Workshop Service Manual

MASSEY FERGUSON

MF 300 series tractors

Beauvais
AGCO S.A.S. - 41 avenue Blaise Pascal - 60000
Beauvais - France - RC B562 104 539
© AGCO 2016

June 2016
ACT0027090
English

300 Series Tractor Workshop Manual

CONTENTS

Section No	Description
1	GENERAL SPECIFICATIONS
2	SPLITTING THE TRACTOR
3	ENGINE DATA
4	CLUTCH
5	GEARBOXES
6	REAR AXLE
7	POWER TAKE-OFF
8	FRONT AXLE
9	HYDRAULICS
10	ELECTRICAL SYSTEM
11	SERVICE TOOLS

SECTION 1

Introduction and Safety

INDEX

1A	INTRODUCTION and SAFETY
1B	TRACTOR SPECIFICATIONS
1C	MISCELLANEOUS DATA
1D	SERVICING the TRACTOR

Introduction and Safety in the Workshop

Section 1 – Part A

Table of Contents

Operation No.	Description	Page No.
-------	Introduction	1A- 2
-------	Safety in the Workshop	1A- 4

Introduction and Safety in the Workshop

INTRODUCTION

The purpose of this manual is to assist Dealers and Distributors in the efficient repair and maintenance of Massey Ferguson farm machinery. Carrying out the procedures as detailed, together with the use of special tools where appropriate, will enable the operations to be completed within the time stated in the Repair Time Schedule.

To assist with locating information, each section of the manual is preceded by a contents page listing the operations. Each instruction within an operation has a sequence number, and to complete the operation in the minimum time it is essential that these instructions are performed in numerical sequence commencing at 1, unless otherwise stated.
When applicable, these sequence numbers identify the components in the appropriate illustration. Where an operation requires the use of a special tool, the tool number is quoted under the operation heading and is repeated in, or following, the instruction involving its use.

Indexing

For convenience the manual is divided into sections and parts, each page bearing a section and part number. The sections are subdivided into numbered operations. Example: 1-7A would be Operation 1 in Section 7, Part A. This simplifies cross referencing and enables the subject to be found easily.

Definition of Terms

The operation descriptions generally used throughout the schedules may be defined as follows:

Removal and Refitment – Remove and refit an original part or assembly, or a new part or assembly which does not involve additional operations or time.

Install – Install a part or component not previously fitted e.g., accessories.

Overhaul – Remove a part or assembly, dismantle, inspect and recondition, re-assemble, and re-install making all necessary adjustments.

Dis-assembly and Re-assembly – The terms 'Dis-assembly' and 'Re-assembly' indicate the orderly taking apart of an assembly into individual parts and rebuilding it into the original assembly.

Adjust – Make the necessary adjustments to restore specified setting or performance.

Check – Ascertain if a setting or condition is within the limits of acceptability, either as defined in the manufacturer's specifications or, where a dimension is not specified, in the judgement of the mechanic. The checking of fixings, e.g. nuts and bolts, includes tightening to the specified torque figures listed in this Manual.

Servicing – All technical work undertaken to maintain the machine in working order.

Special Tools

Where the use of a special tool is specified in an operation the tool number will be shown under the operation heading and also following the instruction requiring its use.

The use of the special tools mentioned in the text contributes to a safe, efficient and profitable repair. Some operations are impracticable without their use, for example, the refitment of the differential unit. Distributors and Dealers are therefore urged to check their tools against the list provided. Where necessary, tools may be ordered from: AGCO Limited. Product Reliability, Banner Lane, Coventry. CV4 9FG (Phone 44 (0) 1203 694400) (Fax 44 (0) 1203 852318).

For further details, refer to the special tool catalogue for this range of tractors, Publication No. 1856 550 M5, or Section 14 of this manual.

Repairs and Replacements

When service parts are required it is essential that only genuine Massey Ferguson replacements are used.

Attention is particularly drawn to the following points concerning repairs and the fitting of replacement parts and accessories:

Safety features embodied in the tractor may be impaired if other than genuine parts are fitted.

In certain territories, legislation prohibits the fitting of parts not to the tractor manufacturer's specification. Torque wrench setting figures given in the Workshop Manual must be strictly adhered to. Locking devices where specified must be fitted. If the efficiency of a locking device is impaired during removal it must be renewed.

The tractor warranty may be invalidated by the fitting of other than genuine Massey Ferguson parts. All Massey Ferguson replacements have the full backing of the manufacturer's warranty. Massey Ferguson Distributors and Dealers are obliged to supply only genuine service parts.

Repair of the Tractor

Follow these important points:

CLEAN THE TRACTOR AND DIAGNOSE THE FAULT BEFORE DIS-ASSEMBLY.

If possible, make a complete diagnosis to determine the extent of the repair required. Take precautions, as necessary, to prevent dirt or other foreign material entering the hydraulic, fuel or air systems.

DO NOT MIX PARTS.

Make particular note of special parts which should not be interchanged.

DURING DIS-ASSEMBLY, CLEAN PARTS THOROUGHLY AND INSPECT THEM FOR WEAR, DAMAGE, ETC.

LABEL PARTS. PROTECT PRECISION OR MACHINED SURFACES.

Amendments

Under normal conditions revised pages are issued carrying the same number as the existing pages requiring amendment. The new pages are inserted in place of the existing ones. The old pages should then be destroyed.

The issue number is printed on the bottom of each page, e.g. Issue 4, 2 or 3 etc.

In some cases additional pages or completely new sections may be issued. These pages are to be inserted immediately following the page carrying the next lowest page number, or section number as appropriate.

Where new pages are required to be positioned between existing pages, the new page numbers will contain a suffix letter - example: New page number 7A-16a. This page is inserted after existing page number 7A-16 and before page number 7A-17. Correspondingly a further new page numbered 7A-16b would be positioned after 7A-16a but before 7A-17.

To ensure that a record of amendments to this manual is readily available, the list of amendments will be re-issued with each set of revised pages, quoting the amendment number, date of issue and appropriate instructions.

NOTE: *Service Bulletins and Amendment Sheets are issued to the Massey Ferguson Distributors and Dealers only and are not for general circulation.*

SAFETY ALERT SYMBOL AND TERMS

This safety alert symbol means ATTENTION! BECOME ALERT! YOUR SAFETY IS INVOLVED!

The safety alert symbol identifies important safety messages on machines, safety signs, in manuals, or elsewhere. When you see this symbol, be alert to the possibility of personal injury or death. Follow the instructions in the safety message.

Why is SAFETY important to you?

★ ACCIDENTS DISABLE AND KILL ★

★ ACCIDENTS ARE COSTLY ★

★ ACCIDENTS CAN BE AVOIDED ★

SAFETY in the WORKSHOP

This safety section of your Workshop Service manual is intended to point out some of the basic safety situations which may be encountered during the normal repair operations of the tractor, and to suggest possible ways of dealing with these situations.

Additional precautions may be necessary, depending on the type of repair and the conditions at the work site or in the workshop. Massey Ferguson has no direct control over the repair procedures, operation, inspection, lubrication or general maintenance. Therefore it is YOUR responsibility to use good safety practices in these areas.

SAFETY – A WORD to the MECHANIC

It is your responsibility to read and understand this safety section before carrying out repairs on Massey Ferguson equipment.

Remember that YOU are the key to safety. Good safety practices not only protect you, but also the people around you. Study the features in this section and the rest of the manual and make them a working part of your safety programme. Practice all other usual and customary safe working precautions, and above all – REMEMBER – SAFETY IS YOUR RESPONSIBILITY. YOU CAN PREVENT SERIOUS INJURY OR DEATH.

SAFETY – DANGER, WARNING and CAUTION

Whenever you see these signal words and symbol used in this manual and on decals, you MUST take note of their instructions.

DANGER: The symbol and the word DANGER indicates an imminently hazardous situation which, if not avoided, will result in DEATH OR VERY SERIOUS INJURY.

WARNING: The symbol and the word WARNING indicates a potentially hazardous situation. If the instructions or procedures are not correctly followed it could result in PERSONAL INJURY, OR LOSS OF LIFE.

CAUTION: *The symbol and the word CAUTION is used to indicate a potentially hazardous situation that, if not avoided, may result in MINOR OR MODERATE INJURY.*

IMPORTANT: *The word IMPORTANT is used to identify special instructions which, if not observed, could result in damage to, or destruction of the machine, process or its surroundings.*

NOTE: *The word NOTE is used to indicate points of particular interest for more efficient and convenient repair or operation.*

SAFETY DECALS

WARNING: DO NOT remove or obscure Danger, Warning or Instruction Decals.

Replace any Danger, Warning, Caution or Instruction Decals that are not readable, damaged or are missing.

GENERAL

Practically all service work involves the need to drive a tractor. The Operator Instruction Book, supplied with each tractor or implement, contains detailed safety precautions relating to driving, operating and servicing. These precautions are as applicable to the service mechanic as they are to the operator, and should be read, understood and practised by all personnel.

Prior to undertaking any maintenance, repair, overhaul, dismantling or re-assembly operations, whether within a workshop facility or out 'in the field', consideration should be given to factors that may have an effect upon Safety, not only upon the mechanic carrying out the work, but also upon bystanders.

- DO NOT allow children or bystanders around or on the machine while it is being adjusted, serviced, repaired or operated.

PERSONAL CONSIDERATIONS

Clothing

- The wrong clothes or carelessness in dress can cause accidents. Check to see that you are suitably clothed. DO NOT wear loose clothing or long hair around equipment.

  Some jobs require special protective equipment

Eye Protection

- The smallest eye injury may cause loss of vision. Injury can be avoided by wearing the proper eye protection when engaged in chiselling, grinding, discing, sanding, welding, painting etc.
- Wear safety goggles or safety glasses appropriate to the job in hand.

Breathing Protection

- Fumes, dust and paint spray are unpleasant and harmful. These can be avoided by wearing respiratory protection.

Hearing Protection

- Loud noise may damage your hearing and the greater the exposure the worse the damage. If you think the noise is excessive, wear ear protection.

Hand Protection

- It is advisable to use a protective barrier cream before work to prevent irritation and skin contamination. After work clean your hands in soap and water. Solvents such as white spirit, paraffin, etc., may harm the skin.
- Wear gloves when ever possible to protect your hands. DO NOT wear rings or wrist watches when working on machinery, as they could catch on moving parts and cause serious injury.

Foot Protection

- Substantial or protective footwear with reinforced toe-caps (safety shoes) will protect your feet from falling objects. Additionally, oil-resistant soles will help to avoid slipping.

Special Clothing

- For certain work it may be necessary to wear flame or acid-resistant clothing.

EQUIPMENT CONSIDERATIONS

Machine Guards

- Before using any machine, check to ensure that the machine guards are in position and serviceable. These guards not only prevent parts of the body or clothing coming in contact with the moving parts of the machine, but also ward off objects that might fly off the machine and cause injury. Ensure that missing guards are replaced.

Lifting Appliances

- Always ensure that lifting equipment, such as chains, slings, lifting brackets, hooks and eyes are thoroughly checked before use. If in doubt, select stronger equipment than is necessary.
- Never stand under a suspended load or raised implement.
- Avoid injury through incorrect handling of components. Make sure you are capable of lifting the object. If in doubt get help.

Jacking

- Select a jack strong enough to carry the load.
- Stabilise the tractor and chock the wheels.
- Put support stands under the tractor. Lower the jack and let the tractor rest on the stands.
- DO NOT go under a tractor supported by a chain hoist or jack.

Compressed Air

- The pressure from a compressed air line is often as high as 7 bar (100 lbf/in^2). It is perfectly safe if used correctly. Any misuse may cause injury.
- Never use compressed air to blow dust, filings, dirt etc., away from your work area unless the correct type of nozzle is fitted and eye protection is used.
- Compressed air is not a cleaning agent, it will only move dust, etc., from one place to another. Look around before using an air hose as bystanders may get grit into their eyes, ears or skin.
- Used approved air guns, wear safety goggles, and use proper shielding to protect others in the work area.
- Never point an air nozzle at a persons body.

Hand Tools

- Many cuts, abrasions and injuries are caused by defective tools. Never use the wrong tool for the job, as this generally leads either to some injury, or to a poor job.
- Never use:
  - A hammer with a loose head or split handle.
  - Spanners or wrenches with splayed or worn jaws.
  - Spanners or files as hammers; or drills, clevis pins or bolts as punches.
- Grind off mushroom heads from chisels. The sharp edges can tear your skin if the tool slips. And, when the tool is struck, chips could break off and fly into your eyes.
- Keep a handle on every file to prevent the tang from piercing your palm or wrist if the file should slip or catch.
- For removing or replacing hardened pins use a copper or brass drift rather than a hammer.
- For dismantling, overhauling and assembly of major components, always use Special Service Tools recommended.

  These will reduce the work effort, labour time and repair cost.
- Always keep tools clean and in good working order.

Electricity

- Electricity has become so familiar in day to day usage, that its potentially dangerous properties are often overlooked. Misuse of electrical equipment can endanger life.
- Before using any electrical equipment - particularly portable appliances - make a visual check to make sure that the cable is not worn or frayed and that the plugs, sockets, etc., are intact; make sure you know where the nearest isolating switch is located. Always use an earthed (grounded) 3 pin electrical cord.

GENERAL CONSIDERATIONS

Solvents

- Use only cleaning fluids and solvents that are known to be safe. Certain types of fluids can cause damage to components such as seals, etc., and can cause skin irritation. Solvent labels should be checked that they are suitable not only for the cleaning of components and individual parts, but also that they DO NOT affect the personal safety of the user.

Housekeeping

- Many injuries result from tripping or slipping over or on, objects or material left lying around by a careless worker. Prevent these accidents from occurring. If you notice a hazard, don't ignore it - remove it.
- A clean, hazard-free place of work improves the surroundings and daily environment for everybody.
- Keep work organised and clean. Wipe up spills of any kind to minimise the possibility of a fall. Keep tools and parts off the floor to further reduce the possibility of tripping and causing serious injury.

Fire

- Fire has no respect for persons or property. The destruction that fire can cause is not always fully realised. Everyone must be constantly on guard.
  - Extinguish matches, cigars, cigarettes, etc., before throwing them away.
  - Work cleanly, disposing of waste material into proper containers.
  - Locate the fire extinguishers and find out how to operate them.
  - DO NOT allow or use open flame near the fuel tank, fuel lines, battery, hydraulic hoses or component parts
- When using a gas torch, always keep a fully charged fire extinguisher within reach.
- In the event of fire:
  - DO NOT panic - warn those near and raise the alarm.

First Aid

- In the type of work that mechanics are engaged in, dirt, grease, fine dust, etc. all settle upon the skin and clothing. If a cut, abrasion or burn is disregarded it may be found that an infection has formed within a short time. What appears at first to be trivial could become painful and injurious. It only takes a few minutes to have a fresh cut dressed, but it will take longer if you neglect it. Make sure you know where the First Aid box is located and that it is kept fully stocked at all times.

OPERATIONAL CONSIDERATIONS

- Stop the engine, if at all possible, before performing any service.
- Place a warning sign on self propelled equipment which, due for service or overhaul, would be dangerous to start. Disconnect the battery leads if leaving such a unit unattended and remove the key.
- DO NOT attempt to start the engine while standing beside the tractor or attempt to by-pass the safety start switch. Make a practise of checking that neutral start switches are functioning correctly.
- Avoid prolonged running of the engine in a closed building or in an area with inadequate ventilation as exhaust fumes are highly toxic.
- Always turn the radiator cap to the first stop to allow pressure in the system to dissipate when the coolant is hot.
- Never work beneath a tractor which is on soft ground. Always take the unit to an area which has a hard level working surface - concrete is preferred.
- If it is found necessary to raise the equipment for ease of servicing or repair, make sure that safe and stable supports are installed, beneath axle housings, casings, etc., before commencing work.
- Certain repair or overhaul procedures may necessitate 'Separating the tractor', either at the engine gearbox or gearbox/rear axle locations. These operations are simplified by the use of the Tractor Splitting Kit/Stands (Use the Massey Ferguson MF.3012 Tractor Splitting Track, also available, MF.3013 Cab Stands). Should this equipment not be available, then every consideration must be given to stability, balance and weight of the components, especially if a cab is installed.
- Use footsteps or working platforms when servicing those areas that are not within easy reach.
- Cleanliness of the tractor hydraulic system is essential for optimum performance. When carrying out service and repairs plug all hose ends and component connections to prevent dirt entry.
- Clean the exterior of all components before carrying out any form of repair. Dirt and abrasive dust can reduce the efficiency and working life of a component and lead to costly replacement. Use of high pressure washer or steam cleaner is recommended.
- Before loosening any hoses or tubes connecting implements to remote control valves, etc., switch off the engine, remove all pressure in the lines by operating levers several times. This will remove the danger of personal injury by oil pressure.
- Prior to pressure testing, make sure all hoses and connectors not only of the equipment, but also those of the test equipment, are in good condition and tightly sealed. Pressure readings must be taken with the gauges specified. The correct procedure should be rigidly observed to prevent damage to the system or equipment, and to eliminate the possibility of personal injury.
- Hydraulic fluid escaping under pressure can have enough force to penetrate the human skin. To locate a leak under pressure, use a small piece of cardboard, never use your hands. If you are injected with hydraulic fluid seek medical help immediately.
- When equipment or implements are required to be attached to the hydraulic linkage, either for testing purposes or for transportation, the 'Position Control' should be used.
- Always lower equipment to the ground when leaving the tractor.
- If high lift attachments are installed on a tractor beware of overhead power, electric or telephone cables when travelling. Drop the attachment near to ground level to increase stability and minimise risks.
- DO NOT park or attempt to service the equipment on an incline. If unavoidable, take extra care and chock all wheels.
- Observe recommended precautions as indicated in this Service Manual when dismantling the air conditioning system as escaping refrigerant can cause frostbite.
- Prior to removing wheels and tyres from a tractor, check to determine whether additional ballast (liquid or weights) has been added. Seek assistance and use suitable equipment to support the weight of the wheel assembly. Store the wheel so that they cannot fall over and cause injury.
- When inflating tyres beware of over inflation - constantly check the pressure. Over inflation can cause tyres to burst and result in personal injury.

Heed these safety precautions, and the ones found in this manual, and you will protect yourself accordingly. Disregard them and you may become injured for life.

SERVICING TECHNIQUES

Service Safety

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all farm machinery as well as the personal safety of the individual doing the work.

This Service Manual provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help assure that a thorough repair is successfully completed.

There are numerous variations in procedures, techniques, tools, and parts for servicing tractors, as well as in the skill of the individual doing the work. This Manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Anyone who departs from the instructions provided in this Manual must realise that one compromises their personal safety and the tractor's integrity by the choice of repair methods, tools and/or parts.

Service Techniques

Clean the exterior of all components before carrying any form of repair. Dirt and abrasive dust can reduce the efficient working life of a component and lead to costly replacement.

Time spent on the preparation and cleanliness of working surfaces will pay dividends in making the job easier and safer and will result in overhauled components being more reliable and efficient in operation.

Use cleaning fluids which are known to be safe. Certain types of fluid can cause damage to 'O' rings and cause skin irritation. Check the label on Solvents to ensure that they are suitable for the cleaning of components and also that they DO NOT risk the personal safety of the user.

Replace 'O' rings, seals or gaskets whenever they are disturbed. Never mix new and old seals or 'O' rings, regardless of condition. Always lubricate new seals and 'O' rings with hydraulic oil before installation.

When replacing component parts use the correct tool for the job.

Hoses and Tubes

Always replace hoses and tubes if their ends are damaged.

When installing a new hose, loosely connect each end and make sure the hose takes up the designed position before tightening the connection. Clamps should be tightened sufficiently to hold the hose without crushing and to prevent chafing or contact with other parts.

Before removing hoses or tubes make sure they are identified so that they can be correctly re-assembled.

Be sure any hose which has been installed is not kinked or twisted after it is tightened.

Bearings

Bearings which are considered suitable for further service should be cleaned in a suitable solvent and immersed in clean lubricating oil until required.

DO NOT spin bearings with compressed air. The centrifugal force could cause a ball or roller to fly outward with enough force to cause an injury.

Installation of a bearing can be classified in two ways: press fit on rotating parts such as shafts, and gears, and push fit into static locations such as reduction gear housings. Where possible, always install the bearing onto the rotating component first.

Always use pullers or a press to remove and/or install bearings, bushings and cylinder sleeves, etc. Use hammers, punches and chisels only when absolutely necessary and be sure to wear safety goggles.

Shims

When shims are removed, tie them together and identify them as to location. Keep shims clean and flat until they are re-installed.

Gaskets

Be sure the holes in the gasket correspond with the lubricant passages in the mating parts. If gaskets are to be made, select material of the proper type and thickness. Be sure to cut holes in the right places. Blank gaskets can cause serious damage - always renew gaskets prior to re-installation.

Lip Type Seals

Lubricate the lips of the lip-type seals before installation. Use petroleum jelly. DO NOT use grease. Ensure that the oil seal is fitted the right way round, the lip of the seal is placed next to the lubricant that is sealed. Some seals have a second auxiliary lip, which is used to prevent the ingress of dirt to the seal lip.

If, during installation, the seal lip must pass over a shaft that has splines, a keyway, rough surface or a sharp edge, the lip can be easily damaged. Always use a seal protector, when one is provided.

Use of Bolts in Blind Holes

Use bolts of the correct length. A bolt which is too long may 'bottom' before the head is tight against the part it is to hold. The threads can be damaged when a 'long' bolt is removed. If a bolt is too short, there may not be enough threads engaged to hold the part securely.

Locking Devices

Lockwashers, flat metal locks or split pins are used to lock nuts and bolts.

Flat metal locks must be installed properly to be effective. Bend one end of the lock around the edge of the part. Bend the other end against one flat surface of the nut or bolt head. Always install new locks.

Always fit new split pins/cotter pins and bend the ends round so that they will not catch in clothing and help to prevent cuts.

Cables and Wires

When removing or disconnecting a group of cables or wires, tag each one to assure proper re-assembly.

Always clip back wires and cable looms properly to prevent chafing, cable damage and possible damage by fire.

Tractor Specification

Section 1 – Part B

Table of Contents

Operation No.	Description	Page No.
	Engine	1B-2
	Engine Cooling System	1B-2
	Engine Air System	1B-2
	Engine Fuel System	1B-2
	Clutch	1B-2
	Transmissions	1B-3
	Rear Axle	1B-3
	Brakes	1B-3
	Power Take-off	1B-3
	Steering	1B-4
	Front Axle - Two-wheel Drive	1B-4
	Front Axle - Four-wheel Drive	1B-4
	Electrical System	1B-5
	Hydraulic System	1B-5
	Drawbars	1B-5
	Capacities	1B-6
	Wheels	1B-6
	Dimensions and Weights	1B-7
	Tractor Mounting Points - 2 Wheel Drive	1B-8
	Tractor Mounting Points - 4 Wheel Drive	1B-9
	Serial Numbers - Tractor	1B-10
	Transmission Identification	1B-11
	Four-wheel drive front axle	1B-12
	Fuel Specifications	1B-13
	Fuel Handling, Storage and Specification	1B-14

Tractor Specification

Engine:

All engines listed below are	Perkins diesel to Massey Ferguson specification. Four stroke, water cooled, direct injection.

See Section 3 for the full engine specification

Engine – 3 cylinder:

Tractor Models applicable:

MF345, MF350	AD3.152 - naturally aspirated.
MF355,MF360	AT3.152.4 - Turbocharged.

Engine – 4 cylinder:

Tractor Models applicable:

MF375, MF385	Diesel 4.41

Engine Cooling System:

Type - All tractors	Thermostat controlled with centrifugal pump to assist circulation. Fan driven by a single belt from the crankshaft pulley.
Radiator pressure cap rating	0,75 bar.
Fan belt (s) deflection	10 mm.

Engine Air System:

Air cleaner	Two-stage dry element with warning light. Removable main and safety element or oil type.
Air intake pre-cleaner	Over-bonnet bowl type.

Engine Fuel System:

Fuel System

Fuel lift pump	Hand primed, mechanically driven from camshaft.
Fuel filter	Lucas filter with transparent sediment bowl.
Injection pump	Lucas distributor type with mechanical governor.

Clutch:

Tractor Models applicable:

MF345, MF350, MF355, MF360, MF375:

Type	Dual
Size - main clutch	305 mm.
PTO clutch (dual clutch)	254 mm.
Pedal clearance	11 mm.
PTO clutch clearance	2 mm.

MF385:

Type	Dual.
Size - main clutch	330 mm.
PTO clutch	254 mm.
Pedal free travel	11 mm.
PTO clutch clearance	2 mm.

Transmissions:

Gearbox type:

8 x 2 gearbox	The 8 x 2 gearbox, standard or synchromesh, has eight forward and two reverse speeds. This is achieved by using a four forward and one reverse speed gearbox, compounded by an epicyclic unit.
Final drive	Bevel drive with epicyclic final reduction.

Crownwheel and pinion ratio:

MF345	6.1667:1 ratio with 6 x 37 teeth.
MF355	3.454:1 ratio with 11 x 38 teeth.
MF350, MF360, MF375	4.375:1 ratio with 8 x 35 teeth.
MF385	3.889:1 ratio with 9 x 35 teeth.

Rear Axle:

Tractor Models applicable:

Rear Axle

Final drives	Bevel drive with epicyclic final reduction
Differential lock	Mechanical,foot operated.

Brakes:

Tractor Models applicable:

Brakes

Foot brakes - MF 345	355 x 50 mm drum brakes, mechanically operated, together or independently to assist steering.
Foot brakes - MF350, MF355, MF360, MF375, MF385	Oil immersed mechanical operation, disc brakes, epicyclic drive operated together or independently to assist steering.
Parking brake - all tractors	Operates on both rear wheels at the same time independent of the foot brakes.

Power Take-off:

Tractor Models applicable:

Power Take-off (PTO):

Live PTO	Engine and ground-speeds are engaged by a lever on the left of the centre housing.
PTO Speeds	540 rev/min.
Shaft Diameter	35 mm.
No. of splines	6.
Engine to PTO shaft ratio	3.3125:1.

Tractor Specification

Steering:

Tractor Models applicable:

Steering – MF350, MF360, MF375, MF385

Type	Orbitrol hydrostatic power steering
Pump	Engine mounted gear pump with reservoir or engine mounted auxiliary tandem pump.
Front wheel toe-in	0-5 mm.
Turns - lock to lock	
MF350, MF360	2.7
MF375, MF385	3.6
MF385 4WD	4. 3
Turning circles - less brakes:	
MF350, MF360	6,9 m.
MF375, MF385	7,5 m.

Front Axle – Two-wheel Drive:

Type	Three section with telescopic outer arms.	
Wheel camber/caster angles:	Camber angle	Caster angle
MF345, MF350, MF355	3° 30'	4° 56'
MF360	5°	4° 56'
MF375, MF385	4° 30'	0°
Maximum turning angle:		
MF345, MF350, MF355, MF360	55°	
MF375, MF385	52°	
Maximum static load capacity:		
MF345	2025 kg	
MF355	2385 kg	
MF350, MF360	2605 kg	
MF375	3459 kg	
MF385	4357 kg	

Drag link bolt torques:

Clamp bolt	45 Nm.
Peg bolt	45 Nm.

Front Axle – Four-wheel Drive:

Type	Side drive mechanically or hydraulically engaged with or without Autolock or Hydralock differentials.
Maximum turning angle	50° (Adjustable stops to give 35°, 40° and 50° turning angle)
Turning circle - less brakes	
MF385	9,4 m
Maximum static load capacity:	
MF385	4904 kgf

Electrical System:

Voltage	12 volt negative earth
Battery	1 battery
Alternator	45 amp hour

Light Bulbs

Headlights	45/40 W
Plough and work light	55 W
Side lights	5 W
Stop and rear lights	5/21 W
Direction indicatiors	21 W
N° plate lights	5 W
Range indicator lights	2 W
Instruments lights	2 W
Warning lights	
Alternator	3 W
All others	2 W

Hydraulic System:

Linkage pump	Four-cylinder scotch yoke pump, driven from the forward end of the PTO shaft supplying oil under pressure to the linkage ram cylinder, and four external take off points.
Maximum pump output	16,7 litre/min.
Maximum pump pressure	176 - 204 bar.
Filtration	140 micron washable strainer.

Maximum lift capacity at the lower links with links horizontal:

All models	1415 - 1588 kg
Hydraulic linkage	Category 1 and 2 interchangeable ball ends.

Drawbars and Linkage:

Swinging drawbar capacity:

	Normal-duty:	Heavy-duty:
Inner position	1000 kgf.	1633 kgf.
Centre position	775 kgf.	1180 kgf.
Outer position	775 kgf.	1180 kgf.
Distance drawbar clevis to PTO shaft:		
Inner position	240 mm.	
Centre position	345 mm.	
Outer position	395 mm.	
Drawbar off-set:		
Normal-duty	120 and 240 mm.	
Heavy-duty	194 mm.	
Nut torques:		
Drawbar frame to transmission case	420 Nm.	
Drawbar frame to PTO bracket	245 Nm.	
Lift linkage capacity:		
Interchangeable Cat. 1 & 2 ends	2145 kgf.	
Cat. 2 Fixed ends	2290 kgf.	

Tractor Specification

Capacities:

	MF 345	MF 350	MF 355	MF 360	MF 375	MF 385
Fuel tank	47,5 l	45 l	47,5 l	47,5 l	108 l	108 l
Cooling system	10,2 l	11,7 l	10,2 l	11,7 l	15,2 l	15,2 l
Engine oil	6,8 l	6,8 l	6,8 l	6,8 l	7,5 l	7,5 l
Transmission/hydraulics	33 l	36 l	36 l	36 l	36 l	47,4 l
Power steering reservoir	0,9 l	2,0 l	0,9 l	2,0 l	2,0 l	2,0 l
Oil bath air cleaner	0,65 l	0,7 l	0,5 l	0,5 l	0,7 l	0,7 l

Wheels:

Wheel, Rim Nut and Bolt Torques – 275, 290

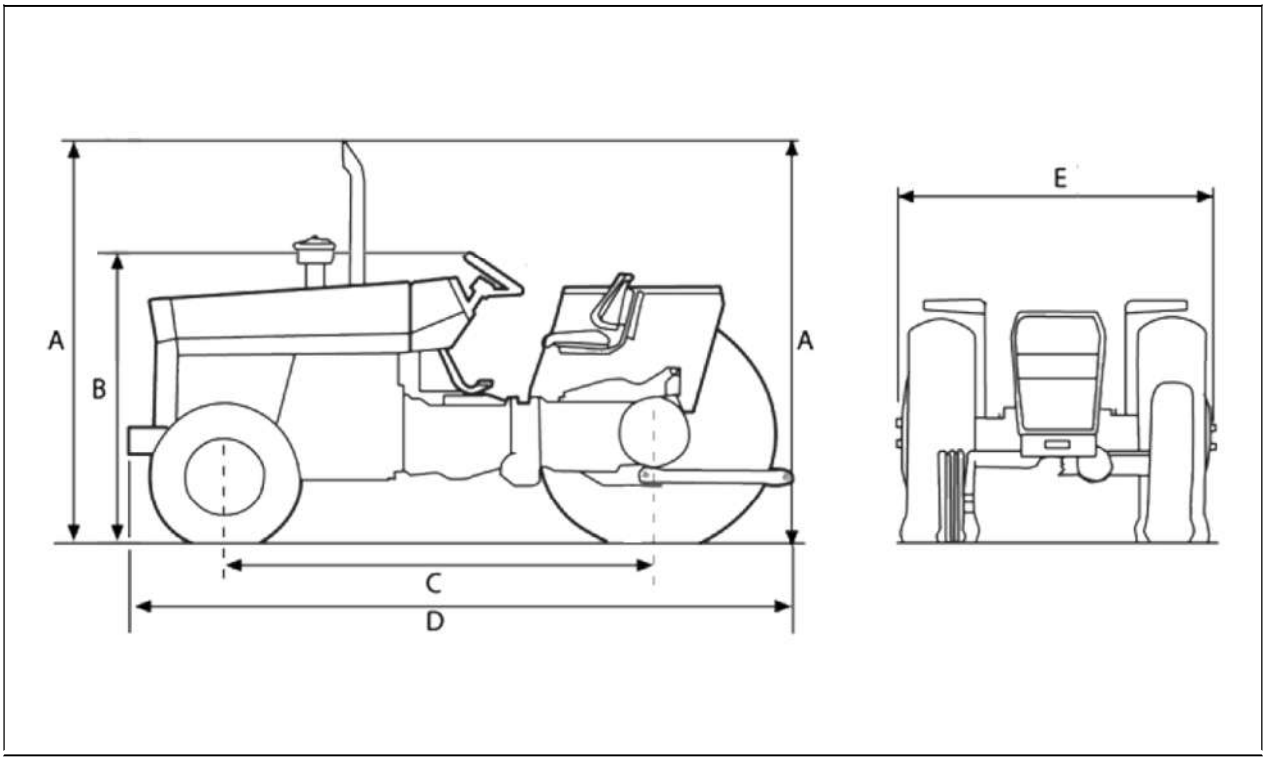
Front axle - two-wheel drive
- Wheel nuts .... 95 Nm.
- Wheel bolts ..... 108 Nm.

Front axle - four-wheel drive
- Wheel nuts ..... 270 Nm.
- Rim to disc .... 190 Nm.

Rear wheels - pressed steel:
- Wheel nuts ..... 325 Nm.
- Rim to disc ..... 240 Nm.

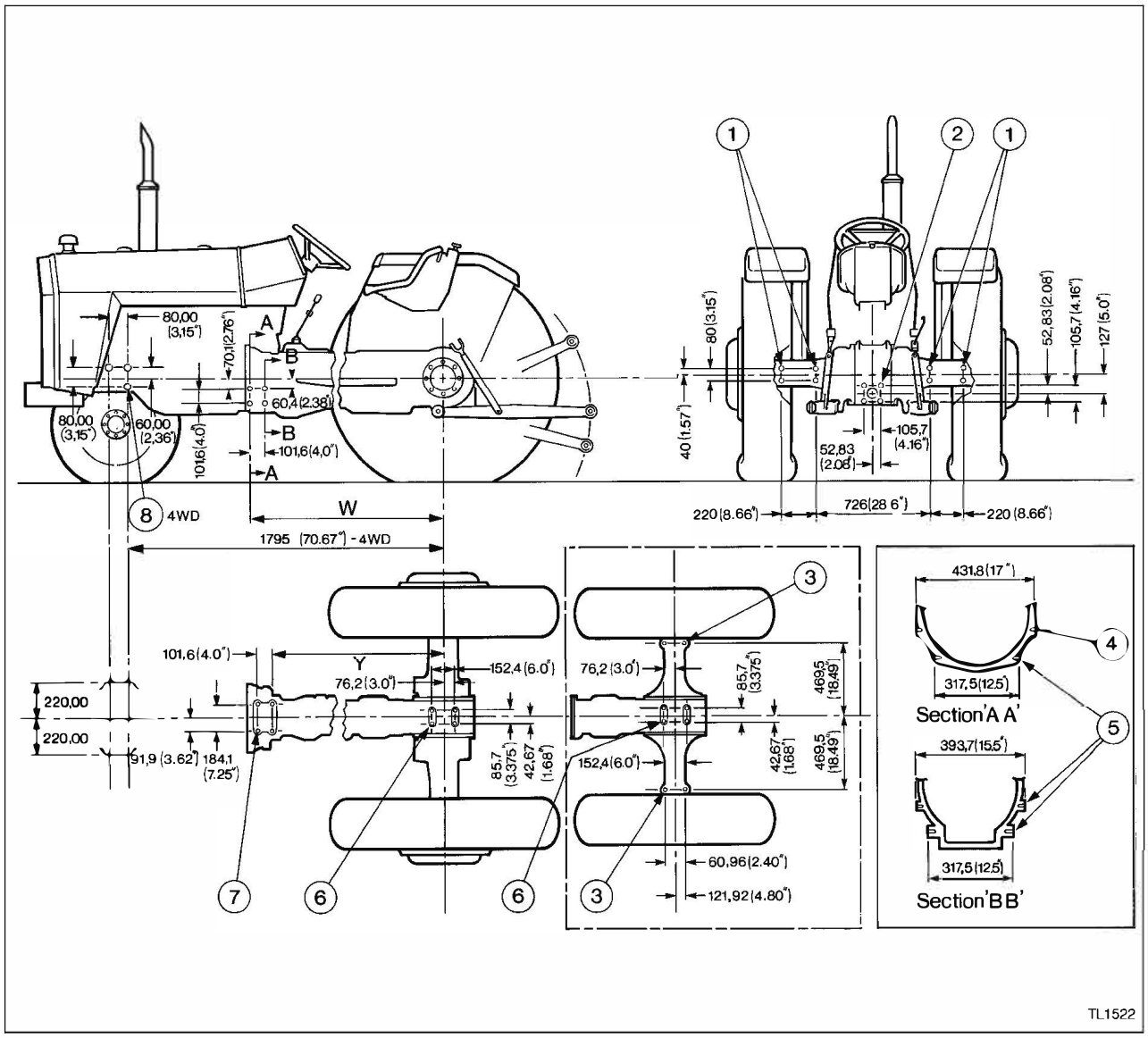
Track Adjustments

Front track - two-wheel drive ..... 1227-1880 mm.
Front track - four-wheel drive ..... 1407-1908 mm.
Rear track (Pressed steel wheels) ..... 1320-2134 mm.



	MF 345	MF 350	MF 355	MF 360	MF 375	MF 385
A - Overall height - Over exhaust	2145 mm	2200 mm	2200 mm	2236 mm	2485 mm	2485 mm
B - Overall height - Over steering wheel	1410 mm	1520 mm	1490 mm	1499 mm	1730 mm	1781 mm
C - Wheelbase	1892 mm	2022 mm	1892 mm	2032 mm	2170 mm	2350 mm
D - Overall length	3260 mm	3390 mm	3260 mm	3353 mm	3670 mm	3810 mm
E - Overall width	1651 mm	1820 mm	1890 mm	1890 mm	1970 mm	1871 mm
Weight	1650 kg	1940 kg	1900 kg	2010 kg	2295 kg	2760 kg
Front tires	6.00-16		6.00-16	7.50-16	7.50-16	12.4-11-24
Rear tires	12.4/11-28		14.9/13-28	14.9/13-28	16.9/14-30	18.4/15-30

TRACTOR MOUNTING POINTS – 2 WHEEL DRIVE TRACTORS

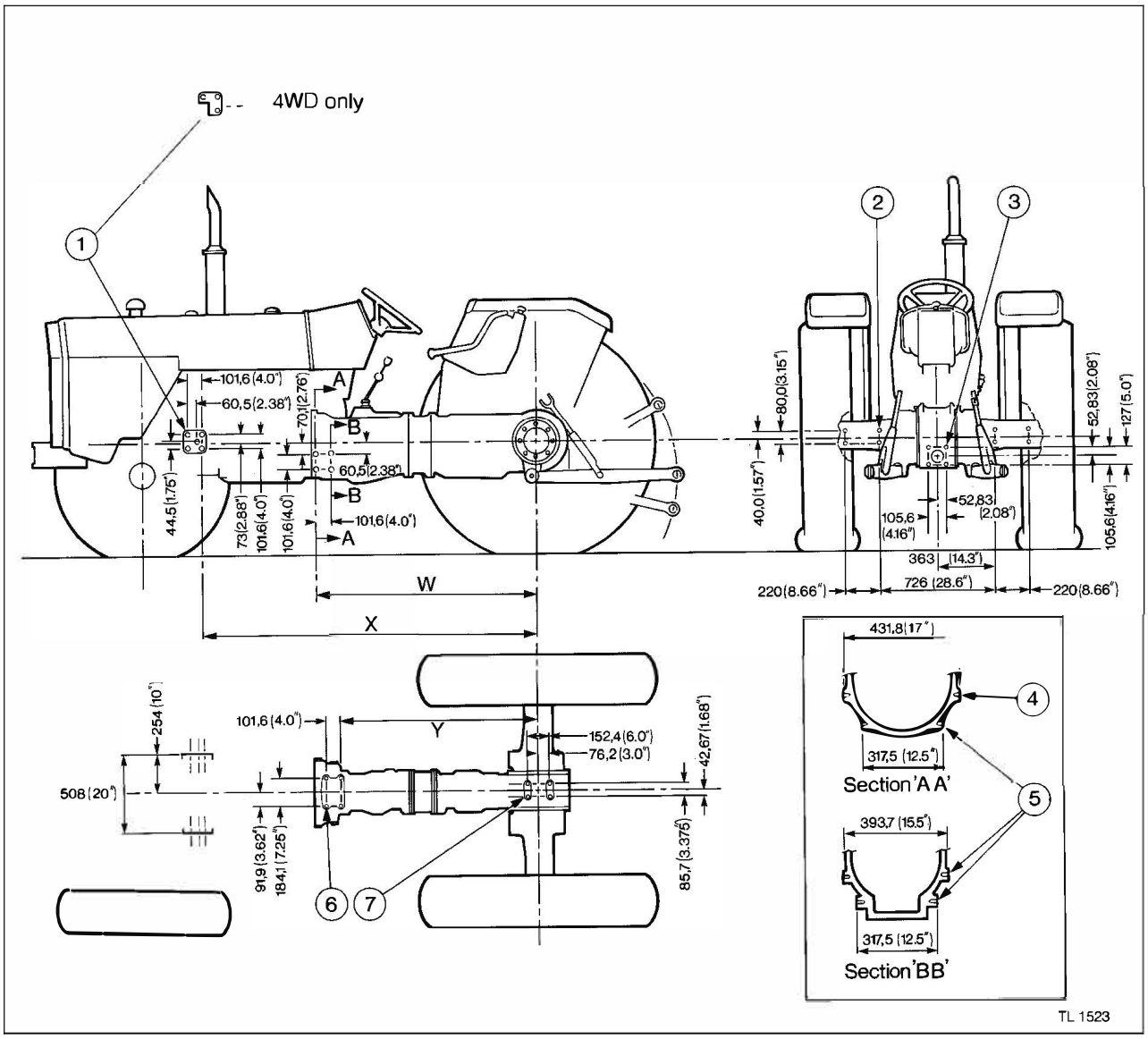


W ... 1379,00 mm with spacer
W ... 1229,00 mm without spacer

Y .... 1242,56 mm with spacer
Y .... 1092,56 mm without spacer

1. ... 8 holes 5/8 inch - 11UNC - 2B x 28 mm deep.
2 .... 4 holes 1/2 inch - 13UNC - 2B x 22 mm deep.
3 .... 4 holes 16,20/16,46 mm diameter through.
4 .... 2 holes 5/8 inch - 11UNC - 2B x 24 mm deep.
5 .... 6 holes 5/8 inch - 11UNC - 2B x 32 mm deep.
6 .... 4 holes 3/4 inch - 10UNC - 3B x 29 mm deep.
7 .... 4 holes 5/8 inch - 11UNC - 3B x 32 mm deep.
8. ... 6 holes 5/8 inch - 11UNC - 2B x 35 mm deep.
(these 6 holes (8) are on 240 - 4WD tractors only).

TRACTOR MOUNTING POINTS – 4 WHEEL DRIVE TRACTORS



W . . . 1379,00 mm with spacer
W . . . 1229,00 mm without spacer

X . . . . 2052,00 mm with spacer
X . . . . 1902,00 mm without spacer

Y . . . . 1242,56 mm with spacer
Y . . . . 1092,56 mm without spacer

1 . . . . 10 holes 3/4 inch - 10UNC - 2B x 38 mm deep (2WD)
1 . . . . 6 holes 3/4 inch - 10UNC - 2B x 38 mm deep (4WD)
2 . . . . 8 holes 5/8 inch - 11UNC - 2B x 28 mm deep.
3 . . . . 4 holes 1/2 inch - 13UNC - 2B x 22 mm deep.
4 . . . . 2 holes 5/8 inch - 11UNC - 2B x 24 mm deep.
5 . . . . 6 holes 5/8 inch - 11UNC - 2B x 32 mm deep.
6 . . . . 4 holes 5/8 inch - 11UNC - 3B x 32 mm deep.
7 . . . . 4 holes 3/4 inch - 10UNC - 3B x 29 mm deep.

Tractor Specification

SERIAL NUMBERS – TRACTOR

The serial number of the tractor is located in two positions, on the serial number plate.
Please quote the serial number of your tractor in all correspondance with your dealer or agent.

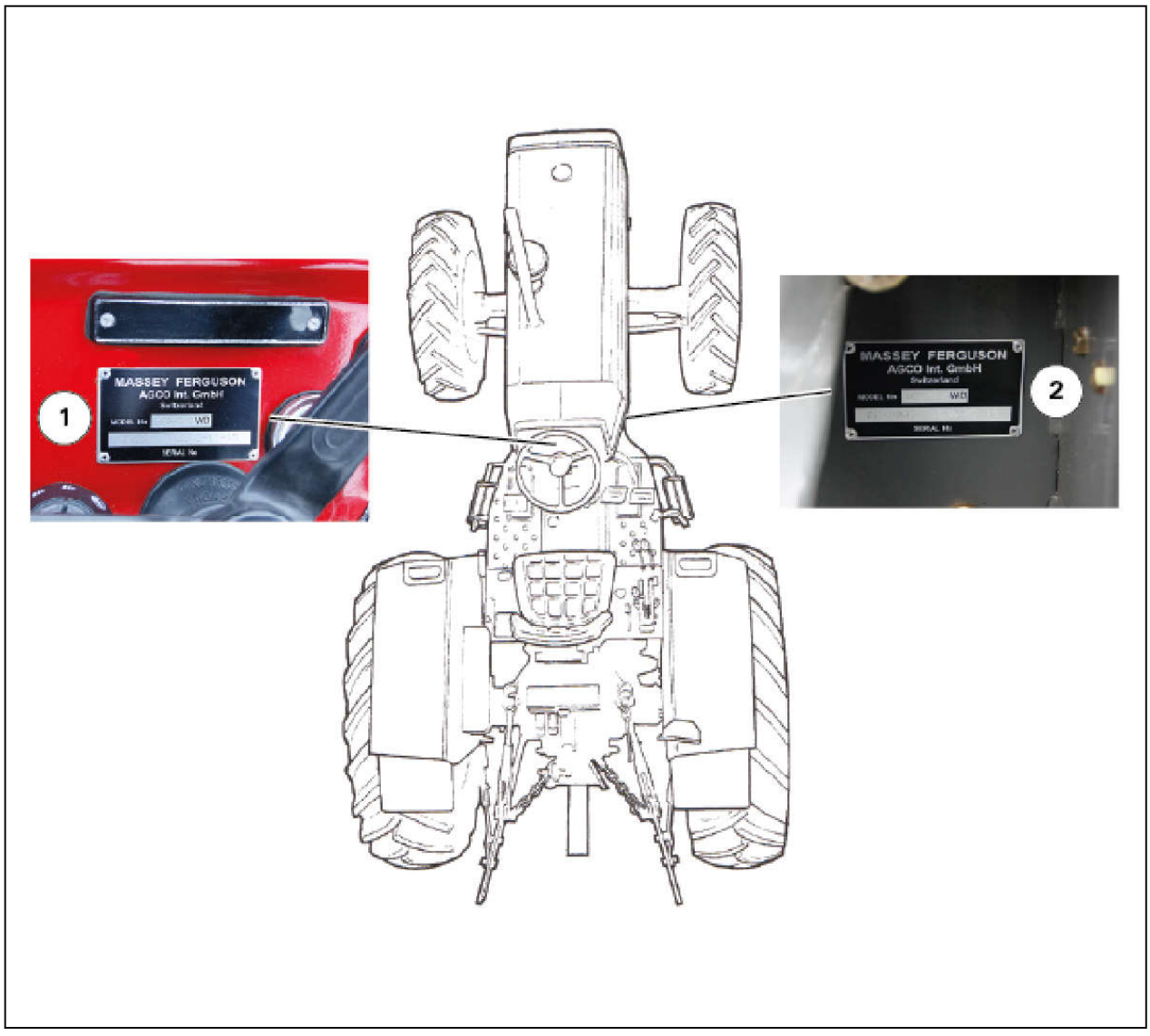


Fig. 1

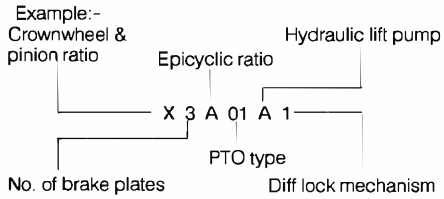
1 Name plate with serial number - tractors MF 345 - MF 355

2 Name plate with serial number - tractors MF 350 - MF 360 - MF 375 - MF 385

TRANSMISSION IDENTIFICATION
Tractor serial number D11073 onwards

Rear axle

A new transmission identification code has been introduced from tractor serial number D11073, manufactured in March 1995. The new code is a series of numbers and letters stamped on the left-hand rear centre housing lug and identifies the following (Fig.9).



Crownwheel and pinion ratio

W =	3.454 : 1	11 x 38
X =	4.375 : 1	8 x 35
Y =	3.889 : 1	9 x 35
Z =	6.167 : 1	6 x 37

No. of brake plates

3 =	Three friction plates
4 =	Four friction plates
5 =	Five friction plates
6 =	Six friction plates
0 =	None, direct drive drum brakes

Epicyclic ratio

A =	Normal-duty	3.75 : 1
B =	Normal-duty	3.14 : 1
C =	Heavy-duty	3.75 : 1
E =	Heavy-duty	4.8 : 1
F =	Direct drive disc brake	
G =	Direct drive drum brake	

PTO type

01 = Live single speed low flow lift pump 540 rev/min
02 = Live single speed high flow lift pump 540 rev/min
03 = Single speed independent PTO 540 rev/min
04 = Two speed shiftable 540/1000 rev/min IPTO
05 = Two speed shiftable 540/1000 rev/min IPTO with lockout
06 = Two speed shiftable economy 540/540E
07 = Less PTO

Hydraulic lift pump

A = Stand flow pump with black marked relief valve
B = Stand flow pump with plain (no mark) relief valve
C = Stand flow pump. Auxiliary pump. Plated drive. Plain relief valve
D = Stand flow pump. Auxiliary pump. Plated drive. Black relief valve
E = High flow pump. Centre shift gearbox. Shiftable PTO
F = High flow pump. Side shift gearbox. Shiftable PTO

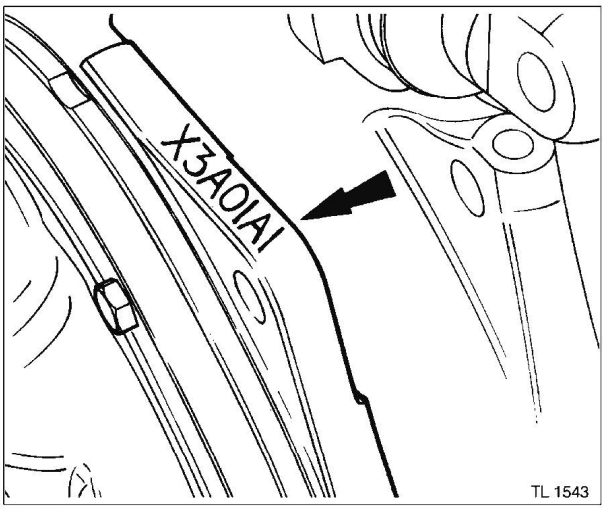


Fig.9

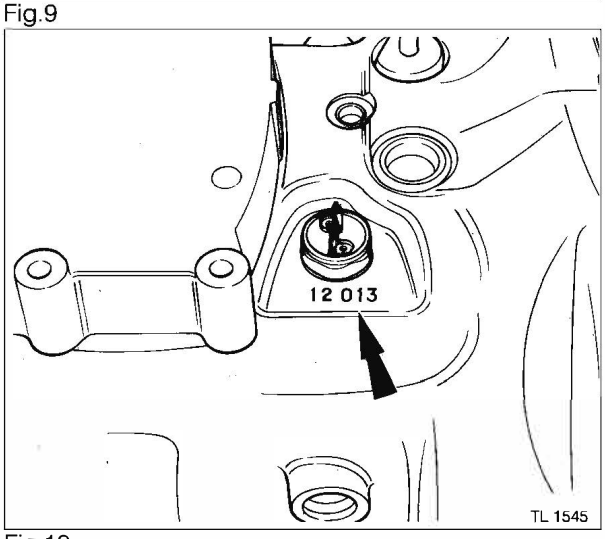


Fig.10

G = Industrial tractors - no pump
L = Less hydraulic pump

Differential lock mechanism

1 = Mechanical - foot operated
2 = Hydraulic operated

Transmission gearbox

Identification remains unchanged at D11072.

All gearboxes are stamped with a unit number adjacent to the safety start switch (Fig.10). This number identifies the build of the gearbox in respect of constant mesh ratio, PTO ratio, normal or heavy-duty epicyclic unit and whether the box is fitted with a long or short PTO shaft. Long shafts are fitted to tractors with a spacer, short shafts to non-spacer tractors.

SERIAL NUMBERS – FRONT AXLE

The serial number plate for the four-wheel drive front axle (Fig.11) is important, it identifies the model and size of the front axle fitted to the tractor because different axles can be fitted to many tractors. The plate is divided into five sections, each section giving information as follows:

1. Axle

AG 65 SDN	Type 65 Side Drive - Narrow Normally fitted to 3 cylinder tractors.
AG 85	Type 85 Parallel Drive - Autolock differential - Normally fitted to 4 cylinder tractors.
AG 85 SD	Type 85 Side Drive - No differential - Normally fitted to 4 cylinder tractors.

2. Differential

NS	No-spin (autolock).
ST	Standard (no differential lock).
HY	Hydrolock (hydraulic).

3. Total Ratio

This is the total ratio value of the axle from the input to the wheel.

4. Serial Number

Progressive serial number:

The last two letters of the number refer to the date of build.

The first letter denotes the month:

A	January.
B	February.
C	March.
D	April.
E	May.
F	June.
G	July.
H	August.
I	September.
L	October.
M	November.
N	December

The second letter denotes the year:

A	1991.
B	1992.
C	1993.
D	1994.
E	1995.
F	1996.
G	1997.
H	1998.
J	1999.
K	2000.

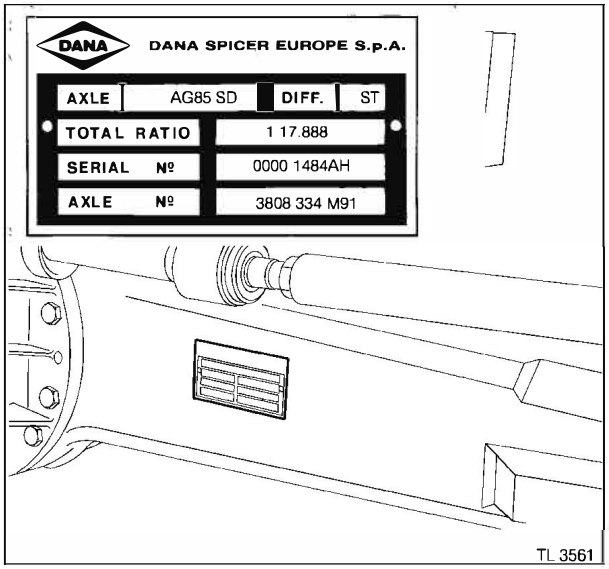


Fig.11

5. Axle Number

Part numbers of axle.

NOTE: *The above part numbers may be subject to change.*

FUEL SPECIFICATIONS

Limiting requirements for diesel fuel oils

Grades of diesel fuel oil	Flash point °F (°C)	Pour point °F (°C)	Water and sediment volume	Carbon residue on 10% residium	Ash weight	Distillation temperatures °F (°C)		Viscosity at 100 °F (37.8 °C)		Sulphur weight	Copper strip corrosion	Cetane numbers
						90%		Kinematic,cSt (or SUS)				
	Min	Max	Max %	Max %	Max %	Min	Max	Min	Max	Max %	Max	Min
No.1-D. A volatile distillate fuel oil for engines in service requiring frequent speed and load changes.	100 or legal (37.8)	b	0.05	0.15	0.01	--	550 (287.8)	1.4	2.5 (34.4)	0.5 or legal	No 3	40f
No.2-D. A distillate fuel oil of lower volatility for engines in industrial and heavy mobile service.	125 or legal (51.7)	b	0.05	0.35	0.01	540c (282.2)	640 (338)	2.0c (32.6)	4.3 (40.1)	0.50d or legal	No 3	40f

1. To meet special operating conditions, modifications of individual limiting requirements may be agreed upon between purchaser, seller and manufacturer.
2. For cold weather operation, the pour point should be specified 10°F below the ambient temperature at which the engine is to be operated except where fuel oil heating facilities are provided.
3. When pour point less than 0°F is specified, the minimum viscosity shall be 1.8 cSt (32.0 SUS) and the minimum 90 percent shall be waived.
4. In Countries outside the U.S.A., other sulphur limits may apply.
5. Where Cetane number by Method D 613 is not available, ASTM Method D 976 Calculated Cetane Index of Distillate Fuels 2 may be used as an approximation. Where there is disagreement, Method D 613 shall be the referee method.
6. Low atmospheric temperatures as well as engine operation at high altitudes may require use of fuels with higher cetane ratings.

NOTE: *Diesel fuels are classified as either No 1 (No 1-D) or No 2 (No 2-D) fuel. The grade No 1 fuel is recommended for service when the air temperature is below 32°F. The grade No 2 fuel, which will produce more work per gallon, is recommended for service when the air temperature is 32°F, or above. See chart for fuel requirements.*

Fuel Handling, Storage and Specification

Diesel Fuel

Before handling fuel, filling tanks etc., observe the following:

Under no circumstance should gasoline, alcohol, gasohol or dieselhol (a mixture of diesel fuel and alcohol) be added to diesel fuel because of increased fire or explosion risks. In a closed container such as a fuel tank they are more explosive than pure gasoline. DO NOT use these blends. Additionally, dieselhol is not approved due to possible inadequate lubrication of the fuel injection system.

- Clean the filler cap area. Fill the tank at the end of each day to reduce overnight condensation.
- Never take the cap off or refuel with the engine running or hot.
- When filling the tank, keep control of the nozzle. DO NOT smoke.
- Don't fill the tank to capacity. Allow room for expansion and wipe up spilt fuel immediately.
- If the original cap is lost, replace it with a Massey Ferguson cap and tighten securely. A non Massey Ferguson cap may not be suitable.
- Keep equipment properly maintained.

Recommended Fuel Specification

To get the correct power and performance from your engine, use good quality fuel. The recommended fuel specification for Perkins engines is indicated below:

Cetane No. .	45 minimum.
Viscosity .	2/4.5 centistokes at 40°C.
Density	0,820/860 kg/litre at 15°C.
Sulphur	0.20% of mass, maximum.
Distillation ..	85% at 350°C.

Cetane Number

Cetane number indicates ignition performance. A fuel with a low cetane number can cause cold start problems and affect combustion.

Viscosity

Viscosity is the resistance to flow and engine performance can be affected if it is outside the limits.

Density

A lower density reduces engine power, a higher density increases engine power and exhaust smoke.

Sulphur

A high amount of sulphur can cause engine wear.

Distillation

Distillation is an indication of the mixture of different hydrocarbons in the fuel. A high ratio of light-weight hydrocarbons can affect the combustion characteristics.

Low Temperature Fuels

Special winter fuels may be available for engine operation at temperatures below 0°C. These fuels have a lower viscosity and also limit the wax formation in the fuel at low temperatures. If wax formation occurs, this could stop the fuel flow through the filter.

If you need advice on adjustments to an engine setting or to the lubricating oil change periods which may be necessary because of the standard of the available fuel, consult your nearest Massey Ferguson Dealer.

Miscellaneous Data

Section 1 – Part C

Table of Contents

Operation No.	Description	Page No.
-------	Bolt Torque Specifications	1C- 2
-------	Chemicals and Sealants	1C- 4
-------	Conversion Tables	1C- 5

BOLT TORQUE SPECIFICATIONS (GENERAL GUIDE FOR INCH FASTENERS)

Use the "Standard Torque" charts as a general guide when tightening fasteners that DO NOT HAVE SPECIFIC TIGHTENING RECOMMENDATIONS.

Inch Fasteners Standard torque in Newton Metres (Foot Pounds)					
* Inch bolt size	SAE grade 5 **mild steel below grade 5	SAE grade 8 ISO grade 8.8 BS grade S		ISO grade 10.9 BS grade V	
		*** Non-rigid joint	**** Rigid joint	*** Non-rigid joint	**** Rigid joint
1/4 inch	6-8 (4-6)	9-12 (7-9)	11-15 (8-11)	13-18 (10-13)	16-22 (12-16)
5/16 inch	12-16 (9-12)	18-24 (13-18)	22-30 (16-22)	25-34 (18-25)	31-43 (23-32)
3/8 inch	22-30 (16-22)	31-42 (23-31)	39-53 (29-39)	44-60 (32-44)	55-75 (41-55)
7/16 inch	35-47 (26-35)	51-69 (38-51)	64-86 (47-63)	72-96 (53-71)	90-120 (66-89)
1/2 inch	54-72 (40-53)	80-104 (59-77)	100-130 (74-96)	110-140 (81-103)	140-180 (103-133)
5/8 inch	110-140 (81-103)	160-210 (118-155)	200-260 (148-192)	220-300 (162-221)	280-370 (207-273)
3/4 inch	190-250 (140-184)	280-370 (207-273)	350-460 (258-339)	390-530 (287-391)	490-660 (361-487)
7/8 inch	310-410 (228-302)	450-610 (332-450)	560-760 (413-561)	640-850 (472-672)	800-1060 (590-782)
1 inch	460-620 (339-457)	670-900 (494-664)	840-1120 (620-826)	960-1280 (708-944)	1200-1600 (885-1180)

Key to table above:

* *NOTE: The size is the diameter of the shank - not the head width.*

** *NOTE: Mild steel torque values to be used for SAE Grade 5 bolts when weld nuts, or other low strength nuts are used.*

*** *NOTE: Use these values when any of the following conditions exist:*
1. Possible damage to the joined members of the assembly may occur.
2. Thick and/or highly compressible gaskets are used between members.
3. Non-flat unmachined seating surfaces for bolt head (or nut) occurs.
4. Non-flat or non-parallel joint faces are encountered.

**** *NOTE: Use these values when ALL of the following conditions exist:*
1. Damage will not occur to the joined members of the assembly.
2. It is desirable to use this higher clamping force to ensure tightness.
3. Fastener thread is not lubricated prior to assembly.

BOLT TORQUE SPECIFICATIONS (GENERAL GUIDE FOR METRIC FASTENERS)

Use the "Standard Torque" charts as a general guide when tightening fasteners that DO NOT HAVE SPECIFIC TIGHTENING RECOMMENDATIONS.

Metric Fasteners Standard torque in Newton Metres (Foot Pounds)					
* Metric bolt size	SAE grade 5 ** mild steel below grade 5	SAE grade 8 ISO grade 8.8 BS grade S		ISO grade 10.9 BS grade V	
		*** Non-rigid joint	**** Rigid joint	*** Non-rigid joint	**** Rigid joint
M6	4-5 (3-4)	8-11 (6-8)	10-14 (7-10)	12-16 (9-12)	14-20 (10-15)
M8	10-13 (7-10)	20-28 (15-21)	25-35 (18-26)	29-37 (21-27)	36-46 (27-34)
M10	19-25 (14-18)	40-56 (30-41)	50-70 (37-52)	57-77 (42-57)	72-96 (53-71)
M12	33-43 (24-32)	72-96 (53-71)	90-120 (66-89)	100-130 (74-96)	120-160 (89-118)
M16	84-110 (62-81)	160-210 (118-155)	200-260 (148-192)	240-320 (177-236)	300-400 (221-295)
M20	160-210 (118-155)	340-450 (251-332)	420-560 (310-413)	480-640 (354-472)	600-800 (443-590)

Key to table above:

* *NOTE: The size is the diameter of the shank - not the head width.*

** *NOTE: Mild steel torque values to be used for SAE Grade 5 bolts when weld nuts, or other low strength nuts are used.*

*** *NOTE: Use these values when any of the following conditions exist:*

1. Possible damage to the joined members of the assembly may occur.
2. Thick and/or highly compressible gaskets are used between members.
3. Non-flat unmachined seating surfaces for bolt head (or nut) occurs.
4. Non-flat or non-parallel joint faces are encountered.

**** *NOTE: Use these values when ALL of the following conditions exist:*

1. Damage will not occur to the joined members of the assembly.
2. It is desirable to use this higher clamping force to ensure tightness.
3. Fastener thread is not lubricated prior to assembly.

Miscellaneous Data

CHEMICALS and SEALANTS

The following chemicals and sealants quoted in this Workshop Service Manual are available from Massey Ferguson Parts Departments.

Description	Quantity	Part No.
Hylomar Jointing and sealing compound.	100 g tube 280 g aerosol	1447 390 M1 3638 340 M91
High Flex Gasket Loctite 5205 - Specially prepared for Massey Ferguson to seal and prevent flexing of the lift cover to the rear axle casing. This sealant must be used at all times.	10 ml	3931 226 M1
Lock 'n' Seal Loctite 222 - prevents small components from vibrating loose and provides an effective pipe thread seal against liquids or gases.	10 ml	3930 904 M1
Studlock Loctite 270 - a heavy duty version of Lock 'n' Seal for larger components which need less frequent stripping down. Highly resistant to industrial fluids and gases.	10 ml	3405 352 M5
Crownwheel Retainer Loctite 638 - for high strength retaining of close fitting parts. Designed to retain slip fitted or to strengthen press fitted parts, shafts bushes, pulleys etc.	6 ml	3930 274 M92
574 Multi-Gasket Loctite 573 - forms a strong, flexible gasket which provides a gas-tight, water-tight, oil-tight seal up to 200° C (392° F). Does not shrink,crack, tear or perish.	50 ml	3900 613 M2
Super Lube Multi-purpose synthetic lubricant containing Teflon®. Reduces friction and wear. Excellent dielectric properties, prevents tracking. Contains anti-oxidants and rust inhibitors, protects against moisture and corrosion.	7 gm Oiler 357 ml Aerosol	3931 224 M1 3931 225 M1
Cleaner and Degreaser Loctite 7061 - a all-purpose solvent for removing grease and dirt.	400 ml aerosol	3930 907 M1
Super Glue Instant bonding for metals, plastics,rubber and ceramics.	5g	3930 905 M1
Clear Silicone A clear, tough, flexible and waterproof seal for metal,rubber, glass and plastics.	80g 310 ml	3405 357 M5 3405 423 M2
Penetrating oil A highly effective multi-purpose lubricant, moisture dispersant and dismantling spray.	330 ml aerosol	3930 850 M2
Gasket Remover Disolves gaskets for easy removal.	300 ml	3930 908 M1
Citrus Handcleaner Works with or without water.	3 litre	3930 906 M1
Anti-freeze Ethylene-glycol based, designed for protection down to minus 33° C (minus 27° F). Suitable for all types of engines, including those with aluminium cylinder heads.	1 litre 5 litre 25 litre 205 litre	1894 799 M2 1891 780 M2 1891 781 M2 1891 782 M2
Brake Fluid (Green) Specially developed for braking systems requiring a mineral fluid.	0,5 litre	3405 389 M1
Anti-Squawk Additive Specially developed to be added to the transmission oil to prevent noise from wet brake installations.	1 litre	1889 891 M2
Protective Grease Specially prepared grease for electrical components and connectors with dielectric properties, protects against moisture and corrosion. Long lasting, won't dry out.	Tin	3600 553 M1

CONVERSION TABLES

Area	Multiply by
mm^2 to in^2	0.0015
in^2 to mm^2	645.16
m^2 to ft^2	10.764
ft^2 to m^2	0.0929
ha to acre	2.4711
acre to ha	0.4047

Capacity	Multiply by
ml to fluid oz	0.0351
fluid oz to ml	28.413
litre to gal	0.2200
gal to litre	4.5640
litre to US gal	0.2640
US gal to litre	3.7850
gal to US gal	1.2010
US gal to gal	0.8330

Length	Multiply by
mm to in	0.0394
in to mm	25.400
m to ft	3.2808
ft to m	0.3048
km to mile	0.6214
mile to km	1.6093

Power	Multiply by
ps to hp	0.9863
hp to ps	1.0139
kW to hp	1.3410
hp kW	0.7457

Pressure	Multiply by
bar to lbf/in^2	14.504
lbf/in^2 to bar	0.0690

Speed	Multiply by
km/hr to mile/hr	0.6214
mile/hr to km/hr	1.6093

Torque	Multiply by
Nm to lbf ft	0.738
lbf ft to Nm	1.356

Volume	Multiply by
mm^3 to in^3	0.6102
in^3 to mm^3	163.87
m^3 to ft^3	35.315
ft^3 to m^3	0.0283

Weight	Multiply by
gram to oz	0.3530
oz to gram	28.350
kg to lb	2.2046
lb to kg	0.4536
kg to ton	0.0010
ton to kg	1016.1
tonne to ton	0.9842
ton to tonne	1.0160

Temperature	
^oC to ^oF	$1.8 \times {}^oC + 32$
^oF to ^oC	$(^oF - 32) \div 1.8$

Page left blank intentionally

Servicing the Tractor

Section 1 – Part D

Table of Contents

Operation No.	Description	Page No.
-----	General	1D - 2
2.01D-01	Pre-delivery Check	1D - 2
2.01D-02	Tractor Installation on the Farm	1D - 3
2.01D-03	Running In the Tractor	1D - 4
2.01D-04	50 Hour Service	1D - 4
2.01D-05	250 Hour Service	1D - 5
2.01D-06	Tractor Storage	1D - 5
2.01D-07	Tractor Waterproofing	1D - 7
-----	Maintenance Chart	1D - 8
-----	Massey Ferguson Recommended Lubricants	1D -11
-----	Alternative Lubricants	1D -13

General

This section has been compiled to enable the reader to ascertain quickly what action is necessary to prepare a new tractor for sale, install it on the farm and carry out the 50 and 250 hour services, which should be rendered during the warranty period.

The timing of these two services has been calculated to provide maximum tractor efficiency throughout the warranty period thus safeguarding the subsequent life of the tractor.

Also detailed is the 'Running-in' procedure which will ensure that the engine will give a satisfactory performance through-out its life.

NOTE: *This is an optimum list of checks, instructions, etc., and may not apply to the tractor you are working on.*

PRE-DELIVERY INSPECTION 2.01D–01

Before Checking

1. Verify and record for future use the serial numbers of the tractor, engine, and four-wheel drive front axle.
2. Assemble all parts that have been removed for transport.

Checking Levels

Check and top-up if necessary the following levels with their appropriate liquids:

3. Cooling system, water or anti-freeze.
4. Engine oil.
5. Engine air cleaner (when fitted).
6. Transmission and rear axle.
7. Rear epicyclic hubs (when fitted).
8. Steering box oil (when fitted).
9. Power steering reservoir (when fitted).
10. Hydraulic brake reservoir (when fitted).
11. Front axle (four-wheel drive).
12. Front axle epicyclic hubs (four-wheel drive).
13. Fuel tank.
14. Battery electrolyte.

Lubrication

Lubricate the following points:

15. All grease nipples.
16. Four wheel drive shaft.
17. Four wheel drive front axle drive shafts (some axles do not require greasing).
18. Lightly oil the clutch linkage, throttle linkage both hand and foot.

Adjustments

Make the following checks and adjust if necessary:

19. Drain plugs for tightness.
20. Tightness of engine air intake and cooling system hose and pipe connections.

Ensure that all pipes, hoses and wiring are not fouling the exhaust system or sharp edges, check that they are securely clipped in place.

21. Alternator/fan belt tension.
22. Clutch linkage, free pedal clearance.
23. PTO clutch lever clearance (dual clutch only).
24. Brake pedal, free pedal clearance.
25. Differential lock clearance.
26. Torque all wheel and rim nuts and bolts.
27. Tyre pressures.
28. Front wheel alignment.
29. Battery condition, charge if necessary. Clean the battery top and smear the terminals with petroleum jelly.

Checks Before Road Test

Turn the starter switch to the 'Auxiliary' position, check the following, and if necessary rectify the fault:

30. All warning lights are 'On'.
31. Lights - head, side, direction indicator, work and interior.
32. Horn.
33. Headlight alignment.

Start the Engine

Start the engine, check the following, rectify if necessary:

34. Safety start function on the high/low gear lever and PTO lever.
35. All warning lights extinguish.
36. Engine idling, and maximum off-load speeds to specification using both hand and foot throttle.
37. PTO function and speed at 540 or 1000 rev. with a hand tachometer and that the speeds agree with the speed chart.
38. Air cleaner restriction indicator by momentarily blanking off the air intake.
39. Fuel shut-off function.

Stop the Engine.

40. Remove all traces of oil, fuel, and coolant from the tractor to permit a leak check after road test.

Road Test

Restart the engine and warm-up the tractor. Drive forward and check the following, investigate and rectify any fault:

41. Gear selection is 'normal' for the model.
42. Balance and operation of the brakes.

43. Differential lock function.
44. Four wheel drive function.
45. Parking brake.
46. Operation of all instruments, warning and indicator lights.

After the Road Test

Check the hydraulic lift performance with a weight or implement fitted to the lower links.

47. Draft Control.
48. Position Control.
49. Transport - correctly positioned.
50. Constant Pumping - correctly positioned.
51. Response Control - effective.
52. Selector valve - operation.

Auxiliary Hydraulics and Brake Valve:

53. Auxiliary control valve - function.
54. Trailer tipping pipe connection - function.

Final Checks

Carry out these final checks:

55. Ensure that no leaks are apparent from areas previously cleaned.
56. Check that all safety guards and decals are in place and correctly fitted.
57. Clean off preservatives and remove labels.
58. Clean the tractor.
59. Ensure that the tool box content is correct and the Operator instruction Book, Maintenance Chart, and Service Voucher Book are with the tractor.

TRACTOR INSTALLATION 2.01D–02

Instruction

These instructions are to be given to the Owner and/or Operator of the tractor, all items must be fully explained and where applicable, performed. Emphasis must be given to all safety precautions in the operation and servicing of the tractor and its implements.

Use the Operator Instruction Book and Maintenance Chart supplied with the tractor to assist in explaining the following:

1. Location and significance of tractor and engine serial numbers.
2. All safety points and decals on the tractor and in the Operator Instruction Book.
3. The use of all instruments and controls.
4. Running-in procedure.
5. The operation of the throttle lever and foot pedal, use of the engine speed indicator, travel and PTO speed chart.
6. Use and adjustment of the clutch.
7. Differential lock, its engagement, disengagement and adjustment.
8. Four wheel drive, its engagement and disengagement.
9. Brakes, latched and unlatched, method of adjustment.
10. The attachment of auxiliary hydraulic equipment.
11. The method of making wheel width adjustments, front wheel alignment and tyre pressures.
12. Drawbar and hitch positions.
13. Servicing of the tractor, explain the oil changes and services as detailed in the maintenance section of the instruction book. Point out the position of the drain plugs, filler plugs and dipsticks. Include the power steering reservoirs.

Draw attention to the recommended grades of lubricants and advise on engine and hydraulic filter replacement and cleaning.

14. Cooling system frost precautions and the fan belt adjustment.
15. Maintenance of the engine air cleaner.

Demonstrate the Following:

16. Engine starting and stopping procedure, when hot and cold.
17. How to remove the air from the fuel system, stress the importance of clean fuel.
18. Driving the tractor, starting and stopping, the use and sequence of gears, operation of clutches.
19. Operation of the PTO and the method of changing the speed.
20. How to use the hydraulic lift system, make adjustments and attach implements. Use of check chains, stabilisers and pick-up hitch (when fitted).

Carry Out the Following:

21. Complete the information on the Installation and Registration Certificate and request the Owner to sign.
22. Enter the serial numbers etc. in the front of the Operators Instruction Book and hand to the Owner.
23. Explain to the Owner his Warranty entitlement and the services due during the warranty period.

RUNNING-IN 2.01D–03

Instruction

The following precautions should be taken during the running-in period:

1. Experience has shown that the first 50 hours of tractor operation have a significant effect on the performance and life of the engine. From new, the tractor should be engaged in work which will load the engine as near as possible to full working conditions, emphasis should be given on varying the load to assist in the running-in.

Full load should not be applied until the engine has reached a temperature of at least 60°C.

2. Use low gear when pulling heavy loads.
3. During the running in period, check frequently the tightness of all wheel nuts and bolts.
4. To ensure proper clutch life, care must be taken to bed-in the friction plates properly.

NOTE: *During the first 15 hours of the tractor's life, frequently, but carefully engage and disengage the clutch. During the first 50 hours a careful watch must be kept on the clutch pedal free travel, which should be adjusted as soon as the pedal travel decreases. This is particularly important when a loader is fitted.*

50 HOUR SERVICE 2.01D–04

Servicing

The following operations are to be carried out after 50 hours running by the Dealer service engineer.

Engine

1. Change the engine oil.
2. Change the engine oil filter.
3. Check the tappets, and adjust if necessary
4. Re-torque the cylinder head nuts and bolts on the MF 275, 283 and 290 tractors only.
5. Check the engine low and maximum off load speed, and adjust if necessary

Fuel System and Air Cleaner

6. Change the primary fuel filter element.
7. Check the air cleaner, change the oil or clean the filter if necessary.
8. Check the air cleaner hose connections and tighten if necessary.

Cooling System

9. Check the coolant level and replenish if necessary.
10. Check the alternator/fan belt tension and adjust if necessary.

Electrical System

11. Check the battery electrolyte level and replenish if necessary.
12. Check the tightness of the battery connections, ensure that the battery is clean and that the terminals are covered with petroleum jelly.
13. Check the tightness of all cable clips and terminals and check all wiring for chafing.
14. Check the operation of the safety start switches.

Front axle and Steering

15. Change the power steering pump oil and filter element (if fitted).
16. Check the front axle oil (four-wheel drive).
17. Check the front axle epicyclic oil (four-wheel drive).

Transmission and Hydraulics

18. Check the transmission oil level and top-up if necessary.
19. Clean the lift hydraulic filter screen.
20. Check the oil in the rear epicyclic hubs and top-up if necessary (heavy-duty axles only).
21. Check the torque of all wheel and rim nuts and bolts.
22. Check the tyre pressures and adjust if necessary.

Clutch and Brakes

23. Check the clutch pedal free travel and adjust if necessary.
24. Check the live PTO clutch setting and adjust if necessary.
25. Check the foot brakes and adjust if necessary.
26. Check the parking brake and adjust if necessary.

General

27. Lubricate all grease points.
28. Lightly oil the clutch linkage, throttle linkage both hand and foot.
29. Road test the tractor, checking all instruments, lights and services for correct functioning, in the event of any fault being found this must be corrected.
30. After the road test, check for leaks in the oil, coolant and fuel systems.
31. Enquire if any operational difficulties are being experienced by the Owner, correct or demonstrate as necessary.
32. Complete the 1st Service record card.

250 HOUR SERVICE 2.01D–05

Servicing

The following operations are to be carried out after 250 hours running or before the end of the warranty period which ever is first by the Dealer service engineer.

Engine

1. Change the engine oil.
2. Change the engine oil filter.

Fuel system and air cleaner

3. Check the air cleaner, change the oil or clean the filter if necessary.

Cooling System

4. Check the coolant level and replenish if necessary.
5. Check the alternator/fan belt tension and adjust if necessary.

Electrical System

6. Check the tightness of the battery connections, ensure that the battery is clean and that the terminals are covered with petroleum jelly.
7. Check the tightness of all cable clips and terminals and check all wiring for chafing.
8. Check the operation of the safety start switches.

Front Axle and Steering

9. Check the power steering pump oil level and top-up if necessary.
10. Check the front axle oil level (four-wheel drive), top up if necessary.
11. Check the front axle epicyclic oil level (four-wheel drive), top up if necessary.

Transmission and Hydraulics

12. Check the transmission oil level top-up if necessary.
13. Check the oil in the rear epicyclic hubs and top-up if necessary (heavy-duty axles only).
14. Check the torque of all wheel and rim nuts and bolts.
15. Check the tyre pressures and adjust if necessary.

Clutch and Brakes

16. Check the clutch pedal free travel and adjust if necessary.
17. Check the live PTO clutch setting and adjust if necessary.
18. Check the foot brakes and adjust if necessary.
19. Check the parking brake and adjust if necessary.

General

20. Lubricate all grease points.
21. Lightly oil the clutch linkage, throttle linkage both hand and foot.
22. Check all brake rods and cables for signs of rust, damage or excessive wear.
23. Road test the tractor, checking all instruments, lights and services for correct functioning, in the event of any fault being found this must be corrected.
24. After the road test, check for leaks in the oil, coolant and fuel systems.
25. Enquire if any operational difficulties are being experienced by the Owner, correct or demonstrate as necessary.
26. Complete the 2nd Service record card.

TRACTOR STORAGE 2.01D–06

General

When preparing a tractor for storage, comply with the following recommendations to ensure that the tractor is in good condition when required for use. Thoroughly clean the tractor, giving particular attention to the greasing points and oil filler plugs. Park the tractor in a dry, level and covered area away from the weather and livestock with easy exit in case of fire.

When the tractor has to be stored in the open air, park it on level ground in the shelter of a building or wall and completely cover it with a good tarpaulin.

Tyres

1. Jack up the tractor and position wooden blocks under the axles to relieve the tyres of all weight.
2. Inflate the tyres a little above the normal pressure and chalk that pressure on the tyre wall. Protect the tyres from direct sunlight.
3. When ballasted tyres are not filled with calcium chloride, deflate the tyres, empty out the water and re-inflate with air.
4. When wheel weights are fitted, remove, clean and paint any bare metal and refit.

Hydraulic Lift System

5. Check and replenish the transmission oil level in the centre housing to the high mark on the dipstick.
6. Using the tractor hydraulics, with the Response Control in FAST, raise and lower the linkage several times.
7. Engage the PTO for a short period to obtain the maximum circulation of transmission oil around the centre housing.
8. Raise the linkage to the Transport Position and support the two lift arms in this position with wooden chocks.
9. Leave the two quadrant levers in the Transport Position i.e., the Draft Control (outer) lever past the UP and the Position Control (inner) lever in Transport Position. DO NOT MOVE the quadrant control levers from these positions.

Steering

10. Clean and coat the exposed steering cylinder rod with grease.

Engine

11. Drain the engine sump oil, when hot if possible.
12. Change the filter element.
13. Refill the engine sump with an approved grade of oil.
14. Seal the crankcase breather, exhaust and air cleaner pipes with adhesive tape after running the engine.
15. Clean the dry air cleaner unit.

Cooling System

16. Drain the header tank, radiator and cylinder block, when hot if possible and leave the taps in the open position.
17. Rest the header tank cap on the filler neck.

Fuel System

18. Clean the fuel filter bowl(s), renew the elements and drain any sediment out of the fuel tank.
19. Top up the fuel tank completely to prevent condensation forming on the unfilled portion of the tank, thus resulting in water contaminating the fuel.
20. Remove the injectors and spray approximately 2 ml of engine oil into each cylinder bore. Using new joint washers, refit the injectors and slowly rotate the crankshaft one complete revolution. DO NOT bleed the fuel system of air.
21. Lubricate the foot and hand throttle control linkage.

Clutch

22. Fully depress the clutch pedal and hold down with a wooden chock. The clutch friction plates will then not bond themselves to the flywheel or pressure plates.

Battery

23. Remove the battery from the tractor.
24. Check the electrolyte level and top up as necessary.
25. Clean the battery top and coat the terminals with petroleum jelly.
26. Fully charge the battery from an external source.
27. Repeat the external charge every month during the storage period and top up the electrolyte as necessary.
28. Store the battery in a cool, dry, dust free location but not directly on a concrete or metal surface. There must be no possibility of freezing.

Alternator and Starter Motor

29. Remove any dust or dirt from the alternator.
30. Smear the starter motor and solenoid terminals with petroleum jelly.

Sheet Metal

31. All rusty, scratched or bare patches of castings and/or sheet metal must be cleaned with abrasive papers and repainted. Matching colours are available for all Massey Ferguson tractors.
32. The bright metal components and surfaces must be cleaned and/or degreased and the protectives sprayed or brushed on.

TRACTOR WATERPROOFING 2.01D–07

General

Before working in water, such as in paddy fields or flooded areas, certain waterproofing modifications must be made to the tractor.

In addition, two extra maintenance services are required.

Starter Motor and Solenoid Assembly

1. Remove the starter motor and solenoid assembly.
2. Thoroughly clean the exterior of the starter motor and solenoid assembly.
3. Blank off the drive end bracket.
4. Seal all the openings in the starter motor and solenoid assembly with suitable waterproof putty.
5. Apply a thick coating of grease to the starter motor and solenoid terminals and ensure that the drive end bracket is blanked off.
6. Coat the exterior of the starter motor and solenoid assembly with a water repellent spray.
7. Refit the starter motor and solenoid assembly to the engine.
8. Reconnect the wiring harness.

Battery

9. Clean the battery top and smear the battery terminals with petroleum jelly.

Engine Breather Pipe

NOTE: *The engine breather pipe is of a critical length and after modification it can be longer but NEVER shorter. When refitted it must point generally in a downward direction without 'U' bends or restrictions to trap liquid or dirt.*

10. Route the plastic breather pipe to the front of the engine and secure it to one of the timing case bolts with a suitable clip.

Engine Dipstick

11. Remove the engine dipstick and store in the tool box.
12. Fit a tapered rubber plug to the engine dipstick tube.

Clutch Housing Drain Hole

13. Discard the split pin in the drain hole in the clutch housing.
14. Enlarge the drain hole, tap and fit a screwed plug.

PTO Shaft Cap

15. Remove the PTO cap.
16. Grease both threads
17. Refit the PTO cap and screw it fully home.

Extra Maintenance

Every 10 Hours or Daily

Charge all grease points with an approved grease until it exudes from the seals or shafts.

Every 50 Hours or Weekly

18. Remove the clutch housing drain plug, permit any water to drain away and refit the drain plug.
19. Ensure that the engine breather pipe is unobstructed.

Service Guide	Flex	100 h	250 h	500 h	1000 h
General					
Lubricate the throttle pedal pin and the linkage control with the oil can			°		
Engine					
Check the engine oil level.	°				
Change the engine oil.			°		
Change the engine oil filter.			°		
Check the valve tip clearance					°
Check the radiator coolant level.	°				
Clean the radiator and the oil cooler fins	°				
Drain the sediment form the fuel fitter bow(s)	°				
Change the fuel filter elements				°	
Service the fuel injectors					°
Clean the fuel lift pump strainer				°	
Check the air pre-cleaner	°				
Clean the dry air cleanser element	°				
Change the dry air cleaner element					°
Check the oil bath air cleaner level	°				
Service the oil bath air cleaner and pre-cleaner			°		
Transmission and hydraulics					
Check the level of the hydraulic oil/transmission oil		°			
Check the oil level for the rear planetary hub (Heavy Duty only)			°		
Change the transmission/hydraulic oil					°
Clutch					
Check the clutch pedal free travel and adjust		°			
Check and adjust the direct PTO clutch					°
Brakes					
Check the brakes	°				
Check the hydraulic brake fluid level	°				
Change the brake fluid and check the condition of the brake pipes	Every 2000 hours or two years whichever comes first				
Front axle and steering					
Check the four wheel drive front axle and epicyclic oil levels			°		
Check the level of the power-steering fluid		°			

Service Guide	Flex	100 h	250 h	500 h	1000 h
Check the front wheel hub adjustment				°	
Differential lock					
Check and adjust the differential lock (Mechanical type only)				°	
Electrical equipment					
Wipe the battery(ies), smear the terminals with petroleum jelly and check the condition and level			°		
Check tension of alternator fan belt			°		
Wheels and tyres					
Check the tire pressures		°			
Check wheel nut tightness			°		
Grease points					
Grease four wheel drive shaft universal joints and couplers				°	
Grease four wheel drive front axle universal joints				°	
Grease all other grease nipples		°			

NOTE: *Flexible maintenance times very according the individual conditions of operation. You must establish your own times for servicing flexible items. An average interval time checking these items is at every fuel fill up. Where tractors are used in operating areas of arduous work cycles coupled with lack of maintenance care and low specification fuel and oil, certain intervals may need to be shortened, such as oil and filter changes and grassing.*

MASSEY FERGUSON RECOMMENDED LUBRICANTS

Engine crankcase

Use Massey Ferguson Super Tractor Universal Oil 10W-30.

or

Massey Ferguson Super Premium Universal Oil 15W-30.

or

Super Tractor Universal Oil (STUO) covered by Massey Ferguson specification M1139 to one of the viscosities listed in Table 1 below.

or

One of the alternative lubricants listed on page 1D-12 or its equivalent.

Engine crankcase capacity:

See section 1B.

Engine oil specification

must meet one of the following minimum specifications:

Naturally aspirated engines ..... API CC/CCMCD1
Turbocharged engines ..... API CD/CCMCD2

Engine oil viscosity

Ambient temperature range			Oil viscosity - SAE number
	Degree F	Degree C	
Cold	Below 41	Below 5	10W. 10W/20 10W/30
Temperate	25 to 81	-4 to +27	10W/30. 20W. 15W/30. 20W/30. 10W/40. 15W/40. 20W/50.
Hot	Above 64	Above 18	15W/40. 20W/30. 20W/40. 20W/50. 30.

Table 2

Oil bath air cleaner

Use engine oil as listed on page 1D-12 or its equivalent.

Oil bath capacity:

See section 1B.

Transmission and hydraulics

Use Massey Ferguson Super Tractor Universal Oil 10W-30.

or

Massey Ferguson Super Premium Universal Oil 15W-30.

or

Super Tractor Universal Oil (STUO) covered by Massey Ferguson specification M1139 to one of the viscosities listed in Table 2 below.

or

One of the alternative lubricants listed on page 1D-12 or its equivalent.

Transmission and hydraulics capacity:

See section 1B.

Transmission and hydraulic oil viscosity

Ambient temperature range			Oil viscosity - SAE number
	Degree F	Degree C	
Cold	Below 41	Below 5	10W/20 10W/30.
Temperate	25 to 81	-4 to +27	10W/30. 15W/30. 20W/30. 10W/40. 15W/40. 20W/50.
Hot	Above 64	Above 18	15W/40. 20W/30. 20W/40. 20W/50.

Table 3

Four-wheel drive front axle

Use Massey Ferguson Super Tractor Universal Oil 10W-30.

or

Massey Ferguson Super Premium Universal Oil 15W-30.

or

Massey Ferguson Universal Gear Oil EP 80W-90.

or

One of the alternative lubricants listed on page 1D-12 or its equivalent.

Four wheel drive front axle capacity:

See section 1B.

Power Steering Reservoir

Use Massey Ferguson 'Vector' Automatic Transmission Fluid Dexron 11.

or

Massey Ferguson 'Vector' Super Tractor Universal Oil (STOU) or an STOU covered by Massey Ferguson specification M1139 to a viscosity of 10W/30 at all temperatures.

or

Massey Ferguson 'Vector' Super 500 multi-use oil.

or

One of the lubricants listed on page 1D-12 or its equivalent.

Power steering reservoir capacity:

See section 1B.

Steering box oil

Use Massey Ferguson 'Vector' Super Tractor Universal Oil (STOU) or an STOU covered by Massey Ferguson specification M1135 or M1139 to any viscosity.

or

Massey Ferguson 'Vector' Super 500 multi-use oil.

or

Massey Ferguson 'Vector' Super 500 multi-use oil or 'Vector' Hi-Load Universal oil EP80W/90.

or

EP90 GL5 gear oil.

or

One of the lubricants listed on page 1D-12 or its equivalent.

Steering box capacity:

See section 1B.

Grease Points

Use Massey Ferguson 'Vector' Multi-Purpose Grease NLG1 EP2 or any multi-purpose lithium-based grease. Always clean the grease gun and fittings before and after use.

Grease points are located as follows on 230/240/253 tractors:

Front wheel hubs	2 points.
Steering column	1 point.
Front axle king pins	2 points.
Front axle pivot pin	2 points.
Brake pedal bearing	1 point.
Lift rods and levelling box	3 points.
Clutch pedal bearing	1 point.
Four-wheel drive swivel pins	4 points.
Four-wheel drive pivot pin	1 point.
Four-wheel drive shaft universal joints	3 points.

Grease points are located as follows on 275/283/290 tractors:

Front wheel hubs	2 points.
Front axle king pins	2 points.
Front axle pivot	1 point.
Steering ram pivot pin	2 points.
Brake pedal bearing	1 point.
Vertical steering shaft	1 point.
Clutch pedal bearing	1 point.
Lift rods and levelling box	3 points.
Four-wheel drive shaft - rear, universal joint and sliding coupling	2 points
Four-wheel drive shaft - front, universal joint	1 point
Four-wheel drive front axle universal joints	2 points
Four-wheel drive front axle swivel pins	4 points

Oil can lubrication

With an oil can lubricate throttle and control linkage every 250 hours.

IMPORTANT: *Severe working conditions.*
Where tractors are operating arduous work cycles, or when working in areas where there are dusty conditions, paddy fields, deep water etc, coupled with a lack of maintenance care and low specification fuel and oil, the intervals of service should be halved, particularly for oil and filter changes.

CAUTION: *Tractor lubricants and greases:*
No significant hazard when properly used and in the application for which they were designed. Frequent and/or prolonged skin contact may give rise to skin irritations. Emergency treatment of acute effects:

- **Ingestion:** DO NOT induce vomiting. Administer 250 ml of milk or 50 ml olive oil - seek medical advice.
- **Skin contact:** Remove by wiping - wash with soap and water.
- **Inhalation:** Saturated vapour is non-toxic at room temperature - remove from exposure.
- **Eye contact:** Wash with copious amounts of warm water.

RECOMMENDED ALTERNATIVE LUBRICANTS – ALL TERRITORIES

For engine oil viscosities and temperature - see tables on page 1D-9.

Unit	Temp.	BP	CALTEX	CASTROL	ESSO
Engine naturally aspirated Oil bath air cleaner	See page 1D-9	Vanellus M Terrac Extra	Delo 100 Delo 200 Delo 350 Delo 500 Super Tractor Oil Delo 350 Delo 500 Multigrade	Castrol Agri MP Castrol Agri MP Fortec Castrol CRF	Unifarm Super Tractor Oil Essolube DX-34+ Essolube MHX
Engine turbocharged Oil bath air cleaner	See page 1D-9	Vanellus C3 Terrac Extra BP Multigrade 15W-40	Delo 350 Delo 350 Multigrade Delo 500 Delo 500 Multigrade Super Tractor Oil Delo SMP Delo SMP Multigrade	Castrol Agri MP Castrol Agri MP Fortec Castrol Agri Trimax Castrol Agri Powermax Castrol RX Castrol RX Super Plus	Unifarm Super Tractor Oil Essolube MHX SAE 15W40 Essolube Cargo 15W40 Esso Super Diesel Oil TD
Transmission, hydraulics and 4WD front axle	Cold	Tractran 9 Terrac Extra 10W30	RPM Tractor Hydraulic Fluid	Castrol Agri MP Castrol Agri MP Fortec Castrol Agri Power Trans Castrol Agri Multi Trans	Torque Fluid 56 Unifarm AL 3100
	Temperate	Terrac Extra 10W30 Terrac Extra 10W40 Terrac 15 Tractran 8	Super Tractor Oil TDH Fluid HT RPM Tractor Hydraulic Fluid	Castrol Agri MP Castrol Agri MP Fortec Castrol Agri Power Trans Castrol Agri Multi Trans Castrol Agri AS Super	Torque Fluid 56 Torque Fluid 62 Unifarm AL 3100 Super Tractor Oil
	Hot	Terrac Extra 10W40 Terrac 15 Tractran 8	Super Tractor Oil TDH Fluid HT	Castrol Agri MP Castrol Agri MR Fortec Castrol Agri Power Trans Castrol Agri Multi Trans Castrol Agri AS Super	Unifarm Torque Fluid 62 AL 3100 Super Tractor Oil
Power steering reservoir	All temps.	Autran MBX Vanellus C3 10W Autran GM-MP	Texamatic Fluid Dexron IIE ATF HDA Delo 200 Delo 350 10W	Castrol RX Super 10 Agricastrol ATF Castrol TQ D	Essolube XD-3+ SAE 10W
Grease	All temps.	Energrease LS-EP2	Molytex EP2	Castrol LM Castrol LMX	Esso Beacon 2 Esso Beacon EP2

Unit	Temp.	MOBIL	SHELL	TEXACO	TOTAL
Engine naturally aspirated Oil bath air cleaner	See page 1D-9	Mobil Super Universal Mobil Universal Delvac 1300 Delvac Super 1300	Rotella X Rimular X Rimular XT Harvella S Harvella TX Super Universal Farm Oil	Universal Tractor Oil Ursatex Super Universal Tractor Oil Super Universal Tractor Oil-Premium	Rubia S Rubia XT Multagri TM Multagri Super
Engine turbocharged Oil bath air cleaner	See page 1D-9	Mobiland Super Universal Delvac 1300 Delvac Super 1300 Delvac XHP	Harvella S Harvilla TX Super Universal Farm Oil Rimula X Rimula XT Rotella TX	Ursa Super LA Ursa Super TD Texfarm Super Universal Tractor Oil Super Universal Tractor Oil-Premium	Multagri Super Multagri TM Rubia XT
Transmission, hydraulics and 4WD front axle	Cold	Mobiland Super Universal Mobilfluid 423	Donax TD Harvella TX	TDH Oil Texfarm 10W30	Multagri Super 10W30 Transmission MP
	Temperate	Mobiland Super Universal	Donax TT Harvella Harvella TX Super Universal Farm Oil Farmecon Universal Oil	Texfarm Super Universal Tractor Oil Super Universal Tractor Oil-Premium	Multagri Super Multagri TM Transmission MP
	Hot	Mobiland Super Universal	Harvella 10W40 Harvella TX Donax TT	Super Universal Tractor Oil	Multagri Super Multagri TM Transmission MP
Power steering reservoir	All temps.	Delvac 1310 ATF 220	Rotella X 10W Rotella TX 10W Rimula X 10W Donax TM, TA or TX	Texamatic 9226 Texamatic 429 Ursa Super LA 10W Textran C3	Rubia S 10W Fluid ATX
Grease	All temps.	Mobilux EP2 Mobilgrease HP222	Farm Grease Universal Retinax LX	Multifak All Purpose EP2	Multis or Multis EP2

Table 4

NOTE: *All engine oils recommended for turbocharged engines are suitable for use in naturally aspirated engines after running in.*

SECTION 2

Splitting the Tractor

INDEX

2A SPLITTING THE TRACTOR

Splitting the Tractor

Section 2 – Part A

Table of Contents

Operation No.	Description	Page No.
-------	Specification	2A-1
2.02A-01	Between front axle and engine (3 cylinder)	2A-2
2.02A-02	Between front axle and engine (4 cylinder)	2A-3
2.02A-03	Between engine and gearbox (3 cylinder)	2A-4
2.02A-04	Between engine and gearbox (4 cylinder)	2A-6
2.02A-05	Between gearbox and spacer or centre housing (3 cylinder)	2A-7
2.02A-06	Between gearbox and spacer or centre housing (4 cylinder)	2A-9

Specification

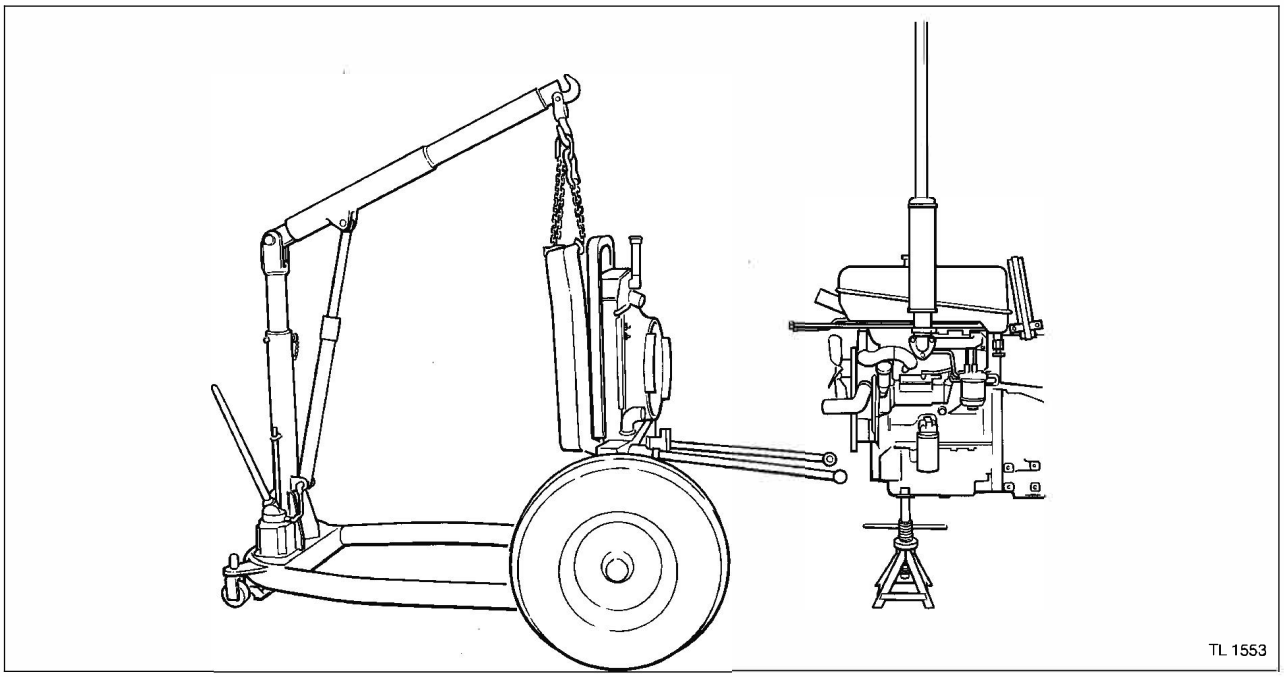
Shear tube end float	0,4-2, 5mm

Bolt Torques

Front axle support casting retaining bolts (3 cylinder)	235 Nm
Front axle support casting retaining bolts (4 cylinder)	75 Nm
Engine to gearbox retaining bolts	270 Nm
Gearbox to spacer housing	112 Nm
Spacer housing to centre housing	112 Nm

Special Tools

MF.3012	Tractor splitting track
MF.367B	Transmission housing wrench



Splitting the tractor between the front axle and the engine (3 cylinder)

SPLITTING the TRACTOR BETWEEN the FRONT AXLE and ENGINE (3 cylinder)

Splitting procedure **2.02A–01**

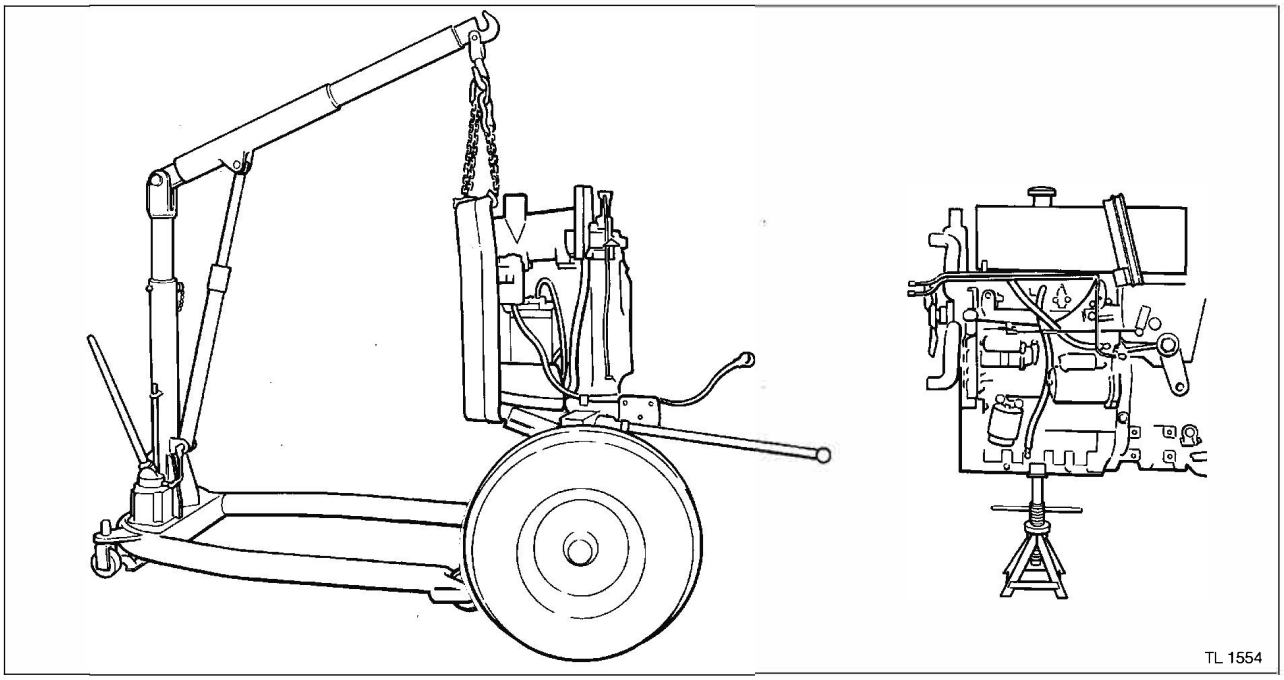
Dis-assembly

WARNING: Take care to keep the front axle assembly level once it has been withdrawn from the engine, otherwise it could overbalance and cause injury.

1. Apply the tractor parking brake, remove the front weights (if fitted), and fit chocks to hold the rear wheels.
2. Remove the radiator cap and drain the cooling system via the drain taps on the radiator and cylinder block.
3. Remove the hood.
4. Remove the front grille.
5. Disconnect the battery negative (-) cable from the battery.
6. Disconnect the radiator top and bottom hoses.
7. Disconnect the headlight wires and thread them through the retaining clips to leave the cable on top of the engine.
8. Disconnect the hoses from the power steering rams on both sides (if fitted).
9. Disconnect the hoses from the oil cooler (if fitted).
10. Disconnect the radiator support bar.
11. Fit hardwood wedges between the front axle casting and beam on both sides to prevent the beam from pivoting.
12. Disconnect the drag links from the steering box drop arms on both sides (if fitted).
13. Support the nose assembly using a jib crane and chain.
14. Support the tractor under the sump using a suitable jack stand.
15. Remove the four bolts, two nuts, washers and spacers (if fitted).
16. Carefully wheel the two front wheels, front axle and jib crane forwards away from the engine.

Re-assembly

17. Reverse procedures 1 to 16 except:
    a. Tighten the front axle retaining nuts and bolts to a torque of 235 Nm.
    b. Refit the power steering hose retaining chains (if fitted) to the support casting.
    c. Check the power steering reservoir oil level (if fitted).



Splitting the tractor between the front axle and the engine (4 cylinder)

SPLITTING the TRACTOR BETWEEN the FRONT AXLE and ENGINE (4 cylinder)

Splitting procedure **2.02A–02**

Dis-assembly

WARNING: Take care to keep the front axle assembly level once it has been withdrawn from the engine, otherwise it could overbalance and cause injury.

1. Apply the tractor parking brake, remove the front weights (if fitted), and fit chocks to hold the rear wheels.
2. Remove the radiator cap and drain the cooling system via the drain taps on the radiator and cylinder block.
3. Remove the hood.
4. Remove the front grille and front side panels.
5. Disconnect the battery negative (-) cable from the battery.
6. Disconnect the positive battery cable (+) from the starter motor solenoid.
7. Disconnect the headlight, air cleaner indicator and horn wires, thread them through the retaining clips to leave the cable on top of the engine.
8. Disconnect the steering drag link from the steering box drag arm (if fitted).
9. Disconnect the pipes from the power steering pump (if fitted).
10. Disconnect the air induction pipe from the inlet manifold.
11. Disconnect all pipes from the front bulkhead unions.
12. Disconnect and remove the radiator top and bottom hoses.
13. Support the nose assembly using a jib crane and chain.
14. Support the tractor under the sump using a suitable jack stand.
15. Fit hardwood wedges between the front axle casting and beam on both sides to prevent the beam from pivoting.
16. Remove the four bolts, two nuts, washers and spacers.
17. Carefully wheel the two front wheels, front axle and jib crane forwards away from the engine.

Re-assembly

18. Reverse procedures 2 to 17 except:
    a. Tighten the front axle retaining nuts and bolts to a torque of 270 Nm.

SPLITTING the TRACTOR BETWEEN the ENGINE and GEARBOX (3 cylinder)

Splitting procedure **2.02A–03**

Special Tools:
MF.3012 Tractor splitting track.
MF.367B Transmission housing wrench.

Dis-assembly

1. If the tractor is fitted with a cab refer to the relevant cab section, for removal.
2. Apply the tractor handbrake and fit wedges to hold the rear wheels.
3. Remove the hood.
4. Remove the instrument panel.
5. Disconnect both battery cables from the battery, negative cable (-) black first.
6. Remove the battery.
7. Fit a suitable wooden wedge between the engine rocker cover and the fuel tank. Take care not to damage the fuel tank.
8. Disconnect the fuel tank rear support bracket bolts.
9. Remove the fuel tank rear support bracket.
10. Disconnect the air cleaner hose from the air cleaner and inlet manifold.
11. Disconnect the air cleaner indicator pipe at the air cleaner (dry air cleaner).
12. Turn off the fuel supply at the tap beneath the fuel tank. Disconnect the injector pump supply and return pipes to the secondary filter. Also disconnect the injector leak back pipe between the union and the thermostart.
13. Disconnect the four power steering ram hoses (if fitted).
14. Disconnect the power steering pipe clamp brackets (if fitted).
15. Disconnect the two power steering pump pipes adjacent to the starter motor (if fitted).
16. Disconnect the oil cooler pipes (if fitted) at the transmission housing.
17. Remove the two bolts securing the steering box side panels lower bracket to the rear of the engine.
18. Disconnect the stop control at the injection pump.
19. Disconnect the throttle control rod from the injection pump at the cross shaft.
20. Remove the front grille.
21. Disconnect the wiring from the temperature gauge transmitter, oil warning light switch, fuel gauge sender unit and the front headlights.
22. Disconnect the tractormeter drive cable from the rear of the engine.
23. Disconnect the positive battery cable (+) from the starter motor solenoid.
24. Disconnect the wiring from the starter motor solenoid.
25. Remove the starter motor and solenoid.
26. Disconnect the alternator wiring.
27. If the tractor is fitted with a horizontal exhaust system, remove the bolt, nut, washer and clip securing the silencer to the exhaust down pipe, then release the down pipe from the silencer.
28. Place hard wood wedges between the front axle support casting and the front axle beam on both sides, to prevent the beam from pivoting.
29. Disconnect the drag links from the steering box drop arms (if fitted).
30. Using the MF.3012 tractor splitting track, support the tractor under the transmission with the fixed axle stand, and under the engine sump with the rails and trolley.
31. Remove the 12 engine to flange bolts and the one nut and bolt securing the earth cable.
32. Withdraw the engine and front axle forwards.

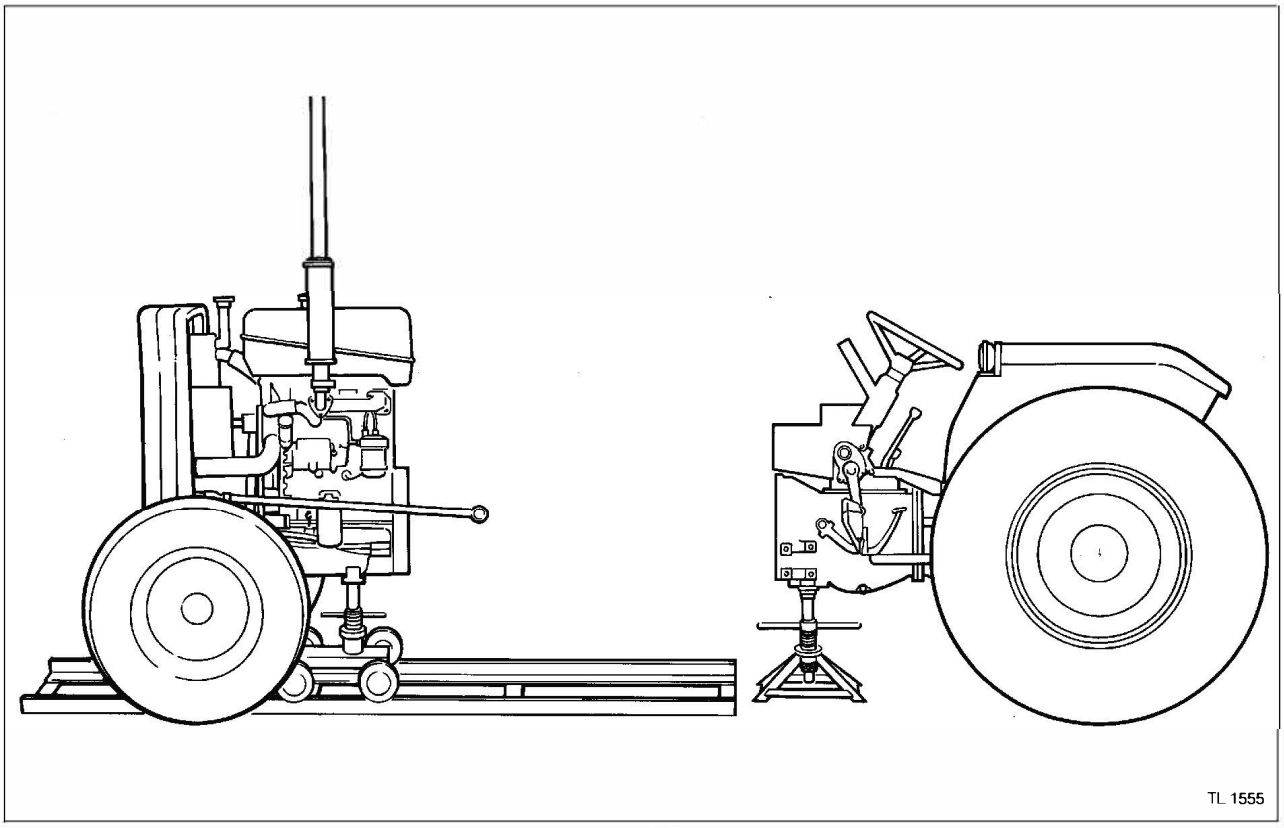
Re-assembly

33. Align the engine with the gearbox, two guide studs, approximately 100 mm long X M12, will assist its alignment.
34. Turn the flywheel and, at the same time, push the engine and front axle towards the gearbox.

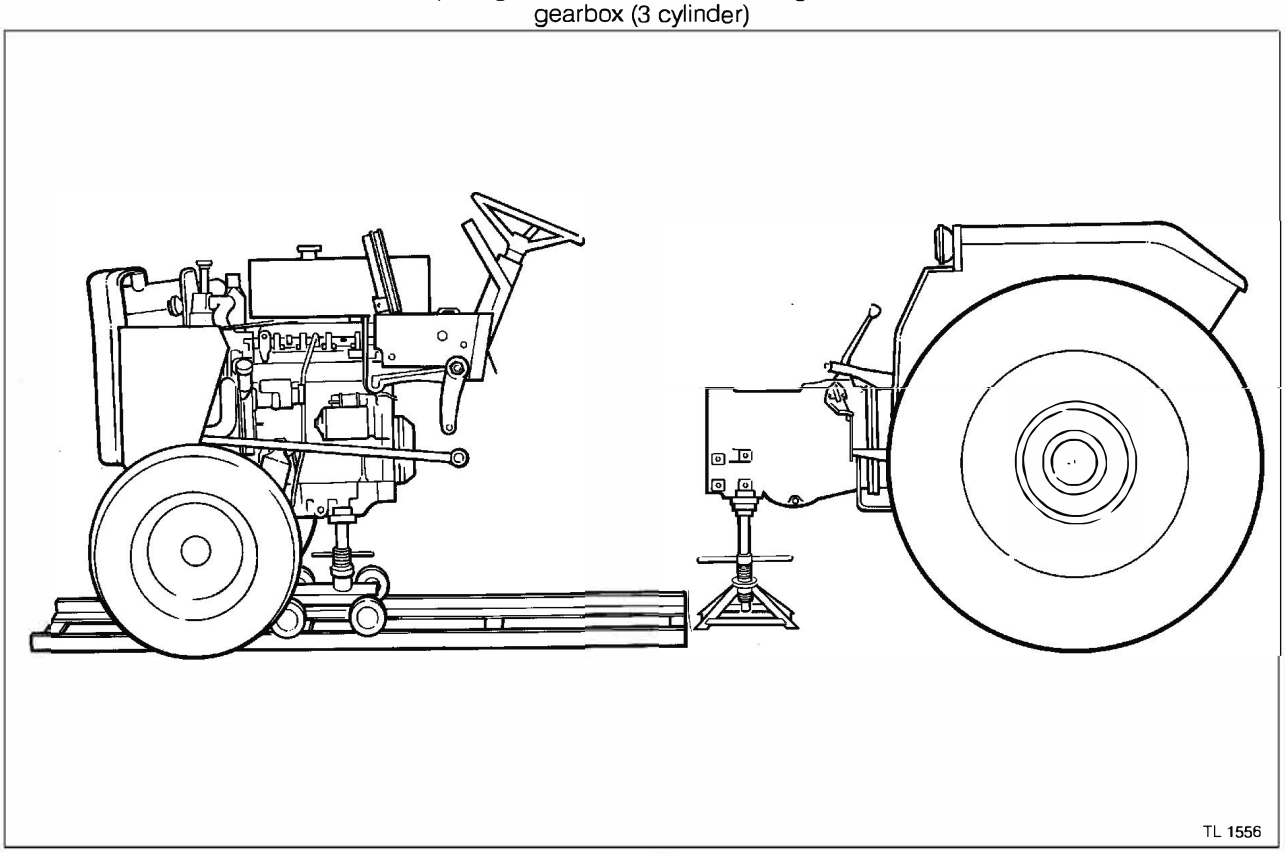
    Turning the flywheel aligns the clutch plate splines with the gearbox main and PTO input shaft splines. Continue pushing and turning until the engine and gearbox flanges meet.

CAUTION: *Do not force, fit and/or tighten any of the bolts until the two flanges meet, or serious damage may occur to the gearbox and clutch.*

35. Fit some of the bolts, remove the guide studs, if used, and fit the remainder of the bolts and nuts, and tighten them to a torque of 75 Nm using the transmission housing wrench MF.367B.
36. Reverse procedures 1 to 32.
    a. Refill the power steering reservoir.
    b. Adjust the clutch linkage.



Splitting the tractor between the engine and gearbox (3 cylinder)



Splitting the tractor between the engine and gearbox (4 cylinder)

SPLITTING the TRACTOR BETWEEN the ENGINE and GEARBOX (4 cylinder)

Splitting procedure **2.02A–04**

Special Tools:
MF.3012 Tractor splitting track.
MF.367B Transmission housing wrench.

Dis-assembly

1. If the tractor is fitted with a cab refer to the relevant cab section.
2. Apply the tractor handbrake and fit chocks to hold the rear wheels.
3. Remove the front grille.
4. Disconnect both battery cables from the battery, negative cable (-) black first.
5. Remove the hood.
6. Remove the instrument panel cover.
7. Disconnect the positive battery cable (+) from the starter motor solenoid.
8. Remove the cover panel.
9. Disconnect the rear wiring section at the block connector.
10. Remove the two bolts retaining the steering column to the shift tower.
11. Disconnect the auxiliary hydraulic services oil cooler pipes (if fitted) at the transmission housing.
12. Remove the two bolts retaining the engine side panels to the engine and transmission (if fitted).
13. Disconnect the foot throttle rod from the throttle cross shaft.
14. Remove the starter motor and solenoid assembly.
15. Place hardwood wedges between the front axle support casting and the front axle beam on both sides, to prevent the axle from pivoting.
16. If the tractor is fitted with a horizontal exhaust system, remove the bolt, nut, washer and clip securing the silencer to the exhaust down pipe, then release the down pipe from the silencer, and disconnect the bracket.
17. Using the MF.3012 tractor splitting track, support the tractor under the transmission with the fixed axle stand, and under the engine sump with the rails and trolley.
18. Remove the 14 bolts and the one nut and bolt securing the engine to the gearbox case.
19. Withdraw the engine and front axle forwards.

NOTE: *On manual and power steering tractors, withdraw the engine and front axle section forward, until the gearbox input shaft has fully disengaged from the clutch. Then raise the engine sufficiently to allow the rear steering box mounting lugs to clear the top of the gearbox case as the engine section is rolled fully forward.*

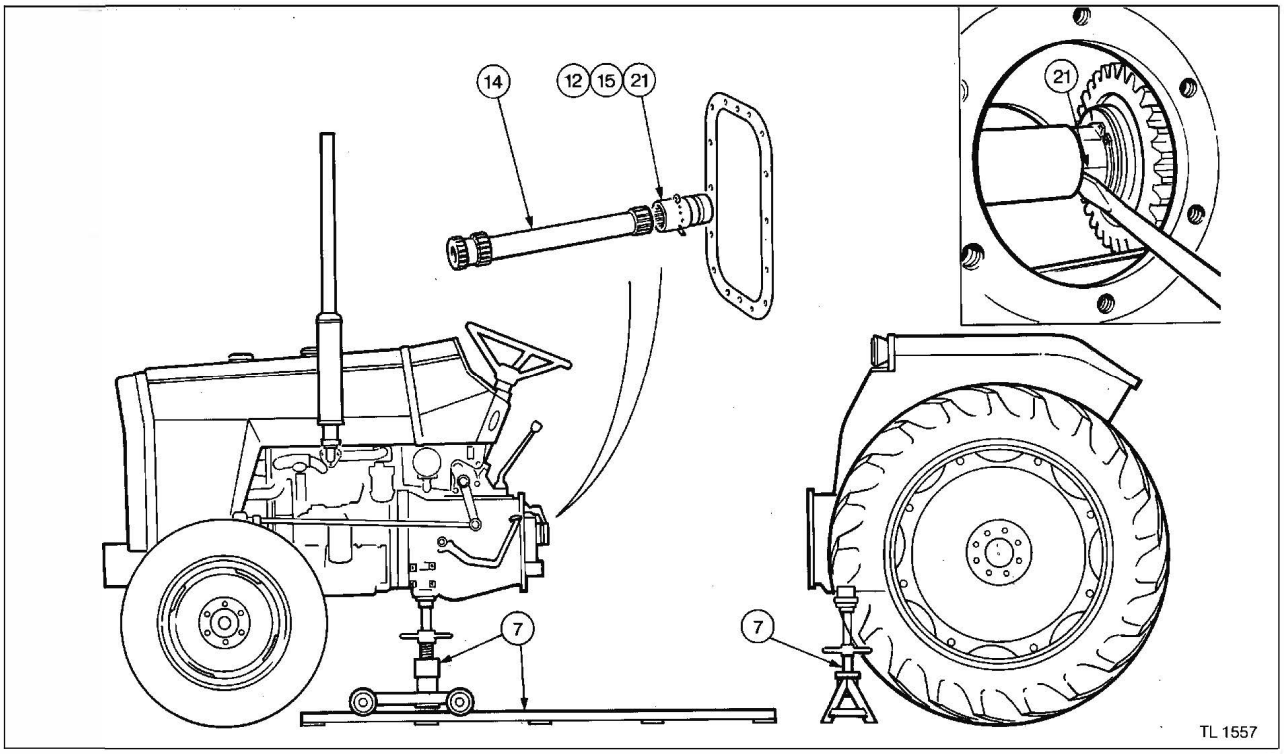
Re-assembly

20. Align the engine with the gearbox, two guide studs, approximately 100 mm long X M12, will assist its alignment.
21. Turn the flywheel and, at the same time, push the engine and front axle towards the gearbox.

    Turning the flywheel aligns the clutch plate splines with the gearbox main and PTO input shaft splines. Continue pushing and turning until the engine and gearbox flanges meet.

CAUTION: *Do not force, fit and/or tighten any of the bolts until the two flanges meet, or serious damage may occur to the gearbox and clutch.*

22. Fit some of the bolts, remove the guide studs if used, fit the remainder of the bolts and nuts, and tighten them to a torque of 75 Nm.
23. Reverse procedures 1 to 17.
24. Adjust the clutch linkage.



Splitting the tractor between the gearbox and the spacer or centre housing (3 cylinder)

SPLITTING the TRACTOR BETWEEN the GEARBOX and the SPACER or CENTRE HOUSING (3 cylinder)

Splitting procedure **2.02A–05**

Special Tools:
MF.3012 Tractor splitting track.
MF.367B Transmission housing wrench

Dis-assembly

1. If the tractor is fitted with a cab, refer to the relevant cab section, for removal.
2. Fit chocks to hold the front wheels.
3. Drain the transmission oil via the drain plugs on the transmission case and centre housing.
4. Disconnect both foot plates at their front mounting brackets.
5. Disconnect the rear lighting cable from under the left hand side of the instrument panel and the securing clip from a gearbox top cover securing bolt.
6. Disconnect the the footbrake rods.
7. Using the MF.3012 tractor splitting track, support the tractor under the transmission with the fixed stand, and under the centre housing with the trolley and rails.
8. If the tractor is fitted with a horizontal exhaust system, remove the bolt, nut, washer and clip securing the silencer to the exhaust down pipe, then release the down pipe from the silencer.
9. Remove the 16 bolts and 11 nuts securing the gearbox and spacer housing to the centre housing.
10. Withdraw the rear axle and centre housing rearwards.
11. Discard the gasket.
12. Remove the split pin from the shear tube, but only if absolutely necessary.

Re-assembly

13. If the split pin has been removed, refit it in the centre of the five pairs of holes in the shear tube.
14. Fit the rear drive shaft into the epicyclic high/low coupler, with the high/low gear lever in low gear, and the main gear lever in the third gear position.
15. Fit the shear tube onto the pinion with the holes around the tube towards the front.
16. Remove the PTO shift lever and cover from the centre housing (8 speed transmission only).
17. Fit two guide studs, approximately 100 mm long x 7/16 inch UNC, in to the top left and right sides of the transmission flange.
18. Clean off both flanges of the gearbox and centre housing removing all traces of oil and grease.

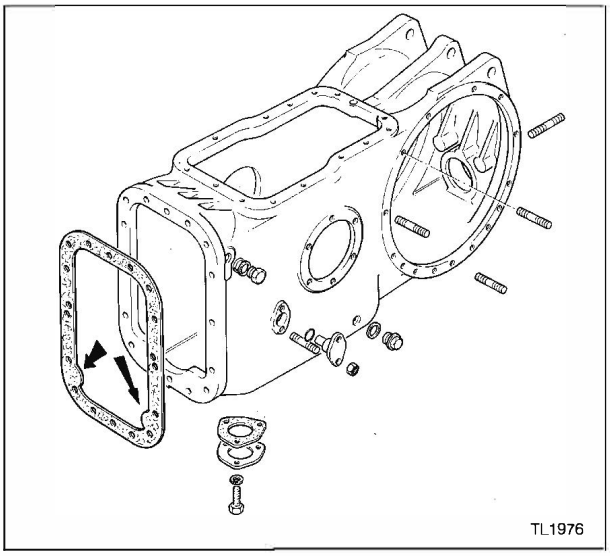
19. Fit a new gasket dry with the two internal lobes fitted to the bottom of the transmission case as shown in the illustrations on page 2A-8.
20. Push the rear half of the tractor into engagement with the transmission, simultaneously aligning the shear tube splines onto the rear axle pinion splines and the hydraulic pump drive gear splines onto the gearbox front PTO drive shaft. Alignment of the shear tube can be effected through the PTO lever aperture in the centre housing (8 speed transmission only).

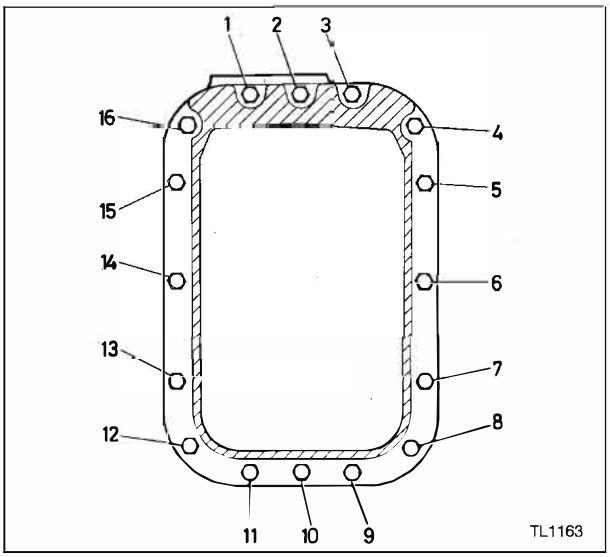
    Alignment of the hydraulic pump drive is facilitated by rotating the flywheel. This is effected by the removal of the hexagon socket plug in the left hand side of the clutch housing.
21. Using a suitable lever, turn the flywheel, align the guide studs in the transmission with the corresponding holes in the centre housing. Continue turning and pushing until the two flanges meet.

NOTE: *DO NOT fit and/or tighten any of the bolts until the two flanges meet, or serious damage may occur to the PTO and main drive components. To facilitate easy re-assembly, the spacer and transmission flanges must be aligned as near as possible.*

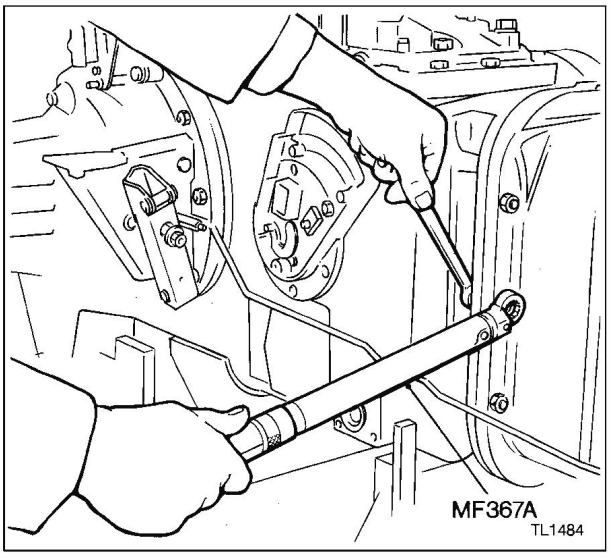
22. Secure the two flanges with a nut and bolt on each side.
23. Push the shear tube forwards (which will push the rear drive shaft against a spring, continue pushing until the spring is fully compressed) and measure the distance between the shear tube and locking collar. This measurement should be 0,4 - 2,5 mm.
24. If the end float is not within the specified limits separate the gearbox and centre housing. Remove the split pin and reposition it nearer the front of the shear tube if the measurement is too large, or nearer the rear of the shear tube if the measurement is too small.

    Repeat procedures 22 to 24 until the end float obtained is within the specified limits.
25. Remove the guide studs, lubricate the threads of all the bolts and replace them in their respective holes. Coarse bolts are threaded into the casting, fine bolts are fitted with nuts.
26. Bolt holes 7 and 15 are 'fitted' bolts and will be a tighter fit to ensure the correct alignment of the transmission cases and to ease assembly of the remaining bolts.
27. No bolt is fitted in hole 10 on the gearbox.
28. All bolts are fitted with their heads facing to the rear except bolts 8, 9, 11 & 12 facing forwards.
29. Tighten the bolts and nuts, using MF.367B transmission housing wrench, by working around the flange in a clockwise direction starting from the top, until a torque of 112 Nm is reached.
30. Refit the PTO lever and cover (8 speed transmission only).
31. Reverse procedures 1 to 9 except:
    a. Fill the transmission with an approved oil to the required level.

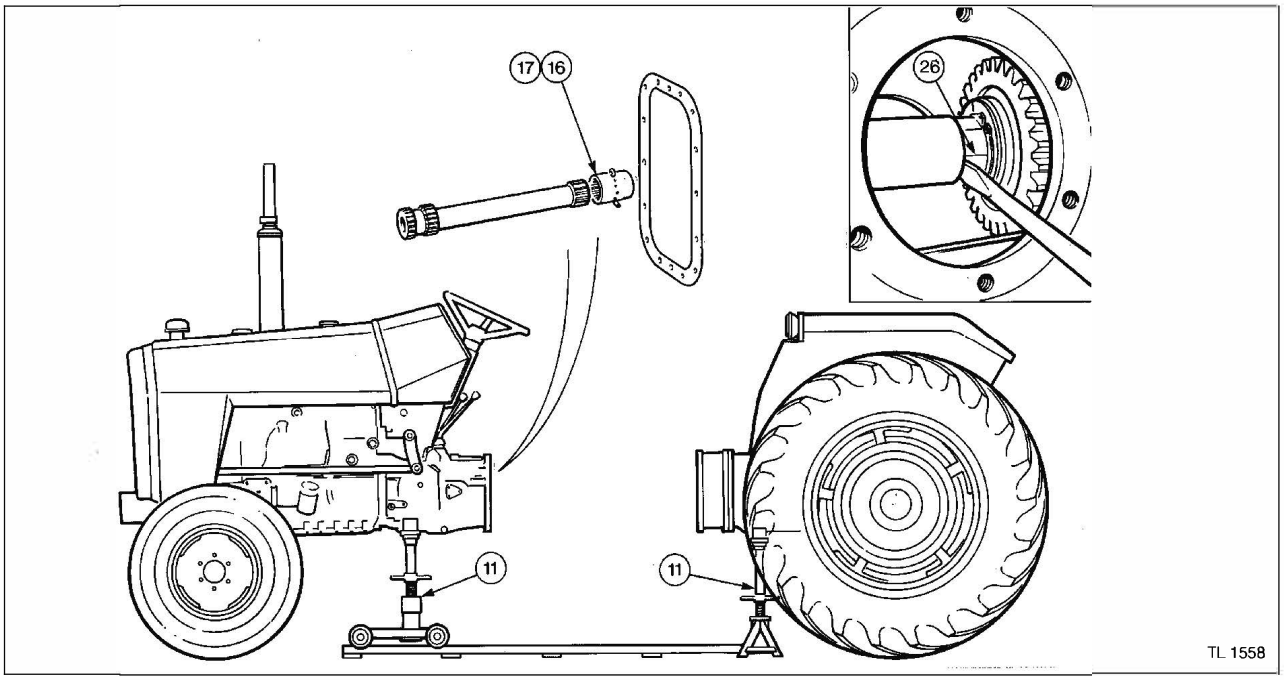

TL1976



TL1163



TL1484



Splitting the tractor between the gearbox and the spacer or centre housing (4 cylinder)

SPLITTING the TRACTOR BETWEEN the GEARBOX and the SPACER or CENTRE HOUSING (4 cylinder)

Splitting procedure **2.02A–06**

Special Tools:
MF.3012 Tractor splitting track.
MF.367B Transmission housing wrench

Dis-assembly

1. If the tractor is fitted with a cab, refer to the relevant cab section, for removal.
2. Drain the transmission oil via the drain plugs on the transmission case and centre housing.
3. Disconnect the clutch operating rod from the clutch release shaft arm (certain models).
4. Remove the two footsteps.
5. Disconnect the handbrake and footbrake rods.
6. Disconnect the handbrake lever and bracket from the top of the spacer housing.
7. Disconnect the rear lighting harness from the left hand side of the instrument panel (multi-connector) and at the rear securing clips on the left hand and right hand foot plate mounting brackets.
8. Place hard wood wedges between the front axle support casting and the front axle beam on both sides, to prevent the beam from pivoting.
9. Fit chocks to hold the front wheels.
10. Using the MF.3012 tractor splitting track, support the tractor under the transmission housing with the fixed stand, and under the centre housing with the rails and trolley.
11. If the front engine and gearbox section is to be removed forwards, support the tractor under the engine sump or transmission housing with the trolley, and under the centre housing with the fixed stand, depending on work to be done.

NOTE: *If the gearbox is to be removed from the front section of the tractor, support the front section under the tractor sump before removing the gearbox from the engine.*

12. If the tractor is fitted with a horizontal exhaust system, remove the bolt, nut, washer and clip securing the silencer to the exhaust down pipe, and then release the down pipe from the silencer.
13. Remove the 16 bolts, nuts and washers securing the gearbox to the spacer flange to the rear centre housing.
14. Withdraw the rear axle, centre housing and spacer housing rearwards, or the engine and gearbox section forwards as required.
15. Discard the gasket.
16. Remove the split pin from the shear tube only if absolutely necessary.

Re-assembly

17. If the split pin has been removed, refit it in the centre of the five pairs of holes in the shear tube.
18. Fit the rear drive shaft into the epicyclic high/low coupler, with the high/low gear lever in low gear, and the main gear lever in the third gear position.

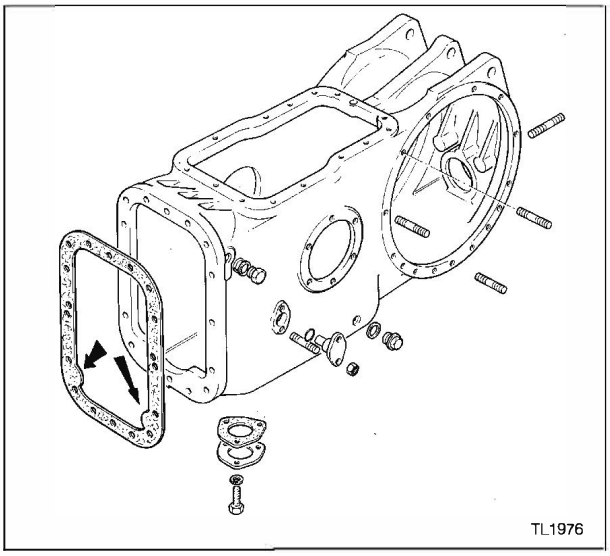
19. Fit the shear tube onto the pinion with the holes around the tube towards the front.
20. Remove the PTO shift lever and cover from the centre housing (8 speed transmission only).
21. Fit two guide studs, approximately 100 mm long x 7/16 inch UNC, in to the top left and right sides of the transmission flange.
22. Clean off both flanges of the gearbox and centre housing removing all traces of oil and grease.
23. Fit a new gasket dry with the two internal lobes fitted to the bottom of the transmission case as shown in the illustration opposite.
24. Push the rear half of the tractor into engagement with the transmission, simultaneously aligning the shear tube splines onto the rear axle pinion splines and the hydraulic pump drive gear splines onto the gearbox front PTO drive shaft. Alignment of the shear tube can be effected through the PTO lever aperture in the centre housing (8 speed transmission only).

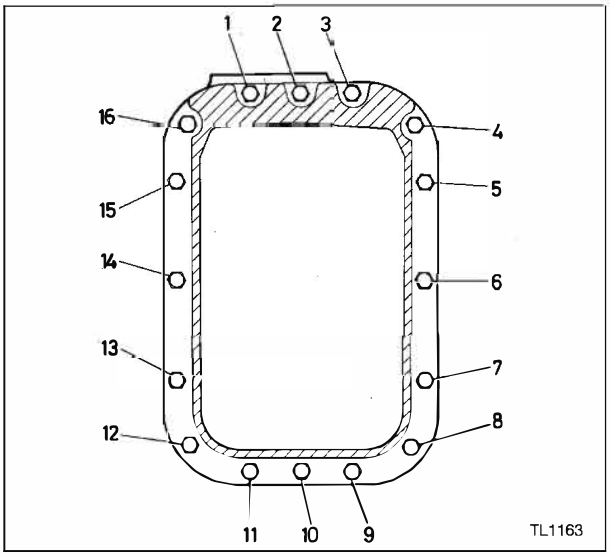
    Alignment of the hydraulic pump drive is facilitated by rotating the flywheel. This is effected by the removal of the hexagon socket plug in the left hand side of the clutch housing.
25. Using a suitable lever, turn the flywheel, align the guide studs in the transmission with the corresponding holes in the centre housing. Continue turning and pushing until the two flanges meet.

NOTE: *DO NOT fit and/or tighten any of the bolts until the two flanges meet, or serious damage may occur to the PTO and main drive components. To facilitate easy re-assembly, the spacer and transmission flanges must be aligned as near as possible.*

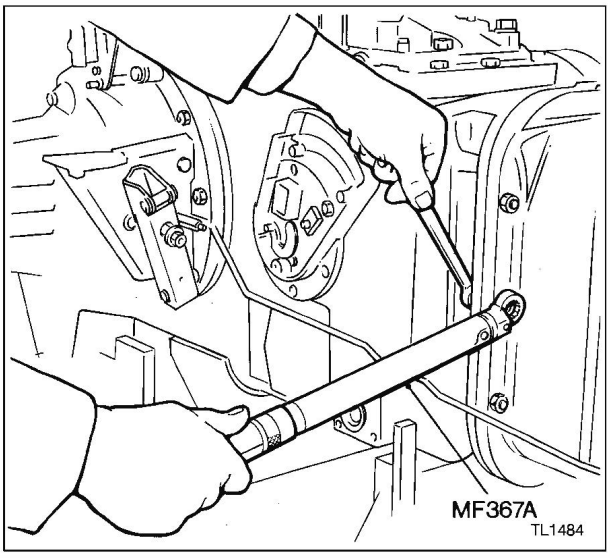
26. Secure the two flanges with a nut and bolt on each side.
27. Push the shear tube forwards (which will push the rear drive shaft against a spring, continue pushing until the spring is fully compressed) and measure the distance between the shear tube and locking collar. This measurement should be 0,4 - 2,5 mm.
28. If the end float is not within the specified limits separate the gearbox and centre housing. Remove the split pin and reposition it nearer the front of the shear tube if the measurement is too large, or nearer the rear of the shear tube if the measurement is too small.

    Repeat procedures 26 to 28 until the end float obtained is within the specified limits.
29. Remove the guide studs, lubricate the threads of all the bolts and replace them in their respective holes. Coarse bolts are threaded into the casting, fine bolts are fitted with nuts.
30. Bolt holes 7 and 15 are 'fitted' bolts and will be a tighter fit to ensure the correct alignment of the transmission cases and to ease assembly of the remaining bolts.
31. No bolt is fitted in hole 10 on the gearbox.


TL1976



TL1163



TL1484

32. All bolts are fitted with their heads facing to the rear except bolts 8, 9, 11 & 12 facing forwards.
33. Tighten the bolts and nuts, using MF.367B transmission housing wrench, by working around the flange in a clockwise direction starting from the top, until a torque of 112 Nm is reached.
34. Refit the PTO lever and cover (8 speed transmission only).
35. Reverse procedures 1 to 9 except:
    a. Fill the transmission with an approved oil to the required level.

Page left blank intentionally

SECTION 3

Engine

INDEX

3A	D 3.152 AND T 3.1524 ENGINES
3B	4.41 ENGINES
3C	COOLING SYSTEM
3D	AIR SYSTEM
3E	FUEL SYSTEM

AD 3.152 and T 3.1524 engines

Section 3 – Part A

Table of Contents

	Description	Page No.
A	General information	3A-2
B	Engine views	3A-7
C	Technical data	3A-13
E	Fault diagnosis	3A-29
F	Cylinder head	3A-31
G	Pistons dans connecting rods	3A-43
H	Cylinder block and liners	3A-53
J	Crankshaft and main bearings	3A-57
K	Timing case and drive	3A-65
L	Timing	3A-77
M	Lubrification system	3A-83
N	Cooling system	3A-89
P	Fuel system	3A-95
Q	Flywheel and flywheel housing	3A-103
R	Electrical system	3A-107
T	Turbocharger	3A-111
W	Marine engines	3A-119
Y	Approved service tools	3A-123
Z	Index	3A-129

SECTION A

General Information

Introduction A2

Safety precautions A3

Asbestos joints A3

Engine identification A4

Running-in procedure A4

GENERAL INFORMATION—A.2

Introduction

This manual has been written to give assistance to all personnel engaged in the maintenance and overhaul of Perkins 3.152 Series engines.

Most of the general information which is included in the multi-lingual 3.152 series Users Handbooks has not been repeated in this workshop manual and the two publications should be used together.

There are five engine types in the 3.152 Series for agricultural and industrial applications. These are the 3.152, D3.152, 3.1522, 3.1524 and T3.1524 engines. Information on two marine versions of the D3.152 engine, the D3.152(M) and the 3HD46 are also included in section W of this manual. The information applies to all engine types unless indicated. Where specific information is given for Massey Ferguson engines, A3.152 and AD3.152 etc. reference is made in the text.

Overhaul of the engine or components must only be done by personnel who have had the correct training.

When setscrews or studs are fitted into holes which are tapped through into the inside of the engine, a suitable sealant must be used on the threads. Some setscrews already have sealant coated threads. These can be identified by the colour of the threads which will be red or blue etc.

The left and right side of the engine are as seen from the rear.

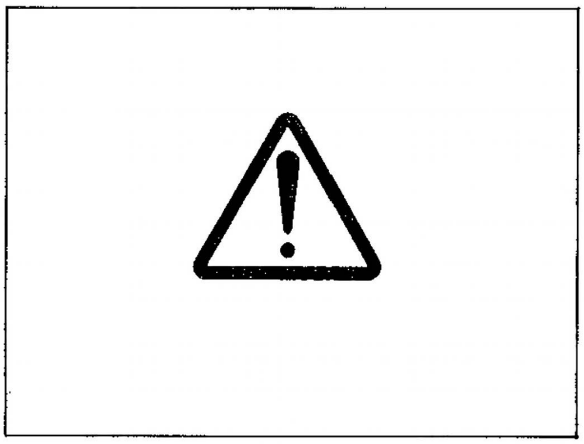
Parts and other services are available from your Perkins distributor.

Read and remember the Safety Precautions. These are given for your protection and must be used at all times.

Safety precautions

These safety precautions are important. You must refer also to the local regulations in the country of use. Some items only apply to specific applications.

- Only use these engines in the type of application for which they have been designed.
- Do not change the specification of the engine.
- Do not smoke when you put fuel in the tank.
- Clean away fuel which has been spilt. Material which has been contaminated by fuel must be moved to a safe place.
- Do not put fuel in the tank while the engine runs (unless it is absolutely necessary).
- Do not clean, add lubricating oil, or adjust the engine while it runs (unless you have had the correct training; even then extreme caution must be used to prevent injury).
- Do not make adjustments that you do not understand.
- Ensure that the engine does not run in a location where it can cause a concentration of toxic emissions.
- Other persons must be kept at a safe distance while the engine, or equipment, is in operation.
- Do not permit loose clothing or long hair near moving parts.
- Keep away from moving parts during engine operation. **Attention:** Some moving parts cannot be seen clearly while the engine runs.
- Do not operate the engine if a safety guard has been removed.
- Do not remove the filler cap of the cooling system while the engine is hot and while the coolant is under pressure, because dangerous hot coolant can be discharged.
- Do not use salt water or any other coolant which can cause corrosion in the closed coolant circuit.
- Do not allow sparks or fire near the batteries (especially when the batteries are on charge) because the gases from the electrolyte are highly flammable. The battery fluid is dangerous to the skin and especially to the eyes.
- Disconnect the battery terminals before a repair is made to the electrical system.
- Only one person must control the engine.
- Ensure that the engine is operated only from the control panel or from the operator's position.
- If your skin comes into contact with high-pressure fuel, obtain medical assistance immediately.
- Diesel fuel and lubricating oil (especially used lubricating oil) can damage the skin of certain persons. Protect your hands with gloves or a special solution to protect the skin.
- Do not wear clothing which is contaminated by lubricating oil. Do not put material which is contaminated with oil into the pockets.
- Discard used lubricating oil in a safe place to prevent contamination.
- Do not move mobile equipment if the brakes are not in good condition.



- Ensure that the control lever of the transmission drive is in the "out-of-drive" position before the engine is started.
- Use extreme care if emergency repairs must be made at sea or in adverse conditions.
- The combustible material of some components of the engine (for example certain seals) can become extremely dangerous if it is burned. Never allow this burnt material to come into contact with the skin or with the eyes.
- Read and use the instructions relevant to asbestos joints given on this page.
- Fit only genuine Perkins parts.

Asbestos joints

Some joints and gaskets contain compressed asbestos fibres in a rubber compound or in a metal outer cover. The "white" asbestos (Chrysotile) which is used is a safer type of asbestos and the risk of damage to health is extremely small.

The risk of asbestos from joints occurs at their edges or if a joint is damaged when a component is removed or if a joint is removed by abrasion.

To ensure that the risk is kept to a minimum, the procedures given below must be applied when an engine which has asbestos joints is dismantled or assembled.

- Work in an area with good ventilation.
- Do not smoke.
- Use a hand scraper to remove the joints - do not use a rotary wire brush.
- Ensure that the joint to be removed is wet with oil or water to contain loose particles.
- Spray all loose asbestos debris with water and put it in a closed container which can be sealed for safe disposal.

Engine identification

The first two letters of the engine number give an indication of the engine type as shown below.

CD 3.152 engine
CE D3.152, D3.152(M) and 3HD46 engines
CJ 3.1522 engine
CM 3.1524 engine
CN T3.1524 engine

The engine number is stamped on a machined pad on the right side of the cylinder block forward of the fuel lift pump (see fig. A1). A typical engine number is CJ30060U510251F.

If you need any parts, service or information for your engine, you must give the complete engine number to your Perkins distributor.

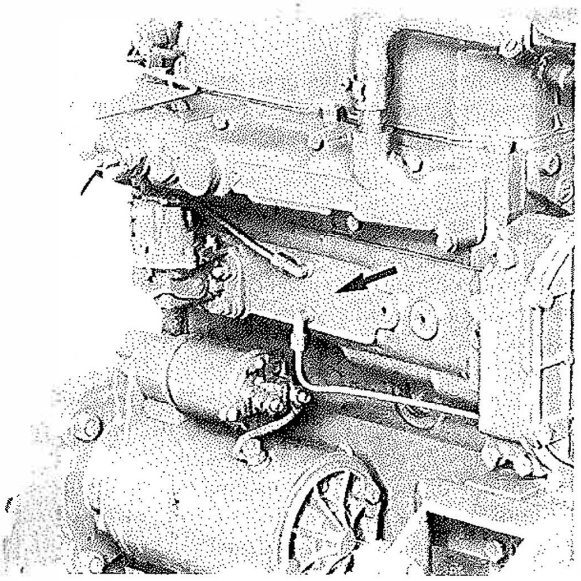


Fig. A1

SECTION B

Engine views

Perkins engines are made for specific applications and the views which follow are not necesarily correct for your engine specification.

ENGINE VIEWS—B.2

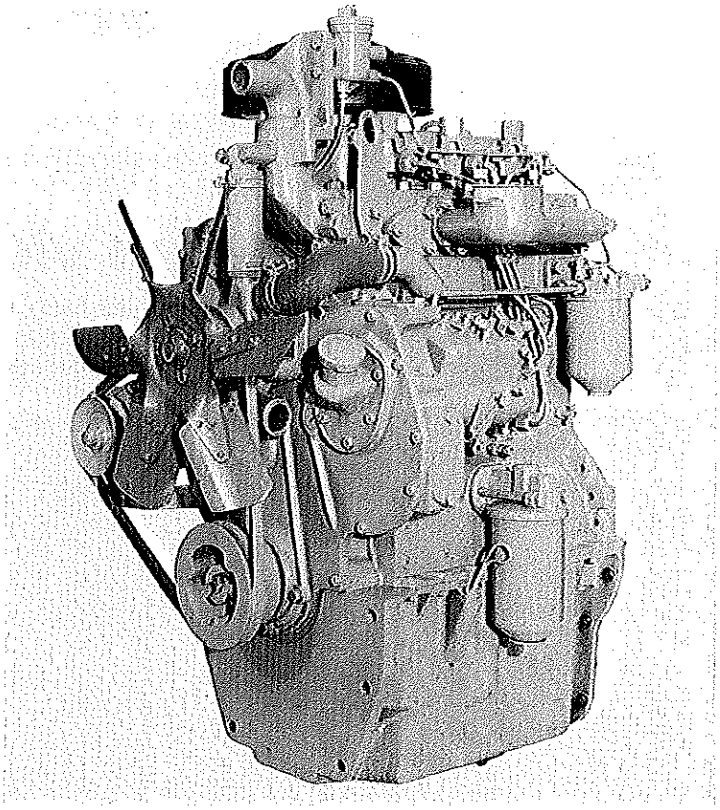


Fig. B1
Front/left side of 3.152 engine

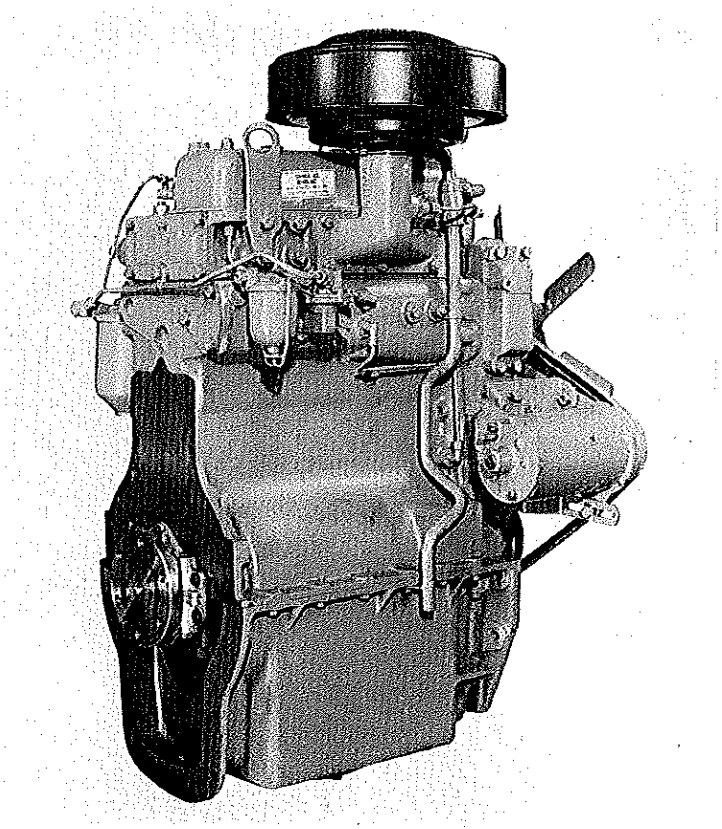


Fig. B2
Rear/right side of 3.152 engine

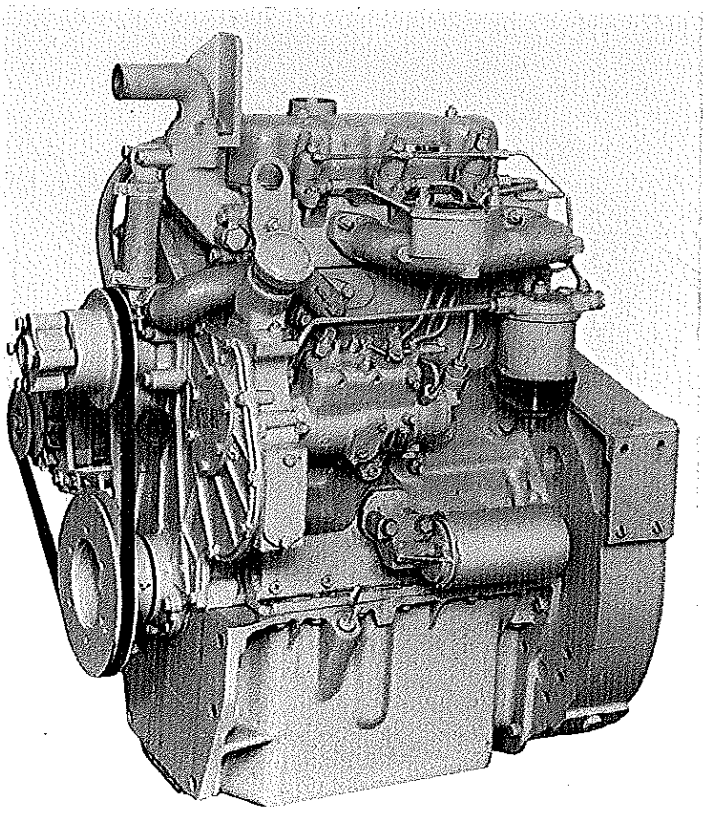


Fig. B3
Front/left side of D3.152 engine

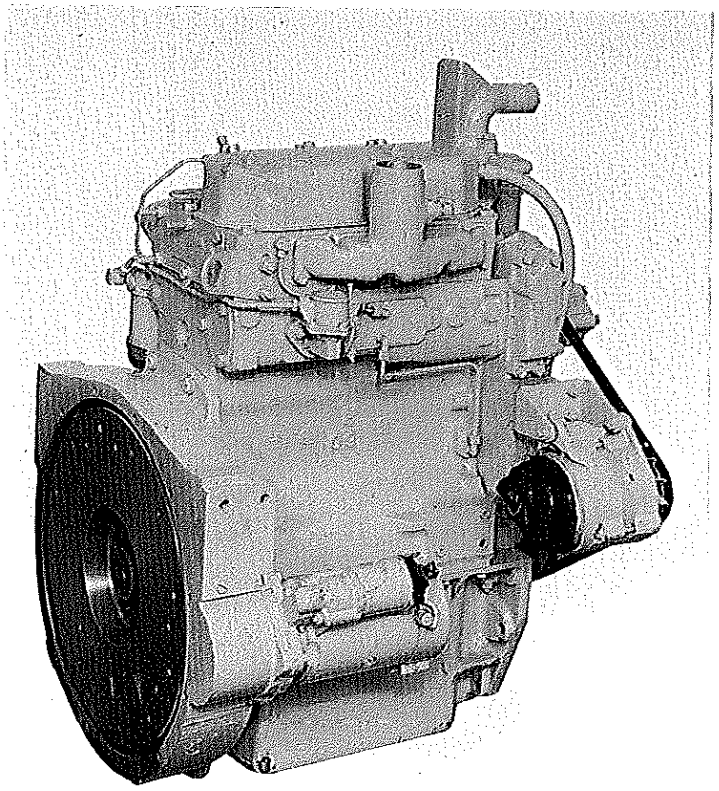


Fig. B4
Rear/right side of D3.152 engine

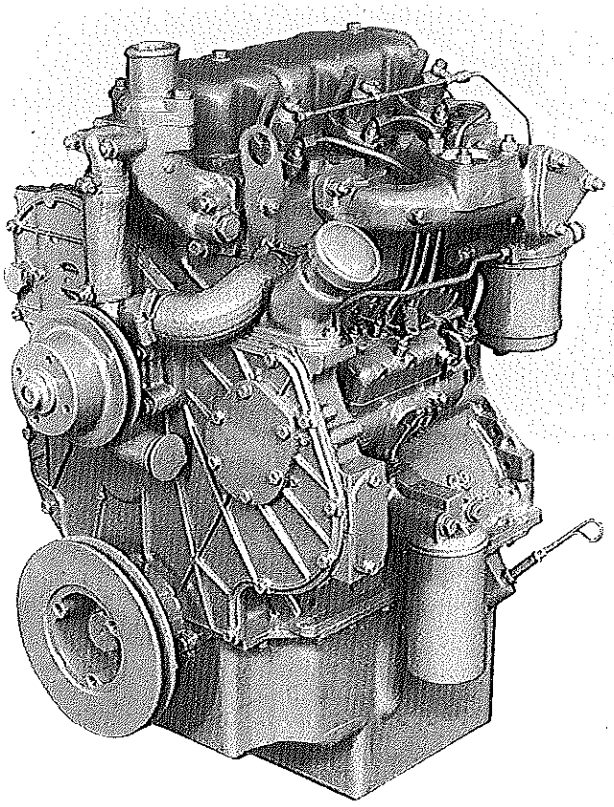


Fig. B5
Front/left side of 3.1522 engine

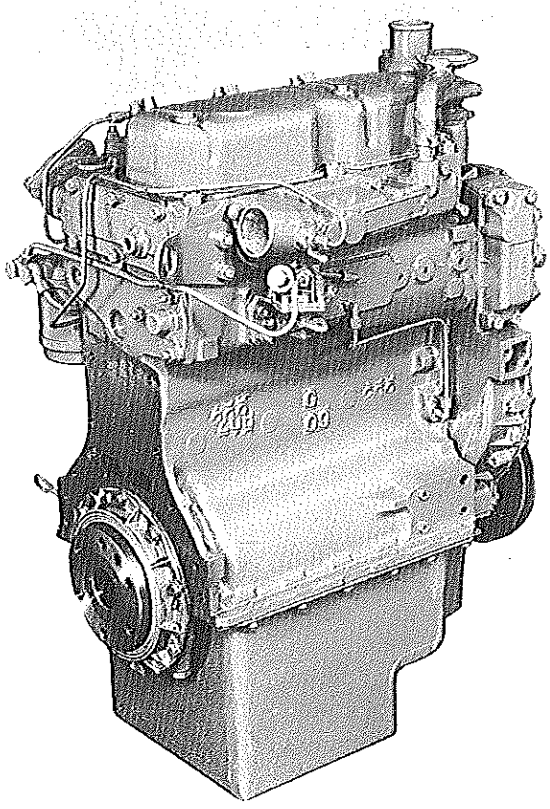


Fig. B6
Rear/right side of 3.1522 engine

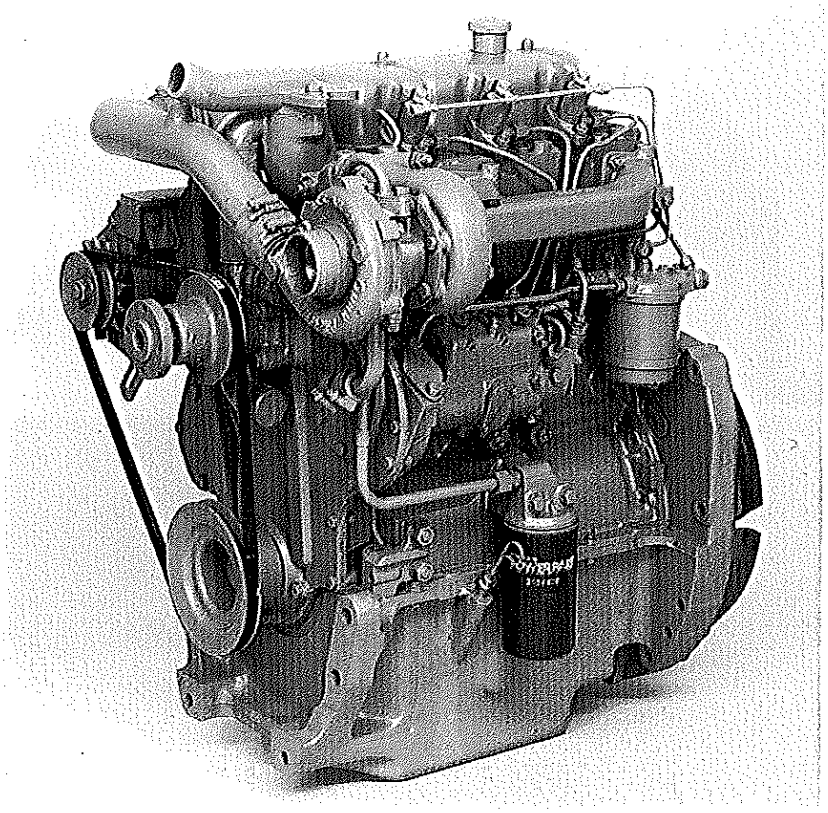


Fig. B7
Front/left side of T3.1524 engine

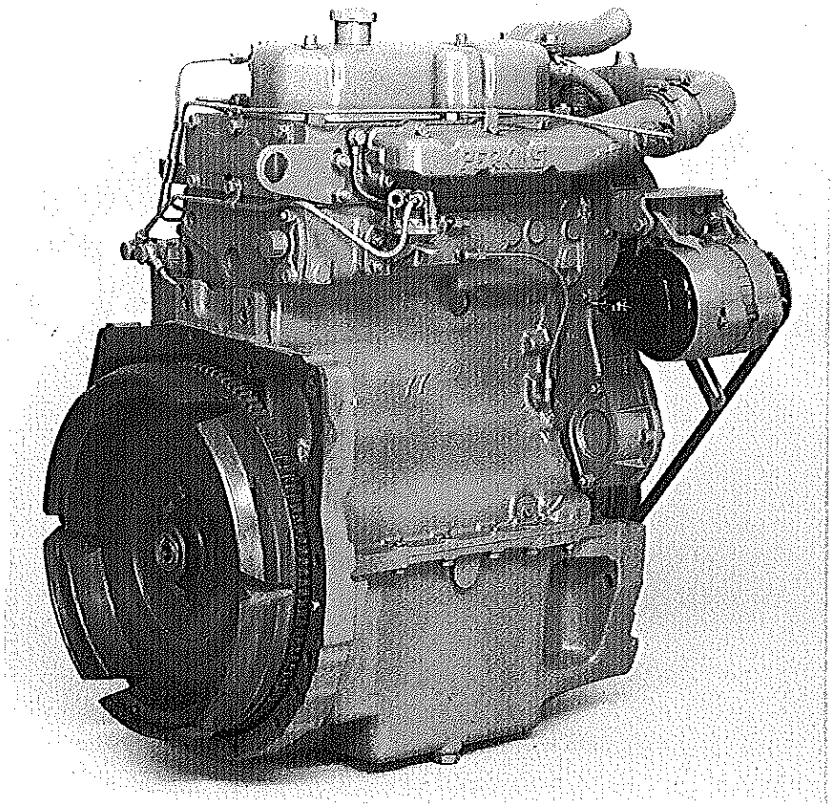


Fig. B8
Rear/right side of T3.1524 engine

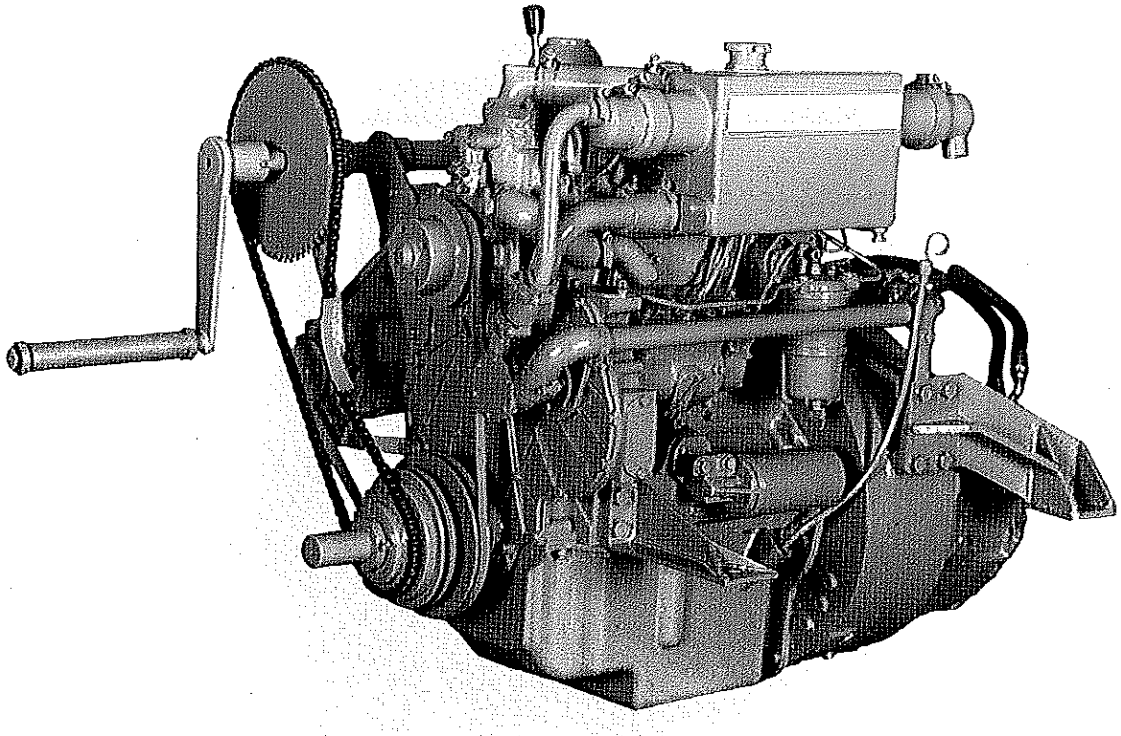


Fig. B9
Front left side of 3HD46 Mk2 engine

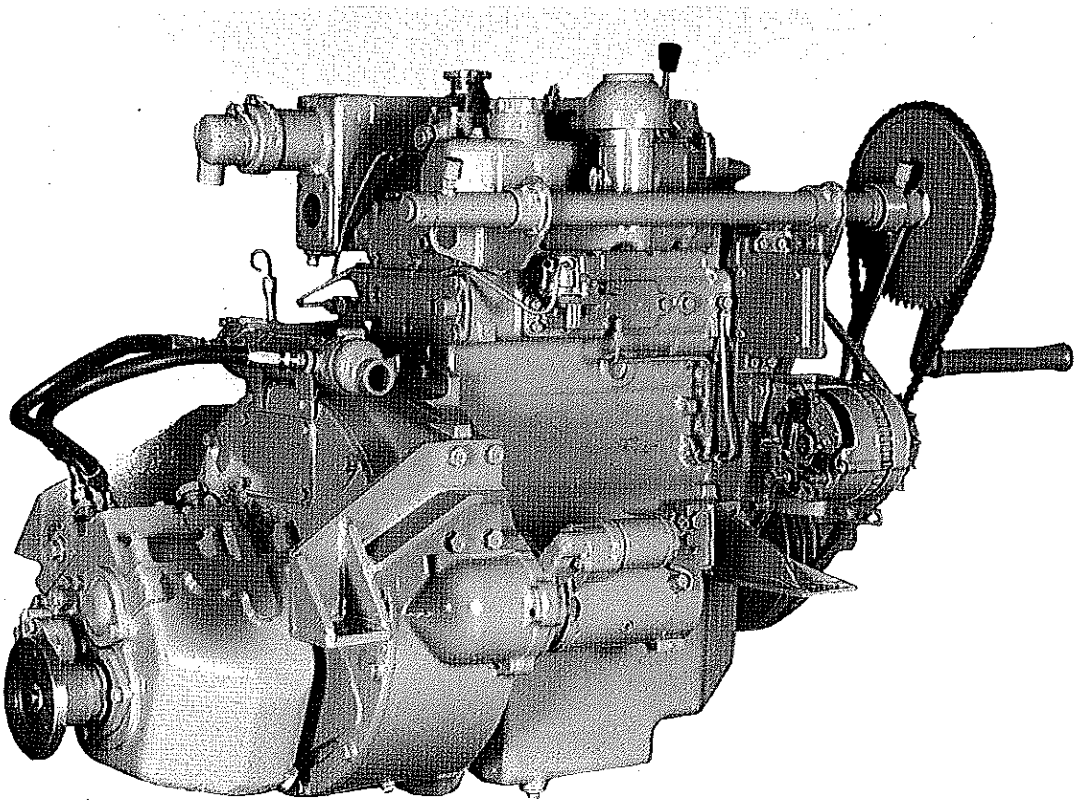


Fig. B10
Rear right side of 3HD46 Mk2 engine

SECTION C
Technical Data

Engine Data

No. of cylinders	3
Cycle	Four stroke
Combustion system 3.152	Indirect injection
Combustion system - All other engines	Direct injection
Nominal bore	91,44 mm (3,6 in)
Stroke	127 mm (5 in)
Compression ratio – 3.152	17.4:1
– D3.152	18.5:1
– Uprated D3.152	16.5:1
– 3.1522	19:1
– 3.1524	16.5:1
– T3.1524	15.5:1
Cubic capacity	2,5 litres (152 in^3)
Firing order	1, 2, 3
Tappet clearance (cold) – 3.152, D3.152	0,30 mm (0.012 in)
Tappet clearance (hot or cold) – 3.1522, 3.1524, – T3.1524	Inlet – 0,20 mm (0.008 in) Exhaust – 0,32 mm (0.0125 in)
Lubricating oil pressure	207 kN/m^2 (30 lbf/in^2) 2,1 kgf/cm^2 minimum at maximum engine speed and normal engine temperature
Direction of rotation	Clockwise from the front
Turbocharger boost pressure* (measured at induction manifold)	41 kN/m^2 (6.0 lbf/in^2) 0,42 kgf/cm^2

*Variable according to application, load and speed.

Approximate dry engine weights (with accessories but no flywheel or backplate)

3.152	202 kg (445 lb)
D3.152	204 kg (450 lb)
3.1522	210 kg (463 lb)
3.1524	210 kg (463 lb)
T3.1524	217 kg (478 lb)

Typical dry installed engine weights

Agricultural	290 kg (640 lb)
Industrial	310 kg (685 lb)

Rating details

3.152

Maximum gross rating	33.5 kW (45 bhp) at 2,500 rev/min
Maximum torque	155 Nm (115 lbf ft) 15,9 kgf m at 1,350 rev/min

D3.152

Maximum gross rating	36 kW (49 bhp) at 2,500 rev/min
Maximum torque	160 Nm (118 lbf ft) 16,3 kgf m at 1,400 rev/min

3.1522

Maximum gross rating	33.2 kW (44.5 bhp) at 2,500 rev/min
Maximum torque	160 Nm (118 lbf ft) 16,3 kgf m at 1,400 rev/min

3.1524

Maximum gross rating	39 kW (52.0 bhp) at 2,500 rev/min
Maximum torque	174 Nm (128 lbf ft) 17,8 kgf m at 1,350 rev/min

T3.1524

Maximum gross rating	45 kW (60.0 bhp) at 2,250 rev/min)
Maximum torque	210 Nm (155 lbf ft) 21,4 kgf m at 1,500 rev/min)

Note: The rating and torque information given above is general for BS. AU 141a:1971 conditions and can change with different applications. For more details, apply to Technical Services Department, Perkins Engines Limited, Peterborough, England or to one of the companies given on page A6.

Recommended torque tensions

The torque tensions given below will apply with the components lightly lubricated with clean engine lubricating oil before assembly.

Cylinder head nuts (cold)	81 Nm (60 lbf ft) 8,3 kgf m
Cylinder head nuts/setscrews (cold)	95 Nm (70 lbf ft) 9,7 kgf m
Connecting rod self locking nuts (not plated)	95 Nm (70 lbf ft) 9,7 kgf m
Connecting rod nuts (cadmium plated)	61 Nm (45 lbf ft) 6,2 kgf m
Connecting rod nuts (phosphated)	81 Nm (60 lbf ft) 8,3 kgf m
Main bearing setscrews	150 Nm (110 lbf ft) 15,0 kgf m
Idler gear hub setscrew	68 Nm (50 lbf ft) 6,9 kgf m
Camshaft gear setscrews	28 Nm (21 lbf ft) 2,9 kgf m
Balance weight setscrews	75 Nm (55 lbf ft) 7,6 kgf m
Flywheel setscrews	106 Nm (78 lbf ft) 10,8 kgf m
Flywheel housing/Adaptor plate setscrews	49 Nm (36.0 lbf ft) 5,0 kgf m
Atomiser flange nuts	16 Nm (12 lbf ft) 1,7 kgf m
Atomiser clamp nuts	12 Nm (9lbf ft) 1,2 kgf m
Crankshaft pulley setscrew with 4,8 mm (3/16 in) thick washer	142 Nm (105 lbf ft) 14,5 kgf m
Crankshaft pulley setscrew with 8,9 mm (0.35 in) thick washer	325 Nm (240 lbf ft) 33,2 kgf m
Dynamo pulley nut (7/16 in)	27 Nm (20 lbf ft) 2,7 kgf m
Dynamo pulley nut (5/8 in)	34 Nm (25 lbf ft) 3,5 kgf m
Alternator pulley nut (7/16 in)	41 Nm (30 lbf ft) 4,1 kgf m
Alternator pulley nut (9/16 in)	41 Nm (30 lbf ft) 4,1 kgf m
Alternator pulley nut (5/8 in)	51 Nm (42 lbf ft) 5,8 kgf m
High pressure fuel pipe nuts	20 Nm (15 lbf ft) 2,1 kgf m
Thermostart	13,6 Nm (10 lbf ft) 1,4 kgf m
Thermostart adaptor (where fitted)	13,6 Nm (10 lbf ft) 1,4 kgf m
Fuel injection pump with tapered shaft nut	81 Nm (60lbf ft) 8,3 kgf m

Shim washers and tab washers fitted under the main bearing setscrews have been discarded and need not be fitted in service.

Where self locking nuts are removed, they must not be used again.

Component Data and Dimensions

This information is given as a guide for personnel engaged on engine overhauls and the dimensions are mainly those used in the factory.

Where the information changes for different engine types, this is indicated in the text.

Cylinder block

Height of cylinder block between top and bottom faces	349,01/349,08 mm (13.7405/13.7435 in)
Parent bore diameter for cylinder liner	93,66/93,69 mm (3.6875/3.6885 in)
Depth of recess for liner flange (cast iron liners)	3,76/3,86 mm (0.148/0.152 in)
Depth of recess for liner flange (chromium faced liners)	1,17/1,24 mm (0.046/0.049 in)
Diameter of recess for liner flange (cast iron liners)	97,03/97,16 mm (3.820/3.825 in)
Diameter of recess for liner flange (chromium faced liners)	97,03/97,16 mm (3.820/3.825 in)
Main bearing parent bore diameter	74,08/74,10 mm (2.9165/2.9175 in)
Parent bore for No. 1 camshaft bearing bush (where fitted)	50,80/50,83 mm (2.000/2.0012 in)
Inside diameter of No. 1 camshaft bearing bush (where fitted)	47,55/47,60 mm (1.872/1.874 in)
Camshaft bore diameter – No. 1	47,60/47,68 mm (1.874/1.877 in)
Camshaft bore diameter – No. 2	47,35/47,42 mm (1.864/1.867 in)
Camshaft bore diameter – No. 3	46,84/46,91 mm (1.844/1.847 in)

Cylinder liners — cast iron, plain

Type	Dry-interference fit
Outside diameter	93,71/93,74 (3.6895/3.6905 in)
Inside diameter (finished size)	91,48/91,50 mm (3.6015/3.6025 in)
Length	215,77/216,03 mm (8.495/8.505 in)
Interference fit in cylinder bore	0,03/0,08 mm (0.001/0.003 in)
Relationship of top of liner to top face of cylinder block	0,05 mm (0.002 in) above to 0,10 mm (0.004 in) below

Cylinder liners — cast iron, flanged

Type – Factory fitted liner	Dry – interference fit
– Service liner	Dry – pre-finished – interference/clearance fit
Outside diameter of factory fitted liner	93,71/93,74 mm (3.6895/3.6905 in)
Outside diameter of service liner	93,66/93,69 mm (3.6875/3.6885 in)
Interference fit of factory fitted liner in cylinder block	0,03/0,08 mm (0.001/0.003 in)
Interference/clearance fit of service liner in cylinder block	0,03/0,03 mm (0.001/0.001 in)
Inside diameter of finished factory fitted liner in cylinder block	91,48/91,50 mm (3.6015/3.6025 in)
Inside diameter of pre-finished service liner in cylinder block	91,50/91,53 mm (3.6025/3.6035 in)
Outside diameter of liner flange	96,60/96,72 mm (3.803/3.808 in)
Flange thickness	3,76/3,81 mm (0.148/0.150 in)
Liner flange relationship to top face of cylinder block	+0,10/– 0,10 mm (+0.004/– 0.004 in)
Maximum bore wear (new liner needed)	0,18 mm (0.007 in)

Cylinder liners – chromium faced

Type	Dry – interference/clearance fit – pre-finished
Outside diameter of liner	93,66/93,69 mm (3.6875/3.6885 in)
Interference/clearance fit of liner in cylinder block	0,03/0,03 mm (0.001/0.001 in)
Inside diameter of liner in cylinder block	91,48/91,50 mm (3.6015/3.6025 in)
Flange thickness	1,07/1,14 mm (0.042/0.045 in)

Flange diameter	96,65/96,77 mm (3.805/3.810 in)
Depth of liner flange below top face of cylinder block	0,03/0,18 mm (0.001/0.007 in)

Pistons – 3.152

Type	Flat topped
Relationship of piston height to top face of cylinder block	0,00/0,13 mm (0.000/0.005 in) **BELOW**
Bore diameter of gudgeon pin	31,753/31,758 mm (1.2501/1.2503 in)
Ring groove width – top and 2nd	2,43/2,46 mm (0.0957/0.0967 in)
– 3rd	3,23/3,25 mm (0.127/0.128 in)
– 4th and 5th	6,40/6,43 mm (0.252/0.253 in)
Maximum top ring clearance (with new ring fitted)	0,18 mm (0.007 in)

Pistons – D3.152

Type	Toroidial cavity in top
Relationship of piston height to top face of cylinder block	0,10 mm (0.004 in) **ABOVE** to 0,03 mm (0.001 in) **BELOW**
Bore diameter for gudgeon pin	31,753/31,758 mm (1.2501/1.2503 in)
Ring groove width – top and 2nd	2,43/2,46 mm (0.0957/0.0967 in)
– 3rd	3,23/3,25 mm (0.127/0.128 in)
– 4th and 5th	6,40/6,43 mm (0.252/0.253 in)
Maximum top ring clearance (with new ring fitted)	0,18 mm (0.007 in)

Pistons – Up-rated AD3.152

Type	Cavity in top
Relationship of piston height to top face of cylinder block	0,03/0,15 mm (0.001/0.006 in) **BELOW**
Bore diameter for gudgeon pin	31,753/31,758 mm (1.2501/1.2503 in)
Ring groove width – top, 2nd and 3rd	2,43/2,46 mm (0.0957/0.0967 in)
– 4th	4,81/4,84 mm (0.1895/0.1905 in)
Maximum top ring clearance (with new ring fitted)	0,18 mm (0.007 in)

Pistons — 3.1522, 3.1524, T3.1524

Type 3.1524	Re-entrant bowl piston. Four ring piston has steel insert in top groove. Three ring piston has top ring groove machined in a hard insert.
Relationship of piston height to top face of cylinder block	0,03 mm (0.0012 in) **ABOVE** to 0,17 mm (0.0065 in) **BELOW**
Type 3.1524, T3.1524	Cavity in crown. Three ring piston
Relationship of piston height to top face of cylinder block	0,02/0,15 mm (0.001/0.006 in) **BELOW**
Centre point of gudgeon pin to top of piston ...	Grade H – 61,80/61,85 mm (2,3429/2,4349 in) Grade L – 61,66/61,69 mm (2.4274/4.4289 in)
Bore diameter for gudgeon pin	31,753/31,758 mm (1.2501/1.2503 in)
Top ring groove width (four ring piston only) ...	2,43/2,48 mm (0.0957/0.0977 in)
All other compression ring groove widths	2,43/2,46 mm (0.0957/0.0967 in)
Oil control ring groove width	4,81/4,84 mm (0.1895/0.1905 in)
Maximum top ring clearance (with new ring fitted)	0,18 mm (0.007 in)

Ring gaps

The ring gaps given are when checked in part of the cylinder bore which is not worn.

Piston rings – 3.152 with cast iron liners and D3.152 rated up to 2,250 rev/min

Type	top	Chromium plated compression
	2nd	Parallel face compression
	3rd	Laminated segment compression
	4th	Spring loaded laminated scraper
	4th – 3.152 rated above 2,250 rev/min	Slotted scraper
	5th	Slotted scraper
Ring width	top and 2nd	2,36/2,38 mm (0.0928/0.0938 in)
	scraper	6,32/6,35 mm (0.249/0.250 in)
Ring clearance in groove		
	top and 2nd	0,05/0,10 mm (0.0019/0.0039 in)
	scraper	0,05/0,10 mm (0.002/0.004 in)
Ring gap	top	0,36/0,76 mm (0.014/0.030 in)
Ring gap	2nd and scraper	0,28/0,69 mm (0.011/0.027 in)

Some D3.152 engines rated up to 2,250 rev/min use the piston rings as given for higher rated D3.152 engines. A fuel injection pump code (see pump data plate) which starts with TW50 or WW47E normally indicates this piston ring arrangement.

Piston rings – 3.152 with chromium faced liners

Type	top	Parallel face compression
	2nd	Tapered face compression
	3rd	Laminated segment
	4th and 5th	Slotted scraper
Ring width	top and 2nd	2,36/2,38 mm (0.0928/0.0938 in)
	4th and 5th	6,32/6,35 mm (0.249/0.250 in)
Ring clearance in groove –		
	top and 2nd	0,05/0,10 mm (0.0019/0.0039 in)
	4th and 5th	0,05/0,10 mm (0.002/0.004 in)
Ring gap	top, 2nd, 4th and 5th	0,28/0,61 mm (0.011/0.024 in)

Piston rings – D3.152 rated above 2,250 rev/min

Type	top	Chromium plated compression
	2nd	Parallel face compression
	3rd	Internally stepped compression
	4th	Chromium faced, coil spring loaded scraper
Ring width	top and 2nd	2,36/2,38 mm (0.0928/0.0938 in)
	3rd	2,35/2,38 mm (0.0927/0.0937 in)
	4th	6,32/6,35 mm (0.249/0.250 in)
Ring clearance in groove –		
	top and 2nd	0,05/0,10 mm (0.0019/0.0039 in)
	3rd	0,05/0,10 mm (0.002/0.004 in)
Ring gap	top	0,36/0,69 mm (0.014/0.027 in)
	2nd and 3rd	0,28/0,61 mm (0.011/0.024 in)
	4th	0,36/0,69 mm (0.014/0.027 in)

Piston rings – up-rated AD3.152

Type	top	Chromium plated compression
	2nd and 3rd	Internally stepped compression
	4th	Chromium faced, coil spring load scraper
Ring width	top	2,36/2,38 mm (0.0928/0.0938 in)
	2nd and 3rd	2,35/2,38 mm (0.0927/0.0937 in)
	4th	4,72/4,76 mm (0.1862/0.1975 in)
Ring clearance in groove –		
	top	0,05/0,10 mm (0.0019/0.0039 in)
	2nd and 3rd	0,05/0,10 mm (0.002/0.004 in)
	4th	0,05/0,11 mm (0.002/0.0045 in)
Ring gap	top	0,36/0,69 mm (0.014/0.027 in)
	2nd and 3rd	0,28/0,61 mm (0.011/0.024 in)
	4th	0,25/0,74 mm (0.010/0.029 in)

Piston rings – 3.1522

Type	top	Chromium insert, copper finished compression
	2nd or 2nd and 3rd	Internally stepped, copper finished compression
	3rd or 4th	Chromium faced, coil spring loaded scraper
Ring width	top	2,36/2,38 mm (0.0928/0.0938 in)
	2nd or 2nd and 3rd	2,35/2,38 mm (0.0927/0.0937 in)
	3rd or 4th	4,72/4,76 mm (0.1860/0.1875 in)
Ring clearance in groove –		
	top (4 ring piston only)	0,05/0,10 mm (0.0019/0.0039 in)
	all other rings	0,05/0,10 mm (0.002/0.004 in)
Ring gap	top	0,30/0,74 mm (0.012/0.029 in)
	2nd or 2nd and 3rd	0,20/0,64 mm (0.008/0.025 in)
	3rd or 4th	0,25/0,76 mm (0.010/0.030 in)

Piston rings – 3.1524, T3.1524

Top compression	Tapered semi inlay, chrome faced compression
Second compression	Tapered face compression
Oil control	Spring loaded, laminated scraper

Piston rings – 3.1522, 3.1524, T3.1524

Top ring width	2,36/2,38 mm (0.0928/0.0938 in)
2nd or 2nd and 3rd ring width	2,35/2,38 mm (0.0927/0.0937 in)
Oil control ring width	4,72/4,73 mm (0.1860/0.1865 in)
Top ring clearance in groove (4 ring piston only)	0,05/0,12 mm (0.0019/0.0049 in)
All other ring clearances in groove	0,05/0,10 mm (0.002/0.004 in)
Ring gap top	0,30/0,74 mm (0.012/0.023 in)
2nd or 2nd and 3rd	0,20/0,64 mm (0.008/0.025 in)
oil control	0,25/0,76 mm (0.010/0.030 in)

Gudgeon pins

Type	Fully floating
Outside diameter	31,744/31,750 mm (1.24975/1.25000 in)
Clearance fit in piston boss	0,003/0,015 mm (0.00012/0.00060 in)
Clearance fit in small end bush	0,01/0,04 mm (0.0005/0.00175 in)

Small end bushes

Type	Steel back, lead bronze face
Outside diameter	35,01/35,05 mm (1.3785/1.3800 in)
Length	26,62/26,87 mm (1.048/1.058 in)
Inside diameter when machined	31,76/31,79 mm (1.2505/1.2515 in)

Connecting rods

Type	H section
Big end parent bore diameter	60,83/60,85 mm (2.3950/2.3955 in)
Small end parent bore diameter	34,92/34,96 mm (1.37475/1.37620 in)
Big end width	39,38/39,43 mm (1.5502/1.5525 in)
Big end side clearance on crankpin	0,24/0,50 mm (0.0095/0.0198 in)
Length between bore centres (D3.152, 3.1522, 3.1524, T3.1524	223,80/223,85 mm (8.811/8.813 in)
Length between bore centres (3.152)	228,57/228,63 mm (8.999/9.001 in)

Connecting rod alignment

Large and small end bores must be square and parallel to each other inside the tolerance of ± 0,25 mm (0.010 in) measured 127 mm (5 in) each side of the axis of the rod on a test mandrel as shown in fig. C1. With the small end bush fitted, the tolerance of ± 0,25 mm (0,010 in) is reduced to ± 0,06 mm (0.0025 in).

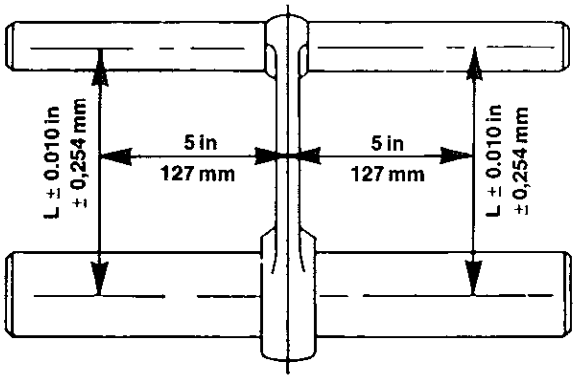


Fig. C1

Connecting rod bearings

Type	Steel back, aluminium tin face
Inside diameter	57,19/57,21 mm (2.2515/2.2525 in)
Clearance on big end	0,06/0,10 mm (0.0023/0.0041 in)
Shell thickness	1,816/1,822 mm (0.07150/0.07175 in)

Crankshaft

Main journal diameter	69,81/69,83 mm (2.7485/2.7493 in)
Main journal length – Nos. 2 and 3	30,85/31,06 mm (1.2147/1.2227 in)
Main journal length – No. 4 (rope seal)	47,60/47,68 mm (1.8742/1.8772 in)
Main journal length – No. 4 (lip seal)	46,80/46,88 mm (1.8427/1.8457 in)
Main journal fillet radii	2,38/2,78 mm (0.0937/0.1094 in)
Crankpin diameter	57,11/57,13 mm (2.2484/2.2492 in)
Crankpin length	39,75 mm (1.562/1.565 in)
Crankpin fillet radii	3,97/4,37 mm (0.1562/1.1719 in)
Finished surface – all main journals and crankpins	0,4 microns (16 micro inches) maximum
Finished surface – Fillet radii	1,3 microns (50 micro inches)
Rope seal helix depth	0,10/0,20 mm (0.004/0.008 in)
Rope seal helix width	1,27/2,03 mm (0.050/0.080 in)
Crankshaft end clearance	0,05/0,38 mm (0.002/0.015 in)
Main journals and crankpin diameters service grind undersizes	– 0,25 mm (0.010 in) – 0,51 mm (0.020 in) – 0,76 mm (0.030 in)
Maximum permissible main journal and crankpin wear	0,038 mm (0.0015 in)

Crankshaft thrust washers

Type	Steel back, aluminium tin face
Position	Each side of rear main bearing
Thickness – standard	3,07/3,12 mm (0.121/0.123 in)
Thickness – oversize	3,26/3,31 mm (0.1285/0.1305 in)

Crankshaft main bearings

Type	Steel back, aluminium tin face
Bearing width – No. 1	32,11/32,36 mm (1.264/1.274 in)
Bearing width – No. 2 and 3	23,55/23,80 mm (0.927/0.937 in)
Bearing width – No. 4	38,91/39,17 mm (1.532/1.542 in)
Bearing thickness	2,096/2,102 mm (0.08250/0.08275 in)
Inside diameter	69,88/69,91 mm (2.7510/2.7525 in)
Bearing clearance	0,04/0,10 mm (0.0017/0.0040 in)

Camshaft

No. 1 journal diameter	47,47/47,50 mm (1.869/1.870 in)
No. 2 journal diameter	47,22/47,24 mm (1.859/1.860 in)
No. 3 journal diameter	46,71/46,74 mm (1.839/1.840 in)
No. 1 journal clearance (with bush)	0,05/0,13 mm (0.002/0.005 in)
No. 1 journal clearance (no bush)	0.10/0.20 mm (0.004/0.008 in)
Nos. 2 and 3 journal clearance	0,10/0,20 mm (0.004/0.008 in)
Cam lift	7,90/7,98 mm (0.311/0.314 in)
Spigot diameter of gear	50,76/50,79 mm (1.9985/1.9995 in)
Maximum permissible camshaft journal wear	0,05 mm (0.002 in)

Cylinder head

Depth	75,82/76,58 mm (2.985/3.015 in)
Maximum permissible distortion	0,076 mm (0.003 in) across head 0,152 mm (0.006 in) along head
Permissible amount to machine off head face – 3.152	Head depth must not be less than 75,69 mm (2.980 in) minimum
Permissible amount to machine off head face – D3.152	0,30 mm (0.012 in) maximum. Nozzle protrusion must not be more than 4,67 mm (0.184 in) when machined
Permissible amount to machine off head face – Up-rated AD3.152	0,30 mm (0.012 in) maximum. Nozzle protrusion must not be more than 4,55 mm (0.179 in) when machined
Permissible amount to machine off head face – 3.1522, 3.1524, T3.1524	0,30 mm (0.012 in) maximum. Nozzle protrusion must not be more than 6,32 mm (0.249 in) when machined

Note: Shim washers or extra atomiser seating washers must not be used to reduce the nozzle protrusion.

Leakage pressure test	207 kN/m² (30 lbf/in²) 2,11 kgf/cm²
Valve seat angle – 3.152	45°
Valve seat angle – D3.152 before engine number CE.....U584638F	45° or 35° (variable with application)
Valve seat angle – D3.152 from engine number CE.....U584638F	35°
Valve seat angle – 3.1522, 3.1524,	35°
Valve seat angle – T3.1524	45° or 35° (variable with application)
Tappet bore in cylinder head	15,86/15,89 mm (0.6245/0.62575 in)
Valve guide bore in cylinder head	12,69/12,71 mm (0.4995/0.5005 in)

Valve guides – 3.152 and D3.152

Inside diameter	7,98/8,01 mm (0.3141/0.3155 in)
Outside diameter	12,73/12,75 mm (0.5013/0.5018 in)
Interference fit of guide in head	0,02/0,06 mm (0.0008/0.0023 in)
Length	61,60/62,36 mm (2.425/2.455 in)
Protrusion above spring seat face	14,73/15,09 mm (0.580/0.594 in)

Valve guides – 3.1522, 3.1524, T3.1524

Inside diameter	7,98/8,01 mm (0.3141/0.3155 in)
Outside diameter	12,73/12,75 mm (0.5013/0.5018 in)
Interference fit of guide in head	0,02/0,06 mm (0.0008/0.0023 in)
Length – inlet	55,98/56,74 mm (2.204/2.235 in)
Length – exhaust	61,54/62,31 mm (2.423/2.453 in)
Protrusion above spring seat face – inlet	9,19/9,55 mm (0.362/0.376 in)
Protrusion above spring seat face –exhaust	14,73/15,09 mm (0.580/0.594 in)

TECHNICAL DATA—C.10

Inlet valves

Valve stem diameter	7,90/7,92 mm (0.311/0.312 in)
Clearance fit of valve in guide	0,05/0,11 mm (0.0021/0.0045 in)
Maximum permissible stem/guide clearance	0,15 mm (0.006 in)
Face angle – 3.152	45°
Face angle – D3.152 before engine number CE.....U584638F	45° or 35° (variable with application)
Face angle – D3.152 from engine number CE.....U584638F	35°
Face angle – 3.1522, 3.1524, T3.1524	35°
Valve head depth below cylinder head face	
– 3.152	1,68/2,03 mm (0.066/0.080 in)
– D3.152 with 45° seats	1,50/1,89 mm (0.059/0.074 in)
– D3.152 with 35° seats	1,32/1,63 mm (0.052/0.064 in)
– 3.1522, 3.1524, T3.1524	1,32/1,63 mm (0.052/0.064 in)
Maximum permissible valve head depth in service	
– 3.152	3,50 mm (0.140 in)
– D3.152 with 45° seats	2,40 mm (0.094 in)
– D3.152 with 35° seats	2,13 mm (0.084 in)
– 3.1522, 3.1524, T3.1524	2,13 mm (0.084 in)

Exhaust valves

Valve stem diameter	7,90/7,92 mm (0.311/0.312 in)
Clearance fit of valve in guide	0,05/0,11 mm (0.0021/0.0045 in)
Maximum permissible stem/guide clearance	0,14 mm (0.0055 in)
Face angle – 3.152	45°
Face angle – D3.152 before engine number CE.....U584638F	45° or 35° (variable with application)
Face angle – D3.152 from engine number CE.....U584638F	35°
Face angle – 3.1522, 3.1524,	35°
Face angle – T3.1524	45° or 35° (variable with application)
Valve head depth below cylinder head face	
– 3.152	1,68/2,03 mm (0.066/0.080 in)
– D3.152 with 45° seats	1,47/1,87 mm (0.058/0.073 in)
– D3.152 with 35° seats	1,60/1,92 mm (0.063/0.0755 in)
– 3.1522, 3.1524, T3.1524	1,60/1,92 mm (0.063/0.0755 in)
Maximum permissible valve head depth in service	
– 3.152	3,50 mm (0.140 in)
– D3.152 with 45° seats	2,40 mm (0.094 in)
– D3.152 with 35° seats	2,40 mm (0.094 in)
– 3.1522, 3.1524, T3.1524	2,40 mm (0.094 in)

Outer valve springs

Free length	45,29/45,80 mm (1.783/1.803 in)
Fitted length	38,10 mm (1.500 in)
Load at fitted length	10,34 kg ± 0,90 kg (22.75 lb ± 2 lb)

Inner valve springs (where fitted)

Free length	34,67/35,69 mm (1.365/1.405 in)
Fitted length	30,16 mm (1.1875 in)
Load at fitted length	3,63 kg ± 0,45 kg (8.0 lb ± 1 lb)

Tappets

Stem diameter	15,80/15,84 (0.6222/0.6237 in)
Clearance in cylinder head bore	0,02/0,09 mm (0.0008/0.0036 in)

Rocker shaft

Outside diameter	15,81/15,84 mm (0.6223/0.6238 in)

Rocker levers

Bore diameter	15,86/15,89 mm (0.62480/0.62610 in)
Clearance fit on rocker shaft	0,03/0,10 mm (0.0010/0.0038 in)
Maximum permissible clearance	0,13 mm (0.005 in)

Camshaft gear

Number of teeth	50
Gear bore diameter	50,79/50,83 mm (1.9995/2.001 in)
Clearance fit of gear on spigot	0,00/0,06 mm (0.0000/0.0025 in)

Idler gear and hub

Number of teeth	90
Gear bore diameter	53,98/54,02 mm (2.1250/2.1266 in)
Hub diameter	53,92/53,94 mm (2.1230/2.1238 in)
Clearance of gear on hub	0,03/0,09 mm (0.0012/0.0036 in)
Gear width	33,47/33,59 mm (1.3175/1.3225 in)
Length of hub	33,72/33,85 mm (1.3275/1.3325 in)
Gear end clearance	0,13/0,38 mm (0.005/0.015 in)
Maximum permissible gear end clearance	0,46 mm (0.018 in)

Crankshaft gear

Number of teeth	25
Bore diameter	38,09/38,13 mm (1.4995/1.5010 in)
Spigot diameter of crankshaft	38,10/38,11 mm (1.5000/1.5005 in)
Clearance/interference fit of gear on crankshaft	0,03/0,03 mm (0.001/0.001 in)

Fuel pump gear

Number of teeth	50
Bore diameter	44,45/44,48 mm (1.750/1.751 in)
Spigot diameter of pump	44,40/44,42 mm (1.7480/1.7488 in)
Clearance fit of gear on spigot	0,03/0,08 mm (0.0012/0.003 in)

Timing gear backlash

All gears	0,08 mm (0.003 in) minimum

Lubricating oil pump idler gear

Number of teeth	21
Bore diameter	19,05/19,08 mm (0.750/0.751 in)
Outside diameter of bush	19,10/19,14 mm (0.7520/0.7535 in)
Interference fit of bush in gear	0,03/0,09 mm (0.0010/0.0035 in)
Inside diameter of bush – fitted	16,67/16,69 mm (0.6562/0.6572 in)
Shaft diameter for gear	16,63/16,64 mm (0.6548/0.6553 in)
Clearance of gear on shaft	0,02/0,06 mm (0.0009/0.0024 in)
Gear end clearance	0,20/0,58 mm (0.008/0.023 in)

Lubricating oil pump drive gear

Number of teeth	19
Bore diameter	12,60/12,63 mm (0.4962/0.4972 in)
Pump drive shaft diameter	12,67/12,69 mm (0.4990/0.4995 in)
Interference fit of gear on shaft	0,05/0,08 mm (0.0018/0.0033 in)

Lubricating oil pump clearances

Pump part numbers 41314121, 41314124

Inner rotor to outer rotor	0,06/0,11 mm (0.0025/0.0045 in)
Inner rotor end clearance	0,04/0,09 mm (0.0015/0.0035 in)
Outer rotor end clearance	0,03/0,08 mm (0.001/0.003 in)
Outer rotor to pump body	0,25/0,30 mm (0.010/0.012 in)

Pump part numbers 41314026, 41314046 and 41314078

Inner rotor to outer rotor	0,01/0,06 mm (0.0005/0.0025 in)
Inner rotor end clearance	0,04/0,08 mm (0.0015/0.0030 in)
Outer rotor end clearance	0,01/0,06 mm (0.0005/0.0025 in)
Outer rotor to pump body	0,28/0,33 mm (0.011/0.013 in)

Pump part numbers 41314043, 41314079 and 41314081

Inner rotor to outer rotor	0,03/0,15 mm (0.001/0.006 in)
Inner and outer rotor end clearance	0,03/0,13 mm (0.001/0.005 in)
Outer rotor to pump body	0,14/0,25 mm (0.0055/0.010 in)

Pump part number 41314178

Inner rotor to outer rotor clearance	0,038/0,127 mm (0.0015/0.0050 in)
Inner rotor end clearance	0,038/0,089 mm (0.0015/0.0035 in)
Outer rotor end clearance	0,013/0,076 mm (0.0005/0.0030 in)
Outer rotor to pump body clearance	0,229/0,330 mm (0.0090/0.0130 in)

Lubricating oil relief valve

Bore diameter in pump body	14,24/14,29 mm (0.5605/0.5625 in)
Outside diameter of plunger	14,19/14,21 mm (0.5585/0.5595 in)
Clearance fit of plunger in bore	0,03/0,10 mm (0.001/0.004 in)
Load at 32,5 mm (1.28 in) spring length	35,59 N ± 1.07 N (8 lbf ± 0.24 lbf) 3,63 kgf ± 0,11 kgf
Setting pressure	345/448 kN/m² (50/65 lbf/in²) 3,52/4,57 kgf/cm²

Lubricating oil filter

Type	Full flow
Element type	Paper or canister
By-pass setting	55/83 kN/m² (8/12 lbf/in²) 0,56/0,84 kgf/cm²

Lubricating oil sump – 3.152 and D3.152

Capacity for agricultural engines to full mark ...	6,1 litres (10.7 imp. pints) 6.4 US quarts
Capacity for industrial engines to full mark	7,4 litres (13 imp. pints) 7.8 US quarts

Lubricating oil sumps – 3.1522, 3.1524 and T3.1524

Capacity for industrial engines to full mark	6,8 litres (12 imp. pints) 7.2 US quarts

Note: The above capacities are variable with application. Fill to "FULL" mark on dipstick.

Cooling system

Type	Thermosyphon – pump assistance
Coolant capacity – engine only	4,8 litres (8.5 imp. pints) 5.1 US quarts

Thermostat

Type		Bellows or wax
Starts to open	– bellows type	77/82°C (170/179°F)
	– wax type	81/84°C (177/183°F)
Full open	– bellows type	93°C (199°F)
	– wax type	98°C (208°F)

Water pump

Type	Centrifugal
Bore diameter in pulley	15,85/15,87 mm (0.6239/0.6247 in)
Shaft diameter	15,91/15,92 mm (0.6262/0.6267 in)
Interference fit of pulley on shaft	0,04/0,07 mm (0.0015/0.0028 in)
Bore diameter in impeller	15,88/15,89 mm (0.6250/0.6257 in)
Shaft diameter	15,91/15,92 mm (0.6262/0.6267 in)
Interference fit of impeller on shaft	0,01/0,04 mm (0.005/0.0017 in)
Clearance between impeller blades and pump body	0,25/0,51 mm (0.010/0.020 in)

Fuel lift pump

Type	AC Delco
Method of drive	Eccentric on camshaft
Static pressure – no delivery	41/69 kN/m² (6/10 lbf/in²) 0,4/0,7 kgf/cm²

Fuel injection pump

Make	CAV – DPA (distributor type)
Direction of rotation	Clockwise from drive end
Timing letter	E (earlier pumps only)
No. 1 outlet	W or Z

Make	Stanadyne (distributor type)
Direction of rotation	Clockwise from drive end
No. 1 outlet	at 11 o'clock position from rear

Engine check and fuel pump mark angles – static timing

The correct angles and static timing can be decided from the first letters and figures of the setting code next to the word "Set" on the fuel injection pump data plate. Angles are for use with timing tool MS67B and adaptors (PD.67B-6). For Stanadyne pumps the tool will have to be fitted to the pump in the reverse position to normal, the fuel pump mark angle has been adjusted to allow for this.

Note: The setting code of current pumps start with the pump part number, followed by two code letters, the governor spring number and the flight speed. For identification purposes, only the two code letters are used here for the new pumps.

Fuel pump setting code	Engine check angle (degrees) (with engine at TDC compression)	Fuel pump mark angle (degrees)	Static timing (BTDC-degrees)	Piston displacement	
				mm	in
3.152					
LW45, LW49	32	40	16	3,15	0.124
LW51, LW52	29	38	18	3,94	0.155
LW58, LW59	29	40	22	5,84	0.230
PW43, PW44	30	38	16	3,15	0.124
PW50	29	38	18	3,94	0.155
D3.152					
AW	27	41	28	9,42	0.371
CW	27	35	16	3,15	0.124
MW47E, MW49, MW53E, MW57	25	37	24	6,93	0.273
RW50, RW52, RW54	25	37	24	6,93	0.273
SW (except below)	25	37	24	6,93	0.273
SW46	25	37	24	6,93	0.273
SW/8/1800*	22¼	37	29½	10,43	0.411
SW/8/1890*	22¼	37	29½	10,43	0.411
SW48	24	37	26	8,00	0.315
SW52, SW57, SW58	25	37	24	6,93	0.273
TW48E	27	37	20	4,88	0.192
TW50	26	37	22	5,84	0.230
WW (except below)	25	35	20	4,87	0.192
WW/3/2470	27	35	16	3,15	0.124
WW/6/2470	27	35	16	3,15	0.124
WW47E, WW48	27	35	16	3,15	0.124
*Lincoln Electric U.S.A.					
3.1522					
XW50E	29	36	14	2,37	0.092
3.1524					
EW (Stanadyne pumps)	26	322	24	6,98	0.275
WW47E	25	35	20	4,87	0.192
WW (except below)	25	35	20	4,87	0.192
WW/3/2470	27	35	16	3,15	0.124
WW/6/2200	27	35	16	3,15	0.124
WW/6/2470	27	35	16	3,15	0.124
ZW	25	37	24	6,98	0.275
T3.1524					
BW, YW	27	35	16	3,15	0.124
DW	26½	35	17	3,55	0.140

Atomisers

Code	Holder	Nozzle	Setting Pressure kgf/cm²	atm	lbf/in²	Check and Reset Pressure kgf/cm²	atm	lbf/in²
3.152								
DD	BKB35S5258	BDL110S6133	129	125	1840	124	120	1760
DE	BKB35S5258	BDL110S6267	129	125	1840	124	120	1760
GC	BKB35SD5259	BDL110S6709	191	185	2720	176	170	2500
GW	BKB35SD5258	BDL110S6709	191	185	2720	176	170	2500
D3.152								
BV	BKBL67SD5151	BDLL150S6513	191	185	2720	176	170	2500
CR	BKBL67S5151	BDLL150S6513	191	185	2720	176	170	2500
CS	BKBL67SD5151	BDLL150S6554	191	185	2720	176	170	2500
DF	BKBL67S5151	BDLL150S6558	181	175	2570	176	170	2500
DN	BKBL67S5299	BDLL150S6554	191	185	2720	176	170	2500
EE	BKBL67S5299	BDLL150S6602	196	190	2790	181	175	2570
FS*	BKBL67S5299	BDLL150S6674	191	185	2720	176	170	2500
GM	BKBL67S5299	BDLL150S6743	191	185	2720	181	175	2570
ND	2645L301	2645L604	196	190	2790	181	175	2570
UB	BKBL67S5151	BDLL150S6372	191	185	2720	176	170	2500
XC	OKLL67S2931	OLL150S6743	191	185	2720	181	175	2570
XG	2645C305	2645C620	196	190	2790	181	175	2570
*	When FS atomisers need service, they must be changed to DN type by the use of the correct nozzle.							
3.1522								
GS	BKBL67S5446	BDLL150S6771	258	250	3670	243	235	3450
3.1524								
EE	BKBL67S5299	BDLL150S6602	196	190	2792	181	175	2570
HN	BKBL67S5366	BDLL150S6771	263	255	3747	248	240	3530
ND	2645L301	2645L604	196	190	2790	181	175	2570
XG	2645C305	2645C620	196	190	2790	181	175	2570
T3.1524								
HM	LRB67015	JB6801029	258	250	3670	258	250	3670
HN	BKBL67S5366	BDLL150S6771	263	255	3747	248	240	3530
HX	LRB67015	JB6801029	217	210	3090	217	210	3090

Dynamo

Make	Lucas
Type	C40A
Maximum output	11A

Alternator

Make	Lucas, CAV, Motorola or Perkins
Type	15, 16, 17, 18, 23 ACR, A115/36, A115/45, A127, CA45, 9AR, LR135 or LR150
Maximum output (hot)	
15ACR	28A
16ACR	34A
17ACR	36A
17ACR (de-rated)	25A
18ACR	45A
23ACR	55A
A115/36	36A
A115/45	45A
A127	55/65A
9AR Series	70A
LR135 Series	35A
LR150 Series	50A

Starter motor

Make	Lucas, CAV or Perkins
Type	2M113, M45G, M50, M127, CA45, S12-84 or S12-85
Number of teeth on pinion	10
Starter cable resistance	0.0017 ohms maximum

SECTION E
Fault Diagnosis

FAULT DIAGNOSIS—E.2

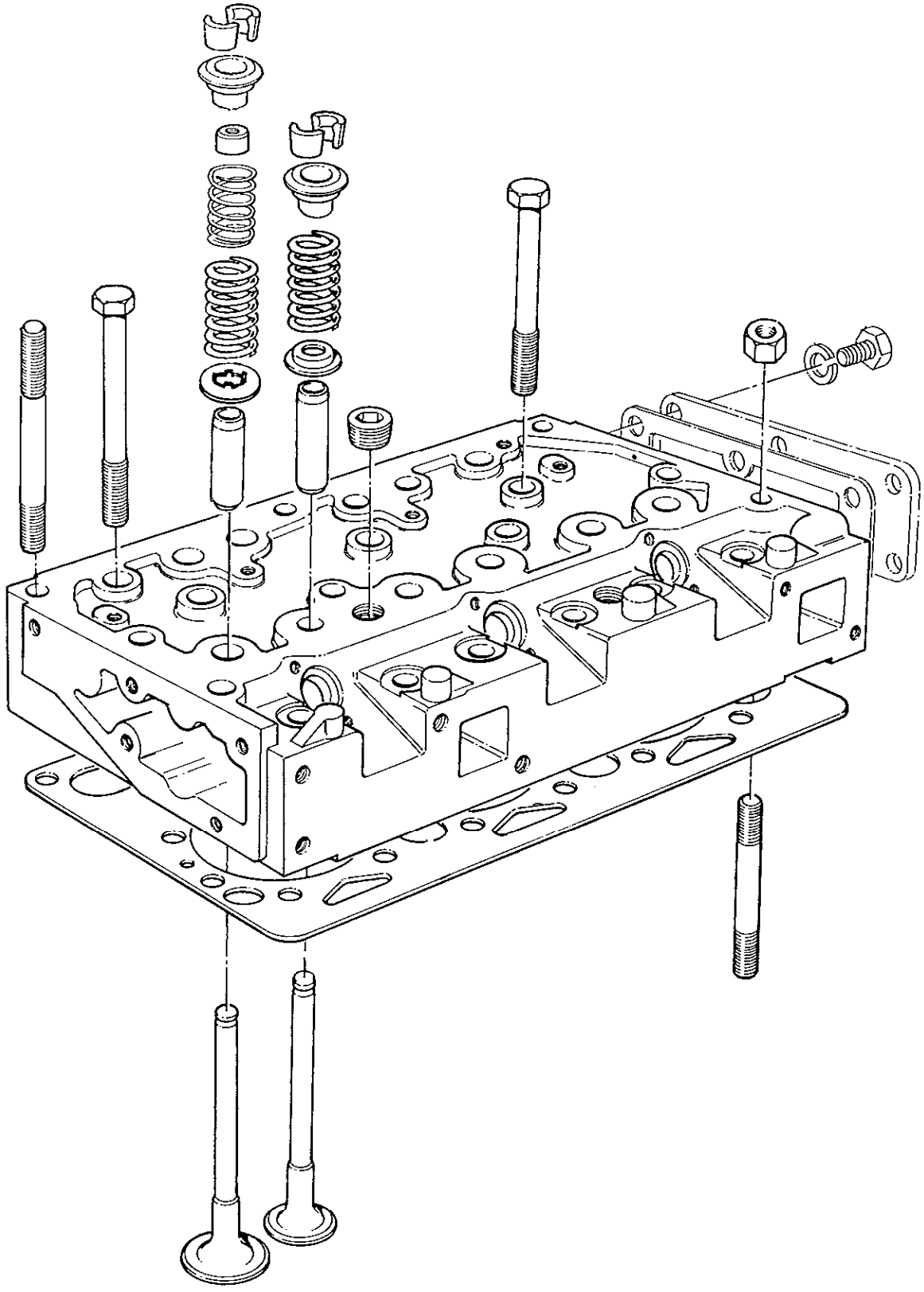
Fault diagnosis chart

Problem	Possible causes
Starter motor turns engine too slowly.	1, 2, 3, 4
Will not start	5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 31, 32, 33, 63
Difficult to start	5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24, 29, 31, 32, 33, 63
Not enough power	8, 9, 10, 11, 12, 13, 14, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 31, 32, 33, 60, 62
Misfire	8, 9, 10, 12, 13, 14, 16, 18, 19, 20, 25, 26, 28, 29, 30, 32
High fuel consumption	11, 13, 14, 16, 18, 19, 20, 22, 23, 24, 25, 27, 28, 29, 31, 32, 33
Black exhaust	11, 13, 14, 16, 18, 19, 20, 22, 24, 25, 27, 28, 29, 31, 32, 33, 60, 62
Blue/white exhaust	4, 16, 18, 19, 20, 25, 27, 31, 33, 34, 35, 45, 56, 61
Low lubricating oil pressure	4, 36, 37, 38, 39, 40, 42, 43, 44, 58
Engine knocks	9, 14 16, 18, 19, 22, 26, 28, 29, 31, 33, 35, 36, 45, 46, 59
Runs erratically	7, 8, 9, 10, 11, 12, 13, 14, 16, 20, 21, 23, 26, 28, 29, 30, 33, 35, 45, 59
Vibration	13, 14, 20, 23, 25, 26, 29, 30, 33, 45, 47, 48, 49
High lubrication oil pressure	4, 38, 41
Engine temperature too high	11, 13, 14, 16, 18, 19, 24, 25, 45, 47, 50, 51, 52, 53, 54, 57
Crankcase pressure	25, 31, 33, 34, 45, 55
Bad compression	11, 19, 25, 28, 29, 31, 32, 33, 34, 46, 59
Starts and stops	10, 11, 12

Code list of possible causes

1 Battery capacity low.
2. Bad electrical connections.
3. Fault in starter motor.
4. Wrong grade of lubricating oil.
5. Low engine speed from starter motor.
6. Fuel tank empty.
7. Stop control fault.
8. Restriction in fuel pipe.
9. Fault in fuel lift pump.
10. Dirty fuel filter element.
11. Restriction in air filter or induction system.
12. Air in fuel system.
13. Fault in fuel injection pump.
14. Fault in atomisers or not correct type.
15. Cold start equipment not used correctly.
16. Fault in cold start equipment.
17. Broken fuel injection pump drive.
18. Fuel injection pump timing not correct.
19. Valve timing not correct.
20. Bad compression.
21. Restriction in fuel tank vent.
22. Type or grade of fuel not correct.
23. Restriction of engine speed control movement.
24. Restriction in exhaust pipe.
25. Cylinder head gasket leaks.
26. Engine temperature too high.
27. Engine temperature too low.
28. Valve tip clearances not correct.
29. Valves not free.
30. Wrong high pressure pipes.
31. Worn cylinder bores.
32. Valves and seats do not seal correctly.
33. Piston rings not free or are worn or broken.
34. Valve stems and/or guides worn.
35. Wet type air cleaner too full or wrong type of oil used.
36. Crankshaft bearings wear or damage.
37. Not enough lubricating oil in the sump.
38. Gauge not correct.
39. Lubricating oil pump worn.
40. Relief valve not free to close.
41. Relief valve not free to open.
42. Relief valve spring broken.
43. Fault in suction pipe of lubricating oil pump.
44. Dirty lubricating oil filter element.
45. Piston damage.
46. Piston height not correct.
47. Fan damage.
48. Fault in engine mounting (housing).
49. Flywheel housing or flywheel not aligned correctly.
50. Fault in thermostat or wrong type.
51. Restriction in coolant passages.
52. Water pump drive belt loose.
53. Restriction in radiator.
54. Fault in water pump.
55. Restriction in breather pipe.
56. Damage to valve stem oil seals (where used).
57. Not enough coolant in system.
58. Restriction in sump strainer.
59. Valve spring broken.
60. Turbocharger impellor damage, or dirty impellor.
61. Turbocharger lubricating oil leaks.
62. Leakage in induction system (turbocharged engines).
63. Fault in lubricating oil pressure switch or low lubricating oil pressure.

SECTION F
Cylinder Head



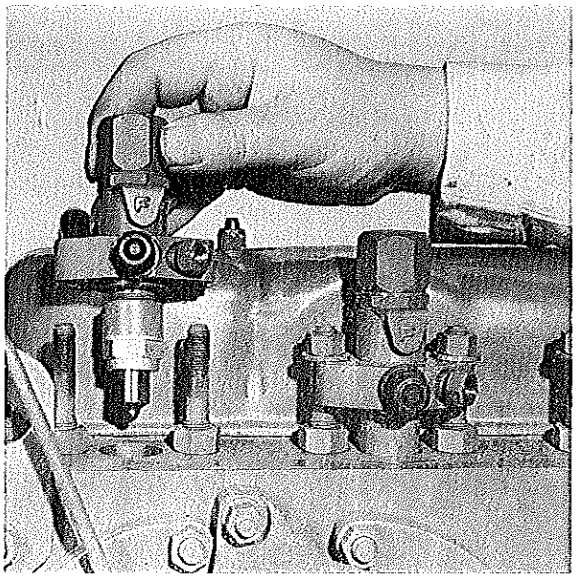


Fig. F1

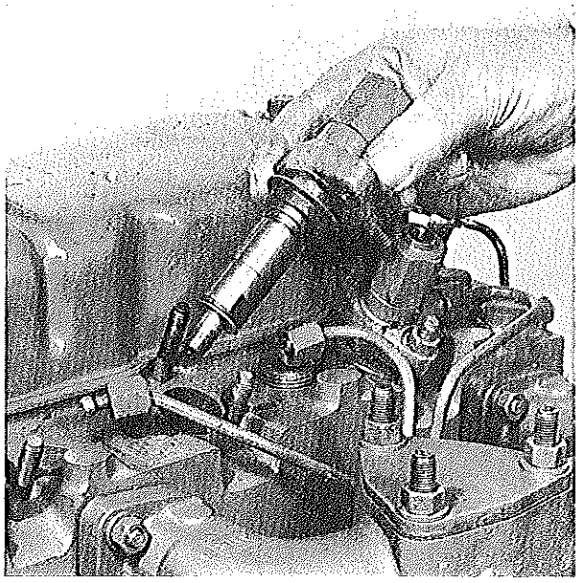


Fig. F2

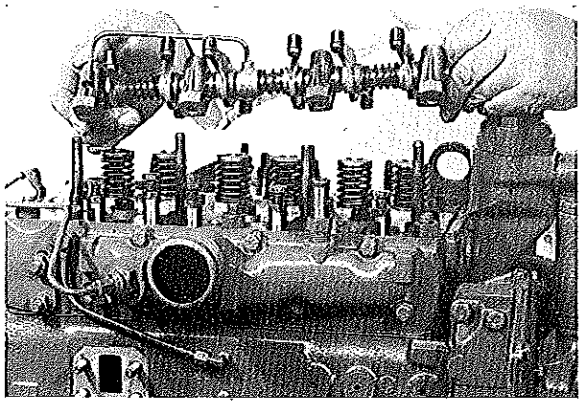


Fig. F3

To remove cylinder head

1. Drain the coolant from the radiator and cylinder block.
2. Disconnect the hose connection from the thermostat housing at the front of the cylinder head.
3. Remove crankcase vent valve and hose from cylinder head cover and induction manifold – 3.1522 engines only.
4. Remove coolant connections to and from exhaust manifold (flame-proof engines only).
5. Remove the air cleaner or filter, or disconnect the air inlet hose from the induction manifold.
6. Disconnect cold start equipment connections.
7. Remove the lubricating oil pipe from the camshaft housing to the cylinder head.
8. Disconnect the exhaust pipe from the exhaust manifold. Remove turbocharger (T3.1524 engines).
9. Disconnect and remove the high pressure fuel pipes from the fuel injection pump and atomisers. Fit suitable caps to the pump and atomiser connections.
10. Remove atomiser leak off pipes.
11. Remove atomisers (see figs. F1 or F2).
12. Where necessary, remove fuel filter and fuel pipe from filter to cold start aid. Remove clip which secures fuel pipe to rear of cylinder head.
13. Remove the cylinder head cover.
14. Disconnect lubricating oil pipe to rocker shaft and remove rocker shaft assembly with pipe (see fig. F3).
15. Remove the cylinder head nuts/setscrews in the reverse sequence to that given in figs. F15 or F16.
16. Remove the cylinder head (see fig. F4) and put it on a flat wood surface to prevent damage. Do not use a sharp tool between the cylinder head and the cylinder block.

To remove valves

Put a suitable mark on the face of each valve so that they can be fitted in their original positions if they are used again.

Compress the valve springs with a suitable valve spring compressor (see fig. F5) and remove the split collets. Tool 6118B with adaptor PD6118-3 can be used to compress the valve springs with the head on a flat surface.

Remove the spring caps, springs, seals and spring seats and the valves can be removed.

Valve and valve seat overhaul

Valve face and seat angles are as follows:-

Angle	Engine type
45°	All 3.152 engines. All D3.152 engines before engine number CU.....U584638F except for those shown below. All T3.1524 engines to lists CN31185, CN31195, CN31196, CN31198, CN31225, CN80444 use 45° exhaust valves.
35°	D3.152 engines rated above 2,250 rev/min. Some D3.152 engines rated below 2,250 rev/min. (A fuel injection pump setting code which starts with TW50 or WW47E usually indicates these engines. Up-rated AD3.152 engines. All D3.152 engines from engine number CE.....U584638F and all 3.1522, 3.1524 and T3.1524 engines except lists CN31185, CN31195, CN31196, CN31198, CN31225, CN80444 which use 45° exhaust valves.

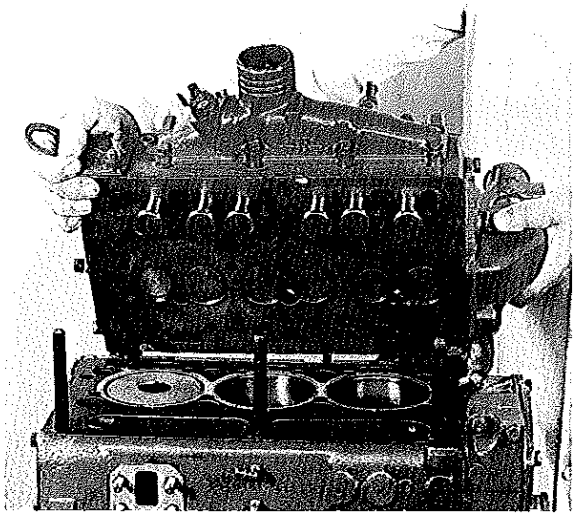


Fig. F4

Before any work is done on valves or seats, check the depth of the valves below the face of the cylinder head (see fig. F6).

Maximum permissible service valve head depths below the cylinder head face are as follows:-

Engine type	Valve and seat angle	Valve depth Inlet	Valve depth Exhaust
3.152	45°	3,50 mm (0.140 in)	3,50 mm (0.140 in)
D3.152	45°	2,40 mm (0.094 in)	2,40 mm (0.094 in)
D3.152	35°	2,13 mm (0.084 in)	2,40 mm (0.094 in)
3.1522, 3.1524	35°		
T3.1524	35°/45°	2,13 mm (0.084 in)	2,40 mm (0.094 in)

Where engines have to be to the smoke regulation BS. AU 141a:1971, then the maximum permissible service valve head depth for 3.152 engines must not be more than 2,15 mm (0.085 in). For D3.152 engines, the factory limits must not be extended (see page C10).

If the cylinder head face needs to be machined or the valve guides renewed, this must be done before the valve seats are corrected.

45° valve seats on 3.152 engines are lower than the cylinder head face and a groove is machined where the real valve seat ends in the recess in the cylinder head. When valves or seats have been corrected several times, this groove can be cut as given later.

Valve seats can be corrected by the use of the cutters which follow:-

Valve seat angle	Valve seat cutter Inlet	Valve seat cutter Exhaust
45° (3.152)	MS275*	MS285*
45° (D3.152)	MS281*	MS275*
35°	MS695	MS690

* These cutters are in the valve seat cutter kit MS73.

The pilot and handle used with 35° and 45° seat cutters are in the cutter kit MS73, but if this cutter kit is not available, then pilot MS150-8 and handle MS76 must be used.

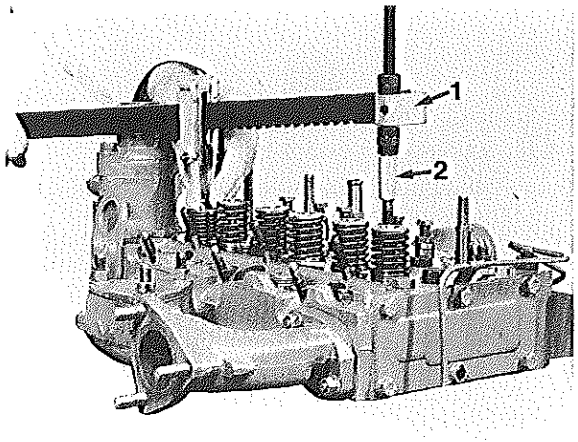


Fig. F5
1. Tool 21825020 2. Adaptor 21825022

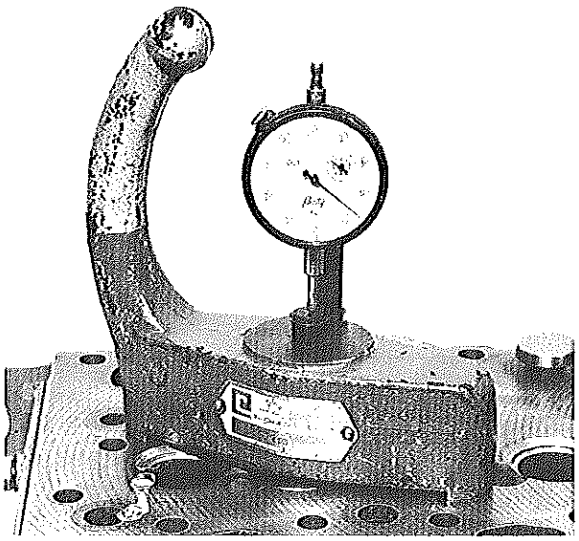


Fig. F6

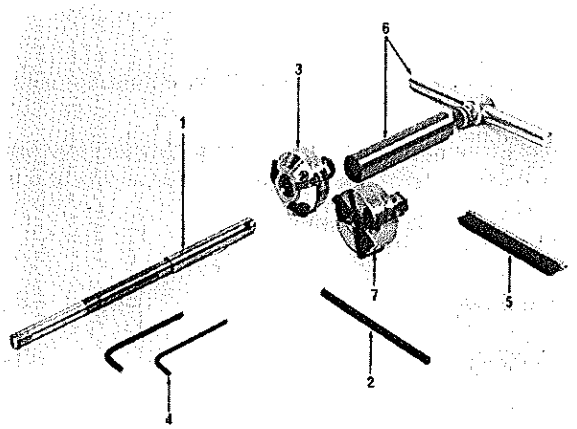


Fig. F7

1. Pilot
2. Puller Pin
3. Seat Cutter
4. Keys
5. Cleaning Brush
6. Cutter Handle
7. Valve Seat Width Reducer

Put the pilot (see fig. F7) in the valve guide with the expansion section inside the guide and the shoulder of the pilot approximately 3mm (⅛ in) above the guide. Tighten the pilot in the guide by use of the nut and a pin in the pilot hole. Adjust the blades of the cutter to approximately the same location in their slots with the square ends outside and tighten the blade screws, finger tight only. Make sure that the blades are clean before use.

Lower the cutter into position on the pilot with the blades towards the seat – do not drop the cutter on to the seat as damage can easily occur to the blades. Fit the handle to the cutter and cut the seat. Turn the cutter clockwise with the use of very light pressure and ensure that the pressure is applied directly above the pilot. Not many turns are necessary to get a good seat.

With 45° seats on 3.152 engines, the seat width can be reduced when the groove is corrected by the use of the suitable flat cutter from the cutter kit MS73.

Earlier D3.152 engines with 45° seats had a 30° flare between the seat and the cylinder head face.

After the seats have been cut, clean the cylinder head and check the contact between the valve and seat, which can be lapped if necessary. Check the valve head depth below the cylinder head face as given on page F3.

Rocker shaft assembly

Clean the rocker shaft assembly.

Check the bushes in the rocker levers for wear. The rocker levers must be an easy fit on the shaft without too much side movement.

If the rocker lever bushes are worn, it will be necessary to renew the complete rocker lever. The rocker levers are a complete assembly and new bushes cannot be fitted.

When the rocker shaft assembly is dismantled, make a note of the assembly of parts, so that when the assembly is put together, the left and right rocker levers are in their correct positions to locate with their respective tappets and valves. If there is a slot in the end of the rocker shaft, ensure that the slot is towards the front of the engine (see fig. F8). For correct location, later rocker shaft assemblies have a tapered pin that is fitted into a 4 mm diameter hole in the rocker shaft. Ensure that this pin fits into the slot in the second rocker lever bracket. (See 1. fig. F8A). Note: Later cylinder heads use shorter length tapped holes for the rocker shaft studs. Ensure that only the correct studs supplied with the cylinder head are used.

Valve guides

Check the valve guides for wear. If necessary, renew the guides.

Clean the new guides and check for damage.

With 3.152 and D3.152 engines, inlet and exhaust valve guides are the same length and the valve guide height above the spring seat face of the cylinder head must be 14,73/15,09 mm (0.580/0.594 in) when fitted.

With 3.1522, 3.1524 and T3.1524 engines the inlet valve guides are 5,5 mm (7/32 in) shorter than the exhaust valve guides. Ensure that the correct guide is fitted. When fitted, the valve guide height above the spring seat face of the cylinder head must be 9,19/9,55 mm (0.362/0.376 in) for inlet guides and 14,73/15,09 mm (0.580/0.594 in) for exhaust guides.

The inside of all guides have a counterbore at one end and this counterbore must be fitted towards the valve seat.

Fig. F9 shows a new valve guide being fitted.

Valve seat inserts

It is permissible to fit valve seat inserts to both inlet and exhaust valve seats of 3.152 engines and the 45° exhaust valve seat only of D3.152 and some T3.1524 engines where the original seat can not be corrected because of damage or the permissible service valve depth below the cylinder head is more than that already given. The valve seat insert recess dimensions are important and correct Perkins parts must be used.

The recess for an insert must not be cut with a worn valve guide fitted.

The recess must be cut from the bore of a new valve guide.

To fit valve seat inserts:-

1. Remove the old valve guide and clean the parent bore.
2. Fit a new valve guide to enable the bore to be used as a pilot to cut the recess.
3. By the use of a suitable tool, cut the old seats to the dimensions given in fig. F10.
4. Using a tool made to the dimensions given in fig. F11 and again by the use of the valve guide bore as a pilot, press in the insert. A hammer or lubrication must not be used.
5. Check to ensure that the insert is square and installed to the bottom of the recess, see fig. F12.
6. For D3.152 exhaust valve inserts, use the valve guide bore as a pilot to cut the flare to the dimensions given in fig. F13.
7. Cut the valve seats so that the valve head depths below the cylinder head face are to the dimensions given on page F3.

Note: Some T3.1524 engines have 45° exhaust valve inserts fitted in production. (See fig. F13A). Where necessary they can be renewed if the recess diameter is within the production limits of 37,224/37,249 mm (1.4655/1.4665 in).

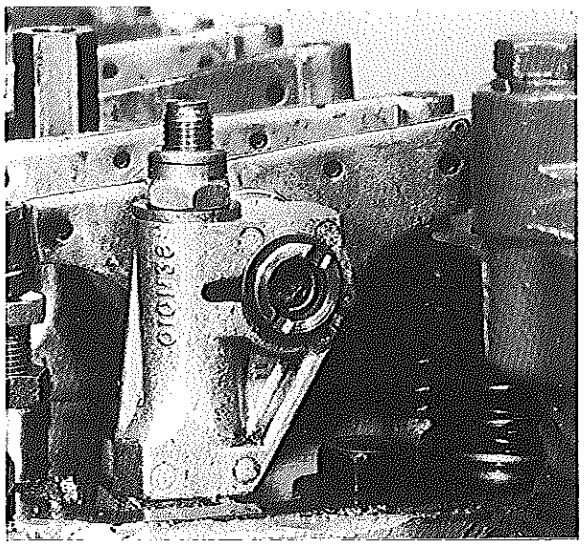


Fig. F8

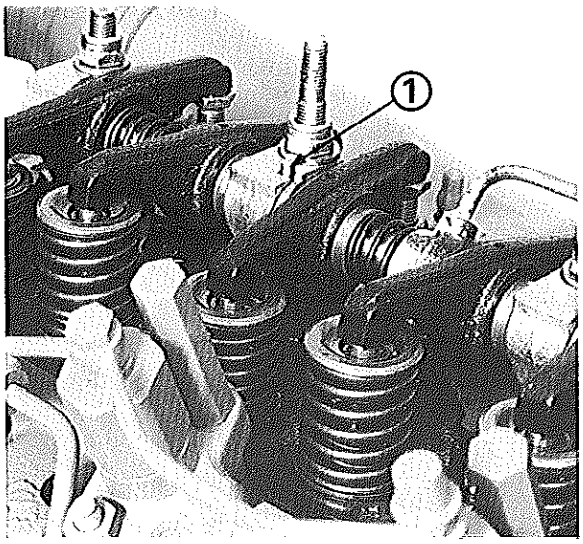


Fig. F8A

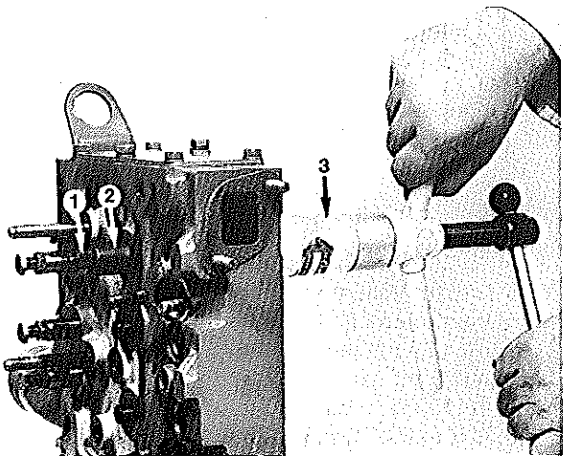


Fig. F9

1. Puller Bar PD1D-A
2. Inlet Guide Stop PD1D-9
   Exhaust Guide Stop PD1C-4
3. Main Tool PD1D

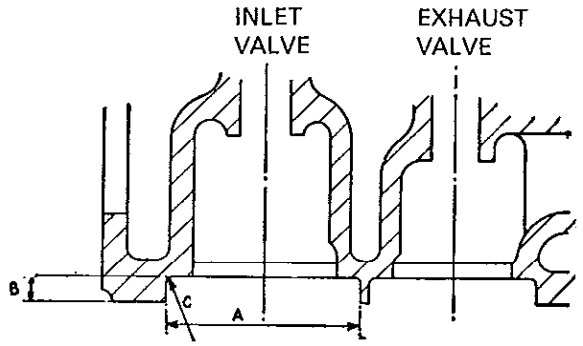


Fig. F10
Valve Seat Cutting Dimensions

Inlet (3.152)
A.—1.874 to 1.875 in (47,60 to 47,62 mm).
B.—0.248 to 0.250 in (6,30 to 6,35 mm).
C.—0.040 to 0.050 in (1,02 to 1,30 mm) Radius.

Exhaust (3.152)
A.—1.624 to 1.625 in (41,25 to 41,28 mm).
B.—0.248 to 0.250 in (6,30 to 6,35 mm).
C.—0.040 to 0.050 in (1,02 to 1,30 mm) Radius.

Exhaust (D3.152)
A.—1.678 to 1.679 in (42,62 to 42,64 mm).
B.—0.310 to 0.312 in (7,87 to 7,92 mm).
C.—0.015 in (0,38 mm) Maximum Radius.

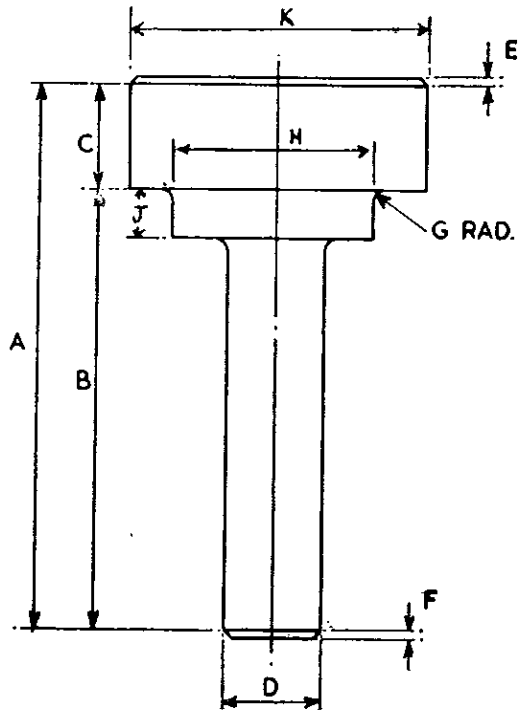


Fig. F11
Press Tool for Valve Seat Inserts

Inlet Dimensions (3.152)
A.—2¾ in (69,85 mm).
B.—2 in (50,80 mm).
C.—¾ in (19,05 mm).
D.—0.309 to 0.310 in (7,85 to 7,87 mm).
E.—1/16 in (0,06 mm) at 45°.
F.—1/16 in (0,06 mm) at 45°.
G.—1/32 in (0,03 mm) Radius.
H.—1.401 to 1.402 in (35,58 to 35,61 mm).
J.—0.212 to 0.215 in (5,38 to 5,46 mm).
K.—1.855 to 1.865 in (47,12 to 47,37 mm).

Exhaust Dimensions (3.152)
A.—2¾ in (69,85 mm).
B.—2 in (50,80 mm).
C.—¾ in (19,05 mm).
D.—0.309 to 0.310 in (7,85 to 7,87 mm).
E.—1/16 in (0,06 mm) at 45°.
F.—1/16 in (0,06 mm) at 45°.
G.—1/32 in (0,03 mm) Radius.
H.—1.182 to 1.183 in (30,02 to 30,05 mm).
J.—0.212 to 0.215 in (5,38 to 5,46 mm).
K.—1.605 to 1.615 in (40,77 to 41,02 mm).

Exhaust Dimensions (D3.152/T3.1524)
A.—3½ in (88,90 mm).
B.—2¾ in (69,85 mm).
C.—¾ in (19,05 mm).
D.—0.309 to 0.310 in (7,85 to 7,87 mm).
E.—1/16 in (0,06 mm) at 45°.
F.—1/16 in (0,06 mm) at 45°.
G.—1/32 in (0,03 mm) Radius.
H.—1.200 to 1.201 in (30,48 to 30,50mm).
J.—¼ in (6,35 mm).
K.—1.667 to 1.677 in (42,34 to 42,59 mm).
Material EN32A Case Hardened and Ground.
K.—1.4605 to 1.4615 (T3.1524 with 45° exhaust valves).

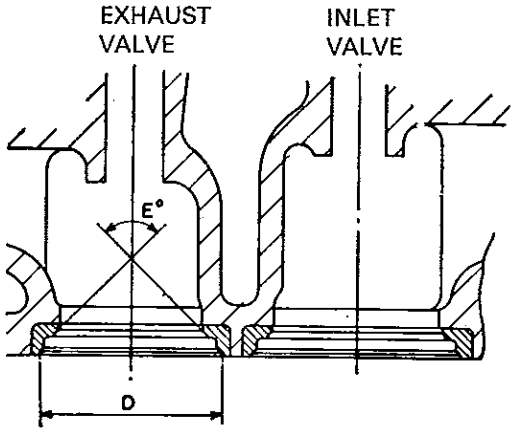


Fig. F12
Valve Insert Finished Dimensions (3.152).

Inlet
D.—1.704 to 1.714 in (43,28 to 43,53 mm).
E.—90°.

Exhaust
D.—1.485 to 1.495 in (37,72 to 37,97 mm).
E.—90°.

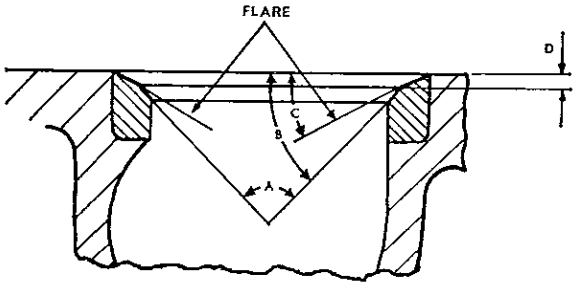


Fig. F13
Valve Insert Finished Dimensions (D3.152)

Exhaust
A.—90°. C.—30°.
B.—45°. D.—0.130 to 0.138 in (3,30 to 3,51 mm).

Tappets

The tappets operate in holes bored in the cylinder head. Wear is not normal.

The tappets can be removed through the bottom face of the cylinder head after the tappet adjustment setscrews and lock nuts have been removed.

Combustion chamber caps and joints (3.152)

It is not necessary to remove the combustion chamber caps during cylinder head overhaul as carbon deposits do not occur in these chambers.

If the caps are removed, new copper joints must be fitted when they are assembled.

If new copper joints are not available, the old joints can be used again if they are made soft before being fitted.

To make these joints soft, heat them to a dull red heat and then put them in cold water.

Ensure that there is no leakage from the joints when the caps are fitted.

Note: With flame proof applications, combustion chamber caps are not fitted. Steel inserts are fitted to the outer part of the chambers (see fig. F14) and these are sealed by the exhaust manifold.

Cylinder head inspection

Clean the cylinder head face and coolant and lubricating oil passages.

If possible, the cylinder head can be pressure tested with warm water for leakage at a pressure of 207 kN/m² (30 lbf/in²) 2,11 kgf/cm².

All studs on the cylinder head and the tapped holes in the top face of the cylinder block must be checked for damage or wear. The nuts and setscrews which fasten the cylinder head to the block must also be checked for damage or wear.

Check all joint faces, especially the bottom face of the cylinder head and the top face of the cylinder block for damage.

Check the bottom face of the cylinder head for distortion. The maximum permissible distortion is 0,08 mm (0.003 in) across the head and 0.15 mm (0.006 in) along the head.

Cylinder head faces can be machined (see page C9).

After the head has been machined, the valve depths must be checked and the seats recut if necessary as detailed under "Valve and Valve Seat Overhaul, page F3.

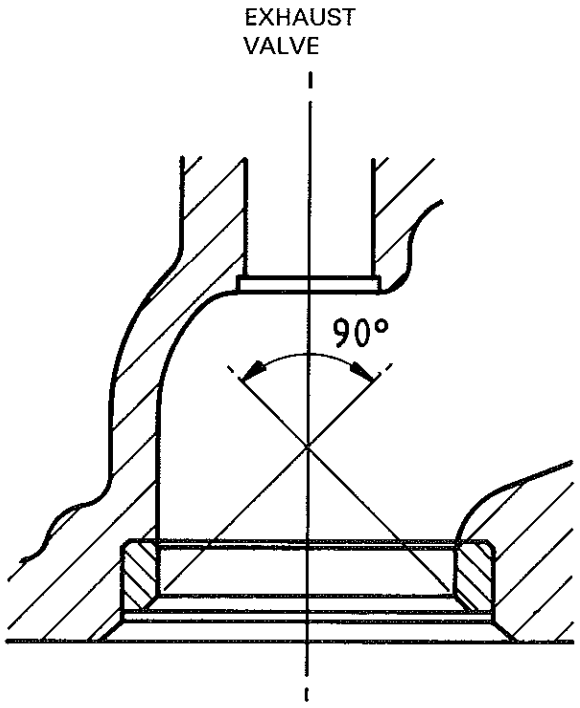


Fig. F13A

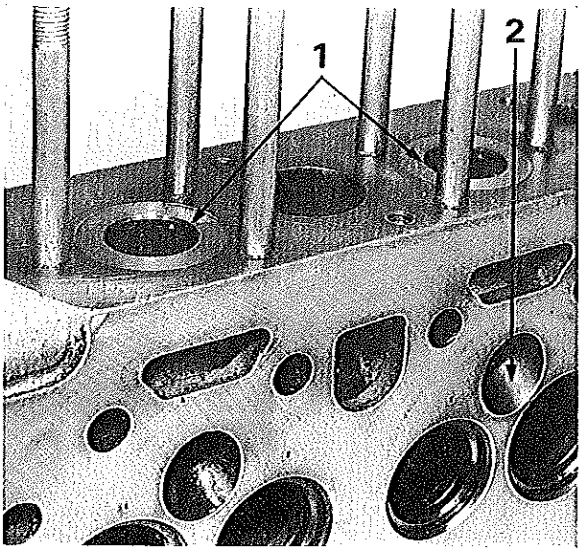


Fig. F14
3.152 Flameproof Engines only.
1. Combustion Chamber Inserts.
2. Combustion Chamber Throat.

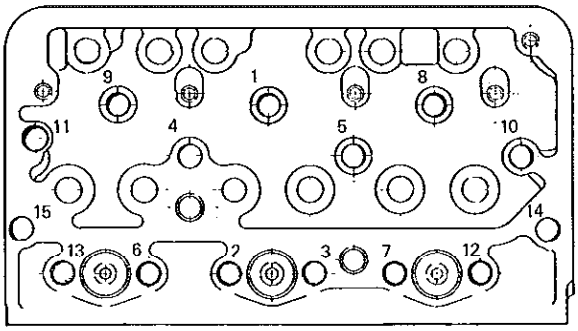


Fig. F15
Cylinder Head Tightening Sequence (3.152 engines)

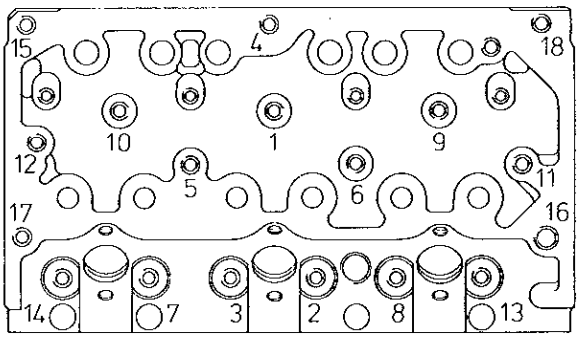


Fig. F16
Cylinder Head Tightening Sequence
(All engines except 3.152)

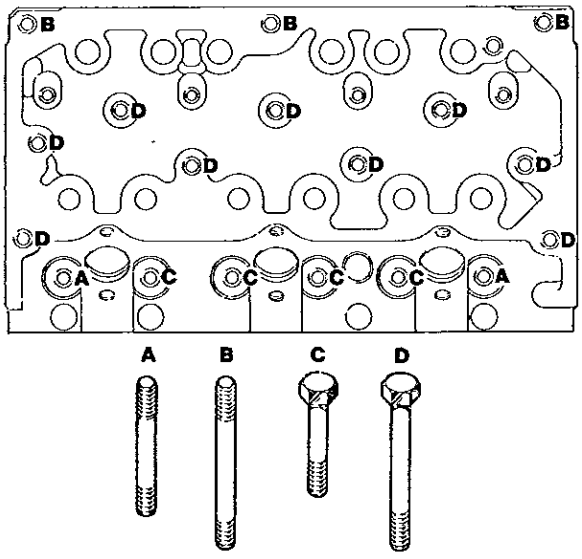


Fig. F17
Cylinder Head Stud/Setscrew Positions

Cylinder head fasteners

Different cylinder head fastners have been used on 3.152 and D3.152 engines.

Original cylinder heads were fastened to the cylinder block by studs and nuts.

As from the engine numbers which follow, cylinder head studs, nuts and setscrews were fitted.

152U21416CL
152U98250D
152UA28411DSL
152UA431805DL

On 3.152 engines, the studs were changed to setscrews except for the six which fasten the atomisers. These six studs which were not changed are fitted in positions 13, 6, 2, 3, 7 and 12 in fig. F15.

On D3.152 engines, all but two of the original studs were changed to setscrews. The two studs which were not changed were fitted to the holes marked 13 and 14 in fig. F16. Three different lengths of setscrew were used and it is important that these be fitted in their correct positions. The four short 82,5 mm (3¼ in) setscrews must be fitted in positions 7, 3, 2 and 8. The three 92 mm (3 5/8 in) setscrews must be fitted in positions 15, 4 and 18. The nine long 98,4 mm (3 7/8 in) setscrews must be fitted in positions 10, 1, 9, 12, 5, 6, 11, 17 and 16.

A later change of cylinder head fasteners was made to D3.152 engines from engine number CE.....U597494F when the setscrews in positions 15, 4 and 18 were changed to studs.

Nuts and setscrews fitted to later engines have an integral head washer.

Cylinder head fasteners for 3.1522 engines are shown in fig. F17.

Note: Where the cylinder head is fastened by all nuts, the torque is 81 Nm (60 lbf ft) 8,3 kgf m. Where the cylinder head is fastened by nuts and setscrews, the torque is 95 Nm (70 lbf ft) 9,7 kgf m.

To fit valves

1. Lubricate the valve stems with clean engine lubricating oil and fit them in their correct positions.

2. Fit the spring seat washers.

3. Put the valve stem seals in position on inlet guides only.

4. Put the valve springs into position.

   Note: With most D3.152, 3.1524, T3.1524 and 3.152 engines, only one spring is fitted to each valve, but some applications have two springs fitted. Different valve spring seat washers are fitted with the number of springs used. With 3.1522 engines, two springs are fitted to each inlet valve (see fig. F18) and a single spring to each exhaust valve. Inlet valve spring seat washers have tags on their inside diameters.

5. Fit the valve spring caps, compress the springs with a valve spring compressor and fit the split collets. Ensure that the valve spring cap is not tilted as the springs are compressed as this can cause damage to the valve stem.

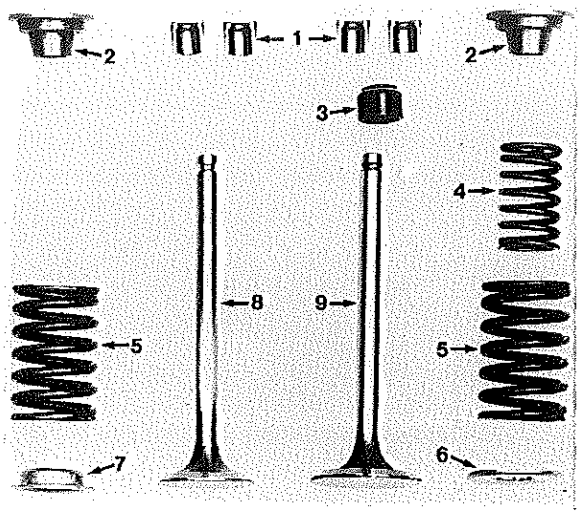


Fig. F18
Valve and Spring Assemblies.

1. Split Collets
2. Spring Cap
3. Stem Seal
4. Inner Spring
5. Outer Spring
6. Double Spring Seating Washer
7. Single Spring Seating Washer
8. Exhaust Valve
9. Inlet Valve

To fit cylinder head

A new cylinder head gasket must be used. The gasket has a mark to show how it should be fitted.

Ensure faces of the cylinder block and head are clean.

With 3.152 and D3.152 engines, the cylinder head gasket must be fitted with jointing compound on both sides. With all later 3.152 series engines, the cylinder head gasket (part number 3681E006) is fitted dry and does not need a tightness check at the 25/50 hour service.

Put the cylinder head in position and fit the nuts/setscrews as already described.

Tighten the cylinder head nuts/setscrews gradually in the sequence given in figs. F15 or F16 to the torque given on page C3. A different torque is used according to whether the cylinder head fasteners are all nuts, or nuts and setscrews.

Fit all components taken off during cylinder head removal. If the manifolds have been removed, ensure that the new joints are fitted correctly and do not cause restrictions in the ports.

Fit atomisers (see page P7).

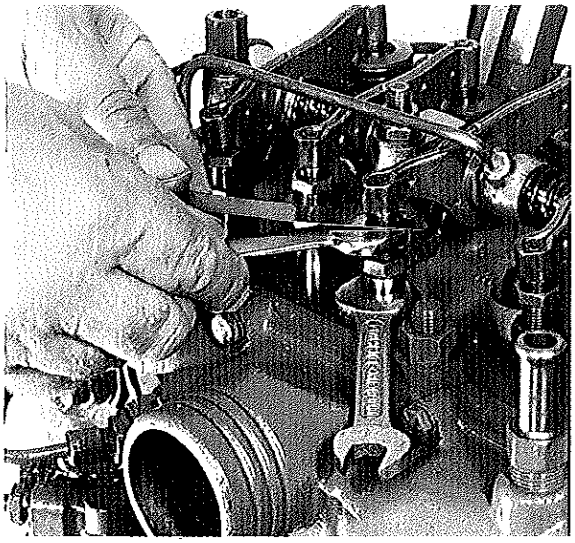


Fig. F19

Fit the rocker shaft assembly. Before the nuts which secure the rocker shaft are tightened, the shaft should be in a position to ensure correct lubrication of the assembly. The correct position for the shaft is when the slot in the end of the shaft is set 40° after the vertical position (see fig. F8). Later rocker assemblies will not have the slot in the end of the rocker shaft. On these rocker shaft assemblies, correct location is ensured by a tapered pin that fits into a hole in the rocker shaft and then into a slot in the second rocker shaft bracket (see fig. F8A).

When the rocker shaft is in the correct position, tighten the nuts which secure the shaft and set the tappet clearances as given later.

Fit cylinder head cover. Fit crankcase vent valve between cylinder head cover and induction manifold – 3.1522 only.

Connect pipes and make connections as given in 'To remove cylinder head'.

The thermostat in the cylinder head water outlet must be fitted. If the engine is run without a thermostat fitted, the engine temperature can be too high.

Run the engine and then remove rocker shaft and atomisers and tighten the cylinder head nuts/setscrews again as given below.

With the coolant outlet temperature higher than 77°C (170°F) tighten the nuts/setscrews in the order given in figs. F15 or F16 to the torque given on page F8.

If a nut/setscrew moves when checked, tighten it to the correct torque.

If a nut/setscrew does not move before the correct torque is reached, loosen the nut/setscrew by 1/12 to 1/6 (30° to 60°) of a turn and then tighten to the correct torque.

After all the nuts/setscrews have been tightened, check the first 10 positions again to ensure that they are still to the correct torque. During this last check, do not loosen the setscrews.

When the engine is cold, adjust the tappet clearances as shown below.

Fit all necessary components. It is advised that a new cylinder head cover joint is fitted.

Note: With earlier 3.152 and D3.152 engines, the cylinder head nut/setscrews must be tightened again to the correct torque after the engine has run 25/50 hours. This is not necessary with 3.1522, 3.1524, T3.1524 and all later 3.152 series engines fitted with cylinder head gasket part number 3681E006.
(Engines fitted with gasket 3681E006 can normally be recognised by the cylinder head fasteners which have integral head washers.)

To adjust tappet clearances

The clearances are checked between the rocker lever and the tappet adjustment screw.

For 3.152 and D3.152 engines, the tappet clearances for both inlet and exhaust are 0,30 mm (0.012 in), with the engine cold.

For 3.1522, 3.1524 and T3.1524 engines, the tappet clearances are 0,20 mm (0.008 in) for inlet and 0.32 mm (0.0125 in) for exhaust, with the engine hot or cold.

Adjust the clearances (see fig. F19) as follows:-

1. Turn the crankshaft in the normal direction of rotation, until the inlet valve of No. 1 cylinder has just opened and the exhaust valve of the same cylinder has not fully closed. Check and adjust clearances of Nos. 4 and 6 valves (No. 1 valve at front of engine).
2. Make a mark on the crankshaft pulley and timing case cover and turn the crankshaft one complete revolution (360°) until marks align again. Check and adjust clearances of Nos. 1, 2, 3 and 5 valves.

Crankcase vent valve – 3.1522 only

This is fitted between the cylinder head cover and induction manifold (see fig. F20).

To clean, seal the small breather hole in the top face and wash the unit in gasolene or kerosene. If air pressure is used to dry the unit, only low pressure must be used, because high pressure will damage the unit.

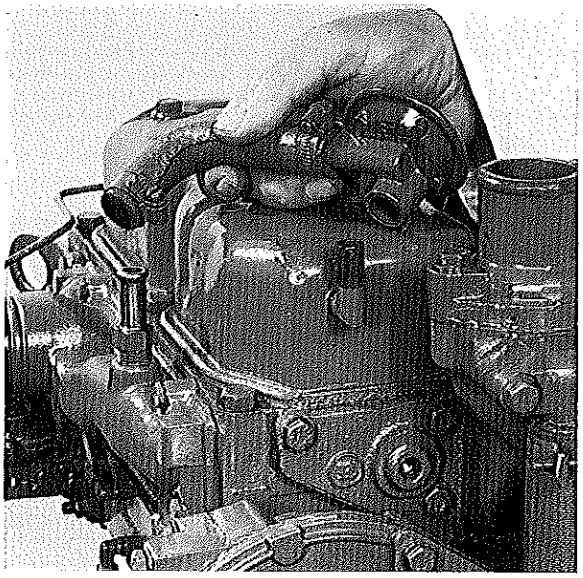
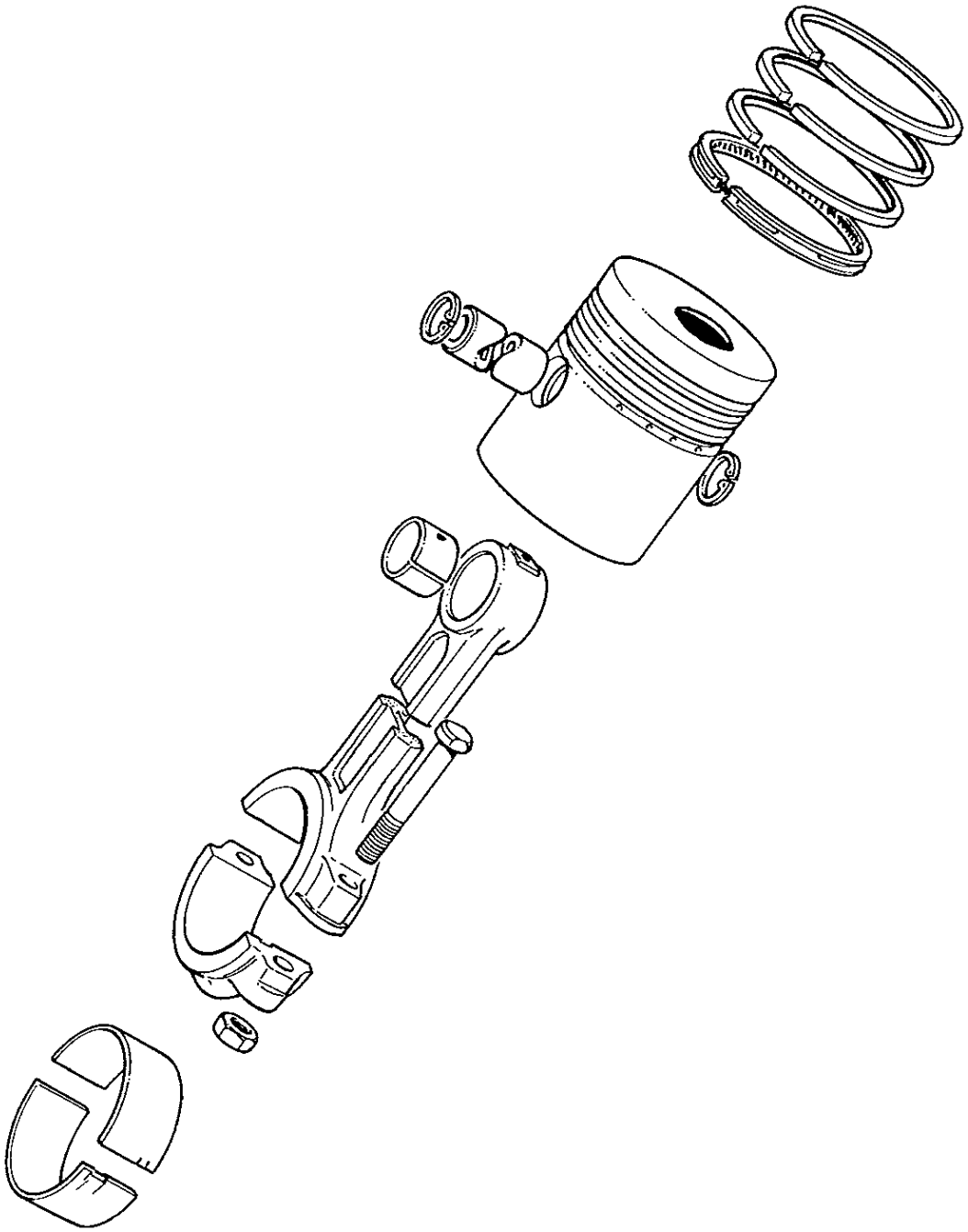


Fig. F20

SECTION G
Pistons and Connecting Rods



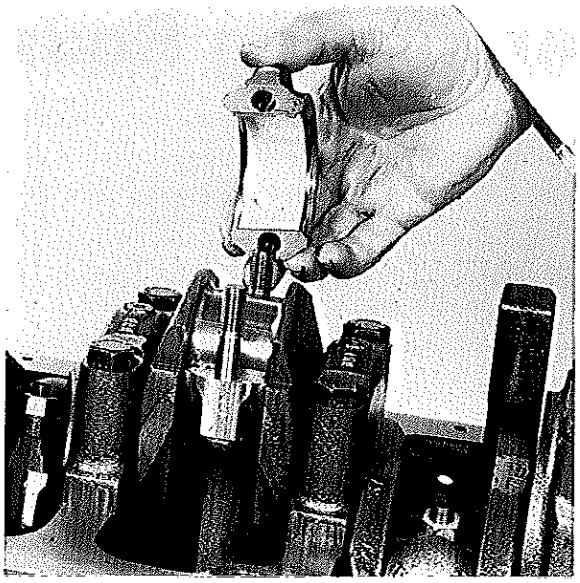


Fig. G1

Pistons and connecting rods

Pistons for 3.152/A3.152 engines have a flat top.

