NOTE

The information contained within this manual is applicable to both the New Holland Series 40 and Series S range of tractors. There is information contained within that is not currently applicable to the Series S tractor. Throughout the manual the terms S, SL and SLE are mentioned, these terms are not applicable to the Series S, but where S is mentioned this refers to a tractor with 8x2 transmisson, SL to a tractor with 12x12 transmission and SLE to a tractor with a 16x16 transmission. As the product and model numbers have not been updated in the manual, transpose as follows:

For	–	Read
Series 40	–	Series S
6640	–	S90
7740	–	S100
S	–	8x2 Transmission
SL	–	12x12 Transmission
SLE	–	16x16 Transmission

After Sales Service
Europe

NEW HOLLAND

Repair Manual – Series 40 and Series S Tractors

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SE 4840–8
English

CONTENTS (Continued)

FOREWORD

Appropriate service methods and correct repair procedures are essential for the safe, reliable operation of all equipment as well as the personal safety of the individual performing the repair.

This Repair Manual provides fault finding, overhaul and pressure testing instructions using recommended procedures and equipment. Following these instructions will ensure the safe, efficient and timely completion of the service or repair. Anyone who departs from these instructions should be aware that they do so at the risk of compromising their own personal safety and the safety of others.

Throughout this Manual you will see text in *italics*, preceded by the words **NOTE, IMPORTANT** or **WARNING.** Such text has the following significance.

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The Manual is divided into Parts, each sub–divided in turn into Chapters. Each Chapter contains information on general operating principles, detailed inspection, overhaul and where applicable, specific trouble shooting, special tools and specifications. Any reference in this Manual to right, left, rear, front, top or bottom, is as viewed from the Operator's seat, looking forward.

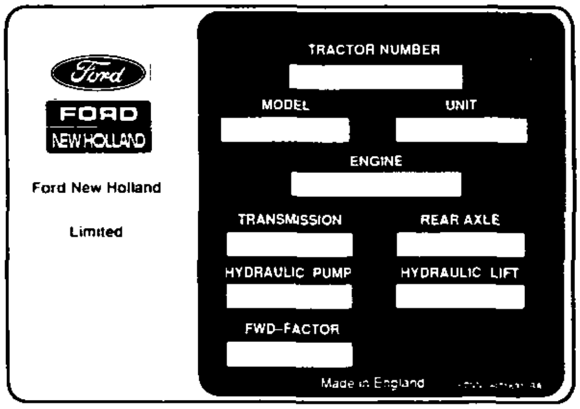
All data and illustrations in this Manual are subject to variations in build specification. This information was correct at the time of issue, but Ford New Holland policy is one of continuous improvement and the right to change specifications, equipment or design at any time, without notice, is reserved.

PRODUCTION DATE CODES AND SERIAL NUMBERS

Series 40 Tractors have an identification plate located under the right–hand hood panel.

Whenever effecting a repair or overhaul, the relevant information should be noted and used when referring to Service Bulletins and/or the Parts Catalogue.

TRACTOR IDENTIFICATION PLATE



358–176

This plate is stamped with the following information:

- **TRACTOR NUMBER** –
  Serial number prefixed by the letters 'BD'.
- **MODEL** –
  Production model code.
- **UNIT** –
  Production unit date code.
- **ENGINE** –
  Serial number and engine production date code.
- **TRANSMISSION** –
  Transmission production date code.
- **REAR AXLE** –
  Rear axle production date code.
- **HYDRAULIC PUMP** –
  Hydraulic pump production date code.
- **HYDRAULIC LIFT** –
  Hydraulic power lift production date code.
- **FWD FACTOR** –
  Four wheel drive factor.

KEY TO PRODUCTION DATE CODES:–

First Number YEAR	First Letter MONTH		Second Number DAY OF MONTH	Second Letter PRODUCTION SHIFT
1–1991	A–Jan.	G–July	01/28/29/30/31	A–Midnight
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5–1995	E–May	L–Nov.		
	F–June	M–Dec.		

Example of Production Unit Date Code 2 A 0 3 B

Year of Production (1992) | Month of Year (January) | Day of Month (Third) | Shift Period (Day)

CAB, ROPS POST AND FOUR WHEEL DRIVE AXLE IDENTIFICATION PLATES

Figure 1

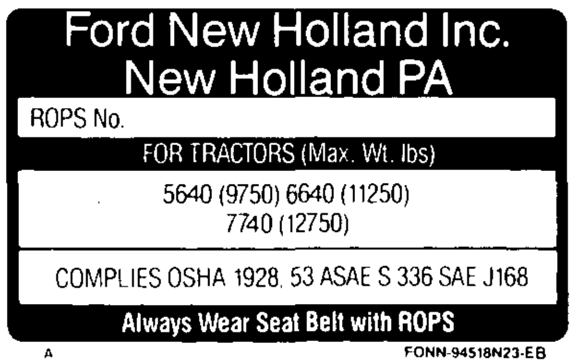

Figure 2

The cab/ROPS identification plate, Figure 1 and Figure 2, are located on the left–hand side of the "Cab" below the windscreen, or the right–hand side "ROPS" post (where fitted).

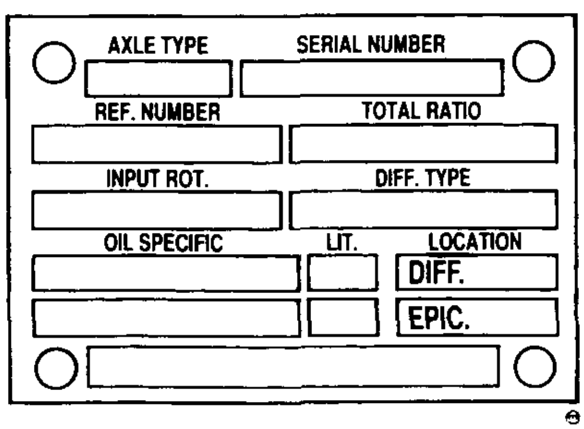

Figure 3

FUEL INJECTION PUMP DATE CODES

The fuel injection pumps carry an identification plate with the pump type number, serial number and manufacturer's production date code. The date code can be identified by reference to the following chart:

MONTH	1991 – 1994 CODE	YEAR	CODE
January	A	1991	J
February	B		
March	C	1992	K
April	D		
May	E	1993	L
June	F		
July	G	1994	M
August	H		
September	J	1995	N
October	K		
November	L	1996	O
December	M		

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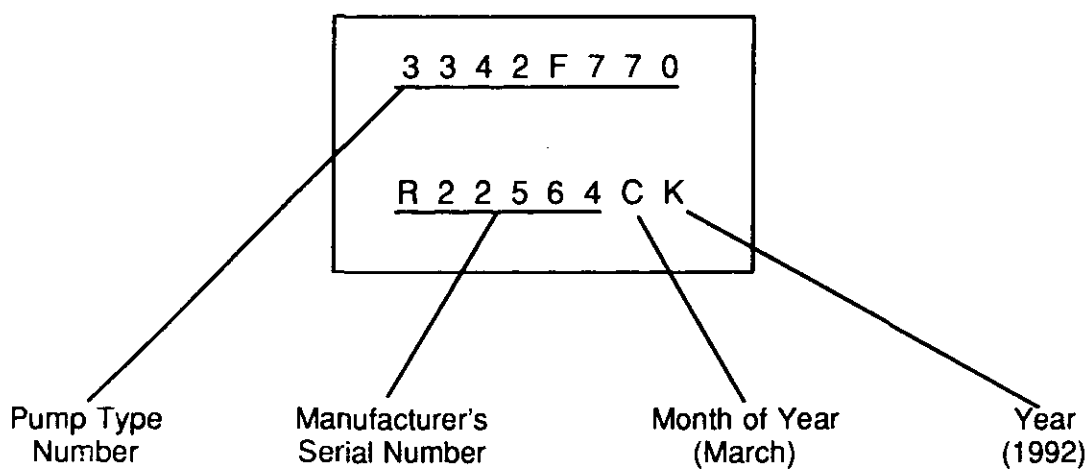

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After Sales Service
Europe

NEW HOLLAND

NEW HOLLAND SERVICE

Repair Manual – Series 40 and Series S Tractors

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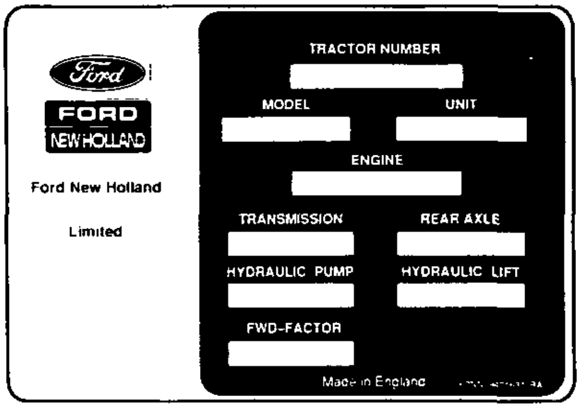

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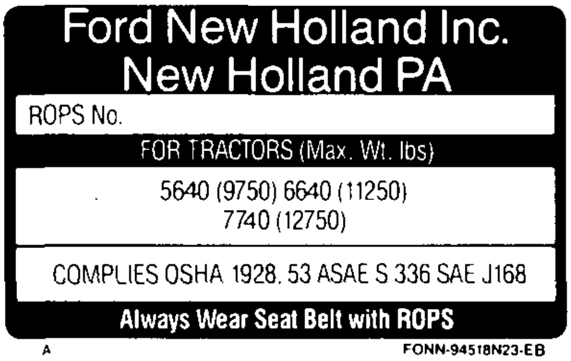

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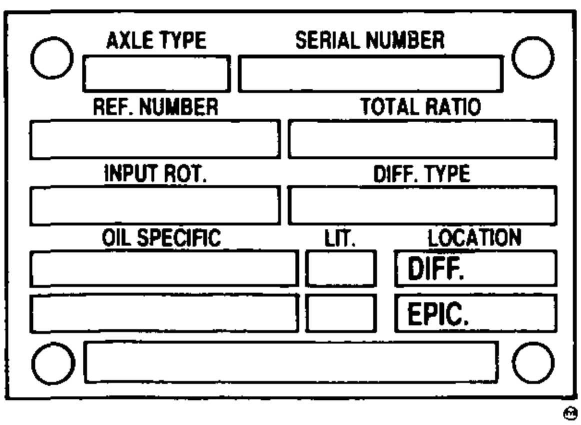

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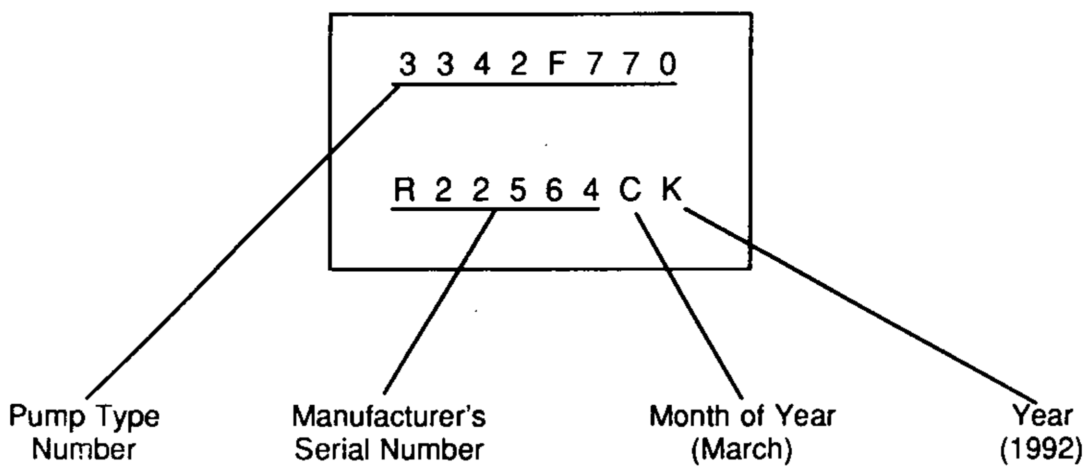

HEALTH AND SAFETY

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HEALTH AND SAFETY PRECAUTIONS

Many of the procedures associated with vehicle maintenance and repair involve physical hazards or other risks to health. This section lists, alphabetically, some of these hazardous operations and the materials and equipment associated with them. The precautions necessary to avoid these hazards are identified.

The list is not exhaustive and all operations and procedures and the handling of materials, should be carried out with health and safety in mind.

ACIDS AND ALKALIS – see Battery acids, e.g. caustic soda, sulphuric acid.

Used in batteries and cleaning materials.

Irritant and corrosive to the skin, eyes, nose and throat. Causes burns.

Avoid splashes to the skin, eyes and clothing. Wear suitable protective gloves and goggles. Can destroy oridnary protective clothing. Do not breathe mists.

Ensure access to water and soap is readily available for splashing accidents.

ADHESIVES AND SEALERS – see Fire

Highly Flammable, Flammable, combustible.

Generally should be stored in "No Smoking" areas; cleanliness and tidiness in use should be observed, e.g. disposable paper covering benches; should be dispensed from applicators where possible; containers, including secondary containers, should be labelled.

Solvent based Adhesives/Sealers – See Solvents.

Follow manufacturers instructions.

Water based Adhesives/Sealers

Those based on polymer emulsions and rubber lattices may contain small amounts of volatile toxic and harmful chemicals. Skin and eye contact should be avoided and adequate ventilation provided during use.

Follow manufacturers instructions.

Resin based Adhesives/Sealers – e.g. epoxide and formaldehyde resin based.

Mixing should only be carried out in well ventilated areas as harmful or toxic volatile chemicals may be released.

Skin contact with uncured resins and hardeners can result in irritation; dermatitis and absorption of toxic or harmful chemicals through the skin. Splashes can damage the eyes.

Provide adequate ventilation and avoid skin and eye contact. Follow manufacturers instructions.

Anaerobic, Cyanoacrylate and other Acrylic Adhesives

Many are irritant, sensitizing or harmful to the skin. Some are eye irritants.

Skin and eye contact should be avoided and the manufacturers instructions followed.

Cyanoacrylate adhesives (super–glues) must not contact the skin or eyes. If skin or eye tissue is bonded cover with a clean moist pad and get medical attention. do not attempt to pull tissue apart. Use in well ventilated areas as vapours can cause irritation of the nose and eyes.

For two–pack systems see Resin based adhesives/sealers.

Isocyanate (Polyurethane) Adhesives/ Sealers – see Resin based Adhesives.

Individuals suffering from asthma or respiratory allergies should not work with or near these materials as sensitivity reactions can occur.

Any spraying should preferably be carried out in exhaust ventilated booths removing vapours and spray droplets from the breathing zone. Individuals working with spray applications should wear supplied air respirators.

ANTIFREEZE – see Fire, Solvents e.g. Isopropanol, Ethylene Glycol, Methanol.

Highly Flammable, Flammable, Combustible.

Used in vehicle coolant systems, brake air pressure systems, screenwash solutions.

Vapours given off from coolant antifreeze (glycol) arise only when heated.

Antifreeze may be absorbed through the skin in toxic or harmful quantities. Antifreeze if swallowed is fatal and medical attention must be found immediately.

ARC WELDING – see Welding.

ASBESTOS – see Brake and Clutch Linings and Pads.

BATTERY ACIDS – see Acids and Alkalis.

Gases released during charging are explosive. Never use naked flames or allow sparks near charging or recently charged batteries.

BRAKE AND CLUTCH FLUIDS (Polyalkylene Glycols) – see Fire.

Combustible.

Splashes to the skin and eyes are slightly irritating. Avoid skin and eye contact as far as possible. Inhalation of vapour hazards do not arise at ambient temperatures because of the very low vapour pressure.

BRAKE AND CLUTCH LININGS AND PADS – see Legal Aspects.

These items contain asbestos, which if inhaled may cause lung damage and in some cases, cancer.

The normal handling and fitting of these items should not cause any hazard, but any drilling, grinding or filling of friction materials may produce asbestos dust, and should only be carried out under strictly controlled conditions.

The dust in brake drums etc., contains very little asbestos but care should be taken to avoid inhalation of this dust during servicing of brakes and clutches. The use of drum cleaning units, vacuum cleaning or damp wiping is preferred to the use of air jets for "blowing–out".

The dust should be collected in a sealed plastic bag and disposed with, according to local *laws and regulations.*

BRAZING – see Welding.

CHEMICAL MATERIALS – GENERAL – see Legal Aspects.

Chemical materials such as solvents, sealers, adhesives, paints, resin foams, battery acids, antifreeze, brake fluids, oils and grease should always be used with caution and stored and handled with care. They may be toxic, harmful, corrosive, irritant or highly inflammable and give rise to hazardous fumes and dusts.

The effects of excessive exposure to chemicals may be immediate or delayed; briefly experienced or permanent; cumulative; superficial; life threatening; or may reduce life–expectancy.

DO'S

Do remove chemical materials from the skin and clothing as soon as practicable after soiling. Change heavily soiled clothing and have it cleaned.

Do carefully read and observe hazard and precaution warnings given on material containers (labels) and in any accompanying leaflets, poster or other instructions. Material health and safety data sheets can be obtained from Manufacturers.

Do organise work practices and protective clothing to avoid soiling of the skin and eyes; breathing vapours/aerosols/dusts/fumes; inadequate container labelling; fire and explosion hazards.

Do wash before job breaks; before eating, smoking, drinking or using toilet facilities when handling chemical materials.

Do keep work areas clean, uncluttered and free of spills.

Do store according to national and local regulations.

Do keep chemical materials out of reach of children.

DO NOTS

Do Not mix chemical materials except under the manufacturers instructions; some chemicals can form other toxic or harmful chemicals; give off toxic or harmful fumes; be explosive when mixed together.

Do Not spray chemical materials, particularly those based on solvents, in confined spaces e.g. when people are inside a vehicle.

Do Not apply heat or flame to chemical materials except under the manufacturers' instructions. Some are highly inflammable and some may release toxic or harmful fumes.

Do Not leave containers open. Fumes given off can build up to toxic, harmful or explosive concentrations. Some fumes are heavier than air and will accumulate in confined areas, pits etc.

Do Not transfer chemical materials to unlabelled containers.

Do Not clean hands or clothing with chemical materials. Chemicals, particularly solvents and fuels will dry the skin and may cause irritation with dermatitis. Some can be absorbed through the skin in toxic or harmful quantities.

Do Not use emptied containers for other materials, except when they have been cleaned under supervised conditions.

Do Not sniff or smell chemical materials. Brief exposure to high concentrations of fumes can be toxic or harmful.

Clutch Fluids – see Brake and Clutch Fluids.

Clutch Linings and Pads – see Brake and Clutch Linings and Pads.

CORROSION PROTECTION MATERIALS – see Solvents, Fire.

Highly flammable, flammable.

These materials are varied and the manufacturers instructions should be followed. They may contain solvents, resins, petroleum products etc. Skin and eye contact should be avoided. They should only be sprayed in conditions of adequate ventilation and not in confined spaces.

Cutting – see Welding.

De–Waxing – see Solvents and Fuels (Kerosene).

DUSTS

Powder, dusts or clouds may be irritant, harmful or toxic. Avoid breathing dusts from powdery chemical materials or those arising from dry abrasion operations. Wear respiratory protection if ventilation is inadequate.

ELECTRIC SHOCK

Electric shocks can result from the use of faulty electrical equipment or from the misuse of equipment even in good condition.

Ensure that electrical equipment is maintained in good condition and frequently tested.

Ensure that flexes, cables, plugs and sockets are not frayed, kinked, cut, cracked or otherwise damaged.

Ensure that electric equipment is protected by the correct rated fuse.

Never misuse electrical equipment and never use equipment which is in any way faulty. The results could be fatal.

Use reduced voltage equipment (110 volt) for inspection and working lights where possible.

Ensure that the cables of mobile electrical equipment cannot get trapped and damaged, such as in a vehicle hoist.

Use air operated mobile equipment where possible in preference to electrical equipment.

In cases of electrocution:–

– switch off electricity before approaching victim

– if this is not possible, push or drag victim from source of electricity using dry non–conductive material

– commence resuscitation if trained to do so

– SUMMON MEDICAL ASSISTANCE

EXHAUST FUMES

These contain asphyxiating, harmful and toxic chemicals and particles such as carbon oxides, nitrogen oxides, aldehydes, lead and aromatic hydrocarbons. Engines should only be run under conditions of adequate extraction or general ventilation and not in confined spaces.

Gasolene (Petrol) Engine

There may not be adequate warning properties of odour or irritation before immediate and delayed toxic or harmful effects arise.

Diesel Engine

Soot, discomfort and irritation usually give adquate warning of hazardous fume concentrations.

FIBRE INSULATION – see Dusts.

Used in noise and sound insulation.

The fibrous nature of surfaces and cut edges can cause skin irritation. This is usually a physical and not a chemical effect.

Precautions should be taken to avoid excessive skin contact through careful organisation of work practices and the use of gloves.

FIRE – see Welding, Foams, Legal Aspects.

Many of the materials found on or associated with the repair of vehicles are highly flammable. Some give off toxic or harmful fumes if burnt.

Observe strict fire safety when storing and handling flammable materials or solvents, particularly near electrical equipment or welding processes.

Ensure before using electrical or welding equipment but that there is no fire hazard present.

Have a suitable fire extinguisher available when using welding or heating equipment.

FIRST AID

Apart form meeting any legal requirements it is desirable for someone in the workshop to be trained in first aid procedures.

Splashes in the eye should be flushed with clean water for at least ten minutes.

Soiled skin should be washed with soap and water.

Inhalation affected individuals should be removed to fresh air immediately.

If swallowed or if effects persist consult a doctor with information (label) on material used.

Do not induce vomiting (unless indicated by manufacturer).

FOAMS – Polyurethane – see Fire.

Used in sound and noise insulation. Cured foams used in seat and trim cushioning.

Follow manufacturers instructions.

Unreacted components are irritating and may be harmful to the skin and eyes. Wear gloves and goggles.

Individuals with chronic respiratory diseases, asthma, bronchial medical problems or histories of allergic diseases should not work with or near uncured materials.

The components, vapours, spray mists can cause direct irritation, sensitivity reactions and may be toxic or harmful.

Vapours and spray mists must not be breathed. These materials must be applied with adequate ventilation and respiratory protection. Do not remove respirator immediately after spraying, wait until vapour/ mists have cleared.

Burning of the uncured components and the cured foams can generate toxic and harmful fumes.

Smoking, open flames or the use of electrical equipment during foaming operations and until vapours/mists have cleared should not be allowed. Any heat cutting of cured foams or partially cured foams should be conducted with extraction ventilation (see Body Section 44 Legal and Safety Aspects).

FUELS – see Fire, Legal Aspects, Chemicals – General, Solvents.

Used as fuels and cleaning agents.

Gasolene (Petrol).

Highly flammable.

Swallowing can result in mouth and throat irritation and absorption from the stomach can result in drowsiness and unconsciousness. Small amounts can be fatal to children. Aspiration of liquid into the lungs, e.g. through vomiting, is a very serious hazard.

Gasolene dries the skin and can cause irritation and dermatitis on prolonged or repeated contact. Liquid in the eye causes severe smarting.

Motor gasolene may contain appreciable quantities of benzene, which is toxic upon inhalation and the concentrations of gasolene vapours must be kept very low. High concentrations will cause eye, nose and throat irritation, nausea, headache, depression and symptoms of drunkeness. Very high concentrations will result in rapid loss of consciousness.

Ensure there is adequate ventilation when handling and using gasolene. Great care must be taken to avoid the serious consequences of inhalation in the event of vapour build up arising from spillages in confined spaces.

Special precautions apply to cleaning and maintenance operations on gasolene storage tanks.

Gasolene should not be used as a cleaning agent. It must not be siphoned by mouth.

Kerosene (Paraffin)

Used also as heating fuel, solvent and cleaning agent.

Flammable.

Irritation of the mouth and throat may result from swallowing. The main hazard from swallowing arises if liquid aspiration into the lungs occurs. Liquid contact dries the skin and can cause irritation or dermatitis. Splashes in the eye may be slightly irritating.

In normal circumstances the low volatility does not give rise to harmful vapours. Exposure to mists and vapours from kerosene at elevated temperatures should be avoided (mists may arise in de–waxing). Avoid skin and eye contact and ensure there is adequate ventilation.

Gas–Oil (Diesel Fuel) – see Fuels (Kerosene).

Combustible.

Gross or prolonged skin contact with high boiling gas oils may also cause serious skin disorders including skin cancer.

GAS CYLINDERS – see Fire.

Gases such as oxygen, acetylene, carbon dioxide, argon and propane are normally stored in cylinders at pressures of up to 2000 lb/sq. in. (13,790 kn/m^2) and great care should be taken in handling these cylinders to avoid mechanical damage to them or to the valve gear attached. The contents of each cylinder should be clearly identified by appropriate markings.

Cylinders should be stored in well ventilated enclosures, and protected from ice and snow, or direct sunlight. Fuel gases (e.g. acetylene and propane) should not be stored in close proximity to oxygen cylinders.

Care should be exercised to prevent leaks from gas cylinders and lines, and to avoid sources of ignition.

Only trained personnel should undertake work involving gas cylinders.

Gases – see Gas Cylinders.

Gas Sheilded Welding – see Welding.

Gas Welding – see Welding.

GENERAL WORKSHOP TOOLS AND EQUIPMENT

It is essential that all tools and equipment are maintained in good condition and the correct safety equipment used where required.

Never use tools or equipment for any purpose other than that for which they were designed.

Never overload equipment such as hoists, jacks, axle and chassis stands or lifting slings. Damage caused by overloading is not always immediately apparent and may result in a fatal failure the next time that the equipment is used.

Do not use damaged or defective tools or equipment, particularly high speed equipment such as grinding wheels. A damaged grinding wheel can disintegrate without warning and cause serious injury.

Wear suitable eye protection when using grinding, chiselling or sand blasting equipment.

Wear a suitable breathing mask when using sand blasting equipment, working with asbestos based materials or using spraying equipment.

Glues – see Adhesives and Sealers.

High Pressure Air, Lubrication and Oil Test Equipment – see Lubricants and Greases.

Always keep high pressure equipment in good condition and regularly maintained, particularly at joints and unions.

Never direct a high pressure nozzle at the skin as the fluid may penetrate to the underlying tissue etc. and cause serious injury.

LEGAL ASPECTS

Many laws and regulations make requirements relating to health and safety in the use of materials and equipment in workshops. Some of these laws which apply in the U.K. are listed. Similar laws exist for other territories:–

- The Factories Act (1961).
- The Asbestos Regulations (1969).
- Highly Flammable Liquids and Liquified Petroleum Gases Regulations (1972).
- Deposit of Poisonous Waste Act (1972).
- Control of Pollution Act (1974).
- Health and Safety at Work Act (1974).
- The Packaging and Labelling of Dangerous Substances Regulations (1978).
- Control of Lead Regulations (1981).

Workshops should be familiar, in detail, with these and associated laws and regulations. Consult local factory inspectorate if in any doubt.

LUBRICANTS AND GREASES

Avoid all prolonged and repeated contact with mineral oils, especially used oils. Used oils contaminated during service (e.g. routine service change sump oils) are more irritating and more likely to cause serious effects including skin cancer in the event of gross and prolonged skin contact.

Wash skin thoroughly after work involving oil. Proprietary hand cleaners may be of value provided they can be removed from the skin with water. Do not use petrol, paraffin or other solvents to remove oil from the skin.

Lubricants and greases may be slightly irritating to the eyes.

Repeated or prolonged skin contact should be avoided by wearing protective clothing if necessary. Particular care should be taken with used oils and greases containing lead. Do not allow work clothing to be contaminated with oil. Dry clean or launder such clothing at regular intervals. Discard oil soaked shoes.

Do not employ used engine oils as lubricants or for any application where appreciable skin contact is likely to occur. Used oils may only be disposed of in accordance with local regulations, e.g. in the U.K., the Control of Pollution Act.

There are publications describing the problems and advising on precautionary measures. For the U.K. these include:

SHW 295:	Effects of mineral oil on the skin
SHW 295A:	Cancer of the skin caused by oil
SHW 397:	Cautionary notice: Effects of mineral oil on the skin

Noise Insulation Materials – see Foams, Fibre Insulation.

PAINTS – see Solvents and Chemical Materials – General.

Highly Flammable, Flammable.

One Pack. Can contain harmful or toxic pigments, driers and other components as well as solvents. Spraying should only be carried out with adequate ventilation.

Two Pack. Can also contain harmful and toxic unreacted resins and resin hardening agents. The manufacturers instructions should be followed and the section of page 05–2 on resin based adhesives, isocyanate containing Adhesives and Foams should be consulted.

Spraying should preferably be carried out in exhausted ventilated booths removing vapour and spray mists from the breathing zone. Individuals working in booths should wear respiratory protection. Those doing small scale repair work in the open shop should wear supplied air respirators.

Paint Thinners – see Solvents.

Petrol – see Fuels (Gasolene).

Pressurised Equipment – see High Pressure Air, Lubrication and Oil Test Equipment.

Resistance Welding – see Welding.

Sealers – see Adhesives and Sealers.

SOLDER – see Welding.

Solders are mixtures of metals such that the melting point of the mixture is below that of the constituent metals (normally lead and tin). Solder application does not normally give rise to toxic lead fumes, provided a gas/air flame is used. Oxy–acetylene flames should not be used, as they are much hotter and will cause lead fumes to be evolved.

Some fumes may be produced by the application of any flame to surfaces coated with grease etc. and inhalation of these should be avoided.

Removal of excess solder should be undertaken with care, to ensure that fine lead dust is not produced, which can give toxic effects if inhaled. Respiratory protection may be necessary.

Solder spillage and filing should be collected and removed promptly to prevent general air contamination by lead.

High standards of personal hygiene are necessary in order to avoid indigestion of lead or inhalation of solder dust from clothing.

SOLVENTS – see Chemical Materials – General Fuels (Kerosene), Fire.

e.g. Acetone, white spirit, toluene, xylene, trichlorethane.

Used in cleaning materials, de–waxing, paints, plastics, resins, thinners etc.

Highly Inflammable, Flammable.

Skin contact will degrease the skin and may result in irritation and dematitis following repeated or prolonged contact. Some can be absorbed through the skin in toxic or harmful quantities.

Splashes in the eye may cause severe irritation and could lead to loss of vision.

Brief exposure to high concentrations of vapours or mists will cause eye and throat irritation, drowziness, dizziness, headaches and in the worst circumstances, unconsciousness.

Repeated or prolonged exposures to excessive but lower concentrations of vapours or mists, for which there might not be adequate warning indications, can cause more serious toxic or harmful effects.

Aspiration into the lungs (e.g. through vomiting) is the most serious consequence of swallowing.

Avoid splashes to the skin, eyes and clothing. Wear protective gloves, goggles and clothing if necessary.

Ensure good ventilation when in use, avoid breathing fumes, vapours and spray mists and keep containers tightly sealed. Do not use in confined spaces.

When the spraying material contains solvents, e.g. paints, adhesives, coatings, use extraction ventilation or personal respiratory protection in the absence of adequate general ventilation.

Do not apply heat or flame except under specific and detailed manufacturers instructions.

Sound Insulation – see Fibre Insulation, Foams.

Spot Welding – see Welding.

SUSPENDED LOADS

There is always a danger when loads are lifted or suspended. Never work under an unsupported suspended or raised load, e.g. jacked up vehicle, suspended engine, etc.

Always ensure that lifting equipment such as jacks, hoists, axle stands, slings, etc. are adequate and suitable for the job, in good condition and regularly maintained.

Never improvise lifting tackle.

Underseal – see Corrosion Protection.

WELDING – see Fire, Electric Shock, Gas Cylinders.

Welding processes include Resistance Welding (Spot Welding), Arc Welding and Gas Welding.

Resistance Welding

This process may cause particles of molten metal to be emitted at high velocity and the eyes and skin must be protected.

Arc Welding

This process emits a high level of ultraviolet radiation which may cause eye and skin burns to the welder and to other persons nearby. Gas–shielded welding processes are particularly hazardous in this respect. Personal protection must be worn, and screens used to shield other people.

Metal spatter will also occur and appropriate eye and skin protection is necessary.

The heat of the welding arc will produce fumes and gases from the metals being welded and from any applied coatings or contamination on the surfaces being worked on. These gases and fumes may be toxic and inhalation should always be avoided. The use of extraction ventilation to remove the fumes from the working area may be necessary, particularly in cases where the general ventilation is poor, or where considerable welding work is anticipated. In extreme cases where adequate ventilation cannot be provided, supplied air respirators may be necessary.

Gas Welding

Oxy–acetylene torches may be used for welding and cutting and special care must be taken to prevent leakage of these gases, with consequent risk of fire and explosion.

The process will produce metal spatter and eye and skin protection is necessary.

The flame is bright and eye protection should be used, but the ultra–violet emission is much less than that from arc welding, and lighter filters may be used.

The process itself produces few toxic fumes, but such fumes and gases may be produced from coatings on the work, particularly during cutting away of damaged body parts and inhalation of the fumes should be avoided.

In brazing, toxic fumes may be evolved from the metals in the brazing rod, and a severe hazard may arise if brazing rods containing cadmium are used. In this event particular care must be taken to avoid inhalation of fumes and expert advice may be required.

SPECIAL PRECAUTIONS MUST BE TAKEN BEFORE ANY WELDING OR CUTTING TAKES PLACE ON VESSELS WHICH HAVE CONTAINED COMBUSTIBLE MATERIALS, E.G. BOILING OR STEAMING OUT OF FUEL TANKS.

White Spirit – see Solvents.

1

PART 1
ENGINE SYSTEMS
Chapter 1
DIESEL ENGINES

A. DIESEL ENGINE – DESCRIPTION AND OPERATION

MODEL		**5640**	**6640**	**7740 (T)**	**7840**	**8240**	**8340**
No of Cylinders		4	4	4	6	6	6
BORE	(ins.)	4.4	4.4	4.4	4.4	4.4	4.4
	(mm)	111.8	111.8	111.8	111.8	111.8	111.8
STROKE	(ins.)	4.4	5.0	5.0	4.4	5.0	5.0
	(mm).	111.8	127.0	127.0	111.8	127.0	127.0
DISPLACEMENT	(cu. in.)	268	304	304	401	456	456
	(cu. cm.)	4393	4983	4983	6570	7472	7472

(T) = Turbocharger

This chapter describes the overhaul and repair of the new series, direct injection diesel engines.

These engines are available in 4 or 6 cylinder naturally aspirated forms, with the 4 cylinder also being available in turbocharged form.

As these engines are of similar design and service procedures are common throughout the range. The 4 cylinder engines have a design difference in that they are fitted with a dynamic balancer assembly.

All engines feature cross flow cylinder heads, with the inlet and exhaust manifolds on opposite sides of the cylinder head. The fuel and air combustion process, takes place in the specially designed bowl in the crown of the pistons.

CYLINDER HEAD ASSEMBLY

The cylinder head incorporates valves and springs with the valve rocker arm shaft assembly bolted to the cylinder block through the cylinder head. Cylinder head retaining bolts are evenly spaced with a six point pattern around each cylinder, this ensures an even clamping load across the cylinder head area.

The intake and exhaust manifolds are bolted to the head. The intake manifold is mounted on the right hand side of the engine with the diesel injectors mounted outside the rocker cover. The exhaust manifold is mounted on the left hand side of the engine, water outlet connections and thermostat being attached to the front of the cylinder block directly behind the radiator.

Valve guides are integral in the cylinder head and valves with oversize stems are available in service. Special replaceable cast alloy valve seats are pressed into each valve port during manufacture, with oversize valve seats also available in service.

All valves are fitted with positive valve rotators, with both Intake and exhaust valves using umbrella type oil seals. Valve lash is maintained by adjustment of the self locking adjusting screw, mounted in each of the rocker arms.

CAMSHAFT ASSEMBLY

The camshaft runs in replaceable bearings, with 3 fitted in the 4 cylinder and 5 fitted in the 6 cylinder. The camshaft drive gear is in mesh with, and driven by the camshaft idler gear and crankshaft timing gear.

Camshaft end thrust is controlled by a thrust plate bolted to the block and located between the camshaft gear and the front camshaft journal.

A helical gear is mounted on the rear of the camshaft and drives the engine oil lubrication pump mounted forward of the flywheel.

CRANKSHAFT ASSEMBLY

The crankshaft is supported in the cylinder block by 5 main bearings on the 4 cylinder engine and 7 main bearings, on the 6 cylinder engine.
Two types of material are used in the manufacture of the crankshafts:–
Nodular Iron, that has rough cast crank webbs, for the 5640 & 6640 models and Steel Crankshafts, that have machine finished crank webbs, for the larger models.
End thrust is controlled by a thrust bearing incorporated in the centre main bearing of the crankshaft.

A crankshaft driven dynamic balancer is installed on the 4 cylinder engines to ensure smooth running performance during their working life. The balancer assembly is bolted to the bottom of the cylinder block and contains two meshing weighted gears. These are driven and timed from a gear heat shrunk to the crankshaft.

In addition to the internal balancer, a damper is also fitted externally to the crankshaft pulley. The six cylinder engine requires only this external damper to ensure smooth running operation. Front and rear crankshaft oil sealing is effected by one piece seals that are designed for long and durable service life.

CONNECTING RODS

Connecting rods "Teepee" (wedge) shaped at the small end have been designed to reduce the reciprocating weight at the piston end. The connecting rods are of a heavy beam construction and are assembled as a matched set to each engine, attached to the crankshaft, by means of insert–type copper/lead or aluminium tin alloy bearings.

They are retained in position by the connecting rod big end cap and secured by two bolts per rod. The small end of the connecting rod is fitted with a replaceable bronze bushing, through which the free floating piston pin is fitted. The steel pin being held in place within the piston by two snap rings.

PISTONS

Pistons of increased weight and strength, are constructed of an aluminium silicon alloy with an iron insert for the top ring. The combustion chamber being recessed into the piston crowns.
Each piston has two compression rings and one oil control ring, to reduce friction and increase positive sealing. All rings are located above the piston pin.

MANIFOLDS

The cross flow design aluminium intake, and cast iron exhaust manifolds, are on opposite sides of the cylinder head. This is designed to maintain balanced heat distribution within the cylinder head. The configuration of the manifolds also ensures minimum heat transfer to the intake manifold.

The intake manifold is connected through tubing to the air cleaner and in the rear end of the manifold a tapped hole is provided for installation of a thermostart or an ether cold starting aid.

NOTE: *On tractors where cold start equipment is not installed ensure the plug in the intake manifold is kept tight at all times. Considerable damage to the cylinder bores, may be incurred by entry of grit or other foreign material if the plug is left loose or missing. Also dirt and grit may be drawn through the air cleaner connections if they are not properly secured.*

CYLINDER BLOCK ASSEMBLY

The cylinder block is an alloy cast iron with deep cylinder skirts, and water jackets for cooling the cylinders. The cylinder bores are machined integral with the cylinder block, during the manufacturing process.

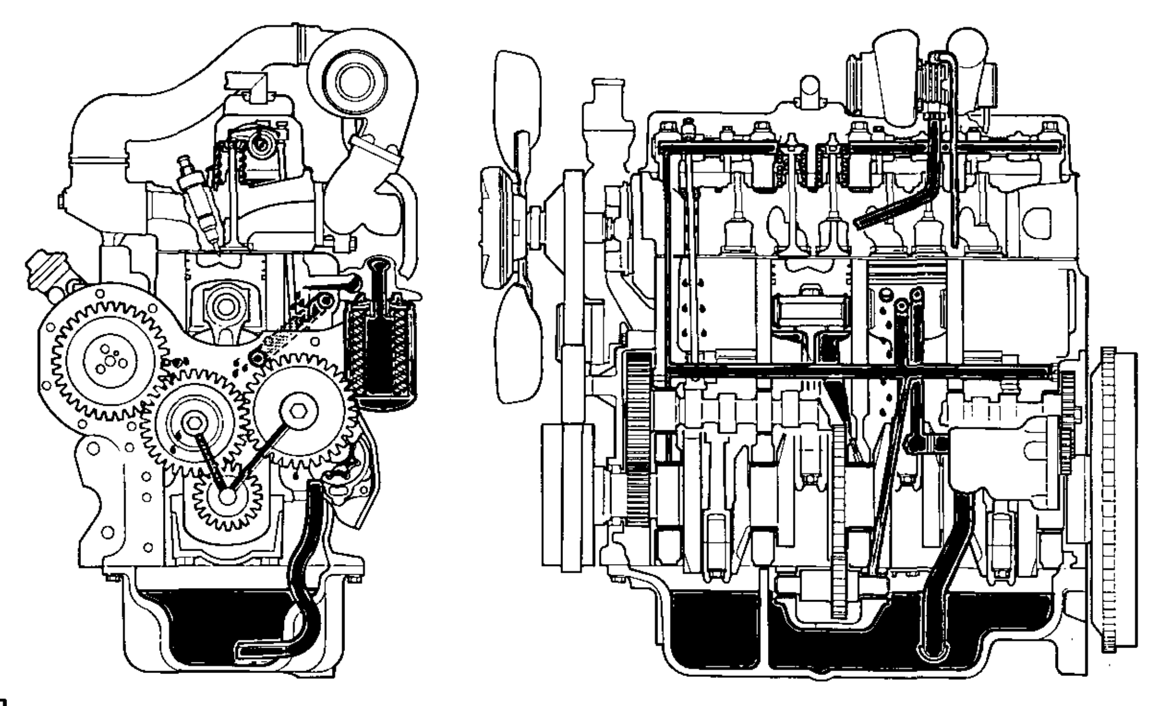
Cylinders are in line and vertical and numbered from 1 to 4 or 6, from the front to the rear of the engine. They can be bored oversize for the fitment of sleeves or oversize pistons, which are available in service.

The oil pan which is attached to the bottom of the cylinder block, is the reservoir for the engine oil lubrication system. An aluminium engine front cover is attached to the front engine adapter plate and covers all of the timing gear assembly.

TIMING GEARS

The crankshaft timing gear is heated and press fitted on to the front of the crankshaft, to a high degree of accuracy during manufacturing. This enables precise timing being maintained during the life of the engine.
The crankshaft gear drives the camshaft idler gear which is attached to the front of the cylinder block. The idler gear then drives the camshaft and the injection pump via meshing helical gears.
The camshaft gear is bolted to the front of the camshaft, and is keyed to maintain position of the gear on the camshaft. All gears can be checked for timing by observing the punch marks on the gears.

LUBRICATION SYSTEM



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Engine Oil Flow

Engine Lubrication System With Turbocharger Fitted

Lubrication of the engine, Figure 1, is maintained by a rotor type oil pump mounted in the rear of the engine block, forward of the flywheel on the left hand side of the engine. The oil pump is driven from the rear of the camshaft and draws oil from the engine oil pan through a tube and screen assembly.

A spring loaded relief valve is integral with the oil filter body mounted on the left hand side of the engine block and prevents over pressurisation of the system.

The spin on type oil filter mounted externally to its support housing on the left hand side of the engine, allows easy access at service intervals. Oil flows from the filter to the main oil gallery which runs the length of the cylinder block, which also intersects the camshaft follower chamber.

The main gallery also supplies oil to the crankshaft main bearings, connecting rods, big ends and small ends. The underside of the pistons and pins, are lubricated by oil pressure jets mounted adjacent to each main journal housing.

The camshaft drive gear bushing is pressure lubricated through a drilled passage from the front main bearing. The gear has small oil passages machined on both sides allowing excess oil to escape.

Timing gears are lubricated by splashed oil from the cam follower chamber and the pressure lubricated camshaft drive gear bushing.

On 4 cylinder engines the dynamic balancer is lubricated, through a drilled passage, from the cylinder block crankshaft thrust bearing web to the balancer housing. Oil flows through the balancer housing to the drilled balancer gear shafts and onto the bushings in the balancer gears.

An intermittent flow of oil is directed to the valve rocker arm shaft assembly via a drilled passage in the cylinder block. This is located vertically above above No.1 camshaft bearing and aligns to a hole in the cylinder head. The rotation of the camshaft allows a controlled intermediate flow of lubrication.

The turbocharger where fitted, is supplied with oil from the oil filter support housing mounted on the left hand side of the engine.

DIESEL ENGINE STRIPDOWN

In the following procedures and illustrations the engine in the main is shown removed from the tractor.

However, there are certain operations that can be performed with the engine still in the tractor, or separated at the connection to the front axle support, or separated from the transmission housing.

The engine overhaul procedure initially describes the assembly process for rebuilding an engine using all new components. Following this section are defined headings which describe detailed repair specifications and procedures, where components are suitable for re–use.

Where overhaul of components is required without engine being removed from the tractor refer to the following headings and the relevant paragraphs in the main overhaul procedure.

Operations or repairs that can be performed with the engine still in the tractor.

1. Cylinder head and associated inlet and exhaust components.
2. Fuel injection pump and related parts.
3. Water pump, thermostat and associated components.
4. Oil pump relief valve.
5. Oil pan and gasket.
6. Turbocharger.

Operations or repairs that can be performed with the engine separated from the front axle.

1. Front timing cover/timing gear removal.
2. Oil pan removal for access to crankshaft and balancer, bearing shells, piston removal and oil pump suction tubing.
3. Front pulley and damper assembly.

Operations or repairs that can be performed with the engine separated from the transmission housing and with oil pan removed.

1. Crankshaft rear oil seal and carrier removal (with oil pan removed).
2. Oil pump and drive gear removal.

B. FAULT FINDING

IMPORTANT: *When effecting a repair the cause of the problem must be investigated and corrected to avoid repeat failures.*

The following table lists problems and their possible causes with recommended remedial action.

PROBLEM	POSSIBLE CAUSES	REMEDY
Engine does not-develop full power	1. Clogged air cleaner	1. Clean or renew element
	2. Fuel line obstructed	2. Clean
	3. Faulty injectors	3. Clean and reset
	4. Incorrect valve lash adjustment	4. Check and reset
	5. Burnt, worn or sticking valves	5. Replace valves with new or oversize and/or machine the valve guide bores
	6. Blown head gasket	6. Check head flatness and fit new gasket
	7. Incorrect fuel delivery	7. Check injectors and pump
	8. Low cylinder compression	8. Renew piston rings or re–bore/re–sleeve as necessary

PROBLEM	POSSIBLE CAUSES	REMEDY
Engine knocks	1. Diluted or thin oil	1. Check crankshaft bearings for damage, change as required. Drain and refill with specified oil and renew filter. Ascertain cause of dilution
	2. Insufficient oil supply	2. Check oil level and top up as necessary. Overhaul or renew pump as necessary. Check oil filter is not clogged
	3. Low oil pressure	3. Overhaul pump or relief valve as necessary
	4. Excessive crankshaft end play	4. Install new thrust bearing liner
	5. Flywheel or ring gear run–out excessive	5. Skim flywheel or fit new ring gear
	6. Excessive connecting rod or main bearing clearance	6. Install new bearing inserts and/or re–grind crankshaft
	7. Bent or twisted connecting rods	7. Renew connecting rods
	8. Crankshaft journals out–of–round	8. Re–grind crankshaft and fit undersize bearing inserts
	9. Excessive piston–to–cylinder bore clearance	9. Re–bore/re–sleeve block and fit new pistons
	10. Excessive piston ring clearance	10. Fit new pistons and rings
	11. Broken rings	11. Fit new rings, check bore and pistons for damage
	12. Excessive piston pin clearance	12. Fit new piston or pin
	13. Piston pin retainer loose or missing	13. Install new retainer and check bore/pistons for damage
	14. *Excessive camshaft play*	14. *Install new thrust plate*
	15. Imperfections on timing gear teeth	15. Renew timing gear
	16. Excessive timing gear backlash	16. Renew timing gear

PROBLEM	POSSIBLE CAUSES	REMEDY
Engine overheats	1. Hose connection leaking or collapsed	1. Tighten hose connection, renew hose if damaged
	2. Radiator cap defective or *not sealing*	2. Renew radiator cap
	3. Radiator leakage	3. Repair/renew radiator
	4. Improper fan belt adjustment	4. Re–adjust fan belt
	5. Radiator fins restricted	5. Clean with compressed air
	6. Faulty thermostat	6. Renew thermostat
	7. Internal engine leakage	7. Check for source of leakage, renew gasket or defective parts
	8. Water pump faulty	8. Overhaul water pump
	9. Exhaust gas leakage into cooling system	9. Renew cylinder head gasket, check head for damage or distortion
	10. Coolant aeration	10. Tighten all connections and check coolant level is correct. Ensure cylinder head gasket has not blown
	11. Cylinder head gasket improperly installed	11. Renew cylinder head gasket
	12. Hot spot due to rust and scale or clogged water jackets	12. Reverse flush entire cooling system
	13. Obstruction to radiator air flow	13. Remove the obstruction
	14. Extended engine idling	14. Do not allow engine to idle for long periods
	15. *Oil cooler tube blocked*	15.*Clean*
	16. Radiator core tubes blocked	16. Check free flow

PROBLEM	POSSIBLE CAUSES	REMEDY
Low oil pressure	1. Engine oil level low	1. Top up as necessary
	2 Wrong grade of oil	2. Drain and refill with correct grade of oil
	3 Blocked oil pump sump screen	3. Clean pump screen
	4 Oil pressure relief valve faulty	4. Fit new relief valve
	5 Oil pump worn	5. Renew Oil Pump
	6 Excessive oil pump rotor and shaft assembly clearance	6. Overhaul pump
	7 Excessive main or connecting rod bearing clearance	7. Install new bearings inserts and / or re–grind crankshaft
Excessive oil consumption	1. Engine oil level too high	1. Reduce oil level
	2. External oil leaks	2. Renew gaskets and seals where necessary. Check mating surfaces for damage or distortion
	3. Worn valves, valve guides or bores	3. Renew
	4. Cylinder head gasket leaking	4. Renew gasket. Check head for damage or distortion
	5. Oil loss past the pistons and rings	5. Renew rings and/or re–bore/ re–sleeve block as necessary
	6. Oil cooler leak	6. Repair/renew oil cooler assembly
Engine tends to keep firing after fuel is shut off	1. Air cleaner dirty or restricted	1. Clean or renew element
	2. Oil leak on compressor side of turbocharger where fitted	2. Overhaul turbocharger
Oil pressure warning light fails to operate	1. Bulb burnt out	1. Renew bulb
	4. Warning light pressure switch faulty	2. Renew pressure switch
	5. Warning light circuit faulty	3. Check and renew wiring

PROBLEM	POSSIBLE CAUSES	REMEDY
Excessive exhaust smoke	1. Oil leak on compressor or turbine side of turbocharger where fitted	1. Overhaul turbocharger
	2. Exhaust leak on exhaust manifold side of turbocharger where fitted	2. Fit new gasket
	3. Air cleaner dirty or restricted	3. clean
	4. Excessive fuel delivery	4. Overhaul injection pump and injectors
Water temperature gauge fails to reach normal operating temperature	1. Faulty temperature sender	1. Renew sender switch
	2. Incorrect or faulty thermostat	2. Renew thermostat
	3. Faulty water temperature gauge	3. Renew temperature gauge

C. 4&6 CYLINDER DIESEL ENGINE – DISASSEMBLY AND OVERHAUL

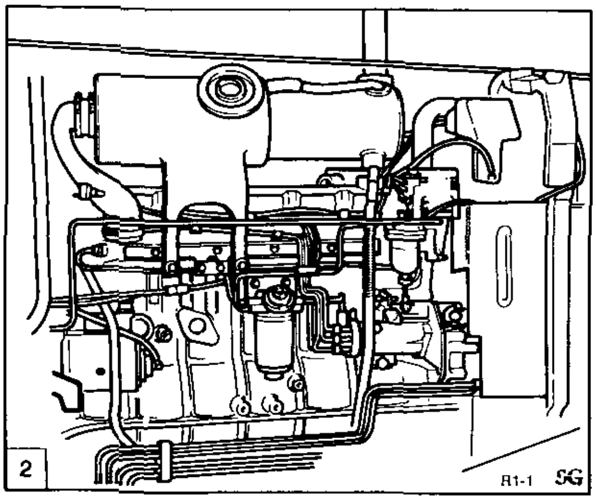
Dismantle the engine following conventional techniques, or by referring to the following removal procedure, referring to the "Specification" section as necessary.

NOTE: *All gaskets, seals and 'O' rings must be replaced with new, upon re–assembly. Where new sealant is to be applied, refer to "Engine Specifications".*

CYLINDER HEAD, VALVES AND RELATED PARTS

NOTE: *The cylinder head can be removed with the engine installed in the tractor.*

1. Disconnect the battery.
2. Remove the engine side panels.
3. Drain the coolant from the radiator and engine block.
4. Shut off heater hose taps, then disconnect and plug heater hoses (where fitted).
5. Remove the radiator top hose.
6. Remove exhaust muffler and exhaust extension pipe.
7. Remove the air cleaner pre cleaner.
8. Remove the air cleaner to intake manifold tube and hoses.
9. Shut–off fuel tank tap, disconnect low pressure fuel lines and remove inlet manifold (cap all exposed openings).



Right Hand View of Engine

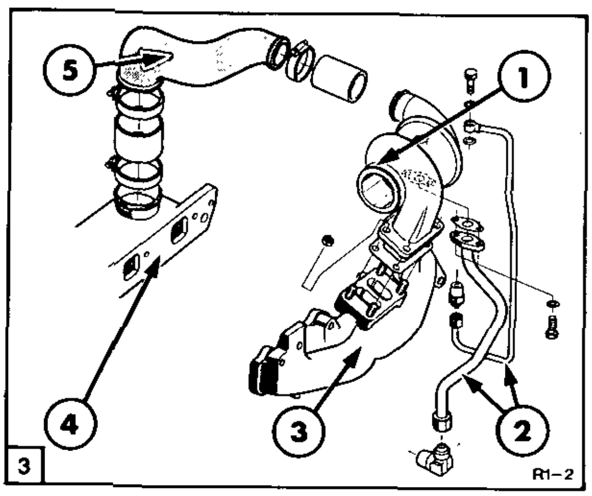
10. Disconnect and remove injector fuel pipes from the fuel injection pump (cap all exposed openings).

11. Disconnect thermostart fuel pipe on the intake manifold (cap exposed opening).

12. Disconnect and remove the rocker cover ventilation tube.

13. Remove the alternator.

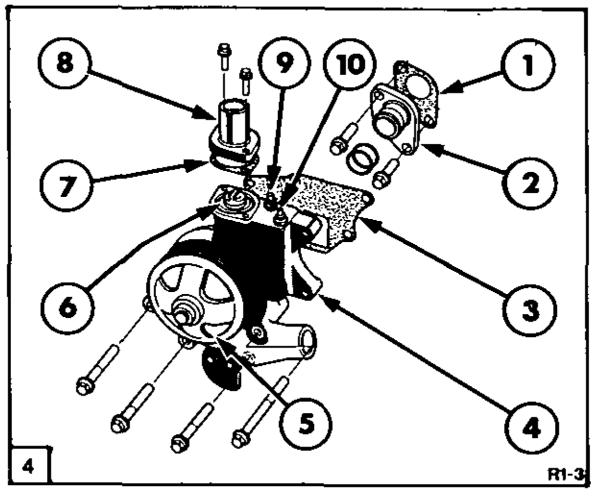
14. Disconnect all loom connections on engine harness and secure clear of the engine.



Turbocharger Assembly

1. TurboCharger Housing
2. Oil Feed/Return Tubes
3. Exhaust Manifold
4. Inlet Manifold
5. Inlet Hoses/tubes

15. Remove the turbocharger assembly, Figure 3, ensuring all openings are capped to prevent dirt ingress. For additional information on the turbocharger refer to, Fuel Systems, Part 2.

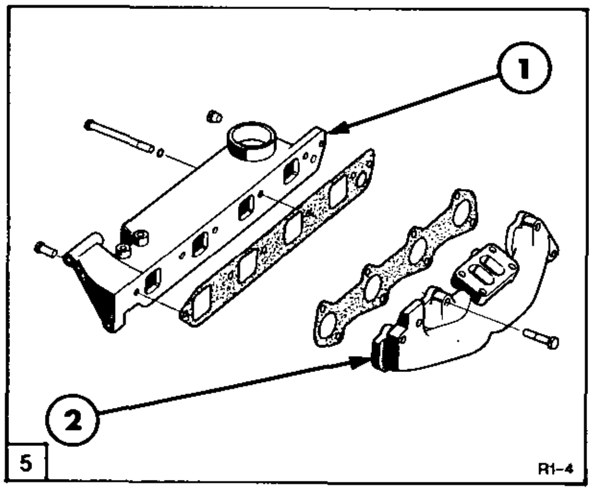


Water Pump Assembly

1. Gasket
2. Connector & 'O' rings
3. Pump Gasket
4. Pump Body
5. Pulley Assembly
6. Thermostat
7. Gasket
8. Thermostat Housing
9. Temperature Sender
10. Temperature Sender

16. Where applicable remove the water pump from the engine, Figure 4. For more information refer to cooling system, Part 1, Chapter 2.

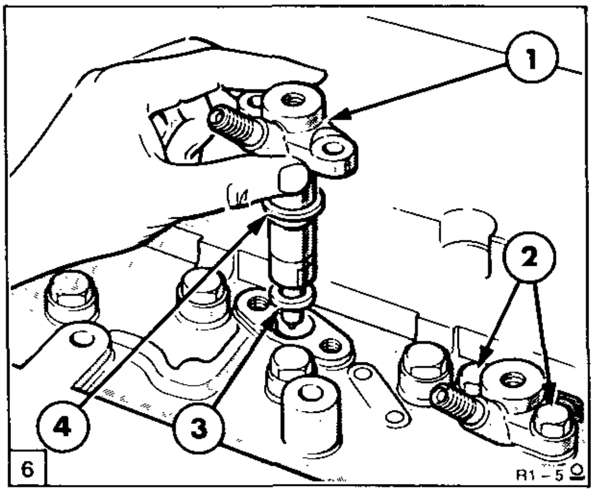
17. Remove the water pump connector from the engine cylinder head.



Manifold Assembly

1. Inlet Manifold
2. Exhaust Manifold

18. Loosen and remove the manifold bolts and remove the exhaust manifold and gasket. Repeat for the inlet manifold and gasket, Figure 5.

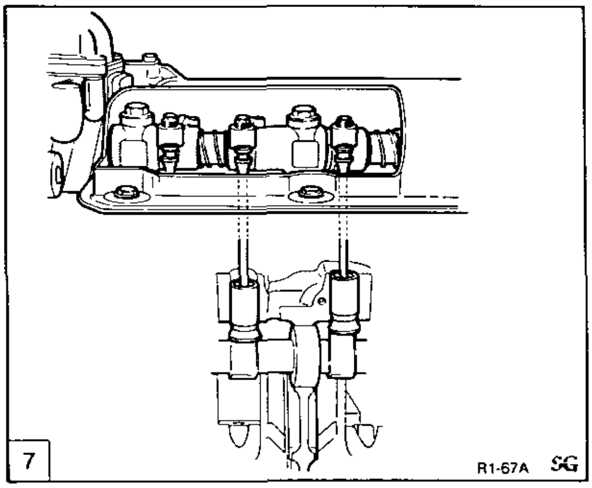


Injector Removal

1. Fuel Injector
2. Mounting Bolts
3. Copper Washer
4. Cork Washer

19. Clean area surrounding the fuel injectors, hold leak off pipe at each injector and carefully disconnect, Figure 6.

20. Remove the rocker cover and gasket.



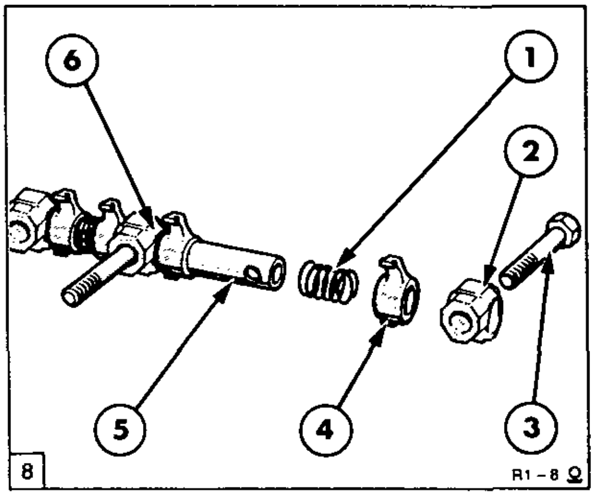
Push Rod Installation

21. Check push rods for concentricity, by rotating the rods with the valve closed and identify any bent rods, Figure 7.

ROCKER SHAFT DISASSEMBLY

NOTE: *Leave bolts in the rocker shaft supports during removal as they retain the support on the shaft.*

1. Remove the cylinder head bolts which pass through the rocker shaft supports, Figure 8.



Rocker Shaft Assembly

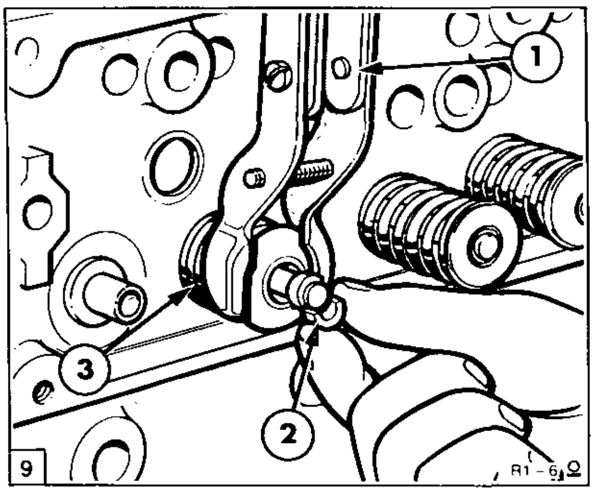
1. Spring
2. Shaft Support
3. Retaining Bolt
4. Rocker Arm
5. Shaft
6. Spacer

2. Loosen the rocker shaft retaining bolts, which also serve as head bolts evenly and alternately and remove the rocker shaft assembly.

3. Remove push rods in turn and place in a numbered rack to maintain the same position for re–assembly.

4. Remove remaining cylinder head bolts working inwards from the end of the cylinder head, alternately to the centre of the cylinder head.

CYLINDER HEAD DISASSEMBLY

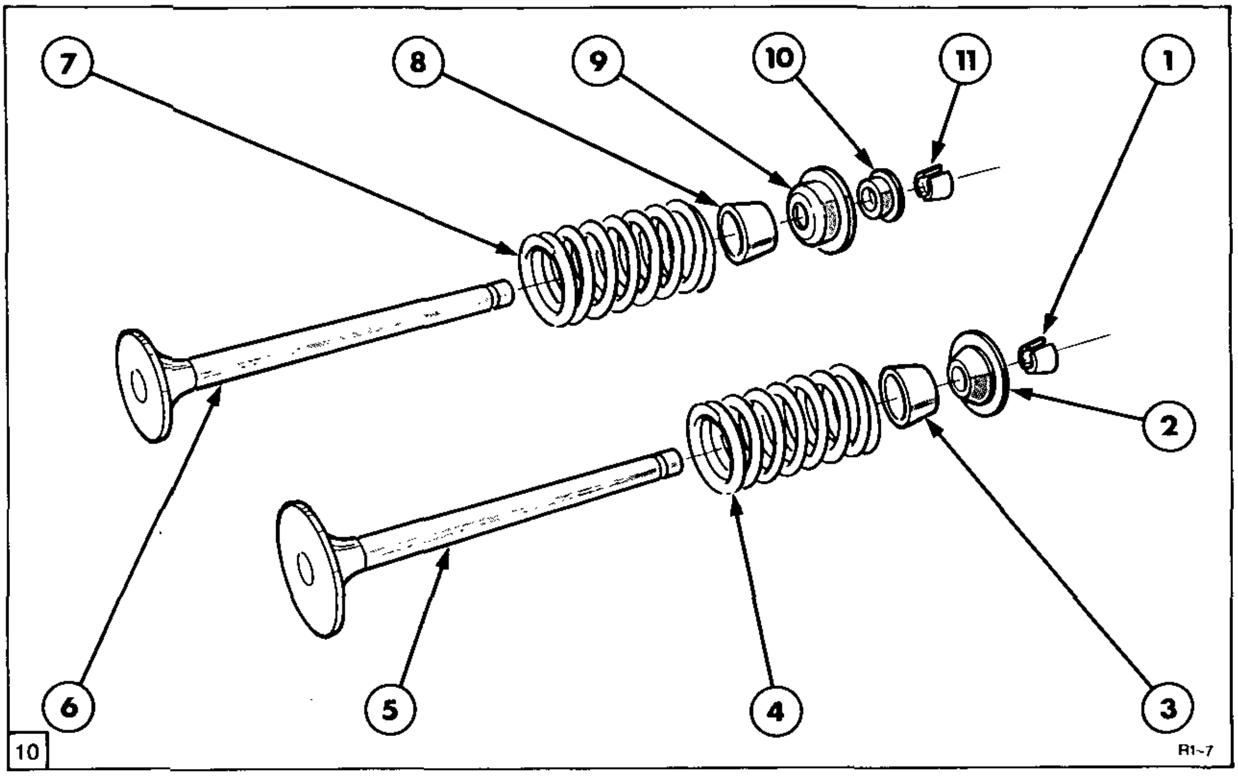


Valve Removal

1. Valve Spring Compressor
2. Retainer Locks
3. Valve Springs

1. Using a valve spring compressor remove the retainer locks, springs, seals and rotators and place in a numbered rack, Figure 9.

2. Clean the cylinder head and remove carbon deposits from around the valve heads.



Valve Assemblies

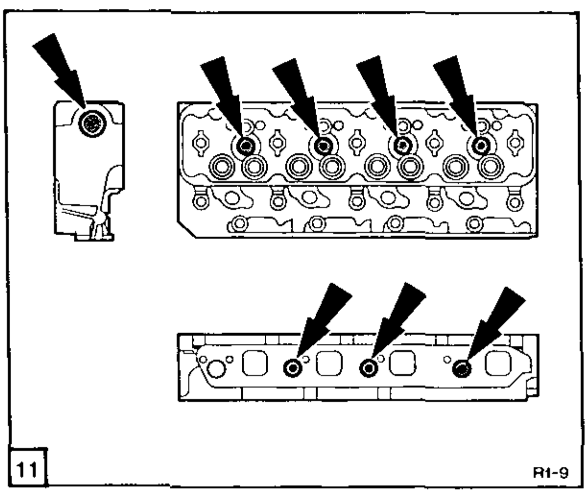
Intake Valve

1 Valve Spring Lock
2. Spring Rotator
3. Seal
4. Spring
5. Valve

Exhaust Valve

6. Valve
7. Spring
8. Seal
9. Spring Rotator
10. Spring Rotator
11. Valve Spring Lock

Inspection and Repair, Cylinder Head



Core Plug Installation

1. Cylinder head core plugs if discoloured (rusty), or leaking require changing. Before fitting new plugs remove all old sealer from the cylinder head. Apply sealant G, see "Specifications", to the new plug mating faces, and drive the new plugs into location, Figure 11.

Core plugs required, 4 Cylinder Head:–

4 off, in the top and 1 off, in the rear of the cylinder head.
3 off, in the Intake face.

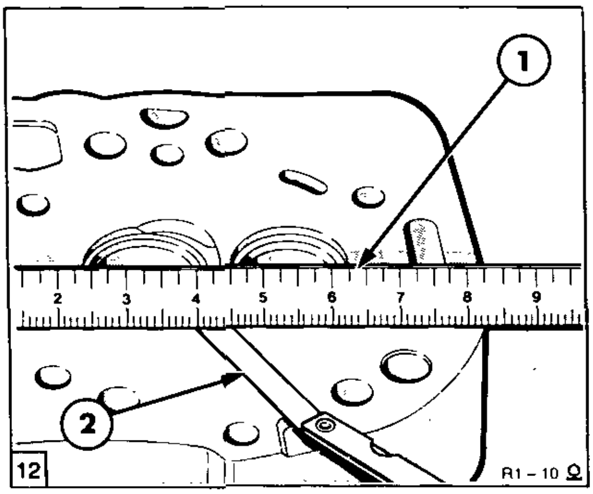
Core plugs required, 6 Cylinder Head:–

6 off, In the top and 1 off, in the rear of the cylinder head.
5 off, in the intake face.

2. Scrape all gasket surfaces clean and wash cylinder head in a suitable solvent, also cleaning valve guide bores.

NOTE: *Ensure injector washers have been removed prior to cleaning.*

3. Inspect cylinder head for nicks and burrs on mating face remove using a suitable abrasive and ensure faces are clean after repair.



Cylinder Head Flatness
1. Straight Edge 2. Feeler Gauge

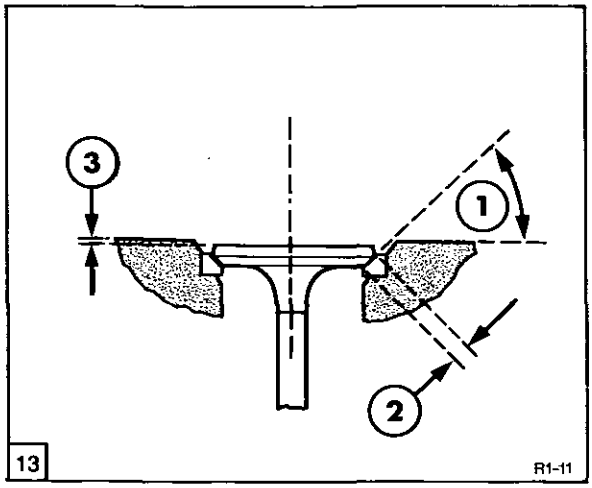
4. Using a special tool with a straight edge and feeler gauges, check flatness of cylinder head in all directions does not exceed,
   0.001 in (0.03mm) in any 1 in (25.4mm), or 0.005 in (0.127mm) overall limit, Figure 12.

5. If the cylinder head has been resurfaced, determine that all head bolt faces will seat by placing the cylinder head less gasket, on the cylinder block and installing the cylinder head bolts hand tight.

6. Ensure rocker shaft supports are fitted with long bolts. Using a feeler gauge, check clearance between underside of bolt heads and cylinder head or rocker shaft support.

7. If a 0.010 in (0.25mm) feeler gauge can be inserted under the bolt head the bolt has bottomed. Therefore the cylinder block thread must be increased using a 9/16–13 UNC–2A Thread tap. Identify the bolt heads and ensure they are reinstalled in the bolt holes they were checked in.

VALVE INSERTS



Valve Seat Dimensions
1. Valve Seat Angle
2. Valve Seat Width
3. Valve Head Face to Cylinder Head Depth

NOTE: *Refacing the valve seat should always be co-ordinated with refacing of the valve to ensure a compression tight fit.*

1. Examine the valve seat inserts and reface if pitted, renew if loose or damaged.

2. To install a new valve insert, the cylinder head must be counter bored, as dimensioned in the chart below. The new insert must be chilled in dry ice prior to installation.

Insert Oversize	Counter Bore in Cylinder Head	
	Exhaust valve insert	Intake valve insert
0.010 in (0.25mm)	1.739–1.740 in (44.17–44.20mm)	1.969–1.970 in (50.01–50.04mm)
0.020 in (0.58mm)	1.749–1.750 in (44.42–44.45mm)	1.979–1.980 in (50.27–50.29mm)
0.030 in (0.76mm)	1.759–1.760 in (44.68–44.70mm)	1.989–1.990 in (50.52–50.55mm)

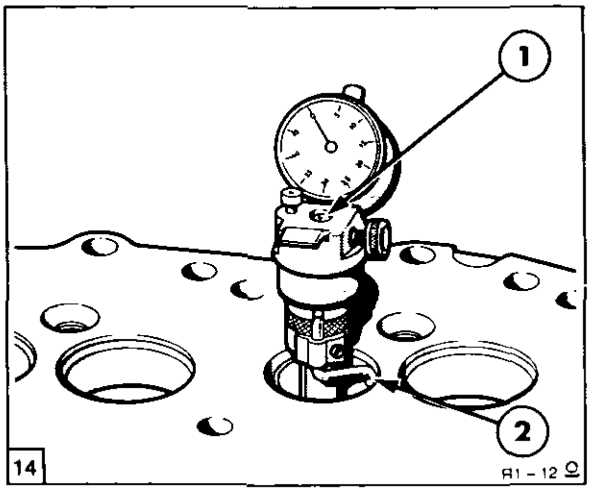
Valve Seat Specifications, Figure 13.

1, Valve seat angle:–
Intake = 30.0°–30.30°
Exhaust = 45.0°–45.30°

2, Valve seat width:–
Intake = 0.078–0.098 in (1.9–2.4mm)
Exhaust = 0.072–0.092 in (1.8–2.3mm)

3, Valve head face to cylinder head face depth:–
Intake = 0.034–0.052 in (0.86–1.32mm)
Exhaust = 0.047–0.065 in (1.2–1.6mm)

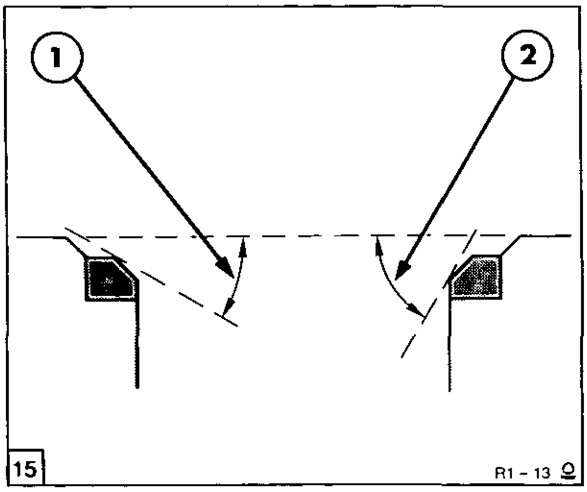
NOTE: *Valve inserts of 0.010 in (0.25mm) and 0.020 in (0.5mm) oversize on diameter are sometimes installed during manufacture. Cylinder Heads with oversize inserts are stamped so10/os, so20/os, on the exhaust manifold side in line with the valve seat concerned.*



Valve Seat Concentricity

1. Dial Indicator
2. Measuring Probe

3. Check the width of the valve seat inserts and as required reface by grinding to dimensions, Figure 13.
4. Measure the concentricity of valve seats, using a dial indicator and measure concentricity of seat to the valve guide bore. Total Indicator Reading should not exceed 0.002 in (0.051mm), Figure 14.
5. Use a seat cutter to correct any seat eccentricity or clean up of pits and grooves. Ensure after any rework that seat width is within specified limits, Figure 13.



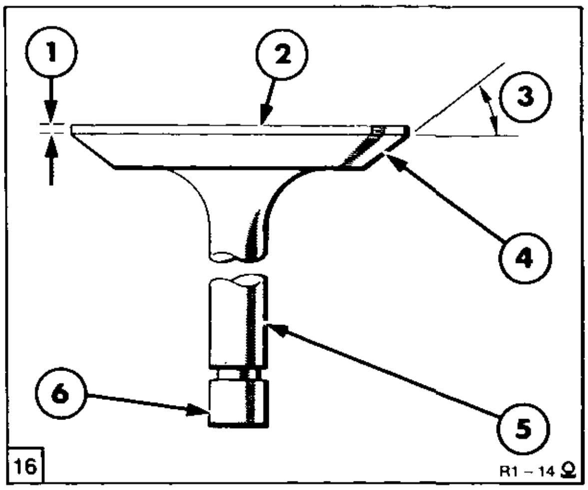
Raising and Lowering of Valve Seats

1. Lowering the Valve Seat
2. Raising the Valve Seat

6. Rotate a new or refaced valve in the seat using engineering blue, ensure all the blue is transferred to the valve head protrusion if any blue remains below or around the seat, raise or lower the seat accordingly, Figure 15, in the following manner.

Lower the valve seats by removing material from the top of seat using a:–
30° grinding wheel for, Exhaust valves and a 15° grinding wheel for, Intake valves.

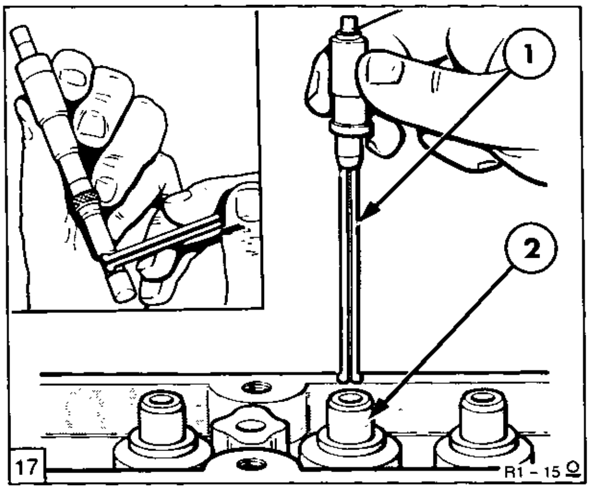
Raise the valve seats by removing material from the bottom of seat using a:–
60° grinding wheel for Exhaust valves and a 45° grinding wheel for Intake valves.



Critical Valve Points

1. Valve Land Edge
2. Valve Head
3. Valve Face Angle
4. Valve Face
5. Valve Stem
6. Valve tip

VALVE GUIDES



Measuring the Valve Guide Bore
1. Telescopic Gauge 2. Valve Guide Bore

1. Using a telescopic gauge and micrometer, measure the valve guide bore clearance and ensure it does not exceed 0.0009–0.0027 in (0.023–0.069mm) on the intake valve stem, 0.0019–0.0037 in (0.048–0.094mm) on the exhaust valve stem, Figure 17.

NOTE: *Production cylinder heads may have one or more machined, oversize valve guide bores or valves installed 0.015 in (0.38mm). Such cylinder heads have 15 or VO15OS stamped on the cylinder head exhaust manifold side adjacent to the valve concerned.*

2. Using a suitable reamer, ream out the valve stem guide with three reamer and pilot combinations as follows:–

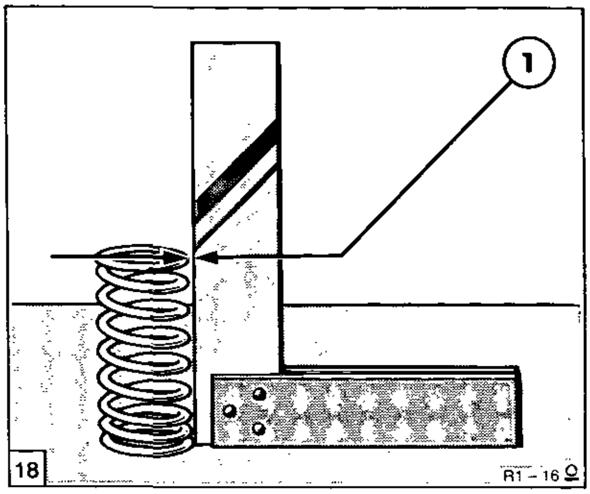
0.003 in (0.076mm) oversize reamer and standard diameter pilot.

0.015 in (0.38mm) oversize reamer and 0.003 in (0.076mm) oversize pilot.

0.030 in (0.76mm) oversize reamer and 0.015 in (0.38mm) oversize pilot.

3. When going from a standard valve stem to an oversize, always use reamers in sequence.

VALVE SPRINGS



Valve Spring Squareness
1. Measuring spring squareness

1. Checked on a flat surface squareness, should not exceed 0.060 in (1.52mm), between the square and spring at the top edge, Figure 18.

Length of valve springs should be checked on both free length and loaded length.

Free length = 2.39 in (60.7mm)

Installed length =1.86–1.95 in (47–49.6mm)

Loaded length = 1.9 in (48.26mm) using a weight of 61.96 lb (28–31 kg)

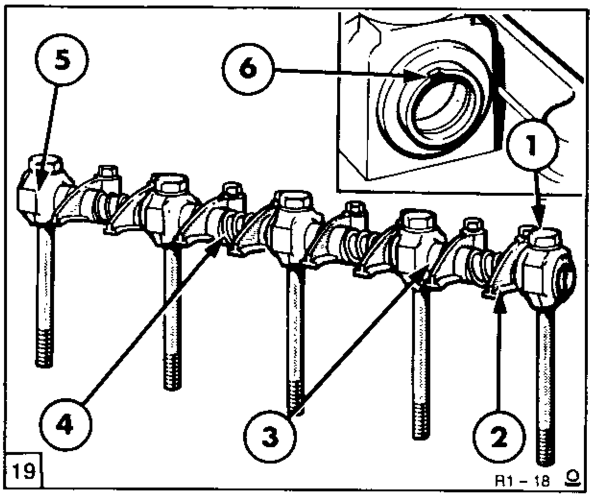
Loaded length = 1.4 in (35.69mm) using a weight of 135–153 lb (61–69 kg)

Ensure the valve spring retainer locks are in good condition and replace if worn or damaged.

ROCKER SHAFT RE–ASSEMBLY

1. Check the rocker shaft for signs of wear or damage on internal and external diameters respectively. If not to specification replace with new. If re–used, before reassembly clean thoroughly in solvent making sure all oil passages are clear.

2. Position the shaft identification groove forwards and upwards. This ensures oil grooves and holes face downwards.

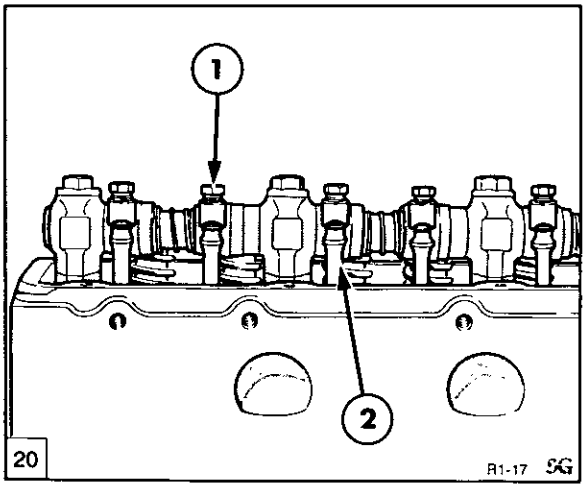


Rocker Shaft Assembly

1. Bolts
2. Rocker Arm
3. Spacer
4. Spring
5. Rocker Arm Shaft Support
6. Groove at Front of Shaft

3. Assemble rocker shaft support with long head bolts, ensuring springs and spacers are re–assembled as in, Figure 19.

ROCKER SHAFT INSTALLATION



Rocker Shaft Assembly

1. Rocker Arm Adjusting Screw
2. Push Rod

1. Inspect rocker arm adjusting screws, and push rod ends of the rocker arm, including the ball end of the screws for nicks, damage, or excessive wear, Figure 20.

2. Also inspect the inside diameter of the rocker arm for damage or wear. If any of these characteristics are not to specification replace with new parts.

3. Check the ends of the push rods for damage or wear. If not to specification or push rods were found not to be straight during dismantling install new rods.

NOTE: *Do not attempt to straighten bent push rods, replace with new.*

CYLINDER HEAD RE–ASSEMBLY

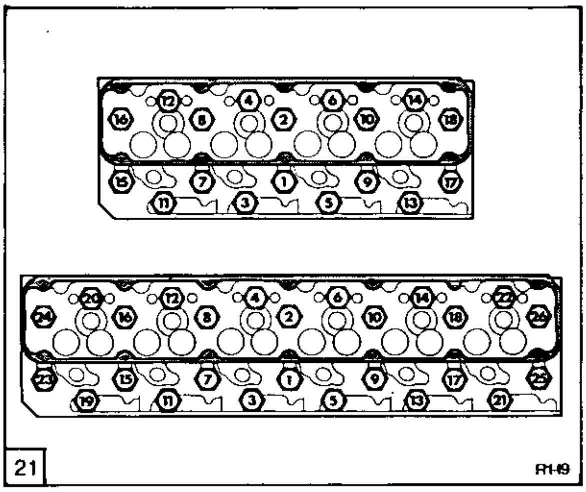
1. Insert the valves into the guide bores from which they were removed and lap with a suitable paste, ensure all traces of paste are removed after lapping.

2. Lubricate all components with clean engine oil on re–assembly. Use a spring compressor to reassemble the valves, valve springs, retainers, rotators, and collets, and install new umbrella seals.

3. Coat all components with clean engine oil prior to assembly, and insert each push rod into its original position, ensuring each ball end is seated in its cam follower, Figure 20.

CYLINDER HEAD INSTALLATION

Installation of the cylinder head assembly and components is the reverse of the removal procedure, observing the following,



Cylinder Head Bolt Tightening Sequence

1. Install new cylinder head, intake and exhaust manifold gaskets, Figure 21.

NOTE: *Ensure exhaust manifold gasket is fitted correctly to suit profile of exhaust ports.*

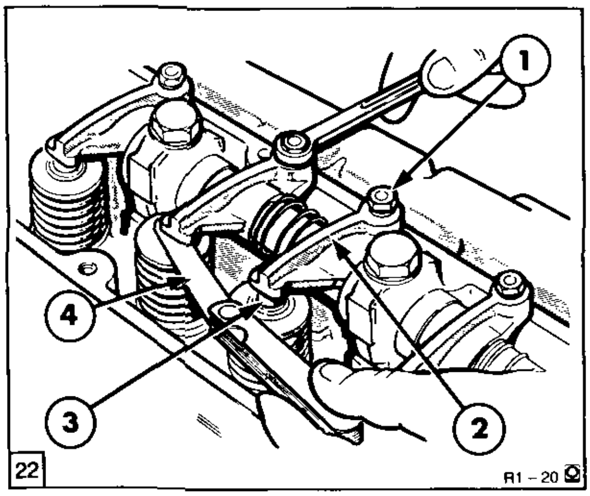
2. Tighten the cylinder head bolts in sequence progressively in three stages, Figure 21.

Stage1, 115 lbf ft (156N m) 15.6 kgf m

Stage2, 140 lbf ft (190N m) 19.3 kgf m

Stage3, 160 lbf ft (217N m) 22.0 kgf m

NOTE: *Bolts to be lubricated prior to assembly, and should be tightened to torque specification, with the engine cold.*



Setting Valve Lash

1. Adjuster Screw
2. Rocker Arm
3. Valve Stem
4. Feeler Gauge

3. Adjust valve lash setting with each piston in turn at Top Dead Centre and rockers free to move, Figure 22.

Intake Valve Lash:
0.014–0.018 in (0.36–0.46mm).

Exhaust Valve Lash:
0.017–0.021 in (0.43–0.53mm).

NOTE: *Valve lash is to be set only when the engine is cold.*

4. Install the injectors with new seat washers, cork seals and torque to 17 lbf ft (23N m) 2.3 kgf m, Figure 6.

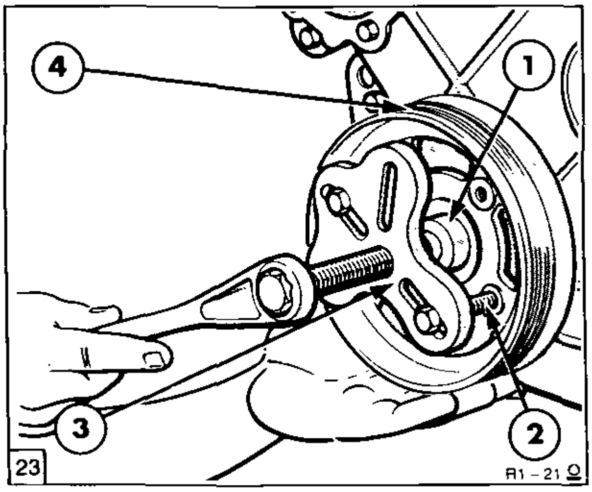
5. Install the injector lines and leak off pipes with new washers and torque the leak off banjo bolts to 8 lbf ft (10N m) 1.1 kgf m.

NOTE: *Hold the leak off plastic tubing when tightening to prevent the pipes pivoting during torque up.*

6. Exhaust manifold bolts are to be refitted and tightened to a torque of 28 lbf ft (38N m) 3.8 kgf m.

7. Intake manifold bolts are to be refitted and tightened to a torque of 28 lbf ft (38N m) 3.8 kgf m.

ENGINE FRONT COVER AND TIMING GEAR REMOVAL



Crankshaft Pulley Removal

1. Shaft Protector
2. Bolt
3. Puller
4. Crankshaft Pulley

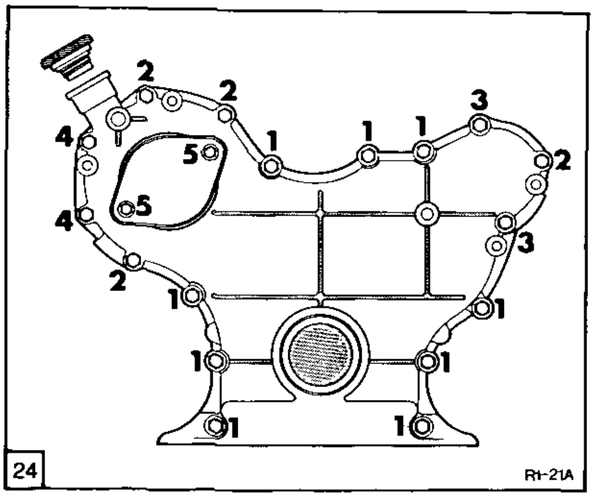
NOTE: *Timing cover and gears can only be serviced after removing the front support assembly, refer to PART 10 "SEPARATING THE UNIT".*

1. Remove the fan belt and tensioner and withdraw the bolt and washer from the crankshaft pulley.

2. Using puller No 518 or FT 9539 and shaft protector No 625–A or 9212, remove pulley, spacer and 'O' ring from the shaft, Figure 23.

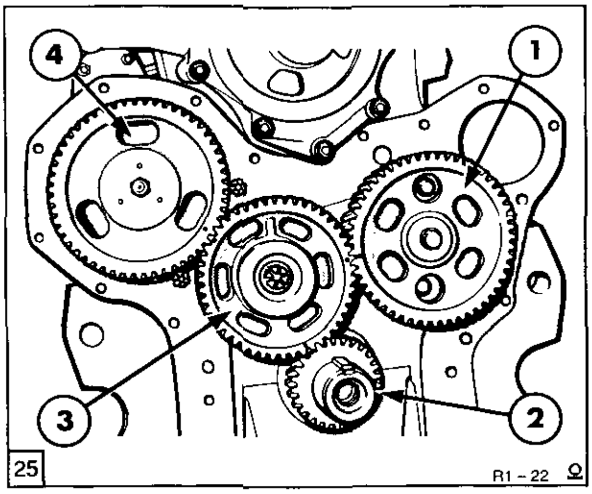
3. Disconnect the hydraulic auxiliary pump tubes where fitted, draining the oil into a suitable container and plug all ports to prevent dirt ingress.

4. Drain the engine oil and remove the oil pan.



Front Cover Retaining Bolt Sequence

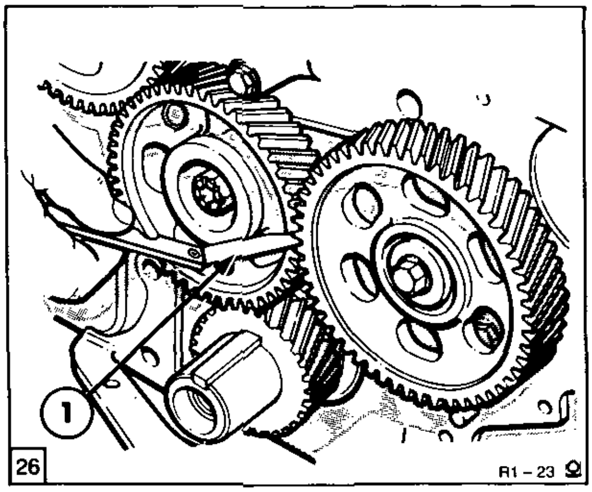
5. Withdraw the retaining bolts, and remove the front cover and gasket, Figure 24.



Timing Gears
1. Camshaft Gear
2. Crankshaft Gear
3. Camshaft Idler Gear
4. Injection Pump Drive Gear

NOTE: *The crankshaft timing gear No. 2, Figure 25, should not be removed. The gear is heat shrunk on to the crankshaft and aligned to the crankshaft No.1 pin to 0.004 in (0.10mm). If the gear is damaged a new crankshaft is required.*

6. Before removing the timing gears, Figure 25, use a dial indicator or feeler gauge, Figure 26, to measure the backlash between each set of gears.



Timing Gear Backlash
1. Feeler Gauge

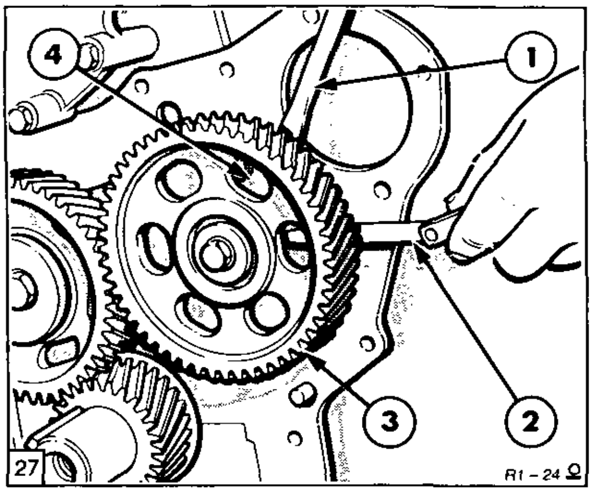
7. Rotate the gears and check the backlash using a feeler gauge or dial indicator at four equal points on the gears. Renew if the backlash exceeds the following, Figure 26:–

Backlash to crankshaft gear:
0.006–0.018 in (0.15–0.46mm)

Backlash to camshaft gear:
0.006–0.018 in (0.15–0.46mm)

Backlash to fuel injection pump gear:
0.004–0.021 in (0.10–0.53mm)

CAMSHAFT DRIVE GEAR



Camshaft End Play Measurement
1. Lever
2. Feeler Gauge
3. Camshaft Gear
4. Thrust Plate

1. Pry the camshaft gear using a lever away from thrust plate. Using a dial indicator or feeler gauge, check the clearance to 0.002–0.007 in (0.076–0.35mm). If outside of limits fit a new camshaft thrust plate, Figure 27.

2. Remove the camshaft idler gear retaining bolt, gear and adaptor from the block, then remove the camshaft gear bolt and disassemble.

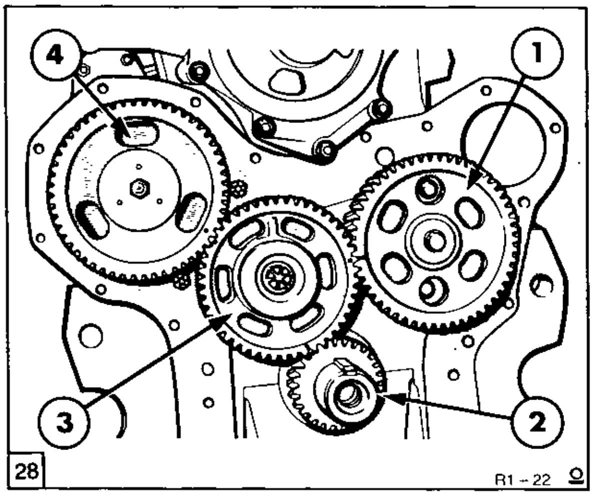
3. Remove retaining nut and washer from the fuel pump and remove the gear from the shaft using a puller. For more information refer to "FUEL SYSTEMS" Part 2.

Inspection and repair of gears

1. Wash the gears using a suitable solvent and examine gear teeth for wear, burrs or scratches. Minor marks can be removed using a fine abrasive, thoroughly clean before re–assembly.

2. Ensure the camshaft idler gear adaptor is free from obstruction and bushing is not damaged. Camshaft key and key–way should be checked for damage and repaired as required.

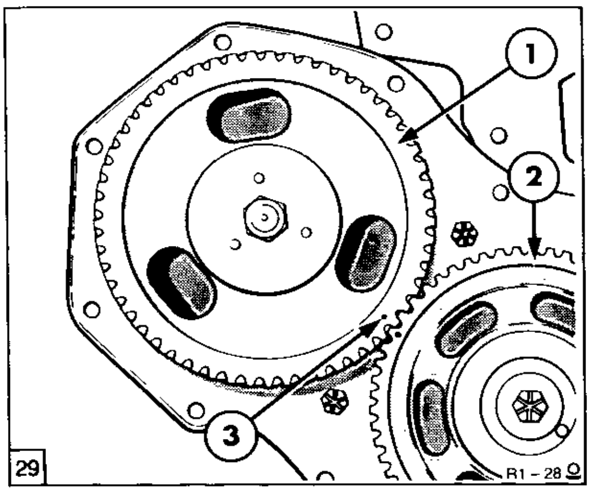
Installation



Alignment of Timing Gears
1. Camshaft Gear
2. Crankshaft Gear
3. Camshaft Idler Gear
4. Injection Pump Drive Gear

1. Position piston No.1 at Top Dead Centre, install the spacer, key and camshaft gear and tighten to 51 lbf ft (69N m) 7.0 kgf m, Figure 28.

2. Install the camshaft idler gear to the block, align timing marks and torque to 175 lbf ft (237N m) 24kgf m, Figure 28.

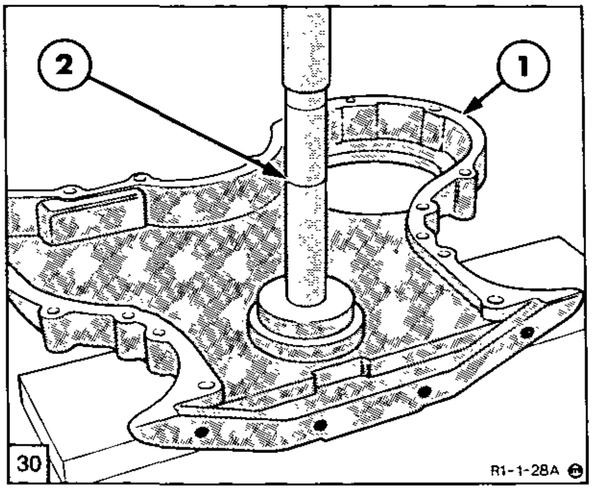


DPS Pump Gear to Camshaft Drive Gear
1. Pump Drive Gear
2. Camshaft Idler
3. Timing Mark

3. With piston No.1 at Top Dead Centre, assemble fuel injection pump with a new seal and align mark on pump flange to 0° timing mark on the front plate. Torque bolts to 18 lbf ft (22Nm) 2.2 kgf m. Install pump gear with timing marks aligned to the idler gear, and torque to 58 lbf ft (78N m) 7.8 kgf m, Figure 29.

NOTE: *Fuel pump (injection) timing is set at 10° before Top Dead Centre, when the piston face to cylinder block height is:–*
0.043 in (1.1mm) for 4.4 in (112mm) stroke.
0.050 in (1.3mm) for 5.0 in (127mm) stroke.

4. The front oil seal should be renewed every time the front cover is removed. Drive out the old seal using a punch taking care not to damage the front cover.



Front Cover Oil Seal Installation
1. Front Cover
2. StepTool No 630–16 or T87T–6019–A

5. Coat a new seal in a suitable lubricant and drive the seal into the rear of the front cover using Tool No. 630–16 as in Figure 30. Alternatively, use Tool No. T87T–6019–A and drive the seal into position from the front of the cover.

6. Position gasket on the front cover plate.

7. Install the front cover ensuring alignment with dowel pins and tighten the bolts to:–

5/16 in–18 UNC bolts tighten to 13–18 lbf ft (18–24N m) 1.8–2.5 kgf m.

3/8 in–16 UNC bolts tighten to 25–30 lbf ft (34–41N m) 3.4–4.1 kgf m.

8. Lubricate the crankshaft, fit a new 'O' ring and slide the pulley spacer over the key. Place pulley onto the crankshaft and push home, tightening the securing bolt to 210 lbf ft (284N m) 29kgf m.

9. Apply sealer D, or J to the front and rear housing joints, fitting a new gasket to the oil pan, and torque the bolts to 28 lbf ft (38N m) 3.9 kgf m.

10. Refill the fluid levels to the correct specification and quantities as defined in "SPECIFICATIONS", install radiator and front axle, refer to "SEPARATING THE UNIT"

OIL PAN REMOVAL

WARNING: *Due to the weight of the oil pan it is recommended that a hydraulic jack is used to support and lower the oil pan to the ground.*

1. Drain engine oil through oil pan plug and remove oil level indicator.

2. Remove oil pan bolts including those through transmission front support and lower to ground.

Inspection and repair

1. Clean gasket material from sump face, clean sump in a suitable solvent, inspect sump for cracks damaged threads or damaged sump face.

Installation

1. Installation is the reverse of removal but with the following requirements:–

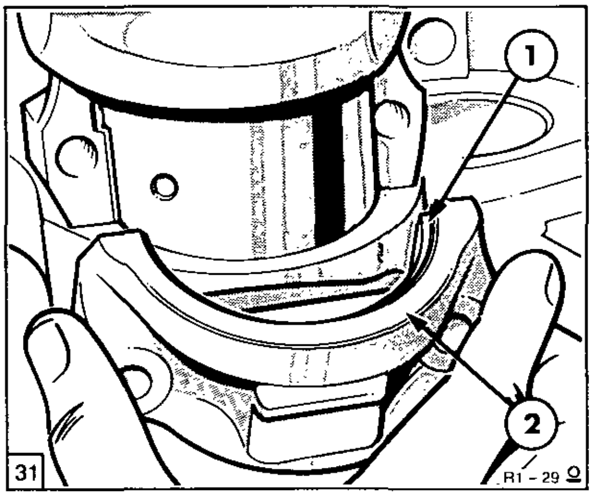
2. Ensure block face is clean and free of gasket material. Install a new gasket to the front cover and oil pan. Ensure sealer is applied to the front plate and rear oil seal return joints.

3. Position the oil pan and install a bolt at each corner finger tight to hold in position, install remaining bolts and torque to 28 lbf ft (38N m) 3.9 kgf m.

CONNECTING RODS, BEARINGS, PISTONS AND RINGS, REMOVAL.

NOTE: *The connecting rods and pistons can be removed with the engine installed after removal of the cylinder head and oil pan sump.*

1. With cylinder head removed, clean off any ridge from the top of the cylinder bores with a ridge remover to enable removal of the pistons. This is essential if old pistons are to be re–used as failure to do so could result in ring land damage.

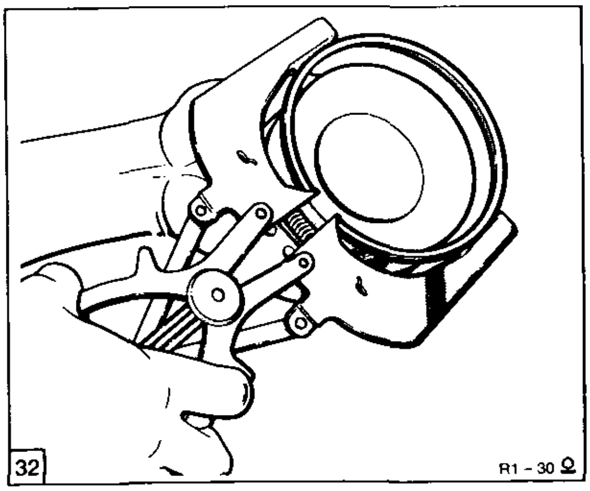


Connecting Rod End Cap Removal
1. Bearing Liner 2. End Cap

2. With the piston at the bottom of the stroke remove the end cap bolts, cap and liner. Using the handle end of a hammer push the piston assembly out through the top of the block and remove the liner from the connecting rod, Figure 31.

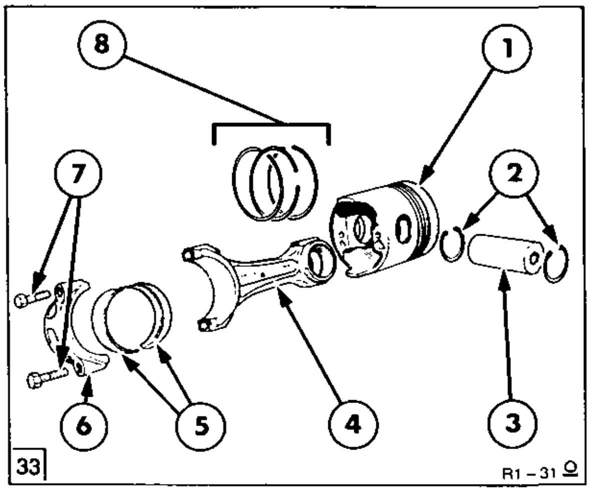
3. Turn the crankshaft again and repeat the process for the remaining pistons.

NOTE: *Bearing caps and liners must be kept with their respective connecting rods.*



Piston Ring Removal

4. Remove piston pin snap rings from each side of piston and remove pin. Using an expander, remove the piston rings, Figure 32.



Piston Assembly Disassembled

1. Piston
2. Pin Retainers
3. Piston Pin
4. Connecting Rod
5. Bearing Liners
6. Bearing Cap
7. Retaining Bolts
8. Piston Rings

5. Ensure each piston and rod assembly remains matched together for re–assembly, Figure 33, into the cylinder block.

Inspection and Repair

1. Clean the piston and connecting rod assembly in a suitable solvent and inspect for damage to ring lands, skirts, or pin bosses.
2. Check connecting rod components for damage and place in an alignment fixture to check for distortion. Ensure that any distortion, is within specification as follows:–

Maximum Twist 0.012 in (0.30mm).

Maximum Bend 0.004 in (0.10mm).

3. Check piston pin bushing for damage or wear in the following manner.

Measure the outside diameter of the piston pin, and inside diameter of the connecting rod bushing to the following,

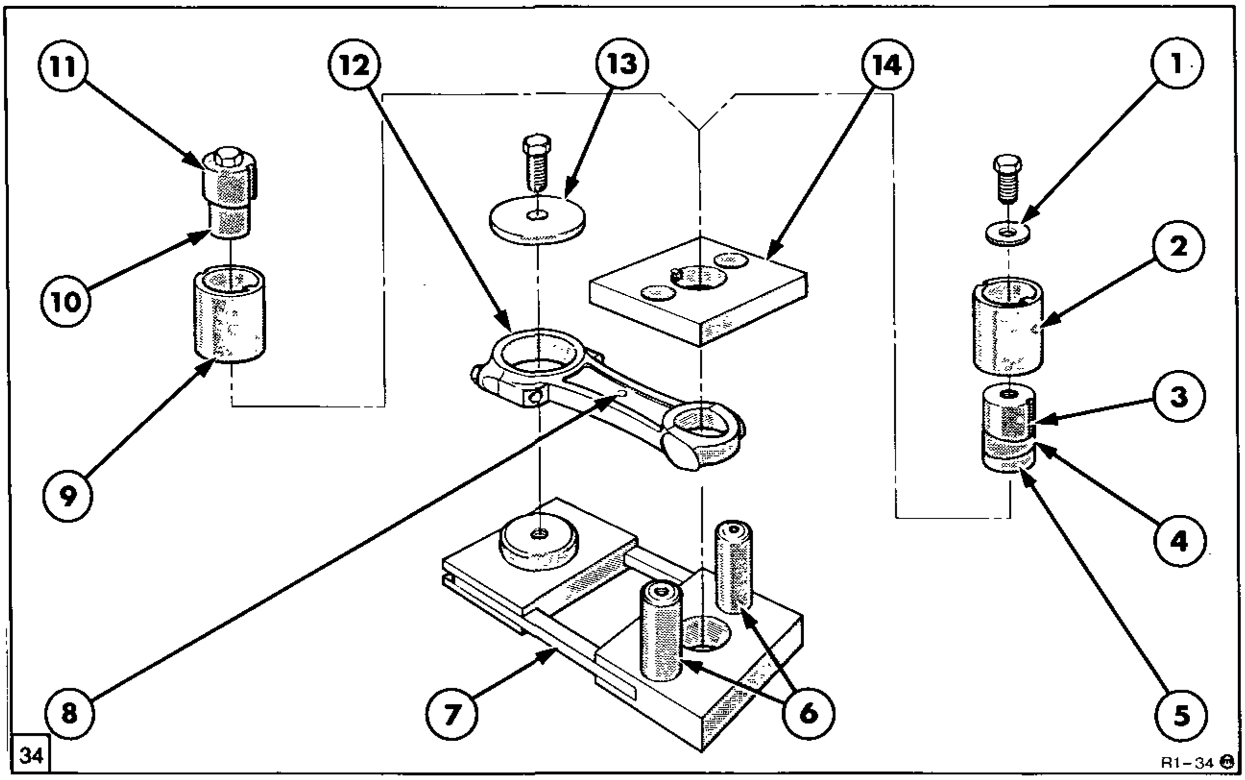
Piston Pin Outside Diameter

Naturally Aspirated:
1.4998–1.500 in (38.095–38.100mm).
Turbocharged:
1.6248–1.625 in (41.270–41.275mm).

Connecting Rod Bush Internal Diameter

Naturally Aspirated:
1.5005–1.5008 in (38.113–38.120mm).
Turbocharged:
1.6255–1.6258 in (41.288–41.295mm)

CONNECTING ROD BUSH



Connecting Rod Bush Installation

Removal

1. Washer
2. Collar
3. Installation Insert 1
4. Bush
5. Installation Insert 2
6. Pins
7. Fixture
8. Connecting Rod Facing up
9. Remover Insert 1
10. Remover Insert 2

Installation

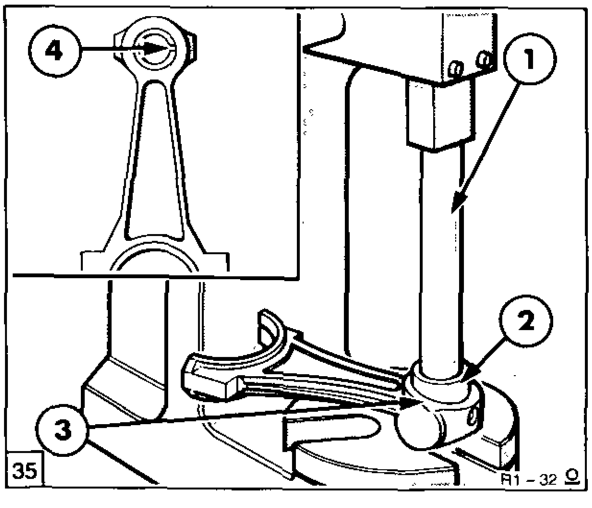
11. Remover Insert 3
12. Connecting Rod Location
13. Washer
14. Location Plate

1. If not to specification use Tool No. FNH 00053 and press out the old bush using the removal fixture as shown in Figure 34. Press fit a new bush through the fixture using the installation detail and into the connecting rod as shown in Figure 34. After fitting a new bush ensure all sharp edges and burrs are removed.

NOTE: ***A,*** *Ensure the split in the small end bush is at right angles to centre line of connecting rod.* ***B,*** *Connecting rods should only be changed as matched sets.*

2. Where special tooling is not available for the removal or fitment of the connecting rod bush a standard bush can be fitted, Figure 35, in the following manner:

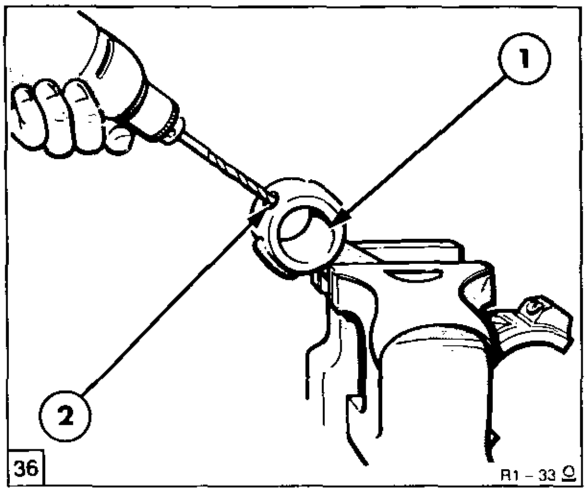
3. *Place the connecting rod securely in a* bench press. Manufacture from suitable bar stock, a press tool with the end face ground at an angle to suit the connecting rod bush side face. Position the tool on the bush and gently drive the bush from its position. It is recommended a guide is *manufactured* to assist alignment of the bar stock during this operation.



Connecting Rod Bush Fitment
1. Press Tool
2. Bush
3. Machined Side
4. *Bush Slot Alignment*

4. A new bush can then be fitted in a similar manner by using a suitable piece of bar stock with an end face machined flat to suit the standard parallel bush. Use a *guide as described and gently drive in the* new bush into the connecting rod.

5. After installation grind the side faces of the new bush to match the side faces of the connecting rod. Ensure all sharp edges are removed and loose chippings are cleaned from the connecting rod before re–assembly into the engine.



Drilling of Connecting Rod
1. Connecting Rod 2. Drill

6. With a new bush fitted, drill a hole through the top of the connecting rod using a 0.187 in (4.6mm) and drill through the existing oil hole, Figure 36.

7. Use an expanding reamer to obtain correct *bushing to piston pin clearance* referring to specification section. Remove burrs and chippings before refitting.

CYLINDER BLOCK OVERHAUL

1. Cylinder block plugs and senders require changing if leaking or rusty and must be replaced. Clean the old sealant off the block and fit new plugs with sealer, this applies to both the 4 and 6 cylinder engine range.
   Figure 37 refers to the front and left hand side of the cylinder block.

NOTE: *New part mating faces and threads should be coated in sealant, refer to "Specifications". Assemble in the following manner:–*

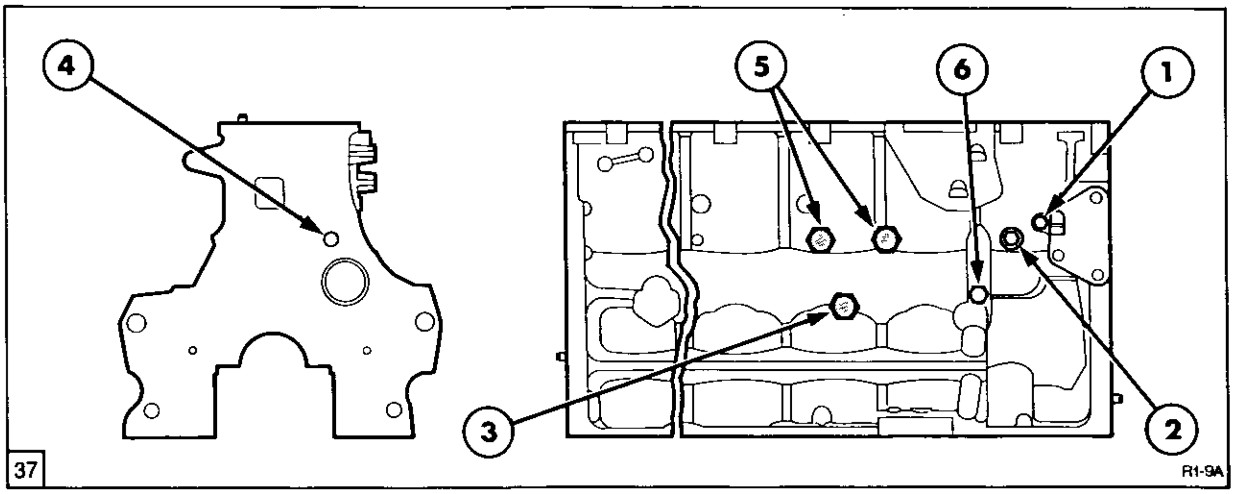
Plug (1) torque to 6–10 lbf ft (8–14N m) 0.8–1.3 kgf m. Use sealant C.

Switch (2) torque 18–25 lbf ft (24–34N m) 2.4–3.4 kgf m. Use sealant E.

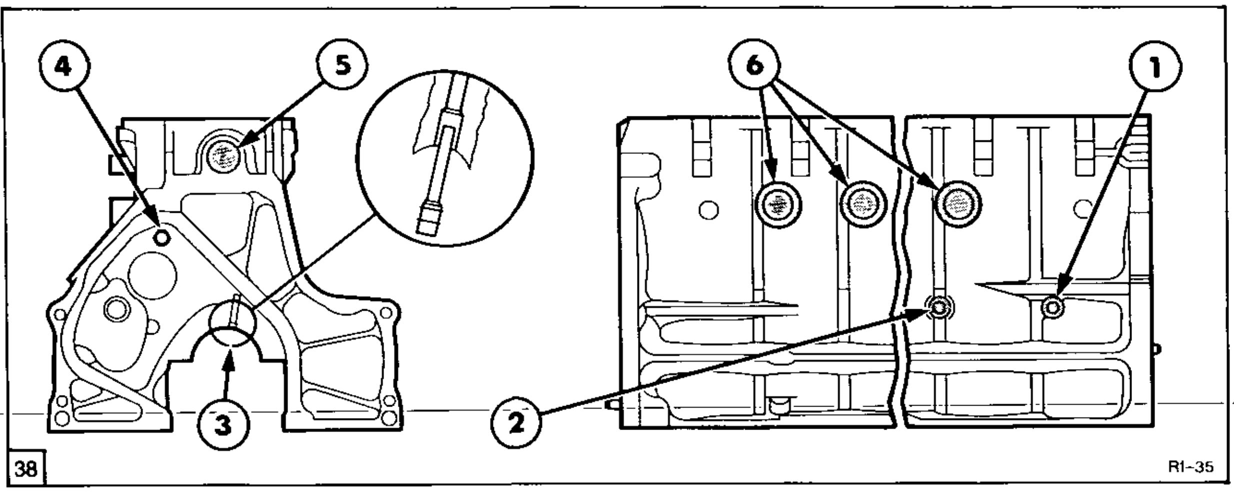
Plug(3) torque to 50–70 lbf ft (68–95N m) 6.9–9.6 kgf m. Use sealant F.

Plug (4) drive in to block.

Plug (5) torque to 18–25 lbf ft (24–34N m). 2.4–3.4 kgf m. Use sealant E.



Cylinder Block Core Plug and Sensor Ports, Front and Left Hand Side



Cylinder Block Core Plug and Sensor Ports, Rear and Right Hand Side

Plug (6) torque to 20–35 lbf ft (27–47N m). 2.7–4.8 kgf m. Use sealant, E.

2. Figure 38 refers to the rear and right hand side of the block.

Plug (1) torque to 18–25 lbf ft (24–34N m). 2.4–3.4 kgf m. Use sealant E.

Plug (2) torque to 6–10 lbf ft (8–14N m). 0.8–1.4 kgf m. Use sealant E.

Oil Jets (3) replace with new if damaged, apply engine oil only on re–assembly "Do not use sealant".

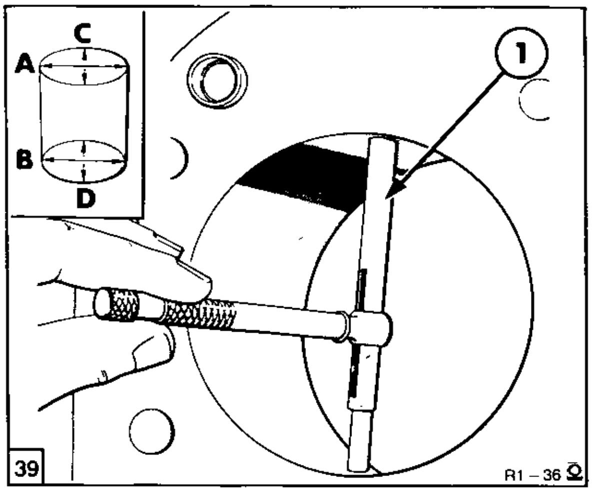
Plug (4) torque to 40–60 lbf ft (54–81N m) 5.5–8.2 kgf m.

Plug (5) drive into block. Use sealant G.

Plug (6) drive into block. Use sealant G.

CYLINDER BORE

1. Check the cylinder bore for scuffing or rings around the ring travel area. Irregularities can be felt by running a finger over the surface. To check out–of–roundness, wear, or taper, use a telescopic gauge, Figure 39.



Measurement of Cylinder Bore

1. Telescopic Measuring Gauge

Measure lengthwise:
A to B and C to D and compare dimensions, *variances between the readings will indicate* "taper".

Measure crosswise:
C to D and compare dimensions lengthwise. *A to B variances will indicate an out–of–round* condition.

Specifications:–

Taper of cylinder bore:
repair limit–0.001 in (0.025mm)
wear limit –0.005 in (0.127mm)

Cylinder bore out of round:
repair limit–0.0015 in (0.03mm)
wear limit–0.005 in (0.127mm)

Cylinder bore diameter:
4.4007–4.4032 in (111.778–111.841mm).

2. Where only minor imperfections exist and bores are to specification, hone the bores prior to installing new piston rings, provided piston to bore clearance does not exceed 0.0065 in (0.165mm).

3. If cylinder bores are outside the specification they should be bored or honed, to fit the next oversize piston. The finished bore size can be determined by measuring piston diameter at right angles to the piston pin and adding the appropriate piston to bore clearance.

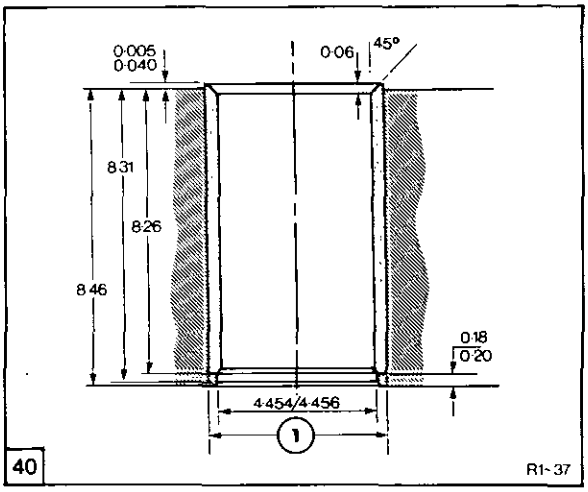
4. Oversize pistons available:
   0.004 in (0.10mm)
   0.020 in (0.51mm)
   0.040 in (1.0mm)

5. Bores to take 0.004 in (0.10mm) oversize pistons need only be honed using a rigid hone with a grit size of 150–220. Clean thoroughly after boring and honing.

6. Sleeving of the cylinder bores becomes expedient when:–
   1, Oil consumption is high due to porosity.
   2, Replacing sleeves, installed in service.
   3, Cylinder bore is damaged beyond re–boring limits.

NOTE: *When reconditioning engines equipped with sleeves, use only standard or 0.004 in (0.1016mm) oversize pistons*

SLEEVING – BORING AND HONING



Cylinder Block Sleeving

1. Measure the outside diameter (1) of the sleeve in several places and average the dimension. Counter bore the cylinder block (see step 2) using the average di*mension to obtain a press fit between* bore and sleeve. Interference of sleeve to the cylinder bore to be 0.001–0.003 in (0.025–0.076mm), Figure 40.

2. Counter bore to a depth of 8.26 in (209mm) from the block face, surface finish of the bore is not to exceed (80 microns). Leave a step at the bottom of the bore a minimum of 0.180–0.200 in (4.572–5.080mm), allowing for run out of chamfers.

3. Bore through diameter to the diameter of 4.454–4.456 in (114.3–116.0mm).

4. Clean the cylinder bores and thoroughly dry.

5. Grease the sleeve with ESA–MIC75–B or similar and press the sleeve home to the lip in the bore. The top of the sleeve should protrude through the top of the block 0.005–0.040 in (0.127–1.0mm).

6. Bore the sleeve to:
   4.3985–4.400 in (110.00–111.76mm).

7. Skim the block face and top of sleeves to achieve the specified flatness of 0.003 in (0.08mm) in any 6 in (152mm), 0.001 in (0.03mm) in any 1 in (25.4mm). A chamfer in the internal diameter at the top of the sleeve to 45°x0.020 in (0.5mm) should be maintained to prevent piston damage on re–assembly.

8. Break the sharp edge at the bottom of the sleeve prior to honing.

9. Hone the cylinder bore to:–
   Grade A, 4.4007–4.4015 in.
   Grade B, 4.4015–4.4023 in.

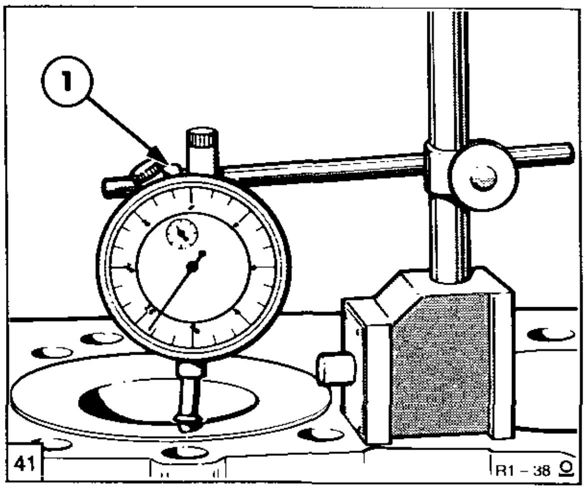
NOTE: *Surface finish to be an average of 20 to 30 Microns, cross hatched at 35°–55°.*

Maximum Taper:
0.001 in (0.025mm) through to bottom of the bore.

Maximum Ovality:
0.0015 in (0.038mm)

Re–Assembly

NOTE: *Pistons that are replaced must be of the same type that were removed and have the same identification letters and numbers as embossed on the underside of the old piston.*



Piston to Cylinder Block Height
1. Dial Indicator

1. Upon re–assembly with the piston at Top Dead Centre, ensure the piston to block height is correct using a dial indicator, Figure 41.

Naturally Aspirated:
0.011–0.023 in (0.28–0.58mm)

Turbocharged:
00.00–0.012 in (0–0.3mm)

2. Check the piston to bore clearance in the following manner.

A, Measure the cylinder bore diameter crosswise, then measure piston diameter at right angles to the piston pin.

B, Subtract piston diameter from the bore diameter and the resultant figures should be:–

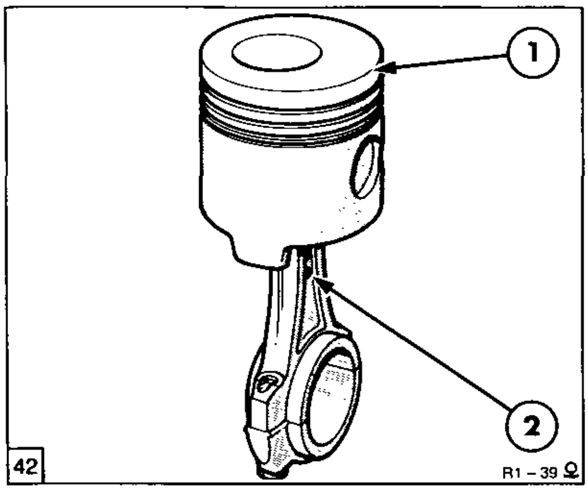
0.0065–0.0055 in (0.165–0.140mm)
Naturally Aspirated,
0.0065–0.0075 in (0.165–0.190mm
Turbocharged engines.

NOTE: *Pistons are available as standard and oversize, new pistons should always be fitted if the clearance exceeds specification.*

C, If clearance is "greater" try a similar new piston, if limit is still exceeded measure remaining cylinder bores and pistons and establish greatest clearance.

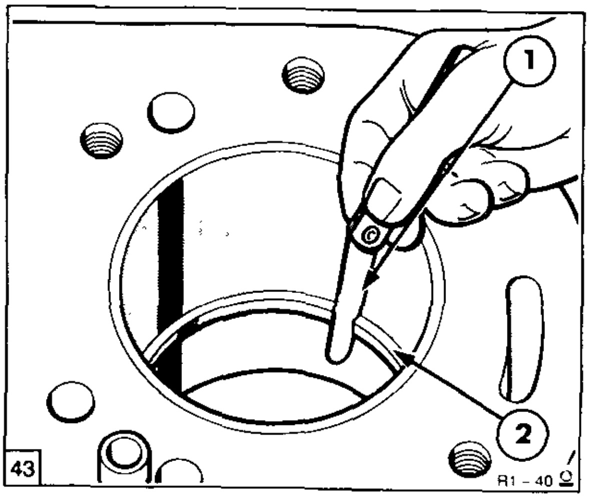
Based on the highest figure, re–bore to take the next oversize piston.

D, If the clearance is "less" hone bore to obtain desired clearance.



Piston Connecting–Rod Alignment
1. Piston 2. Pip on Rod

3. Lubricate all of the components with engine oil and assemble the connecting rod and piston, with the letter or grade mark on the piston, aligned to the pip on the connecting rod. Install the piston pin and retainers, Figure 42.



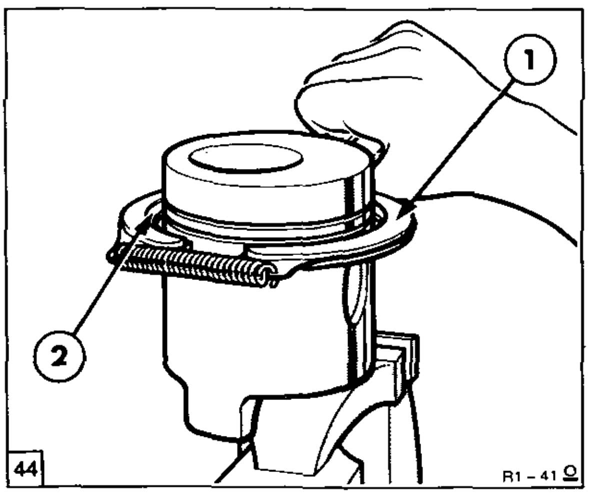
Piston Ring Gap
1. Feeler Gauge 2. Ring

4. Check the piston ring gap width using a feeler gauge, in a vertical position at the top, middle and bottom of the bore, Figure 43.

Top compression ring:
0.015–0.033 in (0.38–0.84mm).

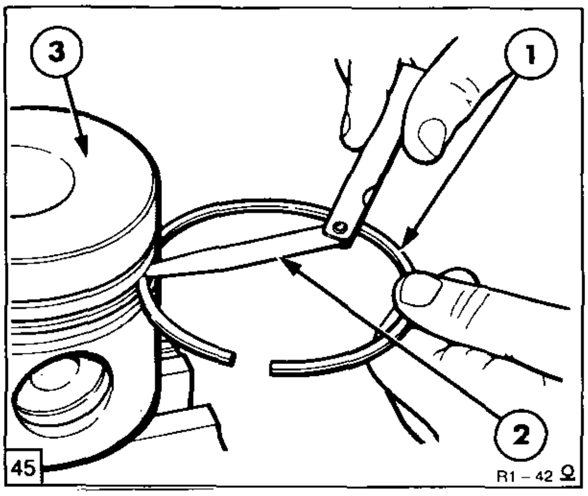
2nd compression ring:
0.026–0.044 in (0.66–1.12mm).

Oil control ring:
0.015–0.033 in (0.38–0.84mm).



Piston Ring Installation
1. Piston Ring Expander 2. Piston Ring

5 Ensure the correct expander is used to remove or install rings, Figure 44.



Piston Ring Side Clearance
1. Piston Ring 3. Piston
2. Feeler Gauge

6. Using a new piston ring, check with a feeler gauge the gap between the ring and groove, Figure 45.

Top compression ring:
0.0044–0.0061 in (0.112–0.155mm).

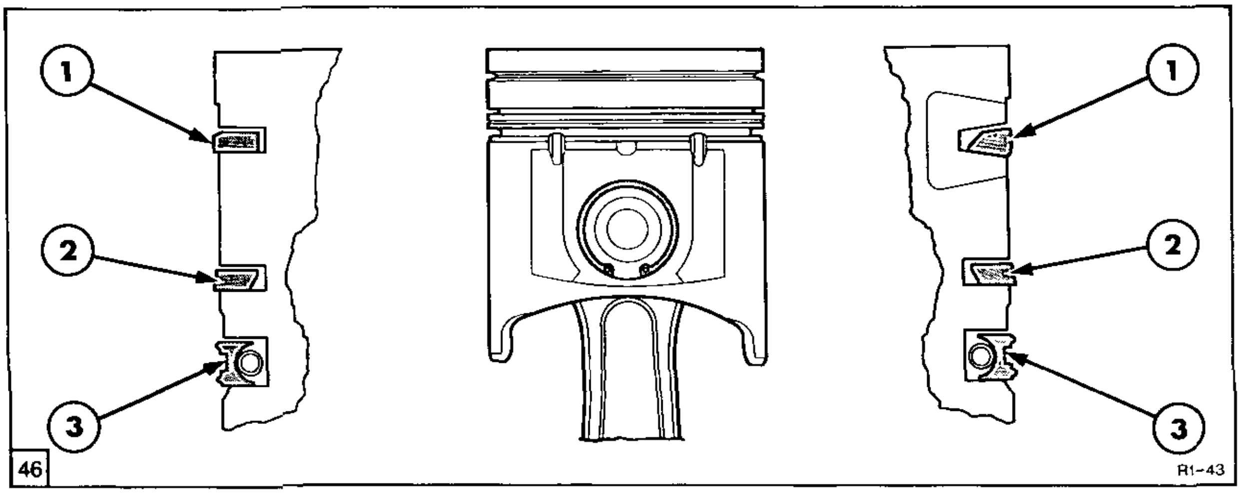
2nd compression ring:
0.0039–0.0056 in (0.099–0.142mm).

Oil control ring:
0.0024–0.0041 in (0.061–0.104mm).

7. Install the piston rings, Figure 46, but *note the following:*

NOTE: *Before installing new pistons and rings into a used cylinder bore , remove the high polish from the cylinder walls by honing as previously described.*

8. Install top and second compression rings *with the word top towards the top of the* piston. Ensure the ring gaps are staggered a minimum of 40° from each other on the diameter and with no gap on the *thrust side of the piston.*



Piston Ring Assembly

Naturally Aspirated

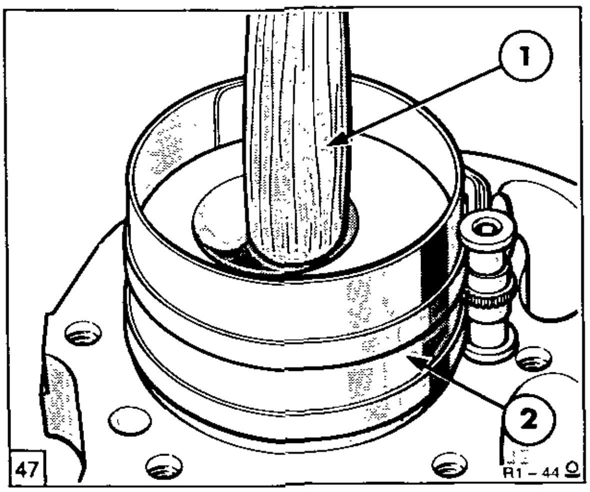
1. 1st Compression Ring
2. 2nd Compression Ring
3. Oil Control Ring

Turbocharged

1. 1st Compression Ring
2. 2nd Compression Ring
3. Oil Control Ring

PISTON ASSEMBLY INSTALLATION INTO BLOCK

1. Select the correct bearing liners as in the following crankshaft section and install in the rod and cap, ensure the liner tang locates in the slots of the rod and cap.

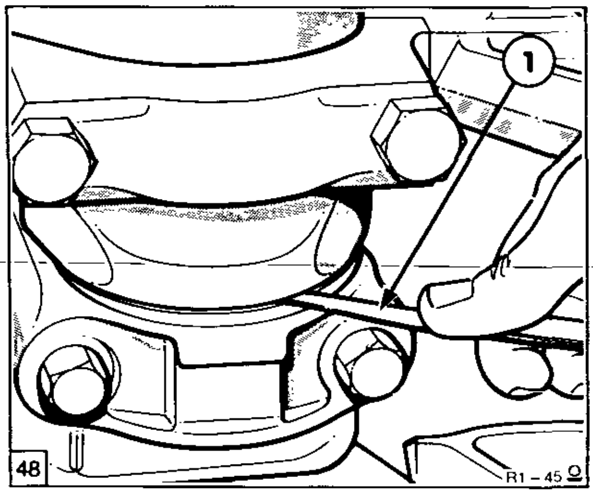


Piston and Connecting Rod Installation

1. Soft Drive
2. Ring Compressor

2. Turn the crankshaft, to position No.1 crankpin at the bottom of the stroke and lubricate all parts with new engine oil. Using a ring compressor and a soft drive, slide pistons into bores, ensuring grade letter on pistons is towards the front of the engine, Figure 47.

3. Ensure the connecting rod bearing liner, seats on the crankpin with the bearing cap fitted to the connecting rod as a matched assembly. Fit new bolts lubricated with oil and tighten to a torque value of 110 lbf ft (149N m) 15 Kgf m.



Connecting Rod Bearing Side Clearance

1. Feeler Gauges

4. Using feeler gauges, check the side clearance of each connecting rod to crankshaft, Figure 48: 0.005–0.013 in (0.13–0.33mm) and continue for remaining assemblies.

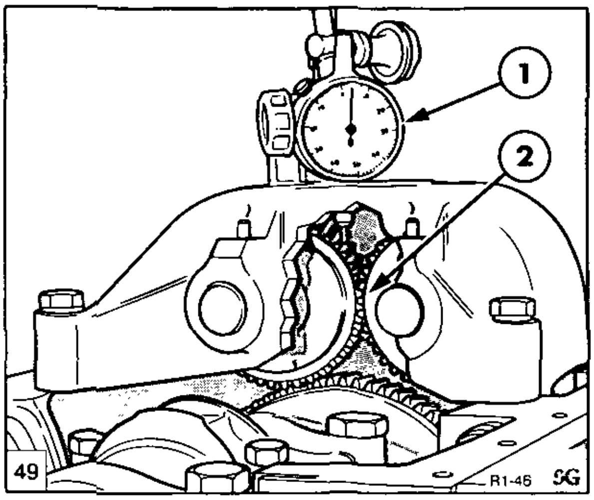
5. Refit the oil pump tube/screen, balancer and oil pan as previously described, refill engine oil and coolant and run the engine checking for leaks.

BALANCER, MAIN BEARINGS, FLYWHEEL AND CRANKSHAFT

NOTE: *Replaceable bearing liners are installed in production to ensure correct crankshaft journal to bearing clearance is maintained in service. The main bearings can be overhauled with the engine in the tractor. The crankshaft can only be serviced after removal from the tractor.*

To remove the flywheel, the engine requires to be split from the transmission housing or removed from the tractor totally. Refer to "SEPARATING THE UNIT".

Balancer Removal



Balancer Gear Backlash

1. Dial Indicator 2. Backlash Check

1. Remove the oil pan to expose the balancer and using a dial indicator gauge, check backlash between crankshaft gear and balancer drive gear, Figure 49. Position the dial plunger to the face of one of the drive gear teeth, then rock the gear to measure backlash. Readings should be taken at 90° intervals around the drive gear to 0.002–0.012 in (0.05–0.30mm). If the specification is exceeded, install new balancer gears.

Disassembly

1. Extract the roll pins securing the shafts to the housing and disassemble, Figure 50.

Inspection and repair

1. Measure the outside diameter of shafts and the inside diameter of the gear bushings and establish if clearance is to specification. If exceeded, replace shaft and / or gear assembly: 0.0002–0.008 in (0.005–0.020mm).

2. Examine shafts and balancer gear teeth for wear and damage and replace as necessary. Ensure lubrication holes in the shafts are free from obstruction upon re–assembly.

For crankshaft balancer gear repair and assembly, refer to the crankshaft section.

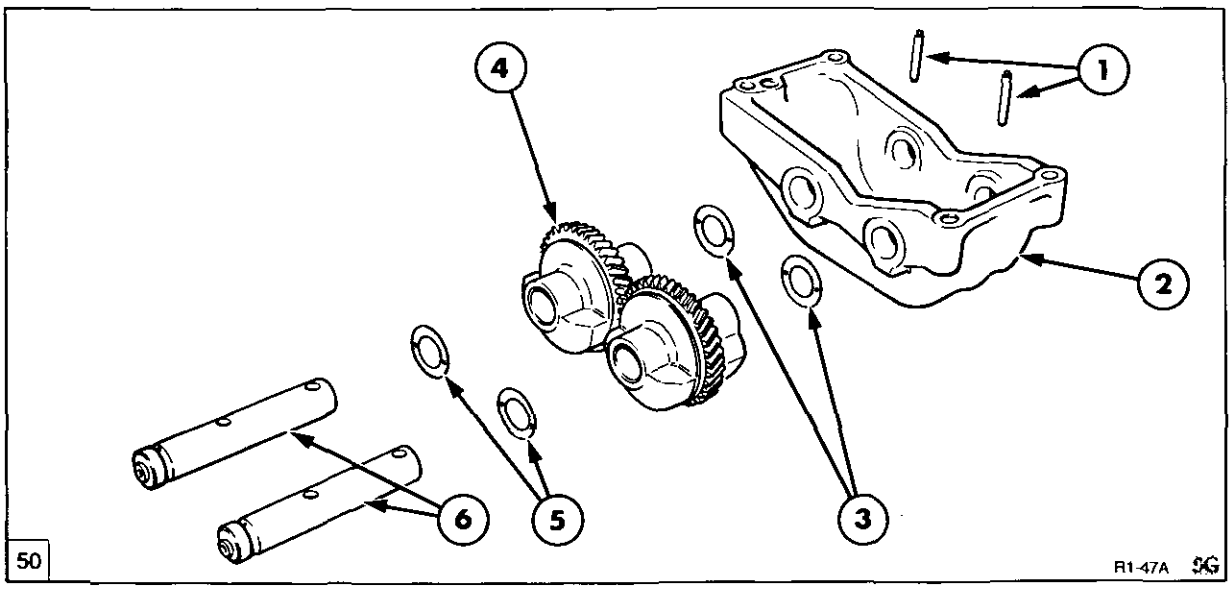
Re–Assembly

1. Position balancer gears and thrust washers in the housing, with timing marks aligned and facing the roll pin side of the balancer. Install shafts from the opposite side and secure with roll pins.

2. Using a feeler gauge measure end float of assembled gears is to the specification: 0.008–0.020 in (0.20–0.51mm).

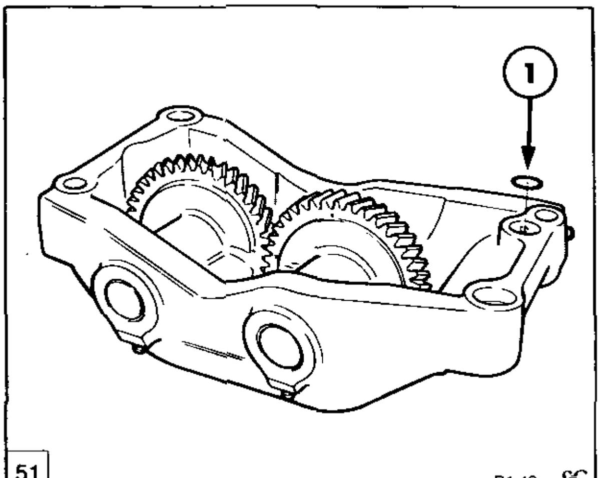
3. Position a dial indicator gauge to the tooth of one gear and hold the other firmly. Rocking the free gear, measure backlash at 90° intervals around the gears to 0.002–0.010 in (0.05–0.25mm).

Installation



Balancer Gears

1. Roll Pin
2. Housing
3. Thrust Washers
4. Driven Gears
5. Thrust Washers
6. Shafts



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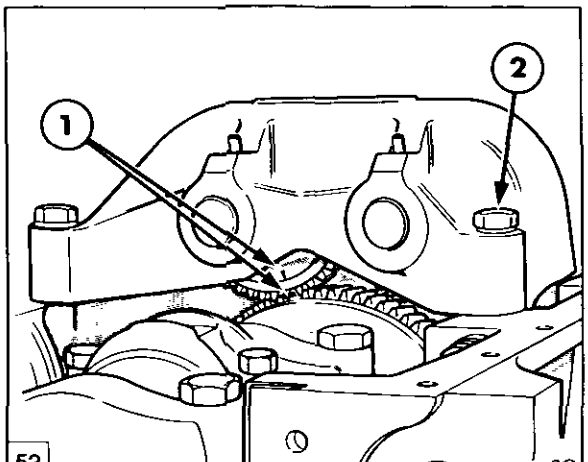
Balancer Gear Assembly
1. '0' Ring

1. Clean all the mating surfaces and install a new 'o' ring in the lubrication port, Figure 51.



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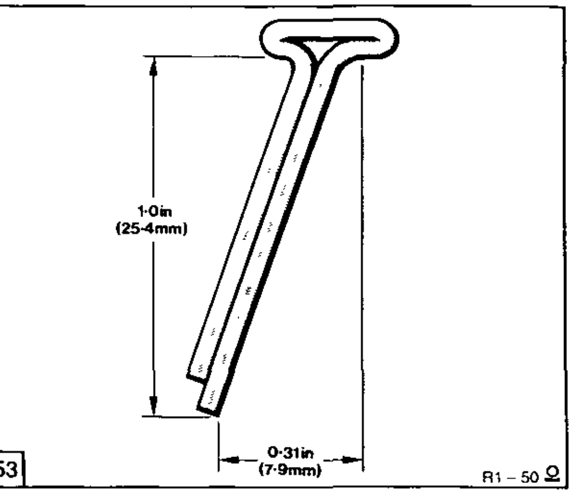
Timing of Balancer to Crankshaft
1. Gear Alignment Marks
2. Attaching Bolts

2. Rotate crankshaft until timing mark on crankshaft gear aligns with timing mark on balancer drive gear, Figure 52. Position balancer on dowels, install the bolts and torque to 80–90 lbf ft (108–120N m) 11–12.4 kgf m.

3. Recheck the gear backlash between crankshaft and balancer gear, as previously described and replace the oil pan.

MAIN BEARING REMOVAL

1. Remove the oil pan and balancer, to gain access to the crankshaft. Remove the main bearing cap from the journal to be repaired and install only one set at a time. Leave the remainder securely in place.



53

Bearing Liner Removal Tool

NOTE:–*A liner removal tool can be fabricated from a 1 in (25mm)x1/8 in split pin, flatten and bend the head to conform to angle of oil passage in the crankshaft.*

2. Install the bearing liner removal tool Figure 53, in the crankshaft journal oil passage. Turn the crankshaft counter clockwise until the tool forces the bearing out of the cylinder block.

Inspection and Repair

1. Thoroughly clean bearing liners, journals and caps and inspect for wear, scores or damage, replace as required.

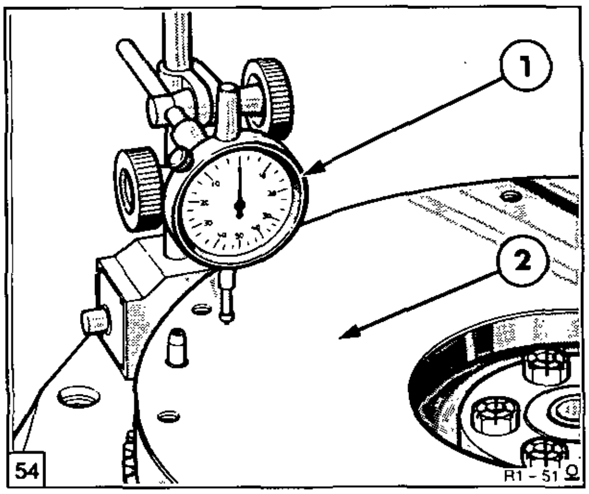
Installation

1. Coat all parts in new engine oil prior to assembly. Position the bearing cap with locking tang towards the camshaft side of the engine and fit the bolts, tighten evenly to 140–150 lbf ft (190–203N m) 19.3–20.1 kgf m.

2. If a new thrust bearing liner is installed bearing must be aligned as in following crankshaft chapter.

FLYWHEEL REMOVAL

1. To gain access to the flywheel separate the engine to transmission. Refer to "SEPARATING THE UNIT ".



Flywheel Runout
1. Dial Indicator 2. Flywheel

2. Prior to removal and using a dial indicator, rotate the flywheel, Figure 54, and measure to specification 0.005 in (0.127mm) Total Indicator Reading. If not to specification check crankshaft to flywheel seating.

Inspection and Repair

1. Inspect the flywheel ring gear and if damaged renew in the following manner:–

Cut old ring gear free from the flywheel.

Clean the mating surfaces of the new ring gear and flywheel.

2. Use temperature indicating crayons to mark the side face of the ring gear in six equal places, mark with a 204°C (400°F) crayon at a point 0.5 in (13mm) below the root of the teeth and mark with a 212°C (450°) crayon at a point just below root of the teeth.

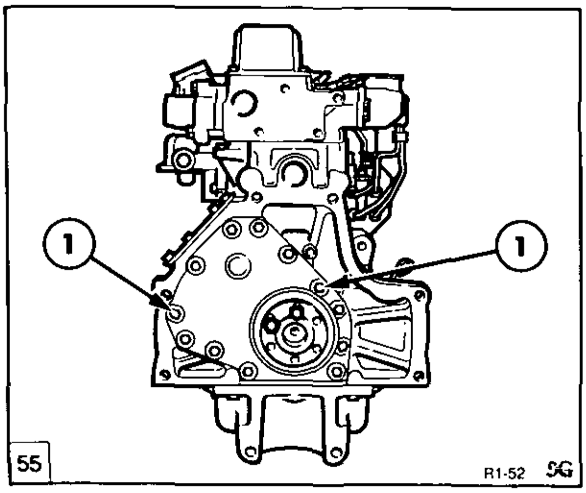
3. Use an oxy–acetylene torch with a tip size *of No.2 maximum and direct the flame* against the internal face of the gear.

4. Quickly place the hot gear on the flywheel, with flat face against the shoulder on the flywheel. The gear to flywheel runout should be checked using a dial indicator and should not exceed a Total Indicator Reading of 0.025 in (0.63mm).

Installation

1. Clean the crankshaft rear flange and mating surface of the flywheel and install the flywheel, torque the bolts to:
145 lbf ft (197N m) 20 kgf m.

REAR COVER PLATE REMOVAL



Rear Cover Plate Removal
1. Retaining Bolts

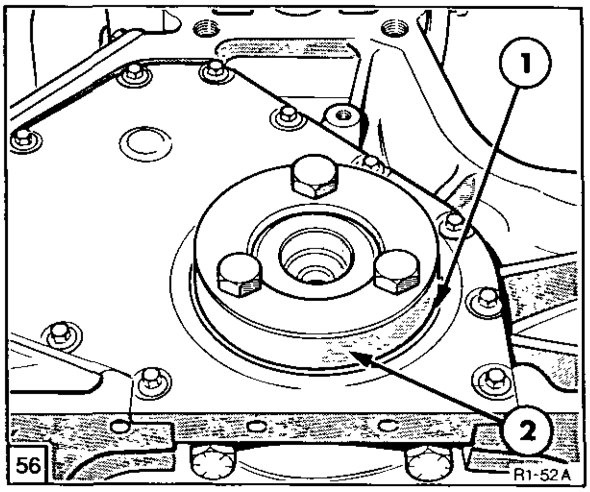
1. *To gain access to the engine oil pump,* camshaft gear or end of crankshaft, remove the oil pan as previously described and the rear cover, Figure 55, in the following manner:

Split tractor see "SEPARATING THE UNIT"

2. With rear of engine exposed loosen and remove the 12 attaching bolts and gently pry off cover plate.

3. Clean off all sealer, remove crankshaft oil seal and check for damage or distortion around the sealing faces.

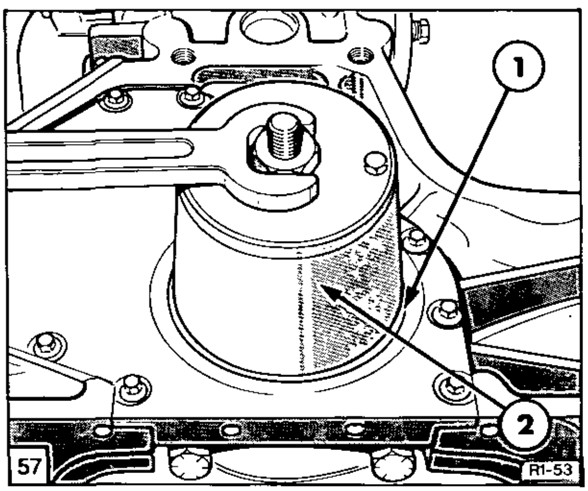
Installation



Rear Crankshaft Oil Seal Installation
1. Rear Oil Seal
2. Tool No. FNH 01301

1. Apply a liberal coating of new engine oil on a new oil seal and position the rear seal over the end of the crankshaft. Locate Tool. No FNH 01301 on the end of the crankshaft using the three attaching bolts. Tighten evenly and squarely, until the seal is fully seated, Figure 56.

As an alternative the rear crankshaft oil seal can be installed using the following installation tool.



Rear Crankshaft Oil Seal Installation
1. Rear Oil Seal
2. Tool No. FT 6212

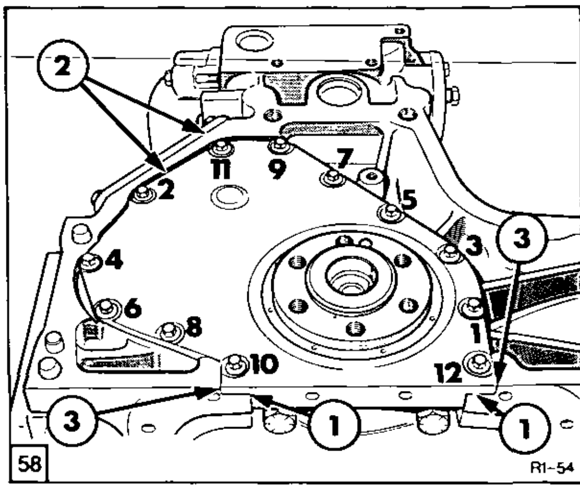
1. Apply a liberal coating of clean engine oil to the rear seal retainer, seal and journal.

A new seal should be mounted on the crankshaft, then bolt Tool No. FT 6212 to crankshaft end and install the new seal squarely, Figure 57.

2. Secure centre stock of tool to crankshaft flange with two screws. Assemble cylinder end plate to centre stock and secure with nut and washer as in Figure 57. Tighten the nut until outer diameter of tool abuts retainer. Tool must not be over tightened as stress and distortion could be imposed on the retainer.

3. Remove the tool after assembly and check the crankshaft seal run out as shown in Figure 59.

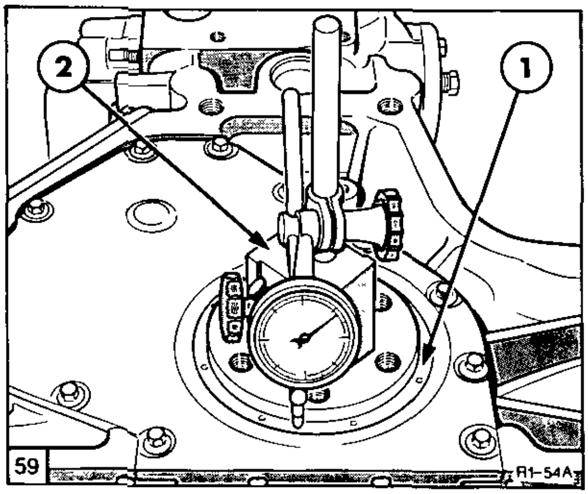
NOTE: *The first seal replacement should be pushed into retainer with plain end of tool and subsequent seals with stepped end of tool which will reposition seal 0.060 in (1.52mm) further in.*



Rear Cover Plate
1. Sealer Application
2. Retaining Bolts
3. Plate Alignment

4. Ensure rear of block face is clean and free of old sealer, install a new gasket and apply sealer D or J to faces (1), Figure 58. With the plate in the recess, install and tighten the twelve bolts in sequence to 12–17 lbf ft (16–23N m) 1.6–2.3 kgf m, Figure 58.

5. Ensure edges of the retainer and seal assembly are even with edges of block within 0.003 in (0.08mm), Figure 58. If not to specification, loosen and re–align retainer in the recess and repeat the installation procedure.

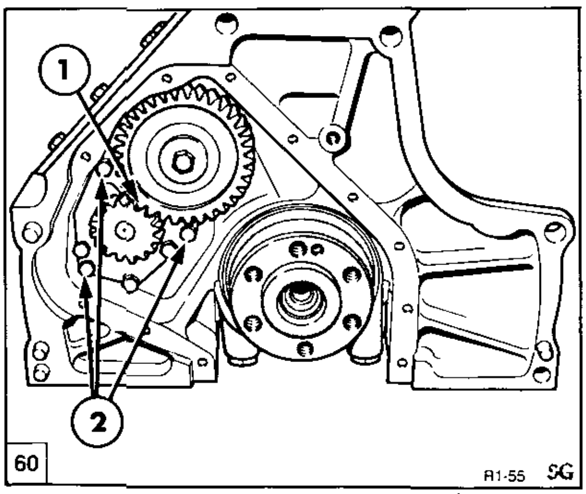


Measuring Crankshaft Seal Runout
1. Crankshaft Seal 2. Dial Indicator

6. With new crankshaft seal installed, place a dial indicator on the end of the crankshaft and ensure seal runout is within 0.020 in (0.51mm) Total Indicator Reading, Figure 59.

OIL PUMP REMOVAL

NOTE: *The oil pump can only be removed with the engine split from the transmission and the flywheel, back plate, engine oil pan and oil pump tube removed.*

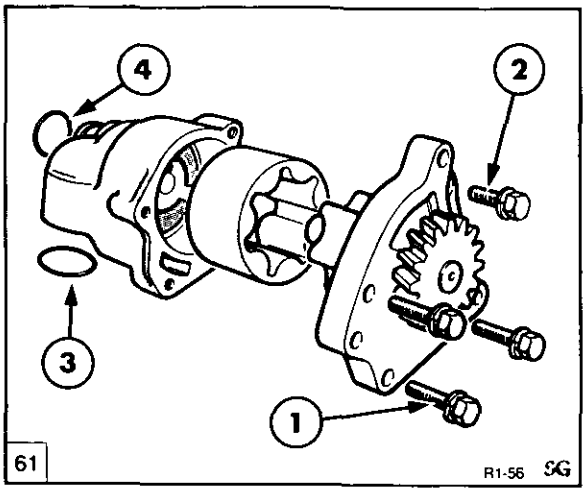


Engine Oil Pump
1. Gear Backlash Measurement
2. Pump to Block Mounting Bolts

1. Prior to pump removal check pump gear to camshaft gear backlash does not exceed, 0.016–0.022 in (0.40–0.56mm), Figure 60.

2. Loosen and remove the camshaft gear to expose the oil pump, detach the 3 pump mounting bolts (this is the same for both 4 and 6 cylinder models), and withdraw the pump from the block, Figure 60.

Disassembly

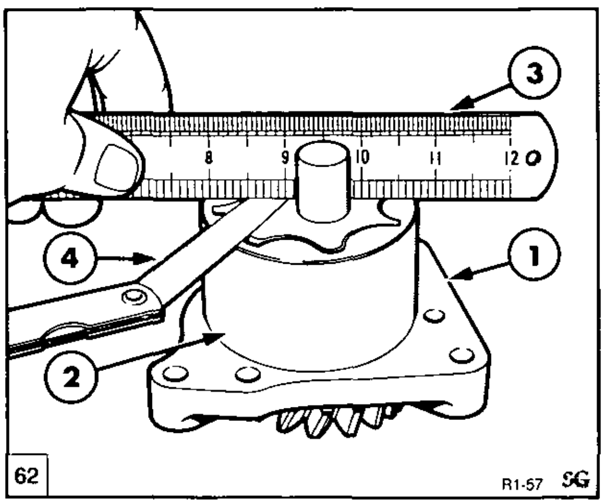


Oil Pump Disassembly
1. Retaining Bolts
2. Retaining Bolts 6Cyl
3. 'O' Ring Intake Port
4. 'O' Ring Outlet Port

1 Loosen and remove the pump face plate to body bolts. There are 3 off in the 4cylinder pump face and 4 off, in the 6 cylinder pump face. Disassemble the pump and discard the 'O' rings, Figure 61.

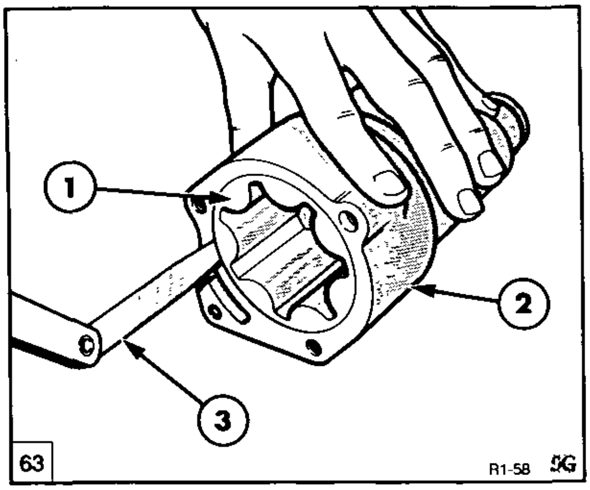
Inspection and Repair

1. Wash all parts in a suitable solvent and inspect inside of pump plate and body, for excessive wear or damage. If visually okay check in the following manner.



Measuring Oil Pump Rotor
1. Rotor Body 3. Straight Edge
2. Outer Rotor 4. Feeler Gauge

2. Invert pump plate/rotor assembly and place outer rotor over inner rotor. Placing a ruler across top of both, slide a feeler gauge between ruler and inner rotor to 0.001–0.0035 in (0.025–0.089mm), Figure 62.



Measuring Outer Rotor to Pump Body
1. Outer Rotor
2. Pump Body
3. Feeler Gauge

3. Place outer rotor in pump body and check clearance by inserting a feeler gauge between the rotor and body. Check to a max of 0.022 in (0.55mm), Figure 63. If exceeded a new pump is required.

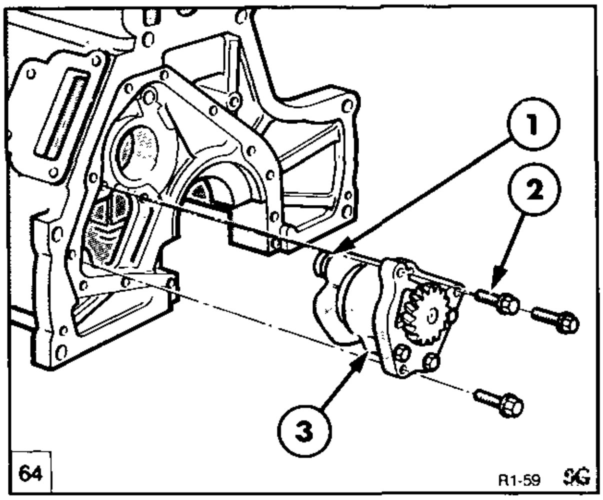
NOTE: *If not to specification replace the oil pump, as reduced pump pressure through wear could result in reduced engine life.*

Installation

1. Clean and coat parts in new engine oil. Place outer rotor in pump body and ensure free rotation. Insert inner rotor and pump plate assembly into the body and ensure that shaft is fully seated into bushing.

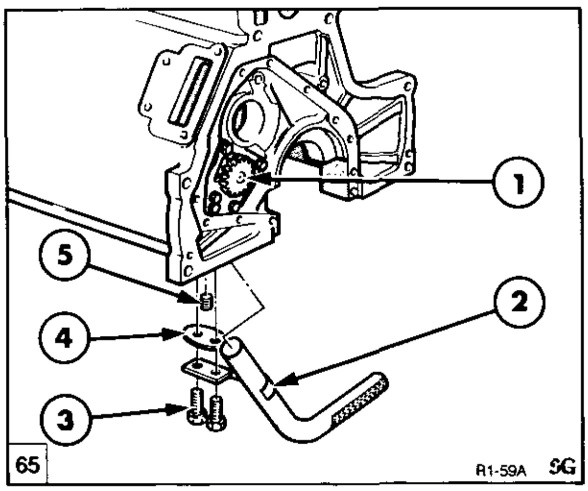
2. Assemble the front plate to the body using 3 or 4 bolts and torque to 17–21 lbf ft (23.0–28.4Nm) 2.3–2.9 kgf m.

NOTE: *After tightening ensure the drive gear rotates freely by hand at least 5 revolutions, if not "disassemble" and repeat the exercise.*



Assembly of Oil Pump
1. 'O' Ring Output Tube
2. Retaining Bolts
3. Oil Pump

3. Fit a new 'O' ring to the output tube, lubricate and insert the pump into the block tightening the bolts, Figure 64 to 17–21lbf ft (23.0–28.4N m) 2.3–2.9kgfm



Oil Pump Intake Tube
1. Oil Pump
2. Pump IntakeTube
3. Gasket
4. Retaining Bolts
5. Plug

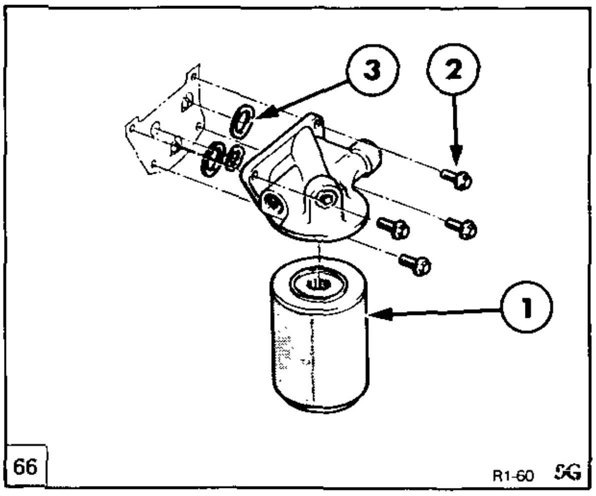
4. Fit a new 'O' ring, Figure 61, into suction port. Lubricate and insert tube/screen assembly into pump through bottom of engine. Fit a new gasket and torque the attaching bolts, Figure 65, to 20–25 lbf ft (27–34N m) 2.7–3.4 kgf m.

NOTE: *Plug item 5, in Figure 65, is factory installed to facilitate machining and should not be removed during the life of the engine.*

5. Refit gears as previously described along with the rear plate and flywheel.

OIL FILTER SUPPORT ASSEMBLY

Removal

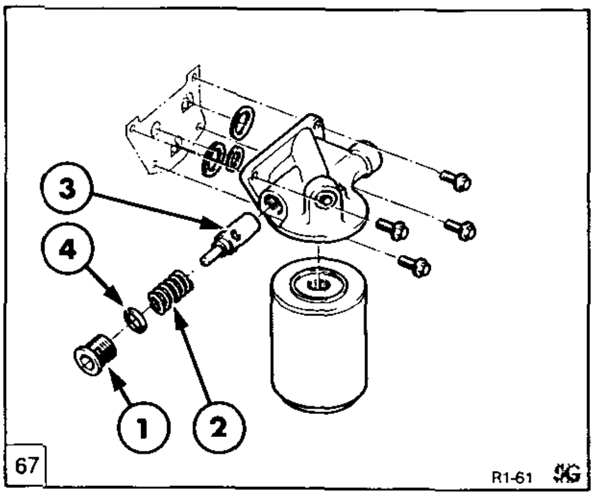


Oil Filter Assembly

1. Oil Filter
2. Filter Housing Support Bolts
3. 'O' Rings

1. Unscrew and discard the old filter, loosen the 4 attaching bolts and oil connections and remove filter support assembly from the block. Discarding the three 'O' rings, Figure 66.

2. *Clean the filter support in a suitable solvent.*



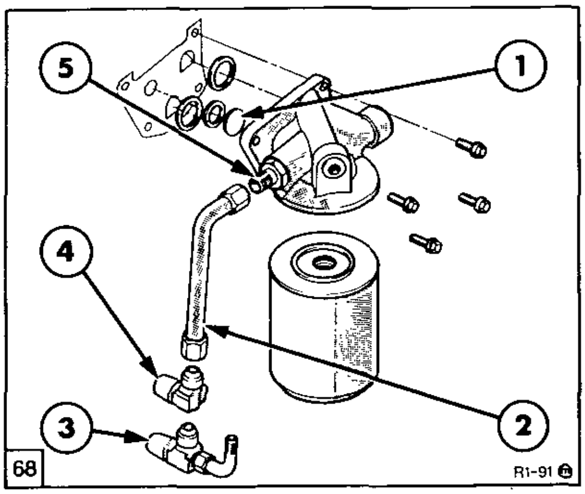
Oil Filter Relief Valve

1. Relief Valve Plug
2. Spring
3. Valve
4. 'O' Ring

3. Remove pressure relief valve plug, removing valve and spring. To ensure correct operation of the pressure relief valve, check spring length:–
   Free length = 2.08 in (52.8mm).
   Compressed length = 1.46 in (37.0mm) using a weight of 34.3 lbs (15.6 kgs).

4. Clean assembly in a suitable solvent and ensure all ports are free of dirt, Figure 67.

5. Check the parts for damage, wear, and replace as necessary. Failure to do so could result in premature wear to the engine, due to oil bypassing the filter and returning back to the system.



Oil Filter Assembly

1. Blanking Disc
2. Oil Return Pipe
3. Connector with Turbocharger 4 Cylinder
4. Connector less Turbocharger 6 Cylinder
5. Connector to Filter Head

6. On 6 cylinder vehicles the design varies slightly in that the oil return to block port is blanked off at the filter head. An oil return tube to block is then fitted to the pressure relief valve port, Figure 68.

Installation

1. Lubricate the pressure relief valve, and spring, and insert into housing ensuring free movement. Fit a new 'O' ring to plug (1) Figure 67, or connector (5), Figure 68 and torque to 42 lbf ft (55N m) 5.5 kgf m. Fit tube to connector and torque to 20 lbf ft (27Nm) 2.7 kgf m, Figure 68.

CRANKSHAFT REMOVAL

1. When removing the engine from the tractor refer to "SEPARATING THE UNIT" and place on an engine stand.

2. Remove the flywheel, rear cover plate, crankshaft pulley and engine front cover as previously described.

NOTE: *If crankshaft is removed with cylinder head in position ensure all timing marks are realigned prior to re–assembly. This action will prevent possible interference upon re–assembly between valves and pistons.*

3. Remove the oil pan, oil pump tube and balancer as previously described.

4. Remove the connecting rod caps, main bearing caps and liners and identify to facilitate re–assembly.

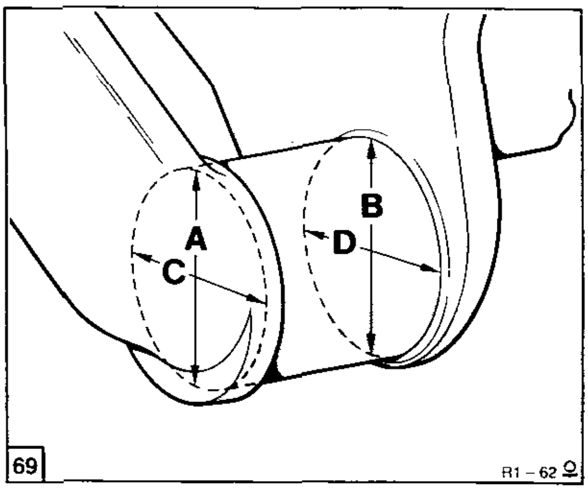
5. Carefully remove crankshaft from cylinder block.

Inspection and repair

NOTE: *Current production engines may have a crankshaft with main or crankpin journals ground 0.010 in (0.25mm) undersize. These are identified with the letters 010 MUS and or 010 PUS respectively, letters being stamped on one of the crankshaft counter balance weights.*

1. If crankshaft timing gear teeth are worn or damaged replace as necessary as described.

2. Wash the crankshaft and drilled passages in a suitable solvent. Dress minor imperfections using an oil stone but for severely marked journals machine to the next undersize bearing size.



Measuring Crankshaft Journal

3. Measure diameter of each journal, Figure 69, in four places to determine out–of–round, taper, or wear.
   Measuring A compared with B indicates vertical taper.
   Measuring C compared with D indicates horizontal taper.
   Measuring A and B compared with C and D indicates journal out–of–round.

4. If the journal exceeds specified limits refer to "Specifications" and refinish journal to the next undersize bearing.

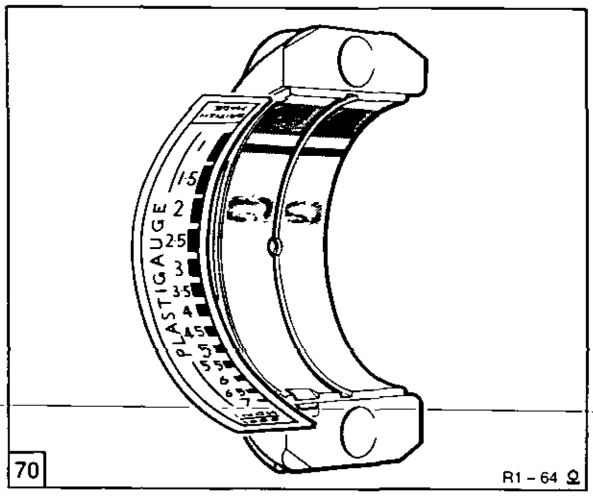
5. Examine the rear oil seal journal for score marks, remove minor imperfections with fine emery cloth and if severely damaged renew the crankshaft.

BALANCER GEAR

NOTE: *Inspect the balancer gear for wear or damage to teeth, if damage or wear is evident a new crankshaft must be fitted.*

CRANKSHAFT RE–ASSEMBLY

1. Check the crankshaft bearing clearance using a plastigauge as follows.



Checking Bearing Clearance

2. Position a piece of correct size plastigauge across the full width of the bearing cap, approximately 0.25 in (6.35mm) off centre, Figure 70.

3. Install the cap and tighten bolts to 110 lbf ft (149N m) 15.2 kgf m.

4. Remove the cap and use the scale to check the width of the flattened plastigauge, Figure 70.

5. Widest point of gauge establishes the minimum clearance.

6. Narrowest point of gauge establishes maximum clearance. The difference between the two readings is the taper.

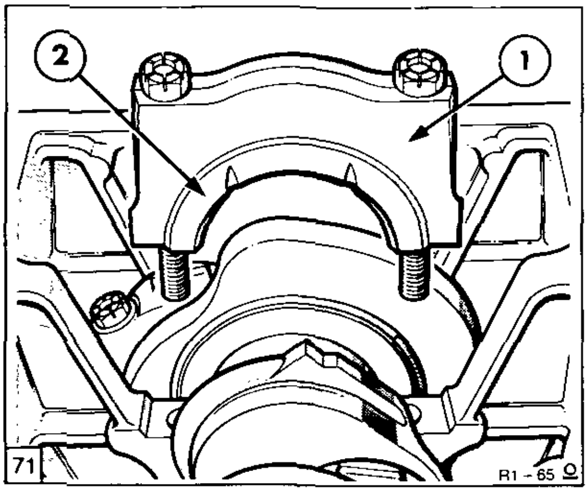
NOTE: *Normally main bearing journals wear evenly and will not be out–of–round, but if a liner which is to specification is fitted to an out–of round journal, ensure liner suits maximum diameter of journal.*

7. If these combinations of liners do not produce specified clearance refinish crankshaft and fit undersize bearings.

IMPORTANT: *Engines may be assembled with liners of different material, but liners of the same material must be used on the same journal.*

8. Position the bearing liners and caps in the block and coat with oil. If the crankshaft has been refinished, fit correct undersize bearing liners.

9. Ensure the bearing surfaces are clean and bearing liner tangs align with slots in the block and cap.



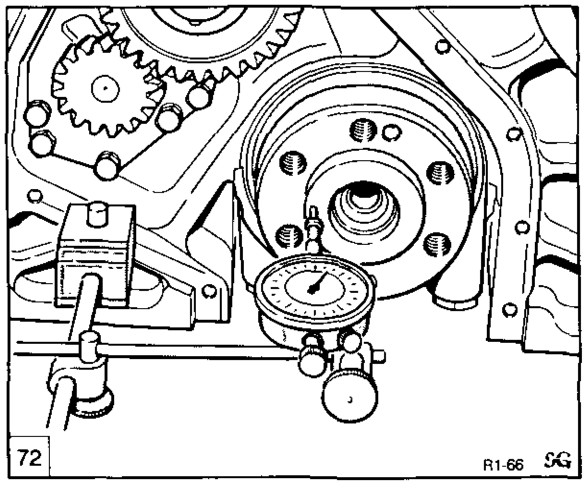
Thrust Bearing Installation
1. Thrust Bearing Cap   2. Liner

10. Align the timing mark on the crankshaft gear with that of the camshaft idler gear and install the crankshaft. Install a thrust bearing cap with flange type bearing liner first, installing remaining bearing caps to their original location, Figure 71.

11. Tighten all bearing caps (except thrust bearing cap, leave finger tight) to a torque of 145 lbf ft (197N m) 19.5 kgf m.

12. Pry the crankshaft forward against thrust surface of bearing, hold crankshaft forward and pry bearing cap rearwards taking care not to pry against flange of bearing liner. This will align thrust surfaces of both halves of bearing, hold forward pressure on crankshaft and tighten bearing cap bolts to a torque of 145 lbf ft (197N m) 19.5 kgf m.

13. Check crankshaft end play with a dial indicator gauge, pry crankshaft towards front of engine and set dial indicator to zero. Pry crankshaft towards rear of engine and note reading on dial. If end play exceeds 0.004–0.008 in (0.10–0.20mm) fit a new thrust bearing liner, Figure 72.



Measuring Crankshaft End Play
1. Dial Indicator

14. If the end play is less than specification check thrust bearing for burrs, scratches or dirt and re–align thrust bearing as in paragraph 12.

15. Install rear crankshaft oil seal as previously described in back plate removal.

NOTE: *Do not pre–install seal into retainer. To ensure seal concentricity, it must be assembled with rear plate and installation tool when fitted to crankshaft.*

CAMSHAFT REMOVAL

NOTE: *The camshaft bearings and tappets can only be serviced with engine removed from the tractor, see "SEPARATING THE UNIT".*

1. Remove the engine front cover and cylinder head.

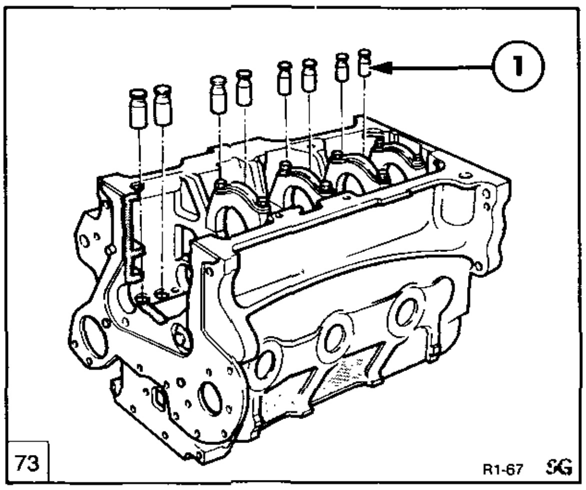
2. Check the camshaft end play, see "Timing Gears Section" and remove gear. Install a new thrust plate prior to re–assembly.

3. After removal of the flywheel and rear cover, remove the camshaft oil pump drive gear.

4. Invert the engine on the stand, if camshaft bearings are to be replaced and remove the oil pan.

5. Carefully withdraw the camshaft from the rear of engine.

NOTE: *With 4 cylinder camshafts, 3 sets of bearing shells are fitted. With 6 cylinder camshafts, 5 sets of bearing shells are fitted.*



Camshaft Tappet Assembly

1. Tappets

6. Lift out the tappets, Figure 73 and place in a numbered rack for re–assembly.

Inspection and repair

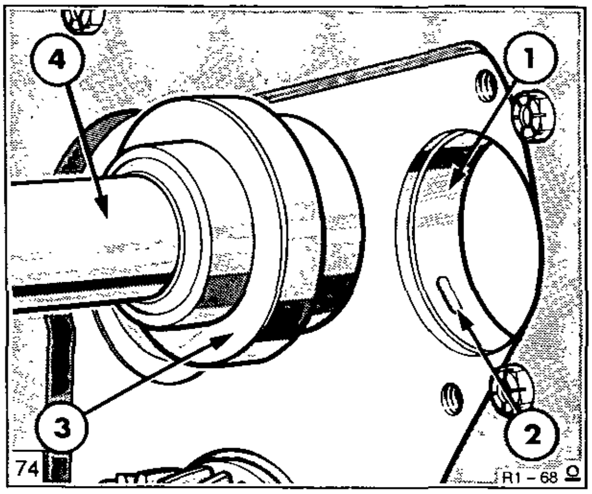
1. Inspect the camshaft journals and lobes, for damage, pitting or heat discolouration. If any of these conditions exist install a new camshaft.

2. Inspect the oil pump drive gear on camshaft for broken or worn teeth and mating gear on oil pump. If any wear or damage is apparent fit new gears.

3. Check each tappet, Figure 73, for wear or damage and check diameters, if not to specification renew: 0.9900–0.9910 in (25.15–25.17mm).

4. Measure the diameter and out–of–round condition of bearing journals, if exceeded fit a new camshaft: 2.389–2.390 in (60.693–60.719mm).

CAMSHAFT BEARINGS



Camshaft Bearing Removal and Installation

1. Camshaft Bearing
2. Oil Hole
3. Tool No 6203/1255
4. Handle N6261–A

1. Inspect the camshaft bearings for wear or damage. Measure the clearance between the internal diameter of bearing and outside diameter of respective journal, 0.001–0.003 in (0.025–0.076mm).

2. If specification is exceeded install new bearings using Remover/Replacer Tool No. FT 6203, or 1255 and handle, Tool No N6261–A or 1442, Figure 74.

3. To remove, position tool against bearing to be removed and attach handle, driving bearing from bore.

4. To install, align oil holes of new bearing with holes in block and drive bearing into bore using tools as described.

NOTE: *A positive alignment check can only be made with crankshaft removed when an 0.018 in (4.6mm) rod can be passed down the oil passage from the crankshaft main bearing. Liner is correctly positioned when end of rod passes through oil hole in the liner.*

Installation

1. Apply petroleum jelly to each tappet foot and coat tappet body with oil. Install tappets in bores from which they were removed.

2. Oil camshaft journals and apply petroleum jelly to the cam lobes and install camshaft into engine.

3. Install new spacer and keyway on end of camshaft.

4. Install camshaft gear and align the camshaft gear timing mark and recheck end play.

5. Apply sealant ESE–M2G–114A to the sealing flange of the front cover plate on re–assembly.

D. ENGINE COMPRESSION TEST

TEST PROCEDURE

1. Be sure battery performance meets specifications.

2. Warm up the engine by operating for a minimum of half an hour at 1200 rev / min.

3. Stop the engine and remove the injector and seat washer from No.1 cylinder.

4. Clean the injector bore and crank the engine to blow out any loose carbon particles.

5. Install a proprietary engine compression test gauge into the injector bore, using the injector mounting bolts and a new seat washer.

6. Connect the gauge and hose to the adaptor.

7. Crank the engine at 200 rev/min with the engine stop cable pulled out where fitted, or the electric fuel shut off wire disconnected to prevent engine start up.

8. Observe the gauge reading and repeat the compression test, steps 5–7, for each cylinder.

TEST READINGS

1. All cylinder compressions should be uniformly within 25 lbf in^2 (1.7 bar) of each other.

2. A reading of more than the 25 lbf in^2 (1.7 bar) below the other cylinders indicates leakage at the cylinder head gasket, piston rings or valves.

3. A reading of more than 25 lbf in^2 (1.7 bar) above the other cylinders indicates excessive carbon deposits on the piston and cylinder head.

4. A low even compression in two adjacent cylinders indicates a cylinder head gasket leak. Check this item before condemning the rings or valves.

TEST CONCLUSION

To determine whether the rings or the valves are at fault, squirt the equivalent of a tablespoon of heavy oil into the combustion chamber. Crank the engine to distribute the oil and repeat the compression test.

The oil will temporarily seal any leakage past the rings. If approximately the same reading is obtained, the rings are satisfactory but the valves are leaking.

If compression has increased over the original reading, there is leakage past the rings.

During a compression test, if the pressure fails to climb steadily and remains the same during the first two successive strokes, but climbs higher on the succeeding strokes, or fails to climb during the entire test, suspect a sticking valve.

E. SPECIFICATIONS

Model (T=Turbocharged)	5640	6640	7740 (T)	7840	8240	8340
No of Cylinders	4	4	4	6	6	6
Bore ins (mm)	4.4 111.8	4.4 111.8	4.4 111.8	4.4 111.8	4.4 111.8	4.4 111.8
Stroke ins (mm)	4.4 111.8	5.0 127.0	5.0 127.0	4.4 111.8	5.0 127.0	5.0 127.0
Displacement cu in (cu cm)	268 4393	304 4983	304 4983	401 6570	456 7472	456 7472
Compression Ratio	17:5–1	17:5–1	17:5–1	17:5–1	17:5–1	17:5–1
Cylinder Bore Compression at cranking speed of 200 R.P.M lbs in² bar	375 25.5	375 25.5	375 25.5	375 25.5	375 25.5	375 25.5
Firing Order	1342	1342	1342	153624	153624	153624
Idle Speed R.P.M	700 800	700 800	700 800	700 800	700 800	700 800
Maximum no Load Speed R.P.M	2310	2310	2205	2205	2205	2205
Rated Engine Speed	2200	2200	2100	2100	2100	2100

CYLINDER BLOCK

Taper of Cylinder Bore	0.001 in (0.025mm) Repair Limit 0.005 in (0.127mm) Wear Limit
Cylinder Bore out of Round	0.0015 in (0.03mm) Repair Limit 0.005 in (0.127mm) Wear Limit
Cylinder Bore Diameters	4.4007–4.4032 in (111.778–111.841mm)
Rear Oil Seal Bore Diameter	5.542–5.546 in (140.77–140.87mm)
Block to Head Surface Flatness	0.003 in (0.08mm) in any 6 in (152mm) 0.001 in (0.03mm) in any 1 in (25.40mm)

CYLINDER HEAD

Valve Guide Bore Diameter	0.3728–0.3738 in (9.469–9.495mm)
Head to Block Surface Flatness	0.001 in (0.03mm) in any 1 in (25.4mm), or 0.005 in (0.127mm) overall limit

EXHAUST VALVES

Face Angle	44°15'–44°30' Relative to the Head of Valve
Stem Diameter	Standard : 0.3701–0.3709 in (9.401–9.421mm) 0.003 in (0.076mm) Oversize : 0.3731–0.3739 in (9.477–9.497mm) 0.015 in (0.38mm) Oversize : 0.3851–0.3859 in (9.781–9.802mm) 0.030 in (0.76mm) Oversize : 0.4001–0.4009 in (10.163–10.183mm)
Head Diameter	1.688–1.698 in (42.88–43.13mm)
Stem to Guide Clearance	0.0019–0.0037 in (0.048–0.094mm)
Lash Clearance (Cold)	0.017–0.021 in (0.43–0.53mm)

INTAKE VALVES

Face Angle	29°15'–29°30' Relative to Head of Valve
Stem Diameter	Standard : 0.3711–0.3719 in (9.426–9.446mm) 0.003 in (0.076mm) Oversize : 0.3741–0.3749 in (9.502–9.522mm) 0.015 in (0.381mm) Oversize : 0.3861–0.3869 in (9.807–9.827mm) 0.030 in (0.762mm) Oversize : 0.4011–0.4019 in (10.188–10.208mm)
Head Diameter	1.865–1.875 in (47.37–47.63mm)
Stem to Guide Clearance	0.0009–0.0027 in (0.023–0.069mm)
Lash Clearance (Cold)	0.014–0.018 in (0.36–0.46mm)

VALVE SPRINGS

Number per Valve	1
Free Length	2.39 (60.7mm)
Length, loaded at 61.69 lb (27.7–31.3kg)	1.900 in (48.26mm)
Length, loaded at 135–153 lb (61–69kg)	1.405 in (35.69mm)

VALVE TIMING

Intake Opening	12° Before Top Dead Centre
Intake Closing	38° After Bottom Dead Centre
Exhaust Opening	48° Before Bottom Dead Centre
Exhaust Closing	12° After Top Dead Centre

VALVE INSERTS

Insert Oversize	Exhaust Valve Insert Counterbore Diameter in Cylinder Head	Intake Valve Seat Insert Counterbore Diameter In Cylinder Head
0.010 in (0.254mm)	1.739–1.740 in (44.17–44.20mm)	1.969–1.970 in (50.01–50.04mm)
0.020 in (0.508mm)	1.749–1.750 in (44.42–44.45mm)	1.979–1.980 in (50.27–50.29mm)
0.030 in (0.762mm)	1.759–1.760 in (44.68–44.70mm)	1.989–1.990 in (50.52–50.55mm)

VALVE SEATS

Exhaust Valve Seat Angle	45°00' – 45°30'
Intake Valve Seat Angle	30°00' – 30°30'
Interference Valve Face Angle to Valve Seat Angle	0°30' – 1°15'
Concentricity with Guide Diameter	0.002 in (0.051mm) Total Indicator Reading Max
Seat Width Exhaust Valve	0.072–0.092 in (1.8–2.3mm)
Seat Width Intake Valve	0.078–0.098 in (1.9–2.5mm)

CAMSHAFT IDLER GEAR

Number of Teeth	47
End Play	0.003–0.014 in (0.076–0.35mm)
Bushing Inside Diameter	2.005–2.0015 in (50.813–50.838mm)
Adaptor Outside Diameter	1.9985–1.9990 in (50.762–50.775mm)
Backlash with Crankshaft Gear	0.001–0.009 in (0.025–0.23mm)
Backlash with Camshaft Gear	0.001–0. 015 in (0.025–0.381mm)
Backlash with Fuel Injection Pump	0.001–0.012 in (0.025–0.30mm)

CAMSHAFT GEAR

Number of Teeth	52
Timing Gear Backlash	0.001–0.015 in (0.025–0.38mm)

ROCKER ARM SHAFT

Shaft Diameter	1.000–1.001 in (25.40–25.43mm)
Shaft Support Internal Diameter	1.002–1.004 in (25.45–25.20mm)

ROCKER ARM

Inside Diameter	1.003–1.004 in (25.48–25.50mm)

TAPPETS

Clearance to Bore	0.0006–0.0021 in (0.015–0.053mm)
Tappet Diameter	0.9889–0.9894 in (25.118–25.130mm)
Tappet Bore Diameter	0.9900–0.9910 in (25.15–25.17mm)

CAMSHAFT

Bearing Journal Diameter	2.3895–2.3905 in (60.693–60.719mm)
Bearing Clearance	0.0010–0.0030 in (0.025–0.076mm)
End Play	0.0020–0.0070 in (0.051–0.18mm)

CONNECTING RODS

Small End Bushing (Internal Diameter)	
Naturally Aspirated	1.5005–1.5008 in (38.113–38.120mm)
Turbocharged	1.6255–1.6258 in (41.288–41.259mm)
Clearance Bushing to Piston Pin	0.0005–0.0010 in (0.013–0.025mm)
Side Float	0.0050–0.0130 in (0.13–0.33mm)
Maximum Twist	0.0120 in (0.30mm)
Maximum Bend	0.0040 in (0.10mm)

PISTON PIN

Outside Diameter	
Normally Aspirated Engine	1.4998–1.5000 in (38.095–38.100mm)
Turbocharged Engine	1.6248–1.6250 in (41.270–41.275mm)

PISTONS

Skirt to Cylinder Clearance Naturally Aspirated & Turbocharged	 0.0055–0.0065 in (0.140–0.165mm)
Taper (Out of Round)	0.0025–0.0050 in (0.063–0.127mm)
Grading Diameter (at Right Angles to Piston Pin)	4.3951–4.3991 in (111.64–111.74mm) in increments of 0.0005 in (0.0127mm)
Piston Pin Clearance	0.00012–0.00055 in (0.0030–0.0140mm) at 70°F (21°C)
Piston Crown to Block Face: Naturally Aspirated Turbocharged	 0.011–0.023 in (0.28–0.58mm) 0.0–0.012 in (0.0–0.3mm)

PISTON RINGS

Compression; Number and Location	 2 of,1st and 2nd from the top of the piston
Naturally Aspirated: Top Compression Ring 2nd Compression Ring	 Parallel Sides–Inner Chamfer or no Chamfer Straight Face–Inner Step
Turbocharged; Top Compression Ring 2nd Compression Ring	 Keystone Tapered With Internal Chamfer to Top Straight Face–Inner Step
Oil Control: Number and Location Type	 1 of,–Directly above the Piston Pin, Slotted With Expander
Side Face Clearance To Ring Groove: Top Compression Ring 2nd Compression Ring Oil Control Ring	 0.0044–0.0061 in (0.112–0.155mm) 0.0039–0.0056 in (0.099–0.142mm) 0.0024–0.0041 in (0.061–0.104mm)
Gap Width: Top Compression Ring 2nd Compression Ring Oil Control Ring	 0.015–0.033 in (0.38–0.84mm) 0.026–0.044 in (0.66–1.12mm) 0.015–0.033 in (0.38–0.84mm)

CRANKSHAFT

Main Journal Diameter–Blue –Red	3.3713–3.3718 in (85.631–85.644mm) 3.3718–3.3723 in (85.644–85.656mm)
Main Journal Length (except thrust, rear or intermediate)	1.455–1.465 in (36.96–37.21mm)
Main Journal Wear Limits	0.005 in (0.127mm) Maximum
Main and Crankpin Fillet Radius	0.12–0.14 in (3.048–3.556mm)
Thrust Bearing Journal Length	1.459–1.461 in (37.06–37.11mm)
Intermediate Bearing Journal Length	1.455–1.465 in (36.96–37.21mm)
Rear Bearing Journal Length	1.495–1.515 in (37.97–38.48mm)
Crankpin Journal Length	1.678–1.682 in (42.62–42.72mm)
Crankpin Diameter – Blue – Red	2.749–2.7500 in (69.840–69.850mm) 2.750–2.7504 in (69.850–69.860mm)
End Play	0.004–0.008 in (0.10–0.20mm)
Crankpin Out of Round	0.0002 in (0.005mm) Total Indicator Reading
Taper Surface Parallel to Centre Line of Main Journal	0.0002 in (0.005mm)
Crankshaft Rear Oil Seal Journal Diameter	4.808–4.814 in (122.12–122.28mm)
Crankshaft Pulley Journal Diameter	1.750–1.751 in (44.45–44.48mm)
Crankshaft Timing Gear Journal Diameter	1.820–1.821 in (46.23–46.25mm)
Crankshaft Flange Runout	0.0015 in (0.038mm) Max

CRANKSHAFT DRIVE GEAR

Number of Teeth	26

MAIN BEARING

Liner Length (except Thrust Liner)	1.10–1.11 in (27.94–28.19mm)
Liner Length (Thrust Liner)	1.453–1.455 in (39.91–39.96mm)
Vertical Assembled Bearing Clearance	0.0021–0.0046 in (0.055–0.117mm)

CRANKPIN BEARINGS

Liner Length	1.40–1.41 in (35.56–35.81mm)
Vertical Assembled Bearing Clearance	0.0014–0.0037 in (0.035–0.094mm)

CRANKSHAFT RE–GRINDING

When re–grinding a crankshaft the main and crankpin journal diameters should be reduced the same amount as the undersize bearings used, and the following dimensions apply. The rear end of the crankshaft should be located on the 60° Chamfer of the pilot bearing bore .

UNDERSIZE BEARING AVAILABLE	MAIN JOURNAL DIAMETERS
0.002 in (0.051mm)	3.3693–3.3698 in (85.580–85.593mm)
0.010 in (0.254mm)	3.3618–3.3623 in (85.390–85.402mm)
0.020 in (0.508mm)	3.3518–3.3523 in (85.136–85.148mm)
0.030 in (0.762mm)	3.3418–3.3423 in (84.882–84.894mm)
0.040 in (1.016mm)	3.3318–3.3323 in (84.628–84.640mm)

UNDERSIZE BEARING AVAILABLE	CRANKPIN JOURNAL DIAMETERS
0.002 in (0.051mm)	2.7476–2.7480 in (69.789–69.799mm)
0.010 in (0.254mm)	2.7400–2.7404 in (69.956–69.606mm)
0.020 in (0.508mm)	2.7300–2.7304 in (69.342–69.352mm)
0.030 in (0.762mm)	2.7200–2.7204 in (69.088–69.098mm)
0.040 in (1.016mm)	2.7100–2.7104 in (68.834–68.844mm)

CRANKSHAFT BALANCER

Gear Backlash	0.002–0.010 in (0.05–0.25mm)
Shaft to Bushing Clearance	0.0002–0.008 in (0.005–0.020mm)
Shaft Diameter	0.9895–1.000 in (25.133–25.400mm)
Backlash Between Balancer and Crankshaft Gear	0.002–0.008 in (0.05–0.20mm)
End Float Balancer Gear to Support	0.008–0.020 in (0.20–0.51mm)

FLYWHEEL

Runout of Clutch Face (between Outer Edge of Friction Surface and Mounting Bolt Holes)	0.005 in (0.127mm)
Ring Gear Runout	0.025 in (0.63mm)

OIL PUMP

Rotor Clearance	0.001–0.006 in (0.025–0.15mm)
Rotor to Pump Housing Clearance	0.006–0.011 in (0.15–0.28mm)
Rotor End Play	0.001–0.0035 in (0.025–0.089mm)
Pump Gear to Camshaft Gear Backlash	0.016–0.022 in (0.40–0.56mm)

OIL FILTER SUPPORT

Relief Valve, Operating Pressure	55–60 lbf/in^2 (379–414 kpa)
Flow Rate	15–16.6 imp gals/min (18–20 US gals/min)

Temperature	Oil Viscosity and Type	API Classification	Engine Oil & Filter Change Period (hours)	
			4 CYL	6 CYL
Below –12°C (10°F)	Low Ash, SAE 5W Supplement 1 or Low Ash SAE 5W/20 Supplement 1 or SAE 10W–30	SF/CC SF/CC SF/CD	150 150 150	150 150 150
–12°C to 4° C (10°F to 40°F)	Low Ash, SAE 10W Series 3 or SAE 10W–30	SF/CD SF/CD	300 300	300 300
0°C to 32°C (32°F to 90°F)	Low Ash, SAE 20W Series 3 or SAE 10W–30	SF/CD SF/CD	300 300	300 300
Above 24°C (75°F)	Low Ash, SAE 30W Series 3	SF/CD	300	300

NOTE: *When using diesel fuel with a sulphur content below 1.0% Series 3 diesel engine oil with an A.P.I. classification of CC may be used instead of CD oil, but the oil and filter interval must be reduced to 150 hours .*

When using diesel fuel with a sulphur content between 1% and 1.3% use only oils listed above but reduce the oil and filter change period to every 50 hours .

ENGINE OIL CAPACITIES (Less Oil Filter)

Model	Imp Qts	U.S Qts	Litres
4 CYL	10.0	12.00	11.6
6 CYL	17.6	21.12	20.0

ENGINE OIL CAPACITIES (With Oil Filter)

Model	Imp Qts	U.S Qts	Litres
4 CYL	11.5	13.8	13.6
6 CYL	19.3	23.2	22.0

THERMOSTAT

Opening Temperature	178°F (81°C)

WATER PUMP

Type	Centrifugal
Drive	Poly V Belt

FAN BELT

Belt Tension	Maintained by Tensioner

COOLING SYSTEM CAPACITIES

Model	Imp Pts	U.S. Qts	Litres
4 Cyl	26.75	16.05	15.2
6 Cyl	30.0	18.0	17.0

COOLING FLUID

Content Mixture – Water 50%, Ford Antifreeze WSN–M97B18–D 50%.
If Ford Antifreeze is not used, a heavy duty antifreeze must be used with a 5% solution of Inhibitor. This inhibitor must be added to the cooling system and is available from Dealers, Part No. FW 15.

TORQUE VALUES

The following general nut and bolt installation torque requirements (lubricated) apply to any operation not previously listed.

INCH SERIES	lbf ft	Nm	Kgf m
1/4 – 20	8	11	1.1
1/4 – 28	8	11	1.1
5/16 –18	14	19	1.9
5/16 –24	17	23	2.3
3/4 – 16	23	31	3.2
3/4 – 24	33	45	4.6
7/16 –14	48	65	6.6
7/16 –20	55	75	7.6
1/2 – 13	65	88	8.9
1/2 – 20	75	102	10.4
9/16 –18	90	122	12.4
5/6 –18	138	187	19.0
CYLINDER BLOCK PLUGS			
1/4 – 27 NPT	8	11	1.1
1/4 – 18 NPT	22	29.8	3.0
3/4 – 18 NPT	28	38	3.8
3/4 – 14 NPT	20	27	2.7

TORQUE VALUES – VARIOUS	lbf ft	Nm	Kgf m
Balancer Bolts	85	115	12.0
Main Bearing Bolts	145	197	20.0
Connecting Rod Bolts	110	149	15.2
Cylinder Head Bolts (with Engine Cold)	160	217	22.0
Intake Manifold–to–Cylinder Head	26	35	3.5
Exhaust Manifold–to–Cylinder Head	28	38	3.9
Exhaust Pipe–to–Flange	23	31	3.2
Flywheel–to–Crankshaft	145	197	20.0
Oil Pan Drain Plug	30	41	4.2
Valve Rocker Cover Bolts	18	24	2.4
Crankshaft Pulley–to–Crankshaft	210	224	23.0
Self–Locking Screw – Valve Rocker Arm	18	24	2.4
Injector Attachment Bolts	17	23	2.3
Cover Bolts (Blanks Oil Drilling)	23	31	3.1
Oil Pump to Block	17	23	2.3
Water Pump–to–Cylinder Block	48	35	3.6
Water Pump Cover–to–Pump	20	27	2.8
Oil Pan–to–Cylinder Block (Cast)	28	38	3.9
Injector Line Nuts	18	24	2.4
Leak–off Tube Banjo Fitting Bolts	8	11	1.1
Injection Pump–to–Front Adaptor Plate	18	24	2.4
Camshaft Idler Drive Gear–to–Block	175	237	24.0
Front Adaptor Plate–to–Cylinder Block	18	24	2.4
Thermostat Housing Bolts	18	24	2.4
Camshaft Gear Bolt	51	69	7.0
Camshaft Rear Gear Plate Bolts	35	47	4.8
Oil Filter Adaptor Bolts	31	42	4.2
Oil Filter Mounting Bolt Insert	25	34	3.5
Starting Motor–to–Rear Adaptor Plate	23	31	3.2
Dynamic Balancer – Cylinder Block	86	117	11.8
Injection Pump–to–Gear Nut (4 cyl.)	58	79	8.0
Oil Pressure Switch Assembly	23	31	3.2
Turbocharger–to–Exhaust Manifold Nut	33	44	4.5
Single Fan to Pulley Nose Thread	21	27	2.8
Crankshaft Rear Oil Seal Retainer –			
Initial Tightening	9	12	1.2
Final Tightening	17	23	2.3

F. SPECIAL TOOLS

(Prior Tool Numbers, where applicable, shown in brackets)

DESCRIPTION	V.L. CHURCHILL TOOL No.	NUDAY TOOL No.	FNH TOOL No.
Adjustable Bridge Puller	518	9539	09539
Shaft Protectors	625–A	9212	09212
Step Plate Adaptors	630–S	9210	09210
Bushing Kit	818	9514	09514
Valve Guide Reamer Kit	FT.6202 (SW.502)	2136 (SW.502)	02136
Camshaft Bearings – Remover/Installer Handle	FT.6203 N6261–A	1255 (SW.506) 1442	01225 01442
Water Pump Seal Replacer	FT.6209	4672	T87T–6312–A
Connecting Rod Bush – Removal Installation			FNH 00035 OTC 134–00002
Crankshaft Seal Replacer Front Seal Rear Seal	 630–16 FT 6212		 T87T–6019–A FNH 01301

GREASE and SEALANTS

Code	Number	Name
A	NLG1 Grade 2	Grease
B	ESF–M1C43–A	Grease–Silicone Light Consistency
C	ESE–M4G194–B	Sealer–Anaerobic Low strength
D	ESE–M4G195–A	Sealer–Silicone
E	SP–M4G9112–A	Sealer–Polyester Urethane
F	SP–M4G9112–C	Sealer–Polyester Urethane
G	ESE–M4G217–A	Sealer–Anaerobic
J	SP–M2G9121–B	Sealer–RTV Silicone rubber

PART 1
ENGINE SYSTEMS

Chapter 2
COOLING SYSTEM

Section		Page
A.	DESCRIPTION AND OPERATION	1
B.	FAULT FINDING	2
C.	OVERHAUL	3
D.	SPECIFICATIONS AND TOOLS	11

A. DESCRIPTION AND OPERATION

The cooling system operation and overhaul, as described in this section, covers all of the new series 4 & 6 Cylinder model range.

The function of the water pump mounted at the front of the engine is to maintain a continuous flow of water around the cooling system. This is essential to ensure correct engine temperature, and performance during vehicle operation.

The pump is driven by a, "Poly V" Belt from the crankshaft pulley, when the engine is running. The fan belt tension is maintained by a spring loaded belt tensioner bolted to the front face of the water pump.

The cooling system for the new generation of engines is of the recirculating by–pass type, with full length water jackets for each cylinder. The coolant is drawn from the bottom tank of the radiator by the water pump, which passes the coolant to the cylinder block. This coolant then flows through cored passages to cool the cylinder walls.

Passages in the cylinder head gasket allow coolant to flow from the cylinder block into the cylinder head. Cored passages also conduct the coolant to the fuel injector nozzle locations, before re–entering the water pump below the thermostat.

The thermostat is located in the top of the water pump body and controls the flow of the water as required by temperature changes.

NOTE: *A faulty thermostat may cause the engine to operate at too hot or cold an operating temperature. If not replaced this could result in a damaged engine or impaired engine performance.*

When the thermostat is closed a recirculating by–pass is provided to allow the coolant to recirculate from the head to the block, to effect a faster warm–up.

Once the engine has reached its normal operating temperature, the thermostat will open and allow water to be drawn through the radiator by the pump action. Cooled water then returns to the engine system.

Cooling occurs as the coolant passes down through the radiator cores (which are exposed to the air) as it is drawn through the radiator by the fan.

NOTE: *Do not operate an engine without a thermostat. It is recommended that a solution of a 50% clean water and 50% Ford antifreeze WSN–M97B18–D is used. When Ford Antifreeze is not used a 5% solution of inhibitor FW 15 obtainable from FNH dealers, must be added to the cooling system.*

The cooling system incorporates a drain plug on the left hand side of the cylinder block.

B. FAULT FINDING

PROBLEM	POSSIBLE CAUSES	REMEDY
Engine overheats	1. Hose connection leaking or collapsed	1. Tighten hose connection, renew hose if damaged
	2. Radiator cap defective or not sealing	2. Renew radiator cap
	3. Radiator leakage	3. Repair/renew radiator
	4. Improper fan belt adjustment	4. Re–adjust fan belt
	5. Radiator fins restricted	5. Clean with compressed air
	6. Faulty thermostat	6. Renew thermostat
	7. Internal engine leakage	7. Check for source of leakage, renew gasket or defective parts
	8. Water pump faulty	8. Overhaul water pump
	9. Exhaust gas leakage into cooling system	9. Renew cylinder head gasket, check head for damage or distortion
	10. Coolant aeration	10. Tighten all connections and check coolant level is correct. Ensure cylinder head gasket has not blown
	11. Cylinder head gasket improperly installed	11. Renew cylinder head gasket
	12. Hot spot due to rust and scale or clogged water jackets	12. Reverse flush entire cooling system
	13. Obstruction to radiator air flow	13. Remove the obstruction
	14. Extended engine idling	14. Do not allow engine to idle for long periods
	15. Oil cooler tube blocked	15.Clean
	16. Radiator core tubes blocked	16. Check free flow

PROBLEM	POSSIBLE CAUSES	REMEDY
Water temperature gauge fails to reach normal operating temperature	1. Faulty temperature sender 2. Incorrect or faulty thermostat 3. Faulty water temperature gauge	1. Renew sender switch 2. Renew thermostat 3. Renew temperature gauge

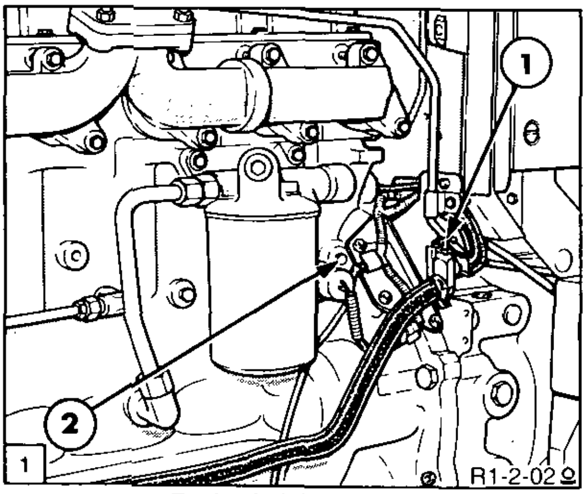
C. OVERHAUL

RADIATOR REMOVAL

1. Remove the right, and left hand engine lower side panels, where fitted.

2. Remove the muffler stack pipe from the vehicle.

3. Loosen and remove the right and left hand, top hood panels.

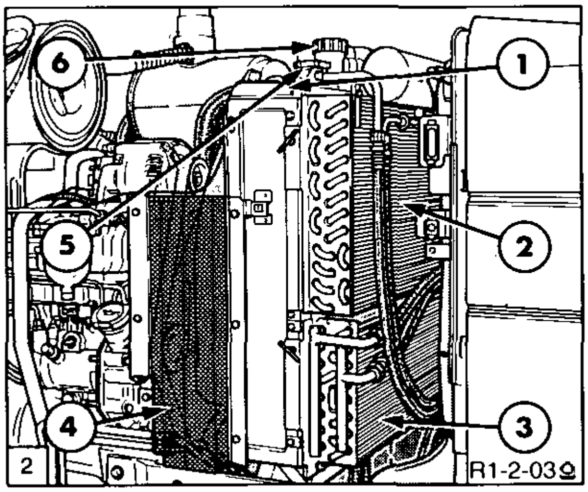


Engine Left Hand Side

1. Heater Hose Tap (where Fitted)
2. Engine Coolant Drain Plug

4. Close the cab heater hose top, situated to the rear of the left hand side and the right hand side of the engine (where fitted), Figure 1.

5. With the top hoods removed, loosen and remove the left engine side guards to expose the radiator assembly.



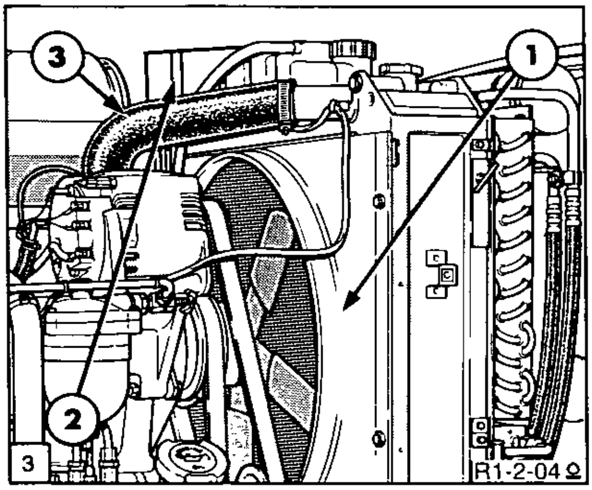
Radiator Assembly Front View

1. Radiator Assembly
2. Air–Conditioning Condenser
3. Transmission Oil Cooler
4. Right Hand Engine Side Guard
5. Radiator Pressure Cap
6. Expansion Tank Cap

6. Attached to the front of the radiator by means of "T" handle bolts on the right hand side is the transmission oil cooler radiator and the air–conditioning condenser (where fitted), Figure 2.

7. Loosen the "T" bolts of both coolers and slide out, placing them carefully out of the way with their respective hoses still attached. This is important where air conditioning is fitted, as refrigerant could be lost if hoses are disconnected from the condenser.

8. Loosen the radiator lower hose at the base of the radiator and drain the coolant off. Remove the radiator cap to speed up the draining, using caution if the system is hot.



Radiator Assembly Rear View

1. Fan Shroud
2. Coolant Overflow Tank
3. Radiator Top Hose

9. Disconnect the radiator top hose, and oil cooler pipes in the lower part of the radiator.

10. Loosen the fan shroud screws, Figure 3, placing the fan shroud behind the fan blade.

11. Ensuring all pipes are disconnected and looms are unclipped and away from the radiator assembly. Lift the radiator up and clear of the vehicle.

Inspection and Repair

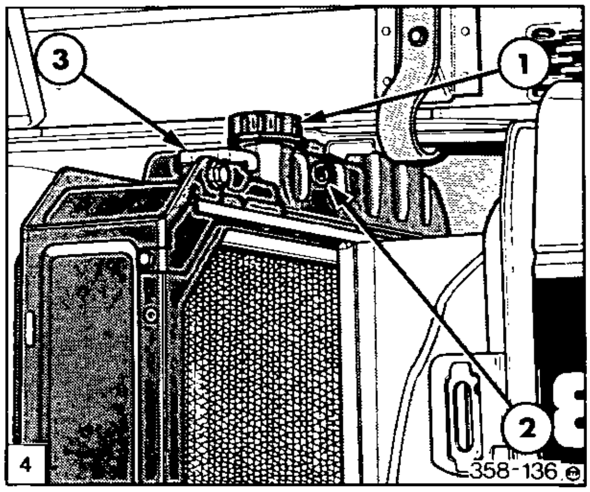
1. Inspect the fins for damage and repair as required, ensuring they are free from any obstruction.

2. Check the radiator for leaks and repair as required. The radiator is fitted with an engine oil heat exchanger in the lower tank which should be checked for leaks. If the lower tank is found to be leaking replace the radiator.

Installation

Installation of the radiator follows the removal procedure in reverse, but upon installation observe the following requirement.

1. Ensure the correct grade and quantity of antifreeze is added to the coolant. Recommended content mixture is Water 50%, with FNH Antifreeze 50% to specification WSN–M97B18–D.



Radiator Refilling

1. Expansion Tank Filler Cap
2. Expansion Tank Sight Glass
3. Radiator Pressure Cap

2. Refill the system through the radiator pressure cap until completely full. Re–install the 13 lb radiator cap and continue filling through the expansion tank until the coolant is seen through the sight glass. Refit expansion cap, Figure 4.

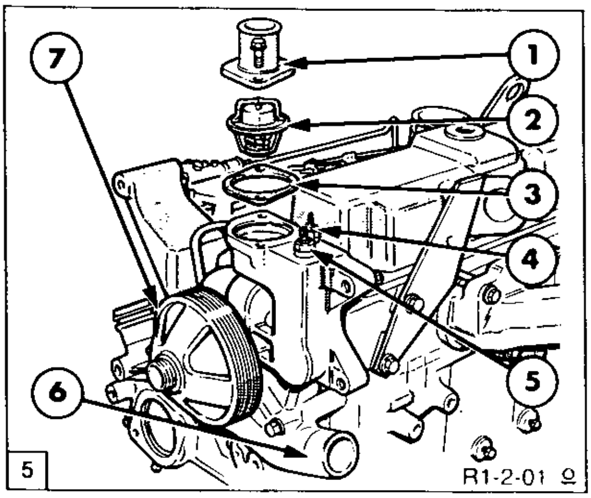
3. If engine oil cooler tubes have been disturbed check the engine oil level.

4. Run the engine for several minutes checking for leaks, topping up any fluid levels that may have settled during testing.

THERMOSTAT REMOVAL

1. Drain the coolant system below that of the level of the thermostat housing, where a cab is fitted shut off heater hose tap, Figure 1.

2. Remove the thermostat housing retaining bolts and move the housing with tube attached to one side.

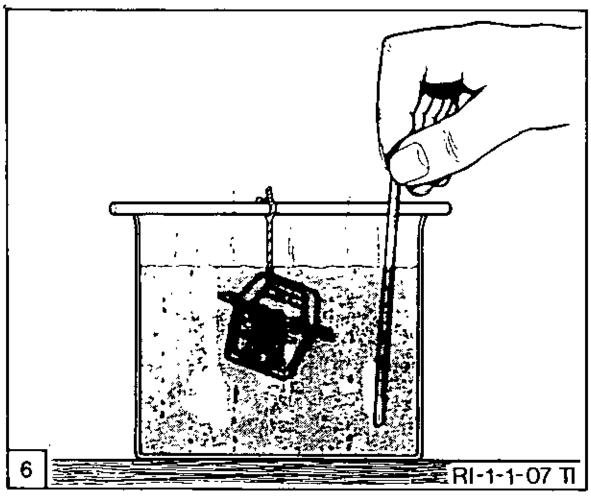


Water Pump Assembly

1. Thermostat Housing
2. Thermostat
3. Gasket
4. Temperature Sender Warning Light
5. Temperature Sender Gauge
6. Water Inlet
7. Water Pump Pulley

3. Withdraw the thermostat from the housing along with the gasket, Figure 5.

Inspection and Repair



Checking the Thermostat

1. Place the thermostat in a container of water and raise the temperature to 212°F (100°C). If the thermostat fails to open when hot, or close properly when cooled, it must be replaced, Figure 6.

Installation

Installation of the thermostat is the reverse of the removal procedure but observing the following:–

1. Coat a new gasket with sealer and position in the recess on the thermostat housing, prior to installing the thermostat.

2. Coat the edge of the thermostat with grease and install, with the heat element located in the cylinder head, Figure 5.

3. Refit the thermostat housing and torque the two bolts to 15–21 lbs ft (20–28Nm) 2–3 kgf m.

TEMPERATURE WARNING SENDERS

1. The temperature sender for the gauge, and the temperature warning light, (where fitted), are both located to the left of the thermostat housing.

Installation

1. If a fault occurs see "Electrical Systems" Part 3. If new senders are to be fitted apply sealant to the threaded portion of the new sender body and torque the senders to
12–18 lbf ft (16–24Nm) 1.6–2.5 kgf m.

FAN BLADE REMOVAL

1. Removal of the fan blade from the water pump spigot, or the viscous clutch pack can be achieved in the following manner: hold the fan blade in a fixed position and remove the four attaching screws.

Re–Assembly

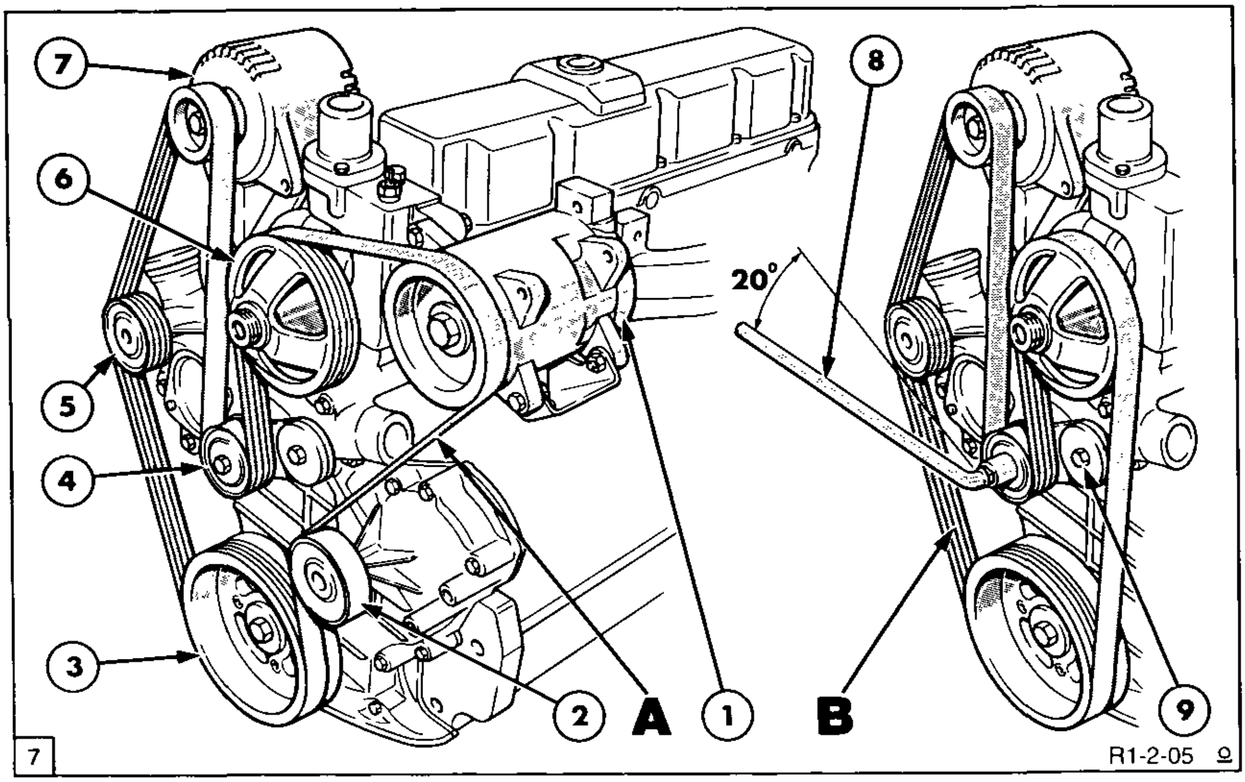
1. Re–assemble the fan blade using the four attaching bolts and torque the bolts to, 15–18 lbf ft (20–25 Nm) 2.0–2.5 kgf m.

