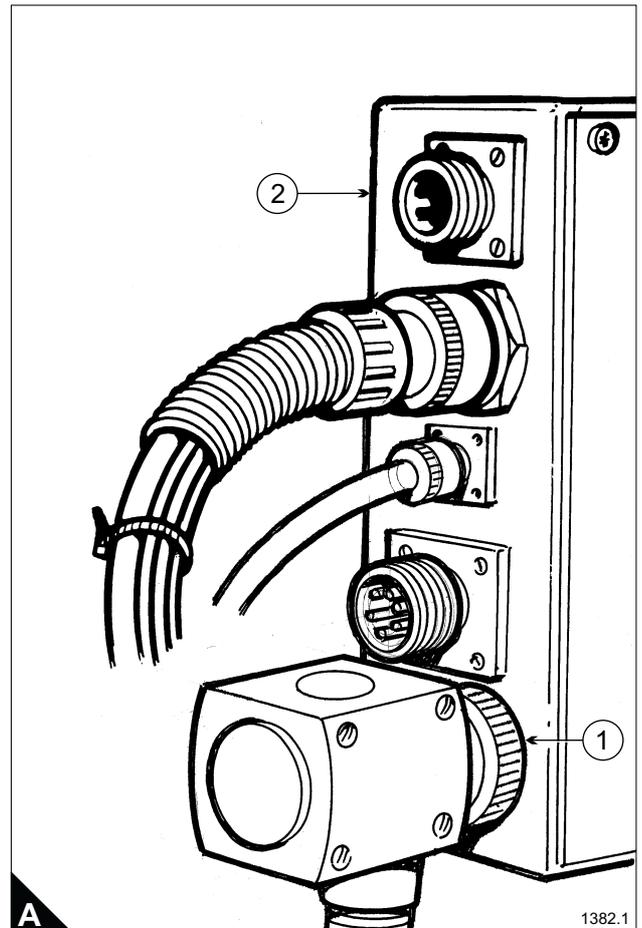
15 There are fifteen connections 'A' bank and fourteen 'B' bank using two types of plug. The larger metal bodied multi-pin plug has a screw type retaining ring (B1) serrated on its outer edge, unscrew the ring and pull the plug from its socket.

Note: When refitting the locating slot (B1) in the plug body must engage the peg in the socket.

16 The smaller plugs on the power cables are plastic bodied with a bayonet locking ring (C1) to release the plug turn the locking ring clockwise (C2) and pull the plug apart (C3).

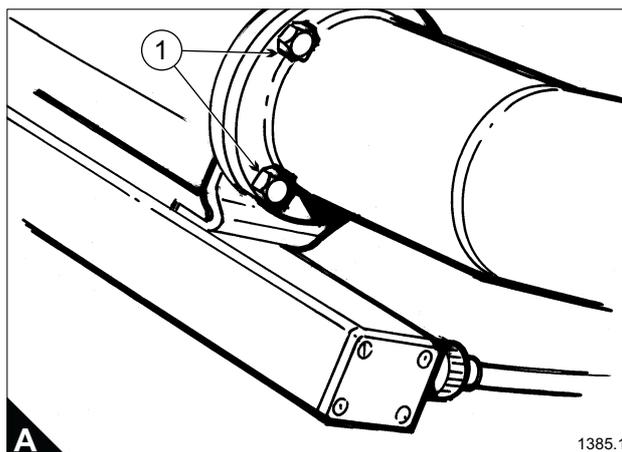
Note: When reconnecting the slots (C4) on two of the connector bosses must engage the pegs in the socket.

Continued



12

17 Remove the retaining bolts (A1) from the four mounting brackets and lift off the sensor rail.

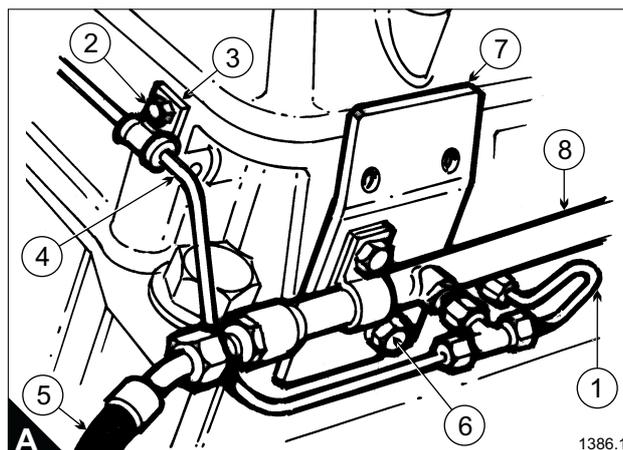


Cylinder heads oil feed 'A' and 'B' bank

To remove

12-2

- 1 Remove the short oil feed pipe (A1).
- 2 Remove the bolt (A2) to disconnect the oil pipe support clip (A3).
- 3 Remove the long oil feed pipe (A4).
- 4 Disconnect the flexible oil feed pipe (A5).
- 5 Remove the retaining bolt (A6) from the three per bank support brackets (A7) then lift the oil feed pipe (A8) and brackets as an assembly.



Inlet manifolds 'A' and 'B' bank

To remove

12-3

- 1 Remove the retaining bolts (B1) holding the charge cooler pipework (B2) to the inlet manifold.

Note: The four sections of the inlet manifold can be removed as an assembly by two people.

Warning!

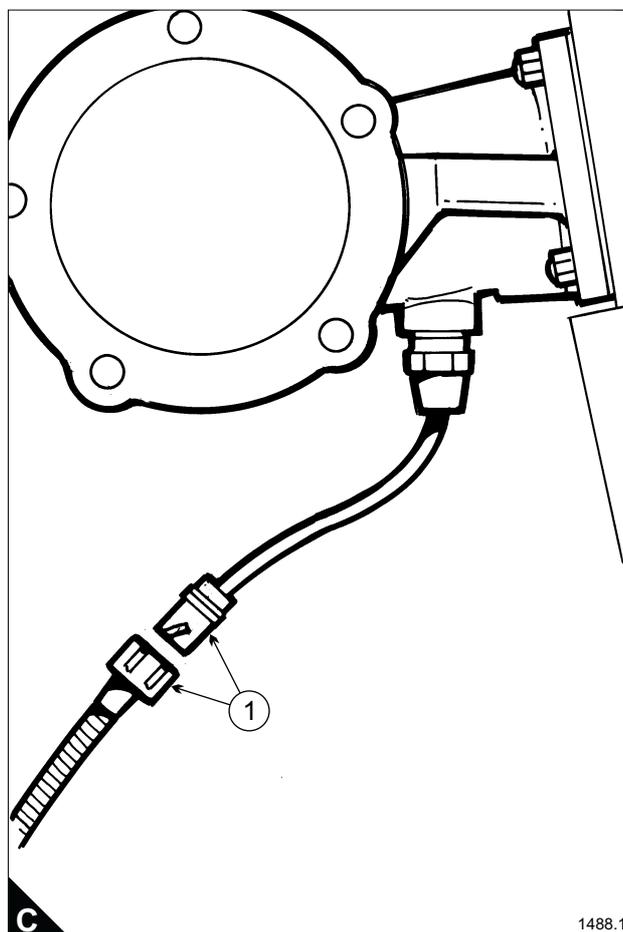
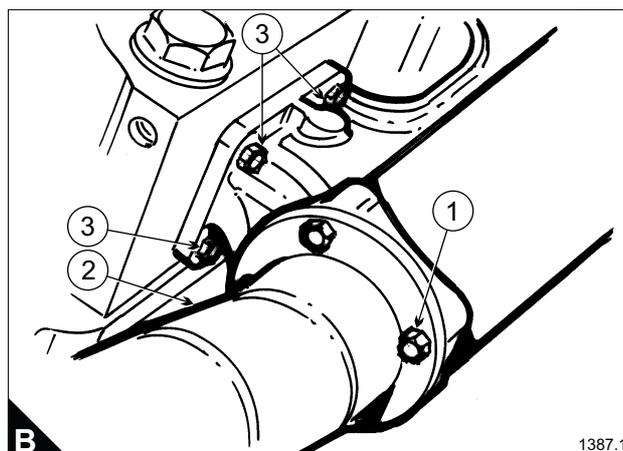
- 2 Disconnect the manifold temperature sensor at the plug (C1) located on the underside of the inlet manifold 'B' Bank flywheel end of the engine.

- 3 Remove the bolts (B3) holding the inlet manifold to the cylinder heads and lift the manifold from the engine.

- 4 To remove the manifold as individual sections first remove the bolts from the joining flanges then follow step 2.

Note: If the manifold sections are separated the sealing 'O' rings must be replaced.

Warning! If the 'O' rings have been burned or overheated the dangerous "hydroflouric acid" is produced, follow the "Safety precautions" and environmental protection on page 13, Section 10.



12

Heat shield side sections 'A' and 'B' bank

To remove

12-4

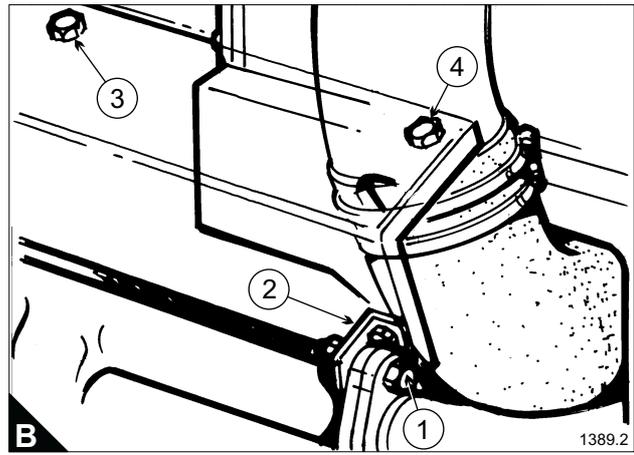
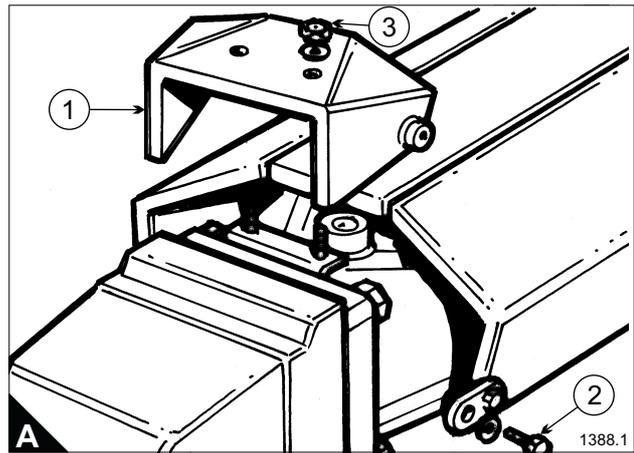
1 Remove the short section of heat shield (A1) between the turbocharger and the exhaust manifold. Take out the side bolts (A2) and the top retaining nuts and washers (A3) then lift off the section.

2 Remove the bolts (B1) holding the three heat shield brackets (B2) to the water rail.

3 Remove the five retaining bolts (B3) from the top edge of the heat shield.

Note: One bolt (B4) is under the charge cooler support bracket.

4 Lift off the heat shield.



Coolant rail

To remove

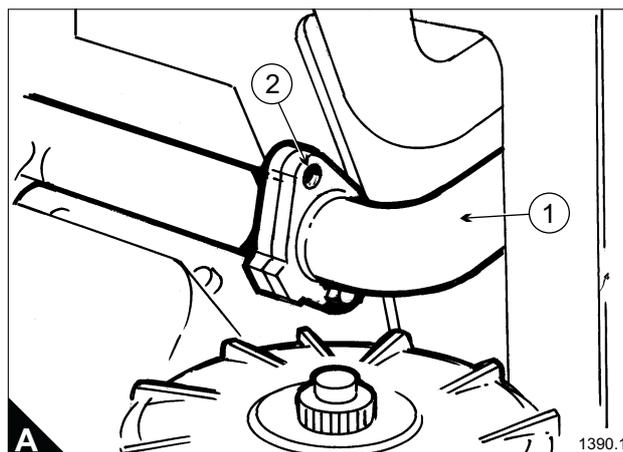
12-5

1 Remove the pipework (A1) joining the coolant rails.

Note: To gain access to the retaining bolts (A2), the container and filter unit must be removed see User's Handbook Section 4, page 17.

2 Remove the two retaining bolts (B1) holding the coolant rail to each cylinder head, then lift off the rail as a unit.

3 Discard the 'O' ring seals.



Exhaust manifold

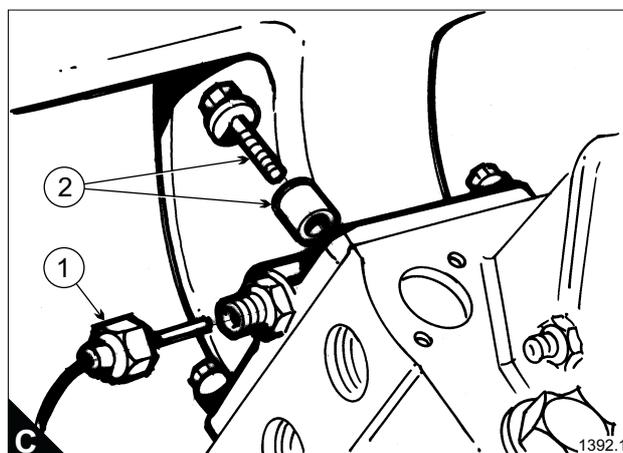
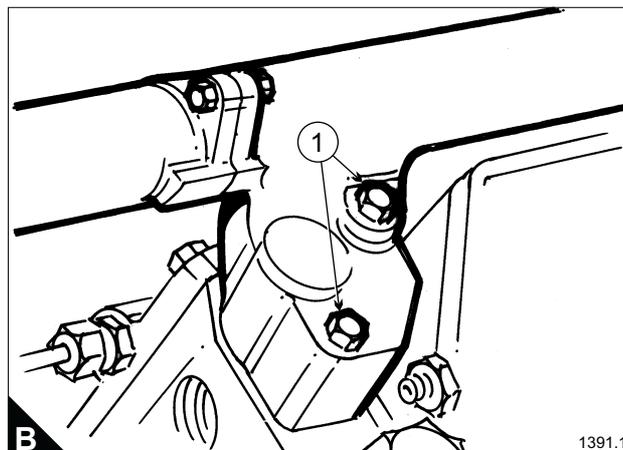
To release from cylinder heads

12-6

Caution: To stop distortion of the flexible bellows between manifold sections when the manifold is released from each cylinder head, it must be supported in the middle, and flywheel section using slings and hoist.

1 Remove the exhaust temperature probe (C1) from the manifold flange.

2 Remove the four retaining bolts and spacers (C2) holding the manifold to each cylinder head.



12

Detonation sensors

To remove and to fit

12-7

Special tools

Long socket - 27610177

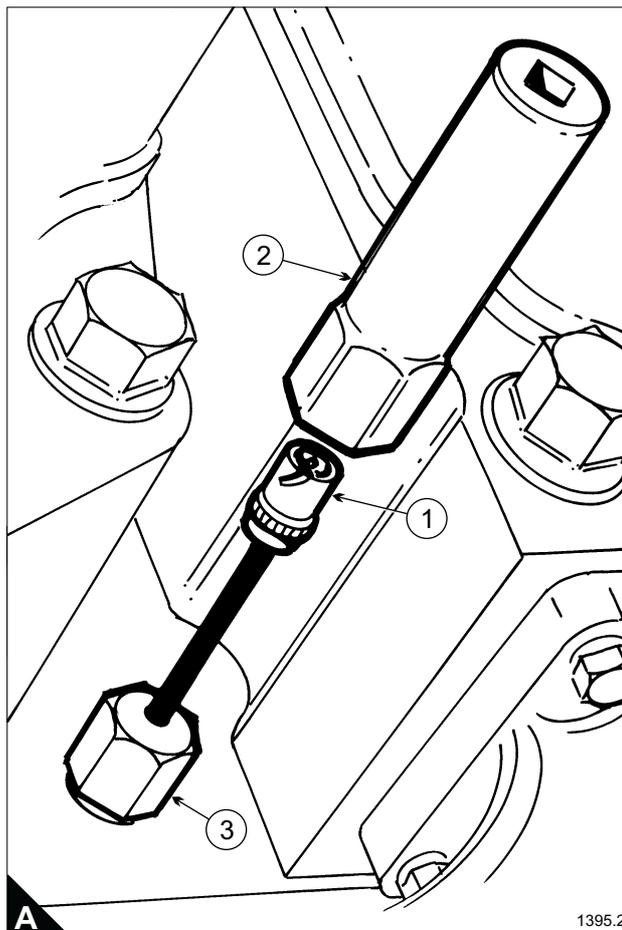
To remove

Caution: The four detonation sensors per bank must be removed to avoid them being damaged when the cylinder heads are being removed, or when a major overhaul is undertaken.

- 1 Disconnect the detonation sensor power cable plug (A1) from the sensor rail.
- 2 Fit the plug and cable into the long socket (A2) then locate the socket onto the hexagon of the detonation sensor (A3) and remove the sensor.

To fit

- 1 Check the thread on the sensor and in the crankcase is clean and dry.
- 2 Fit the sensor assembly into the long socket, carefully locate the sensor in the crankcase and screw down hand tight, then torque down to 10 lb.ft (15 Nm).
- 3 Reconnect the plug (A1) to the sensor rail.



Rocker box and valve gear

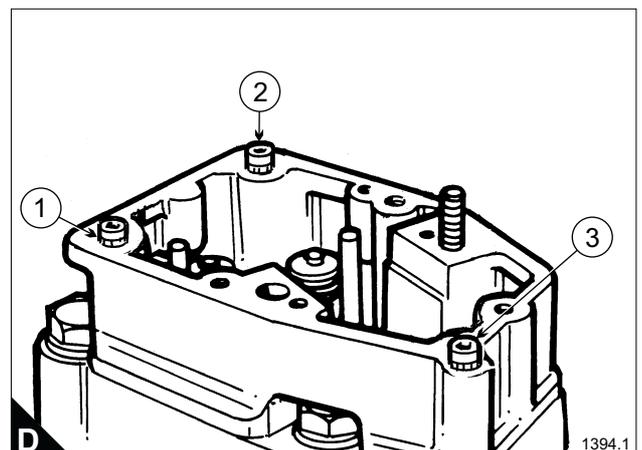
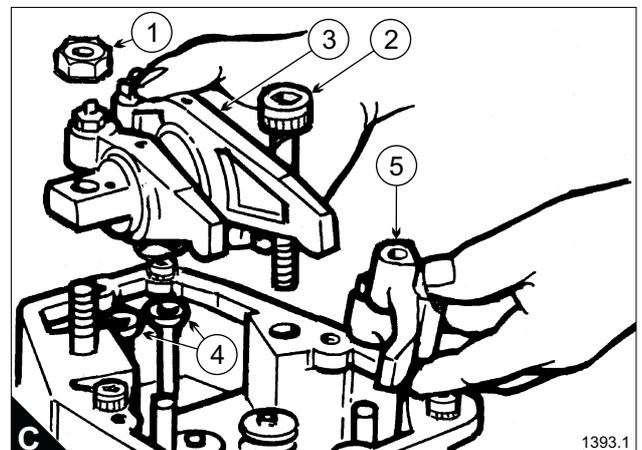
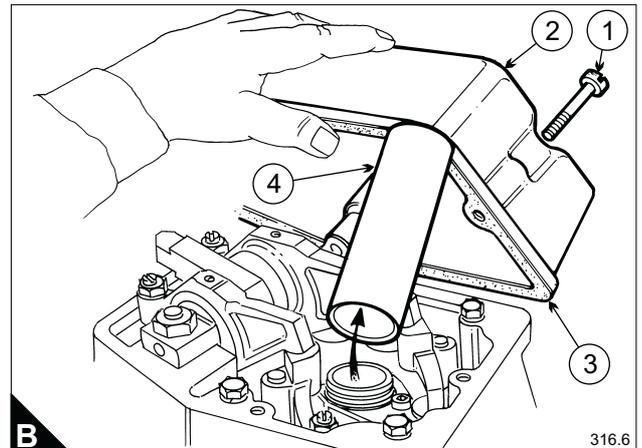
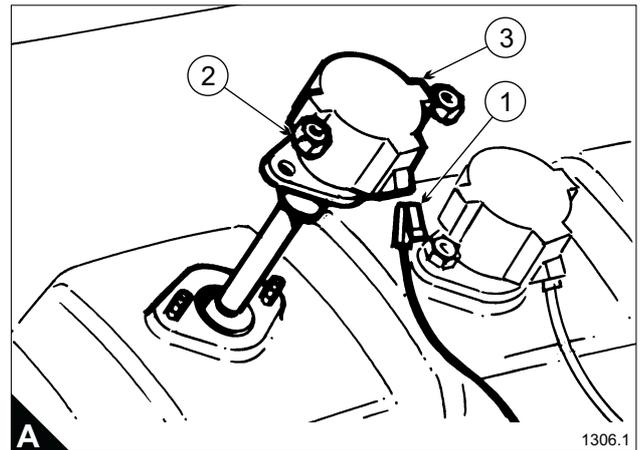
To remove and to fit

12-8

To remove

- 1 Disconnect the power lead (A1) to the ignition coil.
- 2 Remove the two retaining nuts (A2).
- 3 Pull the combined ignition coil / plug cap (A3) out of the rocker cover.
- 4 Remove the four retaining screws (B1) from each rocker cover (B2).
- 5 Lift off the rocker cover, remove and discard the gasket (B3).
- 6 Pull the spark plug cover tube (B4) out of the cylinder head.
- 7 Remove the nut (C1) and the capscrew (C2) retaining the rocker shaft. Then lift off the rocker assembly (C3) take out the push rods (C4), plus the inlet and exhaust rocker bridges (C5) marking them for reassembly.
- 8 Remove the rocker box retaining capscrews (D1) to (D3) in the order shown. Remove the rocker box.

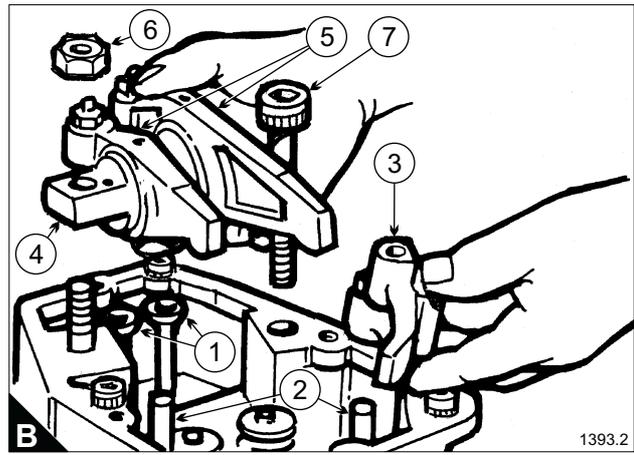
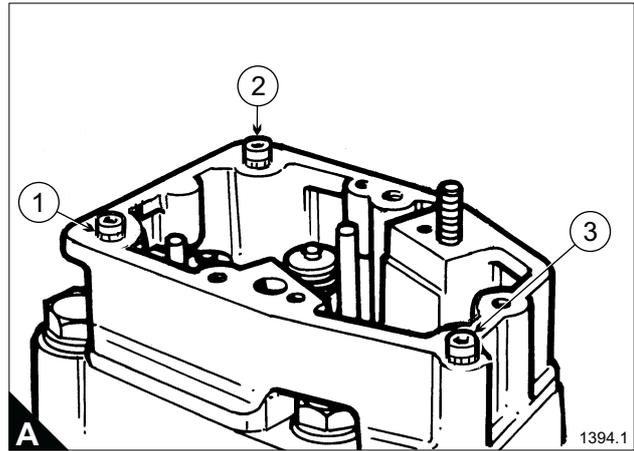
Note: To free the rocker cover and rocker box from the jointing material a light blow with a soft faced hammer may be necessary.



12

To fit

- 1 Fit a new rocker box sealing joint to the cylinder head.
- 2 Fit the rocker box locating it onto the dowels in the cylinder head face.
- 3 After lubricating the thread fit the rocker box locating capscrews and washers finger tight (A).
- 4 Lubricate the bearing surfaces of the push rods and fit them. Check they are located in the cam followers (B1).
- 5 Lubricate the bridge piece guide pillars (B2) and fit the bridge pieces (B3).
- 6 Lubricate the rocker shaft (B4) then fit the rockers (B5).
- 7 Fit the rocker assembly to the rocker box, checking the rockers are located in the push rods.
- 8 Lubricate the threads and fit the locating nut (B6) and the capscrew (B7), tighten them down hand tight checking the push rods remain located on the rockers.
- 9 Torque the nut (B6) and capscrew (B7) to 90 lb.ft (120 Nm) then rocker box capscrews to 50 lb.ft (70 Nm) in the order shown in (A1-A3).
- 10 Set bridge pieces, valve clearances, spark plug tube, rocker cover etc (see User's Handbook, section 4 pages 20-21).



Cylinder heads

To remove and to fit

12-9

Special tools

Cylinder head lifting tool T6253/154

To remove

1 Release the torque loading on the cylinder head bolts in the order shown (A1) then remove them.

Caution: The cylinder head bolts can only be used twice to record their fitting each bolt should be marked with a centre punch dot. **BOLTS SHOWING TWO DOTS MUST BE REPLACED (D).**

2 Fit cylinder head lifting tool (B1) and hoist the cylinder head from the engine.

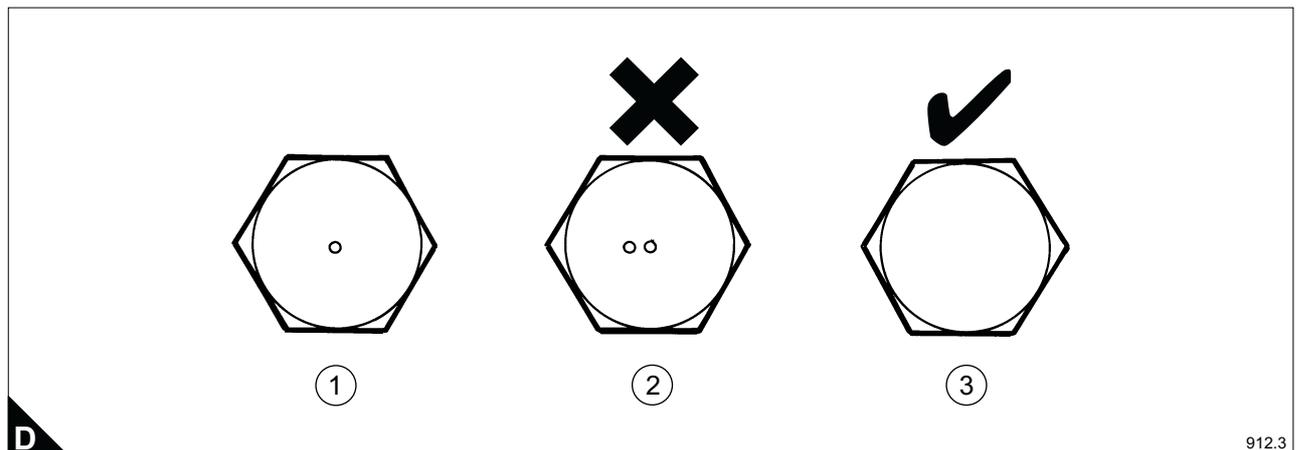
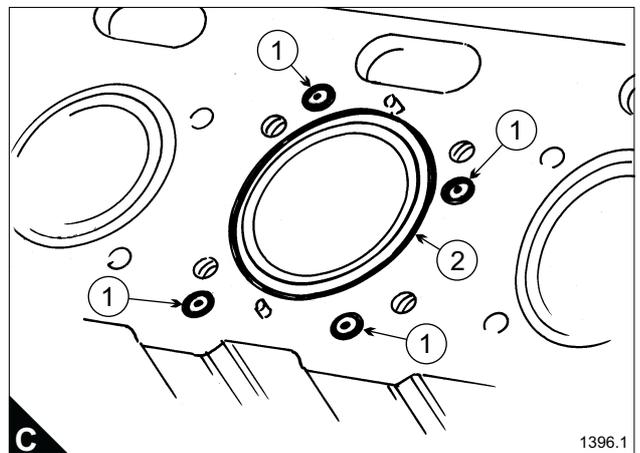
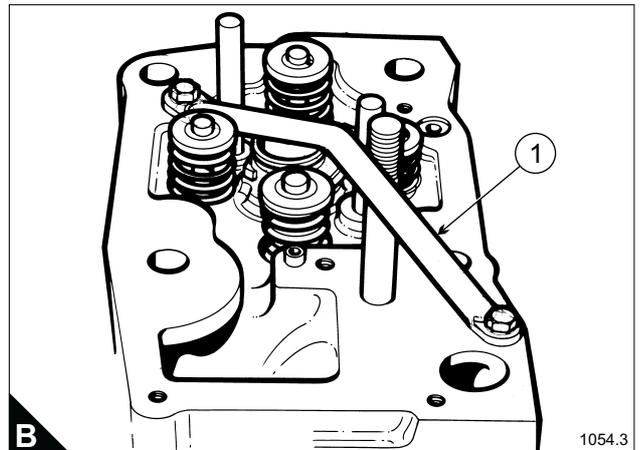
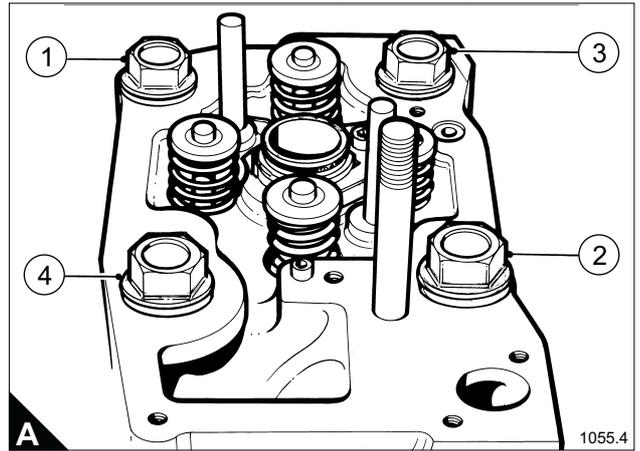
Warning! If the 'O' rings have been burned or overheated the dangerous "hydrofluoric acid" is produced, follow the "Safety precautions" and environmental protection on page 13, Section 10.

3 Discard the 'O' rings (C1) and flame ring (C2) clean the surface of the crankcase.

4 Rotate the engine setting the piston halfway down its cylinder.

5 Rotate the engine, setting the piston at TDC, clean the carbon deposit from the piston use compressed air to blow carbon particles away.