Pistons for D3.152/AD3.152 engines have a toroidal cavity in the top and up-rated AD3.152 pistons have a flat bottom cavity in the top.

3.1522 engines have re-entrant bowl pistons.

3.1524 and T3.1524 engines have a semi-spherical cavity in the crown.

Five ring pistons are fitted to all 3.152 engines and to D3.152 engines rated up to 2,250 rev/min, except those given below.

Four ring pistons are fitted to D3.152 engines rated above 2,250 rev/min, up-rated AD3.152 engines and some D3.152 engines rated up to 2,250 rev/min. A fuel injection pump setting code (see pump data plate) which starts with TW50 or WW47E normally indicates a four ring piston on these D3.152 engines.

3.1522 engines fitted in fork lift truck applications have four ring pistons and other applications have three ring pistons.

3.1524 and T3.1524 engines have three ring pistons.

The piston rings are all fitted above the gudgeon pin except for the bottom scraper ring on five ring pistons.

To ensure the pistons are fitted correctly, they are stamped 1 to 3. No. 1 is at the front of the engine. The number is stamped on the top of each piston.

The connecting rods are also stamped on one side to indicate their position in the engine.

Fig. G2

To remove pistons and connecting rods

1. Remove the cylinder head assembly (Section F).
2. Remove the lubricating oil sump and lubricating oil pump (Section M).
3. Remove any carbon from the top of the cylinder liner bores.
4. Remove the big end caps (see fig. G1) and connecting rod bearings from the connecting rods and push the pistons and connecting rods out of the top of the cylinder block (see fig. G2).
5. Keep the bearings with the correct piston/connecting rod assembly.

To remove pistons from connecting rods

1. Remove the piston rings. Ensure that the ends of the rings do not cause damage to the piston.
2. Ensure that there are identification marks on the piston and connecting rods to ensure easy assembly.
3. Remove the circlips from the piston bore.
4. Push out the gudgeon pin. If the pin is tight, heat the piston to 40/50°C (100/120°F) for easy pin removal.

To renew small end bush

1. Press out old bush with a suitable adaptor.
2. Remove any sharp edges from the connecting rod bore.
3. Press in new bush so that the lubricating oil hole in the bush aligns with the lubricating oil hole in the top of the connecting rod (see fig. G3).
4. Ream the bush bore to get the correct clearance with the gudgeon pin (see page C7).
5. Check that the small end bore is parallel with the big end bore.

To assemble piston and connecting rod

If original pistons are to be used again, they must be assembled to their correct connecting rods, that is, piston stamped No. 1 must be fitted to connecting rod stamped No. 1.

Pistons must be fitted with the offset cavity in the top towards the side of the connecting rod that is stamped with the identification number (fig. G4 shows a 3.1522 piston).

If a new connecting rod is used, it must be stamped with the cylinder number on the side of the rod and cap which has the recess for the location tag for the connecting rod bearings.

Assemble the piston to the connecting rod and fit the gudgeon pin. Heat the piston to 40/50°C (100/120°F) for easy gudgeon pin assembly.

Ensure that the circlips are correctly fitted in their grooves.

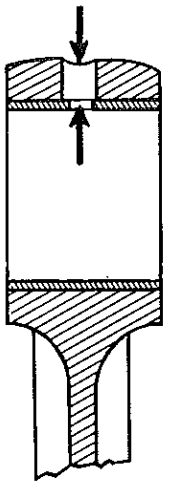


Fig. G3

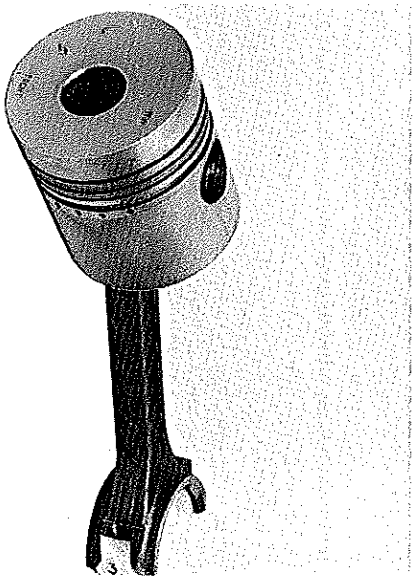


Fig. G4

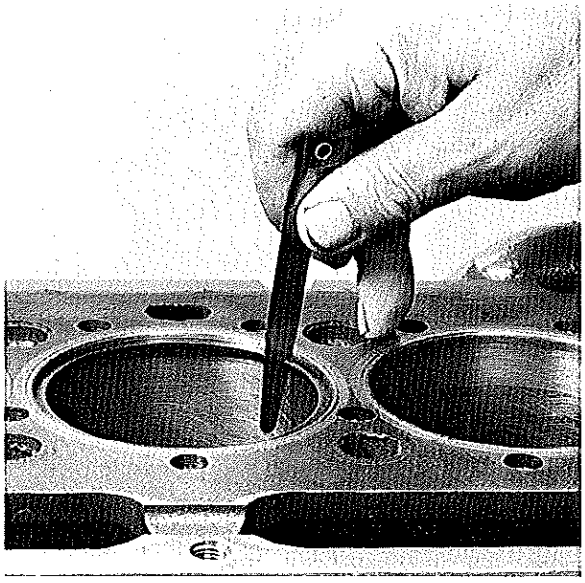


Fig. G5

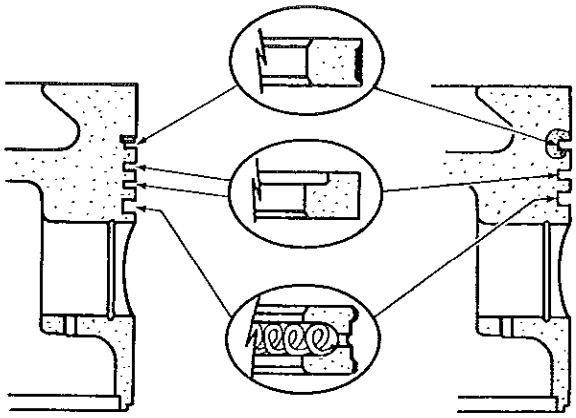


Fig. G6

To fit new rings

Check the piston rings for correct gap (see page C6). To check the gap of the coil spring loaded scraper ring, the spring must be fitted to push the ring against the cylinder liner bore.

In worn cylinder liners, gaps must be checked at the top of the bore which is not worn, after the carbon has been removed (see fig. G5).

With 3.1522 engines, the compression rings have a thin layer of copper on the outside surface to help the rings adjust to the bore. This layer will soon wear off in service. The ring gap will increase 0,08/0,15 mm (0.003/0.006 in) without the copper layer on the ring.

Fit the rings to the piston in the order which follows (from the top of the piston) as shown in fig. G6 for the 3.1522 engine.

3.152 engines fitted with chrome liners

1. Parallel face compression.
2. Tapered face compression.
3. Laminated segment compression.
4. Slotted scraper.
5. Slotted scraper.

3.152/A3.152 and D3.152/AD3.152 engines rated up to 2,250 rev/min fitted with cast iron liners

1. Chromium plated compression.
2. Parallel compression.
3. Laminated segment compression.

*4. Spring loaded laminated scraper.

5. Slotted scraper.

* With 3.152 engines rated above 2,250 rev/min, a slotted scraper is used.

Some D3.152 engines rated up to 2,250 rev/min use piston rings as given for higher rated D3.152 engines. A fuel injection pump setting code (see pump data plate) which starts with TW50 or WW47E normally indicates this piston ring arrangement.

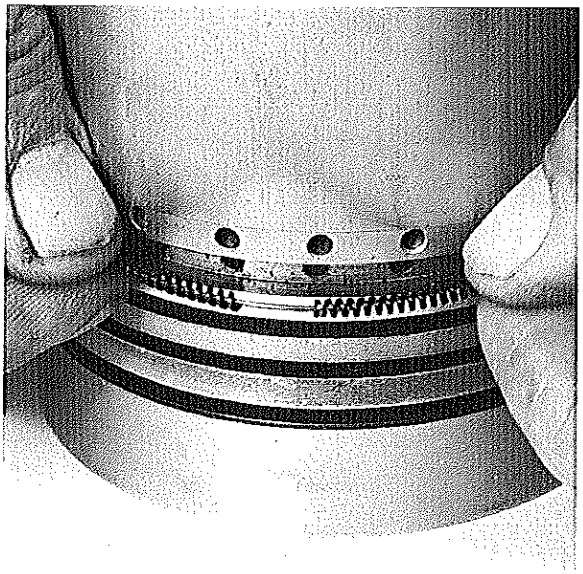


Fig. G7

D3.152 rated above 2,250 rev/min

1. Chromium plated compression.
2. Parallel compression.
3. Internally stepped compression.
4. Chromium faced, coil spring loaded scraper.

Up-rated AD3.152

1. Chromium plated compression.
2. Internally stepped compression.
3. Internally stepped compression.
4. Chromium faced, coil spring loaded scraper.

3.1522

1. Chromium insert, copper finished compression.

2 or

2 & 3 Internally stepped, copper finished compression.

3 or 4 Chromium faced, coil spring loaded scraper.

3.1524/T3.1524

1. Tapered semi-inlay, chrome face compression.
2. Tapered face compression.
3. Chrome face, coil spring loaded scraper.

The tapered face compression rings have a mark 'T' or 'TOP' to ensure that they are fitted correctly.

To fit the coil spring loaded scraper ring, fit the coil spring in the piston ring groove. Ensure that the location pin goes in both ends of the spring (see fig. G7) and then fit the ring over the spring. Ensure the spring goes into the inside groove of the ring and the ring gap is on the opposite side to the location pin.

Fit internally stepped rings with the step towards the top of the piston.

When new rings are fitted to original pistons, clean the piston ring grooves by the use of an old ring.

The pistons must be checked for damage of the ring grooves and to ensure that the rings move freely in their grooves. If the piston outside surface is damaged or badly worn, it must not be used again.

Laminated compression rings

The laminated compression ring fitted in the third groove is different on early and later engines.

On early engines, it consisted of three segments. On later engines, it consists of four segments.

It is important that the laminated compression ring is correctly assembled to the piston.

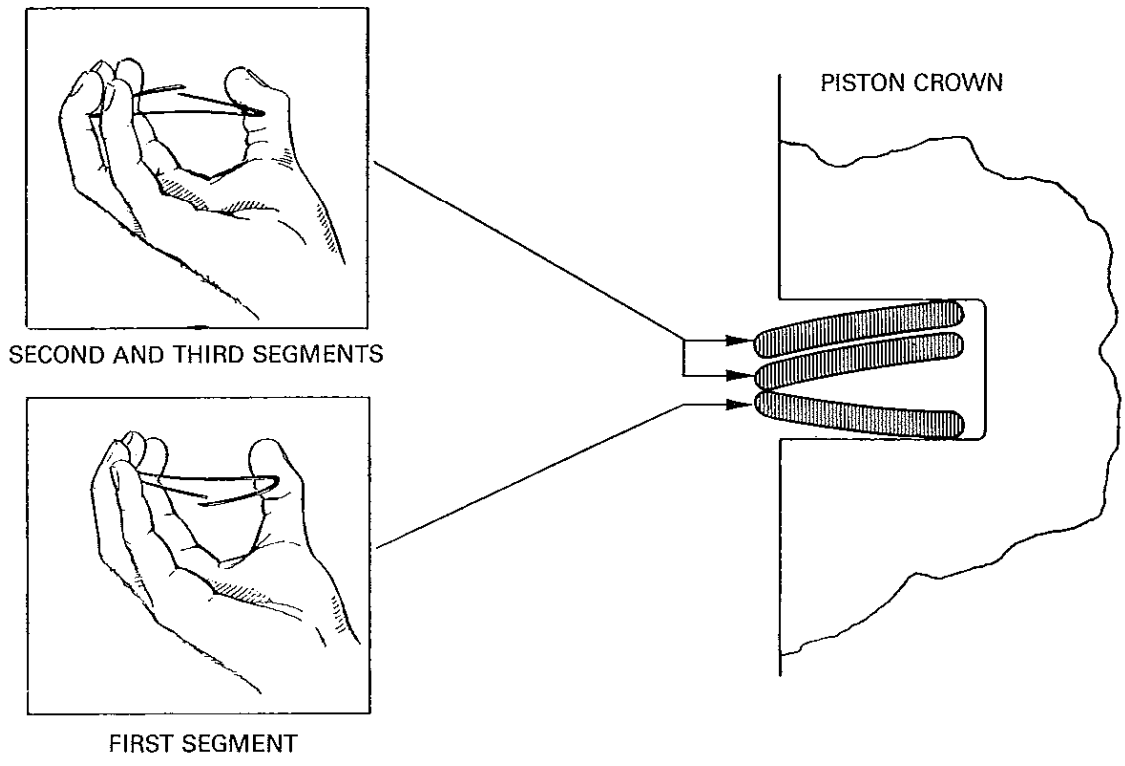


Fig. G8

To fit three segment type (see fig. G8)

1. Fit the first segment so that when held and lightly pressed by hand, the ends of the ring are in the down position. Put this ring at the bottom of the groove with the gap over the gudgeon pin bore.
2. Fit the second segment on the top of the first, so that when held and pressed as already given, the ends of the ring are in the up position. Put the gap at 180° to the first segment gap.
3. Fit the third segment on the top of the second with the ends of the ring in the up position. Put the gap above that of the first segment.

To fit four segment type (see fig. G9)

1. Fit the first segment so that when held and lightly pressed by hand, the ends of the ring are in the down position. Put this ring at the bottom of the groove with the gap over the gudgeon pin bore.
2. Fit the second segment on the top of the first so that when held and pressed as already given, the ends of the ring are in the up position. Put the gap 180° to the first segment gap.
3. Fit the third segment on the top of the second so that when pressed, the ends of the ring are in the down position. Put the gap above that of the first segment.
4. Fit the fourth segment on the top of the third with the ends of the ring in the up position. Put the gap above that of the second segment.

To fit spring loaded scraper ring (see fig. G10)

This ring consists of one inside expander ring (1) and two flat rings (2) each side of the wavy spring ring (3).

1. Fit the inside expander ring.
2. Fit the two lower flat rings.
3. Fit the wavy spring ring.
4. Fit the two upper flat rings.

To fit spring loaded scraper ring (see fig. G11)

This ring consists of four flat segments, one dished segment and a spacer.

1. Fit the two flat segments.
2. Fit the spacer.
3. Fit the flat segment on top of the spacer.
4. Fit the dished segment with the dish down. This segment has its end cut at an angle. The correct direction of the dish can be found if the ring is lightly pressed by hand and the ends move up. On later rings, a round area of the dull surface of the ring has been removed to give a bright area and this must be fitted towards the top.
5. Fit the flat segment on the top of the dished segment.

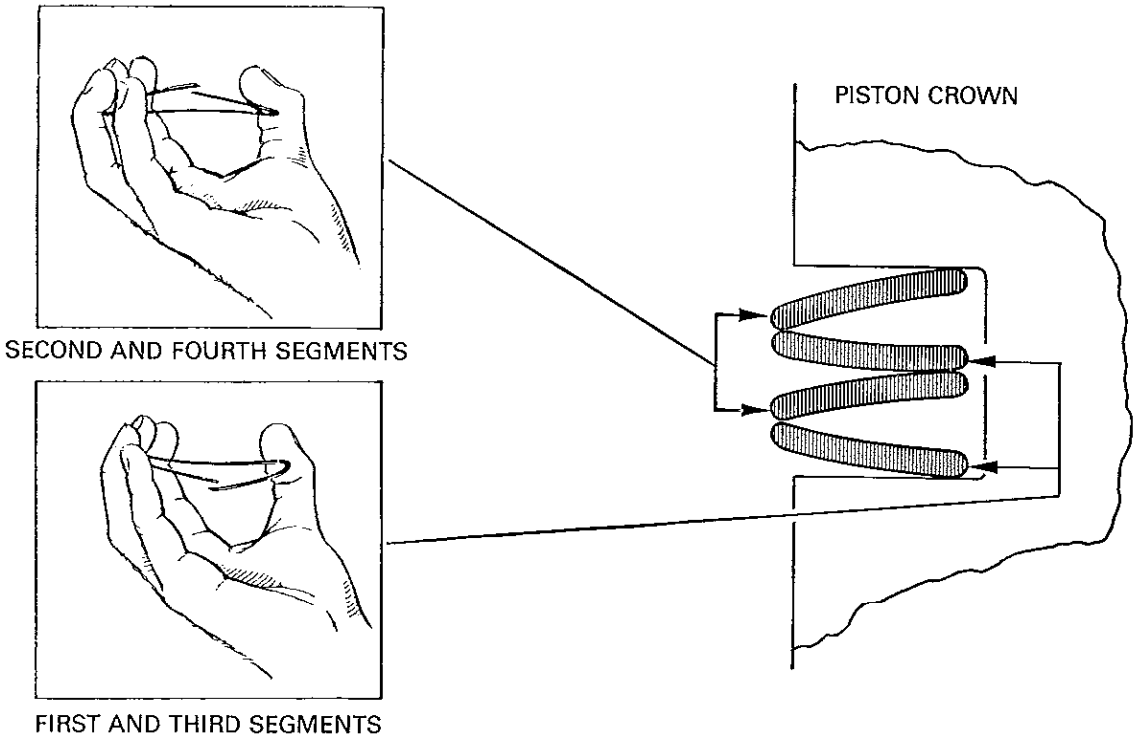


Fig. G9

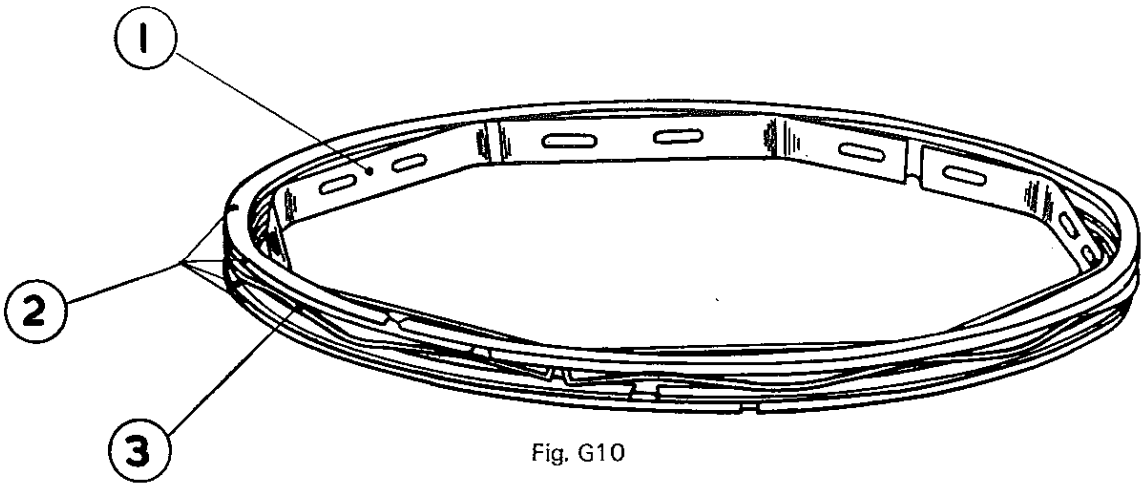


Fig. G10

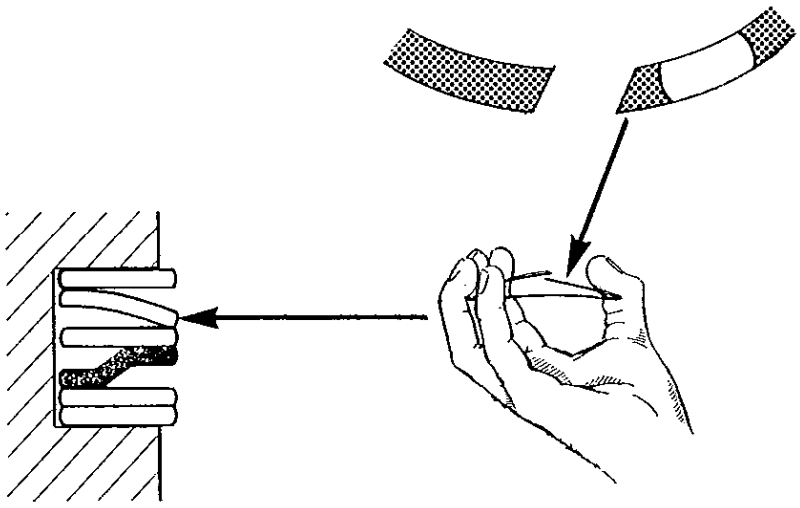


Fig. G11

To fit piston and connecting rod

Connecting rods and caps have marks to show their original position in the engine (see fig. G12). The numbers are stamped on the side of the connecting rod and cap which have the recesses for the location tags for the connecting rod bearings.

Ensure that the pistons, cylinder liner bore, crankpin and connecting rod big end are clean. Lubricate the piston and cylinder liner with clean engine lubricating oil.

When the pistons and connecting rods are fitted to the cylinder block and crankshaft, ensure that the side of the connecting rod which is stamped with the number goes to the fuel injection pump side of the engine.

Ensure that the letter 'F', word 'FRONT' or the arrow stamped on the top of the piston (see fig. G13) is towards the front of the engine. If the identification has been removed, ensure that the offset cavity in the piston top is towards the fuel injection pump side of the engine. Stamp the front of the piston top with a suitable identification mark.

Turn the crankshaft until the correct crankpin is at the bottom.

Space the ring gaps equally around the piston.

Compress the piston rings with a suitable tool (see fig. G14).

Push the pistons and connecting rods into the cylinder bores from the top. Ensure piston and rod stamped No. 1 are fitted into No. 1 cylinder and No. 2 into No. 2 cylinder etc. No. 1 cylinder is at the front of the engine.

Fit the bearings in the connecting rod and cap with the location tags correctly fitted in their recesses. Lubricate the bearings with clean engine lubricating oil and fit the connecting rod and cap to crankpin. Ensure that the cylinder numbers on the rod and cap are the same.

The nuts on the big end bolts must not be used a second time. New nuts must be fitted when they are removed.

Tighten the connecting rod nuts to the correct torque as given on page C3.

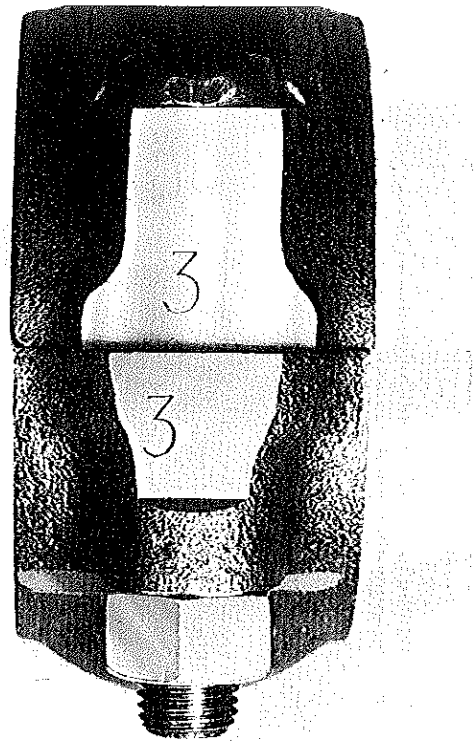


Fig. G12

Three types of connecting rod nuts have been used. The original were self locking nuts. These were changed to cadmium plated nuts which have a bright finish. Current nuts are phosphated which have a dull black finish.

Check that the crankshaft will turn freely.

It is important that the correct piston height relationship to the cylinder block top face is checked when a new piston is fitted.

These piston heights at TDC are as follows:-

3.152	0,00/0,13 mm (0.000/0.005 in) below the top face of the cylinder block.
D3.152	0,10 mm (0.004 in) above to 0,03 mm (0.001 in) below the top face of the cylinder block.
Up-rated AD3.152	0,03/0,15 mm (0.001/0.006 in) below the top face of the cylinder block.
3.1522	0,03 mm (0.0012 in) above to 0,17 mm (0.0065 in) below the top face of the cylinder block.
3.1524, T3.1524	0,03/0,15 mm (0.001/0.006 in) below the top face of the cylinder block.

In the factory, the correct height is controlled by the use of three different grades of piston. The grade is stamped on the top of the piston. 'H' is for high. 'M' is for medium. 'L' is for low.

For service use with 3.152 and D3.152 engines, a piston to the finished height is available. Pistons are also available which are not finished to the correct height and the tops of these must be machined to give the correct heights as given above.

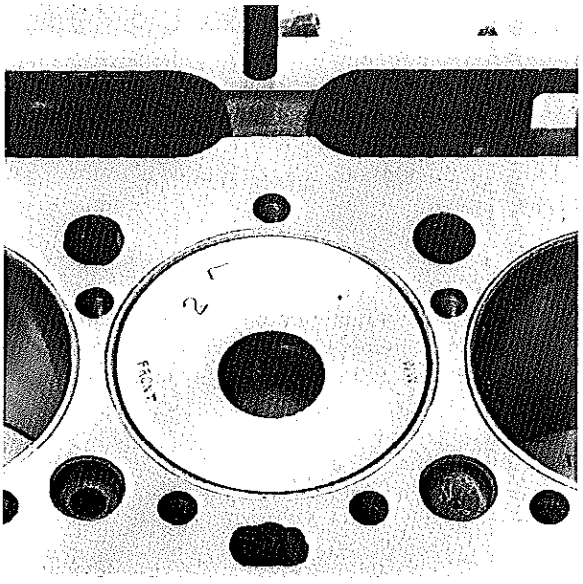


Fig. G13

For service use with 3.1522, 3.1524 and T3.1524 engines, 'H' and 'L' grades are available. 'L' grade pistons can be used in place of 'M' or 'L' grade pistons but, if used in place of 'H' grade pistons, they can be below the correct height and cause loss of power. 'H' grade pistons can be used in place of original 'H' grade pistons but, if use in place of 'M' or 'L' grade pistons, the top must be machined to give the correct height as already given.

To find the amount necessary to machine from the top of the piston, the piston and connecting rod assembly must be fitted to the cylinder block and crankshaft as already given.

When fitted, turn the crankshaft until the piston is at TDC and check the distance between the piston top and the top face of the cylinder block. Tool PD41B can be used to check the height (see fig. G15).

Do this with each piston in sequence. When the necessary amount has been removed from each piston top, fit the piston assemblies to the engine as already given. Check piston heights. If these are correct, stamp the top of the pistons with their cylinder numbers and a mark to indicate the front.

Note: After 3.1522 piston tops are machined, remove the sharp edge from the edge of the top of the cavity in the piston by the use of emery paper (360 grit size) to give a radius of 0,4 to 0,8 mm (1/64 to 1/32 in) as shown in fig. G16.

Fit the cylinder head (see page F9).

Fit the lubricating oil sump and lubricating oil pump (see pages M5 and M6).

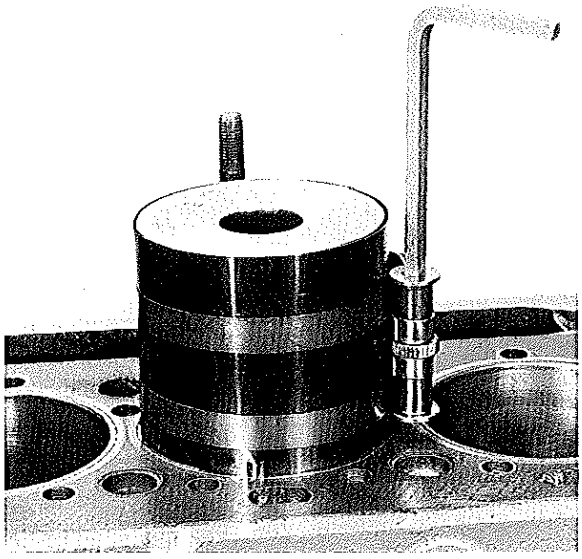


Fig. G14

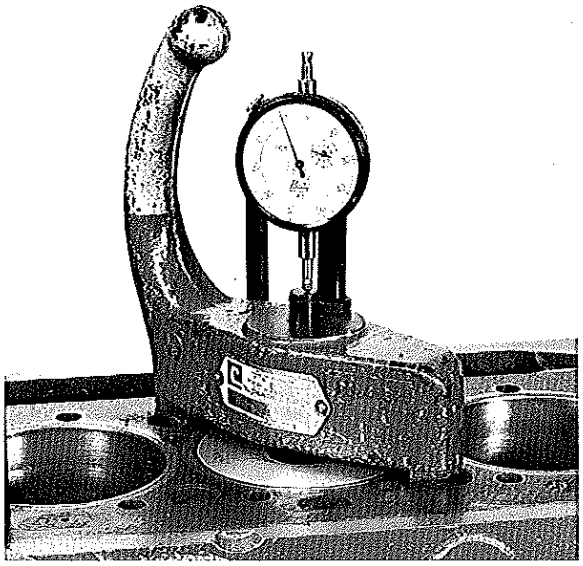


Fig. G15

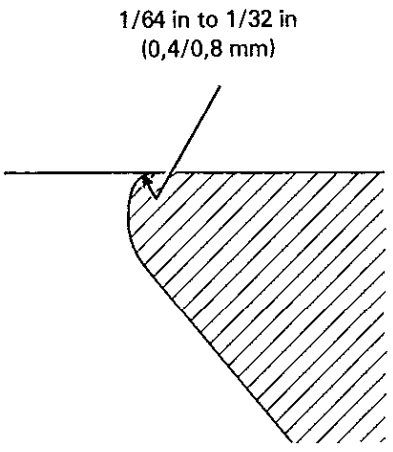
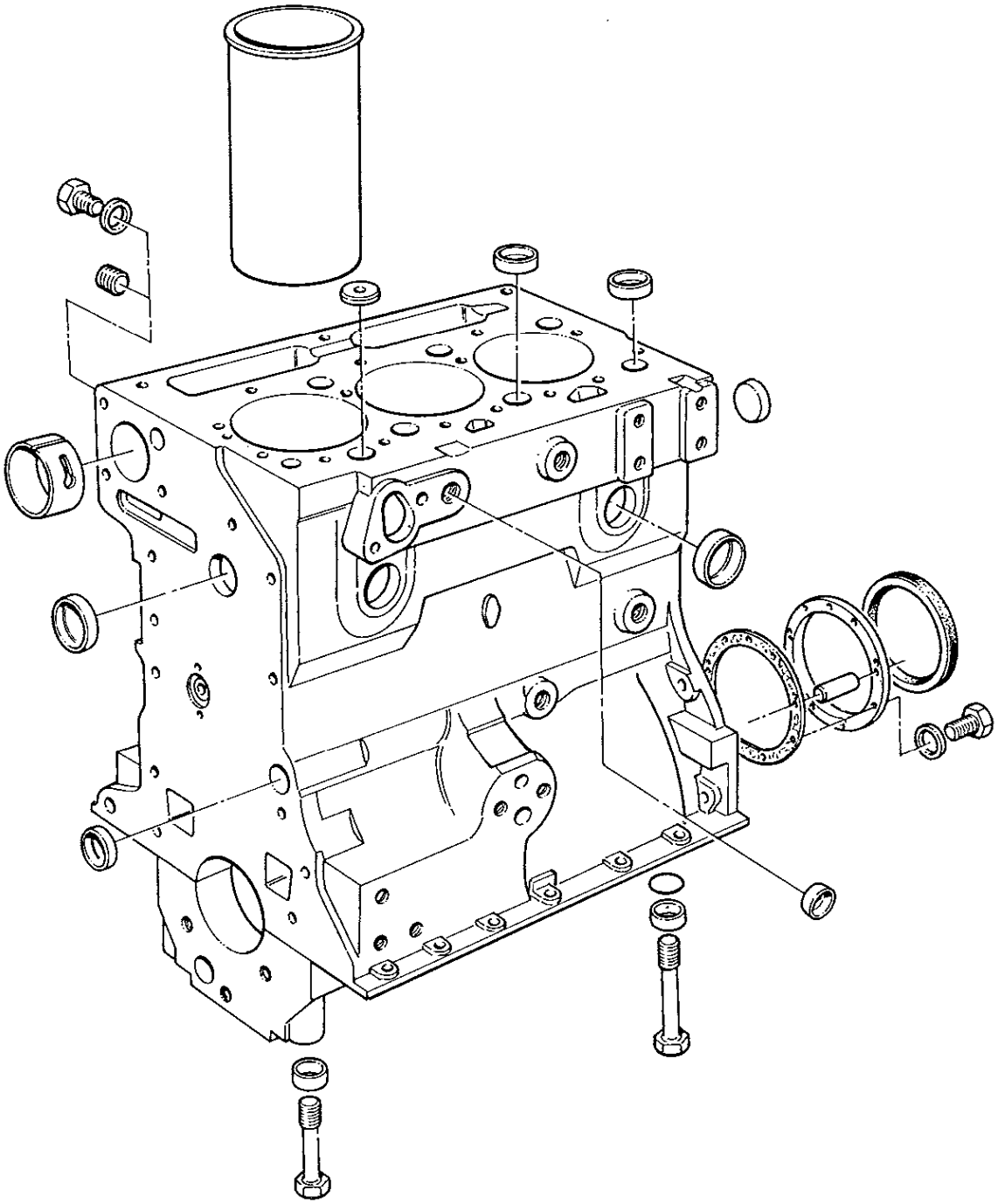


Fig. G16

SECTION H
Cylinder Block and Liners



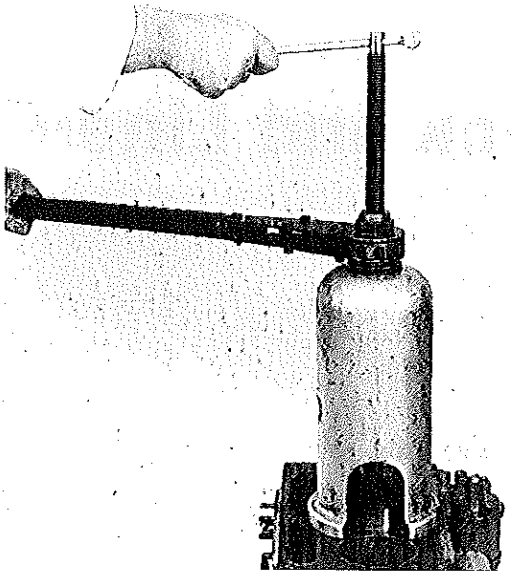


Fig. H1

Cylinder block and liners

The cylinder block is fitted with thin wall flanged cast iron or chromium faced dry cylinder liners. (Later T3.1524 engines are fitted with plain liners). They can be renewed in service. Factory cast iron liners are an interference fit and have to be bored and honed after they are fitted. Service flanged cast iron liners and all chromium faced liners are an interference/clearance fit and are pre-finished to correct size. They do not need to be machined after installation. (Pre-finished plain liners are not available).

Chromium faced liners are only fitted to 3.152 engines.

Factory and service cast iron liners are interchangeable, but cast iron and chromium faced liners are not interchangeable because the liner flange dimensions and the recess for the flange in the cylinder block are different.

Cylinder liners must not be bored oversize. When they are worn more than 0,18 mm (0.007 in) on the inside diameter, they must be renewed.

On some 3.152 and D3.152 engines and all 3.1522, 3.1524 and T3.1524 engines, a pre-finished bush is fitted in the cylinder block as a bearing for the front camshaft journal. To renew this bush, ensure that the oil hole in the bush aligns with the oil passage in the cylinder block and the end of the bush with the mark 'FRONT' is towards the front of the block.

To remove cylinder liners

1. Remove the cylinder head assembly (see Section F).
2. Remove piston and connecting rod assemblies, crankshaft and all component parts of the cylinder block as given in the other sections of this workshop manual.
3. Remove the cylinder head studs from the cylinder block.
4. Press out the liners through the top of the cylinder block (see fig. H1). Do not cause damage to the parent bores. Factory cast iron liners are an interference fit and must be removed with a heavy duty press.

Note: Cylinder liner removing/relacing tool PD.150B with adaptor PD.150-1B can be used for the removal of single liners without the removal of the engine from the application. The centre thread and ratchet of the tool must be lubricated with Shell Spirex Oil or a similar specification.

Preparation to fit new cylinder liners

Clean the top recess for the liner flange (flanged liners) and the parent bore.

Check that parent bores are free from damage or corrosion.

Ensure that the new liner is clean before it is fitted. If a fluid is used to clean the liner, it must be dried and lubricated with clean engine lubricating oil before it is fitted.

During the complete operation, all parts must be kept clean or local distortion of the liner bore can occur.

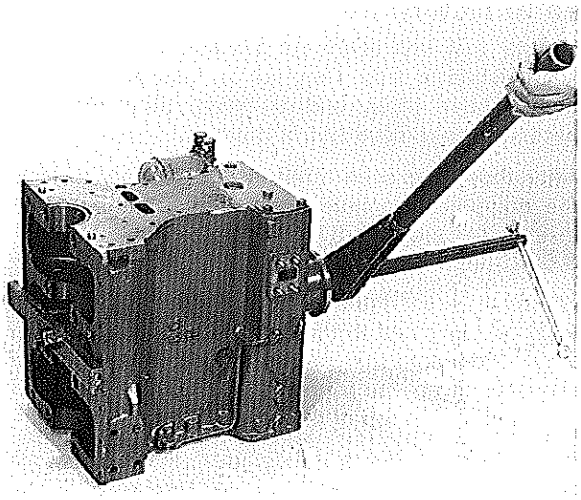


Fig. H2

To fit new service liners – flanged

1. Lubricate the outside diameter of the liners with clean engine lubricating oil which must be applied with a pressure container. Do not use a brush.

2. Press in new liners (see fig. H2) by the use of a suitable tool and adaptor. Ensure that the flanges of the liners are correctly located in their recesses at the top of the parent bore.

   When completely fitted, the top face of the liner flange must be between 0,10 mm (0.004 in) above to 0,10 mm (0.004 in) below the top face of the cylinder block for cast iron liners or 0,02/0,18 mm (0.001/0.007 in) below the top face of the cylinder block for chromium faced liners.

   To ensure correct liner height, it is permissible to use shims under the cylinder liner flange. These are 0,13 mm (0.005 in) thick, Part No. 33127107. Before a liner is fitted, the flange and recess must be measured to decide if shims are necessary to give the correct liner height relationship to the top face of the cylinder block.

   The new liners are a clearance/interference fit in the parent bore, that is – 0,03 mm (0.001 in) to + 0,03 mm (0.001 in).

3. Give the liner time to adapt to its fitted shape before the inside fitted bore diameter is checked (see fig. H3). The correct inside diameter of a pre-finished liner is 91,50/91,53 mm (3.6025/3.6035 in) for a cast iron liner or 91,48/91,50 mm (3.6015/3.6025 in) for a chromium faced liner. Each new liner must be checked in three positions – top, centre and bottom, both across and along the cylinder block at each position.

4. After new liners have been fitted, assemble remainder of components to cylinder block.

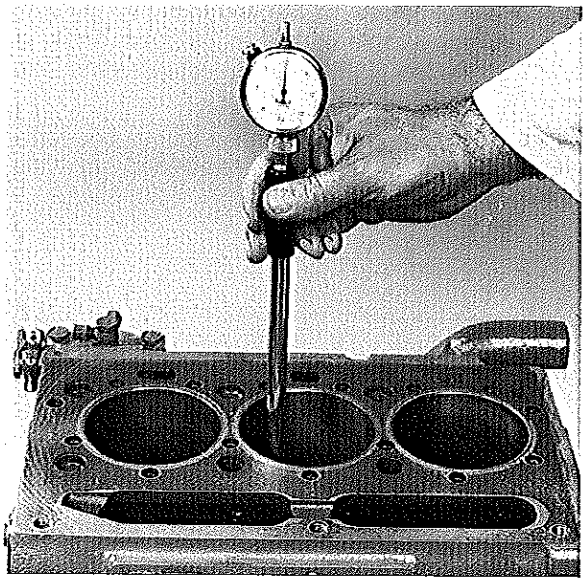


Fig. H3

To fit factory liners

Factory cast iron liners are available and these are not finished to size. They are an interference fit in the cylinder block and a heavy duty press is necessary to remove and fit them.

After they have been fitted, it is necessary to have the equipment to bore and hone the liners to an inside diameter of 91,48/91,50 mm (3.6015/3.6025 in).

Where a parent bore is made larger in service, it must be machined to the dimension by the addition of the liner oversize to the standard parent bore diameter given on page C4. A chamfer must be machined at the top of the new parent bore.

When oversize liners are fitted at the factory, the liner oversize is stamped on the top face of the cylinder block between the liner and the edge of the cylinder block.

To fit new liners – plain

Thoroughly clean the parent bore and the outside of the liner and remove all grease with 'Loctite Safety Solvent'.

Apply 'Loctite Retaining Compound' Grade 640 to the complete parent bore except for a 25 mm (1 in) high area around the top and bottom of the bore.

Enter the liner into the parent bore with the end that has an external chamfer at the bottom. With a suitable flat faced adaptor, press or pull in the liner until the top of the liner is 0,05 mm (0.002 in) above to 0,10 mm (0.004 in) below the top face of the cylinder block. Remove any 'Loctite' from around the bottom of the bore. The interference fit of the new liners in the parent bore is 0,03/0,08 mm (0.001/0.003 in).

Allow 15 minutes for the 'Loctite' to harden and then bore and hone the liner to the finished dimension of 91,48/91,50 mm (3.6015/3.6025 in). For best results, use a diamond hone – base hone at an inclusive angle of 30° to 35° and then plateau hone at an inclusive angle of 15° to 35° to a finish of 0,8/1,2 microns (32/48 micro inches) centre line average.

Clean the liner bore and the main journal housings, etc. and assemble the remainder of the components.

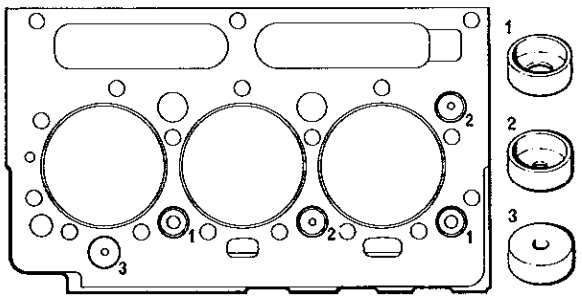


Fig. H4
Coolant Restriction Plug Positions

Oversize cylinder liners

Oversize outside diameter cylinder liners are available for service use if the standard parent bore has been made larger to remove damage.

They are available as follows:-

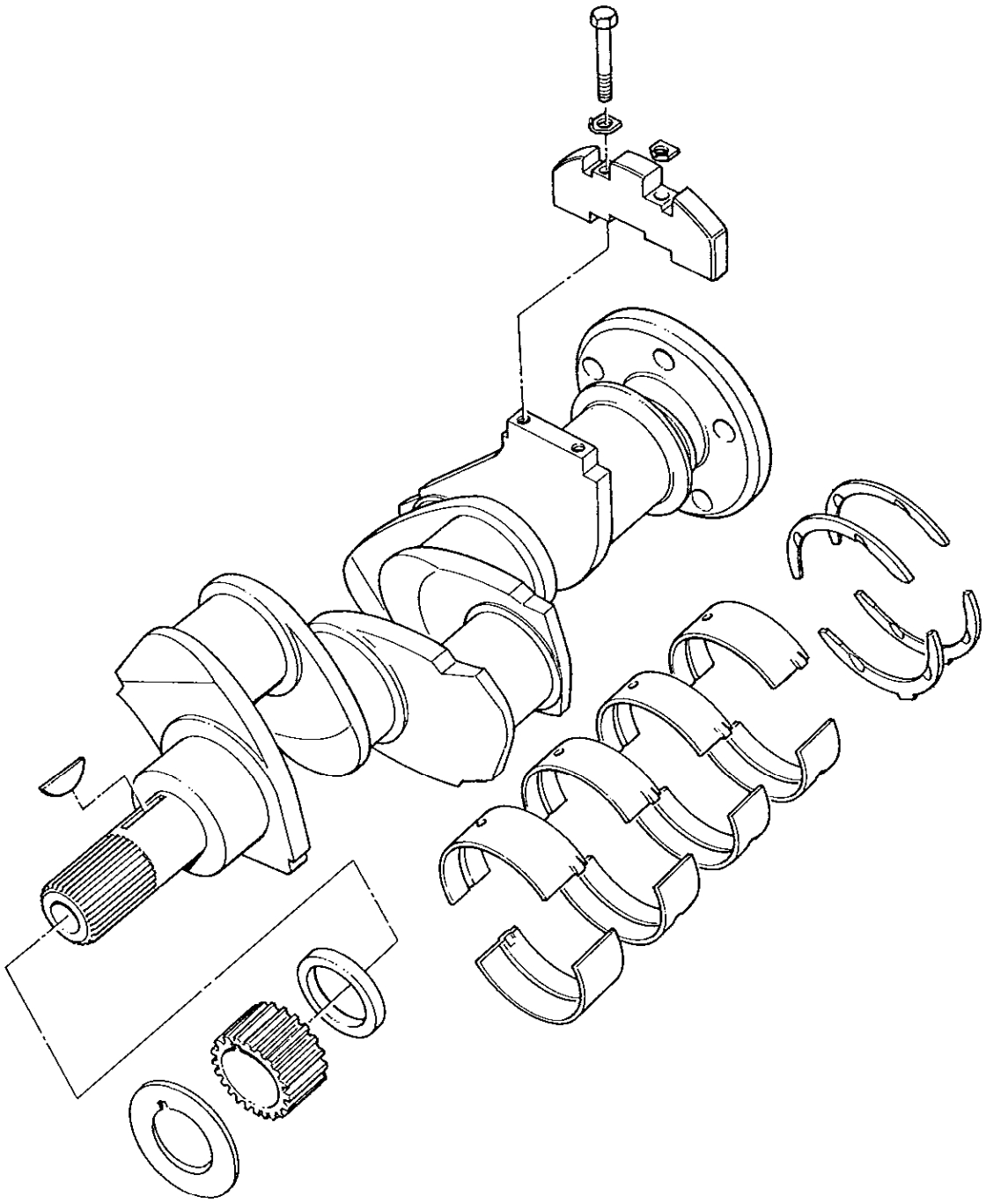
Oversize	Description
0,13 mm (0.005 in)	Chromium faced – prefinished
0,25 mm (0.010 in)	Cast iron – bore and hone
0,76 mm (0.030 in)	Cast iron plain – bore and hone
0,76 mm (0.030 in)	Cast iron flanged – pre-finished

Coolant restriction plugs

On up-rated AD3.152 and some 3.1522, 3.1524 and T3.1524 engines, five of the water passages on the top of the cylinder block are fitted with restriction plugs. If these are removed, ensure that the correct size of plug is fitted in its correct position as shown in fig. H4. The plugs must not extend above the top face of the cylinder block.

The plug (3) is fitted in the cylinder block before the top face of the cylinder block is machined in the factory. If this plug is renewed in service, it must be machined so that it is on the same level with the top face of the block.

SECTION J
Crankshaft and Main Bearings



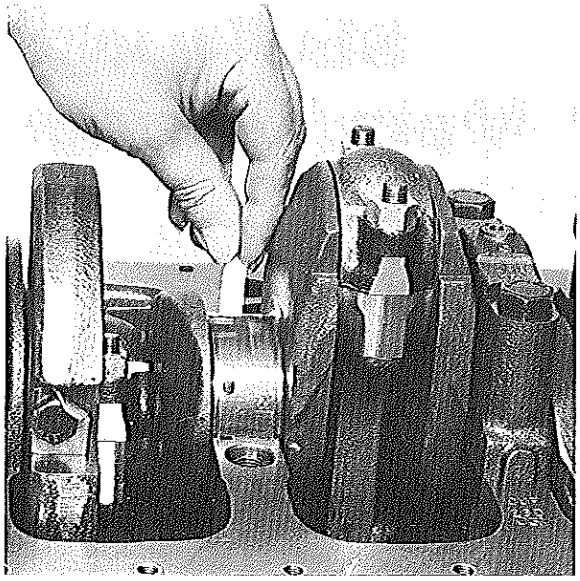


Fig. J1

Crankshaft and main bearings

The crankshaft runs in four pre-finished bearings which have a steel back and an aluminium tin face.

The crankshaft is fitted with two cast iron balance weights, one at the front crankshaft web and one at the rear crankshaft web, to give full rotation balance.

The main bearing location is by tags which fit into recesses machined in the bearing housings.

The seal at the rear end of the crankshaft is either a rope seal in a two piece housing or a lip seal in a one piece housing.

Note: The shim washers and tab washers fitted under the main bearing setscrews have been discarded and need not be fitted in service.

To fit new main bearings and thrust washers

If one or more of the main bearings or thrust washers have to be renewed or removed for inspection, it is not necessary to remove the crankshaft from the engine. With some applications, the engine will have to be removed.

1. To remove a main bearing, remove its cap. For the rear main bearing cap, see (1) below.
2. Do not remove more than one main bearing at a time.
3. Loosen the other main bearing cap setscrews one to two turns.
4. Remove the bottom half of bearing from cap.
5. With a suitable piece of wood, push out the top half of the bearing (see fig. J1). During this operation, turn the crankshaft in the correct direction and push the bearing on the opposite side to the bearing tag. The bearing tag is on the camshaft side of the engine.
6. Inspect the bearings and if they have to be renewed, fit a new half bearing in the top. Insert plain end first. Fit new half bearing to cap.
7. Fit main bearing cap and tighten setscrew lightly before the next bearing is removed.
8. When all main bearings and caps have been fitted, tighten the setscrews to the torque given on page C3.

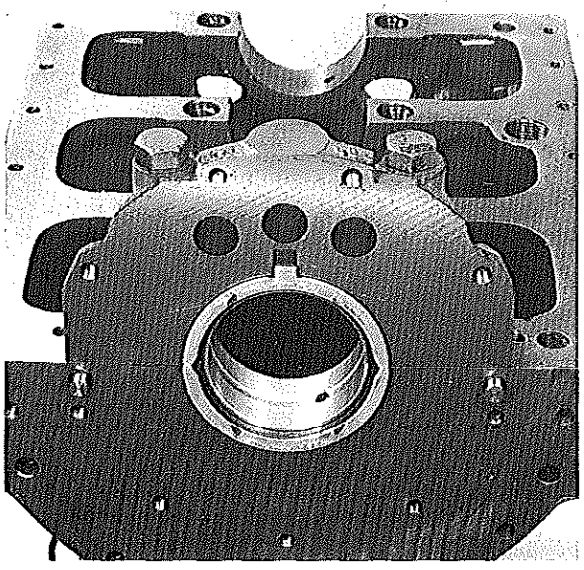


Fig. J2

The thrust washers fit in recesses machined on each side of the rear main bearing housing and cap (see fig. J2). Ensure the correct size thrust washers are fitted.

1. To renew the thrust washers, remove the rear main bearing cap. To do this, it is necessary to remove the two nuts which fasten the two halves of the rope seal housing or to release the lip seal housing.

2. Remove the two bottom half thrust washers from the rear main bearing cap.
3. The two top half thrust washers can be removed by the use of a suitable piece of wood to push them out when the crankshaft is turned (see fig. J3).
4. To fit new thrust washers, lightly lubricate the two top halves with clean lubricating oil and push one into the recess on each side of the rear main bearing housing. The steel side of the thrust washers must be towards the bearing housing.
5. Renew the main bearing cap 'O' rings (lip seal crankshafts only). Lightly apply Perkins POWERPART Hylomar jointing compound to the rear main bearing cap mounting faces, outside the grooves machined in the faces (see fig. J7). The jointing compound must not go into the grooves.
6. Fit a bottom half thrust washer on each side of the rear main bearing cap and fit the cap.
7. Tighten the main bearing setscrews to the torque given on page C3. Check crankshaft end clearance (see fig. J4).
8. Fit rear oil seal housing, flywheel, sump and other components as given in this workshop manual.

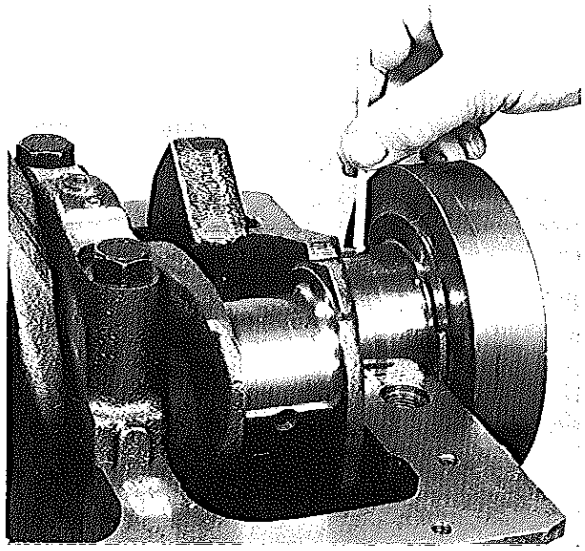


Fig. J3

To remove crankshaft

1. Remove sump and lubricating oil pump (see Section M).
2. Remove water pump (see Section N).
3. Remove crankshaft pulley.
4. Remove timing case front cover and remove idler gear.
5. Remove starter motor, flywheel and flywheel housing. Before the flywheel is removed, fit two guide studs in the crankshaft flange to give support when the flywheel is removed.
6. Remove connecting rod caps and big end bearings.
7. Remove the bolts which fasten the two halves of the rope seal housing or remove the lip seal housing.
8. Remove the main bearing setscrews and the main bearing caps and bottom half bearings. Keep the bearings and caps together.
9. Lift out the crankshaft (see fig. J5) and remove the top half main bearings. Make a mark on the bearings to ensure that they are fitted to their original positions.

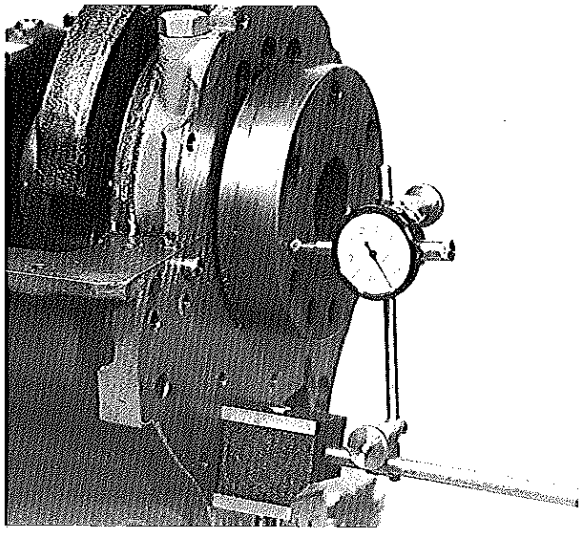


Fig. J4

If it is necessary to remove the crankshaft gear, ensure that the timing mark is to the front of the gear when it is fitted. The distance piece between the gear and crankshaft must be fitted with the chamfer to the inside.

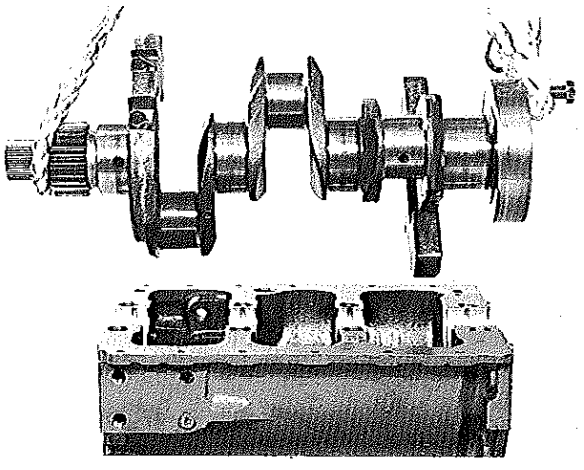


Fig. J5

If the main bearings are to be used again, they must be suitably marked to ensure they are fitted in that same positions from which they were removed.

Balance weights

If it is necessary to renew crankshaft balance weights. These are normally supplied in sets of two and must be fitted as a set. Where one weight is renewed, then the weight difference must not exceed 28.3 g (1 oz).

Crankshaft overhaul

The main journals and crankpins of a standard crankshaft can be machined 0,25 mm (0.010 in), 0,51 mm (0.020 in) or 0,76 mm (0.030 in) undersize on diameter. Special bearings are available for these undersize journals and pins.

Note: Crankshafts fitted to all 3.1522, 3.1524 and T3.1524 engines and crankshaft Part Nos. 31312718, 31312722 and 31313057 are Tufftrided and must be hardened by the Tufftrided process after they have been machined. If this is not possible, they can be nitrided for 20 hours, or if this is not possible, a new or Power Exchange crankshaft must be fitted.

Check the crankshaft for cracks before and after the crankshaft is machined.

Ensure that the fillet radii are machined correctly.

The finished sizes for corrected crankshafts are given below.

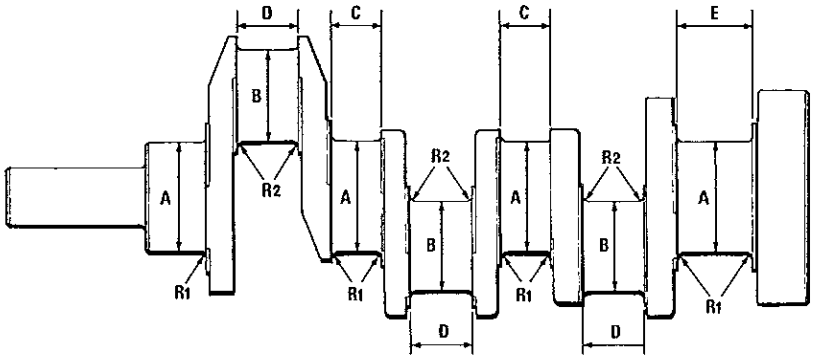


Fig. J6

	0,25 mm (0.010 in) Undersize	0,51 mm (0.020 in) Undersize	0,76 mm (0.030 in) Undersize
A	69,56/69,58 mm (2.7385/2.7393 in)	69,30/69,32 mm (2.7285/2.7293 in)	69,05/69,07 mm (2.7185/2.7193 in)
B	56,86/56,88 mm (2.2384/2.2392 in)	56,60/56,62 mm (2.2284/2.2292 in)	56,35/56,37 mm (2.2184/2.2912 in)

C 31,184 mm (1.22775 in) maximum

D 40,00 mm (1.575 in) maximum

E Crankshafts with rope seal – 48,06 mm (1.892 in) maximum

E Crankshafts with lip seal – 47,27 mm (1.861 in) maximum

R1 2,38/2,78 mm (0.0937/0.1093 in) all journals

R2 3,97/4,36 mm (0.1562/0.1718 in) all crankpins

Finished surface of journals and crankpins, 0,40 microns (16 micro inches). Fillet radii 1.3 microns (50 micro inches) centre line average maximum.

Magnetic crack check DC flow – 2 amps AC current – 1300 amps

Maximum taper and out of round for journals and crankpins —

Taper	0,009 mm (0.00035 in)	Out of round	0,010 mm (0.004 in)

Maximum run-out with crankshaft mounted on end journals —
Crankshaft pulley diameter (total indicator reading) 0,025 mm (0.001 in)
Rear oil seal diameter (total indicator reading) 0,025 mm (0.001 in)
Flywheel flange diameter (total indicator reading) 0,025 mm (0.001 in)

Journals (total indicator reading). Run-out must not be opposite.

Number 1	Number 2	Number 3	Number 4
Mounting	0,05 mm (0.002 in)	0,05 mm (0.002 in)	Mounting

After the crankshaft has been machined, removed any sharp corners from the lubricating oil holes.

To fit crankshaft

1. Ensure that all lubricating oil passages are free from restriction.
2. Check the main bearing setscrews for distortion and thread damage and renew them as necessary. Ensure that only the correct setscrews are used.
3. Clean the main bearing housings and fit the top half bearings in position with the location tags of the bearings in the slots of the housings. Lubricate the bearing surfaces with clean engine lubricating oil.
4. Put the crankshaft in position on the top half bearings.
5. Clean and lubricate the top half thrust washers and slide them into their recesses on both sides of the rear main bearing housing. The steel side must be towards the housing.
6. Renew the rear main bearing cap 'O' rings (lip seal crankshafts only).
7. Lightly apply Perkins POWERPART Hylomar jointing compound to the rear main bearing cap mounting faces, outside the grooves in the faces. The jointing compound must not go into the grooves (see fig. J7).
8. Fit the bottom half bearings to the main bearing caps with the location tags in their slots and lubricate the bearing surfaces. Put the main bearing caps in their correct positions and ensure that the bottom half thrust washers are correctly fitted to No. 4 cap (see fig. J7A). The inner caps are stamped 2 and 3 from the front of the engine. Each cap is stamped with a serial number and when fitted, this serial number must read in line with the serial number stamped on the cylinder block bottom face (see fig. J8).
9. Fit the main bearing cap setscrews and tighten them to the torque given on page C3.
10. Assemble the engine according to the instructions given in this workshop manual.
11. Tighten the crankshaft pulley setscrew to the torque given on page C3. With most applications, the pulley is fastened with a 38 mm (1.5 in) AF setscrew and a 8,9 mm (0.35 in) thick washer and this needs a higher torque than setscrews which use a 4,8 mm (3/16 in) thick washer.

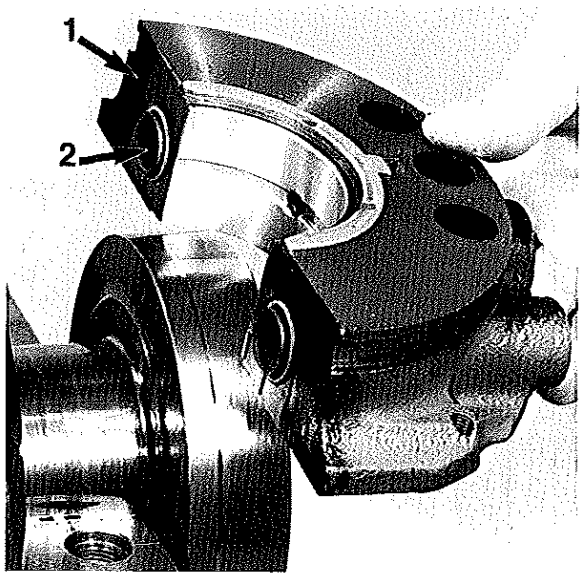


Fig. J7
1. Jointing Compound 2. 'O' Ring and Dowel

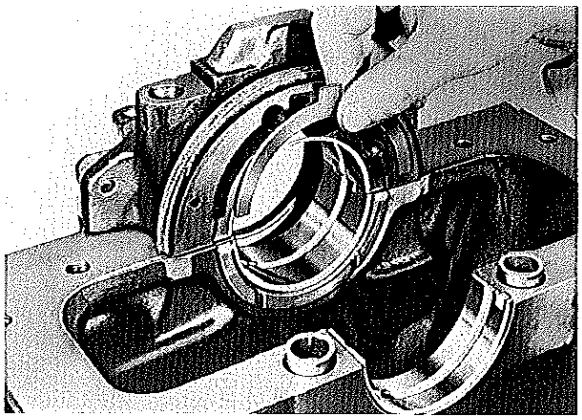


Fig. J7A

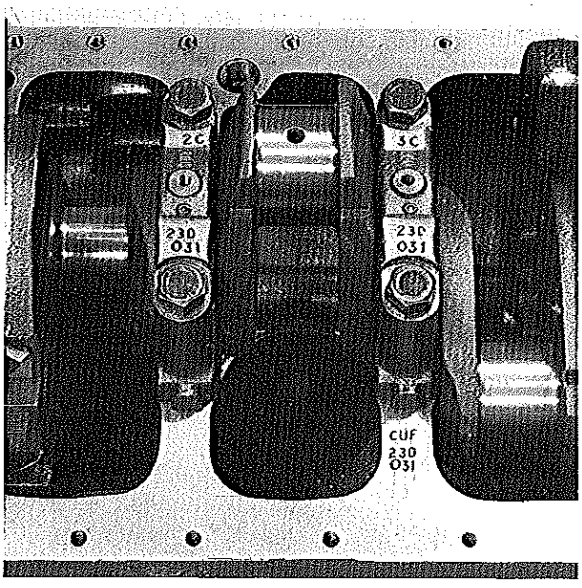


Fig. J8

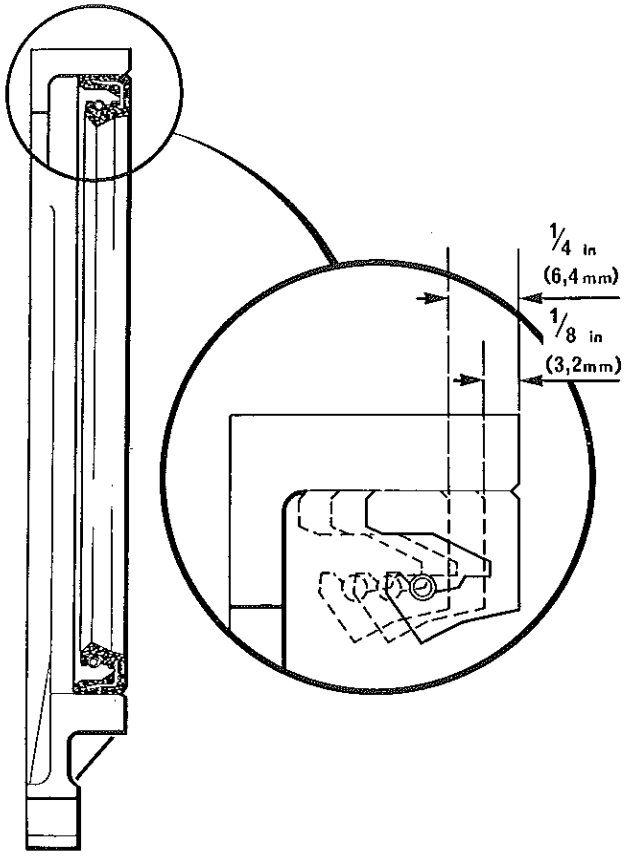


Fig. J9

Crankshaft rear end rope oil seal

This consists of a two piece housing which goes around the rear of the crankshaft which has a spiral oil groove machined to a depth of 0,10 to 0,20 mm (0.004 to 0.008 in) to return the lubricating oil to the inside of the housing. The bore of the housing is machined to take a rubber insert asbestos seal. The seal consists of two halves, one for each half of the housing.

Fit the seals as follows:-

1. Put one half housing in a vice with the seal recess to the top.
2. Fit 25 mm (1 in) of the seal at each end into the ends of the groove so that each end of the seal extends 0,25/0,50 mm (0.010/0.020 in) above the half housing end face.
3. Press the remainder of the seal into the groove by hand. Start this operation from the centre of the seal. Then use a round shaft to roll in the seal by the use of pressure on its inside diameter.
4. Fit seal to other half housing as already indicated.
5. Clean the half housing faces.
6. Lightly apply jointing compound to both sides of the joint and put the joint in position.
7. Lightly apply jointing compound to the end faces of the half housings.
8. Lubricate the inside diameter of the rope seal with graphite grease.
9. Lubricate the rear end of the crankshaft round the oil groove.
10. Put the half housing in position on the engine. Ensure that the half housing with the oil shroud is in the upper position. Fit all setscrews to cylinder block and bearing cap faces finger tight only.
11. Fit the two bolts which fasten the two housings together and tighten the nuts to 8,13 Nm (6 lbf ft) 0,83 kgf m.
12. Tighten the setscrews in the cylinder block and bearing cap to 16,3 Nm (12 lbf ft) 1,66 kgf m.
13. Tighten the two nuts to 16,3 Nm (12 lbf ft) 1,66 kgf m.

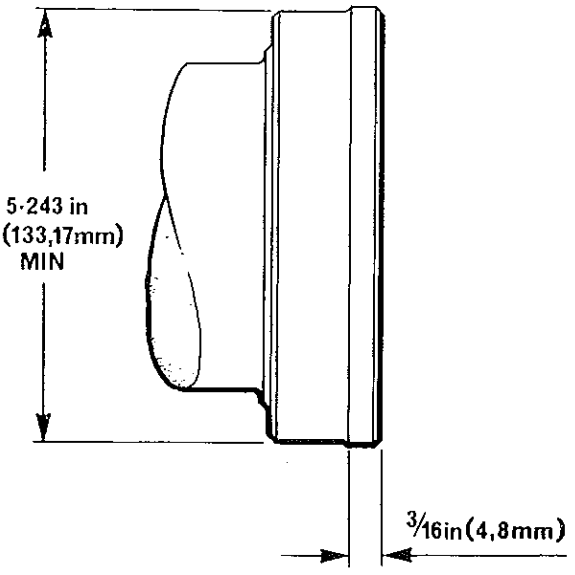


Fig. J10

Crankshaft rear end lip seal (earlier type)

On later 3.152 and D3.152 engines and all 3.1522, 3.1524 and T3.1524 engines, a spring loaded lip seal is fitted round the rear flange of the crankshaft.

Damage can easily occur with the lip seal and extreme care must be used when the lip seal and housing are fitted.

With a new engine, the lip seal is fitted with its rear face in line with the rear face of the oil seal housing (see fig. J9). If a new seal is fitted to a worn crankshaft, the seal can be pressed further into the housing to 3 mm (1/8 in) below the housing rear face or, if this position has been used, to 6 mm (1/4 in) below the housing rear face. Lubricate the seal with clean engine lubricating oil before it is pressed into the housing and ensure that it is pressed in squarely. If all three positions have been used, the worn seal area of the flange (not the spigot area on which the flywheel fits) can be machined (see fig. J10).

Fit the seal and housing by the use of the seal guide PD.145 as follows:-

Clean faces of cylinder block, oil seal housing and outside diameter of the crankshaft flange.

Ensure that the two dowels are fitted in the cylinder block. Apply jointing compound to both sides of the joint and position the joint over the dowels.

Lubricate crankshaft flange, seal and seal guide with clean engine lubricating oil. Lubrication of the seal is necessary to prevent damage that can be caused if the seal is run dry.

Push seal and housing on seal guide, fit guide on crankshaft flange and press seal and its housing into position on flange. Ensure the housing fits on the dowels (see fig. J11).

Remove the guide and fasten the housing with setscrews and washers.

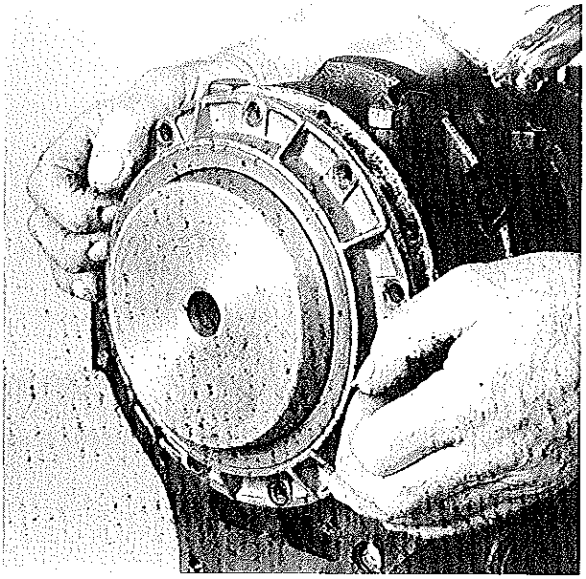


Fig. J11

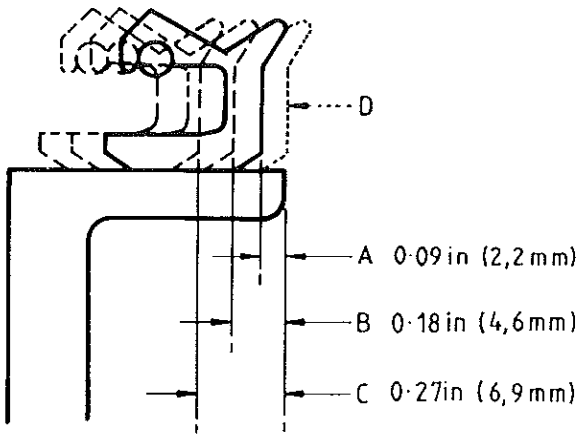


Fig. J12

Crankshaft rear end lip seal (later type)

The later type of spring loaded lip seal has a dust seal lip with a protrusion to the rear face. It is fitted similarly to the earlier lip seal, but the data which follows must be noted.

In the factory, the later seals will now be fitted below the rear face of the seal housing as shown in fig. J12 so that the standard housing assembly can be used on engine applications with an oil filled flywheel housing. Two new service positions have been introduced with the later seal position and these are also suitable for use with the earlier seal where it is fitted level with the rear face of the housing. Tool PD145C is suitable for both earlier and later seals. Tool PD145 can not be used with the later seals without modification.

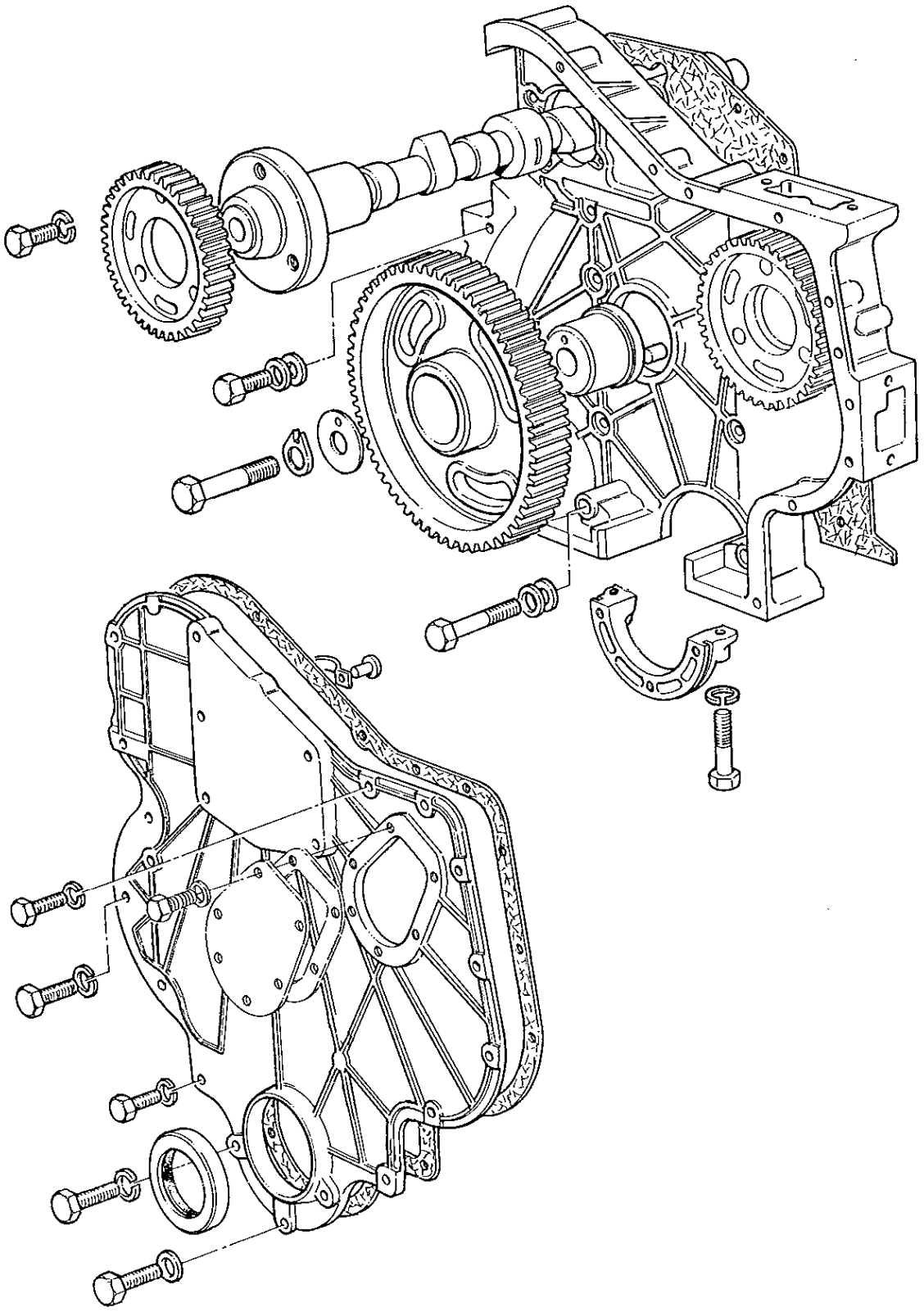
A. Seal position as fitted in the factory.

B. First service position.
This can be used when the original seal is renewed (original seal fitted at position A or level with rear face of the housing) without modification to the crankshaft palm. Do not use if the earlier seal has been fitted 3,2 mm (⅛ in) below the housing face.

C. Second service position.
This can be used when positions A and B have already been used without modification to the crankshaft palm. Do not use if the earlier seal has been fitted 6,4 mm (¼ in) below the housing face.

D. Extra service position.
This can be used for engines with dry flywheel housings if a new crankshaft is fitted or the crankshaft palm has been corrected, but ensure that the seal is fitted squarely in the housing.

SECTION K
Timing Case and Drive



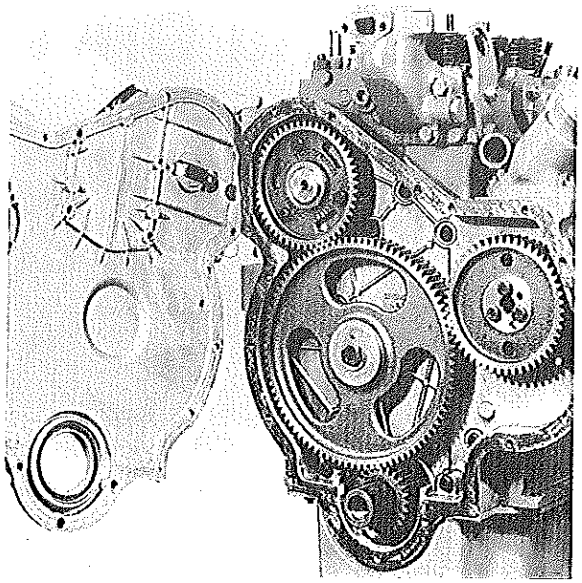


Fig. K1

Timing case and drive

The camshaft is installed in a high position on the right side of the cylinder block. This arrangement does not need push rods.

The camshaft and fuel pump drive are through an idler gear from the front of the crankshaft.

The timing gears are installed in a timing case and cover.

Camshaft bush – No. 1 bearing

With some D3.152 engines and all 3.1522, 3.1524 and T3.1524 engines, the No. 1 camshaft journal runs in a bush fitted in the front of the cylinder block.

This bush can be removed with a suitable tool and adaptor and a new pre-finished bush fitted. The bush must be fitted with the word FRONT to the front of the cylinder block and the hole drilled in the bush in line with the hole drilled in the cylinder block.

To remove timing case cover

1. Loosen the bolts which hold the dynamo or alternator and remove the fan belt.
2. Loosen the hose clips on hoses fitted to the water pump and remove the water pump.
3. Remove the crankshaft pulley.
4. Remove the dynamo or alternator.
5. Remove the dynamo or alternator bracket and linkage.
6. Remove the timing case cover setscrews. Two long bolts go through the timing case to fasten a cover at the rear of the timing case which seals off the power take off bore. There are also two long bolts which go through the timing case to fasten the dynamo or alternator bracket. There is another long bolt which goes through the timing case cover above the position of the dynamo or alternator bracket. The bottom setscrew below the front oil seal is fitted with an aluminium or copper washer.
7. Remove timing case cover (see fig. K1). Ensure that no damage occurs to the front oil seal.

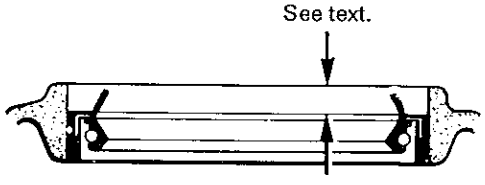


Fig. K2
Crankshaft Front Oil Seal Position

To renew crankshaft front oil seal

1. Press out old seal from timing case with a support under the seal housing.
2. Press in new seal with spring loaded lip towards inside of cover.

Note: Early engines were fitted with a black nitrile seal with no dust lip protrusion and a crankshaft oil thrower.

Later engines had a red silicone seal with a dust seal protrusion and a distance piece was fitted instead of an oil thrower.
The depths of these seals from the front of the cover must be as follows (see fig. K2).
3.152, D3.152 Ind., 3.1522, 3.1524 and T3.1524 engines – 15,88 mm (0.625 in)
D3.152 Ag. and marine engines – 11,91 mm (0.469 in)
AD3.152 and A3.152 engines – 11,43 mm (0.450 in)
Current engines are fitted with a black 'Viton' seal with a dust seal protrusion and the depths of these seals from the front face of the cover must be as follows (see fig. K2).
All engine types except marine – 9,35 mm (0.375 in)
All marine engines – 11,83 mm (0.465 in)

3. Fit the timing case cover to the timing case by the use of two opposite setscrews loosely tightened. Ensure that the cover is correctly aligned by the use of centralising tool PD159 on the crankshaft and in the seal housing and tighten the assembly by the crankshaft pulley setscrew and washer. Do not apply too much force on the setscrew. Tighten all the timing cover setscrews and nuts and remove the tool. If the centralising tool is not available, the crankshaft pulley can be used to align the cover, but as this method uses the inside diameter of the seal which is soft, the cover can be out of alignment which can cause leakage.

Timing gears

The camshaft and fuel injection pump gears are driven by an idler gear from the front of the crankshaft. All the gears are stamped with marks to ensure correct timing. These marks are made with No. 1 piston at TDC on its compression stroke. These timing marks will not align at every rotation of the crankshaft when No. 1 piston is at TDC on its compression stroke because the gears turn at different speeds.

If any of the timing gears are renewed, ensure that there is a minimum backlash of 0,08 mm (0.003 in) – see fig. K3.

To remove idler gear and hub

1. Turn the crankshaft until the timing mark teeth of the crankshaft and camshaft gears are in mesh with the idler gear.
2. Release locking washer on the setscrew which fastens idler gear and remove setscrew, locking washer and idler gear end plate.
3. Remove idler gear from its hub (see fig. K4).
4. Remove idler gear hub from its bore in the timing case. (See fig. K4A).

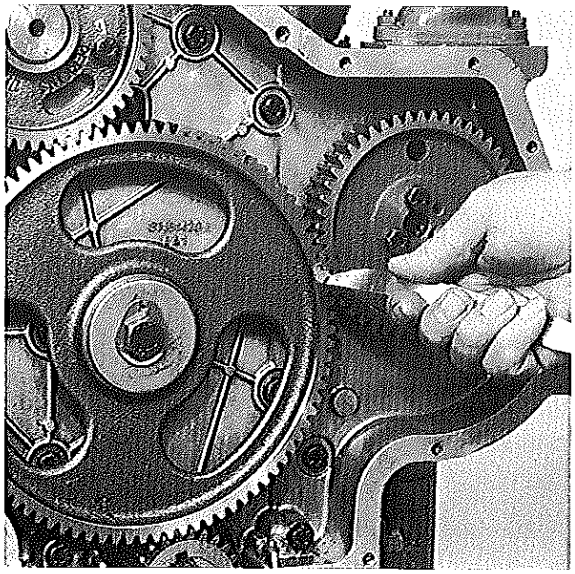


Fig. K3

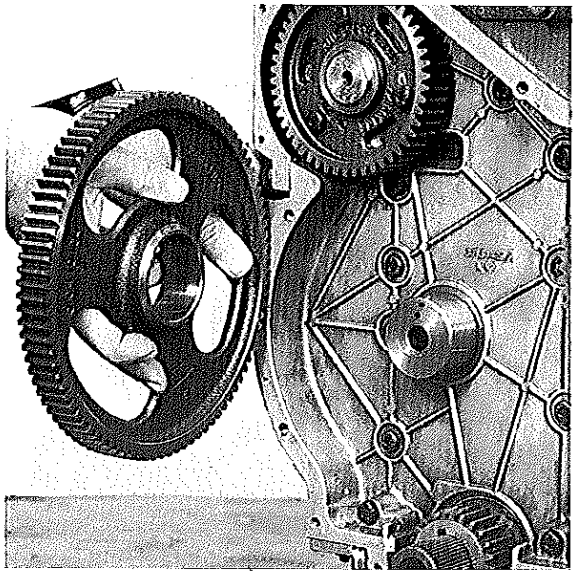


Fig. K4

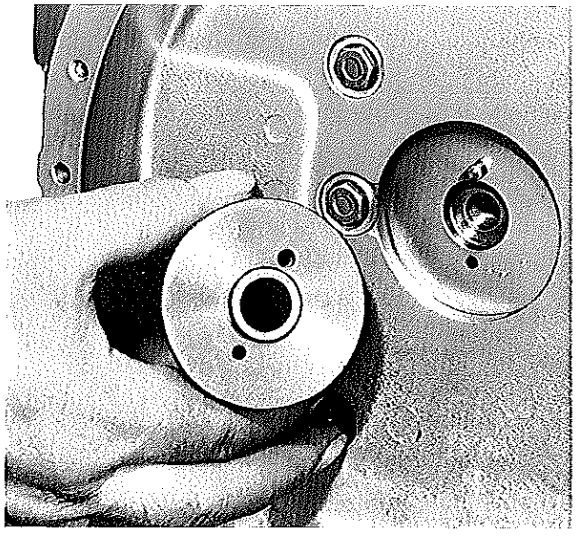


Fig. K4A

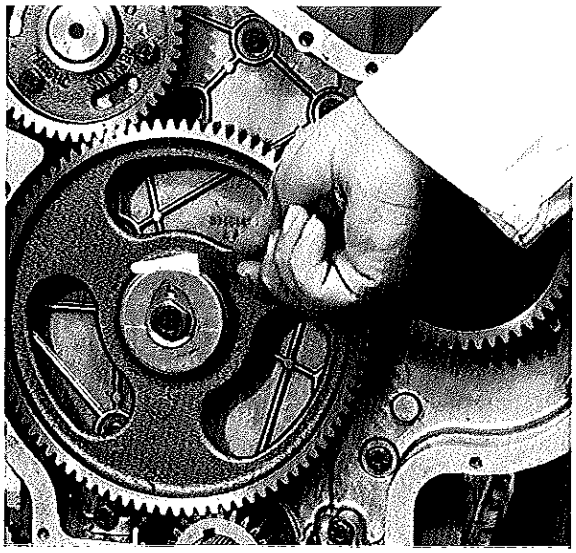


Fig. K5

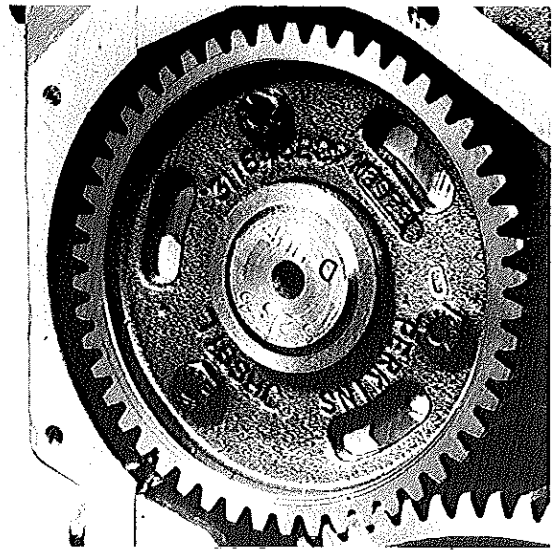


Fig. K6

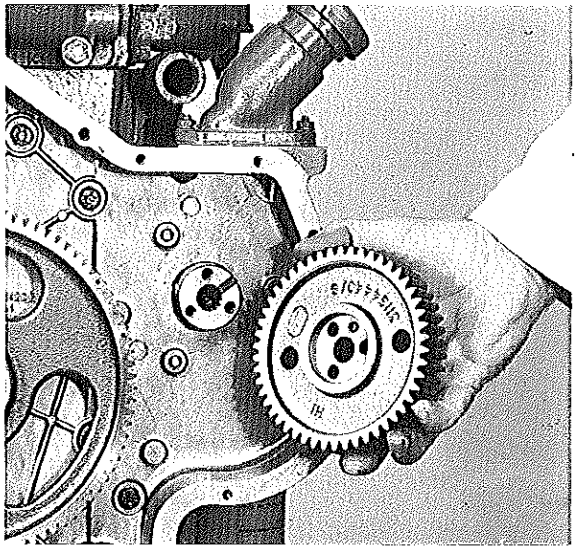


Fig. K7

To fit idler gear and hub

1. Ensure that the crankshaft, camshaft and fuel injection pump gears are in a position as shown in fig. L1 with the marks on the teeth towards the idler gear position. If the crankshaft or camshaft has to be turned, it will be necessary to remove the rocker shaft to ensure a piston does not contact a valve.
2. Fit idler gear hub so that small hollow dowel locates in hole in hub. The hub should be in its fully fitted position in the bore of the timing case.
3. Fit idler gear on hub with the long tapered centre boss towards the cylinder block and the timing marks aligned.
4. Fit idler gear end plate, locking washer and setscrew. Fully tighten setscrew and bend up locking washer. Ensure that idler gear has end clearance on hub (see fig. K5). End clearance must be 0,13 to 0,38 mm (0.005 to 0.015 in).

To remove camshaft gear

1. Turn crankshaft until timing mark teeth of crankshaft and camshaft gears are in mesh with idler gear.
2. Remove the three setscrews and washers which fasten gear to camshaft.
3. Remove camshaft gear from camshaft.

To fit camshaft gear

1. Remove idler gear and if necessary, remove rocker shaft to permit camshaft to be turned.
2. The spigot of the camshaft is stamped with the letter "D" and the camshaft gear is also stamped with the letter "D" (see fig. K6). Fit camshaft gear to camshaft with the letters "D" aligned. Do not fasten gear to camshaft by use of the slotted holes.
3. Fit and tighten the three washers and setscrews.
4. Turn camshaft until Nos. 4 and 6 cams are to the top. This can be checked by inspection of the tappets and this is the approximate position to align the timing marks.
5. Fit idler gear with all timing marks aligned and where necessary, fit rocker shaft.

To remove fuel injection pump gear

1. Turn crankshaft until timing mark tooth on fuel injection pump gear is in mesh with idler gear.
2. Remove the idler gear.
3. Remove setscrews or nut which fasten fuel injection pump gear.
4. Remove the fuel injection pump gear (see fig. K7). Ensure that no damage occurs to the dowel or key.

Note: Some engines are fitted with a fuel injection pump that has a tapered drive shaft which has a keyway and a single nut to fasten the gear. To remove the gear, use puller tool PD155B and metric adaptors PD155B-5.

To fit fuel injection pump gear

1. Where necessary, fit dowel to fuel injection pump gear.
2. Fit gear. Ensure dowel is in correct location between gear and fuel injection pump.
3. Fit and tighten washers and setscrews or nut. Tighten nut to the torque given on page C3.
4. Fit idler gear. Ensure all timing marks align.

To remove camshaft

1. Remove rocker shaft assembly.
2. Turn crankshaft until timing mark teeth of crankshaft and camshaft gears are in mesh with idler gear.
3. Remove fuel lift pump (see Section P).
4. Lift the tappets and remove the camshaft and gear from the cylinder block (see fig. K8). Ensure that no damage occurs to journals, cams or tappets.

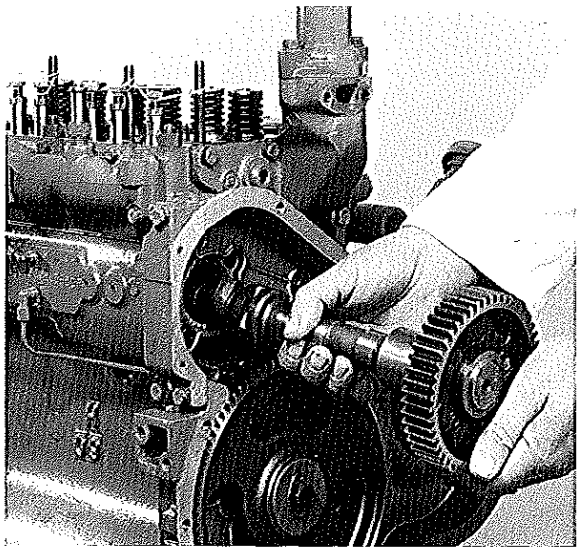


Fig. K8

To fit camshaft

1. Where necessary, remove idler gear and put into position with timing mark teeth aligned with timing mark teeth of crankshaft and fuel injection pump gears.
2. Lift tappets and carefully fit camshaft and gear. During this operation, the camshaft must be continuously turned. Ensure that no damage occurs to journals, cams or tappets. Ensure that the timing marks on idler gear and camshaft gear are correctly aligned.
3. Fit fuel lift pump.
4. Fit rocker shaft assembly and adjust tappet clearances.

Camshaft thrust

The camshaft end clearance is controlled by a steel spring fitted to the inside of the timing case cover. This is shown in fig. K1.

To remove timing case

1. Remove timing case cover.
2. Remove rocker shaft aasembly.
3. Remove lubricating oil sump (see Section M).
4. Remove timing case bottom cover (see fig. K9).
5. Remove idler gear as already given. It is easier to remove the idler gear hub when the timing case has been removed.
6. Remove fuel lift pump.
7. Lift tappets and remove camshaft and gear. Ensure that no damage occurs to journals, cams or tappets.
8. Release the three setscrews or nut and remove the gear from the fuel injection pump.

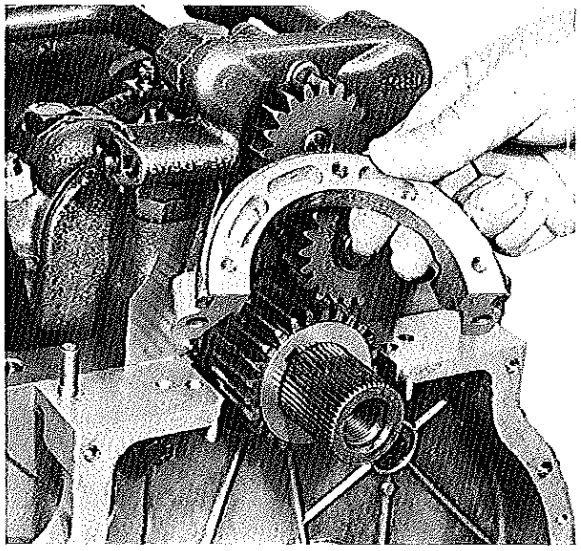


Fig. K9

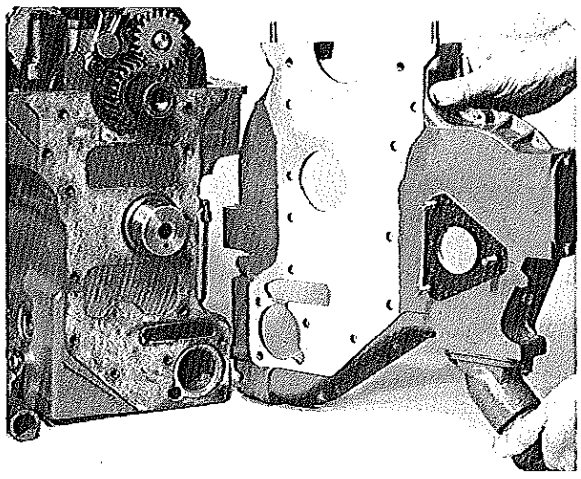


Fig. K10

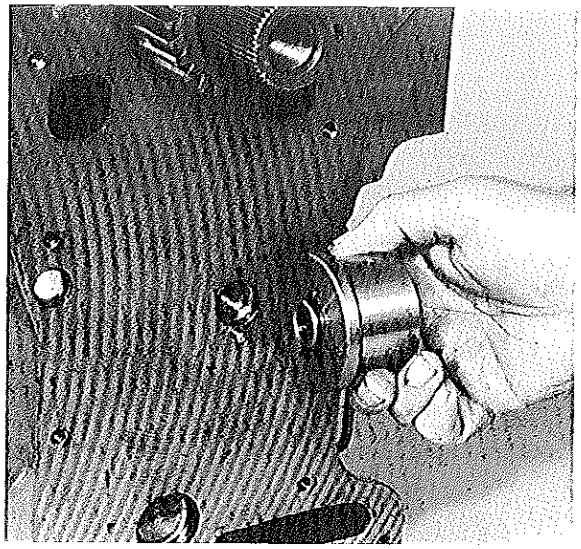


Fig. K11

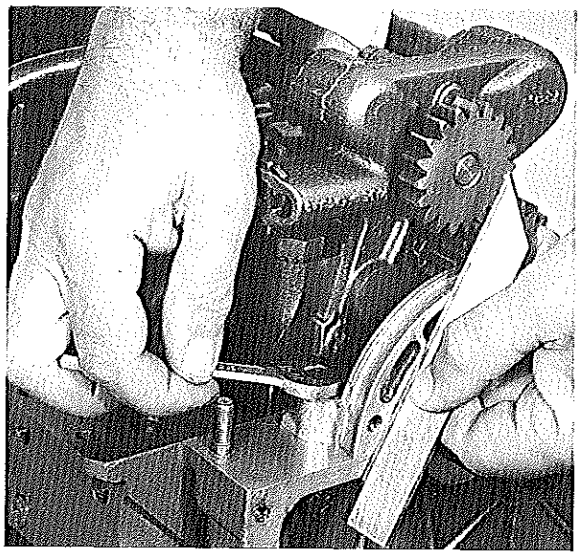


Fig. K12

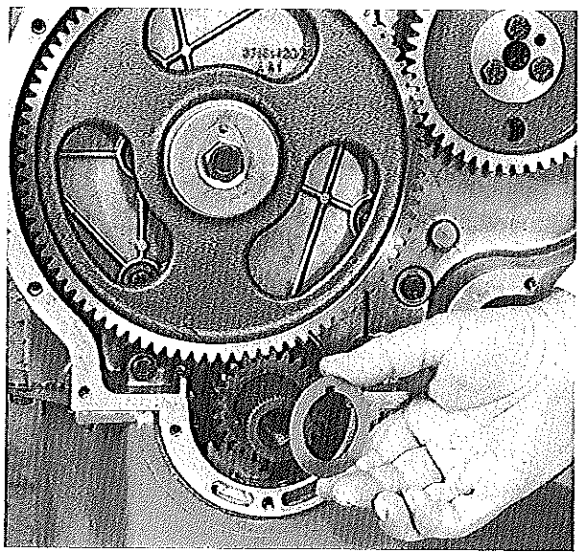


Fig. K13

9. Remove all controls and pipes from injection pump. To remove the high pressure pipes from the pump, release the pipes at the atomiser end first and then remove the pipes completely.
10. Remove the three nuts, spring washers and plain washers which fasten the fuel injection pump flange to the timing case and remove the pump. Ensure that all inlet and outlet connections of the fuel injection system are sealed to prevent dust or dirt contamination.
11. Remove setscrews and washers which fasten timing case to cylinder block and by means of light force, remove timing case from block (see fig. K10).
12. Remove idler gear hub (see fig. K11).

To fit timing case

1. To ensure correct location of timing case, fit and fully fasten idler gear hub to cylinder block (see fig. K11).
2. Use a new joint and fit the timing case to the front face of the cylinder block.
3. Fit timing case bottom cover. Ensure it is correctly aligned with front face of timing case (see fig. K12).
4. Fit fuel injection pump to rear face of timing case. Ensure that timing marks on pump flange and rear face of timing case are aligned.
5. Turn crankshaft until No. 1 piston is at TDC (key at front of crankshaft in top position).
6. Fit gear to fuel injection pump. Ensure dowel or key between gear and pump is in correct location.
7. Lift tappets and fit camshaft and gear.
8. Fit idler gear on its hub. Ensure that the timing mark teeth on crankshaft, fuel injection pump and camshaft gears are aligned with timing mark teeth of idler gear.
9. Fit lubricating oil sump (see Section M).
10. Where necessary, fit crankshaft pulley distance piece or oil thrower (see fig. K13).
11. Fit timing case cover.
12. Fit controls and pipes to fuel injection pump.

New timing case

When a new timing case is fitted, this will not be marked on the rear face for the correct alignment of the fuel injection pump.

After a new timing case has been fitted, the fuel injection pump timing must be checked by one of the two methods given in Section L and the rear of the timing case stamped with a timing mark to align with the timing mark on the fuel pump flange or straight edge of the timing tool pointer (see fig. L8).

SERVICE BULLETIN

3.1524

29

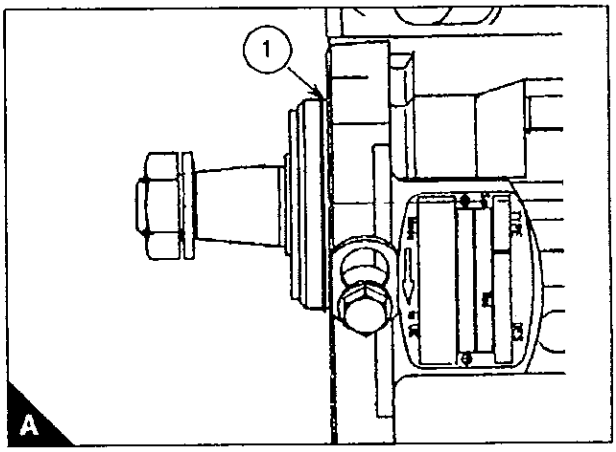
Lucas DP200 Series fuel injection pump

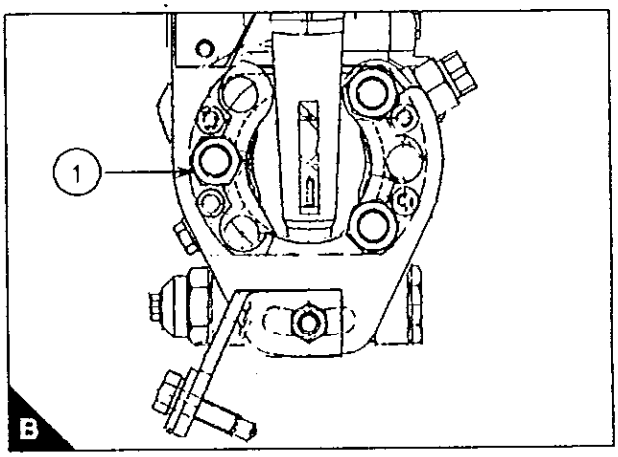
January 1994

The Lucas DP 200 Series fuel injection pump, has been introduced on some 3.1524 engines. The engine build lists affected are: CM50463; CM50449; CM31272; CM31271.

This type of fuel injection pump has an "O" ring (A1) fitted instead of a joint between the pump flange and the timing case.

The high-pressure outlet for number 1 cylinder is shown at (B1).





To remove and to fit the fuel injection pump

To remove

Caution: *Do not turn the crankshaft when the pump is not on the engine; the loose fuel pump gear may damage the timing case.*

1 Remove the pipes and cables from the fuel pump.

2 Loosen the nuts on the pump flange.

3 Release the nut and remove the nut, the bolt and the plain washer from the support bracket for the fuel pump. Release the setscrew and remove the support bracket from the cylinder block. Ensure that the plain washer is not lost.

4 Release the setscrews and remove the gear cover from the timing case cover. Release by one to two turns the nut which retains the drive gear for the fuel pump. Fit the gear puller PD.155C together with adaptors PD.155B-5 and loosen the gear on the drive shaft of the pump. Remove the puller. Remove the nut and the spring washer.

5 Remove the nuts from the flange of the fuel pump and remove the pump.

To fit

1 Inspect the "O" ring (A1) on the flange of the pump and, if necessary, fit a new "O" ring. Lightly lubricate the "O" ring with clean engine lubricating oil and put the pump into position on the timing case. Ensure that the key is engaged correctly in the keyway of the drive gear. Also ensure that the "O" ring is not damaged when the fuel pump is fitted. Fit the nuts finger tight to the flange of the fuel pump.

2 Fit the spring washer and the nut to retain the drive gear. Tighten the nut to approximately 15 Nm (11 lbf ft) 1,5 kgf m.

3 Turn the body of the fuel pump to align the mark on the flange of the pump with the mark on the rear face of the timing case. Tighten the nuts on the flange of the fuel pump to 22 Nm (16 lbf ft) 2,2 kgf m.

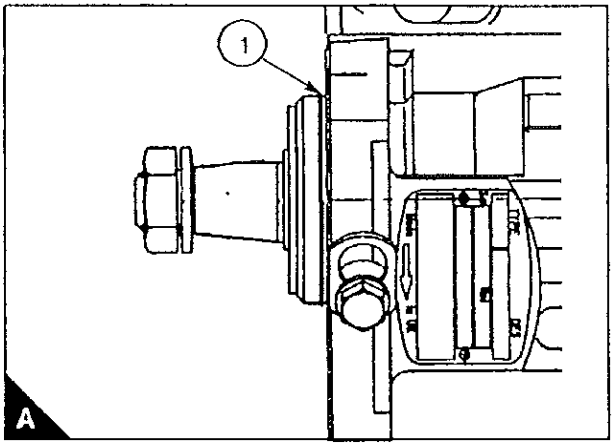
4 Fully tighten the nut for the drive gear to 80 Nm (59 lbf ft) 8,2 kgf m. Fit the gear cover.

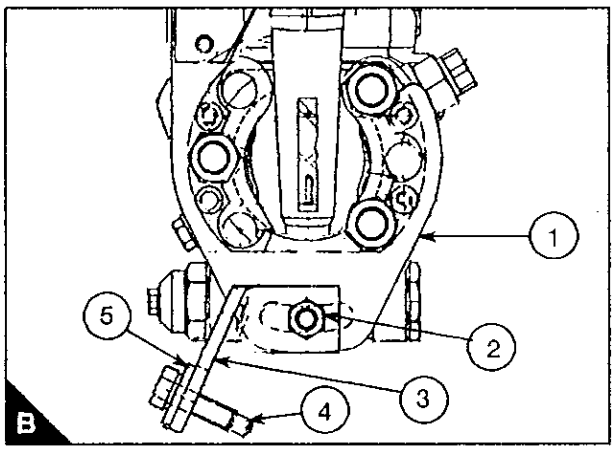
5 Fasten the support bracket (B3) for the fuel pump loosely to the cylinder block with the setscrew (B4). Ensure that the plain washer (B5) is under the head of the setscrew. Put the bolt in position through the bracket (B1) on the rear of the fuel pump and the support bracket. Ensure that the plain washer is under the head of the bolt. Fit the nut (B2) loosely to the bolt. Tighten the support bracket to the cylinder block and then tighten the nut and bolt on the fuel pump bracket to the support bracket.

6 Fit the pipes and cables to the pump.

7 Eliminate air from the fuel system, see page 3.

8 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed and the maximum no-load speed are correct, see page 5.





To eliminate air from the fuel system

Air will be eliminated from the fuel injection pump automatically. If the fuel system is empty or if the canister of the fuel filter has been renewed, it will be necessary to eliminate air from the fuel system.

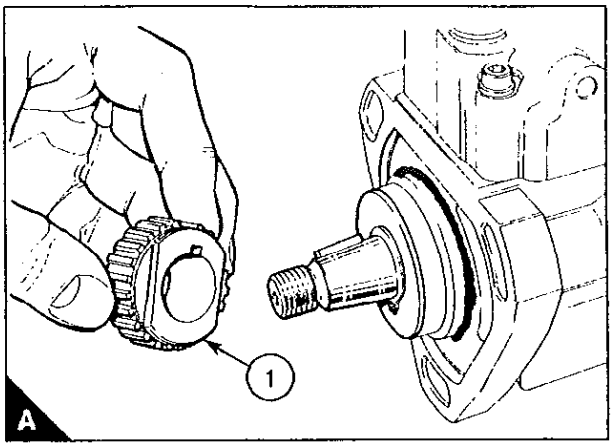
1 Release the vent plug on the fuel filter head.

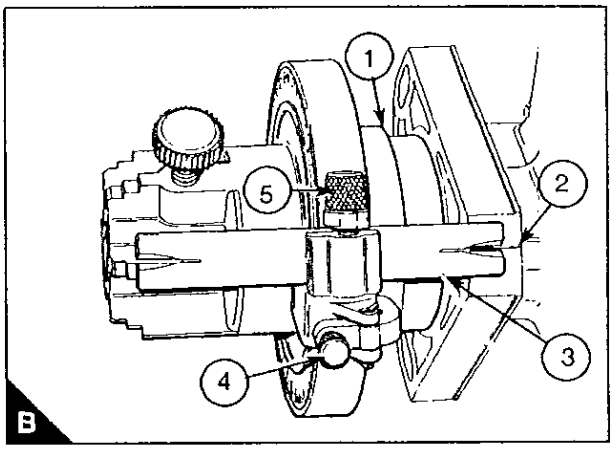
2 Operate the priming lever of the fuel lift pump until fuel, free of air, comes from the vent plug. Tighten the vent plug. If the drive cam of the fuel lift pump is at the point of maximum lift, it will not be possible to operate the priming lever. In this situation, the crankshaft must be turned one revolution.

3 Loosen the high-pressure connections at the atomisers.

4 Ensure that the manual stop control, if one is fitted, is in the "run" position. Operate the starter motor until fuel, free of air, comes from the pipe connections. Tighten the connections to 18 Nm (13 lbf ft) 1,8 kgf m.

5 The engine is now ready to start.





To check the timing mark on the flange of the fuel injection pump

1 Remove the fuel injection pump.

2 Fit the adaptor (A1), PD.67-3, for the timing tool (B), MS.67B, to the drive shaft of the pump. Use the nut for the drive gear to retain the adaptor, tighten the nut finger tight.

3 Connect number 1 high-pressure outlet (B1, page 1) to an atomiser tester. Operate the hand pump until a pressure of 30 atm (440 lbf in^2) 31 kgf/cm^2 is indicated on the gauge.

4 Loosen the locking screw (B4) on the timing tool and set the timing tool to 333.5°.

5 Tighten the locking screw. Fit the timing tool, MS.67B, together with the spacer (B1), to the adaptor on the pump.

6 Release the locking screw (A5) and slide the pointer (A3) forward until it is over the centre of the pump flange and tighten the locking screw.

7 Turn the timing tool together with the drive shaft of the fuel pump in the normal direction of rotation until the fuel pressure prevents further movement of the pump. In this position, the fuel pump is set at the start of injection from number 1 outlet.

8 Check that the slot in the pointer is aligned with the mark (A2) on the flange of the pump. If the mark is not correct, remove the timing tool and eliminate the mark. Fit the timing tool and ensure that the fuel pump is at the start of injection for number 1 cylinder. Loosen the locking screw (A5). Slide the pointer forward to the complete width of the flange and tighten the locking screw. Make a new mark on the flange of the pump through the slot in the pointer.

9 Remove the timing tool and its spacer (A1). Remove the nut and the adaptor, PD.67-3, from the shaft of the pump.

10 Disconnect the atomiser tester from number 1 high-pressure outlet.

11 Fit the fuel injection pump, see page 2.

To check the engine timing mark

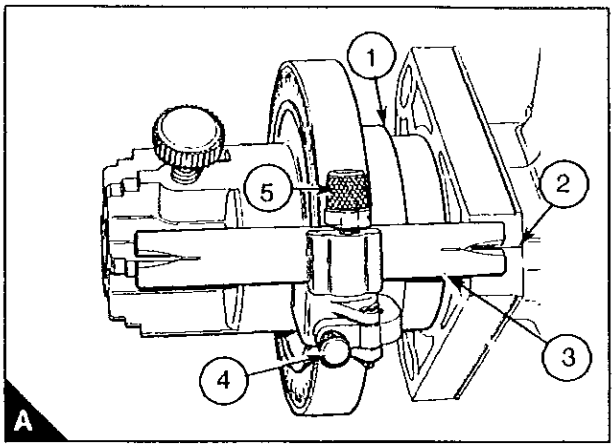
1 Set the piston of number 1 cylinder to TDC on the compression stroke.

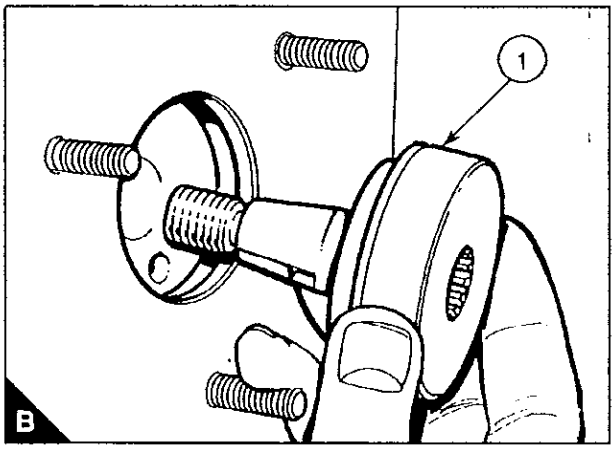
2 Remove the fuel injection pump.

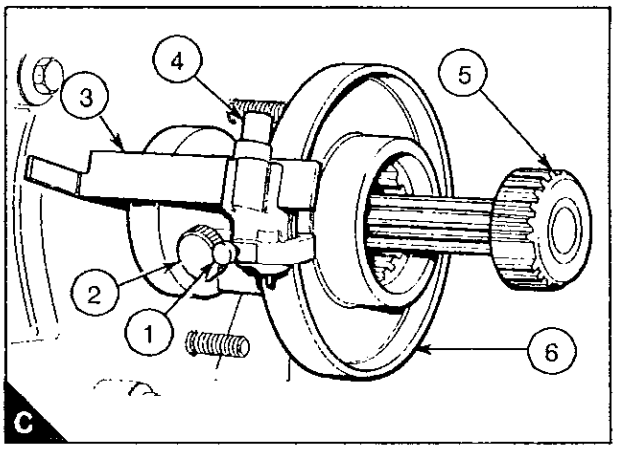
3 Align the key in the adaptor (B1), PD.67-2, for the timing tool, MS.67B, with the keyway in the gear for the fuel injection pump and fit the adaptor to the gear. Ensure that the adaptor is against the rear face of the timing case. Secure the adaptor to the gear with the nut supplied with the adaptor.

4 Loosen the locking screw (C1) on the timing tool MS.67B. Set the timing tool to 37° and tighten the locking screw. Loosen the locking screw (C2) and fit the splined shaft (C5) into the timing tool (C6). Loosen the locking screw (C4). Fit the 90° pointer (C3), PD.67-4 and tighten the locking screw.

5 Fit the splined shaft of the timing tool to the adaptor (B1). Slide the timing tool along the splined shaft until it is against the adaptor and tighten the locking screw (C2).







6 Loosen the locking screw (C4, page 4). Slide the pointer forward until the flat face is against the rear face of the timing case and tighten the locking screw. Hold the timing tool clockwise to eliminate backlash and check that the mark on the rear face of the timing case aligns with the top edge of the pointer (C3, page 4). If the mark on the timing case is not aligned correctly, remove the timing tool and eliminate the mark. Fit the timing tool. Ensure that the pointer is against the timing case and eliminate the backlash. Make a new mark on the timing case along the top straight edge of the pointer.

7 Remove the timing tool and the adaptor.

To adjust the fuel injection pump

To adjust the idle speed

The setting for the idle speed can change for different applications. The correct speed will normally be given in the manufacturer's handbook for the application. If it is not given, consult your nearest Perkins distributor or the Technical Service Department, Perkins Group of Companies Ltd, Peterborough, England.

1 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, the correct idle speed can be obtained by adjustment of the adjustment screw (A1).

2 Release the locknut and turn the adjustment screw clockwise to increase the speed or counter-clockwise to decrease the speed.

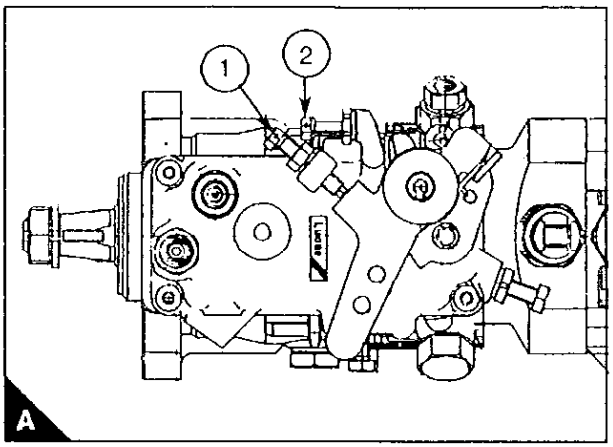
3 When the speed is correct, tighten the locknut.

To adjust the maximum no-load speed

Caution: *The maximum no-load speed must only be adjusted by a person approved by Perkins or by Lucas. Failure to conform with this will make the warranty invalid.*

The maximum no-load speed is indicated by the last part of the setting code for the fuel injection pump. The setting code can be found on the data plate on the side of the fuel injection pump. A typical setting code is 2644A000HW/1/2470. In this example, the maximum no load speed is 2470 rev/min.

1 With the engine at its normal temperature of operation, check the maximum no-load speed. If necessary, this speed can be adjusted by the adjustment screw (A2).



2 Release the locknut and turn the adjustment screw counter-clockwise to increase, or clockwise to decrease, the speed.

3 When the speed is correct, tighten the locknut and seal the adjustment screw. The person who fits the pump must ensure that the adjustment screw is suitably sealed against interference after it has been set initially.

End

SECTION L
Timing

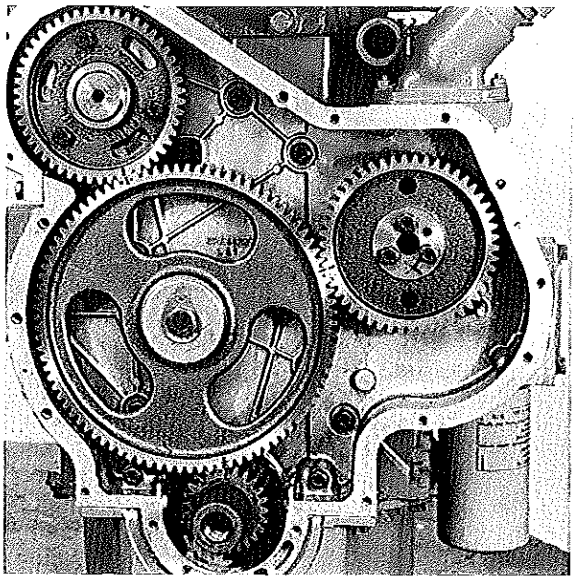


Fig. L1

Gear timing marks

The timing gears are stamped with timing marks to ensure correct assembly (see fig. L1).

See Section K for gear assembly instruction.

Fuel injection pump timing marks

A timing mark is stamped on the fuel injection pump flange and a further mark is stamped on the rear face of the timing case (see fig. L2). If these marks are in alignment and the fuel pump gear is in correct mesh, then the fuel pump timing is correct.

To set engine timing

1. Remove atomisers.
2. Remove rocker shaft assembly.
3. Turn crankshaft so that the crankshaft gear key is at TDC.
4. Fit camshaft gear with the letter "D" in alignment with the letter "D" on the camshaft hub.
5. Fit fuel injection pump gear. This has a dowel and will only fit in one position.
6. Ensure that fuel injection pump is fitted to engine with the timing mark on the flange in alignment with the timing mark on the rear of the timing case (see fig. L2).
7. Fit idler gear with all timing marks on teeth of gears aligned (see fig. L1).

To check valve timing

1. Turn engine until No. 3 cylinder exhaust valve is fully open.
2. In this position set the valve tip clearance on No. 1 inlet valve to 1,09 mm (0.043 in) for 3.152 and D3.152 engines or 0,80 mm (0.0315 in) for 3.1522, 3.1524 and T3.1524 engines.
3. Turn engine clockwise from front until tappet of No. 1 inlet valve just tightens.
4. In this position, No. 1 piston will be within 2½° of TDC. This can be checked by a mark on the flywheel or on some applications, a timing pin is fitted to the timing case front cover. When loosened, it locates in a hole in the rear of the crankshaft pulley.
5. There is no adjustment for valve timing. If the timing is more than 2½° out of position, the timing gears are probably not in correct mesh.
6. After the valve timing has been checked, adjust tappet clearance of No. 1 inlet valve to 0,30 mm (0.012 in) for 3.152 and D3.152 engines or 0,20 mm (0.008 in) for 3.1522, 3.1524 and T3.1524 engines.

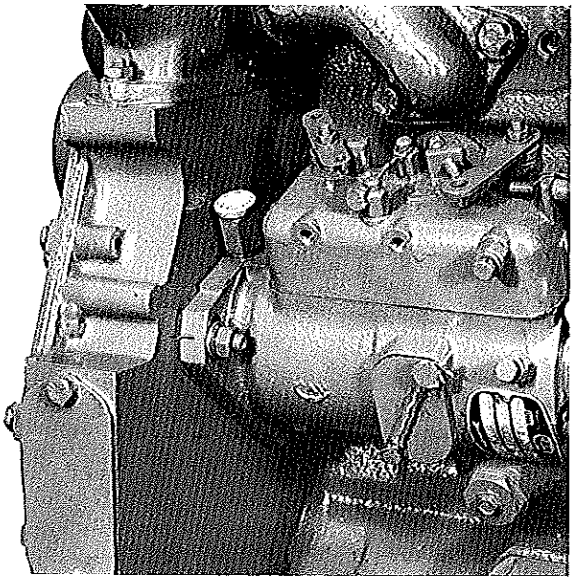


Fig. L2

To check DPA fuel injection pump timing by use of pump rotor marks

A circlip is fitted inside the fuel injection pump and when the square end of this circlip is aligned with the correct mark on the fuel pump rotor (see fig. L3), it indicates when the injection starts to No. 1 cylinder (static timing point).

With earlier fuel injection pumps, the timing circlip is stamped with a line which aligns with the correct mark on the fuel pump rotor (see fig. L4).

To see these timing marks, remove the inspection plate on the left side of the fuel injection pump body.

To set the timing circlip, remove the fuel injection pump from the engine. Connect No. 1 cylinder outlet to an atomiser tester and operate the tester until it reaches 31 kgf/cm^2 (30 atm or 440 lbf/in^2). Turn the pump by hand, clockwise from the front until it stops. The square end or the line on the circlip can now be adjusted until it aligns with the line marked "E" on the fuel injection pump rotor.

Check the fuel injection timing as follows:-

1. Ensure fuel injection pump circlip is in its correct position as already given.
2. Turn the engine until No. 1 piston is at TDC on compression (exhaust valve of No. 3 cylinder fully open). Remove the valve springs from No. 1 inlet valve and permit it to be held by the top of the piston. Fit a suitable collar at the top of the valve stem so that the valve will not fall completely into the cylinder.
3. Put a dial test indicator on the top of the valve stem (see fig. L5) and use the indicator to find the accurate No. 1 piston TDC position. Set the dial to zero.
4. Turn engine counter-clockwise from the front by an eighth of a turn and then clockwise until the piston is at the static timing position as given on page C14.
5. Check the fuel injection pump rotor. The line with the letter "E" must be aligned with the square end or the line on the circlip (see figs. L3 or L4). If the line on the rotor does not align with the circlip, turn the fuel injection pump in either direction on the rear of the timing case to make the necessary adjustment.

The circlip on current pumps is not set and timing tool MS67B must be used, see page L4.

Note: The seals on the fuel injection pump must only be broken by approved personnel who must also fit new seals.

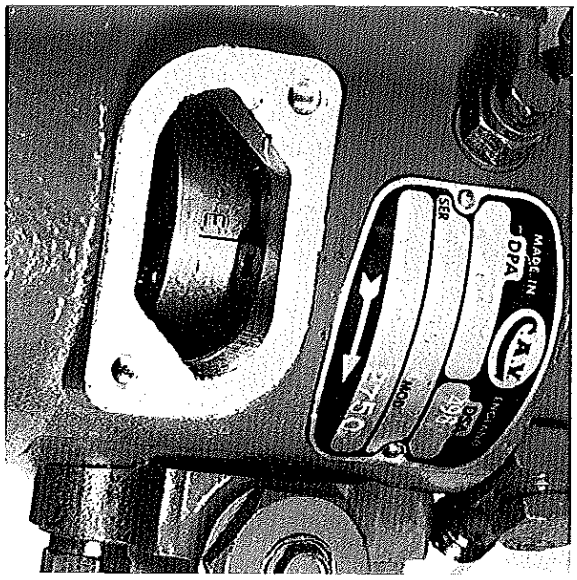


Fig. L3

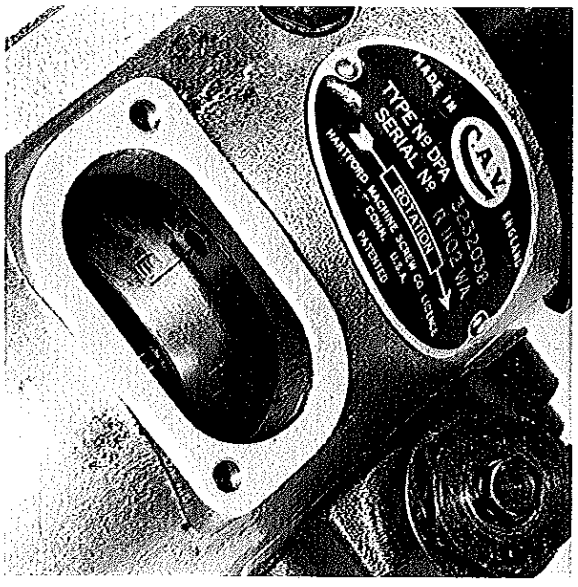


Fig. L4

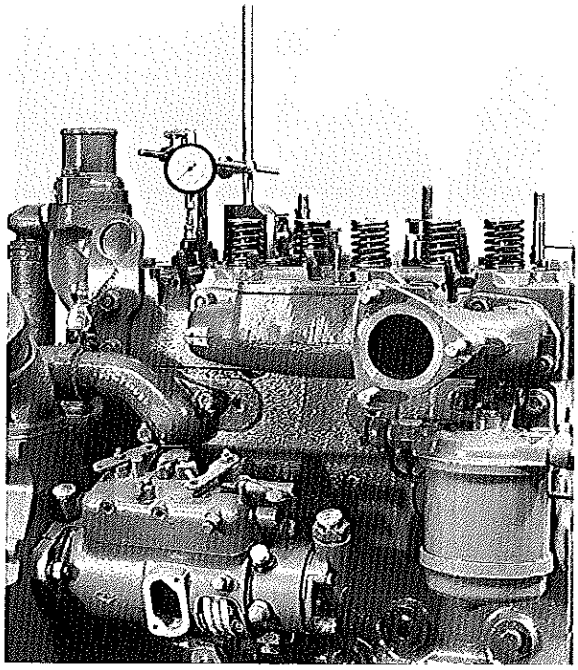


Fig. L5

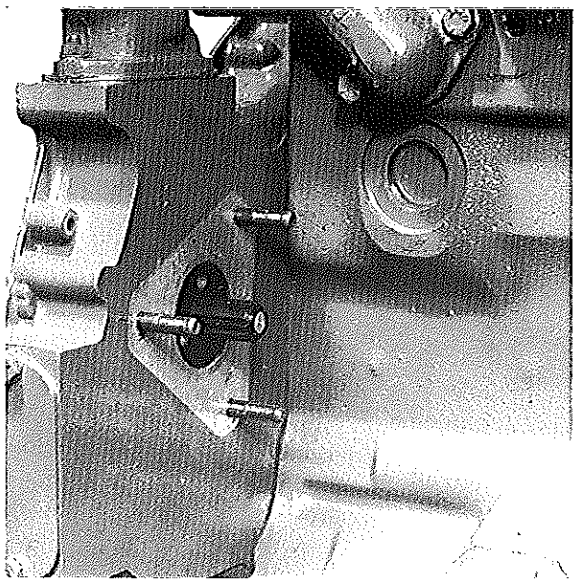


Fig. L6

To check fuel injection pump timing by use of tools MS.67B and adaptor PD.67B-1 and PD.67-2

1. Turn engine clockwise from front until No. 1 piston is at TDC on compression (exhaust valve of No. 3 cylinder fully open). This position can be found on some applications by a mark on the flywheel, or a timing pin fitted to the timing case front cover which, when loosened, engages in a hole in the rear of the crankshaft pulley. If neither of these methods are available, TDC can be found by the use of a dial test indicator on the top of a valve stem as already given.
2. Remove fuel injection pump and fit adaptor PD.67B-1 (see fig. L6) to fuel injection pump gear. Ensure dowel is in corrct location between gear and adaptor. The shaft of the adaptor must be toward the rear of the engine.

   For pumps with tapered drive shafts, fit adaptor PD.67-2 through hole in rear of timing case and secure with nut to fuel pump gear.
3. Loosen screw (5, fig. L7) of timing tool MS.67B and remove splined shaft (6) (retain for tapered drive shaft pumps). The adaptor ring (1) is not used with this engine type.
4. Ensure pointer (2) of timing tool is in position with right angled straight edge to front of tool and notch at the bottom (see fig. L8). The end of the pointer with the straight edge must be kept away from the front of the body. Ensure that the flat of the washer fitted behind the screw (3) which fastens the pointer, is in position over pointer.
5. Loosen screw (4) which fastens bracket and set bracket so that the edge with a chamfer is in line with the correct engine check angle (see page C14).
6. Press fuel injection pump gear and adaptor towards rear and connect splined shaft of adaptor into timing tool with master spline engaged and lock adaptor shaft in timing tool with rear face of adaptor against front face of timing tool.
7. Move tool forward complete with gear so that spigot of the tool fits in the hole in the timing case. For pumps with tapered drive shafts, fit timing tool in fuel pump position, slide splined shaft (6) forward into adaptor and lock with screw (5) (see figs. L7/L8). If pointer is 180° out of position, the engine is on the wrong stroke. Remove the tool and set engine on correct stroke. The fuel injection pump gear must be held in mesh when the engine is turned.
8. Move the pointer forward to reach rear face of timing case and lock in position.
9. Turn tool clockwise from rear to remove backlash and check that mark on rear of timing case aligns with straight edge of the pointer (see fig. L8). Make a new line if necessary or, if there is

no line, make a line along the straight edge of the pointer. If line is 7° or more from the straight edge, this indicates that gears are probably not correctly fitted and the timing of the gears must be checked.

10. Remove tool and adaptor from the fuel injection pump gear and fit fuel pump to engine as given on page P7.

To check mark angle of DPA fuel injection pump by use of tool MS.67B and adaptor PD.67-3

1. Loosen screw (5, fig. L7) and put the splined shaft with the small diameter to the rear to fit in the centre of the fuel injection pump hub. For pumps with tapered drive shafts remove splined shaft.
2. Ensure that pointer (2) of timing tool is in a position with slot to rear of tool and sides of the slot with chamfers are on the outside. The end of the pointer with the slot must be kept toward body of tool. Ensure that the flat of the washer fitted behind the screw (3) which fastens the pointer is in position over pointer.
3. Release screw (4) which fastens bracket and set bracket so that the edge with a chamfer is in line with the correct fuel injection pump mark angle (see page C14).
4. Fit timing tool with splined shaft in fuel injection pump hub and move tool toward the fuel pump to connect on the end of the hub and lock shaft in tool (see fig. L9). For pumps with tapered drive shafts, fit adaptor PD.67-3 onto drive shaft key and then locate timing tool over adaptor and drive shaft.
5. Connect No. 1 cylinder outlet to an atomiser tester and operate the tester until it reaches 31 kgf/cm^2 (30 atm or 440 lbf/in^2). If pressure valve is fitted, this must be removed.
6. Turn pump clockwise from the front until it stops.
7. Move pointer forward until it is half over pump flange. Check that timing mark is central to slot in pointer. Make a new timing mark if necessary.

To check mark angle of Stanadyne Fuel injection pump by use of tool MS.67B and adaptor PD.67B-1 and PD.67B-6.

1. Fit the adaptor PD.67B-1 to the hub of the pump by use of the special setscrews (part of tool PD.67B-6). Ensure that the location slots of the hub and adaptor are together and in line (use the alignment gauge, part of tool PD.67-6) and that the adaptor is concentric with the hub.

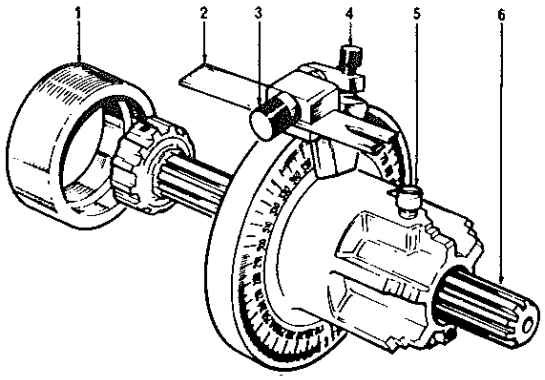


Fig. L7
Timing Tool

1. Adaptor Ring
2. Pointer
3. Pointer Securing Screw
4. Bracket Securing Screw
5. Shaft Securing Screw
6. Splined Shaft

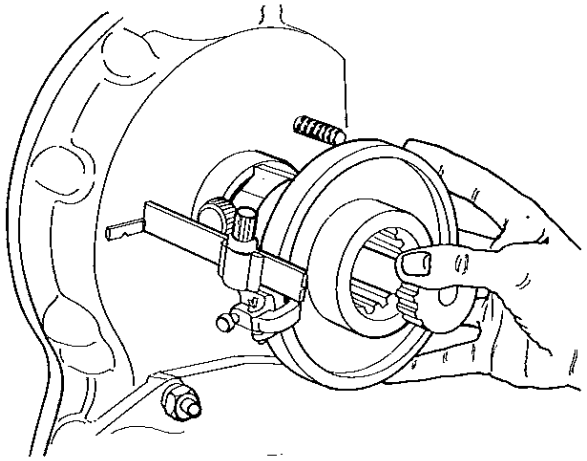


Fig. L8

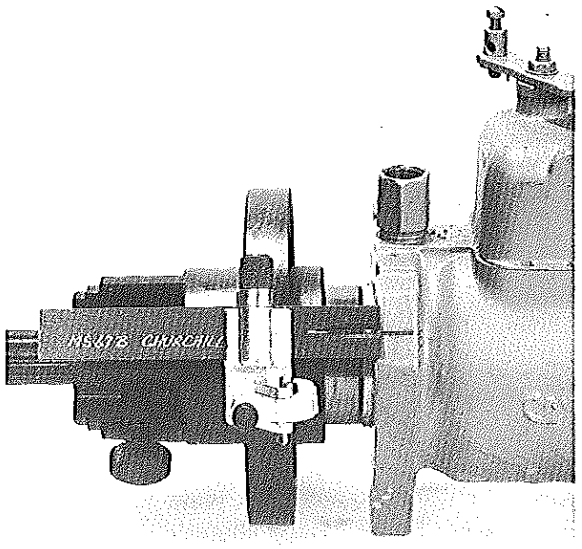


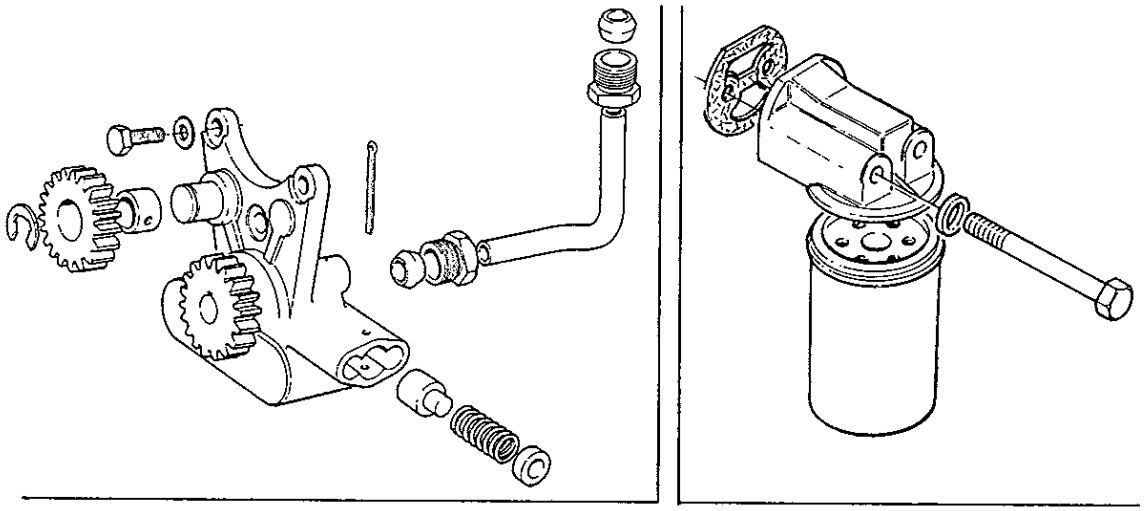
Fig. L9

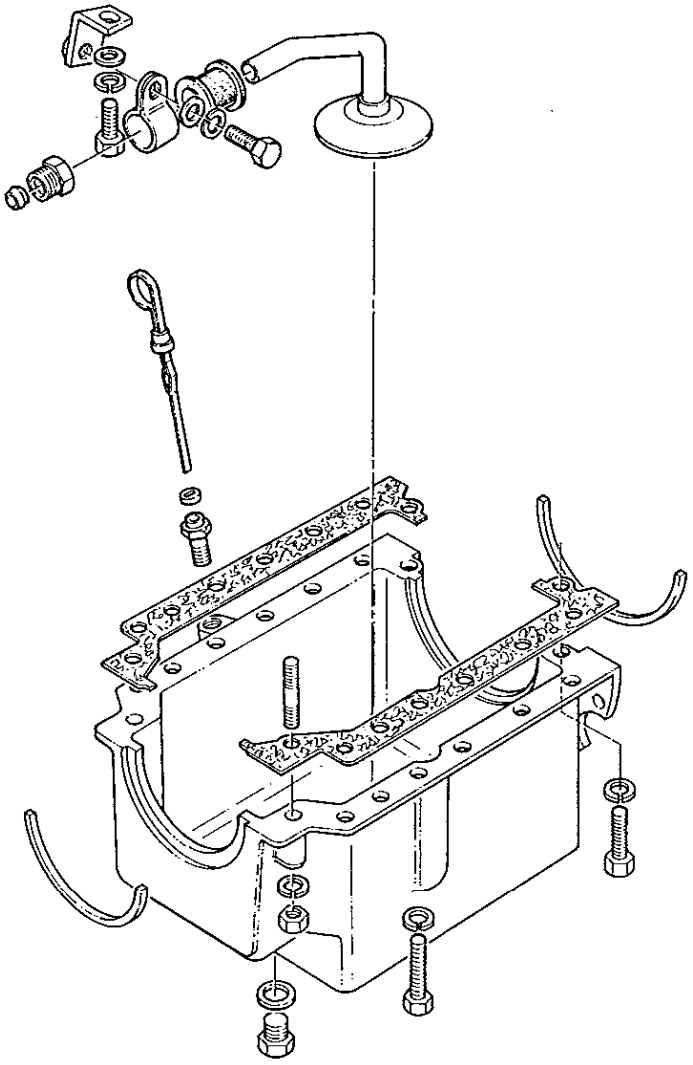
2. Remove the splined shaft from the timing tool (MS.67B) and slide the small splined open end of the timing tool onto the splined shaft of adaptor PD.67B-1. Lock the timing tool into position with securing screw (5, fig. L7).
3. Ensure the long pointer, part of tool PD.67B-6 is in position and sides of slot with chamfers are on the outside. Ensure that the flat of the washer fitted behind the screw (3, fig. L7) which fastens the pointer is in position.
4. Release screw (4, Fig. L7) which fastens bracket and set bracket so that the edge with a chamfer is in line with the correct fuel injection pump mark angle (see page C14).

Note: As the tool will have to be fitted in the reverse position to normal, the setting angle has been adjusted to allow for this (see page C14).

5. Connect No. 1 cylinder outlet to an atomiser tester and operate the tester until it reaches 31 kgf/cm^2 (30 atm or 440 lbf/in^2). If a pressure valve is fitted, this must be removed.
6. Turn pump clockwise from the front until it stops.
7. Move pointer forward until it is half over pump flange. Check that timing mark is central to slot in pointer. Make a new timing mark if necessary.

SECTION M
Lubrication System





Lubrication circuit

The lubrication circuit is shown in fig. M1.

Pressure lubrication is supplied by a rotor type pump driven through gears from the front of the crankshaft. The lubricating oil is sent through a full flow filter to the pressure rail which is horizontally drilled along the left side of the cylinder block. From the pressure rail, lubricating oil passes to the crankshaft main bearings and through the crankshaft to the big end bearings. On T3.1524 engines, lubricating oil is passed from the filter head/pressure rail connection, to the turbocharger bearings. The cylinder bores, pistons and small end bushes are lubricated by splash.

A hole is drilled across the front of the cylinder block which connects with the pressure rail. Lubricating oil comes out of this hole on the camshaft side of the engine and passes through an outside pipe to the lower connection of the centre camshaft bearing. With some engines, oil is also passed to the front camshaft bearing.

As the camshaft turns, a slot in the camshaft centre journal aligns with two holes in the camshaft bearing and a reduced lubricating oil supply passes to the cylinder head through another outside pipe to lubricate the rocker shaft assembly. From the rocker shaft assembly, oil falls from the cylinder head into the camshaft chamber and from the front of the chamber to the timing gears. The timing gears are also lubricated by oil which passes from the horizontal passage at the front of the cylinder block to the idler gear hub. Oil then passes from the hub through a hole in the idler gear boss.

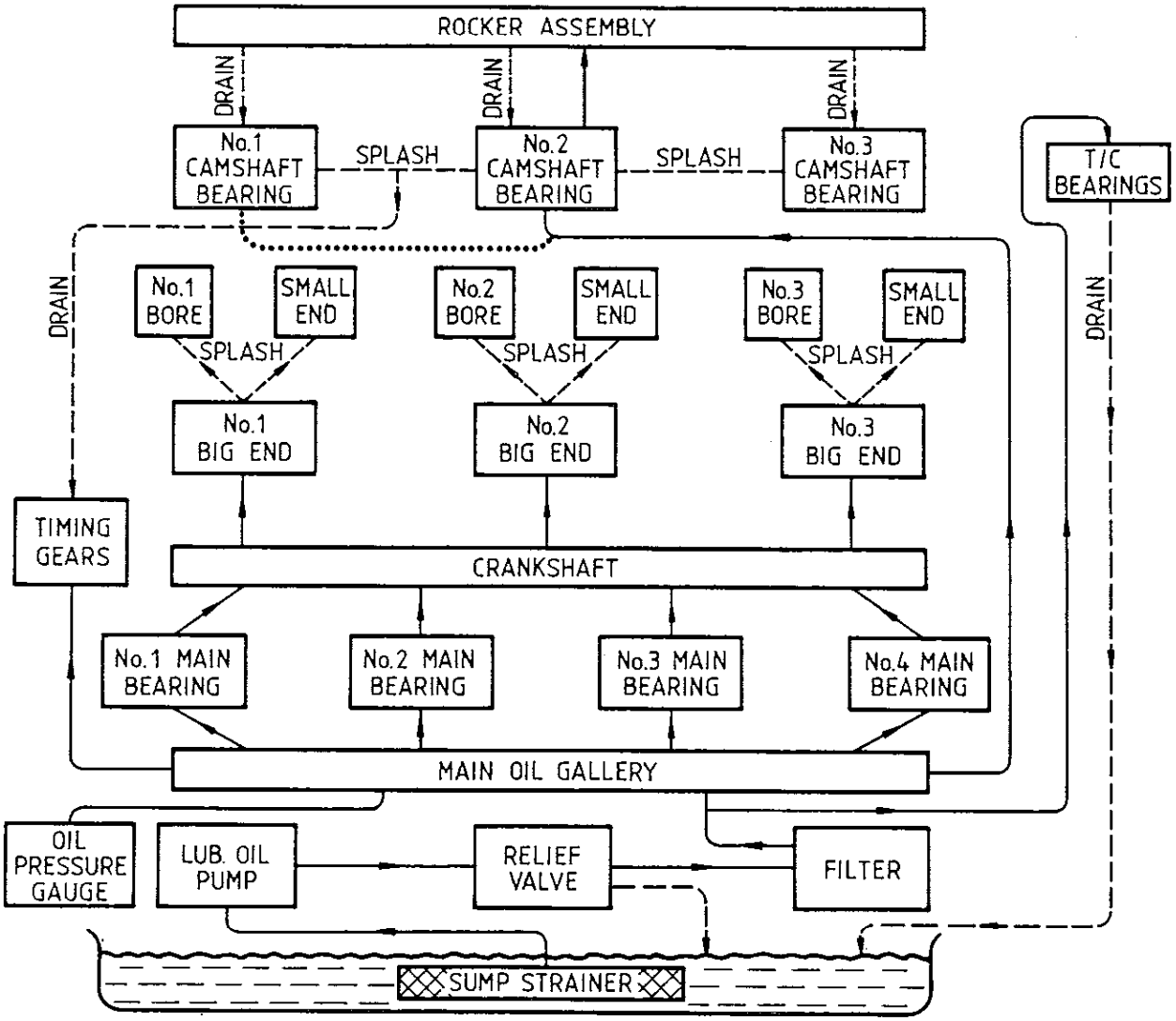


Fig. M1
Lubricating Oil Diagram

Lubricating oil pressure

Ensure that lubricating oil pressure is shown on the gauge.

The oil pressure can be variable with different engines, but the minimum pressure at maximum engine speed and normal engine temperature is 207 kN/m² (30 lbf/in²) or 2,1 kgf/cm².

There can be a decrease in pressure when idling and when the engine is hot.

If the lubricating oil pressure shown on the gauge is below normal, check for the reason in the order which follows.

1. Check for correct amount of lubricating oil in sump.
2. Check oil pressure for accuracy.
3. Ensure lubricating oil filter is not dirty. If necessary, fit new canister or element.
4. Ensure sump strainer is not dirty. Clean if necessary.
5. Ensure that suction and delivery pipes to and from lubricating oil pump are tight.
6. Dirt can keep the lubricating oil relief valve open.

Lubricating oil filters

It is important that the lubricating oil filter canister or element is renewed at the correct interval as given on page D2.

The strainer in the lubricating oil sump needs no special maintenance but can be cleaned every time the sump is removed.

With current engines, the main lubricating oil filter has an element which is integral with the canister.

Earlier engines had a separate element fitted in a filter bowl.

Both types of element must be renewed and not cleaned. The correct service interval is given on page D2.

To renew lubricating oil filter element

1. Remove centre bolt on filter head (see fig. M2).
2. Remove filter bowl (see fig. M3).
3. Remove the filter element and discard.
4. Clean inside of filter bowl and fit new element.
5. Ensure that felt seal and rubber joints are in good condition. Renew them if necessary.
6. Fit element and bowl to filter head and tighten centre bolt.
7. Run engine and check for leakage. Check amount of lubricating oil in sump and fill as necessary.

The bolt which fastens the filter bowl must be checked to ensure that it is still tight after the first 20 hours of operation.

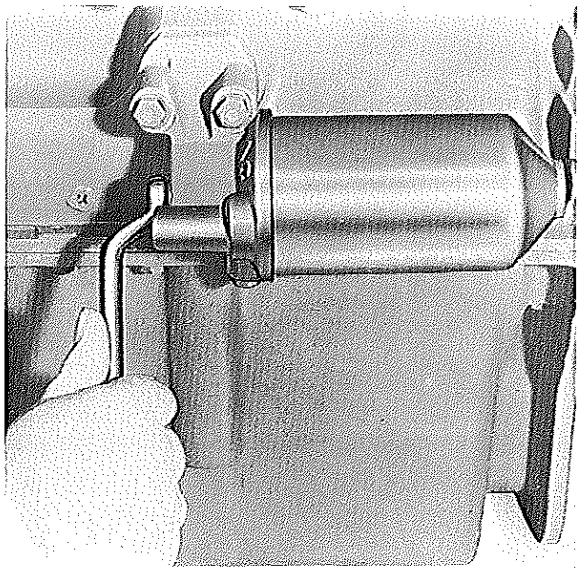


Fig. M2

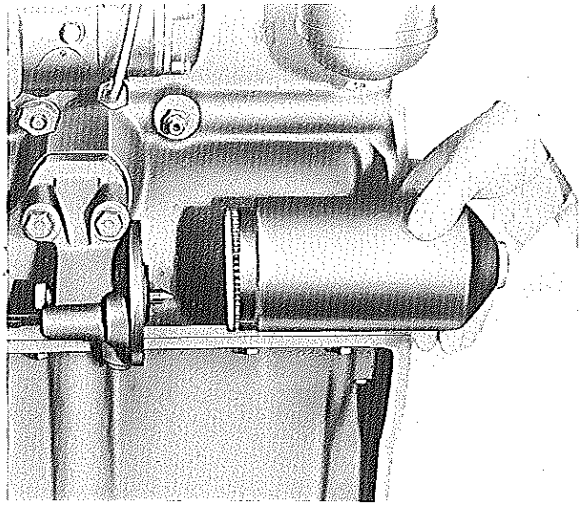


Fig. M3

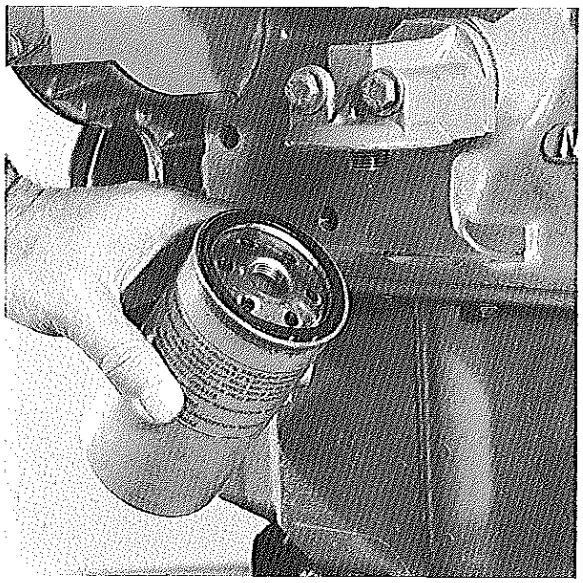


Fig. M4

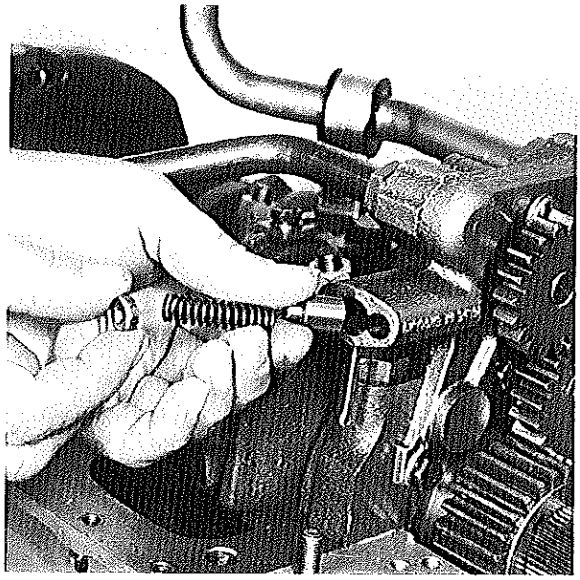


Fig. M5

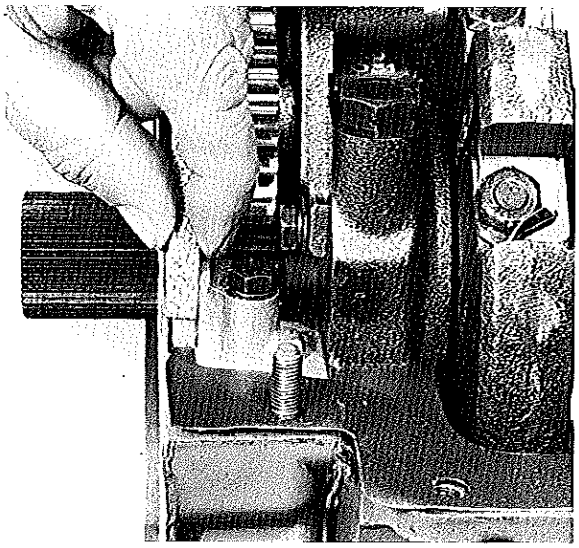


Fig. M6

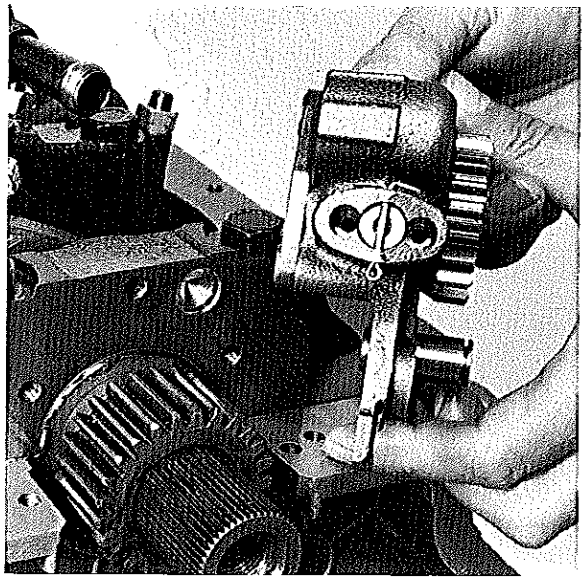


Fig. M7

To renew lubricating oil filter canister

1. Remove the filter canister with a strap wrench or similar tool and discard the canister (see fig. M4).
2. Clean the filter head.
3. Add clean engine lubricating oil to the new canister. Give the oil time to fill the canister through the filter element.
4. Lubricate the top of the canister seal with clean engine lubricating oil.
5. Install the new canister and tighten it by hand only. Do not use a strap wrench.
6. Run engine and check for leakage. Check amount of lubricating oil in sump and fill as necessary.

Note: Always ensure that the correct type of canister is fitted.

Lubricating oil relief valve

The lubricating oil relief valve is fitted in the lubricating oil pump body (see fig. M5) and prevents too much pressure when the lubricating oil is cold.

It consists of a spring loaded plunger.

When the lubricating oil pressure is more than the valve setting pressure, the valve opens and some of the lubricating oil is released to return to the sump. When the oil gets warm and reaches the correct pressure, the valve then closes.

Only adjust the pressure setting by the use of new parts.

To remove lubricating oil sump

1. Remove the drain plug and drain the sump.
2. Remove the dipstick.
3. Where necessary, remove setscrews which fasten rear of sump to flywheel housing.
4. Remove all setscrews and nuts which fasten sump to cylinder block and timing case and remove sump.

To fit lubricating oil sump

1. Ensure that all joint faces are clean. Fit new joints with jointing compound applied.
2. Put sump joints in position. Ensure that the ends of the joints fit into the recesses for the cork joints.
3. Fit cork joints in the recesses in the timing case and rear main bearing cap (see fig. M6).
4. Fit sump and tighten all setscrews and nuts.
5. Fit the sump drain plug and dipstick.
6. Fill the sump to the correct level with engine lubricating oil. Run the engine and check for leakage.

To remove lubricating oil pump

1. Remove lubricating oil sump as shown earlier.
2. Remove the three setscrews at bottom of timing case front cover and the two nuts at bottom of timing case. Remove bottom half of timing case.
3. Remove pump suction pipe and strainer and disconnect delivery pipe from pump to cylinder block.
4. Remove circlip and move idler gear forward.
5. Remove the three setscrews which fasten lubricating oil pump to front main bearing cap and remove the pump (see fig. M7).

To dismantle lubricating oil pump

1. Remove idler gear.
2. The lubricating oil pump gear must not be removed as this can reduce the interference fit of the gear. A pump which is worn can not be corrected as separate parts are not available.
3. Remove the three screws with a special screwdriver and remove the pump end plate.
4. Remove rubber sealing ring – where fitted (see fig. M8).
5. Remove outer rotor from pump body.
6. The lubricating oil relief valve is fitted in the body of the oil pump. It is adjusted before the engine goes out from the factory.

Lubricating oil pump inspection

The clearances for new pumps are given in Section C.

1. Thoroughly clean all parts and check for cracks and other damage.
2. Install outer rotor in pump body. Ensure edge of rotor with chamfer is to the inside of the pump body. Check clearance between maximum diameter of inner rotor and minimum diameter of outer rotor at all positions (see fig. M9).
3. Check the clearances between top of rotors and end of pump body (see fig. M10).

Note: If an oil pump is worn so that it does not give the correct lubricating oil pressure, it must be renewed. Component parts are not supplied separately.

To assemble lubricating oil pump

1. Fit outer rotor in pump body with edge of rotor with chamfer to the inside of the body.
2. Fit rubber sealing ring – where fitted.
3. Fit end cover and tighten screws.

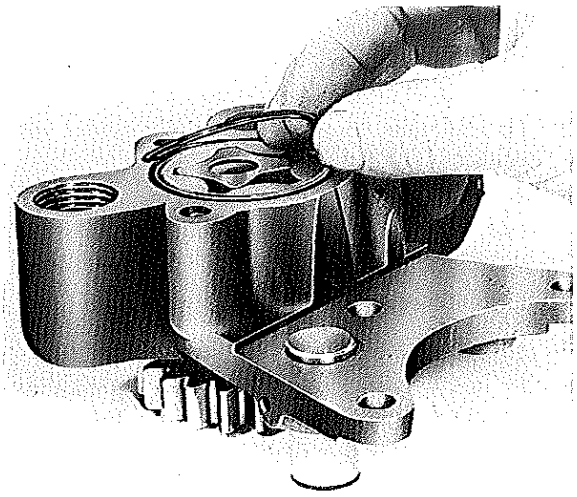


Fig. M8

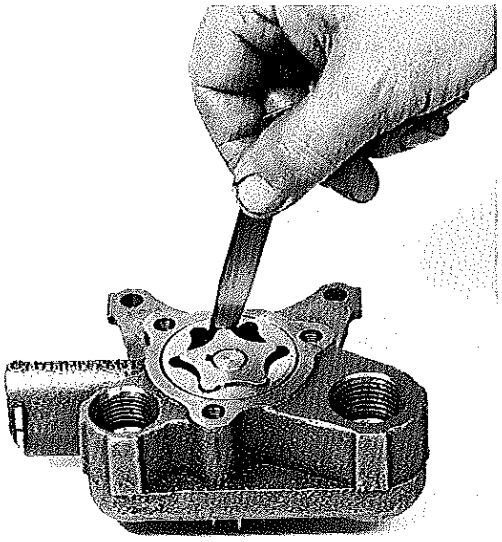


Fig. M9

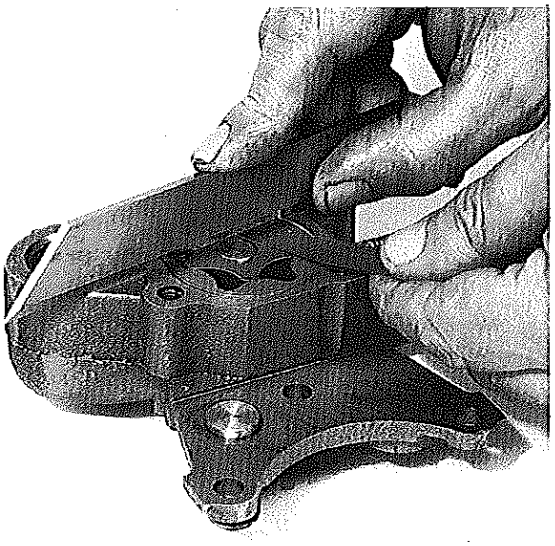


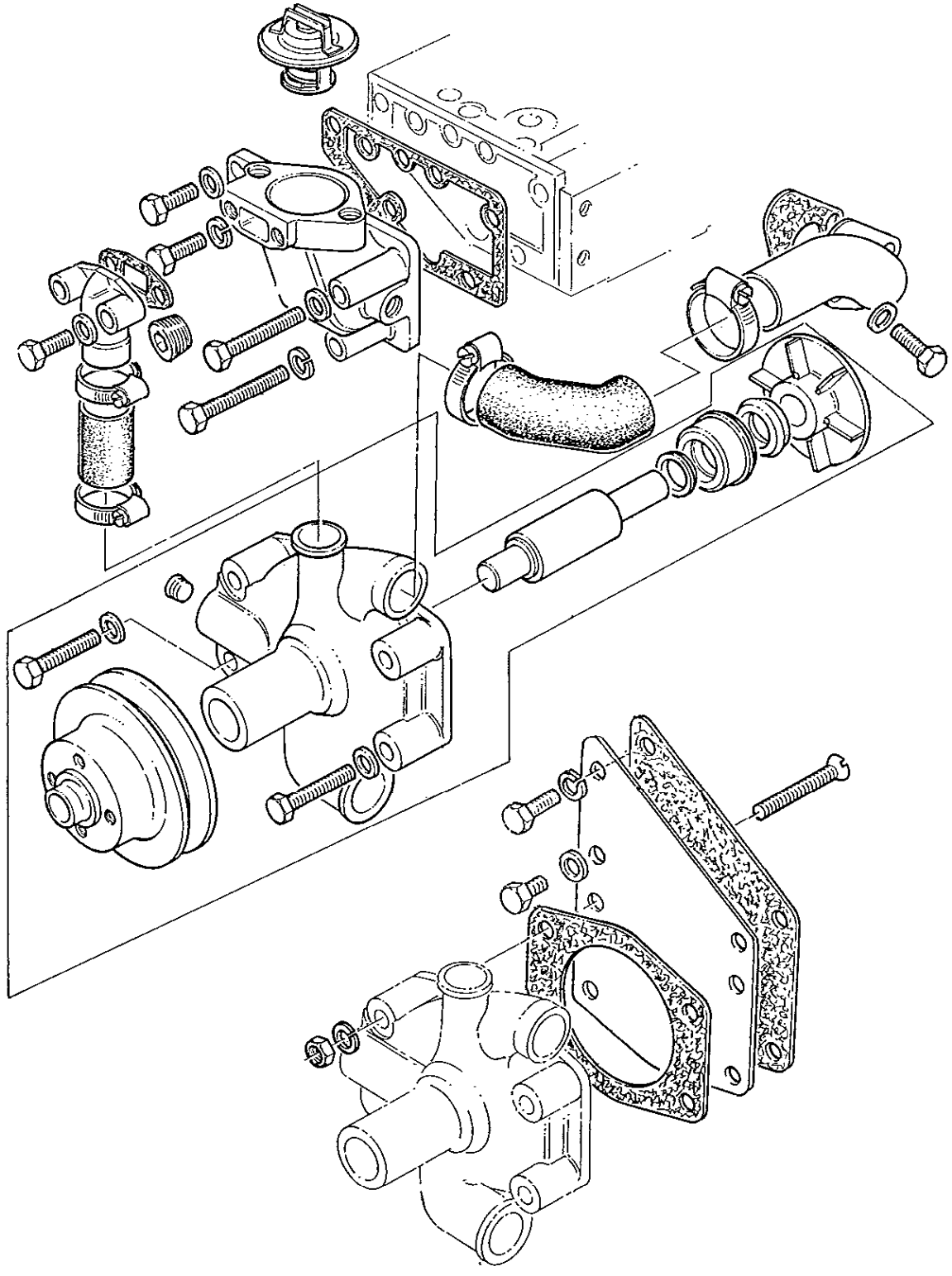
Fig. M10

To fit lubricating oil pump

1. Fill lubricating oil pump with clean lubricating oil.
2. Fit idler gear to shaft but do not fasten with circlip.
3. Fit lubricating oil pump to front main bearing cap and fasten with three setscrews. Connect delivery pipe from pump to cylinder block.
4. Fasten idler gear with circlip.
5. Fit suction pipe and strainer.
6. Fit timing case bottom half and tighten two nuts and washers to timing case top half.
7. Fit the three setscrews at the bottom of the timing case front cover.
8. Fit the lubricating oil sump as already given.

Note: Before the engine is started, it must be turned with the stop control operated until lubricating oil pressure is shown on the gauge.
If an electrical solenoid stop control is fitted, turn the start switch to the "R" position.

SECTION N
Cooling System



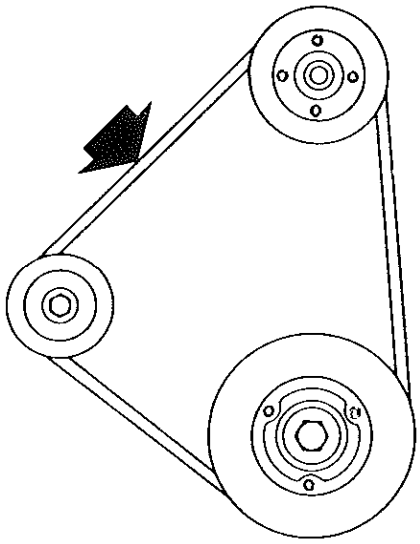


Fig. N1

Cooling system

The engine is supplied with coolant from a centrifugal type water pump installed on the front of the timing case cover. The drive is by belt from the front of the crankshaft.

The pump does not need to be lubricated as the bearings are packed with special quality grease at the factory.

To check and adjust fan belt tension

1. Renew the belt if it is worn or damaged.
2. With thumb pressure of approximately 10 kgf (22 lbf), press the fan belt down at the centre of the longest free length of the belt and check the belt movement (see fig. N1). The belt movement must be 10 mm (3/8 in). Where necessary, adjust the tension as given below.
3. Loosen the alternator or dynamo bolts and adjustment link setscrews.
4. Change the alternator or dynamo position to give the correct tension and tighten the alternator or dynamo bolts and adjustment link setscrew.
5. Check the belt tension again to ensure that it is still correct.

Note: If a new belt is fitted, the belt tension must be checked again after the first 25/50 hours of operation.

To drain cooling system

1. Ensure that the machine is on level ground.
2. Remove the radiator filler cap.
3. Remove the drain plug from the side of the cylinder block to drain the engine. Ensure that the drain hole does not have any restriction.
4. Open the tap or remove the drain plug at the bottom of the radiator to drain the radiator. If a tap or plug is not fitted to the radiator, disconnect the bottom radiator hose.
5. Where necessary, flush the system with clean water.
6. Fit the drain plugs and radiator cap. Where necessary, close the radiator tap or connect the radiator hose.

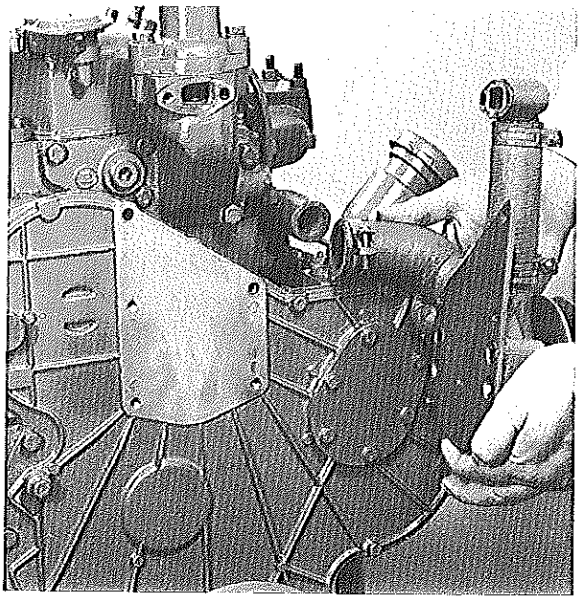


Fig. N2

To remove water pump

1. Drain the cooling system.
2. Remove fan belt and fan.
3. Disconnect water pump inlet and outlet hose connections.
4. Disconnect by-pass connection from thermostat housing.
5. Release the three setscrews which fasten backplate to timing case and cover and the two setscrews which fasten water pump to cover and remove pump complete with backplate (see fig. N2).
6. Release the two nuts and screws and remove water pump from backplate.

To dismantle water pump (see fig. N3)

1. Remove water pump pulley by the use of a suitable tool (see fig. N3). The holes tapped in the pulley can be used for this purpose.
2. Press water pump shaft (2) complete with bearings and impeller (7) out through rear of pump body (1).
3. Press shaft and bearing assembly out of impeller.
4. Remove ceramic counterface (6), seal (5) and thrower where separate, (4) from water pump shaft.

The water pump shaft and bearings are a complete assembly and can not be dismantled.

Note: Later water pumps are fitted with a one piece 'cassette' type seal which includes the counterface and thrower. (See fig. N4A).

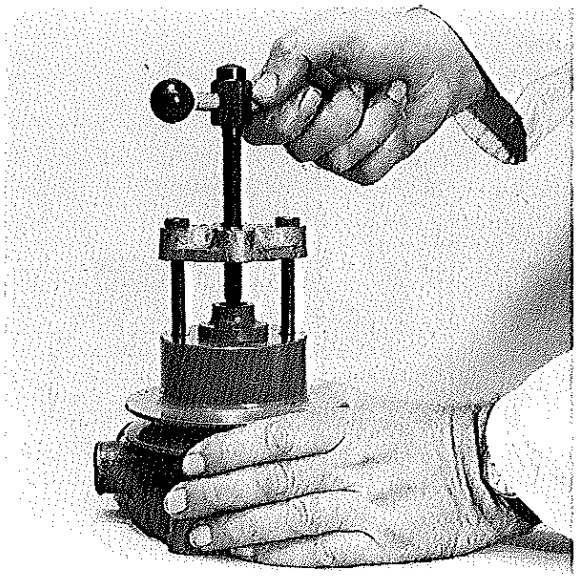


Fig. N3

To assemble water pump (see fig. N4)

1. With the shorter end of the water pump shaft to the front, press the shaft and bearing assembly (2) into rear of water pump (1) until the end of the bearing housing aligns with the front of the water pump body.
2. Fit thrower where separate, (4) and seal (5) with carbon face to rear of pump and flange against the inside face of water pump body.
3. Fit ceramic counterface (6) to shaft with ceramic insert towards seal.
4. With a support on the front end of the water pump shaft, press impeller (7), with blades inwards, on rear of shaft until there is a clearance of 0,25 mm (0.010 in) to 0,51 mm (0.020 in) between blades of impeller and pump body (see fig. N5).
5. Ensure pump turns freely.
6. Fit any setscrews that can not be put in position after the pulley is fitted. These setscrews have aluminium sealing washers.
7. With a support on the impeller end of the water pump shaft, press on water pump pulley until the front end of pulley aligns with front end of shaft. Where the fan mounting face is extended forward (see fig. N6), press the pulley on the water pump shaft until the fan mounting face is 140,49 mm (5.531 in) from the rear face of the pump body.
8. Check the clearance again between impeller blades and water pump body and ensure pump turns freely.

Note: Where a water pump is fitted with a ceramic seal and the engine is run without coolant in the water pump, the carbon seal and ceramic counterface can get very hot and will cause cracks in the ceramic. This can cause water to leak from the pump and does not always indicate that the seals have been fitted wrongly.

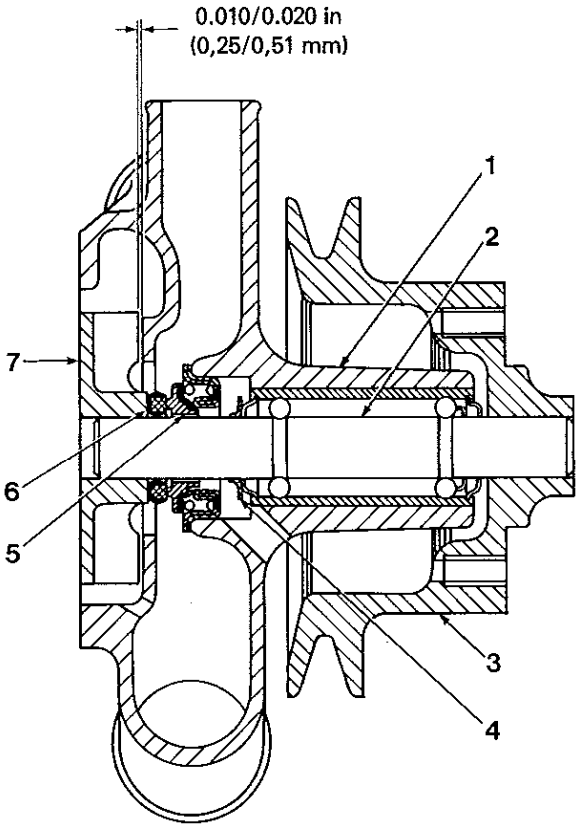


Fig. N4
Water Pump Assembly

1. Pump Body
2. Shaft and Bearing Assembly
3. Pulley
4. Thrower
5. Seal
6. Ceramic Counterface
7. Impeller

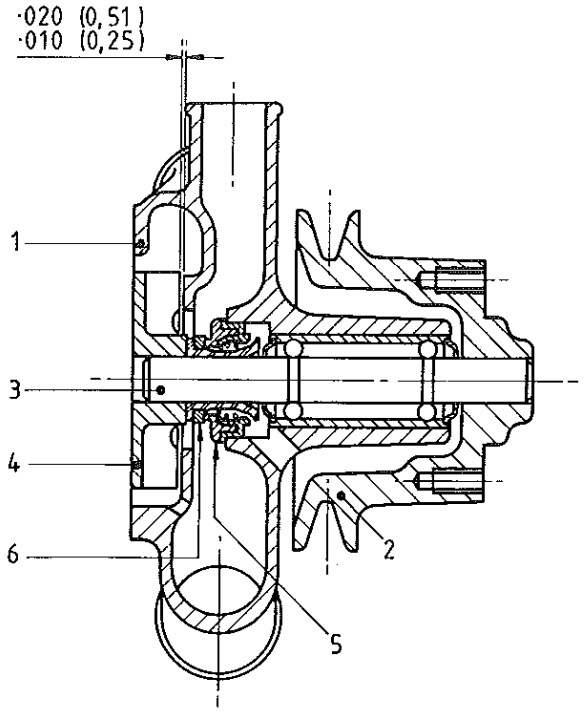


Fig. N4A
WATER PUMP ASSEMBLY
1. Pump Body
2. Pulley
3. Shaft
4. Impeller
5. Seal
6. Ceramic Counterface

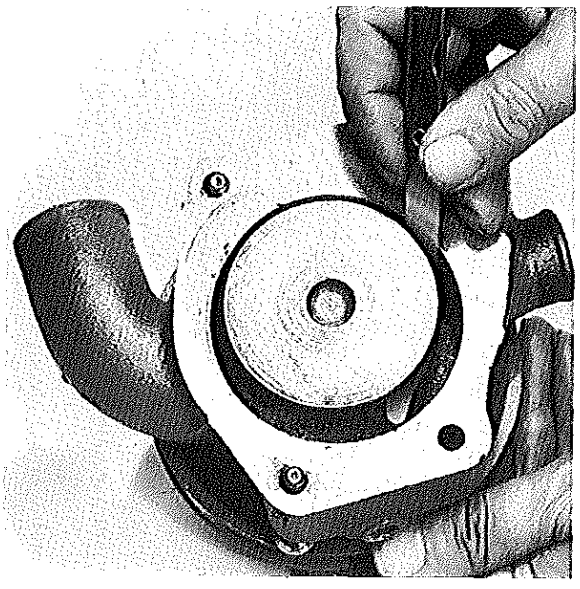


Fig. N5

To fit water pump to engine

1. Fit new water pump joints with jointing compound.
2. Fit water pump to backplate and fasten with screws, spring washers and nuts.
3. Fit pump and backplate assembly to timing case cover and tighten the setscrews. The setscrews which fit in the timing case have spring washers and those which fit into the timing case cover have aluminium washers.
4. Connect water pump inlet and outlet hose connections and by-pass connection from thermostat housing.
5. Fit fan belt and adjust tension (see fig. N1).
6. Fit fan.

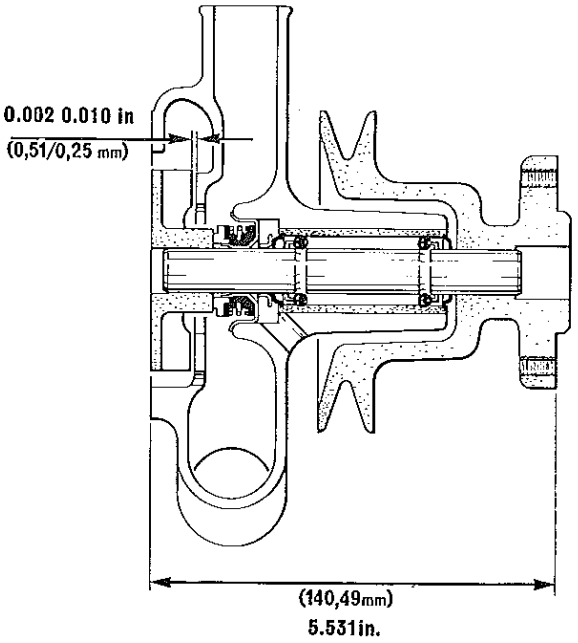


Fig. N6

Thermostat

A thermostat is installed in the cylinder head water outlet to enable the engine to reach its correct temperature faster.

The thermostat can be removed after the water outlet connection has been removed (see fig. N7).

When a thermostat is fitted, ensure that the jiggle pin in the top is free to move and the vent hole is free from restriction.

To check the thermostat, put it in water and heat gradually. With the use of a thermometer, check that the thermostat opens at the temperatures given in Section C. If there is a fault, it must be renewed. A thermostat can not be adjusted.

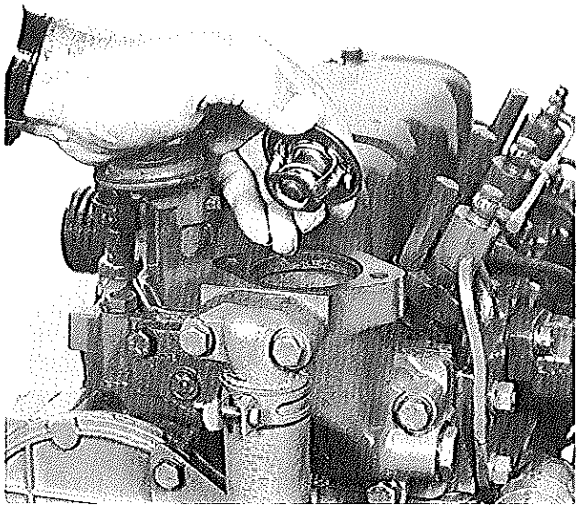
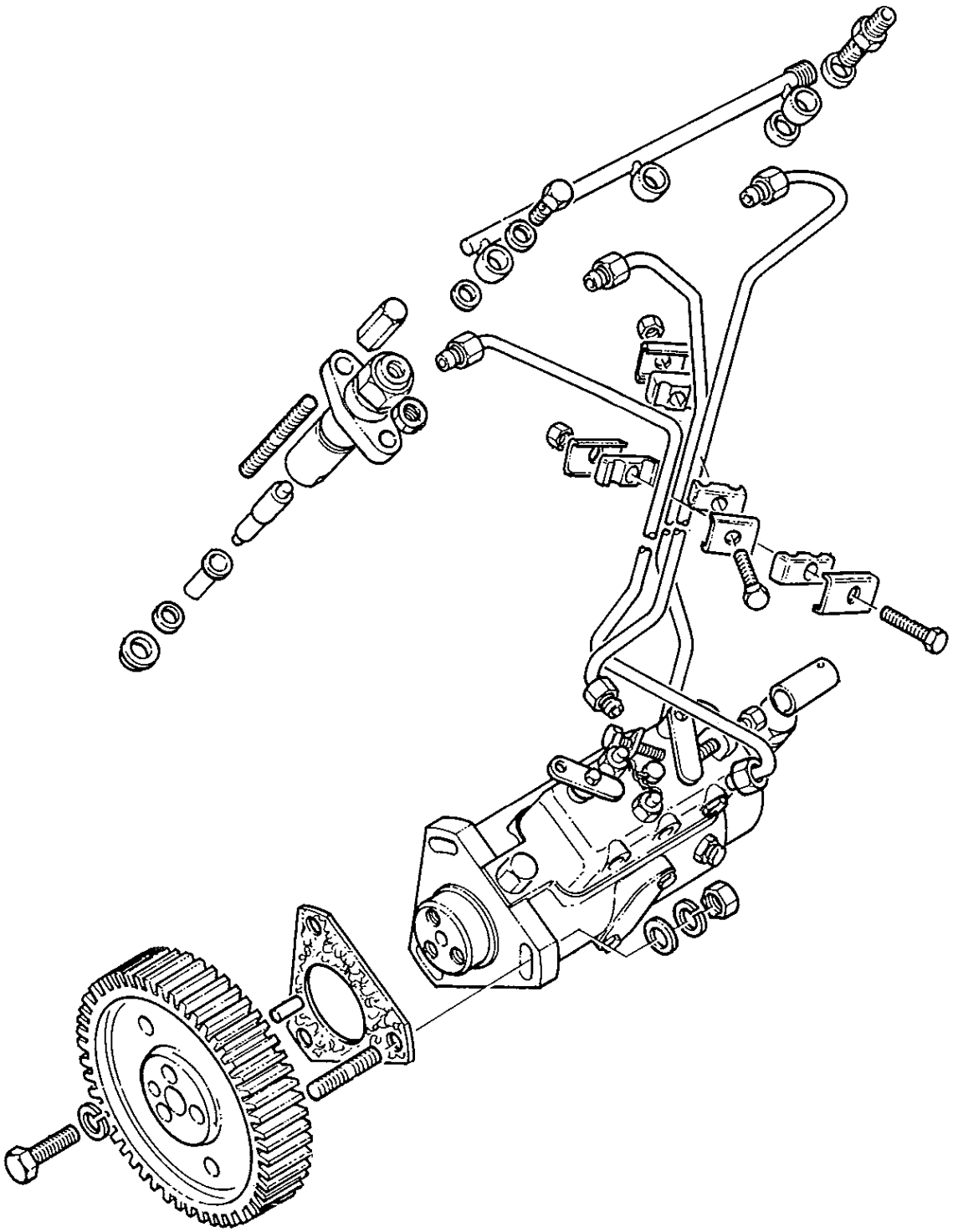


Fig. N7

SECTION P
Fuel System



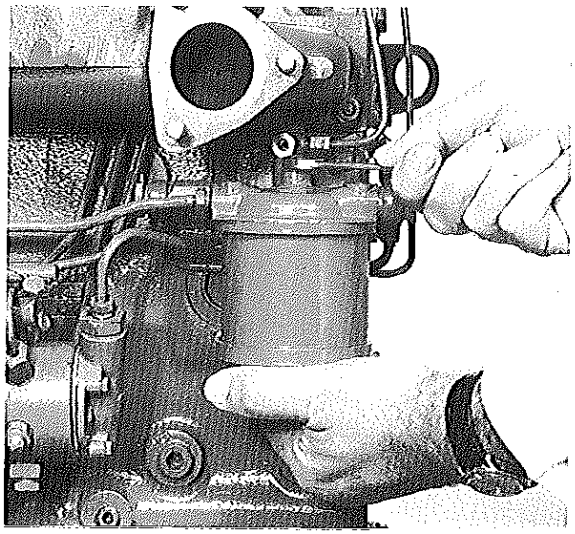


Fig. P1

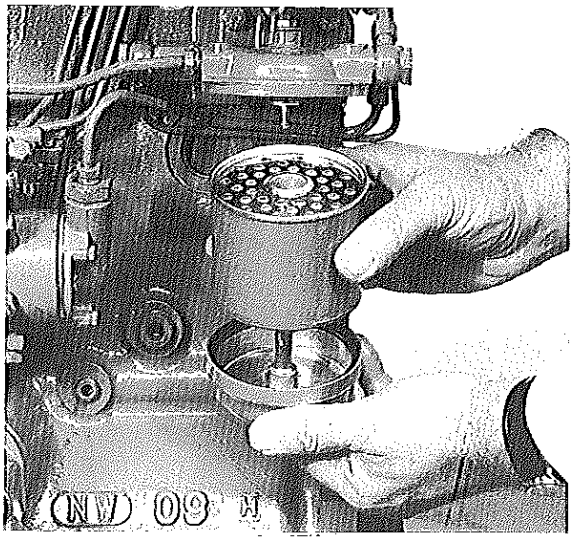


Fig. P2

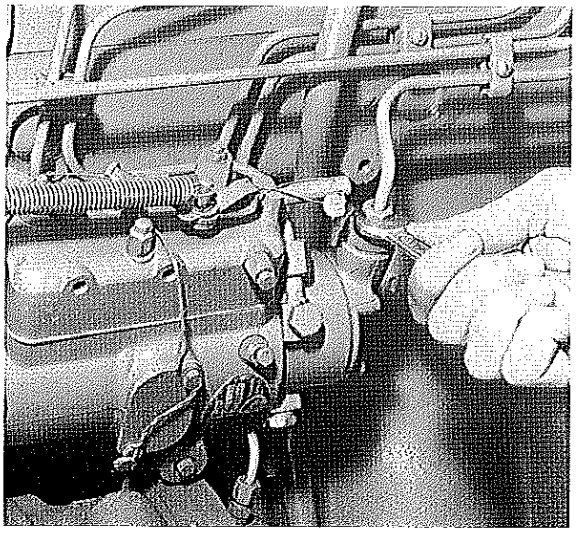


Fig. P2A

Fuel system

The main components of the equipment to supply fuel to the engine are as follows.

1. Fuel filters.
2. Fuel lift pump.
3. Fuel injection pump.
4. Atomisers.

The fuel lift pump supplies fuel from the tank through fuel filters to the fuel injection pump which passes it in measured quantities and at correct intervals to the atomisers.
Fuel must be clean, free from dirt and must be equal to one of the fuel specifications given on page C12.

Fuel filters

Precautions have been made to ensure that only clean fuel reaches the fuel injection pump.
Fuel filters are installed, also a dirt trap in the fuel tank.
The first fuel filter is a fine gauze type in the filler of the fuel tank. If there is no gauze filter in the filler, the tank must be filled through a fine gauze strainer.
The second fuel filter is a pre-filter fitted between the fuel tank and the fuel lift pump. This pre-filter must be dismantled and any water removed and the gauze strainer cleaned at the service interval given on page D2. Ensure that good joints are made when this filter is assembled or air leakage can occur on the suction side of the fuel system.
On some engines, there is an extra filter between the fuel lift pump and the main fuel filter and the maintenance of this filter is the same as for the main filter.
The main filter before the fuel injection pump is a paper element type. The element must not be cleaned but renewed at the service interval given on page D2.

To renew fuel filter element (current engines)

1. Remove setscrew in centre of fuel filter top cover (see fig. P1).
2. Lower filter bottom cover (see fig. P2).
3. Remove the element canister and discard.
4. Before new filter element canister is fitted, clean the top and bottom filter covers.
5. Check that the rubber joints are in good condition. Renew if necessary.
6. Fit element canister and bottom cover and tighten setscrew.

After the filter is assembled, remove air from the fuel system as given later.

To renew fuel filter element (earlier engines)

The earlier type main fuel filter contains a separate paper element in a bowl fastened by a bolt at the bottom of the bowl. A vent plug is fitted in the filter head.

Renew the element as follows:

1. Remove the bolt at the bottom of the filter bowl.
2. Lower the filter bowl.
3. Remove the element and discard.
4. Clean filter bowl and fit new element.
5. Check the washers and joints are in good condition. Renew if necessary.
6. Fit element and bowl and tighten bolt.

After the filter is assembled, remove air from the fuel system as given later.

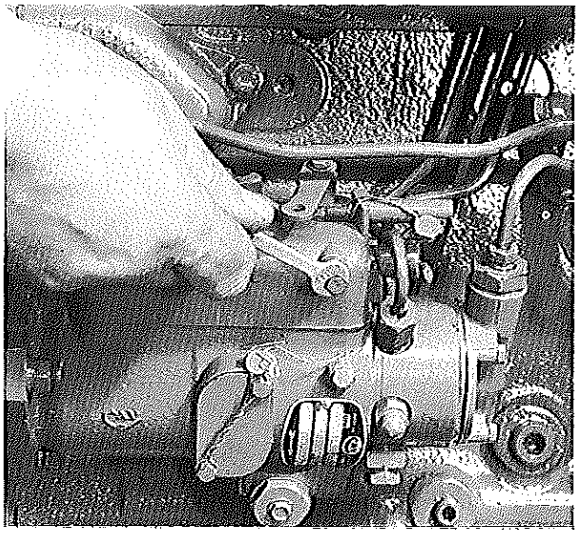


Fig. P3

To remove air from fuel system

If air gets into the fuel system, it must be removed before the engine can be started.

Air can get into the system if:

1. The fuel tank is drained during engine operation.
2. The low pressure fuel pipes are disconnected.
3. Any part of the low pressure fuel system leaks during engine operation.

Note: Some engines are fitted with Stanadyne fuel injection pumps. These pumps are self venting and will automatically remove air from the system.

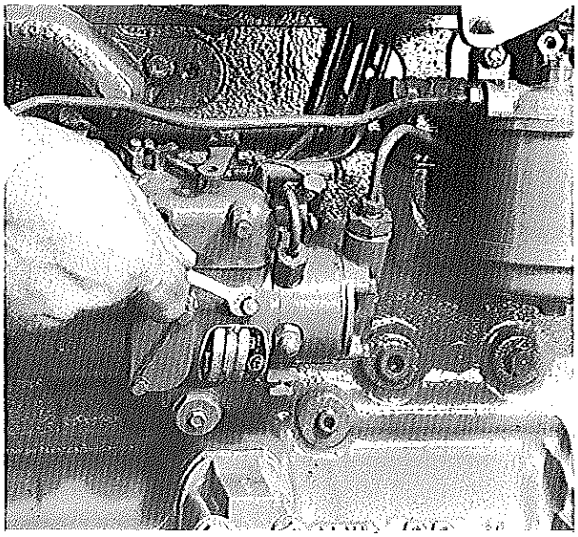


Fig. P4

Remove air from the fuel system as follows:

1. Remove air from the fuel filter through the filter vent plug. If a filter vent plug is not fitted, the return to tank banjo connection in the top of the filter can be loosened to reduce the time needed to fill the filter with fuel. Tighten the plug or connection.
2. Where the fuel filter is fitted lower than the fuel injection pump, loosen the inlet connection at the fuel pump (see fig. P2A) and operate the lift pump to remove any air (see fig. P5). Tighten the connection.
3. Ensure that the stop control is in the "Run" position. If an electrical solenoid stop control is fitted, turn the start switch to the "R" position.
4. Loosen the vent screw on the side of the governor control cover of the fuel injection pump (see fig. P3).

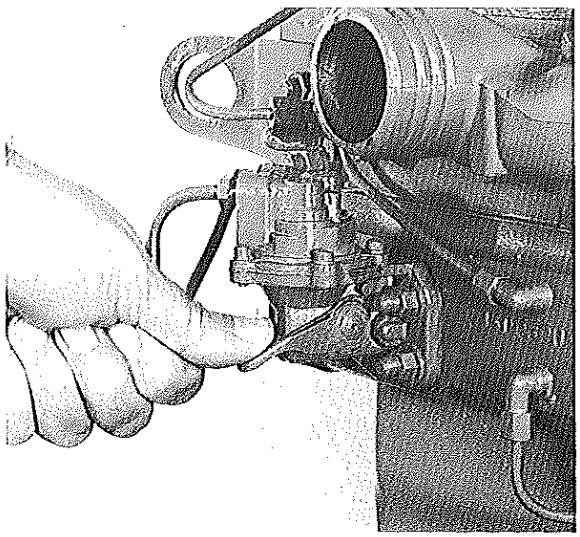


Fig. P5

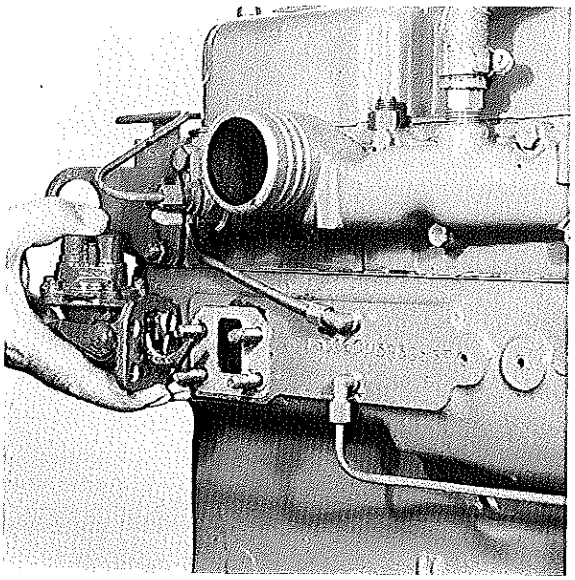


Fig. P6

5. Loosen the vent screw in the hydraulic head lock screw on the side of the fuel injection pump body (see fig. P4). Loosen vent screw on top of main fuel filter (where fitted).

6. Operate the priming lever of the fuel lift pump (see fig. P5) until fuel, free from air, comes from each vent point. If the fuel pump drive cam is on maximum lift, it will not be possible to operate the priming lever and the crankshaft must be turned through one revolution. Tighten the vent screw on filter head cover (where fitted), hydraulic head vent screw and then governor vent screw.

7. Loosen the unions at the atomiser ends of two of the high pressure pipes.

8. With the engine speed control in its maximum position and the engine stop control in the 'run' position, operate the starter motor until fuel, free from air, comes from the pipe connections. Tighten the unions of the high pressure pipes.

9. If fuel oil has drained from the Thermostart fuel supply pipe, the pipe must be disconnected at the Thermostart and the priming lever operated until air free fuel comes from the pipe before the Thermostart is operated.

The engine is then ready to start.

If the engine runs correctly for a short time and then stops or runs roughly, check for air in the fuel system. If there is air in the fuel system, there is probably leakage in the suction or low pressure system.

Fuel lift pump

The fuel lift pump is of the diaphragm type. It is fitted to the side of the camshaft chamber and is driven from an eccentric on the engine camshaft.

It is fitted with a hand priming lever so that the pump can be operated when the engine is stopped, to remove air from the fuel system.

To use this priming lever, operate by hand until fuel pipes, fuel lift pump, fuel filters and fuel injection pump are full of fuel oil.

Note: If the eccentric on the engine camshaft is in its maximum high position, it will not be possible to operate the hand pump. Turn engine until pump can be operated.

Earlier engines had an integral pre-filter fitted but on later engines, the pre-filter is separate.

To test fuel lift pump when fitted to engine.

Disconnect fuel lift pump outlet connection.

Turn engine or operate hand priming lever (see fig. P5). Fuel will be discharged from the outlet connection every second revolution of the engine or every time the hand priming lever is operated.

To check pressure output of fuel lift pump when fitted to engine

1. Fit a 0 to 0,7 kgf/cm² (0 to 10 lbf/in²) or 0 to 70 kN/m² pressure gauge to the fuel lift pump outlet connection. Ensure that there is no leakage at the connection between pump and gauge.
2. Operate starter motor to turn engine for ten seconds and read the maximum pressure on gauge.
3. If the pressure is below 0,3 kgf/cm² (4.5 lbf/in²) or 31 kN/m², the lift pump must be corrected.
4. Check the time for the pressure to fall to half the maximum pressure found under item (2) after the engine has stopped. If this is less than thirty seconds, correct the pump.

To remove fuel lift pump

1. Disconnect fuel pipes from fuel lift pump inlet and outlet connections.
2. Remove the nuts and washers or setscrews and plates which fasten the fuel lift pump to the cylinder block and remove the pump (see fig. P6).

To dismantle fuel lift pump (see fig. P7)

1. Loosen nut at bottom water trap filter (where fitted) and remove glass bowl and gauze strainer.
2. Make a mark across the two flanges for location purposes when the pump is assembled.
3. Remove the five cover screws and divide the two main parts of the pump.
4. Turn diaphragm 90° in either direction and remove diaphragm assembly from bottom half of pump.
5. Remove the valves with a screwdriver or other suitable tool.
6. Put rocker lever in a vice. Remove the fastener plates from the grooves in the casting. Remove rocker lever pin and rocker lever assembly. Check rocker, pin, lever and return spring for wear. Renew if necessary.

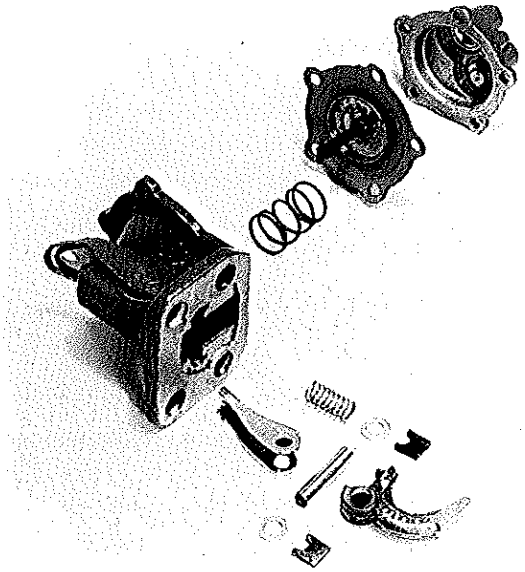


Fig. P7

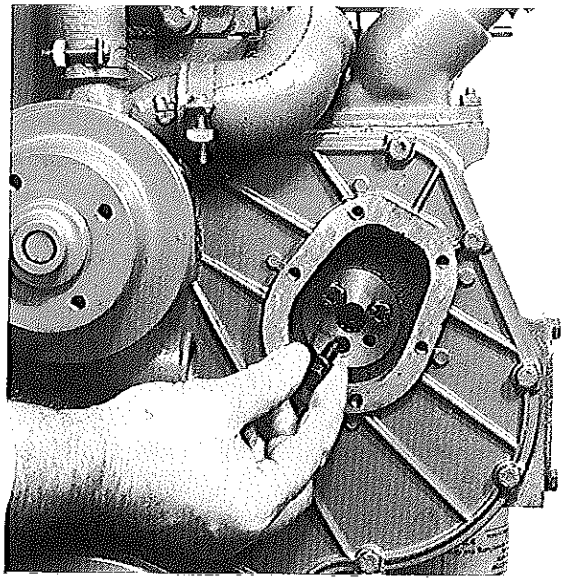


Fig. P8

To assemble fuel lift pump

1. Fit rocker lever assembly into bottom half of fuel lift pump.
2. Fit rocker lever spring. Ensure it is in its correct location.
3. Fit new fastener plates in grooves of casting. To make them secure, hit with centre punch over open ends of grooves.
4. Fit the valves into bottom half of pump. To fasten them in position, hit the casting round the valves in six places with a centre punch.
5. Fit diaphragm assembly over spring with pull rod to the bottom. Ensure top of spring is in correct position in diaphragm protection washer.
6. Ensure that correct end of pull rod engages into rocker lever link.
7. Press down on diaphragm assembly so that notches on pull rod align with rocker lever link. Turn diaphragm 90° in either direction to engage and connect pull rod in the end of the link.
8. When assembling the two halves of the pump, push rocker lever towards pump until diaphragm is aligned with body flanges. The cover assembly can now be fitted with the marks on the flanges aligned. With pressure still applied on rocker lever, fit and tighten screws and washers evenly.
9. Where necessary, fit the gauze strainer and glass bowl to water trap filter. Ensure that an air tight joint is made.

To fit fuel lift pump

1. Ensure that fuel lift pump flange and mounting face on cylinder block are clean.
2. Use a new joint and put pump operation lever into hole in cylinder block.
3. Fit fuel lift pump on studs and tighten nuts and spring washers, or setscrews and plates.

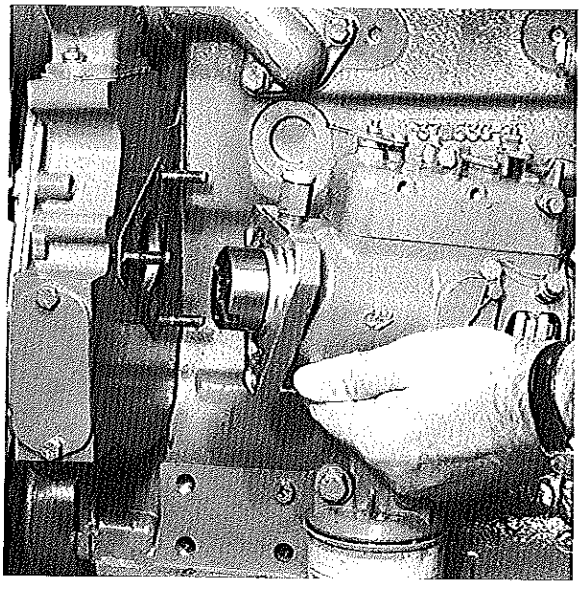


Fig. P9

Fuel injection pump

The fuel injection pump is a distributor type. It is made of very fine parts and any damage or the smallest amount of dirt can prevent its accuracy of operation. Ensure that fuel is thoroughly clean before it reaches the pump.

Where information is needed for the fuel injection pump, its type and number must be given.

If service is needed, this is available from your Perkins Distributor or the fuel injection pump manufacturers distributor.

To remove fuel injection pump

The fuel injection pump is fastened to the back of the timing case on the left side of the engine. The fuel injection pump gear is connected to the pump shaft by three setscrews and a dowel or keyway is fitted to ensure correct location.
Note: Some applications use a fuel injection pump with a tapered shaft and single nut to fasten the fuel pump gear.

To remove pump:

1. Remove fuel pipes from fuel injection pump. Seal open connections.
2. Disconnect engine speed and stop controls at pump.
3. Remove cover plate on left side of timing case front cover in front of fuel pump position.
4. Remove the three setscrews and washers or nut which secure gear to fuel pump shaft (see fig. P8). Do not drop them into timing case. For gears with a tapered drive shaft bore, use puller tool PD155B and adaptor PD155B-5. When gear is loose, ensure it does not drop on aluminium lug in timing case as this can break and fuel pump gear can come out of mesh with idler gear. If gears come out of mesh it will change the fuel pump timing.
5. Remove the three nuts and washers which secure fuel pump to back of timing case.
6. Remove fuel injection pump (see fig. P9). If gear is still tight on fuel pump shaft, hold gear so that it does not drop and break the lug in timing case and come out of mesh. **Do not turn crankshaft with pump removed and gear loose in timing case.**

To fit fuel injection pump

1. Ensure that slot or key in end of fuel pump shaft aligns with dowel or keyway in gear and put pump in position on back of timing case. Fit pump flange nuts but do not fully tighten.
2. Ensure that dowel or keyway in fuel pump gear fits in slot or key in pump shaft and fasten gear to pump shaft with three setscrews and washers or nut. Tighten nut to the torque given on page C3.
3. Adjust fuel injection pump so that line on flange aligns with line on back of timing case and tighten nuts.
4. Fit cover plate to timing case cover.
5. Connect fuel pipes to pump.
6. Remove air from fuel system as given on page P3.
7. Connect engine speed and stop control.
8. Run engine and check for fuel leakage. If a new fuel injection pump has been fitted, set the maximum no load speed as given below.

To set maximum no load speed

When the fuel injection pump is changed, the governor is set to a nominal maximum speed and it must be adjusted on the engine.

The maximum no load speed can be found from the fuel injection pump setting code. A typical code is XW50E600/8/2470. It is the last group of numbers which indicates the no load speed which, in this example, is 2,470 rev/min (engine speed).

Note: Current pump codes are now changed, for example: 2643B131BW/6/2370. (See page C14).
Run the engine until the coolant reaches its normal operation temperature.

With the use of an accurate tachometer, check the maximum speed with no load on the engine.

Where necessary, adjust the maximum no load speed by the adjustment screw on the fuel injection pump. Turn screw out to increase or turn screw in to decrease maximum no load speed.

When the maximum no load speed is correct, the adjustment screw must be sealed by approved personnel.

High pressure fuel pipes

If the union nuts on the high pressure fuel pipes are tightened too much, damage can occur to the olives and the complete pipe must be renewed.

Fit the pipe to the fuel injection pump and atomiser unions. Ensure that the pipe is correctly aligned at both ends. Do not fit one end and then bend the pipe to align it at the other end.

When a pipe is fitted, tighten the union nuts by small amounts until the correct torque of 30 Nm (15 lbf ft) 2,1 kgf m is reached.

When an atomiser is removed, always remove the whole high pressure pipe. Do not bend the pipe.

Atomisers

Each atomiser is fastened in the cylinder head by a flange and two studs.

The joint between the atomiser and the cylinder head is a special thin copper washer between the lower face of the nozzle cap nut and the bottom of the recess in the cylinder head. Only the correct copper washer must be used. The recess in the cylinder head, the faces of the copper washer and the bottom face of the nozzle cap nut must be thoroughly clean or leakage will occur. A new washer must be used every time an atomiser is fitted. Always ensure that the old washer has been removed.
Ensure that a serviceable dust seal is fitted to the atomiser. Earlier dust seals consisted of a single piece rubber seal, later arrangements use a two piece dust seal which consists of a plastic or aluminium sleeve and a rubber seal. The sleeve

must be fitted directly under the atomiser flange with the soft rubber seal up against the sleeve at the nozzle end of the atomiser.

When an atomiser is fitted in the cylinder head, ensure it fits freely on its studs. The nuts on the flange must be tightened by small amounts until a torque of 16 Nm (12 lbf ft) 1,7 kgf m is reached.

If a separate clamp is fitted, tighten to 12 Nm (9lbf ft) 1,2 kgf m.

An atomiser must not be fitted in a tilted position or gas leakage will occur.

The maintenance periods for atomisers are given on page D2.

With 3.1522 engines, a thin metal heat shield is fitted around the atomiser nozzle and this shield must be renewed if an atomiser is dismantled.

Do not remove atomisers for correction unless an atomiser tester pump or other atomisers are available.

An atomiser fault can be shown by an engine misfire.

To find which atomiser is at fault, run the engine at fast idle speed and loosen and tighten the high pressure fuel pipe union at each atomiser. When the union nut of the atomiser at fault is loosened, it will have little or no effect on the engine speed. Do not let the fuel spray onto your skin.

Atomiser pressures are given on page C15 and can be decided from the code letters stamped either on the atomiser body or on the atomiser tab washer.

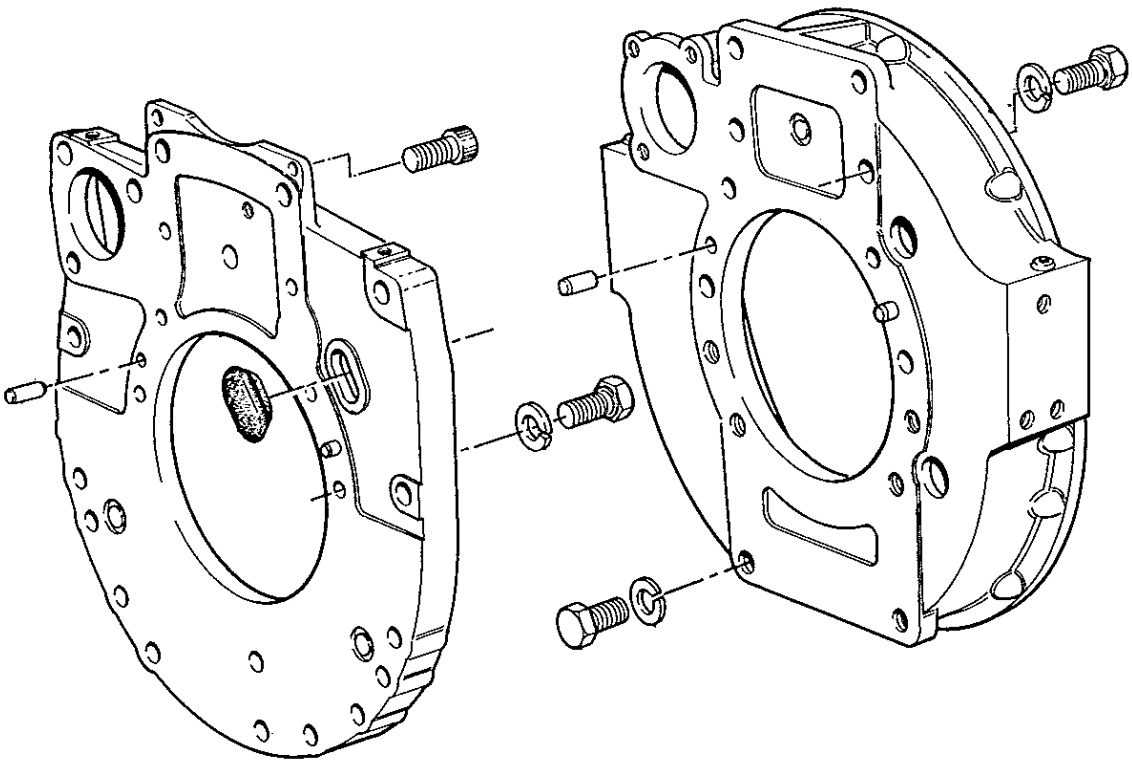
The 'Setting Pressure' is the pressure at which a new atomiser is set and is a little high due to the drop in pressure which occurs during the first hours of operation. The 'Check and Reset' pressure is the pressure at which an atomiser which has been used is checked or set.

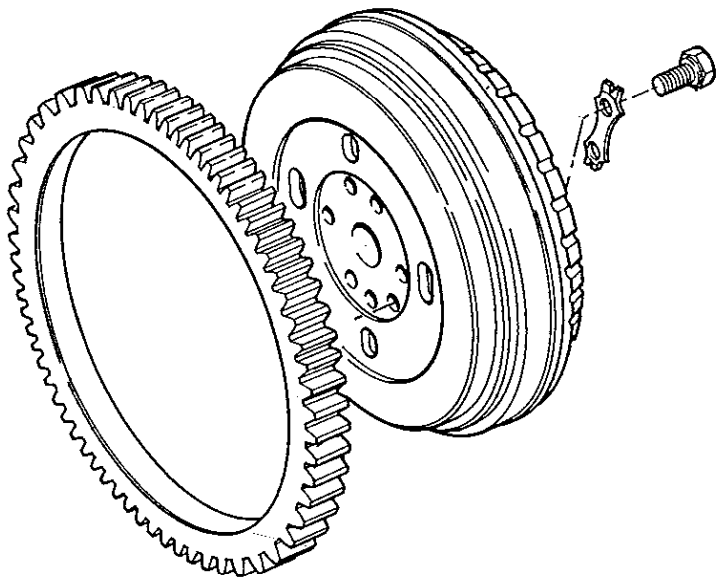
After an atomiser has been corrected, it is set to the setting pressure if a new spring has been fitted or to the check and reset pressure if the old parts have been used.

Do not correct and set the pressure of an atomiser if the necessary equipment is not available.

Always ensure that the correct atomisers are fitted.

SECTION Q
Flywheel and Flywheel Housing





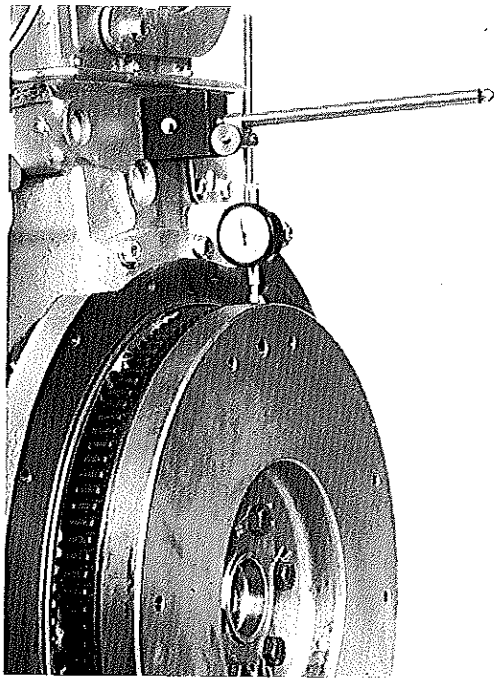


Fig. Q1

To remove and fit flywheel

1. Remove two opposite setscrews from the flywheel and temporarily fit two guide studs to ensure safe removal and assembly.
2. Remove the remainder of the setscrews and lock plates and remove flywheel.
3. Check the fywheel and ring gear for damage and renew as necessary.
4. Ensure that the location faces of the crankshaft and flywheel are clean and free from damage.
5. Fit the flywheel over the guide studs with the small hole in the flywheel aligned with the hole which is not tapped in the crankshaft flange. Fit the lock plates and setscrews in position, remove the guide studs and fit the other two setscrews.
6. Tighten the setscrews to the torque given on page C3.
7. Check the flywheel run-out with a dial test indicator (see fig. Q1). This must not be more than 0,30 mm (0.012 in) total indicator reading.
8. Check the alignment of the flywheel face (see fig. Q2). This must not be more than 0,03 mm (0.001 in) total indicator reading for every 25,4 mm (1 in) of flywheel radius from the crankshaft axis to the indicator plunger. During this check, keep the crankshaft pressed forward towards the front to remove the effect of the crankshaft end clearance.
9. Lock the flywheel setscrews with the ends of the lock plates, where fitted.

Flywheel ring gear

The ring gear is heated on to the flywheel. When a new gear is to be fitted, heat it to an approximate temperature of 246° (475°F). Ensure that the chamfered edges of the teeth are to the front of the flywheel except for some marine engines where they must be to the rear of the flywheel.

Alignment of flywheel housing

1. Ensure that the rear face of the cylinder block and the front face of the flywheel housing are clean and free from damage. Ensure that the location dowels are correctly fitted.
2. Fit the flywheel housing and tighten the setscrews.
3. Check the flywheel housing face alignment with a dial test indicator with the base fitted to the crankshaft flange. The maximum tolerance is given below. During this check, keep the crankshaft pressed forward towards the front to remove the effect of the crankshaft end clearance. Any necessary adjustment must be made on the front face of the housing and not on the cylinder block.
4. Check the run-out of the flywheel housing bore to ensure that it is within the limits given below. If adjustment is necessary, the dowels must be removed and new oversize dowels fitted after the adjustment has been made.

Diameter of flywheel housing	**Maximum tolerance**
Up to 362 mm (14 ¼ in)	0,15 mm (0.006 in)
362 to 511 mm (14 ¼ to 20 ⅛ in) ...	0,20 mm (0.008 in)
511 to 648 mm (20 ⅛ to 25 ½ in) ...	0,25 mm (0.010 in)
648 to 787 mm (25 ½ to 31 in) ...	0,30 mm (0.012 in)

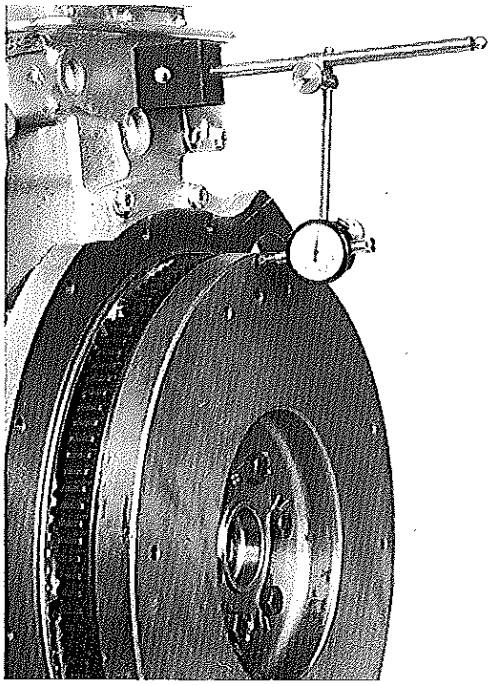
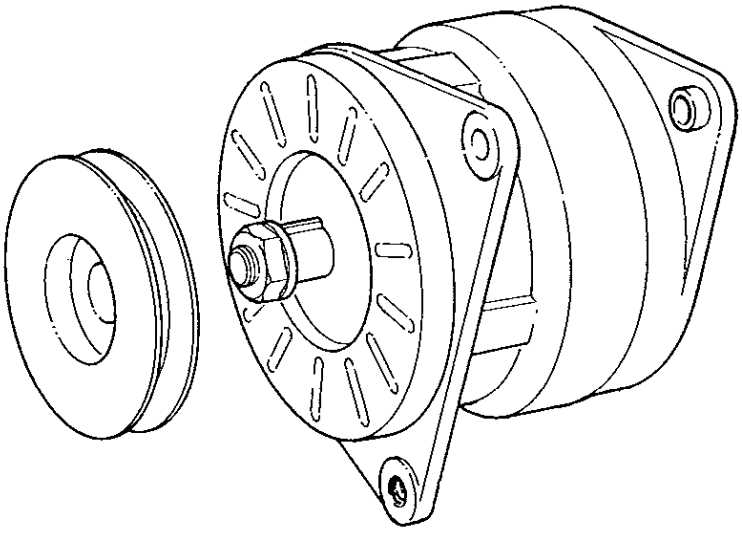
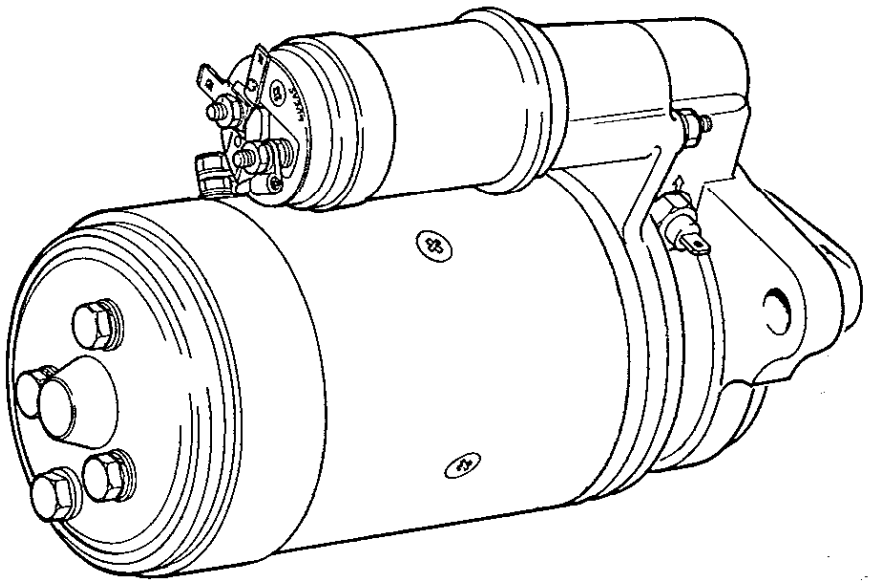


Fig. Q2

SECTION R
Electrical System





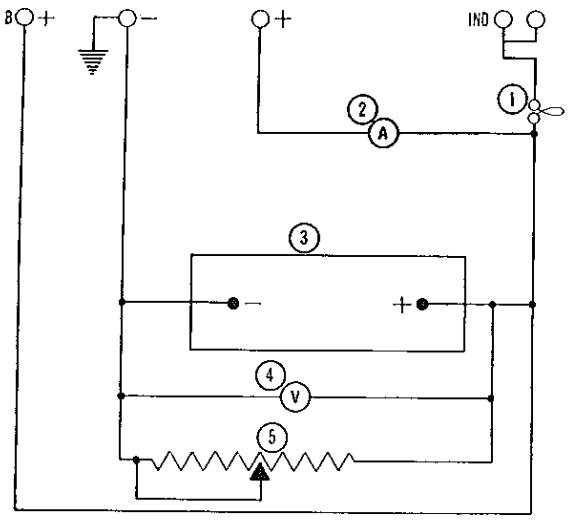


Fig. R1

Fig. R1 shows a test circuit for 15ACR and 17ACR alternators with standard terminals, battery-sensed.

Fig. R2 shows a test circuit for 15ACR and 17ACR alternators with standard terminals and two piece connection plug (machine-sensed).

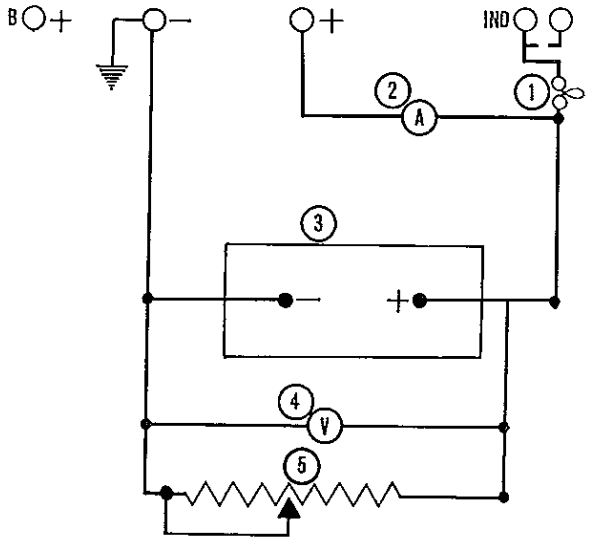


Fig. R2

Components in figs. R1 and R2.

1. 12 volt, 2.2 watt bulb.
2. 0 – 60 ammeter.
3. 12 volt battery.
4. 0 – 20 moving coil voltmeter.
5. 0 – 15 ohm 50 amp variable resistor.

ALTERNATORS
Models 15ACR, 16ACR, 17ACR, 18ACR, 23ACR, A115/36, A115/45, A127, 9AR and LR Series

Precautions

The diodes in the alternator operate as one way valves and the transistors in the regulator/control box operate as fast switches.

They do not wear or need adjustment, but the precautions which follow are necessary to ensure that no damage occurs.

1. **Do not** disconnect the battery while the engine is in operation. This will cause a high voltage in the alternator charge system and immediately burn out the diodes or transistors.
2. **Do not** disconnect a wire while the engine is in operation. Ensure all electrical switches are turned to the off position.
3. **Do not** cause a short circuit by the connection of wires to the wrong terminals. Always connect a wire to its correct terminal. A short circuit or wrong connection can give reverse polarity and burn out transistors or diodes.
4. **Do not** connect a battery into the system with wrong polarity or voltage.
5. **Do not** touch connections together to check for current flow. The transistors can be burnt out.

Maintenance

The alternator charge system needs little attention, but must be kept clean and a check must be made if it does not keep the battery charged.

1. Check the drive belt for correct tension or wear. Where two drive belts are used, they must both have the same tension. Loose belts will wear fast and will not turn the alternator at the correct speed.
2. Tight belts will cause too much of a load on the alternator bearings and wear will occur.
3. Where two drive belts are used, both must be renewed at the same time.
4. Clean the alternator with a cloth used with kerosene or similar fluid. Ensure that slots and air spaces for ventilation are open.
5. Remove any dirt from the regulator/control box and ensure that air can pass over the housing.

To test alternator on engine

Check drive belt for wear and tension. Check hot outputs at 6,000 rev/min (alternator speed) to the nominal values given below.

15ACR	–	28A
16ACR	–	34A
17ACR	–	36A
17ACR (de-rated)	–	25A
18ACR	–	45A
23ACR	–	55A
A115/36	–	36A
A115/45	–	45A
A127	–	55/65A
9AR Series	–	70A
LR135 Series	–	35A
LR150 Series	–	50A

The de-rated 17ACR alternator is used on some applications which operate under very dirty conditions.

These outputs can be more when the alternator is run cold. The test procedure given below must be used when the alternator is at its normal operation temperature.

Alternator output test – regulator disconnected

Remove the two part connector from the alternator, remove the cover (fastened by two screws) and connect the regulator green wire or connector to earth.

Connect a test circuit to the alternator output terminals as shown in figs. R1, R2, R3 or R4.

Carefully note the polarity of the battery and alternator terminals – reversed connections will cause damage to the alternator diodes.

The variable resistor across the battery terminals must not be left connected for more time than is necessary to do the test which follows.

Start the engine. At 1,500 rev/min (alternator speed), the light in the test circuit will go off. Increase engine speed until alternator runs at approximately 6,000 rev/min and adjust the variable resistor until the voltmeter shows 13.6 volts. The reading on the ammeter will then be approximately equal to the rated output as already given. If there is a large difference between the output reading and the rated output, the alternator must be removed from the engine for further inspection.

Failure of one or more of the diodes will be shown in the above test by effect on alternator output and can cause high alternator temperature and noise.

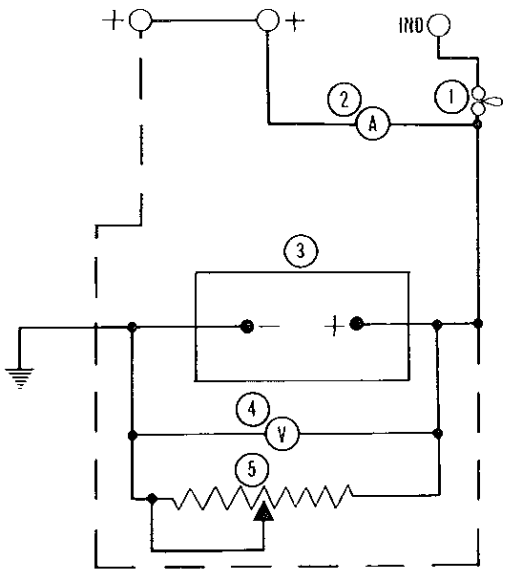


Fig. R3

Fig. R3 shows a test circuit for 15ACR, 17ACR, 18ACR, 23ACR, A115/45, A133/55 and LR series alternators with European terminals and single 3 terminal connector plug (machine-sensed).

Broken line cable connection applies to battery-sensed, in which case, the connections between the two '+' terminals will not apply and the broken line terminal will be marked "S" instead of '+'. (For LR series, 'IND' terminal is marked D+).

Fig. R4 shows a test circuit for Motorola 9AR series.

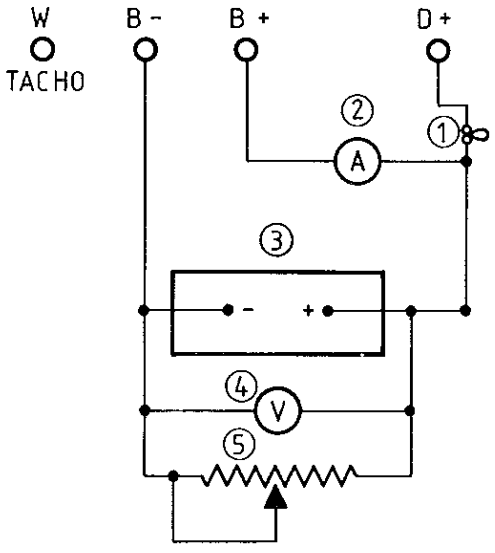


Fig. R4

Components in figs. R3 and R4.

1. 12 volt, 2.2 watt bulb.
2. 0 – 60 ammeter.
3. 12 volt battery.
4. 0 – 20 moving coil voltmeter.
5. 0 – 15 ohm 50 amp variable resistor.

To test regulator

The test which follows is where an alternator has been tested and found to be correct.

Disconnect the variable resistor and remove the earth connection from the regulator green wire or connector strip to frame.

With the remainder of the test circuit connected as for the alternator output test, start the engine and again run the alternator up to 6,000 rev/min until the ammeter shows an output current of less than 10 amperes. The voltmeter will then read 13,6 – 14,4 volts. If there is more than a small difference from this (regulating) voltage, there is a fault in the regulator and it must be renewed.

If the above tests indicate that the alternator and regulator operate correctly, disconnect the test circuit and connect the alternator terminal connector. Connect a (low range) voltmeter between the positive terminal of the alternator (the shaped terminal connector has an open end to permit this) and the positive terminal of the battery. Switch on battery load (headlights etc.), start the engine and increase speed until alternator runs at approximately 6,000 rev/min. Note the voltmeter reading.

Change the voltmeter connections to the negative terminals of the alternator and battery and again note the voltmeter reading.

If the reading is more than 0,5 volt on the positive connections or 0,25 volt on the negative connections, there is a high resistance in the charge circuit which must be corrected.

DYNAMO

Model C40A

The C40A dynamo is used with a compensated voltage control regulator. A ball bearing holds the armature at the drive end and a bronze bush at the rear holds the commutator end.

The output of the dynamo is controlled by a regulator which changes the amount of charge as needed by the battery and the load of the electrical equipment in use. When the charge of the battery is low, the dynamo gives a high output, but if the battery is fully charged, the dynamo gives a low output to keep the battery in good condition. The output is increased to give current for lights and other accessories when in use.

When the control box is renewed only the correct type must be used. A wrong type control box can cause damage to the dynamo.

Maintenance

1. Lubrication.
   Every 250 hours, put a little clean SAE 30 engine oil into the hole stamped 'OIL' at the commutator end bearing housing.
2. Brushes.
   Every 2,500 hours, the dynamo must be removed from the engine and the brushes inspected by an approved electrician.
3. Drive belt adjustment.
   Every 250 hours, check tightness of dynamo drive belt. If loose, make necessary adjustment of dynamo on its bracket.
   Do not tighten the belt too much (see page N2). Check nut which fastens dynamo pulley. Correct torque is given on page C3.

To test dynamo on engine

1. Check drive belt tension and adjust if necessary.
2. Check the connections on the commutator end bracket. The large connector is for the main dynamo output and the small connector is for the field current.
3. Switch off all lights and accessories, disconnect the cables from the terminals of the dynamo and connect the two terminals with a short pieces of wire.
4. Start the engine and set to run at normal idle speed.
5. Connect the negative lead of a 0 – 20 moving coil voltmeter to one dynamo terminal and the positive lead to a good earth point to the outside casing.
6. Gradually increase engine speed when the voltmeter reading must increase rapidly without intermittent movement. The voltmeter reading must not reach 20 volts. Do not run the engine at high speed to increase the voltage. Only run the dynamo up to 1,000 rev/min. If the voltage does not increase rapidly without intermittent movement, the dynamo must be removed from the engine for further inspection. Too many sparks at the commutator in the above test indicates a fault in the armature which must be renewed.

STARTER MOTOR

Maintenance

Maintenance is not necessary other than regular checks to ensure that the starter motor and terminal connections are securely fitted and that the connections are clean.

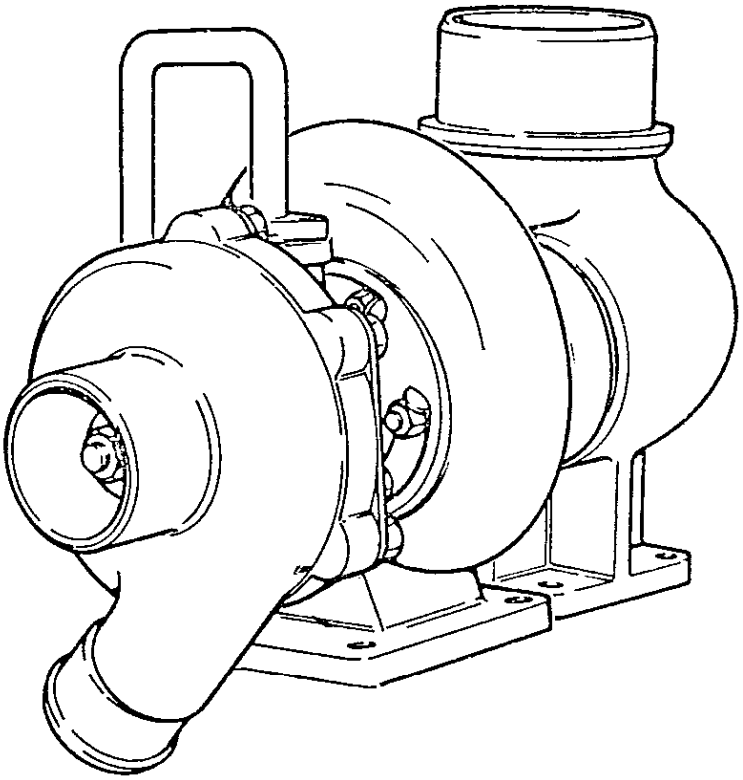
It is advised that the starter motor be dismantled for inspection during complete engine overhaul. The commutator must be inspected and the brushes and bearings renewed.

To test in service

If the starter motor does not operate correctly, check that the battery is fully charged and that all connections are clean and tight. Check that the voltage difference between battery, starter motor and starter switch is not too high.

If these checks show no fault, remove the starter motor for inspection.

SECTION T
Turbocharger



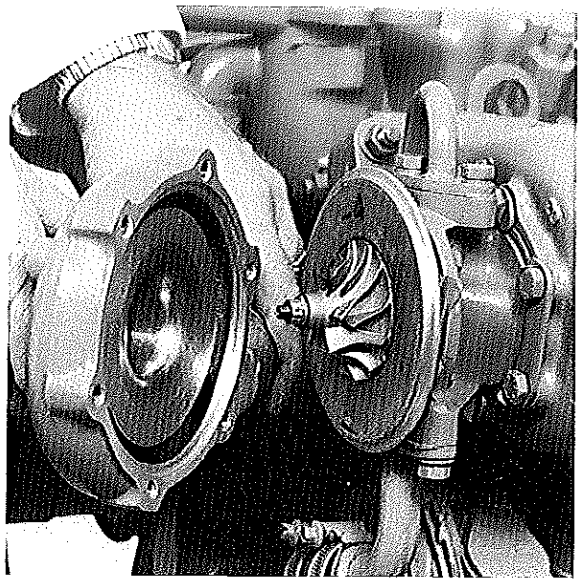


Fig. T1

T3.1524 Engine

The turbocharger is fitted on the exhaust manifold outlet, (see page B5). It is lubricated by oil taken from the engine lubrication system. The minimum permissible lubrication oil pressure is 30 lbf/in^2 (2,11 kgf/cm^2) 207 kN/m^2 at maximum engine speed and normal operation temperature. Check pressure regularly.

The maximum boost pressure is 6.0 lbf/in^2 (0,42 kgf/cm^2) 41,0 kN/m^2 when the engine is run at maximum speed and full load.

With some engines where it is not possible to fully load the engine, the boost pressure will be lower.

Note: The speed of the turbocharger will change automatically with the speed and load of the engine.

Maintenance

Every 20,000 miles (30,000 km) or 1,000 hours, clean the oil drain pipe from turbocharger to sump, also turbocharger compressor wheel and cover.

Remove the air inlet connection and compressor housing and check for dirt etc. (see fig. T1).

Clean the impeller and housing with a soft brush. Find and correct cause of dirt etc. in compressor as it can affect rotor balance and cause bearing failure.

With the compressor housing removed, push the compressor wheel towards the turbine wheel and turn the assembly that rotates, by hand, to see that it moves freely. If it does not move freely or there is bearing noise, remove the turbocharger and dismantle for inspection.

To remove turbocharger

1. Disconnect turbocharger inlet and outlet connections.
2. Disconnect exhaust pipe.
3. Remove oil supply pipe and release oil drain pipe.
4. Release turbocharger outlet assembly from the cylinder block.
5. Remove turbocharger from exhaust manifold, (see fig. T2).
6. Seal open engine connections.

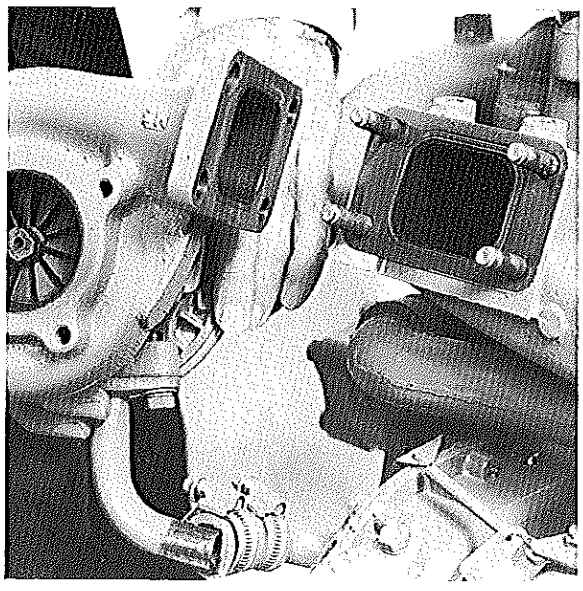


Fig. T2

Airsearch T-31 (see fig. T3)

Clean the outside with a pressure spray of a non-caustic solvent before it is dismantled. Dismantle only as needed to make the necessary inspection or repairs.

Remove the bolts, clamps and lockplates which hold the compressor and turbine housings to the centre housing group, hit the housings with a soft faced hammer if force is needed for removal.

Note: If the housing is removed, be careful to prevent damage to the compressor or turbine wheel, especially the blades, as if the wheels or blades are damaged they cannot be repaired.

Place the centre housing in a suitable clamp so that the turbine wheel does not turn. To stop possible distortion of the shaft use a 'T' handle spanner to remove the compressor wheel locknut.

Remove the compressor wheel from the shaft. Remove the shaft and turbine wheel assembly from the centre housing. Keep the shaft central with bearings until out of centre housing.

Note: The turbine steel shroud is not retained to the centre housing and will fall free when the shaft wheel is removed.

Remove lockplates and bolts from backplate.

Hit backplate with soft mallet to remove from recess in centre housing.

Remove thrust collar and thrust bearing from centre housing.

Remove bearings and retainers from centre housing. Discard rubber sealing ring.

To clean

Inspect all parts that are to be cleaned for signs of burns or other damage which possibly will not be seen after they are cleaned.

Place all parts in clean non-caustic carbon solvent and use a hard brush to remove all dirt particles. Dry parts thoroughly.

Note: Normally a light deposit of carbon particles will not affect turbine operation.

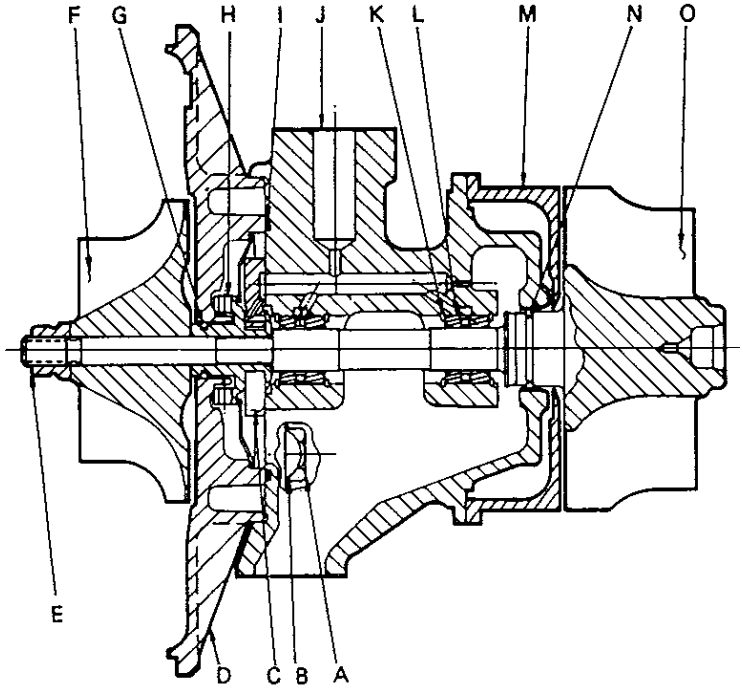


Fig. T3

A. Bolt
B. Lock Plate
C. Thrust Bearing
D. Backplate Assembly
E. Lock Nut
F. Compressor Wheel
G. Piston Ring Compressor
H. Thrust Collar
I. Seal Ring
J. Centre Housing Assembly
K. Retaining Ring
L. Bearing
M. Shroud
N. Piston Ring, Turbine
O. Shaft Wheel Assembly

Internal parts inspection (see fig. T4)

Parts must not show signs of corrosion, wear, or other damage. The turbine wheel must not show signs of wear or contact with other parts. Threads must not be damaged. The shaft must not show signs of scratches or seizure with the bearings.

The compressor and compressor wheel bore must not show signs of damage. Seal parts must not show signs of scratches or damage to the faces that rotate. Housings must not show signs of contact with parts that rotate. Oil and air passages must be clean and free from dirt etc.

Hone out minor surface damage. Use "Silicon carbide abrasive cloth" for aluminium parts and "crocus abrasive paper" for steel parts.

Change any parts that do not conform.

Change parts as follows: Seal ring, lockplates, piston rings, turbine housing bolts, journal bearings, bearing retainer rings and compressor wheel locknut. If thrust bearings and thrust collar show signs of scratches, burns, or other damage, they must be changed. Make a thorough inspection of the bearing bores in the centre housing and if the above conditions apply, change the centre housing.

To assemble

Check each part before installation to ensure it is clean.

Take care to prevent entry of dirt etc. on assembly.

Check thrust collar piston ring groove for cuts or burns.

Assemble as follows:

1. Install inner bearing retainers. Lubricate bearings with clean engine oil. Fit bearings and outer bearing retainers.
2. Place turbine wheel in a vertical position. Carefully guide shaft through shroud and centre housing bearings. Place thrust bearing over thrust collar.
3. Fit piston ring on thrust collar. Place thrust collar over shaft so that thrust bearing is flat against the centre housing and engages the centre housing rotation stop pins.
4. Ensure that thrust spring is installed in backplate. Align mounting holes of centre housing and backplate and install over shaft and thrust collar. Use care not to break piston ring when engaging seal into backplate bore. Backplate is easily installed if open position is engaged into backplate bore first.
5. Install compressor backplate, bolts and lock plate. Tighten to 79 lbf in (104 kgf cm) or 8,93 Nm and secure lockplates.
6. Fit compressor wheel. The larger face of the locknut and the front face of the impeller must be smooth and clean. Lightly oil threads and face of nut and tighten to 20 lbf in (23 kgf cm) or 2,26 Nm. Then continue to tighten until length of shaft increases by 0.0055/0.0065 in (0,14/0,16 mm). Tighten by the use of T-handled spanner to avoid side load which may cause shaft to bend. Check axial end play for 0.001/0.004 in (0,03/0,10 mm) travel. If equipment is not available to measure shaft increase in length, this other method may be used: After installing impeller nut, tighten to 20 lbf in (23 kgf cm) or 2,26 Nm, continue to tighten through an angle of 110°.

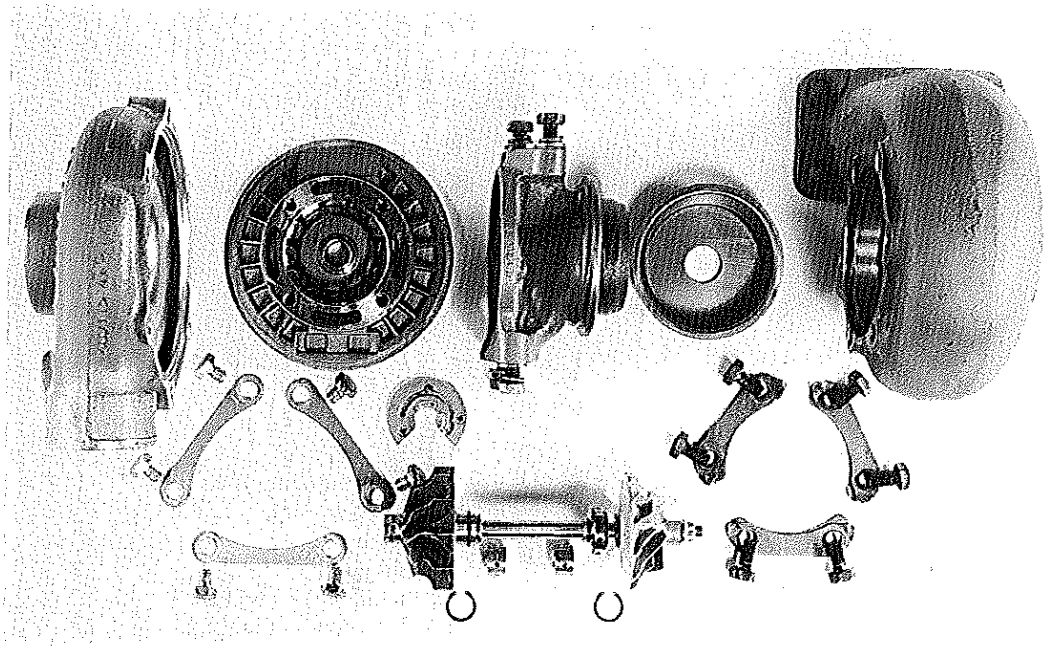


Fig. T4

7. Check for clearance between wheel shroud and turbine wheel.
8. Align compressor housing with centre housing. Fit the six bolts and three lockplates. Tighten bolts to 130 lbf in (150 kgf cm) or 14,09 Nm.
9. Align turbine housing with centre housing. Cover bolt heads with a high temperature thread lubricant. Install bolts, clamps and lockplates. Tighten bolts to 130 lbf in (150 kgf cm) or 14,09 Nm. Bend up lockplates.
10. After assembly, push the rotation assembly as far as possible from the turbine end and check that it moves freely. Push from compressor end, and repeat check.
11. If the unit is to be put into storage, lubricate internally and install protection covers on all open engine connections.

Note: The turbocharger does not need a test after overhaul.

Schwitzer S2A

To dismantle

1. Mark the positions of the compressor cover and turbine housing in relationship to the bearing housing.
2. Fasten the turbine housing in a soft faced vice with the turbocharger shaft vertical.
3. Remove the large circlip which secures the compressor cover and lift off the cover.
4. Remove the V Band clamp which secures the turbine housing and lift the central core assembly out of the turbine housing.
5. Fasten a suitable 12 point socket spanner in a vice with the socket axis vertical.
6. Put the 12 point hub of the turbine wheel into the socket. Hold the core assembly tight and release the compressor wheel locknut.
7. Remove the compressor nut and slide the compressor wheel from the turbine shaft.
8. To remove the turbine shaft and wheel, lightly hit the compressor end of the shaft with a small soft faced hammer. Be careful not to distort or damage the shaft.
9. Put the bearing housing on the turbine back plate and remove the retaining ring which secures the insert.
10. Remove the insert and thrower with the extractor tool as follows:

    Put the expander collet into the thrower bore and unscrew the "T" handle, this will expand the collet until it grips the thrower.

    Turn the aluminium body of the extractor tool in the thread until it makes contact with the bearing housing. Hold the body tight and unscrew the threaded part of the extractor by careful use of a 1-1/8 A.F. (10mm) spanner. This will pull the insert and the thrower out of the "O" ring seal in the bearing housing.
11. To dismantle the insert assembly, push the thrower sleeve out of the insert and remove the oil deflector, thrust bearing, thrust washer and thrust collar from the bearing.
12. Remove the outer circlips from both ends of the bearing housing, then remove the journal bearings and inner circlips.

Internal parts inspection

1. Bearing housing
   (a) Inspect bearing bore visually for signs of damage or wear.
   (b) Check turbine end seal bore for damage.
2. Compressor wheel
   (a) Inspect visually for signs of corrosion wear or other damage and for signs of scratches on the back face. Hone out minor surface damage. Renew if damage affects wheel balance.
3. Shaft and wheel assembly
   (a) Check journal diameter for wear, minimum permissible diameter 0.35 in (8,99 mm)
   (b) Check seal groove width, maximum permissible width 0.06 in (1,58 mm)
   (c) Measure concentricity between large and small shaft diameter. Limit of concentricity, total indicator reading, 0.0003 in (0,0076 mm)
   (d) Check balance to 0.0005 oz in (0.36 gm mm) in both planes. Renew if not within limits.
4. Compressor cover

   Visually inspect cover for signs of damage. Renew if necessary.
5. Turbine housing

   Inspect visually for signs of body damage or high temperature damage such as cracks, distortion or erosion. Renew if necessary.
6. Turbine backplate

   Renew if cracked or distorted.
7. Thrower sleeve

   Check piston ring groove for signs of taper or damage. Maximum permissible width 0.06 in (1,58 mm). Renew if worn.
8. Thrust ring

   Renew if thrust surface is worn. (It can be used again if the side that is not worn is put into contact with the thrust bearing).
9. Thrust collar

   The thrust collar must not show any signs of wear on the thrust face.

To assemble

Use the Schwitzer Service Parts kit.

1. Wash all parts in clean solvent and dry with compressed air.
2. Fit inner bearing retainers to bearing housing bore. Lubricate the bore with clean engine oil and fit the journal bearings and outer bearing retainers.
3. Fit a new piston ring seal to the groove in the shaft and wheel assembly.
4. Fit turbine backplate over the shaft section and put on the back of the turbine wheel.
5. Lubricate the shaft and piston ring and fit the shaft and wheel etc. into the bearing housing.
6. Put this assembly into the turbine housing with the shaft vertical and fit the thrust ring onto the shaft.
7. Fit the thrust bearing into the bearing housing and lubricate the bearing surfaces.
8. Fit the thrust collar and oil deflector and fit a new "O" ring to the groove in the insert.
9. Fit a new piston ring into the thrower sleeve and put the thrower sleeve assembly into the insert. Ensure the piston ring is not damaged.
10. Lubricate the "O" ring and put the insert assembly into the bearing housing and shaft assembly. Ensure the retainer ring has its bevelled edge at the top.
11. Fit the compressor wheel and locknut.
12. Put the 12 point socket spanner in a vice with the socket axis in a vertical position and put the 12 point hub of the turbine wheel into the socket.
13. Tighten the compressor locknut with "T" handle spanner to 7½ lb. ft. (1,04 Kg M) and apply two drops of Loctite 601 to the threads.
14. Fit the core assembly into the assembly cover. Loosely assemble the circlip over the bearing flange with the chamfered edge towards the turbine. Fit the circlip in the groove.
15. Fit the core assembly into the turbine housing, align the marks and fit the "V" band clamp. Tighten the locknut to 5 lb. ft. (0,7 Kg M.).

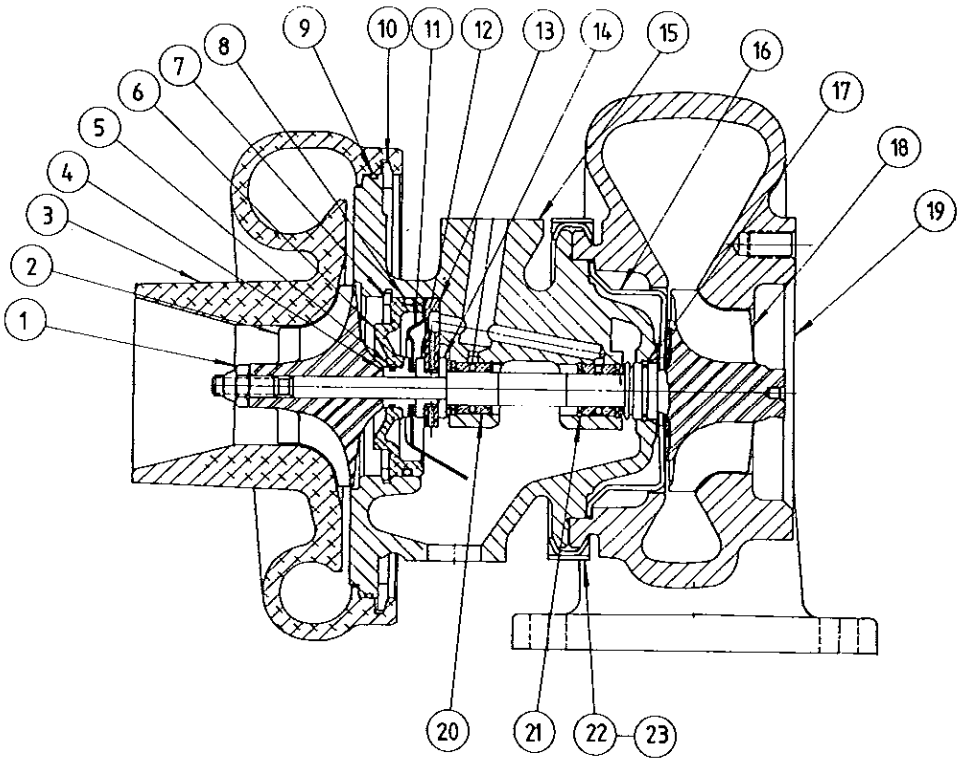


Fig. T5

1. Locknut
2. Compressor wheel
3. Compressor cover
4. Thrower sleeve
5. Piston ring
6. Insert
7. Retainer ring
8. "O" ring
9. "O" ring (Optional)
10. Retainer ring
11. Oil deflector
12. Thrust collar
13. Thrust bearing
14. Thrust ring
15. Bearing housing assy.
16. Backplate
17. Piston ring
18. Shaft and wheel assy.
19. Turbine housing
20. Bearing
21. Circlip
22. "V" band clamp
23. Locknut

To fit turbocharger

1. Remove seals from open engine connections.
2. Fit turbocharger to exhaust manifold, use a new gasket.
3. Fit turbocharger outlet assembly to cylinder block.
4. Fit oil drain pipe, use new gasket.
5. Pour 4 to 5 fluid ounces (110/114 ml) of clean engine oil through oil inlet port of turbocharger central housing. Turn rotation assembly by hand to pass oil over bearing surfaces.
6. Connect compressor inlet and outlet pipes and exhaust pipe.
7. Fit oil supply pipe but do not tighten setscrews.
8. Operate the stop control and turn engine by the starter motor until a steady flow of oil comes from the oil supply pipe.
9. Tighten pipe flange setscrews.
10. Start the engine and check for leaks. The engine must be run at idling speed for three to four minutes to allow the lubricating oil to flow before the engine speed is increased.

SECTION W
Marine Engines

Marine engines

The D3.152(M) marine engine with a rating of 31.5 kW (42.5 b.h.p) at 2,000 rev/min and the 3HD46 rated at 34,5 kW (46.0 b.h.p) at 2250 rev/min are for commercial and heavy duty commercial applications. They are similar in design to other series of D3.152 diesel engies and most of the component parts can be checked as given in other sections in this manual for the D3.152.

Some auxiliaries are used with marine engines and instructions which follow are for the overhaul of these items.

Altitude

Where marine engines operate at an altitude higher than 600 m (2,000 ft), the fuel delivery must be changed as given on page C3.

Preventive maintenance

These preventive maintenance periods are general in application. Check the periods given by the manufacturer of the boat (if supplied) in which the engine is installed and, where necessary, use the shorter periods. These periods must also be adapted to ensure correct operation for any local regulations.

It is good maintenance to check for leakage and loose fasteners at each service interval.

These maintenance periods are only for engines that are operated with fuel and lubricating oils to the specifications given in this manual.

The schedules which follow must be applied at the interval (hours or months) which occurs first.

Daily or every 8 hours

Check amount of lubricating oil in engine sump, gearbox and reduction box.
Check amount of coolant.
Check lubricating oil pressure (where a gauge is installed).

Every 50 hours

Check amount of distilled water in batteries (where fitted).
Check fresh water pump/generator drive belt tension.

Every 100 hours

Lubricate chain drive and bushes of hand start equipment and pawl assembly at rear of crankshaft pulley (where fitted).
Apply grease to hand start ratchet (where fitted).
Clean fuel oil pre-filter (where fitted).
Clean air filter gauze.
Check strainer in the water intake (where the condition of the water makes this necessary).
Check engine mounting bolts.

Every 250 hours or 4 months

Renew the lubricating oil.
Renew the lubricating oil filter canister.

Every 500 hours or 12 months

Check tappet clearances and oil flow to rocker assembly.
Check atomisers.
Clean breather pipe on cylinder head cover.
Check heat exchanger (where fitted) and oil coolers for corrosion and clean where necessary.
Renew the fuel filter element.
Renew lubricating oil in gearbox and reduction gear.
Clean gauze filter in Borg Warner gearbox.

Every 2,500 hours

The accessory equipment must be checked (starter motor, dynamo, alternator etc).

Starting equipment

Hand start or 12 volt electrical start equipment can be fitted.

Where hand start equipment is fitted, this must be used with the decompressor lever of the cylinder head cover.

Where 12 volt electrical start equipment is fitted, the starter motor is fitted on the right side of the engine. The starter pinion engages with the starter ring on the flywheel at the rear end of the engine.

Sump drain pump

With some engines, it is not possible to drain the sump by the sump drain plug. If this occurs, a hand operated sump drain pump can be fitted to the right side of the engine. The sump capacity is 6,3 litres (11 pints) 6.6 US quarts. The total engine capacity is 7,1 litres (12.5 pints) 7.5 US quarts.

Gearboxes

Three types of gearbox can be fitted to D3.152(M) and 3HD46 marine engines. These are the Borg Warner 71CR with 2:1 or 2.9:1 reduction, the PRM 140S with 2:1 reduction and the later PRM 160 with 1.96:1 or 2.94:1 reduction. All boxes are hydraulically operated.

To remove the gearbox

Remove the propeller shaft from the gearbox outlet flange and move away from gearbox. Remove oil pipes between oil cooler and gearbox.

Remove setscrews which fasten gearbox to flywheel housing.

The gearbox can then be removed.

Remove drive plate which connects the gearbox to the flywheel. If either the flywheel or flywheel housing is removed, it must be aligned when fitted as given in Section Q.

To fit the gearbox to the engine is the reverse procedure to removal.

Cooling system

Two systems can be used, either direct or indirect (heat exchanger). With an indirect system, the closed circuit coolant capacity is 8 litres (14 pints) 8.8 US quarts.

With the direct cooling system, a rubber impeller water pump is used. Water is lifted up from the outside water inlet to the engine oil cooler and then through the gearbox oil cooler to the water pump. From the pump, it is supplied to the cylinder block and head. The water passes from the engine at the front of the cylinder head and is discharged to the outside of the boat.

With the indirect cooling system, two separate water pumps are used. A rubber impeller water pump is used to lift the water from the outside water inlet up to the gearbox oil cooler and then to the pump. The water is then supplied to the heat exchanger and the engine oil cooler and then discharged to the outside of the boat.

The coolant in the fresh water side of the closed circuit is moved by a centrifugal pump which is belt driven from the crankshaft pulley. Coolant is supplied from the heat exchanger by this pump to the cylinder block and head and then returns from the front of the cylinder head to the heat exchanger. For service instructions for the centrifugal type water pump, see Section N.

To remove and dismantle rubber impeller water pump

On D3.152(M) and 3HD46 Mk1 engines the pump is driven from the camshaft gear and is fitted on the right side of the engine.

For 3HD46 Mk2 engines, the pump is driven from the fuel injection pump drive gear fitted at the front left side of the engine.

To remove the pump, disconnect the water inlet and outlet hose connections. The pump can then be removed by the removal of the setscrews which fasten it to the engine timing case.

To dismantle the pump:

Remove rear end cover plate.

Remove impeller.

Remove wear plate.

With the front bearing cover removed, a press can be used to press out the impeller shaft (from the impeller end) together with the front bearing. This releases the drive gear in its housing.

The cam in the impeller housing can then be removed by the removal of the single setscrew.

Remove rubber seal in impeller housing.

Remove rubber 'O' ring.

Remove distance pieces.

The drive gear housing and impeller shaft rear bearing can then be removed from the pump body.

Remove front rubber seal.

To assembly the pump, the reverse precedure is used. The rubber impeller blades must all be in the same direction in the correct relationship with the rotation of the pump.

When the water pump is assembled, ensure that the rubber impeller is lubricated with a suitable grease.

Note: The impeller can be removed without the removal of the pump.

When the cam is fitted in the impeller housing, a suitable jointing compound must be applied to all the top surface, rear face and fastener setscrew hole of the cam. The cam will go into place one way only.

With the assembled pump fitted to the engine, the backlash between the pump and camshaft must be 0,08/0,23 mm (0.003/0.009 in). At the factory, two joints can be fitted between the pump housing and timing case. If so, ensure that two new joints are used when the pump is fitted.

If the engine is to be removed from service for an extended period, it will be necessary to remove the pump end cover and lubricate the rubber impeller with Marfak 2HD grease at the start of the storage period.

Oil coolers

These are fitted to D3.152(M) and 3HD46 marine engines to keep the lubricating oil and gearbox oil at the correct temperatures.

To remove oil coolers

Remove inlet and outlet rubber water connections to the oil coolers.

Remove inlet and outlet oil pipes (gearbox oil cooler only).

Remove engine oil cooler by the removal of the bolts which fasten it to the cooler/filter adaptor.
Remove the gearbox oil cooler by the removal of the

two nuts on the ends of the oil cooler fastener clamp.

To fit the oil coolers, use the reverse procedures to that given above.

To clean the oil cooler tube stack

The oil coolers will need little maintenance if the outside water inlet strainer is kept clean.

After a long period of service, it can be found necessary to clean the tube stacks and this can be done in a similar method to that given later for the heat exchanger.

Note: Oil cooler tube stacks are integral with the outer casing and can not be removed.

To dismantle the heat exchanger

With the heat exchanger still fitted to the engine:-

Remove the two water pipes from the end covers.

Remove the two end covers by the removal of the setscrews.

Remove the 'O' ring seals from each end of the tube stack.

The tube stack can now be removed from the heat exchanger casing.

To clean the heat exchanger tube stack

If there are hard deposits or debris in the tubes, the best method to clean them is to use a non-caustic solution approved by the manufacturers. If the deposits or debris are soft, the tubes can be cleaned by a length of steel rod 3,2 mm (1/8 in) diameter, pushed through the tubes in the opposite direction to the coolant flow. (Ensure the steel rod does not cause damage to the tube walls).

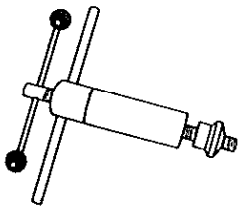
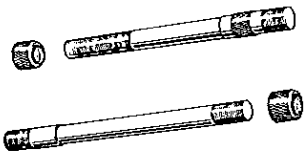
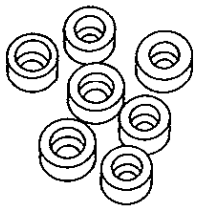
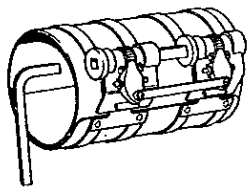
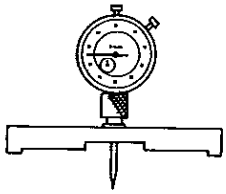
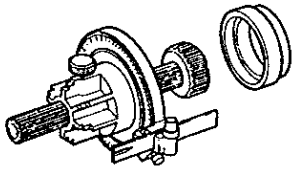
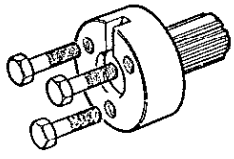
To assemble the heat exchanger

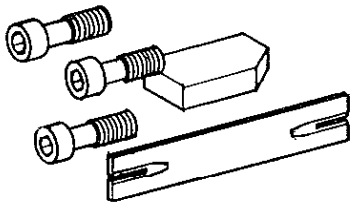
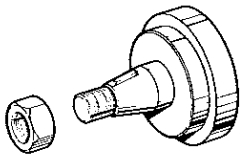
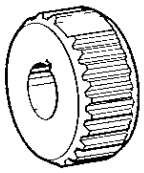
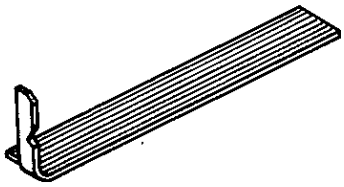
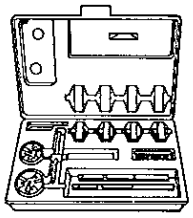
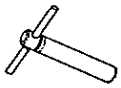
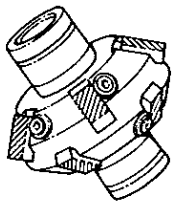
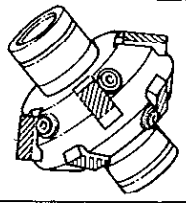
To assemble the heat exchanger, use the reverse procedure to that given to dismantle. If the 'O' ring seals are badly worn or out of shape, they must be renewed.