VISCOUS CLUTCH ASSEMBLY REMOVAL

1. To remove the fan and clutch assembly (where fitted), hold the pump pulley in a fixed position. Placing an open ended spanner on the nut to the rear of the clutch assembly spacer, loosen the nut in a clockwise direction.

Installation

1. On re–assembly of the fan assembly tighten the attaching nut in an anti–clockwise direction and torque to 66–82 lbf ft (90–112 Nm) 9.0–11.2 kgfm



7

Fan Belt Tensioner

A. Fan Belt with Air Conditioning

1. Air Conditioning Compressor (optional)
2. Idler Pulley (with Air Conditioning only)
3. Crankshaft Pulley
4. Tensioner Assembly
5. Idler Pulley

B. Fan Belt less Air Conditioning

6. Water Pump Pulley
7. Alternator
8. Torque Wrench
9. Tensioner Attaching Bolt

FAN BELT TENSIONER REMOVAL

1. The fan belt should be removed in the following manner. Place a lever with socket attachment onto the tensioner retaining bolt and gently lever the tensioner up, Figure 7. Remove the fan belt from the pulley and allow the tensioner to return to its untensioned position once the belt has been removed.

2. Remove the tensioner from the pump by loosening and removing the centre attaching bolt.

Inspection and Repair

1. Checking of the tensioner assembly operation should be carried out with the tensioner assembly still attached to the water pump. To check the spring load, place a "break back" torque bar pre–set to 52–63 lbf ft (70–85Nm) 7.1–8.7 kgfm, on to the pulley attaching bolt. Raise the lever up through an arc of 20° maximum. If the torque bar does not "break" within the range a new tensioner assembly is required.

2. Ensure the tensioner pulley rotates freely by hand. If not replace with new parts.

Re–Assembly

1. Fit a new pulley to the assembly if required, and torque the attaching bolt to 34.5–44 lbf ft (46.5–60Nm) 4.7–6.1kgfm

2. To re–assemble the arm assembly, position the tensioner on to the water pump, fit the mounting bolt through the assembly, and torque the bolt to 34.5–44 lbf ft (46.5–60Nm) 4.7–6.1kgfm

3. Refitment of the fan belt is the reverse of the removal procedure, but ensure the "Poly V" belt is positioned correctly onto all of the pulleys.

IDLER PULLEY

1. One or two idler pulleys are fitted to the vehicle, dependent on the model. One is fitted to the right hand side of the engine front cover, in front of the oil filler cap. The other, where air conditioning is fitted, is situated to the left hand side of the front cover close to the crankshaft, Figure 7.

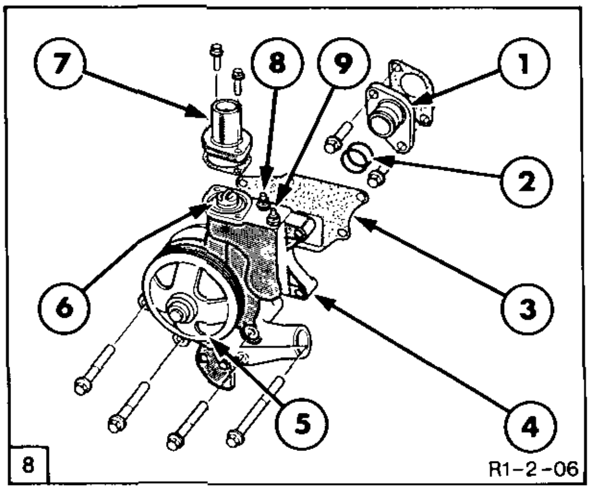
2. Check that the idler pulleys rotate freely, if tight or worn, replace with new. Removal and replacement is by the attaching bolts through the centre of the bodies. Torque the bolts to 34.5–44 lbf ft (46.5–60N m) 4.7–6.1 kgf m.

WATER PUMP REMOVAL

1. Drain the cooling system.

2. Remove the radiator.

3. Loosen or lever the fan belt tensioner to ease the tension and remove the fan belt from the vehicle.



Water Pump Assembly

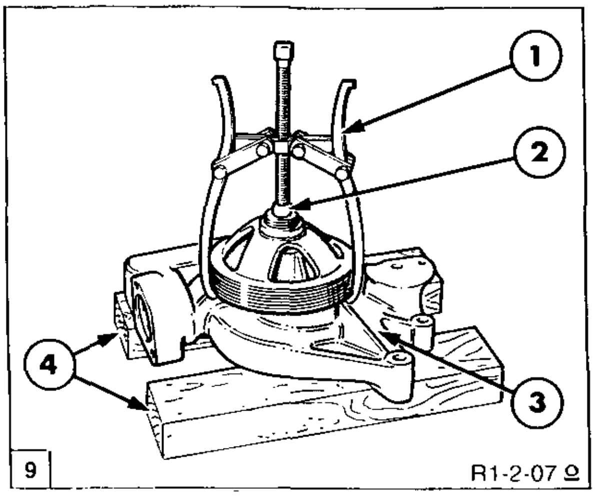
1. Connector & Gasket, Pump to Engine Block
2. 'O' Rings
3. Pump Gasket
4. Pump Body
5. Pulley Assembly
6. Thermostat
7. Thermostat Housing & Gasket
8. Temperature Sender, Warning Light
9. Temperature Sender, Warning Gauge

4. Withdraw the four bolts which pass through the water pump and into the block and slide the pump forward and away from its rear connector, removing the two sealing 'O' rings, Figure 8.

5. Alternatively withdraw six bolts, four in the water pump and two in the pump to block connector and remove from the engine as a complete unit, discarding the gaskets, Figure 8.

Disassembly

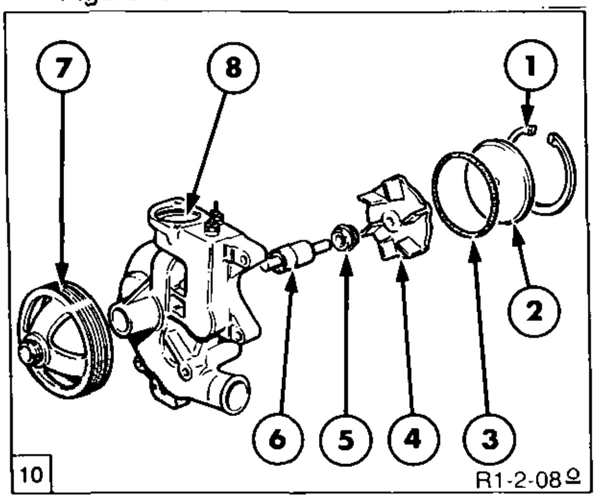
1. To remove the fan and clutch assembly hold the pump pulley in a fixed position, and placing an open ended spanner on the nut to the rear of the clutch assembly spacer, loosen the nut in a clockwise direction.



Water Pump Pulley Removal

1. Tool No FT 1002
2. Sleeve
3. Pump Body
4. Support

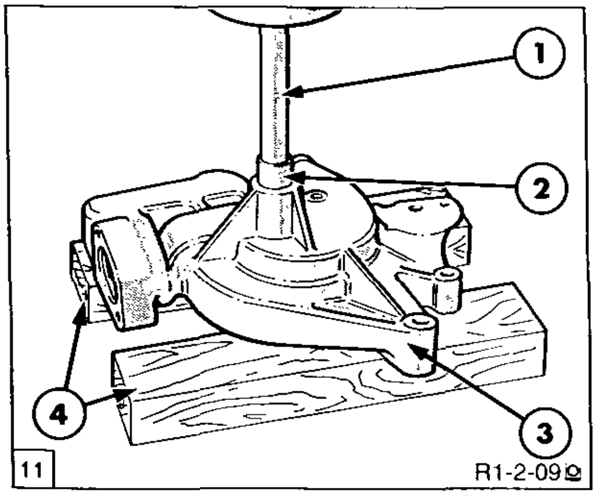
2. Using a puller Tool No. 1002 or 9198 and a sleeve slightly smaller than the pulley shaft, ease the pulley from its shaft, Figure 9.



Water Pump Disassembled

1. *Snap Ring*
2. Backplate
3. 'O' Ring
4. Impeller
5. *Seal*
6. Bearing Assembly
7. Pulley
8. Pump Body

3. Using a pair of heavy snap ring pliers, remove the snap ring from the rear of the pump body. Carefully ease out the backplate. Remove and discard the 'O' ring, Figure 10.

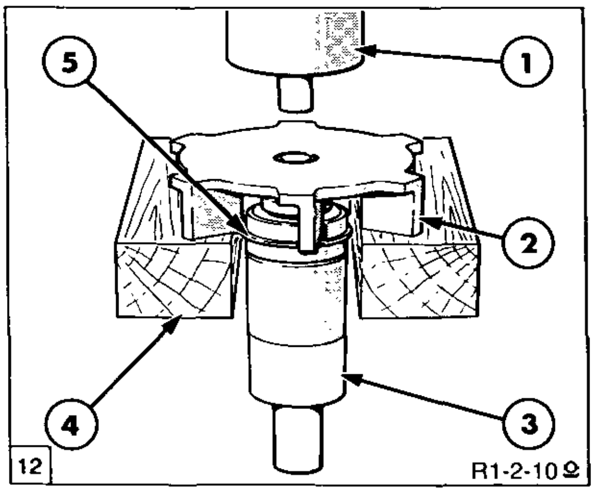


Impeller/Shaft Assembly Removal

1. Press
2. Sleeve
3. Pump Body
4. Supports

1. To remove the impeller/shaft assembly, place the pump body impeller side down. Support the pump in a manner to allow the impeller diameter to drop clear of the pump as it is pressed out from the pump body, Figure 11.

NOTE: *Apply pressure to the outer bearing race and shaft simultaneously to remove, using the correct tool. Do not press the centre shaft only as the shaft may move, leaving the outer bearing case in the pump body.*



Impeller Shaft Removal

1. Press
2. Impeller
3. Bearing Assembly
4. Supports
5. Seal Assembly

2. With the impeller/shaft assembly removed from the pump, place the impeller on supports and press out the shaft assembly from the impeller, Figure 12.

3. The seal assembly attached to the bearing shaft is not removable or servicable. During the manufacturing process the seal is pressed onto the shaft and is destroyed on removal, this is to meet pre load conditions and maintain an effective water seal.

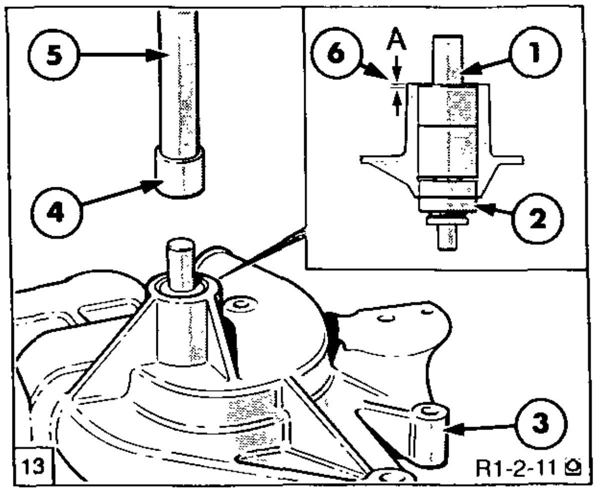
Inspection and Repair

1. Check the bearing shaft and seal assembly for signs of wear or leaks and if evident, the assembly must be replaced with new parts.

2. The impeller should be checked for worn or damaged vanes and must be replaced if not to an acceptable standard.

3. Clean and check the pump body for signs of cracks, erosion or leaks. If any of these faults are in evidence and likely to cause pump failure at a later date, the pump body must be repaired or replaced with a new one.

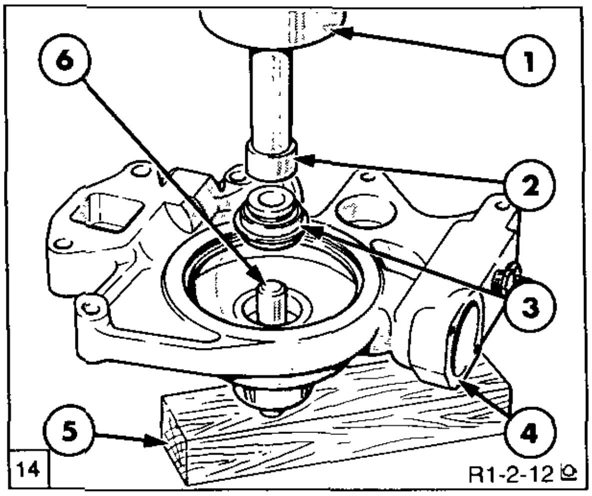
Re–Assembly



Water Pump Bearing Installation

1. Bearing Assembly
2. Seal Assembly
3. Pump Housing
4. Sleeve
5. Press
6. Reference "A"

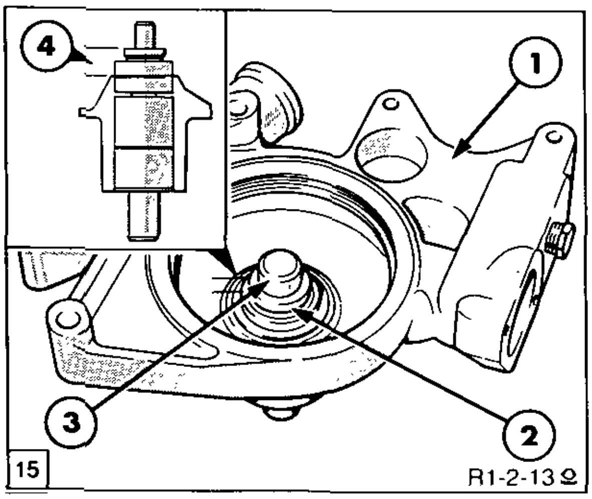
1. To install the bearing into the pump body, place the body rear face down onto a flat surface. Install the bearing with the longer stepped end of the shaft in the body and using a sleeve that contacts the bearing outer race only, press the bearing into the body. Once installed in the body the bearing case end face must be flush with the pump front face to within 0.000–0.006 in (0.00–0.076mm), Reference "A", Figure 13.



Water Pump Seal Installation

1. Press
2. Sleeve
3. Seal Assembly
4. Pump Housing
5. Support
6. Bearing Assembly

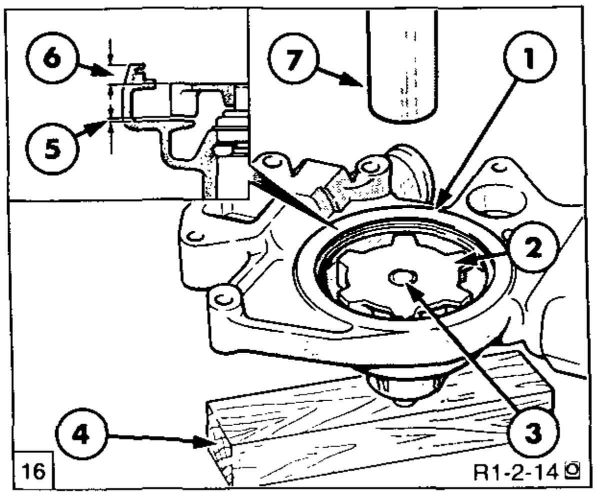
2. With the water pump placed front face down and the shaft supported, place the seal assembly on the end of the shaft, with its smallest diameter uppermost. To insert the seal assembly place Tool No. FT 6209 or 4672 over the seal and press, until the lip on the seal body seats on the pump body, Figure 14.



Water Pump Seal Installed

1. Pump Housing
2. Seal Assembly
3. Bearing Assembly
4. Reference "A"

3. With the seal installed correctly, the seal working height should be maintained at 0.470–0.490 in (11.9–12.4mm), Reference "A", Figure 15.

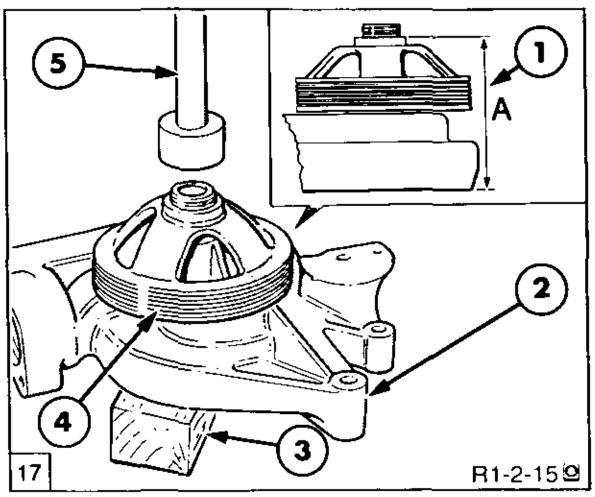


Water Pump Impeller Installed

1. Pump Housing
2. Impeller
3. Bearing Assembly
4. Support
5. Reference "A"
6. Reference "B"
7. Press

4. With the water pump rear face up and the shaft supported, place the impeller over the shaft and press the impeller into the water pump body. Installed correctly the face of the impeller fins to the operating face of the water pump should be 0.010–0.035 in (0.25–0.88mm), *Reference "A" Figure 16.*

5. Check the dimension from the rear face of the impeller to the rear face of the pump. The dimension should be maintained at 0.46–0.485 in (11.6–12.2mm), Reference "B", Figure 16.



Water Pump Pulley Installed

1. Reference "A"
2. Pump Housing
3. Support
4. Pulley
5. Press

6. With the pump rear face down and the shaft supported, press the pulley onto the shaft ensuring that the pulley front face to the rear face of the pump dimension is, 5.091–5.101 in (127–129mm), Reference "A", Figure 17.

7. Ensure a new 'O' ring is fitted and place the water pump backplate in position, refitting the snap ring into its groove, Figure 10. Make sure the water pump pulley/impeller assembly rotates freely by hand prior to re-assembly. If not disassemble and recheck the relevant dimensions.

Installation

1. Installation of the water pump to the engine is the reverse of disassembly, but observing the following requirements.

Clean the block face and fit a new gasket between the connector and block face, Figure 8, then torque the two bolts to 15–21 lbs ft (20–28Nm) 2.0–2.9 kgf m.

Fit two new 'O' rings over the connector outlet port as required, Figure 8.

Place the water pump over the connector and install and torque the four pump bolts to 45–50 lbs ft (61–68Nm) 6.2–6.9 kgf m.

Ensure the fan belt tensioner pulley rotates freely and the swinging arm of the tensioner returns to rest freely. Gently lever the arm up to enable the fan belt to be seated in the grooves on the pulleys. Refit the fan blade assembly.

After installation of the radiator, refill the cooling system as previously described and run the engine checking for leaks.

D. SPECIFICATIONS

GENERAL TORQUES

DESCRIPTION	lbf ft	Nm	kgf m
Thermostat Housing	18	24	2.4
Temperature Senders	15	20	2.0
Tensioner Pulley Bolt	40	54	5.5
Tensioner to Water Pump	40	54	5.5
Idler Pulleys	40	54	5.5
Pump Connector to Block	18	24	2.4
Water Pump to Block	48	65	6.5
Fan Blade to Support Body	17	23	2.3
Fan Blade Clutch to Support Body	78	105	10.5

THERMOSTAT

Opening Temperature	174–181°F (79–83°C)
Fully Open	199–205°F (93–96°C)

RADIATOR CAP

Opening Pressure	13 lbf in^2 (0.9 bar)

WATER PUMP

Type	Centrifugal
Drive	"Poly V" Belt

FAN BELT

Belt Tension	Maintained by Tensioner

COOLING SYSTEM CAPACITIES

Model	Imp Pts	US Qts	Litres
4 Cylinder	26.75	16.05	15.2
6 Cylinder	30.0	18.0	17.0

COOLING FLUID

Content Mixture – Water 50%, Ford Antifreeze WSN–M97B18–D 50%.
If Ford Antifreeze is not used, a heavy duty antifreeze must be used with a 5% solution of corrosion inhibitor. This inhibitor must be added to the cooling system and is available from FNH Dealers, Part No. FW 15.

SPECIAL TOOLS

DESCRIPTION	V.L.CHURCHILL TOOL NO.	NUDAY TOOL NO.	FNH TOOL TOOL NO.
Water Pump Seal Replacer	FT6209	4672	T87T–6312–A
Puller	FT1002	9198	

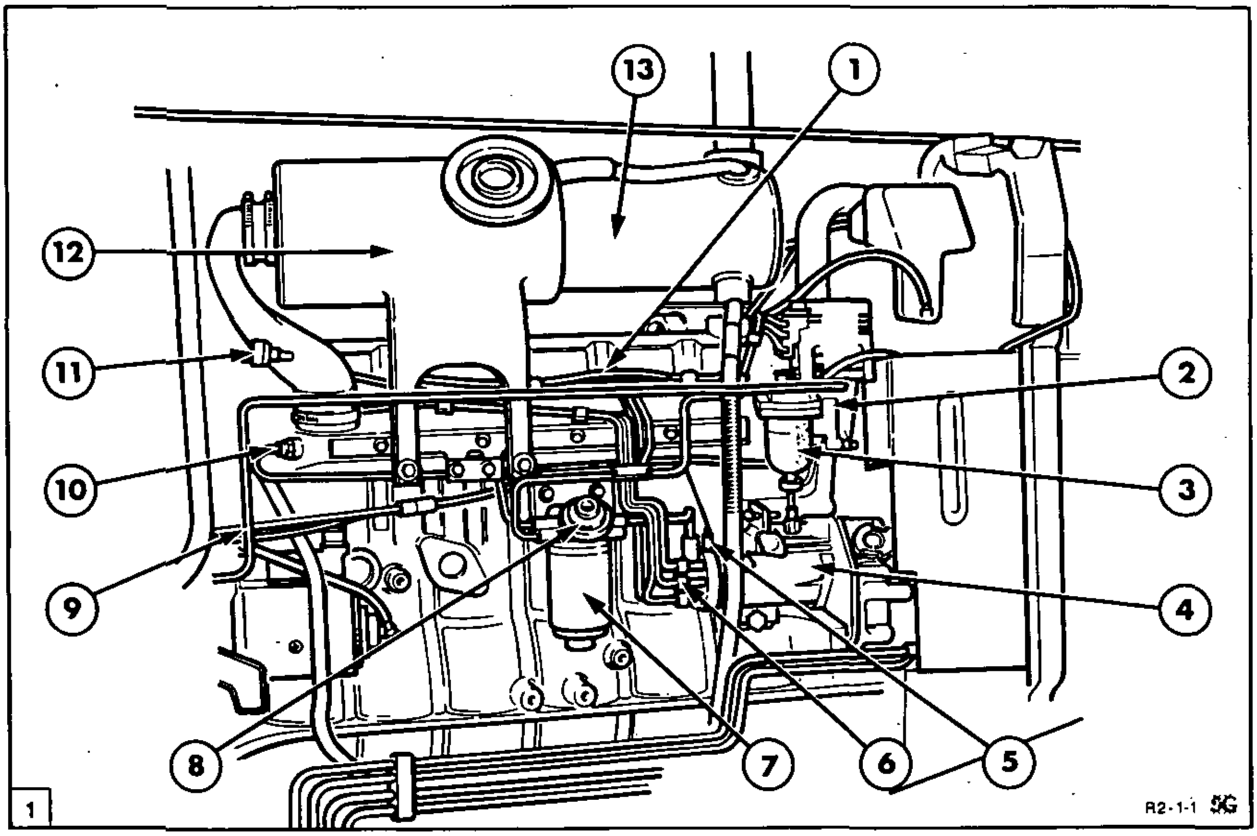
2

PART 2
FUEL SYSTEMS

Chapter 1
FUEL SYSTEM – GENERAL

A. DESCRIPTION AND OPERATION

FUEL SYSTEM



Fuel System

1. Injectors
2. Fuel Shut Off Tap
3. Sediment Seperator
4. DPS Fuel Pump
5. Electric Fuel Shut Off Solenoid (where fitted)
6. Injector High Pressure Feed Pipes
7. Fuel Filter
8. Hand Primer
9. Auxiliary Fuel Tank Feed
10. Cold Weather Thermostart
11. Air Cleaner Restriction Indicator Switch
12. Air Cleaner Body
13. Aspirator Body

The diesel fuel systems of the Series 40 vehicles consist of fuel tank, fuel filter, DPS fuel injection pump, fuel injectors and interconnecting tubes and lines, Figure 1.

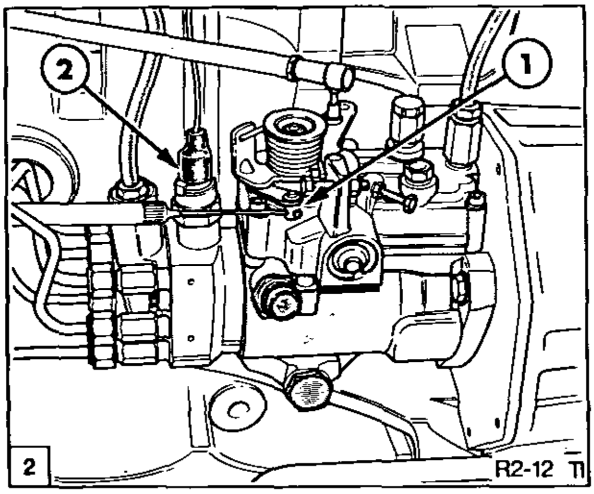
DPS distributor type fuel injection pumps are gravity fed from the fuel tank to the sediment separator. The fuel is then drawn through the hand primer and fuel filter by means of the vacuum created by the transfer pump, which forms the integral part of the fuel injection pump.

The transfer pump delivers fuel to the injection pump to supply fuel at high pressure to each injector and also provides extra fuel which lubricates and cools the injection pump.

This extra fuel is recirculated, via a fitting on the fuel injection pump governor control housing, to the fuel tank by means of the injector leak–off line.

On all models, excess fuel that leaks past the needle valve of the injectors is directed back into the fuel tank by means of the injection leak off line.

FUEL SHUT–OFF (INJECTION PUMP)



Injection Pump Fuel Shut–Off

1. Fuel Shut Off Lever (Mechanical where fitted)
2. Fuel Shut Off Solenoid (Electrical where fitted)

DPS fuel injection pumps are equipped with the ability to have have the fuel shut off by mechanical means (Pull to stop lever) and electrically by a (Fuel shut–off solenoid).

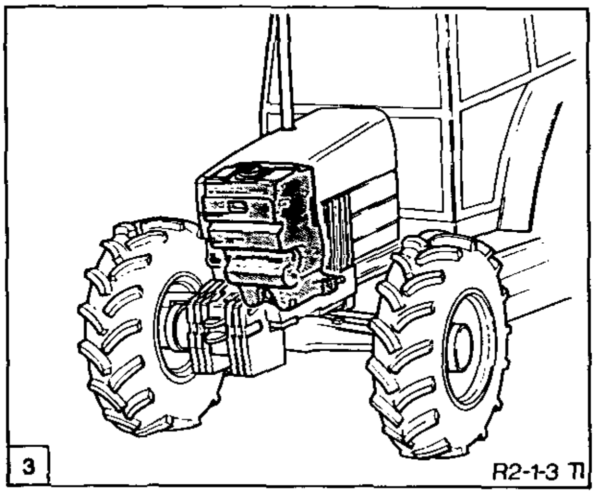
The mechanical pull to stop lever is operated by a cable (where fitted) from the instrument panel, situated close to the ignition switch. When pulled fully out the lever on the pump is moved to a position that stops fuel flow within the injection pump and the engine stops.

The electrically operated fuel shut–off solenoid (where fitted) is energised by operation of the ignition switch mounted in the instrument panel.

With the ignition switched "OFF" a sprung loaded plunger in the solenoid (held in position by the spring tension) prevents fuel flowing into the pump from the main fuel feed port.

With the ignition switched "ON" the magnetised plunger is energised by an internal coil, and is drawn up into the body of the solenoid. Fuel is then allowed to flow with the port open, and into the pump.

MAIN FUEL TANK



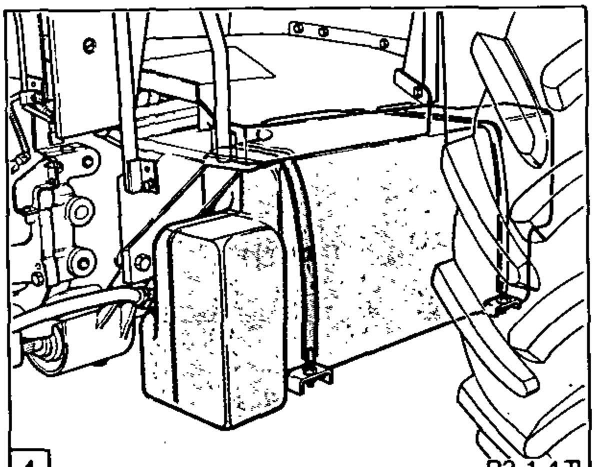
Main Fuel Tank

The new range of vehicles are equipped with the main fuel tank, Figure 3, situated in front of the engine cooling radiator. Fuel tanks are manufactured as a one piece moulded, medium density polyethylene material and secured by a retaining straps, around the rear of the tank.

The tank is vented and allows excess pressure to be released as excess fuel is returned from the injection system.

A fuel shut–off valve is an integral part of the fuel outlet assembly, and is located at the inlet to the sedimentor.

AUXILIARY FUEL TANK



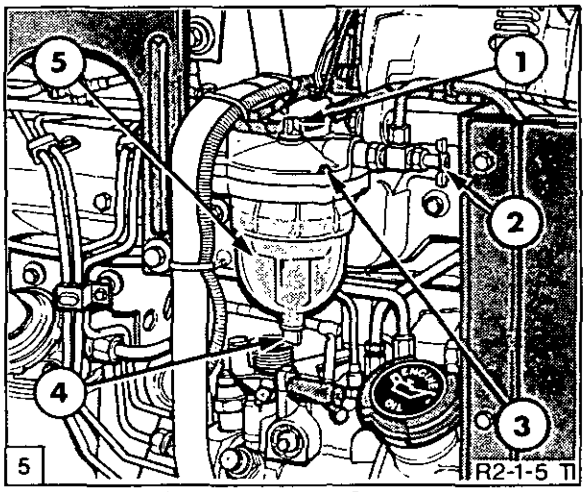
Auxiliary Fuel Tank

To increase the quantity of fuel which may be carried by the tractor an additional fuel tank is available on certain models, Figure 4.

The auxiliary plastic fuel tank (where fitted), being standard on some models and optional on others, is located under the left hand side of platform models or under the left hand side of the cab on cabbed vehicles.

In some applications a heat shield may also be fitted and is unique to locations dependent upon vehicle usage.

SEDIMENT SEPARATOR



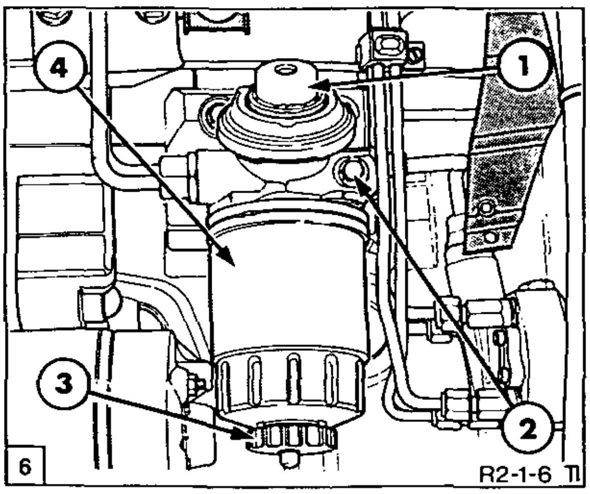
Sediment and Water Separator

1. Bleed Screw
2. Fuel Shut–Off Tap
3. Body Retainer Screws
4. Drain Tap
5. Glass Bowl

The sedimentor is positioned between the fuel tank and the fuel filter on the right hand side of the engine. The fuel enters the sedimentor and flows into the head to be directed down and around the edges of the sediment separator cone.

The larger particles of dirt and water (which are heavier than fuel oil) are separated out and sink to the collecting bowl which can be removed and cleaned. The clean fuel is then drawn back through the top of the unit to the fuel filter.

FUEL FILTER



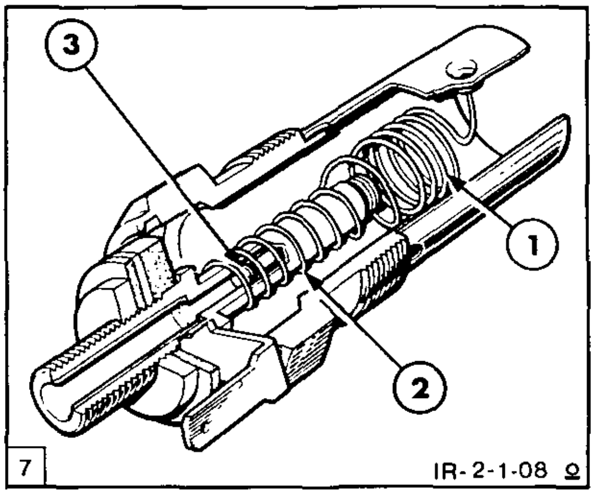
Fuel Filter and Lift Pump Assembly

1. Lift Pump
2. Bleed Screw
3. Filter Retainer
4. Fuel Filter Body

The fuel filter situated to the right hand side of the engine close to the sedimentor receives the clean fuel into the filter head. From the head the fuel is directed down, through the filter paper and into the base chamber, Figure 6.

The filtered fuel then flows up the centre tube of the element to the filter head outlet and into the injection pump.

THERMOSTART



Thermostart Assembly

1. Ignitor Coil
2. Heater Coil
3. Ball Check Valve

To aid engine starting in cold weather conditions, a thermostart cold start device incorporating an integral reservoir system is fitted as standard on all models, Figure 7.

The thermostart cold start device comprises of a plug assembly screwed into the intake manifold. A fuel line connects the cold start to the injector leak–off system and the electrical circuit is connected to the ignition switch.

Fuel is gravity fed to the plug assembly and when an electrical current is applied by operating the key start/stop switch the thermostart switch the heater and ignitor coils are energised.

The heater coil opens a check valve, which allows diesel fuel to flow through the thermostart. The fuel is ignited by the ignitor coil in the manifold, heating indrawn air prior to it entering the combustion chamber.

When the thermostart switch is released to the "Off" position the electrical current is disconnected from the thermostart and the check valve closes.

B. FAULT FINDING

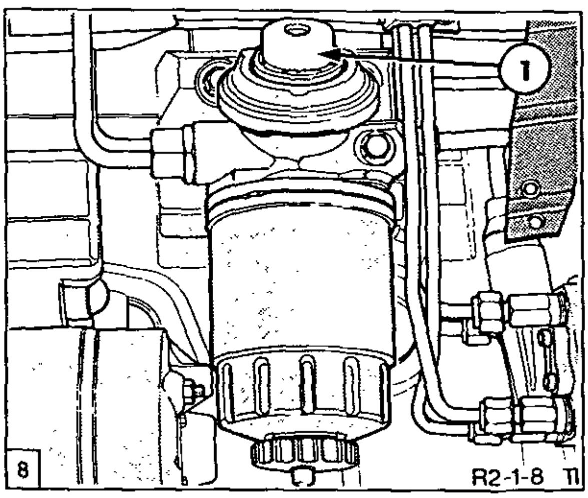
NOTE: *A more detailed analysis of fault finding causes will be found in the relevant sections of the individual major components. Refer to chapters, "Injectors", "Fuel Injection Pump" or "Turbocharger" as required.*

PROBLEM	POSSIBLE CAUSES	REMEMDY
Fuel not flowing from main tank	1. No fuel in tank	1. Refill tank
	2. Fuel tap turned off	2. Turn On Tap
	3. Blocked fuel line from tank	3. Remove and clear fuel Line
Fuel not flowing from auxiliary tank	1. No fuel in tank	1. Check main tank
	2. Fuel tap turned off	2. Turn on tap
	3. Blocked fuel line from tank	3. Remove and clear fuel Line
Fuel starvation or aeration	1. Taps partially open	1. Recheck
	2. Fuel line connections loose	2. Check and retighten
	3. Filters blocked	3. Renew

C. ADJUSTMENTS, FUEL INJECTION PUMP

PRIMING THE FUEL SYSTEM

NOTE: *The fuel system should be primed whenever fuel system components are removed, disconnected or renewed, in order to expel any air in the system.*



Fuel Filter and Lift Pump Assembly

1. Hand Primer

1. Ensure there is sufficient fuel in the tank and all connections are tight and fuel shut off valve is in open position.
2. Operate the hand primer, Figure 8, on the fuel pump until resistance is felt indicating that the system is pressurised (primed).
3. With the throttle in the maximum no load speed position, operate the starter motor to crank the engine. The fuel injection pump is self venting and does not require bleeding.

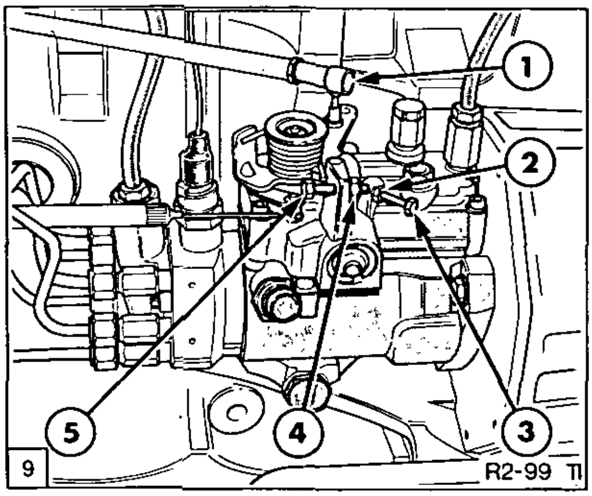
NOTE: *Do not crank the starter motor continuously for more than 60 seconds, as doing so may cause starter motor failure.*

4. If the engine fails to start after 60 seconds repeat the priming procedure.
5. Run the engine and check for leaks.

NOTE: *Turbocharged engines only – The high operating speed of the turbocharger makes it essential that adequate lubrication is supplied when the engine is started.*
Therefore, idle the engine at 1000 rev/min for approximately one minute before driving the tractor.

IDLE SPEED ADJUSTMENT

1. With the engine running and at normal temperature disconnect the throttle rod at the injection pump.



Injection Pump Adjustment Screw

1. Throttle Rod Connector
2. Idle Screw Locknut
3. Idle Speed Adjustment Screw
4. Maximum No–Load Screw Locknut
5. Maximum No–load Speed Adjustment Screw

2. Loosen the locknut and adjust the idle speed stop screw until the idle speed of 750 rev/min is achieved.

3. Operate the throttle lever several times, and check that the idle speed obtained corresponds with the reading in step 2. If excessive free play is felt in either the foot or hand throttle after adjustment, proceed to THROTTLE LINKAGE ADJUSTMENT in this section.

MAXIMUM NO LOAD SPEED ADJUSTMENT

IMPORTANT: *The maximum no load speed screw is adjusted and sealed at the factory for correct fuel delivery and maximum no load speed. If the maximum no load speed is above or below the specified range see "Specifications", adjustments may be made as follows.*

1. With the engine running and at normal operating temperature disconnect the throttle rod at the injection pump, Figure 9.

2. Cut and remove the maximum no–load speed screw sealing wire and remove the locking sleeve.

3. Set the throttle lever at the injection pump in the maximum no–load speed position, then loosen the locknut and adjust the screw until the "specified" maximum no–load speed is obtained.

4. Tighten the locknut to 5–7 lbf ft (7–9Nm) 0.7–0.9 kgf m and secure the adjustment with a new sealing wire and locking sleeve.

5. Ensure the throttle rod can be reconnected to the injection pump and adjust the cable length if necessary, see THROTTLE LINKAGE ADJUSTMENTS.

6. Reconnect the throttle rod and recheck that the maximum no–load and idle speeds, can be obtained using the hand and foot throttles. If the maximum no–load or idle speeds cannot be obtained, proceed to THROTTLE LINKAGE ADJUSTMENTS.

THROTTLE LINKAGE ADJUSTMENTS

NOTE: *If the throttle cables have been removed from the tractor during a repair operation it may be necessary to re–adjust the throttle cables upon re–assembly. The following procedures assume that the fuel injection pump idle, and maximum, no–load speeds are correctly adjusted.*

1. Refit the hand and foot throttle cables to their respective lever anchor points in the cab or platform, Figure 11. Route the cables ensuring they are free of kinks and tight turns, through to the engine mounted adjustment bracket, Figure 10.

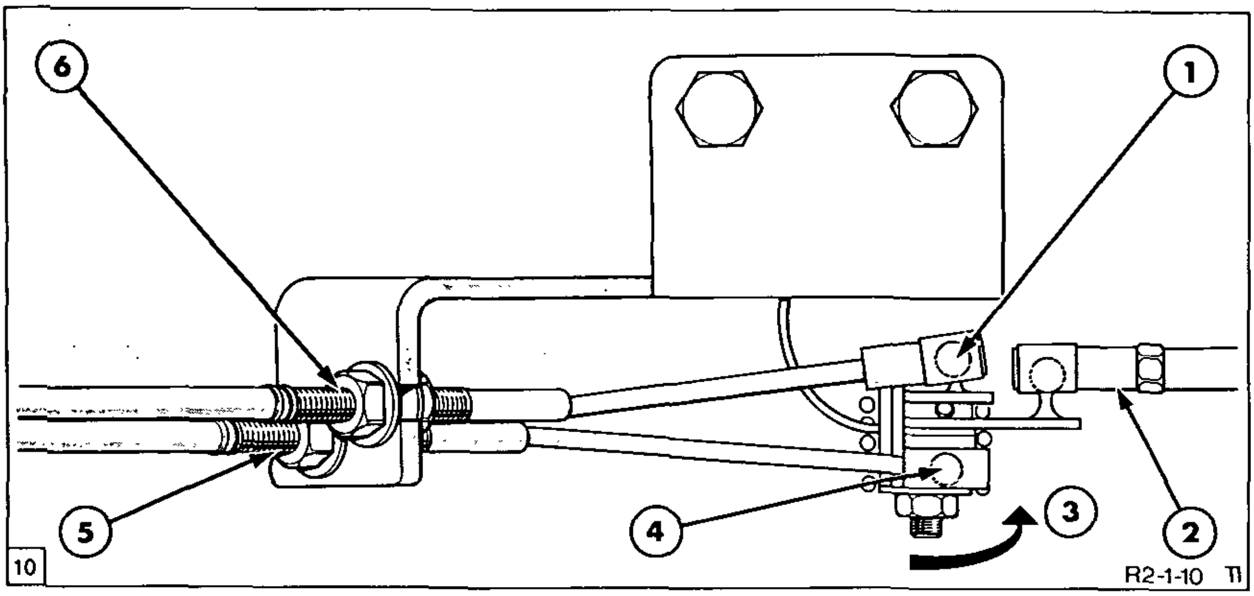
2. Locate the foot throttle cable into the throttle bracket and pull the inner cable taught to remove any free play by ensuring the foot pedal is held at its highest point, Figure 10.

3. Rotate the throttle cable mounting plates on the engine bracket against the spring (clockwise), Figure 10.

4. With the spring compressed connect the inner cable from the hand throttle to the lower point "4". Slide outer cable into back slot "6" and loosely retain, Figure 10.

5. With the spring compressed connect inner cable from foot throttle to top lever at point "1" and leave outer cable out of position, Figure 10.

6. Feed throttle rod "2" behind the fuel filter and connect throttle rod to the injector pump throttle arm, Figure 10.



Engine Mounted Throttle Linkage Adjustment Bracket.

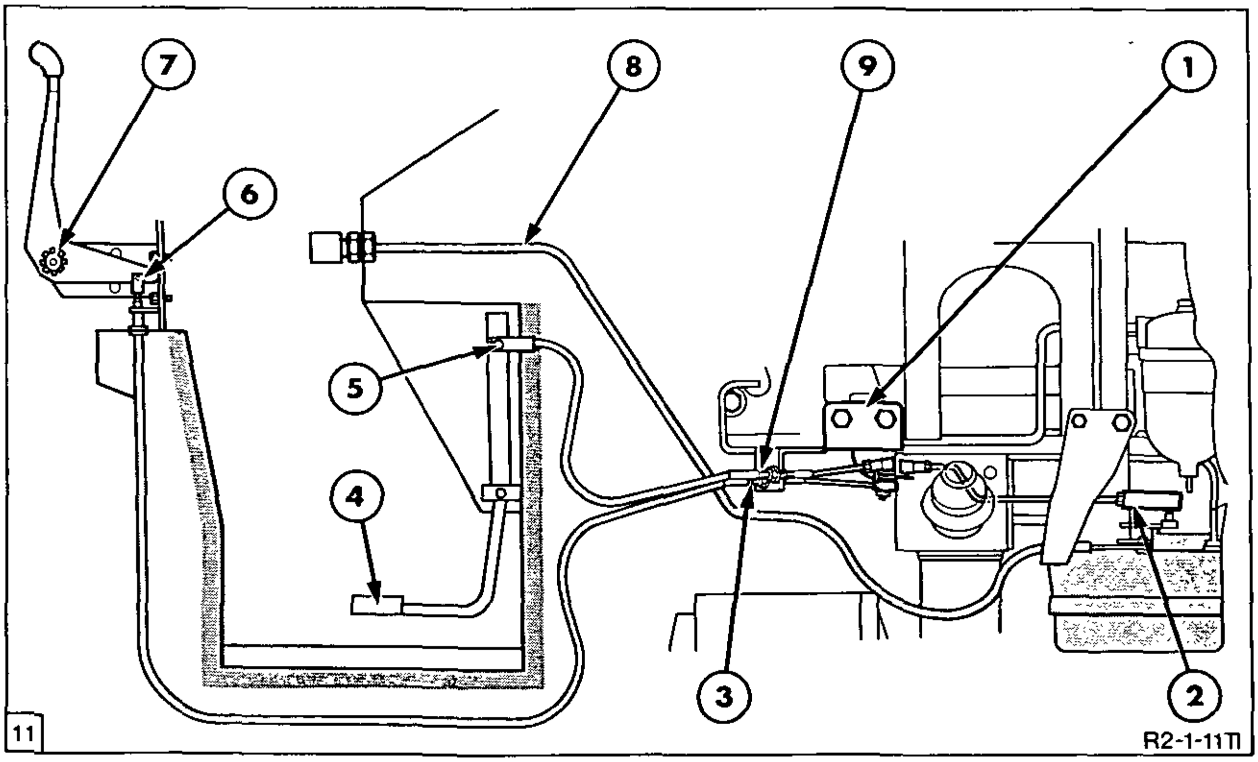
1. Foot Throttle Plate
2. Throttle Rod to Fuel Pump Lever
3. Clockwise Setting Position
4. Hand Throttle Plate
5. Hand Throttle Cable Bracket Position
6. Foot Throttle Cable Bracket Position

7. With hand throttle lever and injection pump lever in idle position, remove all slack from mechanism at point "5", Figure 10. Ensure injector lever moves immediately hand throttle lever moves and tighten the cable locknuts to 8–10.5 lbs ft (11–14 Nm) 1.1–1.4 kgf m.

8. Assemble the foot throttle cable to slot "6", Figure 10.

9. Press the foot throttle to the running board or cab/platform floor mat and adjust outer cable so that the throttle lever on the injection pump is at stop position and not into the override position, tighten locknuts: 8–10.5 lbs ft (11–14 Nm) 1.1–1.4 kgf m.

10. Adjustment can also be made on the fuel pump throttle rod, providing hand and foot throttles are balanced at engine bracket.



Throttle Linkage Adjustment General Layout

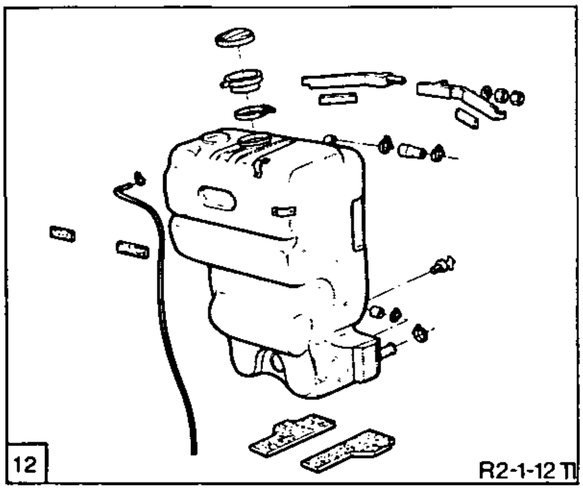
1. Engine Mounted Throttle Bracket (Refer to Figure 10).
2. Throttle Rod Adjuster
3. Hand Throttle Cable Locknuts
4. Foot Throttle
5. Foot Throttle Cable Connection
6. Hand Throttle Cable Connection
7. Hand Throttle Friction Adjuster
8. Pull to Stop Cable (where fitted)
9. Foot Throttle Cable Locknuts

D. FUEL TANK, FILTER AND FUEL LINE OVERHAUL

MAIN FUEL TANK REMOVAL

NOTE: *Prior to removing the fuel tank from the tractor, it will be necessary to drain the tank of fuel.*

1. Disconnect the battery.
2. Withdraw the top hood retaining hardware and remove from the vehicle.
3. Disconnect the wiring harness from the sender at the rear of the fuel tank assembly.
4. Place a suitable container under the fuel tank outlet tube connector, disconnect and drain the fuel off.



Main Fuel Tank (Mounted at the Front)

5. Loosen and remove all attaching ancillary hardware and fuel lines and remove the tank from the vehicle, Figure 12.

Installation

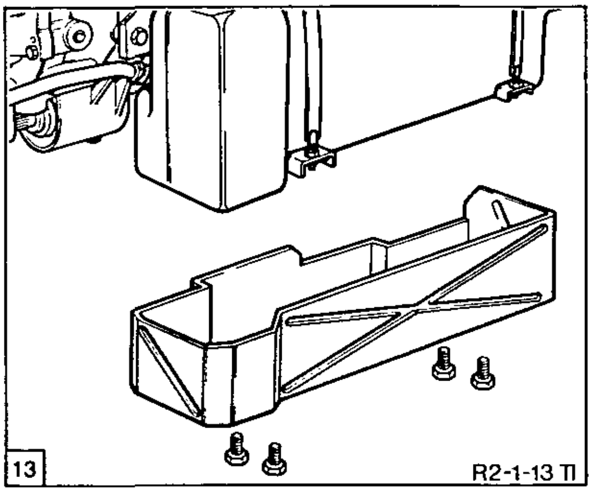
Installation of the tank is the reverse procedure to removal, however, on re–assembly observe the following.

1. Ensure all retaining bolts are tightened to the correct torque, refer to "Specifications".
2. Bleed the fuel system, see "Adjustments."

AUXILIARY FUEL TANK REMOVAL

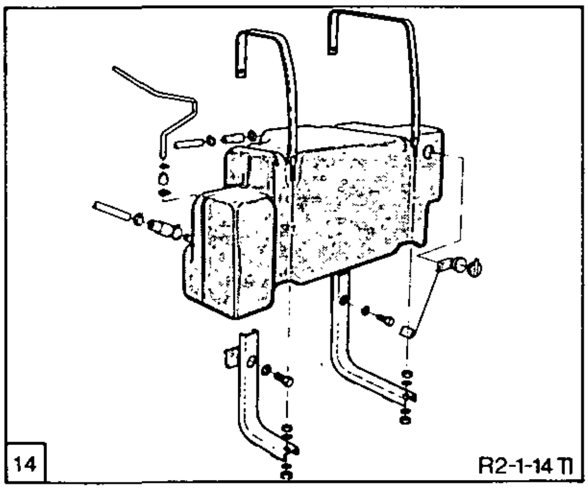
Although fuel tanks vary in design dependent upon model, the basic removal procedure is as follows for both with and less cab.

1. Disconnect the battery.



Auxiliary Fuel Tank Heat Shield

2. Where a heat shield is fitted, remove first before the fuel tank, Figure 13.
3. Place a suitable container under the fuel tank outlet tube and disconnect, drain the fuel off.
4. Where this operation is to be carried out on a with cab or platform unit, the cab can remain in position.



Auxiliary Fuel Tank

5. Loosen and remove all attaching ancillary hardware and fuel lines and remove the tank from the vehicle, Figure 14.

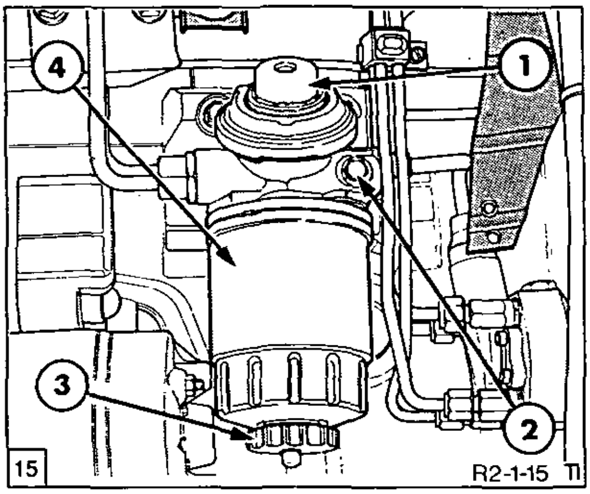
Installation

Installation of the tank is the reverse procedure to removal, however on re–assembly observe the following:–

1. Ensure all retaining bolts are tightened to the correct torque, refer to "Specifications".
2. Bleed the fuel system, see "Adjustments".

FUEL FILTER

Removal



Fuel Filter and Lift Pump Assembly

1. Lift Pump
2. Bleed Screw
3. Filter Retainer
4. Fuel Filter Body

1. Close the fuel shut off taps on the main and auxiliary fuel tank (where fitted) and at the sedimentor fuel tap.

2. Disconnect and remove both fuel lines from the head of the filter assembly.

3. Withdraw the retaining bolts then remove the filter assembly from the tractor, Figure 15.

Disassembly

1. Remove the filter body centre retainer and withdraw the filter.

Overhaul

1. With filter body disassembled clean the inside of the body with clean fuel and replace fuel filter.

Re–Assembly

Re–assembly of the fuel filter is the reverse of disassembly but observe the following requirements:–

1. Ensure the sealing rings are positioned correctly.

2. Tighten the fuel filter body to the correct torque.

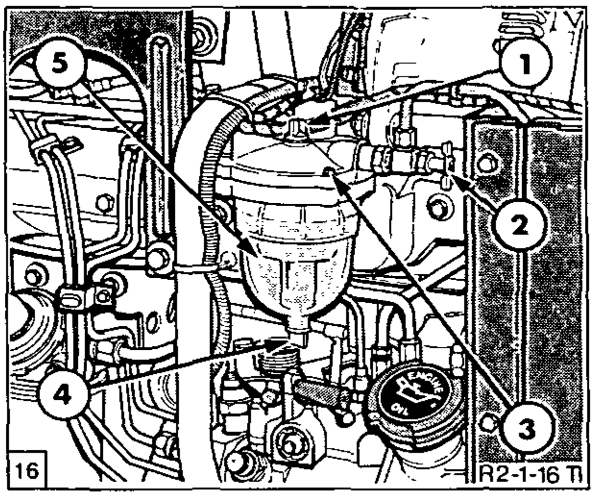
Installation

1. Refit the filter assembly to the vehicle and tighten the bolts to the correct torque.

2. Bleed the fuel system, see "Adjustments".

SEDIMENT AND WATER SEPARATOR

Removal



Sediment and Water Seperator

1. Bleed Screw
2. Fuel Shut–Off Tap
3. Body Retainer Screws
4. Drain Tap
5. Glass Bowl

1. Close the fuel shut off taps on the main and auxiliary fuel tank (where fitted) and at the sedimentor fuel tap, Figure 16.

2. Disconnect and remove both fuel lines from the head of the sedimentor assembly.

3. Loosen and withdraw the retaining bolts and remove the sedimentor assembly from the tractor.

Disassembly

1. The body of the sedimentor can be dismantled by removing the top screws, Figure 16.

Re–Assembly

Re–assembly of the fuel sedimentor is the reverse of disassembly, but observe the following requirements:–

1. Ensure all retaining bolts are tightened to the correct torque.

2. Bleed the fuel system, see "Adjustments".

FUEL LINES

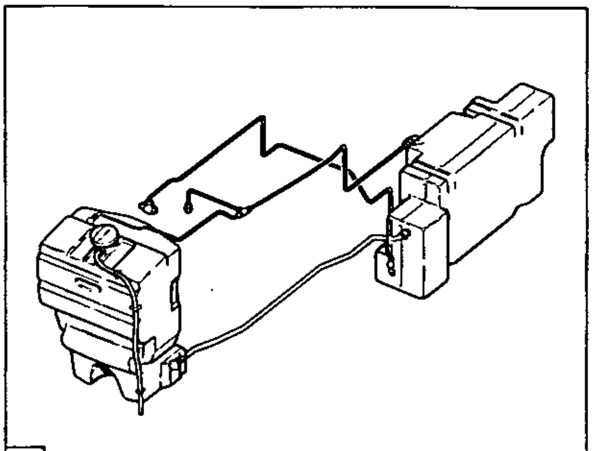
Removal

1. Close the fuel shut–off valve at the main fuel tank and the auxiliary fuel tank (where fitted).

2. Unscrew the retaining nuts at both ends and remove the fuel lines.

IMPORTANT: *With the fuel lines removed, cap all open end connections to ensure no ingress of dirt. Before re–assembly of fuel lines, ensure they are flushed clean using clean diesel fuel.*

Installation



Fuel Lines

1. Position the fuel lines and tighten the retaining hardware. Ensure the nuts are not cross threaded as leaks and aeration will impare engine performance, tighten connections to "Specification".

E. SPECIFICATIONS

SPECIFICATIONS FUEL SYSTEM		5640	6640	7740	7840	8240	8340
Main Fuel Tank –Capacity							
	IMP Gal	20.8	20.8	20.8	24.8	24.8	24.8
	US Gal	25.0	25.0	25.0	29.8	29.8	29.8
	Litres	94.6	94.6	94.6	113	113	113
Auxiliary Fuel Tank – Capacity							
With Cab–	IMP Gal	23	23	23	23	23	23
	US Gal	27.7	27.7	27.7	27.7	27.7	27.7
	Litres	105	105	105	105	105	105
Less Cab–	IMP Gal	18.25	18.25	18.25	23	23	23
	US Gal	21.9	21.9	21.9	27.7	27.7	27.7
	Litres	83	83	83	105	105	105
Fuel Filter Type			Single Disposable Element				
Fuel Sedimentor			Single and Servicable				
Fuel Filter Change Interval				600 Hours			
Maximum No Load Speed –							
High Idle		2350	2350	2250	2250	2250	2250
Low Idle		750	750	750	750	750	750
Rated Speed		2200	2200	2100	2100	2100	2100

GENERAL TORQUES FUEL SYSTEM	lbf/ft	Nm	kgf/m
Throttle Cable Lock Nuts	9	12	1.2
Throttle Lever Stop Bolt Locknut	7	10	1.0
Thermostart Plug	27	37	3.8
Thermostart Pipe Union	7	10	1.0
Thermostart Connector to Fuel Pump	8	11	1.1
Thermostart Tube to Connector	7	10	1.0
Fuel Tank Sender Retaining Ring	18	24	2.4
Fuel Filter Element Retaining Bolt	7	10	1.0
Fuel Filter body Retaining Bolts	22	30	3.1
Air Cleaner Retaining Bolts	17	23	2.3
Air Cleaner Hose Clamps	1.5	2	0.2
Air Cleaner Restriction Indicator Switch	9	12	1.2
Leak Off Pipe to Injector Line	18	24	2.4
Injector Nozzle Retaining Nut	50	70	7.0
Injector Retaining Bolts	17	22	2.2
Injector Leak Off Line Banjo Bolts	8	11	1.1
High Pressure Gland Nuts, at Injector, and Fuel Injection Pump	18	24	2.4
Fuel Tank Drain Valve (where fitted)	5	7	0.7
Fuel Pump to Front Plate Attaching Bolts	18	24	2.4
Fuel Pump Gear Retaining Nut	58	77	7.7
Fuel Filter to Engine Retaining bolts	22	30	3.0
Fuel Seperator Retaining bolts	22	30	3.0
Fuel Tube to Filter Connector	8	11	1.1
Tube Connector to Filter Body	8	11	1.1
Fuel Tube Jubilee Clips	3	4	0.4

GENERAL TORQUES WHERE NOT SPECIFIED			
1/4 – 20	8	11	1.1
1/4 – 28	8	11	1.1
5/16 – 18	14	18	1.8
5/16 – 24	17	23	2.3
3/8 – 16	23	31	3.1
3/8 – 24	33	45	4.5
7/16 – 14	48	66	6.6
7/16 – 20	55	74	7.4
1/2 – 13	65	88	8.8
1/2 – 20	75	101	10.1
9/16 – 18	90	122	12.2
5/18 – 18	137	178	17.8
1/8 – 27NPT	8	11	1.1
1/4 – 18NPT	22	29	2.9
3/8 – 18NPT	44	59	5.9
1 1/2 – 11NPT	70	95	9.5

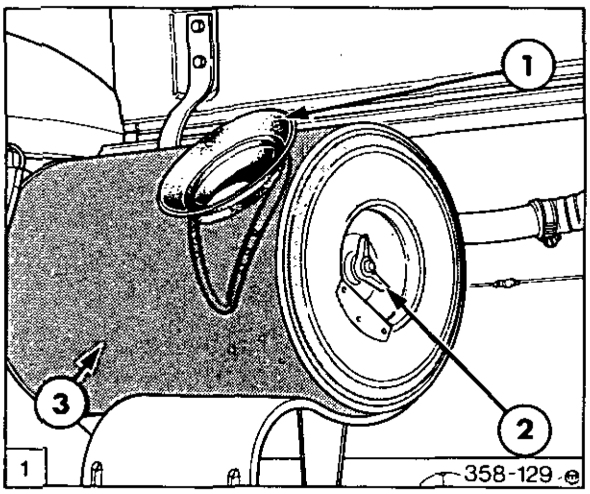
PART 2
FUEL SYSTEMS

Chapter 2
AIR CLEANER DRY

A. DESCRIPTION AND OPERATION

The function of the air cleaner is to remove impurities from the air, but at the same time allow sufficient volume of air to enter the engine, and ensure complete combustion of the fuel.

Ford Tractors for certain locations may be equipped with a dry air cleaner assembly that operates in the following manner. Air is drawn through screens, mounted in front of the radiator and acts as the first defence against chafe and dirt being sucked into the engine.



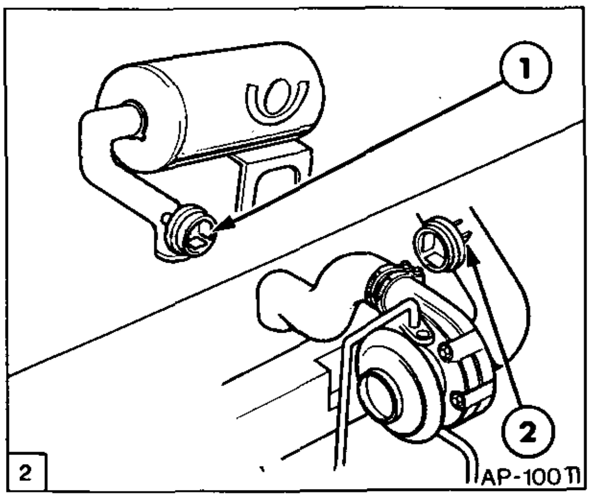
Air Cleaner Assembly

1. Air Seal
2. Filter Element Retaining Wing Nut
3. Air Cleaner Body

The air then passes through a duct fitted inside the hood into the air cleaner system that consists of inner and outer elements within a metal casing located under the rear, right–hand side of the hood, Figure 1.

As air enters the cleaner the heavier particles of dirt are thrown to the outside of the container, and drawn through an aspirator tube connected to the muffler. This allows the heavier particles to be expelled through the exhaust pipe. The lighter particles are then collected on the primary element and will be suspended until cleaned off at the service interval.

The inner secondary element is located within the outer element and protects the engine in the event of dust passing through the outer element if damaged.



Air Cleaner Restriction Switch

1. Switch Mounting – Naturally Aspirated
2. Switch Mounting – Turbocharger

A restriction indicator switch is mounted in the outlet tube of the air cleaner, Figure 2. If the cleaner element becomes blocked, the vacuum in the air cleaner outlet pipe will increase and actuate the vacuum switch. When the switch is actuated a warning light will illuminate in the vehicles instrument panel.

If the air cleaner restriction warning light illuminates when the engine is running, stop the engine as soon as possible or within at least one hour and investigate the cause.

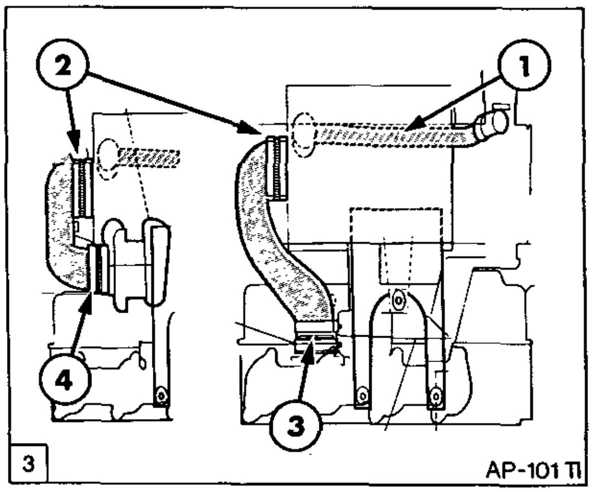
B. FAULT FINDING

PROBLEM	POSSIBLE CAUSES	REMEDY
Air cleaner warning light illuminates	1. Clogged air cleaner	1. Clean or renew outer element
Air cleaner warning light illuminates, after filter service	1. Vacuum switch faulty	1. Replace switch with a new one
Air cleaner warning light illuminates, before service intervals.	1. Aspirator tube not working, debris in filter body	1. Clear aspirator tube, check muffler, clean element and refit.

C. OVERHAUL

NOTE: *The dry air cleaner can be serviced without the need of being removed, from the vehicle.*

Removal



Air Cleaner Assembly Connections

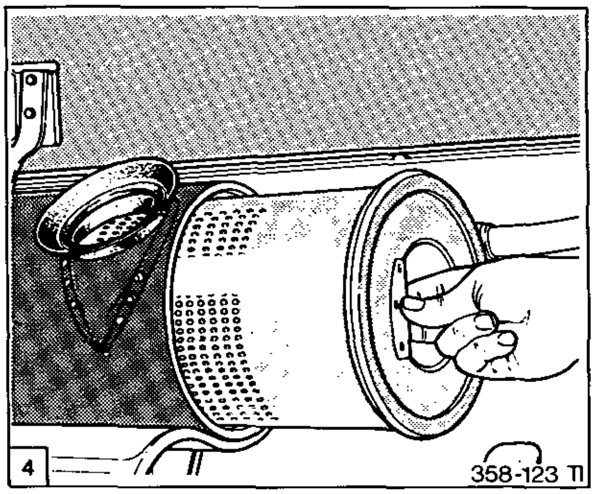
1. Aspirator Tube
2. Air Cleaner Outlet Tube
3. Intake Manifold Connection
4. Turbocharger Connection

1. To remove the air cleaner body from the vehicle, raise the right hand hood and support with the stay. Slacken and remove the hose clamps on the aspirator tube to muffler, inlet manifold and or turbocharger connection where fitted, Figure 3.

2. Remove the air cleaner three attaching bolts and remove the air cleaner body from the vehicle.

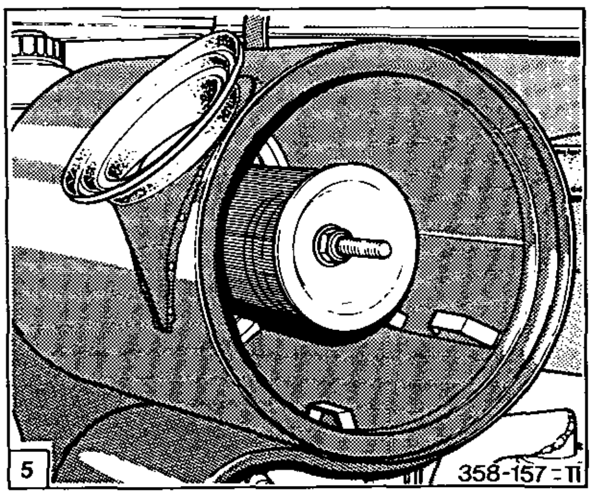
NOTE: *Spacers mounted behind the three fixing legs must be refitted upon re–assembly*

Disassembly



Removal of Outer Element

1. Unscrew the wing nut and extract the outer element as the nut is unscrewed, Figure 4.



Removal of Inner Element

IMPORTANT: *The inner safety element, Figure 5, should not be removed or disturbed unless it is damaged or contaminated with dirt by a faulty outer element.*

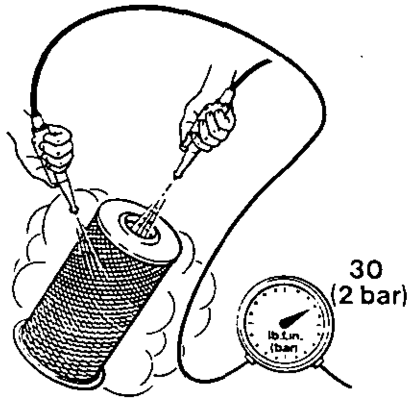
2. Remove the retaining locknut and extract the inner element, Figure 5.

Inspection and Repair

1. Clean and examine the outer casing and repair or seal any damaged seams.

OUTER ELEMENT

1. If dust is present inside the outer element it must be renewed. If satisfactory, clean the element by tapping both ends on the palm of the hand. Do not tap the element against a hard surface as it will be damaged or distorted.



6 IR-2-6-05

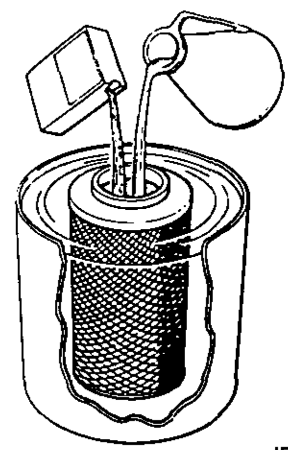
Cleaning Element with Compressed Air

2. Alternatively, compressed air not exceeding 30 lbf in^2 (2 bar) may be used. Insert the air line nozzle inside the element and blow the dust from the inside through the element to the outside. Blow loose particles from the outside of the element by holding the nozzle at least 6 in (150 mm) from the element, Figure 6.

WARNING: *Wear eye protection and a face mask when carrying out this operation.*

If the filter element is undamaged wash the element every 300 hrs or after five dry cleanings.

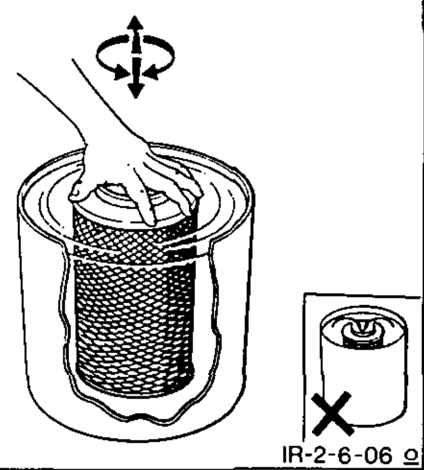
IMPORTANT: *Never use oil, petrol or solvent. Use only water but not hotter than the hand can stand, otherwise the element may be damaged.*



7 IR-2-6-07

Washing the Element

1. Seal the small hole at the closed end of the filter with a strip of adhesive tape and place the filter open end up in a deep flat bottomed container or tub. Add a small amount of non–sudsing washing powder (automatic washing machine type) to the inside of the filter element.
   Add warm water 35° C (100° F) to the inside of the element until the level in the container is just below the open end of the element. Allow the element to soak for at least 15 minutes (but never more than 24 hours) in the cleaning solution.



8 IR-2-6-06

Agitating the Element

2. After soaking gently agitate the element, being careful not to allow dirty cleaning solution from the container to splash into the inside of the element.

3. Rinse the element in clean cold water allowing water to flow from the inside through the element until the water comes through clear. If using a hose do not use a pressured flow, a slow trickle is sufficient. Ensure water is allowed to flow through the entire element.

4. Remove the adhesive tape and shake excess water from the filter element and allow to dry naturally. The element will need 24–48 hours to dry thoroughly. Install a new element at this stage retaining the washed element for the next service.

IMPORTANT: *Do not attempt to dry the element with compressed air or install before thoroughly dry as it may rupture. It is recommended that a new element is installed at this service and the washed element allowed to dry and retained for installation at the next service.*

5. After drying thoroughly, examine the paper pleats carefully. This can be done by inserting a lamp into the middle of the element and observing the element surface. An even, fine pattern of light indicates the element is clean, undamaged and suitable for further service. If this is not the case discard the element.

6. Every 600 hours the element must be renewed.

INNER ELEMENT

1. The inner element should not be disturbed unless damaged, or contaminated by dirt through failure of the outer element. To clean the inner element, follow the procedure for cleaning the outer element, using compressed air only.

2. If the inner element is okay leave assembled in the cleaner body and change only annually, or every 1200 hours whichever occurs first.

Re–Assembly

1. Clean the inside of the air cleaner casing with a damp, lint–free cloth and re–install the inner and outer element. Ensure that the rubber sealing rings on the ends are secure and undamaged.

2. Refitting of the filter body to the vehicle, is the reverse procedure to disassembly.

IMPORTANT: *Ensure the spacers are replaced behind the fixing legs during re–assembly.*

D. SPECIFICATIONS

AIR CLEANER

Type	Dry Element	
Service Interval	300 Hours – Outer Element	1200 Hours – Inner Element
Change Interval	600 Hours – Outer Element	1200 Hours – Inner Element

GENERAL TORQUES DESCRIPTION	lbf ft	Nm	kgf m
Air Cleaner Tube to Manifold Clamps	1.5	2.0	0.2
Air Cleaner Tube to Turbocharger Clamps	1.5	2.0	0.2
Aspirator Tube to Muffler Clamps	1.5	2.0	0.2
Cleaner to Manifold Bolts	17.0	23.0	2.3

PART 2
FUEL SYSTEMS

Chapter 2
AIR CLEANER DRY

A. DESCRIPTION AND OPERATION

The function of the air cleaner is to remove impurities from the air, but at the same time allow sufficient volume of air to enter the engine, and ensure complete combustion of the fuel.

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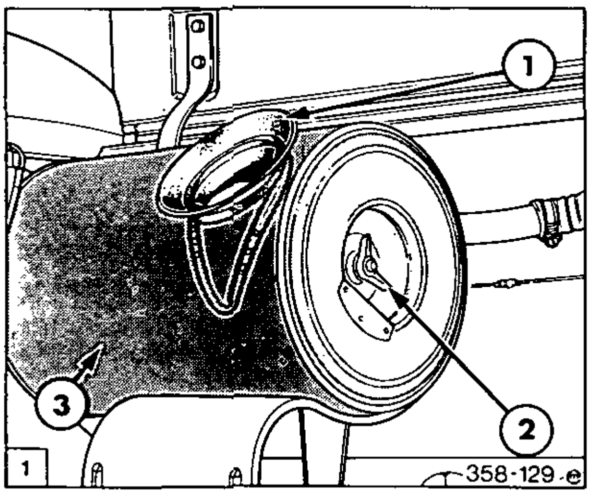


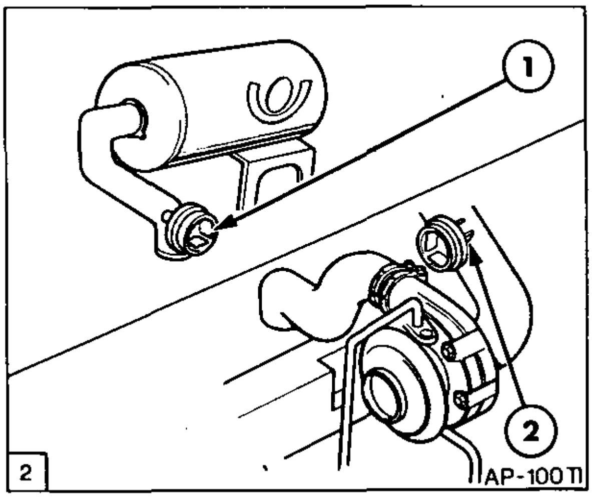
Air Cleaner Assembly

1. Air Seal
2. Filter Element Retaining Wing Nut
3. Air Cleaner Body

The air then passes through a duct fitted inside the hood into the air cleaner system that consists of inner and outer elements within a metal casing located under the rear, right-hand side of the hood, Figure 1.

As air enters the cleaner the heavier particles of dirt are thrown to the outside of the container, and drawn through an aspirator tube connected to the muffler. This allows the heavier particles to be expelled through the exhaust pipe. The lighter particles are then collected on the primary element and will be suspended until cleaned off at the service interval.

The inner secondary element is located within the outer element and protects the engine in the event of dust passing through the outer element if damaged.



Air Cleaner Restriction Switch

1. Switch Mounting – Naturally Aspirated
2. Switch Mounting – Turbocharger

A restriction indicator switch is mounted in the outlet tube of the air cleaner, Figure 2. If the cleaner element becomes blocked, the vacuum in the air cleaner outlet pipe will increase and actuate the vacuum switch. When the switch is actuated a warning light will illuminate in the vehicles instrument panel.

If the air cleaner restriction warning light illuminates when the engine is running, stop the engine as soon as possible or within at least one hour and investigate the cause.

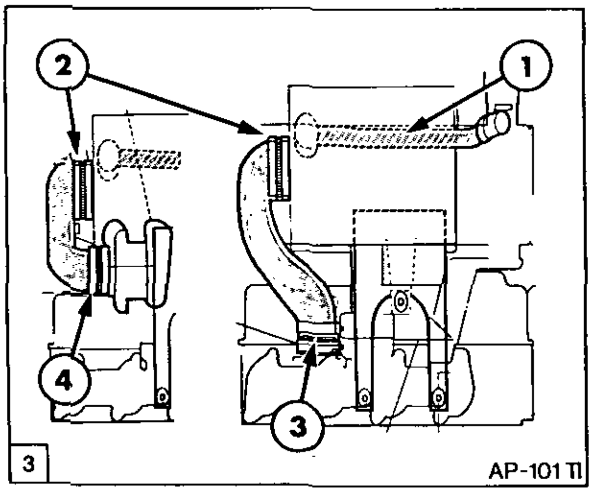
B. FAULT FINDING

PROBLEM	POSSIBLE CAUSES	REMEDY
Air cleaner warning light illuminates	1. Clogged air cleaner	1. Clean or renew outer element
Air cleaner warning light illuminates, after filter service	1. Vacuum switch faulty	1. Replace switch with a new one
Air cleaner warning light illuminates, before service intervals.	1. Aspirator tube not working, debris in filter body	1. Clear aspirator tube, check muffler, clean element and refit.

C. OVERHAUL

NOTE: *The dry air cleaner can be serviced without the need of being removed, from the vehicle.*

Removal



Air Cleaner Assembly Connections

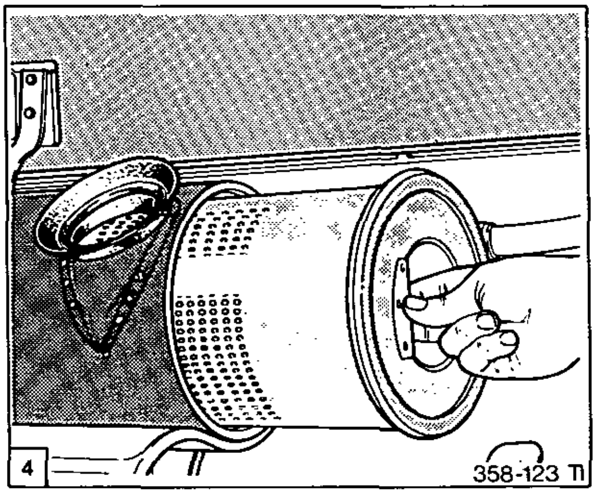
1. Aspirator Tube
2. Air Cleaner Outlet Tube
3. Intake Manifold Connection
4. Turbocharger Connection

1. To remove the air cleaner body from the vehicle, raise the right hand hood and support with the stay. Slacken and remove the hose clamps on the aspirator tube to muffler, inlet manifold and or turbocharger connection where fitted, Figure 3.

2. Remove the air cleaner three attaching bolts and remove the air cleaner body from the vehicle.

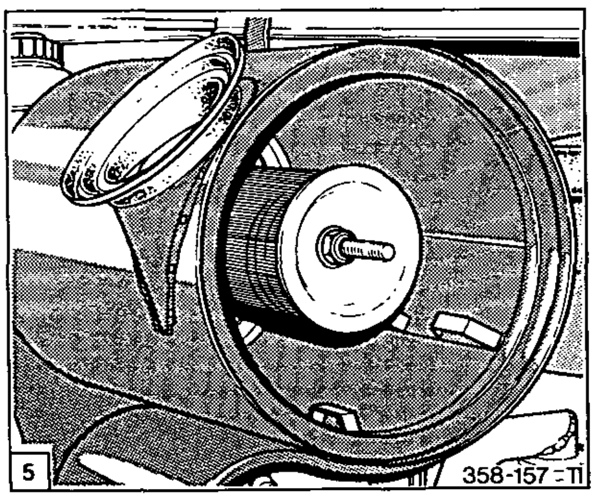
NOTE: *Spacers mounted behind the three fixing legs must be refitted upon re–assembly*

Disassembly



Removal of Outer Element

1. Unscrew the wing nut and extract the outer element as the nut is unscrewed, Figure 4.



Removal of Inner Element

IMPORTANT: *The inner safety element, Figure 5, should not be removed or disturbed unless it is damaged or contaminated with dirt by a faulty outer element.*

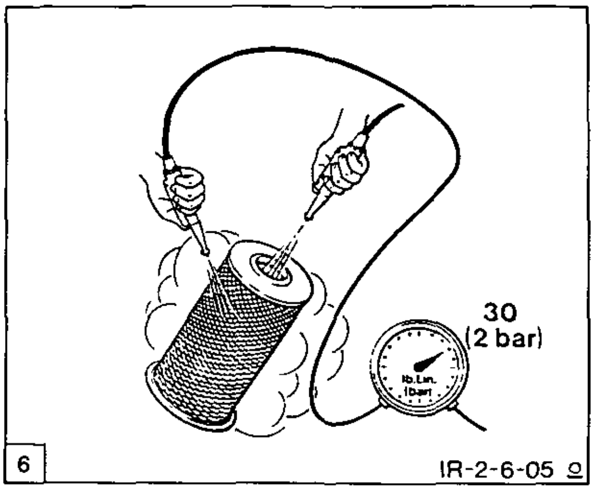
2. Remove the retaining locknut and extract the inner element, Figure 5.

Inspection and Repair

1. Clean and examine the outer casing and repair or seal any damaged seams.

OUTER ELEMENT

1. If dust is present inside the outer element it must be renewed. If satisfactory, clean the element by tapping both ends on the palm of the hand. Do not tap the element against a hard surface as it will be damaged or distorted.



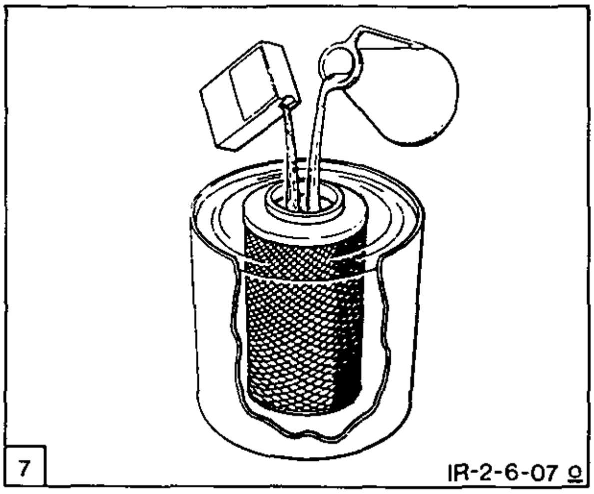
Cleaning Element with Compressed Air

2. Alternatively, compressed air not exceeding 30 lbf in^2 (2 bar) may be used. *Insert the air line nozzle inside the* element and blow the dust from the inside through the element to the outside. Blow loose particles from the outside of the element by holding the nozzle at least 6 in (150 mm) from the element, Figure 6.

WARNING: *Wear eye protection and a face mask when carrying out this operation.*

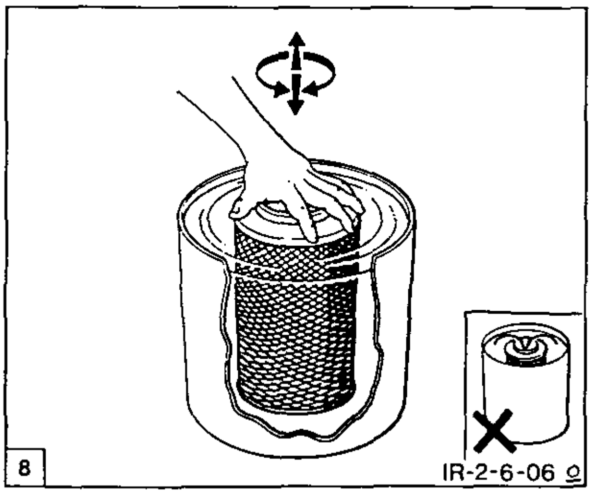
If the filter element is undamaged wash the element every 300 hrs or after five dry cleanings.

IMPORTANT: *Never use oil, petrol or solvent. Use only water but not hotter than the hand can stand, otherwise the element may be damaged.*



Washing the Element

1. Seal the small hole at the closed end of the filter with a strip of adhesive tape and place the filter open end up in a deep flat bottomed container or tub. Add a small amount of non–sudsing washing powder (automatic washing machine type) to the inside of the filter element.
   Add warm water 35° C (100° F) to the inside of the element until the level in the container is just below the open end of the element. Allow the element to soak for at least 15 minutes (but never more than 24 hours) in the cleaning solution.



Agitating the Element

2. After soaking gently agitate the element, being careful not to allow dirty cleaning solution from the container to splash into the inside of the element.

3. Rinse the element in clean cold water allowing water to flow from the inside through the element until the water comes through clear. If using a hose do not use a pressured flow, a slow trickle is sufficient. Ensure water is allowed to flow through the entire element.

4. Remove the adhesive tape and shake excess water from the filter element and allow to dry naturally. The element will need 24–48 hours to dry thoroughly. Install a new element at this stage retaining the washed element for the next service.

IMPORTANT: *Do not attempt to dry the element with compressed air or install before thoroughly dry as it may rupture. It is recommended that a new element is installed at this service and the washed element allowed to dry and retained for installation at the next service.*

5. After drying thoroughly, examine the paper pleats carefully. This can be done by inserting a lamp into the middle of the element and observing the element surface. An even, fine pattern of light indicates the element is clean, undamaged and suitable for further service. If this is not the case discard the element.

6. Every 600 hours the element must be renewed.

INNER ELEMENT

1. The inner element should not be disturbed unless damaged, or contaminated by dirt through failure of the outer element. To clean the inner element, follow the procedure for cleaning the outer element, using compressed air only.

2. If the inner element is okay leave assembled in the cleaner body and change only annually, or every 1200 hours whichever occurs first.

Re–Assembly

1. Clean the inside of the air cleaner casing with a damp, lint–free cloth and re–install the inner and outer element. Ensure that the rubber sealing rings on the ends are secure and undamaged.

2. Refitting of the filter body to the vehicle, is the reverse procedure to disassembly.

IMPORTANT: *Ensure the spacers are replaced behind the fixing legs during re–assembly.*

D. SPECIFICATIONS

AIR CLEANER

Type	Dry Element	
Service Interval	300 Hours – Outer Element	1200 Hours – Inner Element
Change Interval	600 Hours – Outer Element	1200 Hours – Inner Element

GENERAL TORQUES DESCRIPTION	lbf ft	Nm	kgf m
Air Cleaner Tube to Manifold Clamps	1.5	2.0	0.2
Air Cleaner Tube to Turbocharger Clamps	1.5	2.0	0.2
Aspirator Tube to Muffler Clamps	1.5	2.0	0.2
Cleaner to Manifold Bolts	17.0	23.0	2.3

PART 2
FUEL SYSTEMS

Chapter 3
AIR CLEANER WET

Section **Page**

A. DESCRIPTION AND OPERATION

The function of the air cleaner system is to remove impurities from the air, but at the same *time allow sufficient volume of air to enter the* engine and ensure complete combustion of the fuel.

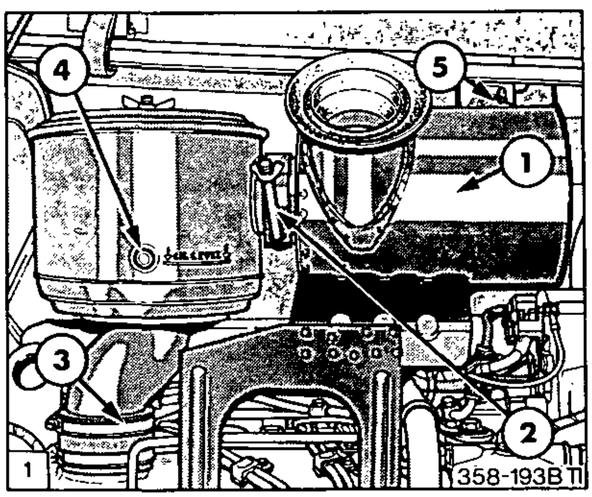
Ford Tractors for certain locations may be equipped with a wet air cleaner assembly that operates in the following manner:
Air is drawn through screens mounted in front of the radiator and acts as the first defence against chafe and dirt being sucked into the engine.

The air is then drawn into the air cleaner system via a duct fitted to the inside of the right hand hood. The system consists of an aspirated pre cleaner and a gauze filter in a bowl of oil, Figure 1.

The aspirator is connected by a tube to the exhaust system where larger particles of dirt in the air are drawn into the exhaust and expelled through the exhaust pipe.
The pre cleaned air is then drawn into the air cleaner downwards to the surface of the oil bath sump, where particles of dust pass and are retained in the oil.

Air is then drawn through the oil soaked gauze filter, where the fine particles of dirt in *the air cling to the oil in the gauze,* this ensures that only clean air is drawn into the inlet manifold of the engine.

IMPORTANT: *The air cleaner will only fulfill this function if it is correctly and regularly maintained. A poorly maintained air cleaner will mean loss of power, excessive fuel consumption and a reduction in engine life.*



Oil Bath Air Cleaner Installation

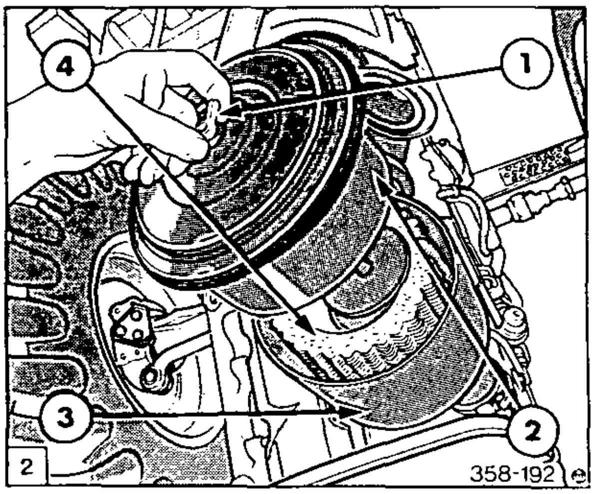
1. Aspirated Pre Cleaner
2. Clamp – Bowl to Pre Cleaner
3. Clamp – Bowl to Manifold
4. Sight Glass
5. Aspirator Tube to Muffler

B. FAULT FINDING

PROBLEM	POSSIBLE CAUSES	REMEDY
Engine performance poor	1. Blocked gauze filter	1. Clean element renew oil in sump
Filter blocks very quickly after Service interval	2. Aspirator tube not working, excess debris in filter body	2. Clear aspirator tube, check muffler clean element and refit

C. OVERHAUL

Removal



Oil Bath Air Cleaner

1. Retaining Wing Nut
2. Air Cleaner Lid
3. Air Cleaner Bowl
4. Gauze Filter

NOTE: *The sump of the wet air cleaner can be serviced, without the need of being removed from the vehicle.*

1. To remove the oil bath from the vehicle, raise the right hand hood and support with the stay. Slacken the clamp between the aspirated pre–cleaner and the oil bath, Figure 1 and slide it towards the pre–cleaner.

NOTE: *Do not tilt the bowl during removal as oil the in the bowl may be spilt.*

2. Unscrew the captive wing nut, Figure 2, while lifting the complete bowl assembly off the manifold tube.
3. With the assembly removed from the vehicle, lift the lid off the bowl. Lift out the gauze filter and drain the old oil away.
4. The aspirated pre–cleaner can now be removed for cleaning or replacement. Slacken and remove the hose clamp on the aspirator tube to the muffler. Remove the three pre–cleaner attaching bolts and spacers behind the fixing legs and remove the pre–cleaner.

Inspection and Repair

1. Hold the filter up to the light. If an even *pattern of light cannot be seen over the* whole of the filter surface then the filter is blocked or partially blocked and must be washed.

WARNING: *This operation should be carried out in a well ventilated area. Wear eye protection and a face mask when carrying out this operation.*

2. Wash the filter thoroughly in a suitable solvent and using compressed air not exceeding 30 lbf in^2 (2 bar) blow air through the filter.
3. Wipe clean the filter body and inspect the casing for leaks or cracks. If any are found a new replacement casing should be fitted.

Re–Assembly

1. Refit the aspirated pre–cleaner to the vehicle ensuring that the spacers are fitted behind the fixing legs.
2. Mount the oil bath without the filter or lid installed onto the manifold tube. Slide the oil bath/pre–cleaner clamp into position and torque to "Specification".
3. Refill the oil bath with new engine oil to the correct level as shown in the sight glass. Replace the filter into the bowl, refit the lid and hand tighten the wing nut.

NOTE: *The oil bath air cleaner should be checked daily or more often when operating in dusty conditions. In extreme conditions, it may be necessary to service the air cleaner two or three times each day.*

Visually check the condition and level of oil in the bowl. If there is more than 0.5 in. (12 mm) of sediment present, clean the bowl and refill with fresh engine oil.

D. SPECIFICATIONS

AIR CLEANER	**Wet Element**
Service Interval	10 Hour and 50 Hour Periods
Change Interval	Nil – Unless damaged

OIL TYPE	
Engine Oil	Ford ESN–M2C121–B,C,D,E or M2C159–C

GENERAL TORQUES DESCRIPTION	**lbf ft**	**Nm**	**kgf m**
Air Cleaner Tube to Manifold Clamps	1.5	2.0	0.2
Aspirator Tube to Muffler Clamps	1.5	2.0	0.2
Air Cleaner to Manifold Bolts	17.0	23.0	2.3

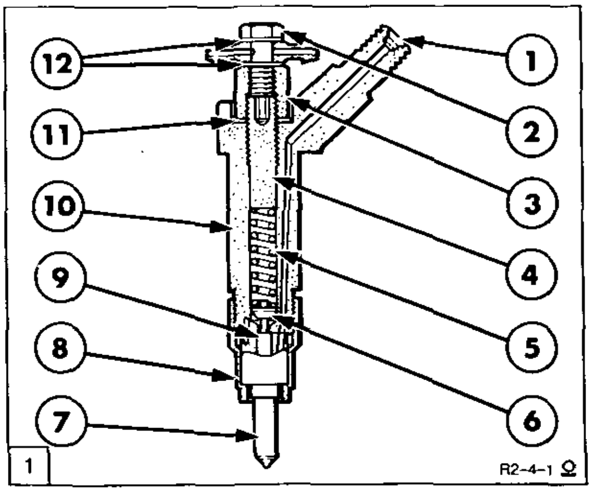
PART 2
FUEL SYSTEMS

Chapter 4
INJECTORS

A. DESCRIPTION AND OPERATION

The engine injector function is to inject fuel, into a pressurised cylinder in a fully atomised condition. This ensures the fuel burns efficiently.

Each injector consists of a nozzle assembly, containing a needle valve and a nozzle holder assembly housing the injector needle valve regulating spring, Figure 1.



Fuel Injector Assembly

1. Fuel Inlet
2. Leak off Line Bolt
3. Cap Nut
4. Spring Adjusting Screw
5. Spring
6. Spring Seat
7. Nozzle Tip
8. Nozzle Retaining Nut
9. Needle Valve
10. Injector Body
11. Copper Washer
12. Copper Washers

Fuel from the fuel injection pump enters the injector fuel inlet and passes down through a drilling in the nozzle holder and body to the needle valve seat.

The fuel pressurised by the injection pump, lifts the needle valve off the seat against the action of a spring. The fuel is then forced in an atomised state, through the four holes in the nozzle tip. When the pressure from the injection pump drops, the needle valve snaps back onto the seat under pressure from the spring.

To provide lubrication of the injector a small amount of fuel is permitted to leak up between the needle valve and the nozzle body. The excess fuel rises to the top of the injector and returns to the fuel tank via an injector leak off line.

B. FAULT FINDING

PROBLEM	POSSIBLE CAUSES	REMEDY
Nozzle does not buzz whilst injecting	1. *Needle valve stuck*	1. *Check needle valve is clean and not binding*
	2. Leakage	2. Check valve seat is not leaking
	3. Nozzle damaged	3. Examine nozzle retaining cap for damage

PROBLEM	POSSIBLE CAUSES	REMEDY
Nozzle leak back	1. Needle valve worn	1. Renew nozzle assembly
	2. Blocked nozzle assembly	2. Check for carbon or foreign material on faces of nozzle holder. Flush clean or renew
	3. Loose nozzle assembly	3. Inspect faces and tighten nozzle retaining nut
Nozzle opening pressure incorrect	1. Incorrectly adjusted nozzle retaining nut	1. Check adjusting nut for looseness and re–set
	2. Damaged nozzle or seized needle valve	2. Renew nozzle assembly
	3. Blocked nozzle holes	3. Check nozzle holes for carbon or foreign material. Flush clean or replace
Nozzle seat leakage	1. Nozzle incorrectly seated	1. Check for carbon or foreign material on faces of nozzle holder
	2. Sticking or binding needle valve	2. Repair or renew nozzle assembly
Spray pattern distorted	1. Obstructed needle valve	1. Check for carbon or foreign material on needle valve tip. Flush clean or renew nozzle assembly
	2. Obstructed needle valve holes	2. Check for carbon in needle valve holes. Flush clean or renew nozzle assembly
	3. Damaged nozzle or needle valve	3. Renew nozzle assembly
Engine emits black smoke	1. Faulty injectors	1. Overhaul or renew injectors

C. OVERHAUL

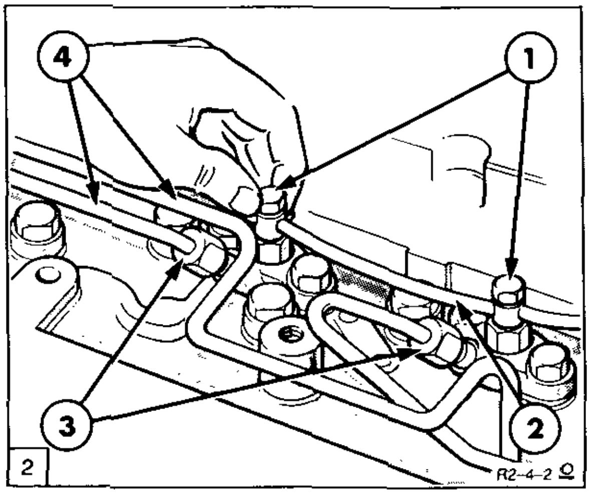
Removal

1. Slacken the high pressure fuel pipe gland nuts, at the injection pump.

2. Clean the area around the injectors.

3. Remove the banjo bolts, and disconnect the fuel leak off lines, discarding the two copper washers from each bolt, Figure 2.

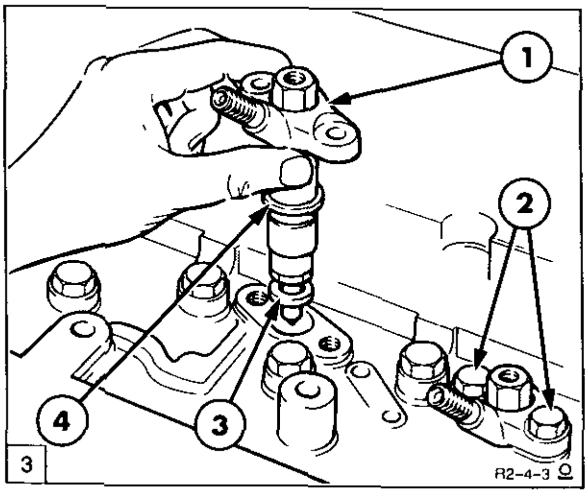
4. Unscrew the gland nuts and disconnect the high pressure pipes from the injectors, Figure 2.



Disconnecting Injector Pipes

1. Banjo Bolts
2. Leak–Off Pipe
3. High Pressure Fuel Pipe Gland Nuts
4. High Pressure Fuel Pipes

5. Unscrew and remove the two retaining bolts from each injector and withdraw the injector from the cylinder head, Figure 3. Ensure no dirt falls into the injector seat.



Removing Injector

1. Injector
2. Retaining Bolts
3. Copper Sealing Washer
4. Cork Dust Washer

6. Discard the cork washer and the copper sealing washer, Figure 3.

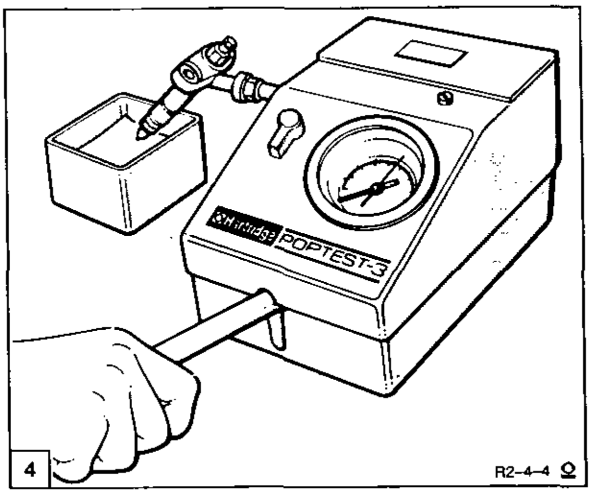
NOTE: *The copper sealing washer may have to be extracted from the bore in the cylinder head.*

7. If a replacement set of injectors is not immediately available, cover the ends of the pipes and the cylinder head apertures to prevent entry of dirt or foreign material.

8. To establish if overhaul or replacement is necessary, test the injectors according to the following procedure. Before testing fit a protective cap to the inlet union and clean the outside of the injectors with a soft wire brush and a carbon solvent.

Testing

WARNING: *The spray from an injec tor tester can pierce human skin, with fatal results. When an injector is spraying, the nozzle holder should be turned away from the operator and any other persons.*



Nozzle Opening Pressure Test

During the NOZZLE OPENING PRESSURE AND SPRAY PATTERN TESTS, collect the spray in a container partly filled with rags to absorb the spray, Figure 4.

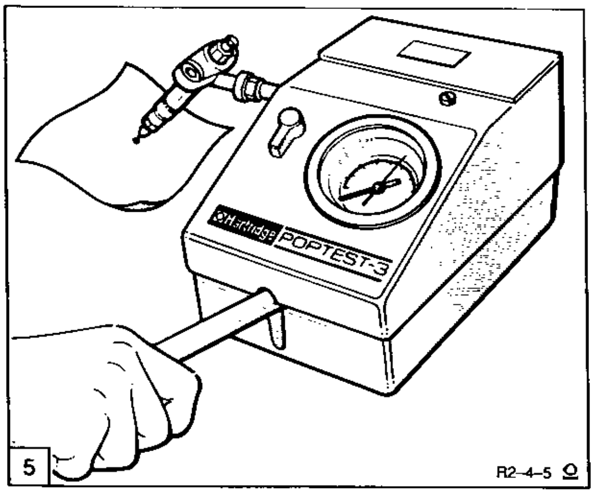
When conducting the NOZZLE SEAT LEAKAGE TEST, release the injector tester pump pressure before touching the nozzle tip with a sheet of blotting paper.

WARNING: *The spray is inflammble. Ensure no naked lights are in the area of the tester and do not generate excessive vapour.*

1. Fill the injector tester with a calibrating type fuel oil and leave the filler cap loose to prevent a vacuum forming during testing.
2. Prime the tester until oil is emitted from the tester line, then connect the injector.
3. Ensure the knob on the right hand side of the tester is screwed in to prevent the gauge being over pressurised if the injector nozzle is blocked.
4. *Pump the tester and check the nozzle is* free to open. Open the pressure gauge valve and commence injector testing. If the nozzle is blocked or the needle jammed commence the disassembly procedure.

5. NOZZLE OPENING PRESSURE: Pump the injector tester and observe the pressure at which the needle valve lifts and fuel is ejected from the nozzle tip. Opening pressure should be: 193 atm (190 bar).

6. SPRAY PATTERN: Pump the tester rapidly and observe the spray pattern from the four holes. Each spray must be similar and spaced at approximate intervals of 110°, 90°, and 70°, respectively. The spray should be well atomised and spread into a 3 in (76mm) diameter cone, 0.38 in (9.5mm) from the injector nozzle.



Nozzle Seat Leakage Test

7. NOZZLE SEAT LEAKAGE: Wipe the nozzle tip dry and apply a pressure of 150 lbf in^2 (10 bar) 10 kgf cm^2 below the opening pressure to the injector. Hold the pressure for six seconds then touch the nozzle tip with a sheet of blotting paper, Figure 5. The fuel stain should not exceed 0.5 in (12.7mm) diameter.

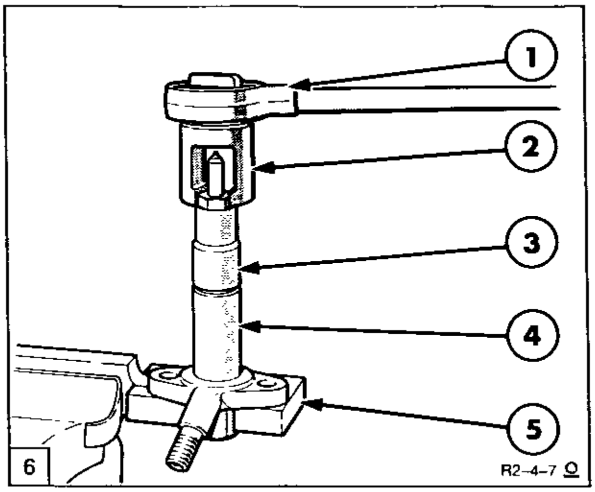
8. NOZZLE LEAK–BACK TEST: Apply approximately 2300 lbf in^2 (158bar) 62 kgf cm^2 pressure to the injector and measure the time taken for the pressure to fall from 2200 lbf in^2 (152bar) 155 kgf cm^2 to 1500 lbf in^2 (103bar) 105 kgf cm^2. If this time is less than 5 seconds, the needle is loose or there is dirt between the nozzle and injector body faces.

9. If the injector passes the tests, re–install in the engine. If the injector fails any of the tests, proceed to disassembly.

Disassembly

1. Place the injector in a holding fixture. Do not clamp the injector body in a vice.

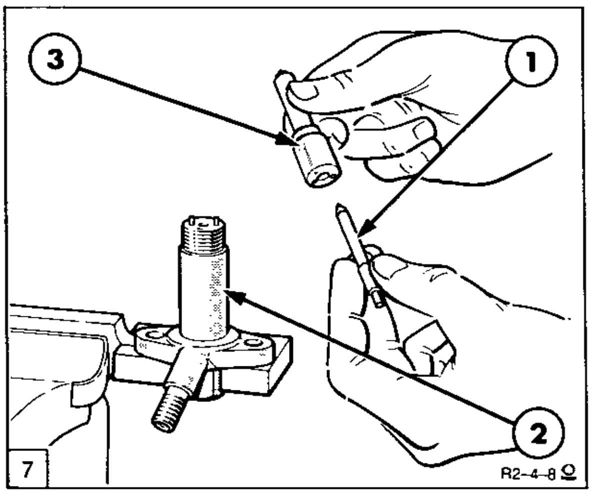
2. Remove the cap nut and spring adjusting nut, Figure 6. Remove the injector spring washer and spindle.



Nozzle Retaining Nut Removal

1. Wrench
2. Nozzle Nut Socket, Tool No CT9009 or 8126
3. Nozzle Retaining Nut
4. Injector
5. Holding Fixture

3. Use Socket, Tool No. CT9009 or 8126, to remove the nozzle retaining nut, Figure 6. Lift off the nozzle and needle valve assembly then withdraw the needle valve.

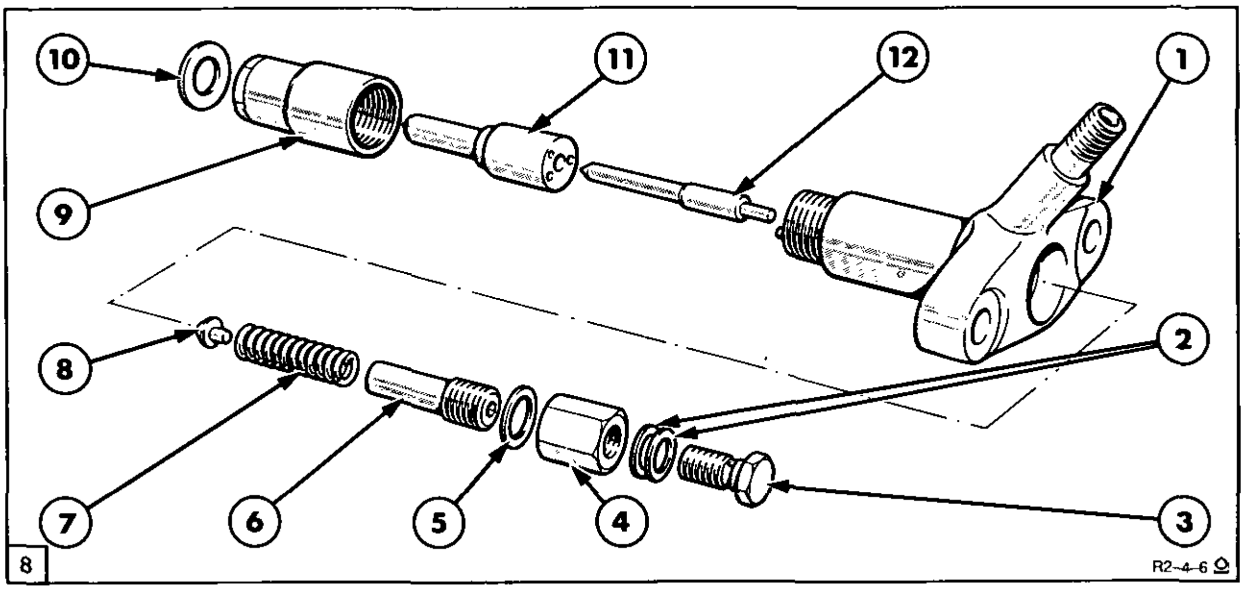


Needle Valve Removal

1. Needle Valve
2. Nozzle Holder
3. Nozzle

4. Place all components in clean fuel oil.

NOTE: *As the nozzles and needle valves are a lapped fit, they are not interchangeable.*



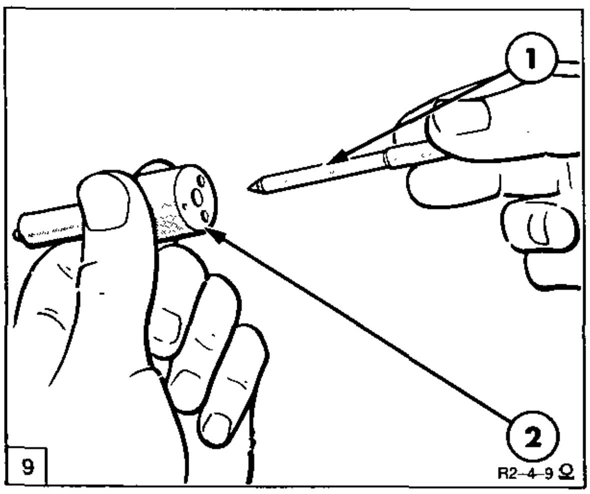
Injector Components

1. Injector Body
2. Leak–Off Line Washers
3. Leak–Off Line Bolt
4. Cap Nut
5. Copper Washer
6. Spring Adjusting Screw
7. Spring
8. Spring Seat
9. Nozzle Body
10. Copper Washer
11. Nozzle Head
12. Needle Valve

Inspection and Repair

1. Clean the needle valve and nozzle by soaking in a carbon solvent and brushing with a soft wire brush. To prevent corrosion rinse the nozzle and valve in clean fuel oil.

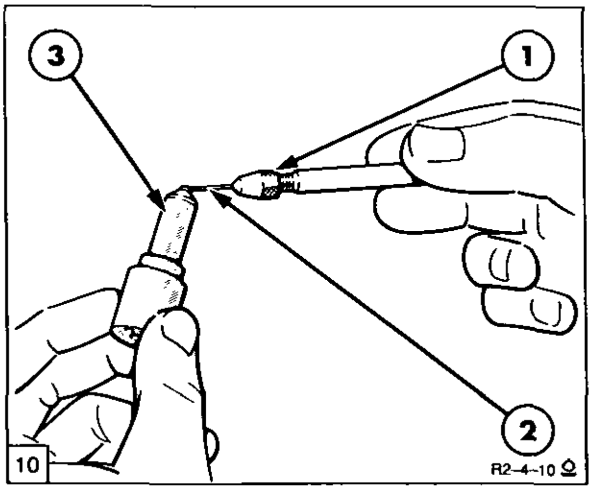
2. Use the tools included in the injector nozzle cleaning kit, Tool No. FT 9101 or 1720 to clean the nozzle as follows:–



Clean Nozzle Pressure Chamber

1. Pressure Chamber Drill
2. Nozzle

3. Clean the nozzle pressure chamber using the pressure chamber drill, Figure 9.

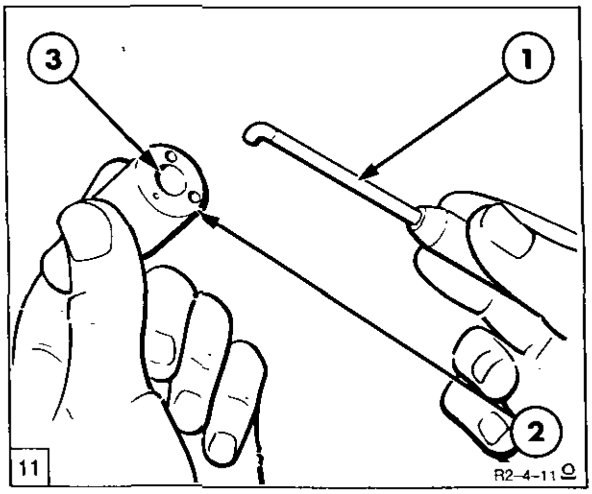


Cleaning Nozzle Spray Holes

1. Pin Vice
2. Nozzle Cleaning Wire
3. Nozzle

4. Clean the spray holes with the nozzle cleaning wire held in a pin vice, Figure 10.

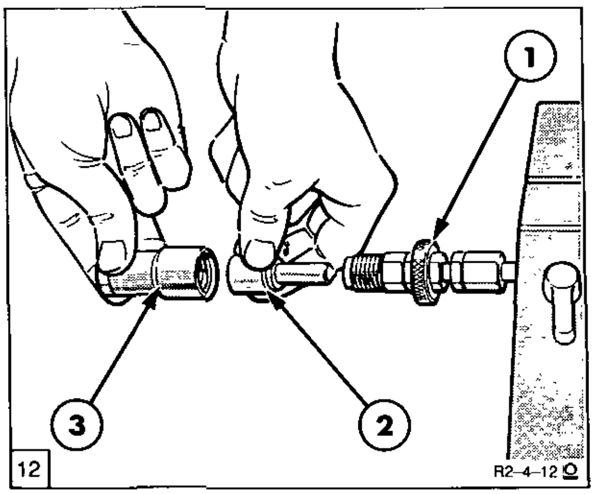
5. Clean the valve seat with the valve seat scraper.



Cleaning Nozzle Annular Groove

1. Carbon Scraper
2. Nozzle
3. Annular Groove

6. Clean the annular groove in the top of the nozzle and the groove in the nozzle pressure chamber, using the pressure chamber scraper, Figure 11.

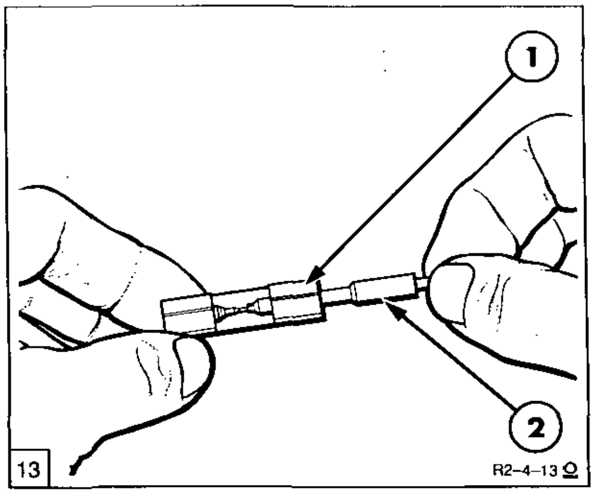


Reverse Flushing the Nozzle

1. Reverse Flush Adapter, Tool No. CT9024
2. Nozzle
3. Nozzle Retaining Nut

7. Use a reverse flush nozzle adaptor, Tool No CT9024 or 8124, on the injector tester, Figure 12. Reverse flush the nozzle to remove the carbon loosened during steps 1 to 4.

8. After flushing the nozzle, polish the valve seat by placing a very small amount of tallow on the end of a polishing stick and rotate in the nozzle.



Cleaning Needle Valve Tip

1. Needle Valve Scraper
2. Needle Valve

9. Clean the top of the needle valve using a needle valve scraper, Figure 13.

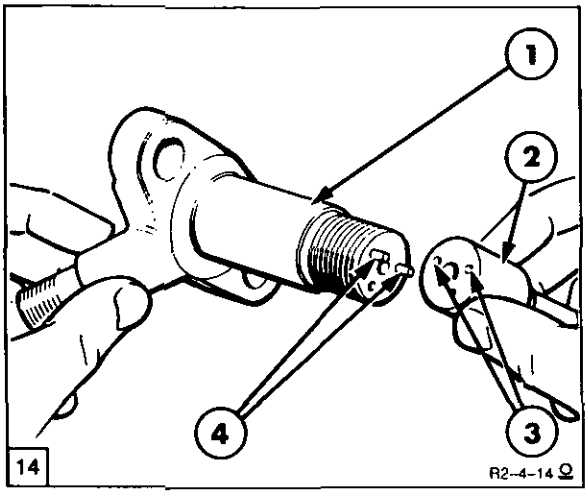
10. If the nozzle leak–back test time was less than five seconds or the valve sticks, the valve and nozzle should be lapped together by placing the tip end of the nozzle in a drill chuck having a speed of 450 revs min or less. Spread a small amount of tallow over the valve surface. Insert the valve into the rotating nozzle, centralise and apply slight pressure as the chuck turns.

NOTE: *Do not lap the valve for more than five seconds at a time. Allow the parts to cool between lapping.*

11. Prior to re–assembly, the lift of the injector needle must be rechecked with a dial indicator. Maximum allowable lift is 0.015 (0.4mm).

Re–Assembly

1. Clean all parts in fuel oil prior to re–assembly. Rinse all parts in clean fuel oil and assemble the components whilst still wet.

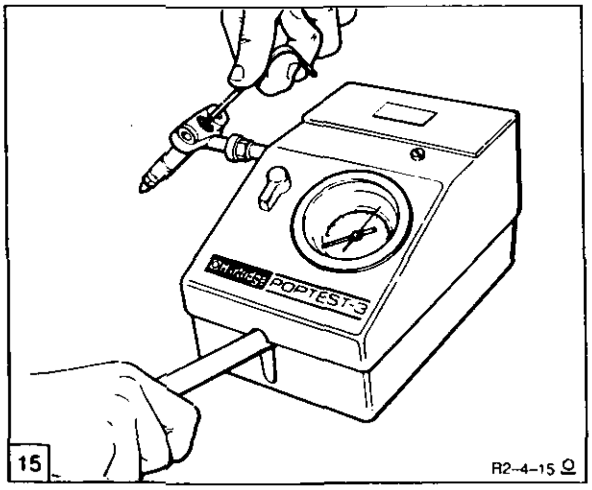


Assembling the Injector

1. Nozzle Holder
2. Nozzle
3. Dowel Pin Holes
4. Locating Holes

2. Position the nozzle and valve assembly onto the nozzle holder and ensure the dowel pin holes are correctly located, Figure 14. Hold the injector body in the fixture, install the retaining nut with a new washer and tighten to: 34 lbf ft (46Nm) 4.6 kgf m.

3. Install the spindle, spring disc, spring and adjusting nut. Turn the nut until spring pressure is felt.



Nozzle Opening Pressure Adjustment

4. To set the nozzle opening pressure, connect the injector to the injector tester. Tighten the adjusting nut, Figure 15, until the specified opening pressure is achieved.

5. Install the cap nut with a new copper washer and retest the injector. If the injector fails any of the tests after cleaning, renew the nozzle and valve.

Installation

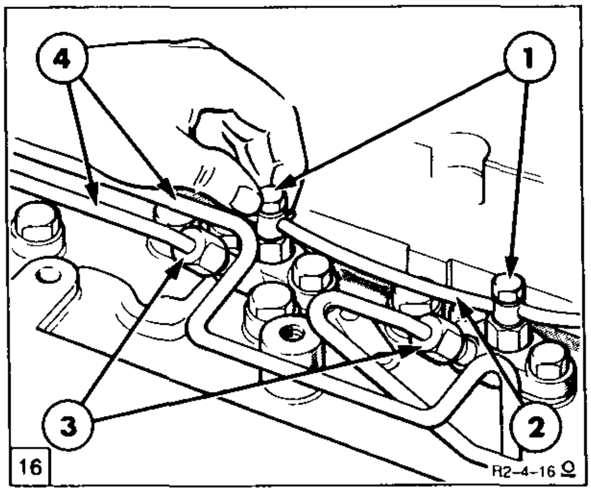
1. Remove any blanking plugs from cylinder head apertures and pipe ends.

2. Insert the new, replacement injector in the cylinder head, having fitted a new cork dust washer and a new copper sealing washer.

3. Secure each injector with the two retaining bolts and tighten to, 15–18 lbf ft (20–24Nm) 2.0–2.4 kgf m.

4. Reconnect the leak–off pipe using new washers either side of the banjo fittings and tighten banjo bolts to, 5–10 lbf ft (7–14Nm) 0.7–1.4 kgf m.

5. Reconnect high pressure fuel pipes to injectors, Figure 16. Tighten the gland nuts to: 16–20 lbf ft (22–27Nm) 2.2–2.7 kgf m.



Connecting Injector Pipes

1. Banjo Bolts
2. Leak–Off Pipe
3. High Pressure Fuel Pipe Gland Nuts
4. High Pressure Fuel Pipes

6. Tighten high pressure fuel pipe gland nuts at the injection pump to, 16–20 lbf ft (22–27Nm) 2.2–2.7kgf m.

7. Bleed the fuel system as detailed in Chapter 1.

8. If the injectors are to be stored before installation, clean in calibrating oil. Storage for longer than 6 months may result in the necessity of disassembling and cleaning the injectors before installation.

D. SPECIFICATIONS AND TOOLS

GENERAL TORQUES	lbf/ft	Nm	kgf/m
Injector Nozzle Retaining Nut	34	46	4.6
Injector Retaining Bolts	17	22	2.2
Injector Leak–Off Line Banjo Bolts	8	12	1.2
High Pressure Gland Nuts, at Injector and Fuel Injection Pump –	18	24	2.4

INJECTOR NOZZLE OPENING (POP OFF) PRESSURE

Model	5640 6640 7740	7840 8240 8340
Bar	240–248 (Reset at 225)	290–299 (Reset at 275)
lbs in2	3480–3590 (Reset at 3260)	4230–4350 (Reset at 4000)

INJECTOR CHANGE INTERVAL	1200 Hours

DESCRIPTION	V L CHURCHILL	NUDAY TOOLS	FNH
Injector Nozzle Nut Socket	CT9009	8126	01588
Nozzle Reverse Flush Adaptor	CT9024	8124	01727/8
Injector Cleaning Kit	DX730/FT9101	1720	01720
Kit consists of– Nozzle Cleaning Wires, Pressure Chamber Drills, Pressure Chamber Scraper Valve Seat Scraper, Brass Wire Brush, Pin Vice			
Tallow		Obtain Locally	
Polishing Sticks		Obtain Locally	

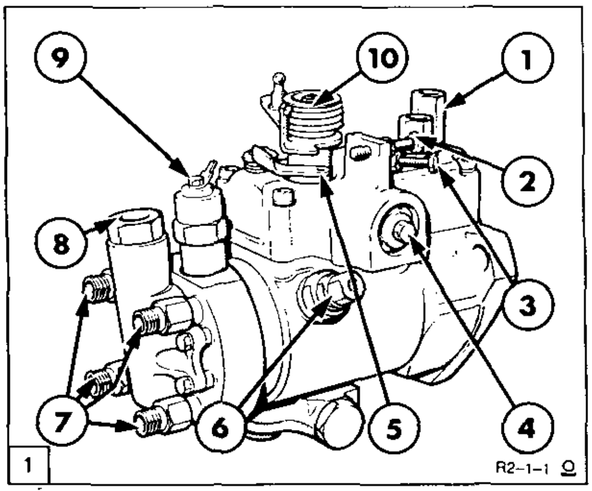
PART 2
FUEL SYSTEMS
Chapter 5
FUEL INJECTION PUMP – DPS DISTRIBUTOR TYPE

A. DESCRIPTION AND OPERATION

The DPS distributor type fuel injection pump, Figure 1, is installed on all of the 4 and 6 cylinder range of engines.

The fuel injection pump is flange mounted to the right hand side, at the front of the engine. It is driven by a gear timed to the camshaft drive gear, as described in Part 1, "ENGINE SYSTEMS". Having a double lip type seal it is oil tight, preventing engine oil entering the pump body and fuel oil entering the engine lubrication system.

During operation all moving parts are lubricated by fuel oil under pressure, preventing ingress of dust, water and other foreign matter.



Fuel Injection Pump

1. Leak Off Connector
2. Maximum No Load Speed Adjuster
3. Idle Speed Adjuster
4. Excess Fuel Device
5. Stop Control
6. Latch Valve
7. Outlets to Injectors
8. Fuel Inlet Connector
9. Fuel Shut–Off Solenoid
10. Throttle Lever

The fuel pump, Figure 1, consists of a pumping and distributing rotor, driven directly from the pump drive shaft. This rotor revolves within the hydraulic head and has a vane type fuel transfer pump connected to it.

A regulating valve controls transfer pressure to the metering valve, this is operated by the throttle lever and regulates the flow of fuel to the filling ports of the rotor. The distributor rotor carries two pairs of opposed high pressure pumping plungers of which, under the action of filling pressure push the rollers into contact with the internal lobes of the cam ring.

Maximum fuelling is pre–set by a sealed external adjuster, which controls a pair of scroll plates located concentrically with and either side of the cam ring. These act as check plates limiting the outward movement of the rollers, in contact with the pumping plungers and can be partially rotated to adjust maximum fuelling.

The scroll plate mechanism also gives automatic excess fuel, for rapid engine starting under all ambient temperatures. At cranking speed, with the throttle lever in the maximum open position, the scroll plates are rotated to a point which allows the pumping plungers to move further apart. This allows fuel to be admitted in excess of the normal permitted maximum.

Once the engine self sustains, excess fuel is terminated, as fuel pressure supplied via the latch valve acts on the piston in the excess fuel device, moving the scroll plates into the maximum fuel position. At this point action of the governor on the metering valve reduces the fuel level to the maximum no load requirements.

In addition to excess fuel during cranking, the advance and start retard unit automatically adjusts the cam ring to retard injection timing. When the engine self sustains the cam ring is partially rotated in the opposite direction to pump rotation and advances the timing as the pump speed increases.

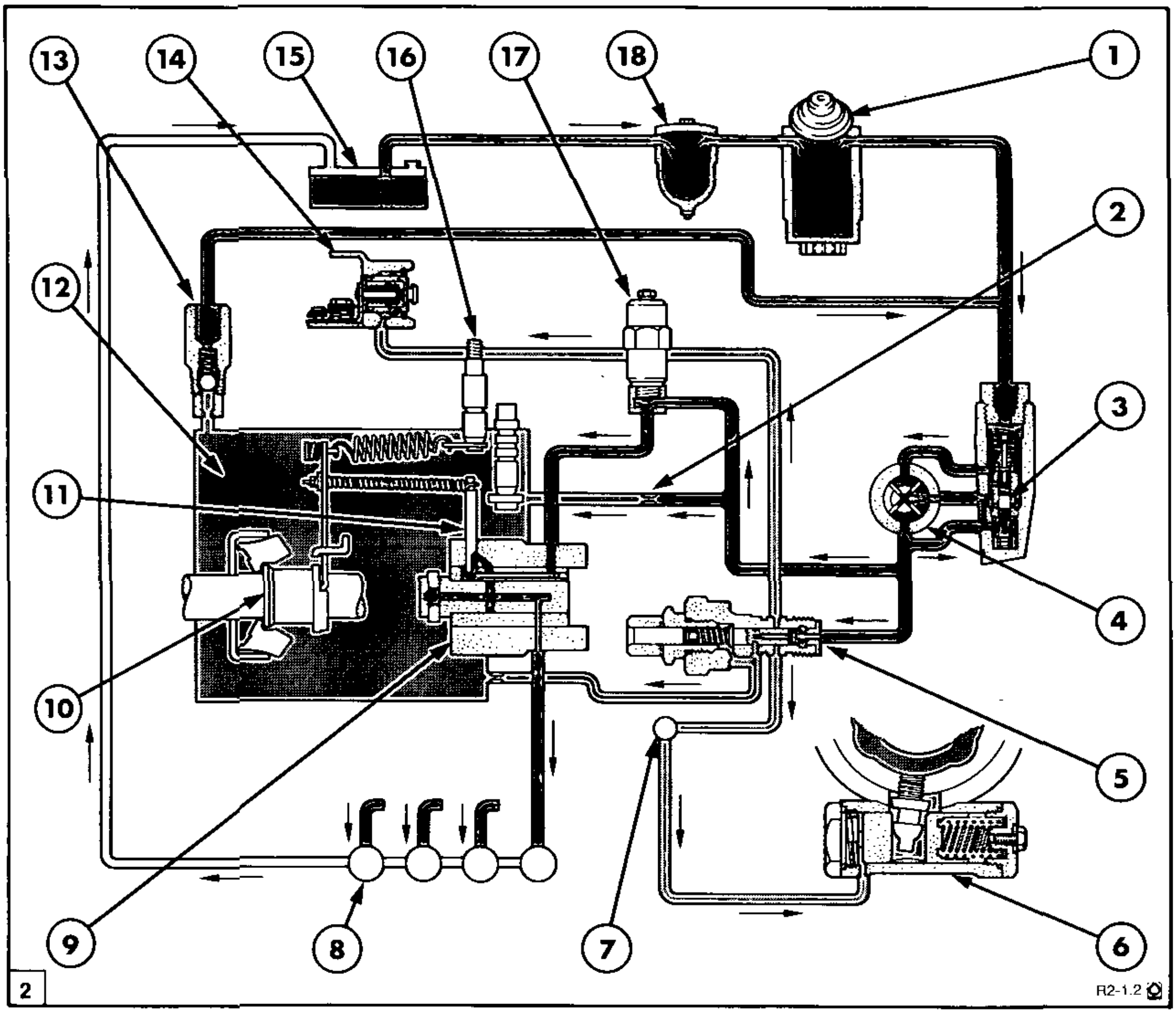
At engine cranking speed the latch valve located in the pump housing ensures that transfer pressure does not reach either the auto advance unit or excess fuel device until the engine has self sustained. When engine is self sustained, transfer pressure opens the latch valve diverting the fuel under pressure to the advance and excess fuel devices.

A variable speed mechanical governor controls the metering valve allowing a constant engine speed to be maintained regardless of engine loading. The governor is fitted with a "cush drive" weight retainer with 4 weights.

An electrically operated fuel shut–off solenoid (where fitted) is screwed into the top of the hydraulic head and controls the fuel supply to the input side of the metering valve. This function provides the operator with an "ignition key" engine start and stop.

FUEL PUMP OPERATION

With reference to Figure 2 and Figure 3, fuel is drawn by the transfer pump from the fuel tank through the sedimentor, hand primer and on through the fuel filter assembly. Fuel at feed pressure (A) passes into the transfer pump which raises the pressure with increasing engine speed, to an intermediate value termed transfer pressure controlled by the regulating valve.



Fuel System Schematic – Engine Cranking

A	Feed Pressure	B	Transfer Pressure	C	Injection Pressure
D	Cam Box Pressure	E	Back Leakage of Fuel		Metering Pressure
G	Differential Pressure				

1. Hand Primer and Filter
2. Vent Orifice
3. Regulating Valve
4. Transfer Pump
5. Latch Valve
6. Automatic Advance and Start Retard Unit
7. Head Locating Fitting
8. Injector
9. Hydraulic Head and Rotor
10. Variable Speed and Governor
11. Metering Valve
12. Cam Box
13. Pressurising Valve
14. Excess Fuel Device
15. Fuel Tank
16. Throttle Shaft
17. Fuel Shut–Off Solenoid
18. Sedimentor

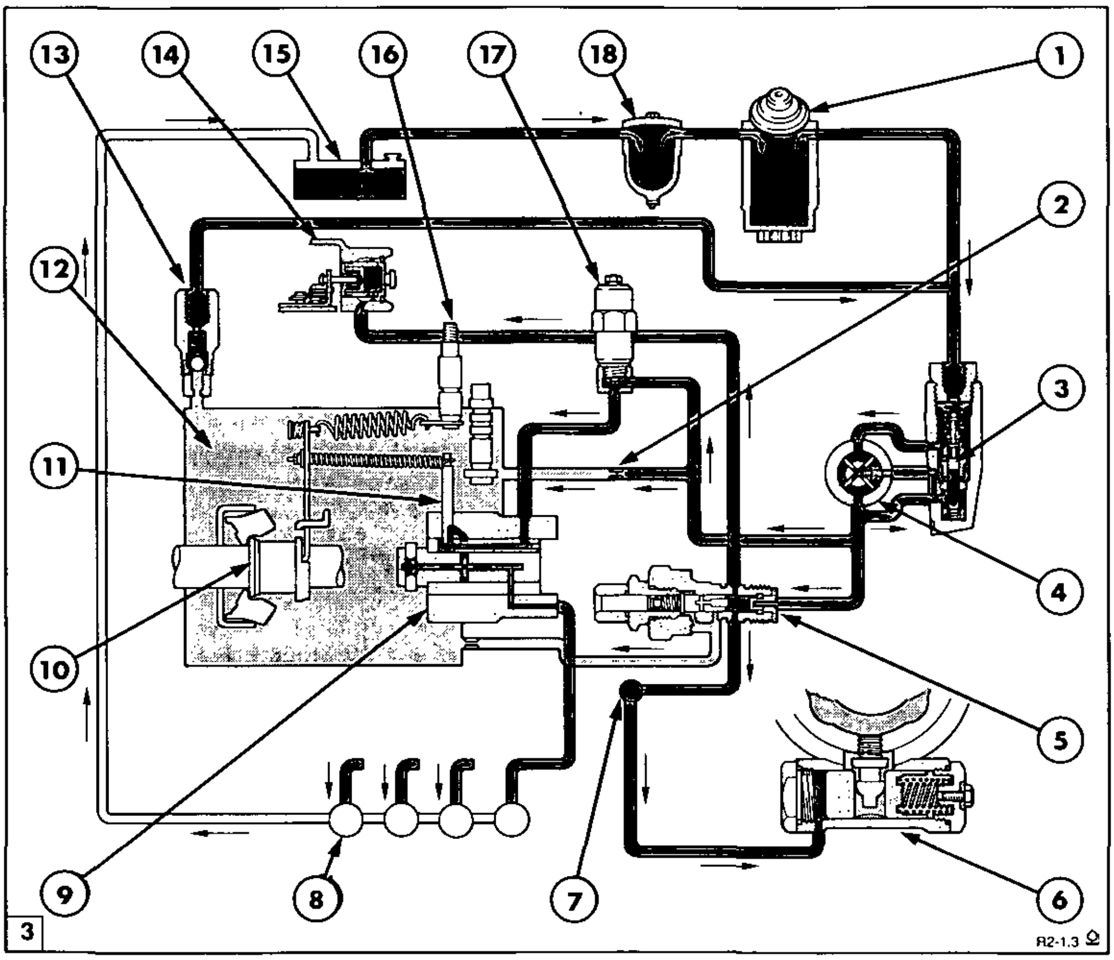
In operation the regulating valve maintains a pre–determined relationship between transfer pressure and the speed of rotation, by returning part of the fuel to the inlet side of the transfer pump.

The transfer pump supplies fuel to the pumping plungers, and via a separate passage actuates the latch valve.

To fill the pumping plungers, fuel at transfer pressure (B) flows around annular grooves in the hydraulic head and passes into a drilling in the top of the hydraulic head sleeve. Fuel then flows to the metering valve, which regulates fuel flow through the throttle linkage to the throttle lever or movement of the governor weights.

As fuel passes through the metering valve orifice in the hydraulic head, a pressure drop occurs reducing transfer pressure (B) to a level known as metering pressure (F). Fuel from the metering valve then passes into two oblique filing ports, via a circular groove in the sleeve to the rotor charging ports. The fuel then continues through a central drilling in the rotor to two pairs of opposed pumping plungers, these are actuated by an internally lobed cam ring.

The lobes of the cam ring are phased with the drillings in the hydraulic head and rotor, which allows alternate filling and injection. The rotor ports first charge the pumping plungers at metered pressure (F), then fuel is pumped from the distributor port at injection pressure (C) to each other of the injectors in turn.



Fuel System Schematic – Engine Running

A Feed Pressure	B Transfer Pressure	C Injection Pressure
D Cam Box Pressure	E Back Leakage of Fuel	Metering Pressure

1. Hand Primer and Filter
2. Vent Orifice
3. Regulating Valve
4. Transfer Pump
5. Latch Valve
6. Automatic Advance and Start Retard Unit
7. Head Locating Fitting
8. Injector
9. Hydraulic Head and Rotor
10. Variable Speed and Governor
11. Metering Valve
12. Cam Box
13. Pressurising Valve
14. Excess Fuel Device
15. Fuel Tank
16. Throttle Shaft
17. Fuel Shut–Off Solenoid
18. Sedimentor

A controlled leakage of fuel for lubricating purposes passes between the rotor, hydraulic head, plungers and bore etc and then to the cam box.

Cam box pressure (D), is maintained by a pressurising valve which unloads excess pressure in the cam box and returns the back leakage fuel (E), to the supply tank. Back leakage from the injectors is returned to the supply tank via a return tube.

To actuate the latch valve, fuel at transfer pressure (B), regulated by pump speed flows into a drilling in the bottom of the hydraulic head sleeve. This is via an annular groove in the sleeve to the latch valve.

At cranking speeds, the latch valve is closed and prevents fuel at transfer pressure (B) flowing to either the head locating fitting to the advance unit, which remains in the retarded position or to the excess fuel device. The passages to both the advance unit and excess fuel device remain at cam box pressure (D).

At a pre–determined pressure (above cranking speed), the latch valve opens to allow fuel at transfer pressure (B) to flow via an annular groove in the hydraulic head sleeve to the head locating fitting and also to the excess fuel device. Fuel flows from the head locating fitting to the pressure side of the piston in the automatic advance and start retard unit.

With an increase in pump speed, transfer pressure (B) acting on the advance piston causes the cam ring to advance the injection timing. Leakage from the advance unit flows back to the cam box.

Two orifices, one situated in the passage between the latch valve and the cam box and the other in the latch valve, are utilised to generate a differential pressure (G). This pressure is only generated at cranking speed when both orifices are open.

When the engine self sustains, transfer pressure exceeds the combined effect of differential pressure and spring forces. The latch valve opens, the valve orifice closes, and differential pressure is reduced to cam box pressure.

Thus the valve will close at a lower pump speed, that is when transfer pressure drops below the combined effect of the latch valve spring force and cam box pressure. This is necessary to prevent the pump retarding during rapid engine deceleration.

METERING OF FUEL

With reference to Figure 4, it can be seen fuel at feed pressure entering the pump through the main inlet connection is pressurised by the sliding vane transfer pump, carried on the rotor inside the hydraulic head. The fuel now at transfer pressure, passes through passages in the hydraulic head and then to the metering valve bore.

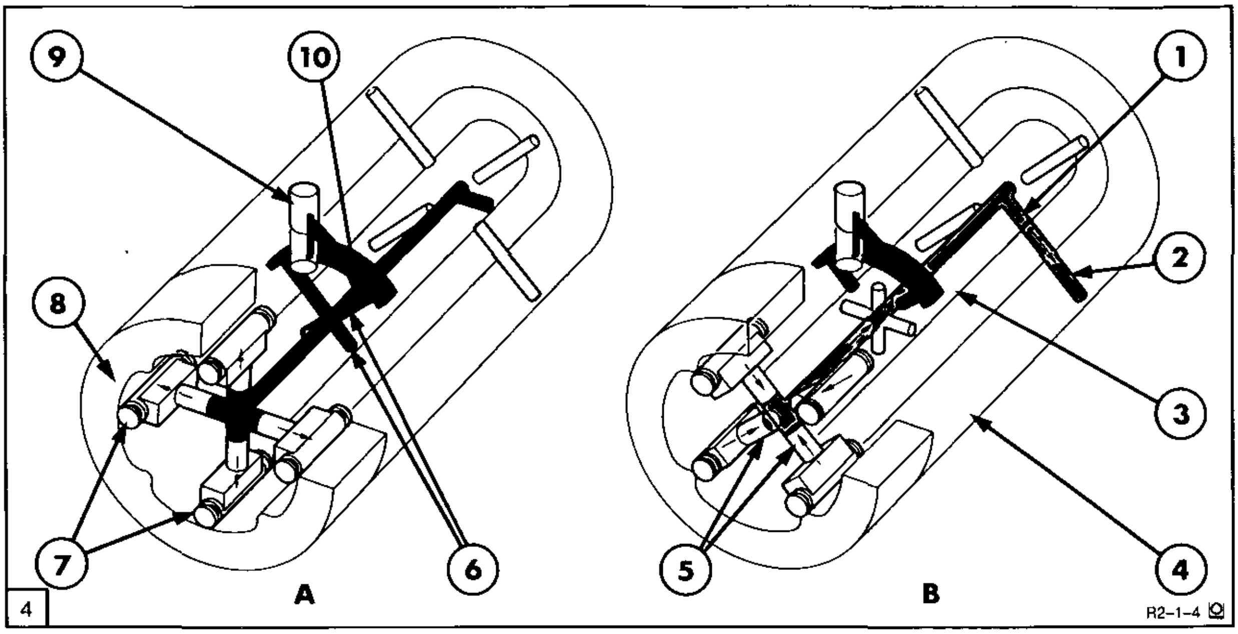
The metering valve operated by the throttle control lever and governor, regulates the flow of fuel through the two oblique filling ports in the hydraulic head and into the pumping section of the rotor.

The volume of fuel passing into the pumping elements is thus controlled by three factors:–

1. By the position of the metering valve, which is sensitive to throttle lever movement at a given engine speed.

2. The pump transfer pressure.

3. The time during which the rotor filling ports are aligned with the hydraulic head filling ports.



Fuel Charging and Injection Cycles–Schematic

A. Charging Cycle
Metering Pressure

B. Injection Cycle
Injection Pressure

1. Single Fuel Delivery Port
2. Outer Port Hydraulic Head
3. Rotor
4. Hydraulic Head
5. Pumping Plungers
6. Charging Ports Rotor
7. Rollers
8. Cam Ring
9. Metering Valve Bore
10. Filling Ports Hydraulic Head

PUMPING AND DISTRIBUTION OF FUEL

With reference to Figure 4, as the rotor turns the two filling ports in the hydraulic head align with the two charging ports in the rotor. Fuel now at metering pressure, flows into the central passage in the rotor and forces the pumping plungers apart. The amount of plunger displacement is determined, by the amount of fuel which can flow into the rotor while the ports are aligned.

With continued rotation, the fuel entering the the two filling ports in the hydraulic head is cut off from the charging ports. The single fuel delivery port in the rotor then registers with an outlet port in the hydraulic head. During this time the pumping plungers are forced inwards by the rollers, in contact with the internal lobes of the cam ring. Fuel at injection pressure then passes through the central passage of the rotor and through the ports to one of the injectors.

With further rotation the charging and injection cycles are repeated in sequence with the rotor alternately charging through a pair of filling ports and discharging into each successive outlet port. The number of outlet ports in the hydraulic head is equal to the number of cylinders on the engine.

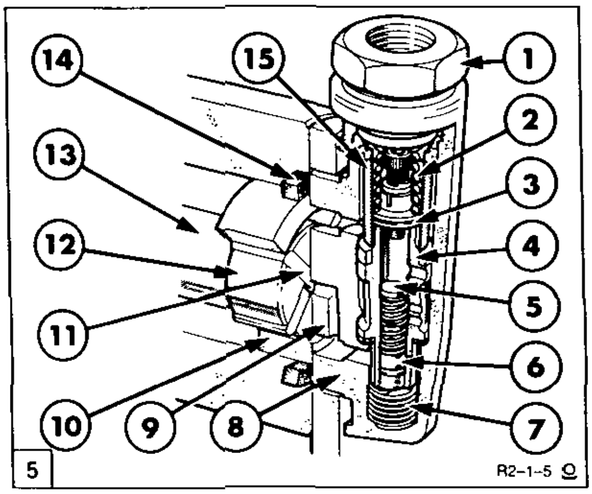
TRANSFER PUMP AND REGULATING VALVE

With reference to Figure 5, Figure 6 and Figure 7, the regulating valve performs two separate functions:–

1. It controls fuel pressure, by maintaining a definite relationship between transfer pressure and speed of rotation.

2. It provides a means of by–passing the transfer pump when the engine is stationary, so fuel passages in the hydraulic head can be primed with the external hand priming pump.

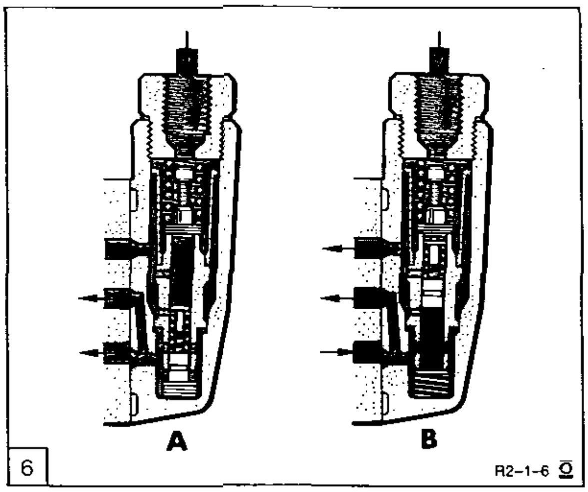
Fuel entering the main inlet connection at feed pressure is raised to transfer pressure, by the transfer pump consisting of rotor, sliding blades and eccentric liner.



Cut–Away of Regulating Valve
and Transfer Pump Assembly

1. Fuel Inlet Connection
2. Regulating Spring
3. Transfer Pressure Adjuster
4. Regulating Sleeve
5. Peg and Spring
6. Regulating Piston
7. Priming Spring
8. End Plate
9. Drilling to Pump Blades
10. Eccentric Liner
11. Blades
12. Rotor Transfer Pump
13. Distributor Rotor
14. Rubber Sealing Ring
15. Filter

The rotor is screwed on to the end of the distributor rotor, the direction of the screw thread being opposite to the direction of the rotation of the injection pump, so that the rotor tends to tighten when running.



Operation of Transfer Pump

Feed Pressure Transfer Pressure

A Priming B Regulating

Four rigid blades at 90° to one another are held in contact with and follow the internal profile of, the eccentric liner, by pressure from two springs. As transfer pressure increases fuel is supplied via the end plate, to force the blades against the internal profile of the liner. Hence the blades stay in contact with the liner at all engine speeds.

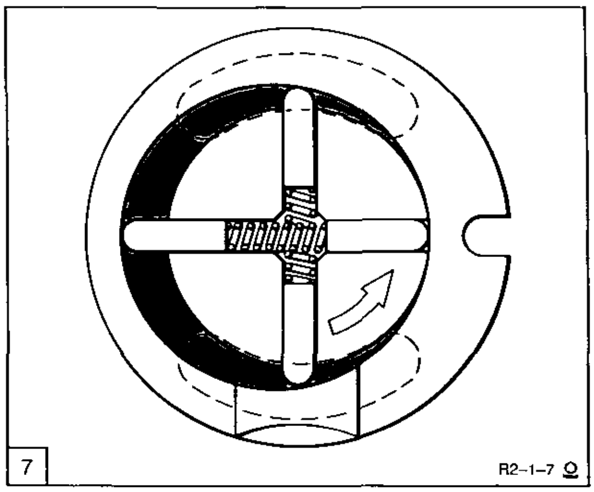
Fuel entering the end plate at feed pressure passes to the inlet side of the transfer pump through the nylon filter and upper fuel passage of the end plate.

This fuel in the upper chambers, formed by the transfer pump blades, liner and rotor, is displaced downwards. It is ejected at a rate in excess of the injection and back leakage requirements of the pump, hence the pressure increases.

This transfer pressure is transmitted to the underside of the regulating piston, through the lower fuel passage to force the piston upwards. The force is opposed by the pressure exerted on the upper face of the piston by the regulating spring.

As transfer pressure rises with increasing engine speed the piston is forced upwards and the regulating spring is compressed.

Such movement of the piston progressively uncovers the regulating port thus transfer pressure is controlled by permitting a metered flow of fuel back to the inlet side of the of the transfer pump. The effective area of the regulating port is thus increased as engine speed is raised.



Operation of Regulating Valve

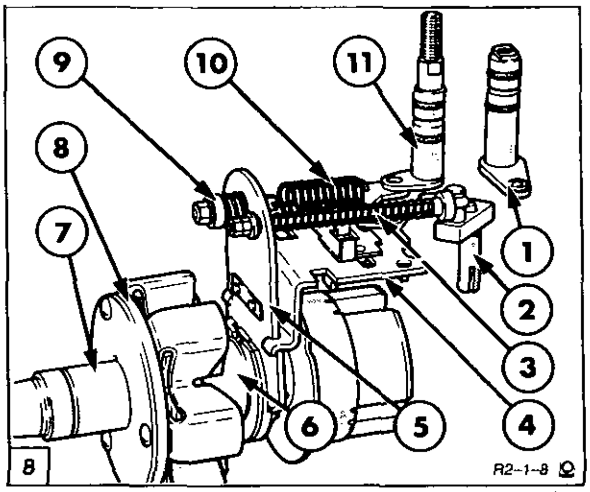
Feed Pressure Transfer Pressure

The maximum lift of the regulating piston is adjusted by a screw in order to control the rate at which transfer pressure rises. This screw which is referred to as the transfer pressure adjuster, is set during test to suit the application concerned.

When priming the pump from the external hand primer, fuel entering the end plate cannot pass through the transfer pump and into the fuel passages in the hydraulic head in the normal way.

Fuel at priming pressure enters the regulating sleeve and acts on the upper face of the regulating piston. The piston is forced to the lower end of the sleeve, compressing the priming spring and uncovering the priming ports. Fuel then passes through the priming ports and the lower fuel passage to the outlet side of the transfer pump and into the fuel passages within the hydraulic head.

VARIABLE SPEED GOVERNOR



Variable Speed Mechanical Governor

1. Fuel Shut Off Shaft
2. Metering Valve
3. Governor Link Arm and Spring
4. Control Bracket
5. Governor Arm
6. Thrust Sleeve
7. Drive Shaft
8. Governor Flyweight Assembly
9. Idling Spring and Peg
10. Main Governor Spring
11. Throttle Spring

The variable speed governor Figure 8, is a mechanical fly–weight type giving accurate control of the engine at maximum and intermediate speeds. The governor fly–weight assembly is mounted on the drive shaft and is entirely contained within the pump body.

Movement of the governor flyweights which pivot outwards when under centrifugal force, set up drive shaft rotation and actuates a thrust sleeve. The sleeve sliding along the drive shaft, causes the governor arm to pivot about a fulcrum on the control bracket. This movement is transmitted by the governor link to the metering valve, which rotates to change the quantity of fuel entering the filling ports. Rotating the metering valve changes the flow area between the groove in the valve and the metering port. The amount of fuel that enters the filling ports is, therefore, changed by varying the effective area of the metering valve.

The governor link arm and spring are located in the upper part of the pump enclosed by the control cover, which houses the throttle shaft and manual fuel shut–off.

The mechanical governor takes control of fuel delivery at maximum and intermediate speeds, when the centrifugal force generated by the flywheel balances the force applied to the governor control arm by the tension of the main control spring. Fuel output is varied by governor action as the control arm operates the metering valve through the governor link.

During idle running with the speed control lever in the minimum speed position, all tension is removed from the main control spring and the governor force is balanced by the idling spring carried on the spring peg. This provides more sensitive response at low RPM when the governor force is minimal thus ensuring an even engine speed.

The spring tension is dependent on the position of the speed control lever, thereby giving variable speed control. This enables the driver to select governed speed according to operating requirements.

SCROLL PLATES

With reference to Figure 9, the scroll plates which are located either side of the cam ring perform two functions:–

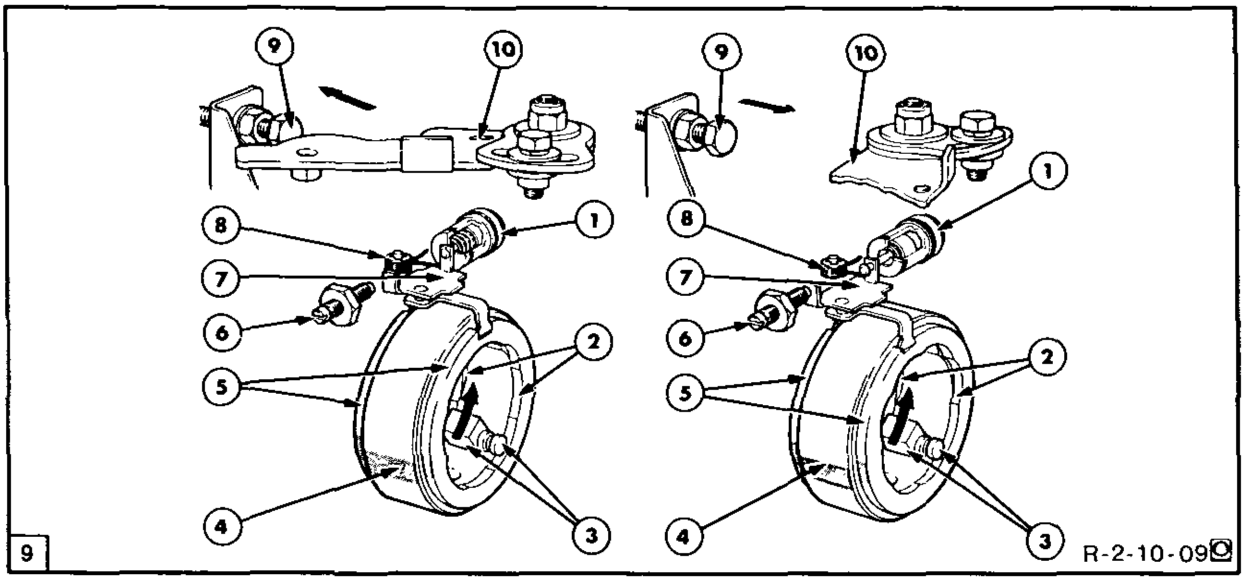
1. To provide automatic excess fuelling for rapid engine starting at cranking speed, under all ambient conditions.

2. To adjust maximum fuelling to a pre determined setting, by limiting the outward movement of the pumping plungers.

The scroll plates are each provided with a slot in the outer rim to control their movement through a transversely mounted link plate, which slides in a slot in the governor control bracket.

Movement of the link plate is controlled in one direction by the excess fuel device and in the opposite direction by the maximum fuel adjuster screw.

When automatic excess fuelling is required, the throttle lever is closed against the low idle stop, the inner tongue of the link plate being held by the excess fuel device. In this position the scroll plates are rotated against pump rotation and the scroll profiles on the internal rims of the plates. This allows the pumping plungers to move further apart admitting fuel in excess of the normal maximum.



Scroll Plate Operation

A Scroll Plate in Excess Fuel Position Throttle Closed

B Scroll Plate in Maximum Fuel Position Throttle Open

1. Excess Fuel Device
2. Scroll Plate Profiles
3. Rollers and Shoes
4. Cam Ring
5. Scroll Plates
6. Maximum Fuel Adjuster
7. Link Plate
8. Link Plate Spring
9. Low Idle Stop Screw
10. Throttle Control Spring

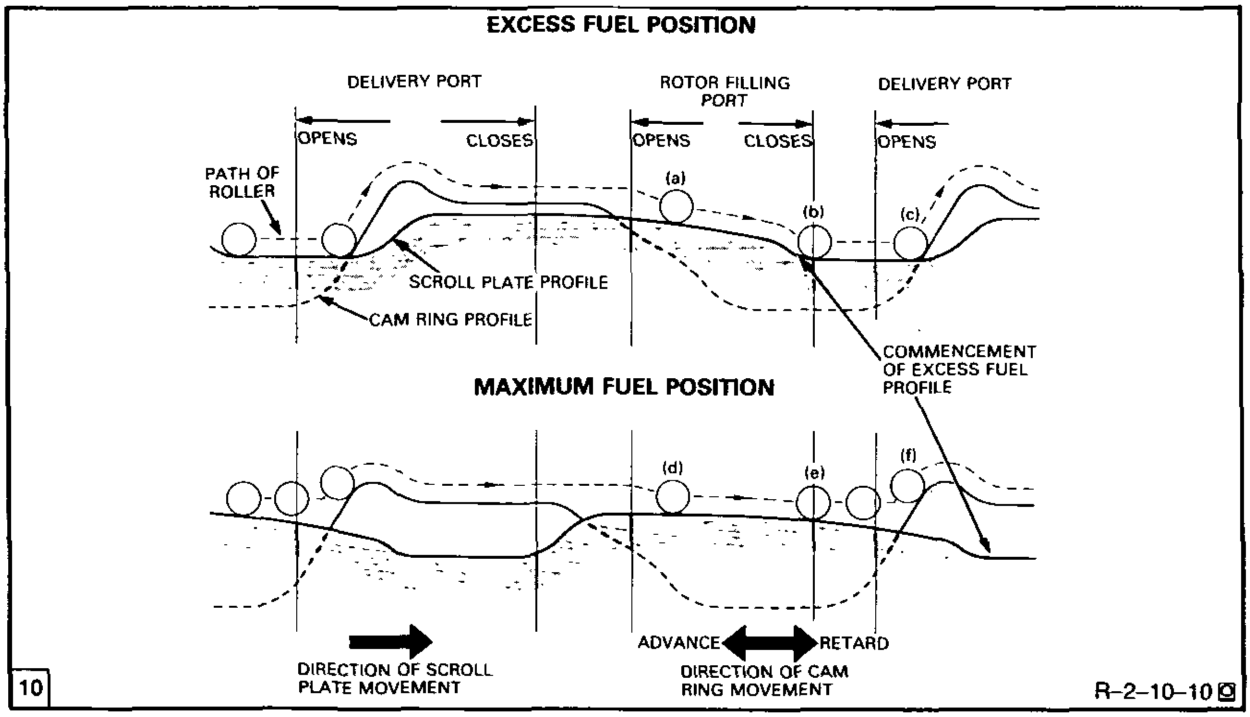
As soon as the engine self sustains, excess fuel is terminated. Fuel at transfer pressure supplied via the latch valve, acts on the piston in the excess fuel device and causes the link plate spring to move the scroll plates transversely, in the direction of pump rotation to the maximum fuelling position against the pre-set adjuster screw.

In this position, the profiles on the internal rims of the scroll plates check the outward movement of the rollers and shoes, in contact with the pumping plungers to the normal maximum fuel level.

SCROLL PLATE PRINCIPLE

A – Excess Fuel Position

At cranking speeds with the throttle lever against the low idle screw, the scroll plates are automatically positioned so that the excess fuel profile corresponds with the rotor filling stage, the cam ring being in the fully retarded position.



Scroll Plate and Cam Ring Phasing

As the rotor filling port opens, metering pressure forces the cam rollers outwards to meet the profile of the scroll plates at point (a), Figure 10. The cam rollers continue to open outwards against the scroll profiles until the filling port closes at point (b) on the excess profile. The rollers contact the cam ring at point (c) and deliver fuel in excess of the normal maximum, Figure 10.

B – Maximum Fuel Position

When the throttle is fully open the scroll plates are rotated to the maximum fuel position and the cam ring is rotated to a position determined by transfer pressure. As the rotor filling port opens metering pressure forces the cam rollers outwards to meet the profile of the scroll plates at point (d), Figure 10.

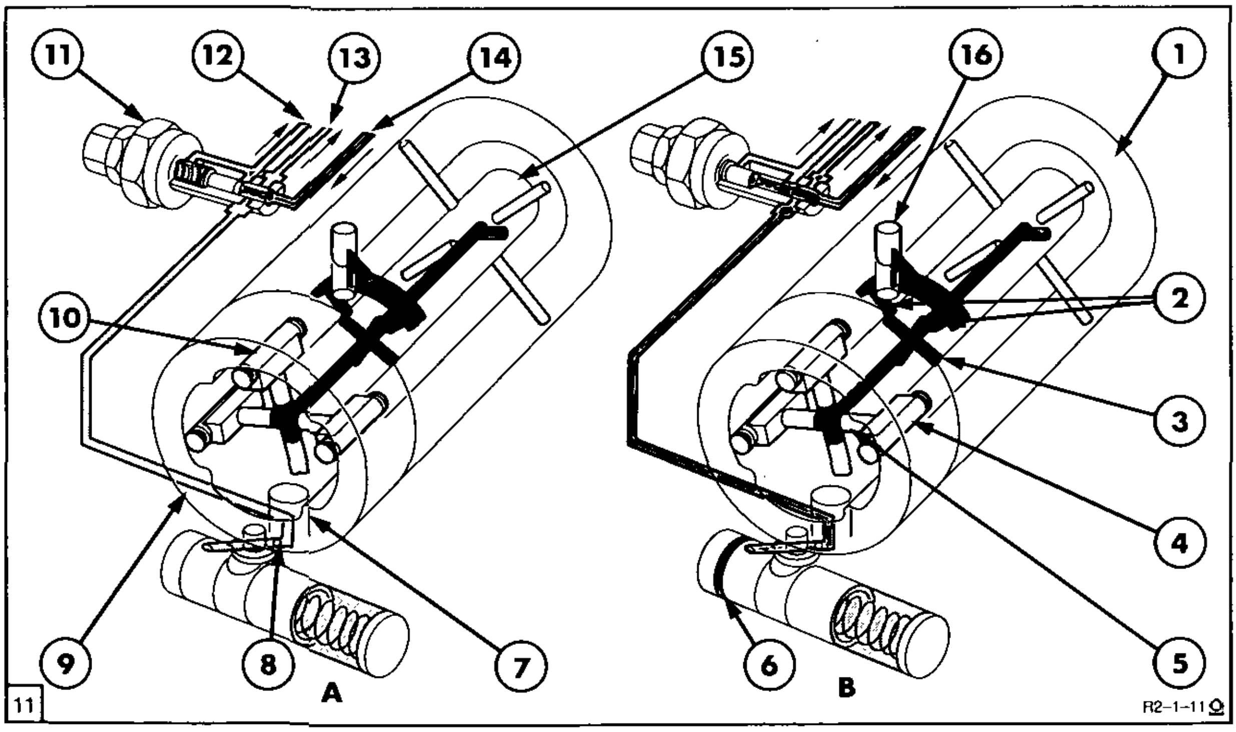
The cam rollers continue to move outwards, remaining in contact with the retracting scroll profiles until the filling port closes at (e). This is the maximum fuel position set by the adjuster screw as shown in Figure 9.

With metering pressure to the pumping plungers now terminated by filling port closure, the rollers are free to leave the scroll plate profiles and "float" until contact is made with the cam lobe at point (f), Figure 10. This is the point at which fuel injection commences via the now open delivery port.

LATCH VALVE

The latch valve Figure 11, viewed from the drive end, is screwed into the left hand side of the pump housing and comprises a spring loaded valve with a central drilling fitted in a threaded body which also retains the hydraulic head in the pump housing.

At cranking speeds (A), the latch valve is closed and serves to delay advance by preventing transfer pressure reaching the advance unit and also the excess fuel device, both of which remain at cam box pressure.



Latch Valve Operation Schematic

A. Engine Cranking

Transfer Pressure

Metering Pressure

B. Engine Self Sustained

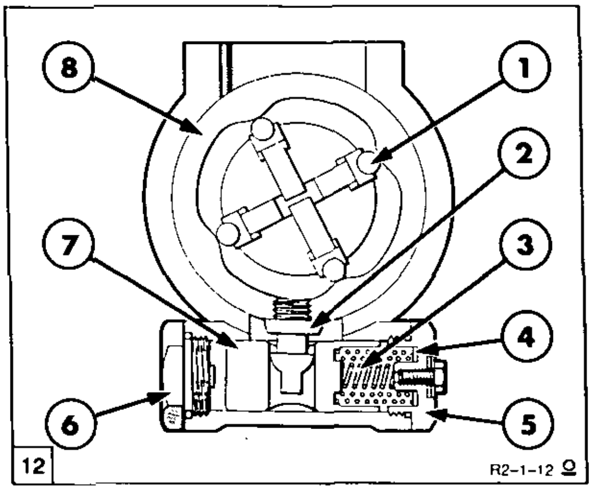
D Cam Box Pressure

G Differential Pressure

1. Hydraulic Head
2. Filling Ports Hydraulic Head
3. Rotor Inlet Ports
4. Roller and Shoe
5. Plunger
6. Pressure Chamber–Auto Advance
7. Head Locating Fitting
8. Ball Valve
9. Cam Ring
10. Roller and Shoe
11. Latch Valve
12. Return to Cam Box
13. Feed to Excess Fuel Device
14. Inlet From Transfer Pump
15. Distributor Rotor
16. Metering Valve

When the engine self sustains (B), increased transfer pressure on the under side of the latch valve opens the valve against its spring. This allows fuel at transfer pressure to flow through a drilling in the valve to the pressure chamber in the advance unit and the excess fuel device.

AUTOMATIC ADVANCE AND START RETARD UNIT



Automatic Advance and Start Retard Unit

1. Roller
2. Cam Screw
3. Spring
4. Shim
5. Spring Cap
6. Piston Plug
7. Advance Piston
8. Cam Ring

With reference to Figure 12, this device progressively advances the commencement of injection as the engine speed increases. The unit incorporates an automatic start retard system that operates at cranking speeds.

Automatic advance is controlled by a piston which slides in the advance housing mounted on the underside of the pump housing. The movement of the piston is transferred via the cam advance screw to the cam ring, which rotates freely in the pump housing. The advance spring is located between the piston and the spring cap and serves to limit the travel of the piston. This balances the effect of fuel at advance pressure entering the chamber. Fuel at advance pressure enters the chamber through a passage from the head locating fitting, which secures the advance device to the body.

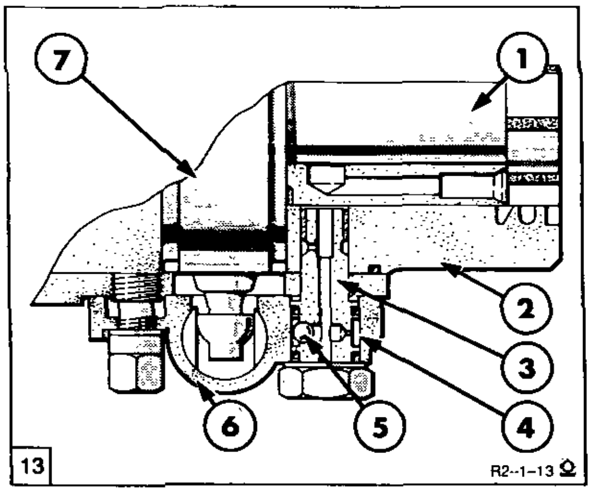
Start retard is controlled by the 1st stage low rated spring which is located between the hollow end of the piston and the spring cap. When the engine is stopped and the latch valve (11) Figure 11, is closed there is no pressure acting on the piston. Under the pre–compression of the advance spring and 1st stage (retard) spring the piston rests against the plug, the system is, therefore, in the fully retarded position.

On starting when transfer pressure from the pump opens the latch valve, pressure in the chamber bearing against the piston compresses the 1st stage (retard) spring and the system reverts to the normal speed advance mode of operation.

As engine speed increases the transfer pressure acting on the piston moves the piston along the bore and compresses the advance spring. This causes the piston and cam ring to move in the opposite direction to pump rotation and progressively advances the point of injection.

When engine speed is reduced the transfer pressure drops and the normal leakage of fuel past the piston permits the device to return, towards the retard position under the action of the spring.

HEAD LOCATING FITTING



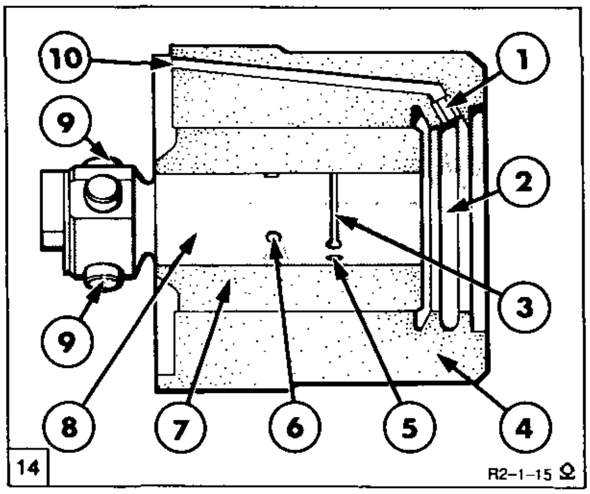
Head Locating Fitting

1. Distributor Rotor
2. Hydraulic Head
3. Head Locating Fitting
4. By–Pass Hole
5. Ball Valve
6. Automatic Advance and Start Retard Unit
7. Cam Ring

The head locating fitting is screwed into the underside of the pump housing and also correctly positions the hydraulic head relative to the pump housing. The head locating fitting connects the fuel passages in the hydraulic head with the advance unit.

The assembly contains a non–return ball valve which serves to balance and reduce the impact effect of the rollers on the cam ring, which during the injection phase would otherwise tend to turn the cam ring in a retard direction.

HYDRAULIC HEAD AND ROTOR



Hydraulic Head with Rotor in Situ

1. Vent Orifice
2. Transfer Pump Recess
3. Equalization Groove
4. Barrel Hydraulic Head
5. Distributor Outlet Port
6. Rotor Filling Port
7. Sleeve
8. Distributor Rotor
9. Plunger
10. Drilling to Cam Box

The hydraulic head and rotor, Figure 14, is a mated assembly which minimizes leakage whilst allowing sufficient bearing clearance and comprises of a barrel and a sleeve. The hydraulic head outlet ports are equally spaced and positioned radially on the outside diameter and register in turn with the rotor distributor outlet port through passages in the sleeve. The sleeve also contains two inlet ports which register with the rotor filling ports.

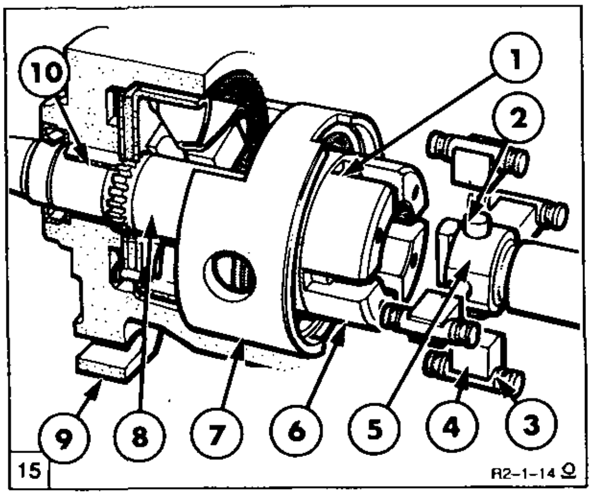
The transfer pump is housed within a recess which has been counter bored in the end of the hydraulic head. This recess contains a self–venting orifice which removes air bubbles from the fuel via drilling to the cam box before fuel flows to the pumping plungers.

The distributor rotor has two plungers which pump simultaneously against the lobes of the cam ring and comprises of a number of filling ports and one port distributór as described under "**Pumping and Distribution of Fuel**".

The rotor has an equalisation groove cut around the majority of the circumference of the rotor on the same plane as the distributor outlet port. This achieves a constant residual line pressure in all the lines and improves line to line deliveries, particularly important at idling speeds.

The fuel lines, except the next in line to be charged, are connected by the groove and the residual pressure in the line which has just injected is "balanced out" with the remaining lines.

PUMP DRIVE SHAFT



Pump Drive Shaft

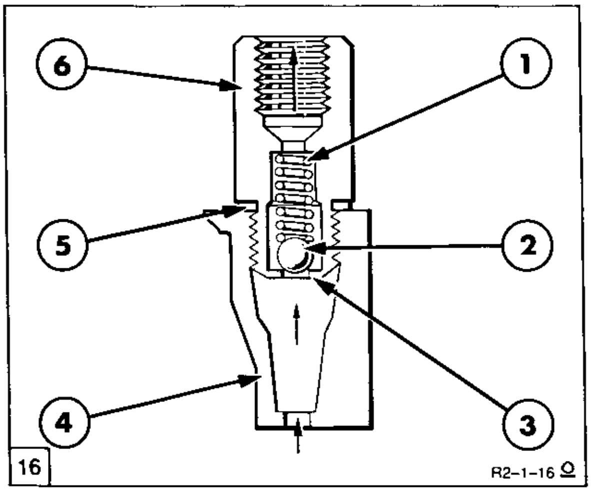
1. Spacer
2. Pumping Plunger
3. Roller
4. Shoe
5. Distributor Rotor
6. Drive Shaft Head
7. Rear Bearing
8. Drive Shaft
9. Pump Housing
10. Front Bearing

With reference to Figure 15, the pump drive (8) is a solid, one piece shaft carried on two bearings located wide apart at each end of the shaft.

Drive to the distributor rotor is through an inner slot in the driving head which engages with the driven tang on the rotor. Two pairs of opposed pumping plungers within the head of the rotor contact the shoes and rollers, each of which slides radially in the outer slots of the drive shaft. The plungers bring the rollers into contact with the cam ring and the outer ends of the rollers with the scroll plates during excess and maximum fuelling.

Long and short spacers are located one in each slot of the driving head, which allow only one position of engagement for the tang on the rotor. The spacers also act as guides for the roller shoes.

PRESSURISING VALVE



Pressurising Valve

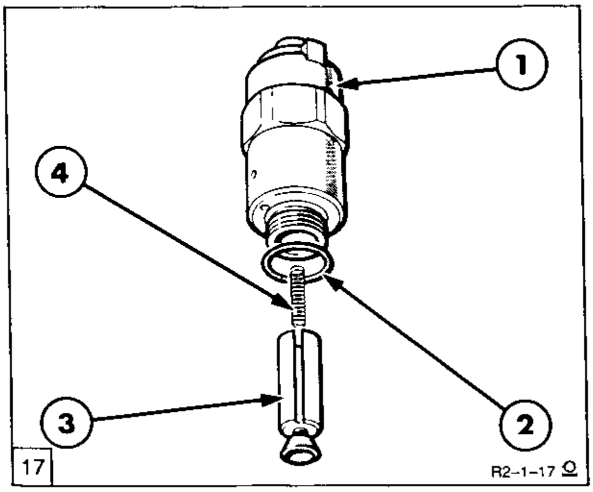
1. Upper Spring
2. Ball Valve
3. Valve Seat
4. Governor Control Cover
5. Sealing Washer
6. Valve Holders

The pressurising valve fitted to the smaller vehicles, Figure 16, is screwed into the governor control cover and comprises a ball, valve seat and spring. During running, constant pressure is maintained in the cam box by the spring retaining the ball on its seating. Only when pressure exceeds the loading on the spring at a pre–determined pressure is fuel allowed to lift the valve.

As changes occur in engine speed with resultant pressure differences in the cam box, the valve reacts by lifting or closing on its seating to allow the back leakage of fuel return to the supply tank, thus controlling the maximum cam box pressure in the pump housing.

Maintaining pressure in the cam box prevents ingress of dirt into the pump and provides smoother governor run–out characteristics.

SOLENOID FUEL SHUT–OFF VALVE



Solenoid Fuel Shut Off Valve

1. Solenoid Valve
2. Rubber 'O' Ring
3. Piston
4. Spring

An electrically operated fuel shut–off valve, Figure 17, is screwed into the top of the hydraulic head. The unit consists of a solenoid assembly which controls a spring loaded piston and is located between the transfer pump outlet and the metering valve.

When the solenoid valve is energised on starting the engine, the solenoid lifts the piston against spring pressure and allows fuel at transfer pressure to pass to the metering valve.

When the solenoid is de–energised by cutting the electrical supply, the return spring pushes the piston back against its seat and prevents the rotor from filling, thereby, stopping the engine.

B. FAULT FINDING

GENERAL

PROBLEM	POSSIBLE CAUSES	REMEDY
Engine starts and stops	1. Fuel starvation	1. Check and flush clean restricted fuel lines or fuel filters
	2. Contaminated fuel	2. Check for water in the fuel
	3. Restricted air intake	3. Check for restrictions in the air intake
	4. Engine overheating	4. Check cooling system
	5. Air in system	5. Check for air leaks on the suction side of the system

PROBLEM	POSSIBLE CAUSES	REMEDY
Fuel not reaching injection pump	1. Fuel shut–off valve closed	1. Check the fuel shut–off valve at the fuel tank is in the "ON" position
	2. Restricted fuel filters	2. Check and flush the fuel filters clean
	3. Air in system	3. Bleed the fuel filters
	4. Fuel leakage	4. Check the fuel lines and connectors for damage
Fuel reaching nozzles but engine will not start	1. Low cranking speed	1. Check the cranking speed
	2. Incorrect throttle adjustment	2. Check the throttle control rod travel
	3. Incorrect pump timing	3. Check the pump timing
	4. Fuel leakage	4. Check the fuel lines and connectors for leakage
	5. Faulty injectors	5. See injector trouble shooting
	6. Low compression	6. Check the engine compression
Engine hard to start	1. Low cranking speed	1. Check the cranking speed
	2. Incorrect pump timing	2. Check the pump timing
	3. Restricted fuel filters	3. Check and flush the fuel filters clean
	4. Contaminated fuel	4. Check for water in the fuel
	5. Low compression	5. Check the engine compression
	6. Air in system	6. Check for air leaks on the suction side of the system
Difficulty in setting delivery by maximum speed stop screw	1. Governor spring damaged or of wrong type	1. Renew spring
	2. Governor link setting incorrect	2. Set correctly
	3. Governor spring linkage incorrectly coupled	3. Assemble correctly
	4. Sticking metering valve	4. Repair or renew valve
	5. Sticking governor thrust sleeve	5. Repair or renew sleeve

PROBLEM	POSSIBLE CAUSES	REMEDY
Erratic engine operation (surge, misfiring, poor governor regulation)	1. Fuel leakage	1. Check the injector lines and connectors for leakage
	2. Fuel starvation	2. Check and flush clean restricted fuel lines or filters
	3. Incorrect pump timing	3. Check the pump timing
	4. Contaminated fuel	4. Check for water in the fuel
	5. Air in system	5. Bleed the fuel system
	6. Faulty or sticking injector nozzles	6. See injector trouble shooting
	7. Incorrect engine timing	7. Check for faulty engine valves
Engine emits black smoke	1. Restricted air intake	1. Check for restricted air intake
	2. Engine overheating	2. Check cooling system
	3. Incorrect timing	3. Check the pump timing
	4. Faulty injectors	4. See injector trouble shooting
	5. Low compression	5. Check the engine compression
	6. Incorrect engine timing	6. Check the engine valves
Engine does not develop full power or speed	1. Incorrect throttle adjustment	1. Check for insufficient throttle control movement
	2. Incorrect maximum no–load speed	2. Check maximum no–load speed adjustment
	3. Fuel starvation	3. Check and flush clean restricted fuel lines and filters
	4. Air in system	4. Check for air leaks on the suction side of the system
	5. Incorrect timing	5. Check pump timing
	6. Low compression	6. Check engine compression
	7. Incorrect engine timing	7. Check for improper valve adjustment or faulty valves
Shut–Off not working	1. Sticking Solenoid valve plunger	1. Repair or renew valve
	2. Permanent electrical feed to solenoid valve	2 Inspect or repair electrical circuit

PROBLEM	POSSIBLE CAUSES	REMEDY
Low transfer pressure	1. Regulating valve inner seal damaged	1. Renew seal
	2. Regulating spring or piston missing	2. Renew spring or piston
	3. Incorrect regulating spring	3. Install correct spring
	4. Worn or damaged transfer pump blades	4. Renew damaged unit
	5. Faulty transfer pump seal	5. Renew seal
	6. Loose or incorrectly tightened end plate	6. Tighten or renew damaged unit
	7. Faulty washers on head locking and head locating screws	7. Renew washers
	8. Damaged seals on head locating fitting	8. Renew seals
High transfer pressure	1. Sticking regulator piston	1. Repair or renew piston
	2. Incorrect regulating spring – too strong	2. Install correct spring
	3. Test bench operating on pressure feed	3. Check maximum pressure feed
	4. Regulating spring guide installed upside down	4. Install correctly
	5. Incorrect regulating spring guide	5. Install correct guide
	6. Regulating sleeve installed upside down	6. Install correctly
Low and fluctuating transfer pressure	1. Regulating sleeve inner gasket faulty	1. Renew gasket
	2. One transfer pump blade chipped	2. Renew unit
Low advance reading	1. Low transfer pressure	1. Inspect and repair transfer pump
	2. Too many shims installed	2. Shim correctly
	3. Spring too stiff, incorrect type installed	3. Install correct spring
	4. Sticking advance piston	4. Repair or renew piston
	5. Sticking cam ring	5. Repair or renew cam ring
	6. Excessive clearance between advance piston and housing	6. Install new components
	7. Leaking advance gasket	7. Renew gasket

PROBLEM	POSSIBLE CAUSES	REMEDY
High advance reading	1. High transfer pressure	1. Inspect transfer pump for restriction on outlet side
	2. Insufficient shims	2. Shim correctly
	3. Incorrect spring, too weak	3. Renew spring
Low delivery during fuel delivery check, at maximum speed	1. Maximum speed stop screw incorrectly adjusted	1. Adjust correctly
	2. Faulty or incorrect governor spring	2. Renew spring
	3. Governor spring linkage coupled to wrong holes	3. Correct linkage coupling
	4. Sticking metering valve	4. Repair or renew valve
Incorrect maximum fuel delivery	1. Throttle not fully open	1. Inspect and renew throttle
	2. Incorrect maximum fuel setting	2. Check and adjust maximum fuel setting
	3. Sticking metering valve	3. Repair or renew valve
	4. Air in system	4. Purge and eliminate source of air
	5. Sticking plungers or roller shoes	5. Repair or renew faulty items
	6. Scroll plate link plate sticking or weak spring	6. Check and repair link plate and return spring
	7. Incorrect transfer pressure	7. Inspect and repair transfer pump
	8. Shut off mechanism fouling metering valve	8. Repair or renew mechanism
	9. Governor link adjustment incorrect	9. Adjust correctly
	10. Governor spring linkage incorrectly assembled	10. Assemble correctly
	11. Cam ring or scroll plates reversed	11. Install correctly

PROBLEM	POSSIBLE CAUSES	REMEDY
Low fuel delivery during excess fuel delivery check	1. Low transfer pressure	1. Inspect and repair transfer pump
	2. Throttle not fully open	2. Inspect and repair throttle
	3. Sticking metering valve	3. Repair or renew valve
	4. Sticking plungers or roller shoes	4. Repair or renew faulty items
	5. Sticking scroll plate link plate or weak spring	5. Check and repair link plate or renew spring
	6. Plungers scored	6. Install new plungers
	7. Outlet ports scored	7. Install new unit
	8. Excessive clearance, rotor to hydraulic head	8. Install new head and rotor assembly
	9. Air in system	9. Purge and eliminate source of air
	10. Scored metering valve	10. Install new valve

C. FUEL INJECTION PUMP–OVERHAUL

Except in the case of complete overhaul full dismantling is not always necessary. When a pump requires attention, the recommended practice is to set it up on a test machine and check to locate specific faults or adjustments.

Repairs or adjustments can be undertaken on the basis of the test results.

Dismantling, assembly, testing and adjustment of the DPS pump must be carried out by trained personnel, using specialised tools and test apparatus. The service tools listed in Special Tools "Section F", must be used to obtain the closest possible approach to factory standards.

Conditions of scrupulous cleanliness must be observed in workshops where pump overhaul is carried out. The following equipment must be available in the workshop when fuel injection equipment is to be serviced:–

1. A bench covered with sheet metal or linoleum, which should be kept for injection equipment only.
2. A divided storage tray of fire retardant material.
3. A vice with soft metal or fibre jaws.
4. A fire proof tank containing clean test oil for large components and a small bath with a lid, containing clean test oil which should be kept only for pump plungers and small components.
5. A complete set of Special Tools see "Section F".
6. Non–Fluffy cloths must be used for drying of hands. Under no circumstances use cotton waste.

TYPEPLATE

The number stamped on the typeplate attached to the pump housing, identifies the type and model of the pump. Pumps that are of identical build but with modified settings for different applications are further identified by the setting code stamped beneath the ordering number. See "Section D" FUEL INJECTION PUMP – ISO TEST CONDITIONS.

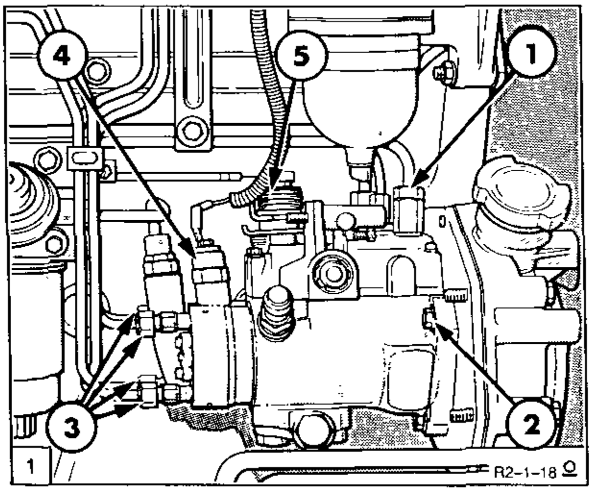
Should the typeplate be obscured by paint care must be taken to ensure that the type details are not defaced when removing the paint.

Overhaul Procedure

If any part in a mated assembly is damaged or worn, the complete assembly must be rejected. Any component showing signs of fretting, wear, damage, corrosion, cracks or distortion must be discarded.

All 'O' rings, gaskets, tab washers, locking and sealing devices must be discarded and new ones fitted.

Removal



Fuel Injection Pump Removal

1. Fuel Return Line
2. Pump Retaining Bolts
3. Injector Lines
4. Fuel Shut–off Solenoid
5. Throttle Linkage

1. Clean all dirt from the injection pump and the surrounding parts.

2. Turn the fuel shut–off valve to the "OFF" position.

3. Drain the cooling system coolant and remove the bottom radiator hose.

4. Disconnect and remove all fuel lines from the injection pump, Figure 1 and cap all openings to prevent entry of dirt.

5. Disconnect the throttle cable and fuel shut–off solenoid wire.

6. If the pump is not to be internally timed then prior to removal, note the setting of the pump relative to the zero degree mark on the rear of the engine front plate. Mark the plate with a centre punch to align with the pump flange scribed line.

7. Remove the engine timing cover. Withdraw the drive gear retaining nut from the injection pump driveshaft.

8. Fabricate a puller as outlined in Special Tools "Section F". Install the pulley to the drive gear using three bolts and remove the gear.

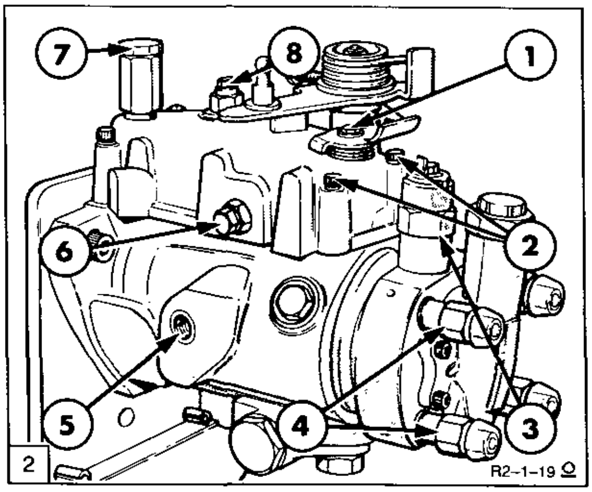
9. Withdraw the pump mounting bolts then remove the pump from the engine front cover plate. Cap all openings to prevent entry of dirt.

Disassembly

Before commencing disassembly remove the surface grime from the exterior of the pump by using a suitable proprietary fluid as a cleansing agent.

Turn the pump on its side drain plug uppermost. Remove the drain plug from the pump housing, detach the Dowty washer and discard. Invert the housing and drain the pump oil into a suitable receptacle.

PRESSURISING VALVE

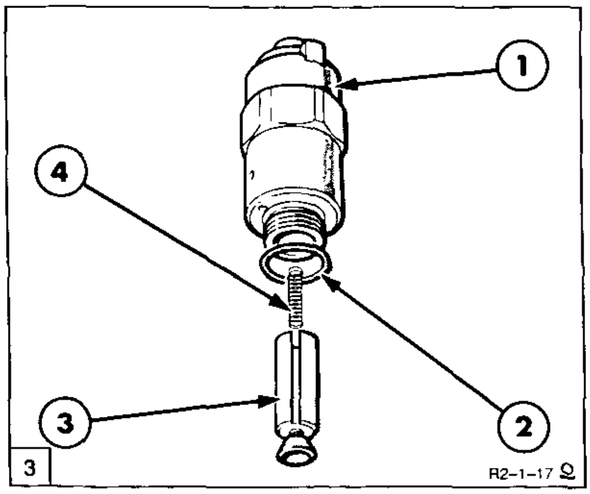


Governor Control Cover Components

1. Fuel Shut–Off Setbolt
2. Governor Control Cover Screws
3. Solenoid Shut–Off Valve
4. Delivery Valves
5. Drain Plug
6. Maximum Fuel Adjustment Screw
7. Pressurising Valve
8. Vent Screw

1. Unscrew and remove the pressurising valve holder (7), Figure 2, from the governor control cover. Remove and discard the duty washer from the valve.

Solenoid Shut–Off Valve

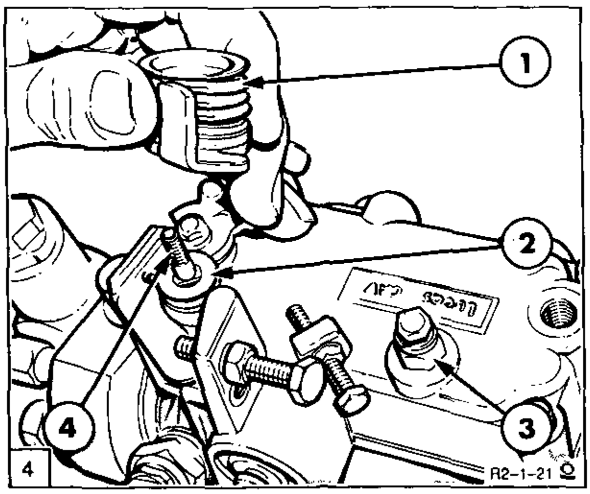


Solenoid Shut–Off Valve Components
1. Solenoid Valve
2. Rubber 'O' Ring
3. Piston
4. Spring

1. Remove the solenoid from the hydraulic head complete with plunger and spring, Figure 3. Discard the rubber 'O' ring from the solenoid.

NOTE: *The solenoid plunger and body are a matched assembly and should not be separated.*

Throttle Lever Assembly



Throttle Lever Disassembly
1. Throttle Lever Assembly
2. Cap Washer
3. Vent screw and Thermostart Connection
4. Throttle Lever Shaft

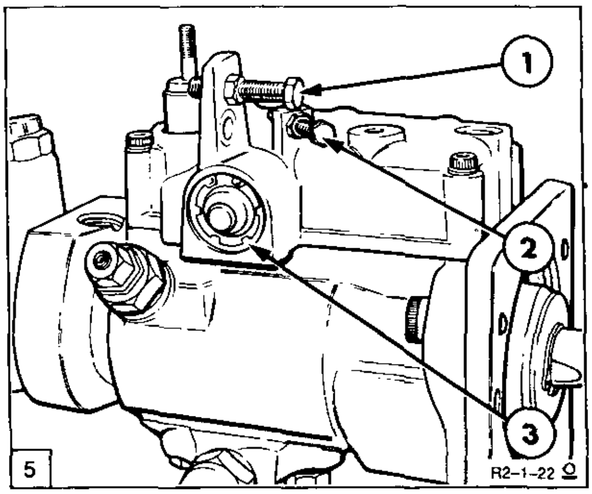
1. Unscrew and remove the self locking nut from the throttle shaft. Remove the washer from inside the spring guide.
2. Remove the throttle lever assembly from the shaft complete with the break back spring and spring guides, Figure 4. Remove the cap and washer from the lever shaft.
3. Loosen the set bolt in the manual fuel shut–off lever, Figure 2 and remove complete with washers. Lift the lever complete with spring from the governor control cover and remove the cap washer from the lever shaft.

Vent Screw

1. Loosen the vent screw, Figure 4 and unscrew and remove from the governor control cover. Discard the copper sealing washer.

Governor Control Cover

1. Loosen and remove the maximum fuel screw locknut (6), Figure 2. Unscrew the maximum fuel adjustment screw from the governor control cover and discard the rubber sealing washer.

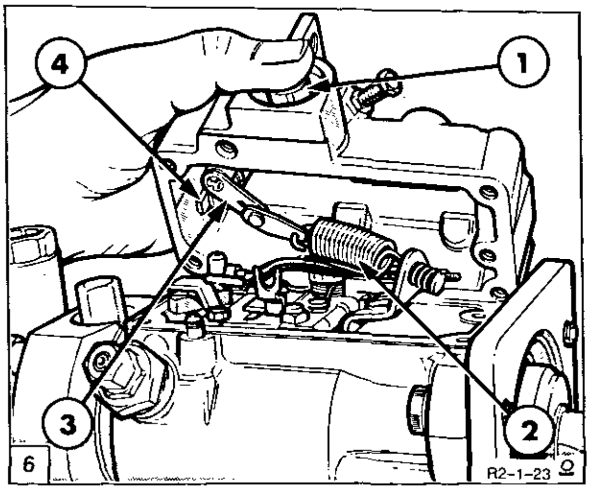


Excess Fuel Device
1. Maximum No–Load Speed Screw
2. Slow Idle Screw
3. Excess Fuel Device Snap Ring

2. Using suitable snap–ring pliers remove the snap–ring from the excess fuel supply device, Figure 5, remove plug and discard the rubber 'O' Ring.

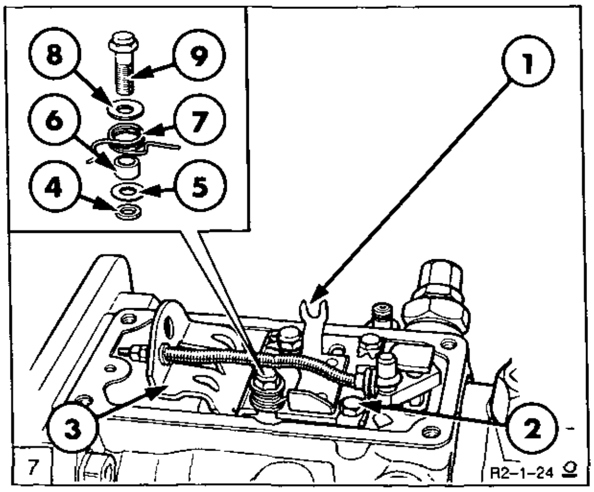
NOTE : *Do not remove the piston from the excess fuel device at this stage as it is used to disengage the excess fuel shaft when removing the governor control cover.*

3. Using a suitable allen wrench remove the four allen screws (2) together with the washers from the governor control cover, Figure 2.



Governor Control Cover Removal

1. Excess Fuel Device Piston
2. Governor Control Spring
3. Throttle Shaft
4. Fuel Shut–Off Shaft



Link Plate Retaining Bolts

1. Link Plate Retaining Bolts
2. Link Plate Spring Retainer
3. Link Plate
4. Small Washer
5. Washer
6. Spacer
7. Spring
8. Washer
9. Bolt

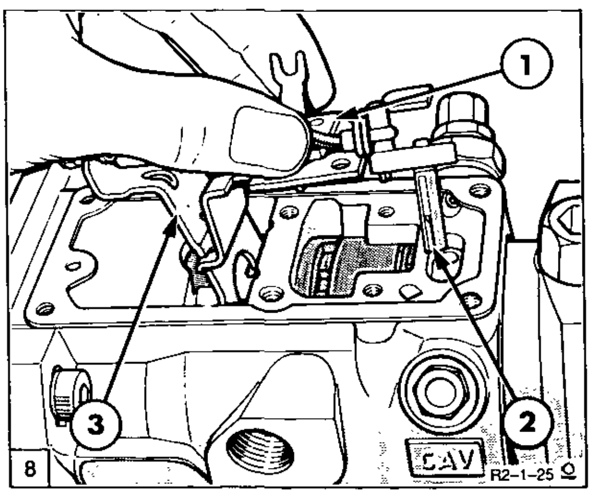
4. Lift the governor control cover away from the pump housing while at the same time, depressing the excess fuel piston to detach the excess fuel shaft from the scroll plate link plate, Figure 6. Once the excess fuel device is detached, push down on the threaded end of the throttle shaft assembly. The shaft must be pressed through the cover to remain connected to the governor spring. Push out the fuel shut–off shaft from the governor control cover. Remove and discard the rubber 'O' rings from the shaft, and remove and discard the governor control cover gasket.

5. Remove the excess fuel piston from the governor control housing. Disconnect and remove the governor spring from the throttle shaft and governor arm. Remove and discard the rubber 'O' rings from the shaft.

GOVERNOR ARM AND CONTROL BRACKET ASSEMBLY

1. From the control bracket remove the scroll link plate spring retainer, spring, sleeve, washers and spacer, Figure 7. Discard the spring retainer, unlock the tab washers, unscrew and remove the three retaining bolts.

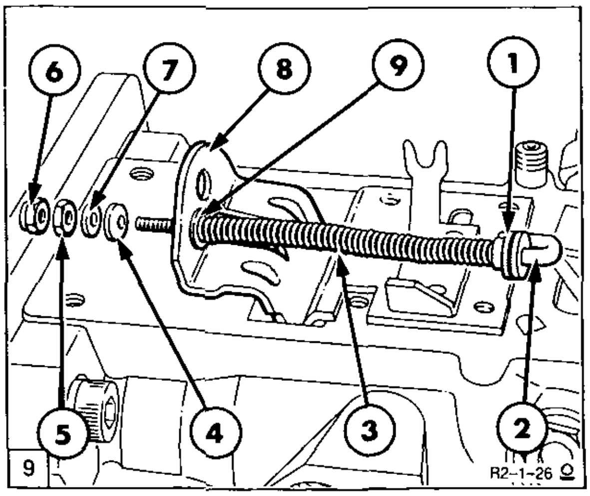
2. Lift off as an assembly the control bracket complete with governor arm, metering valve and spring linkage assembly, Figure 8. Detach the metering valve from the linkage hook and immerse in clean test oil.



Control Bracket and Governor Arm

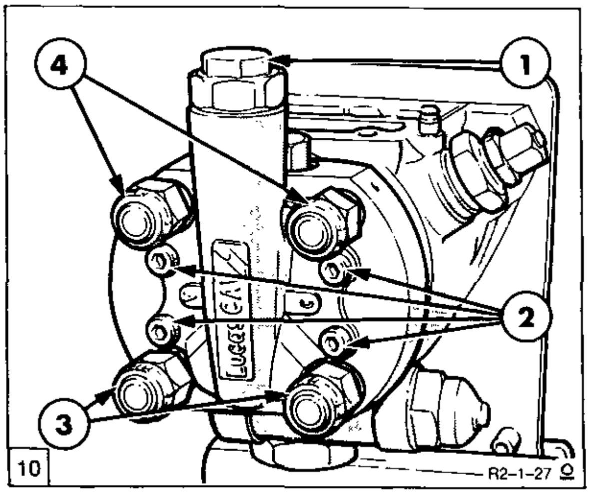
1. Link Plate
2. Metering Valve
3. Governor Arm

3. Disengage the control bracket from the governor arm and dismantle the governor spring linkage from the governor arm in the following sequence, Figure 8.



Governor Linkage Disassembly

1. Spring Retainer
2. Linkage Hook
3. Spring
4. Pivot Ball Washer
5. Adjusting Nut
6. Locknut
7. Washer
8. Governor Arm
9. Washer



End Plate and Regulating Valve Assembly

1. Fuel Inlet Connections
2. End Plate Retaining Screws
3. Delivery Valves
4. Delivery Valves

1. Unscrew and remove the self locking nut (6), the linkage nut, washer and pivot ball washer from the governor linkage hook, Figure 9.

2. Slowly release the compression on the linkage spring and disengage the linkage hook from the governor arm. Be careful not to lose the washer.

3. Slide the spring and spring retainer from the linkage hook.

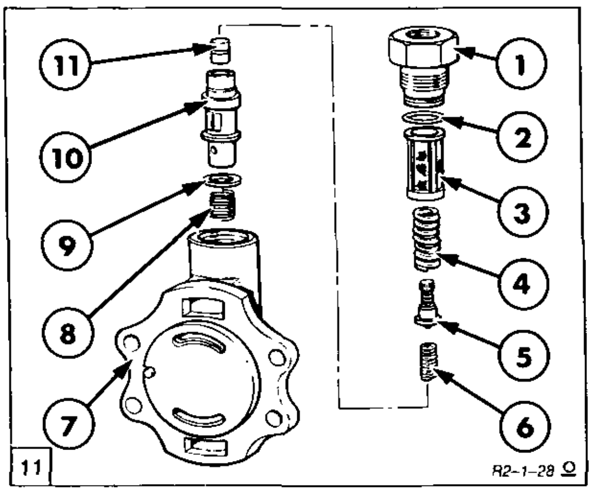
Delivery Valves

1. Slacken each delivery valve in turn and remove from the hydraulic head assembly, Figure 10. Remove and discard the sealing washer from each outlet in the hydraulic head.

End Plate and Regulating Valve Assembly

1. Slacken the fuel inlet connection in the end plate, Figure 10.

2. Using a suitable allen wrench unscrew the four allen screws and carefully remove the end plate from the hydraulic head.



End Plate and Regulating Valve Components

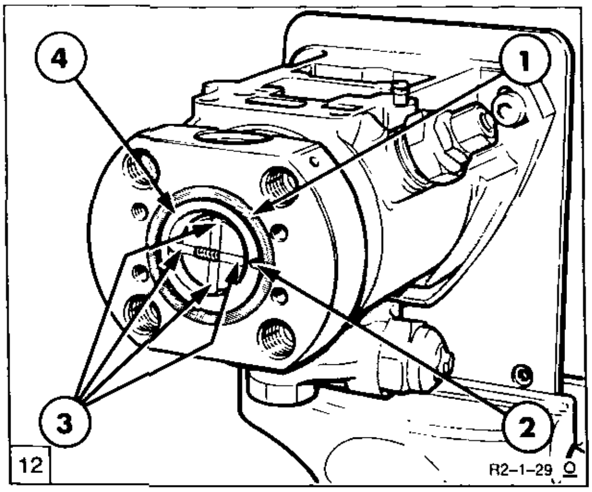
1. Inlet Connection
2. 'O' Ring seal
3. Filter
4. Spring
5. Transfer Pressure
6. Spring and Peg
7. End Plate
8. Priming Spring
9. Sealing Spring
10. Regulating Sleeve
11. Regulating Piston

3 Remove the fuel inlet connection and discard the 'O' ring seal, Figure 11.

4. Invert the end plate and remove the sleeve, retaining spring and peg assembly, regulating sleeve, piston and priming spring, Figure 9. Discard the sealing washer.

Transfer Pump

12



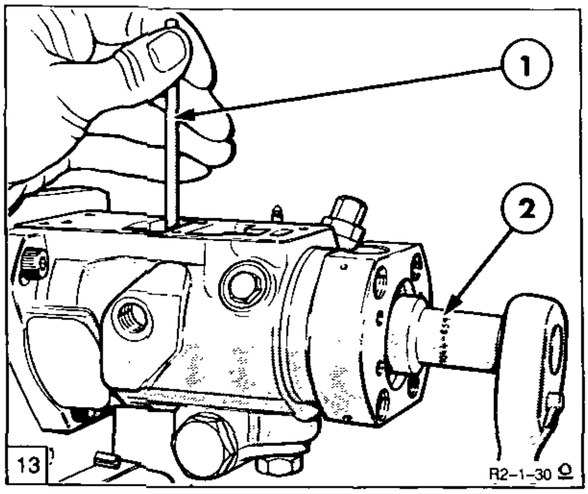
Transfer Pump Components

1. Rubber Seal
2. Rotation Slot
3. Transfer Pump Blades
4. Transfer Pump Liner

1. Remove the transfer pump blades, Figure 12, note the position of the direction of the rotation slot in the transfer pump liner. It should be 3 o'clock when viewed from the transfer pump rotor end. Remove the transfer pump liner and discard the rubber seal.

NOTE: *Rotors are loosened in the direction of the pump rotation shown by the arrow on the pump nameplate.*

13



Loosening Transfer Pump Rotor

1. Tommy Bar
2. Box Spanner Tool No. 7044–889

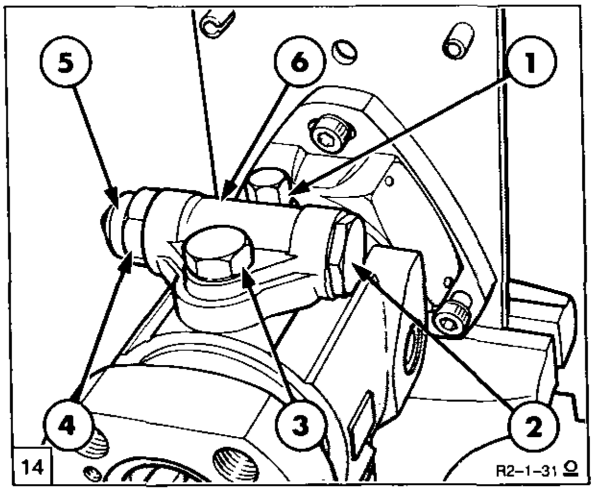
2. To assist in the removal of the transfer pump rotor, Figure 13. Insert a suitable tommy bar of 4mm (0.157in) diameter through the governor aperture in the pump housing and through the hole in the drive shaft.

3. *Still keeping the drive shaft held in with* the tommy bar as shown in, Figure 13, insert the box spanner, Tool No. 7044–889 into the slots in the rotor and loosen the rotor.

4. Remove the tommy bar and finger tighten the rotor.

Automatic Advance and Start Retard Unit

14



Automatic Advance and Start Retard Unit

1. Cap Nut
2. Piston Plug
3. Head Locating Fitting
4. Spring End Cap
5. Vent Screw
6. Auto–Advance Housing

1. Invert the pump fixture so that the automatic advance and start retard unit is uppermost, Figure 14.

2. Unscrew the piston plug from the housing and remove, discard the rubber 'O' ring.

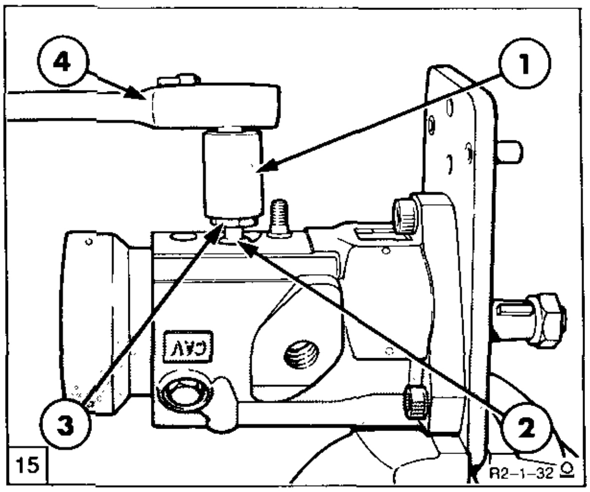
3. *Loosen the spring cap plug and the vent* screw. Remove the vent screw and withdraw the three springs.

4. Remove and discard the rubber 'O' ring from the spring cap, then remove the vent screw and discard the rubber washer.

5. Unscrew and remove the cap nut, then remove and discard the copper sealing washer.

6. Unscrew and remove the head locating fitting from the auto–advance housing, taking care not to lose the steel ball and remove and discard both rubber 'O' rings.

7. Gently ease the auto–advance housing with the piston from the pump housing. Remove and discard the housing joint, but retain the piston in the auto–advance housing.



Cam Advance Screw

1. Socket
2. Cam Advance Screw
3. Socket Adapter Tool No. 7244–125B
4. Wrench

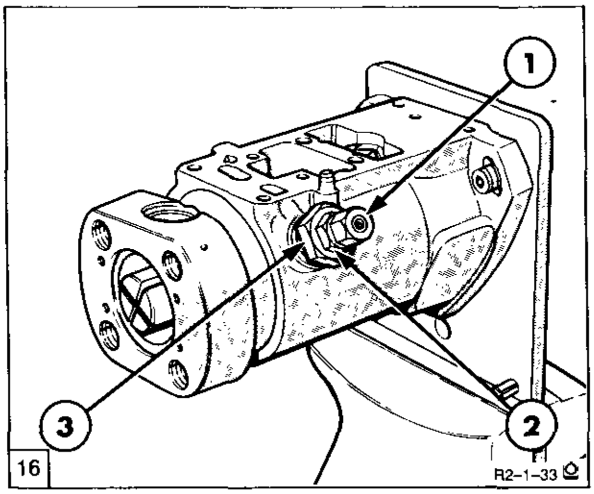
8. Using the socket adaptor, Tool No. 7244–125B, Figure 15, loosen the cam advance screw.

9. Remove the tool and if necessary lightly tap the cam advance screw to free the cam ring in the pump housing before removing the screw.

10. Invert the mounting fixture so that the governor control cover machined face on the pump housing is uppermost.

Latch Valve

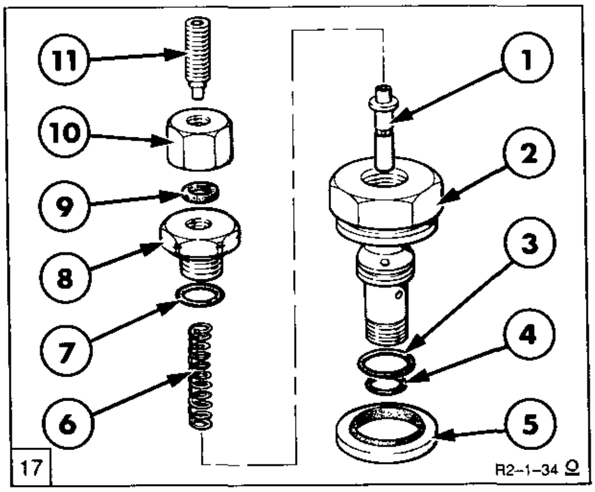
1. Before removing latch valve, Figure 16, loosen both the locknut and sleeve nut in the valve body. Loosen and remove the latch valve body from the pump housing discarding the "Dowty" seal and two rubber 'O' rings.



Latch Valve Removal

1. Locknut
2. Sleeve Nut
3. Valve Body

2 Remove the locknut, adjuster and tip out the valve spring from the sleeve nut, Figure 17. Remove and discard the rubber washer.



Latch Valve Components

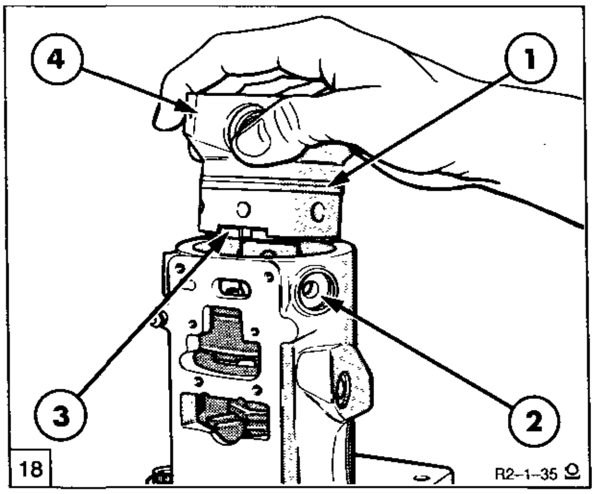
1. Valve
2. Valve Body
3. 'O' Ring Seal
4. 'O' Ring Seal
5. Dowty Washer
6. Valve Spring
7. 'O' Ring Seal
8. Sleeve Nut
9. Rubber Washer
10. Locknut
11. Adjuster

3 Unscrew and remove the sleeve nut from the latch valve and discard the rubber 'O' Ring.

4 Invert the valve body to bring the externally threaded end uppermost and gently tap to dislodge the valve from the

body. Examine the valve and if the condition is satisfactory, re-assemble the valve to the valve body.

Hydraulic Head



Hydraulic Head Removal

1. 'O' Ring Seal
2. Head Retaining Bolt Location
3. Rear Scroll Plate
4. Hydraulic Head

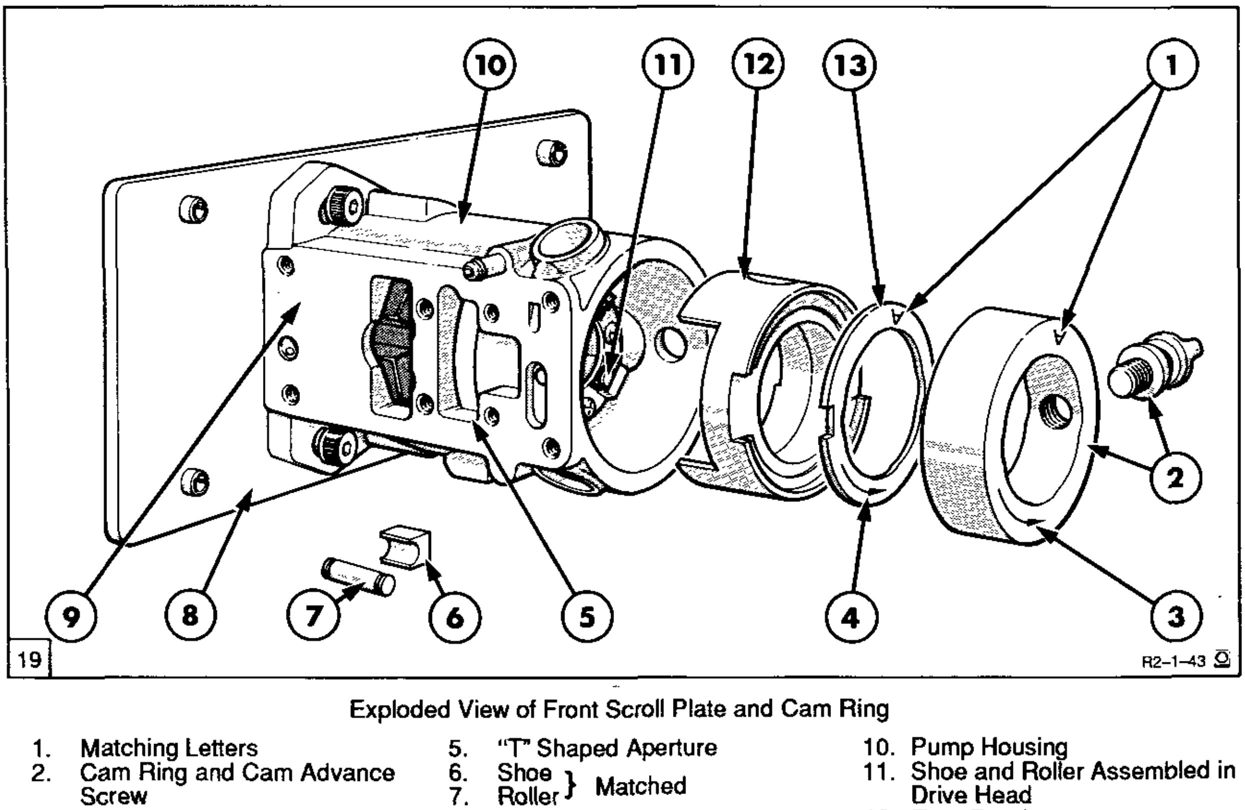
NOTE: *Prior to removing the hydraulic head, turn the pump into the vertical position head uppermost. This will ensure that the plungers do not fall out of the rotor during the removal of the hydraulic head.*

1. With reference to Figure 18, remove the hydraulic head retaining bolt from the side of the pump housing and discard the copper sealing washer.

2. Withdraw the hydraulic head and rotor assembly from the pump housing with a slight twisting motion in each direction. When clear of the housing detach the rear scroll plate noting the direction of the arrow and discard the rubber 'O' Ring from the hydraulic head.

3. The transfer pump rotor, previously loosened should not be removed until the distributor rotor and pump plungers are ready for inspection. To retain the plungers in the rotor fit the plastic retainer C.A.V. Part No. 7174–62, or with suitable synthetic rubber tubing.

Pump Housing and Drive Shaft Assembly



Exploded View of Front Scroll Plate and Cam Ring

1. Matching Letters
2. Cam Ring and Cam Advance Screw
3. Direction Arrow Cam Ring
4. Direction Arrow Scroll Plate
5. "T" Shaped Aperture
6. Shoe } Matched
7. Roller } Matched
8. Mounting Plate
9. Pump Governor Control Plate
10. Pump Housing
11. Shoe and Roller Assembled in Drive Head
12. Rear Bearing
13. Front Scroll Plate

1. With reference to Figure 19, turn the pump housing on its mounting fixture so that the pump governor control cover machined face on the housing is at 9 o'clock.