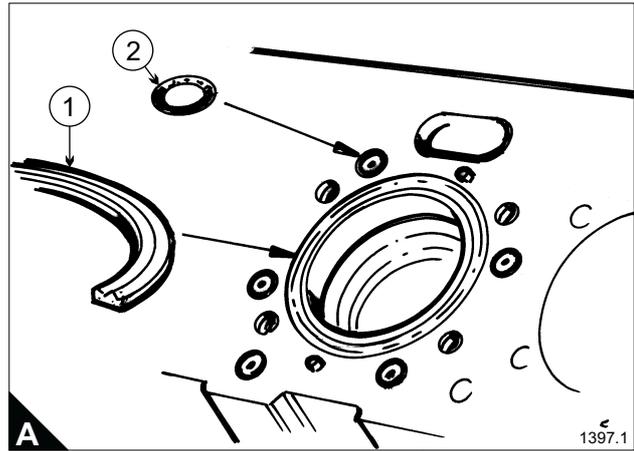
Note: The carbon deposits will vary with the gas being used and the condition of the engine.



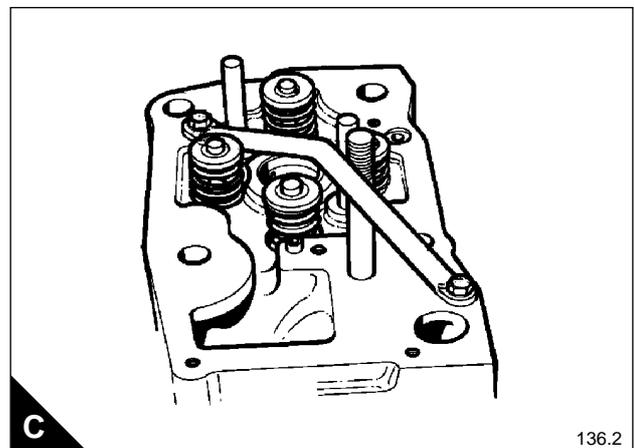
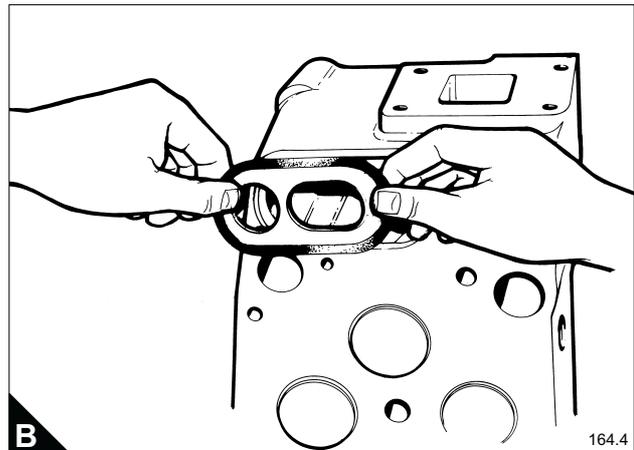
12

To fit

- 1 Check the cylinder block face is clean.
- 2 Fit the flame ring (A1) to the liner flange and place the four 'O' rings (A2) in their recesses, holding them in position using petroleum jelly.
- 3 Fit the push rod tunnel, 'O' ring, and its plastic insert into the recess in the combustion face of the cylinder head, holding it in position with petroleum jelly (B).
- 4 Fit the cylinder head lifting tool and hoist the cylinder head into position (C).
- 5 Seat the head on its two locating dowels also making sure that the push rod tunnel 'O' ring is still in position.
- 6 When the cylinder head is in position, remove the lifting tool.



Continued



7 Using PBC (Poly Butyl Cuprysil) grease, apply one 'stripe' to the threads (A) and coat both sides of the washers fitted under the bolt heads, before starting them in the crankcase.

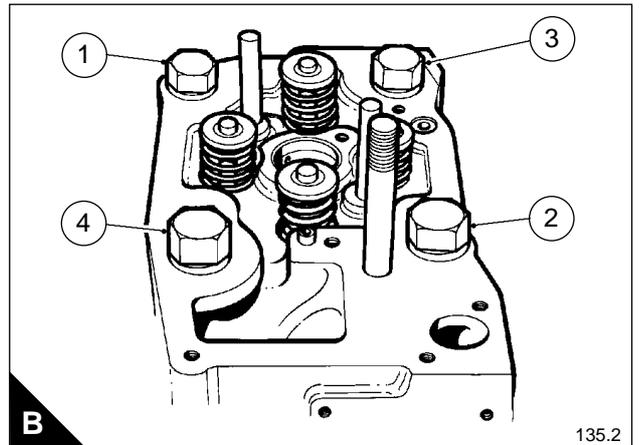
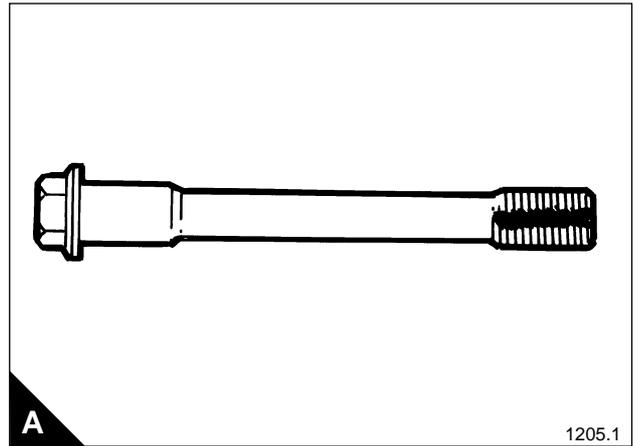
Note: It is important not to exceed the amount of PBC grease recommended above.

8 The bolts should be tightened in the order shown (B) and the torque sequence in the table below.

Head bolt torque sequence

1	Hand tight
2	100 lb.ft (135 Nm)
3	200 lb.ft (270 Nm)
4	400 lb.ft (540 Nm)
5	530 lb.ft (718 Nm)

Caution: Do not exceed the maximum torque setting.



12

Spark plug bush

General description

The spark plug bush need only be removed if a coolant leak occurs.

To remove and to fit

12-10

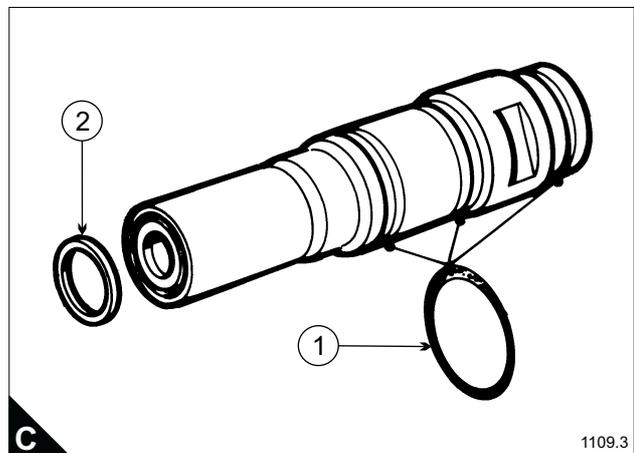
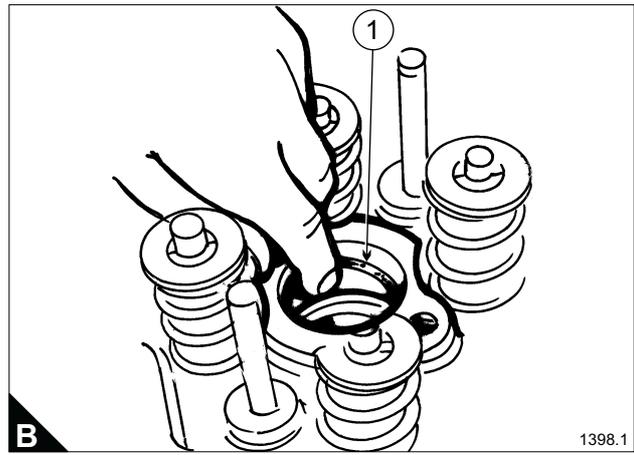
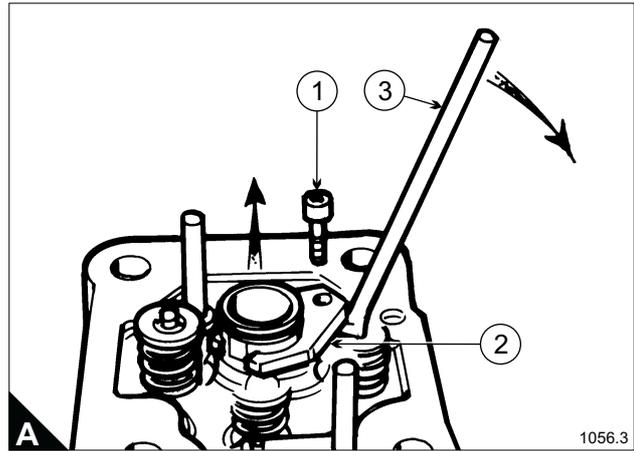
Special tools

Crowfoot lever "Universally available"

To remove

- 1 Remove the capscrew (A1) retaining the spark plug bush clamp (A2).
- 2 Using a crow-foot lever (A3) on the underside of the clamp, extract the spark plug tube from the cylinder head.
- 3 Remove the 'O' rings (B1) from its seat in the cylinder head.
- 4 Discard the 'O' rings (C1) and carefully prise the copper sealing washer (C2) from its counterbore in the end of the spark plug bush.
- 5 Check the spark plug bush and the cylinder head for corrosion and coolant leakage.

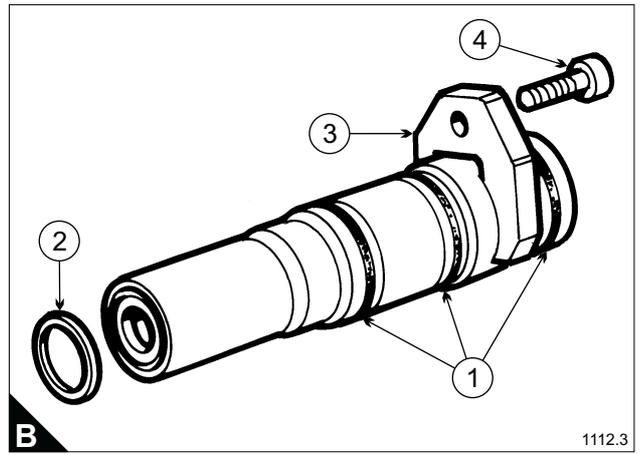
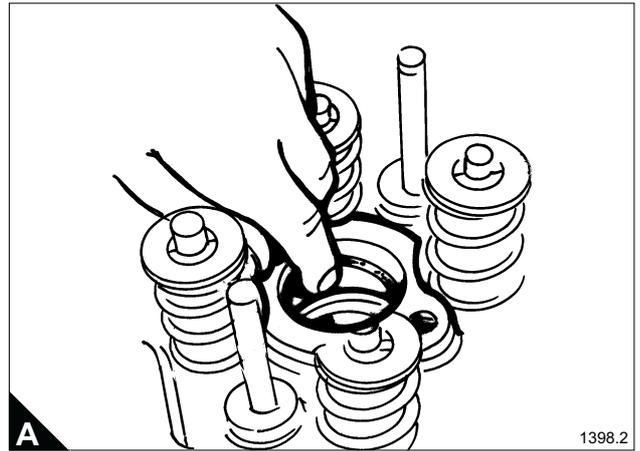
Note: The spark plug bush comes fitted in a service exchange cylinder head.



To fit

Note: The spark plug bush seating in the cylinder head and the bush must be clean and free from corrosion etc before fitting.

- 1 Fit a new 'O' ring into its seat in the cylinder head (A).
- 2 Fit new 'O' rings to the spark plug bush (B1).
- 3 Fit a new copper sealing washer (B2) into its counterbore retaining it using Loctite Ultra Copper RTV Silicone (Loctite part No. 82046).
- 4 Fit the retaining clamp (B3), then lightly oil the spark plug bush to assist fitting.
- 5 Carefully push the bush assembly into the cylinder head locate the capscrew (B4) in the cylinder head and screw down finger tight.
- 6 Torque the retaining capscrew down to 100 lb.ft (135 Nm).



12

Valve gear (rockers)

To inspect

12-11

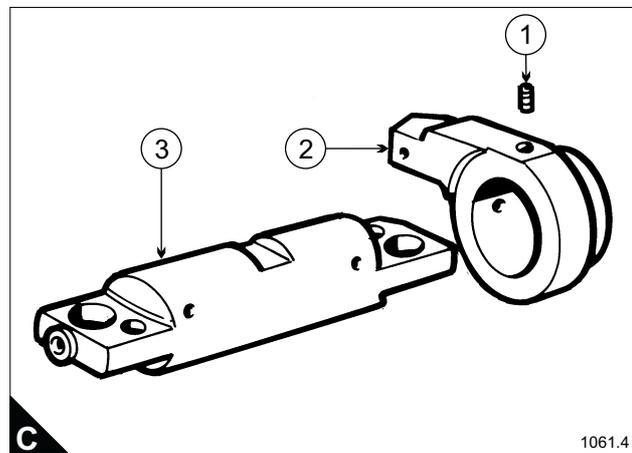
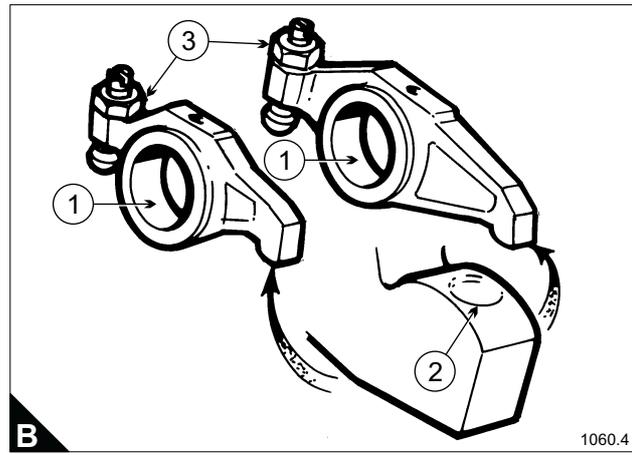
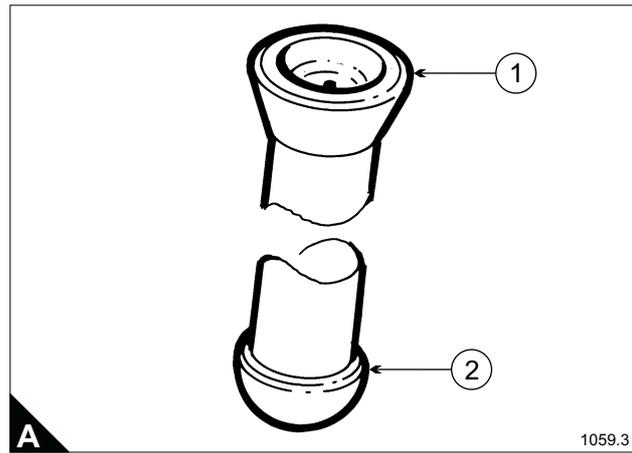
1 Check the push rods are straight and the cup end (A1) and spherical end (A2) are smooth surfaced and concentric with no chips or cracks.

2 Slide the rockers from the rocker shaft check the bearing surface (B1) is free from scoring and is within the Wear and renewal limits on page 30. Check the contact patch (B2) on each rocker is not indented or chipped.

Note: A small indentation may be removed with an oil stone, carefully following the radius.

3 Check the adjuster screws (B3) and their locknuts are undamaged.

4 Remove the grub screw (C1) and slide the spacer/oil jet (C2) from the rocker shaft (C3) check the rocker shaft for scoring and that it is within Wear and renewal limits on page 30. Check the oil galleries in the rocker shaft and the oil jet are clear.



Valve gear (bridge pieces)

To inspect

12-12

1 Check the bridge piece and its guide pillar (A1) are within the specified Wear and renewal limits on page 30.

2 Check the valve contact patch (A2) is not indented.

Note: A small indentation may be removed with an oil stone.

3 Check the equalising screw (A3) and its locknut are undamaged.

4 Check the bridge piece pressure pad (A4) for wear in the form of a deep indentation. If the pressure pad is worn it must be replaced.

To replace the pressure pad

12-13

1 Using a hammer and drift, drive the pressure pad out of the bridge piece from the underside (A5).

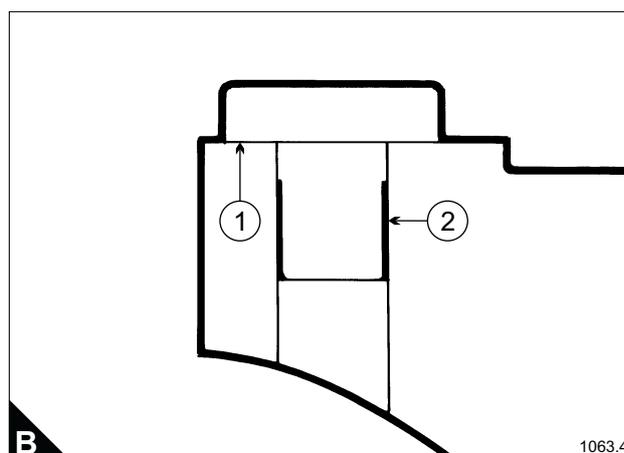
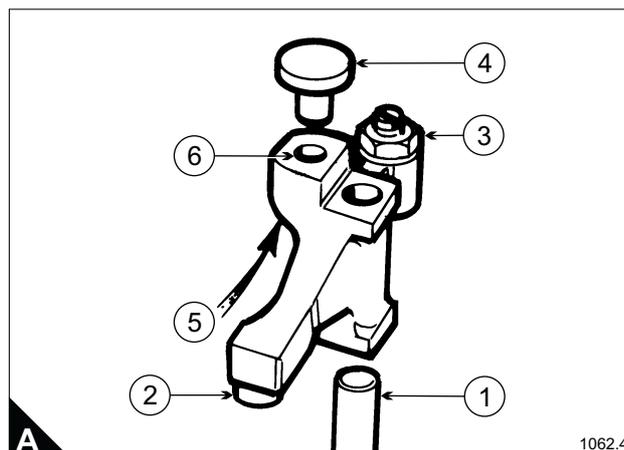
2 Clean the bridge piece paying special attention to old Loctite in the bridge piece bore (A6).

3 Apply Loctite Activator 'T' (aerosol can) to the new pressure pad stem and the bridge piece bore. Allow to dry.

4 Apply Loctite 603 to the pressure pad stem and the bridge piece bore.

5 Rotate the pressure pad when fitting into place. Stand the assembly upright (pressure pad up) and allow to cure for 2 hours minimum.

Caution: Loctite must be applied to the area (B2) and the pressure pad must be seated with no gap between it and the bridge piece. There must be no Loctite in area (B1).



13

Piston and connecting rod

Con rod end float

To remove and to check **13-1**

Special tools

Barring over tool SE253

Piston removal/fitting tool T6253/295

1 Remove the cylinder head in question (see Section 12, page 41).

2 Fit the engine cranking device (see Users Handbook section 4, page 20).

3 Remove the piston cooling jets see Section 19, page 93.

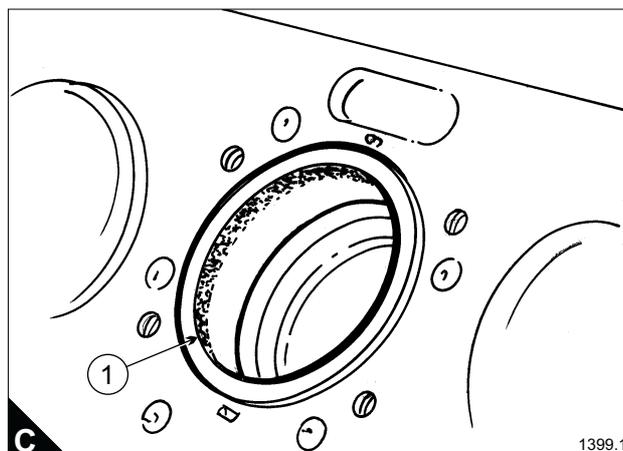
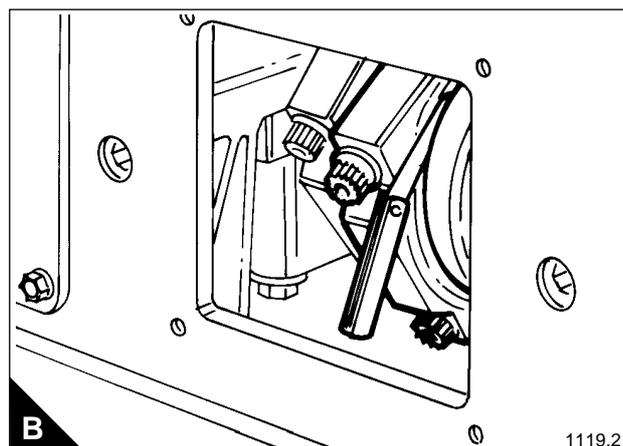
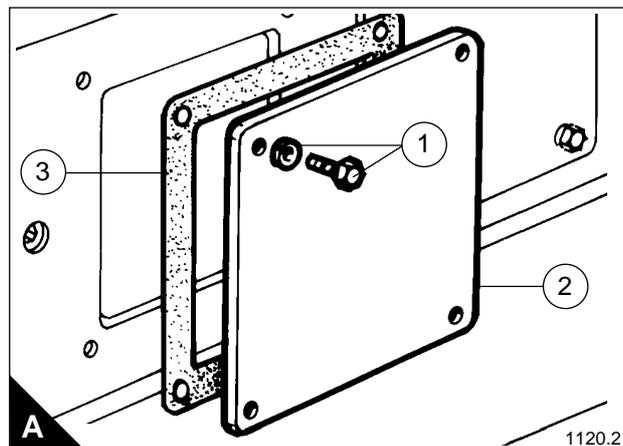
4 Remove the crankcase inspection cover (A2) take out the retaining bolts and washers (A1) discard the sealing joint (A3).

5 Rotate the engine to a position where the conrod end float can be checked. Use the feeler gauges set between the crankshaft and conrod (B). Maximum end float is 0.014 - 0.026 (0.36 - 0.68).

Caution: The carbon ring in the top of each cylinder bore (C1) must be removed to allow for piston removal. Failure to do so can result in broken rings or the piston jammed in the bore.

6 Remove the carbon from the top of the cylinder liner (C1) use a scraper or rotary wire brush, taking care not to scratch the liner surface. All of the carbon deposit must be removed.

7 Rotate the engine to TDC, clean any loose carbon from the piston.



Continued

13

8 Remove the big bolts (A1) and carefully pull off the cap and half bearing (A2).

Caution: The big end cap bolts can only be used three times. To record their fitting each bolt should be marked with a centre punch dot. Bolts showing three dots must be replaced (B).

9 Set the piston at TDC, then place the lifting tool on the piston (C).

Note: The lifting tool operates using suction to hold it to the piston.

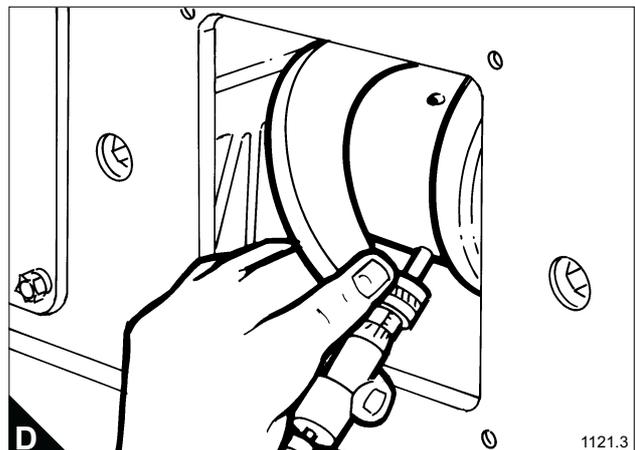
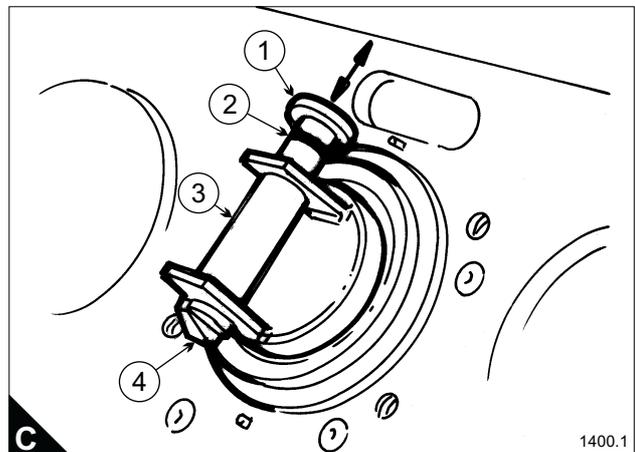
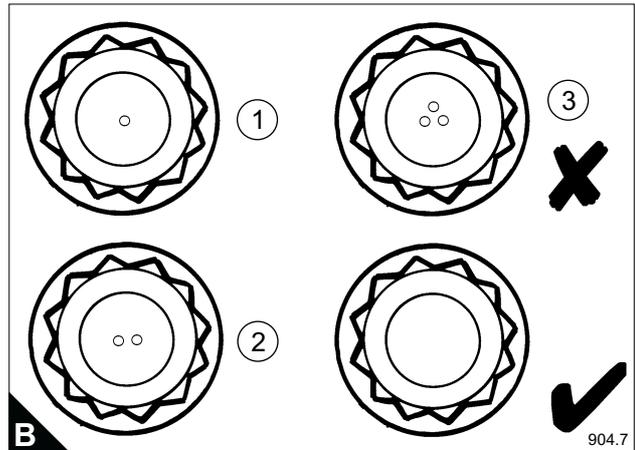
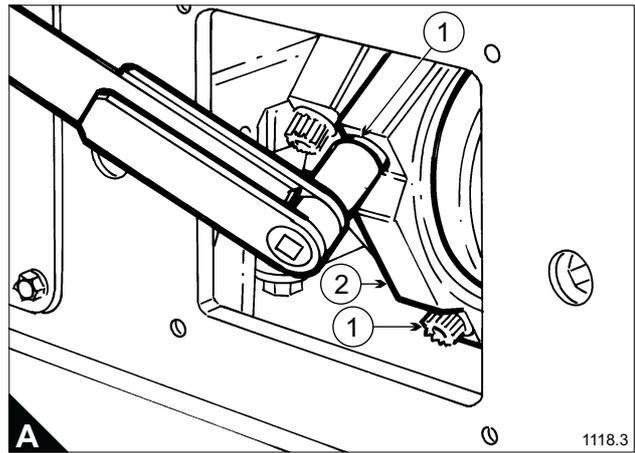
10 To create the required suction operate the pump (C1) until the red line (C2) has disappeared using the handle (C3) pull the piston and con rod from the engine. Detach the lifting tool by pressing the red button (C4).

11 Visually check the condition of the big end shell bearings.

12 Replace the 'big end' cap and shell bearing in the connecting rod, screwing the bolts in finger tight to hold the cap in position.

Caution: 'Big end' caps are NOT interchangeable and must be fitted with the identification numbers on the same side.

13 Visually check the condition of the crankpin, then check its size (D) against The schedule of wear and renewal limits see Section 11, page 30.



Piston

To fit **13-2**

Special tools

Piston slip ring tool T6253/139

Piston removal/fitting tool T6253/295

1 Fit the shell bearing to the con rod, check the tag (A1) is located in the con rod.

Caution: The piston has a cut out in its skirt (B1) to clear the piston cooling jet relative to the offset of the con rod as viewed from the front of the engine.

2 Coat the cylinder liner and crank pin with engine oil.

3 Fit the lifting tool to the crown of the piston (C1).

4 Slide the piston ring compressing tool T6253/139 (C2) onto the piston up to the bottom ring and insert the assembly into the cylinder bore (C).

5 Gently push the piston down the bore while at the same time guiding the con rod onto the crank pin.

6 Remove the piston ring compressing tool.

7 Fit the shell bearing to the connecting rod end cap.

8 Lubricate the shell bearing and the threads and underside of the bolt heads.

9 Fit the end cap making sure the identifying numbers on rod and cap are on the same side (D1).

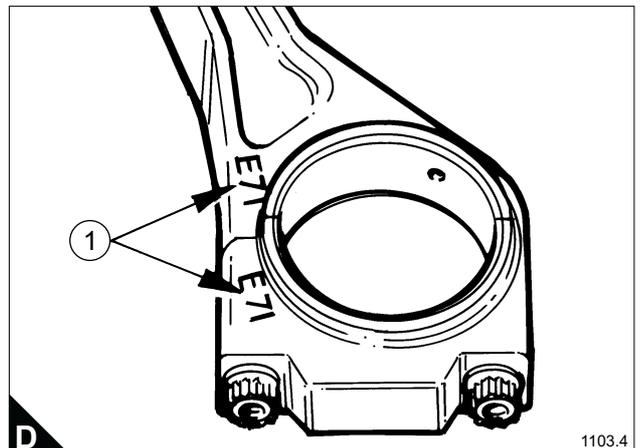
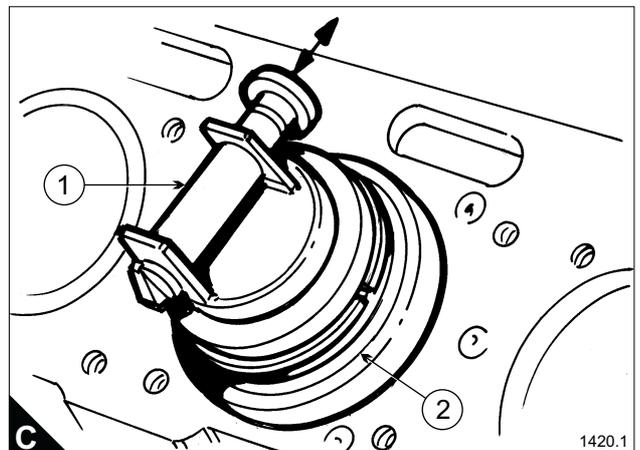
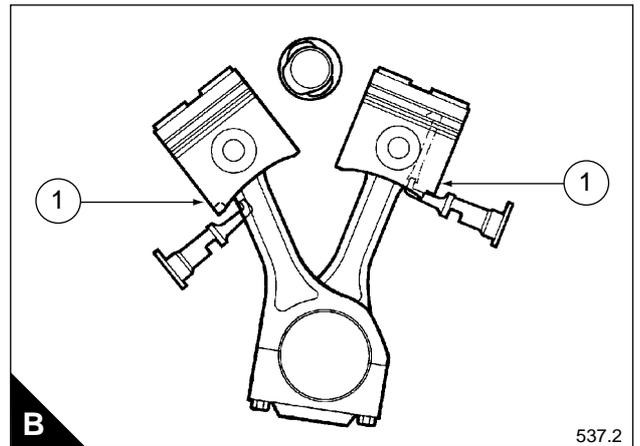
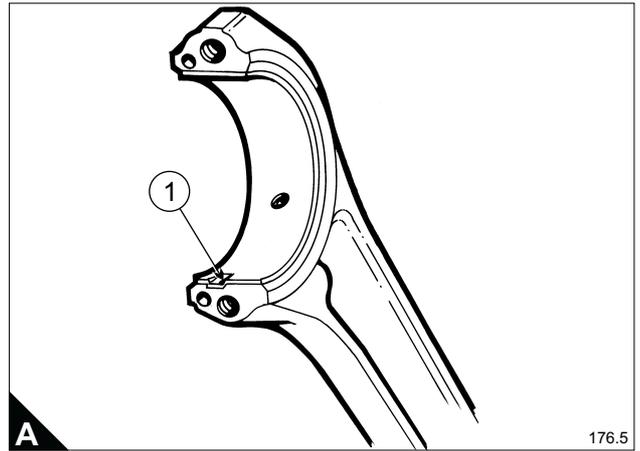
10 Tighten the connecting rod bolts hand tight checking the end cap has pulled fully up to the connecting rod.