SECTION Y
Approved Service Tools

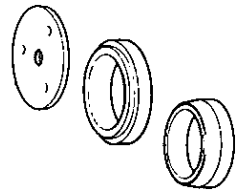
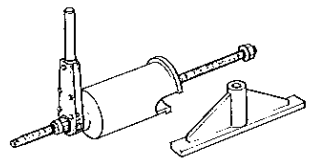
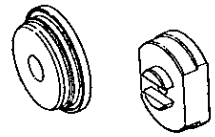
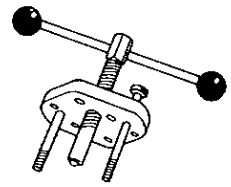
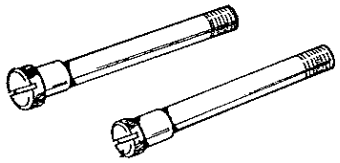
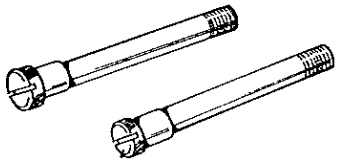
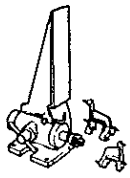
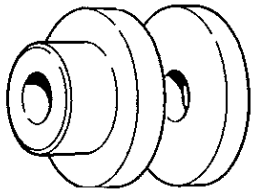
APPROVED SERVICE TOOLS—Y.2

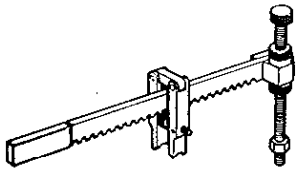
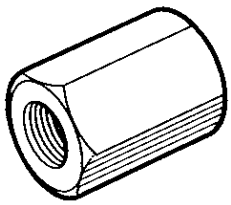
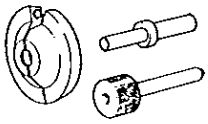
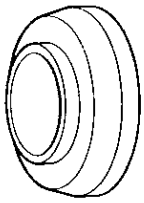
Available from V.L. Churchill & Co. Ltd., Daventry, Northamptonshire, NN11 4NF, England

	Churchills Tool No.	Description
	PD1D	VALVE GUIDE REMOVER AND REPLACER (MAIN TOOL)
	PD1D–1A	ADAPTOR FOR PD1D Two pull bars fitted with nuts. Suitable for 7,94 mm (5/16 in) and 9,52 mm (3/8 in) guides.
	PD1D-4	ADAPTOR FOR PD1D A 15 mm (19/32 in) distance piece used to fit valve guides to the correct height.
	PD1D-9	ADAPTOR FOR PD1D A 9.5 mm (3/8 in) distance piece used to fit valve guides to the correct height.
	No. 8	PISTON RING SQUEEZER
	PD41B	PISTON HEIGHT AND VALVE DEPTH GAUGE An easy method to check piston height and valve depth.
	MS67B –	TOOL TO CHECK FUEL INJECTION PUMP TIMING
	PD67B-1 –	ADAPTOR FOR USE WITH MS67B

	Churchills Tool No.		Description
	PD.67B-6	–	ADAPTOR FOR USE WITH MS67B AND MS67B-1
	PD.67-2	–	ADAPTOR FOR MS.67B For use with tapered drive shaft fuel injection pump.
	PD.67-3	–	ADAPTOR FOR MS.67B For use with tapered drive shaft fuel injection pump.
	PD.67-4	–	ADAPTOR FOR MS.67B For marking timing case
	MS73		VALVE SEAT CUTTER KIT (for 45° seats)
	MS76	–	HANDLE FOR VALVE SEAT CUTTERS Also in 45° valve seat cutter kit MS73.
	MS150-8	–	PILOT FOR VALVE SEAT CUTTERS Also in 45° valve seat cutter kit MS73
	MS690		EXHAUST VALVE SEAT CUTTER (35°) Used with handle MS76 and pilot MS150-8.
	MS695		INLET VALVE SEAT CUTTER (35°) Used with handle MS76 and pilot MS150-8.

APPROVED SERVICE TOOLS—Y.4

	Churchills Tool No.		Description
	PD145C	–	CRANKSHAFT REAR OIL SEAL REPLACER ADAPTOR (lip seal type)
	PD150B		CYLINDER LINER REMOVER/REPLACER (main tool) For use in service to fit single liners. Not advised for complete overhaul. For this work, use adaptors and hydraulic press.
	PD150–1B		ADAPTORS FOR PD150B To remove and fit 91,44 mm (3.6 in) cylinder liners.
	PD155B		BASIC PULLER The head has multiple holes at different centres for use with adaptors given below. (Perkins tool is complete with adaptors).
	PD155-1	–	ADAPTORS FOR PD155B To remove water pump pulleys.
	PD155B-5	–	ADAPTORS FOR PD155B (METRIC) To remove fuel pump drive gear with tapered bore.
	335	–	CONNECTING ROD JIG AND 336 MASTER ARBOR
	336-102	–	CONNECTING ROD ARBOR ADAPTOR Used with 335.

	Churchills Tool No.		Description
	6118B		VALVE SPRING COMPRESSOR
	PD6118-3		ADAPTOR FOR 6118B
	MF200-26	–	WATER PUMP OVERHAUL KIT Used with 370 taper base and press.
	PD159	–	TIMING CASE COVER CENTRALISING TOOL

SECTION Z
INDEX

INDEX—Z.2

Alternator
- Data C15
- Maintenance R2
- Output test R3
- Regulator test R4
- To test in position R4

Atomisers
- Data C15
- General P7

Backlash, timing gears C11
Bearing, connecting rod, data C8
Bearing, main
- Data C8
- To fit J2

Belt, drive, adjustment N2
Bush, small end
- Data C7
- To fit G3

Bush, camshaft K2

Camshaft
- Data C9
- Thrust K5
- To remove K5
- To fit K5

Case, timing
- To remove K5
- To fit K6
- To renew K6

Cooling system, capacity C12
Cover, timing case
- To remove K2
- To fit K3

Crankshaft
- Data C8
- Overhaul J4
- To remove J3
- To fit J5

Data, engine C2
Dynamo
- Data C15
- Maintenance R4
- To test in position R4

Filter, fuel oil
- General P2
- To renew element P2

Filter, lubricating oil
- General M3
- To renew element M3

Flywheel
- To remove Q2
- To fit Q2
- To renew ring gear Q2

Fuel system, to remove air P3

Gear, camshaft
- Data C11
- To remove K4
- To fit K4

Gear, crankshaft, data C11
Gear, idler
- Data C11
- To remove K3
- To fit K4

Gear, fuel pump
- Data C11
- To remove P7
- To fit P7

Gear, lubricating oil
- Pump drive, data C11

Gear, lubricating oil
- Pump idler, data C11

Head, cylinder
- Data C9
- Overhaul F7
- To remove F2
- To fit F9

Housing, flywheel alignment Q3
Hub, idler gear
- Data C11
- To remove K3
- To fit K4

Levers, rocker, data C10
Liners, cylinder
- Data C4
- To remove H2
- To fit H3

Lubricating oil pressure M3
Lubricating oil sump
- Capacity C12
- To remove M4
- To fit M4

Lubrication circuit M2

Marine engines W2

Number, engine location A4

Pin, gudgeon
- Data C7
- To remove G3
- To fit G3

Pipes, fuel P7
Piston
- Data C5
- To remove G2
- To assemble G3
- To fit G7
- To renew G8

Plugs, coolant, restriction H4
Precautions, safety A3
Pump, fuel injection
- Data C14
- To check mark angle L5
- To remove P7
- To fit P7

Pump, fuel lift
- Data C13
- Testing P4
- To remove P5
- To dismantle P5
- To assemble P6
- To fit P6

Pump, lubricating oil
- Data C11
- To remove M5
- To dismantle M5
- Inspection M5
- To assemble M5
- To fit M6

Pump, water
- Data C12
- To remove N2
- To dismantle N3
- To assemble N3
- To fit N4

Rating details C2
Rings, piston
- Data C6
- To fit G4

Rocker shaft assembly F4
Rod, connecting
Data C7
To remove G2
To assemble G3
To fit G7
Seal, crankshaft front end, oil K2
Seal, crankshaft rear end, oil J6
Shaft, rocker
Data C10
Springs, valve
Data C10
Starter motor
Data C15
Maintenance R4
To test R4
Tappets
Data C10
General F7
Tappet clearance
Adjustment F11
Thermostat
Data C12
General N5
Timing
Marks L2
Static position C14
Engine L2
Valve L2
Torque, recommended tensions C3
Turbocharger T2
Valve, crankcase vent F11
Valve guides
Data C9
General F4
Valve, inlet and exhaust C10
Data C10
Overhaul F3
To remove F2
To fit F9
Washers, crankshaft thrust
Data C8
To fit J2
Weights, crankshaft balance J4
Weights, engine dry C2

4.41 engines

Section 3 – Part B

Table of Contents

	Description	Page No.
1	General information	1
2	Specifications	11
3	Cylinder head assembly	31
4	Piston and connecting rod assemblies	53
5	Crankshaft assembly	65
6	Timing case and drive assembly	89
7	Cylinder block assembly	107
8	Engine timing	117
9	Aspiration system	129
10	Lubrification system	131
11	Fuel system	145
12	Cooling system	167
13	Flywheel and housing	177
14	Electrical equipment	181
15	Auxiliary equipment	191
16	Special tools	195

This document has been printed from SPI². Not for Resale

Contents

1 General information

Introduction ... 1

Engine views ... 2

Engine identification ... 3

Safety precautions ... 4

Engine lift equipment ... 6

Viton seals ... 7

POWERPART recommended consumable products ... 8

2 Specifications

Basic engine data ... 11

Data and dimensions ... 12

Recommended torque settings ... 28

Compression test data ... 30

This document has been printed from SPI². Not for Resale

3 Cylinder head assembly

General description 31

Rocker cover

Operation 3-1 To remove and to fit 32

Rocker assembly

Operation 3-2 To remove and to fit 33
Operation 3-3 To dismantle and to assemble 34
Operation 3-4 To inspect and to correct 34

Valve tip clearances

Operation 3-5 To check and to adjust 35

Valve springs

Operation 3-6 To change the valve springs (with cylinder head fitted) 36

Cylinder head assembly

Operation 3-7 To remove 38
Operation 3-8 To fit 40

Valves and valve springs

Operation 3-9 To remove 44
Operation 3-10 To fit 45
Operation 3-11 To inspect and to correct 46

Valve guides

Operation 3-12 To inspect 47
Operation 3-13 To remove 48
Operation 3-14 To fit 49

Cylinder head

Operation 3-15 To inspect and to correct 50
Operation 3-16 To correct a valve seat with a valve seat cutter 51
Operation 3-17 To fit valve seat inserts 52

4 Piston and connecting rod assemblies

General description 53

Big end bearing

Operation 4-1 To remove 54
Operation 4-2 To fit 55
Operation 4-3 To inspect 55

Piston and connecting rod

This document has been printed from SPI². Not for Resale

Operation 4-4 To remove ... 56
Operation 4-5 To fit ... 57
Operation 4-6 To check the piston height above the cylinder block ... 59

Piston rings

Operation 4-7 To remove and to fit ... 60

Piston and connecting rod assembly

Operation 4-8 To dismantle ... 61
Operation 4-9 To assemble ... 62

Piston and piston rings

Operation 4-10 To inspect ... 63

Connecting rod

Operation 4-11 To inspect ... 64

Small end bush

Operation 4-12 To remove and to fit ... 64

5 Crankshaft assembly

General description ... 65

Crankshaft pulley

Operation 5-1 To remove and to fit ... 66

Rear oil seal assembly

Operation 5-2 To remove and to fit ... 67
Operation 5-3 To renew the rear oil seal ... 68

Thrust washers

Operation 5-4 To check the crankshaft end-float ... 69
Operation 5-5 To remove ... 70
Operation 5-6 To fit ... 71

Main bearings

Operation 5-7 To remove (with the crankshaft in position) ... 72
Operation 5-8 To fit (with the crankshaft in position) ... 73
Operation 5-9 To inspect ... 73

Crankshaft

Operation 5-10 To remove ... 74
Operation 5-11 To fit ... 75
Operation 5-12 To inspect ... 77

This document has been printed from SPI². Not for Resale

Balancer unit

Operation 5-13 To remove 78
Operation 5-14 To fit 79
Operation 5-15 To dismantle 80
Operation 5-16 To assemble 82
Operation 5-17 To inspect 85
Operation 5-18 To remove and to fit the needle roller bearings for the drive shaft 86
Operation 5-19 To remove and to fit the bushes for the balance weights 87

6 Timing case and drive assembly

General description 89

Timing case cover

Operation 6-1 To remove 90
Operation 6-2 To fit 91

Front oil seal

Operation 6-3 To remove 92
Operation 6-4 To fit 93

Idler gear and hub

Operation 6-5 To remove 94
Operation 6-6 To fit 95

Fuel pump gear

Operation 6-7 To remove 96
Operation 6-8 To fit 97

Camshaft gear

Operation 6-9 To remove 98
Operation 6-10 To fit 99

Crankshaft gear

Operation 6-11 To remove 100
Operation 6-12 To fit 100

Timing case

Operation 6-13 To remove 101
Operation 6-14 To fit 102

Camshaft and tappets

Operation 6-15 To remove 104
Operation 6-16 To fit 105

This document has been printed from SPI². Not for Resale

7 Cylinder block assembly

General description 107

Cylinder block

Operation 7-1 To dismantle 107
Operation 7-2 To assemble 108
Operation 7-3 To inspect 109

Cylinder liner

Operation 7-4 To inspect 110
Operation 7-5 To recover a glazed liner 111
Operation 7-6 To remove 112
Operation 7-7 To fit a service liner 114

8 Engine timing

Lucas DPA fuel injection pumps

Operation 8-1 General description 117
Operation 8-2 To set number 1 piston to TDC on the compression stroke 118
Operation 8-3 Another method to set number 1 piston to TDC on the compression stroke. 119
Operation 8-4 To check the valve timing 120
Operation 8-5 To check the timing of the fuel injection pump 121
Operation 8-6 To check the timing mark of the fuel injection pump 122
Operation 8-7 To check the engine timing mark 123

Stanadyne fuel injection pumps

Operation 8-8 General description 124
Operation 8-9 To set number 1 piston to TDC on the compression stroke 124
Operation 8-10 To check the valve timing 124
Operation 8-11 To check the timing of the fuel injection pump 125
Operation 8-12 To check the timing mark of the fuel injection pump 126
Operation 8-13 To check the engine timing mark 128

9 Aspiration system

Open engine breather 129

This document has been printed from SPI². Not for Resale

10 Lubrication system

General description 131

Lubrication system flow diagram 132

Lubrication system flow diagram for the relief valve and balancer 133

Filter canister

Operation 10-1 To renew 134

Filter head

Operation 10-2 To remove and to fit 135

Sump

Operation 10-3 To remove and to fit 136

Oil strainer and suction pipe

Operation 10-4 To remove and to fit 137
Operation 10-5 To inspect and to correct 138

Lubricating oil pump

Operation 10-6 To remove 139
Operation 10-7 To fit 140
Operation 10-8 To renew the shaft for the idler gear 141
Operation 10-9 To inspect 142

Relief valve

Operation 10-10 To remove and to fit 143
Operation 10-11 To dismantle and to assemble 144
Operation 10-12 To inspect 144

11 Fuel system

General description 145

Fuel filter element

Operation 11-1 Fuel filter element types 147
Operation 11-2 To renew the filter element of the separate element type 148
Operation 11-3 To renew the filter element of the canister type 149

Atomisers

Operation 11-4 Atomiser fault 150
Operation 11-5 To remove and to fit 151

Fuel lift pump

Operation 11-6 To remove and to fit 152

This document has been printed from SPI². Not for Resale

Operation 11-7 To dismantle ... 153
Operation 11-8 To assemble ... 154
Operation 11-9 To test ... 155

Lucas DPA fuel injection pump

Operation 11-10 To remove ... 156
Operation 11-11 To fit ... 157
Operation 11-12 To adjust ... 158
Operation 11-13 To eliminate air from the fuel system ... 159

Stanadyne fuel injection pump

Operation 11-14 To remove ... 161
Operation 11-15 To fit ... 162
Operation 11-16 To adjust ... 163
Operation 11-17 To eliminate air from the fuel system ... 164

12 Cooling system

General description ... 167

Thermostats

Operation 12-1 To remove and to fit ... 168
Operation 12-2 To test ... 168

Coolant pump

Operation 12-3 To remove ... 169
Operation 12-4 To fit ... 170
Operation 12-5 To dismantle ... 171
Operation 12-6 To assemble ... 172

Fan

Operation 12-7 To remove and to fit ... 174

Lubricating oil cooler

Operation 12-8 To remove and to fit (canister type) ... 175

13 Flywheel and flywheel housing

General description ... 177

Flywheel

Operation 13-1 To remove and to fit ... 178

Ring gear

Operation 13-2 To remove and to fit ... 179

This document has been printed from SPI². Not for Resale

Flywheel housing

Operation 13-3 To remove and to fit 180

14 Electrical equipment

Alternators 181

Operation 14-1 To check and to adjust drive belt tension 182
Operation 14-2 To remove and to fit the drive belt 183
Operation 14-3 To remove and to fit the alternator 184
Operation 14-4 To maintain the alternator 184

Alternator fault diagnosis 185

Starter motors 187

Operation 14-5 To remove and to fit 187
Operation 14-6 To test on the engine 188

Starting aid 189

Operation 14-7 To remove and to fit a fuelled starting aid 189
Operation 14-8 To check the fuelled starting aid 190

15 Auxiliary equipment

Power take-off adaptors (adaptor for a hydraulic pump)

Operation 15-1 To remove and to fit 191
Operation 15-2 To dismantle 192
Operation 15-3 To assemble 193

Exhauster

Operation 15-4 To remove and to fit 194

16 Special tools

List of special tools 195

This document has been printed from SPI². Not for Resale

1

General information

Introduction

This Workshop Manual has been designed to provide assistance in the service and overhaul of Perkins 4.41 engine. For overhaul procedures the assumption is made that the engine is removed from the application.

Most of the general information which is included in the relevant User's Handbook has not been repeated in this workshop manual and the two publications should be used together.

The details of some operations will be different according to the type of fuel injection pump which is fitted. The specific pump type used can be found by reference to the manufacturer's identification plate on the pump body but, generally, the type of pump fitted is as shown below:

- Lucas - DPA
- Stanadyne - DB2.

When reference is made to the "left" or "right" side of the engine, this is as seen from the flywheel end of the engine.

Special tools have been made available and a list of these is given in Chapter 16, Special tools. Reference to the relevant special tools is also made at the beginning of each operation.

Data and dimensions are included in Chapter 2, Specifications.

Read and remember the "Safety precautions" on page 4. They are given for your protection and must be used at all times.

Danger is indicated in the text by two methods:

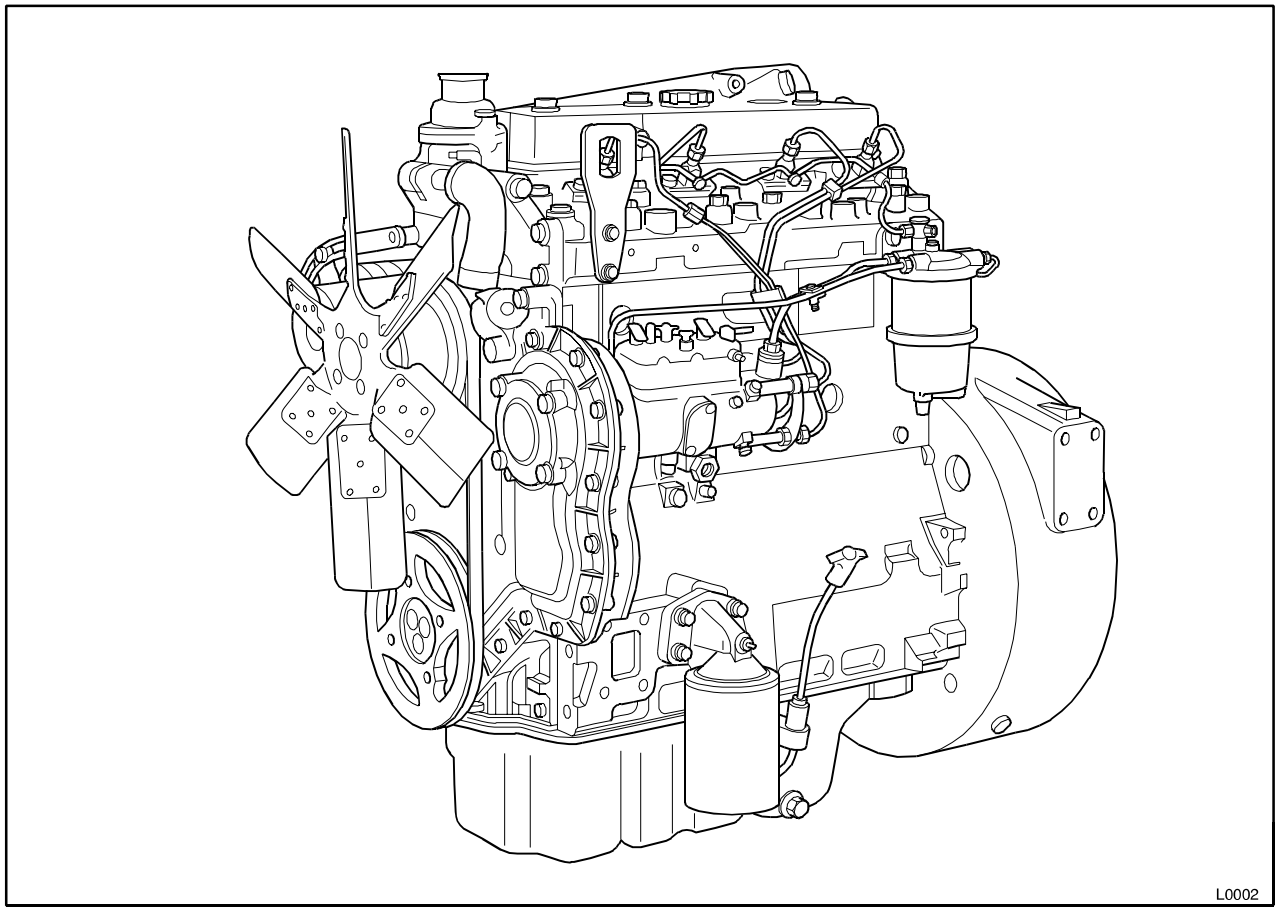
Warning! *This indicates that there is a possible danger to the person.*

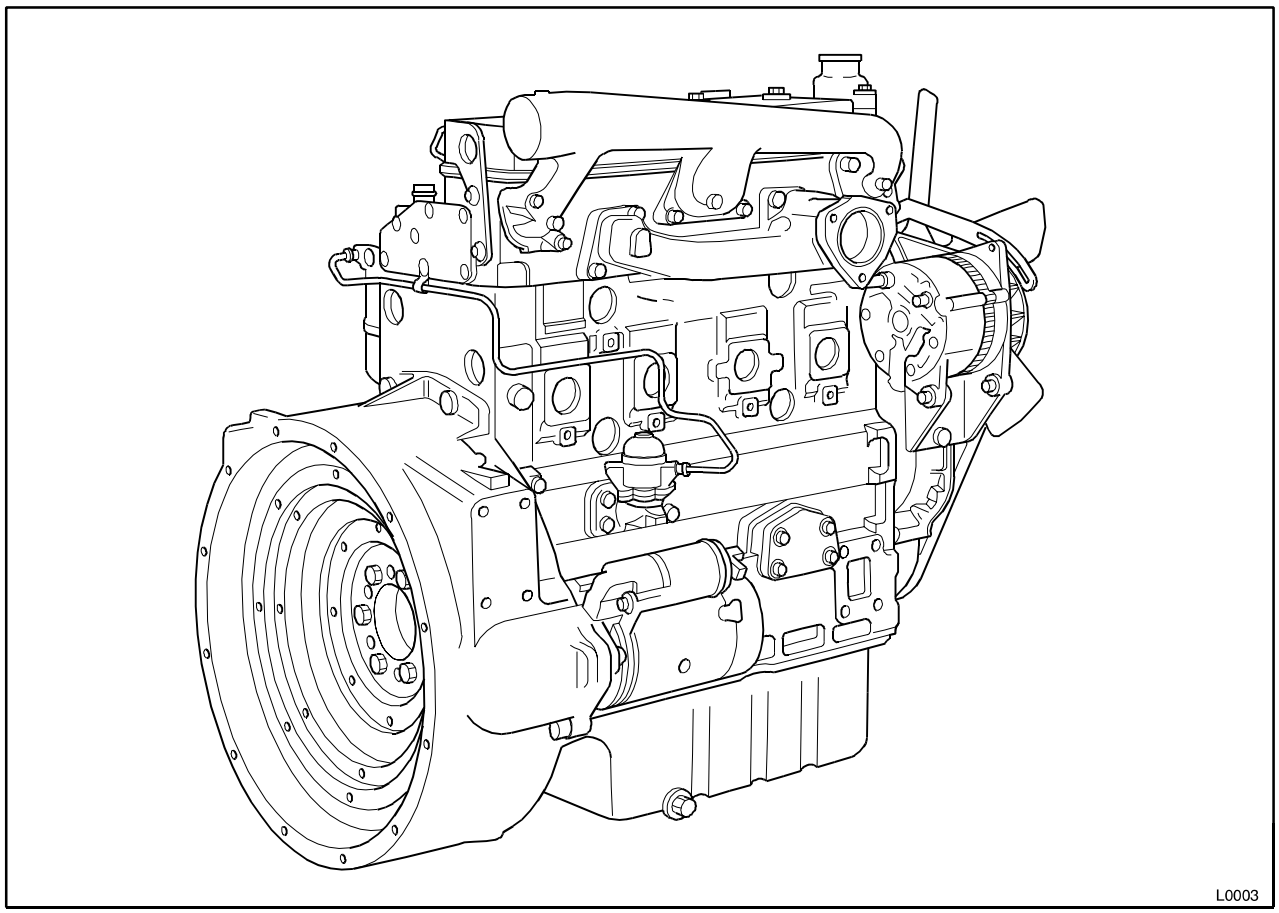
Caution: *This indicates that there is a possible danger to the engine.*

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

This document has been printed from SPI². Not for Resale

Engine views





This document has been printed from SPI². Not for Resale

Engine identification

The Perkins 4.41 engine has been designed for agricultural, industrial and generator set applications.

In this Workshop Manual, the engine type is indicated by code letters. These are the first two letters of the engine number as indicated below:

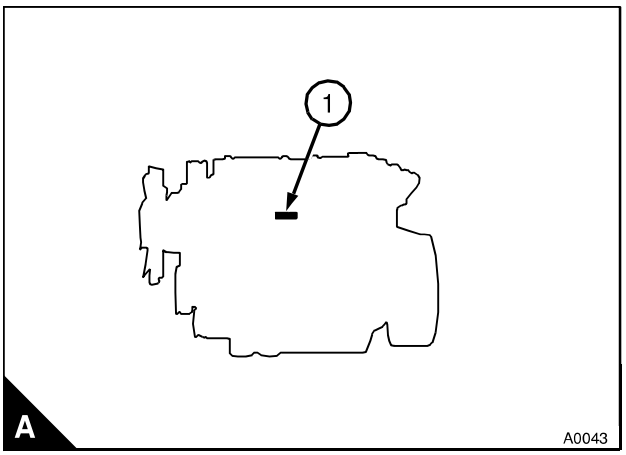
Code letters	Engine type
LM	Four cylinder, naturally aspirated

The engine number is stamped on a label which is fastened to the left side (A1) of the cylinder block. An example of an engine number is:

LM 50190 U 123450 A

Further information about the engine number system can be found in the relevant user's handbook.

Note: If you need parts, service or information for your engine, you must give the complete engine number to your Perkins distributor.



This document has been printed from SPI². Not for Resale

Safety precautions

These safety precautions are important.

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

- Only use these engines in the type of application for which they have been designed.
- Do not change the specification of the engine.
- Do not smoke when you put fuel in the tank.
- Clean away fuel which has been spilt. Material which has been contaminated by fuel must be moved to a safe place.
- Do not put fuel in the tank while the engine runs (unless it is absolutely necessary).
- Do not clean, add lubricating oil, or adjust the engine while it runs (unless you have had the correct training; even then extreme care must be used to prevent injury).
- Do not make adjustments that you do not understand.
- Ensure that the engine does not run in a location where it can cause a concentration of toxic emissions.
- Other persons must be kept at a safe distance while the engine or auxiliary equipment is in operation.
- Do not permit loose clothing or long hair near moving parts.
- Keep away from moving parts during engine operation.

Warning! *Some moving parts cannot be seen clearly while the engine runs.*

- Do not operate the engine if a safety guard has been removed.
- Do not remove the filler cap or any component of the cooling system while the engine is hot and while the coolant is under pressure, because dangerous hot coolant can be discharged.
- Do not allow sparks or fire near the batteries (especially when the batteries are on charge) because the gases from the electrolyte are highly flammable. The battery fluid is dangerous to the skin and especially to the eyes.
- Disconnect the battery terminals before a repair is made to the electrical system.
- Only one person must control the engine.
- Ensure that the engine is operated only from the control panel or from the operators position.
- If your skin comes into contact with high-pressure fuel, obtain medical assistance immediately.
- Diesel fuel and lubricating oil (especially used lubricating oil) can damage the skin of certain persons. Protect your hands with gloves or a special solution to protect the skin.
- Do not wear clothing which is contaminated by lubricating oil. Do not put material which is contaminated with oil into the pockets of clothing.
- Discard used lubricating oil in a safe place to prevent contamination.
- Ensure that the control lever of the transmission drive is in the "out-of-drive" position before the engine is started.
- Use extreme care if emergency repairs must be made in adverse conditions.

Continued

This document has been printed from SPI². Not for Resale

- The combustible material of some components of the engine (for example certain seals) can become extremely dangerous if it is burned. Never allow this burnt material to come into contact with the skin or with the eyes. Refer to "Viton seals" on page 7.
- Read and use the instructions relevant to lift equipment, see "Engine lift equipment" on page 6.
- Always use a safety cage to protect the operator when a component is to be pressure tested in a container of water. Fit safety wires to secure the plugs which seal the hose connections of a component which is to be pressure tested.
- Do not allow compressed air to contact your skin. If compressed air enters your skin, obtain medical help immediately.
- Do not clean an engine while it runs. If cold cleaning fluids are applied to a hot engine, certain components on the engine may be damaged.
- Fit only genuine Perkins parts.

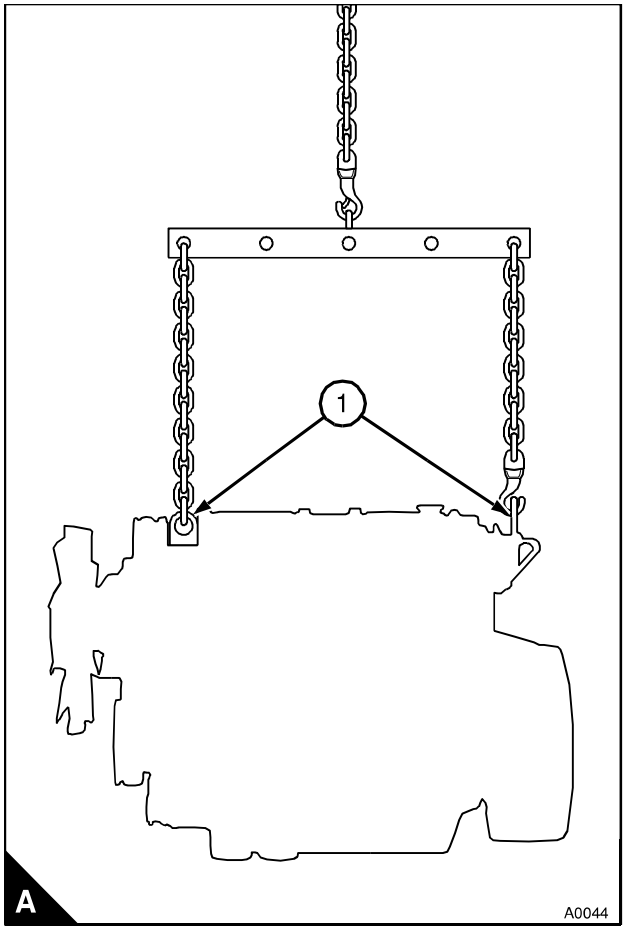
This document has been printed from SPI². Not for Resale

Engine lift equipment

The maximum weight of the engine without coolant, lubricant or a gearbox fitted will vary for different applications. It is recommended that lift equipment of 500 Kg (1100 lbs) minimum capacity is used.

Before the engine is lifted:

- Always use engine lift equipment of the approved type and of the correct capacity to lift the engine. It is recommended that lift equipment of the type shown in (A) is used to provide a vertical lift, directly above the engine lift brackets (A1). Never use a single lift bracket to raise an engine.
- Check the engine lift brackets for damage and that they are secure before the engine is lifted. The torque for the setscrews for the engine lift brackets is 44 Nm (33 lbf ft) 4,5 kgf m.
- To prevent damage to the rocker cover, ensure that there is clearance between the hooks and the rocker cover.
- Use lift equipment or obtain assistance to lift heavy engine components such as the cylinder block, the cylinder head, the balancer unit, the flywheel housing, the crankshaft and the flywheel.



This document has been printed from SPI². Not for Resale

Viton seals

Some seals used in engines and in components fitted to engines are made of Viton.

Viton is used by many manufacturers and is a safe material under normal conditions of operation.

If Viton is burned, a product of this burnt material is an acid which is extremely dangerous. Never allow this burnt material to come into contact with the skin or with the eyes.

If it is necessary to come into contact with components which have been burnt, ensure that the precautions which follow are used:

- Ensure that the components have cooled.
- Use Neoprene gloves and discard the gloves safely after use.
- Wash the area with calcium hydroxide solution and then with clean water.
- Disposal of components and gloves 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 or with calcium hydroxide solution for 15-60 minutes. **Obtain immediate medical attention**.

This document has been printed from SPI². Not for Resale

POWERPART recommended consumable products

Perkins have made available the products recommended below in order to assist in the correct operation, service and maintenance of your engine and your machine. The instructions for the use of each product are given on the outside of each container. These products are available from your Perkins distributor.

POWERPART Antifreeze

Protects the cooling system against frost and corrosion. Part number 1 litre 21825166 or 5 litres 21825167.

POWERPART Chisel

Allows easy removal of old gaskets and joints. Currently Loctite chisel. Part number 21825163.

POWERPART Compound

To seal the outer diameter of seals. Currently Loctite Forma Gasket No 2. Part number 1861147.

POWERPART Easy Flush

Cleans the cooling system. Part number 2182501

POWERPART Gasket eliminator

Improves flange sealing when a gasket is not used. It provides a seal with temperature resistance that is flexible in positions where vibration and pressure occur. Currently Loctite 515. Part number 21826040.

POWERPART Jointing compound

Universal jointing compound which seals joints. Currently Hylomar. Part number 1861155 or 1861117.

POWERPART Lay-Up 1

A diesel fuel additive for protection against corrosion. Part number 1772204.

POWERPART Lay-Up 2

Protects the inside of the engine and of other closed systems. Part number 1762811.

POWERPART Lay-Up 3

Protects outside metal parts. Part number 1734115.

POWERPART Liquid gasket

To seal flat faces of components where no joint is used. Especially suitable for aluminium components. Currently Loctite 518. Part number 21820518

POWERPART Nutlock

To retain and seal threaded fasteners and cup plugs where easy removal is necessary. Currently Loctite 242e. Part number 21820242

POWERPART Platelock

For tight fitted metal surfaces. Suitable for metal plated surfaces and stainless steel, Currently Loctite 243. Part number 21826039.

POWERPART Repel

Dries damp equipment and gives protection against corrosion. Passes through dirt and corrosion to lubricate and to assist removal of components. Currently Loctite repel. Part number 21825164.

Continued

This document has been printed from SPI². Not for Resale

POWERPART Retainer (oil tolerant)

To retain components which have a transition fit. Currently Loctite 603. Part number 21820603.

POWERPART Retainer (high strength)

To retain components which have an interference fit. Currently Loctite 638. Part number 21820638

POWERPART Silicone adhesive

An RTV silicone adhesive for application where low-pressure tests occur before the adhesive sets. Used to prevent leakage where movement of the joint occurs. Currently Loctite 5900. Part number 21826038.

POWERPART Silicone rubber sealant

Silicone rubber sealant which prevents leakage through gaps. Currently Hylosil Part number 1861108.

POWERPART Studlock

To permanently retain large fasteners and studs. Currently Loctite 270. Part number 21820270.

POWERPART Threadlock

To retain small fasteners where easy removal is necessary. Currently Loctite 222e. Part number 21820222.

POWERPART Threadlock (hydraulic/pneumatic)

To retain and seal pipe connections with fine threads. Especially suitable for hydraulic and pneumatic systems. Currently Loctite 542. Part number 21820542

POWERPART Threadlock (pipe)

To retain and seal pipe connections with coarse threads. Pressure systems can be used immediately. Currently Loctite 575. Part number 21820575.

This document has been printed from SPI². Not for Resale

This page is intentionally blank

This document has been printed from SPI². Not for Resale

2

Specifications

Basic engine data

Number of cylinders	4
Cylinder arrangement	In-line
Cycle	Four stroke
Direction of rotation	Clockwise from the front
Induction system	Naturally aspirated
Combustion system	Direct injection
Nominal bore	101 mm (3.98 in)
Stroke	127 mm (5.000 in)
Compression ratio	15.3:1
Cubic capacity	407 litres (248 in^3)
Firing order	1, 3, 4, 2
Valve tip clearance (cold):	
- Inlet	0,20 mm (0.008 in)
- Exhaust	0,45 mm (0.018 in)
Lubricating oil pressure (1)	207 kpa (30 lbf/in^2) 2,1 kgf/cm^2

(1) Minimum at maximum engine speed and normal engine temperature.

This document has been printed from SPI². Not for Resale

Data and dimensions

Note: This information is given as a guide for personnel engaged on engine overhauls. The dimensions which are shown are those which are mainly used in the factory. The information applies to all engines, unless an engine type code is shown.

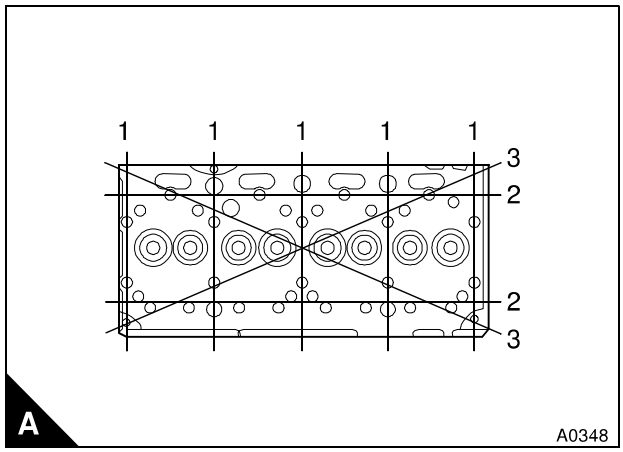
Cylinder head

Angle of valve seat:

Exhaust .. .. 46° (88° included angle)
Inlet ... ... 46° (88° included angle)
Diameter of parent bore for valve guide. ... ... 15,87/15,89 mm (0.6247/0.6257 in)
Leak test pressure . ... 200 kPa (29 lbf/in^2) 2,04 kgf/cm^2
Head thickness .. .. 102,79/103,59 mm (4.047/4.078 in)
Minimum permissible thickness after head face has been machined ... ...102,48 mm (4.035 in)

Maximum permissible distortion of cylinder head

A1... ... ...0,08 mm (0.003 in)
A2... ... ...0,15 mm (0.006 in)
A3... ... ...0,15 mm (0.006 in)



This document has been printed from SPI². Not for Resale

Inlet and exhaust valves

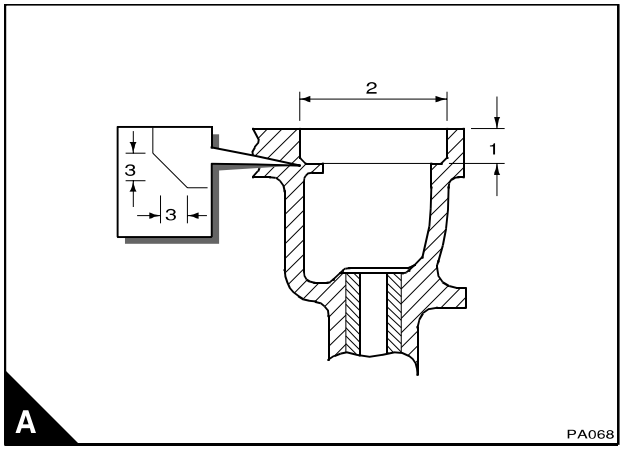
Inlet valves

Diameter of valve stem ... ...9,46/9,49 mm (0.3725/0.3735 in)
Clearance in valve guide . ...0,02/0,10 mm (0.0008/0.0039 in)
Maximum clearance in valve guide . ... 0,13 mm (0.005 in)
Diameter of valve head ... ...44,86/45,11 mm (1.766/1.776 in)
Angle of valve face .. ..

Valve seat inserts

Dimensions of recesses for valve seat inserts

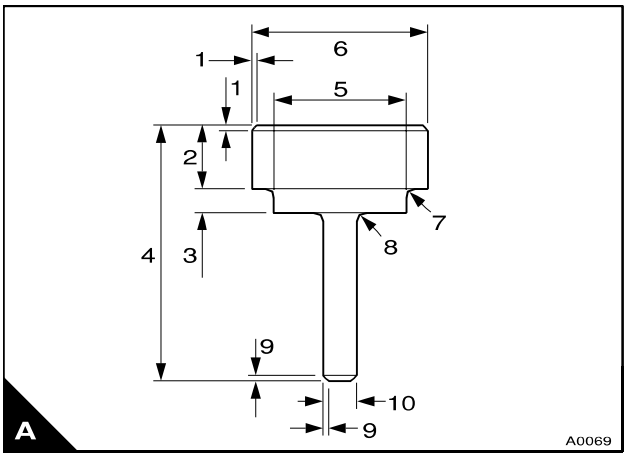
Measurement	Inlet	Exhaust
A1	7,19/7,32 mm (0.283/0.288 in)	9,52/9,65 mm (0.375/0.380 in)
A2	51,22/51,24 mm (2.0165/2.0175 in)	42,62/42,65 mm (1.6780/1.6790 in)
A3	Chamfer 0,38 mm (0.015 in) maximum	Chamfer 0,38 mm (0.015 in) maximum



This document has been printed from SPI². Not for Resale

Valve seat insert tool

Measurement	Inlet	Exhaust
A1	1,59 mm (0.063 in)	1,59 mm (0.063 in)
A2	19,05 mm (0.750 in)	19,05 mm (0.750 in)
A3	6,35 mm (0.250 in)	7,92 mm (0.312 in)
A4	76,20 mm (3.00 in)	76,20 mm (3.00 in)
A5	37,26/37,28 mm (1.467/1.468 in)	32,58/32,84 mm (1.283/1.293 in)
A6	51,00/51,23 mm (2.008/2.017 in)	42,39/42,62 mm (1,669/1.678 in)
A7	0,79 mm (0.031 in)	0,79 mm (0.031 in)
A8	1,59 mm (0.063 in)	1,59 mm (0.063 in)
A9	1,59 mm (0.063 in)	1,59 mm (0.063 in)
A10	9,45/9,47 mm (0.372/0.373 in)	9,45/9,47 mm (0.372/0.373)



This document has been printed from SPI². Not for Resale

Valve guides and valve springs

Valve guides

Inside diameter ... 9,51/9,56 mm (0.3744/0.3764 in)
Outside diameter ... 15,90/15,91 mm (0.6260/0.6265 in)
Interference fit of valve guide in cylinder head ... 0,03/0,07 mm (0.0012/0.0027 in)
Length:

Inlet ... 57,94 mm (2.281 in)
Exhaust ... 61,10 mm (2.406 in)
Protrusion from bottom of recess for valve spring ... 15,10 mm (0.594 in)

Single valve springs

Fitted length ... 40,0 mm (1.57 in)
Load at fitted length ... 312/344 N (70.1/77.3 lbf) 31,8/35,1 kgf
Number of active coils ... 4.5
Number of damper coils ... 0
Direction of coils ... Left hand

Tappets, rocker shaft, rocker levers and bushes

Tappets

Diameter of tappet stem ... 18,99/19,01 mm (0.7475/0.7485 in)
Diameter of tappet bore in cylinder block ... 19,05/19,08 mm (0.7500/0.7512 in)
Clearance of tappet in cylinder block ... 0,04/0,09 mm (0.0015/0.0037 in)

Rocker shaft

Outside diameter ... 19,01/19,04 mm (0.7485/0.7495 in)

Rocker levers and bushes

Maximum permissible clearance between rocker lever bush and rocker shaft ... 0,13 mm (0.005 in)

This document has been printed from SPI². Not for Resale

Pistons and connecting rods

Pistons

Type	"Toroidal" combustion bowl, controlled expansion
Diameter of bore for gudgeon pin	34,928/34,934 mm (1.3751/1.3754 in)
Height of piston above top face of cylinder block	0,14/0,36 mm (0.005/0.014 in)
Width of groove for top ring	2,54/2,56 mm (0.1000/0.1007 in)
Width of groove for second ring	2,54/2,56 mm (0.1000/0.1007 in)
Width of groove for third ring	5,04/5,06 mm (0.1984/0.1992 in)

Piston rings

Top compression ring	Barrel face, molybdenum insert, internal top step
Second compression ring	Taper face, cast iron
Oil scraper ring	Coil spring loaded, chromium faced
Width of top ring	2,46/2,49 mm (0.097/0.098 in)
Width of second ring	2,48/2,49 mm (0.097/0.098 in)
Width of third ring	4,98/4,99 mm (0.1960/0.1964 in)
Clearance of top ring in groove	0,05/0,10 mm (0.002/0.004 in)
Clearance of second ring in groove	0,05/0,08 mm (0.002/0.003 in)
Clearance of third ring in groove	0,05/0,08 mm (0.002/0.003 in)
Gap of top ring	0,41/0,86 mm (0.016/0.034 in)
Gap of second ring	0,40/0,86 mm (0.016/0.034 in)
Gap of third ring	0,40/0,86 mm (0.016/0.034 in)

Connecting rods

Type	'H' section, square shape small end
Location of cap to connecting rod	Serrations
Diameter of parent bore for big end	67,21/67,22 mm (2.6460/2.6465 in)
Diameter of parent bore for small end	38,89/38,92 mm (1.531/1.532 in)
Length between centres	219,05/219,10 mm (8.624/8.626 in)

Connecting rod bearings

Type:	Steel back, aluminium/tin bearing material
Width:	31,62/31,88 mm (1.245/1.255 in)
Thickness at centre of bearings:	1,835/1,842 mm (0.0723/0.0725 in)
Bearing clearance:	0,035/0,081 mm (0.0014/0.0032 in)
Available undersize bearings	-0,25 mm (-0.010 in); -0,51 mm (-0.020 in); -0,76 mm (-0.030 in)

Gudgeon pins

Type	Fully floating
Outside diameter	34,920/34,925 mm (1.3748/1.3750 in)
Clearance fit in piston boss	0,003/0,014 mm (0.0001/0.0006 in)

Small end bushes

Type	Steel back, lead-bronze or lead-bronze tin bearing material
Outside diameter	38,94/39,03 mm (1.535/1.536 in)
Inside diameter (reamed)	34,94/34,96 mm (1.3758/1.3765 in)
Clearance between bush in small end and gudgeon pin	0,020/0,043 mm (0.0008/0.0017 in)

This document has been printed from SPI². Not for Resale

Crankshaft

Diameter of main journals	76,16/76,18 mm (2.998/2.999 in)
Maximum wear and ovality on journals and crank pins	0,04 mm (0.0016 in)
Width of front journal	36,93/37,69 mm (1.454/1.484 in)
Width of centre journal	44,15/44,22 mm (1.738/1.741 in)
Width of all other journals	39,24/39,35 mm (1.545/1.549 in)
Diameter of crank pins	63,47/63,49 mm (2.499/2.500 in)
Width of crank pins	40,35/40,42 mm (1.589/1.591 in)
Diameter of flange	133,27/133,37 mm (5.247/5.251 in)
Depth of recess for spigot bearing	20,22/20,98 mm (0.796/0.826 in)
Bore of recess for spigot bearing	46,96/46,99 mm (1.849/1.850 in)
Crankshaft end-float	0,05/0,38 mm (0.002/0.015 in)
Maximum permissible end-float	0,51 mm (0.020 in)
Fillet radii of journals and crank pins	3,68/3,96 mm (0.145/0.156 in)
Undersize journals and crank pins	-0,25 mm (-0.010 in); -0,51 mm (-0.020 in); -0,76 mm (-0.030 in)
Crankshaft heat treatment	Induction hardened

This document has been printed from SPI². Not for Resale

Crankshaft overhaul

Notes:

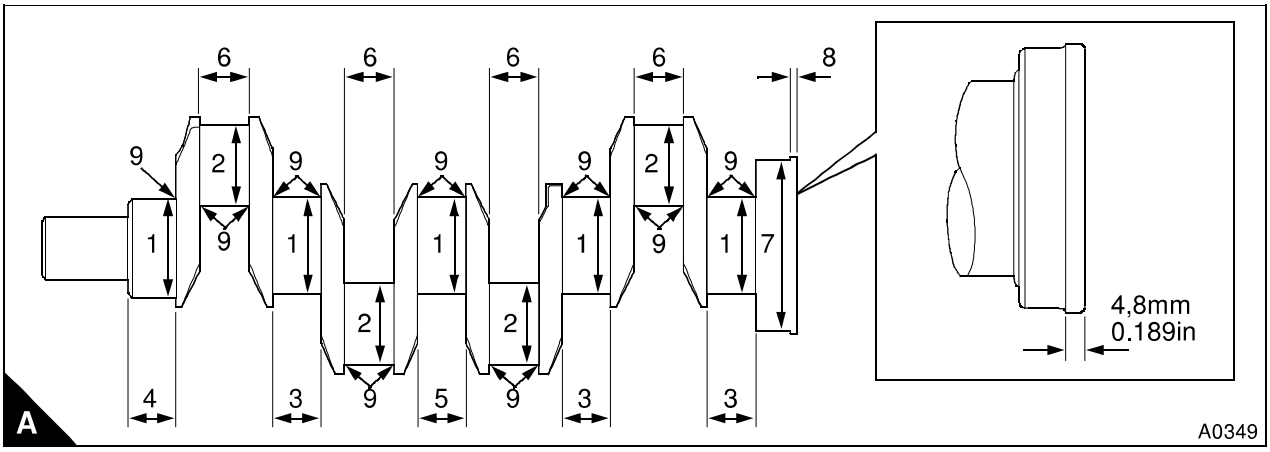
- Induction hardened crankshafts need not be hardened after they have been machined undersize.
- Check the crankshaft for cracks before and after it is ground. Demagnetise the crankshaft after it has been checked for cracks.
- After the crankshaft has been machined remove any sharp corners from the lubricating oil holes.
- Surface finish and fillet radii must be maintained.

The finished sizes for crankshaft journals (A) which have been ground undersize are given in the table below:

Item	0,25 mm (0.010 in)	0,51 mm (0.020 in)	0,76 mm (0.030 in)
1	75,905/75.926 mm (2.9884/2.9892 in)	75,651/75,672 mm (2.9784/2.9792 in)	75,397/75,418 mm (2.9684/2.9692 in)
2	63,216/63,236 mm (2.4888/2.4896 in)	62,962/62,982 mm (2.4788/2.4796 in)	62,708/62,728 mm (2.4688/2.4696 in)
3	39,47 mm (1.554) maximum	-	-
4	37,82 mm (1.489 in) maximum	-	-
5	44,68 mm (1.759 in) maximum	-	-
6	40,55 mm (1.596 in) maximum	-	-
7	133,17 mm (5.243 in) minimum	-	-
8	Do not machine this diameter	-	-
9	3,68/3,96 mm (0.145/0.156 in)	-	-

Surface finish for journals, crank pins and fillet radii must be 0,4 microns (16 micro inches).

Surface finish for seal area of crankshaft palm must be 0,4/1,1 microns (16/43 micro inches).



Continued

This document has been printed from SPI². Not for Resale

With the crankshaft on mountings at the front and rear journals, the maximum run-out (total indicator reading) at the journals must not be more than shown below:

Journal	Crankshaft
1	Mounting
2	0,08 mm (0.003 in)
3	0,15 mm (0.006 in)
4	0,08 mm (0.003 in)
5	Mounting

Run-out must not be opposite. The difference in run-out between one journal and the next must not be more than 0,10 mm (0.004 in).

Run-out on the crankshaft pulley diameter, rear oil seal diameter and the rear flange diameter must not be more than 0,05 mm (0.002 in) total indicator reading.

This document has been printed from SPI². Not for Resale

Crankshaft bearings and thrust washers

Main bearings

Type (All bearings) .. .. Steel back, 20% tin-aluminium bearing material

Bearing width

Centre bearing. ... ...

Timing case and drive assembly

Camshaft

Diameter of number 1 journal ... ... 50,71/50,74 mm (1.9965/1.9975 in)
Diameter of number 2 journal ... ... 50,46/50,48 mm (1.9865.1.9875 in)
Diameter of number 3 journal: ... ... 49,95/49,98 mm (1.9665/1.9675 in)

Cam lift:

Inlet ... ... 7,62/7,69 mm (0.2999/0.3029 in)
Exhaust.. ... ... 7,71/7,79 mm (0.3036/0.3066 in)
Maximum permissible ovality and wear on journals... ... ...0,05 mm (0.021 in)

End-float:

Production limits. ... ... 0,10/0,41 mm (0.004/0.016 in)
Service limit ... ...0,53 mm (0.021 in)
Width of spigot for thrust washer ... ... 5,64/5,89 mm (0.222/0.232 in)

Camshaft thrust washer

Type ... ... 360°
Depth of recess in cylinder block for thrust washer ... ... 5,46/5,54 mm (0.215/0.218 in)
Thickness of thrust washer ... ... 5,49/5,54 mm (0.216/0.218 in)
Relationship of thrust washer to front face of cylinder block.. ... ... -0,05/+0,08 mm (-0.002/+0.003 in)

Camshaft gear

Number of teeth 56
Diameter of bore ... ... 34,93/34,95 mm (1.3750/1.3760 in)
Outside diameter of hub of camshaft. ... ... 34,90/34,92 mm (1.3741/1.3747 in)
Clearance fit of gear on hub... ... ... 0,008/0,048 mm (0.0003/0.0019 in)

Fuel pump gear

Number of teeth 56

Crankshaft gear

Number of teeth 28
Diameter of bore ... ... 47,625/47,650 mm (1.8750/1.8760 in)
Diameter of hub for gear on crankshaft . ... 47,625/47,645 mm (1.8750/1.8758 in)
Transition fit of gear on crankshaft. ... ... -0,020/+0,048 mm (-0.0008/+0.0010 in)

Idler gear and hub

Number of teeth 63
Diameter of bore of gear ... ... 57,14/57,18 mm (2.2495/2.2512 in)
Width of gear and split bush assembly (fitted in position).. ... ... 30,66/31,16 mm (1.207/1.227 in)
Inside diameter of flanged bushes (fitted in position). ... ... 50,78/50,80 mm (1.999/2.000 in)
Outside diameter of hub. ... ... 50,70/50,74 mm (1.9960/1.9975 in)
Clearance of bushes on hub.. ... ... 0,04/0,10 mm (0.0016/0.0039 in)

End float of gear:

Production limits (cast iron gears).. ... ... 0,10/0,20 mm (0.004/0.008 in)
Production limits (steel gears) ... ... 0,24/0,33 mm (0.009/1.299 in)
Service limit ... ...0,38 mm (0.015 in)
Backlash for all gears. ... ... 0,08 mm (0.003 in) minimum

This document has been printed from SPI². Not for Resale

Cylinder block assembly

Cylinder block

Height between top and bottom faces ... ...441,12/441,33 mm (17.367/17.375 in)
Diameter of parent bore for cylinder liner ... ...104,25/104,28 mm (4.104/4.106 in)
Depth of recess for flange of cylinder liner .. ..3,81/3,91 mm (0.150/0.154 in)
Diameter of recess for flange of cylinder liner . ...107,82/107,95 mm (4.245/4.250 in)
Diameter of parent bore for main bearing ... ...80,416/80,442 mm (3.1660/3.1670 in)

Camshaft bore diameter

Four cylinder engines:

Number 1 (for bush) ... ...55,56/55,59 mm (2.188/2.189 in)
Number 2 . ...50,55/50,60 mm (1.990/1.992 in)
Number 3 . ...50,04/50,09 mm (1.970/1.972 in)
Bore of bush for number 1 camshaft journal ... ...50,79/50,85 mm (2.000/2.002 in)

Cylinder liners

Type:

Production ... ...Dry, interference fit, flanged
Service . ... Dry, transition fit, flanged
Outside diameter of production liner ... ...104,25/104,28 mm (4.105/4.106 in)
Interference fit of production liner ... ...0,03/0,08 mm (0.001/0.003 in)
Inside diameter of production liner (finished)... ... ...101,054/101,079 mm (3.978/3.979 in)
Transition fit of service liner . ... +/- 0,03 mm (+/- 0.001 in)
Inside diameter of service liner (fitted) . ... 101,092/101,117 mm (3.980/3.981 in)
Thickness of flange .. ..3,81/3,86 mm (0.150/0.152 in)
Relative position of top of liner flange to top face of cylinder block . ... 0,10 mm (0.004 in) above/
. ...

Engine timing

Static timing - CAV fuel injection pump

The engine check angle must be used with special tool MS.67B and with the engine set with number 1 piston at top dead centre (TDC) on the compression stroke. The pump is checked with the pump set at the start of injection for number 1 cylinder.

The code letters are included in the setting code stamped on the data plate of the fuel injection pump. Some fuel pumps may have the setting code stamped on a modification plate which is fastened to the flange of the pump. If a modification plate is fitted, use the code letters stamped on this plate. A typical setting code is 2643D00AD/2/2420; in this example the code letters are "AD".

Fuel pump code letters	Engine check angle (degrees)	Pump mark angle (degrees)
AD	280.5	291
BD	280.5	293
CD	280.5	287
FD	286	296

Static timing - Stanadyne fuel injection pump

The engine check angle must be used with special tool MS.67B and with the engine set with the piston of the number 1 cylinder at top dead centre (TDC) on the compression stroke. The pump is checked with the pump set at the start of injection for the number one cylinder.

Fuel pump code letters	Engine check angle (degrees)	Pump mark angle (degrees)
DD	286	297

Lubrication system

Lubricating oil pump

Type ... ... Differential rotor, gear driven
Number of lobes. ... ...Inner rotor 6, outer rotor 7

Clearance of outer rotor to body:

Without balancer unit . ... 0,15/0,34 mm (0.006/0.013 in)
With balancer unit .. .. 0,31/0,45 mm (0.012/0.017 in)
Clearance of inner rotor to outer rotor ... ... 0,04/0,13 mm (0.0015/0.0050 in)
End-float of rotor assembly ... ... 0,03/0,10 mm (0.001/0.004 in)

Idler gear for lubricating oil pump

End float. ... ... 0,03/0,33 mm (0.001/0.013 in)
Inside diameter of bush (fitted) .. .. 22,23/22,26 mm (0.875/0.866 in)
Outside diameter of idler shaft... ... ... 22,19/22,21 mm (0.873/0.874 in)
Clearance of bush of idler gear on shaft ... ... 0,020/0,066 mm (0.0008/0.0026 in)

Oil pressure relief valve (standard)

Diameter of bore for plunger .. .. 18,24/18,27 mm (0.718/0.719 in)
Outside diameter of plunger... ... ... 18,16/18,18 mm (0.715/0.716 in)
Clearance of plunger in bore.. ... ... 0,06/0,11 mm (0.002/0.004 in)
Length of spring (fitted) .. ..59,8 mm (2.4 in)
Load on spring (fitted) ... ... 15,9/23,1 N (3.6/5.2 lbf) 1,6/2,4 kgf
Pressure to open valve .. .. 340/395 kPa (49/57 lbf/in^2) 3,4/4,0 kgf/cm^2

Continued

This document has been printed from SPI². Not for Resale

Oil pressure relief valve (with balancer)

Diameter of bore for plunger ... ...16,00/16,03 mm (0.630/0.631 in)
Outside diameter of plunger ... ...15,95/15,98 mm (0.628/0.629 in)
Clearance of plunger in bore ... ... 0,02/0,08 mm (0.0008/0.003 in)
Length of spring (fitted) ... ... 42,7 mm (1.7 in)
Load on spring (fitted):

Engines without piston cooling jets.. ... ... .24/30 N (5.4/6.7 lbf) 2,4/3,1 kgf
Pressure to open valve:

Engines without piston cooling jets.. ... ... 414 kPa (60 lbf/in^2) 4,2 kgf/cm^2

Oil filter

Type. ... ...

Atomiser service settings

CAV fuel injection pump

Code	Holder	Nozzle	Set and reset procedure		
			atm	(lbf/in^2)	MPa
HD	LRB67015	JB6801012	260	3822	26,4
HL	LRB67014	JB6801014	230	3381	23,3
HU	LRB67014	JB6801014	220	3234	22,3
HZ	LRB67014	JB6801014	220	3234	22,3
JS	2645A302	2645A608	220	3234	22,3

Stanadyne fuel injection pump

Code	Holder	Nozzle	Set and reset procedure		
			atm	(lbf/in^2)	MPa
NP	2645L304	2645L613	220	3234	22,3

Note: The code letters are stamped on the side of the atomiser body just below the connection for the nut of the high pressure pipe.

Coolant pump

Type ... Centrifugal, belt driven
Outside diameter of shaft for pulley ... 24,587/24,600 mm (0.9679/0.9685 in)
Inside diameter of bore of pulley ... 24,628/24,648 mm (0.9696/0.9704 in)
Clearance fit of pulley on shaft ... 0,03/0,06 mm (0.001/0.002 in)
Diameter of bore of impeller ... 15,872/15,893 mm (0.6248/0.6257 in)
Outside diameter of shaft for impeller ... 15,9055/15,9182 mm (0.6263/0.6267 in)
Interference fit of impeller on shaft ... 0,01/0,04 mm (0.0004/0.0016 in)
Impeller to body clearance ... 0,69/0,89 mm (0.027/0.035 in)
Diameter of bearing ... 62,000 mm (2.440 in)
Diameter of bore for bearing ... 62,019/62,000 mm (2.441/24.000 in)
Interference fit of bearing in pump body ... 0,01/0,04 mm (0.0004/0.0016 in)

Thermostat

Type ... Single, wax element, by-pass blanking

Nominal temperature stamped on thermostat by-pass valve	"Start to open" temperature	"Fully open" temperature	Minimum valve lift, fully open
82 °C (170 °F)	77/85 °C (170/185 °F)	92/98 °C (198/208 °F)	9 mm (0.35 in)
71 °C (160 °F)	67/75° C (153/167 °F)	85/88 °C (185/190 °F)	9 mm (0.35 in)

This document has been printed from SPI². Not for Resale

Flywheel and flywheel housing

Limits for flywheel housing run-out and alignment (total indicator reading)

Diameter of housing flange bore		Maximum limit (total indicator reading)	
mm	in	mm	in
362	14.25	0,23	0.009
410	16.14	0,25	0.010
448	17.63	0,28	0.011
511	20.11	0,30	0,012
584	22.99	0,36	0.014
648	25.51	0,41	0.016
787	30.98	0,48	0.019

Alternators

Note: The information which follows is general and can change with specific applications.

Make and type . . . . . Magneti Marelli A127, Bosch

Rating:

Magneti Marelli: A127 . . . . . 12V/55A or 12V/65A
Bosch: . . . . . 12V/55A or 24V/55A
Rotation . . . . . Clockwise from drive end

Starter motors

Note: The information which follows is general and can change with specific applications.

Make and type . . . . . Magneti Marelli M127, Magneti Marelli 2M113, Bosch JF

Voltage:

Magneti Marelli M127 . . . . . 12V
Magneti Marelli 2M113 . . . . . 12V
Bosch JF 12V
Bosch JF 24V
Number of teeth on pinion 10

Maximum starter cable resistance at 200 °C (680 °F):

12V . . . . . 0,0017 ohms
24V . . . . . 0,0034 ohms

Starting aid

Note: The information which follows is general and can change with specific applications.

Type . . . . . Electrically operated heater, with a fuel supply
Voltage . . . . . 12V (dropping resistor used on 24V system)
Flow rate of fuel through starting aid . . . . . 3,5/5,9 ml/min

This document has been printed from SPI². Not for Resale

Recommended torque settings

The torque tensions below apply to components lubricated lightly with clean engine oil before they are fitted.

Description	Thread size	Torque		
		Nm	lbf ft	kgf m
Cylinder head assembly				
Setscrews, cylinder head	1/2 UNF	See Operation 3-8		
Fasteners, rocker shaft brackets:				
- Aluminium brackets	M12	40	30	4,1
- Sintered steel brackets	M12	75	55	7,6
Cap nuts, rocker cover	M12	20	15	2,1
Setscrews, inlet manifold to cylinder head	M10	44	33	4,5
Nuts, exhaust manifold to cylinder head	M10	44	33	4,5
Setscrews, engine lift bracket	M10	44	33	4,5
Piston and connecting rod assembly				
Nuts, connecting rods	1/2 UNF	125	92	12,7
Crankshaft assembly				
Setscrews, main bearings	5/8 UNF	250	185	26,0
Setscrews, crankshaft pulley	7/16 UNF	115	85	11,8
Torxscrew, rear oil seal housing to cylinder block	M8	22	16	2,2
Cap screws, bridge piece to cylinder block	M6	16	12	1,6
Cap screws, rear oil seal housing to bridge piece	M6	13	10	1,3
Torxscrew, rear oil seal housing to bridge piece	M8	18	13	1,9
Setscrew, idler gear hub of balancer unit	M12	93	68	9,5
Nut, drive gear of balance weight	1/2 UNF	82	60	8,4
Setscrews, rear cover of balancer frame	M10	54	40	5,5
Setscrews, oil transfer plate (balancer unit)	M10	30	22	3,1
Setscrews, oil pump to balancer frame	M8	27	20	2,8
Setscrews, balancer to cylinder block	M10	54	40	5,5
Timing case and drive assembly				
Setscrews, timing case to cylinder block	M8	22	16	2,2
Setscrews, timing case to cylinder block	M10	44	33	4,5
Bolt, hub of idler gear	M10	44	33	4,5
Setscrew, camshaft gear	M12	78	58	8,0
Setscrews, timing case cover to timing case and block	M8	22	16	2,2
Cylinder block				
Setscrews, fitted instead of piston cooling jets	3/8 UNF	27	20	2,8
Aspiration system				
Setscrew, breather pipe to head	M8	22	16	2,8
Fuel system				
Nuts, high-pressure fuel pipes	M12	22	16	2,2
Setscrews, atomiser	M8	22	16	1,2
Setscrews, fuel lift pump	M8	22	16	2,2
Screw, for gear of fuel injection pump	3/8 UNF	27	20	2,8
Nuts for flange of fuel injection pump	M8	22	16	2,2

This document has been printed from SPI². Not for Resale

Description	Thread size	Torque		
		Nm	lbf ft	kgf m
Lubrication system				
Plug, lubricating oil sump	$^3/_4$ UNF	34	25	3,5
Setscrews, oil pump to front bearing cap	M8	22	16	2,2
Setscrews, cover for oil pump	M8	22	16	2,2
Fasteners, lubricating oil sump	M8	22	16	2,2
Cooling system				
Setscrews, fan drive housing to timing case	M10	44	33	4,5
Setscrews, fan drive pulley to hub	M8	22	16	2,2
Setscrews, fan drive pulley to hub	M10	44	33	4,5
Setscrews, fan	M8	22	16	2,2
Connector, oil cooler to oil filter head	$^3/_4$ UNF	37	27	3,8
Setscrews, coolant pump to cylinder block	M8	22	16	2,2
Setscrews, coolant pump to cylinder block	M10	44	33	4,5
Setscrews, coolant pump front body to rear body	M10	44	33	4,5
Flywheel and housing				
Setscrews, flywheel to crankshaft	$^1/_2$ UNF	105	77	10,7
Setscrews, cast iron flywheel housing to cylinder block	M10	44	33	4,5
- Stamped 8.8	M12	75	55	7,6
- Stamped 10.9	M10	63	46	6,4
- Stamped 10.9	M12	115	85	11,7
Setscrews, aluminium flywheel housing to cylinder block	M10	70	52	7,1
Setscrews, flywheel housing to cylinder block (paper joint)	M10	70	52	7,1
Electrical equipment				
Nut, alternator pulley:				
- Thick (24 mm A/F) A127, and motorola	M17	80	59	8,2
- Thin (22 mm A/F) A127, and motorola	M17	60	44	6,1
Fuelled start aid to induction manifold	$^7/_8$ UNF	31	23	3,1

This document has been printed from SPI². Not for Resale

Compression test data

Tests have shown that many factors affect compression pressures. Battery and starter motor condition, ambient conditions and the type of gauge used can give a wide variation of results for a given engine.

It is not possible to give accurate data for compression pressure, but tests have shown that the results should be within 2000/3500 kPa (300/500 lbf/ in^2) 21,0/35,0 kgf/cm^2 for diesel engines.

Compression tests should only be used to compare between the cylinders of an engine. If one or more cylinders vary by more than 350 kPa (50 lbf/in^2) 3,5 kgf/cm^2, then those cylinders may be faulty.

Compression tests should not be the only method used to show the condition of an engine, but they should be used together with other symptoms and tests.

How to do a compression test

Caution: *Before the compression test, ensure that the battery is in good condition and that it is fully charged. Also ensure that the starter motor is in good condition.*

1 Ensure that the valve tip clearances are set correctly, see Operation 3-5.

2 Remove the atomisers, see Operation 11-5.

3 Fit a suitable gauge into the atomiser hole of the cylinder to be tested.

4 Ensure that the engine cannot start:

Disconnect the stop solenoid or put the stop control in the no-fuel position.

Operate the starter motor and note the pressure indicated on the gauge.

5 Repeat for each cylinder.

This document has been printed from SPI². Not for Resale

3

Cylinder head assembly

General description

In a diesel engine there is little carbon deposit and for this reason the number of hours run is no indication of when to overhaul a cylinder head assembly. The factors which indicate when an overhaul is necessary are how easily the engine starts and its general performance.

The cylinder head assembly has two valves fitted for each cylinder, each fitted with single valve springs. The face angle of the valves is 45°. The angle of the valve seats in the cylinder head is 46°.

The valves move in phosphated guides which can be renewed. The exhaust valve guide has a counterbore at the bottom and is a little longer than the inlet valve guide.

Both valve stems are fitted with oil seals which fit over the top of the valve guides.

The 4.41 engine does not have valve seat inserts fitted as standard in production, but inserts can be fitted in service for repair purposes.

This document has been printed from SPI². Not for Resale

Rocker cover

To remove and to fit — Operation 3-1

Engines are supplied with a rocker cover (A) made of a composite material.

To remove

1 Disconnect the breather pipe.

2 Remove the cap nuts (A2) together with the steel washers (A3) and the shim washers (A4) from the top of the rocker cover.

3 Lift off the rocker cover and the joint (A6).

Caution: *When the rocker cover is fitted, the cap nuts are tightened onto the nuts of the rocker brackets. During removal of the cap nuts, it is possible to loosen the nuts of the rocker brackets. The nuts of the rocker brackets should be tightened to the correct torque every time the cover is removed.*

To fit

1 Check the seal of the oil filler cap (A1), the sealing washers (A5), the steel washer (A3) and, if fitted, the shim washer (A4) for the cap nuts (A2).

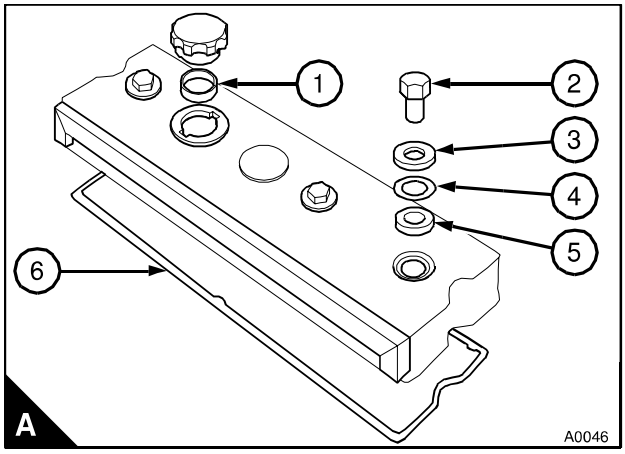
2 Check the condition of the rocker cover joint (A6). If necessary, the joint can be removed and renewed.

3 Clean the joint face of the cylinder head and fit the rocker cover.

4 Fit the sealing washers, the steel washers, the shims (if fitted) and the cap nuts.

Caution: *Damage to the sealing washer can occur if the cap nut is not tightened centrally through the sealing washer and the rocker cover. If the sealing washer is damaged it must be renewed.*

5 Tighten the cap nuts to 20 Nm (15 lbf ft) 2,1 kgf m.



This document has been printed from SPI². Not for Resale

Rocker assembly

To remove and to fit **Operation 3-2**

To remove

1 Remove the rocker cover, see Operation 3-1.

2 Release evenly and gradually the fasteners of the rocker shaft brackets; begin with the end brackets and move toward the centre. Remove the flange faced nuts and setscrews and lift off the rocker assembly.

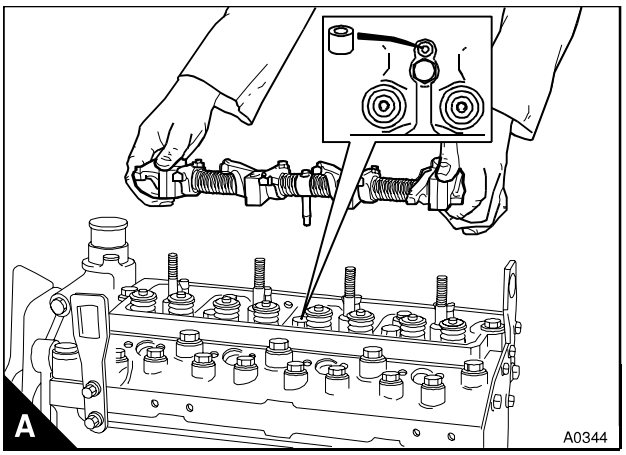
3 Remove the rubber oil seal (A) from the oil supply connection or from the oil supply hole in the cylinder head.

To fit

1 Fit a new rubber oil seal in the oil supply hole in the cylinder head.

2 Check that the push rods fit correctly in the sockets of the tappets. Fit the rocker assembly; ensure that the oil supply connection is fitted correctly into the oil seal. Check that the ends of the adjustment screws fit correctly in the sockets of the push rods.

3 Fit the flange faced nuts and setscrews of the rocker shaft brackets and tighten the fasteners evenly and gradually; begin with the inner fasteners and work towards the end fasteners. Tighten the fasteners gradually and evenly to 75 Nm (55 lbf ft) 7,6 kgf m.



This document has been printed from SPI². Not for Resale

To dismantle and to assemble — Operation 3-3

To dismantle

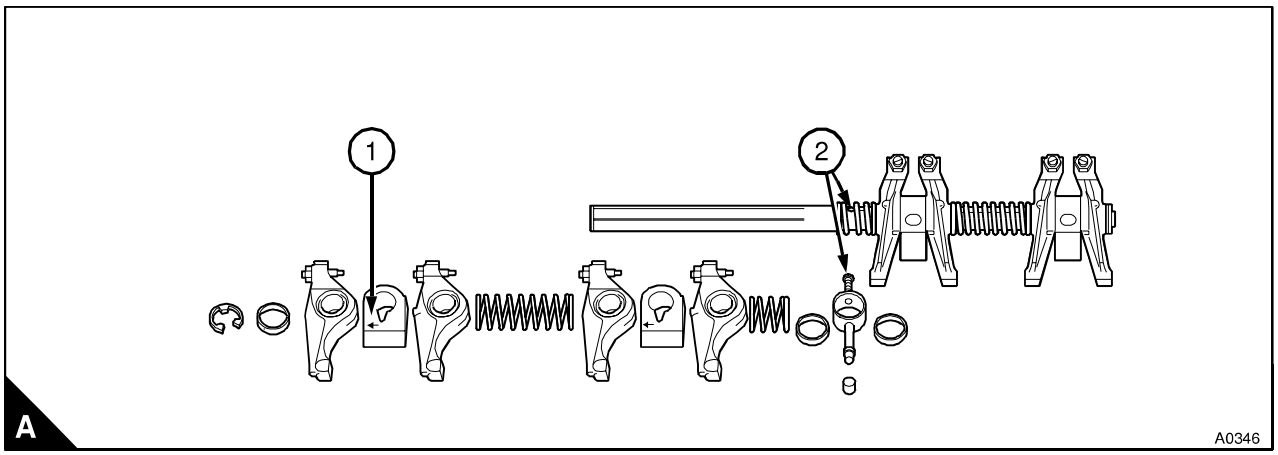
1 Remove the clips from both ends of the rocker shaft. Ensure that the ends of the rocker shaft are not damaged. Release the location screw (A2) for the oil supply connection.

2 Dismantle the assembly and make a note of the position of each component to ensure that they can be assembled more easily.

To assemble

1 Ensure that the oil holes in the rocker shaft and in the rocker levers are not restricted.

2 Lubricate the components with clean engine lubricating oil before assembly. Assemble the components in the correct order (A). Ensure that the arrow (A1) on the bracket faces away from the cylinder head and that the location screw (A2) for the oil supply connection is fitted correctly in the rocker shaft. Fit the clips to the ends of the rocker shaft.



To inspect and to correct — Operation 3-4

1 Clean and inspect all the components for wear and any other damage.

2 Check the clearance of the rocker levers on the rocker shaft. If the clearance is larger than 0,13 mm (0.005 in), renew the rocker lever and/or the rocker shaft.

This document has been printed from SPI². Not for Resale

Valve tip clearances

To check and to adjust **Operation 3-5**

Notes:

- The valve tip clearance is measured between the top of the valve stem and the rocker lever (A). With the engine hot or cold, the correct clearances are 0,20 mm (0.008 in) for the inlet valves and 0,45 mm (0.018 in) for the exhaust valves. The valve positions are shown at (B).
- The sequence of valves from number 1 cylinder is shown in the table below. Number 1 cylinder is at the front of the engine.

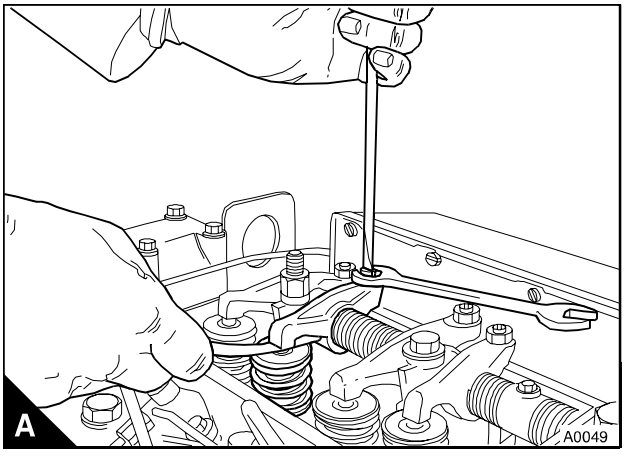
1 Rotate the crankshaft in the normal direction of rotation until the inlet valve (B8) of number 4 cylinder has just opened and the exhaust valve (B7) of the same cylinder has not closed completely. Check the clearances of the valves (B1 and B2) of number 1 cylinder and adjust them, if necessary.

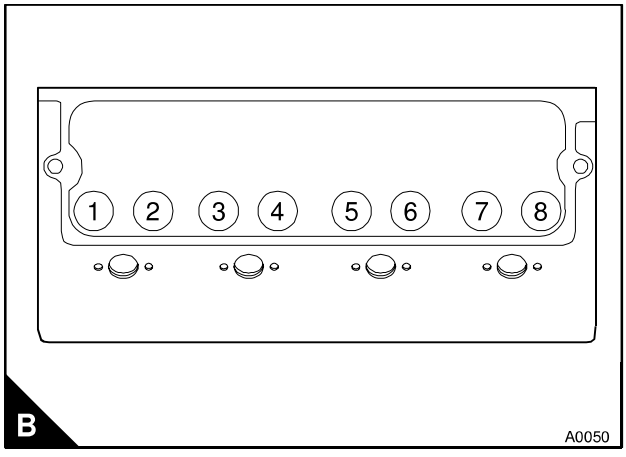
2 Set the valves (B3 and B4) of number 2 cylinder as indicated above for number 4 cylinder. Then check / adjust the clearances of the valves (B5 and B6) of number 3 cylinder.

3 Set the valves (B1 and B2) of number 1 cylinder. Then check / adjust the clearances of the valves (B7 and B8) of number 4 cylinder.

4 Set the valves (B5 and B6) of number 3 cylinder. Then check / adjust the clearances of the valves (B3 and B4) of number 2 cylinder.

Cylinder and Valve number	**1**		**2**		**3**		**4**	
	1	2	3	4	5	6	7	8
Valve I = Inlet E = Exhaust	I	E	E	I	I	E	E	I





This document has been printed from SPI². Not for Resale

To change the valve springs (with cylinder head fitted) **Operation 3-6**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Valve spring compressor	PD.6118B	Setscrew adaptor used with PD.6118B	PD.6118-8
Stud adaptor used with PD.6118B	PD.6118-7		

Warning! *Wear eye protection during this operation.*

Note: Steps 1 to 12 refer to a change of valve springs for a single cylinder.

1 Remove the rocker cover, see Operation 3-1.

2 Rotate the crankshaft in the normal direction of rotation until the inlet valve of the relevant cylinder has just opened and the exhaust valve has not fully closed. In this position the piston will be at approximately top dead centre (TDC).

3 Remove the rocker assembly, see Operation 3-2.

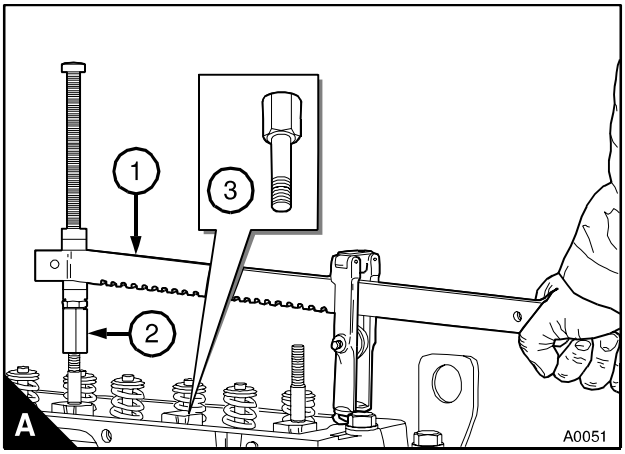
4 Fit the valve spring compressor (A1) and the relevant adaptor (A2 or A3).

5 Compress the valve spring and remove the collets. Ensure that the valve spring is compressed squarely or damage to the valve stem can occur.

Caution: *Do not rotate the crankshaft while the valve springs are removed.*

6 Release the valve spring compressor and remove the valve spring cap and valve spring.

7 Put the new valve spring in position.



Continued

This document has been printed from SPI². Not for Resale

8 Fit the valve spring cap.

Caution: *Ensure that the valve spring is compressed squarely or damage can occur to the valve stem.*

9 Fit the valve spring compressor, compress the valve spring and fit the collets. Remove the valve spring compressor.

10 Fit the rocker assembly, see Operation 3-2.

11 Check the valve tip clearances, see Operation 3-5.

12 Fit the rocker cover, see Operation 3-1.

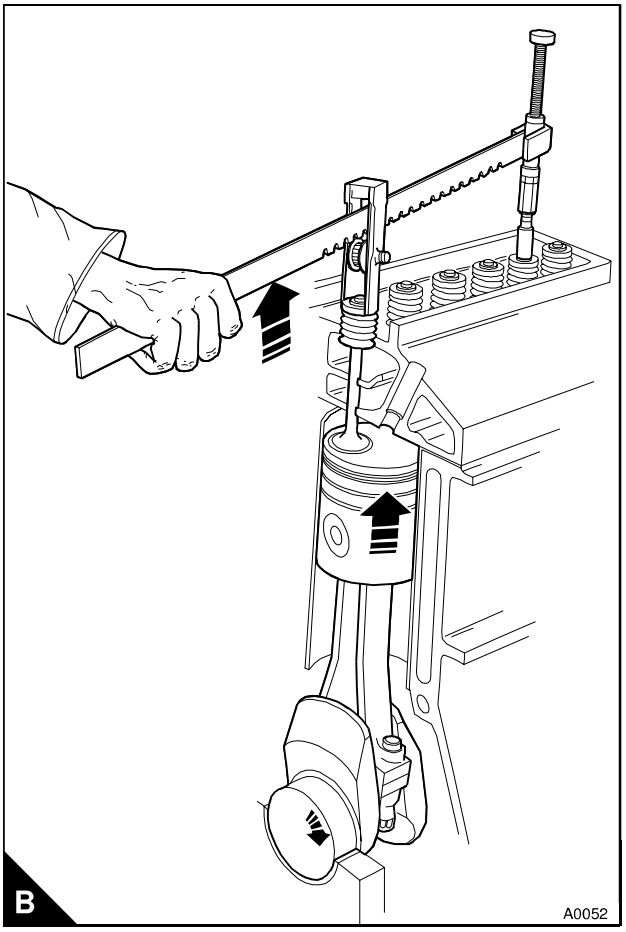
Note: If other or all of the valve springs are to be changed, they can be changed two cylinders at a time. The cylinders are: 1 and 4, then 2 and 3.

If the rocker assembly has been removed, piston TDC can be found as follows:

1 Fit the valve spring compressor and compress the valve springs to open the valve.

2 Rotate the crankshaft, by hand, in the normal direction of rotation until the piston touches the valve.

3 Continue to rotate the crankshaft, and at the same time, release pressure on the valve spring compressor until the piston is at TDC (B).



This document has been printed from SPI². Not for Resale

Cylinder head assembly

To remove **Operation 3-7**

1 Drain the cooling system.

2 Disconnect the battery terminals.

3 Remove the air filter/cleaner hose at the induction manifold.

4 Remove the pipe which is fitted between the fuelled starting aid in the induction manifold and the fuel filter. Disconnect the electrical connection.

5 Remove the induction manifold.

6 Remove the exhaust manifold.

7 Remove the low-pressure fuel pipes which are fitted between the fuel injection pump and the fuel filter.

Remove the fuel pipe fitted between the fuel lift pump and the fuel filter. Remove the fuel filter bracket together with the fuel filter.

8 Remove the high-pressure fuel pipes.

Caution: *Where access to the fuel injection pump outlet unions is possible, ensure that a separate spanner is used to prevent movement of the fuel injection pump outlets when the connections of the high-pressure pipes are released. Fit suitable covers to all open connections on the fuel injection pump.*

9 Remove the atomiser leak-off pipe.

10 Remove the atomisers, see Operation 11-5. Fit suitable covers to the nozzles and the open connections.

11 If a compressor is fitted: Remove the coolant pipe which is fitted between the cylinder head and the compressor. Then remove the coolant pipe which is fitted between the by-pass connection and the compressor.

12 Release the clip of the coolant by-pass hose at the cylinder head, and remove the hose.

13 Disconnect the coolant temperature sender unit.

14 Remove the rocker cover, see Operation 3-1

15 Remove the rocker assembly, see Operation 3-2.

16 Remove the push rods.

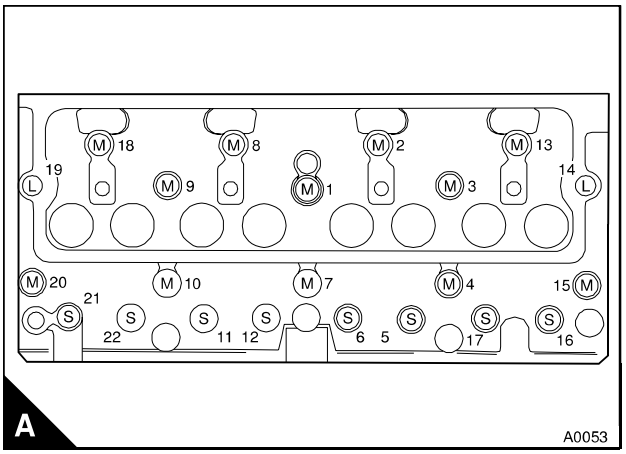
Continued

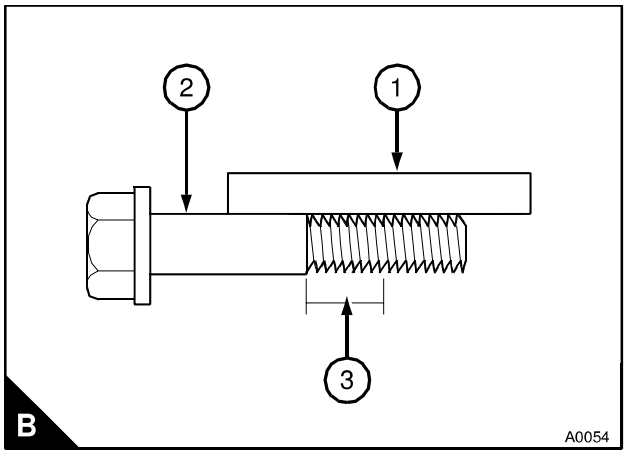
This document has been printed from SPI². Not for Resale

17 Release the cylinder head setscrews evenly and gradually in the reverse sequence to that shown in (A). Check the setscrews for distortion with a straight edge (B1) held along the setscrew (B2). If there is a reduction in the diameter of the thread (B3) that has not been in engagement with the cylinder block, the setscrew must be discarded.

Caution: *Do not use a lever to separate the cylinder head from the cylinder block.*

18 Remove the cylinder head and put it on a surface that will not damage the face of the cylinder head.





This document has been printed from SPI². Not for Resale

To fit **Operation 3-8**

Special requirements

Special tools	
Description	**Part number**
Angle gauge (to tighten cylinder head setscrews)	MS.1531

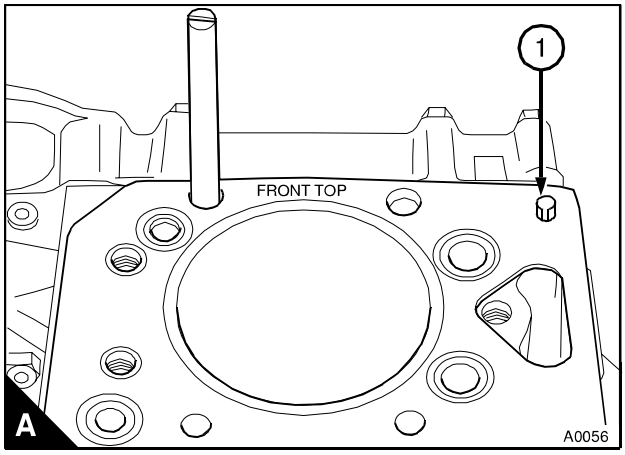
1 Clean the bottom face of the cylinder head and top face of the cylinder block. Ensure that there is no debris in the cylinder bores.

Note: The cylinder head has two location pins (A1), one at each end of the cylinder head, pressed into the cylinder block to hold the cylinder head gasket in the correct position before the cylinder head is fitted and to ensure that the head is in the correct position.

***Cautions*:**

- *To prevent damage to the cylinder head gasket, ensure that the location pins are pressed in the cylinder block before the cylinder head is fitted.*
- *The cylinder head gasket must be fitted without jointing compound.*

2 Put the cylinder head gasket in position; It is stamped "FRONT TOP" for correct assembly (A).



Continued

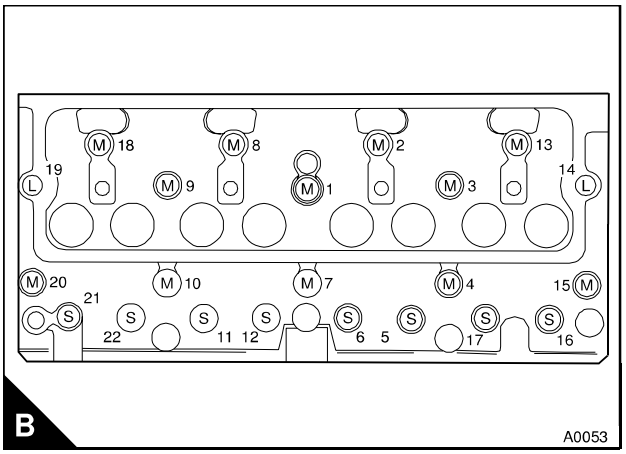
This document has been printed from SPI². Not for Resale

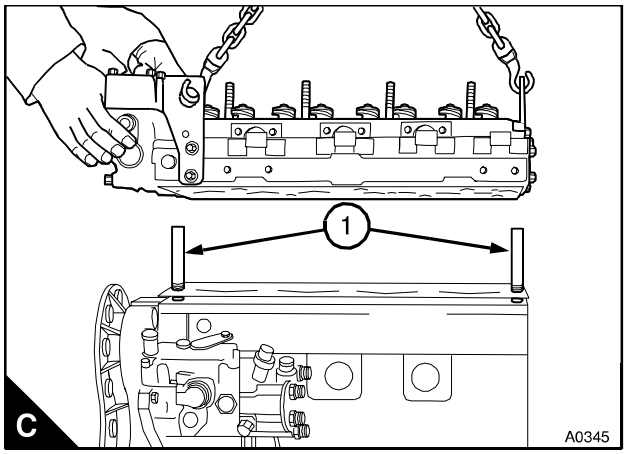
3 To ensure the cylinder head is fitted into the correct position, fit two suitable $^{1}/_{2}$ UNF guide studs (C1) in positions 15 and 20 (B). Put the cylinder head in position.

4 Lightly lubricate the threads of the cylinder head setscrews and the thrust faces of the setscrew heads. Engage some of the setscrews in their correct positions and remove the guide studs. Engage the remainder of the setscrews in their correct positions.

5 Gradually and evenly tighten the setscrews to 110 Nm (80 lbf ft) 11,1 kgf m in the sequence shown in (B).

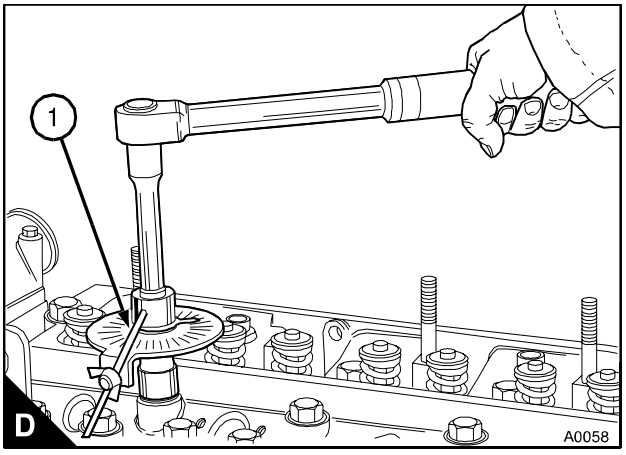
6 Repeat step 5 to ensure that all the setscrews are tightened to the correct torque.





7 Tighten the setscrews, in the correct sequence, a further part of a turn according to the length of the setscrews, see (B). Short setscrews (S) must be turned a further 150° (2.5 flats). Medium length setscrews (M) must be turned a further 180° (3 flats). Long setscrews (L) must be turned a further 210° (3.5 flats). A special tool (D) can be used for this operation.

Fit the tool between the socket and the handle. Position the stop (D1) against a suitable protrusion on the cylinder head to prevent movement of the degree dial in a clockwise direction. Rotate the pointer to align with the relevant angle on the degree dial for the length of setscrew. Tighten the setscrew until the pointer on the tool is aligned with the zero position on the degree dial.



Continued

This document has been printed from SPI². Not for Resale

If no tool is available, make a suitable mark on the cylinder head in line with a corner of each setscrew (E). Make another mark, at the correct angle (counter-clockwise), on the edge of the flange of each fastener according to the length of the setscrew. Tighten each setscrew in the correct sequence until the marks on the flange are next to, and in line with, the marks on the cylinder head.

8 Put the push rods in position. Ensure that the end of each push rod fits correctly in the tappet socket.

9 Fit the rocker assembly, see Operation 3-1.

10 Set the valve tip clearances, see Operation 3-5.

11 Fit the atomisers, see Operation 11-5.

12 Fit the high-pressure fuel pipes; tighten the connection nuts to 22 Nm (16 lbf ft) 2,2 kgf m.

Caution: *Where access to the fuel injection pump outlet unions is possible, ensure that a separate spanner is used to prevent movement of the fuel injection pump outlets when the connections of the high pressure pipes are tightened.*

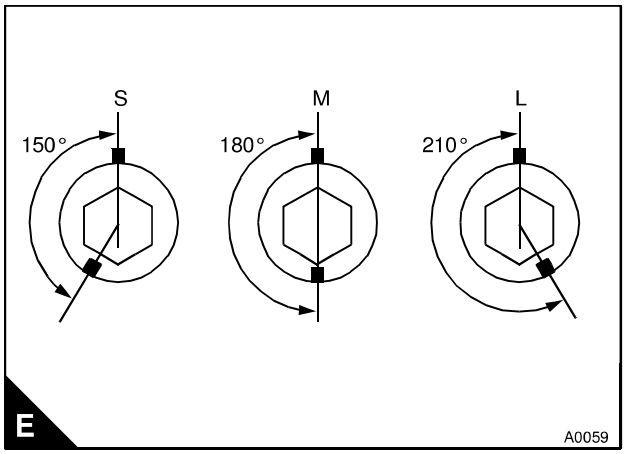
13 Fit the fuel filter and the bracket. Fit the low-pressure fuel pipes between the fuel injection pump and the fuel filter.

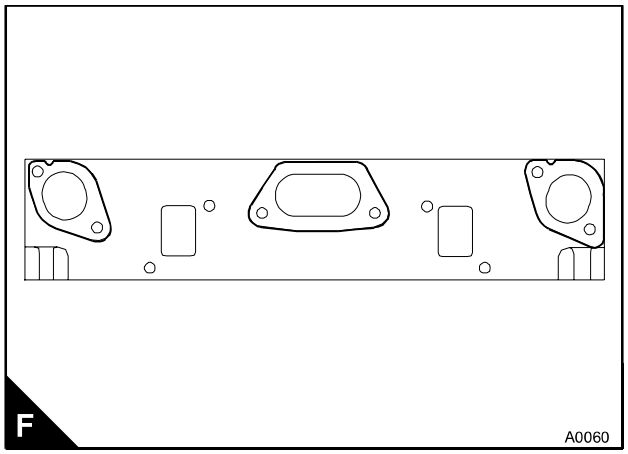
14 Fit the coolant by-pass connection; tighten the setscrews and hose clip.

15 If a compressor is fitted, fit the coolant pipe between the cylinder head and the compressor. Then fit the pipe between the coolant by-pass and compressor.

16 Fit the exhaust manifold. The manifold joints are fitted without jointing compound.

17 Fit the induction manifold. Ensure that the manifold joints for the front and rear positions are fitted with the notch at the top left when the manifold is fitted to the cylinder head (F). The manifold joint for the centre position can be fitted either way. Fit the joints without jointing compound.





Continued

This document has been printed from SPI². Not for Resale

18 Fit the fuel pipe between the fuel filter and the fuel lift pump.

19 Fit the fuel pipe between the fuel filter and the fuelled starting aid in the induction manifold. Connect the electrical connection to the cold start device.

20 Fit the electrical connection to the coolant temperature sender unit.

21 Connect the coolant outlet and the hoses for the cab heater. Tighten the clips.

22 Fill the cooling system.

23 Connect the air filter/cleaner.

24 Connect the battery.

25 Eliminate air from the fuel system, see Operation 11-13 for Lucas DPA fuel injection pumps and Operation 11-17 for Stanadyne fuel injection pumps.

26 Start the engine and run it at low speed, check that oil flows from the holes in the rocker levers. Stop the engine.

27 Fit the rocker cover, see Operation 3-1.

Note: It is not necessary to tighten the cylinder head setscrews again with the engine hot or after a limited period in service.

This document has been printed from SPI². Not for Resale

To remove **Operation 3-9**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Valve spring compressor	PD.6118B	Setscrew adaptor	PD.6118-8
Stud adaptor	PD.6118-7		

Warning! *Wear eye protection during this operation.*

1 Remove the cylinder head assembly, see Operation 3-7.

2 Clean the bottom face of the cylinder head and check the depth of the heads of the valves below the face of the cylinder head, see Operation 3-11.

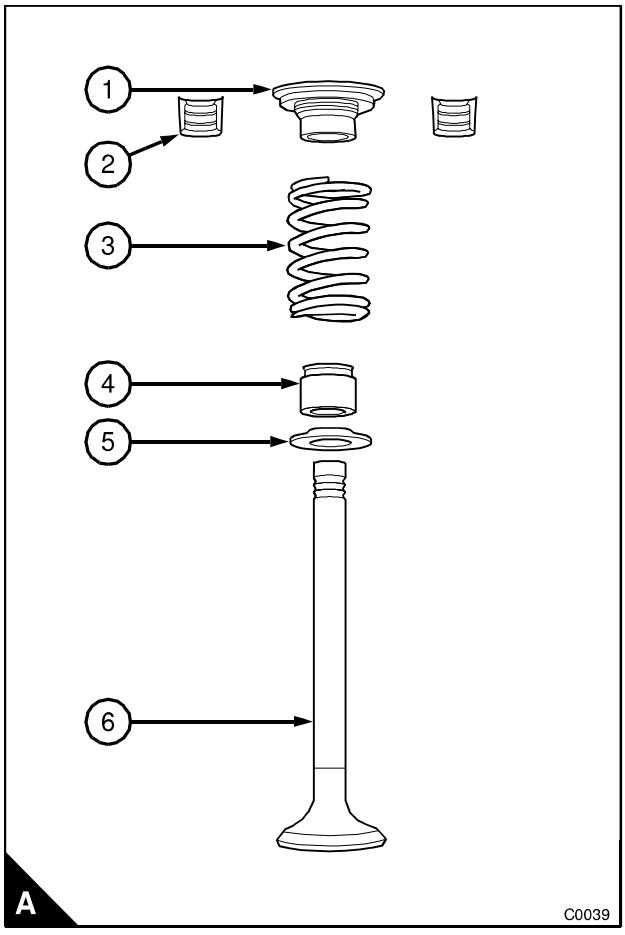
3 Make a suitable mark on the heads of the valves to ensure that the valves can be fitted in their original positions, if they are to be used again.

Caution: *Ensure that the valve springs are compressed squarely or the valve stem can be damaged.*

4 Use the valve spring compressor and the relevant adaptor to compress the valve spring and remove the collets.

5 Release the valve spring compressor and remove the valve spring cap, valve spring, valve stem seal and the valve seat washer.

6 Repeat steps 4 and 5 for the other valves.



This document has been printed from SPI². Not for Resale

To fit **Operation 3-10**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Valve spring compressor	PD.6118B	Setscrew adaptor	PD.6118-8
Stud adaptor	PD.6118-7		

Warning! *Wear eye protection during this operation.*

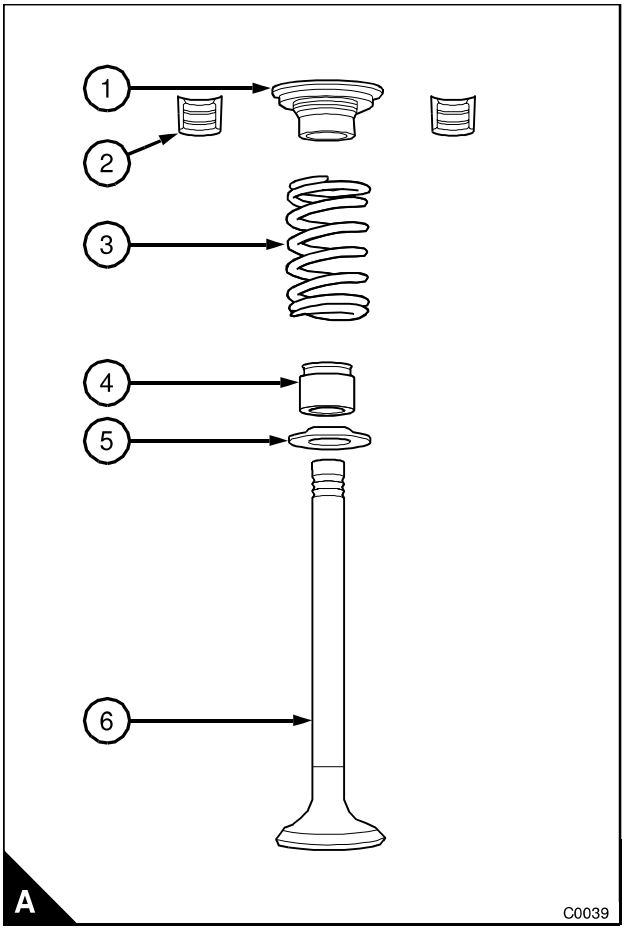
Note: The components of the valve assembly are shown in (A).

1 Lubricate the valve stem (A6) with clean engine oil and fit the valves in their respective guides.

2 Fit the spring seat washer (A5). Fit new valve stem seal (A4) on the valve guides. Fit the valve spring (A3) on the spring seat washer. The spring can be fitted with either end to the cylinder head. Fit the valve spring cap (A1).

Caution: *Ensure that the valve spring is compressed squarely or damage can occur to the valve stem.*

3 Use the valve spring compressor and the relevant adaptor to compress the valve spring and fit the collets (A2).



This document has been printed from SPI². Not for Resale

To inspect and to correct — Operation 3-11

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Gauge, valve depth	PD.41D	Dial gauge for use with PD.41D	PD.208

1 Check the depth of the valves below the face of the cylinder head before the valve springs are removed.

2 Ensure that the heads of the valves and the bottom face of the cylinder head are clean.

3 Put the valve depth gauge on the face of the cylinder head and zero the dial gauge.

4 Carefully put the valve depth gauge in position over the head of each valve (A) and make a note of the measurement. The maximum depth, in service, is given in the relevant Data and dimensions for the "Inlet and exhaust valves" on page 13.

5 If a valve is below the depth limit, check the valve depth with a new valve in position. If the valve depth is still below the limit and a valve seat insert is fitted, the insert must be renewed.

6 Where a valve seat insert is not fitted, the bottom face of the cylinder head can be machined to reduce the valve depth, or an insert can be fitted, see Operation 3-17.

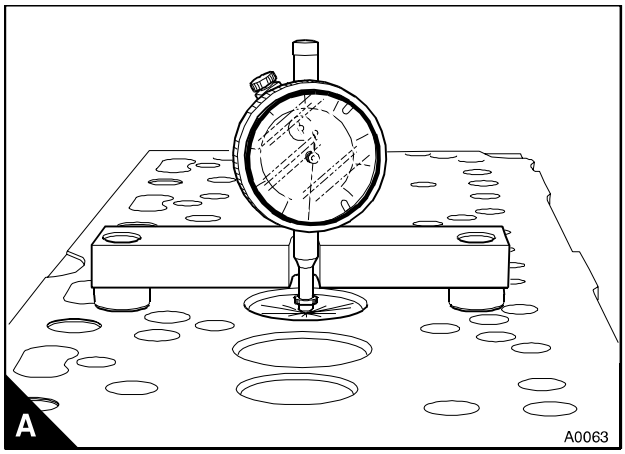
Caution: *If the bottom face of the cylinder head is to be machined, ensure that the thickness, of the cylinder head will not be less than 102,48 mm (4.035 in) after the cylinder head has been machined.*

7 Check the valves for cracks. Check the stems of the valves for wear and for correct fit in their valve guides.

8 Check that the seat faces of the valves are not badly burnt or damaged. Seat faces of valves which are damaged can be ground on a special machine. Valves which have only a little damage can be lapped to their valve seats. When new valves are fitted, the valve depths must be checked, refer to step 1.

9 Check that the load on the valve springs is correct at their fitted length, refer to the relevant Data and dimensions for the "Valve guides and valve springs" on page 16.

Fit new valve springs at every complete engine overhaul.



This document has been printed from SPI². Not for Resale

Valve guides

To inspect — Operation 3-12

To check the valve guides for wear: The maximum clearance (A5), between the valve stem and the bore of the guide is 0,13 mm (0.005 in) for inlet valves and 0,15 mm (0.006 in) for exhaust valves. If the clearance, with a new valve fitted, is more than the limit, then a new valve guide (A4) must be fitted.

It is recommended that the procedure given below is used to check the valve guide clearance:

1 Put a new valve in the valve guide.

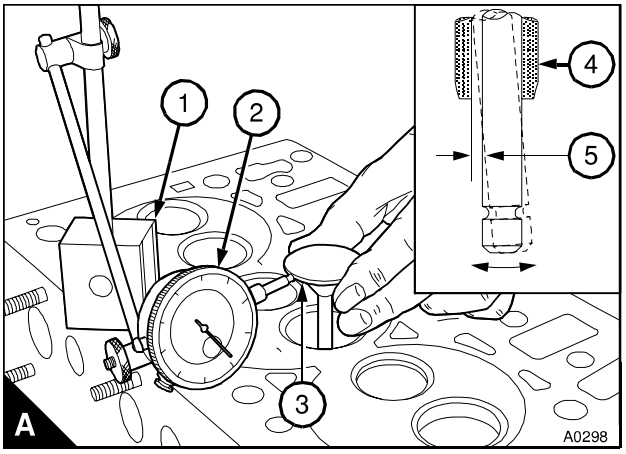
2 Put a dial test indicator with a magnetic base (A1) onto the face of the cylinder head.

3 With the valve lifted 15,0 mm (0.6 in) and the gauge (A2) in contact with the edge of the valve head (A3), move the valve radially away from the gauge. With the valve held in this position, set the gauge zero.

4 Move the valve radially across the axis of the cylinder head towards the gauge. Make a note of the reading on the gauge. If the reading is equal to or greater than the data given below, a new valve guide (A4) must be fitted.

Maximum permissible clearance with a valve lift of 15,0 mm (0.6 in):

- Inlet guide - 0,24 mm (0.009 in)
- Exhaust guide - 0,32 mm (0.013).



This document has been printed from SPI². Not for Resale

To remove **Operation 3-13**

Special requirements

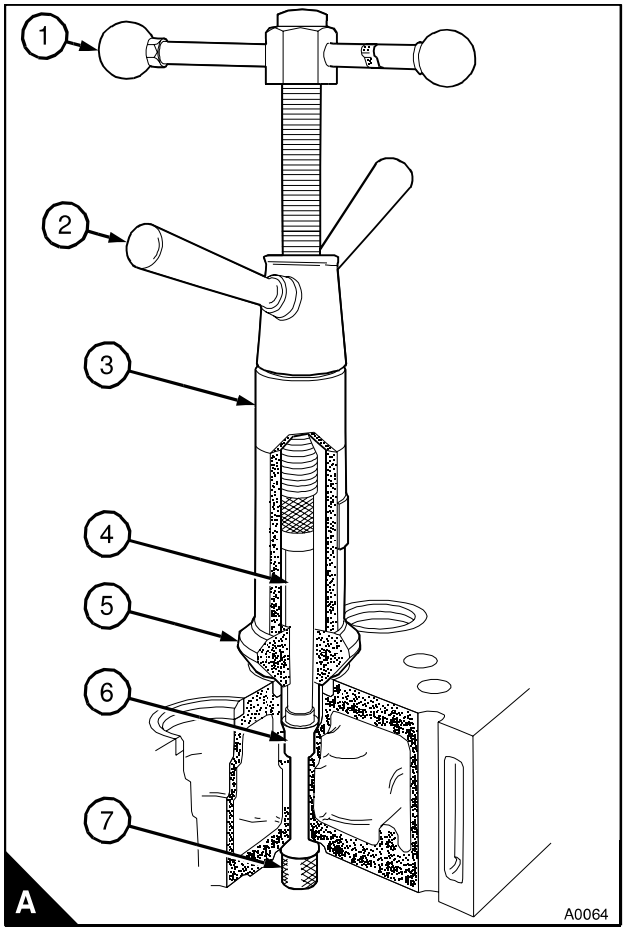
Special tools			
Description	**Part number**	**Description**	**Part number**
Remover/replacer for valve guides	PD.1D	Adaptor used with PD.1D	PD.1D-1A

1 Fit the adaptor (A4), PD.1D-1A, into the remover/replacer tool (A3), PD.1D.

2 With the adaptor fitted to the tool, put the spacer (A5) in position on the tool. Pass the adaptor through the valve guide and put the spacer and tool in position on the valve seat.

3 Fit the attachment (A7) to secure the adaptor to the valve guide.

4 Hold the top handle (A1) and turn the bottom handle (A2) clockwise to pull the valve guide out of the cylinder head.



This document has been printed from SPI². Not for Resale

To fit **Operation 3-14**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Remover/replacer for valve guides	PD.1D	Adaptor used with PD.1D and PD.1D-1A	PD.1C-6
Adaptor used with PD.1D	PD.1D-1A		

1 Clean the parent bore in the cylinder head for the valve guide.

2 Lubricate the outer surface of the new valve guide (A6) with clean engine lubricating oil.

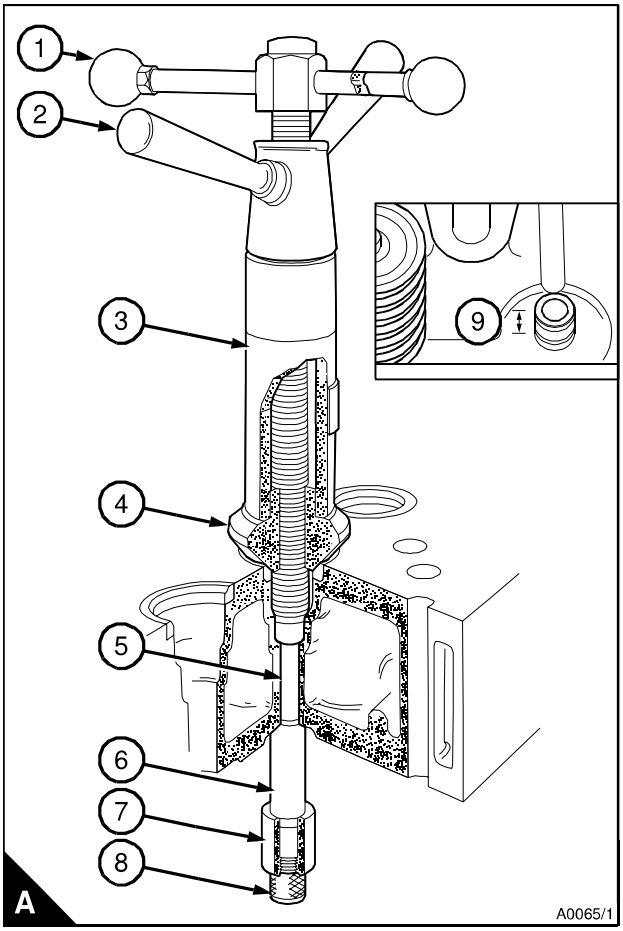
3 Fit the adaptor (A5), PD.1D-1A, into the remover/replacer tool (B3), PD.1D.

4 With the adaptor fitted to the tool, put the spacer (A4) in position on the tool. Pass the adaptor through the cylinder head and put the spacer and tool assembly in position on the valve seat.

5 Put the valve guide in position on the adaptor and fit the distance piece (A7), PD.1C-6. Fit the attachment (A8) to secure the valve guide to the adaptor.

6 Hold the top handle (A1) and turn the bottom handle (A2) clockwise to pull the valve guide until the distance piece contacts the cylinder head.

7 When the valve guide is fitted correctly, the top of the valve guide will have a protrusion (A9) of 15,10 mm (0.594 in) above the valve spring seat.



This document has been printed from SPI². Not for Resale

To inspect and to correct — Operation 3-15

1 Remove the cylinder head assembly, see Operation 3-7.

2 Remove the thermostat housing.

3 Inspect the cylinder head for signs of gas or coolant leakage.

4 Remove the valve springs and the valves, see Operation 3-9.

5 Clean the face of the cylinder head and the passages for coolant and for lubricating oil. The water jacket can be cleaned with a special solvent which must be used in accordance with the manufacturer's instructions.

6 Test the cylinder head for leaks at the pressure given in the relevant Data and dimensions for the "Cylinder head" on page 12.

7 When the cylinder head is thoroughly clean, check it for cracks. Inspect carefully the areas around the valve seats and around the holes for the atomiser nozzles.

8 The bottom face of the cylinder head can be machined if: there is distortion, see step 9; there are deep scratches; or, for engines without valve seat inserts, the valve depths are below the service limit.

9 Use a straight edge and feeler gauges to check the cylinder head for distortion across and along its bottom face, see "Maximum permissible distortion of cylinder head" on page 12. If the distortion is more than the given limit, the bottom face can be machined.

***Cautions*:**

- *Remove only the minimum material and ensure that the thickness of the cylinder head will not be less than 102,48 mm (4.035 in) after the cylinder head has been machined.*
- *After the cylinder head has been machined the valve seats must be corrected to give the correct valve head depth. Work to the minimum limit to allow for later wear.*

10 Check the valve seats for wear and for damage.

11 Before any work is done on the valve seats, new valve guides must be fitted, see Operation 3-13 and Operation 3-14.

12 Where there is little damage, the valve and valve seat can be lapped. When the valve seats are lapped keep the seat as narrow as possible and ensure that all the compound used to lap the valve and the seat is removed.

13 More badly damaged valve seats can be corrected by use of the cutter tool, see Operation 3-16, or new inserts can be fitted, see Operation 3-17.

This document has been printed from SPI². Not for Resale

To correct a valve seat with a valve seat cutter — Operation 3-16

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Cutter for inlet valve seats	MS.281 (1)	Pilot for use with valve seat cutters	MS.150-9.5 (1)
Cutter for exhaust valve seats	MS.275 (1)	Handle set for use with valve seat cutters	MS.76B (1)

(1) Included in set of adjustable cutters for valve seats, MS.76A.

1 Before any work is done on the valve seats, new valve guides must be fitted, see Operation 3-13 and Operation 3-14.

2 Fit the pilot in the valve guide and tighten the pilot.

3 Select the relevant cutter. Set the blades of the cutters to the diameter of the valve seat to be cut. Fit the cutter on the pilot and fit the handle (A). Ensure that the cutter is not allowed to fall on to the seat as this can damage the blades.

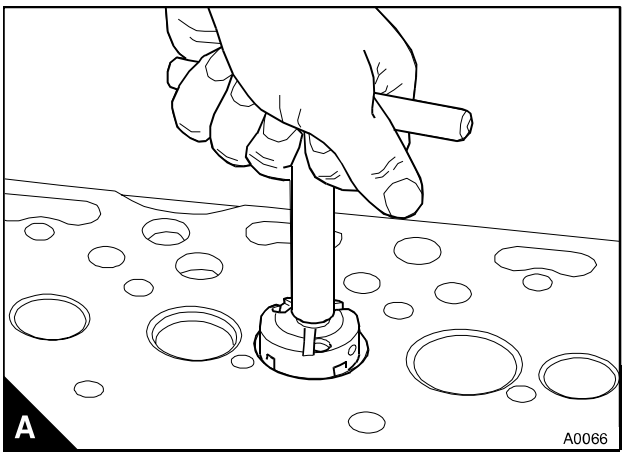
4 Carefully turn the cutter in a clockwise direction. Remove only the minimum material to ensure a good seat. Keep the seat as narrow as possible.

5 When the seat is cut, remove the cutter and the pilot. Remove any debris from the area of the valve seat and the port.

6 Fit the valve and lightly lap the valve and the seat.

7 Check that the valve depth is within limits, refer to the relevant Data and dimensions for the "Inlet and exhaust valves" on page 13.

Note: If a valve seat has become too damaged or too worn to correct, a valve seat insert can be fitted, see Operation 3-17.



This document has been printed from SPI². Not for Resale

To fit valve seat inserts **Operation 3-17**

1 Remove the valve guide and clean the bore into which the guide is to be fitted.

2 Fit new valve guides, see Operation 3-13 and Operation 3-14.

3 With the bore of the new valve guide used as a pilot, machine the recess in the cylinder head to the dimensions shown in "Dimensions of recesses for valve seat inserts" on page 14, or machine out the old insert. Remove all debris and clean the insert recess.

4 If the bottom face of the cylinder head has been machined, the insert will have to be surface ground on the back face to ensure that there is no protrusion of the insert above the bottom face of the cylinder head. After the back of the insert has been ground, ensure that the outer edge of the back face has a 0,9/1,3 mm (0.035/0.051 in) chamfer at 30° to the vertical.

5 With the bore of the valve guide used as a pilot, and with the rear face of the insert towards the cylinder head, press in the insert with the valve seat insert tool, see "Valve seat insert tool" on page 15. Do not use a hammer on the insert and do not use lubrication. Use a hydraulic press or a hand press in one continuous movement. Ensure that the bottom of the insert is in contact with the bottom of the recess.

6 Cut the valve seat at an included angle of 88°, see Operation 3-16, and lap the valve on to the valve seat. Ensure that the depth of the valve head below the face of the cylinder head is within the production limits. Refer to the relevant Data and dimensions for the "Inlet and exhaust valves" on page 13.

Note: Work as near as possible to the minimum figure to allow for future wear on the valve seat.

This document has been printed from SPI². Not for Resale

4

Piston and connecting rod assemblies

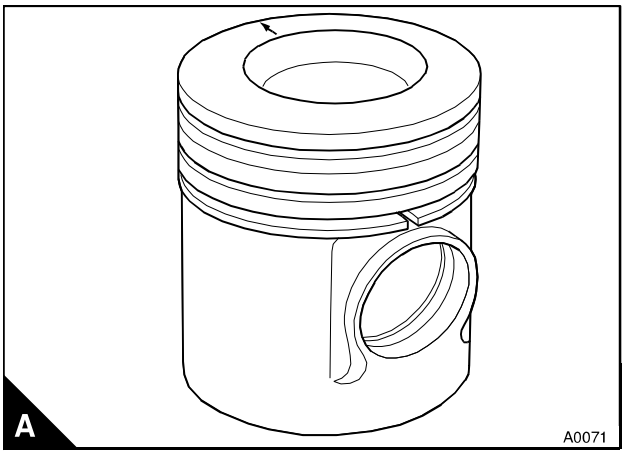
General description

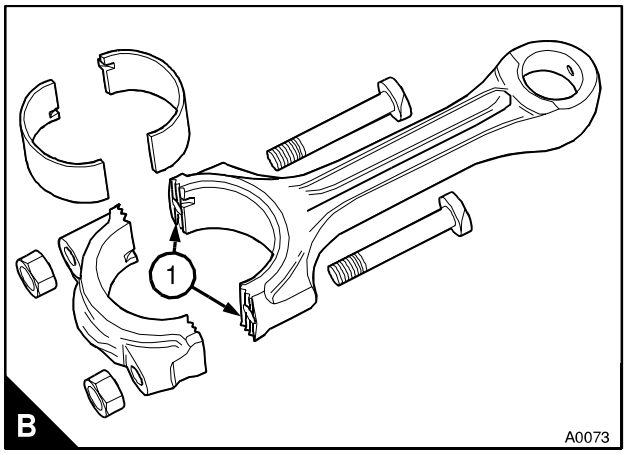
The piston (A) used in 4.41 engine has a combustion chamber in the top of the piston. The combustion chamber is designed to give an efficient mix of fuel and air.

The pistons have two compression rings and an oil control ring. Axial location of the fully floating gudgeon pin is by circlips. The connecting rods are machined from "H" section forgings of molybdenum steel.

The location of the bearing caps to the connecting rods is made by serrations (B1) and the cap is retained by two nuts and bolts (B).

Note: Always use the engine identification number to order new parts.





This document has been printed from SPI². Not for Resale

Big end bearing

To remove **Operation 4-1**

1 Drain the engine lubricating oil.

2 Remove the lubricating oil sump, see Operation 10-3.

3 Remove the lubricating oil strainer and suction pipe, see Operation 10-4 or remove the balancer unit, see Operation 5-13.

4 Rotate the crankshaft until the relevant connecting rod is at its lowest position.

5 Release the nuts and remove the bearing cap. Remove the bolts from the connecting rod.

6 Remove the lower half of the shell bearing from the cap, but keep it with its relevant cap.

7 Carefully push the connecting rod up the cylinder bore just enough to allow access to the upper half of the shell bearing. Remove the bearing from the connecting rod. Keep the bearings from the connecting rod and cap together.

This document has been printed from SPI². Not for Resale

To fit — Operation 4-2

1 Clean the bearing faces of the connecting rod and the crank pin.

2 Clean the complete bearing and lubricate the bearing surface and the crank pin with clean engine lubricating oil. Fit the upper half of the shell bearing to the connecting rod; ensure that the location tag is fitted correctly in its recess (A1). Fit the connecting rod to the crank pin; ensure that the assembly number on the connecting rod is on the same side as the other connecting rods.

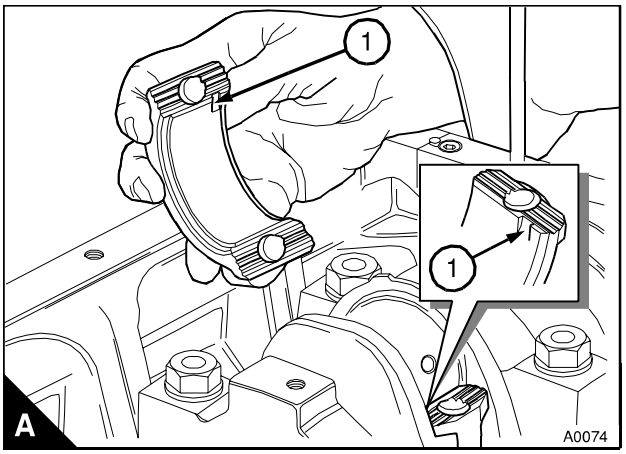
3 Clean, lubricate and fit the lower half of the shell bearings into the cap; ensure that the location tag is fitted correctly in its recess (A1). Fit the connecting rod bolts with the flat side of the head of the bolts towards the connecting rod. Fit the cap to the connecting rod. Ensure that the assembly number on the cap is the same as that on the connecting rod and that both of the assembly numbers are on the same side (B).

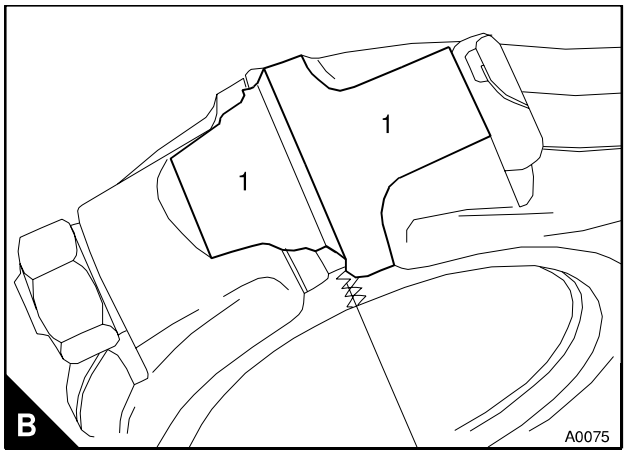
4 Tighten the nuts gradually and evenly to the recommended torque of 125 Nm (92 lbf ft) 12,7 kgf m.

5 Ensure that the crankshaft rotates freely.

6 Fit the lubricating oil strainer and suction pipe, see Operation 10-4 or fit the balancer unit if the engine has one, see Operation 5-14.

7 Fit the lubricating oil sump, see Operation 10-3 and fill the sump to the correct level with lubricating oil of an approved grade.





To inspect — Operation 4-3

Check the bearings and the crank pin for wear or other damage.

This document has been printed from SPI². Not for Resale

Piston and connecting rod

To remove **Operation 4-4**

1 Drain the lubricating oil and the cooling system.

2 Remove the cylinder head assembly, see Operation 3-7.

3 Remove all carbon from the top of the bores of the cylinder liners.

4 Remove the lubricating oil sump, see Operation 10-3.

5 Remove the lubricating oil strainer and suction pipe, see Operation 10-4 or remove the balancer unit, see Operation 5-13.

6 Remove the big end caps and the big end bearings from the connecting rods, see Operation 4-1.

7 Push the pistons and the connecting rods out through the top of the cylinder liners. Keep the bearings and caps together to ensure that they can be fitted in their original positions.

8 Inspect the crank pins for damage.

This document has been printed from SPI². Not for Resale

To fit **Operation 4-5**

Special requirements

Special tools	
Description	**Part number**
Piston replacer tool, No 8	-

1 Ensure that the piston, the cylinder bore, the crank pin and the big end of the connecting rod are clean. Lubricate the piston and the cylinder liner with clean engine lubricating oil.

2 Rotate the crankshaft until the relevant crank pin is at its lowest position. Lubricate the crank pin with clean engine lubricating oil.

3 Fit the upper half of the shell bearings to the connecting rod. Ensure that the location tag is fitted correctly in its recess. Lubricate the bearing with clean engine lubricating oil.

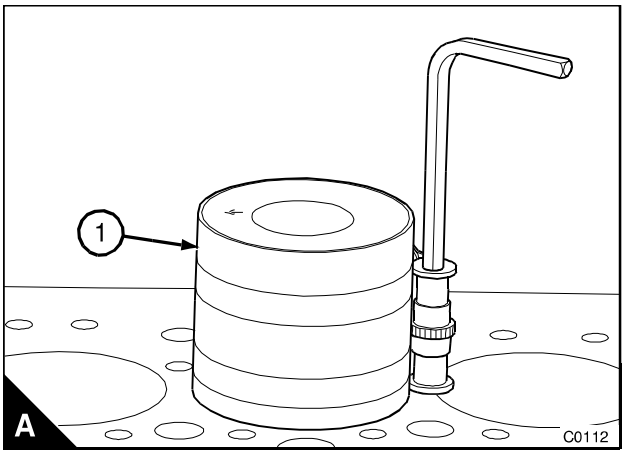
4 Put the piston replacer tool in position at the top of the relevant cylinder. The tool has a tapered bore to compress the piston rings when the piston and connecting rod assembly is fitted. Ensure that the smaller end of the tapered bore is towards the face of the cylinder block.

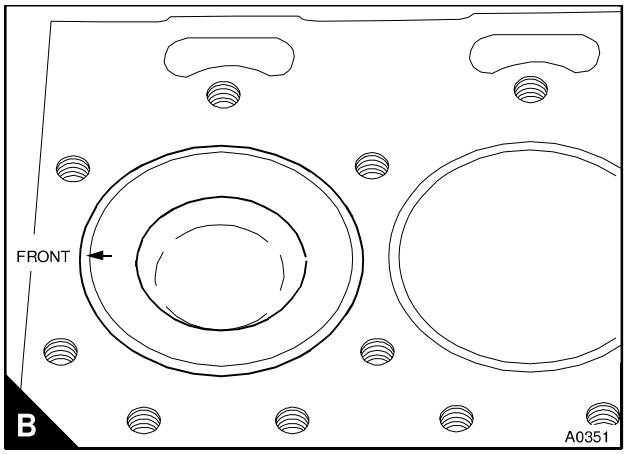
5 Put the piston ring gaps 120° apart. Pass the connecting rod through the piston replacer tool and allow the piston to enter the tool. The arrow or "F" mark (B) on the top of the piston must be towards the front of the engine. In this position the combustion bowl in the top of the piston will be towards the fuel injection pump side of the engine.

6 Push the piston and connecting rod assembly through the piston replacer tool (A1) and onto the crank pin.

Caution: *New nuts must be fitted to the big end bearing bolts.*

7 Clean the connecting rod cap and the lower half of the shell bearings. Fit the bearing to the cap; ensure that the location tag is fitted correctly in its recess. Lubricate the bearing with clean engine lubricating oil. Fit the cap and ensure that the assembly number is the same as that on the connecting rod and that the numbers are on the same side. Fit new nuts; ensure that the flat side of the head of the bolts is towards the connecting rod. Tighten the fasteners gradually and evenly to the recommended torque of 125 Nm (92 lbf ft) 12,7 kgf m.





Continued

This document has been printed from SPI². Not for Resale

8 Check that the crankshaft will rotate freely.

9 Check the piston height above the top face of the cylinder block, see Operation 4-6.

10 Fit the lubricating oil strainer and suction pipe, see Operation 10-4 or fit the balancer unit, see Operation 5-14.

11 Fit the lubricating oil sump, see Operation 10-3.

12 Fit the cylinder head assembly, see Operation 3-8.

13 Fill the sump to the correct level with lubricating oil of an approved grade.

14 Fill the cooling system.

This document has been printed from SPI². Not for Resale

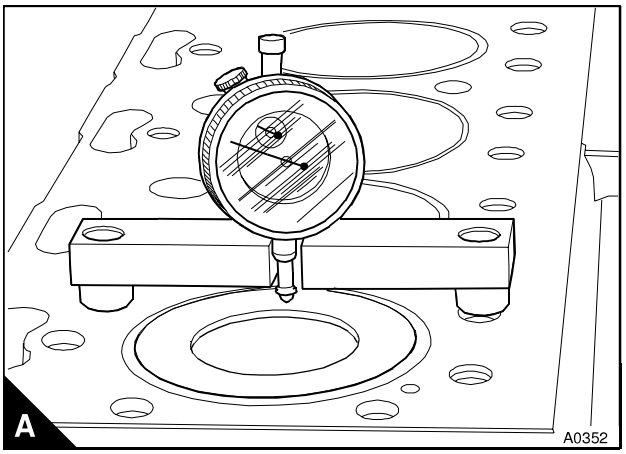
To check the piston height above the cylinder block **Operation 4-6**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Piston height tool	PD.41D	Dial gauge for use with PD.41D	PD.208

1 Put the piston height tool on the face of the cylinder block and rotate the gauge dial to the zero position. Rotate the crankshaft until the piston is approximately at top dead centre (TDC). Carefully put the tool over the top of the piston with the plunger of the gauge in contact with the piston above the axis of the gudgeon pin (A).

2 Rotate the crankshaft to ensure that the piston is at the highest position and make a note of the gauge indication. The piston height above the face of the cylinder block should be 0,14/0,36 mm (0.005/0.014 in).



This document has been printed from SPI². Not for Resale

Piston rings

To remove and to fit **Operation 4-7**

The piston has two compression rings and an oil control ring. All the piston rings are above the gudgeon pin. Piston rings have different design features. To ensure that the correct type is obtained always use the engine identification number to order new parts.

Caution: *Only expand the ring gaps enough to ensure that the ends of the rings do not damage the piston when the ring is removed or put into position.*

To remove

Remove the piston rings with a suitable ring expander. Keep the rings with their relevant piston.

To fit

Use a suitable piston ring expander to fit the piston rings.

1 Fit the spring of the oil control ring in the bottom groove with the latch pin inside both ends of the spring (A). Fit the oil control ring over the spring (B2). Ensure that the ring gap is at 180° to the latch pin.

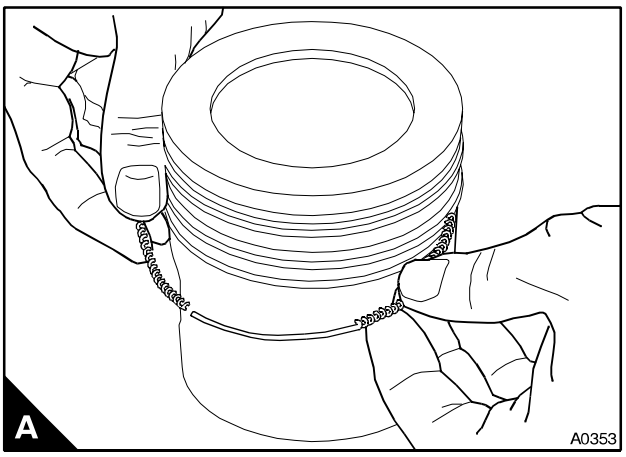
2 Fit the cast iron ring with the taper face (B1) to the second groove with the word "TOP" towards the top of the piston.

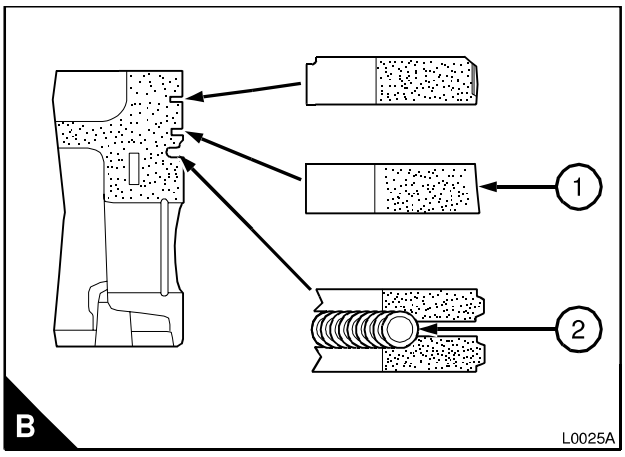
New second rings have a green identification mark which must be on the left of the ring gap when the ring is fitted and the piston is upright.

3 Fit the barrel faced top ring in the top groove, the word 'TOP' must be towards the top of the piston. The top ring has an internal step on the top face.

Note: New top rings have a red identification mark which must be on the left of the ring gap when the ring is fitted and the piston is upright.

4 Ensure that the ring gaps are 120° apart.





This document has been printed from SPI². Not for Resale

Piston and connecting rod assembly

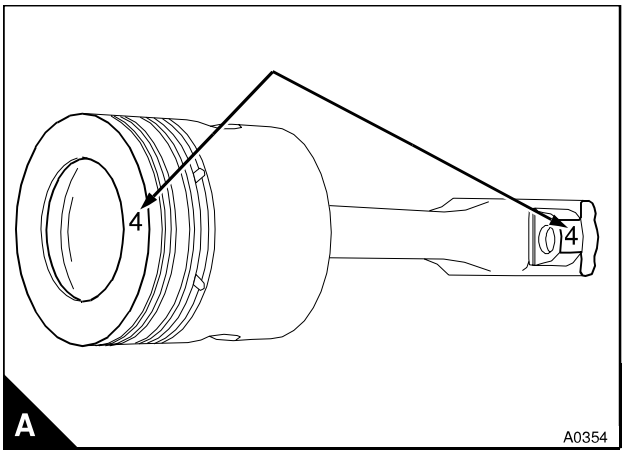
To dismantle — Operation 4-8

1 Remove the piston rings, see Operation 4-7.

2 Remove the circlips which retain the gudgeon pin.

3 Put a mark on the piston to indicate the cylinder number as shown on the connecting rod. Put the mark on the piston on the same side as the mark on the big end to ensure that they are assembled correctly (A).

4 Push the gudgeon pin out by hand. If the gudgeon pin is tight, heat the piston to 40/50 °C (100/120 °F) for easy removal of the gudgeon pin.



This document has been printed from SPI². Not for Resale

To assemble **Operation 4-9**

1 Clean the bore of the small end bush and lubricate it with clean engine lubricating oil.

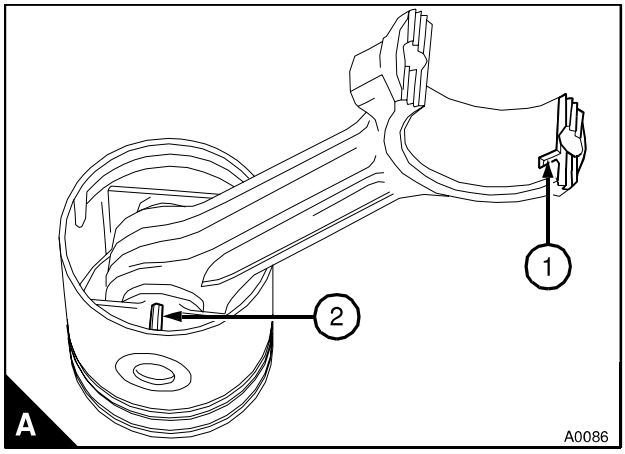
2 Fit a new circlip in the circlip groove of one of the gudgeon pin bosses. Ensure that it fits correctly in the groove.

3 With the piston upside down, put the connecting rod in position with the recess for the location of the big end bearing (A1) on the same side as the lug on the gudgeon pin boss (A2). If the original piston is used, ensure that it is assembled to the correct connecting rod and is used in the original cylinder.

4 Lubricate the gudgeon pin bosses with clean engine lubricating oil and push in the gudgeon pin towards the circlip. If the gudgeon pin is a tight fit in the piston, heat the piston to 40/50 °C (100/120 °F) before the gudgeon pin is fitted.

5 Fit a new circlip in the groove in the other gudgeon pin boss. Ensure that it fits correctly in the groove.

6 Fit the piston rings, see Operation 4-7.



This document has been printed from SPI². Not for Resale

Piston and piston rings

To inspect **Operation 4-10**

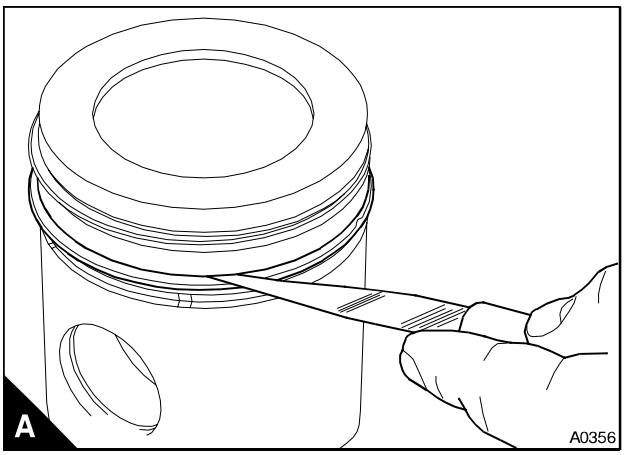
1 Check the piston for wear and other damage.

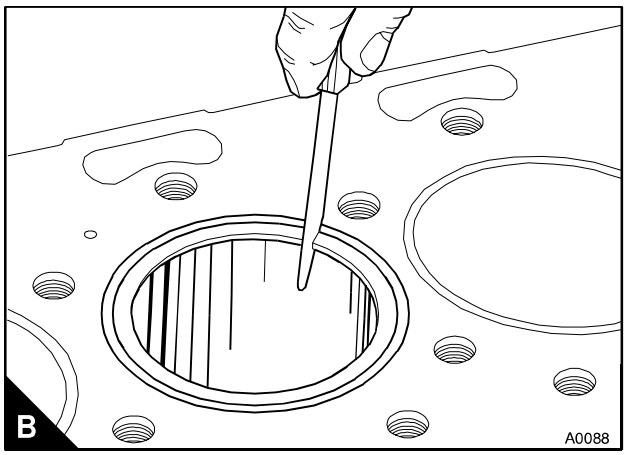
2 Check that the piston rings are free to move in their grooves and that the rings are not broken.

3 Remove the piston rings, see Operation 4-7, and clean the piston ring grooves and the piston rings.

4 Fit new piston rings in the grooves and check for wear of the grooves with feeler gauges (A). Compare the piston ring clearance in the groove to that given for new components in the relevant Data and dimensions for the "Pistons and connecting rods" on page 17, and renew the piston if necessary.

5 Clean all carbon from the top of the cylinder liners. Fit the piston rings in the top part of the cylinder liner and measure the ring gap with feeler gauges (B). The coil spring must be fitted to the oil control ring when the gap of this piston ring is measured. The piston ring gaps for new components are given in the relevant Data and dimensions for the "Pistons and connecting rods" on page 17.





This document has been printed from SPI². Not for Resale

Connecting rod

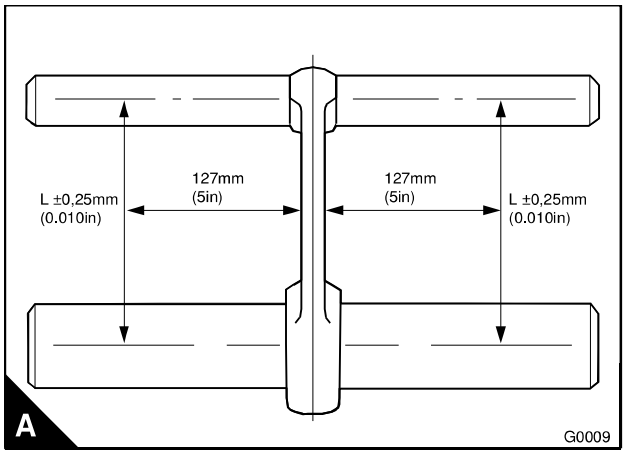
To inspect — Operation 4-11

1 Check the connecting rod for distortion (A).

Note: The large and small end bores must be square and parallel with each other within the limits of +/- 0,25 mm (0.010 in) measured 127 mm (5.0 in) each side of the connecting rod axis on a test mandrel. With the small end bush fitted, the limits are reduced to +/- 0,06 mm (0.0025 in).

2 Check the small end bush for wear or for other damage and renew it, if necessary.

3 Check the fit of the gudgeon pin in the small end bush and check the gudgeon pin for wear, refer to the relevant Data and dimensions for the "Pistons and connecting rods" on page 17.



Small end bush

To remove and to fit — Operation 4-12

1 Press out the old bush with a suitable adaptor.

2 Clean the connecting rod bore and remove any sharp edges.

3 Press in the new bush. Ensure that the lubrication hole in the bush is on the same side as, and is aligned with, the hole in the top of the connecting rod.

4 Ream the bush to get the correct clearance between the gudgeon pin and the bush. Refer to the relevant Data and dimensions for the "Pistons and connecting rods" on page 17.

This document has been printed from SPI². Not for Resale

5

Crankshaft assembly

General description

The crankshaft is a chrome-molybdenum forging which has five main journals.

End-float is controlled by two half thrust washers on both sides of the centre main bearing.

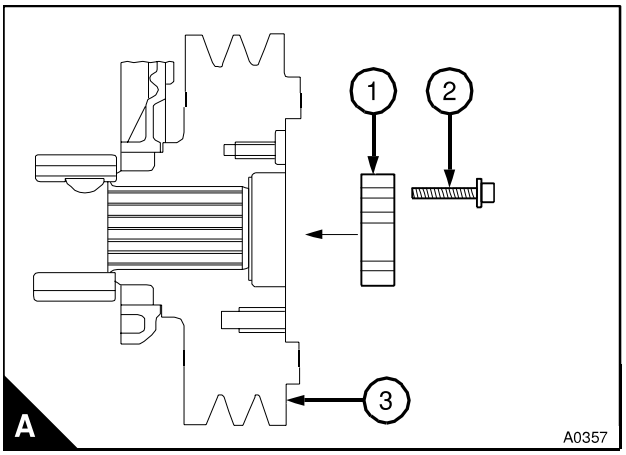
The main bearings have steel backs with a aluminium/tin bearing material. The main bearing caps are made of cast iron or spheroidal graphite (SG) iron.

The front and the rear oil seals are Viton lip seals with a dust lip to the outside of the main lip and with oil return grooves on the face of the main lip.

Warning! *Read the safety precautions for* *"Viton seals" on page 7.*

The crankshaft pulley (A3) is held in position by a plain thrust block (A1) and three setscrews (A2). The nose of the crankshaft is serrated for location.

A balancer unit is fitted to engines which have rigid mountings or which are part of the chassis or frame. The purpose of the balancer unit is to reduce the effect of the out-of-balance forces to an acceptable condition.



This document has been printed from SPI². Not for Resale

Crankshaft pulley

To remove and to fit — Operation 5-1

To remove

1 Remove the drive belt, see Operation 14-2.

2 Release the three setscrews (A2) which hold the pulley and remove the setscrews, the thrust block (A1) and the pulley (A3).

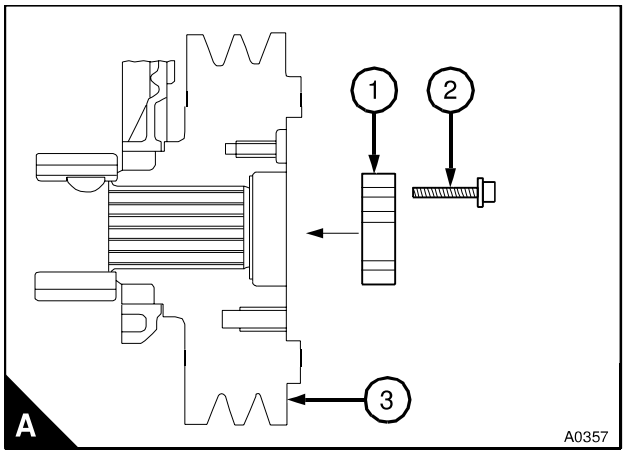
3 Clean the components and check for damage. Renew damaged components.

To fit

1 Put the pulley in position on the crankshaft. Lubricate lightly the threads of the setscrews with engine lubricating oil. Lubricate the main lip of the seal with clean engine oil. Fit the hub and the setscrews and tighten the setscrews gradually and evenly to 115 Nm (85 lbf ft) 11,8 kgf m.

2 Check each setscrew again to ensure that they are still to the correct torque.

3 Fit the drive belt, see Operation 14-2.



This document has been printed from SPI². Not for Resale

Rear oil seal assembly

To remove and to fit **Operation 5-2**

Special requirements

Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Replacer tool for rear oil seal	PD.145D	POWERPART Threadlock	21820222
		POWERPART Silicone rubber sealant	1861108

1 Remove the drive components from the rear end of the engine.

2 Remove the flywheel, see Operation 13-1, and the flywheel housing, see Operation 13-3.

3 Remove the setscrews and the cap screws from the housing and remove the housing and seal assembly.

4 Inspect the seal for wear or for damage to the main lip and renew the seal, if necessary. If there is only a small scratch across the lip, renew the seal.

5 Clean the faces of the cylinder block, the oil seal housing and the crankshaft flange.

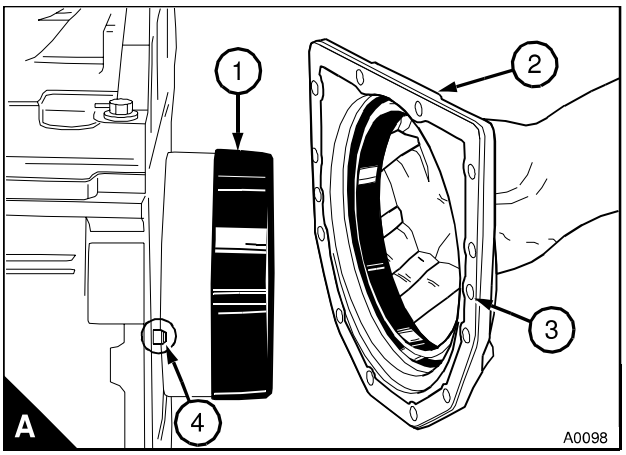
6 Check that the seal and the outer circumference of the crankshaft flange are not damaged. Where a new seal has been fitted, check that it is in the correct position in the housing.

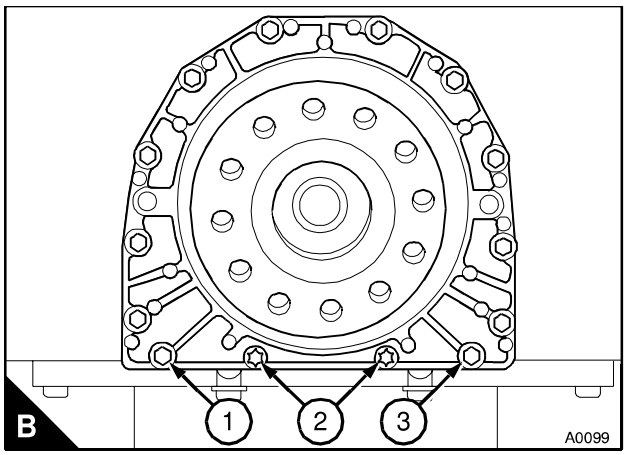
7 Ensure that the two dowels (A4) are fitted in the cylinder block. Put a new joint (A3) in position on the dowels, no jointing compound is necessary.

8 Put the seal replacer tool on the crankshaft flange. Lubricate the crankshaft flange, the main lip of the seal and the seal replacer tool with clean engine lubricating oil. The lubrication of the seal is necessary to prevent damage to the seal when the engine is first started.

9 Put the seal and housing (A2) on the replacer tool (A1) and carefully push the assembly into position on the crankshaft flange and onto the dowels. Remove the tool, fit the setscrews and the cap screws. Tighten the setscrews to 22 Nm (16 lbf ft) 2,2 kgf m and tighten the cap screws to 18 Nm (13 lbf ft) 1,9 kgf m.

Note: On the latest engines two torx screws (B2) are fitted instead of cap screws. Tighten the torx screws to 22 Nm (16 lbf ft) 2,2 kgf m. Two extra setscrews (B1 and B3) have also been fitted to later engines.





This document has been printed from SPI². Not for Resale

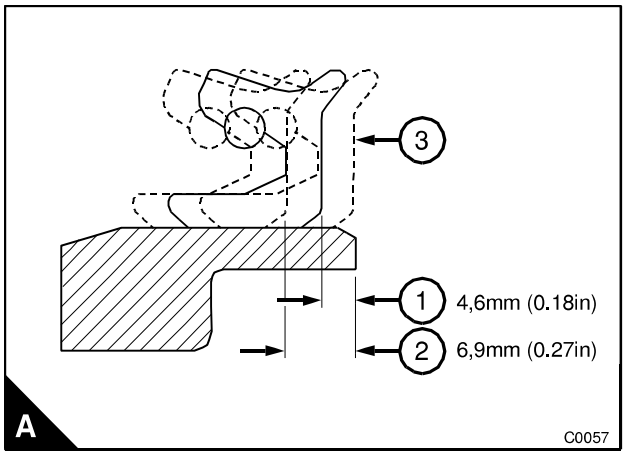
To renew the rear oil seal — Operation 5-3

Special requirements

Special tools	
Description	**Part number**
Replacer tool for rear oil seal	PD.145D

There are three positions in which the seal can be fitted in the housing (A).

- Position 1 (A1) is used when a new seal is first fitted in service.
- Position 2 (A2) is used when a new seal is fitted in service and the crankshaft flange is worn in position 1.
- Position 3 (A3) can be used with a new seal in service, if a wet clutch is not used and the crankshaft is new or the crankshaft palm area has been corrected. Ensure that the seal is fitted square in the housing.



If all positions have been used it is permissible to grind the crankshaft flange, refer to the relevant Data and dimensions for the "Crankshaft" on page 18.

1 Remove the seal and housing assembly, see Operation 5-2.

2 Put the engine side of the housing on a suitable support and press out the seal with a suitable adaptor.

3 Lubricate the outer circumference of the seal and the bore of the seal housing with clean engine lubricating oil.

4 Put the engine side of the housing on a suitable support. Put the seal into position on the flywheel end of the bore with the spring of the seal towards the housing.

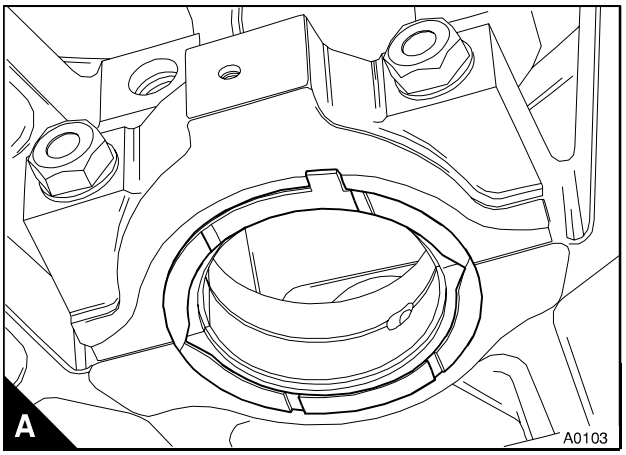
5 Use a press and the replacer tool, PD.145D, to fit the seal at the correct depth. The special tool has two sides and is used in accordance with either position "1" or "2". Press the seal into the housing to the correct position with the relevant side of the tool.

This document has been printed from SPI². Not for Resale

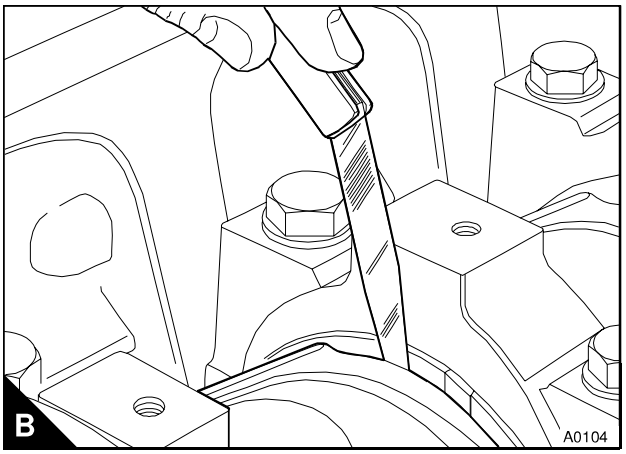
Thrust washers

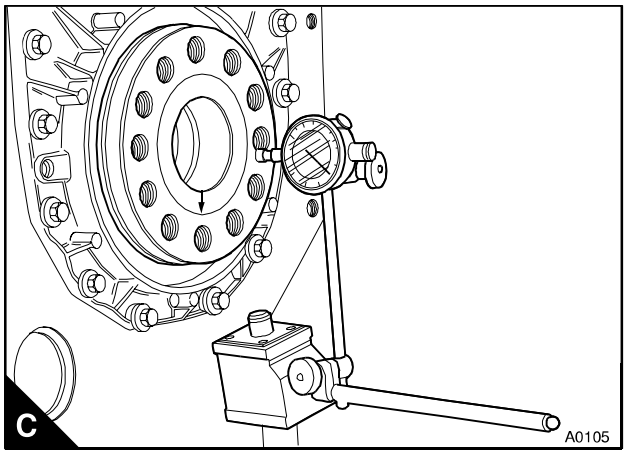
To check the crankshaft end-float **Operation 5-4**

The axial movement of the crankshaft is controlled by two half thrust washers fitted both sides of the centre main bearing (A).



The end-float can be checked with a feeler gauge between a thrust washer and the crankshaft (B), or with a dial test indicator on one end of the crankshaft to check the movement (C).





If the end-float is more than the tolerance given in the relevant Data and dimensions for the "Crankshaft" on page 18, thrust washers which are 0,019 mm (0.0075 in) oversize can be fitted.

The oversize thrust washers can be fitted to one or to both sides of the main bearing. They are fitted instead of the standard size washer, to reduce the end-float to the factory tolerances.

This document has been printed from SPI². Not for Resale

To remove **Operation 5-5**

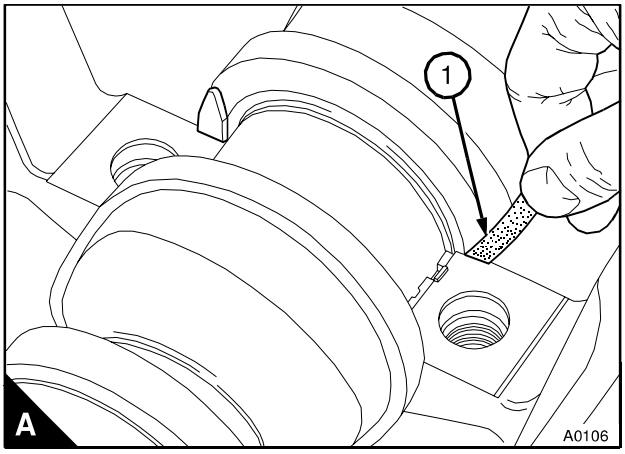
1 Drain the lubricating oil and remove the lubricating oil sump, see Operation 10-3.

2 If necessary, remove the balancer unit, see Operation 5-13.

3 If necessary, remove the lubricating oil strainer and suction pipe, see Operation 10-4.

4 Release the setscrews of the centre main bearing and remove the main bearing cap complete with the lower half thrust washers.

5 Press down one end of each upper half thrust washer, with a suitable tool made of a soft material (A1), to slide the washer from its recess. Where necessary, move the crankshaft to the front or to the rear to loosen a tight washer.



This document has been printed from SPI². Not for Resale

To fit **Operation 5-6**

1 Lubricate the thrust washers with clean engine lubricating oil.

2 Slide the upper half thrust washers into their recesses in the cylinder block. Ensure that the sides of the thrust washers which have the grooves are against the crankshaft.

3 Fit the lower half thrust washers to the main bearing cap with the location tags in their recesses.

4 Ensure that the location thimbles are fitted correctly in the main bearing cap or in the cylinder block.

5 Ensure that the bearing is fitted correctly in the cap and that the bearing and the crankshaft journal are clean. Lubricate the bearing with clean engine lubricating oil.

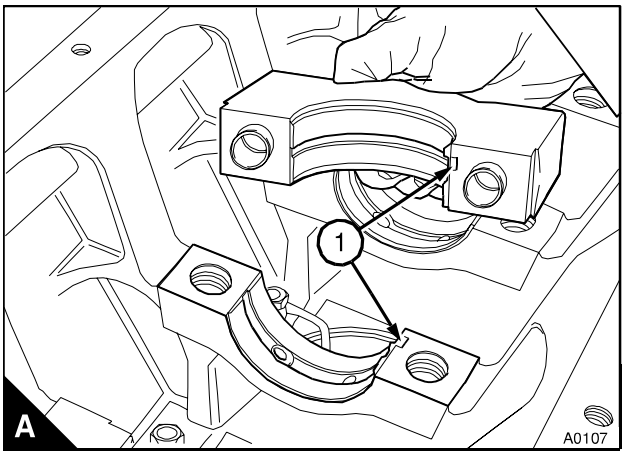
6 Fit the cap with the location tags of both half of the shell bearings to the same side (A1). Tighten the main bearing setscrews gradually and evenly to 250 Nm (185 lbf ft) 26,0 kgf m.

7 Check the crankshaft end-float, see Operation 5-4.

8 If necessary, fit the balancer unit, see Operation 5-14.

9 If necessary, fit the lubricating oil strainer and the suction pipe, see Operation 10-4.

10 Fit the lubricating oil sump, see Operation 10-3, and fill it to the correct level with an approved lubricating oil.



This document has been printed from SPI². Not for Resale

To remove (with the crankshaft in position) **Operation 5-7**

If the rear main bearing is to be removed with the crankshaft in position, the flywheel, the flywheel housing, the rear oil seal housing and the bridge piece will have to be removed.

The balancer unit or the suction pipe and strainer, the delivery pipe and the relief valve will have to be removed.

1 Drain the lubricating oil and remove the sump, see Operation 10-3.

2 Remove all necessary components to get access to the specific bearing cap.

3 Release the setscrews of the bearing cap and remove the bearing cap. Remove the lower half of the shell bearing from the cap.

4 With a suitable tool, push the upper half of the shell bearing from the side opposite to the location tag to remove the bearing tag from its recess in the bearing housing. Carefully rotate the crankshaft to release the bearing from its housing. Keep the bearing halves in their relevant positions.

This document has been printed from SPI². Not for Resale

To fit (with the crankshaft in position) **Operation 5-8**

1 Clean the upper half of the shell bearing and lubricate the bearing surface with clean engine lubricating oil.

Caution: *Only the upper half of the bearing has lubrication holes and must be fitted to the side of the cylinder block.*

2 Fit the plain end of the upper half of the shell bearing between the crankshaft journal and the side of the bearing housing which has the recess for the location tag. Slide the bearing into its housing until the tag on the bearing is fitted correctly in its recess in the housing.

3 Clean the lower half of the shell bearing and the cap, lubricate the bearing surface with clean engine lubricating oil.

4 Fit the bearing into the cap with the tag of the bearing fitted correctly in the recess in the cap.

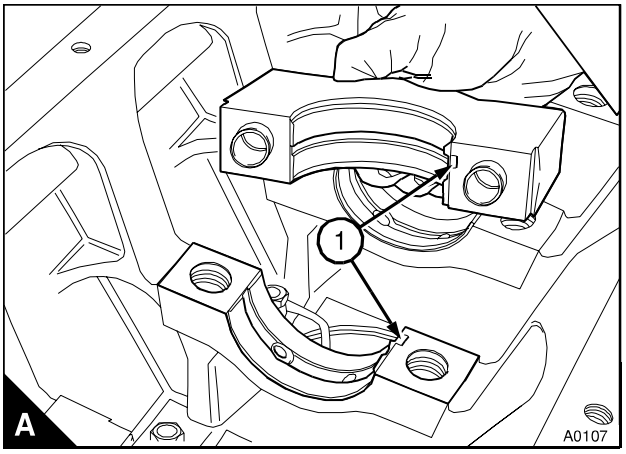
5 Ensure that the location thimbles are fitted correctly to the cap or to the cylinder block. Fit the bearing cap with the location tags of both bearings on the same side (A1).

6 Inspect the setscrews for damage and for distortion and renew them if necessary. Lightly lubricate the setscrew threads with clean engine lubricating oil. Fit the setscrews and tighten the setscrews gradually and evenly to 250 Nm (185 lb ft) 26,0 kgf m.

7 Ensure that the crankshaft turns freely. If the thrust washers have been removed and fitted, check the crankshaft end-float, see Operation 5-4.

8 Fit all the components which were removed for access to the main bearing cap.

9 Fit the lubricating oil sump, see Operation 10-3 and fill it to the correct level with an approved lubricating oil.



To inspect **Operation 5-9**

Inspect the bearings for wear and for other damage. If a bearing is worn or damaged, renew both half of the shell bearings and check the condition of the other bearings.

This document has been printed from SPI². Not for Resale

To remove — Operation 5-10

Warnings!

- *Use lift equipment or obtain assistance to lift heavy engine components such as the balancer unit, flywheel housing, crankshaft and flywheel.*
- *It is recommended that this operation is done with the engine upside down.*

1 Before the engine is removed from the vehicle or from the machine, drain the lubricating oil and the coolant.

2 Remove the lubricating oil sump, see Operation 10-3.

3 Remove the fan, the drive belt, the fan drive pulley and housing and the coolant pump, refer to Chapter 12, Cooling system.

4 Remove the crankshaft pulley, see Operation 5-1.

5 Remove the alternator and its mounting bracket, see Operation 14-3.

6 Remove the compressor and its drive assembly, or remove the exhauster, see Operation 15-4.

7 Remove the timing case cover, see Operation 6-1.

8 Remove the fuel injection pump, see Operation 11-10 for Lucas DPA fuel injection pumps and Operation 11-14 for Stanadyne fuel injection pumps.

9 Remove the timing gears and the timing case, see Chapter 6, Timing case and drive assembly.

10 Remove the flywheel, see Operation 13-1, and the flywheel housing, see Operation 13-3.

11 Remove the rear oil seal housing, see Operation 5-2.

12 Remove the balancer, see Operation 5-13.

13 Remove the bridge piece and the rubber seals. Later engines may not have rubber seals fitted.

Warning! *It is recommended that the operation that follows is done with the engine up side down.*

14 Remove the caps of the connecting rods. Keep the shell bearings and caps together. Remove the bolts of the connecting rods and carefully push the pistons towards the top of their bores.

15 Ensure that the tops of the main bearing caps are stamped with their relevant position number. Remove the main bearing caps, the lower half of the shell bearings and the upper and lower thrust washers. Keep the shell bearings with their relevant caps.

16 Lift out the crankshaft. Remove the upper half of the shell bearings and keep each bearing with its relevant lower half and cap.

This document has been printed from SPI². Not for Resale

To fit **Operation 5-11**

Special requirements

Consumable products			
Description	**Part number**	**Description**	**Part number**
POWERPART Silicone rubber sealant	1861108	POWERPART Liquid gasket	21820518

1 Ensure that all lubricating oil passages are clean and free from restriction.

2 Clean the main bearing housings and the upper half of the shell bearings. Fit the shell bearings with the location tags fitted correctly in their recesses. Lubricate the bearings with clean engine lubricating oil.

3 Ensure that the main journals of the crankshaft are clean. Put the crankshaft in position on the upper bearings.

4 Clean and lubricate the upper thrust washers and slide them into their recesses on both sides of the bearing housing. Ensure that the slotted sides of the thrust washers are towards the crankshaft.

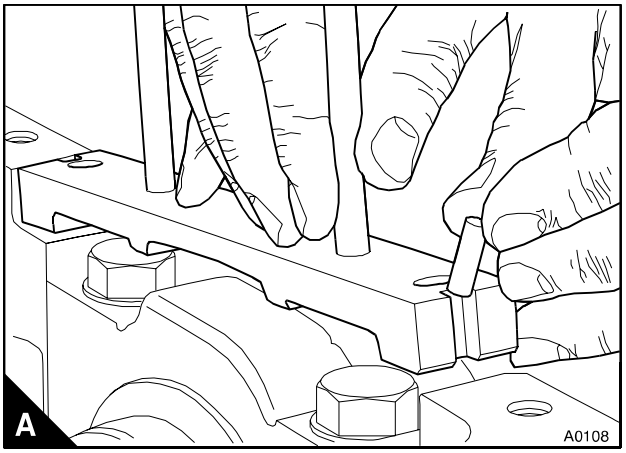
5 Clean the bearing caps and the lower half of the shell bearings. Fit the bearings to the caps with the location tags fitted correctly in their recesses. Lubricate the bearings with clean engine lubricating oil.

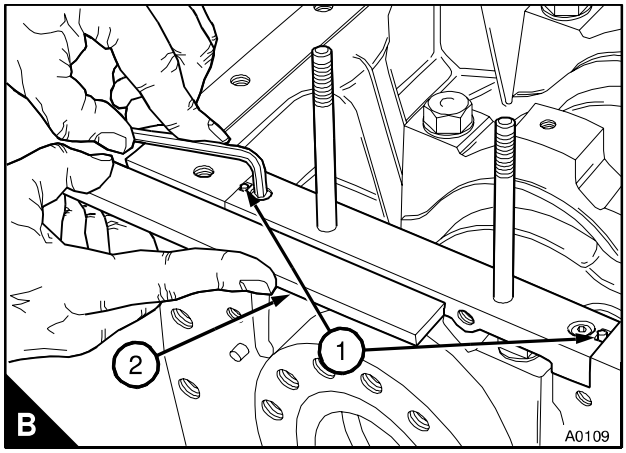
6 Clean the lower thrust washers and lubricate them with clean engine lubricating oil. Fit the thrust washers on both sides of the bearing cap for the centre main bearing.

7 Check that the location thimbles for the main bearing caps are fitted correctly in the caps or in the cylinder block. Fit the bearing caps in their correct positions (as shown by the position number stamped on the top of the cap) with the location tags of the bearings on the same side. In this position the serial numbers stamped on the bearing caps will be in line. The serial number stamped on the bearing caps must be the same as the number stamped on the bottom face of the cylinder block.

8 Fit the setscrews to the main bearing caps and tighten the setscrews gradually and evenly to 250 Nm (185 lb ft) 26,0 kgf m.

9 For early engines fitted with rubber seals: Clean the bridge piece and the location areas for the bridge piece in the cylinder block. Apply a narrow strip of POWERPART Silicone rubber sealant in the corners and around the thread holes of the bridge piece seat in the cylinder block. Fit the bridge piece and the two rubber seals (A). The rubber seals will be a little higher than the bridge piece when they are fitted correctly. Use a straight edge (B2) to ensure that the bridge piece is in line with the rear face of the cylinder block. Tighten the bridge piece cap screws (B1) to 16 Nm (12 lbf ft) 1,6 kgf m.





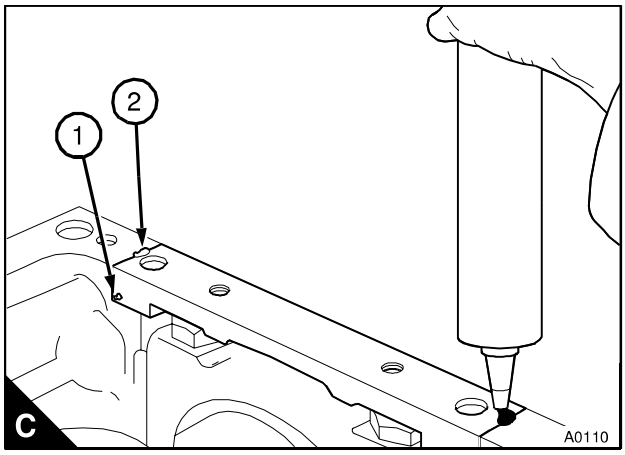
Continued

This document has been printed from SPI². Not for Resale

For later engines fitted with POWERPART Liquid gasket: A bridge piece has been introduced which uses POWERPART Liquid gasket instead of the rubber seal in the groove at each end of the bridge piece. The groove at each end of the new bridge piece is cast and is off-centre. The procedure to fit the new bridge piece is the same as for the earlier bridge piece, except for the instructions given below. Apply a $^{1}/_{8}$ in (3.0 mm) bead of POWERPART Liquid gasket along the corner in the top of the recess in the cylinder block for the bridge piece.

When the bridge piece is in position and the cap screws have been tightened, inject POWERPART Liquid gasket into the groove (C2) at each end of the bridge piece. Continue to inject sealant until the groove is completely full and the sealant leaves the lower groove (C1) at the front and rear of the bridge piece.

It may be necessary to stop the sealant at one side of the lower groove in order to ensure it will flow from the opposite side of the groove.



Caution: *When the sump joint is removed, damage can occur to the seal in the grooves of the bridge piece. If the seal is damaged, apply enough sealant to completely fill the grooves.*

Note: The latest engines have setscrews in place of studs to fasten the sump to the bridge piece. The threads of the setscrews have a sealant applied by the manufacturer. When the setscrews are to be used again, ensure that the threads of the setscrews and of the bridge piece are clean and a sealant is applied to the threads of the setscrews. These instructions also apply to studs.

10 Fit the connecting rod caps, see Operation 4-2. Rotate the crankshaft two turns to ensure free movement.

11 Fit the balancer unit, see Operation 5-14.

12 Fit the rear oil seal housing, see Operation 5-2.

13 Fit the flywheel housing, see Operation 13-3, and the flywheel, see Operation 13-1.

14 Fit the timing case and the timing gears, see Chapter 6, Timing case and drive assembly.

15 Fit the fuel injection pump, see Operation 11-11 for Lucas DPA fuel injection pumps and Operation 11-15 for Stanadyne fuel injection pumps.

16 Fit the timing case cover, see Operation 6-2.

17 Fit the compressor and its drive assembly or fit the exhauster, see Operation 15-4.

18 Fit the alternator and its mounting bracket, see Operation 14-3.

19 Fit the crankshaft pulley, see Operation 5-1.

20 Fit the coolant pump, the fan drive pulley and housing, the drive belts and the fan, see Chapter 12, Cooling system.

21 Fit the lubricating oil sump, see Operation 10-3.

22 After the engine has been installed, fill the lubricating oil sump to the correct level with an approved oil. Fill the cooling system.

This document has been printed from SPI². Not for Resale

To inspect **Operation 5-12**

Check the crankshaft for wear and other damage. The maximum permissible wear and ovality on the crankshaft journals and crank pins is 0,04 mm (0.0016 in).

The main journals and the crank pins of standard size crank shafts can be machined to 0,25mm (0.010 in), 0,50mm (0.020 in) or 0,75 mm (0.030 in) undersize in diameter. Refer to "Crankshaft overhaul" on page 19. Special undersize bearings are available.

If the seal has been used in all of the service positions, the crankshaft palm can be machined to remove the wear marks. Further information can be found in the relevant Data and dimensions for the "Crankshaft" on page 18.

This document has been printed from SPI². Not for Resale

Balancer unit

To remove **Operation 5-13**

1 Drain the lubricating oil from the sump and remove the sump, see Operation 10-3.

Warning! *The weight of the unit is approximately 25 kg (55 lb).*

2 Provide a support for the balancer unit before release of the setscrews from the engine.

3 Release the setscrews and lower carefully the balancer unit. Make a note of the positions of the setscrews of different lengths.

This document has been printed from SPI². Not for Resale

To fit **Operation 5-14**

1 Ensure that the contact faces of the cylinder block and of the balancer unit are clean and that the two thimbles (A1) are fitted correctly to the cylinder block.

2 Set the piston of number 1 cylinder to TDC, see Operation 8-2.

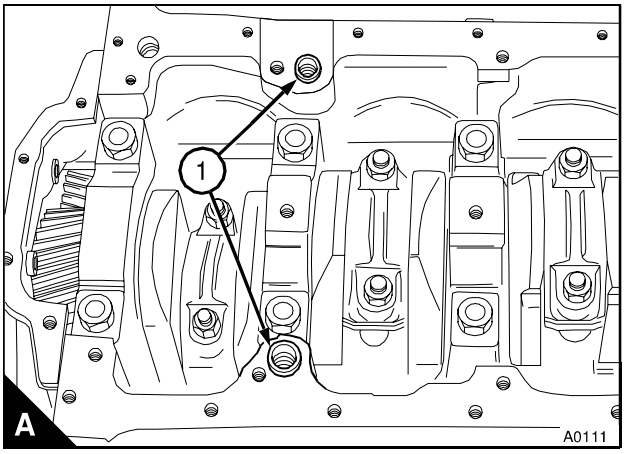
3 Before the balancer unit is fitted, ensure that the flat faces of the balance weights are level with each other (B1) and the weights hang down away from the cylinder block (B2). The timing of the balance weights to the drive shaft is correct when the large hole and small hole in the front of the drive shaft gear are in the positions shown (B).

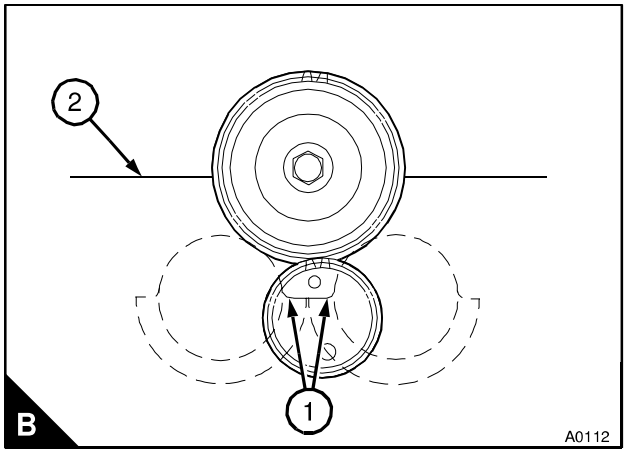
Note: If the gear position shown in (B) cannot be obtained, then the balancer must be partially dismantled and the timing corrected, refer to step 6 of Operation 5-16.

4 Fit the balancer unit to the cylinder block with the correct screws in the centre positions of the balancer frame. Ensure, when the idler and crankshaft gears are in mesh, that the flat faces of the balance weight are level with each other and that they are towards the cylinder block. Check that the balancer unit is fitted correctly on the thimbles and fit the remainder of the setscrews in their correct position. Tighten the setscrews to 54 Nm (40 lbf ft) 5,5 kgf m.

5 Rotate the crankshaft through two turns to ensure that it is free to rotate.

6 Fit the lubricating oil sump, see Operation 10-3 and fill the sump to the correct level with an approved oil.





This document has been printed from SPI². Not for Resale

To dismantle **Operation 5-15**

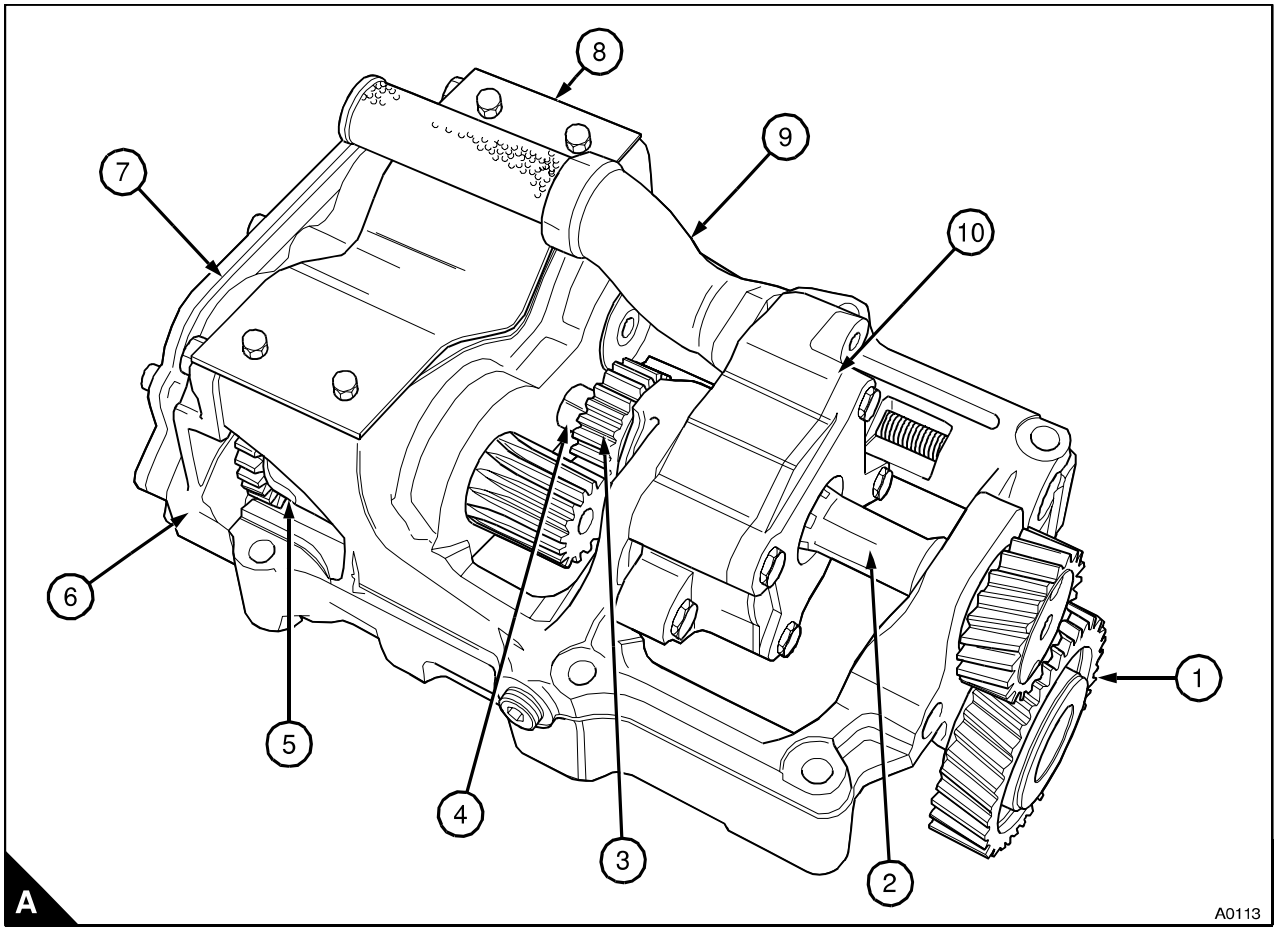
1 Remove the balance weight cover (A8).

2 Release the setscrew and remove the idler gear assembly (A1). Keep the components together as an assembly to protect the needle roller bearing.

3 Prevent movement of the drive shaft (A2) and loosen the nut (A4) of the drive gear for the balance weights (A3). Put a suitable flat distance piece in position between the nut and the balancer frame. Turn the nut until it is against the face of the distance piece. Continue to turn the nut with a suitable spanner until the Loctite seal on the splines of the drive shaft is broken and the gear is loose on the shaft. Remove the nut and the drive gear and remove the drive shaft. Ensure that the needle roller bearings are not damaged when the drive shaft is removed.

4 Release the setscrews which hold the lubricating oil pump and the suction pipe (A10 and A9) to the balancer frame and remove the lubricating oil pump and the suction pipe.

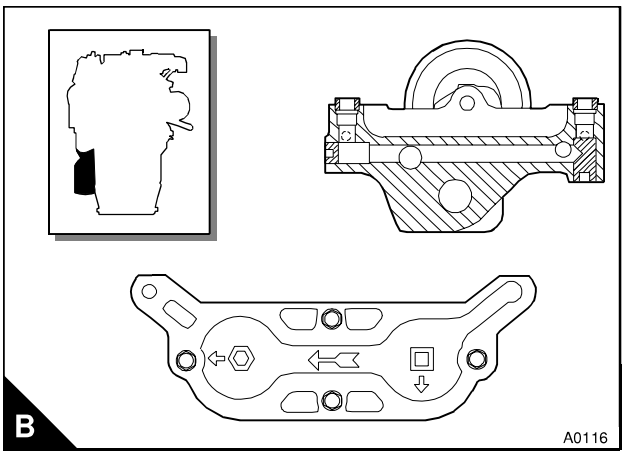
5 Release the setscrews and remove the transfer plate and joint for the lubricating oil (A7) from the rear of the balancer unit.

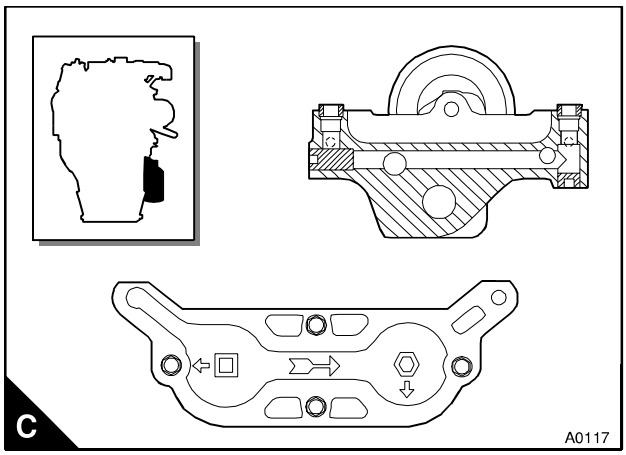


Continued

This document has been printed from SPI². Not for Resale

Make a note of the position of the direction arrows on the outside of the transfer plate (B or C) to ensure that it can be assembled correctly.





Notes:

- The latest oil transfer plate is fitted without a joint or sealant; always give the correct engine number when parts are needed.
- There are two plugs in the balancer frame, a short tapered plug with a hexagonal socket head and a long plug with a square socket head. These plugs control the flow of oil through the balancer frame. The position of the plugs is decided by which side of the engine the filter is fitted. When the filter is fitted on the left side, the short plug is fitted in the side of the balancer and the long plug is fitted in the bottom (B). When the filter is fitted on the right side of the engine, the short plug is fitted in the bottom of the balancer and the long plug is fitted in the side (C).

Caution: *Removal of these plugs can cause damage to the threads in the balancer frame and a new balancer frame will be needed. When a balancer unit is to be fitted, ensure that the lubricating oil flow through the balancer frame is correct for the position of the lubricating oil filter.*

6 Release the setscrews and remove the rear cover of the balancer frame (page 80/A6). A hammer and a suitable drift will be necessary to remove the rear cover from the dowels.

7 Remove the balance weights (page 80/A5). Ensure that the gear of the driven weight does not damage the bush in the balancer frame.

8 Dismantle the lubricating oil relief valve, see Operation 10-11.

9 Clean the lubricating oil passages with an approved kerosene cleaning solution and dry them with low pressure compressed air.

This document has been printed from SPI². Not for Resale

To assemble **Operation 5-16**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Nutlock	21820242

1 Ensure that the location thimble (A8) in the rear of the lubricating oil pump is 5,6/6,4 mm (0.220/0.252 in) above the rear face of the pump. Clean the contact faces of the lubricating oil pump and the balancer frame. Fit the lubricating oil pump (A16) to the balancer frame and tighten the setscrews to 27 Nm (20 lbf ft) 2,8 kgf m.

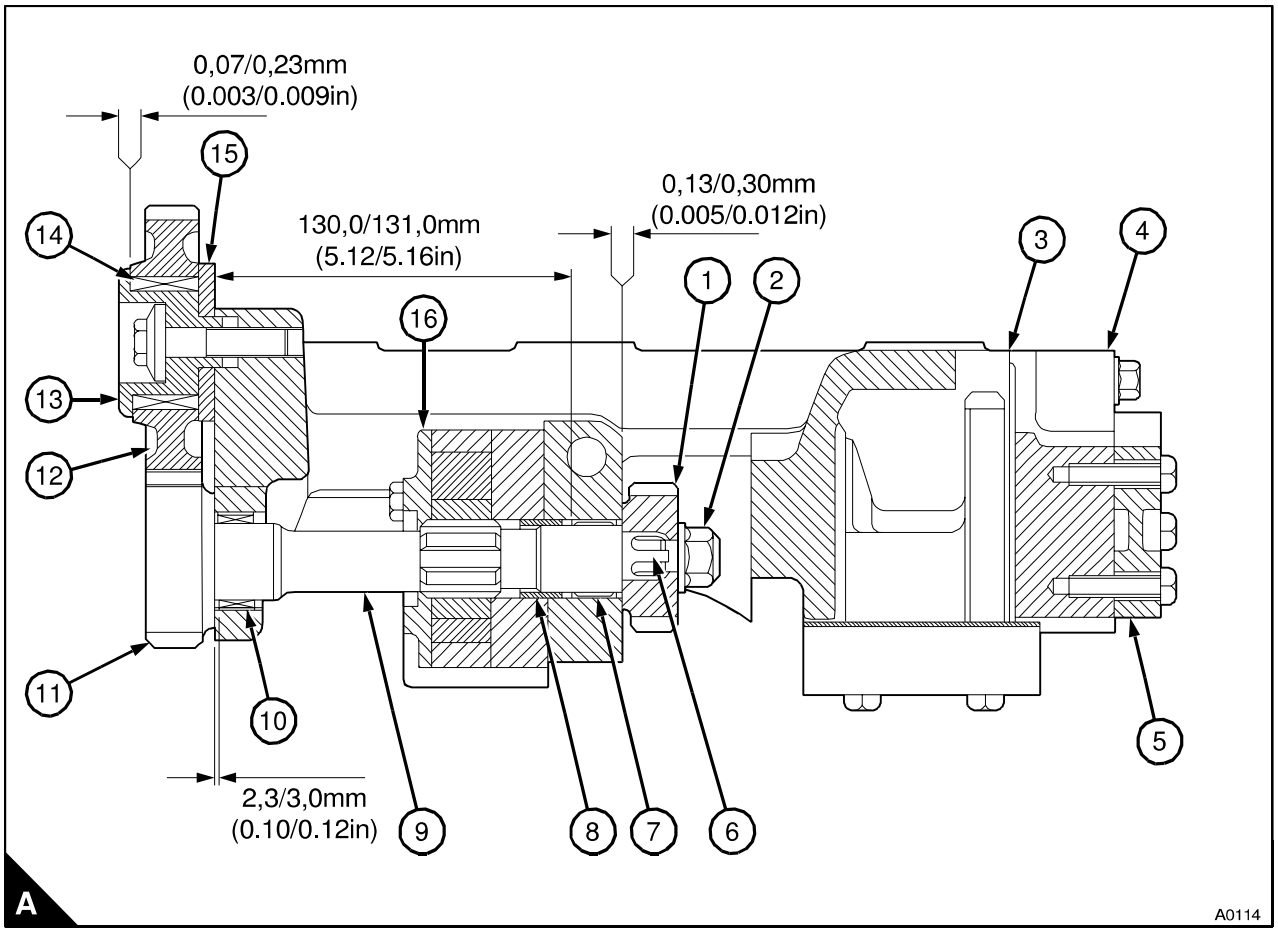
Note: The latest balancers do not have a thimble for the oil pump location. The location of the latest oil pump is by a spigot on the rear face of the pump.

2 Assemble the lubricating oil relief valve, see Operation 10-11.

3 Lubricate the needle roller bearings (A7 and A10) with clean engine lubricating oil. Fit the drive shaft (A9) and engage the splines for the lubricating oil pump with the pump rotor. Ensure that the needle roller bearing at the front of the balancer frame is not damaged by the splines on the drive shaft.

4 Clean and dry the splines (A6) and the thread on the end of the drive shaft. Apply a small amount of POWERPART Nutlock to the splines and to the thread. Fit the drive gear of the balance weights (A1) with the flat face of the gear towards the rear of the balancer unit. Fit and tighten the nut (A2) to 82 Nm (60 lbf ft) 8,4 kgf m. To tighten the nut, a peg spanner must be made to fit into the two holes in the front of the drive shaft and be suitable for use with a torque wrench. Fit the peg spanner to the front of the drive shaft. Hold the nut with a suitable spanner and apply the torque to the peg spanner.

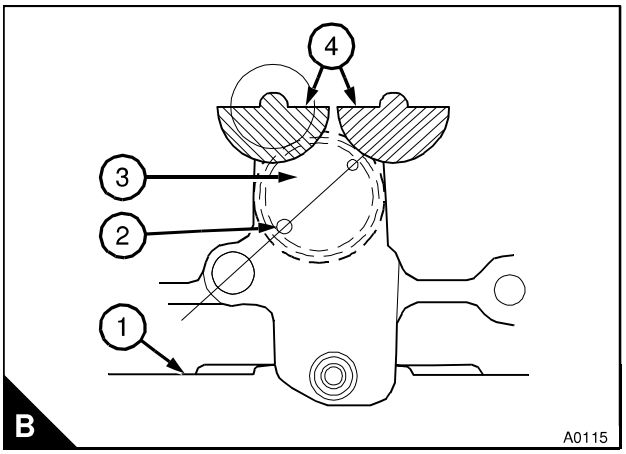
5 Ensure that the drive shaft turns freely. Check the end-float of the drive shaft with feeler gauges between the front face of the drive gear for the balance weights and the frame (A).



Continued

This document has been printed from SPI². Not for Resale

6 Put the balancer frame upside down on the bench (B1). Turn the gear of the drive shaft (B3) until the larger of the two outer holes (B2) - in the front face of the drive gear - is in the position shown in (B). Ensure that the drive shaft will not move from this position. Lubricate the bushes in the rear of the balancer frame with clean engine lubricating oil and fit the balance weights in the position shown (B). Ensure that the flats on the balance weights are level with each other (B4). With the balance weights in the correct position, check that the drive shaft is still in the correct position.



7 Fit the two dowels to the rear face of the balancer frame. Lubricate the bushes in the rear cover of the balance frame with clean engine lubricating oil. Put the rear cover (page 82/A4) in position with the rear spigots of the balance weights in the bushes of the cover. Hit lightly the rear cover with a soft face hammer to fit the cover onto the dowels. Fit the cover setscrews and tighten them to 54 Nm (40 lbf ft) 5,5 kgf m.

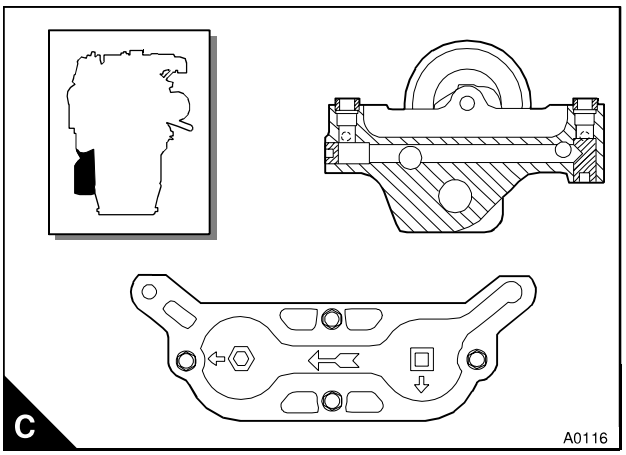
Check the end-float of the balance weights with feeler gauges between the rear face of the balance weights and the front face of the rear cover, refer to Operation 5-19. The correct end-float is given in the relevant Data and dimensions for the "Balancer unit" on page 21.

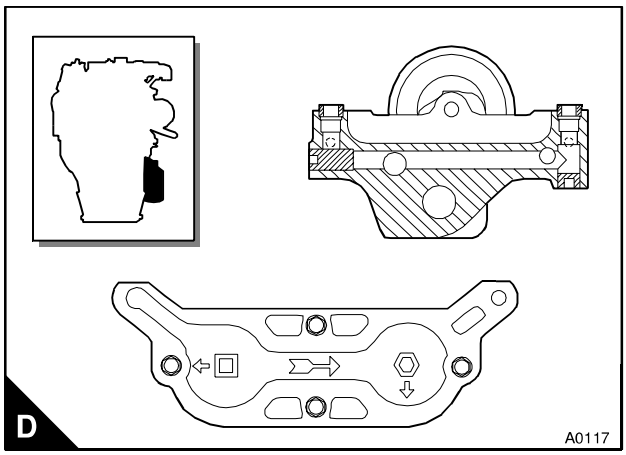
Check the backlash between the drive gear of the balance weights and the driven gear on the balance weight. The correct backlash is given in the relevant Data and dimensions for the "Balancer unit" on page 21.

8 Fit the oil transfer plate and the joint, if fitted, to the rear of the rear cover and tighten the setscrews to 30 Nm (22 lbf ft) 3,1 kgf m. Ensure that the plate is fitted correctly for the oil filter position.

Note: The direction arrow (C or D) indicates the direction of lubricating oil flow for left side (C) and right side (D) oil filter positions. The symbols and arrows (C or D) indicate the position of the plugs in the balancer frame and the shape of their socket heads.

9 Ensure that the plug on the bottom face of the frame is just below the face. If a new frame and plugs are used, ensure that the plugs are fitted correctly for the oil filter position and the symbols on the oil transfer plate.





Continued

This document has been printed from SPI². Not for Resale

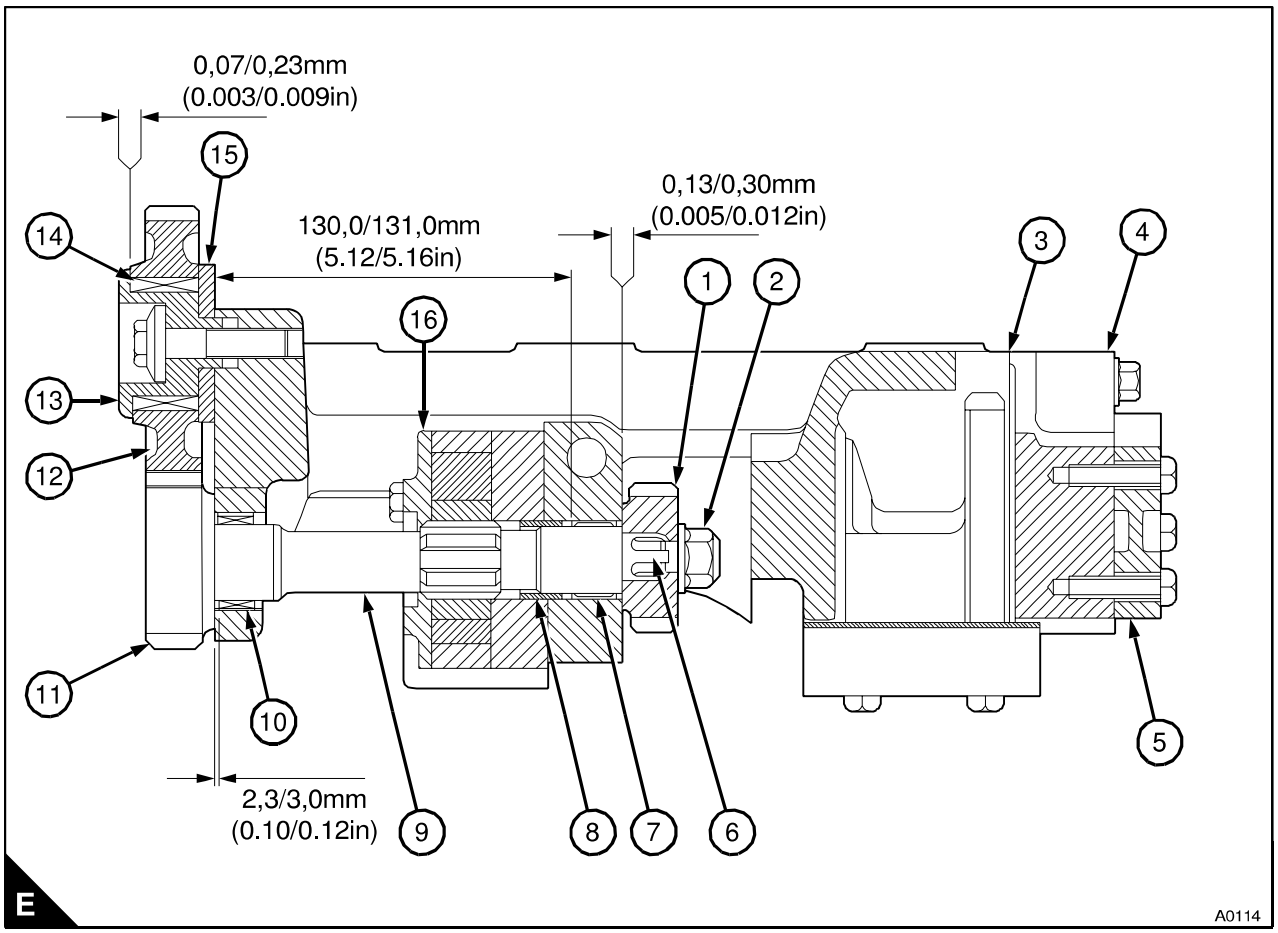
10 If necessary, press a new bearing (E14) into the idler gear (E12). Lubricate the bearing with clean engine lubricating oil. Fit the hub (E13) into the bearing and fit the thrust washer (E15) onto the rear of the hub. Ensure that the threads of the setscrew are clean and dry. Fit the setscrew through the assembly and apply a small amount of Loctite Nutlock to the thread. Fit the assembly to the front of the balancer unit with the idler gear in mesh with the gear of the drive shaft (E11). Tighten the setscrew to 93 Nm (68 lbf ft) 9,5 kgf m.

11 Check the end-float of the idler gear with a feeler gauge between the front face of the idler gear and the hub (E).

12 Check the backlash between the idler gear and the drive shaft gear. The correct backlash is given in the relevant Data and dimensions for the "Balancer unit" on page 21.

13 Fit the balance weight cover and tighten the setscrews.

14 Fit the suction tube and the joint and tighten the setscrews.



This document has been printed from SPI². Not for Resale

To inspect **Operation 5-17**

1 Clean all the components before inspection.

2 Check the gear teeth and the splines of the drive shaft for wear or other damage. Renew the drive shaft if necessary.

3 Check the idler gear, needle roller bearing, hub and thrust washer for wear or other damage. Renew the components if necessary.

4 Check the drive gear for the balance weights for wear or other damage. Renew the gear if necessary.

5 Check the balance weights for wear or other damage. If either balance weight is worn or damaged, both balance weights must be renewed.

6 Check the needle roller bearings for the drive shaft for wear or other damage. Renew the bearings, see Operation 5-18, if necessary.

7 Check the bushes for the balance weights for wear or other damage. Renew the bushes if necessary, see Operation 5-19.

8 To inspect the lubricating oil pump, see Operation 10-9.

This document has been printed from SPI². Not for Resale

To remove and to fit the needle roller bearings for the drive shaft **Operation 5-18**

1 Press out the bearings with a suitable adaptor.

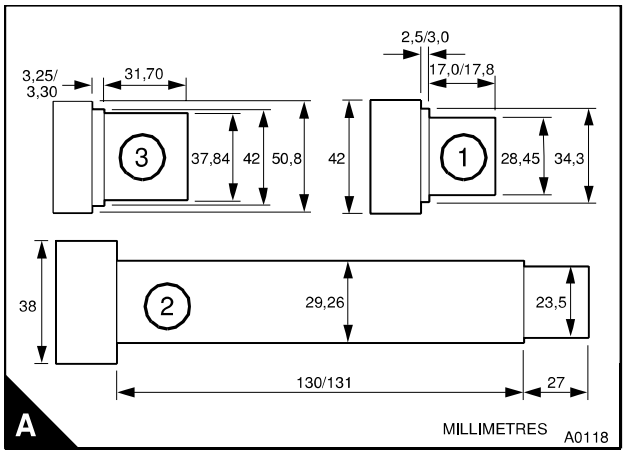
2 Clean the parent bores and lubricate them with clean engine lubricating oil.

3 Make a suitable adaptor to the dimensions given in (A2). Fit the rear bearing (Operation 5-16/A7) onto the adaptor with the stamped face of the bearing towards the shoulder of the adaptor. Press the bearing into the parent bore in a continuous movement until the shoulder of the adaptor is against the front face of the balancer frame.

In this position the front face of the bearing should be 130,0/131,0 mm (5.12/5.16 in) from the front face of the balancer frame, see Operation 5-16 (A).

4 Make a suitable adaptor to the dimensions given in (A1). Fit the front bearing (Operation 5-16/A10) onto the adaptor with the stamped face of the bearing toward the shoulder. Press the bearing into the parent bore in a continuous movement until the shoulder of the adaptor is against the front face of the balancer frame.

In this position the front face of the bearing should be 2,5/3,0 mm (0.01/0.12 in) from the front face of the balancer frame, see Operation 5-16 (A).



This document has been printed from SPI². Not for Resale

To remove and to fit the bushes for the balance weights **Operation 5-19**

1 Press the bushes out of the balancer frame and the rear cover with a suitable adaptor.

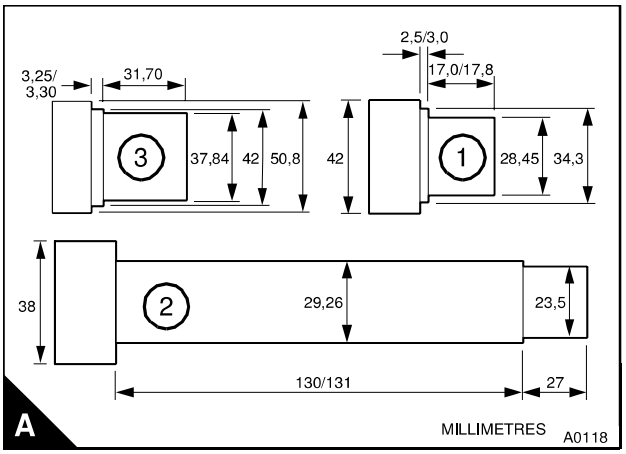
2 Clean the parent bores and lubricate them with clean engine lubricating oil.

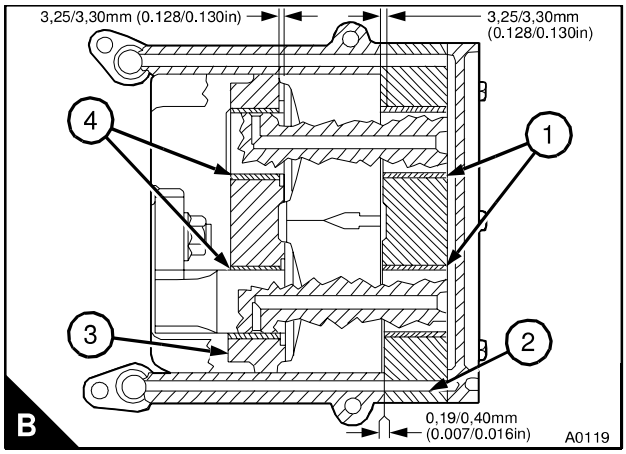
3 Make a suitable adaptor to the dimensions given in (A3). Fit a bush onto the adaptor. Press the bush (B4) into the parent bore in the rear of the balancer frame (B3), in a continuous movement, until the shoulder of the adaptor is against the rear face of the balancer frame.

In this position the rear face of the bush should be 3,25/3,30 mm (0.128/0.130 in) from the rear face of the balancer frame (B). Repeat this operation for the other bush.

4 Fit a bush (B1) onto the adaptor and put it into position at the front end of one of the parent bores in the rear cover (B2). Press in the bush, in a continuous movement, until the shoulder of the adaptor is against the front face of the rear cover.

In this position the front face of the bush should be 3,25/3,30 mm (0.128/0.130 in) from the front face of the rear cover (B). Repeat this operation for the other bush.





This document has been printed from SPI². Not for Resale

This page is intentionally blank

This document has been printed from SPI². Not for Resale

6

Timing case and drive assembly

General description

The timing case is made of aluminium.

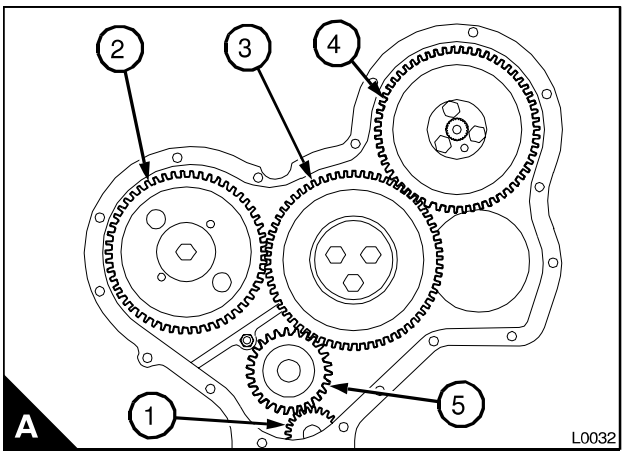
The timing gears are made of cast iron. A power take-off position (A1) is available on the right side of the aluminium timing case. When a power take-off is fitted some of the timing gears are made of steel, it is important that the correct gears are fitted. The complete engine number must be given to the distributor when a new gear is needed.

The drive from the crankshaft gear (A5) passes through an idler gear (A3) to the camshaft gear (A2) and to the gear of the fuel injection pump (A4). The drive from the crankshaft gear also passes through a lower idler gear to the gear of the balancer unit. The camshaft and the fuel injection pump run at half the speed of the crankshaft.

The aluminium cover of the timing case contains the front oil seal; this is made of Viton and has a dust lip in front of the main lip.

Warning! *read the safety precautions for* *"Viton seals" on page 7.*

The camshaft is made of cast iron. The cam lobes and the eccentric for the fuel lift pump are chill hardened.



This document has been printed from SPI². Not for Resale

Timing case cover

To remove — Operation 6-1

1 Remove the fan, see Operation 12-7 and the drive belts, see Operation 14-2.

2 If necessary, remove the fan drive pulley.

1 Remove the alternator together with its mounting bracket and front support plate, see Operation 14-3.

2 Remove the crankshaft pulley, see Operation 5-1.

3 Drain the coolant and remove the coolant pump, see Operation 12-3.

4 Release the setscrews and nuts of the cover and remove the cover. There is no need to remove the noise shield from the cover.

This document has been printed from SPI². Not for Resale

To fit **Operation 6-2**

Special requirements

Special tools	
Description	**Part number**
Centralising tool	PD. 162B

1 Clean the faces of the timing case cover.

2 Put the cover and a new joint in position on the timing case. Loosely fit two setscrews which are in opposite locations to hold the cover in position. Fit the centralising tool in the oil seal housing (A) and use the special washer and the crankshaft pulley setscrews to put the cover in its correct position. Do not overtighten the setscrews. Fit the remainder of the setscrews and nuts and tighten all of the cover fasteners to 22 Nm (16 lbf ft) 2,2 kgf m. Remove the centralising tool.

Caution: *It is important that the cover of the timing case is centred correctly. If the cover is not centred, the backlash between the fuel pump gear and coolant pump gear could be affected. This could cause the seizure of the fuel injection pump.*

3 Fit the coolant pump, see Operation 12-4.

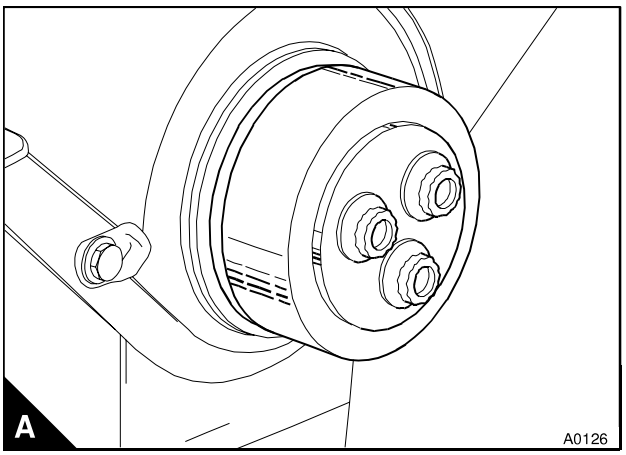
4 Fit the crankshaft pulley, see Operation 5-1.

5 Fit the alternator, see Operation 14-3.

6 Fit the drive belts, see Operation 14-2, and adjust the belt tension, see Operation 14-1.

7 Fit the fan, see Operation 12-7.

8 Fill the cooling system.



This document has been printed from SPI² Not for Resale

Front oil seal

To remove **Operation 6-3**

1 Remove the fan, see Operation 12-7 and the drive belts, see Operation 14-2.

2 Remove the crankshaft pulley, see Operation 5-1.

3 Remove the oil seal with a suitable lever behind the main lip of the oil seal.

Caution: *Do not damage the edge of the oil seal housing.*

This document has been printed from SPI². Not for Resale

To fit **Operation 6-4**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Replacer tool for front oil seal	PD170	Fastener plate for use with PD.170	PD170-3
Pressure plate for use with PD.170	PD170-1	Adaptor for seal for use with PD.170	PD170-4
Sleeve for use with PD.170	PD170-2		

Note: The seal is fitted to a depth of 10,92/11,43 mm (0.431/0.450 in) from the front face of the oil seal housing to the flat front face of the oil seal.

1 Clean the oil seal housing. Inspect the new seal for damage. If a scratch can be seen across the lip of the seal, do not fit the seal.

2 Lubricate the outer circumference of the oil seal with clean engine lubricating oil and enter the seal into the housing. Ensure that the spring loaded lip of the oil seal is towards the inside of the timing case cover and that the oil seal is square to the bore of the seal housing.

3 Assemble the oil seal replacer tool (A). Fit the fastener plate, PD.170-3, (A3) to the front of the crankshaft. For the standard seal, put the adaptor, PD.170-4, (A5) on the nose of the crankshaft and against the seal. Ensure that the adaptor has the side stamped 9,3 mm towards the seal. When the adaptor is fitted, ensure that the front lip of the seal is fully onto the taper of the adaptor.

Note: The other side of adaptor PD.170-8 can also be used to fit the standard seal.

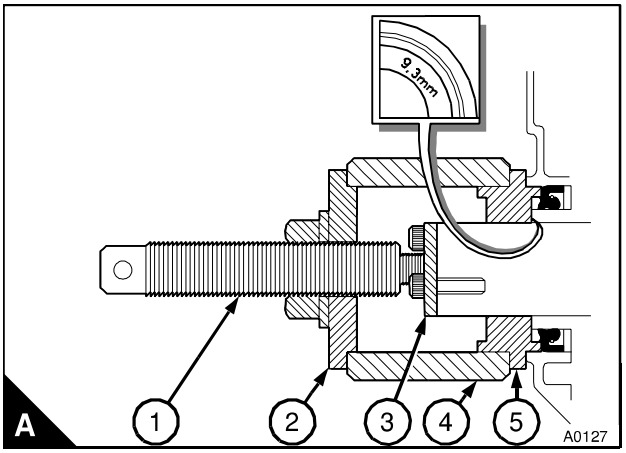
Assemble the pressure plate, PD.170-1, (A2) together with the sleeve, PD.170-2, (A4) onto the threaded bar, PD.170, (A1). Put the tool assembly in position on the adaptor, PD.170-4 or PD.170-8, and tighten the threaded bar onto the stud of PD.170-3 (A3).

Fit a rod through the hole in the end of the threaded bar to prevent movement of the bar when the nut is tightened. Tighten the nut to push the seal into the housing to the correct depth. If the standard seal is to be pushed in to the service position, turn the nut until the face of PD.170-4 is against the face of the seal housing.

4 Remove the replacer tool and lightly lubricate the seal location area of the crankshaft pulley with clean engine lubricating oil. Fit the crankshaft pulley, see Operation 5-1.

5 Fit the drive belts, see Operation 14-2, and adjust the belt tension, see Operation 14-1.

6 Fit the fan, see Operation 12-7.



This document has been printed from SPI². Not for Resale

Idler gear and hub

To remove — Operation 6-5

1 Remove the timing case cover, see Operation 6-1.

2 Rotate the crankshaft until the marked teeth (B) of the crankshaft gear, the camshaft gear and the fuel pump gear are all in mesh with the idler gear.

Note: The marked teeth of the idler gear (A4) will not necessarily be in mesh with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

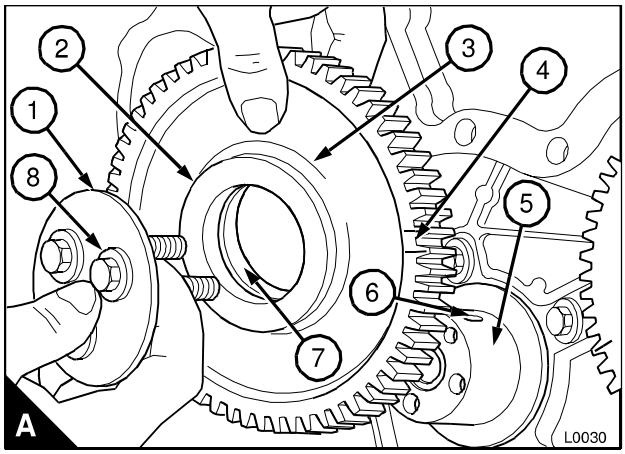
3 Release the three setscrews (A8), remove the plate (A1) of the idler gear and remove the gear (A3) from the idler gear hub (A5). The drive gear of the fuel injection pump may rotate counter clockwise when the idler gear is removed.

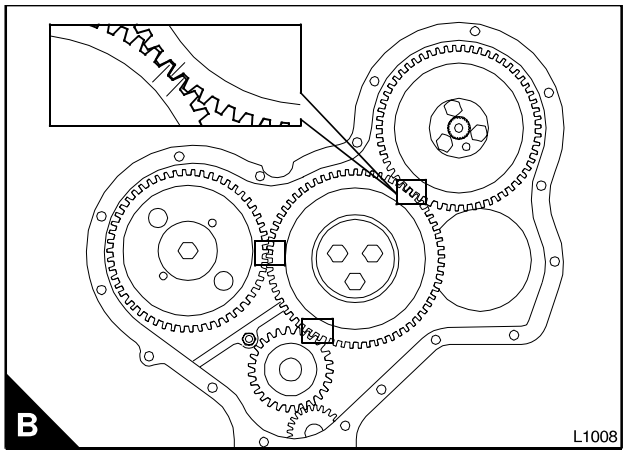
Caution: *Do not turn the crankshaft with the idler gear removed.*

4 Remove the idler gear hub, note the position of the oil hole (A6).

5 Inspect the gear and the bushes (A2) and (A7) for wear and other damage and renew as necessary. The gear and bushes are available as an assembly or separate bushes are available.

6 If the bushes are to be changed, remove them with a suitable puller. If a puller is not available, machine off the face of one of the bushes and press them out. Press in new bushes, machine the bores to get the correct clearance on the hub and machine the faces to get the correct end clearance. Refer to the relevant Data and dimensions for the "Timing case and drive assembly" on page 22.



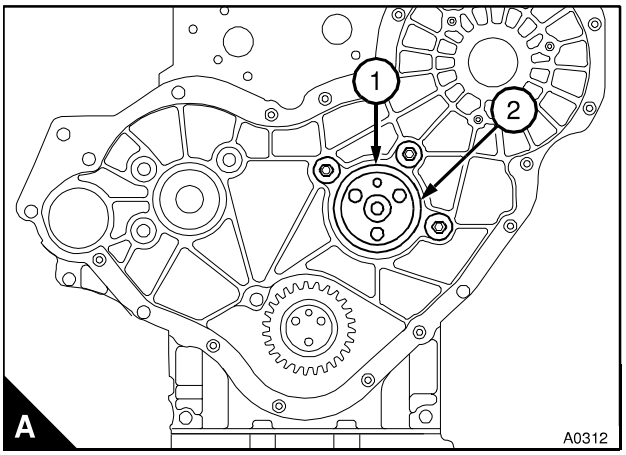


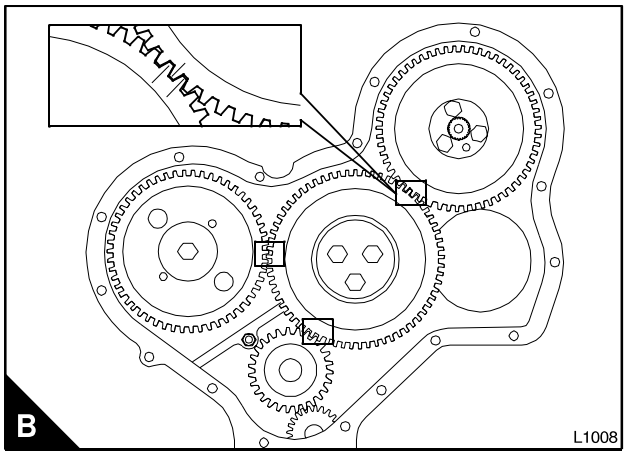
This document has been printed from SPI². Not for Resale

To fit **Operation 6-6**

1 Use the three idler gear setscrews to ensure the correct position of the idler gear hub (A2) with the lubrication hole (A1) at the top. Push the hub into position and remove the setscrews.

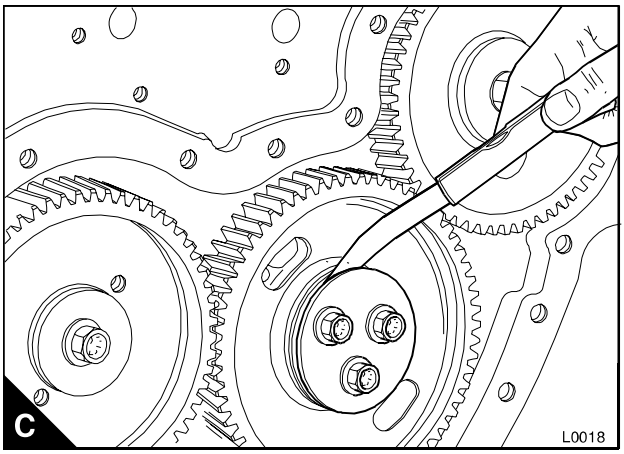
2 Lubricate the idler gear bushes with clean engine lubricating oil. Align the timing marks on the idler gear with the marks on the crankshaft and camshaft gears (B).

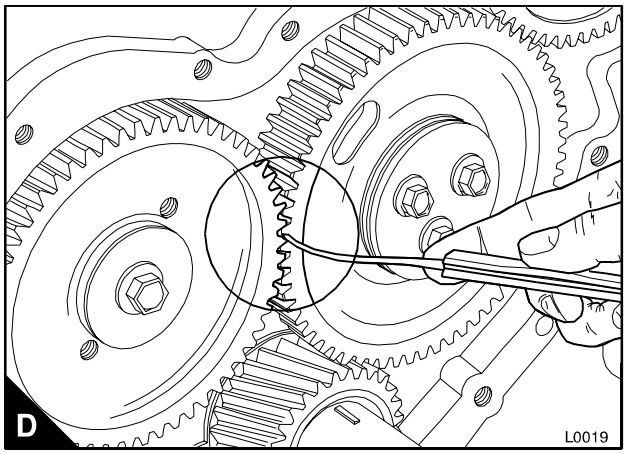




3 If necessary, rotate the gear of the fuel injection pump clockwise to align the relevant timing mark with the marks on the idler gear and slide the idler gear into position. On engines with gears which do not have timing marks align the temporary mark on the fuel pump gear with the mark on the timing case before the idler gear is fitted. Remove the marks on the fuel pump gear and the timing case after the idler gear has been fitted. Check that all the timing marks are in correct mesh (A). Fit the plate and the setscrews to the idler gear hub and tighten the setscrews to 44 Nm (33 lbf ft) 4,5 kgf m.

4 Check the idler gear end-float (C) and the timing gear backlash (D).





5 Fit the timing case cover, see Operation 6-2.

6 Fit the coolant pump, see Operation 12-4.

7 Fit the crankshaft pulley, see Operation 5-1.

8 Where necessary, fit the fan drive pulley.

9 Fit the drive belts, see Operation 14-2, and adjust the belt tension, see Operation 14-1.

10 Fit the fan, see Operation 12-7.

11 Fill the cooling system.

This document has been printed from SPI². Not for Resale

Fuel pump gear

To remove — Operation 6-7

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Gear puller	PD.155C	Adaptors for use with PD.155C	PD.155B-5

1 Remove the timing case cover, see Operation 6-1.

2 Rotate the crankshaft until the marked teeth of the crankshaft gear, the camshaft gear and the fuel pump gear are all in mesh with the idler gear. The marked teeth of the idler gear will not necessarily be in mesh with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

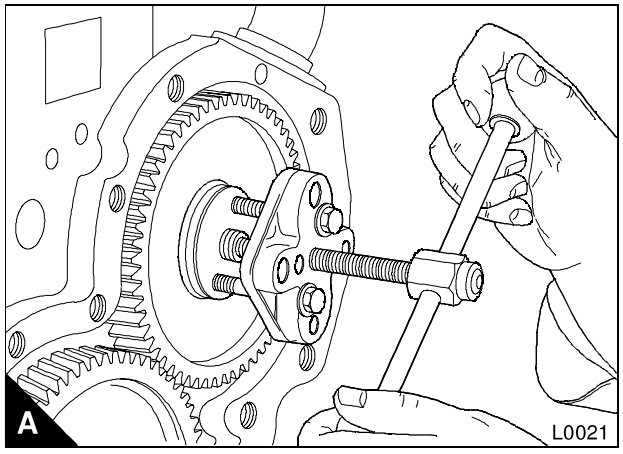
3 Remove the nut and the spring washer from the fuel pump gear.

4 Remove the idler gear, see Operation 6-5.

5 Remove the fuel pump gear with the puller and the adaptors (A).

Note: Ensure that the key in the fuel pump shaft is not lost.

6 Inspect the gear for wear and other damage and renew it, if necessary.



This document has been printed from SPI². Not for Resale

To fit **Operation 6-8**

1 Ensure that the key is fitted correctly in the fuel pump shaft. Fit the gear and the spring washer and loosely fit the setscrew(s).

2 Rotate the fuel pump gear to ensure that the relevant marked tooth of the fuel pump gear will align with the marked teeth of the idler gear (A). Fit the idler gear, see Operation 6-6.

3 Tighten the setscrew(s) of the fuel pump gear to 27 Nm (20 lbf ft) 2,8 kgf m. The teeth of the drive gear and the idler gear should be fully in mesh when the fuel pump gear is tightened onto the hub of the fuel injection pump.

4 If a new gear has been fitted, check the backlash.

5 Fit the timing case cover, see Operation 6-2.

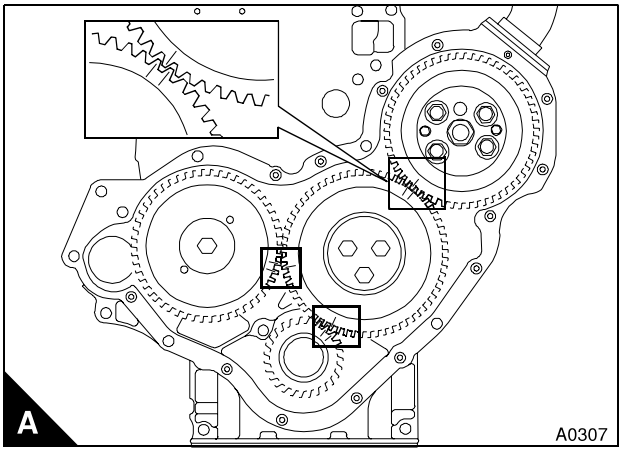
6 Fit the crankshaft pulley, see Operation 5-1.

7 If necessary, fit the fan drive pulley.

8 Fit the drive belts, see Operation 14-2, and adjust the belt tension, see Operation 14-1.

9 Fit the fan, see Operation 12-7.

10 Fill the cooling system.



This document has been printed from SPI². Not for Resale

Camshaft gear

To remove — Operation 6-9

Special requirements

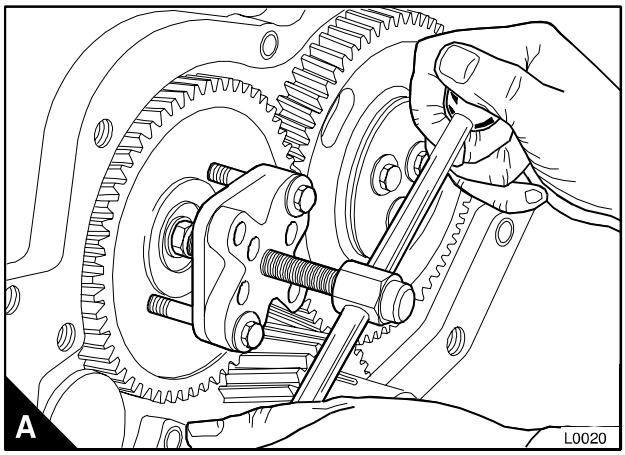
Special tools			
Description	**Part number**	**Description**	**Part number**
Gear puller	PD.155C	Adaptors for use with PD.155C	PD.155B-5

1 Remove the timing case cover, see Operation 6-1.

2 Rotate the crankshaft until the marked teeth of the crankshaft gear, the camshaft gear and the fuel pump gear are all in mesh with the idler gear. The marked teeth of the idler gear will not necessarily be in mesh with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

3 Remove the setscrew and washer of the camshaft gear. Put a suitable adaptor onto the end of the camshaft and remove the gear with the puller and adaptor (A). Ensure that the key in the camshaft is not lost.

4 Inspect the gear for wear and any other damage and renew it, if necessary.



This document has been printed from SPI². Not for Resale

To fit **Operation 6-10**

1 Ensure that the key in the camshaft is fitted correctly.

2 Remove the idler gear, see Operation 6-5.

3 Fit the camshaft gear to the camshaft with the marked teeth towards the front and the keyway correctly aligned with the key. If necessary, lightly hit the gear with a soft face hammer to engage the key into the keyway.

4 Fit the idler gear with the marked teeth in correct mesh, see Operation 6-6. If the camshaft has to be turned and a valve hits a piston, disengage the rocker assembly.

5 Fit the washer and the setscrew for the camshaft gear and tighten the setscrew to press the camshaft gear into position. Tighten the setscrew to 78 Nm (58 lbf ft) 8,0 kgf m. If a new camshaft gear has been fitted, check the backlash.

6 Fit the timing case cover, see Operation 6-2.

7 Fit the coolant pump, see Operation 12-4.

8 Fit the crankshaft pulley, see Operation 5-1.

9 Fit the drive belts, see Operation 14-2, and adjust the belt tension, see Operation 14-1.

10 Fit the fan, see Operation 12-7.

11 If it was drained earlier, fill the cooling system.

This document has been printed from SPI². Not for Resale

Crankshaft gear

To remove — Operation 6-11

1 Remove the timing case cover, see Operation 6-1.

2 Rotate the crankshaft until the marked teeth of the crankshaft gear, the camshaft gear and the fuel pump gear are all in mesh with the idler gear. The marked teeth of the idler gear will not necessarily be in mesh with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

3 Remove the idler gear, see Operation 6-5.

4 The crankshaft gear is a transition fit on the crankshaft. It may slide off easily or, if it is a tight fit and the gear is to be renewed, it may be necessary to remove the crankshaft, see Operation 5-10, to remove the gear safely.

To fit — Operation 6-12

1 The gear can fit easily, or it may be necessary to heat the gear before it will fit onto the crankshaft. If the gear is to be heated, heat it in an oven to not more than 180 °C (226 °F). If an oven is not available, heat it in coolant which is at its boiling point. Do not use a flame as this can cause local damage. Fit the gear with the timing marks to the front.

2 Fit the idler gear, see Operation 6-6 and ensure that all the timing marks are correctly aligned.

3 Fit the timing case cover, see Operation 6-2.

4 Fit the coolant pump, see Operation 12-4.

5 Fit the crankshaft pulley, see Operation 5-1.

6 Fit the drive belts, see Operation 14-2, and adjust the belt tension, see Operation 14-1.

7 Fit the fan, see Operation 12-7.

8 Fill the cooling system.

This document has been printed from SPI². Not for Resale

Timing case

To remove — Operation 6-13

1 Remove the timing case cover, see Operation 6-1.

2 Rotate the crankshaft until the marked teeth of the crankshaft gear, the camshaft gear and the fuel pump gear are all in mesh with the idler gear. The marked teeth of the idler gear will not necessarily be in mesh with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

3 Remove the fuel injection pump, see Operation 11-10 for Lucas DPA fuel injection pumps and Operation 11-14 for Stanadyne fuel injection pumps.

4 Remove the idler gear, see Operation 6-5, and the camshaft gear, see Operation 6-9.

5 Remove the setscrews which hold the timing case to the cylinder block and the setscrews which hold the sump to the bottom of the timing case.

6 Remove the timing case and the joint, do not allow the idler gear hub to fall. Ensure that the camshaft thrust washer is not lost.

This document has been printed from SPI². Not for Resale

To fit **Operation 6-14**

Special requirements

Consumable products			
Description	**Part number**	**Description**	**Part number**
POWERPART Jointing compound	1861155 or 1861117	POWERPART Nutlock	21820242

1 Ensure that the sump joint is not damaged. If the joint is damaged, remove the sump and fit it with a new joint after the timing case has been fitted. The front section of the joint can be cut away and the front section of a new joint fitted, without the removal of the sump, but extreme care must be used to prevent possible leaks.

2 If the sump has been removed, fit the idler gear hub (A2) to the front of the cylinder block; use the three setscrews of the idler gear to hold the hub in position. Ensure that the oil hole is at the top.

3 Ensure that the thrust washer for the camshaft is in position.

4 Fit a new joint for the timing case to the cylinder block. Cut the bottom ends of the joint to fit correctly. Apply POWERPART Jointing compound to the bottom ends of the joint.

5 Put the timing case in position. If the sump has not been removed, fit the idler gear hub, refer to step 2. Fit the three setscrews (A1) around the idler gear hub. Ensure that the bottom of the timing case is correctly aligned with the bottom of the cylinder block before the setscrews are tightened. Put the alternator and its front support plate in position and fit and tighten the remainder of the setscrews of the timing case. If the front support plate has been separated from the alternator bracket, ensure that the right side of the plate is level with the machined face on the cylinder block where the alternator bracket is fitted. If a new timing case is fitted, remove the two studs from the timing case and clean the threads which fit into the timing case. Seal the threads with POWERPART Nutlock and fit the studs into the new timing case. Remove the setscrews from the idler gear hub.

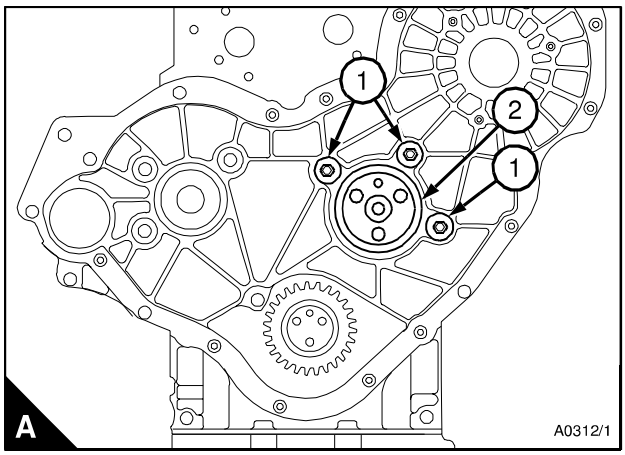
6 If necessary, fit the lubricating oil sump, see Operation 10-3.

7 Fit the camshaft gear, see Operation 6-10, and the idler gear, see Operation 6-6. Ensure that all the timing marks are correctly aligned.

8 If the timing case is new and the old timing case had a timing mark, put a timing mark on the new timing case, see Operation 8-7.

Fit the fuel injection pump and the drive gear, see Operation 11-11 for Lucas DPA fuel injection pumps and Operation 11-15 for Stanadyne fuel injection pumps.

Eliminate air from the fuel system, see Operation 11-13 for Lucas DPA fuel injection pumps and Operation 11-17 for Stanadyne fuel injection pumps.



Continued

This document has been printed from SPI². Not for Resale

9 Fit the timing case cover, see Operation 6-2.

10 Fit the coolant pump, see Operation 12-4.

11 Fit the crankshaft pulley, see Operation 5-1.

12 Fit the alternator, see Operation 14-3 and the alternator front bracket.

13 Fit the drive belts, see Operation 14-2 and adjust the belt tension, see Operation 14-1.

14 Fit the fan, see Operation 12-7.

15 Fill the cooling system.

16 If, necesssary, fill the sump to the correct level with an approved lubricating oil.

This document has been printed from SPI². Not for Resale

Camshaft and tappets

To remove — Operation 6-15

Note: Before the engine is removed from the vehicle or the machine, drain the lubricating oil and the coolant.

1 Remove the exhauster, see Operation 15-4.

2 Remove the timing case cover, see Operation 6-1.

3 Remove the timing gears, see Operation 6-5, Operation 6-7 and Operation 6-9.

4 Remove the fuel injection pump, see Operation 11-10 for Lucas DPA fuel injection pumps and Operation 11-14 for Stanadyne fuel injection pumps.

5 Remove the timing case, see Operation 6-13.

6 Remove the rocker cover, the rocker assembly and the push rods, see Chapter 3, Cylinder head assembly.

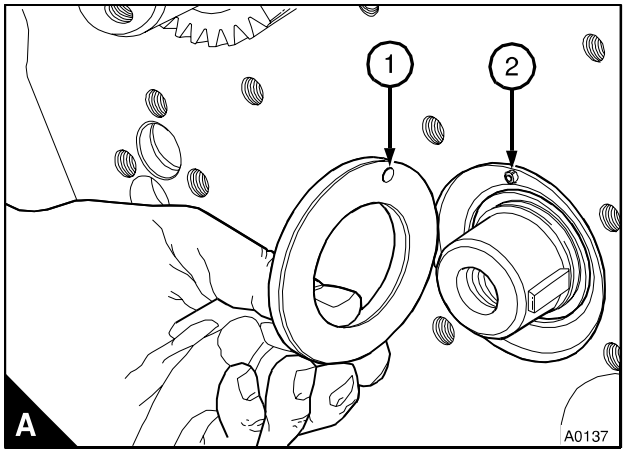
7 Remove the fuel lift pump, see Operation 11-6.

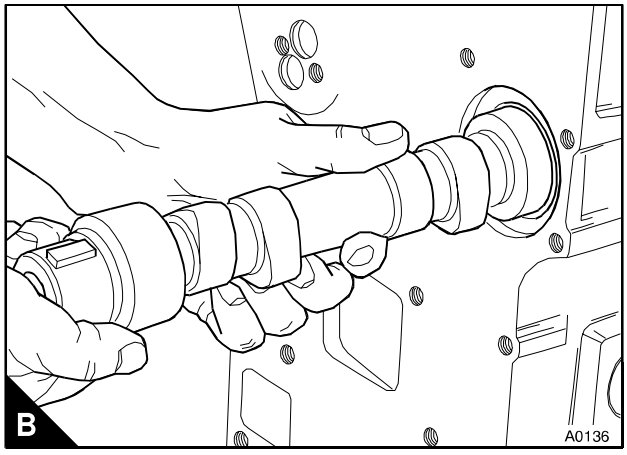
8 Turn the engine upside down and remove the lubricating oil sump, see Operation 10-3.

9 Remove the camshaft thrust washer (A) and carefully remove the camshaft (B).

10 Remove the tappets, retain them in the correct sequence for assembly.

11 Inspect the camshaft and the tappets for wear and other damage, also inspect the camshaft bush. Renew the components as necessary.





This document has been printed from SPI². Not for Resale

To fit — Operation 6-16

1 Ensure that all components are clean and are lubricated with clean engine lubricating oil.

2 Fit the tappets in position.

3 Carefully fit the camshaft (B).

4 Fit the camshaft thrust washer (A1). Ensure that it is fitted correctly on the hollow dowel (A2).

5 Fit the timing case together with a new joint, see Operation 6-14.

6 Check that the camshaft end-float is within the limits shown in the relevant Data and dimensions for the "Timing case and drive assembly" on page 22.

7 Rotate the camshaft until the cam for the fuel lift pump is at the minimum lift position and fit the fuel lift pump, see Operation 11-6.

8 Turn the engine to an upright position. Rotate the crankshaft until the keyway in the crankshaft is at the top. Fit the timing gears, see Operation 6-6, Operation 6-8 and Operation 6-10 and ensure that all the timing marks are correctly aligned.

9 Fit the fuel injection pump, see Operation 11-11 for Lucas DPA fuel injection pumps and Operation 11-15 for Stanadyne fuel injection pumps.

10 Fit the push rods, the rocker assembly and the rocker cover, see Chapter 3, Cylinder head assembly.

11 Set the valve tip clearances, see Operation 3-5.

12 Fit the timing case cover, see Operation 6-2 and the lubricating oil sump, see Operation 10-3.

13 Fit the exhauster, see Operation 15-4.

14 Fit the coolant pump, see Operation 12-4.

15 Fit the crankshaft pulley, see Operation 5-1.

16 If necessary, fit the alternator and its mounting brackets.

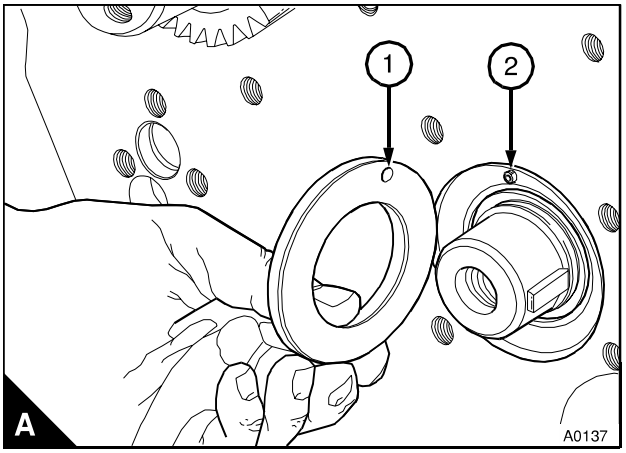
17 Fit the drive belts, see Operation 14-2, and adjust the belt tension, see Operation 14-1.

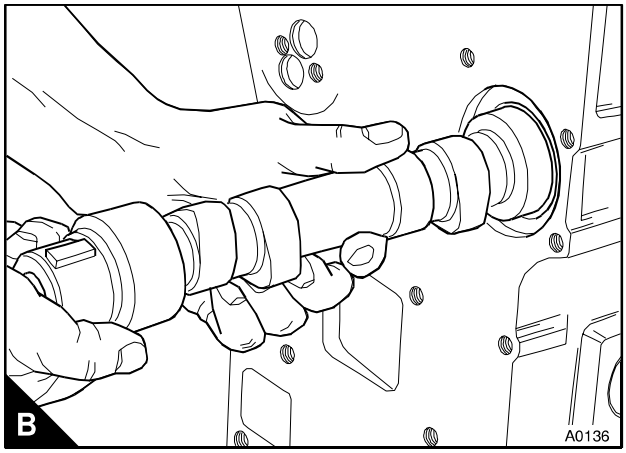
18 Fit the fan, see Operation 12-7.

19 After the engine has been installed:

Fill the cooling system. Fill the lubricating oil sump to the correct level with an approved lubricating oil.

Eliminate air from the fuel system, see Operation 11-13 for Lucas DPA fuel injection pumps and Operation 11-17 for Stanadyne fuel injection pumps.





This document has been printed from SPI². Not for Resale

This page is intentionally blank

This document has been printed from SPI². Not for Resale

7

Cylinder block assembly

General description

The cylinder block is made of cast iron and provides a full length support for the dry liners which are also made of cast iron. Production liners are a press fit in the block and service liners are a transition fit. Both types of liners are honed with silicon carbide tools to a controlled finish to ensure long life and low oil consumption. A bush is fitted in the cylinder block for the front camshaft journal and the other camshaft journals run directly in the block.

Cylinder block

To dismantle **Operation 7-1**

1 Drain the cooling system and the lubricating oil.

2 Remove the engine from the vehicle or machine.

3 Remove the alternator drive belts, see Operation 14-2, and the alternator and its mounting brackets, see Operation 14-3.

4 Remove the fan, the fan drive and the coolant pump, see Chapter 12, Cooling system.

5 Remove the exhauster, where fitted, see Operation 15-4.

6 Remove the fuel filter, the atomisers and the fuel injection pump, see Chapter 11, Fuel system.

7 Remove the lubricating oil cooler, where fitted, see Operation 12-8.

8 Remove the lubricating oil filter assembly and the lubricating oil sump, see Operation 10-3.

9 Remove the fuel lift pump, see Operation 11-6.

10 Remove the starter motor, see Operation 14-5.

11 Remove the cylinder head assembly, see Operation 3-7.

12 Remove the timing case and the timing gears, see Chapter 6, Timing case and drive assembly.

13 Remove the lubricating oil pump, see Operation 10-6, and the pressure relief valve, see Operation 10-10, or remove the balancer unit, see Operation 5-13.

14 Remove the piston and connecting rod assemblies, see Operation 4-4.

15 Remove the camshaft and the tappets, see Operation 6-15.

16 Remove the flywheel, see Operation 13-1, and the flywheel housing, see Operation 13-3.

17 Remove the rear oil seal assembly, see Operation 5-2, and the crankshaft, see Operation 5-10.

18 Inspect the cylinder block, see Operation 7-3.

This document has been printed from SPI². Not for Resale

To assemble **Operation 7-2**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Nutlock	21820242

1 Clean thoroughly the new cylinder block. Ensure that all the oil passages are clean and free from debris.

2 Remove the threaded plugs from the old cylinder block and clean the threads. Seal the threads with POWERPART Nutlock, or a similar sealant, and fit the threaded plugs into the new cylinder block.

3 Fit the crankshaft, see Operation 5-11, and the rear oil seal assembly, see Operation 5-2.

4 Fit the piston and connecting rod assembly, see Operation 4-5.

5 Fit the flywheel housing, see Operation 13-3, and the flywheel, see Operation 13-1.

6 Fit the tappets and the camshaft, see Operation 6-16.

7 Fit the lubricating oil pump, see Operation 10-7, and the pressure relief valve, see Operation 10-10, or fit the balancer unit, see Operation 5-14.

8 Fit the timing case and the timing gears, see Chapter 6, Timing case and drive assembly.

9 Fit the cylinder head assembly, see Operation 3-8.

10 Fit the starter motor, see Operation 14-5.

11 Fit the fuel lift pump, see Operation 11-6.

12 Fit the lubricating oil filter assembly and the lubricating oil sump, see Operation 10-3.

13 If necessary, fit the lubricating oil cooler, see Operation 12-8.

14 Fit the fuel filter, the atomisers and the fuel injection pump, see Chapter 11, Fuel system.

15 If necessary, fit the exhauster, see Operation 15-4.

16 Fit the fan, the fan drive and the coolant pump, see Chapter 12, Cooling system.

17 Fit the alternator and its mounting brackets, see Operation 14-3, and the alternator drive belts, see Operation 14-2.

18 Install the engine into the vehicle or machine.

19 Fill the cooling system.

20 Fill the lubricating oil sump to the correct level with an approved lubricating oil.

21 Eliminate air from the fuel system, see Operation 11-13 for Lucas DPA fuel injection pumps and Operation 11-17 for Stanadyne fuel injection pumps.

This document has been printed from SPI². Not for Resale

To inspect **Operation 7-3**

1 Clean the passages for the coolant and for the oil.

2 Check the cylinder block for cracks and for other damage.

3 The top face of the cylinder block must not be machined as this will affect the liner flange depth and the piston height above the top face of the cylinder block.

4 Check the camshaft bush for wear. If the bush is to be renewed, use a suitable adaptor to press it out of the bore. Ensure that the lubricating oil hole in the new bush will be towards the front of the engine, when fitted. Press in the bush with the oil hole on the same side and aligned with the oil hole in the block until the front end of the bush is aligned with the face of the recess.

This document has been printed from SPI². Not for Resale

Cylinder liner

To inspect — Operation 7-4

To ensure the best performance during the life of the engine it is important that worn or damaged cylinder liners are renewed. If a change of liner becomes necessary in service, a service liner is available.

The condition of a cylinder liner is decided by:

- The amount and location of any polished areas.
- Wear.
- Damage to the liner wall.

Note: It will not be necessary to renew the liners, if:

- The honed finish can still be clearly seen.
- The engine performance and oil consumption is acceptable.

To check the condition of a cylinder liner

1 Inspect the liner surface for cracks and deep scratches.

2 Check the liner wall for areas where the honed finish has been polished away. Check especially the area around the top of the liner bore just below the carbon ring. In this area, thrust from the top piston ring is at its maximum.

***Cautions*:**

- *Damaged or worn liners must be discarded.*
- *New piston rings must be fitted when the cylinder liner is renewed.*
- *An engine can have high oil consumption with very little wear of the liner bores, if the surfaces of the liners are glazed.*

This document has been printed from SPI². Not for Resale

To recover a glazed liner **Operation 7-5**

A tool, known as a "Flex-Hone", is available to correct the liner surface. This tool can be used with an electric hand drill at low speed. The pistons and connecting rods must be removed and the piston cooling jets, where fitted, must also be removed. Use covers to protect all engine components from the debris which is caused during the process. Details and supply of the "Flex-hone" are available from:

Pacehigh: PO box 128, Hatfield, Herts, AL9 5LD. Tel: 01707 665707. Fax: 01707 646816.

1 Grade 80SC Flex-Hone is to be used. A 4 inch or 4 $^{1}/_{8}$ inch size Flex-Hone can be used according to how badly the bore is glazed.

2 New Flex-Hones must be operated in an old liner before use on an engine to remove all loose material and sharp edges.

3 Lubricate lightly the liner and the Flex-Hone with clean engine lubricating oil.

4 Put the tool in position on top of the liner, but do not press the tool into the liner until the tool is operated.

5 Operate the tool and move it up and down the liner bore once a second for 30-50 seconds. Remove the tool while it rotates.

6 Clean thoroughly the liner bore to remove all dirt from the operation, use a hard brush and kerosene.

7 Dry the liners and remove carefully all the covers used to protect the components. Clean thoroughly all the engine components which have been affected by debris.

8 Ensure that new piston rings are fitted when the engine is assembled in accordance with Operation 4-7.

Caution: *After a glazed bore has been corrected, the following recommendations are advised for the first 240 km (150 miles) or 5 hours of operation:*

- Do not operate the engine at full load.
- Do not operate the engine at high speed.
- Do not allow the engine to run at low idle speed for extended periods.

This document has been printed from SPI². Not for Resale

To remove **Operation 7-6**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Remover/replacer for cylinder liner	PD.150B	Adaptors for use with PD.150B	PD.150-7A

Note: Where several liners are to be removed or a very tight production liner is fitted, a press should be used. Where a single liner is to be removed or the crankshaft is to remain in position, a tool for hand operation is available.

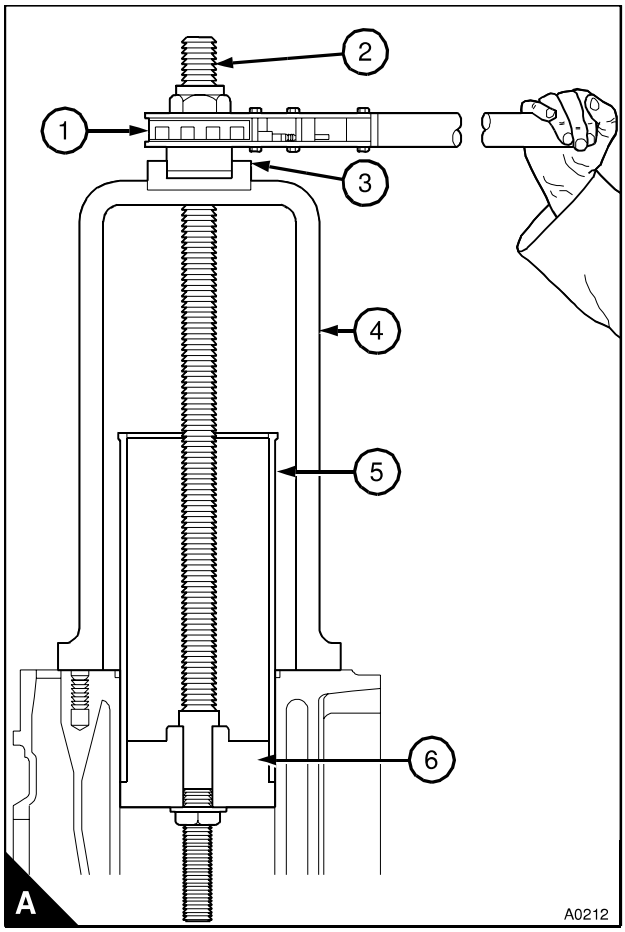
1 Drain the lubricating oil and remove the lubricating oil sump, see Operation 10-3.

2 Remove the cylinder head assembly, see Operation 3-7.

3 Remove the piston and connecting rod assembly, see Operation 4-4.

4 Rotate the crankshaft to give access to the cylinder liner. Protect the crank pin.

5 Put the tool (A4) on the top face of the cylinder block and over the centre of the liner (A5). Ensure that the base of the tool is not on top of the liner flange of the next cylinder.



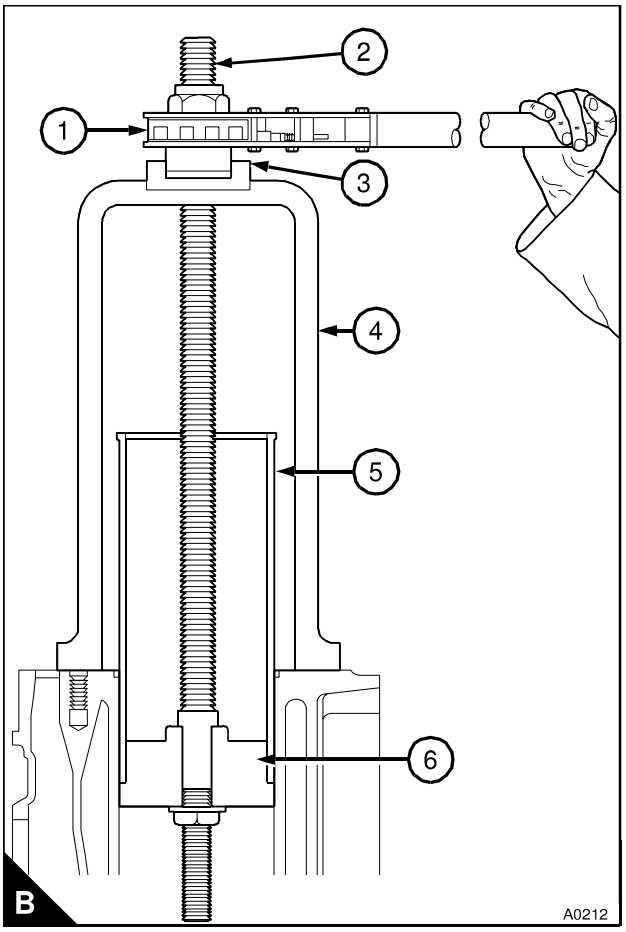
Continued

This document has been printed from SPI². Not for Resale

6 Put the bearing (B3) in the recess in the top of the tool with the flat face of the bearing to the bottom of the recess.

7 Fit the threaded rod (B2) through the bearing and the top of the tool until the handle (B1) is in the recess in the top of the bearing. In this position adjust the threaded rod until the end is below the bottom of the cylinder liner. Fit the adaptor PD.150-7A (B6) onto the threaded rod and against the bottom of the cylinder liner. Ensure that the two lugs on the top of the adaptor engage with the flats on the threaded rod. Fit the washer and nut and tighten the nut onto the adaptor.

8 Lubricate the ratchet of the handle and the threaded rod with Shell Spirax oil or an equivalent oil. Operate the handle and pull the cylinder liner out of the top of the cylinder block.



This document has been printed from SPI². Not for Resale

To fit a service liner — Operation 7-7

Special requirements

Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Remover/replacer for cylinder liner	PD.150B	POWERPART Retainer (oil tolerant)	21820603
Adaptors for use with PD.150B	PD.150-7A		
Depth gauge, liner flange	PD.41D	Loctite Safety Solvent or a similar product	
Dial gauge for use with PD.41D	PD.208		

A service liner is a transition fit of +/- 0,03 mm (+/- 0.001 in) in the parent bore. A special tool will not be necessary to fit some liners, but where a liner is a tight fit, tool PD.150B can be used.

Caution: *Do not hit a liner with a hammer.*

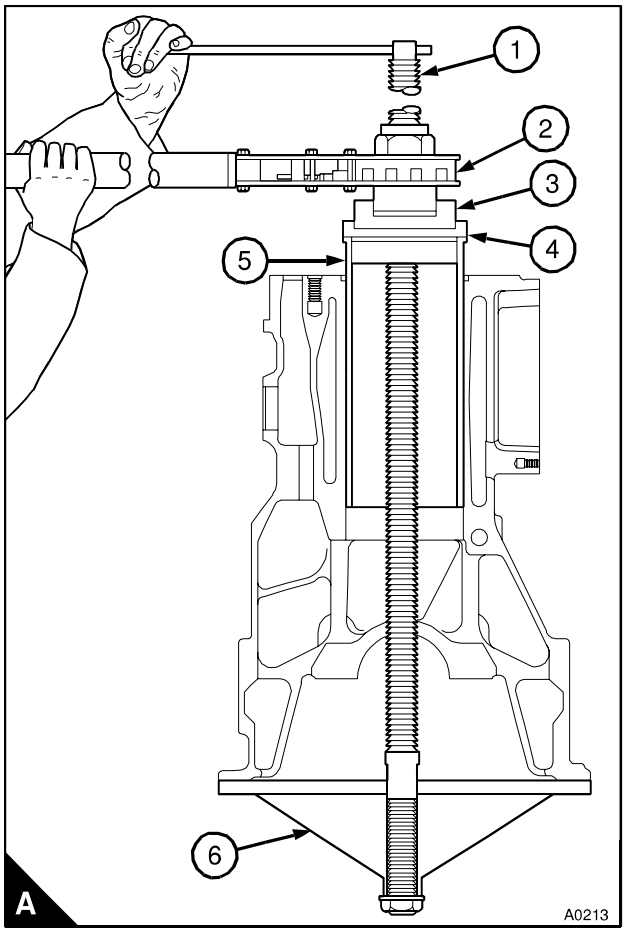
1 Clean thoroughly the parent bore. Clean the top 50 mm (2.0 in) and the recess for the liner flange with Loctite Safety Solvent or a similar product; use it in accordance with the manufacturer's instructions.

2 Clean thoroughly the outer surface of the liner with Loctite Safety Solvent.

3 Lubricate lightly the parent bore with clean engine lubricating oil, except for the top 50 mm (2.0 in).

4 Engage the cylinder liner (A5) into the parent bore; ensure that the liner is vertical. Put the adaptor PD.150-7A (A4) onto the top of the liner with the shoulder of the adaptor on the liner flange. Put the bearing (A3) into position in the recess in the top of the adaptor with the flat face of the bearing to the bottom of the recess.

5 Fit the threaded rod (A1) through the bearing, the adaptor and the liner until the handle is against the recess in the bearing. In this position adjust the threaded rod until the end is below the bottom face of the cylinder block.



Continued

This document has been printed from SPI². Not for Resale

6 Fit the adaptor PD.150B/6 (B6) onto the threaded rod; ensure that the flat face of the adaptor is against the bottom face of the cylinder block. Fit the washer and the nut; ensure that the threaded rod is in the centre of the liner and tighten the nut onto the adaptor.

7 Lubricate the ratchet of the handle (B2) and the threaded rod with Shell Spirax oil or an equivalent oil. Operate the handle and press the liner into the parent bore to within 50 mm (2.0 in) of the fitted position. Clean the area below the flange of the liner with Loctite Safety Solvent.

Apply POWERPART Retainer (oil tolerant) to the top 25 mm (1.0 in) of the outer surface of the liner and under the flange; also apply POWERPART Retainer (oil tolerant) to the bottom of the flange recess in the parent bore.

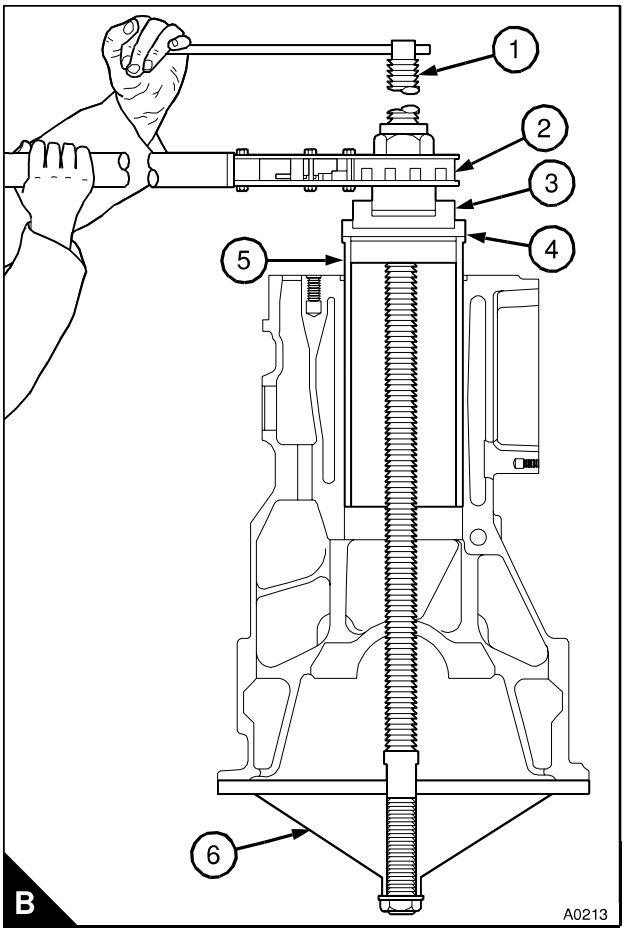
8 Press the liner in to the fully fitted position. Remove the tool and clean the retainer from the top of the cylinder block.

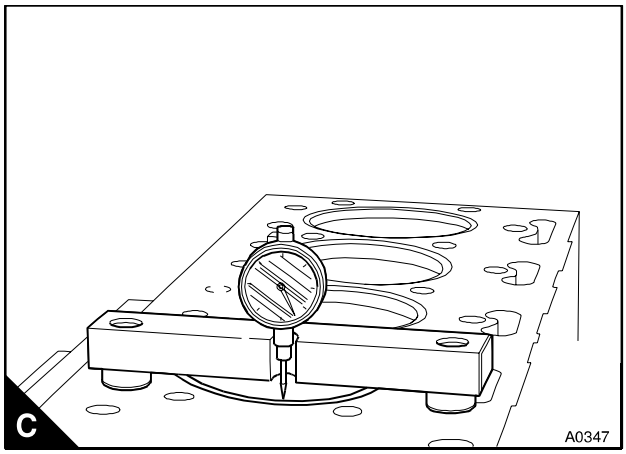
9 Allow 15 minutes to elapse before the liner bore dimension is checked. The retainer will reach full strength after 6 hours.