2. Withdraw the cam ring from the pump housing with a twisting motion and detach the front scroll plate noting the direction of the arrows on both cam ring and scroll plate.

3. Rotate the drive shaft to dislodge one roller and shoe assembly into the well of the pump housing and remove the roller and shoe. Repeat the same operation with the other shoe and roller assemblies. Immerse the roller and shoe assemblies in clean test oil.

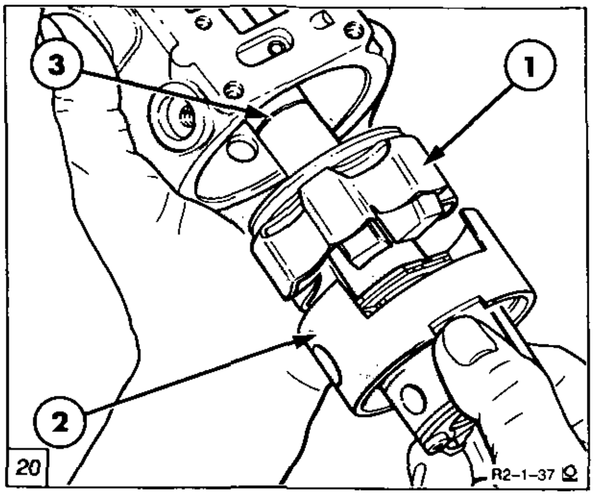
NOTE: *The rollers and shoes are matched and should be kept in their respective assemblies.*

4. Remove the woodruff key from the drive shaft. Using suitable snap ring pliers remove the snap ring from the drive shaft and then remove the thrust washer.

5. Remove the pump housing from the mounting fixture and lay the housing on the bench drive end uppermost.

6. While holding the rotor end of the drive shaft through the housing aperture, invert the pump housing so that the tapered end of the driveshaft is uppermost and lift the pump housing clear of the drive shaft assembly and rear bearing, Figure 20.

NOTE: *The front drive shaft bearing bush must not be removed. If damaged a new pump housing and bush assembly will be required.*

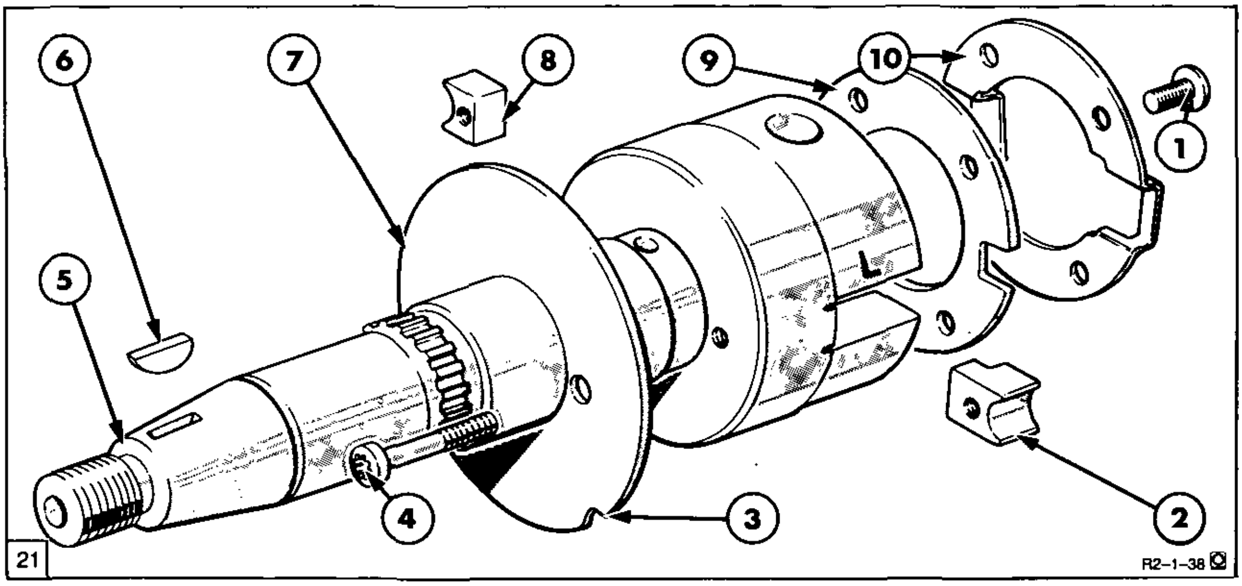


Rear Bearing and Governor Weight Removal

1. Governor Weight Assembly
2. Rear Bearing
3. Drive Shaft

7. Remove the rear bearing and governor weight assembly, Figure 20, from the drive shaft and detach the thrust sleeve, washer and governor weights from the weight retainer.

8. Fit the drive shaft between the soft jaws of a vice and using a suitable "Torx" bit, unscrew and remove the four "Torx" screws from the rear of the drive shaft and detach the catch plate and shoe plate, Figure 21.



Exploded View of Drive Shaft

1. "Torx" Screw
2. Long Shoe Spacer
3. Timing Disc Notch
4. "Torx" Screw
5. Drive Shaft
6. Woodruff Key
7. Timing Disc
8. Short Shoe Spacer
9. Shoe Plate
10. Catch Plate

NOTE: *Before removing the timing disc and shoe spacers, it will be necessary as an aid to assembly to etch the disc and drive shaft as follows. Mark the timing disc with a vertical line in the same plane as the drive shaft key way. Mark the drive shaft with a letter "L" on the unmachined surface adjacent to the long shoe spacer slot.*

9. Again holding the drive shaft, unscrew the two "Torx" screws from the front of the drive shaft. Remove the timing disc and shoe spacers.

10. Remove the oil seal from the pump housing and discard.

INSPECTION OF COMPONENTS

The following information lists the possible defects and indicates the main items which may require replacement. The inspection requirements listed are the minimum advisable. If any part in a mated assembly is damaged or worn, the complete assembly must be renewed. The following items must be considered as mated parts.

HEAD AND ROTOR ASSEMBLY,
ROLLERS AND SHOES,
ADVANCE PISTON AND BODY,
LATCH VALVE AND BODY,
CAM RING AND SCROLL PLATES,
DRIVE SHAFT HOUSING AND BUSH,
SOLENOID PLUNGER AND BODY.

1. Check for damage to internal and external threads, especially on the transfer and distributor rotor, hydraulic head, studs, inlet and outlet connections.

2. Look for distorted or fractured springs. Check that all springs quoted in the Parts List for the particular pump are present. In cases of fouling or malfunctioning, ensure the correct springs are fitted.

3. Check for any signs of scoring, wear or corrosion to machined surfaces, including the pump body and bush, drive shaft, rear bearing, hydraulic head bore, cam ring, scroll plates, end plates, auto–advance device location and end plate locating face.

4. When fitting new 'O' rings and oil seals, care must be taken to use protection caps to avoid damage. Inspection of seals after assembly is recommended. Internal seals should be dipped in clean test oil prior to being assembled, external seals should be lightly coated with grease.

5. Inspect for wear and damage to drive shafts, splines and associated parts. If the thrust faces of the housing are worn, check the drive shaft end float.

6. Inspect for wear and scoring of all mechanical linkages, shafts, pivot points, arms and weights.

7. Inspect for nicked, scratched, worn, corroded or otherwise damaged pump plungers and their mated bores.

NOTE: *Great care must be taken with pump plungers and bores.*

Plungers must only be removed from the bore if there is a need to inspect them and then only for the short time required for inspection. Ensure that each plunger is correctly replaced in the end of the bore from which it came.

Plungers and bores must be cleaned with clean test oil and assembled wet. The plungers should be retained in the bore of the rotor with the plastic retainer, C.A.V. Part No. 7174–62 or with suitable synthetic rubber tubing. The rotor must be assembled to the hydraulic head and the complete assembly immersed in a covered bath of clean test oil until required for assembly.

8. Examine the transfer pump for chipped, broken or worn transfer pump blades. The blades are not interchangeable and replacement blades must be of the same type.

9. Inspect for damage to rollers and shoes. Examine roller surfaces and check for free rotation in shoes. Roller and shoe assemblies must be kept together.

10. Inspect all small orifices for blockage, delivery valve bodies, latch valve, head locating fitting and clear any restriction with dry compressed air.

RE-ASSEMBLY

Drive Shaft

1. With reference to Figure 21, locate the timing disc with the two "Torx" screws to the head of the drive shaft so that the vertical mark previously etched on the disc during dismantling is aligned with the key way on the drive shaft.

2. Fit the short and long spacers into their respective slots in the head of the drive shaft. The long shoe spacer should be located in the slot previously etched with the letter "L". The slots in the spacers must face outwards.

3. Hold the shoe spacers in position and secure the spacers and timing disc with two "Torx" screws.

4. To hold the assembly, insert the drive shaft between the soft jaws of the vice and with a suitable "Torx" bit, tighten to a torque of 25 lbf in (2.8Nm) 0.3 kgf m.

5. Fit the catch plate against the shoe plate and assemble both plates centrally against the rear head of the drive shaft with the four "Torx" screws.

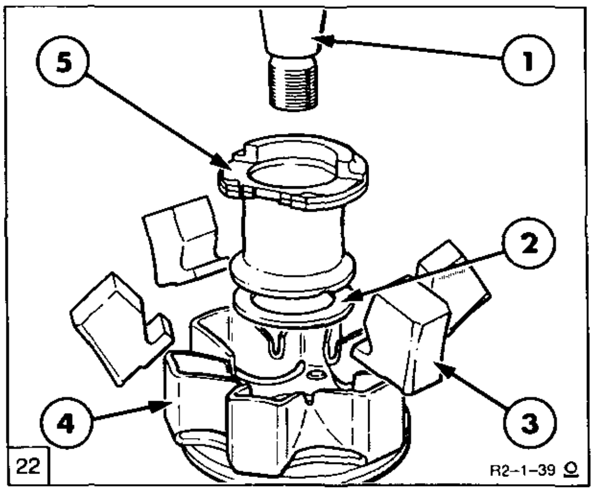
6. Again holding the drive shaft, tighten the screws with a suitable "Torx" bit to 35 lbf in (4.0Nm) 0.4 kgf m.

Governor Weight Assembly

1. Lay the governor "cush" drive assembly on the bench with the weight retainer uppermost, as shown in Figure 20.

2. The governor is fitted with four weights, Figure 22. Fit the weights into the retainer in opposing pairs. The toes of the weights should face inwards and be in contact with the base of the retainer.

3. Insert the thrust washer into the toes of the weights followed by the thrust sleeve tapered end first. Tilting the thrust sleeve to engage with one pair of weights while at the same time lifting the opposite pair, will facilitate entry of the thrust sleeve.



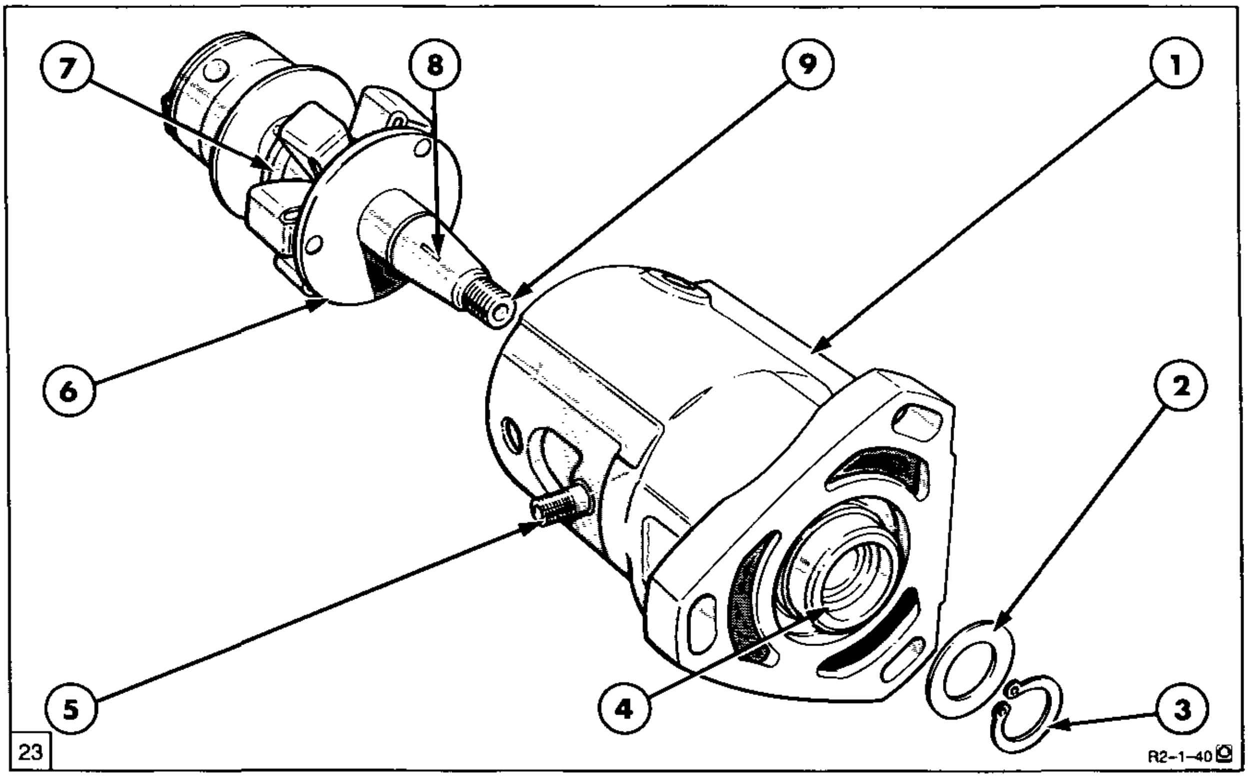
Governor Weight Assembly

1. Drive Shaft
2. Thrust Washer
3. Governor Weight
4. Weight Retainer and Cush Drive
5. Thrust Sleeve

4. Fit the drive shaft assembly through the sleeve and locate the splined teeth on the shaft with those on the splined hub of the cush drive.

Pump Housing and Drive Shaft Assembly

NOTE: *The front drive shaft bearing bush is supplied fitted to the pump housing as an assembly.*



Exploded View of Pump Housing and Drive Shaft

1. Pump Housing
2. Thrust Washer
3. Snap Ring
4. Bearing Bush
5. Auto Advance Housing Stud
6. Governor Weight Assembly
7. Governor Thrust Sleeve
8. Key Way
9. Drive Shaft

1. If the auto-advance housing stud, Figure 23, has been removed from the pump housing, secure the housing to the mounting plate, Tool No. 7244–200 and mount the fixture in the jaws of a vice so that the housing stud aperture is uppermost.

2. Screw in a new stud using a locknut and capnut and tighten the stud to 60 lbf in (6.8Nm) 0.7 kgf m.

3. Reposition the pump mounting fixture, so that the governor cover machined face on the pump housing is uppermost.

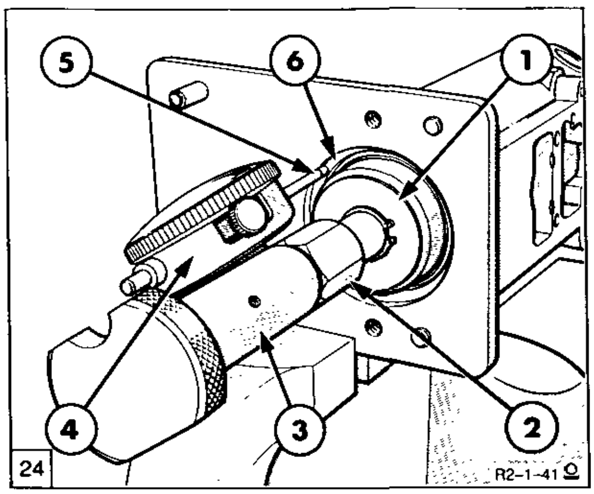
4. Insert the drive shaft and governor weight assembly into the pump housing and rotate the drive shaft so that the machined flat is uppermost.

5. Slide the thrust washer over the end of the drive shaft and abut against the pump housing. Retain the thrust washer with the snap ring.

6. After assembly check the drive shaft end float and if necessary adjust, as per the following procedure.

Checking of Drive Shaft End Float

1. To assist in checking the drive shaft end float, temporarily fit the rear bearing, Figure 26, to support the drive shaft.



Drive Shaft End Float Check

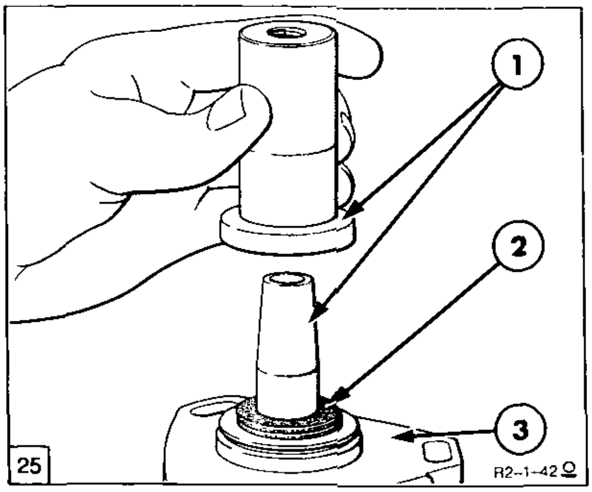
1. Thrust Washer
2. Adaptor Tool No. 89559/11
3. Holder Tool No. ST183
4. Dial Indicator Tool No. 23764
5. Stylus
6. Pump Housing

2. Fit an adaptor, Tool No 89559/11, to the threaded end of the drive shaft. Screw in the holder, Tool No. ST 183 (3). Adjust the stylus to contact the machined face of the pump housing, Figure 24.

3. Push the drive shaft inwards and zero the dial gauge Tool No. 23764. Pull the drive shaft outward and note the maximum reading on the gauge. The drive shaft end float should be between a maximum of 0.008in (0.2mm) and a minimum of 0.002in (0.05mm). If necessary, adjust the end float by selective assembly of the thrust washers.

4. Thrust washers of variable thickness are available to adjust the drive shaft end float to specification.

5. When the end float has been checked remove the rear bearing, snap ring and thrust washer. Then remove the pump housing from the mounting fixture and stand the housing upright on the bench.



Drive Shaft Oil Seal Installation

1. Punch and Protection Cap Tool No. 7244–445
2. Oil Seal
3. Pump Housing

6. Fit the protection cap of Tool No. 7244–445, over the threaded end of the tapered shaft, Figure 25.

7. Immerse a new drive shaft oil seal in clean test oil. Slide the seal over the protection cap with the lip of the seal facing inwards towards the recess in the pump housing.

8. With the punch of Tool No. 7244–445 drive the seal into the housing by tapping squarely with a hide mallet, until the tool abuts the face of the pump housing spigot.

9. When correctly fitted the outer face of the oil seal should be recessed approximately 0.008in (0.2mm) from the end face of the housing. Check that the shaft is able to rotate freely without excessive drag.

10. Refit the pump housing back onto its mounting fixture with the governor cover machined face uppermost. Re–install the selected thrust washer and retain with the snap ring.

Rear Bearing, Cam and Scroll Plates

1. Position the pump housing mounting fixture with the governor cover machined face at 9 o'clock. Alternatively, the pump may be fitted in the vertical position with the drive end downwards.

2. Fit the rear bearing into the pump housing with the large cut–away section of the bearing towards the drive shaft, Figure 26 and the axial slot in the bearing positioned at 3 o'clock to the rear of the auto–advance stud. Push the bearing fully in so that the chamfered edge on the bearing abuts the shoulder within the pump housing.

3. To aid assembly it is recommended that the roller and shoe assemblies are gripped with a suitable pair of tweezers. Keep the matched shoes and rollers in their respective assemblies and insert them through the "T" shaped aperture in the housing. When the slots in the head of the drive shaft are in the horizontal position.

4. To prevent the shoes and rollers being dislodged, fit the first set at 9 o'clock and rotate the shaft 180° in a clock wise direction viewed from the open end of the housing. The opposite shoe and roller assembly can then be fitted.

5. The arrows on both scroll plates and cam ring indicate the direction of pump rotation as viewed from the drive shaft end.

6. Insert the front scroll plate into the recess in the rear bearing with the arrow on the plate facing the same direction as the arrow on the pump name plate, Figure 26.

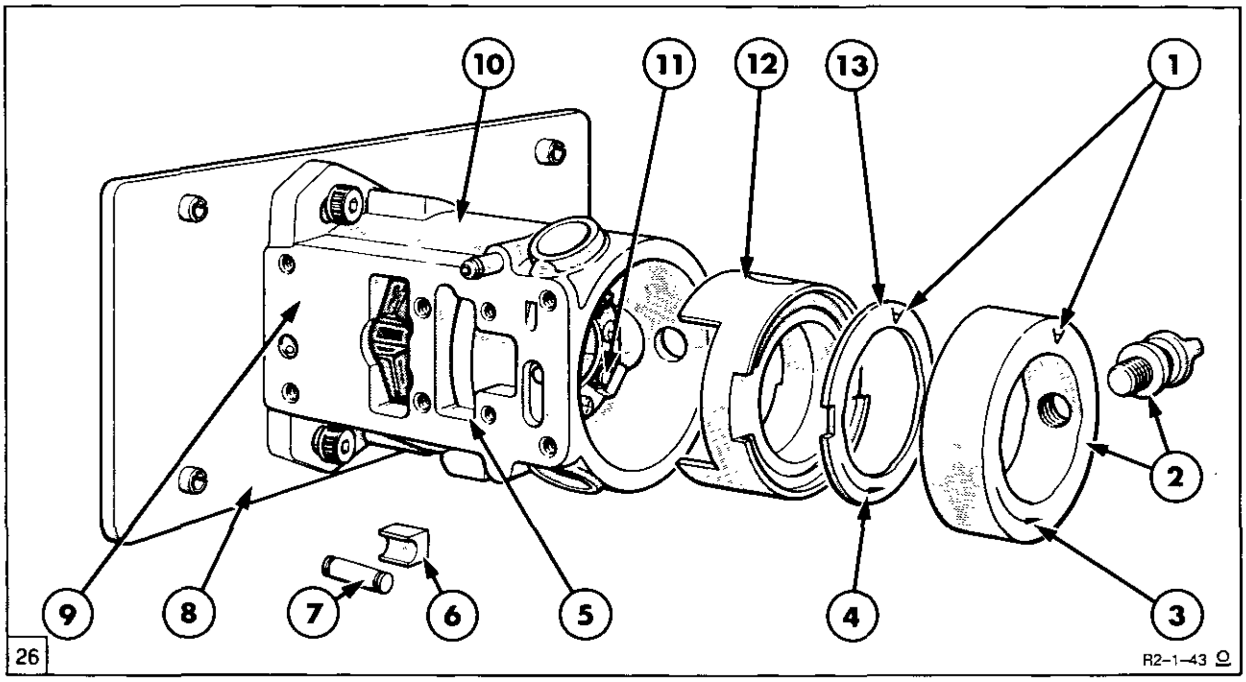
NOTE: *The cam and scroll plates are a matched set and can be identified by a grade letter etched on the side of the ring and plate.*

7. Ensure that the scroll plate rotates freely and position the notch in the plate mid–way between the cut–away section in the rear bearing.

8. Fit the cam ring with the arrow facing in the same direction as the arrow on the pump plate, Figure 26. Align the threaded hole in the ring, with the automatic advance aperture in the housing.

9. Fit the cam advance screw into the cam ring, finger tight.

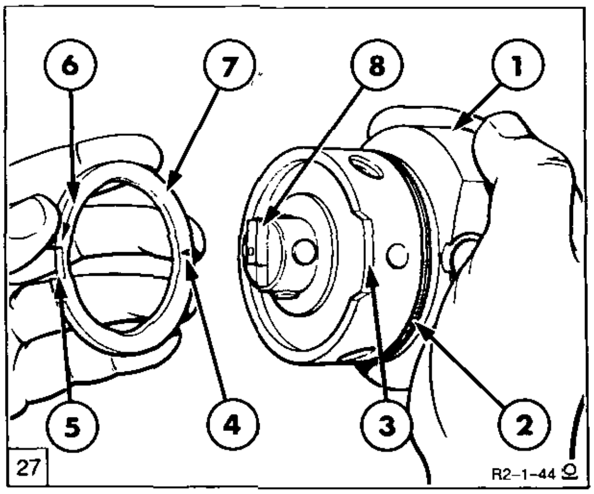
NOTE: *Do not at this stage fit the rear scroll plate to the pump housing, this should be assembled with the hydraulic head.*



Exploded View of Front Scroll Plate and Cam Ring

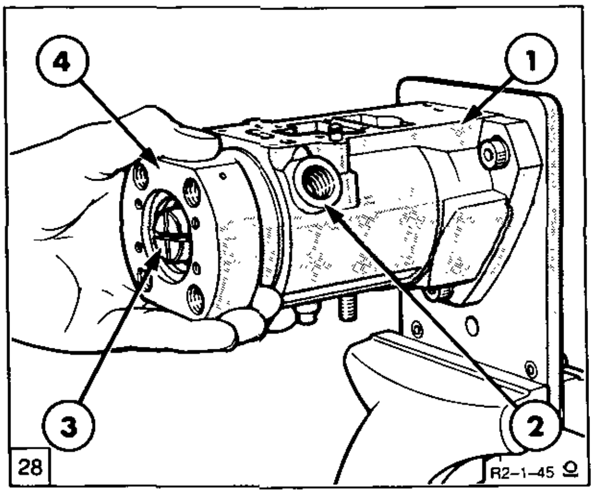
1. Matching Letters
2. Cam Ring and Cam Advance Screw
3. Direction Arrow Cam Ring
4. Direction Arrow Scroll Plate
5. "T" Shaped Aperture
6. Shoe } Matched
7. Roller } Matched
8. Mounting Plate
9. Pump Governor Control Plate
10. Pump Housing
11. Shoe and Roller Assembled in Drive Head
12. Rear Bearing
13. Front Scroll Plate

Hydraulic Head



Rear Scroll Plate Installation

1. Hydraulic Head
2. 'O' Ring Seal
3. Cut Away Section in Hydraulic Head
4. Matching Letter
5. Notch in Scroll Plate
6. Direction Arrow Scroll Plate Rotation
7. Rear Scroll Plate
8. Rotor Tang



Hydraulic Head Installation

1. Pump Housing
2. Latch Valve Aperature
3. Rotor
4. Hydraulic Head

1. Fit a new rubber 'O' ring into the groove in the hydraulic head and assemble the head into the pump housing as follows:–

2. Turn the mounting fixture in the vice so that the governor cover machined face on the pump housing is uppermost, Figure 28.

3. Remove the plastic plunger retainer from the motor tang.

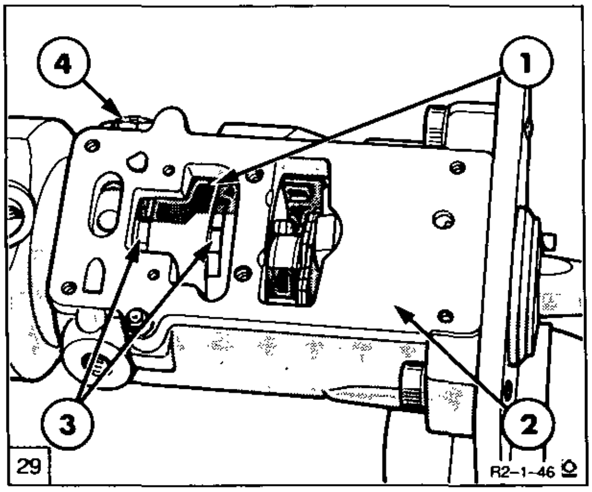
4. Using a suitable pair of tweezers move the shoe assemblies to their innermost positions.

5. Check the position of the tang slot location in the drive shaft and align the tang on the rotor to correspond.

6. Smear clean test oil on the portion of the hydraulic head that fits into the pump housing and keeping the rotor steady with thumb to prevent rotation, insert the head into the housing with a rotating motion, Figure 28. Rotating the head during assembly will facilitate entry and prevent possible damage to the head.

NOTE: *When fitted check the tang drive has engaged fully by ensuring that the transfer pump rotor is in the innermost position, that is, nearest to the head sleeve and flush with the rear face of the hydraulic head.*

7. Align the holes in the hydraulic head for the latch valve and head locating bolt with the respective holes in the pump housing. In this position the metering valve ports should be uppermost.



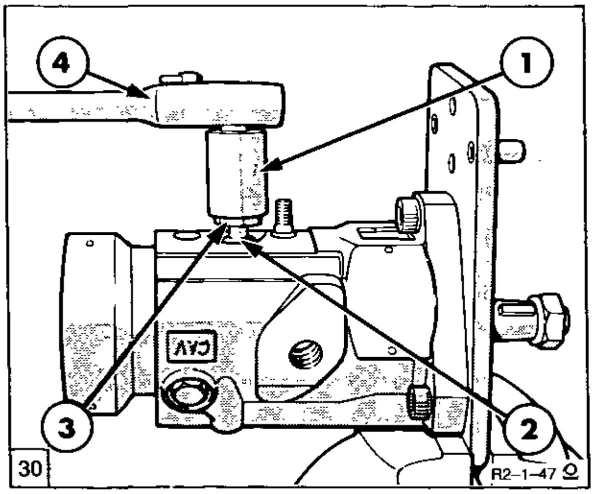
Scroll Plate Alignment

1. "T" Shaped Aperture
2. Governor Cover Machined Face
3. Scroll Plates
4. Head Locating Bolt

8. Ensure that the notches in the scroll plates are positioned between the "T" shaped aperture in the governor cover machined face, Figure 29.

9. Fit a new copper sealing washer then install the head locating bolt, Figure 29, into the pump housing and tighten to 170 lbf in (19.0Nm) 2.0 kgf m.

Automatic Advance Housing Assembly



Tightening Cam Advance Screw

1. Socket
2. Cam Advance Screw
3. Socket Adaptor Tool No. 7244–125B
4. Wrench

1. Invert the pump fixture so that the cam advance screw is uppermost.

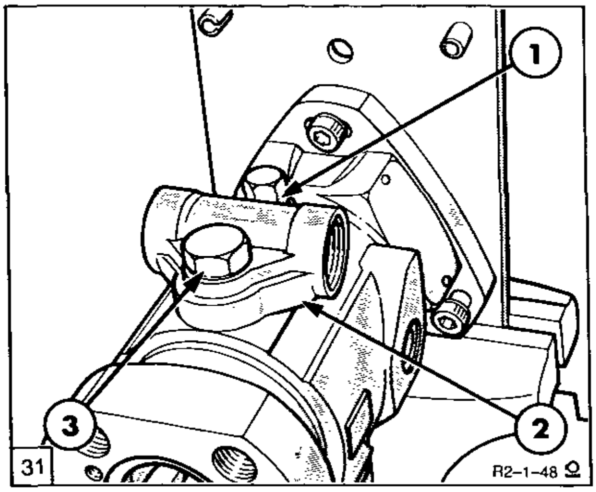
2. Using the socket adaptor Tool No. 7244–125B, Figure 30. Tighten the cam advance screw to 450 lbf in (51.0Nm) 5.2 kgf m.

3. Remove the tool, check for freedom of movement and if the cam ring is binding, lightly tap the cam advance screw to ensure the cam ring is free in the pump housing.

4. Using the protection sleeve Tool No. 7044–897, fit two new rubber 'O' rings to the head locating fitting. Fit the steel ball on its seating in the fitting and insert the assembly into the auto–advance housing to retain the ball.

5. Fit a new gasket to the automatic advance housing.

NOTE: *The piston and auto–advance housing are a matched pair.*



Exploded View of Advance Housing

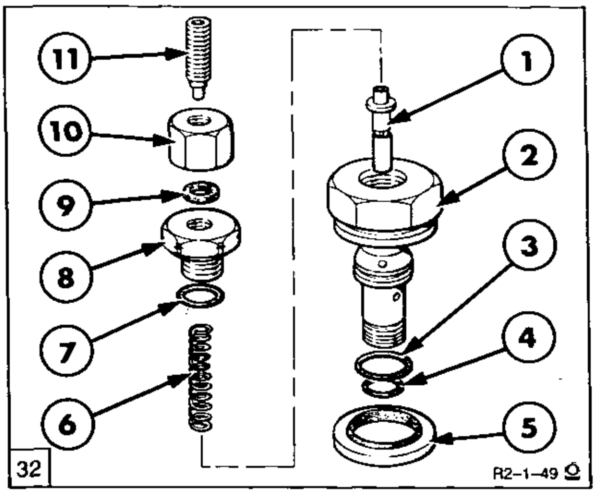
1. Cap Nut
2. Advance Housing
3. Head Locating Fitting

6. Check that the blank (pressure) end of the piston is towards the oil feed drilling end of the housing and fit the advance unit to the pump housing. By engaging the bore in the piston with the cam advance screw, finger tighten the head locating fitting, Figure 31.

7. Fit a new copper sealing washer to the housing stud and screw on the cap nut finger tight.

8. Invert the mounting fixture in the vice so that the pump governor cover machined face on the pump is uppermost.

Latch Valve



Exploded View of Latch Valve

1. Valve
2. Valve Body
3. 'O' Ring seal
4. 'O' Ring seal
5. Dowty Washer
6. Valve Spring
7. 'O' Ring Seal
8. Seal Nut
9. Rubber Washer
10. Locknut
11. Adjuster

NOTE: *When new the valve and body of the latch valve are supplied as a matched assembly fitted with plastic protection caps to retain the valve in situ.*

1. If new, remove the plastic plugs from the latch valve and assemble as follows referring to, Figure 32.

2. Screw the adjuster into the locknut and leave several threads exposed at the top of the nut. Fit a new rubber washer into the recess provided in the locknut.

3. Using the protection sleeve, Tool No. 7144–18, fit two new rubber 'O' rings to the valve body. Using the protection sleeve Tool No. 7144–458C, fit a new rubber 'O' ring to the sleeve nut.

4. Fit the latch valve and body with a new "Dowty" seal into the 2 o'clock position in the pump housing when viewed from the rear end of the pump.

5. Tighten the valve body to 170 lbf in (19.0Nm) 2.0 kgf m. With a suitable pair of tweezers, check for free movement of the valve in the valve body.

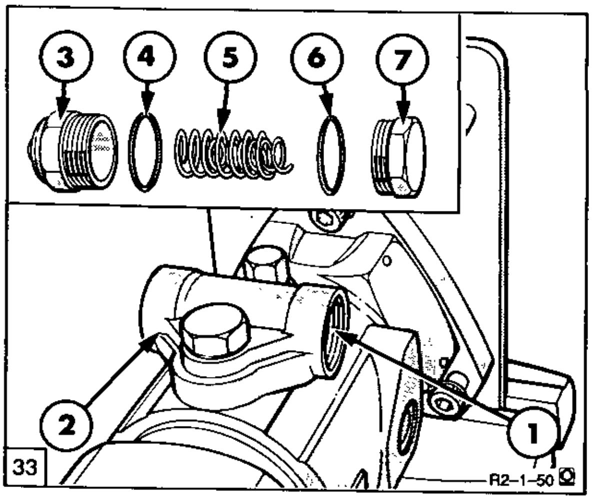
6. Screw on the sleeve nut then fit the spring against the valve.

7. Engage the stem of the adjuster with the spring and screw the adjuster and locknut into the sleeve nut. Tighten the sleeve nut to 140 lbf in (15.6Nm) 1.6 kgf m, followed by the adjuster locknut and tighten to 40 lbf in (4.5Nm) 0.45 kgf m.

Automatic Advance and Start Retard Unit

1. Progressively and evenly tighten both the head locating fitting and cap nut. Tighten the fitting and the cap nut to 130 lbf in (15.0Nm) 1.5 kgf m. Check that both cam ring and piston move freely.

2. Fit the remaining parts of the advance unit as follows, referring to Figure 33.



Exploded View of Advance Housing Components

1. Piston Plug Position
2. Spring Cap Position
3. Spring Cap
4. 'O' Ring Seal
5. Springs (3 off)
6. 'O' Ring Seal
7. Piston Plug

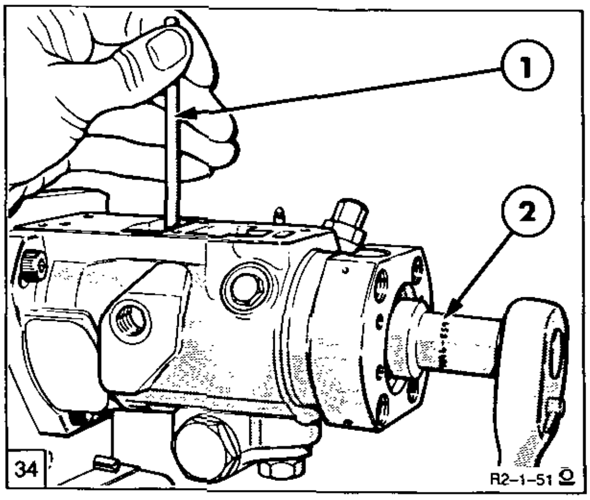
3. Using the Protection Sleeve, Tool No. 7044–898 over the threads of the piston plug (7), fit a new rubber 'O' ring. Screw the piston plug into the advance housing and tighten the plug to 250 lbf in (28.0Nm) 2.9 kgf m.

4. Using the Protection Sleeve, Tool No. 7044–898, fit a new rubber 'O' ring over the threads of the spring cap (3).

5. Fit the advance springs into the piston and screw the spring cap into the housing.

6. Using a suitable socket tighten the spring cap to 250 lbf in (28.0Nm) 2.9 kgf m.

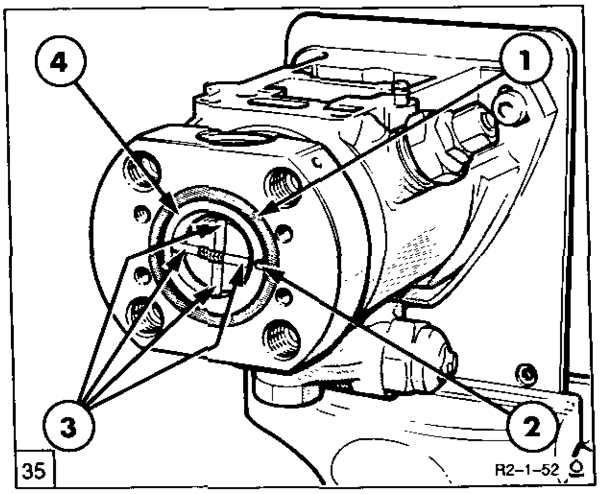
Transfer Pump



Tightening Transfer Pump Rotor
1. Tommy Bar
2. Box Spanner Tool No. 7044–898

1. To prevent the drive shaft from turning, insert a suitable tommy bar of 0.157 in (4mm) diameter through the front aperture in the pump housing and through the hole in the drive shaft, referring to Figure 34.

2. Insert the special box spanner, Tool No. 7044–889, into the slots in the transfer pump rotor and tighten the rotor to 65 lbf in (7.3Nm) 0.75 kgf m.



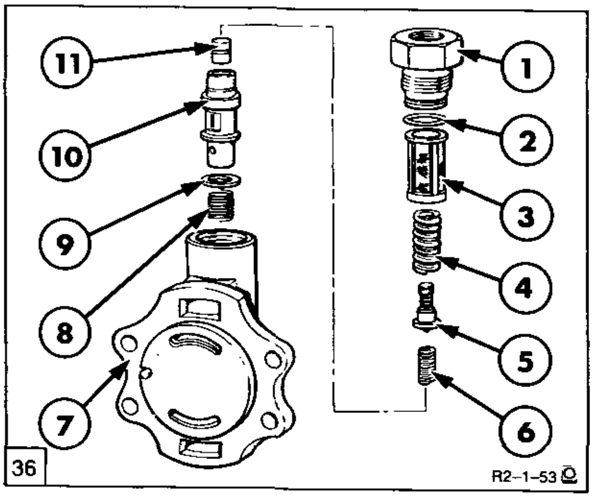
Transfer Pump Components
1. Rubber Seal
2. Rotation Slot
3. Transfer Pump Blades
4. Pump Eccentric Liner

NOTE: *The transfer pump rotor must be tightened in the opposite direction to the pump rotation.*

3. Ensure when the rotor is fitted that the transfer pump blades (3), Figure 35, all slide freely in the slots of the rotor and then remove.

4. Before assembling the transfer pump liner into the hydraulic head ensure that the direction of the rotation slot in the side of the liner is positioned correctly at 3 o'clock when viewed from the rotor end.
5. Insert the liner into the hydraulic head. Dip the transfer pump blades in clean test oil and insert the blades and springs into the slots of the transfer pump rotor. Check again that the blades move freely.
6. Lubricate the transfer pump rubber sealing ring with clean test oil and fit into the recess between the liner and the hydraulic head.

End Plate and Regulating Valve Assembly

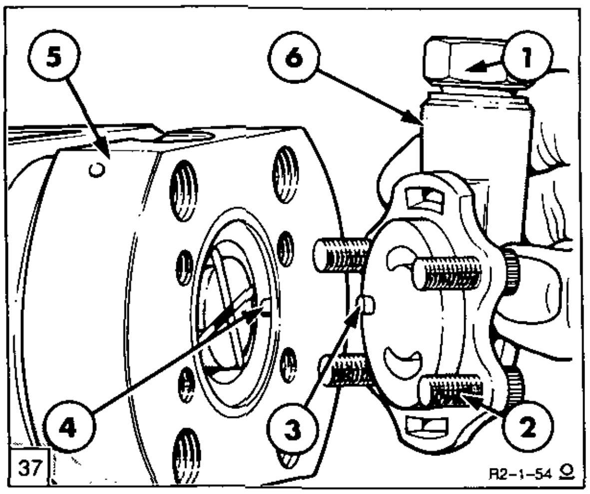


End Plate and Regulating Valve Components

1.	Inlet Connection	6.	Spring and Peg
2.	'O' Ring Seal	7.	End Plate
3.	Filter	8.	Priming spring
4.	Spring	9.	Sealing Washer
5.	Transfer Pressure Adjuster	10.	Regulating Sleeve
		11.	Regulating Piston

1. To assemble the regulating valve, Figure 36, hold the end plate (7) and insert the priming spring (8) into the well of the end plate. Fit a new sealing washer to the small diameter end of the regulating sleeve (10) and hold the sleeve with the sealing washer end down, block this end of the sleeve with a finger.
2. Insert into the open end of the sleeve the regulating piston (11), spring and peg assembly (6) with peg uppermost, followed by the transfer pressure adjuster (5).
3. Fit the sleeve retaining spring to the flange of the adjuster and to retain the complete assembly, push the filter into position against the shoulder of the regulating sleeve.
4. Hold the assembly in a horizontal plane and with the end plate similarly aligned, slide the complete assembly into the end plate.

5. Screw in the inlet connection complete with new 'O' ring seal into the end plate finger tight.



End Plate Installation

1. Inlet Connection
2. Hexagon Screw
3. Dowel
4. Slot
5. Hydraulic Head
6. End Plate

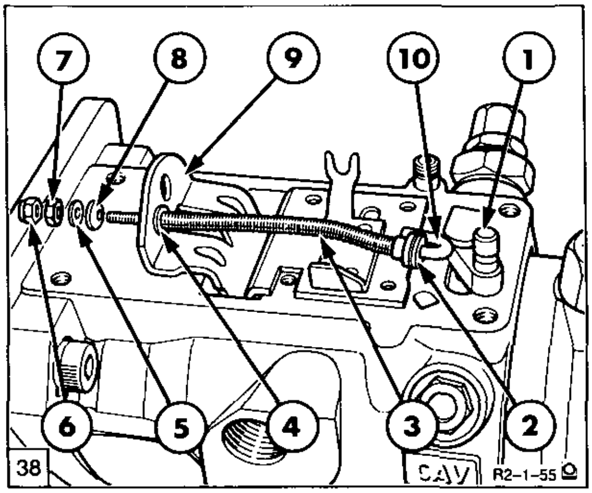
6. Fit the end plate assembly, Figure 37, with the fuel inlet connection uppermost onto the hydraulic head ensuring that the dowel on the inner face of the end plate engages with the slot in the transfer pump liner.

7. Fit the four hexagon screws to the end plate whilst rotating the drive shaft to ensure that the drive remains free, tighten the screws carefully in diagonal sequence to 45lbf in (5.0Nm) 0.5 kgf m.

8. Tighten the fuel inlet connection to a torque of 520 lbf in (50Nm) 6.0 kgf m.

Governor Arm Control Bracket Assembly

1. Assemble the governor spring linkage components, Figure 38, on to the linkage hook in the following order:–



Governor Spring Linkage Components

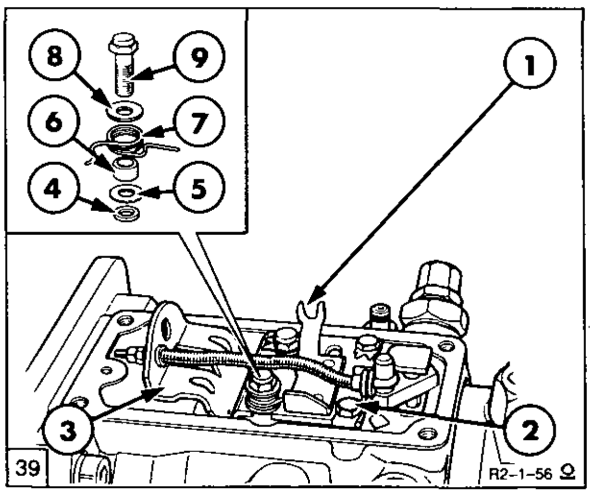
1. Metering Valve
2. Spring Retainer
3. Spring
4. Washer
5. Washer
6. Locknut
7. Linkage Nut
8. Pivot Ball Washer
9. Governor Arm
10. Linkage Hook

2. Spring retainer large end first, long linkage spring and fibre washer. Pass the linkage hook through the small hole in the governor arm and continue assembling the pivot ball washer, washer, linkage nut and locknut.

3. Insert the metering valve into the metering valve bore in the hydraulic head.

NOTE: *Before assembling the control arm and bracket, check that the notches in the front and rear scroll plates are centrally positioned between the "T" shaped aperture in the pump housing as shown, Figure 29.*

1. Ensure that the step on the governor thrust sleeve is uppermost.



Governor Control Bracket

1. Link Plate
2. Screw
3. Governor Arm
4. Spacer
5. Washer
6. Sleeve
7. Spring
8. Washer
9. Screw

2. Engage the control bracket with the governor arm and position into the pump housing by placing the toes at the lower end of the governor arm on top of the step on the governor thrust sleeve. At the same time, align the legs on the link plate to engage with the notches in the scroll plates.

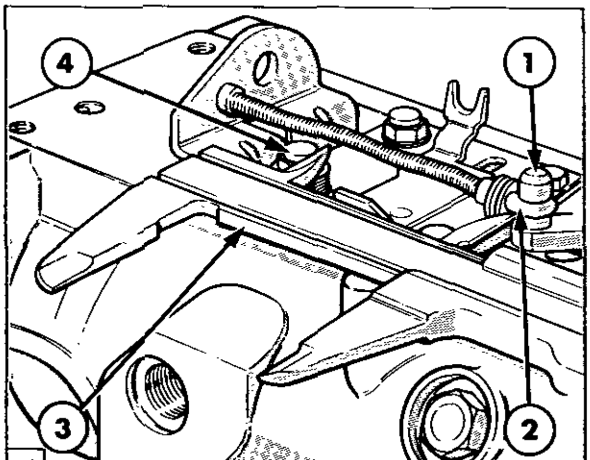
3. Position new tab washers on the control bracket. Screw in the hexagon headed screws and tighten to 20 lbf in (2.3Nm) 0.23 kgf m. Lock all tab washers by bending them over the screw heads.

4. Assemble the link plate spring, washers and sleeve onto the retaining bolt and install the bolt into the housing, refer to inset Figure 39, tighten to 20 lbf in (2.3Nm) 0.23 kgf m.

5. To tension the spring, hook the short leg of the spring behind the stud and abut the link in the long leg of the spring against the inner tongue on the link plate.

6. Attach the metering valve to the hook as illustrated and ensure that the linkage moves freely.

To Set The Governor Linkage



Setting The Governor Linkage

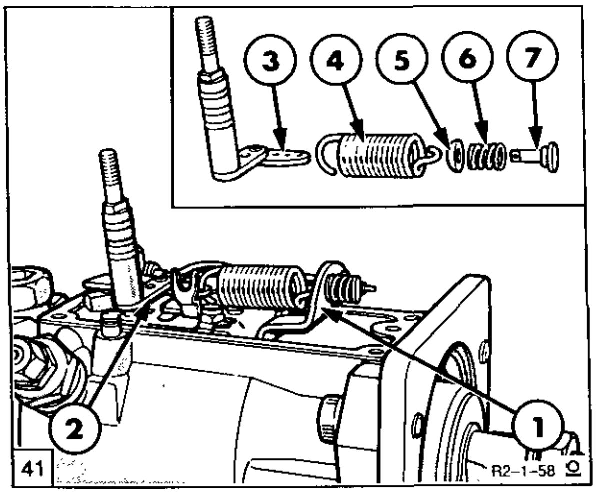
1. Metering Valve Linkage Pin
2. Linkage Hook
3. Vernier Gauge
4. Control Bracket Retaining Bolt

1. Set the linkage length using a vernier gauge as shown in Figure 40, so that the correct dimension as stated on the Test Plan, see "Section G", is obtained, measured inside between the diameters of the link plate stud and the metering valve linkage pin.

2. When setting ensure that the vernier gauge is held as shown in Figure 40 and apply a light pressure to the governor arm to hold the metering valve in the fully open position. Ensure that the measuring caliper does not enter the hook location groove on the metering valve pin. The opposite leg of the caliper should engage the rounded portion above the hexagon stud. Slacken the locknut and adjust the adjuster nut.

3. After setting, tighten the linkage locknut to 20 lbf in (2.3Nm) 0.23 kgf m.

Throttle Shaft



Throttle Shaft and Governor Main Control Spring

1. Governor Control Arm
2. Throttle Shaft
3. Throttle Shaft Link
4. Governor Main Spring
5. Pivot Ball Washer
6. Idling Spring
7. Idling Spring Guide

1. Fit the protection sleeve, Tool No. 7244–458C over the threads of the throttle shaft and slide the new rubber 'O' rings into position on the shaft.

2. Install the idling spring onto its guide and press the guide through the hole in the governor control arm. Secure by fitting the governor main control spring to the guide, Figure 41.

3. Connect the free end of the governor main control spring to the throttle shaft link.

4. Fit the governor control cover gasket to the pump housing, ensuring that the holes align with those in the pump housing.

5. Fit the protection sleeve, Tool No. 7144–458C over the fuel shut–off shaft and slide the new 'O' rings into position on the shaft.

6. Insert the fuel shut–off lever through the bore in the control cover and push into position.

7. Fit the cap washer to the fuel shut–off lever shaft. Assemble the return spring to the fuel shut–off lever then assemble the lever and spring onto the lever shaft and retain the lever with the hexagon headed screw, tighten to 30 lbf in (3.4Nm) 0.35 kgf m.

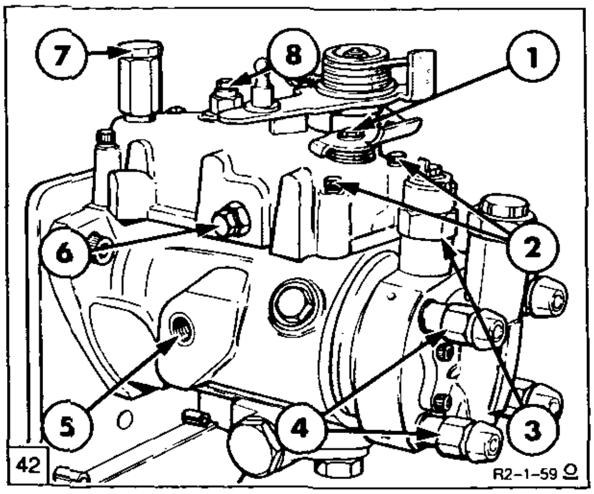
8. Insert the throttle shaft through the bore in the control cover and push the shaft into position.

9. Install the excess fuel device piston into the control cover.

10. Lower the cover towards the pump housing and at the same time depress the excess fuel piston whilst holding the link plate in the excess fuel position with a screwdriver, to engage the excess fuel shaft with the link plate.

11. Insert the four hexagon socket screws with washers into the governor control cover and using a suitable allen wrench, tighten the four screws uniformly to 35 lbf in (4.0Nm) 0.4 kgf m.

Maximum Fuel Adjustment Screw



Governor Control Cover Components

1. Fuel Shut–Off Set Bolt
2. Governor Cover Screws
3. Solenoid Shut–Off Valve
4. Delivery Valves
5. Drain Plug
6. Maximum Fuel Adjustment Screw
7. Pressurising Valve
8. Vent Screw

1. Screw the adjuster into the locknut, Figure 42 and fit a new rubber washer into the recess in the locknut.

2. Screw the adjuster into the governor control cover, Figure 42, approximately halfway down the threads on the screw and tighten the locknut to 30 lbf in (3.4Nm) 0.35 kgf m.

Delivery Valves

1. Insert new sealing washers into the high pressure outlet bores and install the delivery valve assemblies into the bores. Tighten the delivery valves to 360 lbf in (41.0Nm) 4.1 kgf m.

Throttle Lever Assembly

1. Pull the throttle shaft fully upwards into the control cover.

2. Fit the cap washer over the throttle shaft onto the boss of the cover. Assemble the throttle lever, break back spring and spring guides, then install over the throttle shaft.

3. Fit the plain washer onto the throttle shaft and install the locknut, tighten to 40 lbf in (4.5Nm) 0.45 kgf m.

4. Fit the maximum speed screw and secure with the locknut. Fit the idle adjustment screw to the governor control cover and secure with the locknut.

5. Using the protection sleeve, Tool No. 1804–429, fit the sealing washer to the drain plug and screw the plug into the pump. Tighten the drain plug to 40 lbf in (4.5Nm) 0.45 kgf m.

Excess Fuel Device

1. Slide a new 'O' ring seal onto the excess fuel device plug. Install the plug into the governor control cover and retain with the snap ring.

Solenoid Shut–Off Valve

1. Install a new rubber 'O' ring on to the solenoid body using protection cap, Tool No. 7044–897. Insert the spring into the solenoid plunger and place the solenoid body over the spring plunger assembly.

2. Screw the solenoid assembly into the hydraulic head and tighten the solenoid to 250 lbf in (28.0 Nm) 2.9 kgf m.

Pressurising Valve

1. Install the pressurising valve with a new sealing washer into the governor control cover and tighten to 180 lbf in (20.0Nm) 2.0 kgf m.

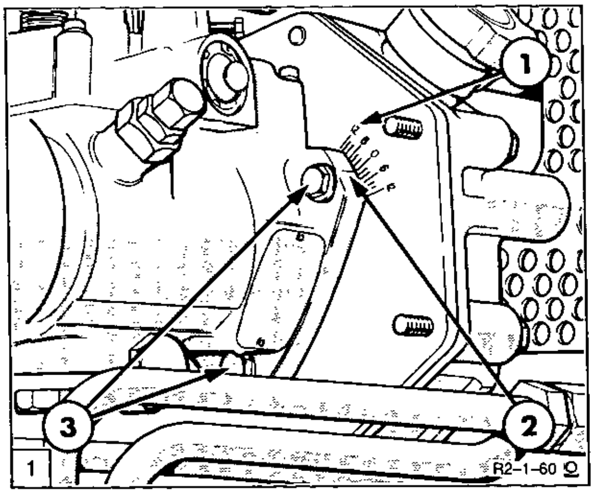
Vent Screw

1. Fit the vent screw with a new copper washer and screw into the governor control cover. Tighten the vent screw to 40 lbf in (4.5Nm) 0.45 kgf m.

INJECTION PUMP TIMING

In production the setting of the distributor type fuel injection pump to engine timing involves the use of specialised equipment, which eliminates the effects of backlash in the timing gears. The removal of backlash in the timing gears effectively advances the timing by 2 degrees.

IMPORTANT: *Injection pump to engine timing cannot be checked by alignment of the scribed line on the pump flange with the zero degree mark on the rear of the engine front plate. The timing can only be established by internal timing of the pump after removal from the tractor. Refer to "Timing the Injection Pump" in FUEL INJECTION PUMP TEST PROCEDURES – "Section E" of this Chapter.*



Fuel Injection Pump Timing Mark

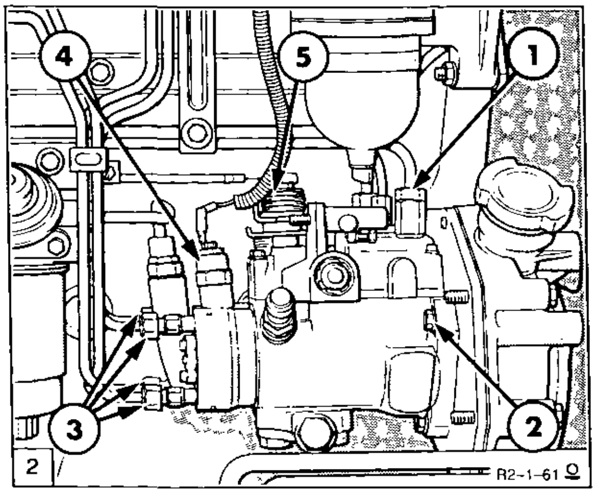
1. Timing Marks on Engine Front Plate
2. Scribe line on Injection Pump
3. Injection Pump Retaining Bolts

To eliminate the effects of timing gear backlash when installing an internally timed pump, advance the engine timing 2 degrees by rotating the pump clockwise (as viewed from the rear end) half a division relative to the zero degree mark on the rear of the engine plate, Figure 1.

If the pump is not to be internally timed then prior to removal note the setting of the pump relative to the zero degree mark on the rear of the engine front plate. Mark the plate with a centre punch to align with the pump flange scribed line.

This mark may be used as a reference point to which the original, re–conditioned or new pump should be set on installation.

INSTALLATION



Fuel Injection Pump Installation

1. Fuel Retain Line
2. Pump Retaining Bolt
3. Injector Lines
4. Fuel Shut–Off Solenoid
5. Throttle Linkage

1. After testing and adjusting the pump to give the correct fuel deliveries, refer to Specifications "Section F". Install a new pump to front engine plate 'O' ring on the pump mounting flange.
2. Install the three injection pump to engine front plate mounting bolts.

If the pump has been internally timed, rotate the pump clockwise as viewed from the rear end, half a division relative to the zero degree mark on the rear of the engine front plate.

If the pump has not been internally timed, align the scribed line on the pump flange with the centre punch reference mark previously made on the rear of the engine front plate. Tighten the mounting bolts to 20 lbf ft (27.0Nm) 2.7 kgf m.

3. Install the pump drive gear, aligning the gear with the woodruff key on the pump drive shaft. Also ensure that the drive gear timing mark aligns with the gear timing mark.
4. Install the lockwasher and retaining nut to the pump drive shaft and tighten to 58 lbf ft (79.0Nm) 7.9 kgf m.
5. Position a new inspection cover gasket and install the inspection cover to the engine front cover, tighten the retaining bolts to 18 lbf ft (25.0Nm) 2.5 kgf m.
6. Connect the fuel lines to the injection pump, Figure 2 and tighten to 20 lbf ft (27Nm) 2.7kgf m.

7. Reconnect the throttle and fuel shut–off controls to the injection pump.

8. Reconnect the bottom radiator hose and tighten the retaining clamps to 18 lbf ft (24.4Nm) 2.5 kgf m and refill the coolant system, refer to operators manual for correct specifications.

9. Turn on the fuel supply and prime the *system using the hand primer mounted* on the fuel filter assembly. Start the tractor and adjust the engine idle and maximum no load speeds, see "Adjustments Fuel Injection Pump".

INJECTION PUMP STORAGE

If after overhaul an injection pump is being stored, the body should be left filled with calibrating oil and all the connections sealed with dust plugs and caps.

If the pump is stored for a period of six months or more, the unit should be re–tested according to the test plan before use in service.

D. FUEL INJECTION PUMP – ISO TEST CONDITIONS

INTRODUCTION: THE NEED FOR ISO

As Government legislation on power, smoke and noise emissions become ever more stringent, manufacturers of fuel injection equipment are faced with the necessity of more accurate measurements and tests for their products.

With the additional objectives of reducing discrepancies between test machines of different manufacturers and improving the correlation between test machine results and engine performance, the International Standards Organisation (ISO) has drawn up new standards for pump test conditions.

The ISO Committee is made up of members from the standards organisation of each country concerned, plus representatives from interested companies including Lucas CAV Limited.

The most noticeable change is the adoption of a test fluid of a lower viscosity, nearer in characteristics to diesel fuel and conforming to ISO Standard 4113. Further ISO Standards relate to the high pressure pipes, test injectors, delivery measurement system, test bench drive and coupling, anti backlash requirements and various other conditions.

Although these standards are not a legal obligation they may be adopted into the legislation of any country where they are practiced.

The accompanying Explanatory notes for "DPS" distributor pumps are typical of those which will be issued for use with all fuel injection pumps manufactured by Lucas CAV Limited. The notes have been written in accor*dance with the conditions set down by the* International Standards Organisation.

Copies of relevant ISO Standards are available from the National Standards Body of each individual country concerned.

EXPLANATORY NOTES (ISO TEST–CONDITIONS) FOR "DPS" DISTRIBUTOR PUMPS

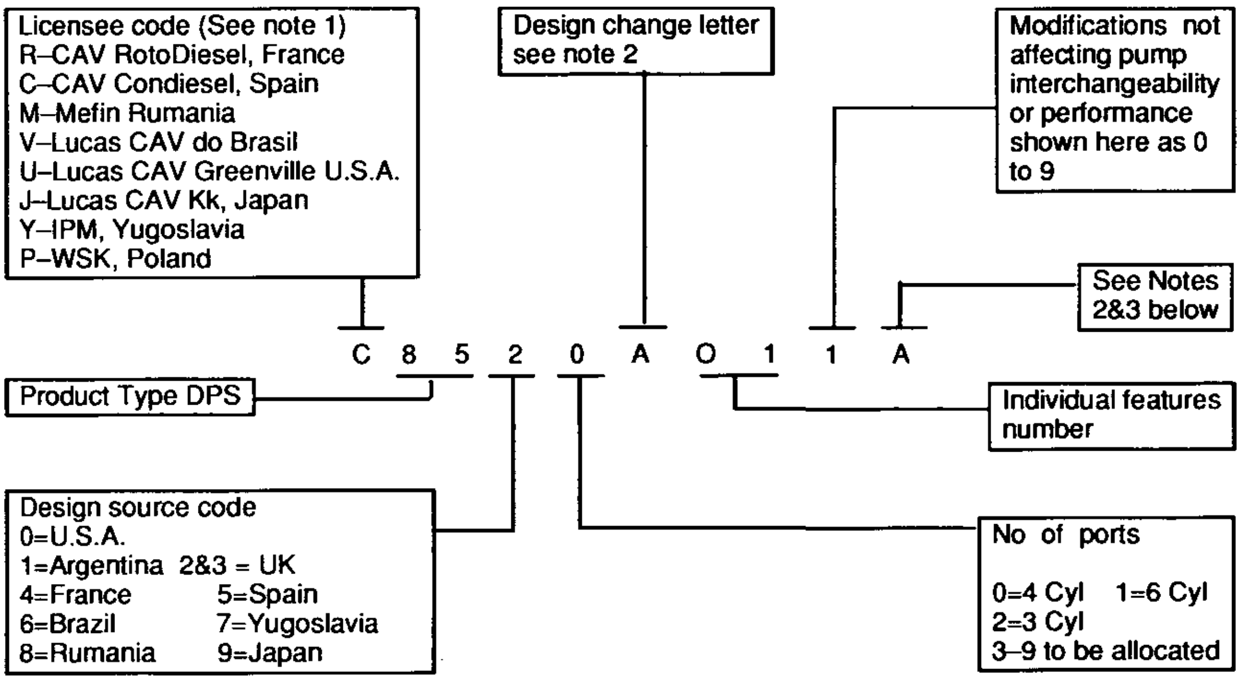
Fuel Pump Test Plans should be used in conjunction with the appropriate Ford Tractor Repair Manual. When tests are superseded the revised information will be distributed under a new issue Service Bulletin.

Test Plans are NOT specification information and must not be used as such.

Test Plans are issued for every pump specification except when two or more pumps form a group applicable to one engine and the pump detail variations do not create any change in the test figures. Related pumps of this type may all be covered by one test plan.

NOTE: *Successive design changes may also be covered by a single Test Plan if they conform to the above rule.*

DPS DISPATCH NUMBER SIGNIFICANCE



NOTE 1, Lucas CAV, Medway, U.K. pumps do not have a code letter.

NOTE 2, The intermediate and suffix letters "A" are an integral part of the pump dispatch number, but at this stage have no significance. The first significant change letter to be used will, therefore, be the letter "B".

NOTE 3, The suffix letter may be used where the change in engine application requires a change in positional fit of external parts. It may also be used to identify a setting code to facilitate Parts and Service administration on coded pumps that have been set and sealed at manufacturing source, should this become a future requirement as a result of legislation.

TEST MACHINE SPECIFICATION

Test Injectors

1. Injectors fitted with orifice plates (ISO 7740*), are principally for direct injection engine applications for testing distributor pumps

Test Injectors are available from Leslie Hartridge, United Kingdom in sets of 4, 6, 8, or 12. The appropriate part number is dependent on the test nozzle required and the test machine type.

These injectors are essential for accurate pump calibration and are manufactured to a standard which will ensure minimum line to line scatter, consistent results between sets and accurate maximum fuel setting. ENSURE THAT TEST NOZZLE TYPE AND OPENING PRESSURE ARE AS SPECIFIED IN THE INDIVIDUAL TEST PLAN, for example, delay pintle type ISO 4010 at 172–0 + 3 bar opening pressure (identified by ISO 4010 marked on their shank).

The use of the ISO nozzle means that test injectors can be serviced in the workshop by changing the nozzles only. Test nozzles are available from Leslie Hartridge in sets of 6 or 8.

NOTE: *Test injectors should be checked as follows:–*

Weekly or every 100 pumps– check and reset open pressure. Check seat leakage, nozzle back leakage and replace nozzle where appropriate.
Every 1,000 pumps– replace the test nozzle.

High Pressure Pipes

Refer to the individual pump test plan.

Pipes to conform to the requirements of ISO 4093, viz.

1. The pipes may be of any ferrous material, usually cold drawn mild steel and shall have a smooth internal bore, free from any cracks or other structural weaknesses and from corrosion or other matter likely to cause damage to the fuel injection system.

2. After making the end connections, any closing in of the pipe shall be removed by inserting a reamer of the nominal internal diameter of the pipe, to a depth at least twice that of the length of the deformed end of the pipe. Any closing in of the ends after extended use shall also be eliminated in a similar manner.

3. The radius of any bend subsequently made in fabricating the pipes shall not be less than 16mm for 6mm pipes, measured from the centre line of the pipe.

4. Pipes shall be washed internally after the making of ends and bending in order to remove extraneous matter.

For storage the ends shall be sealed to prevent inlet of air in order to avoid internal corrosion.

Dimensions

The standard dimensions of high pressure pipes Reproduced from ISO 4093, by kind permission of ISO Geneva, are:–

ISO IDENTIFICATION	INTERNAL DIAMETER	EXTERNAL DIAMETER	LENGTH
ISO 4093.1	2 ± 0.025	6	600 ± 5
ISO 4093.2	2 ± 0.025	6	845 ± 5

Refer to the individual pump test plan for high pressure pipe requirement.

Fuel delivery can be seriously affected by restrictions in the bore or length of pipe. Regular checks should be made to ensure that no closure of the bore occurs in use and that bore ends are maintained at not less than 0.025mm below the nominal size. Shortening of the pipe (to reform a nipple) is only permissible if pipe length remains within the tolerance of the specified length.

Pump Outlet Connections

All tests are to be made using high pressure outlet connections as originally fitted to the pump unless stated otherwise on the Test Plan.

Measuring Glasses

Fuel readings are to be taken in accordance with the test bench manufacturers recommendations (see delivery values). Glasses should be cleaned regularly to ensure accurate and consistent readings.

On some older models of test machine, the graduations may be marked in cc's. On the newer test machines, the equivalent units of ml or cm^3 will be found.

Calibration Fluid (Test Oil)

Refer to the test plan for test oil requirement.

A PUMP SPECIFICATION WITH A TEST PLAN DEVISED ON ISO 4113 CALIBRATION FLUID MUST NOT BE TESTED ON A TRADITIONAL THICK FLUID WITH A VISCOSITY OF 6.5 TO 7.1 cSt AT 21°C.

The following oils conform to ISO 4113 and also meet an oxidation requirement to improve shelf life of fuel injection equipment.

Brugarolas (Spain) Califluid 2
Castrol Diesel Calibration Oil 4113
Dalton (UK) Viscor 1487
Shell (International) S.9365
Shell (France) Normafluid BR

These oils are not necessarily available in all countries and where difficulty is experienced you should contact your normal supplier, quoting the following specification. A sample must be submitted for approval by Lucas CAV Ltd, before commencing tests.

Oil Description

A refined deodorised mineral oil with anti–foaming additives and other additives to improve resistance to wear, aging and corrosion.

Physical Properties

Property	Unit	Requirement	Test Procedure
Colour		3 max	ISO 2049
Specific Gravity at 15°C		0.820–0.830	ISO 3675
Pour Point	°C	–18 max	1P15
Cloud Point	°C	–10 max	ISO 3015
Flash Point	°C	75 min	ISO 2719
Total Acidity	mg KOH/g	0.1 max	1P1
Sulphur Active		Class 1 max	ISO 2160
Water Content	% vol	0.05 max	1P74
Distillation	% vol	5 max at 210°C	ISO 3405
	% vol	95 min at 360°C	ISO 3405
Kinematic Viscosity			
A) at 40°C	cSt	2.45–2.75	ISO 3104
B) at $10^6 sec^{-1}$shear at –12°C	cSt	30 max	IP71
Choking Tendency Vx	Litres	454 min	7–2–66*
	Gallons	100 min	7–2–66*
Corrosion Resistance at 60°C		Pass 24 Hours	ASTM D665A
Rust Protection 50h with Polished Panels		Must pass 5 out of 6 faces of three panels	ASTM D1748
Aging Test Residue	mg/100ml	1.0 max	ASTM D2274
Oxidation Stability – Acidity	mg KOH/9	0.3 max	7–2–68*
Oxidation		Stability	
Sludge	% wt	Less than 0.05	7–2–68*
Foaming Tendency	ml	50 max	(ASTM–D892, (Seq 1 only
Foaming Stability	ml	nil	(in each case
Aromatic Components	%	11 max	(40–25–50*
CA value			(ASTM–D2140

*Lucas Standards

General

Test oil when in use in a test machine will not retain its physical properties indefinitely. It can become contaminated with fuel oil and due to evaporation of the light fractions its viscosity will increase, thus giving inaccurate results.

To reduce such contamination as much as possible, pumps which have been removed from an engine and not dismantled should be drained of fuel oil before being put on a test machine. Ideally the viscosity should be physically checked periodically and the oil changed when it varies from the limits quoted in the preceding specification.

NOTE: *In the absence of a viscosity check, it is recommended that the test oil should be changed at least every two months or after testing 150 pumps, whichever occurs soonest – more frequently where ambient temperature is high. Filters should be renewed at the same time.*

Test Oil Supply

To avoid fuel starvation and irregular pump behaviour the test machine should be able to support calibration fluid at 40°C, at a rate not less than 1.000 cm^3 per minute for a maximum feed pressure of 0.1 bar (1.5lbf in^2). It is an ISO requirement that the test machine should be capable of supplying at least the equivalent of two and a half times the delivery of the pump under test.

For the purpose of testing the Ford range of DPS pumps the supply pressure should be 0.1 bar (1.5 lbf in^2) unless otherwise stated on the test plan.

Temperature of Test Oil

Values given in Test Plans are correct when the oil in the test machine supply connection is at a temperature of 38–42°C. It is recommended that a temperature control unit is fitted to maintain the temperature.

Storage of Test Oil

Calibration fluid conforming to an ISO standard shall be obtained in sealed metal drums bearing two identification marks.

A) The manufacturers (or suppliers) name which shall vouch for conformity with the relevant ISO standard.

B) The ISO standard number to which the fluid conforms to.

Calibration fluid shall be retained, in its sealed original identifiable container, under cover until required for use.

Fluid shall be protected from severe frost (–10°C) at all times.

Reproduced from ISO 4008, by kind permission of ISO, Geneva.

Test Machines

CAV DPS distributor pumps must be tested on machines which conform to the dynamic (drive system) and static (fuel measuring system) requirements, as laid down in ISO 4008, Parts 1 and 2 respectively. The maximum power specified to drive any distributor pump under test, is 1.4 KW at a specified peak injection pressure of 625 bar.

Hartridge 2500 and 1150 test machines are recommended, as they meet the above requirements and are capable of testing the whole range of distributor pumps. Additionally, Hartridge 1100 and 875 test machines are suitable for testing pumps to be fitted to the Ford Tractor Range.

Fuel Pump Drive

Fuel delivery can be substantially affected by the backlash and/or stiffness of the test machine drive system. It is, therefore, important to limit these effects to ensure accurate fuel settings and reduce line to line scatter.

The drive couplings should have zero backlash and exhibit a torsional stiffness which allows less than 0.1° deflection under peak injection torque for the pump under test. Coupling manufacturers quote figures for coupling stiffness and corresponding maximum fuel delivery in mm³ stroke, according to ISO standard 4008/1.

The corresponding maximum fuel delivery in mm³/stroke should not be exceeded for any pump under test. If doubt exists about a couplings performance contact either the coupling manufacturer or CAV Parts and Service.

It is recommended that an anti–backlash coupling (Hartridge Kit HF 533) is used. On no account may flexible rubber or fibre disc type Oldham couplings be used as part of the drive system.

DELIVERY VALUES

To conform with the requirements of ISO 4008/2, all critical fuel delivery values are quoted in mm³/stroke (not cm³ per 200 strokes) on the Test Plan or on the pump nameplate. Using a simple conversion chart supplied by the test machine manufacturer, critical fuel deliveries can be related to the minimum filling requirements of the test machine graduates necessary to ensure accurate readings. This is introduced to minimise the errors due to the variations in the graduate capacities of different machines, count errors and glass drainage requirements.

The appropriate number of strokes in these cases should be determined in accordance with the test machine manufacturers instructions. Where NOT specified by the test machine manufacturer, the number of strokes taken should give at least 50% fill of the graduates. All other fuel readings should be taken over 200 strokes unless stated otherwise on the Test Plan.

When using Hartridge 1150, 1100, and 875 test machines the number of strokes chosen should give at least a 40% fill of the graduate with a single operation of the trip mechanism. Allow 30 seconds glass drainage time and let the test oil settle for 15 seconds before taking readings (unless the test machine is equipped with a piston in graduate measurement system, which enables readings to be taken directly). The bottom of the meniscus must always be used when taking fuel readings.

For Hartridge machines, conversion charts are included at the end of this chapter. These give directly the minimum number of strokes and corresponding cm³ value for each mm³/stroke value. However, critical fuel values can be determined as shown in the following examples:–

Example for Hartridge 1100 Mark 2

Method to determine the minimum number of strokes for a Test Plan critical fuel value of 25 mm³/stroke using a Hartridge 1100 test machine with 30 cm³ graduates.

Delivery for 100 strokes in,
$cm^3 = 25x100 \div 1000 = 2.5\ cm^3$

Hartridge 1100 should give at least a 40% fill of graduates, i.e. 40% of 30 cm^3 = 12 cm^3

Therefore, to achieve at least this fill, it will be necessary to use 500 strokes giving a delivery of 12.5 cm^3 with a single operation of the trip mechanism.

5 x 2.5 cm^3/100 strokes = 12.5 cm^3/500 strokes.

Similarly 60 mm^3/stroke requires 200 strokes giving 12 cm^3 and 30 mm^3/stroke requires 500 strokes giving 15 cm^3

Example of Hartridge 2500

Method to determine minimum number of strokes for a Test Plan critical fuel value of 30 mm^3/stroke using a Hartridge 2500 test machine with 60 cm^3 graduates.

Delivery for 100 strokes in,
$cm^3 = 30x100 \div 1000 = 3\ cm^3$

Hartridge 2500 should give at least a 25% fill of graduates, i.e. 25% of 60 cm^3 = 15 cm^3 Therefore, to achieve at least this fill it will be necessary to use 500 strokes, giving a delivery of 15 cm^3

Before commencing tests, unscrew the maximum stop screw and the idling stop screw to allow full movement of the throttle arm.

The throttle lever is to be fully open and the stop lever and solenoid stop valve in the "run" condition unless otherwise stated.

DO NOT run the pump for long periods with the shut–off lever closed, particularly at high speed.

Pump Adjustment

The maximum fuel adjustment screw should be screwed out initially to the protrusion value stated on the test plan. Final adjustment of maximum fuel must be carried out on the test machine.

Transfer Pressure Adjustment

Various end plate transfer pressure adjusting assemblies or sleeve plugs of different thicknesses can be used to vary the load on the regulating spring. Where this is applicable, it is stated on the Test Plan.

Governor Link Setting

Refer to "Overhaul–Section B" for the method of setting governor link length.

The link length is specified to satisfy two main factors for governor performance:–

1, Fuel cut–off at maximum speed.

2, Non–interference with fuel delivery at the maximum fuel setting.

Whilst most governors will operate satisfactorily with the nominal link length, some units fail for the above reasons and can be corrected by an alteration to the link length. The following procedure should, therefore, be adopted:–

A) Set to nominal link length before commencing test.

B) If unit fails for "no cut off at maximum governed speed", reduce link length.

C) If unit fails for maximum fuel interference, increase link length.

NOTE: *That incorrectly machined, worn or wrongly assembled parts can produce the same faults and alteration to link length, which may already be correct, will not necessarily effect a solution. Should adjustment to the link length fail to correct the fault, then this should be reset to the nominal length and the trouble looked for elsewhere.*

When adjustment to the governor link length has been made, the sequence of governor setting tests must be repeated and the test requirements satisfied. Adjustment must not be made beyond the specified tolerance.

Automatic Advance Devices

1. Before commencement of test ensure the correct thickness of shims is fitted to the advance assembly as stated in the relevant Test Plan. This should not be altered.
2. Tests are carried out strictly in order specified on the relevant Test Plan.
3. The maximum amount of shimming allowed must not be exceeded.

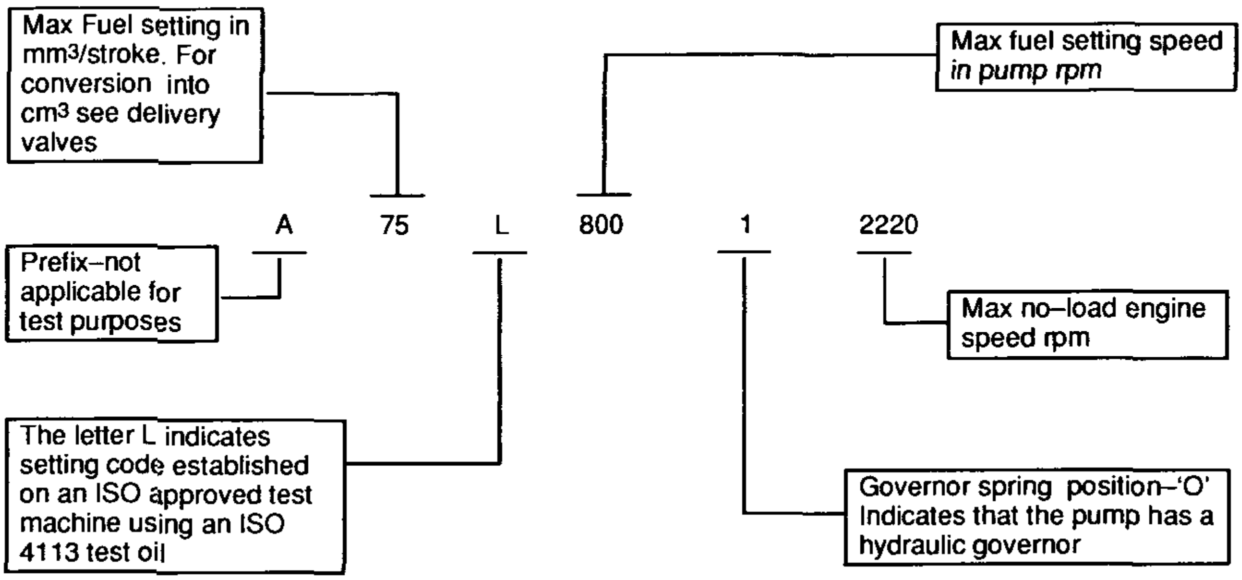
TEST PLANS FOR PUMPS WITH SETTING CODE ON NAMEPLATE

The following test data is not given on the Test Plan for coded pumps and must be obtained from the setting code on the nameplates:

Maximum fuel setting, maximum fuel setting pump speed, governor spring position on all speed mechanically governed pumps and maximum no load engine speed.

For pumps produced before the introduction of ISO standards, the setting code on the nameplate (unlettered code or "E" code) applies only to thick test fluid not conforming to ISO 4113. In these cases when testing with a thin fluid conforming to ISO 4113, The setting code must be disregarded and all necessary information extracted from the relevant ISO Test Plan or CAV dealer or Ford Test Plan (ISO) if available or issued.

Example of Setting Code



E. FUEL INJECTION PUMP–TEST PROCEDURE

1. Prior to installing the pump on the test bench the pump must undergo a pressure test before and after machine test, using the following method:–

A) Drain all fuel oil from the pump and connect a compressed air supply to both the back leak connection and the pump inlet connection.

B) Seal all other connections on the pump and immerse in a bath of clean test oil.

C) Ensure that the air supply to the pump is clean and free from water. Raise the air pressure to 20 lbf in^2 (1.4 bar) and leave the pump immersed in the test oil for 10 minutes. If the pump is leak free, reduce the pressure to 2.1 lbf in^2 (0.14bar) for 30 seconds, if the pump is still free increase the pressure to 20 lbf in^2 (1.4 bar) and if the pump is still leak free after 30 seconds it can be passed as satisfactory.

All leaks must be rectified before testing and setting the pump.

2. Test stand equipment must conform to the following requirements:–

A) The test machine must conform to ISO 4008 Parts1 and 2.

B) The test injectors must conform to ISO 4010.

C) The high pressure pipes must conform to ISO 4093, refer to the test plan for the pipe dimensions.

D) The test oil must conform to ISO 4113.

E) The test oil feed system must be temperature controlled at 40°C ± 2° with a maximum pressure feed of 1.5 lbf in^2 (0.1 bar).

3. Mount the pump on the test bench using a suitable bracket and install a quill shaft between the pump drive shaft and the test bench drive shaft.
4. The test machine must be set to run in the correct direction of rotation for the pump under test i.e clockwise.
5. The pump must not be allowed to run for long periods with low output and high speeds or with the fuel shut off closed.
6. Unless otherwise stated on the test plan, all tests are to be made using high pressure outlet connections as originally fitted to the fuel injection pump.
7. The pump must be primed thoroughly prior to testing and at all times indicated on the Test Plan using the following procedure:–

A) Connect the oil feed pipe to the inlet connection and connect the back leakage pipe.

B) Turn on the oil supply to feed pressure 1.5 lbf in^2 (0.1 bar) to fill the pump. Run the pump at 100 rpm.

8. Slacken the unions at the injector end of the high pressure pipe or if fitted on the test machine, open the bleeder valves at the injectors.
9. When test oil free of bubbles from all high pressure pipes re–tighten the high pressure connections or close the bleeder valves.
10. After priming the pump must be free from leaks at all jointing surfaces, connections and seals when running and when stationary.

TESTING PRESSURE

Injection pump testing must be conducted in conjunction with the Test Plan see Specification "Section G" and in accordance with the following procedure.

Note: *Before commencing tests, unscrew the maximum and idle stop screws to allow full movement of the throttle lever.*

The throttle lever and stop control lever must be fully open except where otherwise stated on the Test Plan.

Fuel Delivery

Fuel delivery is checked at full throttle, setting at one or more speeds of rotation by measuring the volume of test oil passing through each injector during a given number of pumping cycles. The Test Plan quotes the number of strokes, maximum fuel delivery, overall tolerance and the maximum permissible delivery variation between injectors.

Fuel Shut–Off

Fuel shut–Off operation is checked by running the pump at a specified speed, see Test Plan, with the shut off closed. The Test Plan quotes the maximum fuel delivery.

Maximum Fuel Delivery

The maximum fuel delivery is checked at the specified speed with the throttle lever fully open and the fuel shut–off lever open. Run the pump at the speed quoted on the Test Plan and note the fuel delivery from each injector into the graduated glasses for the specified number of strokes. If the fuel delivery is not within these limits adjust as follows:

Slacken the maximum fuel adjuster screw located on the side of the governor control cover and turn the screw clockwise to increase fuelling or anti–clockwise to decrease fuelling. Tighten the locknut after adjustment. Recheck the fuel delivery and if necessary re–adjust the screw, repeat the test until the specified figure is obtained.

Governor Setting

Governor setting is checked by running the pump at the specified speed on the Test Plan and adjusting the maximum speed screw until the specified fuel delivery is obtained. When the speed of rotation is reduced the fuel delivery should increase to a value approximately equal to the maximum fuel delivery.

Transfer Pressure

Transfer pressure is checked by running the pump at the specified speed on the Test Plan. Remove the plug in the top of the hydraulic head and fit adaptor Tool No. 7244–382. A pipe is then coupled to the adaptor from the pressure gauge of the test machine. Transfer pressure is read directly from the gauge.

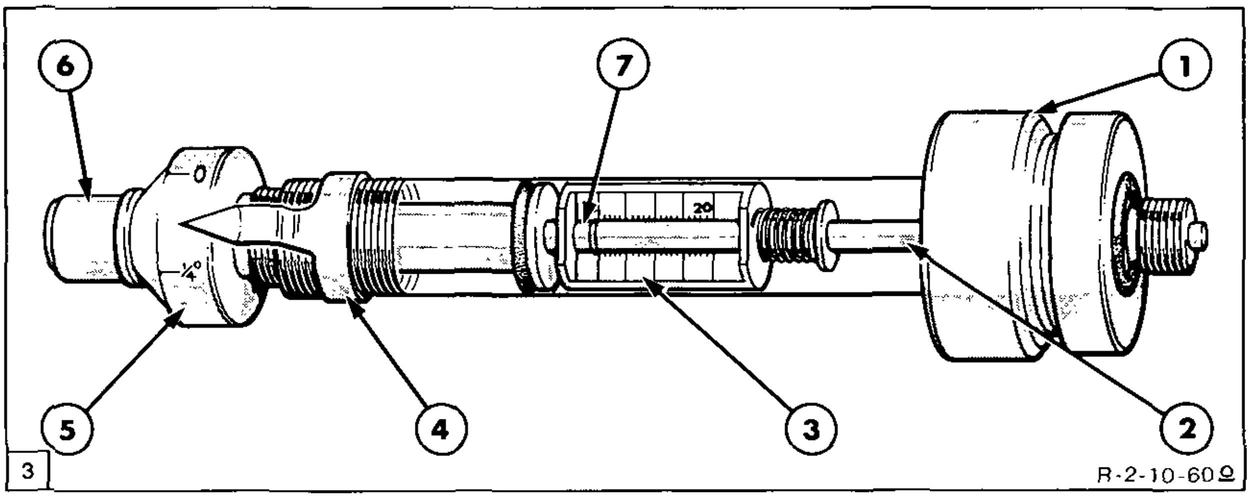
Transfer pressure is controlled by the regulating piston in the plate sleeve. Rotation of the transfer pressure adjuster screw moves a spring peg which varies the pre load on the regulating spring and the maximum lift of the piston. A pressure adjuster Tool No. 7244–410A enables transfer pressure to be set by the adjuster screw while the pump is running.

Cam Box Pressure

The cam box is pressurised during running by a spring load ball pressurising valve in the back leakage connection in the governor control cover. The test pressure gauge is fitted to the vent screw hole in the governor control cover.

The pressure can be checked using the Tool Kit No. 7244–275A.

Pressure limits are given in the appropriate "Test Plan". If the pressure is incorrect check that the pump is not leaking and that there is no restriction in the back leakage passages. If the pressurising valve is faulty, renew the valve and re–check the pressure.



Advance Gauge Tool No 7244–447

1. Locking Ring
2. Spindle
3. Scale
4. Pointer
5. Vernier Adjuster
6. Vent Screw
7. Datum Line on Spindle

Advance Unit Setting

The advance unit is tested by using a measuring gauge, Tool No. 7244–447. The gauge is provided with a scale graduated from 0° to 20°.
To test the advance unit with the measuring gauge proceed as follows:–

1. Remove the pressure end plug from the advance unit on the pump noting the identifying letter stamped on the hexagonal end face of the plug.
   A range of test plugs is available, Tool Part. series 7244–435.

2. Prime the gauge after fitting by running the pump and unscrewing the vent screw at the end of the vernier adjuster. When fuel, free from air bubbles, flows from the gauge tighten the screw.

3. Select the test plug corresponding to the letter of the pressure end plug removed from the pump, screw the test plug into the advance unit and fully tighten.

4. Before fitting the gauge to the advance unit, ensure the vernier adjuster is unscrewed five turns, i.e. with five threads exposed from the fully screwed in position. This precaution will preclude possible distortion or jamming of the spindle when the gauge is fitted.

5. Screw the gauge, finger tight, into the test plug in the advance unit. If necessary, slacken the locking ring to bring the scale uppermost, then tighten the locking ring.

6. Prime the pump again by slackening the connection to the cam box pressure gauge, then stop the pump.

7. To zero the gauge turn the vernier adjuster, Figure 3, to align the datum line on the spindle with the zero degree graduation on the scale. Position the pointer to align with the zero graduation on the vernier adjuster.

8. The gauge is now correctly set for measuring the advance.

9. A specified thickness of shims is fitted to the advance unit on assembly as stated in the Test Plan and these should not be altered. Use the transfer pressure adjuster at the stages stated in the Test Plan, to increase or decrease the degree of advance.

10. To measure the advance at various pump speeds, read the value in degrees on the graduated scale opposite the datum line on the spindle.

11. If the datum line on the spindle is between two graduations, turn the vernier adjuster clockwise to move the scale until the lower degree graduation line corresponds with the datum line on the spindle. The reading indicated on the vernier adjuster, opposite the pointer, indicates the fraction of a degree to be added to the lower reading.

NOTE: *Before changing the pump speed and measuring a new advance value, return the vernier adjuster ANTI–CLOCKWISE to the zero position.*

Timing the Injection Pump

All pumps require timing, refer to "Test Plan" for the relevant setting figure. After completion of the previous tests, remove the test machine and drain by loosening the plug on the pump body.

Remove the delivery valve on the fuel outlet specified for timing on the Test Plan.

Using the adaptor assembly, Tool No. 7144–262, fit relief valve, Tool No. 7144–155 to the stirrup pipe, Tool No. 7144–262A and connect one branch to the outlet on the hydraulic head. Arrange the other branch to face away from the head and seal it off with the blanking bolt, Tool No 7144–558.

NOTE: *The injection pump is fitted with by–pass delivery valves and the rotor has an equalisation groove, fuel could leak from the remaining high pressure outlets. To avoid this the outlets should be plugged.*

Using a suitable length of high pressure pipe, connect the stirrup pipe tool to the pressure phasing outlet on the Hartridge test bench or alternatively, connect to a nozzle setting outfit.

The Test Data gives specific information concerning the static timing of the pump. A static timing gauge Tool No. 7244–449, is available and this comprises a shaft and pointer assembly with a ± 20° offset quadrant which is used in conjunction with a flange marker Tool No. 7244–27 (currently used for DPA pumps).

The flange marking tool consists of a cast aluminium body with a lock screw around which slides a ring carrying a scribing plate. This scribing plate should be removed from the tool and replaced with the quadrant and attached to the flange marking tool by the securing bracket.

A 50 mm bore spigot plate is held in position by a countersunk screw. Three interchangeable inserts adapt the gauge to any type of basic pump drive. The inserts are held by two screws and a dowel pin.

The tools required for static timing of the pump, used in conjunction with Tool Part No. 72440449, are as follows:–

Description	**Tool No.**
Flange marking gauge	7244–27
50 mm spigot plates	7244–26E
Insert, for uprated drive pumps with 20 mm dia. taper driveshaft, (use with 7244–27)	7244–30

A timing plunger, Tool No. 2744–448, will also be required.

The procedure for preparing the pump for timing is as follows:–

Fit the quadrant with the flange marking tool and insert onto the tapered shaft on the shaft key. Clamp in position with a washer and nut. A bar through the 1/4 in (6.35 mm) hole in the insert will hold the insert in position when tightening or removing the nut. Also, a special extractor Tool No. 7044–690, fitted into the thread of the insert permits the withdrawal of the gauge after use.

Screw the shaft and pointer assembly of Tool No. 7244–449 into the cam box pressurising valve body on the governor corner. Adjust the height of the shaft and position the clamp so that the quadrant locates between the recess in the clamp and pointer.

To time the pump, proceed as follows:–

1. Apply pressure to the rotor. Normally a pressure of 30 atm with a relief valve fitted in the system is specified in the Test Plan, but sometimes a higher or lower pressure is quoted. To obtain the higher or lower pressures, re–adjust the relief valve. It is important not to exceed the specified pressure or damage will be caused to the shoe assemblies.
2. Unscrew the locking screw on the ring securing the quadrant and turn the pump drive shaft by the flange marking tool in the direction indicated on the pump nameplate until resistance to the further movement is felt.
3. Maintaining the driveshaft in this position, turn the quadrant to align the zero degree mark with the pointer. Tighten the lock screw.
4. Release the pressure to the rotor and rotate the quadrant 20° in the opposite direction to pump rotation. Re–pressurise the rotor and rotate the quadrant in the direction of the pump rotation until resistance to further movement is felt. If correctly positioned, the pointer should align with the quadrant at zero. If not, repeat operations 2, 3 and 4.

5. Release the pressure at the rotor.

6. Offset the quadrant to the degree value stated in the Test Plan for the pump and lock the quadrant in this position using the clamp.

7. Unscrew and remove the pump body drain plug and screw in fully the timing plunger Tool No. 7244–448 into the "V" notch in the internal timing disc. The grooves on the timing plunger will serve as a guide to determine the fully engaged position.

8. To check the pump timing, **release the clamp securing the quadrant** and rotate the quadrant to the zero degree mark. Again, rotate the quadrant in the direction of pump rotation until the timing plunger fully engages in the "V" notch in the internal timing disc. If correctly timed, the quadrant degree value at the pointer should correspond with the offset degree value stated in the Test Plan. If not, repeat operations 6, 7 and 8.

   After timing, remove the plunger timing tool from the pump. Refit the plug in the pump body and tighten to the specified torque, see "Section F".

   Remove the flange marking gauge and quadrant from the driveshaft. Unscrew and remove the shaft and pointer from the cam box pressurising valve.

   Remove the stirrup pipe tool, replace the delivery valve assembly together with the high pressure washer, tighten the assembly to the specified torque, see "Section F".

SEALING PUMPS

After test, ensure that a suitable length of locking wire and an unclenched seal is loosely attached to the pump for sealing the maximum speed adjusting screw after final setting on the engine.

Latch Valve Setting

The latch valve setting is checked at the specified speed on the Test Plan. To adjust the latch valve proceed as follows:–

Reduce the pump speed to 100 rpm and stop the test machine. Using a suitable allen wrench, screw the latch valve adjuster fully in then restart the test machine and set the pump speed to the specified speed in the Test Plan. Screw out the latch valve adjuster until the advance reading on the measuring gauge is within the limits specified on the Test Plan. Using a suitable wrench tighten the latch valve adjuster locknut to the specified torque, see "Section F", then recheck the latch valve setting.

Excess Fuel Setting

The excess fuel delivery is checked at the specified speed on the Test Plan. Run the pump at the specified speed and note the delivery from each injector into the graduated glasses for the specified number of strokes. The Test Plan will also state the specified advance setting for this check.

The pump must meet both of the settings specified on the Test Plan.

Seal the maximum fuel delivery adjustment screw and the latch valve adjuster screw and locknut, with sealing plugs, using a hot air blower.

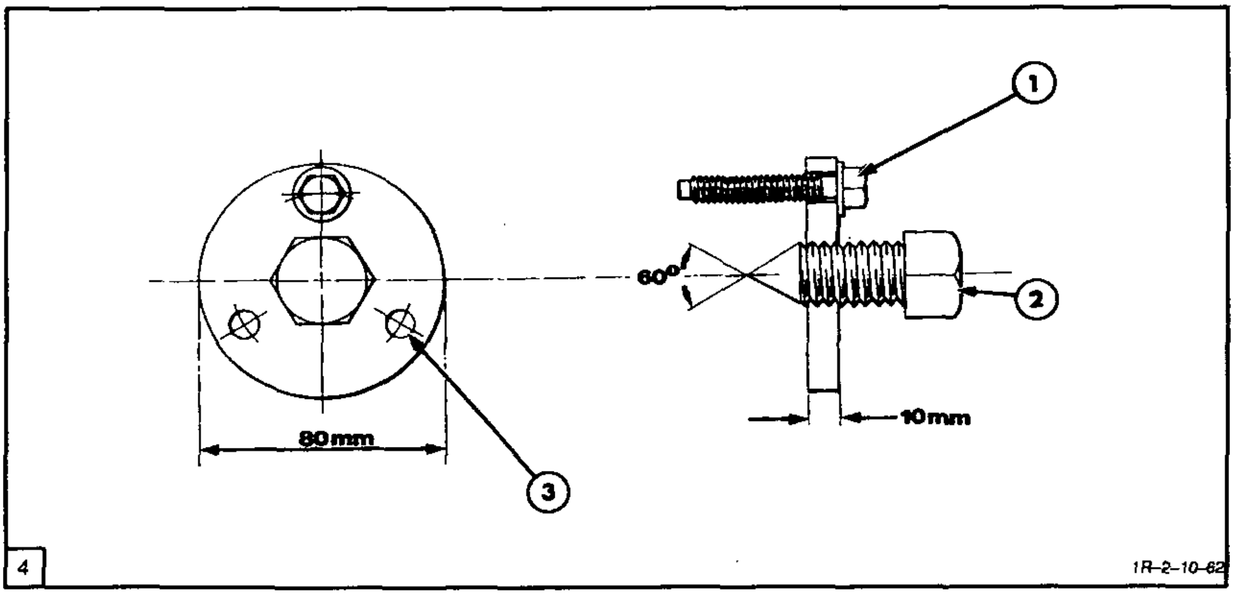
F. SPECIFICATIONS AND TOOLS

SPECIFICATIONS FUEL SYSTEM		5640	6640	7740	7840	8240	8340
Main Fuel Tank Capacity –							
	IMP Gal	20.8	20.8	20.8	24.8	24.8	24.8
	US Gal	25.0	25.0	25.0	29.8	29.8	29.8
	Litres	94.6	94.6	94.6	113	113	113
Auxiliary Fuel Tank Capacity –							
With Cab,	IMP Gal	23	23	23	23	23	23
	US Gal	27.7	27.7	27.7	27.7	27.7	27.7
	Litres	105	105	105	105	105	105
Less Cab,	IMP Gal	18.25	18.25	18.25	23	23	23
	US Gal	21.9	21.9	21.9	27.7	27.7	27.7
	Litres	83	83	83	105	105	105
Fuel Filter Type			Single Disposable Element				
Fuel Sedimentor			Single and Servicable				
Fuel Filter Change Interval				600 Hours			
Injection Pump Timing				10° BTDC			
Injector Nozzle Opening Pressure –							
	Bar		240–248 (Reset at 225)			290–299 (Reset at 275)	
	PSI		3480–3590 (Reset at 3260)			4230–4350 (Reset at 4000)	
Injector Change Interval				1200 Hours			
Maximum No Load Speed –							
High Idle		2350	2350	2250	2250	2250	2250
Low Idle		750	750	750	750	750	750
Rated Speed		2200	2200	2100	2100	2100	2100

GENERAL TORQUES FUEL SYSTEM	lbf/ft	Nm	kgf/m
Throttle Cable Lock Nuts	37	50	5.1
Throttle Lever Stop Bolt Locknut	7	10	1.0
Fuel Tank Shut–Off Valve	9	12	1.2
Thermostart Plug	27	37	3.8
Thermostart Pipe Union	7	10	1.0
Leak–Off Pipe to Injector Line	18	24	2.4
Fuel Tank Sender Retaining Ring	18	24	2.4
Fuel Filter Element Retaining Bolt	7	10	1.0
Fuel Filter Retaining Bolts	22	30	3.1
Air Cleaner Retaining Bolts	17	23	2.3
Air Cleaner Hose Clamps	1.5	2.0	0.2
Air Cleaner Restriction Indicator Switch	9	12	1.2
Injector Nozzle Retaining Nut	50	70	7.0
Injector Retaining Bolts	17	22	2.2
Injector Leak–Off Line Banjo Bolts	8	12	1.2
High Pressure Gland Nuts, at Injector and Fuel Injection Pump	18	24	2.4
Fuel Tank Drain Valve	5	7	0.7

FUEL INJECTION PUMP – SPECIAL TOOLS

DESCRIPTION General	LESLIE HARTRIDGE TOOL No
Pump Mounting Plate	7244 – 200
Cam Advance Screw Socket	7244 – 125B
Transfer Pump Rotor Box Spanner	7044 – 889
Timing Adaptor Assembly	7144 – 262
Flange Marking Tool	7244 – 27
Insert for Flange Marking Tool	7244 – 30
Static Timing Gauge	7244 – 449
Relief Valve	7144 – 155
Stirrup Pipe	7144 – 262A
Blank–Off Bolt	7144 – 558
Plunger Timing Tool	7244 – 448
Transfer Pressure Adjuster	7244 – 410A
Adaptor Hydraulic Head for Transfer Pressure Gauge	7244 – 382
Advance Measuring Gauge	7244 – 447
Pressure End Plug Test Plug	7244 – 435
Punch and Adaptor Drive Shaft Seal	7244 – 445
Dial	23764
Dial Indicator Holder	ST 183
Dial Indicator Holder Adaptor	89559
Protection Caps	
Head Locating Fitting	7044 – 897
Latch Valve Body Seals	7144 – 18
Latch Valve Restrictor Plug Seal	7144 – 124
Latch Valve Sleeve Nut Seal	7144 – 458C
Throttle Shaft Seals	7144 – 458C
Fuel Shut–Off Seals	7144 – 458C
Auto Advance Cap and Plug Seals	7044 – 898



Fuel Injection Pump Drive Gear Puller

1. Bolt 5/16 – UNF x 2 in (51mm), with Integral Washer (3 Bolts required)
2. Bolt 3/4 x 16 – UNC x 2 in (51mm)
3. 3 Holes 0.375 in (9.5mm) dia on 2.2 in (56.87mm) dia equally spaced material of 0.394 in (10mm) Plate HRLC P&O Steel.

G. TEST PLANS

TEST PLAN – FORD 5640, 268 cu in, (4393 cc)
DPS DISTRIBUTOR TYPE FUEL INJECTION PUMP, WITH ELECTRICAL FUEL SHUT–OFF.
TYPE DPS 8523A230A to 9A Coded

BASIC PUMP SPECIFICATION

Rotation (looking on drive end): Clockwise.
Governor Type: Mechanical all–speed.
Governor Link Length: 41.5mm ± 0.5mm.
Governor Spring in Position 2.
Diameter and No. of Plungers: 4 x 7.0mm.
Drive Arrangement : Uprated with Supported Shaft.
Advance Type: Automatic Speed with Start Retard.

SPECIAL FEATURES

Transfer pressure adjuster in end plate.
Cam box pressurising valve.
Solenoid shut–off device, 12 volts.
Axial outlet Head.
Scroll plate maximum fuel adjustment with hydraulic excess fuel device.

ISO TEST CONDITIONS (IMPORTANT : READ EXPLANATORY NOTES).

These figures, for service use only, have been compiled on and must only be used on, a test machine conforming to International Standard ISO 4008.
Test oil: ISO 4113 at temperature 40 ± 2° C.
Inlet feed pressure: 0.1 bar.
Nozzles: ISO 4010.
Nozzle opening pressure: 172 + 3 – 0 bar.
H.P. pipes: 6 x 2 x 845mm (ISO 4093.2).
H.P. outlet connections: Original.
0.5mm orifice/ball vent open to bench.

ISO TEST PROCEDURE

Screw transfer pressure adjuster fully out and then 1.5 turns in before commencing test.
Fit auto–advance gauge and set to zero before commencing test.
A 3.0mm shim is fitted to the piston spring cap on assembly, this must not be removed.
No additional shimming is required.
Maximum fuel adjusting screw to be screwed out until it protrudes 15mm above surface of lock-nut.
Latch valve adjuster to be flush with surface of its locknut.
Where marked thus * use 30 seconds glass draining time and allow fuel to settle for 15 seconds before taking readings unless stated otherwise by the test bench manufactures instructions.

NOTE: *Critical fuel deliveries are given in mm³/stroke. Hence the tester must determine the number of strokes applicable in accordance with the test machine manufacturers instructions.*

TEST OPERATION	RPM	REQUIREMENT
1 Priming	200	Obtain delivery from all injectors and clear flow of fuel from backleak and governor cover vent
2 Stabilisation	1100	Run pump for 3 minutes
3 Transfer pressure	1100	Set to 6.0 – 6.3 bar (90 – 95 lbf/in^2) using transfer pressure adjuster
4 Transfer pressure check	100	0.4 bar, (6.0 lbf/in^2) minimum
5 Advance setting	800	Adjust transfer pressure screw to obtain advance of 4.5° (3.6mm)
6 Transfer pressure check	800	4.1 to 5.3 bar (61 to 79 lbf/in^2)
7 Cambox pressure check	800	0.21 to 0.55 bar, (3.0 to 8.0 lbf/in^2)
8 Full advance check	1000	5.25° to 6.25° (4.2 to 5.0mm)
9 Back Leakage	1000	40 to 100cm^3 per 100 strokes time cycle (Flow rate 400 to 1000cm^3/min)

Stop test machine, fit and energise solenoid. Re–start test machine and prime as in test 1.

10 Maximum delivery setting	62L850/2/2400*	Set to Delivery tolerance ± 0.5mm^3/stroke code on spread between lines not to exceed n/plate 5.0mm^3/stroke. See note 1.
11 Delivery check	1100	Record average delivery in cm^3
12 Governor Setting	1190	Set throttle by max, speed adjustment screw to give average delivery of between 3.0 and 4.0cm^3 lock stop screw.
13 Delivery check	1230	Average delivery to be not more than 1.6cm^3
14 Delivery check	1100	Delivery to be as at test (11) ± 0.3cm^3

Run test machine down to 100 rpm and stop, screw latch valve adjuster fully in. Re–start test machine.

15 Latch Valve Setting	200	Adjust slowly until advance reads 2.25° – 3.25° (1.8 – 2.6mm)

Run test machine to 100 rpm and stop. Re–start test machine.

16 Excess fuel delivery check	150	Average delivery to be 20.0cm^3 minimum, with advance at 0°.
17 Latch valve check	225	Advance to be greater than 2.25° (1.8mm) and no more than 3.25° (2.6mm), if not repeat no (15)
18 Advance check	800	4.5° (3.6mm) If not reset by transfer pressure adjuster, stop test machine. Repeat from test (15)

Move throttle lever to closed position for tests (19), (20) and (21).

19 Idling delivery	360	Set idle screw to give average delivery between 3.0 and 3.5cm^3, lock screw.
20 Cut–off operation	280	With shut–off lever closed, average delivery not to exceed 0.5cm^3
21 Solenoid shut–off check	280	De–energise solenoid and wait for 5 seconds before operating trip gear. Average delivery not to exceed 0.5cm^3.

22 Timing – Use outlet X, supply 55 bar. Timing tool index 264°. Scribe line on mounting flange.

REFER TO STATEMENT AT END OF EXPLANATORY NOTES REGARDING MAXIMUM FUEL AND SPEED SETTING AND VARIATIONS IN ENGINE PERFORMANCE.

TEST PLAN – FORD 5640, 268 cu In, (4393 cc) DPS DISTRIBUTOR TYPE FUEL INJECTION PUMP. TYPE DPS 8523A240A to 9A Coded

BASIC PUMP SPECIFICATION

Rotation (looking on drive end): Clockwise.
Governor Type: Mechanical all–speed.
Governor Link Length: 41.5mm ± 0.5mm.
Governor Spring in Position 2.
Diameter and No. of Plungers: 4 x 7.0mm.
Drive Arrangement: Uprated with Supported Shaft.
Advance Type: Automatic Speed with Start Retard.

SPECIAL FEATURES

Transfer pressure adjuster in end plate.
Cam box pressurising valve.
Axial outlet Head.
Scroll plate maximum fuel adjustment with hydraulic excess fuel device.

ISO TEST CONDITIONS (IMPORTANT : READ EXPLANATORY NOTES).

These figures, for service use only, have been compiled on and must only be used on, a test machine conforming to International Standard ISO 4008.
Test oil: ISO 4113 at temperature 40 ± 2° C.
Inlet feed pressure: 0.1 bar.
Nozzles: ISO 4010.
Nozzle opening pressure: 172 + 3 – 0 bar.
H.P. pipes: 6 x 2 x 845mm (ISO 4093.2).
H.P. outlet connections: Original.
0.5mm orifice/ball vent open to bench.

ISO TEST PROCEDURE

Screw transfer pressure adjuster fully out and then 1.5 turns in before commencing test.
Fit auto–advance gauge and set to zero before commencing test.
A 2.0mm shim is fitted to the piston spring cap on assembly. This must not be removed.
No additional shimming is required.
Maximum fuel adjusting screw to be screwed out until it protrudes 15mm above surface of locknut.
Latch valve adjuster to be flush with surface of its locknut.
Where marked thus * use 30 seconds glass draining time and allow fuel to settle for 15 seconds before taking readings unless stated otherwise by the test bench manufactures instructions.

NOTE: *Critical fuel deliveries are given in mm³/stroke. Hence the tester must determine the number of strokes applicable in accordance with the test machine manufacturers instructions.*

TEST OPERATION	RPM	REQUIREMENT
1 Priming	200	Obtain delivery from all injectors and clear flow of fuel from backleak and governor cover vent
2 Stabilisation	1100	Run pump for 3 minutes
3 Transfer pressure	1100	Set to 6.0 – 6.3 bar (90 – 95 lbf/in^2) using transfer pressure adjuster
4 Transfer pressure check	100	0.4 bar, (6.0 lbf/in^2) minimum
5 Advance setting	800	Adjust transfer pressure screw to obtain advance of 4.5° (3.6mm)
6 Transfer pressure check	800	4.1 to 5.3 bar (61 to 79 lbf/in^2)
7 Cambox pressure check	800	0.21 to 0.55 bar, (3.0 to 8.0 lbf/in^2)
8 Full advance check	1000	5.25° to 6.25° (4.2 to 5.0mm)
9 Back Leakage	1000	40 to 100cm^3 per 100 strokes time cycle (Flow rate 400 to 1000cm^3/min)

Stop test machine, fit and energise solenoid. Re–start test machine and prime as in test 1.

10 Maximum delivery setting	62L850/2/2400*	Set to Delivery tolerance ± 0.5mm^3/stroke code on spread between lines not to exceed n/plate 5.0mm^3/stroke. See note 1.
11 Delivery check	1100	Record average delivery in cm^3
12 Governor Setting	1190	Set throttle by max speed adjustment screw to give average delivery of between 3.0 and 4.0cm^3 lock stop screw.
13 Delivery check	1230	Average delivery to be not more than 1.6cm^3
14 Delivery check	1100	Delivery to be as at test (11) ± 0.3cm^3

Run test machine down to 100 rpm and stop, screw latch valve adjuster fully in. Re–start test machine.

15 Latch Valve Setting	200	Adjust slowly until advance reads 2.25° – 3.25° (1.8 – 2.6mm)

Run test machine to 100 rpm and stop. Re–start test machine.

16 Excess fuel delivery check	150	Average delivery to be 20.0cm^3 minimum, with advance at 0°.
17 Latch valve check	225	Advance to be greater than 2.25° (1.8mm), and no more than 3.25° (2.6mm), if not repeat no (15)
18 Advance check	800	5.0° (4.0mm) If not reset by transfer pressure adjuster, stop test machine. Repeat from test (15)

Move throttle lever to closed position for tests (19), (20).

19 Idling delivery	360	Set idle screw to give average delivery between 3.0 and 3.5cm^3, lock screw.
20 Cut–off operation	280	With shut–off lever closed, average delivery not to exceed 0.5cm^3
21 Solenoid shut–off check (Where Fitted)	280	De–energise solenoid and wait for 5 seconds be fore operating trip gear. Average delivery not to exceed 0.5cm^3

22 Timing – Use outlet X, supply 55 bar. Timing tool index 264°. Scribe line on mounting flange.

REFER TO STATEMENT AT END OF EXPLANATORY NOTES REGARDING MAXIMUM FUEL AND SPEED SETTING AND VARIATIONS IN ENGINE PERFORMANCE.

TEST PLAN – FORD 6640, 304 cu in, (4983 cc)
DPS DISTRIBUTOR TYPE FUEL INJECTION PUMP, WITH ELECTRICAL FUEL SHUT–OFF. TYPE DPS 8523A260A to 9A Coded.

BASIC PUMP SPECIFICATION

Rotation (looking on drive end): Clockwise.
Governor type: Mechanical all – speed.
Governor link length: 41.5mm ± 0.5mm.
Governor Spring in Position 2.
Diameter and No. of Plungers: 4 x 7.0mm.
Drive arrangement: Uprated with Supported Shaft.
Advance Type: Automatic Speed with Start Retard.

SPECIAL FEATURES

Transfer pressure adjuster in end plate.
Cam box pressurising valve.
Solenoid shut–off device, 12 volts.
Axial outlet Head.
Scroll plate maximum fuel adjustment with hydraulic excess fuel device.

ISO TEST CONDITIONS. (IMPORTANT : READ EXPLANATORY NOTES).

These figures, for service use only, have been compiled on, and must only be used on, a test machine conforming to International Standard ISO 4008.
Test oil: ISO 4113 at temperature 40 ± 2° C.
Inlet feed pressure: 0.1 bar.
Nozzles: ISO 4010.
Nozzle opening pressure: 172 + 3 – 0 bar.
H.P. pipes: 6 x 2 x 845mm (ISO 4093.2).
H.P. outlet connections: Original.
0.5mm orifice/ball vent open to bench.

ISO TEST PROCEDURE

Screw transfer pressure adjuster fully out and then 1.5 turns in before commencing test.
Fit auto–advance gauge and set to zero before commencing test.
A 3.0mm shim is fitted to the piston spring cap on assembly, this must not be removed.
No additional shimming is required.
Maximum fuel adjusting screw to be screwed out until it protrudes 15mm above surface of locknut.
Latch valve adjuster to be flush with surface of its locknut.
Where marked thus * use 30 seconds glass draining time and allow fuel to settle for 15 seconds before taking readings unless stated otherwise by the test bench manufactures instructions.

NOTE: *Critical fuel deliveries are given in mm³/stroke. Hence the tester must determine the number of strokes applicable in accordance with the test machine manufacturers instructions.*

TEST OPERATION	RPM	REQUIREMENT
1 Priming	200	Obtain delivery from all injectors and clear flow of fuel from backleak and governor cover vent
2 Stabilisation	1100	Run pump for 3 minutes
3 Transfer pressure	1050	Set to 6.0 – 6.3 bar (90 – 95 lbf/in²) using transfer pressure adjuster
4 Transfer pressure check	100	0.4 bar, (6.0 lbf/in²) minimum
5 Advance setting	800	Adjust transfer pressure screw to obtain advance of 4.5° (3.6mm)
6 Transfer pressure check	800	4.1 to 5.3 bar (61 to 79 lbf/in²)
7 Cambox pressure check	800	0.21 to 0.55 bar, (3.0 to 8.0 lbf/in²)
8 Full advance check	1000	5.25° to 6.25° (4.2 to 5.0mm)
9 Back Leakage	1000	40 to 100cm³ per 100 strokes time cycle (Flow rate 400 to 1000cm³/min)

Stop test machine, fit and energise solenoid. Re–start test machine and prime as in test 1.

10 Maximum delivery setting	78L850/2/2400*	Set to Delivery tolerance ± 0.5mm³/stroke code on spread between lines not to exceed n/plate 5.0mm³/stroke. See note 1.
11 Delivery check	1100	Record average delivery in cm³
12 Governor Setting	1190	Set throttle by max speed adjustment screw to give average delivery of between 3.0 and 4.0cm³ lock stop screw.
13 Delivery check	1230	Average delivery to be not more than 1.6cm³
14 Delivery check	1100	Delivery to be as at test (11) ± 0.3cm³

Run test machine down to 100 rpm and stop, screw latch valve adjuster fully in. Re–start test machine.

15 Latch Valve Setting	200	Adjust slowly until advance reads 2.25° – 3.25° (1.8 – 2.6mm)

Run test machine to 100 rpm and stop. Re–start test machine.

16 Excess fuel delivery check	150	Average delivery to be 20.0cm³ minimum, with advance at 0°.
17 Latch valve check	225	Advance to be greater than 2.25° (1.8mm) and no more than 3.25° (2.6mm), if not repeat no (15)
18 Advance check	800	4.5° (3.6mm), If not reset by transfer pressure adjuster, stop test machine. Repeat from test(15).

Move throttle lever to closed position for tests (19), (20) and (21).

19 Idling delivery	360	Set idle screw to give average delivery between 3.0 and 3.5cm³, lock screw.
20 Cut–off operation	280	With shut–off lever closed, average delivery not to exceed 0.5cm³
21 Solenoid shut–off check	280	De–energise solenoid and wait for 5 seconds be fore operating trip gear. Average delivery not to exceed 0.5cm³

22 Timing – Use outlet X, supply 55 bar. Timing tool index 264°. Scribe line on mounting flange.

REFER TO STATEMENT AT END OF EXPLANATORY NOTES REGARDING MAXIMUM FUEL AND SPEED SETTING AND VARIATIONS IN ENGINE PERFORMANCE.

TEST PLAN – FORD 6640, 304 cu In, (4983 cc)
DPS DISTRIBUTOR TYPE FUEL INJECTION PUMP.
TYPE DPS 8523A270A to 9A Coded

BASIC PUMP SPECIFICATION

Rotation (looking on drive end): Clockwise.
Governor Type: Mechanical all – speed.
Governor Link Length: 41.5mm ± 0.5mm.
Governor Spring in Position 2.
Diameter and No. of Plungers: 4 x 7.0mm.
Drive Arrangement: Uprated with Supported Shaft.
Advance Type: Automatic Speed with Start Retard.

SPECIAL FEATURES

Transfer pressure adjuster in end plate.
Cam box pressurising valve.
Axial outlet Head.
Scroll plate maximum, fuel adjustment with hydraulic excess fuel device.

ISO TEST CONDITIONS (IMPORTANT : READ EXPLANATORY NOTES).

These figures, for service use only, have been compiled on and must only be used on, a test machine conforming to International Standard ISO 4008.
Test oil: ISO 4113 at temperature 40 ± 2° C.
Inlet feed pressure: 0.1 bar.
Nozzles: ISO 4010.
Nozzle opening pressure: 172 + 3 – 0 bar.
H.P. pipes: 6 x 2 x 845mm (ISO 4093.2).
H.P. outlet connections: Original.
0.5mm orifice/ball vent open to bench.

ISO TEST PROCEDURE

Screw transfer pressure adjuster fully out and then 1.5 turns in before commencing test.
Fit auto–advance gauge and set to zero before commencing test.
A 2.0mm shim is fitted to the piston spring cap on assembly. This must not be removed.
No additional shimming is required.
Maximum fuel adjusting screw to be screwed out until it protrudes 15mm above surface of lock-nut.
Latch valve adjuster to be flush with surface of its locknut.
Where marked thus * use 30 seconds glass draining time and allow fuel to settle for 15 seconds before taking readings unless stated otherwise by the test bench manufactures instructions.

NOTE: *Critical fuel deliveries are given in mm3/stroke. Hence the tester must determine the number of strokes applicable in accordance with the test machine manufacturers instructions.*

TEST OPERATION	RPM	REQUIREMENT
1 Priming	200	Obtain delivery from all injectors and clear flow of fuel from backleak and governor cover vent
2 Stabilization	1100	Run pump for 3 minutes
3 Transfer pressure	1100	Set to 6.0 – 6.3 bar (90 – 95 lbf/in^2) using transfer pressure adjuster
4 Transfer pressure check	100	0.4 bar, (6.0 lbf/in^2) minimum
5 Advance setting	800	Adjust transfer pressure screw to obtain advance of 4.5° (3.6mm)
6 Transfer pressure check	800	4.1 to 5.3 bar (61 to 79 lbf/in^2)
7 Cambox pressure check	800	0.21 to 0.55 bar, (3.0 to 8.0 lbf/in^2)
8 Full advance check	1000	5.25° to 6.25° (4.2 to 5.0mm)
9 Back Leakage	1000	40 to 100cm^3 per 100 strokes time cycle (Flow rate 400 to 1000cm^3/min)

Stop test machine, fit and energise solenoid. Re–start test machine and prime as in test 1.

10 Maximum delivery setting	78L850/2/2400*	Set to Delivery tolerance ± 0.5mm^3/stroke code on spread between lines not to exceed n/plate 5.0mm^3/stroke. See note 1.
11 Delivery check	1100	Record average delivery in cm^3
12 Governor Setting	1190	Set throttle by max speed adjustment screw to give average delivery of between 3.0 and 4.0cm^3 lock stop screw.
13 Delivery check	1230	Average delivery to be not more than 1.6cm^3
14 Delivery check	1100	Delivery to be as at test (11) ± 0.3cm^3

Run test machine down to 100 rpm and stop, screw latch valve adjuster fully in. Re–start test machine.

15 Latch Valve Setting	200	Adjust slowly until advance reads 2.25° – 3.25° (1.8 – 2.6mm)

Run test machine to 100 rpm and stop. Re–start test machine.

16 Excess fuel delivery check	150	Average delivery to be 20.0cm^3 minimum, with advance at 0°.
17 Latch valve check	225	Advance to be greater than 2.25° (1.8mm), and no more than 3.25° (2.6mm), if not repeat no (15)
18 Advance check	800	4.5° (3.6mm) If not reset by transfer pressure adjuster, stop test machine. Repeat from test (15)

Move throttle lever to closed position for tests (19), (20).

19 Idling delivery	360	Set idle screw to give average delivery between 3.0 and 3.5cm^3, lock screw.
20 Cut–off operation	280	With shut–off lever closed, average delivery not to exceed 0.5cm^3
21 Solenoid shut–off check (Where Fitted)	280	De–energise solenoid and wait for 5 seconds be fore operating trip gear. Average delivery not to exceed 0.5cm^3

22 Timing – Use outlet X, supply 55 bar. Timing tool index 264°. Scribe line on mounting flange.

REFER TO STATEMENT AT END OF EXPLANATORY NOTES REGARDING MAXIMUM, FUEL AND SPEED SETTING AND VARIATIONS IN ENGINE PERFORMANCE.

TEST PLAN – FORD 7740, 304 cu In, (4983 cc)
DPS DISTRIBUTOR TYPE FUEL INJECTION PUMP, WITH ELECTRICAL FUEL SHUT–OFF. TYPE DPS 8523A280A to 9A Coded

BASIC PUMP SPECIFICATION

Rotation (looking on drive end): Clockwise.
Governor Type: Mechanical all–speed.
Governor Link Length: 41.5mm ± 0.5mm.
Governor Spring in Position 2.
Diameter and No. of Plungers: 4 x 7.0mm.
Drive arrangement: uprated with Supported Shaft.
Advance Type: Automatic Speed with Start Retard.

SPECIAL FEATURES

Transfer pressure adjuster in end plate.
Cam box pressurising valve.
Solenoid shut–off device, 12 volts.
Axial outlet head.
Scroll plate maximum fuel adjustment with hydraulic excess fuel device.

ISO TEST CONDITIONS (IMPORTANT : READ EXPLANATORY NOTES).

These figures, for service use only, have been compiled on and must only be used on, a test machine conforming to International Standard ISO 4008.
Test oil: ISO 4113 at temperature 40 ± 2° C.
Inlet feed pressure: 0.1 bar.
Nozzles: ISO 4010.
Nozzle opening pressure: 172 + 3 – 0 bar.
H.P. pipes: 6 x 2 x 845mm (ISO 4093.2).
H.P. outlet connections: Original.
0.5mm orifice/ball vent open to bench.

ISO TEST PROCEDURE

Screw transfer pressure adjuster fully out and then 1.5 turns in before commencing test.
Fit auto–advance gauge and set to zero before commencing test.
A 3.0mm shim is fitted to the piston spring cap on assembly, this must not be removed.
No additional shimming is required.
Maximum fuel adjusting screw to be screwed out until it protrudes 15mm above surface of lock-nut.
Latch valve adjuster to be flush with surface of its locknut.
Where marked thus * use 30 seconds glass draining time and allow fuel to settle for 15 seconds before taking readings unless stated otherwise by the test bench manufactures instructions.

NOTE: *Critical fuel deliveries are given in mm³/stroke. Hence the tester must determine the number of strokes applicable in accordance with the test machine manufacturers instructions.*

TEST OPERATION	RPM	REQUIREMENT
1 Priming	200	Obtain delivery from all injectors and clear flow of fuel from backleak and governor cover vent
2 Stabilisation	1050	Run pump for 3 minutes
3 Transfer pressure	1050	Set to 6.0 – 6.3 bar (90 – 95 lbf/in^2) using transfer pressure adjuster
4 Transfer pressure check	100	0.4 bar, (6.0 lbf/in^2) minimum
5 Advance setting	800	Adjust transfer pressure screw to obtain advance of 4.5° (3.6mm)
6 Transfer pressure check	800	4.1 to 5.3 bar (61 to 79 lbf/in^2)
7 Cambox pressure check	800	0.21 to 0.55 bar, (3.0 to 8.0 lbf/in^2)
8 Full advance check	1000	5.25° to 6.25° (4.2 to 5.0mm)
9 Back Leakage	1000	40 to 100cm^3 per 100 strokes time cycle (Flow rate 400 to 1000cm^3/min)

Stop test machine, fit and energise solenoid. Re–start test machine and prime as in test 1.

TEST OPERATION	RPM	REQUIREMENT
10 Maximum delivery setting	90L850/2/2300*	Set to Delivery tolerance ± 0.5mm^3/stroke code on spread between lines not to exceed n/plate 5.0mm^3/stroke. See note 1.
11 Delivery check	1050	Record average delivery in cm^3
12 Governor Setting	1140	Set throttle by max speed adjustment screw to give average delivery of between 3.0 and 4.0cm^3 lock stop screw.
13 Delivery check	1180	Average delivery to be not more than 1.6cm^3
14 Delivery check	1050	Delivery to be as at test (11) ± 0.3cm^3

Run test machine down to 100 rpm and stop, screw latch valve adjuster fully in. Re–start test machine.

TEST OPERATION	RPM	REQUIREMENT
15 Latch Valve Setting	200	Adjust slowly until advance reads 2.25° – 3.25° (1.8 – 2.6mm)

Run test machine to 100 rpm and stop. Re–start test machine.

TEST OPERATION	RPM	REQUIREMENT
16 Excess fuel delivery check	150	Average delivery to be 20.0cm^3 minimum, with advance at 0°.
17 Latch valve check	225	Advance to be greater than 2.25° (1.8mm), and no more than 3.25° (2.6mm), if not repeat no (15)
18 Advance check	800	4.5° (3.6mm) If not reset by transfer pressure adjuster, stop test machine. Repeat from test (15)

Move throttle lever to closed position for tests (19), (20) and (21).

TEST OPERATION	RPM	REQUIREMENT
19 Idling delivery	360	Set idle screw to give average delivery between 3.0 and 3.5cm^3, lock screw.
20 Cut–off operation	280	With shut–off lever closed, average delivery not to exceed 0.5cm^3
21 Solenoid shut–off check	280	De–energise solenoid and wait for 5 seconds be fore operating trip gear. Average delivery not to exceed 0.5cm^3

22 Timing – Use outlet X, supply 55 bar. Timing tool index 265°. Scribe line on mounting flange.

REFER TO STATEMENT AT END OF EXPLANATORY NOTES REGARDING MAXIMUM FUEL AND SPEED SETTING AND VARIATIONS IN ENGINE PERFORMANCE.

TEST PLAN – FORD 7740, 304 cu in, (4983 cc)
DPS DISTRIBUTOR TYPE FUEL INJECTION PUMP.
TYPE DPS 8523A290A to 9A Coded

BASIC PUMP SPECIFICATION

Rotation (looking on drive end): Clockwise.
Governor Type: Mechanical all–speed.
Governor Link Length: 41.5mm ± 0.5mm.
Governor Spring in Position 2.
Diameter and No. of Plungers: 4 x 7.0mm.
Drive arrangement: Uprated with Supported Shaft.
Advance Type: Automatic Speed with Start Retard.

SPECIAL FEATURES

Transfer pressure adjuster in end plate.
Cam box pressurising valve.
Axial outlet head.
Scroll plate maximum, fuel adjustment with hydraulic excess fuel device.

ISO TEST CONDITIONS. (IMPORTANT : READ EXPLANATORY NOTES).

These figures, for service use only, have been compiled on, and must only be used on, a test machine conforming to International Standard ISO 4008.
Test oil: ISO 4113 at temperature 40 ± 2° C.
Inlet feed pressure: 0.1 bar.
Nozzles: ISO 4010.
Nozzle opening pressure: 172 + 3 – 0 bar.
H.P. pipes: 6 x 2 x 845mm (ISO 4093.2).
H.P. outlet connections: Original.
0.5mm orifice/ball vent open to bench.

ISO TEST PROCEDURE

Screw transfer pressure adjuster fully out and then 1.5 turns in before commencing test.
Fit auto–advance gauge and set to zero before commencing test.
A 2.0mm shim is fitted to the piston spring cap on assembly. This must not be removed.
No additional shimming is required.
Maximum fuel adjusting screw to be screwed out until it protrudes 15mm above surface of lock-nut.
Latch valve adjuster to be flush with surface of its locknut.
Where marked thus * use 30 seconds glass draining time and allow fuel to settle for 15 seconds before taking readings unless stated otherwise by the test bench manufactures instructions.

NOTE: *Critical fuel deliveries are given in mm3/stroke. Hence the tester must determine the number of strokes applicable in accordance with the test machine manufacturers instructions.*

TEST OPERATION	RPM	REQUIREMENT
1 Priming	200	Obtain delivery from all injectors and clear flow of fuel from backleak and governor cover vent
2 Stabilisation	1050	Run pump for 3 minutes
3 Transfer pressure	1050	Set to 6.0 – 6.3 bar (90 – 95 lbf/in^2) using transfer pressure adjuster
4 Transfer pressure check	100	0.4 bar, (6.0 lbf/in^2) minimum
5 Advance setting	800	Adjust transfer pressure screw to obtain advance of 4.5° (3.6mm)
6 Transfer pressure check	800	4.1 to 5.3 bar (61 to 79 lbf/in^2)
7 Cambox pressure check	800	0.21 to 0.55 bar, (3.0 to 8.0 lbf/in^2)
8 Full advance check	1000	5.25° to 6.25° (4.2 to 5.0mm)
9 Back Leakage	1000	40 to 100cm^3 per 100 strokes time cycle (Flow rate 400 to 1000cm^3/min)

Stop test machine, fit and energise solenoid. Re–start test machine and prime as in test 1.

10 Maximum delivery setting	90L850/2/2300*	Set to Delivery tolerance ± 0.5mm^3/stroke code on spread between lines not to exceed n/plate 5.0mm^3/stroke. See note 1.
11 Delivery check	1100	Record average delivery in cm^3
12 Governor Setting	1140	Set throttle by max, speed adjustment screw to give average delivery of between 3.0 and 4.0cm^3 lock stop screw.
13 Delivery check	1180	Average delivery to be not more than 1.6cm^3
14 Delivery check	1050	Delivery to be as at test (11) ± 0.3cm^3

Run test machine down to 100 rpm and stop, screw latch valve adjuster fully in. Re–start test machine.

15 Latch Valve Setting	*200*	*Adjust slowly until advance reads 2.25° – 3.25° (1.8 – 2.6mm)*

Run test machine to 100 rpm and stop. Re–start test machine.

16 Excess fuel delivery check	150	Average delivery to be 20.0cm^3 minimum, with advance at 0°.
17 Latch valve check	225	Advance to be greater than 2.25° (1.8mm), and no more than 3.25° (2.6mm), if not repeat no (15)
18 Advance check	800	4.5° (3.6mm), If not reset by transfer pressure adjuster, stop test machine. Repeat from test (15)

Move throttle lever to closed position for tests (19), (20).

19 Idling delivery	360	Set idle screw to give average delivery between 3.0 and 3.5cm^3, lock screw.
20 Cut–off operation	280	With shut–off lever closed, average delivery not to exceed 0.5cm^3
21 Solenoid shut–off check (Where Fitted)	280	De–energise solenoid and wait for 5 seconds be fore operating trip gear. Average delivery not to exceed 0.5cm^3

22 Timing – Use outlet X, supply 55 bar. Timing tool index 265°. Scribe line on mounting flange.

REFER TO STATEMENT AT END OF EXPLANATORY NOTES REGARDING MAXIMUM FUEL AND SPEED SETTING AND VARIATIONS IN ENGINE PERFORMANCE.

TEST PLAN – FORD 7840, 401 cu in, (6570 cc)
DPS DISTRIBUTOR TYPE FUEL INJECTION PUMP, WITH ELECTRICAL FUEL SHUT–OFF. TYPE DPS 8521A860A to 9A Coded

BASIC PUMP SPECIFICATION

Rotation (looking on drive end): Clockwise.
Governor type: Mechanical all–speed.
Governor Link Length: 41.5mm ± 0.5mm.
Governor Spring in Position 1.
Diameter and No. of Plungers: 4 x 7.0mm.
Drive arrangement: Uprated with Supported Shaft.
Advance Type: Automatic Speed with Start Retard.

SPECIAL FEATURES

Transfer pressure adjuster in end plate.
Cam box pressurising valve.
Solenoid shut–off device, 12 volts.
Axial outlet Head.
Scroll plate maximum fuel adjustment with hydraulic excess fuel device.

ISO TEST CONDITIONS (IMPORTANT : READ EXPLANATORY NOTES).

These figures, for service use only, have been compiled on, and must only be used on, a test machine conforming to International Standard ISO 4008.
Test oil: ISO 4113 at temperature 40 ± 2° C.
Inlet feed pressure: 0.1 bar.
Nozzles: ISO 4010.
Nozzle opening pressure: 172 + 3 – 0 bar.
H.P. pipes: 6 x 2 x 845mm (ISO 4093.2).
H.P. outlet connections: Original.
0.5mm orifice/ball vent open to bench.

ISO TEST PROCEDURE

Screw transfer pressure adjuster fully out and then 1.5 turns in before commencing test.
Fit auto–advance gauge and set to zero before commencing test.
A 3.0mm shim is fitted to the piston spring cap on assembly, this must not be removed.
No additional shimming is required.
Maximum fuel adjusting screw to be screwed out until it protrudes 15mm above surface of lock-nut.
Latch valve adjuster to be flush with surface of its locknut.
Where marked thus * use 30 seconds glass draining time and allow fuel to settle for 15 seconds before taking readings unless stated otherwise by the test bench manufactures instructions.

NOTE: *Critical fuel deliveries are given in mm³/stroke. Hence the tester must determine the number of strokes applicable in accordance with the test machine manufacturers instructions.*

TEST OPERATION	RPM	REQUIREMENT
1 Priming	200	Obtain delivery from all injectors and clear flow of fuel from backleak and governor cover vent
2 Stabilisation	1050	Run pump for 3 minutes
3 Transfer pressure	1050	Set to 6.3 – 6.6 bar (95 –100 lbf/in^2) using transfer *pressure adjuster*
4 Transfer pressure check	100	0.4 bar, (6.0 lbf/in^2) minimum
5 Advance setting	750	Adjust transfer pressure screw to obtain advance of 3.75° (3.0mm)
6 Transfer pressure check	750	4.4 to 5.6 bar (66 to 85 lbf/in^2)
7 Cambox pressure check	750	0.21 to 0.55 bar, (3.0 to 8.0 lbf/in^2)

Stop test machine, fit and energise solenoid. Re–start test machine and prime as in test 1.

TEST OPERATION	RPM	REQUIREMENT
8 Full advance check	1000	5.25° to 6.25° (4.2 to 5.0mm)
9 *Back Leakage*	*1000*	*40 to 100cm^3 per 100 strokes time cycle* (Flow rate 400 to 1000cm^3/min)
10 Maximum delivery setting	66L75/1/2300	* Set to Delivery tolerance ± 0.5mm^3/stroke code on spread between lines not to exceed n/plate 5.0mm^3/stroke. See note 1. Check and reset ad vance to 3.75° (3.0mm) by T.P. adjuster. If neces sary then recheck maximum fuel
11 Delivery check	1050	Record average delivery in cm^3
12 Governor Setting	1140	Set throttle by max speed adjustment screw to give average delivery of between 3.0 and 4.0cm^3 *lock stop screw.*
13 Delivery check	1180	Average delivery to be not more than 1.6cm^3
14 Delivery check	1050	Delivery to be as at test (11) ± 0.3cm^3

Run test machine down to 100 rpm and stop, screw latch valve adjuster fully in. Re–start test machine.

TEST OPERATION	RPM	REQUIREMENT
15 Latch Valve Setting	200	Adjust slowly until advance reads 1.25° – 2.25° (1.0 – 1.18mm)

Run test machine to 100 rpm and stop. Re–start test machine.

TEST OPERATION	RPM	REQUIREMENT
16 Excess fuel delivery check	150	Average delivery to be 20.0cm^3 minimum, with advance at 0°.
17 Latch valve check	225	Advance to be greater than 1.25° (1.0mm), and no more than 2.25° (1.8mm) if not repeat no (15)
18 Advance check	750	3.75° (3.0mm), If not reset by transfer pressure adjuster, stop test machine. Repeat from test (15)

Move throttle lever to closed position for tests (19), (20) and (21).

TEST OPERATION	RPM	REQUIREMENT
19 Idling delivery	360	Set idle screw to give average delivery between 3.0 and 3.5cm^3, lock screw.
20 Cut–off operation	280	With shut–off lever closed, average delivery not to exceed 0.5cm^3
21 Solenoid shut–off check	280	De–energise solenoid and wait for 5 seconds be fore operating trip gear. Average delivery not to exceed 0.5cm^3

22 Timing – Use outlet X, supply 55 bar. Timing tool index 282°. Scribe line on mounting flange.

REFER TO STATEMENT AT END OF EXPLANATORY NOTES REGARDING MAXIMUM FUEL AND SPEED SETTING AND VARIATIONS IN ENGINE PERFORMANCE.

TEST PLAN – FORD 8240, 456 cu in, (7472 cc) DPS DISTRIBUTOR TYPE FUEL INJECTION PUMP, WITH ELECTRICAL FUEL SHUT–OFF. TYPE DPS 8521A870A to 9A Coded

BASIC PUMP SPECIFICATION

Rotation (looking on drive end): Clockwise.
Governor type: Mechanical all–speed.
Governor link length: 41.5mm ± 0.5mm.
Governor Spring in Position 2.
Diameter and No. of Plungers: 4 x 7.0mm.
Drive arrangement: Uprated with Supported Shaft.
Advance Type: Automatic Speed with Start Retard.

SPECIAL FEATURES

Transfer pressure adjuster in end plate.
Cam box pressurising valve.
Solenoid shut–off device, 12 volts.
Axial outlet head.
Scroll plate maximum fuel adjustment with hydraulic excess fuel device.

ISO TEST CONDITIONS (IMPORTANT : READ EXPLANATORY NOTES).

These figures, for service use only, have been compiled on and must only be used on, a test machine conforming to International Standard ISO 4008.
Test oil: ISO 4113 at temperature 40 ± 2° C.
Inlet feed pressure: 0.1 bar.
Nozzles: ISO 4010.
Nozzle opening pressure: 172 + 3 – 0 bar.
H.P. pipes: 6 x 2 x 845mm (ISO 4093.2).
H.P. outlet connections: Original.
0.5mm orifice/ball vent open to bench.

ISO TEST PROCEDURE

Screw transfer pressure adjuster fully out and then 1.5 turns in before commencing test.
Fit auto–advance gauge and set to zero before commencing test.
A 3.0mm shim is fitted to the piston spring cap on assembly, this must not be removed.
No additional shimming is required.
Maximum fuel adjusting screw to be screwed out until it protrudes 15mm above surface of lock-nut.
Latch valve adjuster to be flush with surface of its locknut.
Where marked thus * use 30 seconds glass draining time and allow fuel to settle for 15 seconds before taking readings unless stated otherwise by the test bench manufactures instructions.

NOTE: *Critical fuel deliveries are given in mm^3/stroke. Hence the tester must determine the number of strokes applicable in accordance with the test machine manufacturers instructions.*

TEST OPERATION	RPM	REQUIREMENT
1 Priming	200	Obtain delivery from all injectors and clear flow of fuel from backleak and governor cover vent
2 Stabilisation	1050	Run pump for 3 minutes
3 Transfer pressure	1050	Set to 6.3 – 6.6 bar (95 –100 lbf/in^2) using transfer pressure adjuster
4 Transfer pressure check	100	0.4 bar, (6.0 lbf/in^2) minimum
5 Advance setting	750	Adjust transfer pressure screw to obtain advance of 5.25° (4.2mm)
6 Transfer pressure check	750	4.2 to 5.4 bar (63 to 81 lbf/in^2)
7 Cambox pressure check	750	0.21 to 0.55 bar, (3.0 to 8.0 lbf/in^2)

Stop test machine, fit and energise solenoid. Re–start test machine and prime as in test 1.

8 Full advance check	1000	5.75° to 6.75° (4.6 to 5.4mm)
9 Back Leakage	1000	40 to 100cm^3 per 100 strokes time cycle (Flow rate 400 to 1000cm^3/min)
10 Maximum delivery setting	69L750/2/2300*	Set to Delivery tolerance ± 0.5mm^3/stroke code on spread between lines not to exceed n/plate 5.0mm^3/stroke. See note 1. Check and reset ad vance to 5.25° (4.2mm) by T.P. adjuster. If neces sary then recheck maximum fuel
11 Delivery check	1050	Record average delivery in cm^3
12 Governor Setting	1140	Set throttle by max speed adjustment screw to give average delivery of between 3.0 and 4.0cm^3 lock stop screw.
13 Delivery check	1180	Average delivery to be not more than 1.6cm^3
14 Delivery check	1050	Delivery to be as at test (11) ± 0.3cm^3

Run test machine down to 100 rpm and stop, screw latch valve adjuster fully in. Re–start test machine.

15 Latch Valve Setting	200	Adjust slowly until advance reads 1.75° – 2.75° (1.4 – 2.2mm)

Run test machine to 100 rpm and stop. Re–start test machine.

16 Excess fuel delivery check	150	Average delivery to be 20.0cm^3 minimum, with advance at 0°.
17 Latch valve check	225	Advance to be greater than 1.75° (1.4mm) and no more than 2.75° (2.2mm), if not repeat no (15)
18 Advance check	750	5.25° (4.2mm) If not reset by transfer pressure adjuster, stop test machine. Repeat from test (15)

Move throttle lever to closed position for tests (19), (20) and (21).

19 Idling delivery	360	Set idle screw to give average delivery between 3.0 and 3.5cm^3, lock screw.
20 Cut–off operation	280	With shut–off lever closed, average delivery not to exceed 0.5cm^3
21 Solenoid shut–off check	280	De–energise solenoid and wait for 5 seconds be fore operating trip gear. Average delivery not to exceed 0.5cm^3

22 Timing – Use outlet X, supply 55 bar. Timing tool index 281°. Scribe line on mounting flange.

REFER TO STATEMENT AT END OF EXPLANATORY NOTES REGARDING MAXIMUM FUEL AND SPEED SETTING AND VARIATIONS IN ENGINE PERFORMANCE.

TEST PLAN – FORD 8340, 456 cu in, (7472 cc) DPS DISTRIBUTOR TYPE FUEL INJECTION PUMP, WITH ELECTRICAL FUEL SHUT–OFF. TYPE DPS 8521A880A to 9A Coded

BASIC PUMP SPECIFICATION

Rotation (looking on drive end): Clockwise.
Governor Type: Mechanical all – speed.
Governor Link Length: 41.5mm ± 0.5mm.
Governor Spring in Position 2.
Diameter and No. of Plungers: 4 x 7.0mm.
Drive Arrangement: Uprated with Supported Shaft.
Advance Type: Automatic Speed with Start Retard.

SPECIAL FEATURES

Transfer pressure adjuster in end plate.
Cam box pressurising valve.
Solenoid shut–off device, 12 volts.
Axial outlet Head.
Scroll plate maximum, fuel adjustment with hydraulic excess fuel device.

ISO TEST CONDITIONS (IMPORTANT : READ EXPLANATORY NOTES).

These figures, for service use only, have been compiled on and must only be used on, a test machine conforming to International Standard ISO 4008.
Test oil: ISO 4113 at temperature 40 ± 2° C.
Inlet feed pressure: 0.1 bar.
Nozzles: ISO 4010.
Nozzle opening pressure: 172 + 3 – 0 bar.
H.P. pipes: 6 x 2 x 845mm (ISO 4093.2).
H.P. outlet connections: Original.
0.5mm orifice/ball vent open to bench.

ISO TEST PROCEDURE

Screw transfer pressure adjuster fully out and then 1.5 turns in before commencing test.
Fit auto–advance gauge and set to zero before commencing test.
A 3.0mm shim is fitted to the piston spring cap on assembly, this must not be removed.
No additional shimming is required.
Maximum fuel adjusting screw to be screwed out until it protrudes 15mm above surface of locknut.
Latch valve adjuster to be flush with surface of its locknut.
Where marked thus * use 30 seconds glass draining time and allow fuel to settle for 15 seconds before taking readings unless stated otherwise by the test bench manufactures instructions.

NOTE: *Critical fuel deliveries are given in mm³/stroke. Hence the tester must determine the number of strokes applicable in accordance with the test machine manufacturers instructions.*

TEST OPERATION	RPM	REQUIREMENT
1 Priming	200	Obtain delivery from all injectors and clear flow of fuel from backleak and governor cover vent
2 Stabilisation	1050	Run pump for 3 minutes
3 Transfer pressure	1050	Set to 6.3 – 6.6 bar (95 – 100 lbf/in^2) using transfer pressure adjuster
4 Transfer pressure check	100	0.4 bar, (6.0 lbf/in^2) minimum
5 Advance setting	750	Adjust transfer pressure screw to obtain advance *of 5.25° (4.2mm)*
6 Transfer pressure check	750	4.2 to 5.4 bar (63 to 81 lbf/in^2)
7 Cambox pressure check	750	0.21 to 0.55 bar, (3.0 to 8.0 lbf/in^2)

Stop test machine, fit and energise solenoid. Re–start test machine and prime as in test 1.

8 Full advance check	1000	5.75° to 6.75° (4.6 to 5.4mm)
9 Back Leakage	1000	40 to 100cm^3 per 100 strokes time cycle (Flow rate 400 to 1000cm^3/min)
10 Maximum delivery setting	78L750/2/2300*	Set to Delivery tolerance ± 0.5mm^3/stroke code on spread between lines not to exceed n/plate 5.0mm^3/stroke. See note 1. Check and reset ad vance to 5.25° (4.2mm) by T.P. adjuster. If neces *sary then recheck maximum fuel*
11 Delivery check	1050	Record average delivery in cm^3
12 Governor Setting	1140	Set throttle by max speed adjustment screw to give average delivery of between 3.0 and 4.0cm^3 lock stop screw.
13 Delivery check	1180	Average delivery to be not more than 1.6cm^3
14 Delivery check	1050	Delivery to be as at test (11) ± 0.3cm^3

Run test machine down to 100 rpm and stop, screw latch valve adjuster fully in. Re–start test machine.

15 Latch Valve Setting	200	Adjust slowly until advance reads 1.75° – 2.75° (1.4 – 2.2mm)

Run test machine to 100 rpm and stop. Re–start test machine.

16 Excess fuel delivery check	150	Average delivery to be 20.0cm^3 minimum, with advance at 0°.
17 Latch valve check	225	Advance to be greater than 1.75° (1.4mm) and no more than 2.75° (2.2mm), if not repeat no (15)
18 Advance check	750	5.25° (4.2mm) If not reset by transfer pressure adjuster, stop test machine. Repeat from test (15)

Move throttle lever to closed position for tests (19), (20) and (21).

19 Idling delivery	360	Set idle screw to give average delivery between 3.0 and 3.5cm^3, lock screw.
20 Cut–off operation	280	With shut–off lever closed, average delivery not to exceed 0.5cm^3
21 Solenoid shut–off check	280	De–energise solenoid and wait for 5 seconds be fore operating trip gear. Average delivery not to exceed 0.5cm^3

22 Timing – Use outlet X, supply 55 bar. Timing tool index 281°. Scribe line on mounting flange.

REFER TO STATEMENT AT END OF EXPLANATORY NOTES REGARDING MAXIMUM FUEL AND SPEED SETTING AND VARIATIONS IN ENGINE PERFORMANCE.

EVERY EFFORT IS MADE TO ENSURE THAT THE DATA GIVEN ON TEST PLANS IS ACCURATE. BUT LUCAS CAV LTD CANNOT GUARANTEE THAT PUMPS SET TO THESE FIGURES WILL REPEAT ORIGINAL ENGINE PERFORMANCE. AS THIS IS DEPENDANT ON MANY FACTORS IN ADDITION TO THE FUEL INJECTION EQUIPMENT.

DELIVERY MEASUREMENT SYSTEM CONVERSION CHART

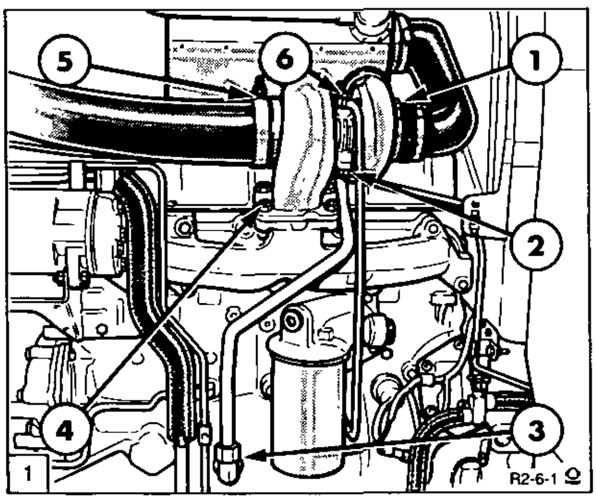
mm^3 per Stroke per cyl	cm^3 in 50 Shots	cm^3 in 100 Shots	cm^3 in 200 Shots	cm^3 in 300 Shots	cm^3 in 400 Shots	cm^3 in 500 Shots	cm^3 in 600 Shots	cm^3 in 700 Shots	cm^3 in 800 Shots	cm^3 in 900 Shots	cm^3 in1000 Shots
0.10	0.005	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10
0.50	0.025	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
1.00	0.05	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
5.00	0.25	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
10.00	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
20.00	1.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00
30.00	1.50	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	27.00	30.00
40.00	2.00	4.00	8.00	12.00	16.00	20.00	24.00	28.00	32.00	36.00	40.00
50.00	2.50	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00
60.00	3.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00	48.00	54.00	60.00
70.00	3.50	7.00	14.00	21.00	28.00	35.00	42.00	49.00	56.00	63.00	70.00
80.00	4.00	8.00	16.00	24.00	32.00	40.00	48.00	56.00	64.00	72.00	80.00
90.00	4.50	9.00	18.00	27.00	36.00	45.00	54.00	63.00	72.00	81.00	90.00
100.0	5.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00
200.0	10.00	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00
300.0	15.00	30.00	60.00	90.00	120.00	150.00	180.00	210.00	240.00	270.00	300.00
400.0	20.00	40.00	80.00	120.00	160.00	200.00	240.00	280.00	320.00	360.00	400.00
500.0	25.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00

PART 2
FUEL SYSTEMS

Chapter 6
TURBOCHARGER

A. DESCRIPTION AND OPERATION

Turbochargers are used to increase power by compressing (or densifying) the air that goes into the engine combustion chambers. Therefore the Increased power comes from the additional fuel that the denser air accommodates during the combustion process.



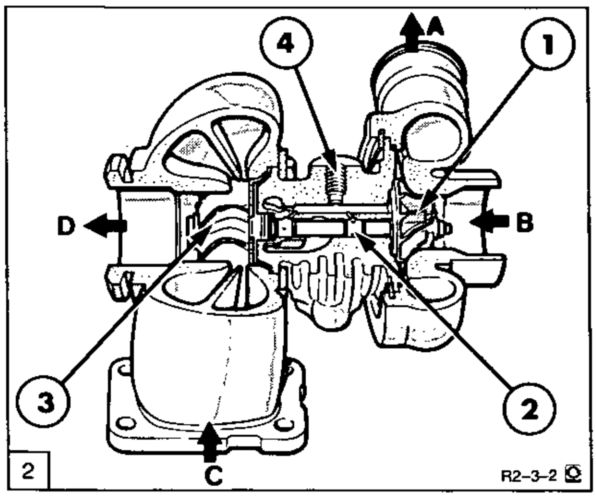
Turbocharger Installed

1. Air inlet Tube Clamps
2. Turbocharger Housing
3. Oil Return Tube to Block
4. Turbocharger to Manifold Bolts
5. Turbine Outlet Clamp
6. Oil Intake Tube to Turbocharger

The turbocharger where fitted, is mounted on the engine exhaust manifold, situated on the left hand side of the engine underneath the top hood, Figure 1.

The turbocharger consists of an exhaust gas driven turbine and air compressor wheels, mounted on opposite ends of a common shaft. The wheels are enclosed by a housing and the shaft by a centre housing, Figure 2.

The turbine is a centripetal (from outside to centre), radial inflow designed mechanism consisting of a cast turbine wheel shroud and a specially designed housing that encloses the wheel and directs the flow of gas through the turbine housing.



Turbocharger Cross Section

A To intake manifold
B From Air Cleaner
C From Exhaust Manifold
D To Exhaust Muffler
1. Compressor Wheel
2. Bearings
3. Turbine Wheel
4. Oil Supply to Bearing

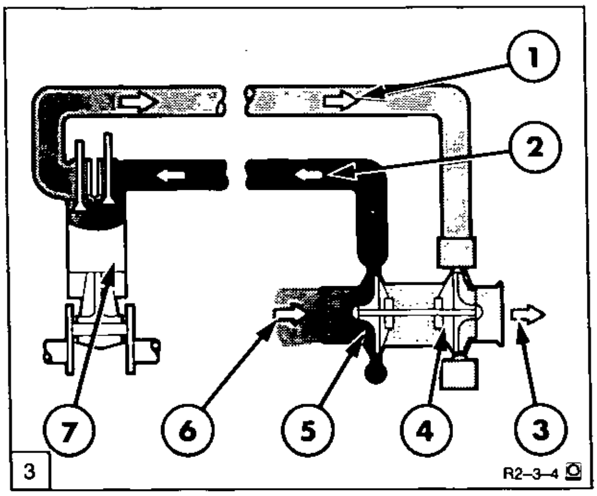
The compressor is a centrifugal, radial outflow mechanism consisting of a cast compressor wheel and a specially designed housing that encloses the wheel and directs the flow of air through the compressor.

The centre housing supports the compressor and turbine wheel shaft in a pair of identical bearings which contain oil holes for directing oil to the bearing bores and shaft journals. Passages drilled in the centre housing provide for directing the oil, supplied by the engine from the inlet port to oil grooves machined in the bearing bores which align with holes in the bearings.

Piston rings are installed at each end of the shaft, between the bearing and the adjacent turbine or compressor wheel, to prevent lubricating oil from entering the turbine and the compressor area.

During operation of a turbocharged engine, exhaust gas from the engine exhaust manifold flows into the turbine. The exhaust gas pressure and the heat energy extracted from the gas, cause the turbine wheel to rotate which in turn, causes the compressor wheel to rotate.

The cooled and expanded exhaust gas leaving the turbine wheel, is directed by the turbine housing to the engine exhaust system, which expels it to the atmosphere.



Turbocharger Engine Schematic

1. Engine Exhaust Gas Flow
2. Compressed Air Flow
3. Exhaust Gas Discharge
4. Turbine
5. Compressor
6. From Air Cleaner
7. Engine Cylinder

Rotation of the compressor wheel causes ambient air from the engine air cleaner to be drawn into the compressor housing, where it is compressed and delivered to appropriate ducting which delivers it to the engine intake manifold, Figure 3.

The increased volume and density of the air thus delivered to the engine cylinders permit a corresponding increase in the volume of fuel that can be introduced into the cylinders while maintaining the air to fuel ratio required for proper combustion. Since engine power output is a function of the volume of fuel burned, the increase in the volume of fuel introduced as a result of turbocharger operation results in an increase in engine power output.

IMPORTANT: *To ensure adequate lubrication of the turbocharger, allow the engine to idle at 1000 rev/min for approximately one minute after starting the engine.*
To allow the turbocharger, and exhaust manifold, to cool down and prevent any possible distortion of components, idle the engine at 1000 rev/min for approximately one minute, before stopping the engine.

B. FAULT FINDING

It is important when fault finding a suspected turbocharger malfunction, to keep in mind that a turbocharger cannot compensate for incorrect engine operating procedures.

Deficiencies of the engine air intake fuel or exhaust systems, or for damaged engine components, such as valves, pistons, rings liners, etc. Replacing a good turbocharger with another will not correct engine deficiencies.

Consequently, systematic fault finding of a suspected turbocharger failure is essential for two very good reasons.
1, it must be determined what, if anything, is wrong with the turbocharger so that it can be repaired.
2, it must be determined what action will prevent a recurrence of the failure.

In many cases the evidence required to determine the cause of a malfunction is destroyed in the process of removing the turbocharger from the engine.

For example, if a turbocharger failed as the result of a faulty installation (such as loose duct connections that permitted ingestion of dirt by the compressor) this would not be evident once the turbocharger was removed from the engine.

Furthermore, failure to take appropriate steps to assure correct installation (such as repairing or replacing defective clamps or ducting) could cause the replacement unit to fail in a similar manner.

The following Fault Finding Chart contains information pertaining to probable failure modes of turbocharged engines, possible causes for such failures and the maintenance action required to remedy each possible cause.

It is not represented that this information is all inclusive, but should be considered as representative of the methods or techniques that should be used during fault finding.

In general fault finding procedures that can be performed with the least effort and least amount of time should be performed first. No removal or disassembly procedures should be performed until all visual inspections and sensory tests (sight and feel) that can be accomplished with the turbocharger have been performed.

The possible causes and procedures are generally arranged in order of ease accomplishment.

SYMPTONS	POSSIBLE CAUSES
Engine lacks power, or emits black smoke	1. Dirty Air Cleaner 2. Loose Compressor to intake manifold connections 3. Leak at engine intake at turbocharger mounting flange 4. Turbocharger rotating assembly binding 5. Air cleaner to turbocharger duct restricted 6. Compressor to intake manifold duct restricted 7. Engine exhaust system restricted 8. Engine malfunction (rings, pistons, valves)
Seal leaks at compressor end of turbocharger	1. Dirty air cleaner 2. Restricted duct between air cleaner and turbocharger 3. Loose compressor to intake manifold dust connections 4. Leaks at engine intake manifold 5. Restricted turbocharger oil drain line 6. Plugged engine crankcase breather 7. Worn or damaged compressor wheel (worn bearings, bores or journals) 8. Excessive piston blowby or high internal crankcase pressure
Seal leaks at turbine end of turbocharger	1. Excessive pre–oiling 2. Plugged engine crankcase breather 3. Restricted turbocharger oil drain line 4. Sludged or coked centre housing 5. Worn turbocharger bearings, bearing bores, or shaft journals

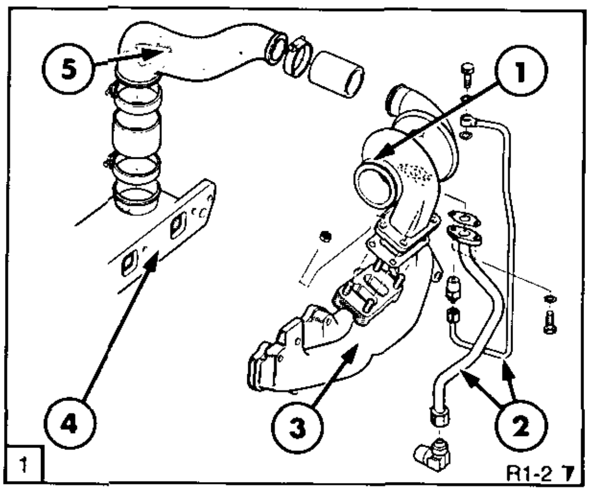
SYMPTONS	POSSIBLE CAUSES
Engine exhaust emits blue smoke	1. Dirty air cleaner 2. Loose compressor to intake manifold connections 3. Leak at engine intake manifold 4. Plugged engine oil filter 5. Restricted duct between air cleaner and turbocharger compressor 6. Seal leak at compressor end of turbocharger 7. Engine malfunction (rings, pistons, valves, etc)
Worn turbocharger bearings, bores or journals	1. Inadequate pre–oiling following turbocharger installation or engine lubrication servicing 2. Contaminated or improper grade of engine oil used in engine 3. Insufficient oil supplied to turbocharger due to oil lag 4. Restricted turbocharger oil feed line 5. Plugged engine oil filter 6. Abrasive wear due to coked material in turbocharger
Excessive engine oil consumption	1. Wrong type or viscosity of engine lubricating oil 2. Seal leaks at compressor end of turbocharger (indicated by oil in housing or on wheel) 3. Oil in engine exhaust manifold (caused by malfunction of rings, pistons, valves, etc)
Noisy turbocharger	1. Dirty air cleaner 2. Foreign material or object in compressor to intake manifold duct 3. Foreign object in engine exhaust system 4. Carbon build up in turbine housing 5. Turbocharger rotating assembly binding or dragging 6. Insufficient lubrication oil, due to malfunction of oil pump

SYMPTONS	POSSIBLE CAUSES
Turbocharger rotating assembly binding or dragging	1. Damaged compressor wheel 2. Damaged turbine wheel 3. Compressor or turbine wheel rubbing on housing due to worn bearings, shaft journals, or bearing bores 4. Excessive dirt build up in compressor (housing or wheel) 5. Excessive carbon build up behind turbine wheel 6. Sludged or coked centre housing (check engine lubrication system)

C. OVERHAUL

Removal

1. Remove the engine side panels.
2. Remove exhaust muffler.
3. Loosen and detach the top hood.
4. Disconnect the air cleaner to the turbocharger tube, and the turbocharger to intake manifold tube, by loosening the tube hose clamps, Figure 1.



Turbocharger Assembly

1. Turbocharger Housing
2. Oil feed and Return Pipes
3. Exhaust Manifold
4. Inlet Manifold
5. Inlet Hoses and Tubes

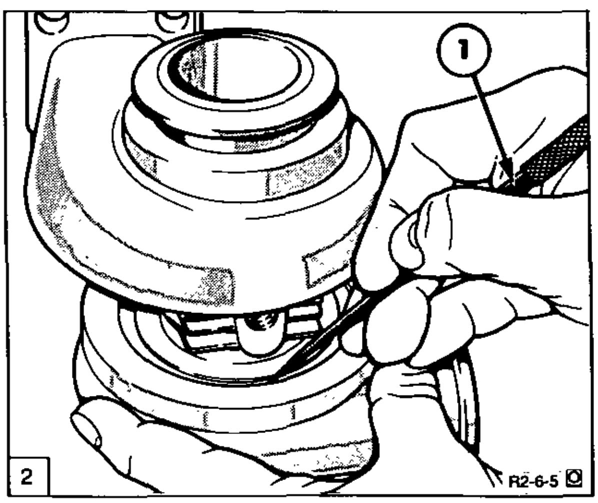
5. Disconnect the oil supply and return tubes from the turbocharger. Cap the ends of the tubes and the oil ports of the turbocharger to prevent entry of foreign material, therefore, preventing future bearing failures.

NOTE: *Before removing and cleaning the unit look for signs of oil and, or gas leakage, also wheel damage which may not be evident after cleaning.*

6. Remove the turbocharger and gasket from the exhaust manifold. Cover the opening in the exhaust manifold to prevent the entry of dirt, which could cause damage to the turbine wheel blades after installation and start up.

Disassembly

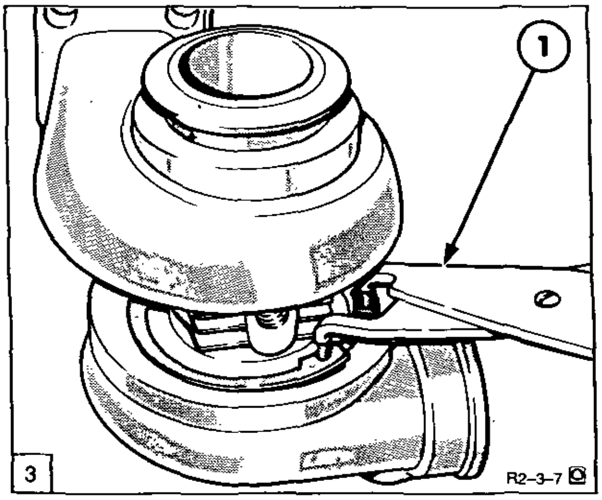
1. Clean the exterior of the turbocharger using a non caustic cleaning solvent to remove accumulated surface matter before disassembly.



Scribing of Turbocharger Housing

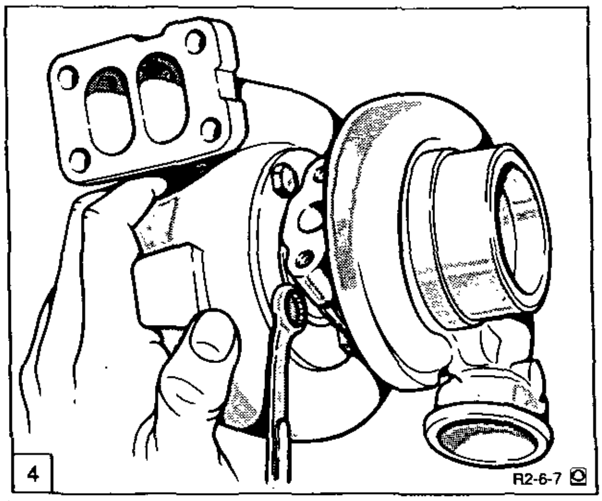
1. Scribe

2. Mark the compressor housing, turbine housing and centre housing with a punch or scribe to facilitate orienting the housings during re–assembly, Figure 2.



Removal of Compressor Housing

3. Remove compressor housing 'C' clip from centre housing intake side using a suitable tool (1), Figure 3.



Removal of Turbine Housing

4. Loosen and remove bolts/lockplates from turbine housing exhaust side, Figure 4.

NOTE: *Exercise care when removing the compressor housing to avoid damaging the compressor wheel blades. Tap the turbine housing with a soft faced hammer if force is needed to remove.*

Cleaning

Before cleaning inspect all parts for burning, rubbing or impact damage that may not be evident after cleaning. Clean all parts in a non caustic solution, using a soft bristle brush, a plastic blade scraper and dry compressed air to remove residue.

DO NOT– use abrasive cleaning methods which might damage or destroy machined surfaces.
DO NOT– immerse Centre Housing and Rotating Assembly (CHRA) in solvent.
DO NOT– blow under compressor wheel with compressed air.
DO NOT– permit wheel/shaft assembly to spin when blowing off solvent and residue.

Inspection

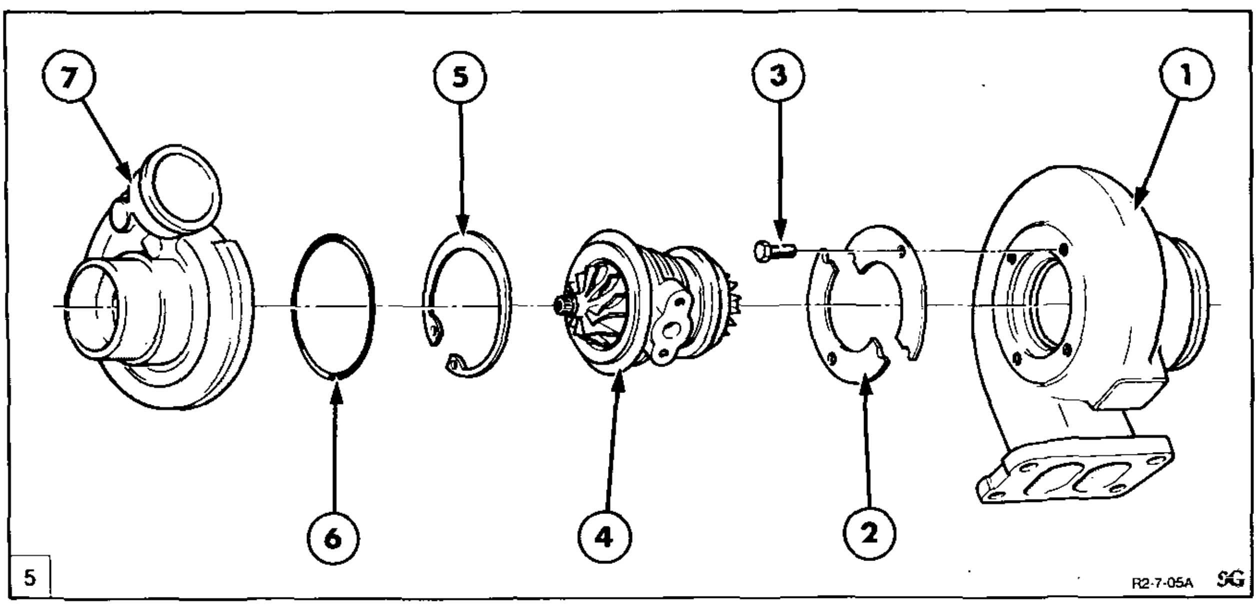
1. Inspect the compressor housing assembly for the following defects:–

Wheel rub damage in the contour area that cannot be polished out with 80 grit silicon carbide abrasive cloth.

Worn, broken or corroded snap ring grooves.

Nicks, dents or distortion that could prevent proper sealing between the compressor housing and the CHRA.

NOTE: *Replace the compressor housing if any of the above defects are found.*



Exploded View of Turbocharger

1. Turbine Housing
2. Retainer Plates
3. Retainer Bolts
4. Turbine CHRA
5. 'C' Clip
6. 'O' Ring
7. Compressor Housing

2. Inspect the turbine housing assembly for the following defects,

Wheel rub damage in the contour area that cannot be polished out with 60 grit silicon carbide abrasive cloth.

Worn, broken, or corroded snap ring grooves (snap ring turbine housing models).

Nicks, dents, or distortion that could prevent proper sealing between the turbine housing and the CHRA.

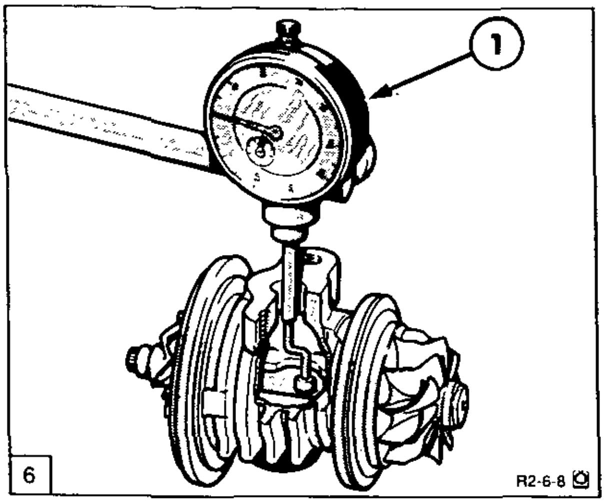
NOTE: *If there is any compressor or turbine wheel blade damage, the CHRA must be replaced. Operating a turbocharger with damaged blades will result in further damage to component parts or the engine. Blades cannot be straightened in service.*

CENTRE HOUSING and ROTATING ASSEMBLY (CHRA)

IMPORTANT: *The CHRA as an assembly, has been balanced at the factory, under precision conditions. As such it must not be disassembled in any way. If disassembled the balance will be destroyed, and a new CHRA must be fitted.*

Centre Shaft Radial Check

Check the journal bearing radial clearance, whenever there is reason to suspect that the bearings are worn enough to allow either the compressor wheel, or the turbine wheel, to rub on its housing. This may be heard as a high pitched whine.



Checking Radial Clearance

1. With the turbocharger removed attach an dial indicator with a dog leg probe (1), Figure 6, to the centre housing. The indicator plunger should extend through the oil outlet port, and contact the shaft of the turbine wheel assembly.
2. Manually apply equal and simultaneous pressure, to the compressor and turbine wheels to move the shaft as far as it will go away from the dial indicator probe.
3. Set the dial indicator to zero.
4. Manually apply equal and simultaneous pressure to the wheels to move the shaft as far as it will go toward the plunger. Make a note of the shaft movement shown on the indicator dial.

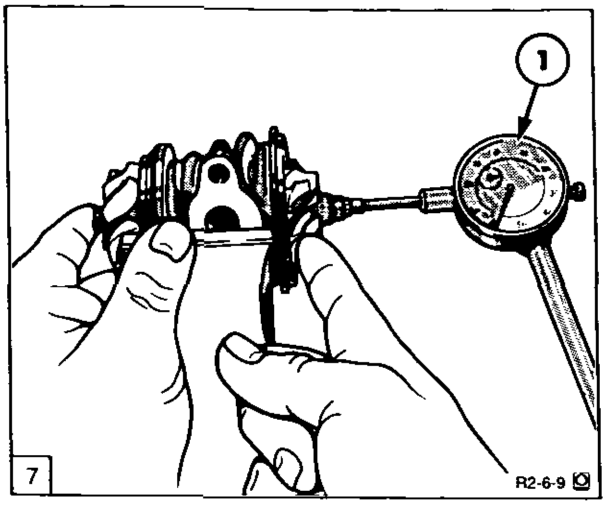
NOTE: *To make sure the reading indicated is the maximum possible, roll the wheels slightly in both directions while applying pressure.*

5. Manually apply equal, and simultaneous pressure to the compressor, and turbine wheels, to move the shaft away from the plunger again. Note that the indicator pointer returns exactly to zero.
6. Repeat the steps 2 to 5 several times, to ensure that maximum radial clearance as indicated by maximum shaft movement, has been measured.
7. If the maximum clearance is less than 0.0022 in (0.056mm) or greater than 0.0050 in (0.127mm) replace the CHRA.

Trouble shoot the engine to find the cause of the bearing failure and correct the problem before resuming operations.

Axle Clearance Check

Check the thrust bearing axial clearance as follows:–



Axial Clearance Check

1. Dial Indicator

1. Place a dial indicator with the probe on the compressor end of the turbocharger shaft assembly, Figure 7.

2. Manually move the compressor/turbine wheel assembly, as far as it will go away from the plunger.

3. Set the dial indicator at zero.

4. Manually move the compressor/turbine wheel assembly as far as it will go toward the dial indicator plunger. Make a note of the shaft movement shown on the indicator dial.

5. Manually move the compressor/turbine wheel assembly as far as it will go away from the plunger. Note that the indicator plunger returns to zero.

6. Repeat steps 2 to 5, several times to make sure that the maximum axial clearance, as indicated by maximum shaft movement, has been measured.

7. If the maximum clearance is less than 0.0010 in (0.0254mm) or greater than 0.0039 in (0.084mm) replace the CHRA

Re–Assembly

1. It is recommended replacing the following with factory authorized parts only, at each overhaul or whenever parts are removed:–

Snap ring, compressor housing retainer

'O' Ring seal, compressor housing

Retainer Plates, turbine housing

Bolts, turbine housing retainers

2. Parts that require changing if faulty or damaged:–

CHRA, turbine assembly

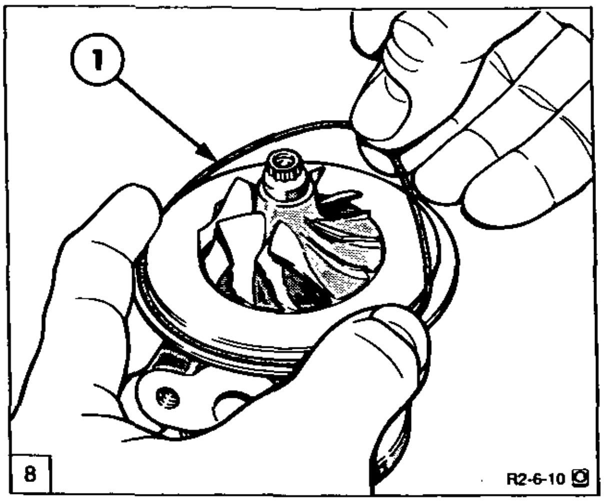
Compressor housing

Turbine housing

3. Inspect all mating surfaces and snap ring groove, to insure that they are free of burrs, foreign matter and corrosion deposits.

4. Transfer scribe marks from old snap rings to new, and coat with a light coating of new engine oil.

5. Install oiled snap ring on compressor end of CHRA, with bevelled face toward the turbine end.



Compressor Assembly

1. 'O' Ring

6. Install an 'O' ring on the centre housing compressor end flange and place compressor housing assembly in position. Be careful not to damage the compressor wheel blades, Figure 8.

7. Carefully rotate the compressor housing onto the CHRA to line up scribed marks.

8. Install the oiled snap ring, lug first, into the compressor housing groove. Be sure that the bevelled side faces the turbine end and the scribe marks are aligned.

9. Tap the inner circumference or lug ends of the ring with an appropriately sized drift to ensure proper seating.

NOTE: *When installing a new CHRA or turbine housing, transfer scribed alignment marks from the old to the new parts.*

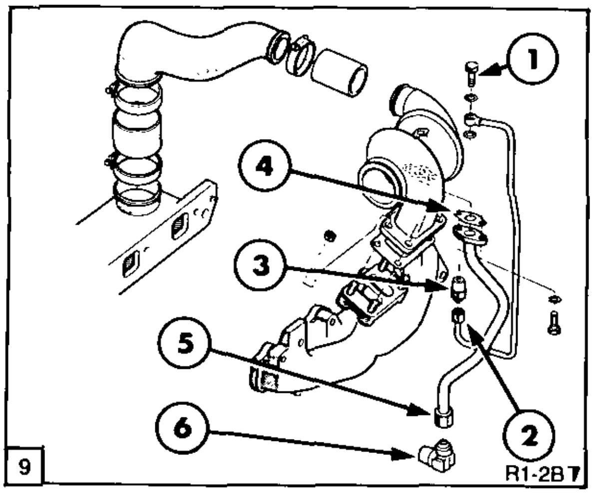
10. Position the turbine housing discharge side down, on a flat, level surface. Place the CHRA turbine wheel end into the housing, use care to avoid damaging the wheel blades. Check visually for proper alignment.

11. Carefully rotate the CHRA in the turbine housing to line up the scribed marks. Recheck for proper alignment and position the locking plates.

12. Coat the bolts in a suitable non–seize compound and tighten to a torque of 15–18 lbf ft (20–25Nm) 2.0–2.5 kgf m.

Installation

1. Prior to installation fill the turbocharger centre housing with new clean oil, and rotate the main shaft to lubricate the bearings.



Turbocharger Exploded View

1. Oil Feed Tube to Turbcharger (Banjo Bolt)
2. Oil Feed Tube to Filter Head Connector
3. Connector to Filter Head
4. Oil Return Tube Bolts from Turbocharger to Block
5. Oil Return Tube to Block Connector
6. Oil Return Connector to Block

2. Installation of the turbocharger follows the removal procedure in reverse. Install a new manifold gasket, and tighten to, 30–35 lbf ft (41–47Nm) 4.1–4.7 kgf m.

3. Replace the washers and re–connect the oil feed tube banjo bolt (1), Figure 9, and torque to 22–30 lbf ft (30–40Nm) 3.0–4.0 kgf m.

4. The oil feed tube connector (3), Figure 9, if disturbed should be refitted. Apply sealer to connector "See Specifications and torque to, 40–60 lbf ft (54–81Nm) 5.4–8.1 kgf m.

5. Apply sealer "See Specifications", assemble the oil feed tube to the oil filter head connector (2) Figure 9, and tighten to,13–15 lbf ft (18–20Nm) 1.8–2.0 kgf m

6. Place a suitable receptacle below the oil outlet port and, **WITH THE ELECTRICAL SOLENOID WIRE DISCONNECTED AT THE FUEL INJECTION PUMP,** crank the engine until oil flows from the outlet port.

7. Reconnect the oil outlet tube (4) Figure 9, using a new gasket and tighten the retaining bolts at the turbocharger to 15–18 lbf ft (20–25Nm) 2.0–2.5 kgf m.

8. Tighten the oil return tube to cylinder block connector, (5) Figure 9 to, 45–50 lbf ft (54–81Nm) 5.4–8.1 kgf m.

9. If disturbed Oil return tube connector (6), Figure 9, should have sealer applied "See Specifications" and torque to 20 lbf ft (27Nm) 2.7 kgf m.

10. Reconnect the air inlet, and outlet tubes, with the hose clamps, and torque to 15–20 lbs in (1.7–2.3Nm), Figure 9.

11. Reconnect the fuel injection pump solenoid wire.

12. Check the engine oil level and add oil if required. Idle the engine and check all tubes and gaskets for leaks.

13. Run the engine at rated speed and listen for sounds of metallic contact from the turbocharger. If any noise is apparent, stop the engine immediately and correct the cause.

NOTE: *After the unit has obtained operating temperatures, the rotating assembly should coast freely to a stop after the engine is stopped. If the rotating assembly jerks to a sudden stop, the cause should be corrected immediately.*

D. SPECIFICATIONS

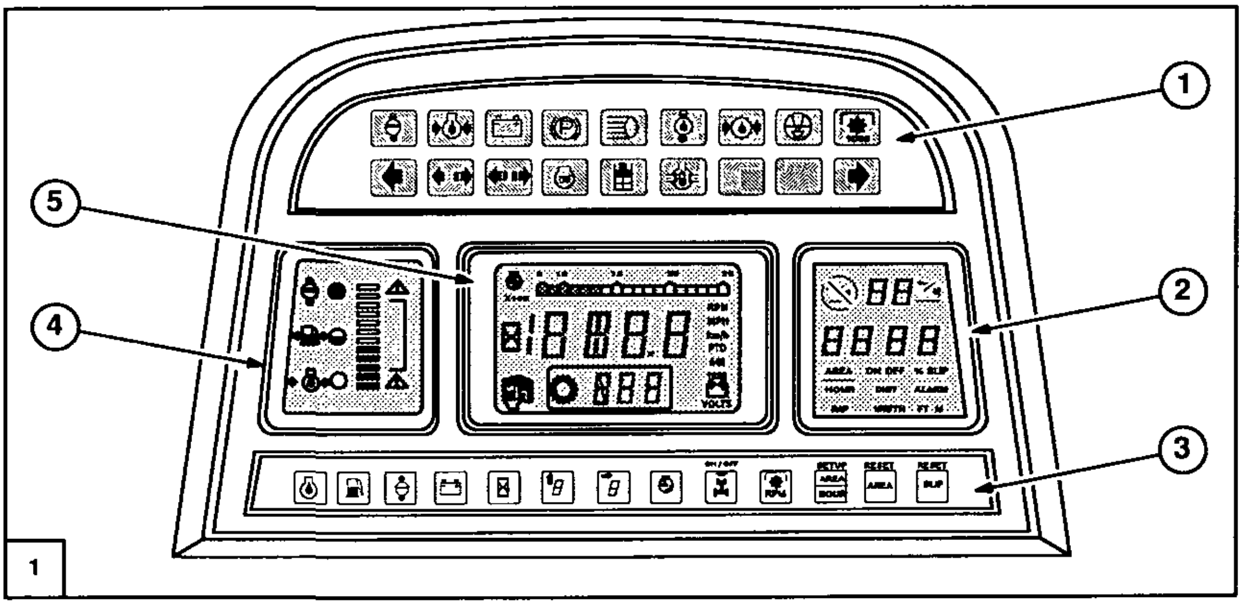
GENERAL TORQUES	lbf ft	Nm	kgf m
Turbine Housing Bolts	15–18	20–25	2.0–2.5
Turbocharger to Manifold	30–35	41–47	4.1–4.7
Oil Feed Tube to Turbocharger (Banjo Bolt)	22–30	30–40	3.0–4.0
Oil Feed Tube to Filter Head Connector	13–15	18–20	1.8–2.0
Connector to Filter Head	40–60	54–81	5.4–8.1
Oil Return Tube Bolts from Turbocharger	15–18	20–25	2.0–2.5
Oil Return Tube to Block Connector	45–50	60–70	6.0–7.0
Oil Return Connector to Block	20	27	2.7
Inlet Hose Clamps	(15–20 lbs in)	1.7–2.3	

SEALER	
Type ESE–M4G194–B	Sealer Anaerobic Low Strength

PART 3
ELECTRICAL SYSTEMS
Chapter 1
ELECTRONIC INSTRUMENT CLUSTER

A. DESCRIPTION AND OPERATION

Overall Description



Electronic Instrument Cluster

1. Upper Section
2. Right Hand Display
3. Lower Section
4. Left Hand Display
5. Main Display

The Electronic Instrument Cluster is shown in Figure 1 above with all displays activated.

When the key-start switch is turned on, the cluster self-tests. All the Liquid Crystal Displays (LCD) segments are activated, the audible alarm sounds and the malfunction warning lamps illuminate briefly.

1. The **Upper Section** (page 2 and 3) has eighteen coloured lights providing operating information and warning of system malfunction.

2. The **Right-Hand Display** (page 5) has LCD's providing Tractor Performance (implement and hydraulics) information.

3. The **Lower Section** has thirteen touch-sensitive function buttons. Touching these buttons displays information on the LCD's.

4. The **Left-Hand Display** (page 6) is a twelve segment LCD bargraph. Touching the appropriate function button displays information on engine coolant temperature, fuel level and engine oil pressure.

5. The **Main Display** (page 3) is a multi-function LCD activated by the function buttons.

UPPER SECTION
(Indicator, Warning Lights and Audible Alarm)

Certain tractor malfunctions are identified by an audible warning, a warning light and a flashing error code in the relevant LCD (see page 8).

The alarms sound as follows:

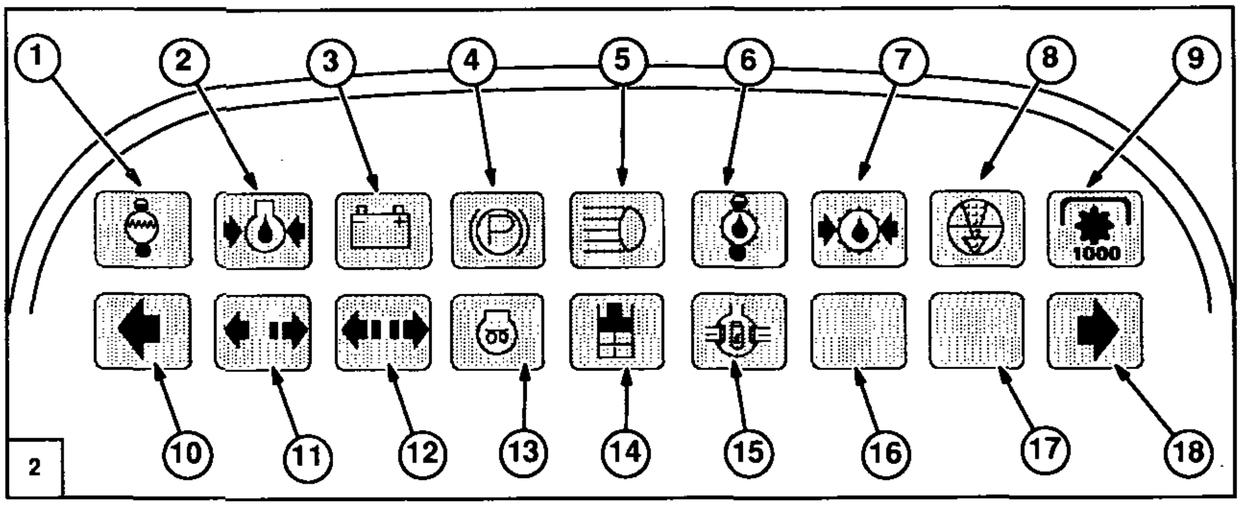
Non-critical alarm: continuous for 5 seconds.

Critical alarm: Intermittent until fault is corrected or engine switched off.

The lights/alarm function as follows:
(with reference to Figure 2),

Upper Row - *left to right*

1. High engine coolant temperature.
   - Light illuminates.
2. Low engine oil pressure,
   - Light illuminates.
3. Alternator not charging,
   - Light illuminates.
4. Parking brake and brake/clutch fluid level,
   - Key-start on, constant light indicates parking brake applied or low fluid level in brake/clutch reservoir. Attempting to drive the tractor with parking brake applied/partially applied, sounds the alarm. With key-start off and parking brake not applied, critical alarm will sound continuously for approximately two minutes.
5. Headlight main beam,
   - Light illuminates when tractor lights are *switched to main beam.*
6. Transmission oil temperature high,
   - *Light illuminates accompanied by the* critical alarm. Stop engine and investigate the cause.



Indicator Lights

Description	Colour
1. Engine Coolant Temperature	Red
2. Engine Oil Pressure	Red
3. Alternator Charge	Red
4. Parking Brake and Brake/Clutch Fluid Level	Red
5. Headlight Main Beam	Blue
6. Transmission Oil Temperature	Red
7. Transmission And Steering Oil Pressure	Red
8. Air Cleaner	Amber
9. 1000 Rev/Min P.T.O. Shiftable P.T.O. Only	Amber

Description	Colour
10. Left Turn Indicator	Green
11. Trailer Turn Signal (When Attached)	Green
12. Second Trailer Turn Signal (When Attached)	Green
13. Thermostart	Amber
14. Hydraulic Filter/Hydraulic Pump Charge Pressure	Red
15. Differential Lock	Amber
16. Not Used	
17. Not Used	
18. Right Turn Indicator	Green

7. Transmission/steering oil pressure low,

- Light illuminates, critical alarm sounds.

8. Air cleaner blocked,

- Light illuminates, non-critical alarm sounds for 5 seconds.

9. 1000 rev/min P.T.O. (shiftable P.T.O. only),

- Constant light indicates that 1000 rev/min P.T.O. speed is selected. If P.T.O. overspeeds in the economy range, the light flashes.

Lower Row - left to right

10. Left turn indicator,

- Light flashes in unison with tractor left-hand turn lamp.

11. Trailer turn signal,

- Light flashes in unison with tractor/trailer turn signals if trailer attached.

12. Second trailer turn signal,

- Light will flash in unison with tractor/trailer turn signals if second trailer attached.

13. Thermostart,

- Light illuminates when Thermostart is activated.

14. Hydraulic filter/hydraulic pump charge pressure,

- Constant light:- filter blocked/partially blocked.
- Flashing light and non-critical alarm:- low hydraulic pump pressure.

15. Differential lock,

- Light illuminates when differential lock is engaged.

16. Not Used.

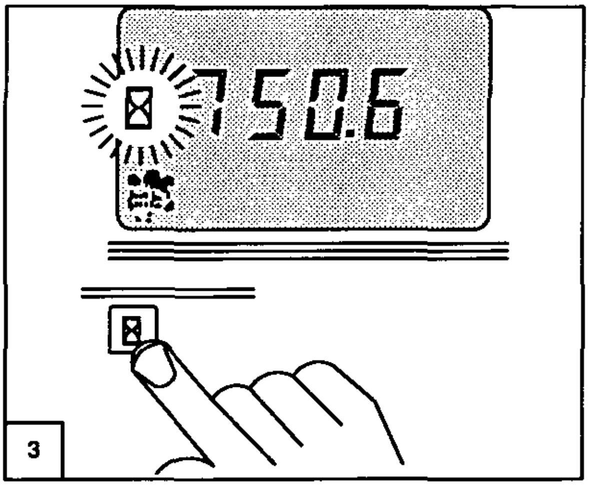
17. Not Used.

18. Right turn indicator.

- Light flashes in unison with tractor right-hand turn lamp.

MAIN DISPLAY (LCD)

Engine Hourmeter



3

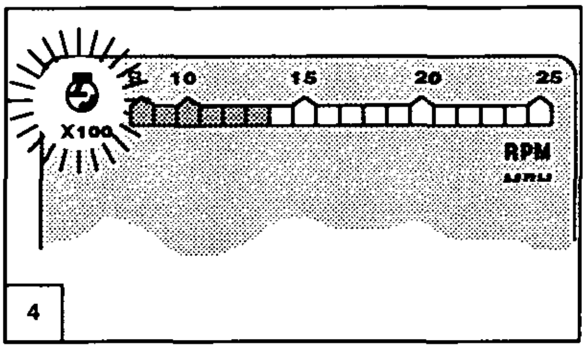
Keystart 'ON', engine stopped – symbol illuminates, hours of operation displays.

Keystart 'ON', engine running – touch function button to display hours of operation.

Hours accumulated in increments of 0.1 up to 1000 and increments of 1.0 after 1000.

NOTE: *Accumulated hours are stored in the computer permanent memory which is unaffected by disconnection of the tractor battery (Keep Alive Memory – KAM). Actual hours are recorded regardless of engine speed.*

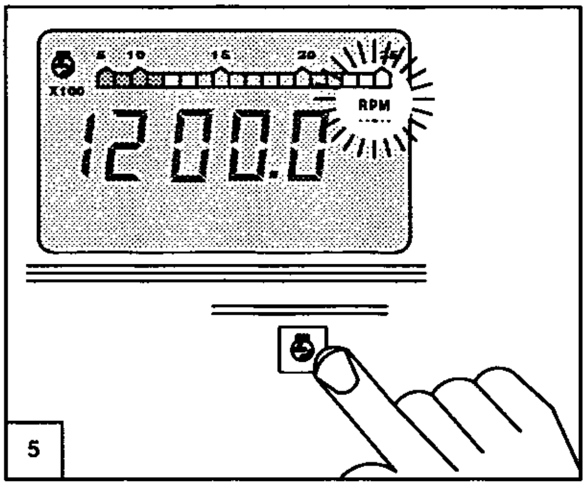
Engine Speed - Bargraph



4

Engine running – symbol illuminates and bargraph displays constant read out of engine speed, regardless of main LCD display.

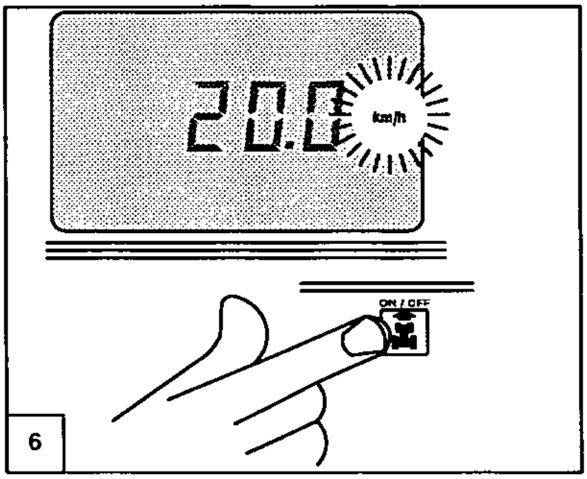
Engine Speed - Digital Display



5

Engine running, touch function button to display 'RPM' legend and engine speed.

Ground Speed Display (Speedometer)



6

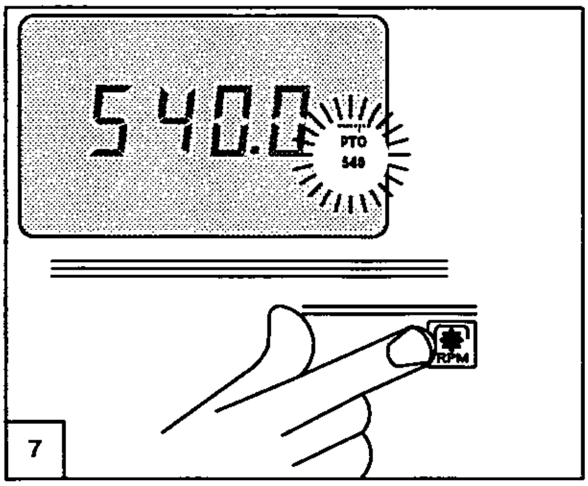
Touch function button to show ground speed

NOTE: *The cluster is set to display either MPH or km/h. The display can be re-programmed to display ground speed in Metric or Imperial units. See* 'Programming the Tractor Performance Monitor', *page 24.*

NOTE 1: *Displayed speed can vary according to wheel slip, tyre pressures/condition, etc. True ground speed is displayed when the radar option is fitted.*

NOTE 2: *The display automatically shows ground speed if the tractor is traveling at more than 20 km/h (12.4 m.p.h.). If another function is required continuously depress the appropriate button.*

Power Take Off Display



7

- **Non-Shiftable P.T.O.**

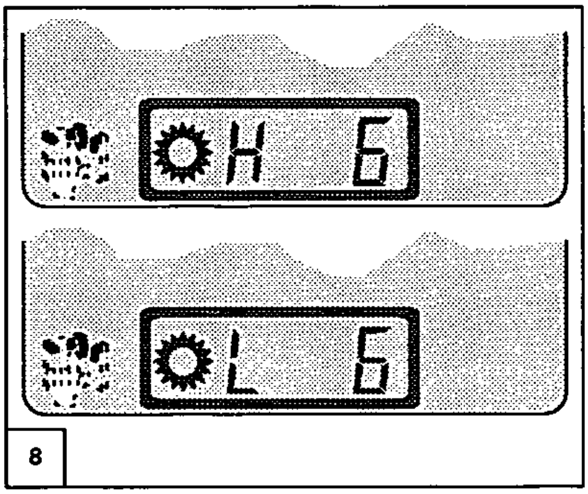
Touch function button to display 'P.T.O. 540' legend and P.T.O. speed. Touch function button again to display 'P.T.O. 1000' legend and speed.

- **Shiftable P.T.O.**

Touch function button to display P.T.O. speed as selected by control lever, also displays when selector knob is disengaged.

NOTE: *The displayed P.T.O. speed is based on a signal from the engine speed sensor. When the P.T.O. function button is theoretical P.T.O. speed will be displayed regardless of selector lever position.*

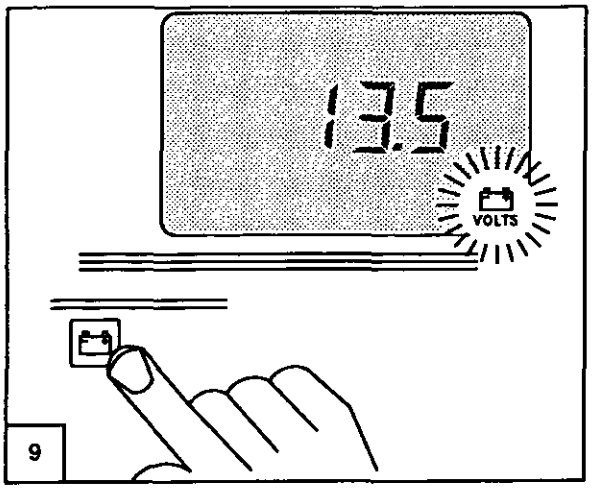
Transmission Gear Ratio Display



8

Key-start 'ON' – the lower LCD provides permanent display of the gear ratio selected.

Battery Voltage



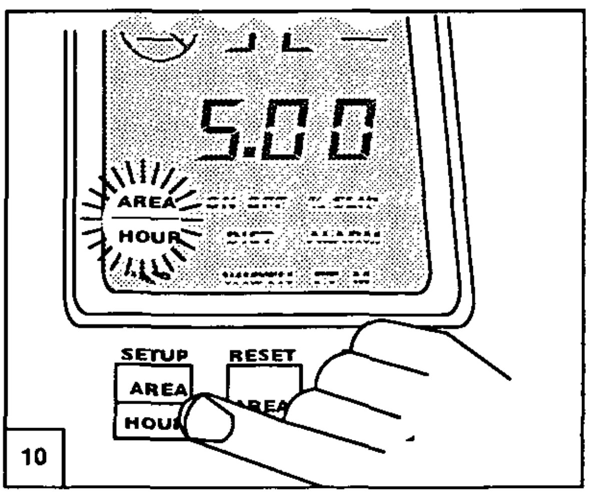
9

Engine running, touch function button to display battery symbol and voltage. The audio alarm sounds and symbol flashes if voltage is below 10.0v or above 16.0v (if another function is selected during this the symbol will continue to flash).

During other function displays, the display will revert to show battery voltage and flashing symbol if voltage goes outside limits.

RIGHT HAND DISPLAY
(Tractor Performance Monitor)

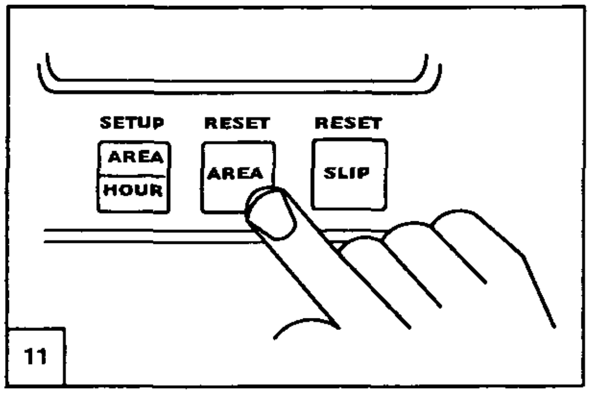
Area per Hour Forecaster



10

Touch AREA/HOUR button to give forecast of the area that will be worked in one hour if current rate of work is continued.

Area Accumulator

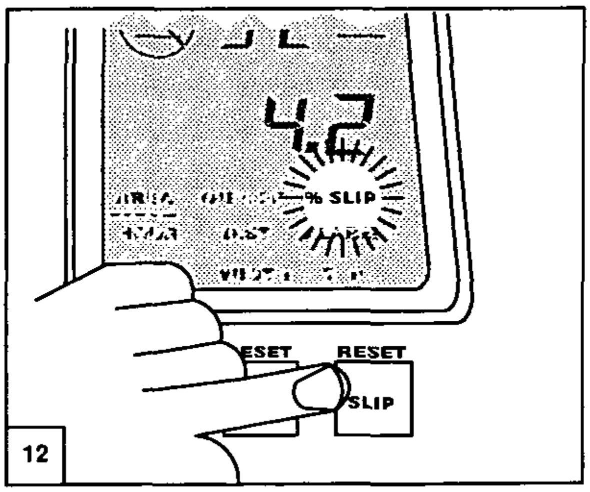


11

Touch 'AREA' button to display accumulated area (in hectares or acres).

NOTE: *If the radar option is not installed, area per hour calculations are based on axle speed.*

Wheel Slip
(with radar option)



12

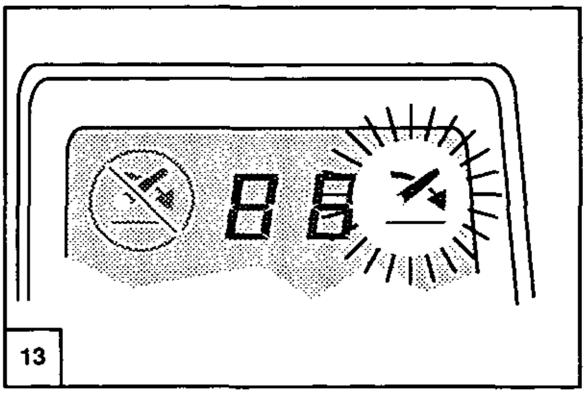
Touching 'SLIP' button displays a slip value calculated by comparing axle rotation with true ground speed (radar sensor).

Slip Alarm
(with radar option)

A maximum percentage slip level can be set to activate the alarm system if slip exceeds this figure.

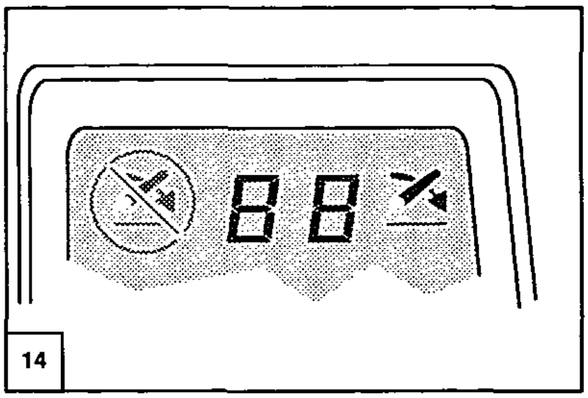
WARNING: *The radar ground speed sensor emits a low intensity microwave signal which will not cause any ill effects in normal use. Although the signal intensity is low, **DO NOT** look directly into the face of the sensor while in operation so as to avoid eye damage. The radar sensor is beneath the front of the footsteps on the left-hand side.*

Hitch Enable Symbol
(with Electronic Draft Control – EDC)


13

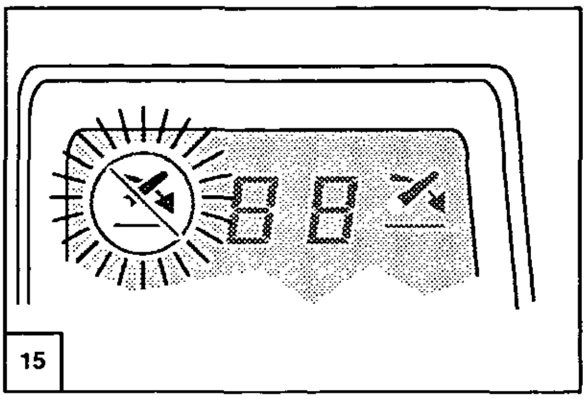
Displayed when three-point linkage (and implement) is raised. Operates in phase with and controlled by the quadrant lever.

Implement Position Display
(with EDC)


14

Advises operator of lower link and implement position.
Range = '0' (lowered) to '99' (raised).

Hitch Disabled Symbol
(With EDC)


15

Displays when three-point linkage is out of phase with the hydraulic lift control lever.

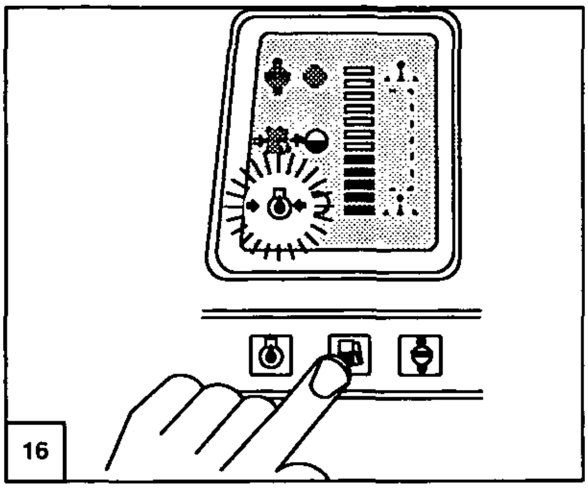
LEFT HAND DISPLAY (Bargraph)

Key-start 'ON' – Bargraph displays fuel level.

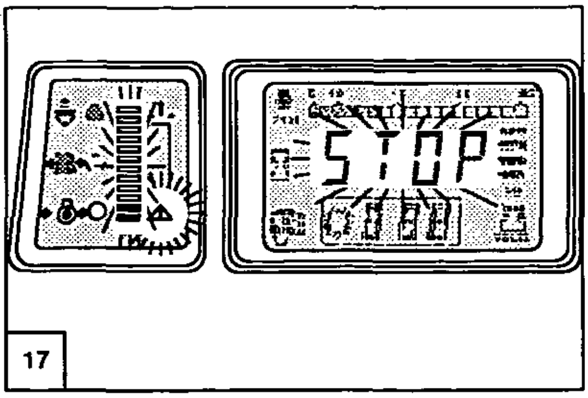
Engine started – bargraph displays engine oil pressure.

After 10 minutes bargraph changes to display engine coolant temperature.

Engine Oil Pressure


16

Touch the button, symbol displays and *bargraph indicates oil pressure.*

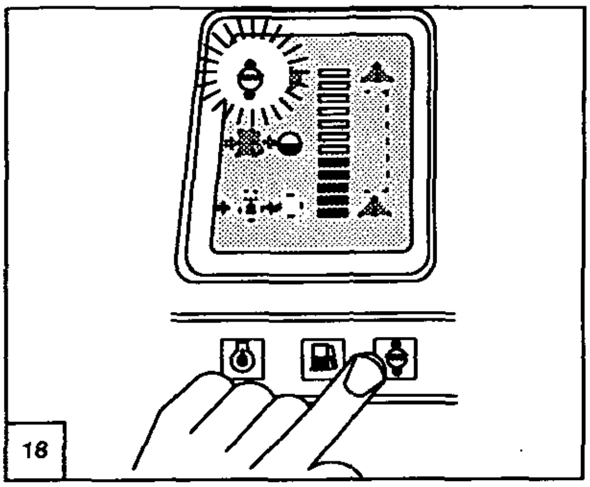


17

If the oil pressure falls below the following pressures, the bargraph, 'Low' warning symbol and 'STOP' flash, the critical alarm sounds and the Performance Monitor display goes blank.

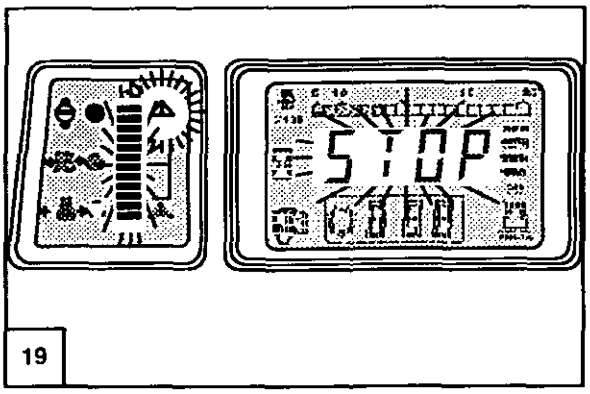
Engine Rev/Min	Pressure lbf/in²	Pressure bar
500–1500	8	0.55
1500–2000	16	1.1
2000–3000	24	1.7

Engine Coolant Temperature



18

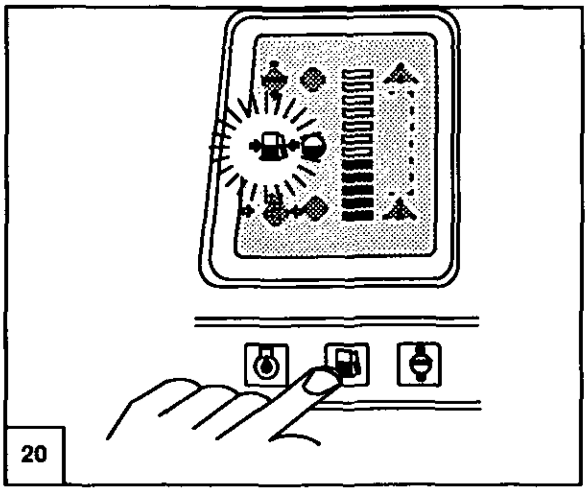
Touch button, symbol displays. Bargraph indicates Temperature.



19

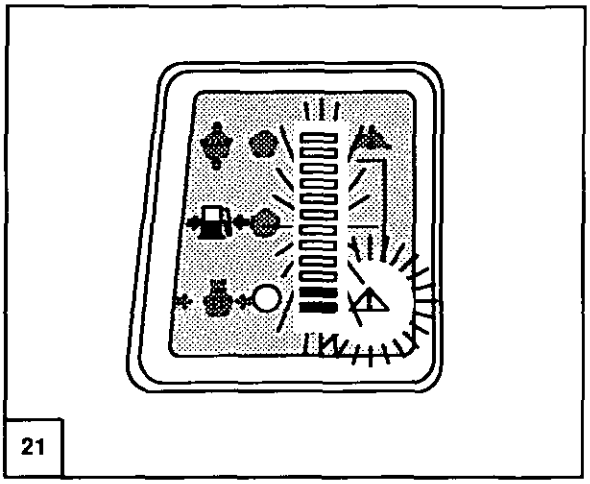
If coolant temperature is greater than 113° C, the bargraph, 'High' warning symbol and 'STOP' flash the critical alarm sounds and Performance Monitor display goes blank.

Fuel Level



20

Touch button fuel symbol displays.



21

With only two segments displayed, the bargraph and 'Low' warning symbol flash Non-critical alarm sounds for 5 seconds.

NOTE: *If content of the fuel tanks falls below designated level, engine oil pressure is too low or coolant temperature too high the bargraph will switch to the applicable display, the alarm will be activated and display will flash.*

Automatic Engine Shut Down (Dealer Installed Accessory)

This feature automatically shuts down the engine within 30 seconds when engine oil pressure falls below or engine coolant temperature rises above pre-determined levels.

WARNING : *The engine shut down feature is fully automatic and **cannot** be overridden by the operator. Consequently, this feature should only be used for stationary P.T.O. work where the tractor may be left unattended for a period.*

B. FAULT FINDING

ERROR CODES

The Electronic Instrument Cluster (EIC) features an integral fault diagnosis system which displays error codes on the LCD as shown in the following Table.

These error codes appear when any one of the listed errors occurs. The alarm sounds continuosly for a critical alarm and for 5 seconds with a non critical alarm.

SENSOR CONDITION	EIC DISPLAY		ALARM
	Less than 500 rev/min Error Code No.	More than 500 rev/min	
Oil Sender Short to Ground/Open Circuit	1	STOP	Critical
Fuel Sender Short to Earth/Ground	3		Non Critical
Fuel Sender Open Circuit or Short to a +ve Voltage	4		Non Critical
Axle Sender Short to Earth/Ground	5	MPH	Non Critical
Axle Sender Open Circuit or Short to a +ve Voltage	6	MPH	Non Critical
Coolant Temperature Sender Short to Earth/Ground	7	STOP	Non Critical
Electronic Draft Control error	8		
Transmission error	9		
Battery Calibration error	10		
Slip Alarm, Slip constant, Width and Service Hours check	11	MPH	Non Critical
Coolant Temperature Sender open circuit or shorted to a +ve Voltage	12	STOP	Critical
Engine Shutdown error	13		
This Code is not displayed, but can be stored in the Service Memory	14		

Non EIC Errors – only displayed during the following procedure.

Read Your Manual (RYM)

The EIC will store the latest 10 error codes displayed, even when power is disconnected.

These ten errors can be reviewed at any time by the following procedure.

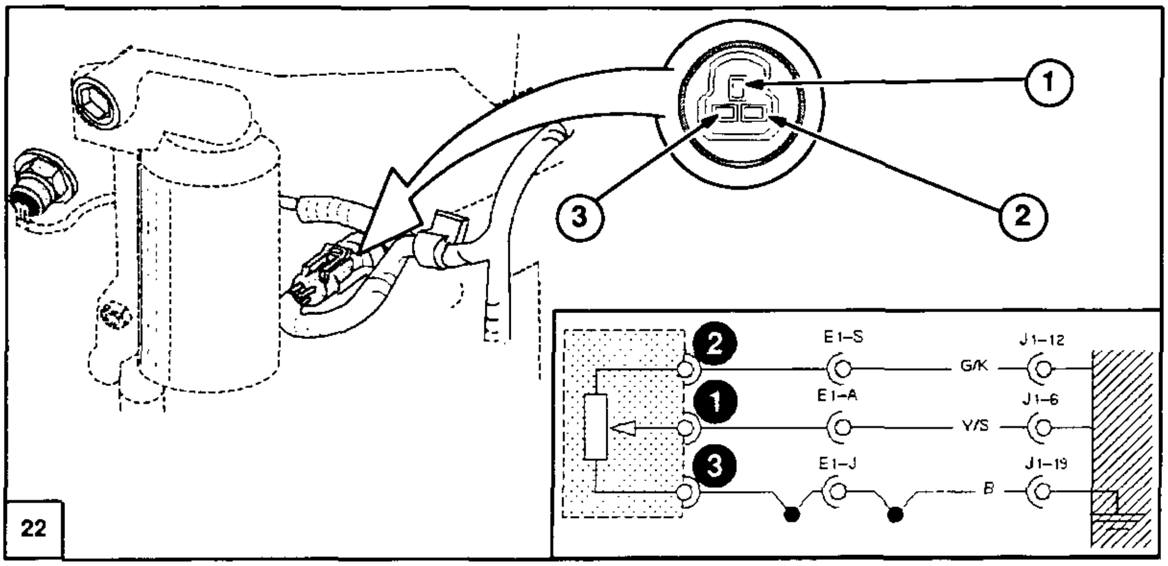
Hold the DIGIT SET button down and switch the keystart 'ON' (engine stationary).

- The malfunction symbol (Read Your Manual – RYM) will flash.
- The last error code stored will be displayed on the appropriate display.
- Engine hour and time of the error will be displayed.
- The word Hour with a bar over it will illuminate.

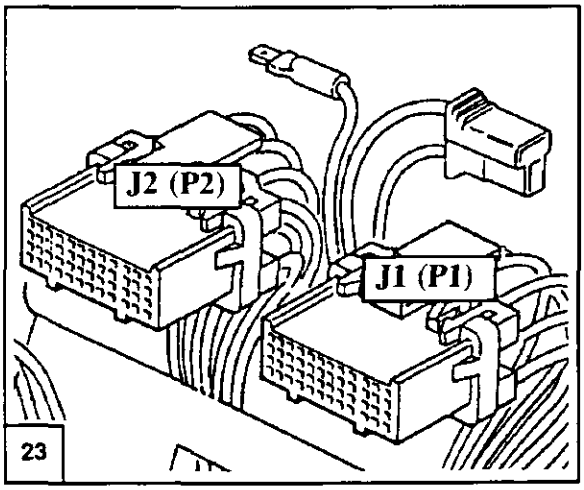
Touching the digit set button cycles the display to the next most recent error progressively to the least recent.

All error codes appear on the original display.

ERROR CODE 1 – Engine Oil Pressure Sender Short or Open Circuit



1. Signal Out Pin 2. +5v Supply Pin 3. Ground Pin



Turn keystart **OFF** and disconnect sender

▼

Short **Signal Out** (Y/S) and **+5** (G/K) pins on connector
Is Error Code 1 still *displayed*?