11 Tighten the connecting rod bolts down in the sequence given in the table checking the engine rotates freely between each torquing stage.

STAGE	TORQUE
1	80 lb.ft (108 Nm)
2	160 lb.ft (216 Nm)
3	200 lb.ft (270 Nm)

Caution: When fitting new big end bolts to a used con rod the torque stages above must be used. For the fitting of a new con rod and bolts see Section 13, page 57.

Continued

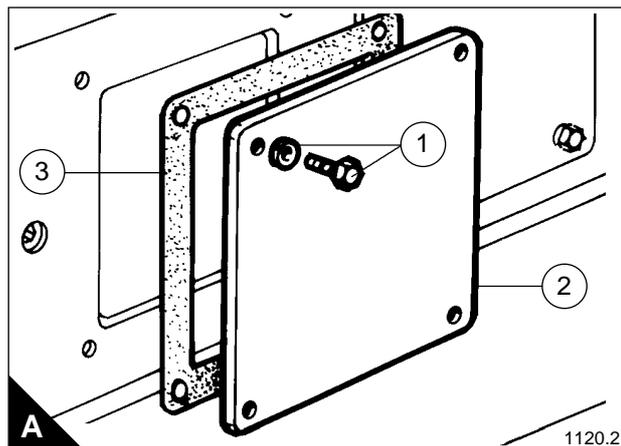


13

12 Refit the crankcase cover (A2) using a new joint (A3) fit the retaining bolts (A1) finger tight, then torque them to 35 lb.ft (50 Nm) in a diagonal pattern pulling the cover squarely to the crankcase.

13 Fit the piston cooling jets see Section 19, page 94.

14 Fit the cylinder heads see Section 12, page 43.



Pistons and rings

To check 13-3

Special tools

Circlip pliers T6253/238

Piston ring pliers T6253/256

1 Remove the piston from the con rod, take out and discard the circlips (A1) then push out the gudgeon pin (A2).

2 Visually check the pistons and rings for seizure marks etc. If any are found the piston / rings and possibly the cylinder liner should be replaced.

3 If the pistons look serviceable check the piston to ring clearance using feeler gauges (B1) see Section 11, page 30 Wear and renewal limits.

Caution: *If new piston rings cannot rectify the excessive clearance a new piston and rings must be fitted.*

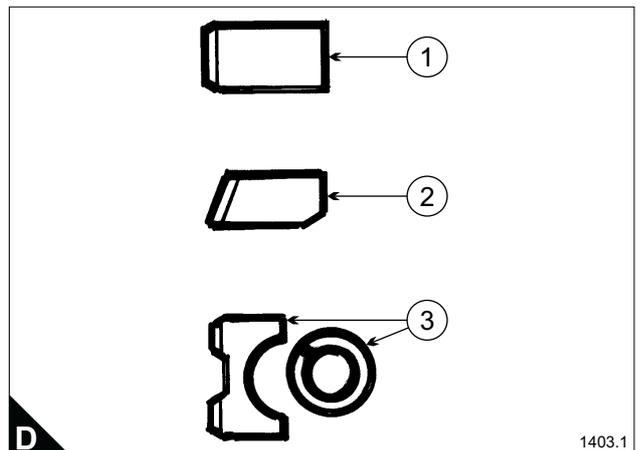
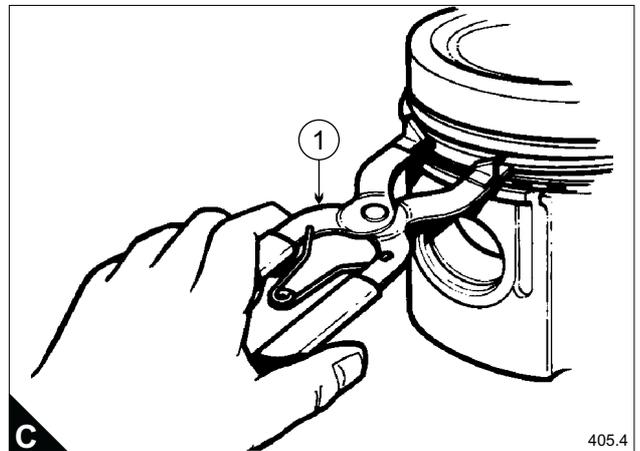
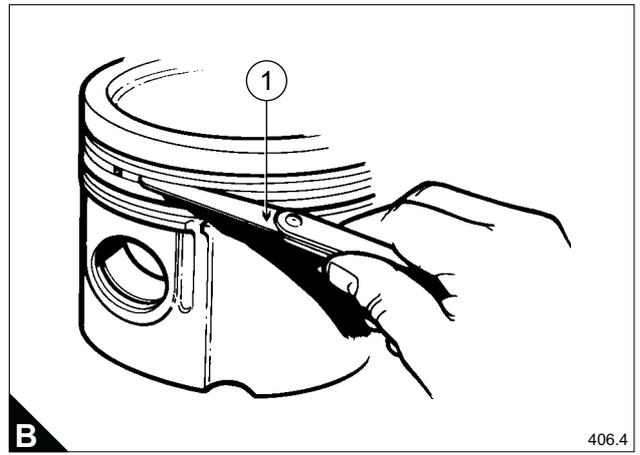
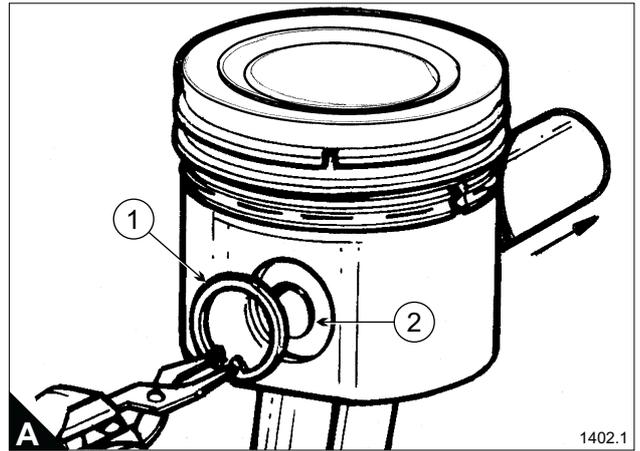
4 Remove the piston rings using the piston ring pliers (C1).

(D) Piston ring identification

- ① First compression, chromium-ceramic faced rectangular ring 4.5 mm width marked top.
- ② Second compression chromium faced tapered ring 3.5 mm width marked top.
- ③ Oil control spring loaded, chromium faced bevel edged ring 6 mm width.

Caution: *The oil control ring is not marked and may be fitted either side up as it is symmetrical. If a used ring is to be refitted, it must be in its original position.*

Continued



13

5 Check the ring gap by setting a piston ring 25 mm (1") from the bottom of the cylinder liner (in the unworn area) (A1).

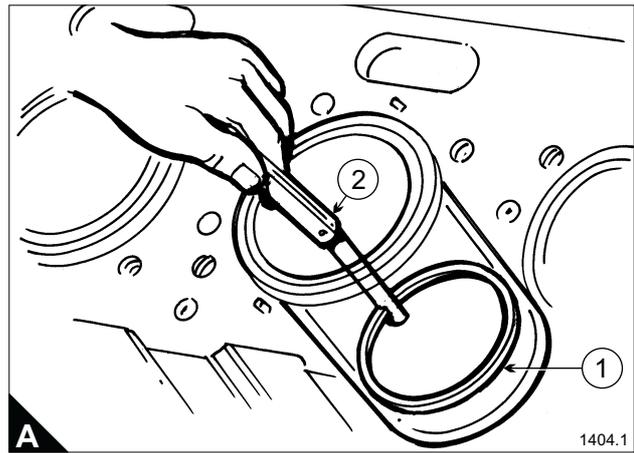
6 Push the ring down the liner using a piston this will set the ring squarely in the bore giving an accurate indication of the piston ring gap.

7 Check the gap using feeler gauges (A2) see Section 11, page 30 Wear and renewal limits.

8 Before fitting the piston rings carefully clean the pistons, removing the carbon deposit from the piston crown and ring lands, also check the piston cooling oil gallery on the underside of the piston is clear.

Note: Do not use an abrasive medium for this operation.

9 Under normal circumstances the gudgeon pin will last the life of the piston. If the gudgeon pin appears to be worn check it using a micrometer and refer to Wear and renewal limits, see Section 11, page 30.



Conrod

To check 13-4

Special tools

Small end bush inserter and extractor T6253/159

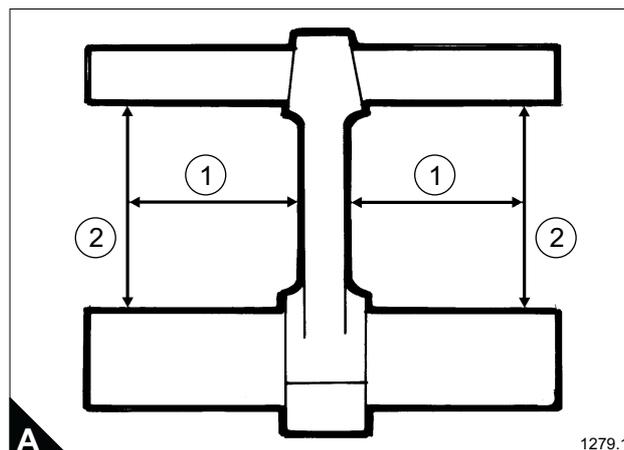
- 1 Visually check the connecting rod for wear or damage.
- 2 At major overhaul check the connecting rods for distortion using test mandrels.
- 3 The con rod bores must be square and parallel with each other within + or - 0.127 mm (0.005") measured 127 mm (5") (A1) each side of the test mandrel (A2).
- 4 Check the small end bush for wear or other damage, see Section 11, page 30 Wear and renewal limits.
- 5 If the small end bush has to be replaced, the special tool is used for removal and fitting.

Note: A new small end bush is pre-finished and does not need reaming after fitting.

Cautions:

- *The engines original set of connecting rods were matched within a defined weight band. The weight of each individual connecting rod is painted on its shank. This information is required by your Perkins Agent when supplying a replacement.*
 - *The torque stages given below are to be used when fitting a new con rod and new big end bolts.*
- 6 Tighten the connecting rod bolts down in the sequence give in the table checking the engine rotates freely between each torquing stage.

STAGE	TORQUE
1	80 lb.ft (108 Nm)
2	160 lb.ft (216 Nm)
3	210 lb.ft (284 Nm)



13

Piston rings and piston to con rod

To fit **13-5**

Special tools

Circlip pliers T6253/238

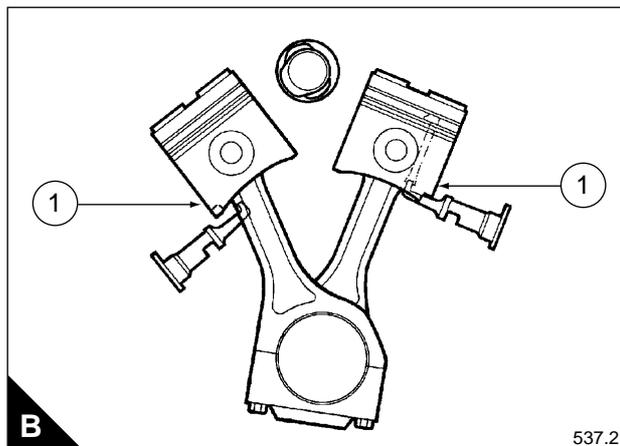
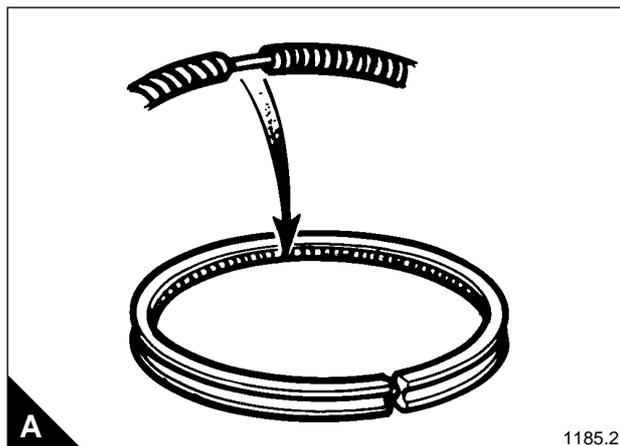
Piston ring pliers T6253/256

Caution: If a piston is fit for further service, ensure it is refitted to its original con rod.

- 1 Coat the piston ring lands and the piston rings with clean engine oil.
- 2 Refit the piston rings in their correct grooves, setting the ring gaps 120° apart, see Section 13, page 55.
- 3 Ensure the locating wire is in position in the oil control ring coil expander and that when fitted the ring gap and expander ends are opposite each other (A).
- 4 Fit a circlip to one side of the piston be sure it locates in its groove.
- 5 Coat the gudgeon pin, the small end bush and the piston with clean engine oil.

Caution: The piston has a cut out in its skirt (B1) to clear the piston cooling jet relative to the offset of the con rod as viewed from the front of the engine.

- 6 Push in the gudgeon pin and fit the second circlip.



14

Crankshaft damper and oil seal

Gearcase, crankshaft oil seal

To change

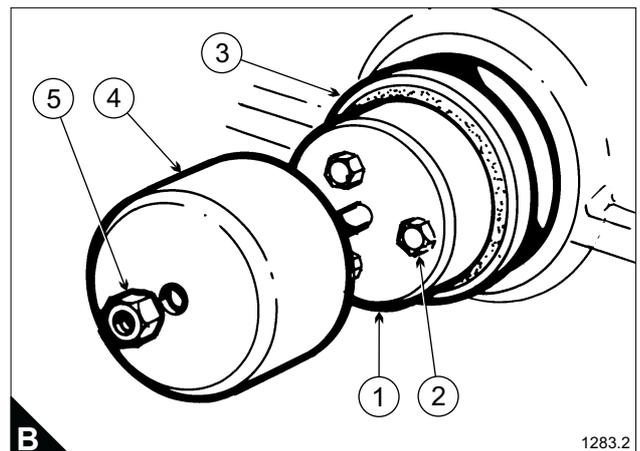
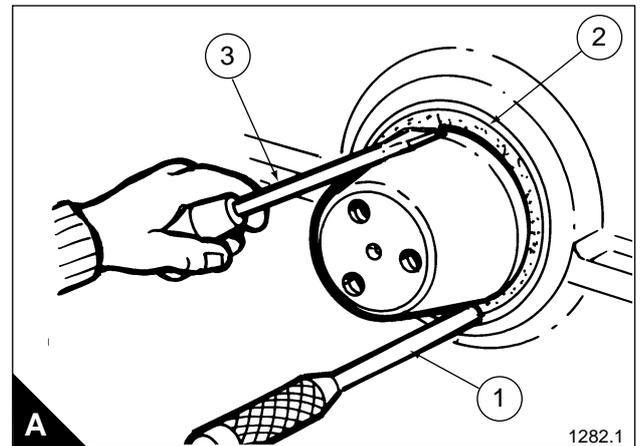
14-1

Special tools

Oil seal fitting tool T85316/1

Note: If a crankshaft oil seal has failed in service it can be replaced without removing the gearcase.

- 1 Remove the crankshaft damper guard, crankshaft damper and its adaptor, see Section 14, page 61.
- 2 Using a hammer and a round punch carefully knock the outer casing of the seal a small way into the gearcase (A1). The seal will distort and step out on its top edge (A2).
- 3 Push a screwdriver between the seal and its casing (A3), then carefully lever the oil seal from the gearcase.
- 4 Clean the seal location and fit the oil seal locator (B1) to the crankshaft. Tighten the three locating bolts (B2) hand tight pulling the locator squarely onto the crankshaft. Lubricate the seal and slide it up the locator to the gearcase (B3).
- 5 Fit the outer sleeve (B4) then tighten the nut (B5) pushing the seal into the gearcase.
- 6 Remove the oil seal fitting tool.
- 7 To fit the crankshaft damper and its guard see Section 14, page 62.



14

Flywheel housing, crankshaft oil seal

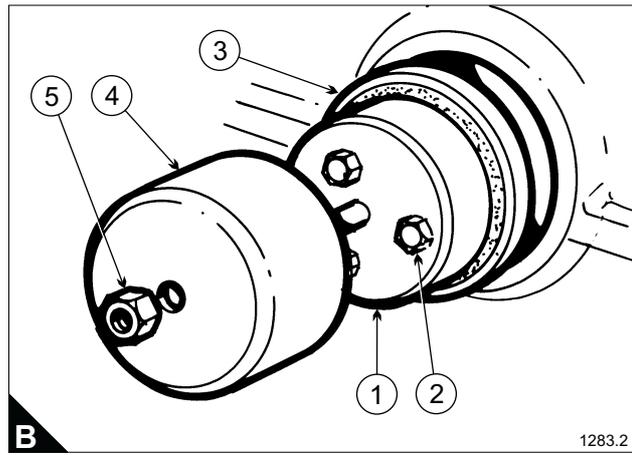
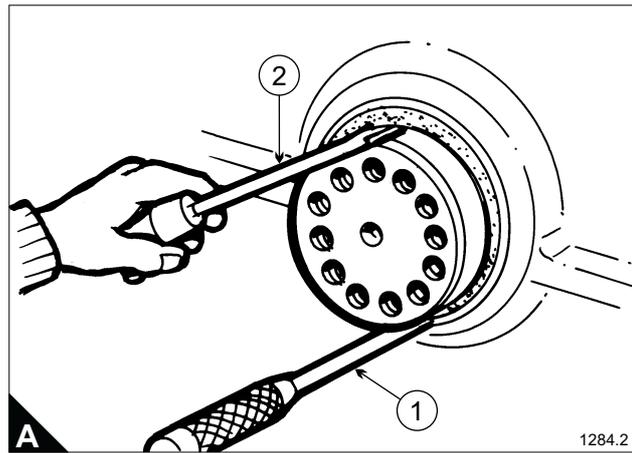
To change the crankshaft oil seal **14-2**

Special tools

Oil seal fitting tool 27610180

Note: If the flywheel housing oil seal has failed in service, it can be replaced without removing the housing.

- 1 Remove the flywheel, see Section 22, page 109.
- 2 Using a hammer and a round punch carefully knock the outer casing of the seal a small way into the housing (A1). The seal will distort and step out on its top edge.
- 3 Push a screwdriver between the seal and its casing (A2) then carefully lever the oil seal from the gearcase.
- 4 Clean the seal location and fit the oil seal locator (B1) to the crankshaft tighten the three locating bolts (B2) hand tight pulling the locator squarely onto the crankshaft.
- 5 Lubricate the seal and slide it up the locator to the gearcase (B3).
- 6 Fit the outer sleeve (B4) then tighten the nut (B5) pushing the seal into the gearcase.
- 7 Remove the oil seal fitting tool.
- 8 To fit the flywheel see Section 22, page 110.



Crankshaft damper

Note: The removal of the crankshaft damper is normally undertaken at major overhaul, the following procedure is based on the assumption the turbocharger and its support bracket have been removed.

Caution: The damper is filled with a silicone fluid contained in a closely fitting sealed casing, great care must be used in its removal as any damage to the outer casing will render.

To remove and to fit

14-3

Special tools

Damper lifting tool T6253/214

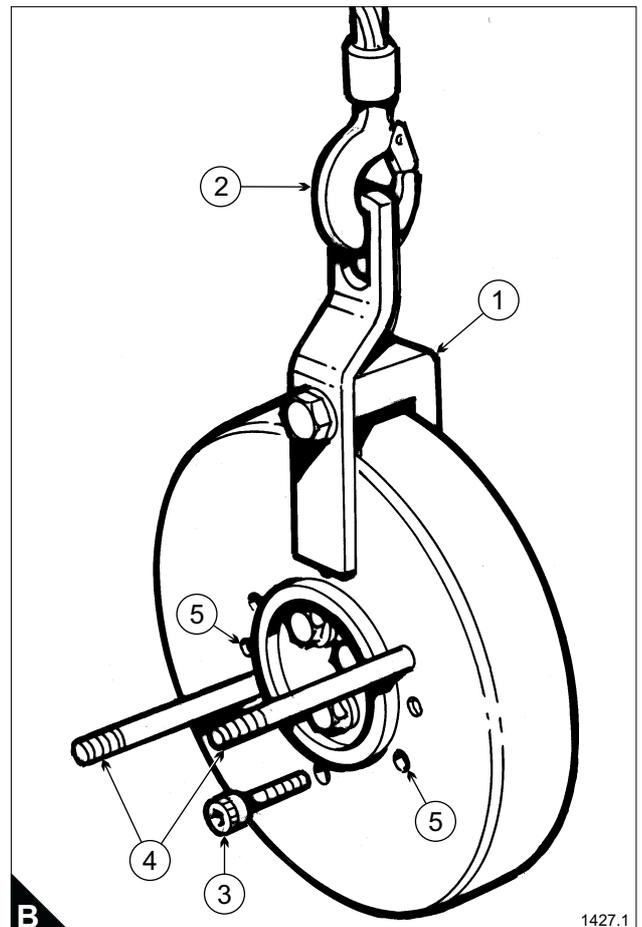
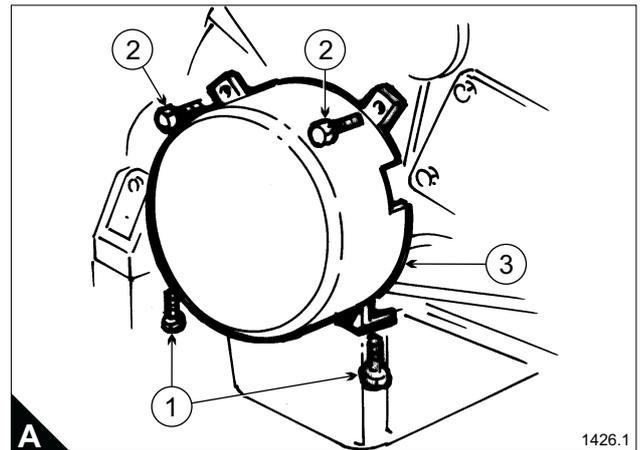
Guide studs T6253/157

Hoist "Universally available"

To remove

- 1 Remove the two retaining bolts (A1) from the sump flange mounting brackets on the damper guard.
- 2 Remove the two retaining nuts (A2) from the top mounting flanges and lift off damper guard (A3).
- 3 Fit the lifting tool (B1) to the damper, set the hoist to give light tension on the sling (B2).
- 4 Remove the eight retaining capscrews (B3) and fit the guide studs (B4).
- 5 Fit two of the retaining capscrews into the threaded holes in the damper (B5) tighten them evenly to pull the damper from the crankshaft damp adaptor and onto the guide studs (B4).
- 6 Take the weight of the damper with the hoist, then slide the damper along the guide studs.

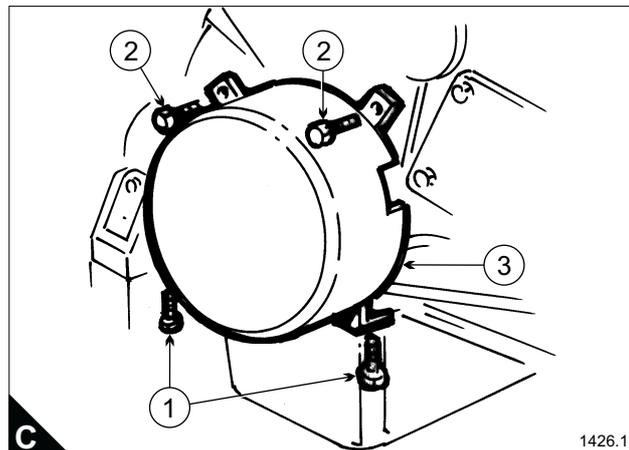
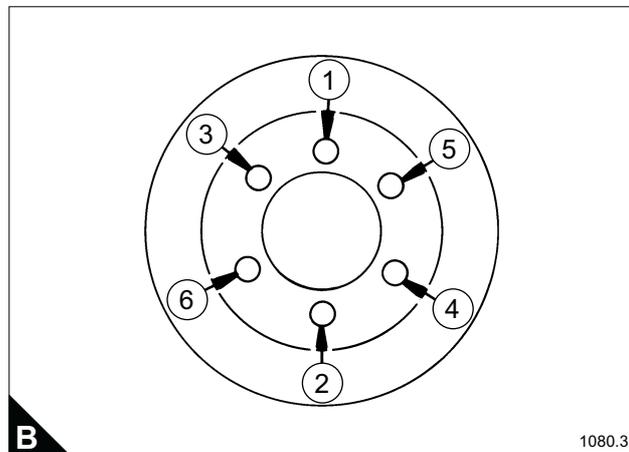
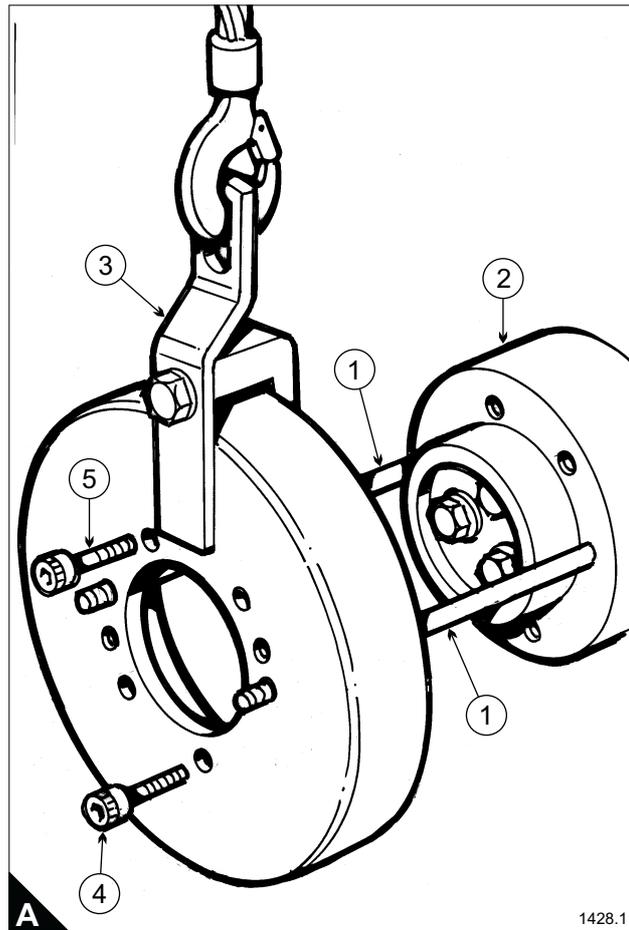
Caution: Check the hoist is set to support the damper when it leaves the guide studs.



14

To fit

- 1 Fit the guide studs (A1) into the crankshaft damper adaptor (A2).
- 2 Fit the damper lifting tool (A3) and hoist the damper into position, lining it up with the guide studs.
- 3 Slide the damper along the guide studs and onto the damper adaptor (A2).
- 4 Fit one retaining capscrew (A4) in the lower edge of the damper, tighten hand tight to hold the damper in position.
- 5 Release tension on sling and remove the lifting tool (A3).
- 6 Fit one retaining capscrew (A5) in the top edge of the damper, tighten hand tight to hold the damper in position.
- 7 Remove the guide studs (A1).
- 8 Fit all of the retaining capscrews tighten them diagonally by hand pulling the damper squarely to the adaptor. Then torque the capscrews to 250 lb.ft (340 Nm) in the order shown (B).
- 9 Refit the damper guard (C1) tighten the retaining nuts (C2) and the bolts (C3) by hand then torque to 41 lb.ft (56 Nm).



To remove and to fit the crankshaft damper adaptor

14-4

Special tools

Damper adaptor pulley T6253/209

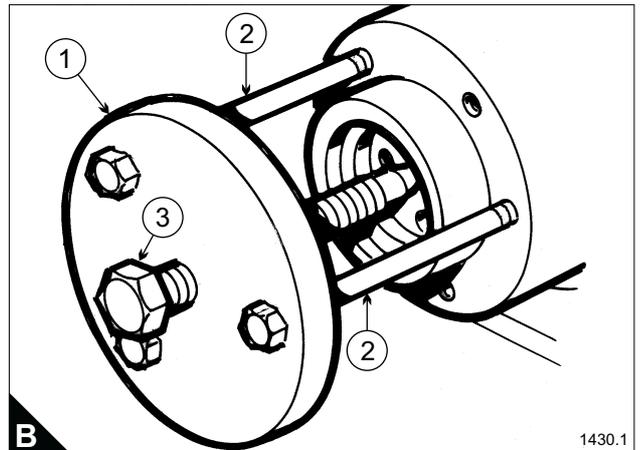
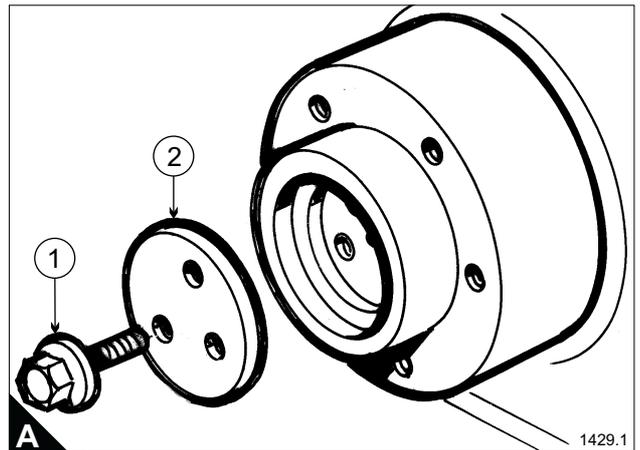
To remove

- 1 Remove the three retaining bolts (A1) and the retaining plate (A2).
- 2 Fit the extractor tool (B1) screwing the three bolts (B2) evenly into the adaptor, and lining the extractor bolt (B3) with the counterbore in the end of the crankshaft.
- 3 Tighten the extractor bolt until the adaptor is released from the taper on the crankshaft.

Warning! *The energy released in this operation can result in the extractor adaptor assembly coming away with violent force. Great caution is required for this operation.*

To fit

- 1 Check the taper end of the crank and the bore of the damper adaptor are clean and dry.
- 2 Fit the damper adaptor onto the crankshaft.
- 3 Lightly lubricate the threads of the retaining bolts (A1) with Poly Butyl Cuprysil grease.
- 4 Fit the retaining plate (A2) and the three bolts, tighten them evenly by hand, bringing the retaining plate in even contact with the adaptor.
- 5 Torque the retaining bolts to 380 lb.ft (520 Nm).