The inside diameter of a service liner, when fitted, should be 101,92/101,117 mm (3.980/3.981 in)

10 Fit new piston rings, see Operation 4-7.

11 Use tool PD.41D to check that the liner flange is between 0,10 mm (0.004 in) above to 0,10 mm (0.004 in) below the top face of the cylinder block (C).





Continued

This document has been printed from SPI². Not for Resale

12 Fit the piston and connecting rod assembly, see Operation 4-5.

13 Fit the cylinder head assembly, see Operation 3-8.

14 Fit the lubricating oil sump, see Operation 10-3, and fill it to the correct level with an approved lubricating oil.

Caution: *After a new service liner has been fitted, these recommendations are advised for the first 240 km (150 miles) or 5 hours of operation:*

- Do not operate the engine at full load.
- Do not operate the engine at high speed.
- Do not allow the engine to run at low idle speed for extended periods.

This document has been printed from SPI². Not for Resale

8

Engine timing

Lucas DPA fuel injection pumps

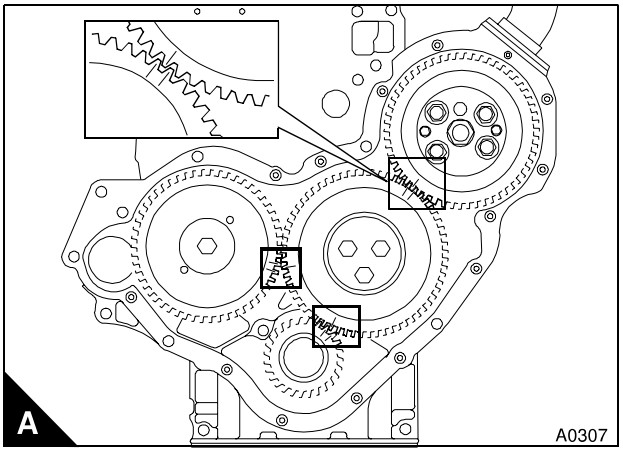
General description **Operation 8-1**

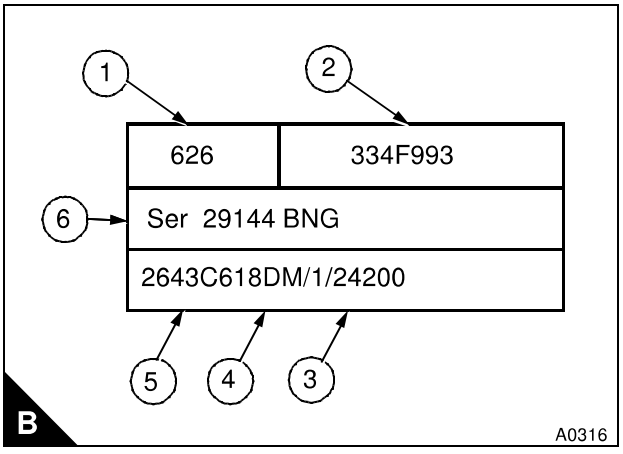
The timing gears are stamped with timing marks to ensure that they are assembled correctly (A). The stamped teeth of the crankshaft, camshaft and fuel pump gears will be in mesh with the idler gear when number 1 piston is at top dead centre (TDC) on the compression stroke. The marked teeth of the idler gear may not necessarily be in mesh in this position, because of the different speeds at which the gears rotate.The fuel pump gear has timing marks for four and six cylinder engines. Also the gear is stamped with the letter "C" where a Lucas fuel pump is fitted. The letter "M" is stamped on the fuel pump gear to indicate that the threads for the screws of the gear puller are metric.

A data plate is fitted to the side of the pump. An example of the information shown on the plate (B) is:

- Manufacturers model number (B1)
- Manufacturers description number (B2)
- Maximum engine no load speed (B3)
- Fuel pump code letters (B4)
- Perkins part number (B5)
- Fuel pump serial number (B6).

Note: For details of the fuel pump code letters for the engine see "Static timing - CAV fuel injection pump" on page 24.





This document has been printed from SPI². Not for Resale

To set number 1 piston to TDC on the compression stroke — Operation 8-2

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Valve spring compressor	PD.6118B	Setscrew adaptor for use with PD.6118B	PD.6118B-8
Stud adaptor for use with PD.6118B	PD.6118B-7		

1 Fasten a temporary pointer to the timing case cover with its tip near to the outer edge of the crankshaft pulley or damper (A1).

2 Remove the rocker cover, see Operation 3-1.

3 Rotate the crankshaft, clockwise from the front, until the push rod for the inlet valve of the rear cylinder just tightens.

4 Remove the spring clip and the spacer from the front of the rocker shaft. Release the fasteners of the front two pedestals of the rocker shaft and remove the front rocker lever; tighten the fasteners of the rocker shaft pedestals.

5 Remove the valve springs from the front valve with the valve spring compressor PD.6118B and the adaptor PD.6118-7, for pedestal studs, or the adaptor PD.6118-8, for pedestal setscrews.

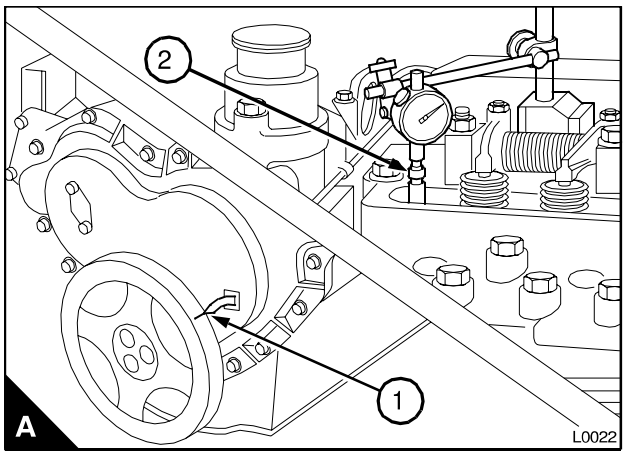
Caution: *Fit a suitable collar near the top of the valve to hold the valve if the crankshaft is rotated too far.*

6 Allow the valve to be held by the top of the piston.

7 Fasten a dial test indicator with its plunger in contact with the top of the valve stem (A2) and with a reading shown on the gauge. Rotate slowly the crankshaft, clockwise from the front, until the clockwise movement of the dial gauge pointer just stops. Make a suitable mark on the crankshaft pulley or damper to align with the temporary pointer.

Continue to rotate the crankshaft, in the same direction, until the gauge pointer just begins to move in a counter-clockwise direction. Make another mark on the pulley or damper to align with the pointer. Mark the centre point between the two marks on the pulley or damper and remove the other two marks.

8 Rotate the crankshaft approximately 45° counter clockwise from the front and then clockwise until the mark on the pulley or damper is aligned with the pointer. Number 1 piston is now at TDC on the compression stroke.



This document has been printed from SPI². Not for Resale

Another method to set number 1 piston to TDC on the compression stroke **Operation 8-3**

1 Fasten a temporary pointer to the timing case cover (or other suitable position) with its tip near to the outer edge of the crankshaft damper or pulley.

2 Loosen the setscrews that retain the atomisers.

3 Remove the rocker cover.

4 Rotate the crankshaft clockwise, from the front, until the push rod for the inlet valve of the rear cylinder just tightens.

5 Rotate the crankshaft a further $^1/_8$ of a turn clockwise. Insert a suitable lever between the rocker lever and the valve spring cap of number 1 inlet valve. Open the inlet valve and put a spacer approximately 5,0 mm (0.2 in) thick between the valve tip and the rocker lever.

6 Slowly rotate the crankshaft counter-clockwise until the piston makes contact with the open valve. Make a temporary mark on the damper or pulley to align accurately with the tip of the pointer.

7 Rotate the crankshaft clockwise one or two degrees and remove the spacer between the valve and the rocker lever. Rotate the crankshaft $^1/_4$ of a turn counter-clockwise. Put the spacer between the valve tip and the rocker lever.

8 Slowly rotate the crankshaft clockwise until the piston makes contact with the open valve. Make another temporary mark on the damper or pulley to align accurately with the tip of the pointer.

9 Make a temporary mark at the centre point between the two marks on the damper or pulley and remove the other two marks. Rotate the crankshaft counter-clockwise $^1/_8$ of a rotation and remove the spacer between the valve and the rocker lever. Slowly rotate the crankshaft clockwise until the mark on the damper or pulley aligns accurately with the tip of the pointer. Number 1 piston is now at TDC on the compression stroke.

This document has been printed from SPI². Not for Resale

To check the valve timing — Operation 8-4

1 Set the piston of number 1 cylinder to TDC on the compression stroke, see Operation 8-2.

2 Remove the dial test indicator from number 1 inlet valve and fit the valve springs and the rocker lever. Ensure that the fasteners for the rocker shaft pedestals are to the correct torque.

3 Rotate the crankshaft, clockwise from the front, until the inlet valve of the rear cylinder is fully open.

4 Set the valve tip clearance of number 1 cylinder inlet valve to 1,5 mm (0.059 in).

5 Rotate the crankshaft, clockwise from the front, until the push rod of number 1 cylinder inlet valve just tightens. In this position, check if the mark on the crankshaft pulley is within +/- 2 $^{1}/_{2}$° of the temporary pointer. Use the formula below to find the measurement which is equal to 2 $^{1}/_{2}$° on the pulley.

$$\frac{\mathbf{C \times P}}{\mathbf{360}}$$

C = Circumference of pulley

P = 2.5 degrees

6 If the timing is more than 2 $^{1}/_{2}$° out of position, the timing gears are probably not in correct mesh.

Note: One tooth on the camshaft gear is equivalent to 22 mm (0.9 in) at the circumference of a pulley of 193,5 mm (7.5 in) diameter.

7 Rotate the crankshaft, clockwise from the front, until the inlet valve of the rear cylinder is fully open. Set the valve tip clearance of the inlet valve of number 1 cylinder to 0,20 mm (0.008 in).

8 Fit the rocker cover, see Operation 3-1.

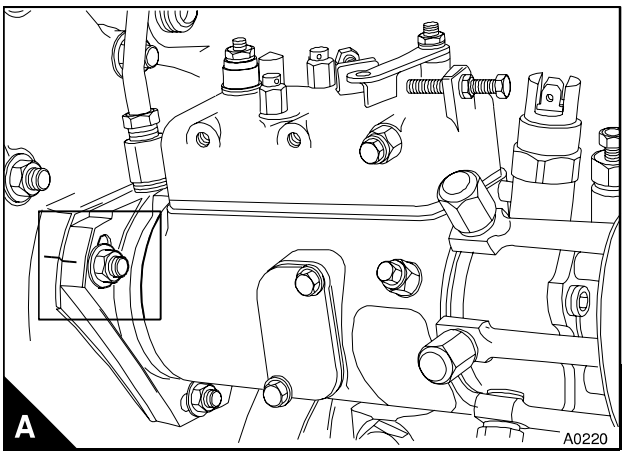
9 Remove the temporary pointer from the timing case and the timing mark from the pulley or damper.

This document has been printed from SPI². Not for Resale

To check the timing of the fuel injection pump — Operation 8-5

If the mark on the flange of the fuel injection pump is in line with the mark on the timing case (A), the timing of the fuel injection pump should be correct.

If the timing marks are in line and the engine performance indicates that the timing is not correct, check that the marks on the flange and on the timing case are in their correct positions, see Operation 8-6 and Operation 8-7.



This document has been printed from SPI². Not for Resale

To check the timing mark of the fuel injection pump — Operation 8-6

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Universal timing tool	MS.67B	Gear adaptor for use with MS.67B	PD.67-3

1 Remove the fuel injection pump, see Operation 11-10.

2 Fit the adaptor PD.67-3 (A) to the drive shaft of the fuel pump and fasten it with the nut of the fuel pump gear.

3 Remove the banjo bolt from number 1 high-pressure outlet (outlet "W") and fit a banjo bolt which does not contain a pressure valve.

4 Connect number 1 outlet to an atomiser tester. Operate the hand pump until a pressure of 30 atm (440 lbf in^2) 31 kgf/cm^2 is indicated on the gauge.

5 Loosen the screw (B3) on the timing tool MS.67B and set the timing tool to the correct angle, see "Static timing - CAV fuel injection pump" on page 24. Tighten the screw.

6 Fit the timing tool to the adaptor on the fuel pump drive shaft. Rotate the drive shaft of the fuel pump by hand in the normal direction of rotation -see arrow on pump data plate - until the fuel pressure prevents movement. In this position, the fuel pump is set at the start of injection from number 1 outlet.

7 Loosen the screw (B1). Slide the pointer (B2) forward until it is over the centre of the pump flange and check that the mark on the flange is in the centre of the slot in the pointer.

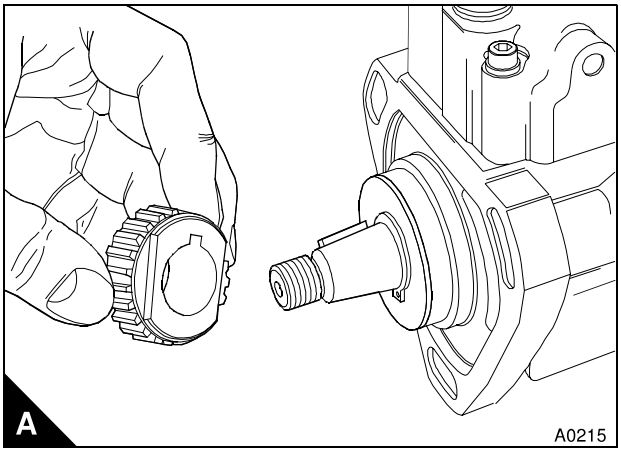
8 If the mark is not correct, remove the timing tool and eliminate the mark. Fit the timing tool and ensure that the fuel pump is at the start of injection for number 1 cylinder. Loosen the screw (B1). Slide the pointer forward to the complete width of the flange and tighten the screw. Make a new mark on the flange of the pump through the slot in the pointer.

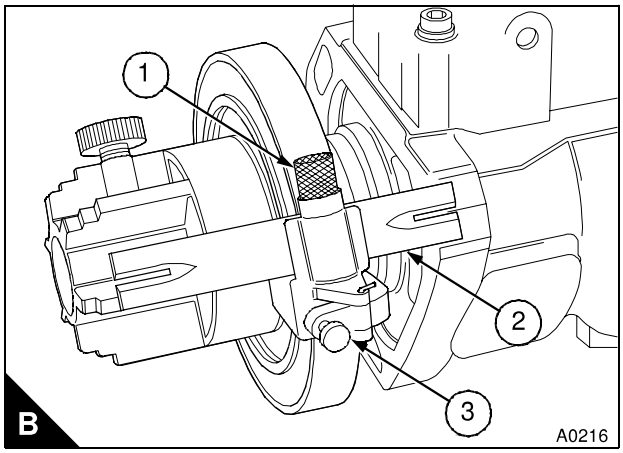
9 Remove the timing tool and the adaptor.

10 Disconnect the atomiser tester and fit the original banjo bolt to number 1 high-pressure outlet.

11 Fit the fuel injection pump, see Operation 11-11.

12 Eliminate air from the fuel system, see Operation 11-13.





This document has been printed from SPI². Not for Resale

To check the engine timing mark **Operation 8-7**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Universal timing tool	MS.67B	Adaptor for use with MS.67B	PD.67-2
Pointer for use with MS.67B	PD.67-4		

1 Set the piston of number 1 cylinder to TDC on the compression stroke, see Operation 8-2.

2 Remove the fuel injection pump and its joint, see Operation 11-10.

3 Align the key in the adaptor PD.67-2 (A) with the keyway in the gear of the fuel injection pump and fit the adaptor to the gear. Ensure that the adaptor is against the rear face of the timing case. Secure the adaptor to the gear with the nut supplied with the adaptor.

4 Loosen the screw (B4) on the timing tool MS.67B. Set the timing tool to the correct engine check angle, see "Static timing - CAV fuel injection pump" on page 24, and tighten the screw. Loosen the screw (B5) and fit the splined shaft (B3) into the timing tool (B). Loosen the screw (B2). Fit the 90° pointer PD.67-4 (B1) and tighten the screw.

5 Fit the splined shaft of the timing tool to the adaptor. Slide the timing tool along the splined shaft until it is against the adaptor and tighten the screw (B5).

6 Loosen the lock screw (B2). Slide the pointer forward until the flat face is against the rear face of the timing case and tighten the screw. If the mark on the timing case is correct, the mark will align with the top edge of the pointer (B1). If the mark is not correct, remove the timing tool and eliminate the mark on the timing case. Fit the timing tool. Ensure that the pointer is against the timing case and make a new mark on the timing case along the top straight edge of the pointer.

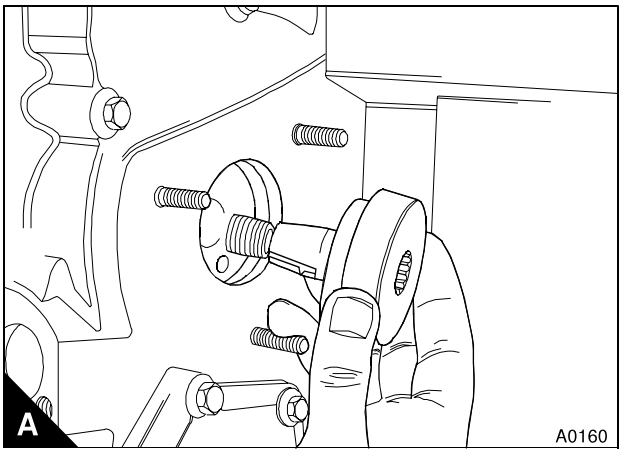
7 Remove the timing tool and the adaptor.

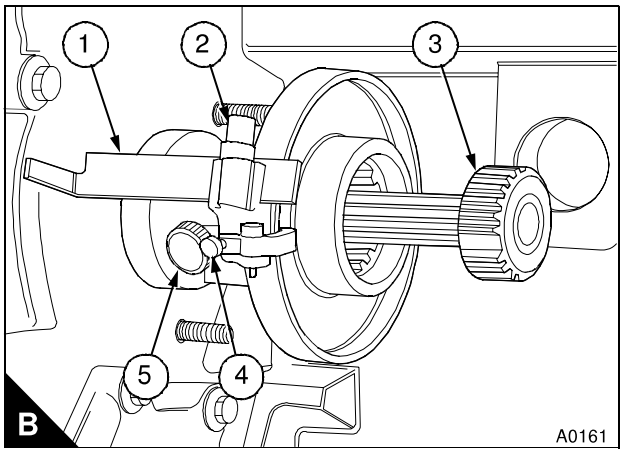
8 Fit the fuel injection pump and a new joint, see Operation 11-11.

9 Remove the dial gauge from number 1 cylinder inlet valve and fit the valve springs and the rocker lever. Set the valve tip clearance of number 1 cylinder inlet valve to 0,20 mm (0.008 in).

10 Fit the rocker cover, see Operation 3-1.

11 Eliminate air from the fuel system, see Operation 11-13.





This document has been printed from SPI². Not for Resale

Stanadyne fuel injection pumps

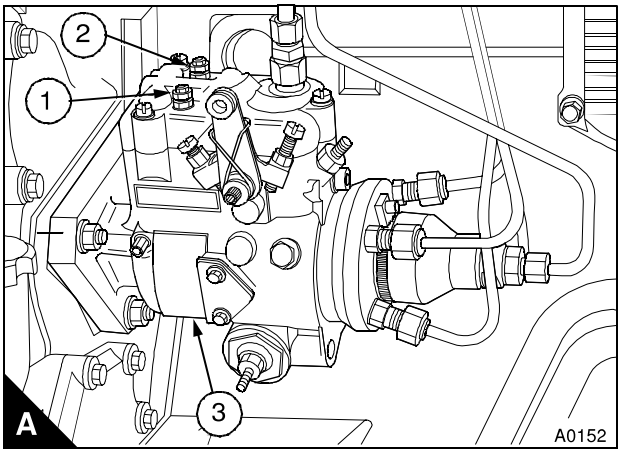
General description — Operation 8-8

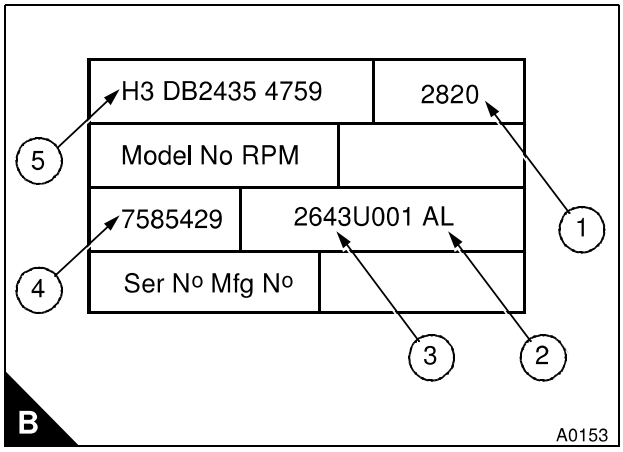
The electrical stop solenoid on these fuel pumps is fitted inside the governor housing. The earth connection (A1) and the electrical connection (A2) are on top of the governor housing.

A data plate (A3) is fitted to the side of the pump . An example of the information shown on the plate (B) is:

- Maximum engine no load speed (B1)
- Fuel pump code (B2)
- Perkins part number (B3)
- Fuel pump serial number (B4)
- Manufacturers model number (B5)

Note: For details of the fuel pump code for the engine see "Static timing - Stanadyne fuel injection pump" on page 24.





To set number 1 piston to TDC on the compression stroke — Operation 8-9

Refer to procedure for Lucas DPA pumps, see Operation 8-2.

To check the valve timing — Operation 8-10

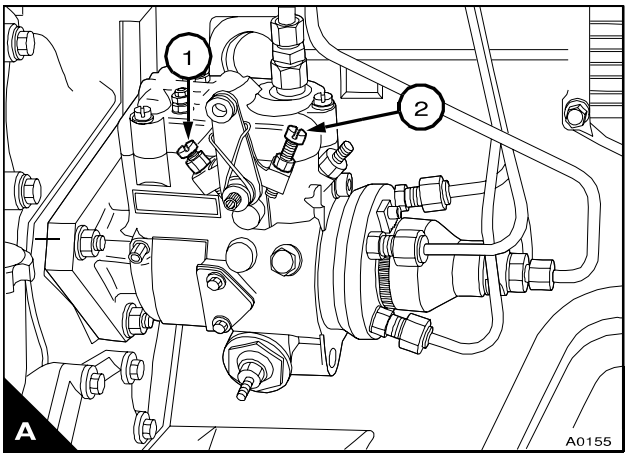
Refer to procedure for Lucas DPA pumps, see Operation 8-4.

This document has been printed from SPI². Not for Resale

To check the timing of the fuel injection pump **Operation 8-11**

If the mark on the flange of the fuel injection pump is in line with the mark on the timing case (A1), the timing of the fuel injection pump should be correct.

If the timing marks are in line and engine performance indicates that the timing is not correct, check that the marks on the flange and on the timing case are in their correct positions, see Operation 8-12.



This document has been printed from SPI². Not for Resale

To check the timing mark of the fuel injection pump — Operation 8-12

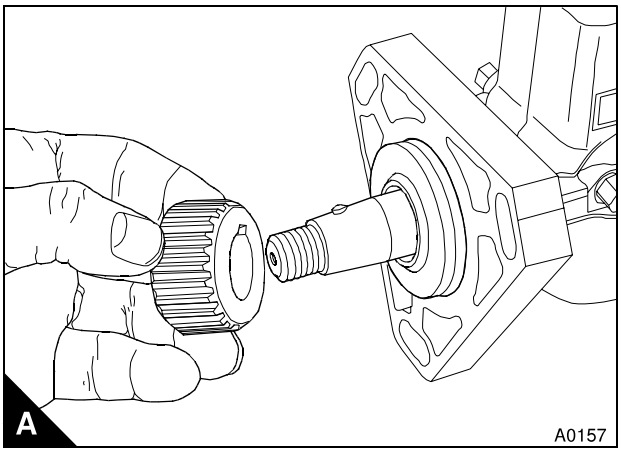
Special requirements

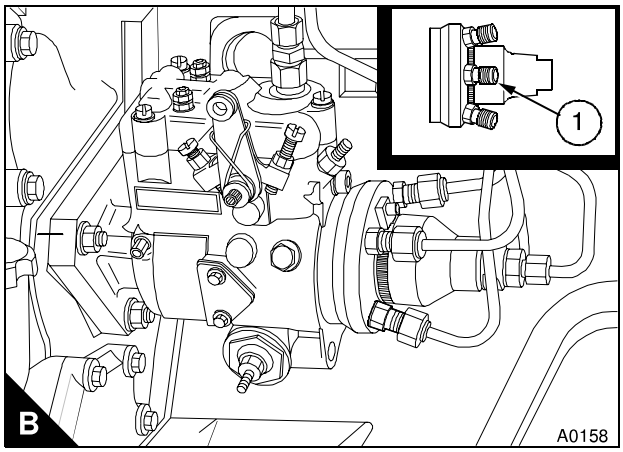
Special tools			
Description	**Part number**	**Description**	**Part number**
Universal timing tool	MS.67B	Gear adaptor for use with MS.67B	PD.67-3

1 Remove the fuel injection pump from the engine, see Operation 11-14.

2 Fit the adaptor PD.67-3 (A) to the drive shaft of the fuel pump and fasten it with the nut of the fuel pump gear.

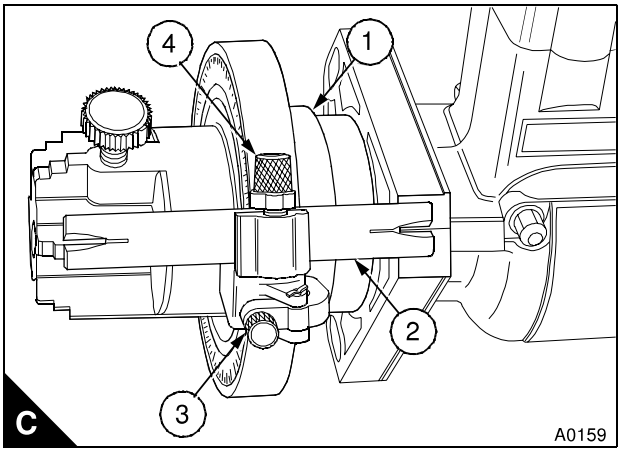
3 Connect number 1 outlet (B1) to an atomiser tester. Operate the hand pump until a pressure of not more than 50 atm (735 lbf in^2) 52 kgf/cm^2 is indicated on the gauge.





4 Rotate the drive shaft of the fuel pump clockwise from the drive end of the pump until the pin in the shaft aligns with number 1 outlet. Loosen the screw (C3) on the timing tool MS.67B and set the timing tool to the correct pump mark angle, see "Static timing - Stanadyne fuel injection pump" on page 24. Tighten the screw.

5 Put the sleeve (C1) for the timing tool in position on the fuel pump. Fit the timing tool to the adaptor on the fuel pump drive shaft. Rotate the shaft backwards and forwards until the fuel pressure prevents movement of the shaft. This is necessary as fuel must pass the delivery valve in the fuel pump before the fuel pressure will prevent movement of the shaft. In this position, the fuel pump is set at the start of injection from number 1 outlet.



Continued

This document has been printed from SPI². Not for Resale

6 Loosen the screw (D4). Slide the pointer (D2) forward until it is over the centre of the pump flange and check that the mark on the flange is in the centre of the slot in the pointer.

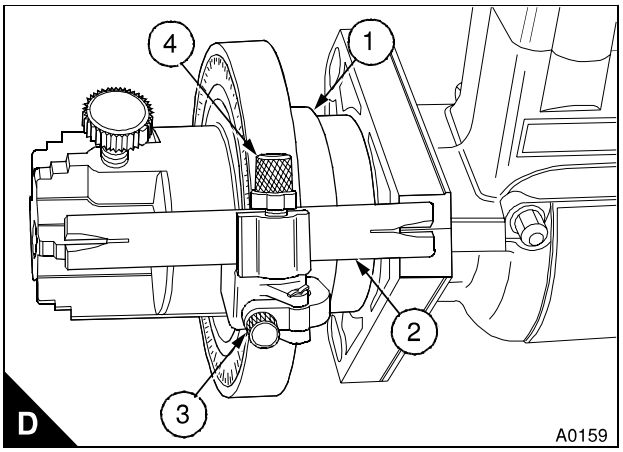
7 If the mark on the flange is not correct, remove the timing tool and eliminate the mark. Fit the timing tool and ensure that the fuel pump is at the start of injection for number 1 cylinder. Loosen the screw (D4). Slide the pointer forward to the complete width of the flange and tighten the screw. Make a new mark on the flange of the pump through the slot in the pointer.

8 Remove the timing tool, the sleeve and the adaptor.

9 Disconnect the atomiser tester from number 1 high-pressure outlet.

10 Fit the fuel injection pump, see Operation 11-15.

11 Eliminate air from the fuel system, see Operation 11-17.



This document has been printed from SPI². Not for Resale

To check the engine timing mark — Operation 8-13

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Universal timing tool	MS.67B	Adaptor for use with MS.67B	PD.67-2
Pointer for use with MS.67B	PD.67-4		

1 Set the piston of number 1 cylinder to TDC on the compression stroke.

2 Remove the fuel injection pump and its joint from the pump flange, see Operation 11-14.

3 Align the key in the adaptor PD.67-2 (A) with the keyway in the gear of the fuel injection pump and fit the adaptor to the gear. Ensure that the adaptor is against the rear face of the timing case. Secure the adaptor to the gear with the nut supplied with the adaptor.

4 Loosen the screw (B4) on the timing tool MS.67B. Set the timing tool to the correct engine check angle, see "Static timing - Stanadyne fuel injection pump" on page 24, and tighten the screw. Loosen the screw (B5) and fit the splined shaft (B3) into the timing tool (B). Loosen the screw (B2). Fit the 90° pointer PD.67-4 (B3) and tighten the screw.

5 Fit the splined shaft (B3) of the timing tool to the adaptor. Slide the timing tool along the splined shaft until it is against the adaptor and tighten the screw (B5).

6 Loosen the lock screw (B2). Slide the pointer forward until the flat face is against the rear face of the timing case and tighten the screw. Rotate the timing tool clockwise, as seen from the rear of the engine, to remove the backlash. If the mark on the timing case is correct, the mark will align with the top edge of the pointer (B1). If the mark is not correct, remove the timing tool and eliminate the mark on the timing case. Fit the timing tool. Ensure that the pointer is against the timing case and make a new mark on the timing case along the top straight edge of the pointer.

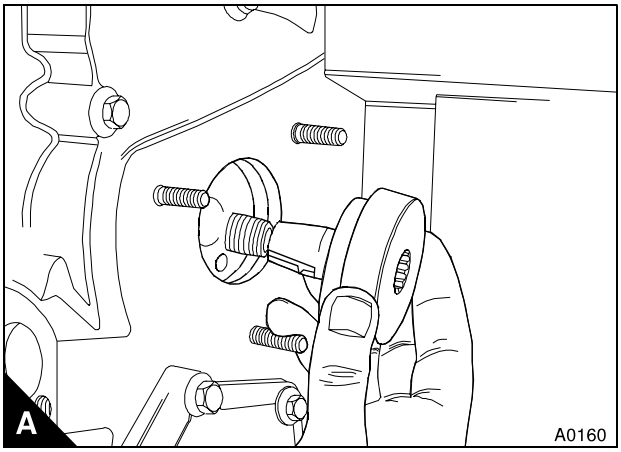
7 Remove the timing tool and the adaptor.

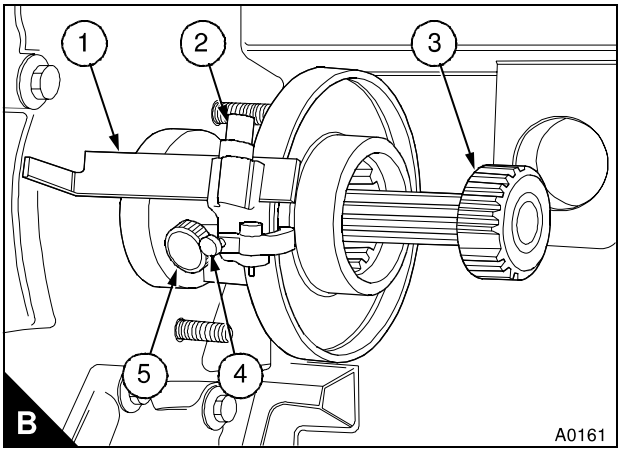
8 Fit a new joint to the fuel injection pump flange and fit the pump, see Operation 11-15.

9 Remove the dial gauge from the inlet valve of the number 1 cylinder and fit the valve springs and the rocker lever. Set the valve tip clearance of number 1 cylinder inlet valve to 0,20 mm (0.008 in).

10 Fit the rocker cover, see Operation 3-1.

11 Eliminate air from the fuel system, see Operation 11-17.





This document has been printed from SPI². Not for Resale

9

Aspiration system

Open engine breather

An open breather is fitted to the engine which has a pipe connected to the rocker cover, crankcase emissions pass directly from the engine.

Ensure that the breather pipe is not restricted.

This document has been printed from SPI². Not for Resale

This page is intentionally blank

This document has been printed from SPI². Not for Resale

10

Lubrication system

General description

Pressure lubrication is supplied by a rotor type pump which is driven through an idler gear from the crankshaft gear. The pump has an inner rotor and an outer rotor which are off-centre to each other. There is a key between the inner rotor and the drive shaft. The inner rotor has six lobes which mesh with the seven lobes of the outer rotor. When the pump rotates, the space between the lobes of the outer rotor which are in mesh increases to cause a suction or decreases to cause a pressure increase. If a balancer unit is fitted, the oil pump is fitted to the balancer frame and is driven by the balancer drive shaft. Refer to "Lubrication system flow diagram for the relief valve and balancer" on page 133.

Lubricating oil (page 132/A1) from the sump passes through a strainer and pipe to the suction side of the pump.

The lubricating oil (page 132/A2) passes from the outlet side of the pump through a pipe to a relief valve, which is fitted to the bottom of the left side of the cylinder block.

If a balancer unit is fitted, the relief valve is fitted in the frame of the balancer. The relief valves opens if the oil pressure is too high; this allows some of the lubricating oil to return to the sump.

From the relief valve, lubricating oil passes to a plate type oil cooler (if one is fitted). The oil cooler is fitted to the oil filter head and has ten plates. Lubricating oil from the oil cooler, passes to an oil filter. The oil filter can be fitted to the left or right side of the engine. If the filter is fitted to the right side of the engine, the oil passes through a pipe connected between the relief valve and the right side of the cylinder block. Refer to "Lubrication system flow diagram for the relief valve and balancer" on page 133. The oil passes from the pipe through a passage in the right side of the cylinder block to an oil cooler and then to the oil filter.

The lubricating oil passes from the filter to the pressure rail which is drilled the complete length of the left side of the cylinder block. If the oil filter is on the right side of the engine, the oil passes through a passage drilled across the cylinder block to the pressure rail.

From the pressure rail, lubricating oil passes to the main bearings of the crankshaft and through passages in the crankshaft to the big end bearings. The pistons and the cylinder bores are lubricated by splash and oil mist.

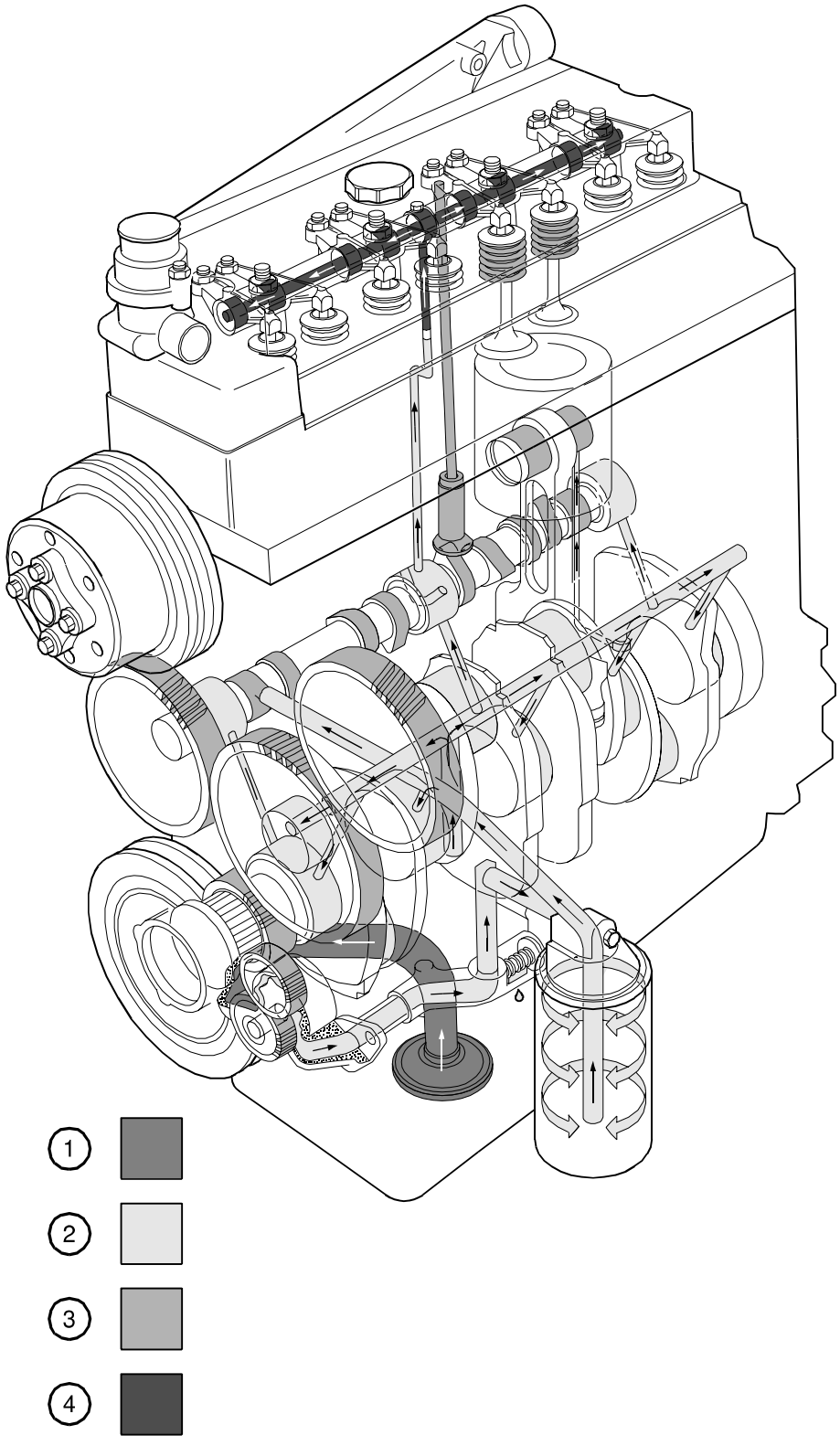
Lubricating oil (page 132/A3) passes from the main bearings through passages in the cylinder block to the journals of the camshaft. Lubricating oil passes from the centre journal of the camshaft through a passage in the cylinder block and cylinder head to a restriction in the pedestal of the rocker shaft, at a reduced pressure (page 132/A4), to the rocker bushes.

The oil passes through a passage in the rocker shaft to the bearings of the rocker levers. The valve stems, valve springs and the tappets are lubricated by splash and oil mist.

The hub of the idler gear is lubricated by oil from the pressure rail and the timing gears are splash lubricated.

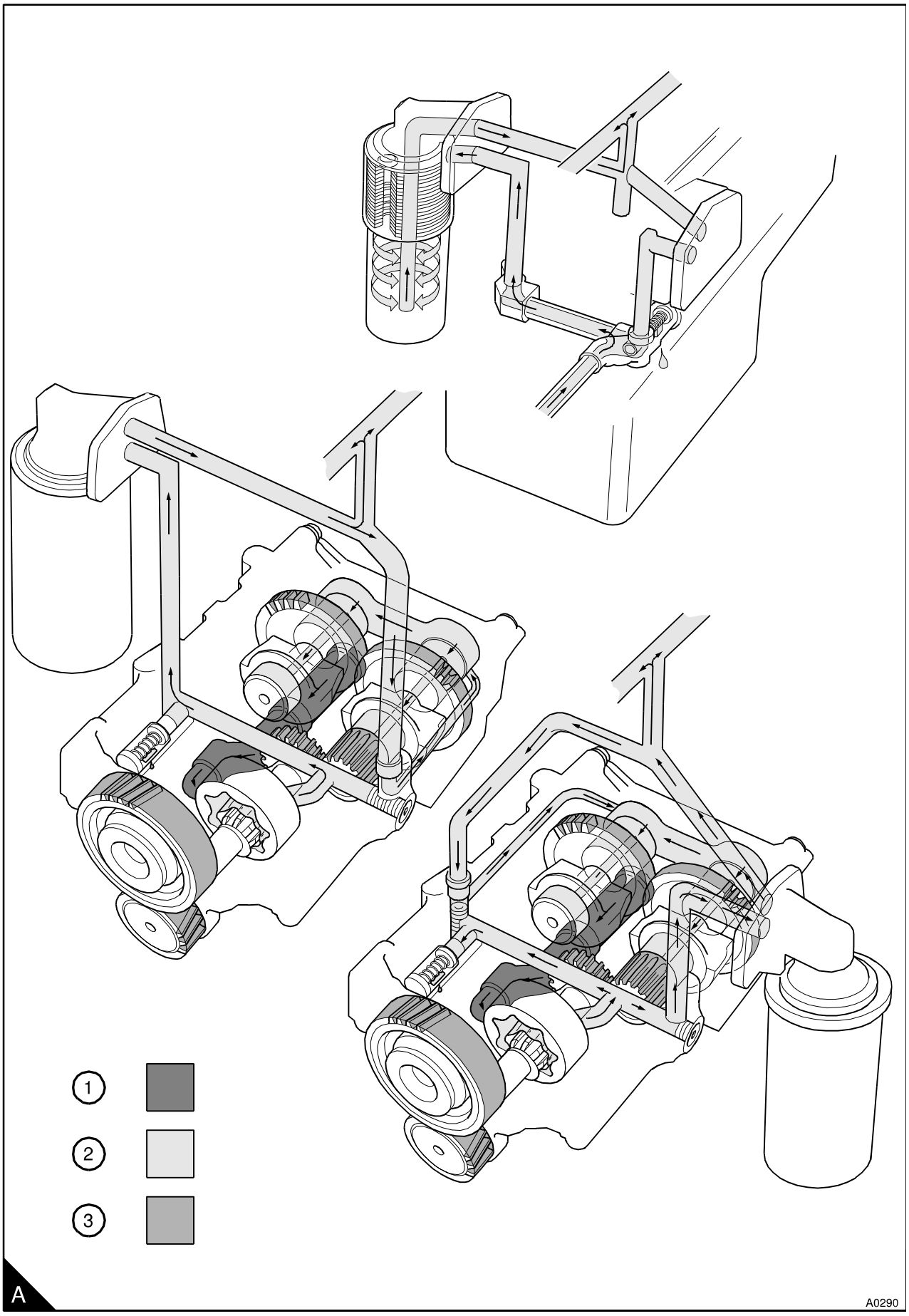
This document has been printed from SPI². Not for Resale

Lubrication system flow diagram



This document has been printed from SPI². Not for Resale

Lubrication system flow diagram for the relief valve and balancer



This document has been printed from SPI². Not for Resale

Filter canister

To renew **Operation 10-1**

1 Put a tray under the filter to retain spilt lubricating oil.

2 Remove the filter canister with a strap wrench or similar tool. Ensure that the adaptor (A1) is secure in the filter head. Discard the canister.

3 Clean the filter head.

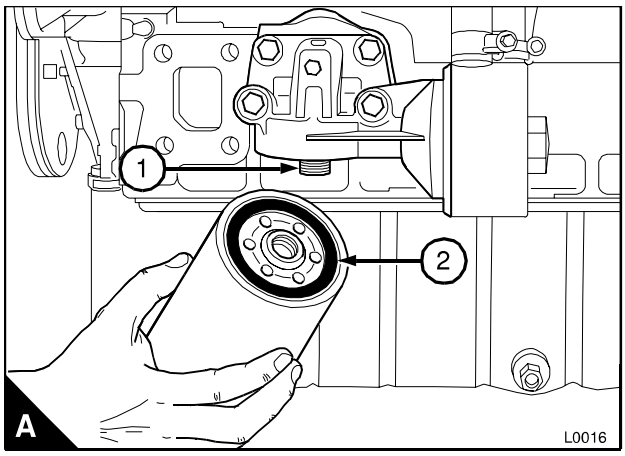
4 Lubricate the top of the canister seal (A2) with clean engine lubricating oil.

5 Fit the new canister and tighten it by hand only. Do not use a strap wrench.

6 Ensure that there is lubricating oil in the sump. Ensure that the engine will not start and operate the starter motor until the oil pressure is obtained. To ensure that the engine will not start, either put the manual control in the "stop" position or disconnect the electrical stop control of the fuel injection pump. Operate the starter motor until the oil pressure warning light is extinguished or there is a reading on the gauge.

7 Operate the engine and check for leakage from the filter. When the engine has cooled, check the oil level on the dipstick and put more oil into the sump, if necessary.

Caution: *The canister contains a valve and special tube to ensure that lubricating oil does not drain from the filter. Therefore, ensure that the correct Perkins POWERPART canister is used.*



This document has been printed from SPI². Not for Resale

Filter head

To remove and to fit — Operation 10-2

Special requirements

Consumable products	
Description	**Part number**
POWERPART Nutlock	21820242

1 Put a tray under the filter head to contain spilt lubricating oil.

2 Remove the filter canister, see Operation 10-1.

3 Remove the oil cooler from the filter head, if one is fitted, see Operation 12-8.

4 Release the setscrews and remove the filter head (A4) from the cylinder block. Discard the joint (A3).

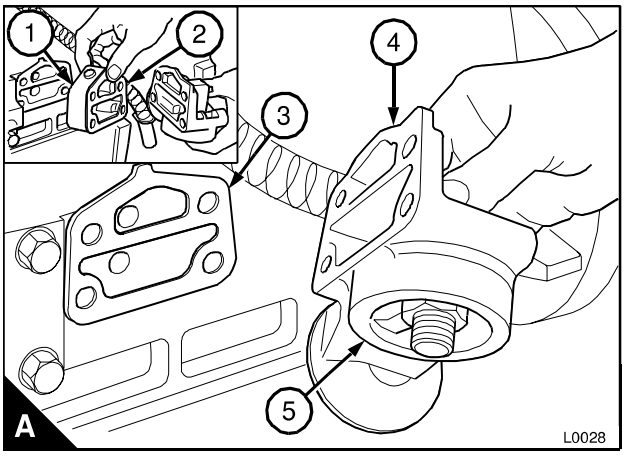
5 Clean the joint face of the filter head (A5) and the flange of the oil cooler, If one is fitted. Fit the filter head and a new joint.

Note: Some engines have an adaptor (A1) between the cylinder block and the filter head. If an adaptor is used, two joints are fitted (A2) and (A3).

Apply POWERPART Nutlock to the first three threads of the setscrews and tighten the setscrews.

6 Fit the oil cooler to the filter head, if one is fitted, see Operation 12-8.

7 Fit new filter canister, see Operation 10-1.



This document has been printed from SPI². Not for Resale

Sump

To remove and to fit **Operation 10-3**

1 Operate the engine until it is warm.

2 Stop the engine, remove the sump drain plug and its "O" ring and drain the oil. where necessary, remove the dipstick and the dipstick tube.

3 Provide a support for the sump and remove the setscrews and the two nuts which fasten the sump to the cylinder block and to the timing case. lower the sump and remove the joint.

4 Wash the sump with an approved cleaning fluid, ensure all the cleaning fluid is removed. clean the flange face of the sump and of the cylinder block. if necessary, renew the felt dust seal which is fitted to the rear of the sump flange on some engines.

5 Fit the sump together with a new joint and ensure the correct location with a setscrew on each side. fit the remainder of the setscrews and the nuts and tighten all the fasteners to 22 Nm (16 lbf ft) 2,2 kgf m. fit the drain plug together with a new "O" ring and tighten the plug to 34 nm (25 lbf ft) 3,5 kgf m. where necessary, fit the dipstick tube and the dipstick. Fill the sump to the "max" level on the dipstick with an approved lubricating oil.

This document has been printed from SPI². Not for Resale

Oil strainer and suction pipe

To remove and to fit **Operation 10-4**

The oil strainer is an integral part of the suction pipe. No regular service is necessary but wash the strainer when it is removed.

When a balancer is fitted, the suction pipe is normally a short pipe which is fastened to the balancer frame and a pipe bracket is not fitted. The short oil strainer and suction pipe are made of a composite material. This arrangement has an "O" ring seal on the flange face of the oil pump instead of a joint.

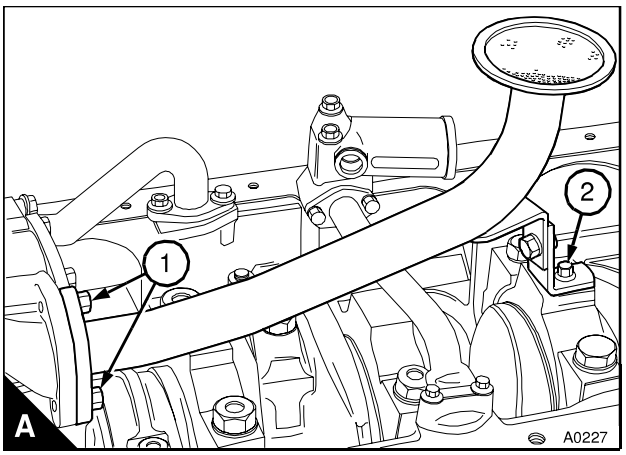
1 Remove the sump, see Operation 10-3.

2 Release the setscrew which holds the bracket to the main bearing cap (A2).

3 Release the setscrews from the flange of the suction pipe (A1). Remove the suction pipe and strainer. Remove and the old joint or the "O" ring. Clean the flange face of the oil pump and of the suction pipe.

4 Loosely assemble the bracket of the suction pipe to the correct main bearing cap. Fit the suction pipe to the oil pump together with a new joint or an "O" ring. Tighten the setscrews. Tighten the setscrew of the suction pipe bracket. Ensure that there is no stress on the suction pipe.

5 Fit the sump, see Operation 10-3, and fill it with an approved oil to the correct level on the dipstick, refer to the User's Handbook.



This document has been printed from SPI². Not for Resale

To inspect and to correct **Operation 10-5**

1 Wash the assembly in an approved cleaning fluid and dry it thoroughly.

2 Check the pipe, the strainer and the welded joints for cracks and other damage. Check that the mounting bracket is secure.

3 If the damaged component cannot be welded correctly, renew the assembly.

4 Composite material parts must be renewed if they have cracks or damage.

This document has been printed from SPI². Not for Resale

Lubricating oil pump

To remove — Operation 10-6

The oil pump is integral with the balancer unit, see Operation 5-13 for removal instructions.

The lubricating oil pump has a channel (B1) in the body of the pump. On some engines lubricating oil from the front main bearing passes down the channel in the body of the pump to an oil hole in the idler shaft. The lubricating oil then passes through the hole in the idler shaft to the bush in the idler gear. There will not be a hole in the idler gear shaft if extra lubricating oil is not needed in the idler gear bush.

1 Drain the lubricating oil and remove the lubricating oil sump, see Operation 10-3.

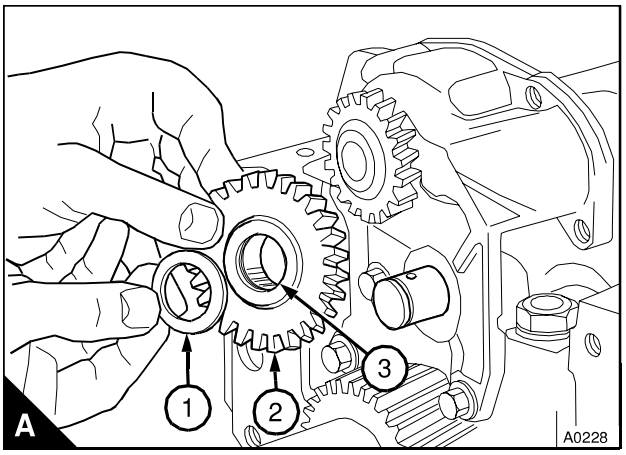
2 Remove the suction pipe and strainer, see Operation 10-4.

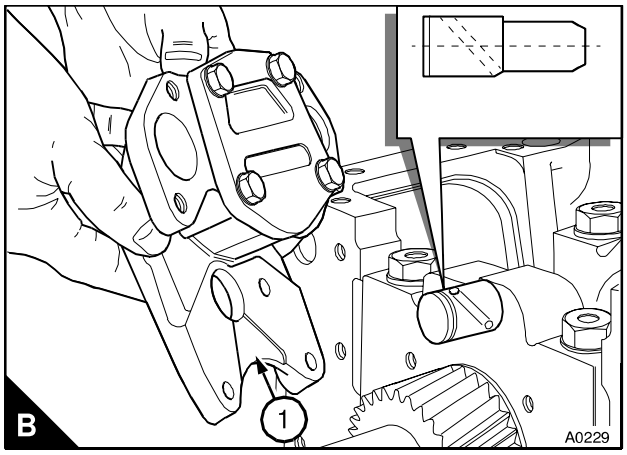
3 Remove the oil pressure relief valve, see Operation 10-10, and the delivery pipe.

4 The oil pump is fitted to number 1 main bearing cap. The oil pump can be removed with the main bearing cap, if a suitable spanner is available that will enable the torque to be applied correctly to the setscrews of the main bearing cap when it is fitted. If a suitable spanner is not available, the timing case must be removed, see Operation 6-13.

5 Release the circlip which retains the idler gear of the oil pump and remove the washer (A1) and the idler gear (A2).

6 Release the setscrews and remove the oil pump (B).





This document has been printed from SPI². Not for Resale

To fit **Operation 10-7**

1 Fill the oil pump with clean engine lubricating oil. Fit the oil pump to the main bearing cap and tighten the setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.

2 Check the idler gear and the bush for wear and other damage. If the gear and/or bush are damaged, they can be renewed as an assembly or the bush can be renewed as a single item. Check the shaft of the idler gear for wear or other damage. If the shaft is worn or damaged, renew the shaft, see Operation 10-8. Lubricate the bush (A3) with clean engine lubricating oil and fit the idler gear (A2), the washer (A1) and the circlip.

3 Check that there is a minimum of 0,076 mm (0.003 in) backlash between the oil pump gear and the idler gear (B).

4 If number 1 main bearing cap was removed, lubricate the bearing with clean engine lubricating oil and fit the bearing cap. Tighten the setscrews to 265 Nm (196 lbf ft) 27,0 kgf m. If the timing case was removed, fit the timing case, see Operation 6-14.

5 Check that there is a minimum of 0,076 mm (0.003 in) backlash between the oil pump idler gear and the crankshaft gear.

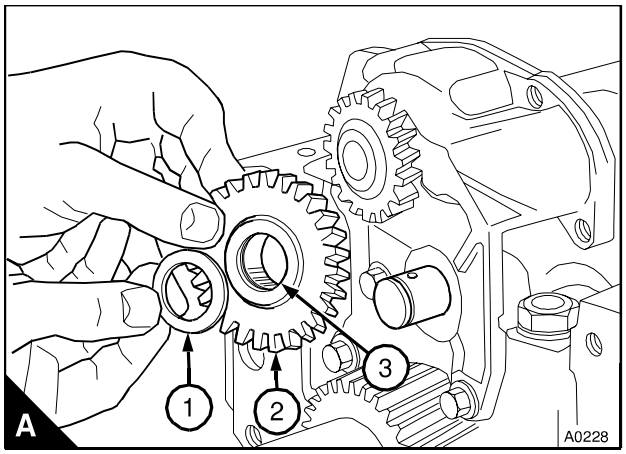
If the latest lubricating oil pump with the oil supply channel is fitted, the end-float for the idler gear is 0,012/0,643 mm (0.0005/0.0253 in)

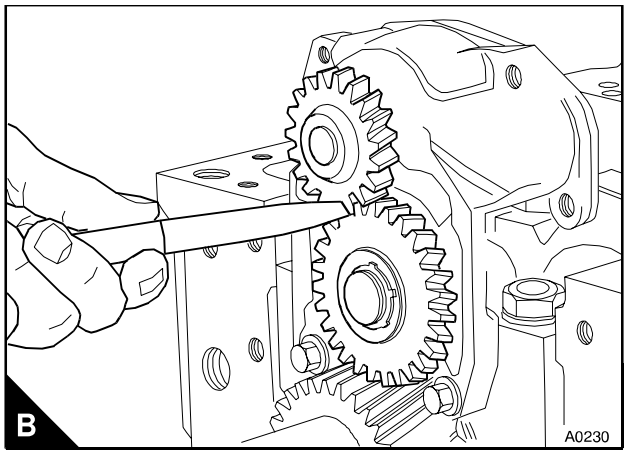
6 Fit the suction pipe and strainer, see Operation 10-4.

7 Fit the delivery pipe and oil pressure relief valve, see Operation 10-10.

8 Fit the lubricating oil sump, see Operation 10-3.

9 Fill the sump to the correct mark on the dipstick with an approved lubricating oil, refer to the User's Handbook.





This document has been printed from SPI². Not for Resale

To renew the shaft for the idler gear — **Operation 10-8**

Special requirements

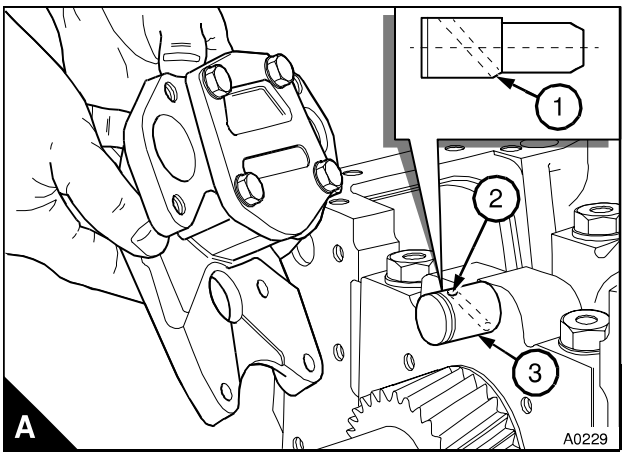
Consumable products	
Description	**Part number**
POWERPART Retainer (oil tolerant)	21820603

1 Support the front of the bearing cap. Put a suitable adaptor on the small diameter of the idler shaft and press the idler shaft out of the bearing cap.

2 Ensure that the idler shaft and the hole in the bearing cap are clean. Support the rear of the bearing cap and ensure that the cap will not move when the idler shaft is pressed in. Apply POWERPART Retainer to the small diameter of the idler shaft.

If the idler shaft (A3) has an oil hole ensure that the hole (A2) in the idler shaft is at the top and that the flat (A1) is at the bottom before the shaft is pressed into the bearing cap.

Enter the chamfer of the idler shaft into the hole. Ensure that the idler shaft is square to the bearing cap and press in the shaft onto its shoulder. Remove the surplus POWERPART Retainer and ensure that the oil hole is not filled with retainer.



This document has been printed from SPI². Not for Resale

To inspect **Operation 10-9**

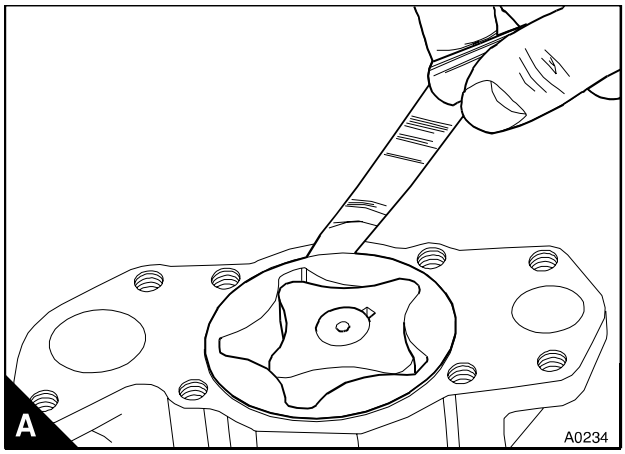
If any part is worn enough to have an effect on the performance of the oil pump, the complete oil pump must be renewed.

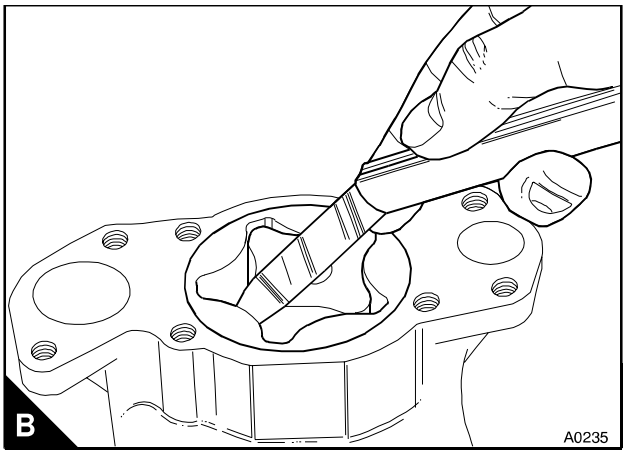
1 Release the setscrews and remove the cover of the oil pump. For pumps which are fitted to a balancer unit, remove the single setscrew and the cover.

2 Remove the outer rotor and clean thoroughly all the parts. Check for cracks and any other damage.

3 Fit the outer rotor and check the outer rotor to body clearance (A).

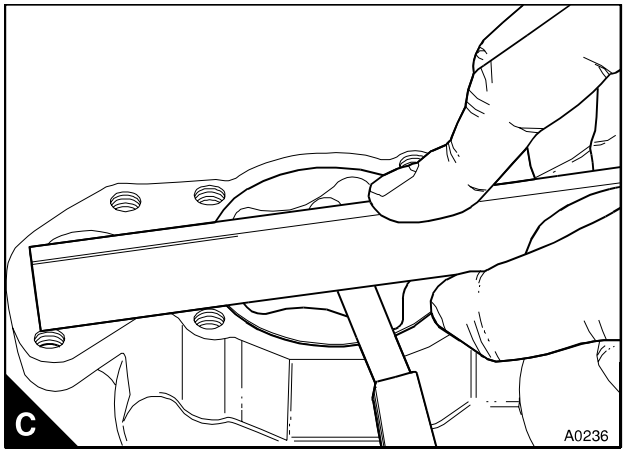
4 Check the inner rotor to outer rotor clearance (B).





5 Check the rotor end-float with a straight edge and a feeler gauge (C). For all the above clearances, refer to the relevant Data and dimensions for the "Lubrication system" on page 24.

6 Clean the top face of the oil pump and the bottom face of the cover and fit the cover. Tighten the setscrews to 28 Nm (21 lbf ft) 2,9 kgf m. For pumps which are fitted to a balancer unit, put the cover in position and tighten the single setscrew to 22 Nm (16 lbf ft) 2,2 kgf m.



This document has been printed from SPI². Not for Resale

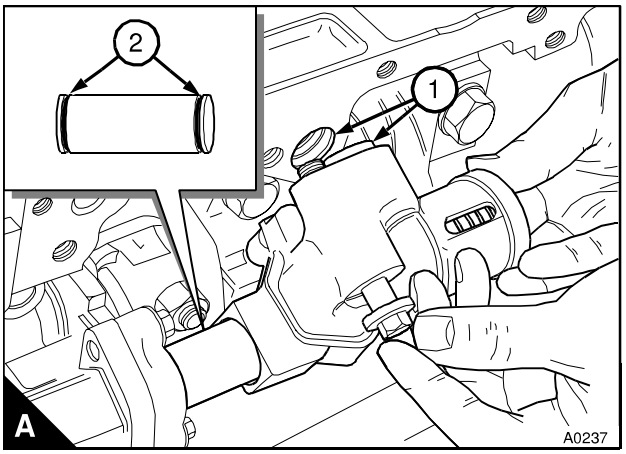
Relief valve

To remove and to fit **Operation 10-10**

The relief valve is fitted inside the balancer frame. The relief valve of these engines cannot be removed as an assembly.

1 Drain the lubricating oil and remove the sump, see Operation 10-3.

2 Release the setscrew and rotate the relief valve to withdraw the thimble from the cylinder block (A1). Pull the relief valve from the delivery pipe and pull the delivery pipe from the oil pump. Renew the "O" rings (A2). Lightly lubricate the "O" rings with clean engine lubricating oil and push the delivery pipe into the oil pump. Push the relief valve onto the delivery pipe and fit the relief valve to the cylinder block; ensure that the thimble is correctly fitted and tighten the setscrew.



This document has been printed from SPI². Not for Resale

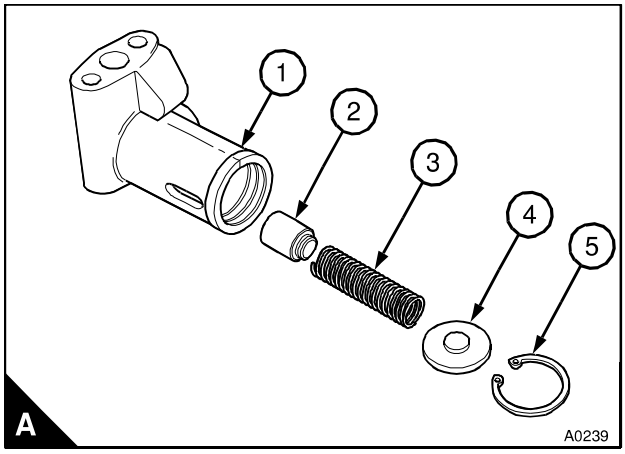
To dismantle and to assemble — Operation 10-11

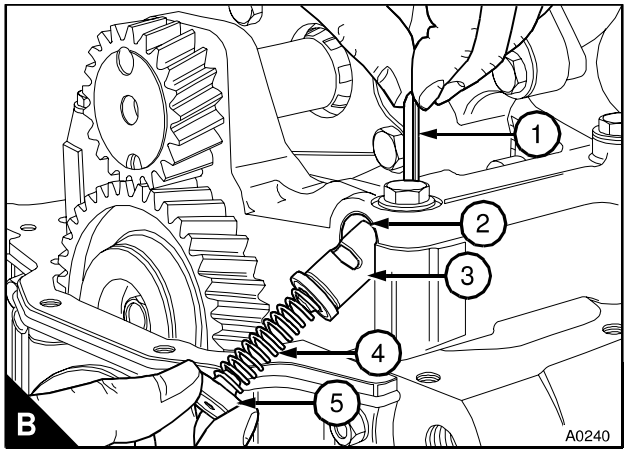
If necessary, the relief valve can be dismantled and assembled while it is fitted to the engine.

1 Apply pressure to the end plate (A4 or B5) of the spring assembly; release the circlip (A5) or remove the pin (B1) and carefully release the pressure to remove the end plate and the spring (A3 or B4) from the valve body. Remove the plunger (A2 or B3) from the bore of the body (A1 or B2).

2 Ensure that all the components are cleaned and then lubricated lightly with clean engine lubricating oil.

3 Fit the plunger into the bore with its hollow end to the inside. Fit the spring and the end cap into the bore with the ends of the spring fitted around the bosses of the plunger and the end plate. Apply pressure to the end plate and fit the circlip into its groove or fit the pin into the holes in the balancer frame.





To inspect — Operation 10-12

Do not try to change the operation pressure of the relief valve by a method other than the installation of new components.

1 Check the spring for wear and other damage and, if possible, check the load necessary to compress the spring to its fitted length. Refer to the relevant Data and dimensions for the "Lubrication system" on page 24.

2 Check the plunger for wear and other damage and ensure that it slides easily in the bore of the relief valve.

3 Check the body and the end plate for wear and other damage.

4 Renew worn or damaged components.

This document has been printed from SPI². Not for Resale

11

Fuel system

General description

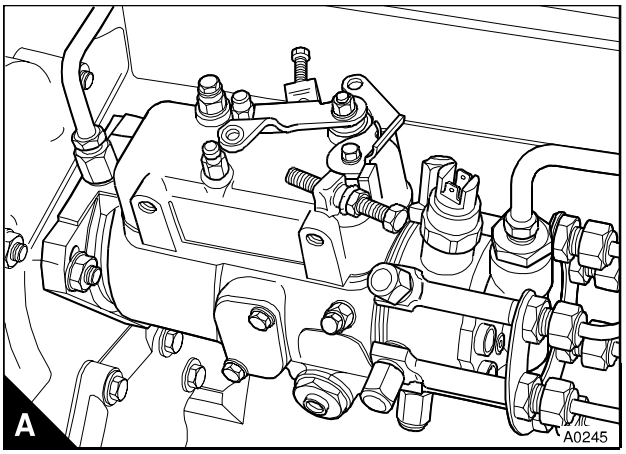
***Cautions*:**

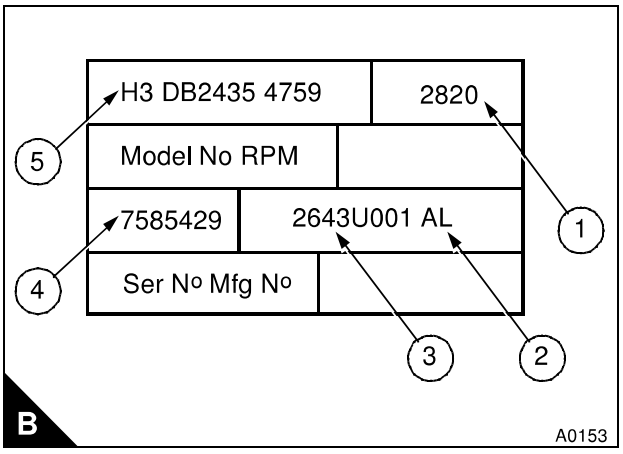
- *It is very important that dirt does not enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After the component has been disconnected, fit a suitable cover to all open connections.*
- *Do not clean an engine while it runs. If cold cleaning fluids are applied to a hot engine, certain components on the engine may be damaged.*

The Lucas DPA fuel injection pump (A) has a mechanical governor to control the engine speed.

A data plate is fitted to the side of the pump. A typical data plate (B) and an example of the information shown on the plate is:

- Maximum engine no load speed (B1)
- Fuel pump code (B2)
- Perkins part number (B3)
- Fuel pump serial number (B4)
- Manufacturers model number (B5)





Continued

This document has been printed from SPI². Not for Resale

For details of the fuel pump code for the engine see the "Static timing - CAV fuel injection pump" on page 24 for Lucas DPA fuel injection pumps and "Static timing - Stanadyne fuel injection pump" on page 24 for Stanadyne fuel injection pumps.

The "low spring" atomisers receive high pressure fuel from the fuel injection pump and inject this fuel into the combustion chamber of the pistons as a very fine spray. The atomisers are set in the factory, but they must be checked in accordance with the preventive maintenance schedules. The pressure at which atomisers operate can be adjusted by a change of shims fitted above the spring.

For details of the atomiser service setting pressures for the engine for both Lucas DPA fuel injection pumps and Stanadyne fuel injection pumps, refer to "Atomiser service settings" on page 26.

The fuel injection equipment must only be checked and adjusted by personnel who have had the correct training.

The fuel lift pump is of the diaphragm type and is mechanically driven. It is fitted on the right side of the cylinder block and is driven by an eccentric on the camshaft. The pump is fitted with a priming lever.

This document has been printed from SPI². Not for Resale

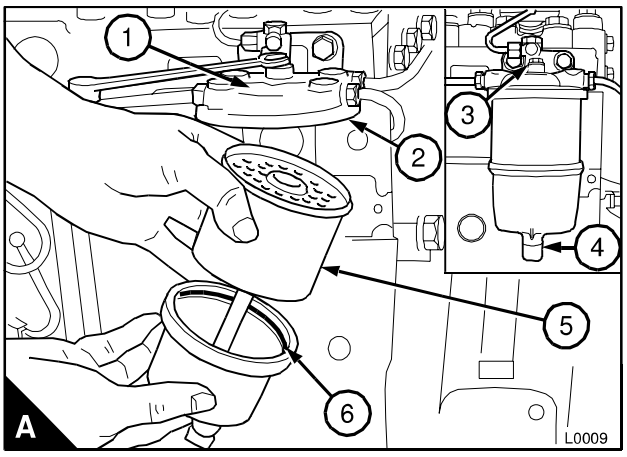
Fuel filter element

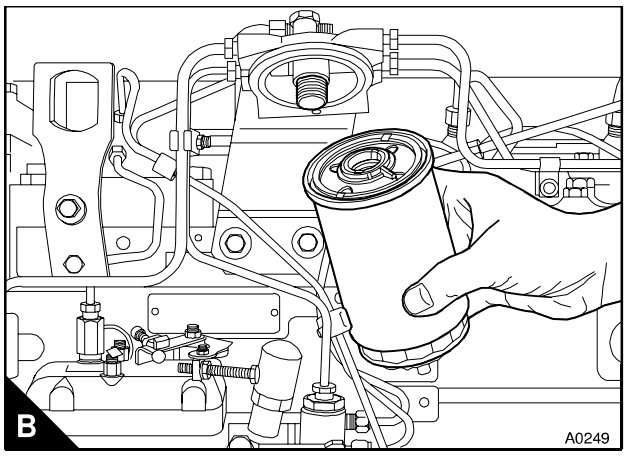
Fuel filter element types — Operation 11-1

A separate element type (A) is fitted, where the filter element is held between the filter head and the bottom cover, refer to Operation 11-2.

The canister type (B) where the filter element has an internal thread at the top and is fastened to a threaded adaptor in the filter head, refer to Operation 11-3.

Some of the latest engines have a clean side return system. Spill fuel from the fuel injection pump and atomisers is returned directly to the inlet side of the fuel injection pump instead of the fuel filter inlet.





This document has been printed from SPI². Not for Resale

To renew the filter element of the separate element type **Operation 11-2**

***Cautions*:**

- *It is important that only the genuine Perkins fuel filter element is used. The use of a wrong element can damage the fuel injection pump.*
- *Do not allow dirt to enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After a component has been disconnected, fit a suitable cover to all open connections.*

1 Clean the outside surfaces of the fuel filter assembly.

2 Loosen the drain device at the bottom of the filter (A4) and allow the water/fuel to drain into a suitable container.

3 Hold the bottom cover of the filter element and release the setscrew (A3) which is fitted through the filter head above the centre of the element.

4 Lower the bottom cover of the filter.

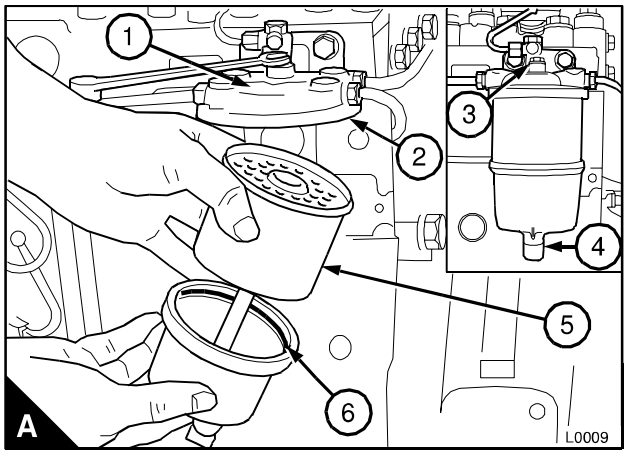
5 Remove the element (A5) and discard it.

6 Clean the inside surfaces of the filter head and of the cover.

7 Renew the joints (A2) and (A6) lightly lubricate them with clean fuel. The largest joint (A2) is fitted to the filter head and the smallest joint (A6) is fitted to the bottom cover.

8 Put the bottom cover under the new element and hold it squarely to the filter head. Ensure that the element is fitted in the centre against the joint in the filter head. With the assembly in this position, engage and tighten the setscrew.

9 Eliminate the air from the fuel filter, see Operation 11-13 for Lucas DPA fuel injection pumps and Operation 11-17 for Stanadyne fuel injection pumps.



This document has been printed from SPI². Not for Resale

To renew the filter element of the canister type — **Operation 11-3**

1 Thoroughly clean the outside surfaces of the fuel filter assembly.

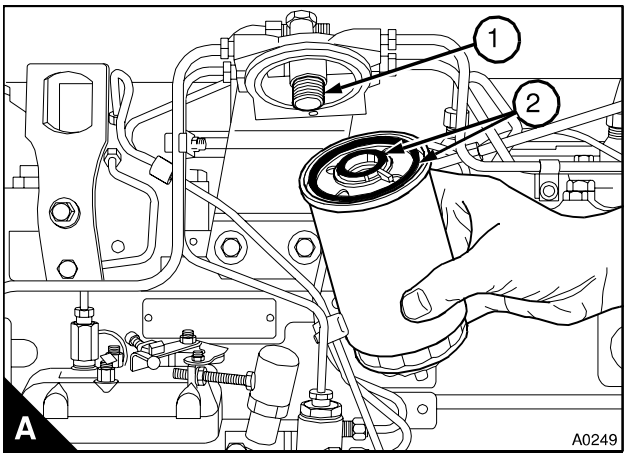
2 Loosen the drain device at the bottom of the canister and allow the water/fuel to drain into a suitable container.

3 Use a strap wrench or similar tool to loosen the filter canister and remove the canister.

4 Ensure that the threaded adaptor (A1) is secure in the filter head and that the inside of the head is clean.

5 Lubricate lightly the seals (A2) on the top of the new canister with clean fuel. Fit the new canister to the filter head and tighten by hand only.

6 Eliminate the air from the fuel filter, see Operation 11-13 for Lucas DPA fuel injection pumps and Operation 11-17 for Stanadyne fuel injection pumps.



This document has been printed from SPI² Not for Resale

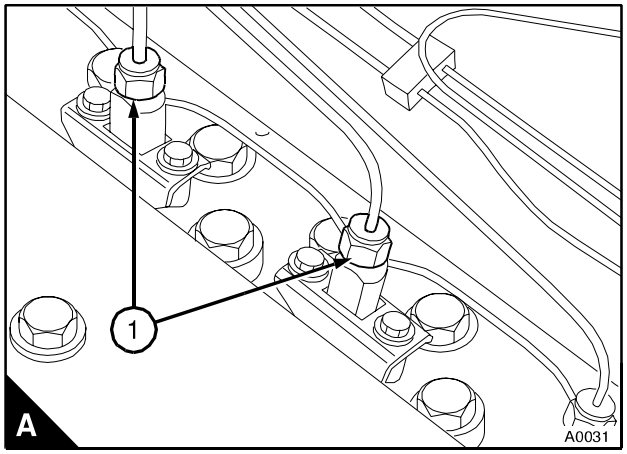
Atomiser fault — Operation 11-4

Warnings!

- *If your skin comes into contact with high-pressure fuel, obtain medical assistance immediately.*
- *Keep away from moving parts during engine operation. Some moving parts cannot be seen clearly while the engine runs.*

An atomiser fault can cause an engine misfire.

In order to find which atomiser is defective, operate the engine at a fast idle speed. Loosen and tighten the union nut (A1) of the high-pressure fuel pipe at each atomiser. Do not loosen the union nut more than half a turn. When the union nut of the defective atomiser is loosened, it has little or no effect on the engine speed.



This document has been printed from SPI². Not for Resale

To remove and to fit **Operation 11-5**

Caution: *Do not allow dirt to enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After a component has been disconnected, fit a suitable cover to all open connections.*

1 Remove the fuel leak-off pipe.

2 Remove the union nuts of the high-pressure pipe from the atomiser and from the fuel injection pump. Do not bend the pipe. If necessary, remove the pipe clamps.

3 Remove the atomiser setscrews and remove the clamp (A1), the atomiser (A5) and its seat washer (A6). Remove the dust seal (A4) and the spacer (A3) and fit the spacer and a new dust seal onto the new atomiser.

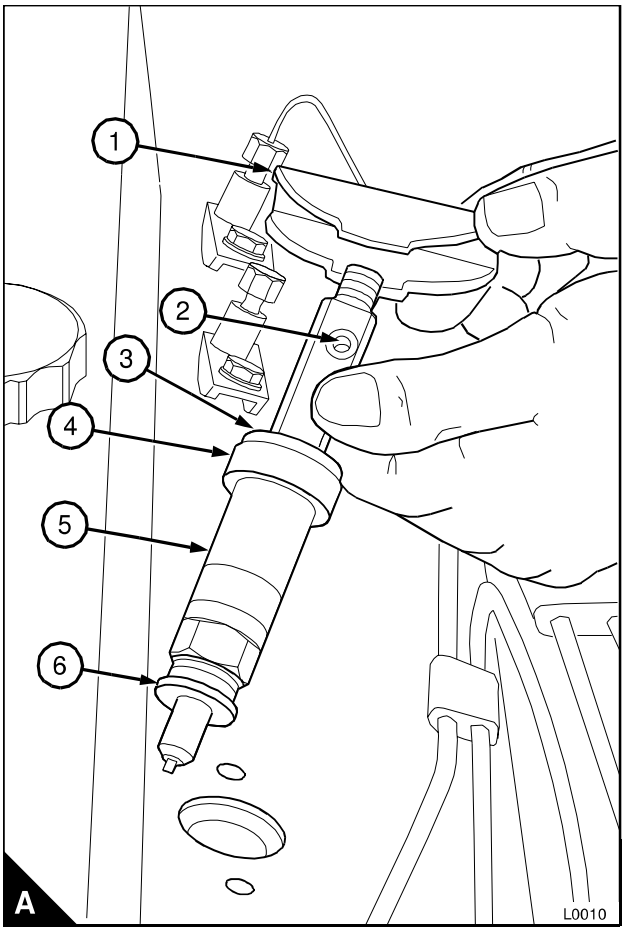
4 Put the new atomiser in position with its spacer, new dust seal and a new seat washer, ensure that the fuel leak-off connection (A2) is not toward the engine. Position the clamp and engage the atomiser setscrews. Ensure that the atomiser is not tilted and tighten the setscrews for the clamp evenly and gradually to 12 Nm (9 lbf ft) 1,2 kgf m.

Caution: *Do not tighten the union nuts of the high-pressure pipes more than the recommended torque tension. If there is a leakage from the union nut, ensure that the pipe is correctly aligned with the atomiser inlet. Do not tighten the atomiser union nut more, as this can cause a restriction at the end of the pipe. This can affect the fuel delivery.*

5 Fit the high-pressure fuel pipe and tighten the union nuts to 22 Nm (16 lbf ft) 2,2 kgf m. If necessary, fit the pipe clamps.

6 Renew the sealing washers and fit the leak-off pipe. Tighten the banjo bolt to 9,5 Nm (7,0 lbf ft) 1,0 kgf m.

7 Operate the engine and check for leakage of fuel and air.



This document has been printed from SPI². Not for Resale

Fuel lift pump

To remove and to fit — Operation 11-6

Special requirements

Consumable products	
Description	**Part number**
POWERPART Nutlock	21820242

1 Disconnect the fuel pipes from the fuel lift pump.

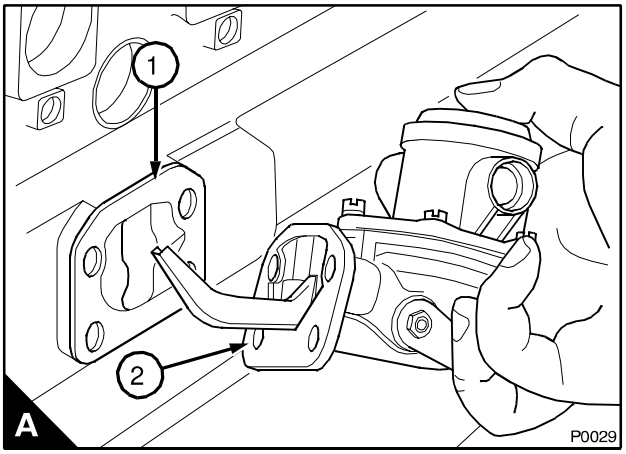
2 Release the setscrews, remove the fuel lift pump (A). The lift pump may be difficult to remove from the engine. If this occurs the crankshaft must be rotated until the camshaft eccentric, that operates the lift pump, is in a position which will free the rocker lever of the lift pump.

3 Ensure that the camshaft eccentric is in the minimum lift position before the lift pump is fitted. Clean the joint face of the lift pump (A2) and the cylinder block and fit the lift pump together with a new joint (A1). Apply POWERPART Nutlock to the first three threads of the setscrews and tighten them gradually and evenly to 22 Nm (16 lbf ft) 2,2 kgf m.

4 Connect the fuel pipes and, if necessary, fit the heat shield.

5 Release the vent screw on the fuel filter head and operate the priming lever of the fuel lift pump to eliminate any air between the lift pump and the fuel filter. Operate the lift pump until fuel, free of air, comes from the vent screw. Tighten the vent screw.

6 Operate the engine and check for any fuel or air leakage.



This document has been printed from SPI². Not for Resale

To dismantle **Operation 11-7**

1 Clean the outside surfaces of the fuel lift pump.

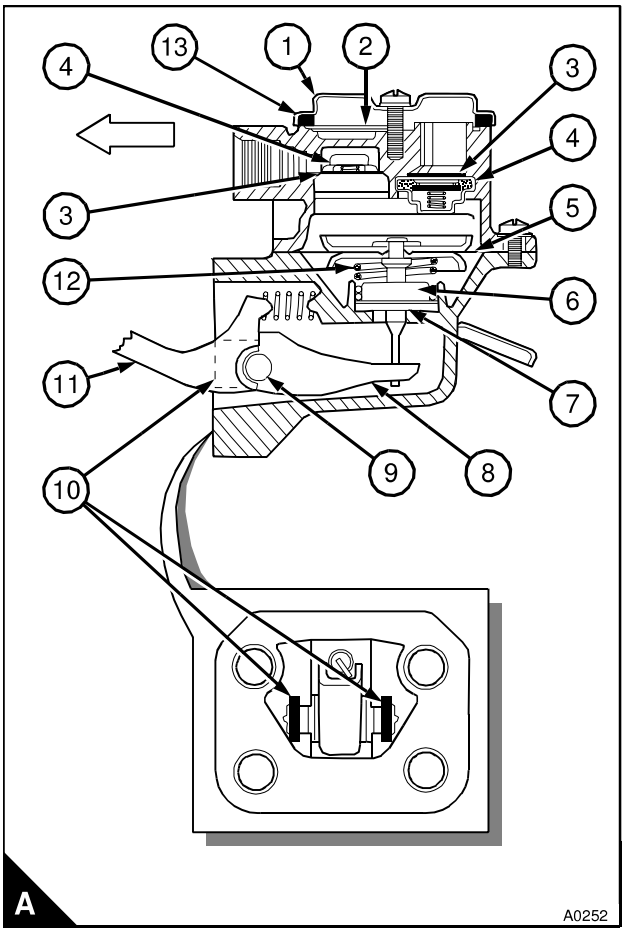
2 Make a mark across the flanges of the two halves of the pump to ensure correct relationship when the pump is assembled.

3 Remove the cover (A1) and the gauze (A2). Release the setscrews and separate the two halves of the pump.

4 Turn the diaphragm assembly (A5) 90° to release the pull rod from the link arm (A8) and remove the diaphragm assembly. Remove the stem seal (A6), the spring seat washer (A7) and the spring (A12) from the pull rod. The diaphragm and pull rod assembly is renewed as an assembly and no service is possible on the diaphragm.

5 The valves (A4) are peened in and can be removed with a suitable lever. Some of the peened metal will have to be removed before the valves can be removed.

6 To remove the link arm: Hold the rocker lever (A11) in a vice and hit the body of the lift pump with a soft face hammer to release the two retainers (A10). Be careful not to damage the joint face of the pump body. Remove the rocker lever, the pin (A9), the link arm and the return spring. Check the components for wear and other damage.



This document has been printed from SPI². Not for Resale

To assemble **Operation 11-8**

1 Thoroughly clean the valve housings. Fit new seat washers (A3) and push the new valves (A4) into position. As the valves are the same, but one valve is fitted in reverse of the other, it is possible to fit the valves upside down. To ensure that the valves are fitted correctly, fit them as shown in A. When the valves are correctly fitted, peen the edge of the valve housings in six places, evenly divided, to keep the valves in position.

2 Fit the rocker lever (A11), pin (A9) and link arm assembly (A8) into the bottom half of the lift pump. Fit the return spring; ensure that the ends of the spring are in their correct location.

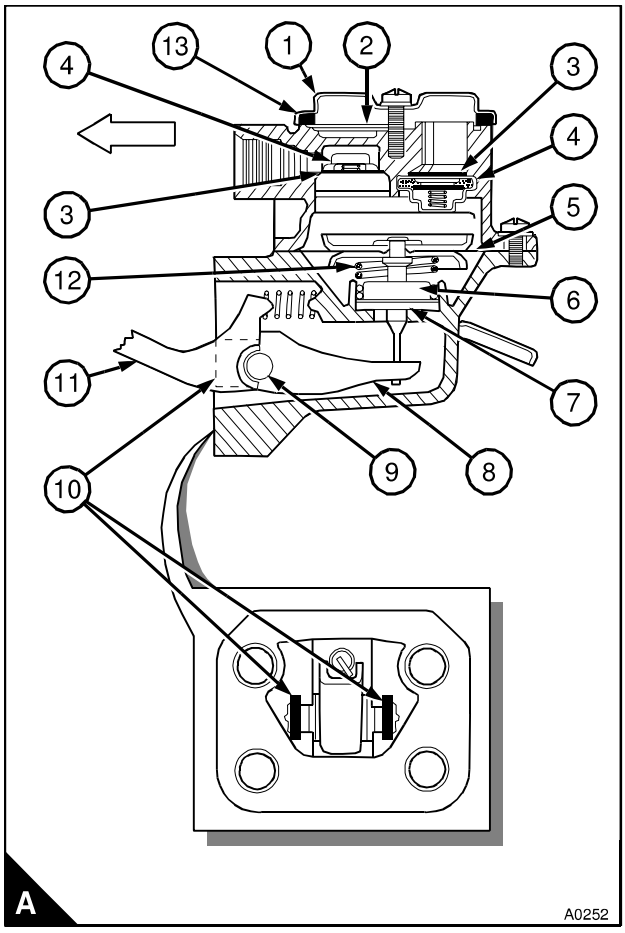
3 With a light hammer and a suitable adaptor, fit two new retainers (A10) in their grooves in the casing until they fasten the pin. Peen the open ends of the grooves to fasten the retainers in position.

4 Fit the diaphragm spring (A12) into its location under the diaphragm (A5) and put the spring seat washer (A7) and a new stem seal (A6) into position on the pull rod. Ensure that the small diameter at the top of the seal is on the round section of the pull rod.

5 Put the diaphragm assembly in position over the lower half of the body with the blade of the pull rod aligned with the slot in the link arm. Press lightly down on the diaphragm until the notch in the pull rod is in the slot in the link arm and turn the diaphragm 90° in either direction. This action will engage and retain the pull rod in the slot of the link arm.

6 Push the rocker arm towards the pump body until the diaphragm is level with the body flange and fit the top half of the body in position with the marks on the flanges aligned. Keep the pressure on the rocker arm; fit the spring washers and the screws and tighten them evenly.

7 Fit the gauze filter (A2) and the cover (A1), ensure that the rubber seal (A13) is fitted correctly and tighten the screw.



This document has been printed from SPI². Not for Resale

To test **Operation 11-9**

1 Disconnect the fuel outlet pipe from the fuel lift pump. Fit a 0-70 kPa (0-10 lbf/in^2) 0-0,7 kgf/cm^2 pressure gauge to the outlet of the lift pump. Release the connection at the gauge and operate the priming lever of the lift pump to eliminate air from the pipe. When fuel, free of air, flows from the pipe tighten the connection. Ensure that there are no leaks at the connections between the pump and the gauge.

2 Operate the starter motor for 10 seconds with the engine stop control in the stop position or with the stop solenoid disconnected.

3 Note the maximum pressure indicated on the gauge. If the pressure indicated is less than the test pressure shown in the relevant Data and dimensions for the "Fuel lift pump" on page 25, repair or renew the pump. Also check the rate at which the pressure reduces to half the maximum pressure obtained. If this is less than 30 seconds, repair or renew the pump.

4 Remove the gauge and connect the outlet pipe to the lift pump. Release the vent screw on the fuel filter head and operate the priming lever until fuel, free of air, flows from the vent screw. Tighten the vent screw.

5 Connect the engine stop solenoid.

This document has been printed from SPI². Not for Resale

To remove — Operation 11-10

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Gear puller	PD.155C	Spanner for flange nuts of fuel injection pump	PD.199
Adaptors for use with PD.155C	PD.155B-5		

1 Remove all the pipes, disconnect the stop control and the control rod of the fuel injection pump.

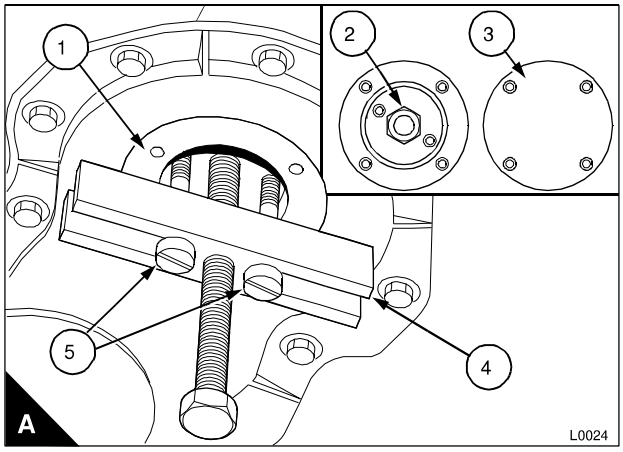
2 Remove the gear cover (A3) from the cover of the timing case (A1). Remove the gear nut (A2) and the spring washer.

3 Rotate the crankshaft to ensure that the keyway in the drive gear of the fuel pump is at or is near to the top.

4 Remove the setscrew and the nut of the support bracket below the fuel pump. Release the flange nuts of the fuel pump. If access to the flange nuts of the fuel pump is restricted by, for example, a compressor, use tool PD.199 to release the flange nuts.

5 Loosen the drive gear of the fuel injection pump with the puller PD.155C (A4) and the adaptors PD.155B-5 (A5).

6 Remove the fuel pump; ensure that the key does not fall from the drive shaft.



This document has been printed from SPI². Not for Resale

Special requirements

Special tools	
Description	**Part number**
Spanner for flange nuts of fuel injection pump	PD.199

1 Rotate the drive shaft of the fuel injection pump to align the key with the keyway in the drive gear. Ensure that the key is correctly fitted and fit the fuel pump to the gear.

2 Align the mark on the flange of the fuel pump with the mark on the rear face of the timing case (A1). Fit the flange nuts of the fuel pump and the setscrew and the nut of the support bracket. Ensure that force is not applied to the fuel pump when the support bracket is fitted.

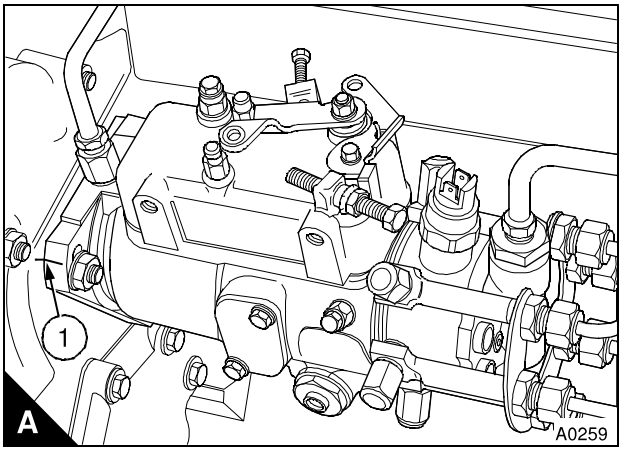
3 Fit the spring washer and the nut to the drive shaft of the fuel pump and tighten the nut to 80 Nm (59 lbf ft) 8,2 kgf m. Fit the gear cover to the cover of the timing case together with a new joint.

4 Fit all the pipes. Connect the stop control and the control rod of the fuel pump.

5 Eliminate air from the fuel system, see Operation 11-13.

6 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed is correct, see Operation 11-12.

7 If a new fuel pump has been fitted, check the maximum no load speed, see Operation 11-12.



This document has been printed from SPI². Not for Resale

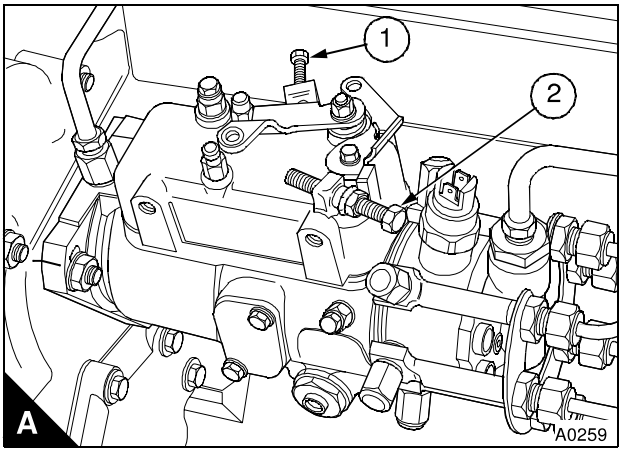
To adjust **Operation 11-12**

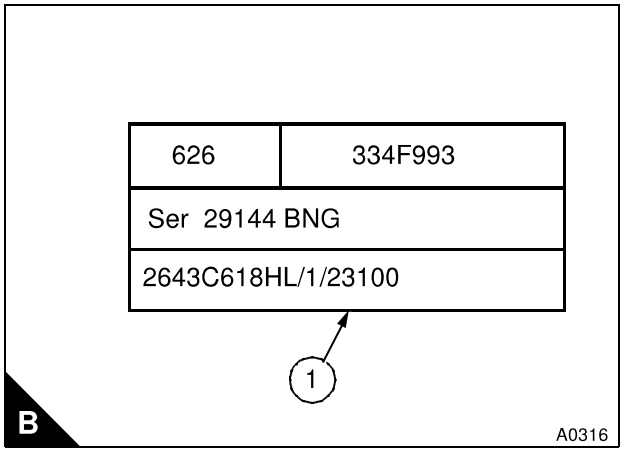
1 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, adjustment can be made by the inner adjustment screw (A1). Release the lock nut and rotate the adjustment screw clockwise to increase the speed or counter-clockwise to decrease the speed. When the speed is correct, tighten the lock nut. The setting of the idle speed can change for different applications. The correct speed will normally be given in the manufacturer's handbook for the application. If it is not given, apply to your nearest Perkins distributor or to Technical Services Department, Perkins International Ltd, Peterborough, England.

Caution: *The setting for the maximum no load speed can change for different applications. Always check the fuel injection pump data plate (B) fitted to a specific engine, before any adjustment to the maximum no load speed.*

2 With the engine at its normal temperature of operation, check the maximum no load speed. The maximum no load speed is indicated by the last part of the setting code for the fuel injection pump. The setting code can be found on the data plate (B1) on the side of the fuel pump. A typical setting code is 2643C618HL/1/2310. In this example, the maximum no load speed is 2310 rev/min. If necessary, this speed can be adjusted by the outer adjustment screw (A2). Release the lock nut and rotate the adjustment screw counter-clockwise to increase, or clockwise to decrease, the speed. When the speed is correct, tighten the lock nut and seal the screw. The person who fits the pump must ensure that the adjustment screw is suitably sealed against interference after it has been set initially.

The adjustment screw on original fuel pumps is set and sealed by the manufacturer. The setting must not be changed as this could affect the engine warranty.





This document has been printed from SPI². Not for Resale

To eliminate air from the fuel system — **Operation 11-13**

If air enters the fuel system, it must be removed before the engine can be started.

Air can enter the system if:

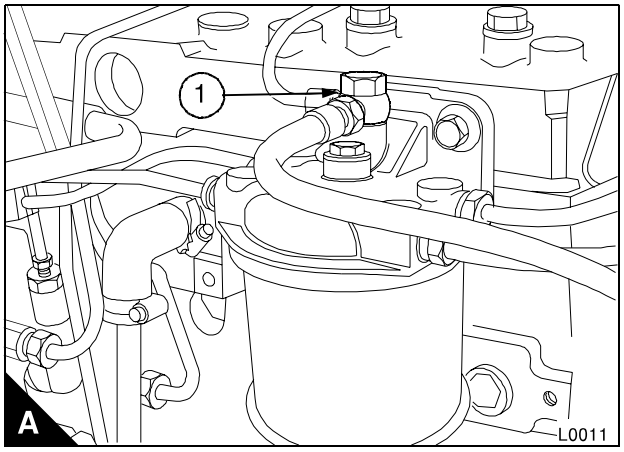
- The fuel tank is drained during normal operation.
- The low-pressure fuel pipes are disconnected.
- A part of the low-pressure fuel system leaks during engine operation.

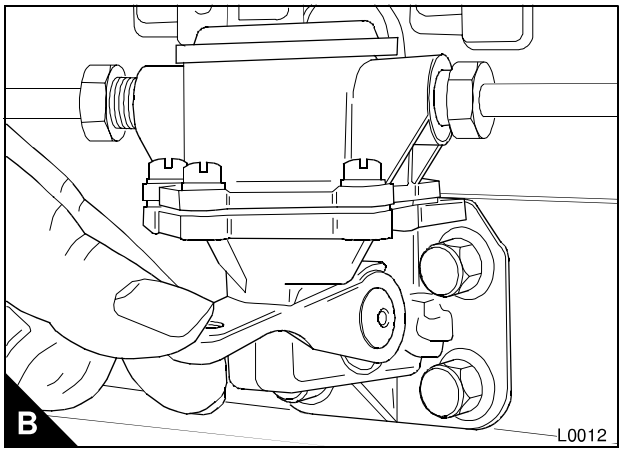
In order to eliminate air from the fuel system, proceed as follows:

1 Loosen the banjo bolt connection (A1) on the top of the filter head.

2 Operate the priming lever on the fuel lift pump (B) until fuel, free from air, comes from the filter vent point. Tighten the banjo bolt connection.

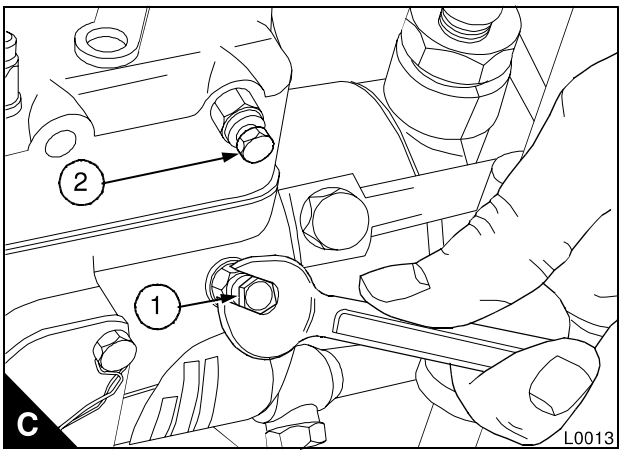
Note: If the drive cam of the fuel lift pump is at the point of maximum cam lift, it will not be possible to operate the priming lever. In this situation, the crankshaft must be turned one revolution.





3 Ensure that the manual stop control is in the "run" position. If an electrical stop control is used, turn the start key to the "R" position.

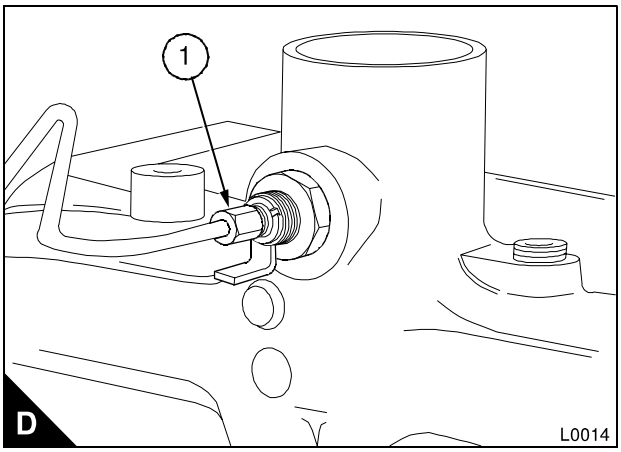
4 Loosen the vent screw in the lock screw (C1) for the hydraulic head. Operate the priming lever of the fuel lift pump until fuel, free from air, comes from the vent screw. Tighten the vent screw. Loosen the vent screw (C2) on the governor cover. Operate the priming lever of the fuel lift pump until fuel, free from air, comes from the vent screw. Tighten the vent screw.

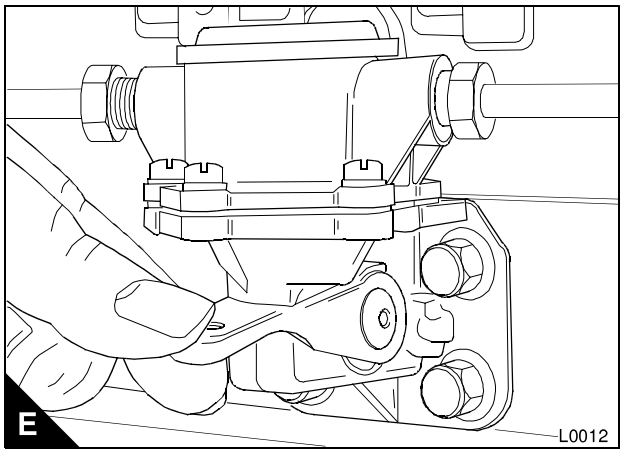


Continued

This document has been printed from SPI². Not for Resale

5 If the pipe to the fuelled starting aid has been drained, loosen the union nut (D1) at the fuelled starting aid and operate the lift pump (E) until fuel, free from air, comes from the connection. Tighten the union nut at the starting aid. Use a spanner on the hexagon of the fuelled starting aid to prevent its movement when the union nut is loosened and tightened.

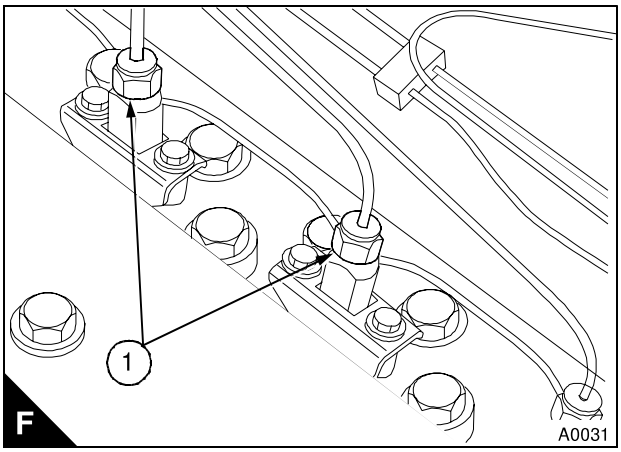




6 Loosen the union nuts (F1) of the high-pressure pipes a half turn at two of the atomisers. Operate the starter motor until fuel free from air, comes from the pipe connections. Tighten the high pressure pipe connections to 22 Nm (16 lbf ft) 2,2 kgf m.

7 The engine is now ready to start.

If the engine runs correctly for a short time and then stops or runs roughly, check for air in the fuel system. If there is air in the fuel system, there may be a leak in the low pressure system.



This document has been printed from SPI². Not for Resale

Stanadyne fuel injection pump

To remove **Operation 11-14**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Gear puller	PD.155C	Adaptors for use with PD.155C	PD.155B-5

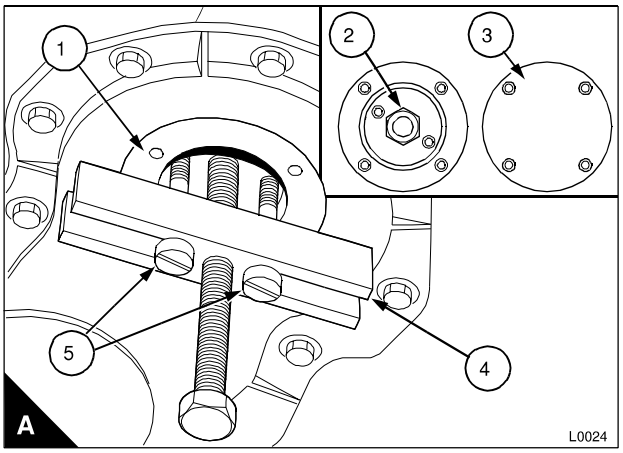
1 Remove the fuel pipes, disconnect the electrical stop control and the control rod of the fuel injection pump.

2 Remove the gear cover (A3) from the cover of the timing case (A1). Remove the gear nut (A2) and the spring washer.

3 Release the flange nuts of the fuel pump. If access to the flange nuts of the fuel pump is restricted by, for example, a compressor, use tool PD.199 to release the flange nuts.

4 Loosen the drive gear of the fuel injection pump with the puller PD.155C (A4) and the adaptors PD.155B-5 (A5).

5 Remove the fuel injection pump.



This document has been printed from SPI². Not for Resale

To fit **Operation 11-15**

1 Fit a new joint (A1) to the timing case. Fit a new "O" ring (A3) to the fuel pump.

2 Rotate the drive shaft of the fuel pump to align the pin (A2) or key with the keyway in the drive gear. Ensure that the pin or key is correctly fitted and fit the fuel pump to the gear. Fit the spring washer and the nut to retain the drive gear and tighten the nut lightly.

3 Align the mark on the flange of the fuel pump with the mark on the rear face of the timing case (B1). Fit the flange nuts of the fuel pump. Tighten them to 22 Nm (16 lbf ft) 2,2 kgf m.

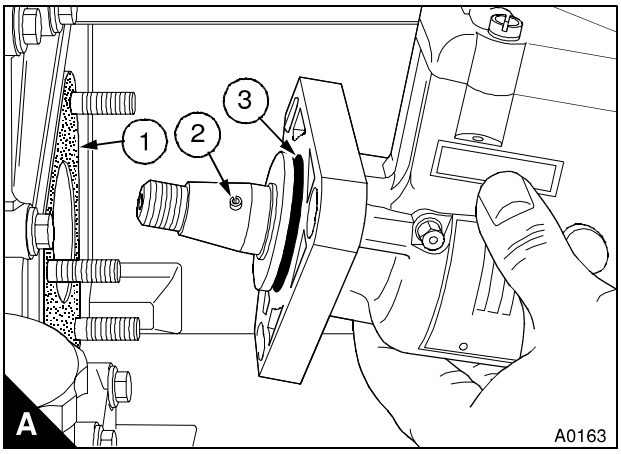
4 Fully tighten the nut for the drive gear to 80 Nm (59 lbf ft) 8,2 kgf m. Fit a new joint for the gear cover and fit the gear cover.

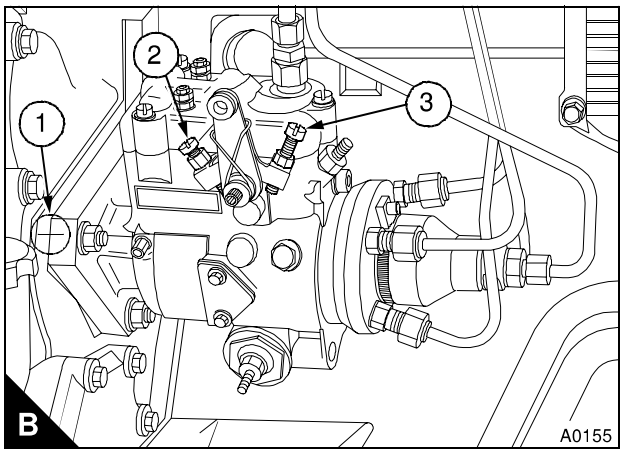
5 Fit the fuel pipes. Connect the electrical stop control and the control rod of the fuel pump.

6 Eliminate air from the fuel system, see Operation 11-17.

7 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed is correct, see Operation 11-16.

8 If a new fuel pump has been fitted, check the maximum no load speed, see Operation 11-16.





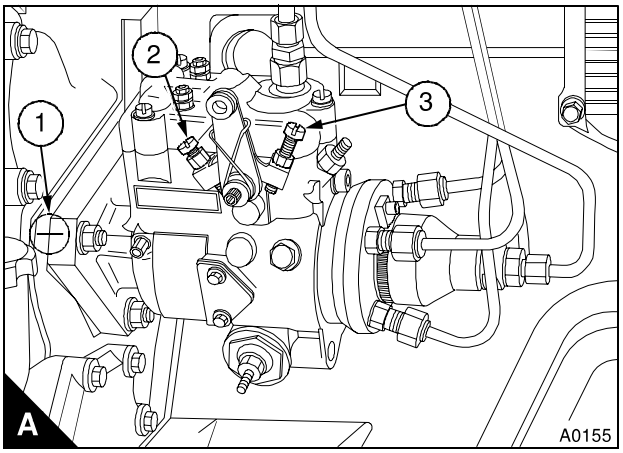
This document has been printed from SPI². Not for Resale

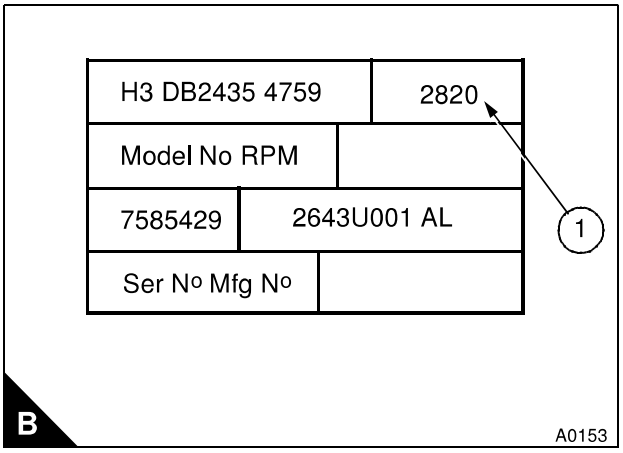
To adjust **Operation 11-16**

1 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, adjustment can be made by the adjustment screw (A2). Release the lock nut and rotate the adjustment screw clockwise to increase the speed or counter-clockwise to decrease the speed. When the speed is correct, tighten the lock nut. The correct speed will normally be given in the manufacturer's handbook for the application. If it is not given, apply to your nearest Perkins distributor or to Technical Services Department, Perkins International Ltd, Peterborough, England.

Caution: *The setting for the maximum no load speed can change for different applications. Always check the fuel injection pump data plate (B) fitted to a specific engine, before any adjustment to the maximum no load speed.*

2 With the engine at its normal temperature of operation, check the maximum no load speed on the fuel pump data plate. An example is given at (B1); if necessary, this speed can be adjusted by the adjustment screw (A3). Release the lock nut and rotate the adjustment screw counter-clockwise to increase the speed, or clockwise to decrease, the speed. When the speed is correct, tighten the lock nut and seal the screw. The person who fits the pump must ensure that the adjustment screw is suitably sealed against interference after it has been set initially. The adjustment screw on original fuel pumps is set and sealed by the manufacturer. The setting must not be changed as this could affect the engine warranty.





This document has been printed from SPI². Not for Resale

To eliminate air from the fuel system — Operation 11-17

If air enters the fuel system, it must be removed before the engine can be started.

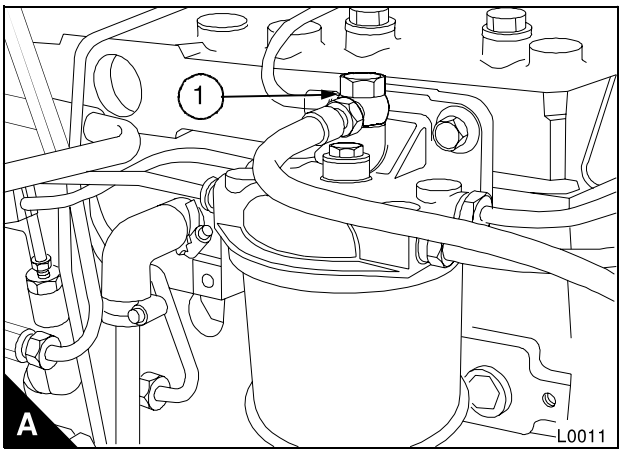
Air can enter the system if:

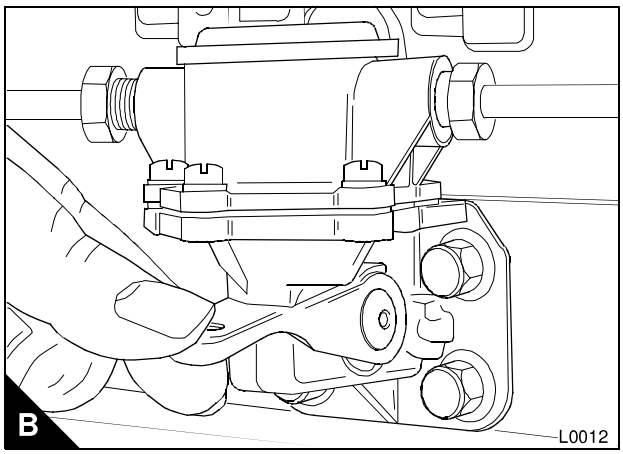
- The fuel tank is drained during normal operation.
- The low-pressure fuel pipes are disconnected.
- A part of the low-pressure fuel system leaks during engine operation.

In order to eliminate air from the fuel system, proceed as follows:

1 Loosen the vent plug (A1) on the top of the filter head.

2 Operate the priming lever on the fuel lift pump (B) until fuel, free from air, comes from the filter vent point. Tighten the vent plug.

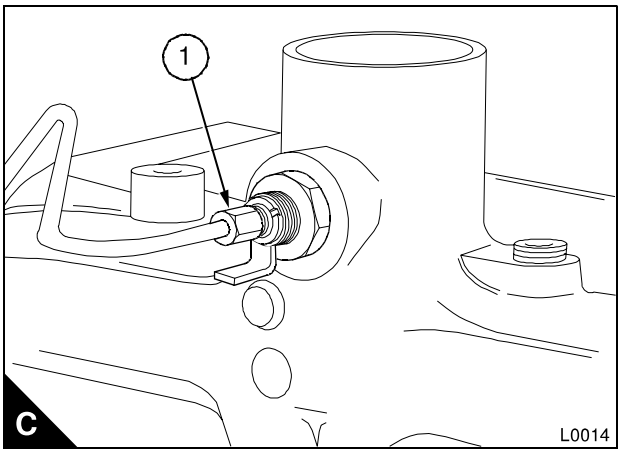


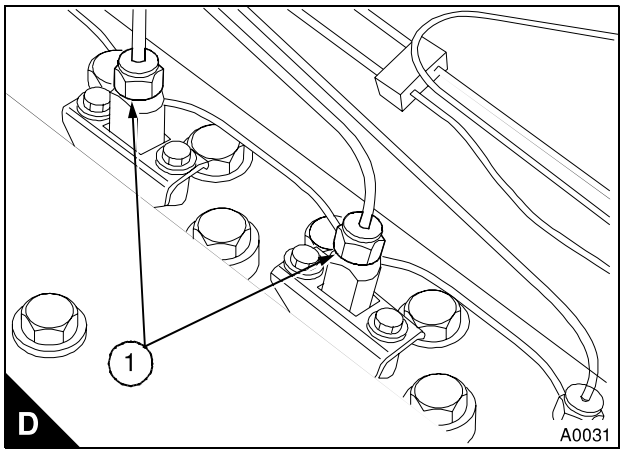


Note: If the drive cam of the fuel lift pump is at the point of maximum cam lift, it will not be possible to operate the priming lever. In this situation, the crankshaft must be rotated one revolution.

3 If the pipe to the fuelled starting aid has been drained, loosen the union nut (C1) at the fuelled starting aid and operate the lift pump until fuel, free from air, comes from the connection. Tighten the union nut at the starting aid. Use a spanner on the flats of the fuelled starting aid to prevent its movement when the union nut is loosened and tightened.

4 Loosen the union nuts (D1) of the high-pressure pipes a half a turn at two of the atomisers.





Continued

This document has been printed from SPI². Not for Resale

5 Put the electrical system switch to the "ON" position. Operate the starter motor until fuel, free from air, comes from the pipe connections. Tighten the high-pressure pipe connections to 22 Nm (16 lbf ft) 2,2 kgf m. Return the switch to the "OFF" position.

6 The engine is now ready to start.

If the engine runs correctly for a short time and then stops or runs roughly, check for air in the fuel system. If there is air in the fuel system, there is probably a leak in the low pressure system.

This document has been printed from SPI². Not for Resale

This page is intentionally blank

This document has been printed from SPI². Not for Resale

12

Cooling system

General description

Coolant from the bottom of the radiator passes through the centrifugal coolant pump, which is fitted onto the front of the timing case to assist the flow of the coolant through the system.

The pump is driven by a "V" belt from the crankshaft pulley.

From the pump, the coolant passes through a passage in the timing case to a passage in the left side of the cylinder block and to the rear of the cylinder block.

Some coolant passes to a plate type oil cooler fitted to the oil filter head.

The coolant then passes around the cylinders and up into the cylinder head. The coolant leaves the cylinder head at the front and passes into the thermostat housing.

If the thermostat is closed, the coolant goes directly through a by-pass to the inlet side of the coolant pump. If the thermostat is open, the thermostat closes the by-pass and the coolant passes to the top of the radiator.

This document has been printed from SPI². Not for Resale

Thermostats

To remove and to fit — Operation 12-1

Note: Identification of the thermostat is by the nominal temperature which is stamped on the by-pass valve (A2) of the thermostat.

To remove

1 Drain the coolant level in the cooling system to below the thermostat position and disconnect the top hose from the coolant outlet connection.

2 Release the setscrews and remove the coolant outlet connection.

3 Remove the thermostat (A).

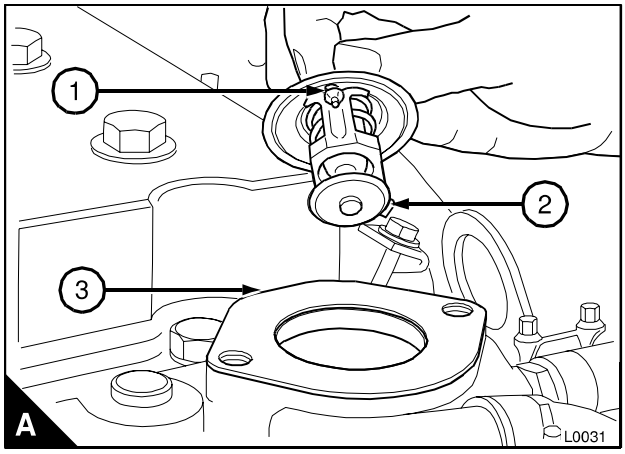
To fit

1 Ensure that the joint faces of the housing and the outlet are clean and that the jiggle pin (A1) in the thermostat is free to move.

2 Put the new thermostat in position in the housing.

3 Fit a new joint (A3) and the coolant outlet connection. Tighten the setscrews.

4 Connect the top hose and fill the cooling system.



To test — Operation 12-2

1 Hang the thermostat in a suitable container filled with coolant.

2 Heat the coolant gradually. Use a thermometer to check the temperature at which the valve starts to open and at which it is fully open. The correct temperatures are given in the relevant Data and dimensions for the "Thermostat" on page 26.

Caution: *If the thermostat does not operate correctly, it must be renewed. Do not try to adjust the settings.*

This document has been printed from SPI². Not for Resale

Coolant pump

To remove **Operation 12-3**

Special requirements

Special tools	
Description	**Part number**
Gear puller	PD.155C

1 Remove the fan, see Operation 12-7.

2 Remove the fan belt, see Operation 14-2.

3 Drain the cooling system and disconnect the hose connections to the coolant pump.

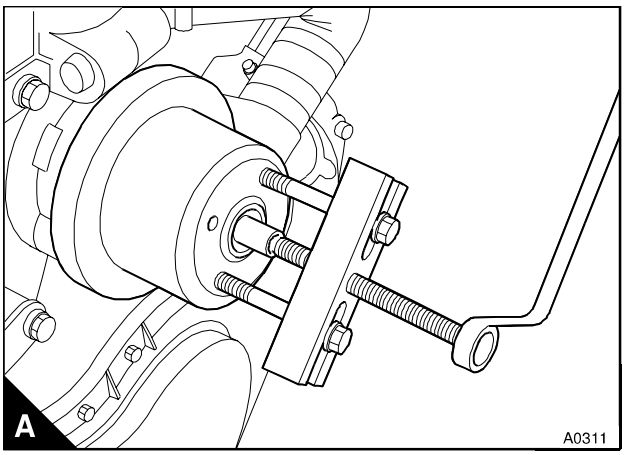
4 Remove the nut, spring washer and plain washer from the pump pulley. It may be necessary to use extractor PD. 155C to remove the pulley from the pump shaft (A).

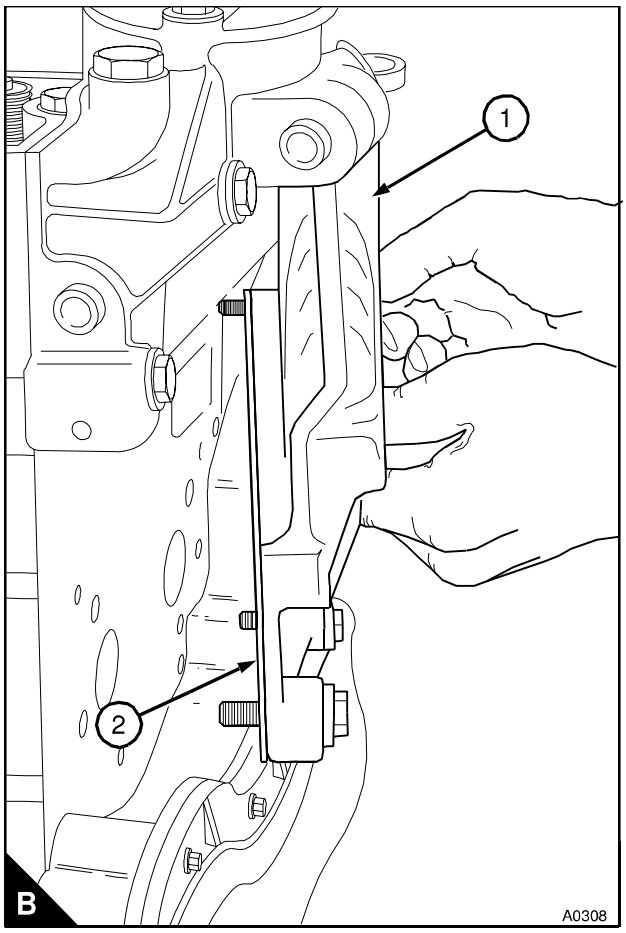
5 If the pump is to be dismantled remove the key from the keyway of the pump shaft.

6 Remove the four setscrews which secure the coolant pump to the rear body of the pump (B) and remove the pump from the engine.

7 Remove the coolant pump and discard the joint.

8 If it is necessary to remove the rear body (B1) of the pump from the cylinder block: Remove the setscrew for the alternator adjustment linkage and the spacer. Remove the four other setscrews and remove the rear body from the cylinder block. Discard the joint (B2).





This document has been printed from SPI². Not for Resale

To fit **Operation 12-4**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Retainer (oil tolerant)	21820603

Note: The joints are fitted without jointing compound.

1 If the rear body of the pump (A1) was removed from the cylinder block: Thoroughly clean the joint faces of the cylinder block and pump rear body. Fit a new joint (A2) between the rear body of the pump and the cylinder block.

2 Fit the rear body of the pump and the joint to the cylinder block. Fit the spacer and adjustment linkage for the alternator and tighten the M10 setscrews to 44 Nm (33 lbf ft) 4,5 kgf m and the M12 setscrews to 75 Nm (55 lbf ft) 7,6 kgf m.

3 Thoroughly clean the joint faces of the pump rear body and coolant pump (B2). Fit a new joint (B4) to the coolant the pump.

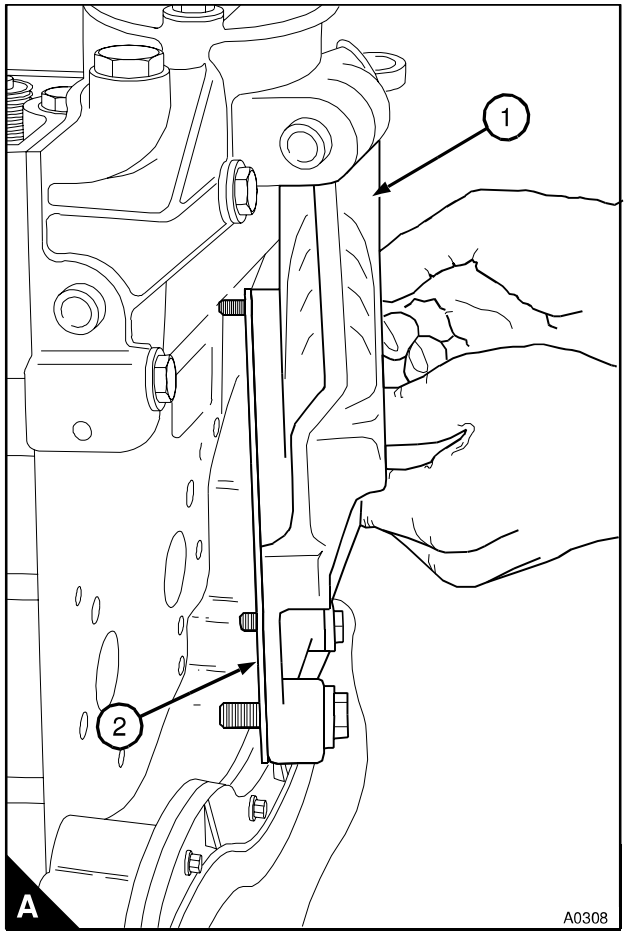
4 Fit the coolant pump and joint to the rear pump body and tighten the four M10 setscrews (B3) to 44 Nm (33 lbf ft) 4,5 kgf m.

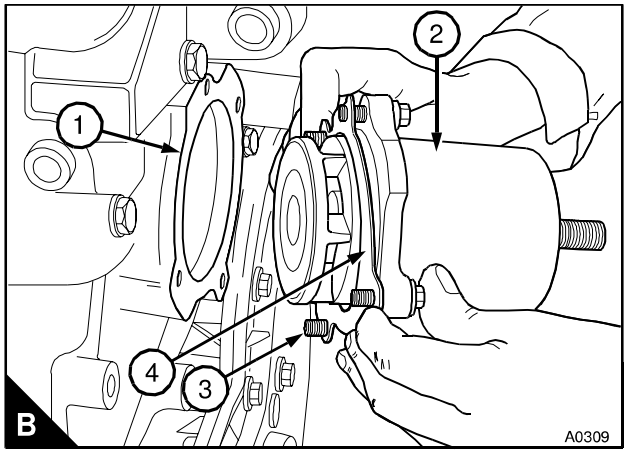
5 Fit the key to the keyway and put the pulley onto the pump shaft. Put the plain washer and the spring washer in position onto the pulley. Fit the nut and tighten it to 82 Nm (60 lbf ft) 8,2 kgf m.

6 Connect the hoses to the coolant pump, tighten the clips and fill the cooling system.

7 Fit the fan belt, see Operation 14-2.

8 Fit the fan, see Operation 12-7.





This document has been printed from SPI². Not for Resale

To dismantle — Operation 12-5

Special requirements

Special tools	
Description	**Part number**
Standard bench press	-

1 Remove the coolant pump (A) from the engine, see Operation 12-3.

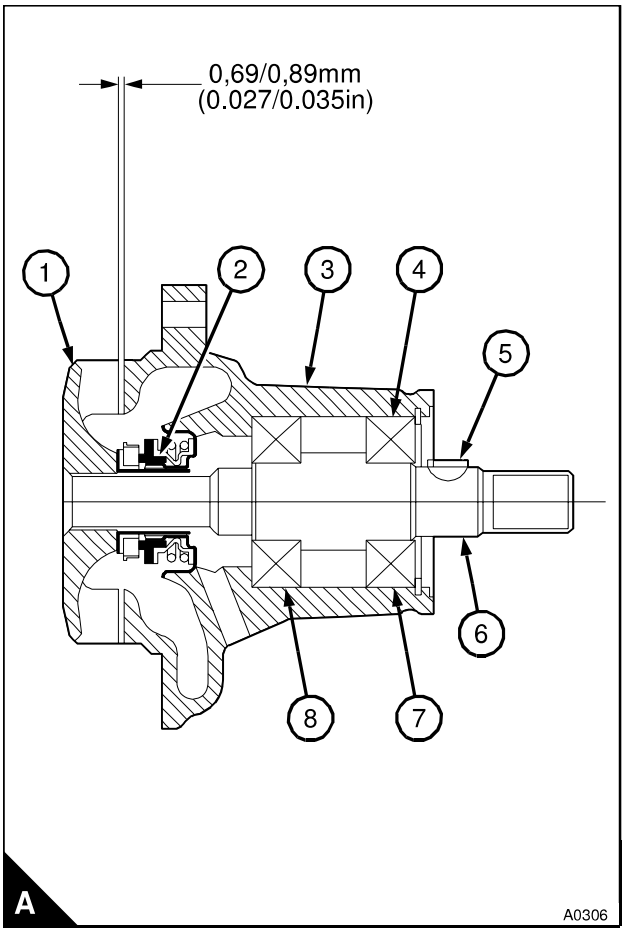
2 Remove the circlip (A4) for the bearing housing.

3 Support the pulley end of the pump and press the shaft (A6) through the impeller (A1) and coolant seal (A2). This will remove the bearing (A7).

4 Remove the impeller. Discard the coolant seal.

5 Support the pulley end of the pump and press out the bearing (A8). Discard the bearings.

6 Clean the body of the pump in a suitable safe cleaning fluid. Inspect the pump body for cracks.



This document has been printed from SPI². Not for Resale

To assemble **Operation 12-6**

Special requirements

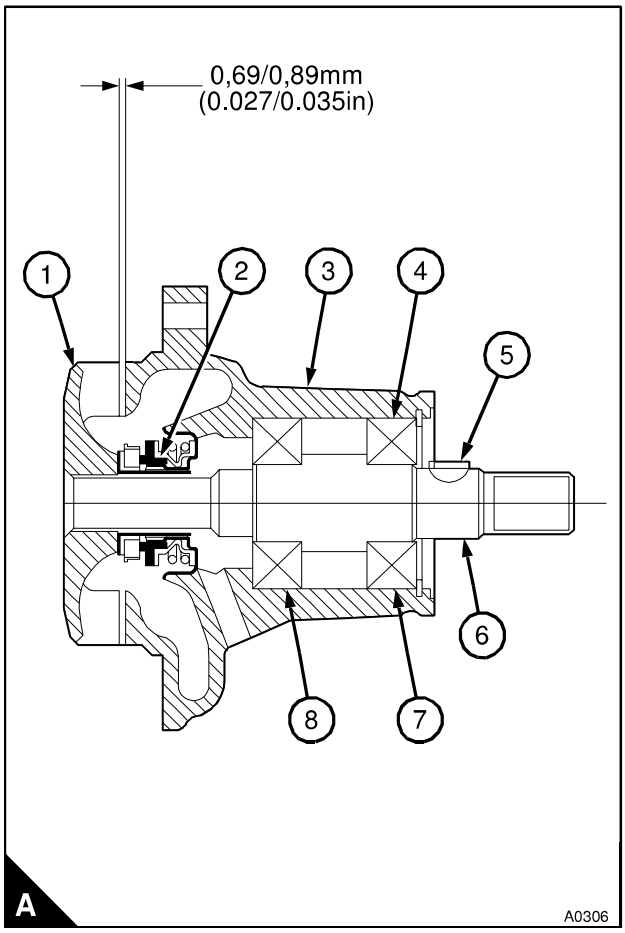
Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Standard bench press	-	POWERPART Retainer (oil tolerant)	21820603

The service kit for the pump contains two bearings, the shaft, a circlip and a coolant seal.

Each bearing is filled with grease and sealed by the bearing manufacturer. The bearings will not need attention during service.

1 Support the impeller end of the pump body. Apply a narrow ring of POWERPART Retainer (oil tolerant) to the face of the outer race of each bearing race. Put the bearing (A8) into position on the pump housing. Use a suitable adaptor on the outer race and press the bearing fully into the back of the bearing housing.

2 Support the inner race of the bearing just fitted from the impeller end of the pump body. Use a suitable adaptor which will allow the shaft (A6) to pass through it. Press the new shaft into the bearing until shoulder of the shaft is fully against the inner race of the bearing. Put the bearing (A7) into position on the pump housing and shaft. Use a suitable adaptor on the inner and outer race to ensure the pressure is applied evenly. Press the bearing onto the shaft and housing until the inner race of the bearing is against the shoulder of the shaft. Remove excess retainer and fit the new circlip (A4).



Continued

This document has been printed from SPI². Not for Resale

3 Fit a new coolant seal (A2) as follows:

Caution: *It is important that only the tool, shown in (C), is used to fit the new coolant seal.*

The coolant seal is an interference fit on the shaft and a tool will be necessary to fit the seal correctly.

The tool should be made of mild steel bar to the dimensions shown in (C), listed as follows:

A 44,0 mm (1.73 in) **C** 11,3 mm (0.44 in) **E** 16,1 mm (0.63 in) **G** 2,00 mm (0.08 in) at 45°
B 40,0 mm (1.57 in) **D** 37,3 mm (1.47 in) **F** 1,00 mm (0.04 in) at 45°

The dimensions of the tool to fit the coolant seal, will ensure that the seal is the correct length after it is installed. It will also prevent axial distortion of the seal when it is pressed onto the shaft.

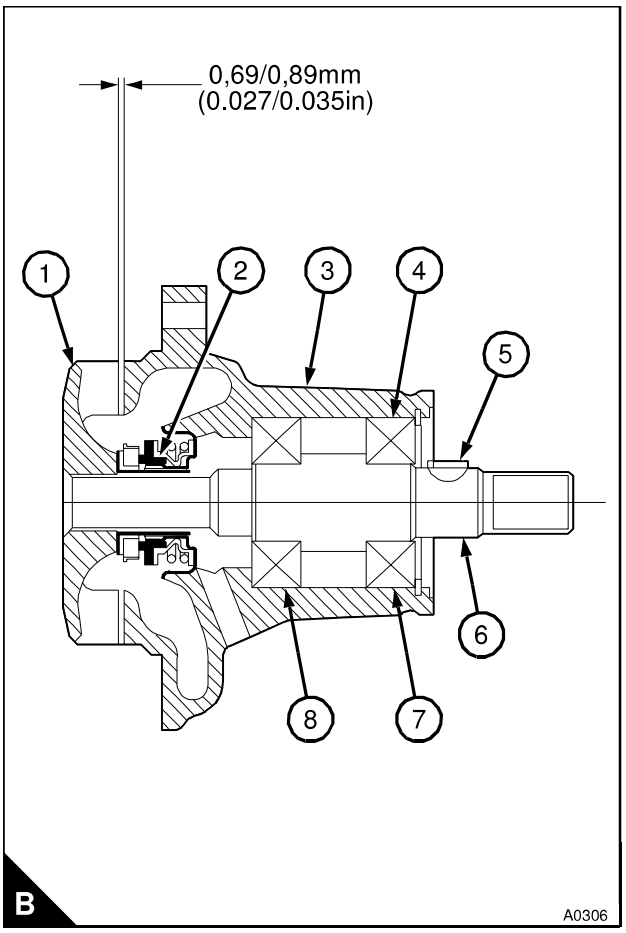
Do not lubricate the seal. It is important that the seal is not contaminated by oil or grease and if it is held in the hand, it should be held by the edge of the flange. Do not damage the ring of green sealant applied to the body of the coolant seal just behind the flange of the seal.

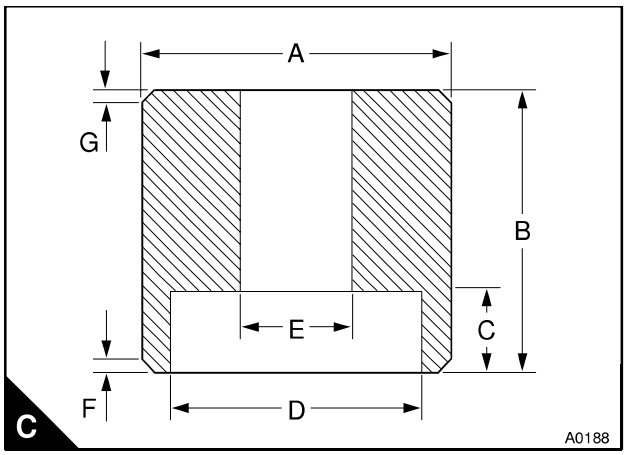
Support the pulley end of the shaft, ensure that there are no sharp edges on the edge of the shaft and put the seal into position on the end of the shaft. Ensure that the ring of sealant is towards the bearings. Use the tool to press the seal onto the shaft until the bottom of the seal flange is in complete contact with the pump body. Continue to apply force for approximately ten seconds to ensure that the seal remains in position when the force is released.

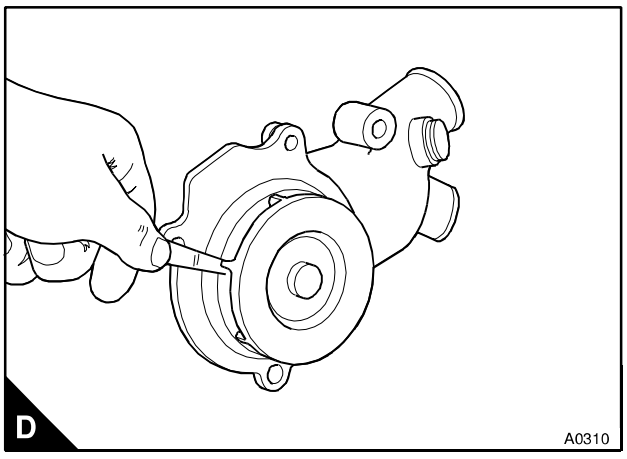
4 Support the pulley end of the shaft and press the new impeller (B1) onto the shaft until the clearance between the impeller blades and the pump body is 0,69/0,89 mm (0.027/0.035 in) (B). The clearance can be checked with a feeler gauge (D). The minimum clearance with end float is 0,19 mm (0.007 in).

Rotate the shaft to ensure that the impeller is free.

5 Fit the coolant pump to the engine, see Operation 12-4.







This document has been printed from SPI². Not for Resale

To remove and to fit — Operation 12-7

To remove

1 Release the setscrews and remove the fan.

2 If necessary, fit the setscrews to retain the fan extension and the pulley to the hub.

To fit

1 Clean thoroughly the rear of the fan where it fits onto the fan extension. Also ensure that all paint is removed from this area.

2 Put the pulley into position on the hub and the fan extension onto the pulley. Clean the front face of the fan extension.

3 Fit the fan and tighten the setscrews to the torque shown in "Recommended torque settings" on page 28.

This document has been printed from SPI². Not for Resale

Lubricating oil cooler

To remove and to fit (canister type) — Operation 12-8

To remove

1 Drain the cooling system.

2 Release the hose clips of the coolant pipes at the oil cooler (A3). Release the threaded adaptor (A5) from the lubricating oil cooler and pull the oil cooler (A6) from the hose connections and the filter head (A1).

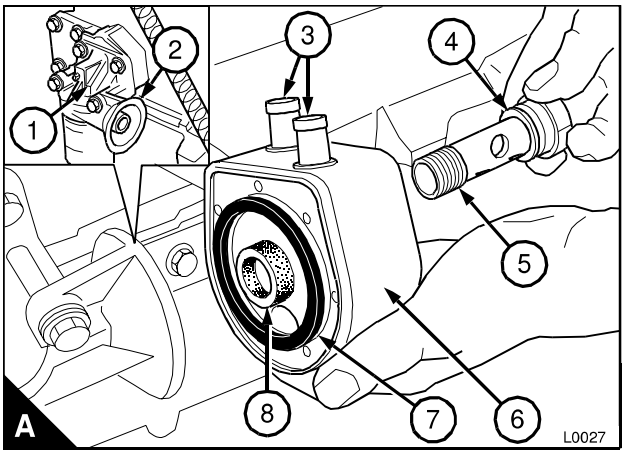
To fit

1 Clean the joint face of the filter head (A2).

2 Check the Washer (A4) and the seals (A7) and (A8) for damage and renew the washer and the seals if they are damaged or worn. Lightly lubricate the seals with clean lubricating oil.

3 Push the hose connections for the coolant pipes onto the lubricating oil cooler. Hold the oil cooler in position against the filter head and fit the threaded adaptor. Tighten the threaded adaptor to 37 Nm (27 lbf ft) 3,8 kgf m. Ensure that the hose connections are fitted correctly and tighten the hose clips.

4 Fill the cooling system.



This document has been printed from SPI². Not for Resale

This page is intentionally blank

This document has been printed from SPI². Not for Resale

13

Flywheel and flywheel housing

General description

The steel flywheel is fitted with a hardened starter ring. Generally the starter rings have 126 teeth, but certain starter rings have 132 teeth.

The flywheel housing is normally made of cast iron, but certain flywheel housings are made of aluminium alloy.

This document has been printed from SPI². Not for Resale

Flywheel

To remove and to fit — Operation 13-1

Warning! *The flywheel is heavy, use lift equipment or get help to assist with the lift operation before removal of the flywheel fasteners.*

To remove

1 Remove two opposite setscrews from the flywheel and fit temporarily two guide studs to ensure safety when the flywheel is removed and fitted.

2 Remove the remainder of the setscrews and washers and remove the flywheel.

3 Check the flywheel and ring gear for damage and renew, if necessary.

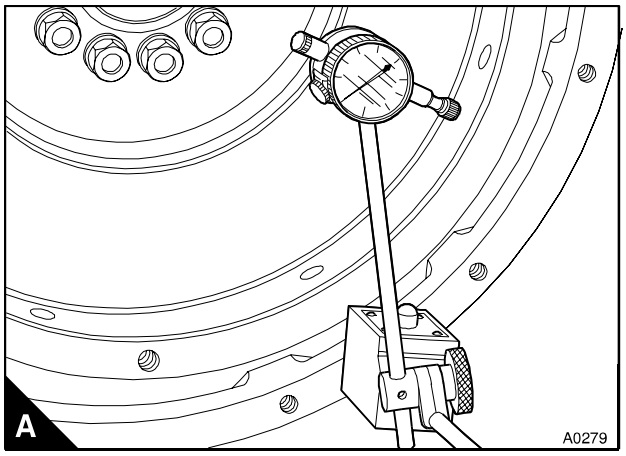
To fit

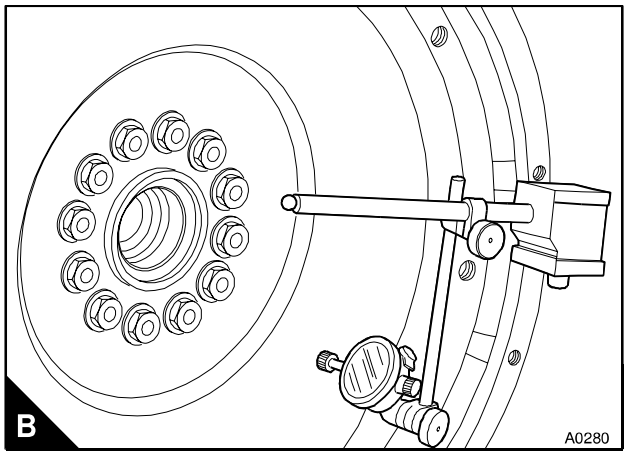
1 Ensure that the location faces of the crankshaft and the flywheel are clean and free from damage.

2 Fit the flywheel over the guide studs. Fit four setscrews and their washers. Remove the guide studs and fit the remainder of the setscrews and the washers. Tighten the setscrews to 105 Nm (77 lbf ft) 10,7 kgf m.

3 Check the flywheel run-out with a dial test indicator (A). This must be less than 0,30 mm (0.012 in) total indicator reading.

4 Check the alignment of the flywheel face (B). The error in alignment must not be more than 0,03 mm (0.001 in) total indicator reading for every 25 mm (1.0 in) of the flywheel radius from the crankshaft axis to the indicator plunger. During this check, keep the crankshaft pressed toward the front to remove the effect of crankshaft end-float.





This document has been printed from SPI². Not for Resale

Ring gear

To remove and to fit **Operation 13-2**

To remove

Warning! *wear eye protection during this operation.*

Before the ring gear is removed, check the position of the chamfer on the teeth.To remove the ring gear use a hammer and a chisel to break the ring.

Caution: *Ensure that the flywheel is not damaged during this operation.*

To fit

The ring gear is heated onto the flywheel. When a new gear is to be fitted, ensure that it is not heated to more than 250 °C (480 °F). Ensure that the chamfer on the teeth of the gear is in the correct direction.

This document has been printed from SPI². Not for Resale

To remove and to fit — Operation 13-3

Warning! *The flywheel housing is heavy, use lift equipment or get help to assist with the lift operation before removal of the flywheel housing fasteners.*

To remove

1 Remove the starter motor, see Operation 14-5, and the flywheel, see Operation 13-1.

2 Release the housing setscrews and with a soft face hammer, hit carefully the housing to remove it from the dowels.

To fit

1 Ensure that the rear face of the cylinder block and the faces of the housing are clean and free from damage. Ensure that the location dowels are fitted correctly. If a felt seal is fitted to the rear flange of the sump, renew the seal.

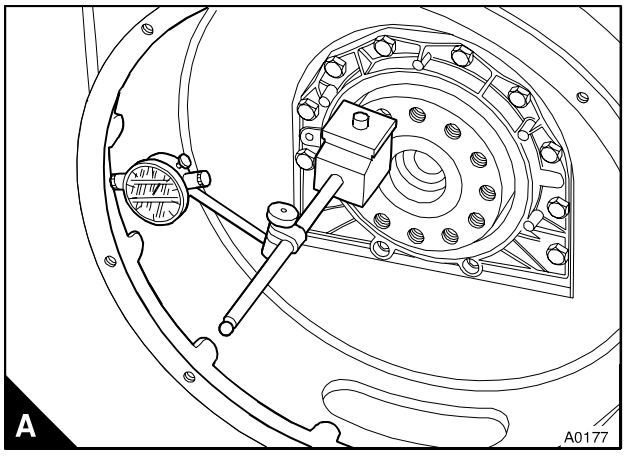
2 Fit the housing onto the dowels and tighten lightly the setscrews.

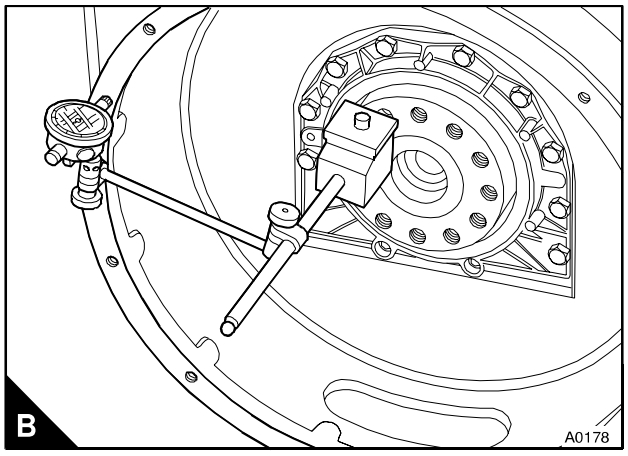
3 Check the housing concentricity with a dial test indicator (A). The run-out limit is given in the relevant Data and dimensions for the "Flywheel and flywheel housing" on page 27. If any adjustment is necessary, it must be made on the housing and the concentricity checked again.

4 Tighten the setscrews to the torque recommended in "Recommended torque settings" on page 28.

5 Check the housing alignment (B). The maximum tolerance is given in the relevant Data and dimensions for the "Flywheel and flywheel housing" on page 27. Any necessary adjustment must be made on the housing and not on the cylinder block.

6 Fit the flywheel, see Operation 13-1 and the starter motor, see Operation 14-5.





This document has been printed from SPI². Not for Resale

14

Electrical equipment

Alternators

General description

The alternator is driven from the crankshaft pulley by a single belt.

Precautions

To prevent damage to the diodes and to the resistors, the precautions given below must be followed:

- Do not disconnect the battery while the engine is in operation. This will cause a voltage surge in the alternator charge system which will immediately cause damage to the diodes or to the transistors.
- Do not disconnect an electrical wire before the engine is stopped and all electrical switches are in the "off" position.
- Do not cause a short circuit by the connection of electrical wires to the wrong terminals. The correct electrical wire must be connected to the correct terminal. A short circuit or wrong connection which gives reverse polarity will immediately cause permanent damage to the diodes and to the transistors.
- Do not connect a battery into the system until it has been checked for correct polarity and voltage.
- Do not check for current flow with a spark contact as damage can be caused to the transistors.

This document has been printed from SPI². Not for Resale

To check and to adjust drive belt tension — Operation 14-1

To check

1 Renew the belt if it is worn or damaged.

2 To check the belt tension: Press down the belt with the thumb at the centre of the longest free length and check the deflection (A). With moderate thumb pressure - 45 N (10 lbf) 4,5 kgf - the correct deflection of the belt is 10 mm ($^{3}/_{8}$ in).

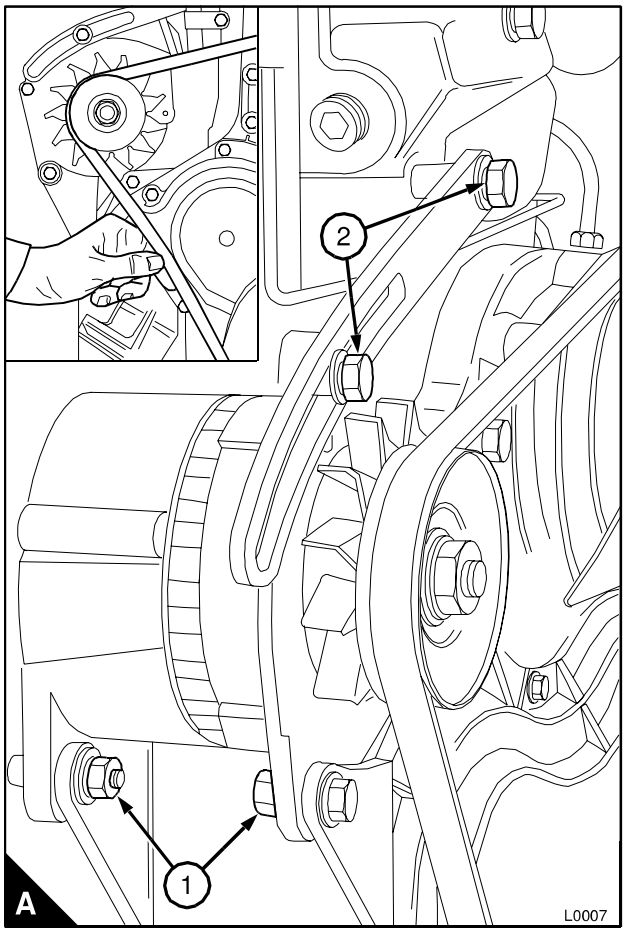
To adjust tension

1 Loosen the pivot fasteners (A1) of the alternator and the adjustment link fasteners (A2).

2 Change the position of the alternator to give the correct tension. Tighten the pivot fasteners of the alternator and the adjustment link fasteners.

3 Check the belt tension again to ensure that it is still correct.

Note: If a new belt is fitted, the belt tension must be checked again after the first 20 hours of operation.



This document has been printed from SPI². Not for Resale

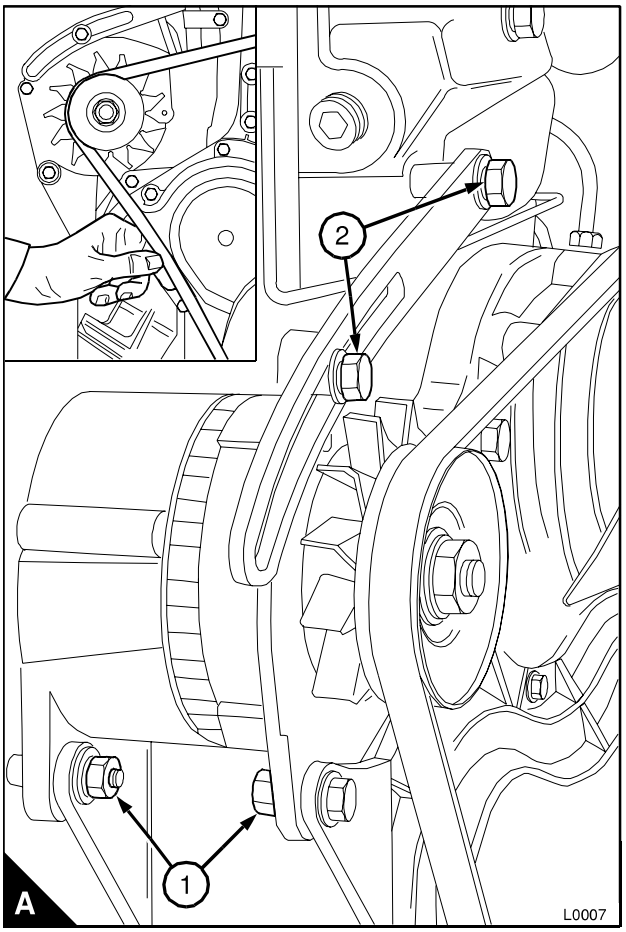
To remove and to fit the drive belt **Operation 14-2**

1 Loosen the pivot fasteners (A1) of the alternator and the adjustment link fasteners (A2).

2 Release all of the tension from the belt and remove the belt.

3 Fit the new belt and adjust the tension, see Operation 14-1.

Note: The belt tension must be checked again after the first 1000 km (600 miles) or 20 hours of operation.



This document has been printed from SPI² Not for Resale

To remove and to fit the alternator — Operation 14-3

To remove

1 Disconnect the electrical connection.

2 Loosen the pivot fasteners of the alternator and the fasteners of the adjustment link.

3 Release all the belt tension and remove the belt.

4 Remove the adjustment link from the alternator and remove the pivot bolt. Make a note of the position of the washers and distance pieces to ensure that they are fitted correctly. Remove the alternator.

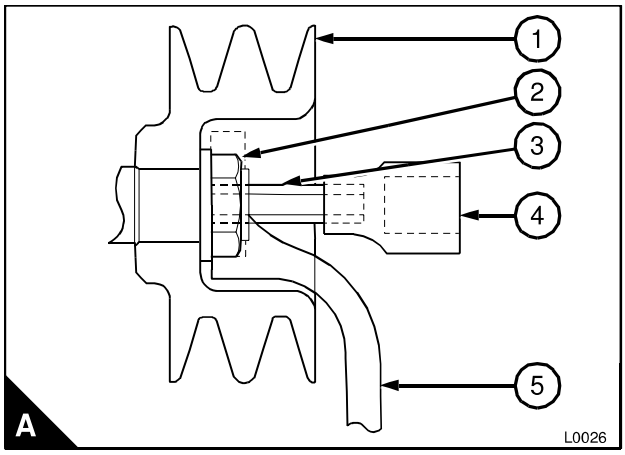
To fit

1 Put the alternator in position and assemble loosely the pivot fasteners and the adjustment link and its fasteners. Ensure that the washers and the distance pieces are fitted in their correct positions and that the alternator pulley (A1) is aligned to the crankshaft pulley within +/- 2,4 mm ($^{3}/_{32}$ in).

Note: Before the nut for the shaft of the A127 alternator pulley can be tightened the shaft must be held in position by an 8 mm allen key (A3) and socket wrench (A4). Torque is then applied to the nut (A2) by a torque spanner (A5), see "Recommended torque settings" on page 28 for the correct torque.

2 Fit the drive belt(s), see Operation 14-2, and adjust the drive belt tension, see Operation 14-1. Tighten the fasteners and check the tension again.

3 Connect the electrical connection.



To maintain the alternator — Operation 14-4

1 Ensure that the drive belts are not worn and that the belt tension is correct.

2 Keep the alternator clean. To clean the alternator, use a material which is damp with kerosene or a special fluid used for this purpose. Ensure that the fluid does not enter the cover of the alternator.

3 Ensure that air can pass easily over the casing to keep it cool.

This document has been printed from SPI². Not for Resale

Alternator fault diagnosis

The alternator is designed in such a way that a flow of current (indicated by no light at the warning light or a reading shown on an ammeter) shows that the system is in correct operation. If the system is in correct operation, no open circuit, voltage or current output checks need to be done on the installation unless:

- The warning light does not show when the alternator is stationary and the switch is in the "on" position or it shows a light when the alternator is in operation.
- No charge current is shown on the ammeter.
- The battery is discharged.
- The battery is hotter than normal which is an indication of loss of voltage control.

If one or more of the above symptoms occur, the procedure indicated below should be applied.

1 Ensure that the battery is fully charged.

2 Connect a moving-coil voltmeter of good quality, with a range of 0-50 volts, across the positive and negative terminals of the alternator. If an ammeter is not fitted in the electrical circuit, fit a moving-coil ammeter of good quality, with a range of 0-100 ampere, in the wire between the alternator and the positive terminal of the battery.

3 Turn the warning light switch to the "on" position (main switch on instrument panel); the warning light should be illuminated.

4 Switch on a 10-15 ampere load, for example, lights, fans, etc.

5 Start the engine and operate it at a fast idle speed; either the warning light should be extinguished or the ammeter indicates a small change in the current in relationship to the engine speed.

6 Increase the engine speed for a moment to near maximum speed, when the charge current should be approximately equal to the rating for the alternator, refer to the relevant Data and dimensions for the "Alternators" on page 27.

7 Operate the alternator at approximately half speed (engine speed approximately 1500 rev/min) and remove the electrical load. The voltage should go up to 14 volts for a 12 volt system or 28 volts for a 24 volt system and then remain constant. At the same time the current reading should show a reduction.

Any change in the above data can indicate a fault and the procedure that follows should be used before any components are disconnected. This procedure is not suitable for A127 alternators and, if a fault is found, the alternator should be removed for test by a specialist.

The regulator is a sealed unit and a repair is not possible. If there is a regulator fault, the regulator must be renewed.

If the warning light is not illuminated when the switch is in the "on" position:

Check the bulb. If no fault:

Check all the connections at the regulator, at the alternator and at the battery.

If no fault:

Turn the switch to the "off" position. Disconnect the wire from the "F" terminal on the alternator and connect a wire between the "F" terminal and the negative terminal on the alternator. Turn the switch to the "on" position.

If the warning light shows, the fault is in the regulator.

If the warning light does not show, the fault is in the alternator.

Continued

This document has been printed from SPI². Not for Resale

If the warning light continues to show and the ammeter shows no output when the alternator is in operation:

Check all the connections at the regulator, alternator and battery.

If no fault:

Turn the switch to the "off" position. Disconnect the wire from the "F" terminal on the alternator and connect a wire between the "F" terminal and the negative terminal on the alternator. Turn the switch to the "on" position and operate the engine at fast idle.

If there is no output, there is a fault in the alternator.

If there is an output, there is a fault in the regulator.

If the warning light continues to show when the alternator is in operation and the ammeter shows a reduced output with maximum output only at maximum engine speed or if the warning light does not show, but there is a reduced output from the alternator with maximum output only at maximum engine speed:

There is a fault in the alternator.

If there is an intermittent light from the warning light and the ammeter needle is not stationary when the battery is charged fully and no load is applied:

Check for a higher than normal resistance in the negative control wire of the regulator.

If the resistance is normal, there is a fault in the regulator.

If the battery charge is too high and the ammeter indicates high or maximum output at all times:

Check the positive control wire and its connection at the regulator.

If the wire and its connection are correct, there is a fault in the regulator.

This document has been printed from SPI². Not for Resale

Starter motors

General description

Magneti Marelli M127 and Bosch JF starter motors are fitted to these engines.

If a Delco Remy starter motor is fitted, a distance piece is fitted between the starter motor flange and the flywheel housing.

To remove and to fit — Operation 14-5

Special requirements

Consumable products	
Description	**Part number**
POWERPART Hylosil	1861108

To remove

If the engine has a flywheel housing which is oil filled, drain the flywheel housing before the starter motor is removed.

1 Disconnect the battery.

2 Disconnect the starter motor cables.

3 Release the fasteners and remove the starter motor and, if fitted, the distance piece.

To fit

1 If one is fitted, put the distance piece in position with its location lip to the flywheel housing. Fit the starter motor and tighten the fasteners.

2 Connect the starter motor cables. If the engine has a flywheel housing which is oil filled, the starter motor must be sealed before it is fitted. Clean the flange face of the starter motor and the face of the flywheel housing. Apply a 2,0 mm (0.080 in) continuous bead of POWERPART Hylosil to the flange face of the starter motor near to the spigot.

3 Connect the battery.

This document has been printed from SPI². Not for Resale

To test on the engine **Operation 14-6**

Ensure that the battery is fully charged.

Turn on the lights and operate the starter switch. If no lights are fitted to the machine, connect a voltmeter across the battery terminals and operate the starter switch.

If the starter does not operate but the lights keep their power or there is no voltage drop across the battery, check the switch and all the connections and wires. Slow action of the starter can be caused by faulty connections.

Failure to engage smoothly between the starter and the flywheel can be caused, on some types of starter motor, by dirt on the helical grooves of the starter motor drive, which can prevent free pinion movement. Clean the shaft thoroughly with gasolene, or a fluid made especially for the purpose, and apply a small quantity of Aero Shell 6B or its equal.

This document has been printed from SPI². Not for Resale

Starting aid

General description

There are two types of electrical starting aid in use: The fuelled starting aid and the port heater.

The fuelled starting aid is a device which is operated electrically and ignites a controlled amount of diesel fuel in the induction manifold to heat the induction air. A heater coil in the body expands a valve holder to allow fuel to flow into the device. The fuel is ignited by the hot coil and the heated air enters the induction manifold when the starter motor is operated.

The port heater has an electrically heated coil that heats the air as it enters the induction manifold. Port heaters are used in a group of two or three.

To remove and to fit a fuelled starting aid **Operation 14-7**

To remove

1 Disconnect the fuel pipe (A1) and the electrical connection (A2).

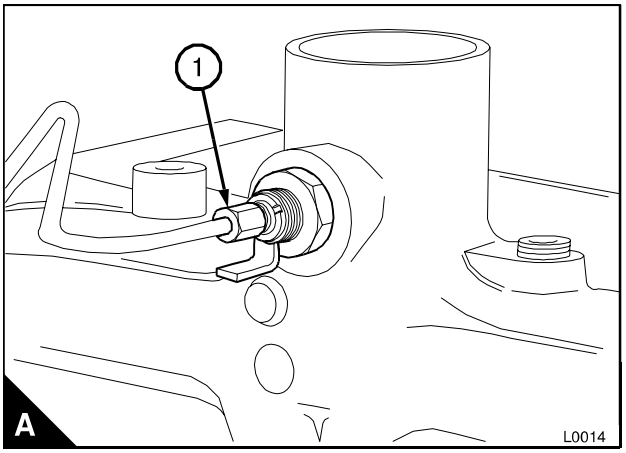
2 Remove the starting aid.

To fit

1 Ensure that the contact faces of the manifold and the starting aid are clean. Put the sealing washer into position and fit the starting aid. Tighten the starting aid to 31 Nm (23 lbf ft) 3,2 kgf m.

2 Check the fuel pipe and, if it is still full of fuel, connect it to the starting aid. If the fuel has drained from the pipe, eliminate the air from the pipe as shown in step of Operation 11-13.

3 Connect the electrical connection (A2).



This document has been printed from SPI². Not for Resale

To check the fuelled starting aid **Operation 14-8**

If the inside of the induction manifold is wet, check that there is not a fuel leak from the fuelled starting aid.

1 Disconnect the fuel pipe and the electrical connection at the starting aid. Remove the starting aid from the manifold and fit a suitable plug in the manifold.

2 Connect the fuel pipe to the starting aid, but leave the connection loose. Do not fit the electrical connection, but ensure that the connector has a suitable insulator fitted. Operate the priming lever of the fuel lift pump until fuel free of air comes from the connection. Tighten the connection.

3 Start the engine and operate it at low speed.

Check that there is no fuel leakage from the valve of the starting aid.

4 If there is no leakage, remove the plug from the induction manifold and fit the starting aid. Connect the fuel pipe to the starting aid and remove the air from the pipe as shown above. Connect the electrical connection.

If there is a leak from the valve of the starting aid, fit a new starting aid.

This document has been printed from SPI². Not for Resale

15

Auxiliary equipment

Power take-off adaptors (adaptor for a hydraulic pump)

To remove and to fit **Operation 15-1**

To remove

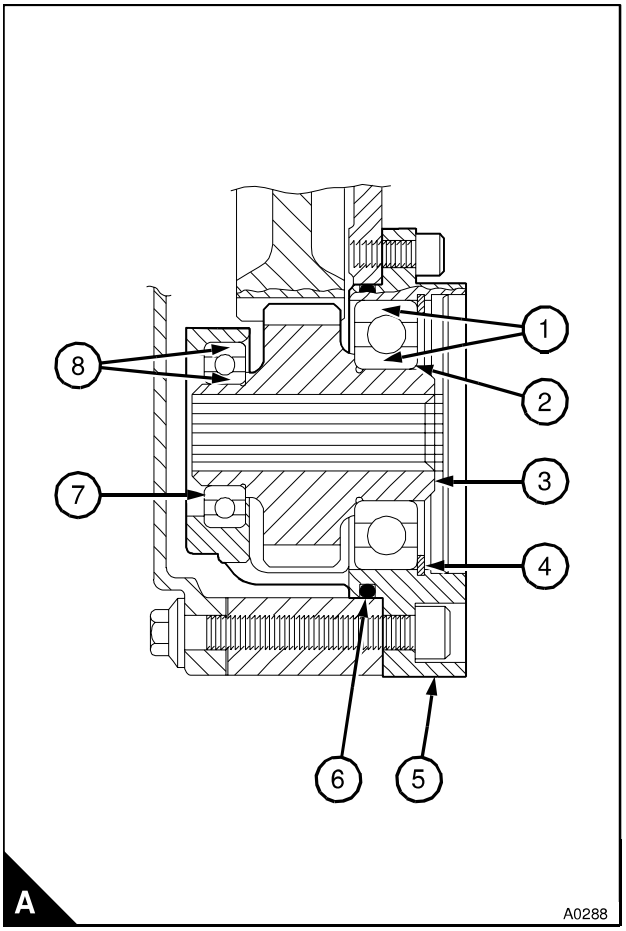
1 Release the cap screws and remove the adaptor assembly from the rear of the timing case.

2 Check the gear, the spline and the bearings for wear and other damage and renew the components as necessary.

To fit

1 Fit a new "O" ring (A6) in its recess in the housing (A5) and lightly lubricate it with clean engine lubricating oil.

2 Lubricate the bearings (A2) and (A7) with clean engine lubricating oil. Fit the adaptor assembly to the timing case and tighten the cap screws.



This document has been printed from SPI². Not for Resale

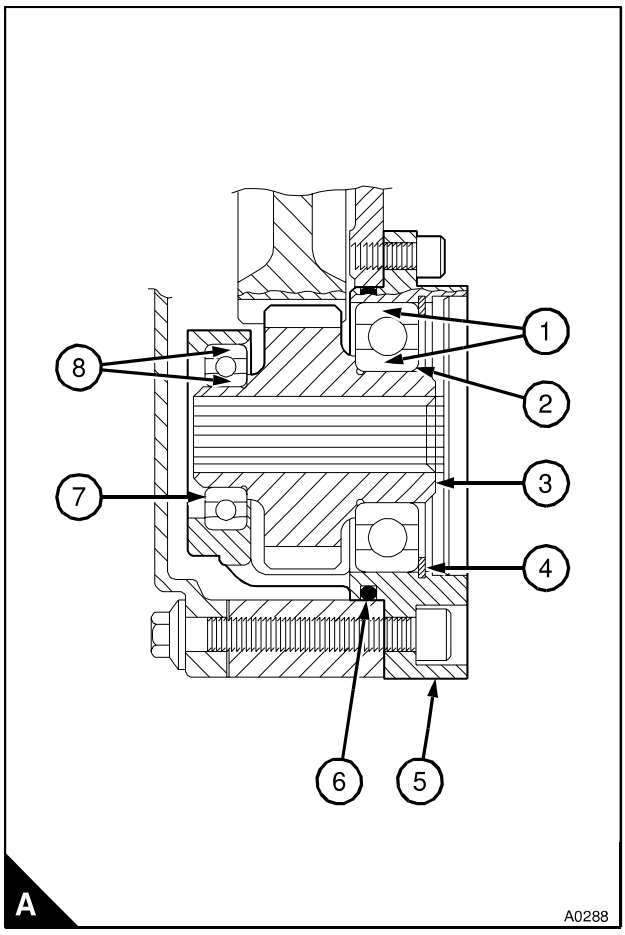
To dismantle **Operation 15-2**

1 Remove the hydraulic pump.

2 Remove the adaptor assembly, see Operation 15-1.

3 Remove the circlip (A4). Provide a support for the flange face of the housing (A5). Use a suitable adaptor on the front bearing (A7) to press the gear and bearings out of the housing.

4 Remove the bearings from the gear (A3) with a suitable gear puller.



This document has been printed from SPI². Not for Resale

Special requirements

Consumable products	
Description	**Part number**
POWERPART Retainer (oil tolerant)	21820603

1 Apply a narrow ring of POWERPART Retainer (oil tolerant) to the outer face of the front bearing (A7) in the position shown (A1). Provide a support for the front face of the housing. Use a suitable adaptor on the outer ball guide of the bearing to press the front bearing onto the shoulder in the housing. Remove excess retainer (oil tolerant).

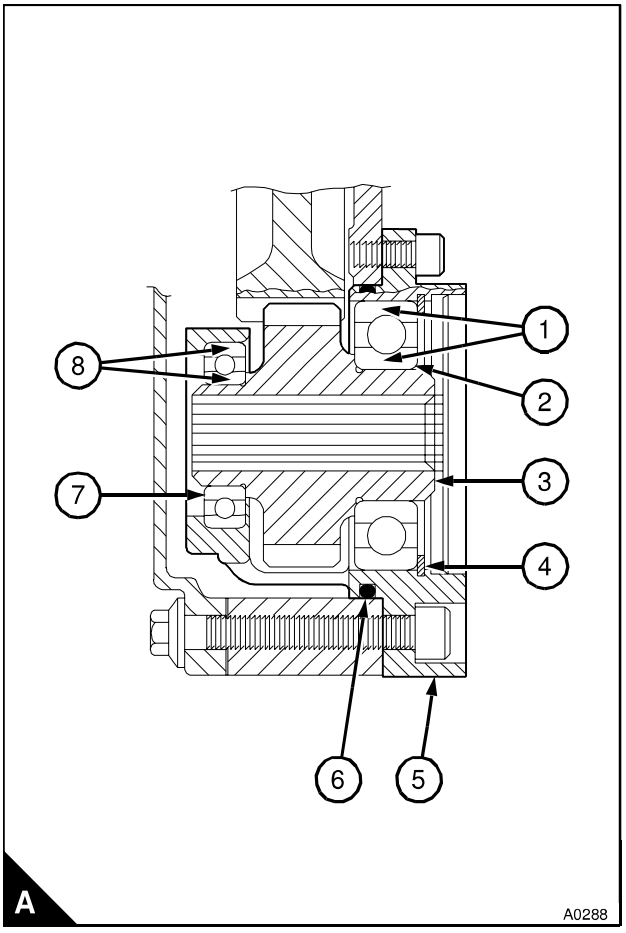
2 Apply a narrow ring of POWERPART Retainer (oil tolerant) to the inner face of the front bearing in the position shown (A1). Provide a support for the bearing. With the small diameter of the gear toward the bearing, press the gear into the bearing until the gear is onto its shoulder.

3 Apply a narrow ring of POWERPART Retainer (oil tolerant) to the outer face and to the inner face of the rear bearing (A2) in the positions shown (A1). Ensure that the support is under the front bearing. Use a suitable adaptor on the outer ball guide of the bearing to press the bearing into the housing and onto the shoulder on the gear. Remove excess retainer. Fit the circlip into its groove in the housing.

4 Check the backlash between the power take-off gear and the idler gear: Power take-off gears are identified by the part number stamped on the gear face.

The backlash for gears with part numbers 3117C111, 3117C112 or 3117C113, is 0,08 mm (0.003 in) minimum.

The backlash for gears with part numbers 3117C114, 3117C115 and 3117C116 is 0,18/0,25 mm (0.007/0.010 in) minimum.



This document has been printed from SPI². Not for Resale

To remove and to fit — Operation 15-4

To remove

1 Disconnect the lubricating oil and vacuum pipes from the exhauster and fit covers to the open ends of the pipes.

2 Release the setscrews and remove the exhauster.

To fit

1 Ensure that the joint faces of the exhauster and the timing case are clean and renew the joint. Fit the exhauster to the timing case and tighten the setscrews.

2 Remove the covers from the open ends of the pipes and connect the oil pipe and the vacuum pipe to the exhauster.

This document has been printed from SPI². Not for Resale

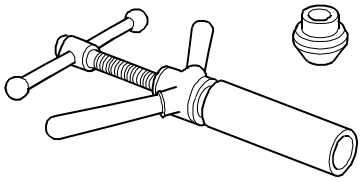
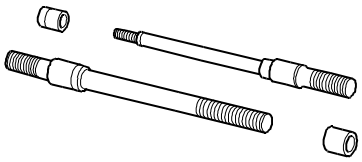
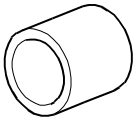
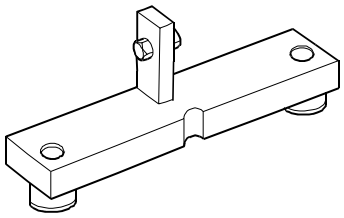
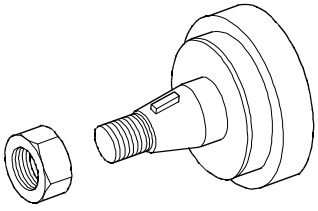
16

Special tools

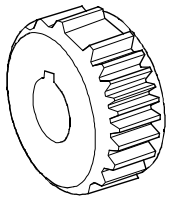
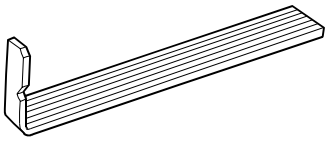
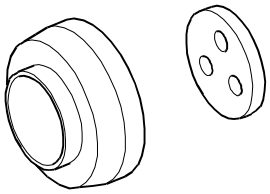
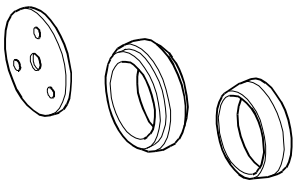
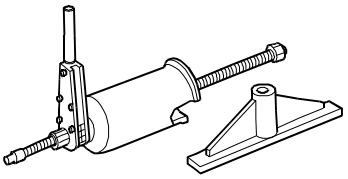
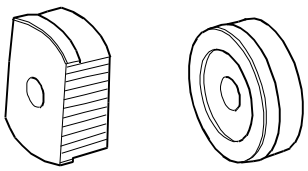
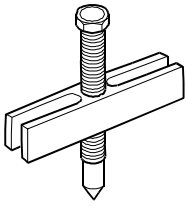
List of special tools

These tools are available through your local Perkins Distributor. If you cannot obtain the correct tool locally contact:

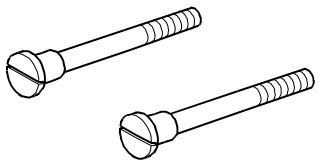
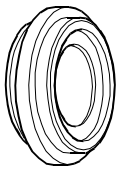
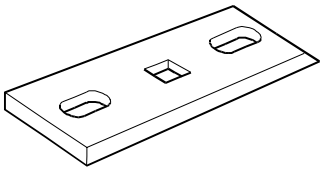
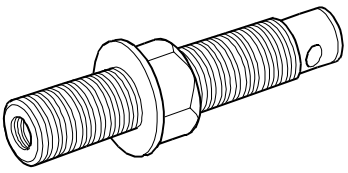
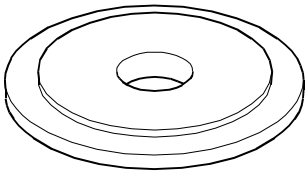
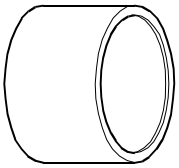
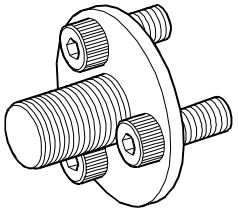
The Perkins Service Department, Peterborough, PE1 5NA, England, UK. Tel 01733 583000, Fax 01733 582240, Telex 32501 PERKEN G.

Number	Description	Illustration
PD.1D	Remover/replacer for valves guides (main tool) Part number 21825478	
PD.1D-1A	Adaptor for use with PD.1D Part number 21825479	
PD.1C-6	Adaptor for use with PD.1D and PD.1D-1A Part number 21825482	
PD.41D	Gauge for piston height, valve depth and cylinder liner flange; for use with PD.208. Part number 21825496	
PD.67-2	Drive adaptor for use with MS.67B. Part number 21825512	

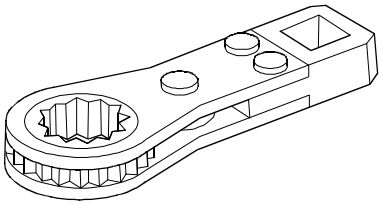
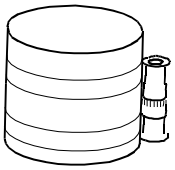
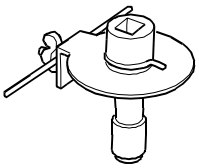
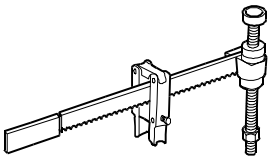
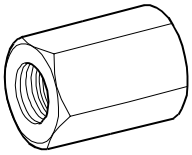
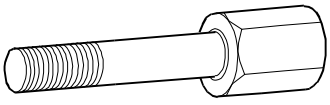
This document has been printed from SPI². Not for Resale

Number	Description	Illustration
PD.67-3	Gear adaptor for use with MS.67B. Part number 21825513	
PD.67-4	Pointer for use with MS.67B. Part number 21825514	
PD.162B	Centralising tool for timing case cover (four cylinder engines) Part number 21825936	
PD.145D	Replacer tool for crankshaft rear seal. Part number 21825540	
PD.150B	Remover/replacer for cylinder liner (main tool). Part number 21825543	
PD.150-7B	Adaptors for use with PD.150B. Part number 21825551	
PD.155C	Basic puller for camshaft and fuel pump gears. Part number 21825565	

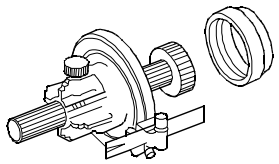
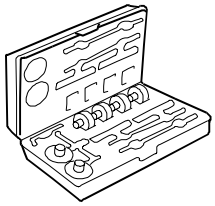
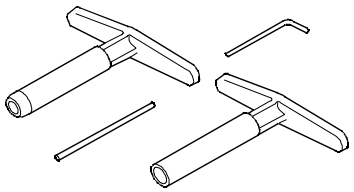
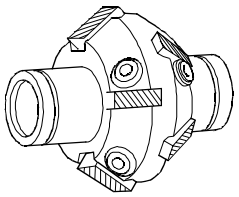
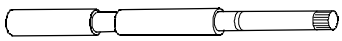
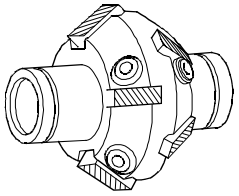
This document has been printed from SPI². Not for Resale

Number	Description	Illustration
PD.155B-5	Adaptors for use with PD.155C. Part number 21825568	
PD.170-4	Adaptor for standard seal for use with PD.170. Part number 21825581 (PD.170-4)	
PD.165B	Crankshaft rotation adaptor for use with a 12,7 mm (0.5 in) square drive. Part number 21825576	
PD.170	Replacer tool for seal of timing case cover (main tool). Part number 21825577	
PD.170-1	Pressure plate for use with PD.170. Part number 21825578	
PD.170-2	Sleeve for use with PD.170. Part number 21825579	
PD.170-3	Fastener plate for use with PD.170. Part number 21825580	

This document has been printed from SPI². Not for Resale

Number	Description	Illustration
PD.239	Spanner for flange nuts of fuel injection pump. Part number 21825964	
PD.206	Replacer tool for pistons. Part number 21825491	
PD.208	Dial gauge for use with PD.41D. Part number 21825617	
PD.198 **(MS.1531)**	Angle gauge to tighten cylinder head setscrews. Part number 21825607	
PD.6118B	Valve spring compressor. Part number 21825666	
PD.6118-7	Stud adaptor for use with PD.6118B. Part number 21825672	
PD.6118-8	Setscrew adaptor for use with PD.6118B. Part number 21825673	

This document has been printed from SPI². Not for Resale

Number	Description	Illustration
MS.67B	Universal timing gauge. Part number 21825610	
MS.76A	Set of adjustable cutters for valve seats. Part number 21825518	
MS.76B	Handle set for valve seat cutters (also included in MS.76A). Part number 21825619	
MS.281	Cutter for inlet valve seats (also included in MS.76A). Part number 21825632	
MS.150-9.5	Adjustable pilot for valve seat cutters (also included in MS.76A). Part number 21825655	
MS.275	Cutter for exhaust valve seats (also included in MS.76A). Part number 21825631	

This document has been printed from SPI². Not for Resale

This page is intentionally blank

This document has been printed from SPI². Not for Resale

COOLING SYSTEM

Section 3 – **Part** C

Table of Contents

Operation No	Description	Page No
—	Specification	2
—	Fault Diagnosis	2
—	Frost Precautions	2
—	General Description	3
3C-01	Radiator – 3 Cylinder engines – Removal	4
3C-02	Radiator – 4 & 6 Cylinder engines – Removal	5
3C-03	Fan belt – Adjust	6

COOLING SYSTEM

Specification

Capacities
- M-F 340, 350, 355, 360 ..... 9,8 litre (2.2 gal) (2.6 US gal)
- M-F 362 ..... 14,4 litre (3.17 gal) (3.8 US gal)
- M-F 365, 375, 383, 390 ..... 15,1 litre (3.32 gal) (3.9 US gal)
- M-F 390T, 398 ..... 15,5 litre (3.41 gal) (4.09 US gal)
- M-F 399 ..... 20,1 litre (4.42 gal) (5.3 US gal)
- M-F 399-1006 series engine ..... 23 litre (5.0 gal) (6.0 US gal)

Radiator cap pressure rating ..... 0,75 bar (10 lbf/in^2)

Thermostat
- M-F 340 to 398
  - Quantity 1
  - Type ..... Bypass
  - Opening temperature (Nominal) ..... 82°C (180°F)
- M-F 399
  - Quantity 2
  - Type ..... Bypass blanking
  - Opening temperature (Nominal) ..... 82°C (180°F)

Fan belt deflection
- M-F 340 to 398 ..... 19 mm (0.75 in)
- M-F 399 ..... 10 mm (0.375 in)

Fault Diagnosis

The faults listed are cooling system faults only and do not cover engine defects which may contribute towards overheating.

FAULT	POSSIBLE CAUSE	SUGGESTED REMEDY
Overheating	Engine racing or pulling hard	Select the correct gear to suit conditions
	Radiator water level	Fill to the correct level, check for leaks at joints and hoses, rectify as necessary
	Loose fan belt	Adjust the fan belt tension
	Radiator cap leaking or valve spring defective	Replace the radiator cap
	Radiator matrix blocked	Clean the radiator using a reverse flow of air or water
	Water flow restricted	Check the thermostat operation and replace if necessary Reverse flush the cooling system Service or renew the water pump
Engine runs cool	Operating conditions (cold head winds)	Blank off a portion of the radiator
	Thermostat stuck open	Replace the thermostat

Frost Precautions

There are three main methods of protecting the cooling system during frost conditions:

1. Draining the cooling system after each days work.

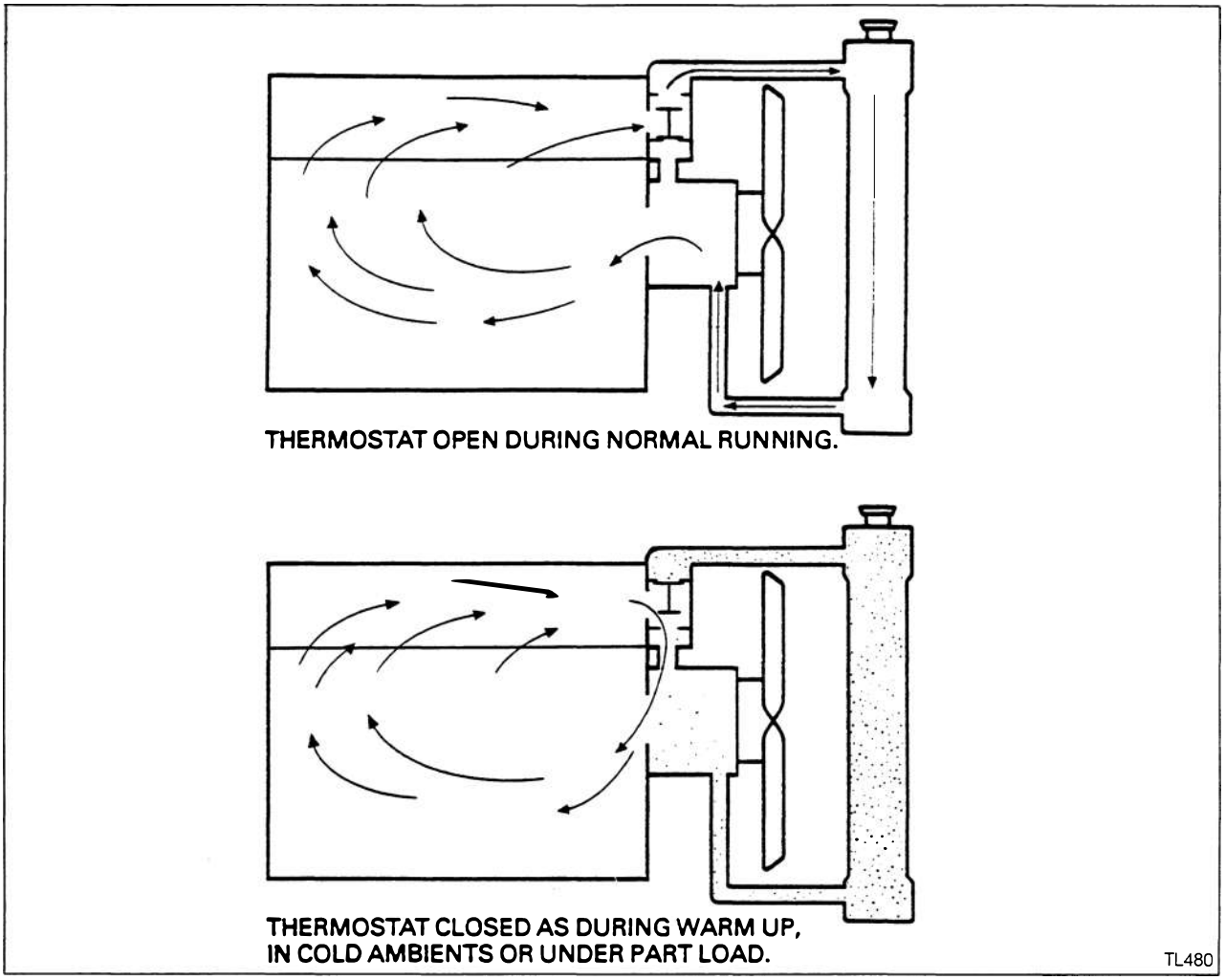
   This method leaves the system unprotected in the idle periods during the day, and in extreme conditions the cooling may freeze while the engine is running. Erosion of the water pump impellor may be accelerated in hard water conditions due to the frequent draining and refilling of the system.

2. Use of heated premises, engine or sump heaters.

   This method also leaves the engine unprotected during the idle periods of the day and extremely cold conditions.

3. Anti-Freeze Solutions.

   Generally the most efficient method of protecting cooling systems but, due to the penetrating properties of the solution, all hoses and joints should be in good condition. A cooling system which is normally free of leaks may well develop them when filled with anti-freeze. Leakage may not occur immediately after initial filling of the system but may develop shortly afterwards. This should be considered and the necessary checks carried out.



THERMOSTAT OPEN DURING NORMAL RUNNING.

THERMOSTAT CLOSED AS DURING WARM UP, IN COLD AMBIENTS OR UNDER PART LOAD.

TL480

General Description

The coolant is circulated by thermo-syphon action assisted by a centrifugal type pump. The system is controlled by a thermostat which prevents the coolant from flowing through the radiator until the correct working temperature has been achieved, and a pressure-sensitive radiator cap, which, by allowing the radiator to pressurise, raises the temperature at which the coolant will boil. A fan attached to the front of the engine assists cooling by drawing air through the radiator.

The water pump and cooling fan are driven by a belt, which is driven by a pulley splined to the front of the crankshaft.

The thermostat fitted to the engine is a by-pass blankig type. These can be identified by the valve disc at its base. This type of thermostat regulates the flow of water through the radiator or by-pass port.

When cold the by-pass port is fully open and the connection to the radiator is closed; when hot the by-pass port is closed and the connection to the radiator is open. If the blanking by-pass thermostat is removed, the greater water flow will be through the by-pass and not the radiator, resulting in severe overheating and consequential damage. Do not run the engine without the thermostat.

Repair information on the water pump and thermostat will be found in the Engine Workshop Manual.

Radiator – 3 Cylinder Engines

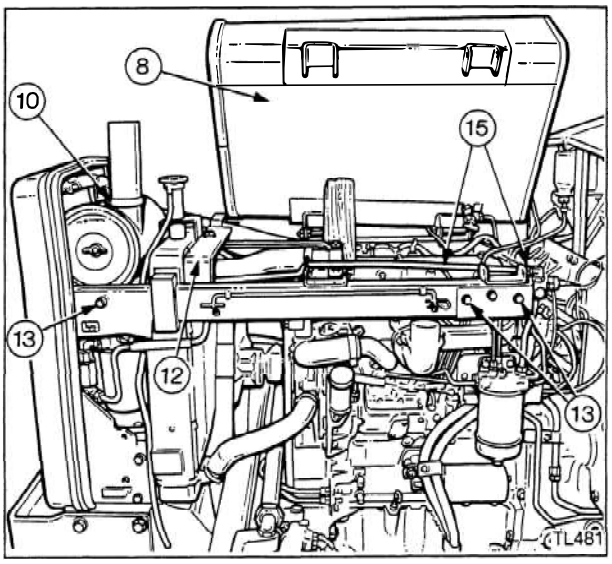
Removal and Refitment 3C-01

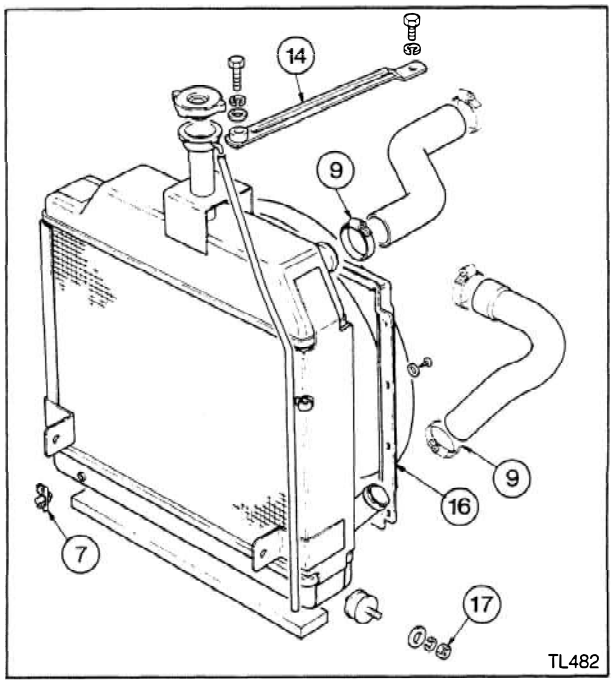
Removal

1. Remove the jubilee clip and centrifugal pre-cleaner.
2. Remove the bonnet.
3. Remove both lower side panels.
4. Disconnect the headlights.
5. Remove the front grille.
6. Remove the battery. (Disconnect the negative (-) terminal first.)
7. Drain the radiator. (Ensure a suitable size container is available.)
8. Raise the fuel tank on its left hand side and support it so that it does not block the removal of the radiator.
9. Disconnect the top and bottom hoses.
10. Disconnect the air cleaner hose at the air cleaner end.
11. Remove the upper section of the exhaust pipe.
12. Remove the cross member bracket supporting front of fuel tank.
13. Remove the bolts from the side support rail and lift the rail away.
14. Remove the top radiator stay.
15. Remove the hydraulic pipe, oil filter to rear of tractor.
16. Unscrew and place the fan shroud over the water pump.
17. Slacken the two lower securing nuts and lift the radiator away to the left-hand side.

Refitment

18. Reverse procedures 1 to 17.
19. Refill the radiator with the original solution of water and anti-freeze or with a fresh solution. Always use M-F Anti-Freeze.





Radiator – 4 & 6 Cylinder Engines

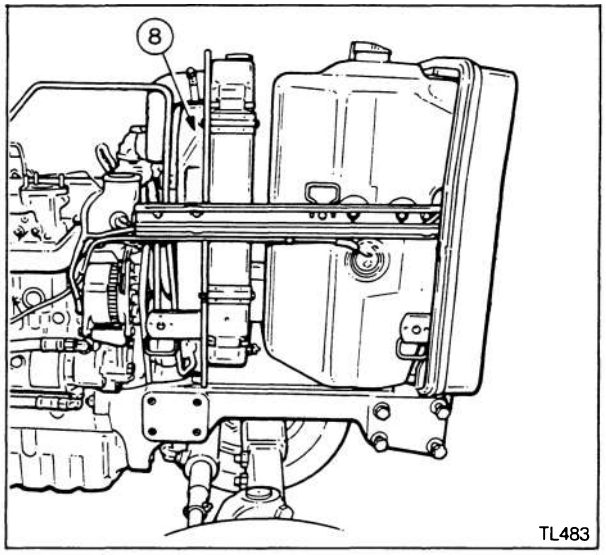
Removal and Refitment 3C-02

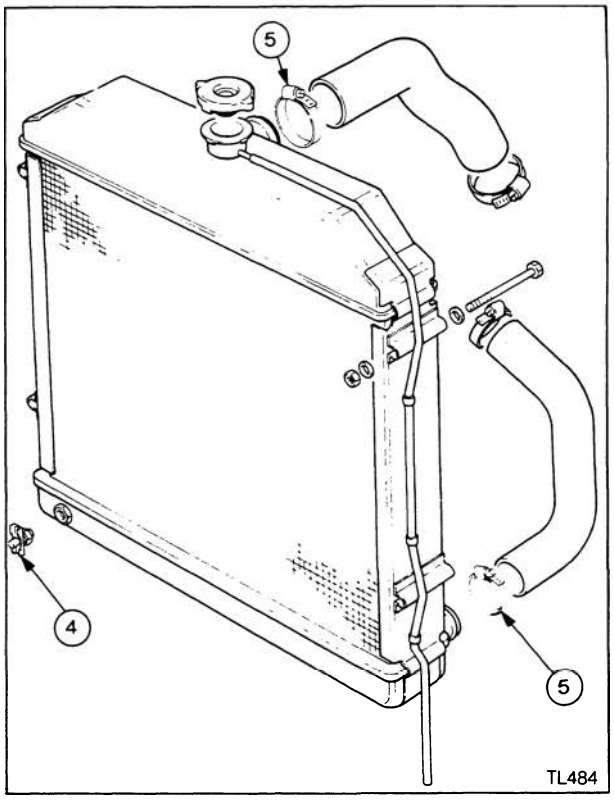
Removal

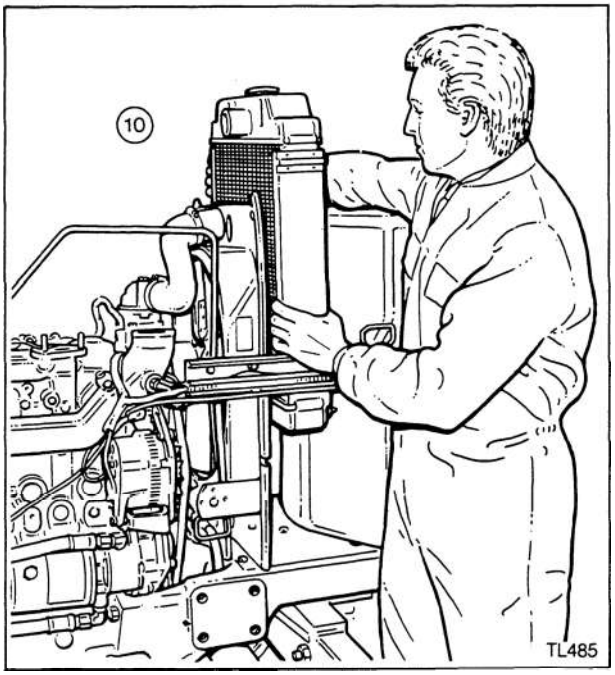
1. Remove the jubilee clip and centrifugal pre-cleaner.
2. Remove the bonnet, complete with the silencer, exhaust pipe and air cleaner.
3. Remove both lower side panels.
4. Drain the radiator. (Ensure a suitable size container is available.)
5. Disconnect the top and bottom hoses.
6. Disconnect the oil cooler supply and return pipes, if fitted.
7. Remove the oil cooler and plug the pipes.
8. Unscrew and place the fan shroud over the water pump.
9. Remove the four radiator securing bolts.
10. Lift the radiator up and out between the fuel tank and the fan shroud.

Refitment

11. Reverse procedures 1 to 10.
12. Refill the radiator with the original solution of water and anti-freeze or with a new solution. Always use M-F Anti-Freeze.







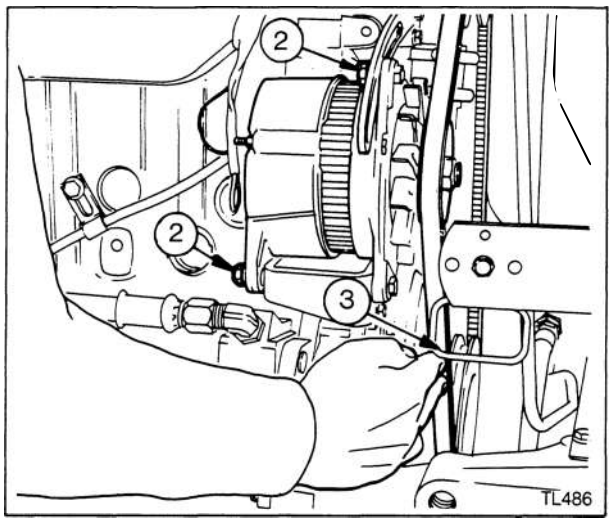
Fan Belt

Adjust 3C-03

Adjust

1. Remove the right-hand bonnet lower side panel.
2. Slacken the nuts and bolts on the alternator securing bracket.
3. Set the fan belt deflection between the crankshaft and alternator pulleys to 19 mm (0.75 in) for M-F 350 to 398 tractors and 10 mm (0.375 in) for M-F 399 tractors.
4. Retighten the alternator securing nuts and bolts to the bracket.
5. Replace the lower side panel.

Note: On M-F 399 the fan belts are fitted in pairs. If one belt is worn a new pair of belts should be fitted.

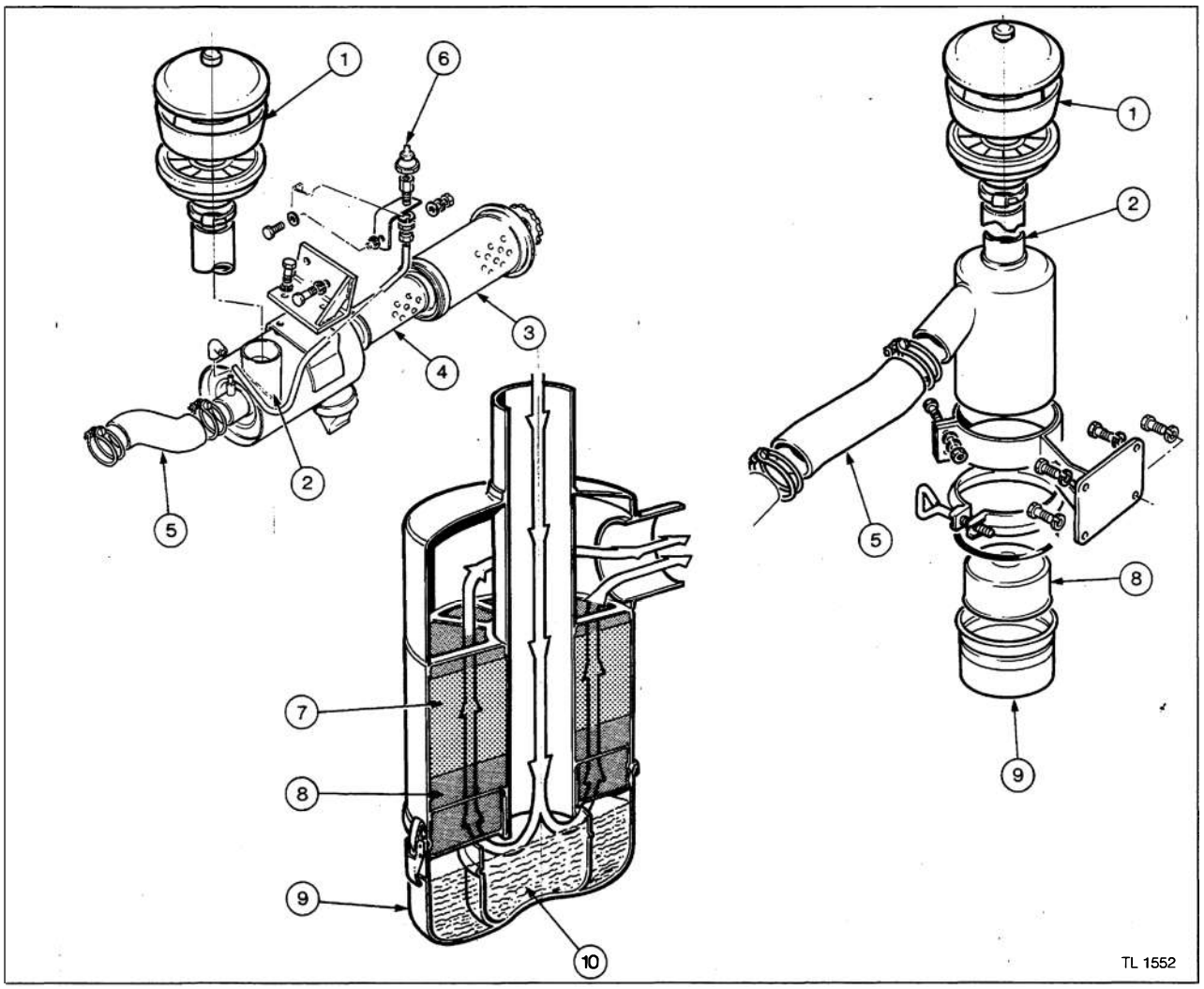


AIR SYSTEM

Section 3 – Part D

Table of Contents

Operation No.	Description	Page No.
———	General description	2
3D–01	Dry air cleaner – Servicing	3
3D–02	Oil bath air cleaner – Servicing	5
3D–03	Air pre–cleaner – Servicing	5



1. Pre-cleaner
2. Intake pipe
3. Main filter element
4. Safety filter element
5. Pipe to engine inlet manifold
6. Filter restriction indicator
7. Filter gauze
8. Removable filter gauze
9. Oil bowl
10. Lubricating oil

GENERAL DESCRIPTION

The air intake system consists of a pre-cleaner and a dry type air cleaner with a safety element or an oil bath type air cleaner in place of the dry type.

The air pre-cleaner uses the centrifugal principle, forcing intake air into a circular motion. Larger particles of dirt are flung out and collected in a detachable transparent dust bowl.

Dry air cleaner

Under the influence of the suction generated by the engine, the intake air flows through the intake pipe from the pre-cleaner into the cleaner body. The air passes through the main filter element and a safety element before being sucked in by the engine.

A restriction indicator switch, in conjunction with an air cleaner indicator light located in the instrument cluster, shows when the air cleaner element requires cleaning.

The main element may be washed up to a maximum of six times. ***The safety element must not be washed.***

Oil bath air cleaner

Air is drawn into the cleaner from the pre-cleaner down the central tube into the removable base. The base of the cleaner is fitted with lubricating oil to collect and retain the dirt. The change in direction that the air has to make to pass up through the filter gauze causes the heavy particles of dust and dirt to fall out into the oil.

The lower section of the gauze filter is removable for cleaning.

Cleaned air, after passing through the filter, is sucked in by the engine through the intake manifold. No restriction indicator is fitted to this type of cleaner.

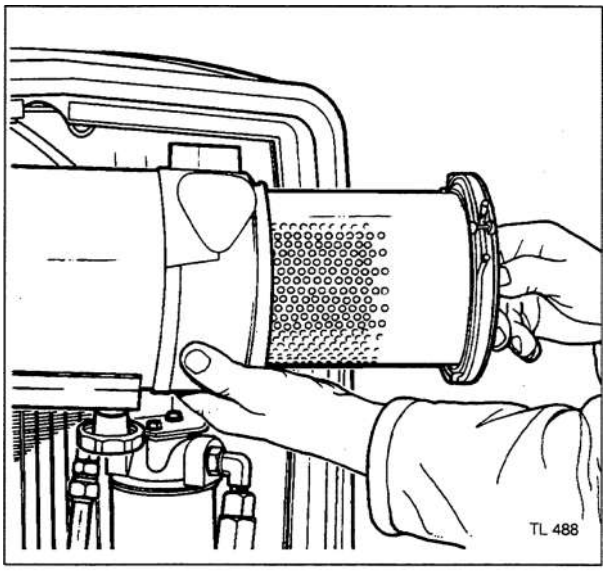
Dry Air Cleaner

Servicing 3D–01

Procedure

3 cylinder engine tractors

1. Disconnect the headlights and remove the front grille.
2. Loosen the hand knob and swing out the air cleaner for access.



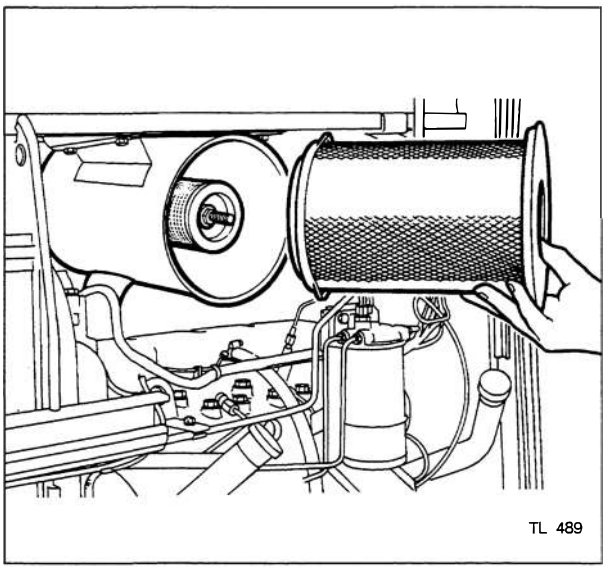
4 & 6 cylinder engine tractors

1. Raise the left-hand bonnet side panel.
2. Clip the bonnet in position.

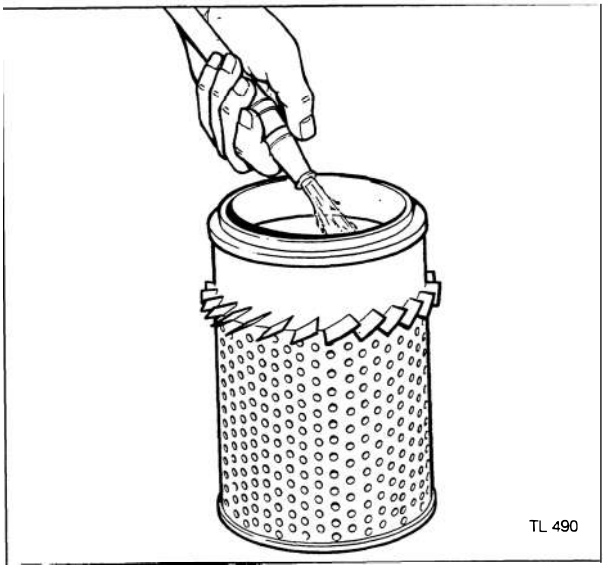
All models

3. Remove the retaining screw, then carefully slide out the main element.

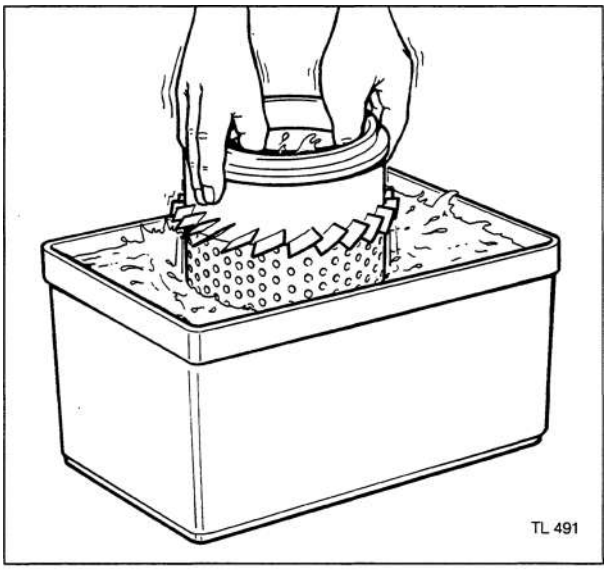
NOTE: Damaged elements must not be washed and reused. DO NOT attempt to clean the inner SAFETY element.



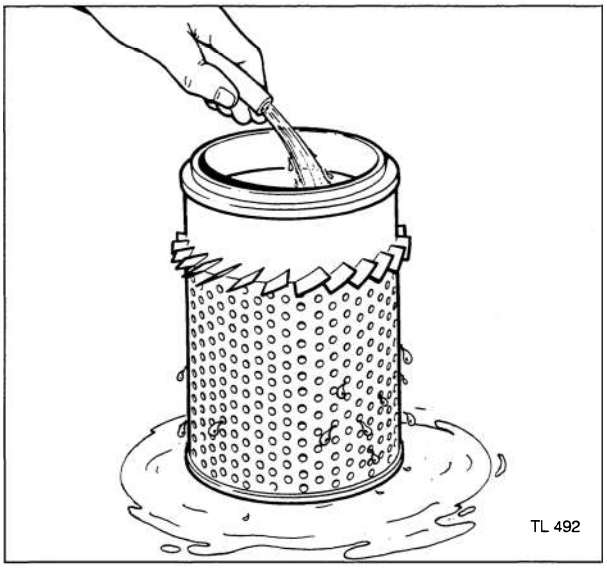
4. Remove all the loose dirt from the element with compressed air or water:
   a. Compressed air at 7 bar (100 lbf in^2) maximum with the nozzle held at least 25 mm (1 in) away from the element.
   b. Water hose at 3 bar (40 lbf in^2) maximum without a nozzle.
5. Mix 30g (1 oz) (2 tablespoons) of automatic washing machine detergent per 10 litre (2 gal) (2.5 US gal) of water (approximately half a cup per 16 litre (6 gal)(7US gal). Stronger solution costs more and is not needed.
6. Soak the element in the solution for 15 minutes. Do not soak for more than 24 hours.



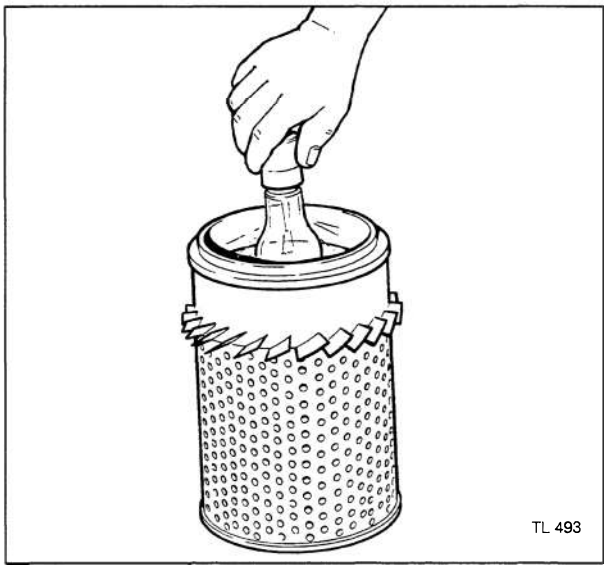
7. Swish the element around in the solution to help remove the dirt.



8. Rinse the element from the 'clean' side to the 'dirty' side with a gentle stream of water (less than 3 bar (40 lbf in^2)) to remove all the suds and dirt. If the clean side has been contaminated with dirty water during the soak cycle, rinsing from both sides will be necessary.
9. Dry the element before reuse. Warm air must be circulated at less than 70^{0}C (160^{0}F). DO NOT use a light bulb to dry the element. The element can be dried in an electric oven.



10. Inspect the element for holes or tears by looking through it towards a bright light. Check for damaged gaskets or dented metal parts. DO NOT reuse a damaged element.
11. Protect the element from dust and damage during drying and storage.
12. Before refitting the element, wipe out the air cleaner body with a damp cloth to remove any loose dust.
13. Slide the cleaned element back into place and secure with the retaining screw.
14. If the warning light comes on after a very short interval of working, the main element is unfit for service and must be replaced.
    However, if after replacement of the main element, the warning light stays on, the safety element must also be replaced - DO NOT attempt to clean it.
15. The inner safety element must be changed every three main element changes.
16. Change the elements after six washings or when damage or inefficiency becomes apparent.



NOTE:

- **Always keep at least one spare main element and inner safety element available ready for use to prevent excessive out of service time.**
- **Store the spare elements in a cool dry place and protect them from dust and damage.**
- **Mark the main element end plate after each washing – DO NOT wash the main element more than six times.**
- **DO NOT attempt to blow the main element clean using the tractor exhaust gases.**
- **Never add oil to the dry air cleaner.**
- **Never use petrol (gasoline), paraffin or cleaning solvents to clean the element.**

17. Replace the air cleaner element.

Oil Bath Air Cleaner

Servicing 3D–02

Procedure

3 cylinder engine tractors

1. Disconnect the headlights and remove the front grille for access.

4 & 6 cylinder engine tractors

1. Raise the left-hand bonnet side panel for access.

All models

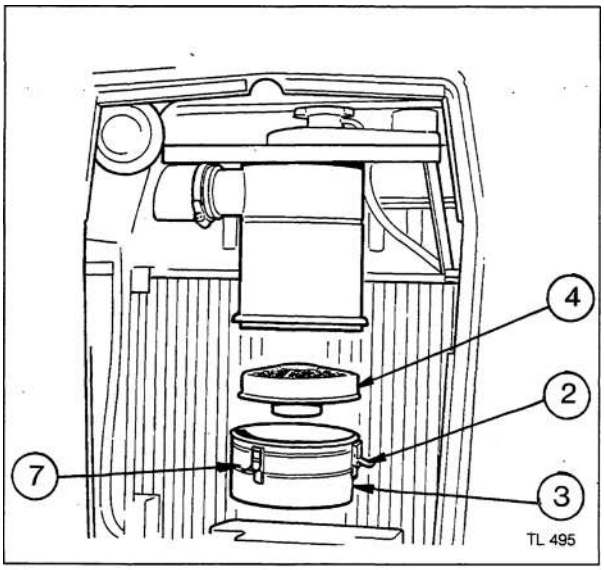
2. Release the three clamp fasteners.
3. Remove the bowl.
4. Remove the filter element.
5. Drain the bowl and carefully clean it.
6. Wash the element in paraffin or diesel fuel, and dry off.
7. Refill the bowl with clean engine oil to the level indicated but no higher.
8. Refit the element in the oil bath.
9. Refit the oil bath to the air cleaner, ensuring that the oil seal is correctly seated and the clamp fastener is properly engaged and secure.

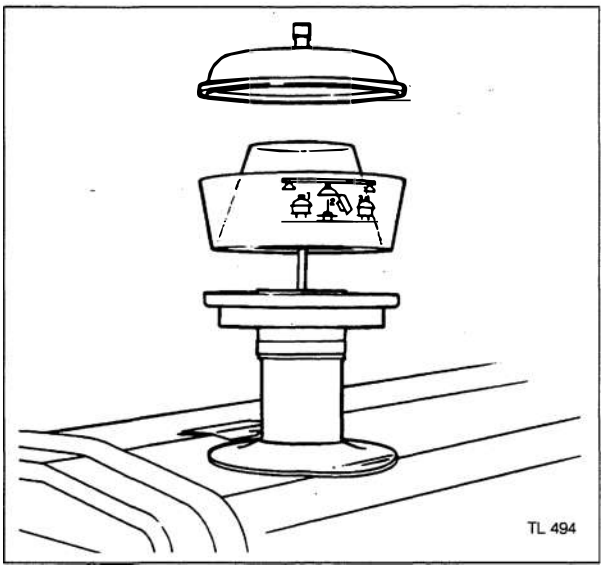
Air Pre–Cleaner

Servicing 3D–03

Procedure

1. Remove the central nut on the pre-cleaner and remove the top cover and bowl.
2. Clean out all dust and dirt and re-assemble.





FUEL SYSTEM

Section 3 – Part E

Table of Contents

Operation No	Description	Page No
—	Specification	2
—	General Description	2
3E-01	Fuel tank 3 cylinder engines – Removal	4
3E-02	Fuel tank 4 and 6 cylinder engines – Removal	4
3E-03	Fuel gauge sender unit 3 cylinder engines – Removal	5
3E-04	Fuel gauge sender unit 4 and 6 cylinder engines – Removal	6
3E-05	Throttle control cables – Removal	6
3E-06	Fuel cut-off cable (Stop control) – Removal	7
3E-07	Fuel filter – Servicing	8

FUEL SYSTEM

Specification

Fuel tank capacities
- M-F 340, 350, 355, 360 ..... 68 litre (15 gal) (18 US gal)
- M-F 362 ..... 75 litre (16.5 gal) (19.8 US gal)
- M-F 365 to 398 ..... 108 litre (24 gal) (28½ US gal)
- M-F 399 and Hiline ..... 118 litre (26 gal) (31 US gal)

Hiline models with
air conditioning ..... 114 litre (25 gal) (30 US gal)

General Description

The fuel tank is located over the engine on tractors with 3 cylinder engines and in front of the radiator, between the front grille and two side panels on 4 and 6 cylinder engines.

The fuel tanks are fitted with a fuel gauge sending unit attached to the top of the tank on 3 cylinder engines and on the right-hand side on 4 and 6 cylinder engines.

The fuel filler cap is vented for safety.

The fuel transfer pump is a diaphragm-type pump, driven by the engine camshaft and attached to the right-hand side of the engine.

The pump can be manualy operated, eg for removing air from the fuel system. Fuel is fed from the fuel tank through either a single of dual filter to the fuel injection pump.

The fuel filter(s) are equipped with a water trap below the filter element. A water drain plug is provided to drain off any water or sediment.

Tractors are equipped with "Thermostart" starting aid. Pressurised fuel is taken off the fuel filter to the burner located in the intake manifold through a fuel line. A filament inside the burner receives current from the battery and a heat-sensitive valve which opens during the cold starting procedure. The thermostart is controled by the key start switch when turned to the cold start or pre-heat position. By turning the key switch to the cold start position, the filament is heated, which, in turn, ignites the fuel, thus providing the engine with preheated air for easier starting.

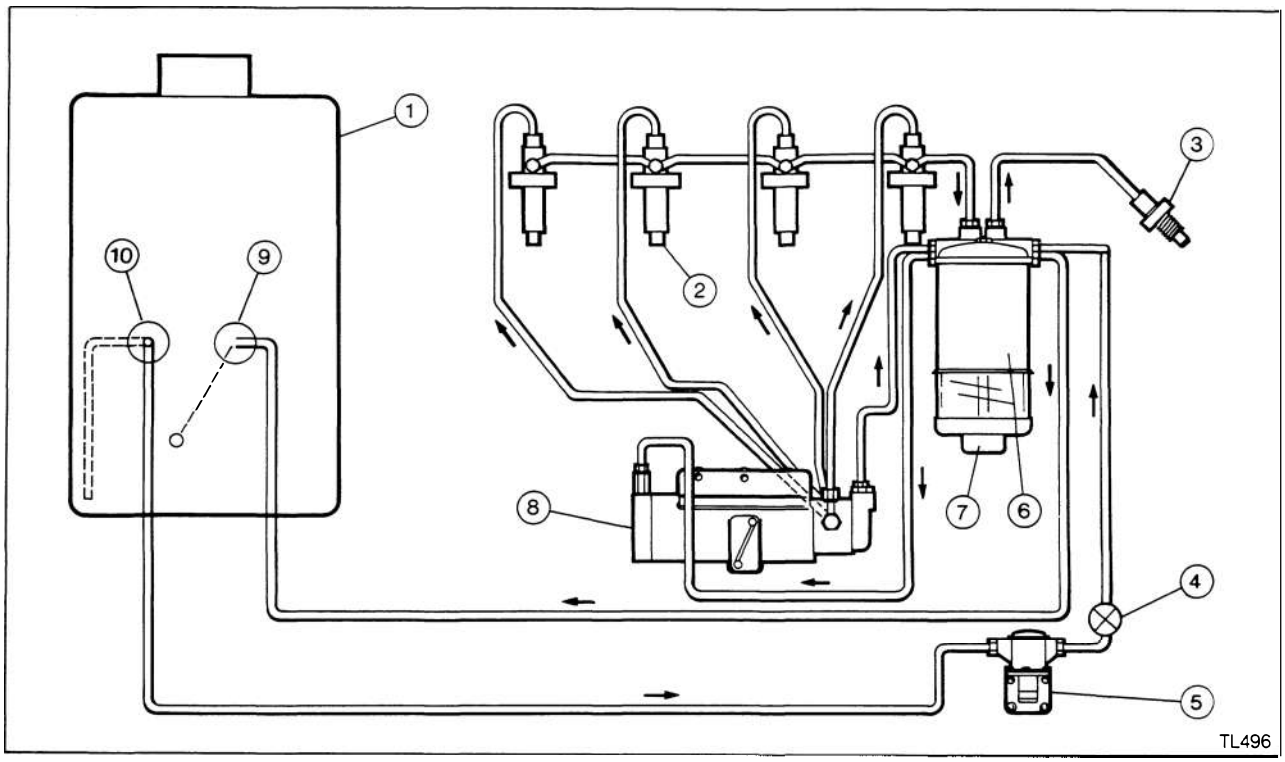
The desired speed is selected by means of a hand or foot throttle. The position of these levers controls, through the governor on the fuel injection pump, the amount of fuel being injected into the cylinders.

The hand throttle shaft is self-locking. Two spring-loaded friction discs keep the hand lever in the position selected.

Flexible control cables are used to convey the movement of the hand and foot throttle to the fuel injection pump.

With engine running at slow idle speed, the slow idle stop screw contacts the control lever. When the hand throttle is turned in a clockwise direction to its stop the engine speed is increased to its maximum.

The engine is stopped by means of a shut-off cable. One end of the cable is connected to the fuel injection pump stop lever, the other to a red knob on the tractor instrument panel.



1. Fuel tank
2. Fuel injectors
3. Thermostart
4. Fuel tap
5. Transfer pump
6. Fuel filter
7. Water trap
8. Fuel injection pump
9. Fuel tank sending unit
10. Fuel suction pipe

Fuel system 4 cylinder engine

Fuel Tank 3 Cylinder Engines

Removal and Refitment

Removal

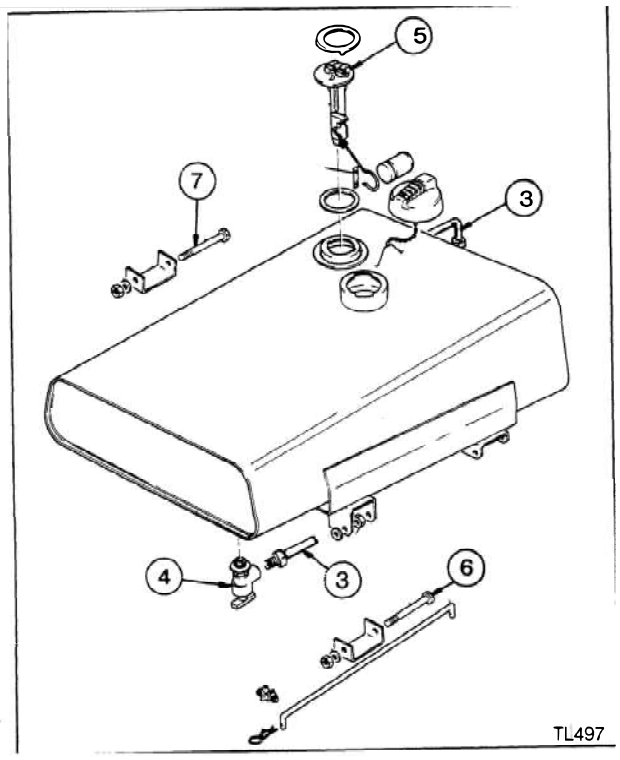
1. Loosen the jubilee clip and remove the centrifugal pre-cleaner.
2. Remove the bonnet.
3. Disconnect the two fuel lines.
4. Drain the fuel tank at the fuel tap.

Note: A container of 68 litre (15 gal) (18 US gal) maximum is required, if full.

5. Disconnect the tank sender unit. (Mark the three wires to assist refitment.)
6. Remove the nuts and bolts securing the left side of the fuel tank.
7. Remove the remaining nuts and bolts securing the fuel tank.
8. Lift the fuel tank away.

Refitment

9. Reverse procedures 1 to 8.
10. Refill the tank.



Fuel Tank 4 and 6 Cylinder Engines

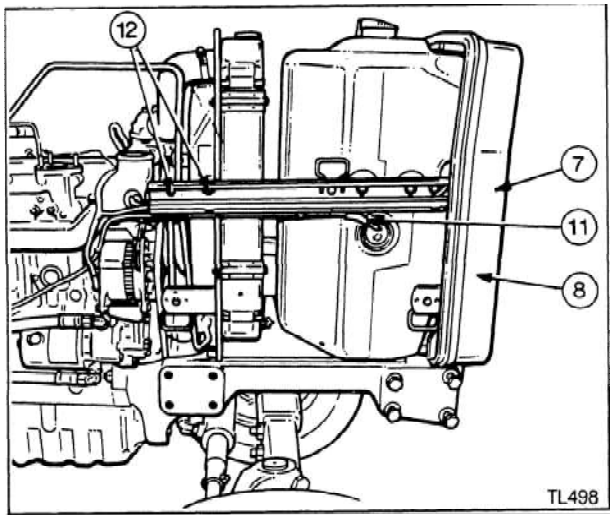
Removal and Refitment 3E-02

Removal

1. Remove the front weights.
2. Remove the front weight frame.
3. Remove the bonnet, complete with exhaust pipe and air cleaner.
4. Disconnect the headlights.
5. Remove the grille.
6. Remove the side panels.
7. Disconnect both side support rails at the front.
8. Remove the nose.
9. Disconnect the fuel sender unit. (Mark the three wires to assist refitment.)
10. Drain the tank using an electric pump.

Note: A container of 108/126 litres (24/28 gal) (28/33 US gal), depending upon model, is required, if full.

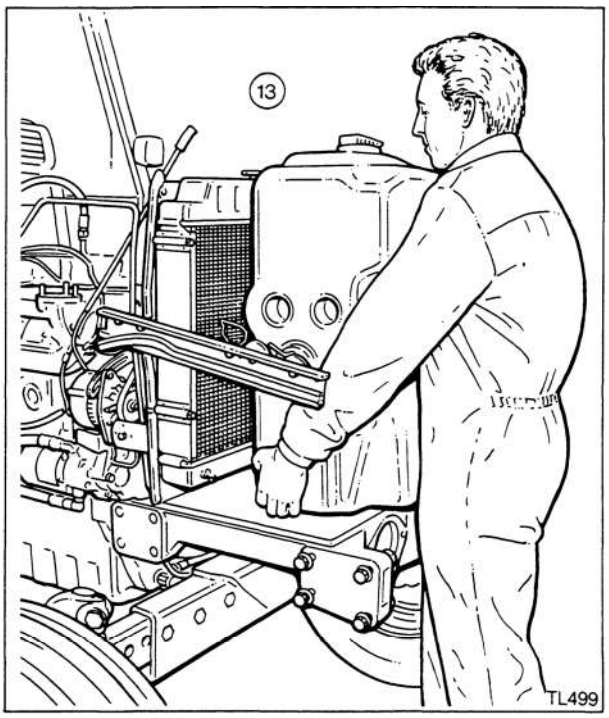
11. Disconnect the fuel lines.
12. Slacken the right-hand side rail at the rear to disengage the rubber mounts side rail to tank.



13. Remove the fuel tank.

Refitment

14. Reverse procedures 1 to 13 except: When refitting the fuel tank, ensure that the top of the front support casting and the bottom of the tank are clean.
15. Refill the fuel tank.



Fuel Gauge Sender Unit 3 Cylinder Engines

Removal and Refitment 3E-03

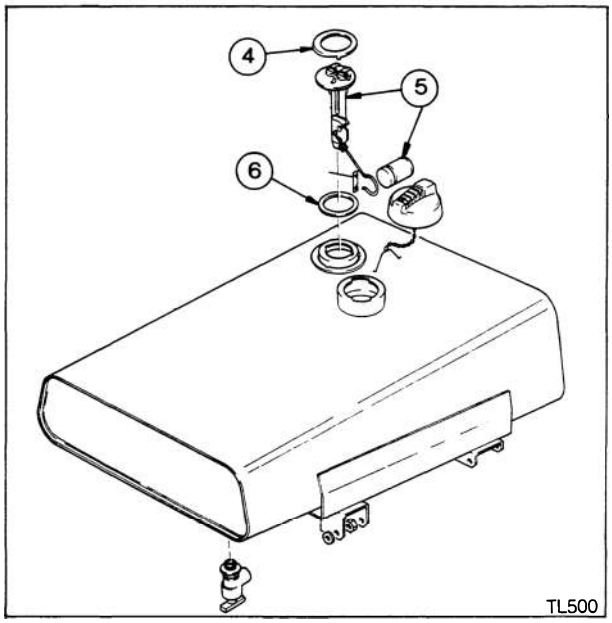
Removal

1. Remove the centrifugal pre-cleaner.
2. Remove the bonnet.
3. Disconnect the sender unit wires. (Mark the wires to assist refitment.)
4. Rotate the securing ring anti-clockwise until it comes free.
5. Lift out the sender unit and float.

Refitment

6. Reverse procedures 1 to 5.

Note: Ensure when refitting the fuel tank sender unit that a new rubber seal is used.



Fuel Gauge Sender Unit 4 and 6 Cylinder Engines

Removal and Refitment 3E-04

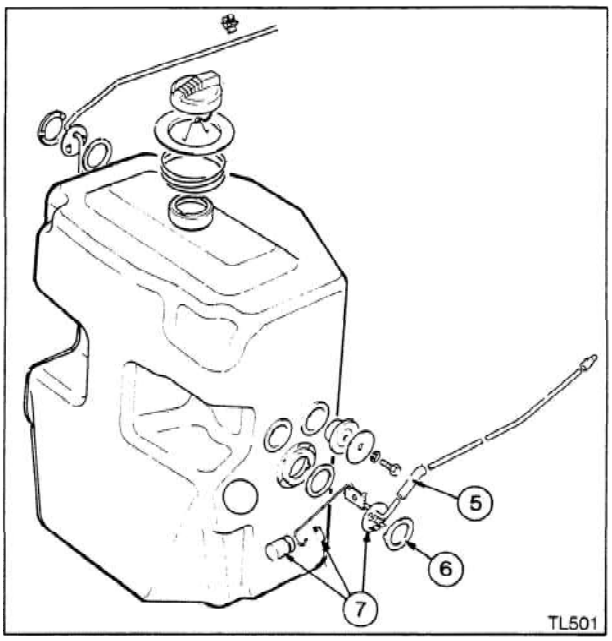
Removal

1. Raise the left hand bonnet side panel.
2. Remove the left hand lower side panel.
3. Drain the tank to below the sender unit using an electric pump.
4. Disconnect the sender unit wires. (Mark the wires to assist refitment.)
5. Disconnect the fuel line.
6. Rotate the securing ring anti-clockwise until it comes free.
7. Withdraw the sender unit and float.

Refitment

8. Reverse procedures 1 to 7.

Note: Ensure, when refitting the fuel tank sender unit, that a new rubber seal is used.



Throttle Control Cables

Removal and Refitment 3E-05

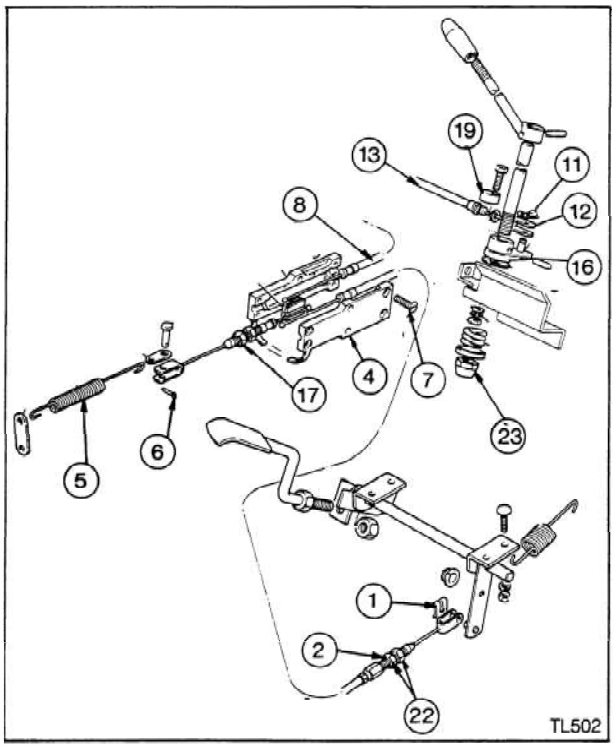
Removal

Foot Throttle Cable

1. Disconnect the throttle control cable at the foot control mechanism by under the right-hand fool plate by removing the spring clip.
2. Unscrew the adjusting nut and remove the cable from the bracket.
3. Pull the cable through from the left-hand side of the engine.
4. Remove the foot and hand throttle junction box from its bracket on the left-hand side of the engine.
5. Disconnect the spring on the fuel injection pump.
6. Remove the split pin and disconnect the control cable to the fuel injection pump.
7. Remove the four screws retaining the two halves of the junction box.
8. Split the junction box and remove the foot throttle control cable.

Hand Throttle Cable

9. Remove the instrument lower panel.
10. Disconnect the horn push and other switches, if fitted.
11. Remove the clip securing the cable end to the hand lever.
12. Remove the clevis from the pin and the cable from its retaining bracket.
13. Pull the cable through from the instrument panel side.



Refitment

Foot Throttle Cable

14. Reverse removal procedures 1 to 8.

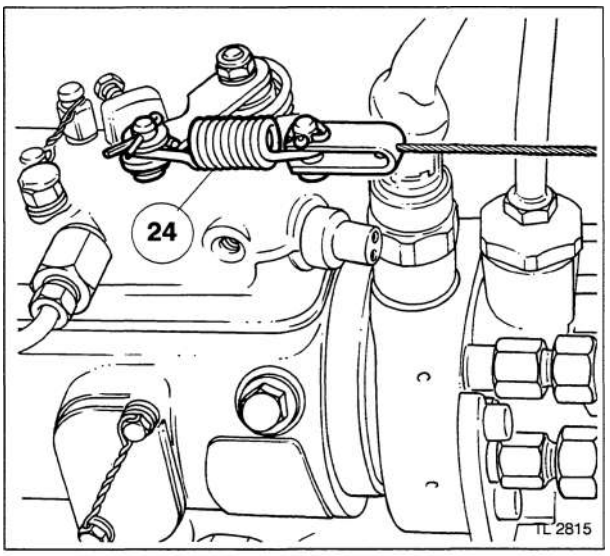
Hand Throttle Cable

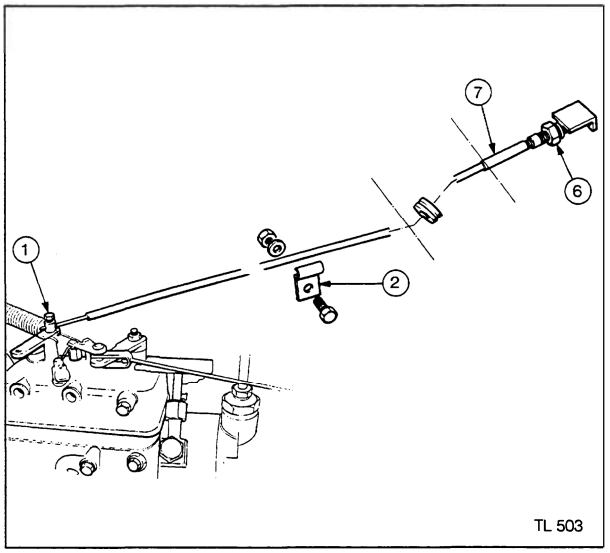
15. Reverse removal procedures 9 to 13 and 4 to 8.

NOTE: When fitting a new cable, ensure that there are no sharp bends.

Adjustment of cables

16. Open the hand throttle until the lever contacts the steering column.
17. Adjust the fuel pump operating cable until the pump lever contacts its maximum engine speed stop.
18. Close the hand throttle until the fuel pump lever contacts its minimum engine speed stop.
19. Slacken the bolt and adjust the minimum stop cam against the throttle lever (16).
20. Set the hand throttle in its maximum position.
21. Depress the foot pedal to its maximum down position.
22. Adjust the foot throttle cable with the two adjusting nuts.
23. Adjust the hand throttle lever friction by the self locking nut.
24. The illustration shows the later arrangement of connecting the throttle cable to the fuel pump with a spring. This was introduced in March 1994 and should be incorporated onto early tractors to prevent cable breakage.





Fuel Cut–off Cable – Stop Control

Removal and Refitment 3E-06

Removal

1. Loosen the securing screw on the fuel cut0off lever on top of the fuel injection pump.
2. Release the cable from its clamping bracket.
3. Pull the cable away from the fuel pump.
4. Remove the instrument side panels.
5. Remove the lower instrument panel to gain access to the nut behind the knob.
6. Remove the securing nut at the rear of the 'Pull to Stop' knob.
7. Pull the cable through from the instrument panel end.

Refitment

8. Reverse procedures 1 to 7 except:
   a. Loosen the securing screw and move the fuel shut-off lever to the 'ON' position. Retighten the screw.
   b. Start the engine and operate the fuel cut-off control cable to ensure the correct setting has been made and the engine stops.

Fuel Filters

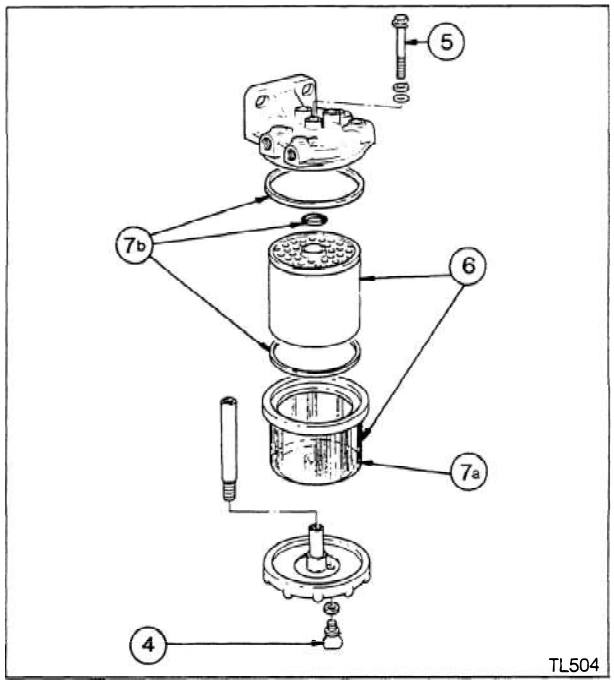
Servicing 3E-07

Procedure

1. Raise the left-hand bonnet side panel (on 3 cylinder models remove the bonnet).
2. Turn off the fuel supply at the tap next to the fuel lift pump.
3. Clean the outside of the filter assembly.
4. Drain the filter by unscrewing the drain plug.
5. Remove the centre bolt.
6. Remove the element and the bowl from the head and discard the element.

Note: On 6 cylinder models there are two filters.

7. Reverse procedures 1 to 6 except:
   a. Before putting a new element into position, clean the filter top and the sediment bowl.
   b. Ensure that the rubber joints are in good condition. If not, replace with new joints.
   c. Always fit a new element.
   d. Remove the air from the fuel system.



SECTION 4

Clutch

INDEX

4A CLUTCH

Clutch

Section 4 – Part A

Table of Contents

Operation No	Description	Page No
-------	Specification	4A- 2
-------	General description - dual clutch	4A- 3
-------	General description - split torque clutch	4A- 4
-------	Fault finding chart	4A- 5
2.04A-01	Clutch pedal - adjustment	4A- 6
2.04A-02	PTO clutch - adjust	4A- 6
2.04A-03	Clutch release bearing - removal	4A- 7
2.04A-04	Clutch release mechanism - removal	4A- 7
2.04A-05	Dual clutch assembly - removal	4A- 8
2.04A-06	Dual clutch assembly - overhaul	4A- 9
2.04A-07	Split torque clutch assembly - removal	4A-11
2.04A-08	Split torque clutch assembly - overhaul	4A-12
2.04A-09	Flywheel pilot bearing - removal	4A-14

Clutch

SPECIFICATIONS:

Dual Clutch

Clutch primary plate diameter	305 mm
Clutch secondary plate diameter	254 mm
Clutch disc thickness - primary plate	9,22 mm
Clutch disc thickness - wear tolerance	2,50 mm
Clutch disc thickness - secondary plate	8 mm
Clutch disc thickness - wear tolerance	2 mm

Primary pressure plate coil springs:	Quantity	Color	Clamp load
MF345, MF350	6	Red	442 kg
MF355, MF360, MF375	9	Green	749 kg

Secondary pressure plate Belleville spring:	Color	Clamp load
MF345, MF350	Dark blue	568 kg
MF355, MF360, MF375	Dark green	749 kg

Release lever height - 305 mm clutch	82,31-82,55 mm
PTO clutch stop bolt adjustment	2 mm

Split torque clutch

Clutch diameter - primary plate:	
MF345, MF350, MF355, MF360, MF375	305 mm
MF385	330 mm
Clutch disc thickness - primary plate	9,22 mm
Clutch disc thickness - wear tolerance	2,50 mm
Release lever height:	
305 mm clutch	82,31-82,55 mm
330 mm clutch	118, 92 - 120, 22 mm
Clutch pedal free travel at measuring points	11 mm
Flywheel machining - maximum permissible	1 mm

Recommended Lubricants for clutch splines

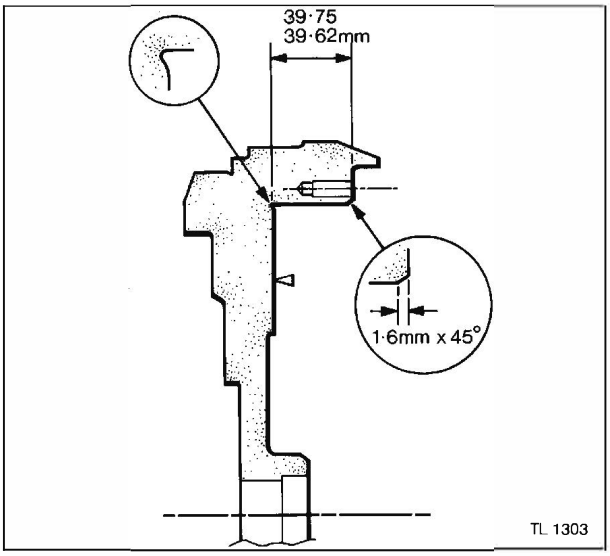
Shell	Retinax DX
Mobil	Mobiltemp 1
Fina	Bentex 3
Gulf	High Temperature Grease No 3
Esso	Unirex N3
Duckhams	Admax B3
Castrol	BNS
Caltex/Texaco	Thermatex EPZ
BP	Energrease HTB2 or B2
Total	Extemp or Coloris 3

Special tools

MF.159B	Clutch centraliser
MF.215	Clutch setting gauge
MF.314	Release lever height gauge 305 mm

Bolt torques

Clutch cover to flywheel (305 mm)	30 Nm
Flywheel to engine	105 Nm
PTO drive plate to clutch cover	37 Nm
Gearbox to engine	75 Nm



Flywheel reclamation

The clutch surface of flywheels can be reclaimed by skimming in 0,25 mm increments to a maximum of 1 mm deep.

The ledge to which the clutch cover is bolted must also be skimmed by the same amount to maintain the distance from the clutch face.

The following dimensions must always be maintained:

39,75-39,62 mm - see figure below.

NOTE: *Never, under any circumstance, attempt to skim either the clutch pressure plate or the false flywheel, as this will adversely affect the heat dissipating properties of these components.*

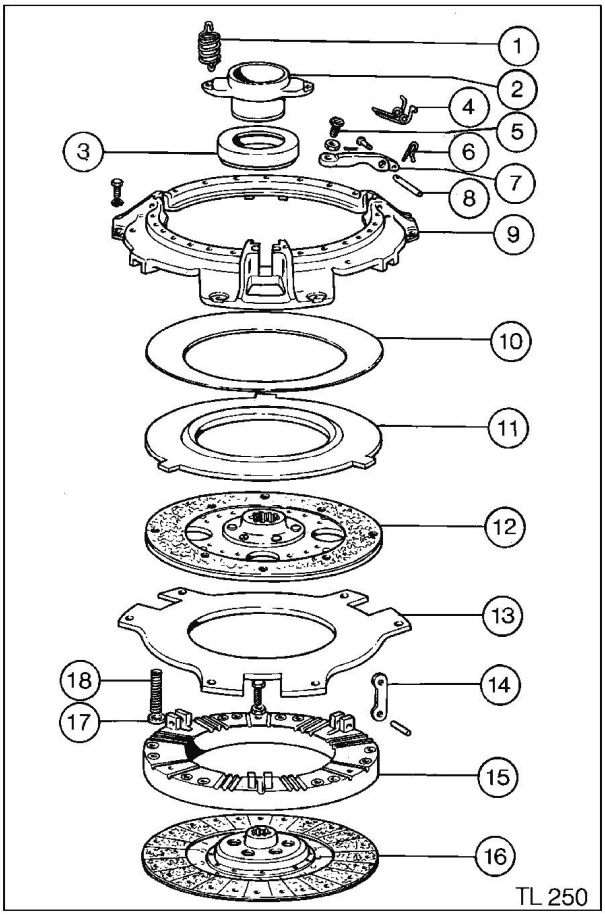
GENERAL DESCRIPTION

Dual clutch

The dual clutch enables the drive to the gearbox and rear wheels to be disconnected without interrupting the drive to the linkage pump and power take off which remains "live". The clutch second stage allows for disconnection of the drive to the PTO and hydraulics. During operation, the main friction disc (16) is held against the engine flywheel by the main pressure plate (15) under the force of twelve coil springs (18). The PTO friction disc (12) is held against a false flywheel (13) by the PTO pressure plate under the force of a Belleville spring disc (10).

Depressing the clutch pedal through its first stage of travel causes the release bearing to move three release levers which are pivot mounted to the clutch cover. Movement of these levers pulls the main pressure plate (15) rearwards against the force of coil springs and so disengages the drive from the main friction disc (16).

Depressing the clutch pedal into the second stage brings set-screws on the main pressure plate (15) into contact with the PTO pressure plate (11). Further pedal movement forces the PTO pressure plate (11) rearwards against the force of its Belleville spring and disengages the main drive from the PTO friction disc (12) to the pump and PTO.



Key to Illustration

1. Spring
2. Carrier
3. Bearing
4. Spring
5. Setscrew
6. Clip
7. Release levers
8. Pin
9. Cover plate
10. Belleville spring disc
11. PTO pressure plate
12. PTO friction disc
13. False flywheel
14. Connecting links
15. Main pressure plate
16. Main Friction disc
17. Washer
18. Springs

GENERAL DESCRIPTION

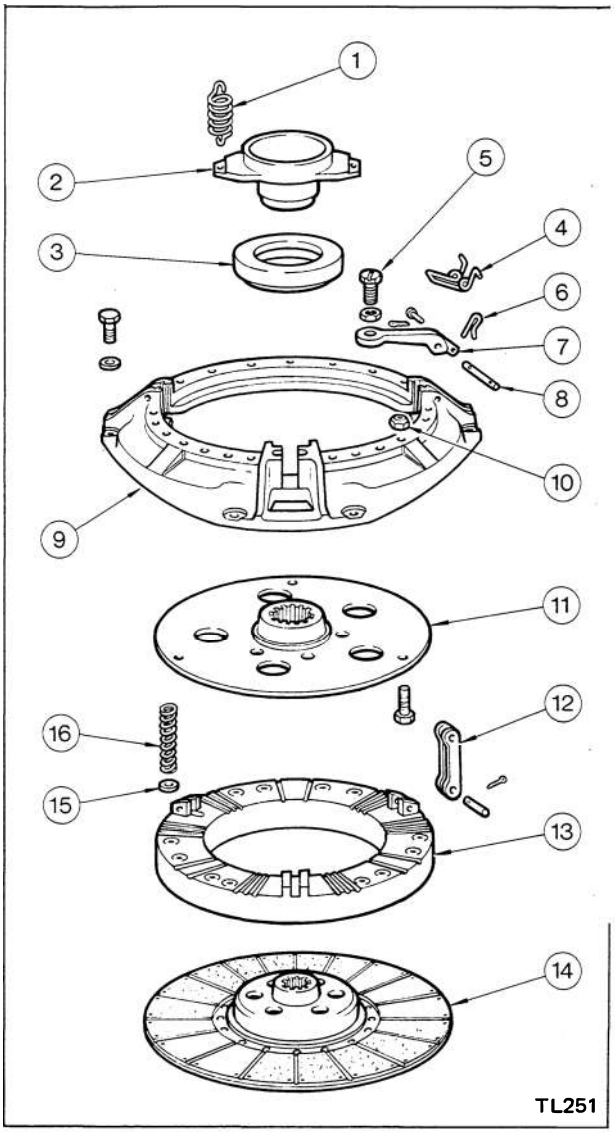
Split-torque clutch – 305 mm

The split torque clutch differs from the dual clutch in that the drive to the Ferguson linkage pump and Power Take-Off (PTO) is taken from the clutch cover and is always engaged when the engine is running. The clutch is therefore fitted to tractors with Independent Power Take-Off (IPTO) which employs a separate hydraulic clutch to engage or disengage the PTO. The drive to the gearbox and rear wheels is transmitted from either a 305 mm or 330 mm driven plate.

The friction disc (14) is operated by the pressure plate (13) against the flywheel. Pressure plate movement is obtained by three release levers (7), pivoted on the clutch cover plate (9). Release lever movement operating against the twelve coil springs (16) moves the pressure plate (13) rearwards and releases the friction disc (14). The clutch release levers (7) are operated by a release bearing (3) which is moved by the clutch pedal.

Key to Illustration

1.Spring
2.Carrier
3.Bearing
4.Spring
5.Screw
6.Retaining clip
7.Levers
8.Pin
9.Cover plate
10.Nut
11.PTO plate
12.Link
13.Pressure plate
14.Friction disc
15.Washer
16.Springs



TL251

Product changes

Spring centre main friction disc

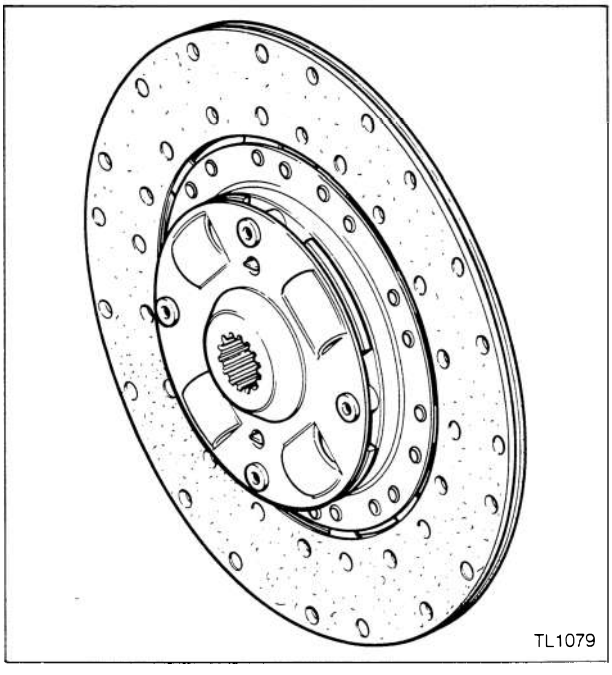
The main drive clutch on the above tractors has been progressively changed to a spring centre type friction plate (See illustration) in production during the period of May to December 1987. This has been done to provide torsional damping between the engine and transmission.

M-F 350, 355, and 360 tractors

At tractor serial number V16040 an interim version of the spring centre clutch cut-in, it had a friction plate similar to that used on the 330 mm (13 in) clutch but fitted with three springs. The pressure plate had its internal diameter increased to allow it to fit over the spring centre. The final version of the spring centre clutch friction plate will service the interim version.

On the interim version, if the pressure plate only is to be replaced, the friction plate must also be replaced with a later four spring type.

The final version of the clutch cut-in at tractor serial number V39421. This uses the new four spring type hub to provide damping and a modification to the original pressure plate.


TL1079

Product changes (continued)

M-F 375 tractors

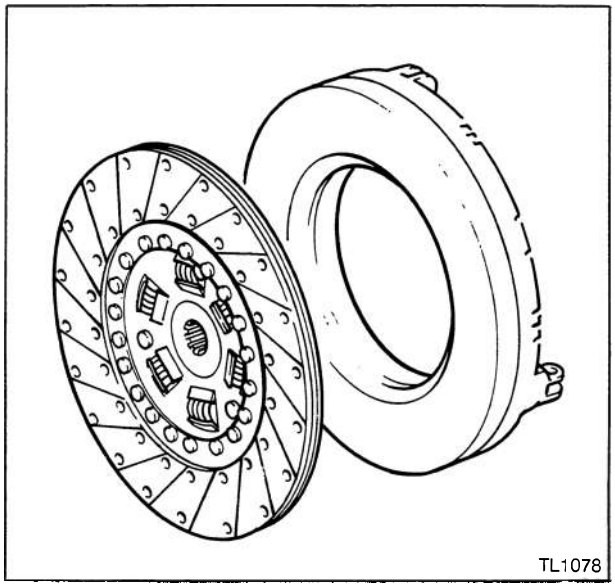
The spring centre friction plate for these tractors cut-in on 12 speed gearbox models only at serial number V46291.

The spring centre friction plate looks similar to the one fitted to the M-F 350, 355 and 360 tractors, although the springs in the hub are different. The plate has a dash of white paint on the spring housing to distinguish it from the M-F 350, 355 and 360 tractor version.

The machined-out pressure plate to take the spring centre friction plate was introduced from serial number V231 00, therefore the later friction plate will fit without any need to change the pressure plate.

M-F 385 tractors

This tractor has had a spring centre clutch with a six spring hub fitted from serial number V1 4268. The clutch cover assembly which is fited with the new plate is the same cover assembly which has always been fitted to the M-F 399tractor. (See illustration)



FAULT FINDING

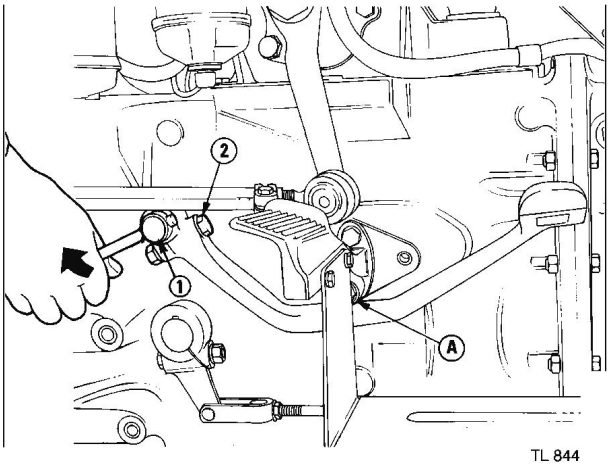
Symptom	Cause	Remedy	Reference
Clutch not engaging	Improper pedal adjustment	Adjust clutch pedal linkage	2.04A-01
	Damaged pressure plate in clutch cover	Replace defective part	2.04A-05 or 07
	Friction plate hub binding on splined drive pinion	Clean up splines and smear with small quantity of a recommended grease	2.04A-04 or 06
	Distorted friction plate or broken facings on friction plate	Install new friction plate	2.04A-04 or 06
	Dirt or foreign matter in clutch	Remove clutch from flywheel, clean and free off	2.04A-05 or 07
Clutch slip	Oil or grease on friction plate	Install new friction plate	2.04A-04 or 06
	Weak or soft pressure springs	Install new set of pressure springs	2.04A-05 or 07
	Clutch pedal linkage sticking	Free bearings and lubricate with a recommended grease	2.04A-03
	Improper pedal adjustment preventing full engagement	Correct pedal adjustment	2.04A-01
	Clutch face worn	Install new friction disc	2.04A-04 or 06

CLUTCH PEDAL

Adjust **2.04A–01**

Procedure

1. Insert a tommy bar in the hole in the end of the clutch operating shaft (1) and rotate it clockwise until resistance is felt.
2. Slacken the clamp bolt (2) securing the arm to the shaft and set the distance between the top of the pedal arm and the bottom of the footstep bracket (A) to 11 mm.
3. Retighten the clamp bolt. Press the clutch pedal down through its full travel five times, re-check the free travel and re-adjust if necessary.



TL 844

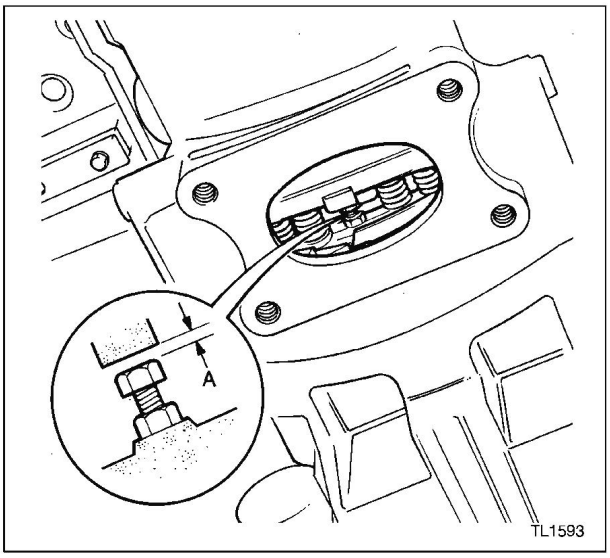
PTO CLUTCH

Adjust **2.04A–02**

Procedure

1. Remove the four bolts and the inspection cover from the underside of the clutch housing.
2. With the stop control out, rotate the engine until one of thee adjusters is visible in the inspection aperture.
3. With the aid of a feeler gauge, check the clearance 'A' between the bolt head and the clutch plate. It should be 2 mm.
4. If adjustment is required, slacken the nut and adjust the bolt to the correct clearance and retighten the nut.
5. Carry out the same procedure for the other two adjusters and replace the inspection cover.