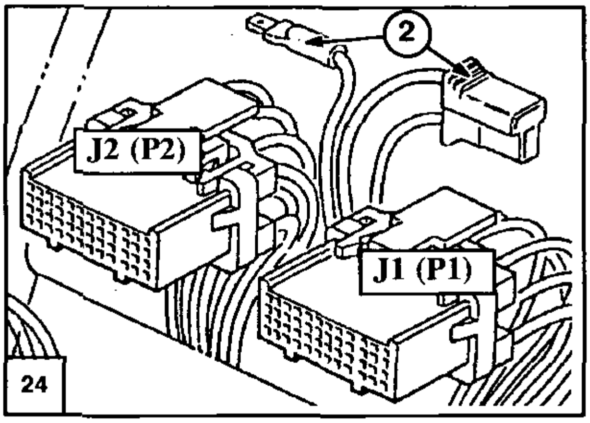
NO ▶ **Does Error Code disappear and oil pressure display indicate maximum?**

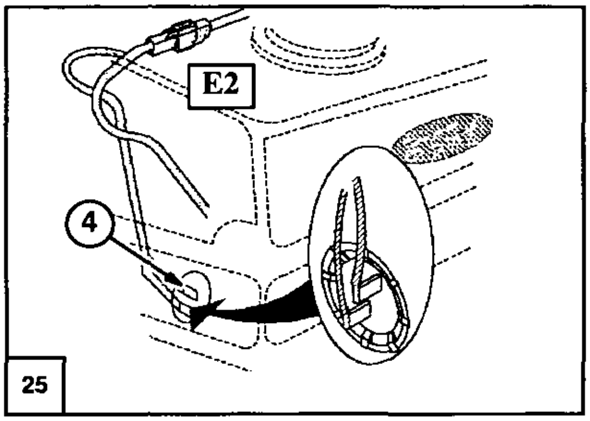
- **YES** ▼ At connector measure voltage between **+5** and **Ground** pins
  Is voltage approx. 5v?
  - **NO** ▶ Replace cable
  - **YES** ▼ Replace sender

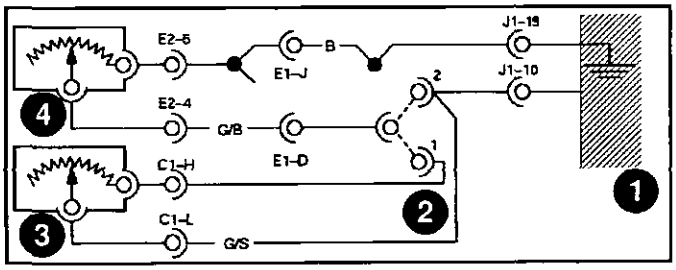
YES ▼ Check for faulty cable between **E1–S/J1–12, E1–A/J1–6** and **E1–J/J1–7**
Is cable O.K?

- **YES** ▼ Rplace EIC
- **NO** ▼ Replace cable

ERROR CODE 3 – Main Fuel Tank Level Sender Short Circuit







1. EIC
2. One/Two Tank Selector
3. Auxiliary Tank Sender
4. Main Tank Sender

Remove the signal wire (G/B), attached to the main fuel tank sender. Move the terminal end of the wire out so that it is not touching any metallic parts of the tractor. With the engine off and the keystart on
Is Error Code '3' displayed?

NO → Renew the main fuel tank level sender and recheck function.

YES ↓

If an auxiliary tank is fitted remove the signal wire (G/S) at the auxiliary tank sender
Is Error Code '3' still displayed?

NO → Locate and repair short circuit to ground in cable between both senders

YES ↓

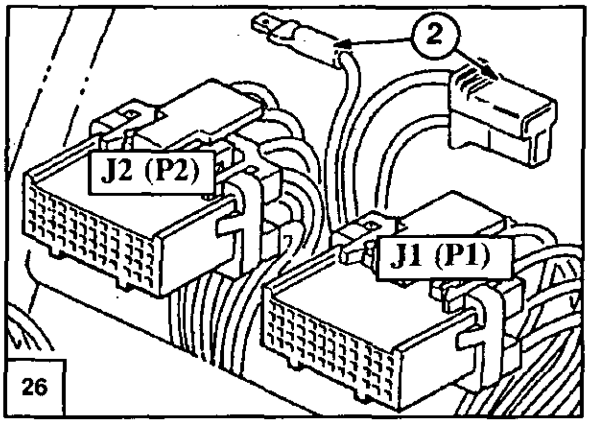
Remove the instrument panel, remove plug **J1** With the signal wire(s) from the fuel tank level sender(s) removed, measure the resistance between connector pins **J1-10** (G/B) and **J1-7**
Is resistance less than 5000Ω?

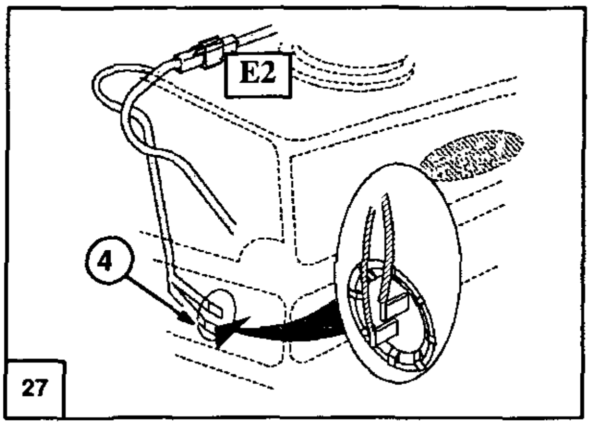
YES → Locate and repair short circuit to ground in signal wire

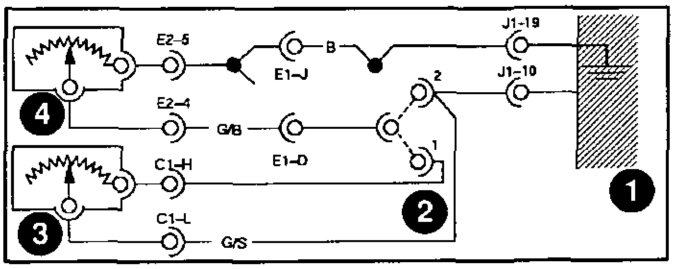
NO ↓

Install a new Instrument Panel and recheck function.

ERROR CODE 4 – Main Fuel Tank Level Sender Open Circuit







1. EIC
2. One/Two Tank Selector
3. Auxiliary Tank Sender
4. Main Tank Sender

Inspect the sender connector
Are the terminals clean and does the connector fit securely?

- NO ▶ Repair poor connection and recheck function
- YES ▼

Remove the signal wire (G/B) attached to the main fuel tank level sender terminal and connect it to ground.
Is Error Code '3' displayed?

- YES ▶ With the signal wire removed from the sender. measure the resistance between the sender terminals. **Is the resistance within the range Full–30 Ω, Empty–250 Ω ?**
  - YES ▼ Locate and repair open circuit in sender ground wire
  - NO ▼ Renew sender and recheck function.
- NO ▼

Is tank selector connector E1–D connected correctly?

- NO ▼ *Repair poor connection and recheck function*
- YES ▼

Are two fuel tanks fitted?

- YES ▶ Remove signal wire (G/S), attached to auxiliary fuel tank sender and connect to ground **Is Error Code '3' displayed?**
  - YES ▶ With the signal wire removed from the sender. measure the resistance between the sender terminals. **Is the resistance within the range 0–125 Ω ?**
    - YES ▼ Locate and repair open *circuit in* sender ground wire
    - NO ▼ Renew sender and *recheck* function.
  - NO ▼
- NO ▼

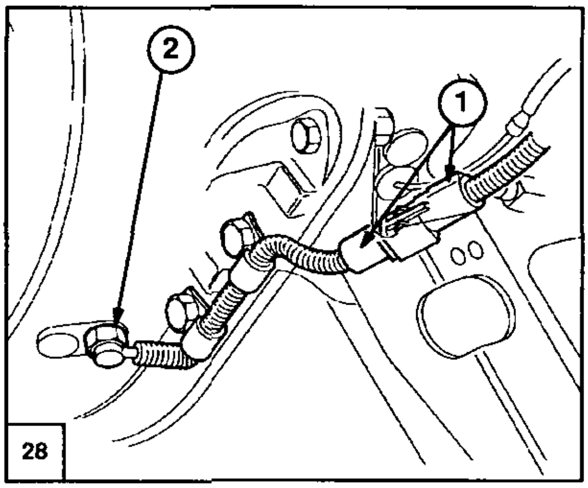
Remove the instrument cluster. Remove plug **J1**. Earth the sender wire and measure the resistance between connector pins **J1-10** (G/B) and **J1-7** (G/W/B)
Is resistance less than 10Ω?

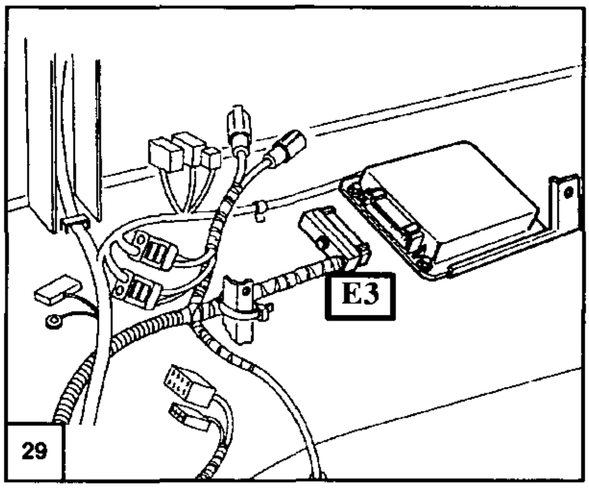
- NO ▼ Locate and repair open circuit
- YES ▼

Clean plug **J1** pins with contact cleaner spray. Reconnect plug and turn keystart switch on.
Does cluster function **correctly without Code '4' displayed?**

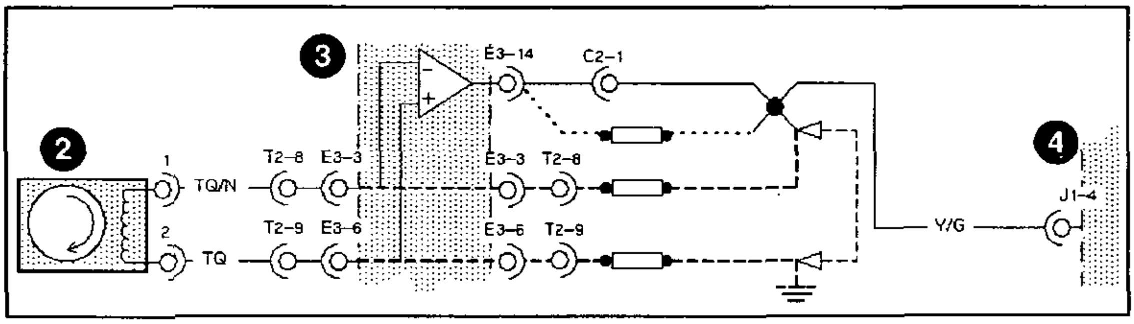
- NO ▶ Install a new instrument cluster and recheck function.

ERROR CODE 5 – Axle Speed Sender Short Circuit





1. Sender Connector
2. Sender
3. EEC IV
4. Instrument Panel



Does tractor have 16x16 transmission or E.D.C.

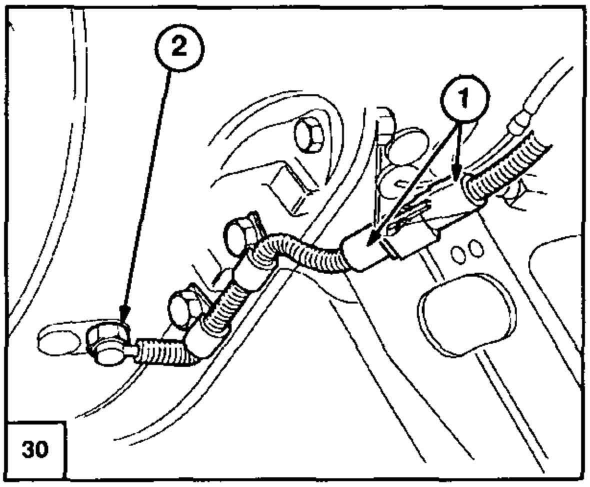
NO → Unplug axle speed sender connector. Turn keystart ON, engine not running **Is Error Code 5 displayed?**

- **YES** → Remove Instrument Panel, disconnect **J1**. With sender still disconnected, measure resistance between **J1–4** and **J1–7** **Is resistance less than 5000Ω?**
  - **YES** → Locate and repair short circuit to ground on signal wire
  - **NO** → Install new Instrument Panel and retest
- **NO** → Renew the sender and recheck function

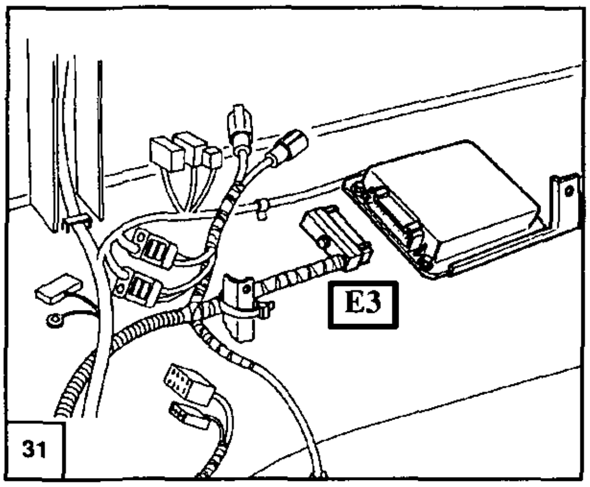
YES → Disconnect EEC IV connector **E3**, turn keystart on **Is Error Code 5 displayed?**

- **YES** → Remove Instrument Panel, disconnect **J1**. Measure resistance between **J1–4** and **J1–7** **Is resistance less than 5000Ω?**
  - **YES** → Locate and repair short circuit to ground on signal wire
  - **NO** → Install new Instrument Panel and retest with EEC IV connected
- **NO** → Install new EEC IV and recheck

ERROR CODE 6 – Tractor Axle Speed Sender Open Circuit

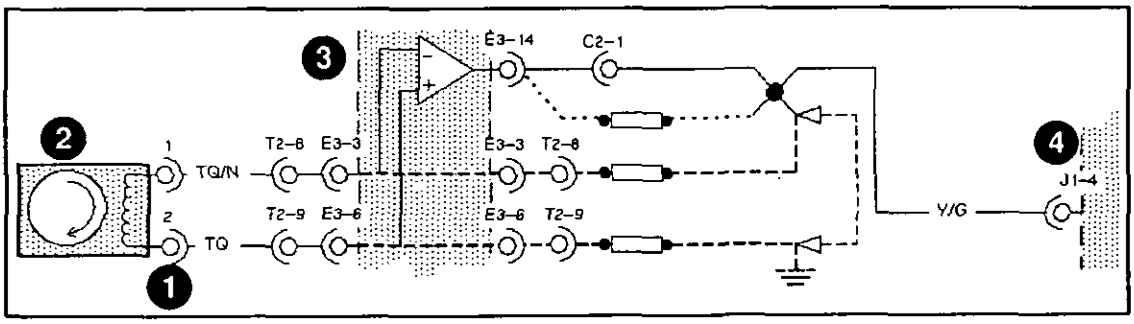


30



31

1. Sender Connector
2. Sender
3. EEC IV
4. Instrument Panel



Does tractor have 16x16 transmission or EDC

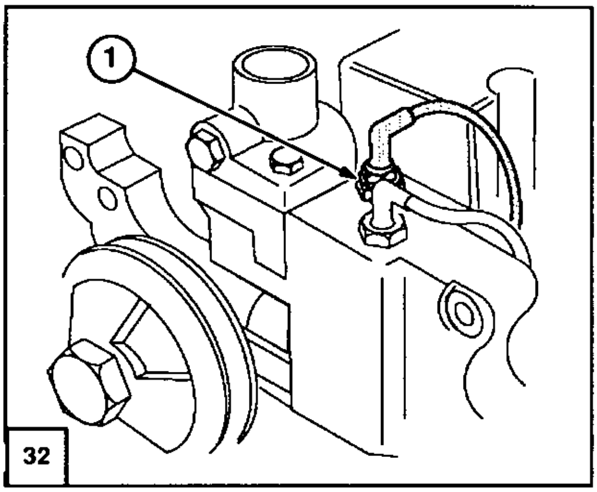
NO →

- Identify the tractor axle speed sender connector. **Are the terminals clean and does the connector fit firmly together?**
  - NO → Rectify poor connection and recheck function.
  - YES ↓
- Disconnect sender Measure resistance between the sender terminals. **Is resistance within the range 1000–3000 Ω?**
  - NO → Renew the sender and recheck function.
  - YES ↓
- With the sender disconnected ground number 1 terminal (TQ). **Does the display show Error Code 5?**
  - YES → Locate and repair open circuit in ground wire
  - NO ↓
- Disconnect plug **J1**. Ground terminal 1 (TQ) of sender connector and measure resistance between frame and pin **J1–4**. **Is the resistance measured less than 10 Ω?**
  - NO → Locate and repair open circuit in sender wire
  - YES ↓
- Clean pins of plug **J1** with contact cleaner spray. Reconnect plug and turn keystart switch on. **Does cluster function correctly without Error Code 6 displayed?**
  - NO → Install a new Instrument Panel and recheck function

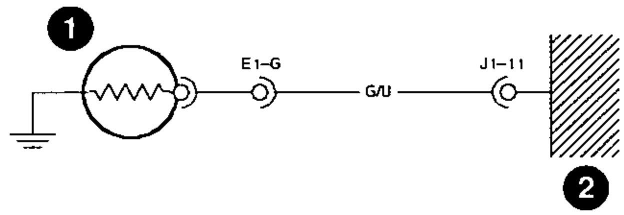
YES →

- Disconnect **EEC IV** connector **E3**. Connect pin **E3–14** to ground. Turn keystart ON, engine OFF. **Is Error Code 5 displayed?**
  - YES → Install a new EEC IV and retest
  - NO ↓
- Remove *Instrument Panel*, disconnect **J1**. Measure risistance between **J1–4** and **J1–7**. Connect **E3–14** to ground. **Is resistance less than 10Ω?**
  - YES → Install a new Instrument Panel
  - NO → Locate and repair open circuit in signal wire

ERROR CODE 7 – Coolant Temperature Sender Short Circuit



1. Coolant Temperature Sender
2. E.I.C.



Remove the connector from the sender. Ensure the end of the wire is not contacting any metallic part. Turn keystart ON, engine OFF
Is Error Code 7 displayed?

NO → Renew sender and recheck function.

YES ↓

Remove the instrument panel, disconnect plug **J1**. Disconnect the signal wire from the sender. Measure the resistance between pins **J1–11** and **J1–7**
Is the resistance less than 5000Ω?

YES → Locate and repair short circuit in signal wire

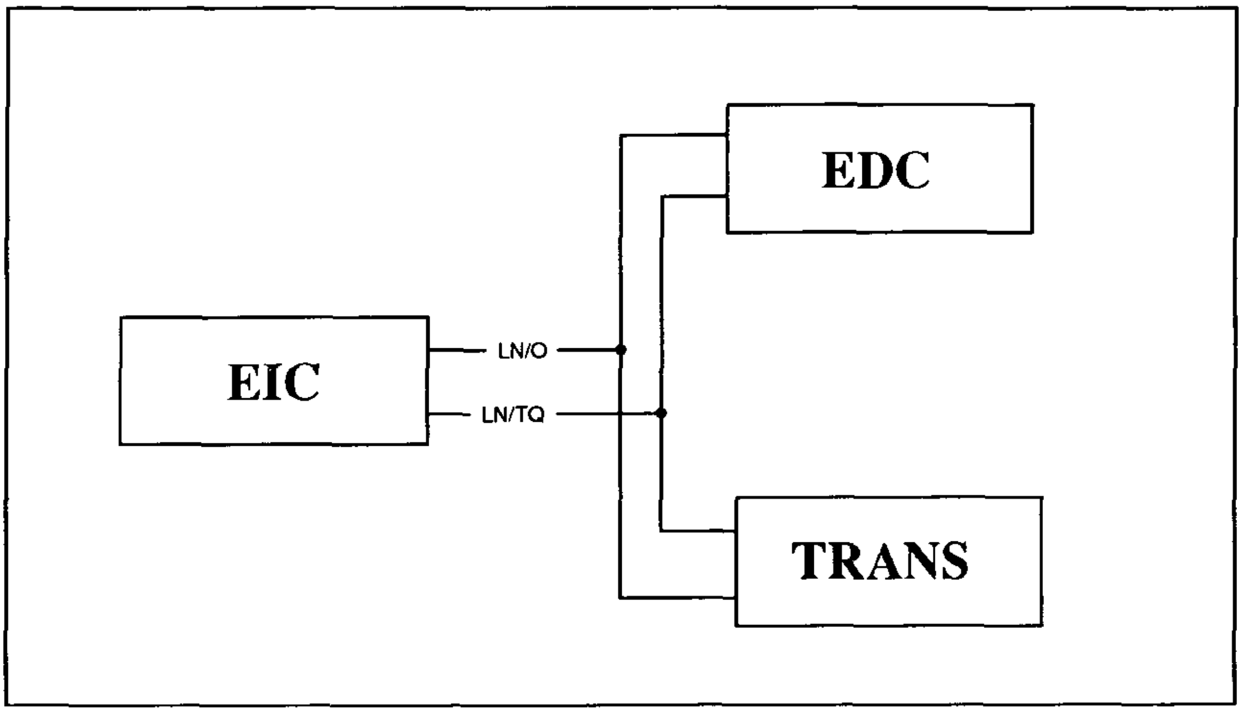
NO ↓

Install a new Central Digital Display Module and recheck function.

ERROR CODE 8 and 9 – Communications Error

The Electronic Draft Control module and the electronic Transmission control (EEC IV) send their display information over a two wire serial communications connection

Communications errors (8&9) occur when the message received by the instrument panel is not correct. This can be caused by an intermittent connection on the signal wires (LN/O or LN/TQ). If these errors are accompanied by reports of intermittent or blank displays in the transmission or hitch position areas, then the circuit wires should be investigated for open circuits, short circuits and intermittent connections.



ERROR CODE 10 – Memory Retention Error of Battery Calibration Constant

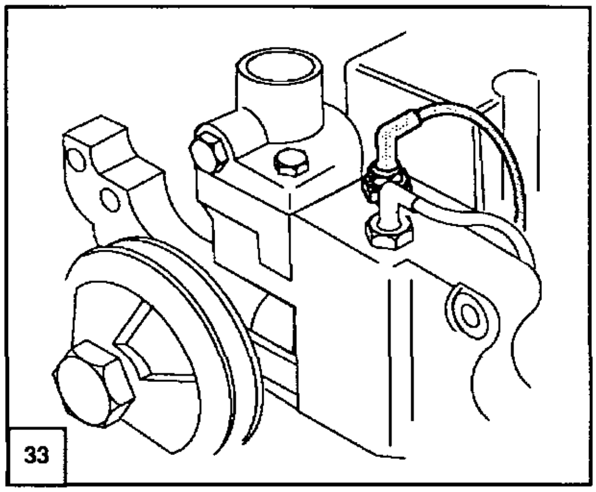
Compare the voltage display of instrument panel to a voltmeter reading at the battery. If the readings differ by more than 2.0 volts, then replace instrument panel and recheck.

ERROR CODE 11 – Memory Retention Error of Operator Setting for Slip Alarm, Slip Zero Reference Constant, Implement Width and Service Hours

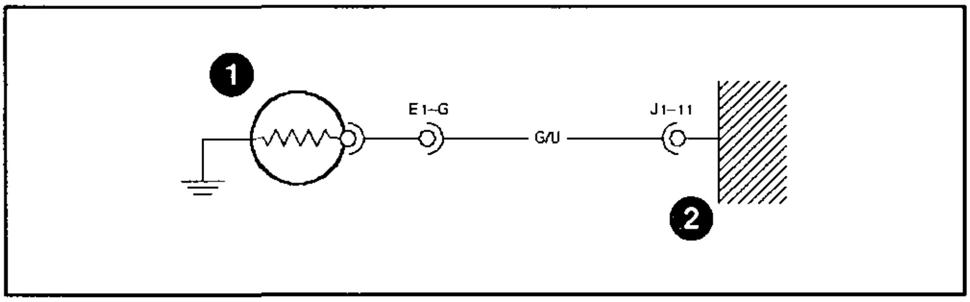
If Error Code 11 persists then replace the instrument panel.

Re–programme the constants listed above using the instructions detailed in Sections C&D of this chapter. Turn keystart OFF and re–check the programmed values. If the values are *not correct then replace the instrument panel*

ERROR CODE 12 – Coolant Temperature Sender Short Circuit



1. Coolant Temperature Sender
2. E.I.C.



Inspect the connection at the sender (1). **Are the terminal and connector clean and do they fit together firmly?**

NO → Rectify poor connection and recheck function

YES ↓

Remove the connector from the sender and hold it firmly against a good ground **Does the display indicate Code 7?**

YES → With the connector removed from the sender measure the resistance between the sender terminal and body **Is the resistance between 80Ω (hot) and 800Ω (cold) ?**

- YES ↓ Sender has poor ground to engine. Remove sender and clean threads
- NO ↓ Renew sender and recheck function.

NO ↓

Remove the instrument plug, disconnect plug **J1**. At the sender ,earth the signal wire and measure the resistance between pin **J1–11** and **J1–7** **Is the resistance less than 10Ω?**

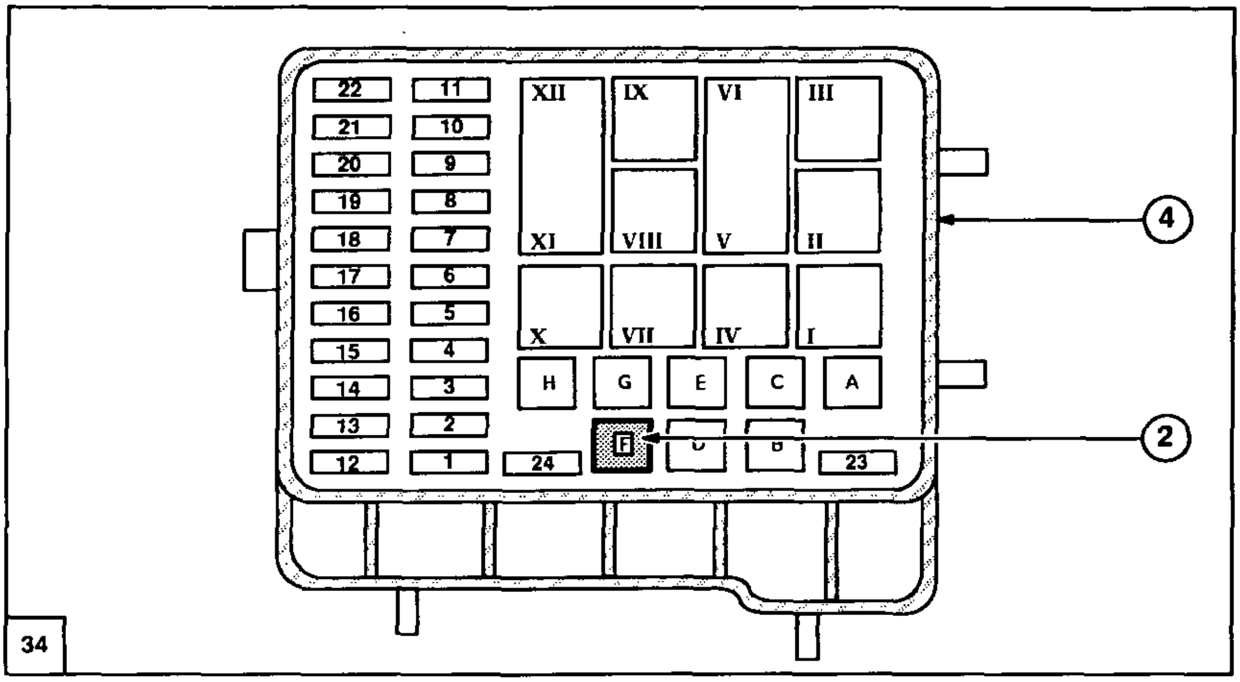
NO ↓ Find and repair an open circuit fault in wiring between plug and sender

YES ↓

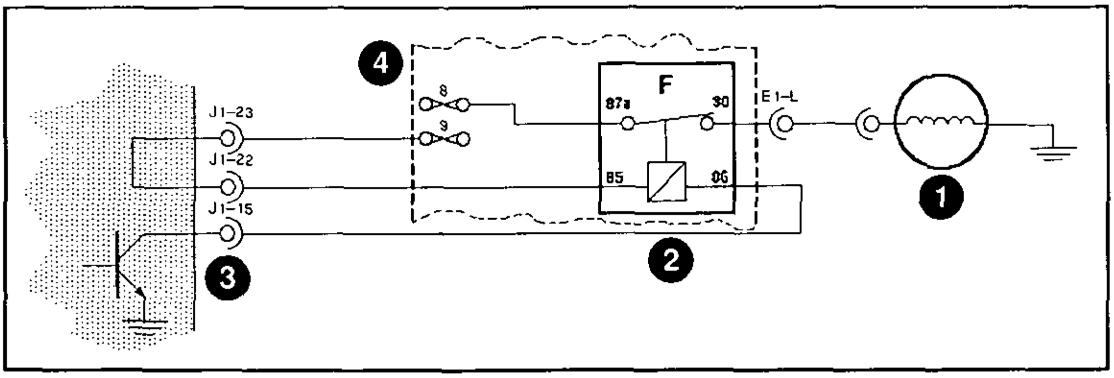
Clean the connector pins with contact cleaner spray Apply a dielectric grease. Reconnect plugs to the instrument cluster and turn keystart switch on **Does the cluster function correctly?**

NO → Install a new Instrument Panel and recheck function.

ERROR CODE 13 – Engine Shut–Down Output Short to a + Voltage



1. Fuel Shut–Off Solenoid
2. Relay 'F'
3. EIC
4. Fuse Panel



Remove the Fuel Shut–Off relay (F) from the fuse panel. Measure the resistance of the relay coil at terminals 85 and 86.
Is resistance less than 95 Ω?

YES → Renew relay

NO ↓

Remove instrument panel, disconnect plug **J1.** With relay removed, measure resistance between harness pins **J1–15** and **J2–22**
Is resistance showing open circuit ?

NO → Locate and repair short in circuit

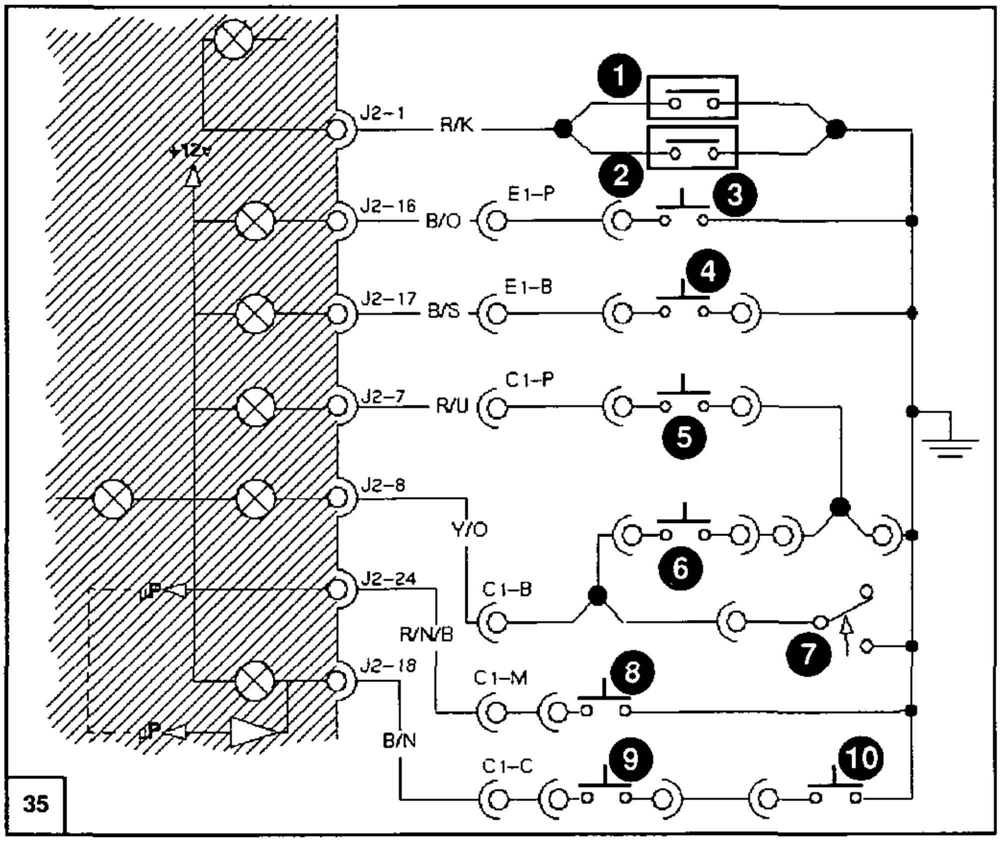
YES ↓

Install a new Instrument Panel

ERROR CODE 14 – This Code is not displayed,but can be stored in the Service Memory

This code is generated if only a single transmission of an error code is detected immediately followed by a different code. This implies intermittent or transient faults may have existed momentarily

Common Test Procedure for ALL of the Switch Circuits Connecting to Ground



1. Handbrake Switch
2. Brake Fluid Level Switch
3. Temperature Switch
4. Vacuum Switch
5. Transmission Oil Temp Switch
6. Transmission Oil Pressure Switch
7. P.A.S. Pressure Switch
8. Low Charge Switch
9. Hydraulic Oil Temp Switch
10. H.P.L. Filter Switch

Disconnect the harness at the sender/switch, and connect signal wire to ground
Is the warning light illuminated?

YES → Check the ground path of the switch and recheck function.
Is the resistance to ground less than 10 Ω?

- YES → Renew the switch and recheck function.
- NO → Locate and repair the open circuit

NO ↓

Unplug wiring harness from instrument cluster. Ground the signal wire at switch/sender and measure resistance between the signal pin and the tractor frame at the panel connector
Is resistance less than 10 Ω?

NO → Locate and repair open circuit in signal wire

YES ↓

Clean wiring harness to instrument cluster connector pins with contact spray Reconnect the plugs to instrument panel Remove the signal wire at the switch and connect to ground
Is the warning light illuminated?

NO → Renew the warning bulb → **Is the warning light illuminated?**

NO ↓

Renew the Instrument Panel and recheck function

Instrument Cluster Inoperative

No display on instrument cluster when the keystart switch is turned on.

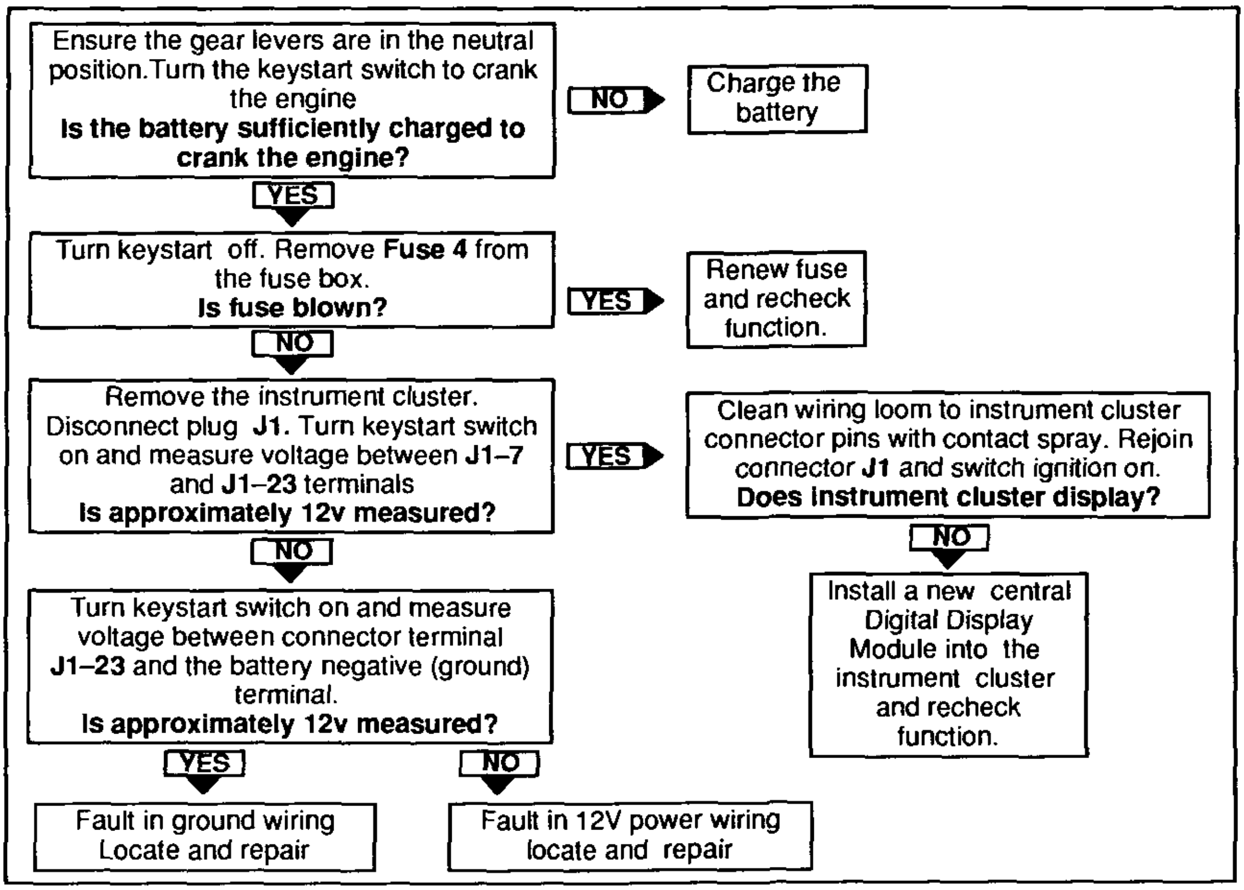


Figure 36
Electronic Instrument Cluster

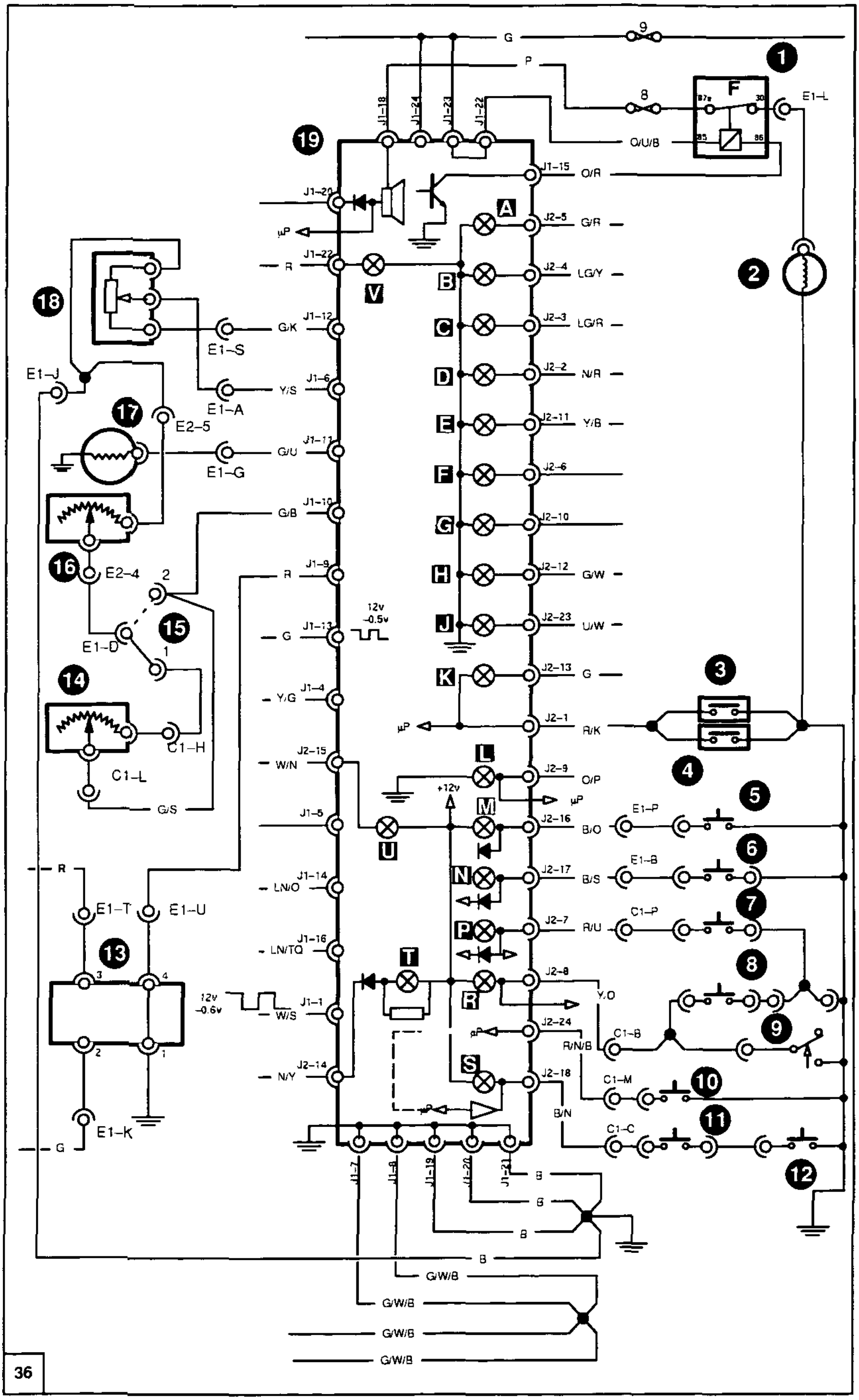
1. Fuel Shut–off Relay
2. Fuel Shut–off Solenoid
3. Handbrake Switch
4. Brake Fluid Level Switch
5. Temperature Switch
6. Vacuum Switch
7. Transmission Oil Temp Switch
8. Transmission Oil Pressure Switch
9. P.A.S. Pressure Switch
10. Low Charge Switch
11. Hydraulic Oil Temp Switch
12. H.P.L. Filter Switch
13. Radar Sender
14. Auxiliary Fuel Tank Sender
15. Fuel Tank Changeover Connector
16. Main Fuel Tank Sender
17. Coolant Temperature Sender
18. Oil Pressure Sender
19. Electronic Instrument Cluster

LAMP IDENTIFICATION

A Left Turn
B Trailer #1
C Trailer #2
D Thermostart
E Diff. Lock
F Not Used
G Not Used
H Right Turn
J Main Beam
K Parking Brake
L P.T.O. 1000
M Engine Coolant Temperature
N Air Filter
P Transmission Oil Temperature
R Transmission Oil Pressure
S Hydraulic Oil Filter
T Alternator
U Engine Oil Pressure
V Instrument Cluster Backlight

COLOUR CODE

B	– Black	G	– GREEN
N	– Brown	LG	– LIGHT GREEN
LN	– Tan	U	– BLUE
S	– Slate	TQ	– TURQUOISE
R	– Red	P	– PURPLE
O	– Orange	K	– PINK
Y	– Yellow	W	– WHITE



G
9
P
8
F
87a
30
85
86
E1–L
O/U/B
J1–18
J1–24
J1–23
J1–22
J1–15
O/R
J1–20
μP
J1–22
R
V
A
J2–5
G/R
B
J2–4
LG/Y
C
J2–3
LG/R
D
J2–2
N/R
E
J2–11
Y/B
F
J2–6
G
J2–10
H
J2–12
G/W
J
J2–23
U/W
K
J2–13
G
J2–1
R/K
E1–S
G/K
J1–12
E1–A
Y/S
J1–6
E1–J
E2–5
G/U
J1–11
E1–G
G/B
J1–10
E2–4
2
R
J1–9
12v
–0.5v
G
J1–13
E1–D
1
Y/G
J1–4
C1–H
C1–L
G/S
W/N
J2–15
L
J2–9
O/P
+12v
M
J1–5
U
J2–16
B/O
E1–P
E1–B
N
J2–17
B/S
LN/O
J1–14
R
E1–T
E1–U
P
J2–7
R/U
C1–P
LN/TQ
J1–16
T
3
4
J2–8
R
Y/O
12v
–0.6v
J1–1
W/S
J2–24
C1–B
2
1
R/N/B
N/Y
J2–14
S
J2–18
C1–M
B/N
E1–K
C1–C
G
J1–7
J1–8
J1–19
J1–20
J1–21
B
B
B
B
G/W/B
G/W/B
G/W/B
G/W/B

36

C. PROGRAMMING THE MAIN LCD

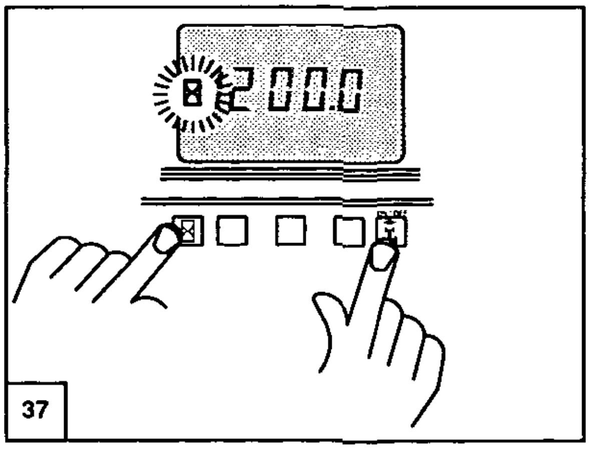
DESCRIPTION

Two functions can be programmed into the computer by the operator:

1. Next service due warning

2. Ground speed calibration

Next Service Due Warning

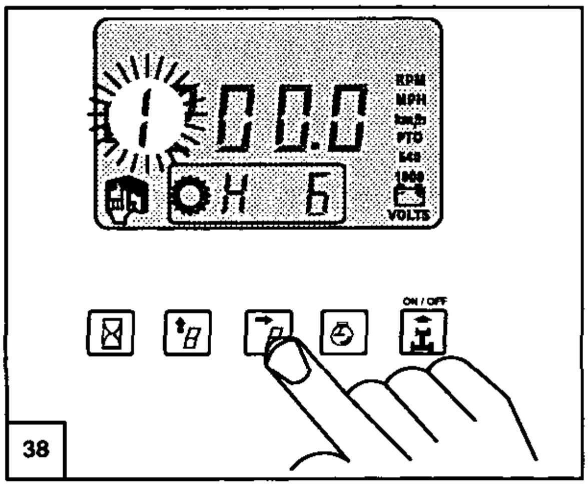


37

If service is due, the hourmeter symbol flashes when hourmeter is displayed. Symbol flashes for up to 10 hours, cancelled by touching hours and speed function buttons simultaneously.

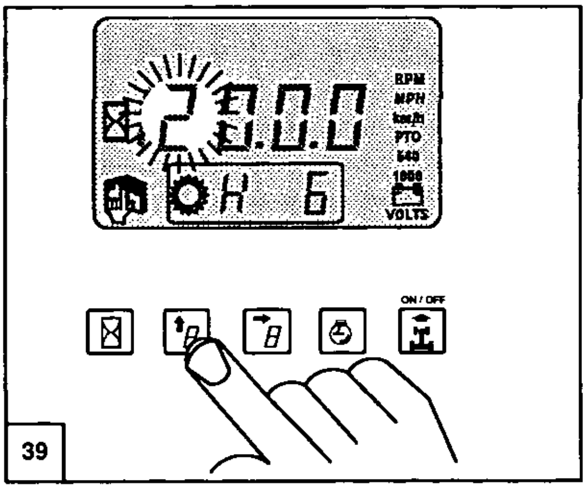
1. Key-start 'ON' (engine stationary) – hourmeter displayed. Press and hold down hourmeter button until a 'beep' from the alarm indicates the computer is in programming mode.

2. Number displayed is the 'Next Service Due' interval previously entered in the memory.



38

3. Left-hand digit flashing, set correct value.



39

4. Select the next digit.

5. Set the correct value as in 3.

6. Repeat paragraphs 3. and 4. for the remaining digits.

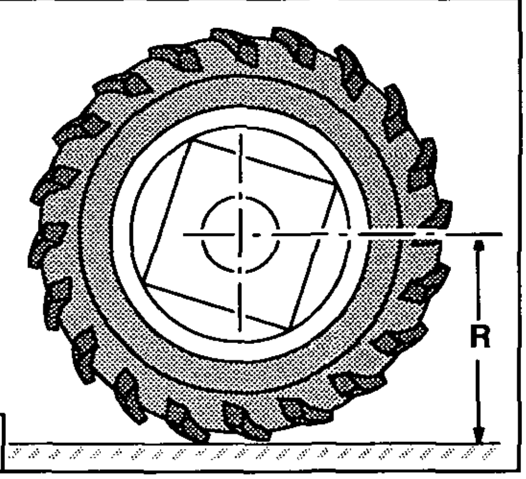
7. To cancel warning set the display to '0000'.

8. Enter the value into the memory by turning key-start switch off.

Ground Speed Calibration

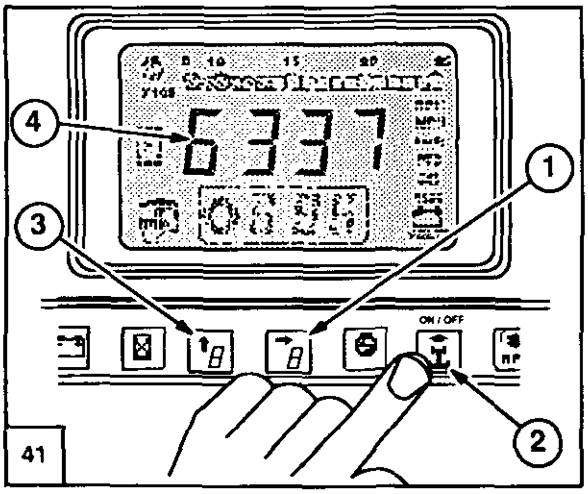
If for any reason the rolling radius of the rear tyres is altered, reset the ground speed calibration as follows:–

1. Ensure the tyre pressures are correct.



40

2. Measure and note the rolling radius (R).



41

1. Digit Set Button
2. Ground Speed Button
3. Digit Select Button
4. Calibration Number

3. Turn key-start 'ON', hold down ground speed button until the alarm 'beeps' and calibration number is displayed (EIC is now in 'Set-Up' mode). If required, change value using 'Digit Select' and 'Set' buttons, (see following table).

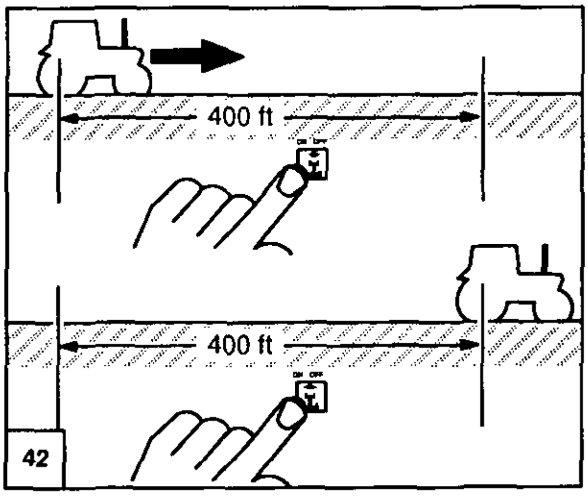
Rolling Radius		Calibration Number	
in.	(mm)	16x16	12x12
23.0	584	8127	
23.5	597	7954	
24.0	610	7789	
24.5	622	7630	9998
25.0	635	7477	9798
25.5	648	7330	9605
26.0	660	7190	9421
26.5	673	7054	9243
27.0	686	6923	9072
27.5	699	6797	8907
28.0	711	6676	8748
28.5	724	6559	8594
29.0	737	6446	8446
29.5	749	6337	8303
30.0	762	6231	8165
30.5	775	6129	8031
31.0	787	6030	7901
31.5	800	5934	7776
32.0	813	5841	7654
32.5	826	5752	7537
33.0	838	5664	7422
33.5	851	5580	7312
34.0	864	5498	7204
34.5	876	5418	7100
35.0	889	5341	6998
35.5	902	5266	6900
36.0	914	5192	6804

4. Enter value in the memory by turning key-start switch off.

NOTE: *If the tractor has the radar option fitted the calibration constant is '4018' regardless of tyre size.*

For improved accuracy in calibrating ground speed, use the following procedure (with or less radar option).

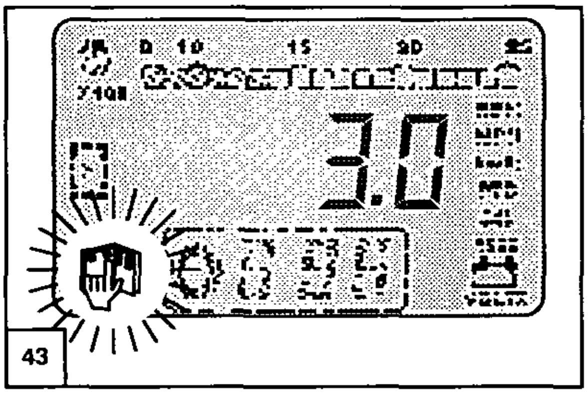
5. Ensure EIC is in Set-Up mode.



42

6. Press button, drive tractor 400 ft. (121.83 m), press button.
7. Enter value in the memory by turning key-start switch off.

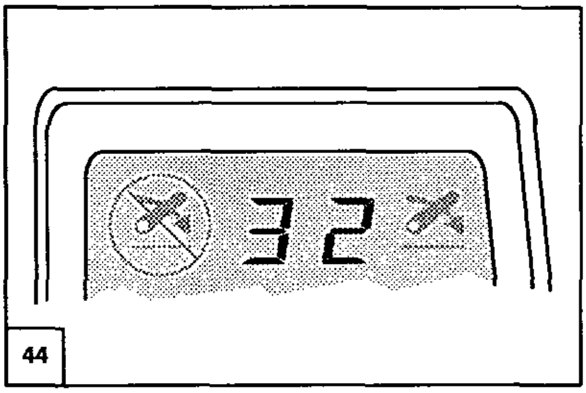
Malfunction Warning Symbol (Read Your Manual – RYM)



43

Fault in the instrument panel – RYM symbol flashing and an error code displayed, see 'Fault Finding', page 8.

Fault in the transmission – RYM symbol flashing and an error code displayed, see Part 5



44

Error code '32' appears for 5 seconds only upon reconnection of the battery. When key-start switch is turned on the microcomputer automatically re-calibrates. No action is required unless code re-appears.

Software Status

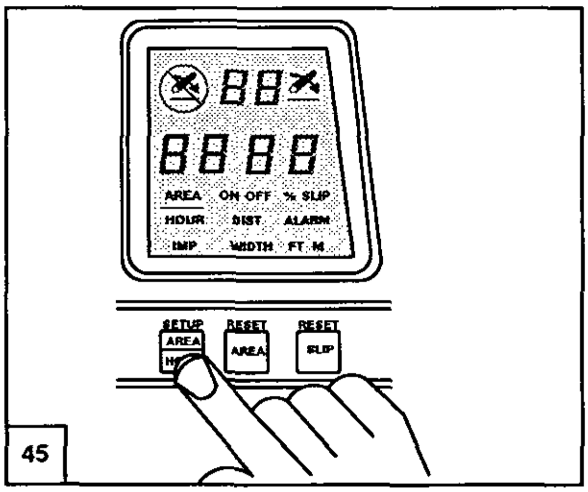
To display the level of software installed to the EIC depress and hold the Engine Speed button and switch the keystart 'ON' (engine stationary).

A four digit code will appear for approximately two seconds and then the EIC will enter normal operating mode.

D. PROGRAMMING THE TRACTOR PERFORMANCE MONITOR (TPM)

To Enter the TPM Set Up Mode:–

1. Turn key-start 'ON'



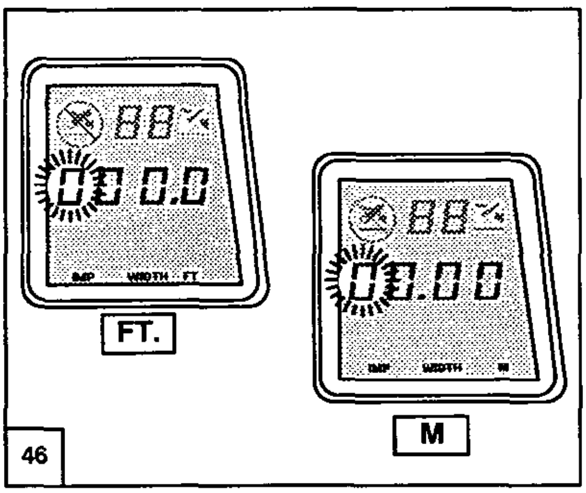
45

2. Touch 'SET UP' button until a 'beep' is heard (approx. 4.0 seconds) Repeatedly touching SETUP button selects features in the following sequence
   (i) Implement Width
   (ii) Slip Alarm Level (with Radar only)
   (iii) Area Pre-set
   (iv) Distance Measurement
   (v) Imperial/Metric Units

To exit the set up mode turn key-start switch 'OFF'.

Set the functions in the following order:

(i) Setting Implement Width



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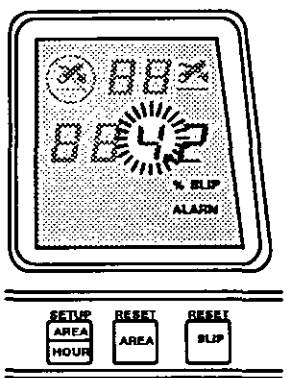
'IMP', 'WIDTH', 'FT' (or 'M') and implement width will be displayed with first digit flashing.

Using the DIGIT SELECT button and the DIGIT SET button, obtain desired value.

Touch 'SET UP' button to enter value in the memory and change display to 'Slip Alarm'.

(ii) Setting the Slip Alarm Point (option)



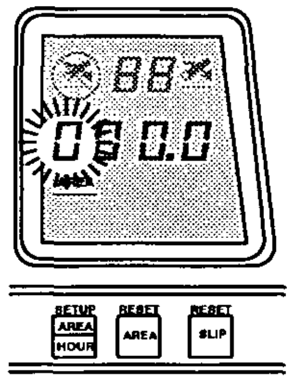
47

Alarm point is displayed with left-hand digit flashing. '% SLIP' and 'ALARM' are also displayed.

Use 'DIGIT SET' and 'SELECT' buttons to set required value If slip alarm is not required, set display to '00'.

Touch 'SET UP' button to enter value in the memory and change display to 'Area Pre-Set'

(iii) Area Pre-set



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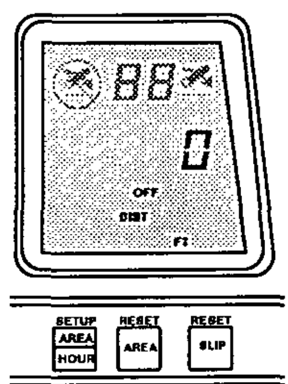
Area pre-set is displayed with the left-hand digit flashing. 'AREA' is also displayed.

Use the DIGIT SET and DIGIT SELECT *buttons to set required value.*

Touch 'SET UP' button to enter value in the memory and change display to 'Distance Accumulation'.

(iv) Distance Measuring Mode



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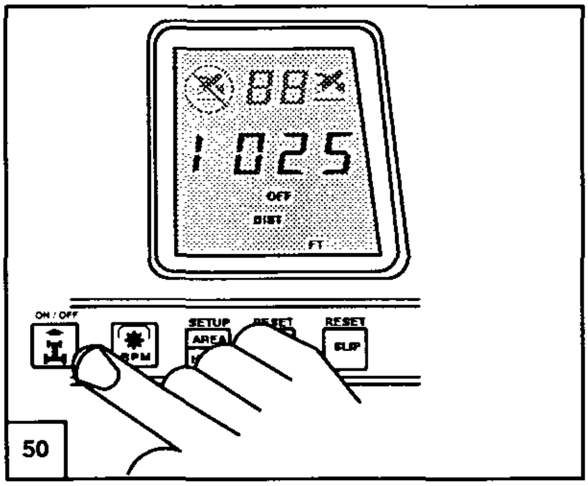
The display shows 'DIST', 'OFF', '0' and 'FT' (or 'M').

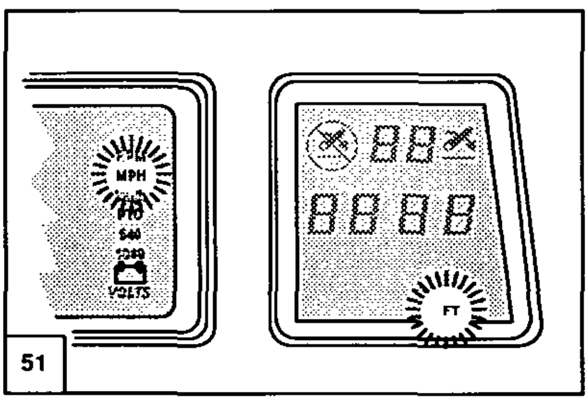


50

Touch ON/OFF button, display shows distance travelled which is constantly changing when the tractor is moving. Touch ON/OFF button again to stop distance measurement.

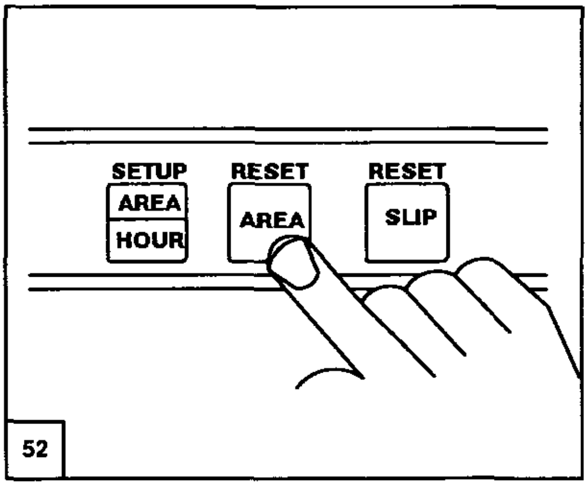
Touch 'SET UP' button to enter value in the memory and change display to Imperial/Metric units selection

(v) Setting Imperial/ Metric Units



51

Display is blank, 'FT' or 'M' and the corresponding ground speed units flashing.

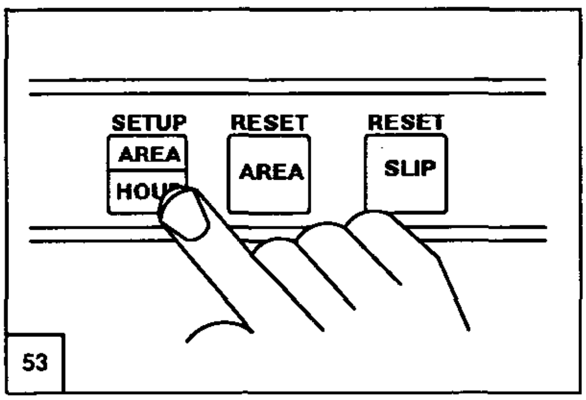


52

Touch either RESET button to change display.

Touch 'SET UP' button to enter units in the memory

Exiting the Set Up Mode



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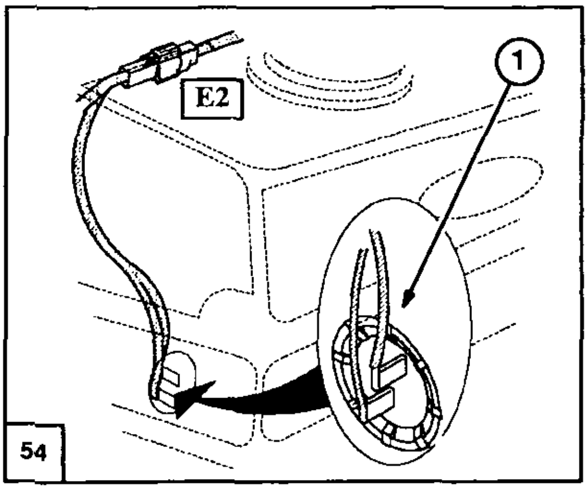
Depress 'SET UP' button for 3 seconds, the audio alarm will 'beep', and the display will go to the AREA/HOUR mode.

The TPM is now programmed for use.

E. FUNCTION SENDERS AND SWITCHES

MAIN FUEL TANK SENDER



Main Fuel Tank Sender

1. *Fuel Sender*

The sender is mounted at the right hand rear of the main fuel tank.

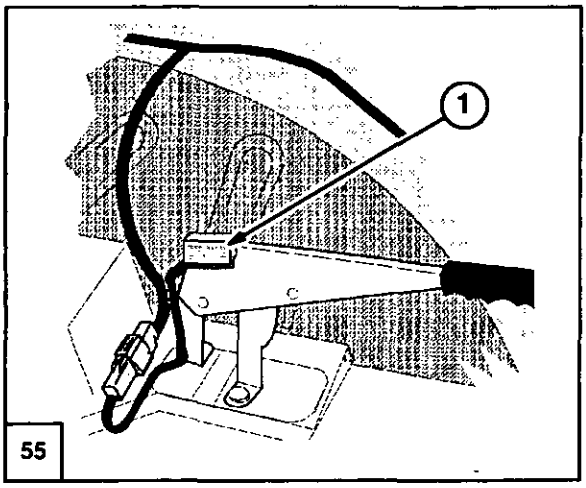
Changing fuel level causes movement of the float, varying the resistance of the potentiometer, which is sensed by the electronic instrument cluster (see following chart).

Bars Displayed	Fuel Reserve	Sender Resistance $(\Omega)\pm9$
1	0–1/12	241
2	1/12-2/12	222
3	2/12-3/12	204
4	3/12-4/12	186
5	4/12-5/12	168
6	5/12-6/12	149
7	6/12-7/12	131
8	7/12-8/12	113
9	8/12-9/12	94
10	9/12-10/12	77
11	10/12-11/12	58
12	11/12–FULL	40

AUXILIARY FUEL TANK SENDER

Located in the top of the tank and similar in construction to the main sender. The instrument cluster combines signals from main and auxiliary senders and total fuel level is computed

HANDBRAKE WARNING SWITCH

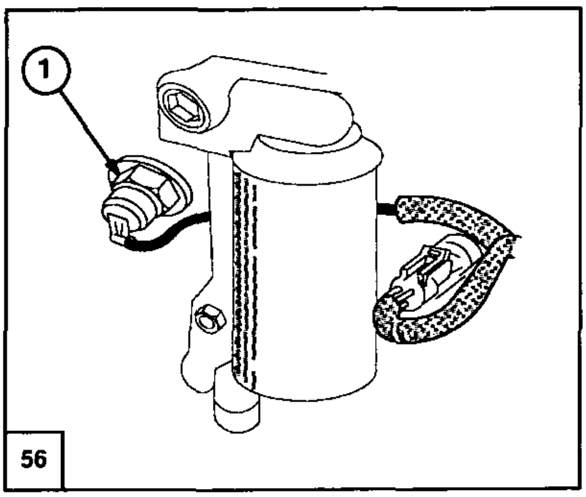


Handbrake Warning Switch

1. *Switch*

The switch is a position sensing microswitch. With the lever lowered a steel tab masks the switching element. As the lever is raised the masking tab is withdrawn and the switch contacts close. This illuminates the warning light. The alarm also sounds if the vehicle speed is in excess of 0.5 m.ph. (0.8 km /h).

ENGINE OIL PRESSURE SWITCH

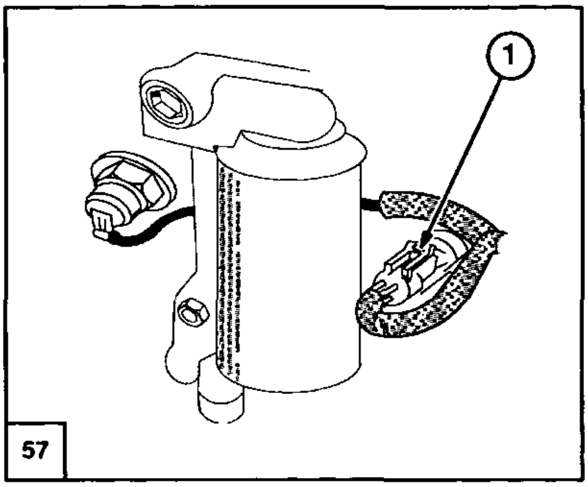


Engine Oil Pressure Switch

1. Switch

The switch is normally closed and opens when engine oil pressure rises above 10 lbf/in^2 (0.68 bar). When the engine is not running or the oil pressure is below 10 lbf/in^2 (0.68 bar) the warning light illuminates

ENGINE OIL PRESSURE SENDER



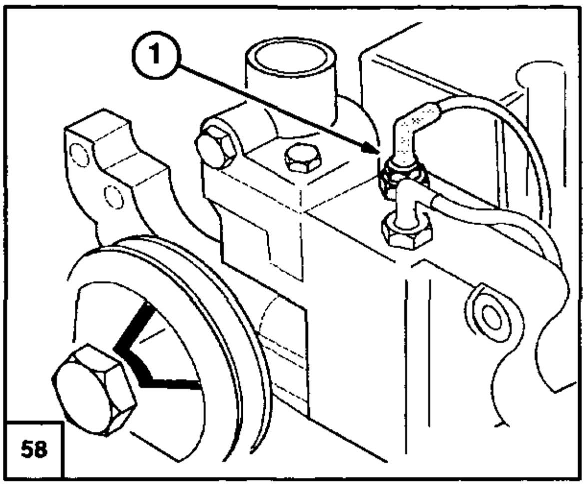
Engine Oil Pressure Sender

1. Sender

The sender monitors the pressure of the engine lubricating oil in the pump delivery gallery and operates on a +5.0 V power supply from the instrument cluster. Changes in engine oil pressure cause the sender to generate a signal voltage proportional to the oil pressure which illuminates a corresponding number of bargraph segments (see following chart).

Bars Displayed	Pressure lb/in² ±4	Pressure Bar ±0.28	Sender Voltage ±0.15
1	<8	<0.55	<1.64
2	12	0.83	1.79
3	20	1.38	2.08
4	28	1.93	2.38
5	36	2.48	2.67
6	44	3.04	2.96
7	52	3.59	3.25
8	60	4.14	3.54
9	68	4.69	3.84
10	76	5.24	4.13
11	84	5.8	4.42
12	92	6.35	4.71

ENGINE COOLANT TEMPERATURE SENDER



Engine Coolant Temperature Sender

1. Sender

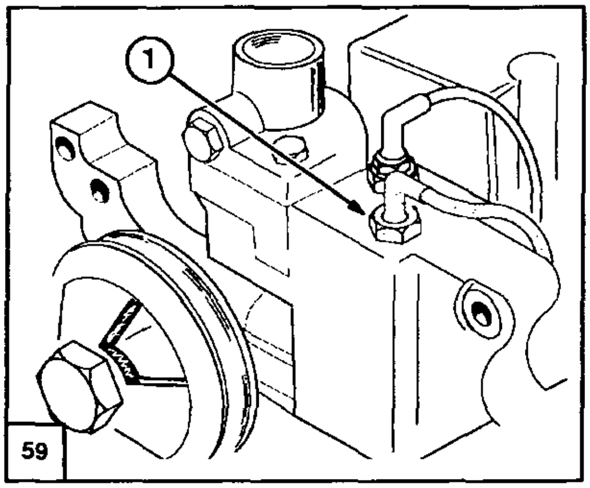
The sender monitors the temperature of the engine coolant and operates on a +5.0 V power supply from the instrument cluster. Changes in coolant temperature cause the resistance of the sender to alter resulting in a varying voltage to the instrument cluster (see following chart).

Bars Displayed	Temp. °C ±3	Temp. °F ±5	Sender Resistance (Ω)
1	63	145	710–580
2	69	155	580–480
3	74	165	480–390
4	80	175	390–330
5	85	185	330–280
6	91	195	280–230
7	96	205	230–190
8	102	215	190–165
9	107	225	165–140
10	113	235	140–115
11	119	245	115–100
12	>121	>250	<100

ENGINE COOLANT TEMPERATURE SWITCH

The switch is normally open. When the engine coolant temperature rises above 235°F (113°C) the switch closes causing: and illuminates the warning light

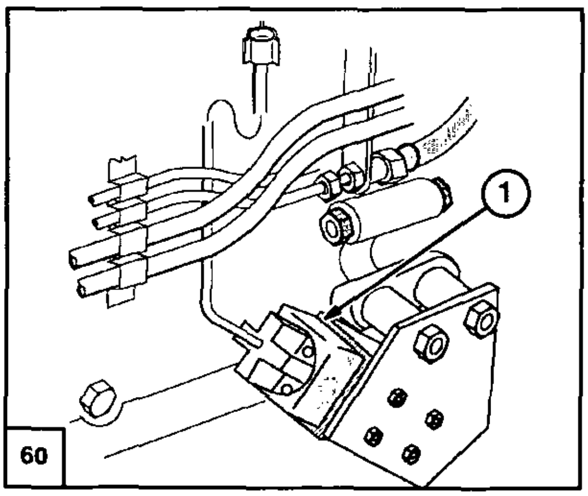
(i) the warning lamp to illuminate
(ii) the critical alarm to sound
(iii) coolant symbol to illuminate
(iv) the word 'STOP' to appear on the main LCD



Engine Coolant Temperature Switch

1. Switch

RADAR GROUND SPEED UNIT

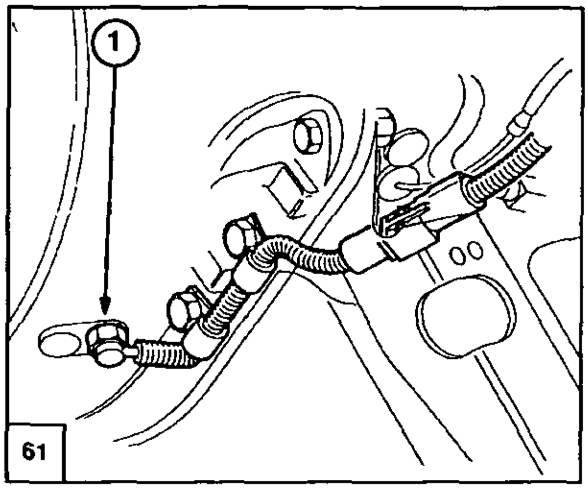


Radar Ground Speed Unit

1. Radar Unit

The radar gun is mounted on the left hand side of the tractor. The unit uses the 'doppler' system to transmit a signal, proportional to speed, to the electronic instrument cluster which displays true ground speed. This signal is compared to the axle speed sensor signal to compute the percentage wheel slip

AXLE SPEED SENDER

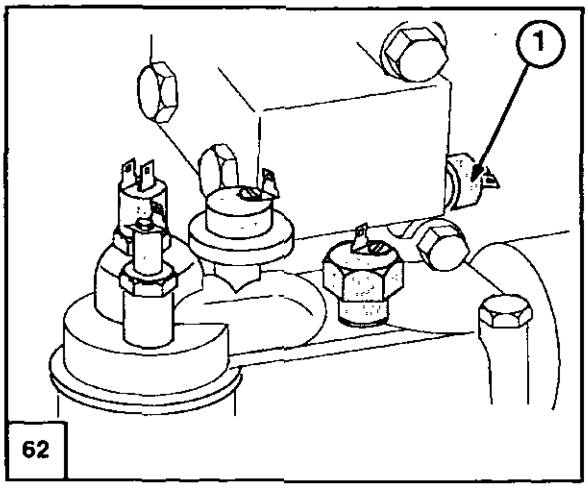


Axle Speed Sender

1. Sender

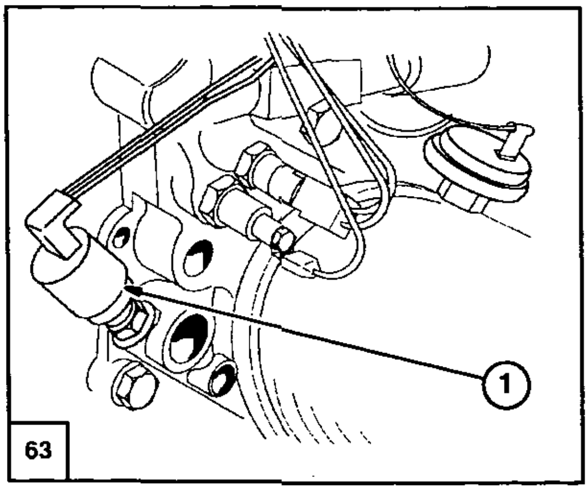
The sender is screwed into the left hand side of the rear axle housing and contains a small wire coil and a magnet in the tip. The sender is positioned so that the coil is close to the teeth of the front gear of the transmission output shaft. When the gear rotates each tooth of the gear induces a pulse of electrical current into the coil which is transmitted to the instrument cluster. The pulse frequency is directly proportional to vehicle ground speed and is converted to ground speed (mph or km/h) to display when the ground speed function button is pressed (units less radar only). If the tractor is fitted with radar speed sensing then the magnetic sensor is only used for computing wheel slip or determine tractor movement.

TRANSMISSION OIL PRESSURE SWITCHES



Transmission Oil Pressure Switch

1. Switch

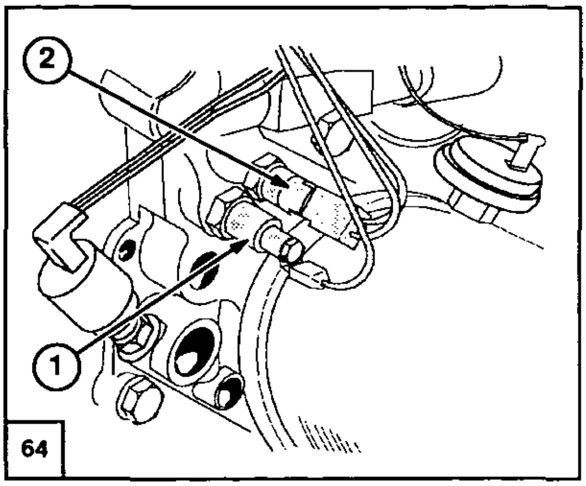


Transmission Oil Pressure Switch

1. Switch

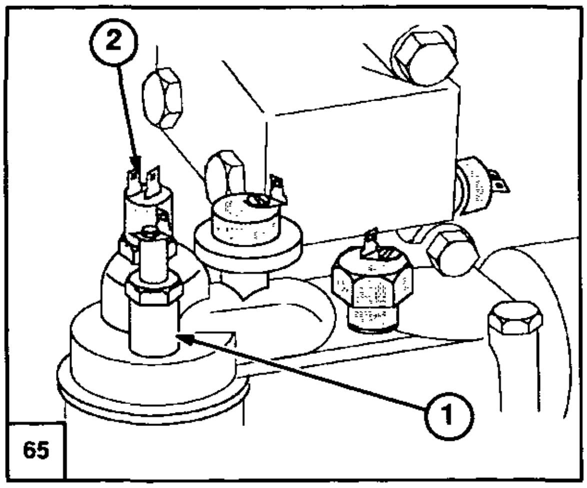
The switch is installed in the hydraulic pump body on the right hand side of the rear axle centre housing assembly. The switch is normally closed opening when transmission oil pressure rises above 120 lbf/in² (8.2 bar) and closing when pressure falls below 80 lbf/in² (5.5 bar). When the switch is closed the transmission oil pressure warning light is illuminated.

TRANSMISSION OIL TEMPERATURE SWITCHES



Transmission Oil Temperature Switches

1. High Temperature Switch
2. Low Temperature Switch



Transmission Oil Temperature Switches

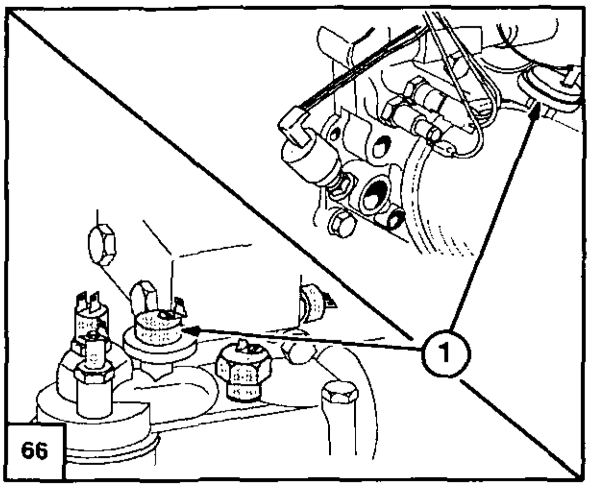
1. High Temperature Switch
2. Low Temperature Switch

The switches are installed in the hydraulic pump and filter assembly and monitor oil temperature.

The high temperature switch is normally open and closes when transmission oil temperature rises above 113°C (235°F) and illuminates the transmission oil temperature warning light.

The low temperature switch prevents the filter restriction/low pressure light illuminating when the oil temperature is below 40°C.

HYDRAULIC OIL FILTER RESTRICTION SWITCH

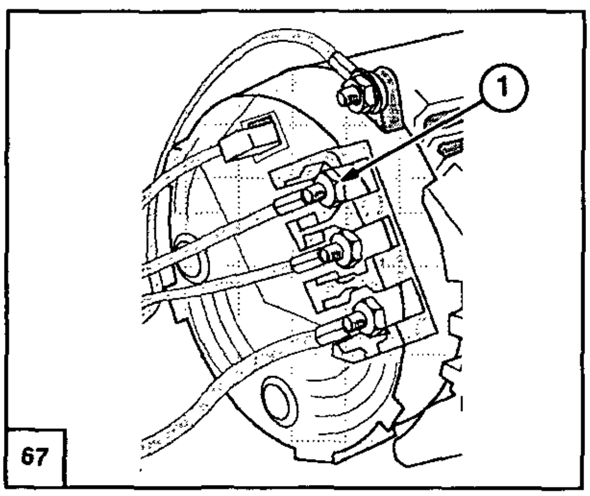


Hydraulic Oil Filter Restriction Switch

1. Switch

The sender is installed to the filter head of the hydraulic pump. A partially blocked filter is indicated by a continuous warning light. A *completely blocked filter or low oil pressure is* indicated by a flashing light and the critical alarm.

ENGINE SPEED SENDER

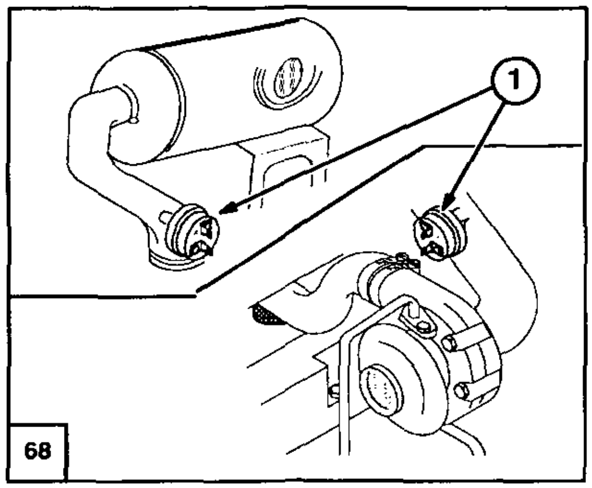


Engine Speed Sender

1. Speed Sender Connection

The engine speed sender is integral with the alternator and outputs a square wave frequency to the E.I.C. The indicated engine speed has an accuracy of 4% at low engine speed and 2% at high engine speed.

AIR CLEANER RESTRICTION SWITCH

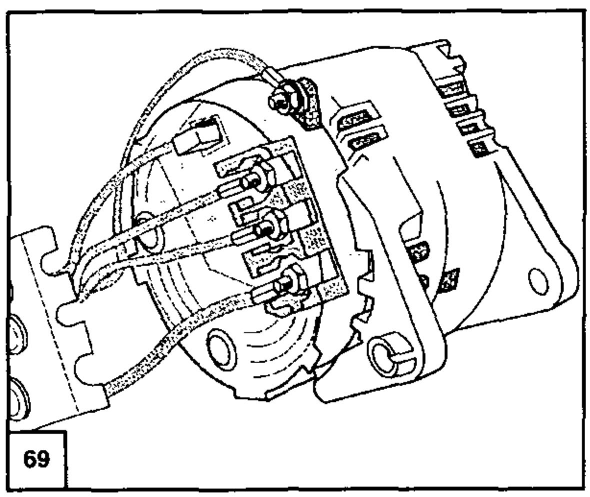


Air Cleaner Restriction Switch

1. Switch

The air cleaner restriction switch is located in the air cleaner to manifold/turbocharger tube and coupled to the main Front wiring harness by two spade type connectors. The switch is normally open and closes when the vacuum in the air intake tube exceeds 25 in. Hg. The air cleaner restriction warning lamp is illuminated when the switch is closed

ALTERNATOR



Alternator

Battery charge condition is sensed at the instrument cluster on *all* models by the electronic instrument cluster which displays charge voltage on the digital display to an accuracy of ± 0.2 volts. The voltage reading is averaged-out over a 2.5 second interval to achieve a steady reading on the display.

The audible alarm will sound for 5.0 seconds and the voltage symbol will flash when battery voltage falls below 10.0V or rises above 16.0V.

PART 3
ELECTRICAL SYSTEMS
Chapter 2
WIRING DIAGRAMS

A. WIRING DIAGRAMS

Included in this chapter are the wiring diagrams for the main versions of the tractor.

The diagrams are broken down into the main function circuits and finally the remaining plug and socket inter-connections.

At the end of each group of diagrams is an Index for easy location of specific components.

Figures 1, 2 and 3 show the approximate positions of the main harness connectors.

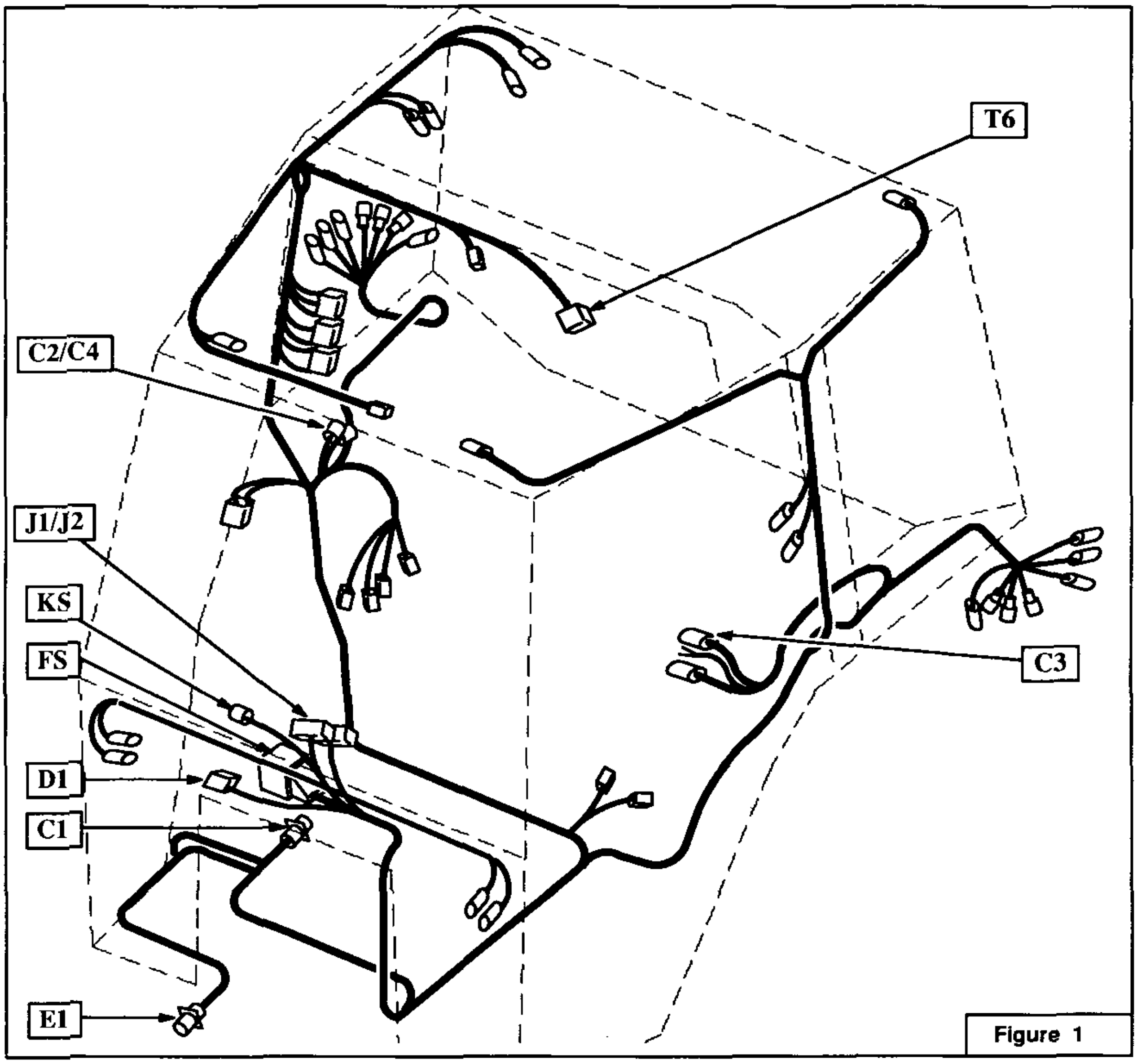


Figure 1

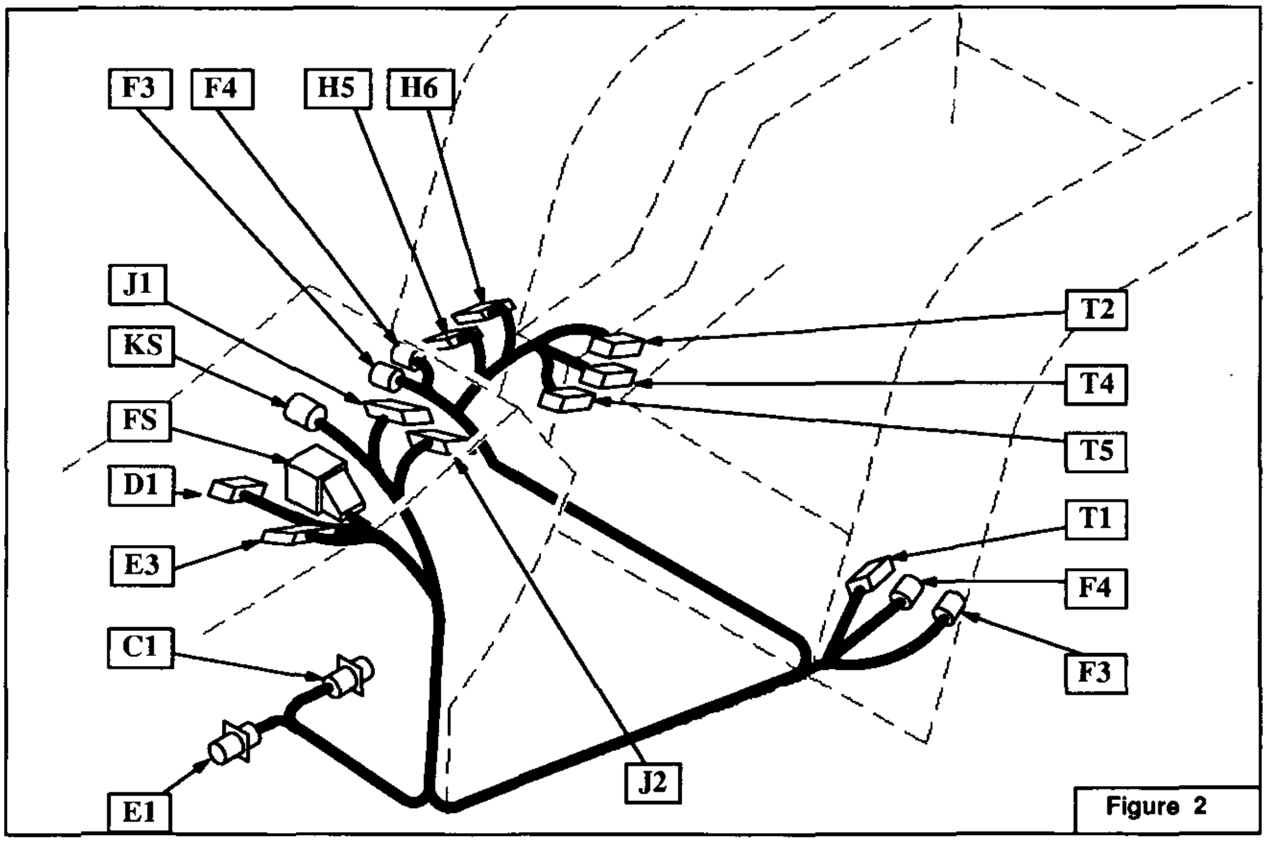


Figure 2

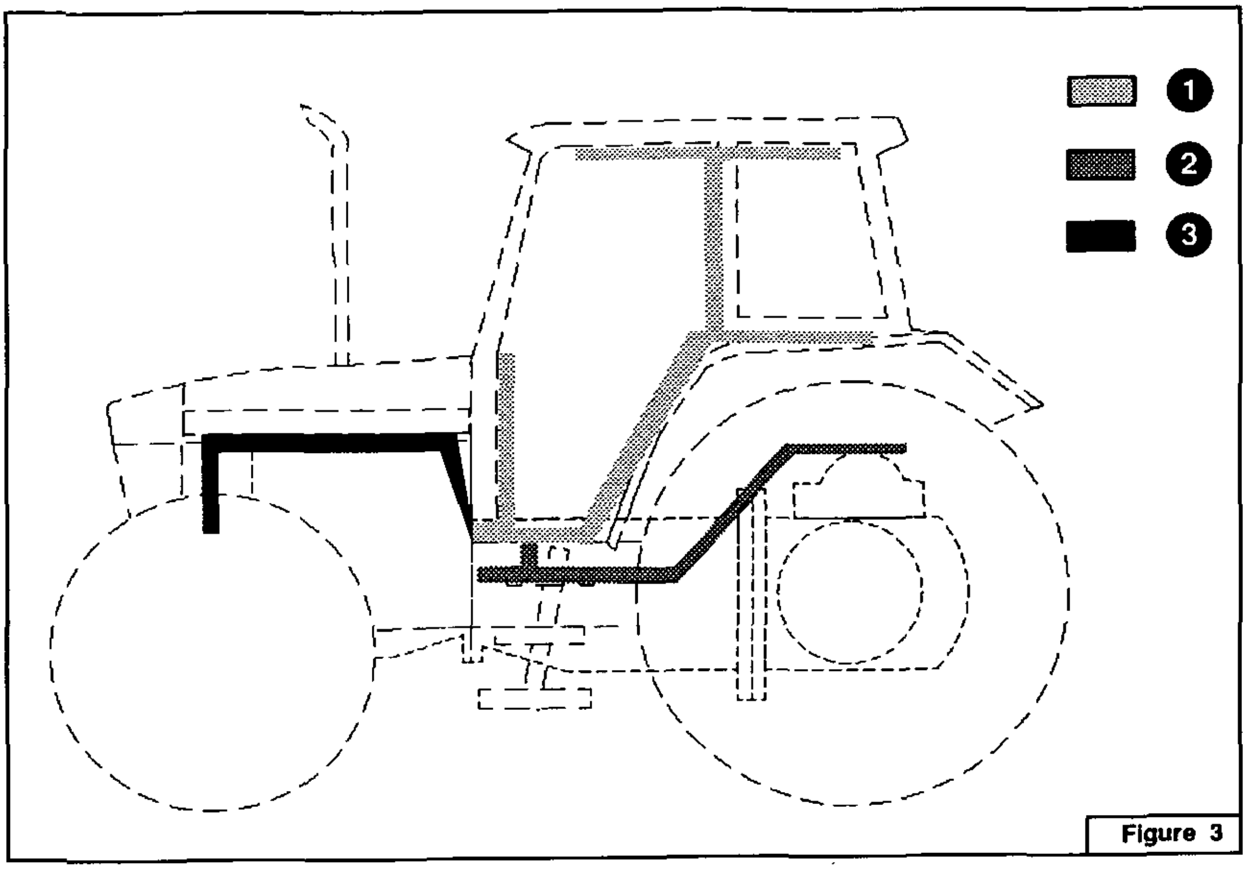


Figure 3

Harness Location

1. Main Rear Harness
2. Extension Harness
3. Engine Harness

Wiring Diagrams 1 to 8
Main Rear Harness
SLE Models with Cab with EEC IV

Diagram 1
Main Rear Harness – SLE Models with Cab, with EEC IV

1. P.T.O. Speed Switch
2. Instrument Harness Connector (J1)
3. Instrument Harness Connector (J2)
4. Extension Harness Connector (C1)
5. P.T.O. Module (Relay V–VI)
6. Thermostart Relay (VII)
7. Diagnostic Connector (D1)
8. Harness Connector (C4)
9. Engine Harness Connector (E1)
10. Fuse Panel (FS)
11. Battery
12. Keystart Switch (KS)
13. P.T.O. Switch
14. Indicator Lamp

Key To Colours

B	Black	G	Green
N	Brown	LG	Light Green
LN	Tan	U	Blue
S	Slate	TQ	Turquoise
R	Red	P	Purple
O	Orange	K	Pink
Y	Yellow	W	White

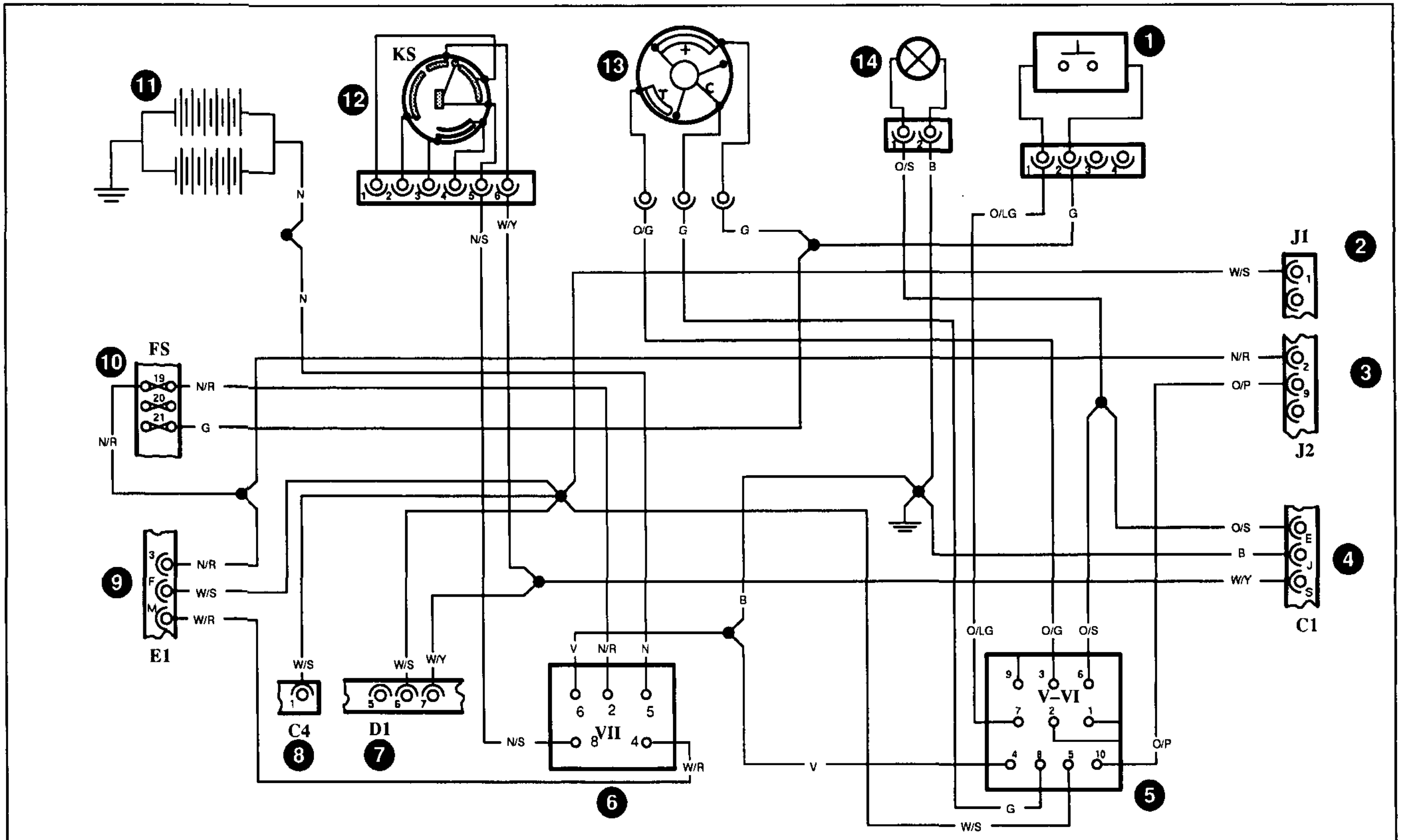


Diagram 1

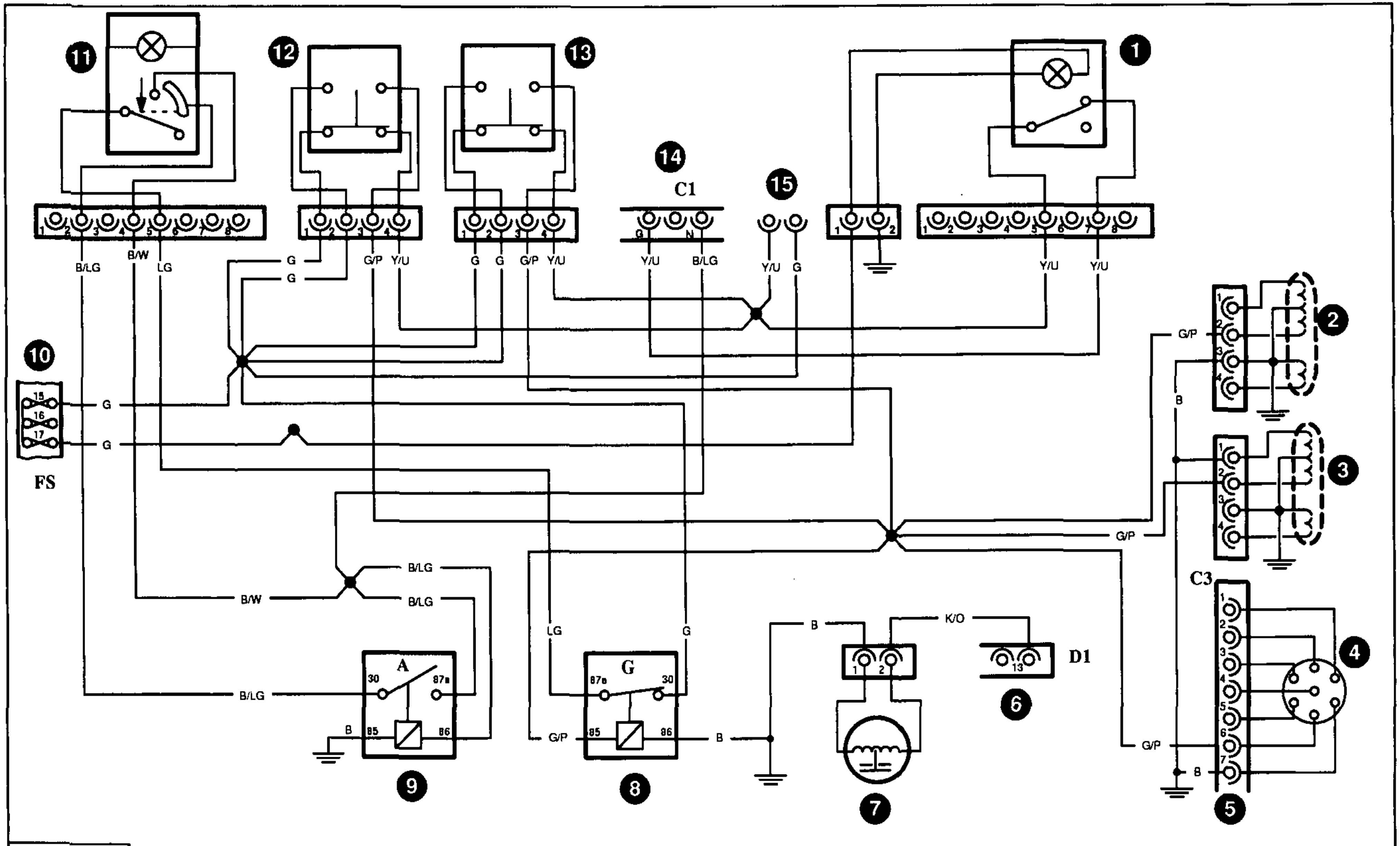
CHAPTER 2

Diagram 2
Main Rear Harness – SLE Models with Cab, with EEC IV

1. F.W.D. Switch
2. R.H. Stop Lamp
3. L.H. Stop Lamp
4. Trailer Socket (C3)
5. Connector (C3)
6. Diagnostic Plug (D1)
7. Front P.T.O. Solenoid
8. Diff Lock Relay (G)
9. Diff Lock Relay (A)
10. Fuse Panel (FS)
11. Diff Lock Switch
12. L.H. Stop Lamp Switch
13. R.H. Stop Lamp Switch
14. Connector (C1)
15. F.W.D. Supply

Key To Colours

B	– Black	G	– Green
N	– Brown	LG	– Light Green
LN	– Tan	U	– Blue
S	– Slate	TQ	– Turquoise
R	– Red	P	– Purple
O	– Orange	K	– Pink
Y	– Yellow	W	– White



11
12
13
1
14
C1
15
G
N
B/LG
B/W
LG
G
G
G/P
Y/U
G
G
G/P
Y/U
Y/U
B/LG
Y/U
G
Y/U
Y/U
2
G/P
B
3
G/P
10
15
16
17
FS
G
G
C3
4
B/LG
B/LG
B/W
LG
G
B
K/O
D1
13
A
30
87a
B
85
86
B/LG
G
87a
30
G/P
85
86
B
G/P
B
9
8
7
6
5

Diagram 2

Diagram 3
Main Rear Harness – SLE Models with Cab, with EEC IV

1. Harness Connector (E1)
2. Harness Connector (J1)
3. Implement Socket
4. Implement Switch
5. Implement Relay (III)
6. Creeper Gear Switch
7. Harness Connector (C4)
8. Harness Connector (C2)
9. Harness Connector (C1)
10. Harness Connector (D1)
11. Fuse Panel (FS)
12. Battery
13. Keystart Switch (KS)
14. Ignition Delay Relay (IX)
15. Fuel Shut-off Relay (F)

Key To Colours

B	– Black	G	– Green
N	– Brown	LG	– Light Green
LN	– Tan	U	– Blue
S	– Slate	TQ	– Turquoise
R	– Red	P	– Purple
O	– Orange	K	– Pink
Y	– Yellow	W	– White

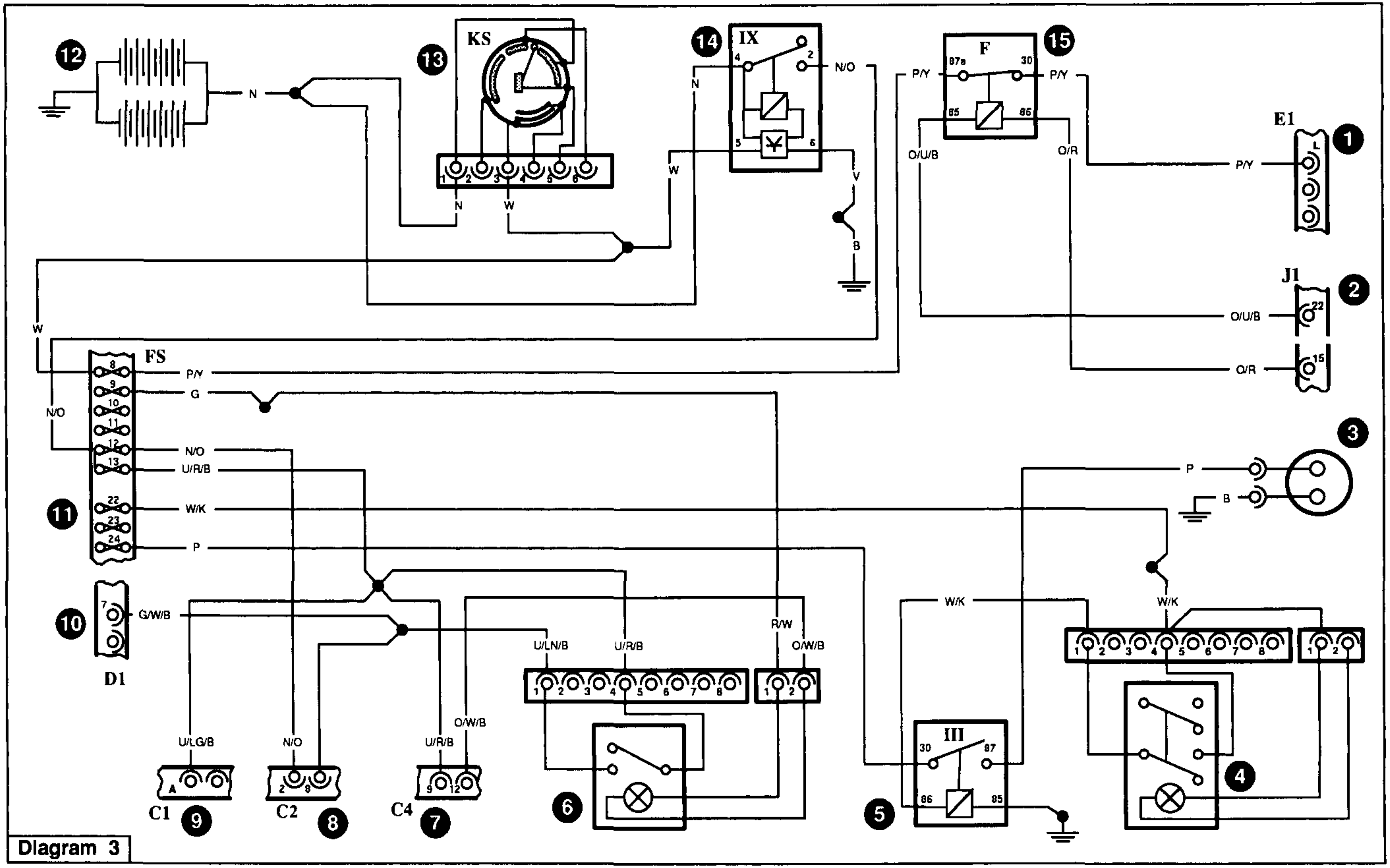

KS
IX
F
E1
J1
FS
D1
C1
C2
C4
III
N
W
N/O
V
B
P/Y
O/U/B
O/R
G
U/R/B
W/K
P
G/W/B
U/LG/B
U/LN/B
R/W
O/W/B
87a
30
85
86
87
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Diagram 3

Diagram 4
Main Rear Harness – SLE Models with Cab, with EEC IV

1. Front Washer Motor
2. Rear Washer Motor
3. Rear Wiper Motor
4. Heater/Air Con. Connector (T6)
5. Harness Connector (E1)
6. Front Wiper Switch
7. Front Wiper Motor
8. Console Lamp
9. Accessory Socket
10. Accessory Relay
11. Auxiliary Relay (I)
12. HPL Enable Relay (H)
13. Harness Connector (C2)
14. Harness Connector (C4)
15. Fuse Panel (FS)
16. Battery
17. Keystart Switch (KS)
18. Harness Connector (J1)
19. Harness Connector (J2)
20. Rear Wiper Switch

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White

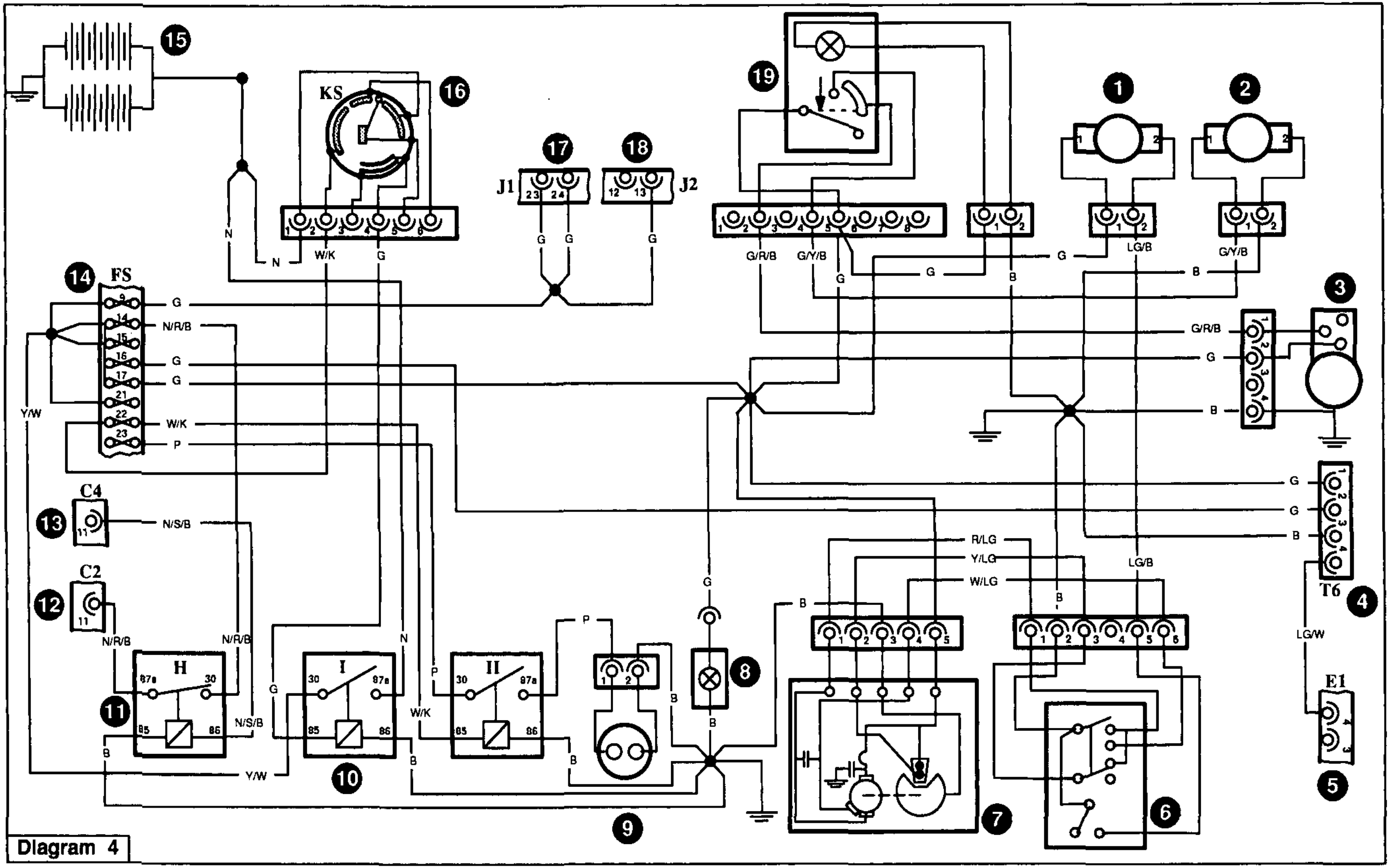


Diagram 4

CHAPTER 2

Diagram 5
Main Rear Harness – SLE Models with Cab, with EEC IV

1. Rear Upper Worklamp Relay (C)
2. Rear Lower Worklamp Relay (E)
3. Rear Worklamp Switch
4. Front Upper Worklamp Relay (B)
5. Front Upper Worklamp Switch
6. Front Lower Worklamp Relay (D)
7. Front Lower Worklamp Switch
8. Fuse Panel (FS)
9. Front Lower Worklamp (L.H.)
10. Front Lower Worklamp (R.H.)
11. Front Upper Worklamp (L.H.)
12. Front Upper Worklamp (R.H.)
13. Rear Fender Worklamp (L.H.)
14. Rear Fender Worklamp (R.H.)
15. Roof Licence Plate Lamp (L.H.)
16. Diode
17. Roof Worklamp (L.H.)
18. Roof Licence Plate Lamp (R.H.)
19. Roof Worklamp (R.H.)

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White

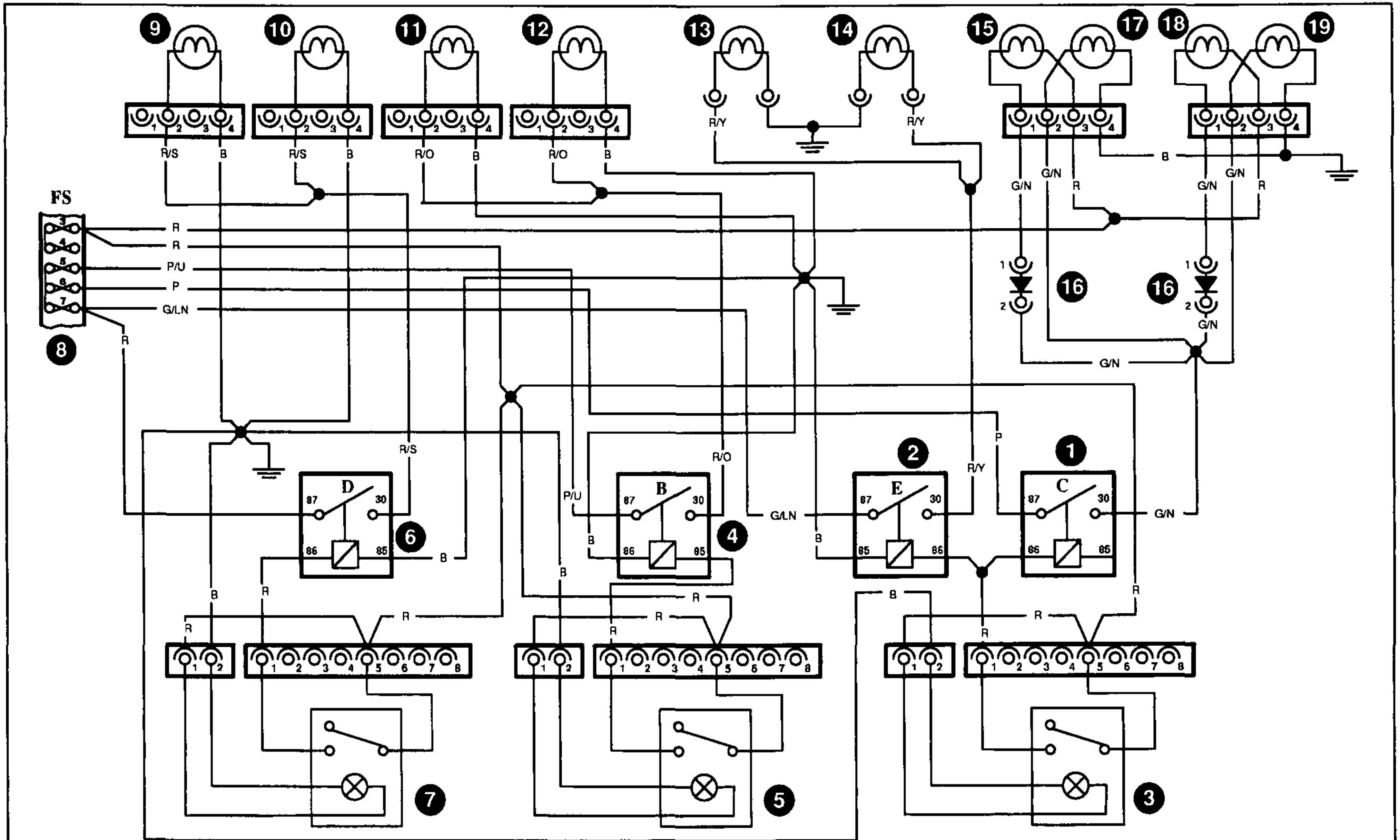

FS
R
R
P/U
P
G/LN
R/S
B
R/O
R/Y
G/N
R
P
D
B
E
C
87
30
86
85
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

Diagram 5

Diagram 6
Main Rear Harness – SLE Models with Cab, with EEC IV

1. Roof Licence Plate Lamp
2. Fender Rear Lights
3. Trailer Socket (C3)
4. Fender Rear Lights
5. Roof Licence Plate Lamp
6. Fender Licence Plate Lamp
7. Diode
8. Worklamp Relay (C)
9. Main Light Switch
10. Harness Connector (C4)
11. Harness Connector (J2)
12. Sidelamp (L.H.)
13. Harness Connector (E1)
14. Fuse Panel (FS)
15. Battery
16. Turn Switch
17. Sidelamp (R.H.)
18. Flasher Unit (IV)
19. I.S.O./N.A.S.O. Module (XI–XII)
20. Hazard Switch

Key To Colours

B	Black	G	Green
N	Brown	LG	Light Green
LN	Tan	U	Blue
S	Slate	TQ	Turquoise
R	Red	P	Purple
O	Orange	K	Pink
Y	Yellow	W	White

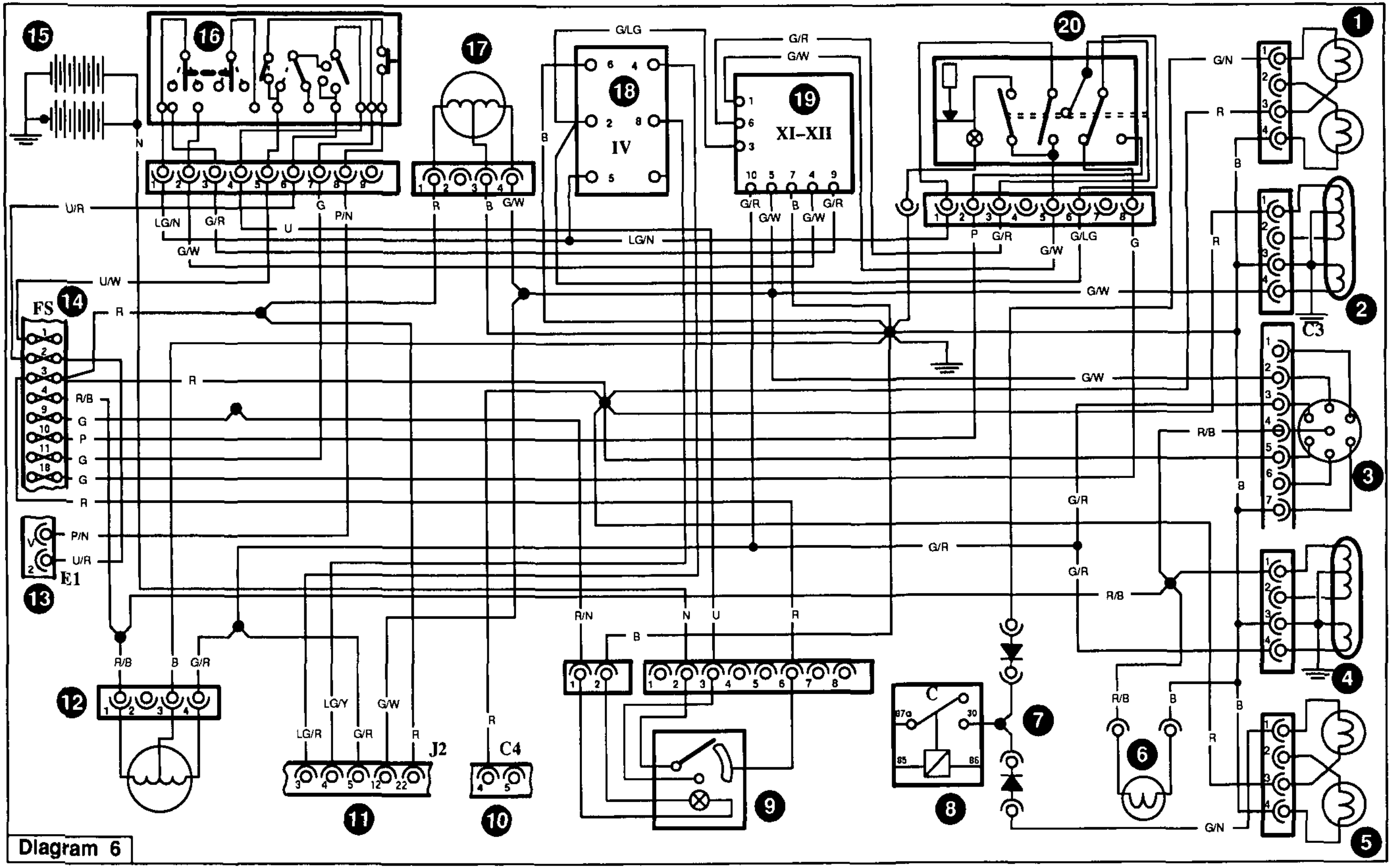

FS
E1
J2
C4
C3
IV
XI–XII
C
87a
30
85
86
U/R
U/W
LG/N
G/R
G/W
G/LG
P/N
R/B
R/N
LG/R
LG/Y
G/N

Diagram 6

Diagram 7
Main Rear Harness – SLE Models with Cab, with EEC IV

1. Harness Connector (C4)
2. Right Hand Speaker
3. Left Hand Speaker
4. H.P.L. Fender Switch
5. H.P.L. Fender Switch
6. Left Hand Beacon
7. Right Hand Beacon
8. Beacon Switch
9. Seat Pump
10. Handbrake Switch
11. Harness Connector (J2)
12. Harness Connector (E1)
13. Fuse Panel (FS)
14. Battery Temperature Sensor
15. Battery
16. Cigar Lighter
17. Interior Light
18. Interior Light Door Switch
19. Interior Light Door Switch
20. Radio
21. Harness Connector (C2)
22. Clutch Potentiometer

Key To Colours

B	Black	G	Green
N	Brown	LG	Light Green
LN	Tan	U	Blue
S	Slate	TQ	Turquoise
R	Red	P	Purple
O	Orange	K	Pink
Y	Yellow	W	White

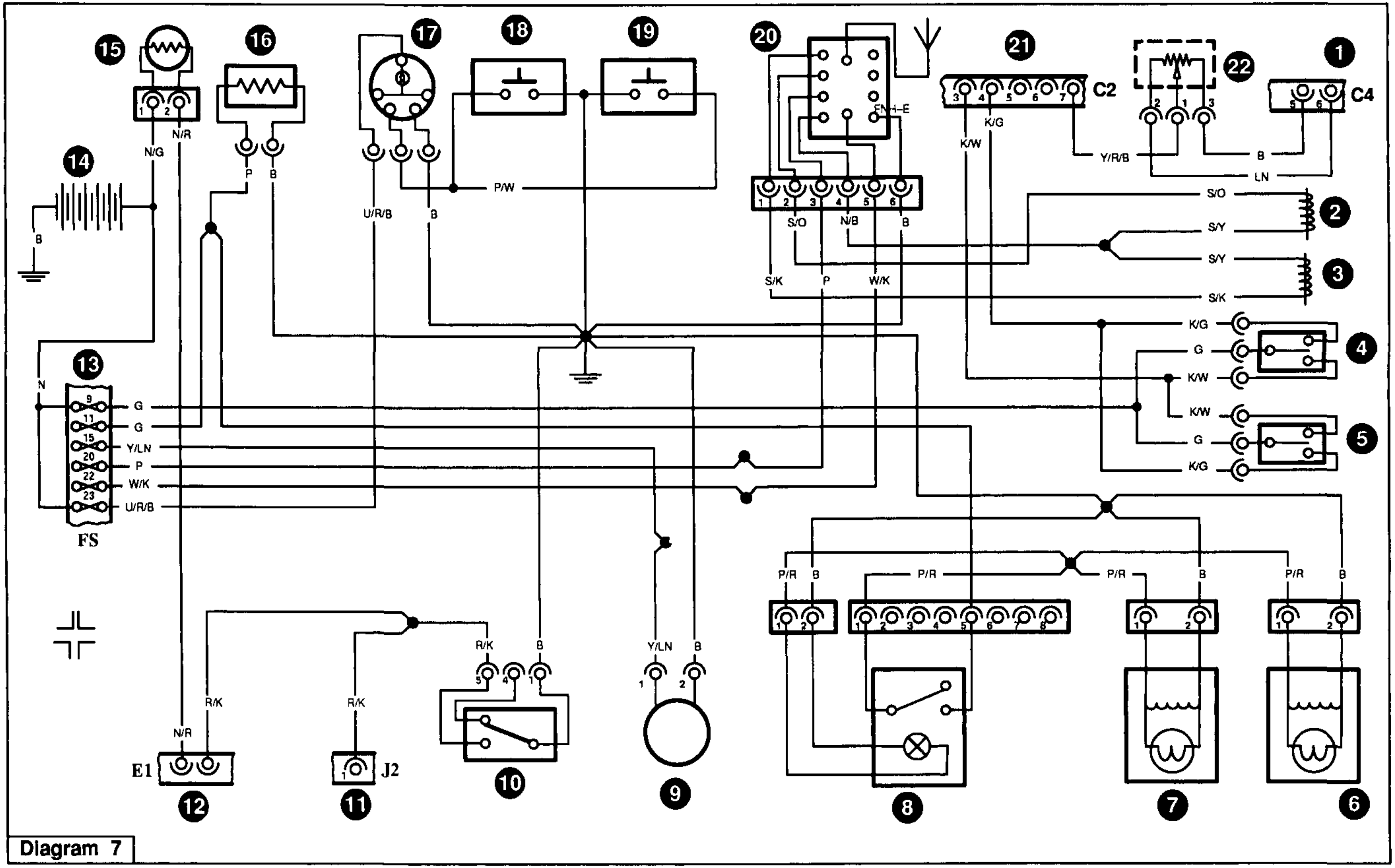


Diagram 7

CHAPTER 2

Diagram 8
Main Rear Harness (Interconnections) – SLE Models with Cab, with EEC IV

1. Transmission/EDC Connector (C2)
2. Instrument Connector (J1)
3. Instrument Connector (J2)
4. Diagnostics Plug (D1)
5. Fuel Tank Connector (FT)
6. Keystart Switch (KS)
7. Front Main Harness Connector (E1)
8. Extension Harness Connector (C1)
9. Fuse Panel (FS)
10. Transmission/EDC Connector (C4)

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White

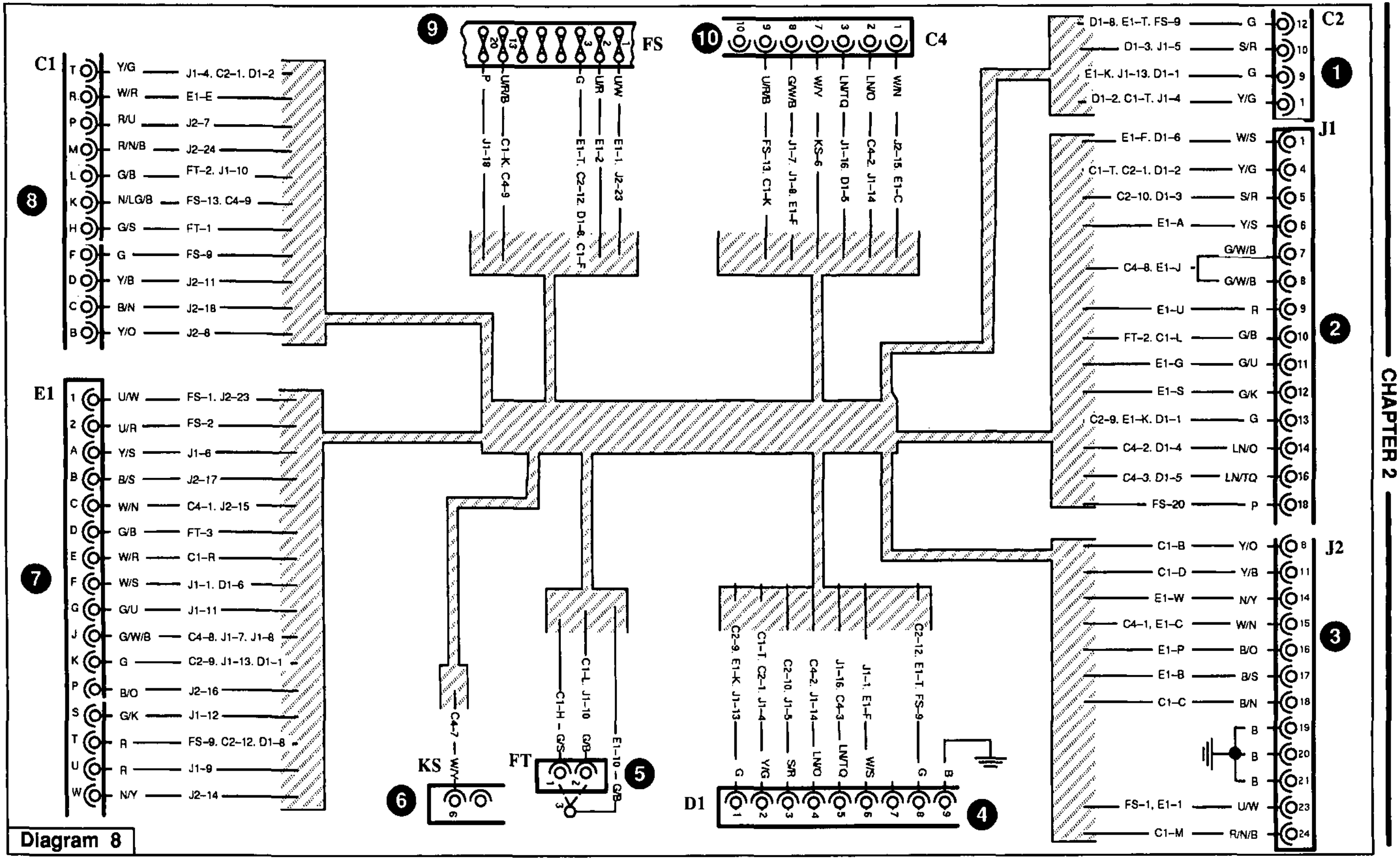

C1
T Y/G J1-4. C2-1. D1-2
R W/R E1-E
P R/U J2-7
M R/N/B J2-24
L G/B FT-2. J1-10
K N/LG/B FS-13. C4-9
H G/S FT-1
F G FS-9
D Y/B J2-11
C B/N J2-18
B Y/O J2-8
E1
1 U/W FS-1. J2-23
2 U/R FS-2
A Y/S J1-6
B B/S J2-17
C W/N C4-1. J2-15
D G/B FT-3
E W/R C1-R
F W/S J1-1. D1-6
G G/U J1-11
J G/W/B C4-8. J1-7. J1-8
K G C2-9. J1-13. D1-1
P B/O J2-16
S G/K J1-12
T R FS-9. C2-12. D1-8
U R J1-9
W N/Y J2-14
FS
P J1-18
U/R/B C1-K. C4-9
G E1-T. C2-12. D1-8. C1-F
U/R E1-2
U/W E1-1. J2-23
C4
U/R/B FS-13. C1-K
G/W/B J1-7. J1-8. E1-F
W/Y KS-6
LN/TQ J1-16. D1-5
LN/O C4-2. J1-14
W/N J2-15. E1-C
C2
D1-8. E1-T. FS-9 G 12
D1-3. J1-5 S/R 10
E1-K. J1-13. D1-1 G 9
D1-2. C1-T. J1-4 Y/G 1
J1
E1-F. D1-6 W/S 1
C1-T. C2-1. D1-2 Y/G 4
C2-10. D1-3 S/R 5
E1-A Y/S 6
C4-8. E1-J G/W/B 7
G/W/B 8
E1-U R 9
FT-2. C1-L G/B 10
E1-G G/U 11
E1-S G/K 12
C2-9. E1-K. D1-1 G 13
C4-2. D1-4 LN/O 14
C4-3. D1-5 LN/TQ 16
FS-20 P 18
J2
C1-B Y/O 8
C1-D Y/B 11
E1-W N/Y 14
C4-1, E1-C W/N 15
E1-P B/O 16
E1-B B/S 17
C1-C B/N 18
B 19
B 20
B 21
FS-1, E1-1 U/W 23
C1-M R/N/B 24
KS
C4-7 W/Y
FT
C1-H G/S
C1-L. J1-10 G/B
E1-10 G/B
D1
C2-9. E1-K. J1-13 G
C1-T. C2-1 J1-4 Y/G
C2-10. J1-5 S/R
C4-2. J1-14 LN/O
J1-16. C4-3 LN/TQ
J1-1. E1-F W/S
C2-12. E1-T. FS-9 G
B
CHAPTER 2

Diagram 8

Index for Diagrams 1–8

Wiring Diagrams 9 to 14
Main Rear Harness
SLE Models with Cab with Analogue Electronic Instrument Cluster

Diagram 9
Main Rear Harness – SLE Models with Cab, with AEIC

1. P.T.O. Speed Switch
2. Instrument Harness Connector (J1)
3. Extension Harness Connector (C1)
4. P.T.O. Module (Relay V–VI)
5. Thermostart Relay (VII)
6. Harness Connector (C4)
7. Diagnostic Connector (D1)
8. Engine Harness Connector (E1)
9. Fuse Panel (FS)
10. Battery
11. Keystart Switch (KS)
12. P.T.O. Switch
13. Indicator Lamp

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White

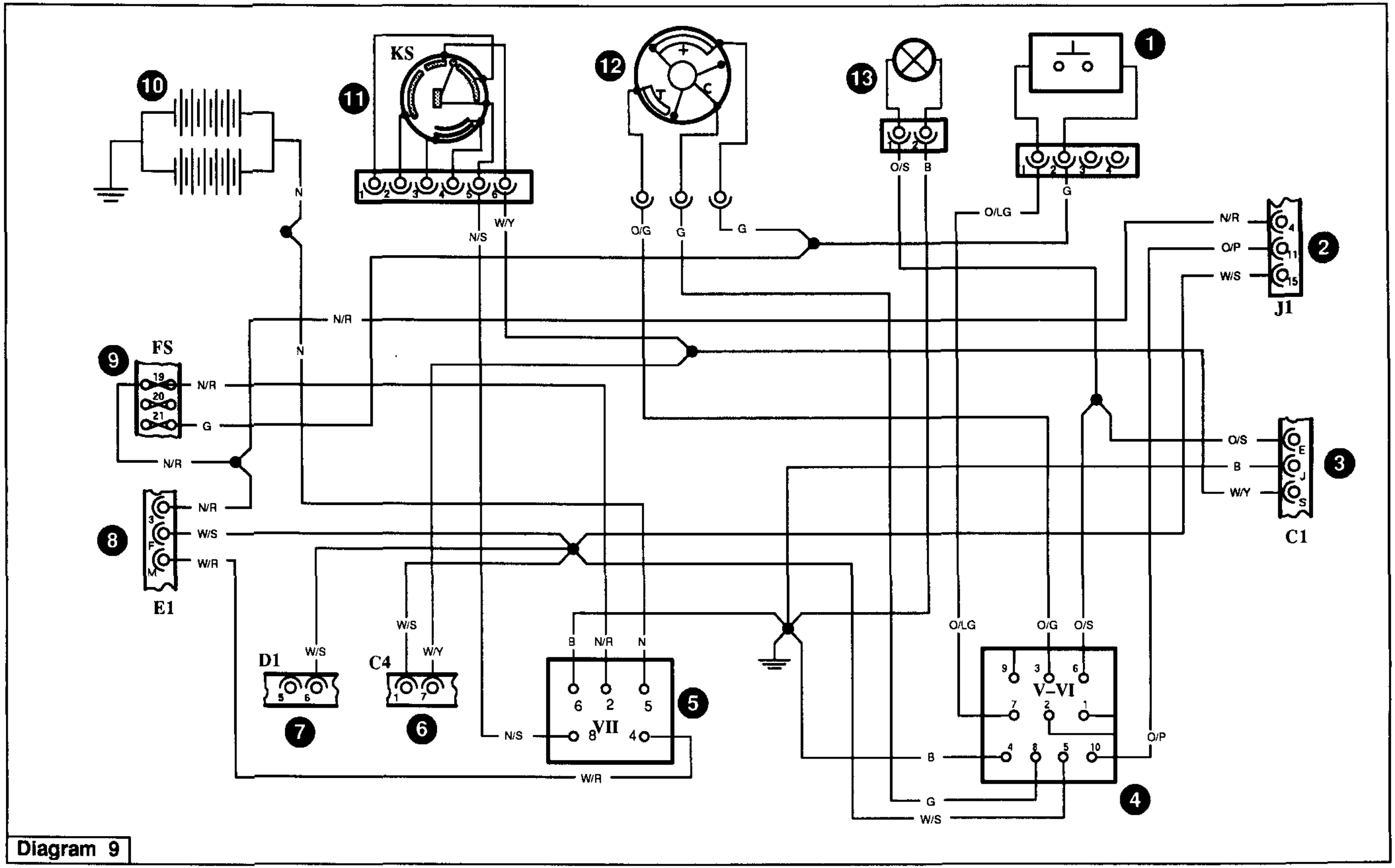


Diagram 9

Diagram 10
Main Rear Harness – SLE Models with Cab, with AEIC

1. R.H. Rear Lamps
2. L.H. Rear Lamps
3. Trailer Socket
4. Implement Socket
5. Implement Relay (III)
6. Implement Relay Switch
7. FWD Switch
8. FWD Relay (G)
9. Diff. Lock Relay (A)
10. Creeper Gear Switch
11. Harness Connector (D1)
12. Trans./EDC Harness Connector (C2)
13. Trans./EDC Harness Connector (C4)
14. Fuse Panel
15. Engine Harness Connector (E1)
16. Battery
17. Keystart Switch
18. Ignition Delay Relay (IX)
19. Extension Harness Connector (C1)
20. FWD Supply
21. Diff. Lock Switch
22. L.H. Brake Light Switch
23. R.H. Brake Light Switch

Key To Colours

B	– Black	G	– Green
N	– Brown	LG	– Light Green
LN	– Tan	U	– Blue
S	– Slate	TQ	– Turquoise
R	– Red	P	– Purple
O	– Orange	K	– Pink
Y	– Yellow	W	– White

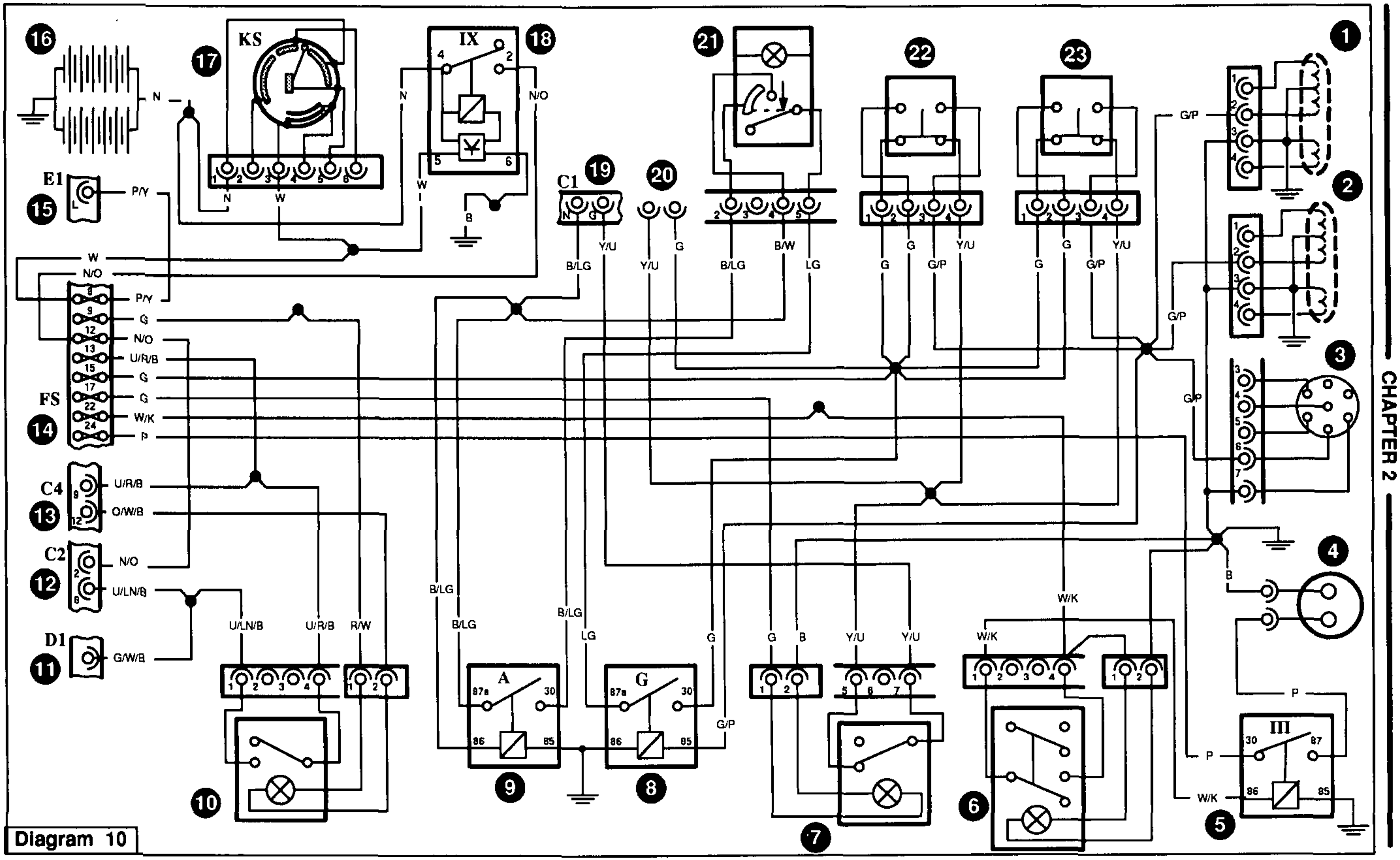

KS
IX
E1
FS
C1
C4
C2
D1
A
G
III
CHAPTER 2
Diagram 10

Diagram 11
Main Rear Harness – SLE Models with Cab, with AEIC

1. Front Washer Motor
2. Rear Washer Motor
3. Rear Wiper Motor
4. Heater/Air Con. Connector (T6)
5. Harness Connector (E1)
6. Front Wiper Switch
7. Front Wiper Motor
8. Accessory Relay (II)
9. Auxiliary Relay (I)
10. HPL Enable Relay (H)
11. Harness Connector (C2)
12. Harness Connector (C4)
13. Fuse Panel (FS)
14. Battery
15. Keystart Switch (KS)
16. Harness Connector (J2)
17. Console Lamp
18. Accessory Socket
19. Rear Wiper Switch

Key To Colours

B	– Black	G	– Green
N	– Brown	LG	– Light Green
LN	– Tan	U	– Blue
S	– Slate	TQ	– Turquoise
R	– Red	P	– Purple
O	– Orange	K	– Pink
Y	– Yellow	W	– White

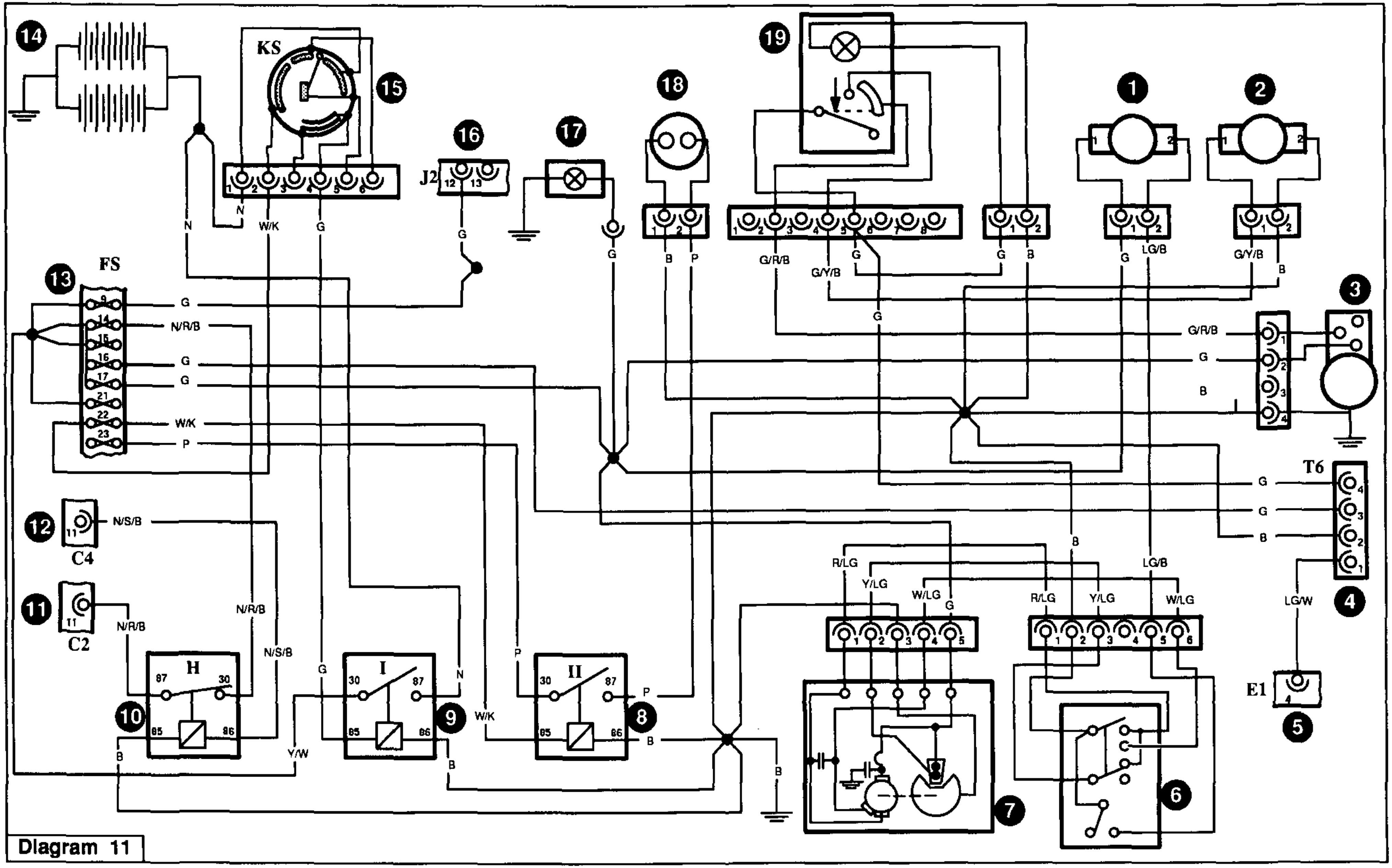

KS
FS
J2
C4
C2
T6
E1
H
I
II
G
N/R/B
W/K
P
N/S/B
Y/W
G/R/B
G/Y/B
LG/B
R/LG
Y/LG
W/LG
LG/W
B
N

Diagram 11

Diagram 12
Main Rear Harness – with Cab, with AEIC

1. Harness Connector (C4)
2. Right Hand Speaker
3. Left Hand Speaker
4. H.P.L. Fender Switch
5. H.P.L. Fender Switch
6. Left Hand Beacon
7. Right Hand Beacon
8. Beacon Switch
9. Buzzer
10. Harness Connector (J1)
11. Handbrake Switch
12. Seat Pump
13. Harness Connector (J2)
14. Harness Connector (E1)
15. Fuse Panel (FS)
16. Battery Temperature Sensor
17. Battery
18. Cigar Lighter
19. Interior Light
20. Interior Light Door Switch
21. Interior Light Door Switch
22. Radio
23. Harness Connector (C2)
24. Clutch Potentiometer

Key To Colours

B	– Black	G	– Green
N	– Brown	LG	– Light Green
LN	– Tan	U	– Blue
S	– Slate	TQ	– Turquoise
R	– Red	P	– Purple
O	– Orange	K	– Pink
Y	– Yellow	W	– White

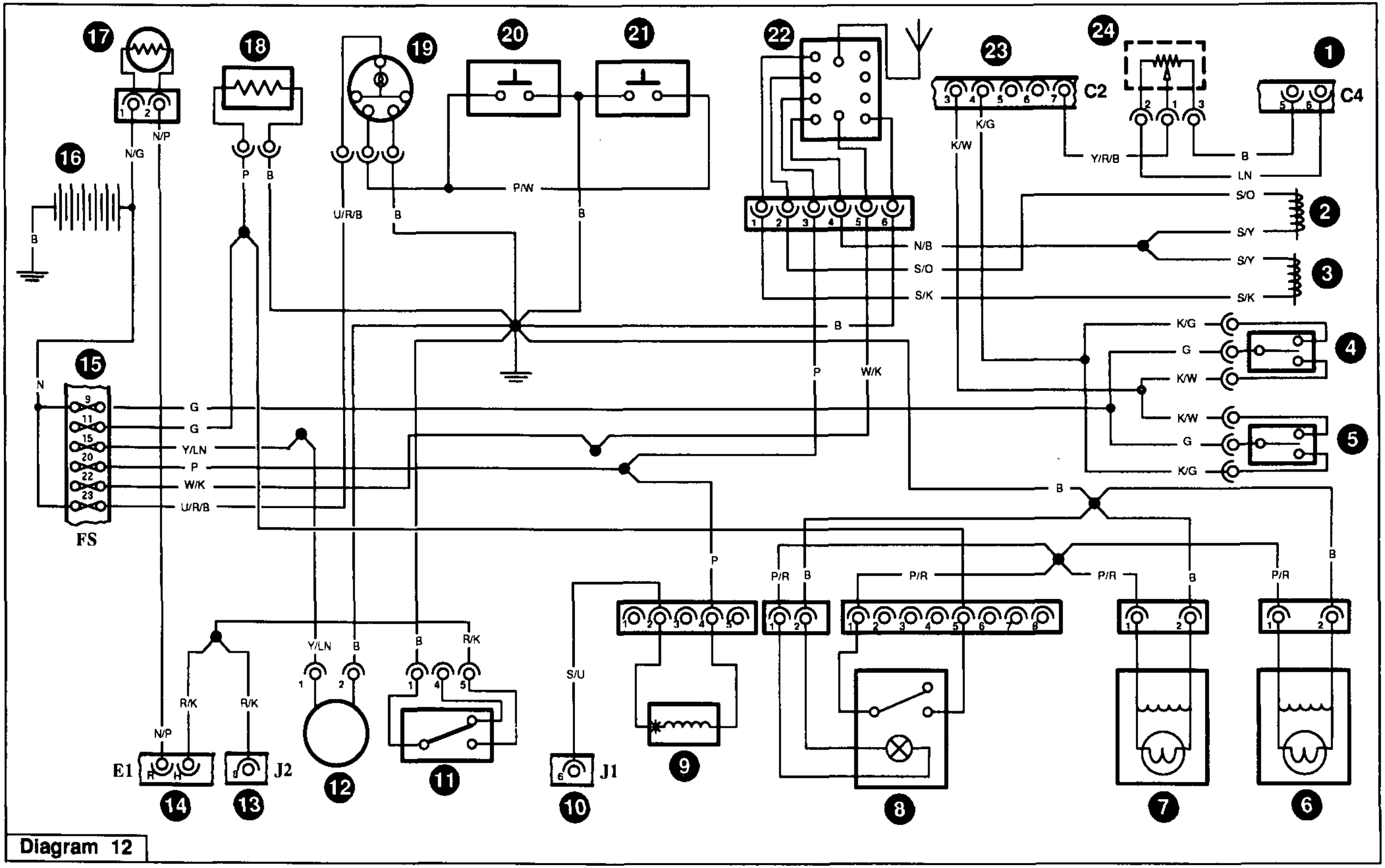

17
18
19
20
21
22
23
24
1
C2
C4
16
N/G
N/P
P
B
U/R/B
P/W
Y/R/B
LN
S/O
S/Y
2
N/B
3
S/K
K/G
G
K/W
4
5
15
FS
Y/LN
W/K
B
P/R
S/U
E1
J2
J1
R/K
14
13
12
11
10
9
8
7
6

Diagram 12

Diagram 13
Main Rear Harness – SLE Models with Cab, with AEIC

1. Roof Licence Plate Lamp
2. Fender Rear Lights
3. Trailer Socket (C3)
4. Fender Rear Lights
5. Roof Licence Plate Lamp
6. Fender Licence Plate Lamp
7. Diodes
8. Worklamp Relay (C)
9. Main Light Switch
10. Harness Connector (C4)
11. Harness Connector (J2)
12. Harness Connector (J1)
13. Sidelamp (L.H.)
14. Harness Connector (E1)
15. Fuse Panel (FS)
16. Battery
17. Turn Switch
18. Sidelamp (R.H.)
19. I.S.O./N.A.S.O. Module (XI–XII)
20. Flasher Unit (IV)
21. Hazard Switch

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White

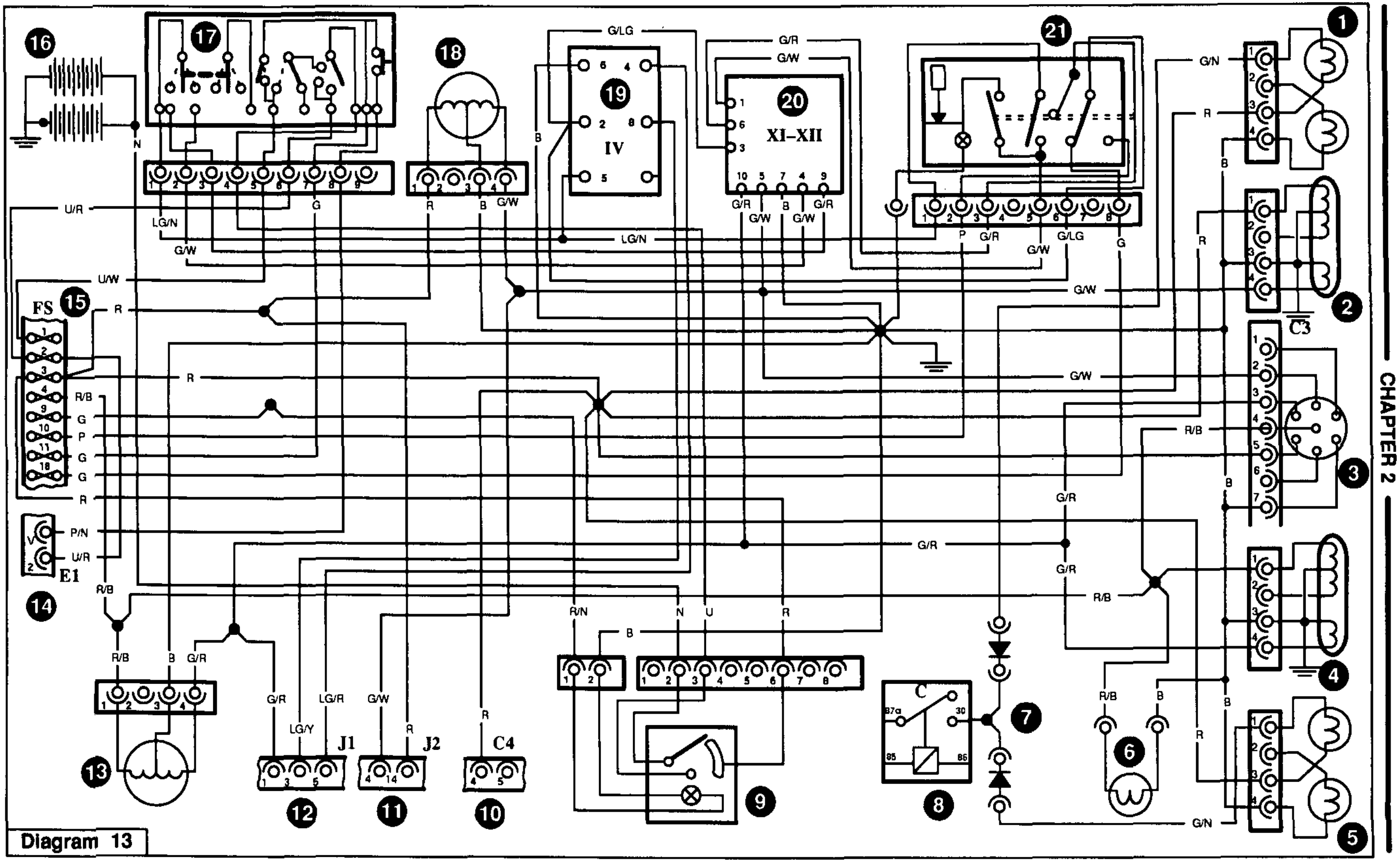

CHAPTER 2
Diagram 13
FS
E1
J1
J2
C4
C3
C
IV
XI–XII

Diagram 14
Main Rear Harness – with Cab, with AEIC

1. Transmission/EDC Connector (C2)
2. Instrument Connector (J1)
3. Instrument Connector (J2)
4. Diagnostics Plug (D1)
5. Fuel Tank Connector (FT)
6. Keystart Switch (KS)
7. Front Main Harness Connector (E1)
8. Extension Harness Connector (C1)
9. Fuse Panel (FS)
10. Transmission/EDC Connector (C4)

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White

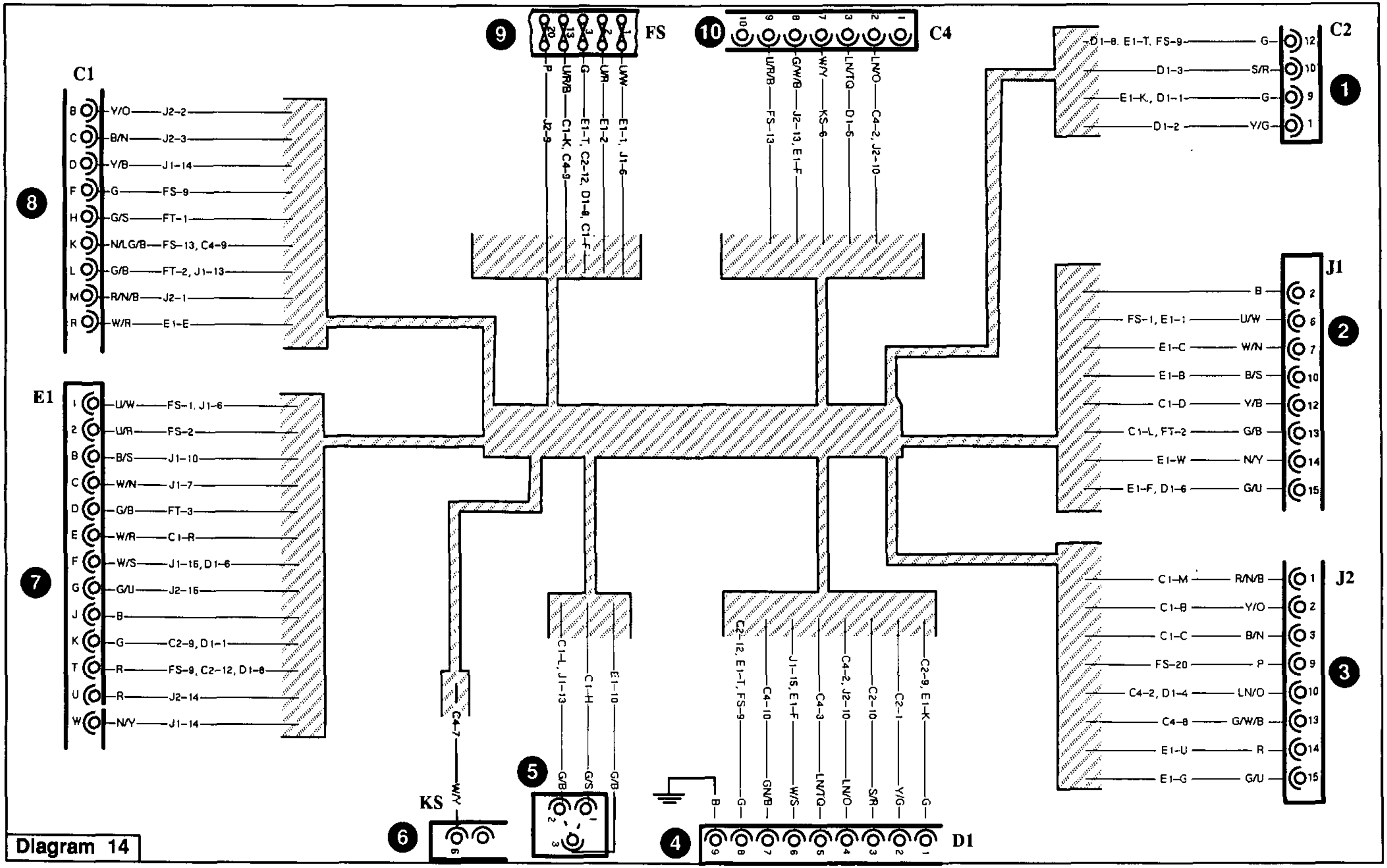


Diagram 14

Index for Diagrams 9–14

Wiring Diagrams 15 to 21
Main Rear Harness
SLE Models less Cab with Electronic Instrument Cluster and Analogue Electronic Instrument Cluster

Diagram 15
Main Rear Harness – SLE Models less Cab, with EIC/AEIC (Except North America)

1. E.D.C. External Switch, R.H.
2. R.H. Fender, Harness Connector (F4)
3. L.H. Fender, Harness Connectorr (F3)
4. E.D.C. External Switch, L.H.
5. Rear Worklamp L.H.
6. Front Worklamp L.H.
7. Rear Lamps L.H.
8. Front Sidelamps L.H.
9. L.H. Fender, Harness Connector (F3)
10. R.H. Fender, Harness Connector (F4)
11. Front Sidelamps R.H.
12. Rear Lamps R.H.
13. Front Worklamp R.H.
14. Rear Worklamp R.H.

Diagram 16
Main Rear Harness – SLE Models less Cab, with EIC/AEIC (North America only)

1. E.D.C. External Switch, R.H.
2. R.H. Fender, Harness Connector (F4)
3. L.H. Fender, Harness Connector (F4)
4. E.D.C. External Switch, L.H.
5. Rear Worklamp L.H.
6. Rear Turn Indicator L.H.
7. Rear Marker Lamp
8. Front Worklamp L.H.
9. Rear Turn Indicator L.H.
10. L.H. Fender, Harness Connector (F3)
11. R.H. Fender, Harness Connector (F3)
12. Front Turn Indicators R.H.
13. Front Worklamp R.H.
14. Rear Turn Indicators R.H.
15. Rear Worklamp R.H.

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White

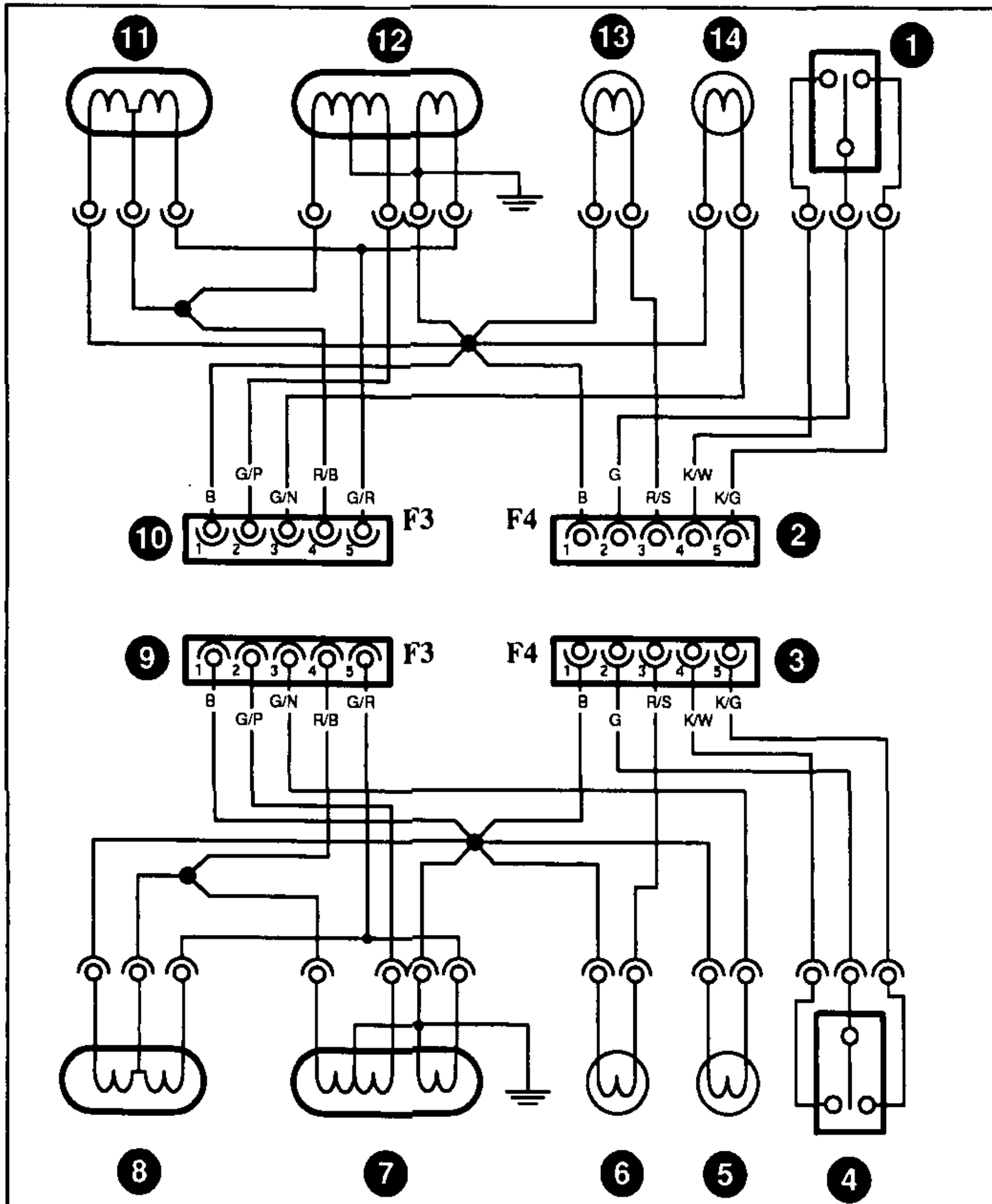


Diagram 15

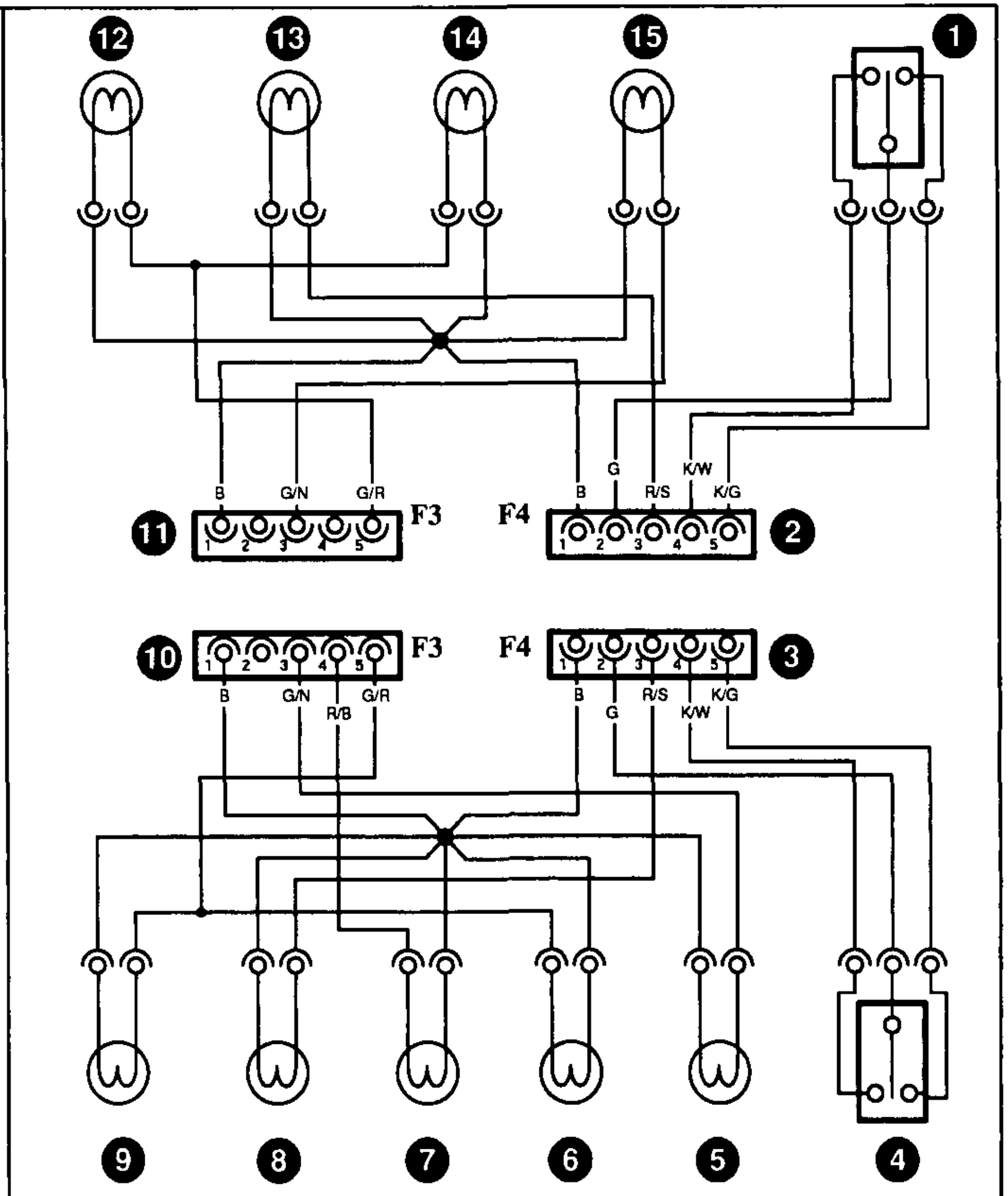


Diagram 16

Diagram 17
Main Rear Harness – SLE Models less Cab, with EIC

1. R.H. Fender Connection (F3)
2. L.H. Fender Connection (F3)
3. Trailer Socket Connector
4. Handbrake Switch
5. F.W.D. Relay (G)
6. Diff Lock Relay (A)
7. P.T.O. Module
8. P.T.O. Speed Switch
9. FWD Supply
10. Front PTO Clutch
11. Diagnostic Plug Connector (D1)
12. Engine Harness Connector (E1)
13. Fuse Panel (FS)
14. L.H. Stop Lamp Switch
15. R.H. Stop Lamp Switch
16. Instrument Harness Connector (J1)
17. Harness Connector (E3)
18. Instrument Harness Connector (J2)
19. Extension Harness Connector (C1)
20. R.H. Console Harness Connector (H5)

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White

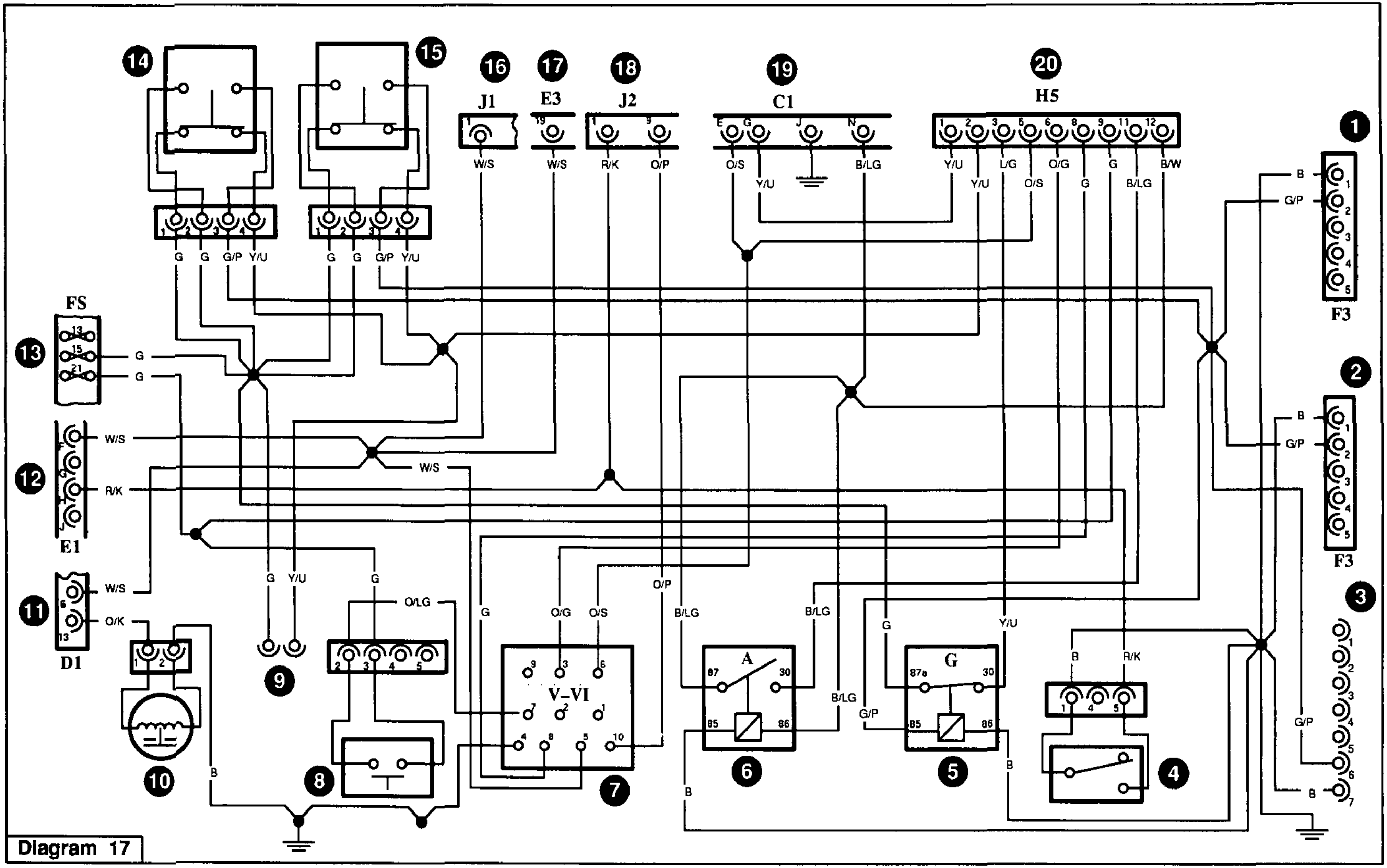

14
15
16
J1
17
E3
18
J2
19
C1
20
H5
W/S
R/K
O/P
O/S
Y/U
B/LG
L/G
O/G
G
B/W
G/P
FS
13
12
E1
11
D1
W/S
O/K
O/LG
V–VI
A
G
87
30
85
86
87a
B
F3
1
2
3
4
5
6
7
8
9
10

Diagram 17

Diagram 18
Main Rear Harness – SLE Models less Cab, with EIC

1. EEC IV Connector
2. EDC Harness Connector
3. EEC Ext. Harness Connector
4. R.H. Console Harness Connector
5. Fast Raise/Lower Switch
6. Creeper Gear Switch
7. Extension Harness Connector
8. Clutch Potentiometer
9. Harness Connector (D1)
10. Fuse Panel
11. Gear Shift Display
12. Gear Shift Up/Down
13. Quadrant Lever Potentiometer

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White

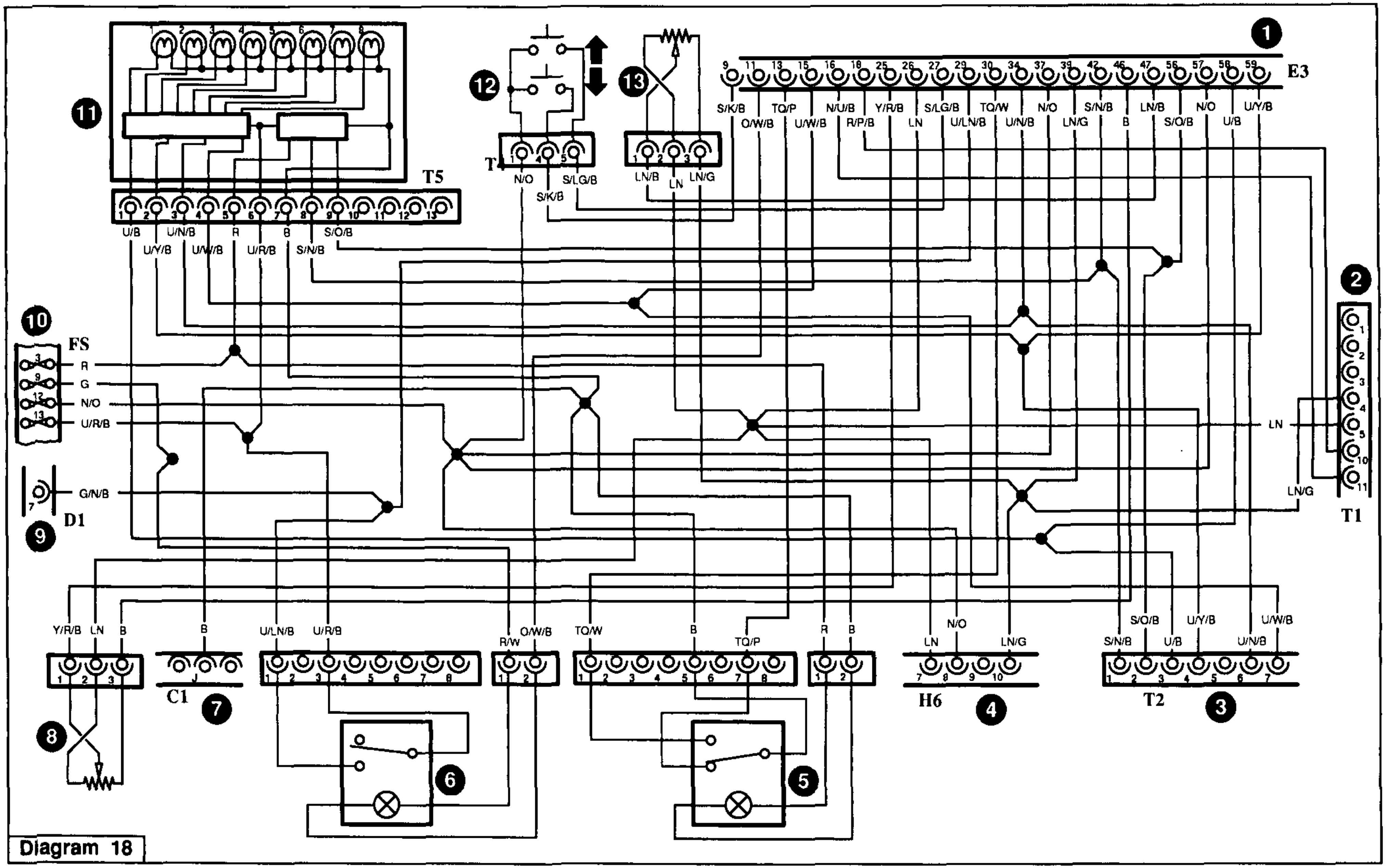

E3
T1
T2
T4
T5
H6
C1
D1
FS
S/K/B
O/W/B
TQ/P
U/W/B
N/U/B
R/P/B
Y/R/B
LN
S/LG/B
U/LN/B
TQ/W
U/N/B
N/O
LN/G
S/N/B
B
LN/B
S/O/B
U/B
U/Y/B
U/R/B
R
G
G/N/B
R/W
LN/B
LN/G

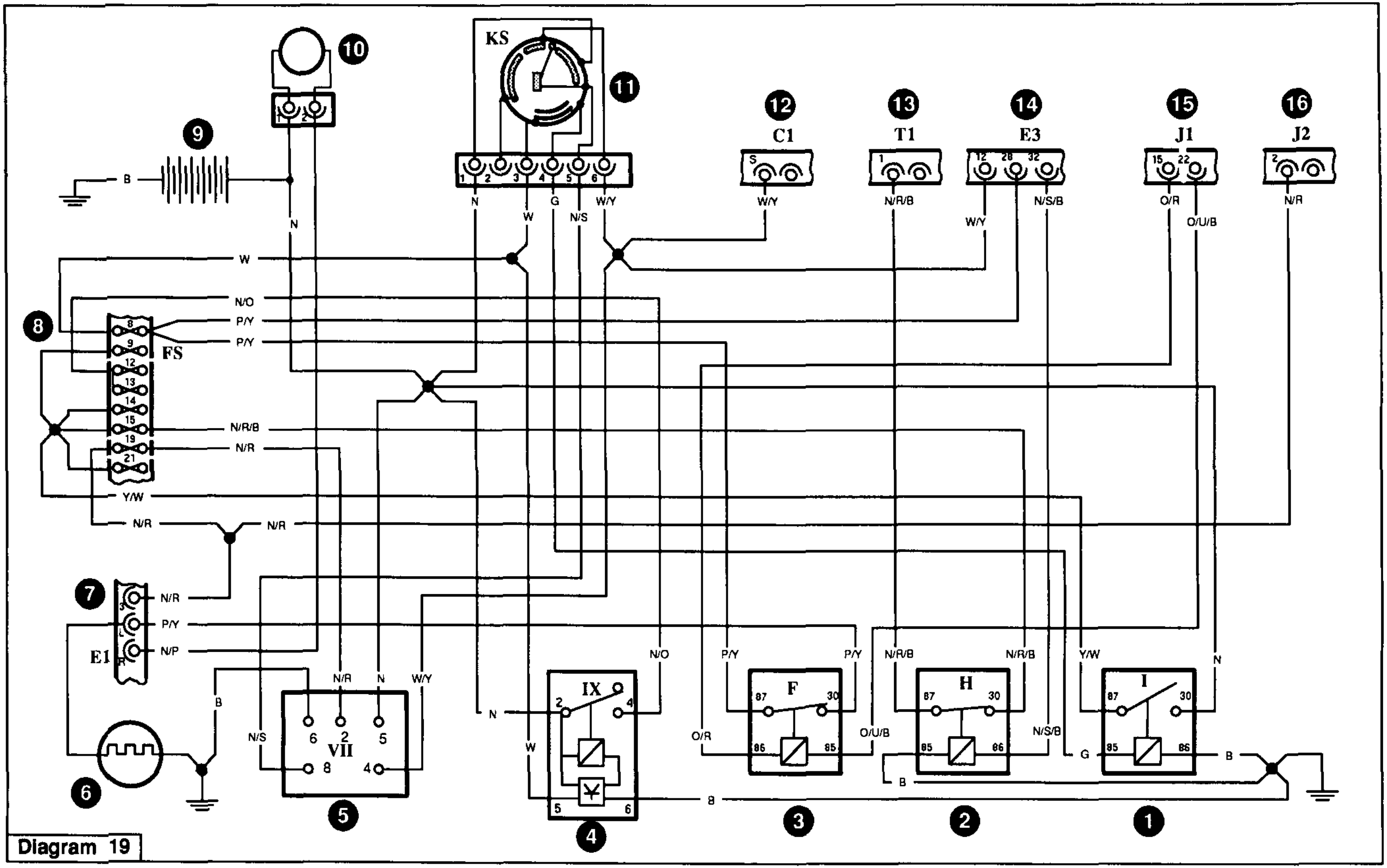
Diagram 18

Diagram 19
Main Rear Harness – SLE Models less Cab, with EIC

1. Auxiliary Relay (I)
2. HPL Enable Relay (H)
3. Fuel Shut–Off Relay (F)
4. Ignition Delay Relay (IX)
5. Thermostart Relay (VII)
6. Thermostart
7. Engine Harness Connector (E1)
8. Fuse Panel (FS)
9. Battery
10. Battery Temperature Sensor
11. Keystart Switch (KS)
12. Extension Harness Connector (C1)
13. EDC Chassis Harness Connector (T1)
14. EEC IV Harness Connector (E3)
15. Instrument Harness Connector (J1)
16. Instrument Harness Connector (J2)

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White


KS
FS
C1
T1
E3
J1
J2
E1
VII
IX
F
H
I
W
N/O
P/Y
N/R/B
N/R
Y/W
N/P
N/S
W/Y
N/S/B
O/R
O/U/B
B
G
N
Diagram 19

CHAPTER 2

Diagram 20
Main Rear Harness – SLE Models less Cab, with EIC

1. R.H. Fender Connection (F4)
2. R.H. Fender Connection (F3)
3. Trailer Socket (C3)
4. L.H. Fender Connection (F3)
5. L.H. Fender Connection (F4)
6. Front Worklamp Switch
7. Front Worklamp Relay (D)
8. Rear Worklamp Switch
9. Rear Worklamp Relay (C)
10. Hazard Switch
11. Main Light Switch
12. Instrument Harness Connector (J2)
13. Engine Harness Connector (E1)
14. Fuse Panel (FS)
15. Battery
16. Turn Switch
17. I.S.O./N.A.S.O. Module (XI–XII)
18. Flasher Unit (IV)

Key To Colours

B	– Black	G	– Green
N	– Brown	LG	– Light Green
LN	– Tan	U	– Blue
S	– Slate	TQ	– Turquoise
R	– Red	P	– Purple
O	– Orange	K	– Pink
Y	– Yellow	W	– White

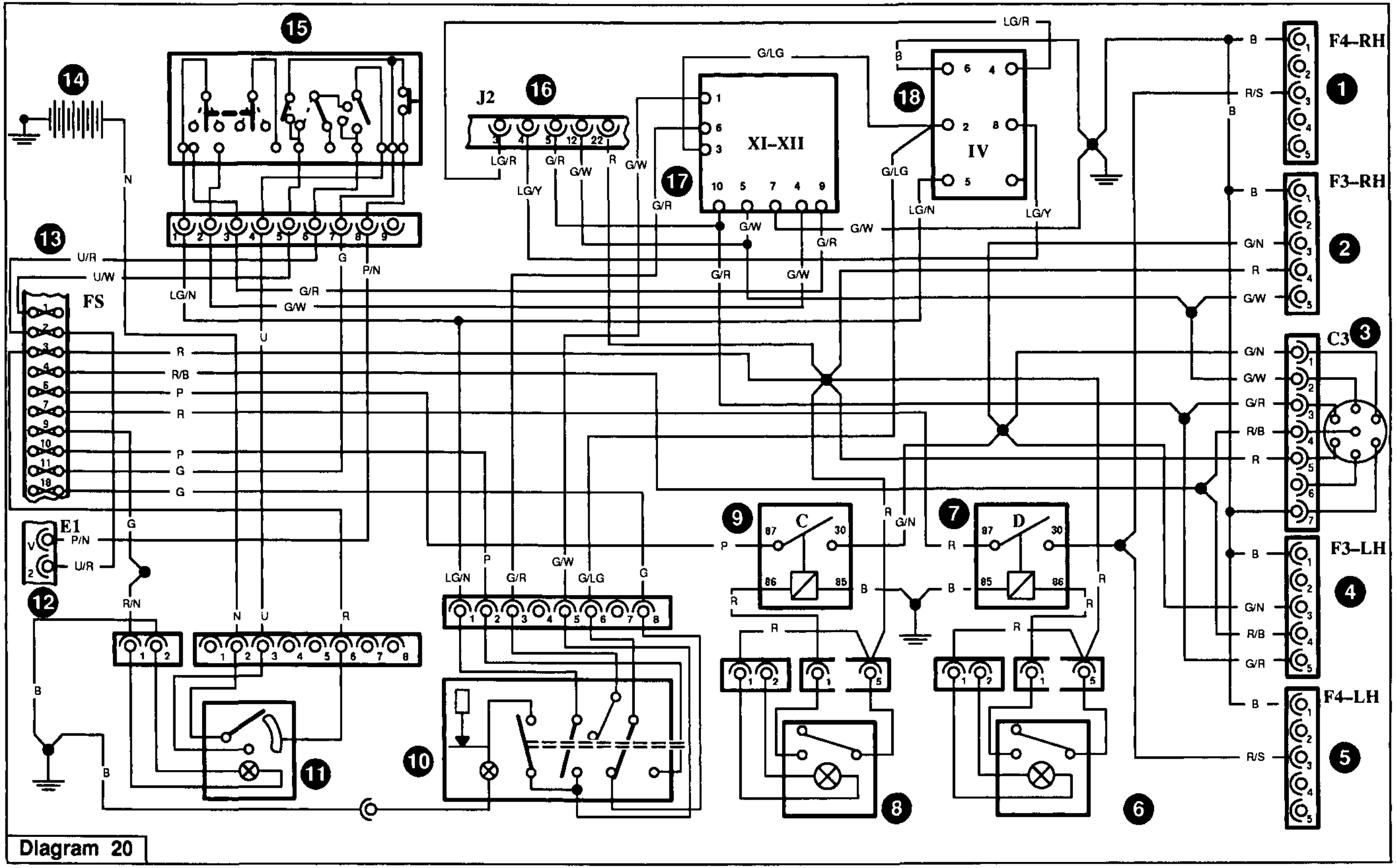


Diagram 20

CHAPTER 2

Diagram 21
Main Rear Harness Interconnections – SLE Models less Cab, with EIC

1. Microprocessor Connector
2. Diagnostics Plug
3. E.D.C. Extension Harness Connector
4. E.D.C. Chassis Connector
5. R.H. Console Connector
6. Instrument Harness Connector
7. Instrument Harness Connector
8. Engine Harness Connector
9. Extension Harness Connector
10. Fuel Tank Changeover Connector

Key To Colours

B	Black	G	Green
N	Brown	LG	Light Green
LN	Tan	U	Blue
S	Slate	TQ	Turquoise
R	Red	P	Purple
O	Orange	K	Pink
Y	Yellow	W	White

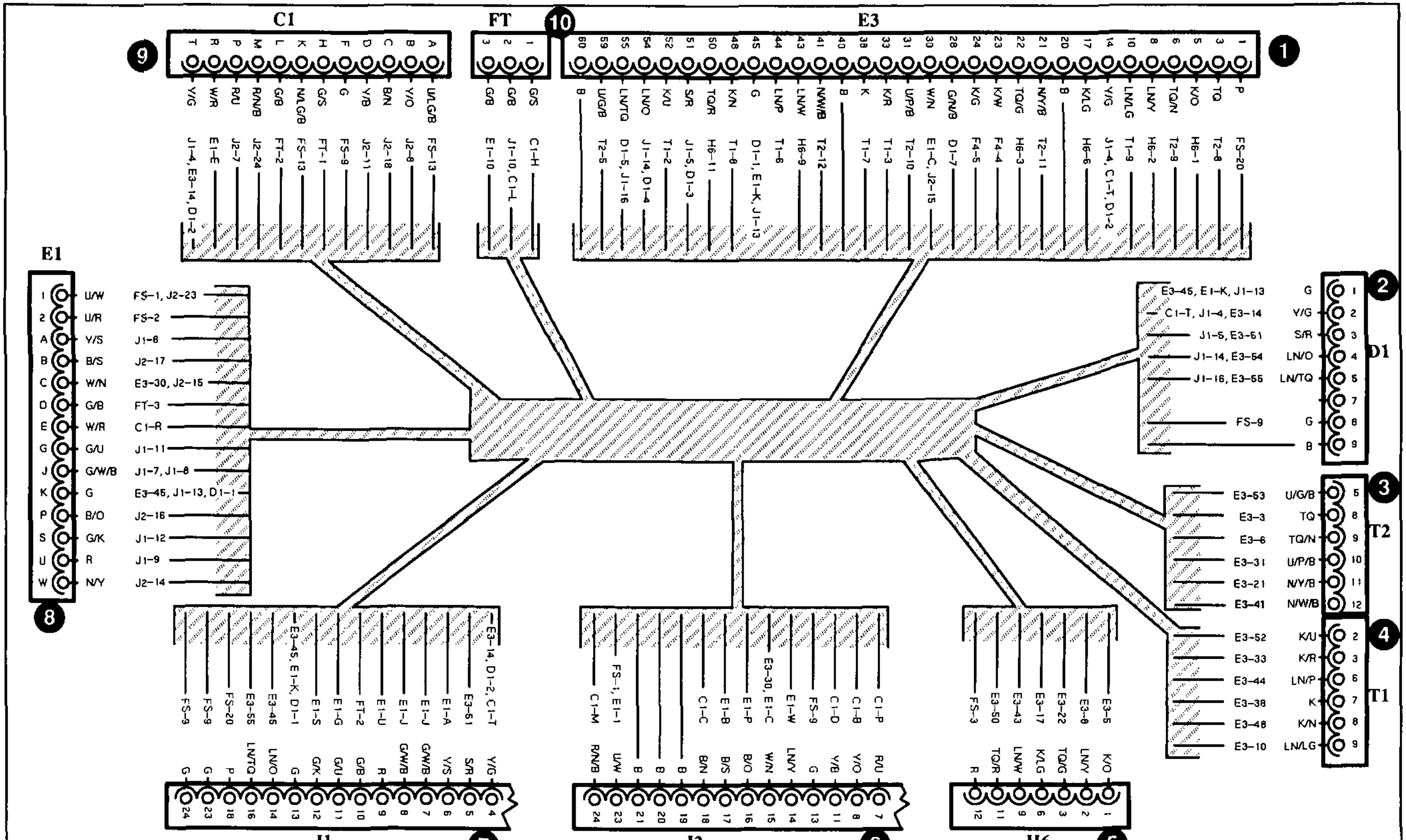


Diagram 21

Index for Diagrams 15–21

Wiring Diagrams 22 to 25
Main Rear Harness
SLE Models less Cab with Analogue Electronic Instrument Cluster

Diagram 22
Main Rear Harness – SLE Models less Cab, with AEIC

1. Auxiliary Relay (I)
2. HPL Enable Relay (H)
3. Buzzer
4. Ignition Delay Relay (IX)
5. Thermostart Relay (VII)
6. Thermostart
7. Engine Harness Connector (E1)
8. Fuse Panel (FS)
9. Battery
10. Battery Temperature Sensor
11. Keystart Switch (KS)
12. Extension Harness Connector (C1)
13. EDC Chassis Harness Connector (T1)
14. EEC IV Harness Connector (E3)
15. Instrument Harness Connector (J1)
16. Instrument Harness Connector (J2)

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White

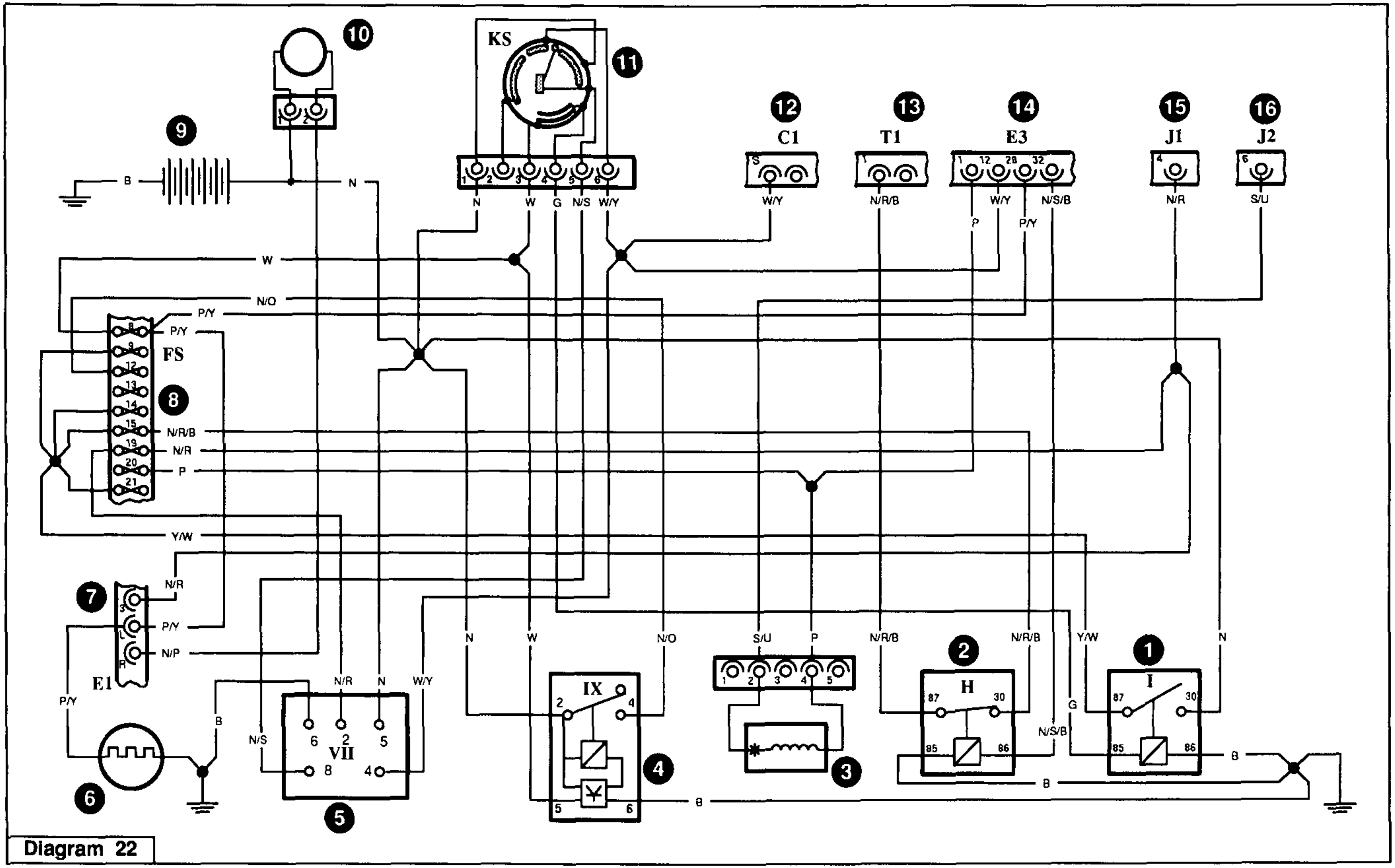

10
KS
11
9
B
N
12
C1
13
T1
14
E3
15
J1
16
J2
N W G N/S W/Y
W/Y
N/R/B
P W/Y P/Y N/S/B
N/R
S/U
W
N/O
P/Y
FS
8
N/R/B
N/R
P
Y/W
N/R
7
P/Y
N/P
E1
P/Y
6
B
N/S
N/R N W/Y
VII
5
N
W
N/O
IX
4
S/U
P
3
N/R/B
2
H
87 30 85 86
N/R/B
N/S/B
G
Y/W
1
I
87 30 85 86
N
B
B
B

Diagram 22

Diagram 23
Main Rear Harness – SLE Models less Cab, with AEIC

1. R.H. Fender Connection (F4)
2. R.H. Fender Connection (F3)
3. Trailer Socket (C3)
4. L.H. Fender Connection (F3)
5. L.H. Fender Connection (F4)
6. Front Worklamp Switch
7. Front Worklamp Relay (D)
8. Rear Worklamp Switch
9. Rear Worklamp Relay (C)
10. Hazard Switch
11. Main Light Switch
12. Engine Harness Connector (E1)
13. Fuse Panel (FS)
14. Battery
15. Turn Switch
16. Instrument Harness Connector (J1)
17. Instrument Harness Connector (J2)
18. I.S.O./N.A.S.O. Module (XI–XII)
19. Flasher Unit (IV)

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White

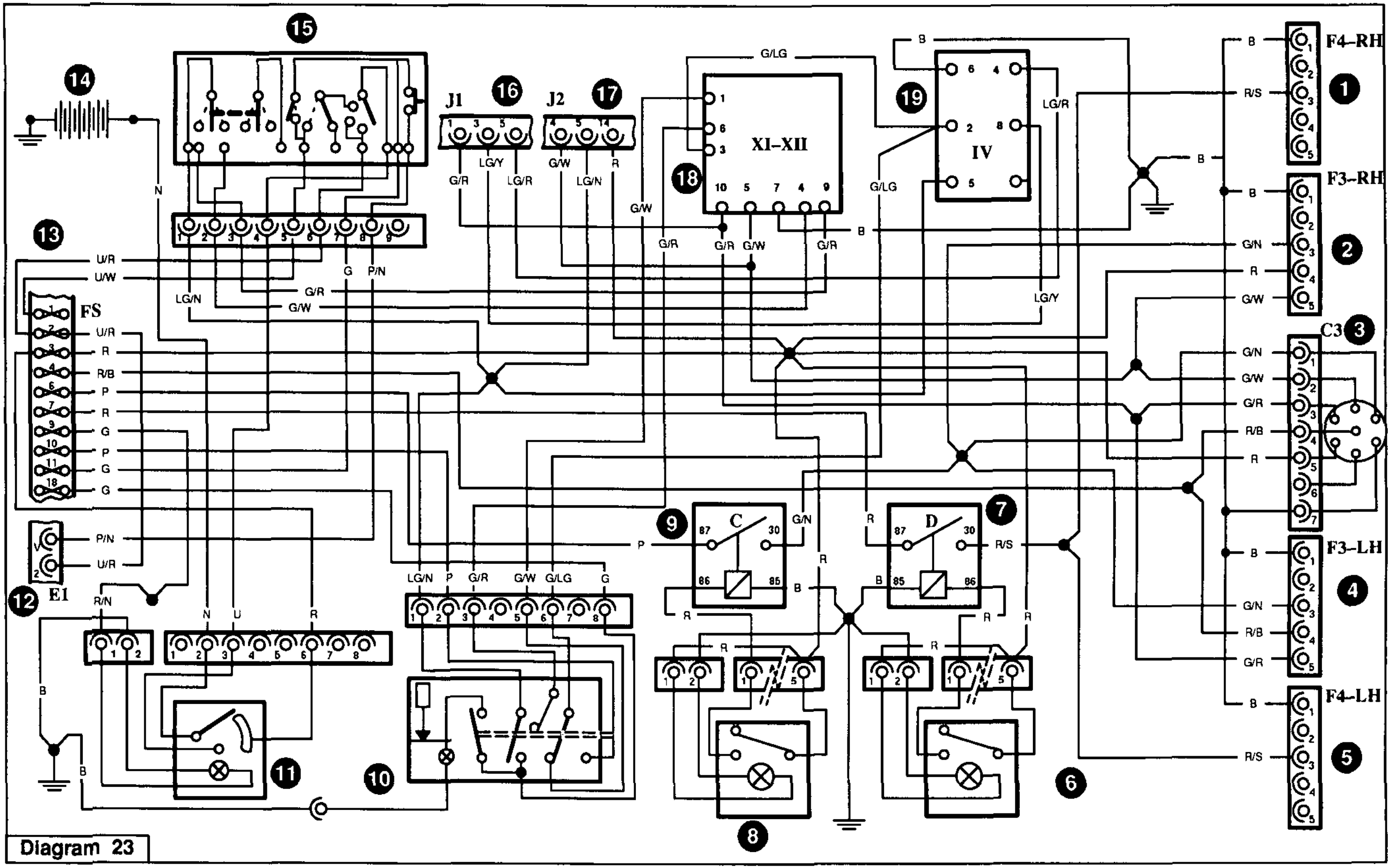


Diagram 23

Diagram 24
Main Rear Harness – SLE Models less Cab, with AEIC

1. R.H. Fender Connection (F3)
2. L.H. Fender Connection (F3)
3. Trailer Socket Connector
4. Handbrake Switch
5. F.W.D. Relay (G)
6. Diff Lock Relay (A)
7. P.T.O. Module
8. P.T.O. Speed Switch
9. Front P.T.O. Clutch
10. Diagnostic Plug Connector
11. Engine Harness Connector (E1)
12. Fuse Panel (FS)
13. L.H. Stop Lamp Switch
14. R.H. Stop Lamp Switch
15. FWD Supply
16. Instrument Harness Connector (J1)
17. Instrument Harness Connector (J2)
18. Extension Harness Connector (C1)
19. Microcomputer Connector (E3)
20. R.H. Console Harness Connector (H5)

Key To Colours

B – Black	G – Green
N – Brown	LG – *Light Green*
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White

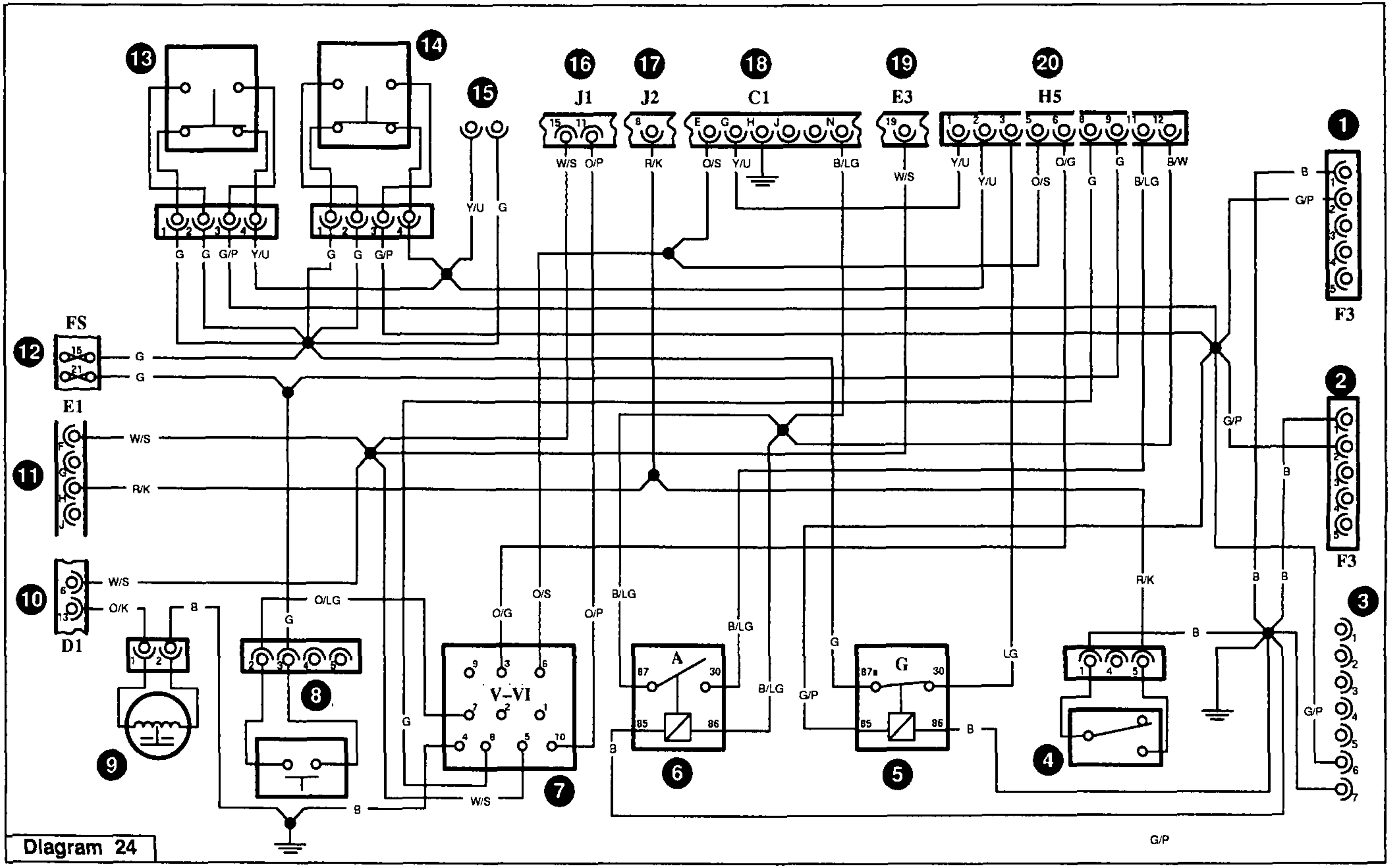

13
14
15
16
J1
17
J2
18
C1
19
E3
20
H5
1
F3
2
F3
3
FS
12
E1
11
D1
10
9
8
7
V-VI
A
6
G
5
4
W/S
O/P
R/K
O/S
Y/U
B/LG
G
G/P
O/G
B/W
B
LG
O/LG
O/K

Diagram 24

Diagram 25
Main Rear Harness Interconnections – SLE Models less Cab, with AEIC

1. Microprocessor Connector
2. Diagnostics Plug
3. E.D.C. Extension Harness Connector
4. E.D.C. Chassis Connector
5. R.H. Console Connector
6. Instrument Harness Connector
7. Instrument Harness Connector
8. Engine Harness Connector
9. Extension Harness Connector
10. Fuel Tank Changeover Connector

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White

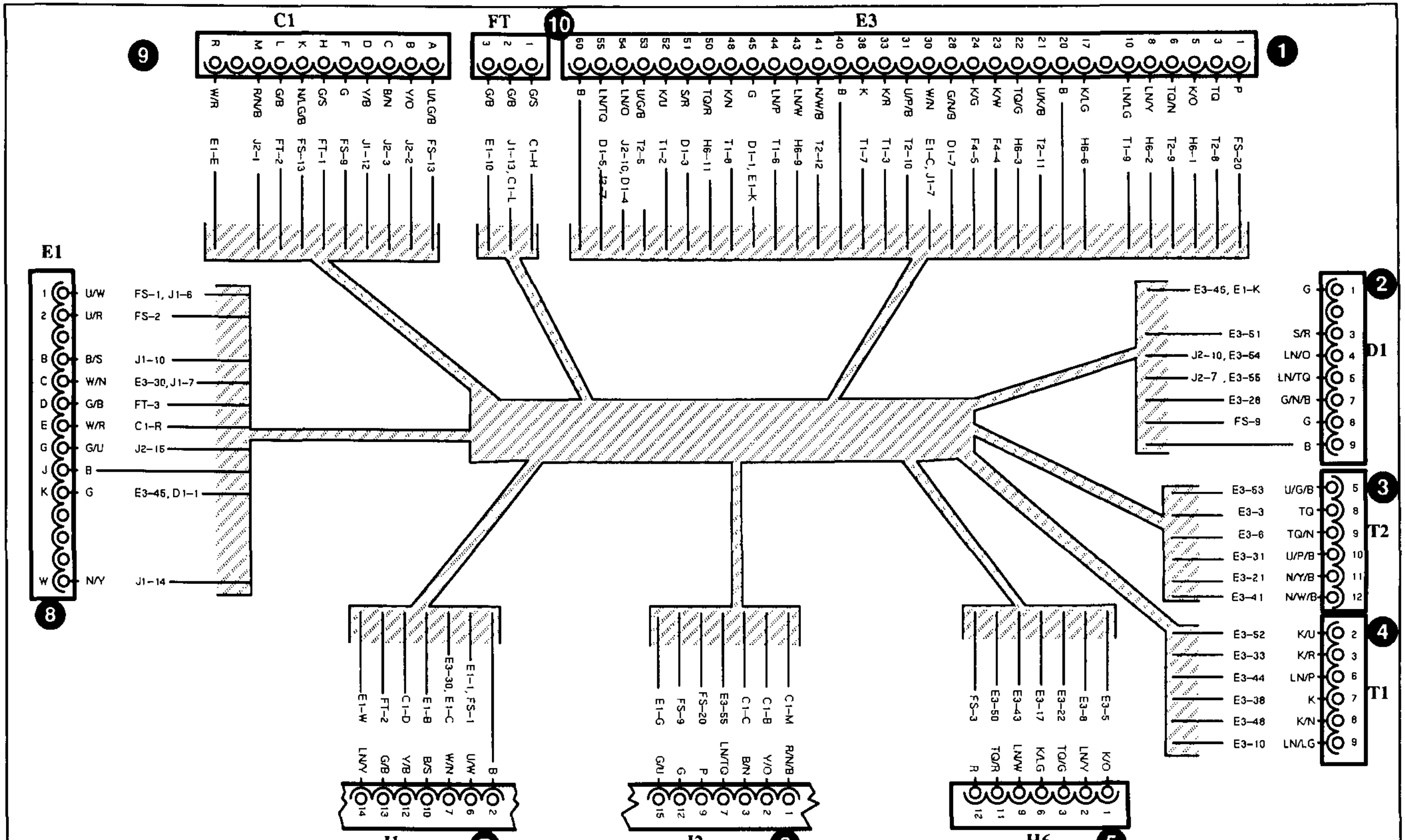

C1
FT
E3
E1
D1
T2
T1
J1
J2
H6
FS-1, J1-6
FS-2
J1-10
E3-30, J1-7
FT-3
C1-R
J2-15
E3-45, D1-1
J1-14
E3-45, E1-K
E3-51
J2-10, E3-54
J2-7 , E3-55
E3-26
FS-9
E3-53
E3-3
E3-6
E3-31
E3-21
E3-41
E3-52
E3-33
E3-44
E3-38
E3-48
E3-10

Diagram 25

Wiring Diagrams 26 to 31
Main Rear Harness
S Models

Diagram 26
Main Rear Harness – S Models

1. Extension Harness Connector (C1)
2. Flasher Unit (IV)
3. Hazard Switch
4. Convertor Module (XII)
5. Worklamp Relay (C)
6. Worklamp Switch
7. Harness Connector (C1)
8. Engine Harness Connector (E1)
9. Fuse Panel (FS)
10. Battery
11. Turn Switch
12. Instrument Connector (J1)
13. Instrument Connector (J2)
14. Main Light Switch

Key To Colours

B	Black	G	Green
N	Brown	LG	Light Green
LN	Tan	U	Blue
S	Slate	TQ	Turquoise
R	Red	P	Purple
O	Orange	K	Pink
Y	Yellow	W	White

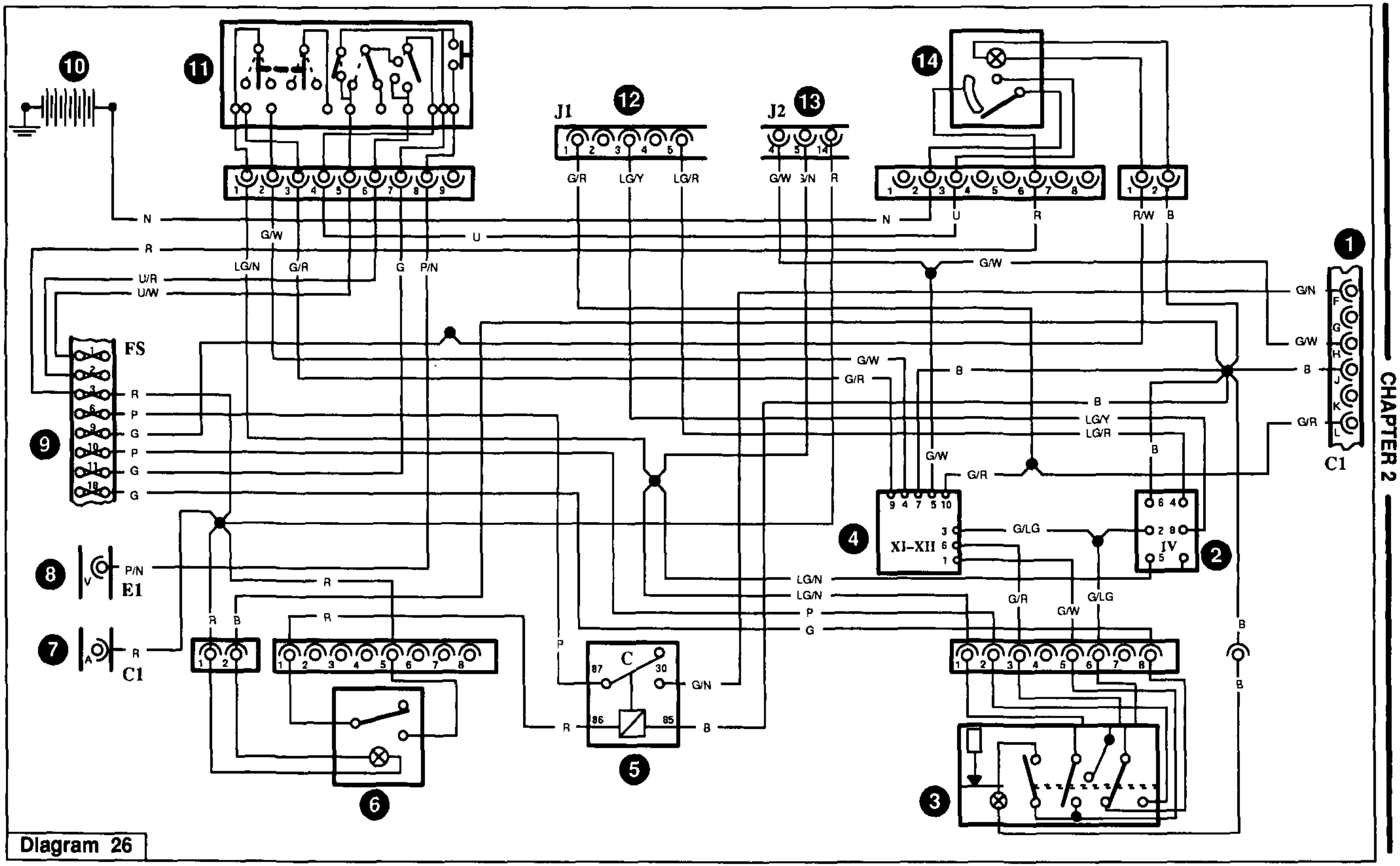


Diagram 26
CHAPTER 2
J1
J2
FS
E1
C1
XI–XII
IV
C

Diagram 27
Main Rear Harness – S Models

1. Harness Connector (C1)
2. Fuel Tank Changeover Connector
3. Dual Power Solenoid
4. Auxiliary Relay (I)
5. Thermostart Relay (III)
6. Harness Connector (E1)
7. Battery Temperature Sensor
8. Fuse Panel (FS)
9. Battery
10. Keystart Switch (KS)
11. F.W.D. Switch
12. Instrument Connector (J1)
13. Instrument Connector (J2)
14. Dual Power Switch