15

Gearcase, timing gears and camshaft

Note: Removal of the gearcase, timing gears and camshaft is normally undertaken at major overhaul. The following procedures are based on the assumption that the engine is to be removed from its installation, the cylinder heads, manifolds, turbo, ignition and sensor rails etc have been removed.

Gearcase

To remove and to fit	15-1
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Special tools

Lifting eye T6253/236

Hoist and slings "Universally available"

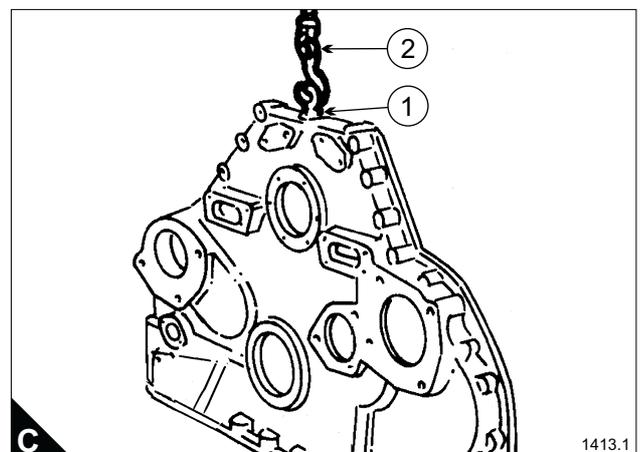
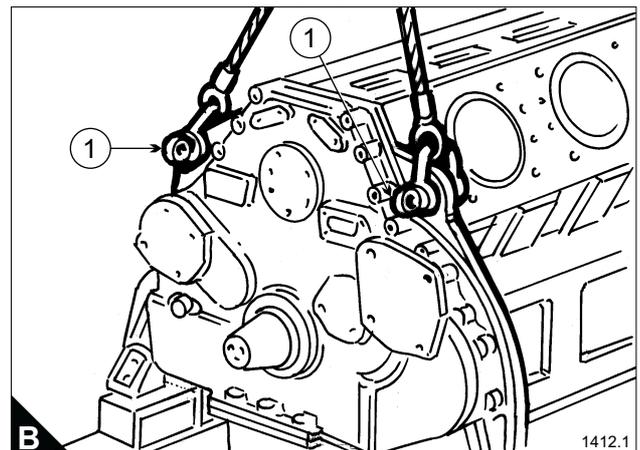
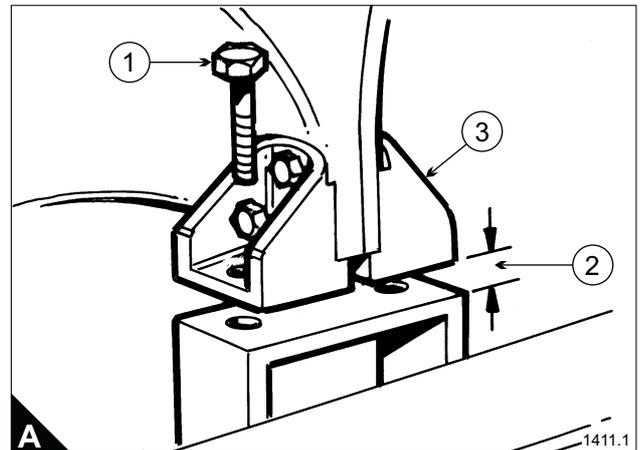
To remove

- 1 Remove the crankshaft damper guard and the crankshaft damper see Section 14, page 61.
- 2 Remove the bolts holding the gearcase mounting feet (A1) to the engine subframe then loosen the bolts holding the flywheel housing mounting feet to the subframe.
- 3 Hoist the engine using the lifting eyes in the suspension plate (B1) to give a 10 mm clearance (A2) between the mounting feet and the subframe.

Note: As the engine is lifted check there is sufficient clearance in the loosend bolts in the flywheel housing mounting feet to allow the engine to be lifted.

- 4 Loosen the bolts holding the oil feed elbow to the oil pump.
- 5 Loosen all sump bolts allowing the sump to drop evenly away from the crankcase and gearcase.
- 6 Remove the bolts between the sump and gearcase, and the bolts around the edge of the gearcase.
- 7 Screw the lifting eye into the top face of the gearcase (C1) then using the hoist support the gearcase (C2) pull the gearcase forward and lift away from the engine.

Caution: As a safety precaution fit the rear mounting feet (A3) to the back face of the suspension plate and lower the engine back onto its subframe.



15

To fit

Note: The mating faces of the gearcase and suspension plate must be clean and free from old jointing material.

- 1 Fit a new joint to the suspension plate.
- 2 Screw the lifting eye into the top face of the gearcase, then using a hoist lift the gearcase into position carefully locating it on the dowels in the suspension plate.
- 3 Refit all the securing bolts, tightening them by hand in a diagonal pattern pulling the gearcase squarely up to the suspension plate, then torque the bolts to 35 lb.ft (50 Nm) following the same pattern.
- 4 If the sump is to be fitted at this stage fit a new joint, tighten all sump securing bolts hand tight pulling the sump squarely to the crankcase and gearcase then torque the bolts to 40 lb.ft (54 Nm) following the same pattern.
- 5 Fit a new crankshaft oil seal, see Section 14, page 59.

Timing gears

To inspect 15-2

Special tools

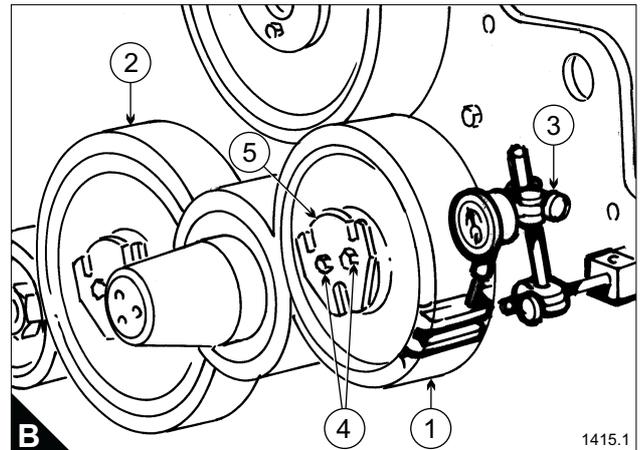
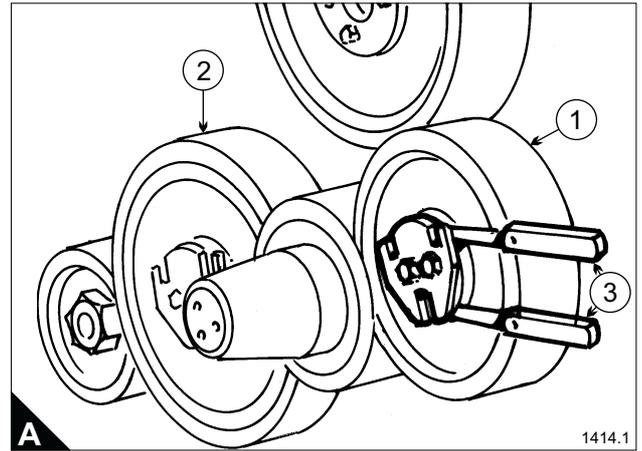
Dial test indicator (DTI) "Universally available"

Feeler gauges "Universally available"

- 1 Visually inspect all gears for wear or broken teeth.
- 2 Check the end float on the camshaft (A1) and oil pump idler gear (A2) by inserting two feeler gauges (A3) between the retaining plate and the idler gear see Section 11, page 30 Wear and renewal limits.

Note: If clearance is excessive, see operation 15-3.

- 3 Check the end float on the camshaft (B1) and the oil pump idler gear (B2) by setting the DTI on the face of a gear tooth (B3), hold the camshaft or oil pump drive gear still and rock the idler gear to get a reading.



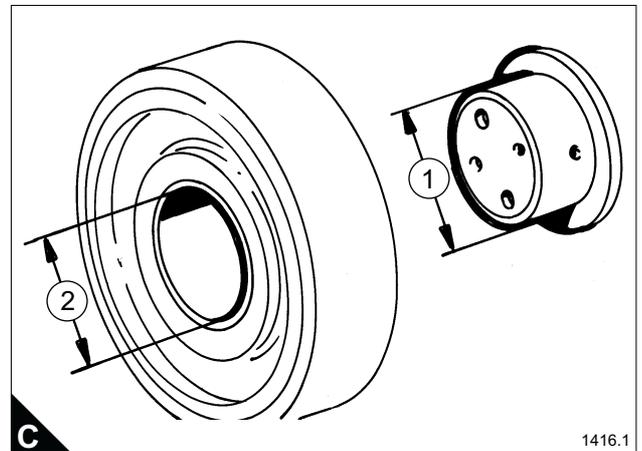
To replace the idler gear bush 15-3

Special tools

Internal and external micrometers 0-3" 0-80 mm

Press "Universally available"

- 1 Remove the two retaining bolts (B4) and the retaining plate (B5) pull the idler gear from its stub shaft.
 - 2 Check the size of the stub shaft (C1) and the bush (C2).
 - 3 If the bush is to be replaced it must be pressed out of the gear.
- Note:** The new bush is pre-finished to size.
- 4 When fitting the idler gear lubricate the stub shaft and retaining plate, then fit and torque the retaining bolts to 35 lb.ft (50 Nm).



15

Crankshaft gear

To remove and to fit

15-4

Special tools

Three legged puller "Universally available"

Induction heater "Universally available"

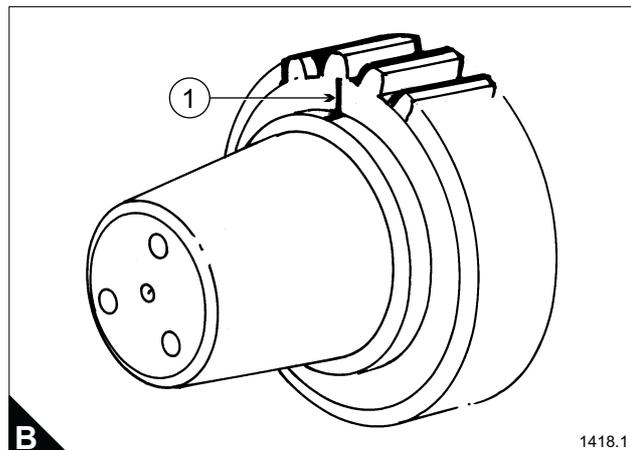
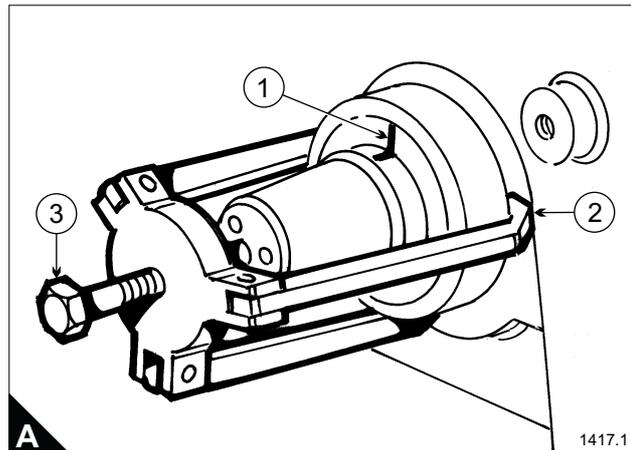
Insulated gloves "Universally available"

To remove

- 1 Remove the gearcase see Section 15, page 65.
- 2 Set the crankshaft gear with its timing mark (A1) in the 12 o'clock position.
- 3 Fit the puller locating the legs (A2) behind the gear, tighten the extractor bolt (A3) by hand, checking the puller legs are evenly located on the gear and the extractor bolt is located in the end of the crank.
- 4 Tighten the extractor bolt to pull the gear from the crankshaft.

To fit

- 1 Using the induction heater the crankshaft gear must be heated to 210°C to give sufficient expansion for fitting.
- 2 Wearing the insulated gloves push the heated gear onto the crankshaft, lining the timing mark on the gear with the timing mark on the crankshaft (B1).



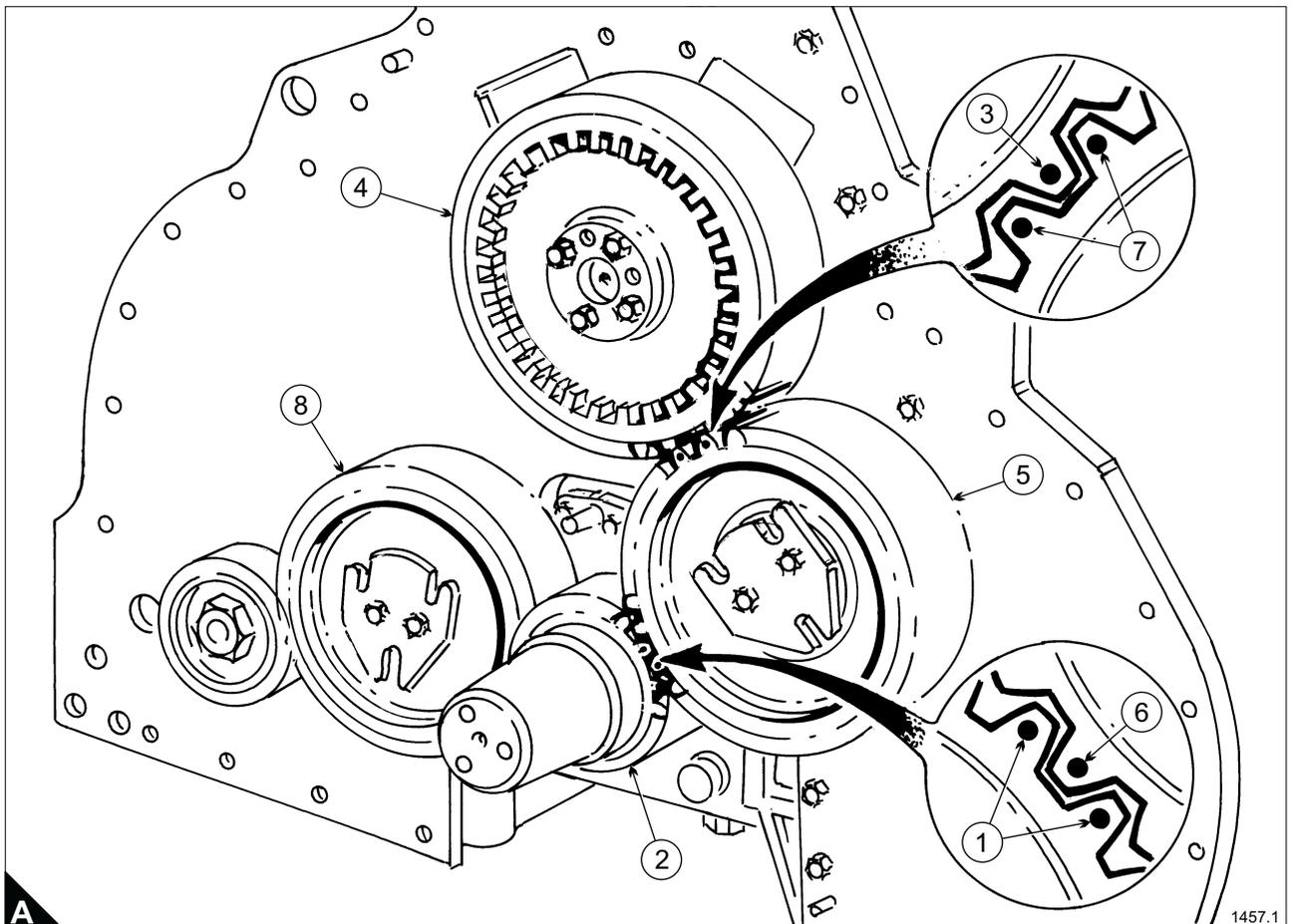
Timing gears

To align

15-5

- 1 Rotate the crankshaft, setting the two timing dots (A1) on the crankshaft gear (A2) in the 2 o'clock position.
- 2 Rotate the camshaft setting the single timing dot (A3) on the camshaft gear (A4) in the 5 o'clock position.
- 3 Fit camshaft idler drive gear (A5) lining up its single timing dot (A6) on its lower left with the two dots (A1) on the crankshaft gear (A2) and its upper left two timing dots (A7) with the single dot (A3) on the camshaft gear.
- 4 Fit the oil pump idle drive gear (A8).

Note: No timing is required on the oil pump.



A

1457.1

16

Crankcase, crankshaft and cylinder liners

Description

Crankshaft removal is normally undertaken at major overhaul. The following procedures are relative to an engine that has been removed from its installation and is dismantled with the flywheel, flywheel housing gearcase, cylinder heads, pistons and all other ancillary equipment removed.

Crankcase

To invert **16-1**

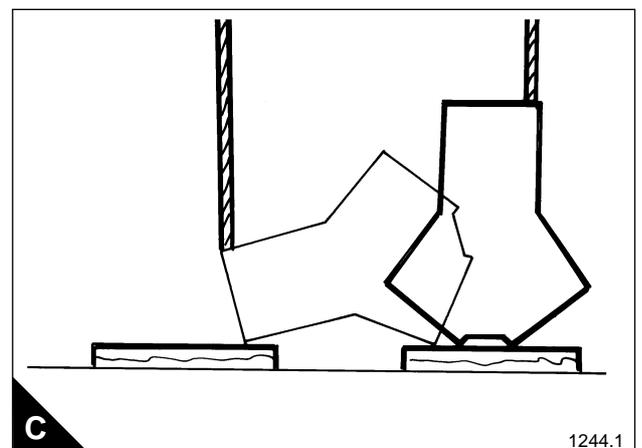
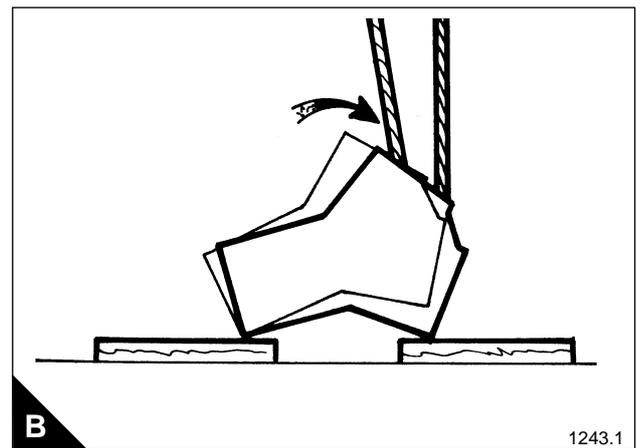
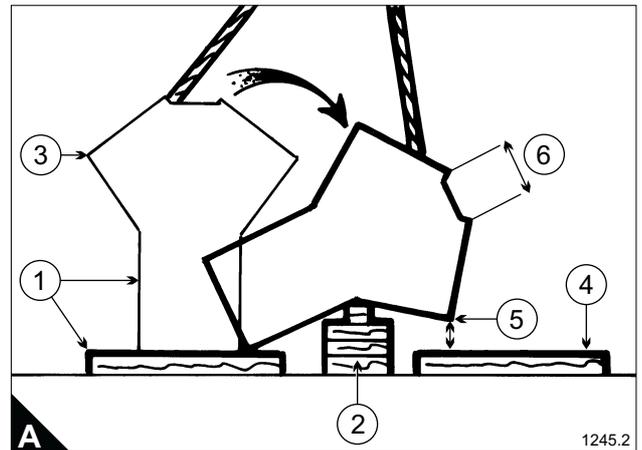
Special tools

Heavy lifting equipment and slings "Universally available"

Warning! Great care will be needed for this operation.

- 1 Remove all bolts holding the sump to the crankcase. Hoist the crankcase away from the sump and lower onto heavy blocks of wood (A1).
- 2 Build a cushion of wooden blocks to the side of the crankcase (A2), sling the crankcase from the cam follower housing (A3) then partially lift and lower the crankcase over on to the blocks.
- 3 Lay another line of blocks along the length of the crankcase (A4) set for contact with point (A5) and long enough to support the crankcase top face point (A6).
- 4 Lift the crankcase to give sufficient clearance to remove the cushion of blocks (A2). Lower the crankcase to the horizontal position (B).
- 5 Re-sling through the crankcase door aperture lift and invert the crankcase (C).

Warning! Make sure the crankcase does not rock and is safe to work on in this position.



16

Crankshaft

To remove and to fit

16-2

Special tools

Heavy lifting equipment and slings "Universally available"

To remove

1 Remove all retaining bolts then lift the stiffening plate out of the crankcase (A).

2 Remove capscrew main bearing side bolts (B1).

Note: The capscrew main bearing bolts are less stressed than the hexagon main bearing bolts. Unless the heads or threads are damaged they have an infinite life.

3 Remove the hexagon head main bearing bolts (B2).

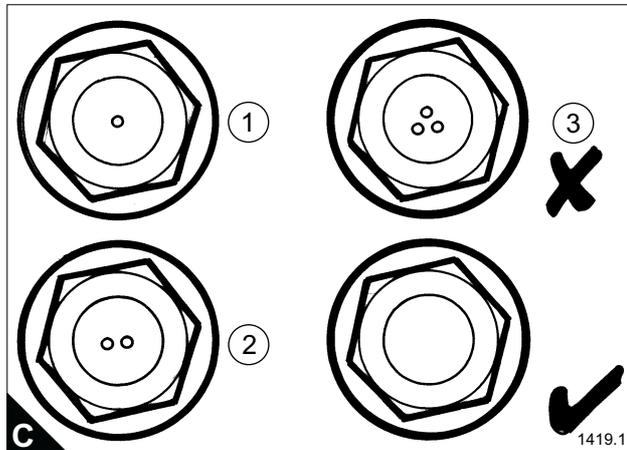
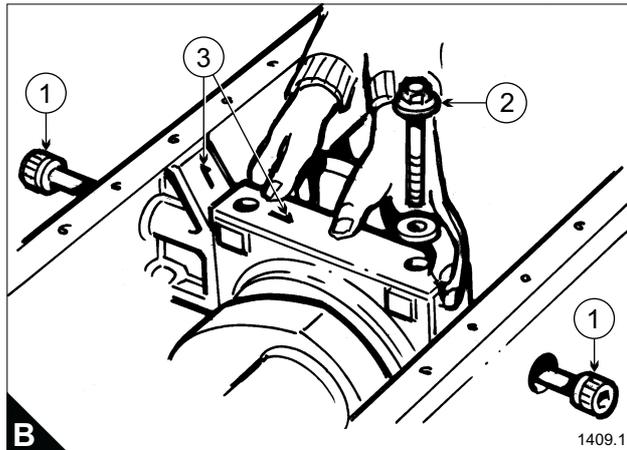
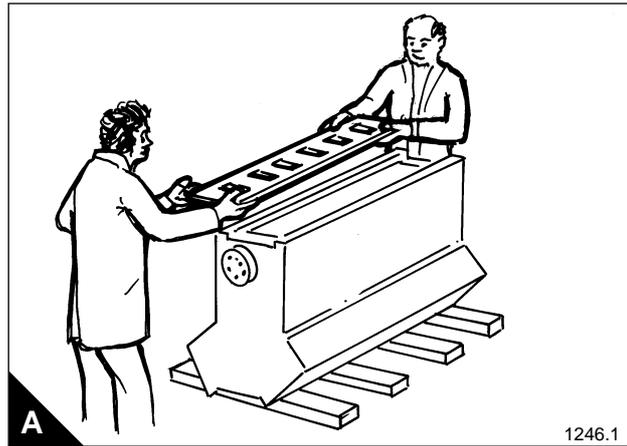
Caution: The hexagon headed main bearing bolts can only be re-fitted three times.

4 To record their fitting, each bolt should be marked with a centre punch dot. Bolts showing three dots must be replaced (C).

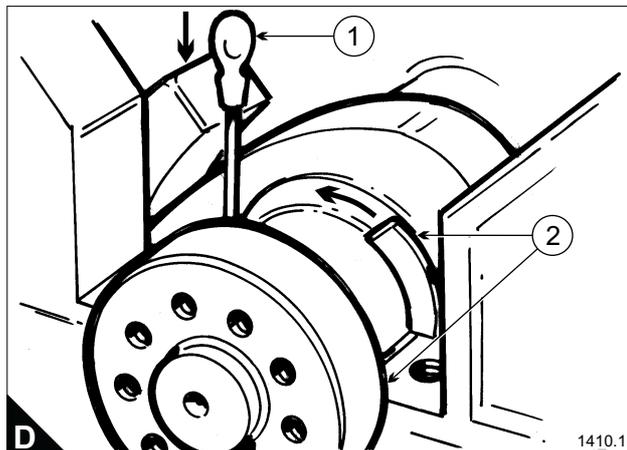
5 With the main bearing bolts removed lift the main bearing caps and shell bearings out of the crankcase, observe the identification number on each cap (B3).

Warning! The rear main bearing cap flywheel end retains two half crankshaft thrust bearings which must be removed to give sufficient clearance for crankshaft removal.

6 Using a screwdriver (D1) push the thrust washer down, rotating it out of the crankcase (D2).

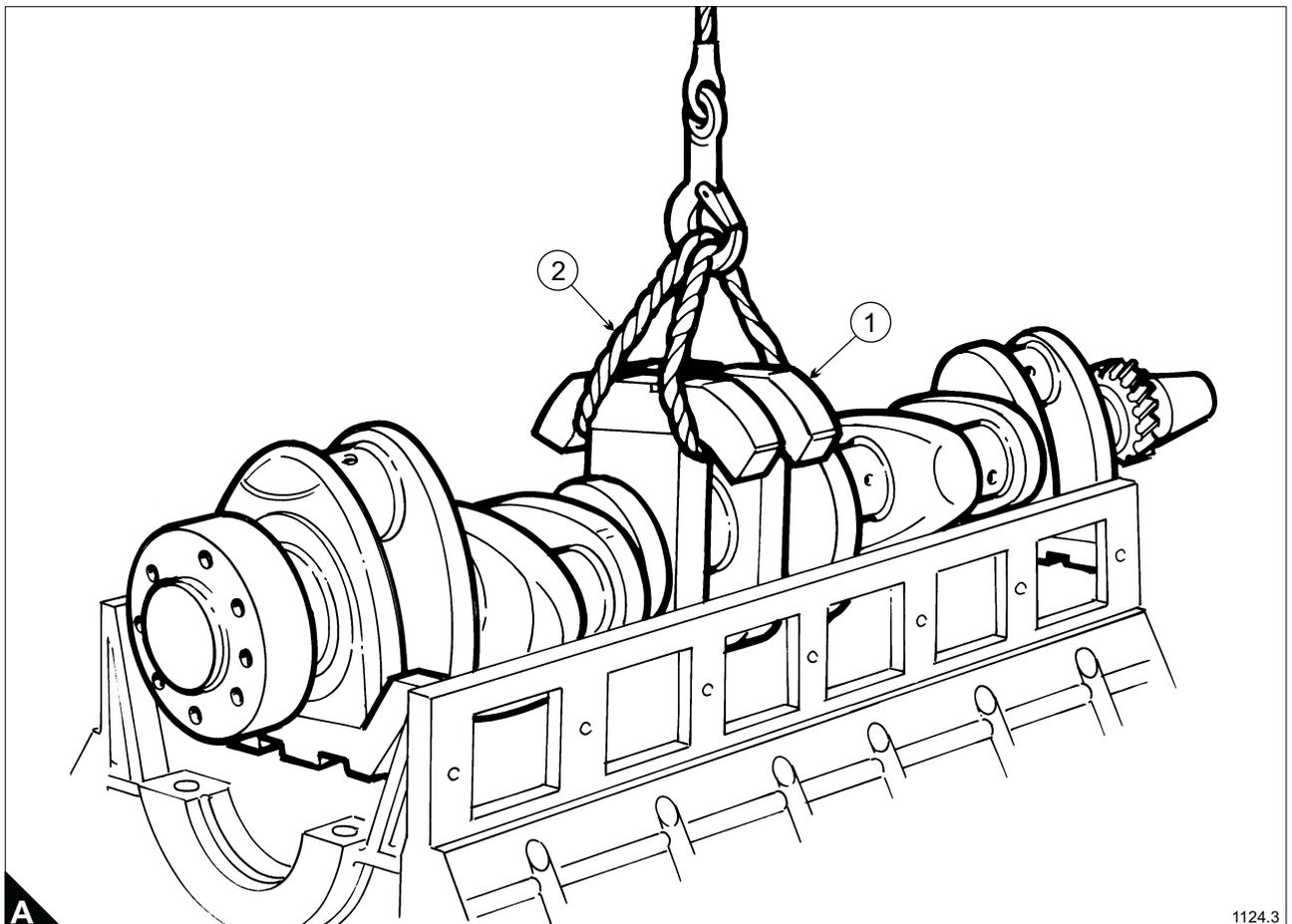


Continued



7 Rotate the crankshaft setting the central balance weights (A1) uppermost.

8 Using a rope sling (A2) around the balance weights (A1) carefully hoist the crankshaft out of the crankcase.



16

To fit

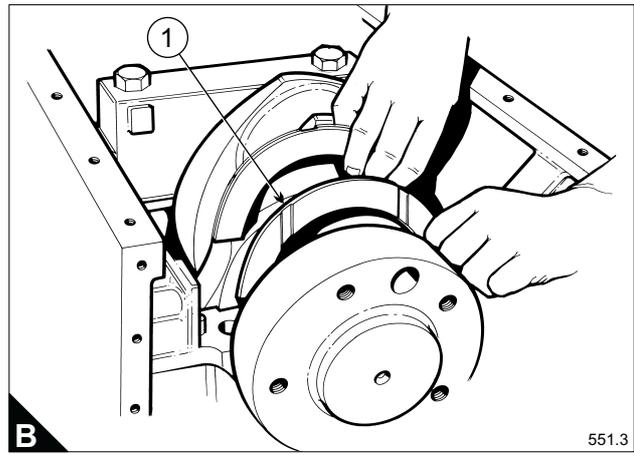
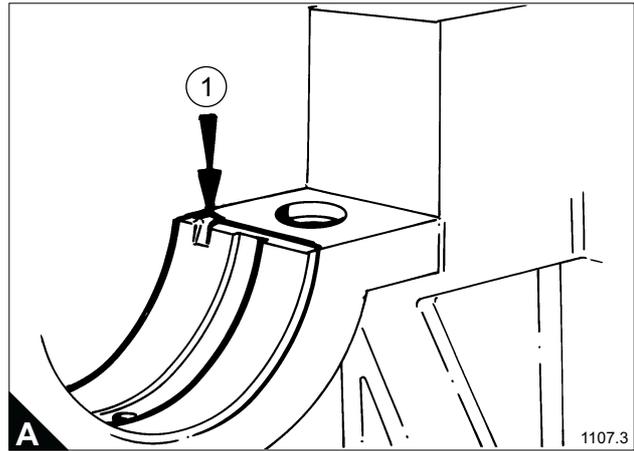
- 1 Check the main bearing housings and caps are clean and the oilways in the crankcase are clear.
- 2 Fit the half bearings into the crankcase, making sure the bearing is fully seated and the tab (A1) is located in its slot, then lubricate the bearings and the crankshaft journals.
- 3 Sling the crankshaft, see Section 16, page 73 and hoist into position above the crankcase, carefully lower it onto its bearings.
- 4 Check the bearings are still located in the crankcase and remove the sling.
- 5 Fit the half bearings to the main bearing caps and lubricate them.