NOTE: *Tractors with IPTO and single plate clutches do not require this adjustment.*



TL1593

CLUTCH RELEASE BEARING

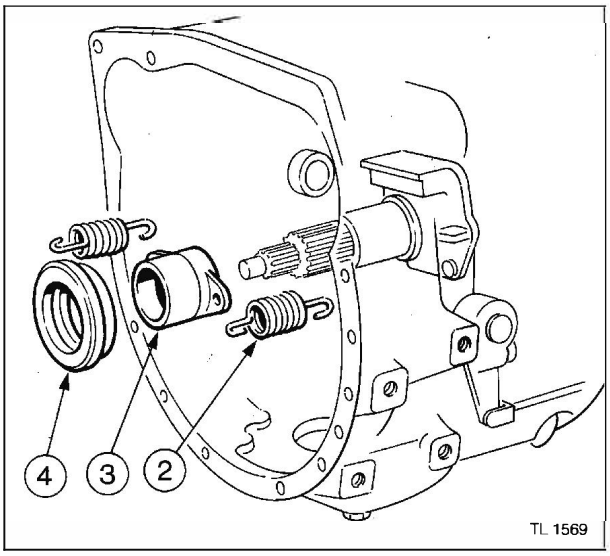
Removal and refitment **2.04A–03**

Removal

1. Split the tractor between the engine and gearbox, see section 2.
2. Release the two springs.
3. Remove the bearing and carrier assembly.
4. Drive the carrier from the bearing.

Refitment

5. Reverse procedures 1 to 4 except:
   a. Press a new bearing onto the carrier.
   b. Smear the input shaft splines and the release bearing carrier bore recess, with one of the greases recommended in the specifications section on page 4A-2.



CLUTCH RELEASE MECHANISM

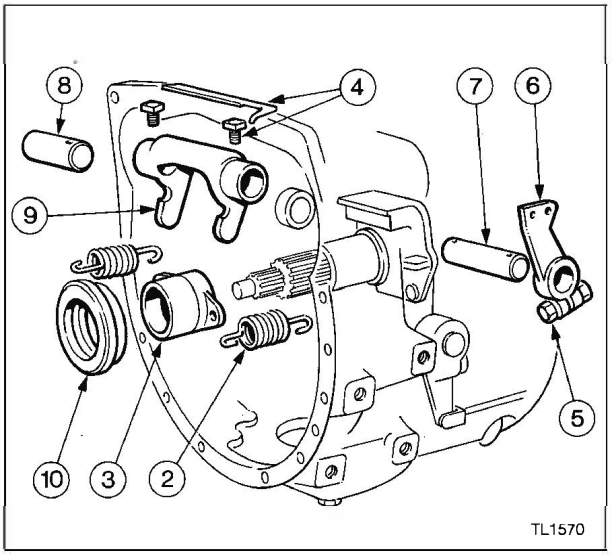
Removal and refitment **2.04A–04**

Removal

1. Split the tractor between the engine and gearbox, see section 2.
2. Remove the two springs.
3. Slide the carrier and release bearing off the input housing.
4. Remove the locking wire and the two locking screws from the release fork.
5. Slacken off the clamp bolt on the clutch pedal lever.
6. Remove the clutch pedal lever.
7. Withdraw the left-hand clutch half shaft from the gearbox casing.
8. Position a suitable drift, through the left-hand clutch shaft bore and carefully drive out the right-hand clutch half shaft.
9. Remove the clutch release fork.
10. Press the release bearing off the carrier.

Refitment

11. Reverse procedures 1 to 10 except:
    a. Lubricate the input shaft splines, release bearing carrier bore and release shaft bearings with one of the greases recommended in the specifications section on page 4A-2.
    b. Ensure that the locking screws are located in the holes in the cross shaft.
    c. Adjust the clutch pedal clearance, see operation 2.04A-01.



DUAL CLUTCH ASSEMBLY

Removal and refitment **2.04A–05**

Special Tools:
MF.159B Clutch centraliser
MF.215 PTO clutch setting gauge
MF.314 Lever height setting gauge

WARNING: The following sequence of instructions must be followed carefully, as spring pressure will cause the clutch cover to fly apart if pressure is not released slowly and evenly.

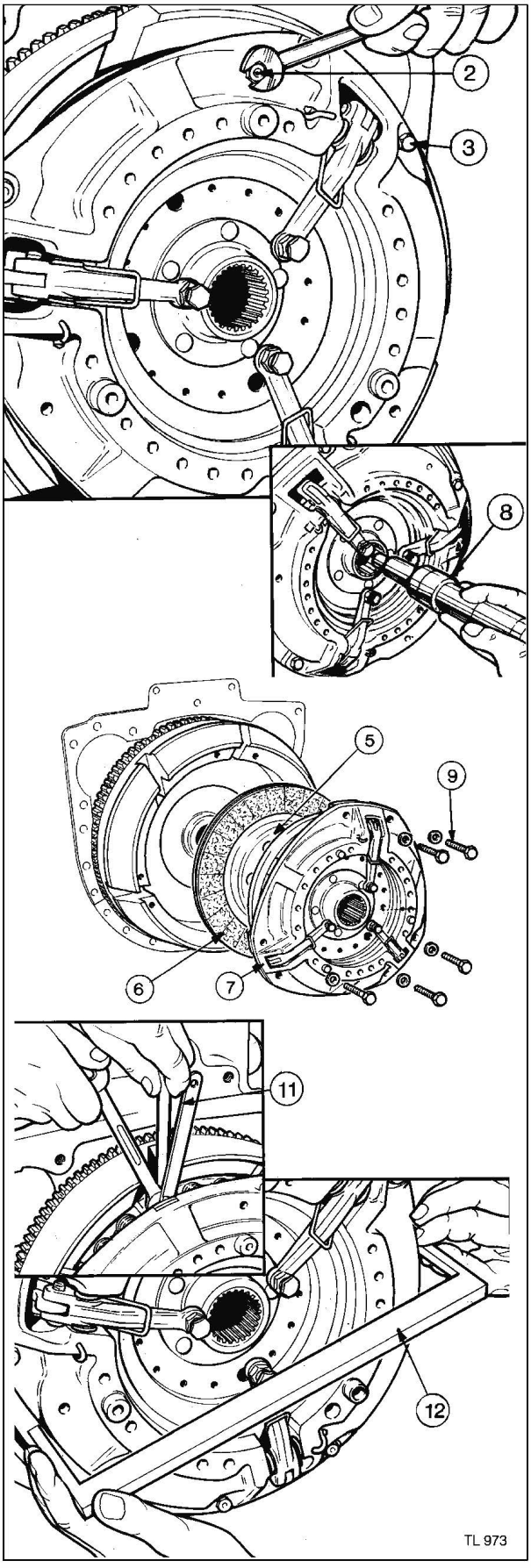
Removal

1. Split the tractor between the engine and the gearbox, see section 2.
2. Fit three slave bolts 1/4 UNC x 2 1/8 inch long to the three equi-spaced holes in the clutch cover.
3. Progressively slacken and remove the six bolts and washers.
4. Lift the clutch assembly clear of the flywheel. The main friction disc will remain separate from the clutch assembly.

WARNING: The organic lining of the friction plate can contain asbestos. Use a face mask when cleaning the clutch and housing. DO NOT USE COMPRESSED AIR.

Refitment

5. Lightly smear the splines of the friction discs with one of the greases recommended in the specifications section on page 4A-2.
6. Locate the main friction disc in the flywheel.
7. Position the clutch assembly on the flywheel.
8. Using MF.159B, centralise the clutch and the main friction disc.
9. Refit the six bolts and washers. Torque to 30 Nm.
10. Remove the three slave bolts and then remove MF.159B.
11. Using MF.215, check the clearance between the PTO clutch adjusting setscrews and the PTO pressure plate. Adjust the setscrews as required to 2 mm. Re-tighten the locknuts.
12. Using MF.314, check the height of each release lever. The domed end of the release lever setscrew must just touch the gauge. Adjust the setscrews as required and re-tighten the locknuts.
13. Connect the engine to the rear half of the tractor, see section 2.
14. Adjust the clutch pedal free travel, see operation 2.04A-01.



DUAL CLUTCH ASSEMBLY

Overhaul **2.04A–06**

Special Tools:
MF.159B Clutch centraliser.
MF.215 PTO clutch setting gauge.
MF.314 Lever height setting gauge.
Hydraulic press.

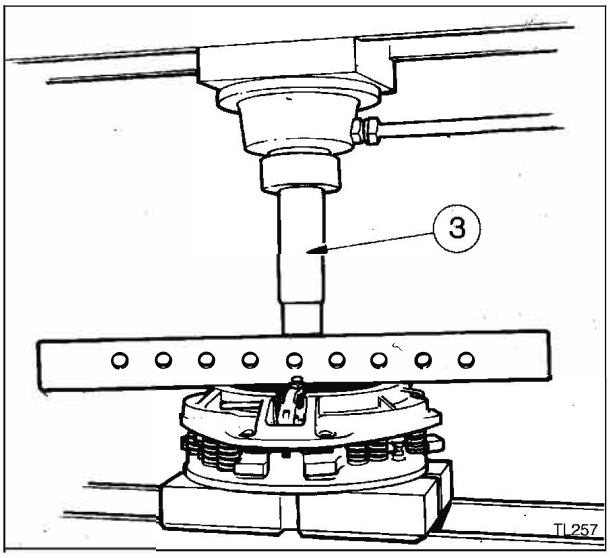
Dis-assembly

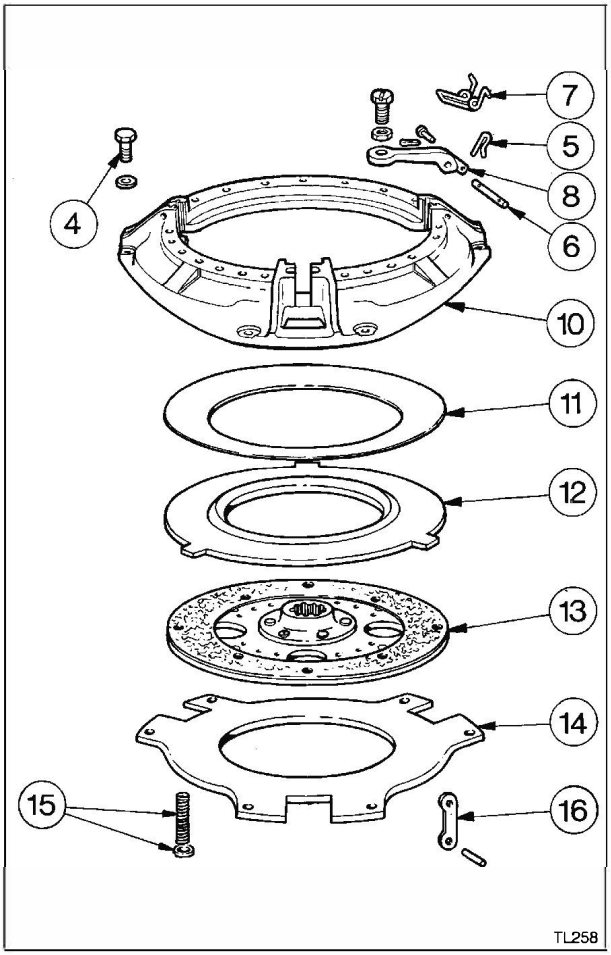
1. Remove the clutch assembly, see operation 2.04A-05.
2. Mark all following components to permit their refitment in the same relative positions:

   Cover plate, PTO pressure plate, false flywheel and main pressure plate
3. Place the clutch assembly on a hydraulic press and locate a suitable bar on top of the cover.

WARNING: Ensure that the clutch is located under the press correctly, that the bar will not slip and that the press has sufficient travel to allow the spring pressure to completely release. Release the pressure evenly and slowly.

4. Apply pressure until the three 1/4 UNC x 2 1/8 inch long slave bolts can be easily removed.
5. Remove the retaining clips from the pivot pins.
6. Remove the pivot pins.
7. Remove the lever springs.
8. Disconnect the release levers from the links.
9. Slowly release the pressure from the press until the springs are out of compression.
10. Lift off the cover plate.
11. Lift off the Belleville spring.
12. Lift off the PTO pressure plate.
13. Lift off the PTO friction disc.
14. Lift off the false flywheel.
15. Remove the springs and the fibre washers.
16. Remove the links.





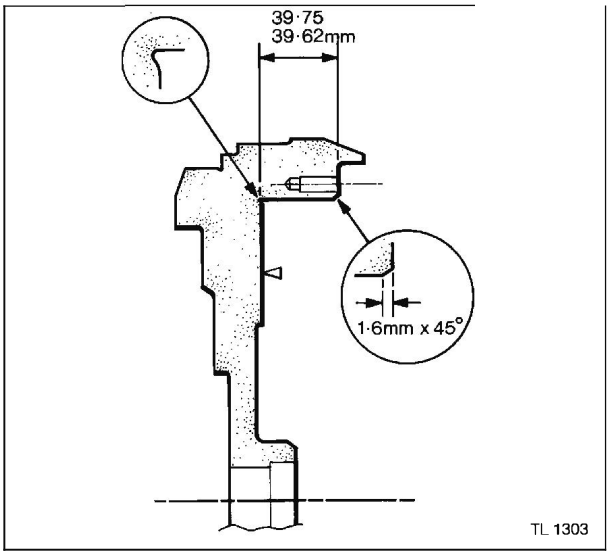
Examination

Inspect all components for wear, scoring, distortion, cracks, or signs of overheating. Check condition of the Belleville springs.

If the tractor flywheel is scored, skimming is permissible in 0,254 mm increments up to a maximum of 1,00 mm.

The ledge to which the clutch cover is bolted must be skimmed by the same amount to maintain the distance from the clutch face to 39,75 to 39,62 mm - see fig below.

NOTE: *Never, under any circumstances, skim either the false flywheel or the pressure plates as this will severely impair their heat dissipation characteristics.*

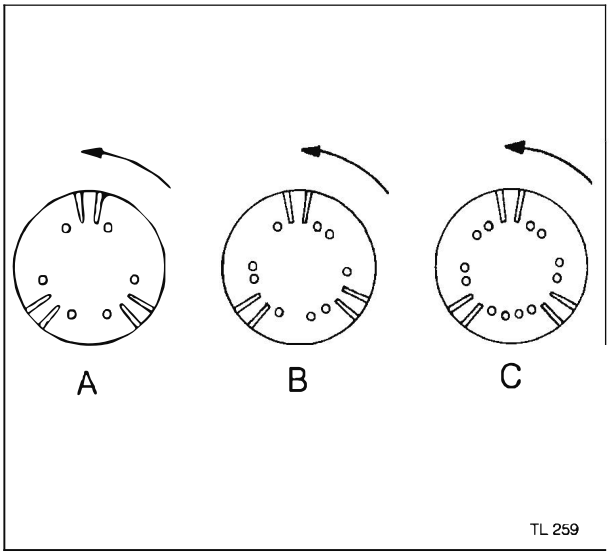


Re-assembly

17. Reverse procedures 1 to 16 except:

    a. Fit new springs and fibre washers to the pressure plate as shown in the chart.

Model	Number of springs	Colour	Illustration
MF345, MF 350	6	Red	A
MF 355, MF 360, MF 375	9	Green	B



SPLIT-TORQUE CLUTCH ASSEMBLY

Removal and refitment **2.04A–07**

Special Tools:
MF.159B Clutch centraliser
MF.314 Lever height setting gauge

WARNING: The following sequence of instructions must be followed carefully, as spring pressure will cause the clutch cover to fly apart if pressure is not released slowly and evenly.

Removal

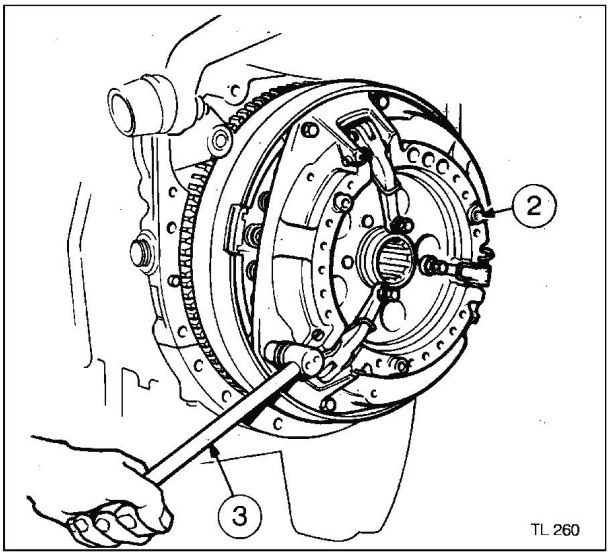
1. Split the tractor between the engine and the gearbox, see section 2.
2. Fit three slave bolts 1/4 UNC x 2 1/8 inch long to the three equi-spaced holes in the clutch cover.
3. Progressively slacken and remove the six bolts and washers.
4. Lift the clutch assembly clear of the flywheel. The main friction disc will remain separate from clutch assembly.

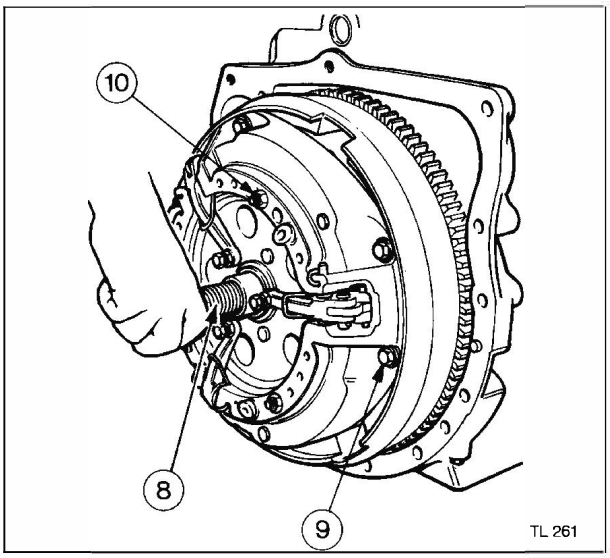
WARNING: The organic lining of the friction plate can contain asbestos. Use a face mask when cleaning the clutch and housing. DO NOT USE COMPRESSED AIR.

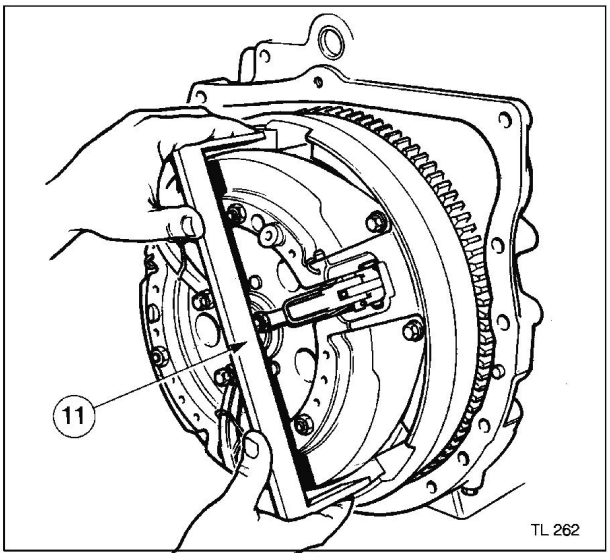
Refitment

5. Lightly smear the splines of the friction disc with one of the greases recommended in the specifications section on page 4A-2.
6. Locate the main friction disc in the flywheel.
7. Position the clutch assembly onto the flywheel.
8. Using MF.159B, centralise the clutch assembly and the friction disc.
9. Refit the six bolts and washers. Torque to 30 Nm.
10. Remove the three slave bolts and then remove MF.159B.
11. Using tool number MF.314 lever height setting gauge, check the adjustment of each release lever.

    The domed end of the release lever setscrew must be just touching the gauge. Adjust the setscrews as required and re-tighten the locknuts.
12. Reassemble the tractor, see section 2.
13. Adjust the clutch pedal free travel, see operation 2.04A-01.







SPLIT-TORQUE CLUTCH

Overhaul **2.04A–08**

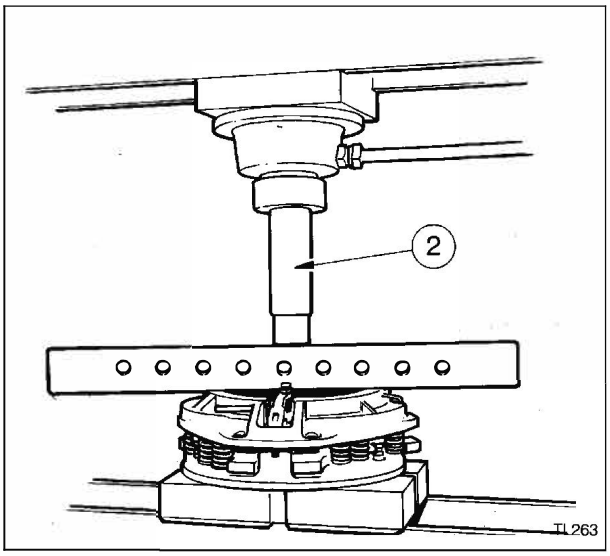
Special Tools:
MF.159B Clutch centraliser
MF.314 Lever height setting gauge
Hydraulic press.

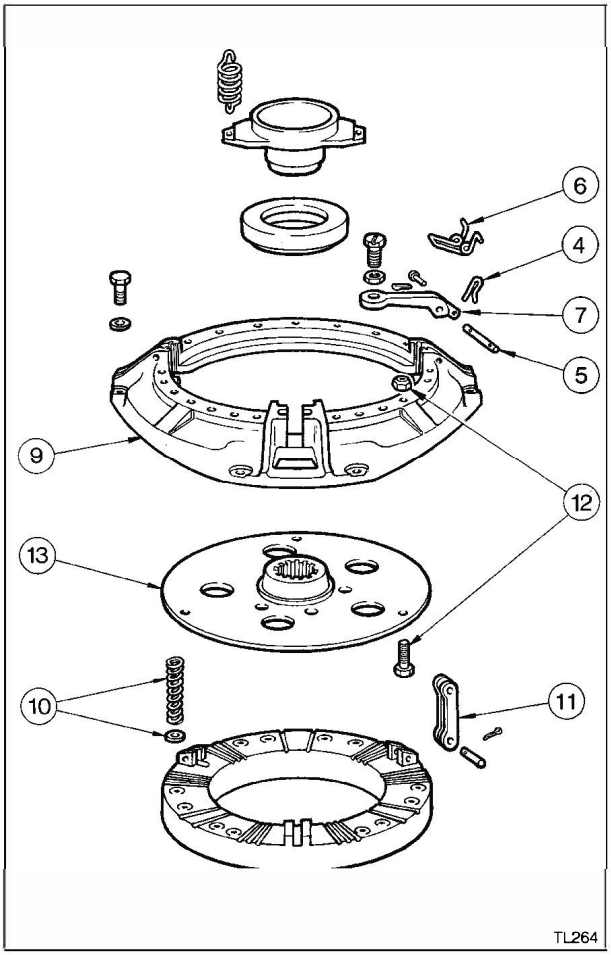
Dis-assembly

1. Remove the clutch assembly, see operation 2.04A-07.
2. Place the clutch assembly on the hydraulic press and locate a suitable bar across the top of the clutch cover.

WARNING: Ensure that the clutch is located under the press correctly, that the bar will not slip and that the press has sufficient travel to allow the spring pressure to come off. Release the pressure evenly and slowly.

3. Apply pressure until the three 1/4 inch bolts can be easily removed.
4. Removing the retaining clips from the pivot pins.
5. Remove the pivot pins.
6. Remove the lever springs.
7. Disconnect the release levers from the links.
8. Slowly release the pressure from the press until the springs are out of compression.
9. Lift off the cover plate assembly.
10. Remove the springs and the fibre washers.
11. Remove the links.
12. Remove the three bolts and nuts.
13. Remove the PTO plate.





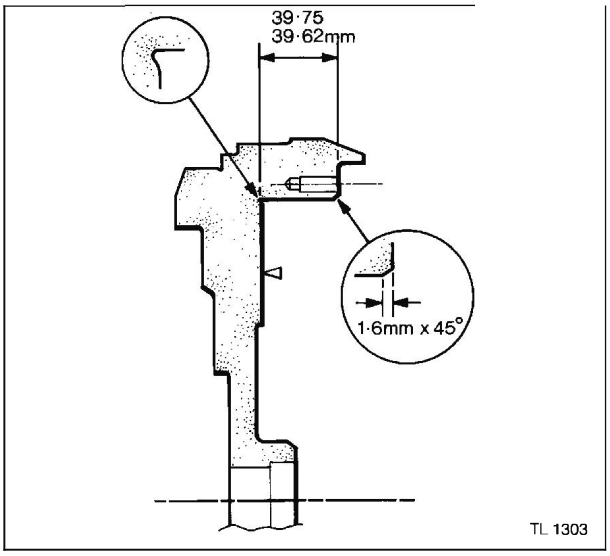
Examination

Inspect all components for wear, scoring, cracks, distortion or signs of overheating.

If the tractor flywheel is scored, skimming is possible, in 0,254 mm increments up to a maximum of 1,00 mm.

The ledge to which the clutch cover is bolted must be skimmed by the same amount to maintain the distance from the clutch face of 39,75 to 39,62 mm - see fig below.

NOTE: *Never, under any circumstances, skim the pressure plate, as this will severely impair its heat dissipation characteristics.*



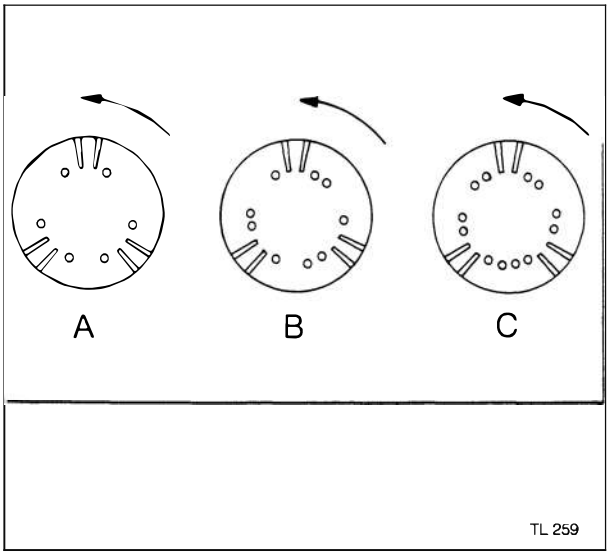
Re-assembly

14. Reverse procedures 1 to 13 except:

    a. Fit new springs and fibre washers to the pressure plate as shown in the chart:

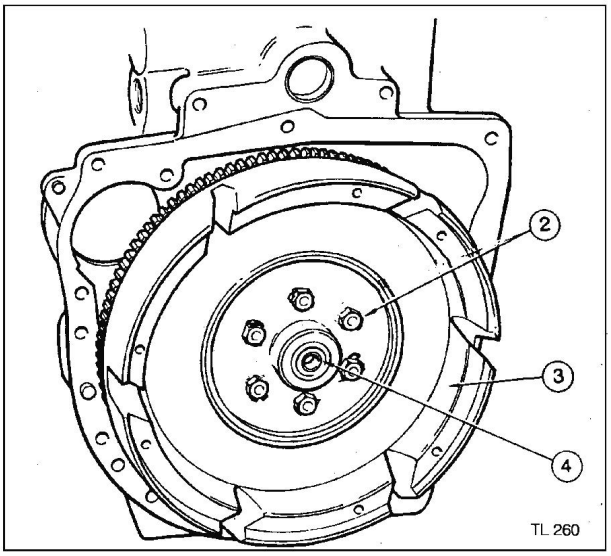
Model	Number of springs	Colour	Illustration
MF345, MF 350	6	Red	A
MF 355, MF 360, MF 375	9	Green	B

    b. Refit the PTO plate (13) and torque the bolts to 37 Nm.



FLYWHEEL PILOT BEARING

Removal and refitment **2.04A–09**



Removal

1. Remove the clutch assembly, see 2.04A-05 or 2.04A-07
2. Remove the six bolts and washers.
3. Remove the flywheel.
4. Fill the pilot bearing bore with heavy grease, then insert a suitable length of 16,9 mm diameter rod into the pilot bearing bore. Tap the rod sharply to hydraulically eject the bearing.

Refitment

5. Fit a new pilot bearing.
6. Locate the flywheel, aligning the untapped hole in the flange to the unused hole in the flywheel.
7. Fit the flywheel bolts and washers then torque to 100 Nm.
8. Refit the clutch.

SECTION 5

Gearbox

INDEX

5A	8 SPEED STANDARD GEARBOX
5B	8 SPEED SYNCHROMESH GEARBOX
5C	FOUR-WHEEL DRIVE UNIT

8 Speed Standard Gearbox

Section 5 – Part A

Table of Contents

Operation No.	Description	Page No.
-------	Specification	5A- 2
-------	General Description	5A- 2
2.05A-01	Gear Shift Levers - Removal	5A- 4
2.05A-02	Gear Shift Levers - Removal	5A- 5
2.05A-03	Selector Rails and Fork - Removal	5A- 6
2.05A-04	Normal- and Heavy-duty Epicyclic Unit - Removal	5A- 7
2.05A-05	Normal-duty Epicyclic Unit - Overhaul	5A- 8
2.05A-06	Heavy-duty Epicyclic Unit - Overhaul	5A- 9
2.05A-07	Input Shafts And Housing - Removal	5A-10
2.05A-08	PTO Drive Shaft Front Bearing - Removal	5A-11
2.05A-09	Layshaft, Mainshaft, PTO Shaft and Gears - Overhaul	5A-13

8 Speed Standard Gearbox

SPECIFICATION

Model	8 x 4 manual MK1 gearbox.
No. of gears:	
Forward	8.
Reverse	4.
Epicyclic reduction unit:	
Type	Normal- or heavy-duty.
Reduction	4 : 1 (low range).

Special Tools

MF.177A	Input shaft oil seal protector sleeve.
MF.218B	PTO bearing housing replacer.
MF.255B	PTO input shaft oil seal replacer.
MF.315A	Needle roller bearing remover/replacer.
MF.331	Input shaft oil seal replacer.

Bolt Torques

Steering wheel nut	47 Nm.
Gear lever cover to gearbox top	112 Nm.
Steering box to top cover	82 Nm.
Shifter fork locking screws	44 Nm.
Interlock mechanism bolt to gearbox case	44 Nm.
Epicyclic unit to gearbox case	44 Nm.
Input shaft housing to gearbox case	58 Nm.
PTO driveshaft bearing housing to gearbox	58 Nm.
Gearbox to engine	115 Nm.
Gearbox to rear transmission case	112 Nm.
Drag link ball joint nuts	122 Nm.

GENERAL DESCRIPTION

The gearbox has four forward speeds and one reverse, doubled by an epicyclic reduction unit to produce eight forward speeds and two reverse.

Main Transmission Drive

The input shaft is driven by the main transmission clutch plate and drives a pair of constant mesh gears. These, in turn, drive a hollow layshaft to which are attached the first, second, third and fourth ratio gears.

The mainshaft is located above the layshaft and has mounted on it three sliding gears, one of which is a compound gear having two sets of teeth. The sliding gears are operated by selector forks mounted on shifter rails which in turn are operated by the gear selector lever located directly above the gearbox.

The sliding gears mesh with the layshaft gears to give, from the front, third, first, fourth and second gears respectively depending upon the gear selected by the lever.

Epicyclic Reduction Unit

The epicyclic unit consists of a ring gear and three planetary pinions. It is mounted on the rear of the gearbox and driven by the mainshaft splined extension which acts as a sun gear.

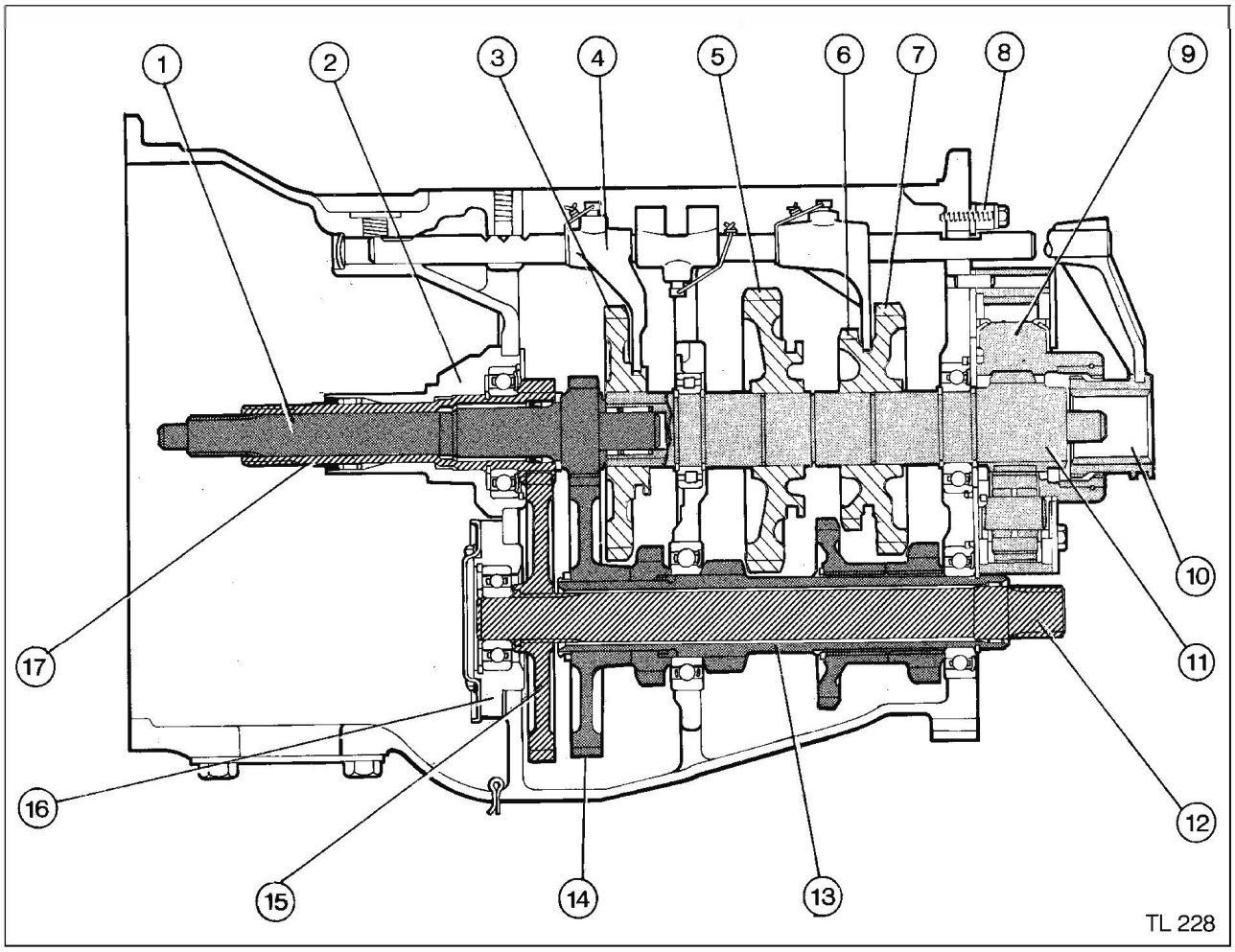
To transmit the drive from the gearbox to the rear axle a drive shaft is connected by a coupler, either directly to the gearbox mainshaft (HIGH range) or the planetary pinion carrier where the speed of the gearbox is reduced by 4:1 (LOW range). The coupler is operated by a selector fork, rail and gear lever which is mounted alongside the main gear selector lever. As well as selecting either HIGH or LOW range, the lever also has a middle or neutral position which disengages the coupler splines from both the mainshaft and the planetary pinion carrier. In this neutral position an electrical switch completes the starting circuit and the danger of starting in gear is prevented.

Reverse Drive

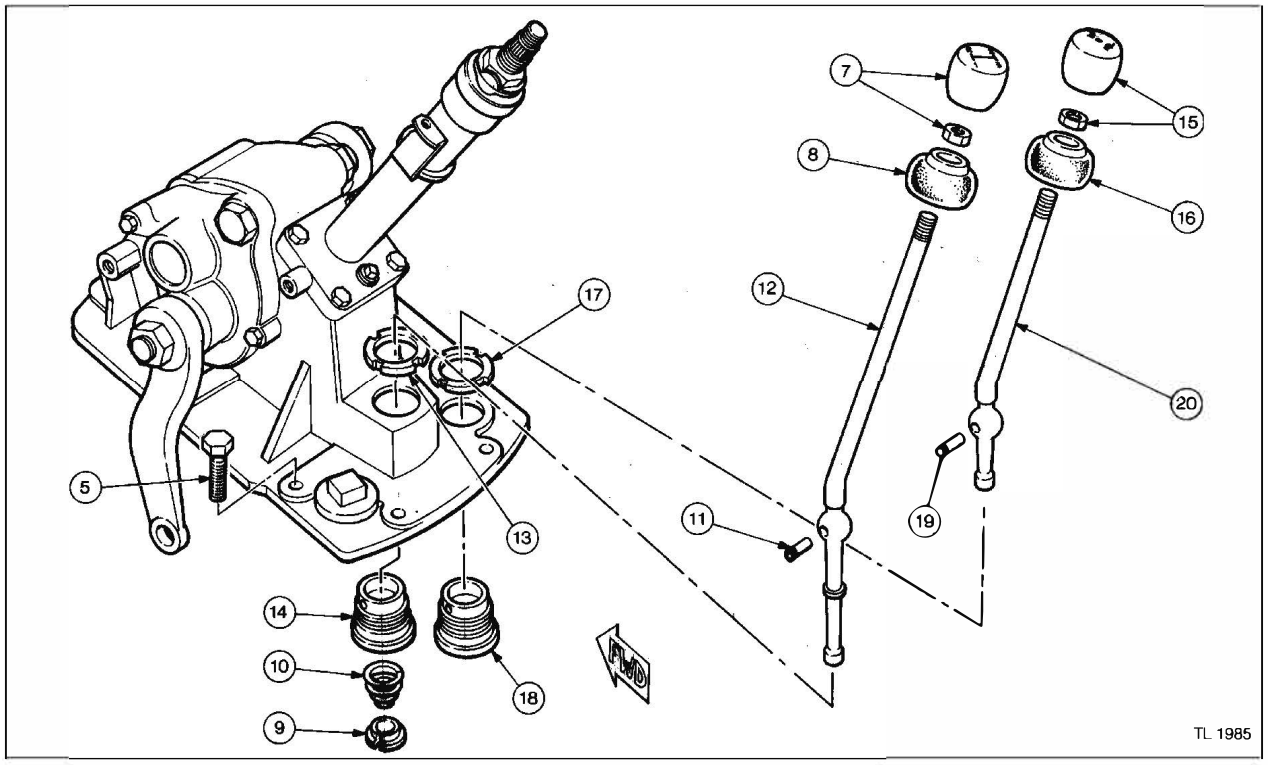
Reverse drive is achieved by the engagement of a compound gear cluster mounted in the left-hand side of the gearbox. One of the gears is in constant mesh with the fourth gear pinion on the layshaft. The other gear is engaged by the sliding first gear on the mainshaft. This combination reverses the rotation of the mainshaft, reduction unit and final drive.

PTO Drive Shaft

The PTO input shaft driven by the secondary plate on the dual clutch, rotates a pair of constant mesh gears. These, in turn, drive the PTO shaft which projects rearwards through the hollow layshaft to drive the linkage pump and PTO.



1. Transmission input shaft and gear.
2. Input shaft housing.
3. Third gear.
4. Selector rail and forks.
5. First/reverse gear.
6. Fourth gear.
7. Second gear.
8. Gear shift interlock.
9. Epicyclic reduction unit.
10. Sliding coupler.
11. Mainshaft.
12. PTO shaft.
13. Layshaft.
14. Transmission constant mesh gear.
15. PTO constant mesh gear.
16. PTO front bearing housing.
17. PTO input shaft and gear.



GEAR SHIFT LEVERS

Removal and refitment 2.05A–01

Removal

1. Remove the steering wheel, instrument panel and other parts necessary to gain access to the gearbox top and steering box assembly.
2. Remove both steering drag links.
3. Disconnect hydraulic pipes if power assist steering is fitted.
4. Move both the gear levers into the neutral position.
5. Remove the bolts securing the steering and gear lever assembly to the gearbox.
6. Remove the assembly from the tractor and place on a work bench.

Main gear lever

7. Remove the gear lever knob and nut.
8. Remove the rubber cover.

WARNING: Spring under compression.

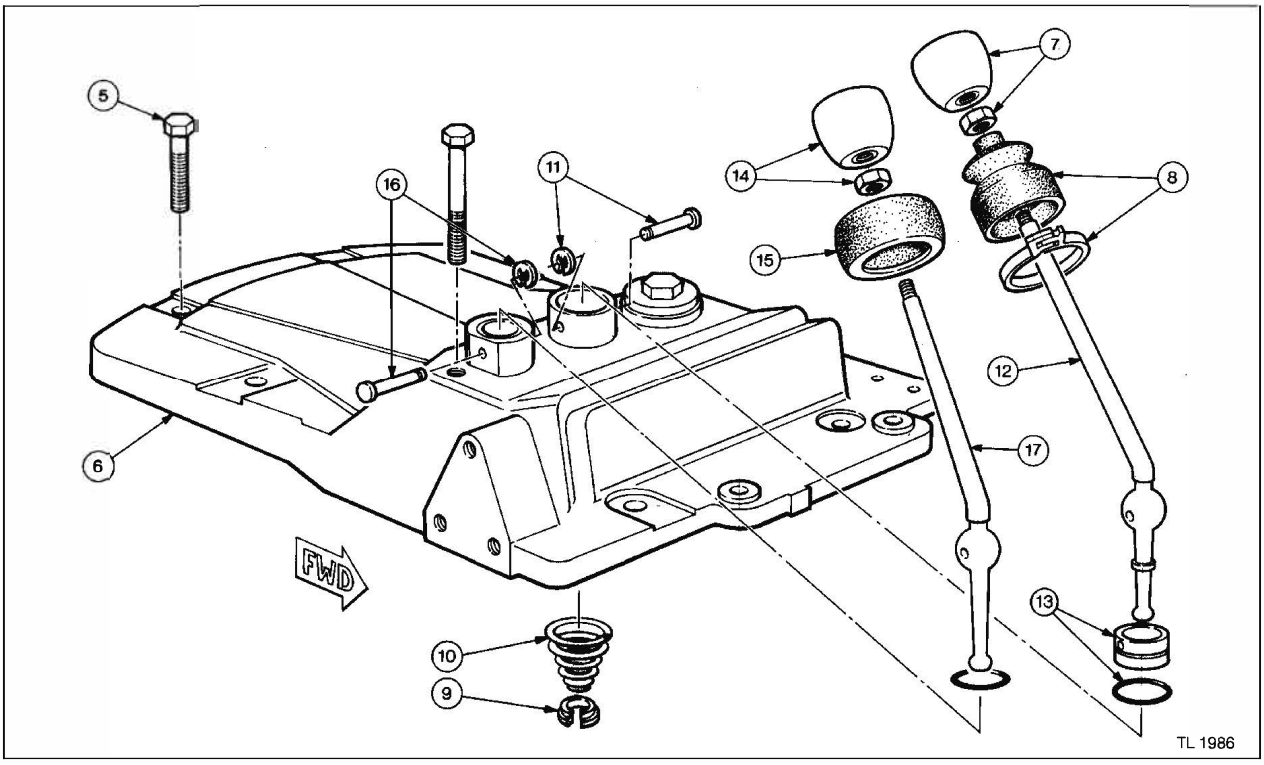
9. Turn the assembly over and unclip the spring retaining clip.
10. Remove the spring.
11. With a hammer and punch drive the gear lever retaining pin out of the gear lever cup.
12. Remove the main gear lever.
13. Unscrew the retaining ring with a 'C' spanner.
14. Remove the gear lever cup.

High/low gear lever

15. Remove the gear lever knob and nut.
16. Remove the rubber cover.
17. Unscrew the retaining ring with a 'C' spanner.
18. Remove the gear lever and cup assembly from the cover.
19. Drive out the gear lever retaining pin.
20. Remove the high/low gear lever.

Refitment

21. Reverse procedures 1 to 20 where applicable except:
    - *a.* When refitting the gear lever cup ensure that the retaining pin is square with the axis of the tractor.
    - *b.* Replace the rubber covers to prevent dirt getting into the transmission.
    - *c.* Coat the underside of the cover with MF Instant Gasket (Loctite 515) and torque the cover bolts to 112 Nm.
    - *d.* Tighten the drag link ball joint nuts to a torque of 122 Nm.
    - *e.* Tighten the steering wheel nut to a torque of 47 Nm.



GEAR SHIFT LEVERS

Removal and refitment **2.05A–02**

Removal

1. Remove the steering wheel, instrument panel and other parts necessary to gain access to the gearbox top and steering box.
2. Disconnect hydraulic hoses to hydrostatic steering units if fitted.
3. Remove the hydrostatic steering unit assembly or the steering box.
4. Move both the gear levers into the neutral position.
5. Remove the bolts securing the top cover assembly to the gearbox.
6. Remove the assembly from the tractor and place on a work bench.

Main gear lever

7. Remove the gear lever knob and nut.
8. Remove the rubber cover and clip.

WARNING: Spring under compression.

9. Turn the assembly over and unclip the spring retaining clip.
10. Remove the spring.
11. Remove the clip and retaining pin.
12. Remove the main gear lever.
13. Remove the gear lever cup and discard the 'O' ring.

High/low gear lever

14. Remove the knob and nut.
15. Remove the rubber cover.
16. Remove the clip and retaining pin.
17. Remove the gear lever and discard the 'O' ring.

Refitment

18. Reverse procedures 1 to 17 where applicable except:
    a. Replace the rubber covers to prevent dirt getting into the transmission.
    b. Coat the underside of the cover with MF Instant Gasket (Loctite 515) and torque the cover bolts to 112 Nm.
    c. Tighten the steering box to top cover bolts to a torque of 82 Nm.
    d. Tighten the drag link ball joint nuts to a torque of 122 Nm.
    e. Tighten the steering wheel nut to a torque of 47 Nm.

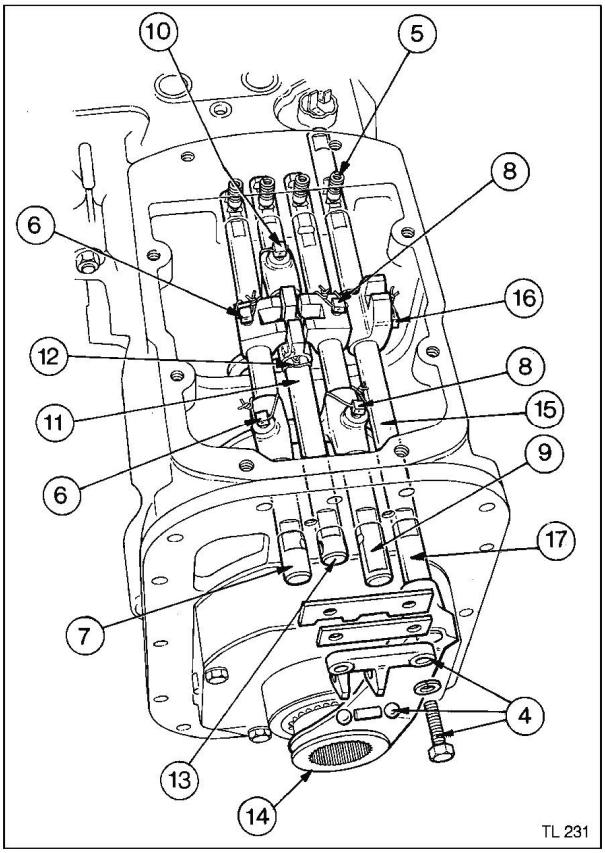
SELECTOR RAILS and FORKS

Removal and refitment **2.05A–03**

Removal

WARNING: Beware of sharp edges around the top of the gearbox case.

1. Split the tractor between the gearbox and the spacer housing and remove the gearbox, see section 2.
2. Remove the gearbox top cover, see operation 2.05A-01 or 2.05A.02.
3. Remove all the locking wires and discard.
4. Remove the bolts, fork, balls, peg, stop plate and plain plate of the gear shift interlock mechanism.
5. Lift out the detent springs and plungers.
6. Loosen the locking screws.
7. Slide the rail rearwards out of the housing retaining the gear lever selector jaw.
8. Loosen the locking screws.
9. Slide the rail rearwards out of the housing and lift out the selector jaw.
10. Loosen the locking screw.
11. Rotate the third gear selector rail through 180°.
12. Loosen the third gear selector jaw locking screw.
13. Slide the rail rearwards out of the housing and lift out the selector jaw.
14. Slide the high/low rail rearwards and remove the coupler.
15. Rotate the high/low rail through 90°.
16. Loosen the locking screw.
17. Slide the rail rearwards out of the housing and lift out the selector jaw.
18. Remove the selector forks from the gearbox.



Refitment

19. Reverse procedures 1 to 18 except:
    - *a.* Apply a few drops of oil to the selector rails before refitment.
    - *b.* Tighten the interlock mechanism retaining bolts to a torque of 44 Nm.
    - *c.* Tighten the shifter fork locking screws to a torque of 44 Nm.
    - *d.* Wire-lock all shifter fork locking screws using new locking wire.
    - *e.* On completion of the refitting procedure, place all the gears in the neutral position.

NORMAL and HEAVY DUTY EPICYCLIC UNIT

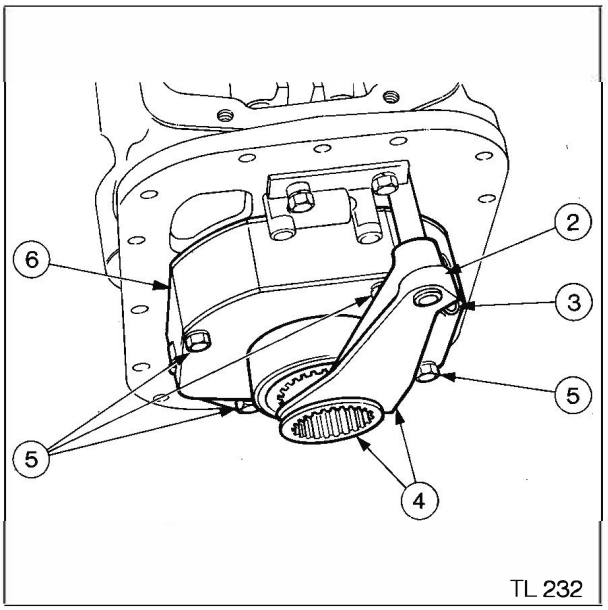
Removal and refitment **2.05A–04**

Removal

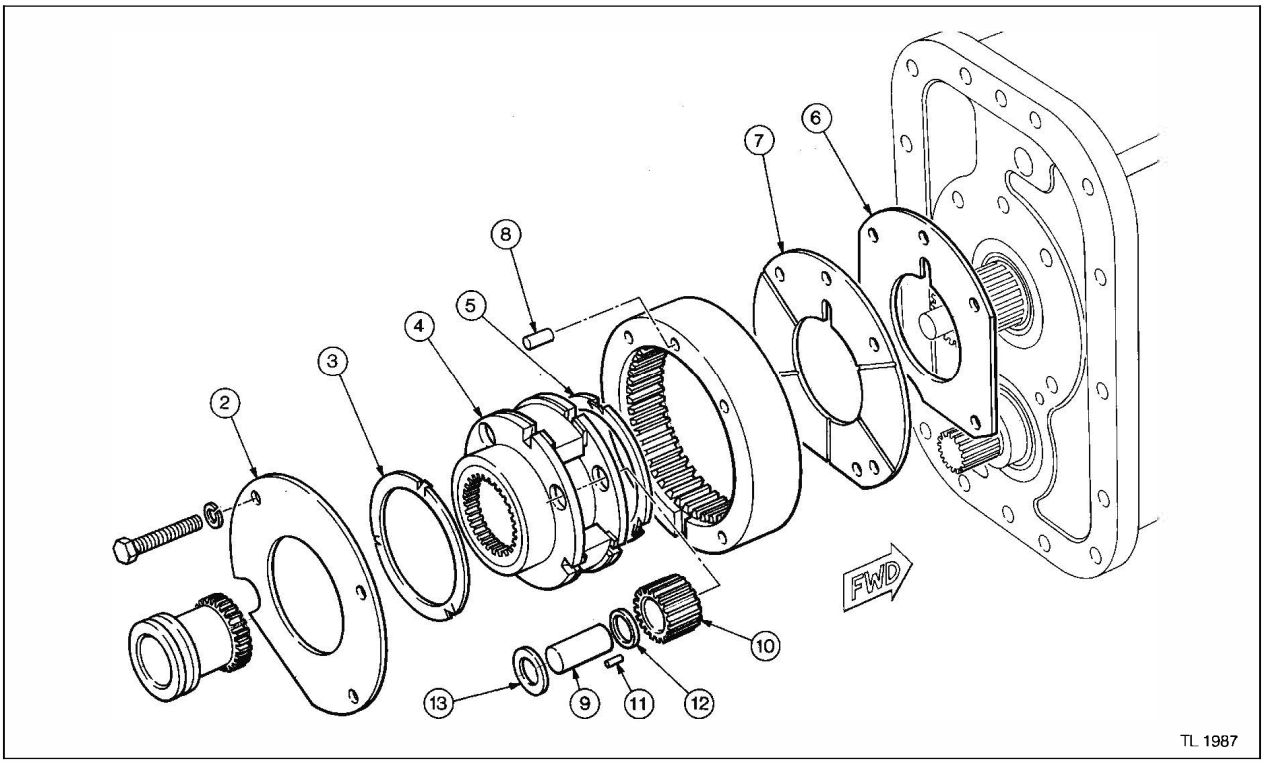
1. Split the tractor between the gearbox and the spacer or centre housing, see section 2.
2. Remove the locking wire and discard.
3. Loosen the locking screw.
4. Remove the selector fork and coupling.
5. Remove the bolts.
6. Remove the complete assembly.

Refitment

7. Reverse procedures 1 to 6 except:
   - *a.* Ensure that the front and rear thrust rings are correctly located before refitment.
   - *b.* Ensure that the dowels are correctly located in the gearbox casing.
   - c. Locate the cover plate with the cut out, to the bottom left hand corner for heavy duty, and the bottom right hand corner for normal duty epicyclics.
   - *d.* Fit a lockwasher to the lower right hand retaining bolt, on normal duty epicyclic only.
   - e. Tighten the retaining bolts progressively and evenly to a torque of 44 Nm.
   - *f.* Tighten the shifter fork lock screws to a torque of 44 Nm.
   - *g.* Wire-lock all fixings affected by procedure 2 using new locking wire.



TL 232



NORMAL DUTY EPICYCLIC UNIT

Overhaul **2.05A–05**

Dis-assembly

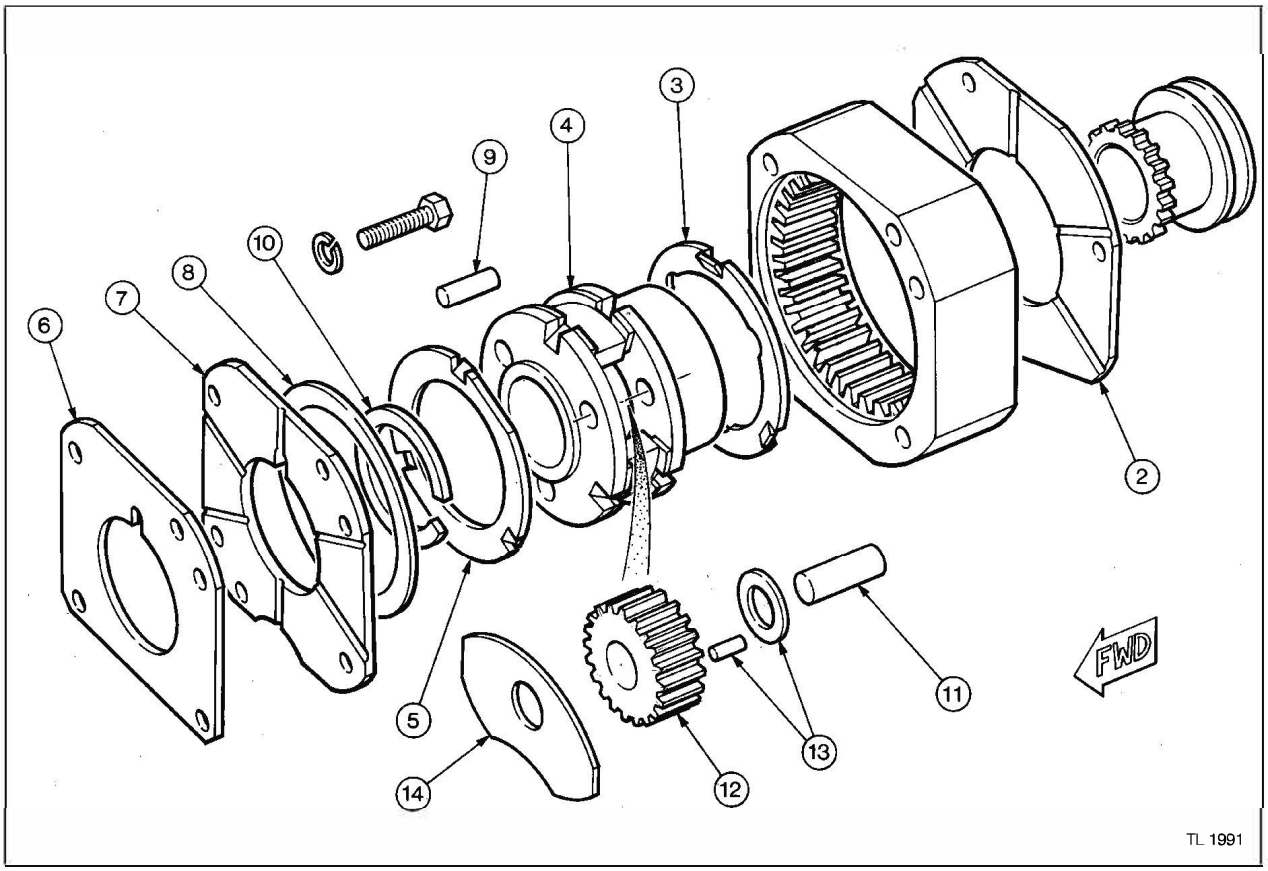
1. Remove the gearbox epicyclic unit, see operation 2.05A-04.
2. Remove the rear plate.
3. Remove the rear thrust ring.
4. Remove the planetary pinion carrier.
5. Remove the front thrust ring.
6. Remove the shim.
7. Remove the front plate.
8. If necessary remove the two dowels from the ring gear.
9. Press each shaft out of planetary pinions and carrier.
10. Retain the three spacers, two thrust washers and needle roller bearings from each pinion.

Examination

Clean and carefully examine all the components, especially those subject to movement, and replace any items that show signs of damage or wear.

Re-assembly

11. Replace the needle rollers in each pinion, a smear of petroleum jelly, NOT GREASE, will help to retain them. There are two rows of 27 rollers to each pinion.
12. A spacer is fitted between each row of needle roller bearings and at each end of the pinion.
13. Fit a thrust washer to each side of the pinions.
14. To assist assembly of the front and rear thrust rings on the planetary pinion carrier, smear them with petroleum jelly, NOT GREASE. Ensure that the tabs on the thrust rings locate in the pinion carrier cut-outs, and the brass faces are fitted away from the planetary pinion carrier.
15. The front and rear plates have oil grooves which must face towards the planetary pinion carrier.
16. Only one shim is fitted.



HEAVY DUTY EPICYCLIC UNIT

Overhaul 2.05A–06

Dis-assembly

1. Remove the gearbox epicyclic unit, see operation 2.05A-04.
2. Remove the cover plate.
3. Remove the rear thrust ring.
4. Remove the planetary pinion carrier.
5. Remove the front thrust ring.
6. Remove the shim.
7. Remove the front plate.
8. Belleville spring disc - **not fitted to this unit.**
9. If necessary, remove the dowels from the planetary ring gear.
10. Remove the external snap ring.
11. Gently tap out the three pinion shafts towards the front.
12. Remove the planetary pinions.
13. Remove the two sets of rollers and spacer from each pinion.
14. Remove the wear plates from each side of each pinion.

Examination

Clean and carefully examine all the components, especially those subject to movement, and replace any items that show signs of damage or wear.

Re-assembly

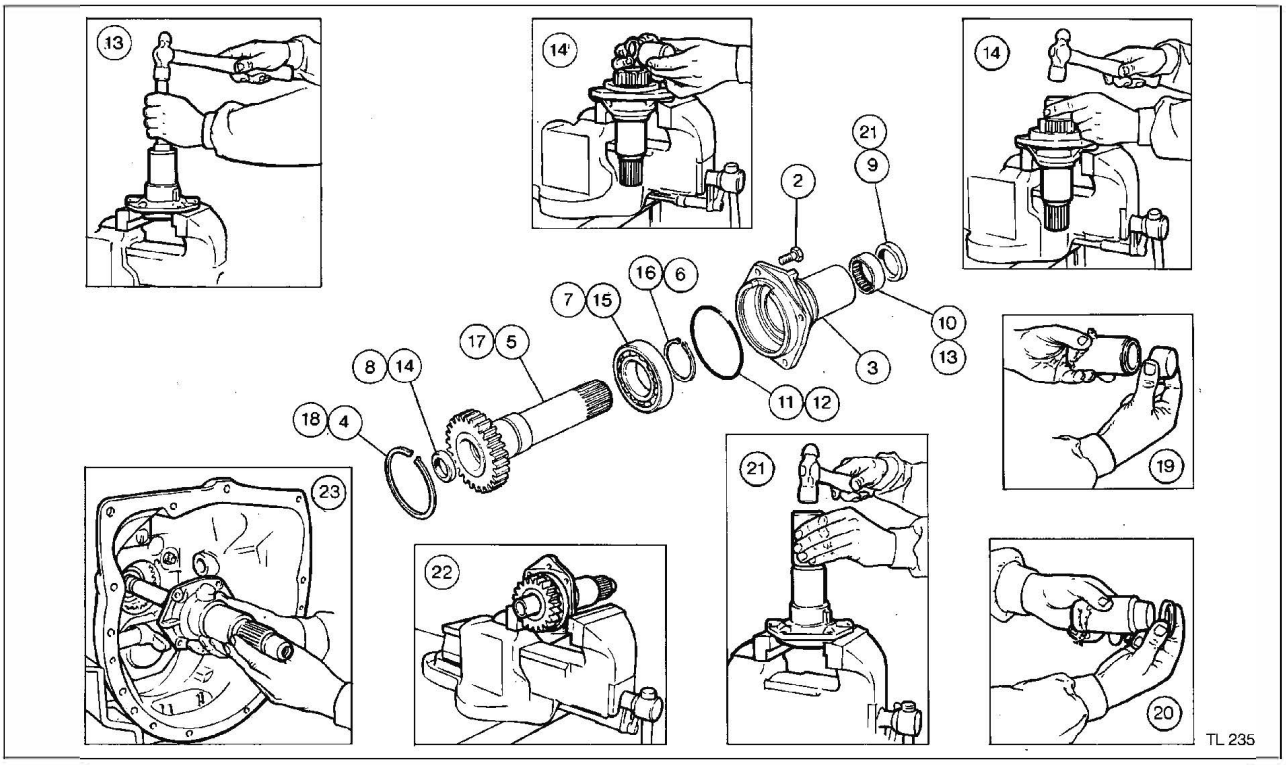
15. Reverse procedures 1 to 14, except:

a. When replacing the rollers in the pinions, a smear of petroleum jelly, NOT GREASE, will help retain them. Do not omit the spacer from between the two rows of rollers. Each row consists of 16 rollers.

b. The front plate and the cover plate must be positioned with the oil grooves towards the pinion carrier.

c. Ensure that the gap of the snap ring is located midway between the planetary pinion shafts.

d. To assist assembly of the front and rear thrust rings on the pinion carrier, smear them with petroleum jelly, NOT GREASE. Ensure that the tabs on the thrust rings locate in the pinion carrier cut-outs, and that the brass faces are away from the pinion carrier.



INPUT SHAFTS AND HOUSING

Removal and refitment **2.05A–07**

Special Tools:

MF.255B PTO input shaft oil seal replacer
MF.315A Needle roller bearing remover and replacer
MF.331 Main input shaft oil seal replacer
MF.177A Input shaft oil seal protector sleeve

Removal

1. Remove the clutch release mechanism, see operation 2.04A-04.
2. Remove the four bolts.
3. Withdraw the input housing complete with PTO input shaft.
4. Remove the large internal circlip.
5. Push the PTO input shaft complete with bearing rearwards out of the housing.
6. If necessary remove the circlip.
7. If necessary press the bearing off the shaft.
8. Lever the PTO shaft seal out.
9. Lever the mainshaft seal out.
10. Using MF.315A remove the needle roller bearing.
11. Remove the 'O' ring (PTO input shaft housing).

Refitment

12. Fit a new 'O' ring (PTO input shaft).
13. Using MF.315A replace the needle roller bearing.
14. Using MF.331 fit a new seal, with the lip of the seal facing the tool.
15. Refit the bearing with the shield towards the gear teeth.
16. Refit the circlip. (Check that it is properly seated).
17. Refit the PTO input shaft and bearing into the input housing.
18. Refit the circlip. (Check that it is properly seated).
19. Place the nylon cone adaptor on PTO input shaft oil seal replacer MF.255B.
20. Place the seal over the nylon cone and onto the tool with the seal lip facing away from the tool and remove the nylon cone.
21. Place the tool over the PTO input shaft and tap the seal into place.
22. Place MF.177A into the input housing assembly.
23. Slide the housing over the input shaft.
24. Reverse procedures 1 to 7, except:
    a. Use petroleum jelly, NOT GREASE, to lubricate all seals and the needle roller bearing when refitting.
    b. Lightly coat the bolt thread with Hylomar sealant when refitting and tighten the bolts to a torque of 58 Nm.

PTO DRIVE SHAFT FRONT BEARING

Removal and refitment **2.05A–08**

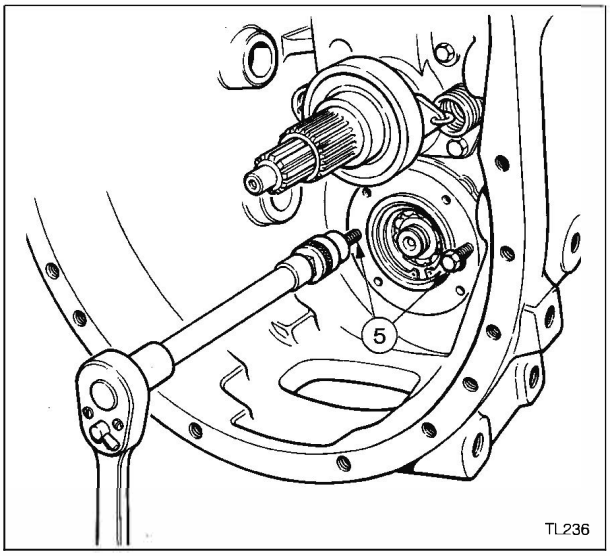
Special Tools:
MF.218B PTO Drive Shaft Puller.

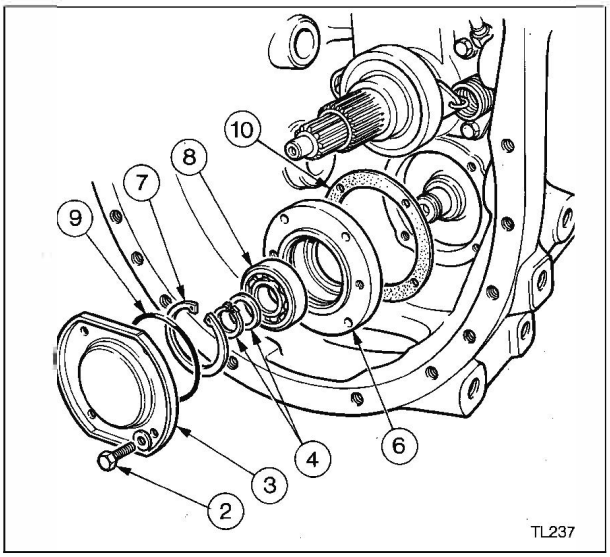
Removal

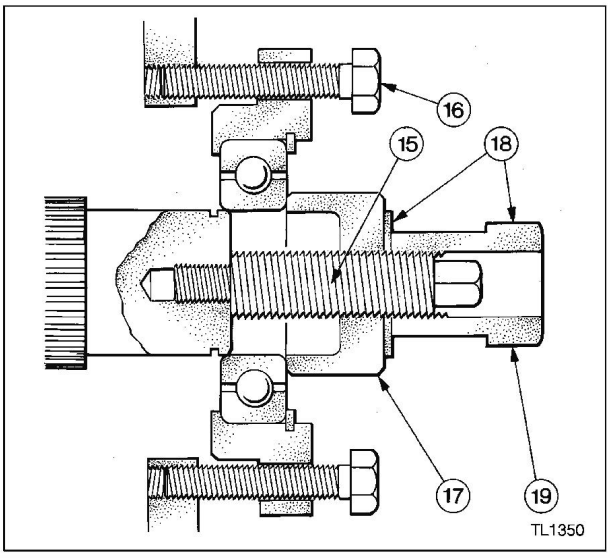
1. Remove the clutch cross-shaft and lever, see operation 2.04A-04.
2. Remove the four bolts and washers.
3. Remove the cover plate.
4. Remove the external circlip and washer.
5. Screw two 3/8 UNC x 3 inch bolts (part of MF.218B) into the bearing housing and tighten them evenly to draw the housing from the case and shaft.
6. Remove the housing.
7. Remove and discard the circlip.
8. Press out the bearing.
9. Remove and discard the 'O' ring.
10. Remove and discard the gasket.
11. If the gearbox has been removed and it is necessary to remove the PTO shaft, insert a 7/16 inch UNF bolt approximately 3-4 inch long into the shaft to protect it, drive the shaft out of the PTO constant mesh gear.

Refitment

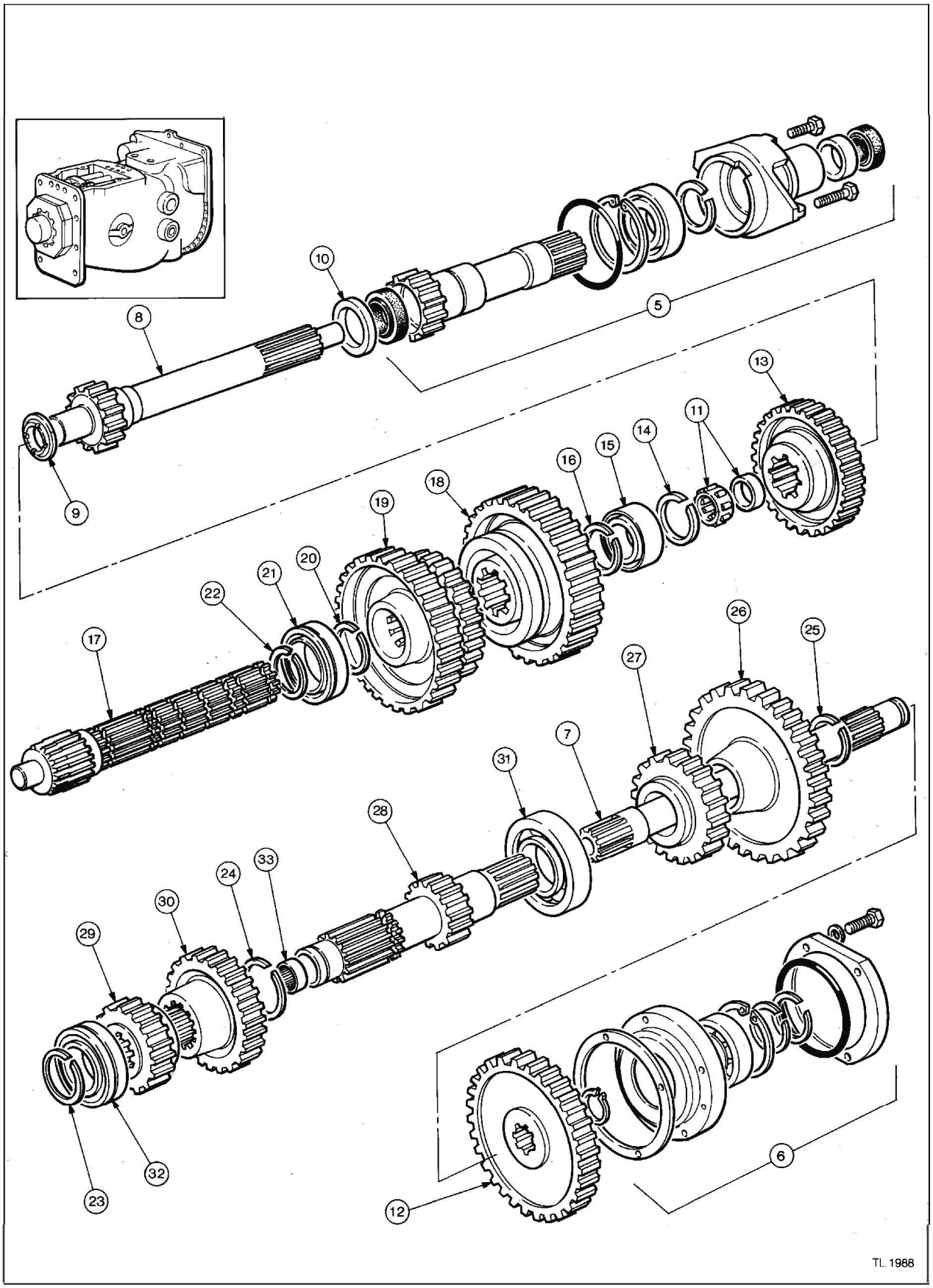
12. Lightly coat the new gasket with Hylomar sealant.
13. Using MF.218B, refit the bearing housing assembly.
14. Check that the PTO drive shaft splines locate with those in the PTO constant mesh gear, if the shaft has been removed.
15. Screw the centre screw into the end of the PTO shaft with the aid of a 9/16 inch across flats spanner.
16. Locate the bearing and housing assembly on the end of the PTO shaft and to the housing with the two long bolts provided with MF.218B through the unthreaded holes.
17. Place the adaptor onto the centre screw with the hollow face against the bearing.
18. Place the washer on the centre screw and put on the nut.
19. Tighten the nut with a 1 1/8 inch across flats spanner until the housing is pushed home and the PTO shaft is drawn through the ball bearing sufficiently to enable the washer and circlip to be fitted.
20. Fit a new circlip and washer.
21. Replace the cover ensuring that a new 'O' ring is fitted.
22. Lightly coat the securing bolt threads with Hylomar sealant.
23. Tighten the bolts to a torque of 58 Nm.







8 Speed Standard Gearbox



LAYSHAFT, MAINSHAFT, PTO SHAFT and GEARS

Overhaul **2.05A–09**

Dis-assembly

NOTE: *Gearboxes supplied to North America have a high ratio fourth gear and two of the gear positions are changed. 3rd gear becomes 4th and 4th gear becomes 3rd.*

1. Remove the gearbox from the tractor, see section 2.
2. Remove the clutch thrust bearing and cross shaft, see operation 2.04A-04.
3. Remove the selector rails and forks, see operation 2.05A-03.
4. Remove the epicyclic reduction unit, see operation 2.05A-04.
5. Remove the input shafts and housing, see operation 2.05A-07.
6. Remove the PTO drive front bearing, see operation 2.05A-08.

Input shaft

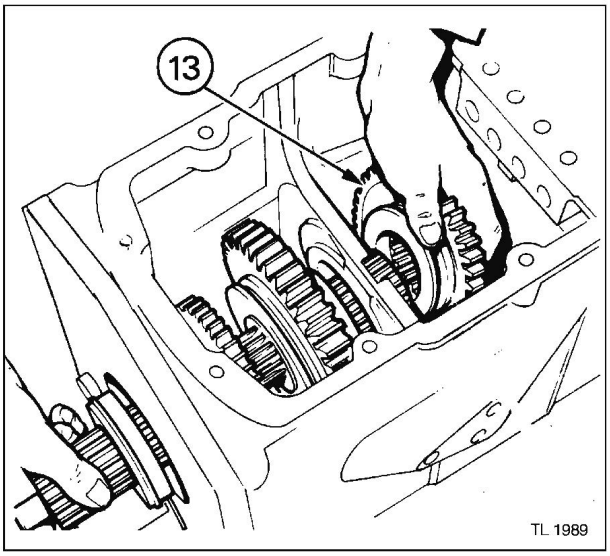
7. Remove the PTO shaft.
8. Remove the input shaft.
9. Remove the main thrust washer.
10. Remove the front thrust washer.
11. Remove the needle roller bearing and spacer.
12. Lift out the PTO constant mesh gear.

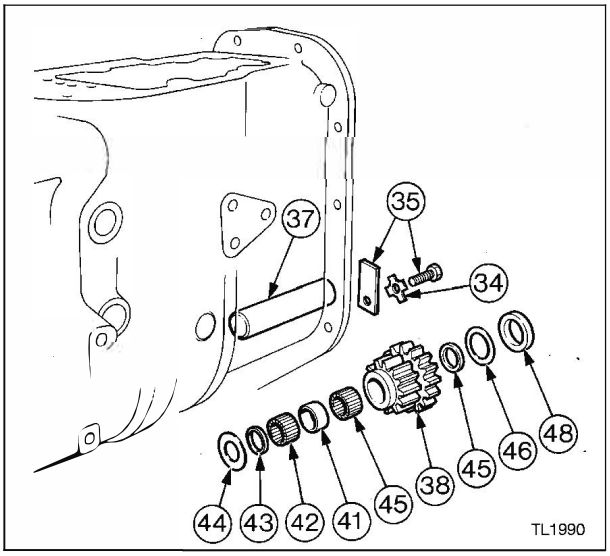
Mainshaft

13. Drive the mainshaft rearwards and remove the 3rd speed sliding gear (41T) [North America 4th (32T)].
14. Remove the front snap ring.
15. Drive the mainshaft out of the front roller bearing.
16. Remove the rear snap ring.
17. Withdraw the mainshaft rearwards lifting out the gears.
18. Remove the 1st and reverse sliding gear (44T).
19. Remove the 2nd and 4th sliding gear (46T x 36T) [North America 2nd and 3rd (46T x 36T)].
20. Remove the rear snap ring.
21. Remove the ball bearing.
22. Remove the front snap ring.

Layshaft

23. Remove the snap ring from the rear of the layshaft.
24. Tap the shaft forwards to uncover the snap ring in front of the 4th speed gear (North America 3rd gear). Move the circlip onto the non splined portion of the shaft.
25. Remove the snap ring from the front of the layshaft.

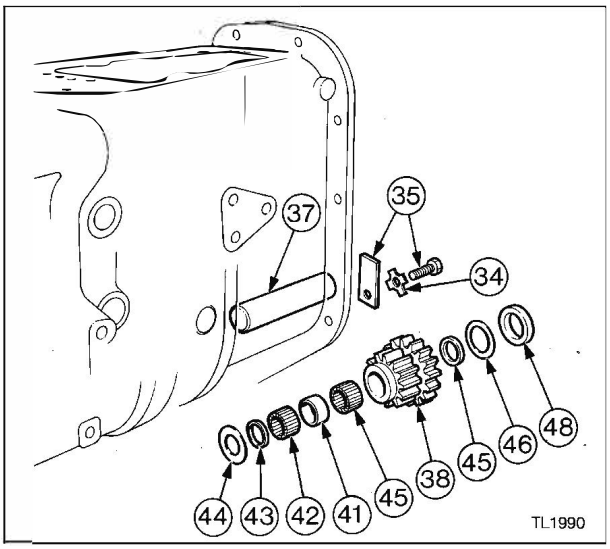




26. Tap the shaft rearwards and remove the constant mesh gear.
27. Continue tapping the shaft rearwards and remove the 3rd speed gear (28T) [North America 4th speed (36T)].
28. Drive the layshaft out through the front of the gearbox.
29. Remove the 2nd gear (23T).
30. Remove the 4th gear (33T) and snap ring [North America 3rd gear (33T)].
31. Remove the front ball bearing.
32. Remove the rear bearing.
33. Remove the needle roller bearing from the rear of the layshaft.

Reverse idler

34. Release the locking washer.
35. Remove the bolt and locating tab.
36. Obtain a length of bright steel bar 1 inch dia x 2 3/16 inch long for removal of the reverse idler.
37. Slide the bar in from the front of the reverse idler shaft towards the rear. This will push out the reverse idler gear shaft, and prevent the needle rollers and spacers dropping into the gearbox case.
38. Remove the idler gear assembly complete with needle rollers, spacers and bar.
39. Remove the bar from the idler gear and release the needle rollers and spacers into a clean container.



Examination

Clean and carefully examine all the components, especially those subject to movement, and replace any items that show signs of damage or wear.

Re-assembly

NOTE: *All circlips and snap rings must be renewed. Ensure that the are all correctly located in their grooves.*

Reverse idler

40. Coat the inside of the reverse idler gear with petroleum jelly, NOT GREASE, to assist in assembly.
41. Refit the centre spacer.
42. Refit the first row of 28 rollers.
43. Refit the spacer.
44. Refit the thrust washer.
45. Refit the second set of rollers and spacer.
46. Refit the thrust washer.
47. Slide the steel bar into the reverse gear assembly.
48. Refit the spacer.
49. Refit the reverse idler gear assembly to the gearbox case using the shaft to push out the bar.
50. Fit a new lock washer to lock the retaining bolt.

Layshaft

51. Reverse procedures 23 to 33.

Mainshaft

52. Reverse procedures 13 to 22.

Input shaft

53. Reverse procedures 7 to 12.
54. Ensure that the main thrust washer (9) is fitted with the oil grooves facing the mainshaft.
55. Re-assemble the rest of the gearbox reversing procedures 1 to 7.

8 Speed Synchromesh Gearbox

Section 5 – Part B

Table of Contents

Operation No.	Description	Page No.
-------	Specification	5B- 2
-------	General Description	5B- 2
2.05B-01	Gear Shift Levers - Removal	5B- 4
2.05B-02	Gear Shift Levers - Removal	5B- 5
2.05B-03	Selector Rails and Fork - Removal	5B- 6
2.05B-04	Normal- and Heavy-duty Epicyclic Unit - Removal	5B- 7
2.05B-05	Normal-duty Epicyclic Unit - Overhaul	5B- 8
2.05B-06	Heavy-duty Epicyclic Unit - Overhaul	5B- 9
2.05B-07	Input Shafts and Housing - Removal	5B-10
2.05B-08	PTO Drive Shaft Front Bearing - Removal	5B-11
2.05B-09	Layshaft, Mainshaft, PTO Shaft and Gears - Overhaul	5B-13

8 Speed Synchromesh Gearbox

SPECIFICATION

Model	8 x 2 manual MK1 ZF synchromesh gearbox.
No. of gears:	
Forward	8.
Reverse	2.
Synchromesh type	ZF.
Epicyclic reduction unit:	
Type	Normal- or heavy-duty.
Reduction	4 : 1 (low range).

Special Tools

MF.177A	Input shaft oil seal protector sleeve.
MF.218B	PTO bearing housing replacer.
MF.255B	PTO input shaft oil seal replacer.
MF.315A	Needle roller bearing remover/replacer.
MF.331	Input shaft oil seal replacer.
MF.414A	Synchromesh centralising pin.
MF.415	Synchromesh hub assembly tool.
MS.550	Drive handle.

Bolt Torques

Steering wheel nut	47 Nm.
Gear lever cover to gearbox top	112 Nm.
Steering box to top cover	82 Nm.
Shifter fork locking screws	44 Nm.
Interlock mechanism bolt to gearbox case	44 Nm.
Epicyclic unit to gearbox case	44 Nm.
Input shaft housing to gearbox case	58 Nm.
PTO driveshaft bearing housing to gearbox	58 Nm.
Gearbox to engine	115 Nm.
Gearbox to rear transmission case	112 Nm.
Drag link ball joint nuts	122 Nm.

GENERAL DESCRIPTION

This gearbox is similar to the 8 speed standard gearbox described in section 5A, having four forward and one reverse gearbox, doubled by an epicyclic reduction unit to give eight forward and two reverse gears.

The gearbox differs by having a synchromesh gear change on the top two gears, 3rd and 4th. This arrangement makes three synchronised gear changes available as follows:

1. From 2nd to 3rd ratio.
2. From 3rd to 4th ratio.
3. From 4th to 3rd ratio.

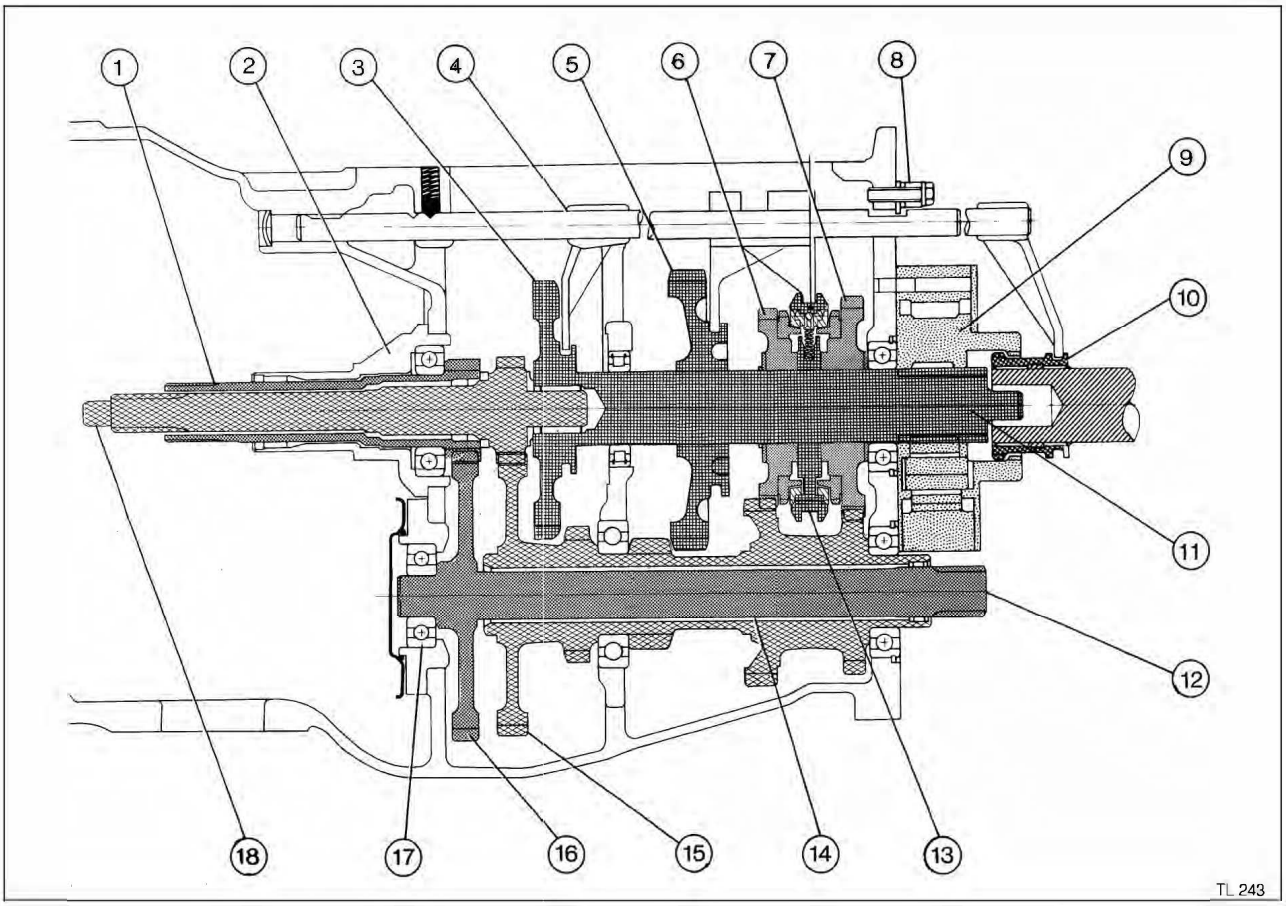
An additional advantage of the arrangement is the very logical sequence of gear changing it makes possible.

The main difference in the construction of the gearbox is that the mainshaft has two free-running gears (3rd and 4th ratios). These free-running gears are in constant mesh with their corresponding gears on the layshaft and are brought into engagement with the mainshaft by means of a ZF synchromesh engagement mechanism.

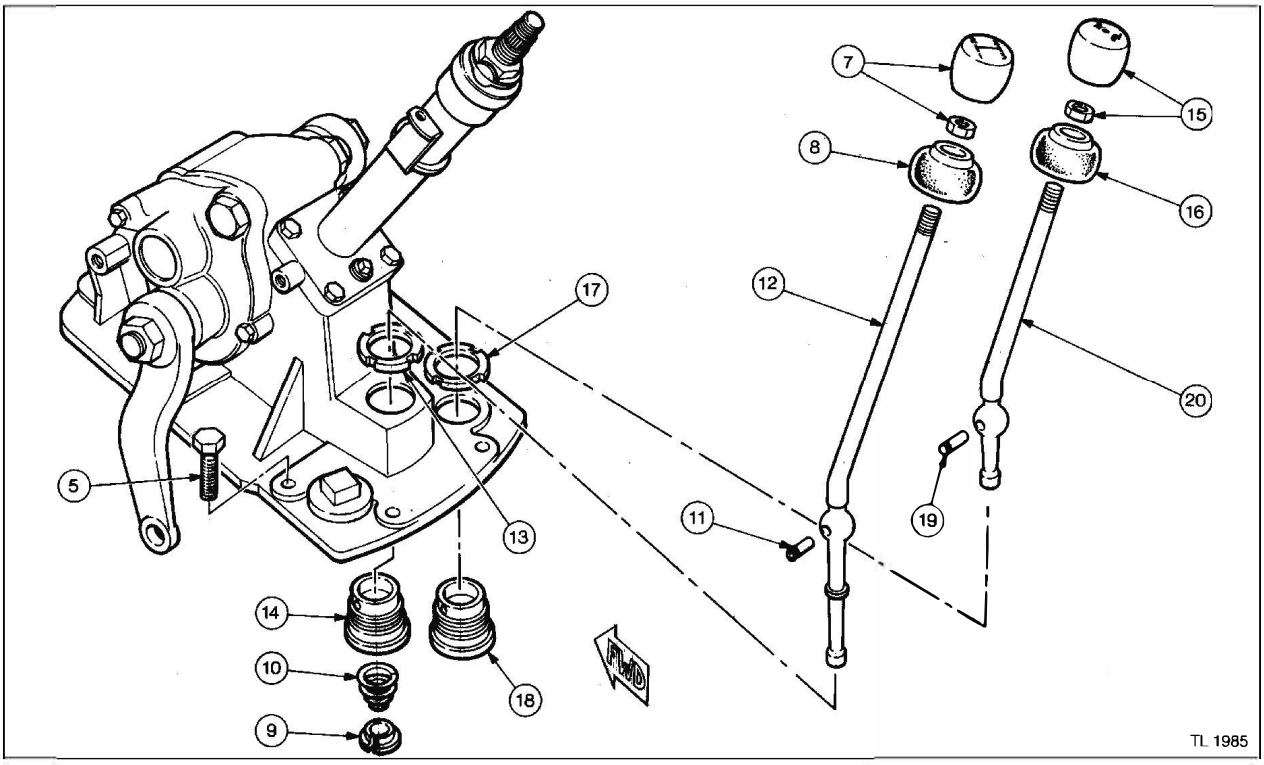
The synchromesh mechanism synchronises (equalises) the speed of the selected free-running gear with the main shaft before drive engagement. This is of great benefit to the driver since fast, easy gear changes can be made on the move without the need to stop the tractor.

The remaining gears, 1st - reverse and 2nd ratios are engaged by sliding gears the same as the 8 speed standard gearbox.

8 Speed Synchromesh Gearbox



1. PTO input shaft and gear
2. Input shaft housing
3. Second gear
4. Selector rail and forks
5. First/reverse gear
6. Fourth gear
7. Third gear
8. Gear shift interlock
9. Epicyclic reduction unit
10. Sliding coupler
11. Mainshaft
12. PTO shaft
13. Synchromesh mechanism and sliding coupler
14. Layshaft
15. Transmission constant mesh gear
16. PTO constant mesh gear
17. PTO front bearing housing
18. Transmission input shaft and gear



GEAR SHIFT LEVERS

Removal and refitment **2.05B–01**

Removal

1. Remove the steering wheel, instrument panel and other parts necessary to gain access to the gearbox top and steering box assembly.
2. Remove both steering drag links.
3. Disconnect hydraulic pipes if power assist steering is fitted.
4. Move both the gear levers into the neutral position.
5. Remove the bolts securing the steering and gear lever assembly to the gearbox.
6. Remove the assembly from the tractor and place on a work bench.

Main gear lever

7. Remove the gear lever knob and nut.
8. Remove the rubber cover.

WARNING: Spring under compression.

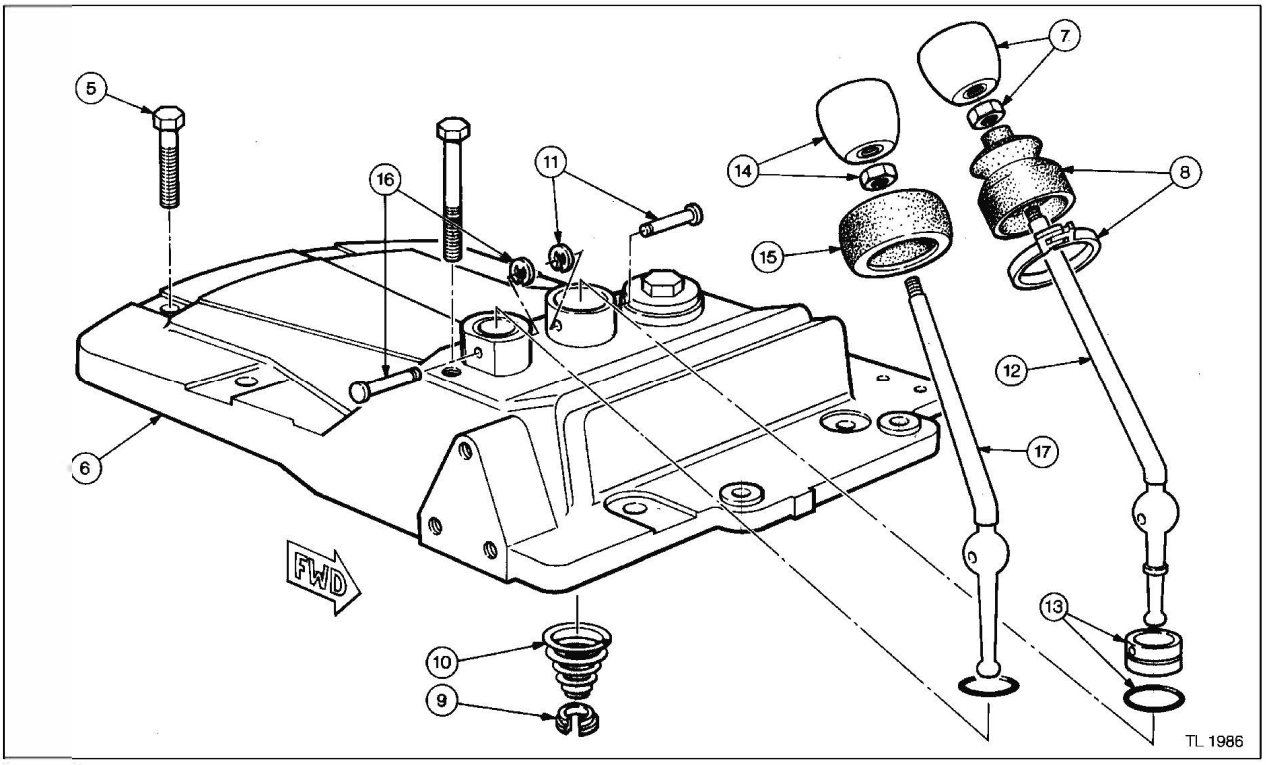
9. Turn the assembly over and unclip the spring retaining clip.
10. Remove the spring.
11. With a hammer and punch drive the gear lever retaining pin out of the gear lever cup.
12. Remove the main gear lever.
13. Unscrew the retaining ring with a 'C' spanner.
14. Remove the gear lever cup.

High/low gear lever

15. Remove the gear lever knob and nut.
16. Remove the rubber cover.
17. Unscrew the retaining ring with a 'C' spanner.
18. Remove the gear lever and cup assembly from the cover.
19. Drive out the gear lever retaining pin.
20. Remove the high/low gear lever.

Refitment

21. Reverse procedures 1 to 20 where applicable except:
    a. When refitting the gear lever cup ensure that the retaining pin is square with the axis of the tractor.
    b. Replace the rubber covers to prevent dirt getting into the transmission.
    c. Coat the underside of the cover with MF Instant Gasket (Loctite 515) and torque the cover bolts to 112 Nm.
    d. Tighten the drag link ball joint nuts to a torque of 122 Nm.
    e. Tighten the steering wheel nut to a torque of 47 Nm.



GEAR SHIFT LEVERS

Removal and refitment **2.05B–02**

Removal

1. Remove the steering wheel, instrument panel and other parts necessary to gain access to the gearbox top and steering box.
2. Disconnect hydraulic hoses to hydrostatic steering units if fitted.
3. Remove the hydrostatic steering unit assembly or the steering box.
4. Move both the gear levers into the neutral position.
5. Remove the bolts securing the top cover assembly to the gearbox.
6. Remove the assembly from the tractor and place on a work bench.

Main gear lever

7. Remove the gear lever knob and nut.
8. Remove the rubber cover and clip.

WARNING: Spring under compression.

9. Turn the assembly over and unclip the spring retaining clip.
10. Remove the spring.
11. Remove the clip and retaining pin.
12. Remove the main gear lever.
13. Remove the gear lever cup and discard the 'O' ring.

High/low gear lever

14. Remove the knob and nut.
15. Remove the rubber cover.
16. Remove the clip and retaining pin.
17. Remove the gear lever and discard the 'O' ring.

Refitment

18. Reverse procedures 1 to 17 where applicable except:
    a. Replace the rubber covers to prevent dirt getting into the transmission.
    b. Coat the underside of the cover with MF Instant Gasket (Loctite 515) and torque the cover bolts to 112 Nm.
    c. Tighten the steering box to top cover bolts to a torque of 82 Nm.
    d. Tighten the drag link ball joint nuts to a torque of 122 Nm.
    e. Tighten the steering wheel nut to a torque of 47 Nm.

SELECTOR RAILS and FORK

Removal and refitment **2.05B–03**

Special Tools:
MF.414 Centralising pin and locating peg

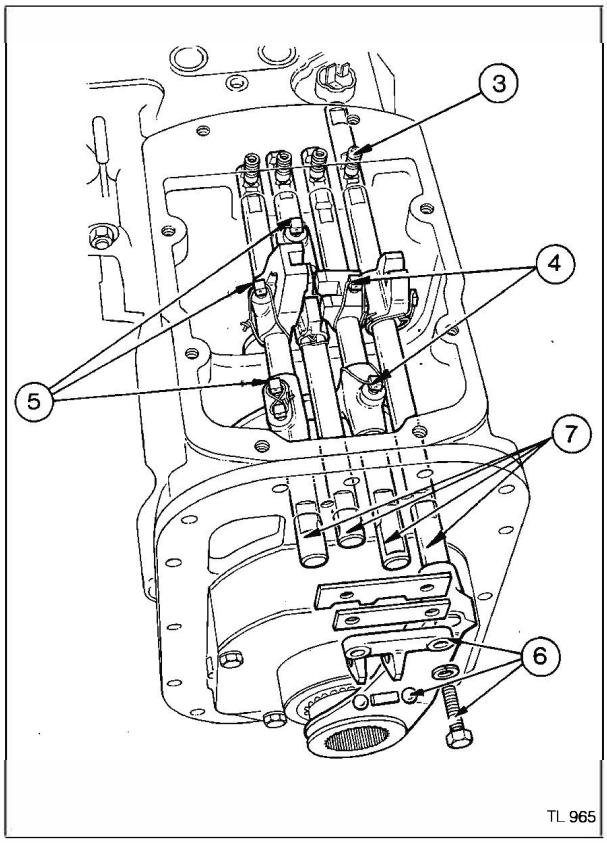
Removal

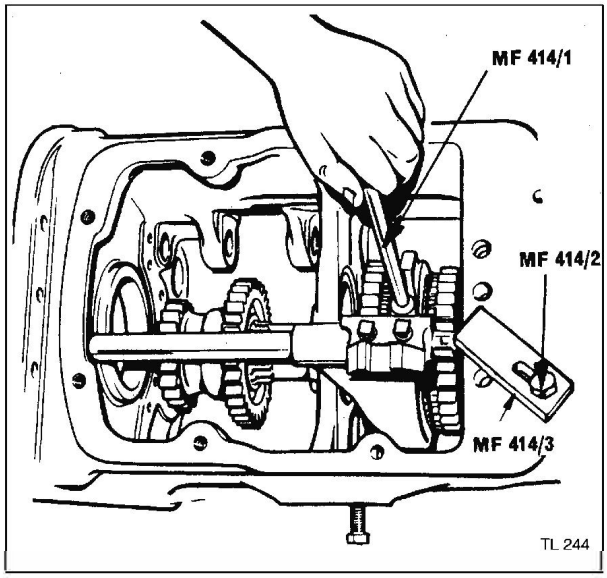
WARNING: Beware of sharp edges around the top of the gearbox case.

1. Split the tractor between the gearbox and the spacer housing and remove the gearbox, see section 2.
2. Remove the gearbox top cover, see operation 2.05B-01 or 2.05B-02.
3. Lift out the detent springs and plungers.
4. Remove all the locking wires and discard.
5. Loosen the locking screws.
6. Remove the bolts, fork, balls, peg, stop plate and plain plate of the gear shift interlock mechanism.
7. Slide the rail rearwards out of the casing retaining the gear lever selector jaws.
8. Lift out the selector forks.

Refitment

9. Reverse procedures 1 to 8 except:
   a. Apply a few drops of oil to the selector rails before refitment.
   b. Tighten the interlock mechanism screws to a torque of 44 Nm.
   c. Tighten all selector fork locking screws to a torque of 44 Nm.
10. On completion of the refitting procedure, place all the gears in the neutral position.
11. Set the synchromesh selector fork to the neutral position by locating the selector rail with locating peg MF.414/3 clamped to the gearbox casting with bolt MF.414/2. Insert centralising pin MF.414/1 into the hole in the top of the selector fork, aligning it with the hole in the sliding coupler.
12. Tighten each locking screw in turn to a torque of 43 Nm and ensure that the centralising pin MF.414/1 rotates freely when the locking screws are tight.
13. Wire-lock all locking screws using new locking wire.





NORMAL- and HEAVY-DUTY EPICYCLIC UNIT

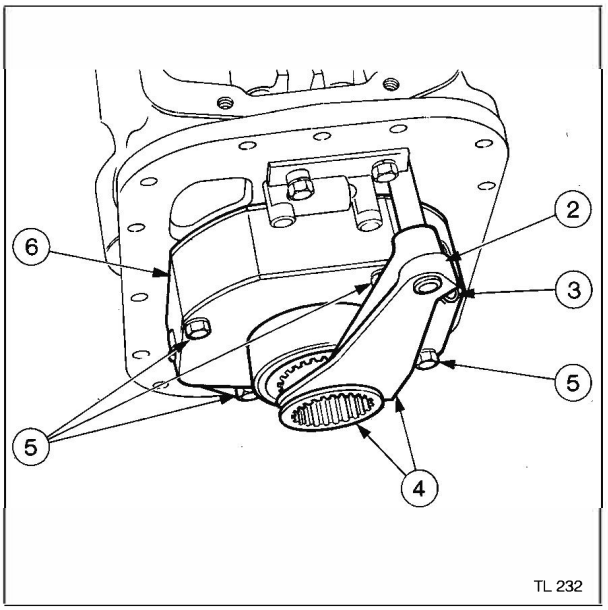
Removal and refitment 2.05B–04

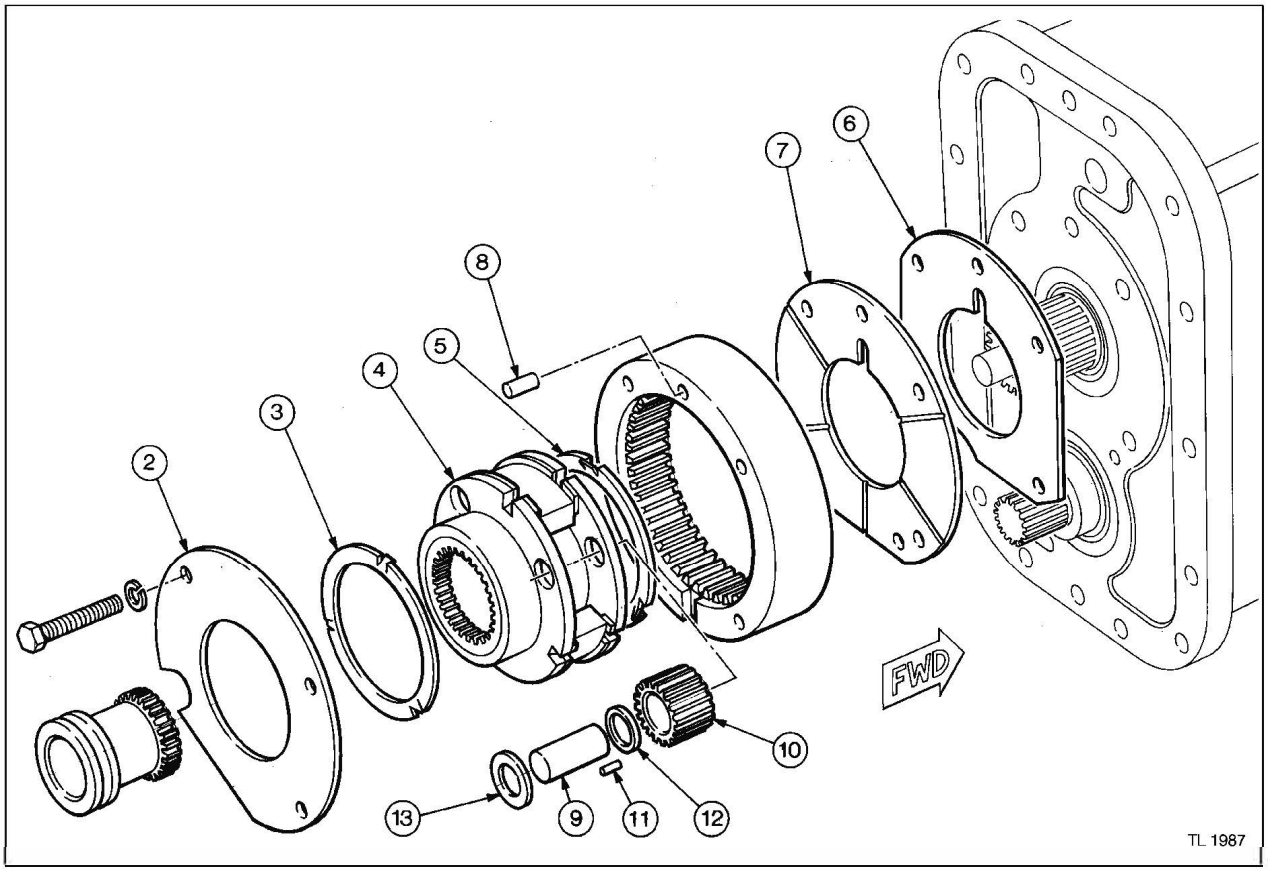
Removal

1. Split the tractor between the gearbox and the spacer or centre housing, see section 2.
2. Remove the locking wire and discard.
3. Loosen the locking screw.
4. Remove the selector fork and coupling.
5. Remove the bolts.
6. Remove the complete assembly.

Refitment

7. Reverse procedures 1 to 6 except:
   - *a.* Ensure that the front and rear thrust rings are correctly located before refitment.
   - *b.* Ensure that the dowels are correctly located in the gearbox casing.
   - c. Locate the cover plate with the cut out, to the bottom left hand corner for heavy duty, and the bottom right hand corner for normal-duty epicyclics.
   - *d.* Fit a lockwasher to the lower right hand retaining bolt, on normal-duty epicyclic only.
   - e. Tighten the retaining bolts progressively and evenly to a torque of 44 Nm.
   - *f.* Tighten the shifter fork lock screws to a torque of 44 Nm.
   - *g.* Wire-lock all fixings affected by procedure 2 using new locking wire.





NORMAL-DUTY EPICYCLIC UNIT

Overhaul **2.05B–05**

Dis-assembly

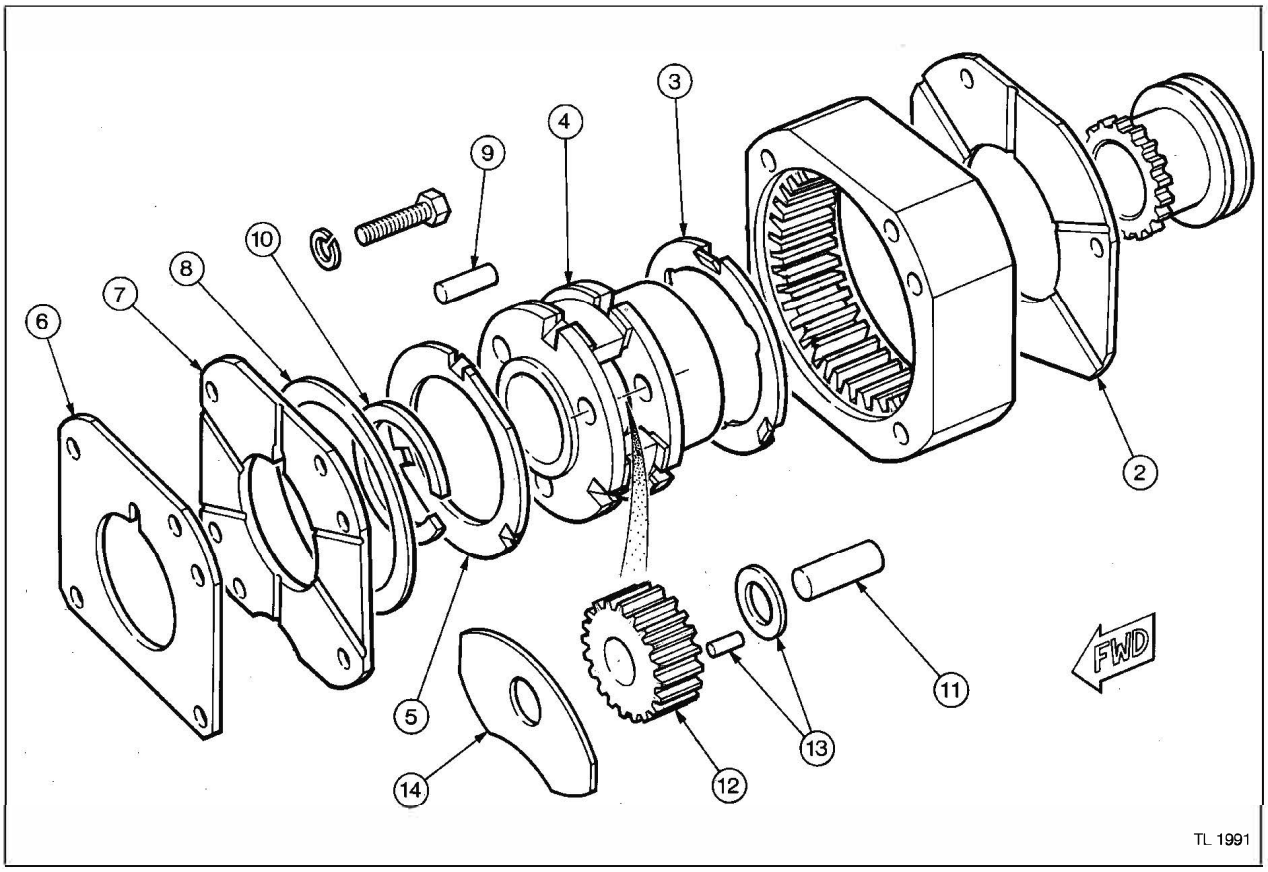
1. Remove the gearbox epicyclic unit, see operation 2.05B-04.
2. Remove the cover plate.
3. Remove the rear thrust ring.
4. Remove the planetary pinion carrier.
5. Remove the front thrust ring.
6. Remove the shim.
7. Remove the front plate.
8. If necessary remove the two dowels from the ring gear.
9. Press each shaft out of planetary pinions and carrier.
10. Retain the three spacers, two thrust washers and needle roller bearings from each pinion.

Examination

Clean and carefully examine all the components, especially those subject to movement, and replace any items that show signs of damage or wear.

Re-assembly

11. Replace the needle rollers in each pinion, a smear of petroleum jelly, NOT GREASE, will help to retain them. There are two rows of 27 rollers to each pinion.
12. A spacer is fitted between each row of needle roller bearings and at each end of the pinion.
13. Fit a thrust washer to each side of the pinions.
14. To assist assembly of the front and rear thrust rings on the planetary pinion carrier, smear them with petroleum jelly, NOT GREASE. Ensure that the tabs on the thrust rings locate in the pinion carrier cut-outs, and the brass faces are fitted away from the planetary pinion carrier.
15. The front and rear plates are fitted with the oil grooves towards the planetary pinion carrier.
16. Only one shim is fitted.



HEAVY-DUTY EPICYCLIC UNIT

Overhaul **2.05B–06**

Dis-assembly

1. Remove the gearbox epicyclic unit, see operation 2.05B-04.
2. Remove the cover plate.
3. Remove the rear thrust ring.
4. Remove the planetary pinion carrier.
5. Remove the front thrust ring.
6. Remove the shim.
7. Remove the front plate.
8. Belleville spring disc - **not fitted to this unit.**
9. If necessary, remove the dowels from the planetary ring gear.
10. Remove the external snap ring.
11. Gently tap out the three pinion shafts towards the front.
12. Remove the planetary pinions.
13. Remove the two sets of rollers and spacer from each pinion.
14. Remove the wear plates from each side of each pinion.

Examination

Clean and carefully examine all the components, especially those subject to movement, and replace any items that show signs of damage or wear.

Re-assembly

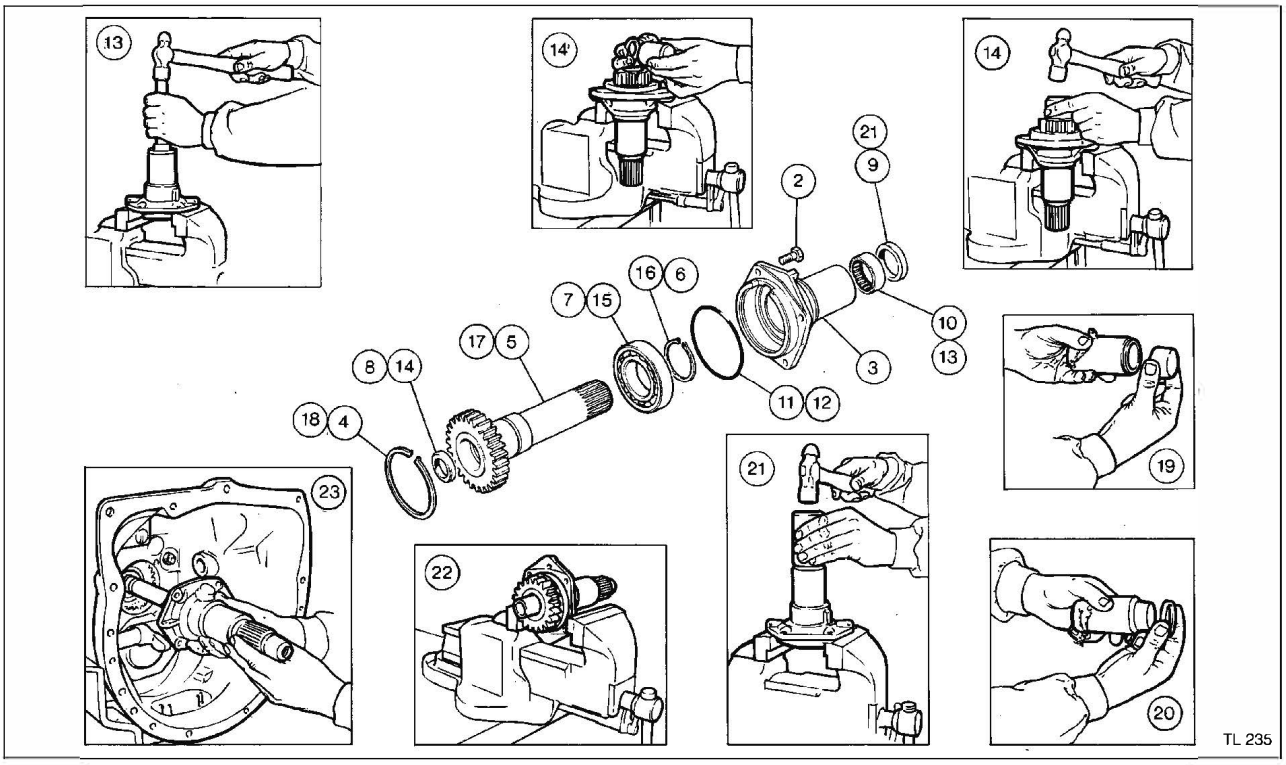
15. Reverse procedures 1 to 14, except:

a. When replacing the rollers in the pinions, a smear of petroleum jelly, NOT GREASE, will help retain them. Do not omit the spacer from between the two rows of rollers. Each row consists of 16 rollers.

b. The front plate and the cover plate must be positioned with the oil grooves towards the pinion carrier.

c. Ensure that the gap of the snap ring is located midway between the planetary pinion shafts.

d. To assist assembly of the front and rear thrust rings on the pinion carrier, smear them with petroleum jelly, NOT GREASE. Ensure that the tabs on the thrust rings locate in the pinion carrier cut-outs, and that the brass faces are away from the planetary pinion carrier.



INPUT SHAFTS and HOUSING

Removal and refitment **2.05B–07**

Special Tools:

MF.255B PTO input shaft oil seal replacer

MF.315A Needle roller bearing remover and replacer

MF.331 Main input shaft oil seal replacer

MF.177A Input shaft oil seal protector sleeve

Removal

1. Remove the clutch release mechanism, see operation 2.04A-04.
2. Remove the four bolts.
3. Withdraw the input housing complete with PTO input shaft.
4. Remove the large internal circlip.
5. Push the PTO input shaft complete with bearing rearwards out of the housing.
6. If necessary remove the circlip.
7. If necessary press the bearing off the shaft.
8. Lever the PTO shaft seal out.
9. Lever the mainshaft seal out.
10. Using MF.315A remove the needle roller bearing.
11. Remove the 'O' ring (PTO input shaft housing).

Refitment

12. Fit a new 'O' ring (PTO input shaft).
13. Using MF.315A replace the needle roller bearing.
14. Using MF.331 fit a new seal, with the lip of the seal facing the tool.
15. Refit the bearing with the shield towards the gear teeth.
16. Refit the circlip. (Check that it is properly seated).
17. Refit the PTO input shaft and bearing into the input housing.
18. Refit the circlip. (Check that it is properly seated).
19. Place the nylon cone adaptor on PTO input shaft oil seal replacer MF.255B.
20. Place the seal over the nylon cone and onto the tool with the seal lip facing away from the tool and remove the nylon cone.
21. Place the tool over the PTO input shaft and tap the seal into place.
22. Place MF.177A into the input housing assembly.
23. Slide the housing over the input shaft.
24. Reverse procedures 1 to 23, except:
    - *a.* Use petroleum jelly, NOT GREASE, to lubricate all seals and the needle roller bearing when refitting.
    - *b.* Lightly coat the bolt thread with Hylomar sealant when refitting and tighten the bolts to a torque of 58 Nm.

PTO DRIVE SHAFT FRONT BEARING

Removal and refitment **2.05B–08**

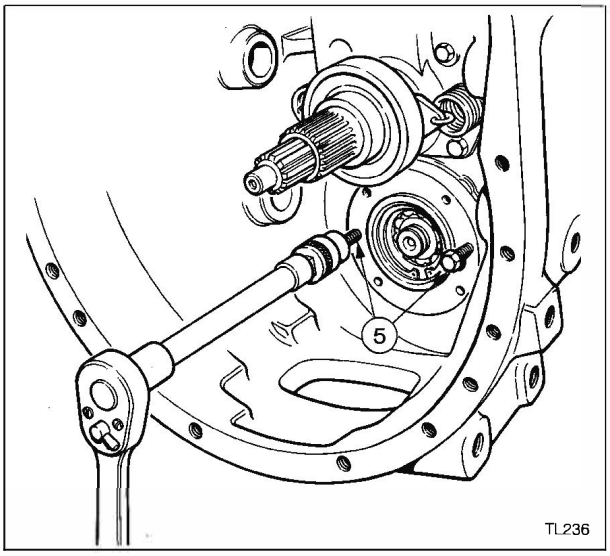
Special Tools:
MF.218B PTO Drive Shaft Puller.

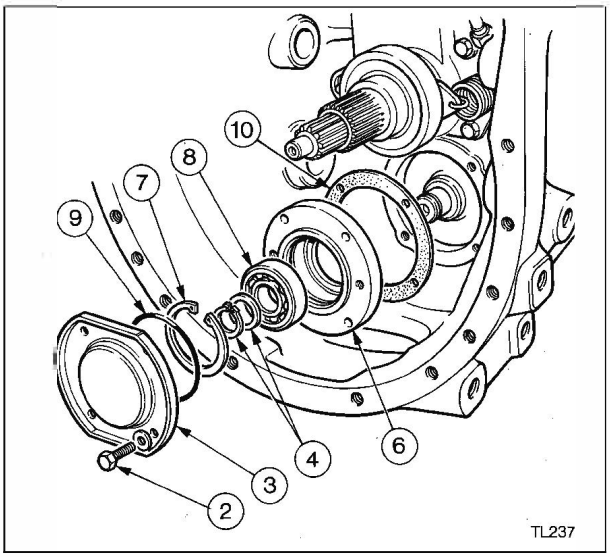
Removal

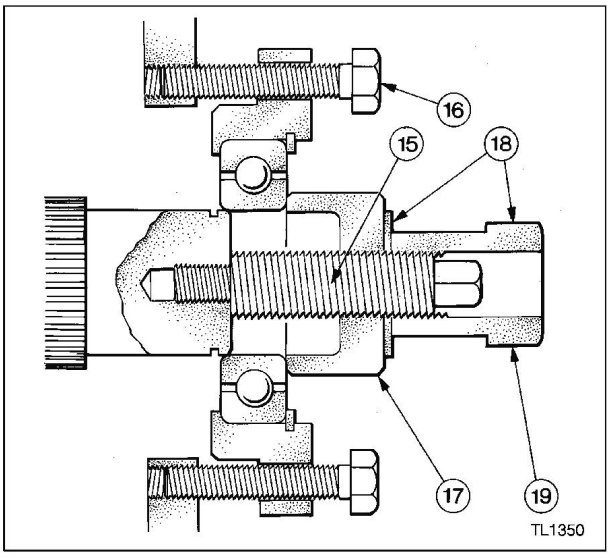
1. Remove the clutch cross-shaft and lever, see operation 2.04A-04.
2. Remove the four bolts and washers.
3. Remove the cover plate.
4. Remove the external circlip and washer.
5. Screw two 3/8 UNC x 3 inch bolts (part of MF. 218B) into the bearing housing and tighten them evenly to draw the housing from the case and shaft.
6. Remove the housing.
7. Remove and discard the circlip.
8. Press out the bearing.
9. Remove and discard the 'O' ring.
10. Remove and discard the gasket.
11. If the gearbox has been removed and it is necessary to remove the PTO shaft, insert a 7/16 inch UNF bolt approximately 3-4 inch long into the shaft to protect it, drive the shaft out of the PTO constant mesh gear.

Refitment

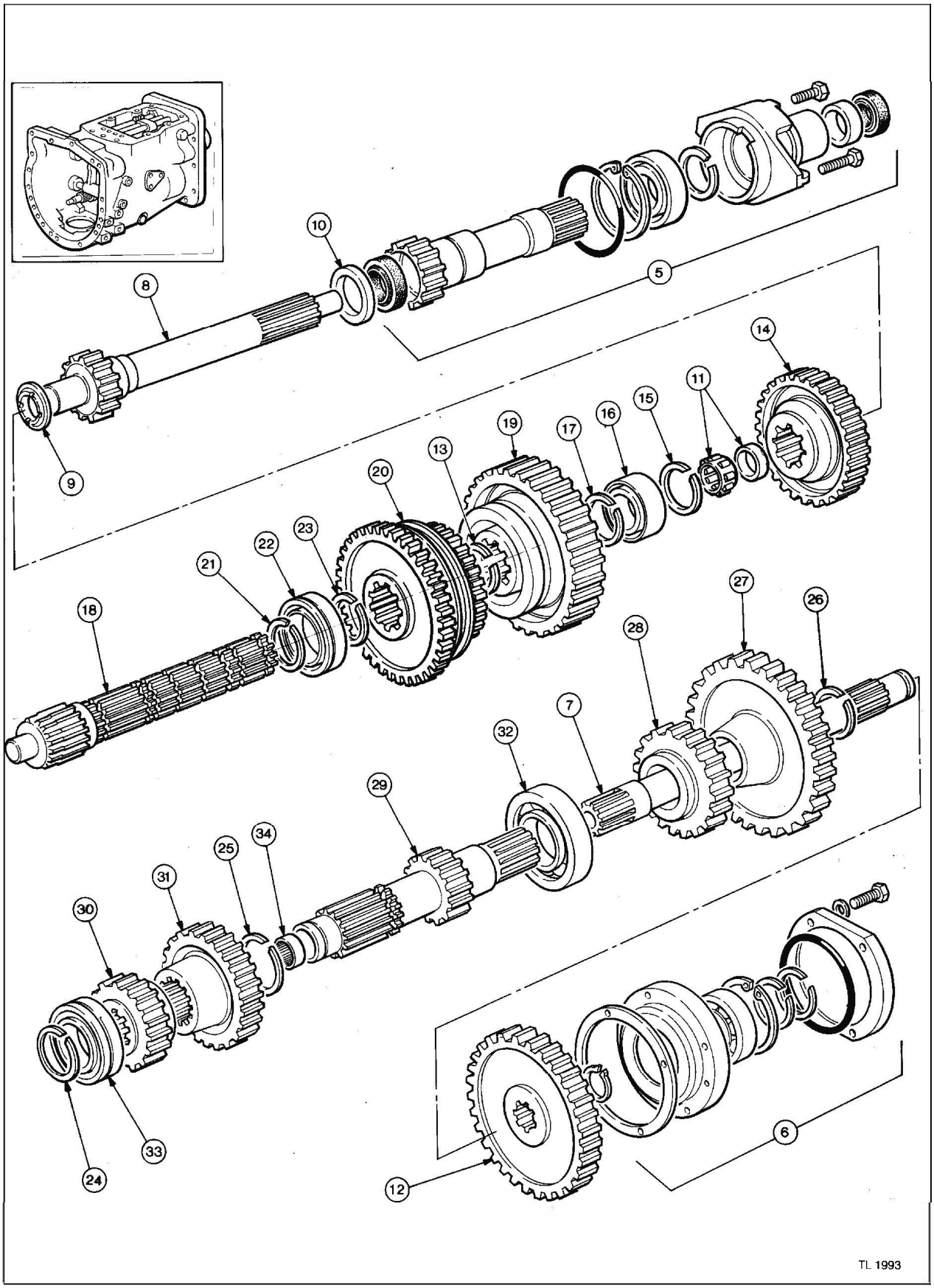
12. Lightly coat the new gasket with Hylomar sealant.
13. Using MF.218B, refit the bearing housing assembly.
14. Check that the PTO drive shaft splines locate with those in the PTO constant mesh gear, if the shaft has been removed.
15. Screw the centre screw into the end of the PTO shaft with the aid of a 9/16 inch across flats spanner.
16. Locate the bearing and housing assembly on the end of the PTO shaft and to the housing with the two long bolts provided with MF.218B through the unthreaded holes.
17. Place the adaptor onto the centre screw with the hollow face against the bearing.
18. Place the washer on the centre screw and put on the nut.
19. Tighten the nut with a 1 1/8 inch across flats spanner until the housing is pushed home and the PTO shaft is drawn through the ball bearing sufficiently to enable the washer and circlip to be fitted.
20. Fit a new circlip and washer.
21. Replace the cover ensuring that a new 'O' ring is fitted.
22. Lightly coat the securing bolt threads with Hylomar sealant.
23. Tighten the bolts to a torque of 58 Nm.







8 Speed Synchromesh Gearbox



LAYSHAFT, MAINSHAFT, PTO SHAFT and GEARS

Overhaul **2.05B–09**

Special Tools:
MF.415 Synchromesh hub assembly tool
MS.550 Handle

Dis-assembly

1. Remove the gearbox from the tractor, see section 2.
2. Remove the clutch thrust bearing and cross shaft, see operation 2.04A-04.
3. Remove the selector rails and forks, see operation 2.05B-03.
4. Remove the epicyclic reduction unit, see operation 2.05B-04.
5. Remove the input shafts and housing, see operation 2.05B-07.
6. Remove the PTO drive front bearing, see operation 2.05B-08.

Input shaft

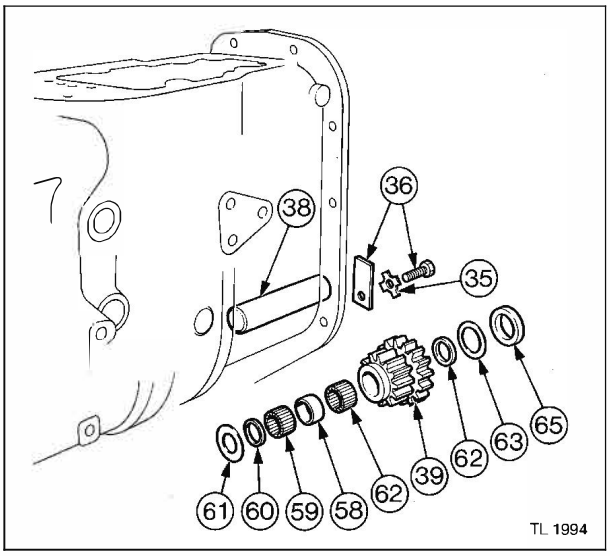
7. Remove the PTO shaft.
8. Remove the input shaft.
9. Remove the main thrust washer.
10. Remove the front thrust washer.
11. Remove the needle roller bearing and spacer.
12. Lift out the PTO constant mesh gear.

Mainshaft

13. Move the snap ring from the front of 4th gear forwards along the mainshaft as far as it will go.
14. Drive the mainshaft rearwards and remove the 2nd speed sliding gear (46T).
15. Remove the front snap ring.
16. Draw the roller bearing off the mainshaft.
17. Remove the rear snap ring.
18. Withdraw the mainshaft rearwards moving the snap ring forwards as necessary and lifting out the gears.
19. Remove the 1st and reverse sliding gear (44T).
20. Remove the 3rd (41T) and 4th (36T) gear synchromesh hub assembly as one unit.
21. Remove the rear snap ring.
22. Remove the ball bearing.
23. Remove the front snap ring.

Layshaft

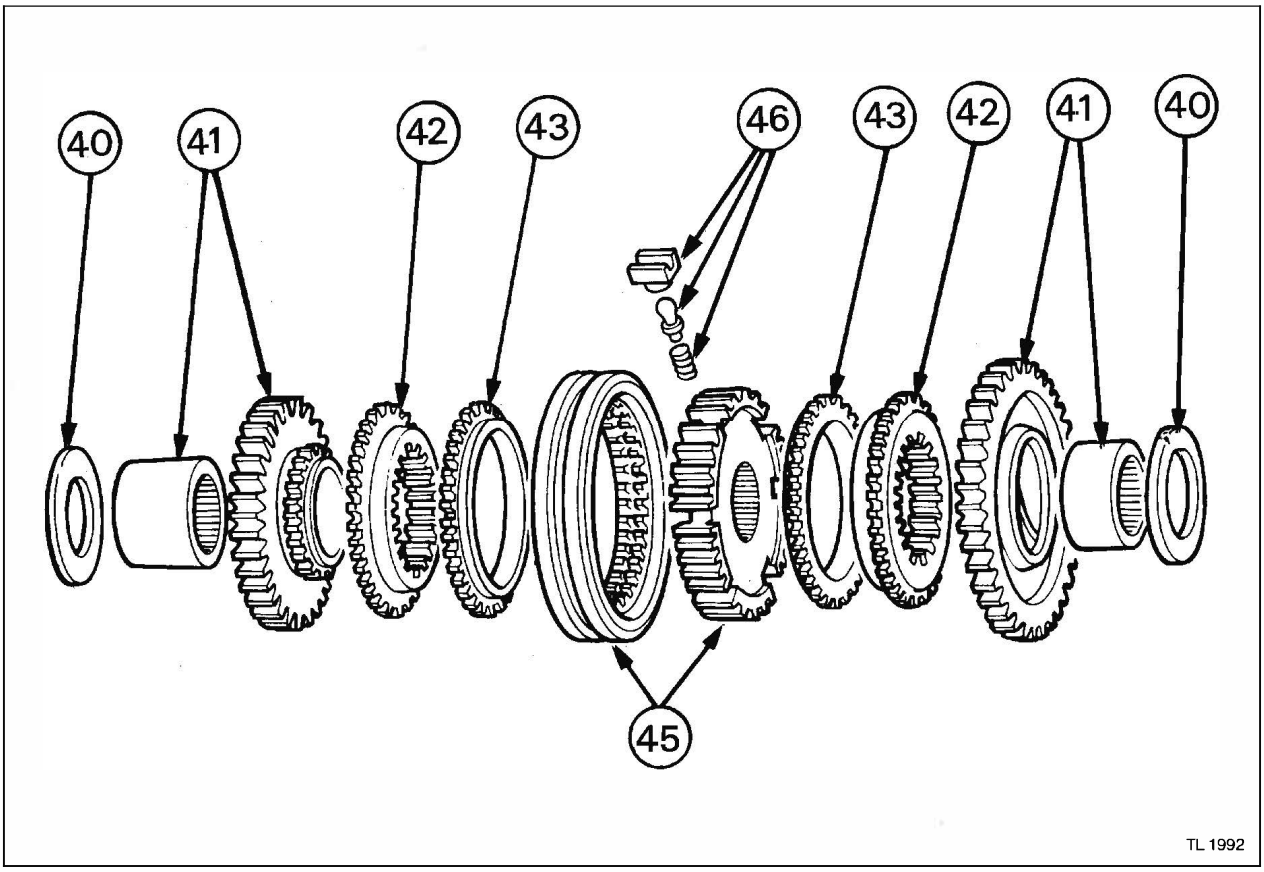
24. Remove the snap ring from the rear of the layshaft.
25. Tap the shaft forwards to uncover the snap ring in front of the 4th speed gear. Move the circlip onto the non splined portion of the shaft.



26. Remove the snap ring from the front of the layshaft.
27. Tap the shaft rearwards and remove the constant mesh gear.
28. Continue tapping the shaft rearwards and remove the 2nd speed gear (23T).
29. Drive the layshaft out through the front of the gearbox.
30. Remove the 3rd gear (28T).
31. Remove the 4th gear (33T) and snap ring.
32. Remove the front ball bearing.
33. Remove the rear ball bearing.
34. Remove the needle roller bearing from the rear of the layshaft.

Reverse idler

35. Release the locking washer.
36. Remove the bolt and locating tab.
37. Obtain a length of bright steel bar 1 inch dia x 2 3/16 inch long for removal of the reverse idler.
38. Slide the bar in from the front of the reverse idler shaft towards the rear. This will push out the reverse idler gear shaft, and prevent the needle rollers and spacers dropping into the gearbox case.
39. Remove the idler gear assembly complete with needle rollers, spacers and bar.
40. Remove the steel bar from the idler gear and release the needle rollers, spacers and thrust washers into a clean container.

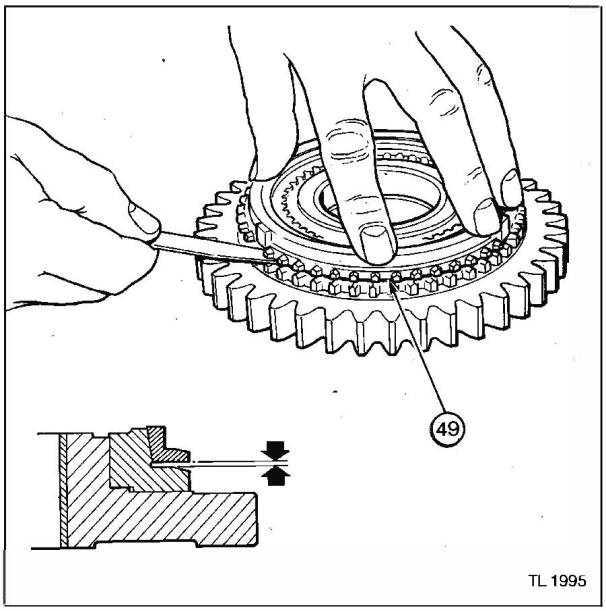


Synchromesh hub

41. Remove the two thrust washers.
42. Remove the 3rd and 4th gears and sleeves.
43. Remove the two synchromesh cones.
44. Remove the two baulk rings.
45. Remove the hub assembly complete with coupler.
46. Wrap the assembly in a cloth and press the coupler off the hub with your fingers. This will prevent loss of the springs, ball pins and pressure blocks.
47. Remove the three pressure blocks, ball pins and springs.

Examination

48. Thoroughly clean all the components.
49. Check the condition of the synchromesh assembly by measuring the clearance between the baulk ring and synchromesh cone on the gear at several points. The baulk ring must be correctly positioned on the synchromesh cone as shown in the illustration. If the clearance is less than 0,5 mm replace the baulk ring. If the clearance is checked with the gearbox assembled, engage the gear and replace the baulk ring if the clearance is found to be less than 0,8 mm.



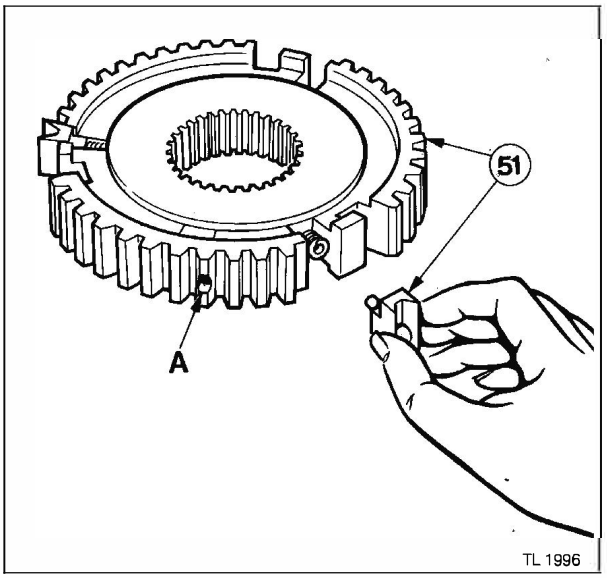
Re-assembly

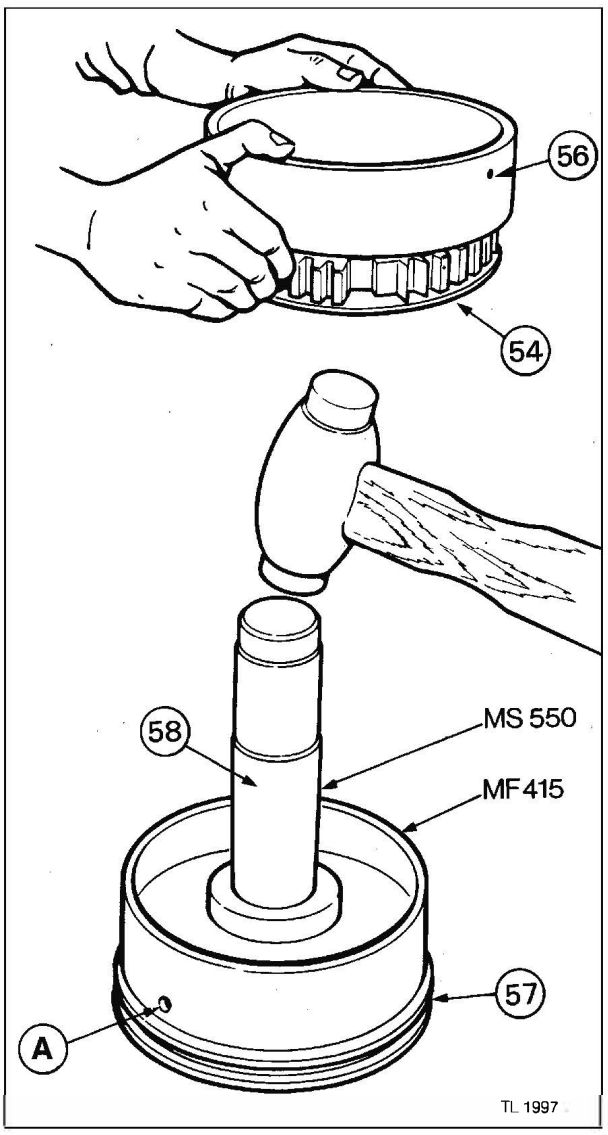
NOTE: *All circlips and snap rings must be renewed. Ensure that they are all correctly located in their grooves.*

Synchromesh hub

NOTE: *When replacing the sliding coupler onto the hub ensure that the centralisation holes 'A' in the hub and coupler are aligned.*

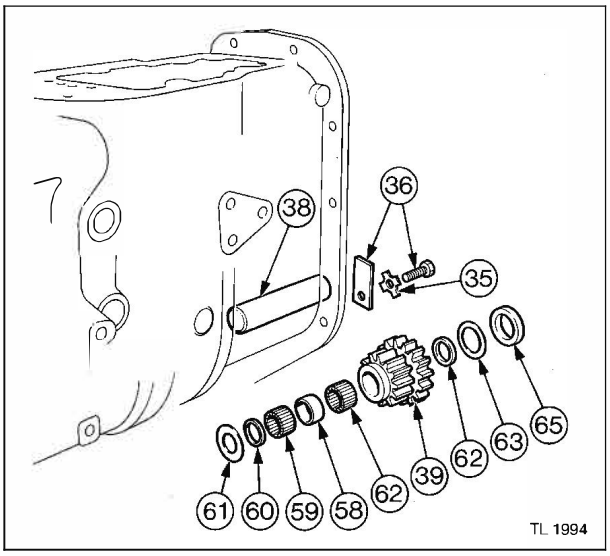
50. Place the disc of MF.415 on the bench and place the hub on top.
51. Refit the three springs, ball pins and pressure blocks in their respective holes.
52. Place the tapered end of MF.415 over the hub and push it down so that it will compress the three pressure blocks. Make sure that the hole in the tool is opposite the centralisation hole 'A' in the hub.
53. Turn the assembly over and place it on the coupler. Ensure that the centralisation hole 'A' in the coupler is opposite the hole in the tool.
54. Using handle MS550 in the central hole in the disc, tap the hub down so that it engages in the coupler. The internal taper of the tool will compress all the pressure blocks so that they will locate into the coupler.
55. Remove the hub assembly and check that it is correctly assembled.
56. Reverse procedures 41 to 44 using petroleum jelly, NOT GREASE, to retain all the parts in position. Ensure that the three small blocks on the baulk rings align with the slots in the hub.





Reverse idler assembly

57. Coat the inside of the reverse idler gear with petroleum jelly, NOT GREASE, to assist in assembly.
58. Refit the centre spacer.
59. Refit the first row of 28 rollers.
60. Refit the spacer.
61. Refit the thrust washer.
62. Refit the second set of rollers and spacer.
63. Refit the thrust washer.
64. Slide the steel bar into the reverse gear assembly.
65. Refit the spacer.
66. Refit the reverse idler gear assembly to the gearbox case using the shaft to push out the bar.
67. Fit a new lock washer to lock the retaining bolt.



Layshaft

68. Reverse procedures 24 to 34.

Mainshaft

69. Reverse procedures 13 to 23.

Input shaft

70. Reverse procedures 7 to 12.
71. Ensure that the main thrust washer (9) is fitted with the oil grooves facing the mainshaft.
72. Re-assemble the rest of the gearbox reversing procedures 1 to 7.

Four-Wheel Drive Unit

Section 5 – Part C

Table of Contents

Operation No.	Description	Page No.
	Specification	5C- 2
	General description	5C- 2
2.5C-01	Four-wheel drive unit - removal	5C-5
2.5C-02	Four-wheel drive unit - overhaul	5C-5
2.5C-03	Drive shaft seal - removal	5C- 9
2.5C-04	Four-wheel drive solenoid valve - removal	5C- 10
2.5C-05	Four-wheel drive axle drive shaft - removal	5C- 10
2.5C-06	Cassette seal installation - removal	5C- 12

Four-Wheel Drive Unit

Specification

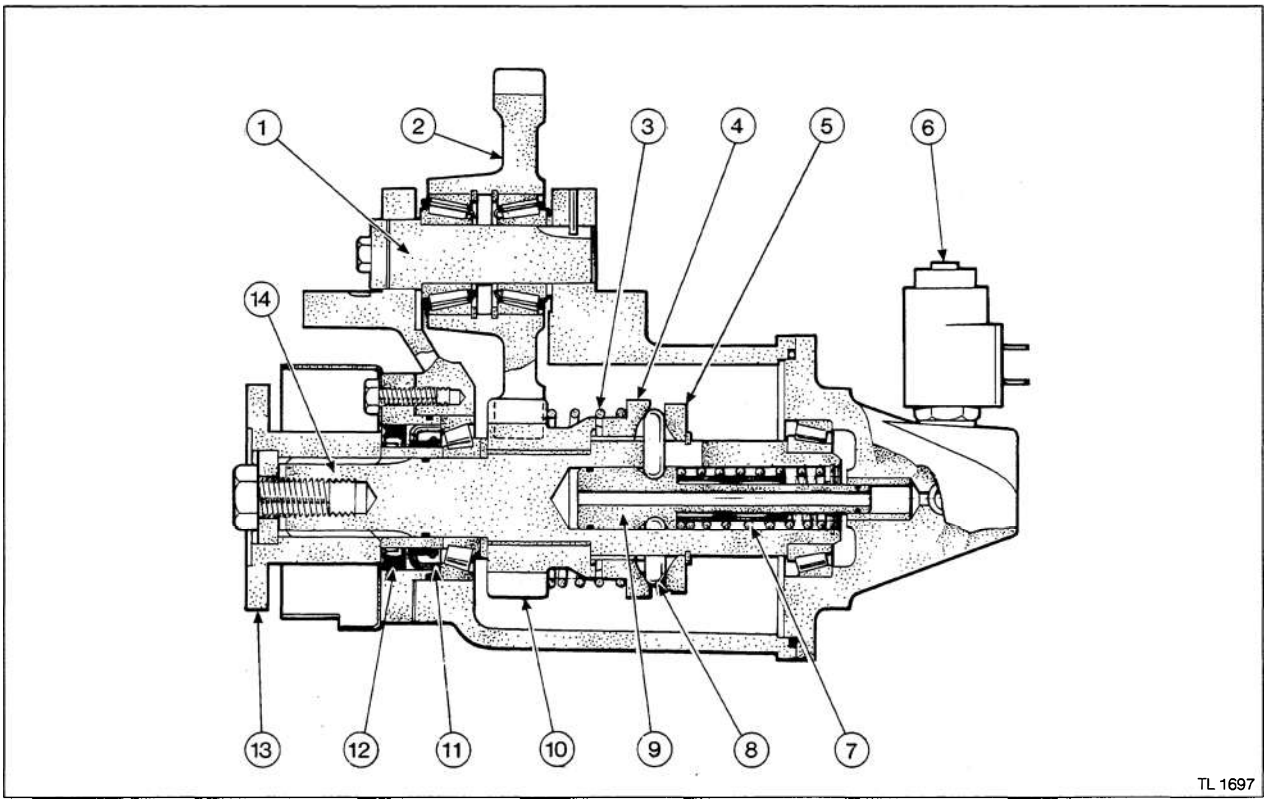
Intermediate gear pre-load	0-0,05 mm (o-0.002 in)
Drive shaft pre-load	0-0,07 mm (0-0.003 in)

Special Tools

MF.490	4WD axle cassette seal installer

Bolt Torques

Four wheel drive unit to range change unit	120-160 Nm (88-118 lbf ft)
Drive coupling to output shaft bolt	113-137 Nm (83-101 lbf ft)
Drive coupling to drive shaft nuts and bolts	55-57 Nm (40-55 lbf ft)



Four-wheel drive unit

1. Intermediate shaft
2. Intermediate gear
3. Return spring
4. Clutch coupler
5. Abutment ring
6. Solenoid valve
7. Piston return spring
8. Toggle pins
9. Actuator piston
10. Drive gear
11. Oil seal
12. Dirt seal
13. Drive coupling to front axle
14. Output shaft

General Description

The Four Wheel Drive Unit is bolted on to the left-hand side of the Range Change Gearbox. The drive is obtained from the upper shaft in the range change box, through a series of intermediate gears to the out put shaft and clutch assembly, and finally to the front axle.

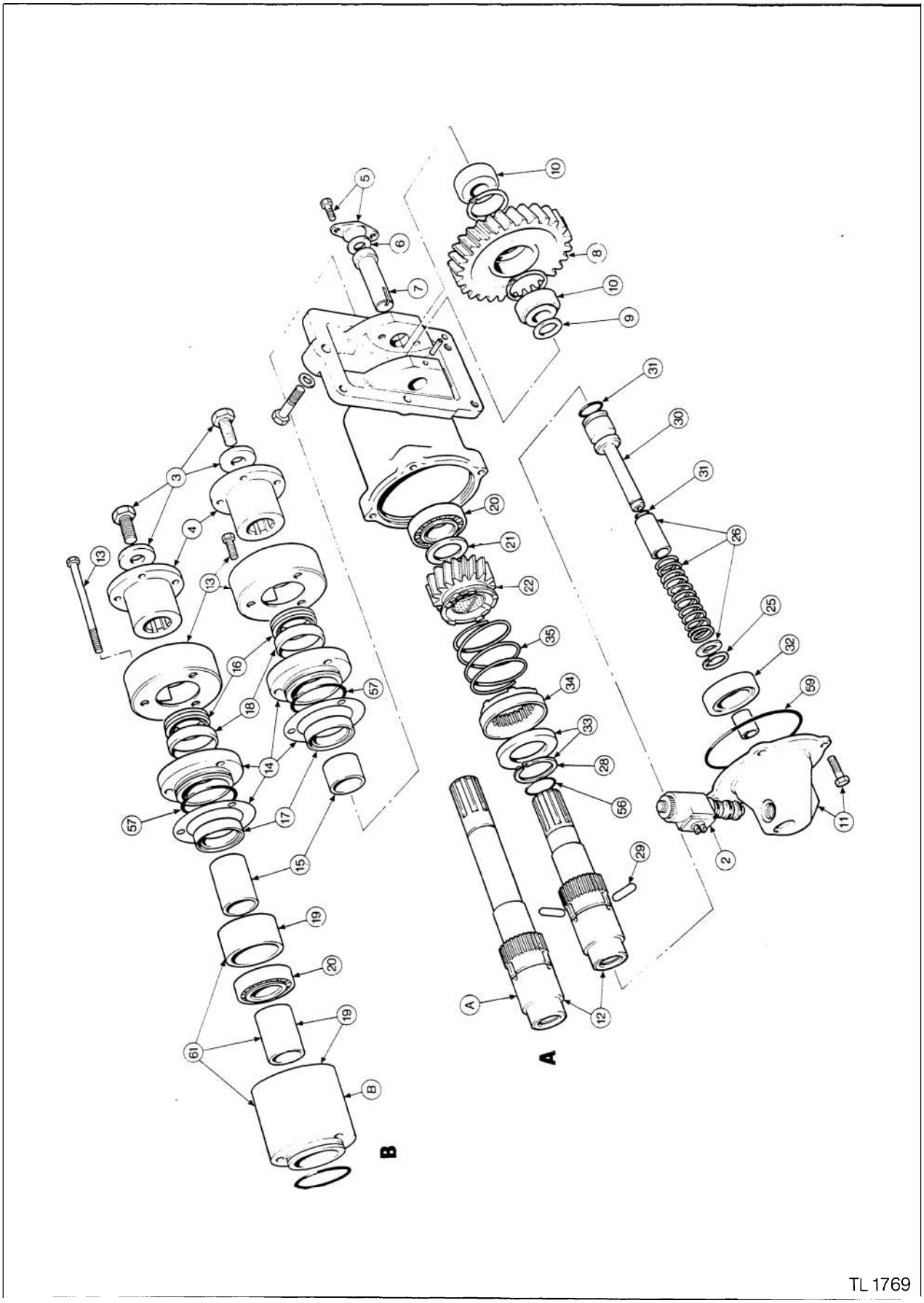
The engagement and disengagement of the unit is controlled by an electric solenoid valve operated by a switch under the drivers control. On cab tractors, the drive is also engaged when the foot or parking brake is applied to give four wheel braking. The four wheel drive unit is normally engaged, requiring energising to disengage.

The drive shaft and clutch assembly is mounted on taper roller bearings and contains in the centre at the rear the hydraulic actuating piston and return spring. A free running gear is mounted on the front end of the shaft driven from the range change box, the rear face of the gear is equipped with a single tooth type clutch. Engaging with the gear and splined to the shaft is a sliding coupler with a light return spring between the gear and coupler. Behind the sliding coupler is an abutment ring held in place on the shaft by a circlip. Between the coupler and abutment ring there are three radial toggle pins which pass through the shaft and engage in a grove in the actuating piston in the centre of the shaft.

The hydraulic piston is spring loaded in the forward (engaged) position, operation of the solenoid valve will apply hydraulic pressure to the front of the piston, as piston moves back the toggle pins will move from the vertical position to an angle of 45°, the tips of the pins will move down the sloping face of the coupler allowing it to move rearwards under spring compression and disengage the coupler and the drive.

Engagement of the clutch is carried out in reverse, the solenoid is de-energised, the piston moves forward under compression of it's spring. The toggle pins move to the vertical position pushing the coupler into engagement as they pass up the sloping face. The rear abutment ring is shaped to guide and retain the toggle pins.

All the gears are helical cut and run on adjustable taper roller bearings, pre-load adjustment being by the introduction of shims between the bearing cap and casing. A double seal arrangement is fitted to the front of the drive shaft to prevent the ingress of dirt and the loss of oil.


A
B
TL 1769

Four Wheel Drive Unit

Removal and Refitment 5C-01

Removal

1. Drain the oil from the transmission case.
2. Remove the clip and slide back the drive shaft cover.
3. Remove the drive shaft coupling nuts and bolts.
4. Disconnect the hydraulic supply pipe.
5. Disconnect the electrical wires from the solenoid valve.
6. Remove the bolts securing the four wheel drive unit to the range change box.
7. Remove the four wheel drive unit from the tractor.

Refitment

8. Clean the mating faces of the range change gearbox and four wheel drive unit.
9. Reverse procedure 1 to 7 except:
   a. Coat the mating face of the four wheel drive unit with Loctite 515 instant gasket.
   b. Tighten the mounting bolts to a torque of 120-160 Nm (88-118 lbf ft).
   c. Tighten the drive shaft coupling bolts to a torque of 55-75 Nm (40-55 lbf ft).

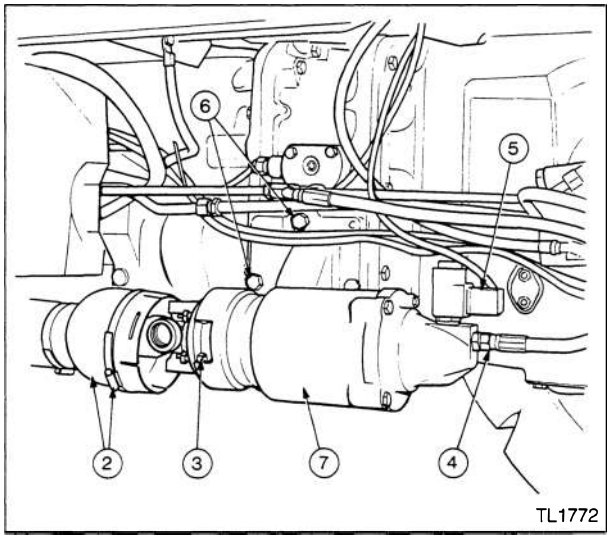
Four Wheel Drive Unit

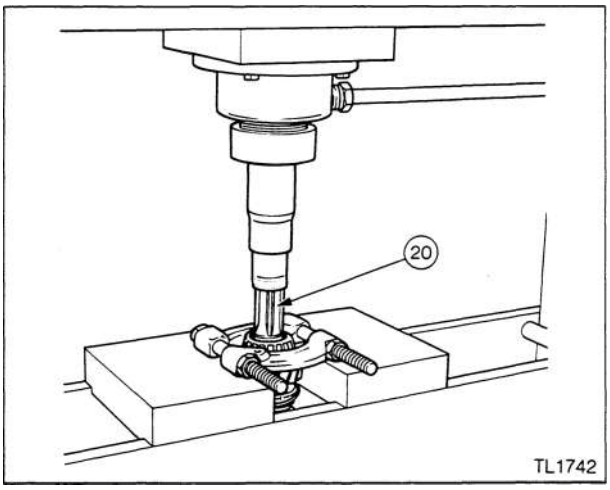
Overhaul 5C-02

Disassembly

Note: There are two types of four wheel drive unit, with or without extended drive shaft. The extended drive shaft is fitted to tractors with a 40 km/hr transmission, the major difference being the longer drive shaft `A' the housing extension `B' (see illustration). The standard length shaft is fitted to all other models.

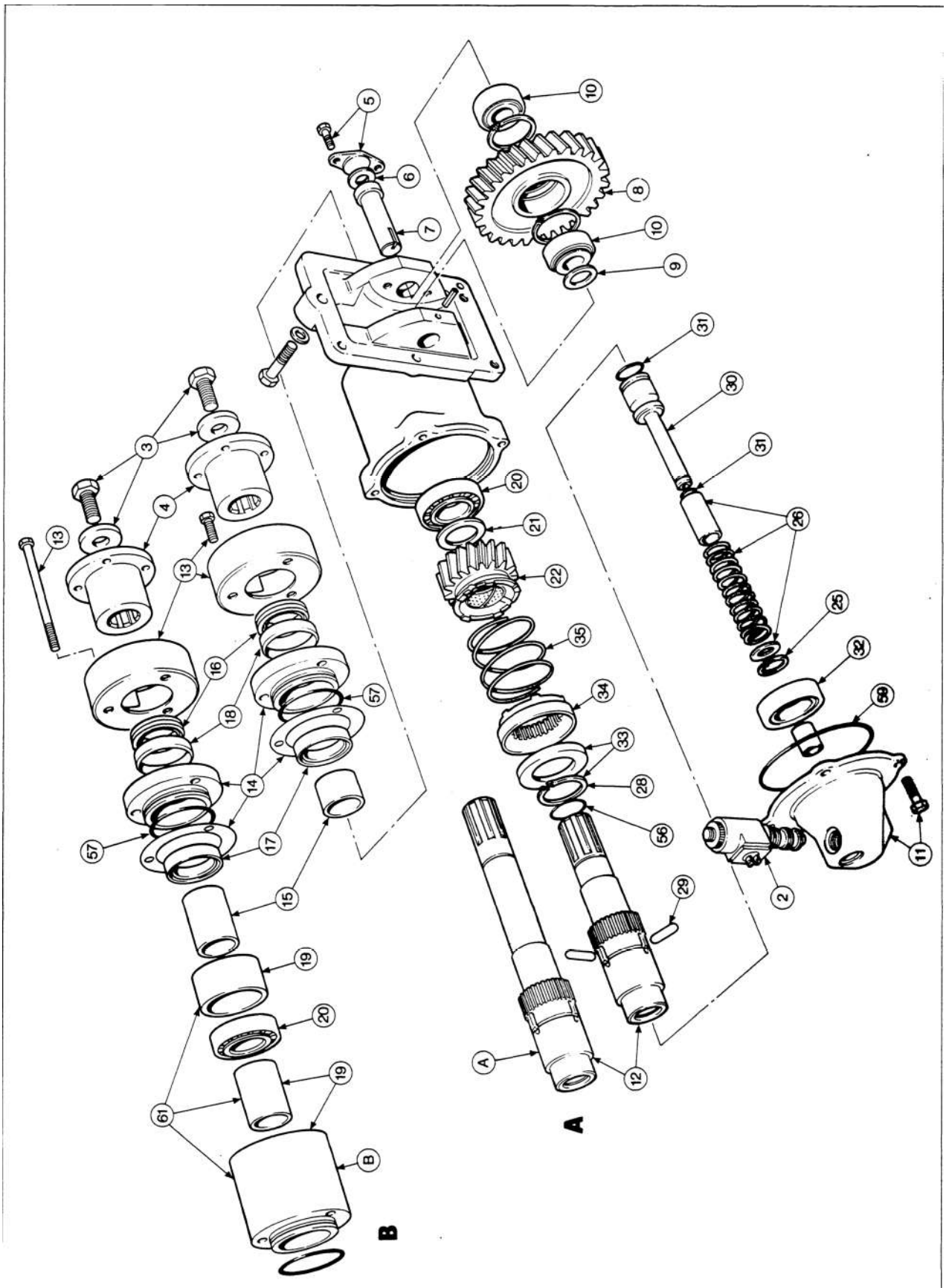
1. Remove the four wheel drive unit, see operation 7J-01.
2. Unscrew and remove the solenoid valve assembly.
3. Remove the central bolt and washer from the drive coupling.
4. Remove the drive coupling.
5. Remove the two bolts and the end cap on the intermediate gear shaft.
6. Remove and save the shims between the end cap and shaft.
7. Push the shaft out of the housing from the back.
8. Lift out the gear and taper roller bearings.
9. Retain the thrust washer between the gear and housing.
10. Remove the taper roller bearings from the intermediate gear, if necessary.
11. Remove the four bolts and the end cover.
12. Remove the drive shaft and clutch assembly from the housing.
13. Remove the four bolts and the rear guard.
14. Remove the end cap and shims.





15. Remove the oil seal sleeve.
16. Remove the dirt seal from the seal sleeve.
17. Press the oil seal out of the end cap.
18. Remove the dirt seal sleeve from the end cap.
19. On tractors with 40 km/hr transmissions, remove the additional extension and spacers.
20. Use a bearing separator plate and a hydraulic press to remove the front taper roller bearing.
21. Remove the thrust washer.
22. Remove the drive gear.

Four-Wheel Drive Unit



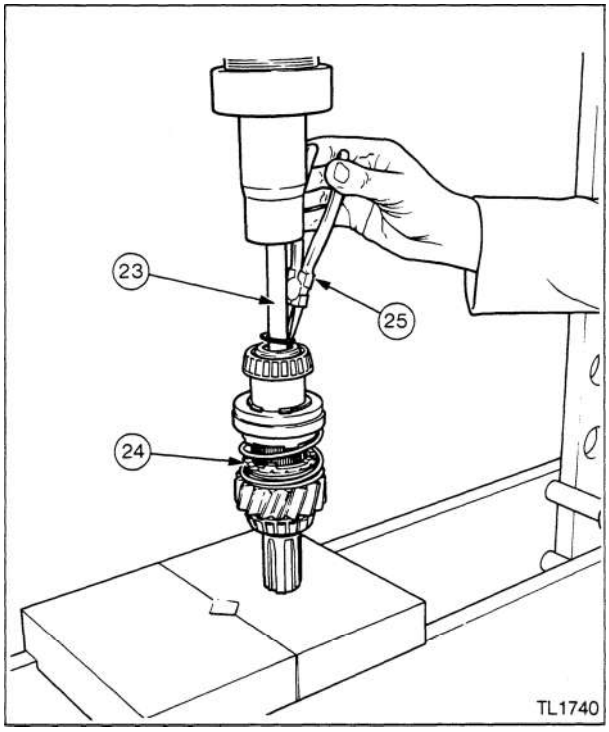
23. To remove the actuator piston cut a piece of tube approximately 16 mm (5/8 in) outside diameter, 13 mm (1/2 in) inside diameter and 100 mm (4 in) long that will pass over the end of the actuator piston rod projecting from the end of the shaft.
24. Place the shaft assembly under a hydraulic press and put the tube over the end of the rod and press down the washer against the spring pressure.
25. Remove the internal circlip.
26. Remove the washer, spring and stop tube.
27. Remove the shaft from the press.
28. To remove the clutch, first remove the circlip from its groove and slide it along the shaft towards the bearing.
29. Remove the three toggle pins from between the abutment ring and clutch coupler.
30. Pull the actuator piston out of the shaft.
31. Remove the actuator piston seals.
32. To remove the spring, clutch coupler, abutment ring and circlip, remove the rear taper roller bearing using a bearing separator plate under a hydraulic press.
33. Remove the circlip and abutment ring.
34. Remove the clutch coupler.
35. Remove the spring.

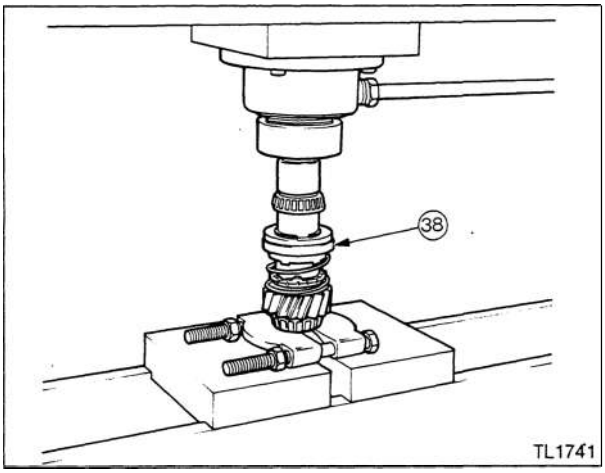
Examination

36. Clean and inspect all parts, pay particular attention the condition of the clutch.
37. Discard all 'O' rings, seals and circlips and replace with new.

Reassembly

38. Refit the drive gear and thrust washer onto the shaft and press the front taper roller bearing into place.
39. Place the spring, clutch coupler, abutment ring and circlip on to the shaft and press the rear taper roller bearing onto the shaft.
40. Replace the seals on the actuator piston and refit it into the end of the shaft.
41. Fit the three toggle pins between the abutment ring and clutch coupler, through the shaft and into the groove in the actuator piston.
42. To hold the toggle pins in place replace the shaft circlip into its groove.
43. Replace the stop tube, spring and washer.
44. Place the shaft assembly under a hydraulic press. Position the internal circlip on the washer and place the tube you used for dismantling over the end of the actuator piston.
45. Operate the hydraulic press and press the washer and spring down into the shaft, replace the circlip in its groove.
46. Replace the shaft assembly in the housing without the seals and drive coupling being fitted. Refit with the original shims removed.
47. The correct pre-load is 0,07 mm (0.003 in), this is obtained by adjusting the shim pack thickness between the end cap and the casing. Shims are available in the following sizes:





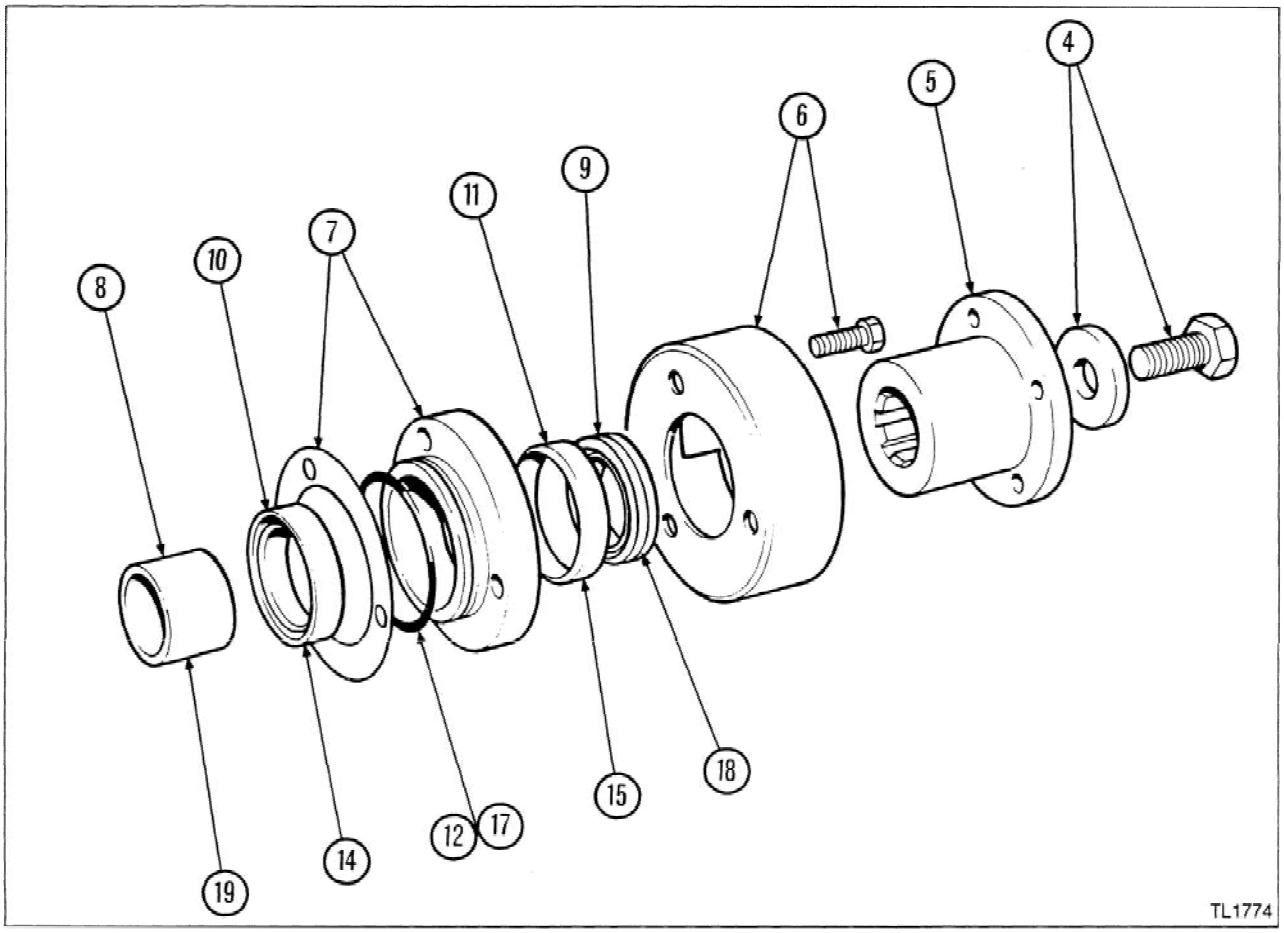
Drive shaft shims		
Part No.	Metric	Imperial
3611 066 M1	0,05 mm	0.002 in
3611 067 M1	0,20 mm	0.008 in
3611 068 M1	0,50 mm	0.010 in

48. Rotate the shaft by hand,when the pre-load is correct a slight drag on the rotation of the shaft should be felt, there must be no free play in the bearings, adjust the thickness of the pack to arrive at this condition.
49. Remove the drive shaft assembly from the case, retain the shims for reassembly.

50. Refit the intermediate gear assembly, pass the shaft through the front face of the housing, through the taper roller bearings in the gear and the thrust washer, ensure that the slot in the shaft locates in the pin in the housing.
51. The correct pre-load for this bearing is 0-0,05 mm (0-0.002 in). shims are available in the following sizes:

Intermediate shaft shims		
Part No.	Metric	Imperial
3612 631 M1	0,05 mm	0.002 in
3612 632 M1	0,10 mm	0.004 in
3612 633 M1	0,20 mm	0.008 in
3612 634 M1	0,30 mm	0.012 in
3612 635 M1	0,50 mm	0.020 in

52. Refit the shims removed and the end cap and check the bearing pre-load, there should be a slight resistance felt when rotating the gear.
53. After setting the pre-load remove the gear assembly and retain the shims for reassembly.
54. Press the oil seal into the end cap from the bearing end.
55. Press a new dirt seal wear sleeve into the end cap from the coupling end.
56. Fit a new 'O' ring to the drive shaft.
57. Fit a new 'O' ring to the end cap.
59. Fit a new 'O' ring to the end cover.
60. Reassemble the drive shaft assembly in the casing fitting the selected shims and rear guard, the slot in the rear guard faces outwards.
61. On tractors with 40 km/hr transmissions, reassemble with the extension piece, spacer and additional 'O' ring.
62. Press the dirt seal on to the seal sleeve and fill the dirt seal labyrinth with general purpose grease.
63. Install the seal sleeve and dirt seal onto the drive shaft.
64. Liberally coat the splines of the drive shaft with Hylomar and fit the drive coupling.
65. Degrease the threads of the central bolt, apply Loctite 270, refit with the washer and tighten to a torque of 113-137 Nm (83-101 lbf ft).
66. Reassemble the intermediate gear to the casing.
67. Refit the solenoid valve assembly.
68. Refit the four wheel drive unit to the range change gearbox, see operation 7J-01.



Drive Shaft Seal

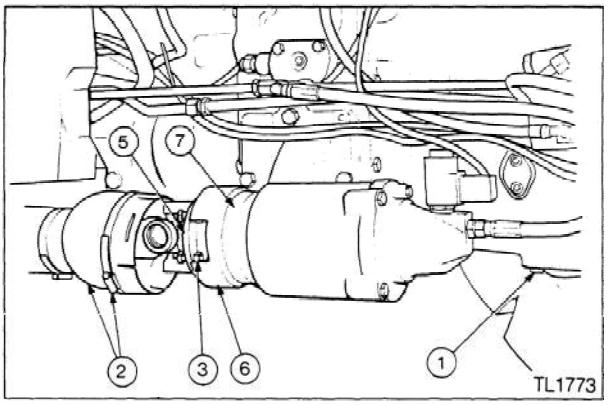
Removal and Refitment 5C-03

Removal

1. Drain the oil from the transmission case.
2. Remove the clip and slide back the drive shaft cover.
3. Remove the drive shaft coupling nuts and bolts.
4. Remove the drive coupling bolt and washer.
5. Remove the drive coupling.
6. Remove the four bolts and the rear guard.
7. Remove the end cap and shims.
8. Remove the oil seal sleeve.
9. Remove the dirt seal from the seal sleeve.
10. Press the oil seal out of the end cap.
11. Remove the dirt seal sleeve from the end cap.
12. Remove and discard the 'O' ring from the end cap and drive shaft.

Refitment

13. Clean all components.
14. Press the new oil seal into the end cap from the bearing end.
15. Press a new dirt seal wear sleeve into the end cap from the coupling end.
16. Fit a new 'O' ring to the drive shaft.
17. Fit a new 'O' ring to the end cap.



18. Press the new dirt seal on to the seal sleeve and fill the dirt seal labyrinth with general purpose grease.
19. Install the seal sleeve and dirt seal onto the drive shaft.
20. Liberally coat the splines of the drive shaft with Hylomar and fit the drive coupling.
21. Degrease the threads of the retaining bolt, apply Loctite 270 and tighten to a torque of 113-137 Nm (83-101 lbf ft).
22. Reconnect the drive shaft and tighten the drive shaft coupling bolts to a torque of 55-75 Nm (40-55 lbf ft).
23. Reconnect the drive shaft guard.
24. Refill the transmission with oil.

4WD Solenoid Valve

Removal and Refitment 5C–04

Removal

Solenoid Coil

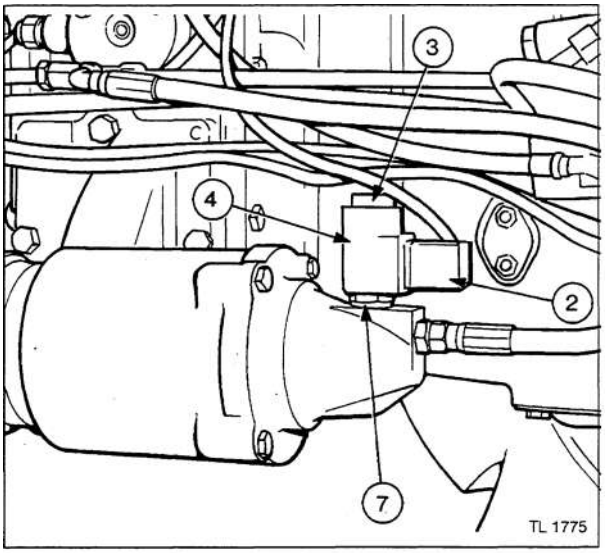
1. Test the electrical system first - with the key switch ON, the four wheel drive switch OFF, there should be a 12 volt supply at the solenoid terminals. If not, check the fuse and wiring system.
2. Remove the electrical system wires.
3. Remove the knurled nut on top of the solenoid.
4. Remove the coil taking care to retain the two 'O' rings each side of the coil.

Solenoid Valve Assembly

5. Ensure that the engine is stopped and allow a few minutes for the hydraulic pressure to subside.
6. Remove the electrical system wires.
7. Unscrew the solenoid valve assembly.
8. When refitting the unit ensure that the 'O' rings are in good condition.

Refitment

9. Reverse procedures 2 to 4 or 5 to 7, except:
   a. Apply Massey Ferguson Screw Lock (Loctite 222) to the knurled nut and tighten only finger tight.
   b. Tighten the solenoid valve body to a torque of 10 Nm (7 lbf ft). This is to prevent distortion of the valve body.

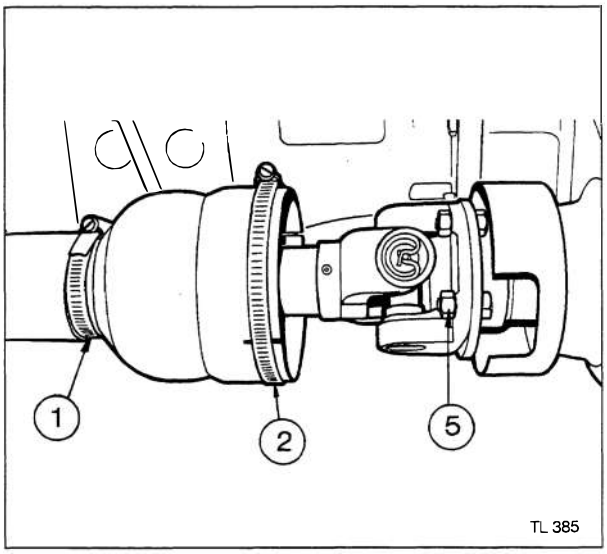


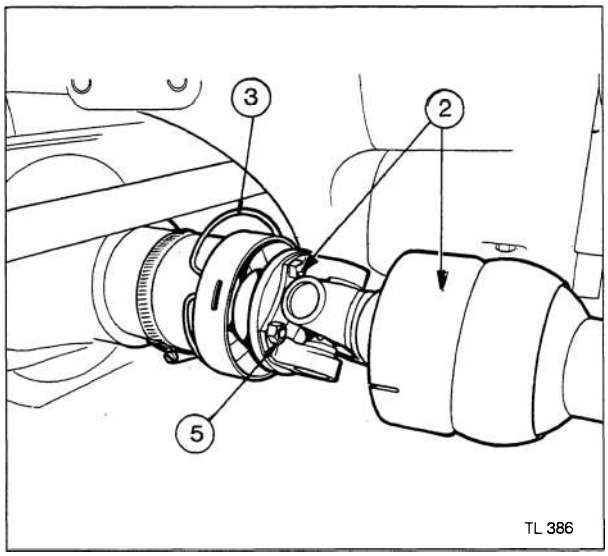
4WD Axle Drive Shaft

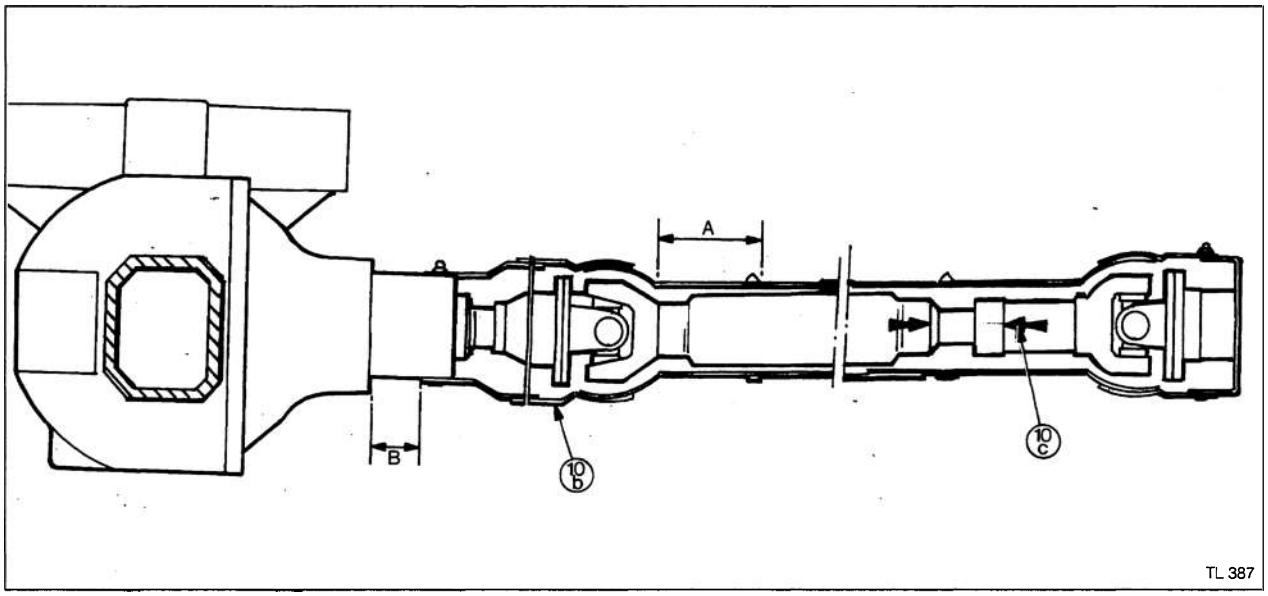
Removal and Refitment 5C–05

Removal

1. Slacken the two clips on the guard.
2. Slacken the clip from the guard at the transfer gearbox end.
3. Remove the spring clip from the guard at the axle end.
4. Slide the guard at both ends towards the centre to gain access to the couplings.
5. Remove the four bolts from each coupling and lift the drive shaft clear of the tractor.
6. Slide the rear part of the cover back to expose the sliding joint in the shaft.
7. Unscrew the retaining ring.
8. Slide the rear part of the coupling off the shaft.
9. The guards can now be removed from the shaft.







Refitment

10. Reverse procedures 1 to 9 except:

a. Lubricate both universal joints and the sliding spline with grease.

b. The drain hole in the guard must be at the axle end and be at the bottom.

c. The arrows on the drive shaft must be in line.

d. The clips must be positioned directly over the grooves in the two end sections. On tractors with six cylinder engines, the clip must be located 90 mm (3.5 in) from the front, dimension 'A'.

e. Apply Massey Ferguson Stud Lock (Loctite 270) to the threads of the coupling bolts and tighten to a torque of 55-75 Nm (40-55 lbf ft).

f. Position the front guard approximately 45 mm (2.3 in) from the step in the differential housing, dimension 'B'.

Cassette Seal Installation

Removal and Refitment 5C–06

Special tools:
MF.490 4WD Cassette seal installer

The new output shaft cassette seal was introduced into production from tractor serial number C45000, manufactured November 1994.

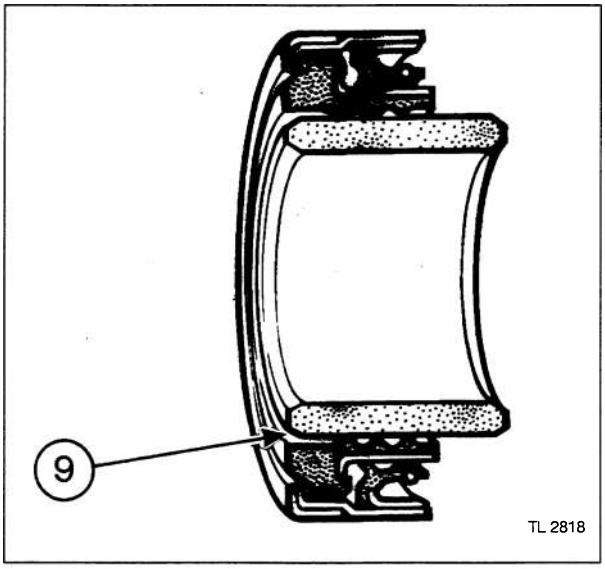
This new type of seal can be fitted to all four wheel drive output shafts

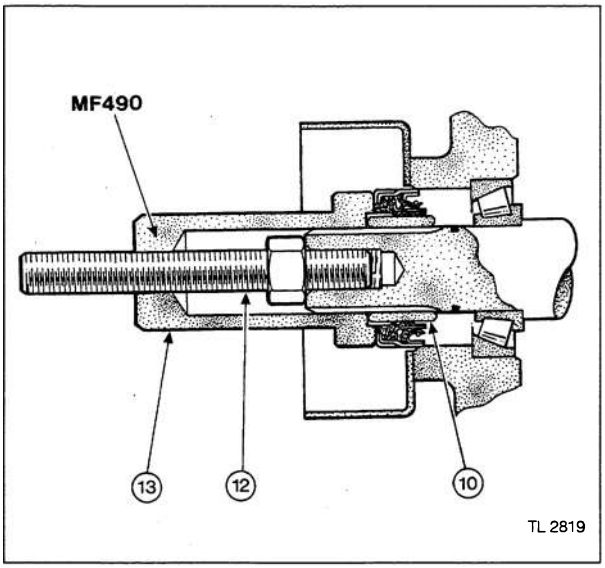
Removal

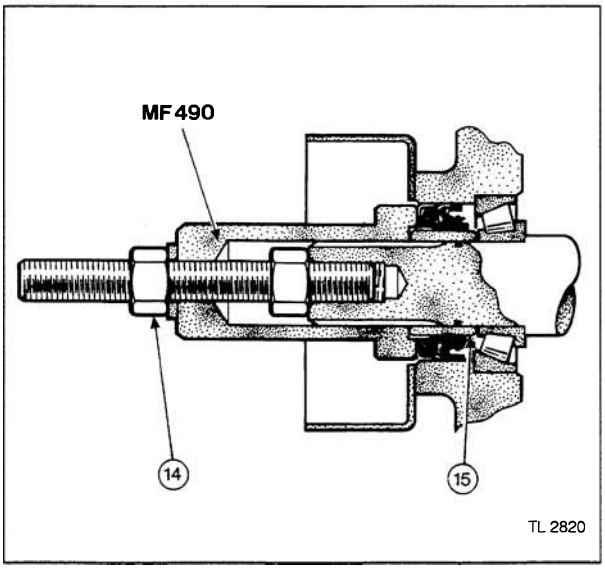
1. Drain the oil from the transmission.
2. Slide back the drive shaft guard and disconnect the drive shaft as described in operation 7J-05.
3. Remove the the drive shaft and seal as described in operation 7J-03 paragraphs 1 to 13,16 and 17 inclusive.
4. Refit the shims and end cap.
5. Check that the new seal will pass freely through the rear guard, if not, open out the guard centre hole to give 0,5 mm clearance all round the seal.
6. Replace the drive shaft as described in paragraphs 54 to 57 inclusive.
7. Renew the 'O' ring.

Installing the new seal

8. Liberally coat the inside of the seal with petroleum jelly.
9. Press the sleeve into the seal so that the front (flat) face of the seal is flush with the end of the sleeve.
10. Slide the seal/sleeve assembly over the output shaft as shown until the seal is just entering the housing.
11. Special tool MF.490 has been designed to install the seal to the correct depth in relation to the housing and sleeve. It also presses the seal in the correct location.
12. Screw the stud of special tool MF.490 into the end of the output shaft.
13. Slide the assembly tool over the stud and shaft.
14. Fit the washer and nut.
15. Screw the nut up the stud until the tool pushes the sleeve hard against the bearing. The seal is now in the correct position.
16. Remove the tool.
17. Coat the splines of the output shaft with Hylomar sealant.
18. Refit the drive coupling, drive shaft and guard as described in operation 7J-03 paragraph 20 to 24 inclusive.
19. Apply Massey Ferguson studlock (Loctite 270) to the central bolt and tighten to a torque of 125 Nm (92 lbf ft).
20. Apply Massey Ferguson studlock (Loctite 270) to the coupling bolts and tighten to a torque of 65 Nm (50 lbf ft).







SECTION 6

Rear Axle

INDEX

6A	BRAKES
6B	CROWNWHEEL, PINION and DIFFERENTIAL LOCK
6C	REAR AXLE
6D	DRAWBAR and LINKAGE
6E	WHEELS and TYRES

Brakes

Section 6 – Part A

Table of Contents

Operation No.	Description	Page No.
-------	Specification	6A- 2
-------	General description	6A- 2
2.06A-01	Drum brakes - adjust	6A- 4
2.06A-02	Disc brakes - adjust	6A- 4
2.06A-03	Drum brakes - removal	6A- 5
2.06A-04	Brake shoe relining	6A- 6
2.06A-05	Drum brakes - overhaul	6A- 7
2.06A-06	Brake actuator housing - disc brakes - overhaul	6A- 8
2.06A-07	Disc brakes - overhaul	6A- 9
2.06A-08	Footbrake linkage and pedals - pendant - removal	6A-11
2.06A-09	Foot pedal - pendant - adjust	6A-11
2.06A-10	Footbrake linkage and pedals - classic - removal	6A-12
2.06A-11	Parking brake - cable operated - removal	6A-13
2.06A-12	Parking brake - linkage operated - removal	6A-13

Brakes

Specification

Multi-disc oil immersed	
Diameter	222,4 mm
Number of plates	
3 indents on carrier plate	3 friction discs per half axle
5 indents on carrier plate	5 friction discs per half axle
6 indents on carrier plate	6 friction discs per half axle
Lining material	Sintered bronze
Depth of groove	0,3 mm when new
Operation	Rods and levers
Parking brake	Cable or rod operated on both brakes independent of the foot brake
Drum brakes	
Diameter	355 mm
Width	50 mm
Operation	Rods and levers
Parking brake	Cable or rod operated on both brakes independent of the foot brake
Brake pedal free travel	25 mm
Brake shoe concavity - maximum	0,25 mm
Gap between brake lining and shoe - maximum	0,1 mm
Pendant type brake pedal height - footstep to pedal	152 mm

Bolt torques

Brake shoe anchor pins	200 Nm
Brake lever grub screw - drum brakes	2,4 Nm

GENERAL DESCRIPTION – MULTI DISC OIL COOLED BRAKES (FIG.1)

The following general description applies to tractors equipped with multi-disc oil cooled brakes fitted between the axle housing and the differential carrier plates adjacent to the centre housing.

Pressure on the brake pedal brings an actuating assembly into contact with two rotating middle (friction) discs splined to each axle shaft, these in turn contact fixed friction faces provided in the axle housing and in the differential carrier plate fitted between the centre and axle housings. The mechanism of each brake consists of two cast iron actuating discs, held together by tension springs and separated by steel balls located in inclined ramps. Pressure on the brake pedal, by pulling on the operating rod, rotates one actuating disc relative to the other, and the steel balls ride up their inclined ramps and so spread the actuating discs apart. These come into contact with the rotating (friction) discs, which are splined to the shaft being braked. The actuating assembly will move slightly in the direction of rotation until the torque ear of one actuating disc comes into contact with a shaft in the housing. The other actuating disc tends to rotate further, increasing the angular displacement between the discs, and assisting the braking action. When the brake pedal is released, the tension springs cause the discs to return to their normal position.

GENERAL DESCRIPTION – DOUBLE ACTING DRUM BRAKES (FIG.2)

The following general description applies to tractors fitted with double acting, floating cam type drum brakes which operate on the rear wheels only. They are internally expanding 356 mm x 51 mm drum brakes fitted with bonded linings in production, but the shoes are drilled to receive riveted linings in service.

Each brake consists of a backplate on which is mounted the double anchor pin assembly securing one end of each shoe. The other end of each shoe fits into slots in the adjuster assembly and is held in position by a spring.

Between the shoe webs at the anchor pin end is the operating camshaft which is connected by linkage to the pedal. A shoe to anchor the pin spring is connected between the anchor pin and shoe web of each shoe.

The shoes are kept square in relation to the backplate by steady posts and shoe hold-down pins. The backplate is secured to the rear axle housing and is enclosed within a drum which is fitted to the rear axle shaft assembly.

GENERAL DESCRIPTION – ALL BRAKING SYSTEMS

The brakes on all tractors are operated by two independently operated foot pedals located on the right-hand side of the transmission tunnel.

To assist turning, the right pedal (outboard) operates the right-hand brake and the left pedal (inboard) operates the left-hand brake.

For highway use the brakes must be used together by operating an interlocking latch which joins the two pedals.

A parking brake is provided which operates both brakes together, independent of the foot brakes, mechanically through a rod or cable control.

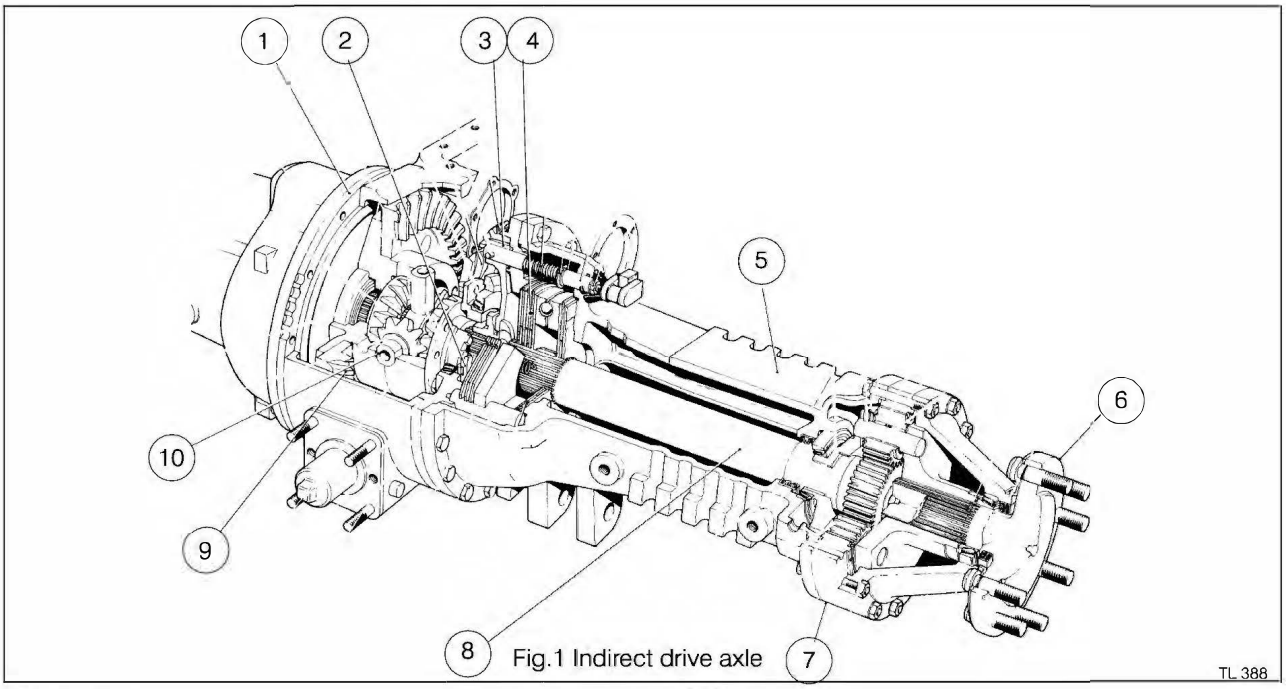


Fig.1 Indirect drive axle

1. Carrier
2. Differential lock
3. Differential lock mechanism
4. Brakes
5. Trumpet housing
6. Axle shaft
7. Epicyclic unit
8. Half shaft
9. Crownwheel and pinion
10. Differential

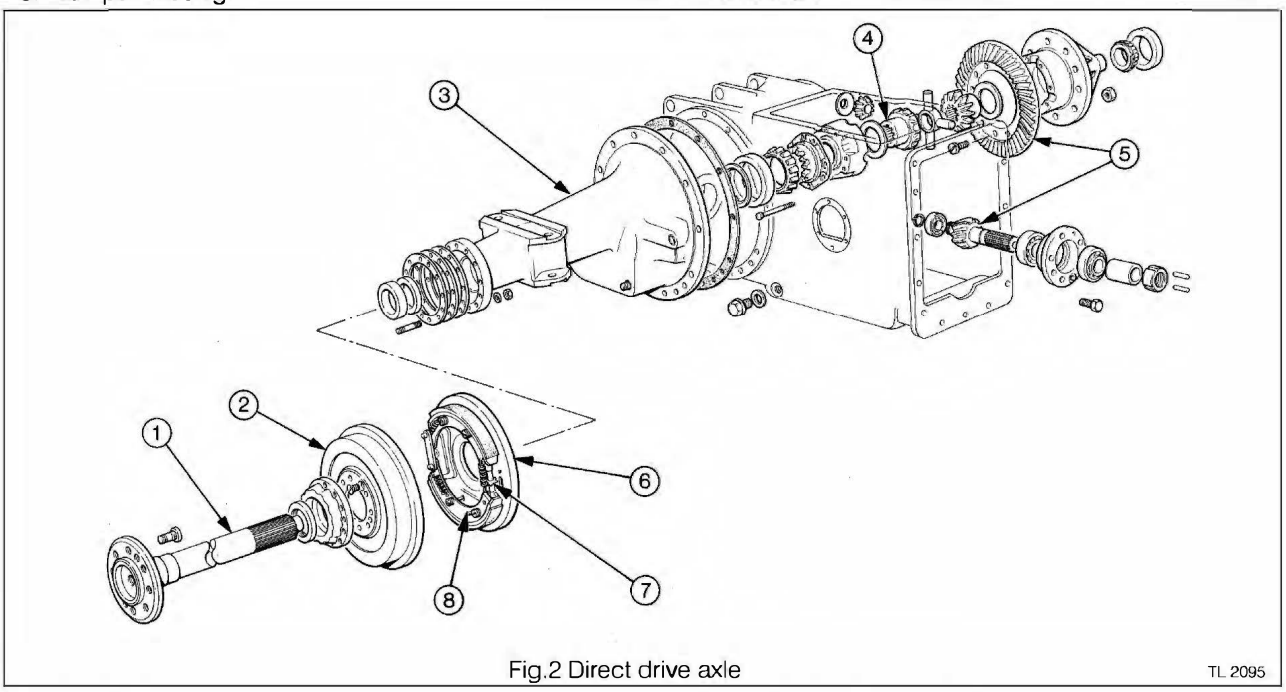


Fig.2 Direct drive axle

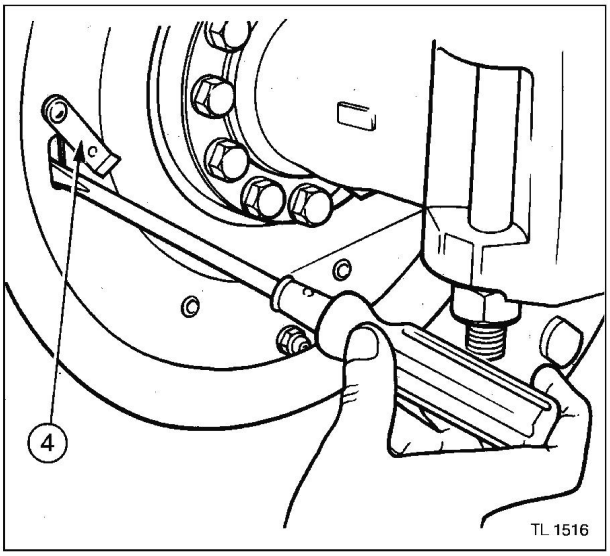
1. Axle shaft.
2. Brake drum.
3. Trumpet housing.
4. Differential.
5. Crownwheel and pinion.
6. Brake back plate.
7. Brake adjuster.
8. Brake shoes.

DRUM BRAKES

Adjust **2.06A–01**

Procedure

1. Chock the front wheels and jack the tractor rear wheels clear of the ground, release the parking brake.
2. Slacken the parking brake adjusters.
3. Unlatch the brake pedals.
4. Move back the cover plate on the brake backplate.
5. Insert a screwdriver through the slot in the backplate and lever the adjuster towards the front of the tractor until the wheel is locked.
6. Slacken the adjuster until the wheel rotates freely.
7. Repeat items 4 to 6 for the other brake.
8. Re-adjust the two parking brake adjusters so that the parking brake is effective at approximately the third click.
9. Latch the two brake pedals together.
10. Road test the tractor, slacken the adjuster on the side to which the tractor pulls.



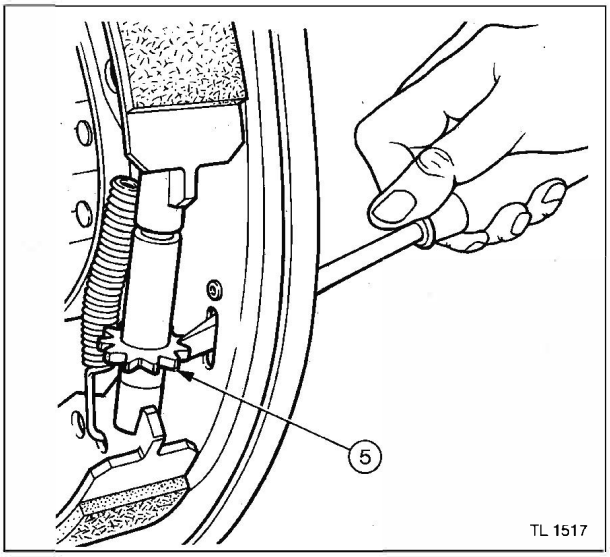
TL 1516

DISC BRAKES

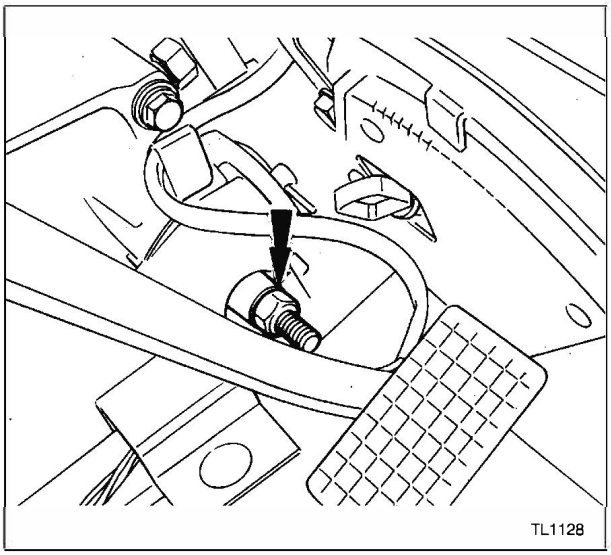
Adjust **2.06A–02**

Procedure

1. Jack up the tractor until both rear wheels are clear of the ground.
2. Disengage the brake return springs and release the parking brake.
3. Unlatch the brake pedals.
4. Measure the height of the right-hand pedal from the footstep, when fully up.
5. Apply a light load to the brake pedal and re-measure the pedal height. The pedal free travel should be 25 mm.
6. If adjustment is necessary, turn the adjustment nut on the right-hand rear axle brake actuating lever clockwise to reduce free travel and counter-clockwise to increase free travel.
7. Having adjusted the right-hand pedal, adjust the left-hand pedal to match for height so that the latch freely engages.
8. Reconnect the brake return springs.
9. Lower the rear of the tractor to the ground.
10. Road test the tractor, and check the brakes for binding or pulling to one side. Any tendency to pull to one side should be counteracted by slackening the adjuster on the side to which the tractor pulls.



TL 1517


TL1128

DRUM BRAKES

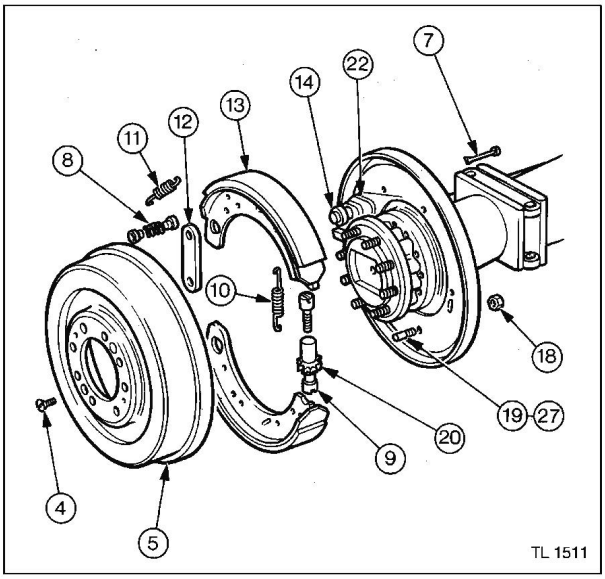
Removal and refitment 2.06A–03

Removal

1. Jack up the tractor.
2. Remove the rear wheel.
3. Slacken off the brake adjustment.
4. Remove the two countersunk screws.
5. Remove the brake drum.
6. Release the parking brake cable or rod from the brake camshaft lever.
7. Remove the shoe hold-down spring assemblies. Grip the pin with a pair of pliers.
8. Simultaneously, press and turn the dished washer until released, then remove the two washers and the spring. Repeat this procedure for the four sets of fixings.
9. Force apart the brake shoes at the adjuster end to allow the adjuster to drop out of position.
10. Remove the spring.
11. Remove the two springs by levering with a screwdriver between the springs and the anchor plate.
12. Remove the anchor plate.
13. Lift off the two brake shoes.
14. Remove the two spacer washers.
15. Clean off all parts, ensure that the adjuster threads are free to rotate.

Refitment

16. Lightly smear both ends of the new brake shoes and the flat end of the camshaft with Girling White Brake Grease.
17. Reverse procedures 6 to 14 except:
    a. To facilitate refitment of the springs, use a length of wire looped around the hook of the spring and pull the spring over the anchor pin.
    b. Ensure that the adjuster is fitted with the star wheel adjacent to the adjusting hole in the back plate.
18. Slacken the steady post nuts.
19. Screw the steady post well into the back plate.
20. Turn the adjuster to the fully 'off' position.
21. Refit the brake drum and secure it with the two countersunk screws.
22. Slacken the anchor pin nuts.
23. Using the adjuster, expand the brake shoes, then tap the anchor pin nuts to ensure that the shoes are seating correctly.
24. Repeat this procedure until the adjuster cannot be tightened any further.



25. Coat the threads of the anchor pins with grease and tighten to a torque of 200 Nm.
26. Slacken off the adjuster, remove the two countersunk screws and remove the brake drum.
27. Screw in the steady posts until they touch the brake shoe webs, then secure the posts with the nuts.
28. Refit the brake drum and secure it with the two countersunk screws.
29. Reconnect the parking brake cable or rod.
30. Refit the rear wheel and tighten the nuts, progressively, and evenly to a torque of 270 Nm.
31. Adjust and balance the brakes, see operation 2.06A-01.

BRAKE SHOE RELINING

Overhaul **2.06A–04**

Special Tools:
Brake lining clamp (Qty 2)
Brake riveting anvil and punch

Dis-assembly

CAUTION: *It is permissible to reline the brake shoes when genuine replacement shoes are not available, but it must be stressed that it is advisable to use genuine Massey Ferguson parts whenever possible.*

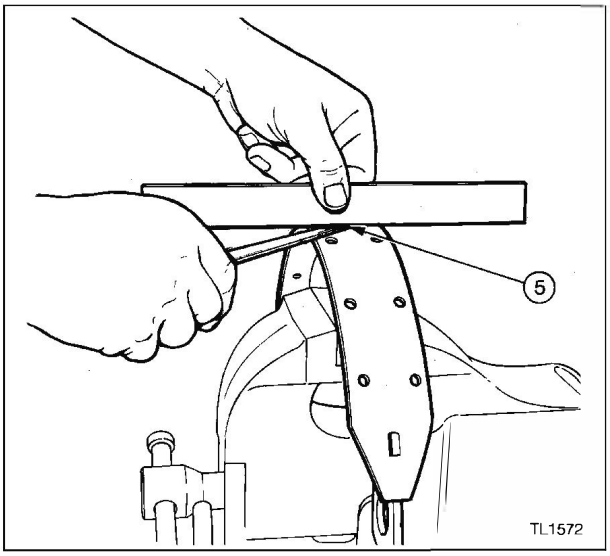
WARNING: The brake shoe lining may contain asbestos. Breathing asbestos dust is dangerous to your health, the following precautions listed below must be observed:

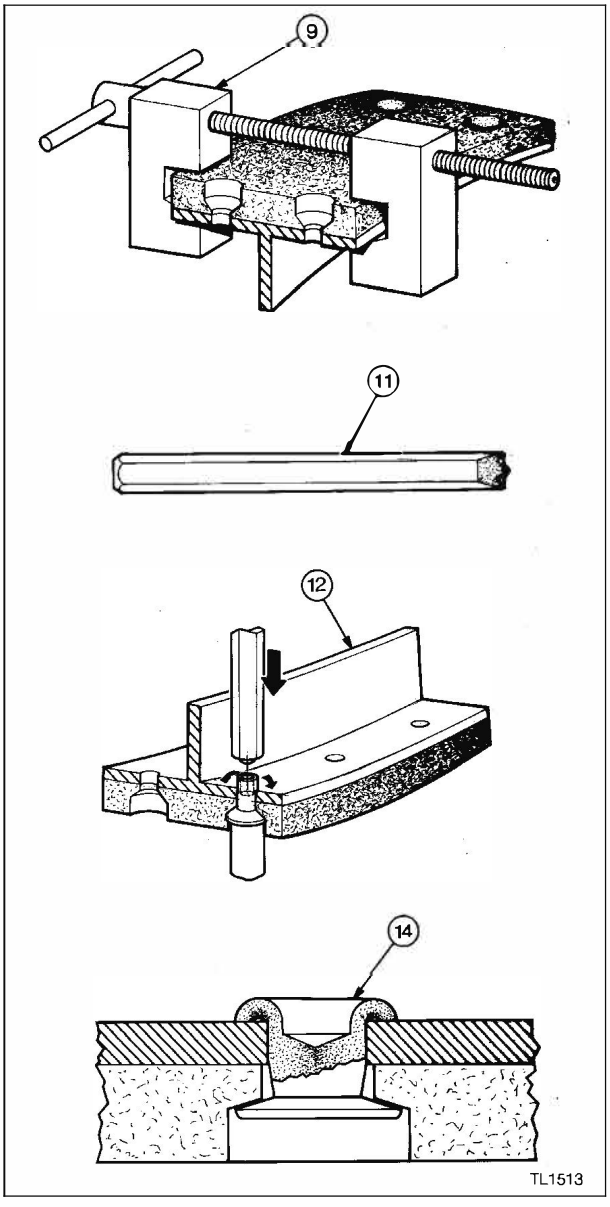
- ***Work out doors or in a well ventilated area.***
- ***Dust found when working on brakes must be removed by extraction and NOT by blowing.***
- ***Dust waste should be dampened, placed in a sealed container and marked to ensure safe disposal.***
- ***If any cutting, drilling etc. is attempted on the brake linings they must be dampened and only hand tools or low speed power tools used.***

1. Remove the brake shoes, see operation 2.06A-03.
2. To remove the bonded linings from the shoes use one of the following methods:
   a. Place the brake shoes in an oven and heat to 600°C; after about 15 minutes at this temperature the old linings will drop off.

WARNING: Eye protection and exhaust ventilation must be used.

   b. Manual stripping involves the use of a hammer and suitably sharp chisel to remove the lining and as much of the bond film as possible; abrasive methods (flexible belt, disc sander or hand sanding) must then be used to remove the remainder of the bond film, but taking great care to preserve the profile of the shoe platform.
3. Thoroughly clean the brake shoes, paying particular attention to the lining contact surface.
4. Ensure that all of the drillings are clear.
5. Check the concavity of the shoe platform. Place a straight edge across the shoe and with a feeler gauge check the gap in the centre of the shoe, it should not exceed 0,25 mm.
6. Paint the shoes with a quick drying black paint to prevent corrosion.



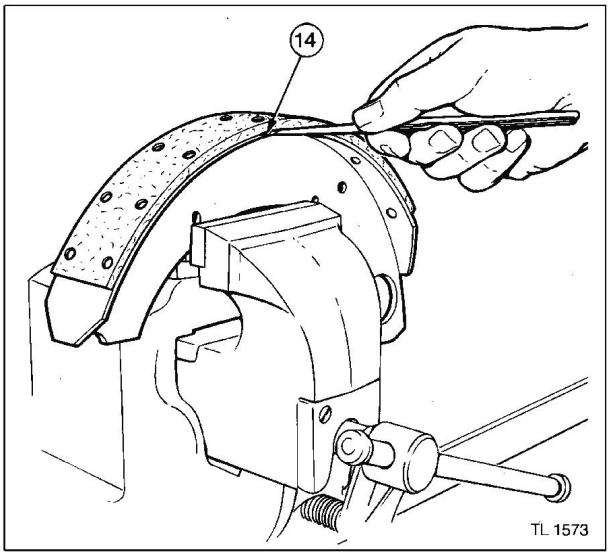


Re-assembly

7. The shoes and linings are pre-drilled and do not require any preparation. Offer up the lining to the brake shoe and align the holes.
8. Locate the lining on the brake shoe by inserting two rivets at the centre of the lining.
9. Place the clamps each side of the two rivets and tighten them securely.
10. Select an anvil of the correct size, a little smaller than the counterbore in the lining.
11. For semi-tubular rivets it is important that a rim punch is used as shown in the illustration.
12. Using a hammer of moderate size and brake rivet punch clench up the rivet by using a series of taps, not by means of only one or two very heavy impacts which might cause damage to the lining.
13. Working alternately from the centre of the brake shoe, move the clamps, insert the rivets and secure them in position.
14. When the rivet is correctly fitted, it should fill the hole in the lining, the shoe and the tubular part of the rivet should be rolled over as shown in the illustration.

NOTE: *The gap between the brake shoe and the lining must not exceed 0,1 mm.*

15. Refit the brake shoes, see operation 2.06A-03.
16. Adjust and balance the brakes, see operation 2.06A-01.



DRUM BRAKES

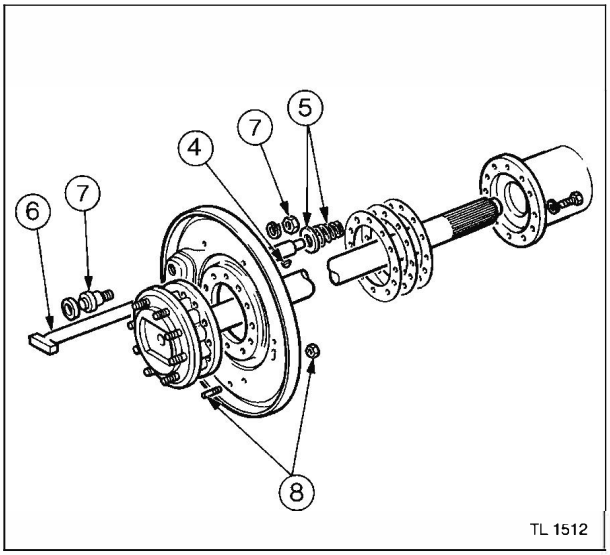
Overhaul **2.06A–05**

Dis-assembly

1. Remove the brake, see operation 2.06A-03.
2. Remove the axle shaft and brake assembly, see operation 2.06A-07.
3. Unscrew the grub screw in the camshaft lever.
4. Remove the camshaft lever and woodruff key.
5. Slide the washer and conical spring off the camshaft.
6. Remove the camshaft.
7. Remove the anchor pins, spring washers and nuts.
8. Remove the steady posts and nuts.

Examination

Clean and inspect all components, any showing signs of excess wear or damage must be replaced. Ensure that all threads are clean and free to turn, coat with Girling White Brake Grease.



Re-assembly

9. Reverse procedure 1 to 8 except:
   a. Refit the washer first, then the conical spring (large diameter towards the back plate). Half compress the spring to load the camshaft.
   b. Position the brake lever on the camshaft with 6 mm clearance from the trumpet housing. Tighten the grub screw to a torque of 2,4 Nm.
   c. Refit the anchor pins, spring washers and nuts but do not tighten until resetting the brakes.
   d. Refit the steady posts and nuts, but do not adjust and tighten until the brakes are set.
10. Adjust and balance the brakes, see operation 2.06A-01.

BRAKE ACTUATOR HOUSING – DISC BRAKES

Overhaul **2.06A–06**

Dis-assembly

1. Drain the transmission oil to below the MIN mark on the dipstick.
2. Disconnect the brake pull rods.
3. Remove the brake return spring.
4. Remove the locknut, nut and spacer.
5. Remove the three bolts, spring washers and spacers (if fitted).
6. Remove the actuator housing.
7. Remove and discard the gasket.
8. Tap out, and if damaged, discard the rubber boot.

Differential lever

NOTE: *Do not remove the differential lock lever mechanism or the brake pull lever unless they are to be serviced.*

Only if necessary, continue as follows:

9. Tap out and discard the grooved pin.
10. Remove the pivot pin.
11. Remove the differential lock lever assembly.

Brake pull lever

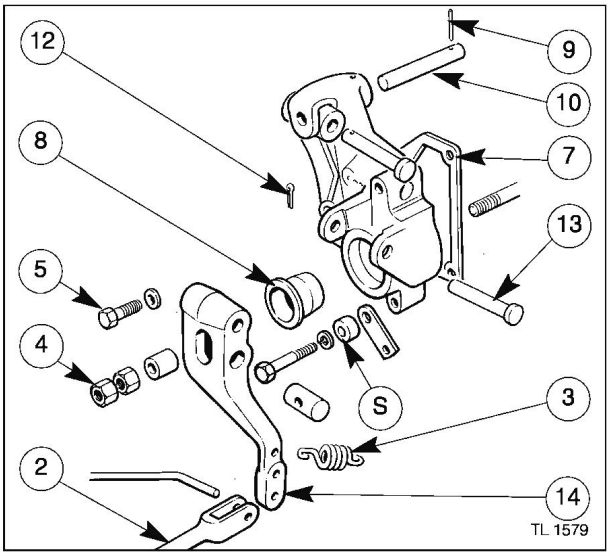
12. Remove and discard the split pin.
13. Push out the pivot shaft.
14. Remove the brake pull lever.
15. Examine the mating faces of the actuator housing and the trumpet housing for damage. Clean both surfaces before reassembly.

Re-assembly

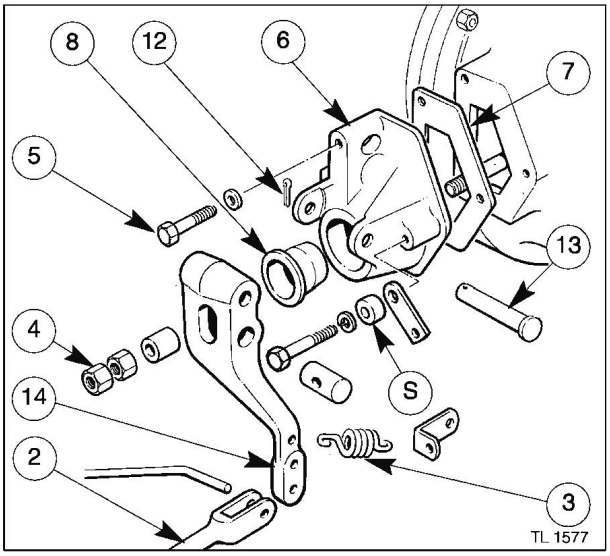
16. Reverse procedures 1 to 8 or 1 to 15 depending on state of disassembly, except:
    - *a.* If necessary fit a new rubber boot, preferably using a hydraulic press. Also fit a new gasket.
    - *b.* Before refitting the housing, smear the brake actuator rod with petroleum jelly. When refitting the housing take care to seat the lips of the rubber boot in the step on the actuator rod, without disturbing the garter spring.
    - c. The three bolts are of varying lengths according to their position in the actuator housing.

NOTE: *A spacer (S) has been added to the lower bolt on later tractors to provide a more constant brake setting.*

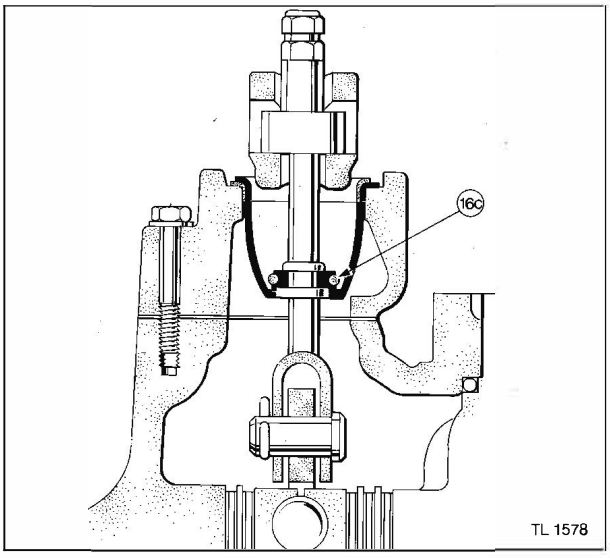
17. Adjust and balance the brakes, see operation 2.06A-02.



Left-hand brake



Right-hand brake



DISC BRAKES

Overhaul **2.06A–07**

Dis-assembly

1. Remove the trumpet housing and carrier plate, see operation 2.06A-07.
2. Manoeuvre the trumpet housing off the trolley jack and stand it on its end.
3. Remove the brake adjusting locknut, nut and spacer.
4. Remove the three bolts and spring washers.
5. Withdraw the left-hand actuator housing, or remove the actuator housing complete with the differential lock lever mechanism on from the right-hand trumpet housing.
6. Tap out and discard the rubber boot.
7. Remove the carrier plate.
8. Remove the brake components, turning each plate over and stacking in reverse order to ensure correct refitment.
9. If necessary, remove the brake stop rod from the housing.

Only if necessary, dismantle the actuator unit as follows:

10. Release the four springs.
11. Remove the actuator rod, links and ball bearings.

Examination

Friction plates: These have a minimum groove depth of 0,3 mm when new. When the grooves begin to disappear, the plates must be replaced.

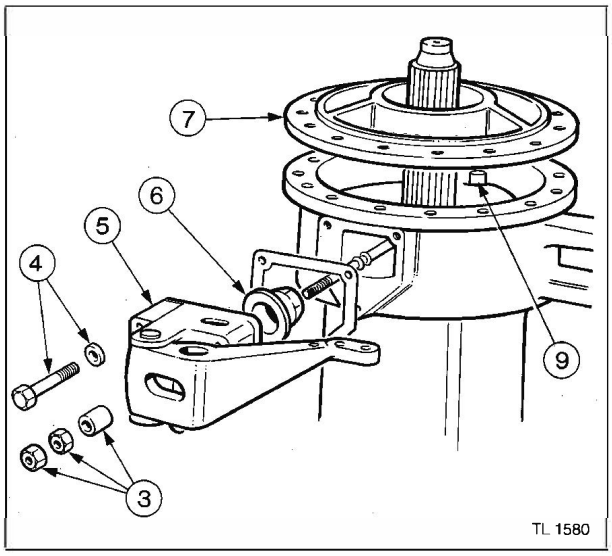
Steel plates: The interplates can generally be refitted, but should be replaced either when badly scored or worn more than 0,13 mm per face. The steel plates should also be replaced when the friction plates are renewed.

Check all plates for signs of severe overheating or distortion.

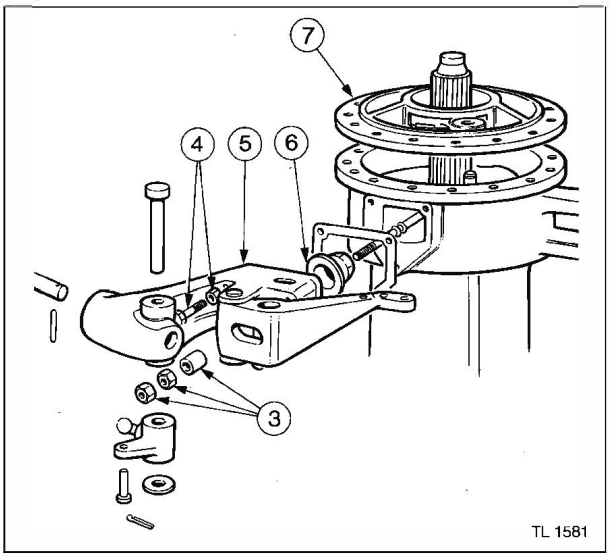
NOTE: *Never attempt to reclaim friction plates or steel plates by lapping or grinding.*

Actuator Plates: The actuator plates do not normally need replacing, but should be checked for severe scoring.

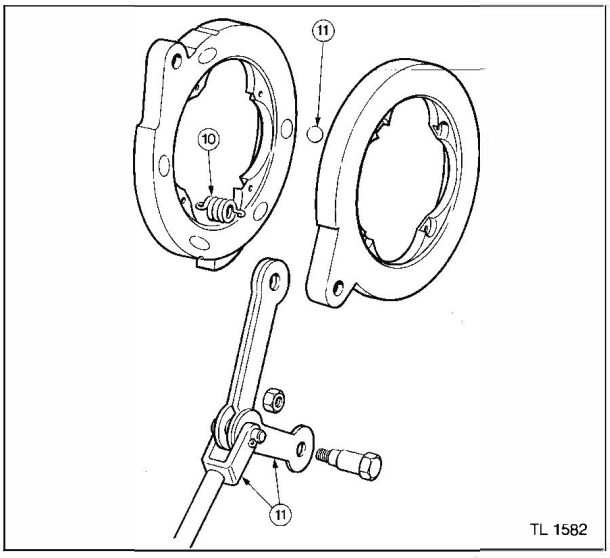
Thoroughly clean out the brake housing and remove any burrs or pieces of old gasket from the actuator and trumpet housings.



Left-hand brake



Right-hand brake



Re-assembly

12. Reverse procedures 1 to 8 or 1 to 11, depending on the extent of disassembly, except:

    a. Dip each friction plate, steel plate and expander unit in clean transmission oil before fitting them into the housing. IT IS VERY IMPORTANT to refit all plates in the order in which they were originally assembled.

    b. Refit the carrier plate.

    c. Fit a new rubber boot, preferably using a hydraulic press.

    d. Smear the expander rod with petroleum jelly, then refit the actuator housing, ensuring that the lip of the rubber boot seats correctly in the ridge on the actuator rod. Do not displace the garter spring.

    e. The three bolts are of varying lengths according to their location in the actuator housing.

    f. If the brake plates have been mixed up or are being replaced, they are fitted into the trumpet housing in the following order:

3 friction discs per half axle	5 friction discs per half axle	6 friction discs per half axle
Friction disc Steel plate **Friction disc** Expander unit **Friction disc** Carrier plate	**Friction disc** Steel plate **Friction disc** Steel plate **Friction disc** Expander unit **Friction disc** Steel plate **Friction disc** Carrier plate	**Friction disc** Steel plate **Friction disc** Expander unit **Friction disc** Steel plate **Friction disc** Steel plate **Friction disc** Steel plate **Friction disc** Carrier plate

13. Refit the trumpet housing and carrier plate, see operation 2.06A-07.

14. Refit the brake actuators, see operation 2.06A-06.

15. Adjust and balance the brakes, see operation 2.06A-02.

FOOTBRAKE LINKAGE and PEDALS – PENDANT

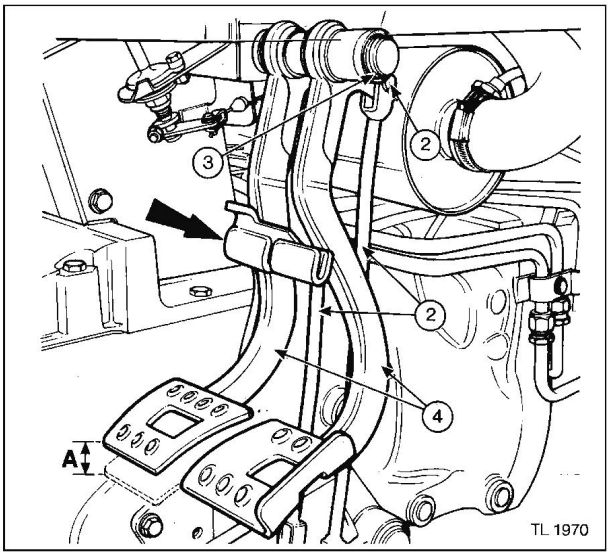
Removal and refitment **2.06A–08**

Removal

1. Remove the lower instrument panel.
2. Remove the clevis pins connecting the two vertical brake rods to the pedals.
3. Remove the circlip from the end of the pivot shaft.
4. Withdraw both pendant pedals from the shaft.
5. Remove any other brake rods as required.

Refitment

6. Reverse procedures 1 to 5 except:
   a. Ensure that the pivot shaft and bearings are lubricated with a lithium based grease.
   b. Adjust the foot pedal height, see operation 2.06A-09.

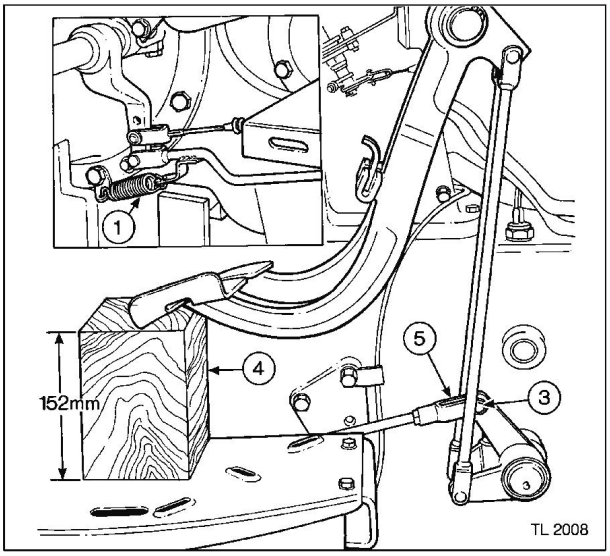


FOOTBRAKE PEDAL – PENDANT

Adjust **2.06A–09**

Procedure

1. Disconnect the spring from the rear brake lever.
2. Loosen the parking brake cable.
3. Remove the clevis pin from the horizontal brake rod.
4. Place a wooden block 152 mm thick under the brake pedals.
5. Adjust the length of the horizontal brake rod so that the clevis pin can be replaced in the yoke.
6. Carry out the same operation for the other side of the tractor.
7. Remove the wooden block and check that both brake pedals are the same height when unlatched. Adjust the length of one of the rods if necessary.
8. Tighten up all the locknuts, replace the split pins in the clevis pins and refit the springs to the rear brake levers.
9. Adjust the brakes, see operation 2.06A-01 or 2.06A-02.
10. Adjust the parking brake so that it is fully engaged at three clicks.



FOOTBRAKE LINKAGE and PEDALS – CLASSIC

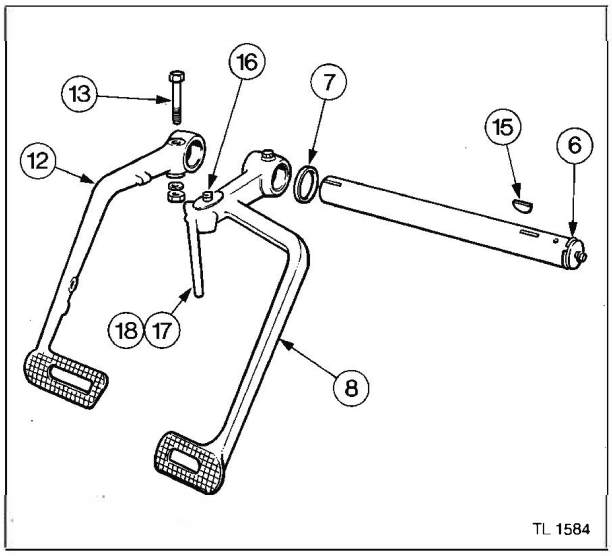
Removal and refitment **2.06A–10**

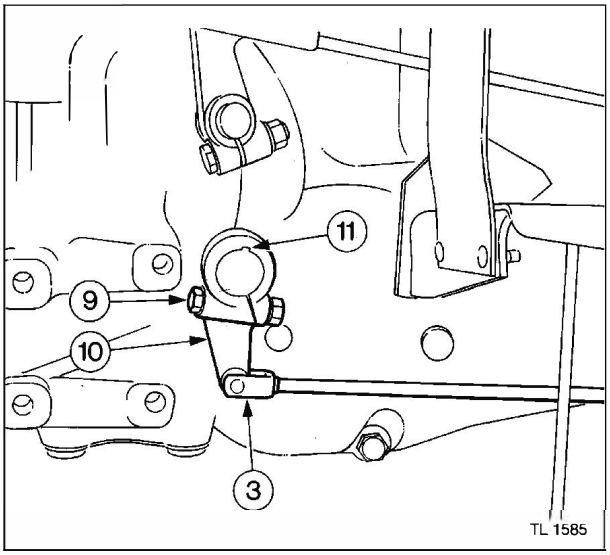
Removal

1. Release the brake return spring at the rear axle.
2. Remove the split pin and clevis pin securing the brake rod to the right-hand pedal.
3. Remove the split pin and clevis pin securing the brake rod to the left-hand pedal lever pull rod.
4. Remove the four nuts and bolts securing the right-hand footstep support bracket.
5. Remove the right-hand footstep front support bracket.
6. Remove the snap ring.
7. Remove the washer.
8. Slide the right-hand brake pedal off the cross-shaft.
9. Slacken the pinch bolt securing the left-hand cross-shaft arm.
10. Remove the left-hand cross-shaft arm.
11. Remove the woodruff key.
12. Push the cross-shaft through the centre housing and remove it, complete with the left-hand brake pedal.
13. Remove the pinch bolt, nut and washer securing the left-hand brake pedal.
14. Slide the pedal off the shaft.
15. Remove the woodruff key.
16. Remove the screw and nut.
17. Remove the plate.
18. Remove the locking latch.

Refitment

19. Reverse procedures 1 to 18.
20. Adjust and balance the brakes, see operation 2.06A-01 or 2.06A-02.





PARKING BRAKE – CABLE OPERATED

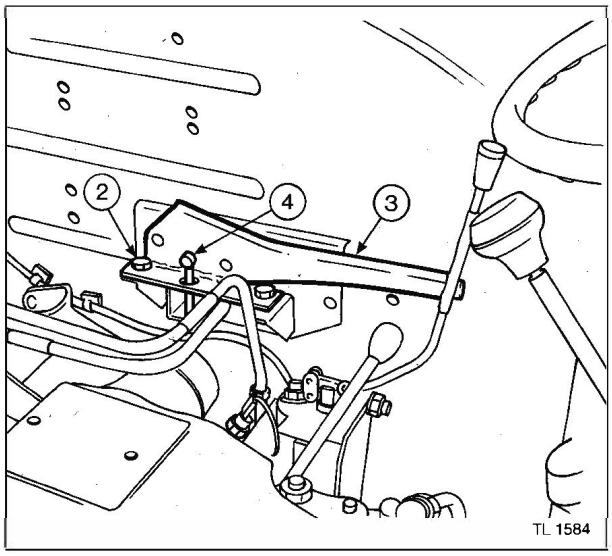
Removal and refitment **2.06A–11**

Removal

1. Disconnect the two parking brake cables from the rear brake actuators and at the anchor points on the side covers.
2. Remove the two bolts securing the parking brake assembly to the frame of the tractor.
3. Withdraw the parking brake assembly and the two cables.
4. Remove the cables if necessary.

Refitment

5. Reverse procedures 1 to 4 except:
   a. Route the right-hand cable over the transmission case, ensure that it has no sharp bends.
   b. Check that the brake operates freely.
6. Adjust and balance the brakes, see operation 2.06A-01 or 2.06A-02.



PARKING BRAKE – LINKAGE OPERATED

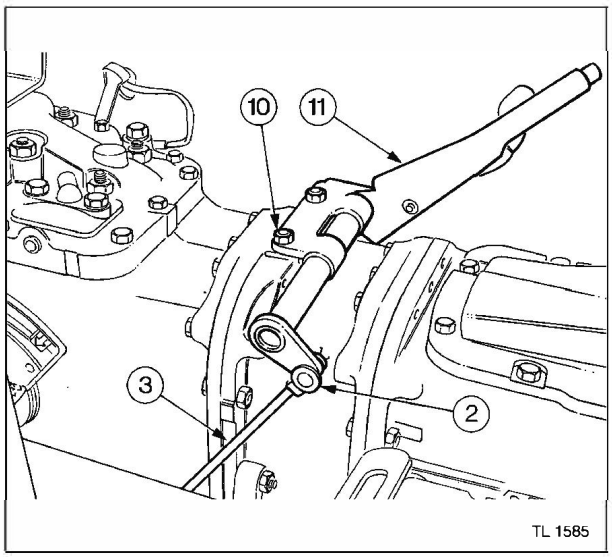
Removal and refitment **2.06A–12**

Removal

1. Remove the split pin, washer and clevis pin from the lever to the rod.
2. Remove the split pin and clevis pin.
3. Remove the rod.
4. Remove the split pin and clevis pin securing the brake rod clevis.
5. Remove the split pin and clevis pin securing the brake rod to the brake lever.
6. Remove the circlip from the pivot shaft.
7. Remove the washer.
8. Remove the pivot arm.
9. Repeat procedures 1 to 8 for the opposite side of the tractor, if necessary.
10. Remove the two bolts securing the lever assembly.
11. Remove the parking brake lever assembly from the lift cover.

Refitment

12. Reverse procedures 1 to 11.
13. Adjust and balance the brakes, see operation 2.06A-01 or 2.06A-02.



Crownwheel, Pinion and Differential Lock

Section 6 – Part B

Table of Contents

Operation No.	Description	Page No.
-------	Specification	6B- 2
-------	General description	6B- 2
2.06B-01	Differential lock - drum brakes - adjust	6B- 4
2.06B-02	Differential lock - disc brakes - adjust	6B- 4
2.06B-03	Differential lock - drum brakes - overhaul	6B- 4
2.06B-04	Differential lock - disc brakes - overhaul	6B- 6
2.06B-05	Lower link pin - drum brakes - removal	6B- 7
2.06B-06	Differential lock coupler cap - removal	6B- 8
2.06B-07	Differential unit - overhaul	6B- 9
2.06B-08	Crownwheel and pinion - overhaul	6B-10
2.06B-09	Differential pre-load - check	6B-15

Crownwheel, Pinion and Differential Lock

Specification

Crownwheel and pinion ratio:	Ratio	Number of teeth
MF 345	6.1667:1	6 x 37
MF 355	3.4545:1	11 x 38
MF 350, MF 360, MF375	4.375:1	8 x 35
MF 385	3.889:1	9 x 35

Differential Lock Pedal clearance between pedal and footstep	
Drum brakes	9 mm
Disk brakes	1mm

Pinion bearing pre-load	21-25 kg cm
Differential pre-load	Use tool MF.245D
Tighten clamp bar to a torque of	27 Nm
Epoxy resin kit part number	1852 913 M91

Special tools

MF.245D	Differential bearing pre-load gauge
MF.245D-1	Straight edge
MS.555	Adjustable puller (main tool)
MF.555-2B	Right-hand differential bearing remover
FT.4062A	Bearing pre-load gauge

Bolt torques

Differential case bolts	108 Nm
Crownwheel bolts	160 Nm
Trumpet housing bolts	130 Nm
Pinion housing to centre housing bolts	108 Nm
Differential lock pedal clamp bolt - drum brakes	115 Nm
Differential lock pedal fork bolts - drum brakes	54 Nm
Lower link pin - drum brakes	163 Nm

GENERAL DESCRIPTION

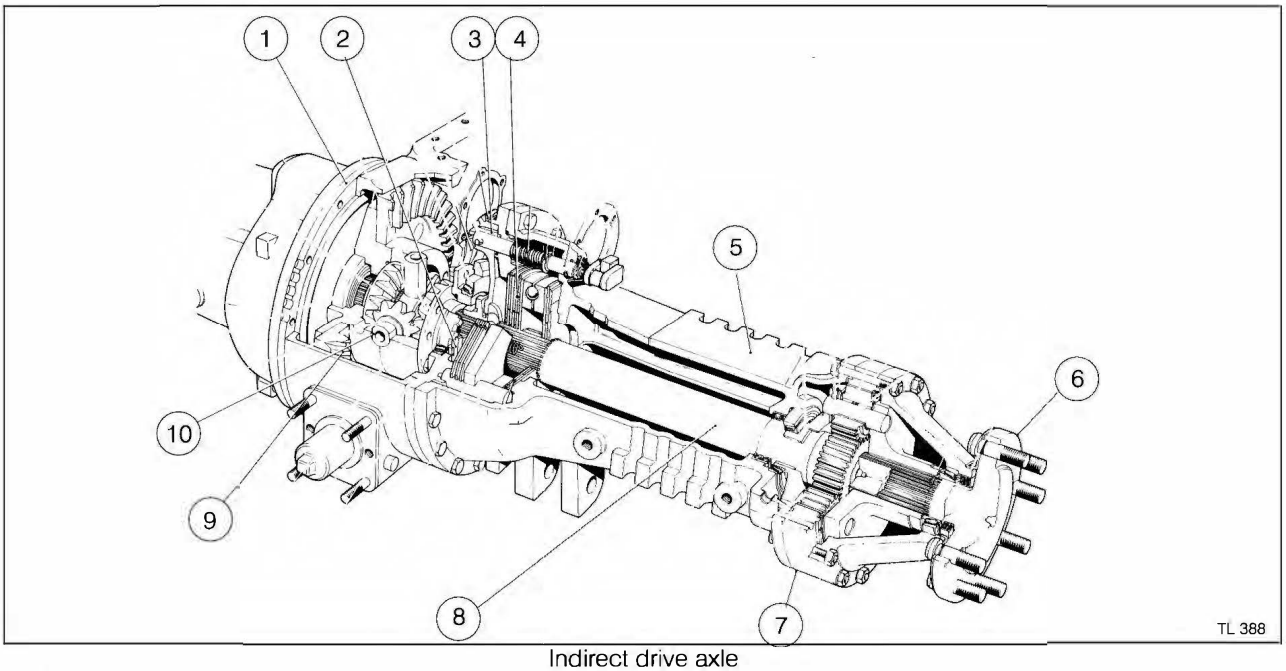
The drive from the transmission main shaft is transmitted through the rear drive shaft and shear tube to a spiral bevel gear driving the pinion and crownwheel, then through the axle shafts, either directly to the rear wheels or indirectly through epicyclic reduction units to the rear wheels.

The driving pinion is supported in the centre housing by a straight roller pilot bearing and a pre-loaded housing assembly carrying two tapered roller bearings.

The crownwheel is attached to the split differential case, which is supported each side by a taper roller bearing. The differential pinions run on a cross joint and the thrust is taken by thrust washers behind the pinions.

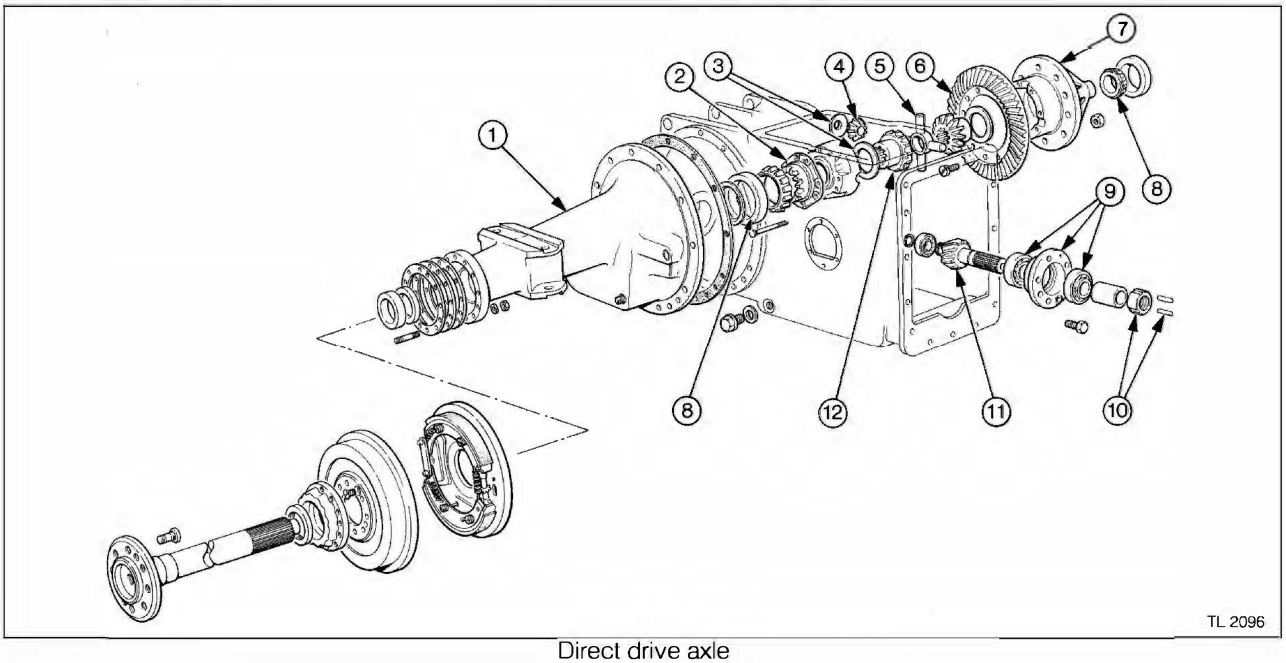
A differential lock is fitted to the right-hand axle housing. When the pedal is pressed, a shaft engages a coupler, locking the differential case to the half shaft, thus locking the differential.

The pinion pre-load is set by tightening a screwed collar behind the two taper roller bearings. The differential bearing pre-load is set with the aid of a special tool and variable thickness bearing shields which are fitted behind the bearing cup of the right-hand carrier plate.



Indirect drive axle

1. Carrier
2. Differential lock
3. Differential lock mechanism
4. Brakes
5. Trumpet housing
6. Axle shaft
7. Epicyclic unit
8. Half shaft
9. Crownwheel and pinion
10. Differential



Direct drive axle

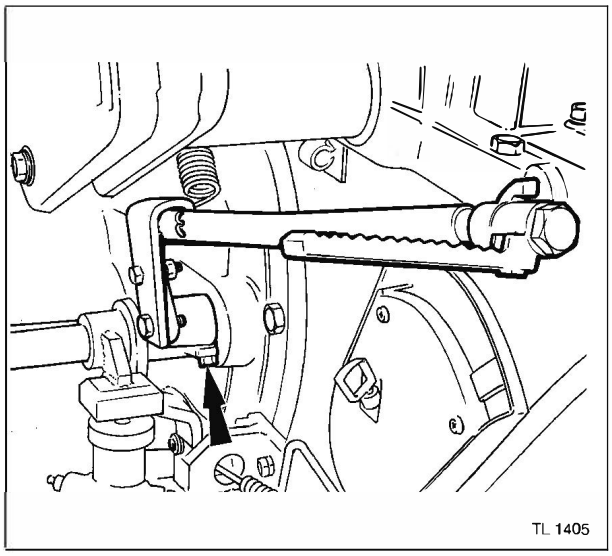
1. Trumpet housing
2. Differential lock
3. Thrust washers
4. Differential pinion
5. Differential cross
6. Crownwheel
7. Differential carrier
8. Differential carrier bearings
9. Pinion bearings
10. Pinion shaft nut and lock
11. Pinion
12. Differential side gears

DIFFERENTIAL LOCK – DRUM BRAKES

Adjust **2.06B–01**

Procedure

1. Ensure that the pedal operates freely throughout its complete travel.
2. Engage the differential lock.
3. Slacken the clamp bolt.
4. Move the pedal to the desired position to give a clearance of 9 mm between the pedal and the footstep.
5. Tighten the clamp bolt to a torque of 115 Nm and check the clearance.

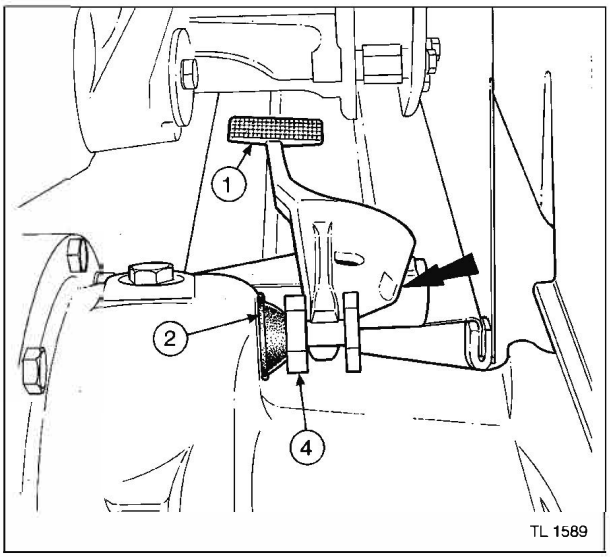

TL 1405

DIFFERENTIAL LOCK – DISC BRAKES

Adjust **2.06B–02**

Procedure

1. Ensure that the pedal operates freely throughout its complete travel.
2. Turn back the rubber seal covering the actuator fork locknut.
3. Slacken the locknut.
4. Unscrew the fork so that the foot pedal casting just contacts the mounting bracket at the position indicated.
5. Tighten the locknut and turn back the seal.



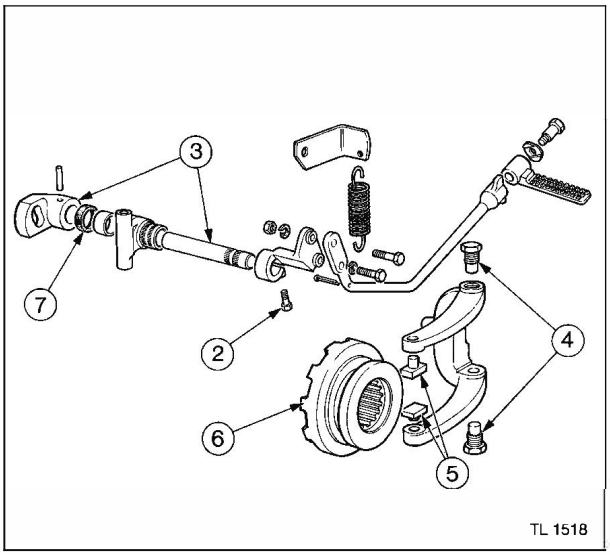
TL 1589

DIFFERENTIAL LOCK – DRUM BRAKES

Overhaul **2.06B–03**

Dis-assembly

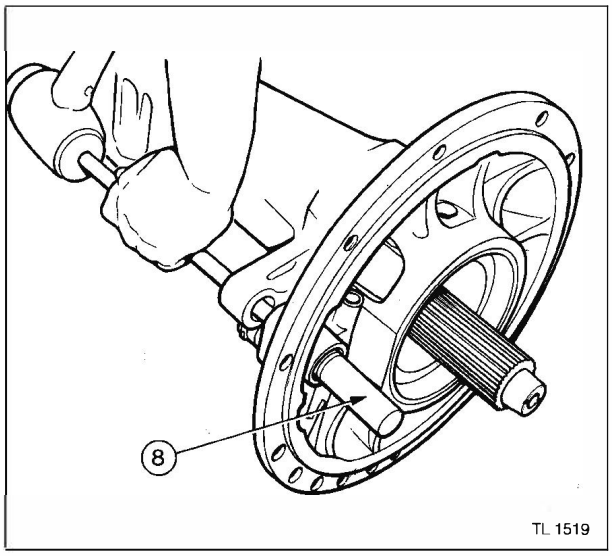
1. Remove the right-hand trumpet housing, see operation 2.06C-09.
2. Remove the bolt securing the foot pedal lever to the actuating shaft.
3. Withdraw the cam and shaft.
4. Remove the two bolts securing the shifter fork.
5. Manoeuvre the shifter fork, with its two guide shoes out of the trumpet housing.
6. Slide the coupler off the axle shaft splines.
7. Remove the actuating shaft seal from the trumpet housing.



TL 1518

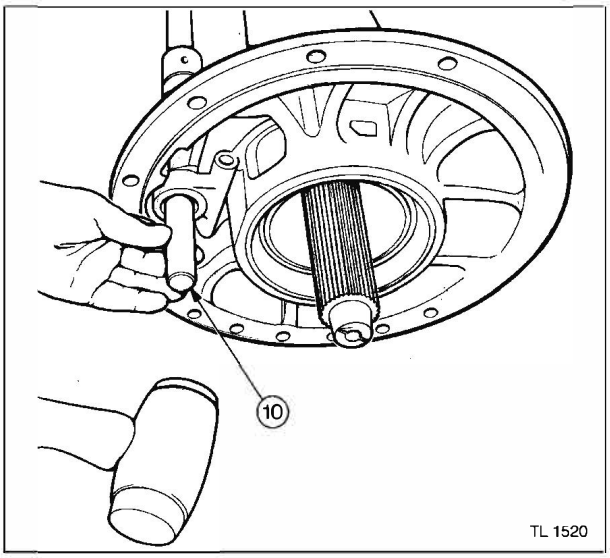
Bush removal
If necessary, the actuating shaft bushes may be changed in the following manner:

8. Using a suitable sized tap, cut a thread into the bush and screw in a piece of steel or bolt, then drive out the bolt and bush as shown using a suitable punch or drift.
9. Repeat the operation for the outer bush.

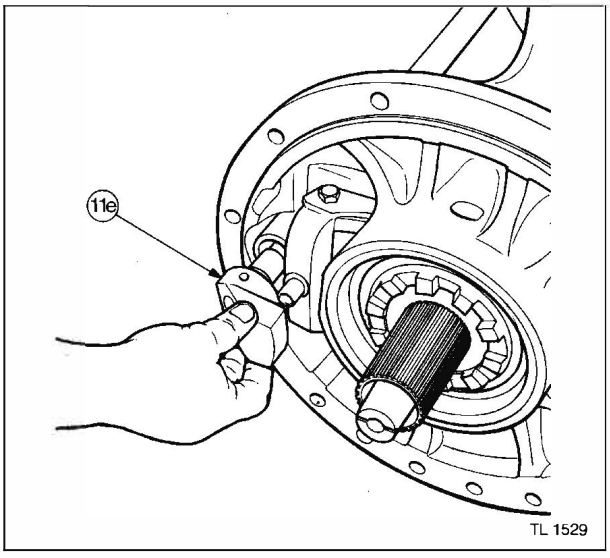


Re-assembly

10. Using a suitable mandrel, fit new bushes into the trumpet housing, if removed.
11. Reverse procedures 1 to 7 except:
    a. Fit the new seal with the lip facing towards the differential.
    b. Slide the coupler onto the axle shaft with the teeth facing towards the differential.
    c. Clean and degrease the threads of the shifter fork. When refitting the shifter fork, ensure that the shoe guides locate correctly on the coupler.
    d. Apply a small quantity of MF Stud Lock (Loctite 270) to the threads of the bolts and secure the shifter fork to the trumpet housing, then tighten the bolts to a torque of 54 Nm.



    e. Smear the shaft bushes and oil seal lightly with engine oil. Carefully insert the shaft through the lip seal, Simultaneously locating the lever on the shaft and the dowel pin on the shifter fork in the cam.
    f. Do not forget to replace the differential lock spring.
12. Adjust the differential lock pedal, see operation 2.06B-01.

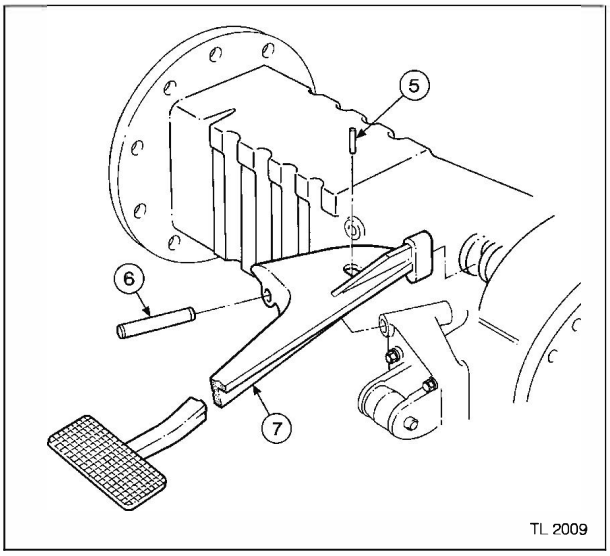


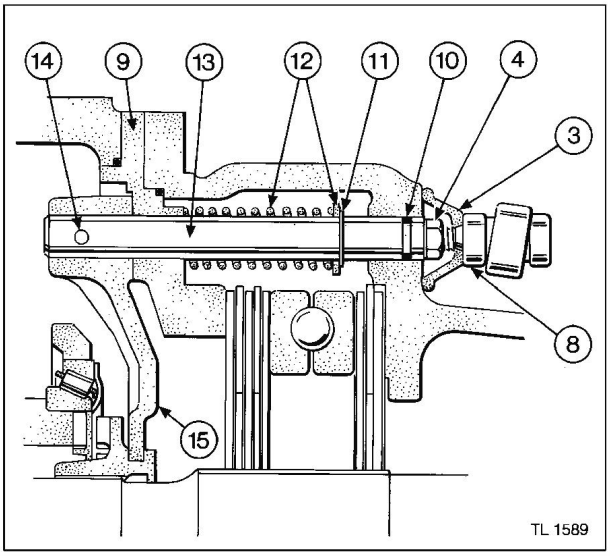
DIFFERENTIAL LOCK – DISC BRAKES

Overhaul 2.06B–04

WARNING: The trumpet housing is heavy and awkward to handle. Take care when both removing and refitting it.

1. Remove the right-hand trumpet housing, see operation 2.06C-06.
2. Manoeuvre the trumpet housing assembly off the trolley jack and stand it on end.
3. Lift up the rubber seal.
4. Release the locknut.
5. Remove the groove pin.
6. Remove the pedal pivot pin.
7. Remove the pedal.
8. Unscrew the fork from the shaft complete with its locknut and rubber seal.
9. Remove the carrier plate.
10. Remove the 'O' ring and discard.
11. Remove the circlip.
12. Remove the washer and spring.
13. Remove the shaft and fork.
14. Drive out the groove pin.
15. Remove the selector fork.





Examination

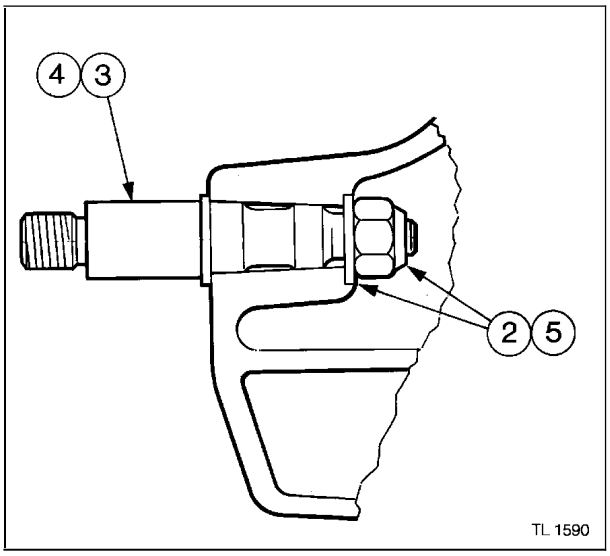
Examine the shaft for signs of wear or scoring. Clean and degrease the threads in the end of the shaft and on the actuator fork.

Re-assembly

16. Reverse procedures 1 to 15.Tighten the locknut.
17. Adjust the differential lock, see operation 2.06B-02.

LOWER LINK PIN – DRUM BRAKES

Removal and refitment **2.06B–05**



Removal

WARNING: The trumpet housing is heavy and awkward to handle. Take care when both removing and refitting it.

1. Remove the trumpet housing, see operation 2.06C-09.
2. Remove the nut and washer.
3. Remove the pin.

Refitment

4. Place a new pin in the trumpet housing.
5. Refit the washer and nut.
6. Tighten the nut to a torque of 163 Nm.
7. Refit the trumpet housing, see operation 2.06C-09.

DIFFERENTIAL LOCK COUPLER CAP

Removal and refitment **2.06B–06**

Special Tools:

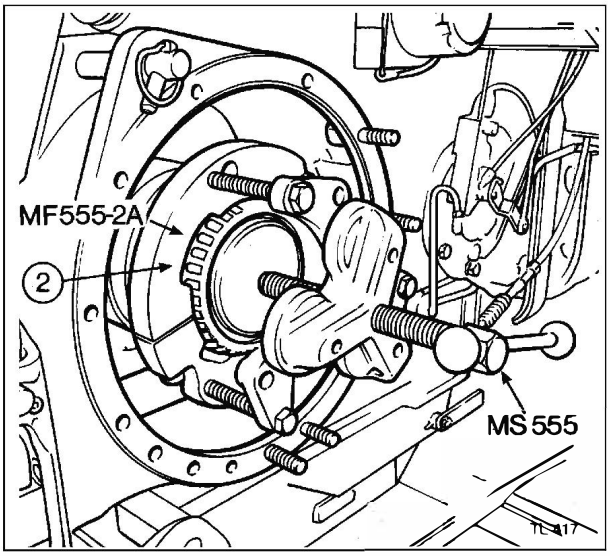
MF.555–2A Right-hand differential bearing remover

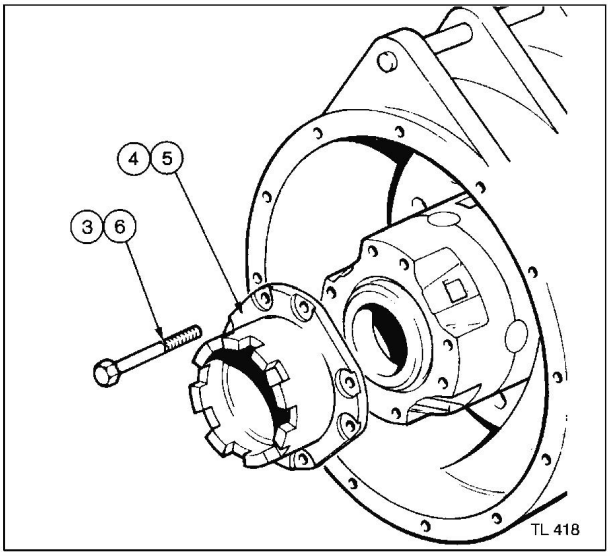
MS.555 Adjustable puller (main tool)

Removal

WARNING: The trumpet housing is heavy and awkward to handle. Take care when both removing and refitting it.