Key To Colours

B	– Black	G	– Green
N	– Brown	LG	– Light Green
LN	– Tan	U	– Blue
S	– Slate	TQ	– Turquoise
R	– Red	P	– Purple
O	– Orange	K	– Pink
Y	– Yellow	W	– White

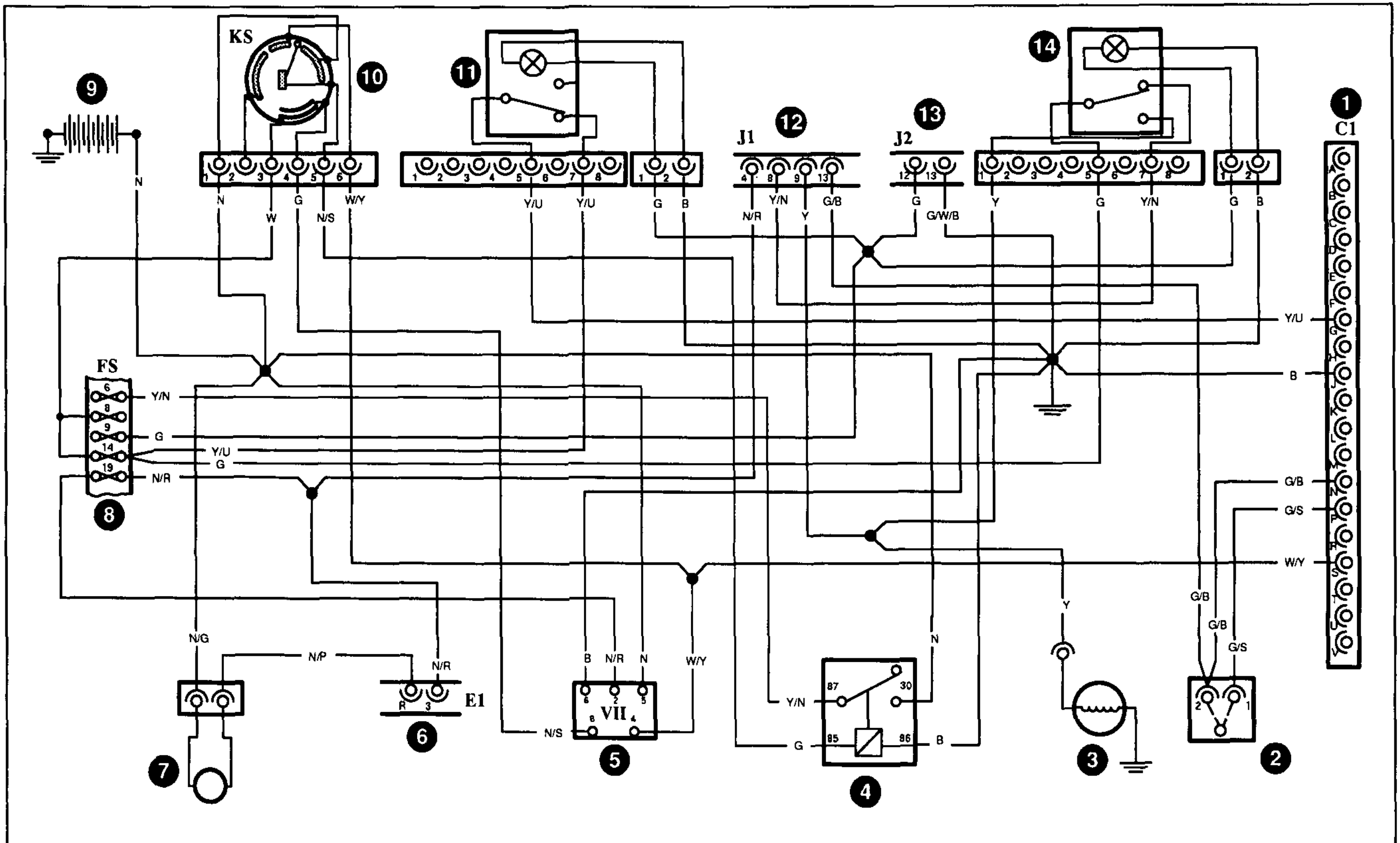

KS
FS
J1
J2
C1
E1
VII
N
W
G
N/S
W/Y
Y/U
B
N/R
Y/N
Y
G/B
G/W/B
N/G
N/P
G/S
A
B
C
D
E
F
G
H
J
K
L
M
N
P
R
S
T
U
V
1
2
3
4
5
6
7
8
9
10
11
12
13
14

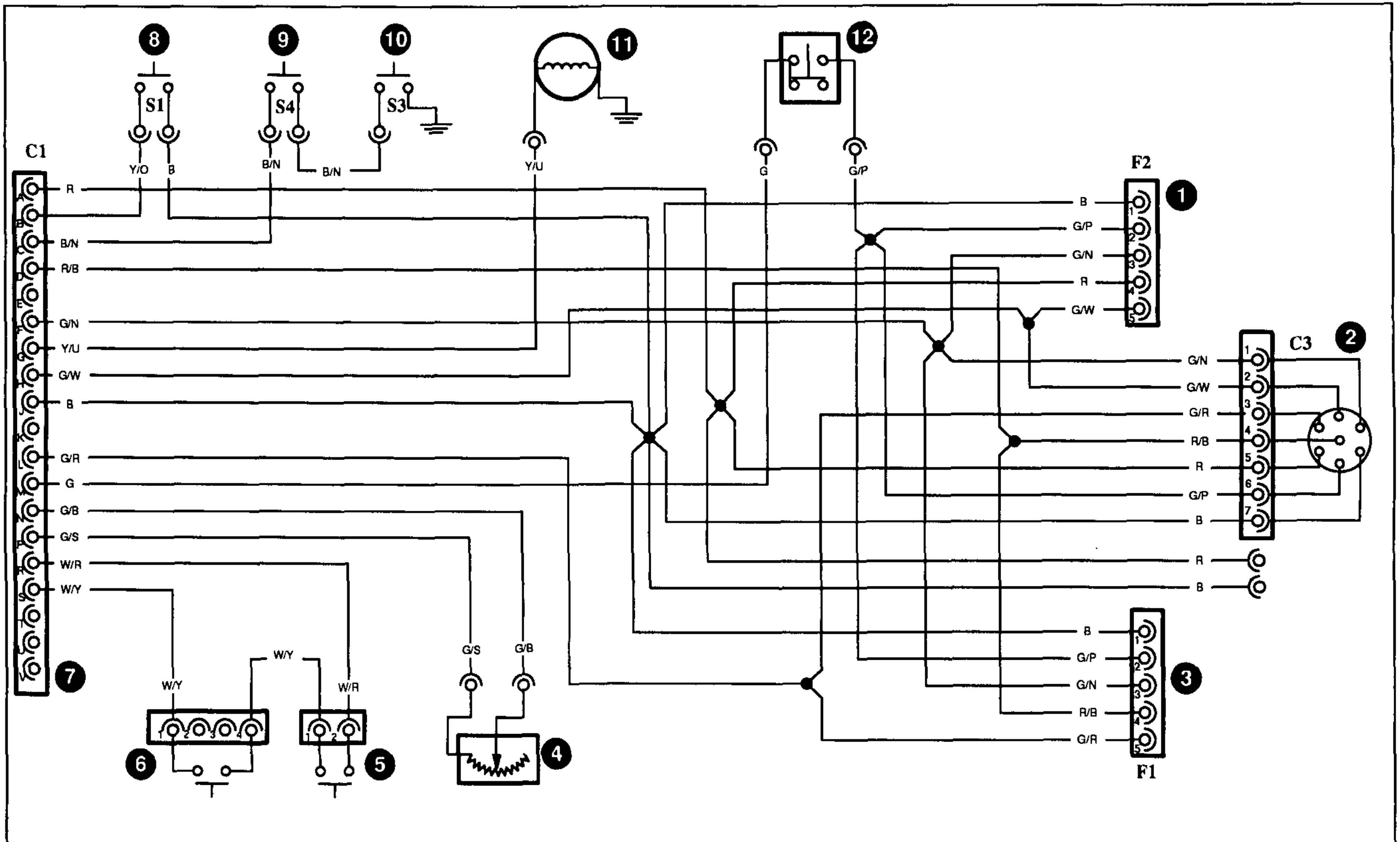
Diagram 27

Diagram 28
Main Rear Harness – S Models

1. R.H. Fender Connector (F2)
2. Trailer Socket (C3)
3. L.H. Fender Connector (F3)
4. Auxiliary Fuel Tank Sender
5. P.T.O. Inhibitor Switch
6. Starter Inhibitor Switch
7. Extension Harness Connector (C1)
8. Transmission Oil Pressure Switch (S1)
9. Transmission Oil Temperature Switch (S4)
10. H.P.L. Filter Switch (S3)
11. F.W.D. Solenoid
12. Stop Lamp Switch

Key To Colours

B	Black	G	Green
N	Brown	LG	Light Green
LN	Tan	U	Blue
S	Slate	TQ	Turquoise
R	Red	P	Purple
O	Orange	K	Pink
Y	Yellow	W	White



C1
S1
S4
S3
Y/O
B
B/N
Y/U
G
G/P
F2
C3
F1
R
R/B
G/N
G/W
G/R
G/B
G/S
W/R
W/Y
1
2
3
4
5
6
7
8
9
10
11
12

Diagram 28

Diagram 29
Main Rear Harness – S Models

1. Harness Connector (F1)
2. Rear Worklamp
3. L.H. Rearlamp
4. L.H. Sidelamp
5. R.H. Sidelamp
6. R.H. Rearlamp
7. Rear Worklamp
8. Harness Connector (F2)

Diagram 30
Main Rear Harness – S Models

1. Rear Worklamp
2. Rear Marker Lamp
3. L.H. Rear Indicator Lamp
4. L.H. Front Indicator Lamp
5. Harness Connector (F1)
6. Harness Connector (F2)
7. R.H. Front Indicator Lamp
8. R.H. Rear Indicator Lamp
9. Rear Worklamp

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White

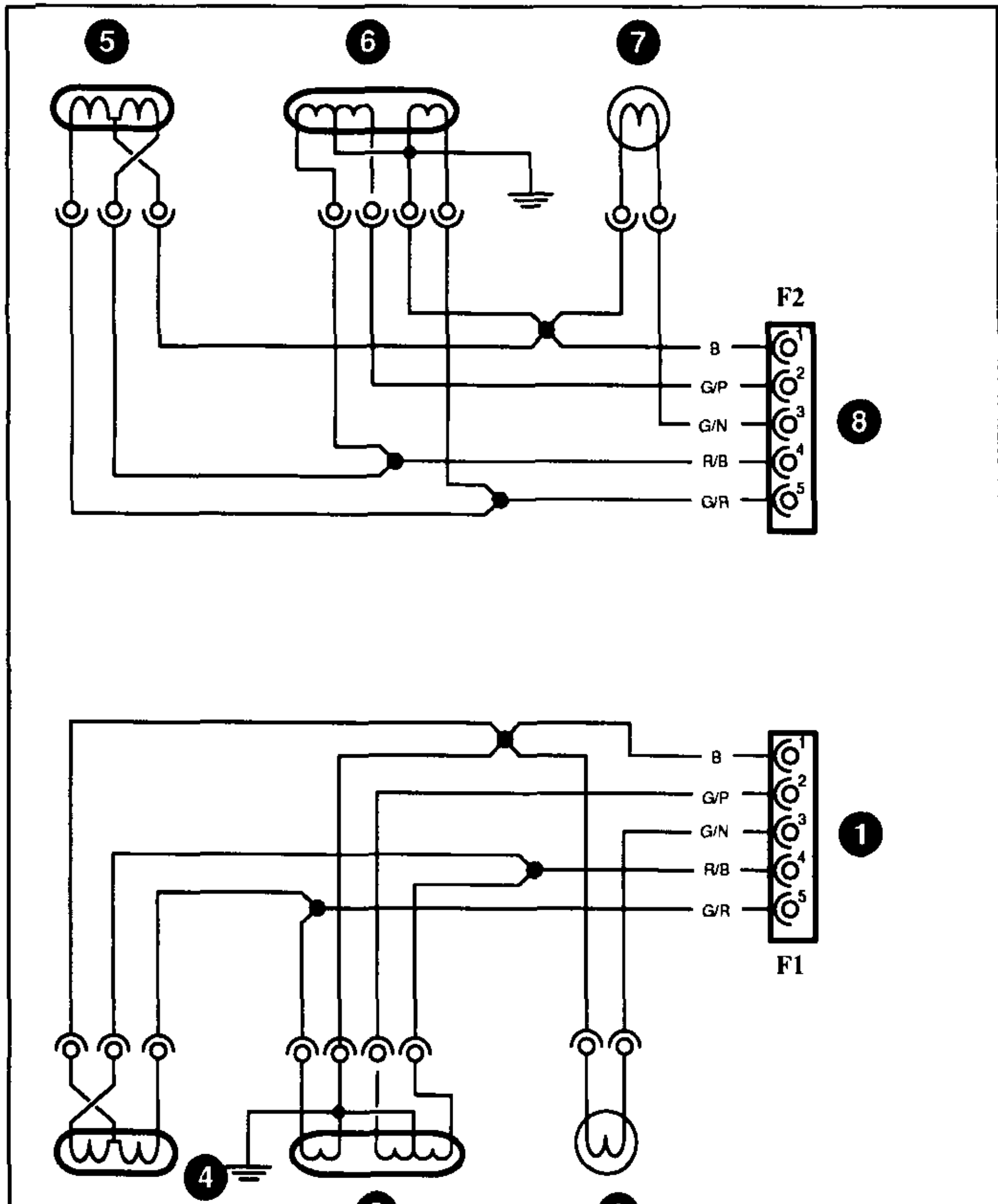


Diagram 29

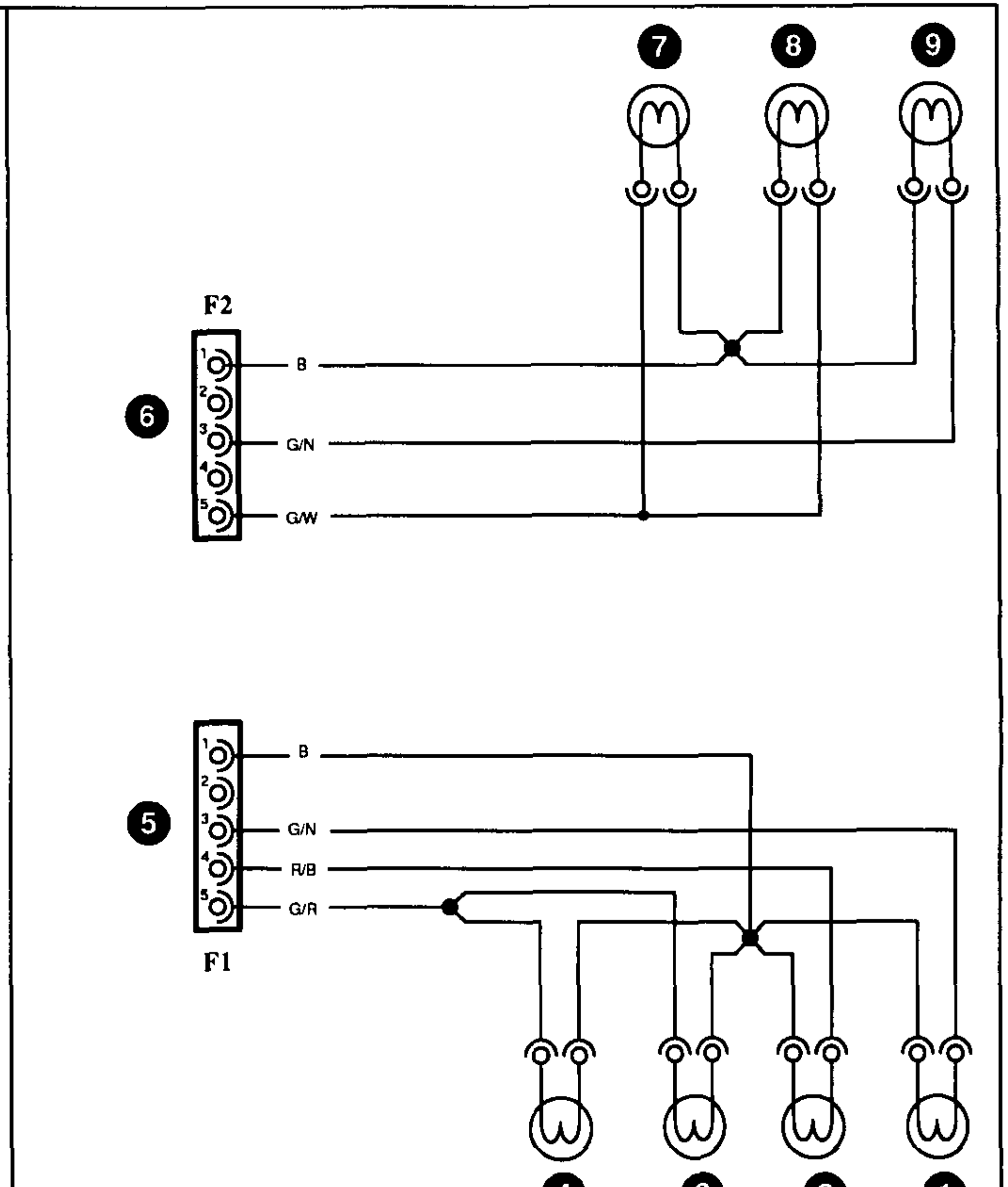
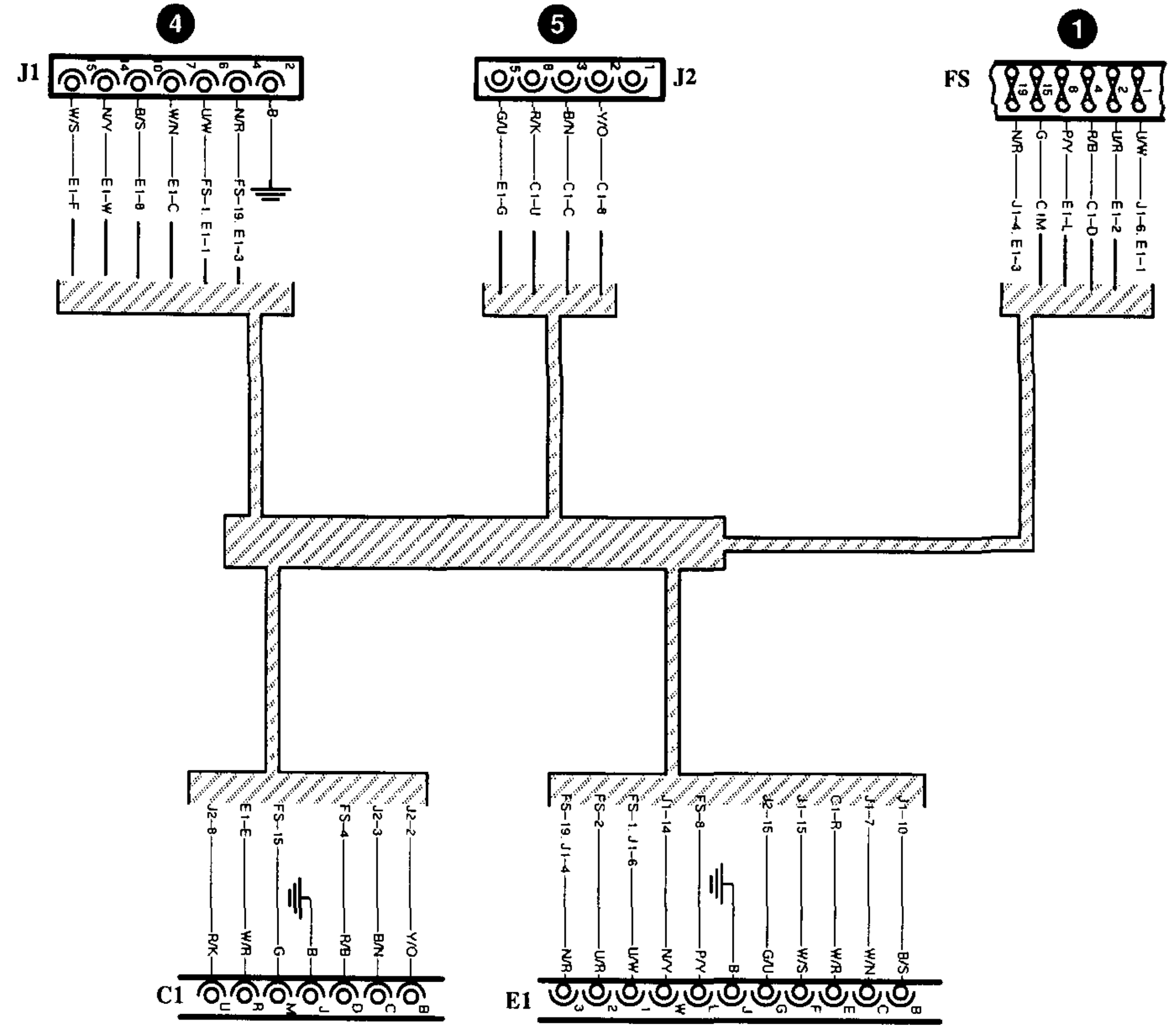


Diagram 30



FS
1 U/W J1-6, E1-1
2 U/R E1-2
4 R/B C1-D
8 P/Y E1-L
15 G C1M
19 N/R J1-4, E1-3
J2
1
2 Y/O C1-8
3 B/N C1-C
8 R/K C1-U
15 G/U E1-G
J1
2 B
4 N/R FS-19, E1-3
6 U/W FS-1, E1-1
7 W/N E1-C
10 B/S E1-8
14 N/Y E1-W
15 W/S E1-F
E1
J1-10 B/S B
J1-7 W/N C
C1-R W/R E
J1-15 W/S F
J2-15 G/U G
B J
FS-8 P/Y L
J1-14 N/Y W
FS-1, J1-6 U/W 1
FS-2 U/R 2
FS-19, J1-4 N/R 3
C1
J2-2 Y/O B
J2-3 B/N C
FS-4 R/B D
B J
FS-15 G M
E1-E W/R R
J2-8 R/K U
1
2
3
4
5

Diagram 31

Index for Diagrams 26–31

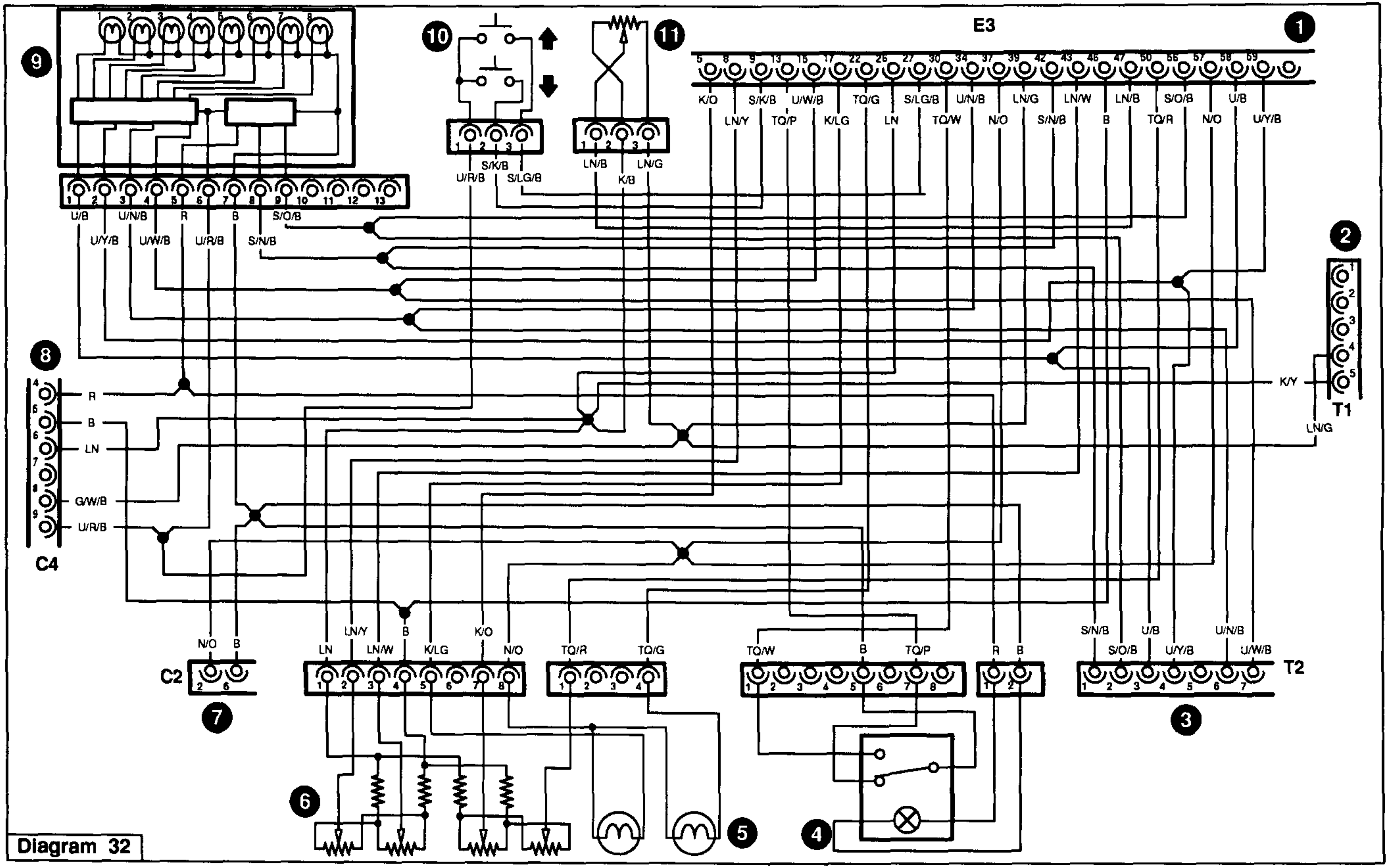
Wiring Diagrams 32 to 34
Extension Harness
SL/SLE with Cab Models, with EDC, EEC IV and 12x12 Transmission

Diagram 32
Extension Harness – SL/SLE Models with Cab, with EDC, EEC IV and 12x12 Transmission

1. Processor Connector (E3)
2. E.D.C Chassis Connector (T1)
3. Extension Harness Connector (T2)
4. Fast Raise/Lower Switch
5. Slip Indicator Lamps
6. E.D.C. Control Panel
7. Transmission E.D.C. Connector (C2)
8. Transmission E.D.C. Connector (C4)
9. Gear Shift Display
10. Gear Shift UP/DOWN Switch
11. Quadrant Lever Potentiometer

Key To Colours

B	Black	G	Green
N	Brown	LG	Light Green
LN	Tan	U	Blue
S	Slate	TQ	Turquoise
R	Red	P	Purple
O	Orange	K	Pink
Y	Yellow	W	White



E3
K/O
S/K/B
U/W/B
TQ/G
S/LG/B
U/N/B
LN/G
LN/W
LN/B
S/O/B
U/B
LN/Y
TQ/P
K/LG
LN
TQ/W
N/O
S/N/B
B
TQ/R
U/Y/B
LN/B
K/B
U/R/B
R
G/W/B
K/Y
T1
C4
C2
T2
Diagram 32

CHAPTER 2

Diagram 33
Extension Harness – SL/SLE Models with Cab, with EDC, EEC IV and 12x12 Transmission

1. Starter Inhibitor Switch
2. Extension Harness Connector (C1)
3. Fuel Tank Sender
4. P.T.O. Solenoid
5. P.A.S. Pressure Switch
6. Oil Pressure Switch
7. Low Charge Switch
8. Speed Sensor
9. Oil Temperature Switch (S5)
10. H.P.L Filter Switch
11. Oil Temperature Switch (S4)
12. Differential Lock Solenoid
13. Differential Lock Switch
14. FWD Solenoid

Key To Colours

B	– Black	G	– Green
N	– Brown	LG	– Light Green
LN	– Tan	U	– Blue
S	– Slate	TQ	– Turquoise
R	– Red	P	– Purple
O	– Orange	K	– Pink
Y	– Yellow	W	– White

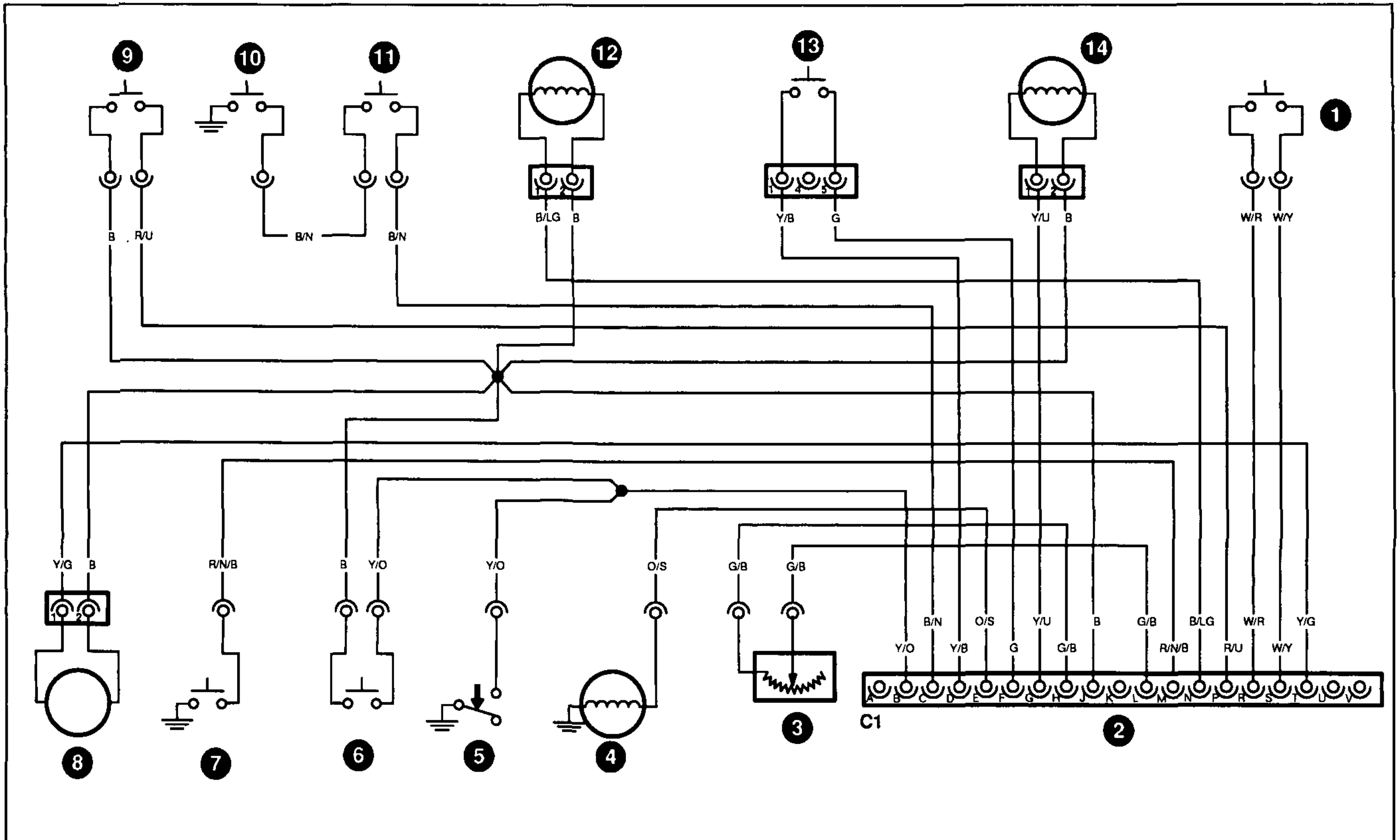

9
10
11
12
13
14
1
B
R/U
B/N
B/N
B/LG
B
Y/B
G
Y/U
B
W/R
W/Y
Y/G
B
R/N/B
B
Y/O
Y/O
O/S
G/B
G/B
B/N
O/S
Y/U
B
G/B
B/LG
W/R
Y/G
Y/O
Y/B
G
G/B
R/N/B
R/U
W/Y
C1
8
7
6
5
4
3
2

Diagram 33

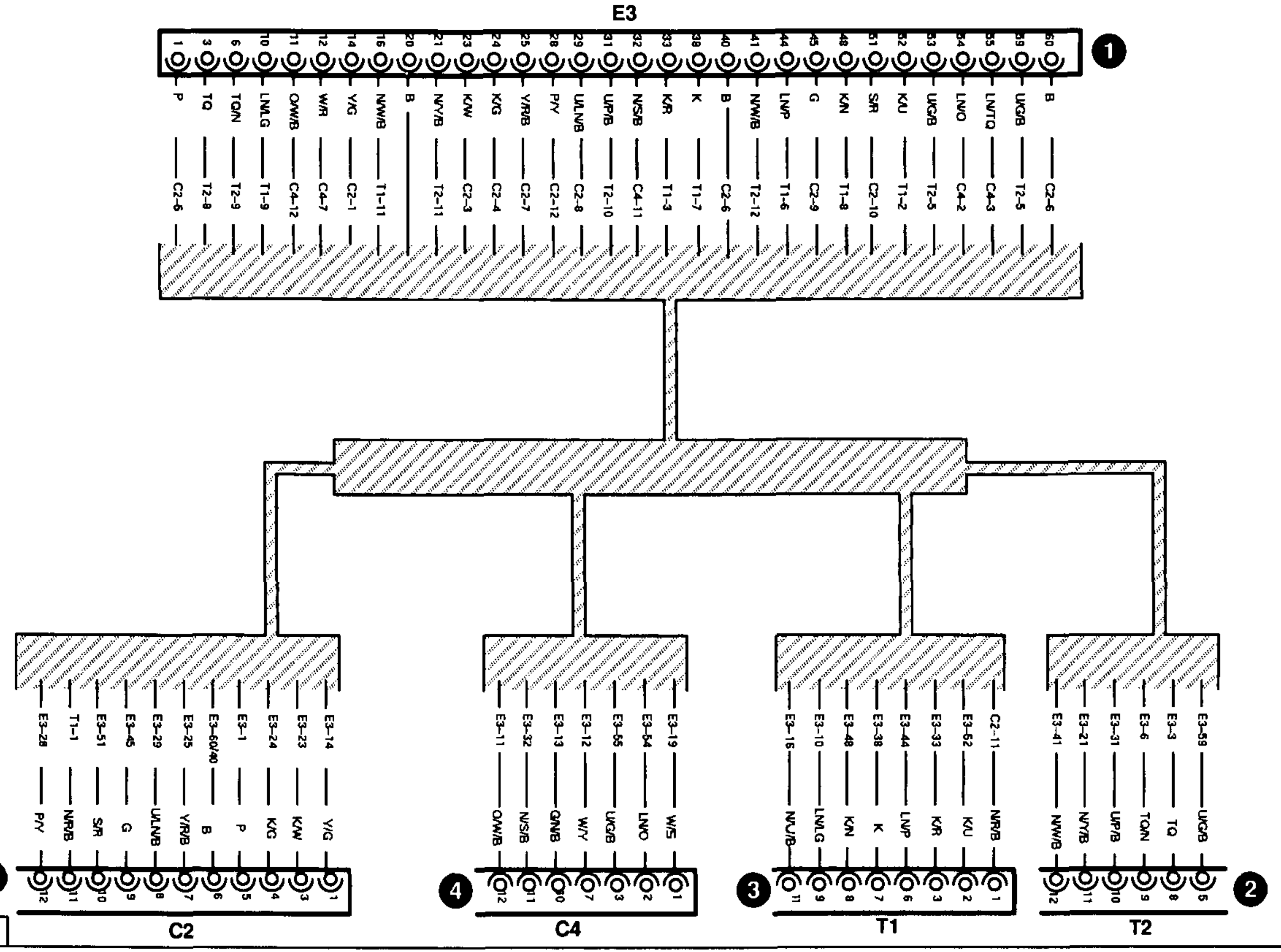


Diagram 34

Wiring Diagrams 35 to 37
Extension Harness
SL/SLE with Cab Models, with EIC/AEIC, EDC, EEC IV and 16x16 Transmission

Diagram 35
Extension Harness – SL/SLE with Cab Models, with EIC/AEIC, EDC, EEC IV and 16x16 Transmission

1. Processor Connector (E3)
2. E.D.C Chassis Connector (T1)
3. Extension Harness Connector (T2)
4. Fast Raise/Lower Switch
5. Slip Indicator Lamps
6. E.D.C. Control Panel
7. Transmission E.D.C. Connector (C2)
8. Transmission E.D.C. Connector (C4)
9. Gear Shift Display
10. Gear Shift UP/DOWN Switch
11. Quadrant Lever Potentiometer

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White

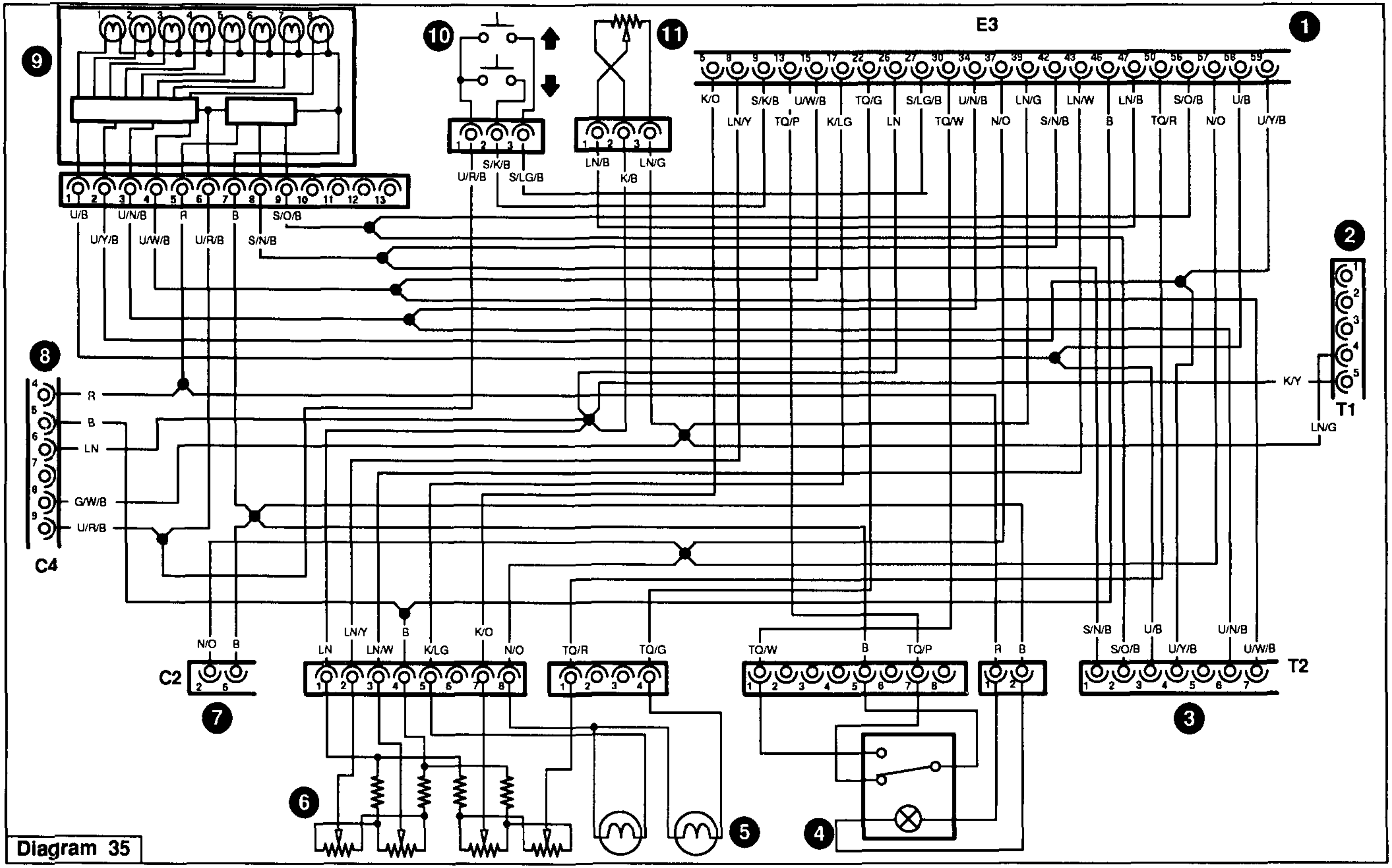

E3
K/O
S/K/B
U/W/B
TQ/G
S/LG/B
U/N/B
LN/G
LN/W
LN/B
S/O/B
U/B
LN/Y
TQ/P
K/LG
LN
TQ/W
N/O
S/N/B
B
TQ/R
U/Y/B
U/R/B
S/LG/B
LN/B
K/B
LN/G
R
U/N/B
U/Y/B
U/W/B
U/R/B
S/N/B
C4
R
LN
G/W/B
K/Y
T1
T2
C2
N/O
LN/Y
LN/W
K/LG
K/O
TQ/R
TQ/G
TQ/W
TQ/P
S/N/B
U/B
U/N/B
U/W/B

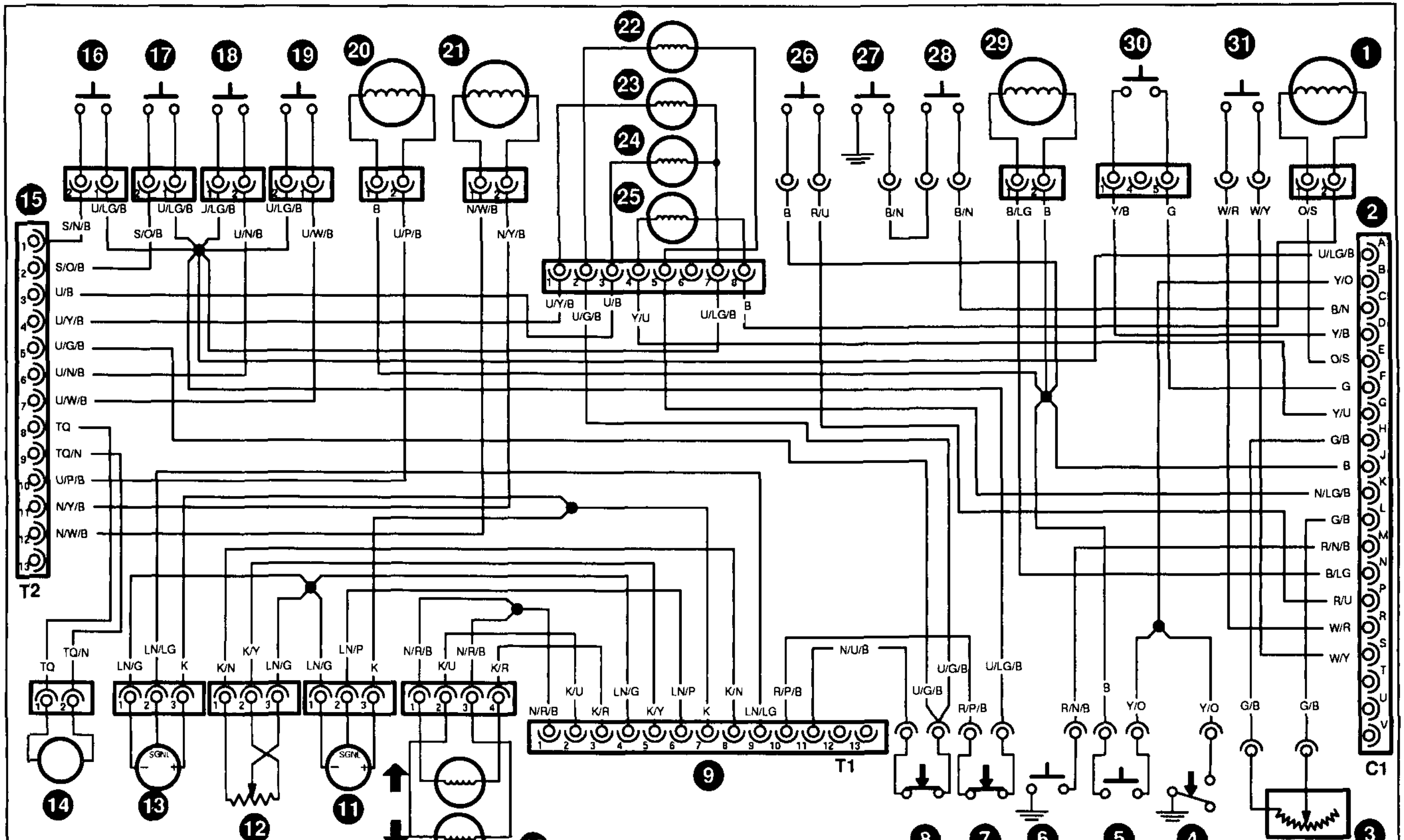
Diagram 35

Diagram 36
Extension Harness – SL/SLE with Cab Models, with EIC/AEIC, EDC, EEC IV and 16x16 Transmission

1. P.T.O. Solenoid
2. Extension Harness Connector (C1)
3. Fuel Tank Sender
4. P.A.S. Pressure Switch
5. Oil Pressure Switch
6. Low Charge Switch
7. Dual Power Pressure Switch
8. Main Clutch Pressure Switch
9. Chassis Harness Connector (T1)
10. EDC Valves
11. R.H. Draft Pin
12. Rockershaft Potentiometer
13. L.H. Draft Pin
14. Speed Sensor
15. Extension Harness Connector (T2)
16. Hi Range Switch
17. Lo Range Switch
18. Range Switch (1–4)
19. Range Switch (5–8)
20. Creeper Solenoid
21. Feathering Solenoid
22. Trans. Dump Solenoid
23. Main Clutch Solenoid (C3 & C4)
24. Front Clutch Solenoid (C1 & C2)
25. FWD Solenoid
26. Oil Temperature Switch (S5)
27. H.P.L Filter Switch (S3)
28. Oil Temperature Switch (S4)
29. Differential Lock Solenoid
30. Differential Lock Switch
31. Starter Inhibitor Switch

Key To Colours

B	Black	G	Green
N	Brown	LG	Light Green
LN	Tan	U	Blue
S	Slate	TQ	Turquoise
R	Red	P	Purple
O	Orange	K	Pink
Y	Yellow	W	White



T2
C1
T1
S/N/B
S/O/B
U/B
U/Y/B
U/G/B
U/N/B
U/W/B
TQ
TQ/N
U/P/B
N/Y/B
N/W/B
U/LG/B
J/LG/B
B
N/W/B
U/Y/B
U/G/B
Y/U
U/LG/B
B/R/U
B/N
B/LG
Y/B
G
W/R
W/Y
O/S
U/LG/B
Y/O
B/N
Y/B
O/S
G
Y/U
G/B
B
N/LG/B
G/B
R/N/B
B/LG
R/U
W/R
W/Y
LN/G
LN/LG
K
K/N
K/Y
LN/G
LN/P
N/R/B
K/U
K/R
N/U/B
R/P/B
U/G/B
U/LG/B
K/U
LN/G
LN/P
K/N
N/R/B
K/R
K/Y
K
LN/LG
R/N/B
Y/O
SGNL

Diagram 36

Diagram 37
Extension Harness Interconnections – SL/SLE with Cab Models, with EIC/AEIC, EDC, EEC IV and 16x16 Transmission

1. Processor Connector (E3)
2. EEC IV Extension Harness Connector (T2)
3. E.D.C Chassis Connector (T1)
4. Transmission E.D.C. Connector (C2)
5. Transmission/E.D.C. Connector (C4)

Key To Colours

B	– Black	G	– Green
N	– Brown	LG	– Light Green
LN	– Tan	U	– Blue
S	– Slate	TQ	– Turquoise
R	– Red	P	– Purple
O	– Orange	K	– Pink
Y	– Yellow	W	– White

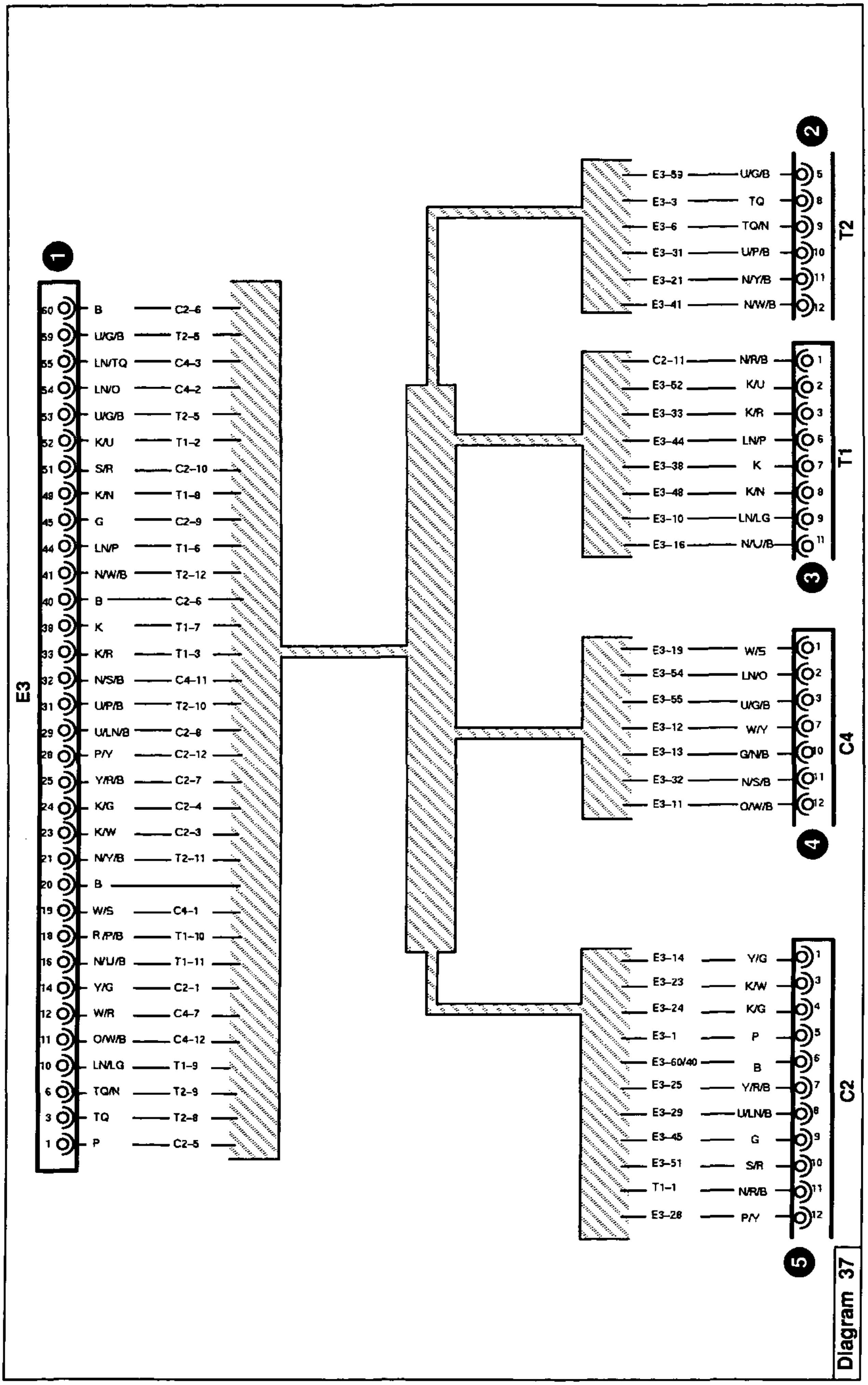

1
E3
60 B C2-6
59 U/G/B T2-5
55 LN/TQ C4-3
54 LN/O C4-2
53 U/G/B T2-5
52 K/U T1-2
51 S/R C2-10
48 K/N T1-8
45 G C2-9
44 LN/P T1-6
41 N/W/B T2-12
40 B C2-6
38 K T1-7
33 K/R T1-3
32 N/S/B C4-11
31 U/P/B T2-10
29 U/LN/B C2-8
28 P/Y C2-12
25 Y/R/B C2-7
24 K/G C2-4
23 K/W C2-3
21 N/Y/B T2-11
20 B
19 W/S C4-1
18 R/P/B T1-10
16 N/U/B T1-11
14 Y/G C2-1
12 W/R C4-7
11 O/W/B C4-12
10 LN/LG T1-9
6 TQ/N T2-9
3 TQ T2-8
1 P C2-5
2
T2
E3-53 U/G/B 5
E3-3 TQ 8
E3-6 TQ/N 9
E3-31 U/P/B 10
E3-21 N/Y/B 11
E3-41 N/W/B 12
T1
C2-11 N/R/B 1
E3-52 K/U 2
E3-33 K/R 3
E3-44 LN/P 6
E3-38 K 7
E3-48 K/N 8
E3-10 LN/LG 9
E3-16 N/U/B 11
3
C4
E3-19 W/S 1
E3-54 LN/O 2
E3-55 U/G/B 3
E3-12 W/Y 7
E3-13 G/N/B 10
E3-32 N/S/B 11
E3-11 O/W/B 12
4
C2
E3-14 Y/G 1
E3-23 K/W 3
E3-24 K/G 4
E3-1 P 5
E3-60/40 B 6
E3-25 Y/R/B 7
E3-29 U/LN/B 8
E3-45 G 9
E3-51 S/R 10
T1-1 N/R/B 11
E3-28 P/Y 12
5

Diagram 37

Index for Diagrams 35–37

Wiring Diagrams 38 to 39
Extension Harness – SL/SLE Less Cab Models, with EIC, less EEC IV, with 12x12 Transmission

Diagram 38
Extension Harness – SL/SLE Less Cab Models, with EIC, less EEC IV, with 12x12 Transmission

1. E.D.C. Control Panel
2. Console Harness Connector, Right Hand (H6)
3. Console Harness Connector, Right Hand (H7)
4. Differential Lock Switch
5. F.W.D. Switch
6. P.T.O. Switch
7. Slip Indicator Lamps

Key To Colours

B	– Black	G	– Green
N	– Brown	LG	– Light Green
LN	– Tan	U	– Blue
S	– Slate	TQ	– Turquoise
R	– Red	P	– Purple
O	– Orange	K	– Pink
Y	– Yellow	W	– White

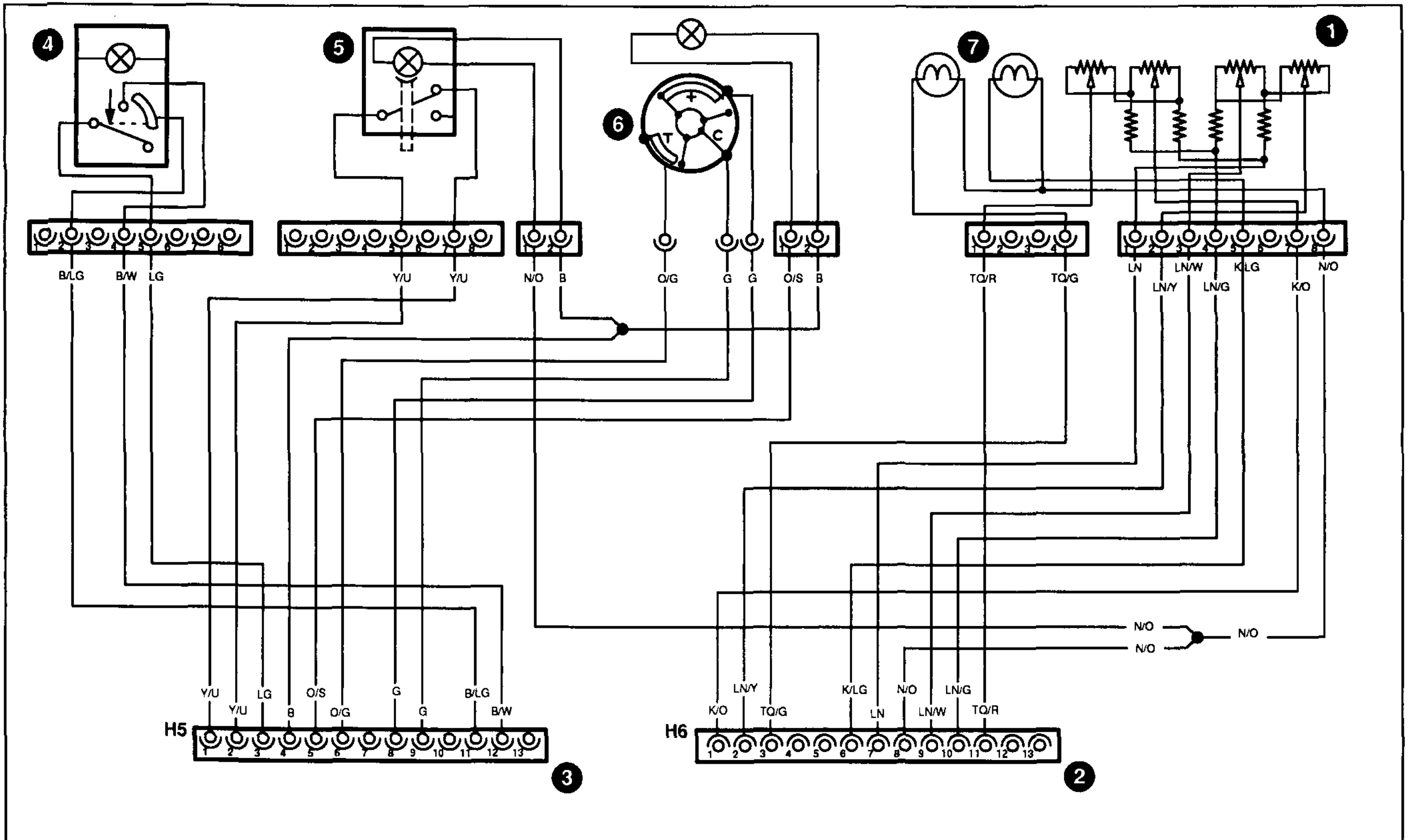

4
5
6
7
1
B/LG
B/W
LG
Y/U
Y/U
N/O
B
O/G
G
G
O/S
B
TQ/R
TQ/G
LN
LN/Y
LN/W
LN/G
K/LG
K/O
N/O
N/O
N/O
N/O
Y/U
Y/U
LG
B
O/S
O/G
G
G
B/LG
B/W
H5
K/O
LN/Y
TQ/G
K/LG
LN
N/O
LN/W
LN/G
TQ/R
H6
3
2

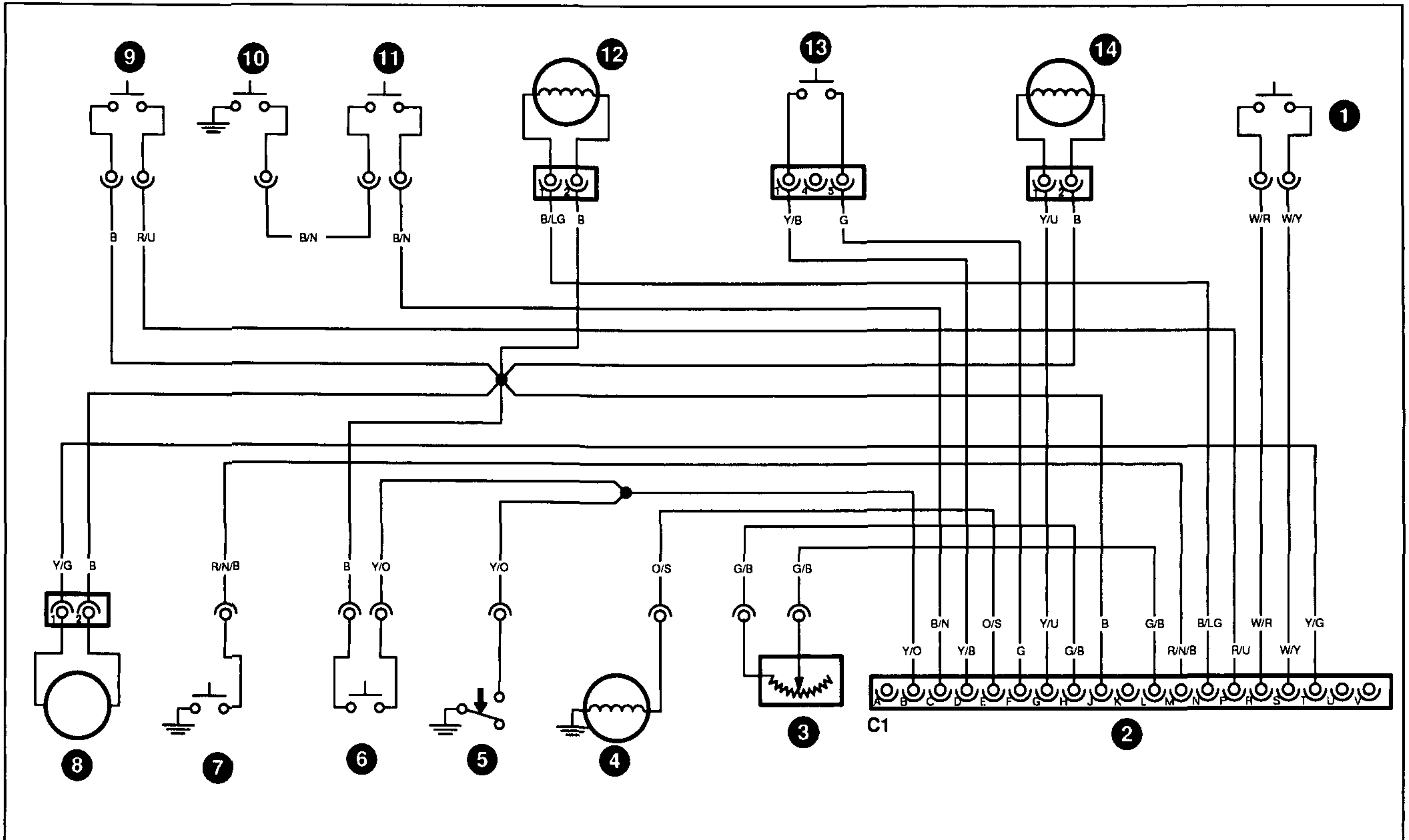
Diagram 38

Diagram 39
Extension Harness – SL/SLE Less Cab Models, with EIC, less EEC IV, with 12x12 Transmission

1. Starter Inhibitor Switch
2. Extension Harness Connector (C1)
3. Fuel Tank Sender
4. P.T.O. Solenoid
5. P.A.S. Pressure Switch
6. Oil Pressure Switch
7. Low Charge Switch
8. Speed Sensor
9. Oil Temperature Switch (S5)
10. H.P.L Filter Switch
11. Oil Temperature Switch (S4)
12. Differential Lock Solenoid
13. Differential Lock Switch
14. FWD Solenoid

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White



B
R/U
B/N
B/N
B/LG
B
Y/B
G
Y/U
B
W/R
W/Y
Y/G
B
R/N/B
B
Y/O
Y/O
O/S
G/B
G/B
B/N
O/S
Y/U
B
G/B
B/LG
W/R
Y/G
Y/O
Y/B
G
G/B
R/N/B
R/U
W/Y
A B C D E F G H J K L M N P R S T U V
C1

Diagram 39

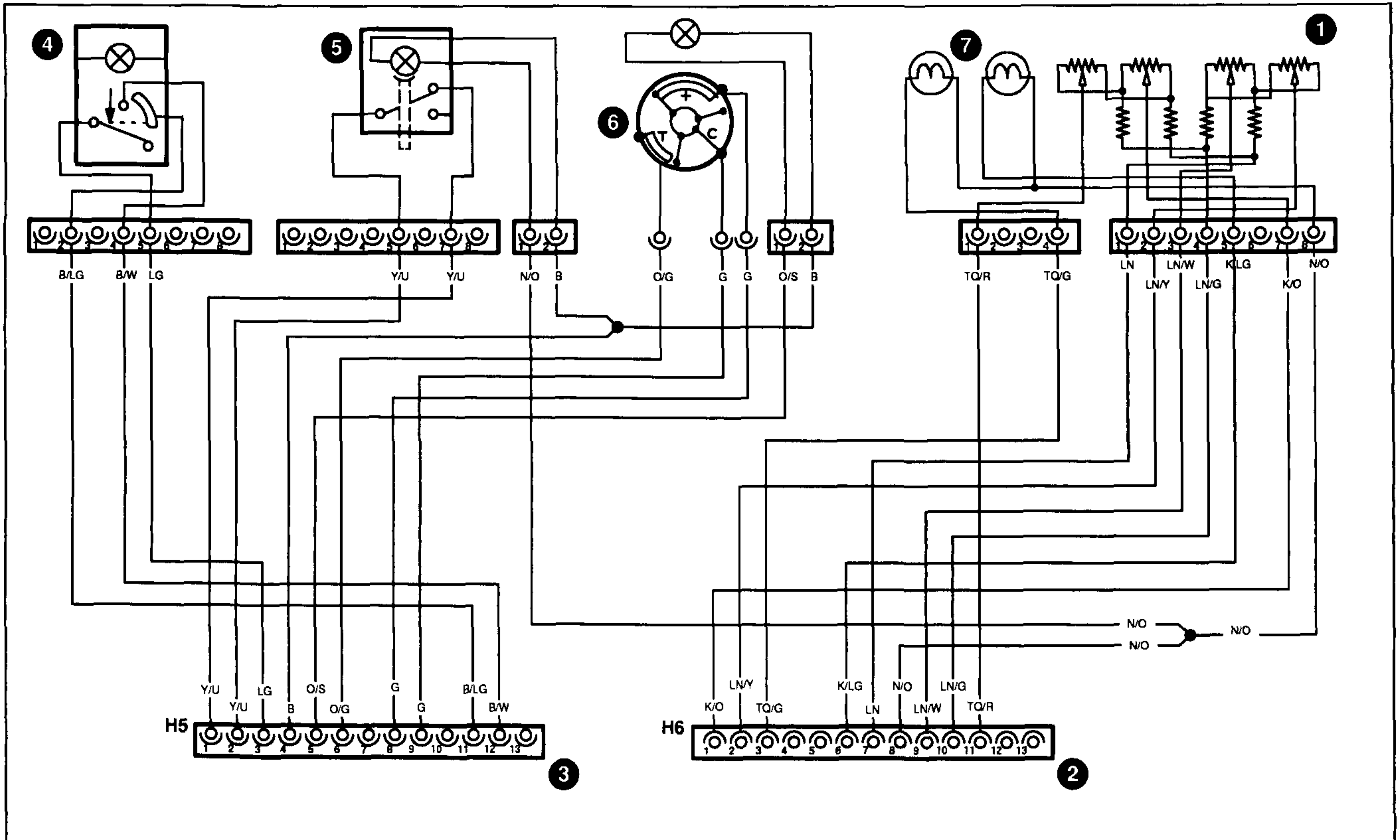
Wiring Diagrams 40 to 41
Extension Harness
SL/SLE less Cab Models, with EIC/AEIC, EDC, EEC IV and 16x16 Transmission

Diagram 40
Extension Harness – SL/SLE less Cab Models, with EIC/AEIC, EDC, EEC IV and 16x16 Transmission

1. E.D.C. Control Panel
2. Console Harness Connector, Right Hand (H6)
3. Console Harness Connector, Right Hand (H7)
4. Differential Lock Switch
5. F.W.D. Switch
6. P.T.O. Switch
7. Slip Indicator Lamps

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White



B/LG
B/W
LG
Y/U
Y/U
N/O
B
O/G
G
G
O/S
B
TQ/R
TQ/G
LN
LN/Y
LN/W
LN/G
K/LG
K/O
N/O
N/O
N/O
N/O
H5
H6

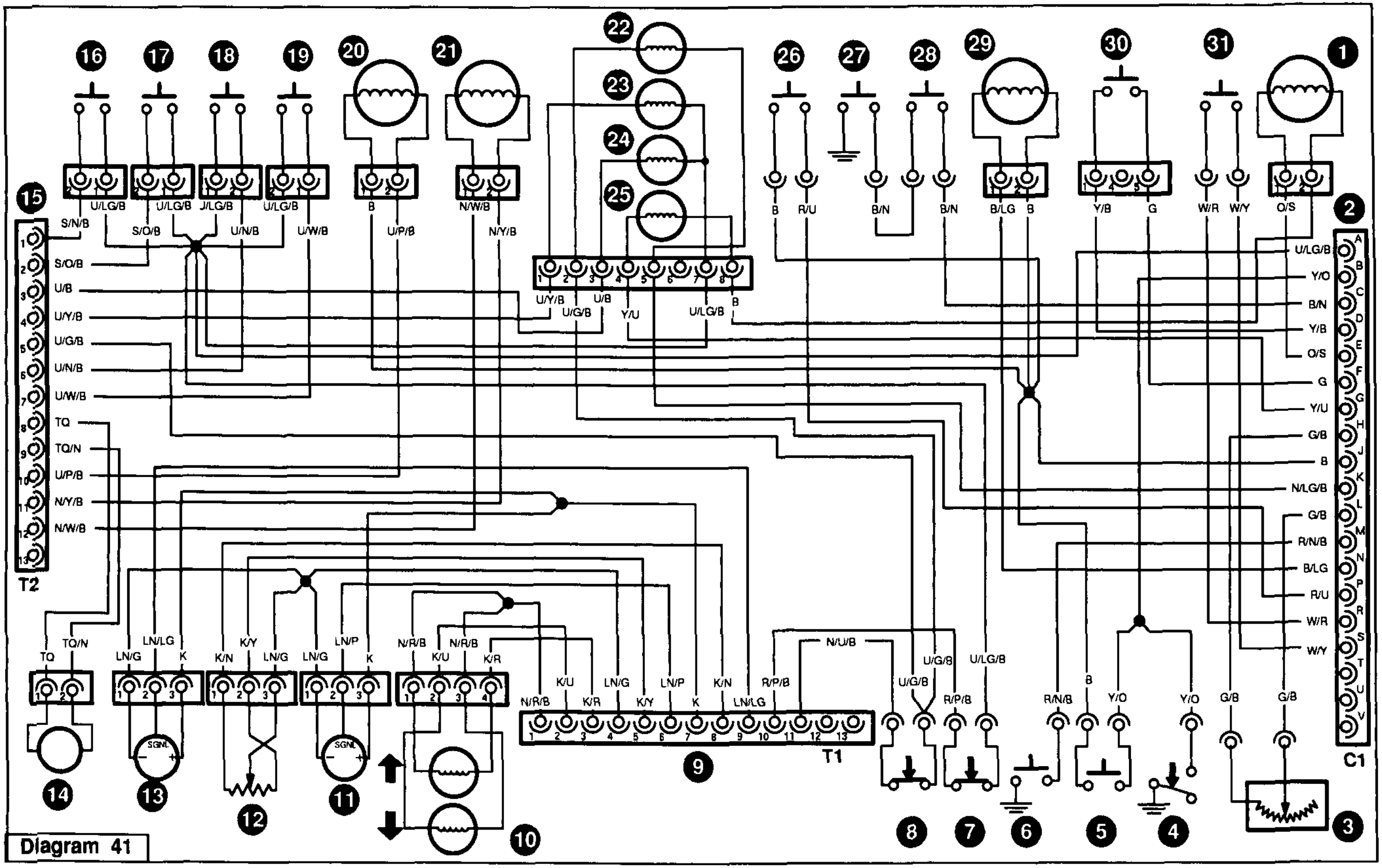
Diagram 40

Diagram 41
Extension Harness – SL/SLE less Cab Models, with EIC/AEIC, EDC, EEC IV and 16x16 Transmission

1. P.T.O. Solenoid
2. Extension Harness Connector (C1)
3. Fuel Tank Sender
4. P.A.S. Pressure Switch
5. Oil Pressure Switch
6. Low Charge Switch
7. Dual Power Pressure Switch
8. Main Clutch Pressure Switch
9. Chassis Harness Connector (T1)
10. EDC Valves
11. R.H. Draft Pin
12. Rockershaft Potentiometer
13. L.H. Draft Pin
14. Speed Sensor
15. Extension Harness Connector (T2)
16. Hi Range Switch
17. Lo Range Switch
18. Range Switch (1–4)
19. Range Switch (5–8)
20. Creeper Solenoid
21. Feathering Solenoid
22. Trans. Dump Solenoid
23. Main Clutch Solenoid (C3 & C4)
24. Front Clutch Solenoid (C1 & C2)
25. FWD Solenoid
26. Oil Temperature Switch (S5)
27. H.P.L Filter Switch (S3)
28. Oil Temperature Switch (S4)
29. Differential Lock Solenoid
30. Differential Lock Switch
31. Starter Inhibitor Switch

Key To Colours

B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White



16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
S/N/B
U/LG/B
S/O/B
J/LG/B
U/N/B
U/W/B
B
U/P/B
N/W/B
N/Y/B
U/Y/B
U/B
U/G/B
Y/U
U/LG/B
B
R/U
B/N
B/LG
Y/B
G
W/R
W/Y
O/S
S/O/B
U/Y/B
U/G/B
U/N/B
U/W/B
TQ
TQ/N
U/P/B
N/Y/B
N/W/B
T2
U/LG/B
Y/O
B/N
Y/B
O/S
G
Y/U
G/B
B
N/LG/B
G/B
R/N/B
B/LG
R/U
W/R
W/Y
C1
LN/LG
LN/G
K
K/N
K/Y
LN/P
N/R/B
K/U
K/R
K/U
LN/G
LN/P
K/N
R/P/B
N/U/B
U/G/B
U/LG/B
R/P/B
R/N/B
Y/O
G/B
K/R
K/Y
K
LN/LG
SGNL
T1

Diagram 41

Index for Diagrams 40–41

Wiring Diagrams 42 to 43
Extension Harness
SL/SLE less Cab Models, with Tandem Pump, with 12x12 Transmission

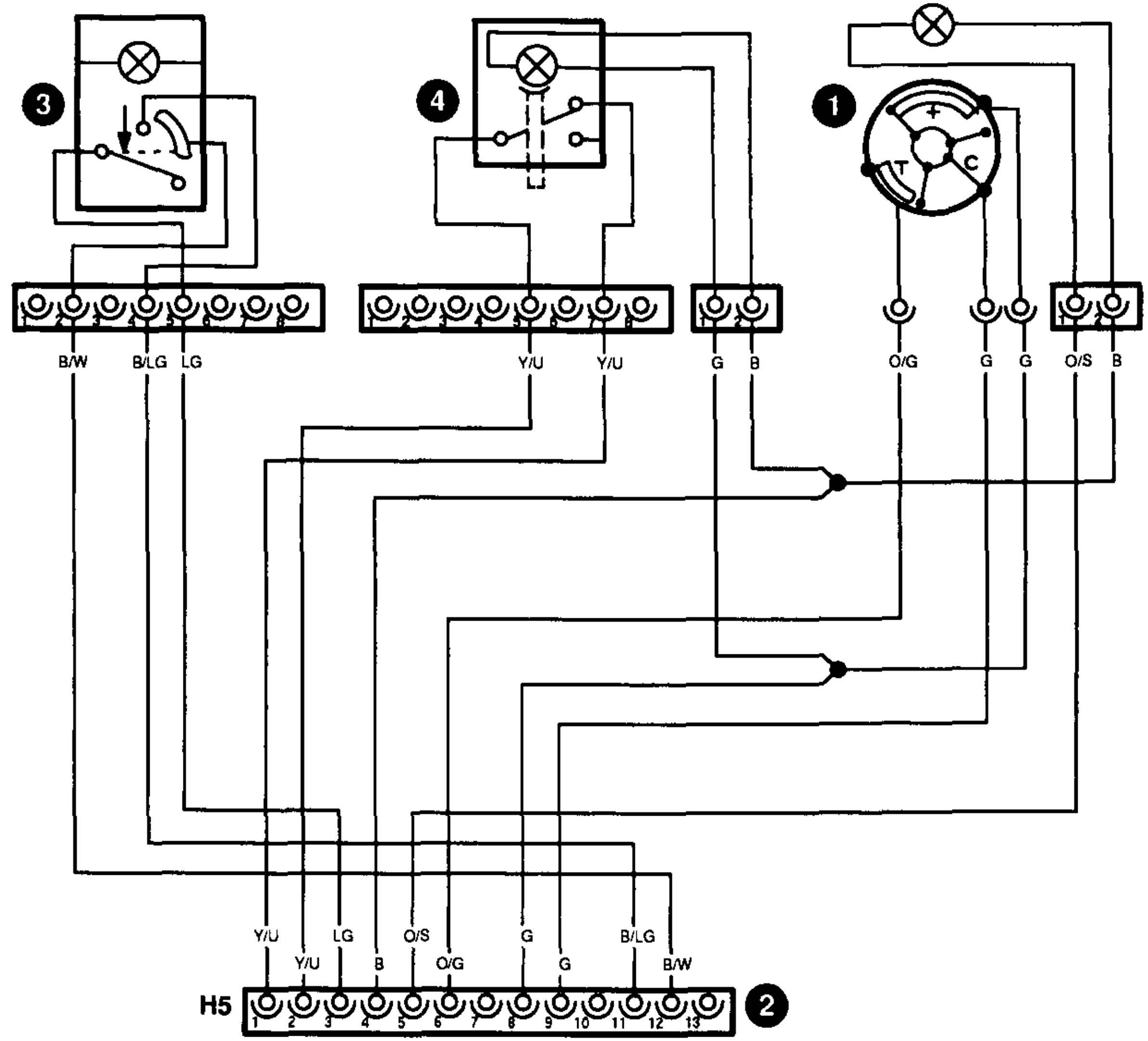


Diagram 42

Diagram 43
Extension Harness – SL/SLE less Cab Models, with Tandem Pump, with 12x12 Transmission

1. Starter Inhibitor Switch
2. Extension Harness Connector (C1)
3. Fuel Tank Sender
4. P.T.O. Solenoid
5. Oil Pressure Switch
6. Speed Sensor
7. Oil Temperature Switch (S5)
8. H.P.L Filter Switch
9. Oil Temperature Switch (S4)
10. Differential Lock Solenoid
11. Differential Lock Switch
12. FWD Solenoid

Key To Colours

B	Black	G	Green
N	Brown	LG	Light Green
LN	Tan	U	Blue
S	Slate	TQ	Turquoise
R	Red	P	Purple
O	Orange	K	Pink
Y	Yellow	W	White

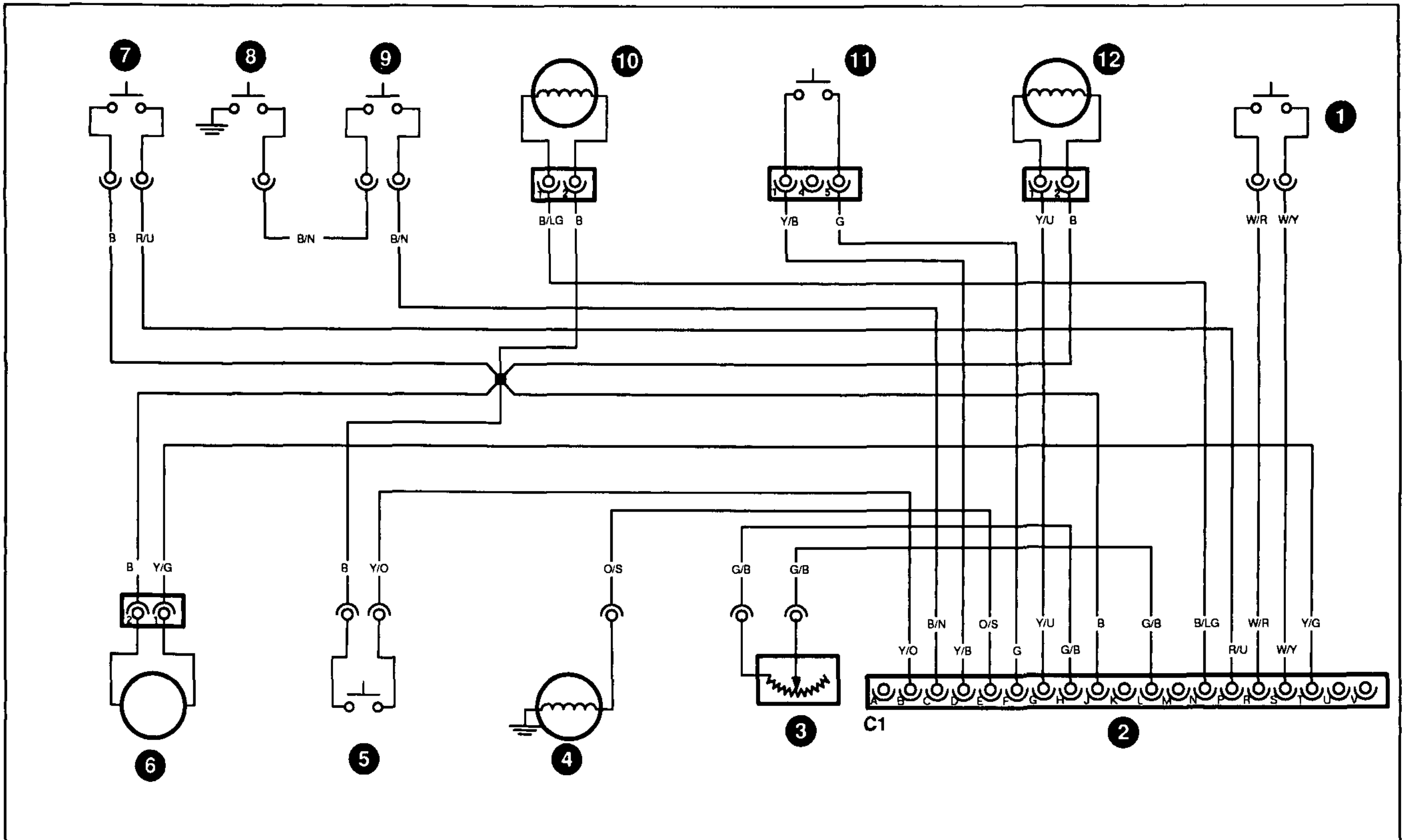

7
8
9
10
11
12
1
B
R/U
B/N
B/N
B/LG
B
Y/B
G
Y/U
B
W/R
W/Y
B
Y/G
B
Y/O
O/S
G/B
G/B
B/N
O/S
Y/U
B
G/B
B/LG
W/R
Y/G
Y/O
Y/B
G
G/B
R/U
W/Y
A B C D E F G H J K L M N P R S T U V
C1
6
5
4
3
2

Diagram 43

Wiring Diagrams 44 to 46

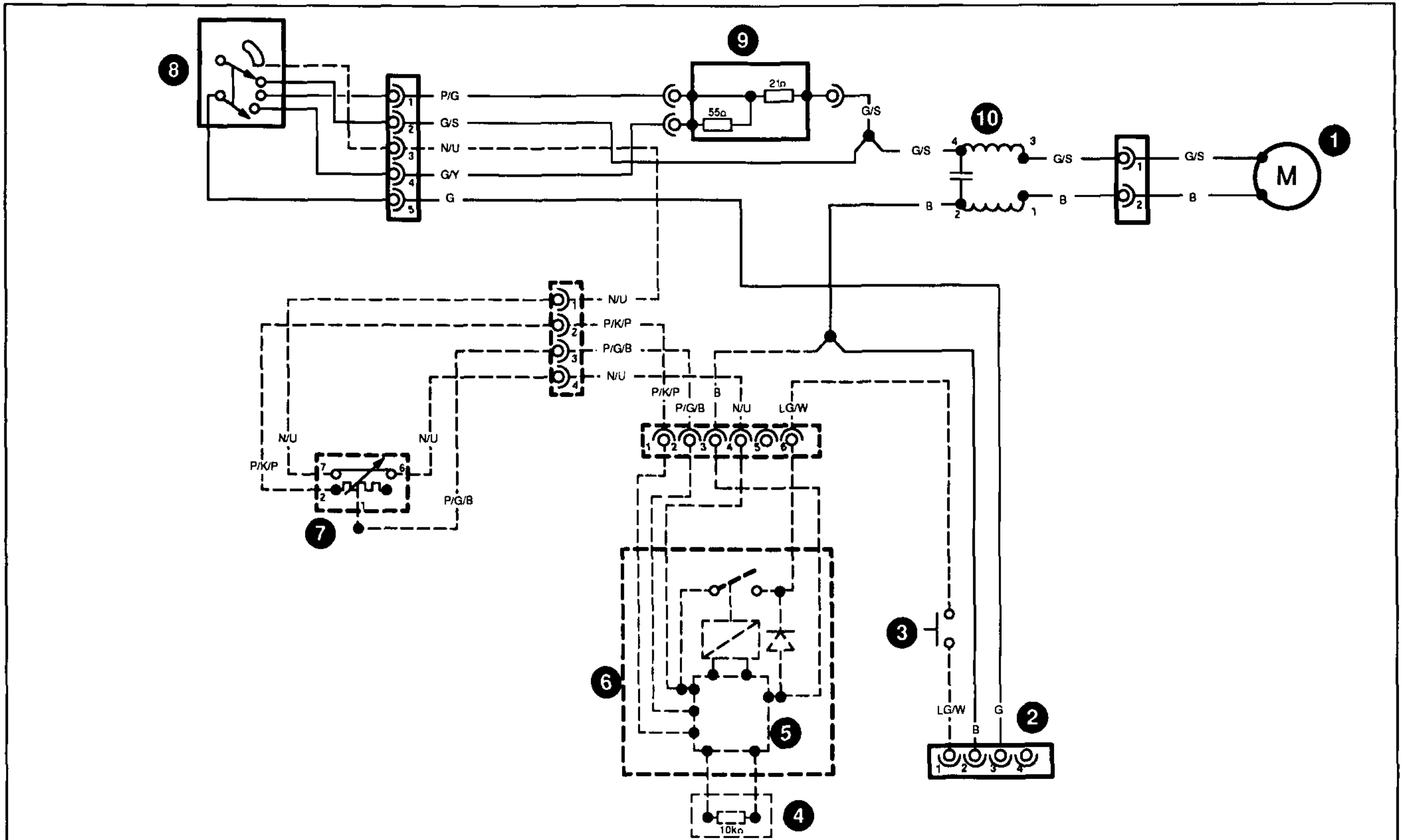

8
9
10
1
P/G
G/S
N/U
G/Y
G
21Ω
55Ω
G/S
G/S
G/S
G/S
B
B
B
M
N/U
P/K/P
P/G/B
N/U
P/K/P
P/G/B
B
N/U
LG/W
N/U
N/U
P/K/P
P/G/B
7
6
5
4
10kΩ
3
2
LG/W
B
G

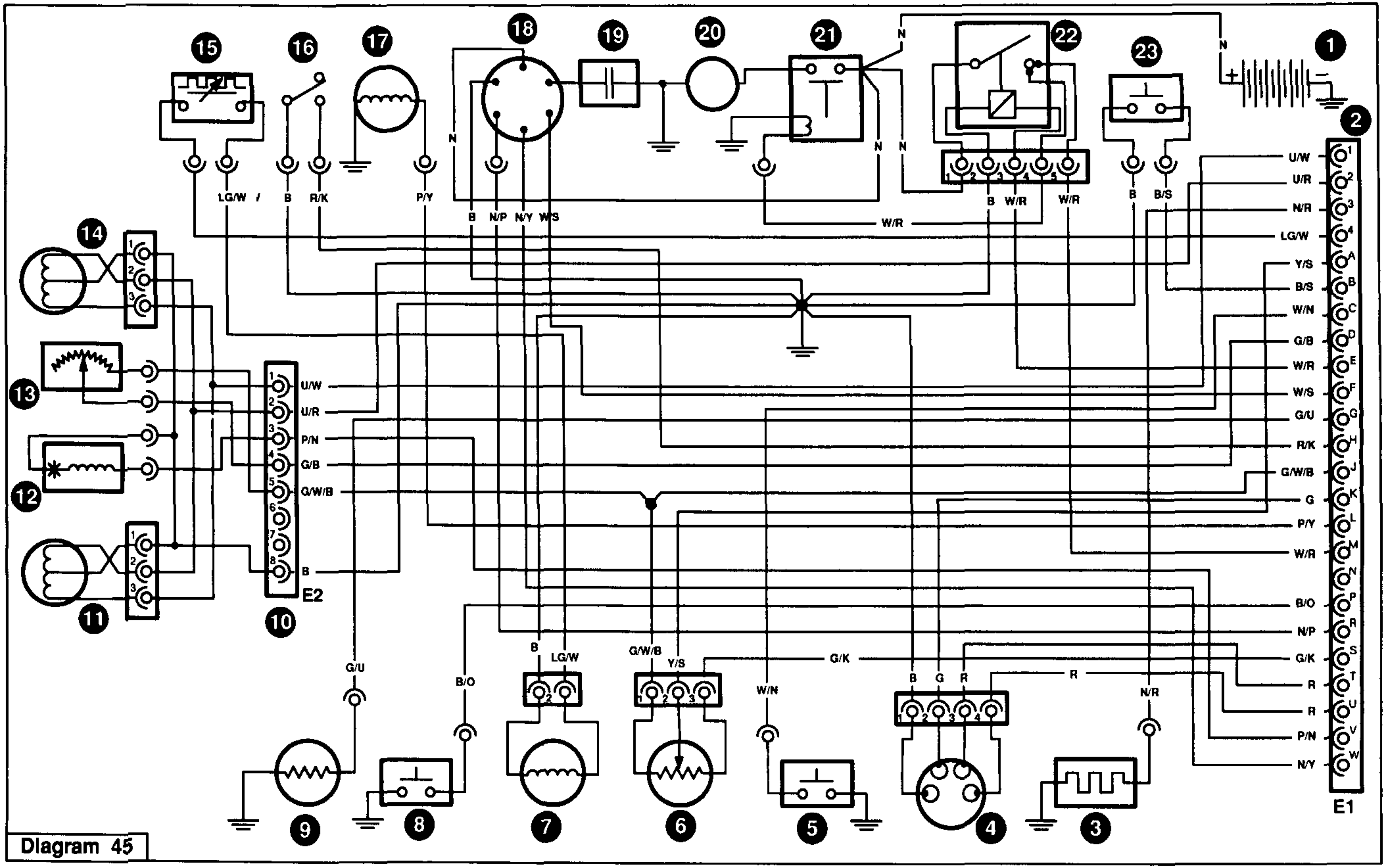
Diagram 44

Diagram 45
Engine Harness – All Models

1. Battery
2. Main Harness Connector (E1)
3. Thermostart
4. Radar Gun (optional)
5. Oil Pressure Switch
6. Oil Pressure Sender (With E.I.C.)
7. Air Conditioning Clutch (optional)
8. Temperature Switch (With E.I.C.)
9. Temperature Sender
10. Headlamp Harness Connector (E2)
11. Left Hand Headlamp
12. Horn
13. Fuel Tank Sender
14. Right Hand Headlamp
15. De-Icing Thermostat (optional)
16. Brake Fluid Level Switch (not 'S' Model)
17. Fuel Shut-Off Solenoid
18. Alternator
19. Suppressor
20. Starting Motor
21. Starting Motor Solenoid
22. Starting Motor Relay
23. Vacuum Switch

Key To Colours

B	Black	G	Green
N	Brown	LG	Light Green
LN	Tan	U	Blue
S	Slate	TQ	Turquoise
R	Red	P	Purple
O	Orange	K	Pink
Y	Yellow	W	White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R/K
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E2
G/U
B/O
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LG/W
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Y/S
G/K
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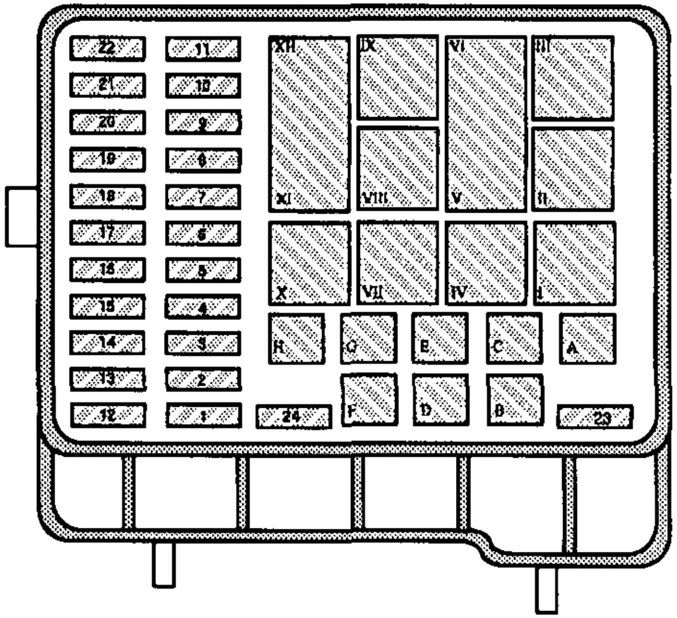
N/R

Diagram 45

Diagram 46
Fuse Box



RELAYS

No.	Description
I	Ignition Delay
II	Accessory
III	Implement Socket
IV	Flasher Unit
V/VI	P.T.O. Module
VII	Thermostart
VIII	Not Used
IX	Ignition Delay
X	Not Used
XI/XII	Converter Module

FUSES

No	Description	Colour	Rating
1	Headlamp – Main	Lt.Blue	15A
2	Headlamp – Dip	Lt.Blue	15A
3	Sidelamp – R.H.	Red	10A
4	Sidelamp – L.H.	Red	10A
5	Worklamp – Front	Red	10A
6	Worklamp – Rear	Lt.Blue	15A
7	Worklamp – Lower	Yellow	20A
8	Fuel Shut–off	Red	10A
9	Gauges, External Switches	Red	10A
10	Hazard Lamps	Lt.Blue	15A
11	Horn, Headlamp Flasher, Cigar Lighter, Beacon	Red	10A
12	E.D.C, EECIV	Red	10A

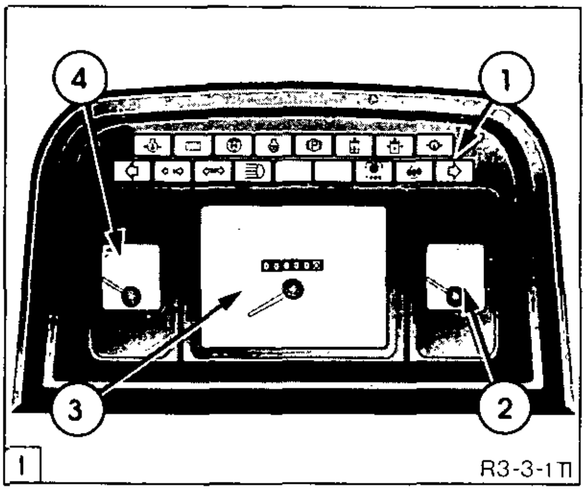
No	Description	Colour	Rating
13	Trans. Dump Solenoid	Lt.Blue	15A
14	E.D.C, EECIV	Red	10A
15	Stoplamps, Seat Pump, Diff. Lock	Lt.Blue	15A
16	Heater Fan	Natural	25A
17	Wipers, Washers, Temperature Control, Console Lamp	Yellow	20A
18	Turn Indicators	Red	10A
19	Thermostart	Natural	25A
20	Keep Alive Memory	Tan	5A
21	P.T.O.	Tan	5A
22	Radio, Implement Socket Switch and Relay	Tan	5A
23	Accessory Socket	Red	10A
24	Implement Socket	Lt.Green	30A

Index for Diagrams 44–46

PART 3
ELECTRICAL SYSTEMS
Chapter 3
ANALOGUE INSTRUMENT CLUSTER (AIC) and ANALOGUE/ELECTRONIC INSTRUMENT CLUSTER (AEIC)

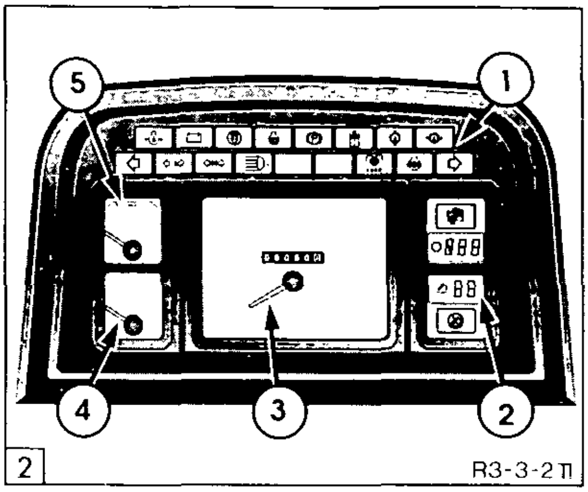
A. DESCRIPTION AND OPERATION

Overall Description



Analogue Instrument Cluster (AIC)

1. Upper Section
2. Right Hand Display (Coolant Temperature Gauge)
3. Main Display
4. Left hand Display (Fuel Gauge)



Analogue/Electronic Instrument Cluster (AEIC)

1. Upper Section
2. Right hand Display
3. Main Display
4. Left hand Display (Fuel Gauge)
5. Left Hand Display (Coolant temperature Gauge)

The AIC and AEIC panels are shown in Figure 1 and Figure 2 above with all displays activated.

When the key-start switch is turned on, the cluster self-tests. the audible alarm sounds and the malfunction warning lamps (items 1, 2, 3, 6, 7 and 8 of Figure 3) illuminate briefly.

1. The **Upper Section** has seventeen coloured lights providing operating information and warning of system malfunction.

2. The **Right-Hand Display** of the AEIC consists of two Liquid Crystal Displays (LCD's) providing Tractor Performance (implement and hydraulics) information and transmission gear and range selection. The right hand display of the AIC panel contains an analogue type coolant temperature gauge.

3. The **Left-Hand Display** of the AEIC panel contains two analogue type gauges providing information on engine coolant temperature and fuel level. The left hand display of the AIC contains the fuel level gauge only.

4. The **Main Display** is a multi-function gauge for indicating Engine rev/min and, operating hours.

UPPER SECTION

Certain tractor malfunctions are identified by a warning light.

The lights function as follows:
(with reference to Figure 3)

Upper Row - Left to Right

1. Low Engine Oil Pressure
   - Light illuminates
2. Alternator Not Charging
   - Light illuminates.
3. Air cleaner unservicable
   - Light illuminates
4. Thermostart
   - Light illuminates when Thermostart is activated.
5. Parking Brake and Brake/Clutch Fluid Level
   - Key-start on, flashing light indicates parking brake applied or low fluid level in brake/clutch reservoir.
   - Key–start off, handbrake off, warning buzzer sounds for 2 minutes.

NOTE: *The warning lights 6 and 7 may serve differing functions, dependent upon whether a variable displacement piston pump, identified by the use of three hydraulic filters or a fixed displacement gear pump, identified by having a single hydraulic filter, is fitted.*

6. Tractors with variable displacement piston pump
   - Constant light:- Steering intake filter blocked or partially blocked.

6. Tractors with fixed displacement gear Gear Pump
   - Constant light:– *Steering/hydraulic in*take filter blocked or partially blocked.

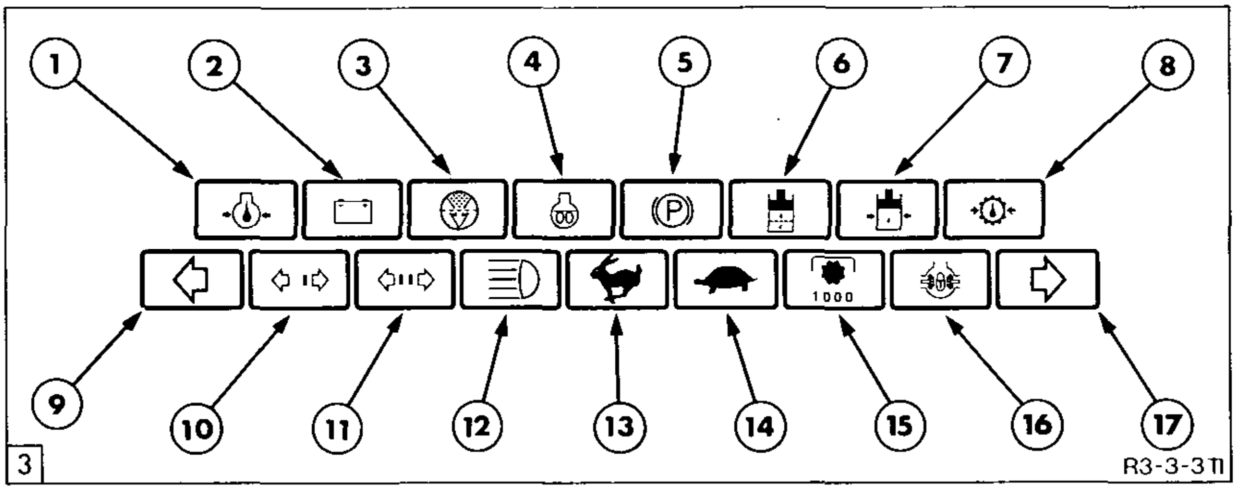
7. Tractors with variable displacement piston pump
   - Charge pump intake and pressure filters blocked or partially blocked.

7. Light not used on tractors with fixed displacement gear pump.

8. Transmission/steering oil pressure low
   - Light illuminates

Lower Row - Left to Right

9. Left turn indicator



Indicator Lights

1. Engine oil pressure (red)
2. Alternator charge (red)
3. Air cleaner (amber)
4. Thermostart (amber)
5. Parking brake and brake/clutch fluid level (red)
6. Steering intake filter (red)
7. Charge pump filters (red)
8. Transmission and steering oil pressure (red)
9. Left turn indicator (green)
10. Trailer turn signal (when attached) (green)
11. Second trailer turn signal (when attached) (green)
12. Headlight main beam (blue)
13. Dual power – high
14. Dual power – Low
15. 1000 rev/min P.T.O. (amber)
16. Differential lock (amber)
17. Right turn indicator (green)

10. Trailer turn signal

- Light flashes in unison with tractor/trailer turn signals if trailer attached.

11. Second trailer turn signal

- Light flashes in unison with tractor left-hand turn lamp
- Light should flash in unison with tractor/trailer turn signals if second trailer attached.

12. Headlight Main Beam

- Light illuminates when tractor lights are switched to main beam.

13. Dual Power – High
(8x2 transmission, AIC only)

- Light illuminates when in direct drive.

14. Dual Power – Low
(8x2 transmission, AIC only)

- Light illuminates when underdrive is selected.

15. 1000 rev/min P.T.O. (shiftable P.T.O. only)

- Constant light indicates that 1000 rev/min P.T.O. speed is selected. If P.T.O. overspeeds in the economy range, the light flashes for 5 seconds then remains constant.

16. Differential lock

- Light illuminates when differential lock is engaged.

17. Right turn indicator

- Light flashes in unison with tractor right-hand turn lamp.

B. FUNCTION SENDERS AND SWITCHES

With reference to Figure 4

B. ENGINE COOLANT TEMPERATURE SENDER
The temperature sender resistance changes proportionally with coolant temperature, causing modulation of the signal voltage (maximum voltage 5.0 volts) which is fed back to the instrument cluster to operate the temperature gauge.

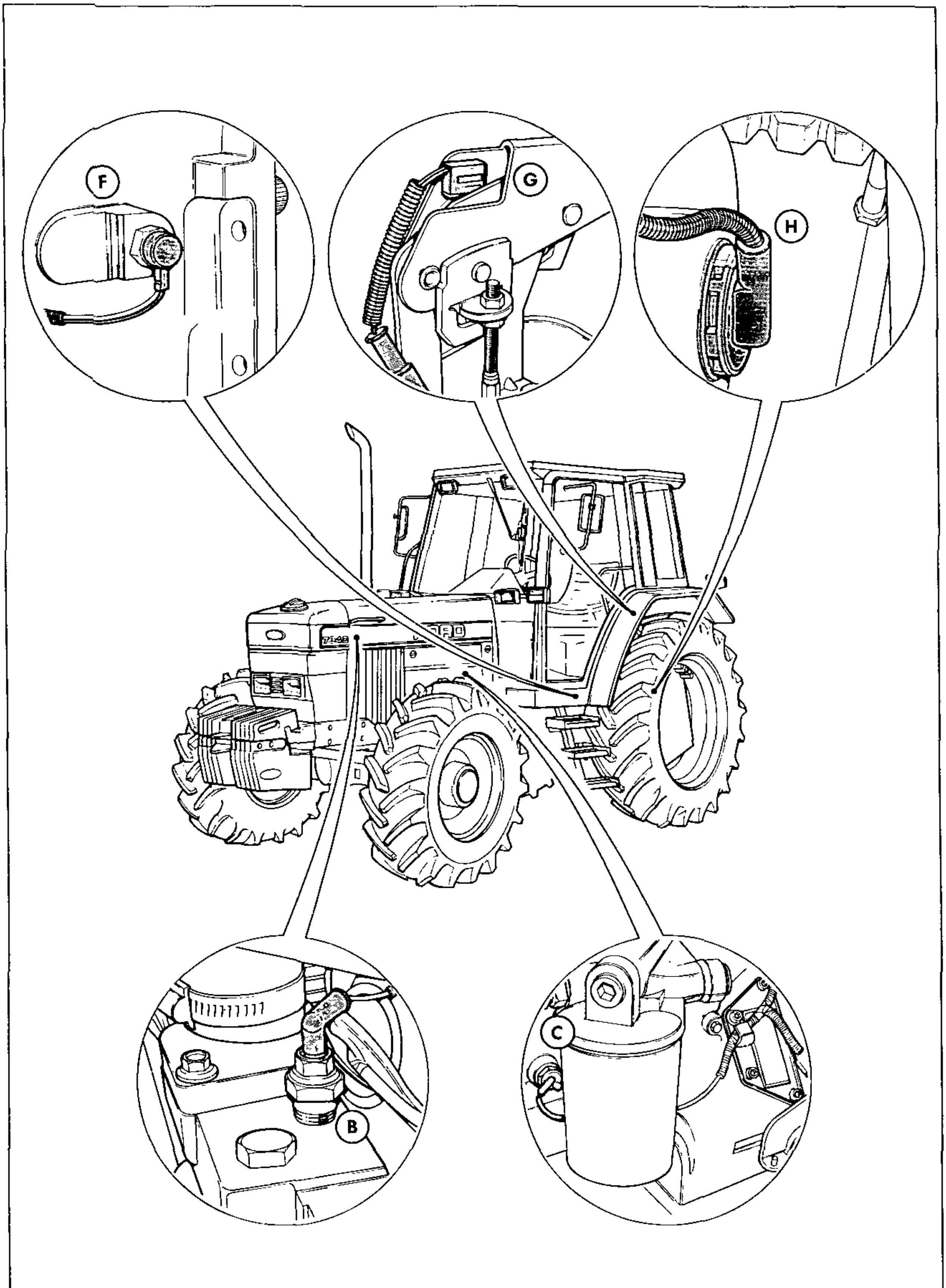
Sender Resistance	Gauge Indication
710–580 Ohms Less than 100 Ohms	COLD HOT

C. ENGINE OIL PRESSURE SWITCH
The switch is normally closed when the engine oil pressure is below 0.68bar (10 lbf.in^2) operating the engine oil pressure warning light.

F. TRANSMISSION SPEED SENSOR (With 16x16 Transmission Only)
Senses transmission output (wheel speed) and generates a signal for EECIV micro–computer for transmission control.

G. PARKING BRAKE SWITCH
Switched closed with parking brake applied, warning light illuminated with key switch on, alarm activated if parking brake on.

H. AUXILIARY FUEL TANK SENDER (Where Fitted)
Connected in series with main fuel tank sender. Refer to 'N'.



4

R3-3-4 TI

With reference to Figure 5

J. **TWO SPEED SHIFTABLE PTO SWITCH (Two speed shiftable PTO only)**
Operates '1000 RPM PTO' cluster light when 1000 rpm PTO selected With two speed PTO lever.

K. **BRAKE AND CLUTCH FLUID LEVEL SWITCH (SL/SLE MODELS)**
Operates fluid level/parking brake warning light when fluid level drops to minimum level, switch normally open.

L. **AIR CLEANER RESTRICTION SWITCH**
Switch normally open but closes when the vacuum in the air intake tube exceeds 25 in.H_2O, operating the air cleaner restriction warning lamp.

M. **ALTERNATOR**
Engine rpm displays are computed from a square wave frequency output from the alternator.
(Frequency 142.5–855.0Hz : 480–3060 rpm displayed)

N. **MAIN FUEL TANK SENDER**
Signals from both sender potentiometers determine the fuel level displayed by the gauge.

NOTE: *Where an auxiliary fuel tank is fitted the two senders total resistance is equivalent to the single main tank installation sender resistance. This allows a common gauge to be fitted to all models.*

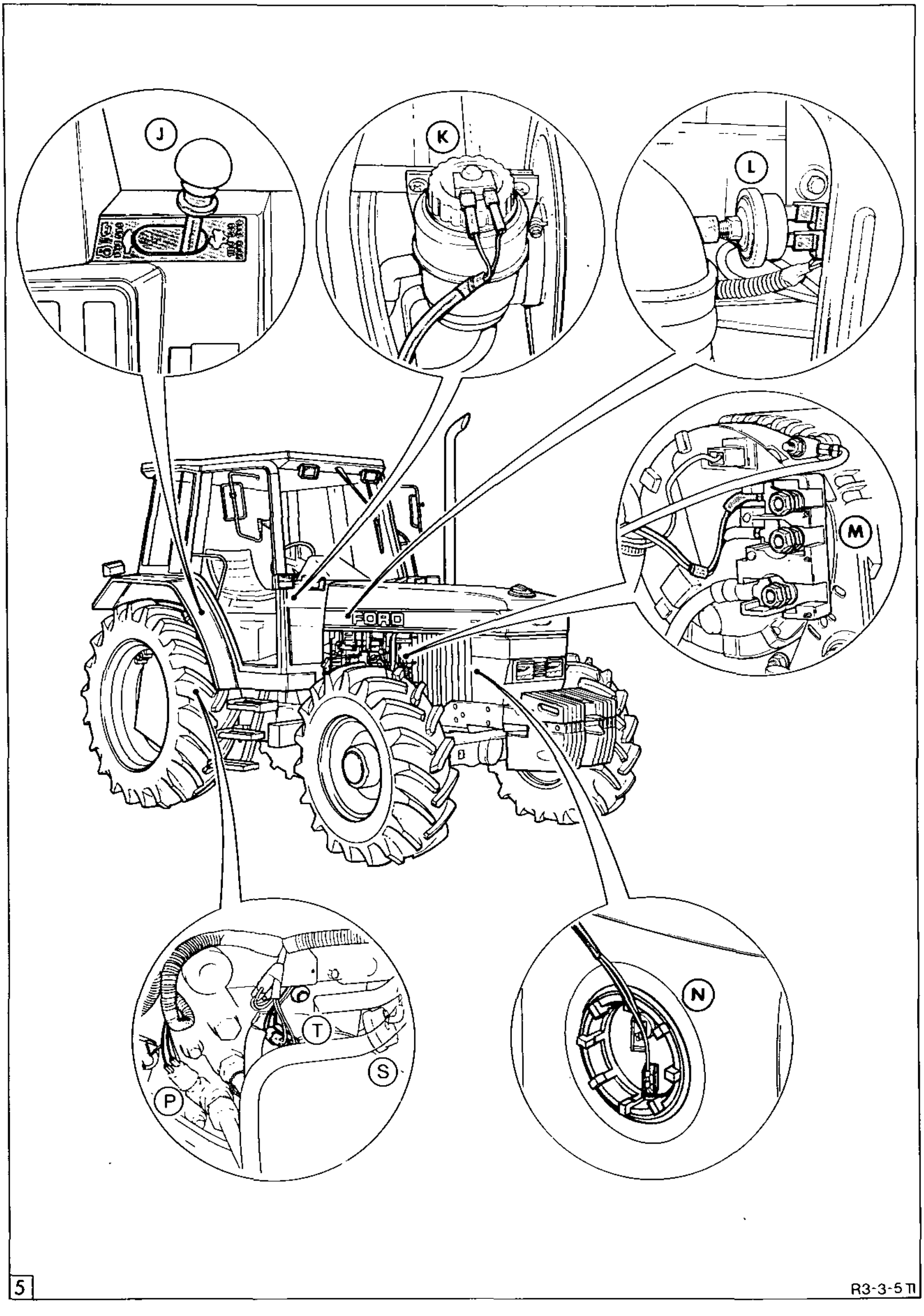
Sender Resistance	Gauge Indication
31–49 Ohms 230–250 Ohms	FULL EMPTY

TRANSMISSION SWITCHES
(Fixed Displacement Gear Pump)

P. **TRANSMISSION PRESSURE SWITCH (Light 8, Figure 3)**
Operates when the hydraulic pressure oil to the transmission falls below 5.5 bar (80 lbf.in^2). The switch is normally closed, opening when the pressure exceeds 8.3 bar (120 lbf.in^2). When the pressure falls below 5.5 bar (80 lbf.in^2) the switch closes and the transmission/steering hydraulic pressure warning light illuminates.

S. **HYDRAULIC OIL FILTER RESTRICTION SWITCH (Light 6, Figure 3)**
The switch is normally open and closes when the vacuum created by the oil being drawn into the filter exceeds 10–16 in.Hg. (254–406 mm.Hg.). The transmission / steering hydraulic pressure warning light will illuminate when the switch is closed.

T. **TRANSMISSION OIL LOW TEMPERATURE SWITCH**
The low temperature switch prevents the filter restriction light illuminating when the oil temperature is below 40°C (104°F). The switch is normally open below 40°C (104°F) and closes above 40°C (104°F) to complete the warning light circuit.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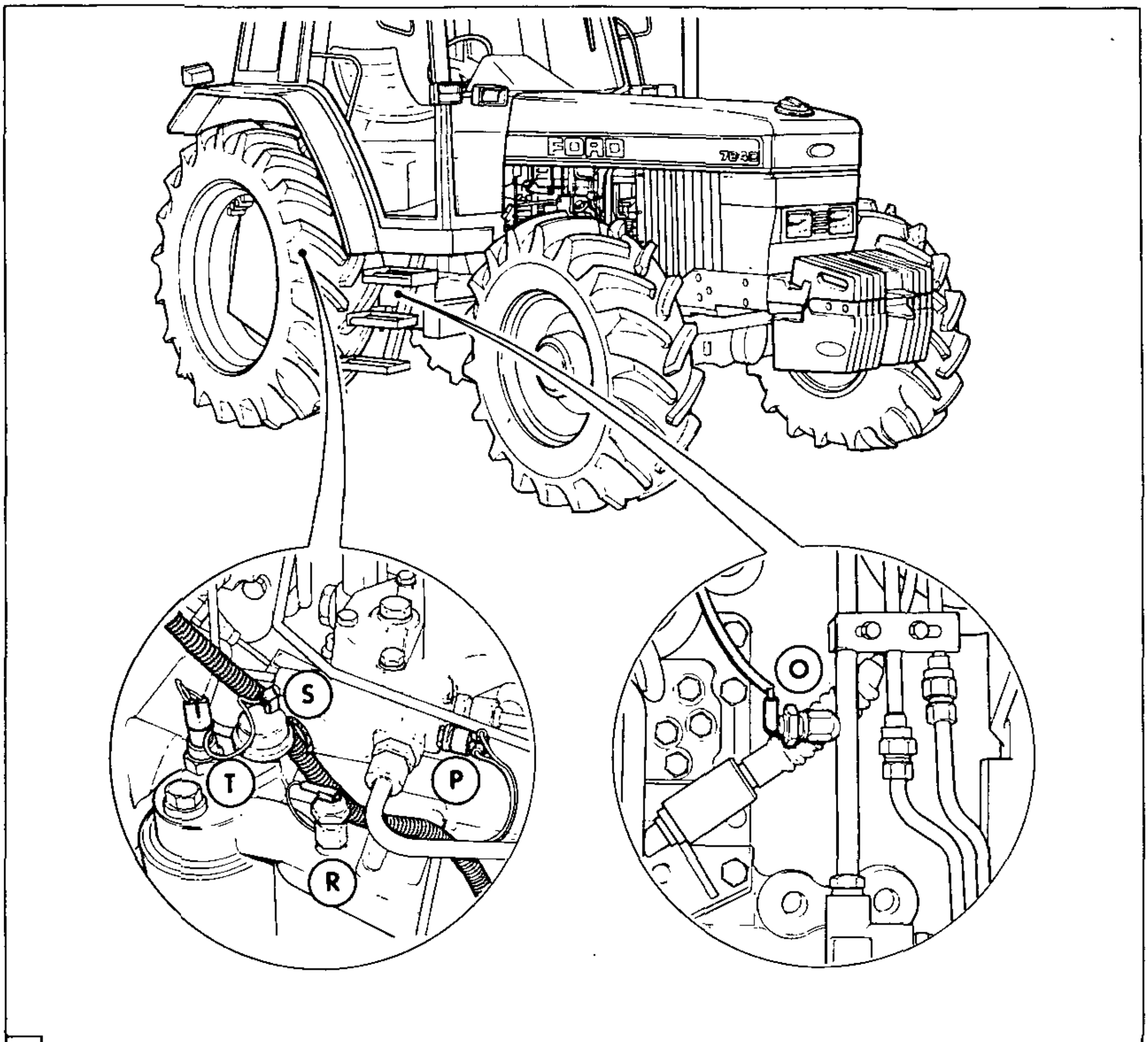
R3-3-5 TI

TRANSMISSION SWITCHES
(Variable Displacement Piston Pump)

With reference to Figure 6



6

R3-3-6 TI

O. STEERING OIL / LUBRICATION PRESSURE SWITCH (Light 8, Figure 3)
Operates when the pressure in the steering return / transmission lubrication circuit falls below 0.8 bar (12 lbf.in^2). A normally closed switch which is held open when pressure exceeds that detailed above, when the switch closes the warning light is illuminated.

P. TRANSMISSION PRESSURE SWITCH (Light 8, Figure 3)
Operates when the pressure for the 16x16 transmission circuit falls below 15 bar (215 lbf.in^2). A normally closed switch which is opened when the pressure exceeds 16.8 bar (245 lbf.in2), when the switch closes, the warning light is illuminated.

R. CHARGE PRESSURE SWITCH (Light 7, Figure 3)
Operates when the charge pressure for the variable displacement piston pump falls below 0.8 bar (12 lbf.in^2). A normally closed switch which is held open when pressure exceeds that detailed above, when the switch closes a warning light flashes.

S. STEERING OIL FILTER RESTRICTION SWITCH (Light 6, Figure 3)
The switch is normally open and closes when the vacuum created by the oil being drawn into the filter exceeds 16 in.Hg. (406 mm.Hg.).

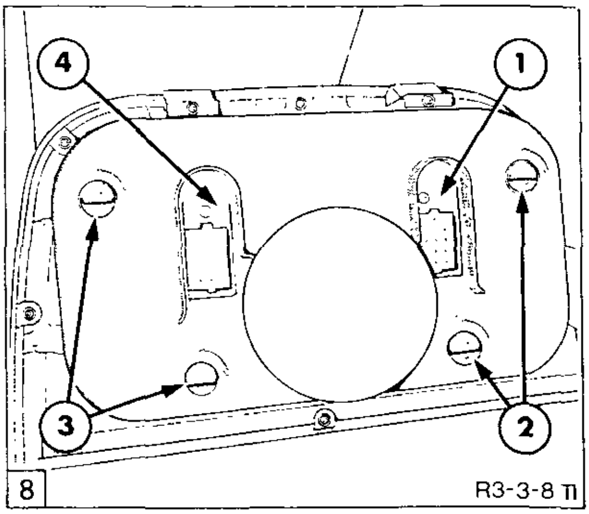
T. TRANSMISSION OIL LOW TEMPERATURE SWITCH
The low temperature switch prevents the filter restriction/low pressure light illuminating when the oil temperature is below 40°C (104°F). The switch is

normally-open below 40°C (104°F) and then closes above 40°C (104°F) to complete the warning light circuit.

C. SERVICE ACCESS

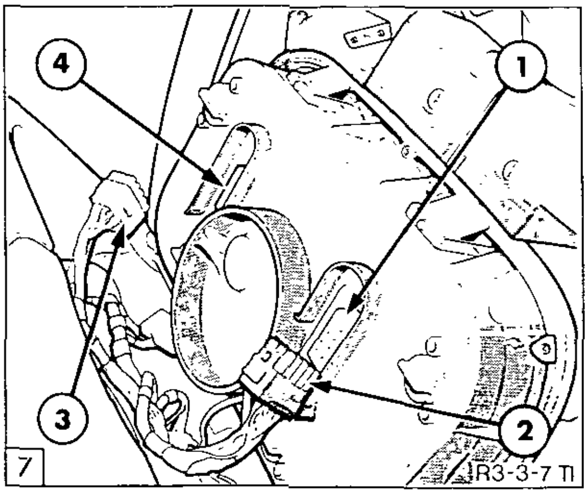
Cluster Removal

To remove either the AIC or AEIC instrument clusters remove the two retaining screws located at the bottom of the cluster and gently lift away. When there is sufficient clearance, disconnect the two multipin connectors from the rear of the cluster and remove the cluster from the tractor, Figure 7.



Rear Cover

1. Multipin Socket
2. Quick Release Fasteners
3. Quick Release Fasteners
4. Multipin Socket

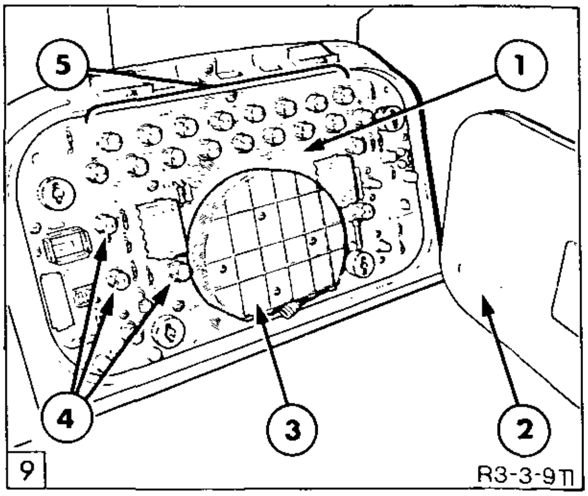


Harness Connectors

1. Multipin Socket
2. J1 Harness Connector
3. J2 Harness Connector
4. Multipin Socket

Cluster Serviceable Components

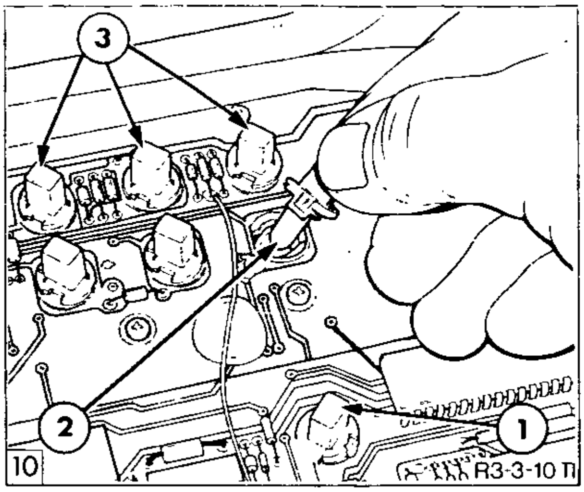
To gain access to the components of the cluster, remove the rear cover as shown in Figure 8.



Service Accessibility

1. Circuit Board
2. Rear Cover
3. Proofmeter
4. Illumination Lights
5. Indicator Lights

The Cluster indicator lights can now be replaced. To remove a light rotate the lamp body anti-clockwise and withdraw. Replacement is the reverse, turning the lamp body clockwise to secure.



Light Replacement

1. Cluster illumination Light
2. Bulb
3. Indicator lights (17)

To replace any components other than indicator/illumination lights it is necessary to remove the eight screws retaining the circuit board assembly to the housing. With the circuit board assembly removed from the housing it is possible to replace the following components using the procedures detailed:

- **Fuel and temperature gauges** – Remove the single nut on the reverse side of the gauge and gently push the gauge from the circuit board.
- **Tachometer** – Disconnect the electrical connector from the circuit board to the tachometer. Remove the four crosshead screws from around the dial face and gently withdraw the tachometer assembly.
- **Liquid Crystal display (LCD) Module** – Carefully disconnect the white electrical connector to the circuit board by pushing the connector horizontally away from the circuit board. Remove the two roundheaded crosshead screws securing the module to the circuit board and withdraw the module.
- **Circuit Board** With the above components and the lights removed the circuit board can be replaced.

NOTE: *Adjacent to the LCD module white connector on early AEIC instrument panels are four red switches. The switches should all be in the down, i.e, 'off position'.*

NOTE: *Do not attempt to dismantle the outer housing assembly. The housing is sealed during production and any tampering will lead to the ingress of moisture into the cluster assembly.*

D. FAULT FINDING

Common Test Procedure for ALL of the Switch Circuits Connecting to Ground

Switches/senders affected:– Handbrake switch, Brake fluid level switch, Engine temperature sender, Engine vacuum switch, Transmission oil temperature switch, Transmission oil pressure switch, Power assisted steering pressure switch, Low charge pressure switch, Hydraulic oil filter restriction switch, Fuel gauge sender/s.

Disconnect the harness at the sender/switch, and connect signal wire to ground
Is the warning light illuminated/gauge operating?

YES ► Check the ground path of the switch and recheck function.
Is the resistance to ground less than 10 Ω?

YES ▼ Renew the switch and recheck function.

NO ▼ Locate and repair the open circuit

NO ▼

Unplug wiring harness from instrument cluster. Ground the signal wire at switch/sender and measure resistance between the signal pin and the tractor frame at the panel connector
Is resistance less than 10 Ω?

NO ► Locate and repair open circuit in signal wire

YES ▼

Clean wiring harness to instrument cluster connector pins with contact spray
Reconnect the plugs to instrument panel
Remove the signal wire at the switch and connect to ground
Is the warning light illuminated/gauge operating?

NO ► Renew the warning bulb or gauge ► **Is the warning light illuminated/gauge operating?**

NO ▼ Renew the Instrument Panel circuit board and recheck function

The following tables detail the instrument connector pins of connectors J1 and J2, the wire colours, connections in a particular circuit and the final component or destination of the wiring from the instrument cluster connector. Use the tables in conjunction with the wiring diagrams in Chapter 2 of this Part to aid fault finding of particular circuits.

NOTE: *If a fault cannot be found in the wiring or component of a particular circuit and the instrument cluster fault persists, remove and inspect the circuit board of the cluster. Inspect the board for continuity of the circuits and burnt out components. If in doubt substitute the circuit board for one of known performance.*

Table 1 – J1 Instrument Cluster Connector Terminal Identification

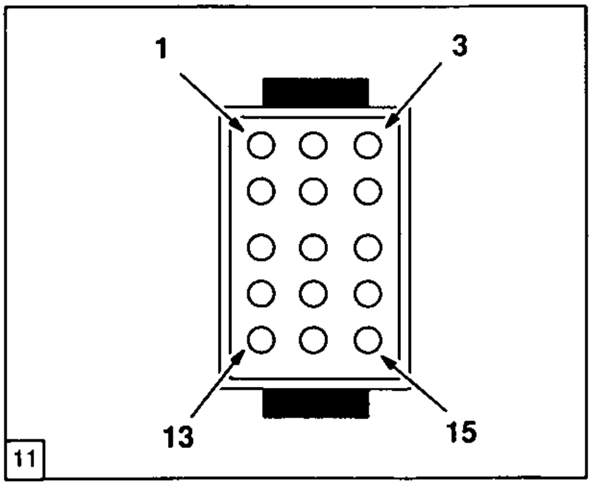
Instrument Connector Pin	Wire Colour	Connections in Circuit	Final Component (Destination)	Cluster Function
J1–1	G/R	ISO/NASO Module & C1–L	Trailer Socket & LH side lamp	Left Hand Indicator
J1–2	B	–	Earth (Ground)	–
J1–3	LG/Y	–	Flasher Unit	1st Trailer Indicator
J1–4	N/R	Fuse 19 & E1–3	Thermostart	Thermostart Indicator
J1–5	LG/R	–	Flasher Unit	2nd Trailer Indicator
J1–6	U/W	Fuse 1 & E1–1	Main Beam Lamp	Main Beam Indicator
J1–7	W/N	E1–C	Engine oil Pressure Switch	Engine Oil Pressure
J1–8	Y	–	D.P Switch & Solenoid	D.P. High
J1–9	Y/N	–	D.P. Switch	D.P. Low
J1–10	B/S	E1–B	Vacuum Switch	Air Cleaner Restriction
J1–11	O/P	–	PTO Module (2 spd. Shiftable)	1000 rev/min Indicator
J1–12	Y/B	C1–D	Diff–Lock Switch	Diff –Lock Indicator
J1–13	G/B	–	Fuel Sender Aux/ Main Connector	Fuel Gauge
J1–14	N/Y	E1–W	Alternator (D+ Terminal)	Battery Charge Lamp & Tacho
J1–15	W/S	E1–F	Alternator (W Terminal)	Tachometer

Table 2 – J2 Instrument Cluster Connector Terminal Identification

Instrument Connector Pin	Wire Colour	Connections in Circuit	Final Component (Destination)	Cluster Function
J2–1	R/N/B	C1–M	Low Charge Switch	Low Charge Pressure
J2–2	Y/O	C1–B	PAS Pressure Switch & Trans. Oil Pressure Switch	Steering/trans Lube pressure
J2–3	B/N	C1–C	Trans. Temp. Switch & HPL Filter Switch	Hydraulic Filter Restriction
J2–4	G/W	ISO/NASO Module & C1–H	Trailer Socket RH Side Lamps	Right Hand Indicator
J2–5	LG/N	–	Flasher Unit	Brake Warning Lamp
J2–6	S/U	–	Buzzer	Audible Alarm
J2–7	LN/TQ	C4–3	EECIV (E3–55)	LCD Module Display
J2–8	R/K	E1–H	Brake Fluid level Switch & Handbrake Switch	Brake Warning Lamp
J2–9	P	–	Fuse 20	LCD Module Display
J2–10	LN/O	–	EECIV (E3–54)	LCD Module Display
J2–11		–NOT USED–		
J2–12	G	–	Fuse 9	Positive Feed to Gauges
J2–13	G/B/W	–	Earth (Ground)	–
J2–14	R	–	Fuse 3	Panel Lights
J2–15	G/U	E1–G	Engine Temp. Sender	Temperature Gauge

Key To Colours

B	– Black	G	– Green
N	– Brown	LG	– Light Green
LN	– Tan	U	– Blue
S	– Slate	TQ	– Turquoise
R	– Red	P	– Purple
O	– Orange	K	– Pink
Y	– Yellow	W	– White



J1 and J2 Connector Pin Identification

J1 Connector is a 'BRICK RED' colour (male pins)
J2 Connector is a 'TAN' Colour (female pins)

PART 3
ELECTRICAL SYSTEMS
Chapter 4
CHARGING SYSTEMS

A. INTRODUCTION

Magnet Marelli (Lucas) A127 type alternators are used on Series 40 model tractors. Used in 55 Amp form with an external cooling fan on less cab models and in 100 Amp form with an internal cooling fan on with cab models. The alternator is mounted high at the front of the engine and is driven from a crankshaft pulley via a 'poly v' drive belt. The alternators feature integral regulators with temperature sensed regulation.

Alternator Operation

With reference to Figure 4.

When the key start switch is turned on a small current flows from the battery through the rotor field wiring. The circuit is made via the charge indicator warning lamp, alternator terminal 'D+' the rotor field winding, the alternator regulator and ground.

At this stage the warning light is illuminated and the rotor partially magnetised.

When the engine is started and the partially magnetised rotor revolves within the stator windings a 3–phase alternating current is generated. A constant portion of the generated current is converted to direct current by the three field diodes incorporated in the rectifier pack.

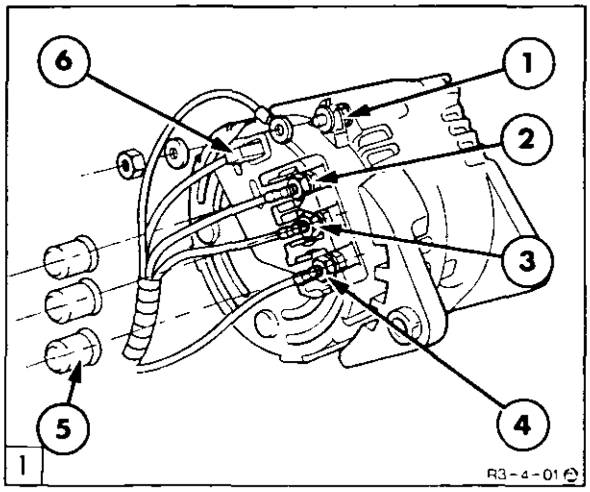
This direct current is fed back to supplement the current flowing through the rotor field winding.

This action results in an ever increasing magnetic influence of the rotor along with an associated rapid rise in generated output current and voltage.

During the rise in generated output voltage (reflected at the 'D+' terminal) the brilliance of the warning lamp is reduced and when the voltage at the 'D+' terminal equates to that at the battery side of the warning light the lamp is *extinquished.*

The voltage continues to rise until the predetermined regulated voltage level is reached.

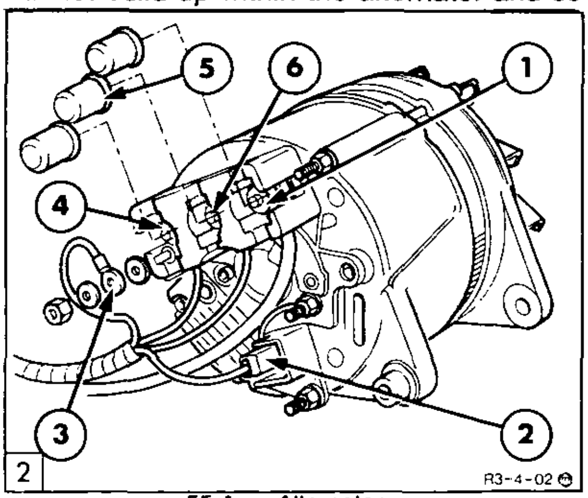
In the event of drive belt breakage the voltage will not build up within the alternator and so



1

100 Amp Alternator

1. Earth (Ground) Connection
2. Engine Speed Sensor Connection (W Terminal)
3. Warning Lamp (D+ terminal)
4. Output Connection (B+ Terminal)
5. Protective Terminal Sleeve
6. Battery Temperature Sensor Connection



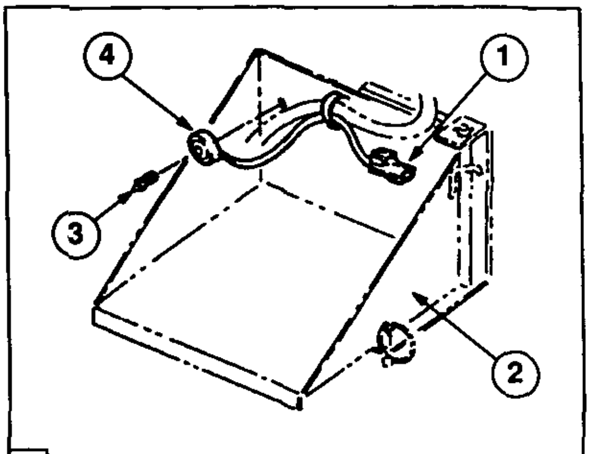
2

55 Amp Alternator

1. Output Connection (B+ Terminal)
2. Battery Temperature Sensor Connection
3. Engine Speed Sensor Connection (W Terminal)
4. Earth (Ground) Connection
5. Protective Terminal Sleeve
6. Warning Lamp (D+ terminal)

the charge indicator light will remain on to indicate failure.

Battery Temperature Compensation



3

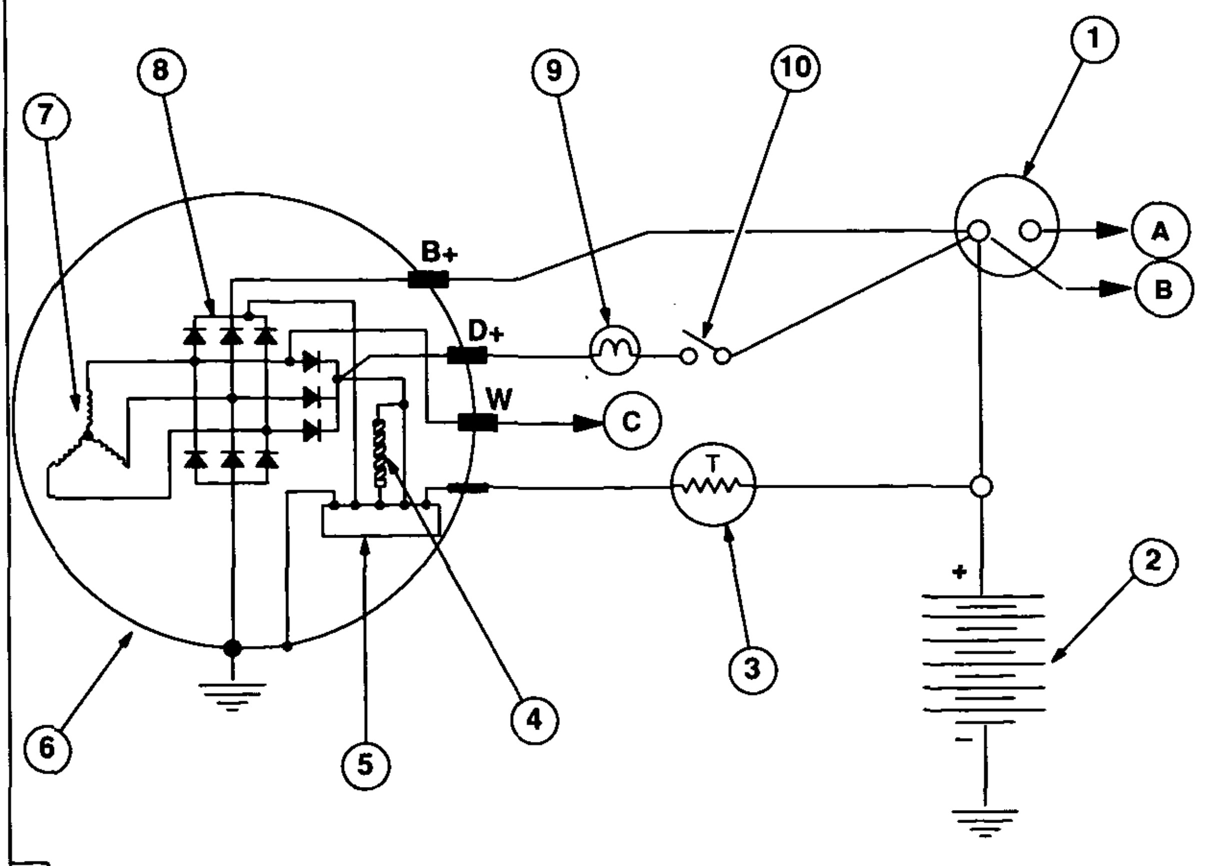
Battery Temperature Sensor

1. Sensor Connector
2. Battery Tray
3. Securing Bolt
4. Temperature Sensor

Because charging systems are directly affected by changes in battery temperature and loading, the alternator charging system features combined battery temperature and system voltage sensing.

A circular temperature sensing pad is located in the battery tray which is in contact with the battery, Figure 3.

The sensor detects any changes in battery temperature and relays this information to the voltage regulator which adjusts the charge rate accordingly.

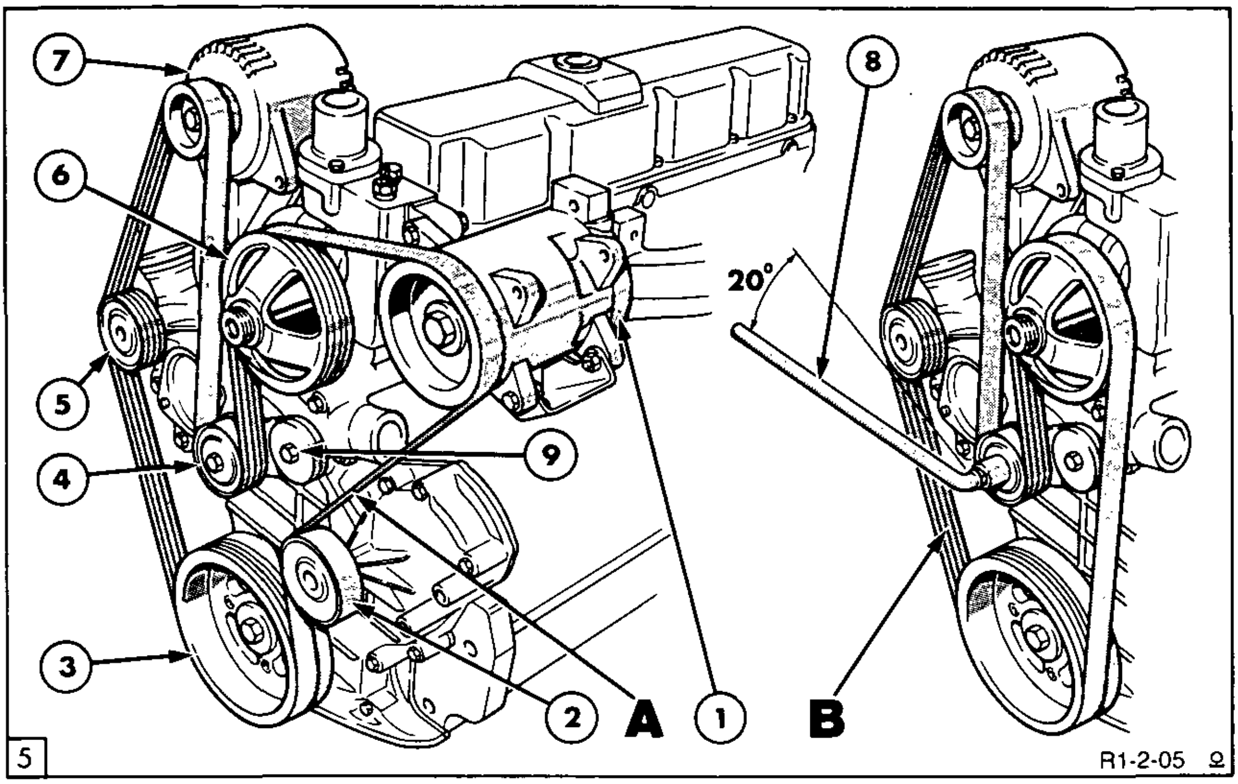


4

Alternator Charging Circuit
(With Battery Temperature Compensation)

A To Starter Motor
B To Starter Relay
C Speed Sensor Terminal to, Diagnostic Plug, ETC Module Terminal 19, PTO Module and Instrument Panel

1. Starter Solenoid
2. Battery
3. Temperature Sensor
4. Rotor Field Winding
5. Regulator
6. Alternator Frame
7. Stator Output Windings (55 Amp Alternator)
8. Rectifier Pack
9. Charge Indicator Lamp
10. Key Start Switch



Fan Belt Tensioner

A. Fan Belt with Air Conditioning

B. Fan Belt Less Air Conditioning

1. Air Conditioning Compressor (optional)
2. Idler Pulley only with (Air Conditioning)
3. Crankshaft Pulley
4. Tensioner Assembly
5. Idler Pulley
6. Water Pump Pulley
7. Alternator
8. Torque Wrench
9. Tensioner Attaching Bolt

B. SYSTEM TESTING AND FAULT FINDING

Service Precautions

To avoid damage to the components of the alternator charging system, service precautions must be observed as follows:

- **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 ground.
- **ALWAYS** disconnect the battery ground cable (negative) when charging the battery on the tractor using a battery charger.
- **ALWAYS** observe correct polarity when installing the battery or using a slave battery to start the engine.

CONNECT POSITIVE TO POSITIVE AND NEGATIVE TO NEGATIVE

Preliminary Checks

Prior to electrical testing thoroughly inspect the charging and electrical system.

Check all leads and connections for continuity and tightness.

1. Check the battery

Using a hydrometer check the individual battery cells. The battery should be at least 70% charged and in good condition.

2. Check the drive belt

Inspect the alternator drive belt and pulley, ensuring that both are clean, free from oil and grease and in good condition.

The alternator drive belt is automatically tensioned by a spring tensioner mounted at the front of the engine, shown in Figure 5. If the the belt tension is suspect, check the tensioner assembly as follows:

Fan Belt Tensioner Removal

1. The fan belt should be removed in the following manner. Place a lever with socket attachment, onto the tensioner retaining bolt and gently lever the tensioner up, Figure 5. Remove the fan belt from the pulley, and allow the tensioner to return to its untensioned position once the belt has been removed,

2. Remove the tensioner from the pump by loosening, and removing the centre attaching bolt.

Inspection and Repair

1. Checking of the tensioner assembly operation should be carried out, with the tensioner assembly still attached to the water pump. To check the spring load, place a "break back" torque bar pre–set to, 52 – 63 lbf. ft (70 – 85 Nm) (7.1 – 8.7 kgf.m), on to the pulley attaching bolt. Raise the lever up through an arc of 20° maximum. If the torque bar does not "break" within the range a new tensioner assembly is required.

2. Ensure the tensioner pulley rotates freely by hand. If not replace with new parts.

Re–Assembly

1. Fit a new pulley to the assembly if required, and torque the attaching bolt to, 34.5 – 44 lbf.ft (46.5 – 60 Nm), (4.7 – 6.1 kgf.m)

2. To re–assemble the arm assembly, position the tensioner on to the water pump, fit the mounting bolt through the assembly, and torque the bolt to, 34.5 – 44 lbf.ft (46.5 – 60 Nm), (4.7 – 6.1 kgf.m).

3. Refitment of the fan belt is the reverse of the removal procedure, but ensure the "Poly V" belt, is positioned correctly onto all of the pulleys.

3. Check the Warning Lamp

Turn on the key start switch and check that the warning lamp is fully illuminated.

If the warning lamp is not fully illuminated check the bulb. If the bulb is not the cause of the fault carry out the Alternator wiring connections test as detailed under 'initial tests' in this section.

If the warning lamp is illuminated start the engine and run above idling speed. The lamp should go out.

If the lamp does not go out, stop the engine and remove the wire from the D+ terminal. If the lamp now goes out a faulty temperature sensor or alternator component is indicated. Conduct the 'Battery temperature sensor circuit test' and 'Alternator components tests' as detailed in this section.

If the warning lamp remains illuminated, check for a short circuit to earth (ground) between the 'D+' cable end and the warning lamp.

INITIAL TESTS

The initial tests may be performed without removing any of the charging circuit components from the tractor and enable the following items to be checked:

- Alternator wire connections
- Battery temperature sensor circuit
- Alternator charging current and controlled voltage
- Alternator charging circuit volt drops
- Alternator maximum output performance

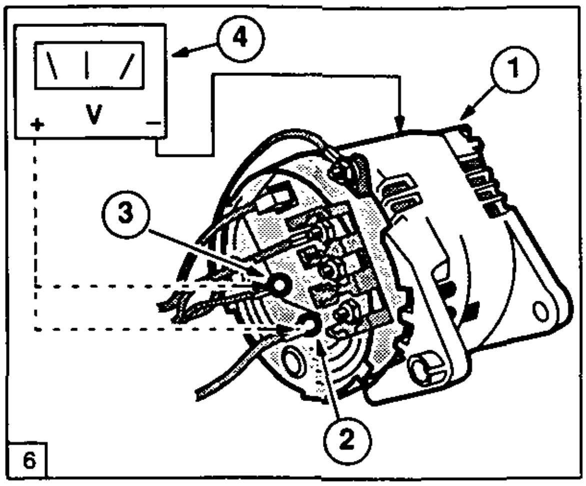
Test equipment required:

- Voltmeter (0–30 volts moving coil type
- Millivoltmeter (0–1 volt)
- Ammeter (0–110 Amperes moving coil type)
- 1.5 Ohm 110 Amperes variable load resistor

NOTE: *Most commercial test equipment incorporates several testing devices within a single unit . Use such equipment in accordance with the manufacturers instructions.*

1. Alternator Wiring Connections Test

With reference to Figure 6.



Alternator Wire Connections

1. Alternator Frame
2. B+ terminal
3. D+ Terminal
4. Voltmeter

1. Disconnect the battery

2. *Disconnect the* B+ and D+ terminals from the alternator.

3. Reconnect the battery and turn the key start on but do not start the engine. Connect a voltmeter between each terminal and earth (ground). Battery voltage should be registered.

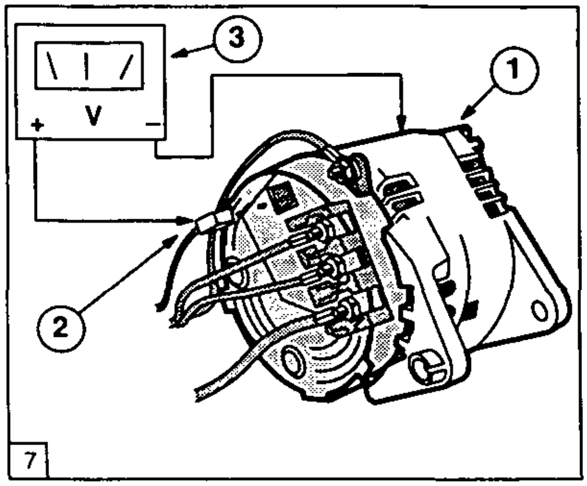
If battery voltage is not registered a continuity fault in the external cable circuitry must be traced and remedied, refer to the circuit diagram shown in Figure 4.

4. Connect the D+ terminal, warning lamp (brown/yellow) wire, to earth (ground). The warning lamp should illuminate.

5. Disconnect the battery and reconnect the removed alternator cable connections to the alternator.

NOTE: *If the warning lamp fails to illuminate when the cable is reconnected to the alternator, a fault is indicated in the alternator regulator or rotor circuits. Ensure that the D+ terminal is clean and then conduct the alternator component tests as detailed in this section.*

2. Battery Temperature Sensor Circuit Test



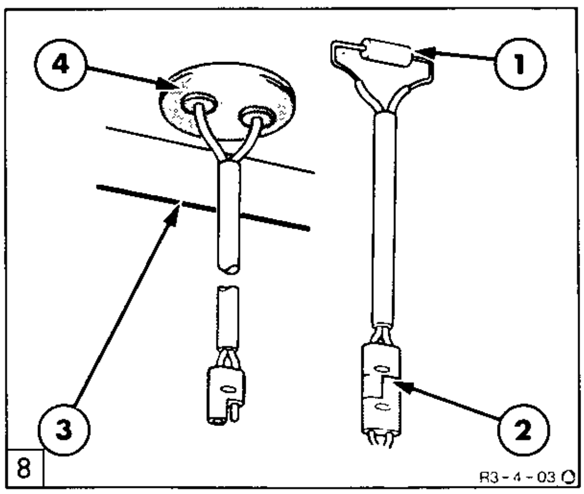
Battery Temperature Sensor Circuit Test

1. Alternator Frame
2. Sensor Lead
3. Voltmeter

1. Disconnect the battery temperature sensor connector. Connect a volt meter between the sensor lead and earth (ground). Battery voltage should be registered.

If battery voltage is not registered, disconnect the harness to sensor plug and connect a 205 ohm resistor (55 amp alternator) or an 11000 ohm resistor (100 amp alternator) across the plug terminal, Figure 8.

NOTE: *it is recommended that a permanent test piece be made by removing the plug and leads from an old sensor unit and connecting the appropriate resistor as shown in Figure 8.*



Connection of Test Resistor

1. Resistor
2. Harness to Sensor Plug
3. Battery Tray
4. Temperature Sensor

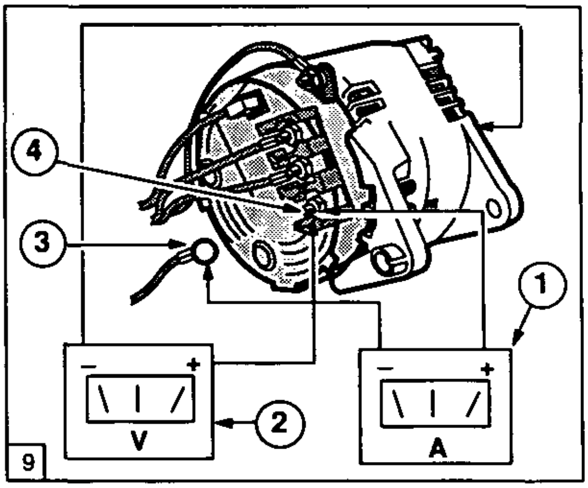
If battery voltage is now registered the sensor unit is faulty (open circuit) and must be replaced.

If battery voltage is not registered a continuity fault in the external circuitry must be traced and rectified. Reconnect the sensor and confirm battery voltage is registered

NOTE: *It is very difficult to test prove the effective resistance of a temperature sensor. If such a unit is suspected of being faulty it should be substituted and proved in Service.*

3. Charging Current And Controlled Voltage Tests

With reference to Figure 9.



Charging Current and Controlled Voltage Tests

1. Ammeter
2. Voltmeter
3. B+ Wire
4. B+ Terminal

1. Ensure all tractor electrical components are switched off and the key start switch is in the 'off' position.
2. Disconnect the battery negative terminal and disconnect the B+ terminal of the alternator.
3. Connect an ammeter between the removed (brown) cable and the B+ alternator terminal.
4. Connect a voltmeter between the alternator B+ terminal and earth (ground)
5. Reconnect the battery. Start and run the engine at 2000 rev/min. and observe the ammeter and voltmeter readings.

If the ammeter registers a charging current stop the engine.

If the ammeter registers zero amperes a faulty alternator component is indicated. Turn off the engine and conduct the 'alternator component tests' as detailed in this chapter.

6. Disconnect the temperature sensor plug and connect the appropriate resistor across the plug terminals, Figure 8.
7. Restart the engine and increase the engine speed to 2000 rev/min. Observe the ammeter and voltmeter readings.

The voltmeter should register in excess of battery voltage and when the ammeter reading falls below 10 Amperes the voltmeter reading should stabilise at 13.6–14.4 volts.

If the voltmeter reading exceeds 14.4 volts the alternator regulator must be replaced as described in this section. (when a new regulator has been installed conduct tests 4 and 5).

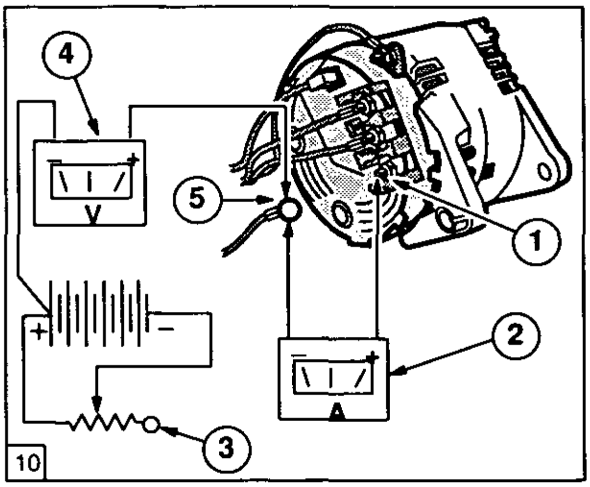
If the voltmeter reading is below 13.6 volts a faulty alternator component or a high resistance fault in the external connections of the charging system is indicated.

8. Stop the engine.

4. Charging Circuit Volt Drop Tests

(a) Insulated–Side Volt Drop Tests

With reference to Figure 10.



Insulated Side – Volt Drop Test

1. B+ Terminal
2. Ammeter
3. Variable Load Resistor
4. Milli–Voltmeter
5. B+ Wire

Ensure the key start switch is in the 'off' position.

1. Disconnect the battery negative cable and disconnect the B+ cable from the alternator
2. Connect a millivoltmeter between the battery positive terminal and the B+ cable. (Positive side to cable).
3. Securely connect an ammeter between the B+ terminal of the alternator and the B+ cable (negative side to cable)
4. Reconnect the battery negative cable and connect a variable load resistor, with the slider in the minimum current draw position (maximum resistance), across the battery terminals.

5. Start the engine and increase the speed to 2000 rev/min.

6. Slowly increase the current loading of the resistor (decrease resistance) until the ammeter registers 55 or 100 Amperes depending on alternator type.

7. Observe the millivoltmeter reading which should not exceed 400 millivolts.

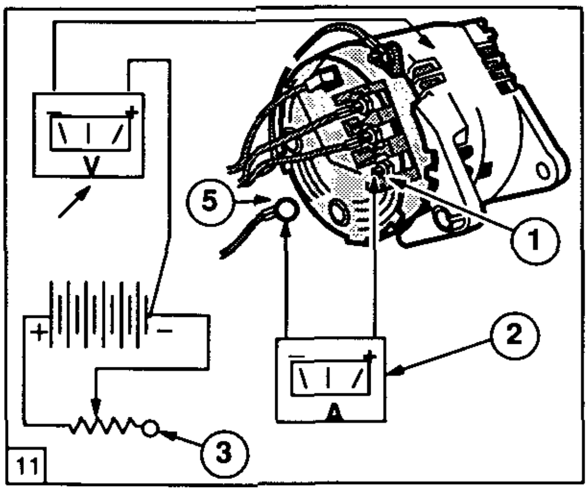
If the reading is in excess of 400 millivolts, a high resistance fault is indicated in the external circuitry.

If the required alternator output cannot be achieved and the millivoltmeter reading is less than 400 millivolts, then a faulty alternator component is indicated. Conduct the' alternator component tests' as detailed in this section.

8. Stop the engine.

(b) Ground–Side Volt Drop Test

With reference to Figure 11.



Ground Side – Volt Drop test

1. B+ Terminal
2. Ammeter
3. Variable Load Resistor
4. Milli–Voltmeter
5. B+ Wire

1. Ensure the key start switch is in the 'off' position.

2. The circuit is the same as that used in the previous test except for the millivoltmeter which is now connected between the battery negative terminal and the alternator frame (negative side to frame).

NOTE: *Ensure the variable load resistor is in the minimum current draw position (maximum resistance).*

3. Start the engine and increase the speed to 2000rev/min.

4. Slowly increase the current loading of the resistor (decrease resistance) until the ammeter registers 55 or 100 Amperes depending on alternator type.

5. Observe the voltmeter reading which should not exceed 200 millivolts.

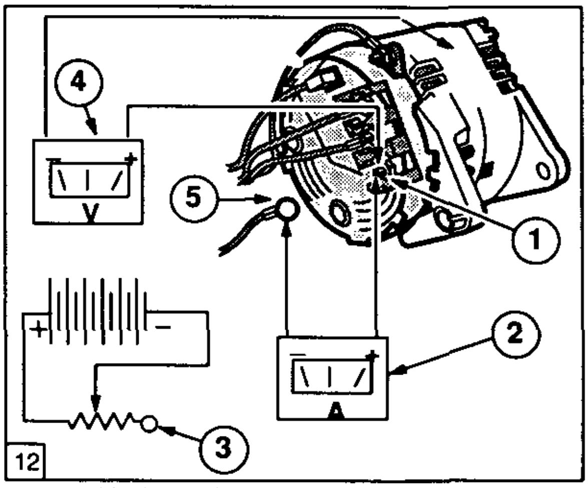
If the reading is in excess of 200 millivolts a high resistance fault is indicated in the external circuitry.

If the required alternator output cannot be achieved and the millivoltmeter reading is less than 200 millivolts then a faulty alternator component is indicated. Conduct the alternator component tests as detailed in this section.

6. Stop the engine.

5. Alternator Maximum Output Performance Test

With reference to Figure 12



Maximum Output Performance Test

1. B+ Terminal
2. Ammeter
3. Variable Load Resistor
4. Milli–Voltmeter
5. B+ Wire

1. Ensure the key start switch is in the 'off' position.

2. Disconnect the battery negative cable and disconnect the B+ cable from the alternator.

3. Securely connect an ammeter between the B+ terminal of the alternator and the B+ cable (negative side to cable).

4. Connect a voltmeter between the alternator B+ terminal and earth (ground)

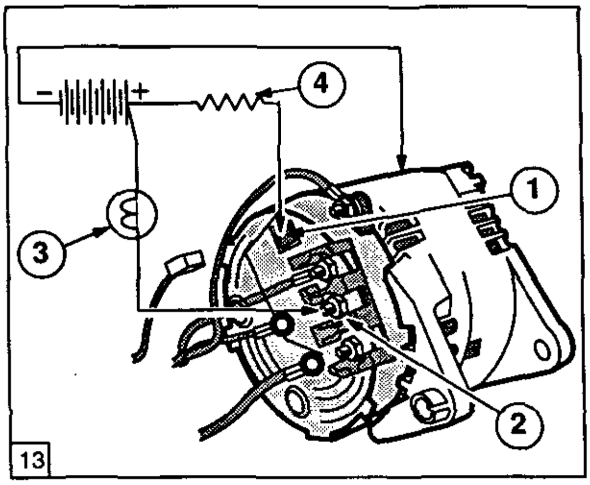
5. Disconnect the harness to battery sensor plug and connect the appropriate resistor across the plug terminals. Refer to Figure 8.

6. Reconnect the battery, start and increase the engine speed to 2000 rev/min.

7. Slowly increase the the current loading of the resistor (decrease resistance) until the ammeter registers either 55 or 100 Amperes depending on alternator type.

8. Observe the voltmeter reading which should not fall below 13.6 volts

If the reading falls below 13.6 volts a faulty alternator component is indicated. Conduct the 'alternator component tests' as detailed in this section.



Regulator and Rotor Field Circuit Test

1. Battery Sensor Terminal
2. D+ terminal
3. 2.2 Watt Test Lamp
4. 205 Ohm Resistor

ALTERNATOR COMPONENT TESTS

The component tests which should only be conducted if the INITIAL TESTS have indicated a faulty alternator component, will enable the the following items to be checked:

- Regulator
- Rotor Field Winding Continuity
- Brushes and Springs and Rotor Slip Rings

NOTE: *The component tests detailed previously may be performed with the alternator installed on the tractor. Testing of the other alternator components will necessitate removal of the alternator from the tractor. Refer to the 'Overhaul' section of this Chapter.*

IMPORTANT: *Prior to removal of the alternator cables from the alternator ensure that the key start switch is in the 'off' position and the battery negative cable is disconnected.*

Test equipment required:

- 12 volt battery
- Multimeter
- 2.2 Watt Test Lamp

1. Regulator and Rotor Field Circuit Test

With reference to Figure 13

1. Disconnect all of the alternator cables.

2. Connect a 12 volt battery and a 2.2 Watt test lamp in series between the D+ and the alternator frame (negative side to frame).

3. Connect a 205 ohm resistor between the positive side of the battery and the sensor terminal.

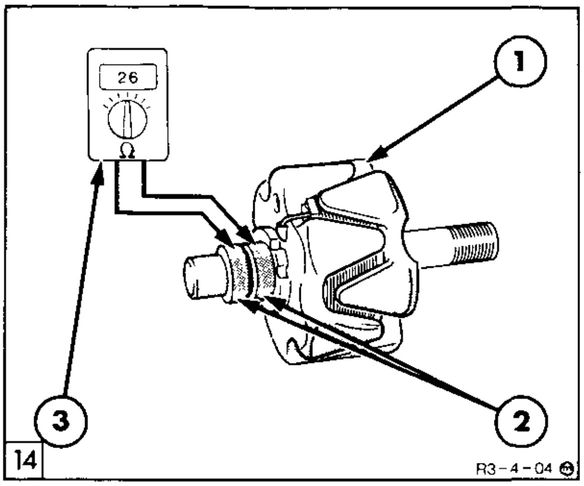
4. The test lamp should illuminate.

If the test lamp is not illuminated a fault is indicated in the rotor circuit. Check brushes, slip rings and continuity of rotor field windings.

If examination indicates these parts to be satisfactory the regulator may be suspect.

2. Rotor Field Winding Continuity Test

with reference to Figure 14



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Rotor Field Winding Continuity Test

1. Rotor
2. Slip Rings
3. Ohmmeter

1. Remove the regulator and brushbox assembly as described in this chapter.

2. Connect an ohmmeter between the two slip rings. The resistance should read 2.6 ohms at 20°C.

If the resistance is outside of the specification renew the rotor as detailed in the following overhaul section.

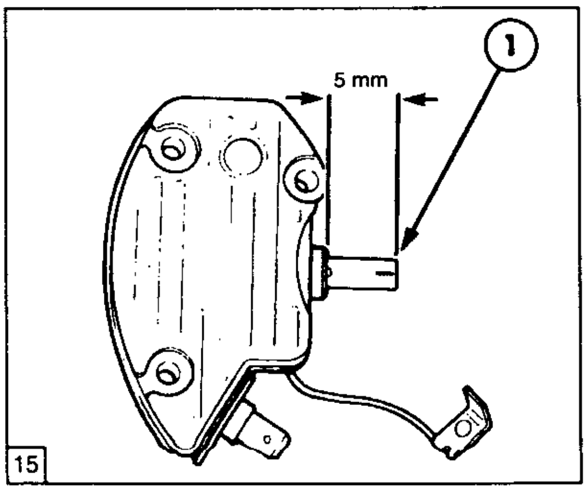
3. Brushes–and–Springs and Rotor Slip Rings

1. Remove the regulator and brushbox assembly as described in this Chapter.

2. Ensure the brushes and slip rings are clean and check for freedom of movement of the brushes in the brushbox moulding.

3. Check the brush spring pressure with a push type spring gauge and record the spring pressure when the brush end face is flush with the moulding. Install a new regulator and brushbox assembly if the pressure is less than specified.

If the visible length of the brushes in the free position is less than 0.25 in. (5mm) this is a probable cause of open circuit in the field circuit and the regulator and brushbox assembly should be renewed, Figure 15.



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Regulator and Brushbox Assembly
(55 Amp Shown, 100 Amp Similar)

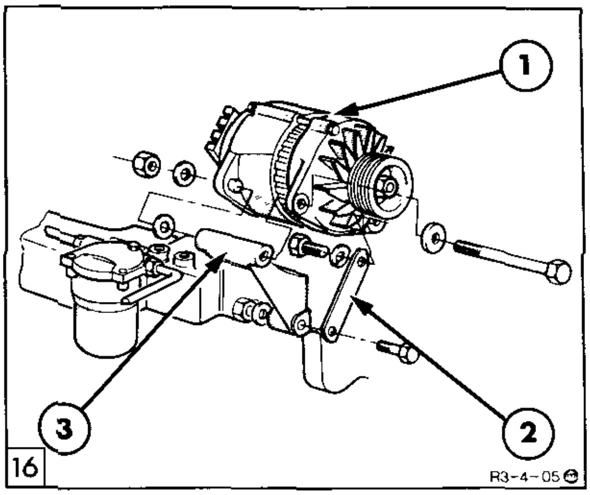
1. Brushes

NOTE: *The brushes are an integral part of the regulator and brushbox assembly and cannot be replaced as individual items.*

C. ALTERNATOR OVERHAUL AND COMPONENT TESTING

Alternator Removal

With reference to Figure 16



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Alternator Installation
(Same Installation for 100 Amp and 55 Amp Alternators)

1. Alternator Assembly
2. Arm
3. Engine Bracket

1. Disconnect the battery negative cable.

2. Disconnect the five cables from the rear of the alternator.

3. Remove the alternator drive belt in the following manner. Place a lever with socket attachment, onto the tensioner retaining bolt and gently lever the tensioner up, Figure 5. Remove the fan belt from the pulley, and allow the tensioner to return to its untensioned position once the belt has been removed.

4. Remove the alternator arm and the lower mounting through bolts and remove the alternator from the tractor.

Disassembly – 100 Amp Alternator

With reference to Figure 17

1. Remove the three nuts securing the plastic end cover.

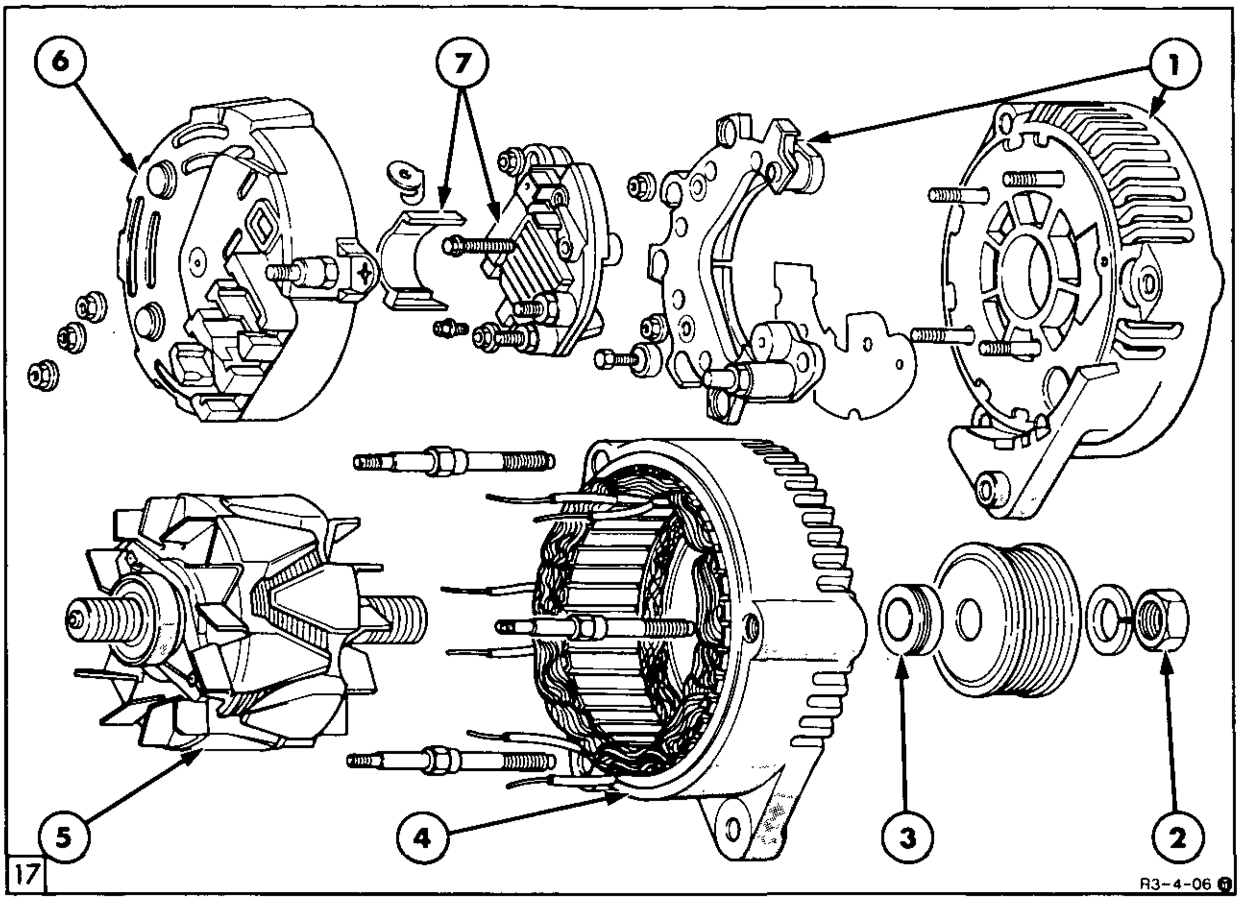
2. Remove the nut securing the blue wire to the warning lamp terminal and disconnect the wire. Remove the two bolts and two nuts securing the regulator and brushbox assembly, withdraw the assembly from the alternator.

3. Using a suitable soldering iron, unsolder the six wires from the stator to rectifier.

4. Remove the three nuts securing the two halves of the outer casing. Mark each half of the casing to aid reassembly and carefully pull the casing apart, it may be necessary to gently tap the casing on the mounting lugs.

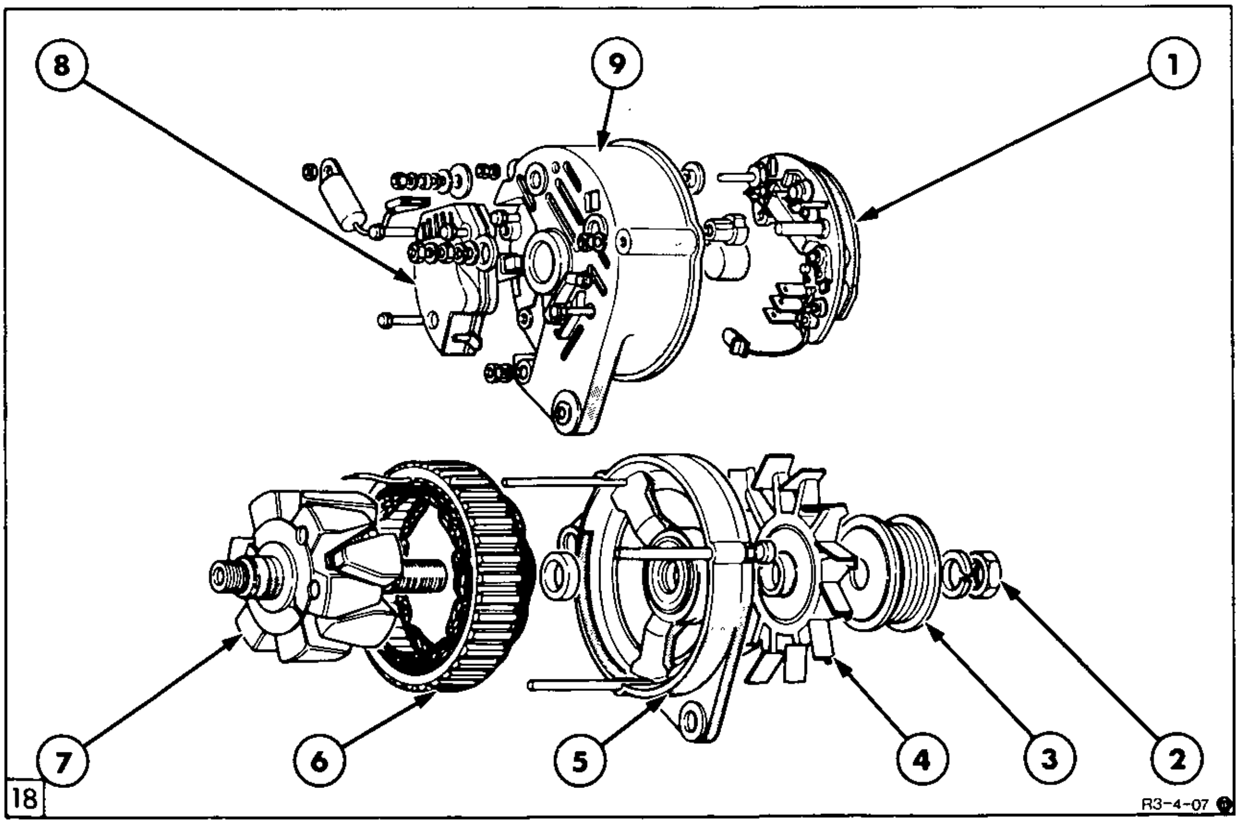
5. Remove the nut securing the pulley to the rotor shaft and withdraw the rotor from the casing.

6. *It is not necessary to remove the rectifier* from the casing as these are serviced as one unit.



100 Amp Alternator Components

1. Rectifier and Housing Assembly
2. Pulley Retaining Nut
3. Spacer
4. Stator and Housing Assembly
5. Rotor Assembly
6. End Cover
7. Regulator and Brushbox Assembly



55 Amp Alternator Components

1. Rectifier assembly
2. Pulley Retaining Nut
3. pulley
4. Cooling Fan
5. Front End Housing
6. Stator
7. Rotor
8. Regulator and Brushbox assembly
9. Rear End Housing

Disassembly – 55 Amp Alternator

With reference to Figure 18.

1. Remove the four nuts securing the terminal block to the alternator.

2. Remove the nut from the temperature sensor terminal block.

3. Remove the three securing bolts and withdraw the regulator/brushbox assembly.

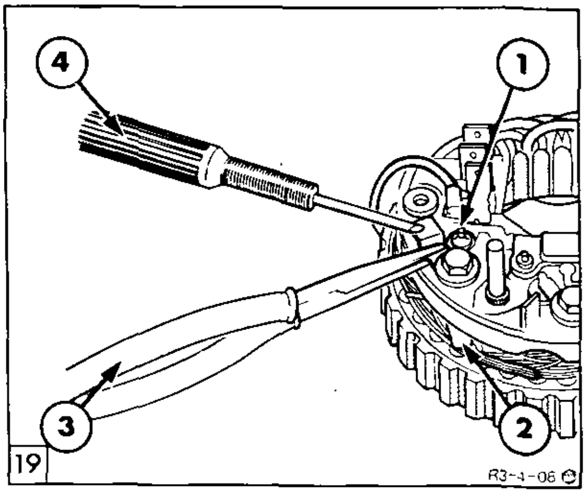
4. Unscrew and remove the remaining three nuts from the alternator through bolts. With a soft mallet tap the threaded end of the through bolts to release the spline at the hexagon head end.

5. Mark the alternator front end bracket, stator and rear end bracket to ensure correct alignment on reassembly.

6. Gently tap the rear face of the alternator front end bracket to separate the front end bracket and rotor assembly from the rear end bracket, stator and rectifier assembly.

7. Remove the nuts, washers and insulators from the stud terminals on the alternator rear end bracket and the two rectifier retaining screws. Remove the stator and rectifier from the rear end bracket.

8. Unsolder the stator leads from the tags on the rectifier, using a pair of pliers as a heat sink to prevent the diodes from overheating. See Figure 19.



Diode Soldering – 55 Amp Alternator

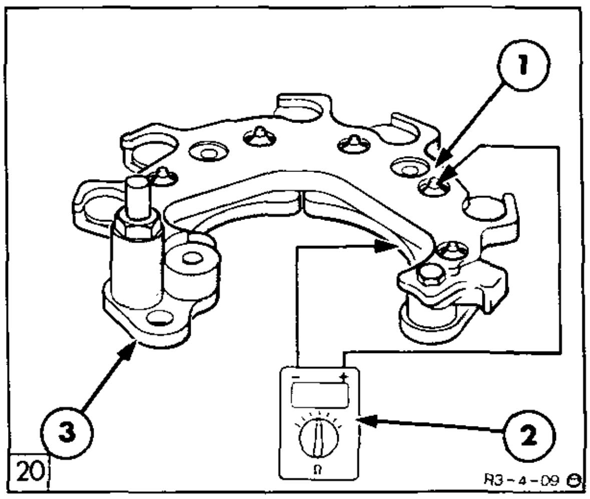
1. Diode
2. Stator Output Wire
3. Pliers Between Diode and Solder Point
4. Soldering Iron

9. Remove the nut, washer, pulley, fan and spacer from the rotor shaft.

10. Press the rotor shaft out of the front end bracket bearing.

COMPONENT TEST

Rectifier Assembly – Diode Testing 100 Amp Alternator



Diode Testing – 100 Amp Alternator

1. Diode Pin
2. Multimeter
3. Lower Plate, two halves

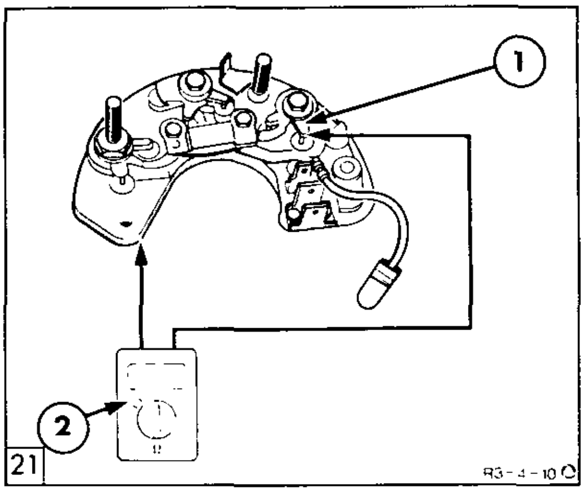
With reference to Figure 20.

1. Test each of the nine diodes separately, using a multimeter with a diode check facility or a multimeter set on the resistance scale.

2. Connect one test lead onto the lower plate and the other to the diode pin.
   On a multimeter with the diode check facility, note if a reading of 0.49 (volts) is shown. Reverse the test lead connections. The meter should indicate 0.49 (volts) during one half of the test and 0 volts with the leads reversed. Repeat this test on all nine diodes. If any one diode fails this test it will be necessary to replace the rectifier and housing assembly.

3. Where only an ohmmeter is available repeat the above test observing the following results, 0 ohms with leads in one direction and when the test leads are reversed a reading of between 900–1000KΩ, again if any one diode fails this test it will be necessary to replace the rectifier and housing assembly.

Rectifier Assembly – Positive / Negative Diode Testing 55 Amp Alternator



Output Diode Test

1. Diode Connecting Pin
2. Multimeter

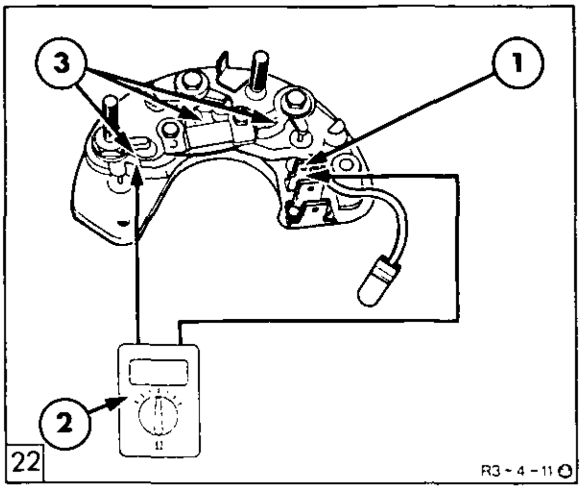
With reference to Figure 21. Test each of the six diodes separately as follows:

1. Connect a multimeter in series with one of the diodes. One test lead is applied to the diode connecting pin and the other lead to the plate into which the diode is mounted.

2. Note the resistance shown on the multimeter. Reverse the test lead connections.

3. The multimeter should indicate an open circuit (infinity ohms) during one half of the test only. If any one diode fails this test the complete rectifier will need replacing.

Rectifier Assembly – Field Diode Testing 55 Amp Alternator



Field Diode Test

1. D+ Terminal Connection
2. Multimeter
3. Field Diode Connections

With reference to Figure 22. Test each field diode separately as follows:

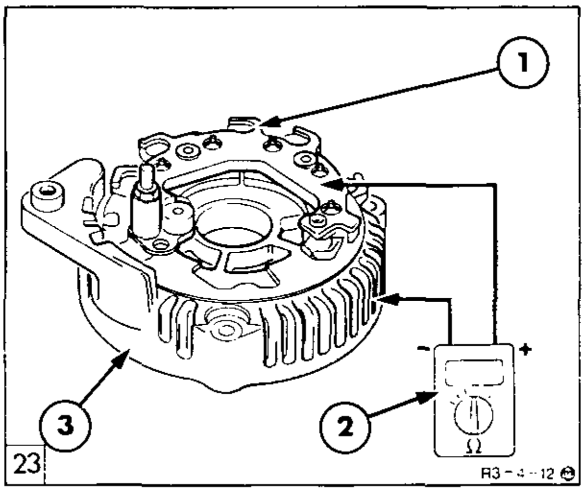
1. Connect a multimeter in series with the field diode module. Apply the negative test lead to the D+ terminal connection and the other lead in turn to each of the field diode connections.

2. Note the resistance shown on the multimeter. Reverse the test lead connections.

3. The multimeter should indicate an open circuit (infinity ohms) during one half of the test only. If any one diode fails this test the complete rectifier will need replacing.

Rectifier Insulation 100 Amp Alternator

With reference to Figure 23.



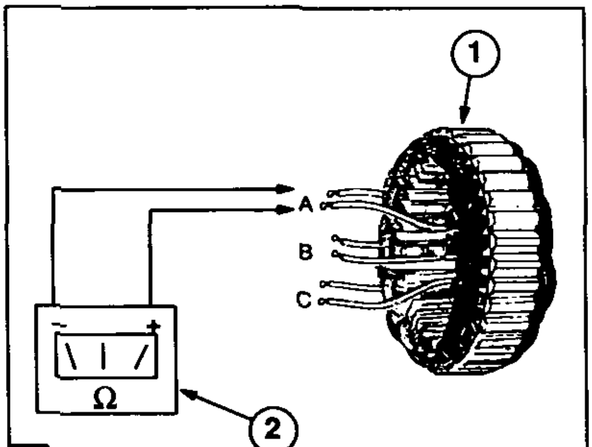
Insulation Testing 100 Amp Alternator

1. Rectifier
2. Multimeter
3. End Housing

1. Check the insulation of the rectifier to the casing. With an ohmmeter, connect the test leads between the alternator casing and the positive plate of the diodes. An infinity reading should be displayed, therefore indicating an open circuit. If a resistance of any kind is indicated, i.e, a short circuit, the rectifier and housing assembly should be replaced.

Stator Test – Winding Continuity
100 Amp Alternator

With reference to Figure 24.



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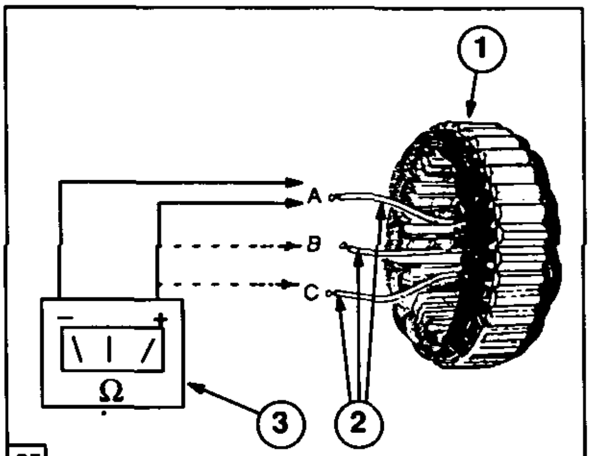
Stator Winding Continuity 100 Amp Alternator

1. Stator Assembly
2. Ohmmeter

1. Connect the ohmmeter test leads between the pairs of wires, A, B and C. There should be a small resistance of 0.1Ω, between each pair of wires. If a resistance higher than this is registered it will indicate a possible break within the winding, i.e, an open circuit. A lower reading, for example 0.0Ω will indicate a short circuit within the winding. If any one of the three pairs of wires fail the test a new stator and housing assembly will be required.

Stator Test – Winding Continuity
55 Amp Alternator



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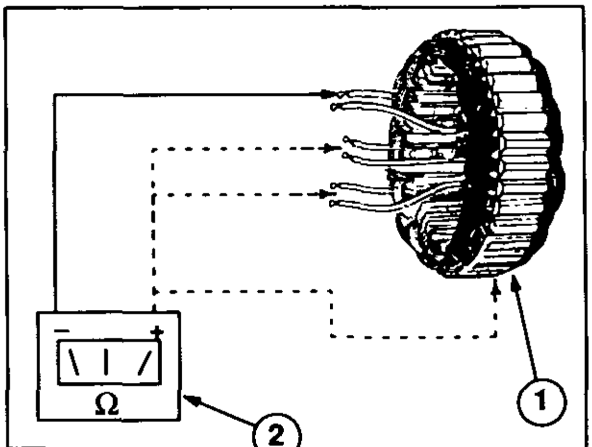
Stator Winding Continuity 55 Amp Alternator

1. Stator Assembly
2. Stator Output Wires
3. Multimeter

1. Connect the ohmmeter test leads between the A, B and C wires. There should be a small resistance of 0.1Ω, between each of the wires. If a resistance higher than this is registered it will indicate a possible break within the winding, i.e, an open circuit. A lower reading, for example 0.0Ω will indicate a short circuit within the winding. If the test proves unsatisfactory a new stator and housing assembly will be required.

Stator Test – Insulation
100 Amp Alternator

With reference to Figure 26.



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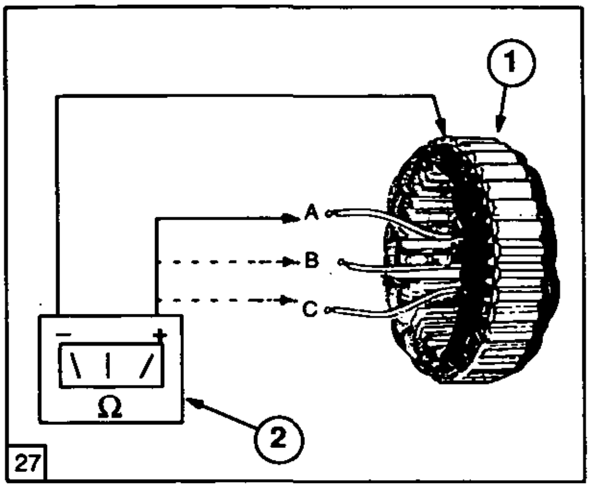
Stator Insulation Testing 100 Amp Alternator

1. Stator Assembly
2. Ohmmeter

1. Check the insulation of each pair of windings to each other and then each pair to the alternator casing. There should be no continuity between the three pairs of windings and no continuity to the casing. If any reading other than open circuit is indicated in any test it will be necessary to replace the stator and housing assembly.

Stator Test – Insulation
55 Amp Alternator

With reference to Figure 27



Stator Insulation Testing 55 Amp Alternator

1. Stator Assembly
2. Ohmmeter

1. Check the insulation of each winding to the alternator casing. There should be no continuity between the winding and the casing. If any reading other than open circuit is indicated it will be necessary to replace the stator assembly.

Rotor Test

Prior to performing component tests on the rotor the following slip ring inspection should be carried out.

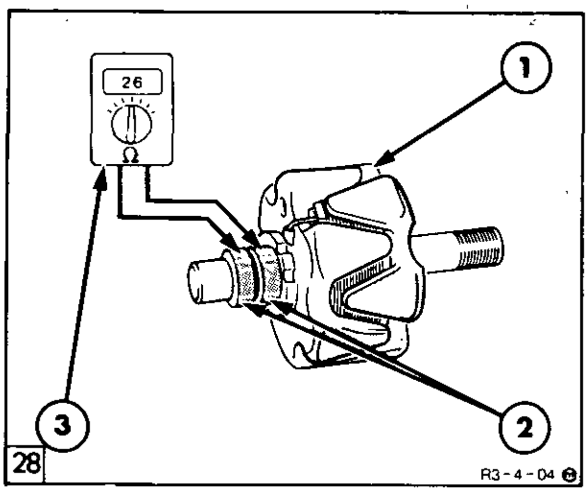
1. Ensure the slip rings are clean and smooth. If necessary the slip rings may be cleaned with a petrol moistened cloth. If the slip rings are burnt and require re–finishing use very fine glass paper (not emery cloth) and wipe clean.

NOTE: *Ensure the re–finishing glass paper is sufficiently fine to produce a highly polished slip ring surface otherwise excessive brush wear will occur.*

2. If the slip rings are excessively worn a new rotor must be installed.

Rotor Field winding Continuity

with reference to Figure 28



Rotor Field Winding Continuity Test

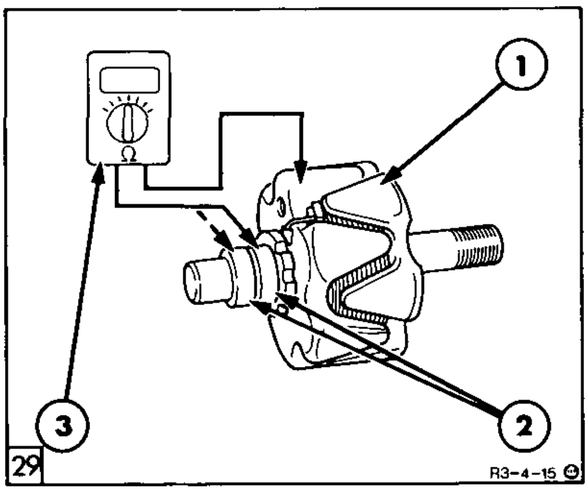
1. Rotor
2. Slip Rings
3. Ohmmeter

1. Connect an ohmmeter between the two slip rings. The resistance should read 2.6 ohms at 20°C.

If the resistance is outside of the specification renew the rotor.

Rotor Field Winding Insulation

With reference to Figure 29.



Rotor Field Winding Insulation Test

1. Rotor Assembly
2. Slip Rings
3. Ohmmeter

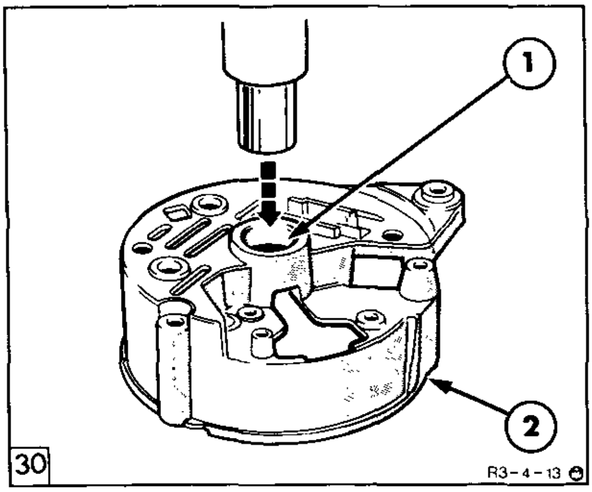
1. Using an ohmmeter test between each of the slip rings and the rotor poles. An infinity reading should be indicated in each case. If any resistance reading is indicated the rotor assembly must be replaced.

INSPECTION AND REPAIR

1. Inspect the rotor poles and stator for signs of rubbing. Areas of rubbing indicates possible worn bearings, misaligned housings or a bent rotor assembly shaft.

NOTE: *Both end bearings of the 100 Amp alternator and the front bearing of the 55 Amp alternator are not serviced separately. It will be necessary to either obtain a new rectifier and housing or stator assembly to renew worn bearings.*

2. Inspect the roller bearing of the 55 Amp alternator located in the rear (slip ring) end bracket for wear and damage

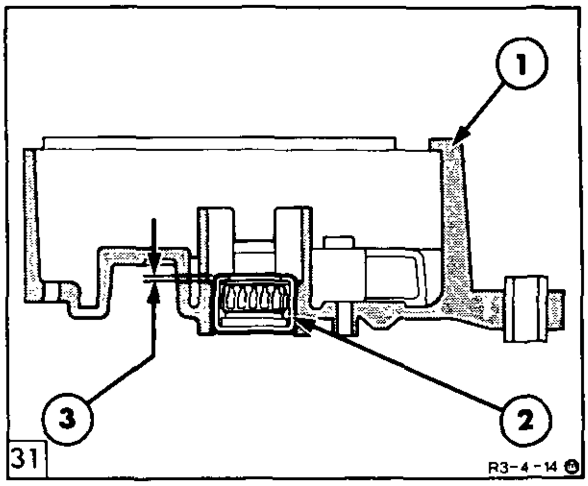


Rear End Bearing Removal (55 amp alternator)

1. Bearing
2. Housing (Rear End Bracket)

3. If bearing replacement is necessary support the housing (rear end bracket) and using a suitable size mandrel carefully drive out the bearing, Figure 30.

4. Clean and examine all components.



Rear End Bearing Installation

1. Housing
2. Bearing
3. Bearing Protrusion

5. Press the new bearing into the housing. The bearing should be positioned .020–.028in (0.50–0.70mm) proud of the inner face of the bearing boss as shown in Figure 31.

RE–ASSEMBLY

1. Re–assembly of the alternator follows the disassembly procedure in reverse.

On reassembly of the 55 Amp alternator observe the following:

- To avoid misalignment of the end brackets, install the stator assembly in the drive end bracket then assemble the slip ring end bracket to the stator laminations.

INSTALLATION

1. Installation of the alternator is the removal procedure in reverse.

On installation observe the following:

- Ensure the battery ground (negative) cable is disconnected from the battery when installing the alternator.

- Adjust the alternator drive belt as previously described in this Chapter.

D. SPECIFICATIONS

	Alternator Type	
	A127–55	A127–100
Polarity	Negative Ground	
Nominal Voltage	12.0 v	
Maximum Rev/Min.	15,000	18000
Maximum Output	55 Amps	100 Amps
Regulator Controlled Voltage	13.6 – 14.4 v	
Rotor Field Winding Resistance	2.9Ω	2.6 Ω
Stator Field Winding Resistance	0.2Ω	0.75 Ω
New Brush Length	20.0 mm	
Minimum Brush Length	5.0 mm	
Brush Spring Pressure	1.3–2.7 N (4.7–9.8 oz)	

TORQUE SPECIFICATIONS

	lbf.ft	Nm
Alternator Through Bolts	4.0	5.5
Pulley Retaining Nut	27.5	37.5
Rectifier Attaching Screws	2.5	3.5
Regulator and Brushbox Screws	2.0	4.0
Terminal Nuts	2.0	4.0

PART 3
ELECTRICAL SYSTEMS
Chapter 5
STARTING SYSTEMS

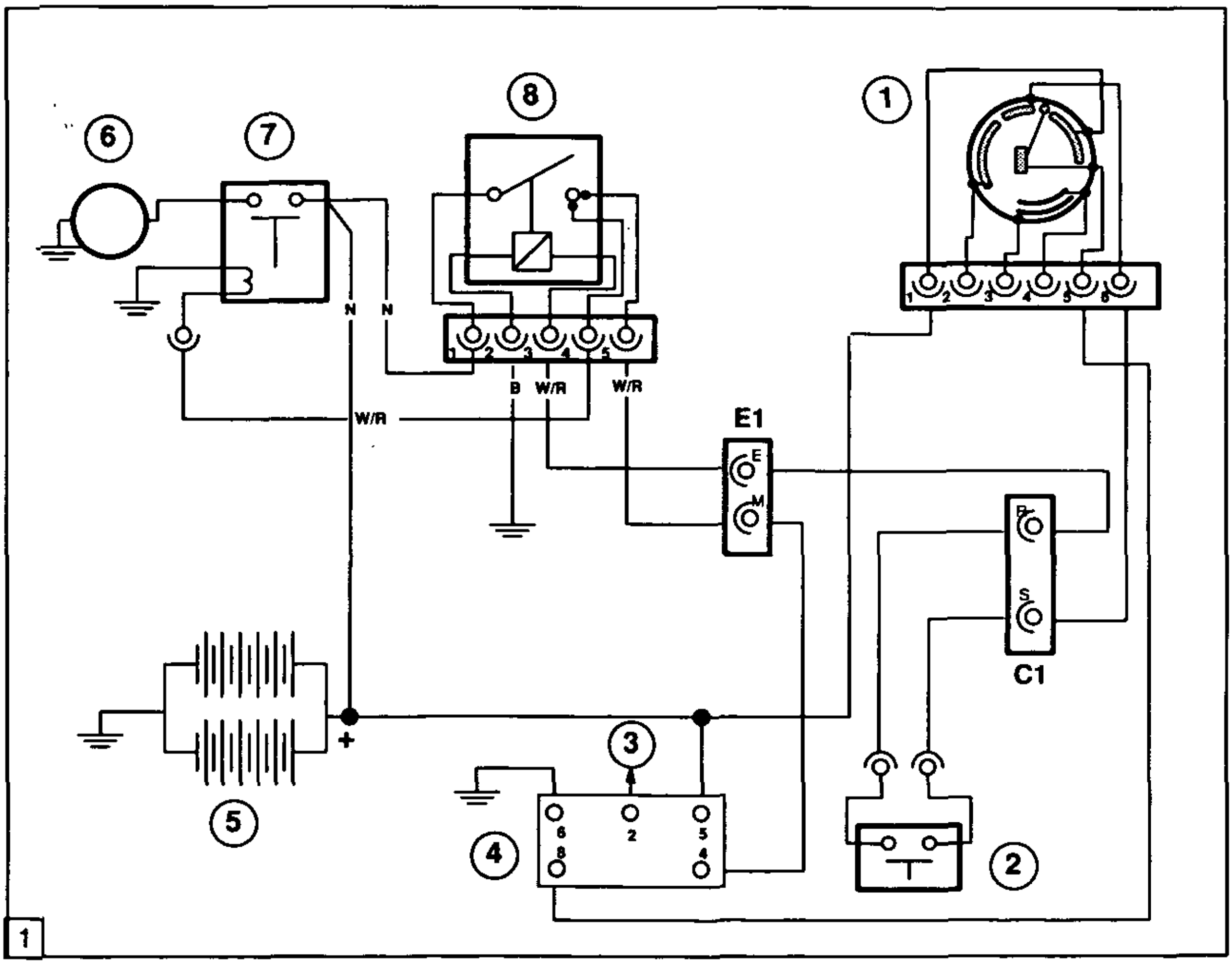
A. INTRODUCTION

The starting system consists of a starting motor and solenoid assembly, a starting relay, a transmission neutral start switch, located in the transmission top cover, heavy duty circuit wiring and a key start switch.

There are two starting motors fitted to the Series 40 range. A 3.6 Kw rated motor for 6 cylinder models and a 3.1 Kw rated motor for 4 cylinder models. Both are four pole four brush type starters with integral solenoid and positive engagement drive assembly.

The integral solenoid incorporates two windings connected in parallel. One winding is the low resistance 'pull–in' coil, grounded through the motor, while the other is the high resistance 'hold–in' coil grounded via the solenoid body.

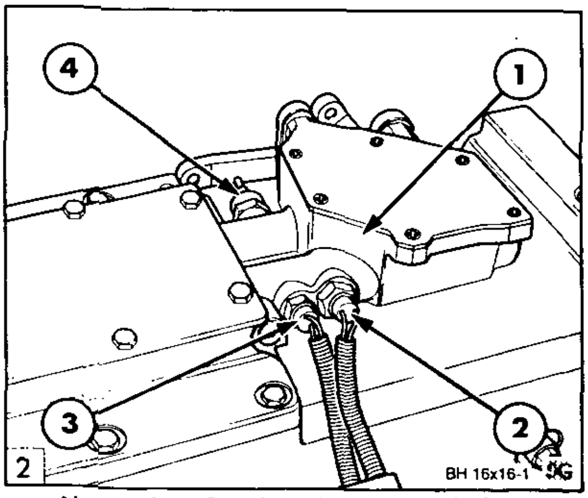
When the key start switch is closed with the transmission in neutral the solenoid coils are energised and the solenoid plunger is magnetically attracted into the solenoid core. This movement, transmitted through a pivoted linkage mechanism forces the drive pinion



1

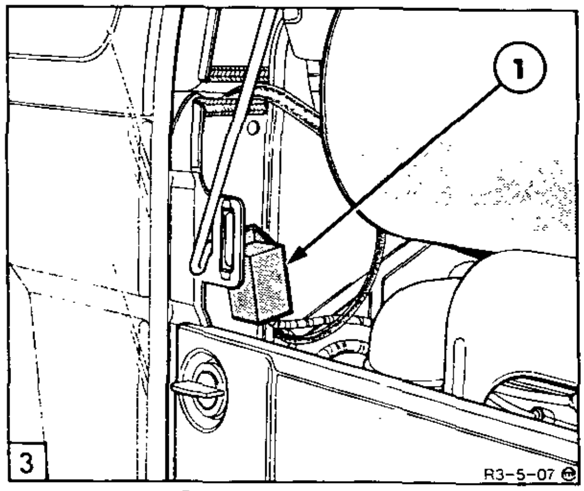
Starter Circuit

1. Key Start Switch
2. Transmission Neutral Start Switch
3. To Thermostart
4. Thermostart Relay, VII
5. Battery
6. Starter Motor
7. Starter Solenoid
8. Starter Relay



Neutral Start Switch – 16x16 Transmission

1. Transmission Top Cover
2. Main Range (5–8) Switch
3. Main Range (1–4) Switch
4. Forward/Reverse Shift (Neutral) Switch



Starter Relay Location

1. Starter Relay

into mesh with the flywheel ring gear. On full engagement, the solenoid plunger closes a set of contacts to give a direct feed from the battery to all four field coils, providing full power to the starting motor.

At this point one end of the 'pull–in' coil is connected to battery positive through the starter switch while the other end is connected to positive through the solenoid contacts. The 'pull–in' coil is thus by–passed, drawing no current and the 'hold–in' coil alone keeps the solenoid plunger engaged.

The starter incorporates a single set of contacts and a two piece solenoid plunger which completely closes the contacts even if the pinion and ring gear teeth are misaligned. When this happens, an engagement spring is compressed which forces the pinion into full engagement as soon as the starter begins to turn.

When the key start switch is released, power to the solenoid and motor is removed. The solenoid return spring acting through the pivoted linkage mechanism pulls the drive pinion out of mesh and reopens the solenoid contacts.

Incorporated in the drive pinion assembly is a roller clutch device. This device prevents the armature from rotating excessively if the pinion remains in mesh with the flywheel ring gear after the engine has started.

B. SYSTEM TESTING

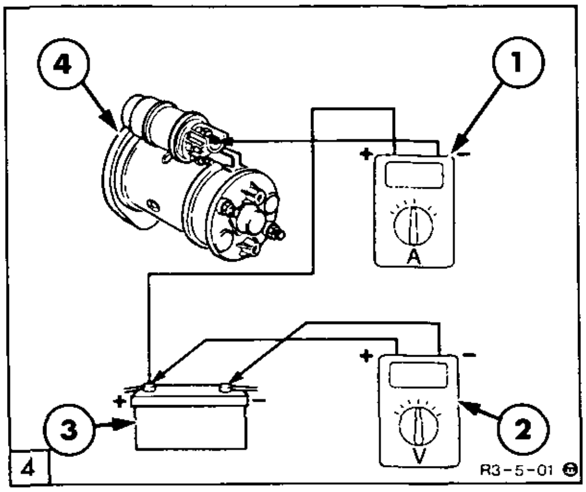
For easier and rapid diagnosis and for most conclusive test results, it is recommended that a battery–starter tester (high rate discharge tester) incorporating a 0–20 volt voltmeter and a 0–500 amp ammeter be used to diagnose starting system problems.

When using test equipment follow the manufacturers recommended test procedures. If test equipment is not available the following test procedure, using a standard 0–20 volt voltmeter and 0–500 amp ammeter can be used to determine the correct operation of the starter without removing it from the engine.

Before testing:

- Check that the battery is fully charged.
- Check the complete starting system wiring circuit for frayed or broken wires or loose terminal connections.
- Check the engine is not seized.

Starter Motor Circuit Current Draw



Circuit Current Draw Test

1. Ammeter
2. Voltmeter
3. Battery
4. Starting Motor

1. Disconnect the Battery ground (negative) cable from the battery.

2. Disconnect the battery positive cable from the starter solenoid. Connect the ammeter positive lead to the battery positive terminal and the negative lead to the solenoid input terminal.

3. Reconnect the battery ground (negative) cable to the battery negative terminal.

4. Connect the voltmeter positive lead to the battery positive terminal and the voltmeter negative lead to the battery negative terminal.

5. Disconnect the wire from the fuel injection pump shut off solenoid.

6. Crank the engine while observing the voltmeter and ammeter readings. The voltage should remain steady at around 12 volts with between 250–300 amps being drawn.

- If the current draw is within specification the starting motor is functioning correctly. If the voltage drops during the test proceed to 'Starting System Circuit Resistance'.

- If the current draw is greater than specified, check the circuit as outlined below. If the starting system circuit tests are satisfactory the starting motor is defective and must be disassembled to determine the cause.

- If the current draw is less than specified, the starting motor is defective and must be disassembled to determine the cause.

Starting System Circuit Resistance (Voltage Drop)

If there is an excessive current draw the circuit should be checked by recording voltage drops across the individual components in the circuit

IMPORTANT: *Disconnect the fuel injection pump fuel shut off solenoid wire.*

Battery Positive Cable:

1. Connect the voltmeter positive lead to the battery positive terminal.

2. Connect the voltmeter negative lead to the starting motor solenoid battery terminal.

3. Crank the engine while observing the voltmeter reading. If the voltage exceeds 0.2 volts, check and tighten the cable connections. Recheck the voltage, if still excessive install a new cable.

Starting Motor Ground Connections:

1. Connect the voltmeter positive lead to the starting motor frame.

2. Connect the voltmeter negative lead to the engine block.

3. Crank the engine while observing the voltmeter reading. If the voltmeter reading exceeds 0.2 volts check the ground connections between the starting motor flange and the rear engine plate.

Battery Ground Cable:

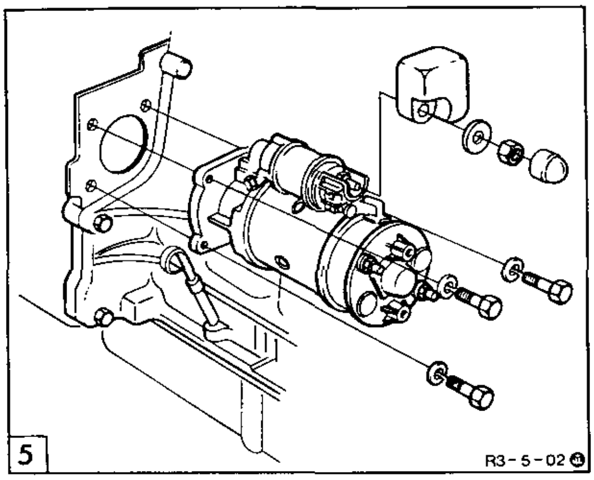
1. Connect the voltmeter positive lead to the engine block.

2. Connect the voltmeter negative lead to the battery negative terminal.

3. Crank the engine while observing the voltmeter reading. If the reading exceeds 0.2 volts, check and tighten the ground cable connections. Recheck the voltage, if it is still excessive install a new ground cable.

STARTER MOTOR REMOVAL

If a starting motor failure is suspected, perform the starting motor tests, as outlined in this chapter, before removing the starting motor. To remove the starting motor proceed as follows:



Starter Installation

1. Disconnect the battery ground (negative) cable from the battery.

2. Remove the protective cover from the solenoid assembly and disconnect the positive cables to the solenoid and the solenoid coil feed wire.

3. Remove the three starting motor mounting bolts and remove the starting motor.

DISASSEMBLY

With reference to Figure 6.

1. Support the starting motor in a soft jawed vice.

2. Disconnect the thick braided wire from the field coil housing to the solenoid assembly.

3. Remove the three screws from the front housing assembly and withdraw the solenoid assembly. Note that the plunger will remain in the drive engagement lever.

4. Remove the solenoid plunger from the drive engagement lever by gripping the plunger and lifting up the front end and releasing it from the drive engagement lever.

5. Remove the two end housing nuts and the two screws retaining the end cap and brush plate to the end housing. Remove the 'C' clip and armature shaft end play shims and withdraw the end housing, leaving the brush gear on the commutator. Remove the thin metal washer from the commutator end of the armature.

NOTE: *At this stage of disassembly inspect the brushes and commutator as detailed under the 'inspection and repair bench test' heading and determine if these are the cause of failure. Further inspection details follow.*

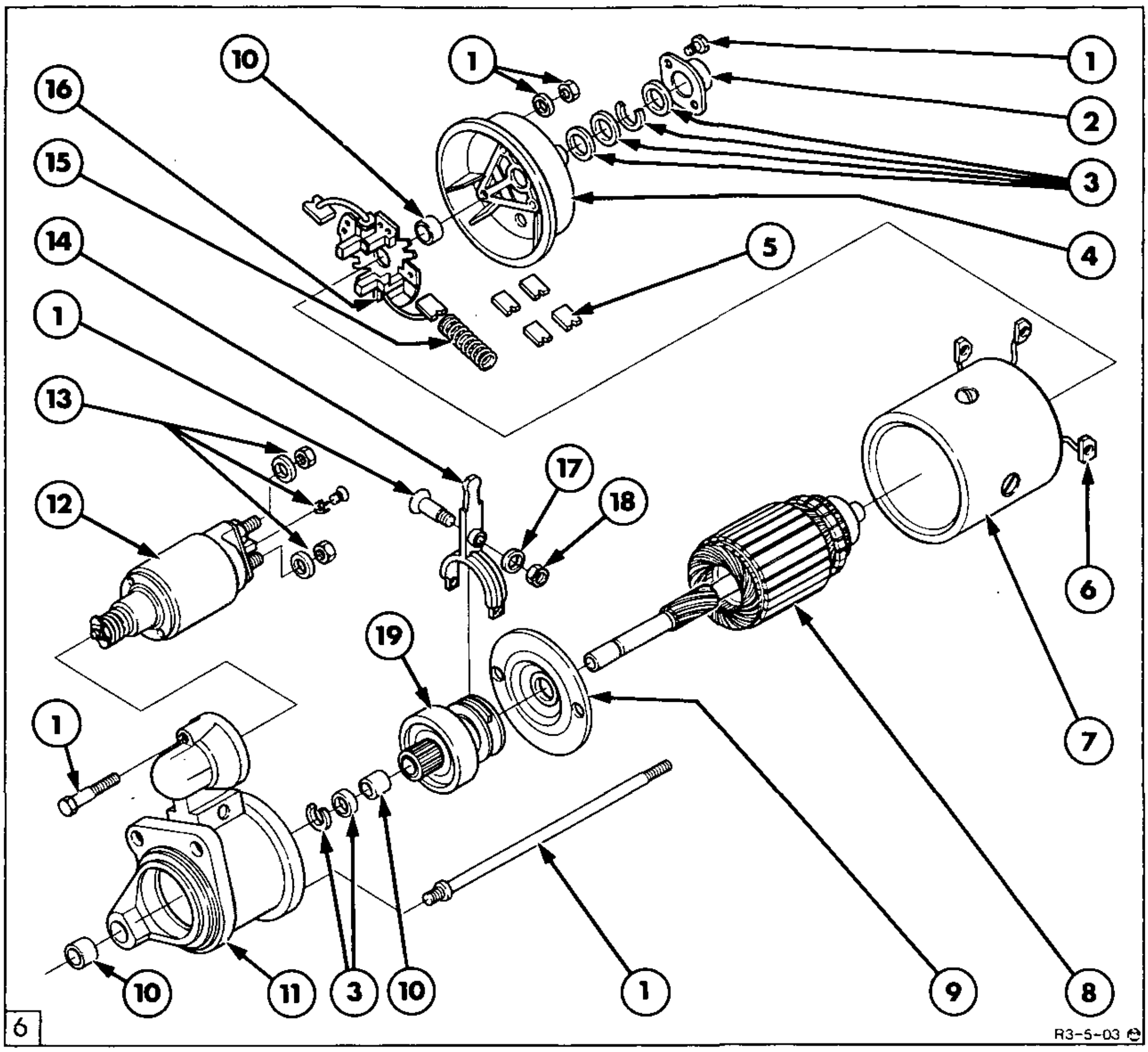
6. To remove the brush carrier and brushes it is necessary to compress the brush springs, a screwdriver through the spring coil, and bend back the spring retaining tabs. Gently release the spring and withdraw the brush from the holder. With the four brushes removed withdraw the carrier.

7. Withdraw the motor casing from the armature and drive end bracket.

8. Withdraw the drive engagement lever pivot pin from the drive end housing.

9. Remove the drive assembly and inner plate retaining snap ring from the armature shaft by driving the securing thrust collar squarely off the snap ring with a suitable diameter tube and then levering the snap ring from the groove.

10. Withdraw the armature and drive assembly.



Starter Motor – Exploded View

1. Stud and Bolt Kit
2. End Cap
3. Collar and Ring Assembly, Drive Thrust
4. Brush End Plate Assembly
5. Brush Assembly
6. Brush Assembly
7. Field Coils and Housing Assembly
8. Armature
9. Centre Bearing Plate
10. Bushing
11. Housing Assembly
12. Solenoid Assembly
13. Solenoid Hardware Kit
14. Lever Assembly
15. Brush Spring
16. Brush Holder Assembly
17. Washer
18. Nut
19. Drive Assembly

INSPECTION AND REPAIR BENCH TEST

Brushgear

1. Check for sticking brushes. If necessary, clean brushes and brush channels with a petrol moistened cloth.

2. Check brushes for wear. If worn below the minimum length specified, of 7.00mm, they should be renewed.

Brush Removal and Installation

1. Unsolder the field brush leads from the field coils.

2. Unsolder the ground brush leads from the brush holders.

3. Install the new brushes, soldering the leads using a 300 watt soldering iron and resin core solder.

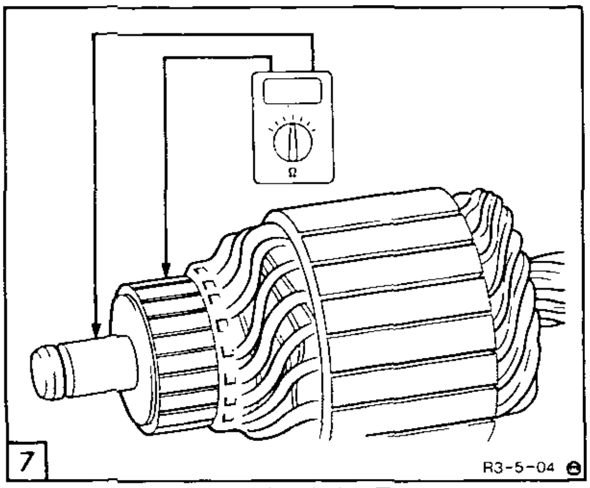
4. Ensure the new brushes move freely in the holders. If necessary, smooth the sides of the brushes with a fine abrasive or smooth file.

Armature Tests

1. The commutator face should be clean and free from burnt spots. If necessary remove any burnt spots using fine glass paper, not emery cloth. Finally clean the commutator with a petrol moistened cloth.

2. If it is necessary to skim the commutator ensure the diameter is not reduced below the *minimum specified diameter* of 42.5mm. Following skimming the commutator should be polished with a fine glass paper and then wiped clean with a petrol moistened cloth.

NOTE: *Do not cut into the commutator metal when recutting insulation slots.*



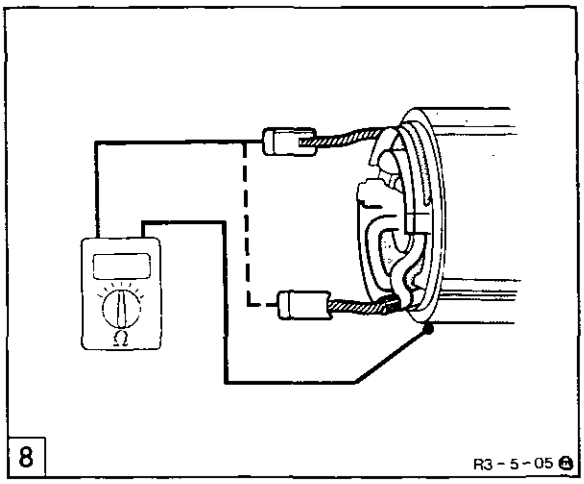
Armature Insulation Test

3. Armature insulation can be checked by connecting an ohmmeter between the commutator segments and the armature shaft. There should be an infinity reading, i.e, no continuity. Figure 7.

4. To test the armature for short circuits it is necessary to use suitable armature testing equipment, the only alternative is to check the armature by substitution.

5. If there is evidence that armature limitations have been in contact with pole pieces, then the armature bearings are probably excessively worn. First check that the pole pieces are tight and that the armature runs true in a lathe, then if necessary renew the armature bearings.

Field Coil Tests



Testing Field Coil Insulation

1. To test the insulation of the field coils connect an ohmmeter in turn between each of the field winding brushes and a clean unpainted part of the housing. There should be no reading, i.e, no continuity.

2. To test the field winding continuity connect an ohmmeter in turn between each of the field winding brushes and the main feed terminal (thick braided wire). A reading of 1 MΩ should be indicated.

3. If a fault is indicated in the field windings it will be necessary to replace the complete field coils and housing assembly.