Note: Start with No. 1 cap (drive gear end of the crankshaft).

- 6 Lubricate the main bearing bolt threads, the heavy washers and the underside of the bolt heads with engine oil. Fit the cap with the hexagon bolts then the capscrew side bolts tightening them hand tight.

Warning! When fitting the rear (flywheel end) main bearing cap ensure the bearing side of the thrust washers (the side with the grooves) is in contact with the crankshaft (B1) or serious damage will be done to the crankshaft thrust faces.

- 7 With all main bearing caps fitted check the crankshaft is free to rotate then torque the main bearing to the sequence shown on page 75.

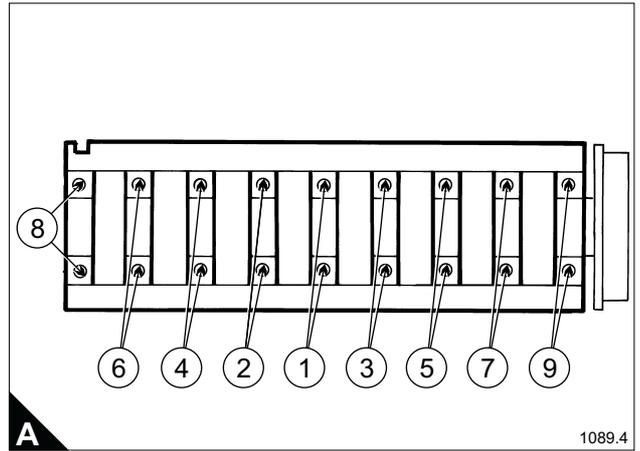


Continued

8 Torque the hexagonal main bearing bolts down in the order shown in (A) following the torque sequence given in the following table:

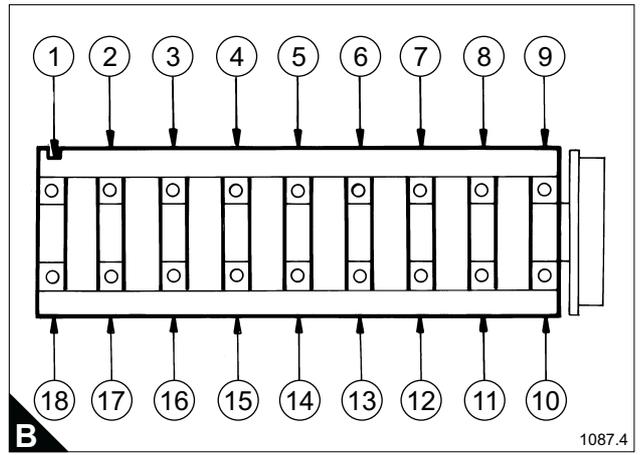
Caution: Check that the crankshaft rotates freely after each torque sequence.

STAGE	TORQUE
1	Hand tight
2	100 lb.ft (135 Nm)
3	200 lb.ft (270 Nm)
4	400 lb.ft (540 Nm)
5	580 lb.ft (783 Nm)



9 Torque the capscrew side bolts down in the order shown in (B) following the torque sequence given in the following table:

STAGE	TORQUE
1	Hand tight
2	124 lb.ft (168 Nm)



16

To inspect

16-3

Special tools

150 mm Micrometer "Universally available"

- 1 Inspect each individual set of crankshaft shell bearings for signs of wear or damage.
- 2 Check the crankshaft journal sizes see Section 11, page 30 Wear and renewal limits.

Note: If the crankshaft is worn beyond the given limits it can be re-ground and undersize bearings fitted. This is a very specialised process and should be done through your Perkins Agent.

To check crankshaft end float

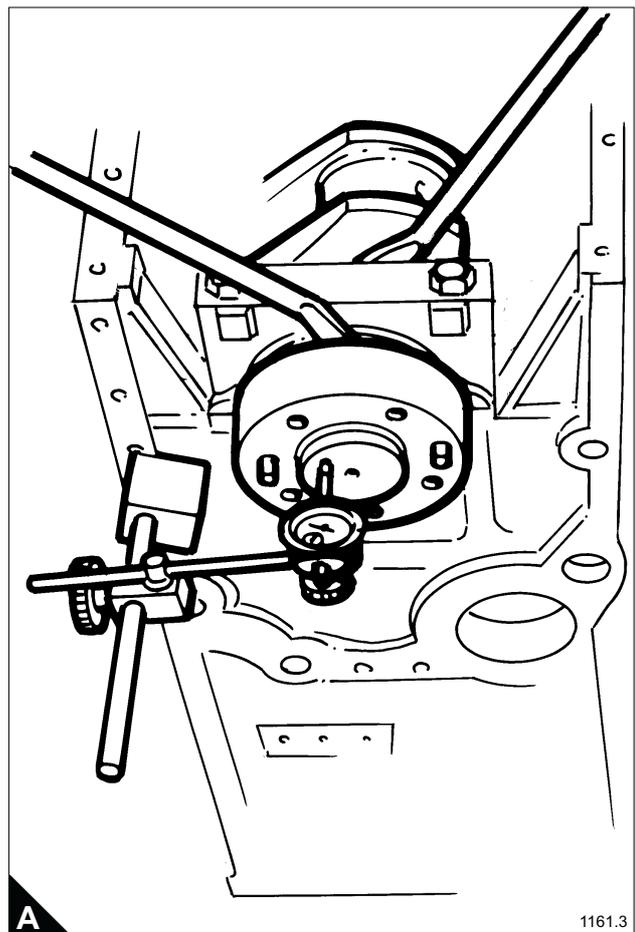
16-4

Special tools

Dial test indicator with magnetic mounting
"Universally available"

- 1 With a DTi mounted on the crankcase, and its plunger in contact with the crankshaft use levers to move the crankshaft in and out to give an end float reading (A) see Section 11, page 30 Wear and renewal limits.

Caution: Failure to ensure correct end float may result in excessive thrust washer wear or even crankshaft seizure.



Cylinder liners

Cylinder liners are normally changed at major overhaul or in the event of a failure. The following procedure is based on the assumption that the cylinder heads, piston cooling jets, and pistons have been removed.

To change

16-5

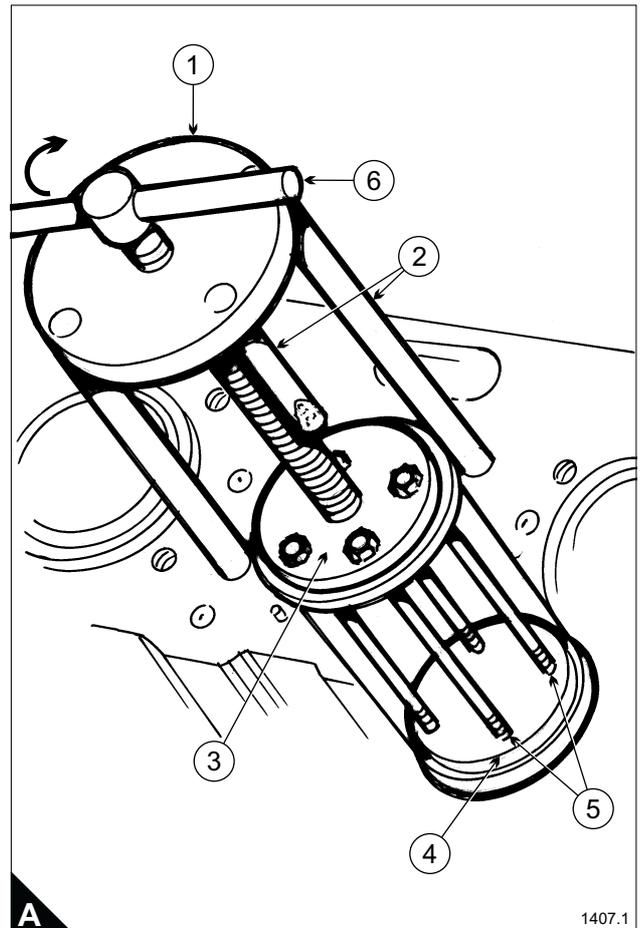
Special tools

Liner extractor T6253/152

Liner clamp T6253/200

- 1 Fit the top section of the extractor (A1) onto the crankcase locating the pillars (A2) in the cylinder head bolt holes.
- 2 Set the extractor with the top plate (A3) resting on the cylinder liner and the support pillars on the face of the crankcase.
- 3 Hold the bottom plate (A4) in position while the four extractor bolts (A5) are screwed in and torqued to 5 lb.ft (7 Nm).
- 4 Turn the tommy bar (A6) in a clockwise direction to extract the liner.

Caution: A small quantity of coolant and rust particles will be released as the liner is removed.



Continued

16

5 Clean the cylinder liner location in the crankcase. Remove all traces of Loctite and rust from the liner seating area (A1).

6 Remove any build up of rust from the 'O' ring guiding chamfer (A2) on the lower liner location (A3).

7 Lubricate the 'O' rings with silicon rubber grease or petroleum jelly and fit them to the liner.

8 Lubricate lower liner location (A3) and the chamfer with silicon rubber grease or petroleum jelly.

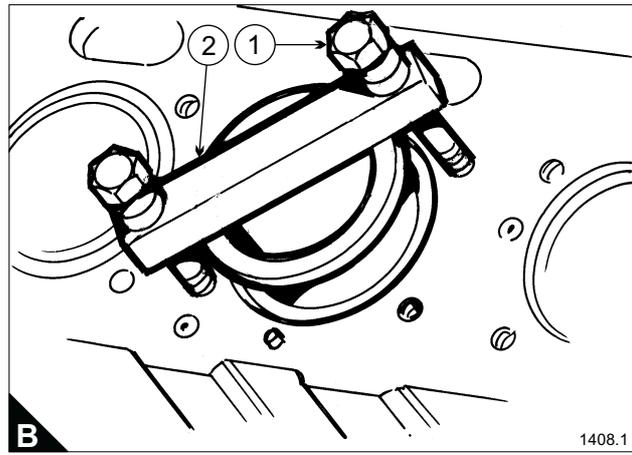
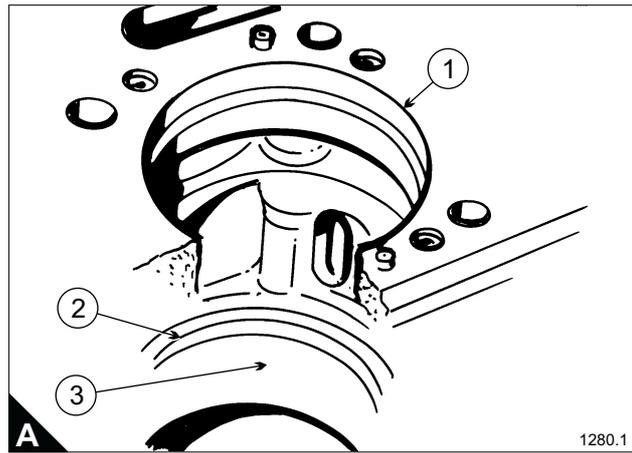
9 Apply Loctite 638 to the liner seating area (A1).

10 Carefully fit the liner pushing it into the crankcase by hand. When the 'O' rings locate on the chamfer a resistance will be felt. Stop pushing.

11 Using two cylinder head bolts (B1) and varying the length spacers or washers with the cylinder liner clamping tool (B2), push the liner into the crankcase.

12 Remove the cylinder head bolts and spacers. Fit short bolts to the clamping tool, tighten the bolts to 10 lb.ft (13.5 Nm).

Warning! Allow 3 hours for the Loctite to cure before removing the liner clamp.



17

Camshaft and cam followers

Note: Camshaft and cam follower removal is normally undertaken at major overhauls. The following procedures are based on the assumption that the engine has been removed from its installation. The flywheel, flywheel housing, front pulley, damper, gearcase, cylinder head and manifolds will all have been removed.

To check and to set camshaft end float 17-1

Special tools

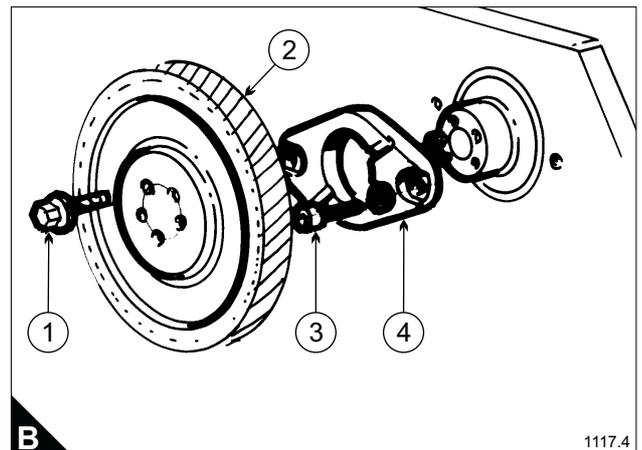
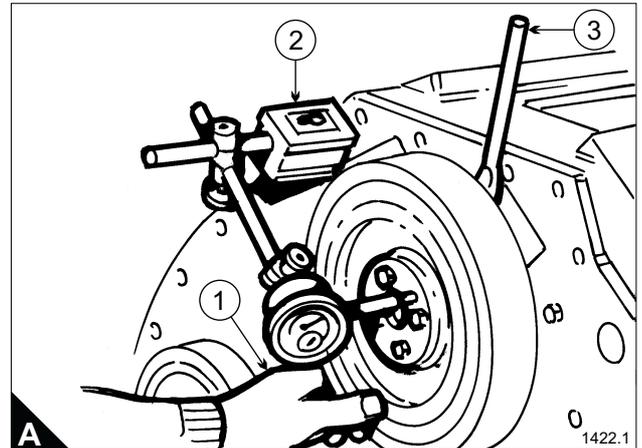
Dial test indicator (DTi) "Universally available"

To check

- 1 Using hand pressure push the camshaft drive gear in onto the thrust plate (A1).
- 2 Set the DTi (A2) in contact with the drive gear, then using a lever (A3) move the drive gear out to give a reading see Section 11, page 30 Wear and renewal limits.

To set

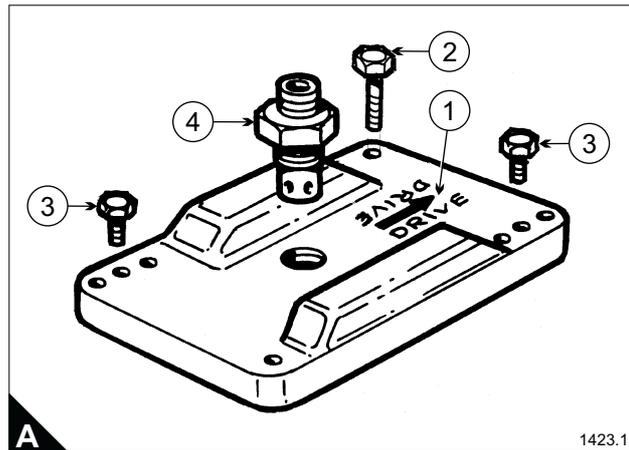
- 1 Remove the four gear retaining bolts (B1) and using hand pressure pull the drive gear (B2) of the camshaft.
- 2 Remove the two retaining capscrews (B3) and lift off the thrust plate (B4).
- 3 Lubricate then fit the new thrust plate, torque the retaining capscrews to 35 lb.ft (50 Nm).
- 4 Fit the camshaft gear torque the retaining bolts to 110 lb.ft (150 Nm).
- 5 Check the camshaft end float, see operation 17-1. If it is still excessive the camshaft drive gear must be replaced.
- 6 Align the timing gears see Section 15, page 69.



17

To remove the cam follower housing 17-2

- 1 Mark each cam follower housing to ensure it is refitted in its original position.
- 2 Note the "legend" drive with an arrow. On reassembly, this must point to the flywheel end of the engine (A1).
- 3 Take out the four retaining bolts (A2) and the blanking bolts (A3) from the threaded jacking holes.
- 4 Fit 50 mm long bolts into the jacking holes, tighten them equally to pull the housing from its locating dowels in the crankcase.



To inspect cam followers and re-fit the housing 17-3

Special tools

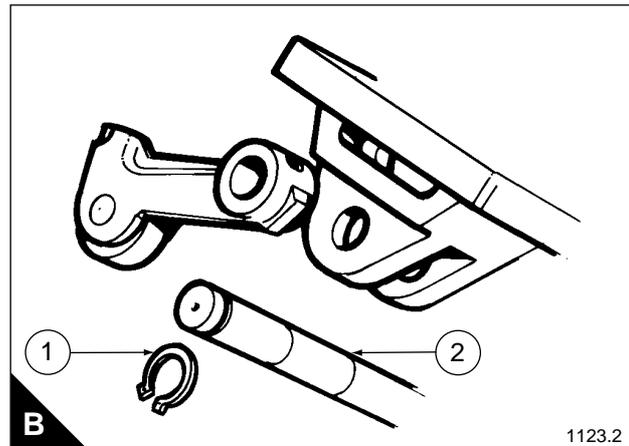
Circlip pliers (internal type) "Universally available"

Note: In the event of failure service exchange cam followers are normally supplied.

- 1 Mark each cam follower housing to ensure it is refitted in its original position.
- 2 Visually check the bearing surface of each cam follower roller for wear and that it is free to rotate without excessive clearance between roller and pivot.

Caution: If a cam follower roller is worn excessively, check the cam lobe on which it ran. If the camshaft is damaged, a new cam and followers must be fitted.

- 3 Check the push rod sockets for wear.
- 4 Check that the end float on the cam followers is between 0.150 and 0.200 mm (0.006 and 0.008").
- 5 Remove the circlips (B1) from the pivot shaft then push the pivot shaft (B2) out of the housing.
- 6 Check the pivot shaft and the pivot end of the cam follower for wear.
- 7 Check the oil spray jet (A4) is clear, if it has been removed for cleaning refit using Loctite 542.
- 8 Lubricate the pivot shaft and rollers, reassemble, making sure the circlips have seated in their grooves.
- 9 Fit the housing assembly into the crankcase using a new sealing joint. Tighten the retaining bolts by hand, pulling the housing evenly onto the crankcase, then torque down the bolts down to 35 lb.ft (50 Nm).
- 10 Fit the two blanking bolts (A2).



Camshaft

To remove and to fit

17-4

Special tools

Camshaft guide tube T6253/142

Slings and hoist "Universally available"

To remove

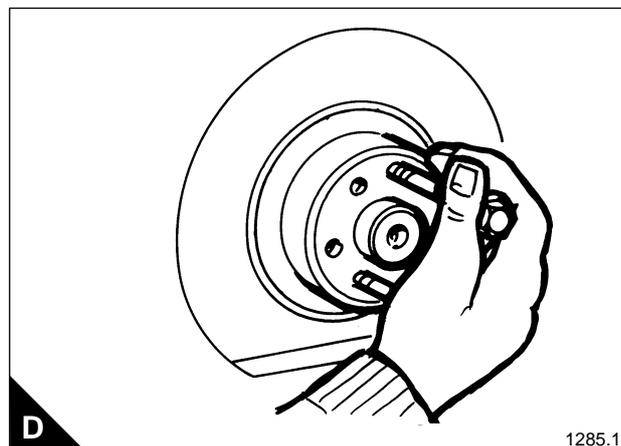
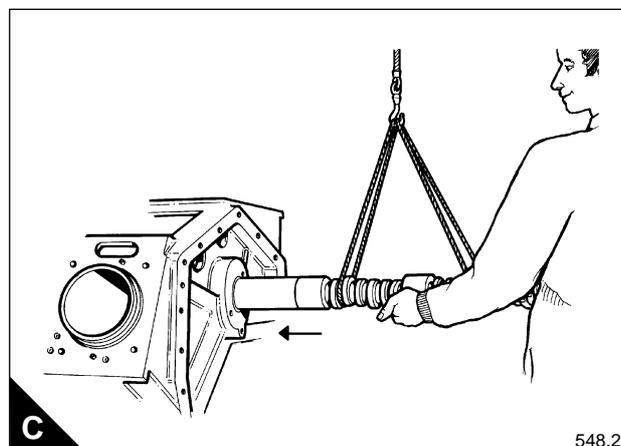
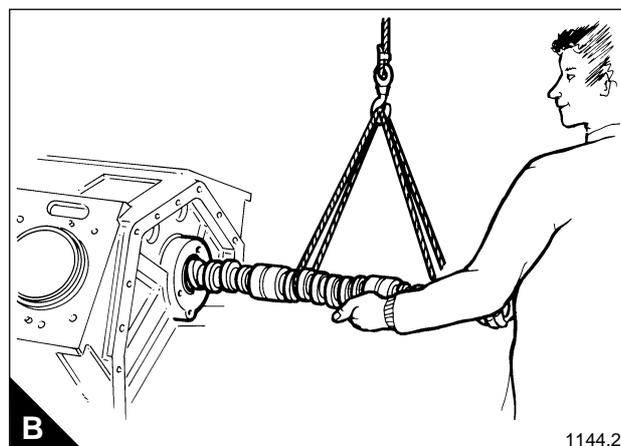
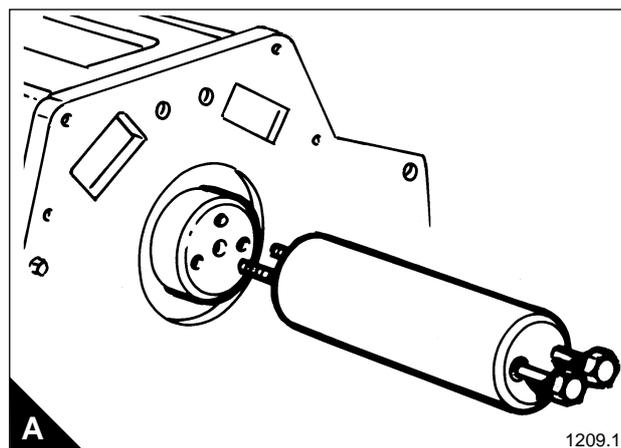
Warning! This operation must be carried out by two service engineers.

- 1 Remove the camshaft drive gear see Section 17, page 79.
- 2 Fit the camshaft guide tube tool to the camshaft (drive end) (A).
- 3 Using a long piece of wood push the camshaft out of the engine. As the camshaft emerges (at the flywheel end) use a rope sling and hoist to support the weight as the camshaft is withdrawn (B).
- 4 Check the bearings in the crankcase and the bearing surfaces on the camshaft, then each individual cam lobe for wear, see Section 11, page 30 Wear and renewal limits.

To fit

Warning! This operation must be carried out by two service engineers.

- 1 Lubricate all camshaft bearings in the crankcase and on the camshaft.
- 2 Fit camshaft guide tube, then using a rope sling and hoist, lift the camshaft into position at the flywheel end of the crankcase.
- 3 Locate the guide tube in the first bearing. Check the alignment of the camshaft with the crankcase and carefully push the camshaft into position (C).
- 4 Check the camshaft is free to rotate by fitting two of the camshaft drive gear retaining bolts into the camshaft. Then using hand pressure on the bolts the camshaft should turn freely (D).



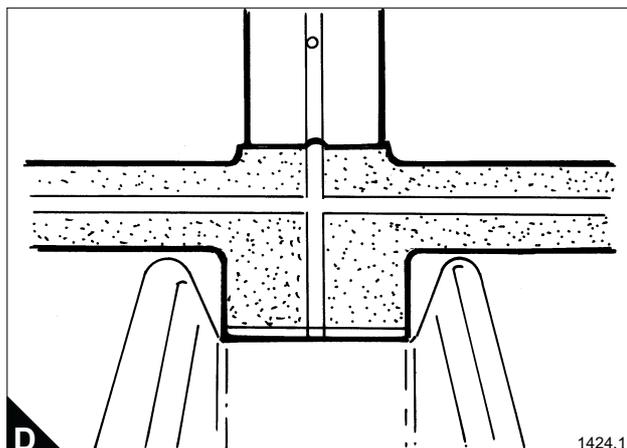
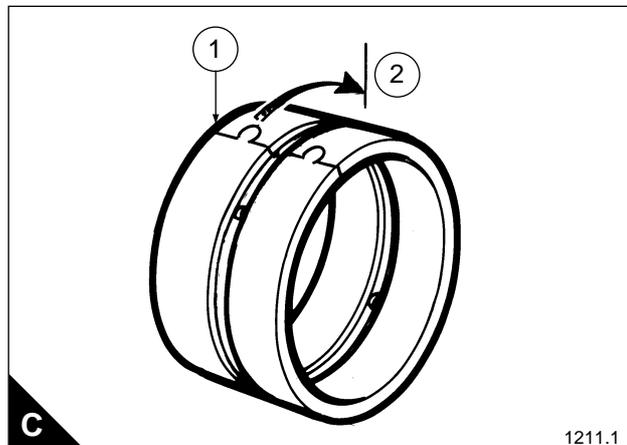
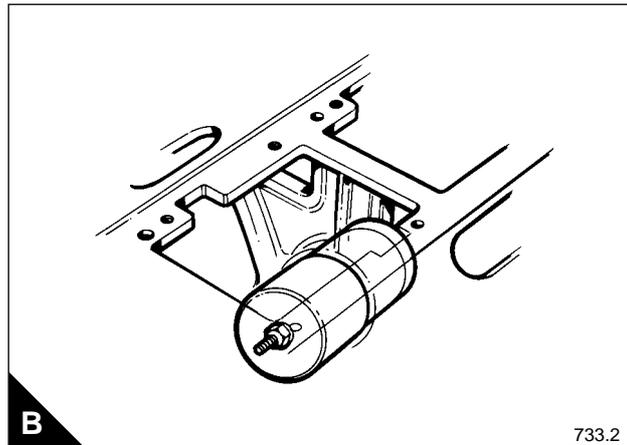
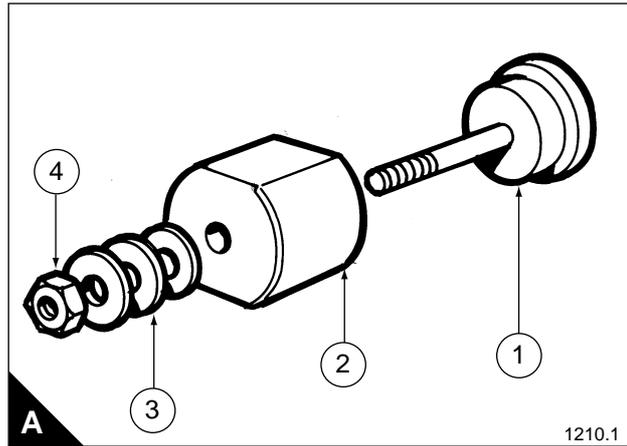
17

To replace the camshaft bearing 17-5

Special tools

Bearing removal and fitting T6253/199

- 1 Remove the camshaft see Section 17, page 81.
 - 2 To remove a bearing fit the mandrel (A1) in the bearing. Fit the sleeve (A2) over the stud, then the spacers (A3) and the nut (A4).
 - 3 With the nut finger tight check the alignment of the tool with the bearing and crankcase. Tighten the nut pulling the bearing out of the crankcase.
 - 4 As the thread on the stud is used add more spacers until the bearing is removed (A and B).
 - 5 Fitting a new bearing needs great care. The bearing bore must be clean and free from burrs.
- Note:** The bearing must be fitted with its joint line in the 12 o'clock position (C1) and the lock tabs pointing to 'A' bank (C2).
- 6 Fit the bearing to the mandrel. Lubricate its outer edge and the bearing bore in the crankcase.
 - 7 Line up the bearing. Fit the sleeve, spacers, and nut.
 - 8 Check the alignment of the bearing crankcase and tool. Carefully tighten the nut, adding spacers until the bearing is in position.
- Caution:** The bearing must be in a central position with the oil groove directly over the main oil feed gallery.



18

Turbocharger

General description

The turbocharger is mounted on the gearcase (crankshaft pulley) front end of the engine. It is driven by the exhaust gases and pressurises the inlet side of the engine. Oil from the engine is fed to the turbocharger bearings from where it drains back to the sump. Also engine coolant is circulated through the turbocharger body reducing its operating temperature. The turbocharger is a none serviceable unit in the event of failure or at a major overhaul a new turbocharger can be obtained from your Perkins Agent.

To remove

18-1

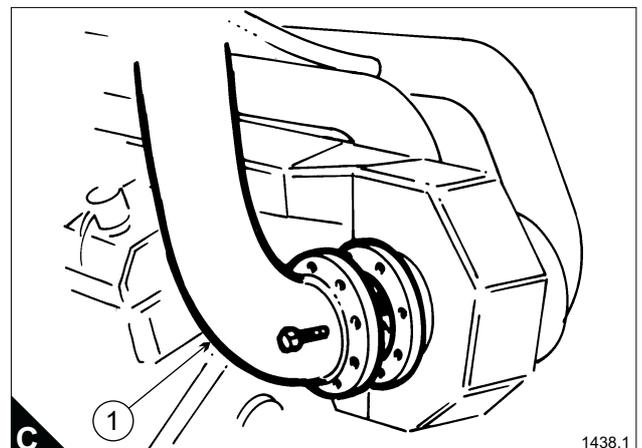
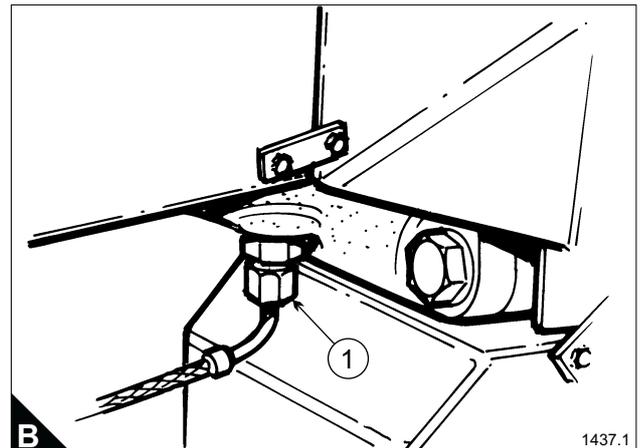
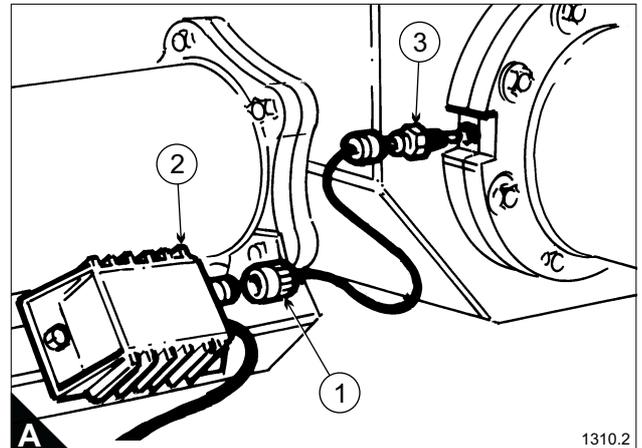
Special tools

Hoist and sling "Universally available"

Ball end allen key

- 1 Disconnect the multi pin plug (A1) on the oxygen sensor power cable from the connector on the oxygen sensor interface (A2).
- 2 Remove the oxygen sensor (A3) from the turbocharger outlet.
- 3 To avoid damage during turbo removal, remove the turbine inlet temperature probe (B1).
- 4 Remove the exhaust pipe (C1) from the turbo.