1. Remove the right-hand trumpet housing, see operation 2.06C-06 or 2.06B-09. Manoeuvre the housing assembly off the trolley jack and stand it on its end.
2. Using puller MS.555 and MF.555-2A, remove the differential bearing cone.
3. Remove the eight bolts.
4. Prise off the differential lock cap, taking care not to dislodge the case which would allow the differential gears to fall out.





Examination

Examine the coupler, fork, cap and operating shaft for wear or scoring. Replace any worn parts.

Refitment

5. Fit the new coupler cap.
6. Insert and hand-tighten the eight bolts.
7. Tighten the bolts progressively and evenly to a torque of 108 Nm.
8. Refit the bearing.
9. Refit the trumpet housing, see operation 2.06C-06 or 2.06B-09.
10. Adjust the differential lock, see operation 2.06B-01 or 2.06B-02.

DIFFERENTIAL UNIT

Overhaul **2.06B–07**

Special Tools:
MF.555–2A Right-hand differential bearing remover
MS.555 Adjustable puller main tool
FT.4062A Bearing pre-load gauge

Dis-assembly

WARNING: The trumpet housing and differential unit are heavy and awkward to handle. Take care when removing and refitting them.

1. Remove the left-hand trumpet housing, see operation 2.06C-06 or 2.06C-09.
2. Manoeuvre the differential assembly out of the centre housing.
3. Place the differential on a stand or in a vice.
4. Using puller MS.555 and MF.555-2A, remove the bearing right-hand cone.
5. Mark the two halves of the differential case to enable them to be assembled in the same relative positions.
6. Remove the eight bolts.
7. Remove the coupler cap and right-hand half of the differential case.
8. Remove the pinion assembly, complete with the thrust washers.
9. Remove the differential gears and their thrust washers.

Examination

Examine all of the differential components and replace any that are worn or damaged.

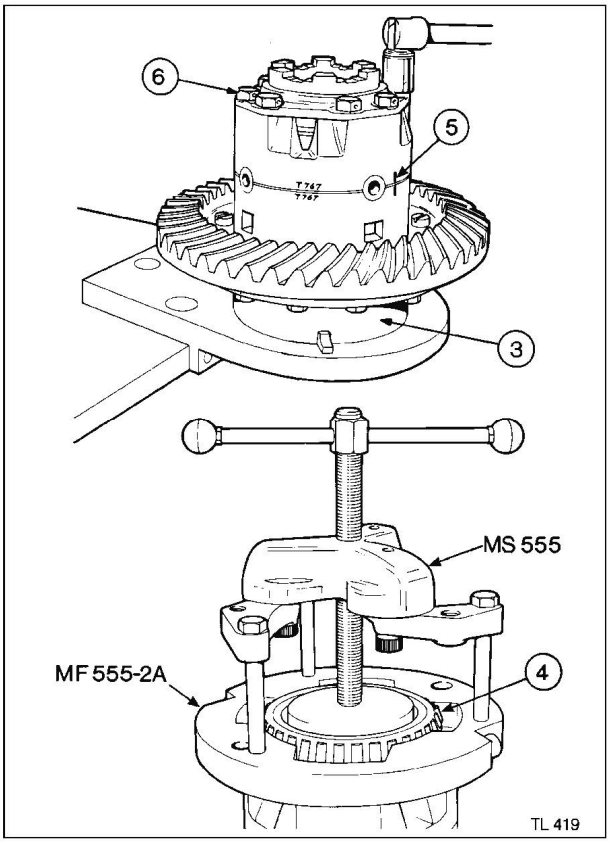
NOTE: *If any of the differential gears are worn, a full set of four new gears must be fitted. In such circumstances, the axle shaft differential gears may also need to be replaced.*

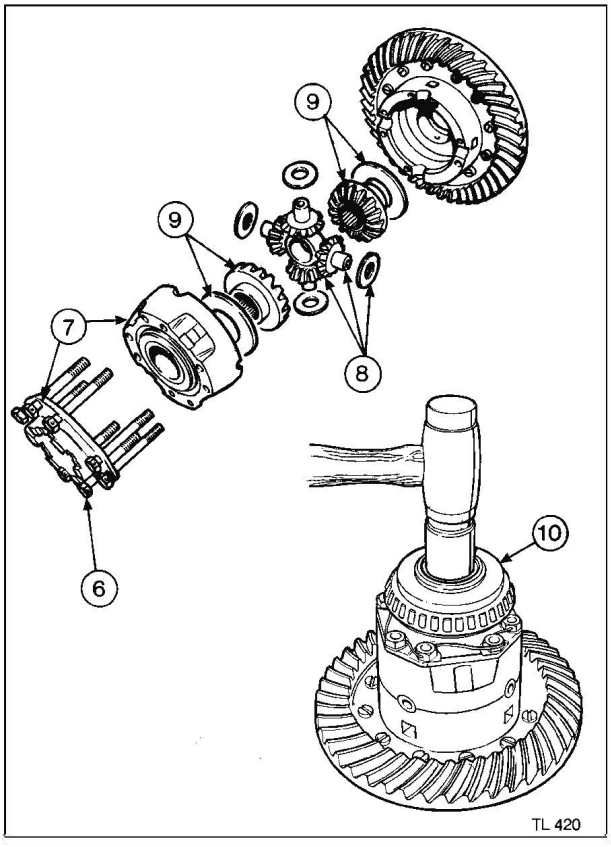
Re-assembly

10. Reverse procedures 2 to 9 except:
    a. Refit the right-hand differential case with markings aligned.
    b. Tighten the eight bolts to a torque of 108 Nm.
    c. Refit the right-hand bearing cone.
    d. Refit the differential unit with care. It must engage with the splines on the right-hand axle shaft.

NOTE: *If the differential bearings or case have been replaced, the pre-load must be checked, see operation 2.06B-09.*

11. Refit the left-hand trumpet housing, see operation 2.06C-06 or 2.06C-09.





CROWNWHEEL and PINION

Overhaul **2.06B–08**

Special Tools:
FT 4062A Bearing pre-load gauge

Dis-assembly

NOTE: *The replacement crownwheel and pinion kit comprises of one pinion, one crownwheel, 12 nuts and bolts and one epoxy resin kit.*

1. Split the tractor between the centre housing and the gearbox or spacer, see section 2.
2. Remove the lift cover, see operation 2.12A-03.
3. Remove the linkage pump and IPTO clutch, if fitted.
4. Remove the differential unit, see operation 2.06B-07.
5. Place the differential unit on a bench with the teeth facing downwards.
6. Centre punch each of the rivets centrally.
7. Using a 13 mm drill, drill out each of the rivet heads until they become detached from their shanks.
8. Drive out the rivets.
9. Drive off the crownwheel.

NOTE: *Crownwheels and pinions are supplied as matched sets, therefore when fitting a new crownwheel, the pinion must also be replaced.*

Pinion

10. Release the snap ring (ground speed PTO only).
11. Slide off the gear (ground speed PTO only)
12. Remove the six bolts and spring washers.
13. Screw one of the bolts into each of the two tapped holes.
14. Tighten the bolts, thus withdrawing the pinion assembly.
15. Remove the locking ring as follows:

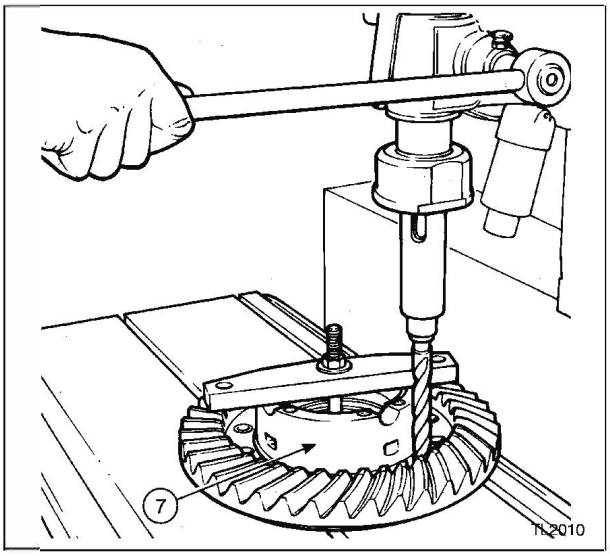
WARNING: Eye protection goggles must be worn during the following operations.

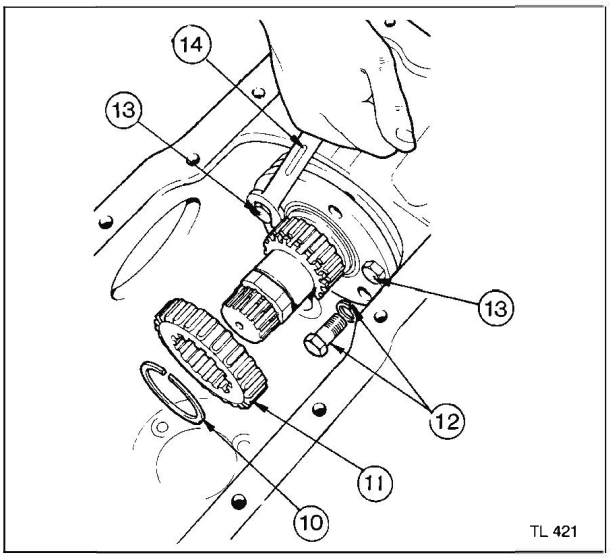
NOTE: *Great care should be taken to avoid damaging the threads of the pinion if it is to be reused.*

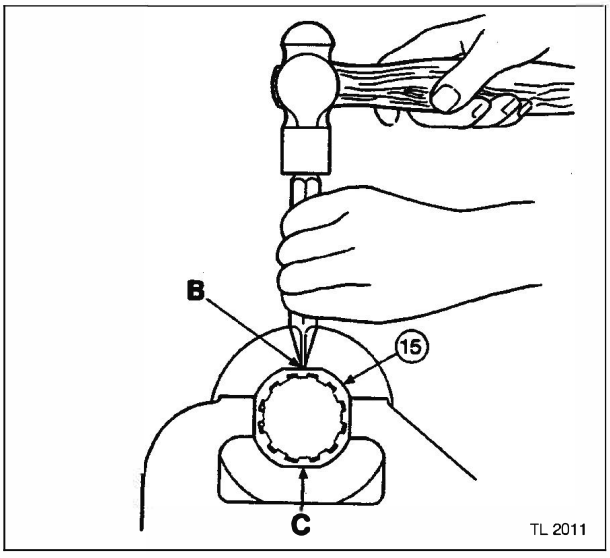
a. Place the pinion in a vice with soft jaws, holding the flats, adjacent to the collar locking rollers.

b. Using a cold chisel, cut one half to two thirds into the locking collar at points 'B' and 'C'.

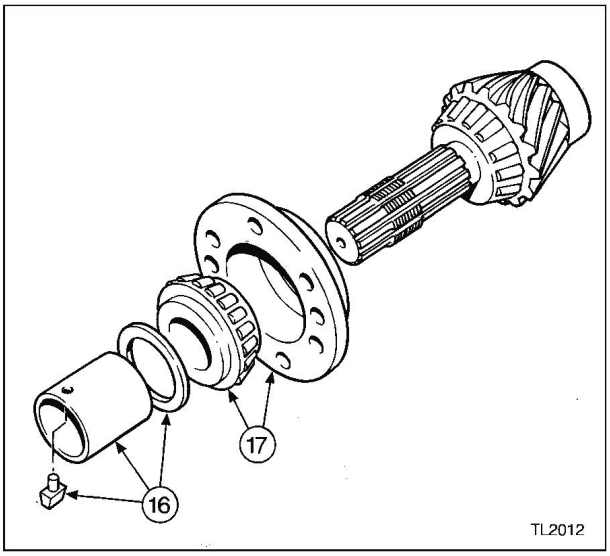
c. Reposition the pinion in the vice and chisel down the splines into the cuts made at points 'B' and 'C'. A few hefty blows will fracture the locking collar enabling it to be removed.



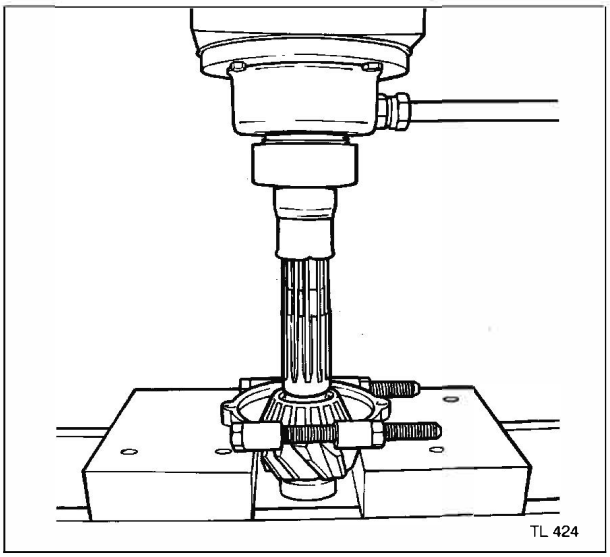




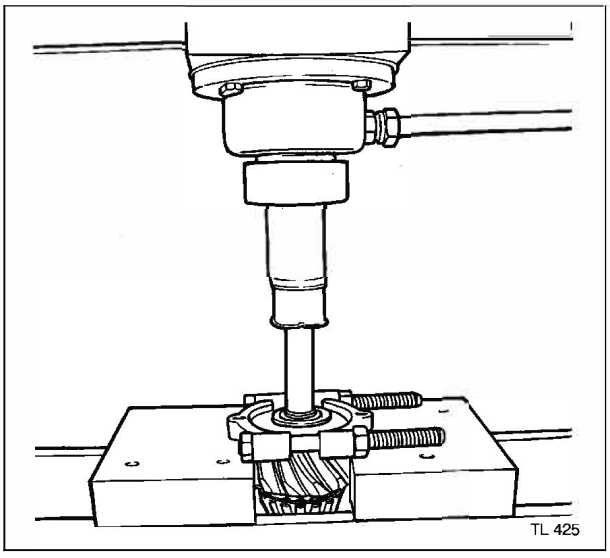
16. Remove the sleeve. On tractors with ground speed PTO remove the sleeve with location peg and the splined hub.
17. Remove the housing, complete with the front bearing cone.



18. Use a hand or hydraulic press and remove the two taper roller bearings.



19. Remove the snap ring securing the pilot bearing to the pinion.
20. Remove the pilot bearing in a press.



Examination

Examine all components for signs of wear, scoring or pitting. Any faulty or worn parts must be replaced.

NOTE:

a. *If the pinion is damaged the crownwheel must also be replaced as these are only supplied in matched sets.*

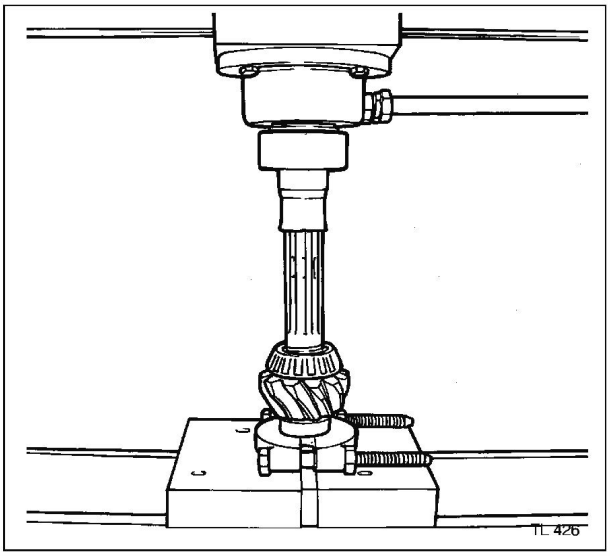
b. *The taper roller bearings are serviced as a pair, assembled with the housing.*

c. *New snap rings should always be fitted.*

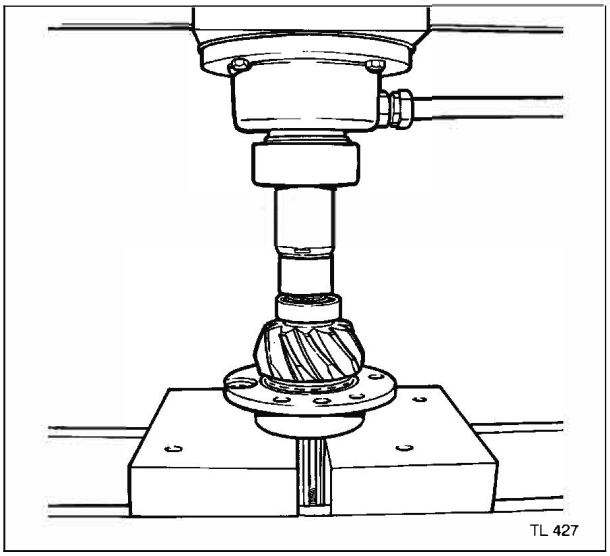
Re-assembly

Pinion

21. Press the pilot bearing onto the pinion.
22. Secure the pilot bearing with a new snap ring.



23. Press the taper roller bearing onto the pinion.
24. Locate the pinion in its housing and fit the front bearing cone.
25. Refit the sleeve and the location peg in position. On tractors with ground speed PTO refit the splined hub and sleeve. Fit a new locking ring and hand tighten.

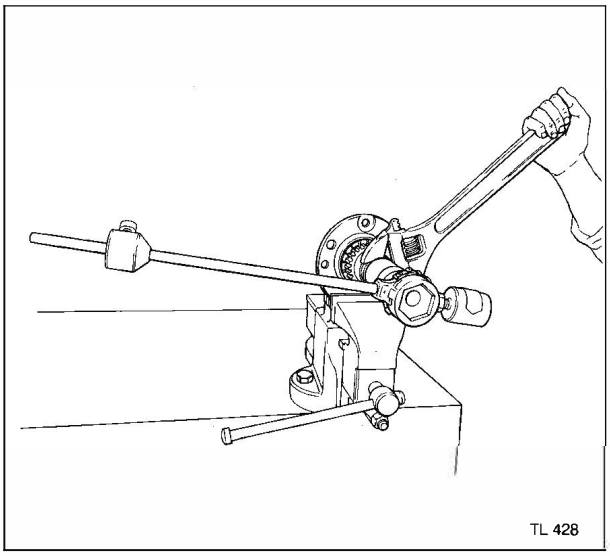


26. Hold the housing in a soft faced vice.
27. Fit the pre-load gauge, FT.4062A, to the pinion and tighten the locking ring to give a pre-load reading of 23 kg cm.

Set the weight on gauge FT.4062A to the 23 cm position. The pre-load is correct when the arm will just fall under its own weight when started with a light touch of the finger.

If a pre-load gauge is not available wrap some string around the pinion shaft and attach the end to a spring balance. Pull the spring balance away from the shaft. The rolling resistance must be 11 kg when the shaft is rotating.

28. Remove the gauge, tap the pinion firmly to centralise the bearings, then re-check the pre-load.



29. Secure the locking ring by driving a locking roller down either side of one of the pinion splines.

NOTE: *The locking rollers must be driven flush with the collar.*

Before refitment, the pinion assembly should be freely lubricated with clean transmission oil.

30. Reverse procedures 10-14 except:
    a. Ensure that the locating pin in the pinion housing is aligned with the hole in the centre housing before pressing the housing into place.
    b. Tighten the six bolts to a torque of 108 Nm.
    c. When the thrust washer shows signs of wear it must be renewed (if fitted).
    d. Fit a new circlip.

Crownwheel

31. Ensure that the mating faces of the differential case and the new crownwheel are perfectly flat.
32. Fit the left-hand differential case, with the mating face upwards in a stand or vice.
33. Degrease the crownwheel, left-hand differential case, differential bolts and nuts.
34. Collect together all items necessary for speedy assembly.
35. Open epoxy resin kit. Its contents are: One jar containing 10 ml of resin. (This jar is also used as a mixing vessel.) One jar containing 5 ml of hardener. One glass stirring rod. One brush.

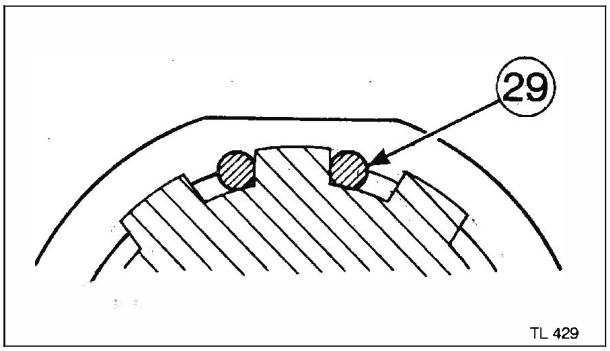
WARNING: Avoid excessive, or repeated skin contact. Observe the directions on the container.

NOTE: *Operations 36-41 that follow, must be completed within 30 minutes of mixing the resin and hardener.*

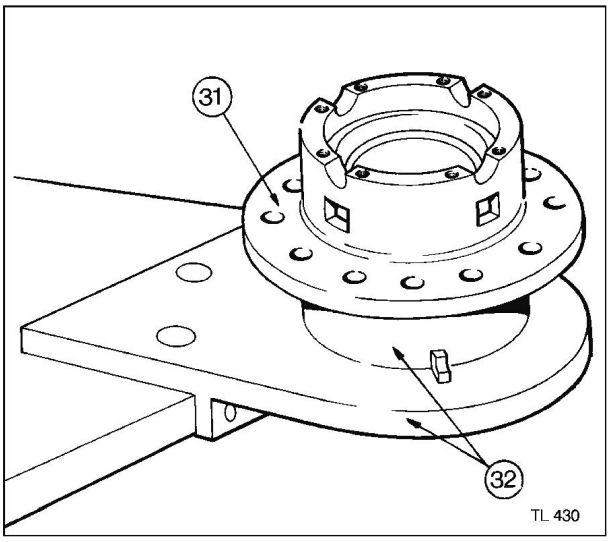
36. Pour the hardener into the resin jar and mix thoroughly using the glass rod.
37. Apply an even coating of adhesive to both mating surfaces.
38. Press the differential case on to the crownwheel.

NOTE: *These two components are an interference fit and must, therefore, have their bolt holes aligned accurately before being fitted together.*

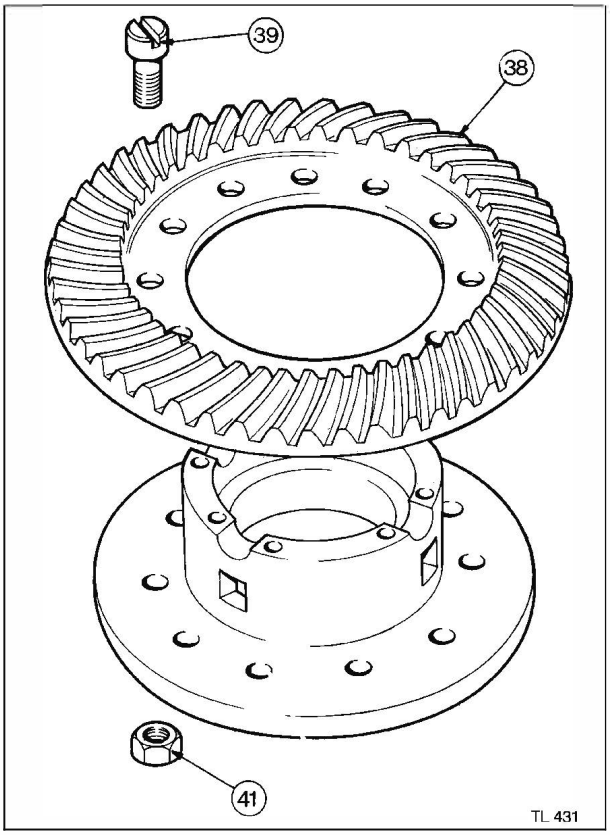
39. Fit the twelve bolts with their heads nearest the crownwheel teeth.
40. Apply two drops of MF Stud Lock (Loctite 270) to the first thread of each bolt.
41. Fit the nuts, and tighten them progressively and evenly to a torque of 160 Nm.
42. Refit the differential components, see operation 2.06B-07.



TL 429



TL 430

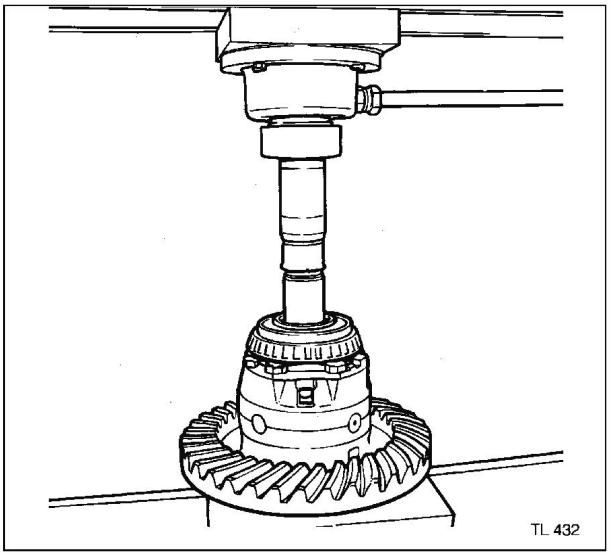


TL 431

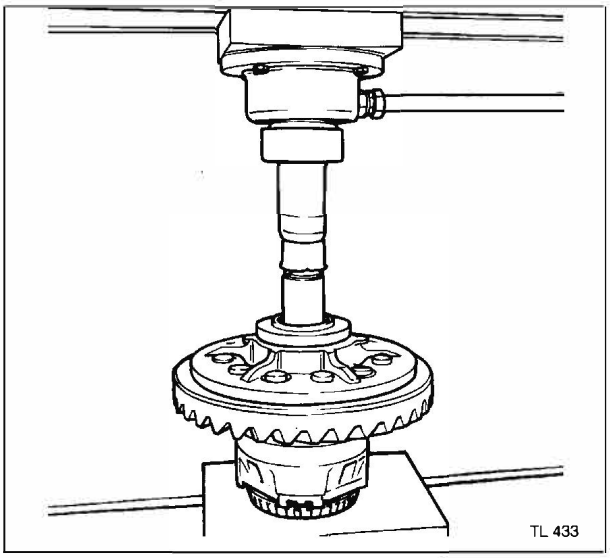
43. Cure the resin bonding by subjecting the differential assembly to uniform heating as follows:

    120°C for a minimum of 1 hour.
    or 40°C for a minimum of 12 hours.
    or 30°C for a minimum of 16 hours.
    or 20°C for a minimum of 24 hours.

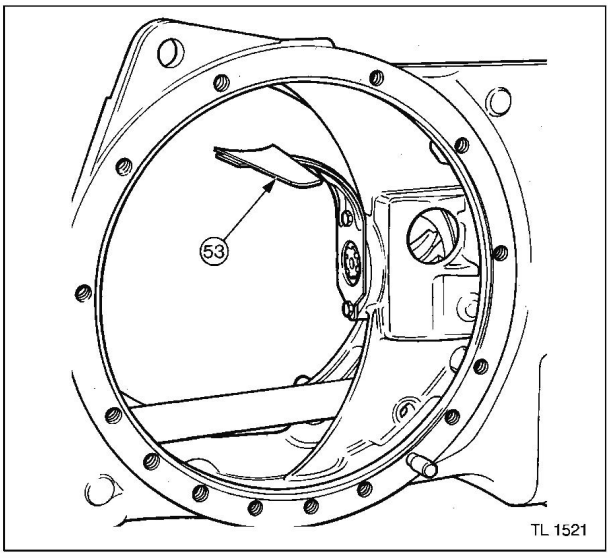
44. Press on the right-hand differential bearing cone.


TL 432

45. Press in the left-hand differential bearing cup.


TL 433

46. On direct drive axles with drum brakes ensure that the oil tray is bolted to the pinion bearing housing.
47. Refit the differential unit, see operation 2.06B-07.
48. Set the differential bearing pre-load, see operation 2.06B-09.
49. Refit the left-hand trumpet housing, see operation 2.06C-06 or 2.06C-09.
50. Refit the lift cover, replace the centre housing and assemble the rest of the tractor.
51. Refill the transmission with oil.
52. Road test the tractor and inspect for oil leaks.



TL 1521

DIFFERENTIAL PRE-LOAD

Check **2.06B–09**

Special Tools:
MF.245D Pre-load Gauge
MF.245D–1 Straight edge

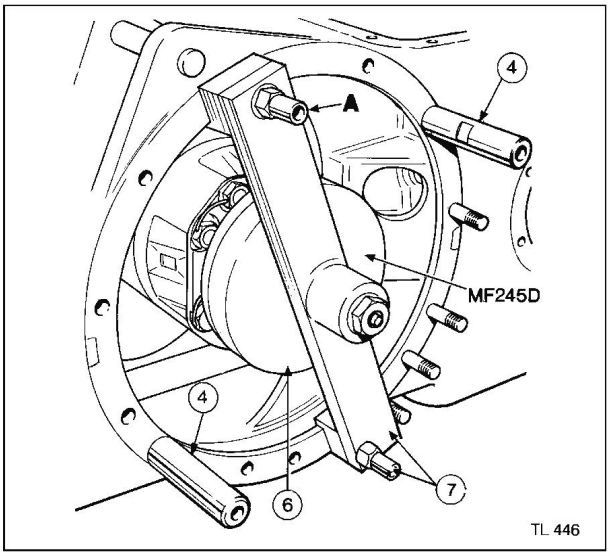
NOTE: *This check must be carried out whenever the differential unit is disassembled, or if the bearings have been replaced.*

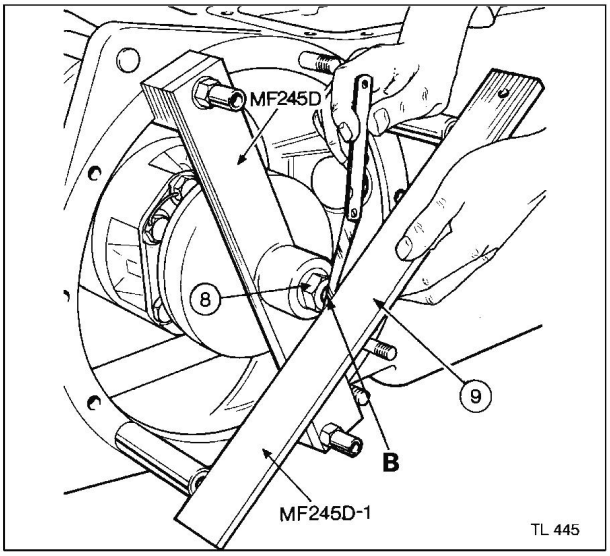
Procedure is as follows:

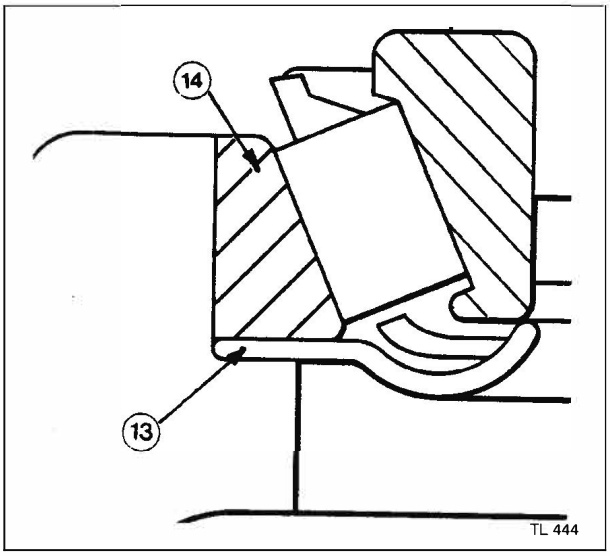
1. All pre-load checks are made on the right-hand side.
2. Assemble the left-hand side complete.
3. Do not fit the bearing cup to the right-hand carrier plate, or remove it and the chip shield.
4. Screw a setting post (part of special tool MF.245D) to two diametrically opposite studs. Remove one stud from an adjacent location to fit the upper block.
5. Remove another stud from the centre housing and fit it in the tapped hole at position 'A'.
6. Place the bearing cup on the bearing cone and fit the centraliser.
7. Position the clamp bar, MF.245D, and secure it with the two tube nuts.
8. Torque the clamp bar nut to 27 Nm whilst using a lever to turn the differential unit. This will ensure correct seating and location of the bearings.
9. Place the straight edge, MF.245D-1, in position, and measure the gap 'B' using feeler gauges.
10. Use the table below to determine the correct chip shield.

Feeler gap (equals shield thickness).		Means of Identification	Part number
mm	inch		
0,45-0,53	0.019-0.021	Eight dots	168 054 M1
0,61-0,66	0.024-0.026	Seven dots	521 401 M1
0,74-0,79	0.029-0.031	No dots	187 689 M1
0,86-0,91	0.034-0.036	One dot	892 173 M1
0,99-1,04	0.039-0.041	Two dots	892 172 M1
1,12-1,17	0.044-0.046	Three dots	892 171 M1
1,25-1,30	0.049-0.051	Four dots	892 170 M1
1,37-1,42	0.054-0.056	Five dots	191 124 M1

11. Remove the tube nuts, clamp bar, centraliser and setting posts.
12. Refit the two studs in their correct holes.
13. Place the new chip shield in the carrier plate, with the dished face towards the differential.
14. Refit the bearing cup, ensuring that it is fully seated.
15. Remove MF.245D, refitting the studs to the holes from which they were removed.
16. Refit the carrier plate and assemble the trumpet housing, see operation 2.06C-06 or 2.06C-09.







Page left blank intentionally

Rear Axle

Section 6 – Part C

Table of Contents

Operation No.	Description	Page No.
-------	Specification	6C- 1
-------	General description	6C- 3
2.06C-01	Rear wheel stud - removal	6C- 5
2.06C-02	Epicyclic unit ring gear - removal	6C- 5
2.06C-03	Epicyclic planets and sun gear - overhaul	6C- 6
2.06C-04	Epicyclic unit - overhaul	6C- 7
2.06C-05	Epicyclic unit pre-load - check	6C- 9
2.06C-06	Trumpet housing and carrier plate - removal	6C-10
2.06C-07	Axle shaft (direct drive axle) - removal	6C-12
2.06C-08	Axle shaft (direct drive axle) - overhaul	6C-13
2.06C-09	Trumpet housing (direct drive axle)	6C-15
2.06C-10	Axle shaft, wet brakes (direct drive axle) - removal	6C-17
2.06C-11	Axle shaft, wet brakes (direct drive axle) - removal	6C-19

Rear Axle

Specification

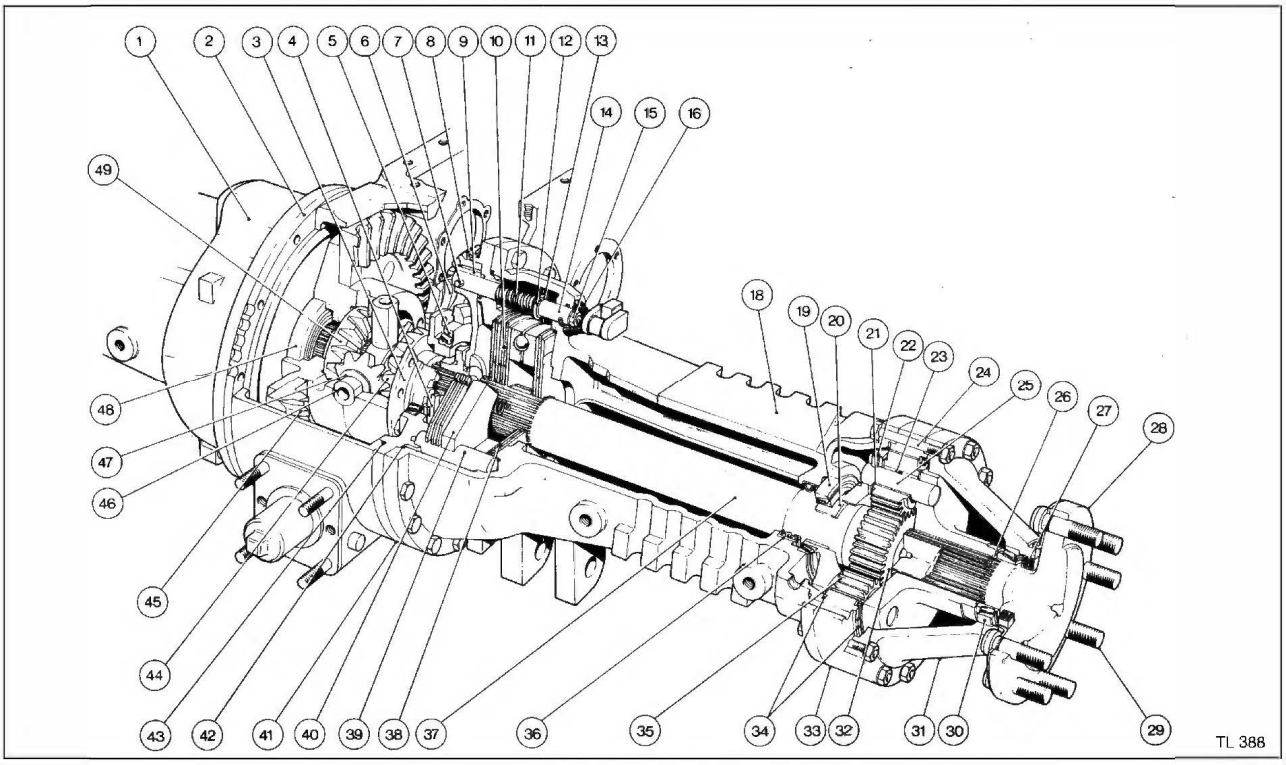
Normal-duty epicyclic axle:	
Epicyclic ratio	3.75:1
Axle shaft oil seal	Fit 2 mm proud of casting
Axle shaft end float	0 to 0,025 mm
Heavy duty epicyclic axle:	
Epicyclic ratio	4.80:1
Axle shaft oil seal	Fit flush with casting

Special tools:

------	Dial test indicator gauge
MF.26C	Wrench
MF.265C	Epicyclic planetary carrier remover
MF.267A	Epicyclic pre-load gauge
MF.267-1	Sleeve - normal-duty axle
MF.267-2	Sleeve - heavy-duty axle
MF.295B	Wheel stud guide sleeves
MF.366	PAVT wheel guide pegs
MS.555	Universal puller
MF.555-2A	Puller adaptor
MS.1713	30 tonne hydraulic puller

Bolt torques:

Epicyclic unit housing bolts - normal-duty	70 Nm
Epicyclic unit housing bolts - heavy-duty	105 Nm
Rear wheel nuts	See Section 2.06E
Trumpet housing to centre housing	130 Nm
Axle hub to trumpet housing (direct drive)	74 Nm
Lower lift arm pivot (direct drive)	156 Nm
Stabiliser bracket bolts	230 Nm

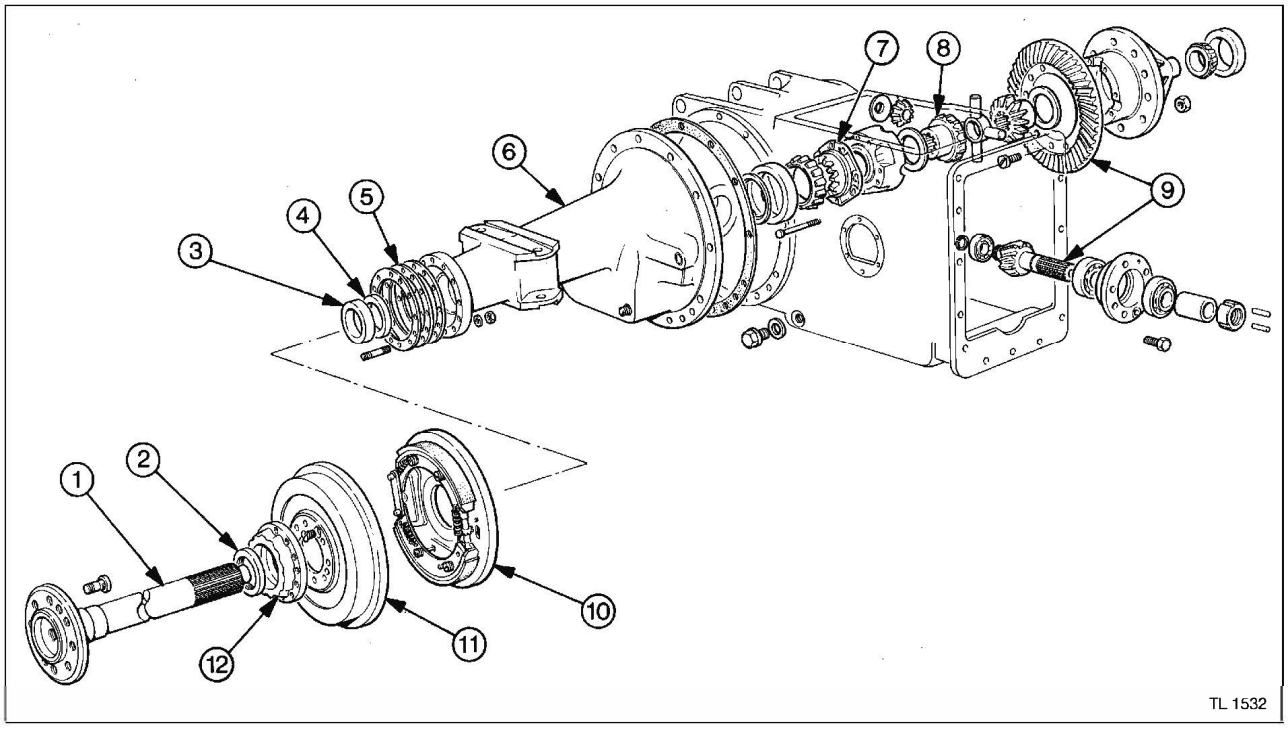


Indirect drive axle

Drawing references are as follows:

1. Trumpet housing - left-hand.
2. Carrier plate - left-hand.
3. Differential lock coupler cap.
4. Differential lock coupler.
5. Right-hand differential bearing.
6. Pinion assembly.
7. Roll pin.
8. Ground speed gear.
9. Differential lock coupler fork.
10. Brake interplate.
11. Differential lock return spring.
12. Washer.
13. Circlip.
14. Differential lock actuator shaft.
15. Differential lock adjusting nut.
16. Dust cover.
17. Not applicable.
18. Trumpet housing - right-hand.
19. Epicyclic hub - inner bearing.
20. Epicyclic hub - bush.
21. Thrust washer.
22. Roll pin.
23. Needle rollers.
24. Epicyclic unit securing bolts.
25. Planet gear - shaft.
26. Half ring.
27. Outer oil seal.
28. Stub axle.
29. Wheel stud.
30. Outer bearing.
31. Outer housing.
32. Sun gear.
33. Ring gear.
34. Gasket.
35. Planet gear.
36. Inner oil seal.
37. Axle shaft.
38. Brake friction plate.
39. Brake stop rod.
40. Actuator unit.
41. Carrier plate - right-hand.
42. 'O' ring - outer.
43. 'O' ring - inner.
44. Differential gear - right-hand.
45. Crownwheel.
46. Cross shaft.
47. Thrust washer.
48. Differential bearing.
49. Differential gear - left-hand.

Rear Axle



Direct drive axle

Drawing references are as follows:
1.Axle shaft.
2.Oil seal.
3.Retaining collar.
4.Oil seal.
5.Axle shims.
6.Trumpet housing.
7.Differential lock.
8.Differential.
9.Crownwheel and pinion.
10.Brake.
11.Brake drum.
12.Bearing housing.

GENERAL DESCRIPTION – INDIRECT DRIVE AXLE

There are two versions of the indirect drive epicyclic rear axle, normal- and heavy-duty depending on the size of the tractor. The rear axles are fitted to each side of the centre housing which houses a bevel tooth crown wheel and pinion, driving through a differential unit to two fully floating half shafts with outboard epicyclic final speed reduction units. All these components run in common transmission oil.

The heavy duty versions of the standard axle use larger epicyclic final speed reduction units. They have an increased reduction ratio to lessen the transmission torque loadings. These axles have their own self contained oil supply for the final speed reduction units separated from the rest of the axle components by lip type oil seals.

The half shafts are splined into the differential gears, and the outer ends are splined into the sun gear of the epicyclic unit.

The wheel axle is splined to the epicyclic carrier which is driven by the sun gear and planetary pinions.

The pre-load on the epicyclic taper roller bearings is set by the use of a special tool and fitting a shim behind the bearing cup in the trumpet housing.

GENERAL DESCRIPTION – DIRECT DRIVE AXLE

The direct drive rear axle is identical in construction without epicyclic reduction units. The axle shafts are splined directly into the differential gears and can be fitted with drum type brakes or inboard oil immersed multi-plate brakes.

REAR WHEEL STUD

Removal and refitment **2.06C–01**

Special Tools:
MF 366 Guide pegs, (PAVT wheels only)

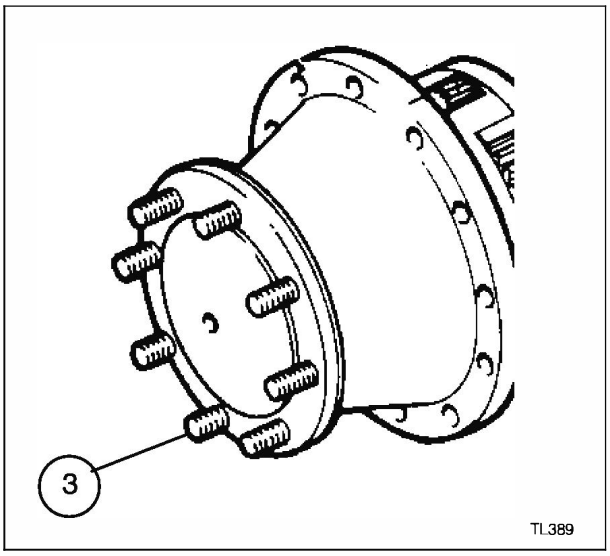
Removal

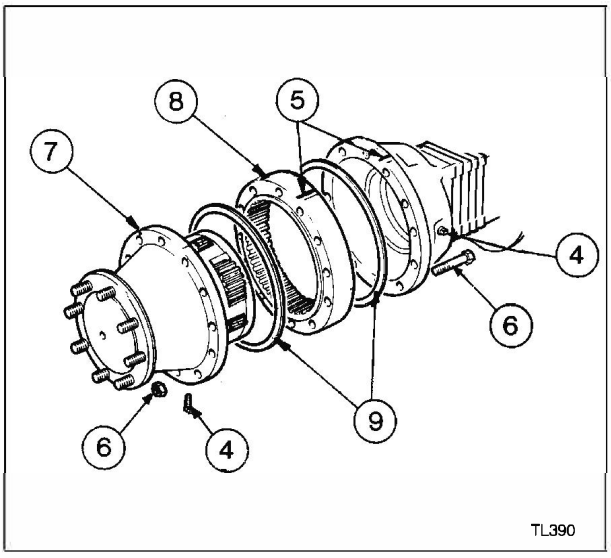
WARNING: PAVT wheels are extremely heavy and should only be removed with the assistance of a crane.

1. Jack up the tractor.
2. Remove the rear wheel.
3. Drive out the damaged stud. Examine the stud hole, the other studs and the wheel disc for signs of fretting or damage.

Replacement

4. Locate a new stud in the wheel axle.
5. Tap the stud gently to locate the splines.
6. Fit a new wheel nut, with the flat side against the axle and pull the stud through the axle to its correct position.
7. Remove the nut.
8. Oil all the studs.
9. Fit a guide peg, MF 366, to two of the wheel studs (PAVT wheels only).
10. Oil the threads of the wheel nuts.
11. Refit the rear wheel and nuts and tighten the nuts progressively and evenly. See section 8D, Wheels and Tyres, for wheel nut torques.
12. Remove the jack.





EPICYCLIC UNIT RING GEAR

Removal and refitment **2.06C–02**

Removal

1. Apply the parking brake.
2. Jack up the tractor.
3. Remove the rear wheel.
4. Remove the drain and level plugs and drain the oil from the epicyclic unit.

NOTE: *Level plugs are only fitted to heavy duty axles.*

5. Scribe a mark across the outer housing, ring gear, and trumpet housing to facilitate refitment. Also scribe a mark across the outer housing and ring gear only; this will ensure that the ring gear is replaced with the teeth in full engagement.
6. Remove the nuts and bolts.
7. Remove the outer housing and ring gear assembly.
8. Remove the ring gear.

NOTE: *Do not withdraw the axle shaft.*

9. Remove and discard the two cork gaskets or 'O' rings. Clean the recesses in which the ring gear spigots are located and check that there is no burr or deformity which could cause leakage.

Refitment

CAUTION: Ensure that the scribe marks are correctly aligned ensuring that the teeth of the ring gear are in full engagement OTHERWISE SEVERE DAMAGE CAN OCCUR.

10. Reverse procedures 1 to 9 except:
    a. Fit new cork gaskets.
    b. Tighten the nuts and bolts to a torque of 70 Nm on normal-duty axles 105 Nm on heavy duty axles.
    c. Refill to the correct level with an approved oil on the heavy-duty axles only. Normal-duty axles are automatically filled from the transmission oil.

EPICYCLIC PLANETS AND SUN GEAR

Overhaul **2.06C–03**

Dis-assembly

1. Remove the outer housing assembly, see operation 2.06B-02. To service the sun gear remove only one planet gear.

NOTE: *The sun gear will only come out through one of the planet gear apertures, it is wider than the other two.*

2. Drive out and discard the roll pin.
3. Fit a 3/8 inch UNF bolt to the planet gear shaft.
4. Withdraw the shaft trying not to dislodge the needle rollers.
5. Remove the 3/8 inch UNF bolt.
6. Remove the thrust washers and the planet gear. Repeat operations 2 to 6 only if the epicyclic hub is to be completely overhauled.
7. Withdraw the sun gear. Inspect all parts and replace any which show signs of wear or damage.

Re-assembly

8. Reverse procedures 1 to 7 except:

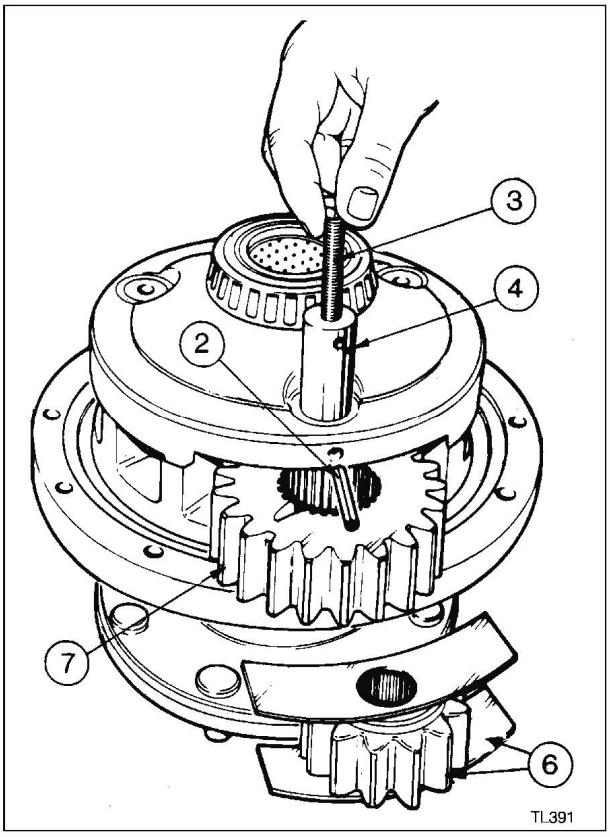
   a. If the needle rollers were dislodged, refit them using petroleum jelly, NOT GREASE. There are 58 needle rollers per planet gear (two rows of 29) plus a spacer washer on normal-duty axles. There are 44 needle rollers per planet gear (two rows of 22) plus a spacer washer on heavy duty axles.

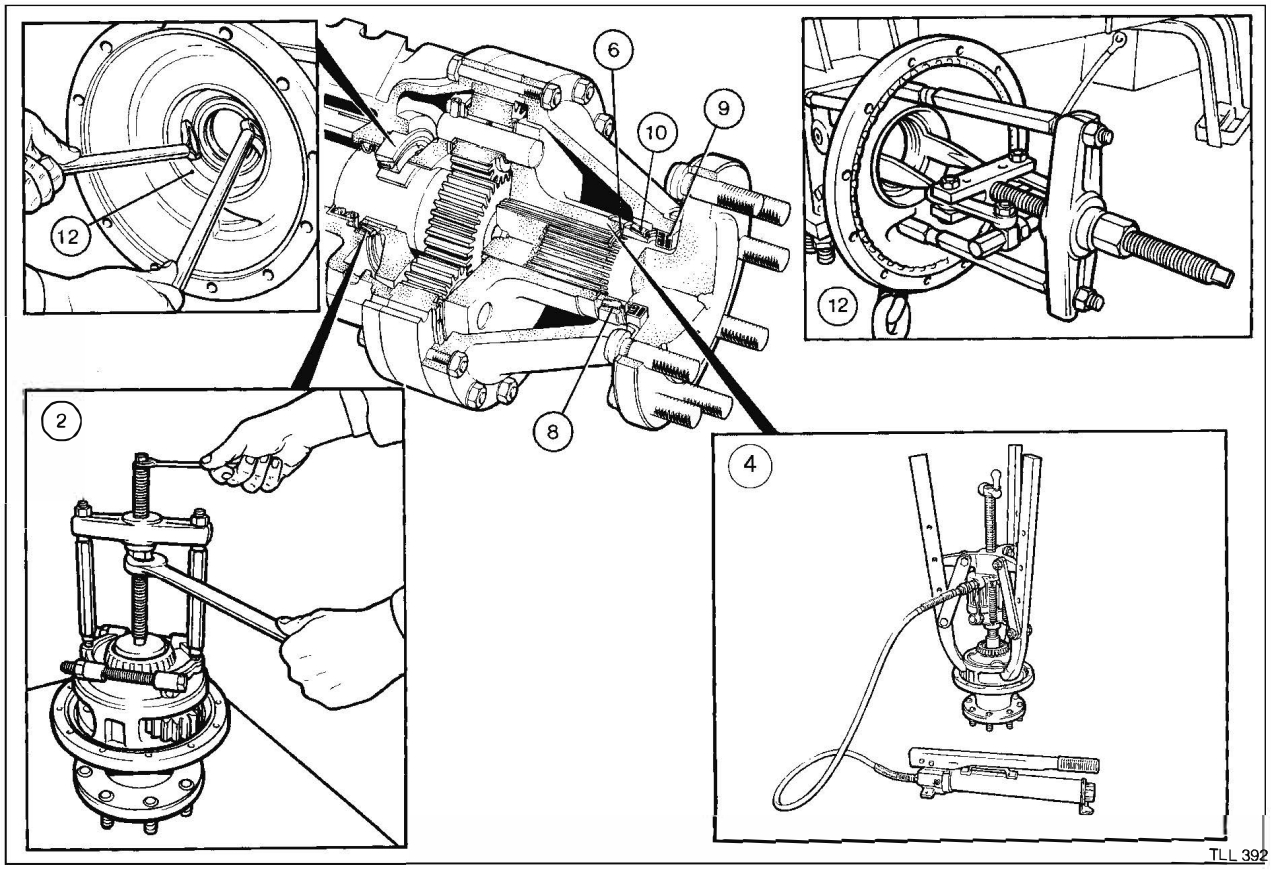
   b. Ensure that the holes in the casting and shaft are aligned.

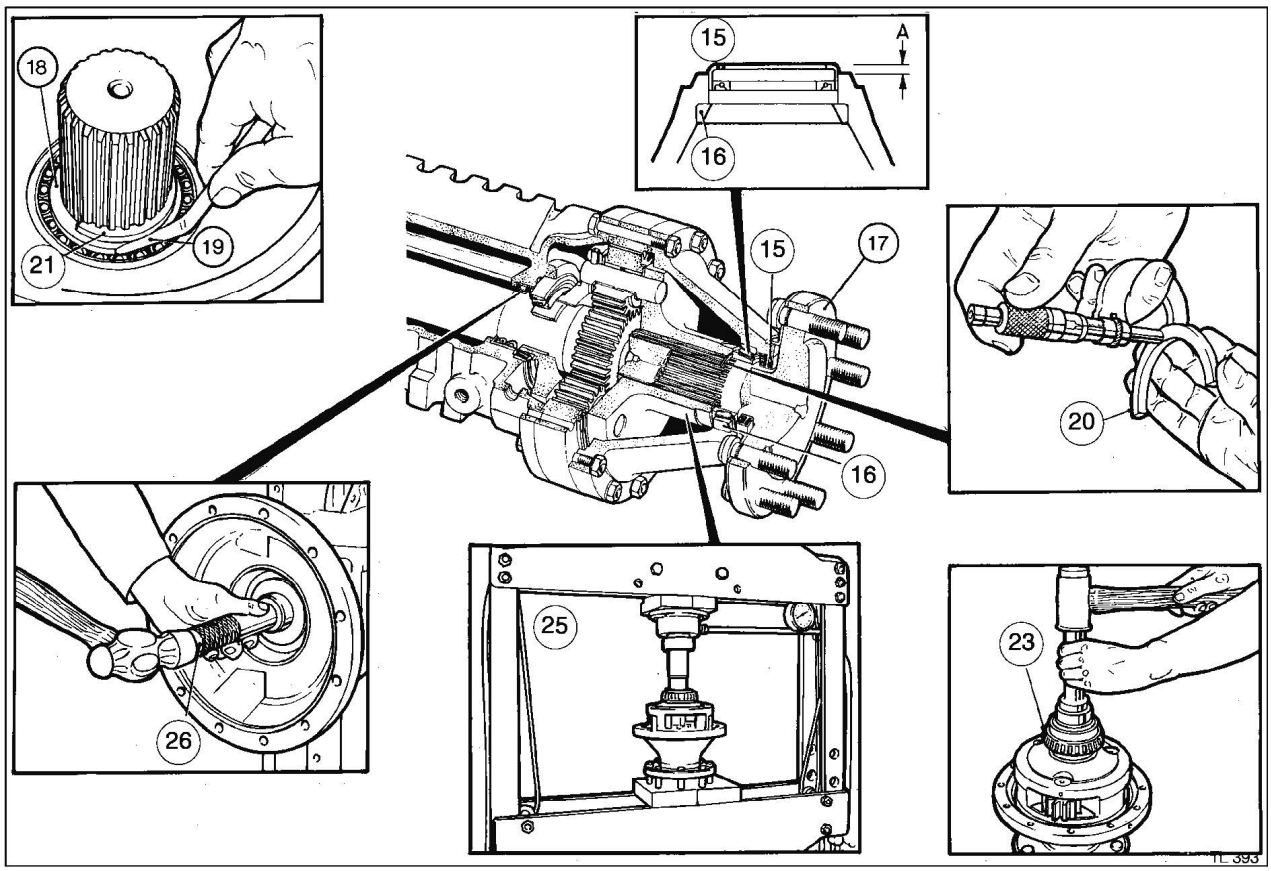
   c. Fit a new roll pin.

   d. The wide aperture for the removal of the sun gear has special wide thrust washers, ensure that they are fitted to the correct planet gear.

NOTE: *On normal-duty axles only, the planet gears MUST be fitted with the large shoulder facing the centre of the axle.*




6
9
10
12
12
8
2
4
TLL 392


18
21
19
15
A
16
15
17
16
20
26
25
23
TL 393

EPICYCLIC UNIT

Overhaul **2.06C–04**

Special Tools:
30 tonne Hydraulic Press
or
MS.1713 30 tonne Hydraulic Puller

Dis-assembly

1. Remove the planetary gears and sun gear, *(see operation 2.06C-03).*
2. Remove the bearing cone using an external bearing puller.
3. There are two methods of removing the epicyclic carrier from the axle shaft. Using a hydraulic puller or a hydraulic press, these must have a minimum capacity of 30 tonne. It will require a pressure of approximately 20 to 25 ton to remove the carrier.
4. Hydraulic puller, position the MS.1713 puller so that the central rod is located in the centre of the axle shaft. It will take two pulls to remove due to the length of spline engaged.
5. Hydraulic press, the illustration shows clearly the method of removal, it is recommended that the three pillars which support the cross bars are welded to a base plate. Allow a 100 mm (4 in) minimum clearance under the axle shaft for removal.
6. Remove the two half rings on normal-duty axles, snap ring on heavy-duty axles.
7. Press the axle shaft out of the bearing and housing.
8. Lift out the bearing cone.
9. Remove the oil seal.
10. If necessary, remove the bearing cup.
11. To remove the half shaft, fully apply the parking brake to lock all the brake plates in position. Pull the half shaft out of the housing.
12. Using pry bars or an internal bearing puller, remove the inner bearing cup and shim.
13. Heavy-duty axles, remove the inner oil seal from the axle housing.

Examination

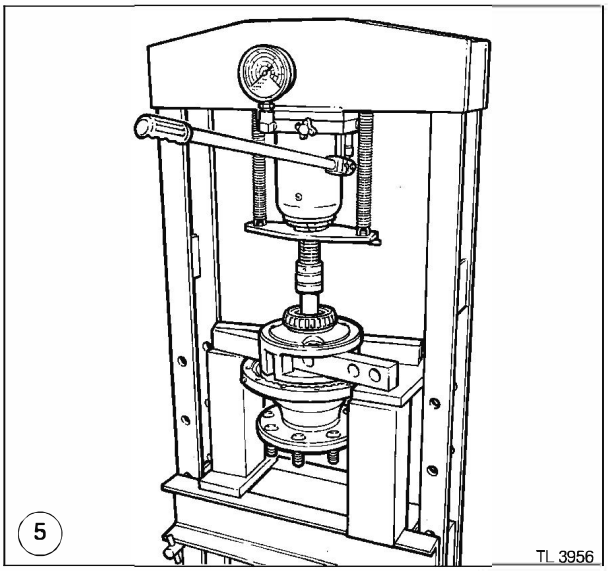
Inspect all parts and replace any which show signs of wear or damage. Replace all seals, gaskets and circlips.

Re-assembly

14. Refit the bearing cup, making sure it is fully seated.
15. Place the axle housing under a hydraulic press and position the outer seal with the lip facing inwards.

    Normal-duty Axle up to serial number G13373:

    Press the seal into the housing until it is 2 mm (0.080 in) proud of the housing (dimension 'A').



Clearances and half rings					
Half ring + feeler gap		Half ring thickness		Part No.	Ring No.
mm	in	mm	in		
5,92 5,94	0.233 0.234	5,84 5,89	0.230 0.232	882 601 M1	0
5,95 5,99	0.234 0.236	5,90 5,94	0.230 0.234	882 602 M1	1
6,00 6,04	0.236 0.238	5,95 5,99	0.234 0.236	882 603 M1	2
6,05 6,09	0.238 0.240	6,00 6,04	0.236 0.238	882 604 M1	3
6,10 6,15	0.240 0.242	6,05 6,09	0.238 0.240	882 605 M1	4
6,15 6,19	0.242 0.244	6,10 6,14	0.240 0.242	882 606 M1	5
6,20 6,24	0.244 0.246	6,15 6,19	0.242 0.244	882 607 M1	6
6,25 6,30	0.246 0.248	6,20 6,24	0.244 0.246	882 608 M1	7
6,30 6,35	0.248 0.250	6,25 6,30	0.246 0.248	882 609 M1	8

Normal-duty Axle serial number G13374 onwards and Heavy-duty Axles:

Press the seal into the housing so that the seal is flush with the housing.

16. Refit the bearing cup, making sure it is fully seated.
17. Lubricate the inside of the seal with engine oil, carefully insert the wheel axle shaft through the outer seal.
18. Drive the bearing cone down the shaft seating the rollers in the cup.

Normal-duty Axles

19. Refit the half rings removed and check the clearance with a feeler gauge between the half ring and the bearing which should be 0,00 to 0,025 mm (0.000 to 0.001 in). The ring most used is Ring No. 2, part number 882 603 M1.
20. If adjustment is required proceed as follows:
    a. Using a micrometer, check the thickness of the half ring you have used to check the clearance.
    b. To this measurement add the thickness of the feeler gauge measurement.
    c. From the chart select the correct ring to be fitted to the shaft.

For example:

No. '2' measures 6,00 mm + feeler gauge thickness 0,10 mm = 6,1 mm

From chart select half ring No. 4 part number 882 605 M1, half ring + feeler gap = 6,10 mm

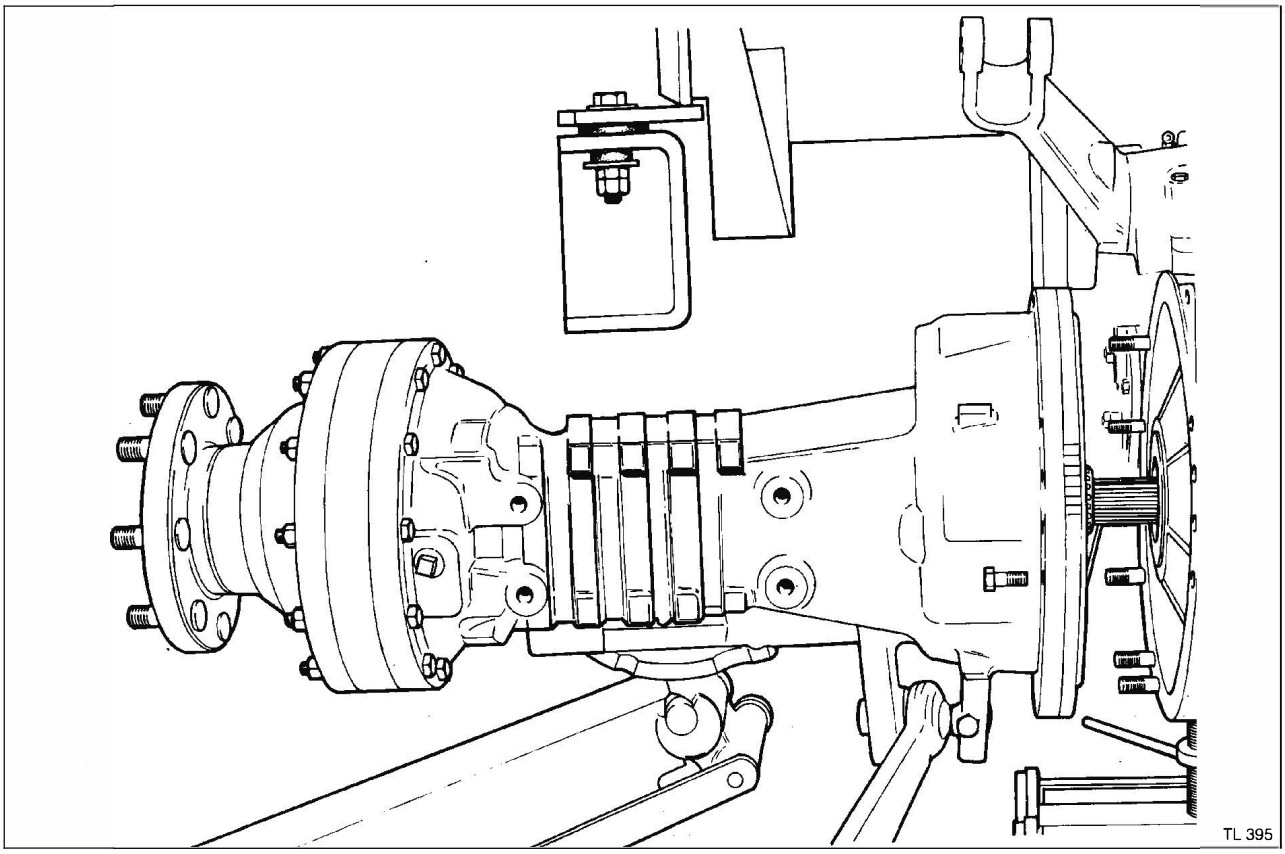
21. Fit the two half rings selected, ensuring that they are fully seated in the groove.

Heavy-duty Axles

22. Fit a new snap ring. Using a suitable puller, pull the housing assembly and bearing back tightly onto the snap ring. No shims or setting is required.

Both Types of Axles

23. Refit the bearing cone onto the spigot on the epicyclic carrier.
24. Reassemble the planet gears and the sun gear in the epicyclic hub, *(see operation 2.06C-3)*.
25. Using the hydraulic press, drive the epicyclic carrier on to the axle shaft.
26. Apply a thin coating of Hylomar sealant to the bore of the axle housing, then fit a new inner seal. The open side of the seal faces outwards. Smear the lips of the seal with petroleum jelly.
27. Refit the axle half shaft.
28. Check the epicyclic pre-load, *(see operation 2.06C-5)*.
29. Fit the selected shim(s) in the bearing cavity in the axle housing.
30. Refit the inner bearing cup.
31. Refit the ring gear and housing assembly, *(see operation 2.06C-2)*.



TRUMPET HOUSING and CARRIER PLATE

Removal and refitment **2.06C–06**

Removal

1. Drain the transmission oil.
2. Disconnect the footbrake control rods.
3. Disconnect the brake return springs.
4. Release the lift rod at the knuckle.
5. Release the check chain at the check chain anchor bracket.
6. Release the stabiliser bracket underneath the trumpet housing.
7. Release the forward end of the lower link from the trumpet housing bracket.
8. Remove the lift arm and lower link assembly complete.
9. Disconnect the parking brake rod/cable.
10. Jack up the tractor under the trumpet housing being serviced.
11. Remove the rear wheel.
12. Place a substantial stand or support under the centre housing and lower the tractor until the jack is just taking the trumpet housing weight.

WARNING: The trumpet housing is heavy and awkward to handle. Take care when both removing and refitting.

13. Left-hand trumpet housing. Remove necessary pipe work to enable the trumpet housing to be withdrawn from the centre housing.
14. Right-hand trumpet housing. Remove the differential lock mechanism.
15. Remove all the nuts and bolts securing the trumpet housing to the centre housing.
16. Lower the trumpet housing slightly and withdraw it far enough to clear the half shaft from the differential splines.
17. Lower the trumpet housing further to clear the fender.
18. Withdraw the trumpet housing completely.
19. Remove the 'O' ring from the flange on the carrier plate.
20. Manoeuvre the trumpet housing off the trolley jack and stand it on end.

Left-hand carrier plate

21. Remove the two countersunk screws.
22. Withdraw the carrier plate from the trumpet housing.
23. Remove and discard the inner 'O' ring.

Right-hand carrier plate

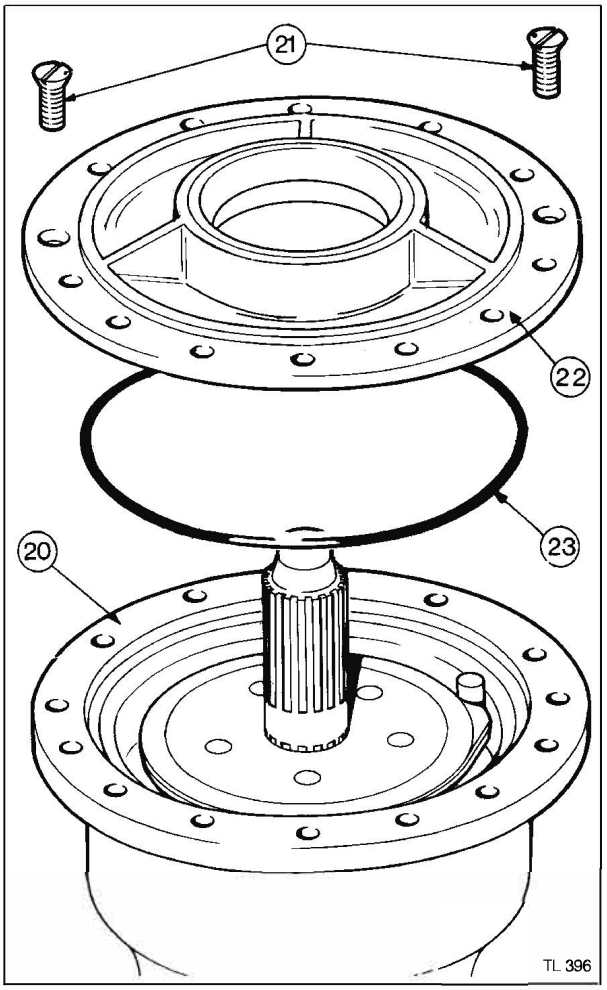
24. Remove the differential lock adjustment bolt and locknut.
25. Remove the two countersunk screws.
26. Remove the carrier plate complete with the differential lock coupler fork and coupler.
27. Remove and discard the inner 'O' ring.
28. Remove the differential lock roll pin, coupler, fork and shaft assembly.

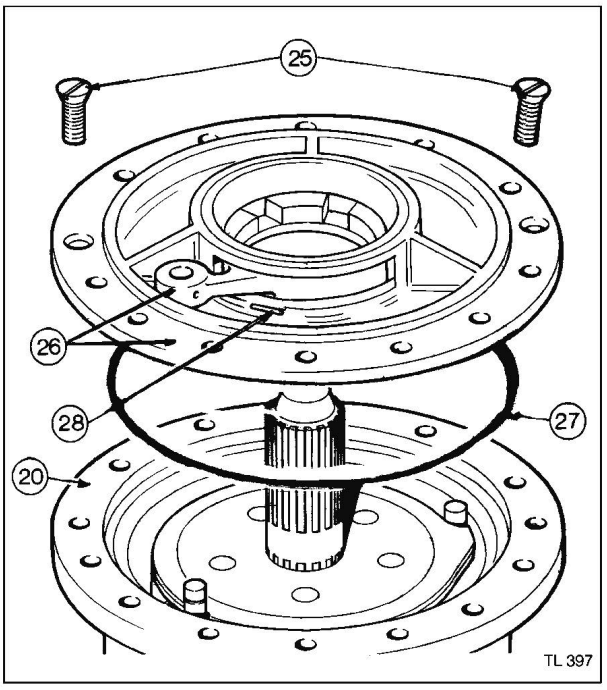
Refitment

29. Reverse procedures 22 to 26 or 29 to 21 except:
    a. Place a new 'O' ring in the recess in the trumpet housing using a smear of petroleum jelly for location. DO NOT attempt to fit the 'O' ring to the carrier plate.
    b. Secure each countersunk screw with a centre punch mark.

Right-hand carrier plate only:

    c. Assemble the differential lock coupler fork, shaft and coupler to the carrier plate with a new roll pin.
    d. Refit the assembly, aligning the coupler splines on the axle shaft and the coupler shaft into the trumpet housing.
    e. Refit the differential lock adjustment bolt and locknut.
30. Reverse procedures 1 to 18 except:
    a. Fit a new 'O' ring, using petroleum jelly.
    b. When manoeuvering the trumpet housing assembly back into position, take care to align the axle shaft splines in the differential unit and the studs through their holes in the centre housing. Tighten the bolts and nuts to a torque of 130 Nm.
    c. Apply a few drops of MF Stud Lock (Loctite 270), then fit and tighten the fender mounting bolts to a torque of 230 Nm.
    d. Brush the wheel stud threads clean.
    e. Refit the rear wheel and lightly oil the stud threads before fitting the wheel nuts.
    f. Tighten the nuts progressively and evenly to a torque of 325 Nm.
31. Adjust the brakes, see operation 2.06A-03 or 2.06A-04.





AXLE SHAFT – DIRECT DRIVE – DRUM BRAKES

Removal and refitment **2.06C–07**

Special Tools:
Dial indicator gauge

Removal

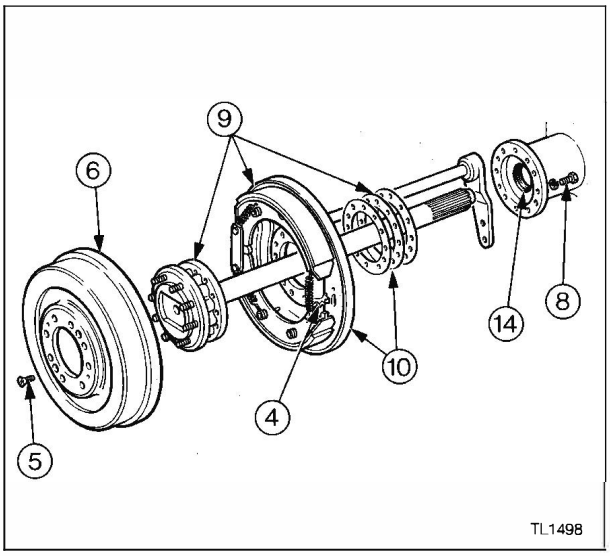
1. Jack up the tractor under the trumpet housing to be serviced.
2. Drain the transmission.
3. Remove the rear wheel.
4. Slacken off the brake adjuster.
5. Remove the two countersunk screws securing the brake drum.
6. Remove the brake drum.
7. Release the parking brake rod/cable from the brake camshaft.
8. Remove the 12 bolts and spring washers securing the hub to the trumpet housing.
9. Withdraw the axle shaft complete with shims, hub and bearing assembly, and brake assembly.
10. Remove the brake assembly and shims from the shaft.

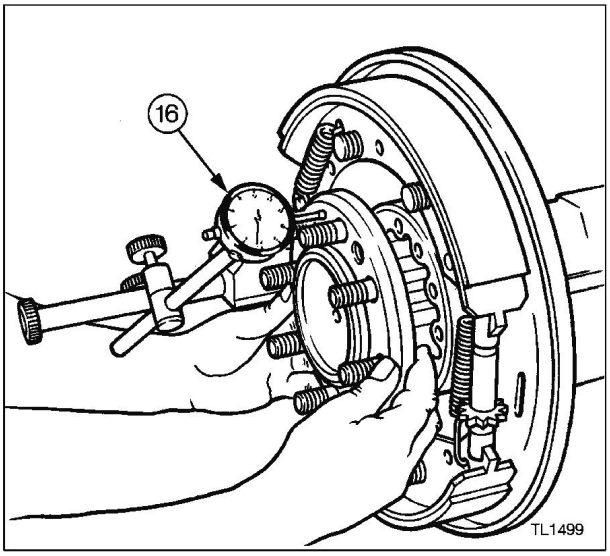
Refitment

11. Smear the inside of the brake camshaft bush in the trumpet housing with a general purpose grease.
12. Check that the bearing cavity is full of grease.
13. Place the brake assembly and more shims than will be necessary on the axle shaft.
14. Taking care not to damage the oil seal, place the axle shaft into the trumpet housing, simultaneously locating the brake camshaft.
15. Secure the hub with three of the bolts and spring washers, equi-spaced and tighten to a torque of 74 Nm.
16. Check the axle end-float on the left-hand trumpet housing, using a dial test indicator gauge. Remove shims as necessary to give an end float of 0,05 to 0,2 mm between the axle ends.

NOTE: *The right-hand axle shaft must be in place to enable this setting to be accomplished. If both shafts have been removed assemble the right-hand shaft with two shims to the value of 0,51 mm, then make your adjustments on the other side. Start with one 0,38 mm, two 0,51 mm and two 0,13 mm shims.*

17. Refit the remaining bolts and spring washers and tighten to a torque of 74 Nm.
18. Reconnect the parking brake rod/cable to the brake camshaft lever if removed.
19. Refit the brake drum.





Shims are available in the following sizes:

Shim Thickness		Part number
mm	inch	
0,05	0.002	964 073 M1
0,13	0.005	183 259 M1
0,38	0.015	183 260 M1
0,51	0.020	183 261 M1

20. Secure the brake drum with the two countersunk screws.
21. Refit the rear wheel and nuts, then tighten the nuts progressively and evenly to a torque of 270 Nm.
22. Refill the transmission with an approved oil to the correct level.
23. Adjust the brakes, see operation 2.06A-03 or 2.06A-04.

AXLE SHAFT – DIRECT DRIVE – DRUM BRAKES

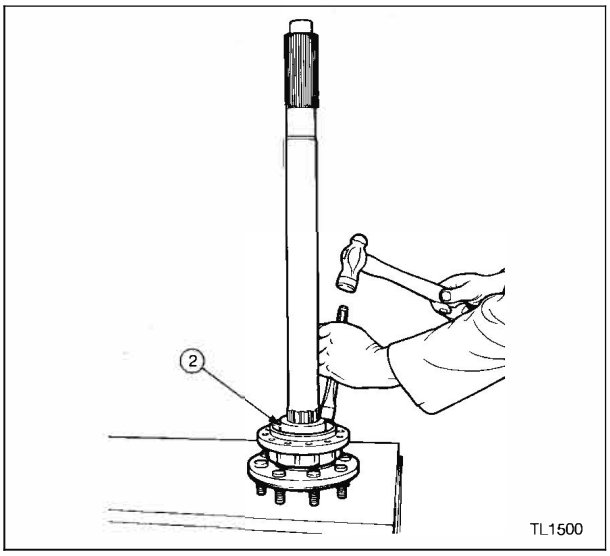
Overhaul **2.06C–08**

Dis-assembly

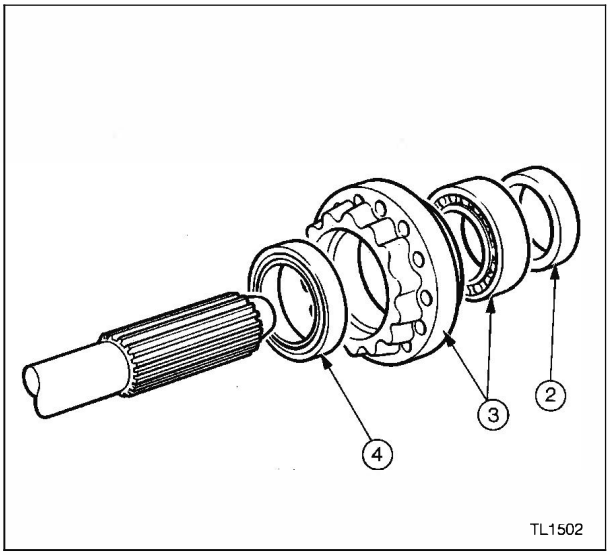
1. Remove the axle shaft, see operation 2.06C-07.

WARNING: You are advised to wear eye protection during procedure 2.

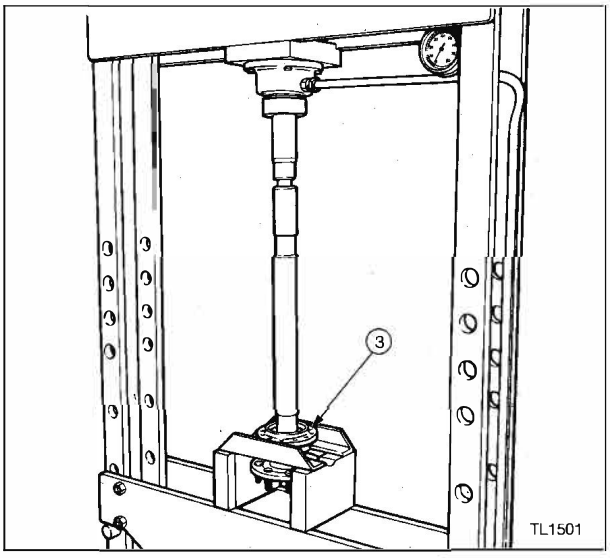
2. Drill into the side of the bearing retaining collar, then using a cold chisel, fracture the collar.



3. With a hydraulic press, press the seal and bearing assembly off the shaft. Only remove the bearing cup if necessary.

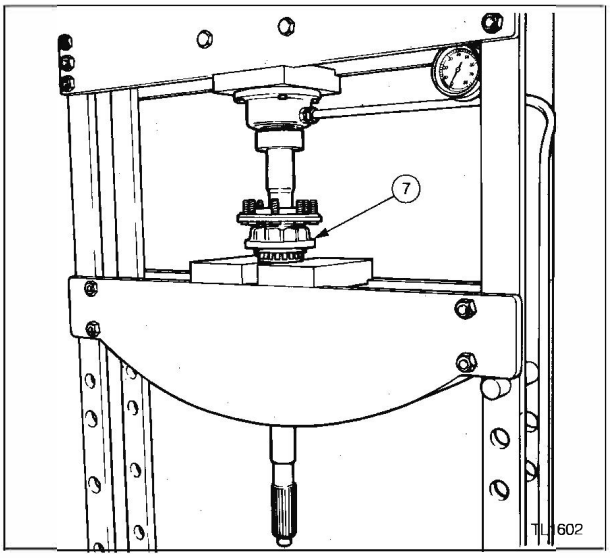


4. Remove and discard the hub oil seal.
5. Remove and discard the oil seal in the trumpet housing.

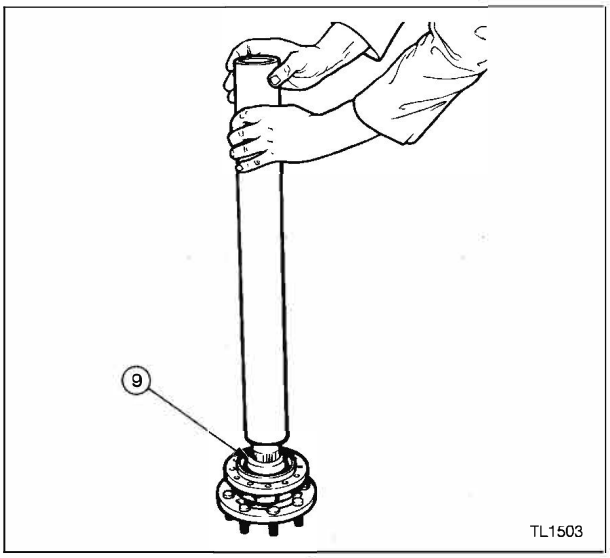


Re-assembly

6. Coat the oil seal with MF Lock and Seal (Loctite 542) and press into the hub up to the shoulder (fit a new bearing cup if necessary).
7. Place a small quantity of high melting point grease between the oil seal and bearing. Position the axle shaft, seal and bearing assembly under a hydraulic press. Press the taper roller bearing cone into position.
8. Heat a new bearing retaining collar, until dull red, and place it in position on the axle shaft.



9. Quickly drive the bearing retaining collar into position with a length of steel tube so that the hub and bearing assembly is held tightly in position.
10. When cool, fill the bearing cavity with approximately 85 g of high melting point bearing grease.
11. Replace the oil seal in the trumpet housing coating it first with MF Lock and Seal (Loctite 542), the lip of the seal faces towards the crownwheel and pinion.
12. Refit the axle shaft, see operation 2.06C-07.



TRUMPET HOUSING – DIRECT DRIVE AXLE

Removal and refitment 2.06C–09

Removal

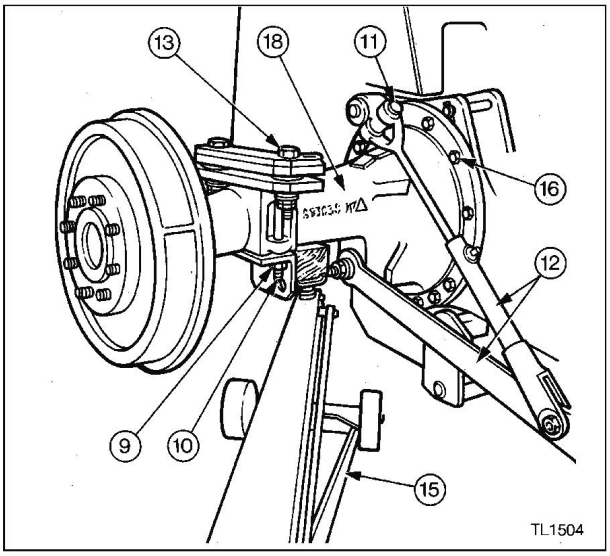
1. Drain the transmission oil.
2. Remove the split pin, nut and washer securing the lower link to the trumpet housing.
3. Jack up the tractor under the trumpet housing being serviced.
4. Remove the rear wheel.
5. Support the tractor on a suitable stand or splitting trolley under the transmission.
6. Release the parking brake rod/cable from the brake cam shaft.
7. When removing the right-hand trumpet housing, release or remove the differential lock pedal.
8. Release the check chain at the check chain anchor bracket.
9. Remove the two nuts securing the stabiliser bracket to the trumpet housing.
10. Remove the stabiliser bracket.
11. Release the lift rod at the lift arm knuckle.
12. Remove the lower link assembly complete.
13. Remove bolts from the fender.
14. Remove the fender assembly.

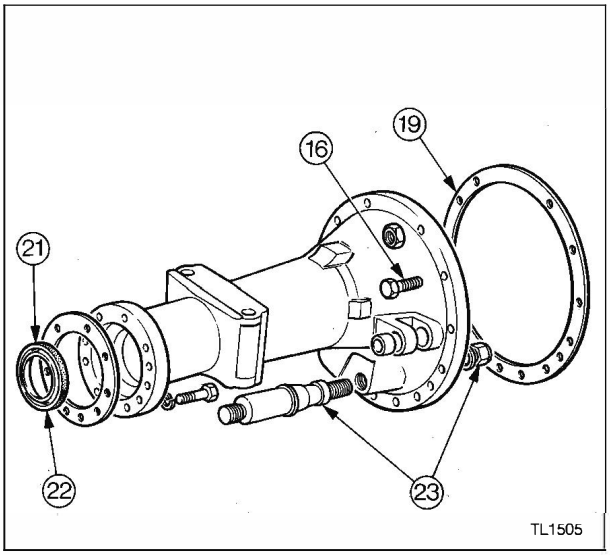
WARNING: The trumpet housing is heavy and awkward to handle. Take care when both removing and refitting.

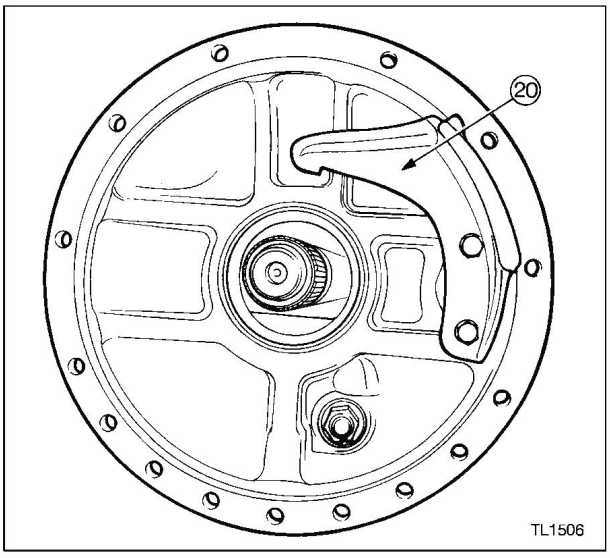
15. Place a trolley jack under the centre of the trumpet housing being serviced, just supporting the housing.
16. Remove all the nuts and bolts securing the trumpet housing to the centre housing.
17. Lower the trumpet housing slightly on the trolley jack.
18. Withdraw the trumpet housing on the trolley jack.

CAUTION: *When removing the left-hand trumpet housing, the differential will need supporting to prevent it falling out.*

19. Remove the gasket from the centre housing.
20. Remove the oil trough from the left-hand housing, if necessary.
21. Remove the oil seal.

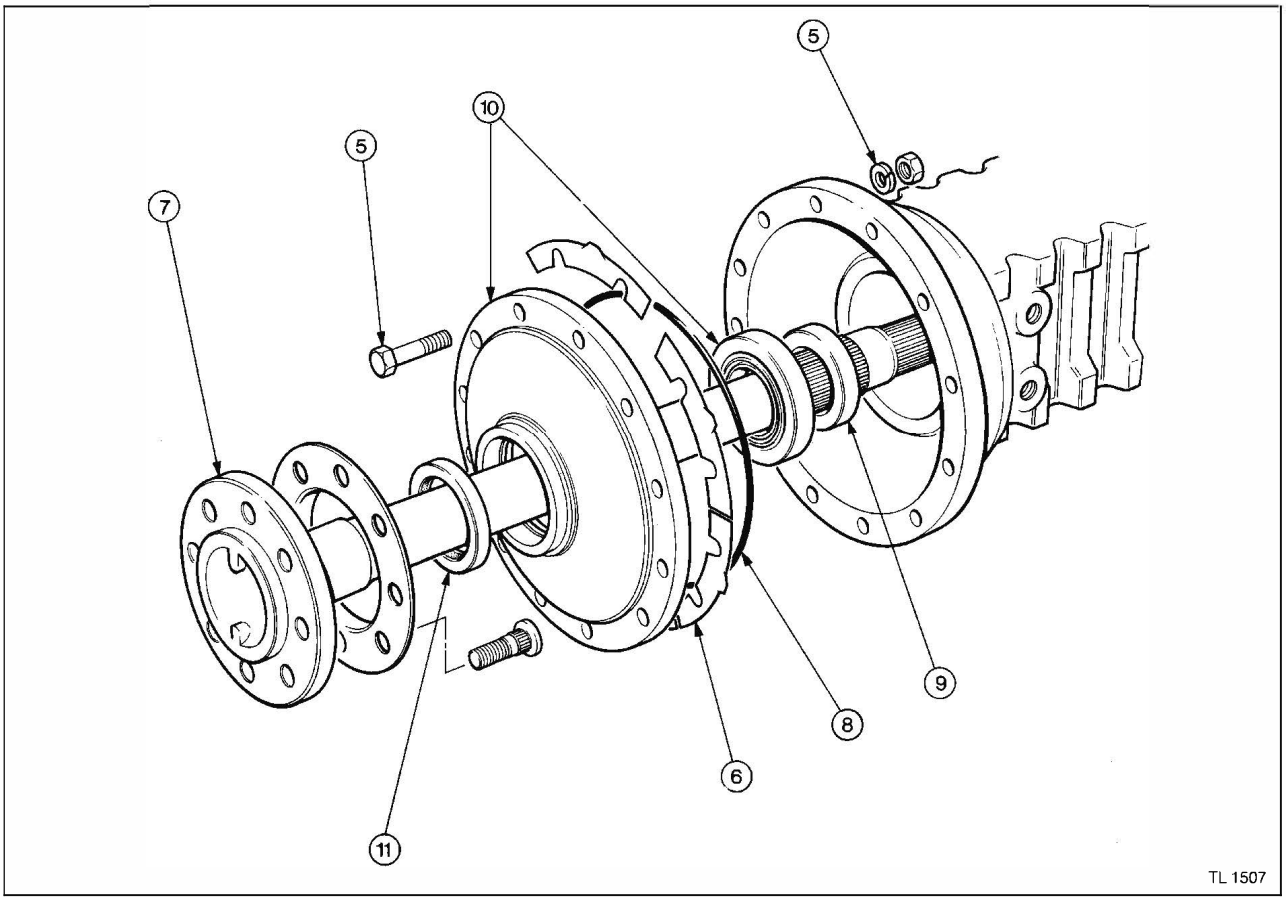






Refitment

22. Replace the oil seal in the trumpet housing coating it first with MF Lock and Seal (Loctite 542), the lip of the seal faces towards the crownwheel and pinion.
23. If the lower lift arm pivot pin has been removed from the trumpet housing, when refitting tighten the nut to a torque of 156 Nm.
24. Reverse procedures 1 to 20 except:
    a. Fit a new gasket to the centre housing using petroleum jelly.
    b. When refitting the trumpet housing, take care to align the axle shaft splines in the differential unit and the studs through their holes in the trumpet housing.
    c. Do not forget to refit the differential lock return spring and attachment plate.
    d. Tighten the trumpet housing nuts and bolts to a torque of 115 Nm.
    e. Apply a few drops of MF Stud Lock (Loctite 270), then fit and tighten the stabiliser bracket/fender bolts to a torque of 230 Nm.
    f. Tighten the wheel nuts progressively and evenly to a torque of 270 Nm.
    g. Refill the transmission to the correct level with an approved oil.



AXLE SHAFT – WET BRAKES – DIRECT DRIVE

Removal and refitment **2.06C–10**

Special Tools:
Dial indicator gauge

Removal

1. Jack up the tractor under the trumpet housing to be serviced.
2. Drain the transmission.
3. Remove the rear wheel.
4. Ensure that the parking brake is hard on.
5. Remove the 12 nuts, bolts and spring washers.
6. Prise apart the axle housing, taking care to retain the shims between the two halves.
7. Remove the axle and hub assembly.
8. Remove the 'O' ring and discard.
9. Drill into the side of the bearing retaining collar, then using a cold chisel, fracture the collar, see operation 2.06C-08.
10. Remove the bearing and hub assembly off the axle shaft with a hydraulic press (remove the bearing cup only if necessary).
11. Remove and discard the oil seal.

Refitment

12. Coat the oil seal with MF Lock and Seal (Loctite 542) and press into the hub up to the shoulder (fit a new bearing cup if necessary).
13. Place a small quantity of high melting point grease between the oil seal and the bearing. Position the axle shaft, seal and bearing assembly under a hydraulic press. Press the taper roller bearing cone into position.
14. Heat a new bearing retaining collar, until dull red, and place it in position on the axle shaft.
15. Quickly drive the bearing retaining collar into position so that the hub and bearing assembly is held tightly as shown in operation 2.06C-08.
16. Replace the 'O' ring.
17. Place the axle shaft into the trumpet housing, carefully passing the shaft through the brake plates.
18. Place more shims than will be necessary between the hub and trumpet housing.

CAUTION: *The shims are in segments, each pack of shims must be equal.*

19. Secure the hub with three of the bolts and spring washers, equi-spaced and tighten to a torque of 74 Nm.

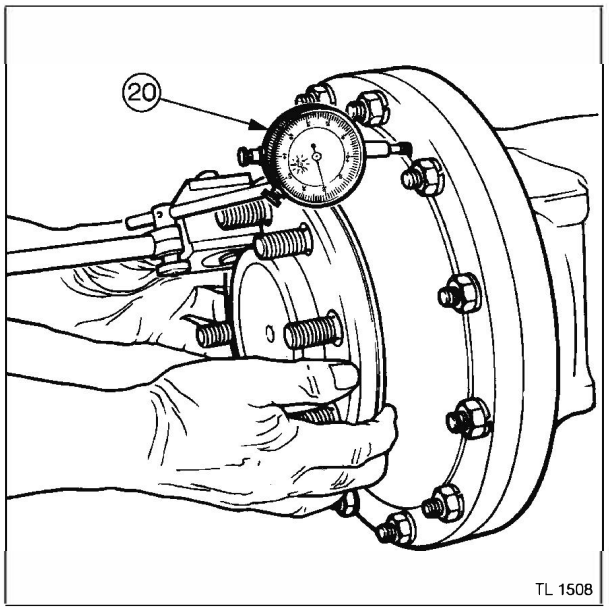
20. Check the axle end-float, using a dial test indicator gauge. Remove shims as necessary to give an end float of 0,05 to 0,2 mm between the axle ends.

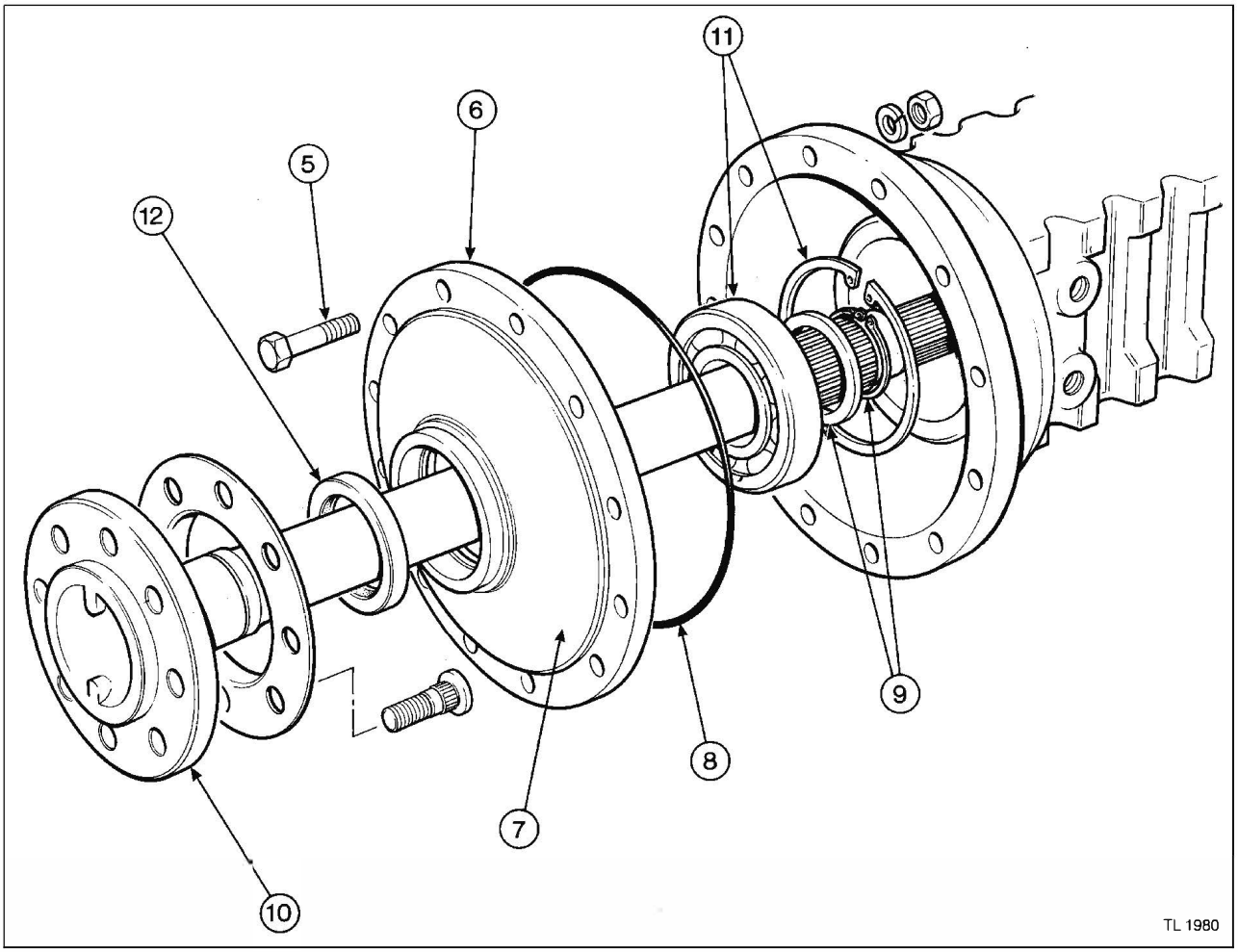
NOTE: *The other axle shaft must be in place to enable this setting to be accomplished. If both shafts have been removed assemble the shaft on one side with shims to the value of 0,5 mm, then make your adjustments on the other side.*

Shims are available in the following sizes:

Shim Thickness		Part number
mm	inch	
0,10	0.004	1660 644 M1
0,25	0.010	1660 645 M1
0,50	0.020	1660 646 M1

21. Refit the remaining bolts and spring washers and tighten to a torque of 74 Nm.
22. Refit the rear wheel and nuts, then tighten the nuts progressively and evenly to a torque of 270 Nm.
23. Refill the transmission with an approved oil to the correct level.
24. Adjust the brakes, see operation 2.06B-03 or 2.06B-04.





AXLE SHAFT – DIRECT DRIVE – WET BRAKES

Removal and refitment 2.06C–11

Removal

NOTE: *This axle shaft replaces the type shown in section 2.06C-10 which has a taper roller bearing retained by a shrink-fit collar. It can be identified by the large ball bearing retained by a spacer and circlips.*

1. Jack up the tractor under the trumpet housing to be serviced.
2. Drain the oil from the transmission.
3. Remove the rear wheel.
4. Ensure that the parking brake is hard on.
5. Remove the 12 nuts, bolts and spring washers.
6. Prise apart the axle housing between the end cover and trumpet housing.
7. Remove the axle and end cover assembly.
8. Remove the 'O' ring and discard.
9. Remove the external circlip and spacer.
10. Drive the axle shaft out of the bearing and cover assembly.
11. Remove the internal circlip and ball bearing if necessary.
12. Remove and discard the oil seal.

Refitment

13. Coat the oil seal with MF Lock and Seal (Loctite 542) and press into the cover up to the shoulder.
14. Replace the ball bearing if necessary.
15. Refit the axle shaft, spacer and circlip.
16. Replace the 'O' ring.
17. Place the axle shaft into the trumpet housing, carefully passing the shaft through the brake plates.
18. Refit the nuts and bolts tightening to a torque of 74 Nm.
19. Refit the rear wheel and nuts, then tighten the nuts progressively and evenly to a torque of 270 Nm.
20. Refill the transmission with an approved oil to the correct level.
21. Adjust the brakes, see operation 2.06B-02.

Page left blank intentionally

Drawbar and Linkage

Section 6 – Part D

Table of Contents

Operation No.	Description	Page No.
-------	Specification	6D- 2
-------	Drawbar adjustment tables	6D- 3
-------	General description	6D- 5
2.06D-02	Left-hand lift rod - removal	6D- 6
2.06D-03	Right-hand lift rod and levelling box - removal	6D- 6
2.06D-05	Swinging drawbar - removal	6D-7
2.06D-07	Swinging drawbar - removal	6D-8

Drawbar and Linkage

Specifications

Linkage

Linkage types:

MF 345,350,355,360,375	Interchangeable ball ends category 1 and 2
MF 375,385	Fixed ball ends category 2
MF 375,385	Hook ends category 2
MF 375	Wrist action ends category 2
MF 385	Telescopic ends category 2

Lift capacity at link ends with links horizontal:

Interchangeable ball ends category 1 and 2

MF 345	1415 kg
MF 355	1588 kg
MF 350,360,375	2145 kg
Fixed ball and hook ends category 2	2586 kg
Wrist action ends category 2	2454 kg
Telescopic ends category 2	2498 kg

Assister lift rams:

MF350,360	Not to be fitted
MF375	One,optional equipment
MF 385	One,standard linkage
MF 385	Two,high tear-out linkage

Drawbars

Drawbar (Fixed Trailer Hitch)

Swinging drawbar static load:

Inner position	1000 kg
Centre position	775 kg
Outer position	775 kg

Swing drawbar distance to PTO shaft:

Inner position	241 mm
Centre position	355 mm
Outer position	400 mm

Telescopic Draw bar static load:	Hook	Drawbar clevis
Retracted position	2718 kg	2265 kg
Intermediate position	2265 kg	2265 kg
Extended position	2265 kg	Not recommended
Maximum horizontal pull	6795 kg	

Telescopic Drawbar distance to PTO shaft	Hook	Drawbar clevis
Retracted position	150 mm	235 mm
Intermediate position	315 mm	400 mm
Extended position	400 mm	Not recommended

Bolt Torques

Drawbar frame to centre housing	420 Nm
Drawbar side supports to trumpet housing bolts	110 Nm
Drawbar frame to Control beam frame	245 Nm

Drawbar adjustment – standard

	Offset Fig.1		Height Fig.2
	Inner	Outer	
A	57 mm	68 mm	159 mm
B	114 mm	135 mm	257 mm
C	221 mm	259 mm	108 mm
D	Not applicable		206 mm

Drawbar adjustment – North America

	Offset Fig.1		Height Fig.2
	Inner	Outer	
A	68 mm	72 mm	159 mm
B	135 mm	144 mm	257 mm
C	259 mm	276 mm	108 mm
D	Not applicable		206 mm

Swinging drawbar maximum vertical static loadings and clearances

Drawbar position	Distance of clevis from end of PTO shaft 'X'	Maximum static loadings
Position (retracted)	254 mm	1000kgf
Position (extended)	356 mm	771 kgf

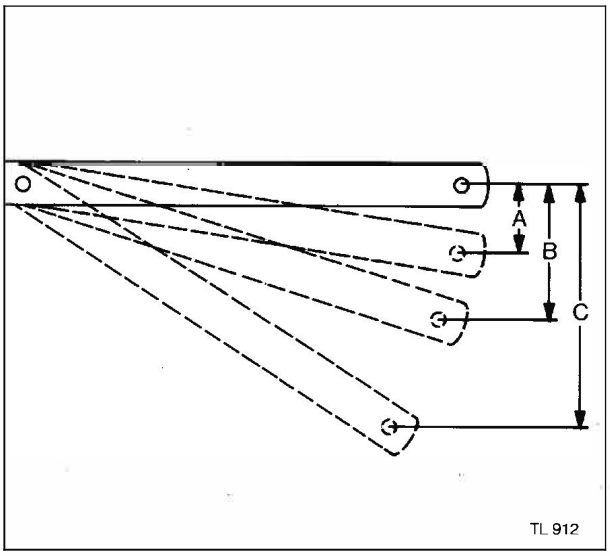


Fig.1

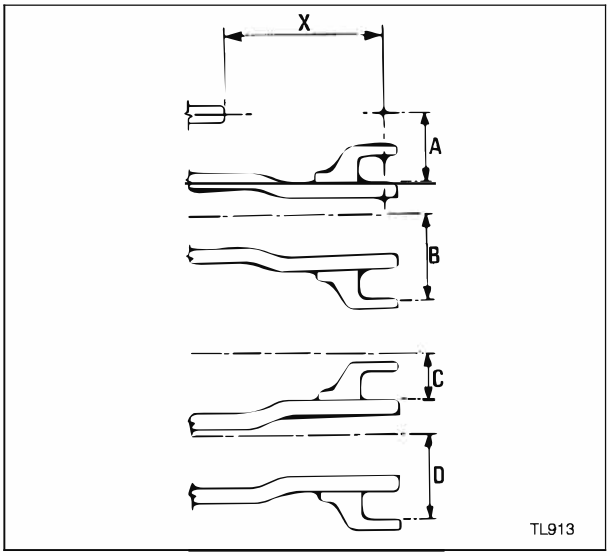
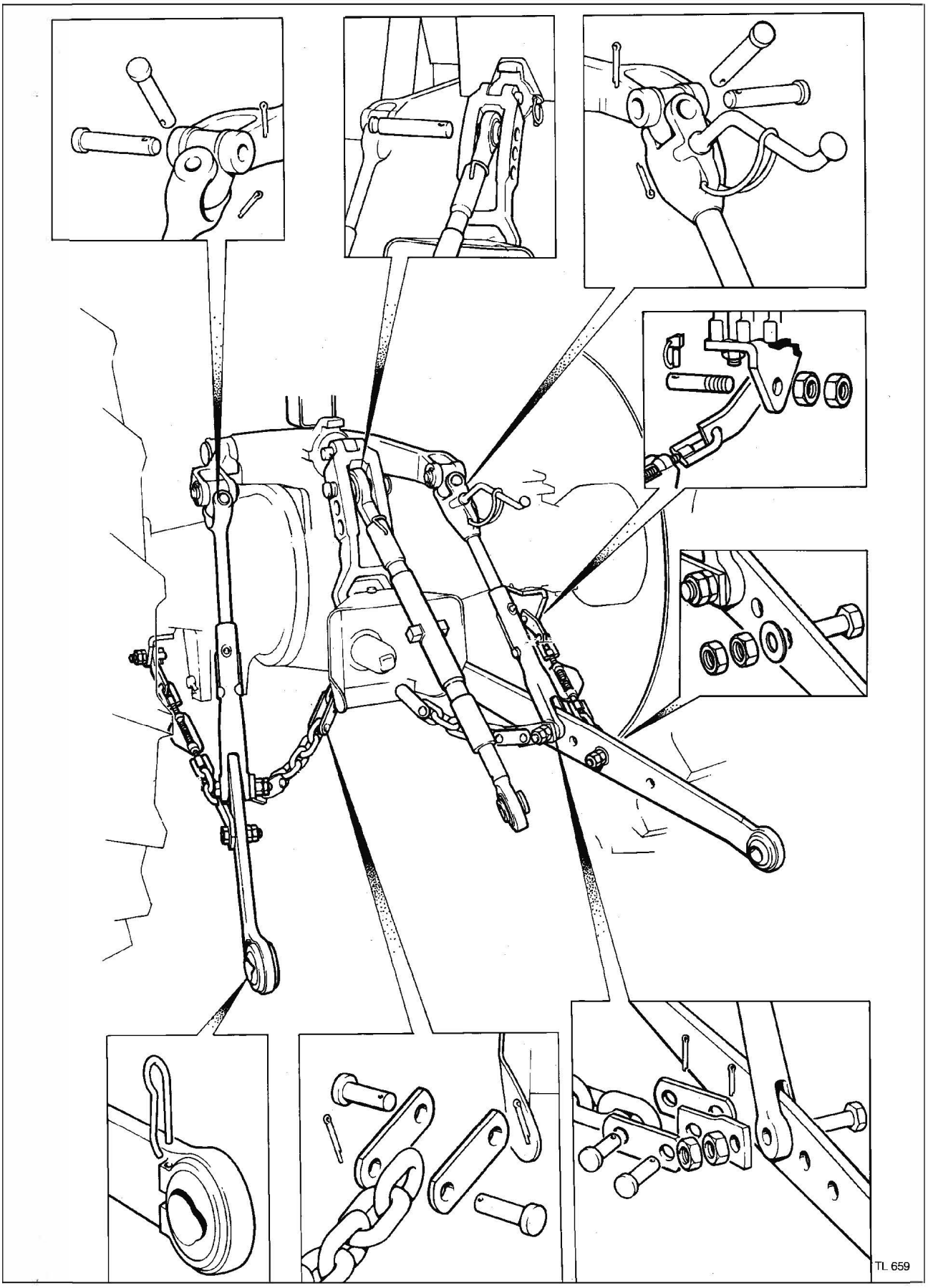


Fig.2

Drawbar and Linkage



GENERAL DESCRIPTION

The three point linkage controls the vertical movement of the mounted and semi-mounted implements.

The linkage consists of:

1. Top link
2. Two lift rods
3. Two lower links
4. Two check chains
5. Control beam
6. Interchangeable ball ends
7. Levelling box
8. Stabilizer chains

Top link (1)

The top link transmits the draft reaction forces from the soil engaging implements to the control spring and plunger assembly in the lift cover.

The top link consists of three main components:

1. Top ball end
2. Turnbuckle barrel and spring locking clip
3. Bottom ball end (Implement end)

The top link is adjustable for length, seven rings are machined on each ball end shank; the centre or wider marker ring indicates its normal length. The turnbuckle is prevented from rotating by the spring locking clip at its top end.

Lift rods (2)

The two lift rods connect the lift arms to the lower links having a knuckle type joint at the top end with the link arms and a swivelling bolt at the bottom end with the lower links.

The left-hand lift rod consists of three main components, knuckle joint, yoke section and lower fork. The lift rod is set to length and should not be changed.

The right-hand lift rod is similarly constructed but the yoke section incorporates a bevel gear levelling box, thus the length can be adjusted for attachment to the implement. By rotating the handle of the levelling box, the yoke shank is screwed out of or into the lower fork.

The lower fork section of both lift rods may have an alternative elongated lower link attachment hole. This will permit lift rod float when working with wide implements. In this instance one lift rod is detached from the lower link and rotated 180° and refitted using the elongated hole. The lubricator will point downwards.

Lower links (3)

The two lower links can be fitted with various types of ends as follows:

Interchangeable ball category 1 or 2 (illustrated).
Wrist action category 2.

Two holes are provided for in the lower link so that the height of lift can be varied.

A spring clip is fitted to the outer end of the lower link toward the implement for stowage of the linch pin when not in use.

Check chains (4)

The two check chains restrict the sideways movement of the lower links to prevent them or the implement fouling the inside walls of the rear tyres.

The check chains are fitted between the bottom end of the control beam bracket and the inner face of each lower link using the lift rod bolts.

The check chains are set longer for category 2 implements.

Control beam (5)

The control beam connects the top link to the control spring rod of the tractor hydraulic system when the draft control is in use and thus governs the action of the implement.

Interchangeable ball ends (6)

Interchangeable ball ends are fitted to the rear ends of the two lower links, thus category 1 and 2 implements can be used.

Normally category 1 ball ends are stowed in the tool box.

The ball ends are changed by pulling up a spring wire clip, laying the ball ends flat and aligning the cut out of the ball end with the slot in the lower link and sliding it out. The replacement ball is fitted by reversing the removal procedure.

Levelling box (7)

The levelling box is used to adjust the length of the right-hand lift rod, to assist in hitching the implement and to adjust the implement for level.

Stabilizer chains (8)

The two stabilizer chains are adjustable for length using the turnbuckles. They must be adjusted to give implement side-swing when fully raised in the transport position.

Drawbar and Linkage

LEFT-HAND LIFT ROD

Removal and refitment **2.06D–02**

Removal

1. Place the position control lever in the lowered position.
2. Unscrew the two locking nuts.
3. Remove the lift rod link arm bolt.
4. Remove the split pin.
5. Remove the lift rod to lift arm pin.

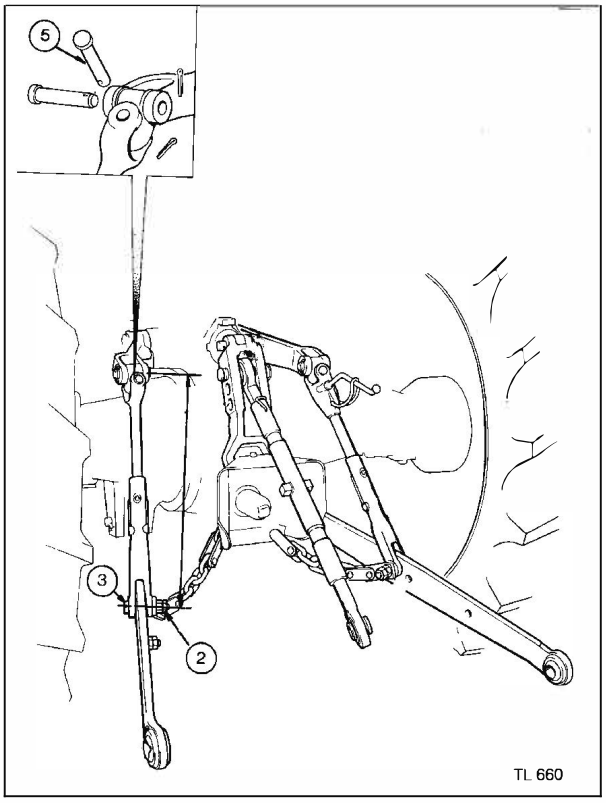
NOTE: *Where an assistor ram is fitted, the collar and retaining roll pin will have to be removed before removing the lift rod to lift arm pin.*

6. Lift the lift rod from its mounted position.

Refitment

7. Reverse procedures 1 to 6.

NOTE: *When refitting the lift rod length 'A' it must be set to one of the dimensions shown in the specification on page 6D-2.*



RIGHT-HAND LIFT ROD AND LEVELLING BOX

Removal and refitment **2.06D–03**

Removal

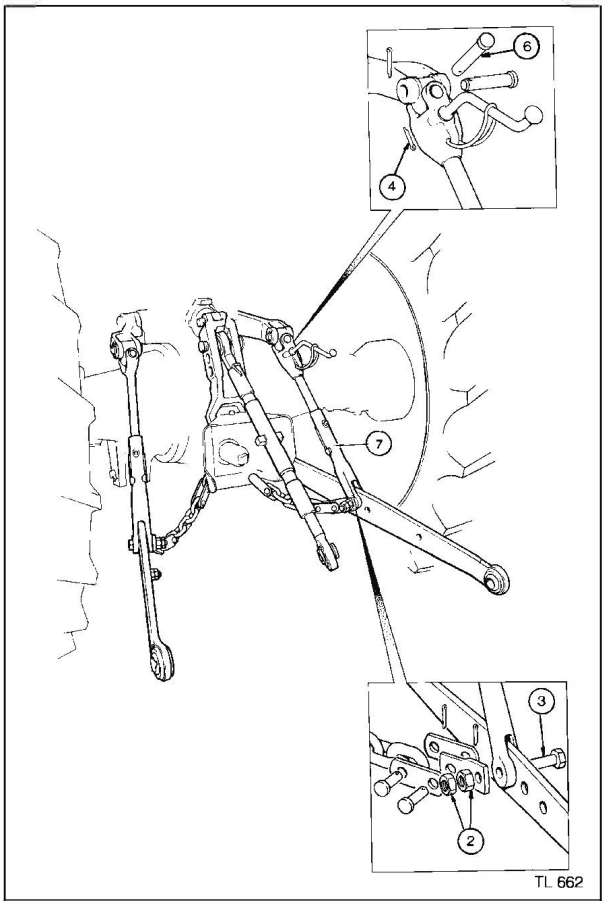
1. Place the position control linkage in the lower position.
2. Unscrew the two locking nuts on the lift rod bolt.
3. Remove the link arm to lift rod bolt.
4. Remove the split pin.
5. Slacken the pick-up hitch arm retaining bolt to aid lift rod to lift arm pin removal and refitment, if fitted.

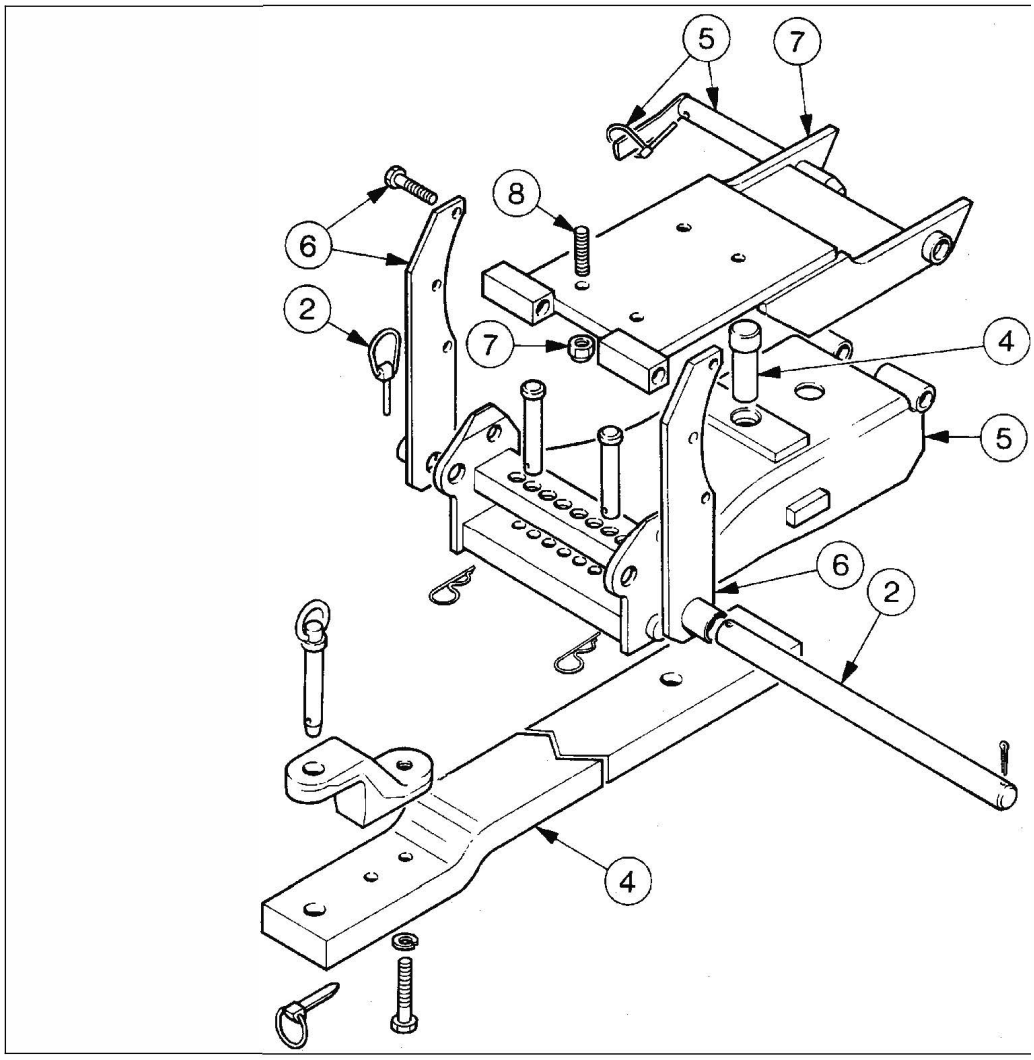
NOTE: Where an assistor ram is fitted, the collar and retaining roll pin will have to be removed before removing the lift rod to lift arm pin.

6. Remove the lift rod to lift arm pin.
7. Lift the lift rod assembly from its mounted position.

Refitment

8. Reverse procedures 1 to 7.





TL 667

SWINGING DRAWBAR

Removal and refitment 2.06D–05

Removal

1. Support the drawbar, with a suitable adjustable jack.
2. Remove the linchpin and withdraw the pin on both normal-and heavy-duty drawbars.
3. Lower the drawbar and carrier.
4. Remove the retaining pin, support the drawbar carrier, and withdraw the drawbar from the carrier.
5. While supporting the drawbar carrier remove the linchpin and withdraw the handled rear pin. Lift the drawbar carrier clear of its mounted position.
6. On heavy-duty drawbar assemblies, remove the three bolts on each side, retaining the support brackets to the rear centre case, and remove the support brackets.
7. Remove the four locking nuts retaining the base plate to the axle centre case, and lower base plate from its mounted position.
8. Remove the four studs from the centre case if necessary.
9. Check all parts for wear or damage and replace, if worn or damaged, with new parts.

Refitment

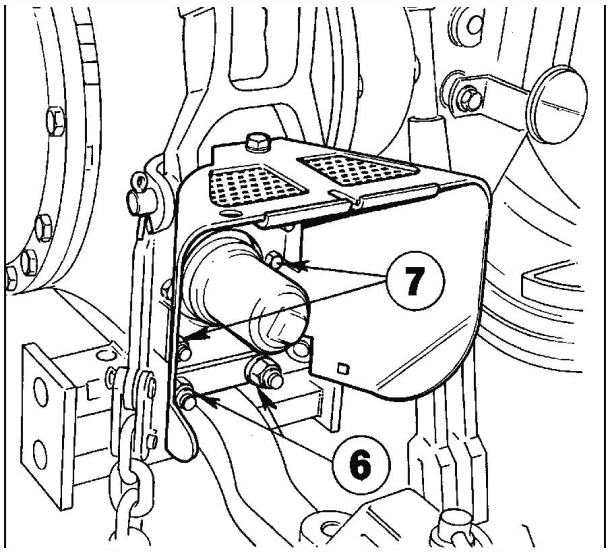
10. Reverse procedures 1 to 9 except:
    a. Use new carrier plate retaining locking nuts and tighten to a torque of 420 Nm.
    b. Tighten the support bracket bolts to a torque of 130 Nm.

SWINGING DRAWBAR FOR FIXED TRAILER HITCH

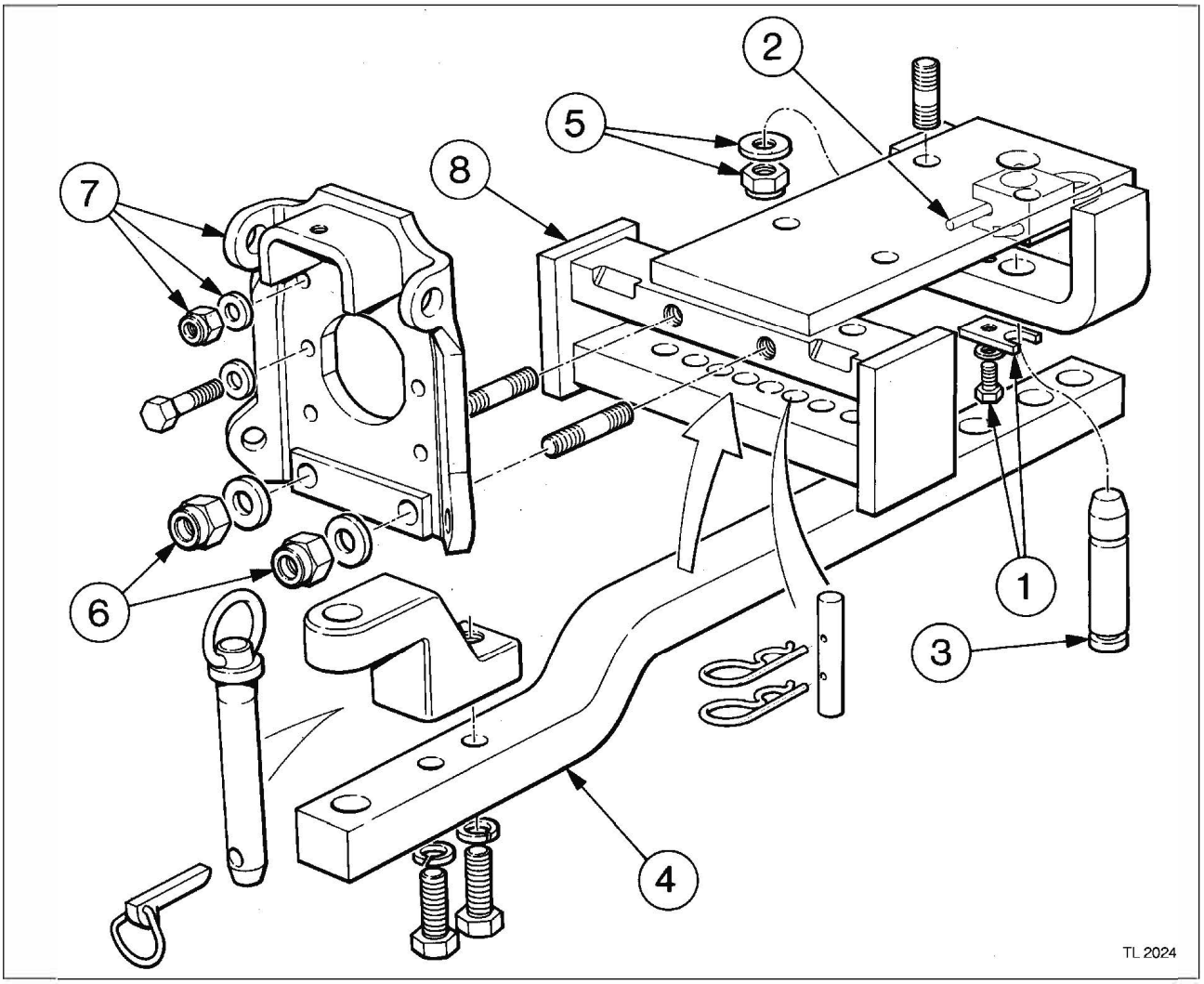
Removal and refitment **2.06D–07**

Removal

1. Remove the locking plate, bolt and lockwasher.
2. Pull the pin retaining spring to the left to release the pin.
3. Remove the drawbar pivot pin.
4. Withdraw the drawbar rearwards from the drawbar frame.
5. Remove the four self locking nuts and washers holding the frame to the bottom of the axle centre housing.
6. Remove the two self locking nuts and washers holding the frame to the rear control beam bracket fitted to the rear of the axle centre housing.
7. Remove the four self locking nuts and two hex head bolts holding the control beam bracket to the tractor. Remove the control beam bracket.



TL 1978



8. Remove the drawbar frame.
9. Check all parts for wear or damage and replace any worn or damaged parts with new parts.

Refitment

10. Reverse procedures 1 to 8 except:
    a. Use new locking nuts or apply MF Stud Lock (Loctite 270) if new locking nuts are not available.
    b. If any studs are being replaced refit using MF Stud Lock (Loctite 270).
    c. Tighten the two locknuts (6) to a torque of 245 Nm.
    d. Tighten the four locknuts (5) to a torque of 420 Nm.
    e. Tighten the four locknuts (7) to a torque of 140 Nm.

Drawbar and Linkage

Wheels and Tyres

Section 6 – Part E

Table of Contents

Operation No	Description	Page No
	Wheel nut and bolt torques	6E- 2
2.04A-01	Inner tybe replacement	6E- 2
2.04A-02	Tyre replacement	6E- 3

Wheels and Tyres

Wheel Nut and Bolt Torques

M-F 350, 355 and 360

Front wheels – Two wheel drive

Wheel nuts	81-108 Nm (60-80 lbf ft)
Wheel screws	95-120 Nm (70-88 lbf ft)

Front wheels – Four wheel drive

Wheel to hub screws	270 Nm (200 lbf ft)
Rim to disc nuts	190 Nm (140 lbf ft)

Rear wheels – Standard

Wheel to hub nuts	325 Nm (240 lbf ft)
Rim to disc nuts	240 Nm (178 lbf ft)

Rear wheels – PAVT

Wheel to hub nuts	325 Nm (240 lbf ft)
Clamp nuts – Stage 1	70 Nm (52 lbf ft)
– Stage 2	140 Nm (103 lbf ft)
– Stage 3	260 Nm (192 lbf ft)

M-F 375, 385

Front wheels – Two wheel drive with pressed wheels

Wheel nuts	81-108 Nm (60-80 lbf ft)
Wheel screws	122-163 Nm (90-120 lbf ft)

Front wheels – Two wheel drive with disc wheels

Wheel nuts	108-144 Nm (80-106 lbf ft)
Wheel screws	163-244 Nm (120-180 lbf ft)

Front wheels – Four wheel drive

Wheel to hub screws	270 Nm (200 lbf ft)
Rim to disc nuts	190 Nm (140 lbf ft)

Rear wheels – Standard

Wheel to hub nuts	325 Nm (240 lbf ft)
Rim to disc	190 Nm (140 lbf ft)

Rear wheels – PAVT

Wheel to hub nuts	325 Nm (240 lbf ft)
Clamp nuts – Stage 1	70 Nm (52 lbf ft)
– Stage 2	140 Nm (103 lbf ft)
– Stage 3	260 Nm (192 lbf ft)

Inner Tube

Removal and Refitment 8D-01

Special Tools:
Bead-breaking tool
3 lb Hammer
Tyre Levers

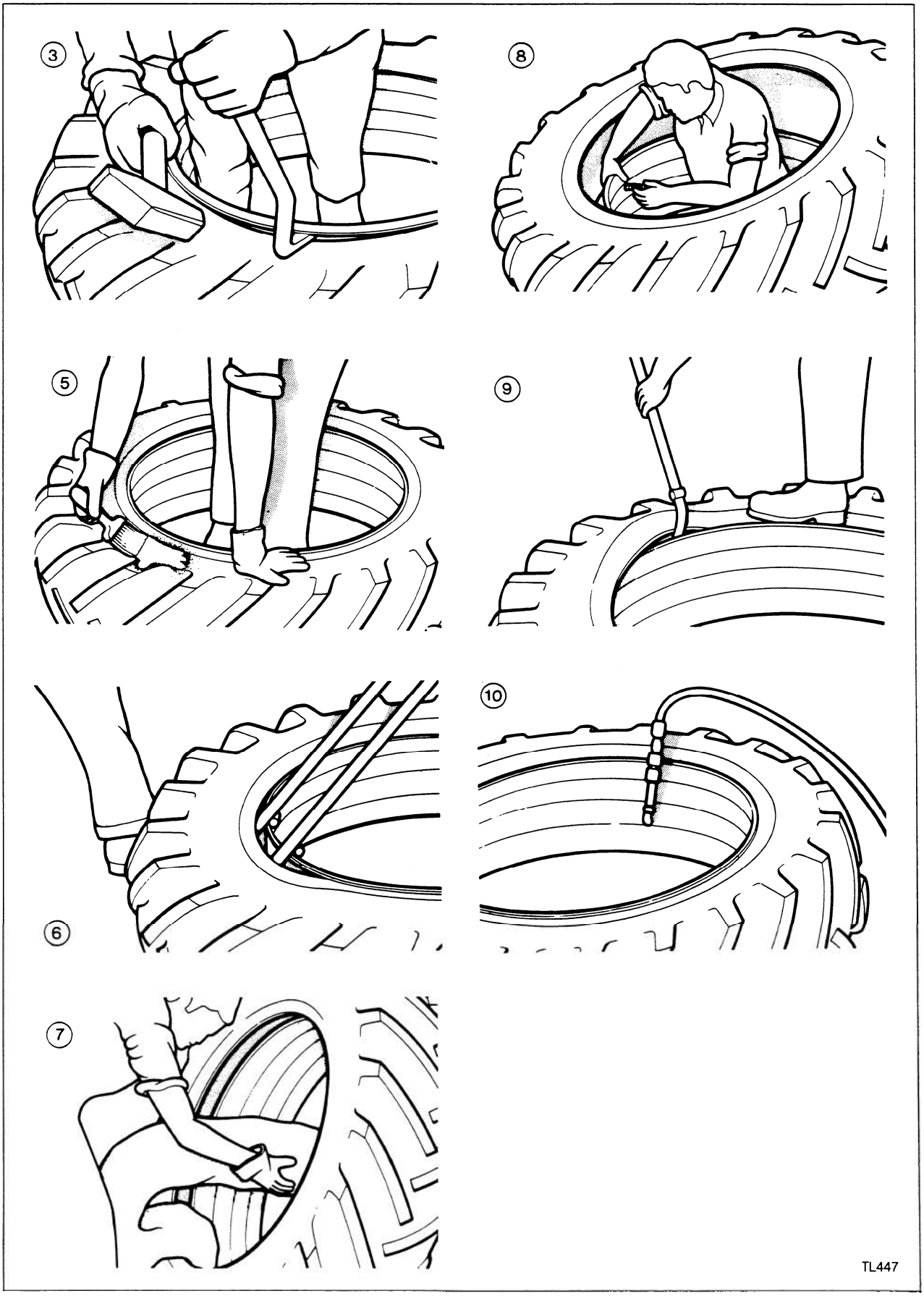
Removal

1. Lay the wheel on the ground with the valve uppermost.
2. Deflate the tyre by removing the valve core. Remove the valve retaining nut.
3. Drive the 'bead-breaking' tool between the tyre and rim, taking care not to damage the rim or the tyre.
4. After the bead has been released from the rim, invert the wheel and repeat procedure 3.
5. Lubricate the rim, tyre and base of the tube with a solution of soap and water or similar rubber lubricant.

Note: Never use petroleum or silicone base greases.

6. Starting at the valve location, pry the tyre off the rim, taking small bites with tyre levers, and ensuring that the bead on the opposite side is fully located in the mounting well.
7. With the wheel in a vertical position, pull the tyre forwards and remove the tube.

Examine the bead seating area of the rim. Remove any build-up of rust, corrosion or old rubber. Inspect inside the tyre casing for foreign matter or damage.


3
8
5
9
6
10
7
TL447

Refitment

8. Inflate the tube until 'rounded out'. Place the tube in the tyre with the valve located in the valve hole. Refit the valve retaining nut finger tight.
9. Refit the tyre, starting opposite the valve location taking small bites with long tyre levers and keeping the fixed part of the bead fully located in the well.

   A solution of soap and water, or similar rubber lubricant, brushed on to the rim and bead will help refitment.

Note: Care must be taken not to pinch the tube when fitting.

10. Centre the tyre on the rim and inflate to approximately 2,5 kg/cm^2 (35 lb/in^2).

Caution: Never stand over the assembly when inflating. Remote control inflation equipment should be used.

11. Remove the valve core and completely deflate the tyre.
12. Refit the valve core and inflate to recommended pressure.

Caution: If beads fail to seat at 2,5 kg/cm^2 (35 lb/in^2) the tube may be pinched, do not increase the pressure but remove the valve core and release the tyre from the rim. Lubricate tyre, bead and rim and re-inflate to 2,5 kg/cm^2 (35 lb/in^2). Repeat process until both beads are properly seated.

Tyre

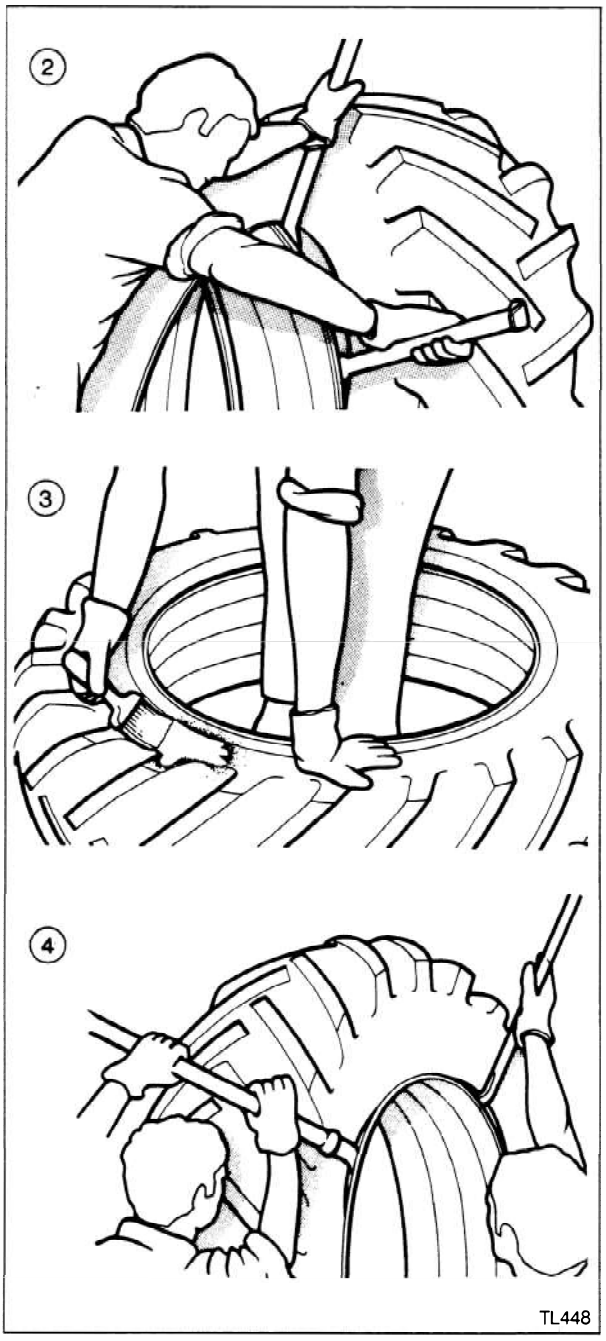
Removal and Refitment	8D-02
Special Tools: Bead-breaking tool	
3 lb Hammer	
Tyre levers	

Removal

1. Remove inner tube as stated in operation 8D-01.
2. With the wheel in a vertical position, pry off the tyre taking small bites with the tyre levers. The use of rubber lubricant will help removal.

Refitment

3. Place the rim on the ground. Lubricate the bead and rim and place the tyre on rim.
4. Refit the tyre to the rim using long tyre levers.
5. Refit the inner tube.



SECTION 7

Power Take-off

INDEX

7A SINGLE SPEED POWER TAKE-OFF

Single Speed Power Take-Off (540 rev/min and ground speed)

Section 7 – Part A

Table of Contents

Operation No.	Description	Page No.
-------	Specification	7A- 2
-------	General description	7A- 2
2.07A-01	PTO shaft bearing and oil seal - removal - up to serial number P38478	7A- 4
2.07A-02	PTO shaft bearing and oil seal - removal - from serial number P38479	7A- 5
2.07A-03	Ground speed gears and bearings - removal	7A- 8
2.07A-04	Left-hand PTO side cover - removal	7A- 9
2.07A-05	Left-hand PTO side cover - overhaul	7A- 9

Single Speed Power Take-Off

SPECIFICATION:

PTO speeds	540 rev/min at 1789 engine rev/min
Engine to PTO shaft ratio	3.3125:1
Number of splines	6
Shaft diameter	34,93 mm
Ground speed ratio, rear wheel to PTO shaft	13.816 :1

Distance travelled per PTO shaft revolution:

Tyre size	Tyre radius		Distance travelled	
	mm	in	mm	in
16.9-30	695	27.38	316	12.44
16.9-34	745	29.35	339	13.35
13.6-36	715	28.17	325	12.80
13.6-38	740	29.16	336	13.23

Special tools

MF.168	Seal and bush remover/replacer
MF.195C	Bearing remover/replacer - maintool
MF.195-5B	Needle bearing remover/replacer
MF.195-6B	Needle bearing and bush remover/replacer
MF.364 A	Seal replacer
MF.474	PTO seal guide and installer
MS.550	Universal handle

Nut torques

Nuts - control beam bracket to centre housing	140 Nm
Nuts - control beam bracket to drawbar	245 Nm

GENERAL DESCRIPTION – SINGLE SPEED POWER TAKE-OFF.

540 rev/min live and ground speed (Fig.1).
540 rev/min single speed only (Fig.2).

NOTE: *Ground speed is no longer fitted as standard and is available in kit form only.*

The PTO shaft projects from the rear of the tractor. It is supported at the rear by a ball bearing and at the front by a needle roller bearing housed in the end of the hydraulic pump drive shaft. Splined onto the front end of the PTO shaft is a sliding gear which is operated by a three position selector lever.

When the selector lever is moved rearwards the sliding gear moves forwards and the internal splines on the gear engage with the splines on the hydraulic pump drive shaft. The PTO shaft is then driven at a speed proportional to that of the engine, the standard shaft speed of 540 rev/min occurring at around 1789 engine rev/min, for example.

When the selector lever is moved forwards the sliding gear moves rearwards and the gear teeth engage with a gear splined onto the rear axle driving pinion. The PTO shaft is now driven by the wheel drive transmission system and its speed is directly related to the ground speed of the tractor.

When the selector lever is moved to the mid-position, the sliding gear moves to neutral and the PTO drive is disengaged.

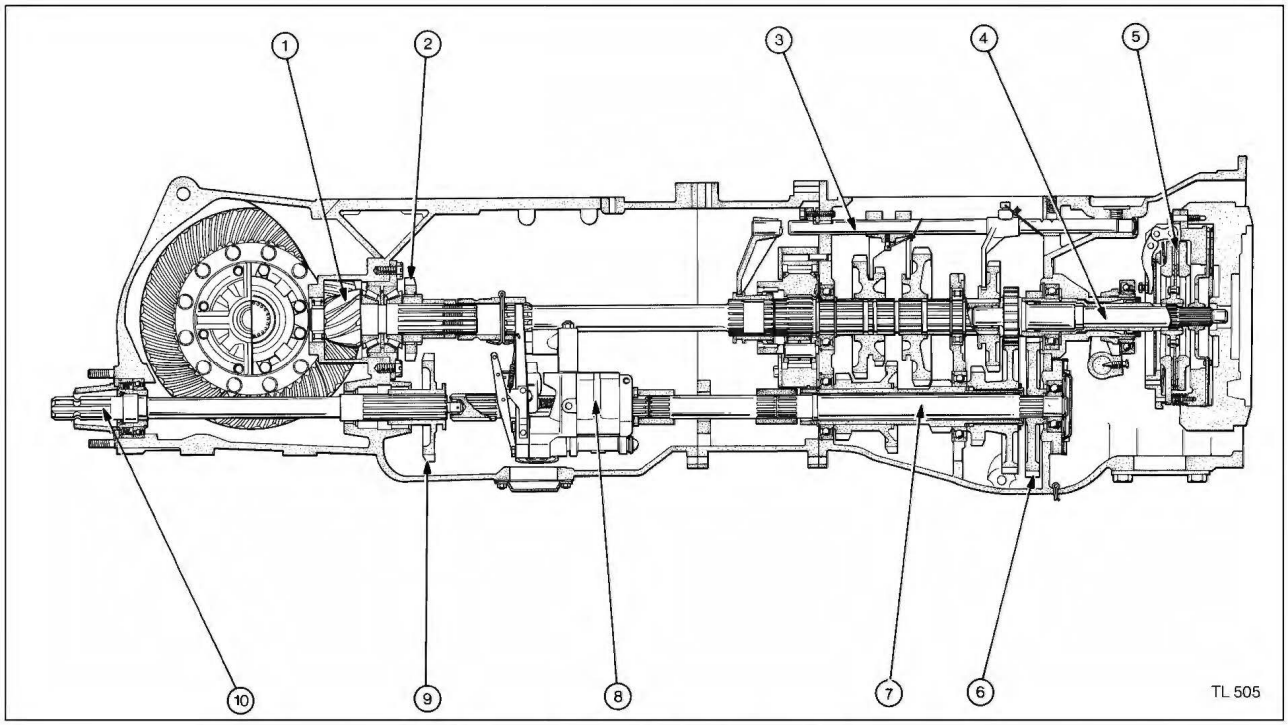


Fig.1 Live and ground speed power take-off

1. Pinion
2. Ground speed gear
3. Gearbox
4. PTO input shaft
5. PTO clutch plate
6. PTO constant mesh gears
7. PTO layshaft
8. Lift pump
9. Coupler gear
10. PTO shaft (540 rev/min)

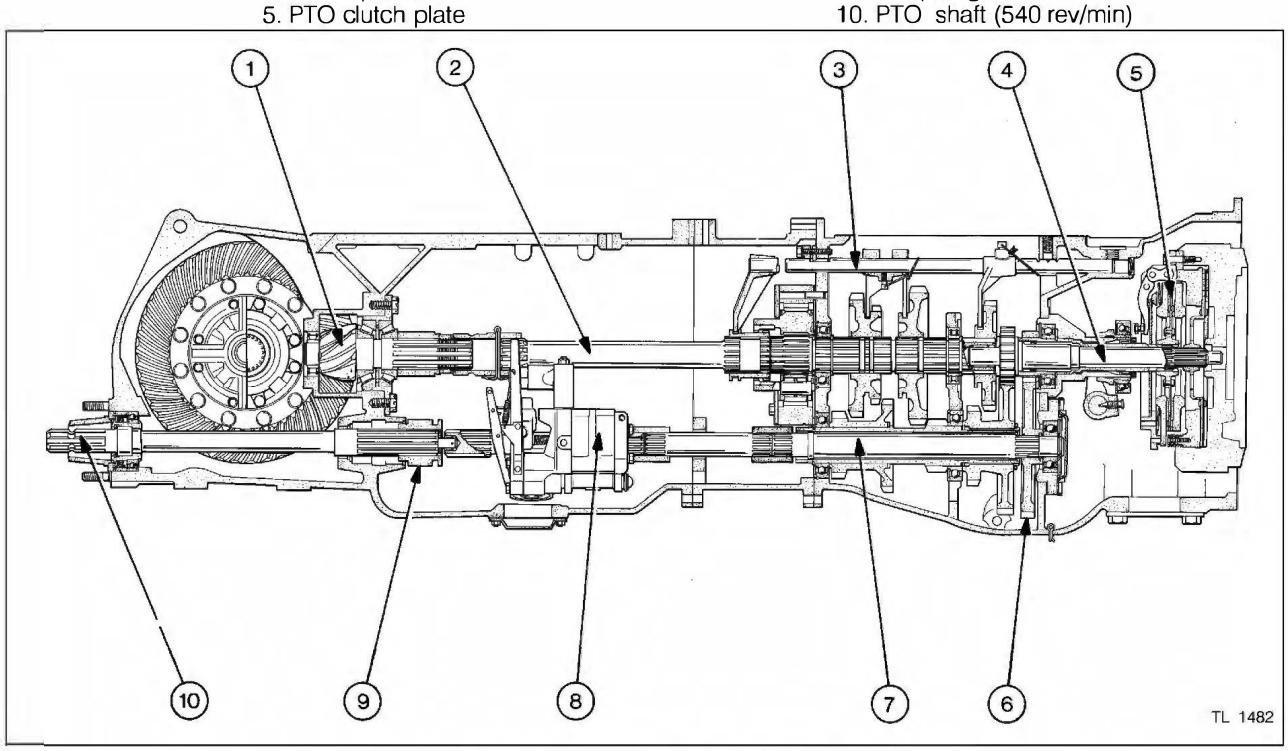


Fig.2 Single speed power take-off

1. Rear axle
2. Drive shaft
3. Gearbox
4. PTO input shaft
5. PTO clutch plate
6. PTO constant mesh gears
7. PTO layshaft
8. Lift pump
9. Coupler
10. PTO shaft (540 rev/min)

PTO SHAFT, OIL SEAL AND BEARING

Overhaul **2.07A–01**

Special Tools:
MF.168 Seal remover
MF.364 Seal replacer
MS.550 Universal handle

Dis-assembly

Up to tractors serial No. P38478.

1. Drain the centre housing of transmission oil and engage the PTO.
2. Remove the bolt.
3. Remove the PTO shield.
4. Detach the bottom of the control beam.
5. Unscrew the PTO cap.
6. Remove the two centre bolts and washers.
7. Remove the four nuts, washers and, when necessary, eight spacers.
8. Remove the control beam bracket or the check chain anchor bracket.
9. Remove the seal housing plate.
10. Withdraw the oil seal housing by screwing on the PTO cap and pulling the cap, seal housing and shaft assembly out of the centre housing.

Oil seal

11. Remove and discard the 'O' ring.
12. Using MF.168 and handle MS.550, remove and discard the lip seal and metal shield.

Shaft

13. Withdraw the PTO shaft.

Bearing

14. Remove the snap ring.
15. Using a length of 60 mm internal diameter tube, drive the bearing forwards off the shaft.

Re-assembly

Bearing

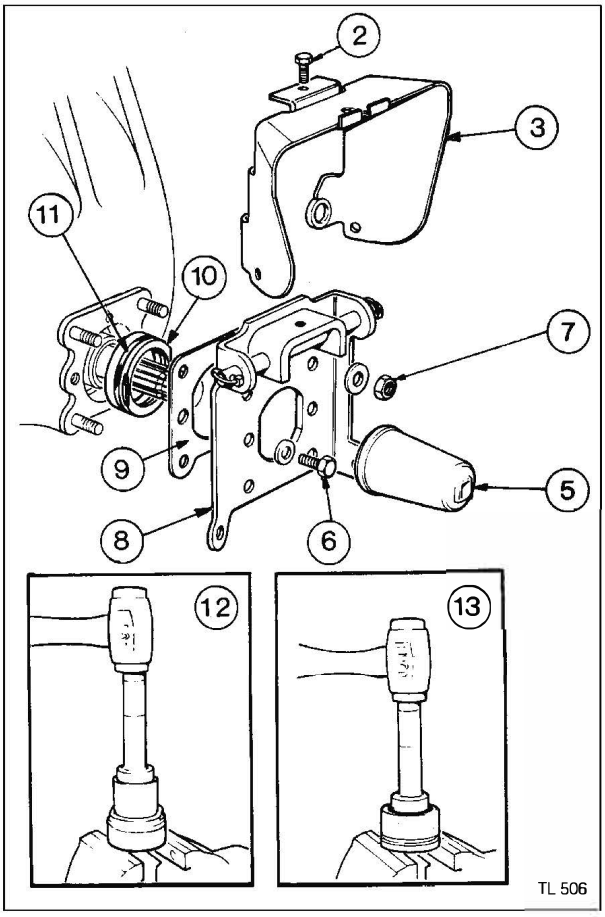
16. Using a hydraulic press, press the new ball bearing onto the PTO shaft.
17. Fit a new snap ring and ensure that it locks correctly in its groove.

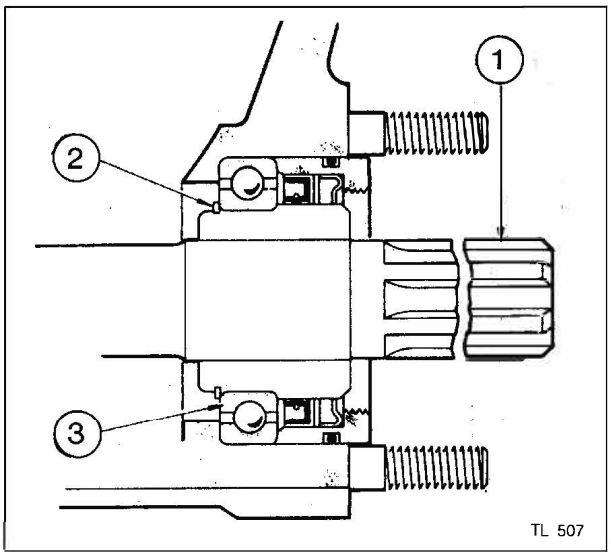
Shaft

18. Slide in the PTO shaft, taking care to align the internal splines and to keep the shaft horizontal.

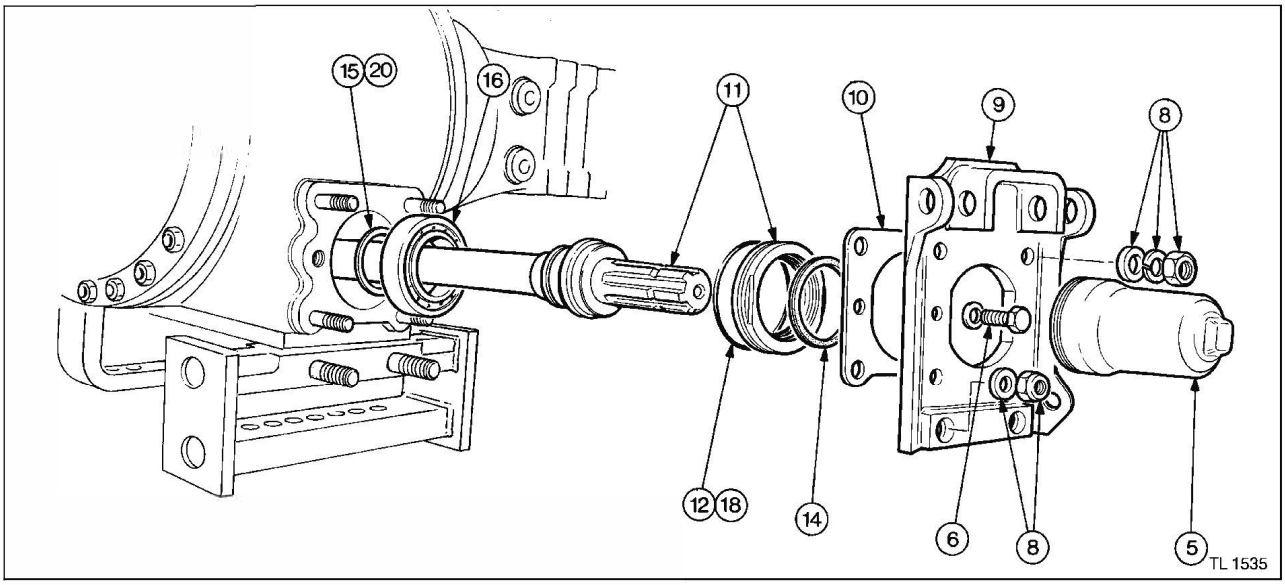
Oil seal

19. Press in the new metal shield, lip curving upwards, to the full limit of its travel.





20. Using MF.364 and handle MS.550 press in the lip seal, lip curving upwards; this will ensure that the lip face of the seal is 1, mm below the edge of the oil seal housing.
21. Fit a new 'O' ring.
22. Fit the oil seal housing so the two flats are vertical.
23. Reverse procedures 1 to 8 except:
    a. Tighten the four retaining nuts with spacers to a torque of 140 Nm.



PTO SHAFT, BEARING AND OIL SEAL

Removal and refitment **2.07A–02**

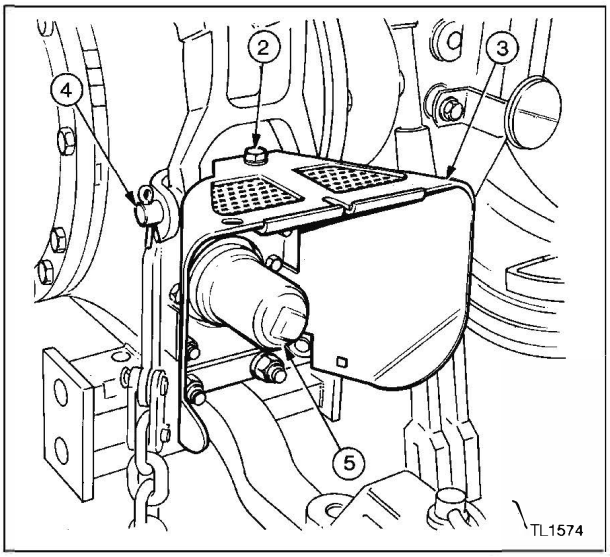
Special Tools:
MF.168 Seal remover
MF.364A Seal replacer
MF.474 PTO Seal guide and installer
MS.550 Universal handle

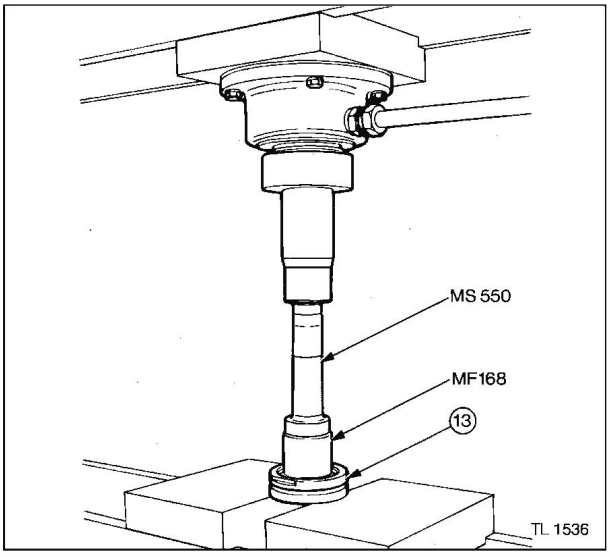
Removal

Tractors serial No. P38479 onwards

CAUTION: To ensure leak proof installation of the rear PTO oil seal assembly, special service tools MF.364A and MF.474 MUST be used as described below.

1. Drain the transmission oil and engage the PTO.
2. Remove the bolt.
3. Remove the PTO shield.
4. Detach the bottom of the control beam.
5. Unscrew the PTO cap.
6. Remove the two centre bolts and washers.
7. Remove the four nuts, washers, spacers and tab washers, if fitted.
8. Remove the two nuts from drawbar bracket.
9. Remove the control beam/check chain bracket.
10. Remove the seal housing plate.
11. Remove the oil seal housing and shaft by screwing on the PTO cap and pulling the cap, withdrawing the shaft and housing from the rear axle.
12. Remove and discard the 'O' ring.
13. Using MF.168 and handle MS.550 press the lip seal out of the housing.

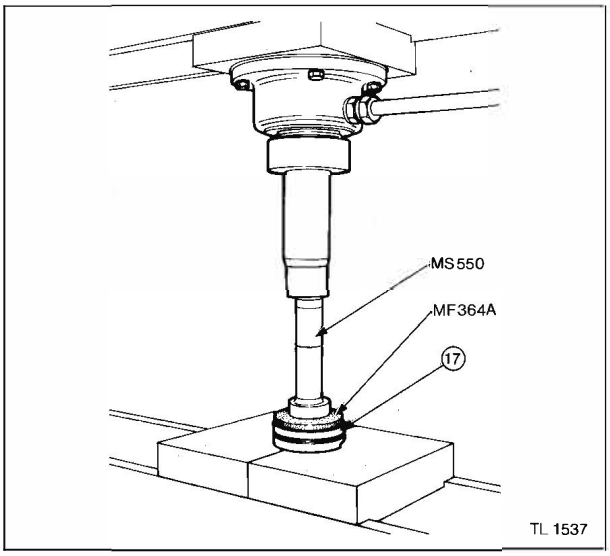




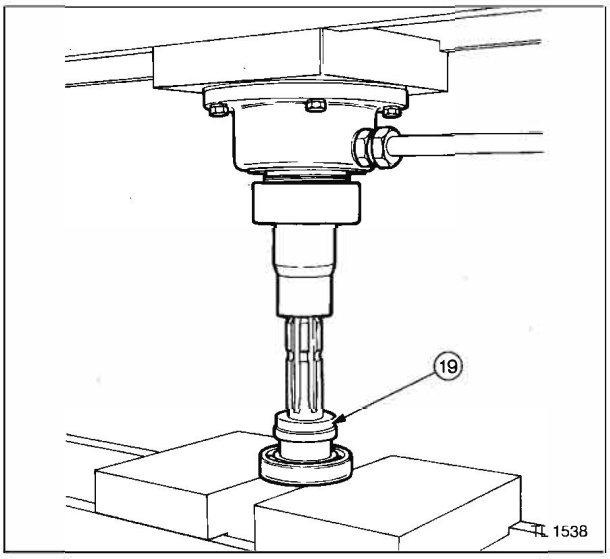
14. Remove the triple lip dirt seal from the shaft and discard.
15. Remove the snap ring.
16. Using a length of 60 mm internal diameter tube, drive the bearing off the shaft.

Refitment

17. Using MF.364A and MS.550 press the lip seal into the oil seal housing with the lip towards the tool; this will ensure that the oil seal is 1 mm below the edge of the housing.



18. Fit a new 'O' ring.
19. Using a hydraulic press, press the new ball bearing onto the PTO shaft.
20. Fit a new snap ring and ensure that it locates correctly in its groove.
21. Slide the PTO shaft into the rear axle, taking care to keep it horizontal to align the internal splines.



22. Place MF.474-1 seal guide onto the PTO shaft, and push the oil seal housing into the rear axle so that the two flats are vertical.

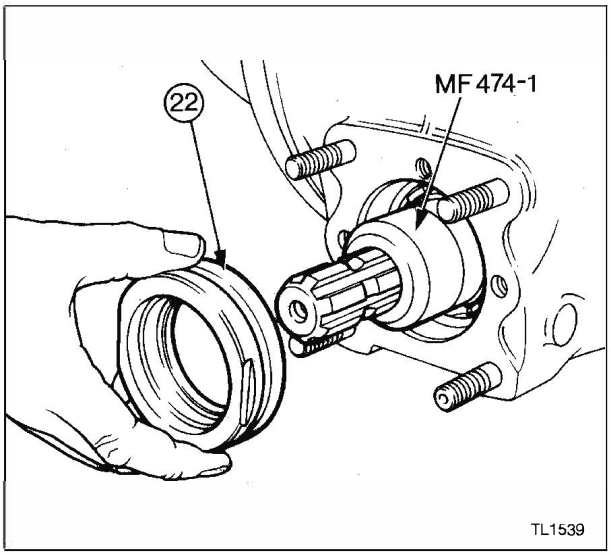
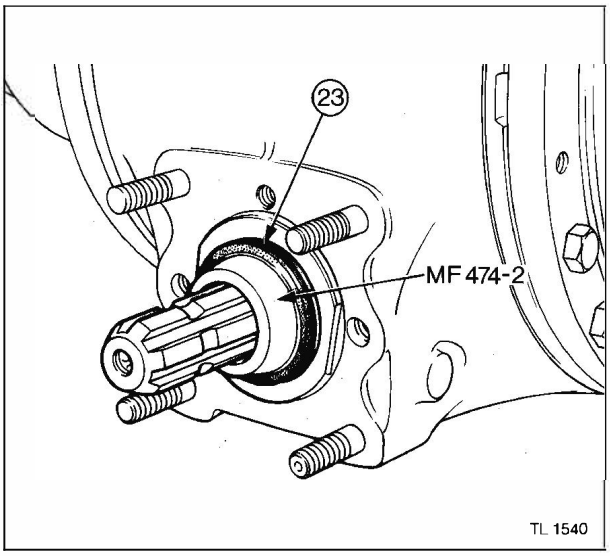
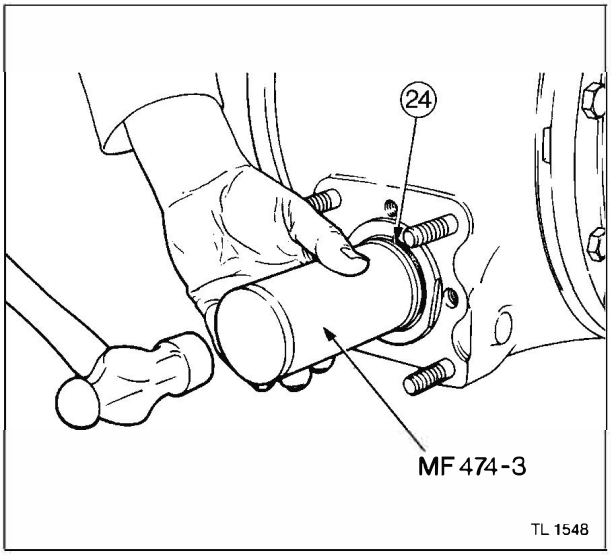


Fig.1

23. Place seal guide MF.474-2 onto the PTO shaft, coat the triple lip dirt seal liberally with general purpose grease and slide it down the PTO shaft and onto the seal guide. The internal radiused edge of the seal must lead onto the shaft.



24. Drive the seal into place on the shaft using MF.474-3 seal installer until it comes in contact with the shoulder.
25. Reverse procedures 1 to 10 except:
    a. Tighten the four retaining nuts with spacers to a torque of 140 Nm.
    b. Tighten the two nuts retaining the drawbar bracket to the check chain bracket to a torque of 245 Nm.



GROUND SPEED GEARS AND BEARINGS

Removal and refitment **2.07A–03**

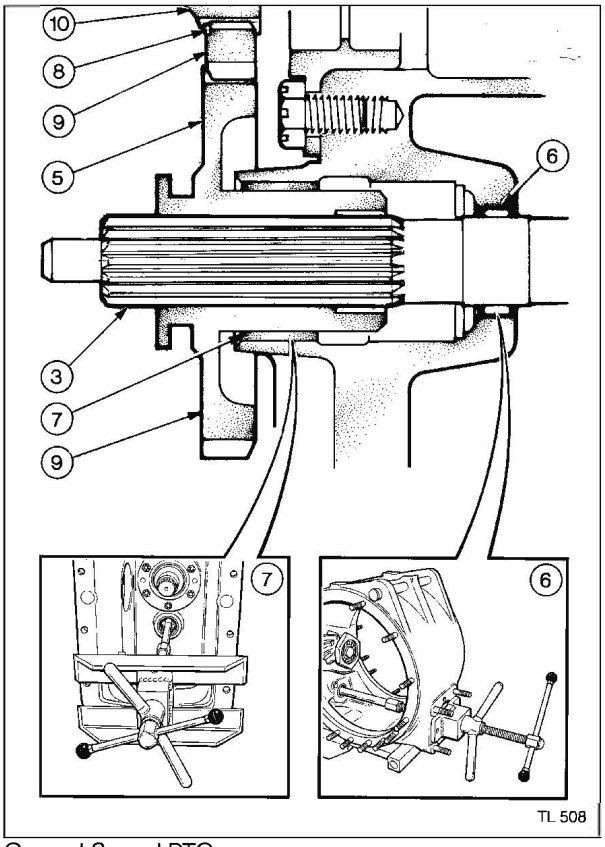
Special Tools:
MF.168 PTO shaft oil seal remover and bush replacer
MF.195C Bearing remover/replacer (main tool)
MF.195–5B PTO needle bearing remover/replacer
MF.195–6B Needle bearing and bush remover/replacer
MS.550 Handle

Removal

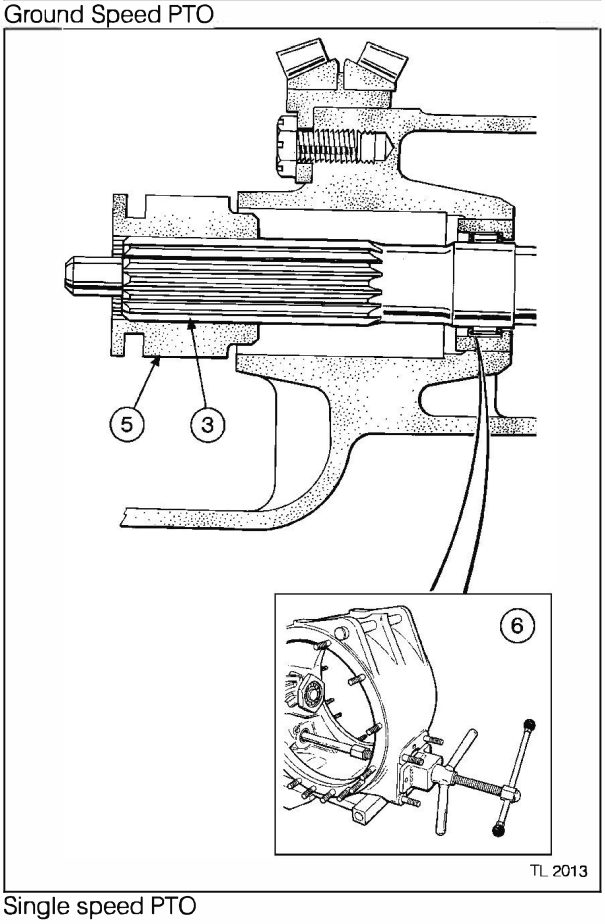
1. Split the tractor between the rear centre housing and gearbox, see operation 2.02A-05 or 2.02A-06.
2. Remove the left-hand trumpet housing and the differential unit, see operation 2.06C-06.
3. Remove the PTO shaft, see operation 2.07A-01.
4. Remove the hydraulic linkage pump, see operation 2.09A-12.
5. Remove the ground speed gear or coupler.
6. Using MF.195C, main puller, MF.195-5B/2, extension rod and MF.195-5B/1, collet, remove the PTO shaft support needle bearing rearwards.
7. Using MF.195C, main puller, MF.195-5B/2, extension rod, and MF.195-6B/1, collet, in conjunction with two pieces of angle bar, pull the bush out of the housing.
8. Remove the retainer ring.
9. Remove the ground speed gear, if fitted.
10. Renew the drive gear splined hub, if necessary, see operation 2.06B-06.

Refitment

11. Reverse procedures 8 to 10 except:
    a. Renew the retainer ring.
    b. Ensure that the retainer ring locates correctly in its groove.
12. Using MF.168 and handle MS.550, drive the new bush into its bore until it is flush with the inner end of the chamfer, 2 mm in from the chamfered face.
13. Using MF.195C, main puller, MF.195-5B/2, extension rod and MF.195-5B/1, collet, in conjunction with two pieces of angle bar, pull the needle bearing into its bore until flush with the rear face.
14. Reverse procedures 1 to 5 except:
    a. When fitting the linkage pump, ensure that the needle bearing in the rear end of the camshaft is in good condition.
    b. Renew all 'O' rings, oil seals and gaskets.



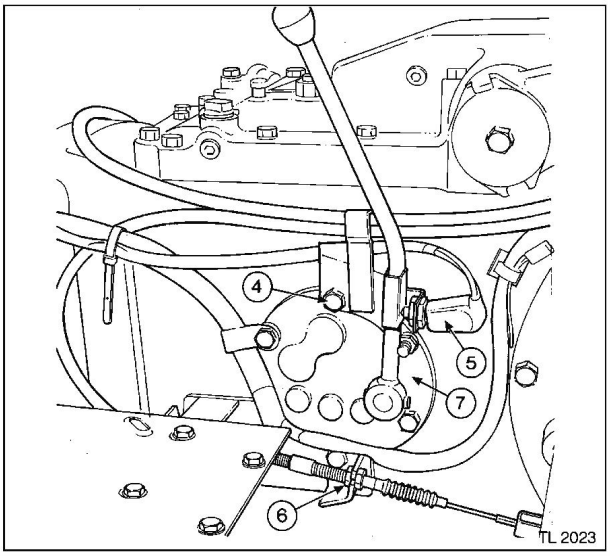
Ground Speed PTO



Single speed PTO

LEFT-HAND PTO SIDE COVER

Removal and refitment **2.07A–04**

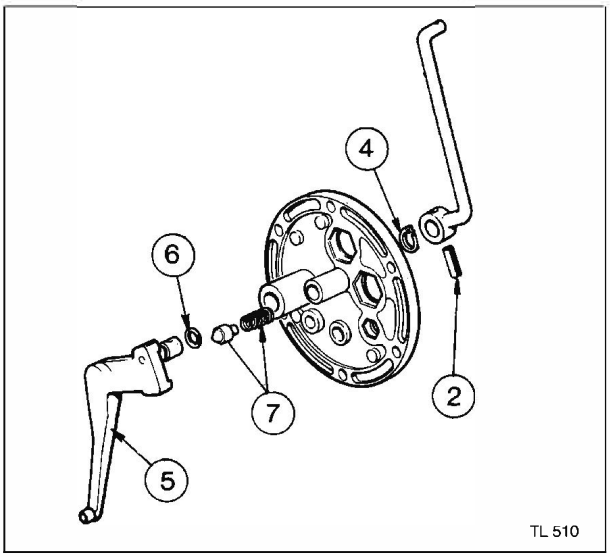


Removal

1. Drain the transmission oil to the LOW mark on the dipstick.
2. Remove the brake actuator, see operation 2.06A-01.
3. Disconnect the auxiliary hydraulic pipes from the side cover, if fitted.
4. Remove the six bolts.
5. Disconnect the wires and remove the PTO safety start switch.
6. Remove the parking brake cable bracket.
7. Remove the side cover.
8. Remove and discard the gasket.

Refitment

9. Reverse procedures 1 to 7 except:
   a. Fit a new gasket.
   b. Locate the shift lever in the annulus of the ground speed gear or shift collar.
   c. Seal the six bolt threads with Hylomar sealant.



LEFT-HAND PTO SIDE COVER

Overhaul **2.07A–05**

Dis-assembly

1. Remove the PTO side cover, see operation 2.07A-04.
2. Drift out and discard the roll pin.
3. Remove the PTO lever.
4. Remove the circlip.
5. Remove the shift lever.
6. Remove and discard the 'O' ring.
7. Remove the detent plunger and spring.

Re-assembly

8. Reverse procedures 1 to 7 except:
   a. Fit a new 'O' ring.
   b. Fit a new roll pin.

Page left blank intentionally

SECTION 8

Front axle

INDEX

8A	2 WHEEL DRIVE - 3 CYLINDER TRACTORS
8B	2 WHEEL DRIVE - 4 & 6 CYLINDER TRACTORS
8C	4 WHEEL DRIVE

FRONT AXLE – 2 WHEELDRIVE – 3 CYLINDER TRACTORS

Section 10 – Part A

Table of Contents

Operation No	Description	Page No
—	Specification	2
—	General Description	2
10A-01	Front wheel toe-in – Adjust	4
10A-02	Front hub – Adjust	4
10A-03	Front hub – Overhaul	5
10A-04	Spindle shaft – Removal	6
10A-05	Spindle housing – Removal	7
10A-06	Spindle housing – Overhaul	8
10A-07	Beam Assembly – Removal	9
10A-08	Front axle support casting – Removal	10
10A-09	Front Axle Support – Overhaul	11

FRONT AXLE – 2 WHEELDRIVE – 3 CYLINDER TRACTORS

Specification

Track settings:

No	7
Minimum	1227 mm (48 in)
Maximum	1837 mm (72 in)
Increments	101 mm (4 in)

Wheel Camber angle

M-F 340, 350	3° 30′
M-F 355, 360, 362	5°

Wheel Castor angle

M-F 340, 350	4° 56′
M-F 355, 360, 362	4° 56′

Front wheel toe-in	0–5mm (0-3⁄16in)
Axle beam to support casting clearance	0,05-0,25 mm (0.002-0.010 in)
Steering arm to spindle housing clearance	0-0,05 mm (0-0.002 in)

Special Tools

MF 263A	Bush remover – main tool
MF 263-2/2	Extractor – 38,1 mm (1.5 in) dia
MF 263-2/1	Bush replacer – 38,1 mm (1.5 in) dia
MF 263-3/1	Bush replacer – 47,6 mm (1.875 in) dia
MF 264	Bush reamer – maintool
MF 264-1/1	Bush reamer – 38,1 mm (1.5 in) dia
MF 264-2/1	Bush reamer – 47,6 mm (1.875 in) dia
MF 264-1/2	Reamer guide – 38,1 mm (1.5 in) dia
MF 264-2/2	Reamer guide – 47,6 mm (1.875 in) dia
MF 444	Axle pivot pin remover
MS 550	Handle

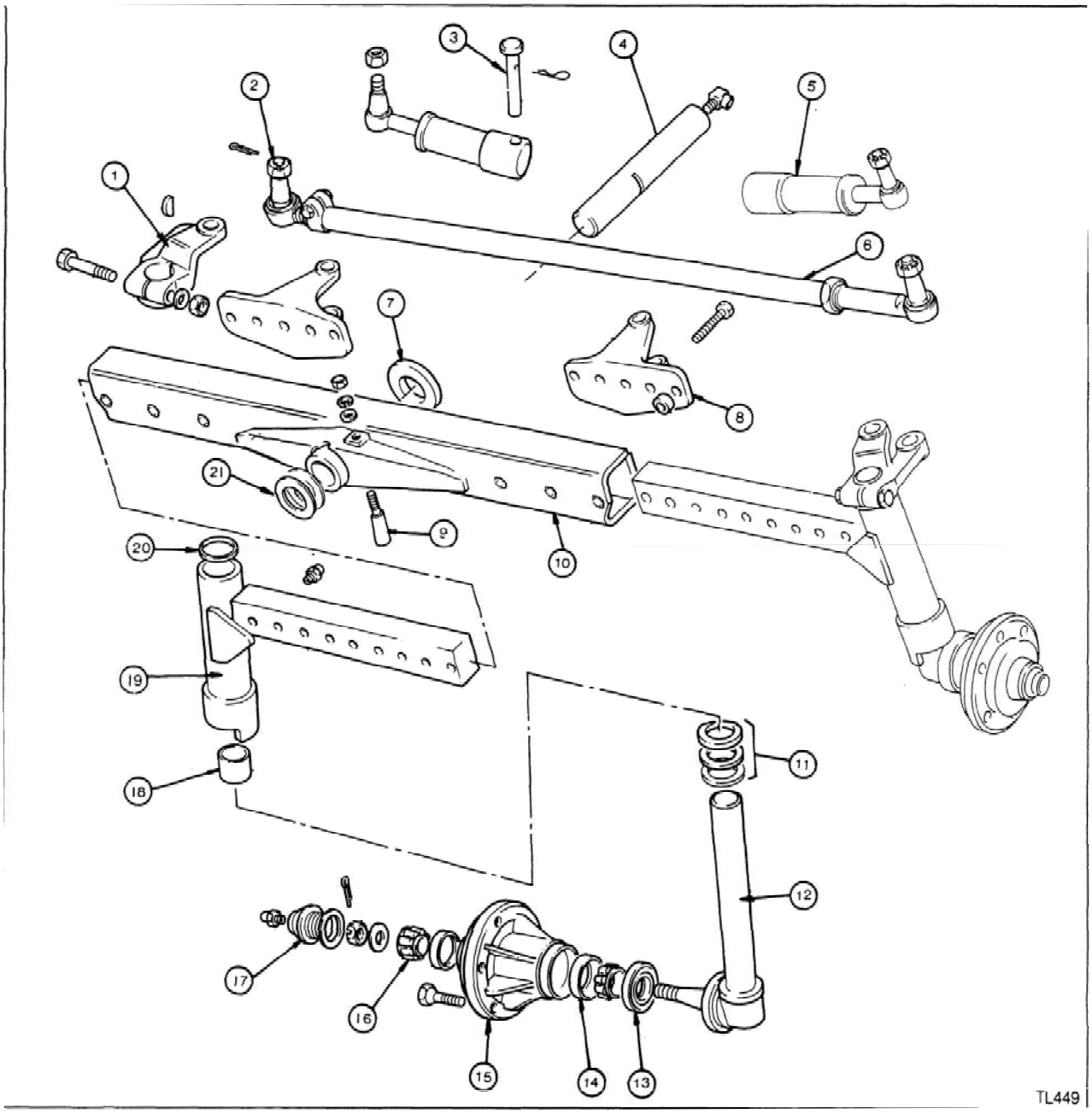
Bolt Torques

Track rod to steering arm	80-100 Nm (59-74 lbf ft)
Steering ram to steering arm	75- 90 Nm (55-66 lbf ft)
Wheel hub cap bolts	20- 28 Nm (15- 21 lbf ft)
Wheel nuts	See Section 8D
Steering arm to spindle	125-165 Nm (92-122 lbf ft)
Track rod clamp bolts	45- 55 Nm (33- 41 lbf ft)
Spindle housings to axle beam	180-230 Nm (134-170 lbf ft)
Axle support casting to engine	240-320 Nm (177-236 lbf ft)

General Description

The front axle assembly consists of a axle beam and two spindle housing assemblies. The axle beam pivots on a pin which is secured to the axle beam. The spindle housing assemblies can be bolted to the axle beam in alternative positions to provide front wheel track adjustment. Figure 1 shows the general arrangement of the front axle assembly.

FRONT AXLE – 2 WHEELDRIVE – 3 CYLINDER TRACTORS

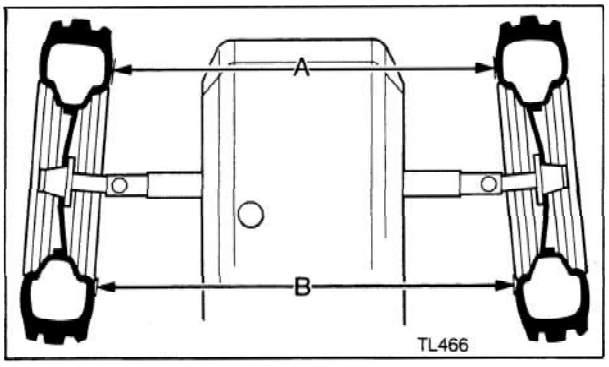


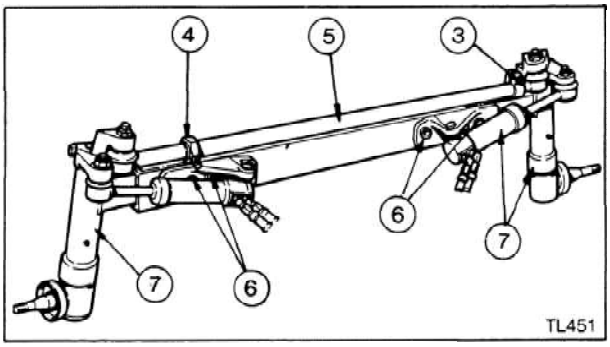
1. Steering arm
2. Ball joint
3. Steering ram pivot pin
4. Pivot pin
5. Steering ram
6. Track rod
7. Thrust washer
8. Steering ram bracket
9. Taper pin
10. Axle beam
11. Thrust washers
12. Spindle
13. Oil seal
14. Taper roller bearing
15. Hub
16. Taper roller bearing
17. Hub cap
18. Bush
19. Spindle arm
20. Seal
21. Shims

Front Wheel Toe-In

Adjustment 10A-01

1. The tractor must be on firm level ground with the wheels facing straight ahead.
2. To check the toe-in, see illustration. Distance B must be 0 to 5mm (0-3⁄16in) greater than distance A, measured on the centre line of the axle, at the wheel rim.
   If adjustment is required:
3. Loosen the bolt and nut.
4. Slacken the setscrew.
5. Screw-out the track rod tube to increase toe-in. Screw-in track rod tube to decrease toe-in.
6. Locate the setscrew in its hole and tighten to a torque of 45-55 Nm (33-41 lbf ft).
7. Retighten the nut and bolt to a torque of 45-55 Nm (33-41 lbf ft).

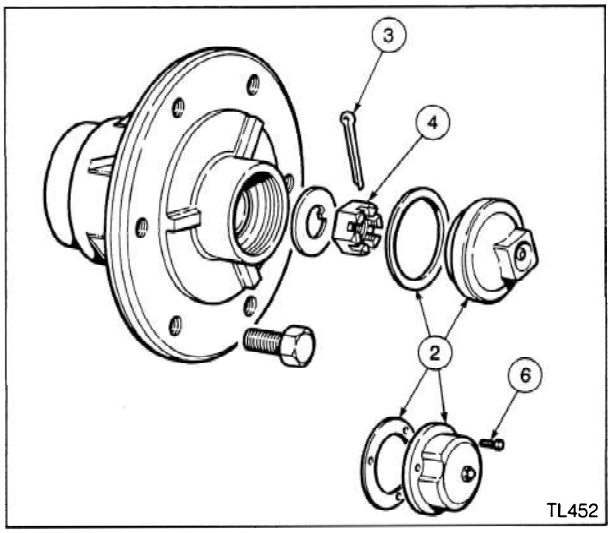




Front Hub

Adjust 10A-02

1. Raise the front wheel off the ground and check the wheel bearings for excessive free play. If movement is found adjust the bearing pre-load as follows:
2. Remove the hub cap.
3. Remove the split pin.
4. Tighten the slotted nut to 80 Nm (60 lb/ft) and then slacken off the nut to the nearest split pin hole to give the correct end float.
5. Fit a new split pin.
6. Refit the hub cap and torque the bolts to 20-28 Nm (15-21 lbf ft). On the M-F 350 tractors tighten the screwed cap.
7. Grease the hub until clean grease appears from the seal.



Front Hub

Overhaul 10A-03

Disassembly

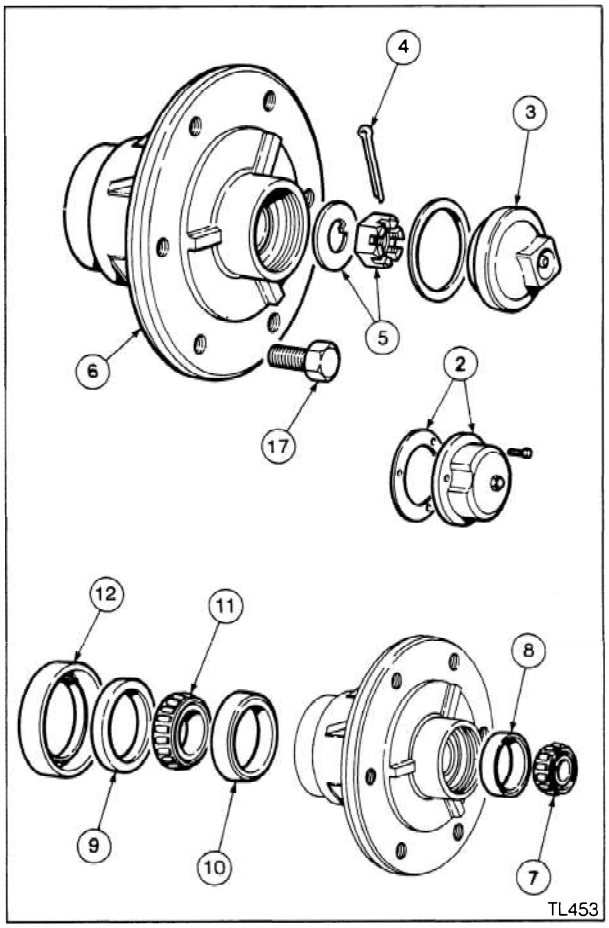
1. Raise front of tractor and remove the wheel.
2. Remove the hub cap and gasket (M-F 355 and M-F 360).
3. For M-F 350 the hub-cap is a screw thread connection. No gasket is used.
4. Remove and discard the split pin.
5. Remove the slotted nut and washer.
6. Remove the hub assembly complete with bearing and seal from the spindle housing assembly.
7. Remove the outer bearing cone.
8. Tap out the outer bearing cup.
9. Remove the seal.
10. Drive out the inner bearing cup.
11. Remove the bearing cone.
12. Remove the dust shield.

Examination

13. Completely clean the hub components using paraffin and check the condition of the hub, spindle and bearings. Any worn or damaged components should be replaced. Always fit a new seal with the lip facing outward and fit the seal right into the recess of the hub.

Reassembly

14. Reverse procedures 1 to 11.
15. Pack the bearings with an approved grease during assembly.
16. Tighten the slotted nut to 80 Nm (60 lb/ft) then slacken off the nut to the nearest pin hole to give the correct end float.
17. Refit the hub cap and torque the bolts to 20-28 Nm (15-21 lbf ft). On the M-F 350 tractors tighten the screwed cap.
18. Grease the hub until grease appears from the seal inside the hub.
19. For wheel nut torques see section 8D.



Spindle Shaft

Removal and Refitment 10A-04

Removal

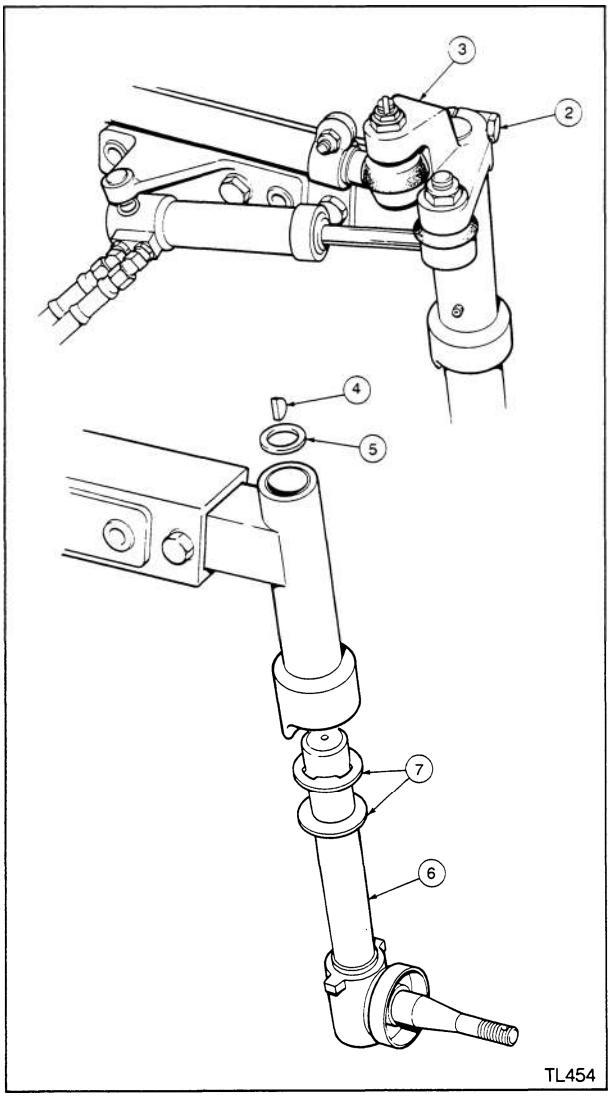
1. Remove the hub, see operation 10A-03.
2. Remove the nut and bolt.
3. Detach the steering arm.
4. Remove the key.
5. Remove the dust seal.
6. Lower the spindle shaft from the housing.
7. Remove the thrust washer and spacer from the spindle.

Examination

Examine the the spindle shaft thrust bearings for wear or damage and replace if necessary.

Refitment

8. Reverse the procedures 1-7 except:
   a. Renew the dust seal.
   b. Lubricate thrust bearings with an approved grease before reassembly.
   c. Fit the spacer to the spindle shaft followed by the thrust washer with the indentations in the bronze face facing downwards in contact with the spacer.
   d. Refit the bolt to the steering arm with the nut on the inside.
   e. Tighten the steering arm nut to a torque of 125-165 Nm (94-122 lbf ft).
   f. With the hub and spindle assembly held firmly against the thrust bearings, measure the gap between the steering arm and the spindle housing, using feeler gauges, the clearance between the arm and housing after assembly should be 0,05 mm (0.002 in) maximum.
   g. Grease the spindle bearings with the wheels off the ground until grease appears at the top and the bottom of the housing.



Spindle Housing

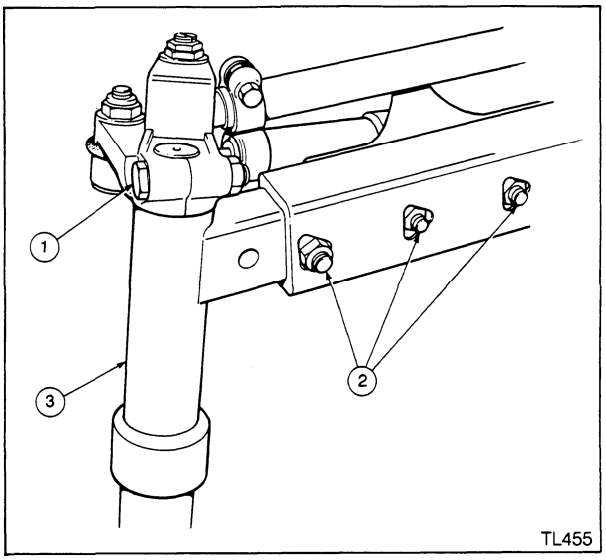
Removal & Refitment 10A-05

Removal

1. Remove spindle shaft, see operation 10A-04.
2. Remove the three nuts and bolts.
3. Withdraw the spindle housing.

Refitment

4. Reverse procedures 1 to 3 except: Tighten the axle beam bolts to a torque of 180-230 Nm (133-170 lbf ft) with wheels on the ground.



Spindle Housing

Overhaul 10A-06

Special Tools:

MF263	*Bush Remover – main tool*
MF263-2/1	*Bush replacer*
MF263-2/2	*Extractor*
MF264	*Reamer Handle – main tool*
MF264-1/1	*Reamer*
MF264-1/2	*Reamer guide*
MS550	*Universal handle*

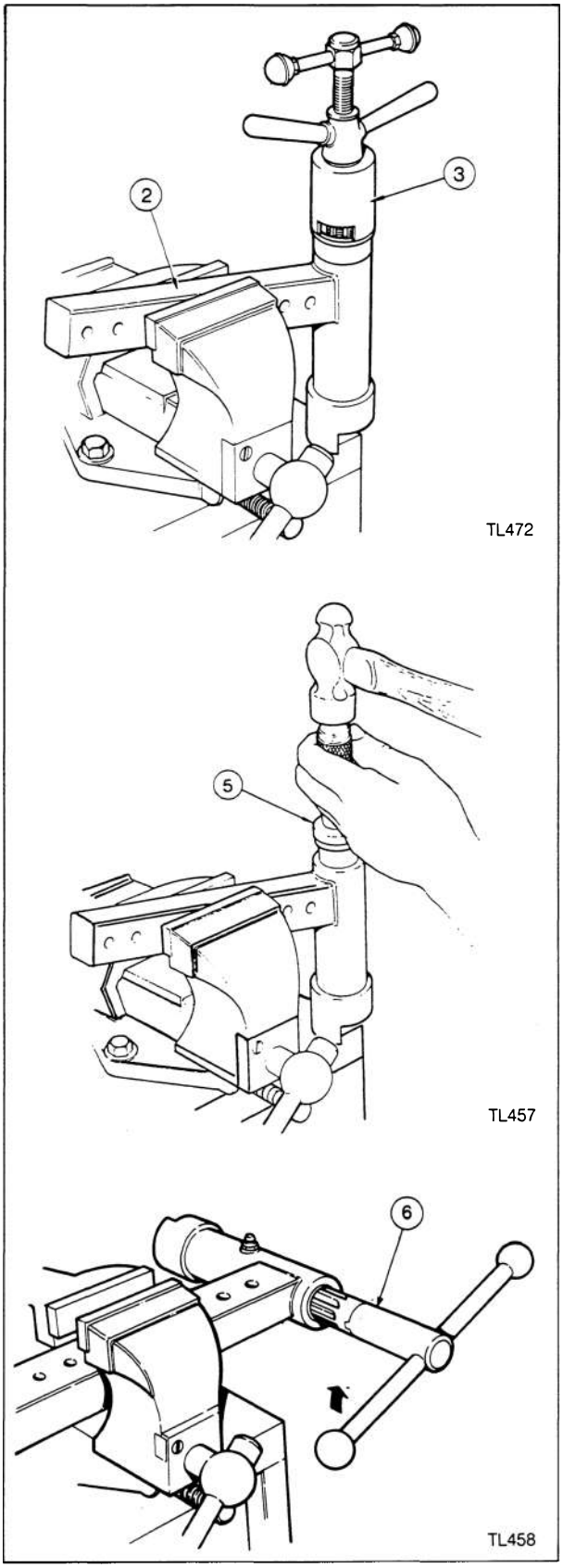
Disassembly

1. Remove the spindle shaft housing, see operation 10A-05.
2. Secure the spindle housing in a vice.
3. Using MF263 and MF263-2/2 remove the bush by screwing the threaded extractor into the bush with the upper handle. Withdraw the bush by turning the lower handle.
4. Invert the housing and remove the other bush.

Reassembly

5. Using the MS550 Handle and the MF263-2/1 replacer, drive in a new bush at each end of the housing.
6. Fit the MF264-1/1 reamer to the MF264 main tool and pass the guide bar through the housing. Fit the reamer guide MF264-1/2 on to the guide bar and into the housing. This will ensure that the bush is reamed parallel.
7. Ream the upper bush to size.
8. Turn the equipment over and ream the lower bush to size.
9. Remove all swarf from the housing and ensure the grease nipple hole is clear.
10. Refit spindle shaft, see operation 10A-05.
11. Reverse procedures 2 and 3, to tighten the axle nuts and bolts into their mounted position, then tighten the axle beam nuts and bolts to 180-220 Nm (134-162 lbf ft).

Note: Ensure all parts are suitably greased before reassembly.



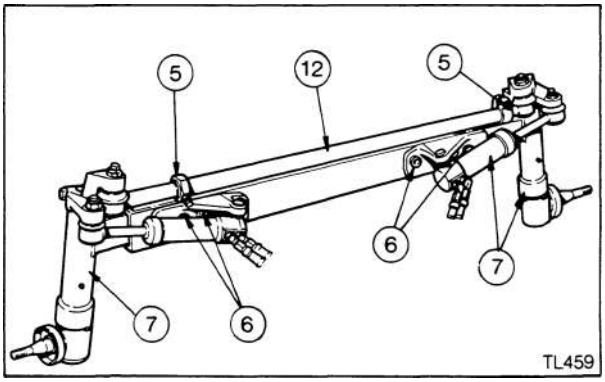
Axle Beam Assembly

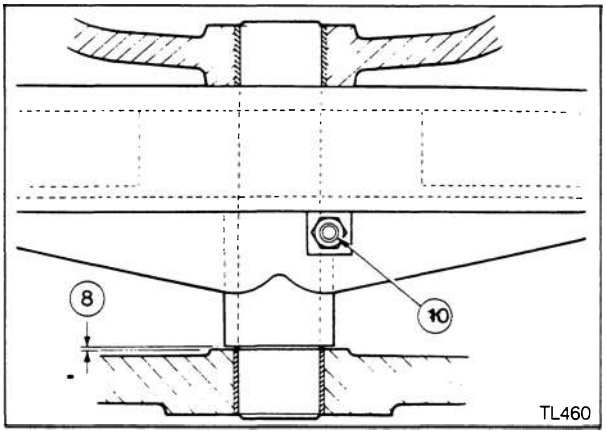
Removal and Refitment 10A-07

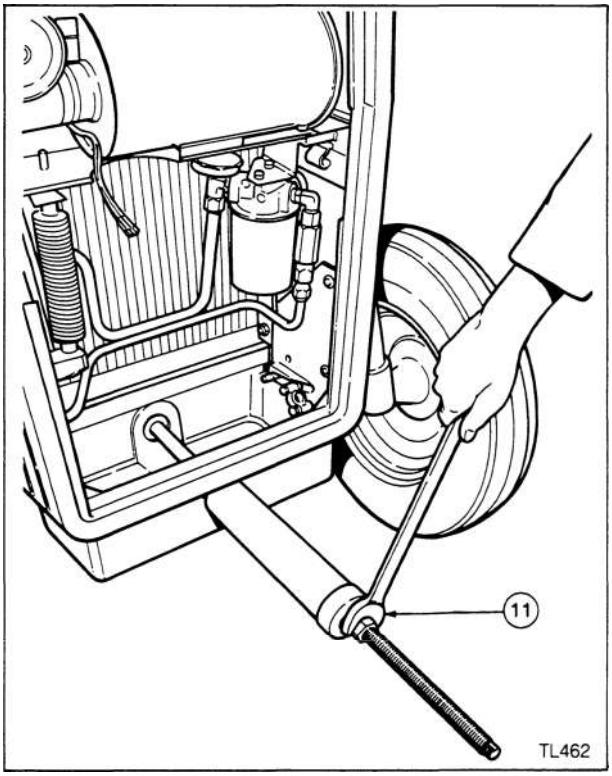
Special tools: MF 444 Pivot pin remover

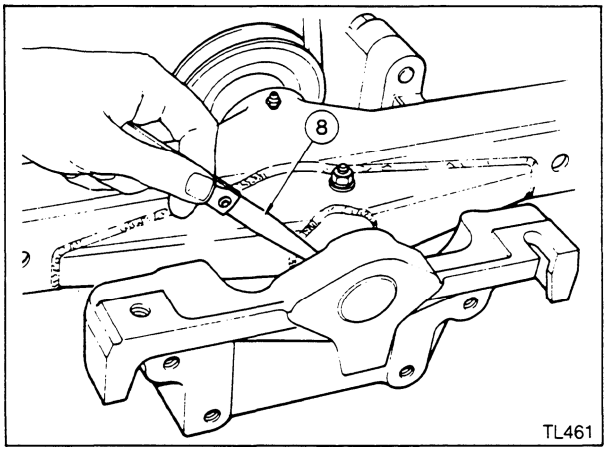
Removal

1. Remove the front weights, weight frame and guard.
2. Support the tractor under the engine sump.
3. Raise the tractor at the front.
4. Disconnect and plug the hydraulic hoses from the steering rams on each side.
5. Remove the setscrew from the track rod assembly.
6. Remove the three nuts and bolts from each end of the the axle beam.
7. Withdraw the spindle housings complete with wheels and steering rams.
8. Push the axle beam back on its pivot pin against the thrust washer. Using feeler gauges check the gap between the front boss on the beam and casting. If it exceeds 0,25 mm (0.10 in) note the dimension.
9. Disconnect the remote greaser tube.
10. Remove locknut, washer and taper pin.
11. With the axle beam supported on both sides, using MF444 and the 7/16 in UNC adaptor, remove the pivot pin from the casting.
12. Lift and remove the beam, thrust washer and shims out from the side of the tractor.









Examination

13. Check the end face of the axle beam boss, the pivot pin and thrust washer for wear. Examine all surfaces for wear or damage. In the event of accident damage check the beam for bending or twisting. If the beam has been in any way deformed, it must be replaced, as steering characteristics and tyre wear can be severely affected. Also the beam may have been dangerously weakened due to straining of the welded seams.

Refitment

14. Reverse procedures 1 to 12 except:
    a. If gap between front boss on beam and the casting, exceeds 0,25 mm (0.010 in) suitable shims from the following chart must be selected to give a gap of 0,05 mm (0.002 in) minimum to 0,25 mm (0.010 in) maximum. Shims must be fitted to the front of the beam and thrust washer to the rear.

Part number	Shim thickness	
	mm	in
898 018 M1	0,70 to 0,76	0.028 to 0.030
898 019 M1	0,86 to 0,91	0.034 to 0.036
898 020 M1	0,99 to 1,04	0.039 to 0.041
882 868 M1	1,12 to 1,17	0.044 to 0.046
882 869 M1	1,24 to 1,30	0.049 to 0.051

    b. Ensure that the tapered pin is located correctly in the hole and the groove in the pivot pin, then tighten nut and lockwasher to a torque of 80-140 Nm (70-110 lbf ft).
    c. Tighten track rod setscrew to a torque of 45-55 Nm (33-41 lbf ft).
    d. Tighten bolts and nuts, securing spindle housings into the axle beam, to a torque of 180-230 Nm (133-170 lbf ft) with the wheels on the ground.

Axle Support Casting

Removal and Refitment 10A-08

Special tools: MF444 Axle pivot pin remover

Removal

1. Remove the front weights and weight frame.
2. Remove the front grille and disconnect the headlights.
3. Remove the hood and side panels.
4. Remove the air cleaner.
5. Disconnect the hydraulic hoses and pipes as necessary.
6. Remove the fuel tank.
7. Remove the battery.
8. Remove the radiator and oil cooler assembly.
9. Remove the nose.
10. Support the tractor under the engine.
11. Support the axle beam to prevent it rolling over after removal of the pivot pin.
12. Using MF444 withdraw the axle beam pivot pin.
13. Lift the axle beam clear using a crane.
    or
    Lower the engine and support casting and wheel out the front axle and beam assembly.
14. Remove the four nuts and bolts and the two nuts and studs securing the front axle support assembly to the engine.
15. Take the weight of the front support casting on a trolley jack, then slide off the support casting – note the support casting is very heavy so care should be taken when handling it.

Refitment

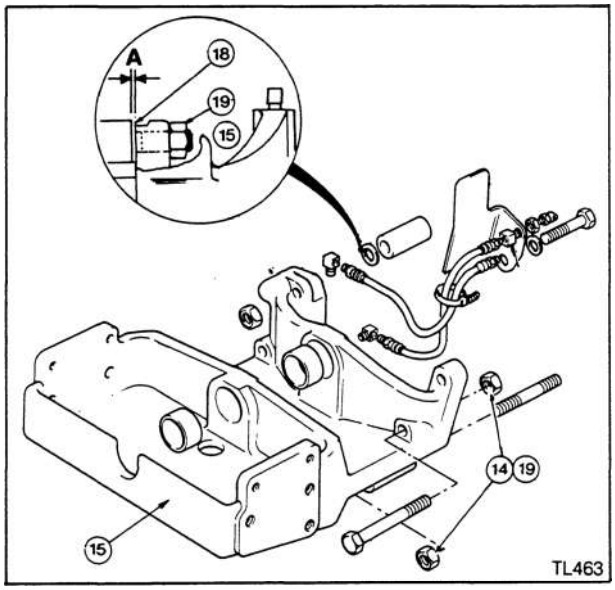
16. Reverse procedures 1 to 15.

Note: When refitting the front axle support, shims are fitted between the top spacer tube and the front axle support casting on the right hand side to give 0,13 mm (0.005 in) slack preload.

17. Fit the front support casting to the engine and tighten all bolts and nuts to a torque of 240-320 Nm (177-236 lbf ft) except the stud with the spacer tube.
18. Measure the gap 'A' with a feeler gauge between the tube and casting. Subtract from the dimension obtained 0,13 mm (0.005 in). Remove the casting and fit shims to this thickness.

Shim Part No	Thickness (mm)	Thickness (in)
377 126 X1	0,05 mm	0.002 in
365 690 X1	0,12 mm	0.006 in
365 691 X1	0,25 mm	0.010 in
377 127 X1	0,90 mm	0.036 in

19. Tighten all nuts and bolts securing the support casting to the engine to a torque of 240-320 Nm (177-236 lbf ft).



Front Axle Support

Overhaul 10A-09

Special Tools:

MF 263-3/1	*Bush Replacer*
MF 264	*Bush reamer – maintool*
MF 264-2/1	*Bush reamer*
MS 550	*Handle*

Removal

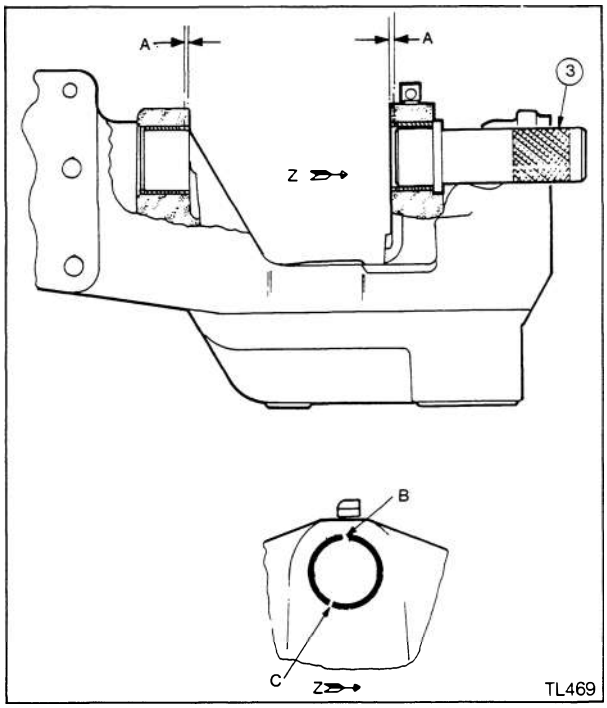
1. Remove the axle beam, see operation 10A-06.
2. Using a suitable drift, drive out the two bushes.

Refitment

3. Reverse procedures 1 and 2 except:
   a. Using MF 263-3/1 bush replacer and MS 550 handle refit the bushes.
   b. The bushes must be 0 to 0,50 mm (0 to 0.020 in) below the faces in the support adjacent to the axle beam 'A'.

Note: When fitting the bush, align the hole in the bush with the greaser tube opening, 'B', and the split in the bush must be as shown in the illustration 'C'.

Note: The pin must be free in the bush. If it is tight, use reamer MF264-2/1 and main tool MF264 to clean out the bush.



FRONT AXLE–2 WHEEL DRIVE–3 CYLINDER TRACTORS

FRONT AXLE – 2 WHEEL DRIVE
4 CYLINDER TRACTORS

Section 10 – Part B

Table of Contents

Operation No.	Description	Page No.
-------	Specification	2
-------	General Description	2
10B-01	Front wheel toe-in - Adjust	4
10B-02	Front hub - Adjust	5
10B-03	Front hub - Overhaul	5
10B-04	Spindle shaft - Removal	6
10B-05	Spindle housing - Removal	6
10B-06	Spindle housing - Overhaul	7
10B-07	Axle beam assembly - Removal	8
10B-08	Axle beam assembly - Overhaul	9
10B-09	Front axle support casting - Removal	10

FRONT AXLE – 2 WHEEL DRIVE

Specification

Front Track	
Normal duty	1247-1857 mm (50-74 in)
Model application	M-F 365, 375, 383, 390, 390T, 393 and 396
Heavy duty	1365-1975 mm (54-78 in)
Model application	M-F 398 and 399
Rowcrop (M-F 383 only)	1829-1439 mm (72-96 in)
Increments	101 mm (4 in)
Wheel camber angle	4º 30'
Wheel caster angle	0º
Axle beam to support casting clearance	0,05-0,25 mm (0.002-0.010 in)
Steering arm to spindle housing clearance	0-0,05 mm (0-0.002 in)
Front wheel toe-in	0-5 mm (0-3/16 in)

Special Tools

MF.263A	Bush remover - main tool
MF.263-3/2	Extractor - 47,6 mm (1.875 in) dia.
MF.263-5/1	Extractor - 44,5 mm (1.77 in) dia.
MF.263-3/1	Bush replacer - 47,6 mm (1.875 in) dia.
MF.263-5/2	Bush replacer - 44,5 mm (1.77 in) dia.
MF.264	Bush reamer - main tool
MF.264-2/1	Bush reamer - 47,6 mm (1.875 in) dia.
MF.264-8/1	Bush reamer - 44,5 mm (1.77 in) dia.
MF.264-2/2	Reamer guide - 47,6 mm (1.875 in) dia.
MF.264-8/2	Reamer guide - 44,5 mm (1.77 in) dia.
MF.444	Axle pivot pin remover
MS.550	Handle

Bolt torques

Track rod to ball joint	160-200 Nm (118-148 lbf ft)
Track rod to steering arm ball joint	50-70 Nm (37-52 lbf ft) - early type axle
Ball joint clamp bolts	45 Nm (33 lbf ft) - later type axle
Wheel hub caps	20-28 Nm (15-21 lbf ft)
Wheel nuts	See section 8D
Steering arm to spindle	410 Nm (300 lbf ft) - Fit '8' grade nuts, 'V' grade bolts
Track rod to steering cylinder	120-160 Nm (90-120 lbf ft)
Spindle housing to axle beam	340-450 Nm (251-332 lbf ft)
Four cylinder engines:-	
Axle support casting to engine	230-255 Nm (170-190 lbf ft)
Six cylinder engines:-	
Support casting hexagon socket screws	340-408 Nm (250-300 lbf ft)
Adaptor blocks to engine bolts	218-245 Nm (160-180 lbf ft)

General Description

The front axle assembly consists of an axle beam and two spindle housing assemblies. The axle beam pivots on a pin which is secured to the axle support casting. The spindle housing assemblies can be bolted to the axle beam in alternative positions to provide front wheel track adjustment. Figure one shows the general arrangement of the front axle assembly

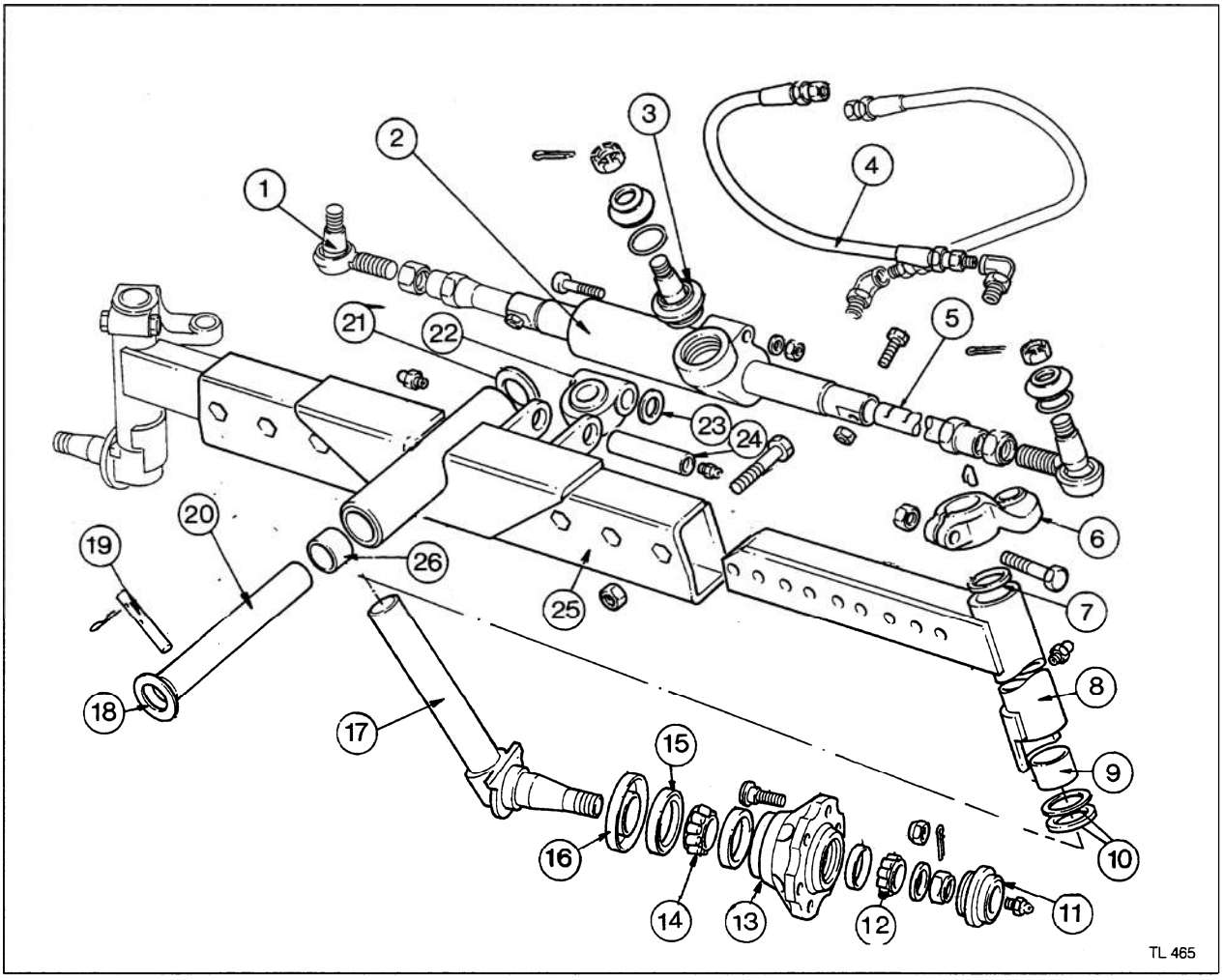


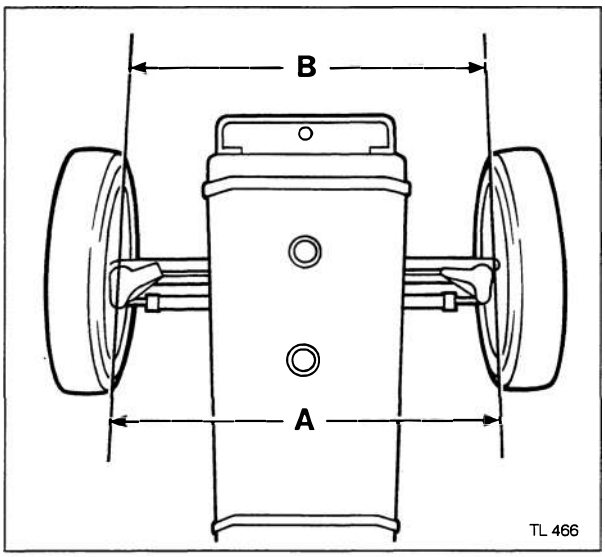
Fig.1 Front axle assembly

1. Ball joint
2. Steering arm
3. Steering ram ball joint
4. Hydraulic hoses
5. Adjustable track rod
6. Steering cylinder
7. Seal
8. Spindle housing
9. Bush
10. Thrust washers
11. Hub cap
12. Taper roller bearing
13. Hub
14. Taper roller bearing
15. Oil seal
16. Shield
17. Spindle
18. Shims
19. Retaining pin
20. Pivot pin
21. Thrust washer
22. Pivot block
23. Shims
24. Pivot pin
25. Axle beam
26. Bush

Front Wheel Toe–in

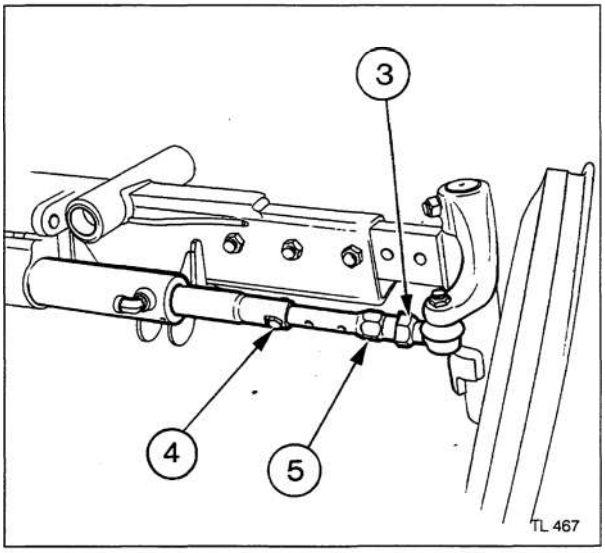
Adjust 10B–01

1. Place the tractor on firm ground and put the front wheels in the straight ahead position.
2. To check the toe-in, see illustration. Distance **'B'** must be 0-5 mm (0-3/16 in) greater than distance **'A'** measured on the centre line of the axle at the wheel rim.
3. If adjustment is necessary proceed as follows:-



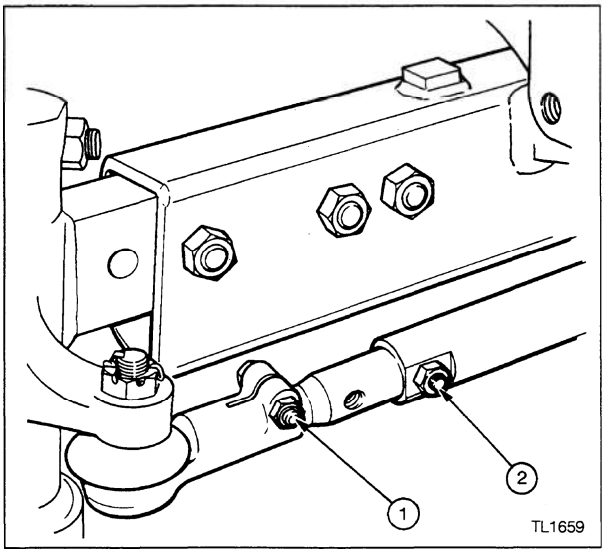
Early models

4. Remove both nuts and bolts securing the track rod.
5. Rotate the track rod at both ends by half a turn. Screw-out the track rod to increase the toe-in. Screw-in the track rod to decrease the toe-in.
6. Replace the nuts and bolts at both ends. Ensure that when refitting that both bolts are in the horizontal position. Tighten to a torque of 120-160 Nm (90-120 lbf ft).
7. Check the toe-in. If the measurement is now acceptable tighten both locknuts (3) to a torque of 160-200 Nm (118-128 lbf ft)



Later models

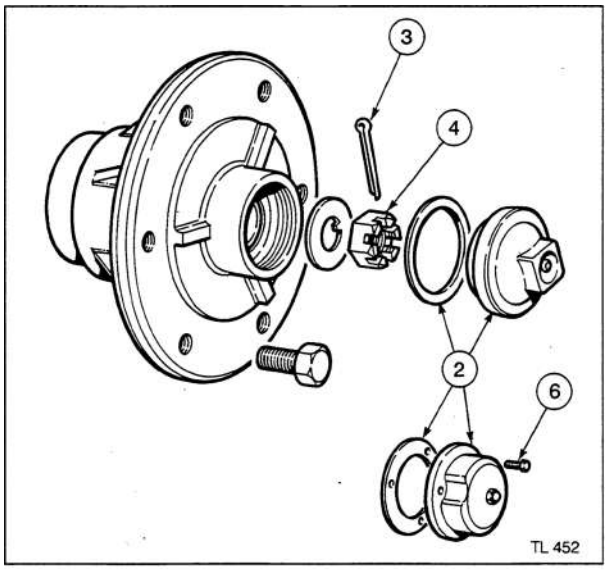
8. Remove both ball joint clamp bolts (1) on each end of the track rod.
9. Remove both pinch bolts (2) from each end of the steering cylinder.
10. Rotate the track rod on both sides by only half a turn at a time. It is important to keep the amount of thread in the both ball joints equal. Screwing out the track rod will increase the toe-in, screwing out will decrease the toe-in.
11. Refit the nuts and bolts (2) and tighten to a torque of 120-160 Nm (90-120 lbf ft)
12. Check the toe-in, if the measurement is now acceptable, set the bolt (2) in the horizontal position.
13. Replace and tighten the two ball joint clamp bolts (1) to a torque of 45 Nm (33 lbf ft).



Front Hub

Adjust 10B–02

1. Raise the front wheels off the ground and check the wheel bearings for wear. If movement is found, adjust the bearing pre-load as follows:-
2. Remove the hub cap.
3. Remove the split pin.
4. Tighten the slotted nut to a torque of 80 Nm (59 lbf ft) then slacken off the nut to the nearest spilt pin hole to give the correct end float.
5. Fit a new split pin.
6. Refit the hub cap. Caps secured with bolts, tighten the bolts to a torque of 20-28 Nm (15-21 lbf ft).
7. Grease the hub until clean grease appears from the seal inside the hub.



Front Hub

Overhaul 10B–03

Disassembly

1. Raise the front of the tractor and remove the wheel.
2. Remove the hub cap.
3. Remove and discard the split pin.
4. Remove the nut and washer.
5. Remove the hub complete with bearing and seal from the axle spindle.
6. Remove the outer bearing cone.
7. Tap out the outer bearing cup.
8. Remove the seal.
9. Drive out the bearing cup.
10. Remove the inner cone.
11. Remove the dust shield.

Examination

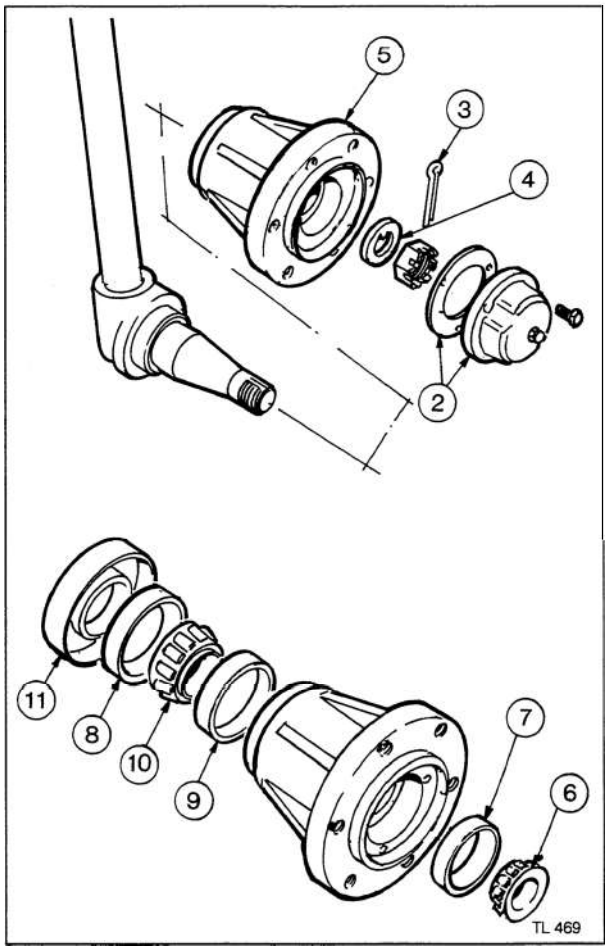
12. Thoroughly wash out the old grease or dirt from the hub components using clean paraffin, and check the condition of the hub spindle and bearings. Any worn or damaged components must be replaced. Always fit a new seal with the lip facing outwards and tap the seal right into the recess in the hub.

Reassembly

13. Reverse procedures 1 to 11.

NOTE: Pack the bearings with an approved grease during assembly.

14. Turn the wheel hub and tighten the slotted nut to a torque of 80 Nm (60 lbf ft). Back off the slotted nut to line up with the nearest pin hole to give the correct end float.
15. Torque the hub cap bolts to 20-28 Nm (15-21 lbf ft).
16. Grease the hub until clean grease appears from the seal inside the hub.
17. For wheel nut torques, see section 8D.



Spindle Shaft

Removal and Refitment 10B–04

Removal

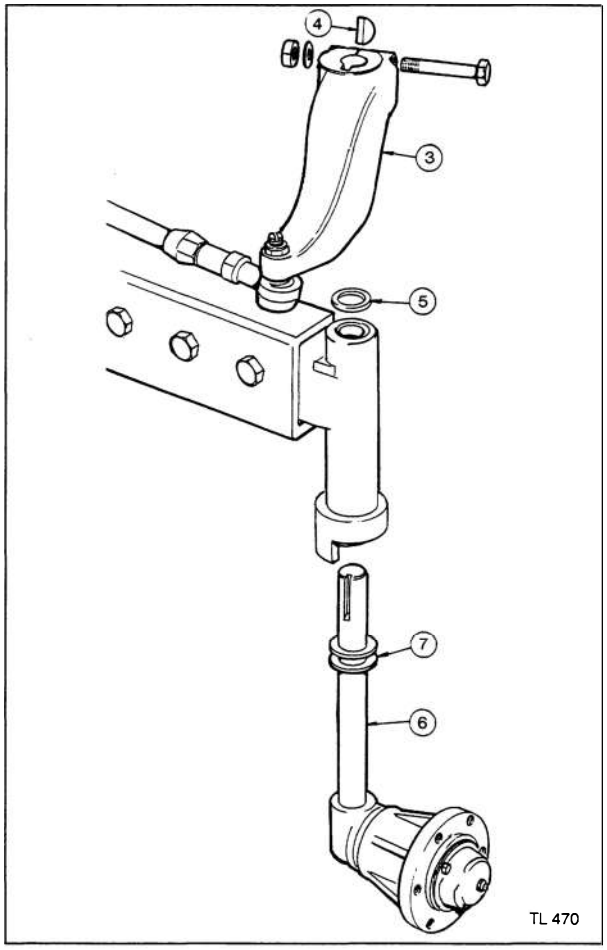
1. Remove the front hub, see operation 10B-03.
2. Remove the nut and bolt.
3. Remove the steering arm.
4. Remove the key.
5. Remove the dust seal.
6. Lower the spindle shaft from the housing.
7. Remove the thrust washer and spacer from the spindle.

Examination

Examine the spindle thrust bearing for damage or wear and replace if necessary.

Refitment

8. Renew the dust seal.
9. Liberally lubricate the thrust bearing with an approved grease before assembly.
10. Fit the thrust washer to the spindle shaft first.
11. Assemble the thrust washer with the indentations in the bronze face facing downwards.
12. Fit the key and steering arm.
13. It is very important that the correct nut and bolt is fitted to the steering arm. The nut must be SAE 8 quality Massey Ferguson part number 373 601 X1. The bolt must be V quality, Massey Ferguson part number 3611 361 M1. Fit the bolt with the nut on the inside.
14. With the hub and spindle assembly held firmly in place against the thrust bearings, measure the gap between the steering arm and the spindle housing using feeler gauges. The gap must not exceed 0,05 mm (0.002 in).
15. When the correct setting has been obtained tighten the steering arm nut to a torque of 410 Nm (300 lbf ft).
16. Thoroughly grease the shaft before the wheel is fitted and it is lowered to the ground.
17. Refit the track rod and tighten the ball joint nut to a torque of 60 Nm (45 lbf ft).



Spindle Housing

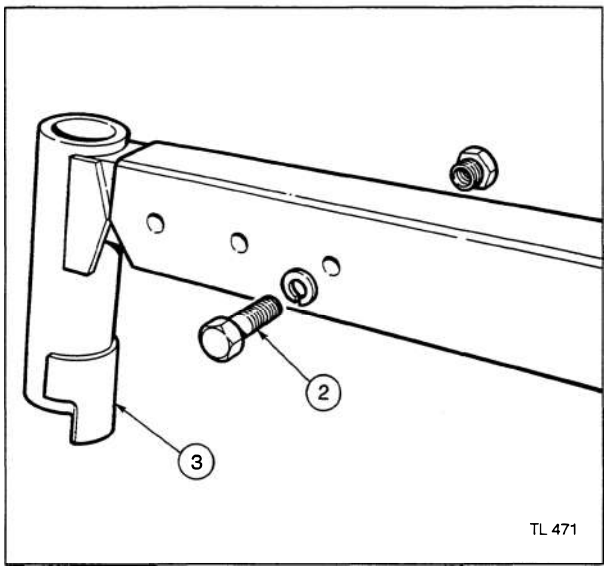
Removal and Refitment 10B–05

Removal

1. Remove the spindle shaft, see operation 10B-04.
2. Remove the three nuts and bolts.
3. Withdraw the spindle housing from the axle beam.

Refitment

4. Reverse procedures 1 to 3 except:-
   a. Tighten the axle beam bolts to a torque of 400 Nm (300 lbf ft) with the wheels on the ground.
   b. Check the front wheel toe-in, see operation 10B-01.



Spindle Housing

Overhaul 10B-06

Special Tools:

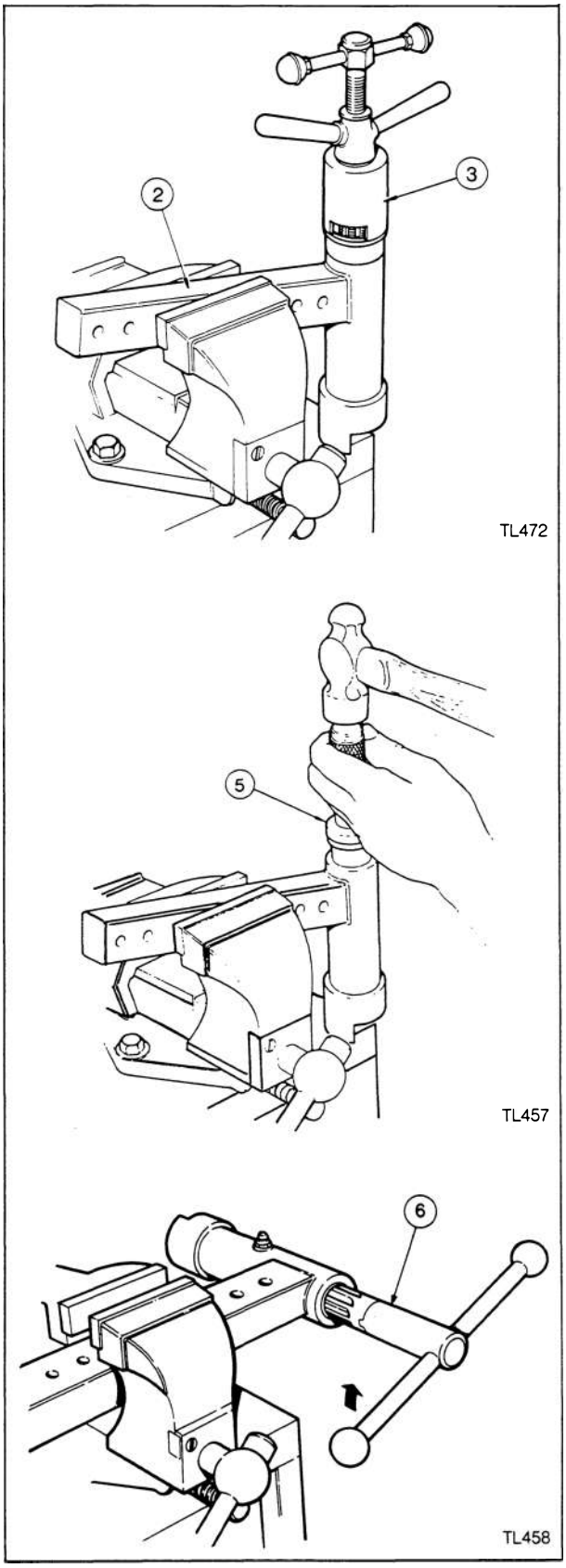
MF263	*Bush remover – main tool*
MF263-5/1	*Extractor*
MF263-5/2	*Bush replacer*
MF264	*Reamer handle – main tool*
MF264-8/2	*Reamer guide*
MF264-8/1	*Reamer*
MS550	*Universal handle*

Disassembly

1. Remove the spindle housing, see operation 10B-05.
2. Secure the housing in a vice.
3. Using MF263 and MF263-5/1 remove the bush by screwing the threaded extractor into the bush with the upper handle. Withdraw the bush by turning the lower handle.
4. Invert the housing and remove the other bush.

Reassembly

5. Using the MS550 Handle and the MF263-5/2 bush replacer drive in a new bush at each end of the arm.
6. Fit the MF264-8/1 reamer to the MF264 main tool and pass the guide bar through the housing. Fit the reamer guide MF264-8/2 on to the guide bar and into the housing. This will ensure that the bush is reamed parallel.
7. Ream the upper bush to size.
8. Turn the equipment over and ream the lower bush to size.
9. Remove all swarf from the housing and ensure the grease nipple hole is clear.
10. Refit spindle shaft, see operation 10B-04.
11. Reverse procedures 2 and 3, then tighten the axle beam nuts and bolts to 340-450 Nm (251-332 lbf ft),with the wheels on the ground.
12. Thoroughly grease all parts before assembly.



Axle Beam

Removal & Refitment 10B-07

Special Tools: MF 444 Axle pivot pin remover

Removal

1. Remove the front weights and weight frame.
2. Support the tractor under the engine.
3. Remove both the spindle housings with the front wheels.
4. Push the beam back on its pivot pin against the thrust washer. Using feeler gauges, check the gap between the front boss on the beam and the support casting. If it exceeds 0,25 mm (0.010 in) note the dimension.
5. Disconnect and plug the hydraulic hoses to the power steering ram.
6. Support the axle beam on a trolley jack.
7. Remove the two 'R' clips and the pivot pin retaining pin.
8. Using MF444 front axle pivot pin puller withdraw the pivot pin.
9. Lower the beam to the ground.
10. Remove the steering ram, see operation 11A.

Examination

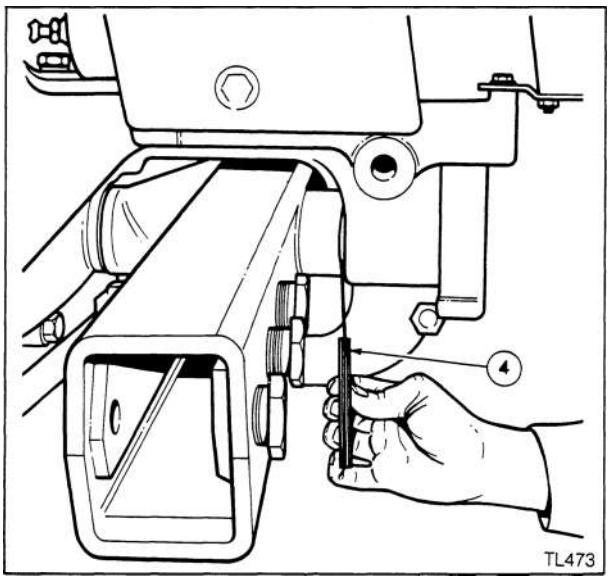
12. Check the end face of the axle beam boss, the pivot pin, shims and thrust washer for wear. Examine all bores and threads for wear or damage. In the event of accident damage check the beam for bending or twisting. If the beam has been in any way deformed, it must be replaced, as steering characteristics and tyre wear can be severely affected. Also the beam may have been dangerously weakened due to straining of the welded seams.

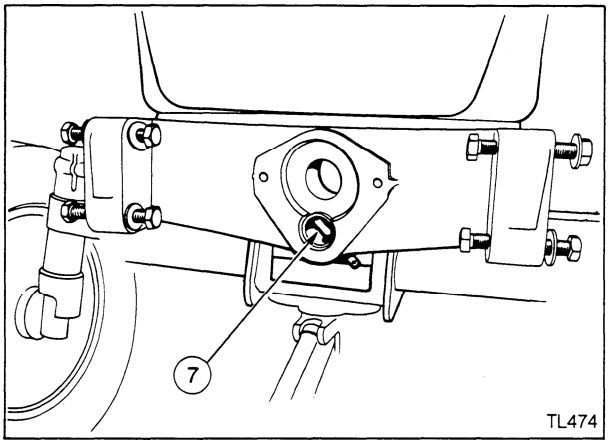
Refitment

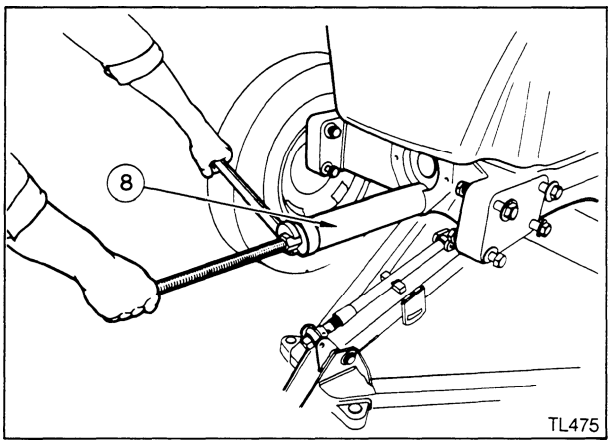
11. Reverse procedures 1 to 10 except:
    a. If gap between front boss on beam and the casting, exceeds 0,25 mm (0.010 in) suitable shims from the following chart must be selected to give a gap of 0,05 mm (0.002 in) minimum to 0,25 mm (0.010 in) maximum. Shims must be fitted to the front of the beam and the thrust washer to the rear.

Part number	Shim thickness	
	mm	in
898 018 M1	0,70 to 0,76	0.028 to 0.030
898 019 M1	0,86 to 0,91	0.034 to 0.036
898 020 M1	0,99 to 1,04	0.039 to 0.041
882 868 M1	1,12 to 1,17	0.044 to 0.046
882 869 M1	1,24 to 1,30	0.049 to 0.051

    b. Tighten nuts and bolts securing trackrod to the power steering ram, to a torque of 29-37 Nm (21-27 lbf ft).
    c. Tighten bolts and nuts, securing spindle housings into axle beam, to a torque of 340-450 Nm (252-333 lbf ft).
13. Check the front axle toe-in, see operation 10B-01.







Axle Beam

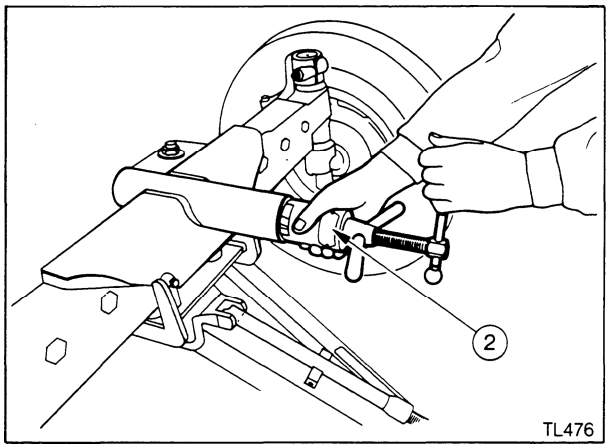
Overhaul	10B-08

Special Tools:

MF 263	*Bush remover – main tool*
MF 263-3/1	*Bush replacer*
MF 263-3/2	*Extractor*
MS 550	*Handle*

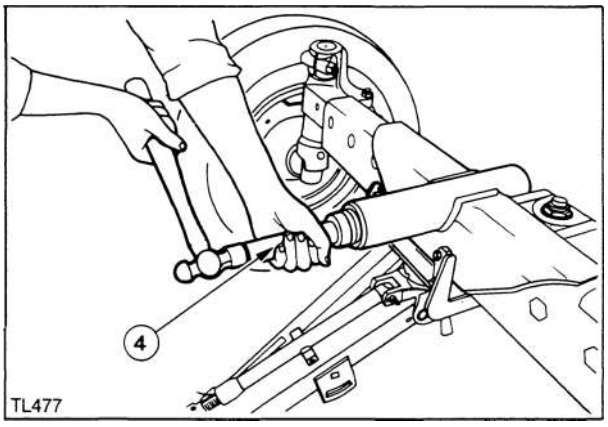
Removal

1. Remove the axle beam, see operation 10B-07.
2. Using MF 263 and MF 263-3/2, remove the bush by screwing the threaded extractor into the bush with the upper handle. Withdraw the bush by turning the lower handle.
3. Turn the beam over and remove the other bush.



Refitment

4. Drive in the new bush with the split positioned vertically and facing the top of the tube with the replacer MF 263-3/1 and handle MS550.
5. Turn the beam over and fit the other bush.
6. The pivot pin must turn freely in the bushes,if not, ream the bushes with MF264 and MF264-2/1.
7. Refit the beam, see operation 10B-07.
8. Check the front wheel toe-in, see operation 10B-01.

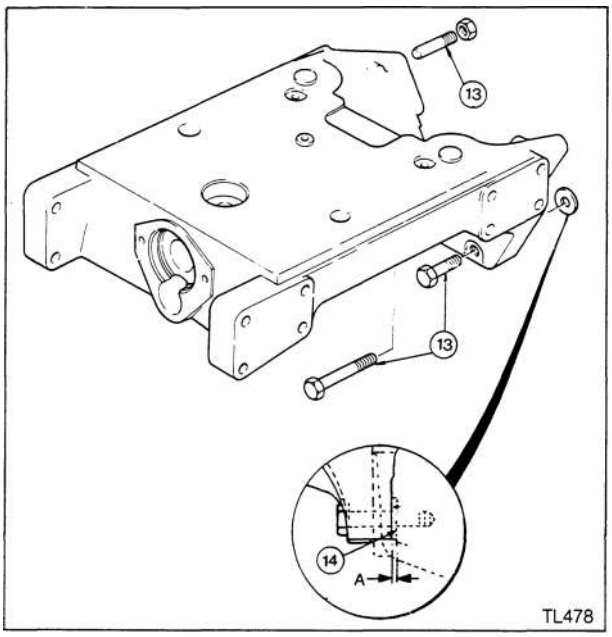


Front Axle Support Casting

Removal and Refitment 10B-09

Removal

1. Remove the front weights and weight frame.
2. Remove the fuel tank, see section 5.
3. Remove the radiator, see section 4.
4. Disconnect and plug the hydraulic hoses and pipes as necessary.
5. Remove the radiator support frame.
6. Support the tractor under the engine sump.
7. Support the front axle and remove the pivot pin, see operation 10B-07.
8. Raise the front of the tractor and wheel out the front axle assembly on its wheels with a trolley jack.
9. Take the weight of the front support casting on a small crane.
10. Remove the bolts and nuts securing the casting to the engine.
11. Slide the casting off the studs on the crane and lower it to the ground.

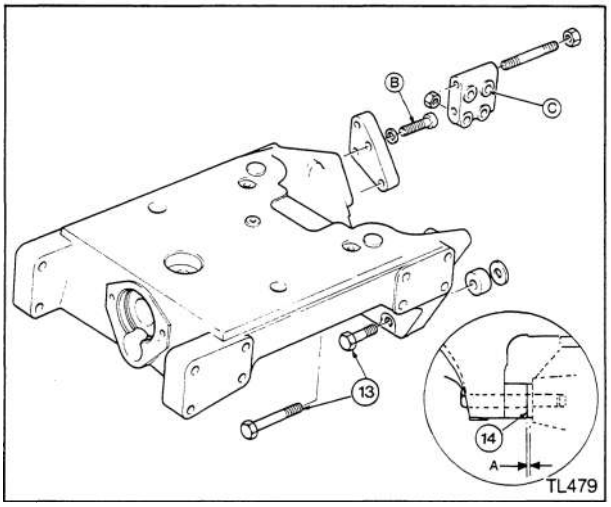


Refitment

12. Reverse procedures 1 to 11.

Note: When refitting the front axle support, shims are fitted between the support casting and the engine (see illustration) to give a 0,13 mm (0.005 in) preload.

13. Fit the front support casting to the engine without shims and tighten the two top rows of nuts and bolts to a torque of 230-255 Nm (170-190 lbf ft), except the two bottom bolts which take the shims.
14. Measure the gap 'A' on each side of the casting with a feeler gauge between the casting and engine on 4 cylinder engines, the spacer tube and engine on 6 cylinder engines. Treat each side individually. Add to the two dimensions obtained 0,13 mm (0.005 in), this is the thickness of shims to be added to each side.



Shim Part No	Thickness (mm)	Thickness (in)
1695 486 M1	0,10	0.004
1695 487 M1	0,25	0.010
1695 488 M1	0,40	0.015
1695 489 M1	0,50	0.020
1695 490 M1	1,50	0.060

Note: When selecting shims the final pack must be tight in gap 'A'.

15. Slacken all nuts and bolts, take the weight of the front support casting on a jack to aid fitting of the shims, insert the correct shim pack to the two bottom bolts on each side.
16. Remove the jack, tighten all nuts and bolts securing the support casting to a torque of 230-255 Nm (170-190 lbf ft).

Note: On tractors with 6 cylinder engines the hexagon socket cap screws 'B' are torqued to 340-408 Nm (250-300 lbf ft).

The four bolts 'C' on each side of the engine retaining the two adaptor blocks to the engine are torqued to 218-245 Nm (160-180 lbf ft).

FRONT AXLE – 4 WHEEL DRIVE

Section 10 – Part C

Table of Contents

Operation No	Description	Page No
—	Specification	2
—	General Description	4
10C-01	Front Axle – Removal	6
10C-02	Planetary Carrier – Removal	7
10C-03	Planetary Carrier – Overhaul	8
10C-04	Front axle swivel housing – Overhaul	9
10C-05	Ring gear, bearings and oil seals – Overhaul	11
10C-06	Universal Drive shaft – Removal	14
10C-07	Universal Drive shaft – Overhaul	15
10C-08	Differential input shaft oil seal – Removal	16
10C-09	Differential assembly – Removal	17
10C-10	Differential – Overhaul	17
10C-11	Autolock differential – Overhaul	19
10C-12	Crownwheel and pinion – Overhaul	21
10C-13	Hydralock Differential–Overhaul	22

Specification

Axle type			
M-F 340, 350, 355, 360 and 362	NG100/SDN	(Category 1 narrow)	
M-F 365 and 375	NG100/SD	(Category 1 wide)	
M-F 390 and 390T	NG200/SD	(Category 2)	
M-F 398 and 399	NG250/SD	(Category 2.5)	
Axle part numbers			
Axles with Standard differential			
3428 057 M91	NG100/SDN	(Category 1 narrow)	M-F 340 only
3426 356 M92	NG100/SDN	(Category 1 narrow)	Sealed unit
3428 054 M91	NG100/SDN	(Category 1 narrow)	Standard unit
Axles with No-spin differential			
3426 358 M92	NG100/SDN	(Category 1 narrow)	Sealed unit
3428 053 M91	NG100/SDN	(Category 1 narrow)	Standard unit
3426 362 M92	NG100/SD	(Category 1 wide)	Sealed unit
3428 058 M91	NG100/SD	(Category 1 wide)	Standard unit
3426 366 M92	NG200/SD	(Category 2)	Sealed unit
3428 061 M91	NG200/SD	(Category 2)	Standard unit
3426 378 M92	NG250/SD	(Category 2.5)	Sealed unit
Axles with Hydrolock differential			
3426 942 M91	NG100/SDN	(Category 1 narrow)	Sealed unit
3428 055 M91	NG100/SDN	(Category 1 narrow)	Standard unit
3426 943 M91	NG100/SD	(Category 1 wide)	Sealed unit
3428 060 M91	NG100/SD	(Category 1 wide)	Standard unit
3426 944 M91	NG200/SD	(Category 2)	Sealed unit
3428 063 M91	NG200/SD	(Category 2)	Standard unit
3426 945 M91	NG250/SD	(Category 2.5)	Sealed unit

Camber angle	1°
Toe-in	0°
Pinion protrusion up to tractor Serial No. N04463 (axles with two differential bearing adjusters)	
NG100/SD (N)	113±0,1 mm (4,449±0,004 in)
NG200/SD	113±0,1 mm (4,449±0.004 in)
NG250/SD	118±0,1 mm (4.646±0.004 in)
Pinion protrusion tractor Serial No. N04464 on (axles with single differential bearing adjuster)	
All axles	118±0,1 mm (4,646±0.004 in)

Crownwheel and Pinion	No of Teeth	Ratio
NG100/SD(N)	9 x 31	3.444:1
NG200/SD	9 x 31	3.444:1
NG250/SD	11 x 45	4.091:1

Pinion pre-load	3,2-3,3 Nm (28-29 lbf in)
Differential carrier pre-load	With zero end float tighten bearing nut three notches
Crownwheel and pinion backlash	0,10-0,25 mm (0.004 to 0.010 in)

Epicyclic Reduction	Ratio
NG100/SD(N) (M-F 340 only)	3.333:1
NG100/SD(N)	5.2:1
NG200/SD	5.2:1
NG250/SD	5.007:1

Swivel hub pre-load	0,2 mm (0.008 in)
Drive hub bearing pre-load	0,05 mm (0.002 in)
Axle pivot pin end float	0,05-0,25 mm (0.002-0.010 in)
Oil Capacities	
M-F 340, 350, 355, 360, 362	
Axle	5,0 litre (9 pt) (9 US pt)
Epicyclic (each side)	1,4 litre (2½ pt) (2½ US pt)
M-F 365, 375, 390, 390T	
Axle	5,8 litre (10 pt) (10 US pt)
Epicyclic (each side)	1,4 litre (2½ pt) (2½ US pt)
M-F 398, 399	
Axle	6,5 litre (11 pt) (11 US pt)
Epicyclic (each side)	1,8 litre (3 pt) (3 US pt)

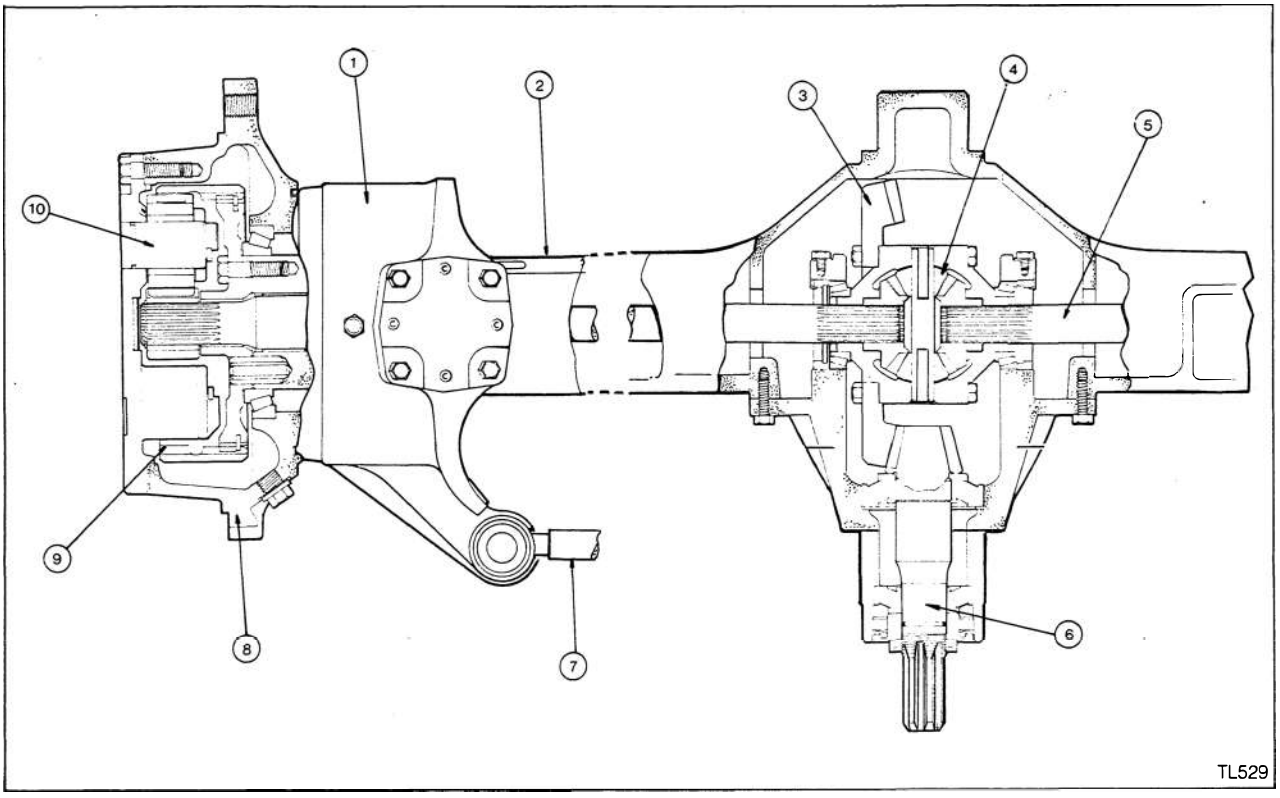
Special Tools

MF 195C	Bearing remover/replacer
MF 444	Axle pivot pin remover
MF 451B	Axle swivel pin remover
FT 4062A	Pinion pre-load gauge
MF 471A	Hydralock spring compressor

Bolt Torques

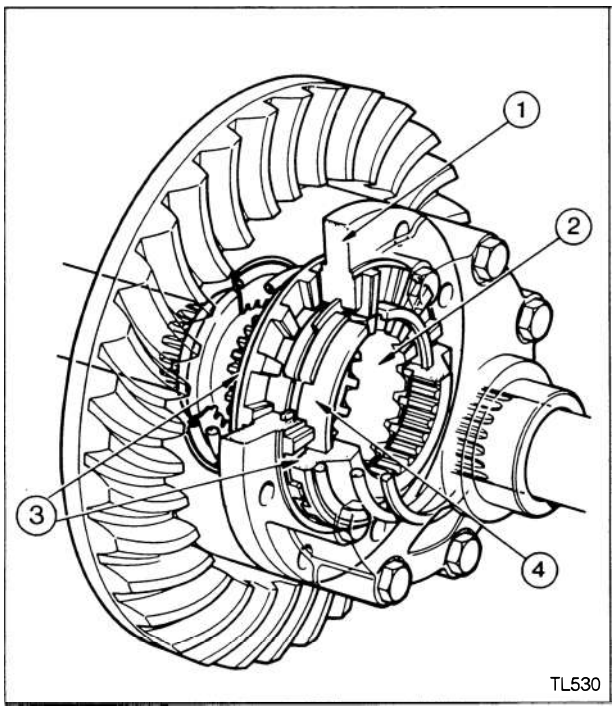
Planetary carrier bolts	96-118 Nm (71-87 lbf ft)
Wheel bolts	See Section 8D
Swivel cap bolts	96-118 Nm (71-87 lbf ft)
Ring gear bolts	147 Nm (108 lbf ft)
Track rod ball joint (NG100SD and NG200SD axles)	78-86 Nm (58-63 lbf ft)
Track rod ball joint (NG250SD axles)	108-118 Nm (80-87 lbf ft)
Steering ram ball joint (NG100SD and NG200SD axles)	98-108 Nm (72-80 lbf ft)
Steering ram ball joint (NG250SD axles)	177-196 Nm (130-145 lbf ft)
Pinion drive coupling bolt	60 Nm (44 lbf ft)
Drive shaft to coupling bolts	55-75 Nm (40-55 lbf ft)
Differential and crownwheel bolts	79-87 Nm (58-64 lbf ft)
Differential bearing cap screws	136-150 Nm (100-110 lbf ft)
Differential bearing lock tabs	16-26 Nm (12-19 lbf ft)
Differential assembly to axle casing	96-118 Nm (71-87 lbf ft)

FRONT AXLE 4 WHEEL DRIVE



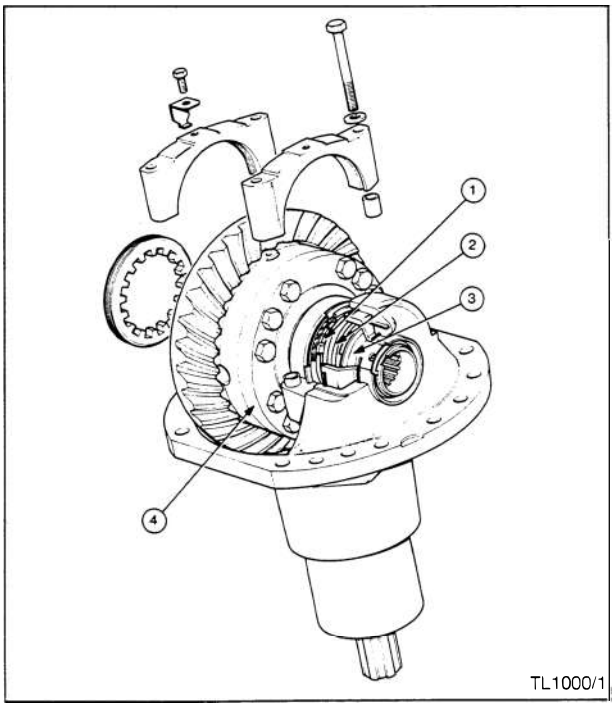
4WD Front axle

1. Swivel housing
2. Axlehousing
3. Crownwheel
4. Differential
5. Drive shaft
6. Pinion
7. Track rod
8. Wheel hub
9. Ring gear
10. Planetary gears



Autolock differential

1. Central driver
2. Centre cam
3. Driven clutches
4. Hold-out ring



Hydralock differential

1. Dog tooth coupler
2. Return spring
3. Piston
4. Differential

General Description

The tractors are available in either two or four wheel drive.

The four wheel drive system consists of a transfer box fitted between the gearbox and centre housing of the tractor.

It contains a train of spur gears which transfers the drive to the left-hand side of the tractor and the main drive shaft. The drive is engaged and disengaged mechanically on all models.

A driveshaft tranmits along the left hand side of the engine sump to the input shaft protruding from the axle differential housing. Drive is taken through the bevel pinion which in turn drives the crownwheel and differential Autolock, Hydralock or Standard). The crownwheel is bolted to the differential case containing the spider and differential gears, into which the inner ends of the axle shafts are splined. Final drive is then transmitted through two driveshafts, universal joints and the epicyclic reduction unit to the front wheels. The axle is attached to the front support by means of a centre pivot pin in a similar manner to the 2 wheel drive axle.

The Autolock Differential

Autolock is a positive locking differential which is used as a traction aid.

It may be fitted to all axles in place of the standard differential. Tractors fitted with an Autolock differential are identified by the letters NS stamped on the differential housing or next to the axle serial number on the right-hand side of the axle beam.

The Autolock differential has two prime functions:

1. It compensates for differences in wheel travel which occur when turning or operating on an uneven surface.
2. It prevents wheel spin and power loss when one wheel loses traction.

The Autolock differential is a speed-sensitive automatic locking differential. It consists of left and right driven clutches with square teeth. These teeth mate with similar teeth on the spider, which is clamped in the differential support case by means of four trunnions. Each clutch can slide on its special side gear, on slip-fitting splines. Cam ramps (not shown) inside the spider assembly and clutch allow a clutch to overrun the spider and disengage itself from the driveline. A spring returns the clutch to engagement with the spider.

When operating a vehicle in a straight line, the Autolock is locked and provides drive torque to both wheels. If one wheel loses traction momentarily due to poor tractive surface conditions, the opposite wheel continues to drive the vehicle until traction is regained by both wheels.

During a turn or when a wheel passes over an obstruction, the outside wheel or the wheel passing over the obstruction must rotate faster than the other wheel. When this occurs, the Autolock automatically allows for difference in wheel speed.