Bearing Bushes

1. Inspect the bushes in the brush end plate assembly and pinion drive end housing for wear. Install the armature shaft and observe the free play, replace bushes wear free play appears excessive. Inspect the field poles for signs of rubbing *by the armature which may also have* been caused by worn bushes.

Drive Pinion Assembly

1. Check the operation of the roller clutch. The pinion should rotate clockwise only. If the pinion is stuck or rotates in both directions, or if the pinion teeth are damaged install a new drive assembly.

If damaged pinion teeth are evident, check the flywheel ring gear teeth as described in Part 1, Engine Systems.

RE–ASSEMBLY

1. Re–assembly of the starting motor follows the disassembly procedure in reverse.

Prior to installation, the armature end play must be checked and the starting motor no load function must be tested.

Checking the Armature End Play:

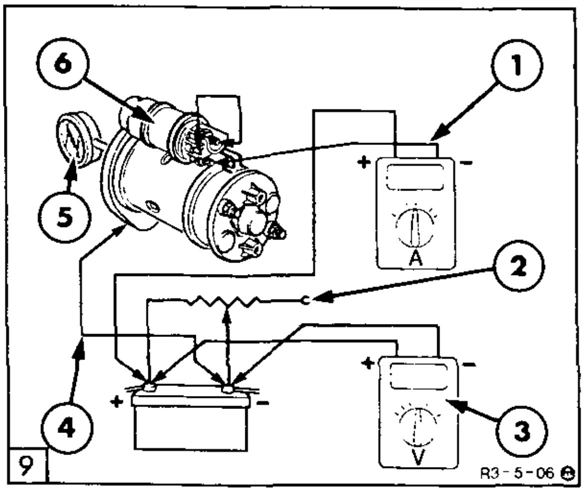
1. Secure the starting motor in a vice equipped with soft jaws and attach a dial indicator to the drive end housing flange. Locate the dial indicator pointer on the end of the armature shaft.

2. Lever the armature fully forward and zero the dial indicator. Lever the shaft fully rearwards and record the gauge reading.

3. The gauge reading should not exceed 0.4mm (0.015in). If the reading is greater, inspect the armature assembly and the brush end plate assembly for wear. Replace worn components as required and recheck the end play.

Starting Motor No–Load Test:

With reference to Figure 9.



Starting Motor No–Load Test

1. Ammeter
2. Variable Load Resistor
3. Voltmeter
4. Jumper Cable
5. Hand Tachometer
6. Jumper Lead

NOTE: *A fully charged battery and a battery starter tester (high rate discharge tester) with a carbon pile (variable load resistor) should be used to perform this test.*

1. Secure the starting motor in a vice equipped with soft jaws.

2. Connect the battery negative cable to the starting motor mounting flange.

3. Connect a short jumper lead between the solenoid battery and solenoid switch terminals.

4. Connect a voltmeter positive lead to the battery positive terminal, the voltmeter negative lead to the battery negative terminal, the ammeter positive lead to the battery positive terminal and the ammeter negative lead to the solenoid battery or starting motor terminal.

5. Hold a hand tachometer on the end of the armature shaft. Actuate the starting motor by adjusting the carbon pile to give 11.7 volts. When the armature rotates between 7500 and 8500 rev/min. the maximum current draw should not exceed 160 amperes.

6. If the starting motor does not perform to specification, check for grounded field coils, a rubbing armature or a distorted armature shaft.

C. FAULT FINDING

Engine Does Not Turn Over When Key Start Is Operated, Transmission In Neutral

Is the battery fully charged?
- NO → Charge or replace battery. Does engine turn over OK? — NO → Inspect starter circuit wiring (below)
- YES ↓

Inspect starter circuit wiring. Are all connections tight, is the battery negative to ground connection O.K, are any wires broken or frayed, possibly causing a short circuit?
- YES → Repair wiring as required
- NO ↓

Is the engine seized?
- YES → Investigate engine failure
- NO ↓

Operate key start switch, is there +12v at the starter solenoid input wire (white/red stripe)
- YES → Can the solenoid be heard 'clicking'?
  - YES → Suspect faulty motor windings, brushes or mechanical failure
  - NO → Suspect faulty starter solenoid, remove starter and inspect
- NO ↓

Inspect starter relay, operate key start switch, can the relay be felt/heard operating?
- YES → Replace relay
- NO ↓

Remove connector to relay is there +12v on pin 4, (white/red stripe wire) when the key start switch is operated?
- YES → Replace relay
- NO ↓

Inspect wiring to transmission inhibitor switch, are wires connected?
- NO → Reconnect wiring to switch
- YES ↓

Check operation of switch, is switch O.K.?
- NO → Replace switch
- YES ↓

Is there +12v on the white/yellow wire to the inhibitor switch?
- YES → Check continuity of the white/red wire from inhibitor switch to pin 3 at starter relay connector
- NO ↓

Is there continuity of white/yellow wire from inhibitor switch to key start switch, connector pin 6?
- NO → Repair/replace wiring
- YES ↓

Do the displays in the instrument panel illuminate when the key start is operated?
- NO → Check the main feed to the key start switch from the battery. Pin 1 of key start connector.
- YES ↓

Inspect the key start switch, if wiring to switch is O.K. replace switch

D. SPECIFICATIONS

	Starter Type	
	Bosch 3.1 Kw	Bosch 3.6 Kw
Maximum No Load Current Draw at 11.7 volts and 8000 rev/min.	160 amps	
Minimum Brush Length	7.00 mm (0.28 in)	
Minimum Commutator Diameter	42.5 mm	
Maximum Armature Shaft End Play	0.4 mm (0.015 in)	

TORQUE SPECIFICATIONS

	lbf.ft	Nm
Starting motor to Engine Block Retaining Bolts	25	34
Ground cable Starter End Housing (3.6 Kw Starters only)	11.8	16
Solenoid Cable nuts	5	7
Starting Motor End Housing Nuts	7	10
Solenoid Retaining Bolts	4	5

PART 3
ELECTRICAL SYSTEM
Chapter 6
BATTERY

A. BATTERY DESCRIPTION AND OPERATION

The Series 40 range of tractors feature a 12 volt, negative ground, lead acid type battery, of six cell construction.

A single 107 ampere hour at 20 hours, 800 c.c.a, (cold cranking amps) battery is the standard specified battery for all models, with the option of an additional battery, connected in parallel, of the same specification being available.

The battery for all with cab and 7840, 8240 and 8340 with and less cab models is located on a swing out tray located under the right hand foot steps. Less cab 5640, 6640 and 7740 models have the battery situated on a fixed tray bolted to the right hand side of the transmission in either a low or high mount location, depending on tractor specification.

The battery has four major functions:

- To provide a source of current for starting, lighting and instrumentation.
- To help control the voltage in the electrical system.
- To furnish current when the electrical demands exceed the alternator output.
- To support quiescent loads from radio and micro processor memory.

The battery is constructed in such a manner that each cell contains positive and negative plates placed alternatively next to each other. Each positive plate is separated from a negative plate by a non–conducting porous envelope separator. If any of the positive plates should make contact with negative plates within a cell, the cell will short circuit and suffer irreparable damage. All of the positive plates are welded to a bus–bar, forming a positive terminal and all of the negative plates are welded to a similar bus–bar forming a negative terminal.

Each positive plate is composed of a lead grid with lead peroxide pasted into the grid openings. The negative plates are composed of a lead grid with spongy lead pasted into the grid openings.

The plates are submerged in a liquid electrolyte solution of diluted sulphuric acid.

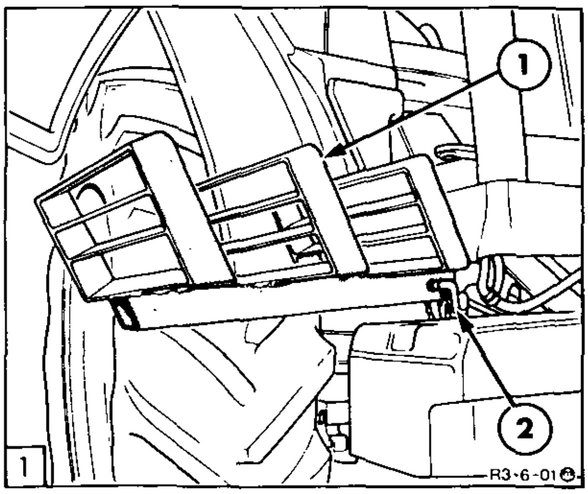
B. BATTERY MAINTENANCE AND TESTS

REMOVAL

1. All with cab and 7840, 8240 and 8340 with and less cab models:
   Remove the 'R' clip and withdraw the securing pin from the top of the steps. Raise the steps and replace the securing pin in the hole provided to hold the steps in the raised position, replace the 'R' clip.

2. Remove the thumb screw from below the toolbox, and remove the toolbox.

3. Remove the securing pin to the right of the battery tray and swing the tray out towards the engine.



Right Hand Footsteps (where fitted)

1. Steps in Raised Position
2. Securing Pin

The following instructions apply for battery removal of all models:

4. Unclip and remove the battery protective cover and securing strap.

5. Disconnect the battery terminals, negative (ground) first and lift the battery from the tray.

SPECIFIC GRAVITY

The specific gravity of the battery electrolyte indicates the state of charge. Fully charged the specific gravity of the electrolyte is 1.280 minimum at 25°C.

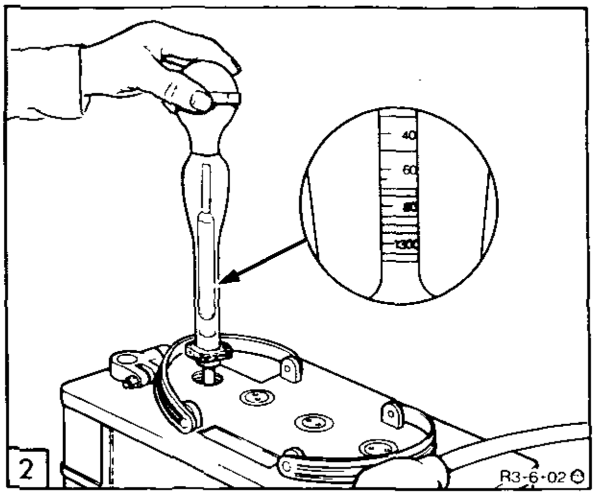
Alternatively the approximate state of charge can be measured by using an accurate digital volt meter (+/– 0.01V) as follows:–

Less than 10.5V Battery un–serviceable*
Less than 11.5V Battery discharged
Less than 12.2V Battery 1/2 charged
Better than 12.6V Battery fully charged

* See note under tests for possible recovery of a mildly sulphated battery.

Battery voltage to be taken with the battery unloaded and:–
A) After the battery has rested unloaded for at least 4 hours.
B) If the vehicle has recently run or battery has recently been charged, switch on head-lamps for 2 minutes.

When a battery discharges, sulphuric acid in the the electrolyte combines chemically with the plates and this action lowers the specific gravity of the solution.



Battery Hydrometer

A battery hydrometer shown in Figure 2, will determine the specific gravity of the electrolyte in a cell and the amount of unused sulphuric acid in the solution is a measure of the degree of charge of that cell.

The lower the temperature at which a battery is required to operate, the more necessary it is that the battery is maintained in a fully charged condition. For example a battery with a low specific gravity of 1.225 at 27°C (80°F) will operate the starting motor at warm ambient temperatures but may not, due to lower battery efficiency at a low temperature.

The following table shows the effect of temperature on the efficiency of a typical battery.

Temperature	Efficiency of a Fully Charged Battery
25.0°C (77.0°F)	100%
–4.5°C (23.9°F)	82%
–24.0°C (–11.2°F)	64%
–27.5°C (–17.5°F)	58%
–31.0°C (–23.8°C)	50%
–34.5°C (–30.1°C)	40%
–37.5°C (–35.5°C)	33%

Maximum battery life will be obtained if the correct care and periodic inspection is given. It is important that output capacity should not be exceeded by constant and excessive overloading and that charging requirements are maintained.

SERVICING THE BATTERY

When servicing a battery the following steps should be observed:

1. Maintain the electrolyte to the recommended level of 0.37 in (10 mm) below the filling funnel. If this is not observed the acid will reach a high concentration that will damage the separators and impair the performance of the plates.

2. Use only distilled or de–mineralised water, do not overfil and never use tap water or water from a rain barrel or other source.

3. Always keep the battery at least 75% charged otherwise the plates will become sulphated and loss of efficiency will result with possible damage from freezing at low temperatures.

4. Avoid overcharging the battery as excessive charging will create high internal heat that will cause plate grid deterioration and produce water loss.

5. When fast charging ensure the battery temperature does not exceed 65°C (149°F).

6. Do not add sulphuric acid to a cell unless the electrolyte has been lost through spilling. Before replenishing ensure the solution is at the correct specific gravity. A slow charge is the only method to be employed to fully charge a battery. A high rate charger can be used to quickly boost the battery capacity but this must be followed by a slow charge rate of 14 amps to bring the battery to full capacity.

DRY CHARGED BATTERIES

Dry charged batteries must be prepared for service as follows:

1. Remove the battery cell vent plugs.

2. Fill each cell to the recommended level with electrolyte of 1.260 specific gravity.

NOTE: *The electrolyte must be diluted sulphuric acid preferably at a temperature of 21°–32°C (70°–90°F).*

3. After filling, allow the battery to stand for 15 minutes then re–check the electrolyte level and top up if necessary.

4. Charge the battery for 4 hours at a rate of 5–8 amperes and check that all cells are gassing freely.

5. Install the battery cell vent plugs.

CHARGING THE BATTERY

Before charging a battery:

1. Thoroughly clean the battery casing and cell covers with dilute ammonia or hot water and clean the terminals.

2. Check the level of the electrolyte in each cell and, if below plates, add distilled water to bring above plate level.

3. With a slow charger use a rate of 3 to 6 amperes for the time necessary to bring the battery to full charge. This may take 36 hours or more if the battery is heavily discharged. A severely sulphated battery might not accept a charge. When the battery is fully charged the cells will gas freely and the specific gravity will remain constant. Remove the charger after three consecutive hydrometer readings taken at hourly intervals indicate that the specific gravity has stopped rising.

4. When using a fast or high rate of charge carefully follow the manufacturers instructions. High rate charging raises the temperature of the electrolyte and unless the charger is equipped with an automatic time or temperature device, the electrolyte temperature could exceed 65°C (149°F), which may cause violent battery gassing and damage to internal components.

5. Re–check the level of electrolyte in each cell and add distilled water as necessary.

WARNING: *When a battery is being charged an explosive gas is produced. Do not smoke or use an exposed flame when checking the electrolyte level and ensure the charger is switched off before connecting or disconnecting to avoid sparks which could ignite the gas.*

TESTS

Before commencing battery tests check the battery for clogged vents, corrosion, raised vent plugs or a cracked case.

Test equipment required:

- Hydrometer
- Battery starter tester (High rate discharge tester)
- Thermometer
- Battery Charger

Specific Gravity: This test will determine the state of battery charge.

1. With the float in the vertical position take the reading.

2. Adjust the hydrometer reading for electrolyte temperature variations by subtracting 4 points (0.004 specific gravity) for every 5.5°C (10°F) below the temperature at which the hydrometer is calibrated and by adding 4 points (0.004 specific gravity) for every 5.5°C (10°F) above this temperature.

The following examples are calculated using a hydrometer calibrated at 30°C (86°F).

Example 1:
Temperature below 30°C (86°F)

Electrolyte temperature	19°C (66°F)
Hydrometer reading	1.270
Subtract $\frac{11.0}{5.5}$ x 0.004	0.008
Corrected specific gravity =	1.262

Example 2:
Temperature above 30°C (86°F)

Electrolyte temperature	40°C (104°F)
Hydrometer reading	1.220
Add $\frac{10.0}{5.5}$ x 0.004	0.007
Corrected specific gravity =	1.227

3. Use the following table to determine the state of charge.

State of Charge	Corrected Specific Gravity @15°C	Corrected Specific Gravity @25°C	Average Battery Voltage
100%	1.295	1.287	12.76
75%	1.253	1.246	12.52
50%	1.217	1.210	12.30
25%	1.177	1.170	12.06
Discharged	1.137	1.130	11.84

NOTE: *Specific gravity should not vary more than 0.025 points between cells.*

4. If the specific gravity is 1.280 or more the battery is fully charged and in good operating condition.

5. Should the corrected specific gravity be below 1.280, charge the battery and inspect the charging system to determine the cause of the low battery charge.

NOTE: *If distilled water has recently been added the battery should be recharged for a short period otherwise accurate hydrometer readings will not be obtained.*

Performance Test: The performance test is to determine if the battery has adequate capacity to turn the engine. The voltage reading obtained is used to determine the battery condition. Prior to testing, ensure the electrolyte level is correct and the open circuit voltage is 12.5V or more. The battery may be tested on or off the tractor.

1. Set the current control switch of the battery starter tester (high rate discharge tester) to the 'off' position and the voltage selector switch equal to, or slightly higher than, the rated battery voltage. Connect the tester positive leads to the battery positive terminal and the negative leads to the negative battery terminal.

2. Turn the current control knob until the ammeter reading is half the CCA rating of the battery and take the voltage reading.

- If the reading is 9.6 volts or more after 15 seconds, the battery has an acceptable output capacity and will readily accept a normal charge.

- If however the reading is below 9.6 volts, the battery is considered unsatisfactory for service and should be test charged as described below.

CAUTION: *Do not leave the high discharge load on the battery for periods longer than 15 seconds.*

Test Charging: This test is designed only for batteries that have failed the previous capacity test.

1. Attach the battery starter (high rate discharge tester) positive leads to the battery positive terminal and the negative leads to the battery negative terminal.

2. Connect the battery charger positive lead to the battery positive terminal and the negative lead to the battery negative terminal.

3. Turn the charger timer past a '3 minutes' charge indication and then back to the '3 minutes' mark.

4. Set the charging rate as close as possible to 40 amperes.

5. After 3 minutes at this fast charge take the voltmeter reading.

- If the total voltage is over 15.5 volts the battery is unsatisfactory and is probably sulphated or worn out and should be replaced.

NOTE: *A mildly sulphated battery can be recovered by using a multiple battery type charger, with an open circuit upper voltage limit of 50 volts. Owing to the high resistance of a sulphated battery, it will primarily require a high voltage setting to overcome the resis-*

tance of the sulphation. initially there may be no visible acceptance of the charge. After a few minutes of inactivity a small charge will be apparent, followed by a rapid increase in the charge rate. The charge rate must not exceed 14.0 amperes or the electrolyte temperature 60°C (140°F). When the ampere rate has stabilised, reset the volts until the charge rate is a steady 5 amperes. Continue at this rate until the electrolyte specific gravity stops rising at approximately 1.275–1.280 at 20°C (68°F), this can take up to 48 hours of charging. Stand the battery for 24 hours and then conduct the capacity test detailed previously.

- If the total voltage is under 15.5 volts, test the specific gravity of each cell and re–charge the battery to the following scale:

Specific Gravity	Fast charge up to:
1.150 or less	60 minutes
1.151 to 1.175	45 minutes
1.176 to 1.200	30 minutes
1.201 to 1.225	15 minutes
	(Slow charge only)

NOTE: *When battery problems are experienced the fan belt tension and the complete charging system should be checked.*

BATTERY INSTALLATION

1. Installation of the battery is the removal procedure in reverse, observing the following points:

- Ensure that the battery is clean and dry and that the vent plugs are fully installed. Smear the terminals with petroleum jelly (vaseline or equivalent), do not use conventional lubricating greases as these can promote electrolytic corrosion.
- Ensure the battery tray and clamps are clean and free from stones or small objects which may puncture the battery casing.
- Ensure that the battery terminal polarity is correct and that the terminal connections are sufficiently tight, but not overtightened.
- The radio, if fitted, will lose its stored information and will require re–programming. It should be noted that on models with electronic instrument panel and micro–processor, that these components will not lose their memories, i.e, electronic draft control and 16x16 transmission calibrations will not be affected.

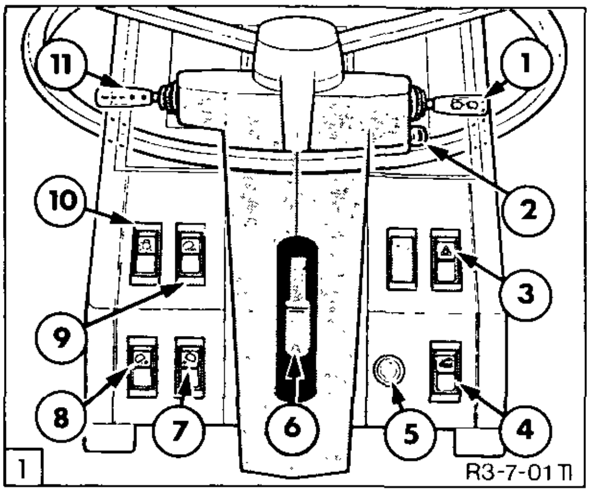
C. SPECIFICATIONS

BATTERY

Capacity (Ampere hour at 20 hour rate)	107
Cold Cranking Ampere Rating	800
Voltage	12
Cells	6
Ground Terminal	Negative

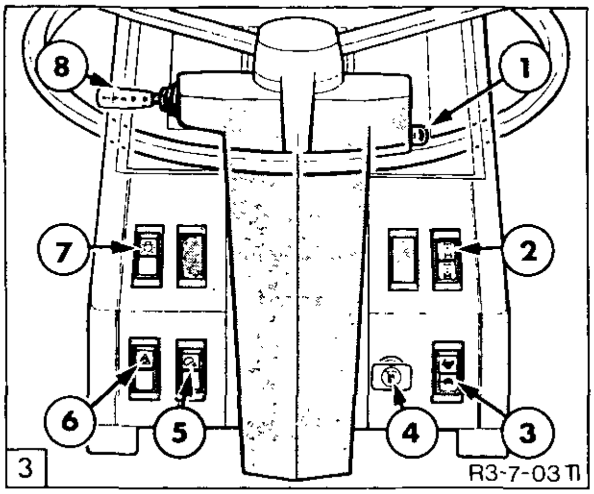
PART 3
ELECTRICAL SYSTEMS
Chapter 7
ELECTRICS – GENERAL

A. HAND CONTROLS AND SWITCHES



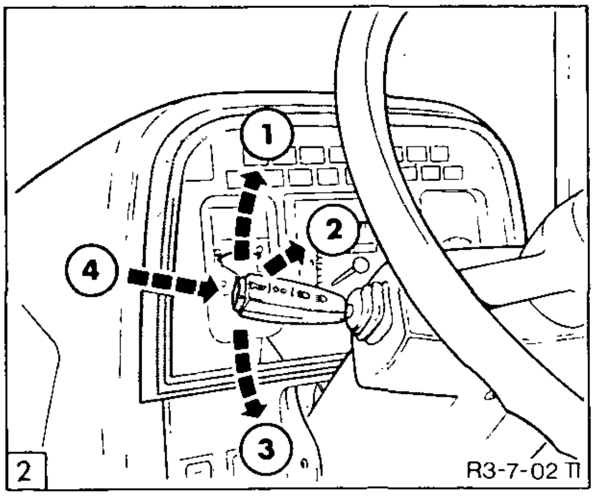
Hand Controls and Switches – SL and SLE Models

1. Windshield Wiper/Washer Control
2. Key–start Switch
3. Hazard Warning Lights Switch
4. Creeper Gear Selector Switch
5. Cigarette Lighter
6. Steering Column Tilt/Telescope Lock Lever
7. Lower Front Worklamp Switch
8. Rear Worklamp Switch
9. Upper Front Worklamp Switch
10. Tractor Lights Switch
11. Multi–function Switch



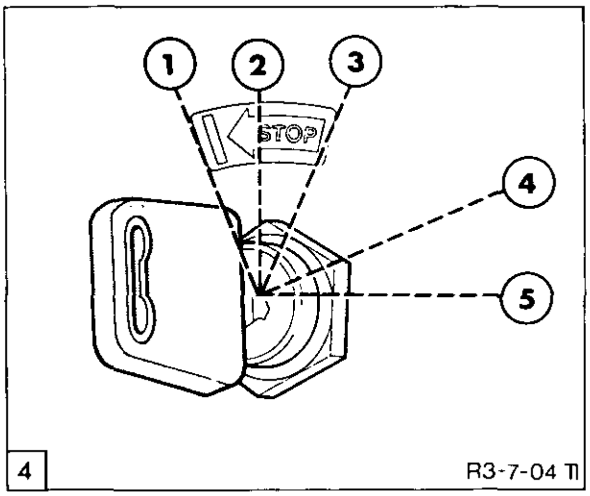
Hand Controls and Switches – S Models

1. Key–start Switch
2. Four Wheel Drive Switch
3. Dual Power Switch
4. Engine Stop Control
5. Worklamp Switch
6. Hazard Warning Lights Switch
7. Tractor Lights Switch
8. Multi–function Switch



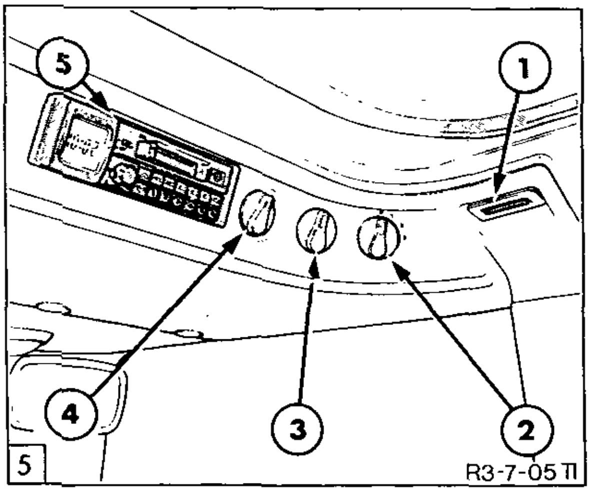
Multi–function Switch

1. Right Turn Signal
2. Headlamp Main/Dipped Beam and Flash
3. Left Turn Signal
4. Horn



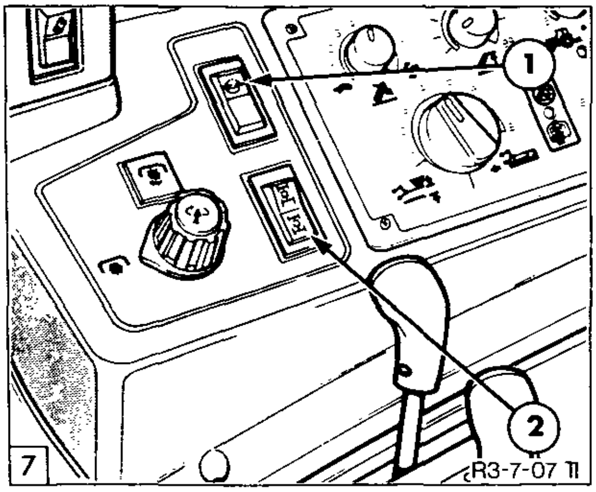
Key Start Switch

1. Thermostart Heater On
2. Electrical Equipment Off
3. Accessories On
4. Warning Lights and Instruments On
5. Starting Motor Operates



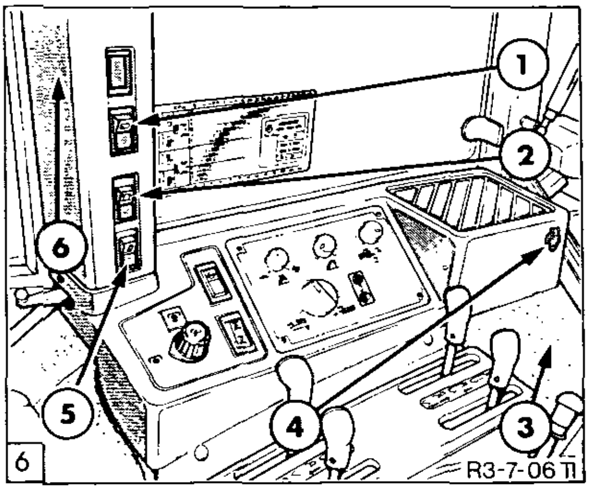
Roof Mounted Controls

1. Console Light
2. Blower Control
3. Air Conditioner Temperature Control
4. Heater Temperature Control
5. Radio



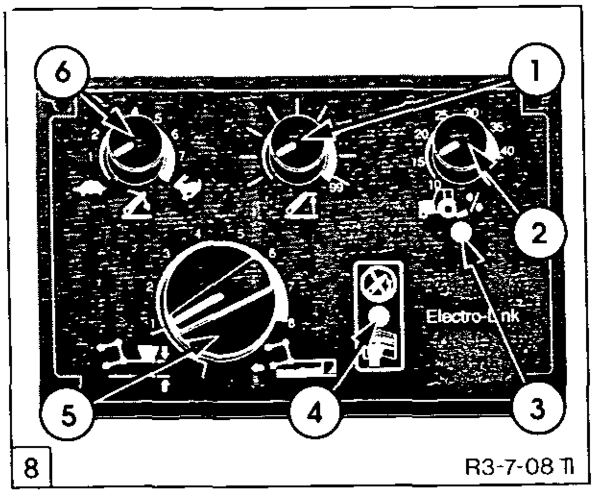
Differential lock and Four Wheel Drive
SL and SLE Models

1. Differential Lock Switch
2. Four Wheel Drive Switch



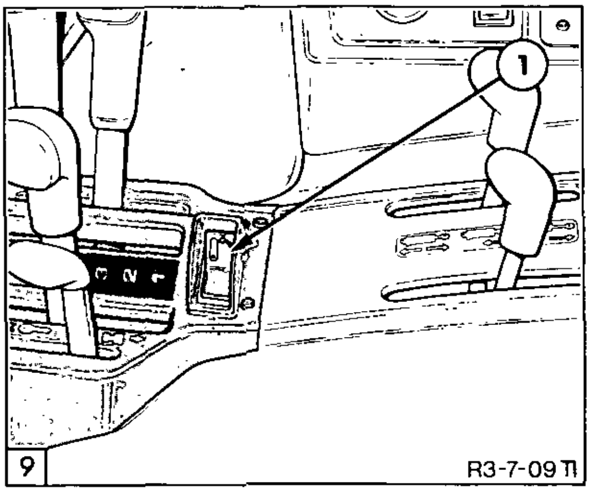
Right Hand 'B' Pillar

1. Rear Wiper/Washer Switch
2. Roof Beacon Switch
3. Mounting Point for Implement Monitor
4. Implement Monitor Supply Socket
5. Switch for External 4–pin Socket
6. Mounting Point for Implement Monitor



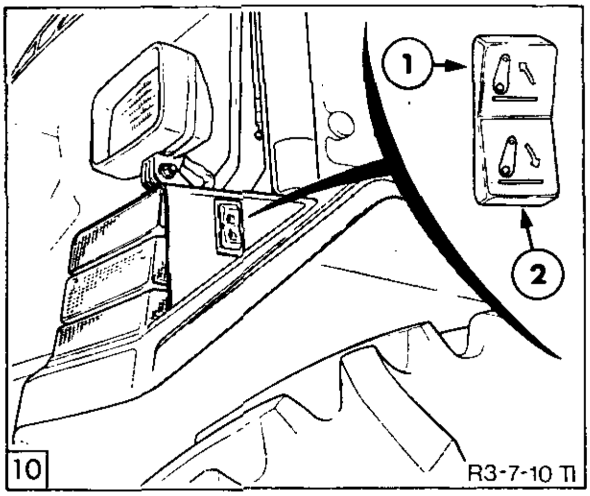
Hydraulic Control Panel

1. Height Limit Control
2. Slip Limit Control
3. Slip Limit 'On' Indicator
4. Malfunction Warning/Hitch Disabled Indicator
5. Position/Draft Sensitivity Knob
6. Drop Rate Control Knob



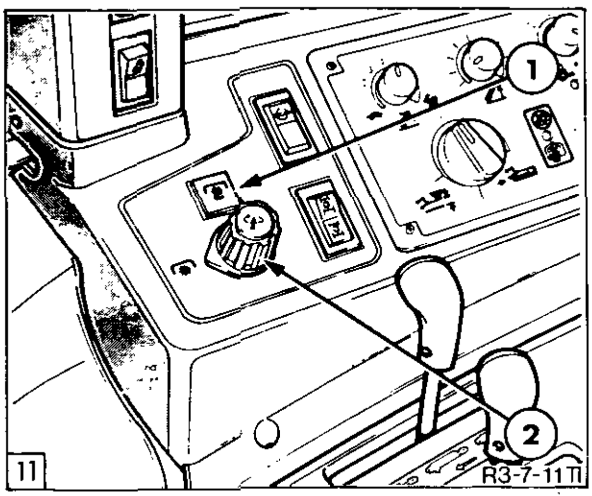
Hydraulic Console

1. Raise/lower Switch



External Lift Control Switch

1. Linkage Raise
2. Linkage Lower

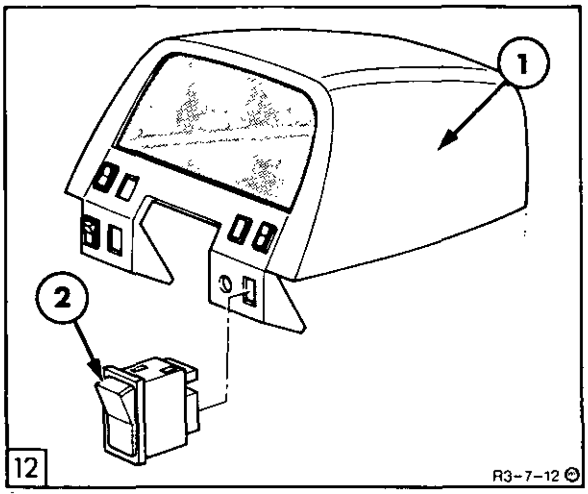


Power Take Off (P.T.O.) Selector

1. P.T.O. Warning Light
2. P.T.O. Selector

Switch Removal and Replacement

Switch removal and replacement such as the hazard warning light type of switch, shown in Figure 1 and Figure 3, are best removed by pushing from behind the switch. Although it is possible to prise the switch out from the front of the console, damage may occur to the paint or the plastic of the console.

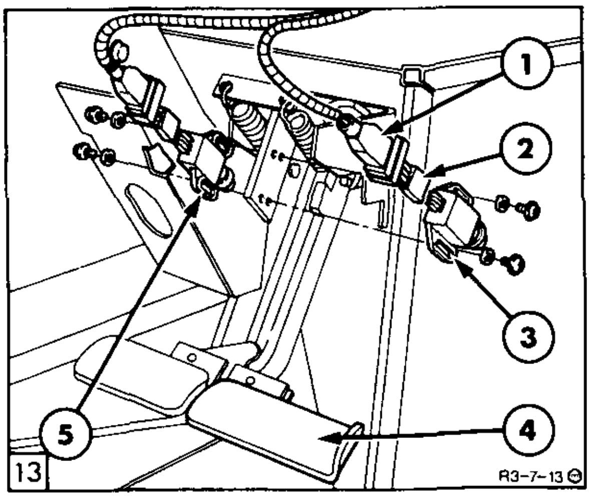


Switch Removal/Replacement

1. Instrument Console
2. Switch

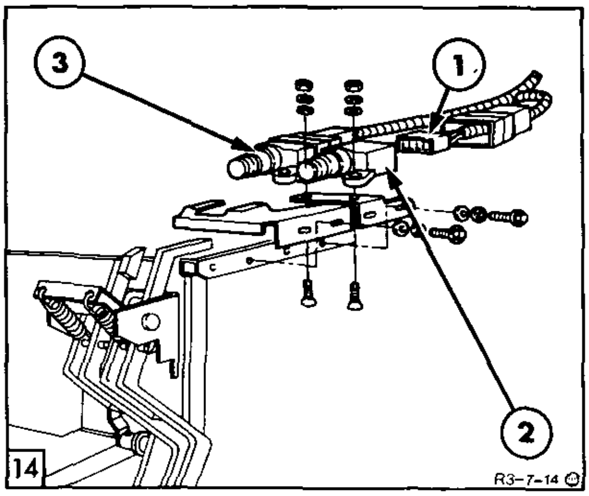
To remove and replace any of the roof console switches, (heater controls), it is necessary to remove the front panel of the cab roof. Pull off the knob and remove the nut and washer from the switch, from inside the cab and withdraw the switch from the top of the cab.

Stop Lamp Switches



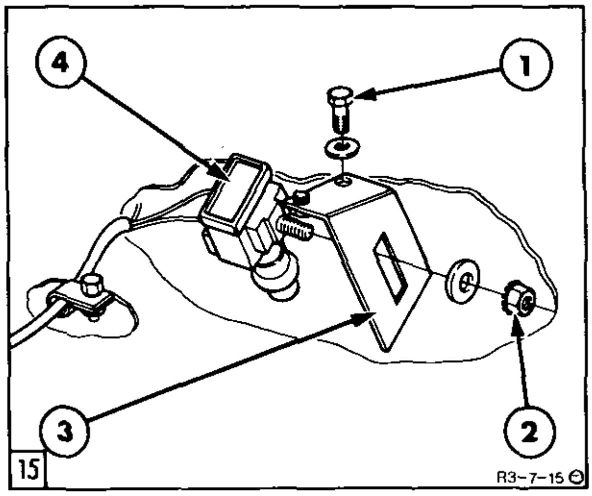
With Cab and Less Cab 6 Cylinder
Stop Lamp Switch Installation

1. Protective Cover
2. Harness Connector
3. Right Hand Switch Assembly
4. Brake Pedal
5. Left Hand Switch Assembly



Less Cab SL/SLE Stop Lamp Switch Installation
(4 Cylinder Models Only)

1. Harness Connector
2. Right Hand Switch Assembly
3. Left Hand Switch Assembly



Less Cab S Model Stop Lamp Switch Installation

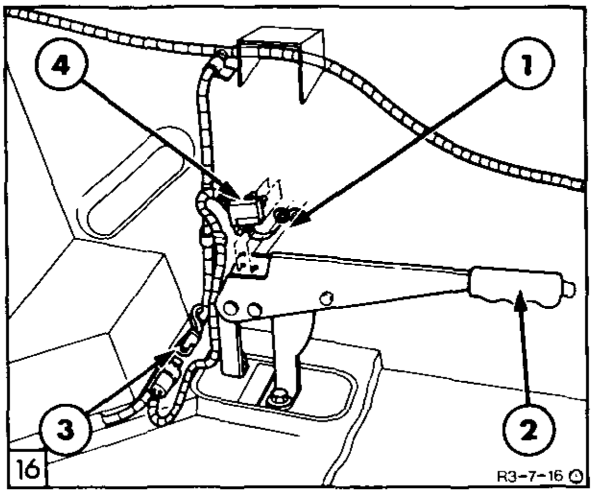
1. Bracket Securing Bolt
2. Switch Securing Nut
3. Switch Bracket
4. Stop Lamp Switch

Stop Lamp Switch Adjustment:

- Locate a 2.5 mm (0.10 in) thick gauge bar between the switch and brake pedal. Push the switch towards the brake pedal to the limit of the plunger travel, whilst ensuring that the pedal(s) are not moved from the rest tighten the switch securing bolts and remove the gauge. Repeat for the other switch if two are fitted. After adjustment ensure that both switches can be heard to operate simultaneously.

NOTE: *(The following is not applicable to NASO models).*
It is important on SL and SLE models with four wheel drive that the brake switches are correctly adjusted. The brake switches control the engagement of the four wheel drive for four wheel braking and it is essential that the four wheel drive is engaged before the brakes become effective. Damage will occur to the four wheel drive output assembly if the switches are incorrectly adjusted.

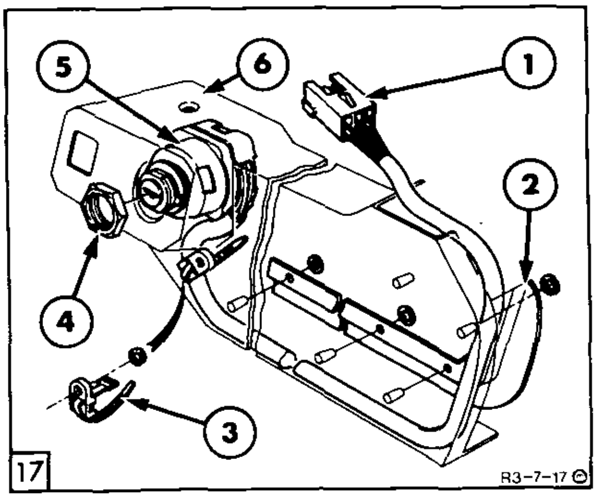
Handbrake Warning Buzzer Switch



Hanbrake Switch Installation
(All Models Similar)

1. Split Pins – 2 off
2. Handbrake Lever
3. Harness Connection
4. Switch Assembly

Key–Start Switch Assembly



Key Start Switch Installation
(Tilt Column Shown , Fixed Column Similar, less Wire Shield)

1. Harness connector
2. Wire Shield
3. Wire Retaining Strap
4. Switch Retaining Nut
5. Key–Start Switch
6. Steering Column Outer Cover

Key Start Removal/Replacement:

- Disconnect the tractor battery.

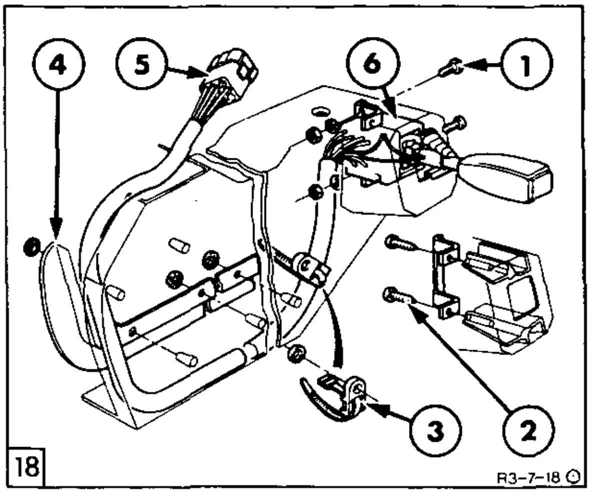
- Remove the three screws securing the right hand cover to the steering column assembly. Lift away sufficiently to gain access to the wire retaining straps and wire shield retainers.

- Remove the wire shield retainers, wire securing straps, disconnect the switch assembly from the harness and remove the nut securing the switch to the cover.

- Withdraw the switch assembly from the vehicle.

Replacement is the reversal of the removal procedure.

Turn Signal Switch Installation

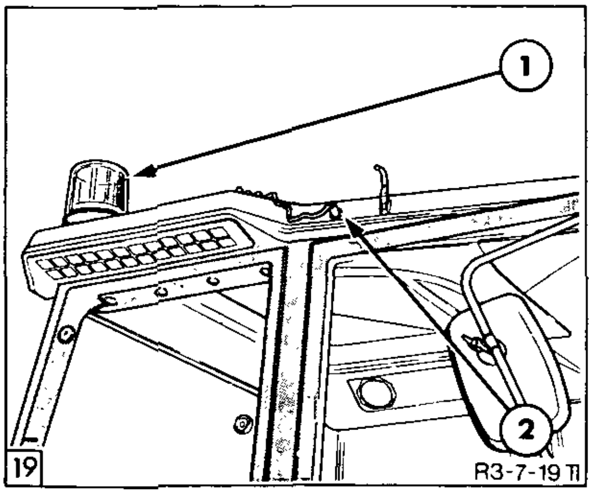


Turn Signal Switch Installation

1. Bracket to Switch Screw
2. Bracket to Cover Screw
3. Wire Retaining Strap
4. Wire Shield – Tilt Column Only
5. Harness Connector
6. Switch Assembly

B. ACCESSORY SOCKETS AND ROTATING BEACON

Rotating Roof Beacon



Rotating Roof Beacon

1. Beacon
2. Roof Socket for Beacon

A roof beacon kit is available and consists of a rotating beacon with a magnetic base, a steel plate, a switch and an electrical outlet socket. The roof is made from fibreglass. Four depressions are provided in the roof panel to accomodate the steel plate which should be fixed into one of the depressions with the screws provided. The beacon may then be attached magnetically to the steel plate.

A hole (with blanking plug) is provided either side of the roof panel. The socket should be mounted in one of these holes as shown in Figure 19. The switch must be mounted in the aperture provided in the right hand 'B' pillar, as shown in Figure 6. Electrical connections for the switch and socket are provided in the cab wiring loom.

NOTE: *In countries where vehicles drive on the right hand side of the road, the beacon should be mounted on the left hand side of the roof. Conversely, in countries where vehicles drive on the left the beacon should be mounted on the right hand side of the roof. In some countries, two beacons are required when driving on public roads.*

Press the upper part of the switch, reference 2, Figure 6, to provide power to the roof beacon socket outlet.

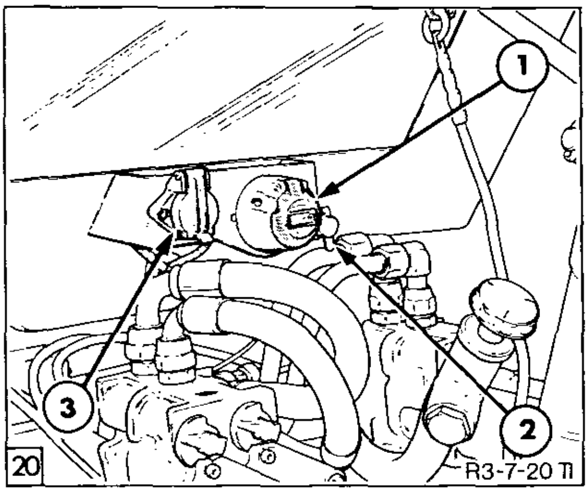
Accessory Sockets

A live, 8 amp power socket, reference 4, Figure 6, is installed on the right hand quarter panel for the operation of an electronic implement monitor. To facilitate installation of the monitor two mounting points are provided:

- To meet SAE standards, the right hand rear quarter panel is pre drilled at reference 3, Figure 6, with two captive nuts provided. The area is covered by the interior vinyl trim. The nuts are accessible from beneath the cab and are directly in line with the right hand rear cab mount, approximately 17.0 and 21.6 in (430 mm and 550 mm) respectively, above the mount. Insert a sharp, pointed implement through the nuts to pierce the vinyl trim.

- An alternative mounting position is provided on the front face of the right hand 'B' pillar at reference 6 in Figure 6. Remove the rigid plasic trim from the pillar in order to locate the two captive nuts and to drill holes in the trim in line with the nuts. The nuts are approximately 12.6 and 17.3 in (320 mm and 440 mm) respectively, from the top of the door frame.

It is recommended that a suitable hinged bracket be screwed to the 'B' pillar to mount the monitor.



20
Accessory Sockets

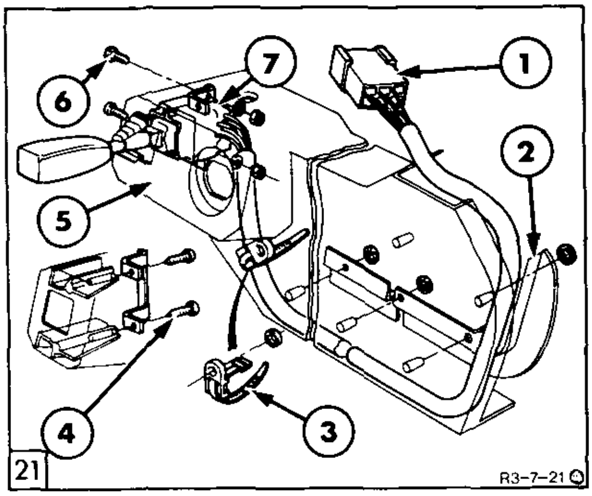
1. 7–pin Trailer Lighting Socket
2. Single pin Implement Work Lamp Socket
3. 4–pin Implement Socket

To enable the operating cable from the monitor to be conveniently routed to the equipment, a small removable panel is provided beneath the rear window.

A standard 7–pin trailer lighting socket, reference 1, Figure 20, is provided and is mounted on the outside of the cab frame beneath the rear window. An 8 amp power outlet reference 2, Figure 20, is attached to the trailer socket and provides power for an implement work lamp when the tractor rear worklamps are switched on.

In addition, a 4–pin, 30 amp socket, reference 3, Figure 20, is available. To provide power to the socket, press the upper part of switch, reference 5, Figure 6.

Windshield Wiper Switch Installation

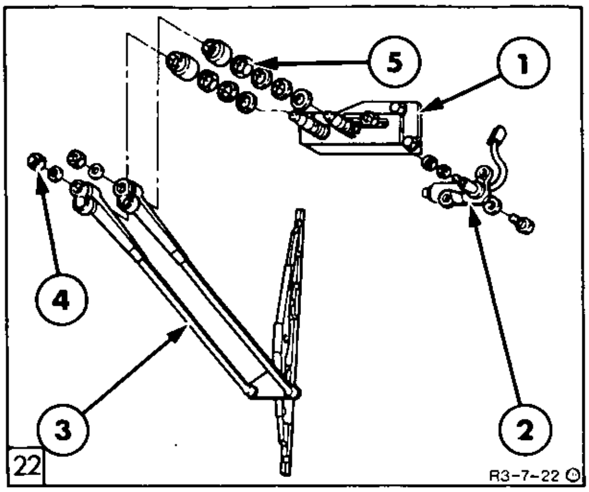


21
Windshield Wiper Switch Installation

1. Harness Connector
2. Wire Shield – Tilt Column Only
3. Wire Retaining Strap
4. Bracket to Cover Screw
5. Cover
6. Bracket to Switch Screw
7. Switch Assembly

C. FRONT AND REAR WIPER MOTORS

Front Windshield Wiper/Motor Installation



Front Windshield Wiper/Motor Installation

1. Bracket Assembly
2. Motor Assembly
3. Wiper Arm assembly (Single Arm on S Model)
4. Wiper Arm Retaining Nut
5. Bracket to Cab Frame Retaining Nut

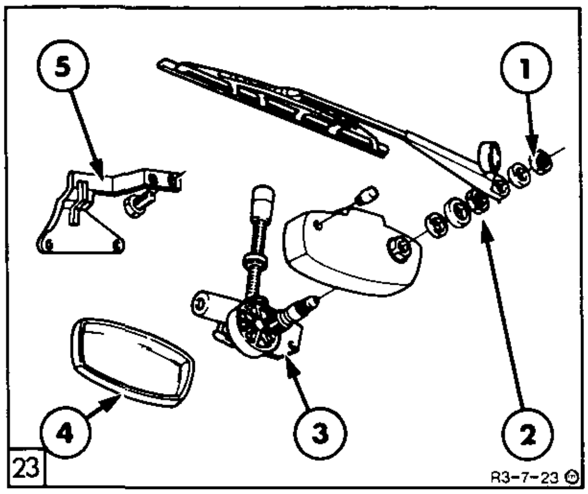
Front Wiper Motor Removal/Replacement:

- Remove the front panel of the cab roof.
- Remove the electrical connector to the motor assembly.
- Remove the nut securing the motor drive shaft to the wiper linkage.
- Remove the three bolts from inside the cab roof securing the motor assembly to the bracket and linkage assembly and withdraw the motor assembly.

NOTE: *The motor is serviced as an assembly only. A fault within the motor will require a complete motor replacement.*

- Replacement is the reversal of the removal procedure.

Rear Windshield Wiper/Motor Installation



Rear Windshield Wiper/Motor Installation

1. Wiper Arm Retaining Nut
2. Motor to rear Glass Securing Nut
3. Motor Assembly
4. Cover
5. Bracket

Rear Wiper Removal/Replacement:

- Prise the plastic cover from the rear of the wiper motor assembly.
- Remove the nut from the wiper arm and withdraw the wiper arm. Remove the nut securing the motor assembly to the rear window.
- Gently pull/pry down the grommet from the cab roof and disconnect the electrical connector from inside the cab. Remove the two bolts securing the wiper motor bracket to the window hinge and withdraw the motor assembly.

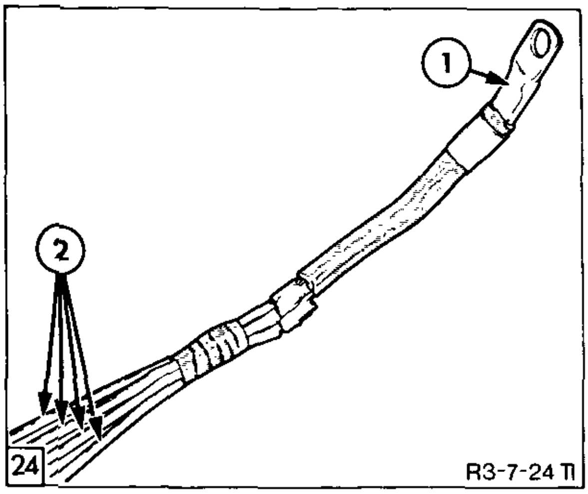
NOTE: *The motor is serviced as an assembly only. A fault within the motor will require a complete motor replacement.*

- Replacement is the reversal of the removal procedure.

D. FUSIBLE LINKS

Fusible Links

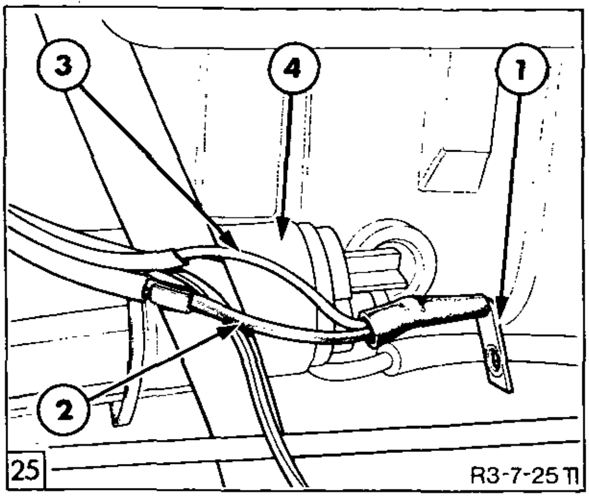
Incorporated within the wiring harnesses, in two locations, there are a number of fusible links to protect circuits and components from severe current overload.



Fusible Link Location

1. Positive Battery Lead
2. Fusible Links

Where a tractor has suffered a current overload and a particular circuit does not function after replacing faulty components and fuses, the fuse links within the harnesses should be inspected. Figure 24 and Figure 25 show the location within the harness of the fusible links.



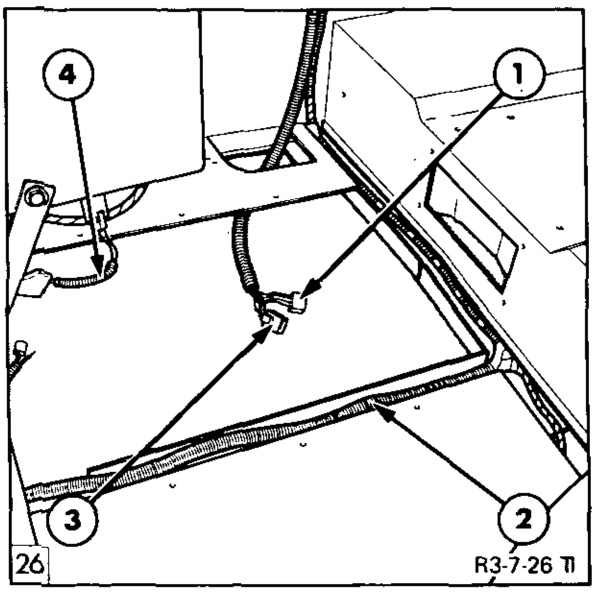
Fusible Link Location

1. Solenoid Connector
2. Alternator Fuse Link
3. Starter Motor Fuse Link
4. Starter Motor Solenoid

To gain access to the links it will be necessary to strip back some of the harness outer covering. If a fusible link requires replacement, it should be cut out of the harness and a new one soldered in place, using conventional soldering techniques.

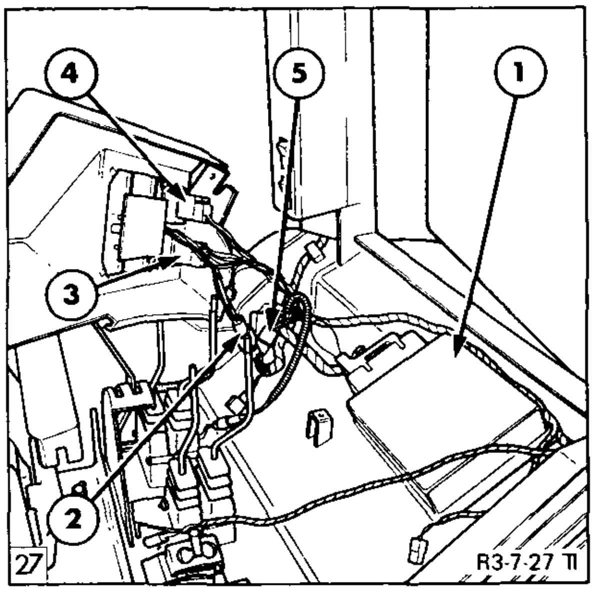
NOTE: *Fusible links are Service parts and can be obtained through the Parts and Accessories department.*

E. HARNESS CONNECTOR LOCATIONS
(See also Part 3, Chapter 2, Wiring Diagrams, Figures 1 and 2)



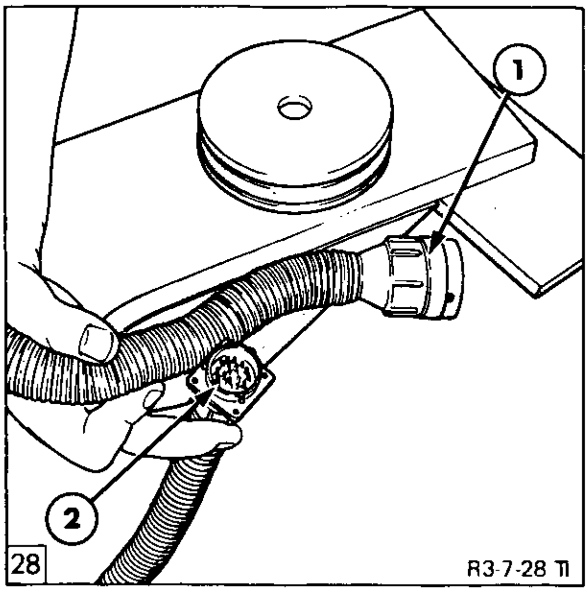
Main Rear Harness
Under Floor Routing

1. EDC Chassis Connector T1
2. Main Harness
3. EDC Chassis Connector T2
4. Clutch Pedal Potentiometer (16x16 Transmissions)



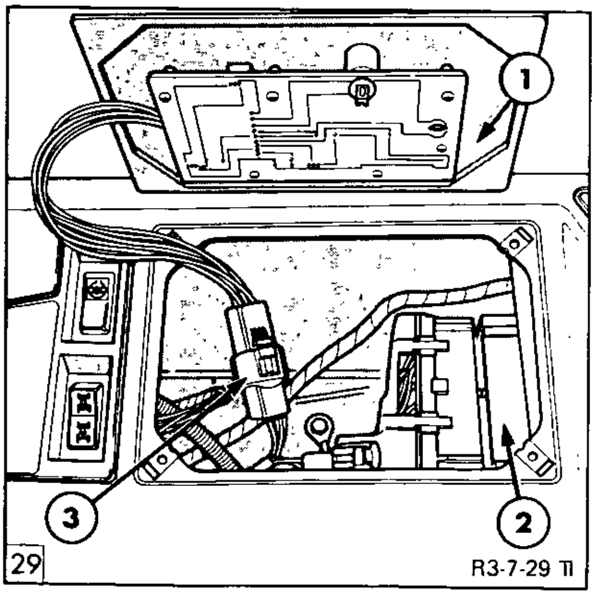
'B' Pillar Switch Connections

1. EEC IV Module (Micro Computer)
2. EDC Control Panel Connector
3. FWD Switch Connector
4. *Diff –Lock Switch Connector*
5. Extension Harness Connectors C2 and C4



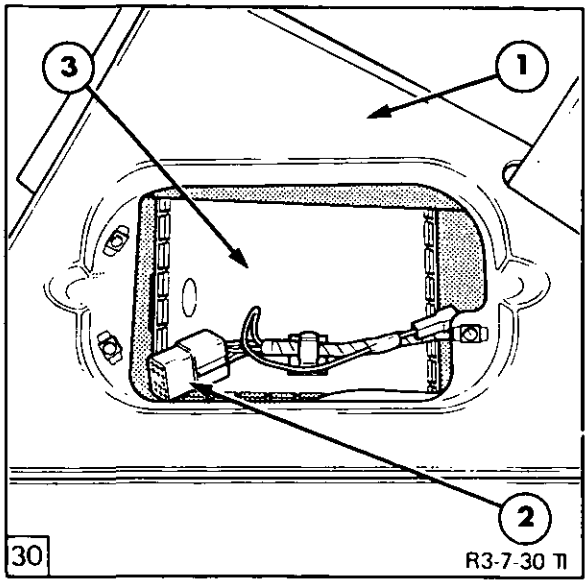
Main Bulkhead Connectors

1. Main Harness Connector E1
2. Extension Harness Connector C1



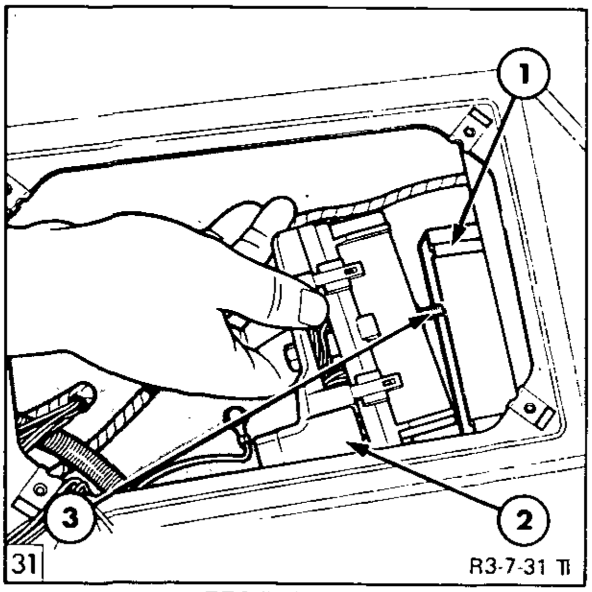
EDC Control Panel

1. Control Panel
2. EEC IV Module (Micro–Processor)
3. Panel Connector



Diagnostic Socket

1. Instrument Console
2. Diagnostic Plug
3. Fuse Box



Access to EEC IV (Micro–Processor)

1. EEC IV Module
2. Connector
3. Retaining Bolt

PART 3
ELECTRICAL SYSTEM

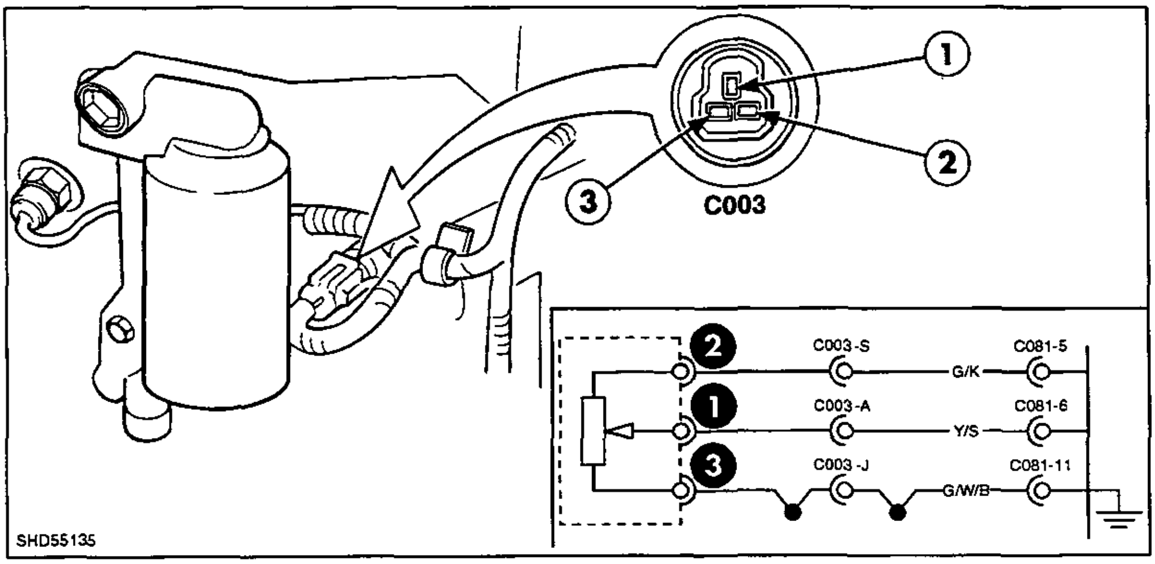
Chapter 8
ELECTRONIC INSTRUMENT CLUSTER FAULT FINDING
(Post November 1995)

CONTENTS

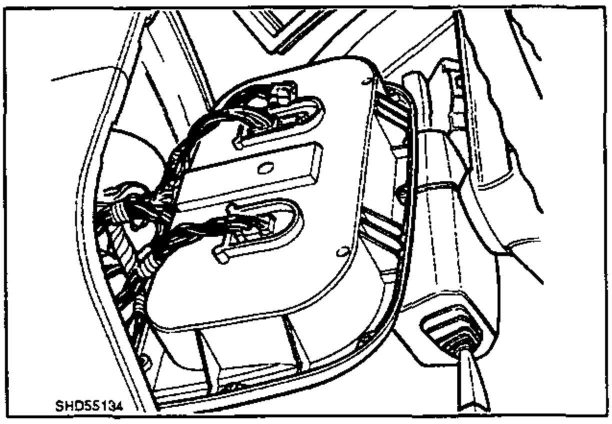
A. INTRODUCTION

With the introduction of new Instrument Clusters and wiring harnesses, which incorporate new connectors and revised wiring details, the fault finding charts for the Electronic Instrument Cluster (EIC) have been updated to reflect the wiring level of tractors from Unit Date Code 5L01 (November 1st 1995).

Error Code 1 - Engine Oil Pressure Sender Short or Open Circuit



1. Signal Out Pin 2. +5v Supply Pin 3. Ground Pin



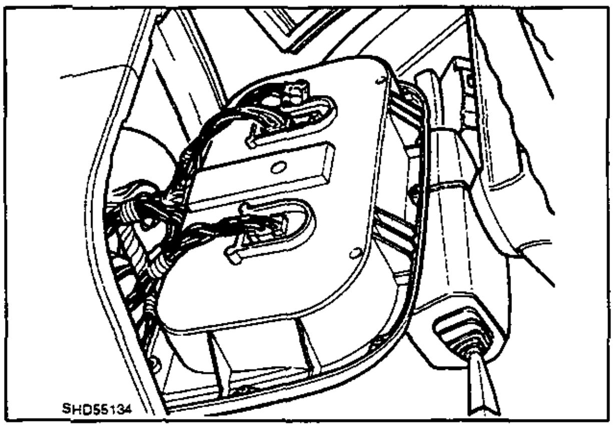
Turn Keystart **OFF** and *disconnect sender*

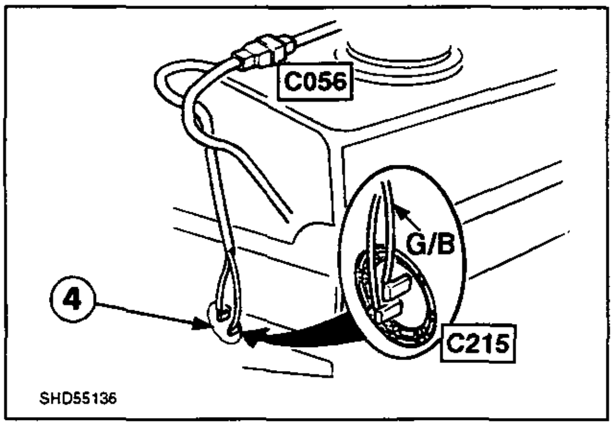
↓

Short out the **Signal Out** (Y/S) and the **+5** (G/K) pins on connector **C003.** **Is Error Code 1 still displayed?**

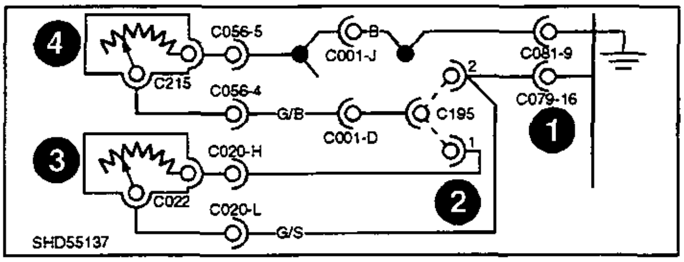
- **YES** → Check for faulty cable between **C1-S/C81-5, C1-A/C81-6** and **C1-J/C81-11. Is cable OK?**
  - **YES** → Replace EIC
  - **NO** → Replace cable
- **NO** → **Does Error Code disappear and oil pressure display indicate maximum?**
  - **YES** → At connector **C003** measure *voltage between* **+5** (G/K) and **Ground pins** (G/W/B). **Is voltage approx. 5v?**
    - **YES** → Replace sender
    - **NO** → Replace cable

Error Code 3 - Main Fuel Tank Level Sender Short Circuit





1. EIC
2. One/Two Tank Selector
3. Auxiliary Tank Sender
4. Main Tank Sender



Remove the signal wire (G/B) attached to the main fuel tank sender **C215**. Move the terminal end of the wire out so that it is not touching any metallic parts of the tractor. With the engine off and the keystart on,
Is Error Code 3 displayed?

NO → Renew the main fuel tank level sender and recheck function.

YES ↓

If an auxiliary tank is fitted remove the signal wire (G/S) at the auxiliary tank sender **C022**.
Is Error Code 3 still displayed?

NO → Renew the auxiliary fuel tank level sender and recheck function.

YES ↓

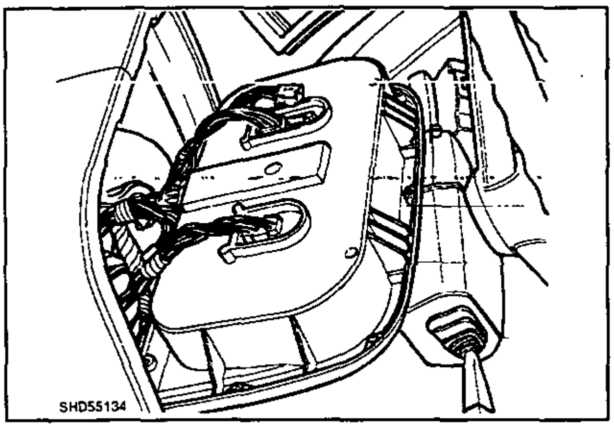
Remove the instrument panel, remove plug **C079**. With the signal wire(s) from the fuel tank level sender (s) removed, measure the resistance between connector pins **C079-16** (G/B) and **C081-9** (G/W/B).
Is resistance less than 5000 ?

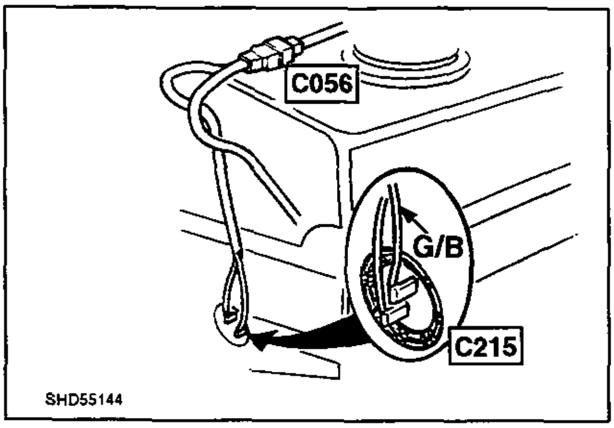
NO → Install a new instrument panel and recheck function

YES ↓

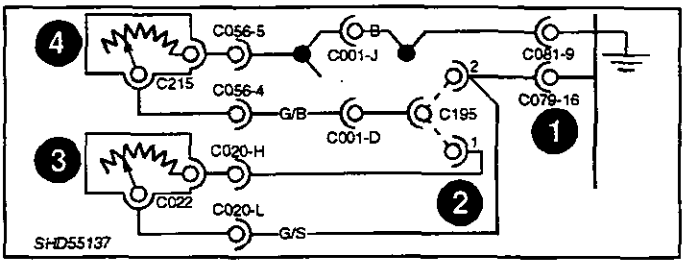
Locate and repair short circuit to ground in signal wire.

Error Code 4 - Main Fuel Tank Level Sender Open Circuit





1. EIC
2. One/Two Tank Selector
3. Auxiliary Tank Sender
4. Main Tank Sender

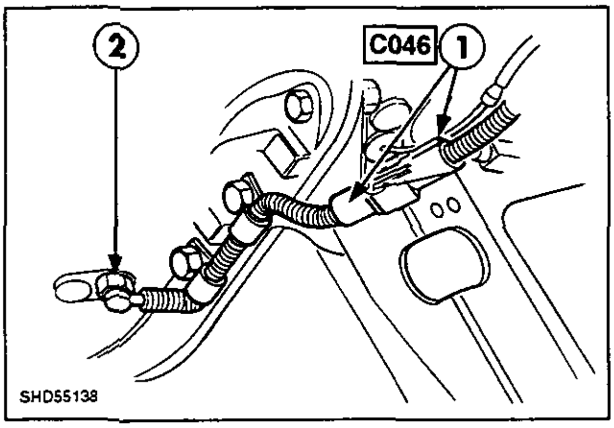


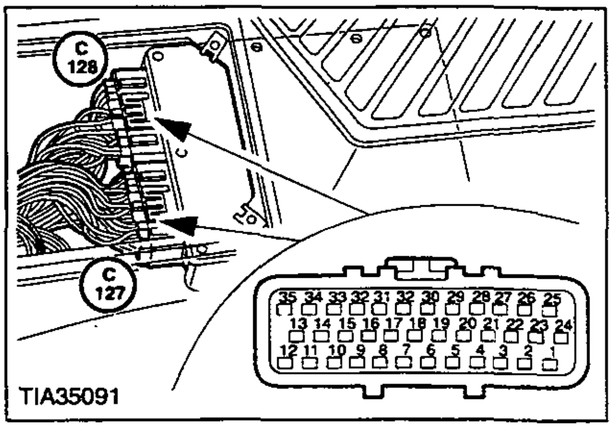
Inspect the sender connector **C215**. **Are the terminals clean and does the connector fit securely?**
- NO → Repair poor connection and recheck function.
- YES → Remove the signal wire (G/B) attached to the main fuel tank level sender terminal **C215** and connect it to ground. **Is Error Code 3 displayed?**

Is Error Code 3 displayed?
- YES → With the signal wire removed from the sender, measure the resistance between the sender terminals. **Is the resistance within the range? Full - 30 , Empty - 250**
  - YES → Locate and repair open circuit in sender ground wire.
  - NO → Renew sender and recheck function.
- NO → **Is tank selector connector C1-D connected correctly?**
  - NO → Repair poor connection and recheck function.
  - YES → **Are two fuel tanks fitted?**
    - YES → Remove signal wire (G/S) attached to auxiliary fuel tank sender **C022** and connect to ground. **Is Error Code 3 displayed?**
      - YES → With the signal wire removed from the sender, measure the resistance between the sender terminals. **Is the resistance within the range 0 - 125 ?**
        - NO → Renew sender and recheck function.
        - YES → Locate and repair open circuit in sender ground wire.
      - NO → Remove the instrument cluster (see below).
    - NO → Remove the instrument cluster (see below).

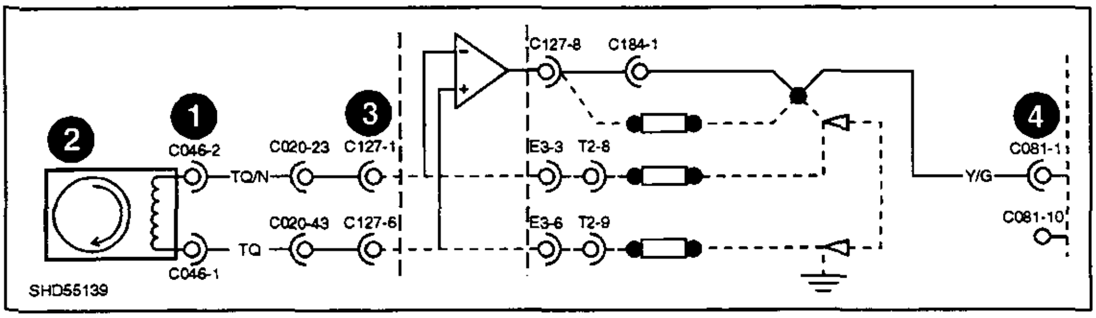
Remove the instrument cluster. Remove plugs **C079** & **C081**. Earth the sender wire and measure the resistance between connector pins **C079-16** (G/B) and **C081-9** (G/W/B). **Is resistance less than 10 ?**
- YES → Clean plugs **C079** & **C081** pins with contact cleaner spray. Reconnect plug and turn keystart switch on. **Does cluster function correctly without Code 4 displayed?**
  - YES → Install a new instrument cluster, recheck function.
- NO → Locate and repair open circuit.

Error Code 5 - Axle Speed Sender Short Circuit





1. *Sender Connector (C046)*
2. *Sender*
3. *Processor Connectors*
4. *Instrument Panel*



Does tractor have 16 x 16 transmission or EDC?

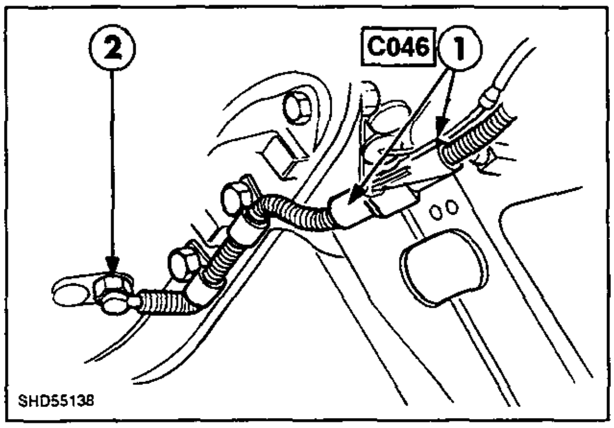
NO → Unplug axle speed sender connector **C046**. Turn keystart on, engine not running. **Is Error Code 5 displayed?**

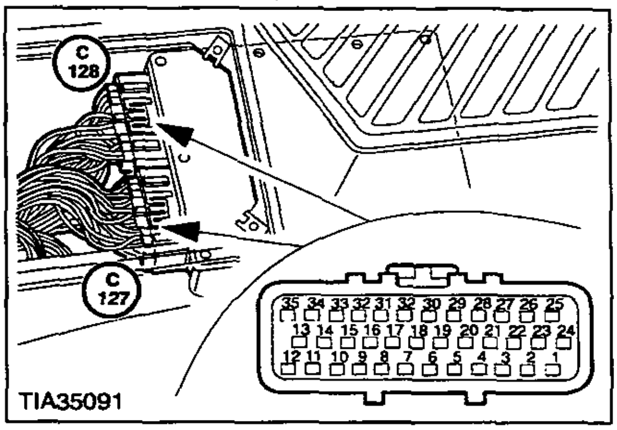
- **YES →** *Remove instrument panel, disconnect* **C081**. With sender still disconnected, measure resistance between **C081-1** & **C081-10. Is resistance less than 5000 ?**
  - **YES →** *Locate and repair short circuit to ground on signal wire.*
  - **NO →** *Install new instrument panel and retest.*
- **NO →** *Renew the sender and recheck function.*

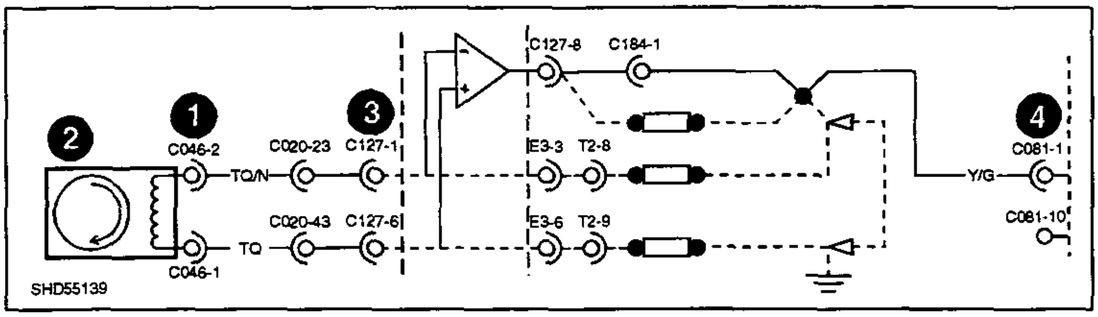
YES → Disconnect Processor connectors **C127** and **C128,** turn keystart on. **Is Error Code 5 displayed?**

- **YES →** *Remove instrument panel,* disconnect **C081**. With sender still disconnected, measure resistance between **C081-1 & C081-10. Is resistance less than 5000 ?**
  - **YES →** Locate and repair short circuit to ground on signal wire.
  - **NO →** *Install new* instrument panel and retest with Processor connected.
- **NO →** *Renew the sender and recheck function.*

Error Code 6 - Tractor Axle Speed Sender Open Circuit







1. Sender Connector (C046)
2. Sender
3. Processor Connectors
4. Instrument Panel

Does tractor have 16 x 16 transmission or EDC?

NO ▶

Identify the tractor axle speed sender connector **C046**. **Are the terminals clean and does the connector fit firmly together?**

- NO ▶ Rectify poor connection and recheck function.
- YES ▼

Disconnect sender. Measure resistance between sender terminals **C046-1/2**. ***Is the resistance within the* range 1000 - 3000 ?**

- NO ▶ Renew the sender and recheck function.
- YES ▼

With the sender disconnected, ground number 1 terminal (TQ). **Does the display Error Code 5?**

- NO ▶ Locate and repair open circuit in ground wire.
- YES ▼

Disconnect plug **C081**. Ground terminal 1 (TQ) of sender connector and measure resistance between frame and pin **C081-1. Is the resistance less than 10 ?**

- NO ▶ Locate and repair open circuit in sender wire.
- YES ▼

Clean pins of plug **C081** with contact cleaner spray. Reconnect plug and turn keystart on. **Does cluster function correctly without Error Code 6 displayed?**

- NO ▶ Install a new instrument panel and recheck function.

YES ▶

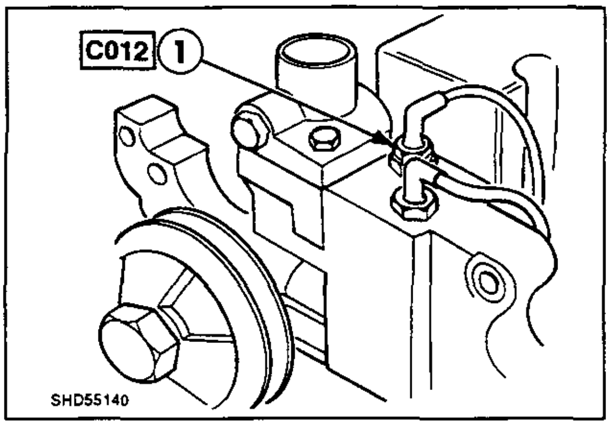
Disconnect Processor connector **C127**. Connect pin **C127-8** (Y/G) to ground. Turn keystart ON, engine OFF. **Is Error Code 5 displayed?**

- YES ▶ Install a new Processor and retest.
- NO ▼

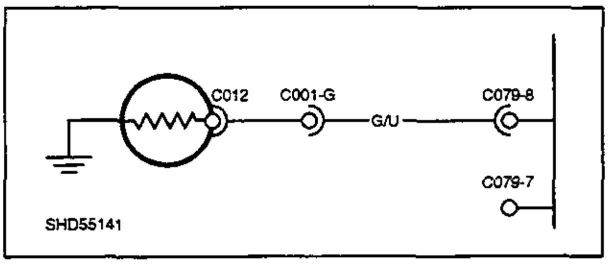
Remove instrument panel, disconnect **C081**. Measure resistance between **C081-1** and **C081-10.** Connect **C127-8** to ground. **Is resistance less than 10 ?**

- YES ▶ Install a new Processor and retest.
- NO ▶ Locate and repair open circuit in signal wire.

Error Code 7 - Coolant Temperature Sender Short Circuit



1. Coolant Temperature Sender



Remove the connector **C012** from the sender. Ensure the end of the wire is not contacting any metallic part. Turn keystart ON, Engine OFF.
Is Error Code 7 displayed?

NO → Renew sender and recheck function.

YES ↓

Remove the instrument panel, disconnect plug **C079**. Disconnect the signal wire from the sender. Measure the resistance between pins **C079-8** (G/U) & **C079-7** (B).
Is the resistance less than 5000 ?

YES → Locate and repair short circuit in signal wire.

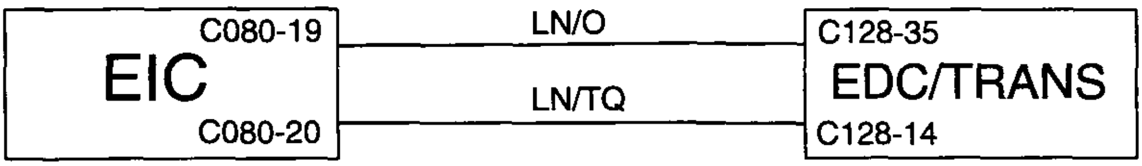
NO ↓

Install a new Central Digital Display Module and recheck function.

Error Codes 8 and 9 - Communications Error

The Electronic Draft Control module and the electronic transmission control (processor) send their display information over a two wire serial communications connection.

Communications errors (8 & 9) occur when the message received by the instrument panel is not correct. This can be caused by an intermittent connection on the signal wires (LN/O or LN/TQ). *If these errors are accompanied by reports of intermittent or* blank displays in the transmission or hitch position areas, then the circuit wires should be investigated for open circuits, short circuits and intermittent connections.



Error Codes 10 - Memory Retention Error of Battery Calibration Constant

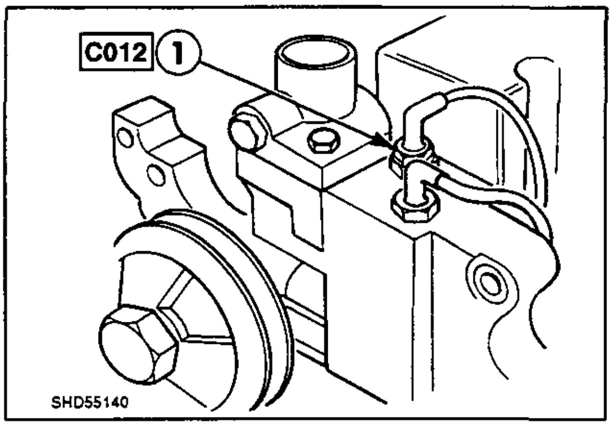
Compare the voltage display of instrument panel to a voltmeter reading at the battery. If *the readings differ by more the 2.0 volts, then replace instrument panel and recheck.*

Error Codes 11 - Memory Retention Error of Operator Setting for Slip Alarm, Slip Zero Referencr Constant, Implement Width and Service Hours

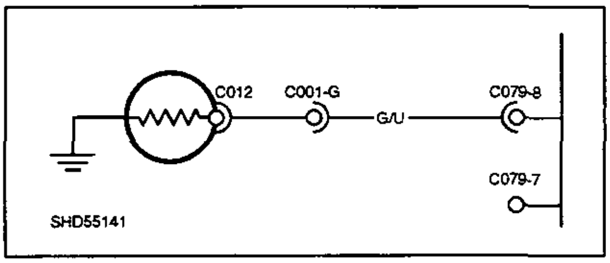
If Error Code 11 persists then replace the instrument panel.

Re-programme the constants listed above using the instructions detailed in the Repair Manual. Turn keystart OFF and recheck the programmed values. If the values are not correct then replace the instrument panel.

Error Code 12 - Coolant Temperature Sender Open Circuit



1. Coolant Temperature Sender



Inspect the connection **C012** at the sender (1). **Are the terminal and connector clean and do they fit firmly together?**

- NO → Rectify poor connection and recheck function.
- YES ↓

Remove the connector from the sender and hold it firmly against a good ground. **Is Error Code 7 displayed?**

- YES → With the connector **C012** removed from the sender, measure the resistance between the sender terminal and body. **Is the resistance between 80 (hot) and 800 (cold)?**
  - YES → Sender has poor ground to engine. Remove sender and clean threads.
  - NO → Renew sender and recheck function.
- NO ↓

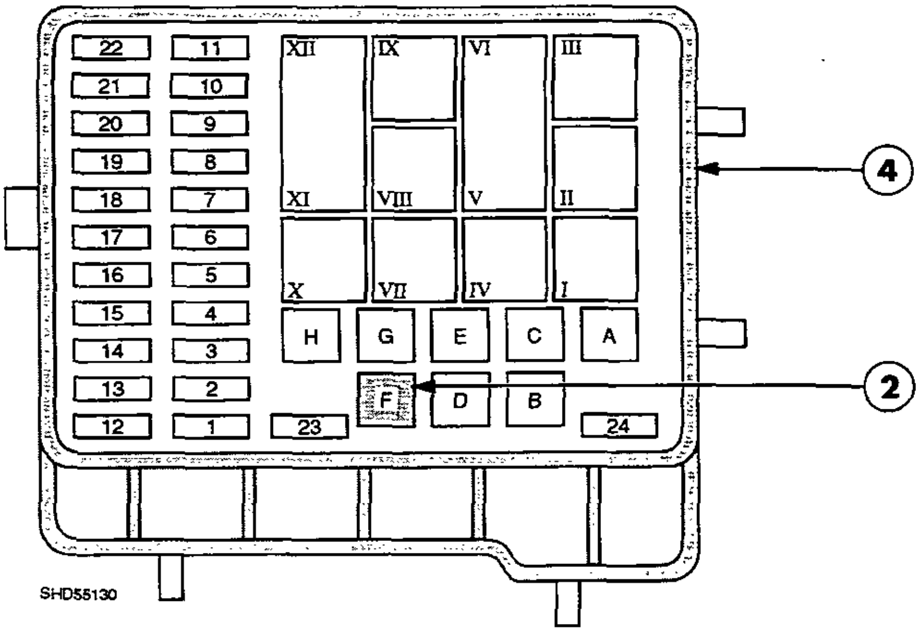
Remove the instrument panel, disconnect plug **C079**. At the sender, earth the signal wire and measure the resistance between pins **C079-8** (G/U) and **C079-7** (B). **Is the resistance less than 10 ?**

- NO → Find and repair an open circuit fault in wiring between plug and sender.
- YES ↓

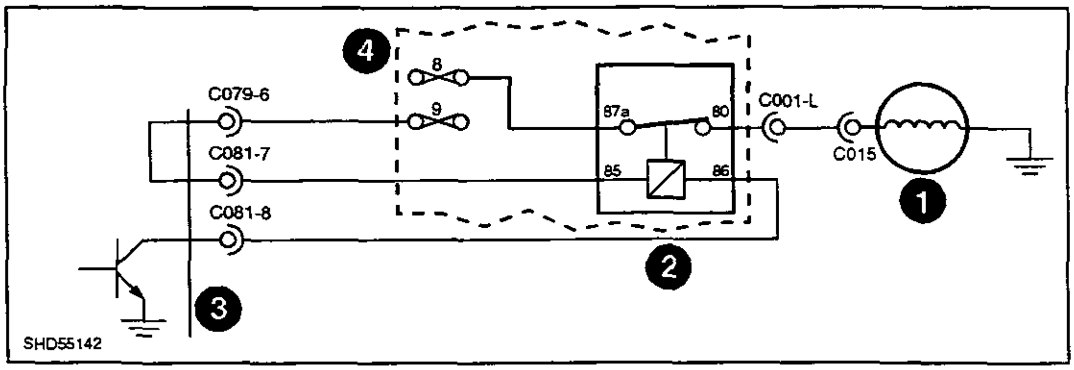
Clean the connector pins with contact cleaner spray. Apply a dielectric grease. Reconnect plugs to the instrument cluster and turn keystart on. **Does the cluster function correctly?**

- YES → Install a new instrument panel and recheck function.

Error Code 13 - Engine Shut-down Output Short to a + Voltage



1. Fuel Shut-off Solenoid
2. Relay 'F'
3. EIC.
4. Fuse Panel



Remove the Fuel Shut-off Relay (F) from the fuse panel. Measure the resistance of the relay coil at terminals **85** and **86**.
Is resistance less than 95 ?

NO → Renew relay.

NO ↓

Remove the instrument panel, disconnect plug **C081**. With relay removed, Measure the resistance between harness pins **C081-8** (O/R) and **C081-7** (O/U/B).
Is resistance showing open circuit?

YES → Locate and repair short in circuit between **C015** and relay **F** holder.

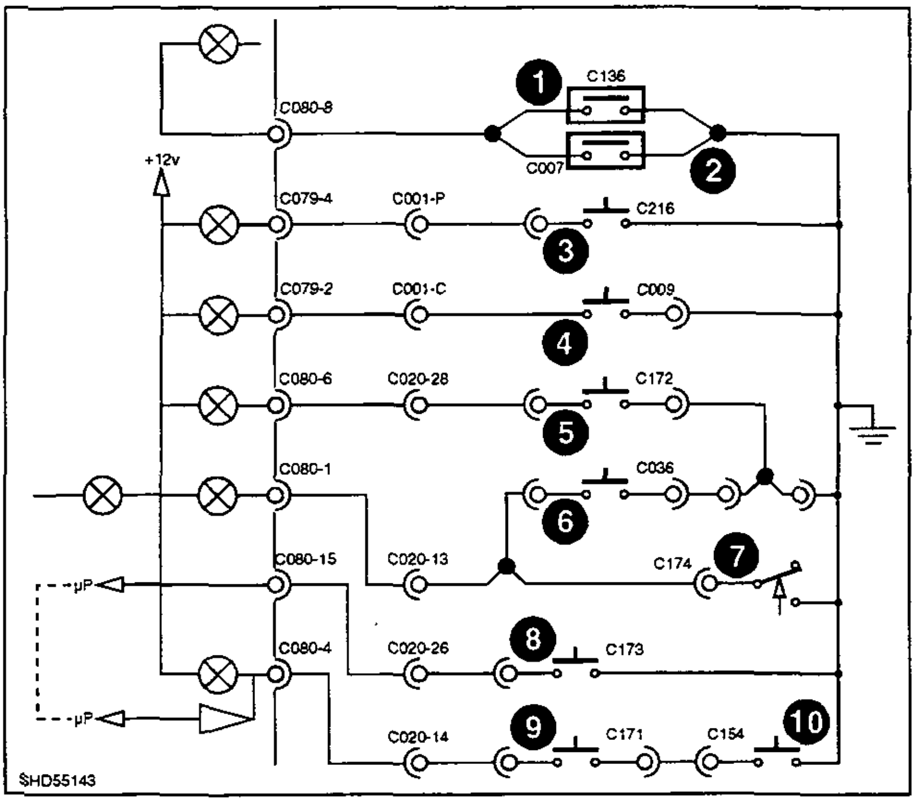
NO ↓

Install a new instrument panel.

Error Code 14 - This code is not displayed but can be stored in the Service memory.

This code is generated if only a single occurence of an error code is detected immediately followed by a different code. This implies intermittent or transient faults may have existed momentarily.

Common Test Procedure for ALL the Switch Circuits connecting to ground.



1. Handbrake Switch
2. Brake Fluid Level Switch
3. Temperature Switch
4. Vacuum Switch
5. Transmission Oil Temp Switch
6. Transmission Oil Pressure Switch
7. PAS Pressure Switch
8. Low Charge Pressure Switch
9. Hydraulic Oil Temp Switch
10. HPL Filter Switch

Disconnect the harness at the sender/switch and connect signal wire to ground. **Is the warning light illuminated?**

YES → Check the ground path of the switch and recheck function. **Is the resistance to ground less than 10 ?**

- YES → Renew the switch and recheck function.
- NO → Locate and repair the open circuit.

NO → Unplug wiring harness from instrument cluster. Ground the signal wire at switch/sender and measure resistance between the signal pin and the tractor frame at the panel connector. ***Is the resistance less than 10 ?***

- NO → Locate and repair open circuit in signal wire.

YES → Clean wiring harness to instrument cluster connector pins with contact spray. Reconnect the plugs to instrument panel. Remove the *signal wire at the switch and connect to ground.* **Is the warning light illuminated?**

NO → Renew the warning bulb. → Is the warning bulb illuminated? NO → Renew the instrument panel and recheck function.

Instrument Cluster Inoperative

No display on instrument cluster when the keystart switch is turned on.

Ensure the gear levers are in the neutral position. Turn the keystart switch to crank the engine.
Is the battery sufficiently charged to crank the engine?

NO → Charge the battery.

YES ↓

Turn keystart off.
Remove fuse 4 from the fuse box.
Is the fuse blown?

YES → Renew the fuse and recheck function.

NO ↓

Remove the instrument cluster. Disconnect plug **C079**. Turn keystart switch on and measure voltage between **C079-7** (B) and **C079-6** (G) terminals.
Is approximately 12v measured?

YES → Clean wiring loom to instrument cluster connector pins with contact spray. Rejoin connector **C079** and switch ignition on.
Does instrument cluster display?

NO ↓

Install a new Central Digital Display Module into the instrument cluster and recheck function.

NO ↓

Turn keystart switch on and measure voltage between connector terminal **C079-6** (G) and the battery negative (ground) terminal.
Is approximately 12v measured?

YES ↓

Locate and repair fault in ground wiring.

NO ↓

Locate and repair fault in 12v power wiring.

4

PART 4
CLUTCHES

Chapter 1
CLUTCHES

A. DESCRIPTION AND OPERATION

The Series 40 range of tractors utilises two methods of clutch operation.

The clutch system of the 12x12 Synchro–Shift transmission is a hydraulically operated single plate clutch with a 13 in. (330 mm) non asbestos dry friction disc, cerametallic on 8240 and 8340 models, designed for high durability and low effort operation. The clutch is conventionally located at the front of the transmission, connecting the engine to the transmission input shaft. The hydraulic actuation is provided with a simple master/slave cylinder arrangement. This provides self adjustment of the clutch system to maintain optimum clutch performance. The pressure plate is a diaphragm spring type also self adjusting and requiring no maintenance.

The clutch system of the 8x2 non synchromesh transmission is a mechanically operated system with a single non asbestos dry friction disc clutch plate of 13 in. (330 mm) diameter. The pressure plate is of the same diaphragm spring type used in the 12x12 transmission.

The 16x16 transmission does not use a conventional clutch arrangement. Engine power is transmitted to the transmission via a damper assembly attached to the engine flywheel. The function and operation of the clutch pedal is described in detail in Part 5, Chapter 1 of this Repair Manual.

Operation

The principle of clutch operation is the same whether the clutch is Hydraulically or mechanically operated.

In the clutch 'engaged' position the spring loaded pressure plate forces the clutch disc into contact with the engine flywheel.

The frictional contact between the clutch disc material and the surfaces of the flywheel and pressure plate enables drive from the flywheel to be transmitted via the clutch disc to the input shaft of the transmission.

A clutch operating pedal is either connected mechanically, by a rod and lever, or hydraulically to a release bearing. The release bearing contacts the operating fingers of the pressure plate.

Depression of the clutch pedal causes the release bearing to move forward and depress the pressure plate release fingers, thus drawing the pressure plate away from the clutch disc and releasing the disc from contact with the flywheel. The frictional drive from the engine to the transmission is thereby disconnected.

When the clutch pedal is released a spring returns the pedal to its free position and the release bearing is drawn away from the release levers of the pressure plate assembly.

The main springs of the pressure plate assembly then re–assert pressure on the pressure plate moving it towards the friction disc and into contact with the flywheel, re–establishing the drive between engine and gearbox.

B. FAULT FINDING

FAULT FINDING

PROBLEM	POSSIBLE CAUSES	REMEDY
No drive when gear selected and clutch pedal released	1. Rear axle or transmission faulty	1. Engage differential lock. If tractor drives, fault indicated from output of differential unit. If still no drive, possible transmission or rear axle input fault. **Note:** If FWD fitted, engage FWD, if tractor drives, transmission O.K.
	2. Clutch incorrectly adjusted (mechanical)	1. Adjust clutch
	3. Clutch bearing not releasing	1. a). Inspect linkage (mechanical) b). Pedal not releasing fully on hydraulic system, keeping bearing engaged. c). Fault in master or slave cylinders.
	4. Friction disc completely worn	1. Replace friction disc
	5. Pressure plate faulty	1. Repair or replace pressure plate
Engine speed increases without a corresponding rise in road speed, clutch pedal released.	1. Clutch friction disc slipping	1. Check clutch adjustment 2. Worn friction disc 3. Pressure plate faulty 4. a). Release bearing of hydraulic clutch not fully releasing, check that pedal to master cylinder rod has some free play b). Master or slave cylinder faulty
Difficulty engaging gears	1. Clutch Dragging (not fully disengaging)	1. Check clutch adjustment 2. Worn friction disc 3. Faulty pressure plate 4. On hydraulic systems: a). Air in system, bleed system b). Faulty seals in either master or slave cylinder

PROBLEM	POSSIBLE CAUSES	REMEDY
Impossible to engage gears, engine stalls when tractor halted, clutch pedal depressed	1. Clutch not disengaging	1. Check clutch adjustment 2. Linkage disconnected / faulty (mechanical) 3. No / low oil (hydraulic system) 4. Faulty seals in master or slave cylinder (hydraulic) 5. Clutch disc seized onto flywheel, pressure plate or input shaft splines 6. Pressure plate faulty, repair or replace as necessary
Noise from transmission bell housing, noise changes when pedal is depressed and released	1. Release bearing worn 2. Clutch pilot bearing worn	1. Replace release bearing 2. Replace pilot bearing
Clutch fails to engage smoothly	1. Defective clutch friction disc 2. Defective pressure plate 3. Worn clutch pilot bearing 4. Defective flywheel	1. Replace friction disc 2. Replace pressure plate 3. Replace pilot bearing 4. Inspect flywheel as detailed in Part 1, Engine Systems

C. CLUTCH ADJUSTMENT

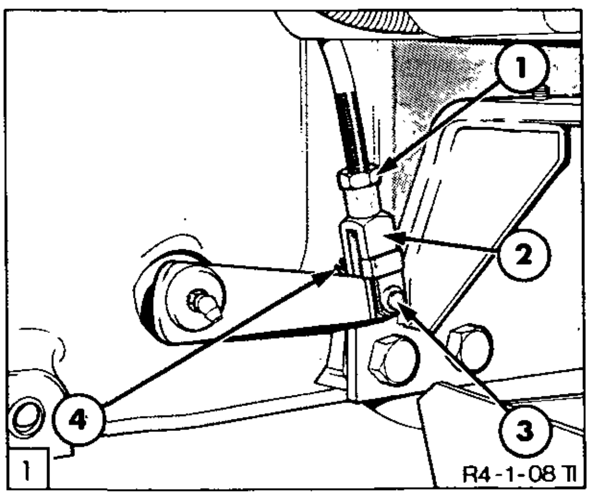
The only clutch adjustment required is to check and, if necessary, adjust the clutch pedal free travel. This is the amount of pedal movement from the fully released position to the point where resistance is first encountered. This adjustment is only required on the mechanically operated clutch system.

ADJUSTMENT PROCEDURE:

With reference to Figure 1.

The clutch free travel should be 1.1 – 1.6 in. (28 – 41 mm) at the clutch pedal.

If adjustment is required, loosen the locknut, remove the split pin and clevis pin. Turn the clevis to lengthen or shorten the operating rod, as required. Secure the clevis pin with a new split pin and tighten the locknut.



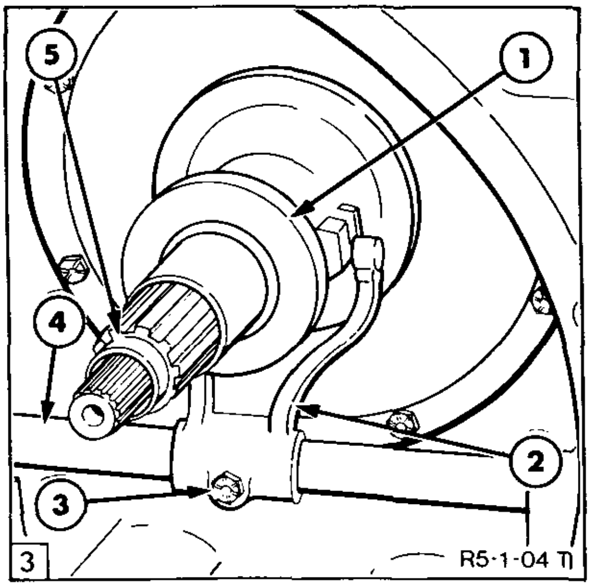
Clutch Pedal Adjustment

1. Locknut
2. Clevis
3. Clevis Pin
4. Split Pin

D. CLUTCH OVERHAUL – MECHANICAL OPERATION

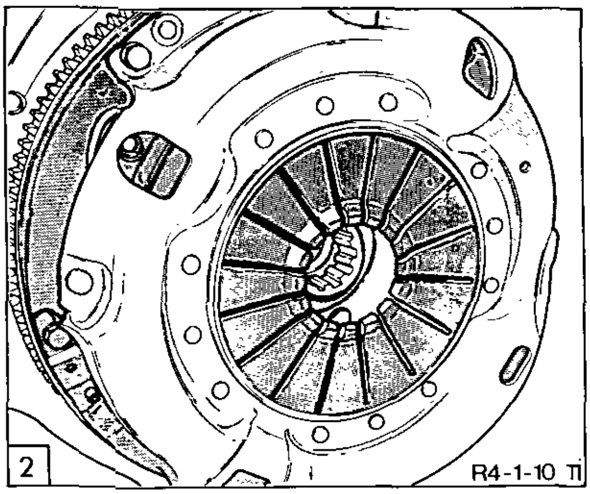
REMOVAL

1. Separate the tractor between the engine and transmission, refer to the section, 'SEPARATING THE TRACTOR'.



Clutch Release Bearing Installation

1. Clutch Release Bearing
2. Clutch Release Fork
3. Retaining Bolt
4. Clutch Release Shaft
5. Main Drive Input Shaft



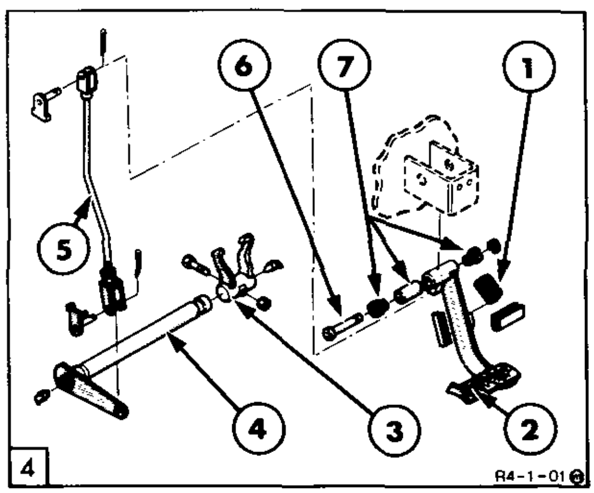
Clutch Assembly Installed onto Engine

2. Remove the bolts securing the clutch pressure plate and cover assembly to the flywheel and remove the pressure plate assembly together with the clutch disc.

NOTE: *The bolts must be slackened evenly and diagonally across the clutch to prevent distortion of the cover assembly.*

3. Remove the clutch release fork retaining bolt, Figure 3, and withdraw the clutch release shaft from the casing. Remove the clutch release fork from the transmission. Slide the clutch release bearing and hub from the clutch release hub support.

4. To remove the clutch pedal, carefully lever off the pedal return spring, remove the clutch pedal shaft retaining snap ring, withdraw the shaft and pull the pedal from the tractor.



Clutch Components – Mechanical Operation

1. Pedal Return Spring
2. Pedal
3. Release Bearing Operating Fork
4. Transmission Cross shaft
5. Operating Rod
6. Pedal Shaft
7. Bushes

INSPECTION AND REPAIR

Friction Disc

1. Inspect the clutch disc to ensure the linings are not loose, cracked, worn or contaminated with oil. Check the rivets are secure. If signs of overheating due to clutch slippage or excessive wear are evident, the disc must be discarded and a new one installed.

IMPORTANT: *Investigate the source of any oil or grease on the facings and rectify before installing a new disc.*

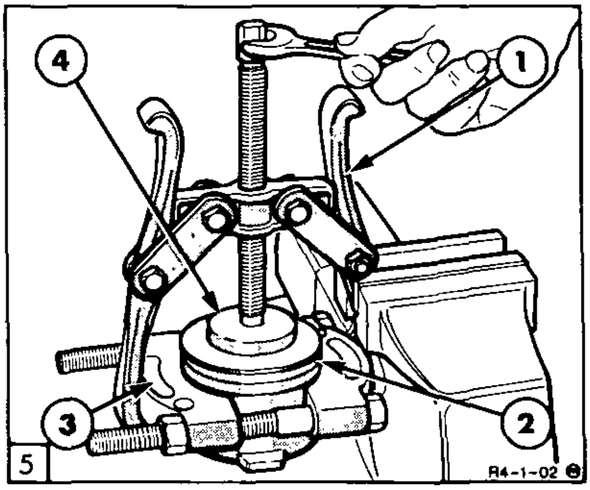
Pressure Plate

2. Examine the pressure plate assembly, ensure the diaphragm fingers are all at the same height, there is no discolouration due to excessive heat and that the assembly operates smoothly. Check the face of the pressure plate for cracks, scoring or distortion. Discard the pressure plate if any faults are found.

NOTE: *The diaphragm type clutch has no serviceable components. A new assembly will be required if any faults are found during inspection.*

Release Bearing

3. Examine the release bearing assembly, ensure the bearing hub moves freely over the transmission hub carrier. Ensure the bearing rotates smoothly and the face of the bearing is not damaged or worn. Examine the clutch release fork, ensure the fork is not cracked or bent, i.e, the fork ends align and that the ends are not worn. Discard and replace any worn or damaged parts.
   Use puller attachment, Tool No. 951, puller Tool No. 1002 and a suitable step plate to separate the release bearing from the hub if necessary to renew either component, Figure 5.



Separating Clutch Release Bearing and Hub

1. Puller – Tool No. 1002
2. Bearing and Hub Assembly
3. Puller Attachment – Tool No. 951
4. Step Plate

Clutch Pedal

4. Inspect the clutch pedal ensuring there are no cracks in the pedal assembly and there is no excessive free play between the bushes and pedal shaft when installed in the pedal. Discard and replace any worn or damaged parts.

Clutch Release Cross Shaft

5. Inspect the clutch release cross shaft and transmission housing bushes. The shaft should rotate smoothly in the bushes without any free play between the bushes and shaft. If the bushes are worn or damaged remove and replace using bushing kit, Tool No. 818.

INSTALLATION

IMPORTANT: *When installing a new pressure plate assembly, the pressure plate friction face must be wiped clean with white spirit to remove the protective coating.*

1. Lightly lubricate the hub splines of the transmission input shaft with a suitable non–fibrous lithium base grease.

2. Position the clutch disc on the flywheel with the marked face and damper springs towards the flywheel, use locator, Tool No. SW 14, to centralise the disc.

3. Locate the pressure plate assembly onto the flywheel and tighten the retaining bolts to a torque of 26 lbf.ft (35 Nm).

4. Remove the locator tool from the clutch disc.

5. Installation of the clutch release bearing follows the removal procedure in reverse, observing the following requirements:

- Lubricate the hub bore with a high melting point grease.

- Tighten the release shaft fork pinch bolt to 35 lbf.ft (47 Nm).

- After installation ensure the release bearing assembly operates correctly when the clutch pedal is depressed and released.

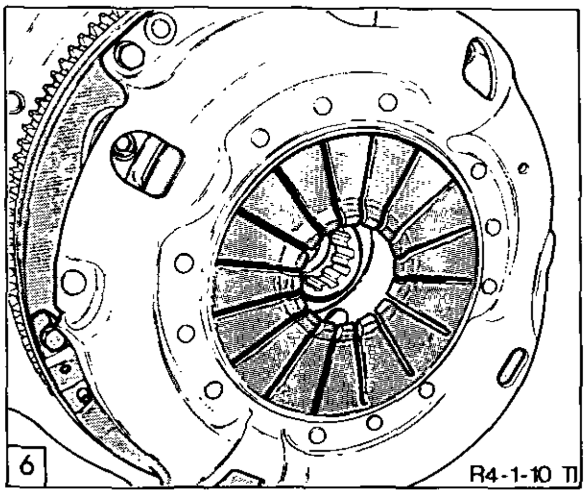
6. Reconnect the engine to the transmission assembly as described in the 'SEPARATING THE TRACTOR' section of this Repair Manual.

7. Check and adjust the clutch pedal free play as previously described in Section C of this Chapter.

E. CLUTCH OVERHAUL – HYDRAULIC OPERATION

REMOVAL

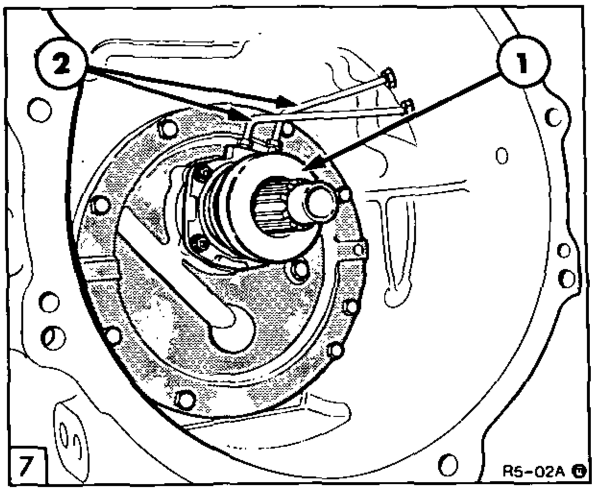
1. Separate the tractor between the engine and transmission, refer to the section, 'SEPARATING THE TRACTOR'.



Clutch Assembly Installed onto Engine

2. Remove the bolts securing the clutch pressure plate and cover assembly to the flywheel and remove the pressure plate assembly together with the clutch disc.

NOTE: *The bolts must be slackened evenly and diagonally across the clutch to prevent distortion of the cover assembly.*

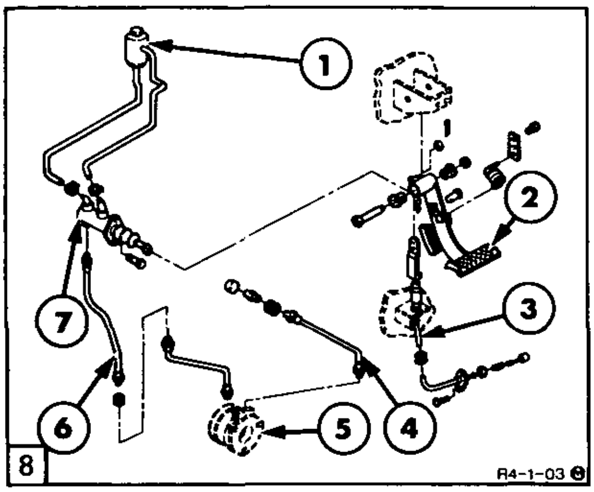


Hydraulic Release Bearing

1. Hydraulic Release Bearing Assembly
2. Hydraulic Tubes

3. At the front of the transmission, remove the two tubes from the hydraulic release bearing, Figure 7. Remove the three bolts securing the release bearing assembly to the transmission front plate and withdraw the release bearing assembly.

4. To remove the clutch pedal, remove the left hand side panel from the instrument console and disconnect the rod to the master cylinder. Carefully lever off the pedal return spring, remove the clutch pedal shaft retaining snap ring, withdraw the shaft and pull the pedal from the tractor.



Clutch Components – Hydraulic Operation

1. Hydraulic Oil Reservoir
2. Clutch Pedal
3. Interlock Cable
4. Slave Cylinder Bleed Tube
5. Slave Cylinder Assembly
6. Slave Cylinder Oil Supply Tube
7. Master Cylinder

INSPECTION AND REPAIR

Friction Disc

1. Inspect the clutch disc to ensure the linings are not loose, cracked, worn or contaminated with oil. Check that the rivets are secure. If signs of overheating due to clutch slippage or excessive wear are evident, the disc must be discarded and a new one installed.

IMPORTANT: *Investigate the source of any oil or grease on the facings and rectify before installing a new disc.*

Pressure Plate

1. Examine the pressure plate assembly, ensure the diaphragm fingers are all at the same height, there is no discolouration due to excessive heat and that the assembly operates smoothly. Check the face of the pressure plate for cracks, scoring or distortion. Discard the pressure plate if any faults are found.

NOTE: *The diaphragm type clutch has no serviceable components. A new assembly will be required if any faults are found during inspection.*

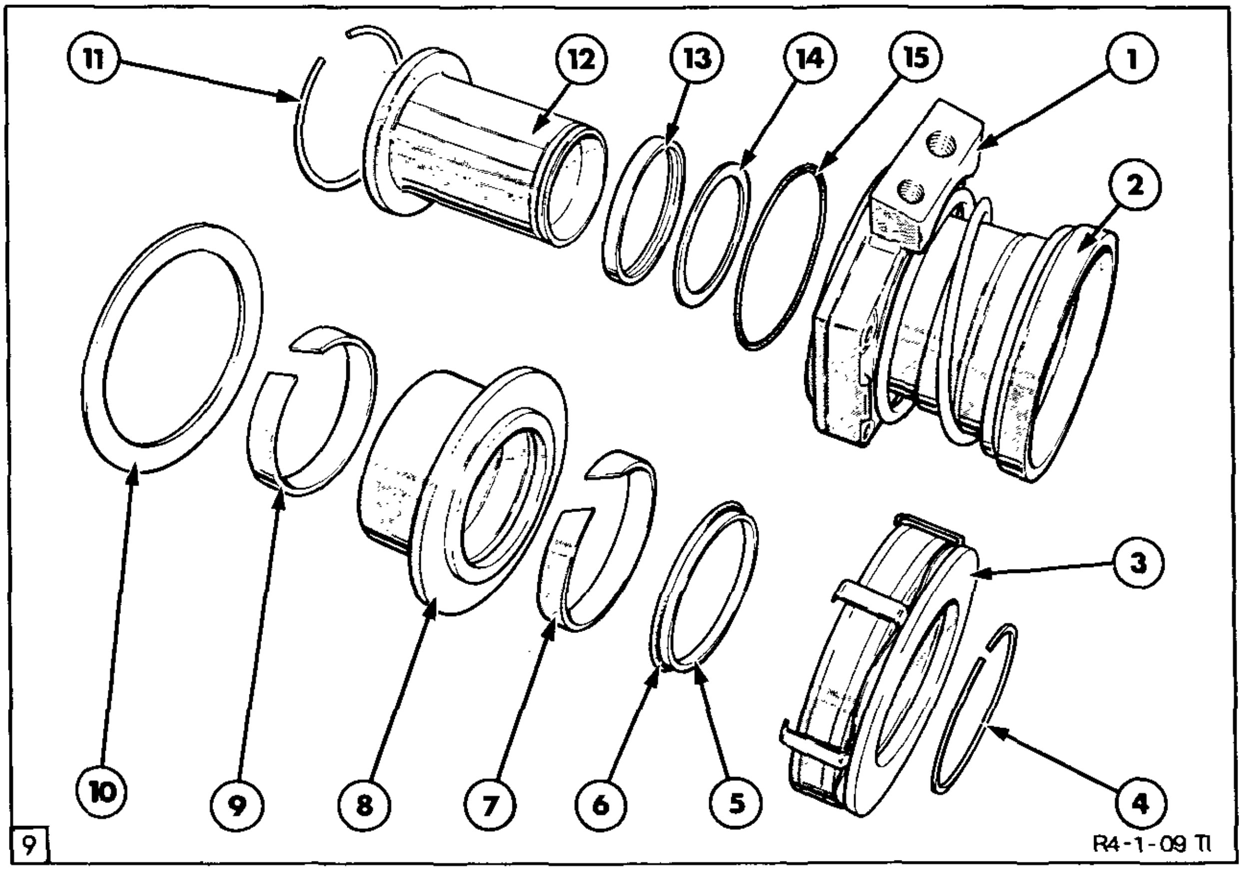
Hydraulic Release Bearing / Slave Cylinder Assembly

1. Inspect the release bearing for the following, oil leakage, weak or broken return spring and wear or damage to the release bearing. Repair kits are available should seals or the bearing assembly require servicing.

Hydraulic Release Bearing / Slave Cylinder Assembly Overhaul.

With reference to Figure 9

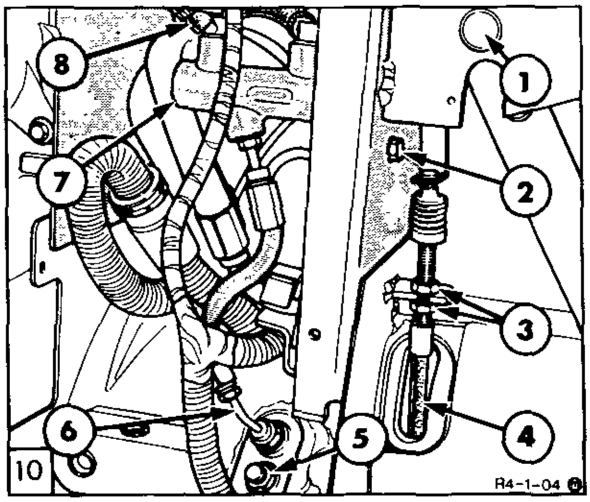
1. Remove bearing retaining snap ring, item 4, and withdraw the bearing assembly.
2. Carefully pry the bearing cage claws open and withdraw the piston assembly.
3. Remove the snap ring from the rear of the housing and withdraw the guide sleeve
4. In the dismantled condition it is wise to replace the seals with new items as a precautionary measure against future failure. Inspect the remaining components for wear or damage and replace as necessary.
5. Reassembly is the reversal of the disassembly. Coat all seals with clean brake oil of the correct specification as they are installed and assembled.



Release Bearing / Slave Cylinder Assembly

1. Housing
2. Protective Cap Assembly
3. Bearing Assembly
4. Snap Ring
5. Wiper Seal
6. 'O' Ring
7. Guide Ring
8. Piston
9. Guide Ring
10. Seal Ring
11. Snap Ring
12. Guide Sleeve
13. Seal
14. Back Up Seal
15. 'O' Ring

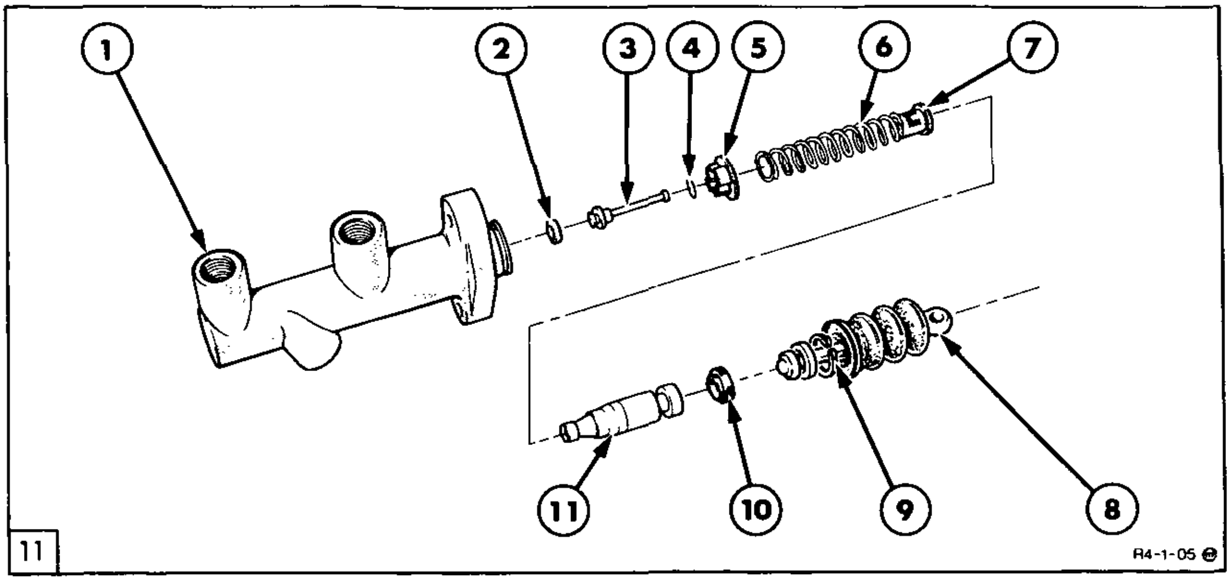
Master Cylinder



Clutch Components

1. Clutch Pedal Pin
2. Master Cylinder Retaining Nut
3. Cable Adjustment Nuts
4. Interlock Cable
5. Bleed Screw
6. Master Cylinder to Slave Cylinder Tube
7. Master Cylinder
8. Oil Supply from Reservoir

1. Remove the left hand instrument panel side cover, if not previously removed.
2. Disconnect the two hoses from the reservoir and plug to prevent excessive oil loss.
3. Disconnect the outlet tube to the slave cylinder and plug.
4. Disconnect the push rod from the clutch pedal.
5. Remove the two bolts securing the cylinder assembly to the tractor bulkhead and withdraw the cylinder.
6. Installation is the reversal of the removal procedure.



Master Cylinder – Exploded View

1. Master Cylinder Body
2. Valve Rubber Seal
3. Rod
4. Wavy Spring Washer
5. Nylon Holder
6. Spring
7. Retainer
8. Push Rod and Boot Assembly
9. Circlip
10. Gland Seal
11. Spool

Master Cylinder – Overhaul

Disassembly

1. Roll back push rod rubber boot, remove the circlip retaining the push rod and spool assembly.

2. Gently tap the cylinder, spool end downwards, onto a firm surface to remove the spool assembly.

3. Withdraw the oil inlet adaptors and carefully hook out the seals.

4. From the spool and spring assembly, bend back the locking tab of the retainer and withdraw the spring assembly. Unhook the rod and disassemble.

Inspection and Repair

1. Inspect the cylinder bore for wear, score marks or burrs. If the bore is not in perfect condition replace the cylinder assembly. Do not attempt to repair.

2. A seal kit is available in Service. When overhauling the master cylinder obtain a kit and replace **ALL** seals.

3. Coat all seals in clean brake oil prior to fitment.

IMPORTANT: *Use only the specified type of brake oil, Ford Specification ESN–M6C59–A. The oil used in this system is a 'Mineral' based oil. Use of a non specified oil will cause seal damage and a resultant failure.*

Reassembly

1. Reassembly is the reversal of the disassembly procedure.

System Bleeding

1. Ensure the reservoir is filled up to the maximum line with the specified brake oil.

2. Install a suitable rubber tube over the bleed screw. Immerse the tube into a jar of clean and correct specification brake oil. Position the jar above the bleed screw, this will prevent possible air ingress at the bleed screw.

3. Open the bleed screw and fully depress the clutch pedal, close the bleed screw with the pedal depressed and then release the pedal. Repeat this procedure until 'air free' oil is entering the jar.

NOTE: *Regularly inspect the oil level in the reservoir during bleeding. Do not allow it to empty.*

Clutch Pedal

1. Inspect the clutch pedal ensuring there are no cracks in the pedal assembly and that there is no excessive free play between the bushes and pedal shaft when installed in the pedal. Discard and replace any worn or damaged parts.

INSTALLATION

IMPORTANT: *When installing a new pressure plate assembly, the pressure plate friction face must be wiped clean with white spirit to remove the protective coating.*

1. Lightly lubricate the hub splines of the transmission input shaft with a suitable non–fibrous lithium base grease.
2. Position the clutch disc on the flywheel with the marked face and damper springs towards the flywheel, use locator, Tool No. SW 14, to centralise the disc.
3. Locate the pressure plate assembly onto the flywheel and tighten the retaining bolts to a torque of 26 lbf.ft (35 Nm).
4. Remove the locator tool from the clutch disc.
5. Installation of the clutch release bearing follows the removal procedure in reverse, observing the following requirements:

- Tighten the release bearing retaining bolts to 18 lbf.ft (25 Nm).
- Install the two hydraulic tubes and bleed the system of air as previously described.
- Check the operation of the slave cylinder. Push and hold the release bearing 'IN' by hand, obtain an assistant to depress and release the clutch pedal. The release bearing should be forced out with the pedal depressed and return 'IN' with the pedal released while still applying hand pressure.

6. Reconnect the engine to the transmission assembly as described in the 'SEPARATING THE TRACTOR' section of this Repair Manual.

F. CLUTCH PILOT BEARING

A pre–lubricated ball bearing assembly is installed at the rear end of the engine crankshaft, within the flywheel. The bearing is located in the PTO drive plate.

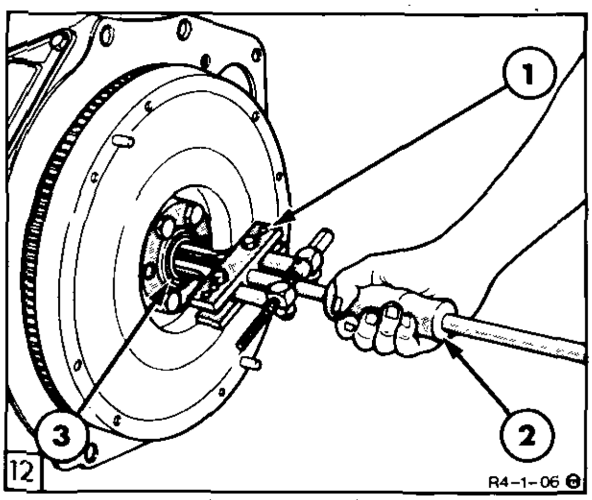
OVERHAUL

Removal

1. Remove the clutch as described in either Section D or E.
2. Use slide hammer, Tool No. 943–S and puller, Tool No. 943 to remove the PTO drive plate bearing as shown in Figure 12.

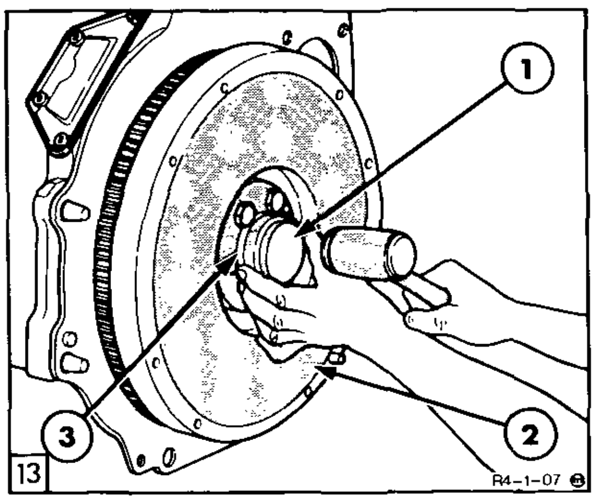
Installation

1. Lightly tap the bearing, shield side facing outwards, into the PTO drive plate.
2. Use Step Plate Adaptor, Tool No. 630–12, to fully install the bearing as shown in Figure 13



Clutch Pilot Bearing Removal

1. Puller Tool No. 943
2. Slide Hammer, Tool No. 943S
3. *Clutch Pilot Bearing*



Clutch Pilot Bearing Installation

1. Step Plate Adaptor Tool No. 630–12
2. Flywheel
3. Clutch Pilot Bearing

G. SPECIFICATIONS, TIGHTENING TORQUES AND SPECIAL TOOLS

SPECIFICATIONS

Components	5640/6640/7740/7840	8240 & 8340
Disc Assembly Type	13in (330 mm) Single Disc Dry Plate	
Material	Organic Non Asbestos	Cera–metallic
Pressure Plate Assembly Type	Belleville (diaphragm) Spring (Self Adjusting – No Maintenance)	
Release Bearing Type	Mechanically Operated with 8x2 (16x4) Transmissions Hydraulically Operated with 12x12 Transmission	
Clutch Pedal Free Play Adjustment – (Mechanically Operated Clutch Only)	1.1 – 1.6 in (28 – 41 mm)	
Transmission Input Shaft Lubricant	Non Fibrous Lithium Base Grease	
Hydraulic Clutch oil	Ford Specification ESN--M6C59–A	
Master Cylinder Push Rod to Plunger Clearance	0.6 mm (0.024 in) Minimum	

TIGHTENING TORQUES

Components	lbf.ft	Nm
Clutch Cover to Flywheel Bolts	26	35
Clutch Pedal Operating Rod Turnbuckle Locknut	25	34
P.T.O. Drive Plate Bolts	95	129
Cross shaft Release Bearing fork Retaining Bolt	35	47
Hydraulic Slave Cylinder Retaining Bolts	18	25
Master Cylinder Retaining Bolts	17	23
Hydraulic Tube Connections	16	22

PART 5
TRANSMISSION SYSTEMS
Chapter 1
16 x 16 TRANSMISSION

A. TRANSMISSION – DESCRIPTION AND OPERATION

General

The 16 x 16 transmission provides 16 forward and 16 reverse gears. The basic transmission can be specified with the following options:–

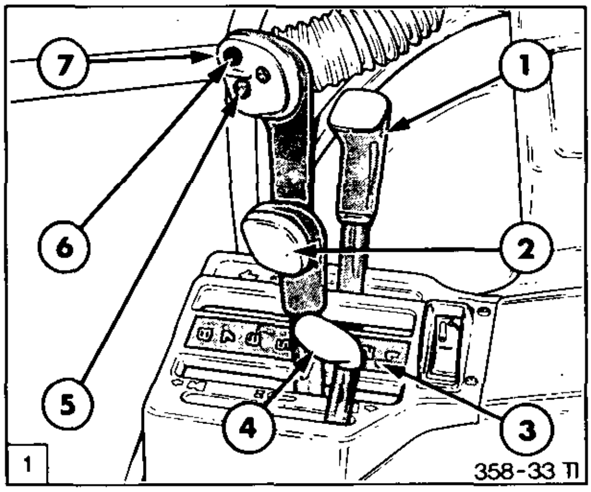
1. Four wheel drive – consisting of an integral gear, clutch and output arrangement that provides a selectable coupling between the transmission and front axle. This four wheel drive output is available with two ratios to suit different tyre combinations. If two wheel drive is specified the output arrangement is deleted.

2. Creep ratios – this option provides a range of 8 further ratios lowering the resultant ground speed. See also ratio and speed charts in the *Specifications Section.*

3. 40 km/hr option may be specified in place of the standard 30 km/hr, but is only available *with four wheel drive.*

The transmission provides four mechanically selected ranges. Within each of these ranges is the ability to select a further four ratios using an electro–hydraulic selection system. This in effect gives a four times four (4x4=16) transmission resulting in 16 ratios.

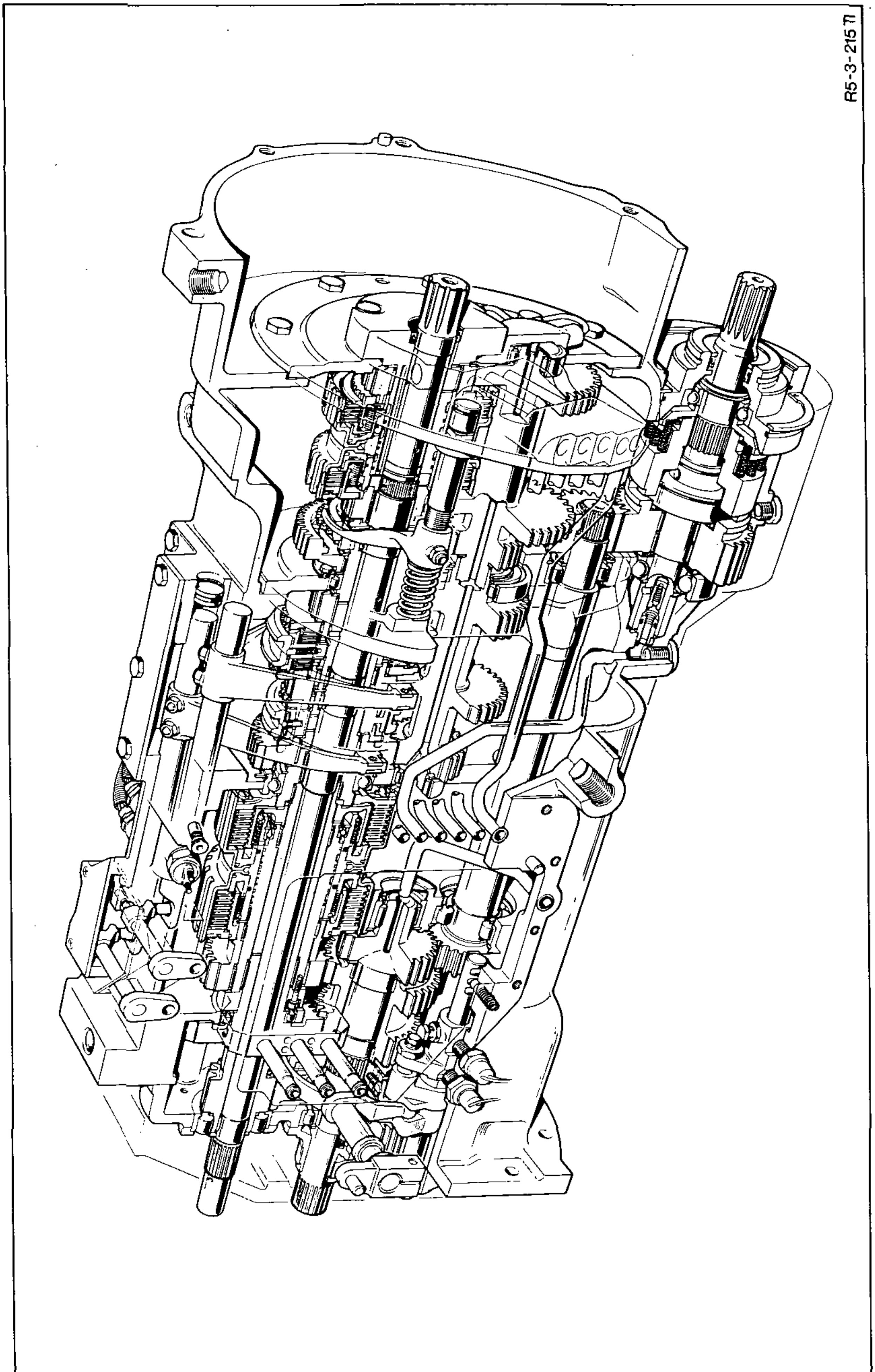
A cutaway illustration of the mechanical aspect of the transmission is shown overleaf.



Transmission Controls

1. High/Low Range Lever
2. Forward/Reverse Shuttle Lever
3. Illuminated Display (gear selected)
4. Hand Throttle
5. Powershift Down Button
6. Powershift Up Button
7. Main Range Lever

Three shift levers control the selection of the 16 forward and 16 reverse gears, Figure 1. The high/low range lever, selects either high range in the forward position or low range in *the rearward position via a synchronised coupler* with a neutral mid–position. The main range lever in rearward position selects an initial range 1–4, in a mid–position gives a neutral position and in the forward position, a second range 5–8. The change between the initial 1–4 *range and the 5–8 range* is also synchronised. Gears between 1–4 and 5–8 are selected using two powershift selection buttons incorporated into the lever knob. The shuttle lever controls a forward or reverse shuttle function, with a neutral position between. The change from forward direction to rearward direction is also synchronised.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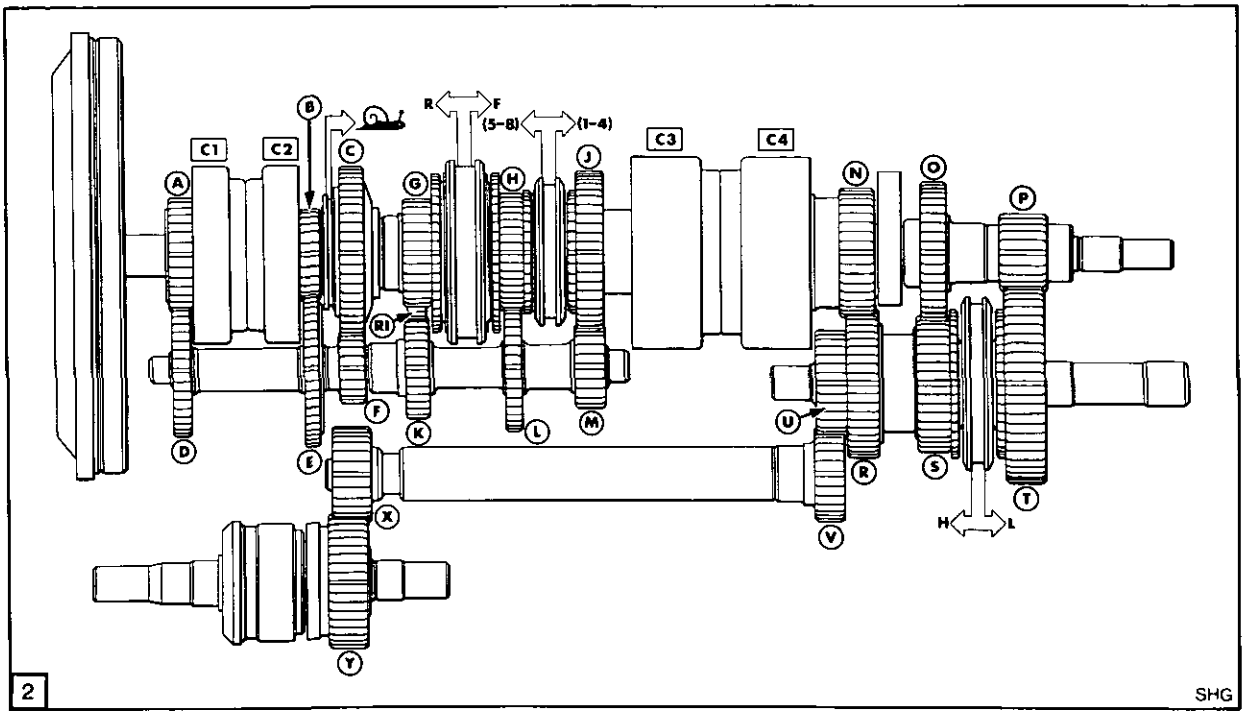


Transmission Gears, Clutches and Couplers – Component Identification

A C1 Clutch Output Gear (34 tooth)
B. C2 Clutch Output Gear (26 tooth)
C. Creeper Driven Gear (55 tooth)
D. Front Bottom Shaft Gear (42 tooth)
E. Front Bottom Shaft Gear (48 tooth)
F. Front Bottom Shaft Gear (20 tooth – Creeper only)
G. Reverse Gear (33 tooth)
H. Forward Gear and/or Coupler (37 tooth)
J. Low Main Gear (53 tooth)
K. Intermediate Bottom Shaft Gear (37 tooth)
L. Intermediate Bottom Shaft Gear (41 tooth)
M. Intermediate Bottom Shaft Gear (25 tooth)
N. C4 Clutch Output Gear (42 tooth 40 km/hr, 37 tooth 30 km/hr)
O. C3 Clutch [High] Output Gear (46 tooth 40 km/hr, 41 tooth 30km/hr)
P. C3 Clutch [Low] Output Gear (22 tooth)
R. Output Gear ((37 tooth 40 km/hr, 43 tooth 30 km/hr)
R1 Reverse Idler Gear (31 tooth)
S. Output Gear ((33 tooth 40 km/hr, 39 tooth 30 km/hr)
T Low Range Output Gear (65 tooth)
U. Output to FWD (29 tooth)
V. FWD Internal Shaft Rear Gear (26 tooth)
X. FWD Internal Shaft Front Gear (26 tooth)
Y. FWD Transfer Assembly Driven Gear (37 or 38 tooth)

C1. is Clutch C1 C2. is Clutch C2 C3. is Clutch C3 C4. is Clutch C4

The reverse mode is accomplished by providing a simple idler system which reverses the power flow direction of the transmission input stages.

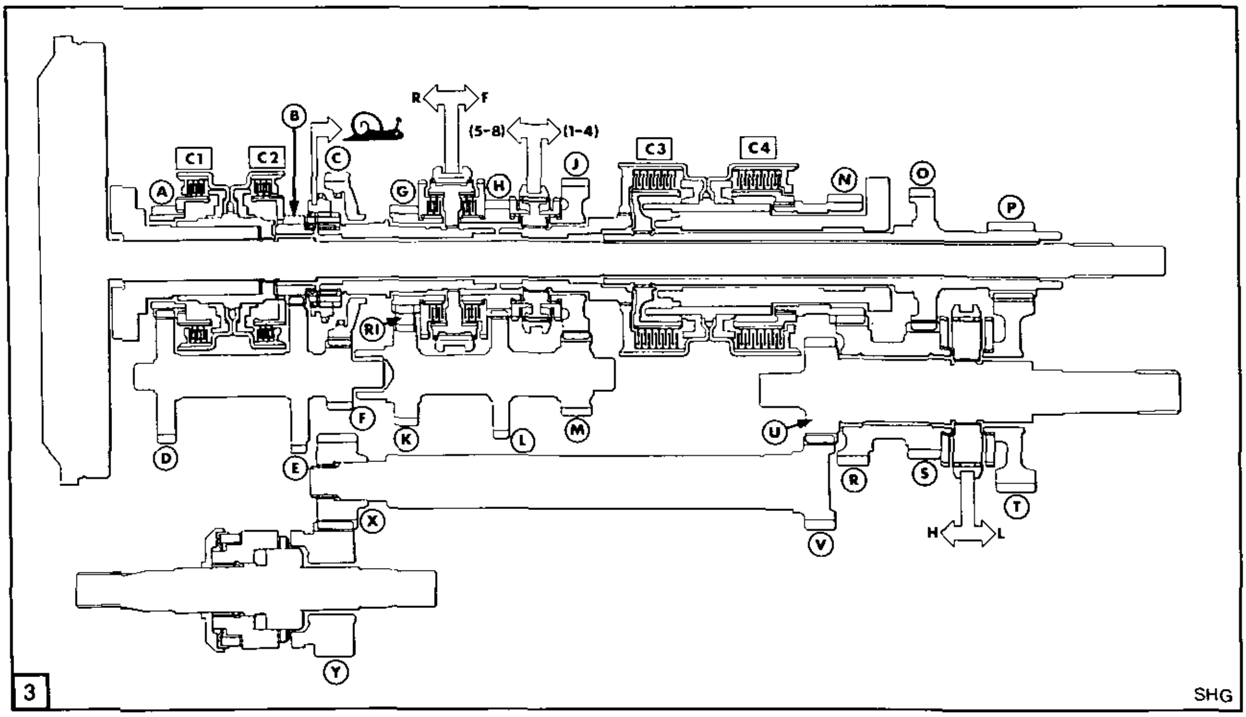
Shown in Figure 2 is a basic representation of the mechanical components of the transmission. In Figure 3 these same components are represented in section.

Within the transmission housing there are four basic compartments. The front compartment is accessed through the front cover plate and contains the C1 and C2 clutch assemblies and the front bottom shaft or gear cluster. The second or intermediate compartment is accessed via a removable intermediate cover plate and houses the forward/reverse and main synchronisers, the intermediate bottom shaft or gear cluster and the reverse idler gear. The third compartment, behind a cast wall or bulkhead, contains the C3 and C4 clutches. The fourth compartment, which overlaps the third, but is on the lower level, contains the high/low range and output shaft assembly and is accessed from a removable rear cover plate.

The drive to the optional front wheel drive is spurred from the output shaft and via a heavy duty internal shaft carried forward to drive the front wheel drive output assembly. This assembly contains a spring engaged dog type clutch which is released electro–hydraulically from an instrument panel mounted switch.

All gears are straight cut and finish honed to very fine limits for durable and extended service life and for low noise levels. Ball, roller and needle roller bearings are used to support the clutches, shafts and gears.

All gears and clutches are pressure lubricated from lateral drillings in the main shafts, which in turn are supplied by oil from manifolds linked to serviceable 'rolled in' internal tubes.



Transmission Gears, Clutches and Couplers – Component Identification

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F. Front Bottom Shaft Gear (20 tooth – Creeper only)
G. Reverse Gear (33 tooth)
H. Forward Gear and/or Coupler (37 tooth)
J. Low Main Gear (53 tooth)
K. Intermediate Bottom Shaft Gear (37 tooth)
L. Intermediate Bottom Shaft Gear (41 tooth)
M. Intermediate Bottom Shaft Gear (25 tooth)
N. C4 Clutch Output Gear (42 tooth 40 km/hr, 37 tooth 30 km/hr)
O. C3 Clutch [High] Output Gear (46 tooth 40 km/hr, 41 tooth 30km/hr)
P. C3 Clutch [Low] Output Gear (22 tooth)
R. Output Gear ((37 tooth 40 km/hr, 43 tooth 30 km/hr)
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S. Output Gear ((33 tooth 40 km/hr, 39 tooth 30 km/hr)
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U. Output to FWD (29 tooth)
V. FWD Internal Shaft Rear Gear (26 tooth)
X. FWD Internal Shaft Front Gear (26 tooth)
Y. FWD Transfer Assembly Driven Gear (37 or 38 tooth)

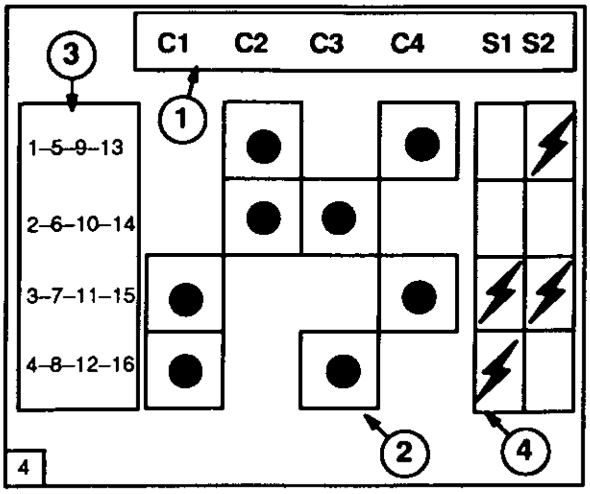
C1. is Clutch C1 C2. is Clutch C2 C3. is Clutch C3 C4. is Clutch C4

The electro–hydraulic selection system of the four ratios within the four mechanical ranges controls the engagement and disengagement of four multi–plate wet clutches. The control system and characteristics of the wet clutches allow a powershift function to be obtained. 'Powershift' can be defined as the ability to change gear or shift gear on the move without interruption of the power delivery to the wheels.

Engine power is transmitted to the transmission via a damper assembly attached to the engine flywheel. The four multi–plate wet clutches are positioned on the upper level of the transmission and are shown as C1, C2, C3 and C4. C1 is paired with C2 and C3 is paired with C4. This pairing permits the clutches to be controlled by two electro–hydraulic solenoid controlled direct acting valves. These two solenoids perform the switching function that controls the selection of the clutches required. Another solenoid controlled by a pulse width modulation signal (PWM) from the micro processor actually controls the timing and rate of engagement of the clutches.

The four mechanical segments or ranges are selected by the engagement of two of the three synchronisers. The range synchroniser selecting either gears or ratios 1–4 or 5–8 and the high/low synchroniser, selecting either gears or ratios 1–8 or 9–16. Forward and reverse direction is selected by the third synchroniser termed the shuttle synchroniser.

When one of each pair of the four multi–plate wet clutches are engaged drive is transmitted to one of the four gears available in the four mechanical ranges and is depicted in Figure 4.



Clutch Application Chart

Item (1), which identifies the clutches and S1 and S2 solenoids, has a box, below (2), and this depicts the clutches which are engaged. To the left of this box, item (3), is shown the gears which will be selected when the clutches are applied. In box 4 the state of the S1 and S2 solenoids are shown. The presence of the symbol signifies that the solenoid is energised. For example in 2nd gear neither S1 *or S2 are energised, in 4th gear* S1 is energised, S2 is not.

With reference to the chart, with clutches C2 and C4 engaged, first gear or ratio will be selected in the first mechanical range, fifth gear or ratio in the second mechanical range, ninth gear or ratio in the third mechanical range and thirteenth in the fourth mechanical range. Power shifting within the ranges is accomplished by engaging and disengaging the wet multi–plate clutches in the following sequence. From, for example, first to second gear or ratio, clutch C2 remains engaged, but C4 has disengaged and C3 engaged. From second to third gear or ratio, C2 has disengaged and C1 engaged and C3 disengaged and C4 engaged. From third to fourth gear or ratio, C1 has remained engaged and C4 disengaged with C3 engaging.

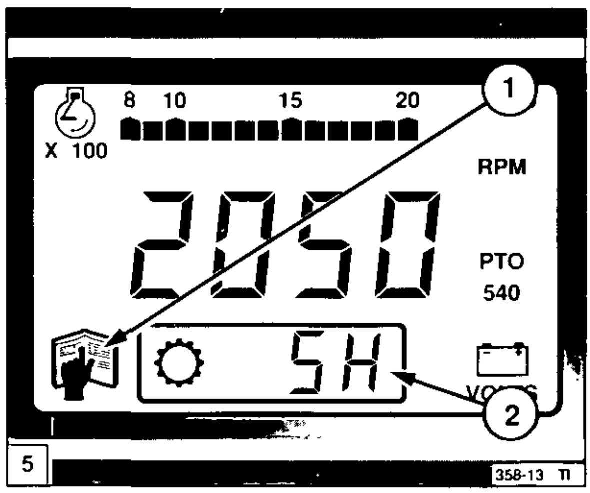
The selection of the clutches is through electro–hydraulic means employing push button switches, electrically activated solenoids, hydraulic oil pressure and control valving. The timing of this circuitry is finitely controlled by a micro processor.

The micro processor or as it will be referred to, the Electronic Transmission Control ('ETC'), is responsible for interfacing or linking to, the operator controls (shift switches, shift lever sensors, and clutch pedal sensor), the transmission (clutch solenoids, dump solenoid, PWM [pulse width modulation] solenoid and creeper solenoid) and the electronic instrument cluster ('EIC'). In addition to performing normal shift, inching/feathering or gear changing operations, the 'ETC' logic or built–in intelligence manages a variety of additional functions which include failure detection, failure management, safe start–up logic and display interfacing (linking–to).

The four synchronised gears, linking the first four powershift gears to the second four (1–4 synchronised to 5–8) and the high range to the low range combine to give the total 16 forward and 16 reverse gears. Additional ratios can be obtained by specifying the creeper option, this could in theory double the available ratios but in practice the creeper is prevented from operating in high range.

Electrical, Electronic Circuitry and Component Description

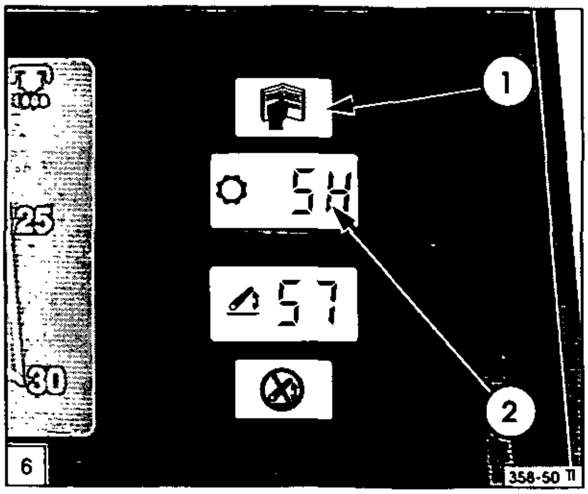
Operator Displays



Electronic Instrument Cluster – Transmission Display Area

1. 'Read Your Manual' Symbol
2. Gear Selected Display and 'Special' Transmission Symbol

The 'ETC' uses a portion of the Electronic Instrument Cluster ('EIC') Figure 5, or where fitted the Analog Electronic Instrument Cluster ('AEIC'), Figure 6, to display related 'ETC' information. The display consists of three alpha/numeric characters and one special 'transmission' symbol. Additionally the micro–processor can activate the 'Read Your Manual' symbol and sound an audible alert, in either a continuous or pulsed mode. In the event of an 'ETC' sub–system failure, the display will flash a letter and number code to indicate the nature of failure. At the same time the 'Read Your Manual' symbol will be illuminated and the audible alert sounded for a limited time.



Analog Electronic Instrument Cluster – Transmission Display Area

1. 'Read Your Manual' Symbol
2. Gear Selected Display and 'Special' Transmission Symbol

Creeper Light

If the optional creeper gear is installed, a light in the creeper switch will be illuminated when the creeper gear is engaged. Should an electrical fault occur within the creeper circuit, the light will flash, signifying the operator to disengage the creeper.

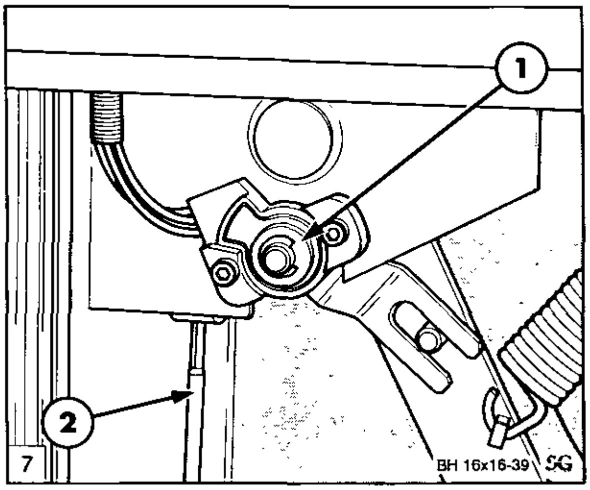
Dynamic Shift Indicator

This is located on the console between the forward reverse shuttle lever and the main shift lever (1–4 and 5–8). The indicator illuminates and shows what gear is selected between 1 and 8. It does not display whether the transmission is in low range or high range. The dynamic shift indicator complements the gear display information shown on the 'EIC' and 'AEIC' and works independently of the micro–processor, using signals from the main lever switches and the status of the powershift solenoids to deduce gear selection information.

Component Descriptions

The 'ETC' module uses several sensors and actuators to sense operator control actions and control the operation of the transmission. A description of these components and their characteristics follow.

Clutch Control Potentiometer



Clutch Potentiometer

1. Clutch Pedal Potentiometer
2. Clutch Cable to Control Valve

The clutch pedal is linked mechanically, via an operating cable, to the transmission control valve and electrically to the micro–processor using a rotary potentiometer. The signals fed from this potentiometer allow the processor to determine at what point the clutch pedal is and in conjunction with other inputs, adjust clutch engagement accordingly.

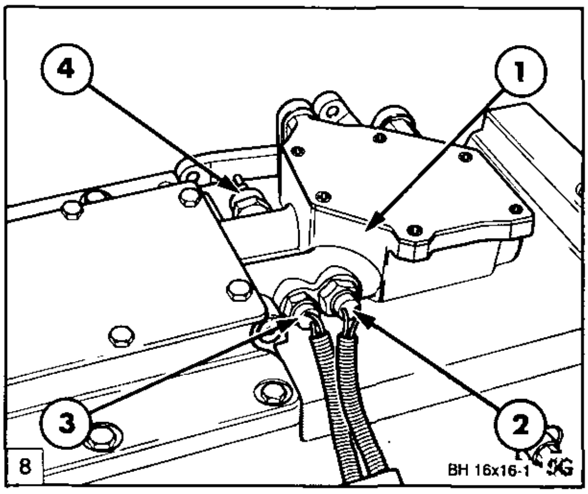
Autocalibration

In order to minimize specialised manual alignment and calibration procedures during manufacturing and servicing, an automatic calibration procedure is designed into the processor to compensate for clutch plate and pedal linkage tolerances and long term wear. Clutch pedal potentiometer auto–calibration requires no action on the part of the operator or serviceman, however, transmission clutch calibration does require action from the serviceman. The actual procedures are described in the Fault Finding, Clutch Calibration and Limp Home section, which includes the following:–
Clutches C3 and C4 – Oil Fill Pressure
Clutches C3 and C4 – Oil Fill Time
Clutches C1 and C2 – Selection Timing
Note that C1 and C2 selection timing is automatic.

Switch Inputs

Powershift Up/Down Switches

The main lever switches are used by the operator to initiate an upshift or downshift.



Top Cover Switch Identification

1. Transmission Shift Cover
2. Main Range (5–8) Switch
3. Main Range (1–4) Switch
4. Forward/Reverse Shift (Neutral) Switch

Switch changes (transitions) rather than shift levels are required to effect shifting. This means that separate switch actuations are required for each shift and the buttons must be released between shifts. This in effect prevents continual shifting in the event of a switch which fails in the 'ON' position. A shift will not occur if both buttons are depressed simultaneously. Powershifts are electronically limited to a 0.5 second shift rate. Transitions on the shift switches which are faster than 0.5 of a second are ignored.

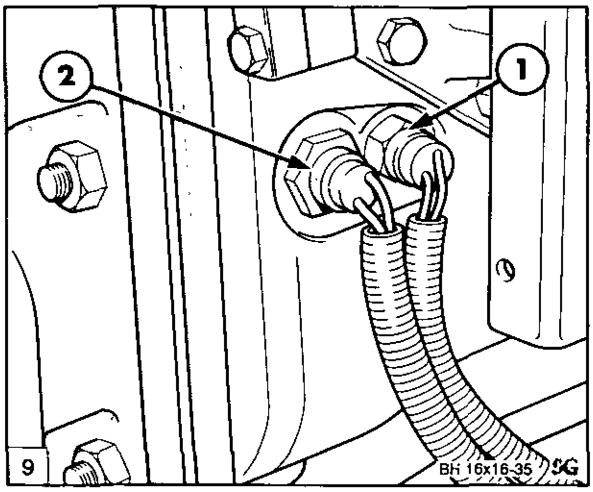
1–4 and 5–8 Switches

These two switches, shown in Figure 8, are used by the 'ETC' to determine the position of the main range lever. The switches are 'ball' or plunger type and are located in the transmission casing, acting on the shift rail. The following table shows the determined position for different switch logic levels.

1–4 Switch	5–8 Switch	Determined Lever Position
Open	Open	Neither 1–4 nor 5–8 Engaged
Closed	Open	1–4 Range Engaged
Open	Closed	5–8 Range Engaged
Closed	Closed	ERROR—Switch Failure
Note:	Closed = switch closed to +12V	
	Open = switch open (internally pulled to earth or ground)	

High and Low Switches

These two switches, shown in Figure 9, are used by the 'ETC' to determine the position of the range lever. The switches are 'ball' or plunger type and are located in the transmission casing, acting on the shift rail. The following table shows the determined position for different switch logic levels.



Transmission Casing Right Hand Side Switch Identification

1. High Range Switch
2. Low Range Switch

Low Switch	High Switch	Determined Lever Position
Open	Open	Neither Low nor High Engaged
Closed	Open	Low Range Engaged
Open	Closed	High Range Engaged
Closed	Closed	ERROR—Switch Failure
Note:	Closed = switch closed to +12V	
	Open = switch open (internally pulled to earth or ground)	

Engine Rev/Min Sensor

The engine rev/min signal from the alternator is used to indicate to the 'ETC' module the speed of the transmission clutches and that the engine is running. This signal provides seventeen pulses for each engine revolution.

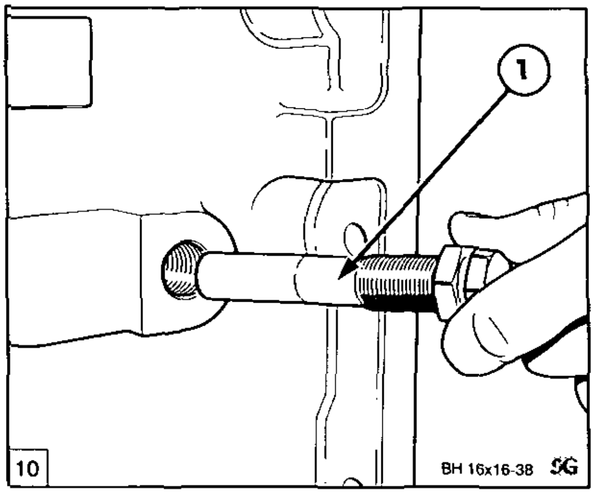
Neutral Switch

The neutral switch, shown in Figure 8, is part of the engine starting circuit and is used to indicate to the 'ETC' module that the forward–neutral–reverse (forward/reverse shuttle) lever is in neutral. When this lever is in neutral an 'N' is displayed in the left of the gear display area of the instrument panel and the neutral switch is closed to earth or ground. If the lever is not in neutral, the switch is open, and the tractor is prevented from starting.

Creeper Switch

With the optional creeper ratios installed, the creep facility is selected using a push button type (momentary) switch. Pushing the switch once will select the creeper ratio. Similarly pushing the switch again will deselect the creeper. The creeper ratios can only be selected and deselected under controlled conditions. These qualifications are defined under the heading 'Creeper Valve Logic'. An open to closed transition of the switch is used to initiate creeper selection or deselection. When closed the switch signal is +12V.

Wheel Speed Sensor



Transmission Speed Sensor

1. Speed Sensor

The wheel speed sensor is a reluctance type sensor which detects the teeth on the 29 tooth gear on the output gear (this gear is used to drive the output to the four wheel drive. The gear is always present even if four wheel drive is not specified). The passing of the teeth provides an output and the resultant speed of the unit is calculated. The signal from the wheel speed sensor is used by the 'ETC' module's logic to detect when the unit is rolling. The primary use of the wheel speed sensor is for wheel slip monitoring and the slip override control function of the EDC (Electronic Draft Control).

C1/C2 Clutches Pressure Switch

The C1/C2 clutches pressure switch, Figure 11, closes to +12V when pressure to the C1/C2 valve exceeds 160 lbf.in^2 (11 bar). It is used for automatic adjustment of C1/C2 clutch timing when double clutch shifts are performed (C1 shifts to C2 and C4 shifts to C3. i.e. 3rd gear to 2nd gear).

C3/C4 Clutches Pressure Switch

The C3/C4 clutches pressure switch, Figure 11, closes when pressure to C3/C4 valve exceeds 160 lbf.in^2 (11 bar). It is used for clutch fill time calibration.

Solenoid Controlled Valves

Figure 11 illustrates the electro–hydraulic components schematically.

C1/C2 Valve

The C1/C2 selector valve is an electro–hydraulic device which controls the hydraulic pressure on the C1 and C2 clutches. The valve's solenoid S1, shown in Figure 11, has a nominal resistance of 6 ohms (at 20°C). The solenoid is energised by sinking current through an electronic switch to earth or ground using a low side driver device in the 'ETC' module. One side of the solenoid is connected to the electronic switch and the other side is supplied with battery voltage. When the solenoid is not energised, as shown in Figure 11, hydraulic pressure is supplied to engage the C2 clutch. When the solenoid is energised hydraulic pressure is supplied to engage the C1 clutch. There is no modulation of the signal which energises this solenoid.

C3/C4 Valve

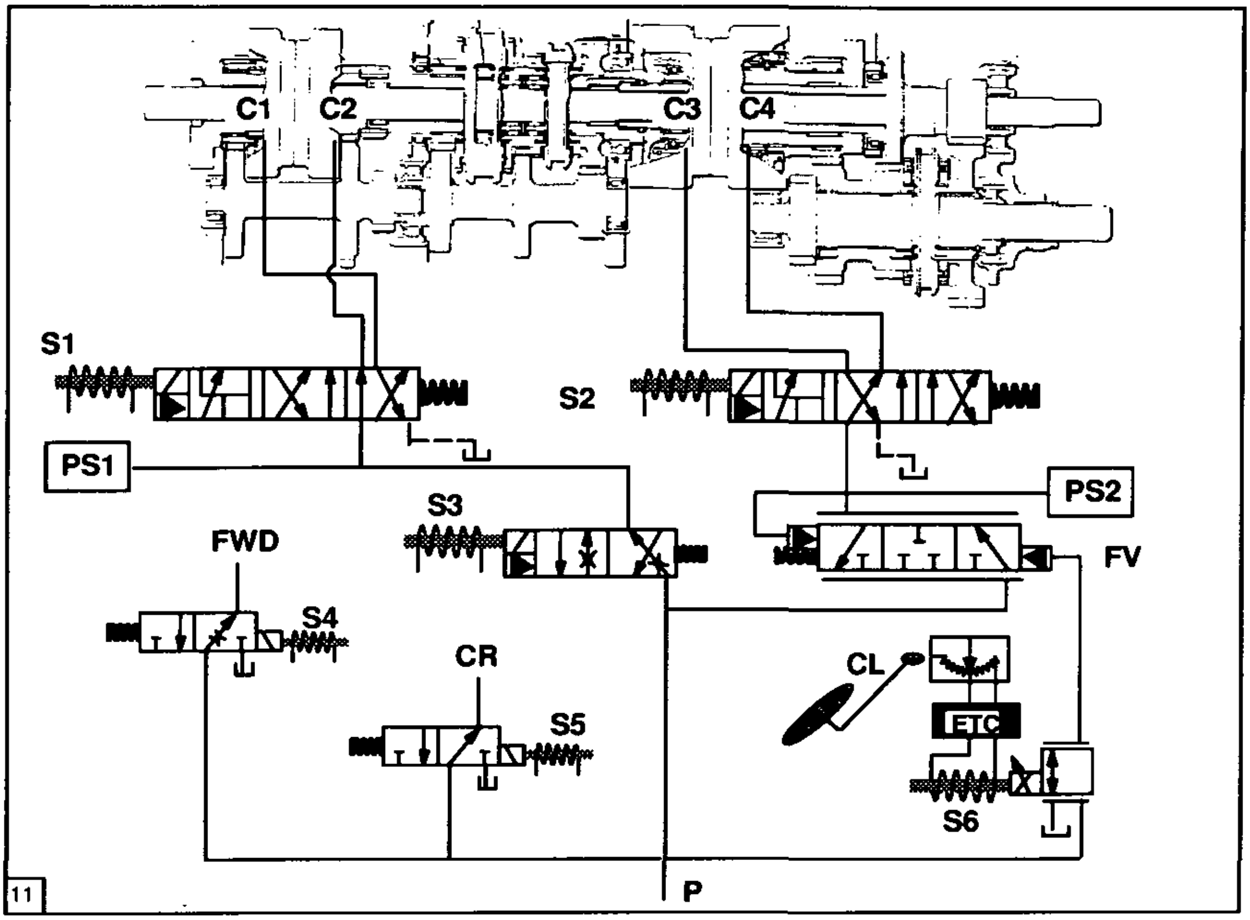
The C3/C4 selector valve is an electro–hydraulic device which controls the hydraulic pressure on the C3 and C4 clutches. The valve's solenoid S2, shown in Figure 11, has a nominal resistance of 6 ohms (at 20°C). The solenoid is energised by sinking current through an electronic switch to ground using a low side driver device in the 'ETC' module. One side of the solenoid is connected to the electronic switch and the other side is supplied with battery voltage. When the solenoid is not energised hydraulic pressure is supplied to engage the C3 clutch. When the solenoid is energised as shown in Figure 11, hydraulic pressure is supplied to engage the C4 clutch. There is no modulation of the signal which energises this solenoid.

Dump Valve

The dump valve is an electro–hydraulic device which controls the hydraulic pressure to the C1/C2 selector valve. The dump valve solenoid, S3, shown in Figure 11, has a nominal resistance of 6 ohms (at 20°C). The solenoid is energised by sinking current through an electronic switch to ground using a low side driver device in the 'ETC' module. One side of the solenoid is connected to the electronic switch and the other side is supplied with battery voltage. When the solenoid is not energised hydraulic pressure is supplied to the C1/C2 valve. When the solenoid is energised hydraulic pressure is 'dumped'. There is no modulation of the signal which energises this solenoid.

Feathering Valve

The 'ETC' uses pulse width modulation (PWM) to drive the pilot stage of a



Schematic View of the Solenoid Actuated Hydraulic Control System

S1	Clutches C1 and C2 Selector Valve Solenoid	S5	Creeper Valve Solenoid		Potentiometer
S2	Clutches C3 and C4 Selector Valve Solenoid	S6	Pulse Width Modulation (PWM) Solenoid	PS1	C1/C2 Clutches Pressure Switch
S3	Dump Valve Solenoid	FV	Feathering Valve	PS2	C3/C4 Clutches Pressure Switch
S4	Four Wheel Drive Valve Solenoid	FWD	Four Wheel Drive Control Valve	ETC	Electronic Transmission Control
		CL	Clutch Pedal and		

proportional valve to control oil pressure to the C3/C4 clutches during inching (feathering) pedal operation and powershifting. The valve's solenoid, S6, shown in Figure 11, has a nominal resistance of 2.4 ohms (at 20°C). During powershifting the clutch pedal is fully released but the PWM can still control the proportional valve and in effect can introduce a degree of slippage in the C3 and C4 clutches. The degree of slippage is controlled by the 'ETC' and is decided by assessing the inputs from engine speed, gear selected and wheel speed. Reference to later paragraphs describing the function of the hydraulic control valve will clarify the part played by PWM during powershifting.

Creeper Valve

The creeper valve is of an electro–hydraulic device which controls the hydraulic pressure to select or deselect the creeper gear. The valve's solenoid S5, shown in Figure 11, has a nominal resistance of 9 ohms (at 20°C). The solenoid is energised by sourcing current though an electronic switch to +12V using a high side driver device in the 'ETC' module. One side of the solenoid is connected to the electronic switch and the other side is connected to ground. The tractor stays in direct drive when the solenoid is not energised, a return spring prevents the creeper gear from being selected. When the solenoid is energised hydraulic pressure is supplied so that creeper gear is selected. There is no modulation of the signal which energises this solenoid.

Front Wheel Drive Valve

The transmission, when front wheel drive is specified, is equipped with a solenoid actuated front wheel drive (FWD). The FWD solenoid, designated S4, is shown in Figure 11 and is de–energised to engage FWD. Although this feature is not controlled by the 'ETC' module, it is a part of the transmission and its wiring is included with the transmission harness.

Control Logic

The software programme in the 'ETC' module contains the logic to control the operation of the 16x16 transmission. This includes: start–up logic, neutral logic, clutch pedal logic, shift logic and creeper gear logic. Each of these is described below.

Option Detection Logic

The 'ETC' module recognises the presence of the 16x16 transmission and the optional creeper solenoid and stores this information in non–volatile memory. The 'ETC' module uses the presence of the clutch potentiometer as an indication that the 16x16 transmission is present and the presence of the creeper solenoid as an indication that the creeper gear is installed. After these are detected and their presence is stored in non–volatile memory, any subsequent detected failures will result in the display of a corresponding error code on the display.

Start–Up Logic

The start–up logic differs depending on whether or not the tractor is stationary or moving. Tractor motion is detected by examining the input from the wheel speed sensor. The tractor is declared to be moving anytime the speed is greater than approximately 0.1 mph (0.06 km/hr). A flow chart of the start–up logic is shown in Figure 12.

Initial Gear Selection

If the tractor is stationary, the initially selected gear depends on the position of the main and high/low shift levers. The 'ETC' module always selects the lowest powershift gear except when the main lever is in the 1–4 position and the high/low lever is in the low position. The following chart depicts the start up positions.

Range Lever Main	Range Lever High/Low	Powershift Gear	Initial Gear
1–4	Low	4	4 Low
5–8	Low	1	5 Low
1–4	High	1	1 High
5–8	High	1	5 High

If the tractor is moving (detected via the wheel speed sensor), the rolling reset logic is invoked and provided that the transmission high/low or main levers have not changed position, the powershift gear engaged prior to reset will be selected. See 'Driveline Engagement' below for a description of the rolling reset logic.

Driveline Engagement

The dump valve, S3 and the PWM valve shown in Figure 11, prevents driveline engagement until a specified sequence of events has occurred which indicates that the system is functioning properly and that the operator is anticipating tractor motion.

This logic is intended to prevent unexpected tractor motion if the engine starter solenoid is externally engaged (hot wired) during jump starting. The logic is different depending on whether the tractor is moving or not.

The variable START–UP indicates whether or not the start–up logic has been completed, i.e. the proper sequence has been seen to engage the driveline. When START–UP equals one it means that the proper sequence has been seen.

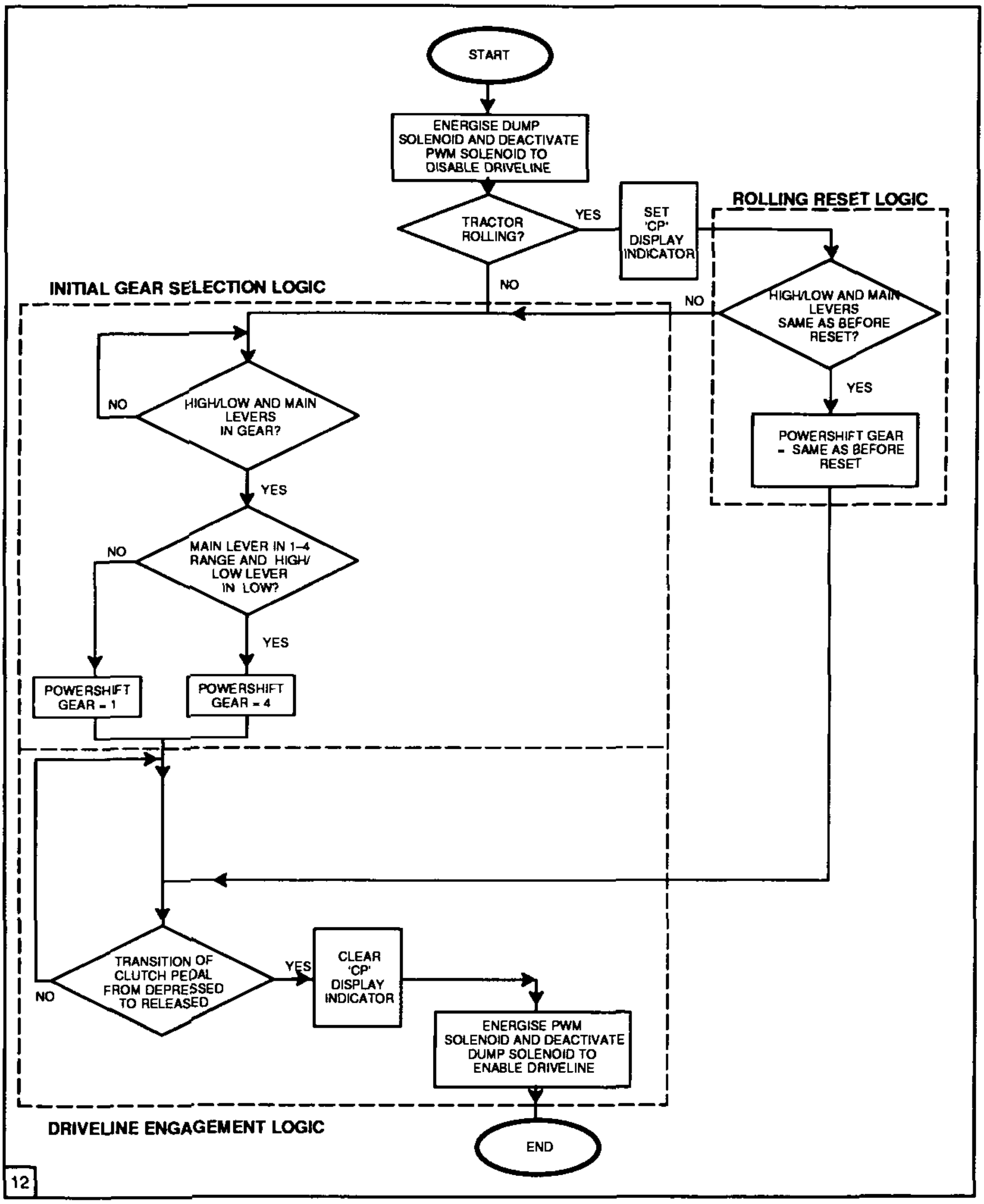
If the tractor is stationary before the driveline is to be engaged, the 'ETC' module looks for an indication that the engine is running, followed by a disengaged to engaged transition of the clutch pedal sensor. It is worth noting that the neutral switch is part of the engine starter circuit and the engine will not normally start if the transmission is not in neutral.

The engine will be recognised as running by the presence of engine rev/min above a prescribed threshold. Engine rev/min information is obtained from the alternator.

If the tractor is moving, the 'rolling reset logic' is invoked and the powershift gear engaged prior to 'ETC' computer reset will be selected, provided that the transmission main and high/low levers have not changed position. The logic uses 'Keep Alive Memory' (KAM) to continually store the current gear so that it may be recalled following reset. This logic is intended to cover situations in which the tractor is restarted while still in motion (i.e. key off/key on, intermittent power connections, electrical noise, engine stall, etc.). The clutch pedal must be depressed and released to enable the transmission following a rolling reset.

Neutral Logic

When the forward reverse shuttle lever is placed in neutral, the dump valve, S3, shown in Figure 11, is switched on and the PWM is switched off to disengage the driveline. The driveline is disengaged in neutral in order to



Transmission Start Up Logic

eliminate the viscous drag of transmission gears in the wet sump during stationary PTO operations.

Clutch Pedal Logic

The clutch pedal is coupled to a linear potentiometer to indicate clutch pedal position. The clutch pedal potentiometer provides signal voltage to the 'ETC' module which provides drive current to the PWM (pulse width modulation) valve supplying pilot pressure to the inching spool modulating C3 or C4 pressure, whichever is selected, but has no effect on C1 or C2. In order to minimise wear on the gear synchronisers during a main range shift, C1 and C2 are disengaged by electronically activating solenoid S3 and pressure to the C3 and C4 clutches is dumped by full depression of the clutch pedal. As a result, the synchronisers are not directly coupled to the engine during a shift. The electronics provide two switching points on the clutch pedal; part clutch and full clutch. The part clutch switching point is used by the change of mind shift logic to determine when the operator has completed the shifting process (see 'Shift Logic'). The full clutch switching point is near the bottom of travel and is used by:

1. The dump solenoid logic to dump pressure during range shifts to relieve stress on the synchronisers.
2. The creeper logic to assure that the clutch pedal is depressed before the creeper gear is selected or deselected
3. The start–up logic since a transition of the clutch pedal may be used to engage the transmission.

NOTE: *If the clutch pedal is not fully depressed during a neutral to an in gear shift, the 'ETC' will disable the transmission and flash 'CP' on the display. The transmission is re–enabled by depressing and releasing the clutch pedal.*

Shift Logic

Powershift Logic

Powershifts are initiated by the operator with the upshift and downshift push button (momentary contact) switches on the main shift lever. All operator initiated shifts are sequential (e.g. 1–2, 2–3, etc.). The electronics limits the minimum time interval between powershifts to 0.5 seconds. When a valid open to closed transition of the intercepted switch input is detected, a powershift is signalled. An upshift signal increases the powershift gear by one (i.e. 1–2, 2–3 etc.) and a downshift signal decreases the powershift gear by one. If the transmission is in the fourth powershift gear and an upshift is signalled or the transmission is in the first powershift gear and a downshift is signalled, there is no change in the powershift gear.

C1 and C2 are controlled by solenoid valve S1, while C3 and C4 are controlled by solenoid valve S2. The following valve combinations produce the four gear selections.

Powershift Gear		S1	S2
1	5	off	on
2	6	off	off
3	7	on	on
4	8	on	off

Note: on = solenoid energised
off = solenoid de–energised

When performing a powershift, the appropriate solenoid is switched to the new state. In the event of a double clutch swap (e.g. 2–3, 3–2), both valves are switched. The PWM valve modulates pressure on C3 and C4 clutches during all powershifts.

Main and High/Low Range Shift Logic

Shifting the synchronised gears requires the use of the clutch. When shifting the main lever, the powershift gear is automatically chosen to minimise the difference in gear ratios. When shifting from the 1–4 range to the 5–8 range, the lowest powershift gear (5th) is chosen. When shifting from 5–8 range to 1–4 range, the highest powershift gear (4th) is chosen. The main (1–4/5–8) shift lever ranges are sensed by the 'ETC' module with the aid of switches.

When shifting low to high range or high to low range, the powershift gear is not changed, i.e. a low to high change shifts up 8 gears (e.g. 6L–6H) and high to low range shift moves down 8 gears (e.g. 3H–3L). High and low lever positions are sensed by the 'ETC' module with the aid of switches.

Change of Mind Shift Logic

Logic has been provided which permits the operator to shift ranges and then return to the original range without changing powershift gears provided that the clutch remains depressed during the lever movement. This logic uses the partially depressed clutch threshold which is near the middle of the clutch pedal travel. This permits the operator to make a shift, change his mind, then return to the original range and powershift gear.

Creeper Gear Logic

The creeper gear is selected with a solenoid valve, S5. Due to the non–synchronised design of the creeper gear, caution must be exercised when selecting and deselecting the creeper as damage to the transmission may occur. Accordingly the creeper gear cannot be selected when high range is engaged. Conversely, high range cannot be engaged when the creeper gear is selected. The transmission is equipped with a hydraulic and electronic interlock, which prevents selection of creeper gear when the high range has been engaged and disengages the drive line if high range is engaged when already in creeper gear (though the latter is prevented by the creeper valve logic under normal circumstances, the hardware redundancy is a worthwhile provision in the event of certain switch failures).

The operator initiates the creeper gear selection by depressing the momentary creeper switch while the transmission is in low range and the engine running with the clutch pedal depressed (this decouples the driveline via the S3 solenoid). If the operator presses the creeper switch at a time when conditions are not correct, creeper will not be selected. When deselecting the creeper, the driveline must again be disengaged with the S3 solenoid as initiated by the clutch pedal.

In order to prevent gear clashing when the tractor is powered down (i.e. key start turned off) and creeper selected, a time delay relay is present on the 'ETC' module power line. The relay continues to supply power to the 'ETC' module for seven to ten seconds after key start is turned off. This allows sufficient time for the engine to stop before the creeper gear is permitted to deselect and direct drive to reselect

Failure Detection and Management

One of the main design goals underlying the Electronic Transmission Controller ('ETC') design is reliable operation. However, as with any system there is always the possibility that component failures will occur and therefore, precautions must be taken to detect and manage them. Detection involves recognition of the failed condition by the 'ETC' module and indication of the condition to the operator.

'Limp Home' provision is provided through the use of a dealership tool which will enable the PWM valve and allow the transmission hydraulic circuits to receive pressure. This facility will allow the tractor to be moved from the field or roadside for repair or transportation to the dealership in the unlikely event of a electrical failure. **NOTE:** *It is recommended that only low range is selected when the limp home tool is connected.*

The 'ETC' module constantly monitors inputs for possible failures and tests the output devices each time the tractor is started. Additionally, the PWM valve is tested continuously. Any detected failures are displayed as a flashing error code on the 'EIC'/'AEIC'.

The 'ETC' module error detection logic recognises a number of different type of failures including:

- Clutch Potentiometer Signal Out of Range
- Switch Failures
- Solenoid Circuit Failures
- Implied Failures

Each failure has a corresponding error flag and numerical error code. The error flags are arranged in priority order so that the highest priority error code will be displayed.

Many error codes remain latched on the display, even if the error condition disappears. This aids in detection of intermittent failures. The 'EIC' has a feature by which the last ten error codes displayed may be recalled to aid service personnel in recalling failures which operators have observed but which cannot be repeated either in the field or in the workshop.

The 'ETC' module error codes and corresponding diagnostic conditions are as follows (in priority order):

Code	Fault Condition	Display Mode
E29	C1/C2 Pressure Switch Open Circuit (Switch Does Not Indicate High Pressure)	Temporary
E28	C1/C2 Pressure Switch Short Circuit (Switch Does Not Indicate Low Pressure)	Temporary
E27	Engine Rev/Min Signal Not Present (Open or Short Circuit Or Alternator Belt Broken)	Temporary
E26	Engine Rev/Min Too High (Possible Intermittent Connection)	Temporary
E25	Tractor Motion Not Detected When Transmission is Engaged (Wheel Speed Sensor Signal Open or Short Circuit or Stuck Transmission Valve)	Temporary
E13	Up/Downshift Switches Both 'ON' (Short Circuit)	Temporary
E14	4/5 Switches Both 'ON' (Short Circuit)	Temporary
E15	High/Low Switches Both 'ON' (Short Circuit)	Temporary
E16	Creeper Solenoid Short Circuit Error or Attempt to Engage Creeper After Prior Creeper Error	Temporary
EC4	C4 Clutch Not Calibrated	Latched
EC3	C3 Clutch Not Calibrated	Latched
E24	C3 and C4 Clutches Not Calibrated	Latched
E17	C3/C4 Solenoid Open or Short Circuit	Latched
E18	C1/C2 Solenoid Open or Short Circuit	Latched
CP	Depress Clutch Pedal to Re–enable Transmission – Neutral to In–gear Shift With Pedal Up – Electrical Re–set While Moving – Engine Re–started After Stall	Recoverable & Temporary
ECC	Electrical Re–set With Creeper Engaged	Recoverable & Disables Trans
HC	Range Shift To High With Creeper Engaged	Recoverable & Disables Trans
C	Wheel Speed Too High For Creeper Gear (Probable Creeper Gear Dis–engagement. Creeper Solenoid Open Circuit)	Recoverable & Disables Trans
E11	Clutch Potentiometer Voltage Below Valid Range	Disables Trans
E12	Clutch Potentiometer Voltage Above Valid Range	Disables Trans
E19	Dump Solenoid Open or Short Circuit or C3/C4 Pressure Switch Open Circuit	Disables Trans
E22	PWM Solenoid Current Below Valid Range (Open or Short Circuit)	Disables Trans
E23	PWM Solenoid Current Above Valid Range (Short Circuit)	Disables Trans
E20	T1 Harness Disconnected	Disables Trans
E21	T2 Harness Disconnected	Disables Trans
E32	Keep Alive Memory (Kam) Power Failure (Battery Previously Disconnected or Fuse No. 20 Failed)	Temporary & Recoverable

Implied Failures

The presence of a combination of error flags is used to infer a cause which is more specific in leading service personnel to the source of the failure. For example, simultaneous indication that all solenoids (including creeper, if present) are open or shorted is most likely caused by separation of the 'ETC' module harness connection (T2) or separation of the extension harness connection (T1). Thus, if testing indicates that all solenoids are shorted or open, error code E21 is generated. Error code E20 is similar in that it is triggered by an indication of multiple solenoid failures (C1/C2, C3/C4 and Dump only).

Solenoid Failures

The 'ETC' module tests the C1/C2 and C3/C4 clutch solenoids at start–up of the tractor. Additionally, the dump and PWM solenoids are monitored continuously during operation. Failures can be caused by solenoid circuits which are:

– disconnected (open circuited),
– shorted to battery voltage,
– shorted to earth or grounded.

In some cases when failures occur the tractor can be moved, although transmission operation may be limited by virtue of the fact that control of some solenoids may be lost.

The 'ETC' module will function at voltages above 7 volts, but low voltage conditions may be insufficient to operate certain outputs. In the event of a functional 'ETC' module failure, the outputs of the module default to the 'Off' condition which implies that most solenoids will default to their non–energised states, i.e. creeper not engaged, second powershift gear selected and pressure not dumped. However the PWM solenoid will not be energized and consequently the C3 clutch will not receive hydraulic pressure.

Dump Solenoid

Electrical current must be supplied to the dump solenoid in order to disengage the driveline. This sense was chosen so that the tractor is operable even when the electrical connection to the dump solenoid has been severed or battery voltage is low. If the dump solenoid control and/or power supply line is open circuited, pressure cannot be dumped and the driveline will be permanently engaged. If the control line is shorted to ground, pressure is continuously dumped and the tractor cannot be moved (the driveline is continuously disengaged). This means that the use of the 'Limp Home' Dealership tool cannot be used for other than moving the tractor from a dangerous position. The use of the 'Limp Home' tool is covered in the Fault Finding, clutch calibration and Limp Home section.

C1/C2 and C3/C4 Solenoids

For the case in which either the C1/C2 or C3/C4 control line, or both control lines, are open or short circuited, operation will be restricted to only certain gear ratios. Open circuited lines will result in the solenoid(s) being 'Off'. Shorts to earth or ground will result in the solenoid(s) being 'On'.

Creeper Solenoid

The creeper is continuously monitored for proper creeper range wheel speeds of less than 2 mph (3.3 km/h).

If creeper overspeed is detected the 'ETC' disables the transmission and flashes 'C' on the display to indicate a fault in the creeper operating mode. This is an operator recoverable error in which he is allowed to depress the clutch, deselect creeper and continue to operate in direct drive.

Once a creeper fault is detected it is stored in 'ETC' memory until erased by a key off. As long as the fault is stored the operator is prevented from re–selecting creeper. If attempted the 'ETC' will display error code E16 momentarily (5 seconds) and creeper is not selected.

The creeper solenoid circuit is checked for shorts at start–up. If one is found the error code E16 is displayed for 5 seconds and stored to prevent future creeper selection until the fault is cleared.

If an 'ETC' module reset occurs when in creeper mode an 'ECC' error code is displayed, transmission pressure is dumped and the creeper solenoid is disengaged. To recover from this disabling condition, the operator must acknowledge that creeper gear is deselected by depressing the clutch pedal and pressing the creeper switch. This will remove the error code, turn off the creeper light, and return the transmission to normal operation, without the creep facility. The 'ECC' error code and the flashing creeper light are intended to draw the operator's attention to the creeper switch.

Switch Failures

Switch inputs are configured in such a manner that certain failures may be detected. Switches for the high and low and main lever positioning and the powershift switches all occur in pairs. Both switches of a pair cannot be activated (closed) under normal circumstances except possibly for a brief period during switch transitions. If both switches are activated for more than a short period of time, an error flag is set. Although the powershift switches could both be in the on state due to the operator simultaneously pressing both of them, this is not normal action and results in the generation of a momentary error code to alert the operator to the possibility of a failure. Failures in which both switches appear to be closed can be caused by:–

– Switch wire shorted to battery voltage.
– Mechanical failure of the switch in its closed position.

Switch wires can also be shorted to earth (grounded), or open circuited, however, these conditions will go undetected. To somewhat overcome these types of failures, some switch inputs assume a default state until a transition from that switch has been monitored. Thus, for these switch inputs the assumption is that the switch is failed until proven otherwise.

In order to assure reliable performance in the event of component/harness failures, care was taken in selecting the signal sense and logic associated with the system inputs. In general, the most likely mode of failure is assumed to be an open circuit, however, the failure modes of both short circuits and low voltage operation were also considered.

Open Circuits

When switch inputs are open circuited, the inputs default to failure modes as defined below:

Signal	**Voltage Level**	**Sensed Condition**
C1/C2 Press Switch	Low	Low Pressure
C3/C4 Press Switch	Low	Low Pressure
High Range Switch	Low	High Range not selected
Low Range Switch	Low	Low Range not selected
Neutral Switch	High	See Note
Downshift Switch	Low	See Note
Upshift Switch	Low	See Note
1–4 Range Switch	Low	1–4 Range not selected
5–8 Range Switch	Low	5–8 Range not selected
Creeper Switch	Low	See Note

Note: The default state of this switch is set to a low logic level (i.e. 0 volts) until a transition is sensed.

Short Circuits

When switch inputs are short circuited the inputs default to failure modes as defined below:

Signal	Voltage Level	Sensed Condition
C1/C2 Press Switch	Low	Low Pressure
C3/C4 Press Switch	Low	Low Pressure
High Range Switch	Low	High Range not selected
Low Range Switch	Low	Low Range not selected
Neutral Switch	Low	See Note
Downshift Switch	Low	See Note
Upshift Switch	Low	See Note
1–4 Range Switch	Low	1–4 Range not selected
5–8 Range Switch	Low	5–8 Range not selected
Creeper Switch	Low	See Note

Note: The default state of this switch is set to a low logic level (i.e. 0 Volts) until a transition is sensed.

Clutch Potentiometer Failures

The clutch potentiometer signal should fall within a known range, any excursion outside this range, either on the high side or the low side, indicates an error condition. The clutch potentiometer sensor, therefore, has two error conditions associated with it, a fail high and a fail low. Each failure condition has several potential causes which may create the error condition. The fail high condition may be caused by:

- Open circuit on sensor ground wire.
- Signal short to reference voltage wire (VREF).
- Signal short to battery voltage.
- Mechanical failure causing over travel of potentiometer.

The fail low condition may be caused by:

- Open circuit on reference voltage wire (VREF).
- Reference voltage wire (VREF) shorted to ground.
- Open circuit on signal wire.
- Signal wire shorted to earth or ground wire.
- Mechanical failure causing over travel of potentiometer.

In order to detect intermittent failures, a single excursion from the correct range will cause an error code to be displayed and latched.

When a clutch failure exists, the transmission is disabled by the 'ETC' and an error code is displayed and latched (i.e. this means that it remains on the display) and the transmission is disabled until the key is turned off and on to clear the error display.

Diagnostics and Testing

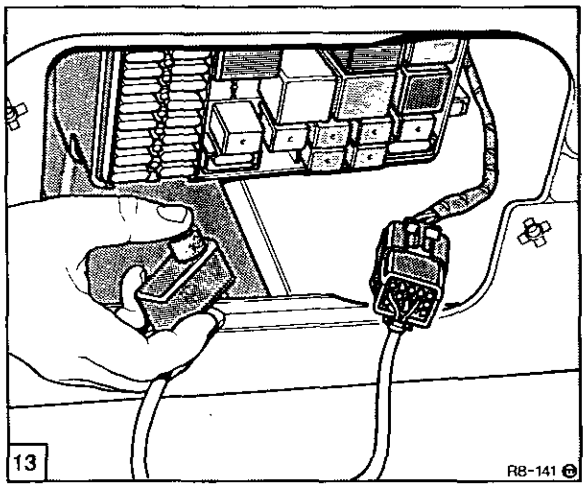
Service Test Routines

The addition of a service diagnostic connector, Service Tool No. 4FT–950, shown in Figure 13, provides a convenient method of gaining access to the special test modes in the 'ETC' module. The connector enables selection of a menu driven test mode selection routine. A switch attached to the test harness is used to select the desired test routine.

An entry port to the 'ETC' is used as the controlling signal for the service test mode. The service test harness consists of a normally closed, momentary, push button switch which is connected between the service input and the +12V battery terminals of the connector. If the service input is high when the 'ETC' module is powered up, then the software will proceed to the service menu selection routine. Subsequent depressions of the service select switch will sequence through the menu selections. A particular menu item can be selected by incrementing to the desired mode and waiting for 4 seconds. Illustrated in Table1 are the menu selections.

NOTE: *The service input and the creeper input are shared. Therefore, if the key is turned on while depressing the creeper switch, the service mode will be selected.*

A particular routine can be selected by incrementing to the desired mode and waiting four seconds. Note that the transmission clutch calibration routines can also be entered by holding depressed both powershift buttons and starting the engine.



Service Diagnostic Connector Installed

The functions of the 'ETC' test routines are further defined as follows:–

H1 and H2 are described in the clutch calibration procedures detailed in the Calibration, Fault Finding, Pressure Testing and Limp Home Section.

H3 – System Configuration View. This test allows the Serviceman to view the configuration byte from the EIC/AEIC. The configuration byte is displayed first by blanking the display for one second, displaying the configuration byte in hexidecimal format for one second, blanking for one second and then returning to the 'HH' main menu. The configuration data will be displayed on both the ETC and the EDC displays.

The default 'EIC' configuration display is 'ØF' and the 'AEIC' is 'ØE'

H4 – Software Revision Display. The production software release level is displayed first followed by 'ØØ'. When the sequence is complete the routine should return to the initial service mode menu 'HH'.

H5 – Switch Diagnosis Routine. When this mode is selected, the software will proceed to the manual switch diagnosis routine (see also the following heading). If the service mode switch is depressed during the manual diagnostic routine then the software will return to the initial service mode menu 'HH'.

H6 and H7 display C1/C2 and C3/C4 clutch timing delay times respectively. This is described in greater detail under the Fault Finding and Calibration section.

H8 – Non–volatile Memory Reset. This feature is provided to easily clear calibration constants which are stored in the Non–volatile memory ('EEPROM'). When this operation is performed, the display will blank for one second, display 'EE' for one second, blank for one second and then return to the main 'HH' menu. Again note that this will be displayed on both the 'ETC' and the 'EDC' displays.

HA – Manual adjustment facility for the C3/C4 clutch fill time, to optimize powershift quality. The operation is described in the Fault Finding, Clutch Calibration and Limp Home section.

Switch Diagnostic Mode

In order to assist the operator and service personnel in trouble shooting switch circuit failures, a special diagnostic mode can be initiated. There are two ways to enter 'Switch Diagnostic Mode':

4. Via the service diagnostics connector switch (as described above).

5. By depressing and holding the digit select switch on the 'EIC' during key on, without starting the engine.

Following entry, the letter 'd' and a zero is displayed in the 'ETC' portion of the display. At this point, any 'ETC' module switch transition (e.g. moving the shift lever, depressing the clutch, etc.) results in an audible tone and the display of a numeric code which corresponds to that particular switch. Returning the switch to its original state will return the display to a zero. In this manner, service personnel can check all 'ETC' module switch circuits for proper function. The 'ETC' module switch diagnostic mode display codes are as follows:

Code	Switch Transition
85	Neutral Safety Switch
83	High Range Switch
82	Low Range Switch
81	1–4 Range Switch
77	5–8 Range Switch
75	Upshift Switch
74	Downshift Switch
71	Clutch Pedal Partially Depressed

Note: If a switch circuit failure is detected the cable and connector should be suspected first.

Select Switch	ETC/EDC Display	ETC Test Routine	EDC Test Routine	ETC/EDC Status
Power Up	HH			Disabled
Press	H1	Trans Calibration Spring/Fill Time	HPL Response/Voltage Calibration	Enabled
Press	H2	Clutch Spring Pre–load Display	Valve Threshold Display	Disabled
Press	H3	Configuration View	Configuration View	Disabled
Press	H4	Software Revision Display	Software Revision Display	Disabled
Press	H5	Switch Diagnostic Mode	Switch Diagnostic Mode	Disabled
Press	H6	C1/C2 Clutch Timing Display	Right Draft Pin Display	Enabled
Press	H7	C3/C4 Clutch Timing Display	Left Draft Pin Display	Enabled
Press	H8	Non–Volatile Memory Reset	Non–volatile Memory Reset	Disabled
Press	H9	Analog Input Data Display	Analog Input Channel # Display	Enabled
Press	HA	C3/C4 Fill Time – Manual Adjustment	(Not Applicable)	Disabled

Table1 – Service Test Routine Menu Selections

Hydraulic Circuitry and Component Description

Figure 11 illustrated part of the hydraulic circuit in a very basic format. The following paragraphs describe in more detail how the hydraulic circuit functions.

Shown in Figure 17 is a sectional view of the transmission control valve and an identification of the various components.

Shown in Table 2 are all of the spools used within the transmission control valve, with the schematic diagram equivalents shown beside.

The following schematic diagrams shown in Figure 18 through to Figure 21 show the complete hydraulic circuit through the situation where initially the tractor engine has been started but the clutch pedal has not been depressed, this identifies the function of the neutral start valve or anti–jump start valve, the situation when the clutch pedal is fully depressed to illustrate the energising of the hydraulic circuit, the situation where the pedal is partially released as in inching, this illustrates the operation of the PWM valve and the additional lubrication directed to the clutch being applied and finally, the situation where the clutch pedal is fully released depicting the action of the off–going clutch and the lubrication circuit.

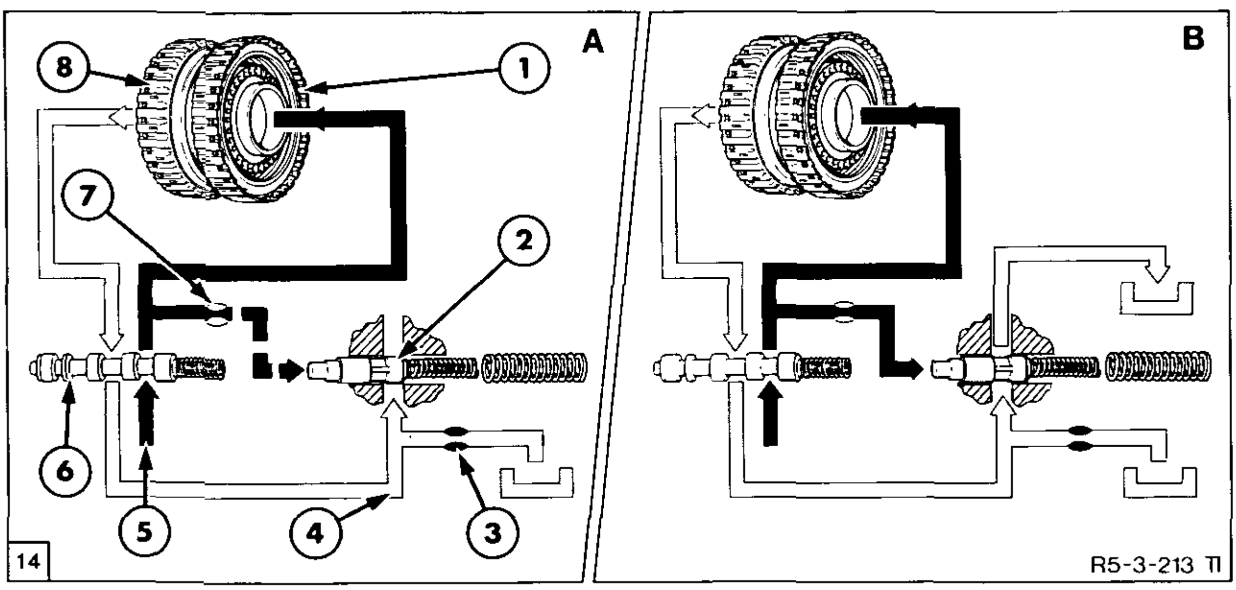
Basic Clutch Actuation

The C1/C2 and C3/C4 selector spool valves are actuated by two identical solenoids. As stated earlier when the solenoids are not energised clutches C2 and C3 will be activated, or open to hydraulic pressure. When the solenoids are electrically energised then clutches C1 and C4 are open to hydraulic pressure. As this switching of solenoids occur the clutch coming off pressure has its circuit opened to dump.

If a powershift between two ratios is considered at the same time as the C2 clutch engages, the C1 clutch must be disengaged. However, to control the rate of slip between the two clutches and ensure a smooth shift of power from one ratio to another, the rate or speed of C1 clutch disengagement must be managed. This is achieved by the use of vent delay valves, one per clutch, item 2, Figure 14, for the C1 clutch.

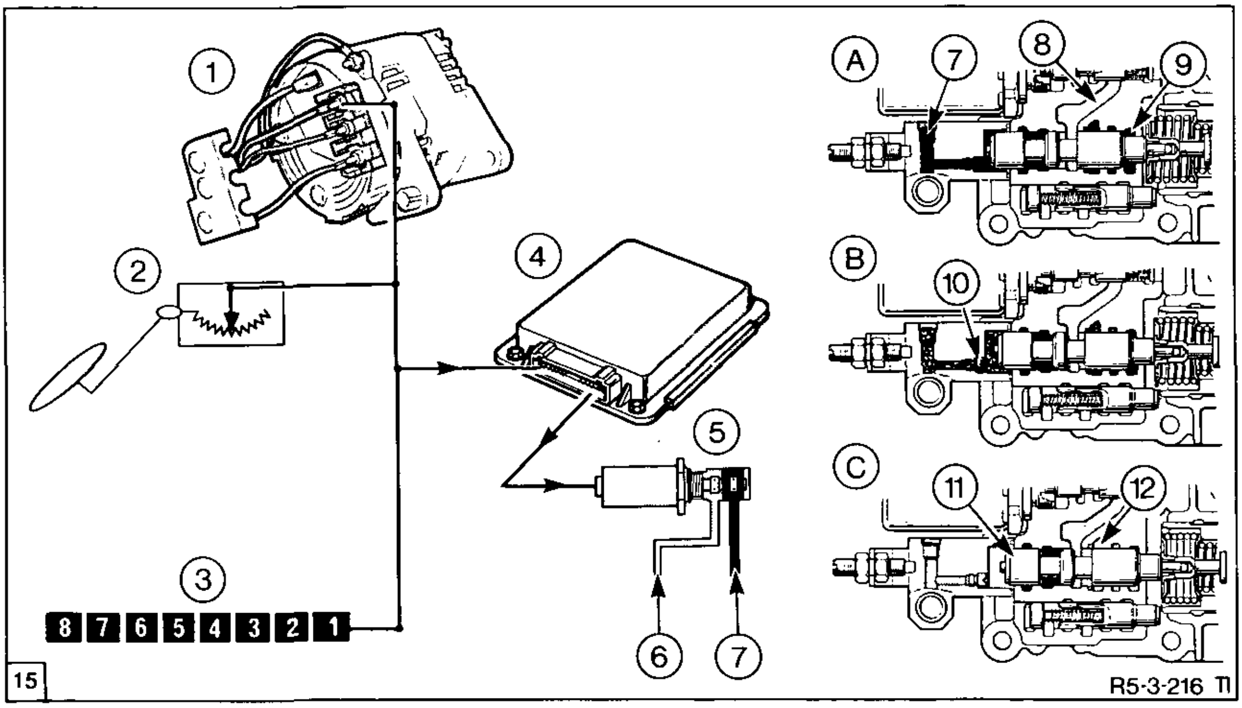
As the C2 clutch becomes pressurised and the C1 clutch is switched off, exhaust oil from the C1 clutch is passed to the vent delay valve. The vent delay valve has two stages of operation. initially oil is only allowed to exhaust to dump through the restricted orifice, item 3, Figure 14. The second stage is hydraulically timed by a pilot line which moves the vent delay valve to the right in the illustration, opening the exhaust route directly to sump. The timing is controlled by a second restricted orifice, item 7, which in effect acts to slow down the secondary rate of disengagement of the C1 clutch. In effect the clutch operating pressure is initially relaxed gradually, controlled by the rate of oil flow through the orifice item 3 and then much more rapidly by the opening of the vent delay valve directly to sump. The ongoing C2 clutch is, therefore, timed by the rate of disengagement of the off–going C1 clutch during a powershift.

The orifice, item 7, has a secondary function, to act as a relief valve should pressure oil leak at the clutch support shaft annular seals and energise a clutch out of sequence, the clutch circuits being open to sump via the orifice.



Vent Delay Valve Operation
A = Initial Clutch Actuation, Dumping of Off–Going Clutch Restricted
B = On–Coming Clutch Fully Engaged, Off–Going Clutch Allowed to Dump Unrestricted

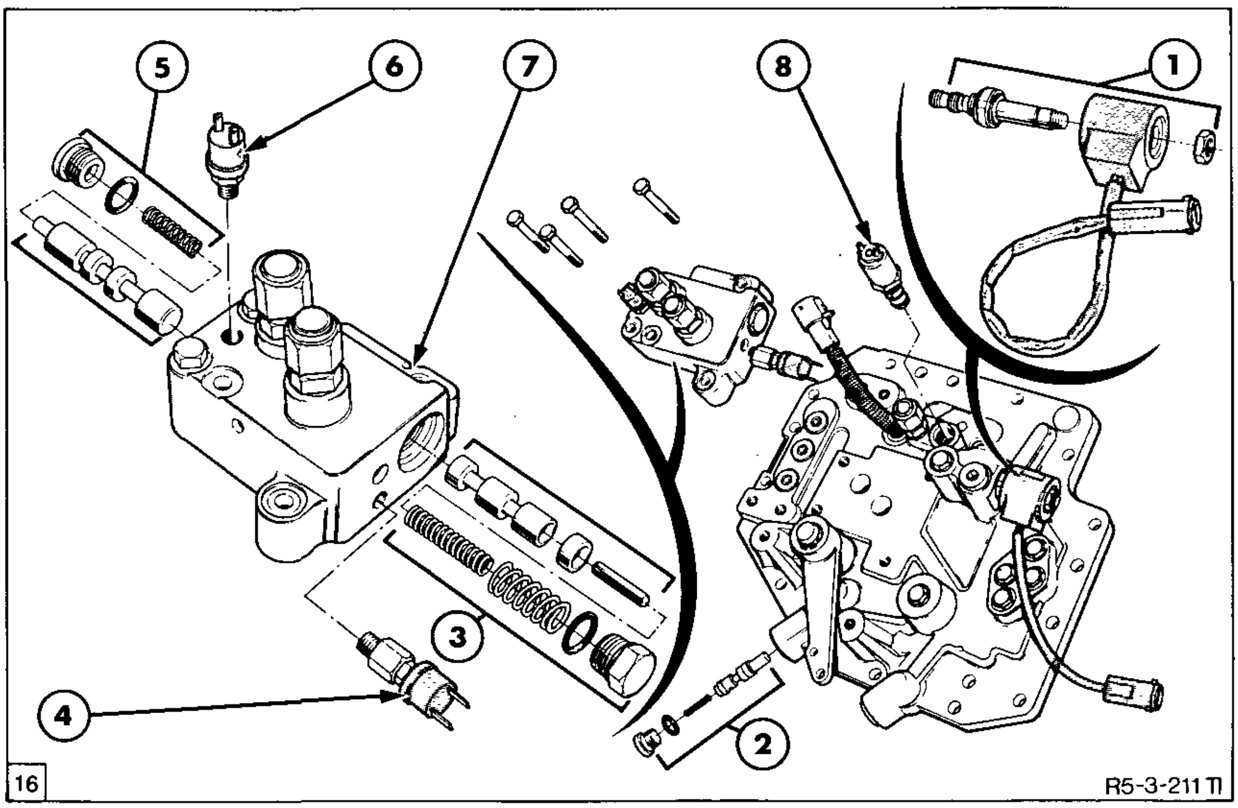
1. On–Coming Clutch
2. Vent Delay Valve
3. Dumping Oil Restriction
4. Off –Going Clutch Dumped Oil
5. Pressure Oil to On–Going Clutch
6. Selector Spool
7. Pressure Line Restriction to Vent Delay Valve
8. Off–Going Clutch



Pressure Regulated Oil 250 lbf.in^2 (17–19 bar)   Oil to Dump   Modulated Oil Pressure

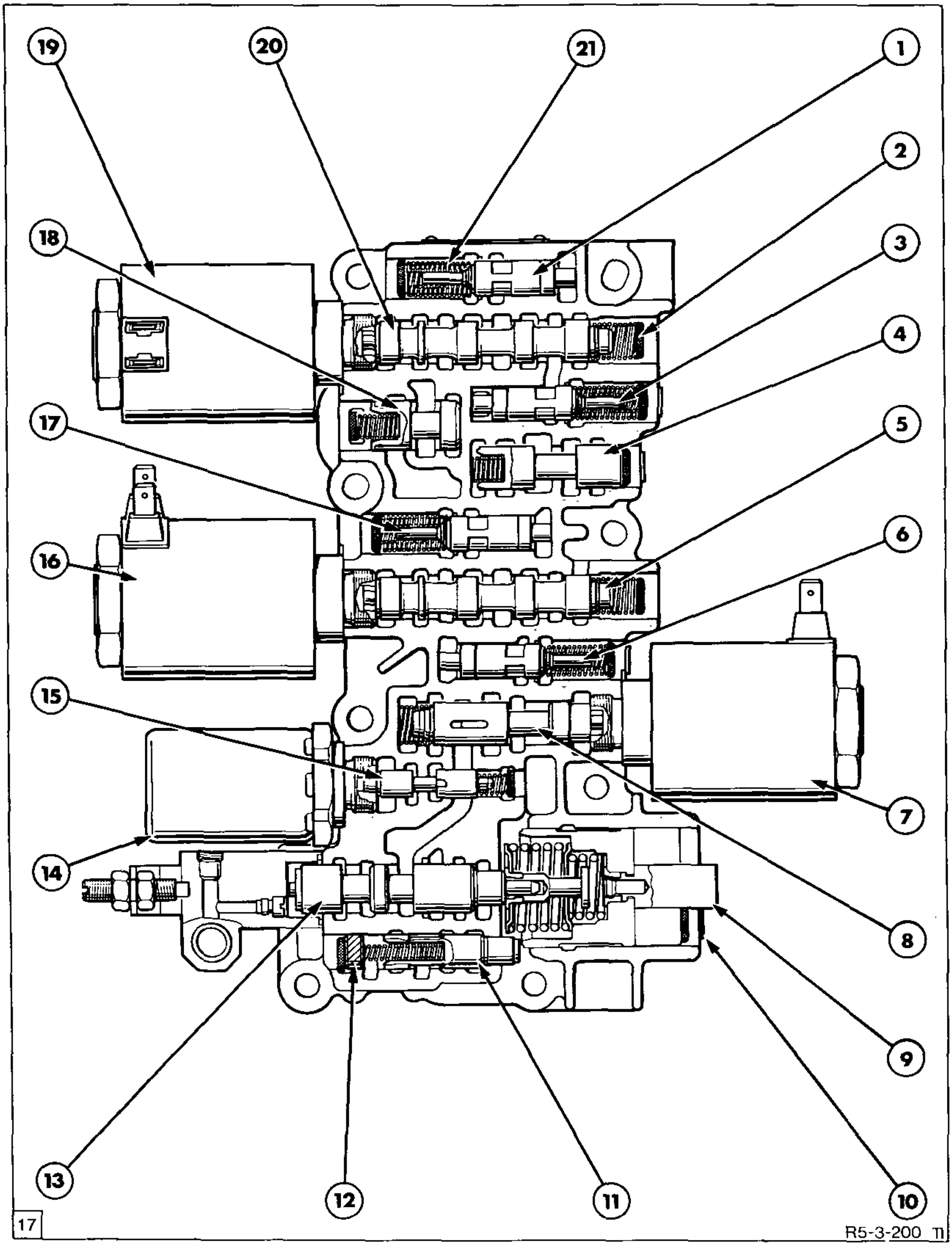
PWM Valve Operation
A = Neutral B= Feathering/Inching/Powershifting C = Tractor Driving

1. Engine Speed Signal From Alternator
2. Clutch Position Potentiometer
3. Gear Selected Information
4. ETC Module
5. PWM Valve
6. Regulated Pressure Oil
7. Modulated Oil from PWM Valve
8. Regulated Pressure Oil
9. Feathering Valve Pilot Line Oil, (Valve Balancing Pressure)
10. Restriction
11. Feathering Valve Spool
12. Oil Gallery to C3/C4 Selector Valve



Hydraulic Control Valve – Externally Located Components

1. Creeper Solenoid and Valve
2. Creeper Interlock Piston
3. C1/C2 Sequencing Valve and Spring
4. C1/C2 Clutch Pressure Switch
5. Lube Combining Valve and Spring
6. C3/C4 Clutch Pressure Switch
7. CALC Valve Body
8. PWM Solenoid/Valve



Hydraulic Control Valve Sectional View – Internal Components

1. C3 Vent Delay Valve
2. Spring Keeper – 10 off, Short
3. C4 Vent Delay Valve
4. Blocked Shuttle Spool
5. *C1/C2 Selector Spool*
6. C1 Vent Delay Valve
7. S3, Neutral/Dump Solenoid
8. Mechanical Connection to Clutch Pedal
9. Keeper – 1 off, Long
10. Safety Start Spool
11. Plug
12. *Feathering Valve Spool*
13. FWD Solenoid
14. Neutral/Dump Spool
15. FWD Spool
16. S1, C1/C2 Solenoid
17. C2 Vent Delay Valve
18. Lube Shut–Off Spool
19. S2, C3/C4 Solenoid
20. *C3/C4 Selector Spool*
21. Double Spring on Vent Delay Valves

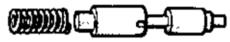
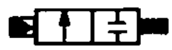
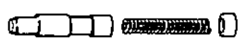
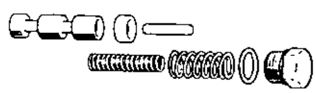
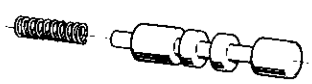
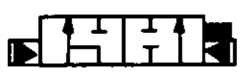
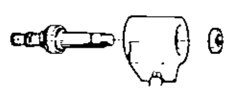
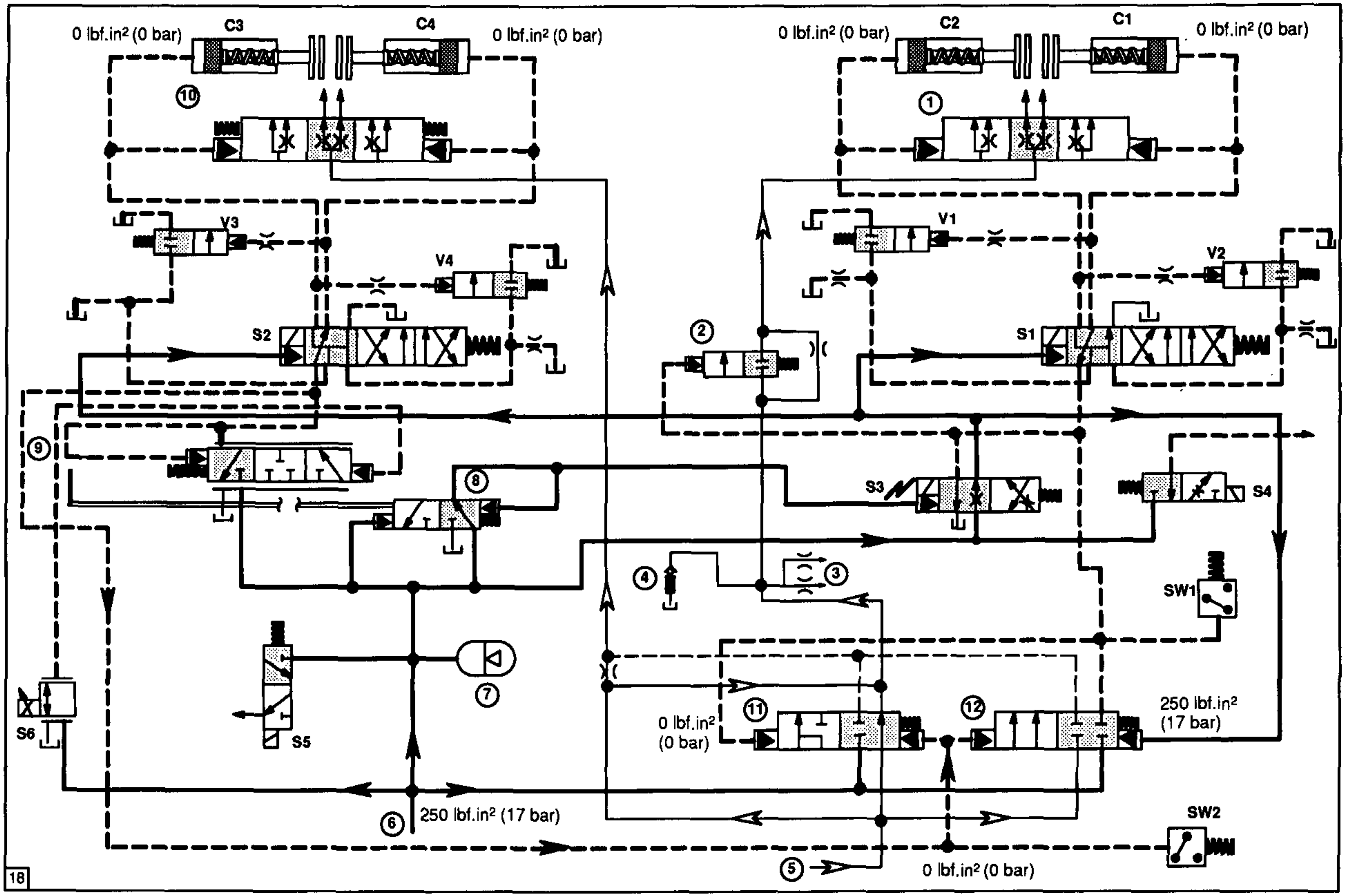
VALVE (Quantity)	IDENTIFICATION	SYMBOL	FUNCTION
FWD Selector			Solenoid operated – Pressure disengages FWD
Clutch Selector (2)			C1/C2 & C3/C4 Solenoid operated when powershifting. Pressure operated to dump when FNR lever is in neutral or clutch fully depressed
Vent Delay (4)			Vent valves (V1, V2, V3, V4) restrict releasing clutch oil pressure drop until engaging clutch pressure is 10 bar, provides smooth shifting.
Neutral Dump			Solenoid operated when FNR lever in neutral or clutch fully depressed. Pressure operates C1/C2 and C3/C4 valves to dump and C1/C2 sequencing valve to cut off oil to C1/C2 clutches
Lube Shut–Off			Decreases lube to C1/C2 clutches when in neutral
Feathering			Mechanically and hydraulically operated to control engagement of C3 and C4 Clutches.
Pulse Width Modulating			Provides controlling / balancing pressure to feathering valve when C3 or C4 is being engaged or during powershifting
Safety Start			Prevents drive engagement on start up until clutch pedal is cycled
Lube Proportioning			Proportions lube oil to clutches. Equally distributed in neutral, during clutch engagement valve directs higher proportion to engaged clutch
C1 and C2 Sequencing			Provides fully regulated oil to C1/C2 clutches as pedal is released from fully depressed position, ensures C1/C2 is fully engaged before C3/C4 are feathered.
Lube Combining			Combines lube oil with regulated pressure oil for C3/C4 clutches during feathering
Creeper Selector			Solenoid operated provides pressure to engage creeper gear

Table 2 – Control Valve Spool Identification



Hydraulic Control Start Up – Neutral Selected, Clutch Pedal Up
(Pedal has not been depressed since engine start–up)

Start Up – Neutral Selected, Clutch Pedal Up (has not been cycled) – Figure 18

Figure 18 shows the complete hydraulic circuit in the situation where the engine has been started, but the clutch pedal has not yet been depressed.