Continued



18

5 Disconnect the flexible breather pipe (A1) from air inlet pipe (A2).

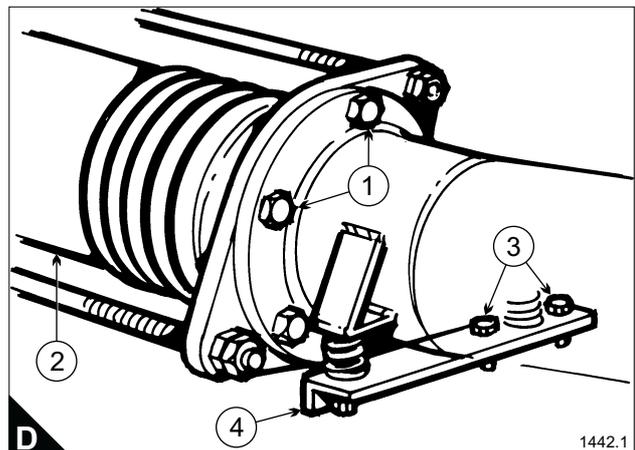
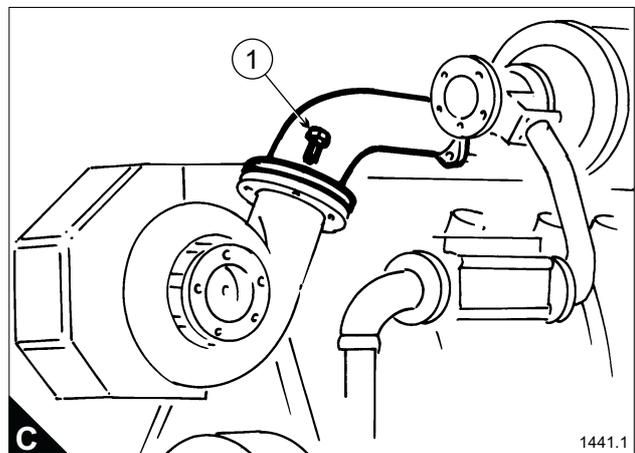
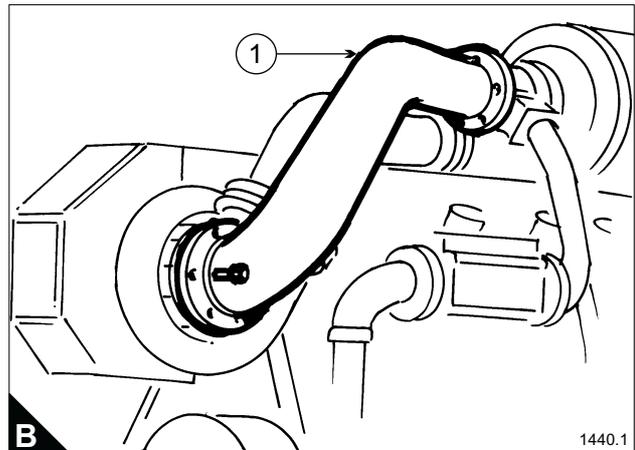
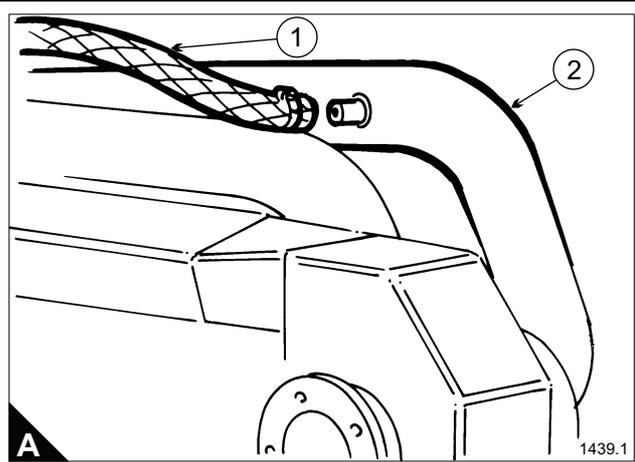
6 Remove the retaining nuts and bolts then lift off the air inlet pipe (B1).

7 Remove the retaining nuts and bolts (C1) holding the air outlet pipe to the turbochargers flange.

8 Remove the retaining nuts and bolts (D1) holding the air outlet pipe to the expansion pipe (D2).

9 Remove the retaining nuts (D3) from the support bracket (D4).

10 Lift off the air outlet pipe.



11 Drain the cooling system.

Note: Prepare for a small spillage of oil and water as the pipework is removed from the turbo.

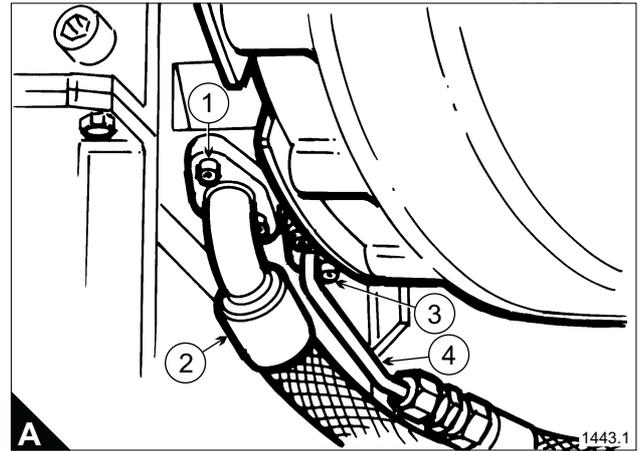
12 Working on the underside of the turbo, take out the retaining capscrews (A1) and pull the oil drain pipe (A2) from the turbo body.

13 Take out the retaining capscrews (A3) and pull the coolant feed pipe (A4) from the turbo body.

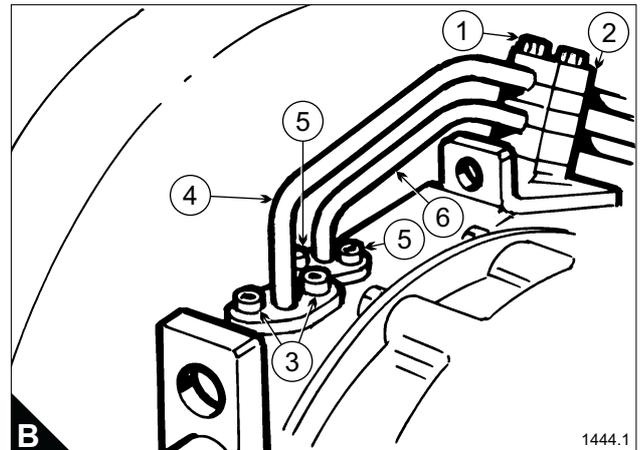
14 Working on the top face of the turbo, take out the retaining bolts (B1) and remove the pipe clamp (B2).

15 Take out the retaining capscrews (B3) and pull the coolant return pipe (B4) from the turbo body.

16 Take out the retaining capscrews (B5) and pull the oil feed pipe (B6) from the turbo body.



Continued



18

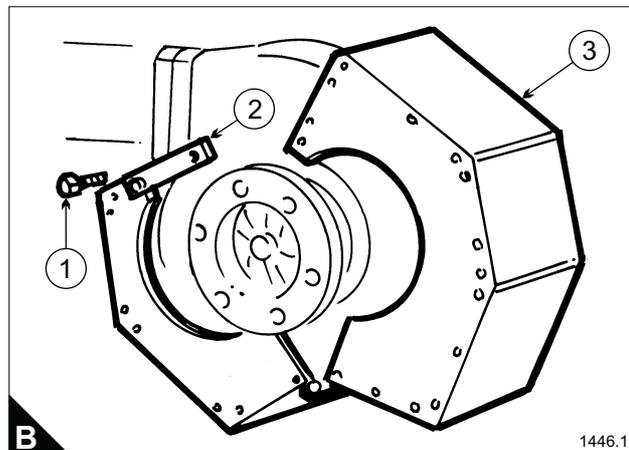
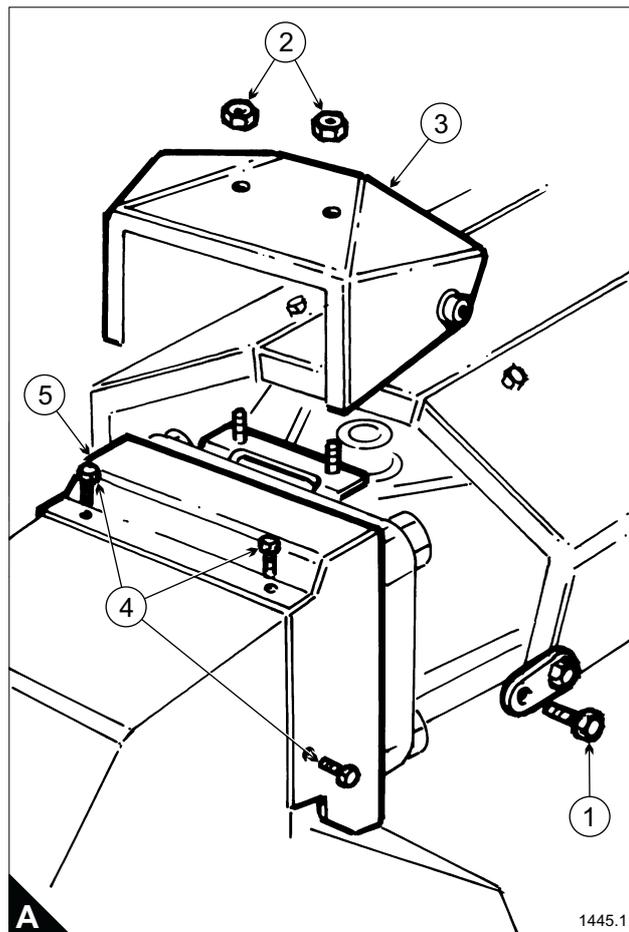
17 Remove the side bolts (A1) and the nuts (A2) then lift off the short section of heat shield (A3) between the turbo and exhaust manifold heat shield.

18 Remove the screws (A4) then lift off the 'U' section cover plate (A5).

19 Remove the screws (B1) from turbo heat shield retaining straps (B2).

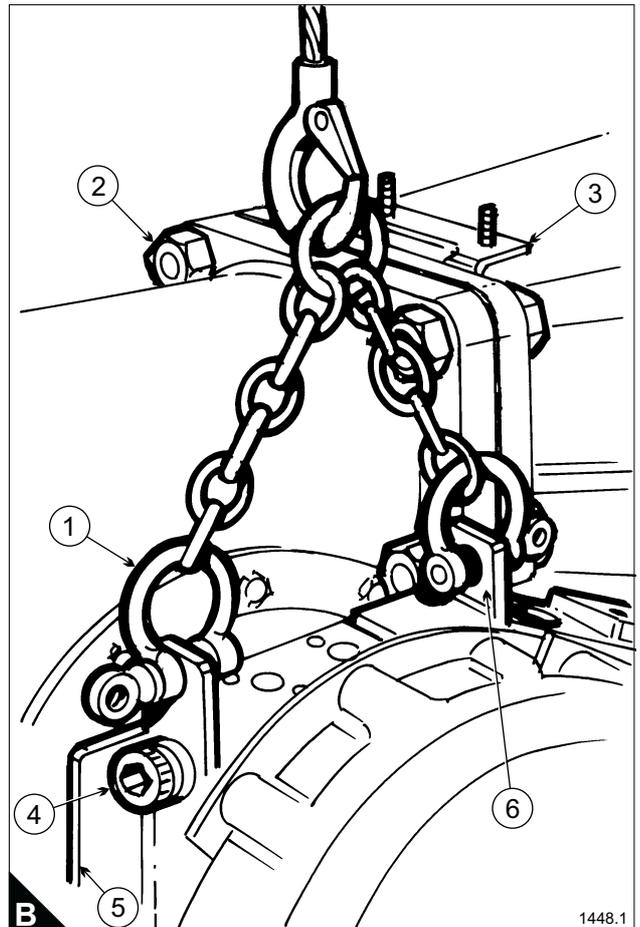
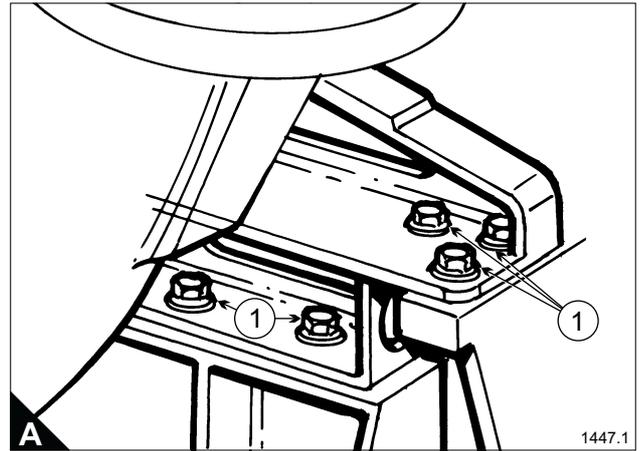
20 The turbo heat shield is hinged, it is opened out (B) to allow for its removal from the turbo.

Caution: The turbocharger heat shield (B3) is lagged internally with a composite aluminium glass-fibre cloth which can cause skin and lung irritation, it must only be handled when wearing protective gloves, goggles and a breathing mask.



- 21** Remove all retaining bolts (A1) from the turbo mounting bracket.
- 22** Fit the lifting shackles (B1) to the lifting eyes on the turbocharger.
- 23** Remove the four bolts (B2) holding the turbo to the exhaust manifold. Note the heat shield support bracket (B3) is held in position by the top mounting bolts.
- 24** Carefully hoist the turbo from the engine.
- 25** Take out the retaining capscrews (B4) and remove the turbo mounting brackets (B5) and (B6) for fitting to the new turbo.

Warning! *If the turbocharger has failed mechanically the air pipes, air filter and oil return pipe must be checked and cleared of any debris.*



Special tools

Hoist and sling "Universally available"

Ball end allen key

17 mm Allen socket

1 Fit the turbo mounting brackets to the turbo, tighten the retaining capscrews to 250 lb.ft (340 Nm).

2 Fit the lifting shackles and hoist the turbo into position (A).

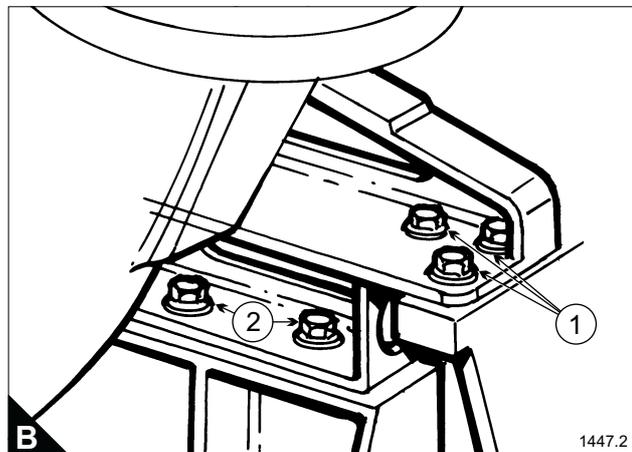
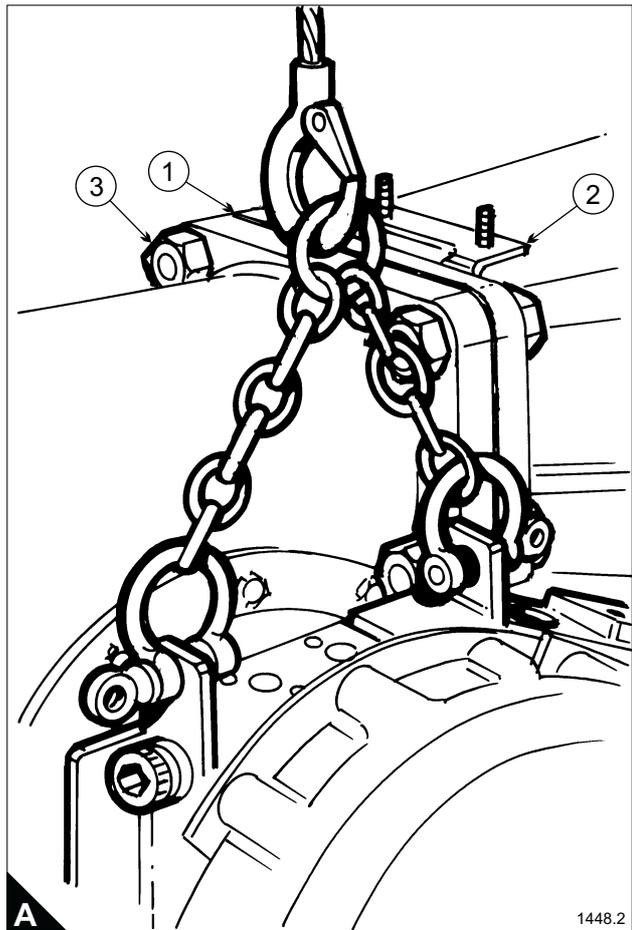
3 Fit a new sealing joint (A1) between the turbo, and exhaust manifold then fit heat shield support bracket (A2) and the retaining bolts (A3) finger tight.

4 Fit the three Durlok bolts (B1) and the three nuts/bolts (B2) finger tight to the turbo mounting brackets.

5 Remove the lifting shackles.

6 Check turbo alignment with the exhaust manifold tighten the retaining bolts (A2) diagonally pulling the turbo squarely onto the exhaust manifold using hand pressure only. Then torque down diagonally to 250 lb.ft (340 Nm).

7 Torque the 12 mm Durlock bolts (B1) to 70 lb.ft (95 Nm) and the 10 mm Durlock nuts and bolts (B2) to 50 lb.ft (70 Nm).



8 Refit the coolant feed pipe (A1) the oil drain pipe (A2) using new joints.

Note: The ball ended allen key will be needed to fit and tighten the capscrew (A3) torque the capscrews to 35 lb.ft (50 Nm).

9 Prime the turbocharger bearings with clean engine oil through the oil feed hole (B1).

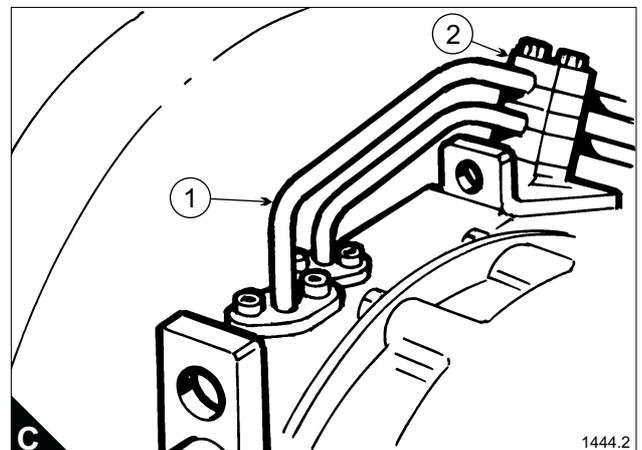
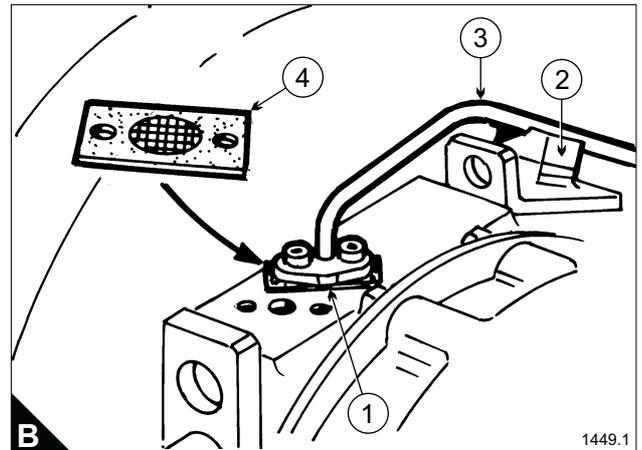
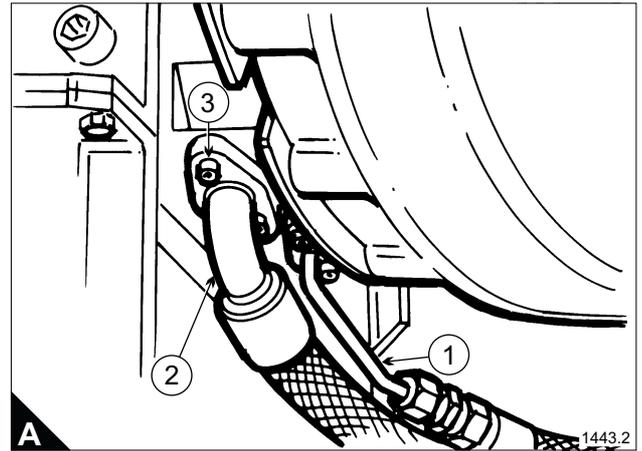
10 Set the lower section of the pipe support/clamp (B2) in position, refit the oil feed pipe (B3) using a filter joint (B4) part No. 278/348 torque the retaining capscrews to 35 lb.ft (50 Nm).

Warning! After the initial run up to full working temperature stop engine and change the filter/sealing joint to the standard non-filtered type.

11 Refit the coolant return pipe (C1) using a new joint torque the retaining capscrews to 35 lb.ft (50 Nm).

12 Fit the top section of the pipe support clamp (C2).

Continued



18

Caution: The internal lagging for the turbocharger heat shield is a composite aluminium glass-fibre cloth which can cause skin and lung irritation. It can only be handled when wearing protective gloves, goggles and a breathing mask.

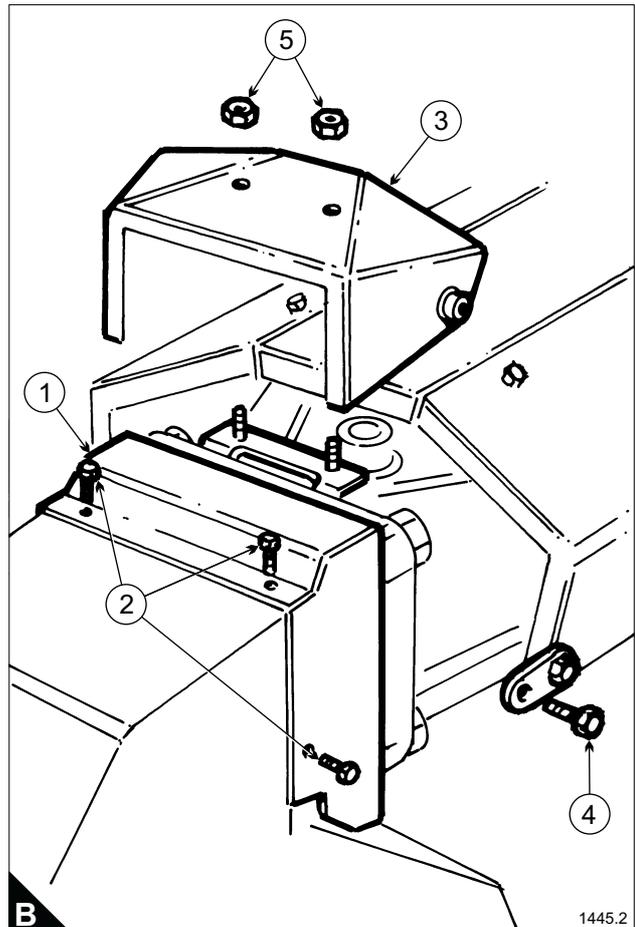
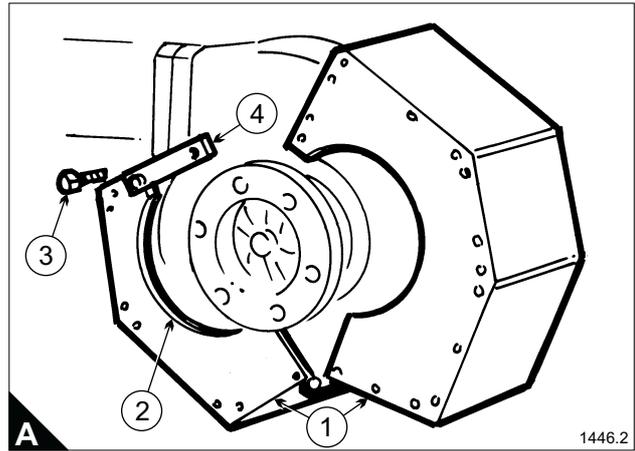
13 Fit the internal lagging to the turbocharger heat shield.

14 Fit the heat shield to the turbocharger, carefully closing the hinged sections together (A1), check the lagging (A2) stays in position.

15 Fit the two screws (A3) through the retaining straps (A4) to hold the assembly together.

16 Fit the 'U' section cover plate (B1) holding it in position with the retaining screws (B2).

17 Fit the short section of heat shield (B3) the side bolts (B4) and the retaining nuts (B5).



18 Using new joints fit the air pipe (A1) locate the support bracket (B1) on its retaining studs (B2). To hold the air pipe in position fit hand tight the retaining bolts in the turbocharger flange (A2) and the expansion pipe flange (B3).

19 Torque the support bracket retaining nuts (B2) to 35 lb.ft (50 Nm).

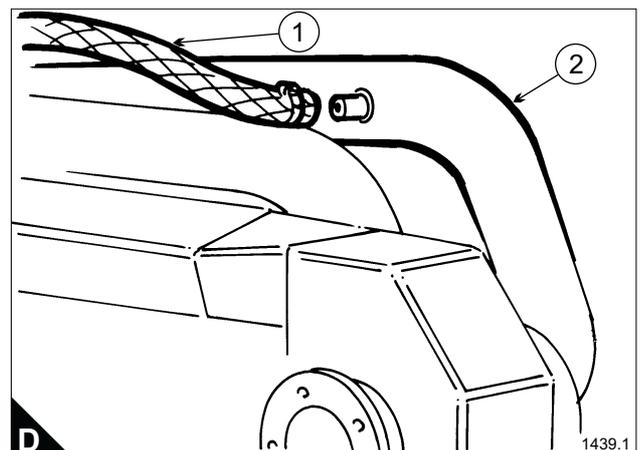
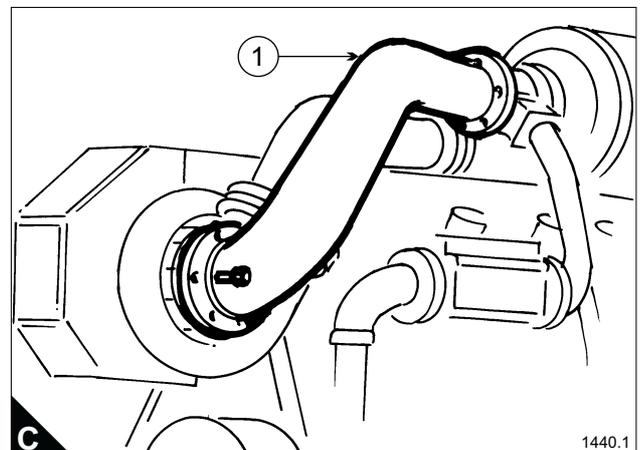
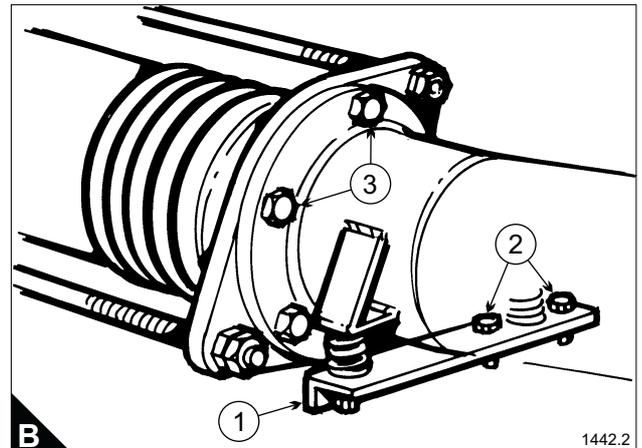
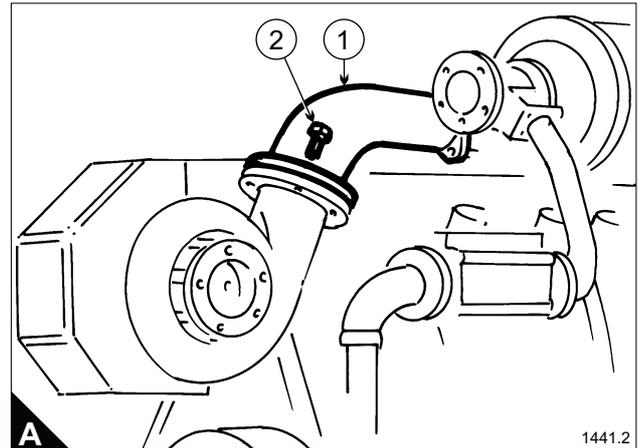
20 Torque the expansion pipe flange retaining nuts and bolts (B3) to 35 lb.ft (50 Nm).

21 Torque the turbocharger pipe flange nuts and bolts (A2) to 50 lb.ft (70 Nm).

22 Using new joints fit the air cleaner to turbocharger air pipe (C1) fit the retaining bolts hand tight pulling the pipe flanges squarely together.