The faster turning wheel will overrun, being ground driven until the two wheels synchronise their respective speeds. At this time the Autolock automatically re-engages to a fully locked operating position.

The Hydralock Differential

Hydralock is a positive locking differential which is used as a traction aid on the four wheel drive front axle, operating in conjunction with the rear wheel differential. It is identified externally by the hydraulic hose feeding the actuating piston.

The hydraulic differential has two prime functions:

1. It compensates for differences in wheel travel which occur when turning or operating on an uneven surface.
2. It prevents wheel spin and power loss when one wheel loses traction.

The hydralock differential operates in the four wheel drive front axle, in conjunction with the rear differential lock pedal. The operation of the rear differential lock pedal operates the rear differential warning light switch. The switch in turn illuminates the warning light on the dashboard and energises the solenoid valve to engage the front differential lock dog tooth coupler.

The oil supply to the solenoid valve comes from the distribution block and when energised, the valve supplies a flow of oil at pressure maintaining valve pressure to the hydralock differential. This pressure acts against a piston which is attached to the moving half of a dog tooth coupler. The hydralock pressure overcomes the resistance of a coil spring and engages the dog tooth coupler. When the rear differential lock is disengaged, the warning light going out triggers the de-energising of the solenoid valve. This in turn cuts off the oil supply from the distribution valve and opens up the hydraulic line to dump. The coil spring disengages the dog tooth coupler and returns oil behind the piston to dump.

Introduced at tractor serial No. NO4464 onwards.

Product changes

After the introduction of the Hydralock differential, the other differentials, Standard and Autolock were brought into line at tractor serial number N04464. The major change was the standardisation of the method of adjusting the crown wheel backlash by shims, this can be identified by the use of only one differential bearing pre-load adjuster ring, the other side being retained by a retainer ring and shims. The previous models had an adjuster ring each side.

The other changes were the introduction of a standard depth of pinion bearing of 118 mm on all axles, and the increase in the nut torque on the ball joints fitted to the track rod and steering ram ends.

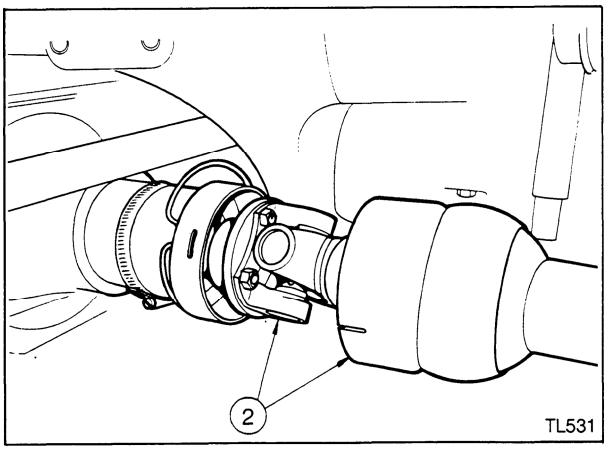
Front Axle 4 Wheel Drive

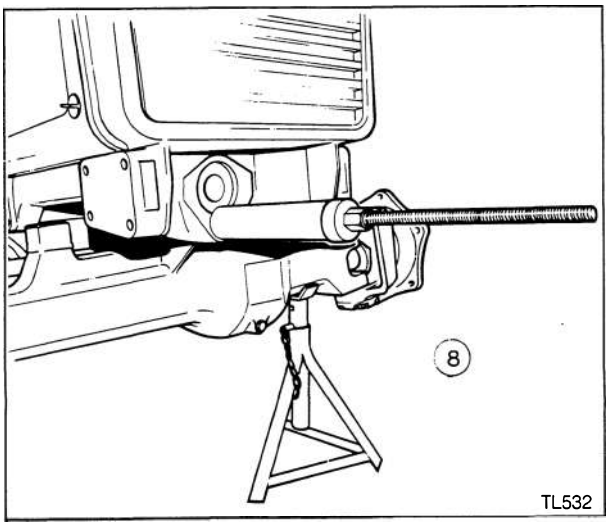
Removal and Refitment 10C-01

Special tools: MF 444 Axle pivot pin remover

Removal

1. Secure the tractor rear wheels and apply the parking brake.
2. Disconnect the drive shaft guard and drive shaft.
3. Disconnect the steering ram hoses and plug the hose and ram connections to prevent dirt ingress.
4. Disconnect the remote greaser tube from the front axle pivot pin and the mounting bracket.
5. Place a trolley jack in position under the tractor sump and adjust to take the weight of the tractor.
6. Remove the front weights.
7. Supporting the front weight frame remove the eight bolts securing it to the front support casting and remove the weight frame.
8. Withdraw the front axle pivot pin using special tool MF444 and remove the two thrust washers and shims. Check them for wear. If they are worn, replace them with new thrust washers.
9. Support the front axle under the differential with a second trolley jack.
10. Raise the jack under the engine sump until the axle can be rolled forward from its mounted position, on its wheels.





Caution: Prevent the axle from tilting when removing the front axle.

11. Place the axle securely on two axle stands. Check the pivot pin and bushes for wear or damage, if they are worn, replace them with new bushes.

Refitment

12. Reverse procedures 1 to 10 except:
    a. Grease the pivot when the axle refitment has been completed.
    b. Fit the shims to the front of the axle and the spacer to the rear.
    c. Check the axle end float which must be 0,05-0,25 mm (0.002-0.010 in). Fit the appropriate shims from the chart.

Part number	Shim thickness	
	mm	in
898 018 M1	0,70 to 0,76	0.028 to 0.030
898 019 M1	0,86 to 0,91	0.034 to 0.036
898 020 M1	0,99 to 1,04	0.039 to 0.041
882 868 M1	1,12 to 1,17	0.044 to 0.046
882 896 M1	1,24 to 1,30	0.049 to 0.051

Planetary Carrier

Removal and Refitment 10C-02

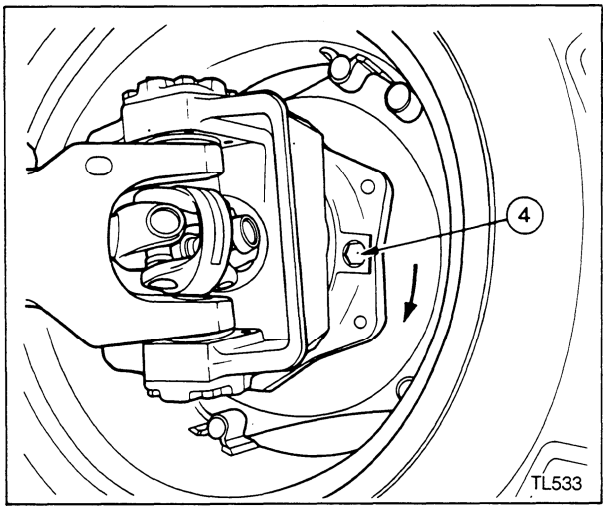
Removal

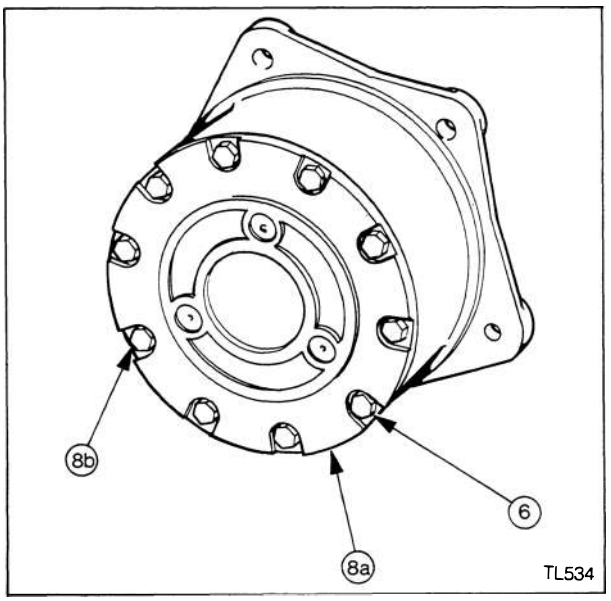
1. Apply the parking brake and secure the rear wheels.
2. Raise the tractor under the side of the axle to be worked on, then support the axle on an axle stand.
3. Remove the wheel.
4. Rotate the hub until the plug is at the bottom, remove the plug and drain the oil from the hub.
5. Mark the position of the planetary carrier to hub to assist alignment during refitment.
6. Remove the ten bolts securing the carrier.
7. Withdraw the planetary carrier.

Refitment

8. Reverse procedures 1 to 6 except:
   a. Apply Loctite 515 Instant Gasket to the face of the hub.
   b. Apply a light coating of lubricating oil to the planetary carrier bolts and tighten to a torque of 96-118 Nm (71-87 lbf ft)
   c. Rotate the wheel so that the plug is horizontal, then fill the hub to this level with an approved oil and and refit the plug.
   d. For wheel nuts torques see section 8D.

Note: Lubricate the wheel bolts before re-assembly.





Planetary Carrier

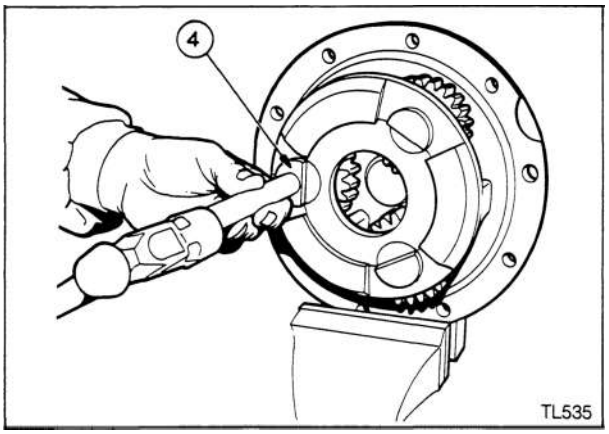
Overhaul 10C-03

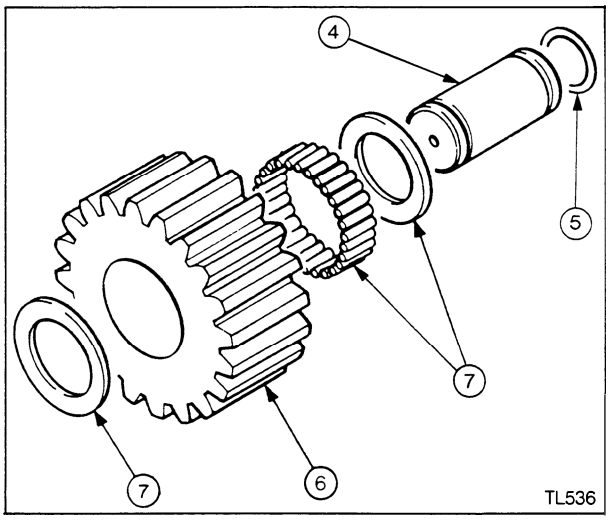
Disassembly

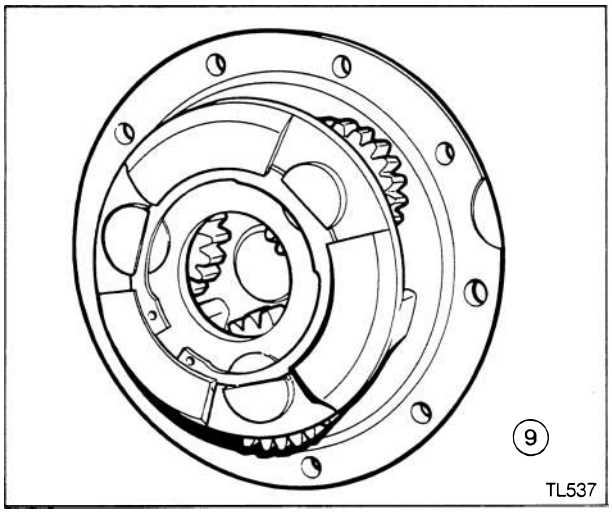
1. Remove the planetary carrier, see operation 10C-02.
2. Place the planetary carrier in a vice.
3. Remove the circlip.
4. Carefully tap out the planetary gear shaft.
5. Remove the 'O' ring.
6. Remove the planetary gear and thrust washers taking care not to dislodge the needle rollers.
7. Remove the needle rollers and the spacer.
8. Repeat procedures 4 to 6 for the remaining two planetary gears. Thoroughly clean and inspect all components and replace any that are worn or damaged.

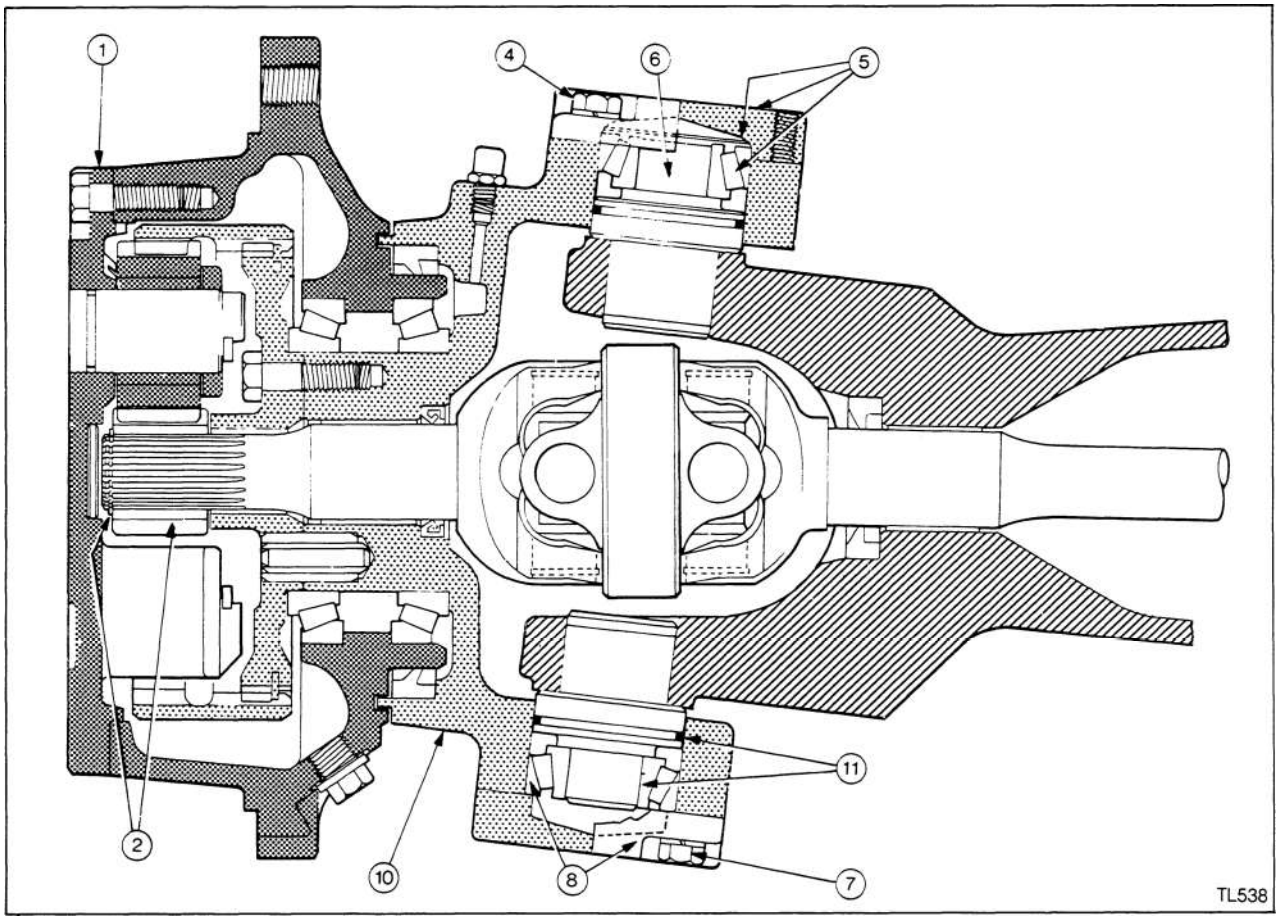
Reassembly

9. Reverse procedures 1 to 8 except:
   a. Using petroleum jelly, refit the needle rollers and thrust washers.
   b. Note the position of the circlip, which should have its open end facing one of the three blocks.









Front Axle Swivel Housing

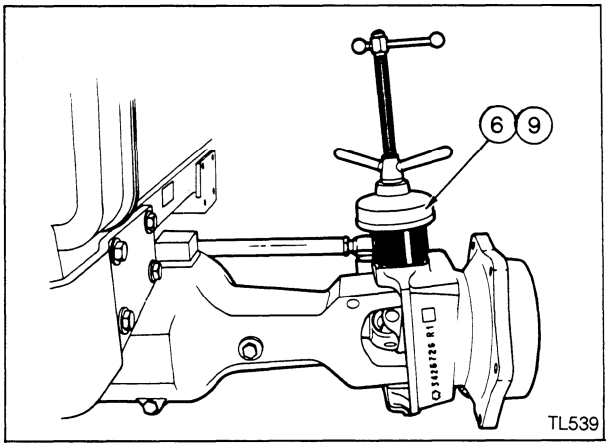
Overhaul	10C-04
Special Tools:	
MF 451A	*4 Wheel Drive Axle pivot pin remover*
MF 195C	*Bearing remover and replacer*

Disassembly

1. Remove the planetary carrier, see operation 10C-02.
2. Remove the circlip and sun gear.
3. Release the track rod and steering cylinder.
4. Remove the four bolts securing the top cover.
5. Remove the upper cap, shims and bearing cup.

Caution: The hub is heavy. Ensure that it is well supported before you attempt to remove the upper and lower pivot pins.

6. Using the MF 451B pivot pin remover and puller MF 195C, extract the upper pivot pin.
7. Remove the four bolts securing the bottom cap.
8. Remove the lower bearing cap and cup.



9. Using the puller, remove the lower pivot pin.
10. Remove the pivot housing.
11. Remove the bearing cones and 'O' rings from the pivot pins.

Examination

Thoroughly inspect all parts for signs of wear or damage and replace if necessary.

Reassembly

12. Fit the bearing cones and 'O' rings to the pivot pins.
13. Position the upper pivot pin, so that it locates the swivel bearing in line.
14. Refit the lower pivot pin, bearing cup, cap and bolts.
15. Tighten two opposed bolts evenly and in sequence to press the lower pivot pin into the housing. Tighten all four bolts to a torque of 96-118 Nm (71-87 lbf ft).
16. Fit the upper pivot pin bearing cup, shims, cap and bolts and tighten two opposed bolts evenly and in sequence to draw the pivot pin into the housing.
17. Check that both pivot pins are fully seated in the axle beam.
18. Remove the upper pivot pin cap and remove the shims.
19. Replace the cap and tighten the four bolts to a torque of 96-118 Nm (71-87 lbf ft).
20. Using a dial indicator gauge as shown in the illustration and a lever, determine the end float of the hub to axle beam.

Note: Work the lever from the side opposite to the dial indicator gauge so as not to affect the readings.

21. Select the required shims by the following method:

Shims required = End float + Pre-load.

Pre-load required is 0,2 mm (0.008 in).

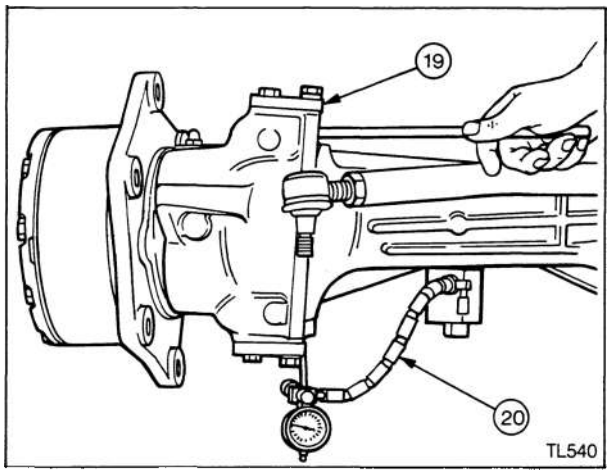
Select shims from one of the following charts:

For axle type NG100SD(N) and NG200SD.

Part Number	Thickness mm	Thickness in
3426 230 M1	1,00	0.039
3426 231 M1	0,50	0.020
3426 232 M1	0,20	0.008
3426 233 M1	0,15	0.006
3426 234 M1	0,10	0.004

For axle type NG250SD

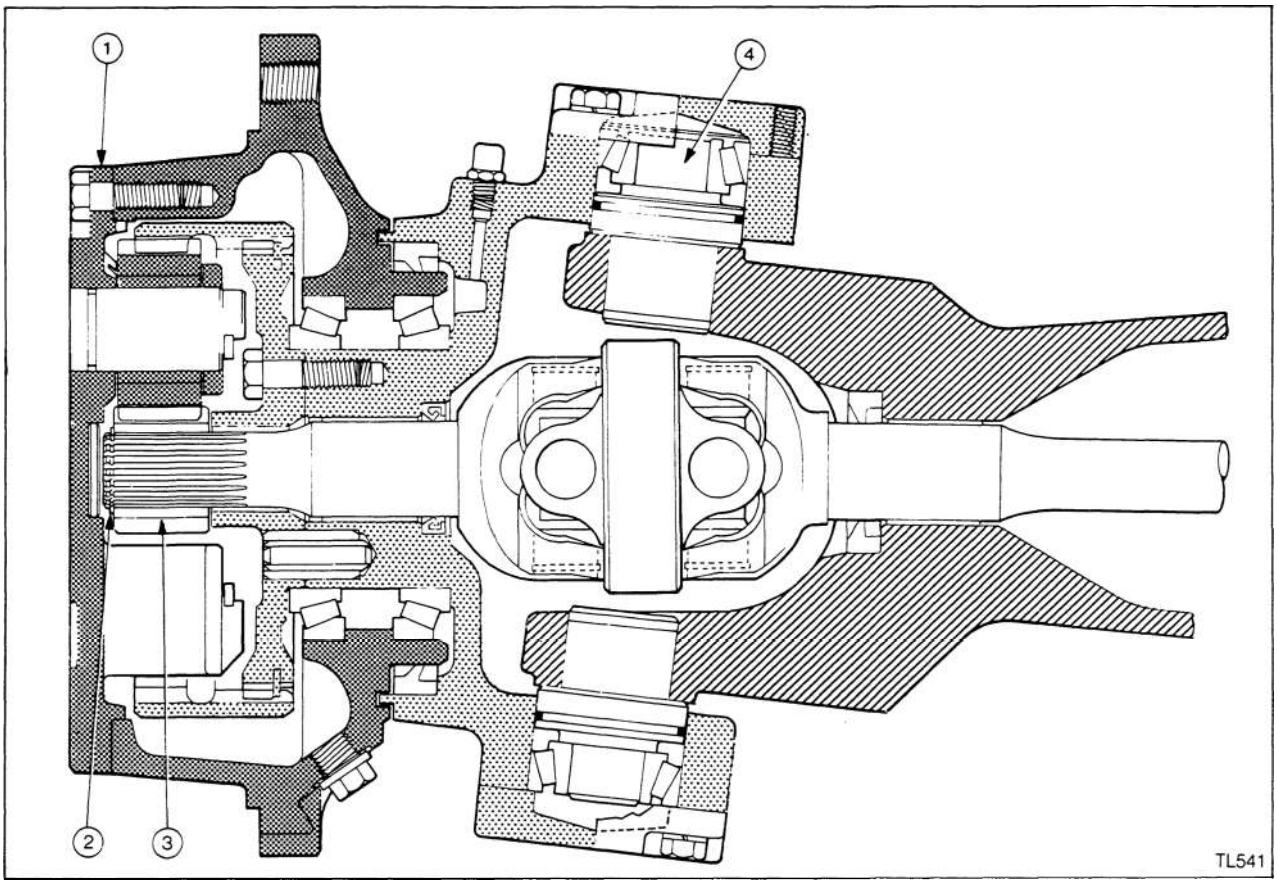
Part Number	Thickness mm	Thickness in
3426 146 M1	1,00	0.039
3426 147 M1	0,50	0.020
3426 148 M1	0,20	0.008
3426 149 M1	0,15	0.006
3426 150 M1	0,10	0.004



22. Remove the upper cap and bearing cup. Fill the bearing with grease, replace the bearing cup and add the correct number of shims.
23. Apply lubricating oil to the cap bolts and tighten to a torque of 96-118 Nm (71-87 lbf ft).
24. Remove the lower bearing cap and fill the bearing with grease. Apply Loctite and torque the cap bolts.

Note: Shims are fitted only to the upper bearing.

25. Apply lubricating oil to the nuts of the track rod ball joint and tighten to a torque of:
    NG100SD and NG200SD axles:
    78-86 Nm (58-63 lbf ft)
    NG250SD axles:
    108-118 Nm (80-87 lbf ft).
26. Apply lubricating oil to the nuts of the steering ram rod ball joint and tighten to a torque of:
    NG100SD and NG200SD axles:
    98-108 Nm (72-80 lbf ft)
    NG250SD axles:
    177-196 Nm (130-145 lbf ft).



Ring Gear, Bearings and Oil Seals

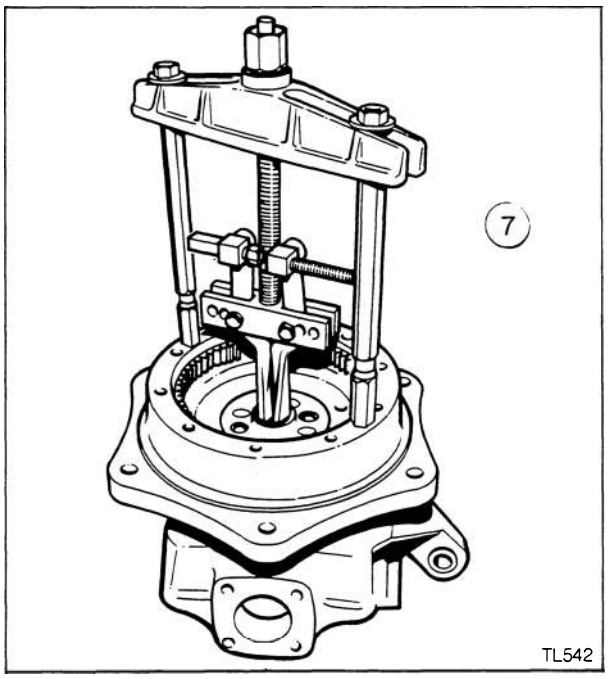
Overhaul 10C-05

Disassembly

1. Remove the planetary carrier, see operation 10C-02.
2. Remove the circlip.
3. Remove the sun gear.
4. Remove the axle pivot pins, see operation 10C-04.
5. Carefully withdraw the hub assembly from the universal drive shaft.

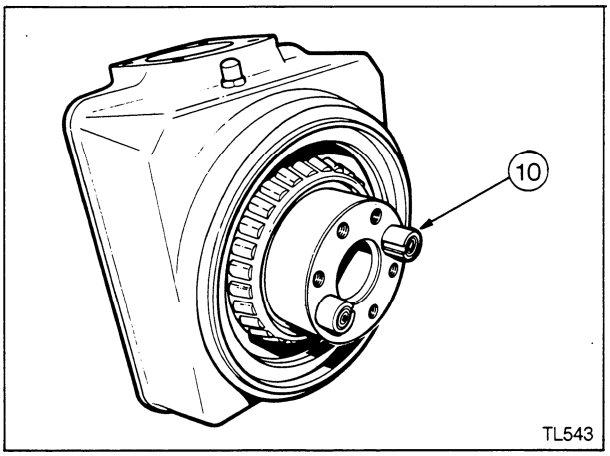
Caution: The hub is heavy and awkward to handle. Take care when removing and refitting it.

6. Place the hub assembly on a work bench and remove the six bolts securing the ring gear.
7. Using an internal bearing puller, withdraw the ring gear from the two sets of roll pins.
   Alternatively, use a hammer and punch through the oil filler hole to remove the ring gear.
8. Remove the hub, bearings, shims and oil seals as necessary.
9. If the oil seals only are being replaced, do not remove the two sets of roll pins.



10. Only remove the dowel pins if necessary.

Note: On later models of front axle the sets of three split tension pins were replaced with solid dowel pins.

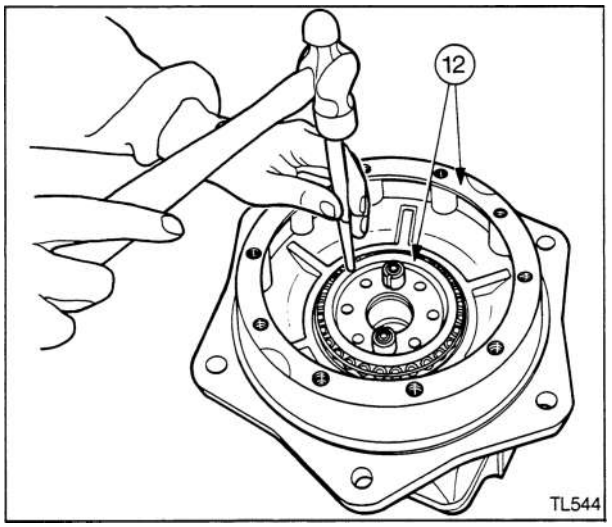


Examination

Pay particular attention to the ring gear teeth and the bearing. Inspect all components and replace any which show signs of wear or damage.

Reassembly

11. Setting the wheel hub bearing adjustment involves calculating the dimension of the shims (dimension A) to be inserted between the ring gear and the taper roller bearing.
12. Replace the hub and bearings.

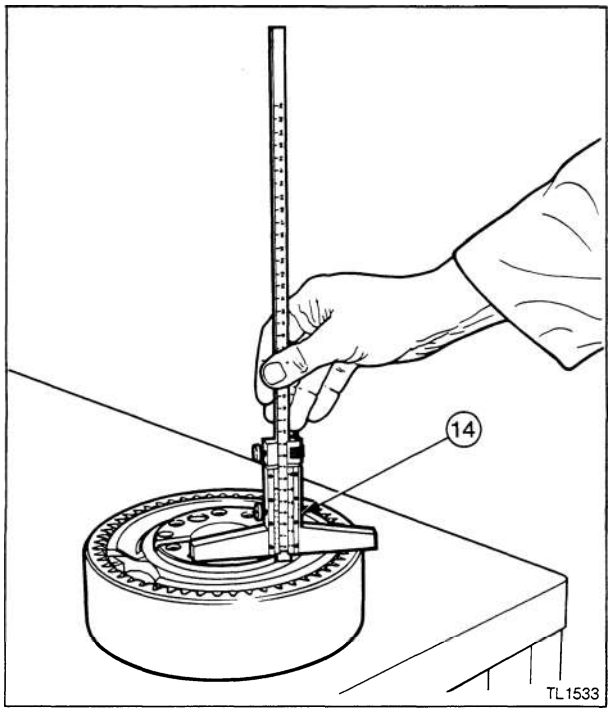


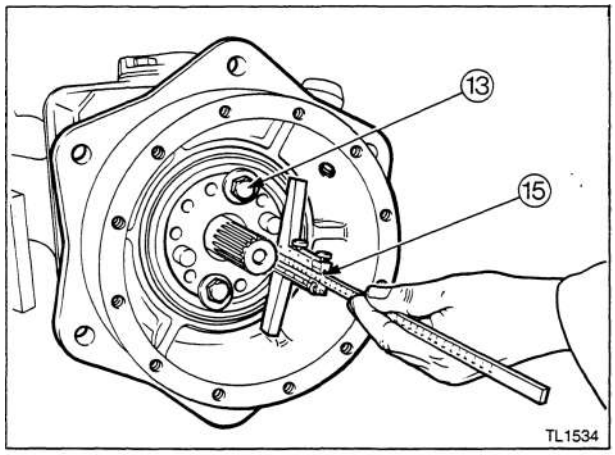
13. Fit two temporary bolts and washers to hold the bearing and hub in place.
14. Measure the projection of the hub on the ring gear (dimension B).
15. Using a depth gauge, measure the projection of the bearing (dimension C) from the central hub.
16. The total shim thickness (dimension A) is the difference between the two values (B - C) plus the bearing pre-load of 0,05 mm (0.002 in) that must be applied. Use the following formula:

    Shim thickness A=(B−C)+0,05 mm

    e.g.

    Shim thickness A=(8,1−6,2)+0,05=1,95 mm

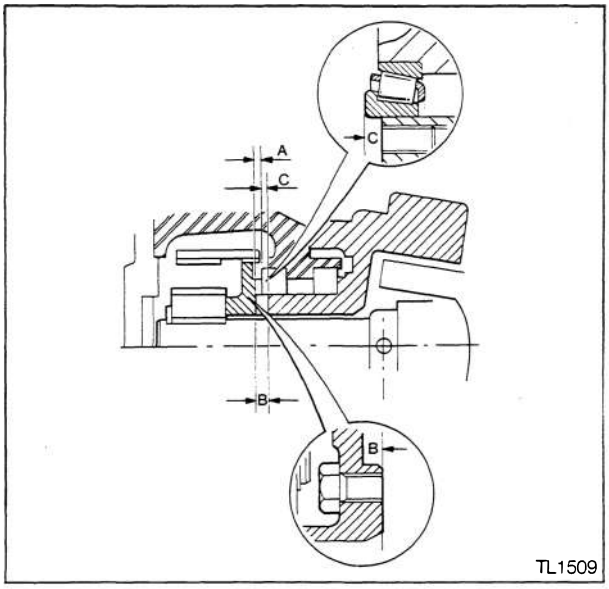


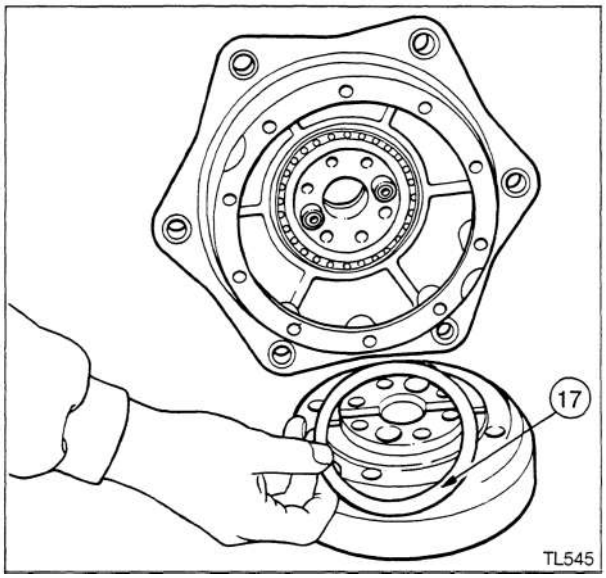


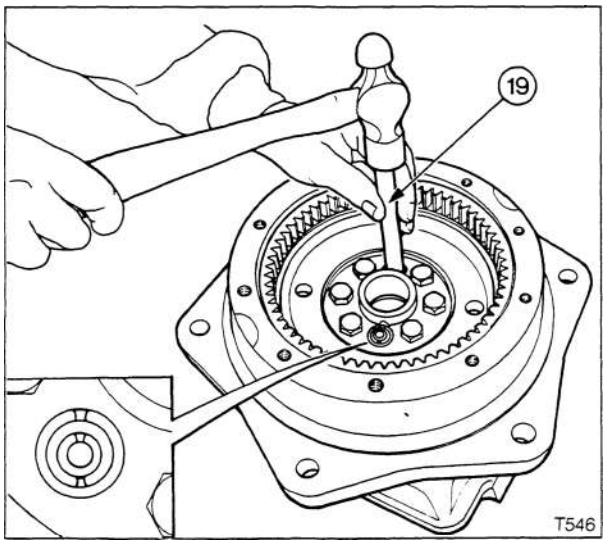
17. Select the shims required from the chart below and insert between the ring gear and hub.

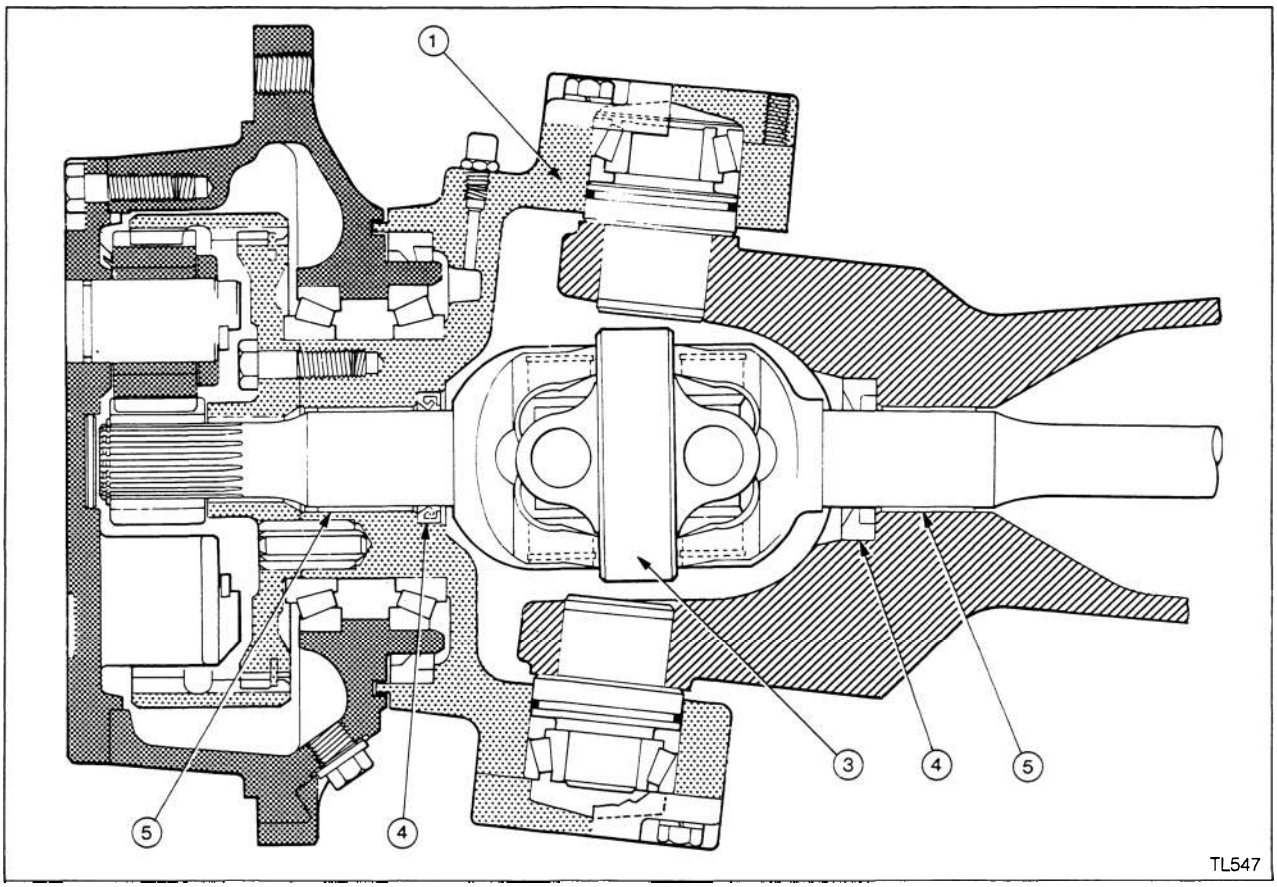
Axle Type NG100SD(N) and NG200/SD		
Part No	Thickness mm	Thickness in
3426 646 M1	0,10	0.004
3426 511 M1	0,15	0.006
3426 512 M1	0,30	0.012
3426 513 M1	0,50	0.020
3426 514 M1	0,70	0.028
3426 515 M1	1,00	0.040
Axle Type NG250/SD		
3426 647 M1	0,10	0.004
3426 300 M1	0,15	0.006
3426 301 M1	0,30	0.012
3426 302 M1	0,50	0.020
3426 303 M1	0,70	0.028
3426 304 M1	1,00	0.040

18. On early axles with tension pin dowels, install the ring gear and shims and loosely refit the six bolts.
19. If necessary, drive the large roll pins first, then the intermediate, and finally the small pin. Ensure that the split in the roll pin is 180° from the split in the adjacent pin.
20. Renew the six bolts, apply Loctite 270 and tighten to a torque of 147 Nm (108 lbf ft).
21. Reverse procedures 1 to 4 except:
    a. Take care when refitting the universal drive shaft support bushes to ensure that they are correctly fitted and to size.
    b. Oil seals must be fully seated in their recesses.
    c. Take care when refitting the large hub oil seal not to distort it. It may be necessary to grind a small lead onto the outer casing to enable the seal to enter the hub.









Universal Drive Shaft

Removal and Refitment 10C-06

Removal

1. Remove the pivot housing, see operation 10C-04.
2. Place a drain tank of at least 12 litres (20 pts) capacity under the front axle and drain sufficient oil to bring the level below the drive shaft bearings. Refit the drain plug.
3. Pull the drive shaft out of the housing.
4. Lever the oil seals out of the housings.
5. If the drive shaft bushes in the housings need replacing, an internal bearing puller will be required to remove them.

Refitment

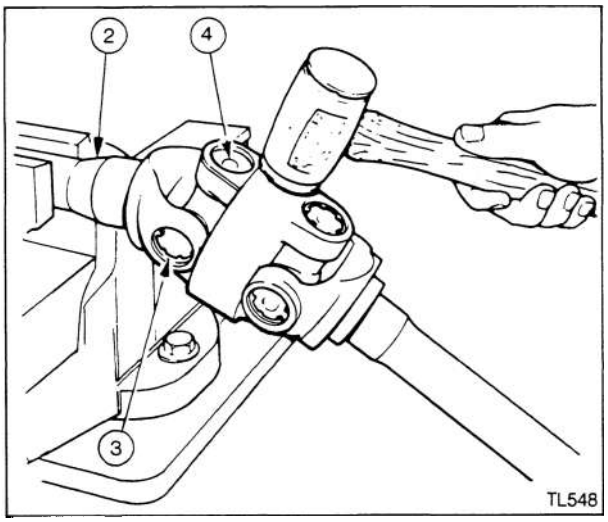
6. Reverse procedures 1 to 5 except:
   a. Fit the shaft oil seals with the lips facing inwards.
   b. Refill the front axle to the correct level with an approved oil.

Universal Drive Shaft

Overhaul 10C-07

Disassembly

1. Remove the drive shaft, see operation 10C-06.
2. Hold the inner section of the drive shaft in a soft-faced vice.
3. Remove the four circlips from each end of the universal joint.
4. Using a soft-faced hammer, drive the central yoke downwards until the bearing sleeve protrudes.
5. Clamp the bearing sleeve in a vice and tap the central yoke from the bearing.
6. Remove the opposing bearing sleeve in the same manner and remove the outer section of the shaft.
7. Turn the shaft assembly through 90^0, then repeat items 4 to 6 to free the universal joint from the shaft.
8. Grip the outer section of the drive shaft in the vice and repeat items 2 to 7.

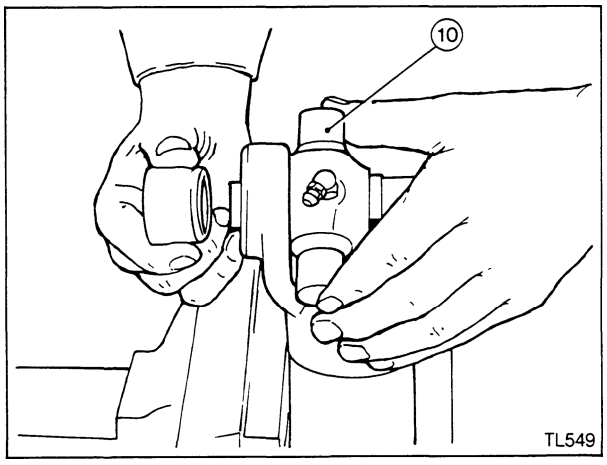


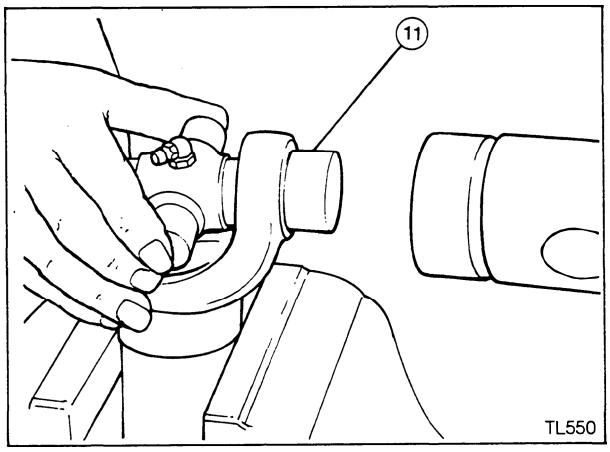
Examination

Pay particular attention to the axle shaft splines. Inspect all components and replace any which show signs of wear or damage. Always replace the universal joint as an assembly including the joint, bearings, caps, circlips and seals.

Reassembly

9. Apply grease to the needle rollers and ensure that all the needle rollers are in the bearing sleeves.
10. Position the universal joint within the yoke and move it sideways as far as possible to provide a guide for the needle rollers of the bearing sleeve being installed.
11. Drive the bearing sleeve into the yoke deep enough to permit insertion of the circlip.
12. Assemble the remaining bearing sleeves and universal joints in a similar method.
13. Thoroughly lubricate the universal joints after completing assembly of the drive shaft and before fitting to the axle.
14. Refit the drive shaft to the axle.





Differential Input Shaft Oil Seal

Removal and Refitment 10C-08

Removal

1. Apply the tractor parking brake.
2. Place a drain tank under the front axle and drain the oil from the axle.
3. Disconnect the drive shaft guard at the differential end.
4. Disconnect the drive shaft at the differential coupling.
5. Remove the central bolt and drive coupling.
6. With a small chisel, unstake the nut securing the splined shaft.
7. Mark the splined shaft where it was staked for refitment.
8. Remove the nut from the shaft.
9. Pull out the oil seal sleeve.
10. Lever out the oil seal.
11. Remove the shaft 'O' ring.

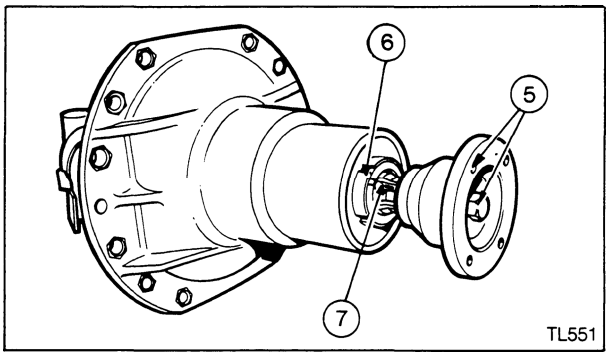
Note: On type NG100/SD(N) and NG200/SD axles, the 'O' ring is fitted to the outside of the shaft at the bottom of the seal sleeve.

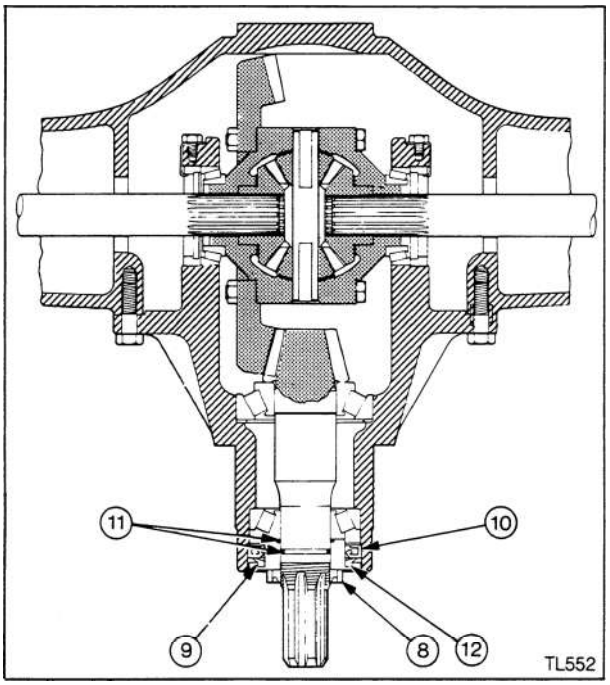
On Type NG250/SD axles, the 'O' ring is fitted in a groove in the pinion shaft.

12. Remove the face type wiper seal from the sleeve.

Refitment

13. Fit a new 'O' ring to the pinion shaft.
14. Carefully fit a new seal with the lip facing inwards.
15. Fit a new wiper seal to the sleeve.
16. Oil the 'O' ring and seals.
17. Grease the face type wiper seal.
18. Fit the sleeve and wiper seal to the shaft.
19. Replace the nut and tighten until the staked mark on the nut lines up with the mark made on the splined shaft. The pinion pre-load will now be set to its original setting.
20. Stake the nut to the shaft in a new position.
21. Reverse procedures 1 to 5 except:
    a. Apply Loctite 270 to the threads of the coupling bolt and tighten it to a torque of 60 Nm (44 lbf ft).
    b. Apply Loctite 270 to the threads of the drive shaft bolts and tighten the nuts to a torque of 55-75 Nm (40-55 lbf ft).





Differential Assembly

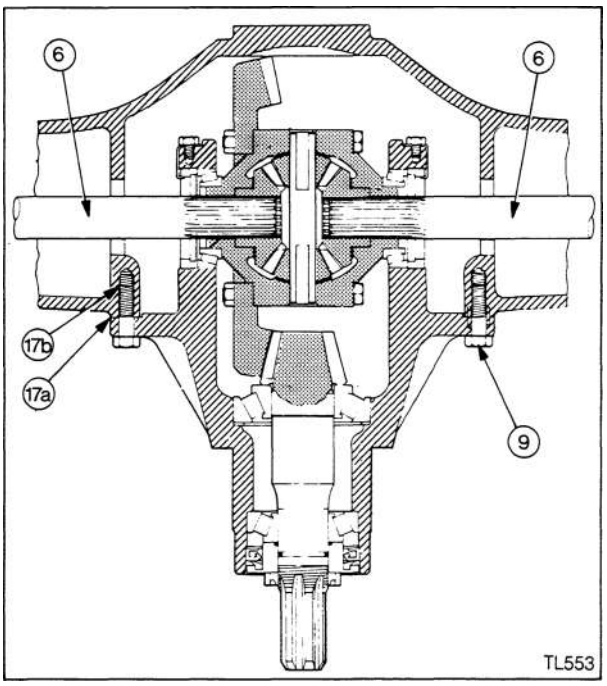
Removal and Refitment 10C-09

Removal

1. Apply the tractor parking brake.
2. Jack up the front of the tractor and support both sides of the axle on axle stands.
3. Remove both front wheels.
4. Drain the oil from the axle and both hubs.
5. Remove both pivot housings, see operation 10C-04.
6. Withdraw both universal drive shafts.
7. Disconnect the drive shaft guard at the front end.
8. Disconnect the drive shaft.
9. Remove the bolts holding the differential case to the axle housing.

Caution: The differential unit is heavy and awkward to handle. Take care when removing and refitting it.

10. The differential case is located by dowels in the axle housing. Carefully prise the case away from the housing, supporting it on a trolley jack.



Refitment

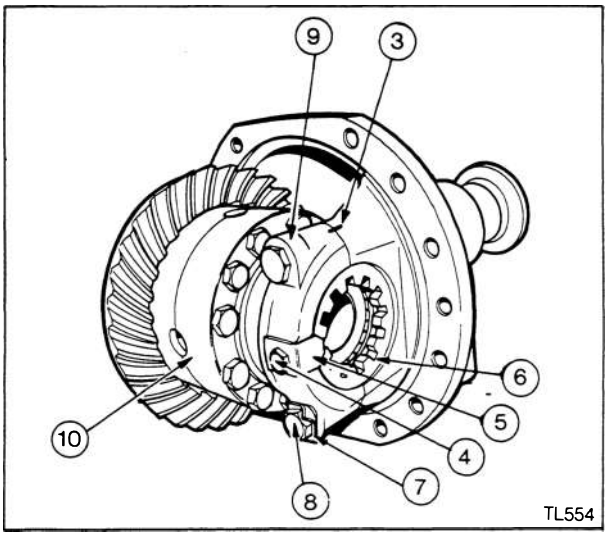
11. Reverse procedure 1 to 10 except:
    a. Apply Loctite 515 Instant Gasket to the joint face of the differential case.
    b. Apply lubricating oil to the differential case securing bolts and tighten them to a torque of 96-118 Nm (71-87 lbf ft).
    c. Apply Loctite 270 to the threads of the coupling bolt and tighten it to a torque of 60 Nm (44 lbf ft).
    d. Apply Loctite 270 to the threads of the drive shaft bolts and tighten them to a torque of 55-75 Nm (40-55 lbf ft).

Differential

Overhaul 10C-10

Disassembly

1. Remove the differential assembly, see operation 10C-09.
2. Hold the differential in a soft faced vice.
3. Mark the end caps and casting to aid reassembly.
4. Remove the securing bolts.
5. Remove the locking tabs.
6. Unscrew and remove the two bearing adjustment ring nuts.
7. Release the four tab locking washers (if fitted).
8. Remove the four bolts.
9. Remove the end caps.
10. Remove the differential unit complete with the bearing cones.



11. Remove the bearing cups.

Note: Keep the two bearing cups separate and identify them to ensure that they are refitted in their original position.

12. Using a universal extractor remove the two bearing cones, if necessary.
13. Remove the crownwheel and differential case securing bolts.

Note: If the crownwheel is to be refitted, mark it in relation to the differential carrier to ensure correct assembly. Mark the two halves of the differential carrier to assist correct assembly.

Two of the bolts are special dowel bolts and are fitted to the holes marked with an arrow. Keep these bolts separate and make a note of the holes in the crownwheel and differential case.

14. Split the differential carrier and remove the differential cross shaft, gears and thrust washers.

Examination

Thoroughly clean and inspect all components. Any parts showing signs of wear must be replaced.

Reassembly

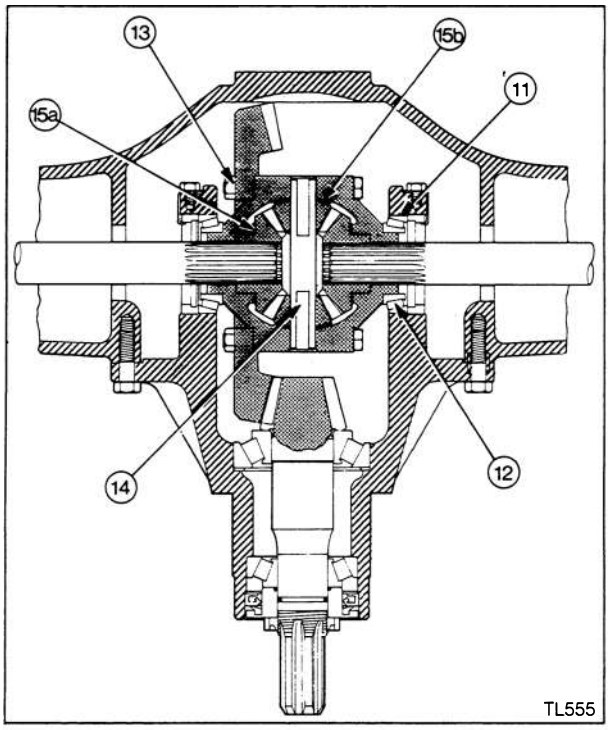
15. Reverse procedures 1 to 14 except:
    a. Fit the thrust washers with their oil grooves towards the differential gears.
    b. Coat the planetary pinion thrust washers with petroleum jelly, then locate them in their repective recesses in their differential case.
    c. Place the planetary pinions directly opposite to each other then roll them into position on the thrust washers.
    d. Ensure that the hole in the planetary pinion shaft aligns with that of the differential case.
    e. Align all marks when reassembling the crownwheel and differential carrier. Fit the dowel bolts to the correct holes.
    f. Apply Loctite 270 to the threads of the crownwheel and differential case bolts and tighten to a torque of 79-87 Nm (58-64 lbf ft).
17. Lightly tighten the bearing caps and lubricate the carrier bearings.

Differentials with two adjuster rings

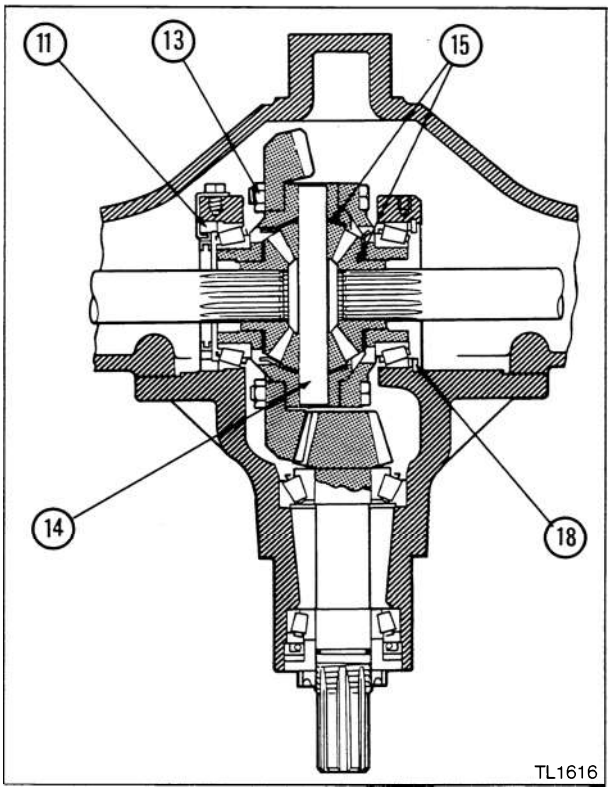
18. Tighten the left and right-hand adjuster rings to ensure that the end float is eliminated. Then apply a pre-load by turning one of the adjuster rings a further three notches until the slot is aligned with the locking plate.

Differentials with one adjuster ring and shims

18. Reinstall the same thickness value of shims as removed from between the bearing and the retainer ring on the right hand side of the differential.
19. Tighten the bearing cap bolts.
20. Tighten the adjuster ring to take up the backlash between the taper roller bearings.



TL555



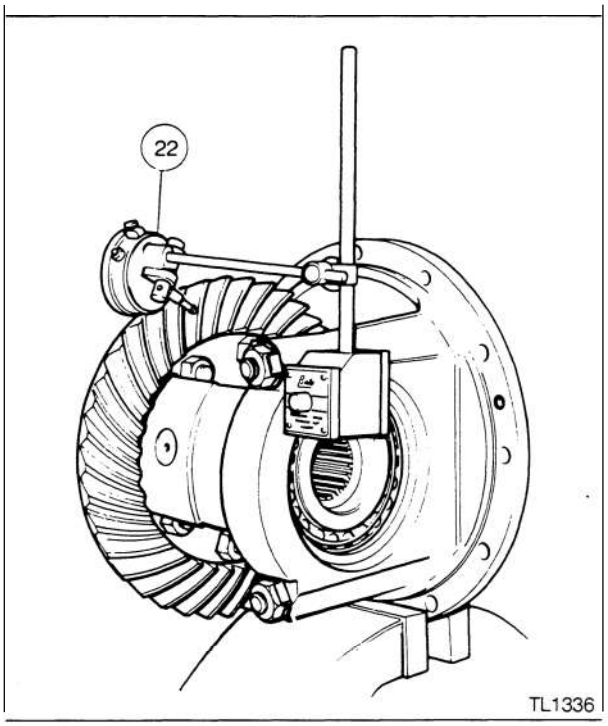
TL1616

21. Finally, turn the adjuster ring a further three notches until the slot is aligned with the locking plate to apply the correct pre-load.

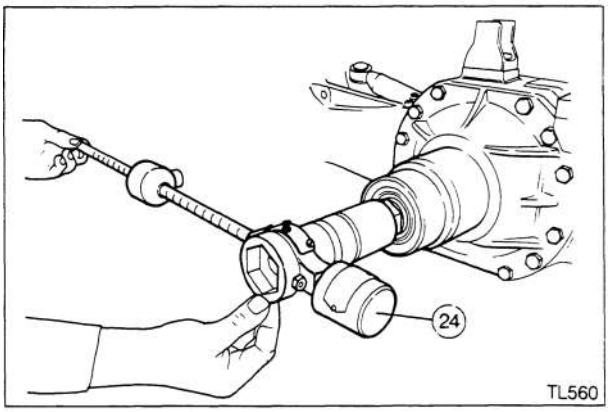
All models

22. With a dial gauge check the backlash between the crown wheel and pinion teeth which should be from 0,10 to 0,25 mm (0.004 to 0.010 in).
23. If the backlash reading is high, the shim thickness must be reduced between the bearing cup and the retainer ring on the right hand side. If low, the shim thickness must be increased until an acceptable backlash is obtained. On early models, readjust the position of the crown wheel using the two adjuster rings but still retaining the bearing preload.
    Shims are available in the following sizes:

Shim part number	Thickness mm	Thickness in
3427 281 M1	0,10	0.004
3427 282 M1	0,15	0.006
3427 283 M1	0,30	0.012
3427 284 M1	0,50	0.020
3427 285 M1	0,70	0.028
3427 286 M1	1,00	0,039



24. Check the rotational torque of the differential assembly at the rear end of the pinion to ensure that the bearings are not too tight. This should be 3,2-3,3 Nm (2.4 lbf ft) which corresponds to the rotation obtained when the 1 kg (2 lb) weight on tool FT4062A is set at a distance of 32 to 33 cm (13.5 to 13.8 in) from the centre of the pinion. This includes the pinion pre-load.
25. If the pre-load is too tight or loose, make adjustment to the differential bearing adjuster ring, still retaining the crown wheel and pinion backlash.
26. Remove each bearing cap bolt in turn, apply Loctite 270 to the thread and lighten to a torque of 136-150 Nm (100-110 lbf ft).
27. Apply Loctite 270 and refit the two ring nut locking tabs and bolts and tighten to a torque of 16-26 Nm (12-19 lbf ft).
28. Refit the differential assembly, see operation 10C-09.



Autolock Differential

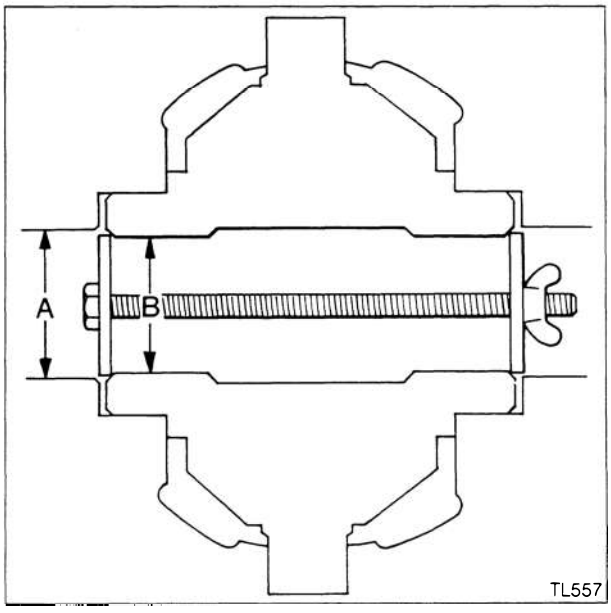
Overhaul 10C-11

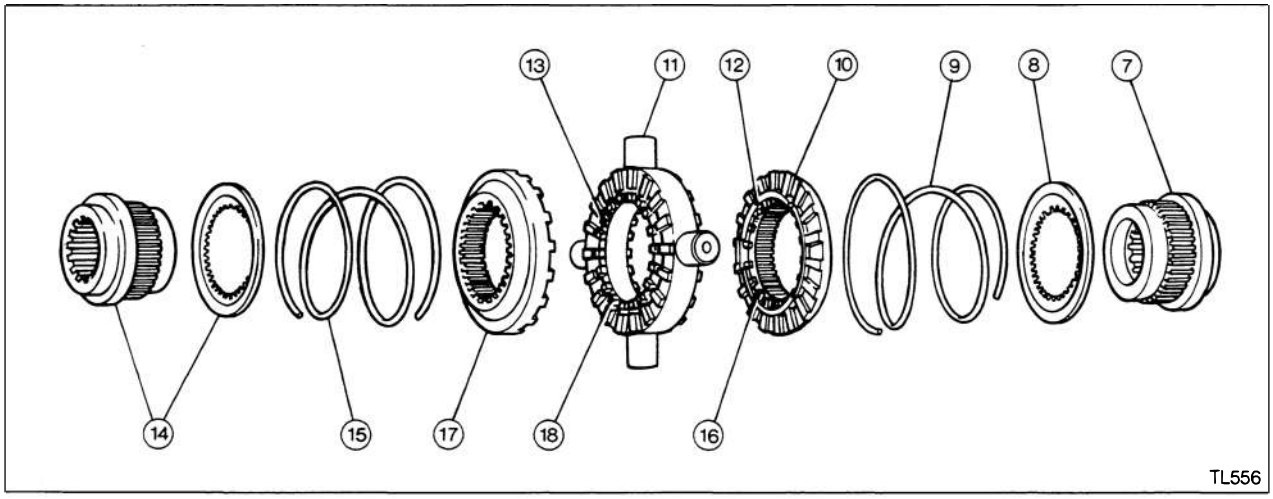
Disassembly

1. Remove and dismantle the differential as described in operation 10C-10 except:
   a. Before removing the differential carrier bolts, insert a retaining bolt washers and wing nut as shown in the illustration to contain the spring pressure within the differential.
   b. The outside diameter of the washer must be smaller than dimension A yet greater than dimension B.

Caution: The two halves of the differential carrier are under spring pressure. If a retaining bolt and washer assembly is not available, place the assembly under a press before removing the bolts.

2. Mark the two halves of the differential case in order to assist reassembly.
3. Remove the crownwheel and differential case retaining bolts.





Note: Two of the bolts are special dowel bolts and are fitted to the holes marked with an arrow. Keep these bolts separate and make note of the holes in the crownwheel and differential case.

4. Remove the differential case cover.
5. Lift out the Autolock differential lock assembly from the main differential case.
6. Carefully release the retaining bolt and washer assembly.

Note: If the Autolock differential is not being replaced, all components MUST be fitted back in the same position. Mark all parts for refitment.

7. Remove the side gears.
8. Remove the spring retainers.
9. Remove the springs.
10. Remove the driven clutches.
11. Remove the central driver and centre cam assembly.
12. Remove the holdout rings by expanding with circlip pliers.
13. If the centre cam from the central driver has to be removed, expand the snap ring into the central driver using three suitable levers and withdraw the centre cam.

Note: Wash all parts thoroughly with a cleaning solvent. Inspect the bearing surfaces for signs of wear or metal pickup. Check the driven clutches and spider assembly for chipping or excessive wear of the teeth.

The centre cam must be able to rotate freely within the limits of the key in the central driver. Check the side gear splines for wear.

The components of the Autolock differential are not available as replacement parts. If any wear has taken place, the whole assembly must be replaced.

Reassembly

14. Fit a spring retainer over the side gear splines and locate the cupped section of the retainer on the side gear flange with the cupped section facing upwards.
15. Fit one conical spring over the side gear and locate the spring retainer seat.

Note: The smaller diameter spring end fits against the spring retainer.

16. Assemble the driven clutch by refitting the holdout ring into the groove.
17. Place the driven clutch into position on top of the coil spring.
18. Refit the centre cam to the central driver by expanding the snap ring into the driver using three suitable levers. Lower the centre cam into place with the narrow gap on the centre cam aligning to the key tooth of the central driver.
19. Place the central driver centre cam assembly onto the driven clutch.

Note: The slot in the hold out ring must mate properly with the central driven key.

20. Follow procedure 14 to 19 for assembly of the other side of the Autolock differential lock assembly.
21. Place the retainer bolt inside the side gear and differential lock assembly.
22. Compress the Autolock differential assembly and fit the second washer and wing nut.

Note: The wing nut is to be finger tight against the washer. Ensure that the splines on the side gears mate to the splines in the driven clutches.

23. Place the Autolock differential assembly into the main differential case.
24. Fit the differential case cover, aligning the two halves with marks previously made. Refit the dowel bolts to the correct holes.
25. Apply Loctite 270 to the crownwheel and differential case retaining bolts and tighten to a torque of 79-87 Nm (58-64 lbf ft).
26. Remove the retaining bolt, wing nut and washers.
27. Set the crownwheel bearing adjustment and pinion backlash, see operation 10C-10.

Crownwheel and Pinion

Overhaul 10C-12

Special Tools: FT 4062A Pinion pre-load gauge

Disassembly

1. Remove and dismantle the differential assembly, see operation 10C-10 or 11.
2. Remove the pinion nut.
3. Press the pinion out of the case complete with the bearings.
4. Remove the oil seal.
5. Remove the inner and outer bearing cups.
6. Press the inner bearing cone off the pinion shaft.
7. Clean and inspect all parts.

Note: The crownwheel and pinion are only available as matched sets.

Reassembly

Pinion Protrusion

It is necessary to carry out a series of measurements and calculations to establish the exact position of the pinion in relation to the crown wheel.

The height of the pinion is adjusted by shims under the taper roller bearing to obtain dimension 'A'. The shims required are calculated in accordance with the following formula:

Sp = 'A' – 118

Where:

Sp = Adjustment shims.

A = Dimension to be measured using depth gauge.

118 = Fixed design dimension which must always be adhered to for fitting. This value may vary, if there is a number proceeded by an + (add) or – (subtract) sign stamped on the pinion head this must be either added or subtracted from the 118 dimension in order to arrive at the correct dimension.

Note: On early NG100 and NG200 axles with two adjuster rings to adjust the diffrential bearing pre-load, the dimension 'A' to be used with these axles is 'A' = 113 mm.

8. To calculate the shims required, place the complete bearing cup and cone into the housing without the pinion or shims.
9. Using a depth gauge measure the distance 'A' between the top of the bearing and the cap face.

   Example:

   Distance 'A' = 119,5 mm
10. Check to see if a number is stamped on the pinion head, if there is, calculate the new dimension in place of 118 mm.

    Example A:

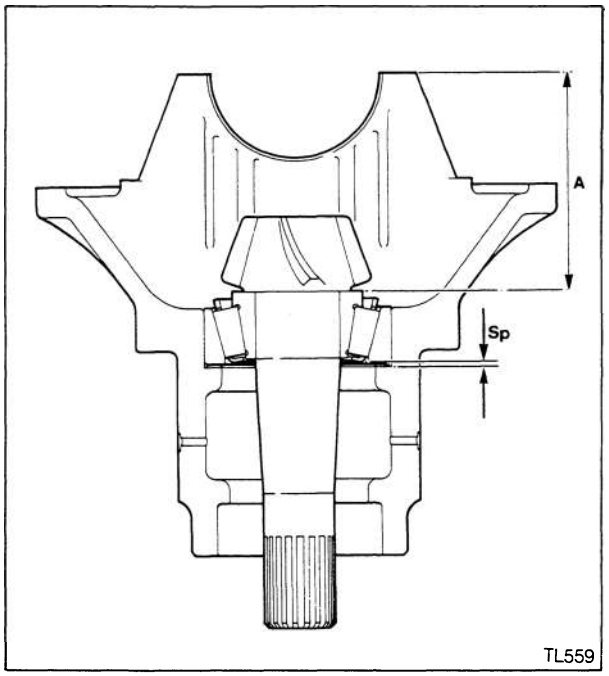
    If +0,20 is stamped on the pinion, correct the dimension as follows:

    118 + 0,20 = 118,20 mm which is the new fixed dimension 'A'.

    Example B:

    If –0,35 is stamped on the pinion, correct the dimension as follows:

    118 – 0,35 = 117,65 mm which is the new fixed dimension 'A'.



11. Calculate the difference between dimension 'A' in paragraph 9 and the fixed dimension in paragraph 10 to find the correct amount of shims to be fitted:

    Example A:

    Sp = (A – 118,20)

    = 119,5 – 118,2

    = 1,3 mm thickness of shims to be fitted

    Example B:

    Sp = (A – 117,65)

    = 119,5 – 117,65

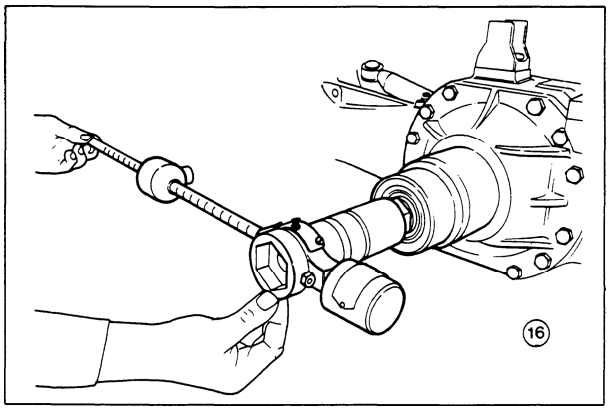
    = 1,85 mm thickness of shims to be fitted.

    It may be necessary to round off to the nearest value that can be made into a shim pack, shims are available in the following sizes:

Axle Type NG100SD(N) and NG200/SD		
Part No	Thickness mm	Thickness in
3426 968 M1	0,10	0.004
3426 464 M1	0,15	0.006
3426 465 M1	0,30	0.012
3426 466 M1	0,50	0.020
3426 467 M1	0,70	0.028
3426 468 M1	1,00	0.040
Axle Type NG250/SD		
3426 289 M1	0,10	0.004
3426 290 M1	0,15	0.006
3426 291 M1	0,30	0.012
3426 292 M1	0,50	0.020
3426 293 M1	0,70	0.028
3426 294 M1	1,00	0.040

12. Remove the bearing, insert the shim pack and refit the bearing again. Recheck that the fixed dimension now corresponds to the value in paragraph 10 example A or B. If it does not correspond, remove or add shims to obtain the established fixed dimension 'A'.
13. Refit the outer bearing, oil seal, sleeve and nut, see operation 10C-08 paragraphs 13 to 18.

Note: A new pinion nut must always be used.

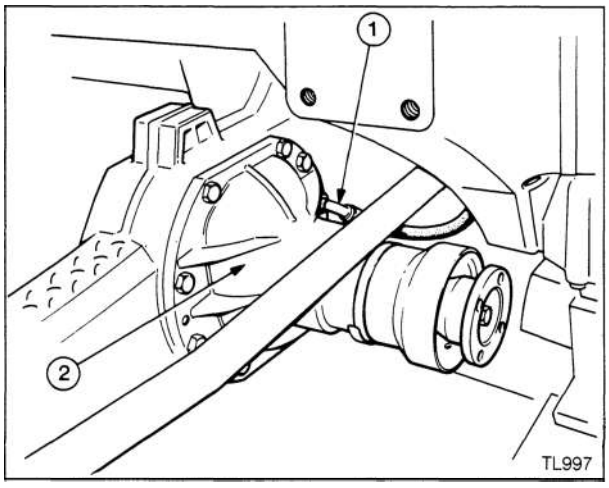


Pinion bearing pre-load

14. Tap the pinion in both directions to ensure that the bearings are fully seated.
15. Lubricate the bearings and rotate the pinion until it rotates freely.
16. Tighten the nut in order obtain a rotational torque of 2,0-2,5 Nm, this corresponds to the rotation obtained when the 1 kg (2 lb) weight of tool FT4062A is positioned 20 to 25 cm (8 to 10 in) from the centre of the pinion.
17. Each time the nut is tightened, reseat the bearings and ensure that the pinion rotates freely or an incorrect reading will be obtained.
18. Stake the nut in position with a hammer and punch ensuring that the lip of the nut is well down into the spline.

Crown wheel and differential assembly

19. Reassemble and install the crown wheel and differential assembly, see operation 10C-10.



Hydralock Differential

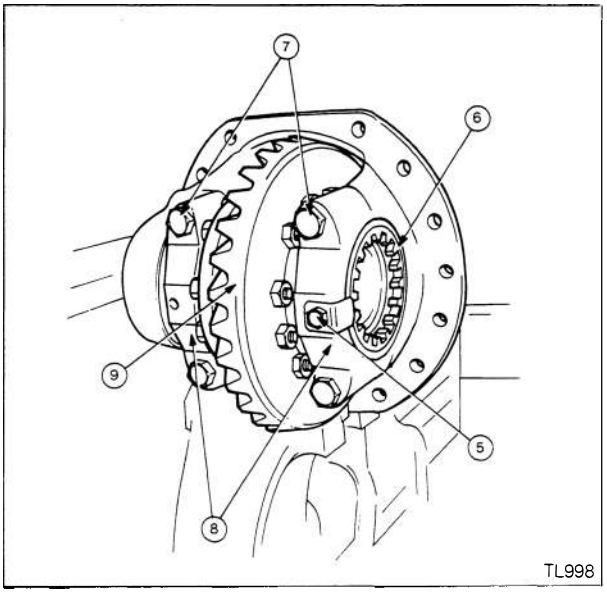
Overhaul 10C-13

Special Tool:
MF471 Hydralock spring compressor

Tractor serial No. NO4464 onwards

Disassembly

1. Disconnect the hydraulic feed hose. Cover the hose end and port connector in the housing to prevent the ingress of dirt etc.
2. Remove the differential assembly from the tractor, see operation 10C-09.
3. Hold the differential in a soft faced vice.
4. Mark the end caps and casting to aid reassembly.
5. Remove the securing bolt and locking tabwasher.
6. Unscrew and remove the bearing adjustment ring nut.
7. Remove the four bolts holding the two bearing end caps in position
8. Remove the two bearing end caps.

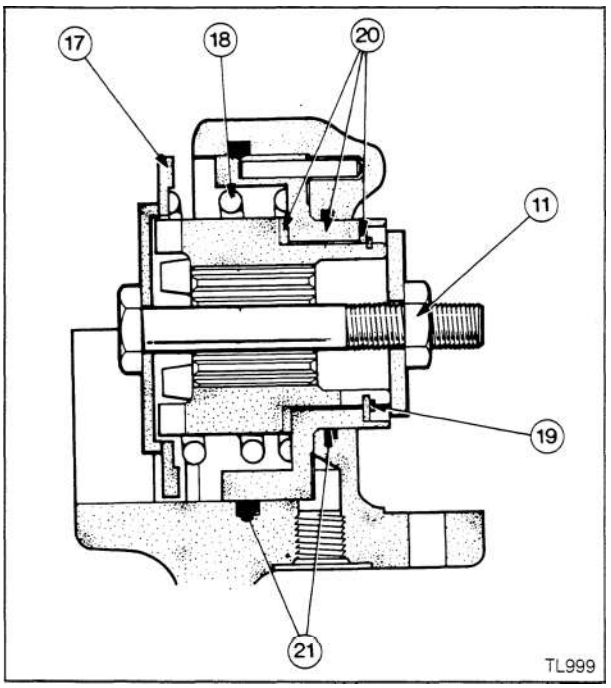


Warning: Remove the bearing cap adjacent to the differential lock with care. SPRING UNDER COMPRESSION. Ensure that the spring retaining ring remains in the differential case.

9. Remove the crownwheel and differential unit complete with the bearing cones.
10. Remove the two bearing cups and shims.

Note: Keep the two bearing cups seperate and identify them to ensure that they are refitted in their original position. For overhaul of the differential assembly see operation 10C-10.

11. Fit the hydralock spring compressor MF471, carefully centralise the two washers.
12. Tighten the spring compressor until all the spring tension has been taken off the retaining ring.
13. Remove the retaining ring from the housing.
14. Tap the unit out of the housing exposing the two oil seals.
15. The hydralock unit can now be disassembled by carefully loosening the spring compressor.
16. Completely remove the spring compressor from the hydralock assembly.
17. Remove the spring guide plate.
18. Remove the coil spring.
19. Remove the piston retaining circlip.
20. Remove the piston from the coupler and the two thrust washers.
21. Remove the two seals from the housing.

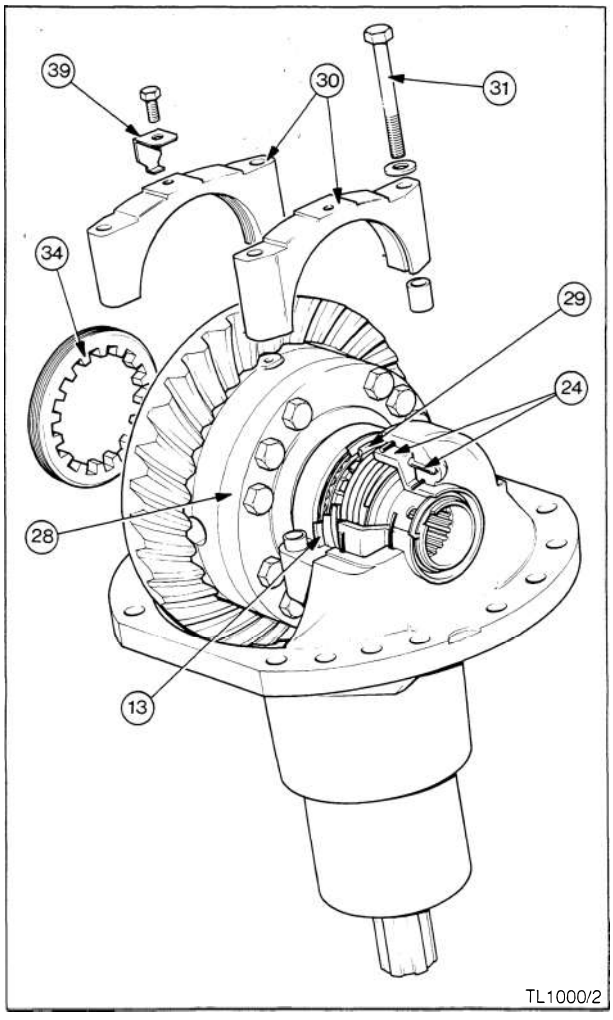


Examination

Thoroughly clean and inspect all the components. Any parts showing signs of wear or damage must be replaced.

Reassembly

22. Reassemble the piston and coupler assembly with the two thrust washers and circlip.
23. Before inserting the piston assembly into the housing ensure that both oil seals are correectly positioned and well lubricated.
24. Tap the position and coupler assembly into the housing ensuring that the locating peg is in the correct radial position.
25. Refit the spring, guide plate and tool MF471.
26. Tighten the spring compressor until the retaining ring can be inserted into its groove.
27. Slowly release the spring compressor and remove it completely from the assembly.
28. Refit the crownwheel and differeential assembly ensuring that the crownwheel is to the left-hand side
29. Refit the shims between the retaining ring and the bearing cup.
30. Refit the two bearing caps making sure that marks are made under procedure 4 correspond.
31. Lightly tighten the bearing cap bolts.
32. Lubricate the carrier bearings before inserting them into the housing. Hold the differential in a vice and place a dial gauge so that the stylus is at right angles to the rear face of the crownwheel.
33. With the aid of a pry bar, move the crown wheel assembly back against the pressure of the hydralock spring, tighten the adjustment ring until there is no movement on the dial gauge. At this point there should be no preload, no clearance, only the force exerted by the hydralock spring.
34. Apply the carrier bearing preload by turning the adjustment ring at a further three notches for the correct load. At this point, the crownwheel assembly will be tight to turn.
35. Check the backlash between the teeth of the crownwheel and the pinion by positioning a dial gauge on a crownwheel tooth.



36. Take three readings at different positions around the crownwheel approximately 120 degrees apart. Take the average reading which must be:

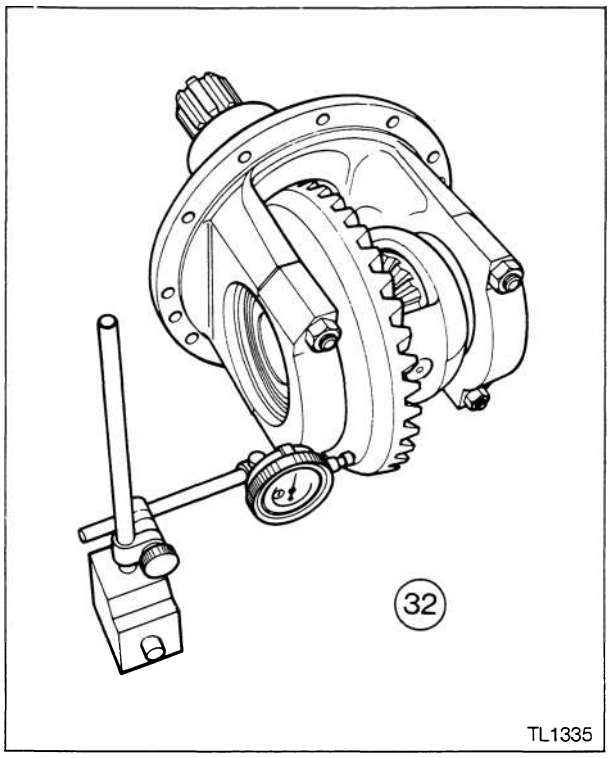
    0,10 to 0,25 mm (0.004 to 0.010 in)

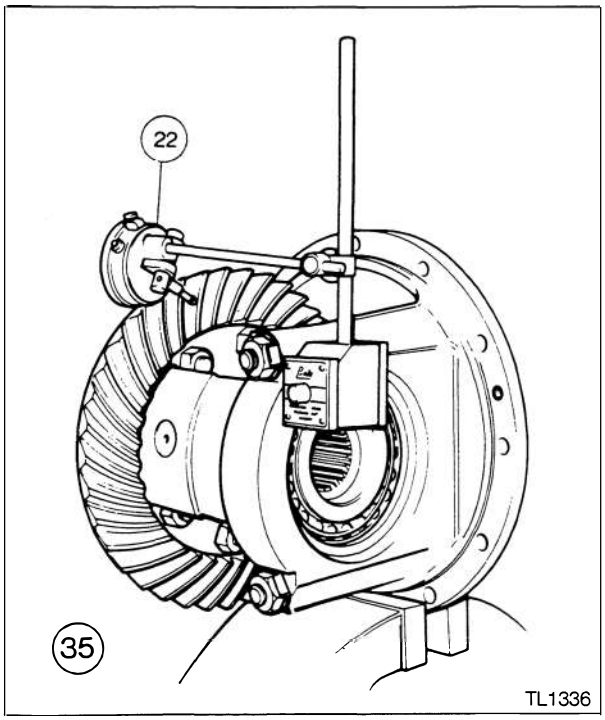
37. If the readings are high, shims thickness must be reduced between the bearing cup and the retainer ring on the differential lock side. If low, shims must be added until an acceptable backlash reading is obtained.

Shims are available in the following sizes:

Shim number	Thickness mm	Thickness in
3427 281 M1	0,10	0.004
3427 282 M1	0,15	0.006
3427 283 M1	0,30	0.012
3427 284 M1	0,50	0,020
3427 285 M1	0,70	0.028
3427 286 M1	1,00	0.040

38. Remove the bearing cap bolts one at a time and apply Loctite 270 to the threads and tighten to a torque of 136-150 Nm (100-110 lbf ft).
39. Apply Loctite 270 and refit the tabwasher and bolt. Tighten to a torque of 16-26 Nm (12-19 lbf ft).
40. Refit the differential assembly to the tractor, see operation 10C-09.
41. Remove the dirt cover from the hydraulic port and feed hose before reconnecting the oil feed to the axle.





SECTION 9

Hydraulics

INDEX

9A	LIFT HYDRAULICS
9B	STEERING - ORBITROL STEERING UNIT
9C	STEERING - BOX AND PUMP
9D	AUXILIARY HYDRAULICS

Lift Hydraulics

Section 9 – Part A

Table of Contents

Operation No.	Description	Page No.
-------	Specification	9A- 2
-------	General description	9A- 3
2.09A-01	Control spring assembly - removal	9A-10
2.09A-02	Control spring assembly - overhaul	9A-10
2.09A-03	Hydraulic lift cover - removal	9A-11
2.09A-04	Hydraulic lift cover - overhaul	9A-12
2.09A-05	Hydraulic lift cylinder - overhaul	9A-15
2.09A-06	Quadrant and support assembly - overhaul	9A-16
2.09A-07	Hydraulic static adjustments - adjust	9A-17
2.09A-08	Hydraulic external adjustments - adjust	9A-19
2.09A-09	Hydraulic pressure test - check	9A-21
2.09A-10	Hydraulic lift pump - removal	9A-22
2.09A-11	Hydraulic lift pump - overhaul	9A-23
2.09A-12	Hydraulic relief valve - adjust	9A-28
2.09A-13	Hydraulic relief valve - removal	9A-28
2.09A-14	Selector valve - removal	9A-29
2.09A-15	Selector valve - overhaul	9A-30
2.09A-16	Right-hand side cover - removal	9A-31
2.09A-17	Right-hand side cover - overhaul	9A-31
2.09A-18	Hydraulic pump oil strainer - servicing	9A-32
2.09A-19	Hydraulic assistor ram - overhaul	9A-32

Lift Hydraulics

SPECIFICATION:

Hydraulic pump

Model	MK 3
Type	Four cylinder, scotch yoke, driven from the PTO drive line
Output Standard flow	16,7 litres/min
Pressure relief valve setting:	
MF 345	157-193 bar
MF 350/355/360/375/385	221-231 bar
Functions	Draft control, Position control, Response control, and Constant pumping.
Lift cylinder size:	
MF 345/350	79,4 mm diameter
MF 355/360/375/385	93,6 mm diameter
Selector shock valve pressure setting	260-275 bar

Settings required

Draft Control rod clearance	5,8 mm
Vertical lever load	1,3 kgf
Vertical lever setting angle	90°
Response lever clearance	6 mm
Linkage loads for running adjustments	400 kgf minimum
Lift arm rotation Transport setting	6 mm

Special Tools

MF.148B	Pressure test gauge
MF.163	Spring retainer nut wrench
MF.226C	Lift cover remover/r eplacer
MF.272 A.	Ram arm gauge
MF.333	Draft Control rod gauge
MF.349	Valve facing cutter and coining tool set
MF.350	Valve chamber circlip replacer
MF.351	Valve chamber plug remover
MF.352	Control valve spring retainer clip
MF.353	Control valve body 'O' ring guide
MF.354	Control valve body replacer
MF.356 E.	Position and Draft Control setting gauge
MF.420	Hydraulic ram piston seal replacer - 79 mm
MF.453	Hydraulic ram piston seal replacer - 93 mm
MF.455	Pressure relief valve test capsule
MF.3001 A.	Pressure test kit

Bolt torques

Control spring screw	7 Nm
Lift cover bolts	88 Nm
Front ram cylinder nuts	220 Nm
Rear ram cylinder nuts	305 Nm
Pump body retaining nuts	40 Nm
Vertical lever end plate bolts	20 Nm
Pressure relief valve assembly	110 Nm
Pressure relief valve manifold nut	27 Nm
Selector valve retaining bolts	44 Nm
Relief valve	25 Nm

GENERAL DESCRIPTION

General

Fig.1. The Ferguson hydraulic system comprises a four cylinder scotch yoke type pump (1) which delivers oil, through a vertical pipe (2) to the cylinder (3).

A connecting rod (4) from the cylinder piston (5) engages in the ram arm (6) which is splined on to the lift shaft (7) which carries the linkage lift arms.

When oil, under pressure from the pump, is delivered to the ram cylinder (3), the piston is forced rearwards and pushes the ram arm upwards, causing the lift shaft to rotate and raise the lift arms.

Conversely, when the oil is allowed out of the cylinder, the piston moves back under the load of the lift arms.

The hydraulic pump is driven by the PTO drive from the main clutch, via the gearbox constant mesh gears and the PTO drive shaft. It is therefore rotating whenever the forward part of the PTO system is being driven.

Oil flow from the pump is controlled by an integral control valve on the suction side of the pump.

The pump control valve is moved by the quadrant levers, forces down the top link, or the cam on the cross shaft.

The speed of movement of the valve into discharge (lower) is controlled by the Response unit.

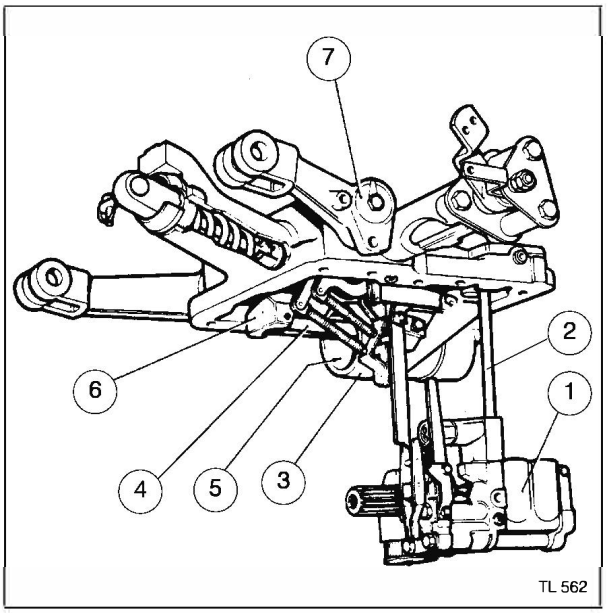


Fig.1

Hydraulic linkage pump (Fig.2).

The pump consists of two piston yokes (1) which ride on cam blocks located on eccentrics on a camshaft (2). The pistons reciprocate in opposed valve chambers (3), each housing two inlet (4) and outlet valves (5) and springs. A sealing plug and snap ring secure the valves in the chambers.

Front and rear pump body castings incorporate the oil galleries connecting the valve chambers, and house the control valve (6) and the oscillator.

Attached to the rear body is the Response control (7) and strainer housing (8) and also the pressure relief valve (9).

The pressure relief valve is adjustable and is connected to the outlet port of the pump to the lift cylinder.

As each of the pump pistons moves in its cylinder it creates suction which lifts the inlet valve from its seat and draws in oil past the control valve (if open) along the intake gallery into the cylinder. During this inlet stroke the outlet valve is held closed by the spring acting on it. When the piston reaches the end of its inlet stroke, the suction ceases with the cylinder, now full of oil, allowing the inlet valve to be closed by the inlet valve spring.

As the piston begins its compression stroke, the resultant pressure in the oil keeps the inlet valve closed and lifts the outlet valve, forcing the oil past the outlet valve into the high pressure gallery and up the stand pipe to the ram cylinder.

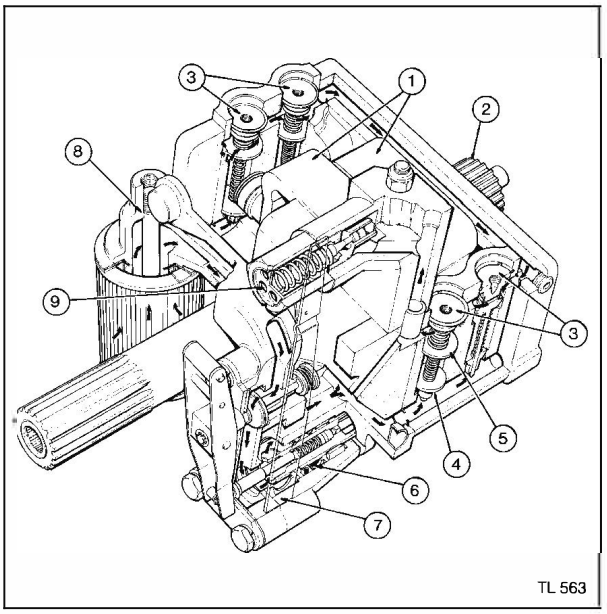


Fig.2

Pump control valve. (Fig.3 to Fig.5).

The function of the pump control valve is to control the oil flow to and from the hydraulic system. In order to carry out this function, it has 3 positions: 'Intake' (raise), 'Neutral' (stationary) and 'Discharge' (lower).

The main advantage of the Ferguson System is that the pump gives a variable flow by controlling the degree of opening of the intake and discharge slots in the control valve assembly giving complete control across the full range.

The control valve has intake and discharge slots at either end and is moved into its various operating positions by a vertical lever controlled by the linkage arrangements within the top cover assembly. It is spring loaded to the intake position. The valve is oscillated to prevent it sticking. It slides within a sleeve which has ports leading to the intake and pressure sides of the pump.

In Fig.3, the vertical lever has moved to allow the valve to move to the intake position under the influence of the spring. This allows oil to be drawn through the intake slots into the pump. In this position, the lift arms would be rising.

Fig.4, shows the valve in its neutral position, the intake and discharge slots being outside the ports in the sleeve. In this position, the lift arms would be stationary.

In Fig.5, the valve is in its discharge position. The discharge slots are open to the pressure chamber allowing oil to flow from the ram cylinder back to sump. In this position, the lift arms would be lowering.

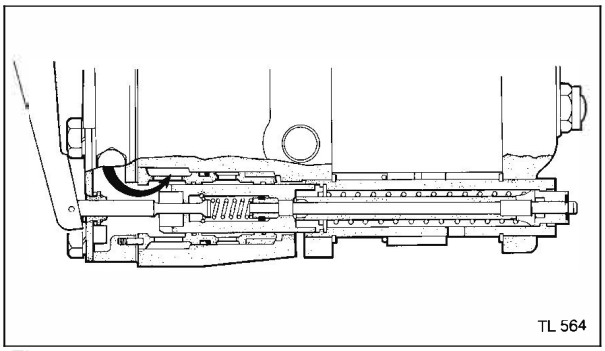


Fig.3

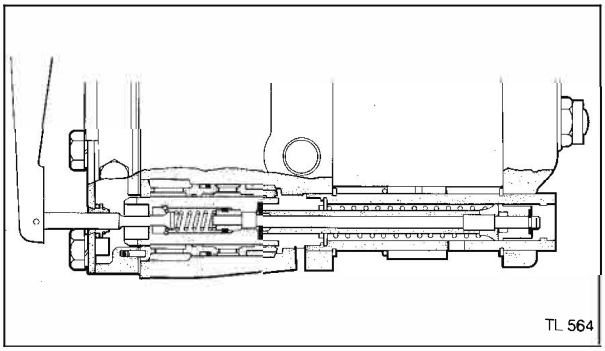


Fig.4

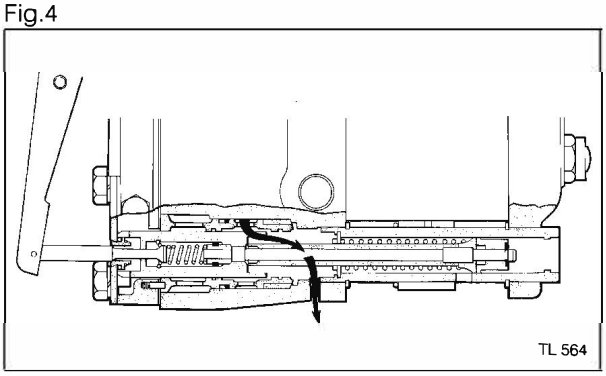


Fig.5

Response Control (Fig.6).

The principle components of the Response Control mechanism are a non-return valve within the pump intake gallery and an oil discharge orifice, the effective size of which is varied by a slide valve.

Whenever the pump control valve moves to the discharge position it displaces oil from the intake gallery (1). The oil is prevented from returning through the intake filter by the non-return valve (2) and is therefore forced to escape through the orifice (3). Altering the Response Control setting moves the slide valve (4) which varies the size of the orifice and consequently the rate of oil discharge from the gallery. This, in turn, determines the speed at which the control valve moves to discharge and the rate at which the implement lowers.

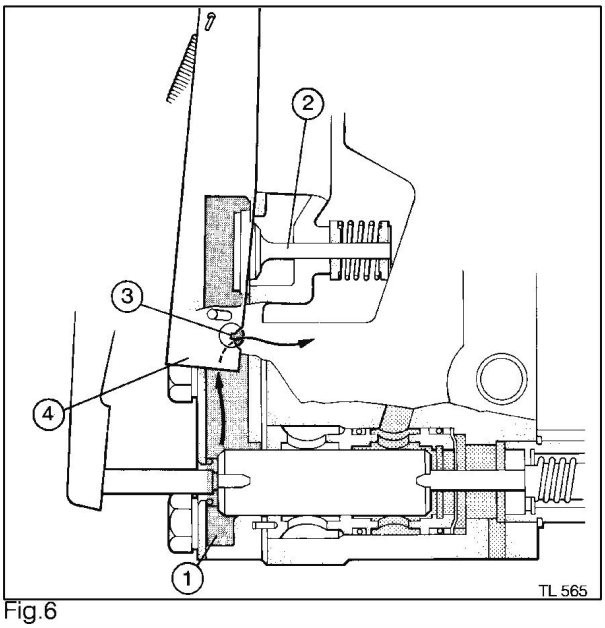


Fig.6

Operation

Draft Control – implement lowering. (Fig.7).

To lower the implement, place the Position Control lever in the Transport position, and move the Draft Control lever down the quadrant. This action presses the eccentric roller (1), on the end of the Draft Control lever shaft, down onto the upper cam face of the Draft Control cam (2), causing the lower face of the cam (2) to be forced downwards into contact with the roller (3) on the Draft Control linkage. The cam (2) is then moved rearward causing the vertical lever (4) to pivot and move the pump control valve, via the lever (5), into the discharge position against the influence of the control valve spring. The Draft Control linkage will move because the force from the control valve is less than the breakout spring (6) force.

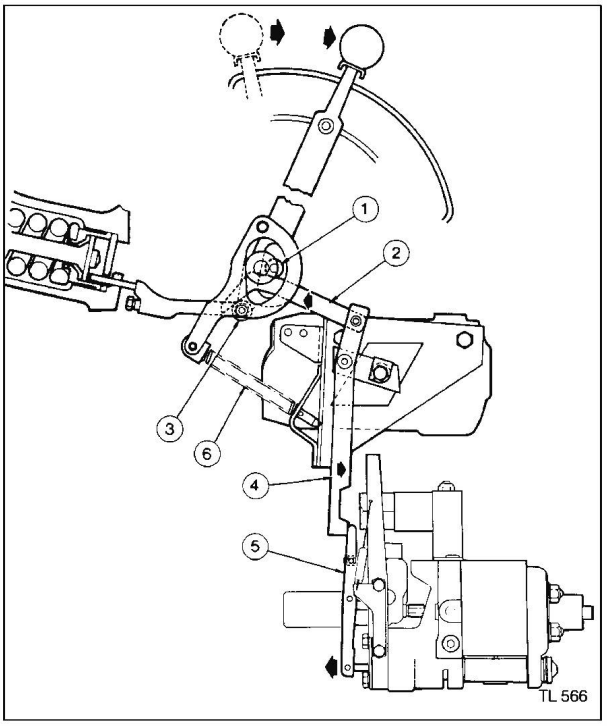


Fig.7

Draft Control – compression force in the top link. (Fig.8).

When the control valve is in the full discharge position, and with further downward movement of the Draft Control lever, the eccentric roller (3) acting on the upper cam face of the Draft Control cam (4), forces the lower cam face of the Draft Control cam (4) to move the roller (5) forwards.

Forward movement of the roller (5) leaves a gap between the Draft Control rod (2) and the Draft Control spring plunger and simultaneously compresses the breakout spring on the guide rod (7).

Forward movement of the tractor will cause an implement to gain depth because the control valve is in the discharge position.

This will continue until the resultant implement draft reaction compression forces, applied through the top link, deflect the control spring.

This causes the Draft Control spring plunger to contact the Draft Control rod (2), and move the Draft Control linkage forwards, acting under the influence of the control valve spring and limited by the position of the roller (5), until the control valve reaches the neutral position.

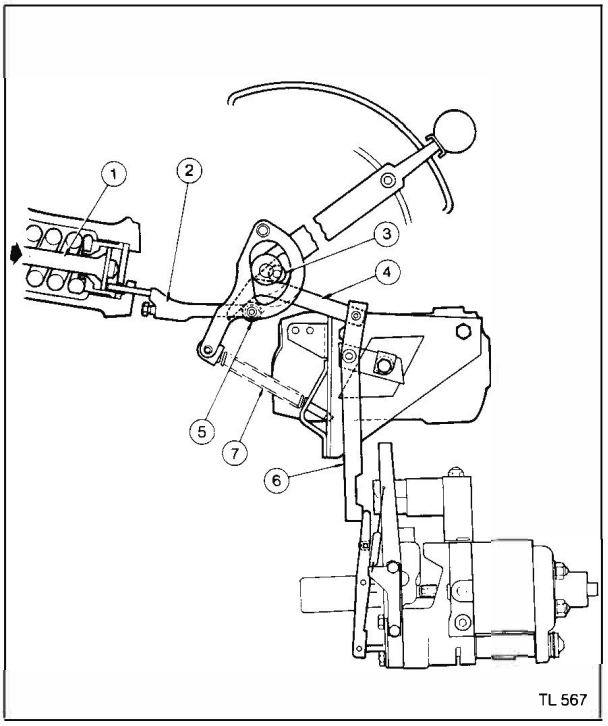


Fig.8

Draft Control – tension force in the top link (Fig.9).

Variations in ground conditions will cause fluctuations in the draft force in the top link. If the draft force decreases, the compression force in the control spring decreases.

The Draft Control linkage follows the control spring plunger under the influence of the breakout spring in the guide rod (7), and moves the Draft Control link rearwards. The vertical lever (4) pivots and moves the pump control valve, via the lever (5), towards discharge. When the correct depth is obtained, the valve is restored to neutral. An increase of draft force in the top link will have an opposite effect.

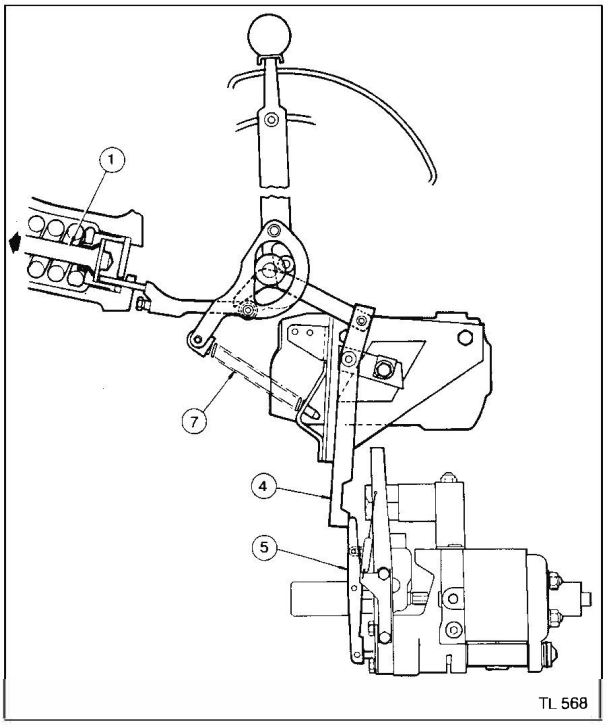


Fig.9

Position Control – implement lowering (Fig.10).

With the Draft Control in the fully UP position downward movement of the Position Control Lever causes the eccentric roller (2) to force the cam (3) downwards. The breakout spring pushes the Position Control link (1) to maintain contact between the roller (8) and the eccentric cam on the cross shaft (9), and the front roller (6) moves the cam (3) rearwards, causing the vertical lever to pivot and move the pump control valve, via the lever (5) into the discharge position.

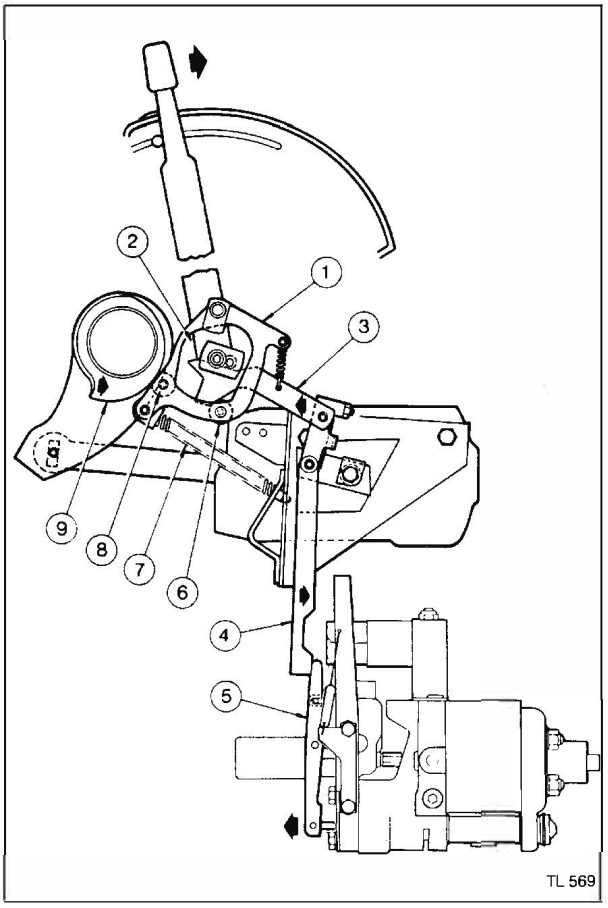


Fig.10

Position Control – implement raising. (Fig.11).

Release of oil from the ram cylinder allows the eccentric cam on the cross shaft (5) to rotate and force the rear roller (4), mounted on the Position Control link (1), forward. This action allows the pump control valve spring to move the Position Control cam (2), which is in contact with the front roller (3), forward, until the control valve reaches the neutral position, which has been determined by the Position Control lever.

For every position that the Position Control lever is moved to, there is a position where the cam moves the control valve to neutral.

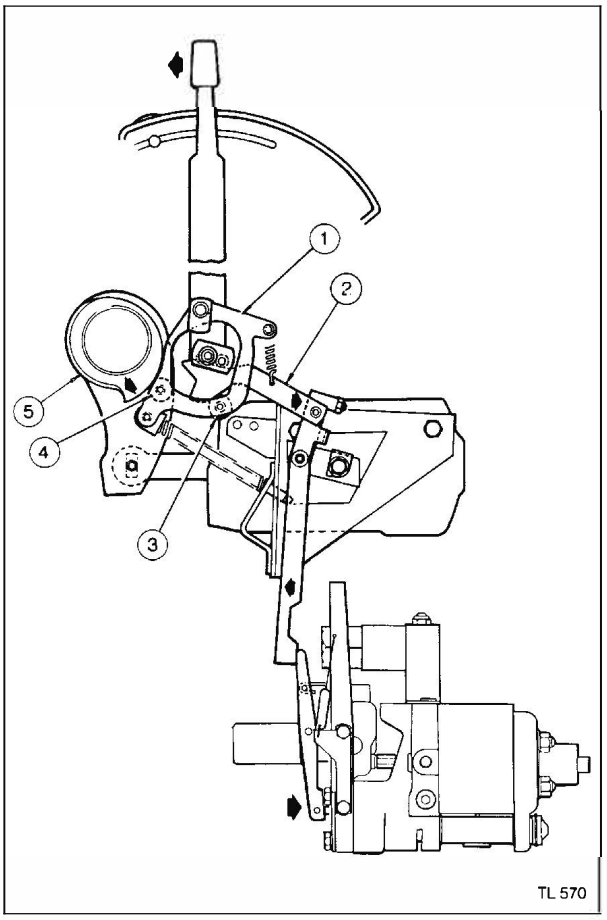


Fig.11

Auxiliary hydraulics from the linkage pump

The Massey Ferguson range of tractors can be fitted with various arrangements that can supply hydraulic power for external use from the linkage pump as follows:

1. Fig.12. Oil direct from the linkage pump (1) via a trailer tipping pipe (2) - single-acting cylinders only. The lower links will raise or lower with the operation of the trailer unless restrained.

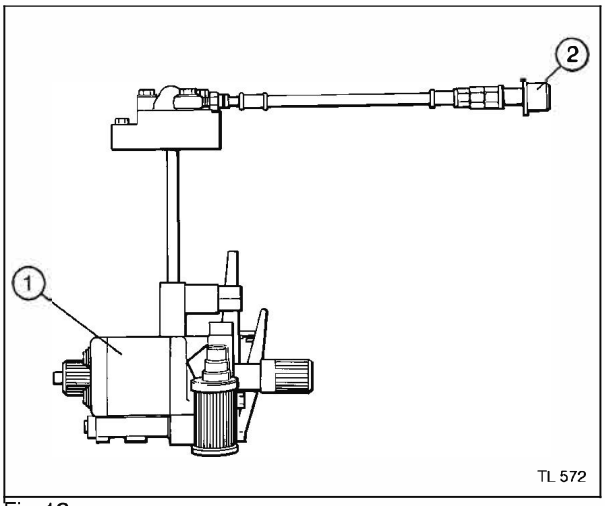


Fig.12

2. Fig.13. Oil from the linkage pump (1) via a selector valve (2) and trailer tipping pipe (3) - single-acting cylinders only. The lower links will be locked when the Selector Valve is moved to the external position.

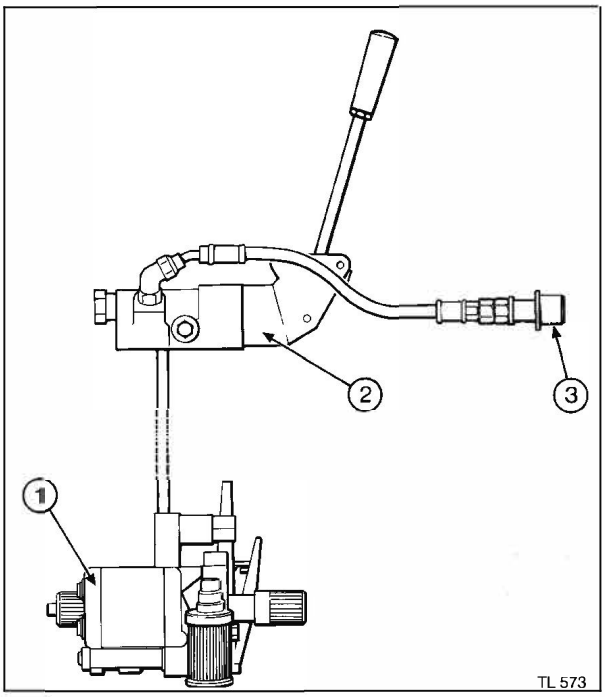


Fig.13

3. Fig.14. Oil from the linkage pump (1) via a selector valve (2) and spool valves (3) - single or double-acting cylinders. The lower links will be locked when the Selector Valve is moved to the external position.

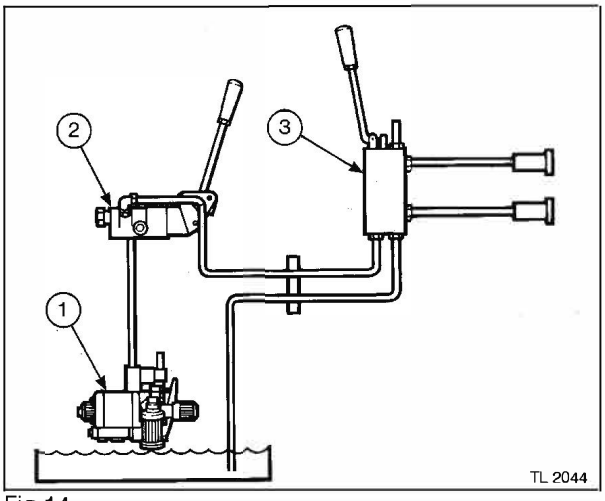


Fig.14

Selector Valve (Fig.15).

This valve can be used on its own or in conjunction with a mechanical linkage which automatically places the linkage pump to Constant Pumping, to supply oil for external use in conjunction with the spool valves.

When the valve is used on its own without the Constant Pumping facility, the oil supply to the valve is governed by the use of the tractor's Position and Draft Control levers. The only function of the valve is to divert oil to the rear linkage system or, alternatively, to an external service. In order to do this, the valve incorporates a spool (1) having two alternative positions. In one position, it diverts the linkage pump flow to the linkage ram cylinder (2) in the other position, to an external supply port (3). Also housed in the valve block is a relief valve (4) which protects the ram cylinder from damage by shock pressures, when the oil flow to an external service is selected, since in this situation, the cylinder is isolated from the pump relief valve. Due to the design of the valve and the zero-leak seal fitted to the ram cylinder piston, there is no appreciable oil leakage past the piston or through the valve and any form of compensating feature is therefore unnecessary. The valve is operated directly by means of a lever.

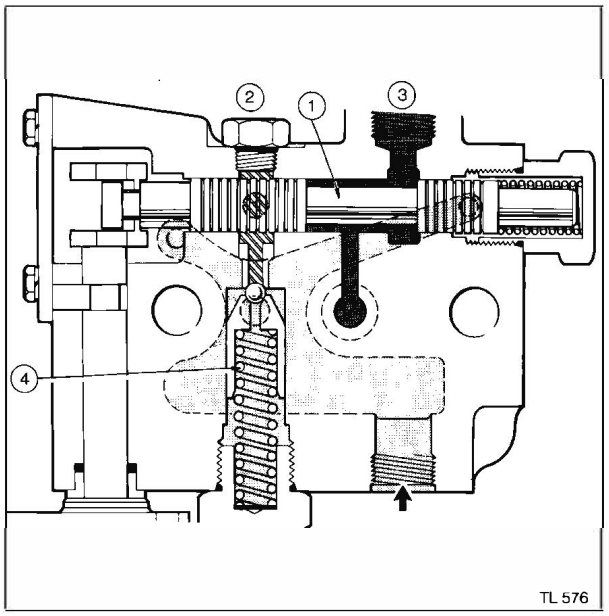


Fig.15

The selector valve with constant pumping facility (Fig.16).

Tractors may use this arrangement to supply oil to spool valves from the linkage pump only, or in combination with the flow from the auxiliary pump.

The valve works in exactly the same way as already described but a linkage mechanism automatically places the linkage pump into Constant Pumping, whenever the operating lever (1) is moved to the external position. This is achieved by means of a bell crank (2) connected to the valve's operating shaft. Attached to this is a linkage (3) running down to the right-hand centre housing side cover. This, in turn, moves the linkage pump control valve to move into full intake. As a result, maximum pump output is automatically supplied to the spool valves via the Selector Valve whenever its operating lever is placed in the external position. This action makes the tractor Draft and Position Control levers inoperative since they have no influence over the position of the pump control valve until the operating lever of the valve is returned to the linkage position.

When the Selector Valve is used to supply oil to a spool valve, returning oil is fed to a return port on the left-hand PTO side cover.

The use of spool valves is particularly valuable in achieving precise and easy independent operation of single- and double-acting rams.

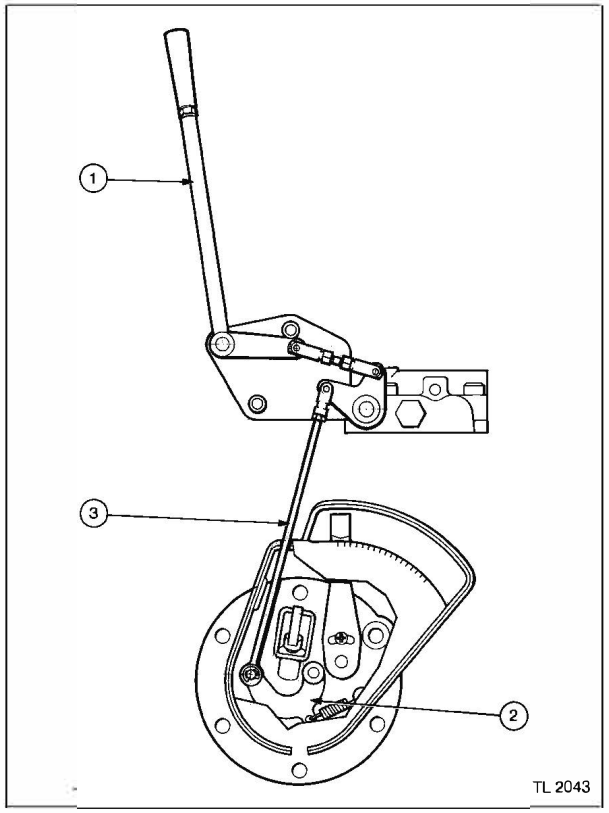
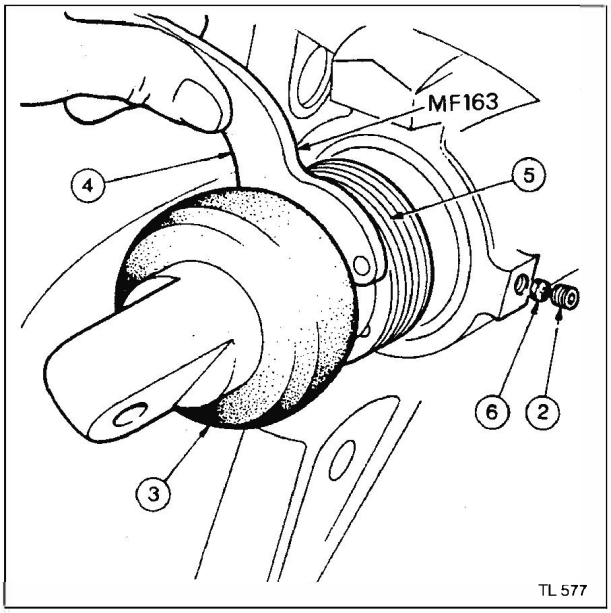


Fig.16

CONTROL SPRING ASSEMBLY

Removal and refitment **2.09A–01**
Special Tools:
MF163 Wrench



Removal

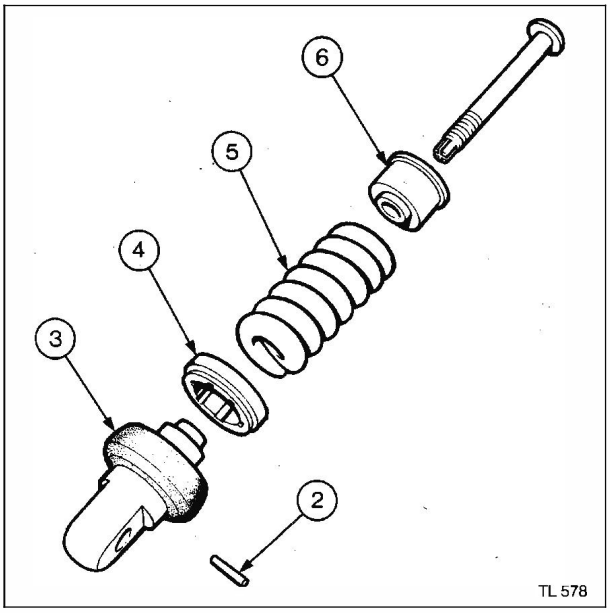
1. Remove the control beam.
2. Remove the hexagon socket screw.
3. Pull back the rubber boot.
4. Using MF.163, unscrew the retainer from the lift cover.
5. Withdraw the control spring assembly from the lift cover.
6. Remove and discard the nylon plug.

Refitment

7. Reverse procedures 1 to 6, except:
   a. With the Draft Control lever in the fully DOWN position, tighten the retainer, until the end-float is eliminated. Do not over-tighten otherwise the end float will reappear.
   b. Fit a new nylon plug.
   c. Tighten the hexagon socket screw to a torque of 7 Nm.

CONTROL SPRING ASSEMBLY

Overhaul **2.09A–02**
Special Tools:
MF163 Wrench



Dis-assembly

1. Remove the control spring assembly, see operation 2.09A-01.
2. Drive out the pin.
3. Unscrew the head using MF.163 wrench
4. Remove the retainer.
5. Remove the spring.
6. Remove the spring seat.

Re-assembly

7. Reverse procedures 1 to 6, except:
   a. Screw the plunger into the head until the end-float is eliminated and the spring is tight to turn by hand.
   b. Fit a new pin.

HYDRAULIC LIFT COVER

Removal and refitment **2.09A–03**

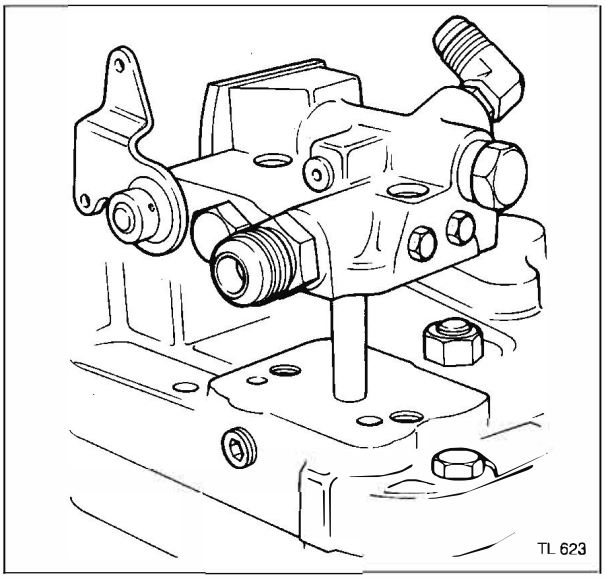
Special Tools:
MF226C Lift cover remover/replacer

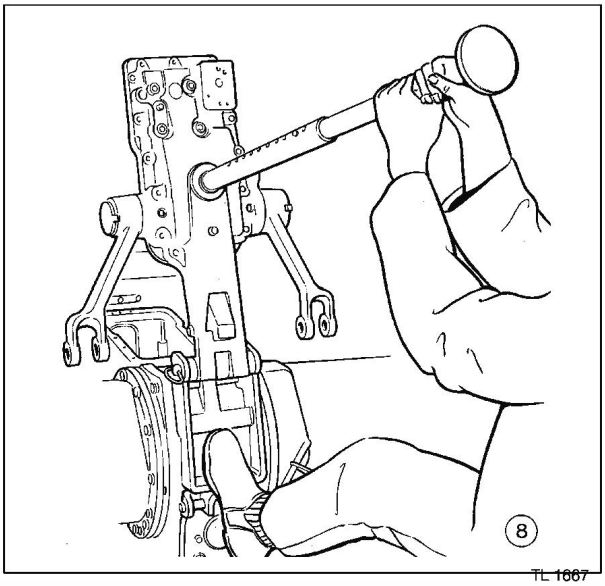
Removal

1. Disconnect the lift rods from the lift arms.
2. Remove the control beam.
3. Place the Draft Control lever in the fully DOWN position.
4. Remove the two bolts and washers.
5. Remove the cap and stand-pipe, or selector valve if fitted.
6. Place the Draft Control lever in the fully UP position and the Position Control lever in the Transport position and lock in position.
7. Remove the lift cover bolts.
8. Using MF.226C (see instructions with the lift cover tool), carefully hinge back the lift cover and place the support leg on the ground.
9. Remove and discard the lift cover gasket (if fitted).
10. Drain the oil to the LOW mark on the dipstick.
11. Remove the screws attaching the Response Control cover plate.
12. Remove the response cover plate.
13. Remove the five bolts and one screw attaching the right-hand side cover to the centre housing.
14. Disconnect the Constant Pumping control rod, if fitted. Remove the side cover.
15. Remove and discard the side cover gasket.

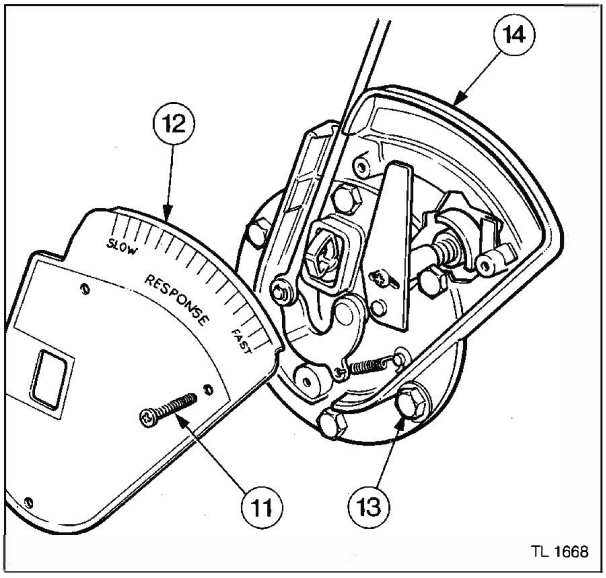
Refitment

16. If any work has been carried out on the lift cover, carry out the static adjustments before refitment, see operation 2.09A-07.
17. Clean the surfaces of the centre housing and lift cover.
18. Reverse procedures 1 to 15 except:
    - *a.* DO NOT replace the lift cover gasket. Coat the face of the centre housing and lift cover with MF Instant Gasket (Loctite 509, 5204 or 5205).
    - *b.* Take care, when refitting the lift cover that the vertical lever does not foul any of the internal components.
    - c. Do not forget to fit the stand pipe and cap or selector valve.
    - *d.* Tighten the lift cover bolts to a torque of 88 Nm.
    - *e.* Tighten the selector valve retaining bolts to a torque of 44 Nm.
19. Carry out external adjustments, see operation 2.09A-08.


TL 623



TL 1667



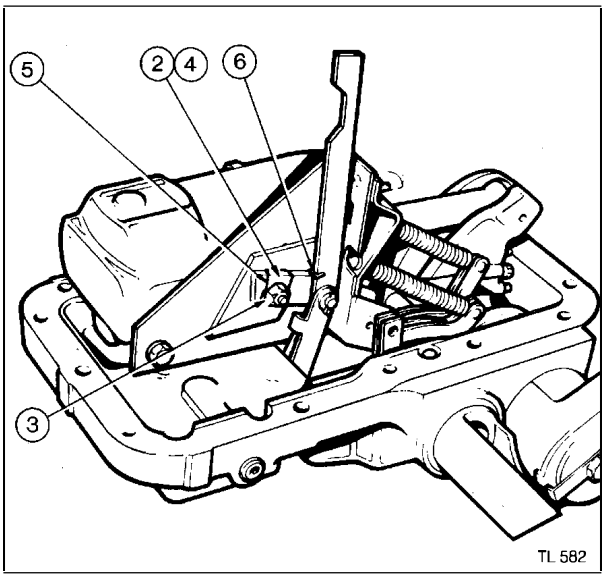
TL 1668

HYDRAULIC LIFT COVER

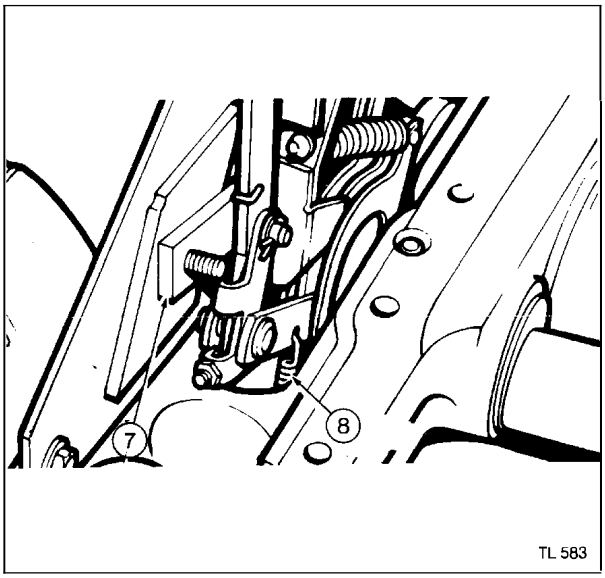
Overhaul **2.09A–04**

Dis-assembly

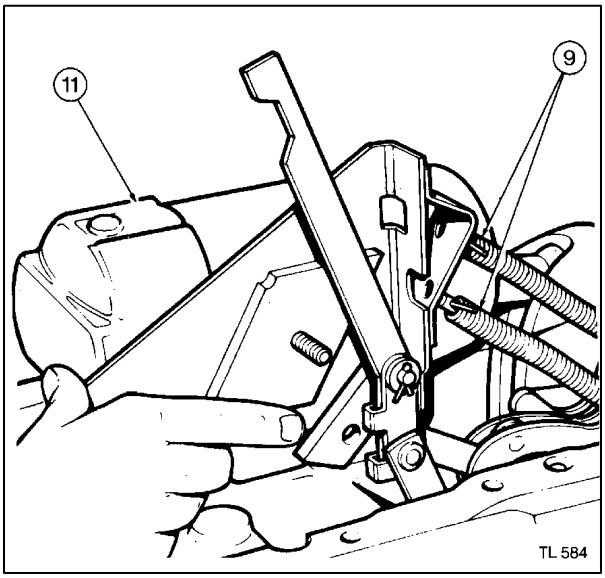
1. Remove the lift cover, See operation 2.09A-03.
2. Release the tabwasher.
3. Remove the nut.
4. Remove the tabwasher.
5. Remove the spacer.
6. Release the spring.



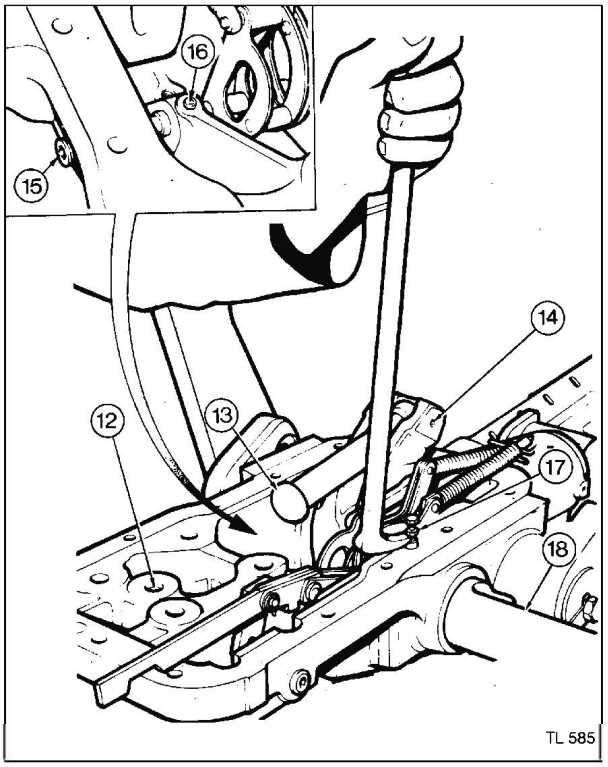
7. Release the slide pivot from the bolt.
8. Remove the spring.



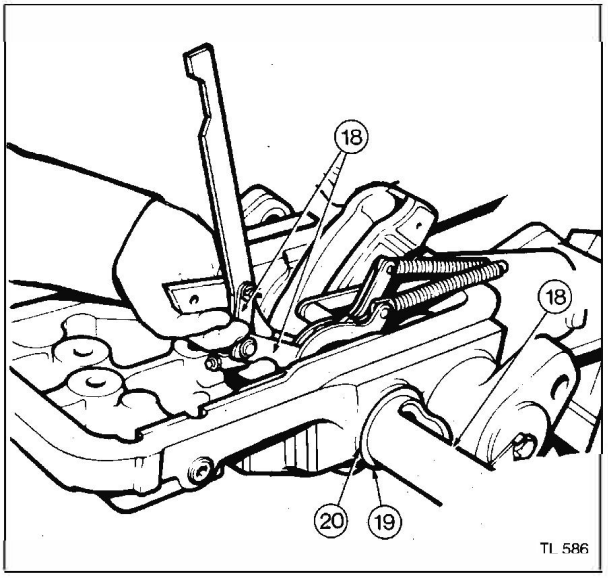
9. Fit a pair of pins to retain the springs.
10. Remove the four nuts securing the ram cylinder to the lift cover.
11. Lift off the ram cylinder.



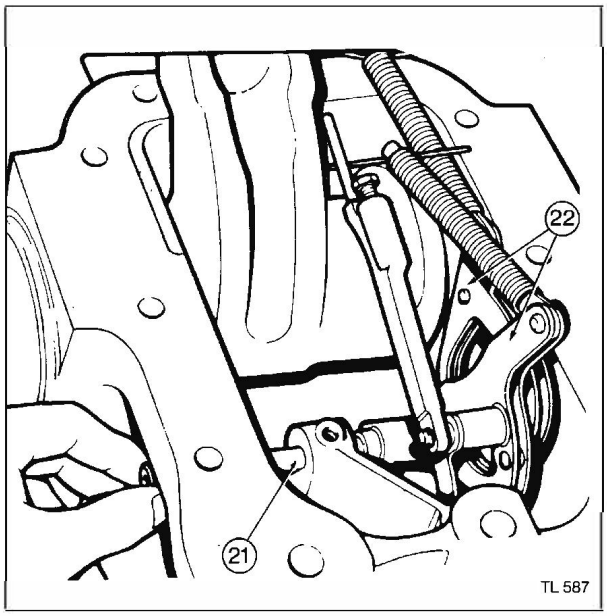
12. Remove and discard the 'O' ring.
13. Remove the connecting rod.
14. Remove the hexagon socket screw. On later models the hexagon socket screw is replaced by a roll pin.
15. Remove the hexagon socket plug.
16. Remove the screw.
17. Screw a Number 10-32 UNF bolt into the pin and remove the pin.



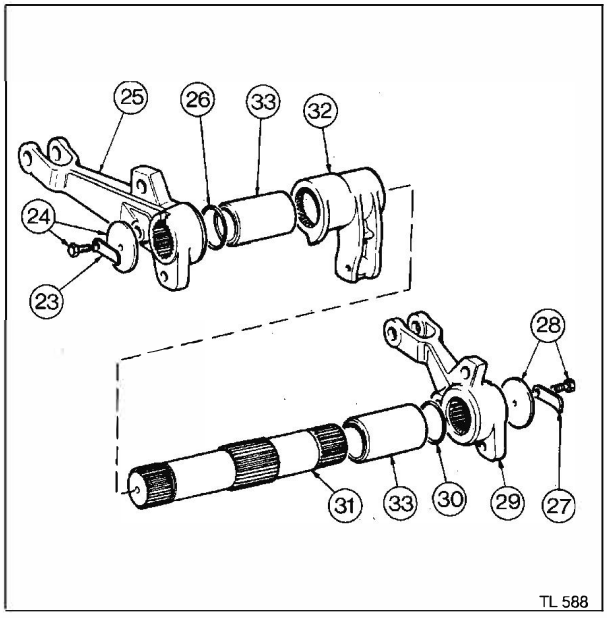
18. Withdraw the quadrant control support assembly, simultaneously lifting out the vertical lever and the cams.
19. Remove the shim(s), if fitted.
20. Remove the Belleville washer.



21. Withdraw the pivot shaft.
22. Lift out the links.



23. Release the tabwasher.
24. Remove the bolt and washer.
25. Slide off the lift arm.
26. Remove and discard the 'O' ring. After tractor serial number P50304 a new type of 'O' ring was fitted and a spacer introduced between the 'O' ring and the lift arm.
27. Release the tabwasher.
28. Remove the bolt and washer.
29. Slide off the lift arm.
30. Remove the 'O' ring, see procedure 26.
31. Drive the lift shaft out of the lift cover.
32. Remove the ram arm.
33. Remove the two bushes.



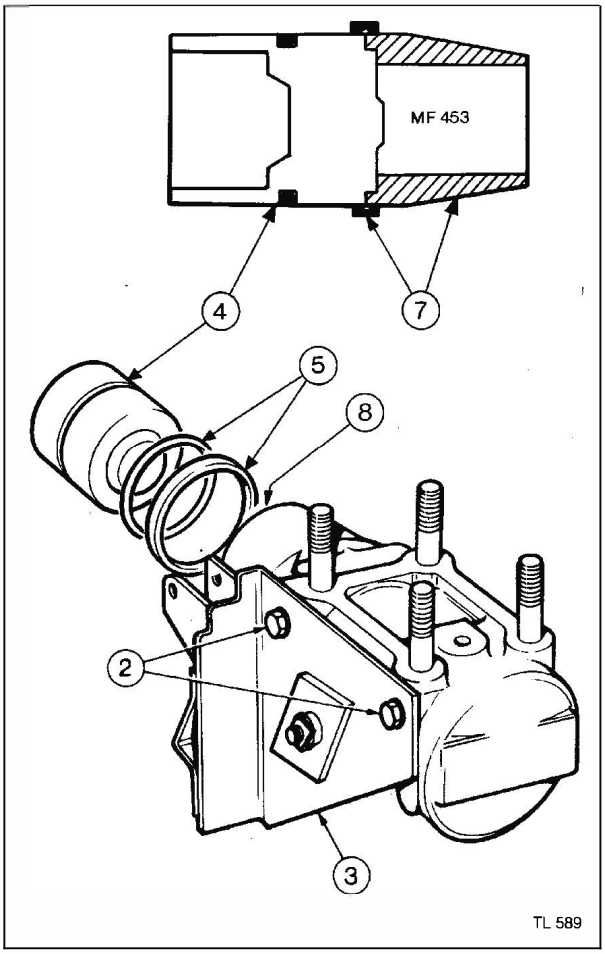
Re-assembly

34. Reverse procedures 1 to 33, except:
    - *a.* Fit new bushes if necessary.
    - *b.* Fit new 'O' rings and tab washers.
    - c. Align the master spline when refitting the shaft and the two lift arms.
    - *d.* Fit the Belleville washer with the concave side towards the lift cover.
    - e. Ensure that the pivot shaft is fully located against the side of the lift cover before tightening the hexagon socket screw.
    - *f.* When refitting the connecting rod hexagon socket screw, apply a drop of MF Lock and Seal (Loctite 542) to the threads, and screw the hexagon socket screw into the ram arm until the screw bottoms on the annular groove in the connecting rod, then back it off 1/4 turn.
    - *g.* When refitting the ram cylinder, locate the connecting rod in the piston and the two rods in the holes in the bracket.
    - *h.* Tighten the front ram cylinder retaining nuts to a torque of 220 Nm and the rear retaining bolts to a torque of 305 Nm.
35. Carry out hydraulic static adjustments, see operation 2.09A-07.

HYDRAULIC LIFT CYLINDER

Overhaul **2.09A–05**

Special Tools:
MF420 Piston seal replacer (79 mm)
MF453 Piston seal replacer (94 mm)



Dis-assembly

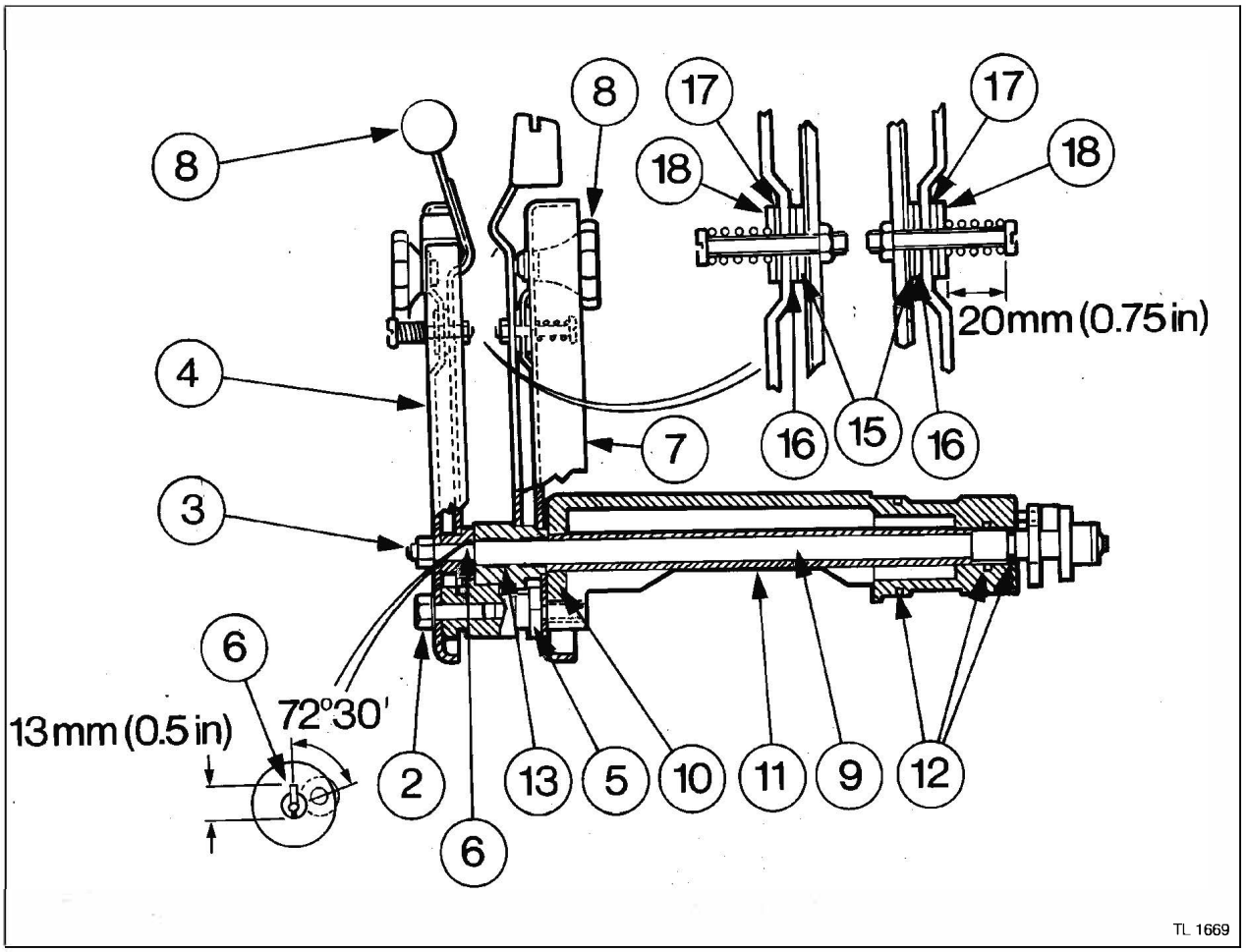
1. Remove the lift cylinder assembly, See operation 2.09A-04, procedures 1 to 11.
2. Remove the two bolts.
3. Remove the support bracket.
4. Withdraw the piston from the cylinder.
5. Remove the piston seal and 'O' ring if necessary.

Examination

Examine all components for wear or damage, replacing any defective components.

Re-assembly

6. If piston seals have been removed apply transmission oil to 'O' ring part of seal and fit it into the piston groove.
7. Lubricate the outside of the tapered guide of MF.420 for the MF.230/240/253 tractors and MF.453 for the MF.275/283/290 tractors, with mineral oil. Place the guide on a firm, flat surface. Locate the seal on the guide and very carefully push the seal down the taper of the guide until it protrudes beyond the end. Locate the lip of the seal on the piston at the closed end. Push the seal off the guide onto the piston and into the groove on top of the 'O' ring.
8. Push the piston into the wide bore end of the sizing ring. Push it through until it protrudes approximately 12 mm from the end of the ring.
9. Lubricate the bore of the cylinder with transmission oil, then locate the protruding portion of the piston in the mouth of the cylinder bore. Push the piston through the sizing ring and into the cylinder.
10. Reverse procedures 1 to 11 in operation 2.09A-04.



QUADRANT AND SUPPORT ASSEMBLY

Overhaul **2.09A–06**

Dis-assembly

1. Remove the quadrant control support assembly, see operation 2.09A-04, procedures 1 to 12 and 17 to 20.
2. Remove the two bolts and washers.
3. Remove the nut.
4. Remove the outer quadrant complete with lever.
5. Remove the two spacer bolts.
6. Drive out the pin.
7. Remove the inner quadrant complete with the lever.
8. If necessary, remove the levers and the stop knobs.
9. Withdraw the Draft Control shaft.
10. Remove the circlip.
11. Withdraw the Position Control shaft.
12. Remove the 'O' rings.
13. Remove the bush.

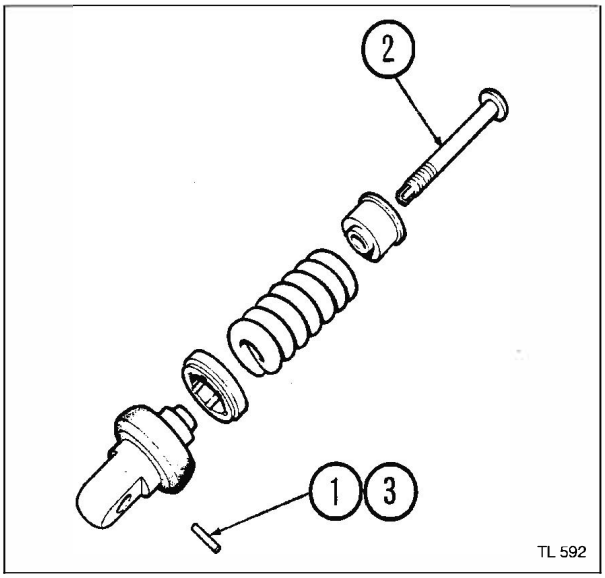
Re-assembly

14. If necessary, refit the levers and the stop knobs to the quadrant. Assemble the washers in the order shown in the following procedures 15 to 19.
15. Fit the steel washers.
16. Fit the polyurethane washer with the shiny side against the quadrant.
17. Fit the nylon washers.
18. Fit the steel washers.
19. Tighten the screws to give a clearance of approximately 20 mm between the screw head and the steel washer.
20. Reverse procedures 1 to 13 except:
    a. Do not overtighten the Draft Control shaft nut and locknut as the roller will not turn freely.
    b. Refit the pin (procedure 6) with the shaft and roller in the position shown and protruding approximately 13 mm from the shaft.

HYDRAULIC STATIC ADJUSTMENTS

Adjust **2.09A–07**

Special Tools:
MF163 Spring retainer nut wrench
MF272 Ram arm gauge
MF333 Draft Control rod gauge
MF356C Position and Draft Control setting gauge

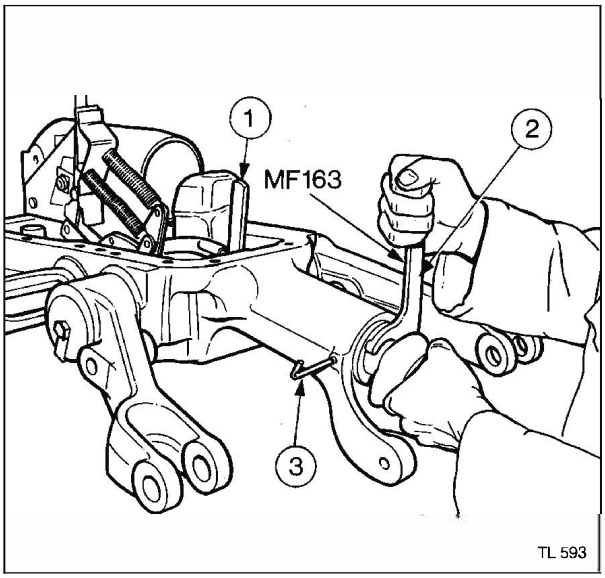


Control spring internal end-float

1. Remove the locking pin.
2. Screw the plunger into the yoke until all the end-float has been removed and the spring is tight to turn by hand.

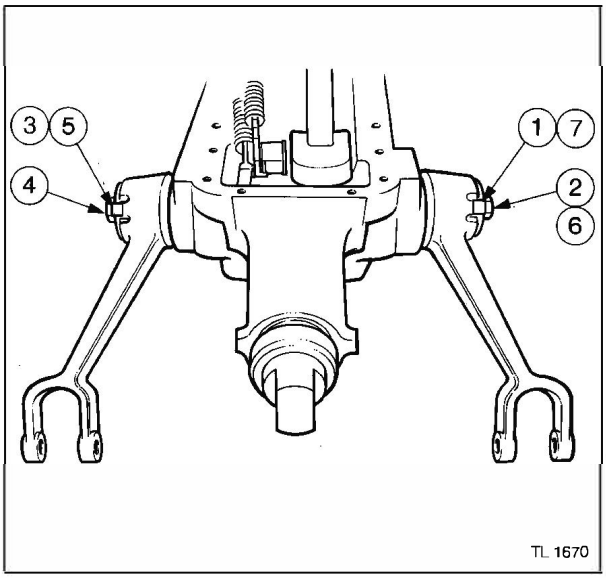
Control Spring external end-float

1. Ensure that the Draft Control rod cannot obstruct the control spring plunger by fitting a suitable wedge between the draft rod adjusting bolt and the lift cover casting. If the lift cover is fitted, move the Draft Control lever to the fully lowered position.
2. Refit the spring assembly into the lift cover housing and using MF.163, tighten the retaining nut until the end float in the spring assembly has been removed. Do not over tighten as this will compress the spring and cause the end-float to return.
3. Tighten the hexagon socket screw to a torque of 7 Nm.
4. Remove the wedge.



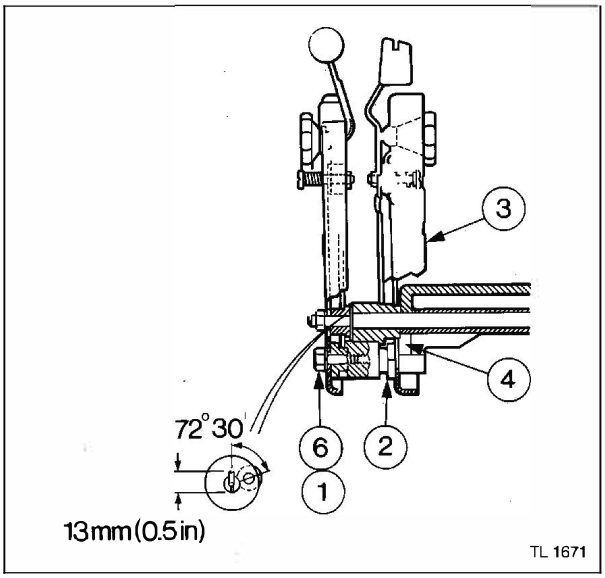
Lift arm end float adjustment

1. Release the tabwasher.
2. Slacken the bolt.
3. Release the tabwasher.
4. Fully tighten the bolt.
5. Secure the bolt and the tabwasher.
6. Tighten the bolt, until the lift arms will move freely throughout their range, but without end-float.
7. Secure the bolt with the tabwasher.



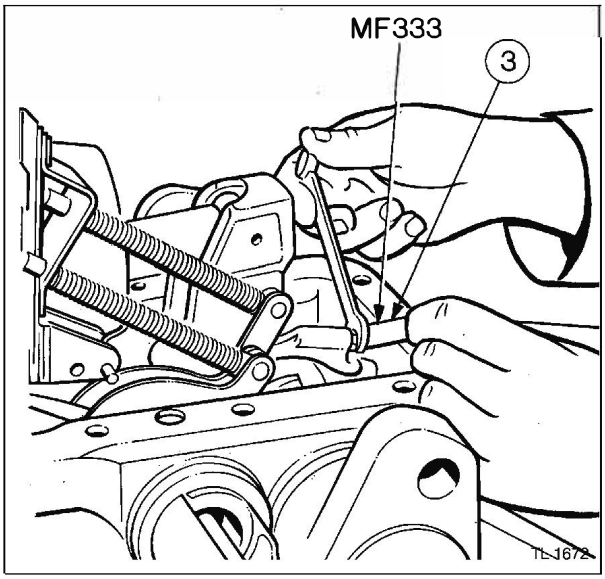
Quadrant location

1. Slacken the two bolts.
2. Slacken the two barrel nuts.
3. Locate the inner quadrant in the centre of the elongated hole.
4. Tighten the two barrel nuts.
5. Locate the outer quadrant in the centre of the elongated hole.
6. Tighten the two bolts.



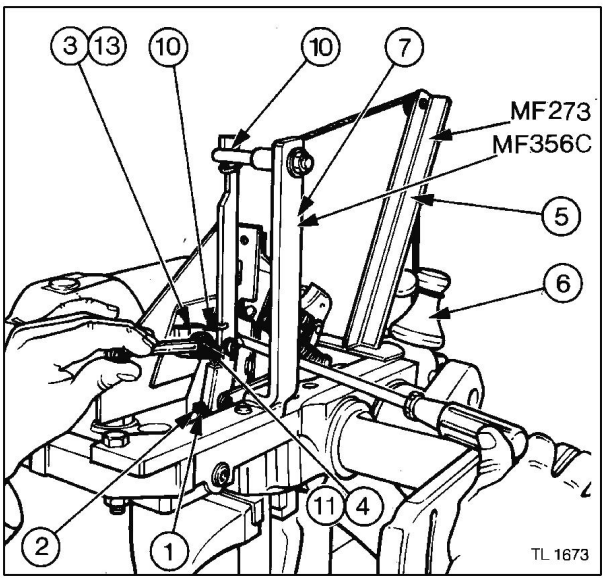
Draft Control rod adjustment

1. Place the Draft Control lever in the UP position.
2. Place the Position Control lever in the Transport position.
3. Using MF.333, adjust the set screw to give a clearance of 5,8 mm between the set screw and the lift cover casting.



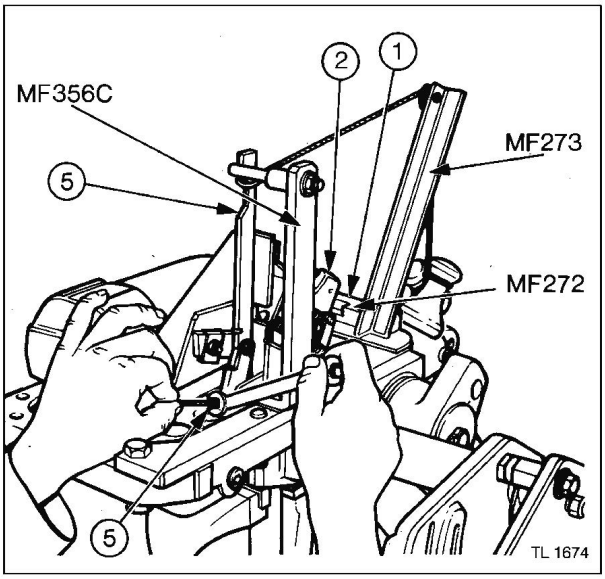
Draft Control neutral setting

1. Slacken the locknut.
2. Slacken the hexagon socket grub-screw and locknut on the vertical lever to the end of its thread. This will ensure that no interference from the Position Control linkage takes place.
3. Release the tabwasher.
4. Slacken the nut.
5. Position MF.273 on the lift cover.
6. Apply a load of 1,3 kg to the end of the vertical lever. This simulates the force of the linkage pump control spring (a spring balance can be used if no tool is available).
7. Locate MF.356C on the lift cover
8. Place the Draft Control lever in the Sector position.
9. Place the Position Control lever in the Transport position.
10. Adjust the slide pivot, until the vertical lever just touches the pin on MF.356C.
11. Tighten the nut.
12. Re-check the setting.
13. Secure the nut with the tabwasher.



Position control neutral (Transport) setting

1. Position MF.272A on the lift cover.
2. Locate the ram arm on MF.272A.
3. Place the Draft Control lever in the UP position.
4. Place the Position Control lever in the Transport position.
5. Adjust the Allen screw until the vertical lever just contacts the pin on MF.356C.
6. Tighten the locknut.
7. Re-check the setting.
8. Remove MF.272A, MF.273 and MF.356C.



HYDRAULIC EXTERNAL ADJUSTMENTS

Adjust **2.09A–08**

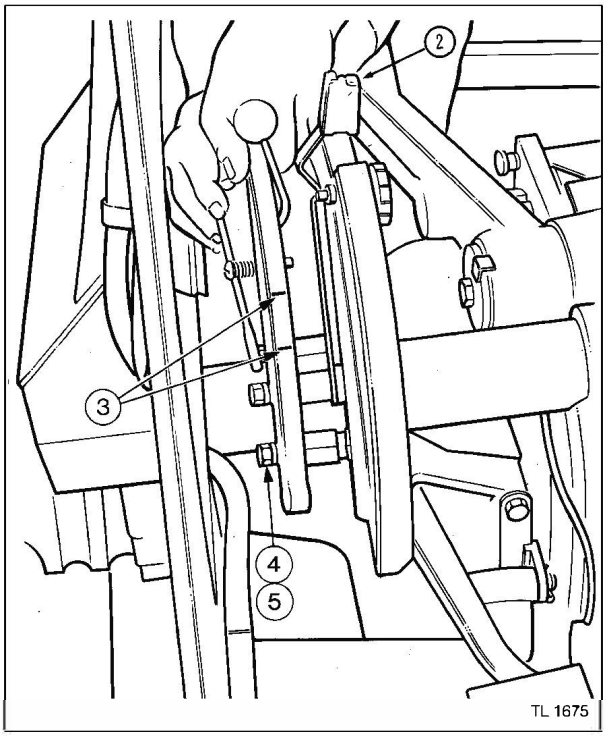
Pre-conditions

1. Refit the lift cover, hydraulic unions, pipes etc. Refill the tractor with oil to the correct grade.
2. Attach a weight of 400 kg to the lower links.
3. Place the Draft Control lever in the fully UP position.
4. Start the engine and set the engine speed at 'tick-over', then operate the Position Control lever through the quadrant range to expel all the air from the system.
5. Warm up the engine oil in the transmission to a temperature of 50-60^{0}C and then stop the engine.

Draft Control setting

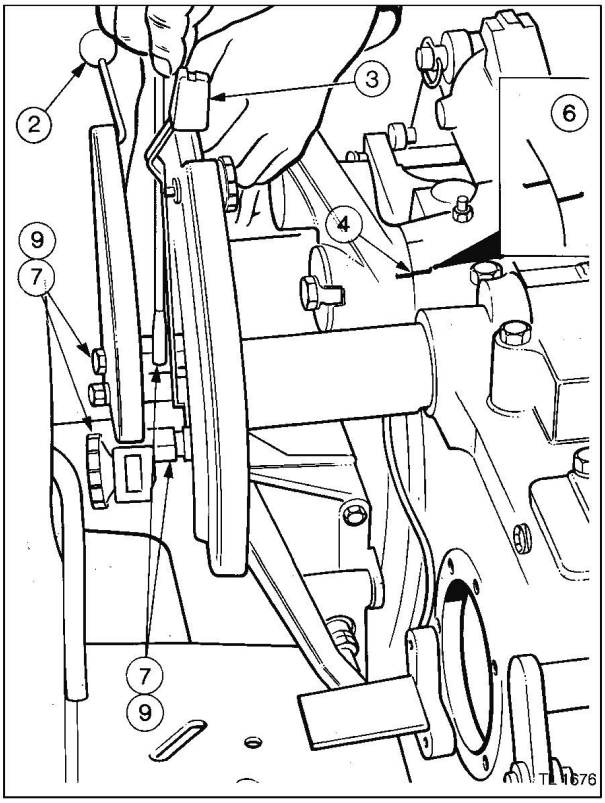
NOTE: *The top link must not be attached when carrying out this adjustment.*

1. Start the engine, and set the engine speed at 1200 rev/min.
2. Place the Position Control lever in the Transport position.
3. Using the Draft Control lever, set the lower links in the horizontal position. The Draft Control lever should be in the sector marks on the quadrant, if not carry out procedures 4 to 6.
4. Loosen the two quadrant support bolts and rotate the Draft Control quadrant and lever until the links remain stationary in the horizontal position.
5. Tighten the two bolts and recheck the setting.
6. Fully lower the links and stop the engine.



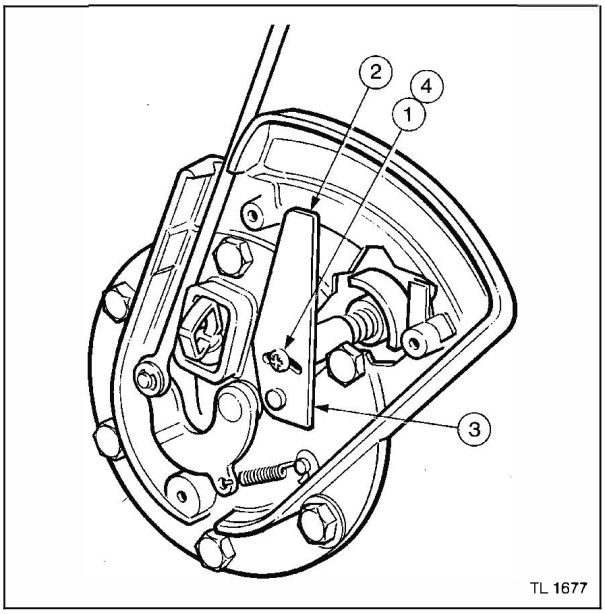
Position control setting

1. Start the engine, and set the engine speed at 1200 rev/min.
2. Place the Draft Control lever in the fully UP position.
3. Place the Position Control lever in the Constant Pumping position.
4. When the links are fully raised scribe a line across the lift cover casting to the lift arm.
5. Place the Position Control lever in the Transport position.
6. The links should drop until the scribe lines are 2-5 mm apart, if the distance is incorrect carry out procedures 7 to 10.
7. Slacken the two bolts and the two barrel nuts.
8. Rotate the Position Control quadrant and lever until the setting is correct.
9. Tighten the two barrel nuts and recheck the setting.
10. Stop the engine.



Response Control setting

1. Release the locking screw.
2. Place the Response Control lever 6 mm from the rear end of its quadrant.
3. Rotate the inner lever, until the cam just contacts the vertical lever on the hydraulic pump.
4. Tighten the locking screw.
5. Refit the Constant Pumping control rod, if fitted.
6. Refit the cover and secure with the four screws.
7. Add an approved oil to the transmission until the required level is reached.



HYDRAULIC PRESSURE TEST

Check **2.09A–09**

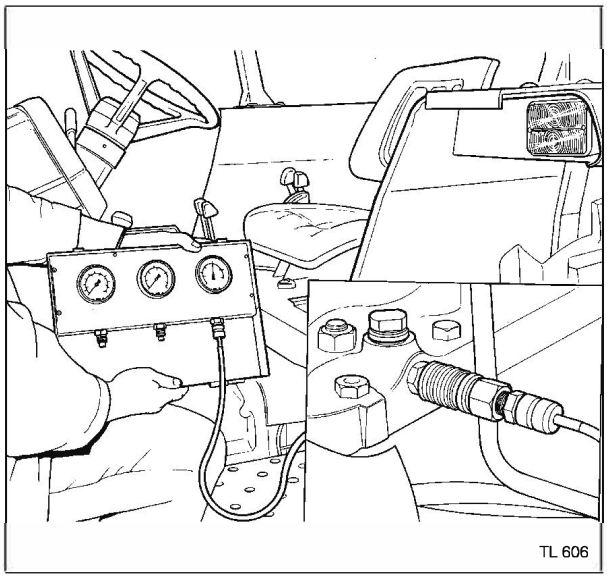
Special Tools:
MF148B Pressure test gauge
MF3001 Pressure test kit

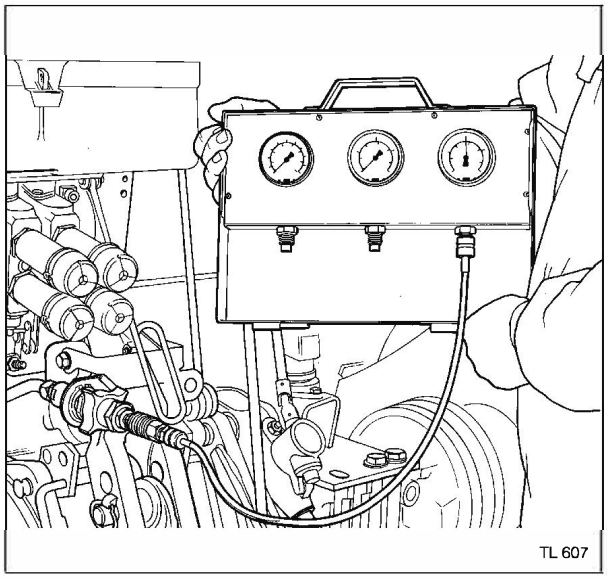
Procedure

1. Remove the plug from the side of the lift cover and install the 3/8 inch NPT adaptor and quick diagnostic coupling from the MF3001 pressure testing kit. Or, alternatively, connect into the system through the trailer tipping pipe self-sealing coupling.
2. Use the 300 bar gauge in the test kit.
3. If a Selector Valve is fitted move the control lever to Linkage position if the gauge is fitted to the side of the lift cover. Move the control lever to External position if the gauge is fitted to the trailer pipe.
4. Move the Draft Control lever to UP position and the position control lever to Transport position.
5. Start the engine and run at 1200 rev/min. The transmission oil must be at 50-60^{0}C.
6. Move the Position Control lever to Constant Pumping.
7. The system pressure should be:

   MF.230/240 tractors 157-193 bar.

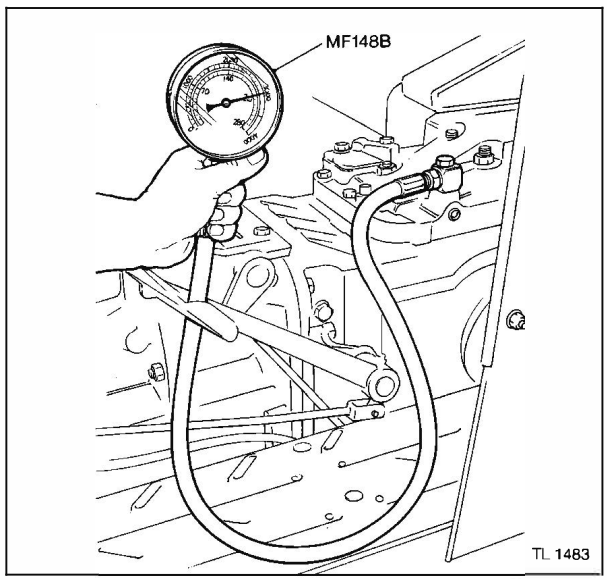
   MF.253/275/283/290 tractors 221-231 bar.
8. If the pressure setting is incorrect, the relief valve is accessible through the right-hand centre housing side cover. See operation 2.09A-12.


TL 606


TL 607

Alternative

9. Connect pressure gauge MF.148B to the connection on the lift cover.
10. Test the system as described in procedures 3 to 8.



TL 1483

HYDRAULIC LIFT PUMP

Removal and refitment **2.09A–10**

Removal

Tractors fitted with single speed (540 rev/min) ground speed PTO only.

1. Remove the lift cover. See operation 2.09A-03.
2. Drain the transmission oil.
3. Remove the left-hand side cover. See operation 2.09A-05.
4. Remove the right-hand side cover. See operation 2.09A-16.
5. Remove the shear tube split pin and discard it.
6. Remove the shear tube and the rear drive shaft.
7. Remove the PTO shaft. See operation 2.09A-02.
8. Remove the two nuts and dowel pins each side of the transmission case holding the lift pump.
9. Manoeuvre the lift pump out of the top of the centre housing.
10. Remove the coupler.

Refitment

11. Reverse procedures 1 to 10 except:
    - *a.* Fit new split pins, 'O' rings and gaskets.
    - *b.* Fit new shear tube split pin to give 0,38-2,54 mm end float.

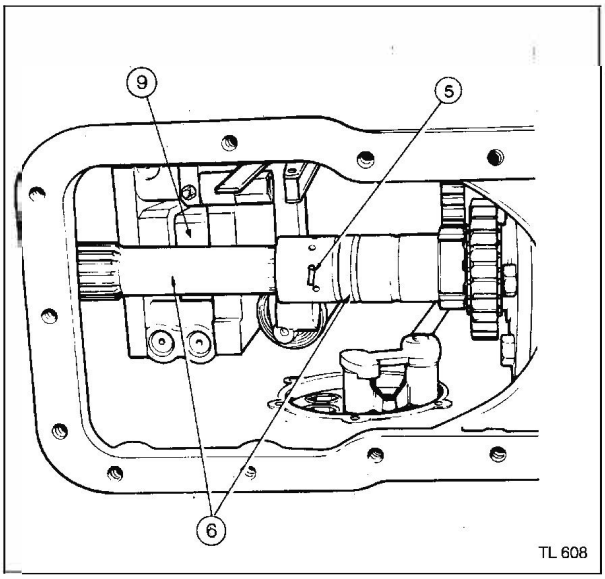
Tractors fitted with single speed (540 rev/min) IPTO.

Removal

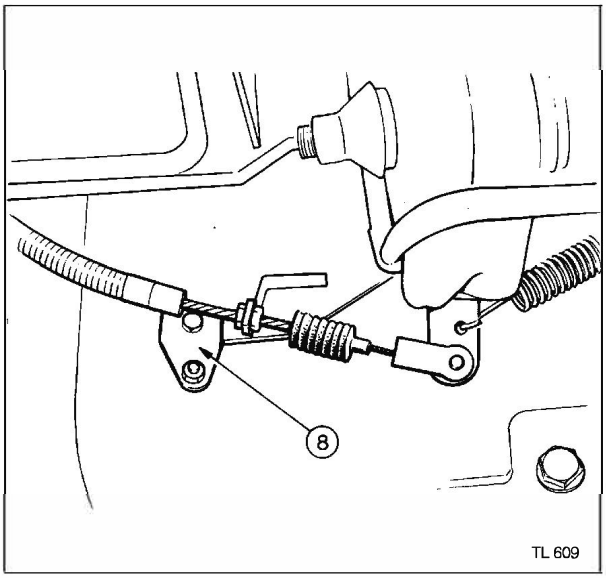
1. Remove the lift cover. See operation 2.09A-03.
2. Drain the transmission oil.
3. Split the tractor between the centre housing and the gearbox, spacer or transfer gearbox, See operation 2.02A-05 or 2.02A-06.
4. Remove the right-hand side cover. See operation 2.09A-16.
5. Remove the two nuts and dowel pins each side of the transmission case holding the lift pump.
6. Withdraw the lift pump from the front of the centre housing.

Refitment

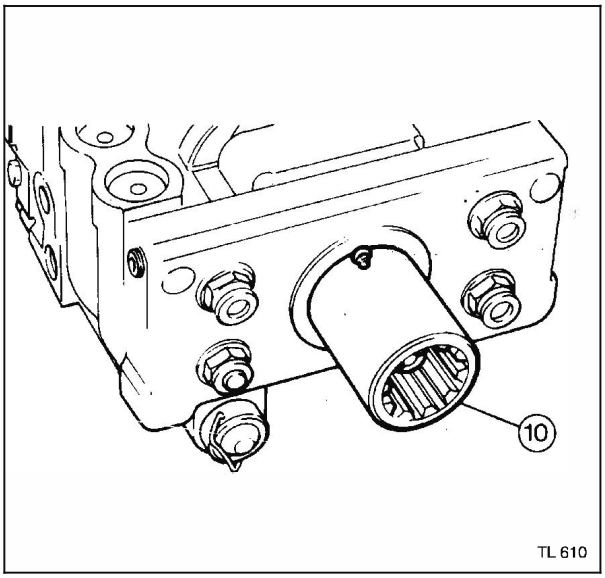
7. Reverse procedure 1 to 6 except:
    - *a.* Locate the lift pump on to the IPTO clutch if fitted.
    - *b.* Fit new split pins, 'O' rings and gaskets.
    - c. Refit the right-hand dowel pin (8) and tighten the two nuts. Fit the left-hand dowel and leave the nuts loose. After re-assembly of the tractor turn the transmission over on the starter motor (stop control out). Fully tighten the left-hand dowel nuts. This procedure is to ensure that PTO and pump shafts are in line.



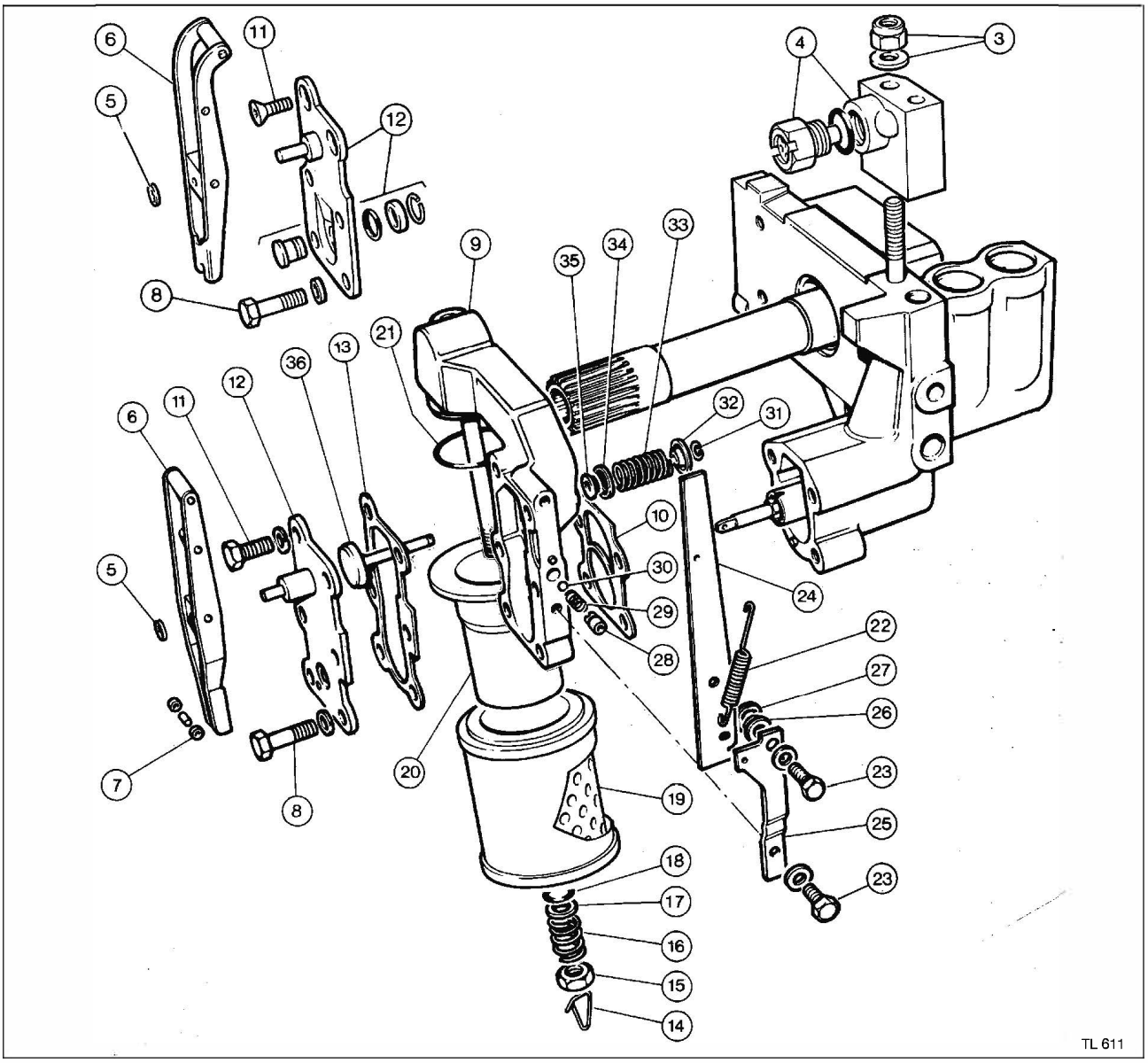
TL 608



TL 609



TL 610



HYDRAULIC LIFT PUMP

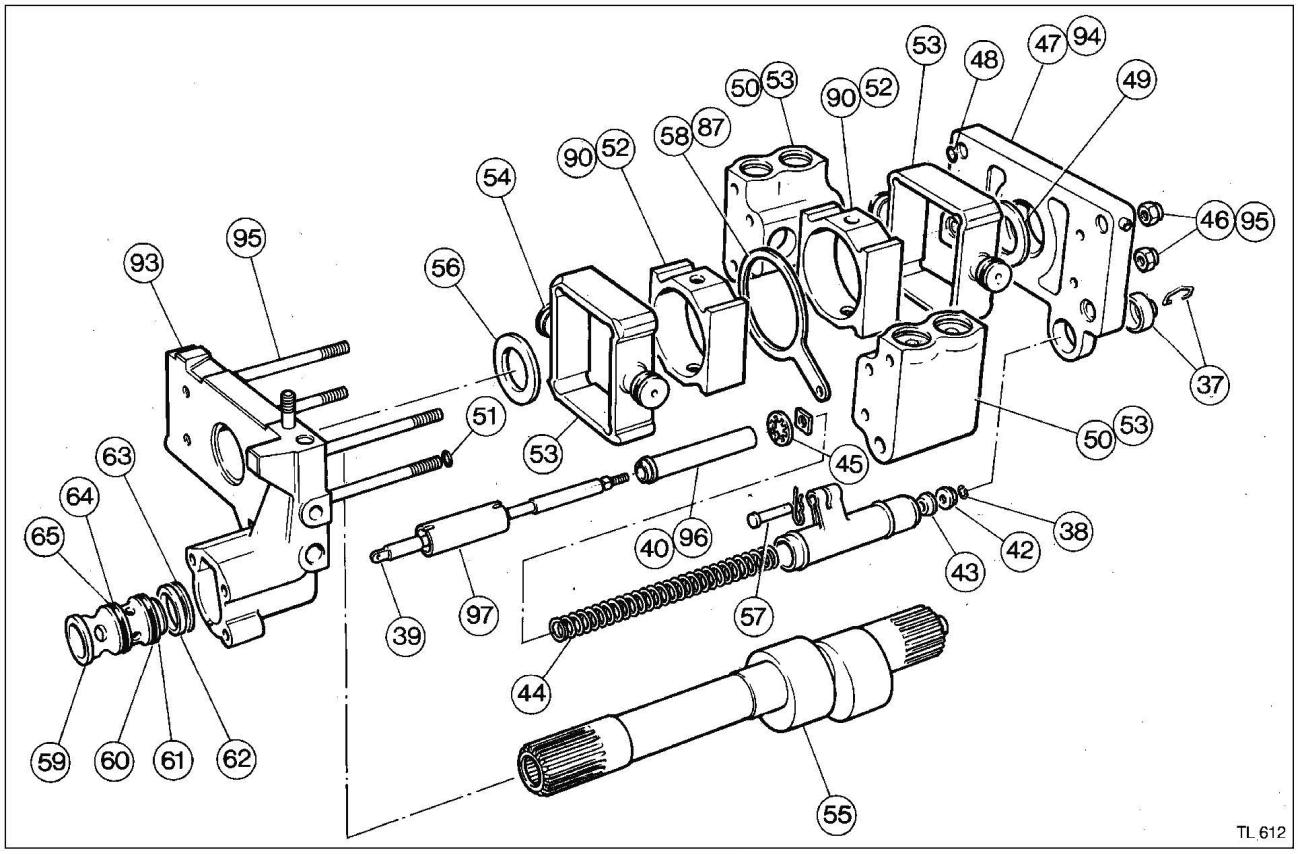
Overhaul **2.09A–11**

Special Tools:

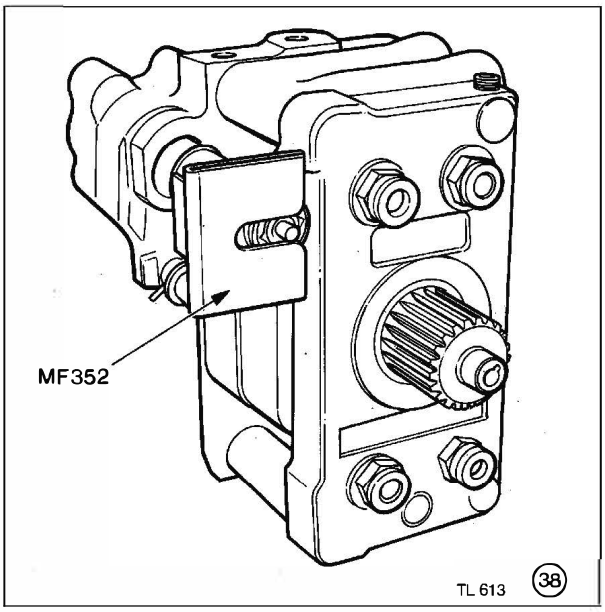
MF349 Valve seat forming tool
MF350 Valve circlip replacer
MF351 Valve plug remover/replacer
MF352 Control valve spring retainer
MF353 Control valve body 'O' ring guide
MF354 Control valve body replacer

Dis-assembly

1. Remove the hydraulic pump. See operation 2.09A-10.
2. Clean the outside of the pump.
3. Remove the nut and washer.
4. Remove the pressure relief valve assembly.
5. Remove the clip.
6. Remove the lever.
7. Remove the two rollers and the pin.
8. Remove the four lower bolts and washers.
9. Remove the strainer housing.
10. Remove the gasket and discard it.
11. Remove the two upper bolts and washers.
12. Remove the end plate.
13. Remove the gasket and discard it.
14. Remove the safety clip.
15. Remove the nut.
16. Remove the spring.
17. Remove the washer.
18. Remove the 'O' ring and discard it.



19. Remove the strainer.
20. Remove the strainer inner shroud.
21. Remove the 'O' ring and discard it.
22. Remove the spring.
23. Remove the two bolts and washers.
24. Remove the response control lever.
25. Remove the retainer.
26. Remove the bush.
27. Remove the washer.
28. Remove the bush.
29. Remove the spring.
30. Remove the ball.
31. Remove the circlip.
32. Remove the cap.
33. Remove the spring.
34. Remove the retainer.
35. Remove the seal and discard it.
36. Remove the valve.
37. Remove the cap.
38. Using MF.352 control valve spring retainer clip, slide it into position to hold back the spring tension. Remove and discard the retaining ring.



39. Withdraw the control valve.
40. Remove the balancer tube.

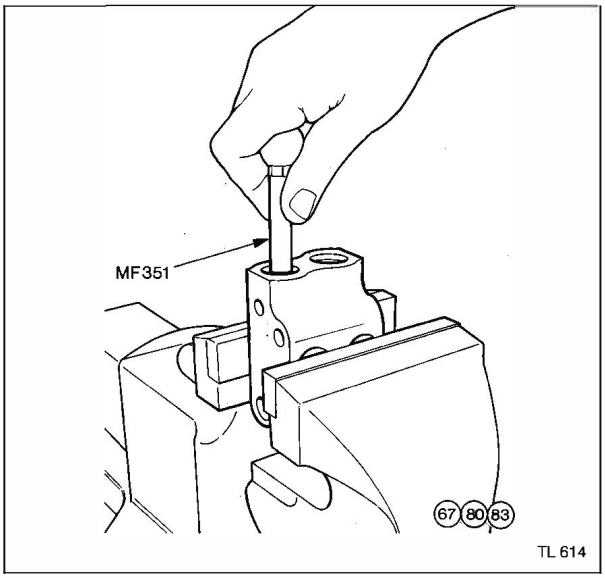
WARNING: Spring under compression, do not stand over the pump when removing the spring. Cover with a cloth to protect your face.

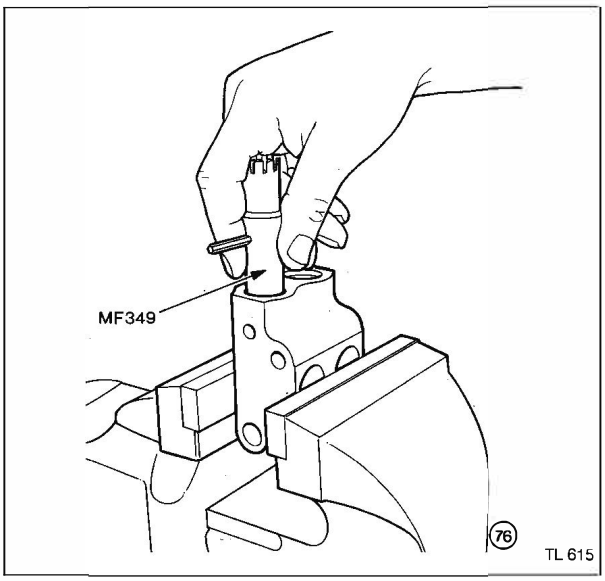
41. Taking care that the spring is not ejected, remove MF.352 retainer clip.

42. Remove the collar.
43. Remove the guide.
44. Remove the spring.
45. Remove the square disc.
46. Remove the four main pump body nuts.
47. Detach the front body.
48. Remove and discard the 'O' rings.
49. Remove the thrust washer.
50. Withdraw the two valve chambers from the rear body, complete with the cam blocks, pistons, cam follower and oscillator tube as an assembly.
51. Remove and discard the 'O' rings.
52. Remove the cam blocks from the pistons.
53. Separate the valve chambers from the pistons.
54. Remove the piston rings, if necessary.
55. Withdraw the camshaft from the rear body and thrust washer.
56. Remove the thrust washer.
57. Remove the pin and retainer clip.
58. Remove the cam follower from the oscillator tube.
59. Carefully drive out the control valve body from the end housing.
60. Remove and discard the 'O' ring.
61. Remove and discard the back-up washer.
62. Remove the sleeve.
63. Remove the washer.
64. Remove and discard the 'O' ring.
65. Remove and discard the back-up washer.
66. Remove and discard the circlip.
67. Using MF.351 valve chamber plug remover/replacer, screw it into the plug and pull it out of the housing.
68. Remove and discard the back-up washer.
69. Remove and discard the 'O' ring.
70. Remove the spring.
71. Remove the valve.
72. Remove the spring.
73. Remove the valve.
74. Repeat procedures 66 to 73 for the other three valves.

Examination

Check the condition of all components for wear or damage, replacing any defective components. Always replace 'O' rings, back-up washer, gaskets and circlips. Lubricate the 'O' rings with oil before fitting.

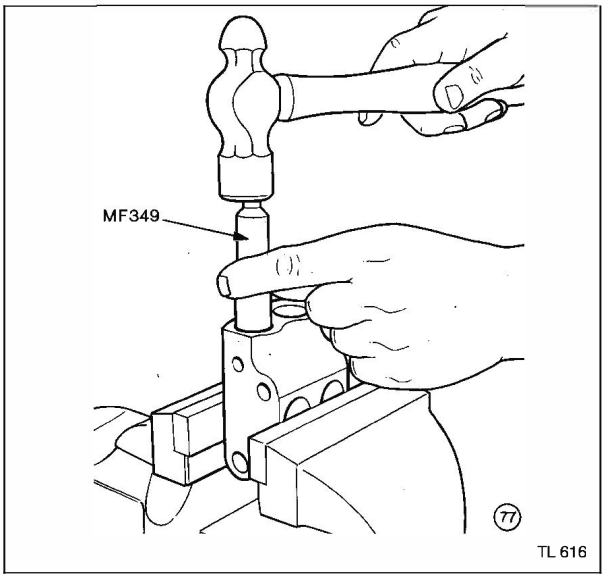




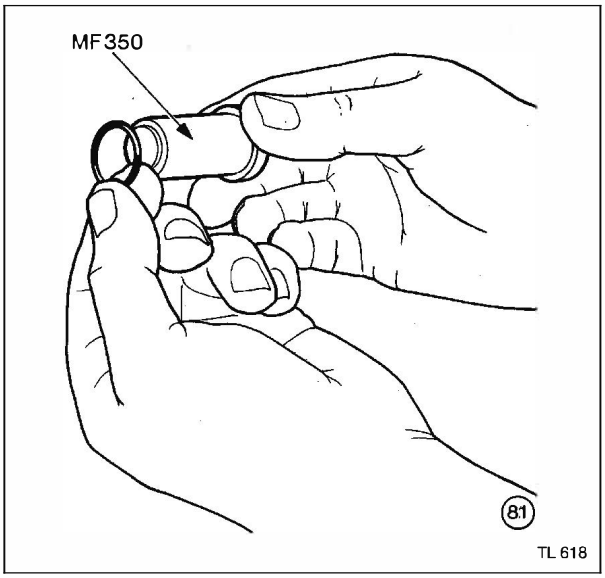
Re-assembly

75. If necessary, form new valve seats, using MF.349 valve seat cutter and forming tool in the following sequence:
76. Carry out the following:
    a. Cut the top seat in the valve chamber using the large end of the cutter and tommy bar provided.
    b. When satisfactory seat has been formed remove the tool and fit the sleeve to the small end of the cutter.
    c. Insert the small end and carefully rotate the cutter to remove the burr around the top seat.
    d. Remove the cutter and sleeve, re-insert and cut the bottom seat until a satisfactory result has been obtained. The cutter has been designed to ensure the correct depth of the bottom seat.

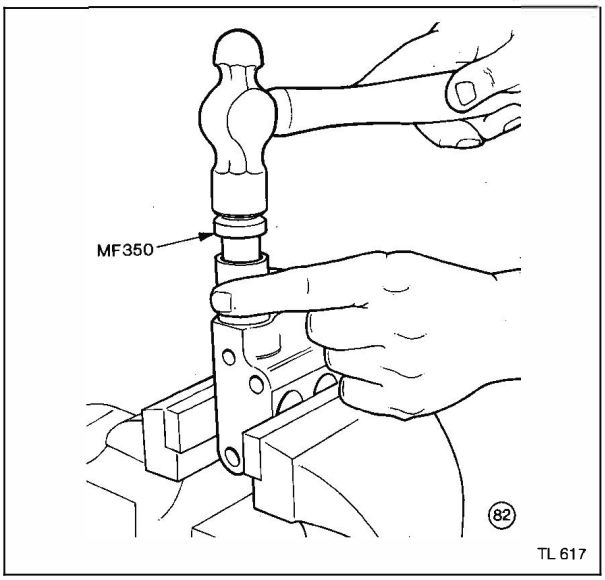
77. Using the seat forming tool, form a new bottom seat by tapping the tool with hammer, invert the tool and form a new top seat in the same manner.
78. Thoroughly clean all the valve chambers.
79. Reverse procedures 68 to 73.
80. Using MF.351, push the plug into the valve chamber until the circlip groove can just be seen.



81. Position a new circlip on the MF.350 valve chamber circlip replacer.



82. Using MF.350, fit the circlip.
83. Using MF.351, pull the plug back against the circlip.
84. Repeat procedures 79 to 83 for the other three valves.

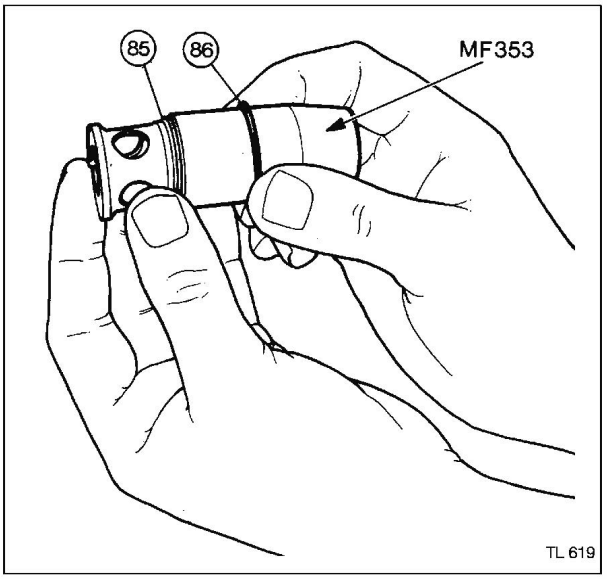


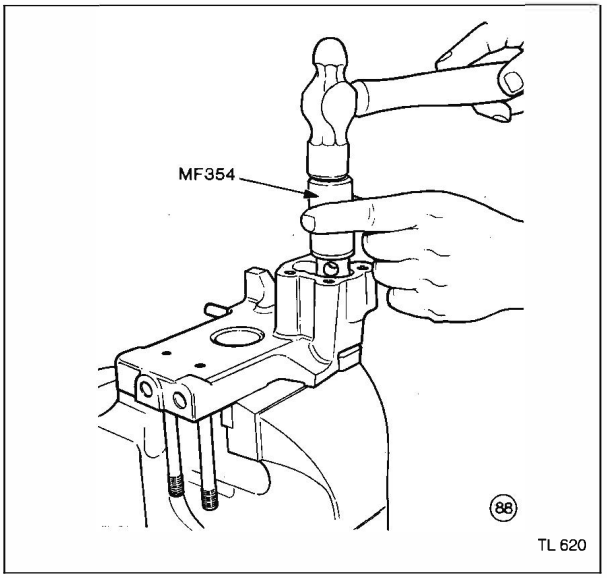
85. Using MF.353 Control valve body 'O' ring guide, fit a new back-up washer to the control valve body.
86. Using MF.353, fit a new 'O' ring to the control valve body.
87. Refit the sleeve and washer to the control valve housing.
88. Using MF.354 control valve body replacer, carefully drive the control valve body into the front of the housing, aligning the pin at six o'clock.
89. Reverse procedures 51, 53, 54, 57 and 58.
90. Place the cam follower between the pistons.
91. Fit the two cam blocks to the camshaft.
92. Replace the front and rear thrust washers.
93. Refit the rear body.
94. Refit the front body.
95. Lubricate the studs with transmission oil, and refit the four nuts and tighten them to a torque of 40 Nm ensuring at all times that the pistons move freely.

NOTE: *The special nuts must be fitted to the top right-hand and the bottom left-hand studs.*

96. Refit the balancer tube to the control valve.
97. Lubricate the control valve with oil and slide it into the rear body.
98. Reverse procedures 1 to 38 and 41 to 45 except:
    a. Tighten the pressure relief valve manifold nut (3) to a torque of 27 Nm.
    b. Lubricate the vertical lever/strainer end plate bolts (8 and 11) with oil and tighten to a torque of 20 Nm, checking at all times that the control valve continues to move freely.

NOTE: *When refitting the retaining clip to pin (57) bend end of clip over.*





HYDRAULIC RELIEF VALVE

Adjust **2.09A–12**

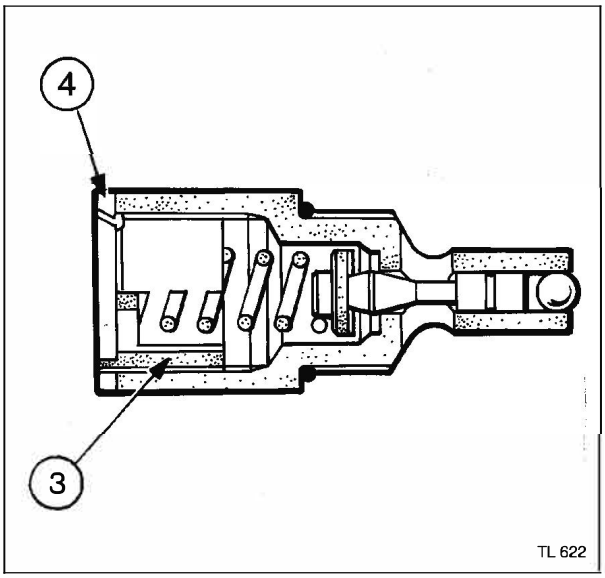
Special Tools:

MF.455 Pressure relief valve test capsule

Adjust

NOTE: *The relief valve can be serviced when the hydraulic lift pump is removed or through the right-hand side cover. Later relief valves are non-adjustable and in the event of failure must be replaced by a new unit, see operation 2.09A-13..*

1. Remove the relief valve from the manifold and fit it to MF.455 pressure relief valve test capsule.
2. Connect the capsule up to an injector tester or hydraulic pump, the thread size is M14-1,5. Pressurise the relief valve and check the pressure which should be 157-193 bar on the MF.230/240 tractor and 221-231 bar on the MF.253/275/283/290 tractor.
3. If the pressure is incorrect, release the staking of the end cap, then adjust by screwing in the end cap to increase the pressure, or screwing out to decrease the pressure setting.
4. Lock the cap after adjustment by staking the edge of the cap into one of the slots in the body.
5. Replace the valve and torque to 110 Nm.



HYDRAULIC RELIEF VALVE

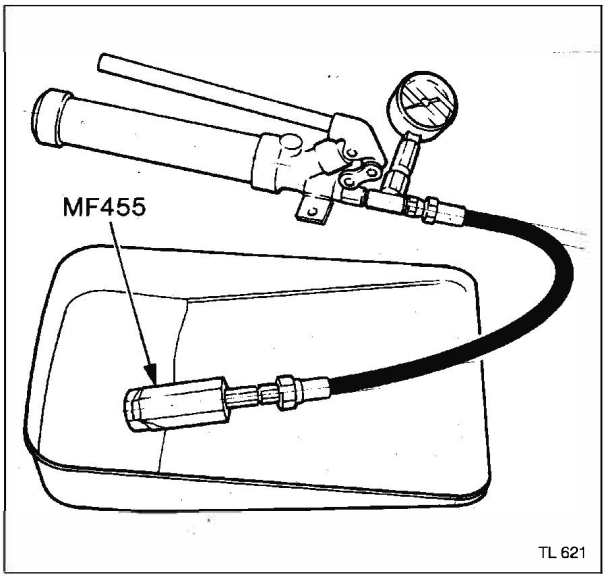
Removal and refitment **2.09A–13**

Tractor serial number N 33359 on for MF.230/240/253 tractors.

Tractor serial number N 42314 on for MF.275/283/290 tractors.

This change deletes the existing relief valve manifold, and the short stand-pipe is replaced by a long one. The new relief valve is non-adjustable, and in the event of failure must be replaced by a new unit. It is identified by a black paint stripe on the outer tube of the relief valve assembly for MF.253/275/283/290 tractors. The pressure of the new valve remains unchanged at 221-231 bar.

On MF.230/240 tractors the relief valve is identified by its plain outer tube. The pressure remains unchanged at 157-193 bar.

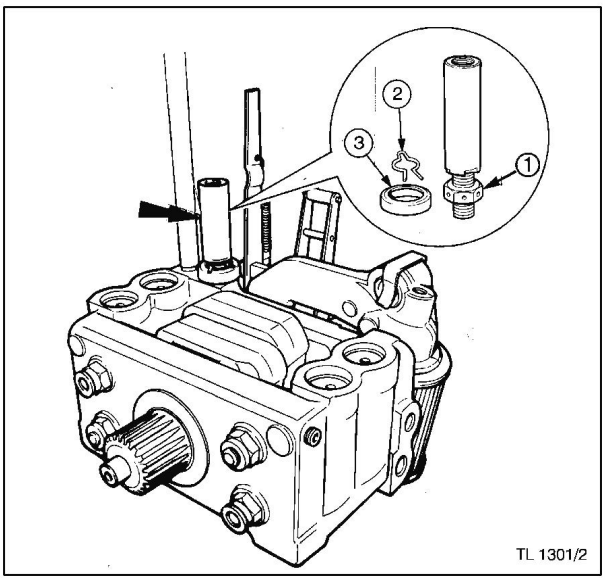


Removal

1. Remove the right-hand side cover, see operation 2.09A-16.
2. Remove the spring clip.
3. Remove the shield.
4. Unscrew the relief valve.

Refitment

5. Reverse procedure 1 to 4 except:
   a. Tighten the relief valve to a torque of 25 Nm.
   b. Ensure that the shroud is held down so as to cover the hexagon part of the valve.
6. Pressure test the system to ensure satisfactory operation, see operation 2.09A-09.



SELECTOR VALVE

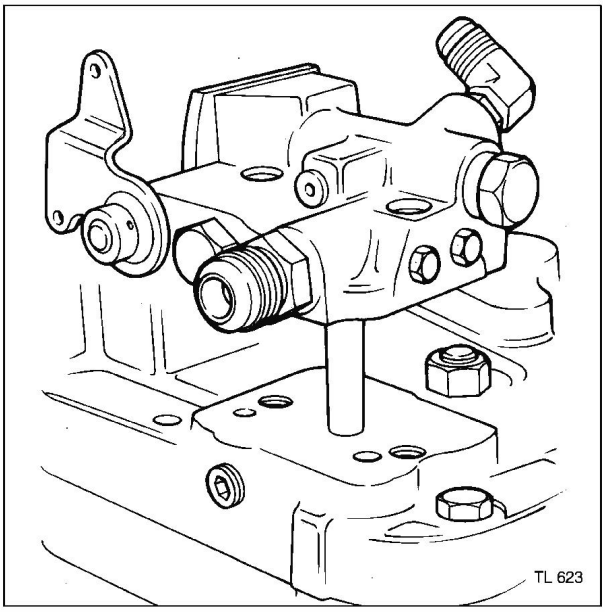
Removal and refitment **2.09A–14**

Removal

1. Disconnect the control rod from the selector valve lever.
2. Disconnect the pipes.
3. Remove the socket screws securing the selector valve to the lift cover.
4. Lift the valve clear, discard gasket and 'O' ring.

Refitment

5. Reverse procedures 1 to 4 except:
   a. Replace the 'O' ring and gasket in the recess in the base, with a new one.
   b. Check that the standpipe is located in the hydraulic pump.
   c. Tighten both socket screws to a torque of 44 Nm.



SELECTOR VALVE

Overhaul **2.09A–15**

Dis-assembly

1. Remove the selector valve. See operation 2.09A-14, and the control linkage.
2. Remove the four screws and lock washers securing the support plate and gasket. Remove the plate and discard the gasket.
3. Remove the dowel and pull the operating lever and spindle assembly, out of the bore. Discard the 'O' ring and remove the shift fork.
4. Remove the spool valve assembly from the aperture.
5. Remove the plug and spring from the opposite end of the spool valve aperture. Discard the 'O' ring.
6. Remove plug, spring, plunger and steel ball from the relief valve aperture. Discard the 'O' ring.
7. Remove the remaining adaptors and plugs. Discard the 'O' rings.
8. Thoroughly clean all components using an air line to clear the oil galleries.
9. Fit all new 'O' rings.

Re-assembly

10. Reverse procedures 1 to 9.

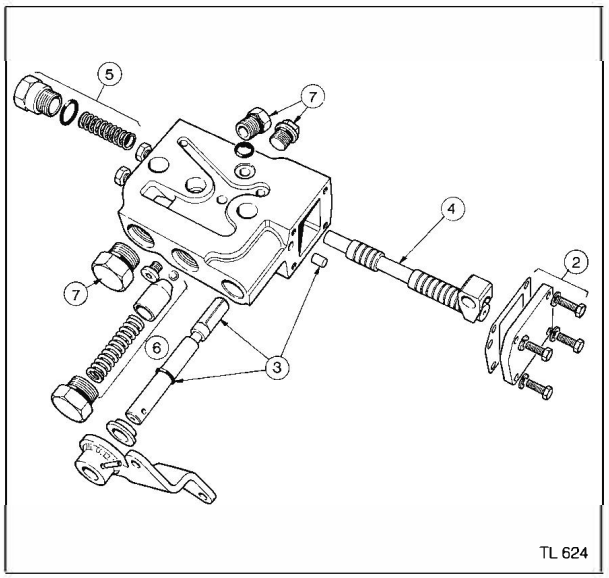
NOTE: *The relief valve (6) can be adjusted - a hydraulic pump and test gauge will be required. The relief valve is set to 262-276 bar.*

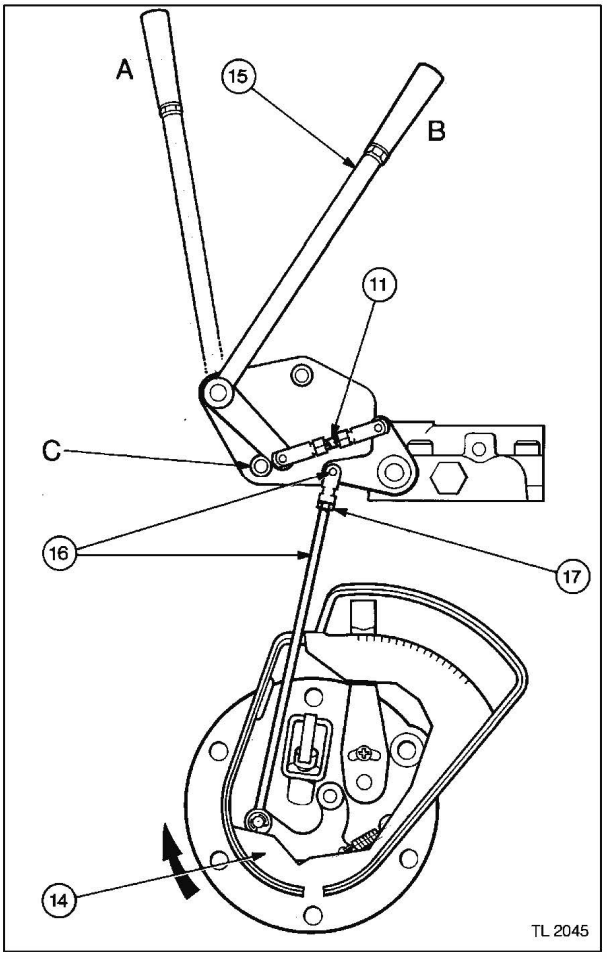
To adjust the relief valve pressure, fit shims (item 12) under the spring in the end plug (item 13). A shim of 0,25 mm will increase the pressure setting by approximately 7 bar.

Shims are available in the following sizes:

Shim Thickness		Part No
mm	in	
0,25	0.010	1679 210 M1
0,50	0.020	1679 211 M1
1,00	0.040	1679 212 M1

11. Adjust the link between the control lever and the selector valve so that it has a 'snap action' into the external position 'A'. It is important that the lever rests against the lower stop 'C' when in the linkage position 'B'.
12. Adjust the length of the rod between the selector valve and the side cover as follows:
13. Place both quadrant control levers in the fully down position.
14. Rotate the side cover lever clockwise until internal resistance is felt.
15. Place the selector valve lever in the linkage position 'A'.
16. Adjust the rod clevis until the pin fits freely.





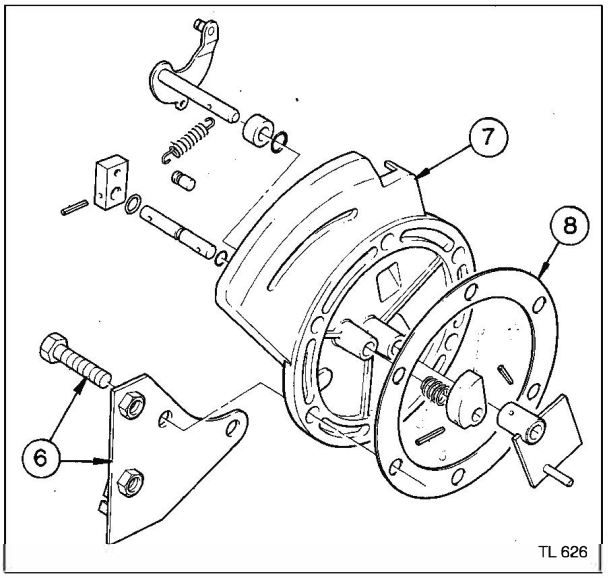
17. Remove the pin and unscrew the clevis one turn to lengthen the rod. Refit the pin.
18. Reposition the quadrant lever in the UP position - DO NOT attempt to operate the Selector Lever with the Quadrant levers in the DOWN position.

RIGHT-HAND SIDE COVER

Removal and refitment **2.09A–16**

Removal

1. Drain the transmission oil to the LOW mark on the dipstick.
2. Remove the brake actuator if necessary, see operation 2.08B-02.
3. Remove the dipstick.
4. Disconnect the Response Control rod.
5. Disconnect the Constant Pumping Control rod, if fitted.
6. Remove the six bolts and parking brake cable support plate.
7. Remove the right-hand side cover.
8. Remove and discard the gasket.



Refitment

9. Reverse procedures 1 to 8 except:
   a. Fit a new gasket.
   b. Locate the Response and Constant Pumping Control levers to the hydraulic pump.
   c. Seal the six bolts with Hylomar sealant.

RIGHT-HAND SIDE COVER

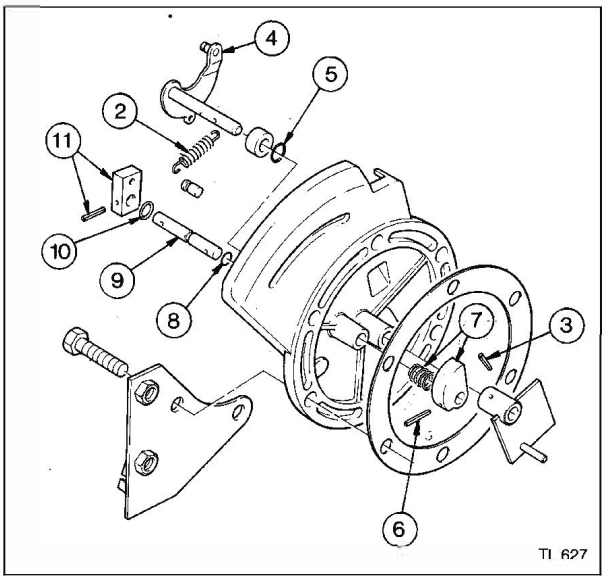
Overhaul **2.09A–17**

Dis-assembly

1. Remove the right-hand side cover. See operation 2.09A-16.
2. Remove the tension spring.
3. Drive out and discard the roll pin.
4. Remove the Constant Pumping lever.
5. Remove and discard the 'O' ring.
6. Drive out and discard the roll pin.
7. Remove the Response Control cam and spring.
8. Remove the spring clip.
9. Remove the Response Control shaft.
10. Remove and discard the 'O' ring.
11. If necessary, dismantle the operating lever.

Re-assembly

12. Reverse procedures 1 to 11 except:
    a. Fit new 'O' rings.
    b. Fit new roll pins.
    c. Adjust the Response Control, See operation 2.09A-08.



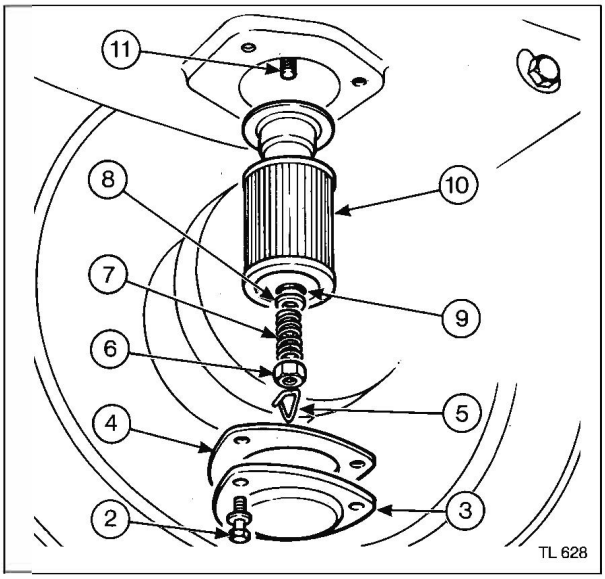
d. Adjust the Constant Pumping Control rod, if fitted. See operation 2.09A-15.

HYDRAULIC PUMP OIL STRAINER

Servicing **2.09A–18**

Procedure

1. Drain the oil.
2. Remove the three bolts and washers securing the cover plate to the bottom of the centre housing.
3. Remove the cover plate.
4. Remove and discard the gasket.
5. Remove the clip.
6. Remove the nut.
7. Remove the spring.
8. Remove the washer.
9. Remove the 'O' ring.
10. Pull out the strainer.
11. Thoroughly clean the strainer in paraffin.
12. Re-assemble by reversing procedures 1 to 9 except:
    a. Fit new 'O' ring.
    b. Fit new cover plate gasket.



HYDRAULIC ASSISTOR RAM

Overhaul **2.09A–19**

Dis-assembly

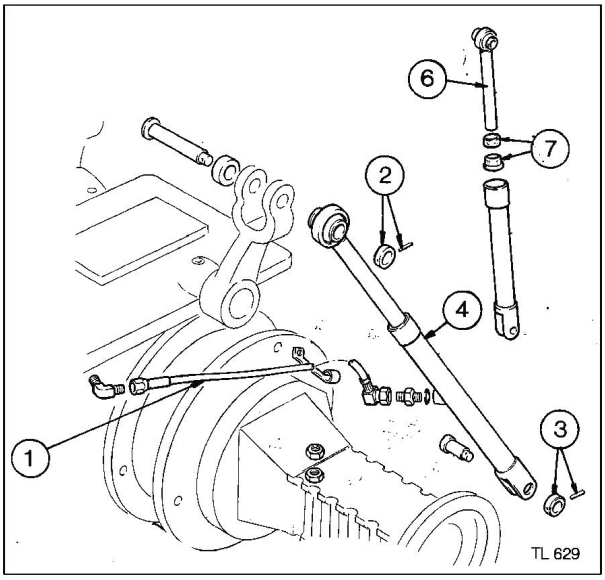
1. Disconnect the hydraulic hoses.
2. Remove the upper collar and pin.
3. Remove the lower collar, pin and pivot pin.
4. Remove the hydraulic ram.
5. Clean the outside of the ram.
6. Pull the piston rod out of the cylinder.
7. Remove the two seals from the top of the cylinder and discard.

Examination

Inspect the piston for scoring, dents or damage. Clean all components.

Re-assembly

8. Reverse procedures 1 to 7 except:
    a. Fit new seals.
    b. Lubricate the parts with clean oil on assembly.



Steering - Orbitrol Steering Unit

Section 9 – Part B

Table of Contents

Operation No.	Description	Page No.
-------	Specification	9B - 2
------	General description	9B - 3
2.09B-01	Steering system pressure test	9B - 6
2.09B-02	Orbitrol steering unit - removal - 3 cylinder tractors	9B - 7
2.09B-03	Orbitrol steering unit - removal - 4 cylinder tractors	9B - 7
2.09B-04	Orbitrol steering unit - overhaul	9B - 8

Steering - Orbitrol Steering Unit

SPECIFICATION:

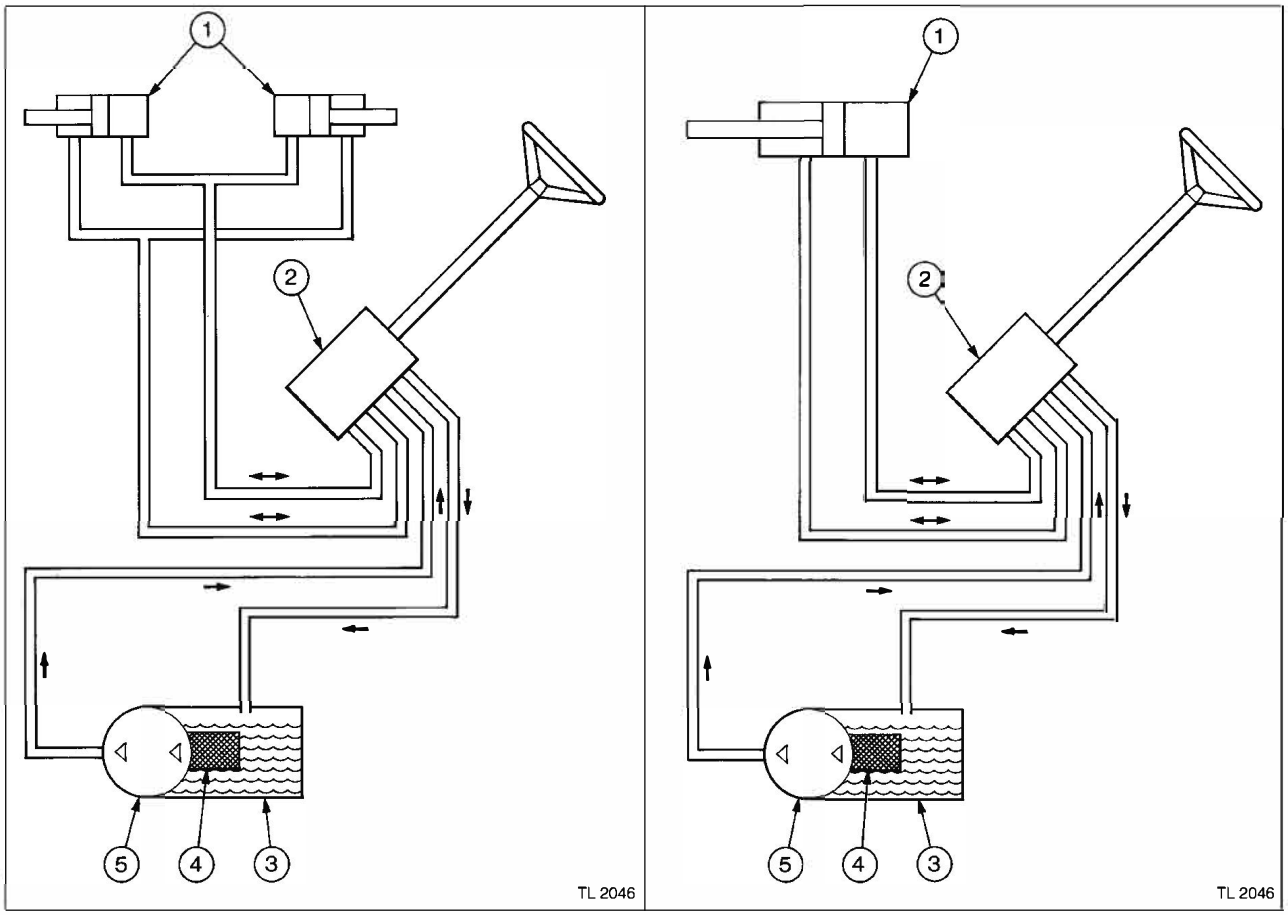
Orbitrol steering unit	
Make	Danfoss
Type code	OSPC100 ON
Nominal displacement	100 cubic centimetres per/rev
Relief valve pressure setting at 1200 engine rev/min:	
3 cylinder engine tractors	140 bar
4 cylinder engine tractors	Relief valve in pump (see section 9C)
Shock valve pressure setting:	
3 and 4 cylinder engine tractors	200 bar

Special tools

MF.3001A	Pressure test kit
MF.3002	Flow test hose kit
MS.62B	Kin-ring fitting tool
MS.63	Centering spring fitting tool

Bolt torques

Steering unit mounting plate bolts	40 Nm
Orbitrol unit bolts	30 Nm
Orbitrol unit relief valve plug	50 Nm
Hydraulic fittings on 9,5 mm (3/8 in) tube	17 Nm
Hydraulic fittings on 12,7 mm (1/2 in) tube	27 Nm



MF 240/253 tractors

MF 283 tractors

Figure.1 Steering circuits (Schematic)
1. Steering cylinder(s).
2. Orbitrol steering unit.
3. Reservoir.
4. Oil filter.
5. Pump.

GENERAL DESCRIPTION

Hydrostatic steering

Hydrostatic steering is a full power steering system with no mechanical connection between the steering wheel and tractor wheels. Oil is delivered from the steering pump to the orbitrol steering control unit, which when the steering wheel is turned, directs the required oil flow to the appropriate side of the steering ram(s). When the wheel is stationary the orbitrol unit allows the supply oil to return to the reservoir. The tractor can be manually steered if the power steering mechanism fails, or if the tractor is being moved without the engine running.

The orbitrol steering unit is splined onto the end of the steering column. Hydraulic tubes and hoses connect the unit to the steering ram(s) and the gear pump.

The orbitrol steering unit on the small tractors with twin steering rams contains the system pressure relief valve and shock valve. On the MF 283 tractor the pressure relief valve is built into the steering pump.

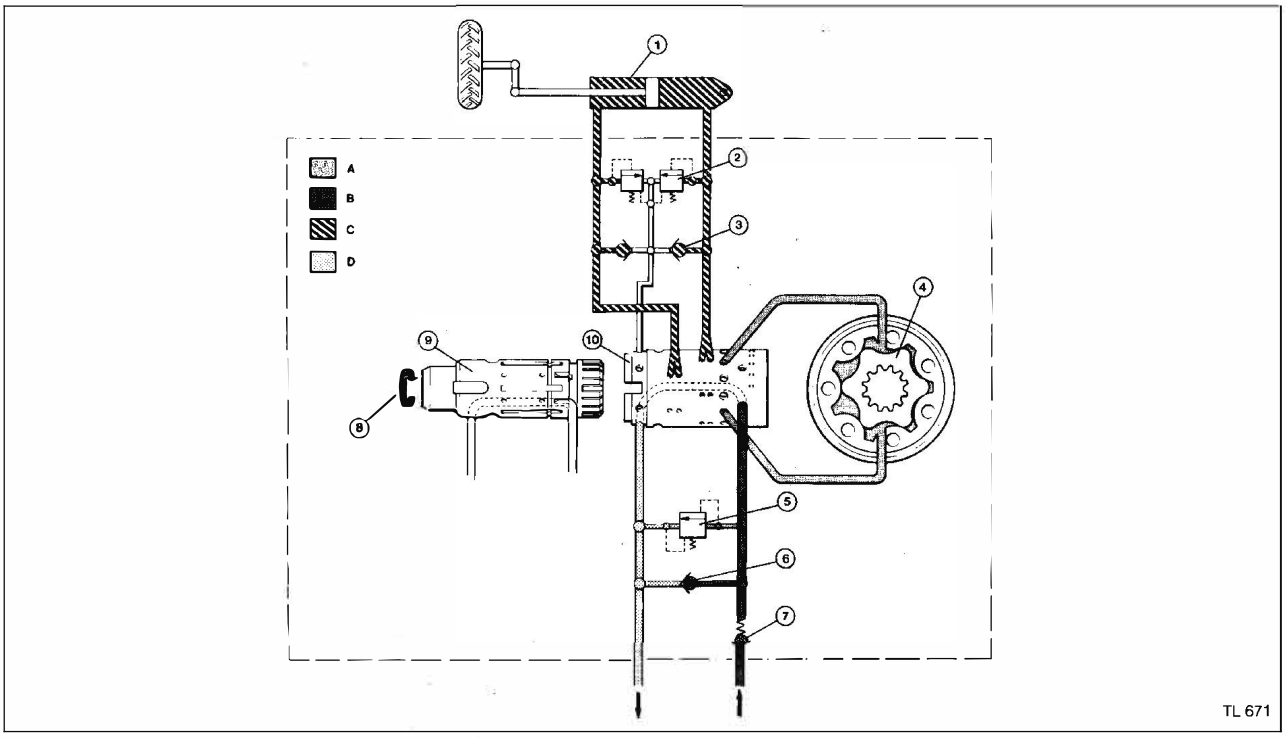


Figure.2 Orbitrol steering unit circuit - Neutral flow

1. Steering cylinder
2. Shock valves
3. Suction valves
4. Metering valve
5. Relief valve
6. Non return valve
7. Check valve
8. Steering wheel connection
9. Spool valve
10. Sleeve valve

A. Metering valve - static oil
B. Pressure line
C. Steering line - static oil
D. Return oil

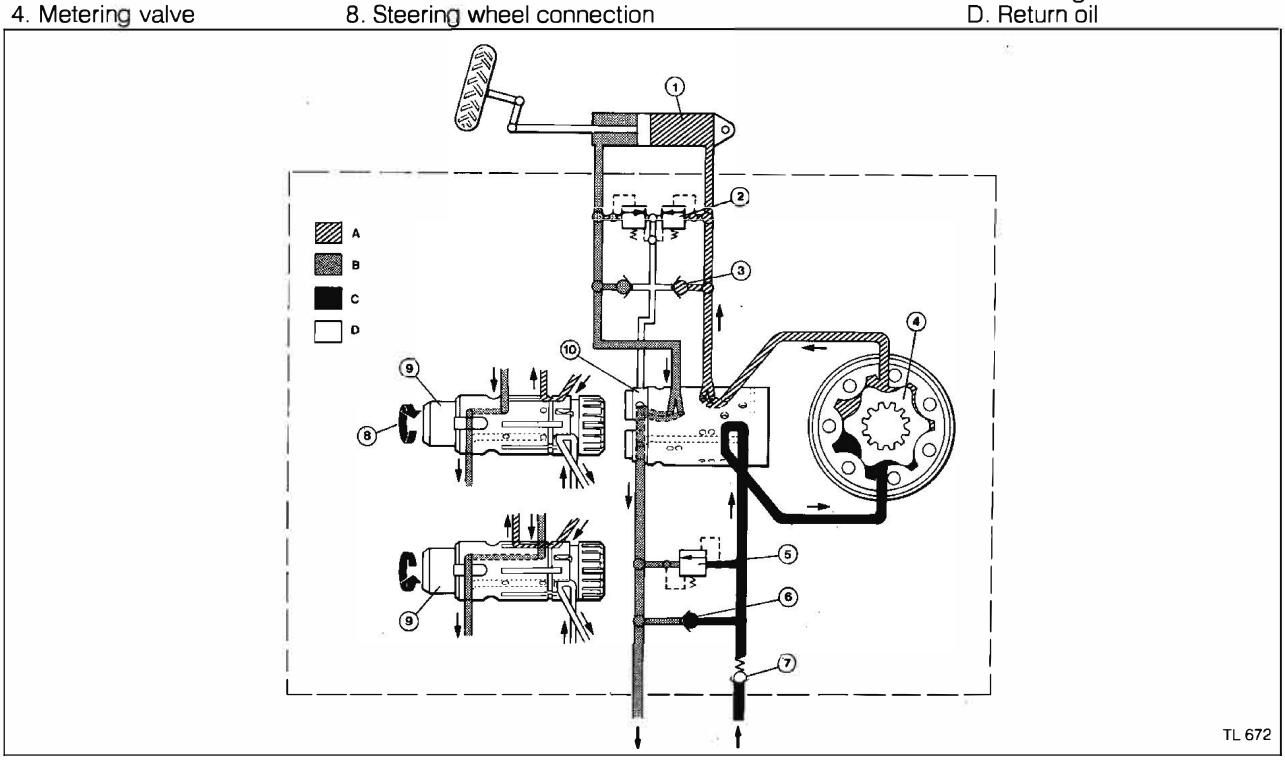


Figure 3 Orbitrol steering unit circuit - Wheel turning with engine running

1. Steering cylinder
2. Shock valves
3. Suction valves
4. Metering valve
5. Relief valve
6. Non return valve
7. Check valve
8. Steering wheel connection
9. Spool valve
10. Sleeve valve

A. Suction line
B. Steering line
C. Return oil
D. Return oil

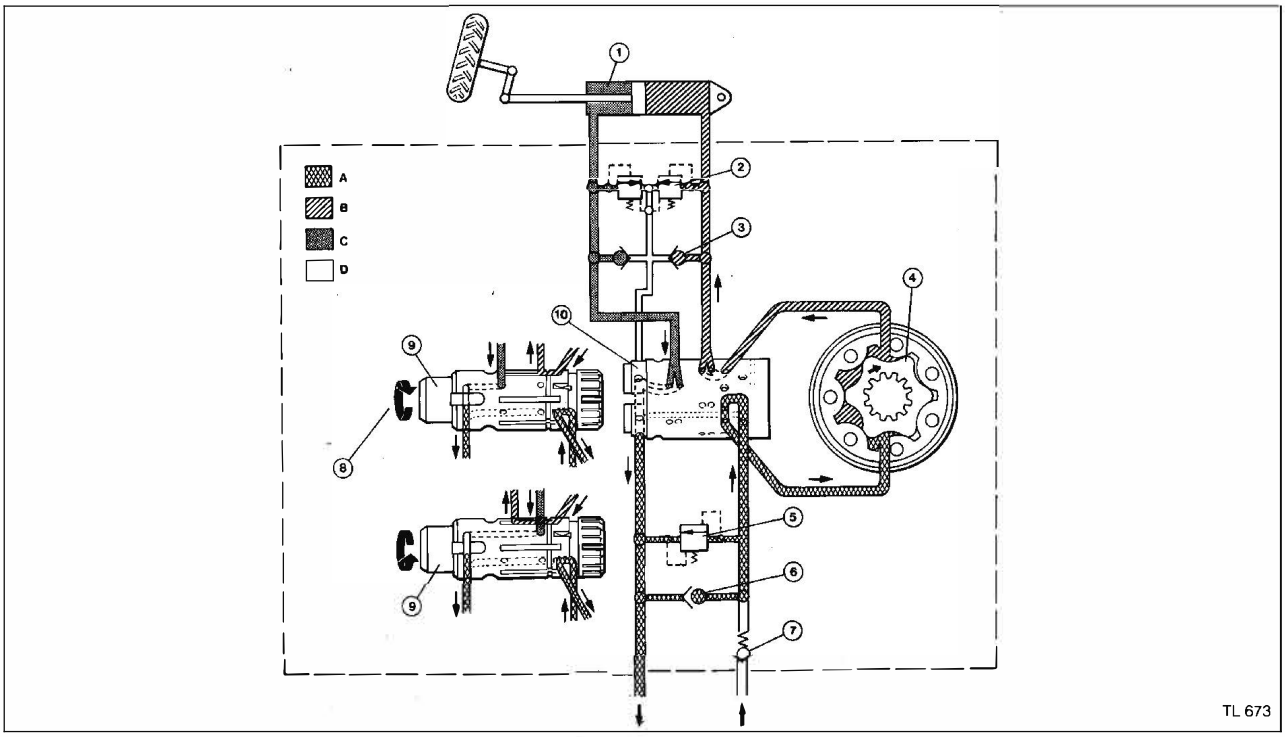


Figure 4 Orbitrol steering unit circuit - Wheel turning with engine stopped

1. Steering cylinder
2. Shock valves
3. Suction valves
4. Metering valve
5. Relief valve
6. Non return valve
7. Check valve
8. Steering wheel connection
9. Spool valve
10. Sleeve valve

A. Suction line
B. Steering line
C. Return oil
D. Return oil

ORBITROL STEERING UNIT

Neutral Flow. Fig.2.

In the neutral position, oil flows from the hydraulic pump to the steering unit. The holes in the spool align with holes in the sleeve to direct the oil through the centre of the valve into the return flow circuit. The hydraulic lines to the ram cylinder are isolated.

Two shock valves and two suction valves are fitted internally to the left and right outlet ports. The shock valve will protect the system between the ram and the orbitrol unit. The suction valve will then allow the other side of the system to compensate for any lack of oil.

Wheel Turning with Engine Running. Fig.3.

First movement of the steering wheel moves the spool against the leaf springs. This opens the closed centre pressure port and aligns slots in the spool with holes in the sleeve, allowing oil to pass to the hand pump. Further movement of the steering wheel continues to turn the wheel, sleeve and hand pump. Simultaneously the hand pump meters the oil flow and directs it back into the sleeve and spool. The oil re-entering is then directed by slots, in the spool which align with the holes in the sleeve, to direct oil to the headside or roadside of the steering ram (the direction is controlled by steering wheel movement). The oil returning from the steering cylinder is directed, (by the slots in the spool valve aligning with holes in the sleeve) into the return line.

In the line between the inlet and the spool valve, situated internally in the orbitrol unit, is a relief valve (small tractors only). Its function is to protect the pump from excessive pressures. For example, when on full lock, or when the road wheels are against an obstruction.

A check valve is fitted in the orbitrol unit in the path of the oil entering from the pump. This is a one-way valve preventing induced peak pressure generated from the road wheels returning to the main pump when steering.

Wheel Turning with Engine Stopped. Fig.4.

Should the pressure from the hydraulic pump cease, it is important that steering should still be maintained. For this reason a by-pass valve is situated between the inlet and return galleries inside the orbitrol assembly.

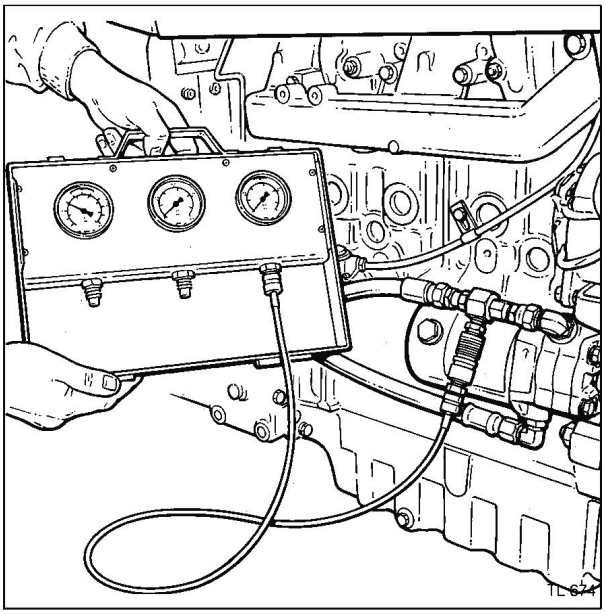
When the hydraulic pump is functioning normally, the by-pass valve is held on its seat by the oil pressure, allowing the oil to pass into the spool valve.

When the pressure from the hydraulic pump drops, the oil returning from the steering cylinder is allowed to pass the by-pass valve to the inlet side of the spool valve, enabling oil to be passed from one side of the steering cylinder to the other. In this way steering control is maintained at all times.

STEERING SYSTEM PRESSURE TEST

Check **2.09B–01**

Special Tools:
MF.3001 Pressure test kit
MF.3002 Flow test kit



Procedure

NOTE: *The illustration shows a typical steering pump installation.*

1. Disconnect the pressure pipe connecting the steering pump to the orbitrol steering unit at the pump end.
2. From the MF.3001 pressure test kit select the 9/16 inch J.I.C. Tee. From the MF.3002 flow test kit select the two adaptors 9/16 x 3/4 inch J.I.C.
3. Connect in-line the tee piece and connect up the 300 bar pressure gauge in the MF.3001 pressure test kit.
4. Start up the engine and warm up the hydraulic systems. The oil temperature must be 50-60°C.
5. Set the engine speed to 1200 rev/min.
6. Turn the steering to full lock, relief valve open.
7. Note the pressure reading on the gauge.
8. The system pressure should be:

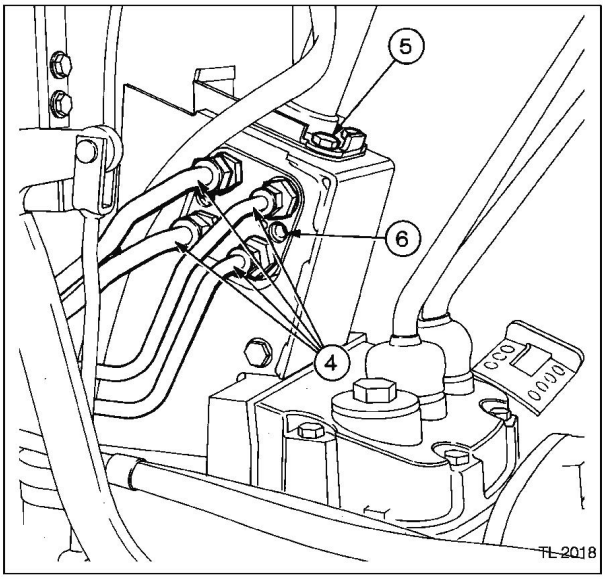
   3 cylinder engine tractors 140 bar.
   4 cylinder engine tractors 170 bar.

Fault finding

SYMPTOMS - Steering pressure LOW	REMEDY	REF
Steering pump performance down.	Replace pump.	2.09C-06
Worn orbitrol steering unit.	Overhaul steering unit.	2.09B-04
Relief valve in steering unit faulty.	Overhaul steering unit.	2.09B-04
Shock valves in steering unit faulty.	Overhaul steering unit.	2.09B-04
Leakage across steering ram seals.	Overhaul steering ram.	2.09C-05

ORBITROL STEERING UNIT – 3 CYLINDER TRACTORS

Removal and refitment **2.09B–02**



Removal

1. Working from the left-hand side of the tractor, remove the battery access panel.
2. Disconnect the battery, negative cable (black) first, and remove the battery.
3. Note and label the position of the pipes connected to the orbitrol unit.
4. Disconnect the four pipes from the orbitrol unit, place plastic caps over the unions on the orbitrol, and over the pipe ends to prevent the ingress of dirt.
5. Remove the four bolts retaining the orbitrol unit to the steering column and support assembly.
6. Lower the orbitrol unit from the steering column spline.
7. Remove the orbitrol unit forward through the access hole in the battery carrier.

NOTE: *On tractors without the access hole in the battery tray the orbitrol mounting support bracket must be loosened and the valve manoeuvred out of the side.*

Refitment

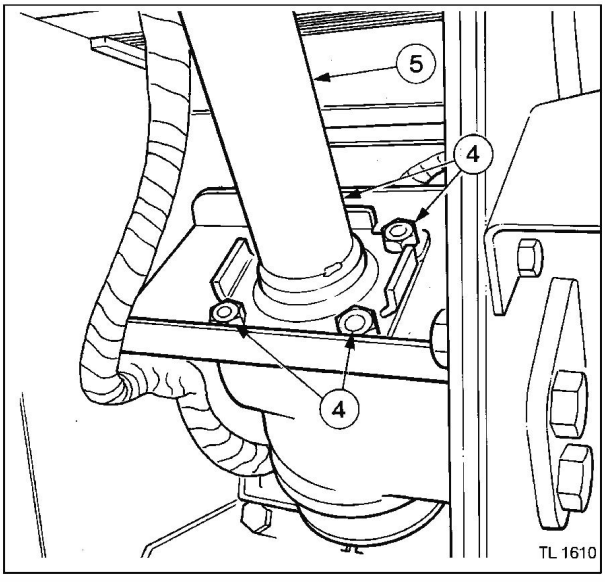
8. Reverse procedures 1 to 7, removing the plastic caps and plugs before refitting the four pipes to the orbitrol unit.

NOTE: *Reconnect the battery cables, POSITIVE (+) red cable first and then the NEGATIVE (-) black cable second.*

9. Bleed the steering system, see operation 2.09C-16 or 2.09D-18.

ORBITROL STEERING UNIT – 4 CYLINDER TRACTORS

Removal and refitment **2.09B–03**



Removal

1. Remove the lower cover panel.
2. Note the position of the pipes connected to the orbitrol unit.
3. Disconnect the four pipes from the orbitrol unit, place plastic caps over the unions on the orbitrol, and over the pipe ends to prevent the ingress of dirt.
4. Remove the four bolts retaining the orbitrol unit to the steering column and support assembly.
5. Remove the bolt retaining the steering column to the instrument panel and lift the steering column up. Remove the orbitrol from its mounted position.

Refitment

6. Reverse procedures 1 to 5, removing the plastic caps and plugs before refitting the four pipes to the orbitrol unit.
7. Bleed the steering system, see operation 2.09C-16 or 2.09D-18.

ORBITROL STEERING UNIT

Overhaul **2.09B–04**

Special Tools:
MS.62B Kin-ring fitting tool
MS.63 Centring spring fitting tool

Dis-assembly

1. Remove the orbitrol steering unit, see operation 2.09B-02 or 2.09B-03
2. Remove the seven screws.
3. Lift off the end plate.
4. Remove the 'O' Ring.
5. Lift off the stator and rotor.
6. Remove the 'O' Ring.
7. Remove the distributor plate.
8. Remove the 'O' Ring.
9. Remove the drive shaft and spacer.
10. Screw out and remove the threaded bushing in the bore of the check valve.
11. Shake out the ball check valve.
12. Remove the outer and inner spools with rings, bearing races and needle bearings from the housing by pressing the inner spool from the steering column end.

NOTE: *The cross pin (14) in the sleeve and spool must be kept horizontal. The pin can be seen through the open end of the inner spool.*

13. Remove the ring, bearing race and needle bearing from the spool and sleeve.
14. Press out the cross pin using the screws with a rolled pin (from end cover).
15. Carefully press the inner spool out of the outer sleeve.
16. Press the neutral position springs out of their slot in the inner spool.
17. Lever out the dust seal.
18. Remove the 'O' ring and kin-ring.

Examination

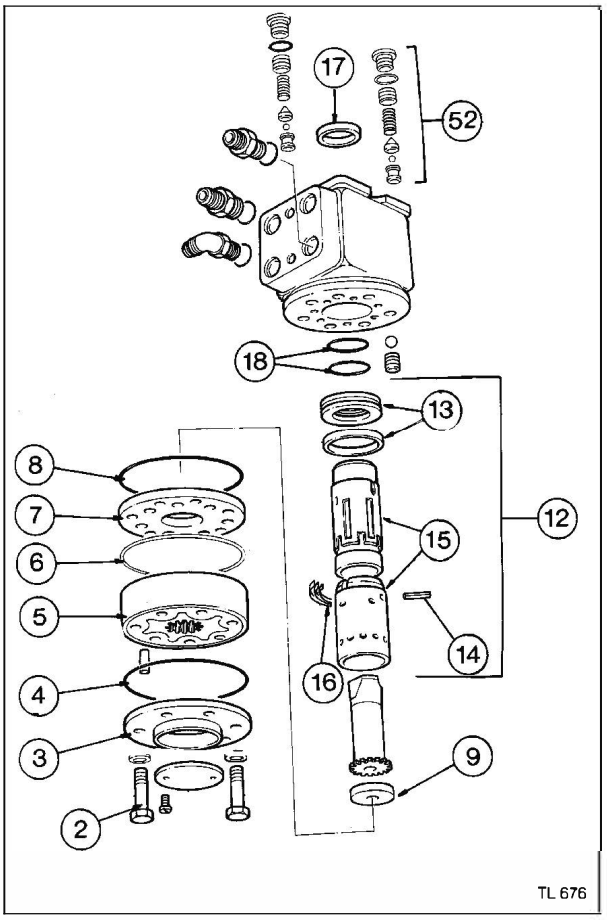
19. Check all parts carefully and replace parts as necessary.

All seals, 'O' rings, washers and neutral position springs must be replaced.

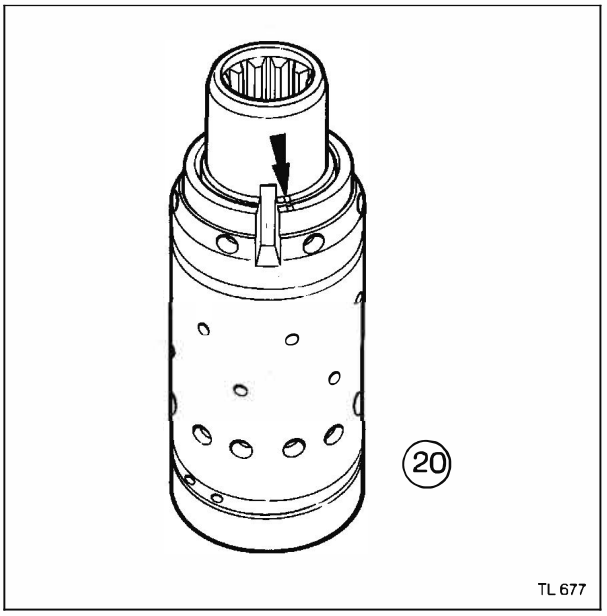
Clean all parts, before assembly lubricate all items in hydraulic oil.

Re-assembly

20. Carefully slide the inner spool into the sleeve with the two marks aligned as shown. Ensure that the slots for the neutral position springs are opposite each other.

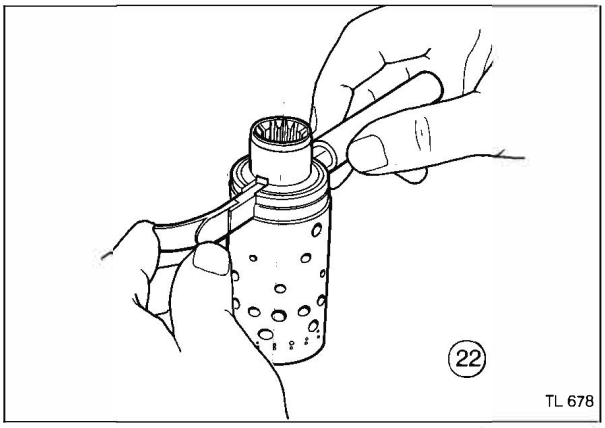


TL 676

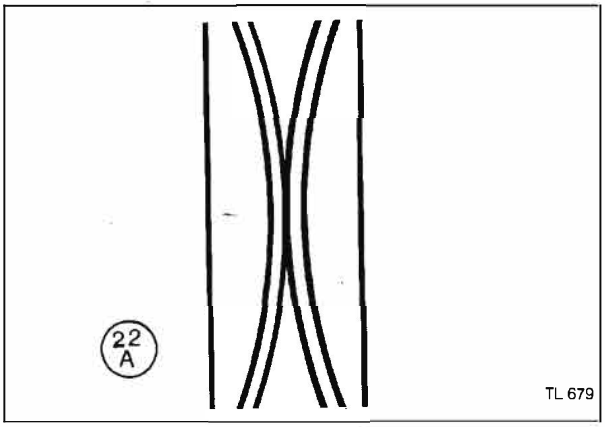


TL 677

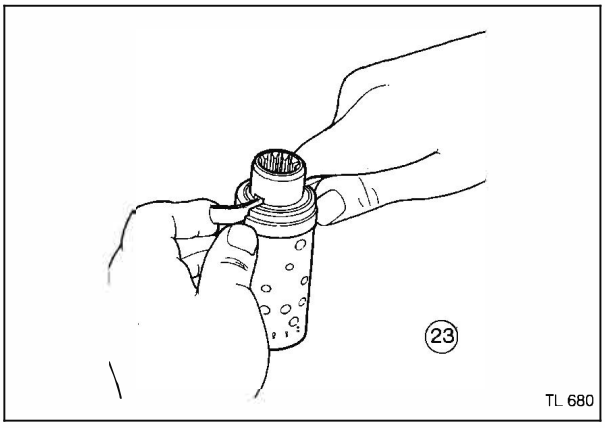
21. Push the assembly tool MS.63 for the neutral position springs right through the slot.



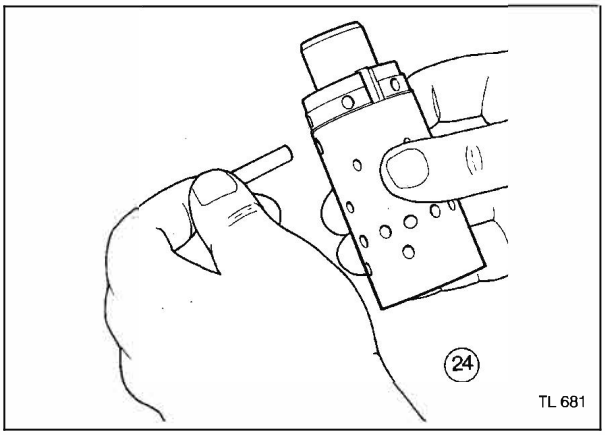
22. Place the springs in the tool in the order shown in illustration ref. 22A.



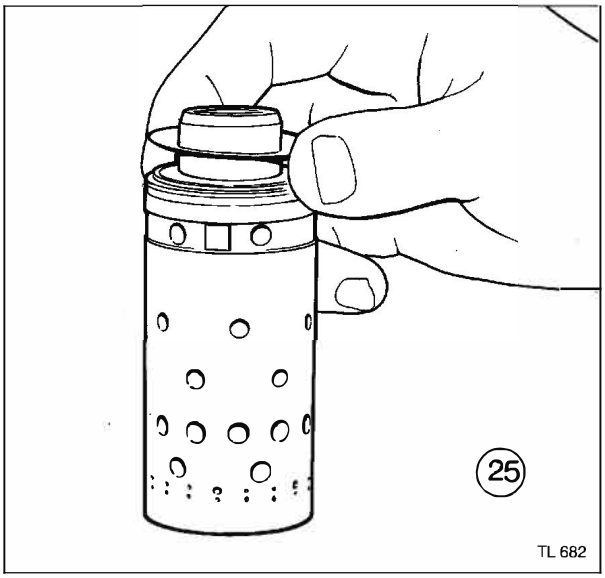
23. Press the neutral position springs together and push them into place, remove the assembly tool.



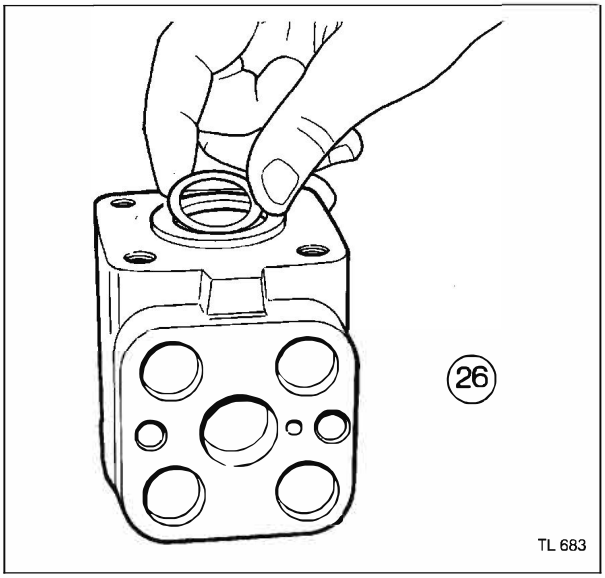
24. Insert the cross pin.



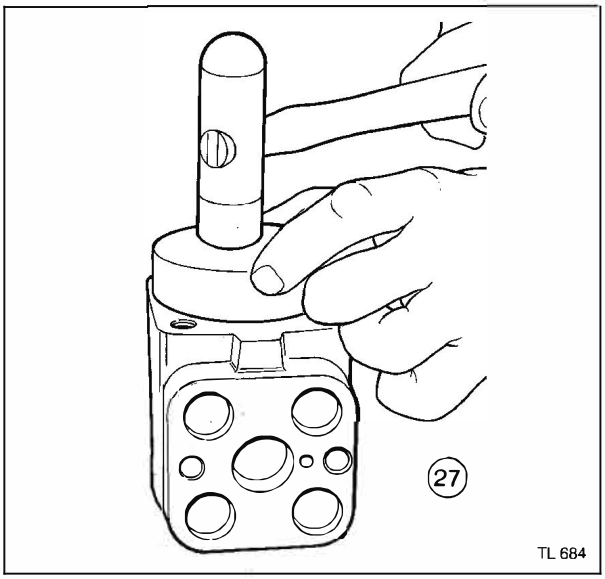
25. Fit the ring, rear bearing race, needle bearing and front bearing race in that order. The chamfer on the rear washer must be facing away from the needle bearing.



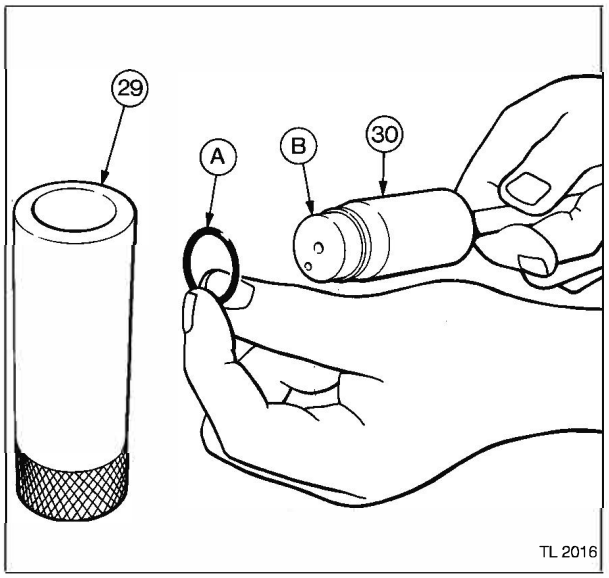
26. Place the dust seal in the groove of the housing.



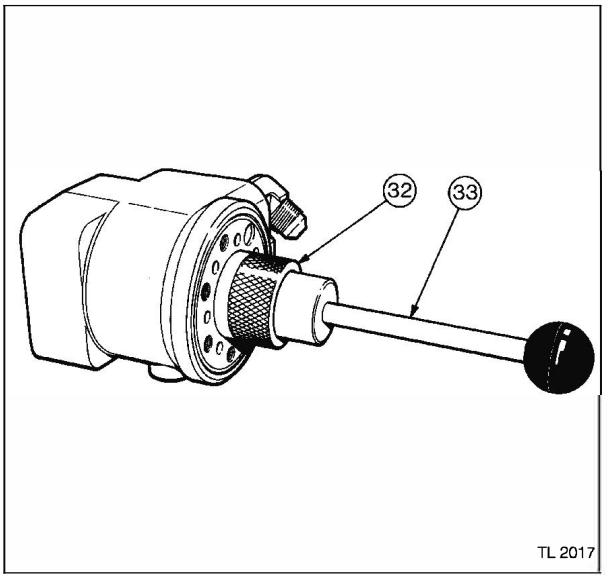
27. Place a flat steel block over the seal and hammering it lightly, drive it into place.



28. Select special tool MS.62B.
29. Remove the outer sleeve.
30. Fit the nylon spigot into the plungers.
31. Ensure that the 'O' ring is fitted over the plastic kin-ring. Fit the assembly 'A' onto the nylon spigot 'B'.

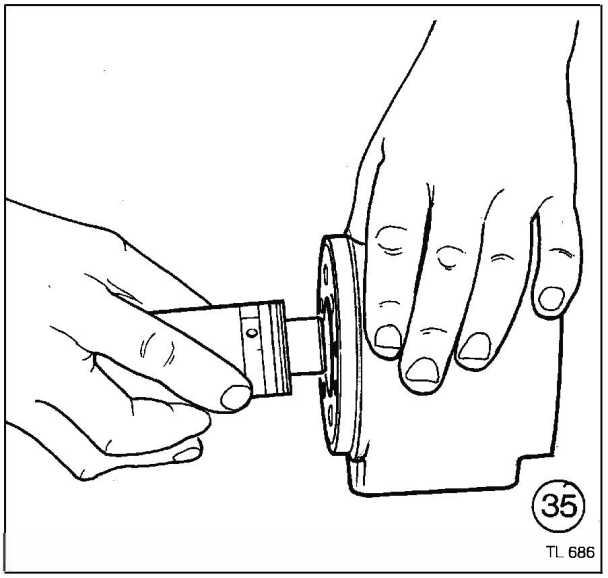


32. Place the outer sleeve of the special tool into the bore of the steering unit.
33. Carefully guide the inner part of the tool with the nylon spigot and seal into the sleeve until a resistance is felt. Push the seal into position in the housing.
34. Withdraw the inner and outer parts of the assembly tool from the bore of the steering unit, leaving the nylon spigot and seals in place.

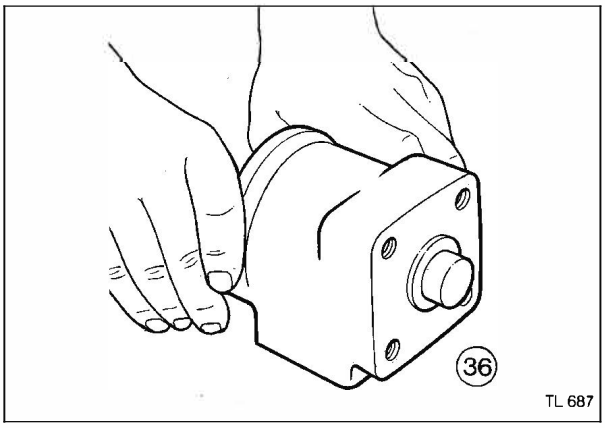


35. Guide the spool and sleeve assembly into the bore with light turning movements.

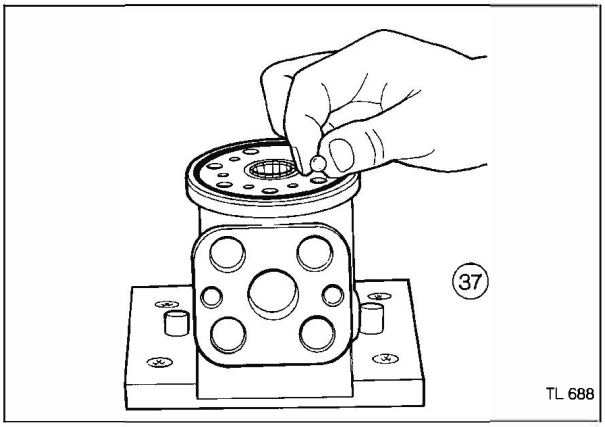
NOTE: *Fit the spool and sleeve in the bore in such a way that the cross pin is kept horizontal.*



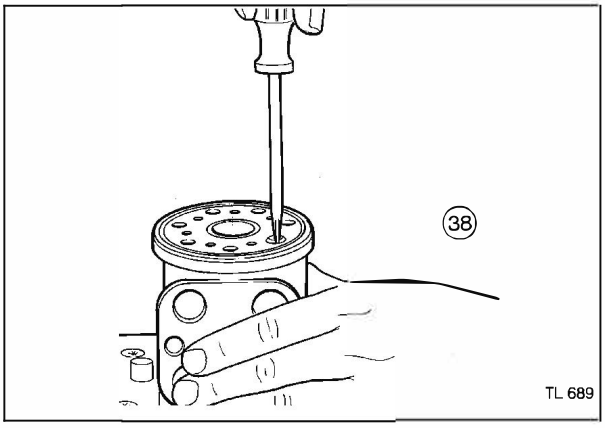
36. Push the spool and sleeve assembly so that it ejects the nylon spigot out of the housing leaving the 'O' ring and kin-ring in place.



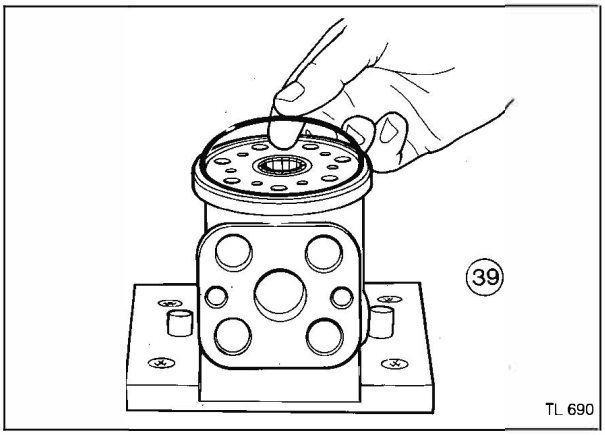
37. Place the ball check valve in the hole shown.



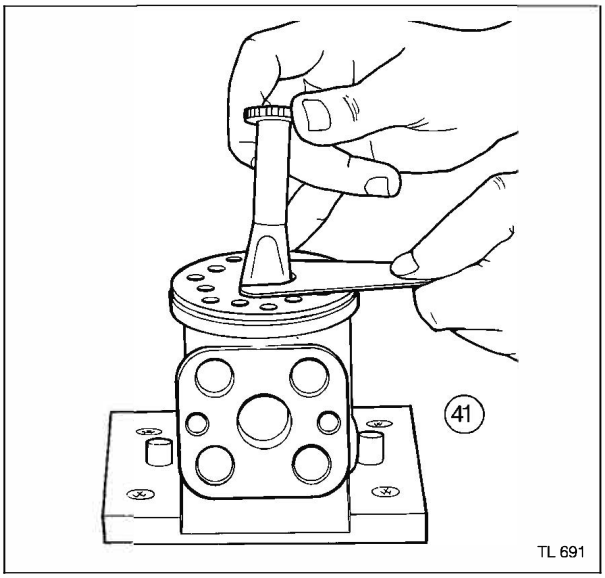
38. Lightly screw in the threaded bushing in the check valve.



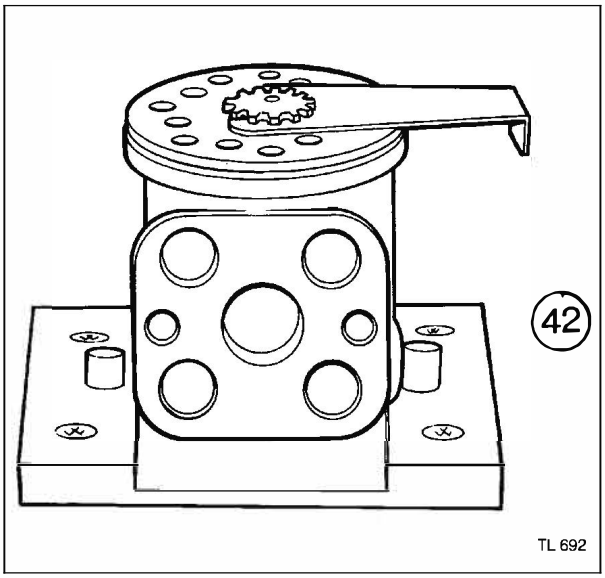
39. Grease the 'O' ring with petroleum jelly and place it in its groove.
40. Place the distributor plate in such a way that the channel holes match the corresponding holes in the housing.



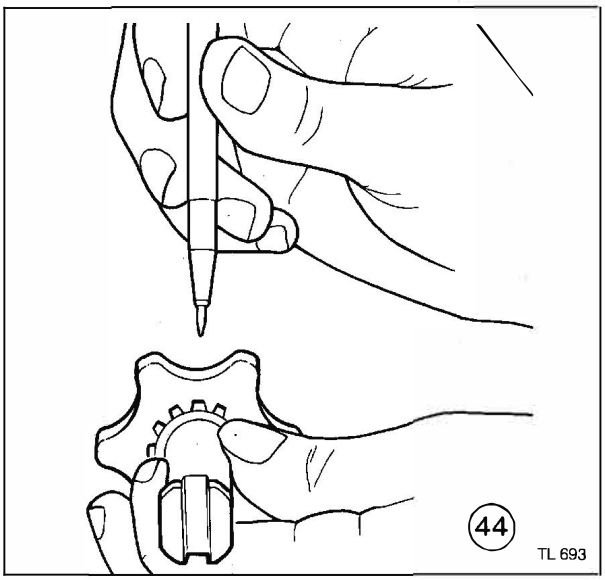
41. Fit the drive shaft down into the bore so that the slot is parallel with the connecting flange.