Oil from the hydraulic pump at 250–280 lbf.in^2 (17–19 bar) enters the control valve circuit at (6). Tracing the solid black line, the oil is blocked by the position of the spools in the clutch and lube control (CALC) valve. The oil is also directed to the PWM valve, to the feathering valve, the neutral start or anti–jump start spool and the neutral dump valve. The neutral dump valve (S3) is moved to the right against the force of the return spring and allows oil at regulated pressure to pass and act on the left hand ends of the C1/C2 and C3/C4 clutch selector valves (S1 and S2). This oil moves the selector spools to the right and allows all clutch circuits to be opened to sump. The oil also acts on the right hand end of the C3/C4 lube combining spool (11) and with the spring keeps this spool to the left preventing regulated oil (6) from combining with the lubrication oil from the power steering return (5). The C1/C2 sequencing valve (12) is held to the left by the force of the return spring.

Regulated oil from the pressure source (6) passes through the neutral start valve or anti–jump start valve (8) and is allowed to act on both ends of the spool, as the spool has a spring acting on the right hand end the valve spool is held to the left. The C1/C2 and C3/C4 circuits are in fact de–activated by this spool. Until the spool has been physically moved, by depressing the clutch pedal, activation of the clutch circuits is not possible.

Key To Hydraulic Schematic Illustrations

1. Lubrication Proportioning Valve C1/C2 Clutches
2. Lubrication Valve
3. Lubrication to Synchronisers, Top and Bottom Shafts and PTO Clutch
4. Lubrication Relief Valve (100 lbf.in^2, 7 bar)
5. Lubrication Feed from Steering Pump Return
6. Regulated Pressure Supply From CCLS Pump (250 lbf.in^2, 17 bar)
7. Accumulator (145 lbf.in^2, 10 bar, with 0.7 litre capacity)
8. Safety Start Valve
9. Feathering Valve
10. Lubrication Proportioning Valve C3/C4 Clutches
11. C3/C4 Lube Combining Spool
12. C1/C2 Sequencing Valve

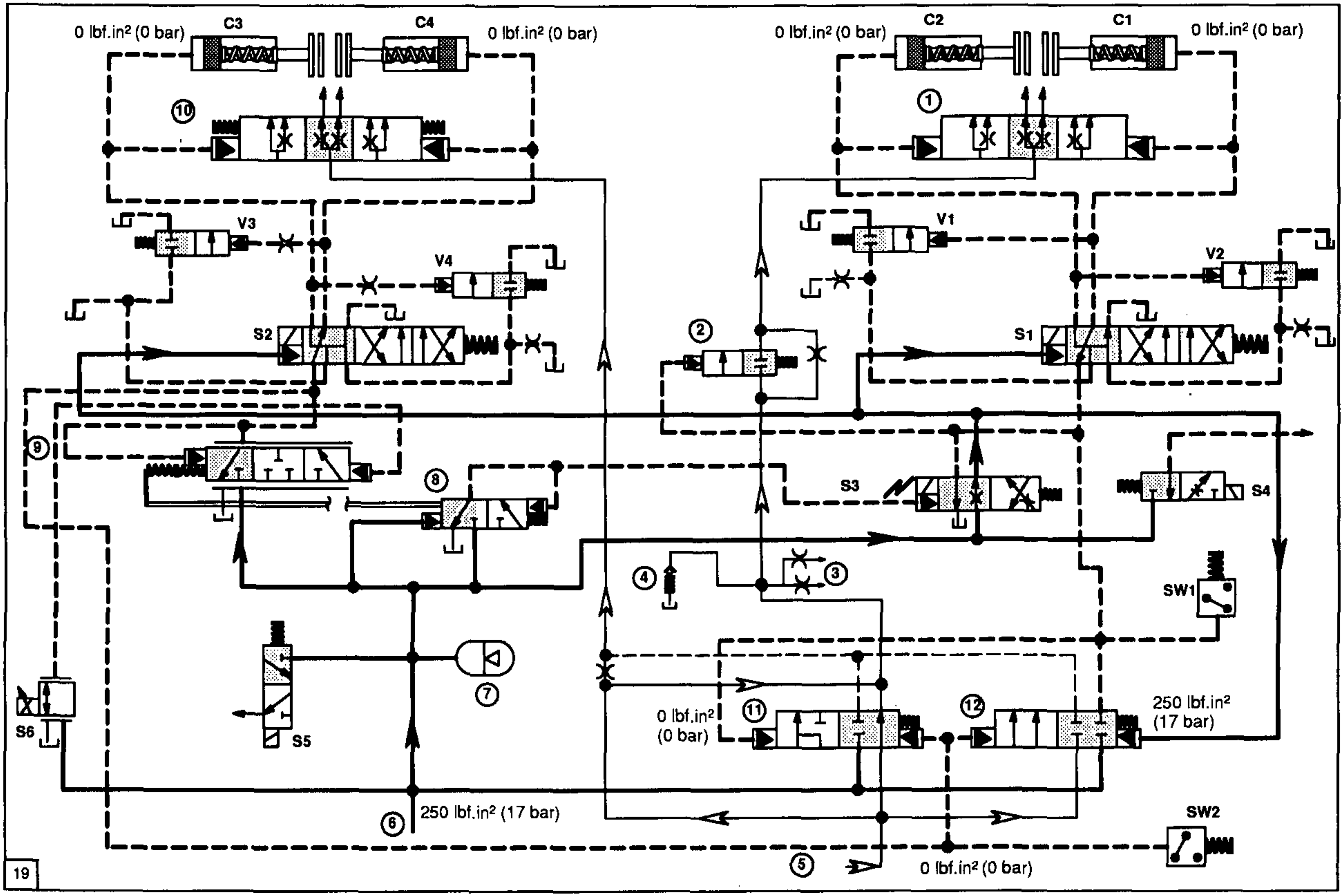
C1 – Dual Power, Clutch 1
C2 – Dual Power, Clutch 2
C3 – Main Clutch, Clutch 3
C4 – Main Clutch, Clutch 4

S1 – Solenoid 1, C1/C2 Clutch
S2 – Solenoid 2, C3/C4 Clutch
S3 – Solenoid 3, Neutral/Dump Valve
S4 – Solenoid 4, Four Wheel Drive Valve
S5 – Solenoid 5,Creeper Valve (where fitted)
S6 – Solenoid 6, PWM (Pulse Width Modulation) Valve

V1 –Clutch 1 Vent Delay Valve
V2 –Clutch 2 Vent Delay Valve
V3 –Clutch 3 Vent Delay Valve
V4 –Clutch 4 Vent Delay Valve

SW1 C1/C2 Pressure Sensing Switch
SW2 C3/C4 Pressure Sensing Switch

Regulated Pressure Supply
Regulated Pressure Line Either to Reservoir or at Zero Pressure
Lubrication Oil
Lube Oil at Reduced Pressure
Line Joining Points
Line Restriction
Pressure Operated Valve
Solenoid Operated Valve
Reservoir
Spring Assisted
Solenoid Activated by +12V



Hydraulic Control Start–Up – Neutral Selected, Clutch Pedal Down

Clutch Pedal Down Situation with all Gear Shift Levers in Neutral – Figure 19

With reference to Figure 19, when the clutch pedal is depressed the safety start spool is mechanically moved by the pedal linkage allowing the pilot pressure which was acting on the right hand side of the safety start spool and neutral dump valve to collapse to sump. As the pressure in this pilot has collapsed, if the pedal is now released there can be no revival of this pressure until the engine is switched off.

The neutral dump valve is also solenoid-controlled and due to the fact that all levers are, in this instance in neutral, the solenoid is energised and the valve electrically held in the right hand position. The clutch being in the depressed position also signals to the ETC to energise the dump solenoid (S3), this prevents clutch engagement if the transmission is not in neutral.

As in the previous circuit, the neutral dump valve is allowing oil pressure to act on the left hand ends of the C1/C2 and C3/C4 selector valves maintaining them in the dump position.

Key To Hydraulic Schematic Illustrations

1. Lubrication Proportioning Valve C1/C2 Clutches
2. Lubrication Valve
3. Lubrication to Synchronisers, Top and Bottom Shafts and PTO Clutch
4. Lubrication Relief Valve (100 lbf.in², 7 bar)
5. Lubrication Feed from Steering Pump Return
6. Regulated Pressure Supply From CCLS Pump (250 lbf.in², 17 bar)
7. Accumulator (145 lbf.in², 10 bar, with 0.7 litre capacity)
8. Safety Start Valve
9. Feathering Valve
10. Lubrication Proportioning Valve C3/C4 Clutches
11. C3/C4 Lube Combining Spool
12. C1/C2 Sequencing Valve

C1 – Dual Power, Clutch 1
C2 – Dual Power, Clutch 2

C3 – Main Clutch, Clutch 3
C4 – Main Clutch, Clutch 4

S1 – Solenoid 1, C1/C2 Clutch
S2 – Solenoid 2, C3/C4 Clutch
S3 – Solenoid 3, Neutral/Dump Valve
S4 – Solenoid 4, Four Wheel Drive Valve

S5 – Solenoid 5, Creeper Valve (where fitted)
S6 – Solenoid 6, PWM (Pulse Width Modulation) Valve

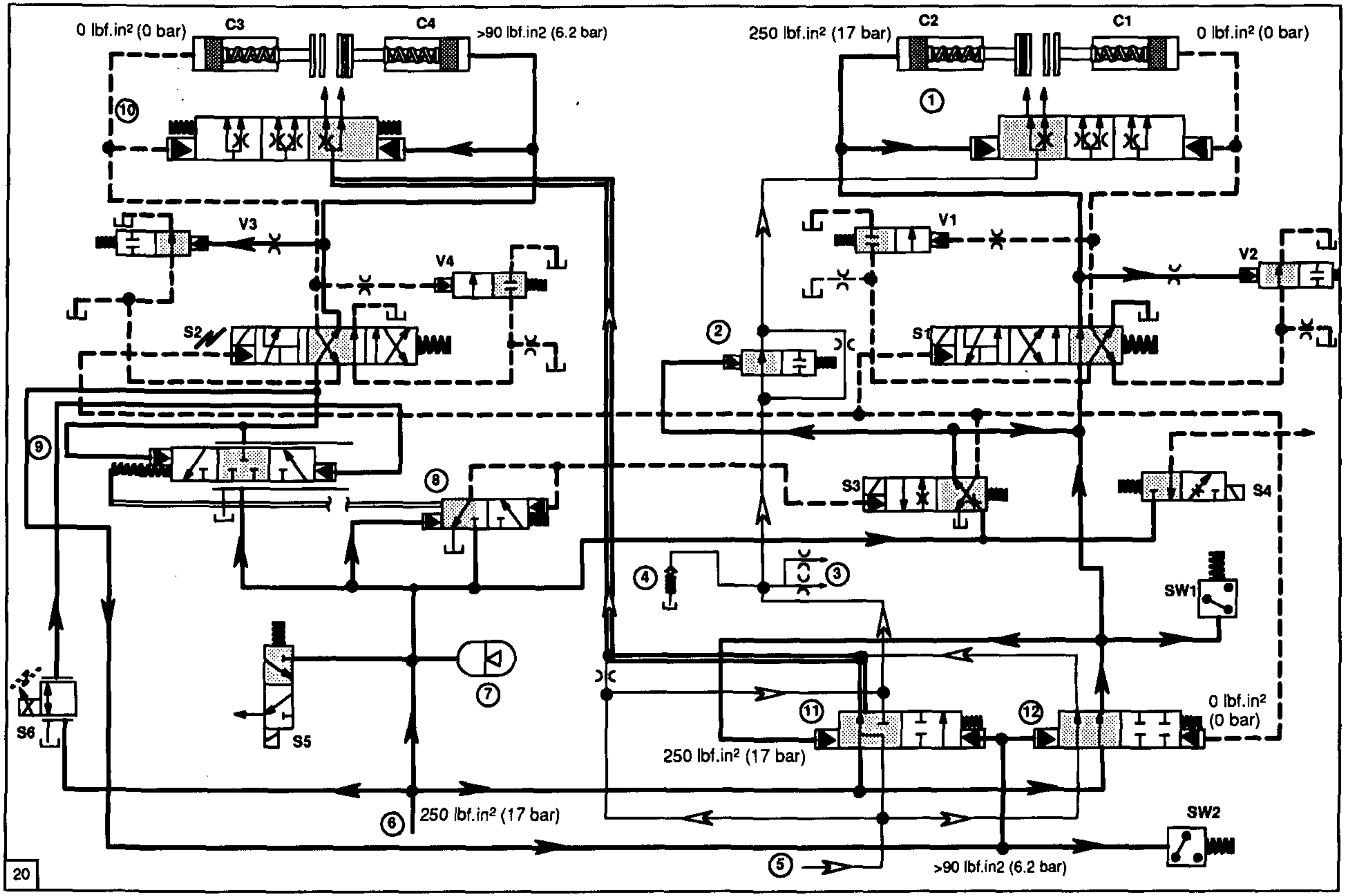
V1 –Clutch 1 Vent Delay Valve
V2 –Clutch 2 Vent Delay Valve

V3 –Clutch 3 Vent Delay Valve
V4 –Clutch 4 Vent Delay Valve

SW1 C1/C2 Pressure Sensing Switch

SW2 C3/C4 Pressure Sensing Switch

Regulated Pressure Supply	Line Restriction
Regulated Pressure Line Either to Reservoir or at Zero Pressure	Pressure Operated Valve
Lubrication Oil	Solenoid Operated Valve
Lube Oil at Reduced Pressure	Reservoir
Line Joining Points	Spring Assisted
	Solenoid Activated by +12V



Hydraulic Control
Gear 1 Selected, Clutch Pedal Partially Raised (Feathering/Inching)

Clutch Pedal Feathering (Inching) in 1st Gear – Figure 20

With the range levers selecting a mechanical range and the main lever selecting, as an example, first (powershift) gear, as the clutch is raised slightly the neutral dump valve solenoid is de–energised and allows the return spring to move the spool to the left. The pilot pressure from the safety start valve has remained at zero.

The pilot pressure which was acting on the ends of the C1/C2 and C3/C4 clutch selector spools has now been allowed to dump. The oil flow from the main regulated supply is now able to pass to the C2 clutch. The regulated supply passes through a restriction in the neutral dump valve and onto the C2 clutch by the fact that the C1/C2 selector valve is in the C2 position, controlled by the powershift button selection. (i.e. C1/C2 selector valve solenoid is de–energised allowing the clutch selector spool to be in the C2 mode). The action of directing the oil flow through the restrictor provides a controlled engagement of either C1 or C2 clutches.

The application of the C2 clutch from an initial start–up, clutch down and release situation is further expanded under the heading 'Clutch and Lube Control Valve'.

With the selection of first gear the S2 solenoid is activated and moves the C3/C4 selector spool to allow oil from the feathering valve to be directed to the C4 clutch.

The action of depressing the clutch activates the PWM circuit. As previously described in the electrical and electronic introduction, the PWM valve allows modulated oil flow to act on the feathering valve and act against the feathering valve spring in a controlled manner, to ensure a gradual pressure build up in the C4 clutch, this gradual build up of pressure providing the feathering or gradual take–up of drive. A pilot line from the output of the feathering valve is connected to the left hand end of the feathering spool. The pilot line pressure is proportional to the pressure released through the feathering valve and acts to balance the feathering spool during inching/feathering. Due to the area differences of the spool ends, the pilot line does not force the spool back to the right.

As the clutch pedal is released and the feathering valve moves across to the full flow position, oil directed to the CALC valve also has a corresponding increase of oil pressure. When the oil pressure exceeds the spring pressure applied to the right hand spool of the CALC valve, full regulated pressure is then allowed to flow up to the C1/C2 selector spool, allowing full engagement of the C1 clutch in this instance.

Key To Hydraulic Schematic Illustrations

1. Lubrication Proportioning Valve C1/C2 Clutches
2. Lubrication Valve
3. Lubrication to Synchronisers, Top and Bottom Shafts and PTO Clutch
4. Lubrication Relief Valve (100 lbf.in^2, 7 bar)
5. Lubrication Feed from Steering Pump Return
6. Regulated Pressure Supply From CCLS Pump (250 lbf.in^2, 17 bar)
7. Accumulator (145 lbf.in^2, 10 bar, with 0.7 litre capacity)
8. Safety Start Valve
9. Feathering Valve
10. Lubrication Proportioning Valve C3/C4 Clutches
11. C3/C4 Lube Combining Spool
12. C1/C2 Sequencing Valve

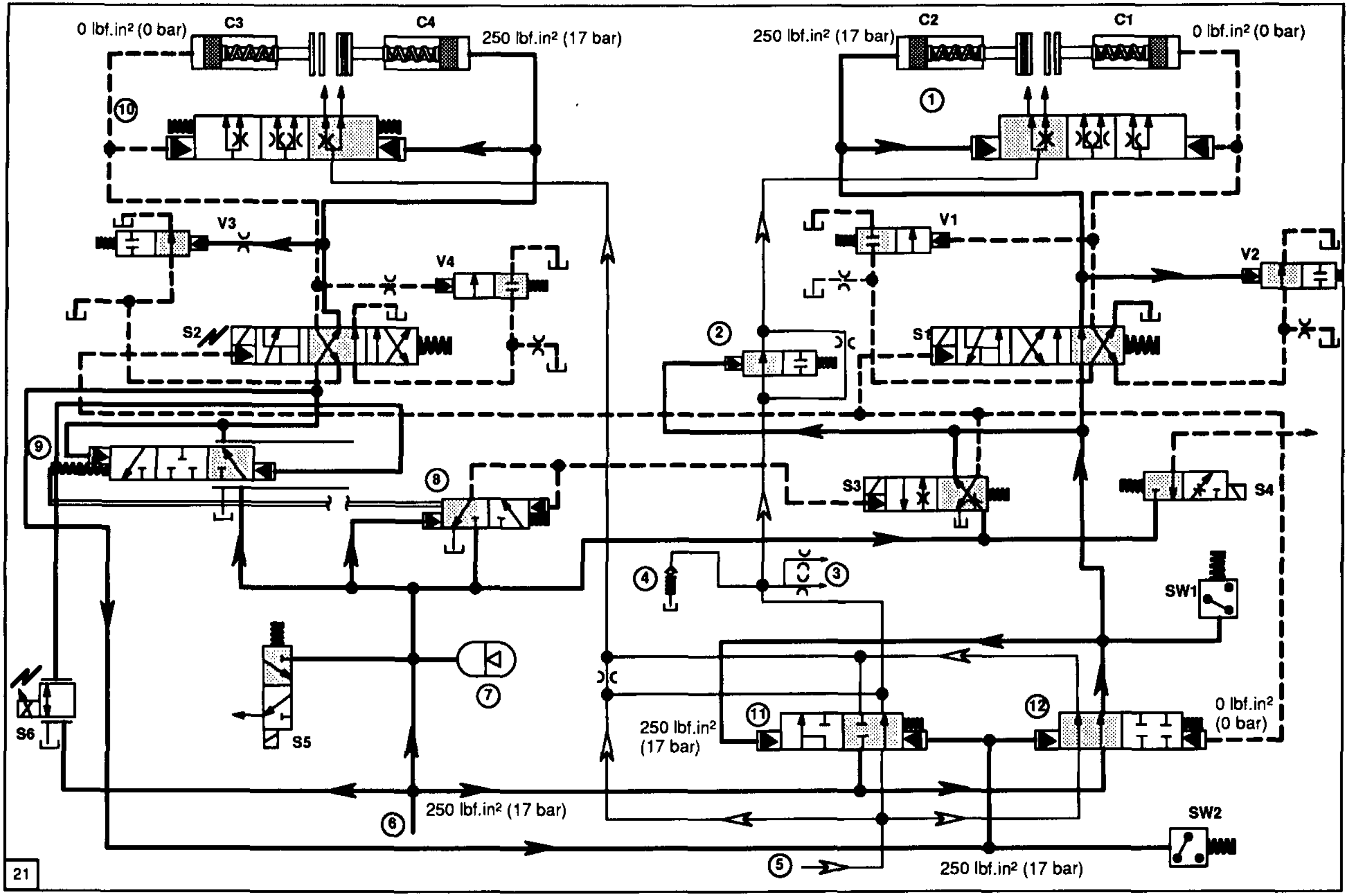
C1 – Dual Power, Clutch 1
C2 – Dual Power, Clutch 2
C3 – Main Clutch, Clutch 3
C4 – Main Clutch, Clutch 4

S1 – Solenoid 1, C1/C2 Clutch
S2 – Solenoid 2, C3/C4 Clutch
S3 – Solenoid 3, Neutral/Dump Valve
S4 – Solenoid 4, Four Wheel Drive Valve
S5 – Solenoid 5, Creeper Valve (where fitted)
S6 – Solenoid 6, PWM (Pulse Width Modulation) Valve

V1 –Clutch 1 Vent Delay Valve
V2 –Clutch 2 Vent Delay Valve
V3 –Clutch 3 Vent Delay Valve
V4 –Clutch 4 Vent Delay Valve

SW1 C1/C2 Pressure Sensing Switch
SW2 C3/C4 Pressure Sensing Switch

Regulated Pressure Supply
Regulated Pressure Line Either to Reservoir or at Zero Pressure
Lubrication Oil
Lube Oil at Reduced Pressure
Line Joining Points
Line Restriction
Pressure Operated Valve
Solenoid Operated Valve
Reservoir
Spring Assisted
Solenoid Activated by +12V



Hydraulic Control – Gear 1 Selected, Clutch Pedal Fully Released

Clutch Pedal Fully Released, Driving in 1st Gear

With the clutch pedal fully released, the PWM valve is now signalled by the ETC to provide full unmodulated oil to operate on the feathering valve. The feathering valve is pushed fully to the left allowing full oil pressure to travel through the C3/C4 selector spool up to clutch 4 in this instance. The other solenoids in the circuit remain unaffected from the previous stage. The left hand spool of the CALC valve will move across to the right hand position and cut off the additional lubrication supplied during the inching period. This occurs just before the pedal is fully released and the operation is described in more detail under the lubrication heading.

Key To Hydraulic Schematic Illustrations

1. Lubrication Proportioning Valve C1/C2 Clutches
2. Lubrication Valve
3. Lubrication to Synchronisers, Top and Bottom Shafts and PTO Clutch
4. Lubrication Relief Valve (100 lbf.in², 7 bar)
5. Lubrication Feed from Steering Pump Return
6. Regulated Pressure Supply From CCLS Pump (250 lbf.in², 17 bar)
7. Accumulator (145 lbf.in², 10 bar, with 0.7 litre capacity)
8. Safety Start Valve
9. Feathering Valve
10. Lubrication Proportioning Valve C3/C4 Clutches
11. C3/C4 Lube Combining Spool
12. C1/C2 Sequencing Valve

C1 – Dual Power, Clutch 1
C2 – Dual Power, Clutch 2
C3 – Main Clutch, Clutch 3
C4 – Main Clutch, Clutch 4

S1 – *Solenoid 1, C1/C2 Clutch*
S2 – Solenoid 2, C3/C4 Clutch
S3 – Solenoid 3, Neutral/Dump Valve
S4 – Solenoid 4, Four Wheel Drive Valve
S5 – *Solenoid 5, Creeper Valve (where fitted)*
S6 – Solenoid 6, PWM (Pulse Width Modulation) Valve

V1 –Clutch 1 Vent Delay Valve
V2 –Clutch 2 Vent Delay Valve
V3 –Clutch 3 Vent Delay Valve
V4 –Clutch 4 Vent Delay Valve

SW1 C1/C2 Pressure Sensing Switch
SW2 C3/C4 Pressure Sensing Switch

Regulated Pressure Supply
Regulated Pressure Line Either to Reservoir or at Zero Pressure
Lubrication Oil
Lube Oil at Reduced Pressure
Line Joining Points
Line Restriction
Pressure Operated Valve
Solenoid Operated Valve
Reservoir
Spring Assisted
Solenoid Activated by +12V

Lubrication Circuit General

The C1/C2 and C3/C4 clutches, the upper and lower shafts, the output shaft and the PTO clutch are pressure lubricated from the power steering return oil flow circuit. When the clutches are in neutral, shown in Figure 18, only this power steering return oil flow is used. However when clutches C3/C4 are in the inching mode, see Figure 20, oil from the regulated main supply is used to supplement the power steering return oil flow. Description of this situation follows under the heading 'Lubrication During Feathering'.

A clutch and lube control valve (CALC Valve) is mounted on the outer surface of the main control valve and serves to distribute the lubrication oil according to the operating mode of the transmission and to control the rate of engagement of the C1/C2 clutches.

The circuit contains a hydraulic accumulator which acts as a reserve oil supply, replenishing the circuit during clutch fill periods and preventing spikes occurring in the main hydraulic system. When the peak demands that occur during clutch fill periods are removed, the accumulator is automatically recharged.

Lubrication Circuit – Neutral

With the transmission levers in the neutral position and the clutch released, pressure oil is supplied from the neutral dump valve to the CALC valve right hand spool, shown in Figure 18. The CALC valve is also connected to the feathering valve output, which in neutral is at zero pressure. The oil flow from the neutral dump valve acts on the CALC valve right hand spool end and together with the spring pressure moves the spool to the left hand position. The left hand spool of the CALC valve is held in the left hand position by the spring acting on the end of the spool.

From the CALC valve the lubrication oil flows to the transmission top shaft to the bottom shafts, to the output shaft and to the PTO clutch lubrication circuit. Note that the shaft lube circuits are protected by a 100 lbf/in^2 (6.9 bar) relief valve.

The output also flows to the C1/C2 clutches via the restricted orifice, which by–passes the dump valve, onto the proportional lubrication valve located in the C1/C2 support shaft. This valve is signalled from the main supply lines to the clutches and has no centering springs. The lubrication split between the two clutches could be 80% or 20% depending where the valve is positioned. Only when the clutches are operating does the true flow distribution come into effect (see following heading with clutches engaged).

Lubrication to the C3/C4 clutches comes directly from the power steering return oil flow and passes through two restrictions and onto the proportional control valve located in the C3/4 support shaft manifold. As the clutches are in neutral and no pressure exists in the supply lines the valve remains in the centre 50/50 position.

Lubrication Circuit – Clutch Feathering (Inching)

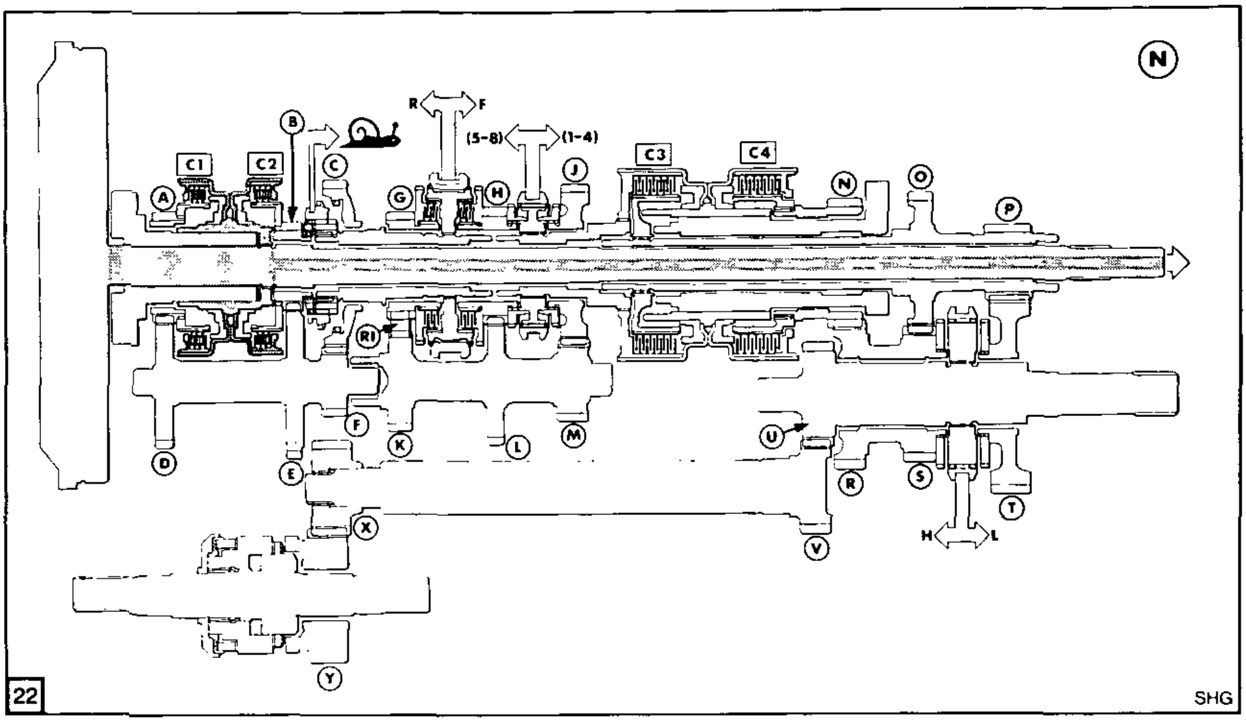
With reference to Figure 20, with C4 clutch and C2 clutch selected (1st, 5th, 9th, and 13th) and the clutch pedal feathering (inching), oil from the power steering return flow has been supplemented with oil from the regulated main flow.

The neutral dump valve has now been de–energised and dumped the oil flow to the right–hand spool of the CALC valve, this has removed any oil pressure in the pilot line acting on the right hand side of the spool and the neutral dump spool will remain to the left due to the spring force. Oil pressure coming from the feathering valve is piloted to both ends of the CALC valve and act on the left–hand end of the right valve and on the right–hand end of the left valve. The right–hand spool will move across to the right when pressure from the feathering valve exceeds 90 lbf.in^2 (6.2 bar), i.e., when the spool spring pressure is overcome as the clutch pedal is released.

The left–hand spool has full regulated main pressure piloted to the left–hand end of the spool from the neutral dump valve (which is de–energised) and allows the regulated supply to join and supplement the power steering return oil flow. These combined oil flows are directed to the C3/C4 clutch and is proportioned by the pilot signal from the engaging C4 clutch. The proportional valve (located in the C3/C4 clutch support shaft manifold) directs 80% of the flow to the C4 clutch and 20% to the C3 clutch. As the clutch pedal is fully released the situation changes, as described under the following heading.

Lubrication Circuit – Tractor Driving

With reference to Figure 21, with C4 clutch and C2 clutch selected (1st, 5th, 9th, and 13th) and the clutch pedal now fully released, the pilot line pressure to the CALC valve from the feathering valve is at full regulated pressure. The left hand spool of the CALC valve is now fully to the left due to regulated pressure being applied to both it's ends and the spring force taking over. The regulated oil flow is thus prevented from combining with the power steering return oil flow. The lube flow to the previously inching C4 clutch circuit which was increased during inching, is now returned to the normal running amount. The right hand spool of the CALC remains in the right hand position as for the feathering situation. C1/2 lube is also unchanged from the feathering situation.



Power Flow – Neutral

Transmission Gears, Clutches and Couplers – Component Identification

A C1 Clutch Output Gear (34 tooth)
B. C2 Clutch Output Gear (26 tooth)
C. Creeper Driven Gear (55 tooth)
D. Front Bottom Shaft Gear (42 tooth)
E. Front Bottom Shaft Gear (48 tooth)
F. Front Bottom Shaft Gear (20 tooth – Creeper only)
G. Reverse Gear (33 tooth)
H. Forward Gear and/or Coupler (37 tooth)
J. Low Main Gear (53 tooth)
K. *Intermediate Bottom Shaft Gear (37 tooth)*
L. Intermediate Bottom Shaft Gear (41 tooth)
M. Intermediate Bottom Shaft Gear (25 tooth)
N. C4 Clutch Output Gear (42 tooth 40 km/hr, 37 tooth 30 km/hr)
O. C3 Clutch [High] Output Gear (46 tooth 40 km/hr, 41 tooth 30km/hr)
P. C3 Clutch [Low] Output Gear (22 tooth)
R. *Output Gear (37 tooth 40 km/hr,* 43 tooth 30 km/hr)
R1 Reverse Idler Gear (31 tooth)
S. Output Gear ((33 tooth 40 km/hr, 39 tooth 30 km/hr)
T. Low Range Output Gear (65 tooth)
U. Output to FWD (29 tooth)
V. FWD Internal Shaft Rear Gear (26 tooth)
X. FWD Internal Shaft Front Gear (26 tooth)
Y. FWD Transfer Assembly Driven Gear (37 or 38 tooth)

POWER FLOWS

The following power flows are described in four stages commensurate with the actual sequence within the transmission. The illustrations depict the transmission in a simplified format and visually indicate which gear and clutch are transmitting power and the respective positions and engagements of the synchronised couplings.

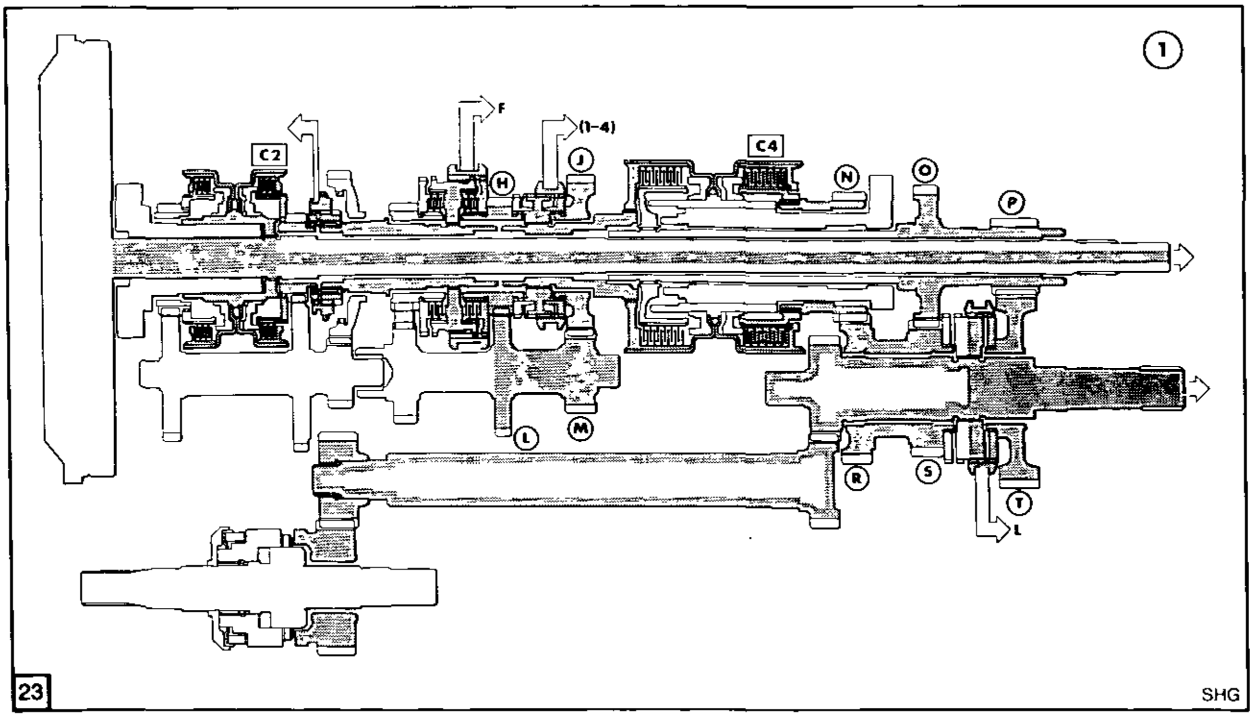
The stages show the individual power flows *for forward gears, initially in neutral with the* forward/reverse, main and range levers in neutral and then in 1st, 2nd, 3rd, 4th, 5th, 8th and 16th gears, for 8th gear reverse and for forward 1st gear in the optional creeper ratio.

Neutral

With reference to Figure 22:
The forward/reverse, main and range levers are in neutral. Engine power enters the transmission from the engine flywheel and damper assembly along the PTO/input shaft. Note that this shaft rotates whenever the engine is running and that engine power is continuously being transmitted along the PTO/input shaft through the transmission and on to the PTO clutch and hydraulic pumps mounted in the rear axle/transmission.

The PTO/input shaft is splined to the C1/C2 clutch housing and this housing, therefore, rotates with the PTO/input shaft at engine speed.

All clutches C1/C2 and C3/C4 are disengaged and no power can be transmitted to the first coupling, the forward/reverse synchroniser and consequently no power reaches the main or range synchronisers.



Power Flow 1st Gear

Forward 1st Gear

With reference to Figure 23:
The main lever is in the 1–4 range and the powershift 1st gear has been selected using the push buttons. The forward/reverse shuttle lever is in the forward direction position and the range lever is in low or gears 1–8.

Engine power enters the transmission from the engine flywheel and damper assembly along the PTO/input shaft.

Clutch C2 is engaged along with clutch C4 when creeper option is fitted. The powered coupler is not activated and held by spring pressure in the disengaged position (coupler is toward the front of the transmission), as shown.

Power is transmitted along the PTO/input shaft to the C1/C2 housing. The engaged clutch C2 locks the clutch housing to the C2 clutch output gear. As the creeper is not selected the C2 output gear is connected directly to the forward/reverse synchroniser support shaft. This shaft in turn, is by position of the forward/reverse shuttle synchroniser (moved rearward), connected to the gear (H) between the forward/reverse synchroniser and the main synchroniser. As the main synchroniser is in 1–4 range the gear (H) drives the intermediate bottom shaft through gears (L) and (M) to the main synchroniser gear (J).

Gear (J) is locked to the main synchroniser support shaft through the position of the synchroniser.

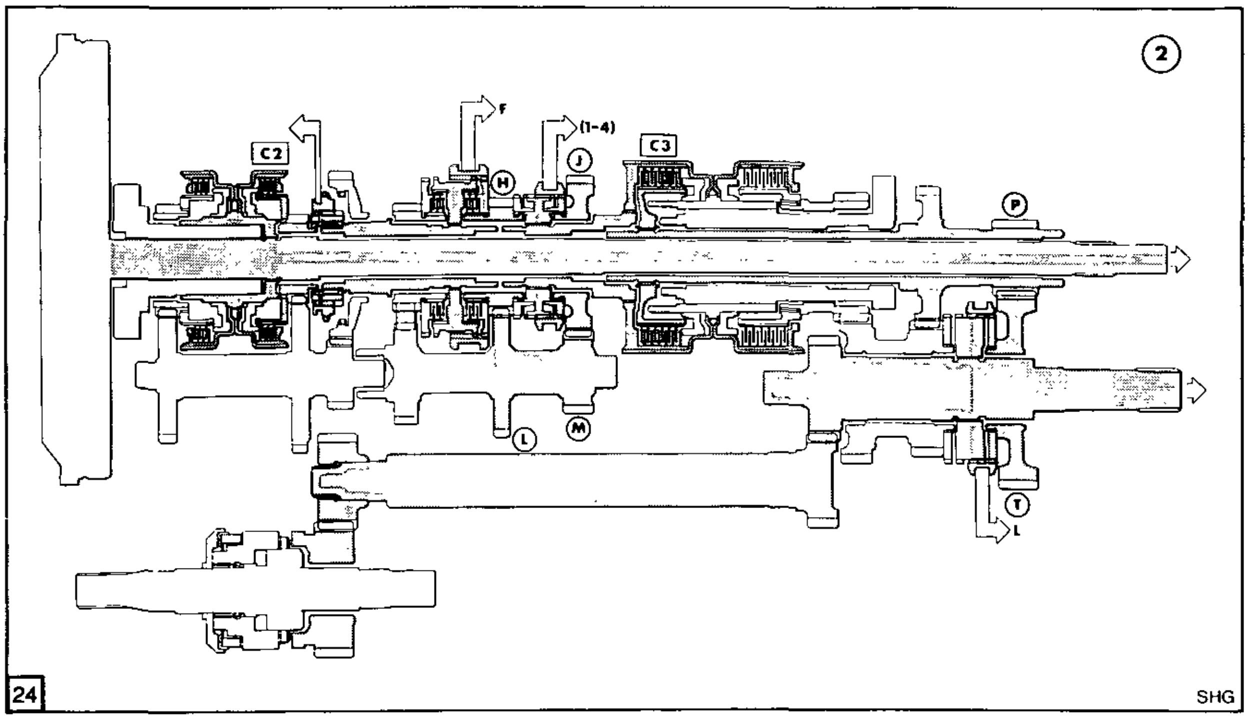
The range synchroniser support shaft drives the hub and pressure plate of the C3 clutch which in turn drives the whole of the C3/C4 clutch housing.

C4 clutch is engaged and power is transmitted to the C4 clutch output gear (N). This gear is in mesh with gear (R) which is in cluster with gear (S). The high/low synchroniser is in the rearward low position and power is transmitted to the gear (O) on to (P) and to the low output gear (T). The rearward position of the high/low synchroniser locks the gear (T) to the output shaft and the power is transmitted on to the rear axle.

Referring to Figure 22 and using the identified gear teeth numbers, the following gear ratio results for a 30 km/h transmission. Substituting the different gears for the 40 km/h option will give the higher ratio. Use Figure 22 in all the following power flows to establish the number of gear teeth on each active gear.

Power flow is :– (H) (L) (M) (J) (N) (R) (S) (O) (P) (T).

Gear ratio is:– 41/37 x 53/25 x 43/37 x 41/39 x 65/22 = 8.48:1



Power Flow 2nd Gear

Forward 2nd Gear

In 2nd gear, Figure 24, clutches C2 and C3 are engaged and all synchronised couplings remain as in 1st gear, the ratio change, which is a powershift, being effected only by the differing applications of the wet clutches. The power flow is similar to 1st gear in the forward stages of the transmission, but where C3 is engaged instead of C4, the final ratio reduction occurs through the gears (P) and (T).

Power flow is :– (H) (L) (M) (J) (P) (T).

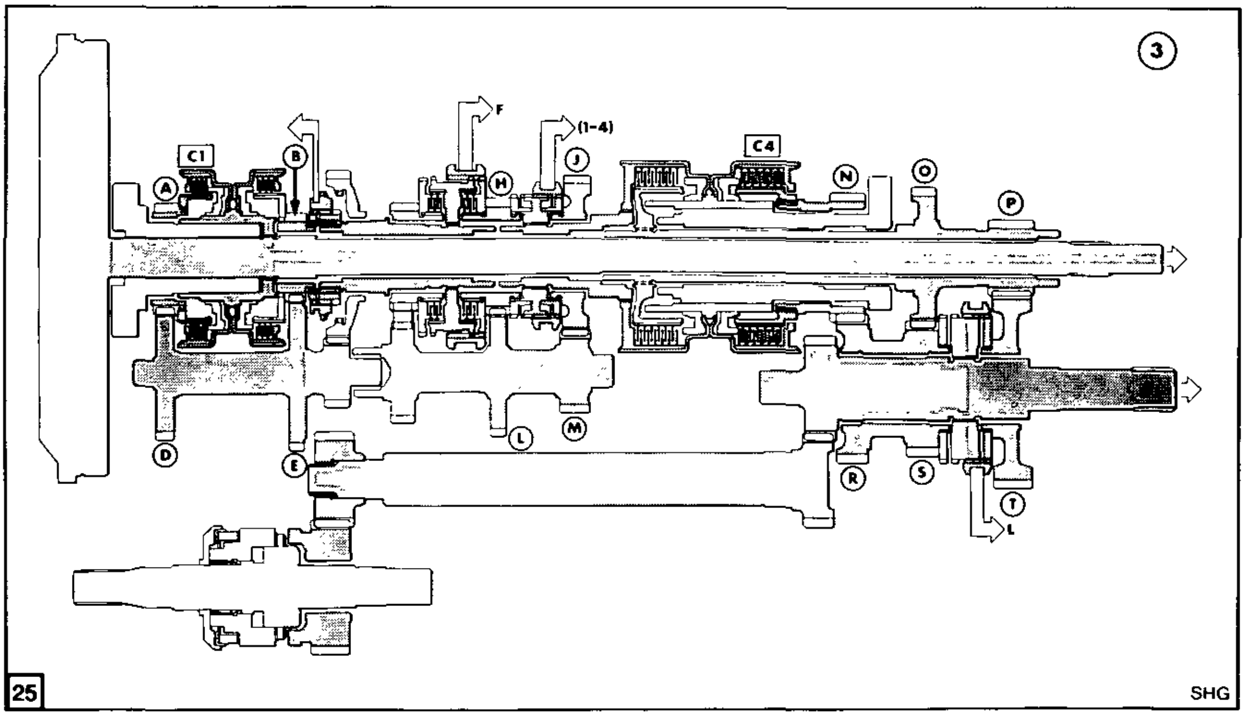
Gear ratio is:– 41/37 x 53/25 x 65/22 = 6.94:1

Forward 3rd Gear

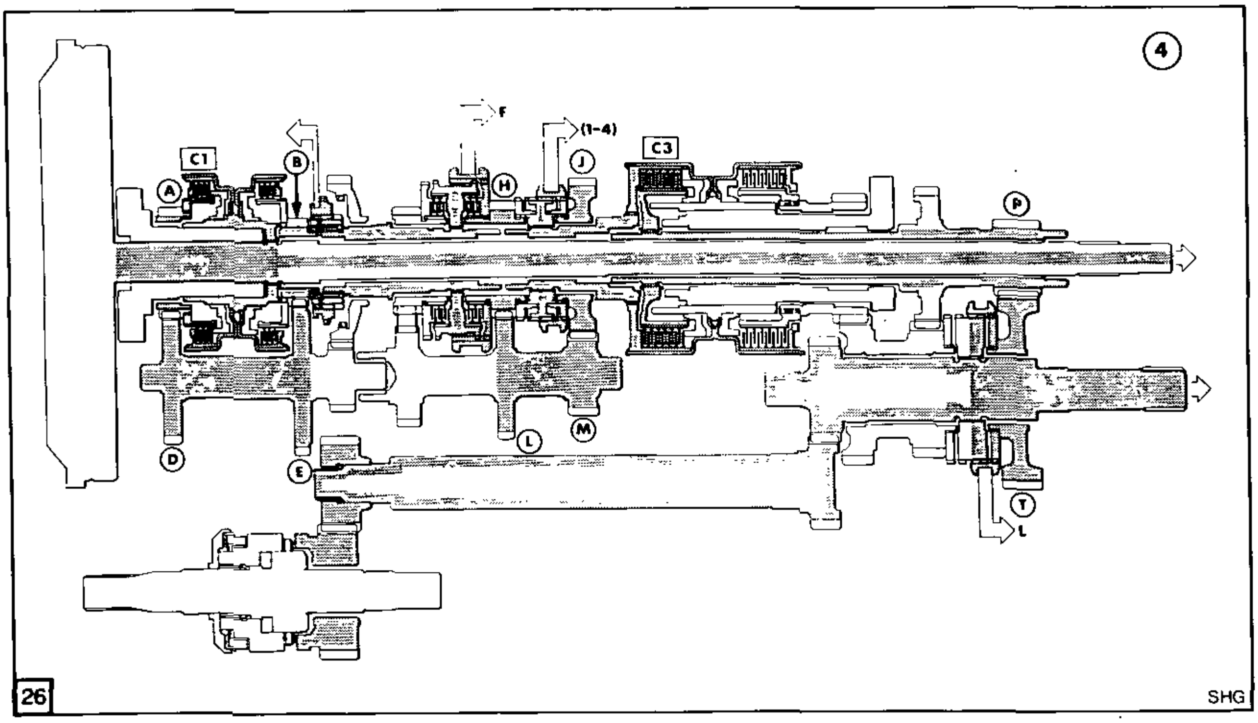
In 3rd gear, Figure 25, clutches C1 and C4 are engaged and all synchronised couplings remain as in 1st gear, the ratio change, which is a powershift, being effected only by the differing applications of the wet clutches. The power flow now utilises the reduction available through the front bottom shaft and also utilises the reduction through the rear output shaft as in 1st gear.

Power flow is :– (A) (D) (E) (B) (H) (L) (M) (J) (N) (R) (S) (O) (P) (T).

Gear ratio is:– 42/34 x 26/48 x 41/37 x 53/25 x 43/37 x 41/39 x 65/22 = 5.67:1



Power Flow 3rd Gear



Power Flow 4th gear

Forward 4th Gear

In 4th gear, Figure 26, clutches C1 and C3 are engaged and all synchronised couplings remain as in 1st gear, the ratio change, which is a powershift, being effected only by the differing applications of the wet clutches.

The power flow now utilises the reduction available through the front bottom shaft, like the power flow in 2nd gear, the reduction through the rear output shaft is not utilised.

Power flow is :– (A) (D) (E) (B) (H) (L) (M) (J) (P) (T).

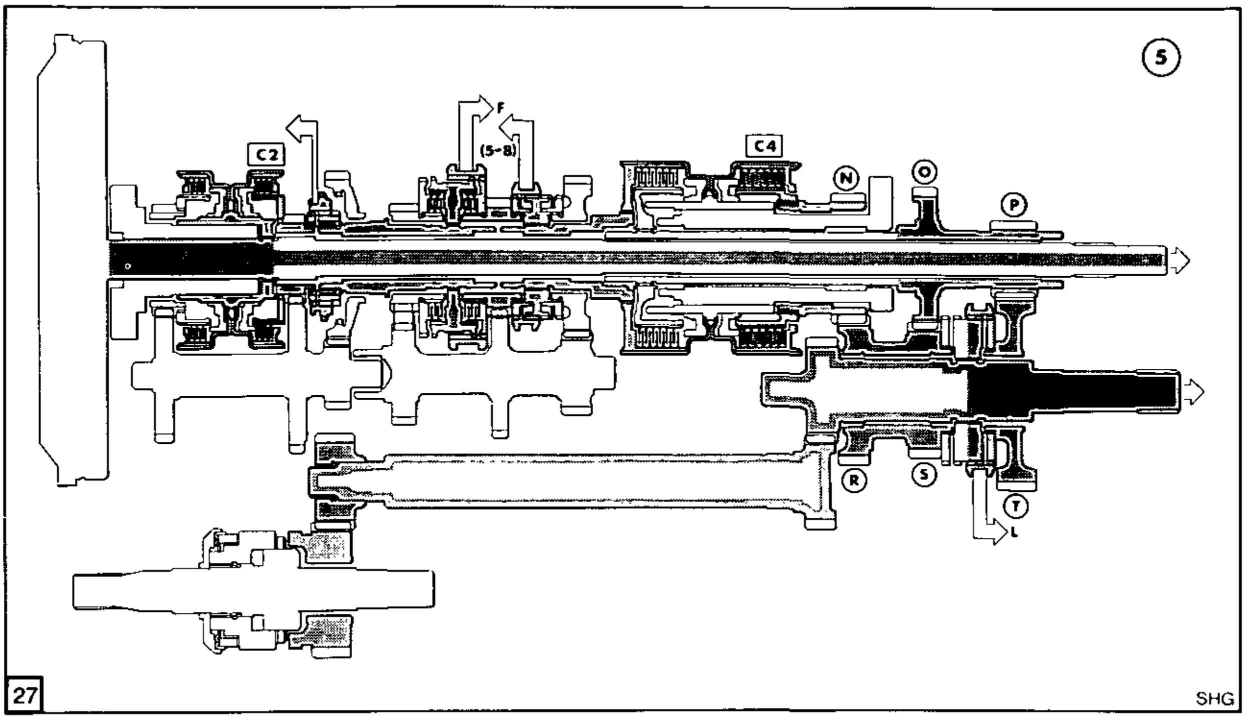
Gear ratio is:–42/34 x 26/48 x 41/37 x 53/25 x 65/22 = 4.64:1

Summary 1st, 2nd, 3rd and 4th Gears and Further Ranges.

The four power flows for the powershift gears have been detailed in the preceding paragraphs. Each gear ratio was obtained by the application of two of the four wet clutches in a controlled sequence.

The following illustrations and paragraphs describe the power flow when one of the synchronised couplers is moved to a different position.

In each of these different positions the four powershift ratios can be selected and the corresponding power flow path follows in a different range. For example, the following power flow is for 5th gear which is the same as 1st gear but with the main gear lever and its respective synchronised coupler moved to the 5–8th range position.



Power Flow 5th Gear

Forward 5th Gear

In 5th gear, Figure 27, clutches C2 and C4 *are engaged as in 1st gear. The main range* coupling now being moved to the 5–8 position. The forward/reverse and high/low couplings remain unchanged.

The transition from 4th to 5th is performed purely by movement of the main range lever. The electronic control automatically moves the prior 4th gear back to the 1st gear pattern of the powershift sequence.

Power flow is :– (N) (R) (S) (O) (P) (T).

Gear ratio is:–43/37 x 39/41 x 65/22 = 3.27:1

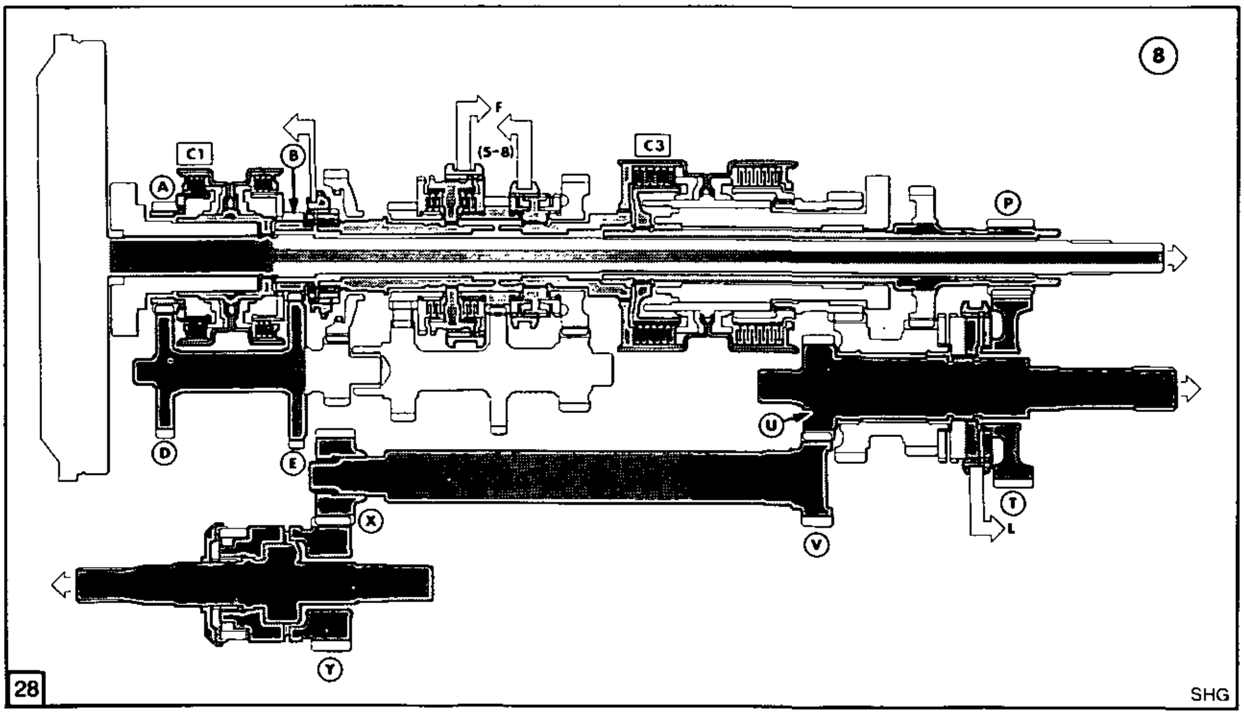
Forward 8th Gear

In 8th gear, Figure 28, the same clutches, C1 and C3, that were used to obtain 4th gear, are applied. The main range coupling is in the 5–8 position. The high/low range coupler still remains in the low range for 8th gear.

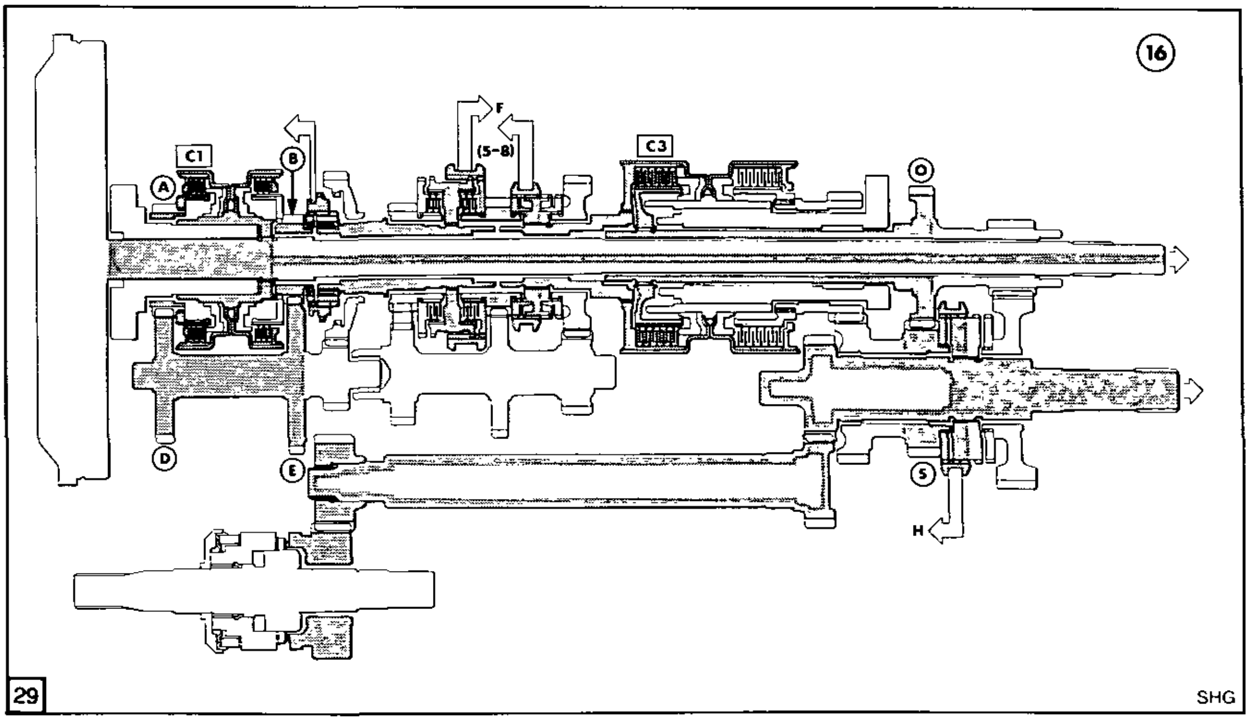
Power flow is :– (A) (D) (E) (B) (P) (T).

Gear ratio is:– 42/34 x 26/48 x 65/22 = 1.98:1

Figure 28 also depicts the power flow when the tractor is equipped with four wheel drive.



Power Flow 8th gear



Power Flow 16th gear

The transmission output shaft carries a gear on its forward end which is in continuous mesh with a gear and shaft carrying the drive forward to the four wheel drive clutch assembly. This clutch assembly is an hydraulically released dog type clutch and is spring engaged.

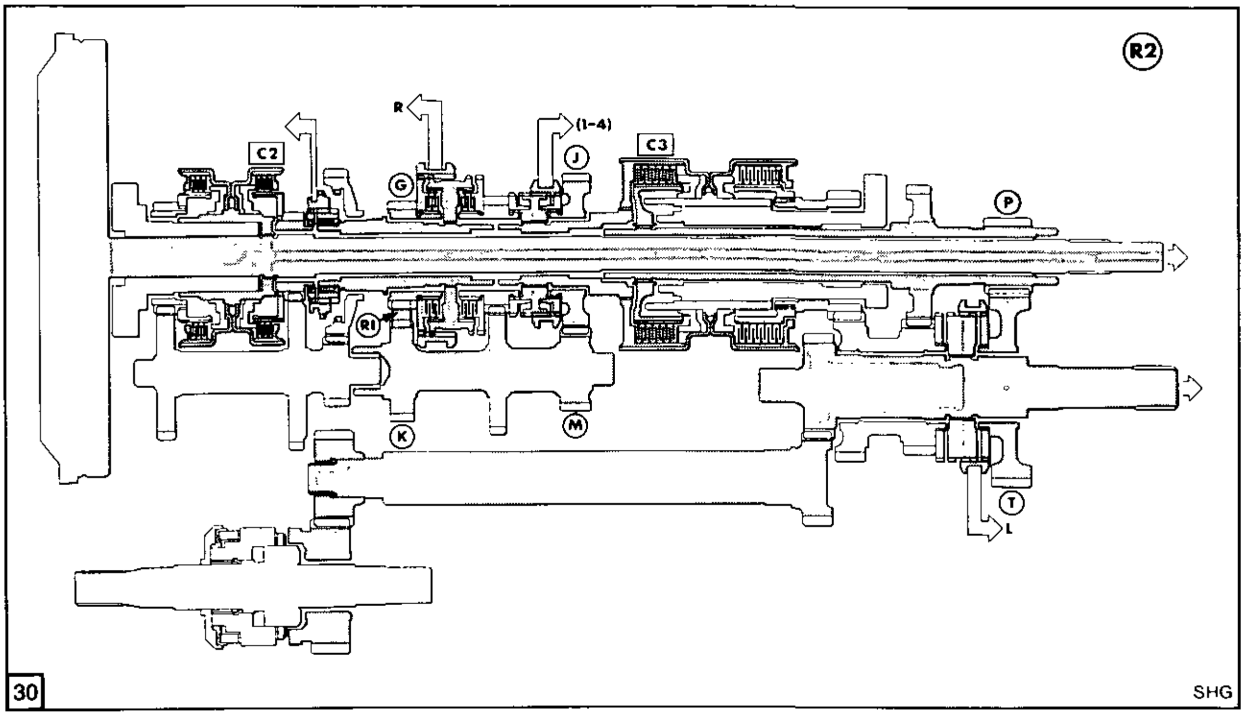
Further detail of the operation of this clutch is given under other headings in this section. Note that the output to the four wheel drive can be varied by the fitting of either a 37 or 38 tooth final output gear. This variation is controlled during manufacture to suit the combination of rear and front tyre sizes.

Forward 16th Gear

In 16th gear, Figure 29, the same clutches, C1 and C3, that were used to obtain 4th gear are applied. The main range coupling, as for 8th gear, remains in the 5–8 gear range position.

The high/low range lever has been moved to the high position which moves the synchroniser forward and couples the front cluster gear on the output shaft to the output shaft.

Power flow is :–(A) (D) (E) (B) (O) (S).



Power Flow 2nd Gear Reverse

Reverse 2nd Gear

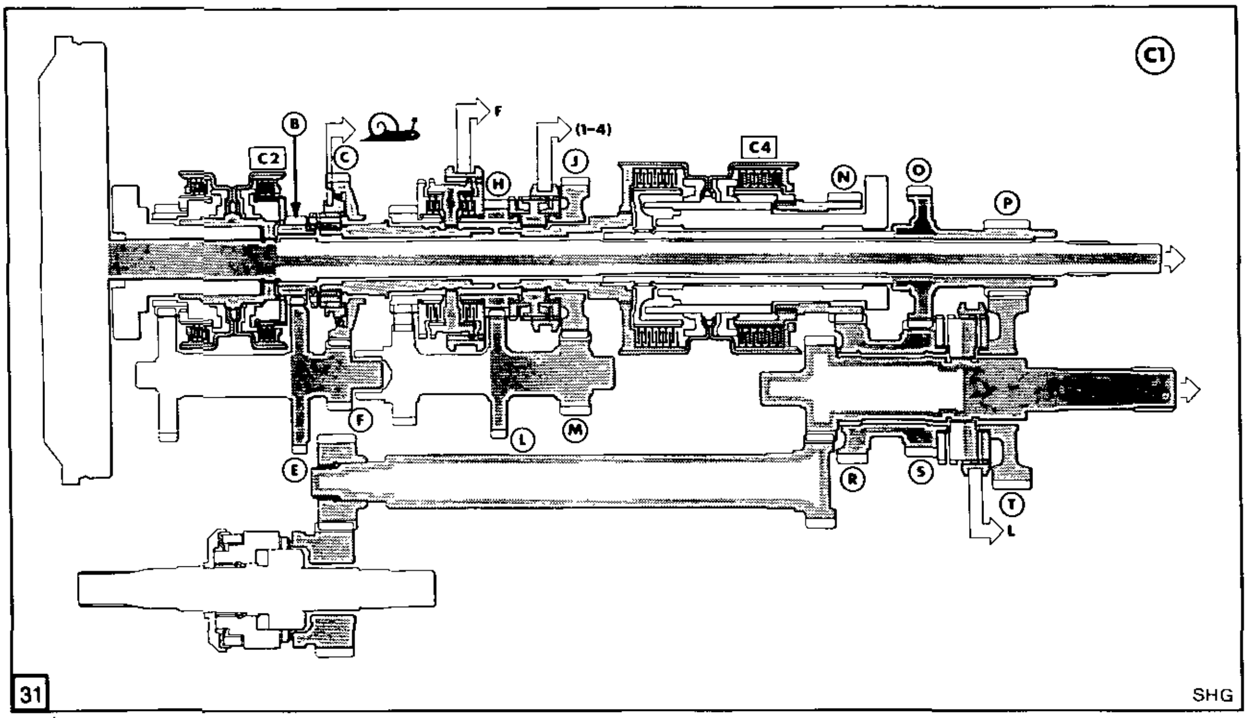
In reverse 2nd gear, Figure 30, the same clutches C2 and C3, that were used to obtain forward 2nd gear are applied. The main range coupling is rearward for 1–4 range and the high/low coupling in the low position.

Reverse is selected by moving the forward reverse shuttle lever to the reverse position. The forward/reverse synchronised coupling is moved forward and directs the power flow to the front gear of the intermediate bottom shaft via the reverse idler gear and the direction of the intermediate bottom shaft is reversed.

The (G) (K) (M) (J) gears, 33, 37, 25, and 53 toothed gears and the reverse idler (R1) are now involved in the power flow and through the use of the idler the direction of power flow has been reversed. The resultant ratio of these four gears is 37/33 x 53/25 = 2.38:1. This ratio equates effectively to a direct reversal of the equivalent 2nd forward gear ratio of 2.37:1, for the four gears in the forward power flow and to all intents and purposes the reverse ratios are equal to the forward ratios for all 16 gears

Power flow is :– (G) (K) (M) (J) (P) (T).

Gear ratio is:– 37/33 x 53/25 x 65/22 = 7.02:1



Power Flow 1st Gear with Optional Creeper Engaged

Forward 1st Gear with Optional Creeper Engaged.

In forward 1st gear with the creeper engaged, Figure 31, the same clutches C2 and C4 are applied as for normal 1st gear.

The powered creeper coupling is moved rearwards by a solenoid controlled small hydraulic cylinder. All other couplers remain as for normal 1st gear. The lower ratio is obtained by using the C2 clutch gear to drive the mid gear on the front bottom shaft and the rear gear on the front bottom shaft to drive the forward/reverse synchroniser support shaft.

Power flow is :– (B) (E) (F) (C) (H) (L) (M) (J) (N) (R) (S) (O) (P) (T)

Gear ratio is:– 48/26 x 55/20 x 41/37 x 53/25 x 43/37 x 41/39 x 65/22 = 43.05:1

The introduction of the gears, (B) – 26 tooth, as a driving gear, (E) – 48 tooth, (F) – 20 tooth and (C) – 55 tooth, to all gears 1–8, effectively gives a ratio of (48/26 x 55/20) = 5.08:1. This ratio lowers the equivalent 1–8 gear ratios by this amount.

B. TRANSMISSION – OVERHAUL

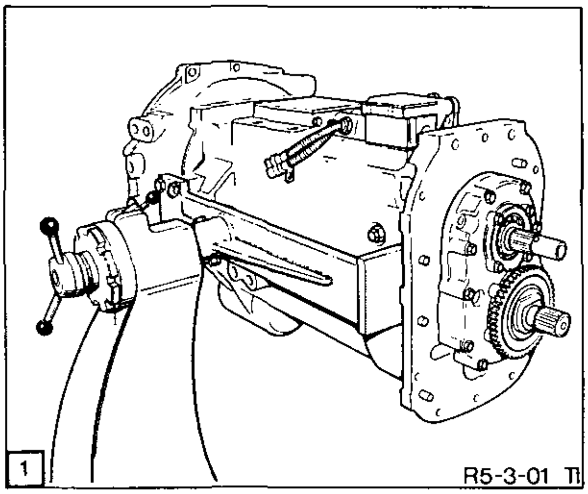
IMPORTANT: ***Cleanliness during overhaul is important. Ensure during the rebuilding stage that all contaminant is eliminated, that working conditions are clean and that all tools used do not introduce contaminant into the previously cleaned components. Pay particular attention to the control valve when this is removed during this overhaul stage.***

The transmission must be removed from the tractor before commencing overhaul. Should any single component be identified as requiring removal, refer to the relevant area within the overhaul procedure and consider if replacement of this single item can be achieved without complete disassembly.

Note that the transmission uses hydraulically actuated components and that cleanliness and the removal of any contaminant is paramount to a successful overhaul.

Separating the tractor between the engine and transmission will not permit any component replacement other than the lubrication transfer tubes. Removal of the PTO/input shaft is not recommended unless the tractor is separated at the transmission to rear axle.

During disassembly and re–assembly it is necessary to place the transmission in the horizontal and vertical positions, therefore a secure suitable stand, Figure 1, is a necessity. See Section under 'Special Tools' for details.

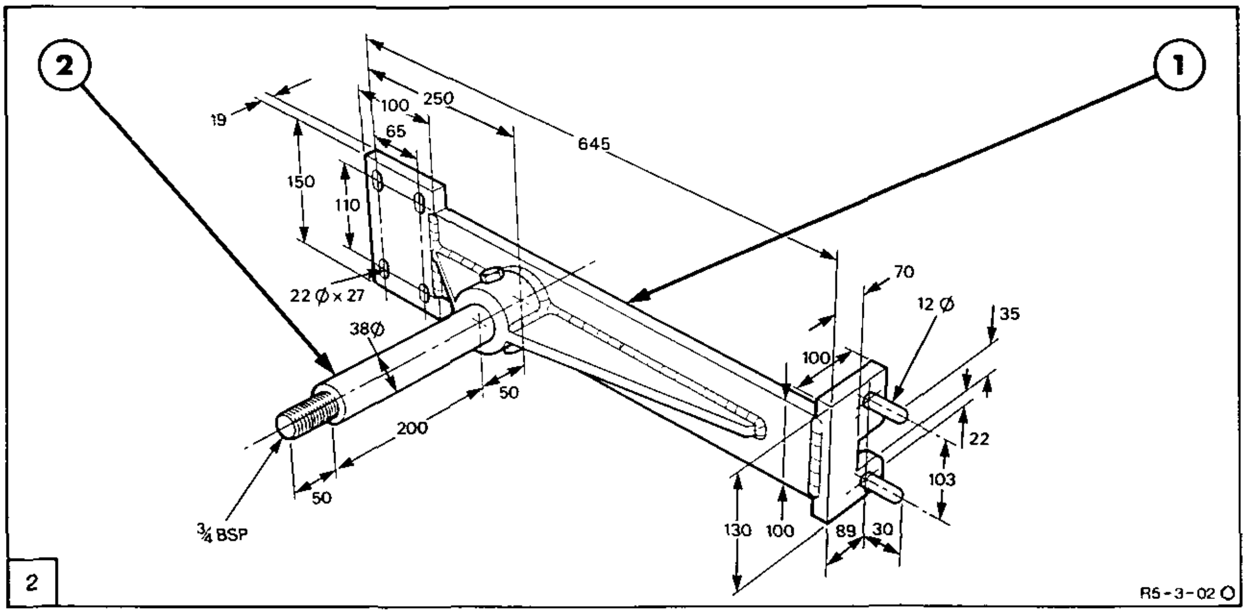


1

Transmission Mounted in Swivelling Stand

Alternatively an engine stand of sufficient strength together with a suitable bracket may be used. Shown in Figure 2 are constructional details that will allow local fabrication of a bracket, if required.

The following procedure, under component headings, details the disassembly process to initially remove each of the transmission component groups from the housing. The procedure then deals with the further disassembly of these groups, overhaul and inspection and re–assembly.



2

Transmission to Stand Attachment Bracket – Constructional Detail

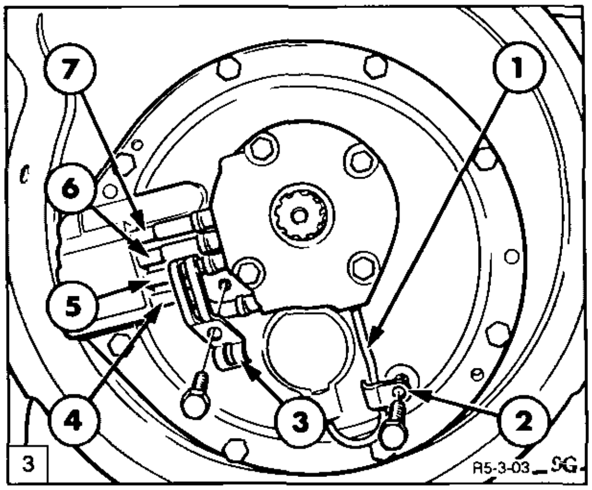
1. Main Bracket (made from 19mm mild steel plate)
2. Centre Spigot (locally adjust to suit base stand – thread detail suits V. L. Churchill engine stand)

NOTE: Strengthening gussets should be of similar plate and welds should be secure, preferably continuous.

IMPORTANT: *It is recommended that boxes or containers are made available to collect and store the various components as they are disassembled. Each box or container should be identified and as each group of components is removed and disassembled the components should be stored in the relevant box. This procedure will readily identify at the completion of the overhaul or re–build, if a small component such as a bearing or thrust washer remains, that an error in the assembly has occurred.*

If parts are replaced with new items remember to maintain stock control on the contents of the boxes or containers.

Within this overhaul section there is reference to thrust washers under the description 'polyimide'. These washers are sometimes referred to as VESPEL® washers. The word VESPEL® is the trademark for parts produced by DUPONT from their SP21 polyimide resin.



Oil Transfer Tubes on Front Cover

1. Bottom Front Shafts Lube Supply Tube
2. Retaining Bracket
3. Retaining Bracket
4. Top Shaft Lube & Supply to Bottom Shafts Tube
5. C1 Clutch Pressure Supply Tube
6. Clutch C1& C2 Lube Tube
7. C2 Clutch Pressure Supply Tube

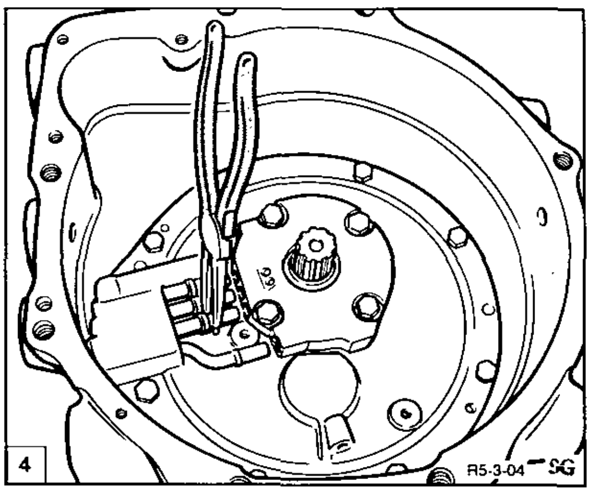
COMPONENT REMOVAL

Before overhaul of the main transmission internal components can proceed, the following items must be removed:–

1. Remove the gearshift control mechanism, as detailed in Section B.
2. Remove the gearshift cover, as detailed in Section C.
3. Remove the control valve assembly, as detailed in Section D.

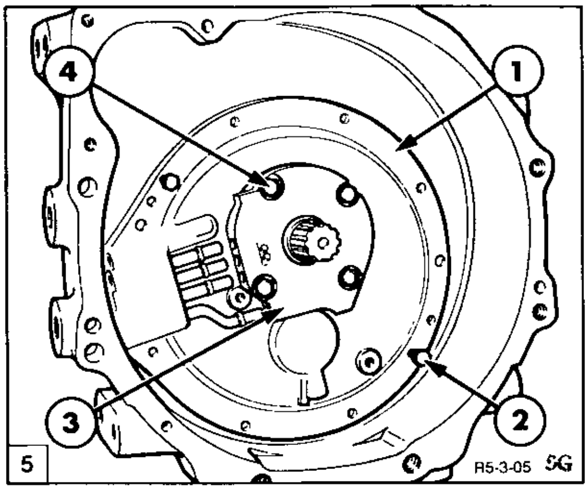
C1/C2 Clutch Assembly, Front Bottom Shaft and Creeper Components (where fitted) – Removal

4. Remove the oil transfer tube retaining brackets, Figure 3.
5. Ease the oil transfer tubes back into the front cover distribution block, Figure 4. Ease the bottom shaft oil transfer lube tube from the C1/C2 support shaft and remove it from the casting.



Easing Oil Transfer Tubes into Distribution Block

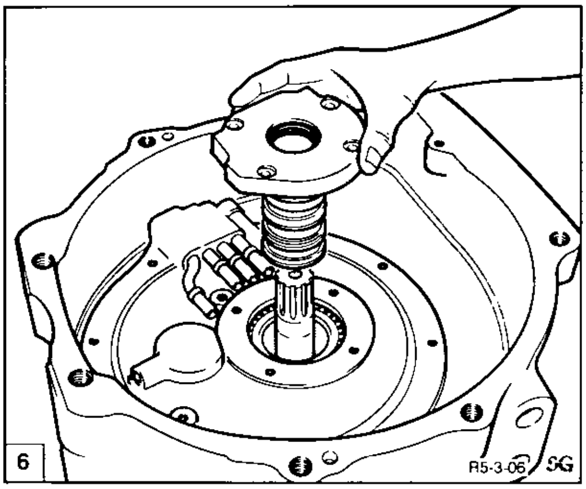
6. Position the transmission in a vertical plane.



Front Cover Plate and C1/C2 Clutch Support Shaft Bolts

1. Front Cover Plate
2. Jacking Bolt x 2
3. C1/C2 Clutch Support Shaft
4. Support Shaft Retaining Bolt x 4

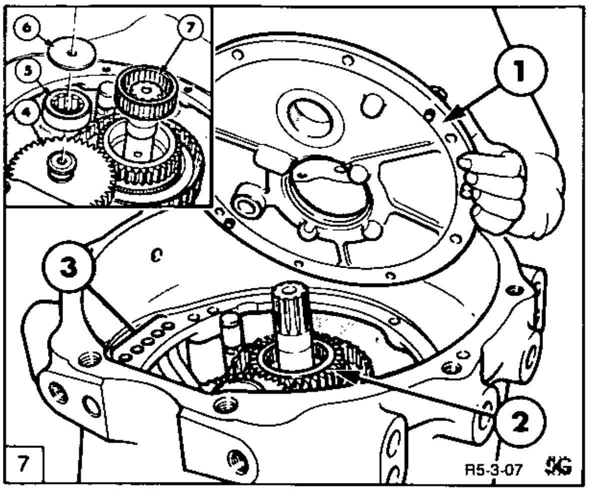
7. Loosen the C1/C2 clutch support shaft retaining bolts and remove the eight front cover bolts. Screw two of these bolts evenly and fully into the two jacking holes to loosen and free the front cover plate, Figure 5.



Removing C1/C2 Clutch Support Shaft

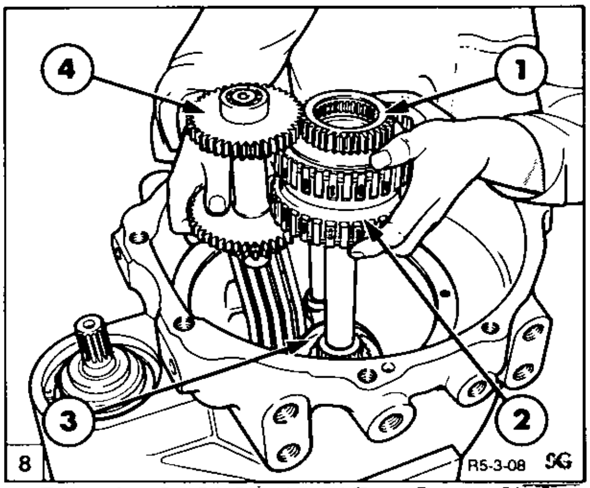
8. Remove the C1/C2 clutch support shaft retaining bolts and pry the shaft away from the cover plate, and remove the shaft, Figure 6.

9. Remove the cover plate, Figure 7. Note that if the transmission is equipped with creeper the creeper rail and fork will become disengaged, see component identification in Figure 11.



Installing Front Cover Plate (with creeper shown)

1. Front Cover Plate
2. C1 Clutch Output Gear
3. Lube Tube 'O' Ring Seals
4. Front Bottom Shaft
5. Front Roller Bearing
6. Lube Oil Baffle
7. C1 Clutch Output Gear Needle Roller Bearing



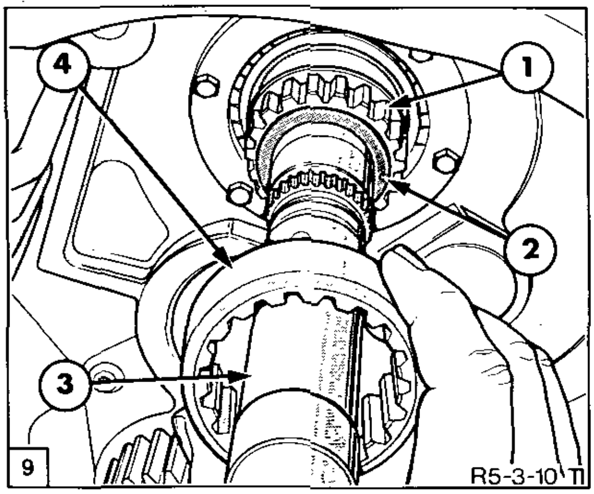
Removing C1/C2 Clutch and Front Bottom Shaft

1. C1 Clutch 34 Tooth Output Gear
2. C1/C2 Clutch Assembly
3. Creeper Fork
4. Front Bottom Shaft

10. Grasp the C1/C2 clutch assembly and the front bottom shaft, Figure 8 and remove these from the housing. Recover the bottom shaft lubrication oil baffle from the front bearing recess in the front cover.

11. Remove the C2 clutch 26 tooth output gear if this has remained on the PTO/input shaft.

NOTE: *If the transmission is equipped with creeper, recover the creeper coupler components.*

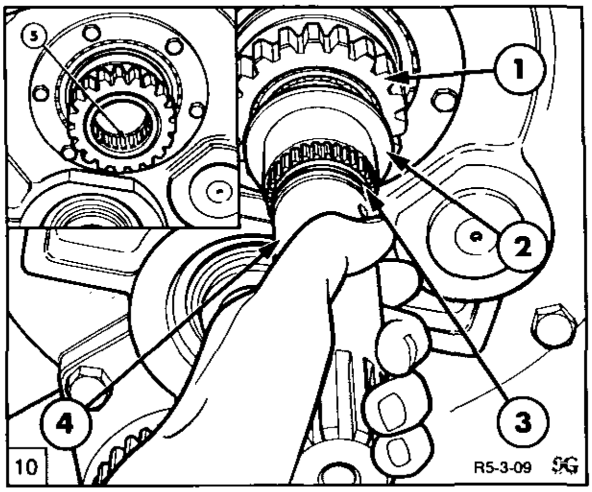


Removing C2 Clutch Output Gear Coupler to Forward/Reverse Synchroniser Support Shaft (Non–Creeper Shown)

1. Forward/Reverse Synchroniser Support Shaft
2. Polyimide Thrust Washer
3. PTO/Input Shaft
4. Coupler (C2 Clutch Output Gear to Forward/Reverse Synchroniser Support Shaft)

12. On transmissions not fitted with creeper remove the coupler that connects the C2 clutch 26 tooth output gear to the forward/ reverse synchroniser support shaft, Figure 9.

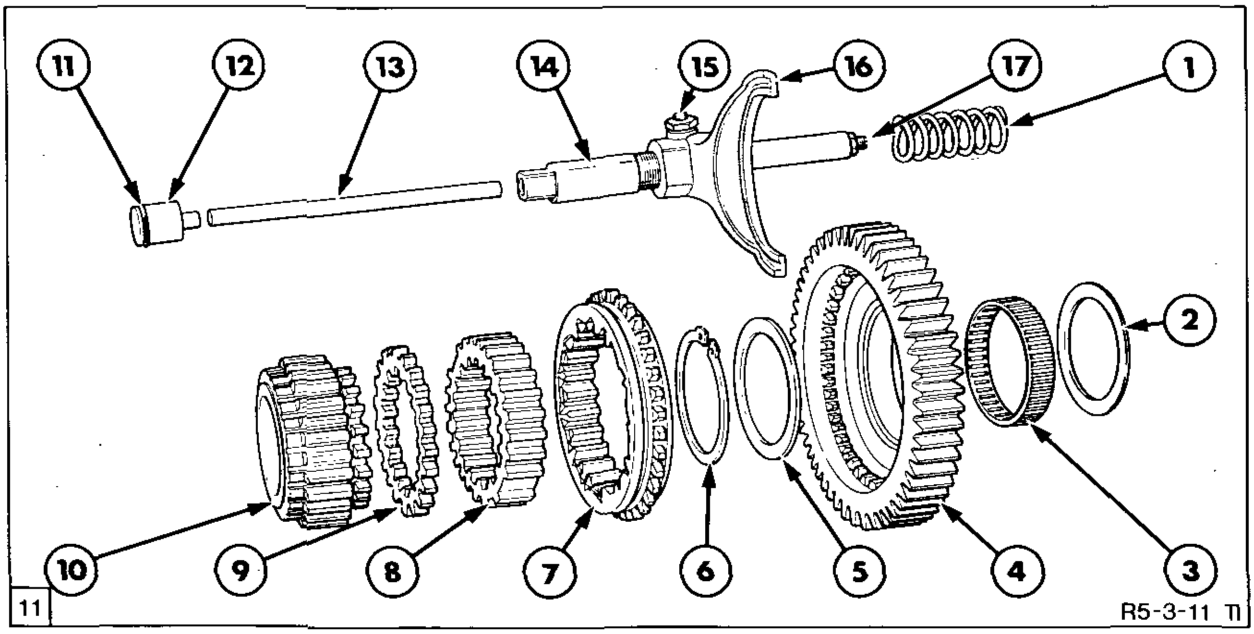
13. Remove the PTO/input shaft, Figure 10. As the shaft is pulled out the polyimide thrust washer on non–creeper transmissions (steel washer on creeper transmissions) separating the C2 clutch 26 tooth output gear and the forward/reverse support shaft will normally come with the shaft.



Removing PTO/Input Shaft (Non–Creeper Shown)

1. Forward/Reverse Support Shaft
2. Polyimide Thrust Washer (Steel if Creeper)
3. Lube Seal
4. PTO/Input Shaft
5. PTO/Input Shaft to Support Shaft Needle Roller Bearing

14. Collect the PTO/Input Shaft to forward/reverse support shaft needle roller bearing from inside the nose of the support shaft, Figure 10.

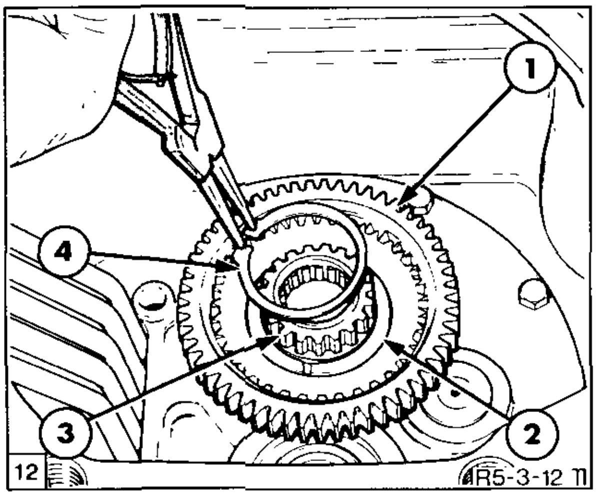


Creeper Transmission – Coupler Components, Gear, Fork, Actuating Piston and Rail Assembly

1. Fork Return Spring
2. Steel Washer
3. Needle Roller Bearing
4. Creeper Gear
5. Steel Washer
6. Snap Ring
7. Sliding Coupler
8. Coupler
9. Plate
10. C2 Output Gear (26 Tooth)
11. 'O' Ring Seal
12. Creeper Engagement Piston
13. Actuator Rod
14. Creeper Fork Rail
15. Creeper Disengagement Adjustment Lock Screw and Lock Nut
16. Coupler Fork
17. Creeper Engagement Adjuster and Locknut

Creeper Transmissions Only

15. Pull out the fork and rail together with the coupler assembly from the forward/reverse synchroniser support shaft. An exploded view of these components is shown in Figure 11. Note that when the front cover was removed the operating piston may have remained in the cover and some of the creeper components may have disengaged.



Creeper Gear Retaining Snap Ring

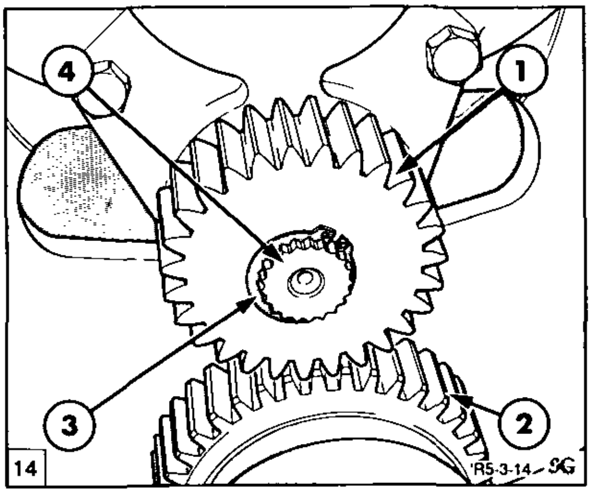
1. Creeper Gear
2. Steel Washer
3. Forward/Reverse Synchroniser Support Shaft
4. Snap Ring

16. Remove the creeper gear retaining snap ring, Figure 12 and remove the steel washer, the gear and bearing and the second steel washer behind the gear. Collect the PTO/input shaft needle roller bearing from the nose of the forward/reverse synchroniser support shaft.

17. An exploded view of the C1/C2 clutch assembly and the front bottom shaft together with the bearings and washers is shown in, Figure 13.

Forward/Reverse and Main Range Synchronisers – Removal

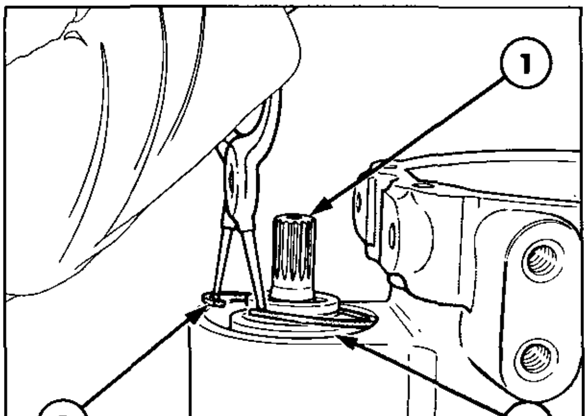
1. Remove the snap ring retaining the four wheel drive gear, Figure 14 and slide the gear from the spline on the shaft.



Front Wheel Drive Shaft Front Gear Retaining Snap Ring

1. FWD Front Gear
2. FWD Output Assembly Drive Gear
3. Snap Ring
4. Internal FWD Shaft

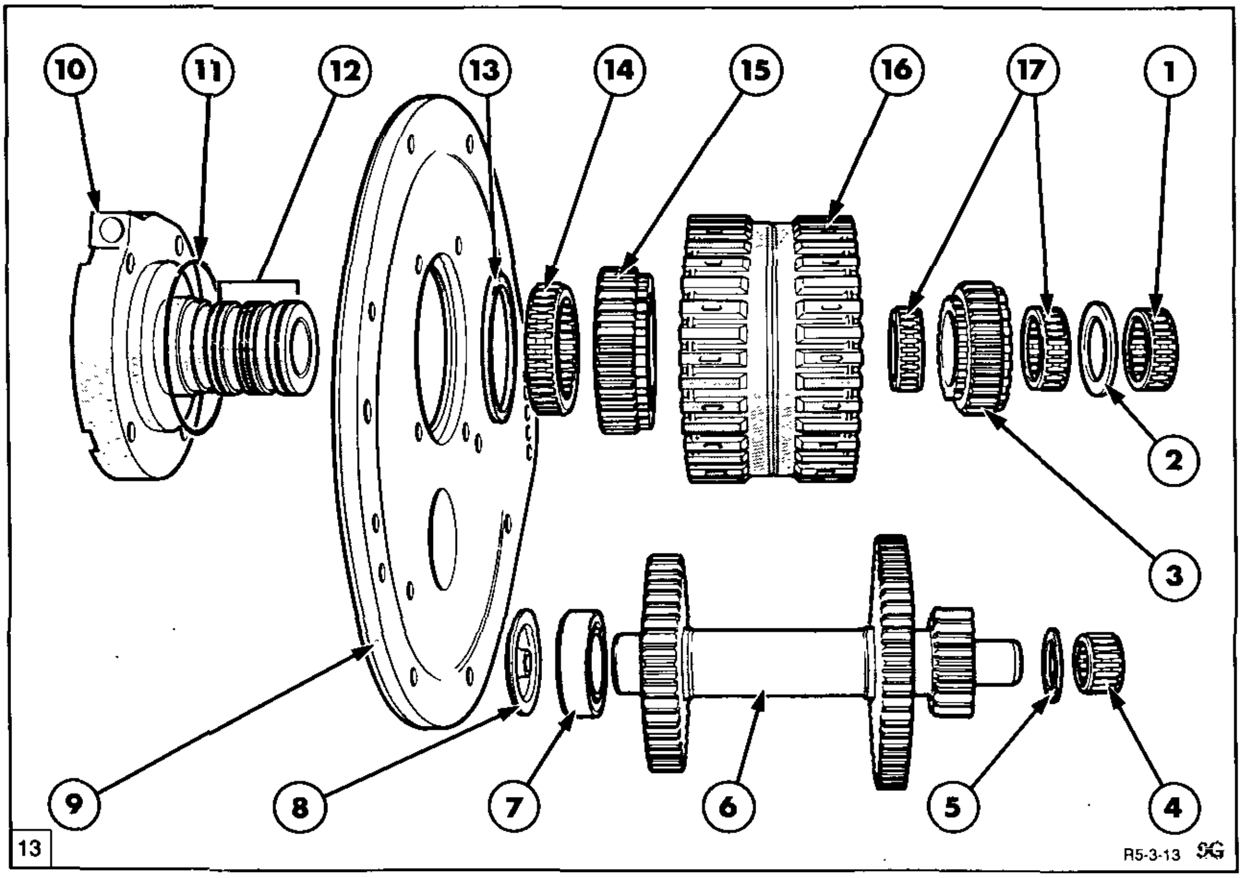
To provide clearance for the removal of the inner cover plate, the FWD output assembly (where fitted) must be removed.



Removing FWD Output Shaft Cover Snap Ring

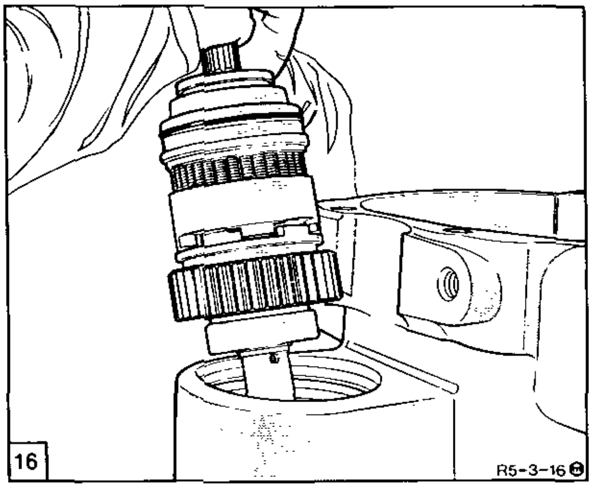
1. FWD Output Shaft
2. Cover Plate
3. Snap Ring

2. Remove the FWD output cover plate retaining snap ring. The snap ring is heavy duty and the use of suitable heavy duty pliers is recommended, Figure 15.

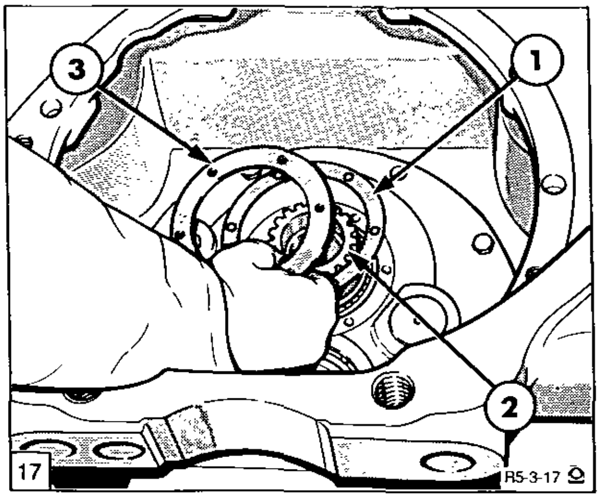


C1/C2 Clutch Assembly, Front Bottom Shaft and Bearings and Thrust Washers – Exploded View

1. PTO/Input Shaft to Forward/Reverse Synchroniser Support Shaft Needle Roller Bearing
2. Steel Washer (with Creeper) Polyimide Thrust Washer (without Creeper)
3. C2 Clutch 26 Tooth Output Gear
4. Needle Roller Bearing
5. Polyimide Thrust Washer
6. Front Bottom Shaft (with Creeper Shown)
7. Roller Bearing
8. Lube Oil Baffle
9. Front Cover Plate
10. C1/C2 Clutch Support Shaft
11. 'O' Ring Seal
12. Clutch Annular Sealing Rings
13. Polyimide Thrust Washer
14. Needle Roller Bearing
15. C1 Clutch 34 Tooth Output Gear
16. C1/C2 Clutch Assembly
17. Needle Roller Bearings



Removing FWD Output Shaft Assembly



Forward/Reverse Synchroniser Front Bearing Retainer Plate

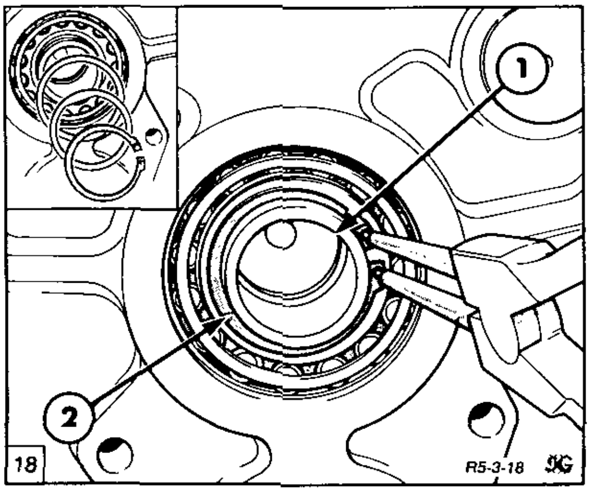
1. Shims
2. Forward/Reverse Synchroniser Support Shaft
3. Support Shaft Bearing Retainer Plate

3. Grasp the output shaft and pull the FWD transfer assembly from the transmission case, Figure 16. If necessary, bump the assembly to free it from the casing.

4. Remove the six bolts that retain the forward/reverse synchroniser support shaft front bearing retainer plate to the inner cover plate, Figure 17 and remove the retainer. Collect and note the shims posi-

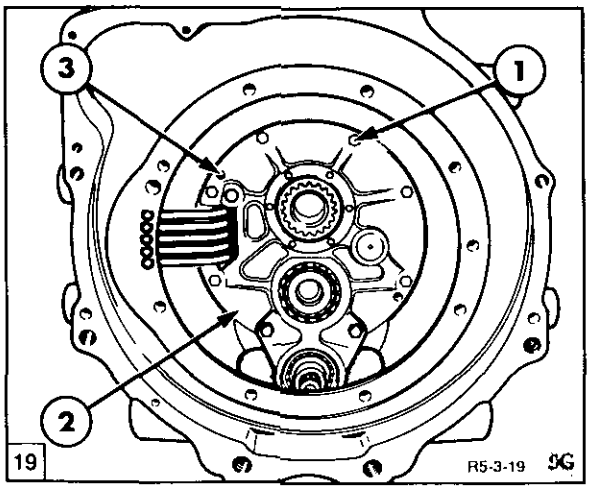
tioned behind the retainer, these will be re–used during reassembly provided certain components are suitable for re–use.

5. Remove the intermediate bottom shaft front bearing to bottom shaft retaining snap ring, Figure 18 and collect the steel 'D' shaped washer and the loose roller bearing thrust washer.



Intermediate Bottom Shaft Front Bearing Snap Ring (inset shows loose thrust washer, 'D' shaped washer, snap ring and needle roller bearing)

1. Intermediate Bottom Shaft
2. Snap Ring

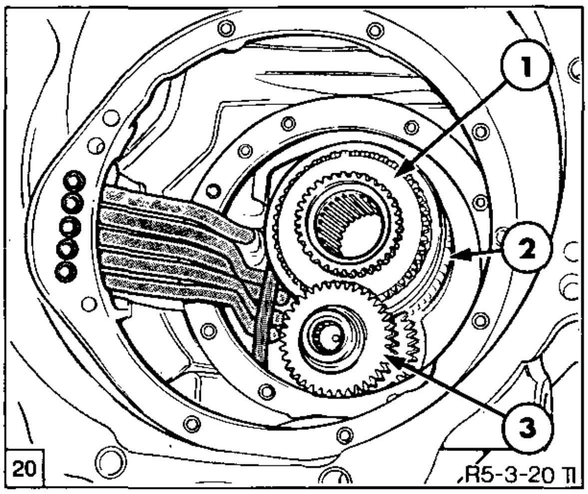


Inner Cover Retaining Bolts

1. Cover Retaining Bolt x 8
2. Inner Cover Plate
3. Cover Jacking Hole x 2

6. Remove the eight inner cover plate retaining bolts, Figure 19 and using two of these bolts in the jacking holes provided, evenly jack the plate from the transmission casing. Withdraw the cover plate from the housing.

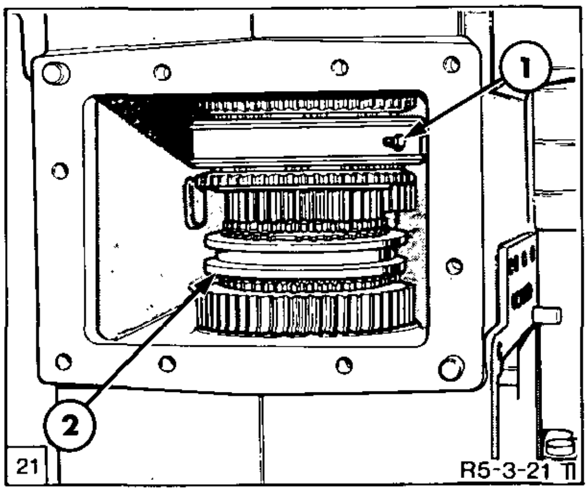
NOTE: *The forward/reverse synchroniser support shaft will be removed with the cover plate. During re–assembly this shaft will be installed after the cover plate is installed. Also note that the reverse idler gear is attached to the inner face of the cover plate.*



Forward/Reverse Synchroniser and Intermediate Bottom Shaft

1. Forward/Reverse Synchroniser
2. Range Synchroniser (behind Forward/ Reverse Synchro)
3. Intermediate Bottom Shaft

7. The forward/reverse synchroniser (without the support shaft), intermediate bottom shaft and main range synchroniser are now exposed, Figure 20.

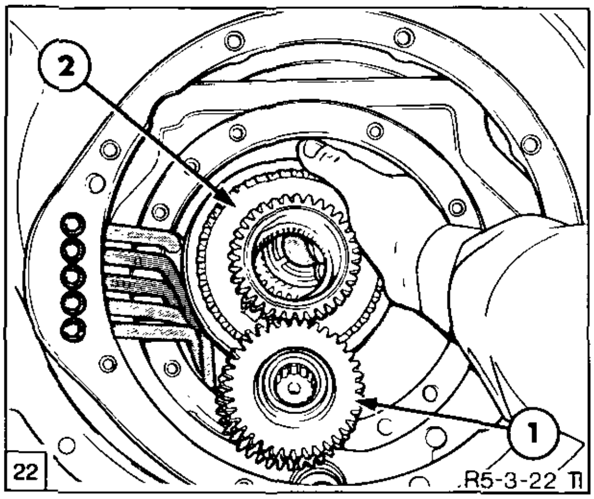


Synchroniser Hub with Locking Screw Installed

1. Locking Screw Installed in Forward/Reverse Synchroniser Sliding Coupler
2. Range Synchroniser

8. Install a locking screw (M5–0.8) into the threaded hole in the forward/reverse synchroniser hub, to prevent disassembly of the hub and detent assembly, Figure 21.

22



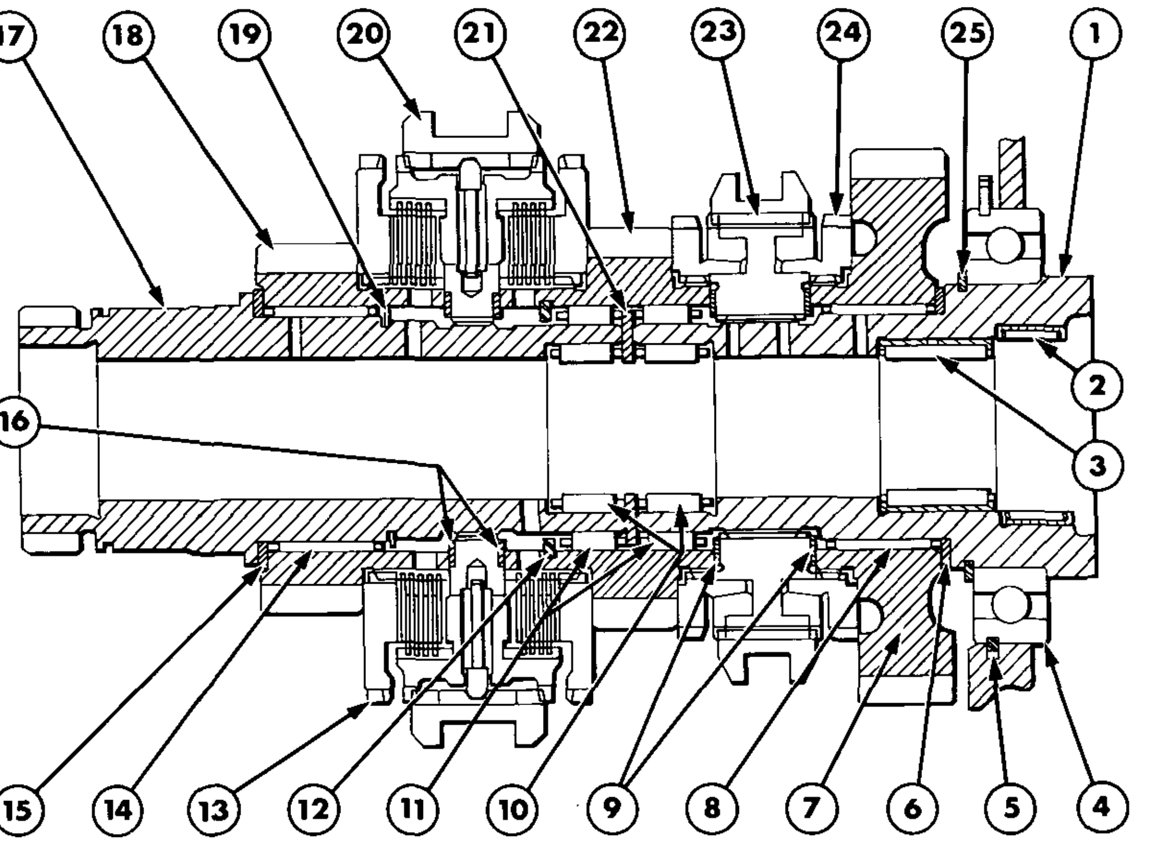
Removing Forward/Reverse Synchroniser and Intermediate Bottom Shaft

1. Intermediate Bottom Shaft
2. Forward/Reverse Synchroniser

9. Grasp the forward/reverse synchroniser and the intermediate bottom shaft and lift the assemblies from the casing, Figure 22. The main range synchroniser and its support shaft will remain in the casing. Refer to Figure 23 sectional view, for the position of the bearings and washers and collect these items.

10. Remove the high range driving gear from the main range synchroniser support assembly, Figure 23. Collect the needle roller bearings from the support shaft (note that this gear in forward acts simply as a coupler, in reverse it becomes a driven gear).

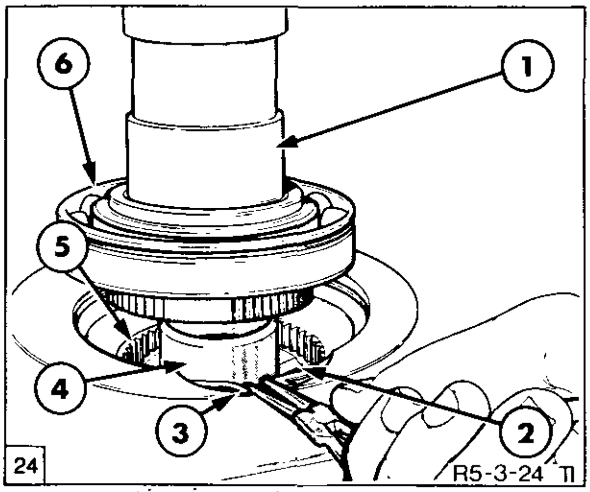
23



Forward/Reverse and Main Range Synchroniser Assemblies – Sectional View

1. Main Range Synchroniser Support Shaft
2. Needle Roller Bearing (press fit)
3. Needle Roller Bearing (press fit)
4. Main Range Synchroniser Support Shaft Rear Bearing
5. Bearing to Housing Snap Ring
6. Polyimide Thrust Washer
7. Driven Gear – Low
8. Needle Roller Bearing
9. Polyimide Thrust Washers x 2
10. Main Range and Forward/Reverse Synchroniser Support shaft(s) to PTO/Input Shaft Needle Roller Bearings
11. Forward Gear to Support Shafts Needle Roller Bearings
12. Retaining Snap Ring
13. Forward/Reverse Synchroniser Coupling
14. Reverse Gear Needle Roller Bearing
15. Polyimide Thrust Washer
16. Polyimide Thrust Washers x 2
17. Forward/Reverse Synchroniser Support Shaft
18. Reverse Driving Gear
19. Needle Roller Bearing Retaining Snap Ring
20. Forward/Reverse Synchroniser
21. Steel Thrust Washer
22. Driving Gear High
23. Main Range Synchroniser
24. Main Range Synchroniser Coupler
25. Main Range Synchroniser Support Shaft Bearing Retaining Snap Ring

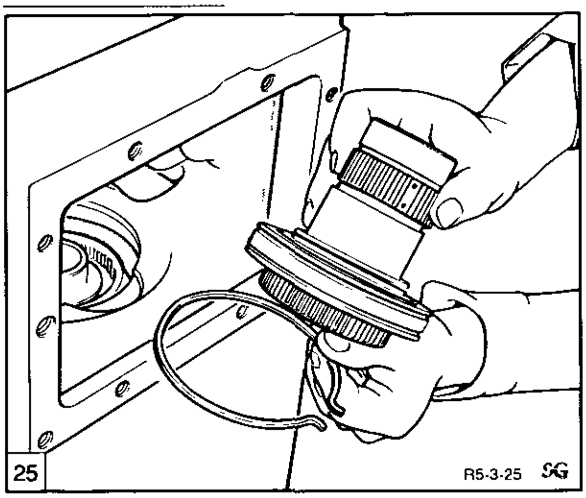
11. Pull off the main range synchroniser assembly from the support shaft and collect the polyimide thrust washers positioned each side of the synchroniser. Slide off the low range gear, needle roller bearing and collect the polyimide thrust washer from behind the gear, refer to Figure 23.



Releasing Main Range Synchroniser Support Shaft Retaining Ring

1. Support Shaft
2. Polyimide Thrust Washer (on C3 clutch hub)
3. Retaining Ring
4. C3 Clutch Output Shaft
5. C3 Clutch Pressure Plate (C3/C4 Clutch Input)
6. Ball Bearing

12. Release the main range synchroniser support shaft (also the C3/C4 clutch input) bearing from the casing by expanding the exposed ends of the retaining ring to move the ring into the groove in the housing and at the same time grasping and lifting the support shaft, Figure 24. The support shaft will come out of the housing once the ring is in the groove in the housing.

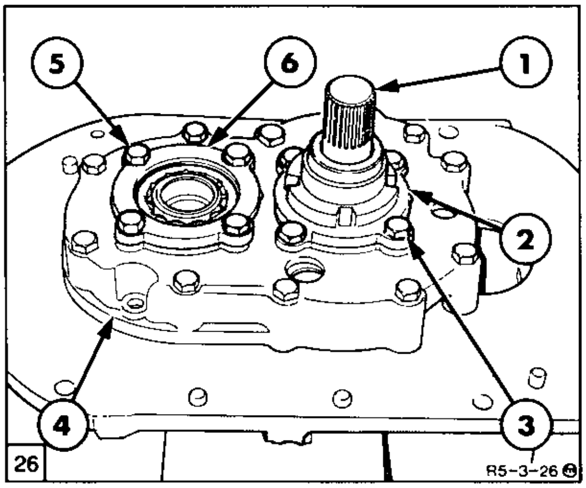


Main Range Synchroniser Support Shaft and Retaining Ring Removed

13. Figure 25 shows the support shaft and ring removed. Note that the two needle roller bearings, in the rear end of the main range synchroniser support, items 2 and 3 in the sectional view Figure 23, are a pressed fit in the shaft.

Output Shaft, High/Low Range Synchroniser and Rear Top Shaft Removal

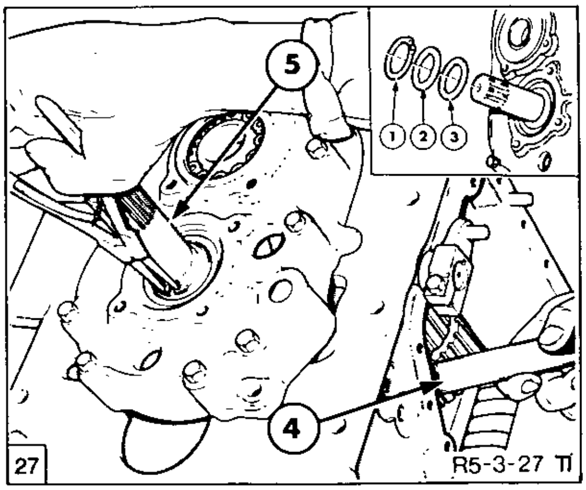
Rotate the transmission 180° so that the rear of the transmission is now uppermost.



Rear Cover Output Shaft Bearing Retainer/Pump Idler Gear Support and Top Shaft Bearing Retainer

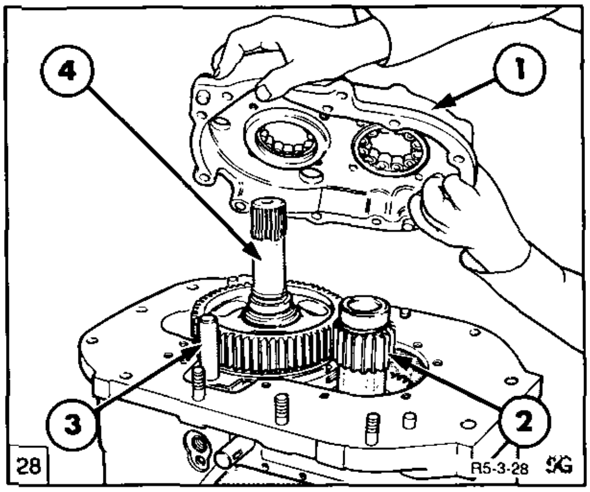
1. Output Shaft
2. Bearing Retainer and Hydraulic Pump Idler Gear Support
3. Retaining Bolt x 4
4. Rear Cover Plate
5. Retaining Bolt x 4
6. Top Shaft Rear Bearing Retainer

1. Remove the four bolts retaining the output shaft rear bearing/hydraulic pump idler gear support and the four bolts retaining the top shaft rear bearing, Figure 26. Remove the idler gear support and the top shaft bearing retainer.



Raising Output Shaft to Release Rear Bearing Snap Ring

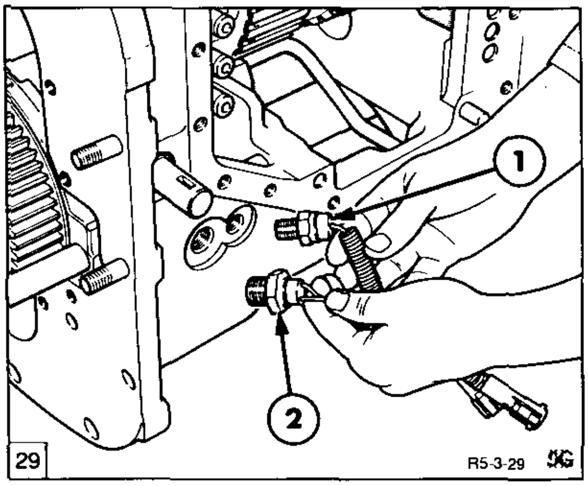
1. Snap Ring
2. 'D' Washer
3. Bearing Thrust (loose)
4. Lever (raising output shaft)
5. Output Shaft



Removing the Rear Cover

1. Rear Cover
2. Top Shaft (C3 clutch output)
3. High/Low Synchro Fork Rail
4. Output Shaft

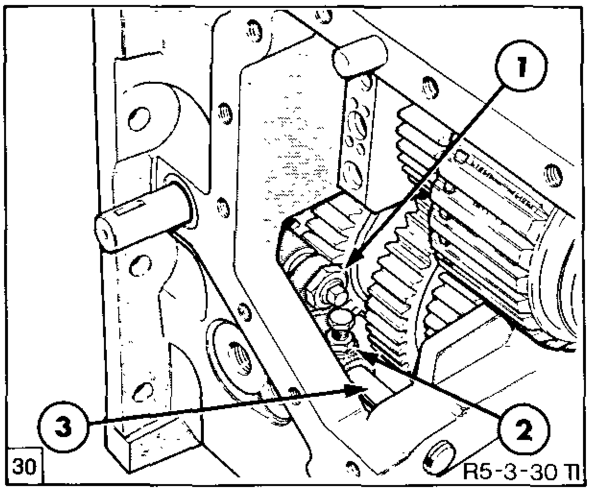
2. Lever up the output shaft assembly to reduce the weight on the snap ring and remove the output shaft rear bearing retaining snap ring, the steel 'D' shaped washer, and the loose roller bearing thrust washer, Figure 27.



High/low Range Sensor Switches

1. High Range Sensor Switch
2. Low Range Sensor Switch

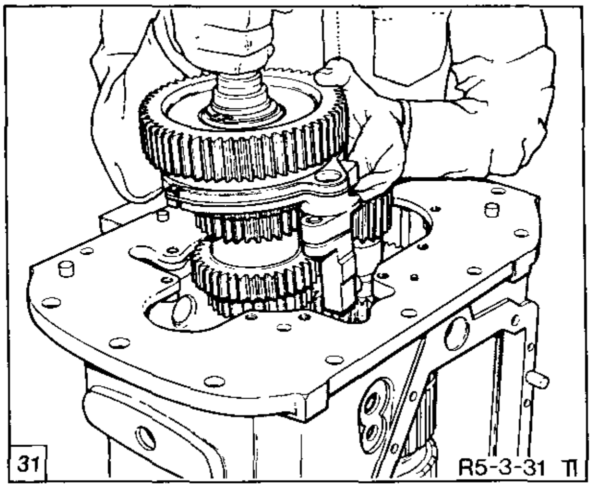
3. Remove the 10 rear cover retaining bolts and gently tap the output shaft downward to free the rear bearing from the output shaft, at the same time easing the rear cover plate upwards then remove the cover plate, Figure 28.



High/Low Range Selector Shift Fork Rail Screw

1. Synchroniser Centering Adjuster
2. Fork to Rail Set Screw and Locknut
3. Selector Rail

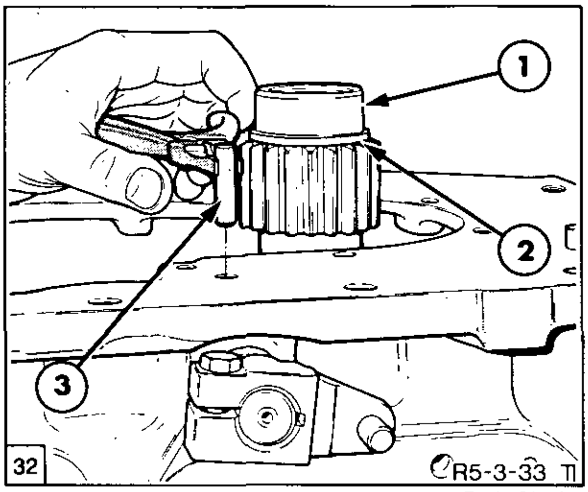
4. Unscrew and remove the two high/low range sensor switches from the housing, Figure 29. Note that the switches have differing thread sizes and cannot be interchanged.



Removing Output Shaft and Fork Assembly

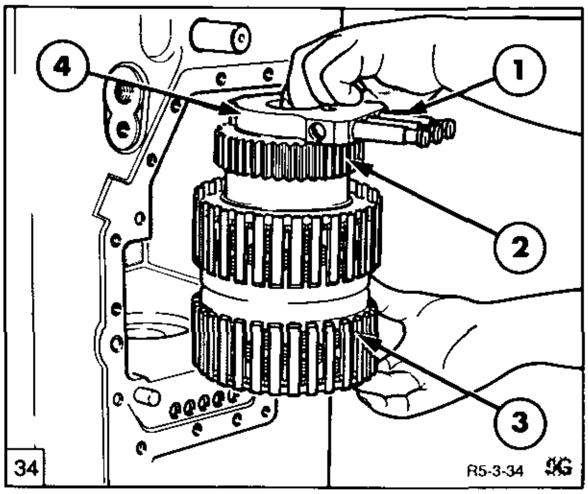
5. Through the valve cover opening, unscrew the high/low synchroniser fork to rail locknut and remove the screw from the rail, Figure 30. Slide the rail rearwards from the transmission leaving the fork still engaged with the coupling. Align the fork to rail boss with the cut out in the right–hand side of the housing rear buckle–up face.

6. Lift the output shaft and high/low synchroniser as an assembly, complete with the shift fork, from the housing, Figure 31.



Removing High/Low Range Synchroniser Fork Shaft Locking Pin

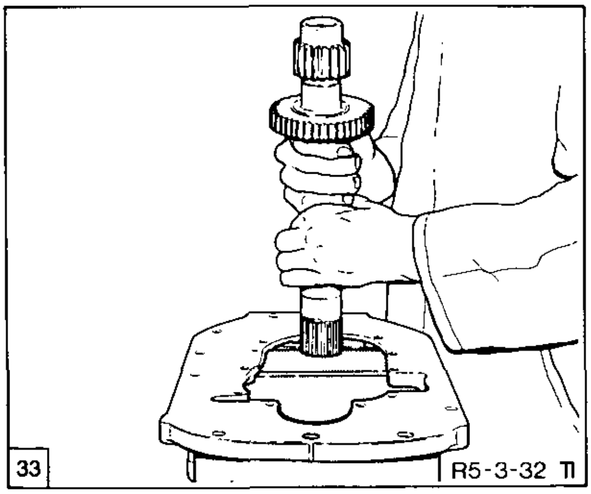
1. Top Shaft (C3 Output)
2. Spacer
3. Shaft Locking Pin



Removing C3/C4 Clutch Assembly

1. Oil Transfer Tubes
2. C4 Clutch Output Gear
3. C3/C4 Clutch Assembly
4. Oil Manifold Assembly

7. Collect the high/low range synchroniser fork shaft locking pin, Figure 32.



Removing Rear Top Shaft

8. Collect the spacer washer from the top shaft and lift out the shaft (C3 clutch output shaft) assembly, Figure 33.

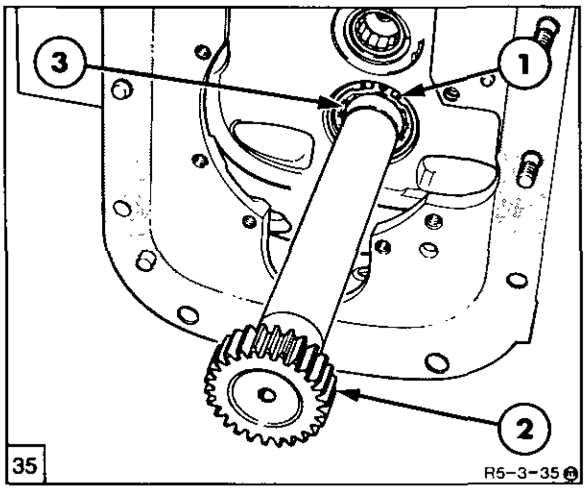
9. If the high/low range synchroniser fork shaft oil seal is in doubt remove the shaft from inside the transmission housing. If the shaft actuating lever was left on the shaft during transmission removal, remove the lever.

C3/C4 Clutch Assembly – Removal

1. Grasp the C3/C4 clutch, support shaft and manifold assembly and carefully remove it from the housing, Figure 34.

Front Wheel Drive Internal Transfer Shaft Assembly – Removal

Rotate the transmission 90° so that the transmission is now horizontal.



Removing FWD Internal Shaft

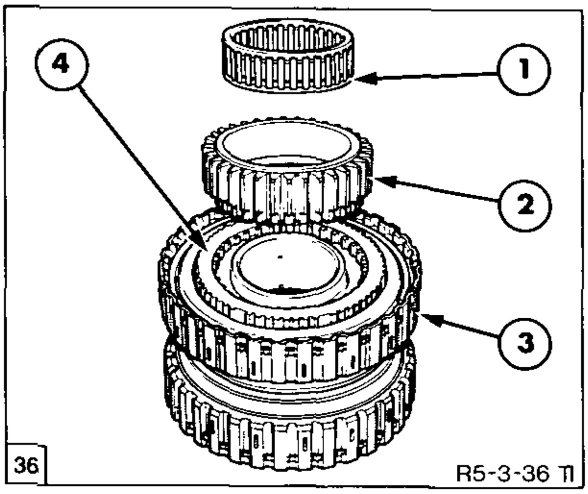
1. Snap Ring
2. FWD Internal Shaft
3. Roller Bearing

1. With FWD fitted, gently tap the FWD internal shaft rearwards and remove it from the housing, Figure 35. Collect the washer positioned between the front gear and the bearing.

All components have now been removed from the transmission housing with the exception of some bearings that are positively retained in the housing, and the oil transfer tubes. Detail of these items follows under the heading 'Transmission Housing' which appears later in this section.

COMPONENT DISASSEMBLY and OVERHAUL

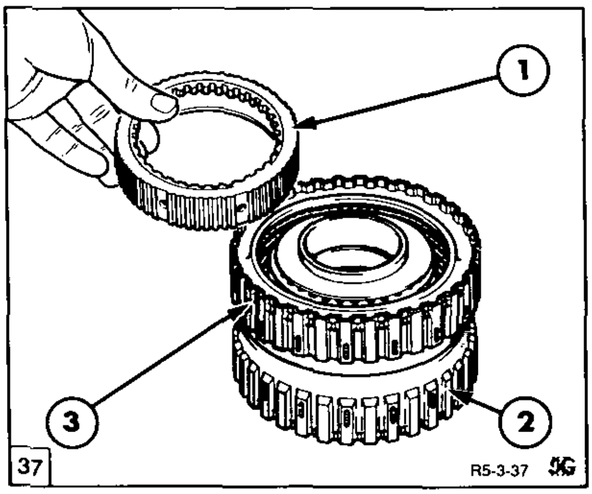
C1/C2 Clutch Assembly, Front Lower Shaft and Creeper Components (where fitted) – Disassembly



Removing C1 Clutch Driven Gear

1. Needle Roller Bearing
2. C1 Driven Gear
3. C1/C2 Clutch Assembly (C1 end arrowed)
4. C1 Clutch Hub

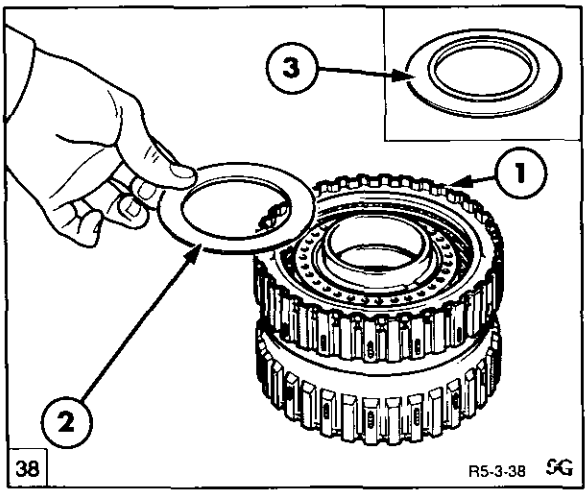
1. Remove the C1 clutch driven gear (34 tooth) and the needle roller bearing from the centre of the clutch, Figure 36.



Removing C1 Clutch Hub

1. Hub
2. C2 Clutch
3. C1 Clutch

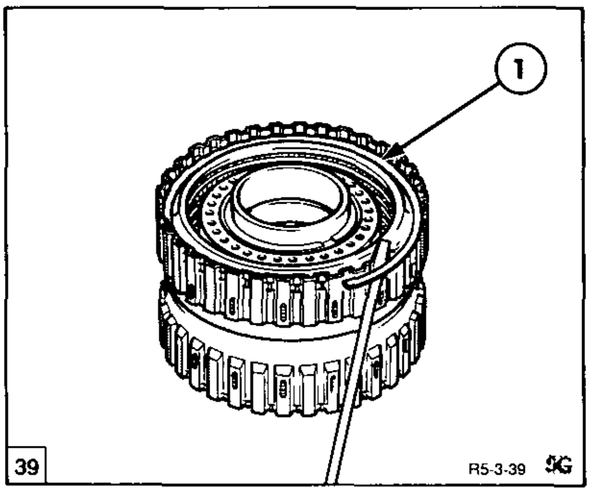
2. Remove the C1 clutch hub from the centre of the clutch, Figure 37.



Removing C1 Clutch Hub Thrust Washer

1. C1 Clutch
2. Hub Steel Washer
3. Under Side of Washer (Showing Raised Face)

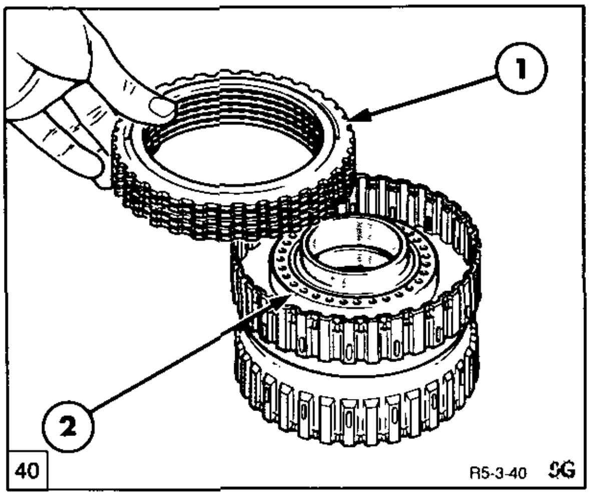
3. Remove now exposed C1 clutch hub steel thrust washer, Figure 38. Note that the inner face of the thrust washer has a raised face to provide clearance for the piston return spring assembly.



Removing Clutch Pressure Plate Snap Ring

1. Snap Ring

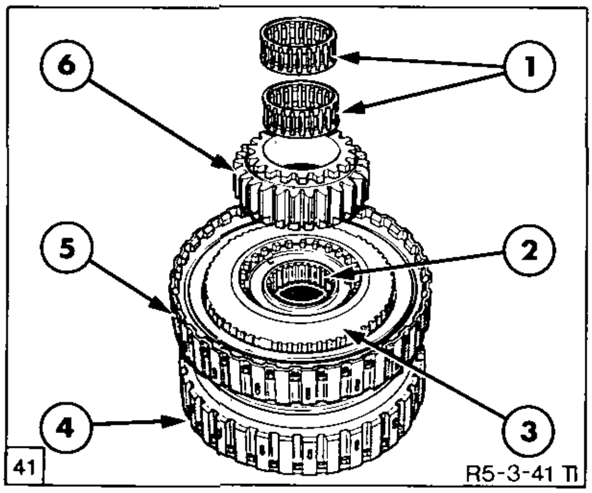
4. Using hand pressure, depress the clutch pressure plate and remove the clutch pressure plate retaining snap ring, Figure 39 and remove the pressure plate.



Removing Clutch Friction and Separator Plates together with Separator (wavy) Springs

1. Friction and Separator Plates with Wavy Springs
2. Clutch Return Spring Assembly

5. Remove the four friction plates, the four wavy springs and the four separator plates, Figure 40.



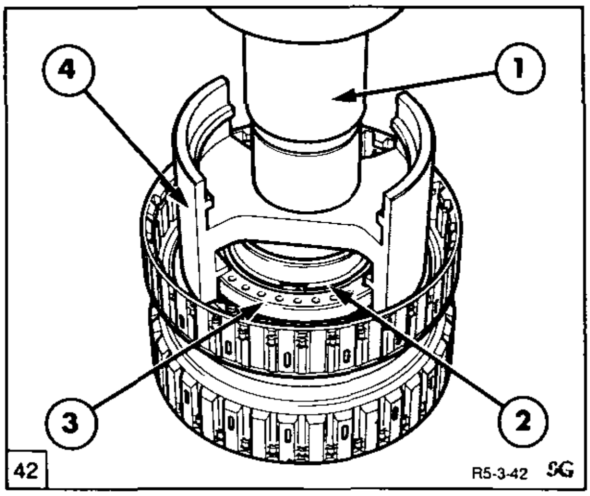
Removing C2 Clutch Output Gear and Hub

1. Needle Roller Bearings
2. C1/C2 Clutch Body Drive Spline
3. C2 Clutch Hub
4. C1 Clutch
5. C2 Clutch
6. C2 Clutch Output Gear (26 tooth)

6. From the C2 clutch, remove the output gear (26 tooth) and its bearings, Figure 41 and the clutch hub.

7. Remove the pressure plate retaining snap ring and remove the four friction plates, the four wavy springs and the four separator plates following the same procedure as used for the C1 clutch.

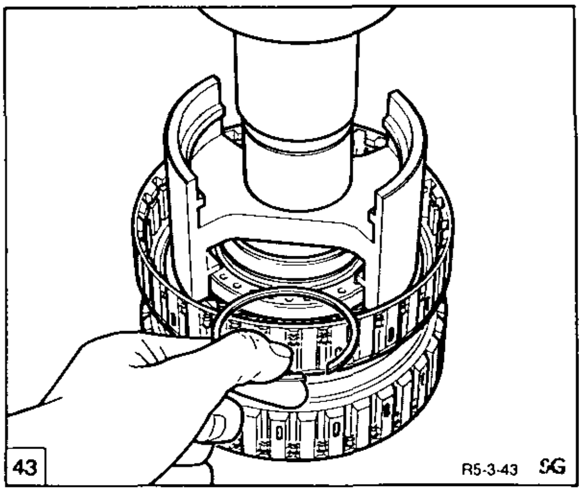
8. Place the C1/C2 clutch assembly on a press and using Tool No. 4FT 508 compress the piston return spring retainer assembly sufficiently to release the snap ring from its groove, Figure 42.



Compressing Clutch Piston Return Spring

1. Press
2. Snap Ring
3. Piston Return Spring Assembly
4. Special Tool No. 4FT 508

9. Remove the piston return spring retainer snap ring, Figure 43.

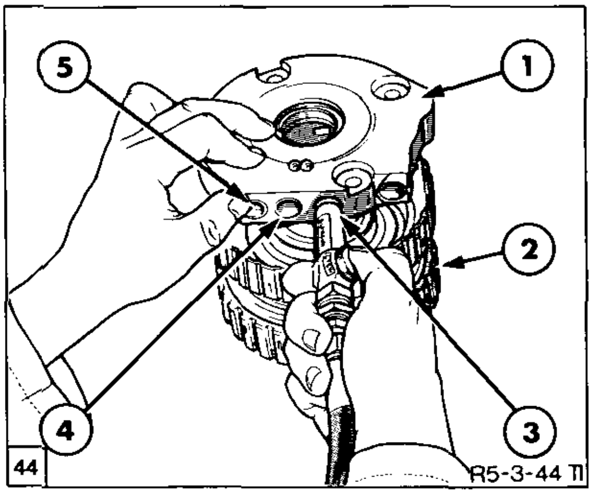


Removing Clutch Piston Return Spring Assembly Retainer Snap Ring

10. Release the press and remove the piston return spring assembly.

11. Repeat the above procedure on the second clutch.

NOTE: *The piston in each clutch consists of three separate items. The main part carries the outer piston seal. Adjacent to this main part of the piston is a belleville spring and a secondary piston. The belleville spring and the secondary part of the piston act as a cushioning device during the application of the clutches. See Figure 123.*

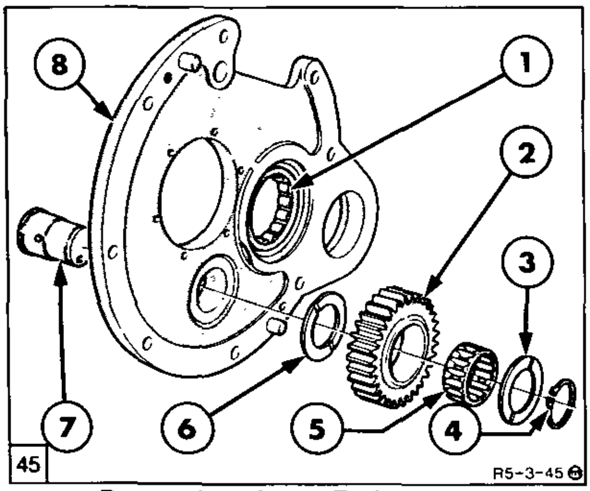


Removing Clutch Piston Using Air Pressure to Expel Piston

1. C1/C2 Clutch Support Shaft Assembly
2. C1/C2 Clutch Assembly
3. Air Nozzle (applied to C1 clutch piston oil feed port)
4. Lube Oil Port
5. C2 Clutch Piston Oil Feed Port

12. Remove the pistons by applying air pressure of not more than 50 lbf/in² (3 bar) to the respective piston oil feed ports, Figure 44. Temporarily installing the C1/C2 support shaft will aid the application of air. Note that the secondary part of the piston and the belleville washer may separate from the main part of the piston during handling.

Forward/Reverse and Main Range Synchronisers – Disassembly

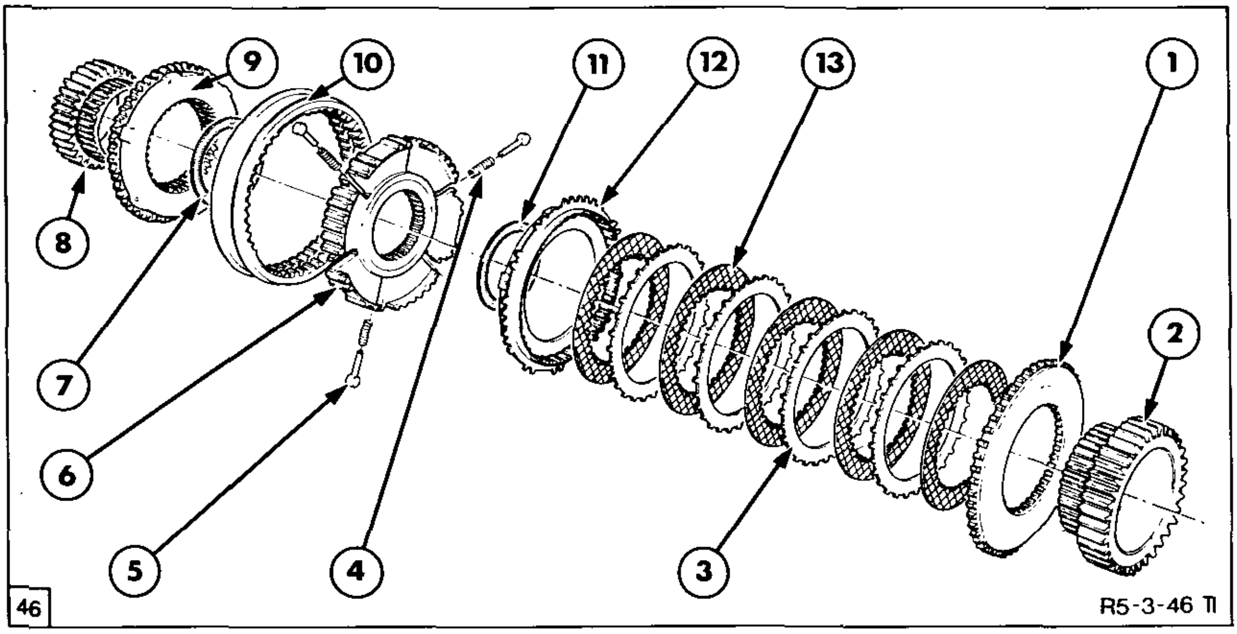


Reverse Idler Gear – Exploded View

1. Intermediate Lower Shaft Front Roller Bearing
2. Reverse Idler Gear
3. Steel Washer
4. Snap Ring
5. Needle Roller Bearing
6. Steel Washer
7. Support Shaft
8. *Inner Cover Plate*

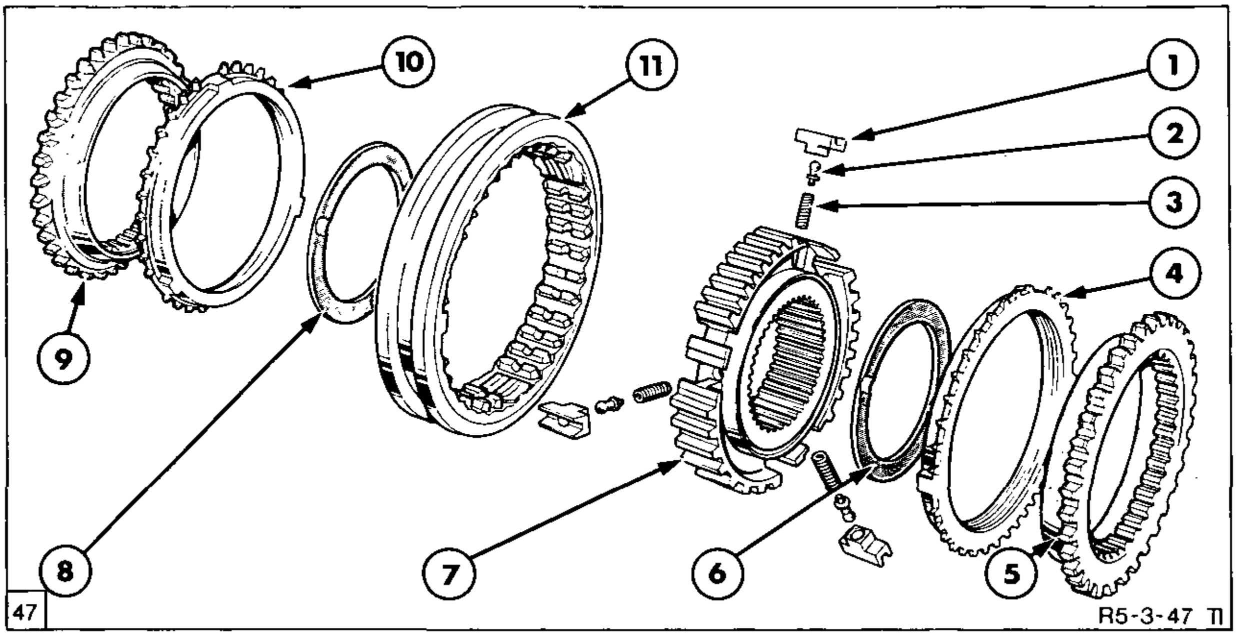
1. If necessary the reverse idler may be removed from the inner cover plate, remove the snap ring, thrust washer, gear and *needle roller bearing and the second* thrust washer, Figure 45. The idler gear shaft is stepped and may be pressed from the cover plate.

2. The forward/reverse and main range synchronisers will easily separate into their component parts. Refer to Figure 46 and to Figure 47 for exploded views of these two synchronisers.



Forward/Reverse Synchroniser – Exploded View

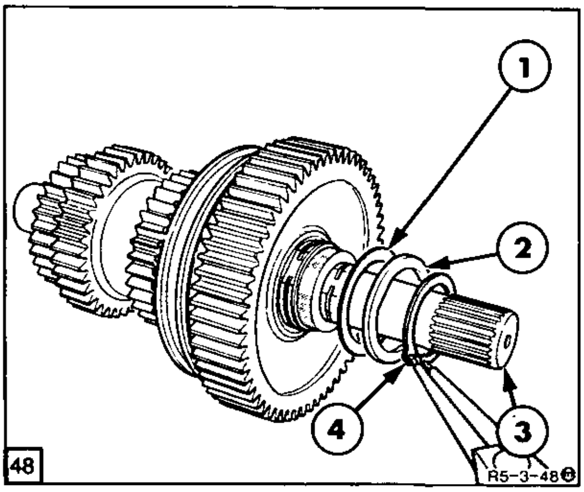
1. End Plate (Part of Forward Synchro Pack)
2. Forward Driving Gear
3. Steel Plate x 4 (each)
4. Spring
5. Pin
6. Centre Hub
7. Polyimide Thrust Washer
8. Reverse Driving Gear
9. Reverse Synchro Clutch Pack
10. Sliding Coupler
11. Polyimide Thrust Washer
12. Housing
13. Friction Plate x 5 (each)



Main Range Synchroniser – Exploded View

1. Detent Guide
2. Detent Pin
3. Spring
4. Friction Cone
5. Outer Cone/Coupling
6. Polyimide Thrust Washer
7. Centre Hub
8. Polyimide Thrust Washer
9. Outer Cone/Coupling
10. Friction Cone
11. Sliding Coupler

Output Shaft, High/Low Range Synchroniser and Rear Upper Shaft – Disassembly



Removing Low Range Output Gear Retaining Snap Ring

1. Polyimide Thrust Washer
2. Steel 'D' Washer
3. Output Shaft
4. Snap Ring

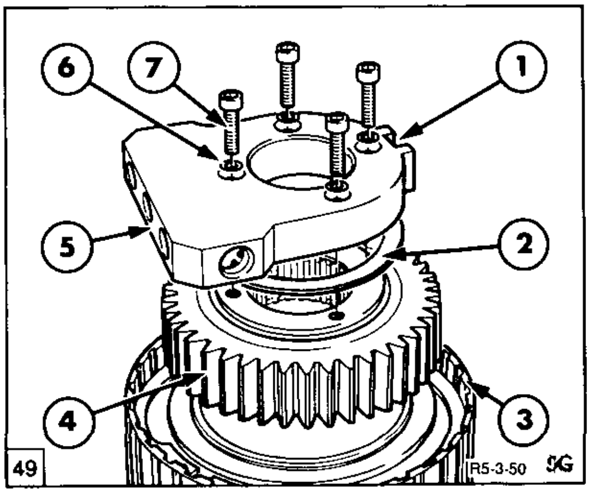
1. Remove the low range output gear retaining snap ring, the end float controlling shim (steel washer – available in various thicknesses) and the polyimide thrust washer, Figure 48. retain the shim for possible re–use.

2. Slide the gear and the needle roller bearings from the shaft.

3. Remove the polyimide thrust washer and high/low synchroniser followed by the second polyimide thrust washer. The polyimide thrust washers will possibly remain adhered to the recesses each side of the synchroniser.

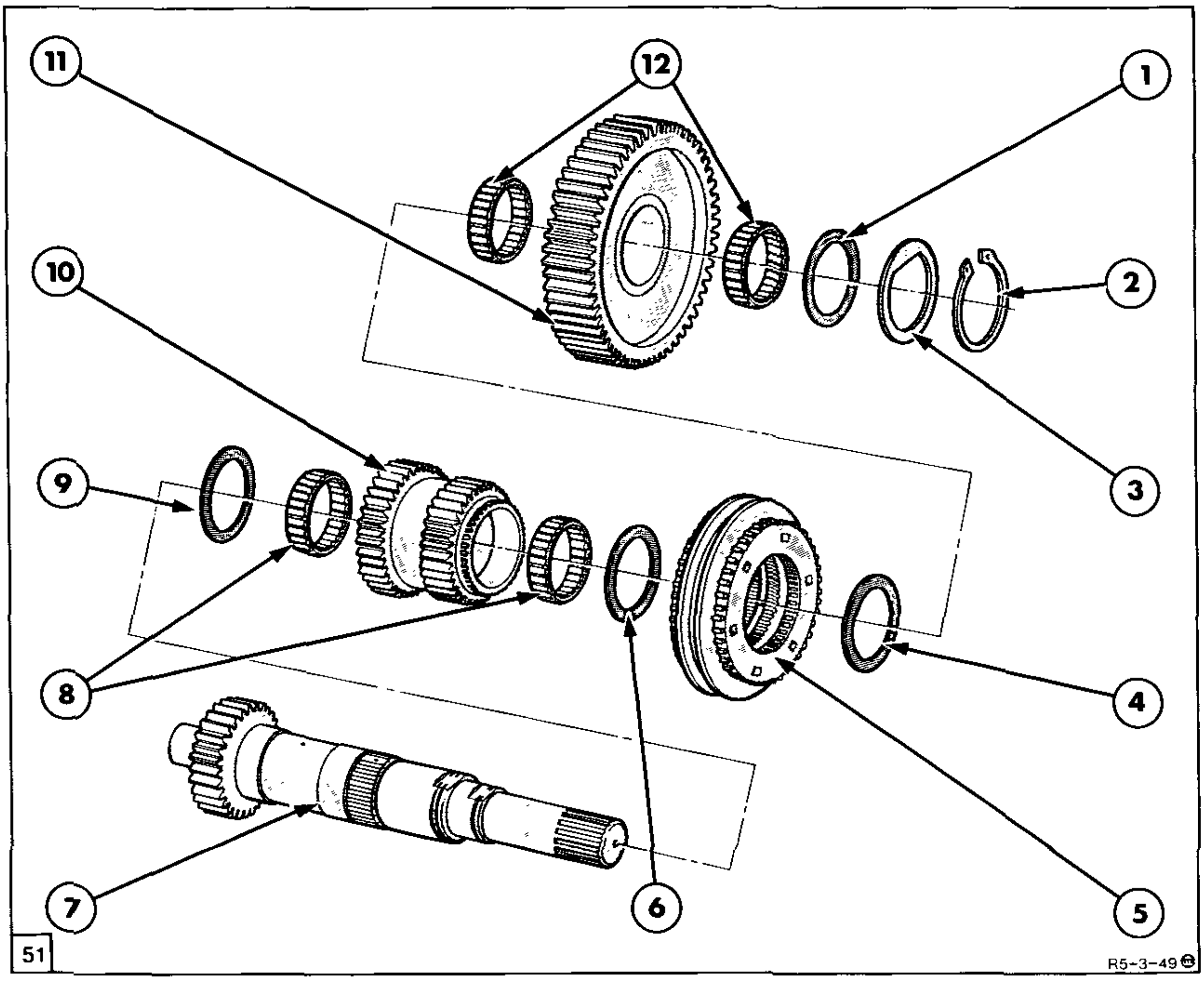
4. The two gear cluster may now be removed from the shaft together with the two needle roller bearings and the front polyimide thrust washer. An exploded view of the output shaft and high/low range synchroniser is shown in Figure 51.

C3/C4 Clutch Assembly – Disassembly



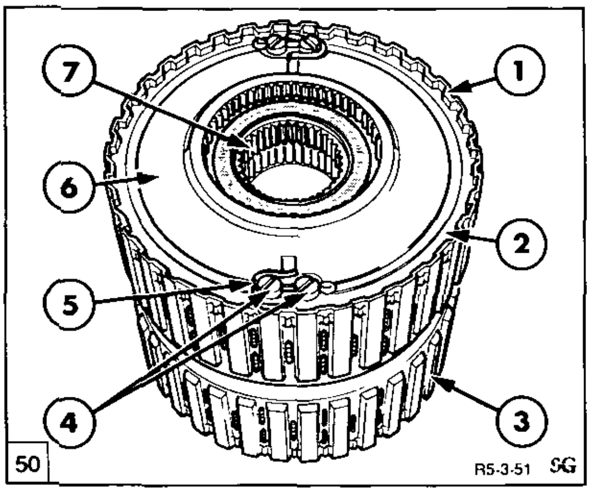
Removing C3/C4 Clutch Manifold from Support Shaft

1. Locating Slot in Manifold
2. Polyimide Thrust Washer
3. Clutch Assembly
4. C4 Clutch Output Gear
5. Manifold
6. Lock washer x 4
7. Retaining Screw x 4



Output Shaft and High/Low Range Synchroniser – Exploded View

1. Polyimide Thrust Washer
2. Snap Ring
3. 'D' Shaped Steel Washer (various thicknesses))
4. Polyimide Thrust Washer
5. Synchroniser
6. Polyimide Thrust Washer
7. Output Shaft
8. Needle Roller Bearings
9. *Polyimide Thrust Washer*
10. Two Gear Cluster
11. Low Range Output Gear
12. Needle Roller Bearings



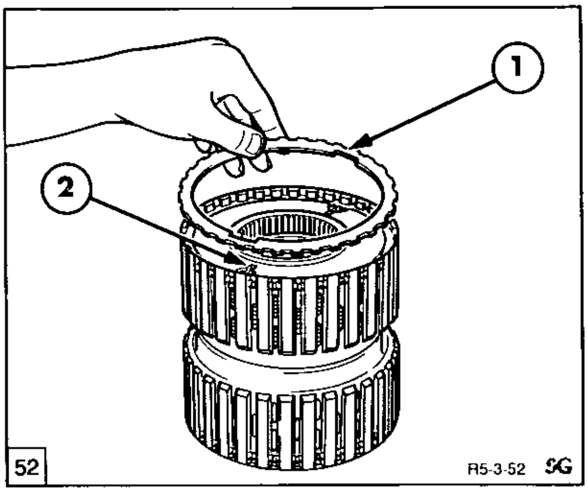
C3 Clutch Pressure Plate Locking Screws

1. C3 Clutch End
2. Locking Ring
3. C4 Clutch End
4. Locking Screws x 4
5. Split Pin x 2
6. C3 Clutch Pressure Plate and C3/C4 Clutch Drive Input
7. C3 Clutch Hub

1. Remove the four screws that secure the manifold to the C3/C4 clutch support shaft and remove the manifold and polyimide thrust washer from the shaft, Figure 49. Collect the screw lock washers and the support shaft inner needle roller bearing.

NOTE: *Do not, at this stage, attempt to slide the support shaft from the clutch assembly.*

2. Remove the two split pins from the C3 clutch outer plate locking screws, Figure 50 and remove the four locking screws.



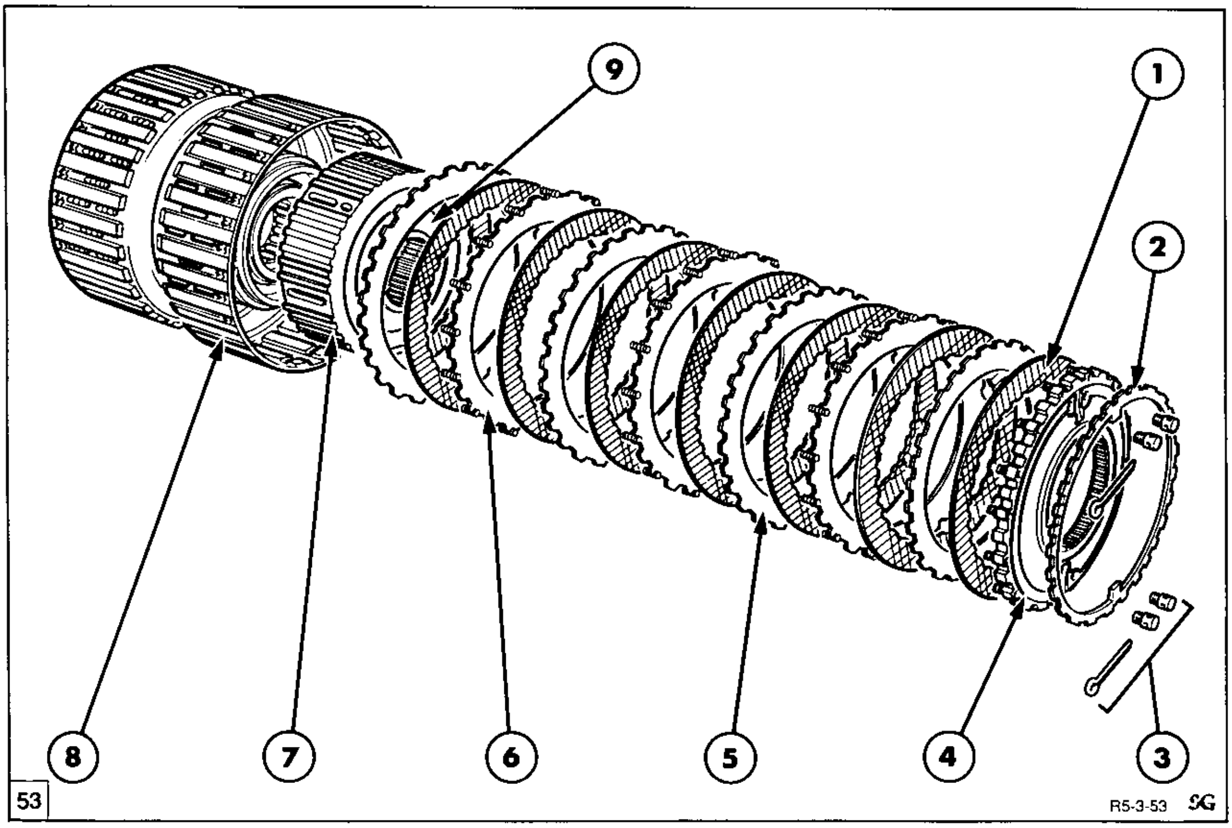
Removing C3 Clutch Pressure Plate Locking Ring

1. Locking Ring 2. Slot for Locking Ring

3. Using hand pressure, depress the clutch pressure plate, to free the loading on the retaining ring (note that only a small amount of movement is available).

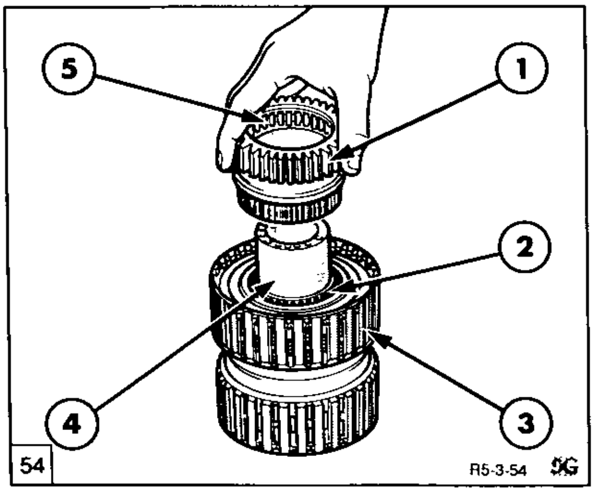
Rotate the locking ring one tooth until the outer teeth align with the stamped grooves in the housing, Figure 52. Remove the retaining ring.

4. Remove the C3 clutch pressure plate, the hub, the friction and separator plates with the coil separator springs, Figure 53. Collect the two polyimide thrust washers positioned either side of the hub. The support shaft inner front needle roller bearing is a pressed in fit and will remain in the shaft.



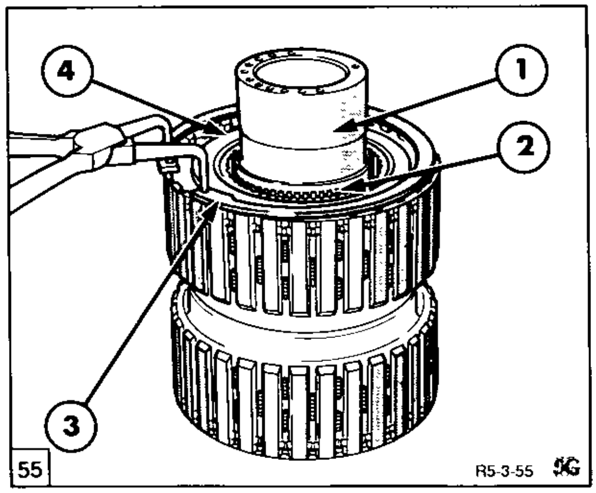
C3 Clutch Friction and Separator Plates – Assembly Order

1. Friction Plates x 7
2. Pressure Plate Locking Ring
3. Locking Ring Retaining Screws and Split Pin
4. Pressure Plate
5. Steel Plates x 4
6. Steel Plates with Separator Springs x 3
7. C3 Clutch Hub
8. C3/C4 Clutch Housing
9. Polyimide Thrust Washer (one each side of hub located in stepped recesses)



Removing C4 Clutch Output Gear

1. C4 Clutch Output Gear
2. Output Gear front Needle Roller Bearing
3. C3/C4 Clutch Body
4. Support Shaft
5. Output Gear Rear Needle Roller Bearing

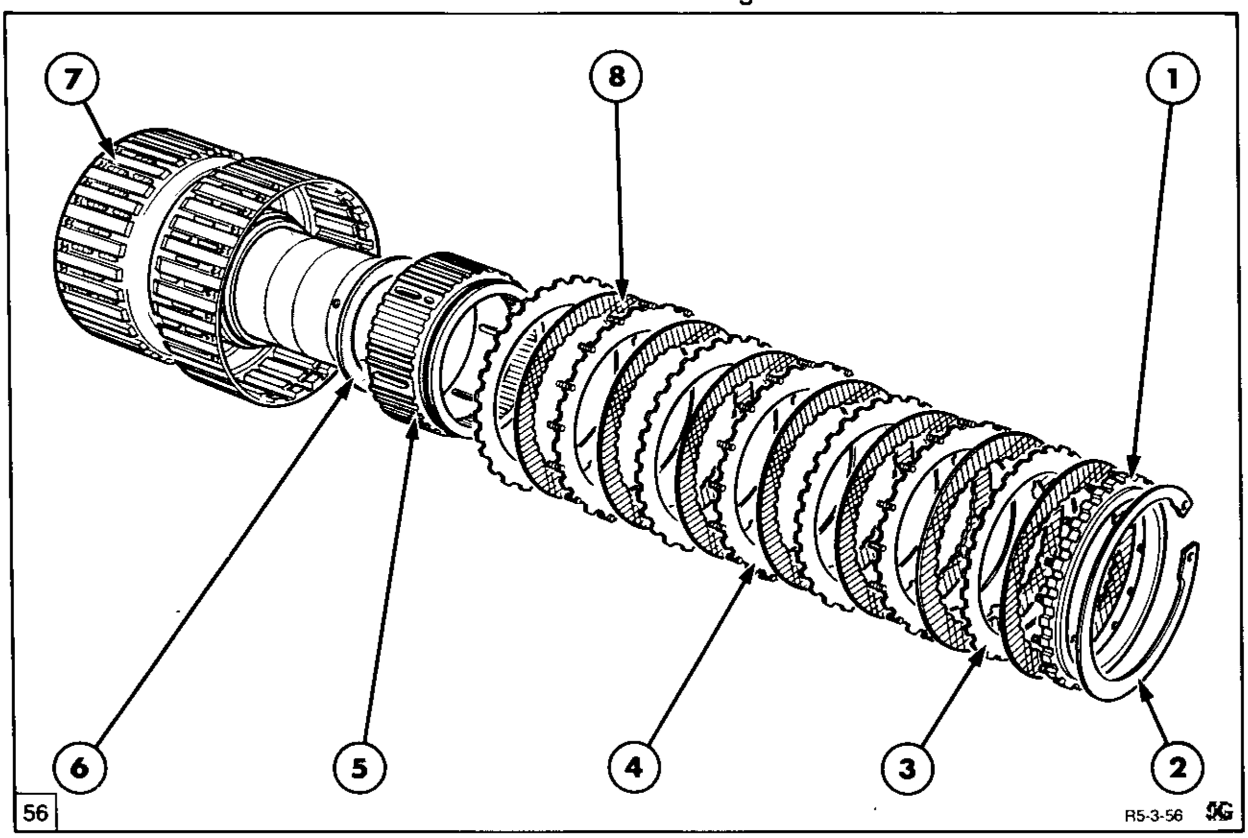


Removing C4 Clutch Pressure Plate Retaining Snap Ring

1. C3/C4 Clutch Support Shaft
2. Output Gear Front Needle Roller Bearing
3. Snap Ring
4. Pressure Plate

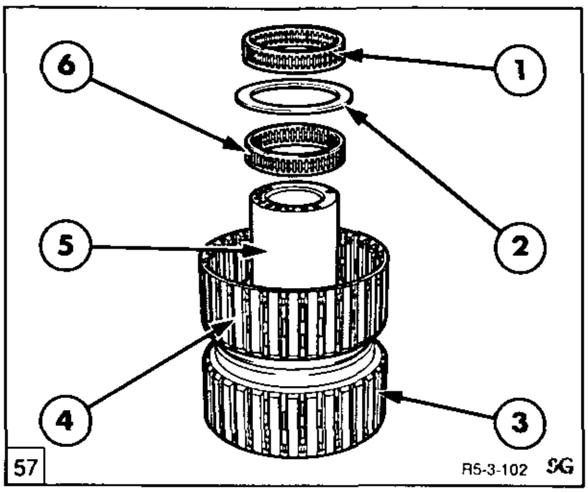
5. Turn the assembly 180° and slide the C4 output gear from the C4 clutch, Figure 54. Collect the C4 gear rear needle roller bearing.

6. Repeat the friction and separator plate removal process for the C4 clutch. Note that the outer plate is retained by a conventional snap ring. Also note that a lube oil seal is positioned in the clutch hub, sealing against the pressure plate, Figure 55. An exploded view of the C4 clutch components is shown in Figure 56.



C4 Clutch Pressure Plate, Hub, Friction and Separator Plates – Exploded View

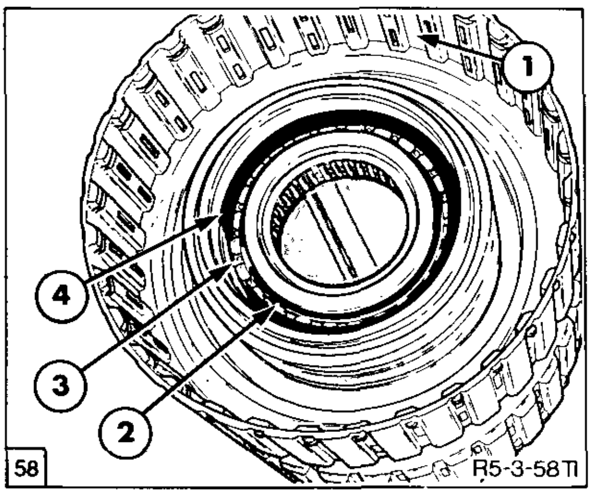
1. Pressure Plate
2. Snap Ring
3. Steel Plates (without separator springs) x 4
4. Steel Plates with Separator Springs x 3
5. Clutch Hub
6. Steel Washer
7. C3/C4 Clutch Housing
8. Friction Plates x 7



Removing C4 Clutch Output Gear Front Bearing and Steel Thrust Washer

1. C4 Output Gear Front Needle Roller Bearing
2. Steel Washer
3. C3 Clutch End
4. C4 Clutch End
5. Support Shaft
6. C3/C4 Clutch to Support Shaft Needle Roller Bearing

7. Collect the C4 output gear front needle roller bearing, the steel thrust washer and the C4 clutch to support shaft needle roller bearing, Figure 57.

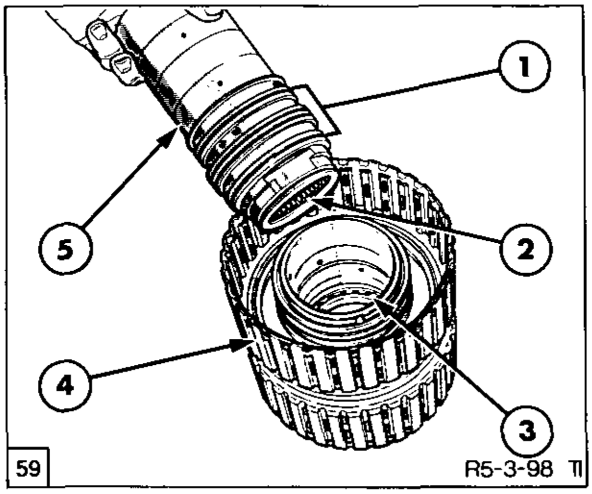


C3/C4 Clutch Support Shaft Front Bearing and Snap Rings

1. C3/C4 Clutch Housing
2. Bearing
3. Bearing to Housing Snap Ring
4. Bearing to Support Shaft Bearing

8. Remove the clutch support shaft front ball bearing retaining snap rings, Figure 58.

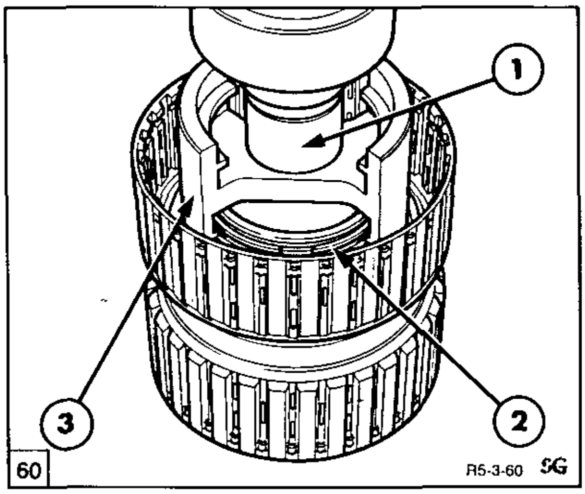
9. Carefully push or bump the support shaft through the bearing (push fit) so that the support shaft is removed from the rear, C4 end, of the housing, Figure 59. Note



Removing C3/C4 Clutch Support Shaft

1. Annular Sealing Rings
2. Support Shaft Inner Needle Roller Bearing
3. C3/C4 Clutch Body to Support Shaft Ball Bearing
4. C3/C4 Clutch Body
5. Support Shaft

that removing the shaft from the C4 end of the housing will prevent damage occurring to the annular sealing rings, should these be fit for further service or temporarily unavailable.

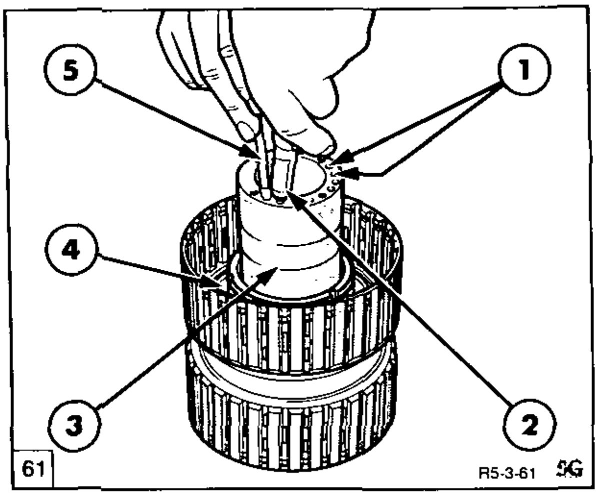


Compressing Clutch Piston Return Belleville Washer Springs

1. Press
2. Snap Ring
3. Special Tool No. 4FT 508

10. Place the clutch housing assembly on a press and using Tool No. 4FT 508, depress the clutch piston return belleville washers and remove the retaining snap ring, Figure 60. Release the press and collect the belleville washes and snap ring retainer. Note that the retainer is shaped to provide a 'lock' for the snap ring.

11. Repeat the process on the second clutch piston return belleville washers.



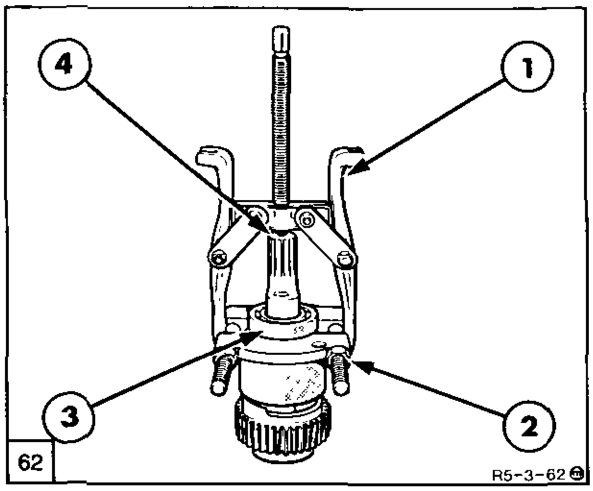
Removing Clutch Piston Using Air Pressure to Expel Piston

1. Clutch Piston Oil Feed Ports
2. Air Nozzle (applying air to C4 clutch oil feed ports)
3. Support Shaft
4. Piston
5. Stopper (to prevent air escape from second port)

12. Remove the clutch pistons by applying air pressure of not more than 50 lbf/in^2 (3 bar) to the clutch piston oil feed ports, Figure 61. Temporarily replacing the support shaft will make the application of air pressure easier. Note that each piston is fed by two longitudinal drillings in the support shaft, apply air to one of these and plug the other.

Front Wheel Drive Transfer Assembly – Disassembly

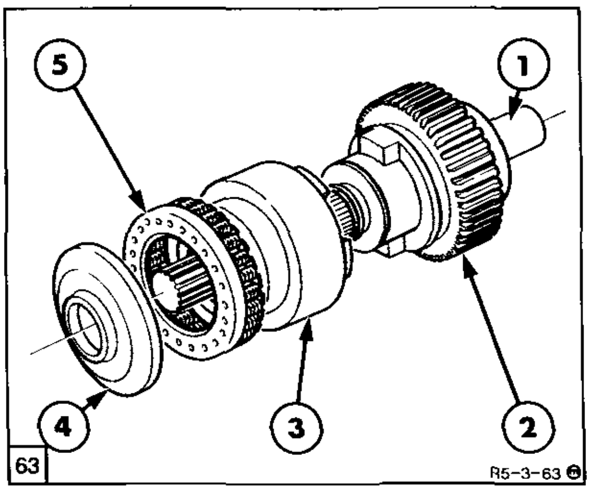
1. Remove the front cover plate by gently bumping the output shaft to free the front cover from the bearing.



Removing FWD Output Assembly Front Bearing

1. Puller 951 or 9190
2. Pulling Attachment 1002 or 9198
3. Front Bearing
4. Shaft Protector

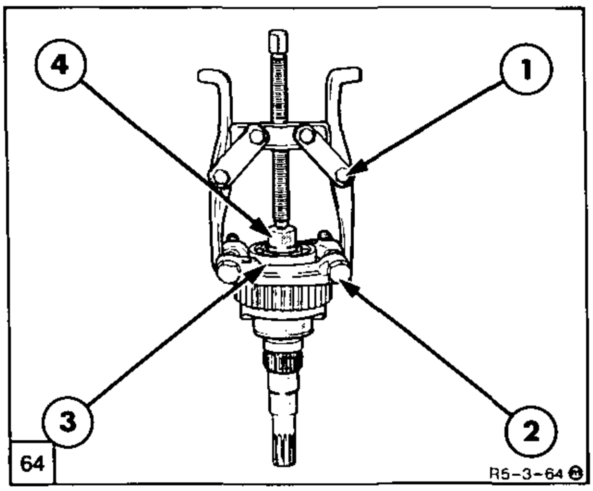
2. Remove the front bearing snap ring, item 9 in Figure 66 and using Tool Nos. 951 or 9190 and 1002 or 9198, with a suitable shaft protector, pull off the front bearing, Figure 62.



Removing FWD Clutch Spring Keeper

1. FWD Output Shaft
2. Gear/Clutch Half
3. Clutch Half
4. Spring Keeper Plate
5. Engagement Spring Assembly

3. Lift off the spring keeper and return spring assembly and slide the front half of the clutch from the shaft, Figure 63.

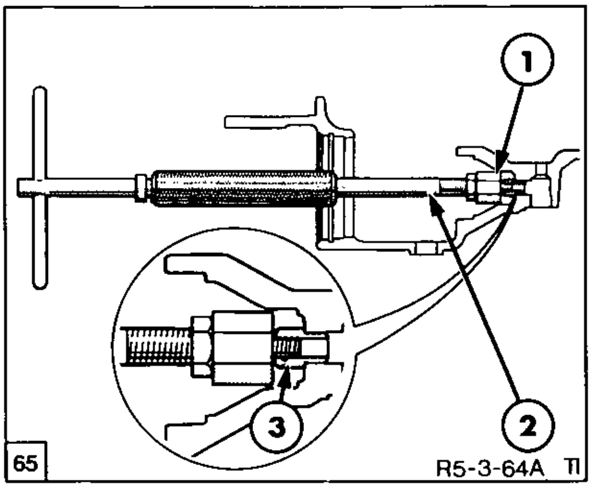


Removing FWD Output Assy Front Bearing

1. Puller 951 or 9190
2. Pulling Attachment 1002 or 9198
3. Rear Bearing
4. Shaft Protector

4. Remove the rear bearing snap ring, item 21 in Figure 66 and using Tool Nos. 951 or 9190 and 1002 or 9198, with a suitable *shaft protector, pull off the rear bearing* (5), Figure 64.

5. Remove the gear/rear half of the clutch and collect the two bearings, items 15 and 17, together with the two spacer washers, items 16 and 19, in the exploded view of the FWD transfer output shaft assembly, *shown in Figure 66.*

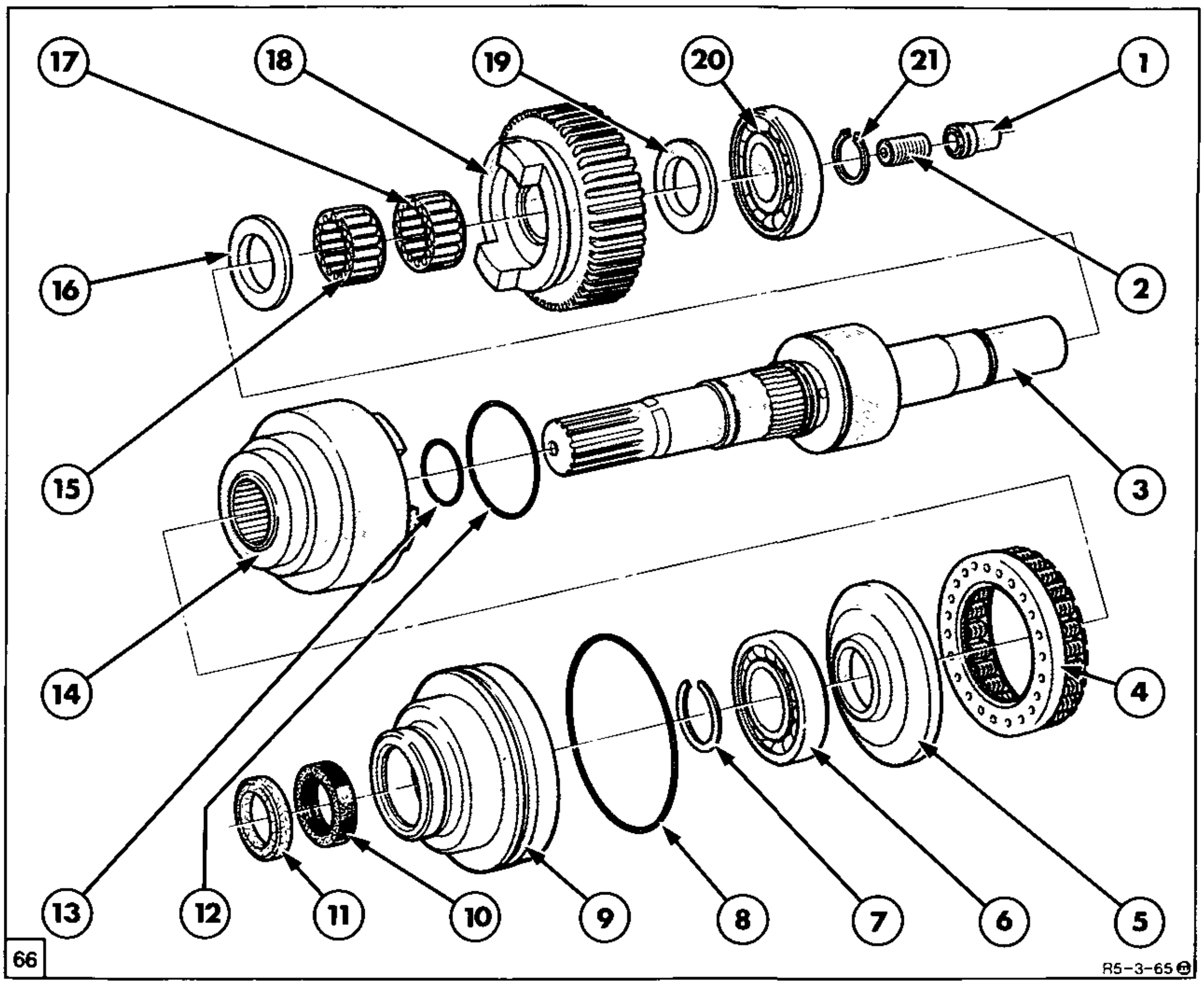


Removing FWD Clutch Oil Supply Transfer Tube

1. Special Tool No. 4FT 509
2. Part of Slide Hammer Tool No. 954C
3. Oil Transfer Tube

6. The oil transfer tube that connects the internal rolled in tube channel to the output shaft, supplies pressure oil to the FWD clutch. This transfer tube is a tight fit in the transmission housing.

It should be removed and the polyimide seal renewed. Remove the tube by threading an M10–1.5 bolt into the centre of the tube and using a conventional slide hammer and suitable adapter withdraw the tube, Figure 65. Alternatively use Tool-No. 4FT 509 with slide hammer, part of Tool No. 954C



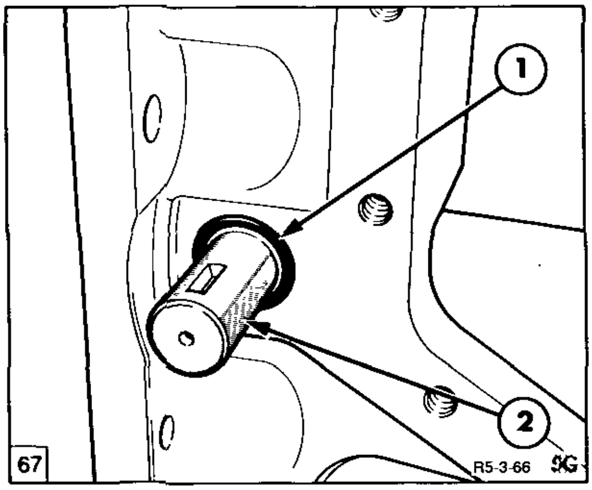
Front Wheel Drive Output Transfer Assembly – Exploded View

1. Oil Transfer Tube (with polyimide seal)
2. Pilot Valve Assembly
3. FWD Output Shaft
4. Engagement Spring Assembly
5. Spring Keeper
6. Front Bearing
7. Snap Ring
8. 'O' Ring Seal
9. Front Cover
10. Lip Type Oil Seal
11. Dust Seal
12. Outer Piston Seal
13. Inner Piston Seal
14. Clutch Half
15. Needle Roller Bearing
16. Spacer
17. Needle Roller Bearing
18. Gear/Clutch Half
19. Spacer
20. Rear Bearing
21. Snap Ring

Transmission Housing – General

After removal of the major assemblies the transmission housing now contains the FWD shaft rear bearing, the output shaft front bearing, the high/low synchroniser fork selector shaft, the output speed sensor and the oil transfer tubes.

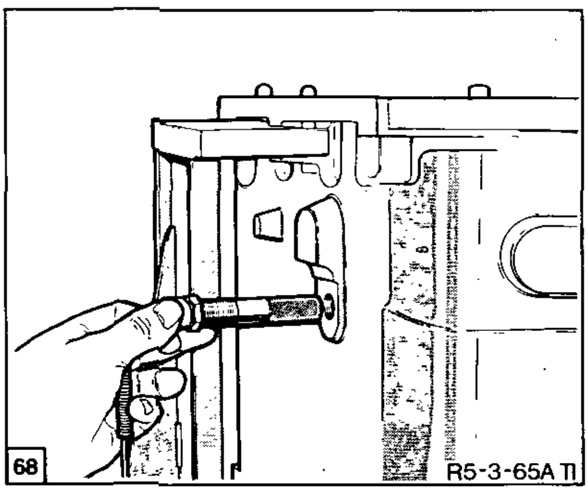
The bearings may be removed after removing the retaining snap rings, either by sliding them out or using a suitable adaptor or slide hammer to drive them out.



High/Low Range Selector Fork Shaft Oil Seal

1. Shaft Oil Seal 2. Shaft

The high/low synchroniser fork selector shaft slides inwards to remove. If necessary lever out the shaft lip type oil seal, Figure 67, and carefully install a new item using a suitable hammer and punch. Grease the seal lip.



Output Speed Sensor on Left–Hand Side of Transmission Housing

The output speed sensor, Figure 68, may be unscrewed from the housing if required.

Removal of the tubes should not be necessary unless they have obvious signs of damage or leakage. Leakage could be suspected if, during diagnosis of a particular function, pressure specifications could not be attained and that inspection of the identified component did not reveal the fault.

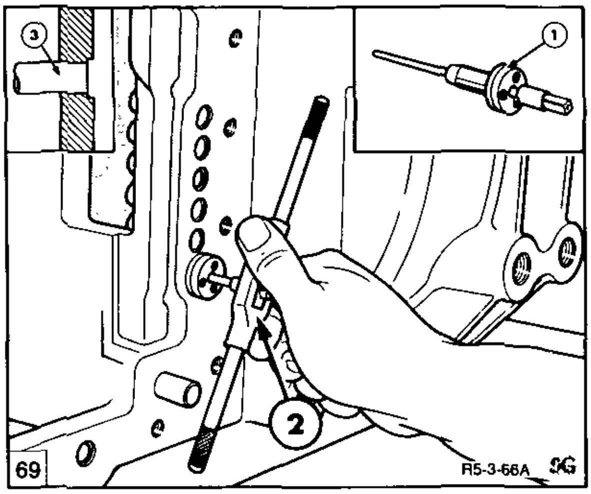
The tubes are 'rolled in' during manufacture. If required the tubes can be removed but cannot be re–used. Installation of new tubes requires a Special Tool. The sealing durability of the tubes is dependent upon the amount of rolling which expands the outside diameter of the tube. Too little rolling will allow leakage and too much will cause flaking of the tube, stress and eventual premature failure of the joint.

Remove and install the tubes as follows:–

1. Cut the tube with a hacksaw at a convenient distance from the rolled in location.

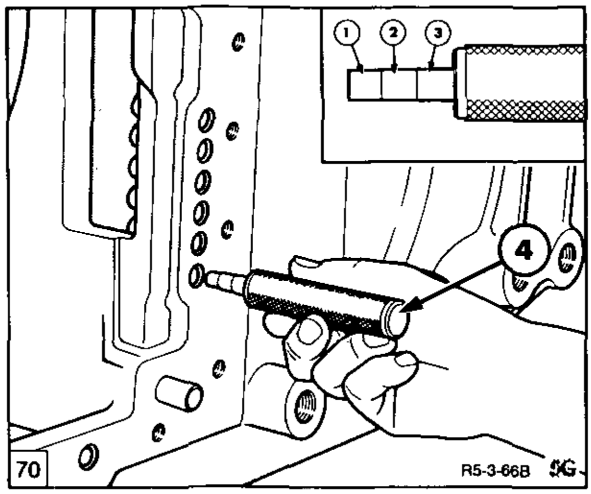
2. Very gently tap the sawn end to drive the rolled in area out of the housing.

3. Thoroughly clean the housing and install the new tube easing it into its location points. The tube ends should be flush with the bottom of the counterbore in the transmission housing, as shown in Figure 69.



Special Rolling In Tool Positioned in Tube

1. *Special Tool No.* 4FT 512
2. Tap Wrench
3. Tube Positioned Flush with Counterbore in Transmission Housing



Using 'Go' and 'No Go' Gauge to Check Amount of Rolling

1. 'Go' and Continue Rolling Diameter
2. 'Go' Stop Rolling
3. Over Rolled Diameter (take new tube and start again)
4. Gauge Special Tool No. 4FT 511

4. Using the special 'rolled in' tube rolling tool and gauge, roll in the tube, shown in Figure 69, as follows:–

a). Position the tool so that the rollers of the tool are fully entered in the tube and using a conventional tap wrench 'screw in' the centre portion until all looseness is removed. Check that the tube ends are still flush with the bottom of the counterbore in the housing.

b). Continue to turn the 'centre screw' of the tool to expand the tube against the housing. Firm pressure will be required on the end of the tool. Remove the tool.

c). Use Special Tool No. 4Ft 511, 'Go/No Go' Gauge, Figure 70, and establish if the 'Go' portion (centre diameter) of the gauge will enter the bore of the tube. The first diameter indicates that rolling has begun.

d). Continue steps b and c until the 'Go' area (middle diameter) of the Special Tool, just enters the tube.

IMPORTANT: *Do not allow the tube to be over rolled (last section of gauge will enter tube) as this could lead to flaking and over stressing of the seal. If the last diameter of the gauge enters the tube, the tube has been over rolled and is not fit for use. Remove the tube, us a new tube and repeat the process.*

5. Repeat the process on the other end of the tube.

NOTE: *The use of a 1/4 inch socket drive extension reversed, will permit the tool to be 'screwed' conveniently with a conventional tap wrench.*

6. Thoroughly clean the tube along its entire length.

INSPECTION

IMPORTANT: *Cleanliness during overhaul is important. Ensure during the rebuilding stage that all contaminant is eliminated, that working conditions are clean and that all tools used do not introduce contaminant into the previously cleaned components. Pay particular attention to the control valve when this is removed during this overhaul stage.*

General

Before commencing a detailed inspection of the transmission components, consider the history of the transmission. If disassembly and overhaul has been dictated by a specific failure at relatively low service hours, a thorough examination of components will identify salvageable bearing seals and other such items. If, however, the transmission has operated considerable service hours, then replacement of all bearings and seals would be recommended.

Wash all components, including the transmission housing, in a suitable solvent and dry using a lint free cloth or compressed air. During re–assembly of any item in this Section use clean transmission fluid as a lubricant unless otherwise stated.

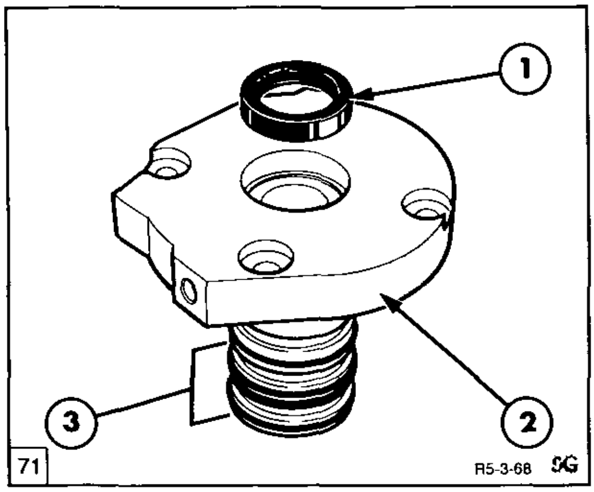
Transmission Housing

1. Inspect the housing for damage especially bearing bores and for any witness marks that may indicate wear or damage in other components.

2. Renew the 'O' ring seals on the C3/C4 clutch assembly support shaft manifold tubes and the oil transfer tubes at the control valve cover opening and at the front cover opening.

C1/C2 Clutch Assembly, Front Lower Shaft and Creeper Components (where fitted) – Inspection

Use the sectional view in Figure 72 to aid identification of components.



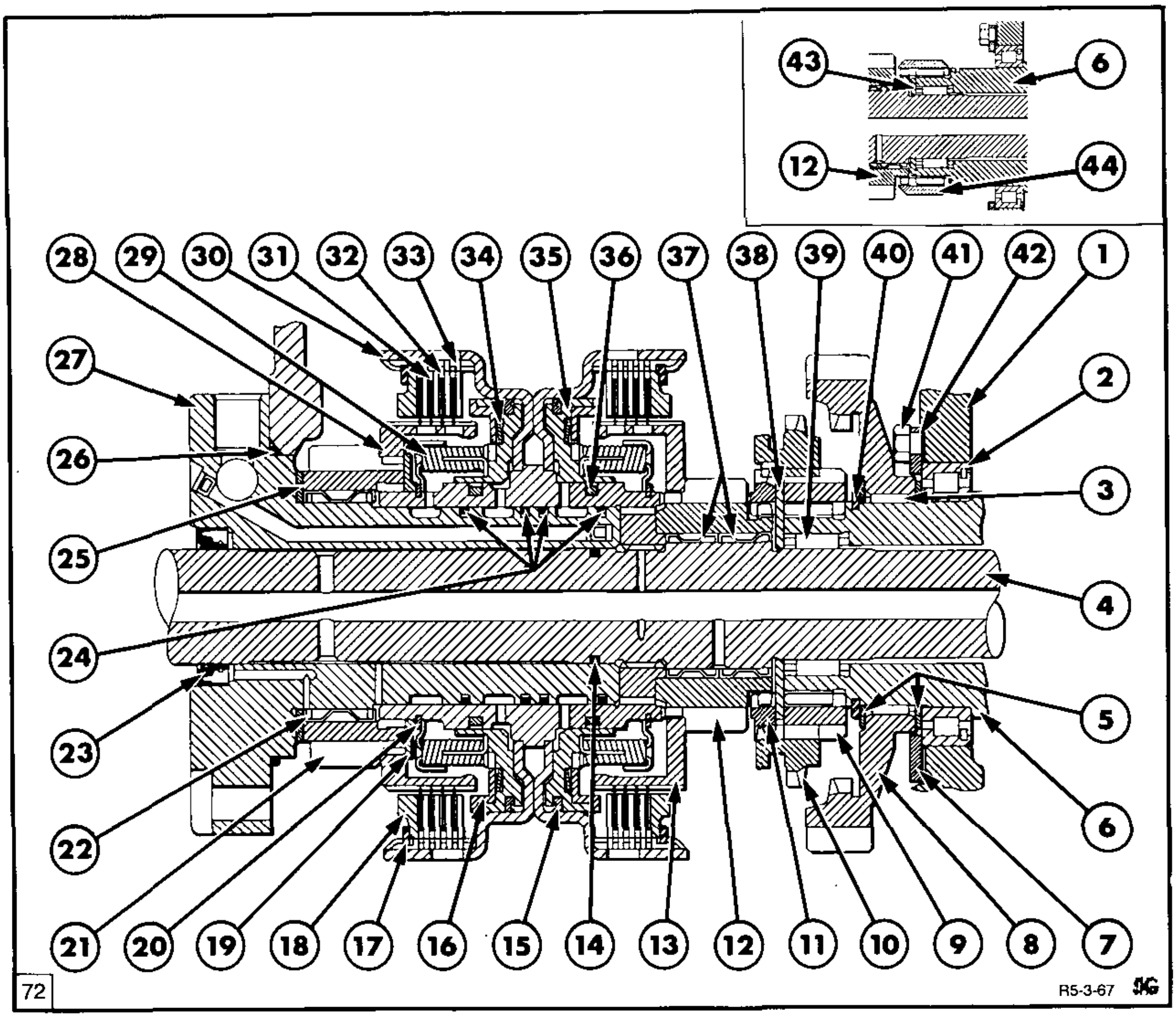
Input Shaft Seal in C1/C2 Clutch Support Shaft

1. Oil Seal
2. *C1/C2 Clutch Support Shaft*
3. Annular Seals

1. Remove the PTO/input seal in the C1/C2 clutch support shaft, Figure 71, by carefully levering it from the shaft. Install a new seal by gently pressing it into the centre of the support shaft, ensure the seal lip is facing inward toward the oil.

2. Remove and discard the four annular groove sealing rings from the C1/C2 clutch support shaft, Figure 71 and carefully inspect the shaft for wear and damage.

3. Install new sealing rings to the support shaft annular grooves. Ensure the seal ends are correctly positioned.



C1/C2 Clutch and Creeper Coupling (inset shows non creeper coupling) – Sectional View

1. Intermediate Cover Plate
2. Forward Reverse Synchroniser Support Shaft Front Roller Bearing
3. Creeper Gear Needle Roller Bearing
4. PTO/Input Shaft
5. Steel Thrust Washers
6. Forward Reverse Synchroniser Support Shaft
7. Bearing Retaining Plate
8. Creeper Gear
9. Creeper Coupler (part of)
10. Creeper Coupler (part of)
11. Creeper Coupling (part of)
12. C2 Clutch Driven Gear
13. C2 Clutch Hub
14. Lube Oil Seal
15. Piston Outer Seal
16. Outer Piston Half
17. Pressure Plate Snap Ring
18. Pressure Plate
19. Stepped Steel Ring
20. Return Spring Snap Ring
21. C1 Clutch Driven Gear
22. C1 Driven Gear Needle Roller Bearing
23. Input/PTO Shaft Lip Seal
24. Annular Sealing Rings
25. Polyimide Thrust Washer
26. Shaft Support to Front Cover 'O' Ring Seal
27. Clutch Support Shaft Assembly
28. C1 Clutch Hub
29. Piston Return Spring Assembly
30. C1/C2 Clutch Body
31. Steel Separator Plate x 4 per Clutch
32. Friction Plate x 4 per Clutch
33. Separator Spring x 4 per Clutch
34. Inner Piston Half
35. Belleville Spring
36. Clutch Piston Inner Seal and Energiser
37. C2 Driven Gear Needle Roller Bearings
38. Steel Washer (Creeper Transmissions)
39. Forward/Reverse Support Shaft Input Coupler Teeth
40. Creeper Gear Retaining Snap Ring
41. Bearing Retaining Plate Bolt
42. Shims
43. Polyimide Thrust Washer (non Creeper Transmissions)
44. Coupler (non Creeper Transmissions)

4. Inspect the PTO/input shaft for damage, evidence of binding, pick–up etc. Check that the splined areas are undamaged and free of any fretting. Ensure all oil ways are free and thoroughly clean.

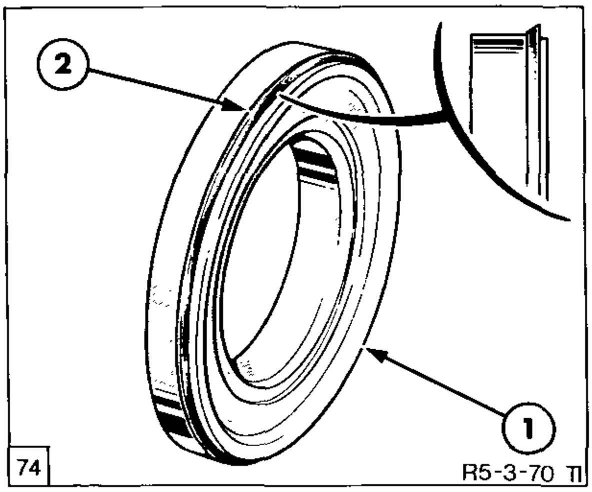
5. Renew the lube seal adjacent to the main input spline, Figure 73.

NOTE: *It is important that the seal is held down in its groove during re–assembly. If the seal is damaged lube oil will not be correctly distributed and possibly unknown damage will occur to related components.*

6. Inspect all snap rings and their grooves for deformation and damage.

7. Remove the piston outer seals from the clutch pistons and the piston inner seals and seal energizers from the clutch housing.

8. Inspect the pistons, both inner and outer components for scoring or damage. Check that the piston belleville washer is not deformed. Compare with a new item if in doubt.



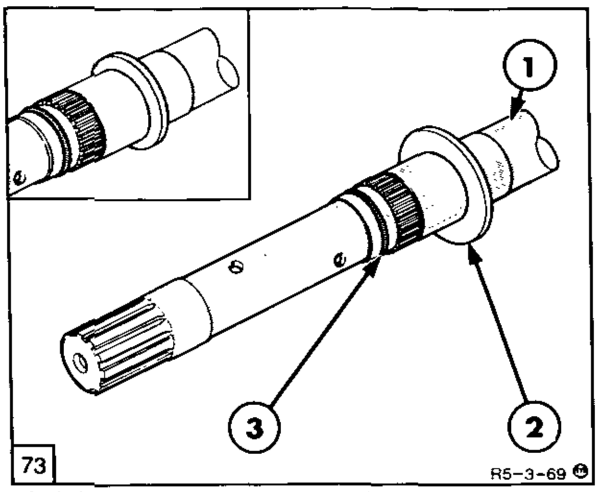
74

Piston Outer Seal Installed on Inner Piston

1. C1/C2 Piston (inner component)
2. Piston Seal (inset shows seal edge facing inside of piston toward oil supply)

9. Check the clutch housing for scratches, scores, excessive wear and piston scuffing.

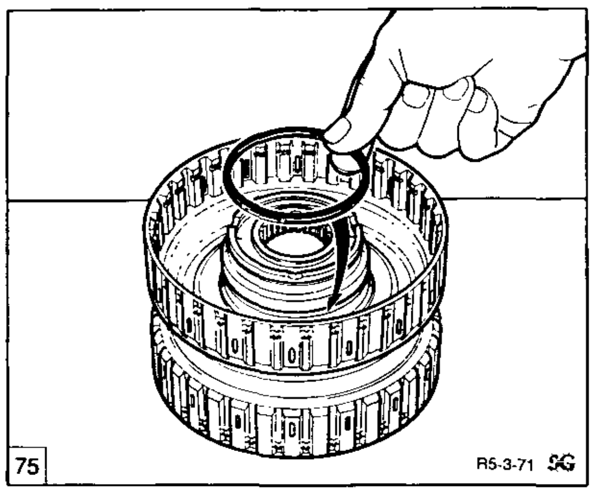
11. Repeat the process on the second clutch piston.



73

Lubrication Seal on PTO/Input Shaft (inset shows non–creeper with polyimide thrust washer)

1. Shaft
2. Steel Washer (with creeper)
3. Lube Seal



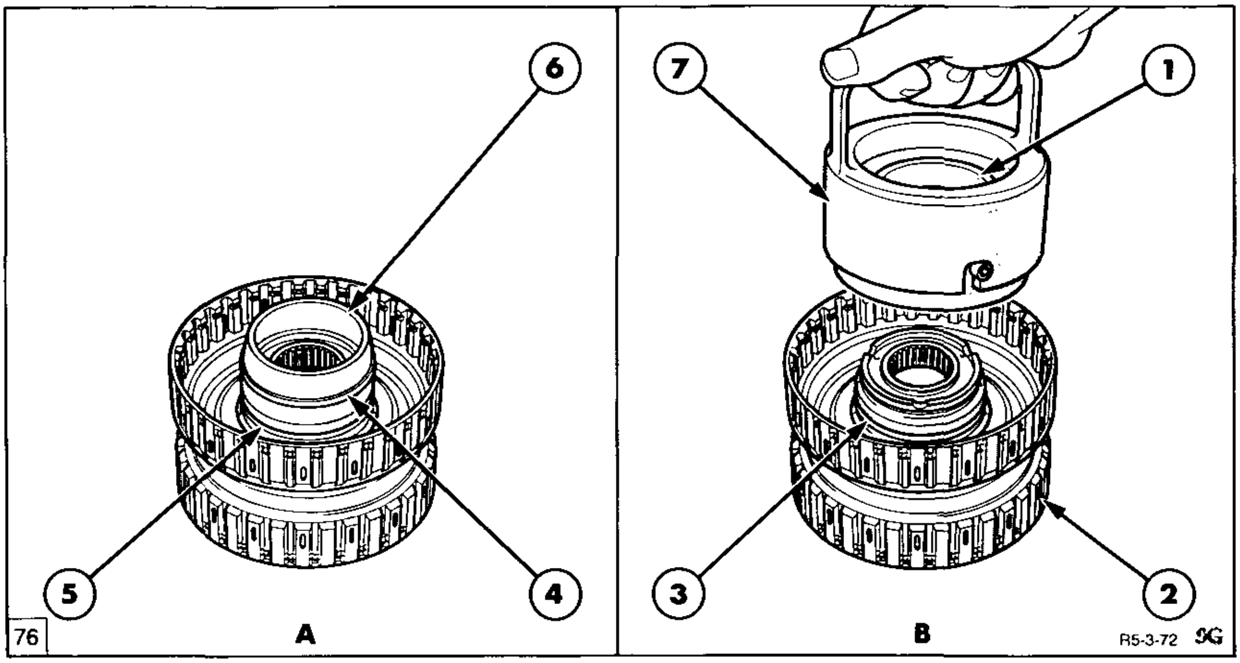
75

Installing Clutch Piston Inner Seal Energizer to Clutch Housing (note identification of groove)

12. Install the clutch piston inner seal energiser into the groove on the clutch housing, Figure 75. Ensure that the seal is perfectly seated and has not 'rolled' in the groove. Use an inspection light to ensure correct seating of this seal.

10. Install the piston outer seal, by hand ensuring the lip on the seal is facing the inner or rear face of the piston, Figure 74.

13. Repeat the above step on the second clutch piston inner seal energizer.



Using Special Tool to Expand, Install and to Resize the Piston Inner Seals on the C1/C2 Clutch Housing

1. Special Tool No. 4FT 507 (Re-sizer)
2. C1/C2 Clutch Housing Assembly
3. Seal Positioned in Groove on top of Seal Energiser
4. Seal Positioned on Expander
5. Seal Groove with Energizer already Installed
6. Special Tool No. 4FT 503 (Tapered Sleeve)
7. Special Tool No. 4FT 501 (Handle)

14. Install the clutch piston inner seals on the clutch housing as shown in Figure 76 and as follows:–

    a) Lubricate the piston inner seal and the Special Tool No. 4FT 503 (tapered sleeve expander) with petroleum jelly and position the expander sleeve on the clutch housing centre and the seal on the sleeve as shown.

    b) Push the piston inner seal up the taper, dropping the seal on top of the seal energizer, already in position on the clutch housing.
    Perform this operation quickly so that the seal is not subjected to the stretching action for too long.

    c) Ensure the seal is fully lubricated. Assemble the resizer, Special Tool No. 4FT 507, to the handle, Special Tool No. 4FT 501, so that the smaller diameter is at the opening. Lubricate the resizer and with the handle, firmly push the resizer over the seal to compress and resize the seal. ***Allow the tool to remain on top of the seal for at least 30 minutes.***

IMPORTANT: *As the tool is positioned over the seal, ensure that the tool slides smoothly and squarely over the seal. Upon completion of the process inspect the seal to ensure that no damage has occurred.*

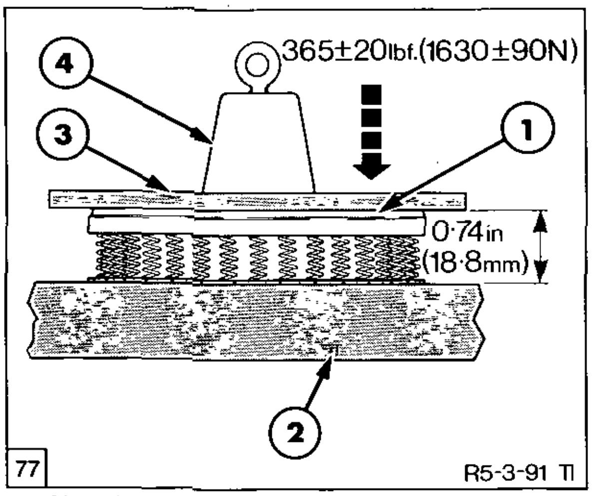
15. Repeat the installation and resizing process on the second clutch piston inner seal.

16. Check the clutch friction and separator plates for excessive wear, the friction plate material should have a clear distinctive pattern to be considered suitable for further service. All plates should be flat without warping and there should not be excessive discolouration.

17. The clutch separator springs (waved) should not be discoloured or distorted. Check each spring's shape and height, comparing with a new item, if in doubt renew the separator springs.

18. Inspect the clutch driven hubs for wear or damage.

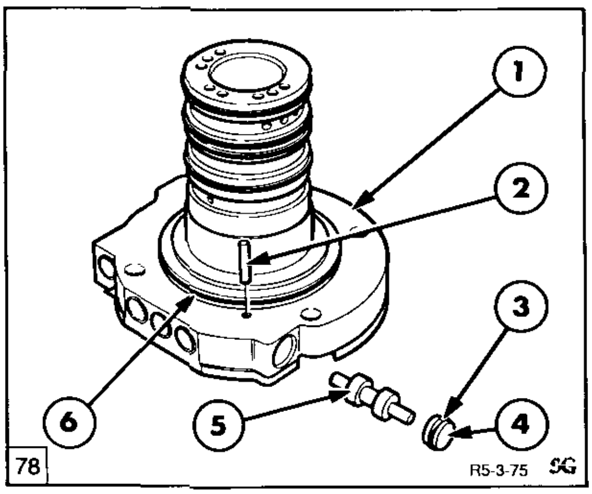
19. Inspect the front lower shaft gears, examining the teeth for wear or pitting.



Checking Compressed Height of Clutch Piston Return Spring Assemblies

1. Piston Return Spring Assembly
2. Base Plate
3. Load Spreader (flat disc)
4. Weight (or load)

20. Inspect the clutch engagement spring assemblies for cracked coils or deformation. Check the spring assemblies loaded height as shown in Figure 77, or compare with a new item. If in doubt renew the spring assembly.

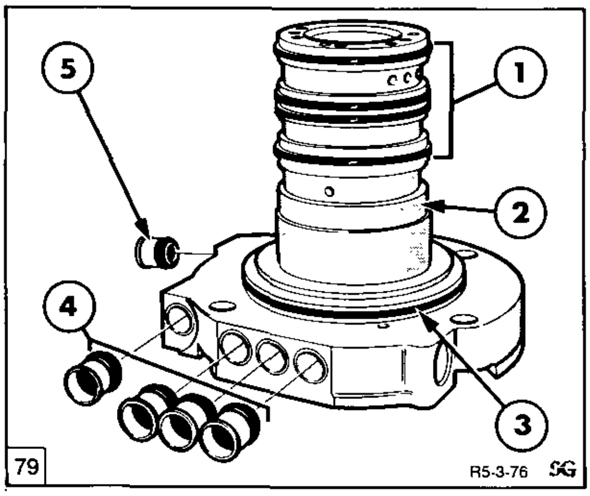


C1/C2 Clutch Support Shaft Lube Proportional Selector Valve – Exploded View

1. Support Shaft
2. Pin
3. Quad Seal
4. Plug
5. Lube Proportional Valve Spool
6. 'O' Ring seal

21. The C1/C2 clutch assembly support shaft contains the lube proportional selector valve. If the function of this valve is suspect, remove the end plug retaining pin and remove the plug and valve spool. Carefully inspect the components for wear or damage, thoroughly clean and re–assemble using a new quad seal on the end plug. The valve spool should move freely in its bore as the support shaft is moved from side to side.

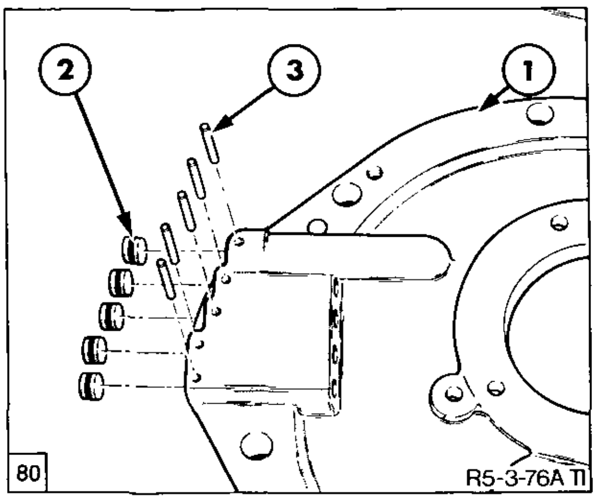
Figure 78 shows an exploded view of the assembly.



C1/C2 Clutch Support Shaft Oil Transfer Tube Rubber Adaptors

1. Annular Seals
2. Support Shaft
3. 'O' Ring Seal
4. Rubber Adaptors x 4 (large)
5. Rubber Adaptor x 1 (small)

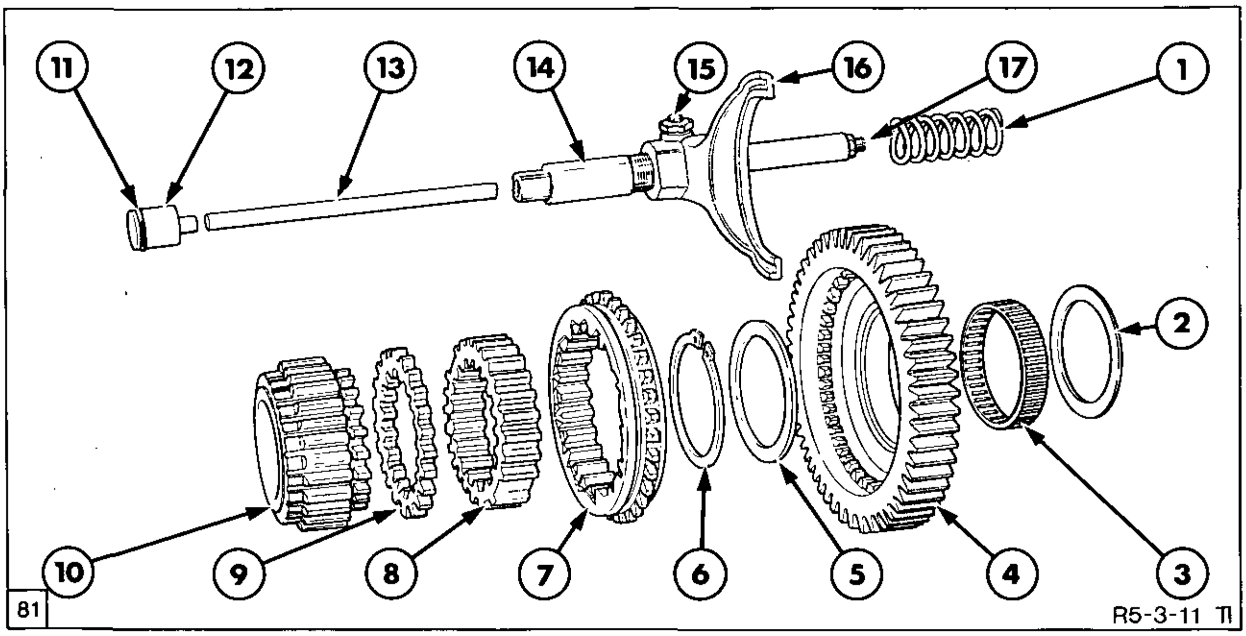
22. The support shaft also contains rubber adaptors that accept the C1/C2 clutch oil transfer tubes and the front lower shaft lube oil supply tube. Should these tubes exhibit leakage in this area the rubber adaptors should be carefully removed and new items installed, Figure 79.