23 Torque all retaining bolts to 35 lb.ft (50 Nm).

24 Fit the flexible breather pipe (D1) to the turbocharger inlet pipe (D2).



Continued

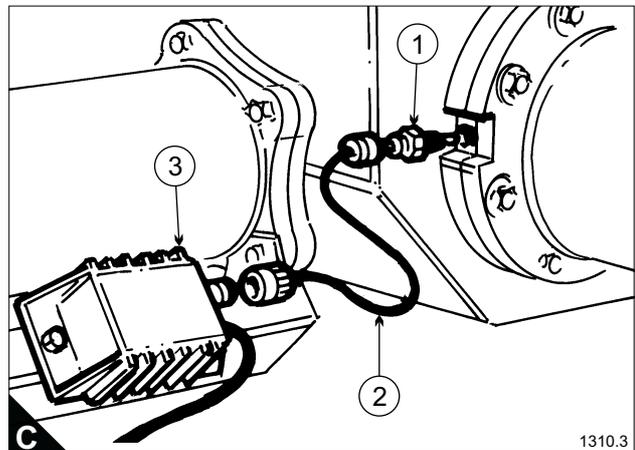
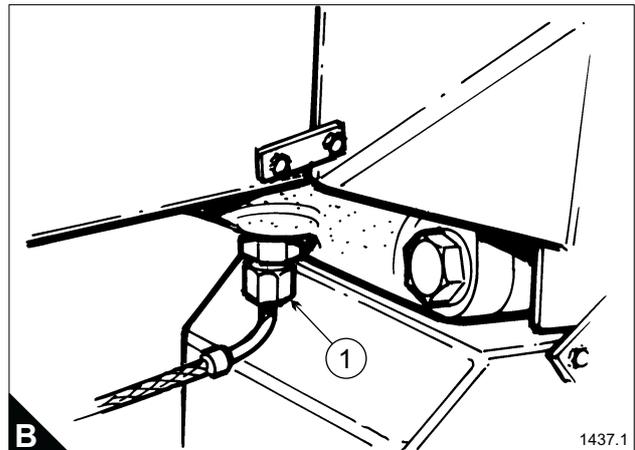
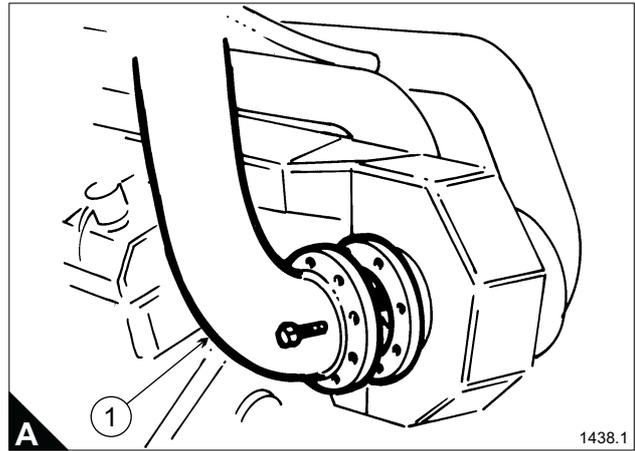
18

25 Using a new joint fit the exhaust pipe (A1) to the turbocharger, fit the retaining bolts tighten them by hand in a diagonal pattern to bring the mounting flanges squarely together then torque to 35 lb.ft (50 Nm).

26 Refit the turbine inlet temperature probe (B1) torque to 22 lb.ft (30 Nm).

27 Refit the oxygen sensor (C1) into the turbocharger outlet torque to 15 lb.ft (20 Nm).

28 Reconnect the power cable (C2) between the oxygen sensor (C1) and the sensor interface (C3).



19

Lubricating system

Piston cooling jet

General description

The piston cooling jets are situated on the side of the crankcase, one per cylinder. They spray oil into an oil gallery on the underside of each piston.

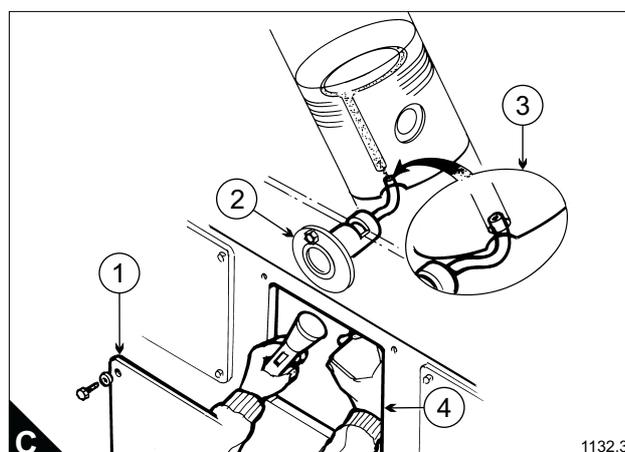
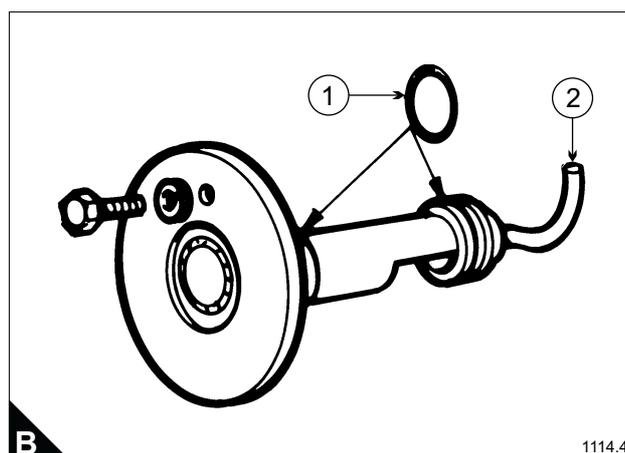
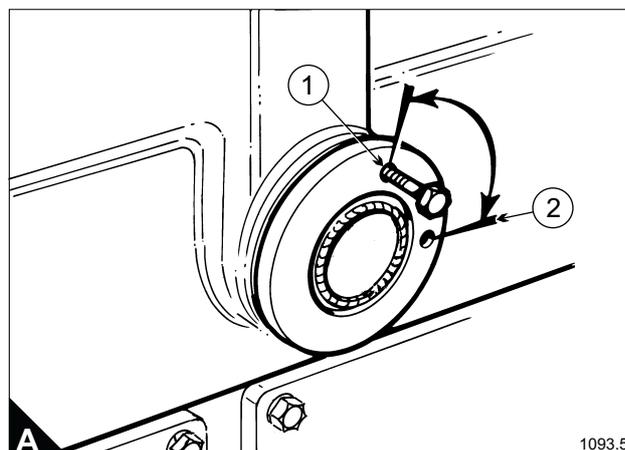
To remove and to check

19-1

Caution: Before attempting to remove or fit a piston cooling jet its piston must be set at TDC, this ensures the piston skirt is clear of the cooling jet oil spray tube.

- 1 Clean the area around the piston cooling jet.
- 2 Remove the setscrew (A1).
- 3 Rotate the jet to the 3 o'clock position (A2) and carefully pull the jet from the crankcase.
- 4 Discard the 'O' rings (B1) and clean the jet in a suitable solvent.
- 5 Check the oil spray hole (B2) is clear.
- 6 Remove the crankcase door (C1) relating to the piston cooling jet.
- 7 Fit the piston cooling jet (C2) without its sealing 'O' rings see Section 19, page 94.
- 8 Rotate the engine bringing the piston down to BDC, the oil spray pipe should fit centrally into the oil gallery in the piston (C3). The use of a torch and mirror (C4) is necessary to see the alignment.

Warning! If after cleaning there is any doubt about oil flow through the jet or its accurate alignment the jet must be replaced as a diminished oil spray pattern will cause the piston to seize.

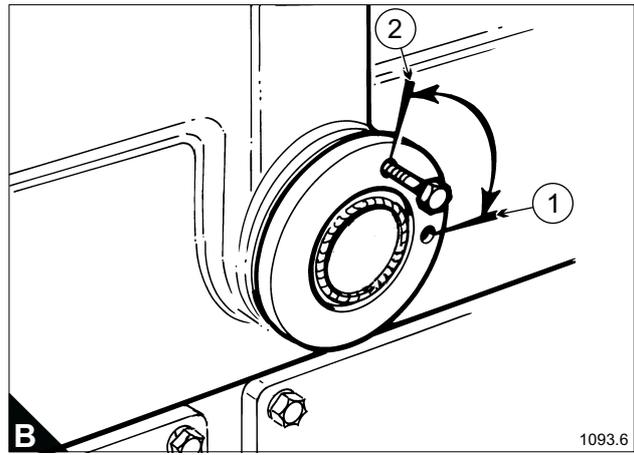
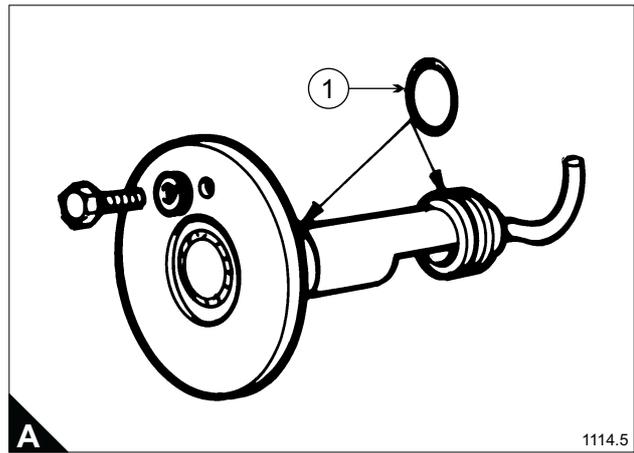


19

To fit

19-2

- 1 Set the piston relative to the cooling jet on TDC, see "Caution" on page 93.
- 2 Fit new 'O' rings (A1) to the piston cooling jet.
- 3 Lubricate the jet body and jet orifice in the crankcase with engine oil.
- 4 Set the retaining bolt hole (B1) in the 3 o'clock position and push the jet into the crankcase. When resistance is felt as the 'O' rings engage their seat rotate the jet to the 12 o'clock position (B2).
- 5 Fit the setscrew and washer finger tight.
- 6 Using a soft face hammer gently tap the jet home and tighten the setscrew to 35 lb.ft (50 Nm).



Oil coolers

General description

Two oil coolers are fitted, one on each side of the engine. Oil is fed directly to 'A' bank cooler from the oil pump and 'B' bank from a crossover pipe passing through the oil sump. In all other aspects the oil coolers are identical.

To remove and to fit

19-3

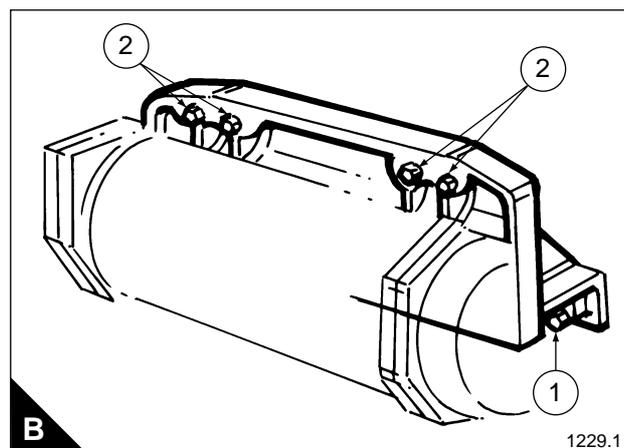
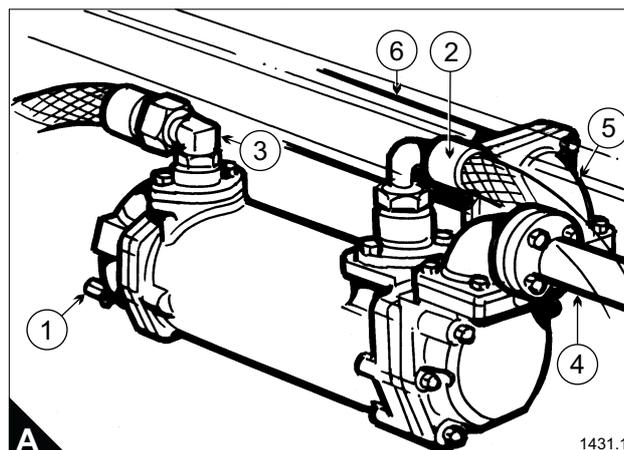
Special tools

Crowfoot spanner "Universally available"

To remove

- 1 Drain the engine cooling system.
- 2 Drain the oil cooler using the drain tap (A1).
- 3 Place a container under the oil cooler to catch oil and water spillage.
- 4 Remove the flexible oil pipe (A2) between the oil cooler and oil pump / crossover pipe using the crowfoot spanner.
- 5 Remove the flexible oil pipe (A3) between the oil cooler and filter header using the crowfoot spanner.
- 6 Remove the coolant feed pipe (A4).
- 7 Disconnect the elbow (A5) from the crankcase coolant feed pipe (A6).
- 8 Remove the four bolts (B1) on the underside of the support bracket.
- 9 Remove the four bolts (B2) from the top of the support bracket. Carefully lever the cooler away from its locating dowels and lift away from the engine.

Warning! The oil cooler is a heavy but manageable unit when removed by two service engineers.



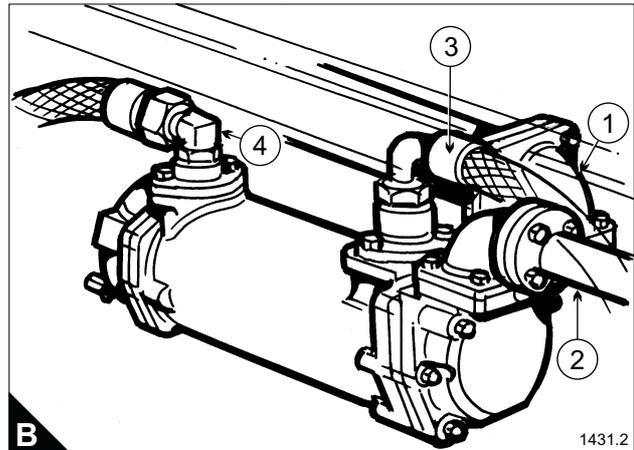
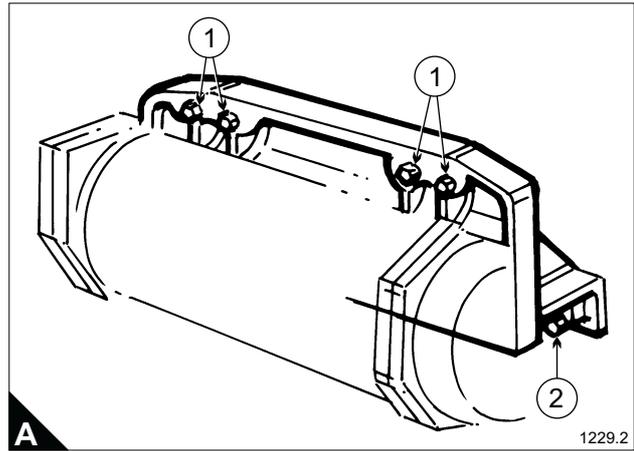
19

Special tools

Crowfoot spanner "Universally available"

To fit

- 1 Lift the oil cooler into position, setting it on its locating dowels. Push against the cooler body holding it in position while the top mounting bolts (A1) are fitted.
- 2 Fit the lower mounting bolts (A2) then tighten all mounting bolts by hand pulling the oil cooler assembly squarely to the crankcase.
- 3 Torque the oil cooler mounting bolts to 35 lb.ft (50 Nm).
- 4 Refit the elbow (A1) using new joints.
- 5 Refit the coolant feed pipe (B2) using a new joint.
- 6 Refit the flexible oil pipes (B3) and (B4) using the crowfoot spanner torque the oil pipe unions to 80 lb.ft (108 Nm).
- 7 Refill the cooling system see User's Handbook pages 11-12, Section 3 and prime the lubricating system see OEM Application, Installation and Commissioning Handbook (Publication TSL4232, Issue 2).



To clean/replace oil cooler tubestack 19-4

Special tools

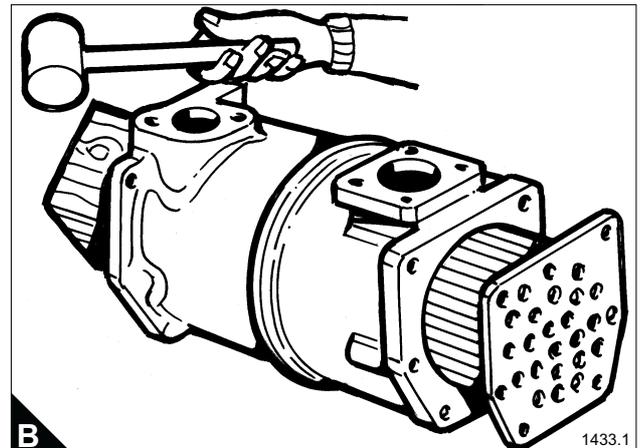
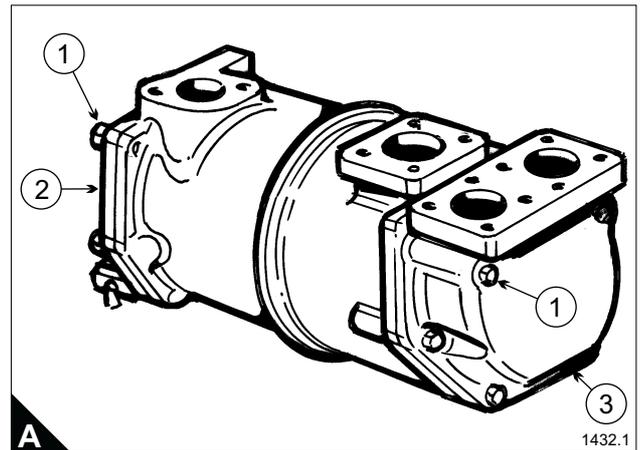
Industrial detergent "Universally available"

Limescale solvent "Universally available"

- 1 Remove the oil cooler mounting bracket, coolant elbows and oil pipe unions.
- 2 Take out the retaining bolts (A1) and remove the end covers (A2) and (A3), a light blow with a soft mallet may be needed to free the covers from their locating dowels.
- 3 Using a block of wood to protect the face of the tubestack carefully knock the tubestack out of the oil cooler body (B).
- 4 Discard the tube stack 'O' ring, remove any jointing material from mating surfaces.
- 5 Check the coolant side of the tubestack for limescale contamination.
- 6 Check the lubricant side of the tubestack for oil sludge contamination.

Note: If the tubestack appears to be in serviceable condition it can be cleaned using industrial detergent and limescale solvent. The manufacturers instruction on the use of these substances must be strictly adhered to.

Caution: If limescale or sludge contamination is still present after cleaning, the tube stack must be replaced as a reduced ability to transfer heat may lead to engine failure.



Continued

19

7 Fit a new joint to the flanged end of the tubestack (A1) and push the tubestack (A2) into the oil cooler body.

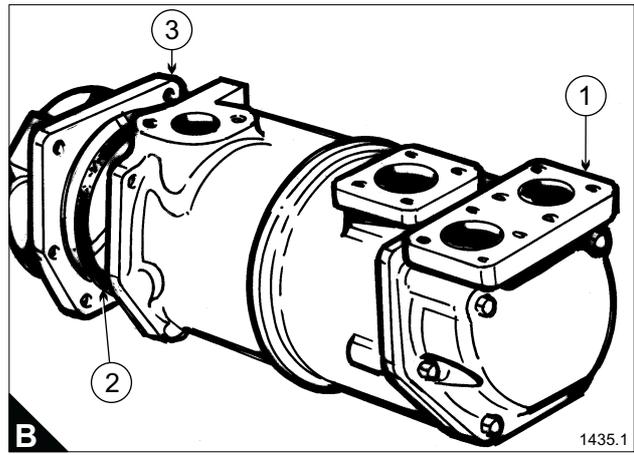
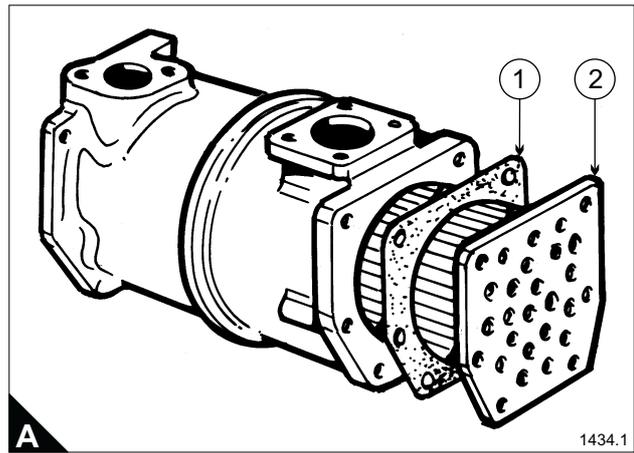
8 Using a new joint fit the end cover (B1) tighten the retaining bolts diagonally by hand pulling the cover squarely to the oil cooler body.

9 Fit a new 'O' ring (B2) to the end of the tubestack.

10 Fit the end cover (B3) using a new joint tighten the retaining bolts by hand in a diagonal pattern pulling the end cover squarely to the oil cooler body.

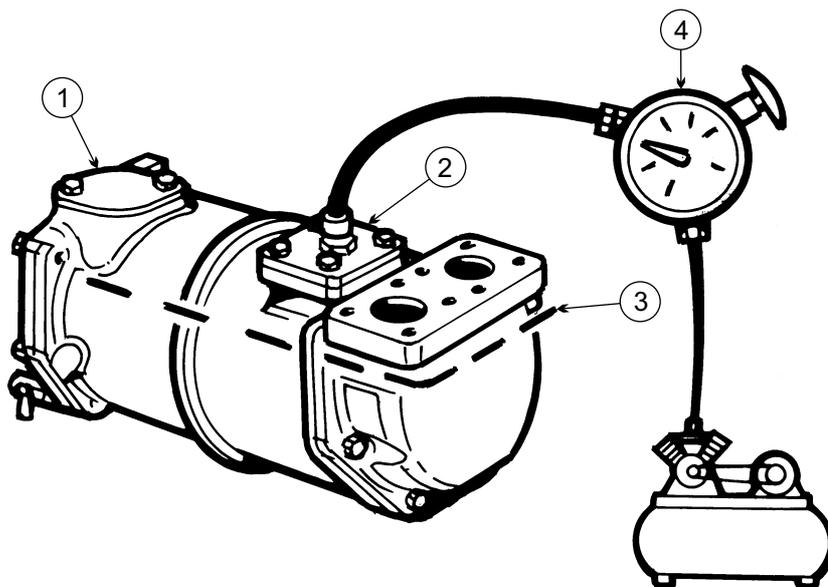
11 Fit the oil feed unions and coolant elbows.

12 Torque all retaining bolts to 35 lb.ft (50 Nm).



To pressure test oil cooler assembly 19-5

- 1 Make up a two bolt adaptor plate (A1) and a four bolt adaptor plate with air pipe fitting (A2).
- 2 Fit the four bolt adaptor plate using a new sealing joint.
- 3 Fill the oil cooler with clean water to the level indicated (A3).
- 4 Fit the two bolt adaptor plate using a new sealing joint.
- 5 Connect compressed air to the oil cooler using a pressure gauge regulator (A4) to give 3 bar (50 psi) maximum.
- 6 Pressure should hold without dropping for 3 minutes.



19

Oil pump

General description

The oil pump is mounted on the engine suspension plate and is driven by the crankshaft idler gear. It is a spur gear pump with internal none adjustable oil pressure relief valve. The oil pump is a none serviceable unit. In the event of failure or at major overhaul a new pump (supplied with drive gear fitted) can be obtained from your Perkins Distributor.

To remove and to fit

19-6

Special tools

15 mm Socket ($\frac{3}{8}$ "-10 mm drive) "Universally available"

12" (300 mm) x $\frac{3}{8}$ " (10 mm) Extension bar
"Universally available"

Crowfoot spanner "Universally available"

To remove

1 Remove the oil pick-up pipe (A1) and discard the sealing 'O' rings.

2 Remove the flexible oil pipes (A2) and (A3) using the crowfoot spanner.

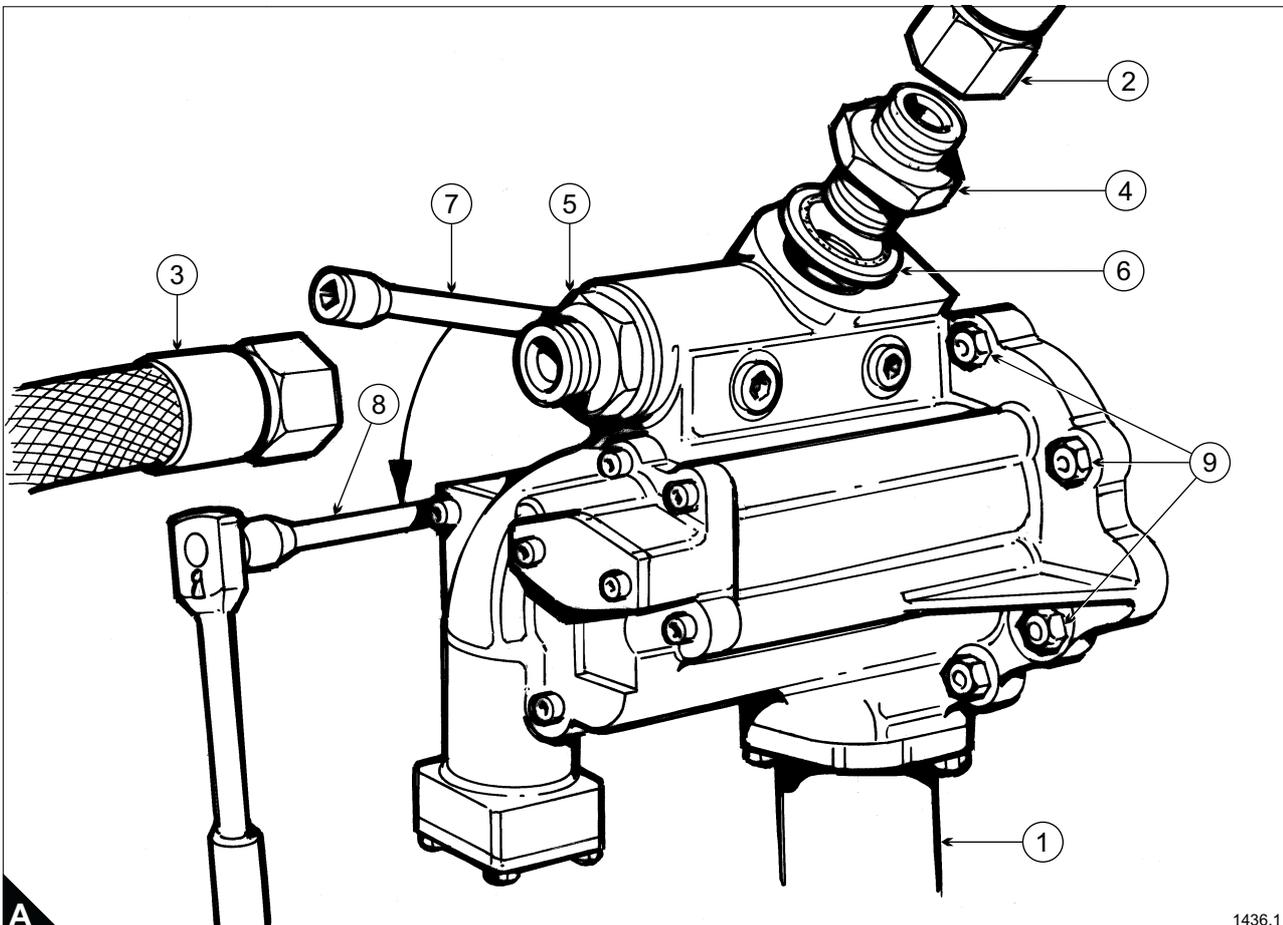
3 Remove the oil pipe unions (A4) and (A5), discard the sealing washers (A6).

Note: The oil pipe unions must be retained for fitting to the new oil pump.

4 Fit the 15 mm socket to the extension bar, locate the socket in turn on the retaining nuts in position (A7) and (A8) on the crankcase side of the oil pump and remove them.

5 Remove the retaining nuts (A9) then pull the oil pump out of its location in the suspension plate.

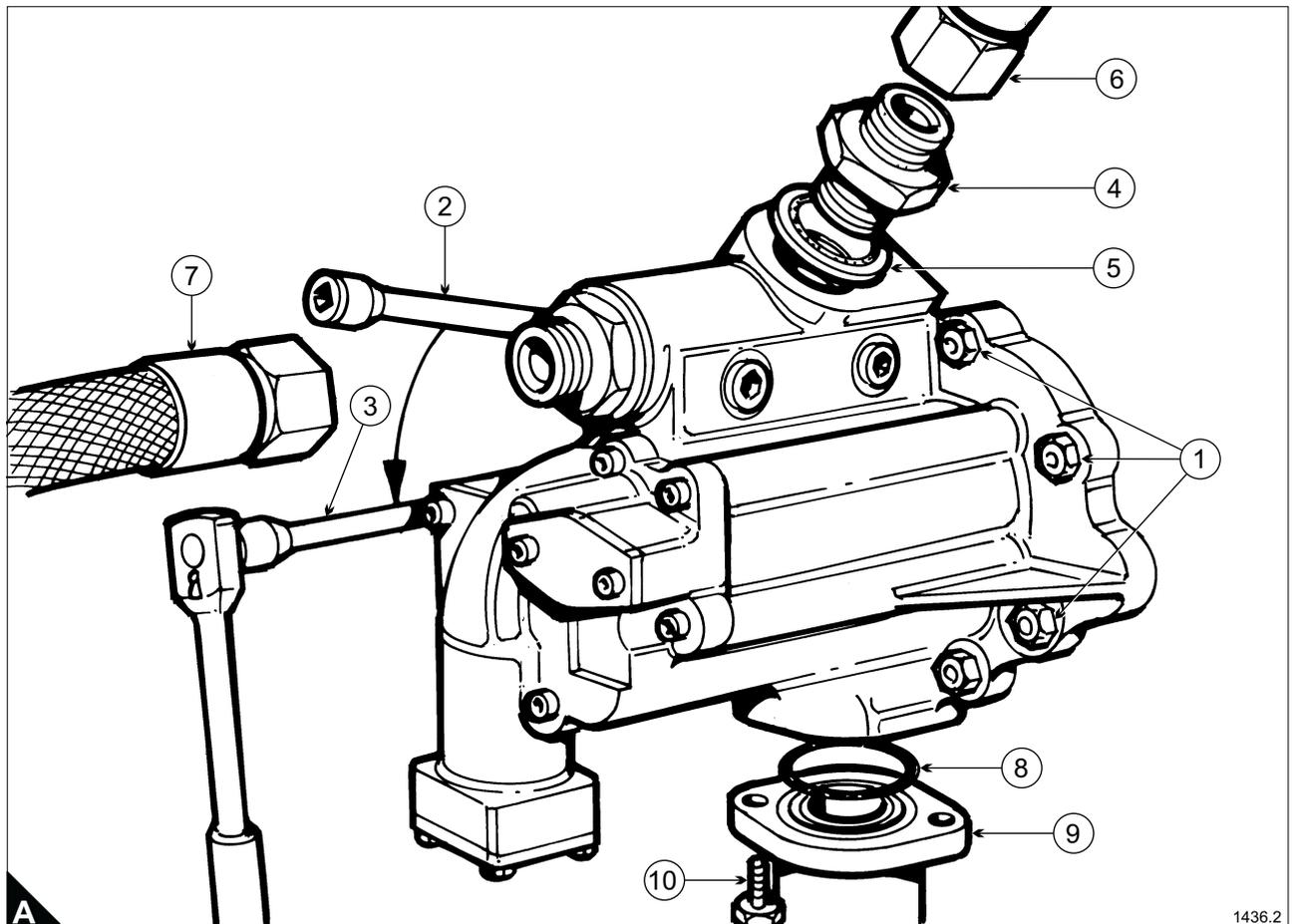
6 Remove the oil pump to suspension plate sealing joint.