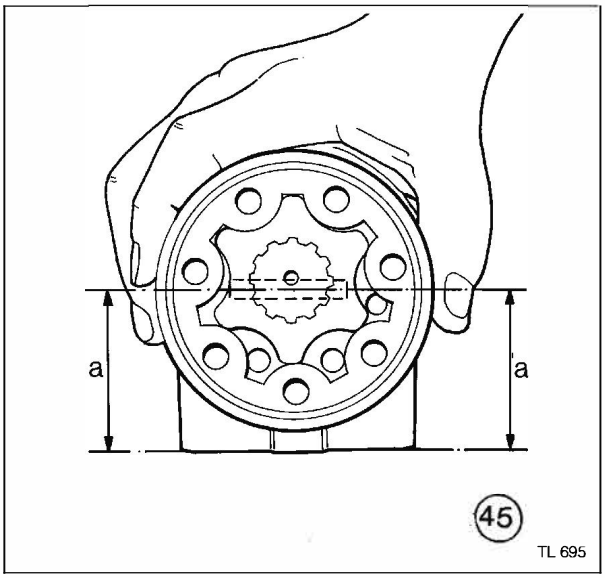
42. Position the drive shaft as shown, make up a thin mounting fork as shown to hold it in position.



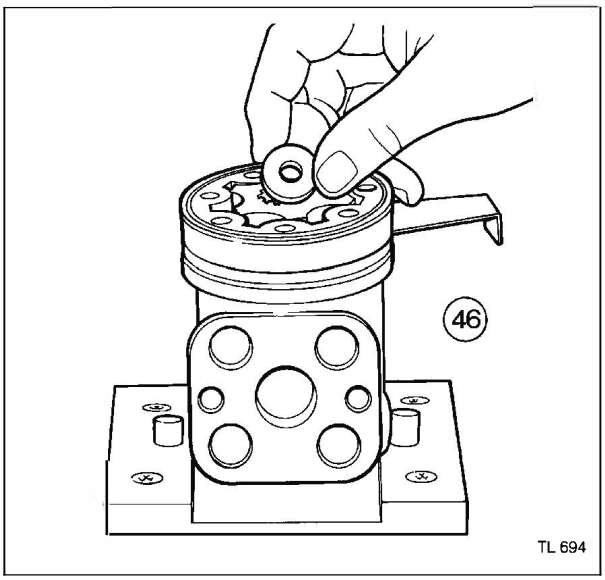
43. Fit the 'O' rings on both sides of the gear rim.
44. The gearwheel of the rotor and the drive shaft must be assembled in such a way that the tooth base in the rotor is positioned in relation to the slot in the drive shaft as shown.



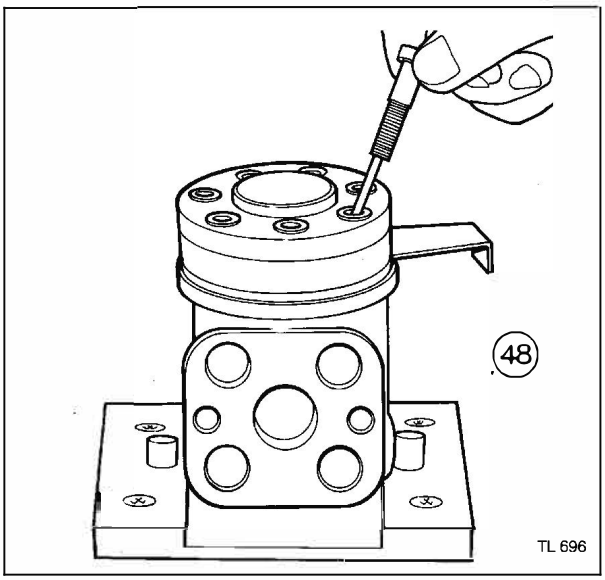
45. Turn the gear rim (stator) in such a way that the seven holes for the screws match the corresponding seven holes in the housing. rotor and pin must be in the position shown in relation to each other. The centre line of the pin 'A' is below the centre line of the shaft.



46. Fit the drive shaft spacer.
47. Fit the end cover.



48. Put the washer on the screw with the roll pin and fit into the hole with the threaded bushing and check valve.



49. Put the washers on the remaining six screws and fit them. Withdraw the drive shaft holding tool and tighten the seven screws to a torque of 30 Nm.

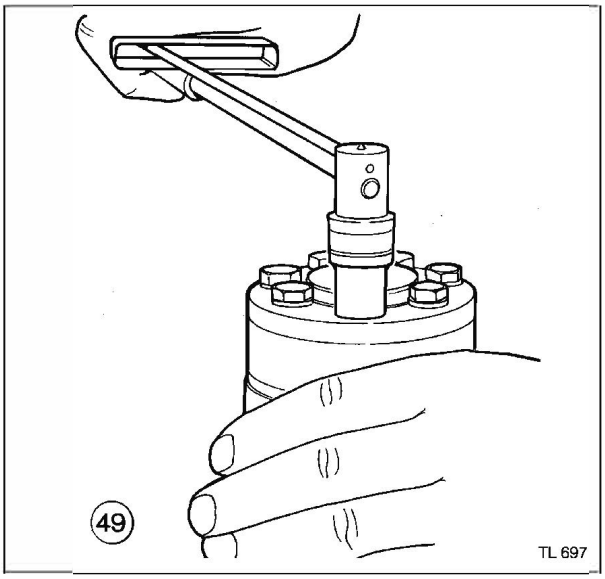
50. The non-return valve fitted to the inlet port which should not require servicing.

51. Two shock valves are fitted to each steering ram port. These should not be removed unless absolutely necessary. Special hydraulic equipment is required to reset the pressure settings of the valves.

MF 240/253 tractors only

52. On the top of the steering unit port face is the pressure relief valve. Adjustment is effected by removing the 8 mm hexagon plug and sealing washer. To obtain the correct pressure of 140 bar:

Turn the internal 8 mm setting screw inwards to increase or outwards to decrease the pressure setting. Refit the valve cover plug and sealing washer and tighten to a torque of 50 Nm.



Page left blank intentionally

Steering - Box and pump

Section 9 – Part C

Table of Contents

Operation No.	Description	Page No.
-------	Specification	9C - 2
-------	General description	9C - 2
2.09C-01	Steering box - removal	9C - 3
2.09C-02	Steering box - overhaul	9C - 5
2.09C-03	Drag links and tie rods - overhaul	9C - 7
2.09C-04	Steering rams - removal	9C - 7
2.09C-05	Steering rams - overhaul	9C - 8
2.09C-06	Steering pump - removal	9C - 8
2.09C-07	Steering pump - hydrostatic - Sunstrand - servicing	9C - 9
2.09C-08	Steering pump - power assisted - Barnes - servicing	9C - 9
2.09C-09	Steering system pressure test - check	9C - 10
2.09C-10	Steering system flow test - check	9C - 11
2.09C-11	Steering pump - hydrostatic - Sunstrand - overhaul	9C - 12
2.09C-12	Steering pump - power assisted - Barnes - overhaul	9C - 14
2.09C-13	Control valve - removal	9C - 16
2.09C-14	Control valve - adjust	9C - 16
2.09C-15	Control valve - overhaul	9C - 17
2.09C-16	Steering system - air removal	9C - 17

Steering - Box and pump

SPECIFICATION:

Steering box

Type	Recirculating ball
Oil capacity	900 ml

Hydraulic pump – power assisted steering

Make	Barnes
Type	GC-5060-A-GA-7
Output at 2000 engine rev/min at 55,2 bar	19 litre/min
Pressure relief valve setting	84,5 bar
Oil capacity (reservoir)	700 ml

Hydraulic pump – hydrostatic steering

Make	Sunstrand
Type	550
Output at 2000 engine rev/min at 140 bar	17,5 litre/min
Oil capacity (reservoir)	700 ml

Special Tools:

MF.148B	Pressure test gauges
MF.263A	Bush extractor (main tool)
MF.263-1	Adaptor
MF.332	Hydraulic pump oil seal protector
MF.473	Steering wheel puller
MS.550	Handle
6312A	Puller
MF.3001A	Pressure test kt
MF.3002	Hose kit
MF.3003	Hydraulic flow meter

Bolt torques:

Gear lever cover	60 Nm
Steering wheel nut	58 Nm
Drop arm securing nuts	340 Nm
Drag link ball joint nuts	122 Nm
Drag link pinch bolt	47 Nm
Track adjustment bolt	47 Nm
Steering ram ball joint nuts - 5/8 inch UNF	95 Nm
Steering ram ball joint nuts - 1/2 inch UNF	60 Nm
Pump drive gear retaining nut	42 Nm
Pump mounting bolts	36 Nm
Control valve retaining bolts	23 Nm
Pump body bolts - Sunstrand	43 Nm
Pump reservoir bolts - Sunstrand	18 Nm
Pump filler plug - Sunstrand	16 Nm
Pump body bolts - Barnes	36 Nm
Pump relief valve locknut - Barnes	40 Nm
Reservoir screws - Barnes	11 Nm

GENERAL DESCRIPTION

Manual and power assisted steering

The steering box is a recirculating ball type unit. A twin drop arm and drag link arrangement transmits the steering wheel movement to the tie rods.

The power assisted steering system comprises an engine driven pump supplying oil under pressure to a spool valve mounted on the outer tube of the steering column. A control link, attached to the spool valve, is actuated upon the initial movement of the steering wheel, causing relative movement of the spool, which allows oil under pressure to the two double acting rams. Each ram cylinder is mounted on a reaction bracket bolted to the axle centre beam and each ram piston is attached to a bell crank lever attached to the top of each front axle spindle. When the wheels have rotated through their required movement and effort is removed from the steering wheel, a return spring within the spool valve returns the spool to its position.

A by-pass valve is incorporated in the spool valve unit to allow the tractor to be steered with the engine stopped. The by-pass valve permits displaced oil to flow from the exhaust side of the ram piston back to the pump reservoir.

Hydrostatic steering (see section 9B for details)

Hydrostatic steering is a full power steering system with no mechanical connection between the steering wheel and tractor wheels. Oil is delivered from the steering pump to the orbitrol steering control unit, which when the steering wheel is turned, directs the required oil flow to the appropriate side of the steering rams. When the wheel is stationary the orbitrol unit allows the supply oil to return to the reservoir. The tractor can be manually steered if the power steering mechanism fails, or if the tractor is being moved without the engine running.

The orbitrol steering unit is splined onto the end of the steering column. Hydraulic tubes and hoses connect the unit to the steering ram and the gear pump.

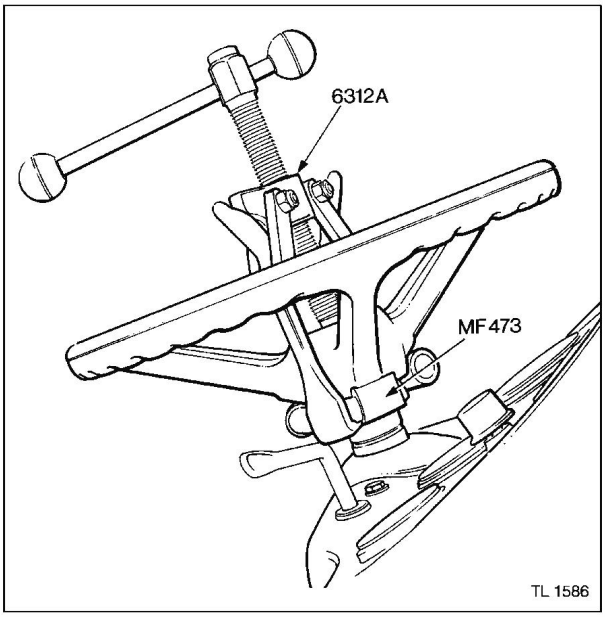
The orbitrol steering unit on the small tractors contains the system pressure relief valve and shock valve.

Steering - Box and pump

STEERING BOX

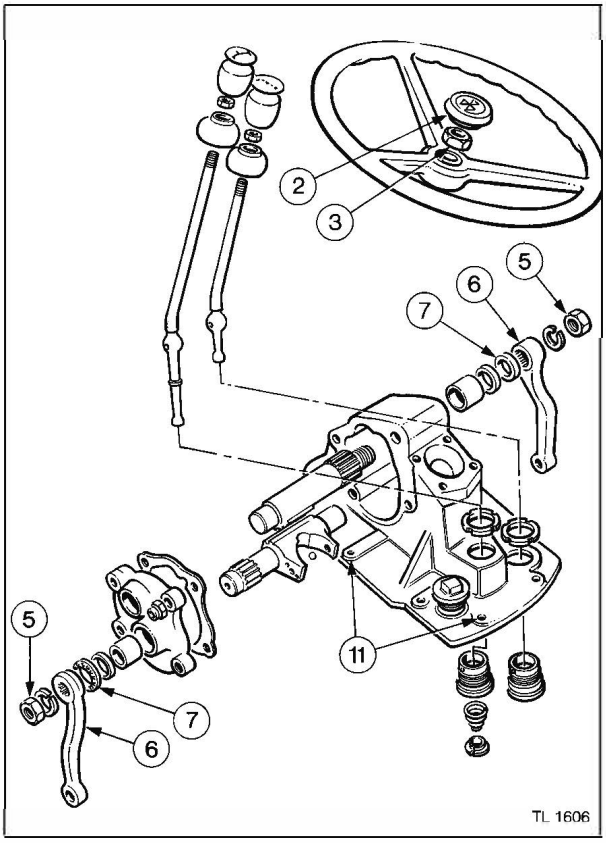
Removal and refitment **2.09C–01**

Special Tools:
MF.473 Steering wheel puller
6312A Puller



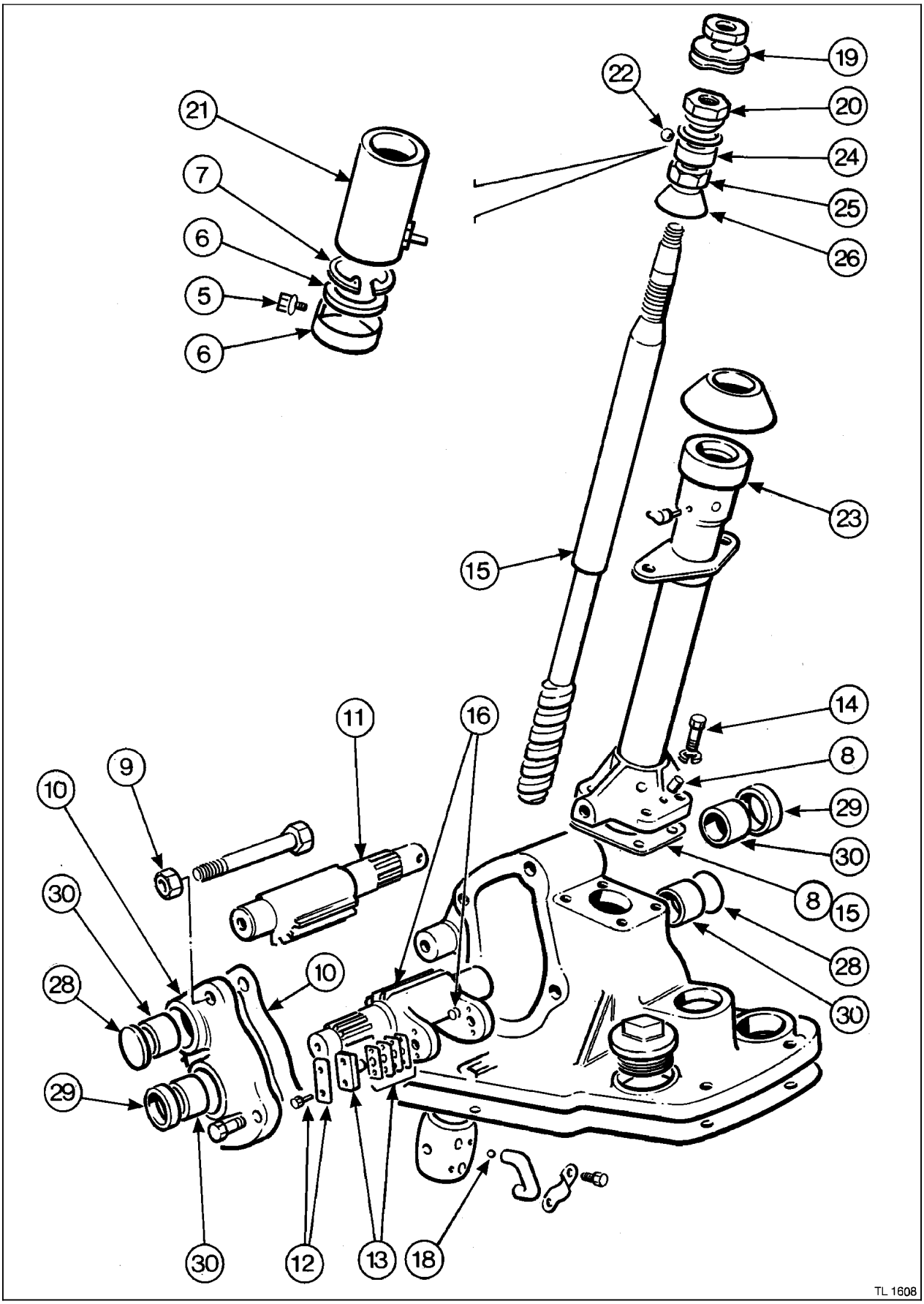
Removal

1. Ensure that the front wheels are set straight ahead.
2. Detach the motif cap from the centre of the steering wheel.
3. Remove the nut securing the steering wheel and detach the wheel using puller MF. 473 in conjunction with puller 6312A.
4. Remove the instrument panel.
5. Remove the nuts and washers securing the drop arms to the rocker shafts.
6. Using puller 6312A remove each drop arm.
7. Remove the felt seals from the rocker shafts.
8. Disconnect the power steering pipes from the control valve (power steering tractors).
9. Remove the bolts securing the steering box to the side support brackets.
10. Remove the bolts and washers securing the rear light wiring clip (if fitted).
11. Remove the eight bolts and washers and manoeuvre the steering box complete with gear levers clear of the tractor. Take care not to damage the gear selector levers.



Refitment

12. Reverse procedures 1 to 11 except:
    a. Coat the underside of the gear lever cover with MF Instant Gasket (Loctite 509, 5204 or 5205) and torque the cover bolts to 60 Nm.
    b. Refit the steering box with the gear levers in the neutral position.
    c. Fit new felt washers to the rocker shaft.
    d. Tighten the drop arm securing nuts to a torque of 340 Nm.
    e. Tighten the steering wheel securing nut to a torque of 58 Nm.
    f. Re-check the steering reservoir (power steering tractors).


19
22
20
24
25
26
21
7
6
5
6
23
15
14
8
29
30
8
15
28
30
11
16
9
10
30
28
10
29
30
12
13
18
TL 1608

Steering - Box and pump

STEERING BOX

Overhaul **2.09C–02**

Special Tools:
MF.473 Steering wheel puller
MF.263 Bush extractor
MF.263–1Adaptor
MF.19A Reamer
MS550 Handle
6312A Puller

Dis-assembly

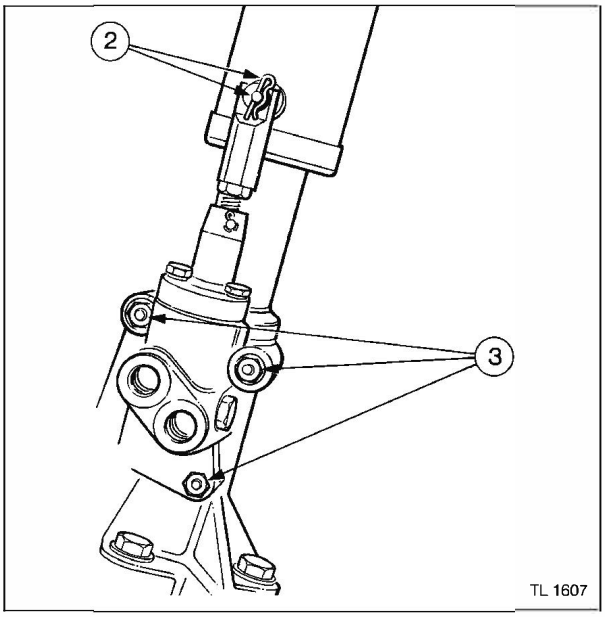
1. Remove the steering box, see operation 2.09C-01

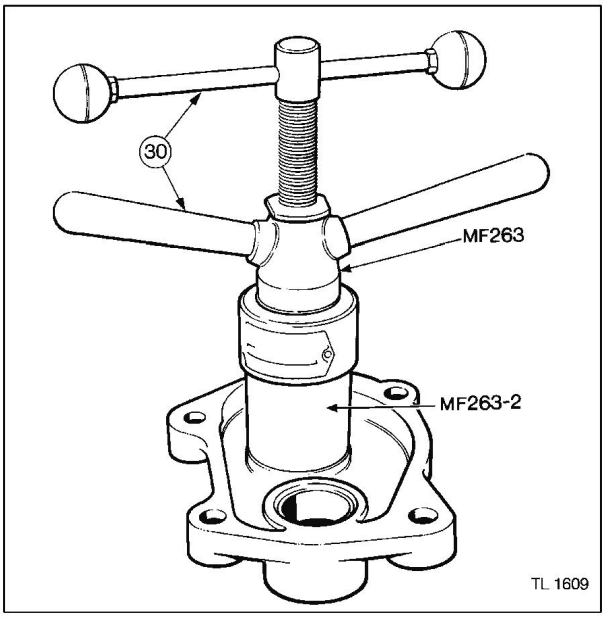
Power steering

2. Remove the hairpin and washer. Release the control valve linkage.
3. Remove the three bolts and washers and remove the control valve.
4. Remove the two 'O' rings from the joint face.
5. Remove the screw and washer securing the retainer.
6. Slide the retainer with the felt seal away from the outer ball race.
7. Using circlip pliers remove the circlip.

All models

8. Remove the plug and drain off the oil.
9. Remove the two bolts, washers and nuts securing the cover plate.
10. Remove the cover plate.
11. Remove the secondary rocker shaft.
12. Release the tabwasher and remove the bolts.
13. Remove the ball peg and shims.
14. Remove the four bolts and washers securing the steering column.
15. Remove the steering column assembly and gasket.
16. Remove the primary rocker shaft and steel ball.
17. Unscrew the main nut from the column.
18. Remove and collect the 28 steel balls.
19. Release the tabwasher and remove the locknut.
20. Remove the adjustable race and seal.
21. Carefully lift the outer ball race from the tube.
22. Collect the 12 steel balls.
23. Withdraw the column out of the tube.
24. Remove the ball race.
25. Remove the ball ring.
26. Remove the seal.
27. Remove the circlip, felt seal and retainer from the column tube.





28. Remove the two core plugs.
29. Remove the two oil seals.
30. Using special tool MF. 263A and adaptor MF. 263-1 cut a thread into the bush in the cover plate by rotating the outer handle. Then extract the bush by rotating the inner handle.
31. Repeat procedure 30 for the remaining bush in the cover plate and the two bushes in the steering box.

Examination

Check the condition of all components for wear or damage and replace any parts which are unfit for future service. Thoroughly clean all components of the steering box, and ensure that the joint face of the steering box and cover plate is undamaged and clean.

Re-assembly

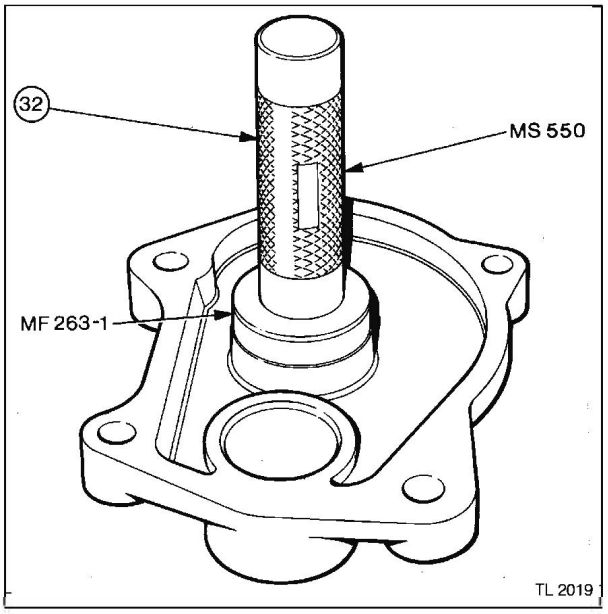
32. Position a new bush squarely over its hole and drive in the bush using adaptor MF. 263-1 and handle MS.550. Repeat for the remaining three bushes.
33. Secure the cover plate to the steering box and ream through each pair of bushes using reamer MF. 19A.
34. Remove the cover plate and thoroughly clean out all swarf from the steering box.
35. Fit a new seal, ball ring and ball race.
36. Fit on the tube, the retainer, a new felt seal and a new circlip.
37. Lower the tube onto the column, then position the 12 balls in the outer race using grease to retain them.
38. Slide the outer race over the column, taking care not to dislodge any of the balls, and locate the ball race on the tube.
39. Fit a new seal to the adjustable race then fit the adjustable race to the column.
40. Tighten the adjustable race to 13,5 Nm, then slacken off one flat to bring a flat adjacent to the tabwasher keyway.

WARNING: Accurate adjustment of the ball race is essential. If adjustment is incorrect, the shaft may be prevented from oscillating, resulting in bending stresses occurring and causing faulty steering.

41. Fit a new tabwasher and locknut. Secure the adjustable race and the locknut with the tabwasher.
42. Place the main nut onto the column and assemble the 28 balls into the main nut channel. Turn the main nut to house the balls as they are assembled.
43. Fit new oil seals and welch washers to the steering box and cover plate.
44. Slide the primary rocker shaft into its bore.
45. Refit the ball to the shaft, using grease to retain it.
46. Screw the main nut to the top of its thread and then locate a new gasket onto the steering box and enter the column assembly into the box, still retaining the main nut at the top of its thread.
47. As the column is lowered into the box, turn the primary rocker shaft until the ball locates in its seating in the main nut.

NOTE: The ball transfer tube on the main nut must be facing away from the rocker shaft.

48. Retain the assembly in position and secure the tube to the steering box with the four bolts and washers.
49. Refit the ball peg and more shims than will be necessary and temporarily secure them with the two bolts.



50. Turn the column until the main nut is halfway along its thread on the column, then remove shims until there is no end float with the main nut rotating freely.
51. When correctly adjusted, secure the ball peg and shims with the two bolts and tabwasher.
52. Refit the cover plate with a new gasket taking care not to damage the oil seal. Secure the cover plate with the two bolts, washers and nuts.
53. Refill the steering box with 900 ml of oil.
54. Refit the circlip to the outer ball race.
55. Fit the new felt seal against the circlip and secure the retainers to the outer ball race with the screw and washer.
56. Fit two new 'O' rings to the steering column valve face and refit the valve, securing it to the steering column with the three bolts and washers torqued to 23 Nm.
57. Refit the linkage to the pin and secure it with the washer and hairpin.
58. Refit the steering box, see operation 2.09C-01.
59. Adjust the control valve, see operation 2.09C-14.

Steering - Box and pump

DRAG LINKS AND TIE RODS

Overhaul **2.09C–03**

Dis-assembly

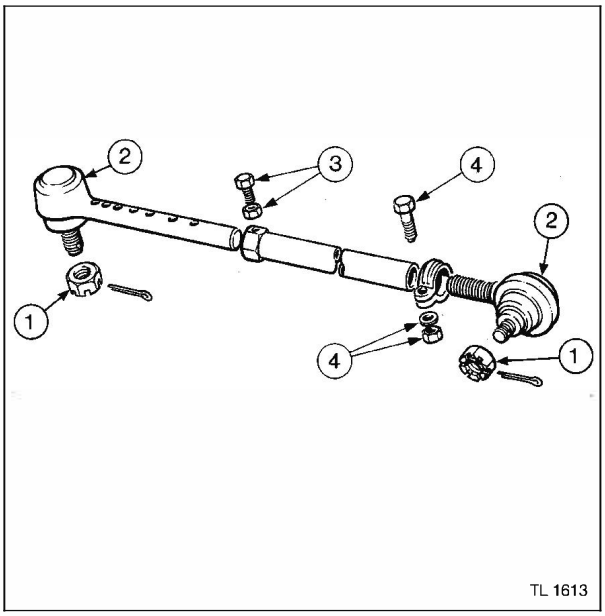
1. Remove the nuts securing the ball joints to the drop arm or spindle arm.
2. Release the ball end by hitting the side of the arm smartly whilst supporting the opposite side with a block of metal or heavy hammer.
3. Loosen the bolt and locknut and withdraw the ball end.
4. Loosen the clamp bolt and unscrew the ball end.

Examination

Check the ball ends for wear, replacing any defective components. ***These are safety critical components.***

Re-assembly

5. Reverse procedures 1 to 4 except:
   a. Torque tighten the nuts and bolts to the following:
      i. Ball joint nuts 122 Nm.
      ii. Clamp bolt 47 Nm.
      iii. Track adjustment bolt 47 Nm.
   b. Reset the front wheel toe in, see operation 2.10A-01



STEERING RAMS

Removal and refitment **2.09C–04**

Removal

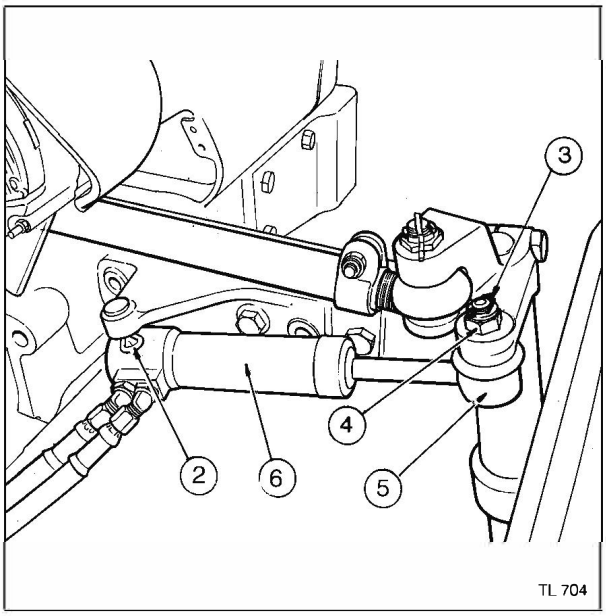
1. Disconnect both hydraulic pipes to the steering ram.
2. Remove the 'R' clip from the inner pivot pin.

NOTE: *On earlier models the inner end of the steering ram is retained by a ball end.*

3. Remove the split pin.
4. Remove the slotted nut.
5. Drive the ball joint taper out of the steering arm.
6. Remove the steering ram assembly.

Refitment.

7. Reverse procedure 1 to 6 except:
   a. Tighten the ball joint nuts to a torque of 95 Nm for 5/8 inch UNF ball end nuts, and 60 Nm for 1/2 inch UNF ball end nuts.
   b. Refill the reservoir.



STEERING RAMS

Overhaul 2.09C–05

Dis-assembly

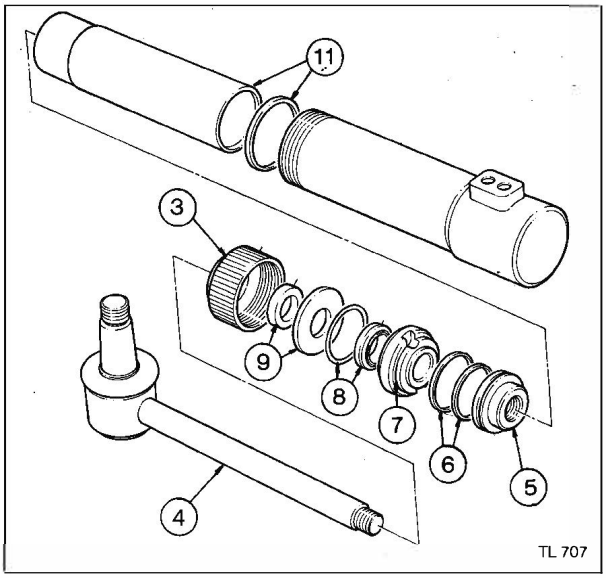
1. Remove the steering ram assembly, see operation 2.09C-04.
2. Place the steering ram in a vice.
3. Unscrew the end cap.
4. Withdraw piston assembly from the cylinder.
5. Unscrew the piston from the rod.
6. Remove the sealing ring and 'O' ring from the piston.
7. Remove the end housing from the rod.
8. Remove the pressure seal and 'O' ring.
9. Remove the washer and dust seal.
10. Remove the end cap (3).
11. Remove the cylinder and sealing ring from the ram tube.

Examination.

12. Clean and inspect all parts. Replace all seals. Lubricate all parts with transmission oil.

Re-assembly

13. Reverse procedure 1 to 11 except:
    a. Apply MF. Stud Lock (Loctite 270) to the thread on the end of the piston rod.
    b. Tighten the piston to the rod and use a centre punch to strake the thread to prevent it unscrewing.



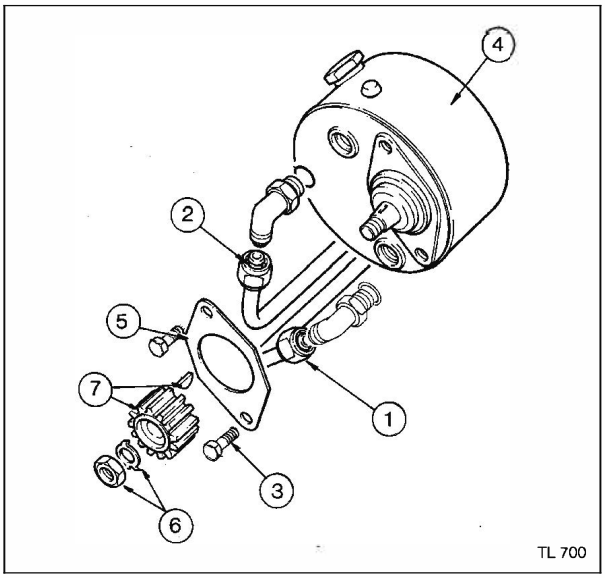
TL 707

STEERING PUMP

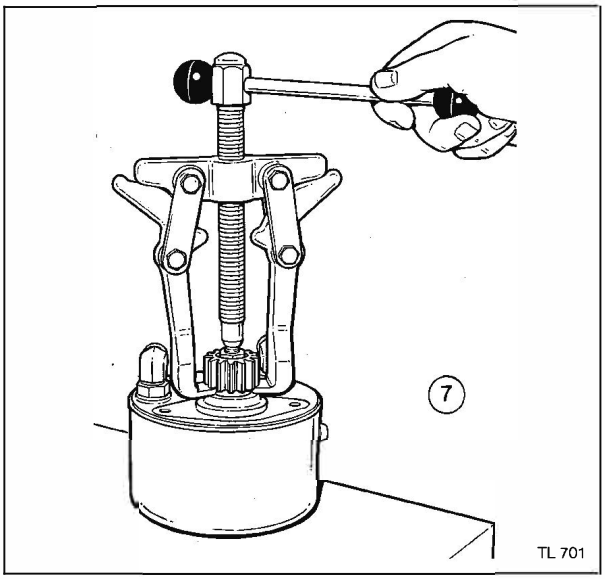
Removal and refitment 2.09C–06

Removal

1. Disconnect the hydraulic pipe to the steering unit.
2. Disconnect the hydraulic pipe return to pump.
3. Remove the two bolts securing the pump to the engine timing case.
4. Withdraw the pump assembly from the engine.
5. Remove and discard the gasket.
6. Remove the drive gear lock nut and tab washer.
7. A mechanical puller MUST be used to remove the drive gear and key from the pump drive shaft.
8. On tractors with power assisted steering remove the split pin, nut and gear. A mechanical puller is not required.



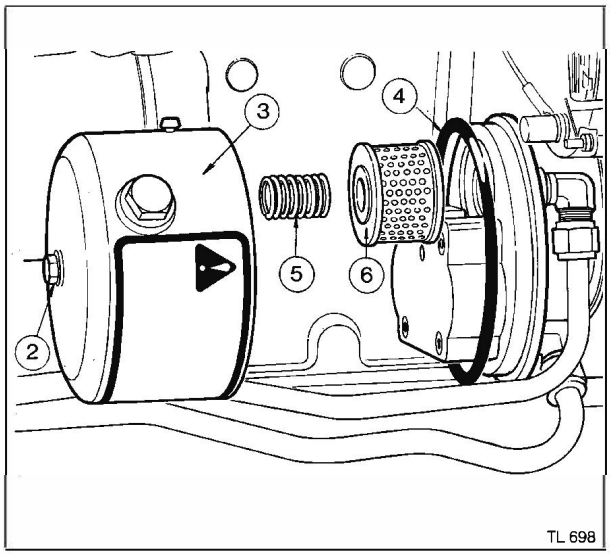
TL 700



TL 701

Refitment

9. Reverse procedure 1 to 8 except:
   a. Tighten the drive gear retaining nut (6) to a torque of 42 Nm.
   b. Replace the gasket (5).
   c. Tighten two pump mounting bolts to a torque of 36 Nm.
10. Refill the reservoir with transmission oil and prime the system as described in operation 2.09C-16.

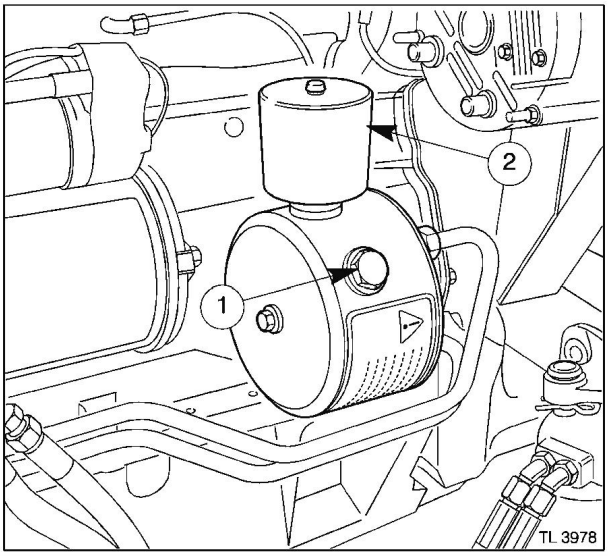


STEERING PUMP – HYDROSTATIC – SUNSTRAND

Servicing **2.09C–07**

Procedure

1. Place a suitable receptacle beneath the pump reservoir.
2. Remove the reservoir retaining bolt and sealing washer.
3. Remove the reservoir.
4. Remove the 'O' ring.
5. Remove the filter retaining spring.
6. Remove and discard the element.
7. Clean the reservoir and pump housing.
8. Fit a new element (6).
9. Ensuring that the reservoir sealing ring (4) is undamaged, refit the spring (5), reservoir (3) and retaining bolt and washer (2).
10. Set the reservoir so that the breather is at the top. Tighten the retaining bolt.
11. Fill the reservoir to the level plug with transmission oil.
12. Start the engine and run at 750-1000 rev/min.
13. Refill the reservoir to the level plug.
14. Turn the steering wheel from lock to lock at least twice. If the system is empty due to other work being carried out the level will fall rapidly during this operation. The reservoir may need refilling in order to reach both extreme locks.
15. Ensure that the oil in the reservoir is air free.
16. Refill the reservoir to its level with the plug and refit the plug.
17. Check the steering system for leaks.



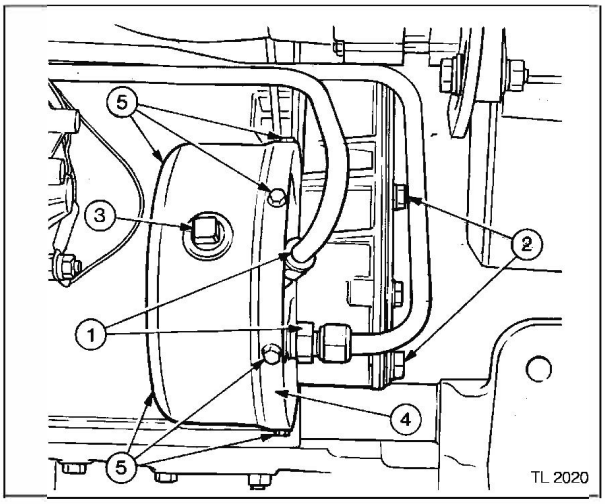
NOTE: *Later models have an expansion chamber fitted to the hydrostatic steering pump. The filler point (1) is in the same position, the expansion chamber (2), requires no maintenance and no attempt should be made to remove it. Removal of the reservoir cover and internal components from the pump are the same.*

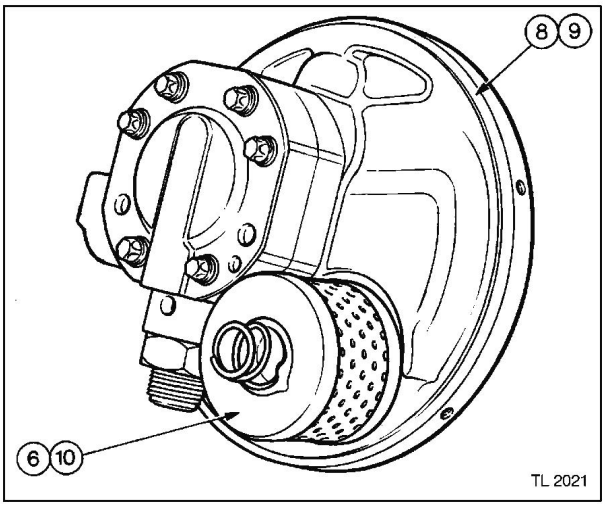
STEERING PUMP – POWER-ASSISTED – BARNES

Servicing **2.09C–08**

Procedure

1. Disconnect the feed and return pipes at the pump unions and plug the open ends.
2. Remove the two pump securing bolts from the timing case and remove the pump.
3. Remove the filler plug and drain the reservoir. Replace the plug.
4. Mark the sides of the reservoir and pump body to ensure correct reassembly.
5. Remove the six screws securing the reservoir to the pump body, and then remove the reservoir.
6. Remove and discard the filter element and spring.
7. Wipe out the reservoir.
8. Remove and discard the pump body 'O' ring.
9. Fit the new filter and spring to the pump body with the spring facing outwards.
10. Lightly lubricate the new 'O' ring with clean power steering fluid and fit to the pump body.
11. Aligning the marks, fit the reservoir to the pump body and replace the six screws. Reservoir screws to be torqued to 11 Nm. Check through the return port that the new filter is correctly located.
12. Fit new gasket between the power steering pump body and timing case.
13. Refit power steering pump to timing case.
14. Refit the two bolts and washers securing the pump body and tighten to a torque of 36 Nm.
15. Reconnect the feed and return pipes.
16. Fill the reservoir and check the oil level as described in operation 2.09C-07 items 11 to 17.





STEERING SYSTEM PRESSURE TEST

Check **2.09C–09**

Special Tools:
MF.3001 Pressure test kit
or
MF.148B Pressure test gauge
MF.3002 Flow meter hose kit

Procedure

1. Disconnect and remove the steel pipe. Install the tee adaptor from the MF. 3001 pressure test kit onto the existing steel pipe as shown. Complete the circuit using hose from MF. 3002 between the tee adaptor and the elbow fitted to the outlet port of the pump, this is the top connection.
2. Start the engine and run it at 2000 rev/min with the steering on full lock until the temperature of the oil is approximately 50^0C. Switch off the engine.
3. Connect the 300 bar pressure gauge in the pressure test kit to the tee adaptor.
4. Start the engine and run at 2000 rev/min, turn the steering wheel to full lock so that the relief valve discharges. The pressure gauge should indicate a pressure of:

Tractors with power assisted steering: 84,5 bar

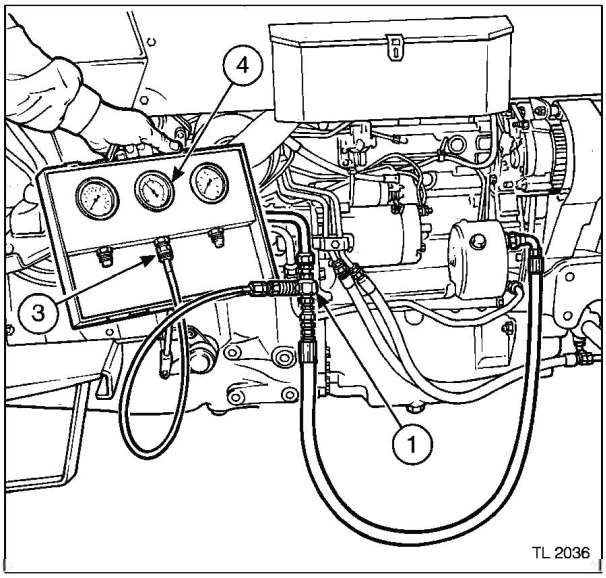
Tractors with hydrostatic steering: 140 bar

5. On tractors with power assisted steering if the pressure needs adjusting it will be necessary to remove the pump, drain the oil and remove the reservoir. The adjusting screw and locknut is inside the reservoir, turn the screw clockwise to increase the pressure or anti-clockwise to reduce the pressure. Tighten the locknut to a torque of 40 Nm, refit the reservoir and retest. One turn of the adjusting screw will change the pressure by approximately 31 bar.
6. On tractors with hydrostatic steering adjustment of the hydraulic pressure is effected by an adjusting screw on the top face of the orbitrol steering unit, see page 11A-15 for procedure.
7. Check the oil level after test and replenish if necessary.

Alternative test procedure

CAUTION: *DO NOT carry out this test on tractors with hydrostatic steering. The pump is NOT equipped with a pressure relief valve.*

8. Pressure test gauge MF. 148B can be used in place of MF. 3001 on MF. 240 tractors with power assisted steering.
9. Warm up the hydraulic system as described in procedure 2.
10. Fit the screwed adaptor with MF. 148B gauge onto the outlet elbow of the pump. Connect the gauge to the adaptor.



CAUTION: *DO NOT run the the engine for for any length of time with the relief valve discharging. The system will overheat and cause damage to the pump.*

11. Start the engine. The relief valve will discharge and should indicate a pressure of 84,5 bar. Adjust the regulator plug as necessary.
12. heck the oil level after the test and replenish if necessary.

Diagnosis

Symptom - steering pressure LOW		
Cause	Action	Operation number
1. Steering pump performance down	Flow test pump	2.09C-10
2. Relief valve setting low	Reset pressure relief valve	2.09C-09 2.09B-04
3. Leakage across steering ram seals	Overhaul steering ram	2.09C-05
4. Worn orbitrol steering unit	Overhaul orbitrol steering unit	2.09B-04

STEERING SYSTEM FLOW TEST

Check **2.09C–10**

Special Tools:
MF.3001 Pressure test kit
MF.3002 Hose kit
MF.3003 Hydraulic flow meter

Procedure

1. Remove the steel pipe. Connect the MF. 3003 hydraulic flow meter into the system with the hoses in the MF. 3002 hose kit as shown in the illustration. Connect the 300 bar gauge in the MF. 3001 pressure test kit to the test point on the flow meter.
2. Ensure that the restrictor valve on the flow meter is fully OPEN.
3. Start up the engine and warm up the hydraulics. Keep a careful check on the oil level, the system does not hold very much oil. Add oil as necessary. The oil temperature must be approximately 50^0C.
4. Set the engine speed to 2000 rev/min.
5. Screw in the flow meter restrictor valve until one of the following pressures is obtained:

Tractors with power assisted steering: 55,2 bar

Tractors with hydrostatic steering: 140 bar

If you are unable to obtain the correct pressure reading adjust the relief valve as described in operation 2.09C-09.

Alternatively - Turn the steering wheel to full lock so that the relief valve discharges and take the readings.

6. The hydraulic oil flow at 2000 engine rev/min should be:

Tractors with power assisted steering:

New - 19 litre/min.

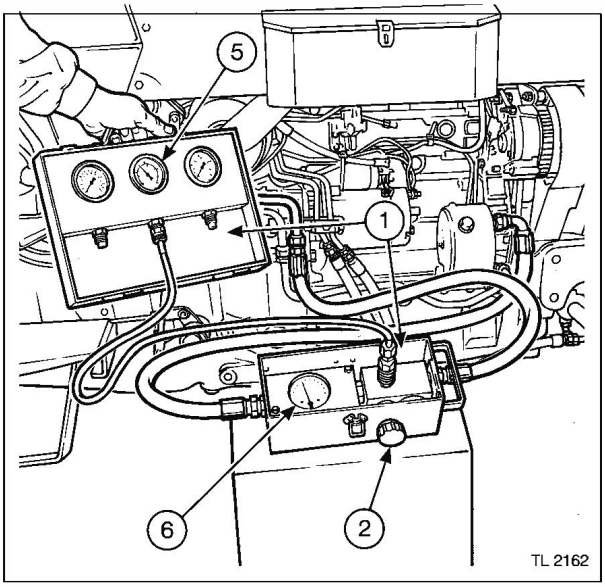
Minimum - 17,5 litre/min.

Tractors with hydrostatic steering:

New - 17,5 litre/min.

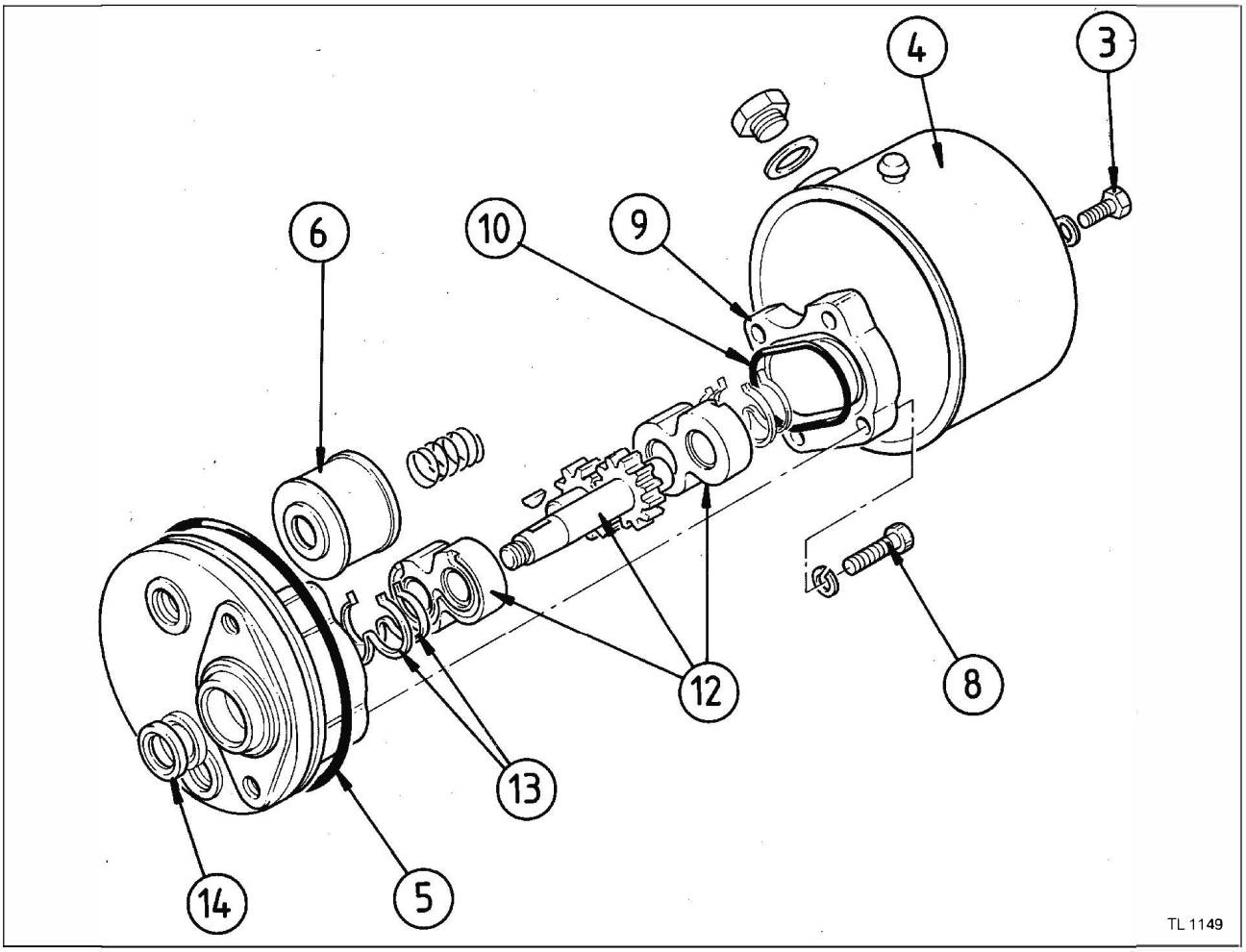
Minimum - 16,0 litre/min.

7. After replacement or repair, check through the system ensuring that there are no leaks. Test drive the tractor and check that the steering system operates satisfactory, if not, carry out necessary rectification - **this is a safety critical area.**



Diagnosis

Symptom - steering pump flow LOW		
Cause	Action	Operation number
1. Steering pump worn	Replace pump Overhaul pump	2.09C-06 2.09C-11 2.09C-12
2. Hydraulic filter blocked	Replace filter	2.09C-07 2.09C-08
3. Insufficient oil	Fill to level	2.09C-07 2.09C-08



STEERING PUMP – HYDROSTATIC – SUNSTRAND

Overhaul **2.09C–11**

Special Tools:
MF.332 Hydraulic pump oil seal protector

Dis-assembly

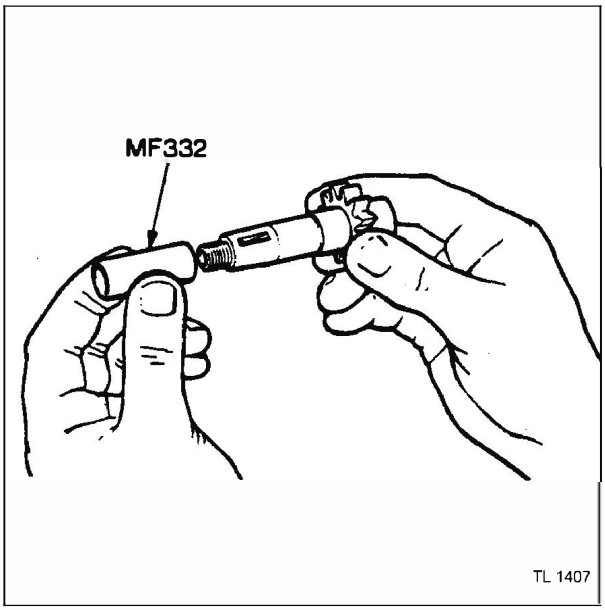
1. Remove the steering pump, gear and key, see operation 2.09C-06.
2. Thoroughly clean the pump exterior.

CAUTION: *When repairing, maximum cleanliness is essential. The work bench must be kept free from dirt and metal swarf etc. When dismantling, also ensure that the seals, bushings and gears are not jammed or knocked. The removed parts must be protected from any kind of damage.*

3. Remove the reservoir retaining bolt.
4. Pull off the reservoir over an empty container to catch the oil.
5. Discard the large 'O' ring seal.
6. Discard the filter element.
7. Mark the pump body and end plate to facilitate their correct refitment.
8. Remove the four bolts and washers.
9. Separate the end plate from the main body.
10. Discard the 'O' ring seal.
11. Carefully mark the bearings with a felt tip pen with permanent ink, noting their positions relative to the pump body for reassembly.
12. Remove the bearing block and pump gear assembly by carefully pushing the drive shaft.
13. Remove the pressure loading seal and backing ring from both bearing blocks.
14. Extract the two shaft seals.

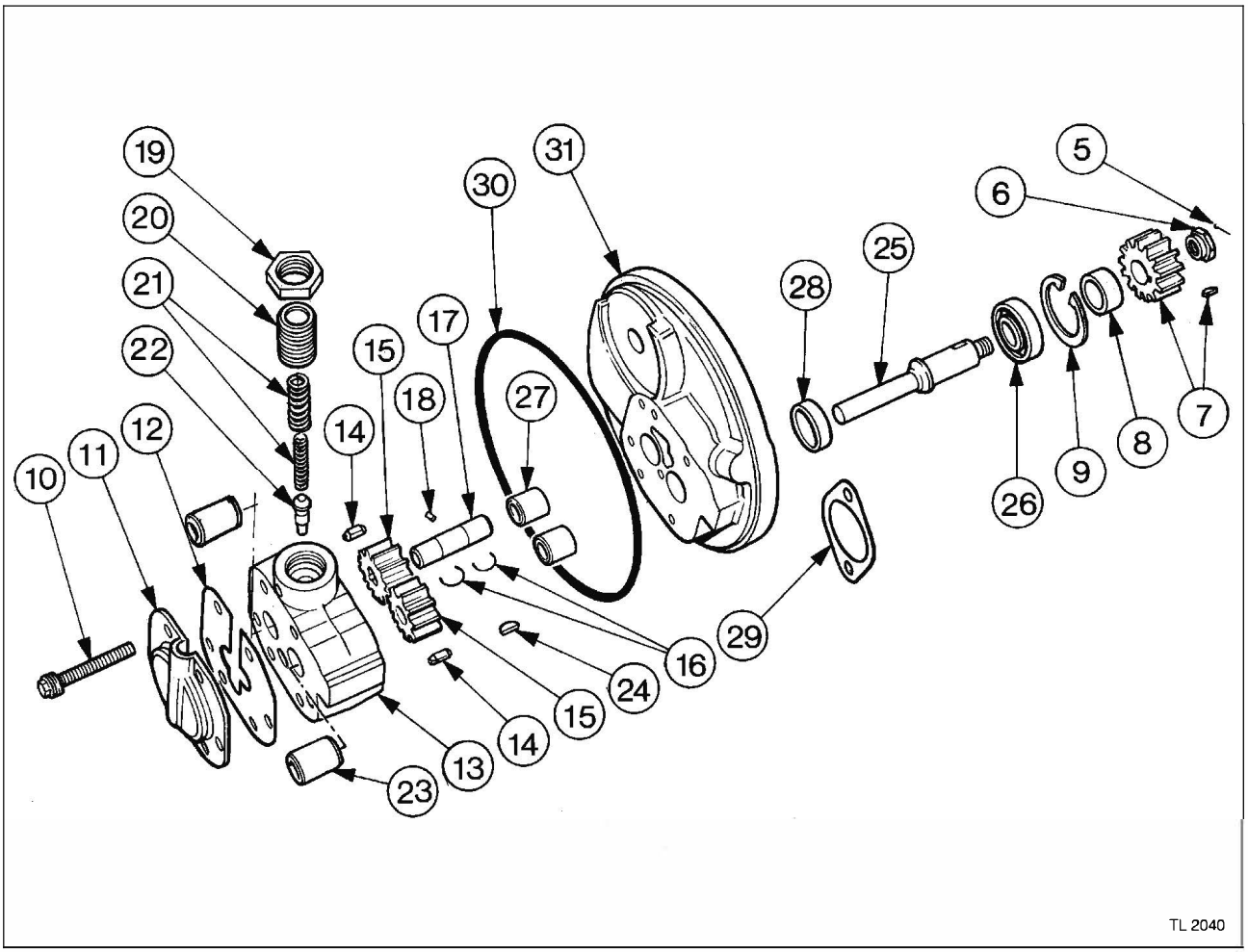
Examination

15. Clean all parts in a clean washing agent (do not use Trichlorethylene or similar as this can damage seals) and dry with compressed air. Lightly oil machined components.
16. Examine the casing, gears and bearings for wear or damage. The wear track on the inlet side of the pump body interior should be free from scoring and not deeper than 0,064 mm.
17. The pump gears should not be scored or pitted.
18. Inspect the bearing blocks for signs of seizure or scoring. Light scoring on the side can be removed by careful light lapping on a surface plate using 400 grade wet/dry emery paper and paraffin (kerosene). Ensure that such parts are thoroughly washed and dried prior to reassembly. Should wear be excessive install new bearing blocks.



Re-assembly

19. Reverse procedures 1 to 13 except:
    a. Renew all 'O' rings, seals and shaft seals.
    b. Press in the first shaft seal squarely with a little grease and the spring side inner most. Press in the second seal with the spring side facing out, pack grease between the lips of the two seals.
    c. Fit the pressure loading seal and the backing rings to the bearing blocks. A little grease in the grooves will help retain them.
    d. Use special tool MF.332 to protect the seals when installing the drive shaft.
    e. Ensure correct installation of the bearing blocks and gears (observe markings). The bearings are assembled with the recesses against the gear faces and the seal ends on the inlet side of the pump.
    f. Fit the sealing ring to the end plate with a little grease.
    g. Lightly oil the four bolts and tighten evenly to a torque of 48 Nm.
    h. Pour a small quantity of clean oil into the pump for internal lubrication and ensure the pump drive gear cam be turned by hand.
    i. Renew the filter element.
    j. Assemble the reservoir with the breather at the top and tighten the bolt to a torque of 18 Nm. Tighten the filler plug to a torque of 16 Nm.
    k. Refill the pump. Refill and prime the system.



STEERING PUMP – POWER-ASSISTED – BARNES

Overhaul **2.09C–12**

Dis-assembly

1. Remove the steering pump, see operation 2.09C-06.
2. Remove the reservoir filler plug and thoroughly clean the pump exterior.

CAUTION: *When repairing, maximum cleanliness is essential. The work bench must be kept free from dirt and metal swarf etc. When dismantling, also ensure that the seals, bushings and gears are not jammed or knocked. The removed parts must be protected from any kind of damage.*

3. Remove the six reservoir retaining bolts and reservoir canister.
4. Remove the filter and spring.
5. Remove the split pin.
6. Unscrew the nut.
7. Remove the pump drive gear and key.
8. Remove spacer.
9. Remove the circlip.
10. Remove the six pump gear body retaining bolts.
11. Remove the pump inlet cover.
12. Remove the pump inlet cover gasket.
13. Remove the pump gear body from the main pump body.
14. Remove the two location dowels.
15. Remove the two pump gears from the gear body.
16. Remove the two snap rings from the idler gear shaft.
17. Slide the gear off the idler shaft.
18. Take care to retain the gear retaining pin.
19. Slacken the locknut.
20. Unscrew the vale adjusting screw.
21. Remove the two rings.
22. Carefully remove the valve poppet.
23. Using a suitable mandrel press out the needle roller bearings from the gear body.
24. Remove the key from the pump input shaft.

25. Press out the input shaft and bearing from the main pump body.
26. Press the bearing off the input shaft.
27. Using a suitable bearing remover, remove the two needle roller bearings in the main pump body.
28. Using a suitable mandrel, carefully press out the oil seal.
29. Remove the main pump body to timing case gasket.
30. Remove the reservoir canister sealing 'O' ring.
31. Remove the clear plastic gasket between the pump gear body and main pump body.

NOTE: *A new gasket must be refitted during reassembly according to gear end float measurements.*

Use gasket number 2260041 (.00075 inch)

Use gasket number 2260027 (.001 inch)

Max end float .00155 to .00085 inches.

Examination

32. Clean all parts in a clean washing agent (do not use Trichlorethylene or similar as this can damage seals) and dry with compressed air. Lightly oil machine components.
33. Examine all parts for wear or damage, and replace all defective components. Always fit new 'O' rings and gaskets, oil seals, split pins and keys.

Re-assembly

34. Reverse procedures 1 to 31.

    a. The six gear body to pump body bolts to be torqued to 13 Nm.

    b. Pack the cavity between the seal and pump body with petroleum jelly.

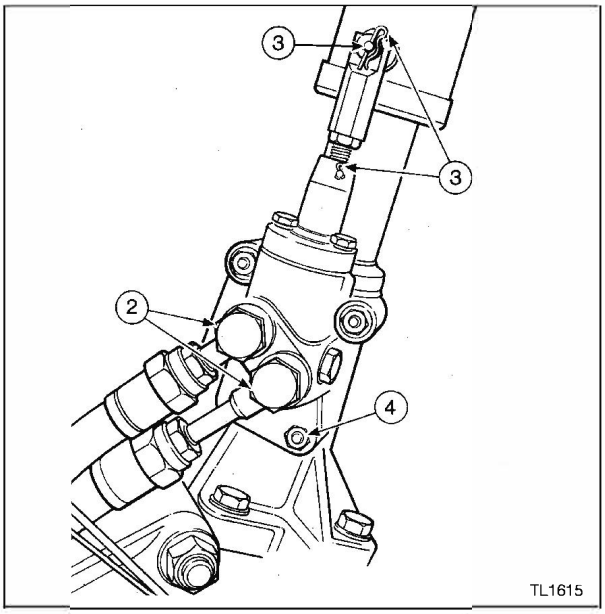
    c. Reset the relief valve as follows: Loosen the hexagon nut, adjust the adjusting screw to the right to increase pressure, 31 bar approx per full turn, tighten locking nut. Re-assemble and refit pump and check steering oil pressure. Repeat until correct pressure is obtained. Steering system operating pressure should be 80 bar.

    d. Torque tighten the relief valve hexagon nut to 40 Nm.

Steering - Box and pump

CONTROL VALVE

Removal and refitment **2.09C–13**



Removal

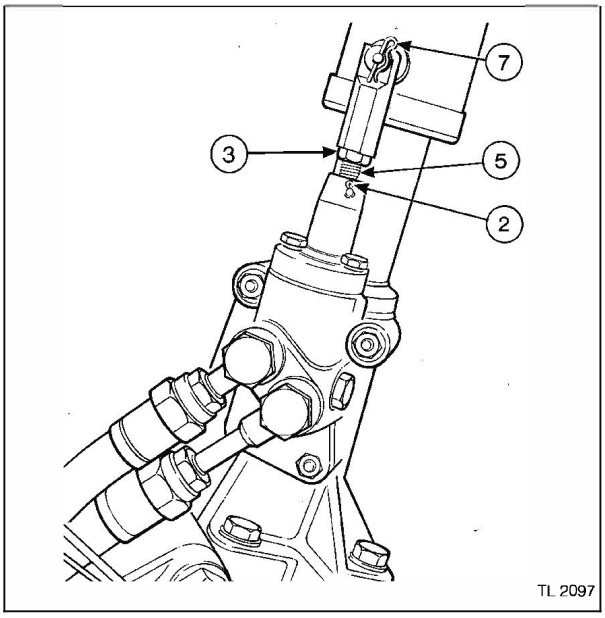
1. Remove the lower instrument panel.
2. Disconnect the feed and return pipes from the control valve.
3. Remove the split pins and remove the valve pins.
4. Remove three bolts and washers securing the control valve. Remove the control valve.
5. Remove the two 'O' rings from the joint face.

Refitment

6. Reverse procedures 1 to 5 except:
   a. Fit new 'O' rings.
   b. Tighten the three retaining bolts to a torque of 23 Nm.
   c. Adjust the linkage, see operation 2.09C-14.

CONTROL VALVE

Adjust **2.09C–14**



Procedure

1. Remove the lower instrument panel.
2. Remove the lower split pin and withdraw the pin.
3. Slacken the locknut.
4. Turn the steering wheel to the RIGHT to take up the slack in the steering box WITHOUT turning the wheels.
5. Adjust the length of the linkage until the pin (2) can be re-inserted.
6. Remove the pin.
7. Remove the 'R' clip, washer and linkage from the bottom of the steering column.
8. Increase the length of the linkage by unscrewing the rod ONE FULL TURN.
9. Tighten the locknut and refit the linkage.
10. Whilst turning the steering to the left for alignment, re-insert the pin.
11. Secure the pin with a new split pin.
12. Start the engine and check that full power assistance is in operation.
13. Refit the lower instrument panel.

CONTROL VALVE

Overhaul **2.09C–15**

Dis-assembly

1. Remove the control valve, see operation 2.09C-13.
2. Thoroughly clean the valve housing.
3. Remove the circlip.
4. Remove the two washers and the felt seal.
5. Remove the two bolts and washers securing the end cover.
6. Withdraw the spool complete with yoke, end cover, springs, washers and seals.
7. Detach the yoke from the spool.
8. Remove the end cover, reaction spring, springs and washer.
9. Remove the 'O' rings.
10. Remove the 'O' ring from the valve body.
11. Invert the valve body and tap out the plug, ball and spring.
12. Remove the 'O' rings from the plug.
13. If necessary, remove the relief valve plug, washer, ball and spring.

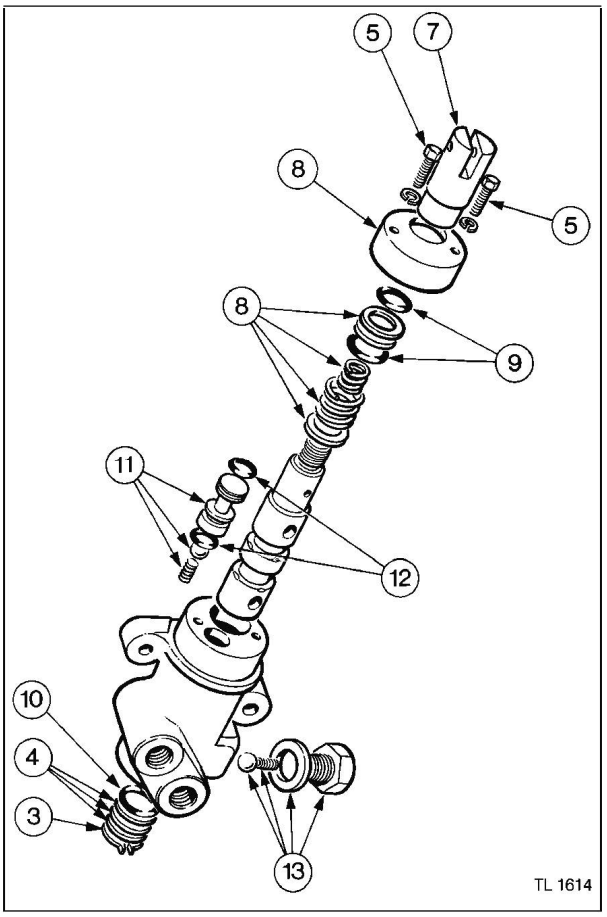
Examination

Thoroughly clean all components and check for wear or damage. Replace any parts which are defective. Always fit new 'O' rings and seals.

NOTE: *If the spool or body is damaged, both parts must be replaced as they are only supplied in matched sets.*

Re-assembly

14. Reverse procedures 1 to 13.



STEERING SYSTEM

Air removal **2.09C–16**

Procedure

1. Remove the filler plug.
2. Fill the pump reservoir with clean oil to the plug level.
3. Replace the filler plug.
4. Start the engine and run it at 900 rev/min for approximately 30 seconds.
5. Rotate the steering to the left and right full lock positions.
6. Switch off the engine and refill the reservoir to the plug level.
7. Run the engine at 1200 rev/min.
8. Repeat procedure 5.
9. Leave the steering at full left lock and full right lock for approximately 10 seconds each time.
10. Repeat procedure 9, three times.
11. Switch off the engine and check all unions for leaks. If leaks are discovered, cure the fault and repeat the whole operation.
12. Tighten the filler plug to a torque of 12 Nm.

Page left blank intentionally

Auxiliary Hydraulics

Section 9 – Part D

Table of Contents

Operation No.	Description	Page No.
-------	Specification	9D - 2
-------	General description	9D - 2
2.09E-01	Pressure maintaining valve (PMV) pressure test - check	9D - 4
2.09E-02	IPTO pump flow and pressure test - check	9D - 5
2.09E-03	Pressure maintaining valve (PMV) - overhaul	9D - 6
2.09E-04	Control valve assembly - removal	9D - 7
2.09E-05	Control valve section - removal	9D - 7
2.09E-06	Control valve - overhaul	9D - 8
2.09E-07	Auxiliary pump flow and pressure test - check	9D - 10
2.09E-08	Auxiliary pump and plated drive - removal	9D - 11
2.09E-09	Auxiliary hydraulic pump - overhaul	9D - 12
2.09E-10	Plated drive - overhaul	9D - 14
2.09E-11	Hydraulic lift and auxiliary pump filter - servicing	9D - 15

Auxiliary Hydraulics

SPECIFICATION

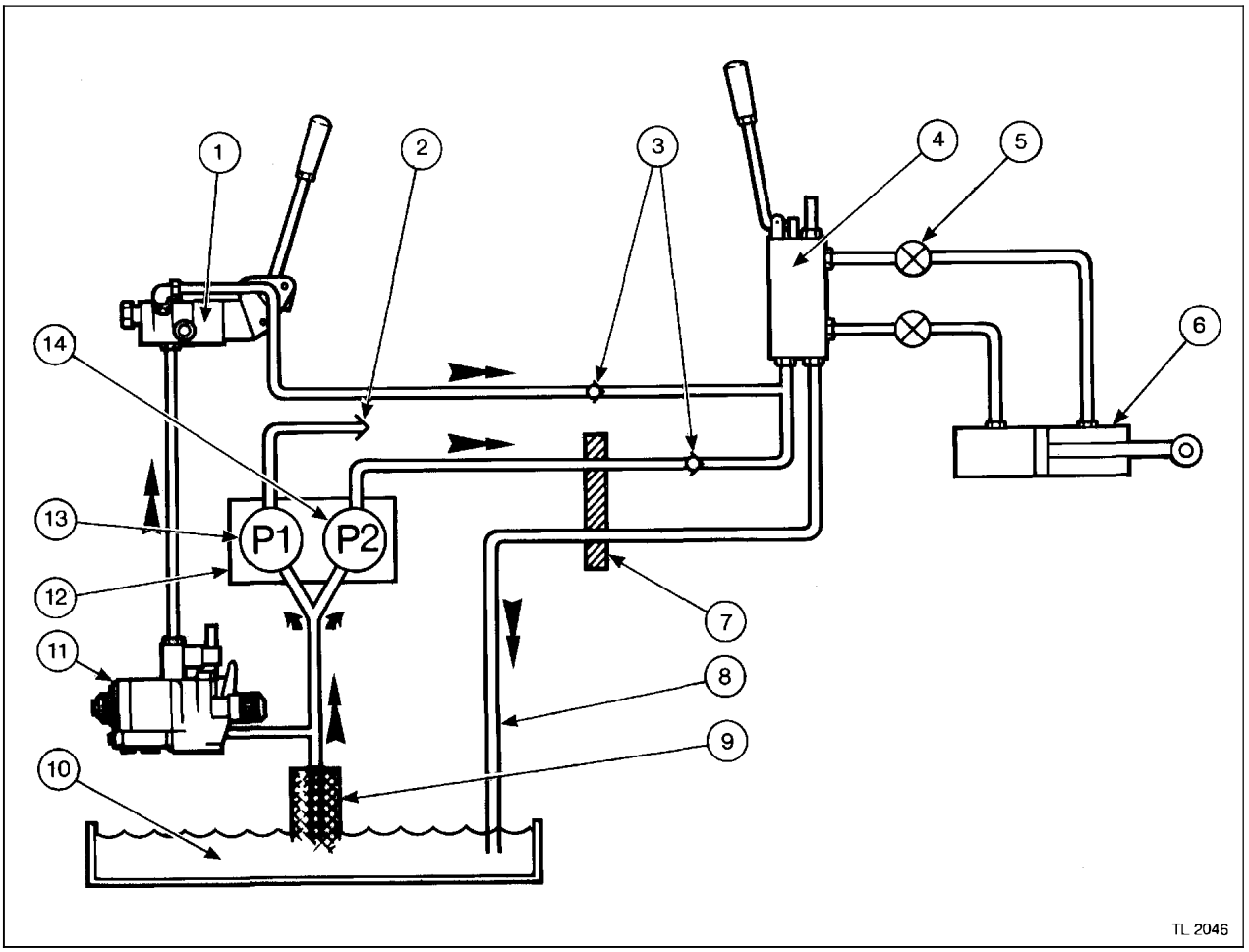
Auxiliary pump type	Gear type 10/4 with two sections for auxiliary hydraulics and IPTO
Pump output:	
Auxiliary	38 litre/min
I.P.T.O	15 litre/min
Relief valve setting at 2000 engine rev/min:	
Auxiliary	175 bar
I.P.T.O	60 bar
Pressure maintaining valve (PMV)	17 bar
Filter	40 micron serving lift pump and auxiliary pump - washable.
Auxiliary pump drive	Plated drive gear train from lift pump.
Auxiliary control valves	
Make	Kontak
Types	Detented with kick-out and float (standard). Spring return to neutral. Detented with pressure kick-out. Hydraulic motor section.
Number of Sections	1 or 2
Kick-out pressure	150/160 bar
Flow at quick release coupling at 2000 engine rev/min at 124 bar:	
Auxiliary pump	36,0 litre/min
Combined flow	54,0 litre/min
Pressure at Quick Release Couplings at 2000 engine rev/min:	
Auxiliary pump	170-190 bar

Special Tools

MF.3001 A.	Pressure Test Kit
MF.3002	Hose Kit
MF.3003	Hydraulic Flow Meter

Bolt Torques

Control valve stud nuts	20 Nm
Control valve shoulder bolt	7 Nm
Control valve seal plate screws	7 Nm
Control valve change-over valve	22 Nm
Control valve tie rod nuts	20 Nm
Plated drive to pump bolts	30 Nm
Plated drive spacer nuts	27 Nm
Plated drive socket head screw	27 Nm
Pump relief valve	50 Nm
Pump end cover bolts	45 Nm



1. Selector valve.
2. Supply to IPTO clutch.
3. Non return valves.
4. Hydraulic control valve.
5. Quick release coupling.
6. External hydraulic cylinder.
7. Left-hand side cover.
8. Return to transmission.
9. Suction filter.
10. Transmission oil.
11. Ferguson lift pump.
12. Dual element pump.
13. P1 - IPTO section.
14. P2 - Auxiliary section.

GENERAL DESCRIPTION

The auxiliary hydraulic system is in two parts and is powered by a dual element auxiliary hydraulic pump driven from a plated drive in front of the hydraulic lift pump. The pump draws its oil through a special 40 micron filter attached to the lift pump and delivers oil at 38 litre/min to the auxiliary control valve. The second section supplies oil to the Independent Power Take-Off (IPTO) clutch at 15 litre/min.

Auxiliary hydraulics

The oil supply from the pump is taken through the left-hand side cover to the auxiliary hydraulic control valve mounted on the left-hand footstep. This valve can be in either one or two sections and the control levers are mounted directly on top of the valve in a position adjacent to the operators left-hand. The following specification of control valve is available:

1. Three position, spring return to neutral.
2. Three position, detented with pressure kick-out.
3. Four position with detent and kick-out plus float position.

The following optional section or kit is available as a parts replacement in addition to the ones listed above:

1. Motor sections for applications involving the use of hydraulic motors.
2. Detent kit to lock the spool in either raise or lower position (no kick-out).

All the spools are of the open centre type and are fitted with a change-over valve situated on the top of each section to convert to either single or double-acting. To operate a single acting ram the change-over valve must be screwed fully out. Double-acting screwed right in.

A check valve is provided within the valve on the pressure side (pump side) which will not open until the pump pressure is greater than the pressure in the ram. This prevents the external ram from dropping before lifting. It also prevents the ram from dropping if the control valve is moved to the lift position when the engine is stopped. Oil from the control valve is conveyed to a series of quick release couplings at the rear of the tractor. Return oil from the control valve is returned through the left-hand side cover back to the transmission.

The operating pressure of 193 bar is controlled by a pressure relief valve built into the hydraulic pump.

The oil flow from the auxiliary control valve can be increased by combining the oil flow from the auxiliary pump with the oil flow from the hydraulic lift pump. This will increase the flow to 54 litre/min. To take advantage of this facility a Selector Valve must be fitted to the lift cover to direct the flow of oil from the lift hydraulics to the control valve. A non-return valve is fitted to the external port of the Selector Valve and to the outlet port from the auxiliary pump on the left-hand side cover. This is to prevent over pressurisation of the pumps. The two supplies then enter the control valve through a tee piece.

Operation of the Selector Valve from the Linkage to External position will then increase the flow of oil and the rear linkage will be locked in its original position.

Independent Power Take-Off hydraulics

The small section of the auxiliary hydraulic pump is to provide the IPTO hydraulic clutch with oil. It is fitted with a safety pressure relief valve set at 69 bar and two common outlet ports. One port is piped forward through the transmission and emerges out of the clutch housing under the instrument panel, it then passes through the Pressure Maintaining Valve (PMV), back into the clutch housing and the oil is discharged back into the transmission through the PTO bearing housing cover. The PMV regulates the line pressure to operate the IPTO clutch. The valve is set to a pressure of 17-20 bar.

The second port on the pump is piped directly to the control valve of the IPTO clutch pack. A smaller pipe is taken from the control valve through the left-hand side cover terminating in a 5/16 inch UNF female thread with plug for pressure testing purposes.

PRESSURE MAINTAINING VALVE PRESSURE TEST

Check **2.09E–01**

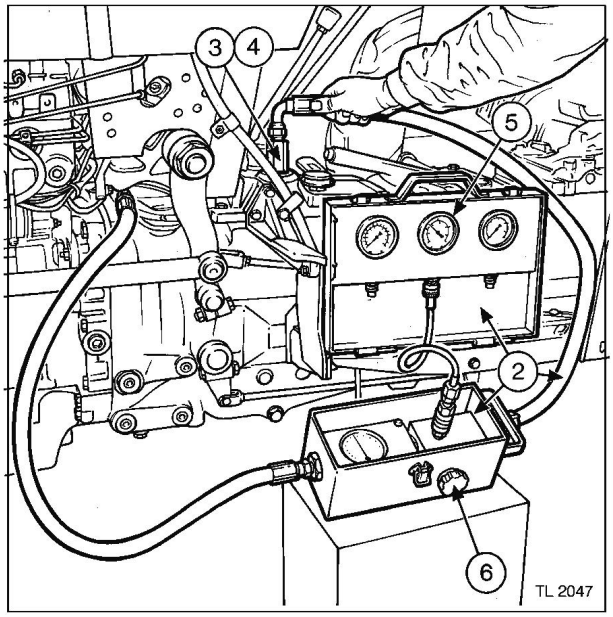
Special Tools:
MF3001 Pressure test kit
MF3002 Hose kit
MF3003 Hydraulic flow meter

Procedure

1. Disconnect the the two pipe joints and remove the pressure maintaining valve.
2. Connect the MF.3003 hydraulic flow meter using hoses from the MF.3002 hose kit to the pressure line, (the outer pipe nearest to you).
3. Connect inlet side of the pressure maintaining valve to the end of the return pipe.
4. Place the outlet side of the maintaining valve over the gearbox filler hole.

CAUTION: *DO NOT insert the pipe into the gearbox filler hole otherwise serious damage to the gearbox may result. Only direct the return flow into the hole.*

5. Connect the 30 bar gauge from the MF.3001 pressure test kit to the test point on the flow meter.
6. Fully OPEN the restrictor valve on the flow meter.
7. Ensure that the IPTO lever is in the disengaged position.
8. Start up he engine and warm-up the hydraulic system. The oil temperature must be 50-60^{0}C.
9. Set the engine speed to 2000 rev/min and the pressure gauge should read 16-18 bar.



Diagnosis

Symptom - PMV pressure low		
Cause	Action	Operation Number
1. IPTO pump worn	Flow test pump	2.09E-02
2. PMV pressure setting low	Reset PMV pressure	2.09E-03
3. IPTO pump relief valve faulty	Flow test pump	2.09E-02
4. IPTO control valve faulty	Repair or replace control valve	
5. Internal pipe leakage	Rectify oil leak	-------
6. Hydraulic filter blocked	Clean filter element	2.09E-11
7. Insufficient oil in transmission	Fill to level	-------

IPTO PUMP FLOW and PRESSURE TEST

Check **2.09E–02**

Special Tools:
MF3001 Pressure test kit
MF3002 Hose kit
MF3003 Hydraulic flow meter

Procedure

1. Disconnect the the two pipe joints and remove the pressure maintaining valve.
2. Connect the MF.3003 hydraulic flow meter using hoses from the MF.3002 hose kit to the pressure line, (the outer pipe nearest to you).
3. Route the outlet hose from the flow meter over the the gearbox filler hole.

CAUTION: *DO NOT insert the pipe into the gearbox filler hole otherwise serious damage to the gearbox may result. Only direct the return flow into the hole.*

4. Fully OPEN the restrictor valve on the flow meter.
5. Ensure that the IPTO lever is in the disengaged position.
6. Start up he engine and warm-up the hydraulic system. The oil temperature must be 50-60^{0}C.
7. Set the engine speed to 2000 rev/min.

Flow test

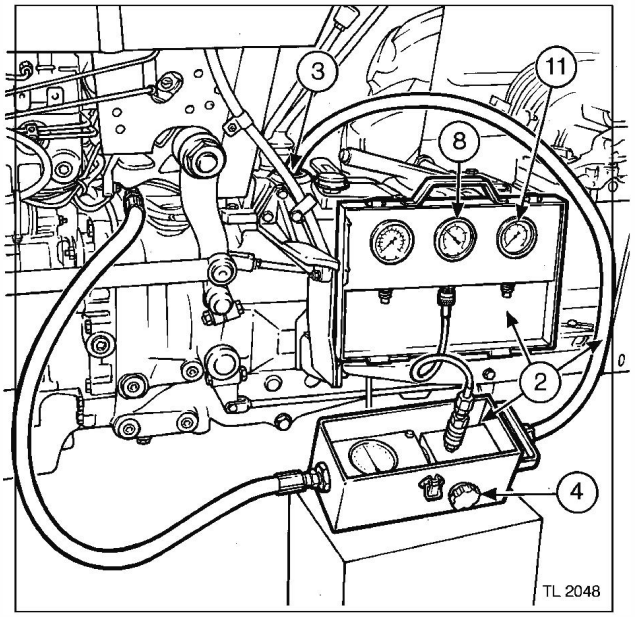
8. Connect the 30 bar gauge from the MF.3001 pressure test kit to the test point on the flow meter.
9. Fully OPEN the restrictor on the flow meter.
10. The flowmeter reading should be as follows:

New pump ..... 7,7 litre/min.

Minimum acceptable .... 6.8 litre/min.

Relief valve pressure test

11. Connect the 300 bar gauge from the MF.3001 pressure test kit to the test point on the flow meter.
12. Slowly screw-in the flow meter restrictor valve until the pressure reading stops rising, this is the point at which the IPTO pump relief valve opens. The pressure reading should be 60 bar.



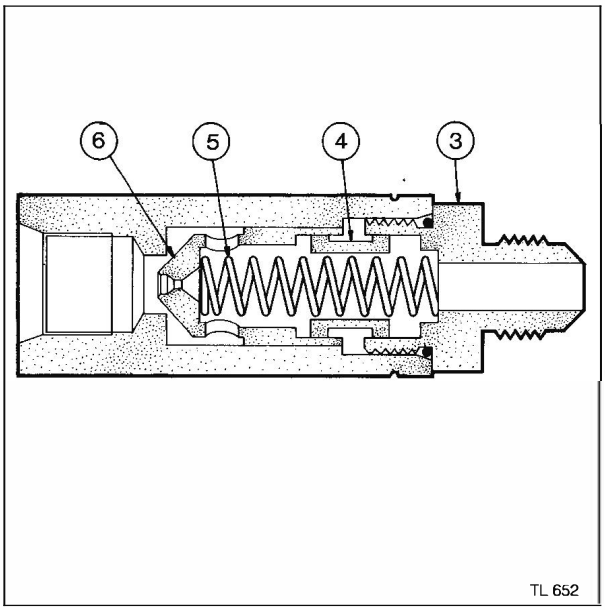
Diagnosis

Symptom - IPTO pump flow or pressure low		
Cause	Action	Operation Number
1. IPTO pump worn	Replace pump or repair	2.09E-08 2.09E-09
2. Pressure relief valve faulty	Replace pump or repair	2.09E-08 2.09E-09
3. IPTO control valve faulty	Repair or replace control valve	
4. Internal pipe leakage	Rectify oil leak	
5. Suction strainer blocked	Clean strainer	2.09E-11
6. Insufficient oil in transmission	Fill to level	-------

PRESSURE MAINTAINING VALVE (PMV)

Overhaul 2.09E–03

The Pressure Maintaining Valve (PMV) is located in the loop pipe feeding and returning to the top of the transmission case.



Dis-assembly

1. Disconnect the inlet and outlet pipes from the valve and remove the valve assembly.
2. Unscrew the adaptor from the end of the valve, and discard the 'O' ring.
3. Remove the sleeve.
4. Remove the spring.
5. Remove the poppet.
6. Examine the poppet and seal, ensure that all parts slide freely in the valve body.

Re-assembly

7. Reverse procedures 1 to 5 except:
   a. Refit the sleeve.
   b. Refit the adaptor with a new 'O' ring.
   c. Check the PMV pressure when refitted to the tractor, see operation 2.09E-01.

NOTE: *The pressure at which the valve regulates is stamped on the valve body. The valve must always be fitted with the poppet assembly retaining union on the return side of the circuit.*

CONTROL VALVE ASSEMBLY

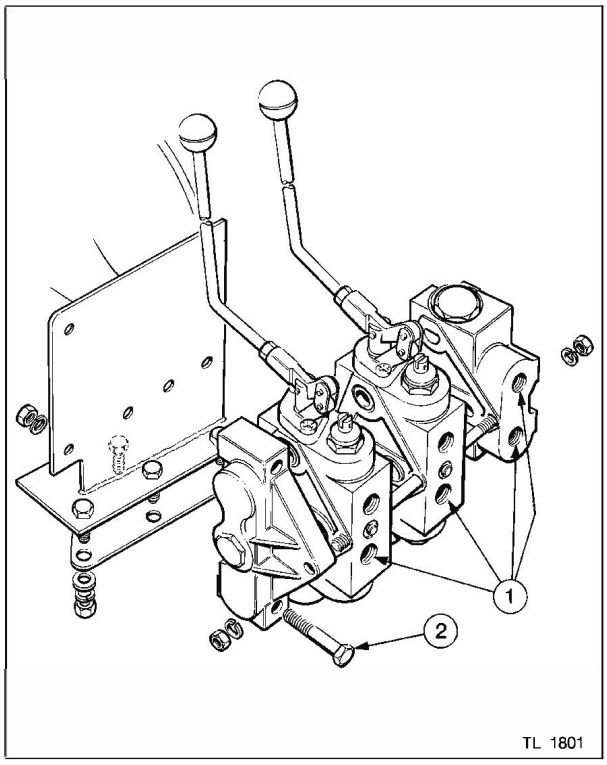
Removal and refitment **2.09E–04**

Removal

1. Disconnect the feed, return and outlet hoses from the control valve.
2. Remove the three attachment bolts, and lift off the control valve assembly.

Refitment

3. Reverse procedures 1 and 2



CONTROL VALVE SECTION

Removal and refitment **2.09E–05**

Removal

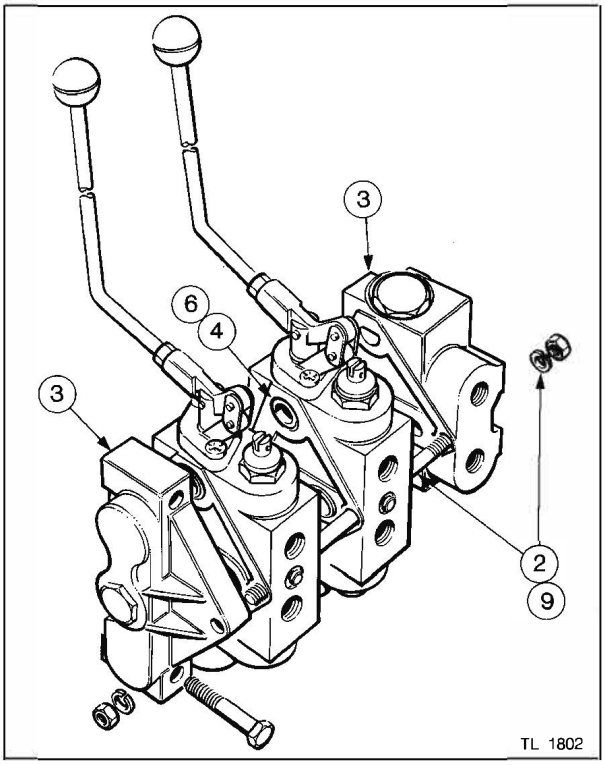
1. Remove the control valve unit from the tractor, see operation 2.09E-04.
2. Remove the three nuts and studs securing the control valve sections.
3. Remove the end plates.
4. Remove the 'O' rings.
5. Thoroughly clean the mating faces of the control valve sections and end plates.

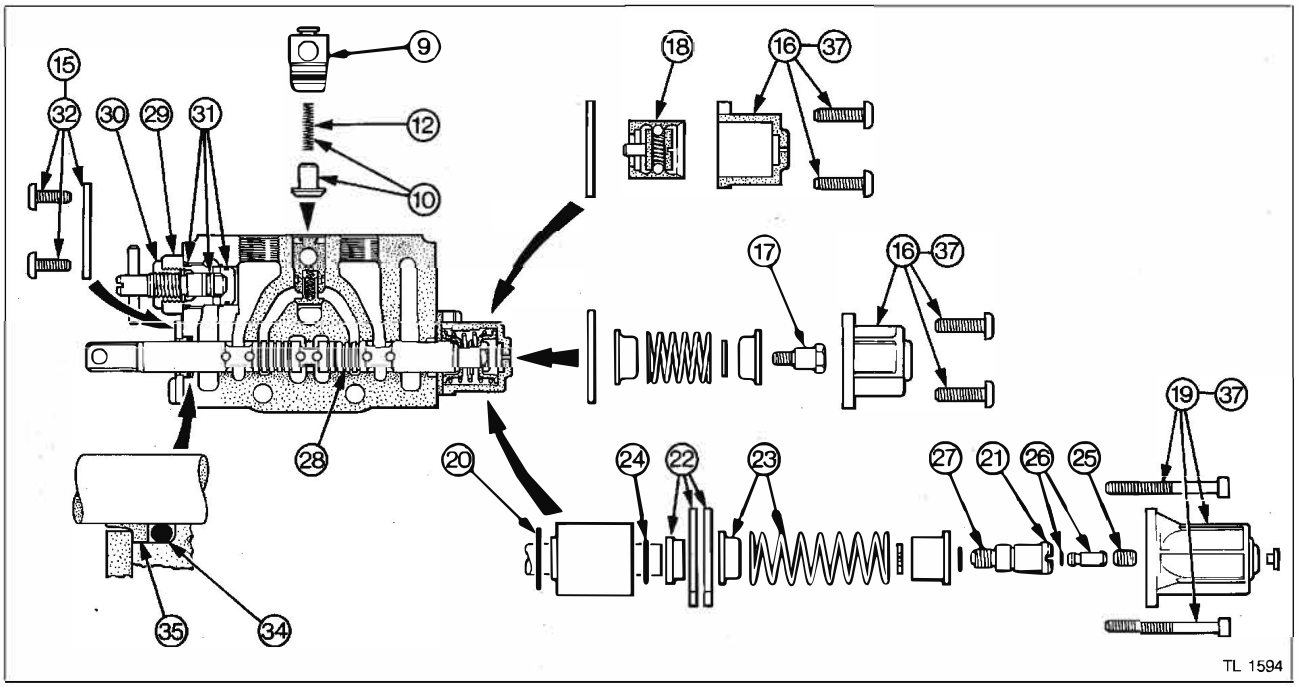
Refitment

6. Fit new 'O' rings to the recesses in the control valve sections.
7. Place the control valve sections on a flat surface with the feed ports uppermost.
8. Align the valve sections and refit the studs, nuts and lockwashers.
9. Fit the green plastic shim washers between the valve sections on the stud which passes through the control valve sections. Stud (2) on the illustration.
10. Re-tighten the nuts to a torque of 20 Nm.

NOTE: *Do not over tighten the nuts as this could cause the spools to stick.*

11. Refit the control valve unit to the tractor, see operation 2.09E-04.





CONTROL VALVE

Overhaul **2.09E–06**

Dis-assembly

1. Disconnect and remove the control valve levers.
2. Disconnect the supply and return hydraulic pipes.
3. Unscrew the retaining bolts and remove the valve assembly from the bracket.
4. Mask off all ports and clean the external surfaces so that they are free of all loose dirt, paint etc.
5. Stand the valve on its feet, loosen but do not remove the three tie rod nuts at the inlet/outlet cover end of the valve.
6. Stand the valve on its plain cover (left-hand end) so that the tie rods are vertical and remove the three loosened tie rod nuts (in this position the inter-section 'O' rings will be uppermost on each section).
7. Note the order in which the sections and spacers are fitted and remove them in turn from the tie rods.
8. Remove and discard all inter-section 'O' rings, and the green shim washers on the top tie rod between sections.

Load check valve

9. Use a large flat bladed screwdriver to lever under the flanged head of the check valve guide and withdraw it from the body.
10. Remove the spring and poppet from the body with a pair of long-nosed pliers.
11. Inspect all components for signs of deterioration or damage. The poppet and seat should show signs of an even ring around its ground conical seat, any damage will not allow the check valve to function correctly.
12. The spring should be undamaged and be approximately 20 mm (0.8 in) long.

NOTE: *If the check valve is to be removed with the valve in position the top tie rod must be removed first.*

Spool 'O' rings

13. Remove any lever mechanism still attached to the valve.
14. Hold the valve in a vice with adequate jaw guards and grip around the area of the bottom stud holes so that the inter-section sealing areas are not damaged.
15. Remove the two Posidrive screws from the front of the valve and remove the seal plate.
16. Remove the two Posidrive screws from the rear of the valve and remove the end cap.

Spring return cap

17. Using a socket and a bar through the spool hole to prevent rotation, loosen and remove the shoulder bolt from the rear of the spool to release the spring, cups and seal plate.

Three position detent cap

18. After removal of the end cap use a large flat bladed screwdriver to remove the detent assembly and seal plate from the spool. Do not dismantle the detent assembly.

Detent with kick-out & float

19. Remove the two socket head cap screws and the cap, withdraw the spool from the rear of the body ensuring that the detent mechanism stays in the neutral position.
20. Remove the 'O' ring between the detent housing and the body.

21. Hold the spool with the spade end down, support the detent housing to prevent movement and with a wide bladed screwdriver remove the shoulder screw in the end of the spool.
22. Remove the two retainer plates and alloy retaining ring.
23. Remove the spring cup and spring.
24. Move the detent housing backwards and forwards by a small amount to ease out the 'O' ring in the end of the housing.
25. Remove the grub screw from the end of the shoulder bolt.
26. Remove the piston and discard the 'O' ring.
27. Remove all traces of Loctite from the thread of the shoulder bolt.

Spool seals

CAUTION: *Valve assemblies are manufactured with spools and bodies as matched sets to control internal leakage. Do not mix bodies and spools.*

28. Pull the spool out of the bore. When pulled out one 'O' ring and wiper seal should come with the spool. Remove these and the other 'O' ring and wiper seal which would still be in position in the valve and discard.

Change over valve

29. Unscrew the change-over valve assembly.
30. Unscrew the end cap and withdraw the valve.
31. Remove and discard the 'O' rings.

Examination and cleaning

Clean all components and check their condition, replace all seals and ensure that all 'O' ring grooves are clean and their mating faces are free from any damage. Lubricate parts with clean transmission oil when refitting.

Re-assembly

Kick-out detent spools

32. Reverse procedures 19 to 26 except:
    a. Apply MF Lock and Seal (Loctite 542) to the thread of the shoulder bolt.
    b. Tighten the shoulder bolt to a torque of 7 Nm.
    c. When the valve is refitted to the tractor reset the kick-out pressure setting.

All models

33. Refit the spool to the body and position it in the neutral position.
34. Onto each end of the spool fit a new 'O' ring seal.
35. Fit a new wiper seal.
36. Using a seal plate fitted over the spool, push the 'O' ring and wiper seal home in turn.

NOTE: *Take great care to ensure that the spool remains in the neutral position. If it moves either way too far then a land edge on the spool could pass over the 'O' ring and cause damage which may result in a leakage.*

37. Refit the action mechanism and seal plate, ensure that the threads of the screws and holes are clean and dry, apply two or three drops of MF Screwlock (Loctite 222) and torque to 7 Nm.
38. Reverse procedures 17 to 20, 22 to 24 and 9 to 12 except:
    a. Tighten the change over valve assembly to a torque of 22 Nm.
39. With the nuts and washers fitted to one end of the tie rods, fit the tie rods through the plain end cover and stand on end so that the the tie rods are vertical.

NOTE: *From September 1989 production, a green shim washer was introduced between each section to prevent distortion of the valve and a tightening of the spool. This washer will be found to be part of the inter-section 'O' ring kit, it should be fitted between each section on the top tie rod that passes through the check valve bodies.*

40. Fit new 'O' rings to the end cover and slide on the next section over the tie rods and down onto the cover.

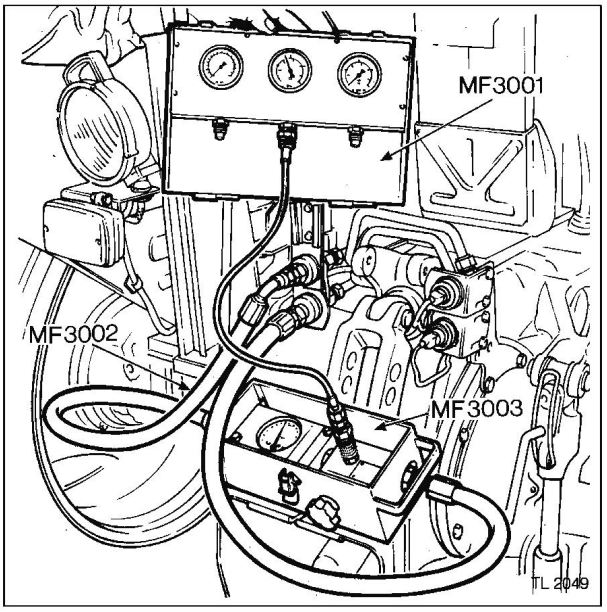
NOTE: *Take great care to ensure there is no contaminant on the underside of the section and that the 'O' rings are fitted completely in their grooves otherwise they may become trapped or damaged.*

41. Fit the 'O' rings to this section and so on until all sections are fitted.
42. Fit the inlet/outlet cover and the three washers and nuts which should be lightly tightened with the valve still in this position.
43. Return the valve to stand on its mounting feet and ensure that the feet are sitting flat on a flat surface.
44. Evenly tighten the three tie rod nuts finishing with a torque of 20 Nm.
45. Refit the valve to the tractor.

AUXILIARY PUMP FLOW and PRESSURE TEST

Check **2.09E–07**

Special Tools:
MF3001 Pressure test kit
MF3002 Hose kit
MF3003 Hydraulic flow meter



Procedure

1. Connect the two hoses from the MF.3002 hose kit to the MF.3003 Flow Meter. Fit to each end of the hoses a quick release coupling that will fit the connections on the rear of the tractor.
2. Fit the flow meter inlet hose to the No. 1 coupler at the rear of the tractor.
3. Fit the outlet hose to the No. 2 coupler.
4. Connect the 300 bar gauge in the MF.3001 pressure test kit to the test point on the flow meter.
5. Fully OPEN the flowmeter restrictor valve.
6. Start up he engine and warm-up the hydraulic system. The oil temperature must be 50-60^{0}C.
7. Set the engine speed to 2000 rev/min.
8. Move the control valve lever serving couplers numbers 1 and 2 rearwards and hold in this position.
9. Slowly screw-in fully the restrictor valve on the flow meter.
10. The pressure reading should be 170-190 bar.

The flow meter should read 36 litre/min.

Minimum accepted flow 32 litre/min

Diagnosis

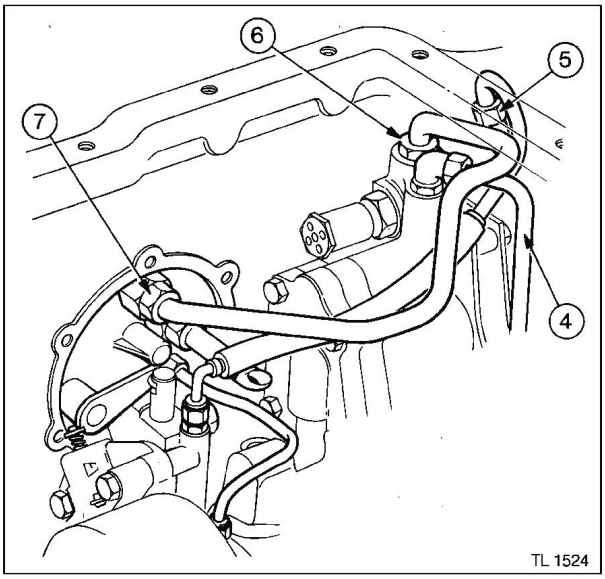
Symptom - Auxiliary pump flow or pressure low		
Cause	Action	Operation Number
1. Auxiliary pump worn	Replace pump or repair	2.09E-08 2.09E-09
2. Pressure relief valve faulty	Replace valve and reset	2.09E-08 2.09E-09
3. Control valve faulty	Overhaul valve	2.09E-06
4. Quick release couplings blocked	Replace couplings	-------
5. Suction strainer blocked	Clean strainer	2.09E-11
6. Insufficient oil in transmission	Fill to level	-------

AUXILIARY PUMP and PLATED DRIVE

Removal and refitment **2.09E–08**

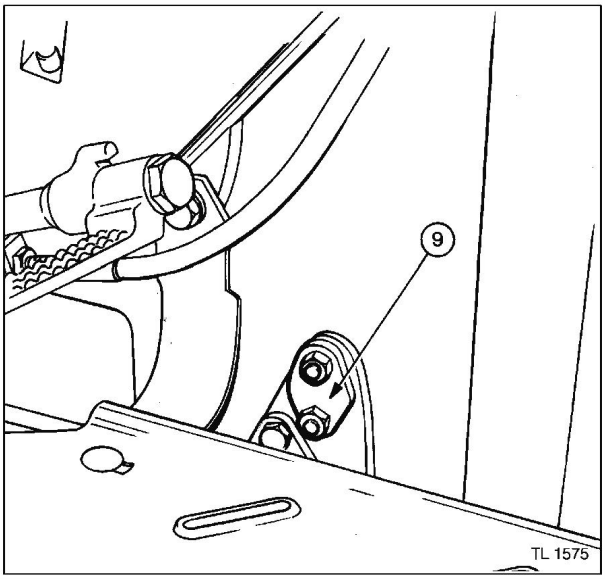
Removal

1. Remove the lift cover, see operation 2.12A-03.
2. Drain the transmission oil.
3. Split the tractor between the gearbox and spacer or centre housing, see operation 2.02A-05 or 2.02A-06.
4. Disconnect and remove the pipe passing forward through the gearbox.
5. Disconnect the flexible pipe supplying the IPTO clutch.
6. Disconnect the pipe to the side cover.
7. Disconnect the pipe at the side cover and remove.
8. Remove the hydraulic lift and auxiliary pump filter, see operation 2.09E-11.
9. Remove the two nuts and the dowel pins each side of the transmission case holding the lift pump.
10. Withdraw the hydraulic lift pump complete with plated drive and auxiliary pump from the front of the centre housing.



Auxiliary Pump

11. Place the lift pump, plated drive and auxiliary pump assembly on a bench; remove the external circlip holding the pump gear in place.
12. Remove the socket head setscrew.
13. Remove the two bolts and spacers.
14. Remove the auxiliary pump.
15. Remove the elbow between the auxiliary pump and the filter manifold.
16. Remove the auxiliary pump drive gear.

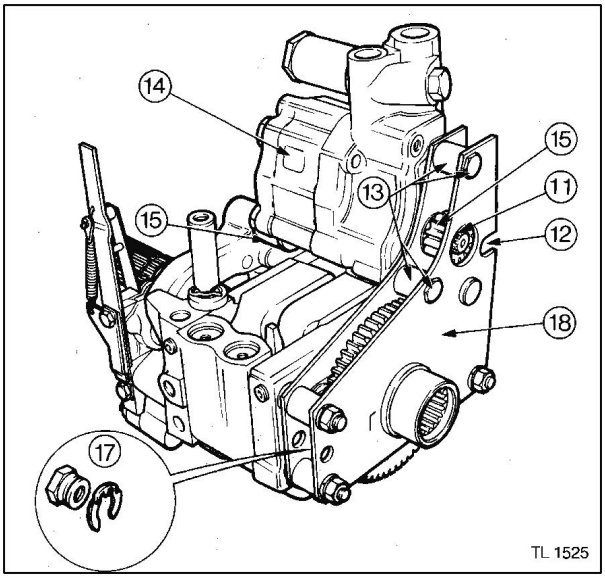


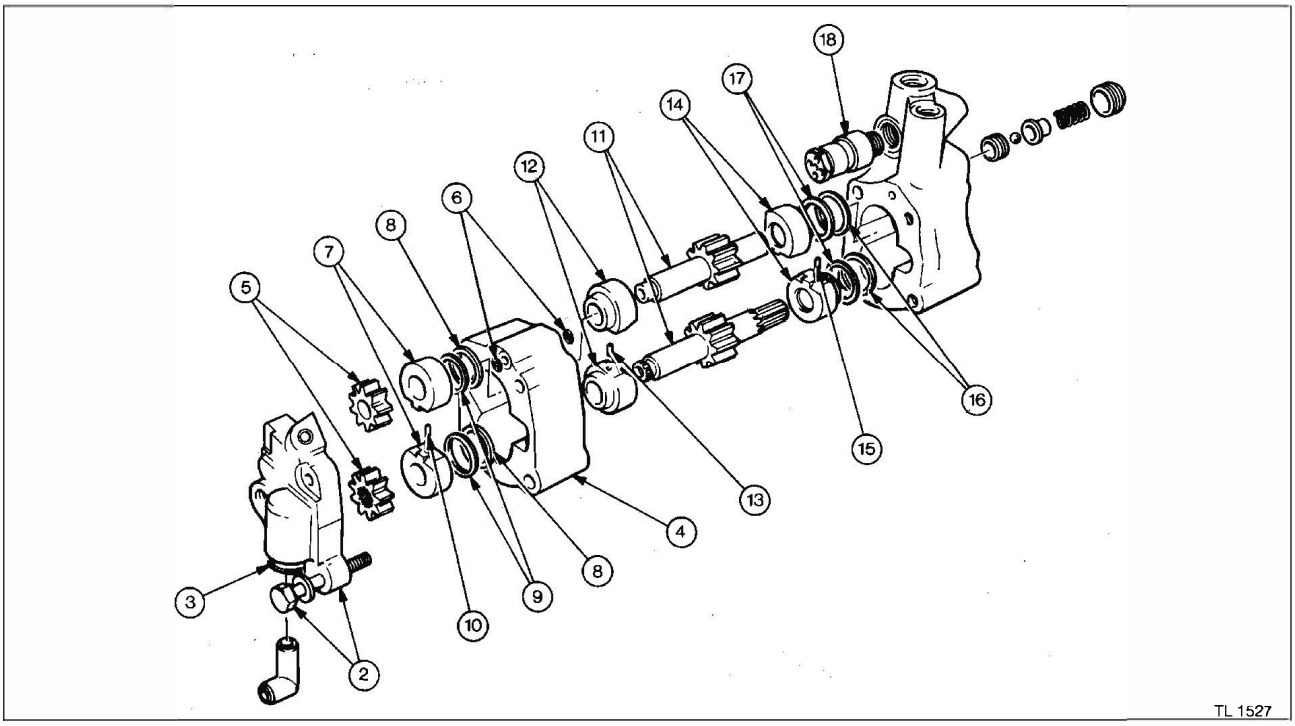
Plated Drive

17. Remove the two 'C' clips holding the plated drive to the hydraulic lift pump.
18. Withdraw the drive off the pump drive shaft.

Re-assembly

19. Reverse procedures 1 to 17 except:
    - *a.* Do not forget the elbow between the auxiliary pump and the filter manifold.
    - *b.* Tighten the two bolts and spacers to a torque of 30 Nm, plated drive to pump.
    - c. Tighten the socket head cap screw to a torque of 27 Nm, plated drive to pump.
    - *d.* Check the total backlash between the three gears, it must be between 0,05 and 0,41 mm.
    - e. Refit the two 'C' clips holding the plated drive to the bottom left and top right nuts on the lift pump body.
    - *f.* Do not forget that the right hand dowel pin (9) is a tight fit while the left hand is an easy fit.





AUXILIARY HYDRAULIC PUMP

Overhaul 2.09E–09

Dis-assembly

1. Remove the auxiliary pump, see operation 2.09E-05.
2. Remove the four securing bolts and remove the end cover.
3. Remove the 'O' ring.
4. Withdraw the centre body section complete with gears off the drive shafts.
5. Remove the gears.
6. Remove the two 'O' rings.
7. Carefully, with finger pressure only, remove the centre section bearings, mark their position with a felt tip pen so they can be refitted in the original position.
8. Remove the seal support rings.
9. Remove the seals.
10. Separate the centre section bearings and remove the dowel pin.
11. Withdraw both shafts complete with bearings from the front body. DO NOT USE FORCE. Mark the bearings with a felt tip pen for refitment.
12. Remove the centre section bearings from the shafts.
13. Separate the bearings and remove the dowel pin.
14. Remove the bearings from the front body, see procedure 7.
15. Separate the bearings and remove the dowel pin.
16. Remove the seal support washers.
17. Remove the seals.
18. Remove the main relief valve, if necessary.

Examination

Bearings

Examine the bearings for wear on their faces and in their bores. During a major overhaul the bearings should be renewed, but if not badly worn they can be salvaged as follows:

Place a sheet of '0' grade emery paper, lubricated with paraffin on a true flat surface, e.g. a surface plate, or plate glass, then polish the bearing face, using a light rotary motion.

Bodies

Inspect the front and centre bodies for external damage and cracks. Examine the bodies for wear and damage. The gears will always cut a light track on the inlet side of the body bores. The depth of this track must not exceed 0,005 mm. The depth of the track can be very difficult to measure with such accuracy. If in doubt replace the body.

Gears

Examine the gears for scored or worn faces or journals, damaged teeth and surface cracks. Always fit replacement gears as a pair and never individually.

Bearing Seals and 'O' Rings

Always fit new seals and 'O' rings on re-assembly.

Relief Valves

The two pressure relief valves are factory preset units, if the valve is suspect it is recommended that the entire unit is replaced.

Re–assembly

19. Reverse procedure 1 to 18 except:

a. Retighten the main relief valve to a torque of 50 Nm.

b. When rebuilding the pump DO NOT use unnecessary force, e.g. a hammer and drift. Using hand pressure only, gently ease the bearings into the bores until they have seated onto their seals.

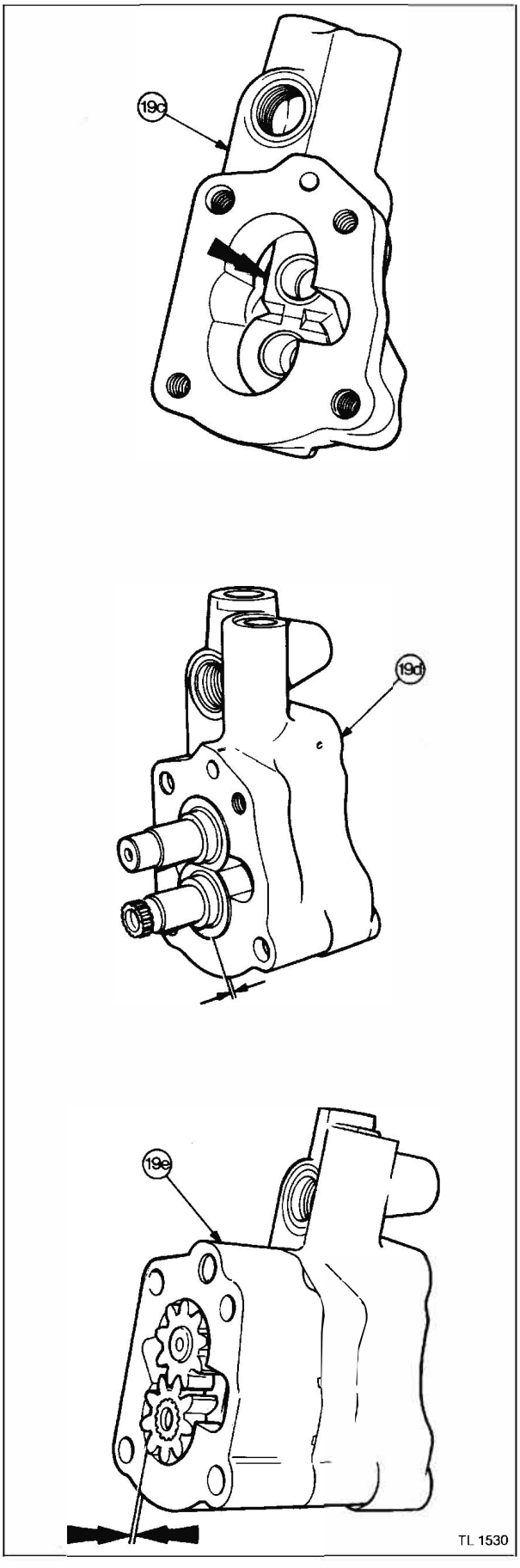
c. When replacing the front body bearings ensure that the uppermost bearing is fitted with its relieved face adjacent to the outlet port.

d. Measure the protrusion of the bearings above the joint face of the body. This dimension must lie between 0-0,5 mm MAXIMUM. If the dimension falls below zero and the bearings become recessed renew the seals. If this dimension is above 0,3 mm then the bearings have not seated correctly because of a slight seizure in the bores.

e. Measure the protrusion of the gear wheels from the centre body face. If the protrusion is not correct take action as detailed in the above paragraph.

f. Retighten the end cover bolts to a torque of 45 Nm.

g. The drive shaft will be difficult to turn by hand when the pump is re-assembled. This condition is quite normal. Check for rotation by temporarily assembling a drive gear to the shaft and turn using a cloth wrapped around the gear.



PLATED DRIVE

Overhaul **2.09E–10**

Dis-assembly

1. Remove the plated drive, see operation 2.09E-08.
2. Remove the nuts and washers.
3. Remove the plate and spacers.
4. Lift out the drive gear and bushes.
5. Remove the idler gear, thrust washers and needle rollers.
6. Push the idler shaft complete with its circlip out of the side plate.

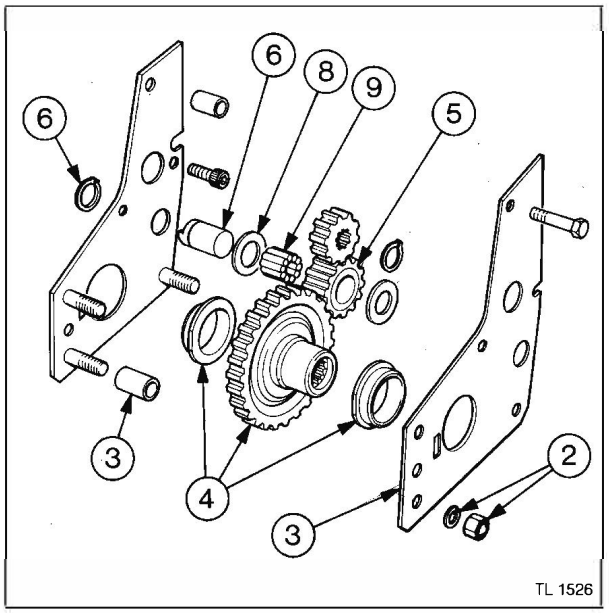
Examination

Check the gear teeth for wear, chipping, or other damage. Examine the bores of the gears, bushes and needle rollers for wear. Check the idler shaft and thrust washers for wear, scoring, or pitting.

Replace any defective components.

Re-assembly

7. Refit the idler shaft to the rear plate complete with circlip.
8. Fit a thrust washer to the idler shaft.
9. Replace the 22 rollers inside the idler gear using petroleum jelly; fit the gear and second thrust washer.
10. Refit the drive gear and bushes, ensure that the flats on the bush locate against the lugs on the plates to prevent rotation.
11. Refit the spacers, plate and nuts. Tighten the nuts progressively to 27 Nm.
12. Refit the lift pump, plated drive and auxiliary pump assembly, see operation 2.09E-08. Check that the flat on the end of the idler gear shaft locates correctly to the bottom of the auxiliary pump.



HYDRAULIC LIFT and AUXILIARY PUMP FILTER

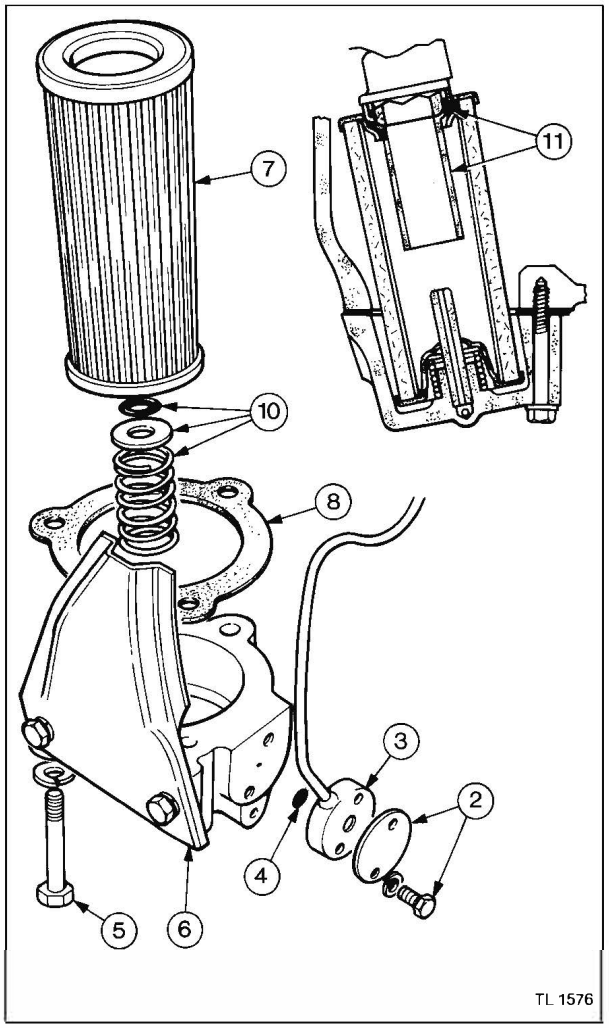
Servicing **2.09E–11**

Procedure

1. Drain the transmission oil.
2. Remove the two bolts and plate from the vacuum tube connector.
3. Ease the connector away from the filter base approximately 6 mm to assist in removal.
4. Remove the connector 'O' ring.
5. Remove the three bolts and washers.
6. Remove the filter base with the shield still attached.
7. Remove the filter element.
8. Remove and discard the gasket.
9. To clean the filter element, brush the mesh with a stiff bristle brush to remove all the particles between the pleats of the filter. Swill the filter around in clean solvent, finally apply compressed air to the inside of the element to remove any remaining dirt particles.

Inspect the the filter under a strong light, if it is not clean replace with a new unit.

10. If necessary, remove the spring, stop plate and 'O' ring from the central post inside the filter base.
11. If necessary, remove the suction tube and two 'O' rings from the pump manifold by gently pulling it down.
12. Replace the filter element in the reverse order except:
    a. Fit the filter with the wider end uppermost.
    b. Place the filter in the base and position it in the centre housing. Replace the bolts, DO NOT attempt to pull the filter base up to the centre housing using the securing bolts.



SECTION 10

Electrical System

INDEX

10A	ELECTRICAL SYSTEM - GENERAL
10B	ELECTRICAL SYSTEM - BATTERY
10C	ELECTRICAL SYSTEM - STARTER MOTOR
10D	ELECTRICAL SYSTEM - ALTERNATOR
10E	ELECTRICAL SYSTEM - WIRING DIAGRAMS

Electrical System

Section 10 – Part A

Table of Contents

Operation No.	Description	Page No.
--------	Specification	10A-2
--------	General description	10A-2
--------	Fault diagnosis	10A-3
--------	Instruments and switches	10A-4
2.10A-01	Headlight beam - adjust	10A-5
2.10A-02	Headlight bulb - removal	10A-5
2.10A-03	Side light/flasher indicator bulb - removal	10A-6
2.10A-04	Rear and brake lights/flasher indicator bulb - removal	10A-6
2.10A-05	Number plate light bulb - removal	10A-6
2.10A-06	Work light bulb - removal	10A-6
2.10A-07	Plough light bulb - removal	10A-7
2.10A-08	Direction indicator/hazard warning light switch bulb - removal	10A-7
2.10A-09	Instrument panel light bulb - tachometer - removal	10A-8
2.10A-10	Instrument panel light bulb - instruments - removal	10A-8
2.10A-11	Warning light bulb - removal	10A-8
2.10A-12	Flashing warning light bulbs - removal	10A-8
2.10A-15	Fuses - removal	10A-9
2.10A-16	Fuse box - removal	10A-9
2.10A-18	Flasher unit - removal	10A-10
2.10A-19	Starter switch - removal	10A-11
2.10A-20	Light switch and horn push - removal	10A-11
2.10A-21	Flashing indicator and hazard warning switch - removal	10A-11
2.10A-22	Fuel and temperature gauges - removal	10A-12
2.10A-23	Tachometer - removal	10A-12
2.10A-24	Headlight wiring connector - removal	10A-12
2.10A-25	Trailer socket - removal	10A-13
2.10A-26	Cigar lighter - removal	10A-14

Electrical System

SPECIFICATION:

Voltage	12 volt negative earth
Light bulb sizes	12 volt

Application	*Watts*	*Type*
Headlight (White)	45/40 W	Unified European contact
Headlight (Yellow)	45/40 W	Unified European contact
Worklight	55 W	Tungsten Halogen
Ploughlight	55 W	Tungsten Halogen
Direction Indicator	21 W	Single centre contact
Stop and rear light	5/21 W	Small bayonet cap index
Side light	5 W	Single centre contact
Number plate (Shell)	5 W	Festoon
Number plate (Flat-top)	5 W	Small bayonet cap
Instrument panel warning lights	3 W	Wedge base (capless)
Hazard/Indicator light switch	2 W	Single contact
Trailer socket	7 pin	See operation 2.10A-22

GENERAL DESCRIPTION

The electrical system for the 200 series tractor is a 12 volt negative earth system, charged by an engine mounted alternator. The alternator has an integral rectifier and regulator, with the charging control being machine sensed.

The alternator (see section 10D) is mounted on the right-hand side of the engine and is driven by a V-belt from the crankshaft pulley. Adjustment of the V-belt tension is provided for with a slotted link and clamp bolts.

The starter motor (see section 10C) is supplied in either standard duty or heavy-duty form and it is mounted on the right-hand side of the 3 cylinder engine tractors and on the left-hand side of the 4 cylinder engine tractors.

A neutral safety start switch is fitted on the top of the transmission and on the PTO control lever. This renders the starter motor inoperative until the dual range selector lever is in the neutral position and the PTO lever in the disengaged position.

Fuses are fitted to protect the lighting, cigar lighter and horn circuits. Wiring diagrams will be found in section 14E.

The battery (see section 10B) access on the three cylinder tractors is through a detachable panel immediately in front of the instrument panel. The 4 cylinder tractor battery is accessed through the detachable front grille.

CAUTION: *To avoid damage to the components of the alternator charging system, the following service precautions must be observed:*

- NEVER make or break any of the charging circuit connections, including the battery when the engine is running.
- NEVER short any of the charging components to earth.
- ALWAYS disconnect the battery earth cable before carrying out arc welding on the tractor.
- ALWAYS disconnect the battery earth cable when charging the battery in the tractor.
- DO NOT use a slave battery of higher than 12 volt nominal voltage.
- ALWAYS observe correct polarity when installing the battery or using a slave battery to start the engine.
- ALWAYS connect the negative cable first.
  POSITIVE terminal and cable marked (+) RED.
  NEGATIVE terminal and cable marked (-) BLACK.

FAULT DIAGNOSIS

Fault diagnosis is the method of locating faults while the electrical equipment is still in position. In the interests of efficiency and economy, the diagnosis must be accurate and must be carried out in the shortest possible time using the minimum amount of equipment.

The following is the minimum equipment necessary to carry out this full diagnosis:

1. MF.3005 Digital multimeter (Fig.1).
2. D.C. Voltmeter (moving coil) Scale 0-50 volts (Fig.2).
3. D.C. Ammeter (moving coil) Scale 10-0-100 amp (Fig.2).
4. Hydrometer (Fig.3).
5. Heavy-duty battery discharge tester (Fig.4).
6. Ohmmeter scale 0-50,000 ohms (Fig.5).

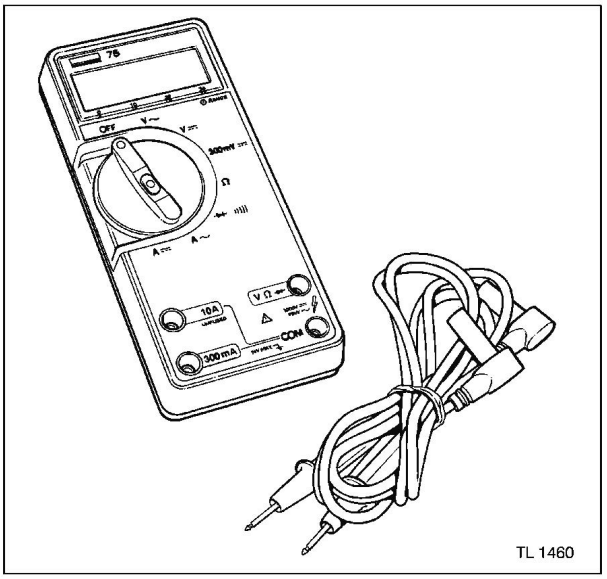


Fig.1

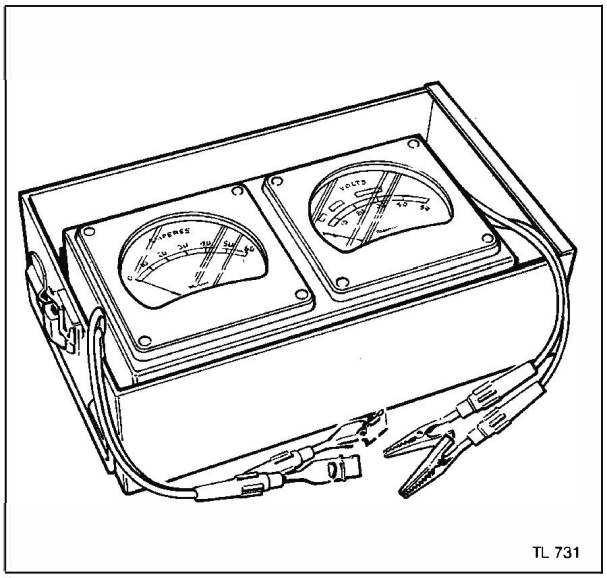


Fig.2

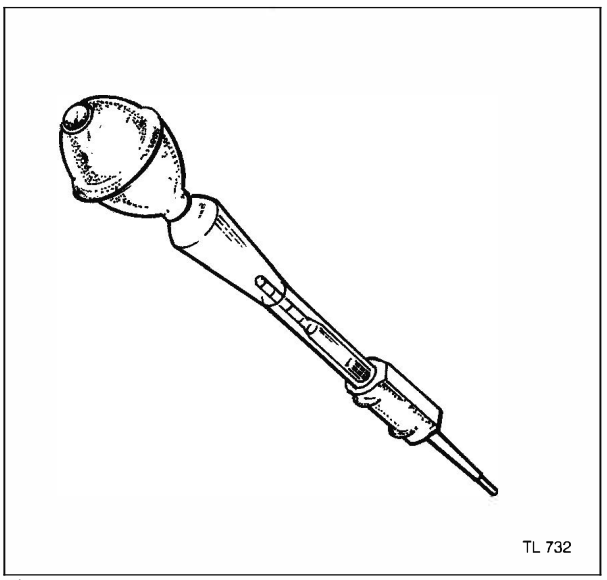


Fig.3

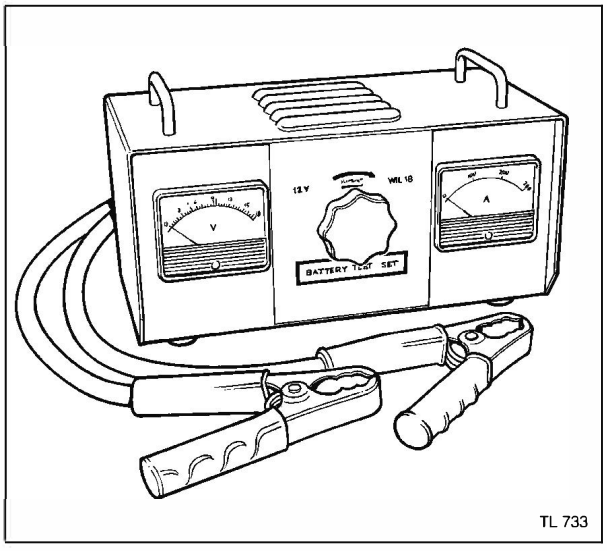


Fig.4

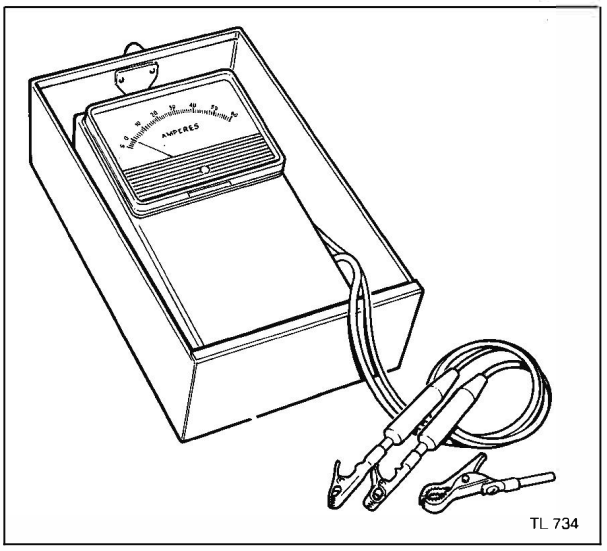
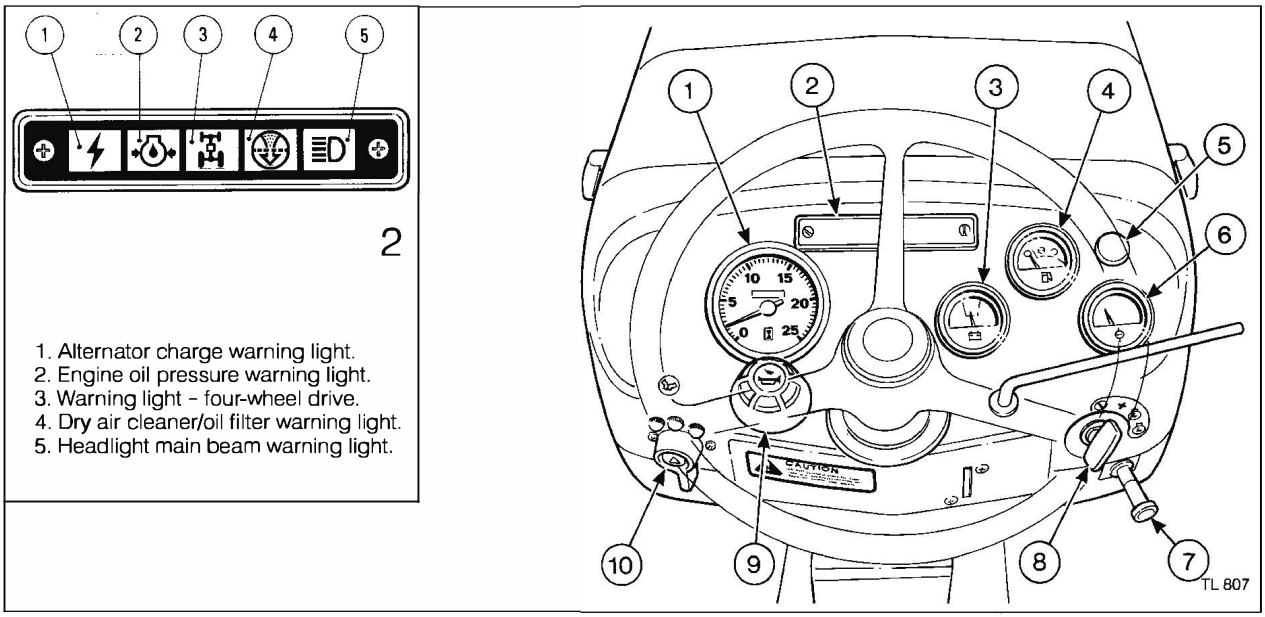


Fig.5

INSTRUMENTS and SWITCHES



1. Tachometer.
2. Warning light panel - see insert.
3. Battery condition indicator.
4. Fuel gauge.
5. Cigar lighter.
6. Temperature gauge.
7. Fuel cut-off control.
8. Starter switch.
9. Light switch and horn push.
10. Hazard warning and direction indicator switch.

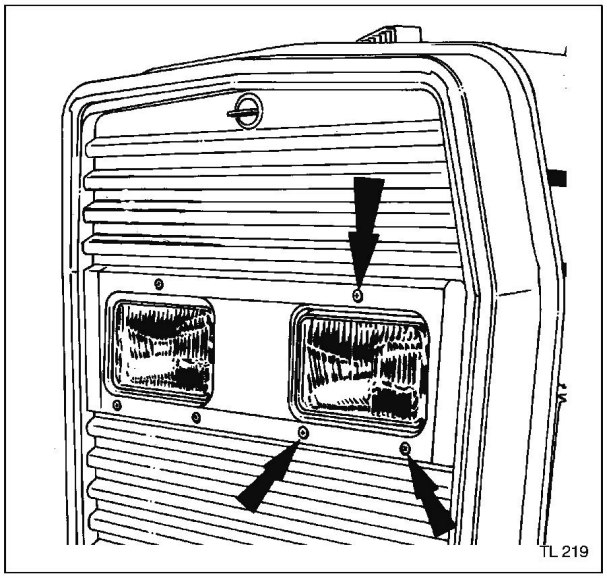
HEADLIGHT BEAM

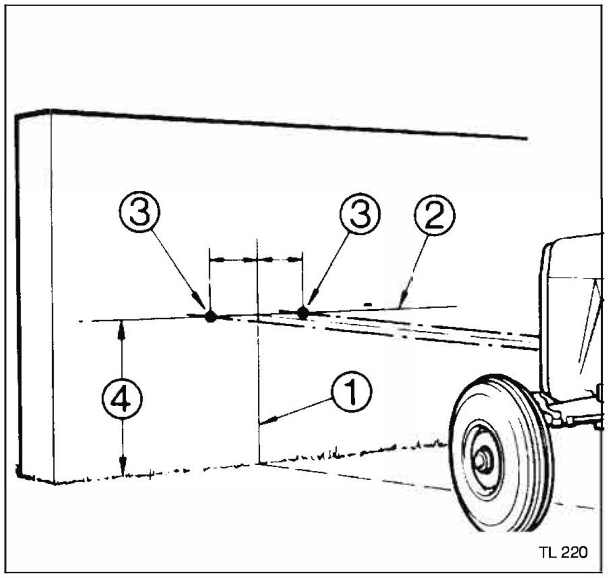
Adjust 2.10A–01

To adjust the headlights, screw the three screws in or out as required, this will deflect the beam up, down or sideways.

To adjust the beam proceed as follows:

1. Position the tractor facing a wall or screen, 2 metres away.
2. Mark a point on the wall or screen by sighting down the hood centre line.
3. Draw a vertical line (1) through the point.
4. Draw a horizontal line (2) through the vertical line (1) at headlight height (4).
5. Mark two points (3) on the horizontal line representing the distance between the two headlights, spaced equally either side of the vertical line (1).
6. Adjust each headlight individually by obscuring the other, so that the points (3) marked on the wall or screen are in the centre of the beam. The centre of the headlight beam may be found by marking the extremities of the beam both vertically and horizontally, by dividing by two.


TL 219



TL 220

HEADLIGHT BULB

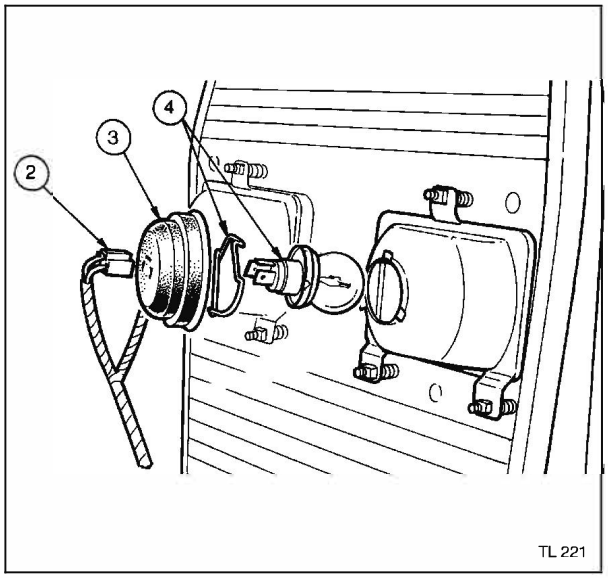
Removal and refitment 2.10A–02

Removal

1. Switch off all light switches.
2. Remove the front grille.
3. Remove the headlight wiring plug (2).
4. Remove the rubber surround (3).
5. Release the spring clip and remove the bulb (4).

Refitment

6. Replace the bulb and re-assemble in reverse order.
7. Replace the front grille and test.



TL 221

SIDE LIGHT/FLASHING INDICATOR BULB

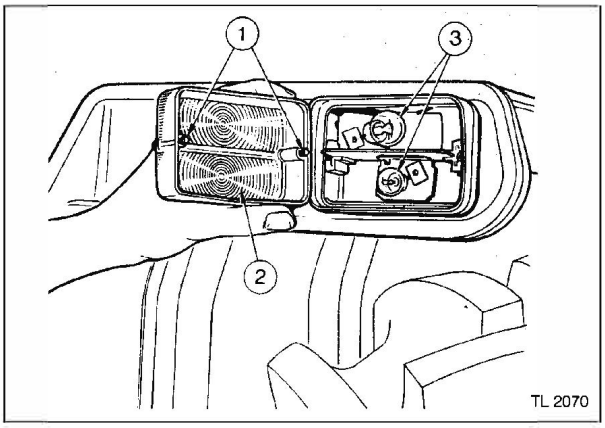
Removal and refitment **2.10A–03**

Removal

1. Remove the two screws attaching the lens.
2. Remove the lens.
3. Remove the failed bulb from its bayonet fitting.

Refitment

4. Fit the bulb to the bayonet fitting.
5. Replace the lens and tighten the attaching screws.
6. Test the lights.



REAR AND BRAKE LIGHTS/FLASHING INDICATOR BULB

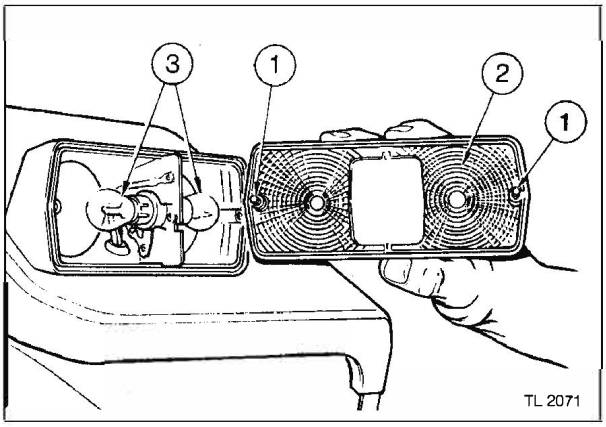
Removal and refitment **2.10A–04**

Removal

1. Remove the two screws attaching the lens.
2. Remove the lens.
3. Remove the failed bulb from its bayonet fitting.

Refitment

4. Fit the bulb to the bayonet fitting.
5. Replace the lens and tighten the attaching screws.
6. Test the lights.



NUMBER PLATE LIGHT BULB

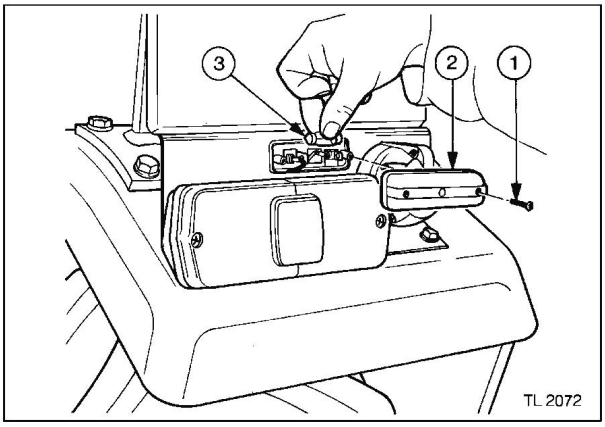
Removal and refitment **2.10A–05**

Removal

1. Slacken the two screws.
2. Remove the lens cover.
3. Remove the failed festoon bulb from the two clips.

Refitment

4. Fit the bulb to the two clips.
5. Replace the cover and lens and tighten the attaching screws.
6. Test the light.



WORK LIGHT BULB

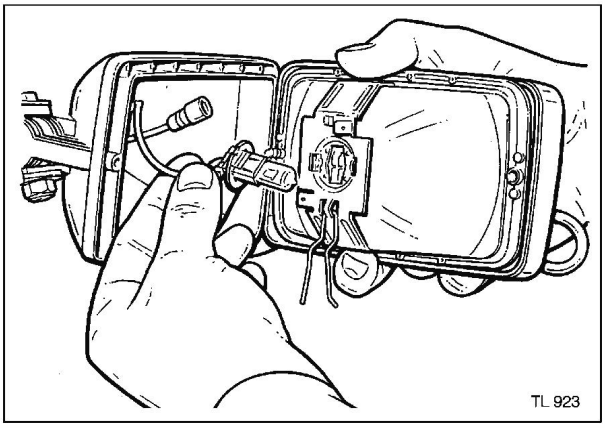
Removal and refitment **2.10A–06**

Removal

1. Remove the retaining screws.
2. Ease the light unit out of the body.
3. Remove the spring clip from the back of the bulb.

Refitment

4. Fit the bulb and re-assemble the light.



PLOUGH LIGHT BULB

Removal and refitment **2.10A–07**

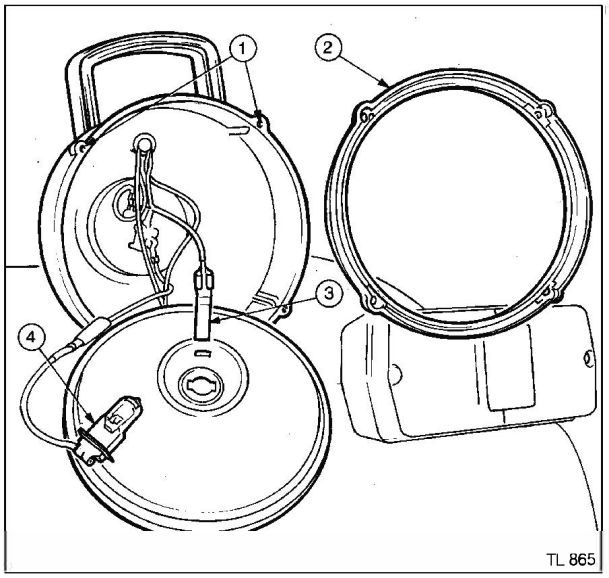
CAUTION: *Plough lights can have halogen bulbs. Never touch a halogen bulb with the fingers. Natural moisture in the skin will cause the bulb to burn out when the light is switched on. Always use a clean cloth or tissue when handling halogen bulbs.*

Removal

1. With the light switched off remove the four screws (1) and the rim (2).
2. Ease the light unit out of the body and disconnect the two spade connectors (3).
3. Remove the spring clip from the back of the bulb holder and remove the failed bulb (4).

Refitment

4. Fit the bulb and re-assemble in reverse order.



DIRECTION INDICATOR and HAZARD WARNING LIGHT SWITCH BULB AND RELAY

Removal and refitment **2.10A–08**

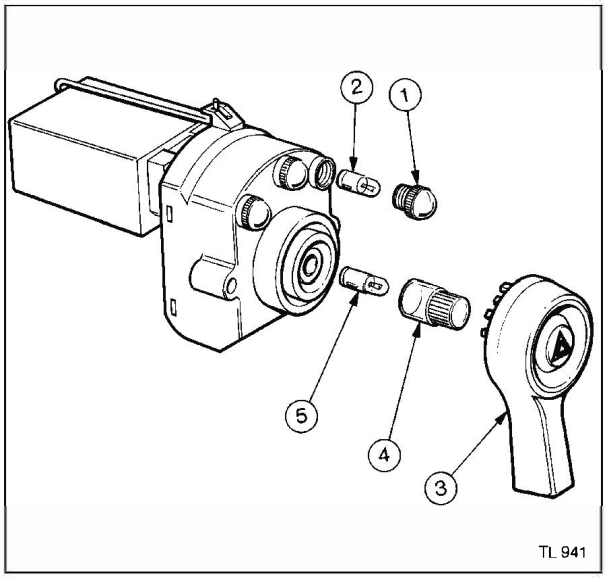
Direction indicator warning light switch bulb:

Removal

1. Ensure that the starter switch is turned off.
2. Unscrew the green lens (1).
3. Pull the bulb from its holder (2).

Refitment

4. Fit the bulb.
5. Refit the lens.



Hazard warning light switch bulb:

Removal

1. Ensure that the starter switch is turned off.
2. Pull off the direction indicator switch lever (3).
3. Unscrew the red lens (4).
4. Pull the bulb from its holder (5).

Refitment

5. Fit the bulb and replace the lens and switch lever.

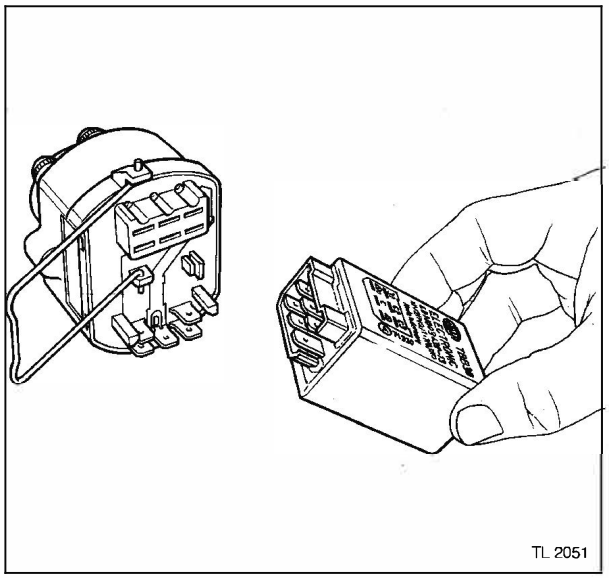
Indicator relay:

Removal

1. Disconnect the battery, removing the negative cable (-) first in the interest of safety.
2. To replace the relay unit, remove the switch unit.
3. Unclip the relay.
4. Pull the relay from the switch body.

Refitment

5. The new relay can be fitted and the switch unit refitted to the tractor.



INSTRUMENT PANEL LIGHT BULB – TACHOMETER

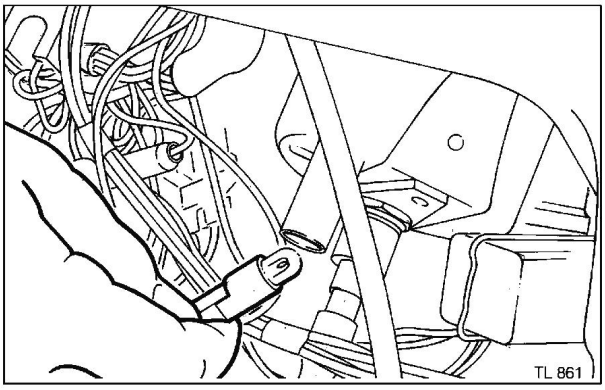
Removal and refitment **2.10A–09**

Removal

1. Pull the bulb and its holder from the instrument panel and remove the bulb from the holder.

Refitment

2. Fit the bulb in its holder.
3. Push the bulb holder and bulb into the instrument.



INSTRUMENT PANEL LIGHT BULB – INSTRUMENTS

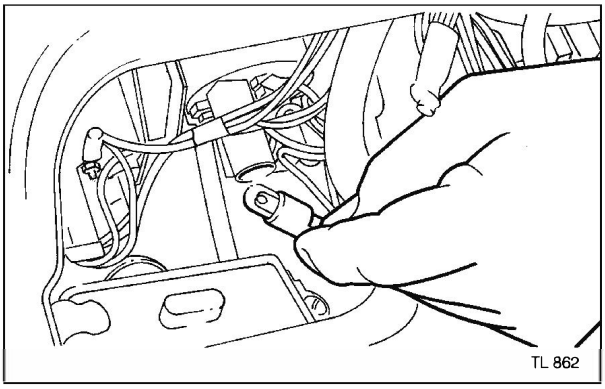
Removal and refitment **2.10A–10**

Removal

1. Pull the bulb and its holder from the instrument panel and remove the bulb from the holder.

Refitment

2. Fit the bulb in its holder.
3. Push the bulb holder and bulb into the instrument.



WARNING LIGHT BULB

Removal and refitment **2.10A–11**

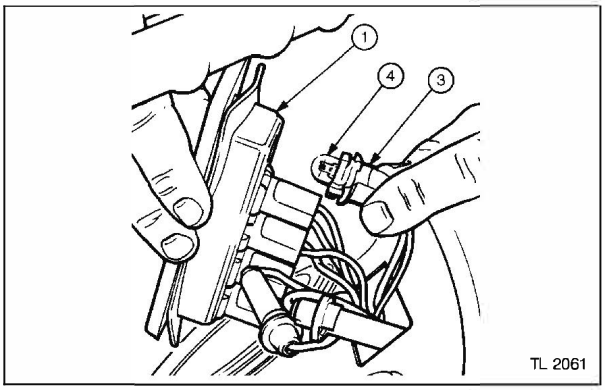
NOTE: *The warning light panel can be removed from the front of the instrument panel by removing two screws.*

Removal

1. Remove the two screws retaining the panel assembly, and lift the panel sufficiently to allow the warning light bulb to be removed.
2. Disconnect the battery, removing the negative cable (-) first in the interest of safety.
3. Turn the holder of the failed bulb anti-clockwise and withdraw it from the light panel assembly.
4. Pull out the capless bulb.

Refitment

5. Reverse procedures 1 to 4.



FLASHING WARNING LIGHT BULBS

Removal and refitment **2.10A–12**

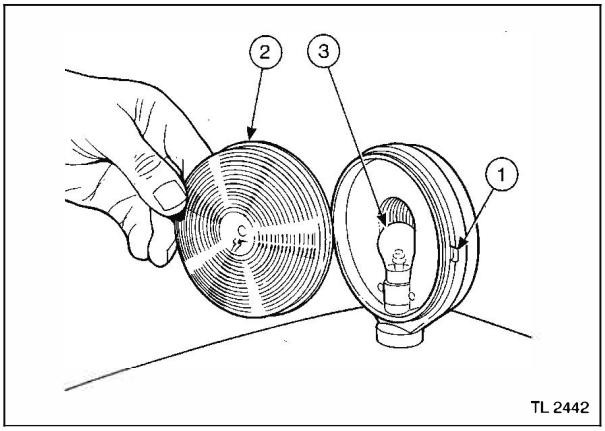
This type of light is fitted to tractors with flat top fenders.

Removal

1. Switch off the light
2. On the side of the central section of the light there is a small indent (1) for the blade of a screwdriver.
3. Insert the blade of a screwdriver and carefully twist off one of the lenses (2).
4. Remove the failed bulb (3) from its fitting.

Refitment

5. Fit a new bulb, refit the lens by pressing it back in place with the palm of the hand.



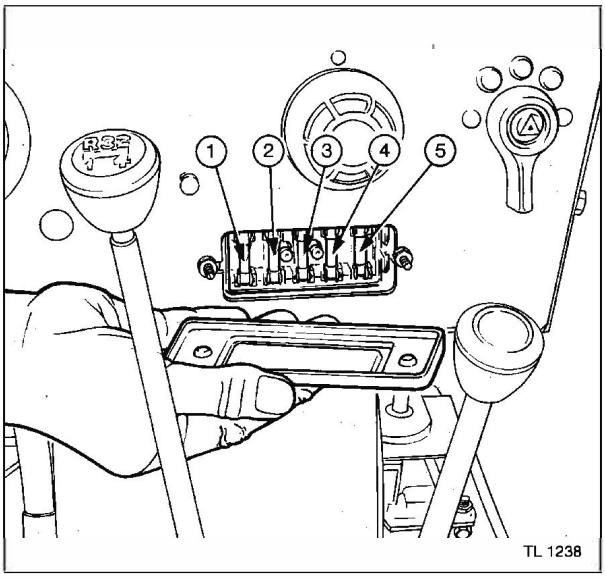
FUSES

Removal and refitment 2.10A–15

The single fuse box is situated at the bottom of the instrument panel.

The fuses in the box protect five different circuits as detailed below:

Fuse	Circuit	Amp
1	Dipped headlights	20 A
2	Main beam headlights warning lights	20 A
3	Left-hand side/tail lights and instrument panel lights.	10 A
4	Right-hand side/tail lights and number plate light.	10 A
5	Instrument power supply, flashing indicators and brake lights.	20 A
6	Spare fuses	10 A 20 A



TL 1238

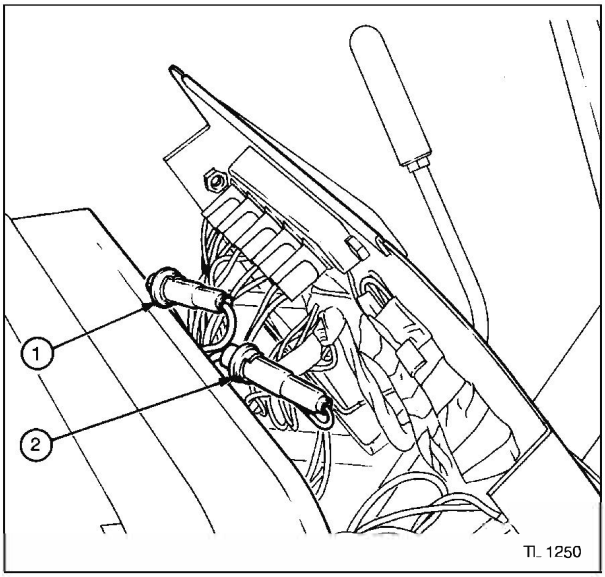
LINE FUSES

Two line fuses are located behind the instrument panel and are accessible by removing the warning light display unit or removing the cowling.

The line fuse (1) protects the horn circuit (grey wire) and line fuse (2) protects the circuit for the hazard warning lights (blue wire).

To renew a line fuse, hold one end of the white plastic casing, push in, twist, pull apart and then tip out the fuse.

Always ensure that the new fuse is of the correct capacity.



TL 1250

FUSE BOX

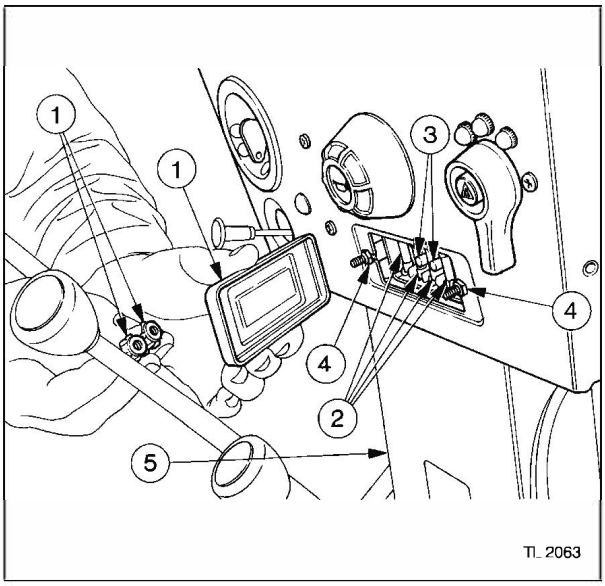
Removal and refitment 2.10A–16

Removal

1. Remove the two knobs retaining the fuse box cover, and lift off the fuse box cover.
2. Remove the fuses as required.
3. Two spare fuses.
4. Remove the two nuts and washers retaining the fuse box to the instrument panel.
5. Remove the lower cover panel.
6. Withdraw the fuse box from its mounted position and disconnect the fuse box from the wiring harness.

Refitment

7. Reverse procedures 1 to 6.



TL 2063

FLASHER UNIT

Removal and refitment **2.10A–18**

The flasher unit for the flashing warning lights can be located in one of two places depending on the type of fender fitted to the tractor.

On tractors fitted with shell type fenders it is located under the plough/rear light bracket.

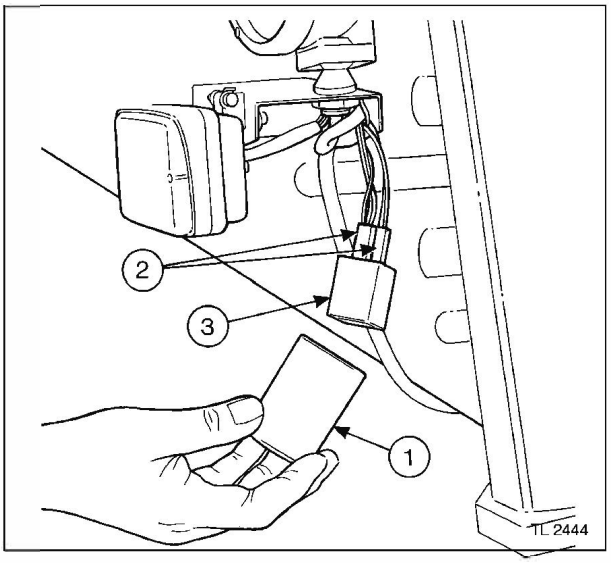
On tractors with flat top fenders, it is located under the fender, between the fender and the mounting bracket.

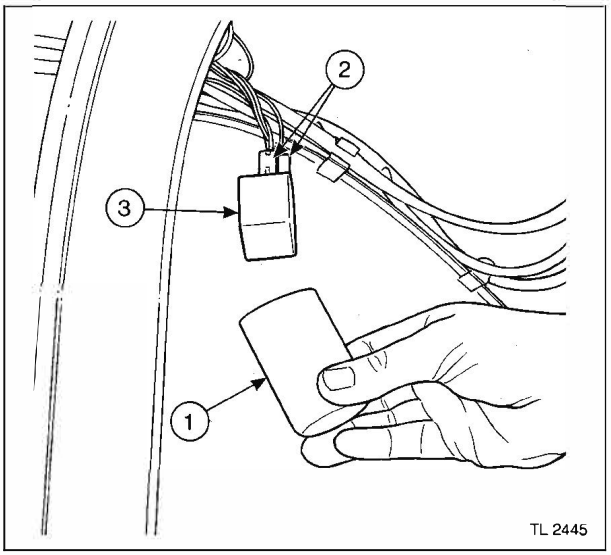
Removal

1. On shell type fenders, loosen the two bracket mounting nuts on the inside of the fender and pull out the wires and flasher unit.
2. On flat top fenders pull out the wires and flasher unit from under the fender.
3. Remove the plastic cover (1).
4. Remove the three wires (2) from the flasher unit (3).

Refitment

5. Replace the flasher unit. The wires are connected as follows:
   Black wire to terminal - 31.
   Orange wire to terminal - 49a.
   Green wire to terminal - 49.
6. Replace the plastic cover.
7. Stow the flasher unit back into its original position. Ensure that the wires are not damaged, twisted or pinched and that they are protected.
8. Tighten any loosened nuts.





STARTER SWITCH

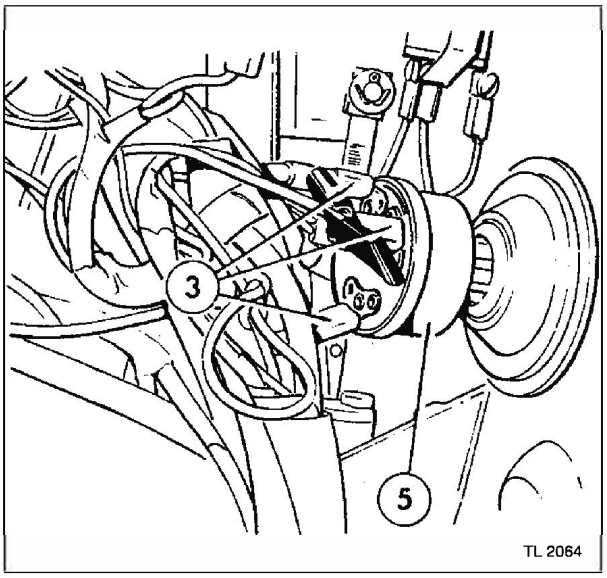
Removal and refitment **2.10A–19**

Removal

1. Remove the instrument cowl.
2. 345 tractors - Remove the battery, see operation 2.14B-03.
   Other models - Remove the front grille and disconnect the battery, removing the negative cable (-) first in the interest of safety.
3. Label and disconnect the cables from the rear of the switch.
4. Remove the slotted nut surrounding the keyhole in the starter switch.
5. Withdraw the switch from behind the instrument panel.

Refitment

6. Reverse procedures 1 to 5.



LIGHT SWITCH and HORN PUSH

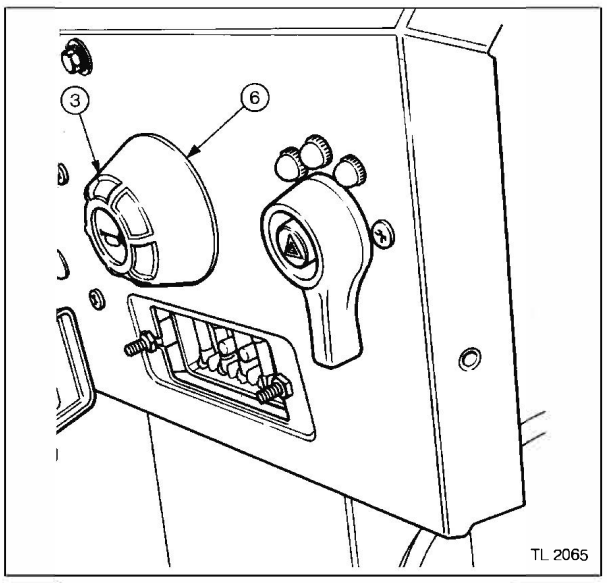
Removal and refitment **2.10A–20**

Removal

1. Remove the instrument cowl.
2. 345 tractors - Remove the battery, see operation 2.14B-03.
   Other models - Remove the front grille and disconnect the battery, removing the negative cable (-) first in the interest of safety.
3. Slacken the screw and remove the switch knob.
4. Remove the spring (if fitted).
5. Label and disconnect the cables from the switch terminals.
6. Remove the locknut.
7. Withdraw the switch from behind the instrument panel.

Refitment

8. Reverse procedures 1 to 7.



FLASHING INDICATOR and HAZARD WARNING SWITCH

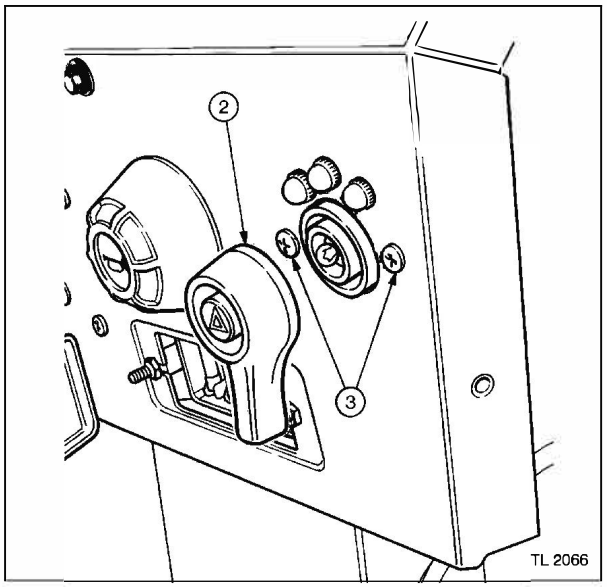
Removal and refitment **2.10A–21**

Removal

1. Remove the instrument panel cover on 275/283/290 tractors. On 230/240/253 tractors remove the lower instrument panel.
2. Pull the indicator switch arm off the indicator switch, away from the instrument panel.
3. Remove the two self-tapping screws.
4. Remove the block connector from the rear of the switch.
5. Remove the switch from its mounted position.

Refitment

6. Reverse procedures 1 to 5.



FUEL and TEMPERATURE GAUGES

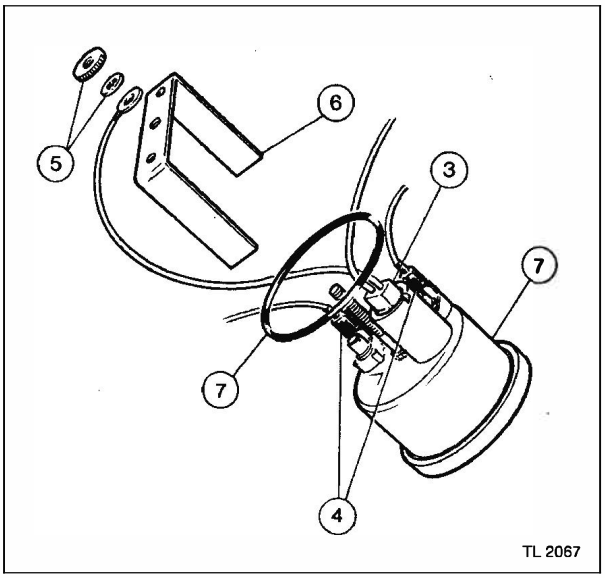
Removal and refitment **2.10A–22**

Removal

1. Remove the instrument cowl or battery cover.
2. 345 tractors - Remove the battery, see operation 2.14B-03.
   Other models - Remove the front grille and disconnect the battery, removing the negative cable (-) first in the interest of safety.
3. Remove the bulb holder.
4. Remove the electrical input connection, or connections.
5. Remove the knurled nut, spring washer, and bulb holder earth wire, or wires.
6. Remove the bracket.
7. Withdraw the instrument, together with the rubber gasket, from the face of the instrument panel.

Refitment

8. Reverse procedures 1 to 7.



TL 2067

TACHOMETER

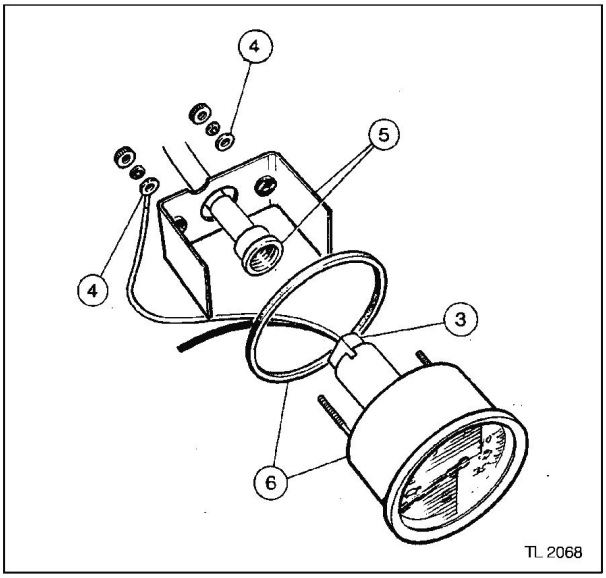
Removal and refitment **2.10A–23**

Removal

1. Remove the instrument cowl or battery cover.
2. 345 tractors - Remove the battery, see operation 2.14B-03.
   Other models - Remove the front grille and disconnect the battery, removing the negative cable (-) first in the interest of safety.
3. Remove the bulb holder.
4. Remove the two nuts and washers securing the bracket, together with the bulb holder earth wire, or wires.
5. Release the bracket and disconnect the drive cable.
6. Remove the instrument, together with the gasket, from the face of the instrument panel.

Refitment

7. Reverse procedures 1 to 6.



TL 2068

HEADLIGHT WIRING CONNECTOR

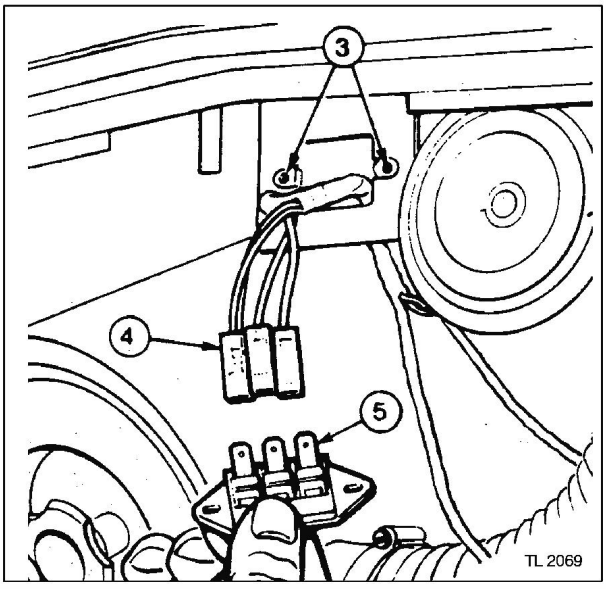
Removal and refitment **2.10A–24**

Removal

1. Remove the front grille.
2. Disconnect the battery cables.
3. Remove the two screws.
4. Disconnect the wiring from the three lugs.
5. Remove the connector.

Refitment

6. Reverse procedures 1 to 5.



TL 2069

TRAILER SOCKET

Removal and refitment **2.10A–25**

Removal

1. Disconnect the battery, removing the negative cable (-) first in the interest of safety.
2. Remove the three screws, nuts and washers.
3. Pull the socket and connecting wire away from the mounting bracket, allowing the connecting wire retaining screws to be slackened, so releasing the connecting wire. Do not over strain the wiring loom.
4. Check for wear, damage or corrosion and replace the socket with a new one if necessary.

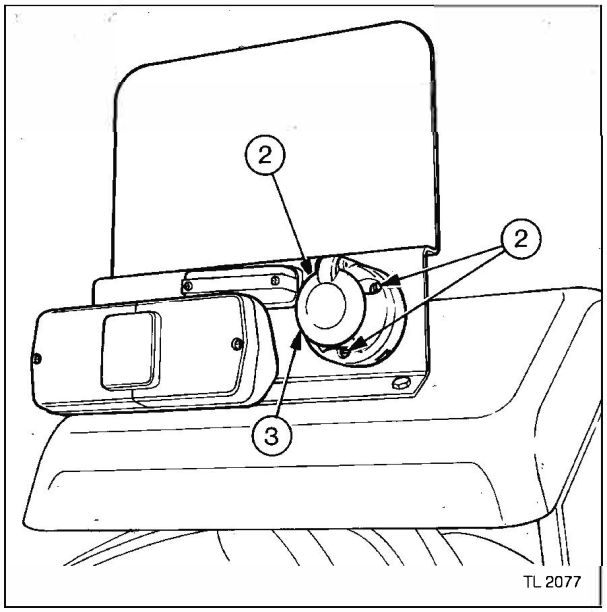
Refitment

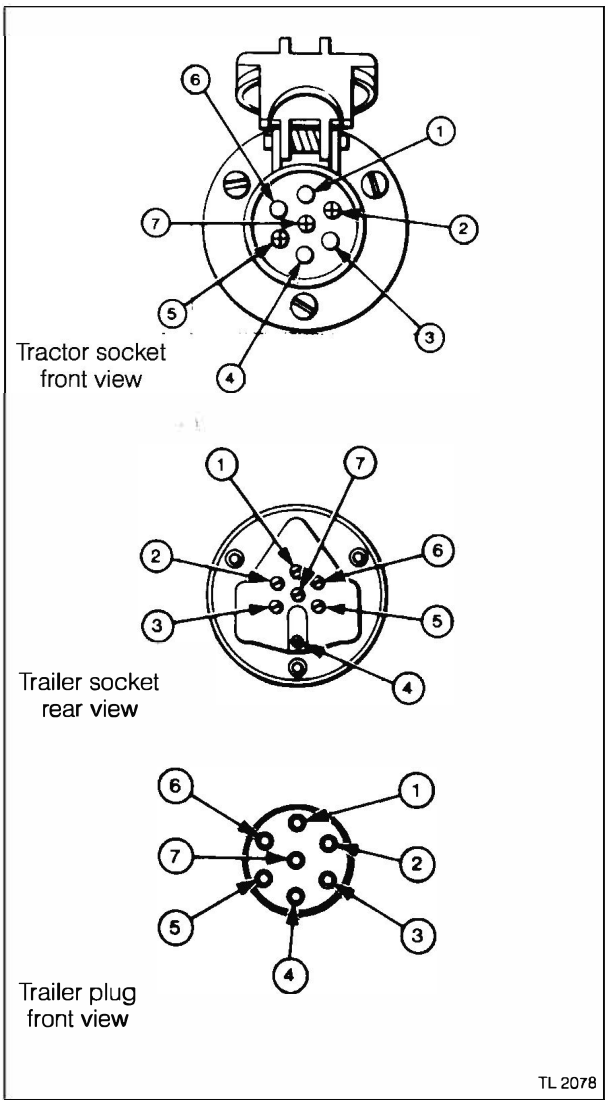
5. Reverse procedures 1 to 4.

Trailer socket wiring

No.	*Ref.*	*Colour*	*Function*
1.	L	Pink	Left-hand indicators.
2	54G	-----	Not used - spare.
3.	31	Black	Earth (-).
4.	R	Brown	Right-hand indicators.
5.	58R	Red/Black	Number plate.
6.	54	White	Stop lights.
7.	58L	Red	Side/tail lights.

NOTE: *The letters and numbers in the reference column are marked on the rear of the socket and plug, next to each terminal.*



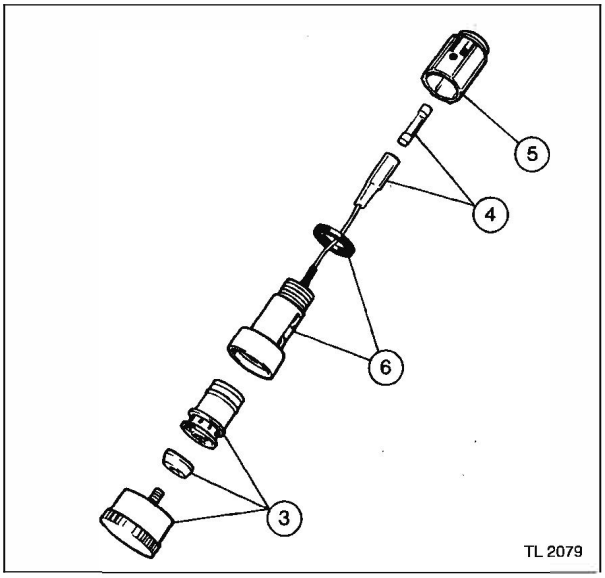


CIGAR LIGHTER

Removal and refitment **2.10A–26**

Removal

1. Remove the instrument cowl or battery cover, depending on model.
2. 345 tractors - Disconnect the battery, see operation 2.14B-03.
   Other models - Remove the front grille and disconnect the battery, removing the negative cable (-) first in the interest of safety.
3. Pull the lighter element from the holder.
4. Disconnect the cable at the spade connector.
5. Unscrew and remove the sleeve from the holder at the rear of the instrument panel.
6. Withdraw the holder, together with the rubber gasket, from the face of the instrument panel.



Refitment

7. Reverse procedures 1 to 6.

Electrical System

Section 10 – Part B

Table of Contents

Operation No.	Description	Page No.
-------	Specification	10B-2
-------	General description	10B-2
2.10B-01	Battery - Introduction	10B-3
2.10B-02	Routine maintenance, charging and commissioning	10B-3
2.10B-03	Battery - removal	10B-6

Electrical System - Battery

SPECIFICATION:

Voltage	12 volt negative earth
Battery	
Make	Massey Ferguson
Type	Maintenance free
Model	372
Part number	1694 592 M1
Cold start performance	420 CCA
Reserve capacity at 25 amp	130 mins
Voltage	12 volts
Bench charging rate	7 amps
Maximum charging voltage	15 volts
Ampere hours	70
Acid capacity	3,54 litres
Weight	19,5 kg
Size	175 mm wide x 271 mm long x 205 mm high
Terminals	Standard post

GENERAL DESCRIPTION

The batteries fitted to the MF 200 series tractors are specified as maintenance free, but are not maintenance impossible. Access to the battery can be obtained through the battery top cover immediately in front of the operator on the 3 cylinder tractors, and through the detachable front radiator grille on the 4 cylinder tractors. Access is necessary for:

1. The addition of acid in the case of a dry charged battery.
2. Topping up due to evaporation caused by an overcharging fault occurring.

Maintenance free batteries are rated to a standard specified by the International Electrotechnical Commission, which demands that a certain ampere output is available at a temperature of -18^{0}C for a period of one minute under continuous cranking conditions. This output is defined as the Cold Cranking Ampere (CCA) capacity of the battery.

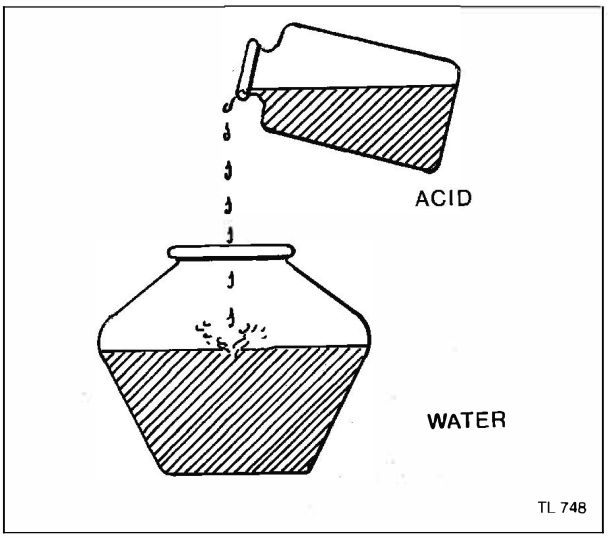
BATTERY

Introduction 2.10B–01

Special Tools:
MF3005 Digital multimeter
Hydrometer
Heavy-duty battery discharge tester

WARNING: It is essential that you read and observe the following safety precautions:

- ***Take care when fitting and filling batteries as they contain sulphuric acid. If splashed on skin or eyes, wash the affected parts immediately in water.***



- ***When mixing acid always ADD ACID TO WATER SLOWLY, NOT WATER TO ACID.***
- ***Explosive gases are given off when charging the battery. Keep the top well ventilated and away from flames or sparks.***
- ***Switch off the charger before disconnecting the charger leads.***
- ***When putting the battery into service on a tractor, connect the earth lead (–) last and when removing the battery, disconnect the earth lead (–) first.***
- ***Keep the battery away from children.***
- ***DO NOT SMOKE when handling or checking batteries.***

ROUTINE MAINTENANCE

Introduction 2.10B–02

Routine maintenance is limited to the following points:

1. Keep the top of the battery clean and dry, wipe away spillage during filling.
2. If the battery requires topping-up because of loss of electrolyte due to overcharging, use only distilled or de-ionised water.
3. Coat the terminals with petroleum jelly, to prevent corrosion.
4. Do not allow the battery to fall below 70% state of charge.
5. Do not store a battery in a discharged state.
6. Ensure the battery is stowed correctly in the tractor.

Battery charging

The boost charging of batteries is not advised at any time, but recharging as necessary should be carried out at a specific current, and a pre-determined period of time according to the model and the tested voltage of the battery.

The ideal method of charging batteries is to use an automatic charger designed for the charging of low maintenance batteries and charged one at a time. If this equipment is not available the following instructions should be observed:

1. Where more than one battery is to be charged at the same time the batteries must be:
   a. Separated by model - do not mix 372 and 665 model batteries.
   b. Separated by tested voltage - use the voltage bands in table 1.
   c. Batteries must be connected in series.

NOTE: *NOTE: The mixing of battery types, sizes and voltage bands will result in a number of batteries not being fully charged.*

2. Test the battery with a voltmeter and note the reading.
3. Connect up the battery or batteries in series.
4. Switch on the battery charger.
5. Set the battery charger output in amps according to the size of the battery being charged. Nothing will be gained by putting up the charge rate, only a damaged battery. The output voltage of the charger should not exceed 15 volts across any one 12 volt battery.

Massey Ferguson battery model 372 charge rate is 7 amps

Massey Ferguson battery model 665 charge rate is 12 amps

6. Charge the battery for a period of time listed in Table 1 according to it's voltage reading.

Battery voltage	Length of charge
Above 12.6 volts	4 hours
12.4 to 12.59 volts	6 hours
12.2 to 12.39 volts	10 hours
12.19 and below	16 hours

Table 1. Battery charging times

7. Check the charger reading after 15 minutes and adjust the amperage if necessary.
8. Check and reset the charger after 2 hours.
9. Leave until the end of the charge period.
10. Switch off
11. Leave the battery for eight hours, then check the voltage which should be:
    12.7 volts for new batteries.
    12.5 volts or more for batteries which have been in service.

Commissioning dry charged batteries

To prevent battery failure in early life the following commissioning procedure should be adopted:

1. Remove the cell covers and fill each cell with dilute sulphuric acid to the correct specific gravity for your climate as given in Table 2.

	Specific gravities of acid at 25^{0}C	
In a climate with an air temperature	For filling new cells	At end of charge
Normally below 32^{0}C	1.270	1.270-1.290
Frequently above 32^{0}C	1.240	1.240-1.260
Maximum permissible temperature of electrolyte during charge	40^{0}C	

Table 2. Specific gravity and temperature of acid

Temperature correction

If the acid temperature is higher or lower than 25^{0}C it will be necessary to make a correction to the specific gravity readings of the acid.
To correct to 25^{0}C:
For every 10^{0}C higher subtract 0.007.
For every 10^{0}C lower add 0.007.

2. The temperature of both acid and battery should preferably be between 15^{0}C (59^{0}F) and 25^{0}C (77^{0}F).

CAUTION: *DO NOT fill dry charged batteries initially with distilled water.*

3. The level of acid above the separators should be:
   Battery 372 acid capacity 3,54 litre acid level 8 mm
   Battery 665 acid capacity 6,50 litre acid level 16 mm
4. Stand the battery for 10 to 15 minutes, after the initial filling the level of acid will fall, this should then be restored by adding more acid.
5. The battery must be immediately placed on a commissioning charge as detailed in "Battery charging" for four hours. This ensures that the acid is sufficiently mixed within the battery.

NOTE: *The time between filling with acid and commencing charging must not exceed ONE HOUR.*

6. After the charge period REMEMBER to switch off the charger before disconnecting the leads, otherwise the resultant spark may cause an explosion.
7. Re-check the acid levels and adjust where necessary by addition of distilled water.
8. Check the voltage and recharge if below 12.7 volts.
9. Replace the cell covers.

Putting the battery into service

When fitting the battery to the tractor ensure that it is properly secured by the hold down devices, and that the terminals and cables are clean and correctly and securely connected to the battery terminals. The connectors and terminals should be lightly smeared with petroleum jelly after they have been fitted.

Battery storage

The dry charged battery has a storage life of approximately two years providing it is removed from the tractor and stored in a cool, clean, dry environment protected from the floor on an even surface.

The storage life of a new charged battery providing it is maintained in accordance with the following instructions is approximately 18 months.

Wet charged batteries in storage or installed on tractors waiting to be sold should be fully charged and inspected every month by testing with an accurate digital voltmeter.
If the voltage is above 12.4 volts - no action
If the voltage is below 12.39 volts - remove and recharge

It is important that the battery receives a freshening charge every 12 weeks (eight weeks in tropical climates).

Prior to delivery of a new unit the battery voltage should be over 12.59 volts, if not, remove and recharge.

Battery testing

Testing must commence at the source of supply, the battery itself. If the battery is discharged or unserviceable the readings in the other tests will be affected.

TEST 1 – Battery testing – Multimeter (Fig.1)

In order to obtain the best results from the battery, it must be maintained in the highest possible state of charge. This is best checked by measuring the open circuit voltage:

12.7+ Fully charged
12.4 50% charged
12.0 Discharged

The voltage should be measured with a digital voltmeter such as the MF3005.

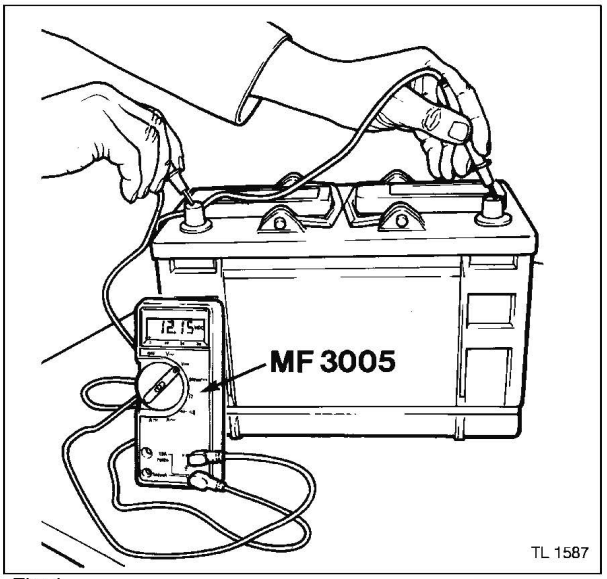


Fig.1

TEST 2 – Battery testing – hydrometer (Fig.2)

There is a relationship between the state of the battery charge and the strength of the electrolyte. As the battery becomes discharged, the specific gravity (S.G.) of the electrolyte becomes lower. The S.G. of the electrolyte is measured by means of an hydrometer.

From the S.G. readings, a fairly accurate indication of the state of the battery charge can be obtained.

State of charge	Specific gravity readings	
	Climates normally below 25^{0}C	Climates normally above 25^{0}C
Fully charged	1.270-1.290	1.210-1.230
70% charged	1.230-1.250	1.170-1.190
Discharged	1.110-1.130	1.050-1.070

NOTE: *The hydrometer readings should not be taken if the battery has only just been topped up. It should be charged for one to two hours before taking any reading.*

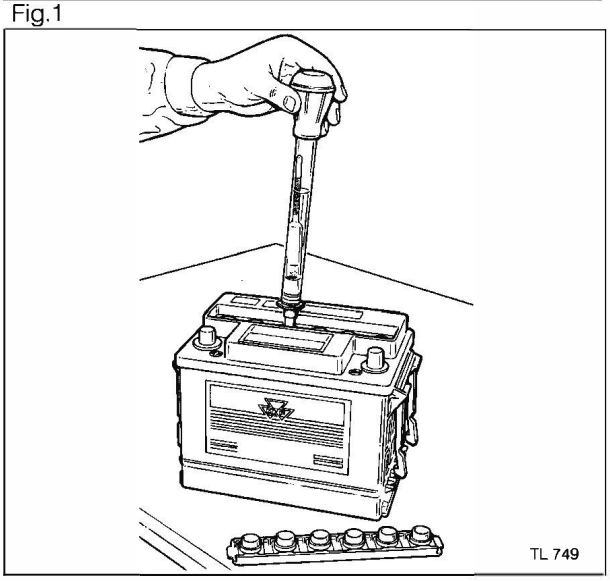


Fig.2

TEST 3 – Battery testing – heavy discharge test (Fig.3)

This test should be carried out as a further check on battery condition. A heavy discharge tester should be connected to the battery terminals as shown in Fig.2. The test ensures that the battery is capable of supplying the heavy currents required by the starter at the moment of starting the engine.

Connect the tester to the battery with the load OFF

Note the battery voltage, the load to be applied is dependent on the voltage in the battery, see chart as follows:

Battery voltage	Load to be applied
12.60 to 12.90	400 amps
12.40 to 12.55	300 amps
12.20 to 12.30	180 amps

Apply the appropriate load given in the chart above and note the voltage reading. The voltage reading should not fall below nine volts.

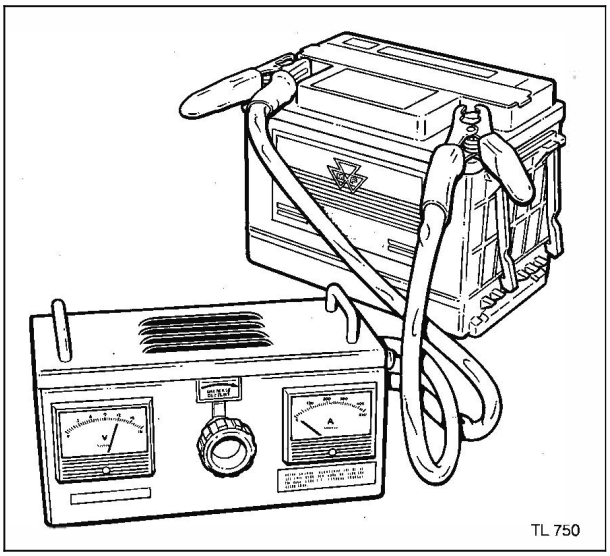


Fig.3

BATTERY

Removal and refitment **2.10B–03**

CAUTION: *When re-connecting the battery leads:*
Connect the positive lead (+) to the terminal marked '+' (red).
Connect the negative lead (-) to the terminal marked '-' (black).
The cover plates must be fitted at all times, except when checking the electrolyte level. Wipe the battery top and smear the terminals with petroleum jelly..

Removal

1. Remove the front grille or battery compartment cover.
2. Disconnect the battery cables, removing the negative (-) cable first in the interest of safety.

MF 275/283/290 tractors

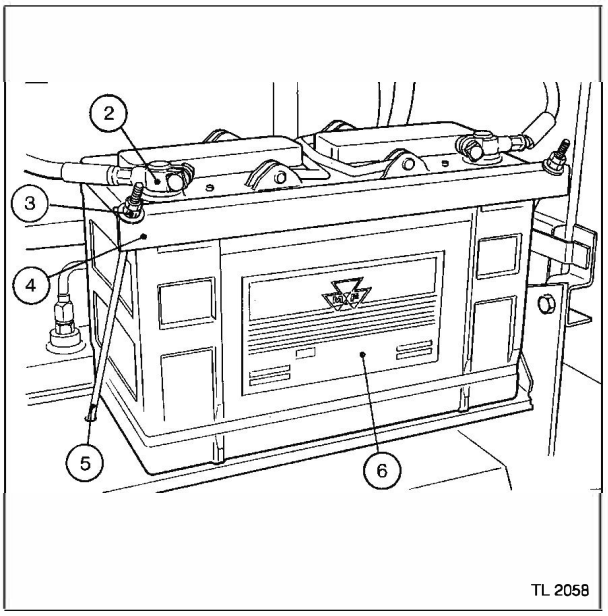
3. Remove the nuts and washers.
4. Remove the battery stay.
5. Lift out the battery stay rods.
6. Lift out the battery.

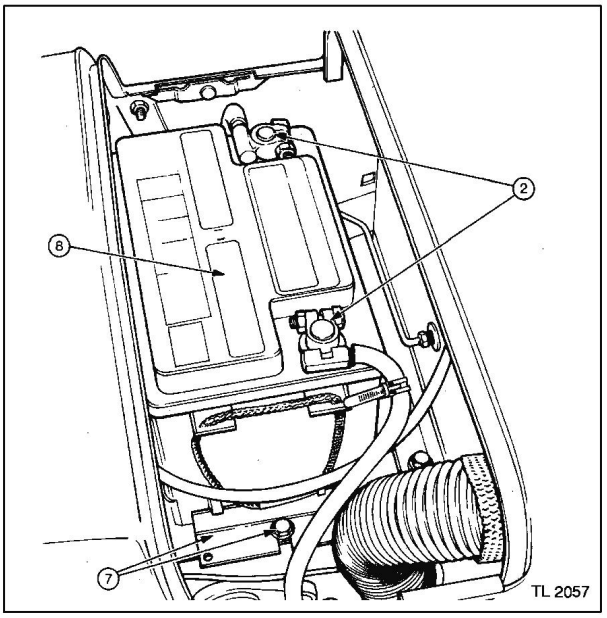
MF 230/240/253 tractors

7. Remove the battery clamp bolt and clamp.
8. Lift the battery up out of the compartment.

Refitment

9. Reverse procedures 1 to 8 except:
   a. Smear the battery terminals and stay rod nuts and/or battery clamp bolt with petroleum jelly.





Electrical System - Starter Motor

Section 10 – Part C

Table of Contents

Operation No.	Description	Page No.
-------	Specification	10C-2
-------	General description	10C-2
2.10C-01	Starter motor - Introduction	10C-3
2.10C-02	Starter motor testing - check	10C-3
2.10C-03	Neutral safety start switch - removal	10C-5
2.10C-04	PTO safety start switch - removal	10C-6
2.10C-05	Starter motor - removal	10C-6

Electrical System - Starter Motor

SPECIFICATION:

Voltage	12 volt negative ground
Starter motor	
Make	Magneti Marelli
Model	
MF 345 / MF 355	2M113
MF 350 / MF 360	M113
MF 375 / MF 385	M127
Voltage	12 volt
Type	Pre-engaged

Bolt torques

Starter motor terminals - M8	7 Nm
Starter solenoid terminals - M8	4 Nm

GENERAL DESCRIPTION

The electrical system for the 200 series tractor is 12 volt negative ground.

The starter motor is supplied in either standard-duty or heavy-duty form and it is mounted on the right-hand side of the 3 cylinder engine tractors and on the left-hand side of the 4 cylinder engine tractors.

A neutral safety start switch is fitted on the top of the transmission and on the PTO control lever. This renders the starter motor inoperative until the dual range selector lever is in the neutral position and the PTO lever in the disengaged position. A relay controls the supply to the starter solenoid to prevent voltage drop.

STARTER MOTOR

Introduction 2.10C–01

The starter is a motor which converts electrical energy, supplied from the battery, into mechanical energy for the purpose of cranking the engine.

The 300 series tractor uses the pre-engaged type which is fitted with a solenoid which engages the starter pinion with the flywheel ring gear before the starter is energised. After engagement the pinion is retained in mesh for as long as is necessary to start the engine. When the engine is firing and the pinion is being driven at high speed by the flywheel, the armature is protected against over-speeding by the flywheel action of an inbuilt clutch.

In the event of a problem with the starter motor or circuit the following procedure should be adopted:

Starter motor testing 2.10C–02

TEST 1–Checking battery condition (Fig.1)

Take the hydrometer reading of the battery cells to establish the state of the charge.

Diagnosis

Result	Action
Reading below 1.230	Recharge battery or replace and retest
Reading 1.230 - 1.290	Proceed to test 2

Alternative test (Fig.2)

Measure the open circuit voltage of the battery with the MF.3005 Digital Multimeter to establish the state of the charge.

Diagnosis

Result	Action
12 volts	Discharged battery - recharge
12.4 volts	50% charge - recharge
12.7 + volts	Fully charged

TEST 2 – Checking connections

Check that all battery, ground, starter motor and solenoid connections are clean and tight.

Diagnosis

Result	Action
Loose and/or dirty	Rectify
Satisfactory	Proceed to test 3

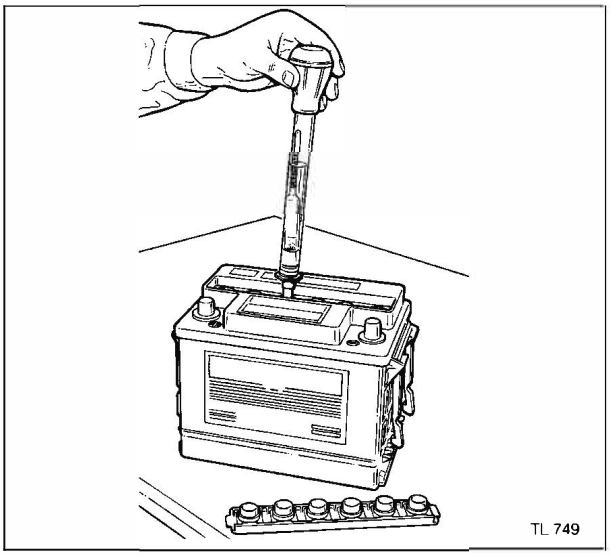


Fig.1

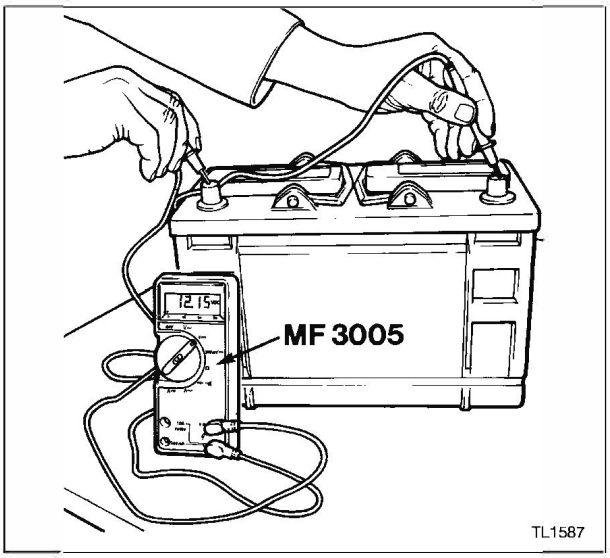


Fig.2

TEST 3 – Checking battery voltage on load (Fig.3)

Connect a voltmeter across the terminals, as shown in Fig.3, stop control out: operate the starter switch.

Diagnosis

Result	Action
Reading below 9 volts	Remove battery for recharging
Reading above 9 volts	Proceed to test 4

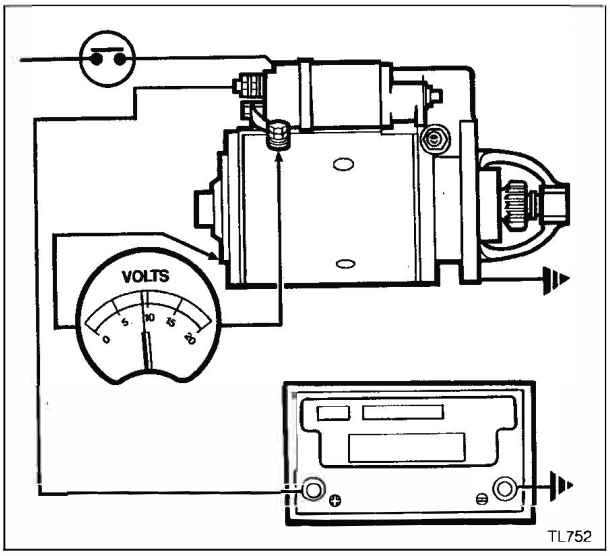


Fig.3

TEST 4 – Checking the voltage to the solenoid (Fig.4)

If the solenoid operates intermittently during the test or the engine is cranked at low or irregular speed, there may be insufficient voltage at the solenoid operating winding terminal or the solenoid is faulty.

To check the circuit for high resistance (poor connections) connect the voltmeter between the solenoid operating terminal and ground (commutator end bracket) as shown in Fig.4. When the switch contacts are closed, the reading on the voltmeter should be slightly less than the reading in the first part of test 1. A satisfactory reading indicates a negligible voltage drop in the circuit and consequently the fault may be in the solenoid.

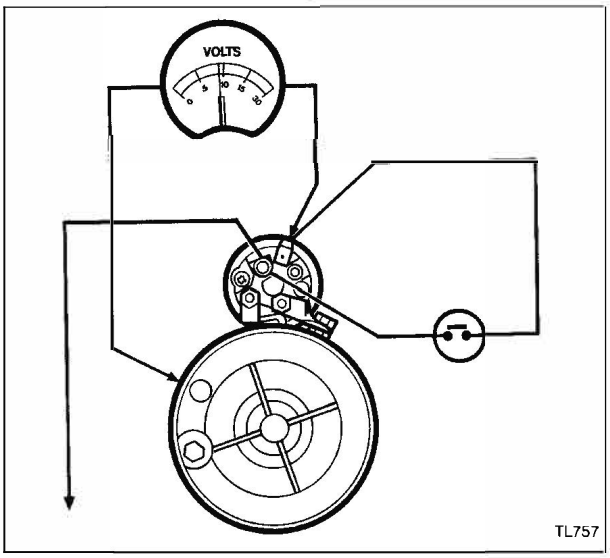


Fig.4

TEST 5 – Checking the starter terminal voltage under load conditions (Fig.5)

Connect a voltmeter between the starter input terminal and ground (commutator end bracket) as shown in Fig.5, stop control out, operate the starter switch.

Diagnosis

Result	Action
Difference in reading taken in test 3 - 0.5 volts	Check all connections
Same as in test 3	Proceed to test 5

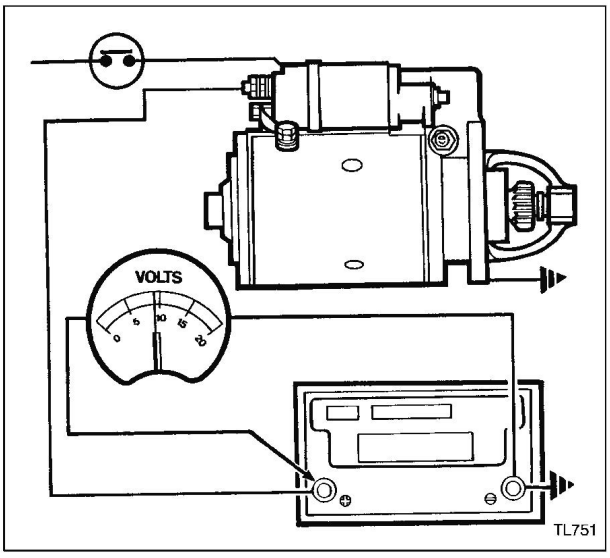


Fig.5

TEST 6 – Checking the voltage drop on the insulated line (Fig.6)

Connect a voltmeter between the starter input terminal and the battery positive (+) terminal as shown in Fig.6.

When the starter switch is open the voltmeter should register battery voltage. Stop control out, operate the starter switch.

Diagnosis

Result	Action
High voltage reading	Rectify faulty or dirty connections
Voltage reading practically zero	Proceed to test 6

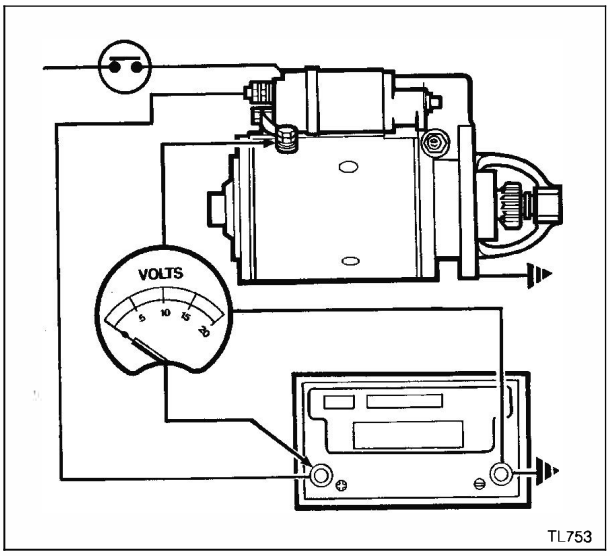


Fig.6

TEST 7 – Checking the voltage drop across the solenoid contacts (Fig.7)

Connect a voltmeter between the two main solenoid terminals as shown in Fig.7. When the starter switch is open the voltmeter should register battery voltage. Stop control out, operate the starter switch.

Diagnosis

Result	Action
High voltage reading (similar to test 5)	Faulty solenoid - replace
Voltage reading practically zero	Solenoid satisfactory

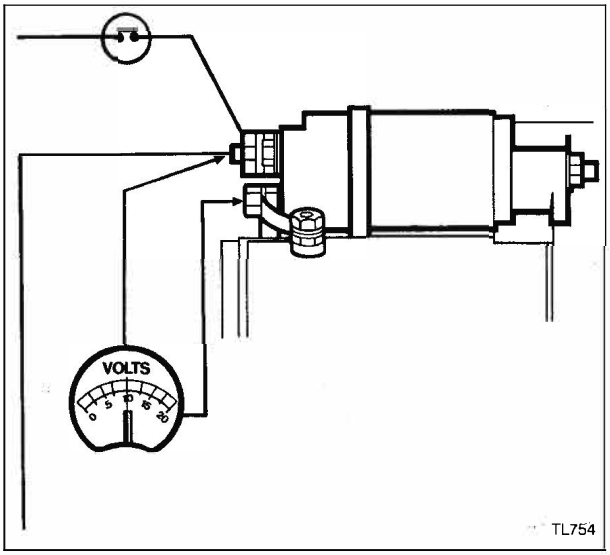


Fig.7

TEST 8 – Checking the voltage drop on the ground line (Fig.8)

Finally check the voltage drop on the ground line. Connect the voltmeter between the battery ground terminal,as shown in Fig.8, at the following points:

1. Starter commutator end bracket.
2. Starter body.
3. Engine.
4. Battery connection to ground.

With the stop control out, operate the starter switch.

Diagnosis

Result	Action
Above 0.5 volt	Check all ground connections between starter and battery
Voltage reading practically zero	Ground lines satisfactory

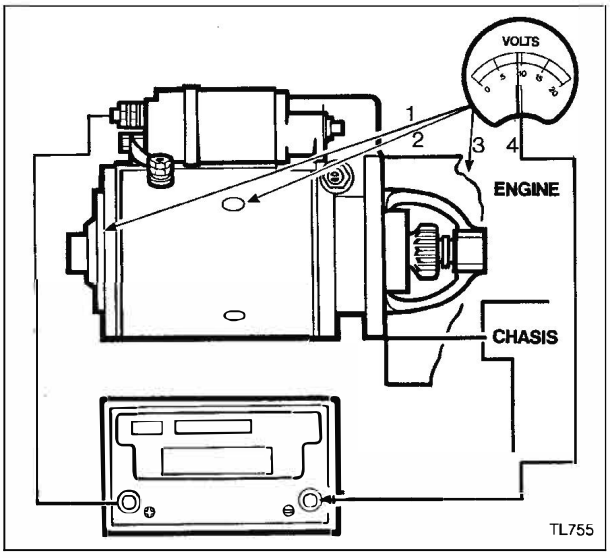


Fig.8

NEUTRAL SAFETY START SWITCH

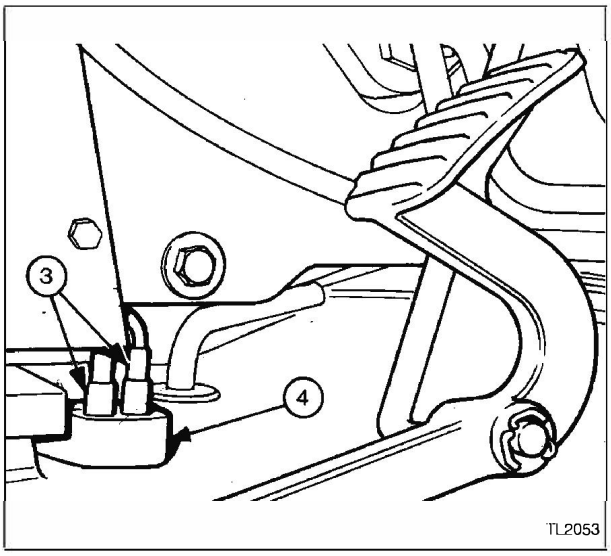
Removal and refitment **2.10C–03**

Removal

1. 230/240/253 tractors - Remove the battery compartment cover.
   275/283/290 tractors - Remove the front grille.
2. Disconnect the battery, removing the negative cable (-) first in the interest of safety.
3. Disconnect the two wires.
4. Unscrew the switch from the top of the gearbox.

Refitment

5. Reverse procedures 1 to 4.



PTO SAFETY START SWITCH

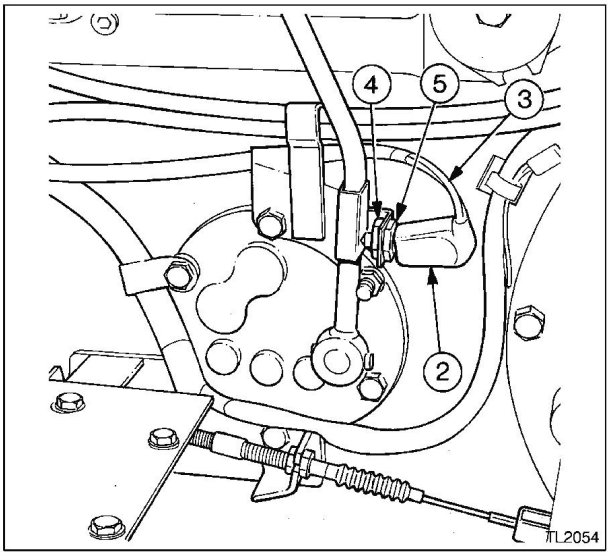
Removal and refitment **2.10C–04**

Removal

1. Disconnect the battery, removing the negative cable (-) first in the interest of safety.
2. Turn back the rubber cover.
3. Disconnect the two wires.
4. Unscrew the retaining nut.
5. Remove the switch.

Refitment

6. Reverse procedures 1 to 5.



STARTER MOTOR

Removal and refitment **2.10C–05**

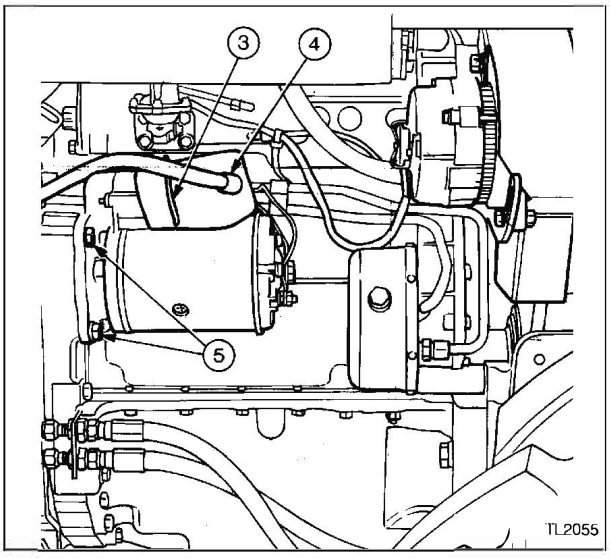
Removal

1. 230/240/253 tractors - Remove the battery compartment cover.
   275/283/290 tractors - Remove the front grille.
2. Disconnect the battery, removing the negative cable (-) first in the interest of safety.
3. Remove the clip and cover.
4. Disconnect the cables from the starter solenoid.
5. Remove the nuts and washers and/or mounting bolts.
6. Withdraw the motor, whilst supporting it from beneath.

Refitment

WARNING: All guards and covers over the electrical terminals on the starter MUST be replaced to prevent starting the engine by shorting across the terminals.

7. Reverse procedures 1 to 5 except:
   a. Tighten the starter motor terminal to a torque of 7 Nm.
   b. Tighten the solenoid terminal to a torque of 4 Nm.



Electrical System - Alternator

Section 10 – Part D

Table of Contents

Operation No.	Description	Page No.
-------	Specification	10D-2
-------	General description	10D-2
2.10D-01	Alternator - introduction	10D-3
2.10D-02	Alternator testing - adjust	10D-3
2.10D-03	Alternator belt tension - adjust	10D-7
2.10D-04	Alternator - removal and refitment	10D-8

Electrical System - Alternator

Specification:

Voltage	12 volt negative ground
Alternator - 230/240/253 tractors	
Make	Magneti Marelli
Type	A127-45
Max output	45 amp
Regulator	Machine sensed
Regulating voltage	14.2 ± 0.2 volts
Alternator - 275/283/290 tractors	
Make	Valeo
Type	9AR 2861K
Max output	55 amp
Regulator	Machine sensed
Regulating voltage	14.2 ± 0.2 volts

Bolt torques

Alternator pulley nut	60 Nm

General description

The alternator is mounted on the right hand side of the engine and is driven by a V-belt from the crankshaft pulley. Adjustment of the V-belt tension is provided for with a slotted link and clamp bolts.

ALTERNATOR

Introduction 2.10D–01

The alternator produces alternating current which is converted to direct current before being connected to the tractor electrical system. The alternator is provided to supply a source of electrical power used to charge the battery after starting and to operate all the tractors electrical services whilst the tractor is running.

Routine maintenance

Routine maintenance is limited to wiping away any oil or dirt from around the apertures on the alternator and cleaning any dust or chaff that has accumulated internally with a soft brush or air line.

Precautions in service

Various precautions should be taken to avoid damage to the semi-conductor components within the alternator.

1. Do not connect or disconnect any part of the charging circuit, including the battery, while the engine is running.
2. When using a slave battery, or battery charger always observe correct polarity (positive to positive, negative to negative).

Alternator testing (Fig.1) 2.10D–02

The following test will check for normal operation of the alternator by taking voltage and ampere readings at selected points in the circuit.

The alternator back cover has a plastic plug and socket supplying the charging circuit with three terminals (see Fig.1). The small terminal is the indicator (IND) connection from the charging warning light on the instrument panel. The two remaining terminals are the positive (+) connections to the battery, two are provided to reduce the load through the connectors and wiring.

TEST 1 – Battery test (Fig.2)

Using the hydrometer, check that the battery is at least 70% charged and in good condition. See Fig.2.

Diagnosis

Result	Action
Reading below 1.230	Recharge battery or replace and retest
Reading 1.230 - 1.290	Proceed to test 2 & 3

A battery fault can have an adverse effect on the charging system.

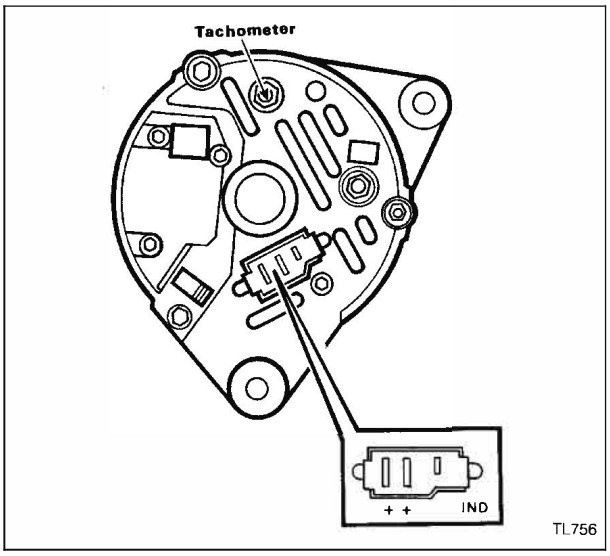


Fig.1

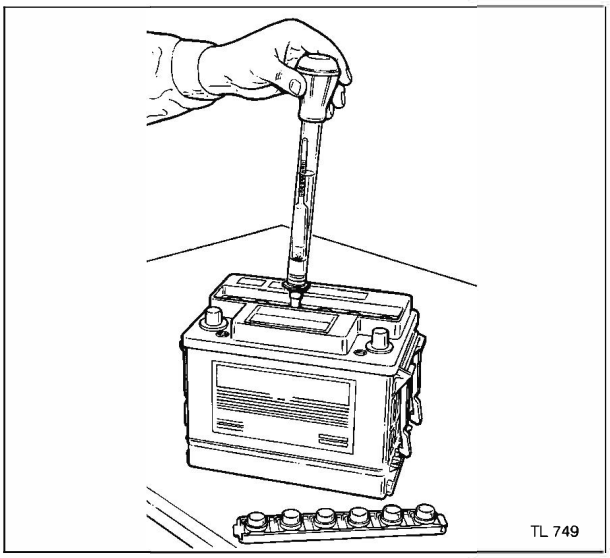


Fig.2

Alternative test (Fig.3)

Measure the open circuit voltage of the battery with the MF.3005 Digital Multimeter to establish the state of the charge.

Diagnosis

Result	Action
12 volts	Discharged battery - recharge
12.4 volts	50% charge - recharge
12.7 + volts	Fully charged

TEST 2 – Drive belt tension (Fig.4)

Allow 10 mm deflection on 3 cylinder engines, 19 mm on 4 cylinder engines, when moderate finger pressure is applied to the longest run at the belt, see 'A' Fig.3.

The alternator will not charge the battery if the belt is too slack. On the other hand, an excessively tight belt may damage the bearings.

If the belt is worn or oily, it must be replaced with a new Massey Ferguson belt.

Diagnosis

Result	Action
Belt slack	Adjust
Belt worn	Replace and adjust
Belt satisfactory	Proceed to test 3

TEST 3 – Wiring connections and continuity (Fig.5)

Ensure that all wires are in position and that connections are clean and tight.

Remove the plastic three pin plug from the alternator and connect the negative lead of the voltmeter to the battery ground, then connect the other lead to each terminal in the plug in turn A,B & C. When testing the small terminal (IND test A) the starter switch must be ON (NOT engine cranking).

The voltmeter should read battery voltage, if a zero reading is obtained on the small terminal (IND) check for faulty bulb in the alternator charging indicator light in the instrument panel.

Diagnosis

Result	Action
Reading below battery voltage	Check all wirings and connections
Readings of battery voltage	Proceed to test 4

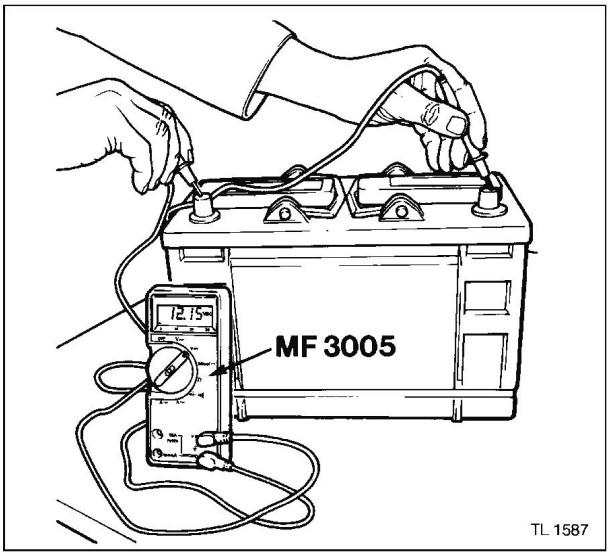


Fig.3

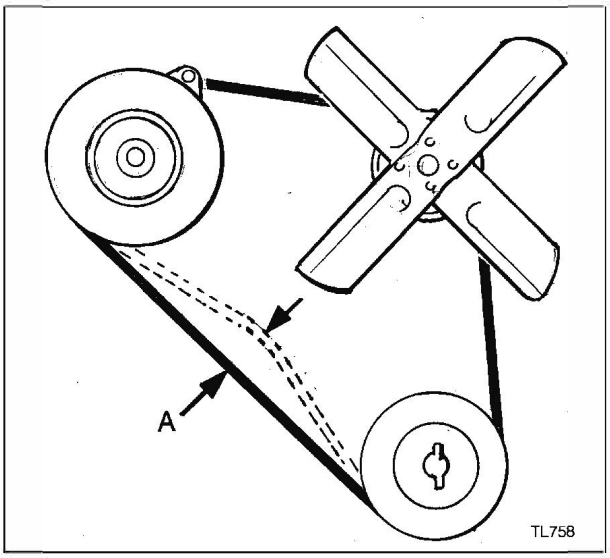


Fig.4

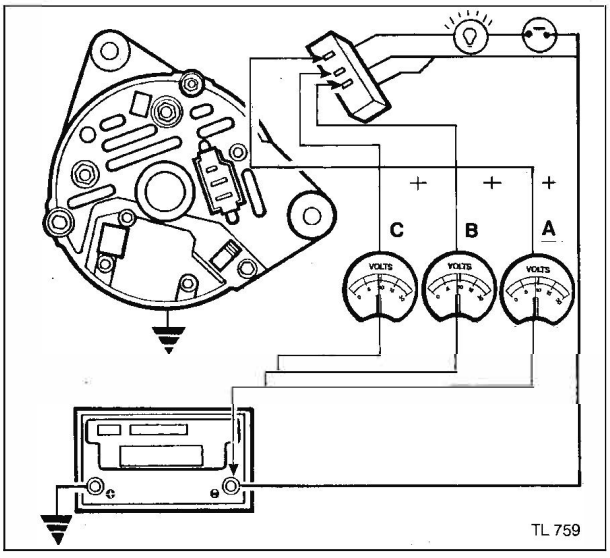


Fig.5

TEST 4 – Checking alternator maximum output (Fig.6)

The alternator should run for a few minutes to ensure that the tests are carried out at the normal operating temperature. Then stop the engine.

1. Switch on all lights to create a load, and discharge the battery for 1 minute.
2. Disconnect the battery ground cable.
3. Disconnect the plug on the back of the alternator.
4. Connect a test link (jump lead) between the small terminal (IND) on the alternator and the plug.
5. Connect the ammeter between one of the large terminals on the alternator and the plug.

NOTE: *The clips or test probes on the ammeter MUST NOT touch the alternator casing before or during the test. A short circuit will result which will damage the alternator.*

6. Re-connect the battery ground cable.
7. Switch on, check that the warning light comes on.
8. Start the engine and slowly increase to maximum rated speed, the ammeter reading should equal the maximum rated output of the alternator of 40-45 amps.

NOTE: *As the state of charge of the battery increases so the output of the alternator will decrease. The rated output of the alternator should be checked quickly.*

Diagnosis

Result	Action
Ammeter reading low	Replace or repair alternator
Ammeter reading 40-45 volts	Proceed to test 5

TEST 5 – Checking voltage drop in charging circuit (Fig.7)

Use a voltmeter to check for high resistance (poor connections) in the charging circuit, see Fig.7.

1. Connect a voltmeter between the battery insulated (+) terminal and the alternator main output terminal.
2. Switch on all lights to create a load. Start the engine and increase to maximum rated speed. The voltmeter reading should not exceed 0.5 volts.
3. Transfer the voltmeter connections to the battery ground (-) terminal and the alternator body.
4. Start and run the engine as in (2). The voltmeter reading should not exceed 0.25 volts.

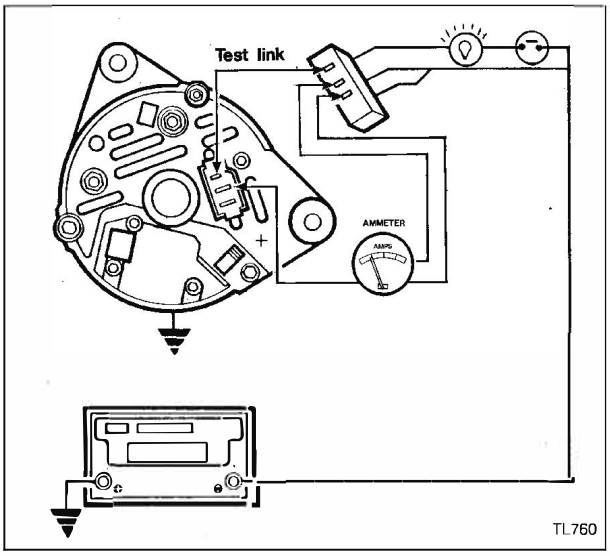


Fig.6

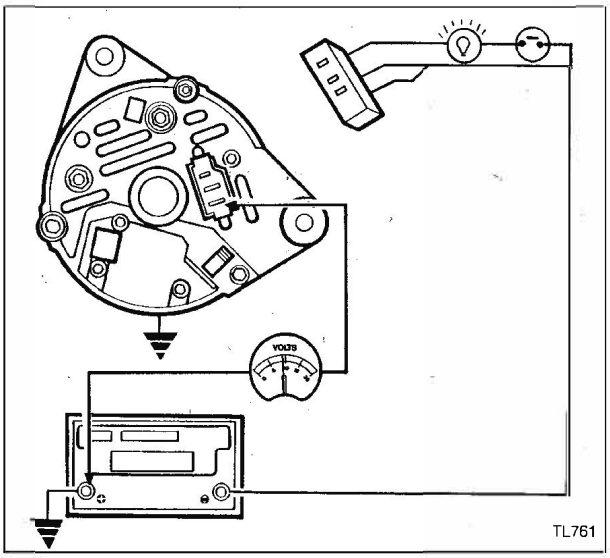


Fig.7

Diagnosis

Result	Action
2. Reading above 0.50 volts 4. Reading above 0.35 volts	Check all wiring for loose connections
Readings below 0.5 volts	Proceed to test 6

TEST 6 – Checking voltage regulator setting (Fig.8)
Before checking the voltage regulator setting, it is essential that a battery in a well charged condition is fitted to the tractor.

1. Disconnect the battery ground (-) cable.
2. Connect an ammeter between the starter solenoid terminal and the alternator main output cable.
3. Connect a voltmeter across the battery terminals. See Fig.8.
4. Reconnect the battery ground cable.
5. Start the engine and increase the speed until the ammeter reading is less than 10 amperes.

The voltmeter should be within the limits of 13.6 to 14.4 volts.

Diagnosis

Result	Action
Reading is unstable or outside specified limits	Voltage regulator faulty - replace
Reading13.6 - 14.4 volts	Regulatorsatisfactory

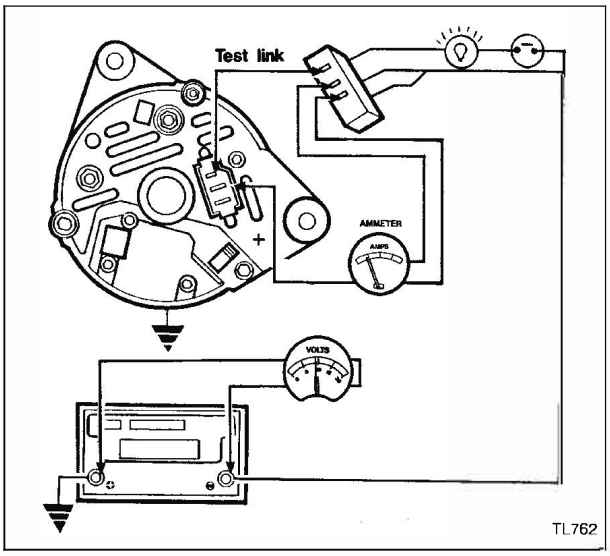
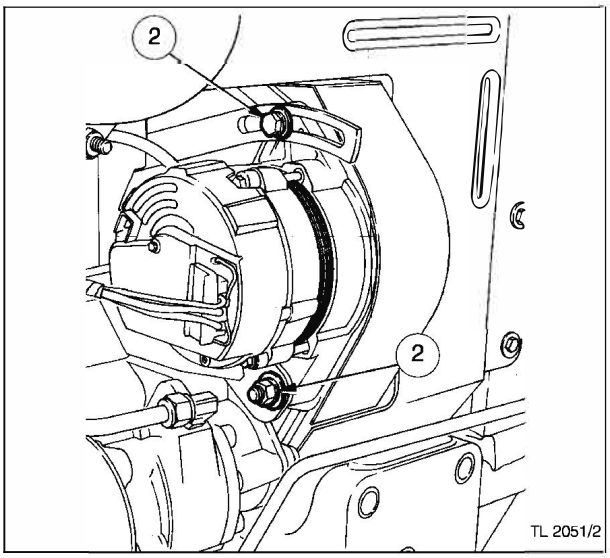


Fig.8



ALTERNATOR BELT TENSION

Adjust **2.10D–03**

Procedure

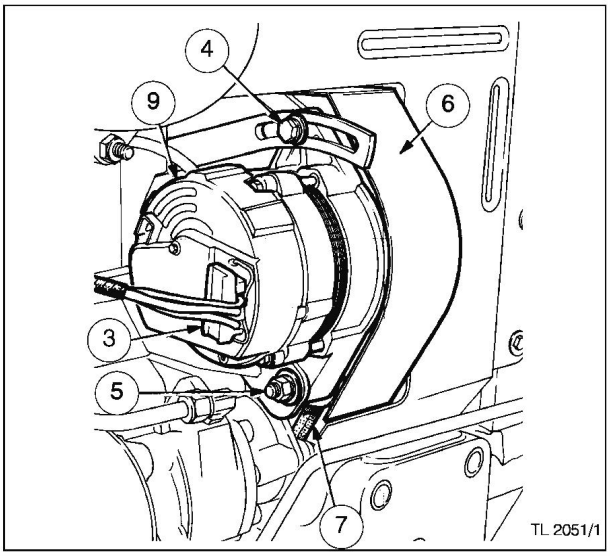
1. Check the belt tension at the centre of the longest span. It should be 10 mm for 3 cylinder engines, and 19 mm for 4 cylinder engines.
2. If the belt tension is incorrect, slacken the mounting bolts.
3. Adjust the tension.
4. Re-tighten the bolts and recheck the belt tension.

ALTERNATOR

Removal and refitment **2.10D–04**

Removal

1. 345 tractors:
   Remove the battery compartment cover.
   Other models:
   Remove the front grille.
2. Disconnect the battery, removing the negative cable (-) first in the interest of safety.
3. Remove the connector from the alternator terminals.
4. Slacken the pivot bolt.
5. Remove the clamp bolt.
6. Hinge the pulley guard upwards or downwards (depending on the model) whilst pushing the alternator towards the engine.
7. Remove the fan belt from the alternator pulley.
8. Whilst supporting the alternator, partially remove the pivot bolt.
9. Remove the alternator.
10. Remove the pulley guard and pivot bolt.



Refitment

11. Reverse procedures 1 to 10.
12. Adjust the belt tension, see operation 2.10D-03.
13. If the pulley has been removed tighten the nut to a torque of 60 Nm.

Left Blank Intentionally

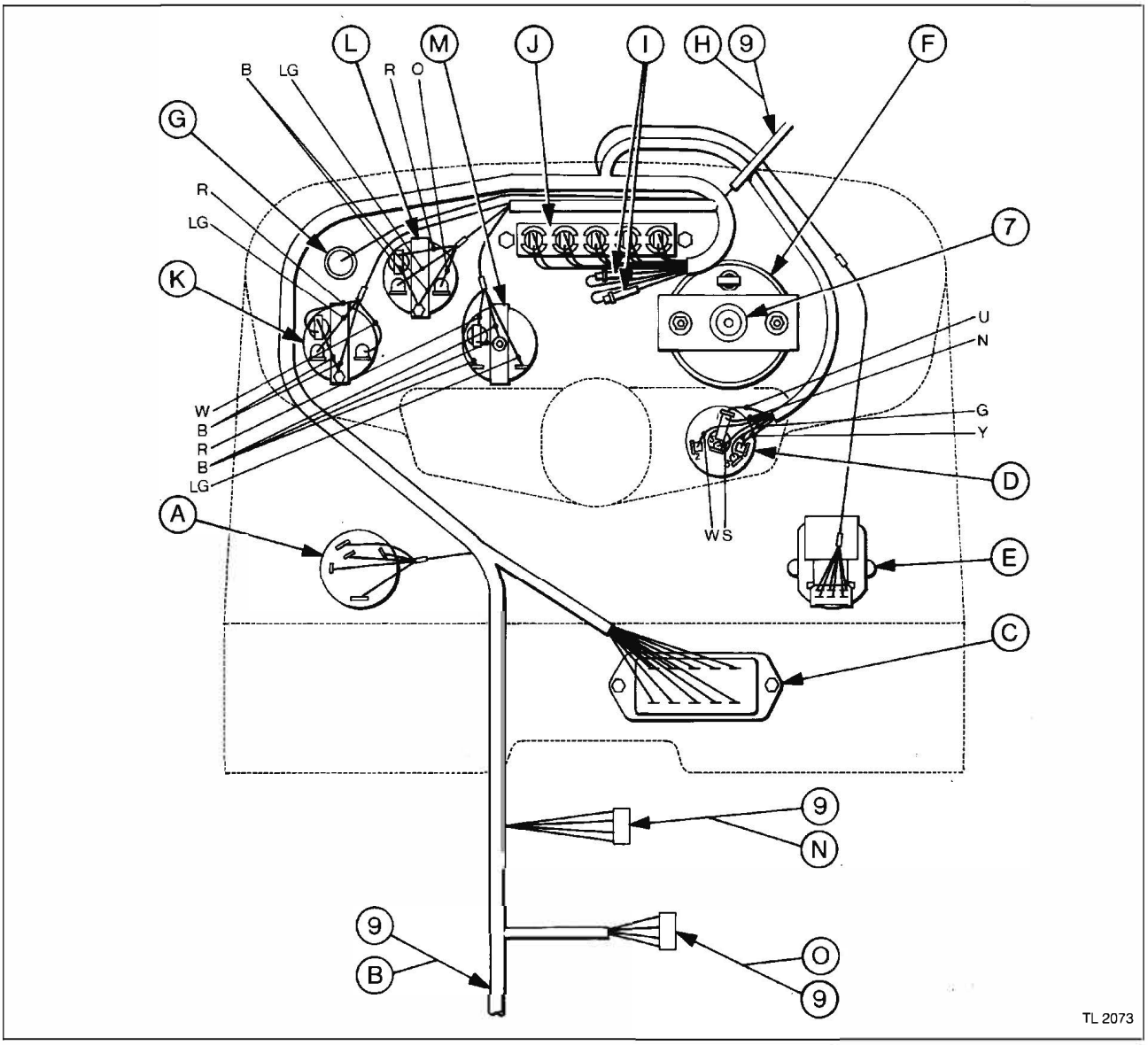
Electrical System - Wiring Diagrams

Section 10 – Part E

Table of Contents

Description	Page No.
Wiring diagram - instrument panel	10E-2
Wiring diagram - tractor	10E-3

INSTRUMENT PANEL WIRING

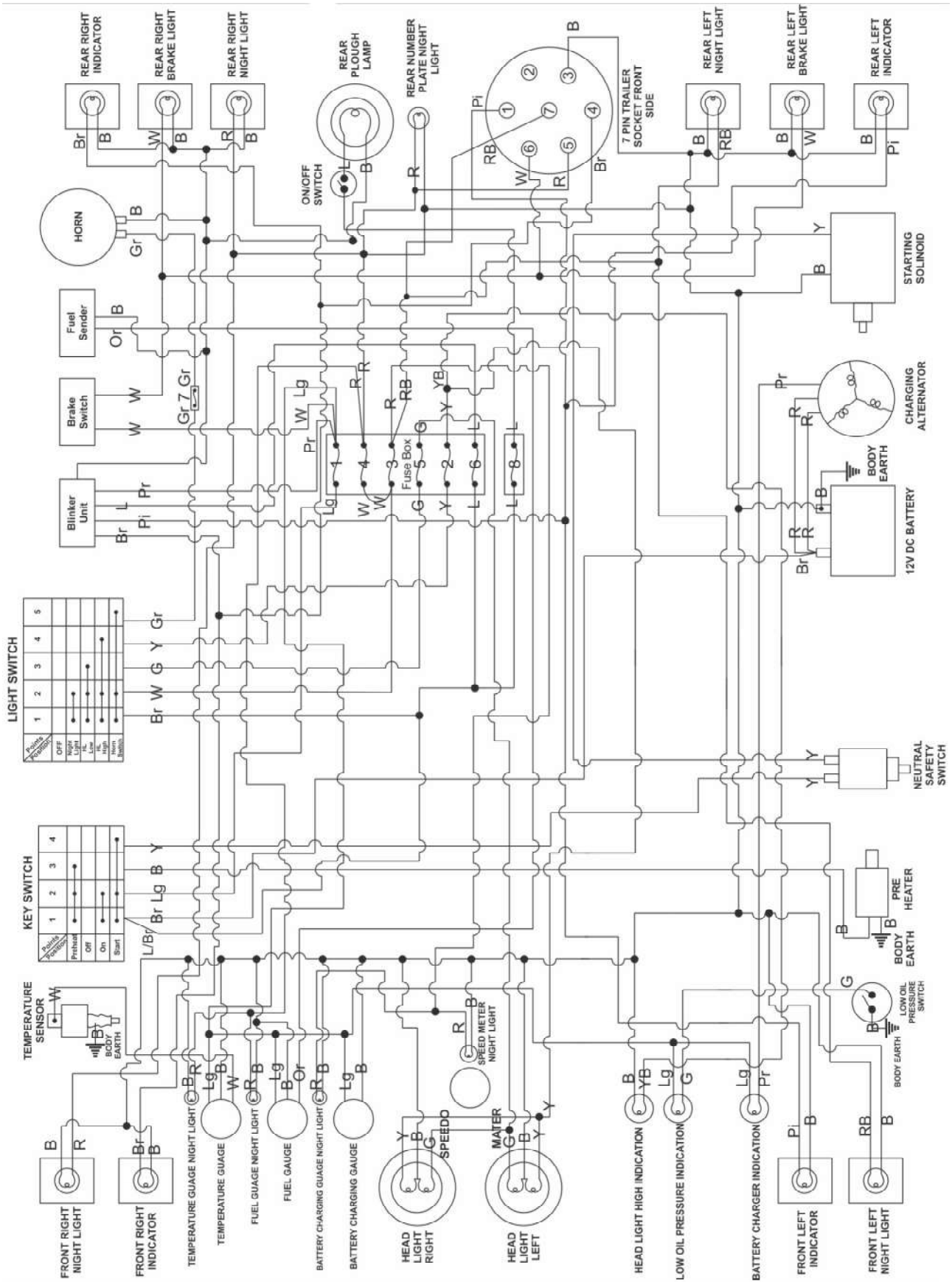


Key to wiring diagram

A.	Starter switch.
B.	To starter motor.
C.	Fuse box.
D.	Main light switch.
E.	Indicator and hazard warning switch.
F.	Tachometer.
G.	Cigar lighter.
H.	To fuel tank sender unit.
I.	Horn and indicator line fuse.
J.	Warning light panel.
K.	Engine water temperature gauge.
L.	Fuel gauge.
M.	Battery condition indicator.
N.	To rear harness.
O.	To front harness.

Wiring colour codes

B	Black.	R	Red.
G	Green.	RB	Red/Black.
K	Pink.	RN	Red/Brown.
LG	Light green.	RW	Red/White.
LU	Light blue.	S	Grey.
N	Brown.	U	Blue.
NW	Brown/White.	W	White.
O	Orange.	WG	White/Green.
P	Purple.	Y	Yellow.


REAR RIGHT INDICATOR
REAR RIGHT BRAKE LIGHT
REAR RIGHT NIGHT LIGHT
REAR PLOUGH LAMP
REAR NUMBER PLATE NIGHT LIGHT
7 PIN TRAILER SOCKET FRONT SIDE
REAR LEFT NIGHT LIGHT
REAR LEFT BRAKE LIGHT
REAR LEFT INDICATOR
HORN
ON/OFF SWITCH
Fuel Sender
Brake Switch
Blinker Unit
Fuse Box
STARTING SOLINOID
CHARGING ALTERNATOR
BODY EARTH
12V DC BATTERY
LIGHT SWITCH
KEY SWITCH
NEUTRAL SAFETY SWITCH
PRE HEATER
TEMPERATURE SENSOR
LOW OIL PRESSURE SWITCH
SPEED METER NIGHT LIGHT
SPEEDO
MATER
FRONT RIGHT NIGHT LIGHT
FRONT RIGHT INDICATOR
TEMPERATURE GUAGE NIGHT LIGHT
TEMPERATURE GUAGE
FUEL GUAGE NIGHT LIGHT
FUEL GAUGE
BATTERY CHARGING GUAGE NIGHT LIGHT
BATTERY CHARGING GAUGE
HEAD LIGHT RIGHT
HEAD LIGHT LEFT
HEAD LIGHT HIGH INDICATION
LOW OIL PRESSURE INDICATION
BATTERY CHARGER INDICATION
FRONT LEFT INDICATOR
FRONT LEFT NIGHT LIGHT

WIRING COLOR CODE		
Sr.#	Symbol	Color Name
1	Br	Brown
2	R	Red
3	B	Black
4	Lg	Light Green
5	W	White
6	Or	Orange
7	Y	Yellow
8	G	Green
9	Sb	Sky Blue
10	Yb	Yellow Black
11	Pi	Pink
12	Rb	Red Black
13	L	Blue
14	Gr	Grey
15	Pr	Purple

Front Face Blinker Socket

Br		Pi
Pr	B^{-ve}	L^{+ve}

KEY SWITCH

Points / Position	1	2	3	4
Preheat	●	●	●	
Off				
On	●	●		
Start	●	●		●

IN LINE CIRCUIT FUSE PROTECTION

Fuse Number	TYPE	Ampere
1	1.Blinker 2.Brake Switch 3.Guages 4.Indication Lights	20A
2	Head Lights High	20A
3	Night Lights	10A
4	Night Lights	10A
5	Head Lights Low	20A
6	Blinker	7.5A
7	Horn	5A
8	Plaugh Lamp	5A

LIGHT SWITCH

Points / Position	1	2	3	4	5
OFF					
Night Light	●	●			
HL Low	●	●	●		
HL High	●	●		●	
Horn	●	●			●

SECTION 11

Service Tools

INDEX

11A SERVICE TOOLS - GENERAL

Service Tools

Section 11 – Part A

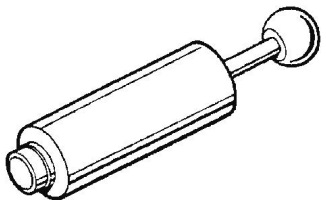
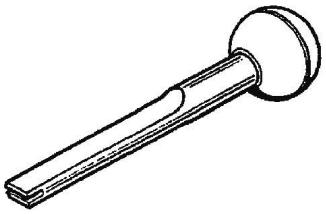
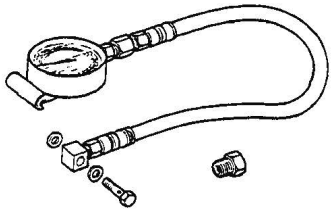
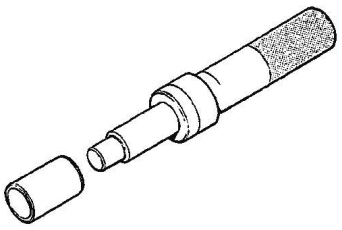
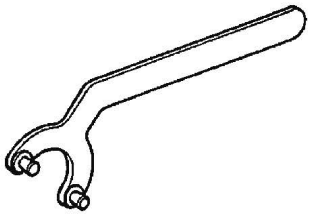
Table of Contents

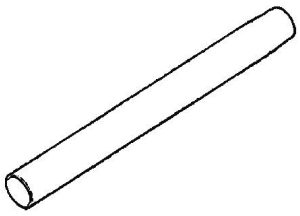
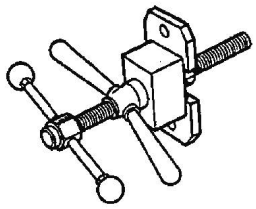
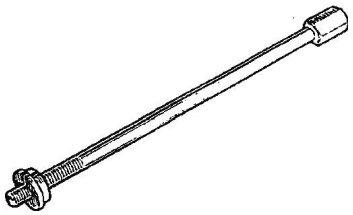
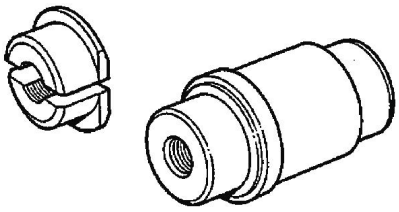
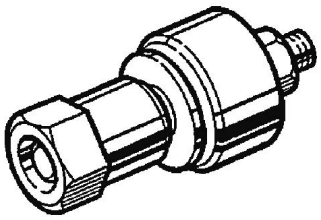
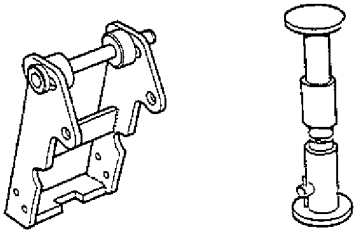
Section No.	Description	Page No.
------	Special Service Tools	11A-2

The importance of the use of approved special tools can hardly be over-emphasised. They are essential if service operations are to be carried out efficiently and safely. The amount of time which they save can be considerable.

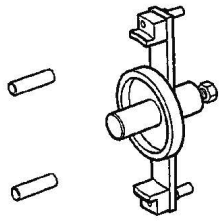
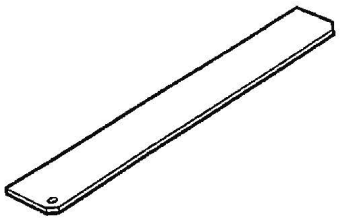
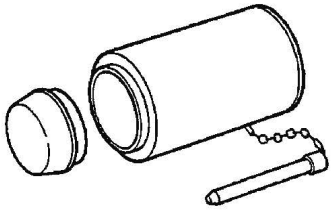
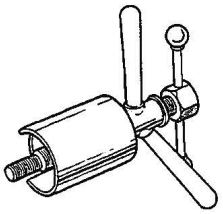
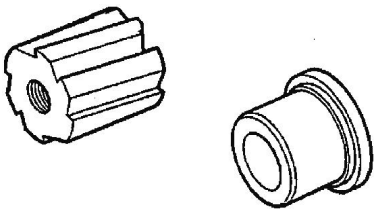
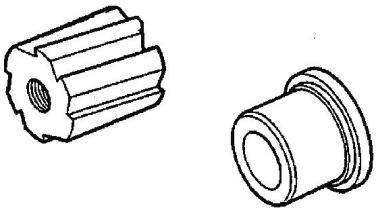
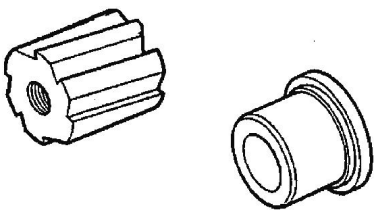
The following pages illustrate the current range of Special Service Tools used on the 300 series range of tractors.

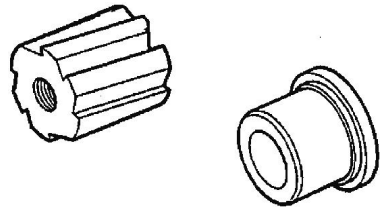
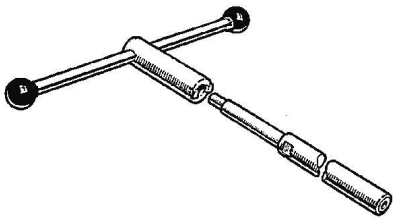
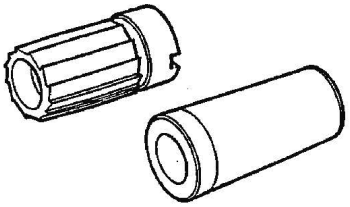
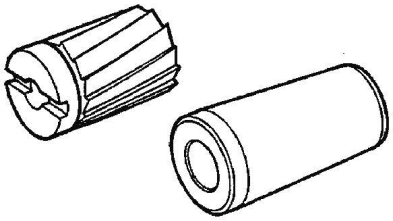
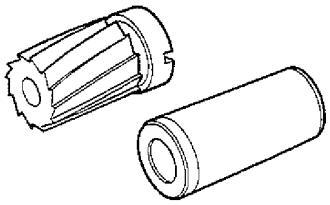
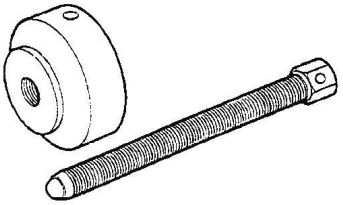
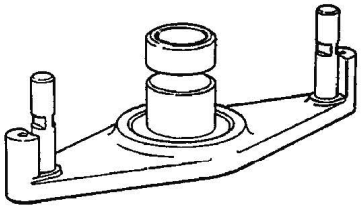
Service Tools

Tool number	Description	Illustration
MF.26C	Wrench	
MS.62B	'O' ring and Kin-ring fitting tool	
MS.63	Plate springs installing tool	
MF.148B	Pressure test gauge	
MF.159B	Clutch centraliser	
MF.163	Spring retainer nut wrench	
MF.168	PTO shaft oil seal remover and bush replacer	

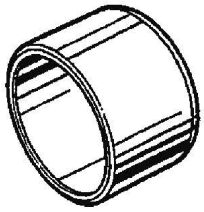
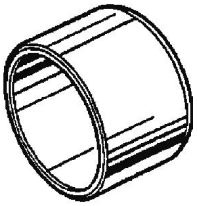
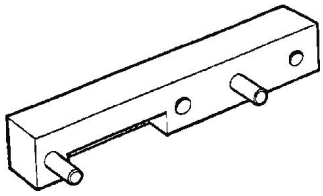
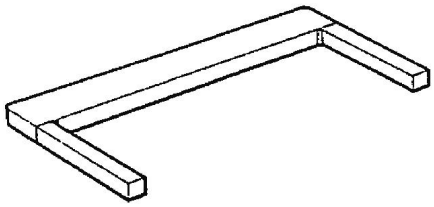
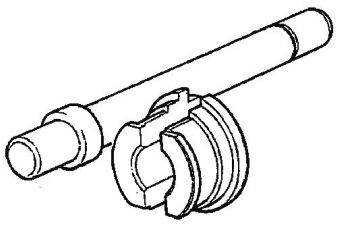
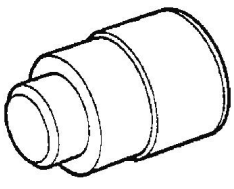
Tool number	Description	Illustration
MF.177A	Input shaft oil seal protector	
MF.195C	PTO shaft needle bearing remover/replacer - main tool	
MF.195-5B	PTO shaft needle bearing remover	
MF.195-6B	PTO shaft needle bearing replacer Used with MF.195-5B	
MF.215	Clutch setting gauge	
MF.218B	PTO bearing housing replacer	
MF.226C	Lift cover remover/replacer	

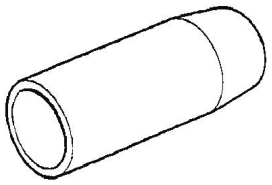
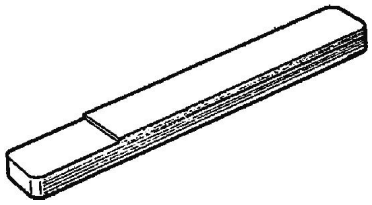
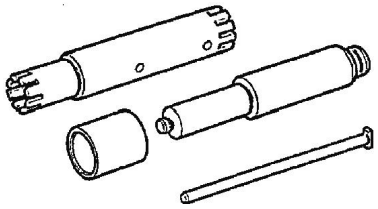
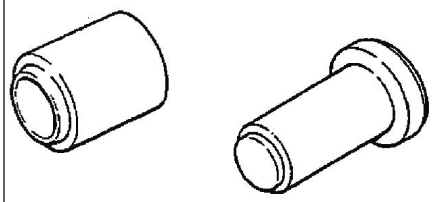
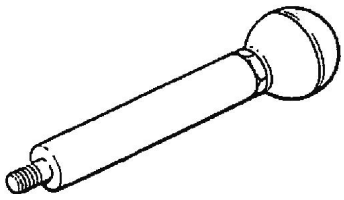
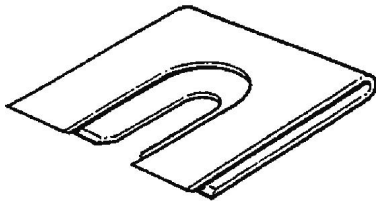
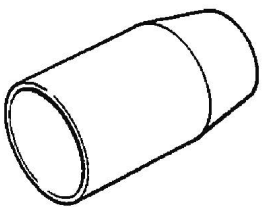
Service Tools

Tool number	Description	Illustration
MF.245D	Differential bearing pre-load gauge	
MF.245D-1	Straight edge	
MF.255B	PTO input shaft oil seal replacer	
MF.263	Front axle and steering bush remover (main tool)	
MF.263-1	Front axle and steering bush remover/replacer adaptors 1 1/4 in diameter bushes Used with MF.263 and MS.550	
MF.263-2	Front axle and steering bush remover/replacer adaptors 1 1/2 in diameter bushes Used with MF.263 and MS.550	
MF.263-3	Front axle and steering bush remover/replacer adaptors 1 7/8 in diameter bushes Used with MF.263 and MS.550	

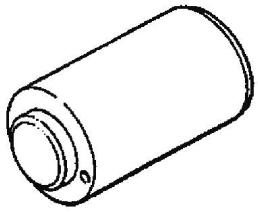
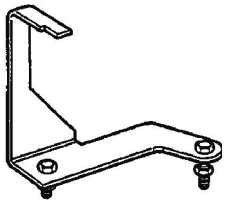
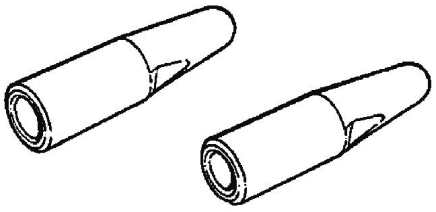
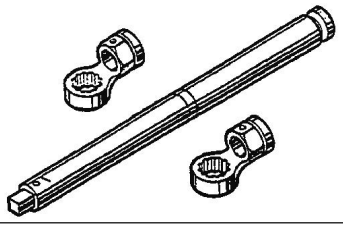
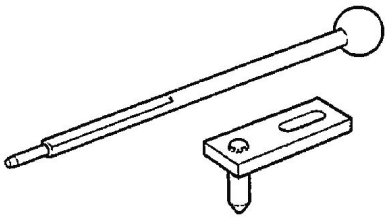
Tool number	Description	Illustration
MF.263-5	Front axle and steering bush remover/replacer adaptors 1 3/4 in diameter bushes Used with MF.263 and MS.550	
MF.264	Front axle and steering bush reamer main tool	
MF.264-1	Reamer and pilot 1 1/2 in diameter bushes Used with MF.264	
MF.264-2	Reamer and pilot 1 7/8 in diameter bushes Used with MF.264	
MF.264-8	Reamer and pilot 1 3/48 in diameter	
MF. 265C	Epicyclic planetary carrier remover	
MF. 267A	Epicyclic pre-load gauge	

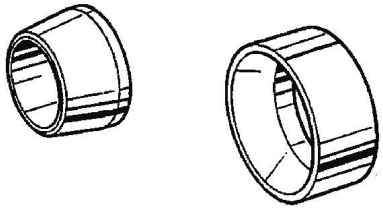
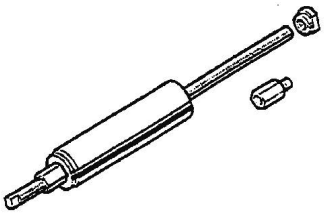
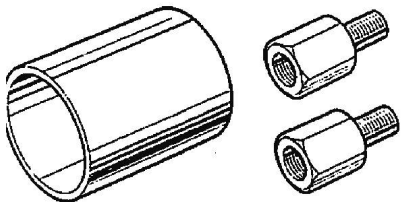
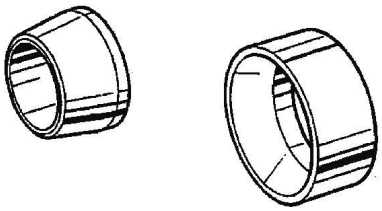
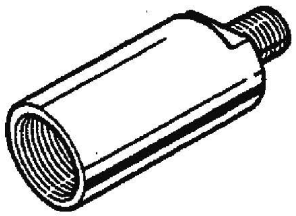
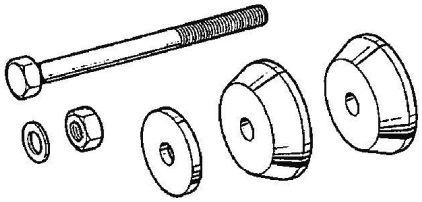
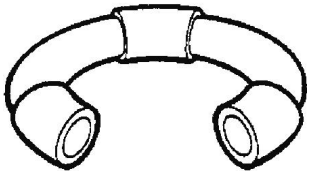
Service Tools

Tool number	Description	Illustration
MF. 267-1	Sleeve - normal-duty axle	
MF. 267-2	Sleeve - heavy-duty axle	
MF. 272A	Ram arm gauge fixture	
MF. 295B	Wheel stud guide sleeves	
MF.314	Clutch release lever height setting gauge - 12 in clutch	
MF.315A	PTO input shaft needle roller bearing remover/replacer	
MF.331	(Part of MF.267A) Input shaft oil seal remover	

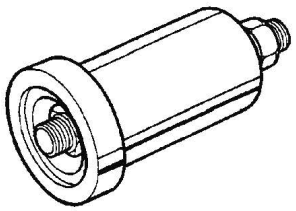
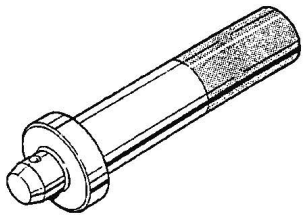
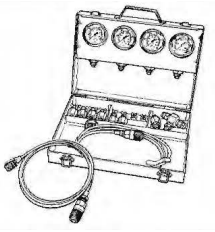
Tool number	Description	Illustration
MF.332	Hydraulic pump oil seal protector	
MF.333	Draft control rod gauge	
MF.349	Pump valve facing cutter and coining tool. Included in kit MF.355	
MF.350	Pump valve chamber circlip replacer. Included in kit MF.355	
MF.351	Pump valve chamber plug remover replacer. Included in kit MF.355	
MF.352	Control valve spring retainer clip. Included in kit MF.355	
MF.353	Control valve body 'O' ring guide. Included in kit MF.355	

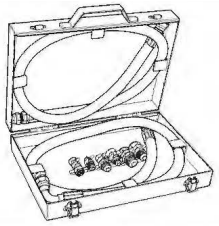
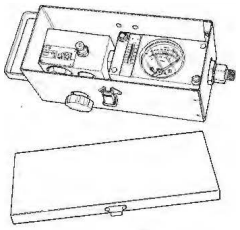
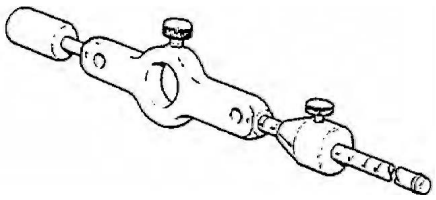
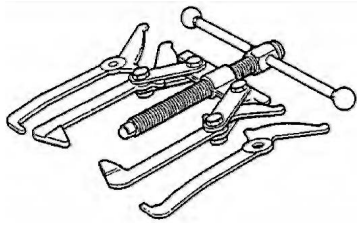
Service Tools

Tool number	Description	Illustration
MF.354	Control valve body replacer. Included in kit MF.355	
MF.356E	Position and draft control setting gauge. Included in kit MF.360	
MF.364A	PTO shaft oil seal replacer	
MF.366	PAVT wheel guide pegs	
MF.367B	Transmission case ring spanner set	
MF.414A	Synchromesh setting pin	
MF.415	Synchromesh assembly tool	

Tool number	Description	Illustration
MF.420	Hydraulic ram piston seal replacer (79 mm diameter)	
MF.444	Axle pivot pin remover 1 7/8 inch diameter	
MF.451B	Four-wheel drive swivel pin remover (used with MF.195C)	
MF.453	Hydraulic ram piston seal replacer (94,5 mm diameter)	
MF.455	Relief valve testing capsule	
MF.471A	Differential lock spring compressor	
MF.473	Steering wheel puller	

Service Tools

Tool number	Description	Illustration
MF.474	Rear PTO shaft dust seal replacer	
MF.490	Four-wheel drive Cassette seal installer	
MS.550	Universal handle	
MS.555	Adjustable puller Main tool	
MS.555-2B	Right-hand differential bearing remover	
MS.1713	30 tonne hydraulic puller	
MF.3001A	Pressure test kit	

Tool number	Description	Illustration
MF.3002	Hose test kit	
MF.3003	Hydraulic flow meter (60 litre/minute)	
MF.3012	Tractor splitting track	
FT.4062A	Bearing pre-load tool	
6312A (18G.2)	Universal puller	

© AGCO Corporation, 2016. All rights reserved.
ACT0027090 (English)
June 2016

PDF
DOWNLOAD