1436.1

To fit

- 1 Fit a new oil pump to suspension plate joint.
- 2 Lubricate the oil pump drive gear the carefully slide the oil pump down its mounting studs into position.
- 3 Fit the four outer retaining nuts (A1) hand tight.
- 4 Using the 15 mm socket and extension bar fit the crankcase side retaining nuts in positions (A2) and (A3) hand tight.
- 5 Torque the retaining nuts to 35 lb.ft (50 Nm) in a diagonal pattern pulling the pump squarely to the suspension plate.
- 6 Fit flexible oil pipe unions (A4) using new sealing washers (A5) torque the unions to 80 lb.ft (108 Nm).
- 7 Fit the flexible oil pipes (A6) and (A7) torquing them to 80 lb.ft (108 Nm).
- 8 Fit the 'O' rings (A8) to the oil pick-up pipe flanges (A9) holding them in position with petroleum jelly.
- 9 Carefully tighten the retaining bolts (A10) by hand pulling the oil pick-up pipe squarely to the oil pump and oil sump. Torque to 35 lb.ft (50 Nm).



1436.2

20

Charge air cooler

General description

The charge cooler heat exchanger matrix is a two stage system using coolant from the engine and an independent supply.

The compressed gas and air mixture passes through the matrix lowering its temperature before it enters the engine inlet manifolds.

The charge air cooler heat exchanger matrix is a non-serviceable unit, in the event of failure or at a major overhaul a new matrix can be obtained from your Perkins Agent.

To remove and to fit

20-1

Special tools

Hoist and sling "Universally available"

To remove

1 Drain the charge cooler cooling system.

Note: Start the charge cooler removal procedure from 'A' bank flywheel end (A).

2 Remove the CMR sensors (A1) and (A2).

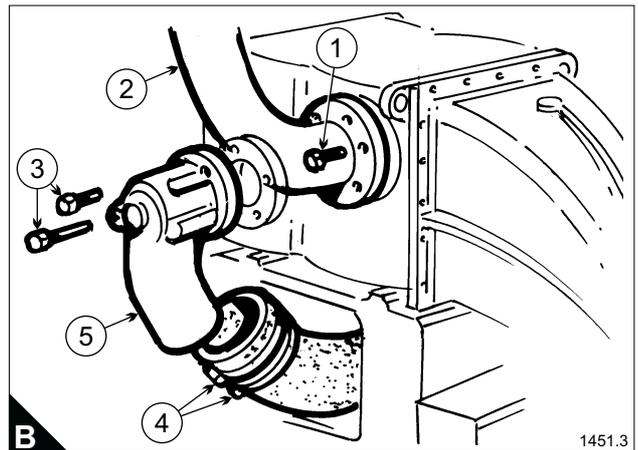
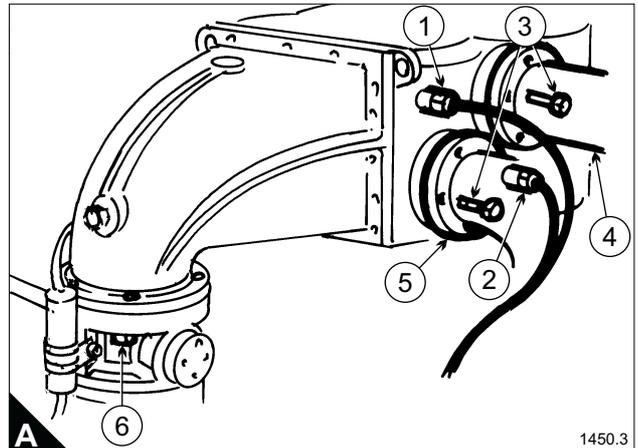
3 Remove the retaining bolts (B3).

4 Remove the coolant pipes (A4) and (A5) (OEM installed).

5 Remove the four retaining bolts (A6) from the butterfly valve flange.

6 Working on 'B' Bank flywheel end remove the retaining bolts (B1) and the OEM installed pipework (B2).

7 Remove the retaining bolts (B3) and release the hose clips (B4) to remove coolant pipe from the engine.



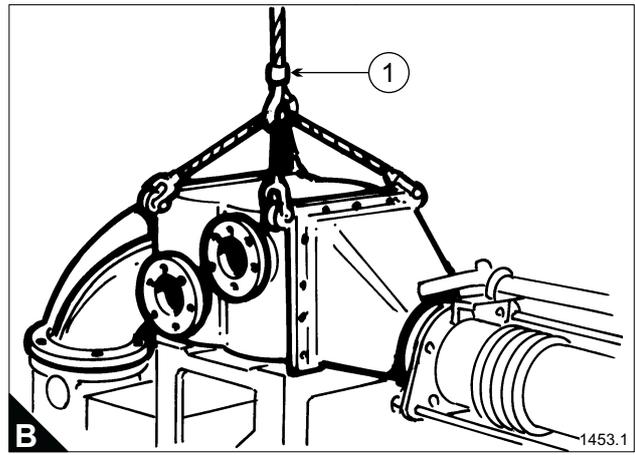
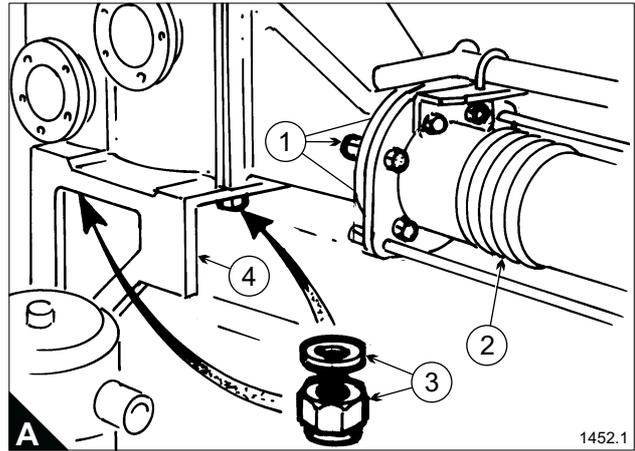
Continued

20

8 Remove the retaining nuts and bolts (A1) holding charge cooler to the expansion pipe (A2).

9 Remove the four charge cooler retaining nuts and washers (A3) from the underside of the support bracket (A4).

10 Fit the lifting sling (B1) to the lifting eyes on the charge cooler, then carefully hoist the unit off the engine.



To fit

1 Fit the sling to the lifting eyes on the charge cooler and hoist the charge cooler into position (A1) then remove the sling.

2 Fit the four charge cooler retaining nuts and washers (A2) to the underside of the support bracket (A3). Torque them in a diagonal pattern to 35 lb.ft (50 Nm).

3 Using a new joint, fit the retaining bolts and nuts (A4) holding the charge cooler and expansion pipe flanges, also fitting the support bracket for the breather pipe (A5). Tighten the bolts by hand pulling the pipe flanges evenly together, then torque to 35 lb.ft (50 Nm).

4 Using a new joint fit the four bolts holding the butterfly valve flange to the charge cooler flange tighten the bolts by hand pulling the flanges evenly together then torque to 35 lb.ft (50 Nm).

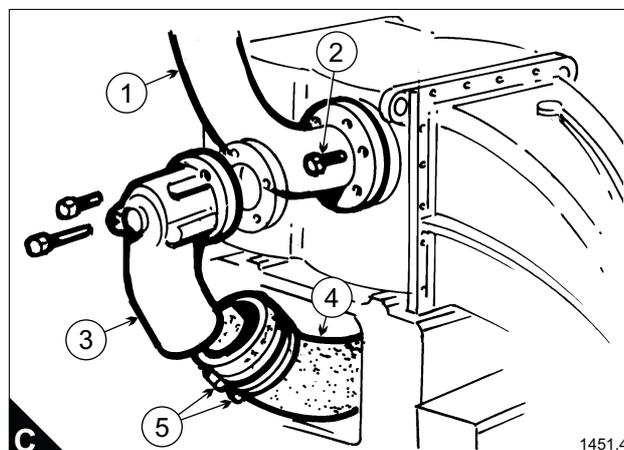
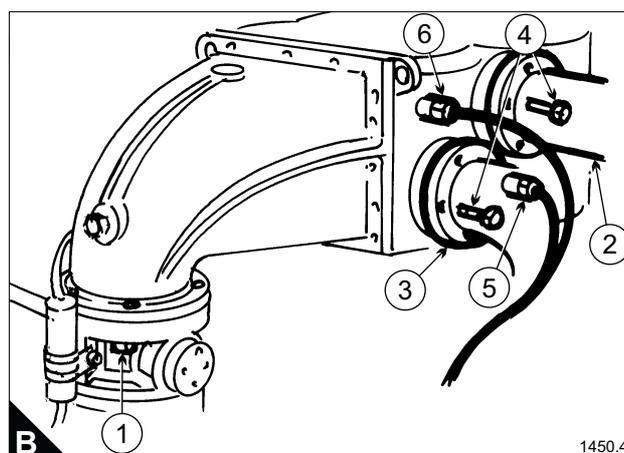
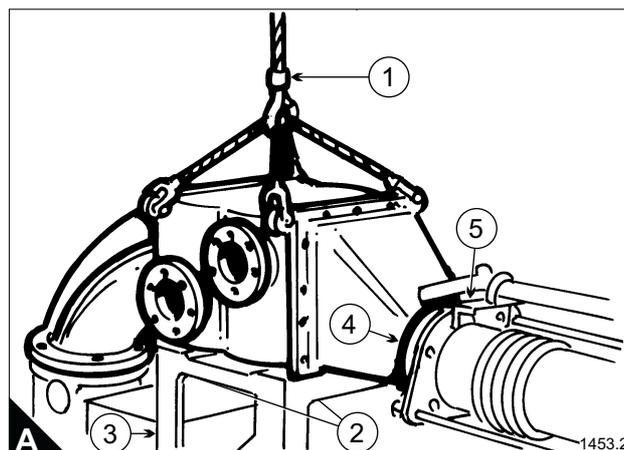
5 Using new joints fit the coolant pipes (B2) and (B3) tighten the retaining bolts (B4) by hand to pull the pipe flanges evenly together then torque to 35 lb.ft (50 Nm).

6 Fit the CMR sensors.

7 Fit the coolant pipe (C1) using a new joint tighten the retaining bolts (C2) by hand to pull the pipe flanges evenly together then torque to 35 lb.ft (50 Nm).

8 Fit the coolant pipe (C3) using a new joint locate the pipe in the hose (C4) tighten the retaining bolts by hand to pull the pipe flanges evenly together then torque to 35 lb.ft (50 Nm).

9 Tighten the hose clips (C5).



20

To clean/replace charge cooler heat exchanger matrix

20-2

Special tools

Industrial detergent "Universally available"

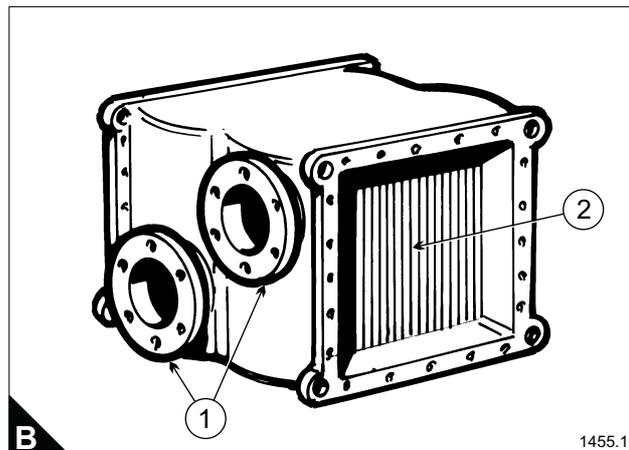
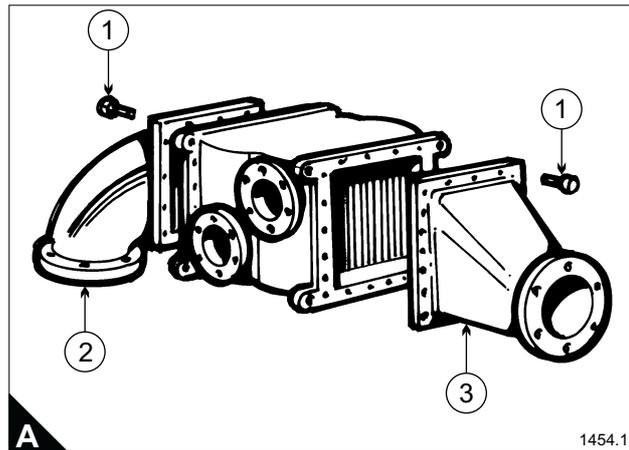
Limescale solvent "Universally available"

- 1 Remove the retaining bolts (A1) then lift off the manifold covers (A2) and (A3).
- 2 Check the limescale contamination in the coolant tubes by looking through the coolant feed and return apertures (B1).
- 3 Check the oil/carbon contamination level on the matrix guiles (B2).

Note: If the heat exchanger matrix appears to be in serviceable condition it can be cleaned using industrial detergent and limescale solvent. The manufacturers instruction on the use of these substances must be strictly adhered to.

Caution: If limescale build up or oil/carbon contamination is still present after cleaning the heat exchanger matrix must be replaced, as its ability to transfer heat will reduce engine power.

- 4 Using a new joint fit the manifold covers to the heat exchanger matrix, tighten the retaining bolt hand tight pulling the covers squarely to the matrix then torque to 20 lb.ft (27 Nm).



21

Starter motors

24 volt starter motor

Warning! The base nuts of all terminals must not be undone. Slackening of these nuts can cause internal damage to the connections.

Note: In the event of failure service exchange starters are normally supplied.

To remove and to fit

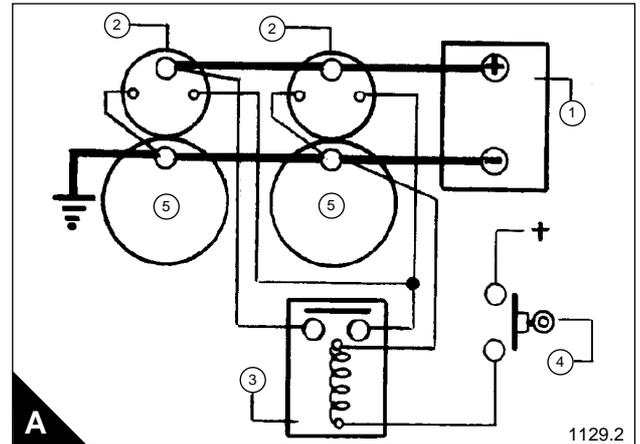
21-1

To remove

- 1 Remove the nut from each main terminal.
- 2 Remove the leads, mark them to ensure correct replacement.
- 3 Remove the retaining setscrews and withdraw the starter motor.

To fit

- 1 Insert the starter motor into the flywheel housing.
- 2 Refit the retaining setscrews in the mounting flange and tighten down evenly to ensure the starter is correctly positioned.
- 3 Re-connect the leads to each main terminal.



(A)

- ① 24 volt battery system
- ② Twin starter motors
- ③ Start relay
- ④ 3 position keyswitch
- ⑤ Starter motor

The chart below provides general fault diagnosis information which should allow the majority of operational problems to be resolved.

Where relays are required to be checked the following procedures must be followed:

2ST Relay or 33RA relay

- 1 Remove the lead to terminal 1 on the starter and energise the circuit.
- 2 Check the positive supply from the control panel to the SR1 relay.
- 3 If there is no supply, check the control panel.
- 4 If the supply is available check the SR1 relay, an audible 'click' will be heard when it is energised and the lead to terminal 1 should become live.
- 5 If there is no response fit a new unit.

TSL5 Repeater relay

- 1 Disconnect the lead to terminal 2 on repeater relay and energise the circuit.
- 2 The repeater relay should pulse approximately once a second until a positive supply is applied to terminal 2 when pulsing should cease.
- 3 If the relay does not operate as described, fit a new one.

Fault	Remedy
When starter is energised nothing happens	<ol style="list-style-type: none"> 1 Check battery voltage. 2 Check supply to solenoid and starter terminals. 3 Fit new starter.
Starter "clicks" and does not engage the pinion or rotate	<ol style="list-style-type: none"> 1 Check battery voltage and connections. 2 Fit new starter.
Starter rotates pinion against the ring gear	<ol style="list-style-type: none"> 1 Fit new starter. <p>Note: In the event of a damaged pinion, the ring gear must be examined and any burrs removed.</p>
Starter engages but fails to crank or cranks slowly	<ol style="list-style-type: none"> 1 Check that the engine is free to rotate. 2 Battery voltage too low.
Starter repeatedly attempts rapid engagements	<ol style="list-style-type: none"> 1 Pinion not able to engage. Examine pinion teeth and ring gear. 2 Faulty TSL5 repeater relay (if fitted).
Starter continues running after switching off	<ol style="list-style-type: none"> 1 Stop by disconnecting the battery. Check the pinion has disengaged. If not, disengage pinion and try starter again. 2 Fit a new starter. 3 Check repeater relay (if fitted).

22

Flywheel and flywheel housing

To remove and to fit

22-1

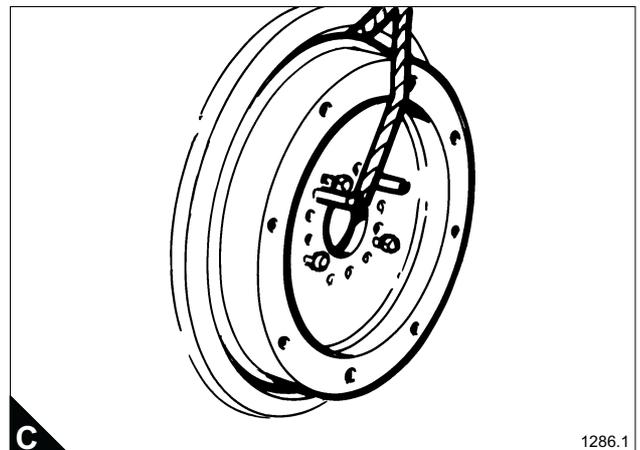
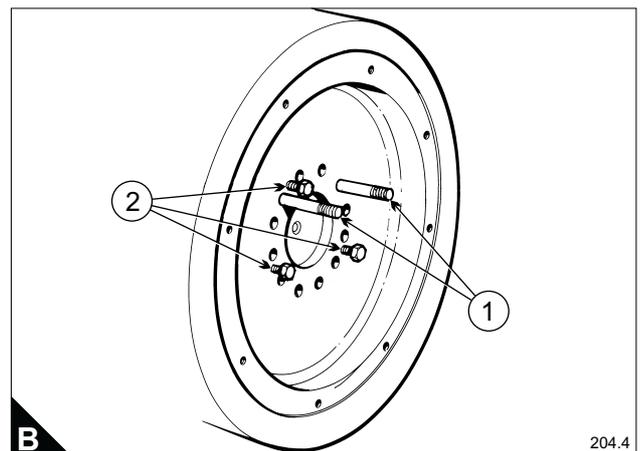
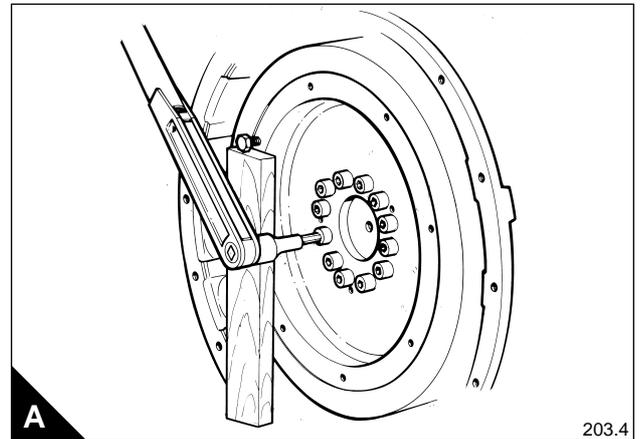
Special tools

Pilot studs 27610179

Hoist and sling "Universally available"

To remove

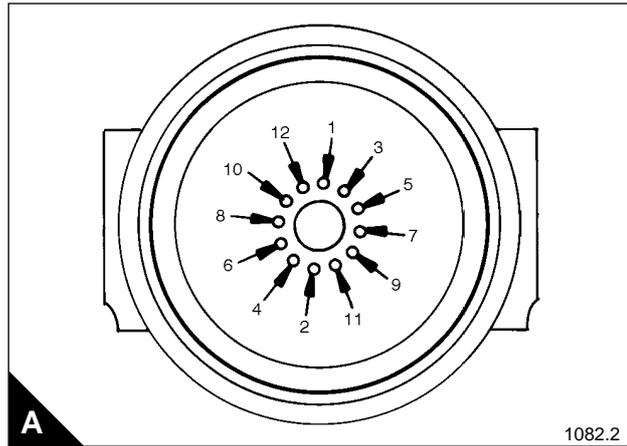
- 1 Lock the flywheel to undo the retaining capscrews. Do this by putting a bolt in one of the tapped holes in the front face of the flywheel at approximately 10 o'clock then set a piece of wood between the underside of the bolt head and the floor (A).
- 2 Loosen all of the capscrews, take out the two top capscrews and fit pilot studs (B1).
- 3 Remove the remaining flywheel bolts and fit three 100 mm (4¹/₂") UNC bolts into the threaded holes in the flywheel (B2).
- 4 Tighten the bolts evenly pushing the flywheel off the crankshaft.
- 5 Screw the jacking bolts in until there is sufficient clearance to thread a rope sling through the flywheel (C).
- 6 Take the weight of the flywheel with the hoist, then slide it along the studs and lift it clear of the engine.



22

To fit

- 1 Screw the long guide studs into the crankshaft.
 - 2 Hoist the flywheel into positions with the pilot studs.
 - 3 Push the flywheel onto the studs as far as the rope sling allows. Remove the rope sling and carefully pull the flywheel up to the crankshaft using the retaining capscrews.
 - 4 Remove the pilot studs, and refit the two capscrews.
 - 5 Lock the flywheel using the same method as at removal, but with the bolt in the front face of the flywheel at approximately 2 o'clock, see Section 22, page 109.
 - 6 Tighten the flywheel retaining capscrews in the order shown (A) hand tight, then in the same order to 100 lb.ft (135 Nm) and finally to 650 lb.ft (878 Nm).
- Caution:** The maximum permissible run-out of the flywheel is 0.005" (0.13 mm).



 To replace the flywheel ring gear **22-2**

Special tools

Equipment to heat ring gear to 250°C "Universally available"

Insulated gloves "Universally available"

1 Remove the flywheel from the engine, see Section 22, page 109.

2 Drill the ring gear at its base (A1) set a chisel (A2) between the gear teeth and above the drilling.

3 A sharp blow with a hammer will split the ring gear allowing for its removal.

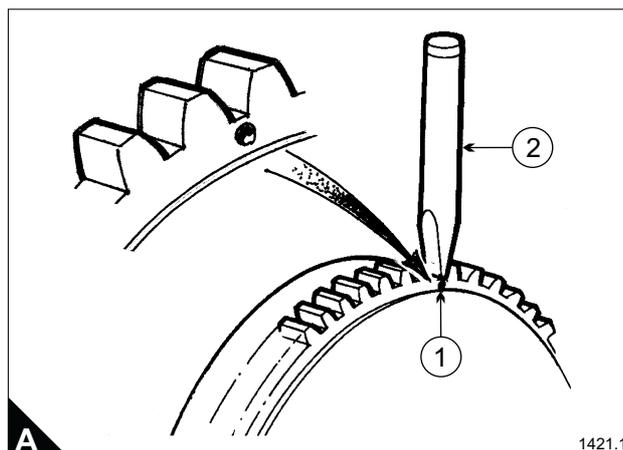
4 Lay the flywheel on its front face and check the ring gear seating is clean and free from burrs.

5 Heat the ring gear.

Caution: *The ring gear is an interference fit and must be heated to 250°C to give sufficient expansion for fitting. This must be accurately monitored or damage to the hardened surface will occur.*

Note: The starter ring gear must be fitted with the chamfer on the teeth facing the starter motor pinion (B1).

6 Holding the heated ring gear with insulated gloves. Fit it to the flywheel check it has seated on the shoulder of the flywheel.



Flywheel housing

Note: Removal of the flywheel housing is normally undertaken at major overhaul, the following procedure is based on the assumption the engine has been removed from its installation and standing on the sump.

To remove and to fit **22-3**

Special tools

Hoist and sling "Universally available"

To remove

- 1 Remove the flywheel see Section 22, page 109.
- 2 Using a rope sling passed through the two starter motors holes in the flywheel housing, set the hoist to slight tension on the sling. Remove the bolts securing the flywheel housing to the crankcase.
- 3 Pull the flywheel housing from the dowels locating it to the crankcase. Lower the flywheel housing to the ground.
- 4 Clean off the flywheel housing and crankcase paying particular attention to cleaning the joint material left on the mating surfaces.

To fit

- 1 Fit a new joint to the crankcase fitting it to the flywheel housing locating dowels.
- 2 Hoist the flywheel housing back into position carefully locating it on the dowels.
- 3 Refit all securing bolts, tightening them down evenly to pull the flywheel housing squarely up to the crankcase then torque the bolts down to 35 lb.ft (50 Nm).

23

Special tools

Basic mechanical tool kit of “Universally available” items

Description	No. Off
Screwdriver (Rocker cover & rocker clearance adjustment)	1
Feeler Gauge Set (Rocker clearance adjustment)	1
19 mm Combination spanner	1
Strap Wrench (Oil filter bowls, removal)	1
22 mm Combination spanner	1
17 mm Combination spanner (Bridge piece adjuster locknut)	1
30 mm Combination spanner (Sump drain)	1
8 mm Hex bit rocker box allen screws	1
14 mm Hex bit damper allen screws	1
17 mm Hex bit turbocharger allen screws	1
17 mm Crows foot air manifold nuts	1
50 mm Crows foot flexible oil pipes	1

Basic mechanical/electronic tool kit (Perkins supplied)

Part No.	Description	No. Off
T6253/325A/ 325B	Spark plug removal tool	1
27610176	Spare retaining clip for spark plug removal tool	1
27610178	Cylinder head spark plug thread cleaning tool	1
27610177	Detonation sensor removal tool	1
27610183	Spare retaining clip for detonation sensor removal tool	1
SE253	Engine barring over tool	1
T6253/312	Valve recession tool	1
X680/180	EMS Diagnostic tool (TIPSS)	1
X838/22-A	Timing calibration pick-up probe	1

Specialised mechanical tool kit (Perkins supplied)

Part No.	Description	No. Off
6253/154	Cylinder head lifting tool	1
T6253/139	Piston ring compressor	1
T6253/295	Suction tool (piston removal)	1
T6253/152	Cylinder liner extractor	1
T6253/200	Liner clamping kit	1
T85316/1	Front oil seal insertion kit	1
T6253/140	Rear oil seal insertion kit	1
T6253/199	Camshaft bearing removal and fitting kit	1
T6253/142	Camshaft guide tube	1
27610179	Flywheel support studs	2
T6253/214	Torsional vibration damper lifting tool	1

Caution: The above tools are required for major overhaul.

23

Basic electronic tool kit (Perkins supplied)

Part No.	Description	No. Off
27610162	TIPSS Service tool kit (CD & Installation Manual)	1
27610164	TIPSS Communication adaptor kit (complete)	1

Specialised electronic tool kit

Part No.	Description	No. Off
27610163	TIPSS Service tool User's Manual	1

Individual components of the TIPSS Communication adaptor kit

Part No.	Description	No. Off
27610165	TIPSS Communication Adaptor unit	1
27619166	TIPSS Communication Adaptor Operators manual	1
27610167	TIPSS Communication Adaptor software (CD ROM)	1
27610168	TIPSS Short Unicable	1
27610169	TIPSS Long PC Serial Cable	1
27610170	TIPSS Plastic carrying case (inc. foam block)	1

Engine wiring and electrical repair kit Part No. 27610181

Description	No. Off
Deutsch contact pin size 16 16/18 AWG	100
Deutsch contact socket size 16 16/18 AWG	100
Deutsch DT female 2 pos. plug + boot adaptor	5
Deutsch DT female 3 pos. plug + boot adaptor	1
Deutsch DT male 3 pos. receptacle in-line + boot adaptor	1
Deutsch HD10 female 3 pos. plug	2
Deutsch contact removal tool STD seal 0411-204-1605	5
Deutsch wedgelock W2S	5
Deutsch wedgelock W3P	4
DIN 72585 cavity plug (blank)	20
DIN 72585 connector 4cts Base with flange APD-1AP-K2 121583-004	3
DIN 72585 connector 4cts female plug APD-1BS-K2 121583-0000	3
DIN 72585 connector flange gasket 075-8503-000	3
DIN 72585 connector gold plated pin contact APK-PB25H10-002	20
DIN 72585 connector gold plated socket contact APK-SB25H10-002	20
DIN 72585 connector straight shell Dia. 10 mm 058-8578-102	3
Aluminium rivets 3 x 12 mm (Gesipa)	30
MIL-C-5015 3 pin female plug DMS3106A-10	1
Deutsch DT male 3 pos. receptacle bulkhead mounting connector	1
Deutsch HD10 male 3 pos. receptacle in-line	1
Deutsch tool crimp sizes 12-20	1
Riveter kit	1
Tool box	1
15 Division compartment tool box	1
9 Division compartment tool box	1
Amp crimper 354940-1 + Die set 90546-2	1

Top up for engine wiring and electrical repair kit Part No. 27610182

Description	No. Off
Deutsch contact pin size 16 16/18 AWG	100
Deutsch contact socket size 16 16/18 AWG	100
Deutsch DT female 2 pos. plug + boot adaptor	5
Deutsch DT female 3 pos. plug + boot adaptor	1
Deutsch DT male 3 pos. receptacle in-line + boot adaptor	1
Deutsch HD10 female 3 pos. plug	2
Deutsch contact removal tool STD seal 0411-204-1605	5
Deutsch wedgelock W2S	5
Deutsch wedgelock W3P	4
DIN 72585 cavity plug (blank)	20
DIN 72585 connector 4cts Base with flange APD-1AP-K2 121583-004	3
DIN 72585 connector 4cts female plug APD-1BS-K2 121583-0000	3
DIN 72585 connector flange gasket 075-8503-000	3
DIN 72585 connector gold plated pin contact APK-PB25H10-002	20
DIN 72585 connector gold plated socket contact APK-SB25H10-002	20
DIN 72585 connector straight shell Dia. 10 mm 058-8578-102	3
Aluminium rivets 3 x 12 mm (Gesipa)	30
MIL-C-5015 3 pin female plug DMS3106A-10	1
Deutsch DT male 3 pos. receptacle bulkhead mounting connector	1
Deutsch HD10 male 3 pos. receptacle in-line	1