Front Cover Plate Oil Transfer Tube Bore Plugs

1. Front Cover
2. Plug and Seal
3. Retaining Pin

23. The front cover contains similar rubber adaptors and plugs for the C1/C2 clutch oil transfer tubes and the front lower shaft lube oil supply tube. Similarly, if these exhibit leakage in this area the rubber adaptors should be carefully removed and new items installed or the plug retaining pins and plugs removed and the plug quad seal renewed, Figure 80.



Creeper Transmission – Coupler Components, Gear, Fork, Actuating Piston and Rail Assembly

1. Fork Return Spring
2. Steel Washer
3. Needle Roller Bearing
4. Creeper Gear
5. Steel Washer
6. Snap Ring
7. Sliding Coupler
8. Coupler
9. Plate
10. C2 Output Gear (26 tooth)
11. 'O' Ring Seal
12. Creeper Engagement Piston
13. Actuator Rod
14. Creeper Fork Rail
15. Creeper Disengagement Adjustment Lock Screw and Lock Nut
16. Coupler Fork
17. Creeper Engagement Adjuster and Locknut

24. Carefully inspect all bearings for wear and damage, if necessary remove the bearings from the front lower shaft and install new components following conventional techniques. Consider the economic value of re–installing new bearings versus the possibility of a further transmission removal and overhaul.

Creeper Transmissions Only

25. Inspect the creeper coupler components and the associated gears, paying particular attention to the teeth on the coupler components and the creeper reduction gear.

26. Examine the creeper fork for wear and the creeper fork rail for damage. Do not, unless these components are unfit for further use, disassemble the fork from the rail or interfere with the adjuster on the end of the actuator rod, Figure 81. Unless certain components are changed the factory set adjustment will not change during the reassembly stage of the transmission.

27. Inspect the creeper actuating piston for scoring and damage and renew the quad seal.

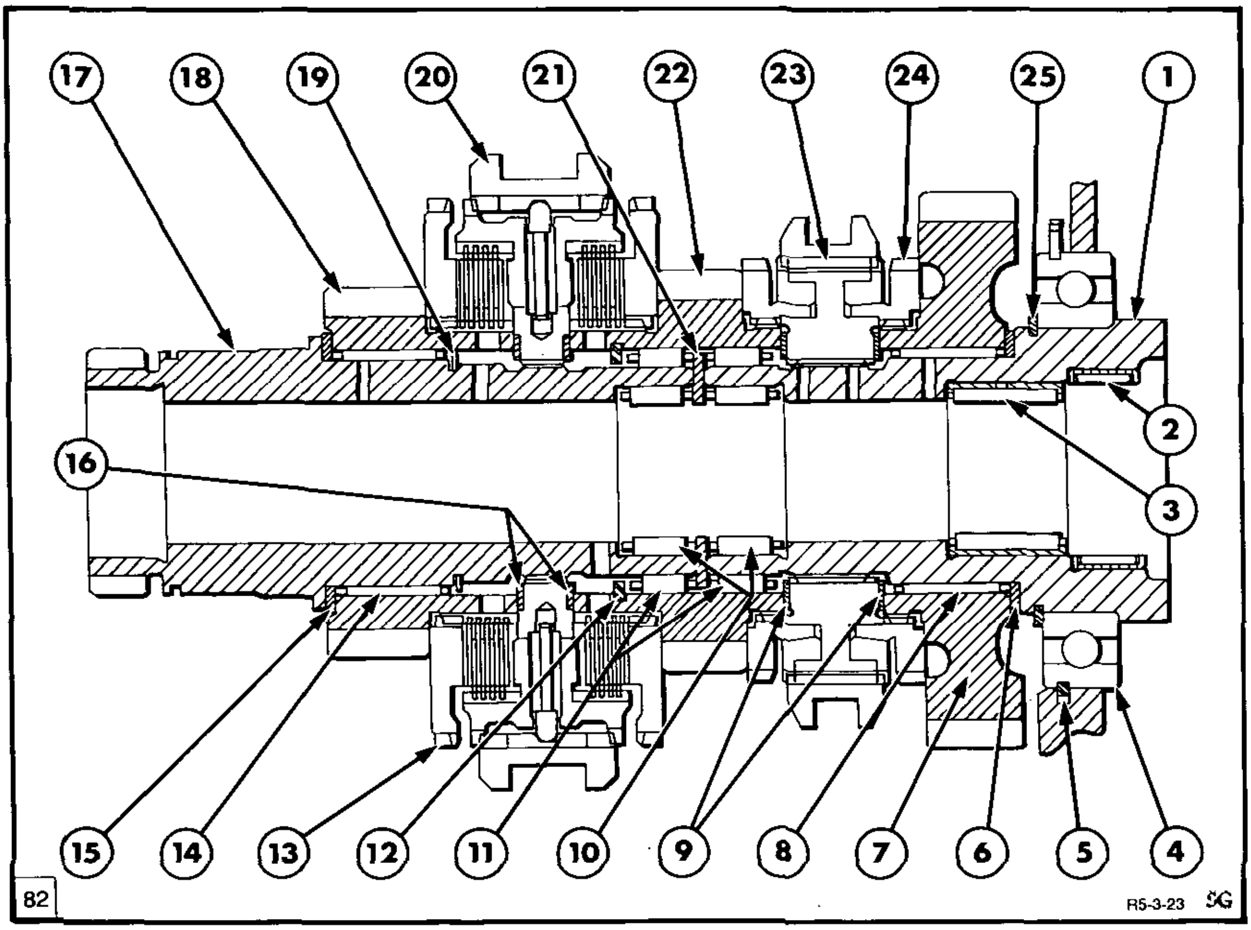
28. Check the creeper fork return spring for deformation and cracks. Compare the spring with a new item to determine any deformation.

NOTE: *If any doubt exists as to the further service life of any component, assess the economic factor involved of a further transmission removal and disassembly cost, versus the replacement cost of that particular part.*

Forward/Reverse and Main Range Synchronisers and Associated Gears and Bearings – Inspection

Use the sectional view in Figure 82 to aid component identification.

1. Inspect the two support shafts for any wear on the bearing surfaces. If necessary remove and replace the range synchroniser support shaft rear bearing and the forward/reverse support shaft front bearing, using established methods. These bearings are a light press fit.



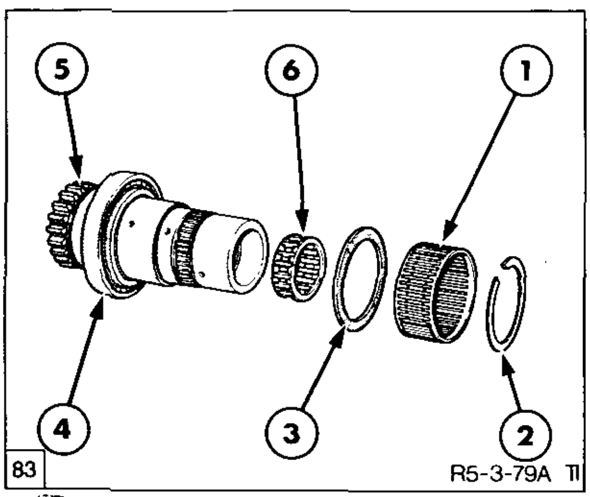
Forward/Reverse and Main Range Synchroniser Assemblies – Sectional View

1. Main Range Synchroniser Support Shaft
2. Needle Roller Bearing (press fit)
3. Needle Roller Bearing (press fit)
4. Main Range Synchroniser Support Shaft Rear Bearing
5. Bearing to Housing Snap Ring
6. Polyimide Thrust Washer
7. Driven Gear – Low
8. Needle Roller Bearing
9. Polyimide Thrust Washers x 2
10. Main Range and Forward/Reverse Synchroniser Support Shaft(s) to PTO/Input Shaft Needle Roller Bearings
11. Forward Gear to Support Shafts Needle Roller Bearings
12. Retaining Snap Ring
13. Forward/Reverse Synchroniser Coupling
14. Reverse Gear Needle Roller Bearing
15. Polyimide Thrust Washer
16. Polyimide Thrust Washers x 2
17. Forward/Reverse Synchroniser Support Shaft
18. Reverse Driven Gear
19. Needle Roller Bearing Retaining Snap Ring
20. Forward/Reverse Synchroniser
21. Steel Thrust Washer
22. Driven Gear High
23. Main Range Synchroniser
24. Main Range Synchroniser Coupler
25. Main Range Synchroniser Support Shaft Bearing Retaining Snap Ring

2. Remove the forward/reverse synchr–oniser support shaft front needle roller bearing retaining ring, Figure 83 and remove the bearing for inspection.

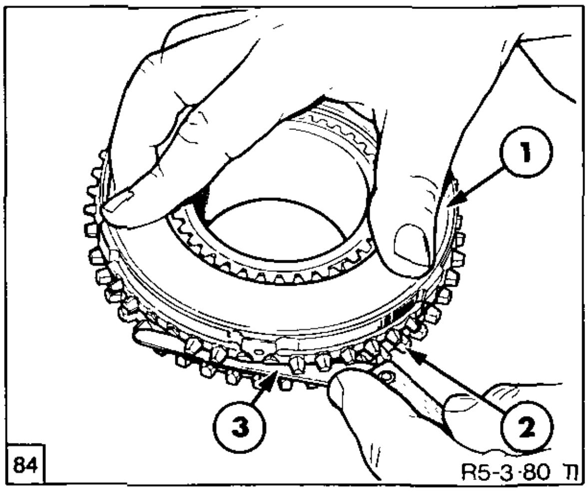
3. Carefully inspect all bearings and thrust washers for wear and damage. Consider the economic value of re–installing new bearings versus the possibility of a further transmission removal and overhaul.

4. The two needle roller bearings in the rear end of the range synchroniser support shaft, items 2 and 3, Figure 82, are a pressed fit in the shaft. If these bearings are unfit for further service, carefully pry the bearings from the shaft and press in new items using suitable adaptors.



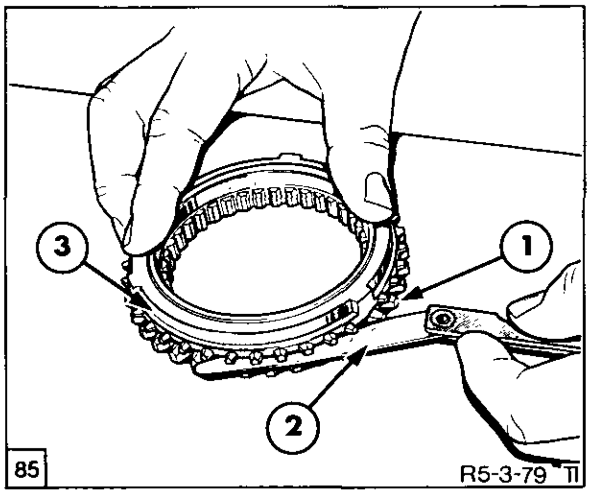
Forward/Reverse Synchroniser Support Shaft Bearings

1. Needle Roller Bearing (33 tooth gear)
2. Retaining Ring
3. Polyimide Thrust Washer
4. Roller Bearing
5. Support Shaft
6. Needle Roller Bearing (Support Shaft to PTO/Input Shaft)



Measuring Forward/Reverse Synchroniser for Serviceable Life

1. Housing
2. End Plate
3. Feeler Blade between Housing and End Plate



Measuring Main Range Synchroniser for Serviceable Life

1. Outer Cone/Coupling 3. Friction Cone
2. Feeler Blade

5. Inspect the forward/reverse synchroniser components for wear and damage as follows:–

   a) The friction plates should be flat and the friction material pattern should be clear and distinctive.

   b) The separator plates are dished (or waved with three high points) and should be free from excessive discolouration.

   c) Replace **all** plates if separator plates are completely black and one or more of the friction plates have areas with no friction material.

   d) Assemble the friction and separator plates in the housings and with the assembly squeezed together to flatten the dished separator plate, measure the gap between the two housings as shown in Figure 84. If the gap is less than 0.048in. (1.20 mm) replace the separator and friction plates. Repeat the gap check on the second half of the synchroniser assembly.

6. Inspect the main range synchroniser components for wear and damage as follows:–

   a) Inspect the cone for wear and damage and discolouration, if excessive renew the synchroniser.

   b) Check the gap between the cone and and end plate, Figure 85, if the gap is less than 0.032in. (0.8mm) renew the synchroniser.

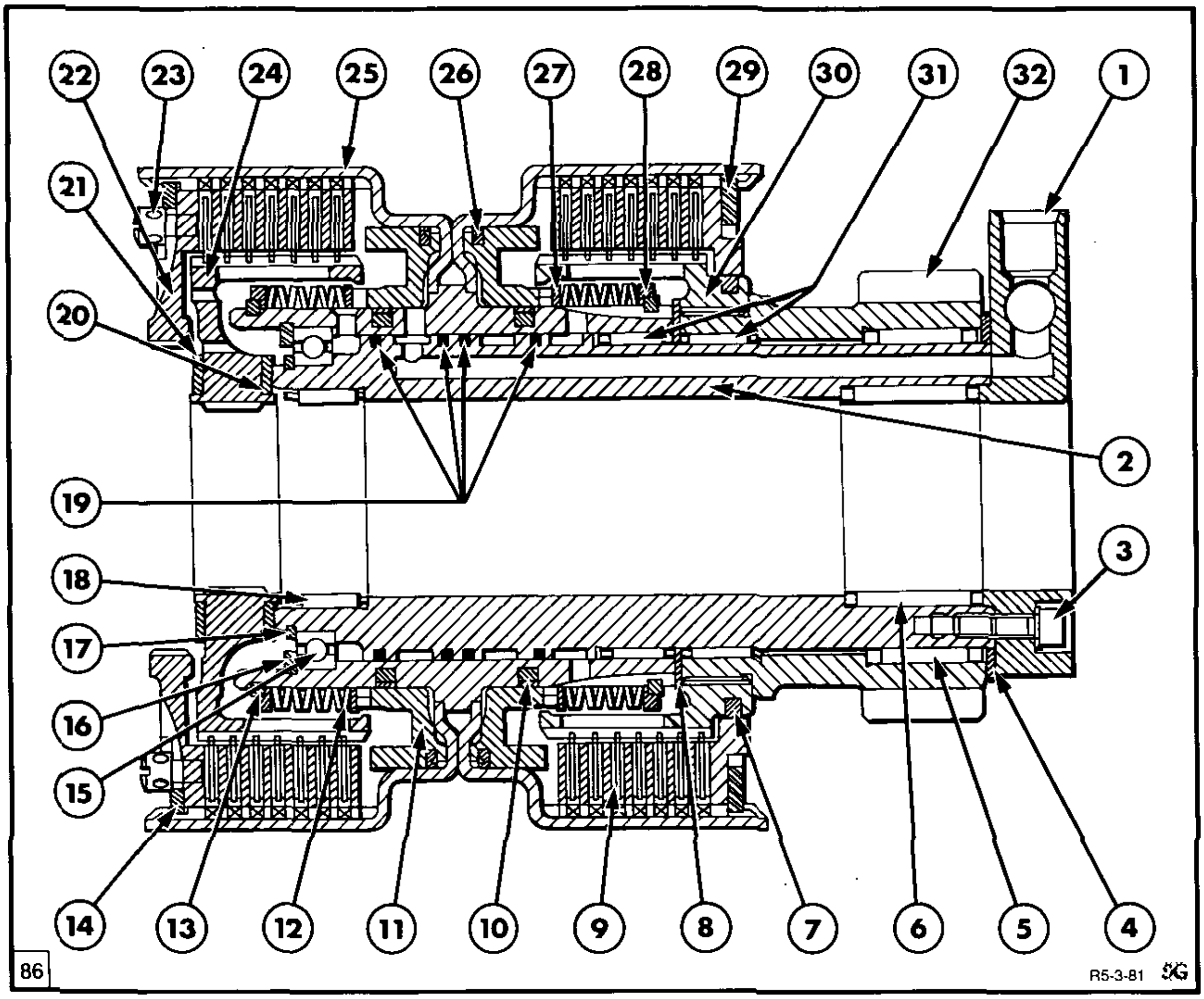
C3/C4 Clutch Assembly – Inspection

Use the sectional view in Figure 86 to aid component identification.

1. Wash all components in a suitable solvent and dry using a lint free cloth or compressed air.

2. Remove and discard the four annular groove sealing rings from the C3/C4 clutch support shaft.

3. Thoroughly inspect the support shaft for wear and damage. The front needle roller bearing to C3 output shaft is a pressed fit in the support shaft, if this bearing is unfit for further service, carefully remove the bearing and press in a new item using a suitable adaptor.



C3/C4 Clutch Assembly – Sectional View

1. Oil Transfer Manifold
2. Support Shaft
3. Manifold Retaining Bolt and Lockwasher.
4. Polyimide Thrust Washer
5. C4 Output Gear Needle Roller Bearing
6. C3 Output Gear Needle Roller Bearing
7. Lube Seal
8. Steel Washer
9. Clutch Plates
10. Piston Inner Seal
11. Piston
12. Belleville Washers – Piston Return x 8
13. Belleville Washer Retaining Snap Ring
14. Clutch Plate Retaining Ring
15. Clutch Housing Ball Bearing
16. Snap Ring
17. Snap Ring
18. Clutch Support Shaft Needle Roller Bearing
19. Clutch Support Shaft Annular Sealing Rings
20. Polyimide Thrust Washer
21. Polyimide Thrust Washer
22. Clutch Pressure Plate
23. Retaining Ring Locking Screw
24. C3 Clutch Hub
25. Clutch Housing
26. Piston Outer Seal
27. Flat Washer (Belleville Washer Seat)
28. Belleville Washer Snap Ring Retainer
29. Snap Ring
30. C4 Clutch Hub
31. Needle Roller Bearings
32. C4 Driven Gear

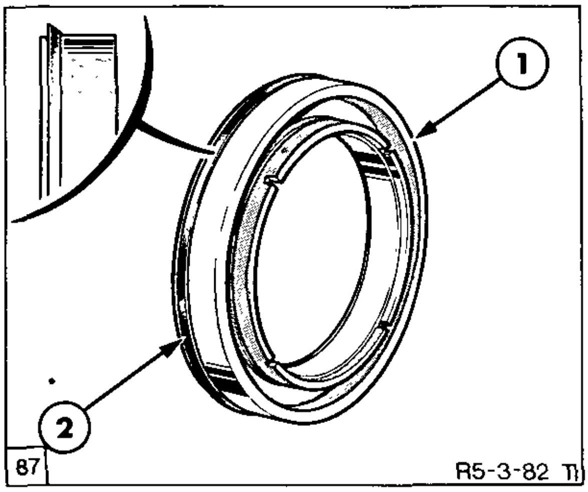
4. The support shaft to clutch housing ball bearing, if still in position in the clutch housing, should be removed from the housing for examination. Renew the bearing if wear exists.

5. Install new sealing rings to the annular grooves. Ensure these rings are allowed to resize to the grooves before re–assembly into the clutch housing.

6. Remove the piston outer seals from the clutch pistons, the piston inner seals (without damaging the clutch housing) and the seal energizers from the clutch housing. Remove the lube seal from the hub of the C4 clutch. Inspect both pistons for scoring or damage.

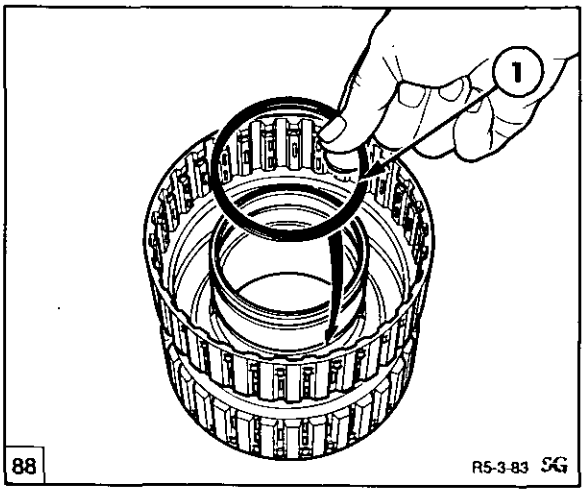
7. Check the clutch housing for scratches, scores, excessive wear, piston scuffing and any evidence of bearing journal pitting etc.

8. Lubricate the piston and install the piston outer seal by hand, ensuring the lip on the seal is facing the inner or rear face of the piston and that the seal is perfectly seated, Figure 87.



Piston Outer Seal Installed on Piston

1. C3 and C4 Piston
2. Piston Seal (inset shows seal edge facing inside of piston toward oil supply)



Installing Piston Inner Seal Energizer on Clutch Housing

1. Seal

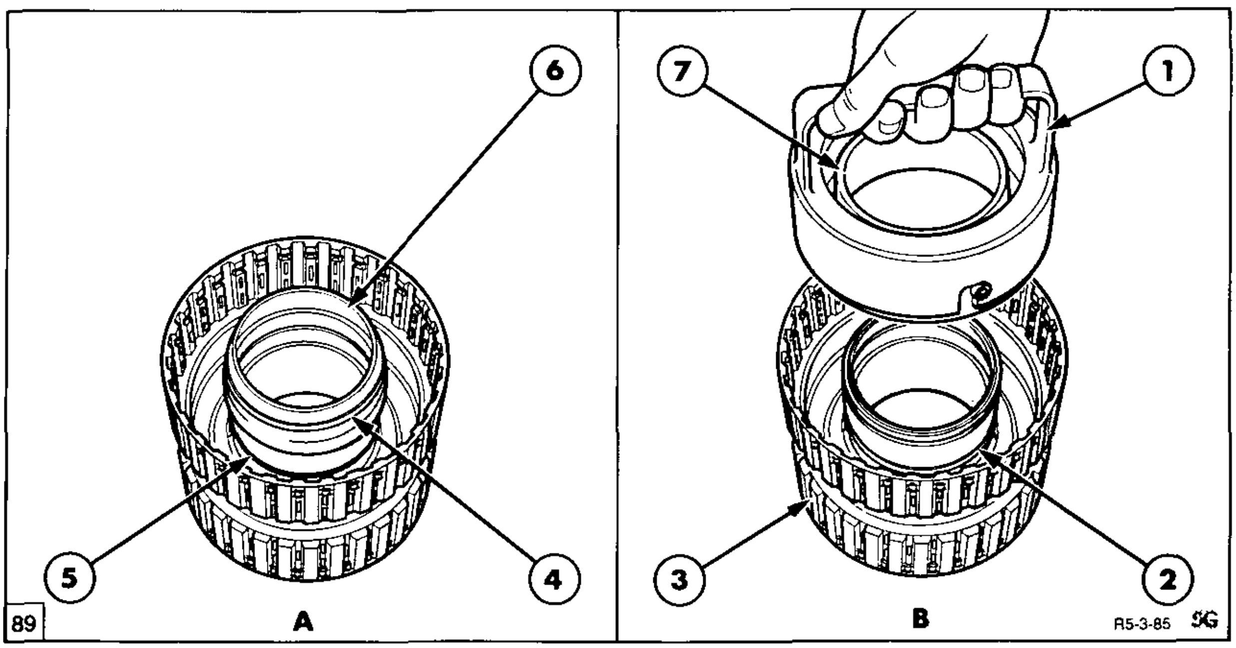
9. Repeat the process on the second clutch piston.

10. Install the clutch piston inner seal energizer into the groove on the clutch housing, Figure 88. Ensure that the seal is perfectly seated and has not 'rolled' in the groove. Use an inspection light to ensure correct seating of this seal.

11. Install the clutch piston inner seals on the clutch housing as shown in Figure 89 and as follows:–

a) Lubricate the piston inner seal and the Special Tool No. 4FT 502 (tapered sleeve expander) with petroleum jelly and position the expander sleeve on the clutch housing centre and the seal on the sleeve as shown.

b) Push the piston inner seal carefully up the taper, dropping the seal on top of the seal energizer already in position on the clutch housing. *Perform this operation quickly so that the seal is not subjected to the stretching action for too long.*



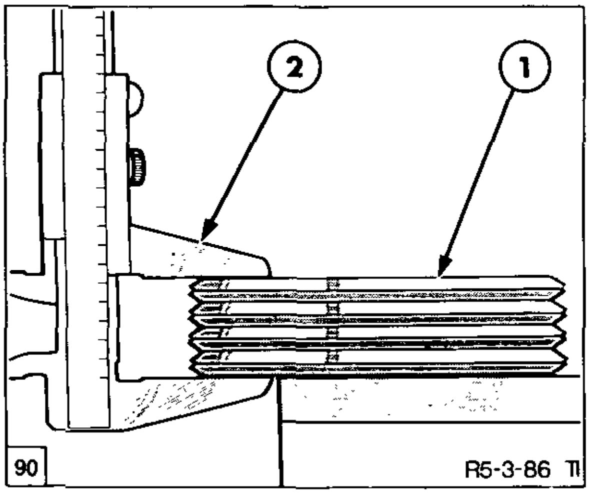
Using Special Tool to Expand, Install and to Resize the Piston Inner Seals on the C3/C4 Clutch Housing

1. Special Tool No. 4FT 501 (Handle)
2. Piston Inner Seal in Groove
3. C3/C4 Clutch Housing
4. Piston Inner Seal on Tapered Sleeve Expander
5. Seal Energiser in Position in Groove
6. Special Tool No. 4FT 502 (Tapered Sleeve)
7. Special Tool No. 4FT 507 (Re–sizer)

c) Ensure the seal is fully lubricated. Assemble the resizer, Special Tool No. 4FT 507, to the handle, Special Tool No. 4FT 501, so that the larger diameter is at the opening. Lubricate the resizer and with the handle, firmly push the resizer over the seal to compress and resize the seal. ***Allow the tool to remain on top of the seal for at least 30 minutes.***

IMPORTANT: *As the tool is positioned over the seal, ensure that the tool slides smoothly and squarely over the seal. Upon completion of the process inspect the seal to ensure that no damage has occurred.*

12. Repeat the installation and resizing process on the second clutch piston inner seal.



Measuring Belleville Spring Pack Stack Height

1. Belleville Springs (stack)
2. Vernier Caliper

13. Check that the splined areas of the input hub and the output gear are undamaged and free of any fretting.

14. Inspect each of the belleville spring washers for cracks and deformation. Assemble the springs to form a stack as though they were in the clutch and measure the height as shown in Figure 90. Compare the measured height with that of new items. If in doubt renew the spring washers.

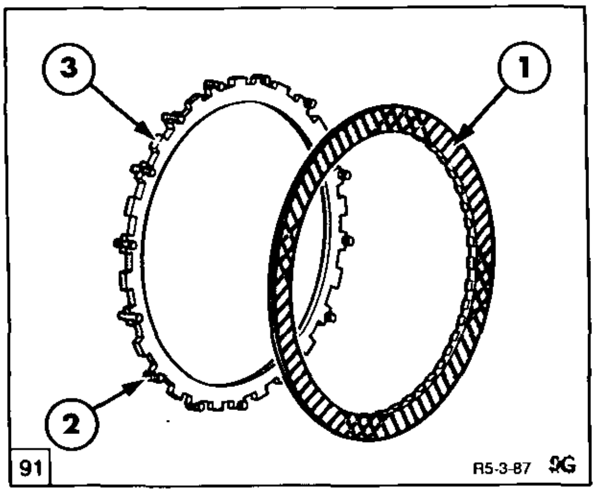
15. Inspect the clutch driven hubs for wear, damage or pitting.

16. Install a new lube seal in the groove of the C4 clutch hub, ensure that it is correctly seated.

17. Ensure all oil ways are free and thoroughly clean.

18. *Inspect all snap rings and their grooves* for deformation and damage.

19. Check the clutch friction and separator plates for excessive wear, the friction plate material should have a clear distinctive pattern to be considered suitable for further service. All plates should be flat without warping and there should not be excessive discolouration.

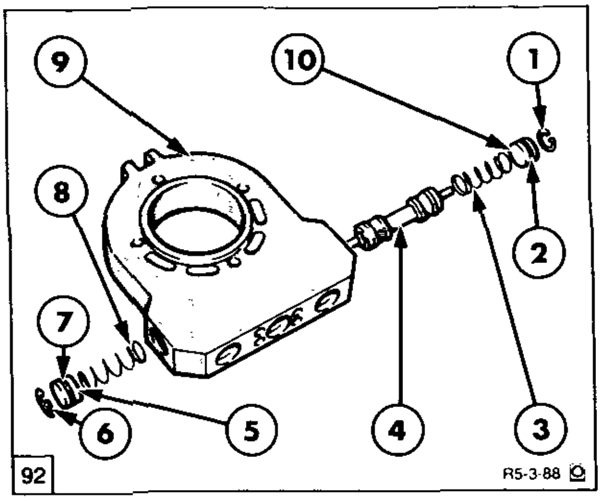


C3/C4 Clutch Separator Plate with Separator Springs and Friction Plate for Reference

1. Friction Plate
2. Coil Separator Springs
3. Steel Separator Plate

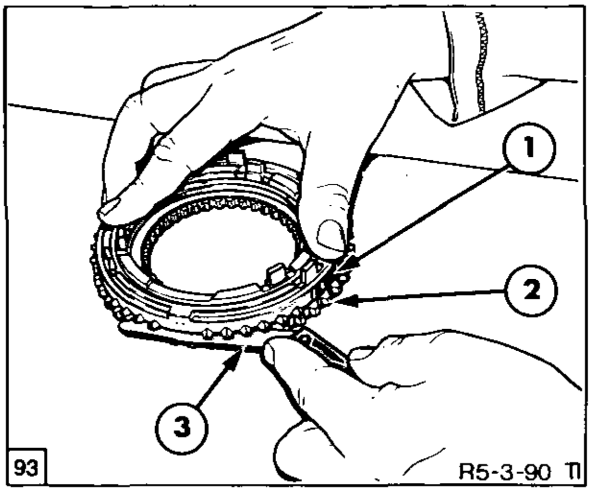
20. Inspect the three separator plates in each clutch that each carry 16 coil type separator springs, Figure 91. Inspect each of the springs for deformation and damage. Replace springs as required. They can be removed by inserting a stiff wire or rod through the centre and prying them from the slot in the separator plate. Replace with new ones in the reverse manner taking care that the spring is not bent. Similarly inspect the pressure plates that carry half springs, these can be wound out of the pressure plates.

21. The C3/C4 clutch assembly support shaft manifold contains the lube proportional selector valve. If the function of this valve is suspect, remove the end plug retaining snap rings and remove the plugs, springs and valve spool. Carefully inspect the components for wear or damage, thoroughly clean and re–assemble using new seals on the end plugs. Ensure that the valve spool moves freely in its bore. Figure shows an exploded view of the assembly.



C3/C4 Clutch Support Shaft Manifold Assembly – Exploded View

1. Snap Ring
2. Quad Seal
3. Spring
4. Lube Proportional Valve Spool
5. Plug
6. Snap Ring
7. Quad Seal
8. Spring
9. Manifold
10. Plug



Measuring High/Low Synchroniser for Serviceable Life

1. Inner and Outer Blocker Rings
2. End Plate
3. Feeler blade

22. Carefully inspect all bearings, polyimide and steel thrust washers for wear, pitting and damage. Consider the economic value of re–installing new items, versus the possibility of a further transmission removal and overhaul.

NOTE: *If any doubt exists as to the further service life of any component, assess the economic factor involved of a further transmission removal and disassembly cost, versus the replacement cost of that particular part.*

Output Shaft, High/Low Range Synchroniser and Rear Upper Shaft – Inspection

Use the sectional view in Figure 94 to aid component identification.

1. Inspect all snap rings and their grooves for deformation and damage.
2. Inspect the rear upper shaft and the output shaft gears, examining the teeth for wear or pitting.
3. Carefully inspect all bearings for wear, pitting and damage. Consider the economic value of re–installing new bearings versus the possibility of a further transmission removal and overhaul.
4. Inspect the high/low synchroniser components for wear and damage as follows:–

   a) If the measured gap between the end plate and outer ring is less than 0.060in. (1.50 mm), Figure 93, change all friction and metal cones.

   b) Change all rings if the intermediate ring is black (cracked oil). Check adjustment procedure during reassembly.

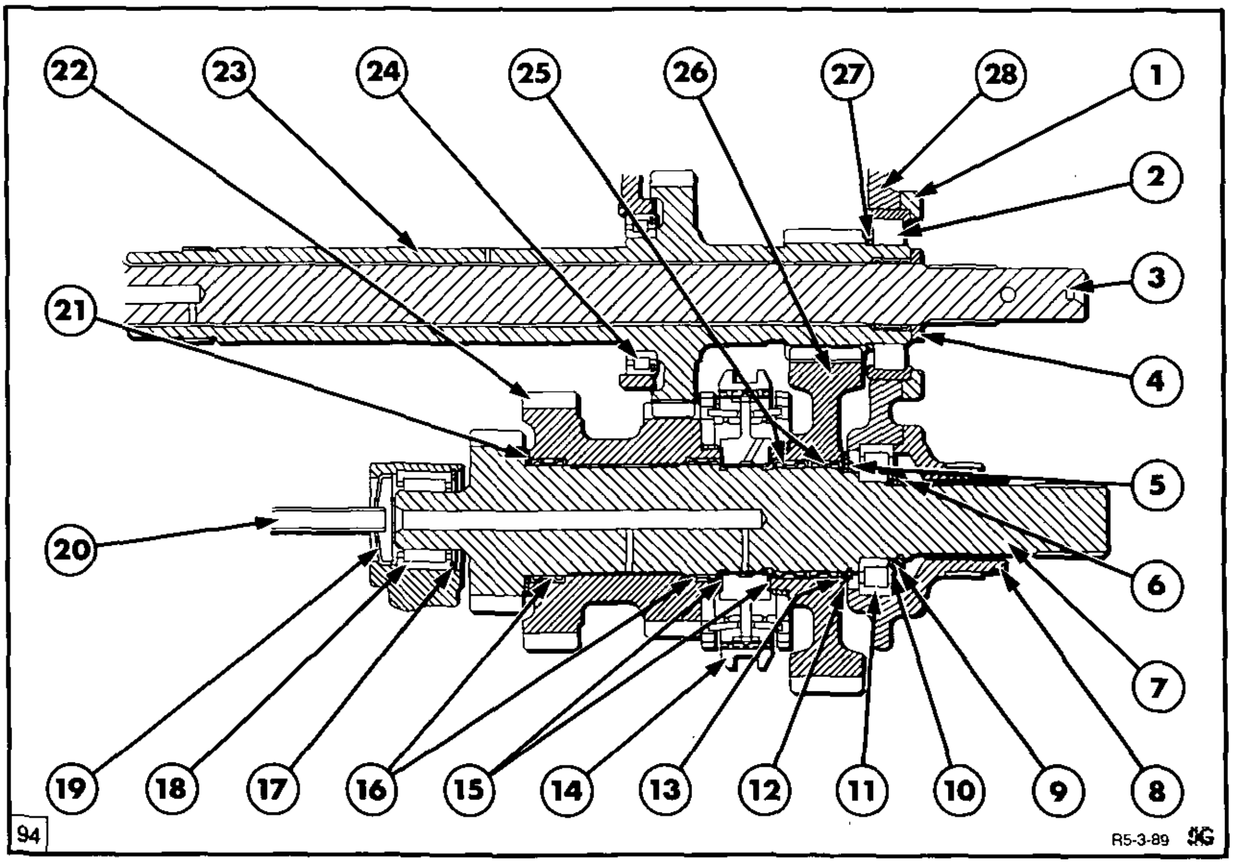
   c) If the steel rings have hot spots of more than 0.25in^2 (25 mm^2), change all the rings including the intermediates.

NOTE: *If any doubt exists as to the further service life of any component, assess the economic factor involved of a further transmission removal and disassembly cost versus the replacement cost of that particular part.*

Front Wheel Drive Transfer Assembly – Inspection

Use the sectional view in Figure 96 to aid component identification.

1. Inspect all snap rings and their grooves for deformation and damage.
2. Inspect the internal drive shaft gear, the shaft front gear and the gear on the clutch half, examining the teeth for wear or pitting.
3. Carefully inspect all bearings for wear, pitting and damage. Consider the economic value of reinstalling new bearings versus the possibility of a further transmission removal and overhaul.



Output Shaft and High/Low Range Synchroniser

1. Top Shaft Bearing Retainer
2. *Roller Bearing*
3. PTO/Input Shaft
4. Polyimide Thrust Washer
5. Snap Ring
6. Snap Ring
7. Output Shaft
8. Retainer/Pump Idler gear Support
9. 'D' Shaped Steel Washer
10. Bearing Loose Thrust
11. *Roller Bearing*
12. 'D' Shaped Steel Washer (various thicknesses)
13. Polyimide Thrust Washer
14. High/Low Range Synchroniser
15. Polyimide Thrust Washers
16. Needle Roller Bearings
17. Snap Ring
18. Roller Bearing
19. Lube Tube Cup plug
20. *Lube tube*
21. Polyimide Thrust Washer
22. Two Gear Cluster
23. C3 Clutch Output Shaft
24. *Roller Bearing*
25. Needle Roller Bearings
26. Low Range Gear
27. Spacer
28. Rear Cover Plate

4. Install new inner and outer seals, items 11 and 22, Figure 96, to the output shaft.

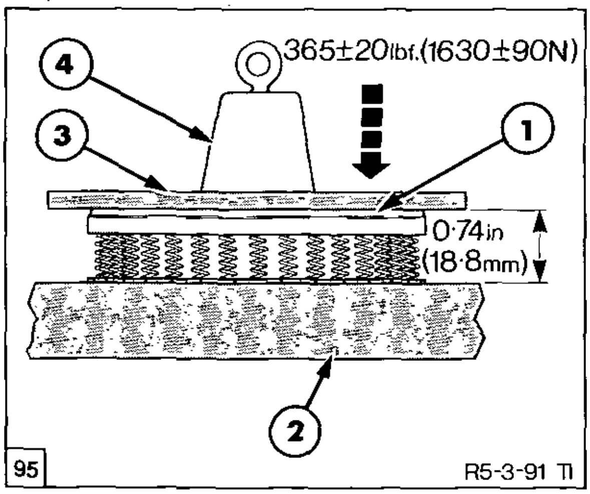
5. *Carefully pry out the output shaft lip seal,* item 17, Figure 96, from the cover plate and press in a new seal using a suitable step plate or adaptor. Renew the outer 'O' ring seal.

6. Inspect the clutch engagement spring assembly for cracked coils or deformation. Check the spring assembly loaded height as shown in Figure 95, or by comparing it with a new item. If any doubt exists renew the spring assembly.

7. Inspect the inner surfaces of the front half of the clutch for damage, ensure that the sealing area is unmarked.

8. Examine the clutch dog teeth for damage and wear.

9. Inspect the splined ares of the front half of the clutch, the output shaft and the internal drive shaft for damage and fretting.

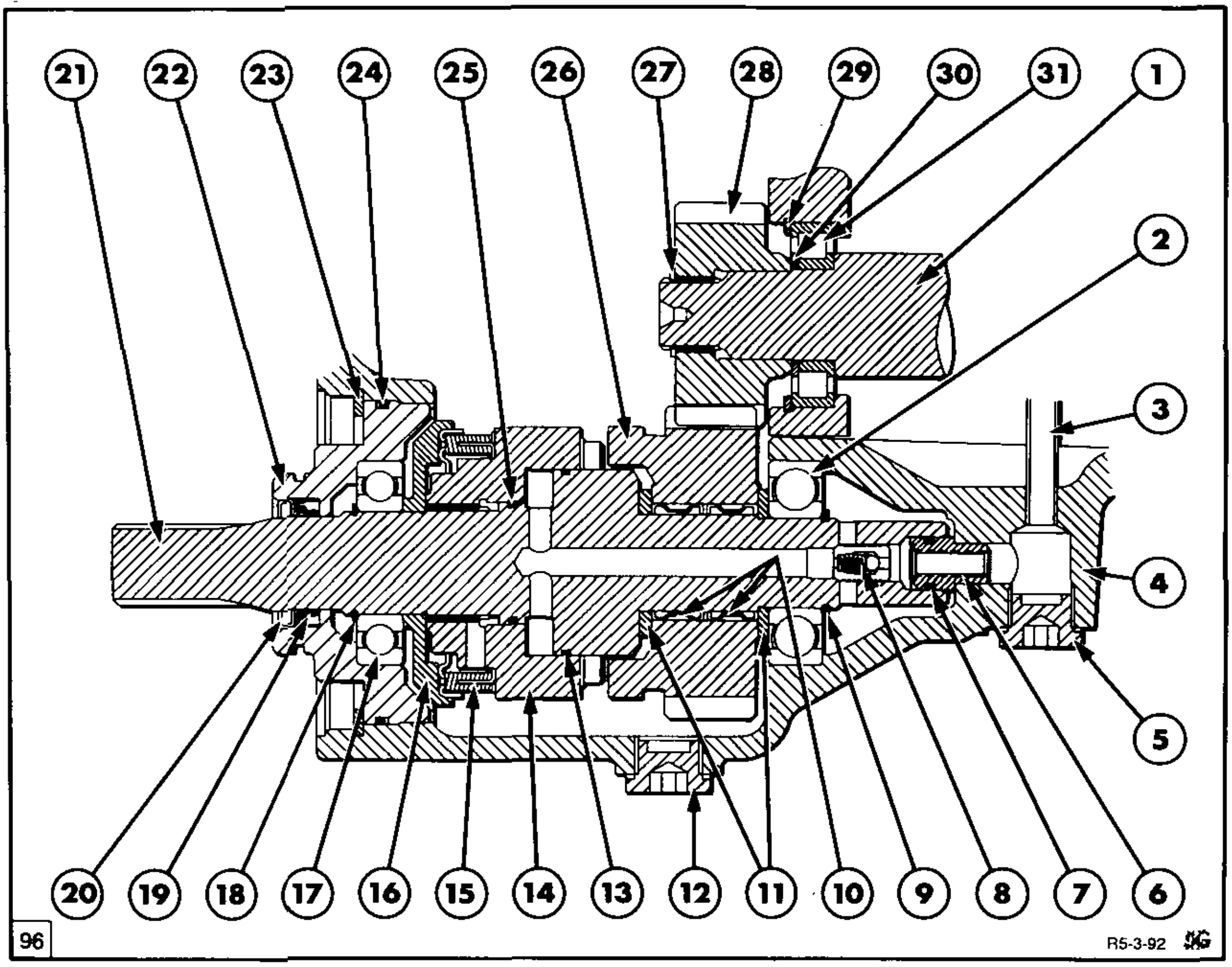


Checking Compressed Height of Clutch Piston Return Spring Assemblies

1. Piston Return Spring Assembly
2. Base Plate
3. Load Spreader (flat disc)
4. Weight (or load)

10. Renew the seal on the oil transfer tube and ensure the tube and the pilot valve assembly are undamaged and functioning correctly.

RE–ASSEMBLY
FWD Output Drive Assembly Re–Assembly



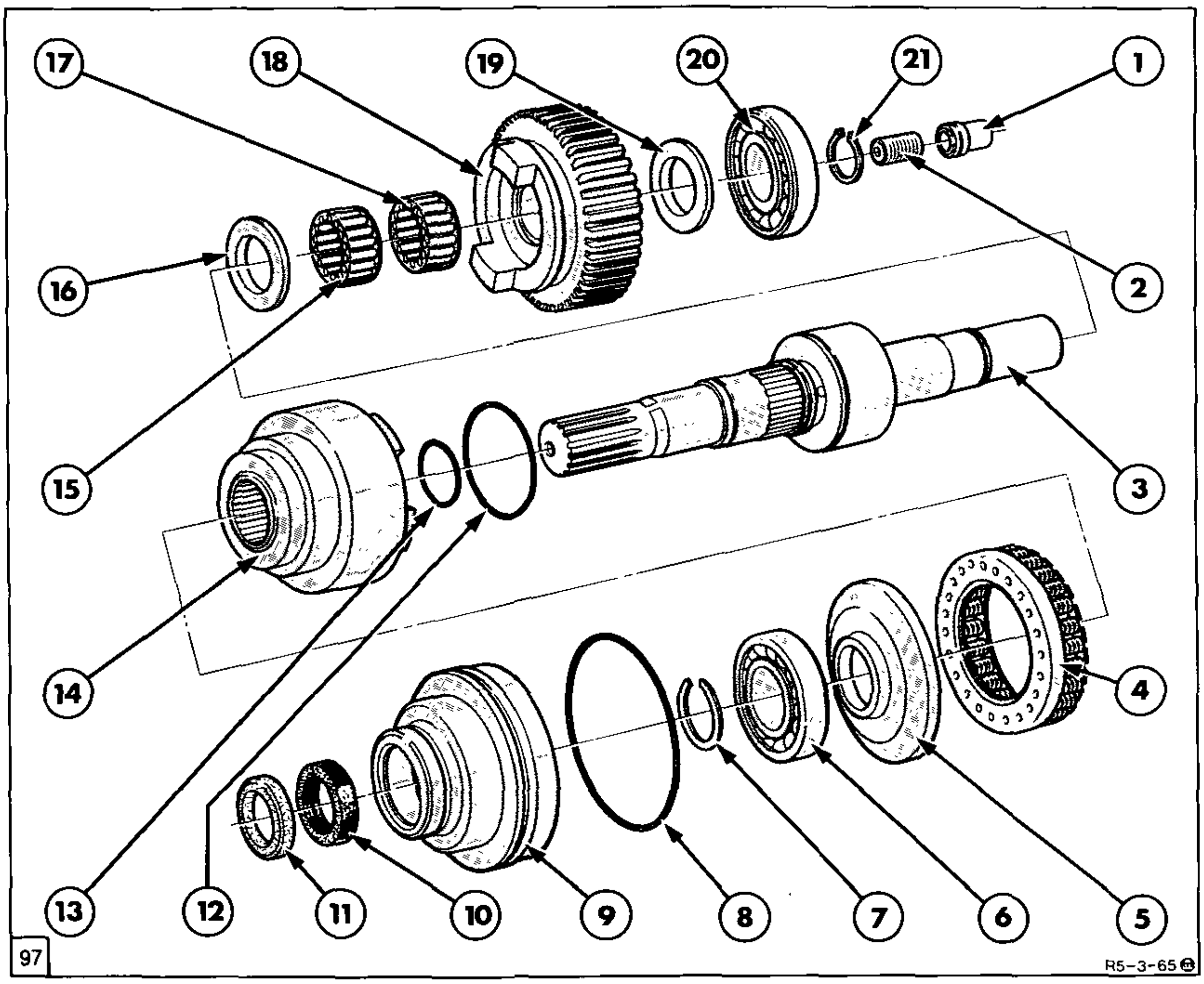
Front Wheel Drive Output Assembly – Sectional View

1. Shaft (from transmission output)
2. Output Shaft Rear Bearing
3. Oil Pressure Supply Tube
4. Transmission Housing
5. Plug (Pressure Supply)
6. Oil Transfer Tube
7. Oil Transfer Tube Seal
8. Pilot Valve Assembly
9. Bearing Retaining Snap Ring
10. Needle Roller Bearings
11. Steel Washers
12. Transmission Drain Plug
13. Outer Piston Seal
14. Sliding Clutch Half
15. Engagement Spring Assembly
16. Spring Keeper
17. Output Shaft Front Bearing
18. Snap Ring
19. Oil Seal
20. Output Shaft
21. Dust Seal
22. Cover Plate
23. Cover Plate Retaining Snap Ring
24. Cover Plate 'O' Ring Seal
25. Inner Piston Seal
26. Clutch Half/Gear
27. Snap Ring
28. Drive Gear (from transmission output)
29. Snap Ring
30. Bearing Thrust Washer
31. Bearing Assembly

IMPORTANT: *Cleanliness during overhaul is important. Ensure during the rebuilding stage that all contaminant is eliminated, that working conditions are clean and that all tools used do not introduce contaminant into the previously cleaned components. Pay particular attention to the control valve when this is removed during this overhaul stage.*

1. Use the sectional illustration in Figure 96 to aid re–assembly and note the following items, giving them special attention:–

2. Re–assembly of the front wheel drive output transfer assembly follows the disassembly procedure in reverse.



Front Wheel Drive Output Transfer Assembly – Exploded View

1. Oil Transfer Tube
2. Pilot Valve Assembly
3. Output Shaft
4. Engagement Spring Assembly
5. Spring Keeper
6. Front Bearing
7. Snap Ring
8. 'O' Ring Seal
9. Front Cover
10. Lip Type Oil Seal
11. Dust Seal
12. Outer Piston Seal
13. Inner Piston Seal
14. Clutch Half
15. Needle Roller Bearing
16. Steel Washer
17. Needle Roller Bearing
18. Clutch Half/Gear
19. Steel Washer
20. Rear Bearing
21. Snap Ring

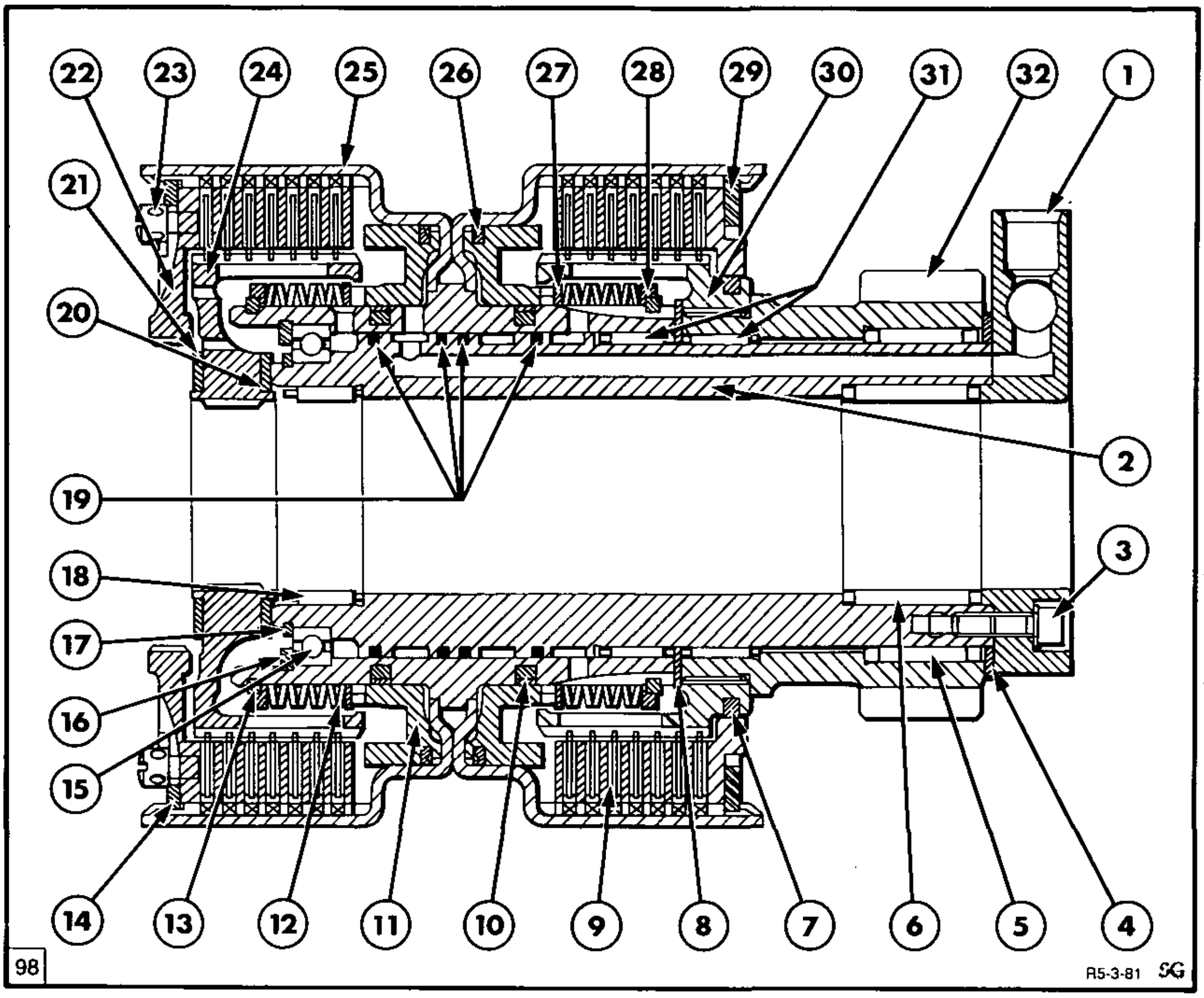
3. Coat the shaft seals with transmission fluid prior to re–assembly and allow the seals to resize before assembling the sliding clutch half.

4. Use a suitable press and sleeve to install the front and rear bearings, ensure when installing the front bearing that the sliding clutch half, the spring assembly and the keeper plate to not become misaligned and damage the seals.

5. Ensure the two washers, items 11, Figure 96, are positioned either side of the gear/clutch half. See also items 16 and 19 in Figure 97.

6. In order for the dog clutch to perform correctly, it is essential that the pilot valve assembly, item 8, Figure 96, is assembled with the ball facing rearwards. An exploded view of the FWD output drive assembly is shown in Figure 97.

7. Do not re–assemble the internal FWD shaft front gear until the intermediate cover plate has been installed



C3/C4 Clutch Assembly – Sectional View

1. Oil Transfer Manifold
2. Support Shaft
3. Manifold Retaining Bolt and Lockwasher
4. Polyimide Thrust Washer
5. C4 Output Gear Needle Roller Bearing
6. C3 Output Gear Needle Roller Bearing
7. Lube Seal
8. Steel Washer
9. Clutch Plates
10. Piston Inner Seal
11. Piston
12. Belleville Washers – Piston Return x 8
13. Belleville Washer Retaining Snap Ring
14. Clutch Plate Retaining Ring
15. Clutch Housing Ball Bearing
16. Snap Ring
17. Snap Ring
18. Clutch Support Shaft Needle Roller Bearing
19. Clutch Support Shaft Annular Sealing Rings
20. Polyimide Thrust Washer
21. Polyimide Thrust Washer
22. Clutch Pressure Plate
23. Retaining Ring Locking Screw
24. C3 Clutch Hub
25. Clutch Housing
26. Piston Outer Seal
27. Flat Washer (Belleville Washer Seat)
28. Belleville Washer Snap Ring Retainer
29. Snap Ring
30. C4 Clutch Hub
31. Needle Roller Bearings
32. C4 Driven Gear

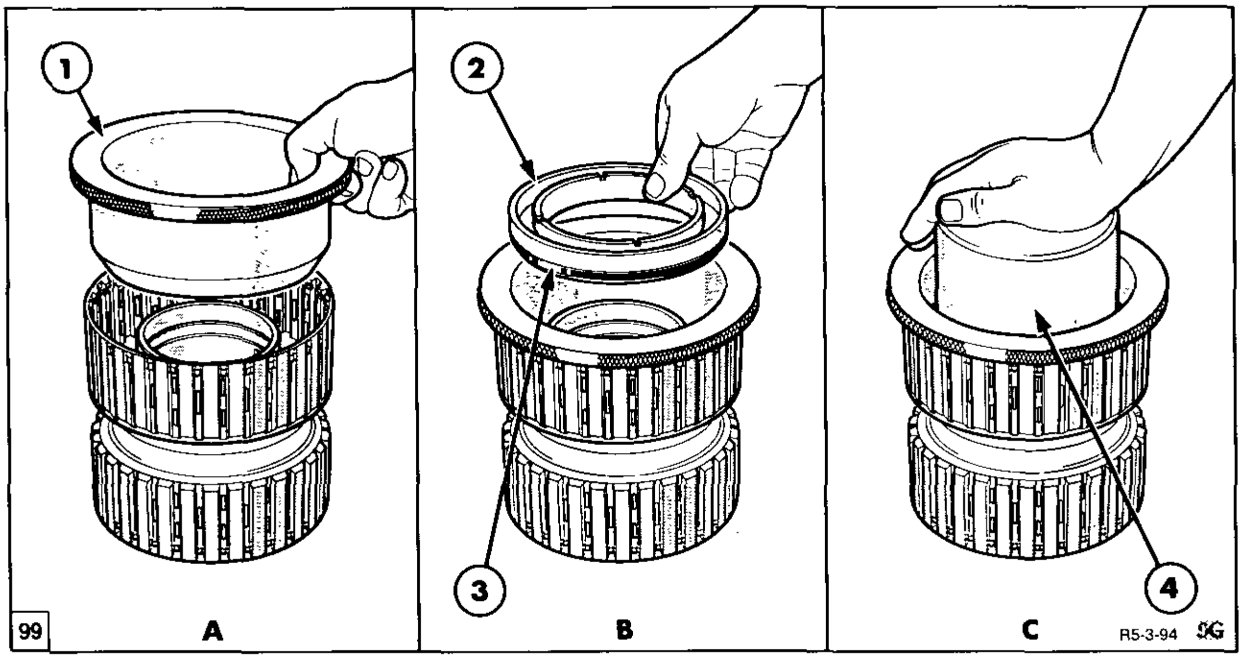
C3/C4 Clutch Assembly – Re–assembly

Use the sectional illustration in Figure 98 to aid re–assembly.

1. Re–assembly of the C3/C4 clutch assembly follows the disassembly procedure in reverse.

NOTE: *The C3/C4 clutches must be adjusted so that a specified piston movement or running clearance of the friction and separator plates is obtained. This piston movement or running clearance must be the same in both the C3 and C4 clutch packs. Pay particular attention when following the relevant re–assembly detail.*

2. Ensure all components are lubricated with transmission fluid prior to re–assembly.



Installing Pistons into C3/C4 Clutch Housing using Special Tools

1. Piston Guide Sleeve Special Tool No. 4FT 505
2. Piston
3. Piston Seal
4. Piston Pusher Special Tool No. 4FT 504

3. Install the piston and seal assemblies into the clutch housing as shown in Figure 99 and as follows:–

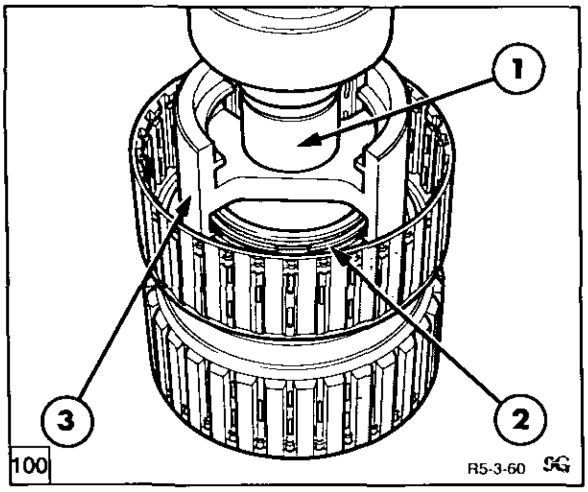
   a) Lubricate piston inner seal inside the clutch housing and check that the seal is resized.

   b) Position the piston guide sleeve Special Tool No. 4FT 505 on top of the clutch housing and lubricate the inside of the tool.

   c) Position the piston in the guide sleeve and using the piston pusher Special Tool No. 4FT 504, evenly and firmly, using hand pressure only, push the piston into the housing. Remove the guide sleeve and pusher.

IMPORTANT: *If more than hand pressure is required to install the piston, this is indicating that the piston inner or outer seal is mis–placed and will be damaged if the piston is forced into the clutch housing. Stop the procedure, remove the piston, reset the seal, add more lubricant and try again.*

4. Repeat the process on the second clutch piston.



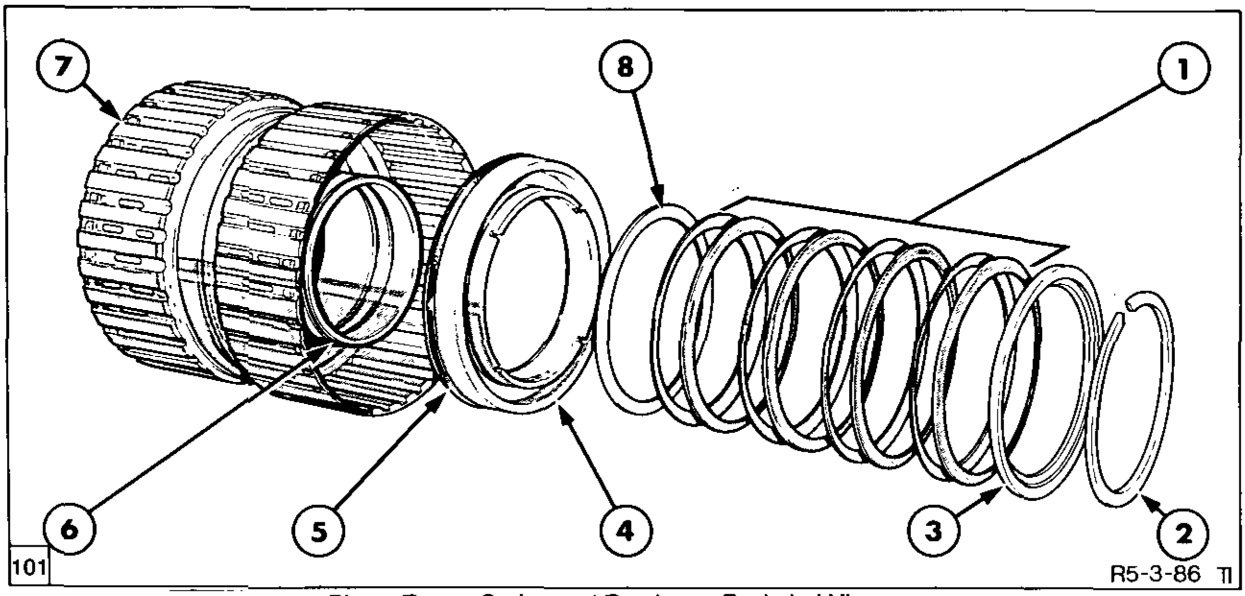
Compressing Piston Return Belleville Washers and Installing Snap Ring

1. Press
2. Snap Ring
3. Special Tool No. 4FT 508

5. Assemble the piston return spring assemblies by placing against each piston, a flat washer, eight belleville springs and a retainer, Figure 101.

6. Compress the spring assemblies in turn using a press and spring compressor Special Tool No. 4FT 508 and install the retaining snap ring, Figure 100. Ensure the snap ring is locked by the step in the retainer when the press is released. Repeat the operation on the second clutch.

7. Using a suitable adaptor press the clutch support shaft front ball bearing, item 15, into the clutch housing and secure with the snap ring, item 16, Figure 98.

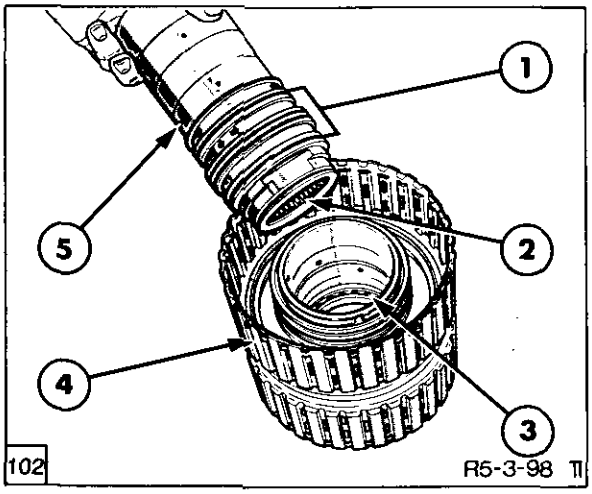


Piston Return Spring and Retainer – Exploded View

1. Belleville Washers
2. Snap Ring
3. Snap Ring Retainer
4. Piston
5. Piston Outer seal
6. Snap Ring Groove
7. C3/C4 Clutch Body
8. Flat Washer

8. Using a suitable adaptor press the clutch support shaft front needle roller bearing into the support, item 18, Figure 98. Check the free running of the bearing after assembly.

9. Apply a liberal amount of petroleum jelly to the support shaft annular seals that were replaced during the inspection process and have been allowed to resize to the grooves. Check that the interlocking ends are engaged.

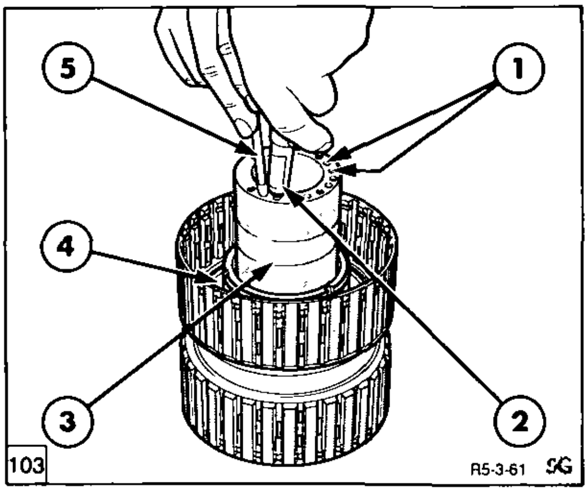


Installing C3/C4 Clutch Support Shaft into Clutch Housing

1. Annular Seals
2. Needle Roller Bearing
3. Ball Bearing
4. Clutch Housing
5. Support Shaft

10. With the clutch housing vertical and with the C4 clutch uppermost, Figure 102, very carefully assemble the support shaft through the clutch assembly from the C4 end so as not to damage the annular sealing rings. When the shaft contacts the front ball bearing, turn the assembly so that the shaft rests on the bench and push the clutch housing assembly downwards to enter the shaft through the bearing. Install the bearing to shaft snap ring, item 17, Figure 98.

11. The operation of the clutch pistons may be checked by applying air pressure to the clutch piston oil supply ports, Figure 103. Use an air pressure not exceeding 50 lbf/in^2 (3 bar) and check that the piston moves over its full travel and that there is no excessive leakage. Coating the inner and outer peripheries of the pistons with transmission fluid will serve to indicate any leakage. Note that each piston has two oil supply ports and one must be plugged during this test.



Applying Air Pressure to C3/C4 Clutch Pistons

1. Clutch Piston Ports
2. Air Nozzle (applied to second clutch)
3. Support Shaft
4. Clutch Piston
5. Plug (applied to piston 2nd feed port)

C3/C4 Clutch Piston Movement Adjustment

IMPORTANT: *Each of the two clutch packs must be adjusted to achieve optimum piston movement or running clearance.*

This is achieved by:–

a) assembling the friction plates, the separator plates (with coil springs), the separator plates (without coil springs) and the pressure plate with the respective locking device (rotating ring for C3 but without the locking screws installed and snap ring for C4), and

b) by compressing the pressure plate against the three coil sprung separator plates and against the piston as the base, and then

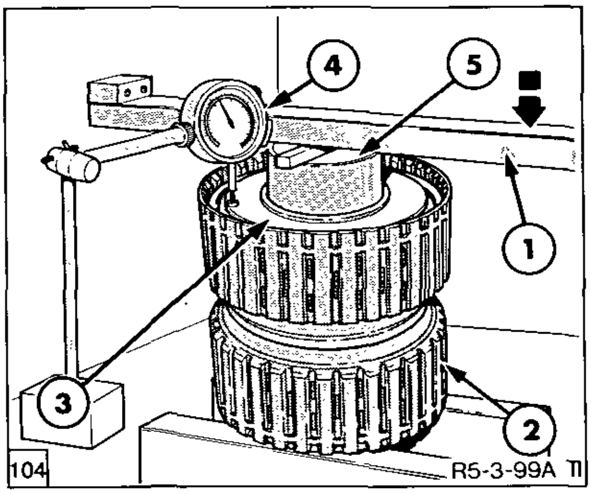
c) measuring the amount of compression with a simple dial indicator.

The resultant reading will equate to the piston movement to compress the clutch pack, as if the piston was applied hydraulically. When this reading is compared to the specification it will indicate the variance in thickness of steel separator plates (plates without coil springs) required, to bring the clutch pack to optimum piston movement. These separator plates are available in two thicknesses 2.76–2.80mm and 2.26–2.30mm.

This measurement procedure **must** be performed without the clutch hubs installed.

1. Three of the seven intermediate plates of each clutch, have 16 small coil springs attached to the outer periphery of the plate and the pressure plate (end plate) has similar half springs screwed into it. Ensure these springs are in place and secure. Install the separator plates and friction plates in the order shown in Figure 105, to the C3 clutch. **Do not install the hub at this point.**

2. Install the pressure plate into the clutch housing and by hand, press the pressure plate to compress the separator springs sufficiently so that the rotatable locking ring, item 14, Figure 98, can be installed and rotated into its location (see also Figure 107).



Compressing Clutch Plates with Simple Lever System to Determine Piston Movement

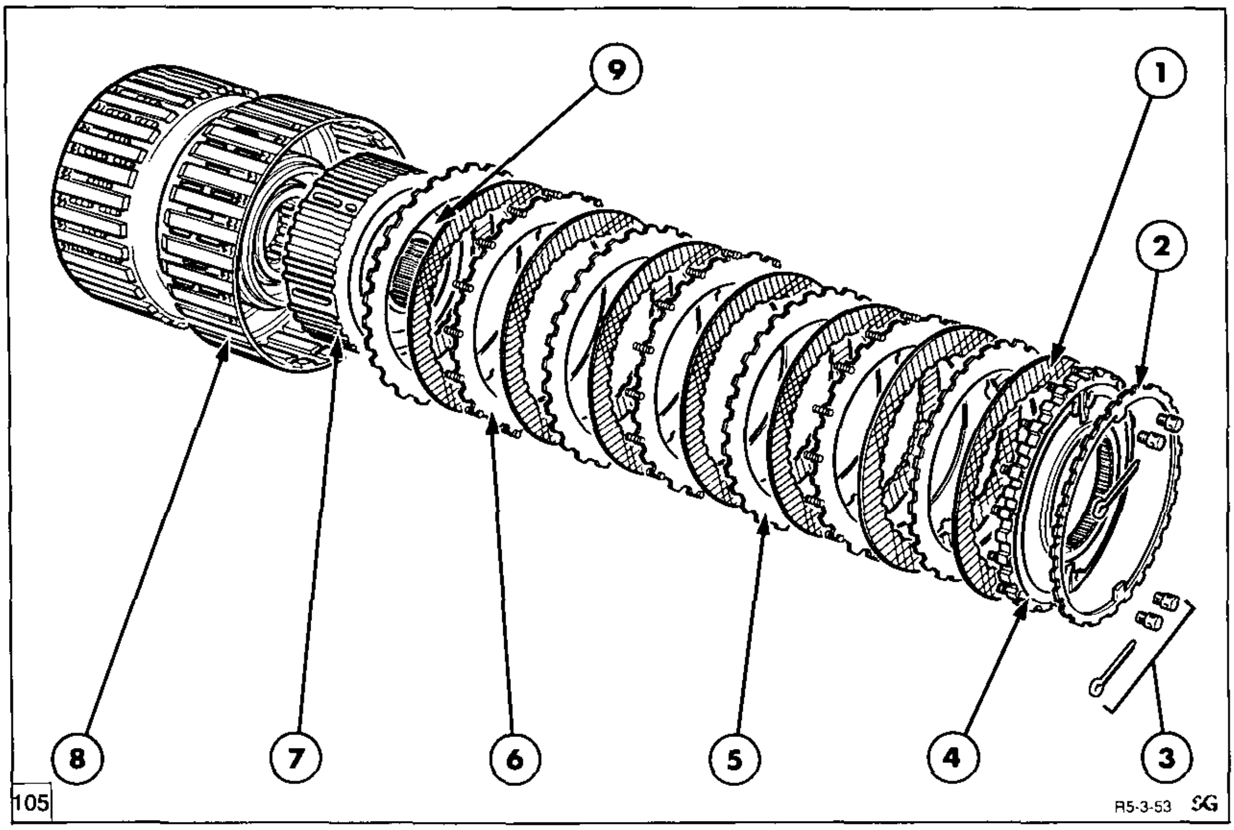
1. Lever
2. Clutch Housing
3. Pressure Plate
4. Dial gauge (magnetic base)
5. Round Adaptor (to press centrally)

Do not install the four pressure plate retaining ring locking screws as these could prevent movement of the pressure plate during the following measuring process.

3. Position the clutch assembly with the C3 clutch end uppermost under a suitable lever assembly as shown in Figure 104. Such a lever device could be as shown in the illustration and with a dial indicator positioned as shown, press down on the pressure plate until the plates have 'bottomed' against the piston. Record the dial gauge reading. **Do not use excessive force.**

4. If the dial gauge reading is between 0.10–0.12 in. (2.50–3.05mm) the resultant piston movement is within specification.

5. If the reading is outside the above figure, install one or more of the alternate thickness plates to bring the reading to specification. For example, of the four steel plates without separator springs one might be of the 2.76–2.80mm. thickness and three might be of the 2.26–2.30mm. thickness or two of each, etc.



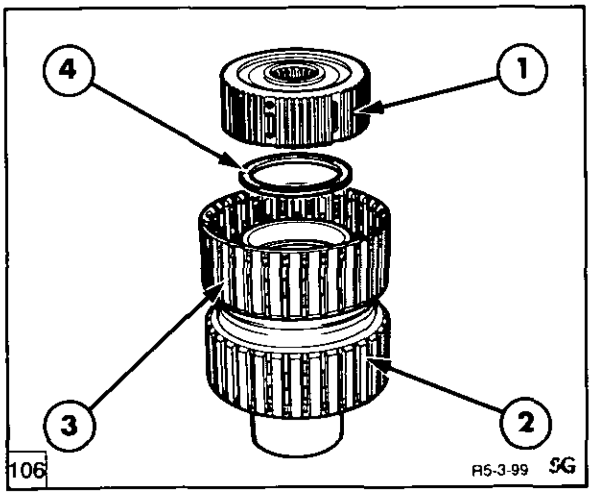
C3 Clutch Friction and Separator Plates – Assembly Order

1. Friction Plates
2. Pressure Plate Locking Ring
3. Locking Ring Retaining Screws and Split Pin
4. Pressure Plate
5. Steel Plates x 4
6. Steel Plates with Separator Springs x 3
7. C3 Clutch Hub
8. C3/C4 Clutch Housing
9. Polyimide Thrust Washer (one each side of hub located in stepped recesses)

6. Repeat the above procedure on the C4 clutch. With this clutch, again the hub must not be installed and note that the pressure plate is retained by a snap ring. See the exploded view of this clutch in Figure 110.

7. Disassemble both the C3 and C4 clutches, removing the pressure plates, separator plate and friction plates. Keep the C3 and C4 clutch components matched to the respective clutches. Continue with the following re–assembly procedure.

8. Assemble the polyimide thrust washers, items 20 and 21, Figure 98, to the inner and outer stepped recesses on the C3 clutch hub. Retain the washer with petroleum jelly and install the clutch hub into the clutch housing, Figure 106.

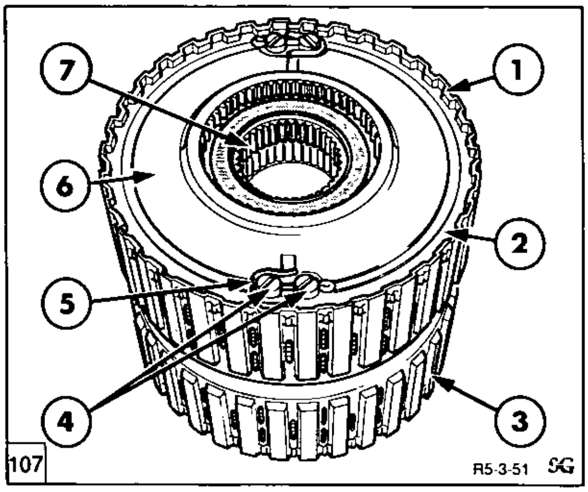


C3 Clutch Hub and Polyimide Thrust Washer Installation

1. Hub (note recess for polyimide thrust washer)
2. C4 Clutch End
3. C3 Clutch End
4. Polyimide Thrust Washer

9. Install the separator plates and friction plates in order as shown in Figure 105, to the C3 clutch.

10. Install the pressure plate into the clutch housing and by hand press the pressure plate to compress the separator springs sufficiently, so that the rotatable locking ring, item 14, Figure 98, can be installed and rotated into its location.



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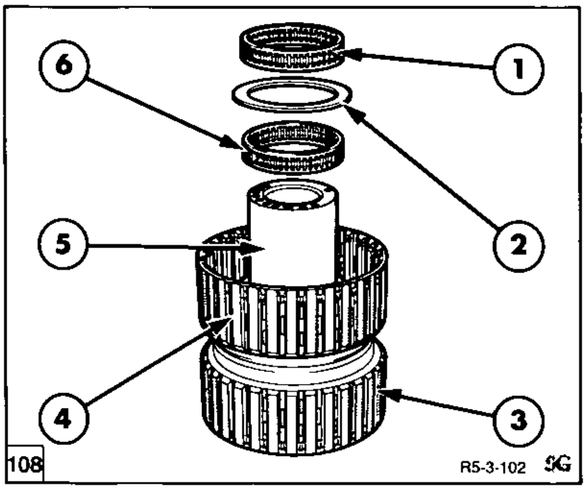
C3 Clutch Pressure Plate/Locking Ring Retention

1. C3 Clutch End
2. Locking Ring
3. C4 Clutch End
4. Retaining Screws
5. Split Pin
6. C3 Clutch Pressure Plate and C3/C4 Clutch Drive Input
7. C3 Clutch Hub

11. Install the locking ring retaining screws and tighten securely. Install the split pins through each pair of screws, fold back the pins to secure, Figure 107. It may be necessary to align the holes in the screws to allow the split pins to assemble.



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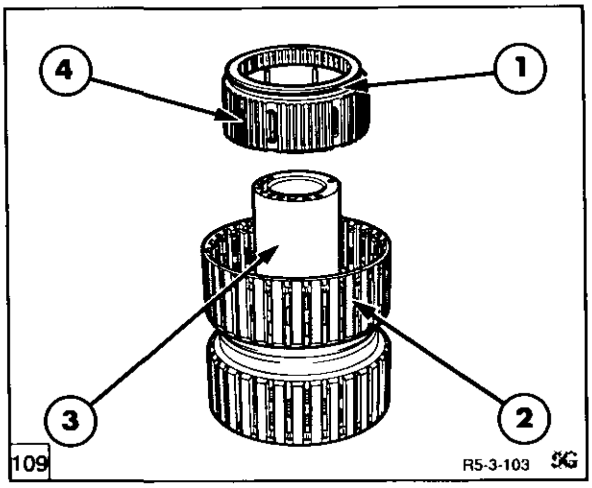
C4 Clutch to Support Needle Roller Bearing, Steel Thrust Washer and C4 Driven Gear to Support Shaft Needle Roller Bearing Installation

1. C4 Output Gear Front Needle Roller Bearing.
2. Steel Washer
3. C3 Clutch End
4. C4 Clutch End
5. Support shaft
6. C3/C4 Clutch to Support Shaft Needle Roller Bearing

12. Position the assembled C3 clutch and support assembly, with the C3 clutch face down on the work bench and slide onto the support shaft, the C4 clutch to support shaft needle roller bearing and the polyimide thrust washer and the C4 driven gear to support shaft needle roller bearing, note that these two bearings are identical, Figure 108.

13. Install the C4 clutch hub onto the support shaft ensuring that the previously assembled lube seal is in place, Figure 109.

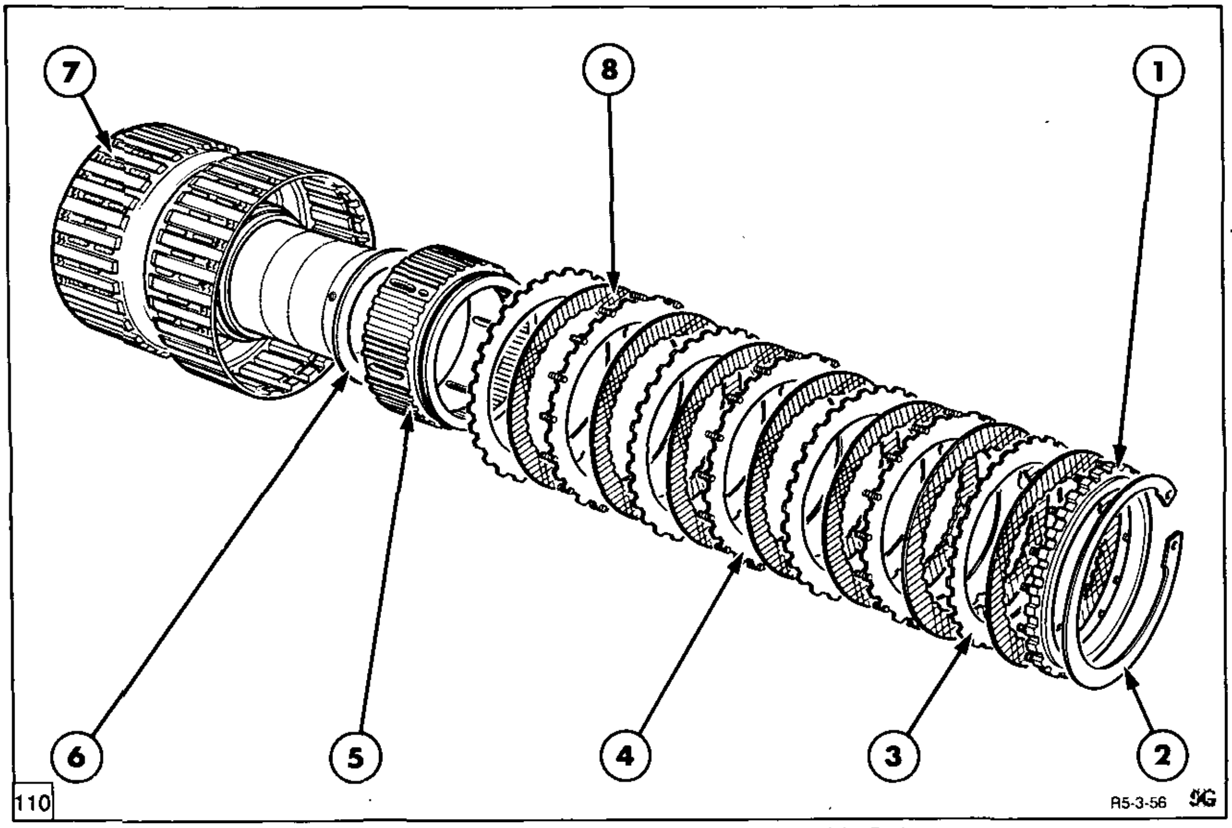


109

Assembling C4 Clutch Hub with Lube Seal to Support Shaft

1. Lube Seal
2. C4 Clutch End
3. Support Shaft
4. C4 Hub

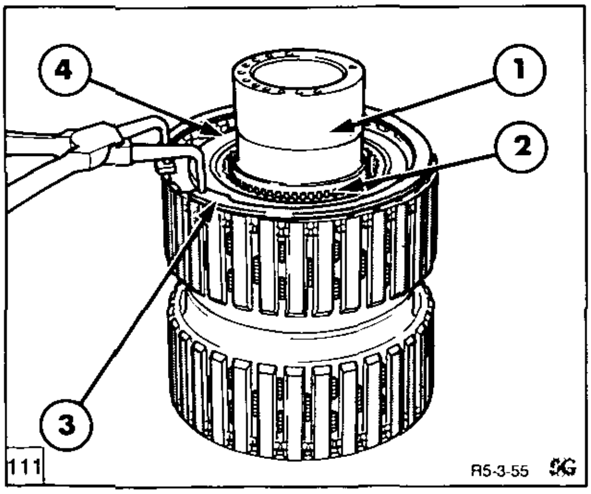
14. Assemble the C4 clutch separator plates, friction plates and pressure plate as shown in Figure 110. Note that the C4 clutch pack is identical to the C3 clutch with the exception of the pressure plate retention detail.



C4 Clutch Friction and Separator Plates – Assembly Order

1. Pressure Plate
2. Snap Ring
3. Steel Plates
4. Steel Plates with Separator Springs
5. Clutch Hub
6. Steel Washer
7. C3/C4 Clutch Housing
8. Friction Plates

15. Compress the pressure plate assembly sufficiently to install the conventional locking snap ring, Figure 111.



Removing C4 Clutch Pressure Plate Retaining Snap Ring

1. C3/C4 Clutch Support Shaft
2. Output Gear Front Needle Roller Bearing
3. Snap Ring
4. Pressure Plate

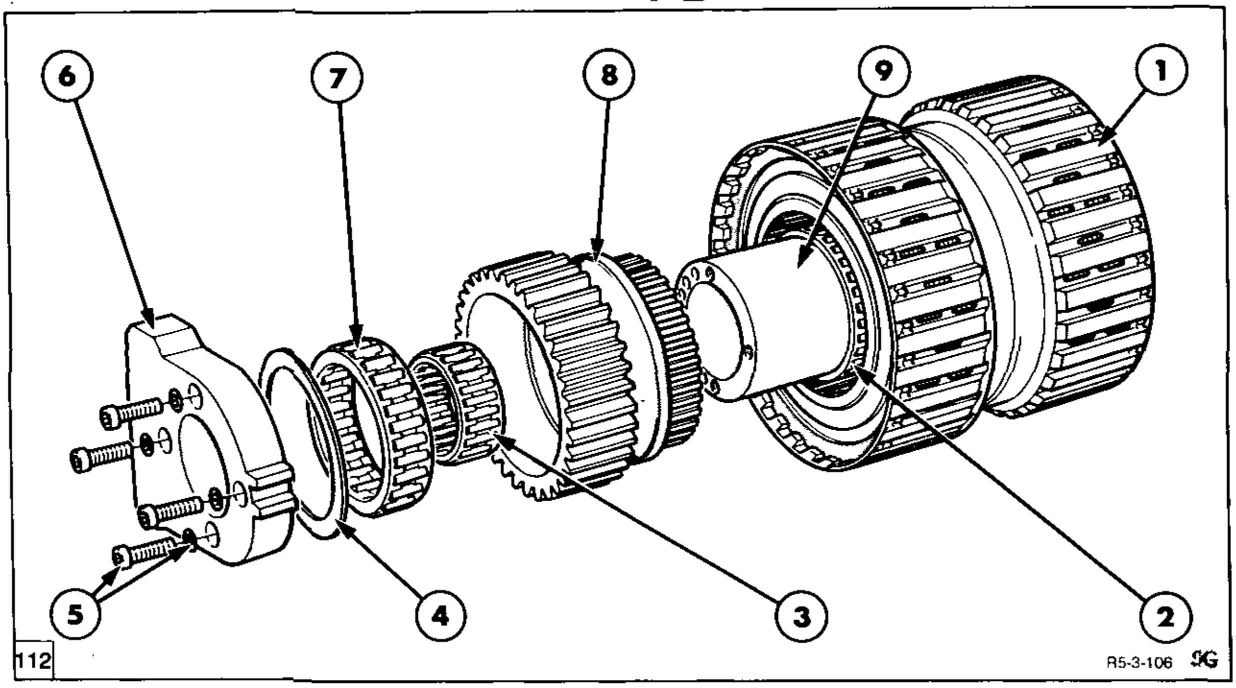
16. Assemble the C4 clutch driven gear, the gear to support shaft needle roller bearing, the support shaft to C3 driven gear needle roller bearing and the polyimide thrust washer, Figure 112. See also items 4, 5, 6, and 31 in Figure 98.

17. Assemble the previously inspected manifold and valve to the support shaft. Install the four securing hex head screws and lock washers and tighten to 4.5 – 8.0 lbf ft (6–8N m).

18. Finally, ensure the clutch assembly is free to rotate on its support shaft without binding and that a small amount of axial end float for the C4 driven gear exists.

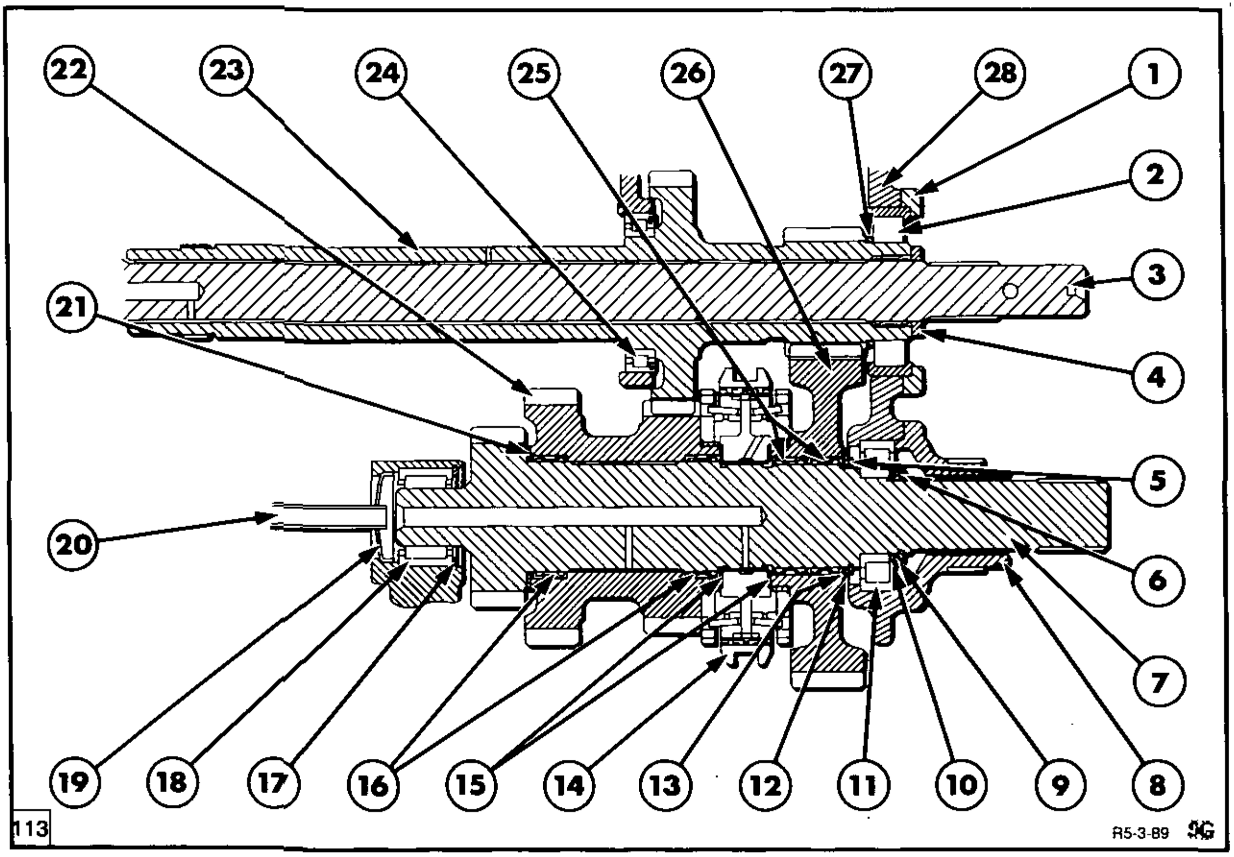
Output Shaft and High/Low Range Synchroniser – Re-Assembly

Use the sectional illustration in Figure 113 to aid re-assembly and note the following items, giving them special attention:–



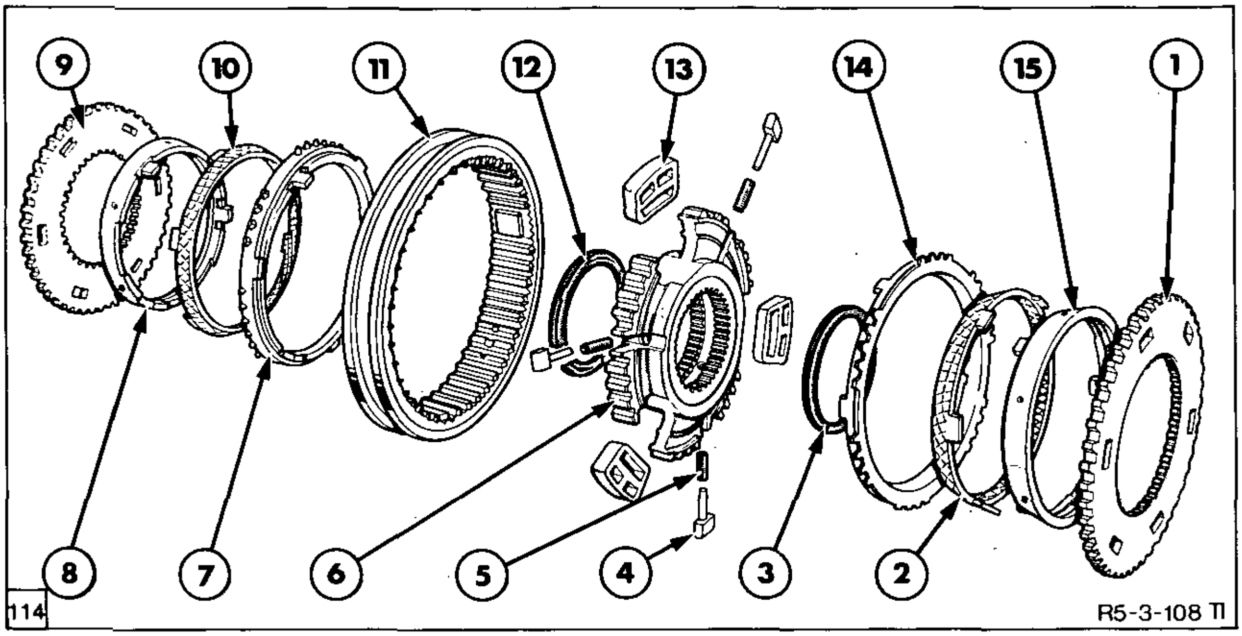
C4 Clutch Driven Gear, Gear Bearing, C3 Driven Gear Bearing and Polyimide Thrust Washer

1. C3/C4 Clutch Assembly
2. C4 Driven Gear Front Bearing
3. C3 Driven Gear to Support Shaft Rear Bearing
4. Polyimide Thrust Washer
5. Manifold Retaining Screws and Washers
6. Manifold
7. C4 Driven Gear Rear Bearing
8. C4 Driven Gear
9. Support Shaft



Output Shaft and High/Low Range Synchroniser

1. Top Shaft Bearing Retainer
2. Roller Bearing
3. PTO/Input Shaft
4. Polyimide Thrust Washer
5. Snap Ring
6. Snap Ring
7. Output Shaft
8. Retainer/Pump Idler Gear Support
9. 'D' Shaped Steel Washer
10. Bearing Loose Thrust
11. Roller Bearing
12. 'D' Shaped Steel Washer (various thicknesses)
13. Polyimide Thrust Washer
14. High/Low Range Synchroniser
15. Polyimide Thrust Washers
16. Needle Roller Bearings
17. Snap Ring
18. Roller Bearing
19. Lube Tube Cup plug
20. Lube Tube
21. Polyimide Thrust Washer
22. Two Gear Cluster
23. C3 Clutch Output Shaft
24. Roller Bearing
25. Needle Roller Bearings
26. Low Range Gear
27. Spacer
28. Rear Cover Plate



High/Low Range Synchroniser – Exploded View

1. End Plate
2. Inner Powdered Metal Friction Cone
3. Polyimide Washer
4. Pin x 3
5. Spring x 3
6. Centre Hub
7. Inner Blocker Ring
8. Outer Steel Blocker Ring
9. End Plate
10. Inner Powdered Metal Friction Cone
11. Sliding Coupler
12. Polyimide Washer
13. Drive Lugs x 3
14. Inner Blocker Ring
15. Outer Steel Blocker Ring

1. Position the needle roller bearings in each end of the two gear cluster, securing them with petroleum jelly.

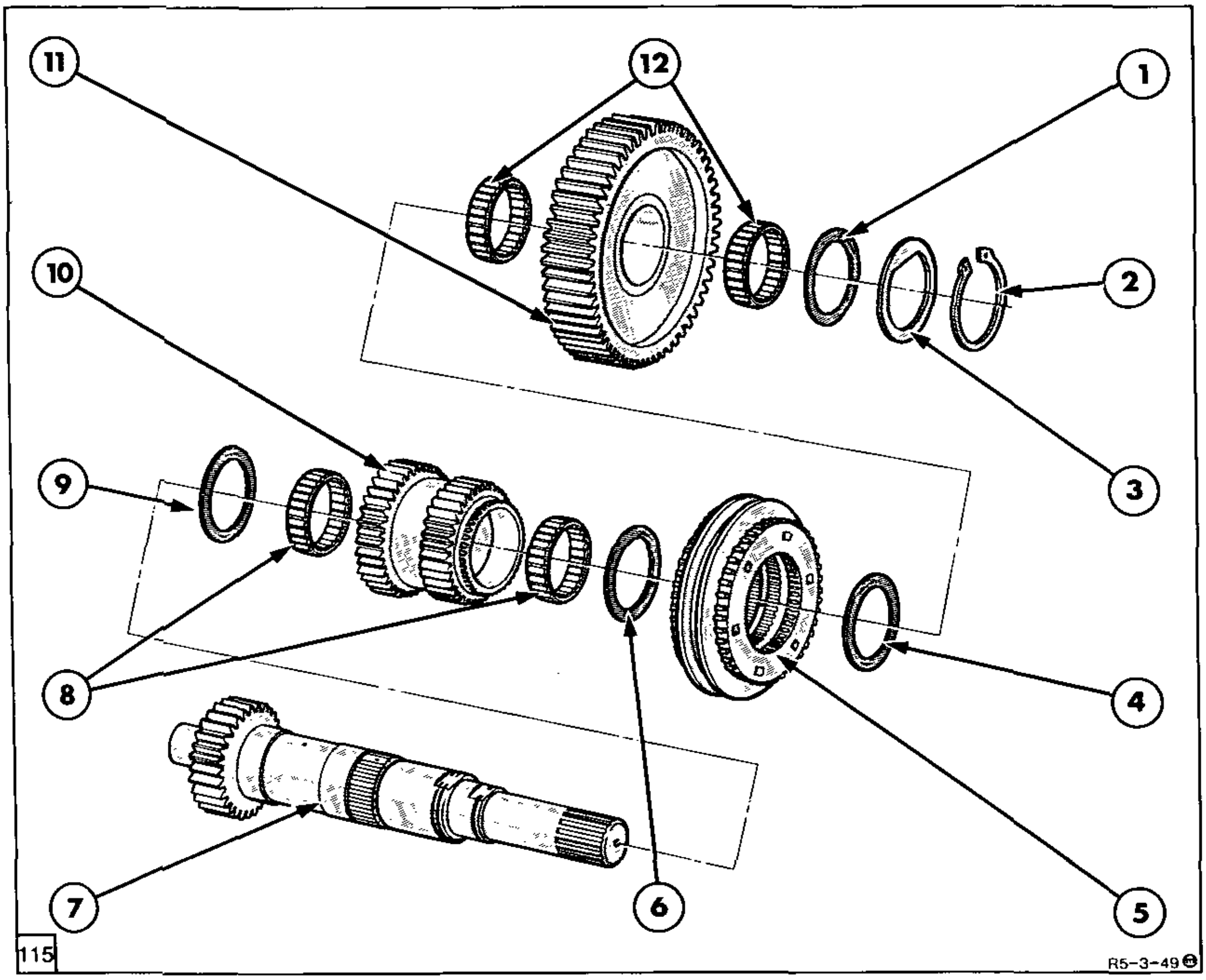
2. Position the polyimide thrust washer, item 21, Figure 113, on the shaft and slide on the two gear cluster and its needle roller bearings.

3. Re–assemble the high/low range synchroniser following the exploded view in Figure 114.

4. Using petroleum jelly, position the two polyimide thrust washers, items 15, Figure 113, in the recesses on the synchroniser hub and slide the assembly onto the shaft, locating with the two gear cluster.

5. Position the two needle roller bearings, item 25, Figure 113, of the large output gear (low range), on the shaft and slide on the gear carefully locating it on the bearings and with the synchroniser. An exploded view of the output shaft assembly is shown in Figure 115.

6. Add the polyimide thrust washer and the original shim washer followed by the retaining snap ring. If it is not possible to install the snap ring use a thinner shim washer, then install the snap ring.



Output Shaft and High/Low Range Synchroniser – Exploded View

1. Polyimide Thrust Washer
2. Snap Ring
3. 'D' Shaped Steel Washer (various thicknesses)
4. Polyimide Thrust Washer
5. Synchroniser
6. Polyimide Thrust Washer
7. Output Shaft
8. Needle Roller Bearings
9. Polyimide Thrust Washer
10. Two Gear Cluster
11. Low Range Output Gear
12. Needle Roller Bearings

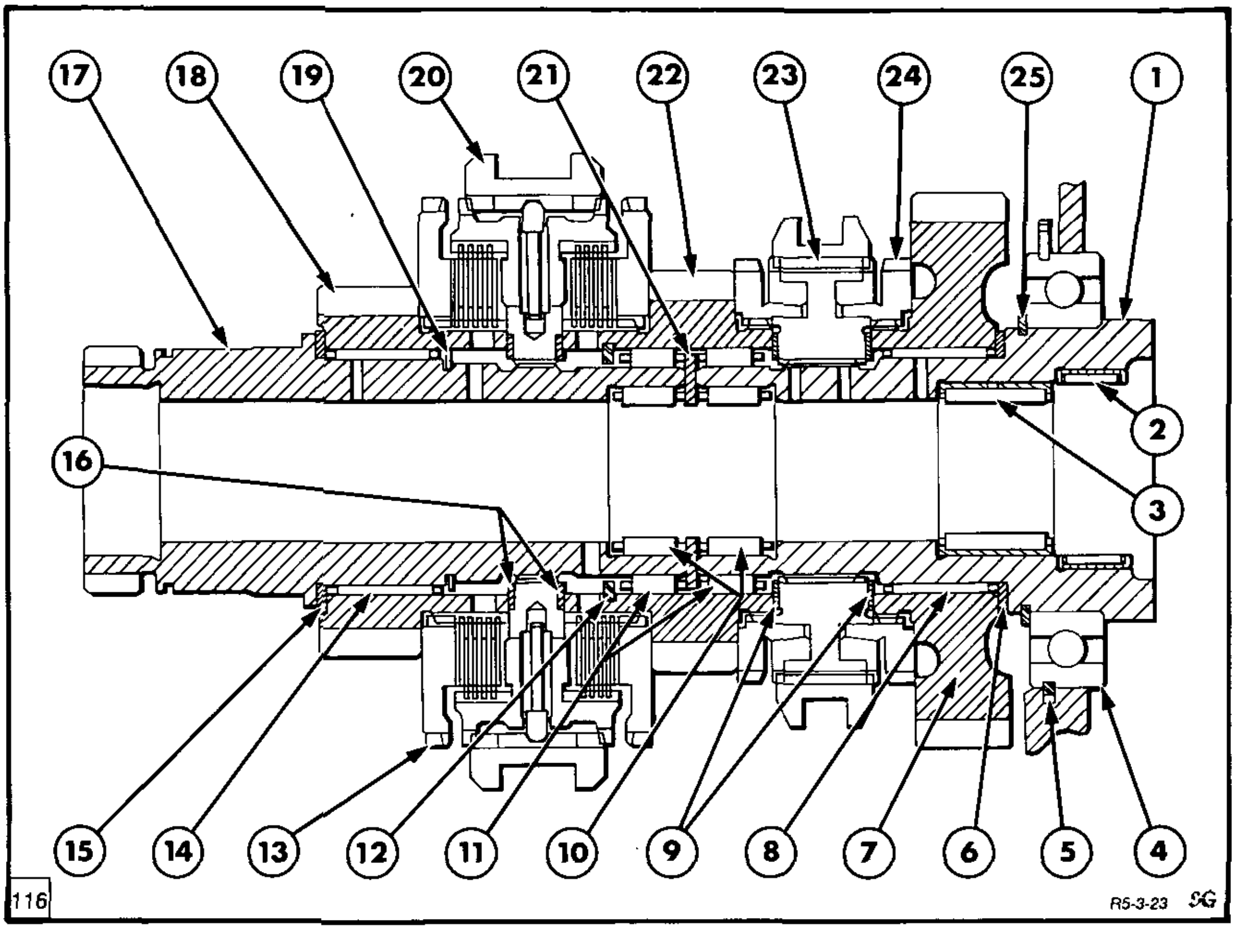
7. Check the shaft assembly axial free play by bumping the output shaft spline end on a firm, but not hard surface and measure the gap between the two gear cluster and the front gear of the shaft. use feeler gauges to check this gap. The gap should be between 0.004–0.012in (0.10–0.30mm). If the gap is not within this limit adjust the value of the shim washer by using an alternative. The shim washer is available in the following thicknesses:–

0.079–0.080in.	(2.00–2.04mm)
0.085–0.086in.	(2.15–2.19mm)
0.091–0.092in.	(2.30–2.34mm)
0.097–0.098in.	(2.45–2.49mm)
0.102–0.104in.	(2.60–2.64mm)

Forward/Reverse and Main Range Synchronisers and Associated Gears and Bearings – Re–assembly

1. Re–assembly of the forward/reverse and main range synchronisers follows the disassembly procedure in reverse.

2. Ensure all components are lubricated with transmission fluid prior to re–assembly.



Forward/Reverse and Main Range Synchroniser Assemblies – Sectional View

1. Main Range Synchroniser Support
2. Needle Roller Bearing
3. Needle Roller Bearing
4. Main Range Synchroniser Support Bearing
5. Bearing to Casing Snap Ring
6. Thrust Washer
7. Driven Gear – Low
8. Needle Roller Bearing
9. Polyimide Thrust Washers
10. Main Range and Forward/Reverse Synchroniser Support to PTO/Input Shaft Needle Roller Bearings
11. Needle Roller Bearing
12. Needle Roller Bearing Retaining Snap Ring
13. Forward/Reverse Synchroniser Coupling
14. Needle Roller Bearing
15. Thrust Washer
16. Polyimide Thrust Washers
17. Forward/Reverse Synchroniser Support
18. Reverse Driven Gear
19. Needle Roller Bearing Retaining Snap Ring
20. Forward/Reverse Synchroniser
21. Steel Thrust Washer
22. Driven Gear – High
23. Main Range Synchroniser
24. Main Range Synchroniser Coupler
25. Main Range Synchroniser Support Bearing Retaining Snap Ring

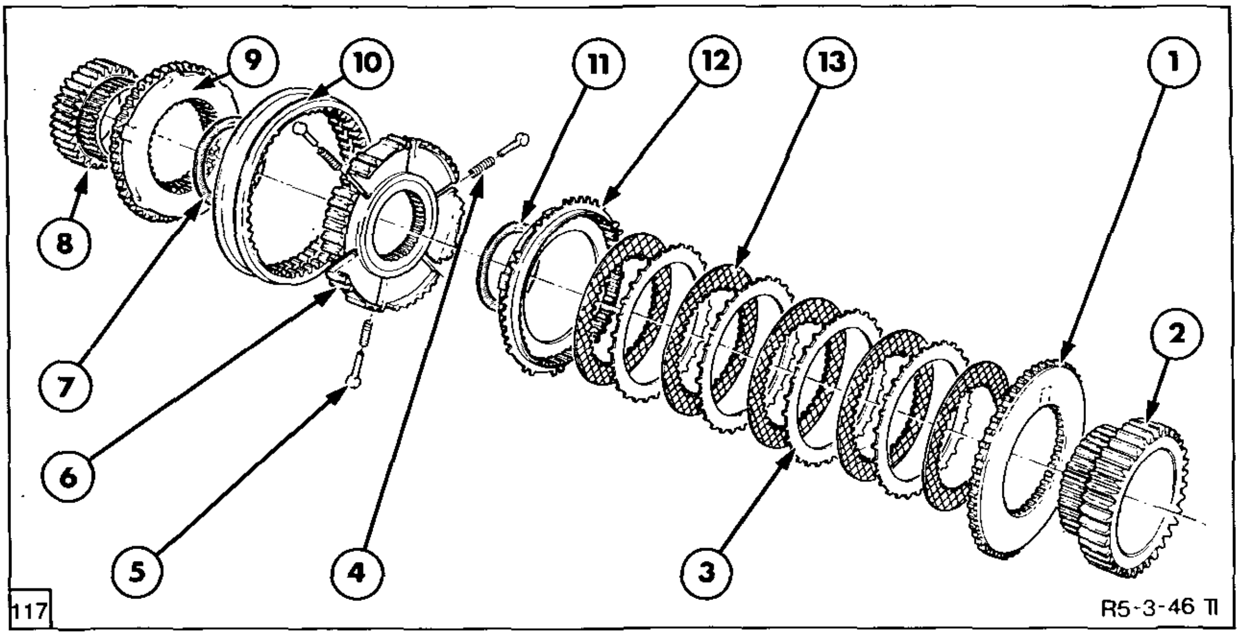
3. Use the exploded views in Figure 117 and Figure 118 to aid re–assembly.

4. Pay particular attention to assembly of the forward reverse synchroniser noting the following:–

– Install two polyimide thrust washers in the recesses each side of the central hub, use petroleum jelly to adhere these washers.

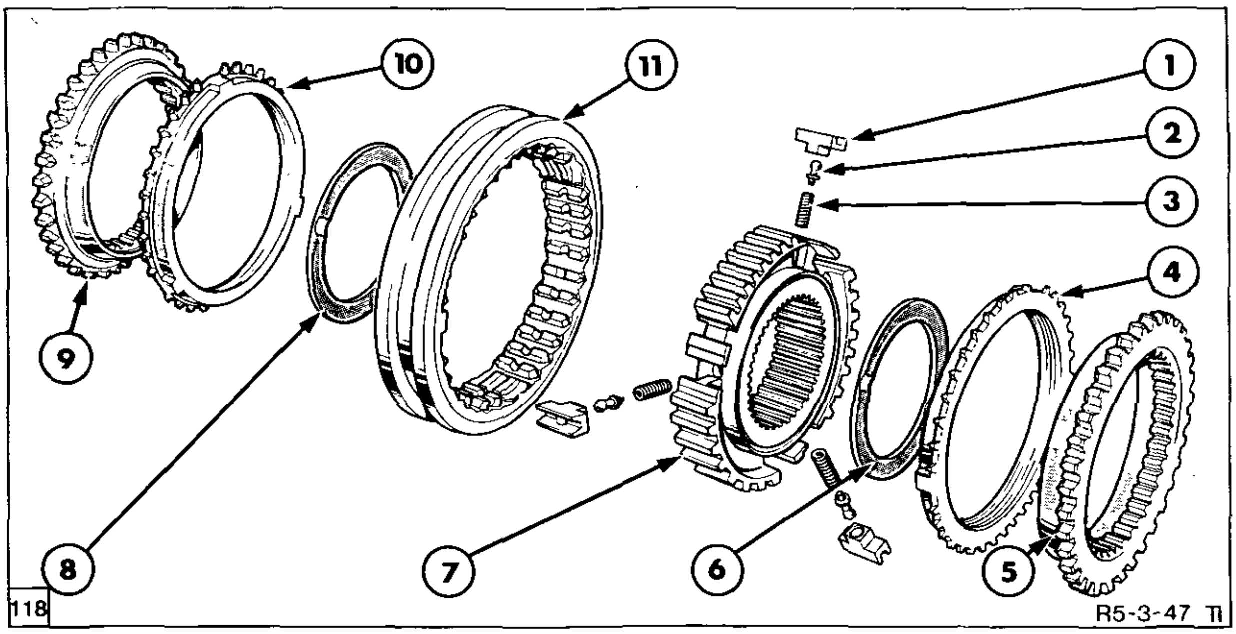
– Carefully assemble the springs and pins to the centre hub and install this into the sliding coupling.

– The re–assembly of the synchroniser plates would be best left to just prior to installation to ensure that the assembly is correct. However, if required assemble the two clutch pack assemblies as shown in Figure 143 on page 99.



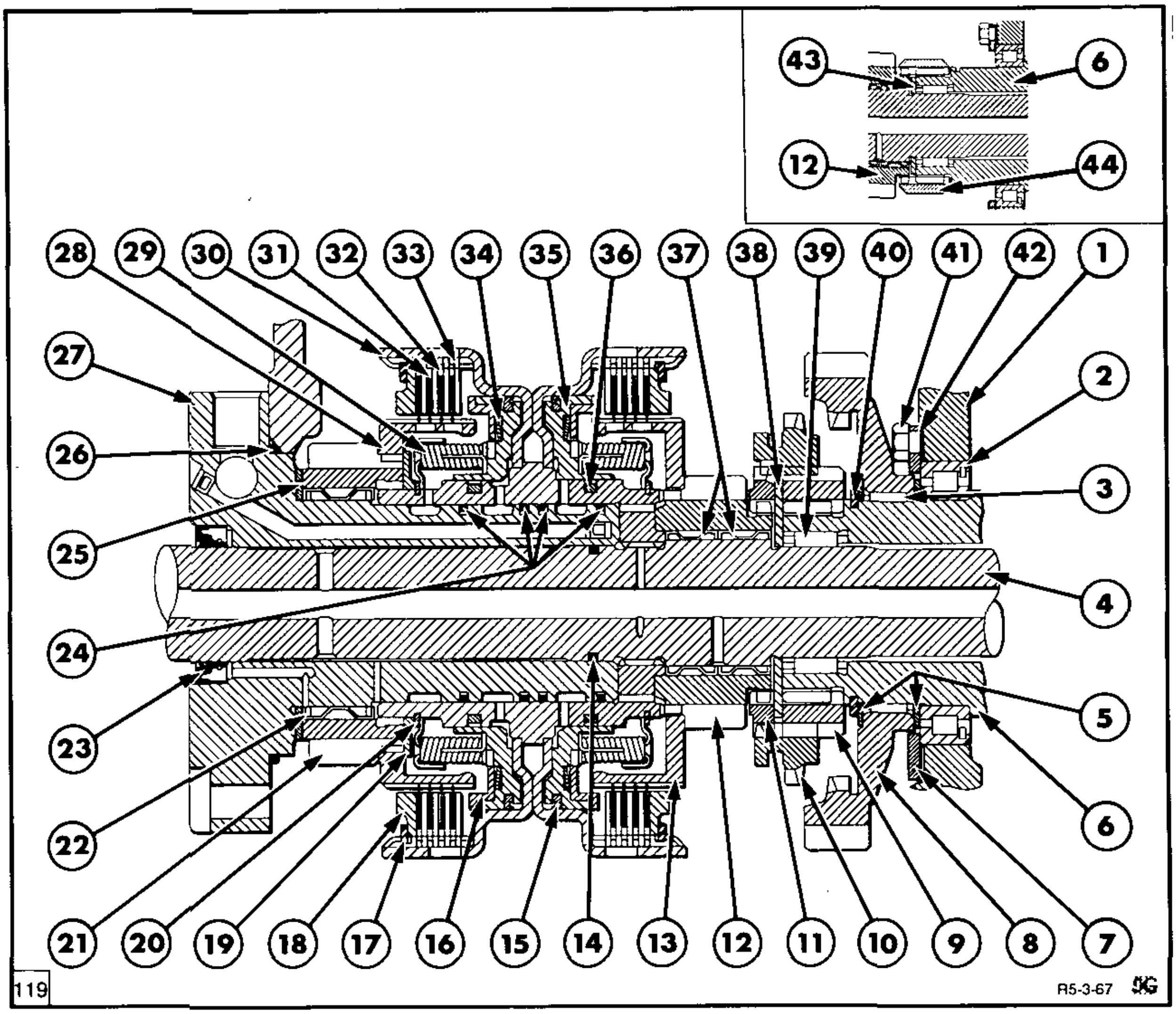
Forward/Reverse Synchroniser – Exploded View

1. End Plate (part of forward synchro pack)
2. Forward Driving Gear
3. Steel Plate x 4 (each)
4. Spring
5. Pin
6. Centre Hub
7. Polyimide Thrust Washer
8. Reverse Driving Gear
9. Reverse Synchro Clutch Pack
10. Sliding Coupler
11. Polyimide Thrust Washer
12. Housing
13. Friction Plate x 5 (each)



Main Range Synchroniser – Exploded View

1. Detent Guide
2. Detent Pin
3. Spring
4. Friction Cone
5. Outer Cone/Coupling
6. Polyimide Thrust Washer
7. Centre Hub
8. Polyimide Thrust Washer
9. Outer Cone/Coupling
10. Friction Cone
11. Sliding Coupler



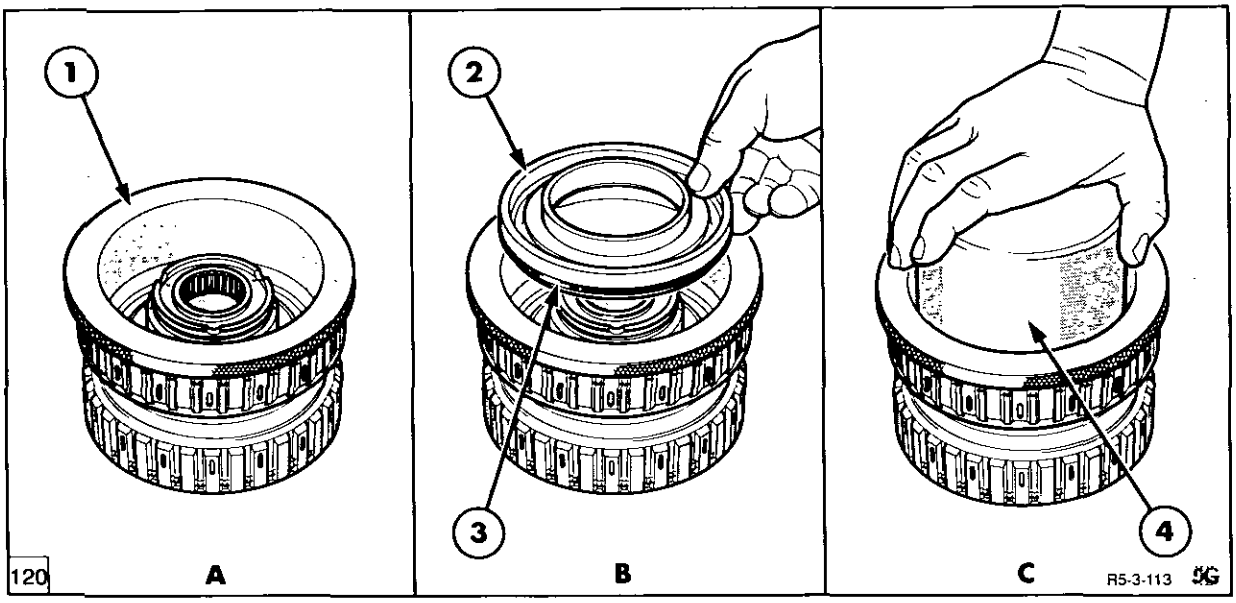
C1/C2 Clutch and Creeper Coupling (inset shows non creeper coupling) – Sectional View

1. Intermediate Cover Plate
2. Forward Reverse Synchroniser Support Shaft Front Roller Bearing
3. Creeper Gear Needle Roller Bearing
4. PTO/Input Shaft
5. Steel Thrust Washers
6. Forward Reverse Synchroniser Support Shaft
7. Bearing Retaining Plate
8. Creeper Gear
9. Creeper Coupler (part of)
10. Creeper Coupler (part of)
11. Creeper Coupling (part of)
12. C2 Clutch Driven Gear
13. C2 Clutch Hub
14. Lube Oil Seal
15. Piston Outer Seal
16. Outer Piston Half
17. Pressure Plate Snap Ring
18. Pressure Plate
19. Stepped Steel Ring
20. Return Spring Snap Ring
21. C1 Clutch Driven Gear
22. C1 Driven Gear Needle Roller Bearing
23. Input/PTO Shaft Lip Seal
24. Annular Sealing Rings
25. Polyimide Thrust Washer
26. Shaft Support to Front Cover 'O' Ring Seal
27. Clutch Support Shaft Assembly
28. C1 Clutch Hub
29. Piston Return Spring Assembly
30. C1/C2 Clutch Body
31. Steel Separator Plate x 4 per clutch
32. Friction Plate x 4 per clutch
33. Separator Spring x 4 per clutch
34. Inner Piston Half
35. Belleville Spring
36. Clutch Piston Inner Seal and Energiser
37. C2 Driven Gear Needle Roller Bearings
38. Steel Washer (creeper transmissions)
39. Forward/Reverse Support Shaft Input Coupler Teeth
40. Creeper Gear Retaining Snap Ring
41. Bearing Retaining Plate Bolt
42. Shims
43. Polyimide Thrust Washer (non creeper transmissions)
44. Coupler (non creeper transmissions)

C1/C2 Clutch Assembly, Front Lower Shaft and Creeper Components (where fitted) – Re –Assembly

Use the sectional illustration in Figure 119 to aid re–assembly.

1. Re–assembly of the C1/C2 clutch assembly follows the disassembly procedure in reverse.
2. Ensure all components are lubricated with transmission fluid prior to re–assembly.



Installing Pistons into C1/C2 Clutch Housing using Special Tools

1. Piston Guide Sleeve Special Tool No. 4FT 506
2. Piston
3. Piston Outer Seal
4. Piston Pusher Special Tool No. 4FT 504

3. Install the piston and seal assemblies into the clutch housing as shown in Figure 120 and as follows:–

   a) Lubricate the piston inner seal inside the clutch housing and check that the seal is resized.

   b) Position the piston guide sleeve Special Tool No. 4FT 506 on top of the clutch housing and lubricate the inside of the tool.

   c) Position the piston in the guide sleeve and using the piston pusher Special Tool No. 4FT 504, evenly and firmly, using hand pressure only, push the piston into the housing. Remove the guide sleeve and pusher.

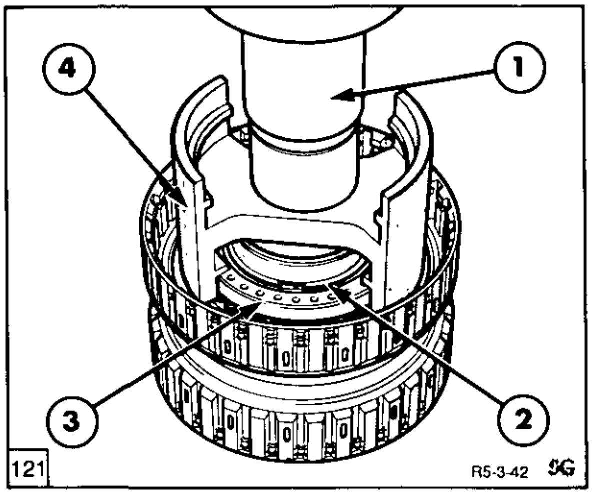
IMPORTANT: *If more than hand pressure is required to install the piston, this is indicating that the piston inner or outer seal is proud and will be damaged if the piston is forced into the clutch housing. Stop the procedure, remove the piston, reset the seal, add more lubricant and try again.*

4. Position the piston cushioning belleville spring on top of the main piston so that the outer edge of the belleville is uppermost and that the inner diameter is resting on the piston and install the outer part of the piston, see Figure 123.

5. Repeat the piston installation process on the second clutch piston.

6. Assemble the clutch return spring assembly onto the clutch housing and using a press and spring compressor Special Tool No. 4FT 508, compress the spring assembly and install the snap ring, Figure 121. Release the press and remove the tool.

7. Repeat the process for the second clutch.



Installing Piston Return Spring Assembly Retaining Snap Ring

1. Press
2. Snap Ring
3. Piston Return Spring Assembly
4. Spring Compressor Special Tool No. 4FT 508

8. The operation of the clutch pistons may be checked by applying air pressure to the clutch piston oil supply port, Figure 122. Use an air pressure not exceeding 50 lbf/in^2 (3 bar) and check that the piston moves over its full travel and that there is no excessive leakage. Coating the inner and outer peripheries of the pistons with transmission fluid will serve to indicate any leakage.

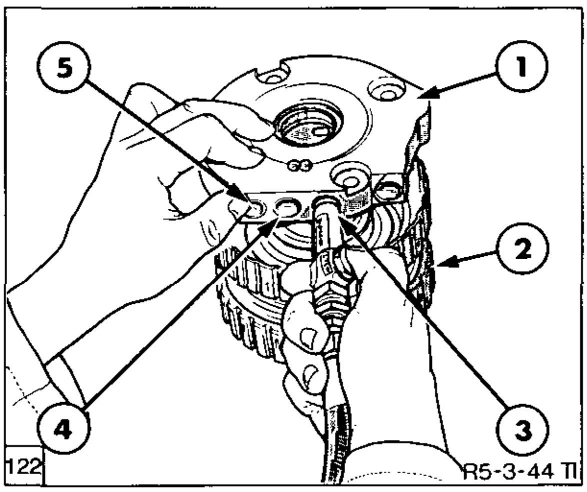
9. Install the separator plates, friction plates and separator springs followed by the pressure plates in the order shown in Figure 123. Note that care must be used when installing the last separating spring in that it does not get hooked in the snap ring groove.

10. Apply hand pressure to the clutch plate pack and install the retaining snap ring.

11. Repeat the operation on the second clutch.

12. Carefully install the C2 clutch hub to the C2 clutch, using a twisting motion to feel the hub through the clutch plate teeth, Figure 124.

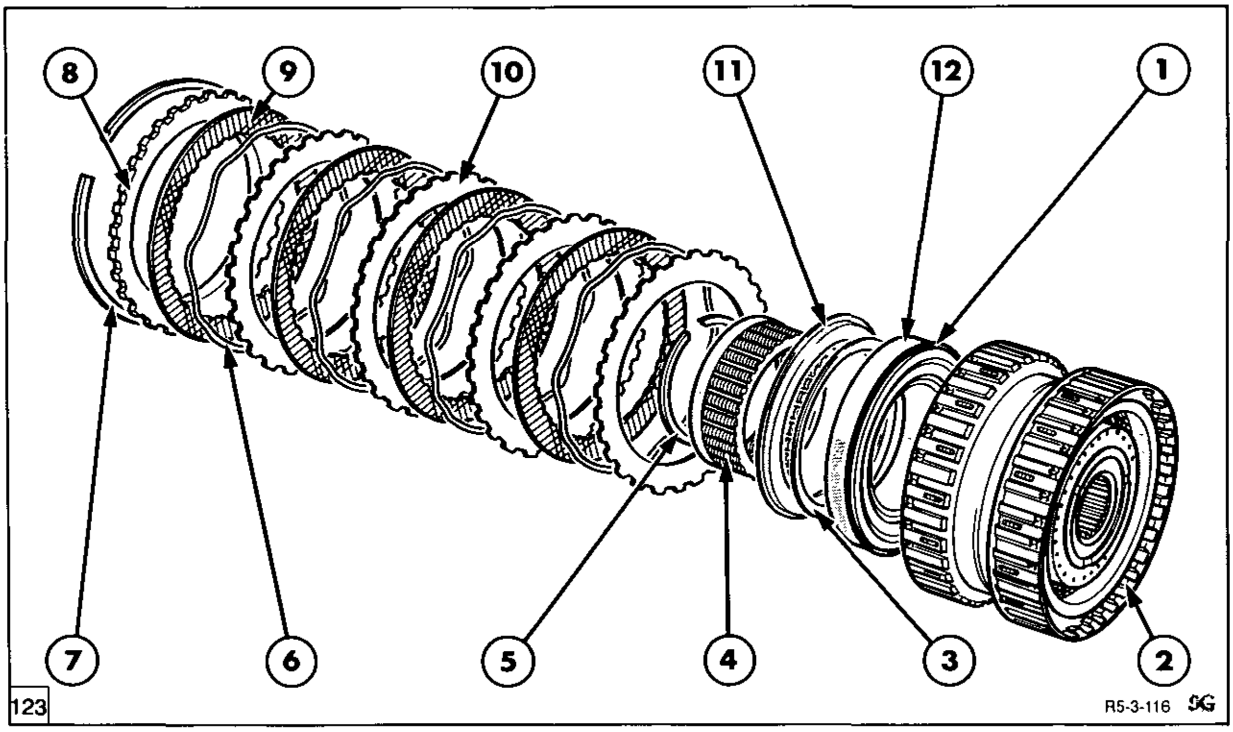
13. Install the washer with its relieved face against the piston return spring assembly of the C1 clutch and carefully install the C1 clutch hub. Again, use a twisting motion to feel the hub through the clutch plate teeth, Figure 124.



Applying Air Pressure to C1/C2 Clutch Pistons

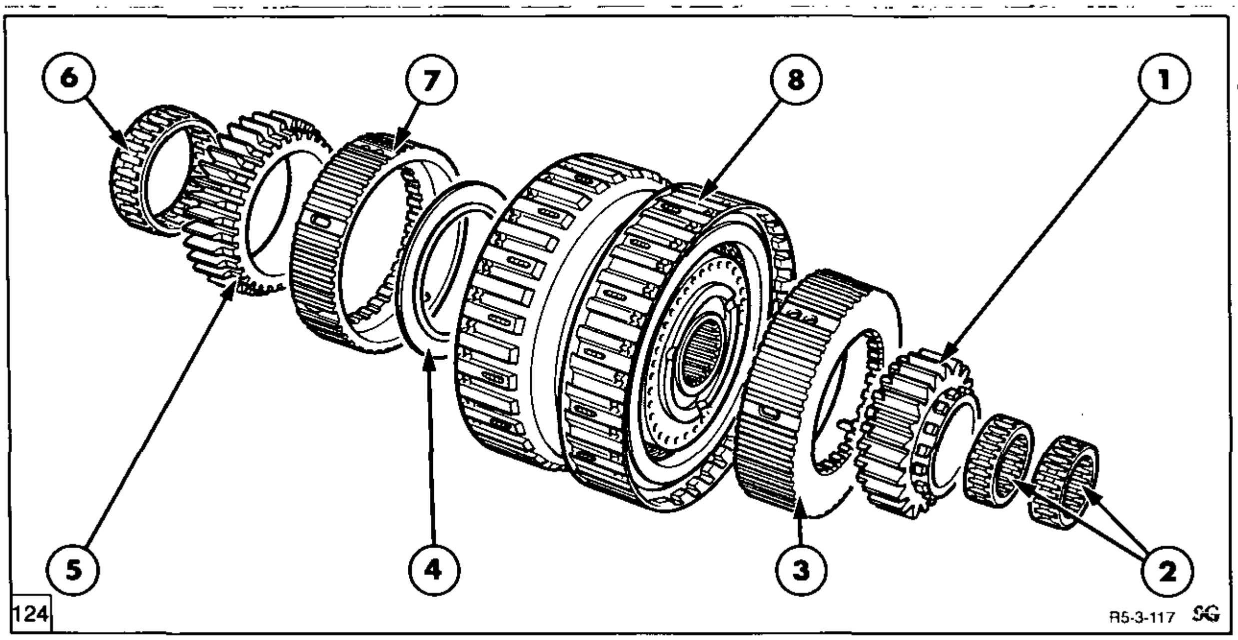
1. C1/C2 Clutch Support Shaft Assembly
2. C1/C2 Clutch Assembly
3. Air Nozzle (applied to C1 clutch piston oil feed port)
4. Lube Oil Port
5. C2 Clutch Piston Oil Feed Port

14. Tie the assembly together to avoid separation of the components prior to installation in the transmission.



C1/C2 Clutch Friction Plate, Separator Plate and Separator Spring Assembly Order – Exploded View

1. Piston Outer Seal
2. C1/C2 Clutch Housing
3. Belleville Washer
4. Piston Return Spring Assembly
5. Snap Ring
6. Wavy Spring x 4
7. Snap Ring
8. Pressure Plate
9. Friction Plate x 4
10. Separator Plate x 4
11. Outer Piston Half
12. Inner Piston Half



C1/C2 Clutch Hubs and Gears – Exploded View

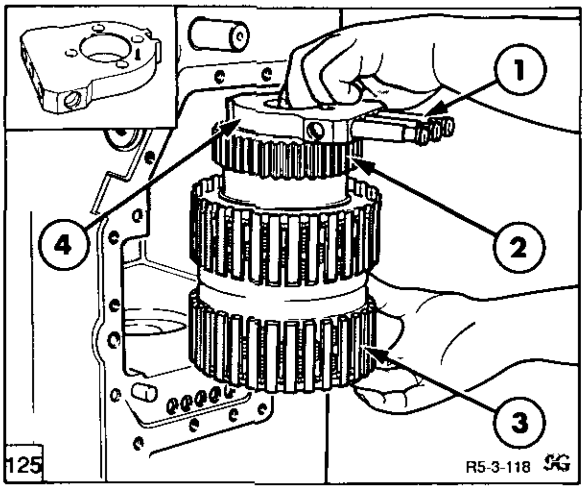
1. C2 Clutch Output Gear
2. Needle Roller Bearings
3. C2 Clutch Hub
4. Steel Washer (note step on inner side)
5. C1 Clutch Output Gear
6. Needle Roller Bearing
7. C1 Clutch Hub
8. C1/C2 Clutch Housing

INSTALLATION

IMPORTANT: *Cleanliness during overhaul is important. Ensure during the rebuilding stage that all contaminant is eliminated, working conditions are clean and that all tools used do not introduce contaminant into the previously cleaned components. Pay particular attention to the control valve when this is removed during this installation stage.*

C3/C4 Clutch Assembly – Installation

1. Position the transmission in a vertical plane with the rear uppermost.
2. Installation of the C3/C4 clutch and support shaft assembly follows the removal procedure in reverse.



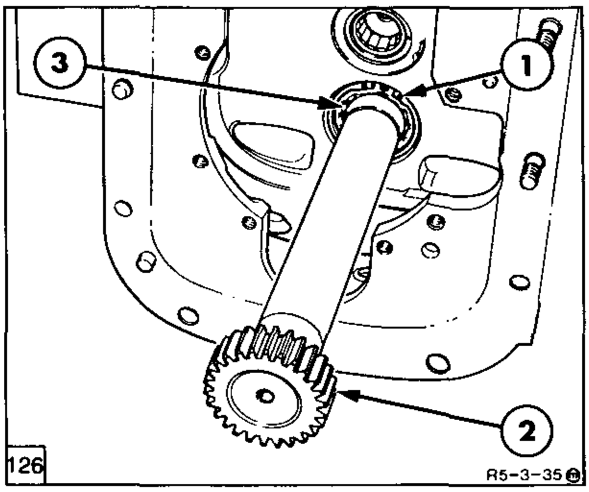
Installing C3/C4 Clutch,Support Shaft and Manifold Assembly (inset shows small pin on Manifold)

1. Oil Transfer Tubes
2. C4 Driven Gear
3. C3/C4 clutch Assembly
4. Manifold

3. Ensure that the small distance pin on the rear surface of the C3/C4 clutch assembly manifold is in place, see inset Figure 125.
4. Carefully support the clutch assembly when entering it into the transmission housing, Figure 125. Ensure the manifold locates with the removable locating pin on the left hand side of the transmission housing, if not previously removed ensure the seal of the locating pin is in good condition. Tighten the locating pin to 40–60 lbf ft (55–80N m).

Output Shaft and High/Low Range Synchroniser – Installation

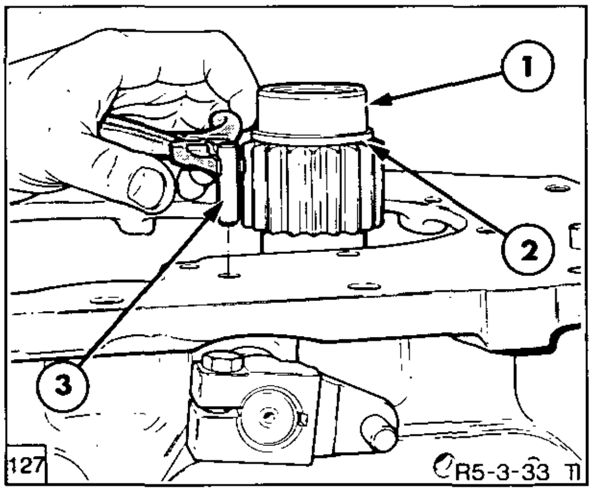
1. Position the transmission in a vertical plane with the rear uppermost.



Installing FWD Internal Shaft

1. Snap Ring
2. FWD Internal Shaft
3. Roller Bearing

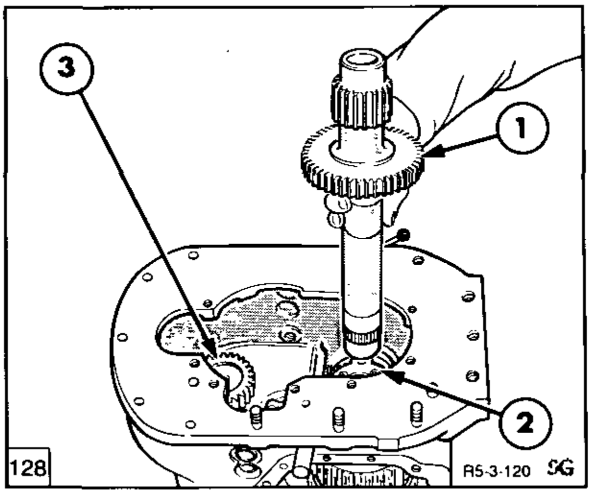
2. Install the FWD internal shaft in the housing, passing it through the front and rear bearings, Figure 126. Do not install the front gear at this stage.
3. If the high/low range synchroniser operating fork selector shaft assembly has been removed, carefully install the shaft from the inside of the transmission housing passing the shaft through the bore and the oil seal. Note that the shaft has a keyway machined in the outer end, ensure that the sharp edges are removed. If necessary cover the keyway to prevent damaging the seal.



Installing High/Low Range Synchroniser Fork Shaft Locking Pin

1. Top Shaft (C3 Output)
2. Spacer
3. Shaft Locking Pin

4. Install the high/low synchroniser fork selector rail shaft locking pin to retain the shaft in the transmission housing, Figure 127.
5. Check that the C3/C4 clutch assembly has not come out of engagement with the locking pin in the side of the housing.

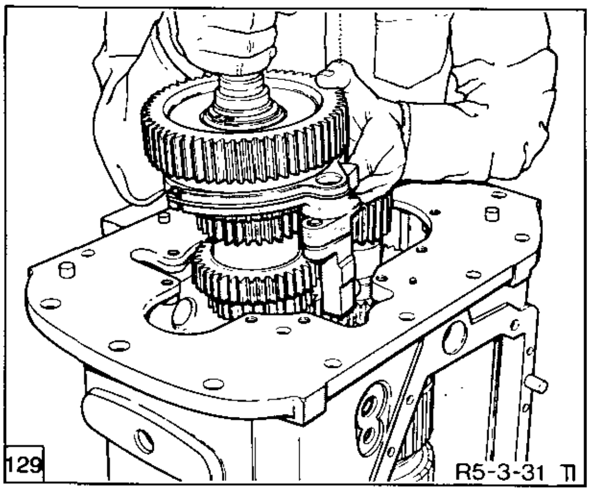


Installing Rear Top Shaft (C3 Clutch Output)

1. Top Shaft (C3 Output)
2. C3/C4 Clutch Assembly
3. FWD Internal Shaft

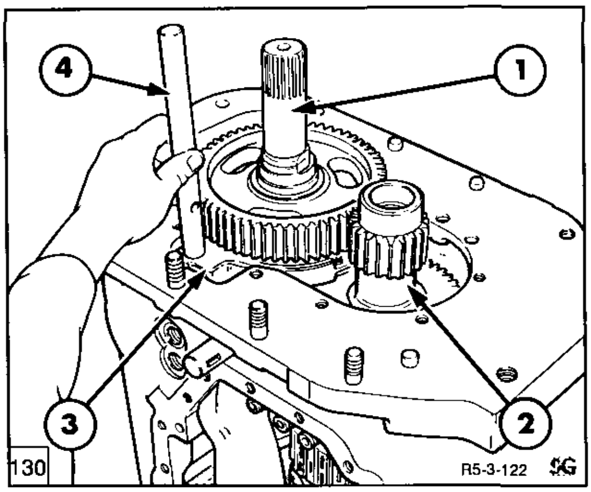
6. Carefully install the top shaft (C3 clutch output shaft) assembly through the C3/C4 housing, and using a twisting motion feel in the engagement of the splines on the C3 clutch, Figure 128. Gently tap the shaft downward to seat the bearing.

7. Ensure the output shaft front bearing, item 18 in Figure 113, is in place and retained by the snap ring.



Installing Output Shaft and Fork Assembly

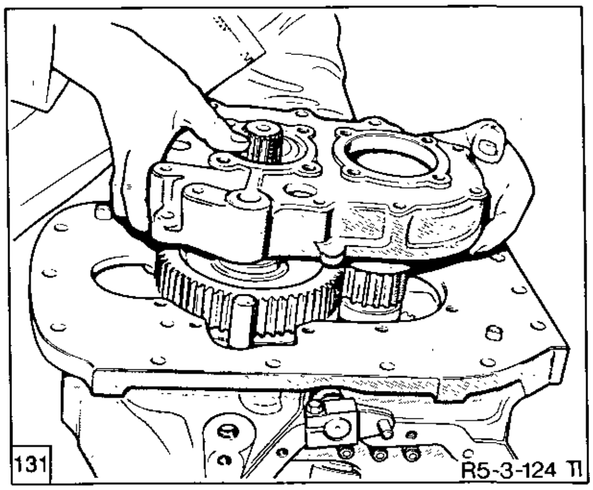
8. Position the high/low range synchroniser operating fork assembly onto the output shaft synchroniser. With the output shaft and operating fork orientated so that the fork aligns with the cutout in the right–hand side of the housing, lower the output shaft assembly into the housing, Figure 129.



Installing the High/Low Synchroniser Fork Rail

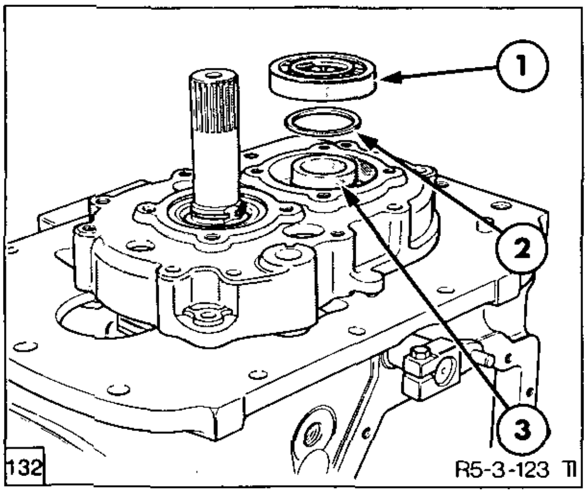
1. Output Shaft
2. Top Shaft (C3 Output)
3. Fork Assembly
4. Fork Rail

9. Engage the fork with the finger of the operating shaft and install the fork rail, Figure 130. The high/low synchroniser fork to rail relationship must be adjusted to a neutral point. Refer to page 110. Tighten the set bolt to 20–25 lbf ft (27–34 Nm) and the locking nut to 15–19 lbf ft (20–26 Nm). Check the engagement of the fork with the operating shaft finger.



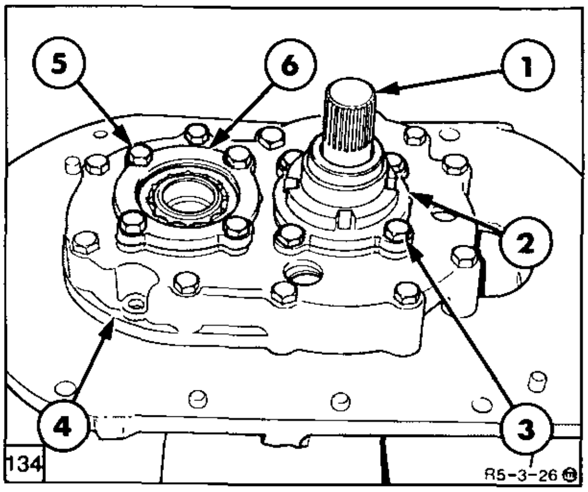
Installing Rear Cover

10. Install the rear cover plate, Figure 131 and locate and install the top shaft bearing, gently tap the cover to seat it.



Installing Rear Top Shaft (C3 Clutch Output) Spacer and Bearing

1. Bearing
2. Spacer
3. Top Shaft

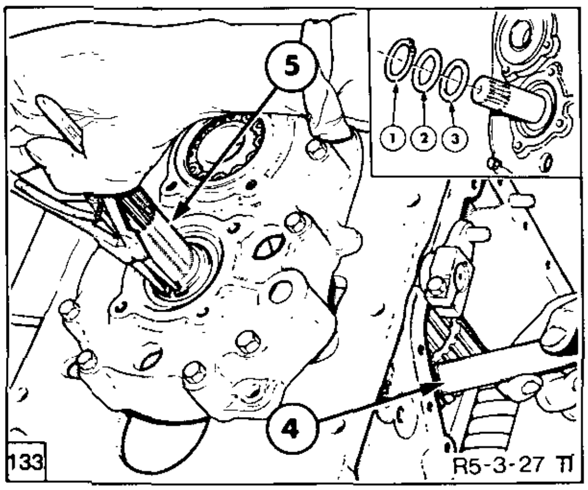


Rear Cover Output Shaft Bearing Retainer/Pump Idler Gear Support and Top Shaft Bearing Retainer

1. Output Shaft
2. Bearing Retainer/Hydraulic Pump Idler Gear Support
3. Retaining Bolt x 4
4. Rear Cover Plate
5. Retaining Bolt x 4
6. Top Shaft Rear Bearing Retainer

11. Install the spacer and bearing (sliding fit) on the rear end of the top shaft (C3 clutch output), Figure 132.

12. Install the output shaft rear bearing (sliding fit), the loose bearing roller thrust and the steel 'D' washer to the shaft.



Installing Output Shaft Rear Bearing Snap Ring and Washer

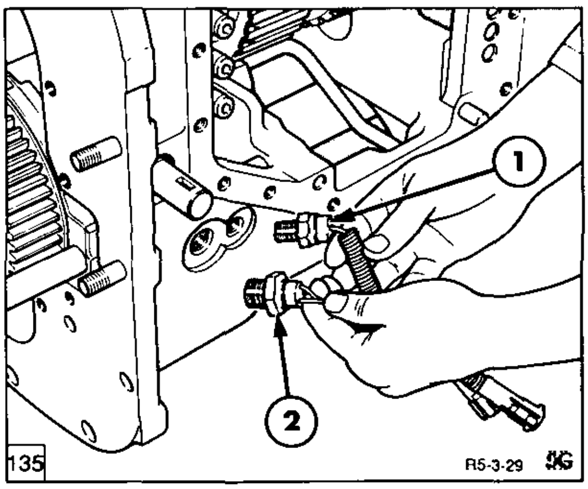
1. Snap Ring
2. 'D' Washer
3. Bearing Thrust (loose)
4. Lever (raising Output Shaft)
5. Output Shaft

13. Using a lever or pry bar positioned under the output shaft front gear (FWD gear), raise the output shaft assembly and install the retaining snap ring, Figure 133.

14. Install the ten rear cover plate retaining bolts, Figure 134 and tighten to 35–48 lbf ft (45–67 Nm).

15. Install the top shaft bearing retainer, Figure 134 and tighten the four retaining bolts to 24–32 lbf ft (32–44 Nm).

16. Install the output shaft bearing retainer assembly, Figure 134 and tighten the four retaining bolts to 24–32 lbf ft (32–44 Nm).

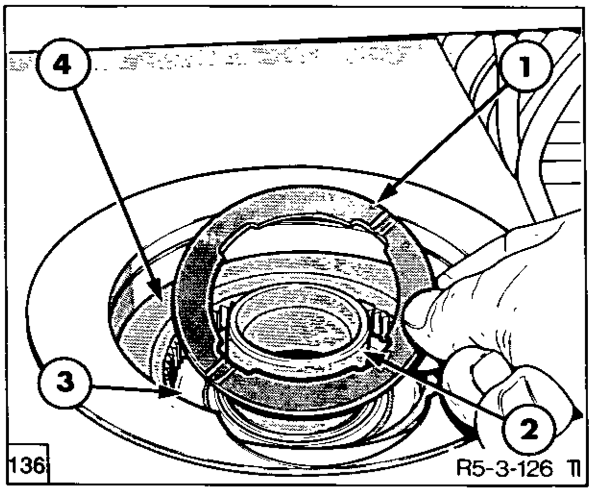


High/low Range Sensor Switches

1. High Range Sensor Switch
2. Low Range Sensor Switch

17. Install the two high/low range sensor switches into the housing, Figure 135. Note that the switches have differing thread sizes and cannot be interchanged.

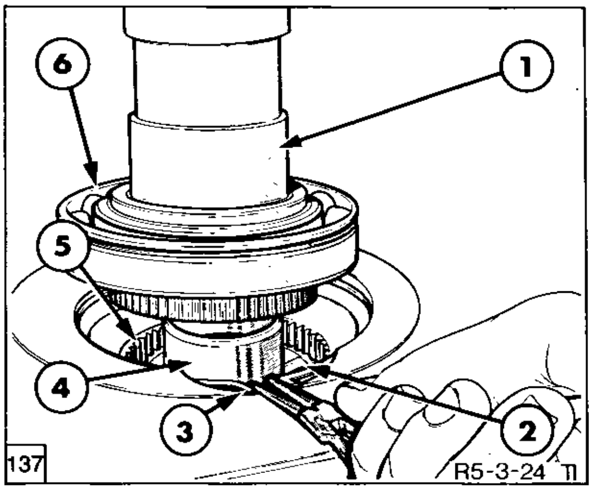
Forward/Reverse and Main Range Synchronisers and Associated Gears and Bearings – Installation



Installing Polyimide Thrust Washer on the Front of C3 Clutch Hub

1. Polyimide Thrust Washer
2. C3 Clutch Output Shaft
3. C3 Clutch Hub
4. C3 Pressure Plate

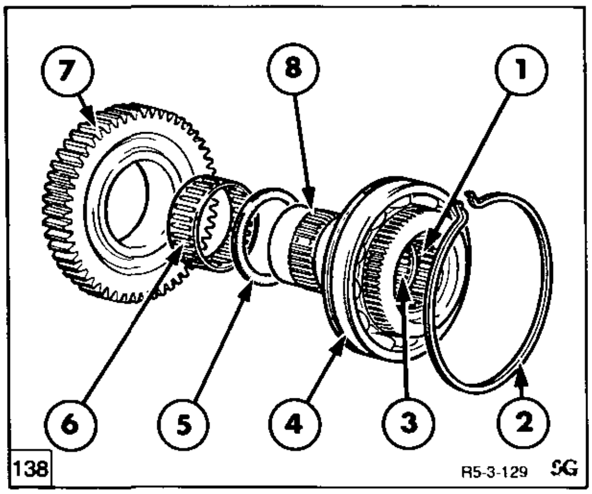
1. Rotate the transmission so that the front end is uppermost and position the polyimide thrust washer on the front of the C3 clutch hub, Figure 136, retaining it with petroleum jelly.



Installing Main Range Synchroniser Support Shaft Retaining Ring

1. Support Shaft
2. Polyimide Thrust Washer (on C3 Clutch Hub)
3. Retaining Ring
4. C3 Clutch Output Shaft
5. C3 Clutch Pressure Plate (C3/4 Clutch Input)
6. Ball Bearing

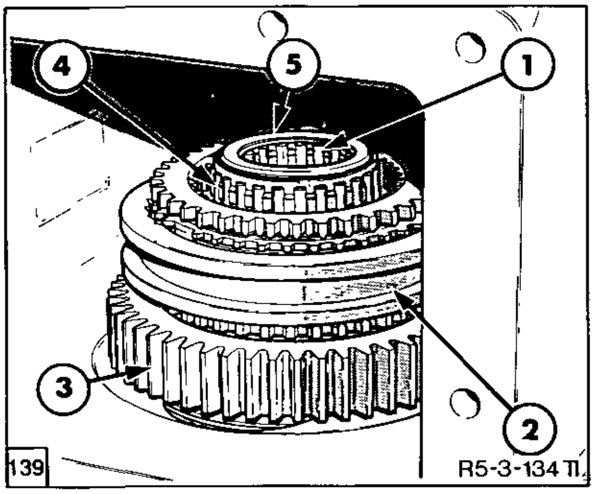
2. Position the range synchroniser support shaft rear bearing retaining ring (retains bearing in transmission housing) in the housing and whilst expanding this ring, install the range synchroniser support shaft and rear bearing assembly, Figure 137. Check that the retaining ring is correctly positioned and the bearing is fully retained.



Main Range Synchroniser Support Shaft, and Gear Assembly

1. C3 Clutch Output Shaft Needle Roller Bearing
2. Retaining Ring
3. PTO/Input Shaft to Range Synchro Support Shaft Needle Roller Bearing
4. Ball Bearing
5. Polyimide Thrust Washer
6. Needle Roller Bearing
7. Low Range Gear
8. Range Synchro Support Shaft

3. Assemble to the support shaft the polyimide thrust washer, the needle roller bearing and the gear, Figure 138.

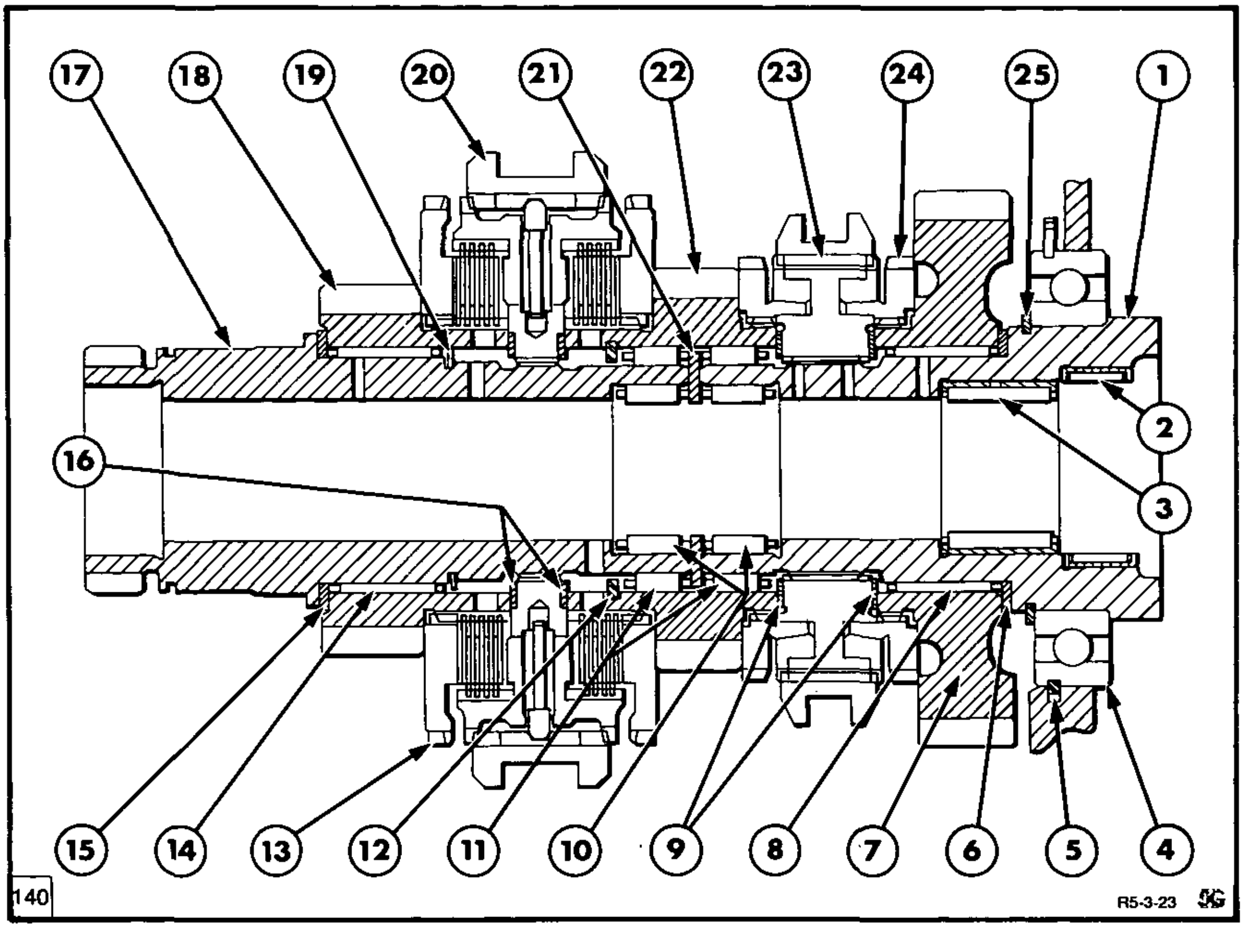


Range Synchroniser Installed on Support Shaft

1. Support Shaft to PTO/Input Shaft Needle Roller Bearing
2. Range Synchro
3. Low Range Gear
4. Needle Roller Bearing (37 tooth High Driven Gear)
5. Steel Washer

4. Using petroleum jelly as a temporary adhesive, stick the polyimide thrust washers, items 9, Figure 140, in the recesses on each side of the range synchroniser.

5. Install the range synchroniser onto the support shaft. Take great care to ensure that the polyimide thrust washers are not displaced.



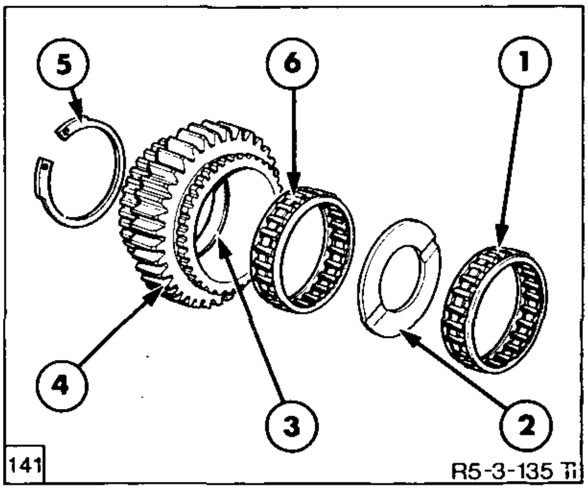
Forward/Reverse and Main Range Synchroniser Assemblies – Sectional View

1. Main Range Synchroniser Support
2. Needle Roller Bearing
3. Needle Roller Bearing
4. Main Range Synchroniser Support Bearing
5. Bearing to Casing Snap Ring
6. Thrust Washer
7. Driven Gear – Low
8. Needle Roller Bearing
9. Polyimide Thrust Washers
10. Main Range and Forward/Reverse Synchroniser Support to PTO/Input Shaft Needle Roller Bearings
11. Needle Roller Bearing
12. Needle Roller Bearing Retaining Snap Ring
13. Forward/Reverse Synchroniser Coupling
14. Needle Roller Bearing
15. Thrust Washer
16. Polyimide Thrust Washers
17. Forward/Reverse Synchroniser Support
18. Reverse Driven Gear
19. Needle Roller Bearing Retaining Snap Ring
20. Forward/Reverse Synchroniser
21. Steel Thrust Washer
22. Driven Gear High
23. Main Range Synchronize
24. Main Range Synchroniser Coupler
25. Main Range Synchroniser Support Bearing Retaining Snap Ring

6. Install on the nose of the range synchroniser support shaft, Figure 139, the inner needle roller bearing (support shaft to PTO/input shaft) and the needle roller bearing belonging to the 37 tooth high driven gear, items 8 and 11 in Figure 140.

7. Position the separating steel washer shown in Figure 139 and item 21 in Figure 140, on top of the range synchroniser support shaft and secure with petroleum jelly.

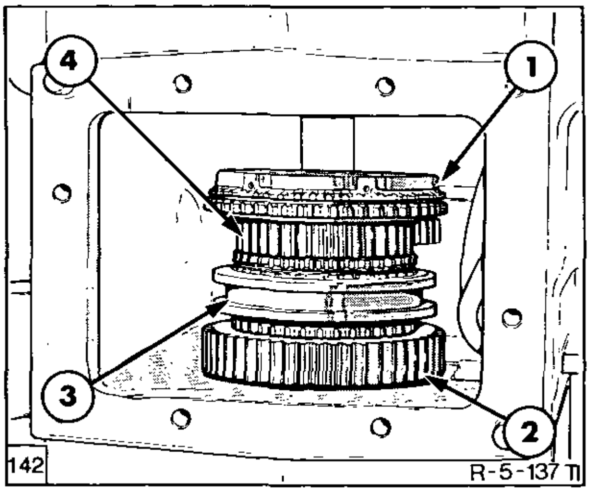
NOTE: *The positioning and installation of the needle roller bearings in the 37 tooth gear may be eased if the two bearings and the steel thrust washer are installed with the gear. If this method is preferred, secure the bearings and the thrust washer in the gear using petroleum jelly. Take great care when installing the gear that the bearings and thrust washer do not fall out or become misaligned.*



High Driven Gear (37 Tooth) Bearings, Washer and Snap Ring

1. Needle Roller Bearing (rear)
2. Steel Washer
3. Snap Ring Groove
4. High Driven Gear (37 tooth)
5. Snap Ring
6. Needle Roller Bearing (front)

8. If not already present, install the snap ring into the bore of the high driven gear (37 tooth), item 22, Figure 140. Into this gear install the front needle roller bearing, Figure 141. Cover the bearing with petroleum jelly and push the bearing against the snap ring. (**Note:** The second bearing in the 37 tooth gear has already been placed on the range synchroniser support shaft along with the separating washer, see Figure 139.) See also preceding note.



High Driven Gear and Forward/Reverse Synchroniser Forward Clutch Pack Half Installed on Range Synchro Support Shaft

1. Synchro Forward Clutch Pack Half
2. High Range Gear
3. Range Synchro
4. High Driven Gear (37 tooth)

9. Take the forward/reverse synchroniser and place it on a clean workbench. Screw a lockscrew (M5–0.8) into the hole in the sliding coupler and tighten the screw to just nip and lock the coupler to its hub.

IMPORTANT: *Remember to remove the locking screw once the forward/reverse synchroniser assembly process is completed.*

10. Disassemble the forward and reverse clutch packs (plates).

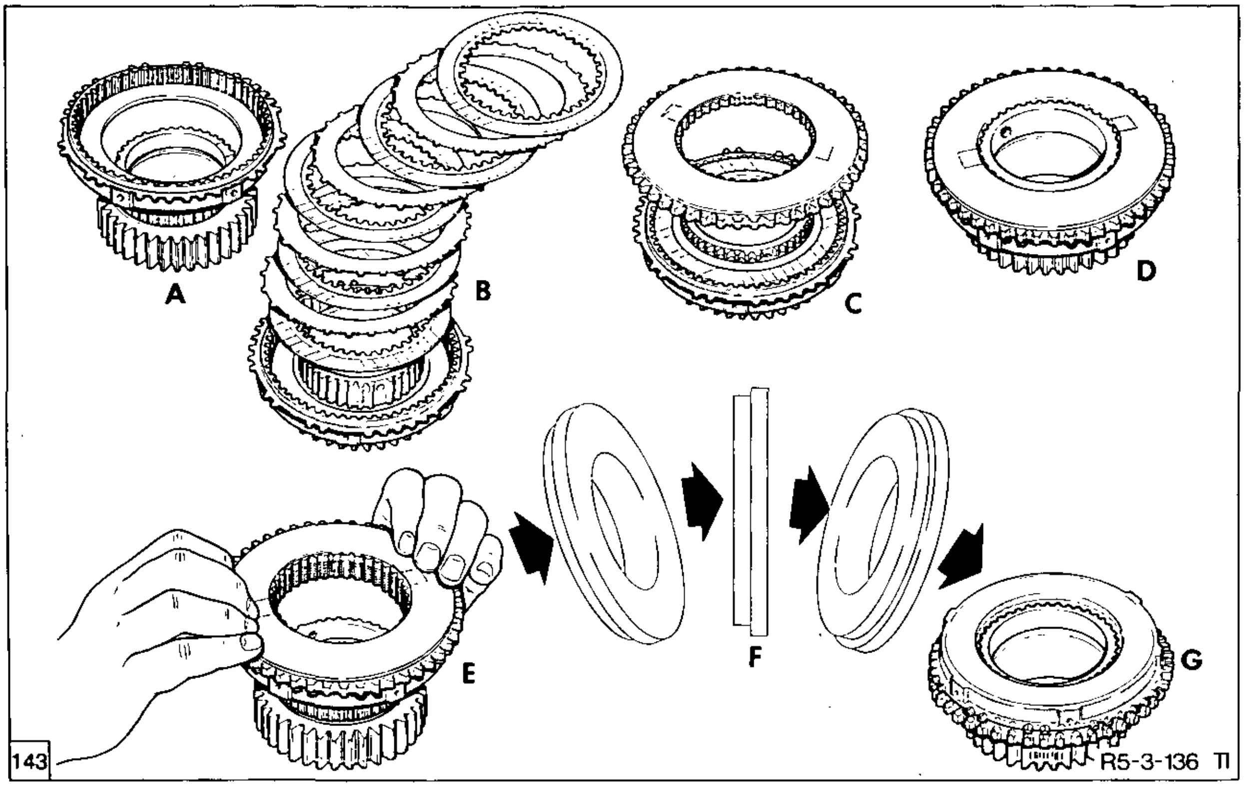
11. Rebuild the forward synchroniser clutch pack onto the high driven gear (37 tooth). Do this by assembling the plates and the synchroniser housing upside down on the gear, using in effect, the gear as a template and then whilst firmly gripping the assembly to keep the plates together, withdraw the gear and re–assemble the gear, this time from the opposite side (correct side), Figure 143.

12. Take the intermediate counter shaft and position in the transmission housing alongside its final assembly position. Do not locate it into the rear bearing yet.

13. Firmly grip the clutch pack and gear and position on the range synchroniser support shaft in the transmission housing and at the same time locate the intermediate bottom shaft in its rear bearing, Figure 142. Ensure the plates remain in line and engage the gear, picking up and aligning the needle roller bearing, the polyimide thrust washer and the splines of the range synchroniser. Refer to Figure 140.

14. Take the locked synchroniser coupling, ensure that the previously adhered polyimide thrust washers are in place in the recesses on each side of the hub, and very carefully place it on the forward clutch plate half. Engage the locating lugs with the coupler.

15. Rebuild the reverse side of the forward/reverse synchroniser clutch pack onto the reverse driven gear (33 tooth) following the same procedure as for the forward half.

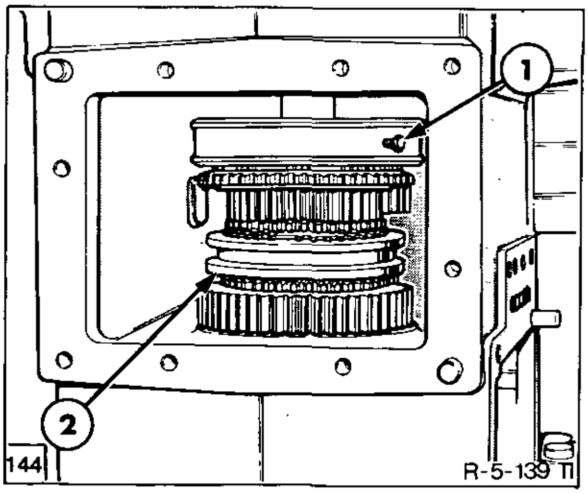


Assembly Sequence of Forward/Reverse Synchroniser Clutch Pack

A. Assemble inner synchro plate to gear
B. Assemble friction and steel plates aligning inner and outer splines to gear and inner plate
C Assemble synchro outer or end plate to gear
D. Assembled end plate, plates and inner plate positioned on gear
E. Squeeze and lift inner plate, end plate and friction/separator plates from gear
F. Rotate squeezed assembly through 180°
G Carefully slide squeezed assembly onto gear splines

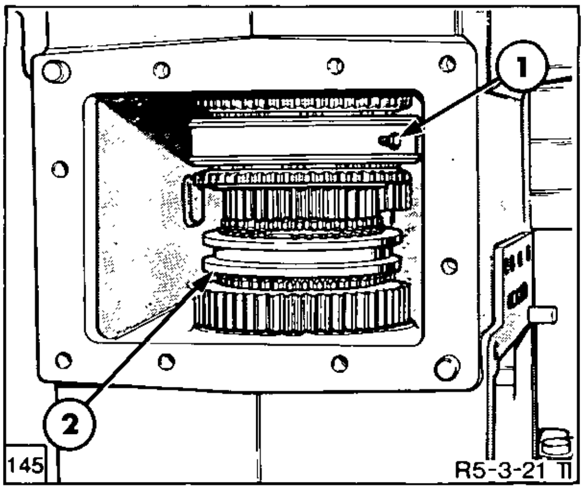
16. Very carefully place this half of the synchroniser on top of the centre coupler, Figure 145.

17. Remove the forward/reverse synchroniser locking screw, Figure 145.



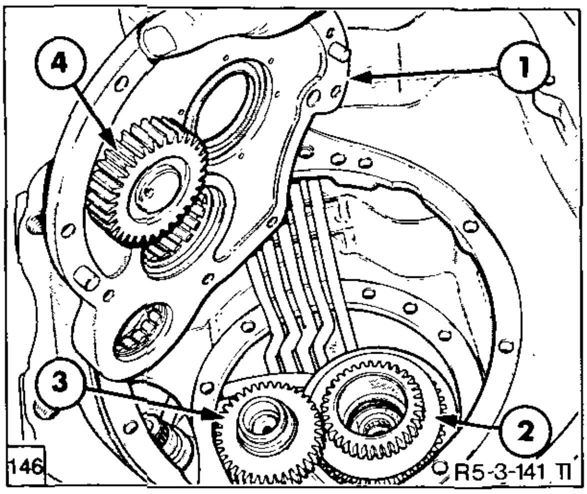
High Driven Gear and Forward/Reverse Synchroniser Forward Clutch Pack Half with Coupler Installed on Range Synchro Support Shaft

1. Forward/Reverse Synchro Coupler (with Locking Screw installed)
2. Range Synchro



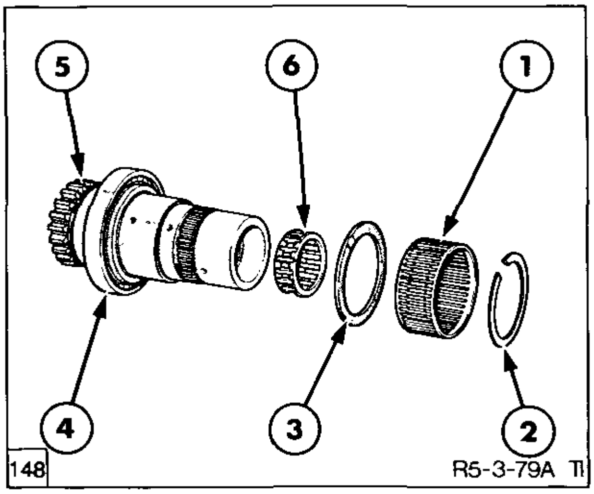
Forward/Reverse Synchroniser Assembly with Reverse Clutch Pack Half (fully installed)

1. Locking Screw (M5–0.8) Installed in Forward/ Reverse Synchro Coupler
2. Range Synchro



Installing Intermediate Front Cover Plate

1. Front Cover
2. Forward/Reverse Synchro
3. Intermediate Bottom Shaft
4. Reverse Idler Gear

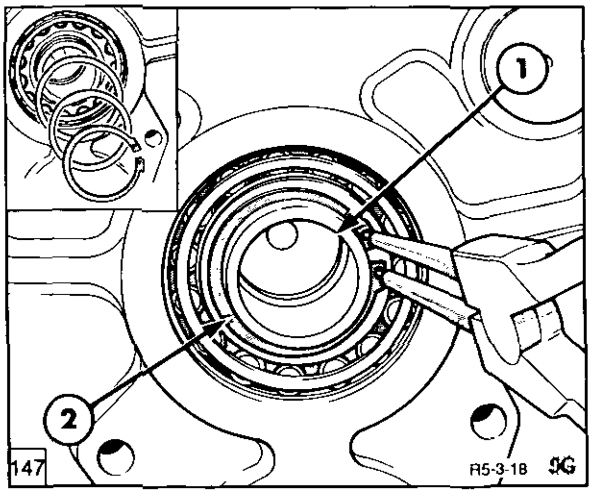


Forward/Reverse Synchroniser Support Shaft Bearings

1. Reverse Gear Needle Roller Bearing
2. Retaining Ring
3. Polyimide Thrust Washer
4. Ball Bearing
5. Support Shaft
6. Support Shaft to PTO/Input Shaft Needle Roller Bearing

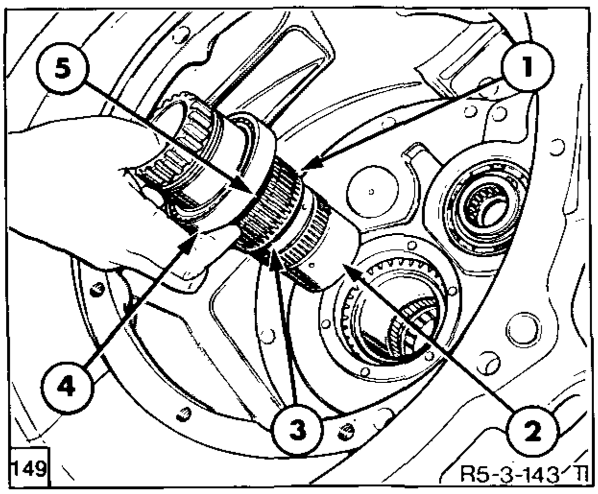
18. Install the intermediate cover plate and reverse idler gear assembly, Figure 146. Install the retaining bolts and tighten systematically and evenly to 34–44 lbf.ft. (45–60 Nm).

20. Assemble the forward reverse synchroniser support shaft bearings, Figure 148, retaining the front needle roller bearing with the snap ring and using petroleum jelly to retain the inner needle roller bearing.



Intermediate Bottom Shaft Front Bearing Snap Ring (inset shows loose Thrust Washer, 'D' Shaped Washer and Snap Ring)

1. Intermediate Bottom Shaft
2. Snap Ring



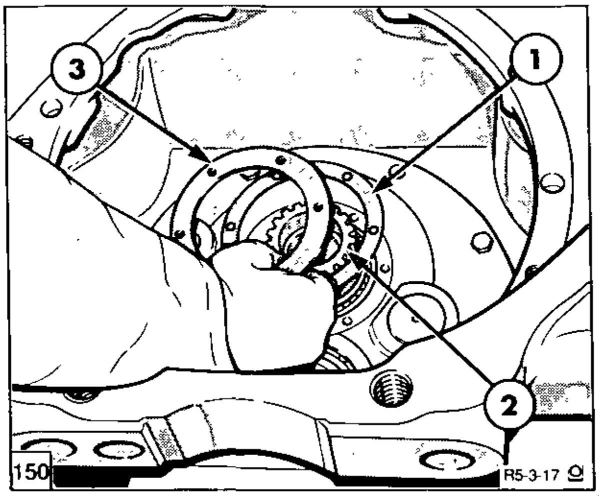
Installing Forward/Reverse Synchroniser Support Shaft into Synchroniser through the Intermediate Cover.

1. Reverse Gear Needle Roller Bearing
2. Support Shaft
3. Retaining Ring
4. Ball Bearing
5. Polyimide Thrust Washer

19. Position the intermediate bottom shaft front bearing roller thrust washer in front of the bearing and the steel 'D' shaped washer and install the bearing to bottom shaft retaining snap ring, Figure 147.

21. Very carefully install the forward reverse synchroniser support shaft through the opening in the cover plate, Figure 149. Feel the shaft through the bearing and ensure it is correctly located.

NOTE: *It is necessary to adjust the running clearance of the components on the forward/reverse and range synchronisers support shafts. The clearance is obtained by the placement of shims behind the forward/reverse synchroniser support shaft front bearing retainer plate.*



Installing Forward/Reverse Synchroniser Support Shaft Front Bearing Retainer and Shims

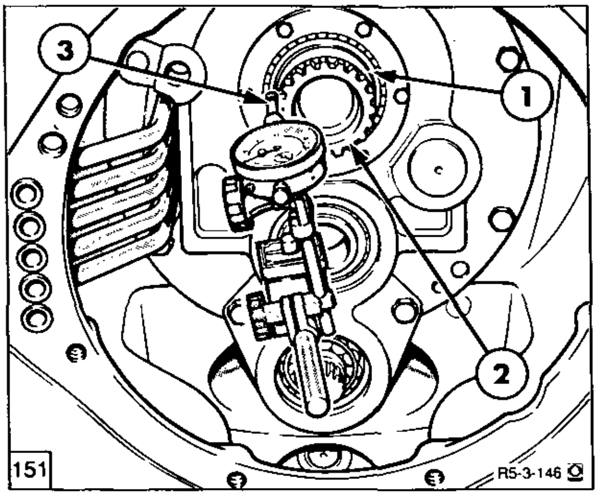
1. Shims
2. Forward/Reverse Synchro Support Shaft
3. Support Shaft Front Bearing Retainer Plate

22. Position shims of at least 0.040in (1.0 mm) thickness in position on the cover plate and install the bearing retainer and retaining screws, Figure 150. Tighten the screws progressively and evenly to 7–9 lbf. ft. (9–13 Nm).

23. Using a soft faced mallet, gently but firmly bump the synchroniser support shaft bearing downward to seat the components. Do not excessively bump the bearing as damage may occur to the polyimide thrust washers.

IMPORTANT: *The transmission must remain in the vertical position during the next operation and the rear end components must have been installed and the rear top shaft rear bearing retainer must be in position and fully secured.*

24. Position a magnetic base dial indicator with the anvil of the dial indicator positioned on the forward/reverse synchr–oniser support shaft bearing. Ensure the gauge is vertical and positioned to give a true reading. Calculate the required shim value as follows:–



Dial Gauge Mounted on Intermediate Cover to Measure Synchroniser Support Shaft Components Running Clearances

1. Forward/Reverse Synchro Support Shaft Front Bearing Inner Track
2. Support Shaft
3. Dial Gauge Anvil

a) Grip the front of the forward/reverse synchroniser support shaft and at the same time lever or pry the shaft upwards. Do this by using a pry bar under any of the components accessible through the gearshift cover opening.

b) Note the dial indicator reading.

c) Repeat the process and check the reading.

d) *Calculate the shim pack value to obtain a running clearance of 0.016–0.024in. (0.4–0.6mm).*

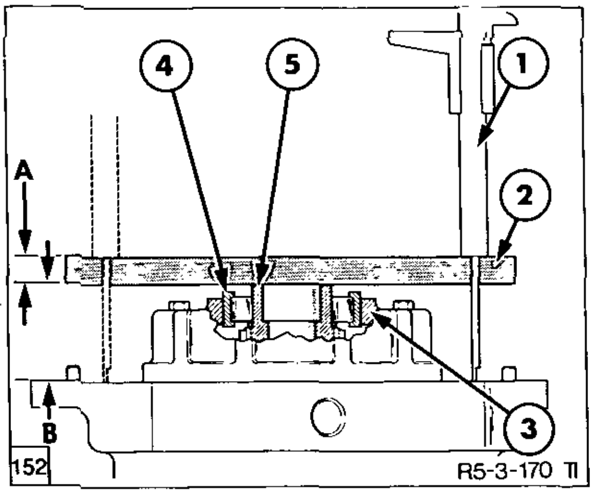
25. Position the selected shims, re–install the bearing retainer and install the retaining screws. Tighten the screws progressively and evenly to 7–9 lbf. ft. (9–13 Nm).

Transmissions with and without Creeper

Setting and Adjusting C3 Clutch Output Shaft to PTO Shaft Relationship

A polyimide thrust washer is positioned on the output end of the PTO shaft against the C3 clutch output shaft. This washer is available in various thicknesses and selection of the correct thickness is necessary to ensure that when the transmission is reconnected to the rear axle assembly, adjustment of the PTO shaft and gearing is possible within specified limits. The selection of the correct polyimide thrust washer is best done before the PTO/input shaft is installed. Measuring the distance between the C3 output shaft and the rear machined face of the transmission housing will allow the correct washer to be selected.

Select the correct thickness polyimide thrust washer as follows:–



Establishing C3 Clutch Output Shaft Relationship to Transmission Rear Buckle–up Face

1. Vernier Caliper
2. Straight/Uniform Bar
3. Rear Cover (sectioned)
4. Bearing Outer Track
5. C3 Output Shaft (Top Shaft)

a) Position the transmission vertically with the PTO output uppermost.

b) With the top shaft (C3 output shaft) rear bearing retainer removed, tap the C3 shaft downwards to seat it and tap the bearing outer track to ensure that this has not risen. Place a straight machine or uniform bar across the bearing outer track.

c) Measure the distance between the rear buckle–up face and the C3 clutch output shaft as shown in Figure 152. Using a vernier caliper, measure the distance both sides and calculate the average, deduct the thickness of the bar (vernier reading – A = B).

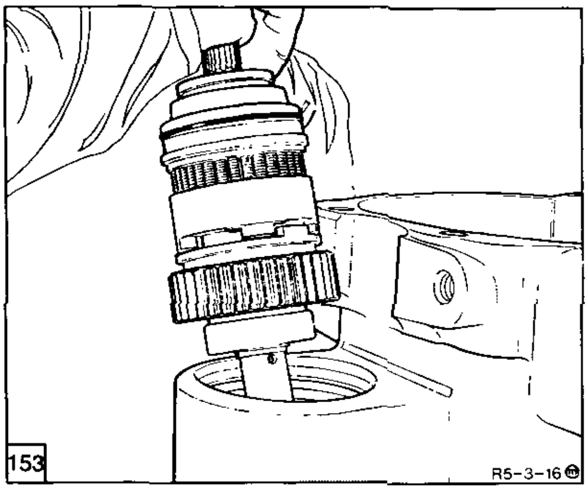
From the following table select the washer thickness that corresponds to the calculated distance:–

Calculated Distance	Washer Thickness
58.82–59.15mm	6.20–6.25mm
59.16–59.40	5.95–6.00
59.41–59.65	5.70–5.75
59.64–59.90	5.45–5.50
59.91–60.17	5.20–5.25
60.18–60.52	4.85–4.90

The selected washer will be placed on the PTO/input shaft and temporarily secured in place to prevent loss prior to installation in the tractor when the shaft has been installed.

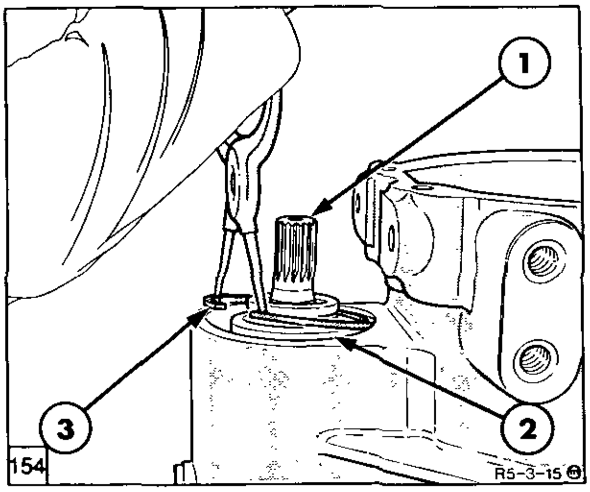
C1/C2 Clutch Assembly, Front Bottom Shaft and Creeper Components (where fitted) – Installation

1. If FWD is fitted, position the FWD transfer assembly oil supply tube, complete with polyimide thrust seal, in the transmission housing. The tube is a press fit in the housing and should carefully be driven into its location using a suitable drift.



Installing FWD Output Shaft Assembly

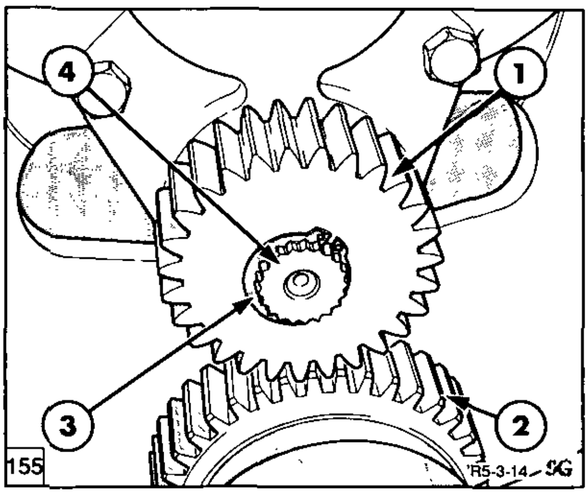
2. Place the FWD clutch quick release check valve in its bore with the ball end facing rearward. If the valve is a new item, use a suitable driver and firmly strike the end of the rear end of the valve to force the front of the valve against the internal oil gallery in the FWD shaft to seat or *'coin' the face. This will ensure an effec-*tive oil seal during operation. Retain the valve with petroleum jelly.
3. Install the FWD transfer assembly into the transmission housing, Figure 153. Bump the assembly to seat it in the casing.



Installing FWD Output Shaft Cover Snap Ring

1. FWD Output Shaft
2. Cover Plate
3. Snap Ring

4. Install the FWD output cover plate retaining snap ring. The snap ring is heavy duty and the use of suitable heavy duty pliers is recommended, Figure 154.

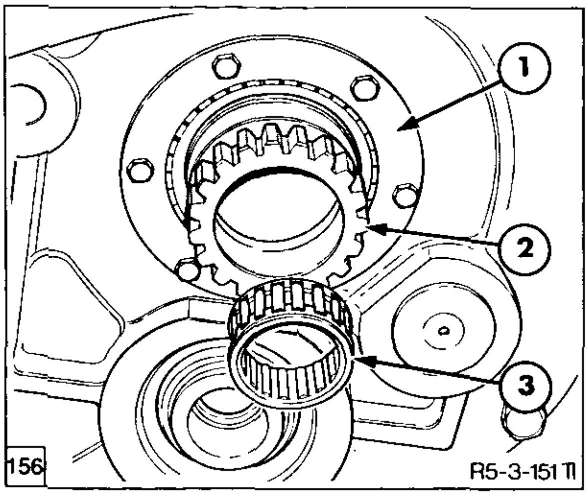


Front Wheel Drive Shaft Front Gear Retaining Snap Ring

1. FWD Front Gear
2. FWD Output Assembly Drive Gear
3. Snap Ring
4. Internal FWD Shaft

5. Position the FWD (where fitted) internal shaft front bearing thrust washer against the front bearing, install the gear, Figure 155 and the retaining snap ring.

6. Install the PTO/input shaft to forward/reverse synchroniser support shaft needle roller bearing into the nose of the forward/reverse synchroniser support shaft, Figure 156.



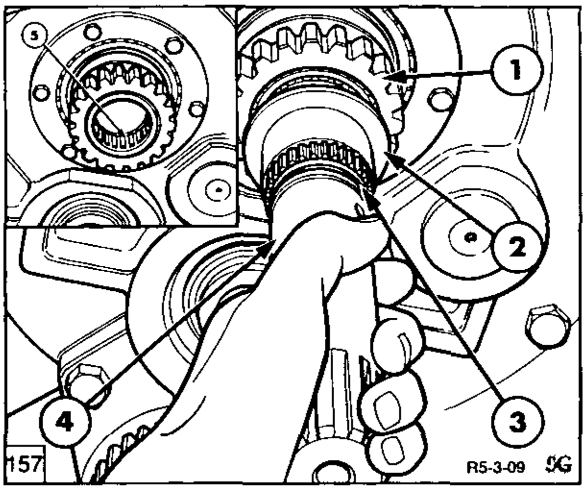
Installing PTO/Input Shaft Needle Roller Bearing into Front of Forward/Reverse Synchroniser Support Shaft

1. Forward/Reverse Synchro Support Shaft Front Bearing Retainer
2. Support Shaft
3. Needle Roller Bearing

Transmissions Without Creeper

The following steps relate to transmissions without the creeper option. If the transmission has creeper, refer to page 104 and follow the adjustment procedure for creeper components and the differing installation procedure.

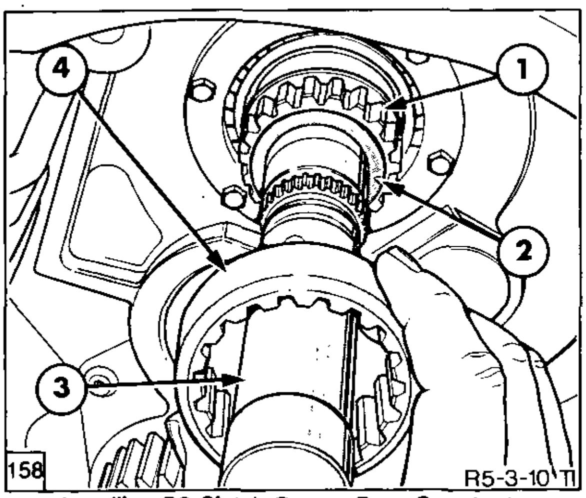
1. Position the polyimide thrust washer (steel on transmissions with creeper) on the PTO/Input shaft, ensure that the lube seal is in place and correctly positioned and install the shaft, carefully sliding it through the forward/reverse synchroniser support shaft, Figure 157. Use a twisting motion during the installation of the shaft.



Installing PTO/Input Shaft (Non–creeper shown)

1. Forward/Reverse Support Shaft
2. Polyimide Thrust Washer (Steel if Creeper)
3. Lube Seal
4. PTO/Input Shaft
5. PTO/Input Shaft to Support Shaft Needle Roller Bearing

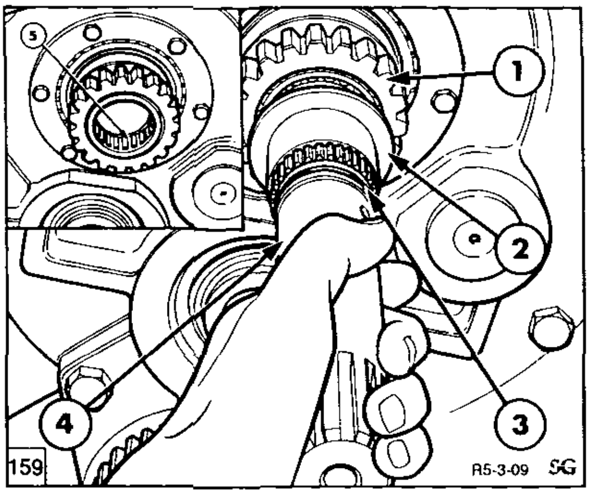
2. Place the previously selected polyimide thrust washer on the rear of the PTO/input shaft and temporarily secure in place to prevent loss prior to installation of the transmission in the tractor. Remember to remove the securing device just before installation.



Installing C2 Clutch Output Gear Coupler to Forward/Reverse Synchroniser Support Shaft (Non–creeper shown)

1. Forward/Reverse Synchroniser Support Shaft
2. Polyimide Thrust Washer
3. Coupler (C2 Clutch Output Gear to Forward/Reverse Synchroniser Support Shaft)
4. PTO/Input Shaft

3. Position the C2 clutch to forward/reverse synchroniser support shaft coupler on the support shaft, Figure 158.



C2 Clutch 26 Tooth Output Gear Installed on PTO/Input Shaft

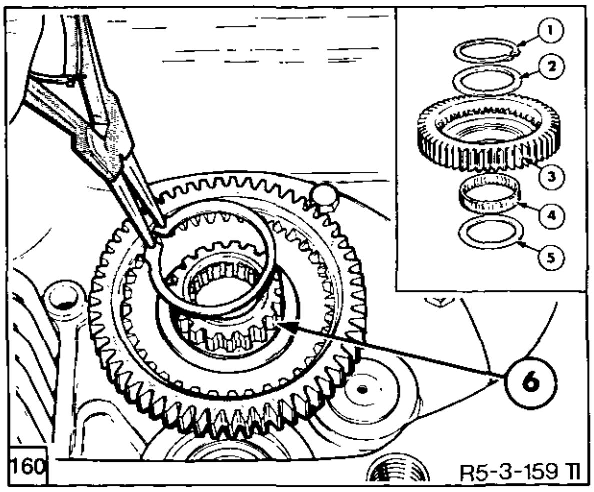
1. C2 Clutch (26 tooth) Output Gear
2. PTO/Input Shaft
3. Lube Oil Seal
4. Coupler (26 Tooth Gear to Forward/Reverse Synchroniser Support Shaft)

4. Assemble the two needle roller bearings to the C2 clutch (26 tooth) output gear and position this gear on the PTO/input shaft, Figure 159.

Creeper Transmissions Only

Before continuing the installation process the creeper components require setting and adjustment.

IMPORTANT: *It is essential that the adjustment procedure is performed exactly as stated. Failure to follow the sequence will result in poor or no engagement of the creeper system.*



Installing Creeper Gear

1. Snap Ring
2. Steel Washer
3. Creeper Gear
4. Needle Roller Bearing
5. Steel washer
6. Forward/Reverse Synchroniser Support Shaft

1. Position the steel washer on the forward/reverse synchroniser support shaft against the shaft bearing. Install the creeper gear (55 tooth) and the needle roller bearing and position the steel washer against the gear. Install the retaining snap ring, Figure 160.

Creeper Adjustment – 1 (Creeper Engaged)

1. Loosen the fork to rail screw lock nut and loosen the screw.

2. Install the creeper coupler components as shown in Figure 161, together with the creeper coupler fork and rail. Do not install the creeper return spring at this point. It will be installed behind the creeper fork when the setting and adjustment is completed.

3. Using the square ended portion of the rail screw the rail through the fork until the stepped rear end of the rail contacts and bottoms against the intermediate cover plate but does not lift the creeper coupling. It is essential that the coupling is not lifted. A dial indicator gauge with the anvil placed on the coupling will indicate movement of the coupling. **Do not allow any lifting of the coupler.**

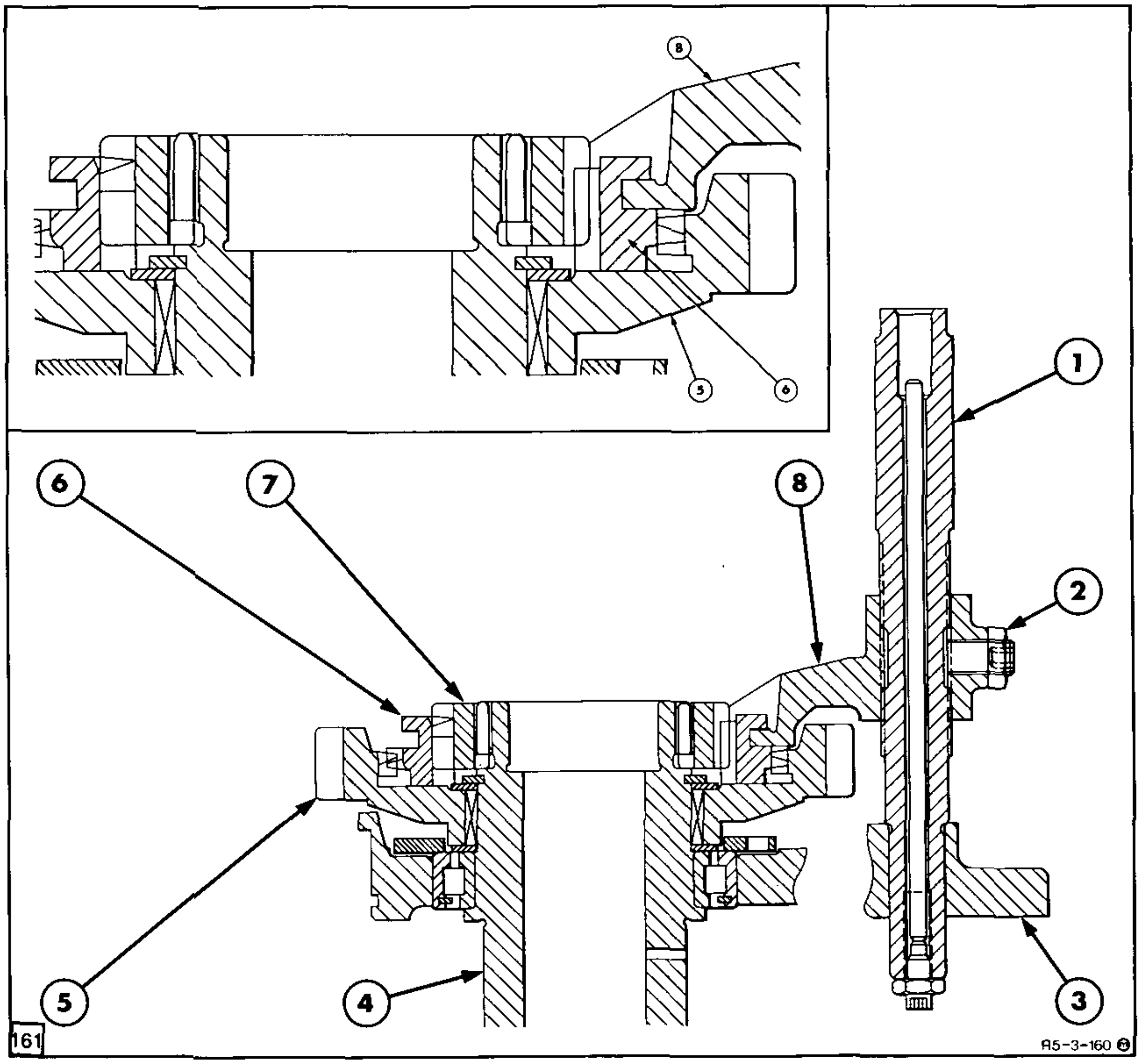
4. Tighten the screw to 18–22 lbf.ft. (24–30 N m). Tighten the lock nut to 14–18 lbf.ft. (19–25 Nm).

NOTE: *As the fork to rail screw is tightened the fork will lift. This amount of lift equates to the designed operating clearance.*

5. Remove all the creeper components except the 55 tooth creeper gear, from the transmission housing.

Creeper Adjustment – 2 (Creeper Disengaged)

1. Position the C1/C2 clutch support shaft through the front cover opening without the 'O' ring seal and without the shaft annular sealing rings (installing the shaft without these items during this adjustment procedure will prevent unnecessary damage to the seals). Install the support shaft retaining bolts and tighten evenly to 34–44 lbf. ft. (45–60 Nm).



Creeper Components Installed on Forward/Reverse Synchroniser Support Shaft for Adjustment

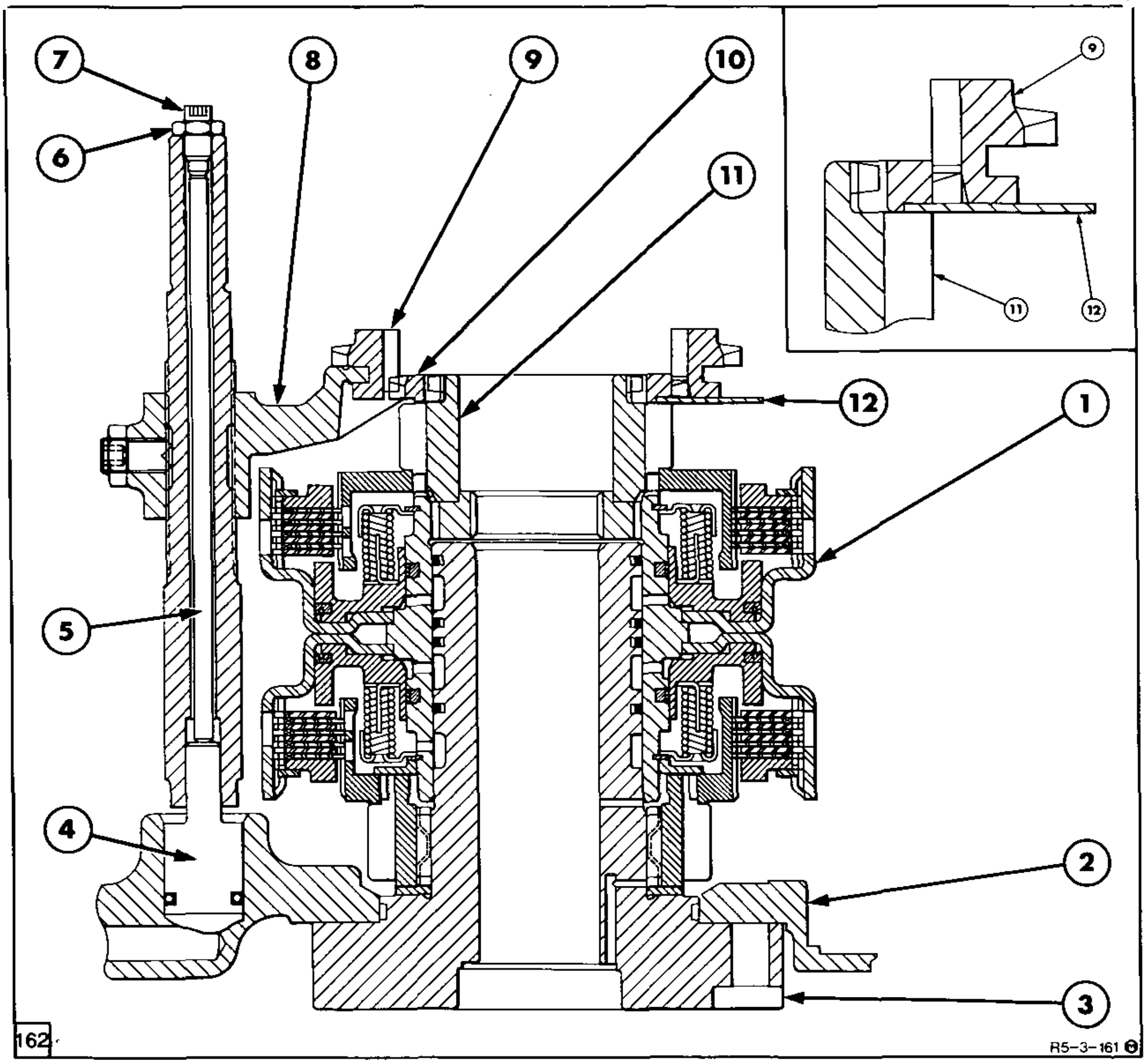
1. Creeper Fork Rail
2. Retainer Screw and Locknut
3. Intermediate Cover Plate
4. Forward/Reverse Synchroniser Support Shaft
5. Creeper Gear
6. Sliding Coupling
7. Coupler
8. Creeper Fork

2. Position the C1 clutch output gear polyimide thrust washer on the support shaft, followed by the C1/C2 clutch assembly and its output gears as shown in Figure 162. Ensure the components are installed exactly as shown and that the output gears are correctly seated and engaged with the clutch hubs.

3. Position the C2 clutch output gear to creeper gear coupler plate on the C2 output gear and taking the fork and rail with the inner actuator rod and the actuating piston and the creeper gear (55 tooth) coupler, position the piston in the operating bore in the front support plate as shown in Figure 162.

4. Fabricate a 0.060 in. (1.50 mm) thick spacer from shim steel and insert it between the creeper gear sliding coupling and the C2 clutch output gear teeth (ensure the shim seats on the flat surface of the teeth), Figure 162.

5. Loosen the inner actuator rod adjuster lock nut and back out the adjusting screw. Screw in the adjuster screw until the fork just begins to lift the coupler off the shim steel spacer (on no account interfere with the previously adjusted rail to fork relationship). Use a dial indicator with the anvil positioned on the sliding coupling to indicate the exact point of lift. The adjustment is correct at the point where the dial indicator exhibits movement.



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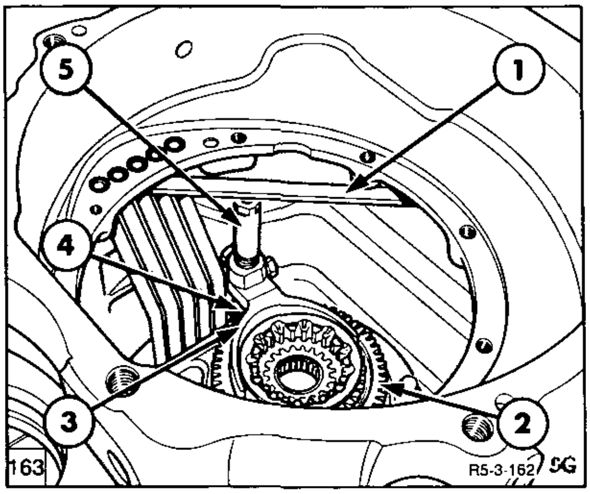
Creeper Components Installed on Front Cover for Adjustment

1. C1/C2 Clutch Assembly
2. Front Cover Plate
3. C1/C2 Clutch Assembly Support Shaft
4. Creeper Fork Rail Piston
5. Piston to Rail Actuator Rod
6. Locknut
7. Adjuster
8. Creeper Fork
9. Sliding Coupling
10. Plate (part of Coupler)
11. C2 Clutch Output Gear (26 tooth)
12. Shim (0.060in./1.50mm)

NOTE: *If after the adjustment is completed, the adjustment screw appears flush or level with the locknut, this is indicating that the C1/C2 clutch assembly is incorrectly positioned with probably one of the output gears not seated. Investigate and repeat the adjustment. If the components are correctly positioned the adjusting screw will be approximately $3/16 \pm 1/16$ in. (4 ± 1 mm) above the lock nut.*

6. Tighten the screw lock nut to 11–13 lbf.ft. (15–18 Nm).

7. Disassemble the components (including separating the support shaft from the front cover), remove the spacer shim and assemble the C1/C2 support shaft 'O' ring seal and the annular sealing rings.

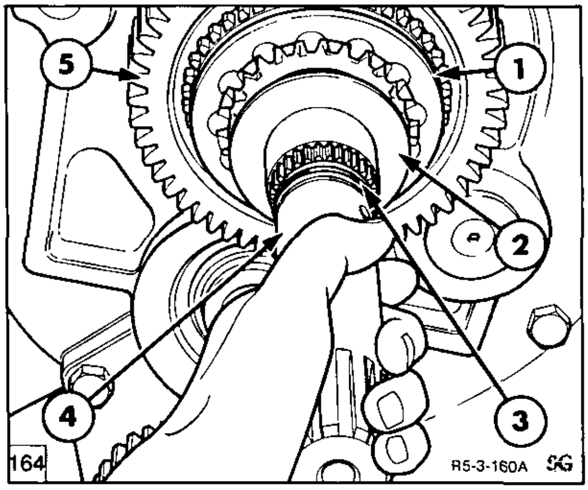


Creeper Coupler, Rail, Fork Installed and Wedged

1. Wedge
2. Creeper Gear
3. Creeper Fork
4. Return Spring
5. Fork Rail

8. Install the creeper fork rail return spring on the rail and position the rail, spring and fork assembly in the transmission housing. Take the creeper gear coupler positioning this onto the creeper gear coupler teeth and at the same time engaging the rail in its bore in the intermediate cover plate. Push the rail against the return spring and using a suitable wedge secure the rail to prevent it pushing upward.

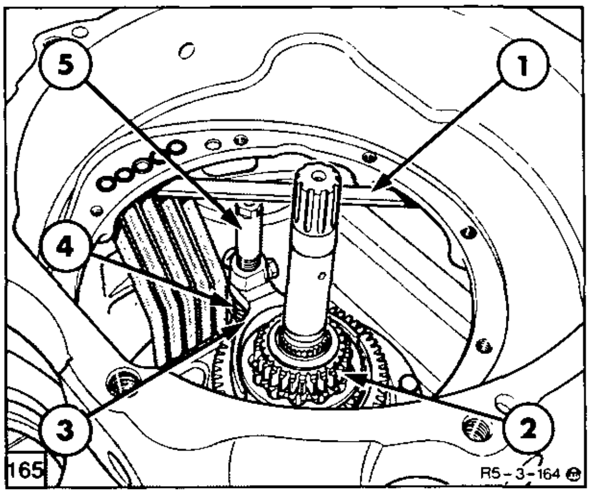
9. Position the steel thrust washer on the PTO/input shaft, ensure that the lube seal is in place and correctly positioned and install the shaft, carefully sliding it through the forward/reverse synchroniser supportshaft, Figure 164. Use a twisting motion during the installation of the shaft. Install the coupler plate to the centre of the sliding coupler.



PTO/Input Shaft Installed – with Creeper

1. Creeper Sliding Coupling
2. Steel Washer
3. Lube Seal
4. PTO/Input Shaft
5. Creeper Gear

10. Install the C2 clutch 26 tooth output gear with the two needle roller bearings, Figure 165.



Creeper Coupler, Rail, Fork and C2 Clutch Output Gear Installed and Wedged

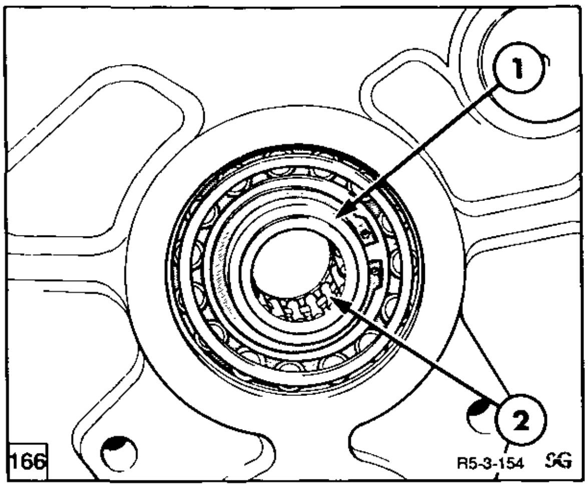
1. Wedge (holding Creeper Rail and Fork against Spring)
2. C2 Clutch Output Gear (26 tooth)
3. Creeper Fork
4. Creeper Fork Return Spring
5. Creeper Fork Rail

Adjustment of the creeper components is now completed.

All Transmissions

Continue the installation as detailed in the following steps:–

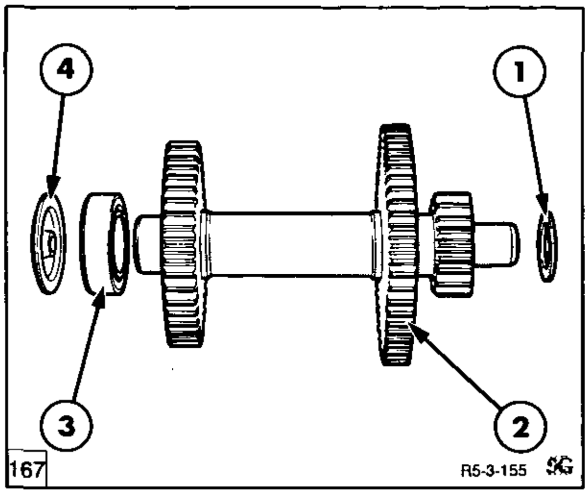
1. Position the front bottom shaft rear needle roller bearing in the front of the intermediate shaft, Figure 166.



Front Bottom Shaft Needle Roller Bearing Positioned in Intermediate Bottom Shaft

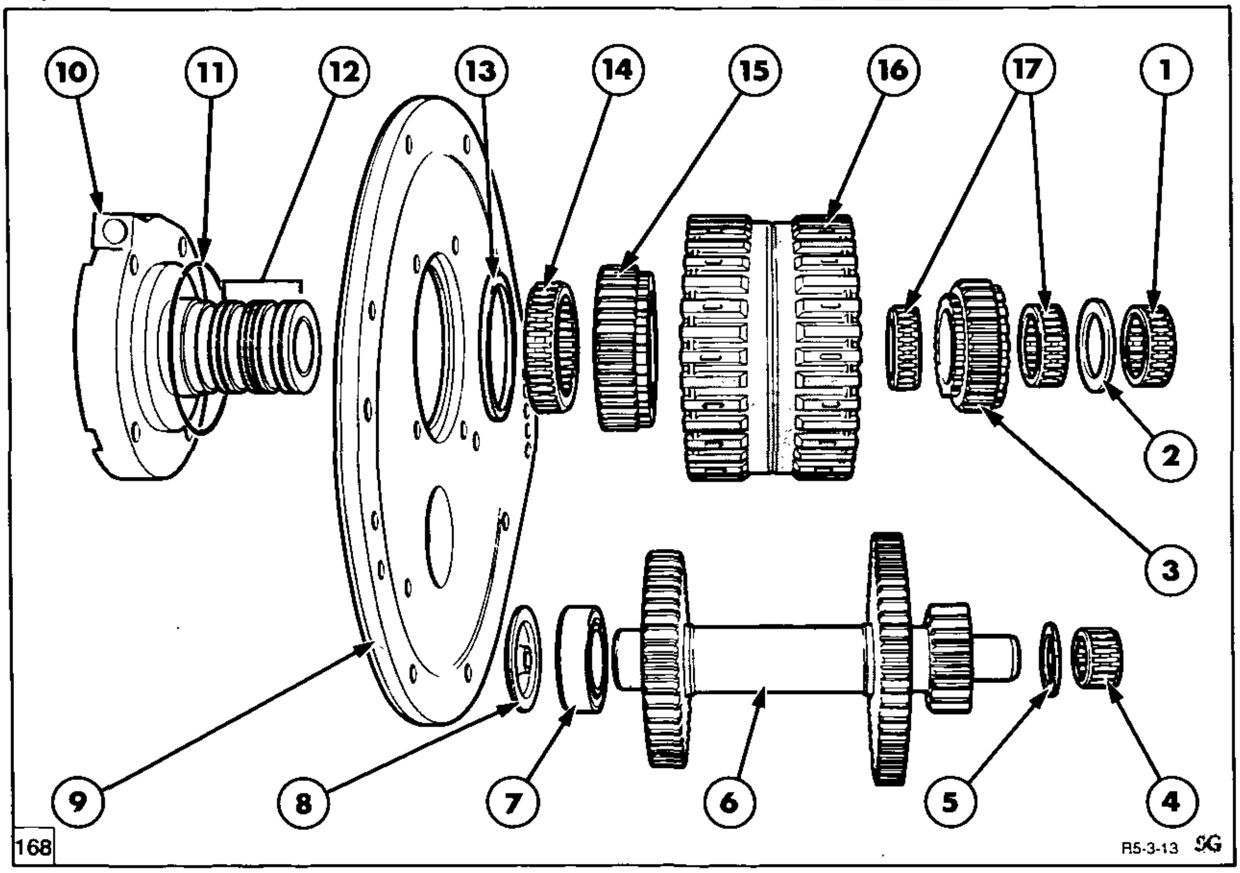
1. Intermediate Bottom Shaft
2. Front Bottom Shaft Rear Needle Roller Bearing

2. Position the polyimide thrust washer on the rear of the front bottom shaft, retaining the washer in position with petroleum-jelly, Figure 167. Ensure the front bearing is installed on the front bottom shaft. Note the lube oil baffle shown in Figure 167.



Front Bottom Shaft, Bearing and Polyimide Thrust Washer (creeper shown)

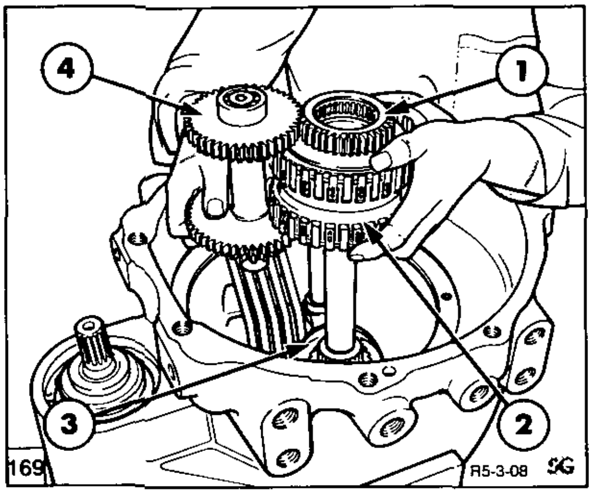
1. Polyimide Thrust Washer
2. Front Bottom Shaft (Creeper shown)
3. Front Ball Bearing
4. Lube Oil Baffle



C1/C2 Clutch Assembly, Front Bottom Shaft and Bearings and Thrust Washers – Exploded View

1. PTO/Input Shaft to Forward/Reverse Synchroniser Support Shaft Needle Roller Bearing
2. Steel Washer with Creeper (Polyimide Washer without Creeper)
3. C2 Clutch 26 Tooth Output Gear
4. Needle Roller Bearing
5. Polyimide Thrust Washer
6. Front Bottom Shaft (with Creeper shown)
7. Roller Bearing
8. Lube Oil Baffle
9. Front Cover Plate
10. C1/C2 Clutch Support Shaft
11. 'O' Ring Seal
12. Clutch Annular Sealing Rings
13. Polyimide Thrust Washer
14. Needle Roller Bearing
15. C1 Clutch 34 Tooth Output Gear
16. C1/C2 Clutch Assembly
17. Needle Roller Bearings

3. The C1/C2 clutch assembly should be checked for assembly detail prior to installation, the 26 tooth gear, item 3 in Figure 168, has been positioned on the shaft PTO/input shaft. Ensure that the C1 output gear (34 tooth) and the needle *roller bearing is installed in the C1 clutch* assembly.



Installing C1/C2 Clutch and Front Bottom Shaft

1. C2 Clutch 26 Tooth Output Gear
2. C1/C2 Clutch Assembly
3. Creeper Fork Rail
4. Front Bottom Shaft

4. Position the front bottom shaft inside the transmission housing alongside it's bearing bore. Take the C1/C2 clutch assembly and slide it on to the PTO/input shaft and at the same time position the bottom shaft in the rear bearing, Figure 169.

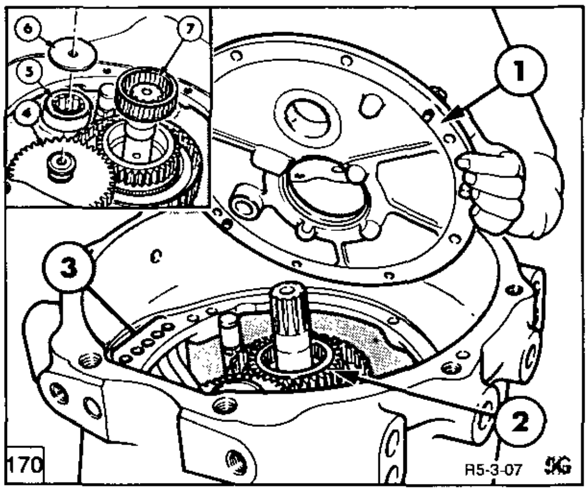
5. *For creeper transmissions only,* the weight of the installed C1/C2 clutch assembly will now hold the creeper components in place. Remove the wedge.

6. Install new lube tube 'O' ring seals to the ends of the lube tubes and retain these in place using petroleum jelly, Figure 170.

7. Position the lube oil baffle on the front bottom shaft front bearing. Position a new front cover gasket on the transmission housing and install the front cover plate, Figure 170. Install the retaining bolts and tighten sequentially and evenly to 34–44 lbf. ft. (45–60 Nm).

NOTE: *On creeper transmissions install the piston to the creeper fork rail and ensure when installing the cover that the piston enters the operating bore in the front cover.*

8. Install the polyimide thrust washer (item 13 in Figure 168) *on top of the C1 clutch* output gear through the C1/C2 support shaft opening in the front cover.

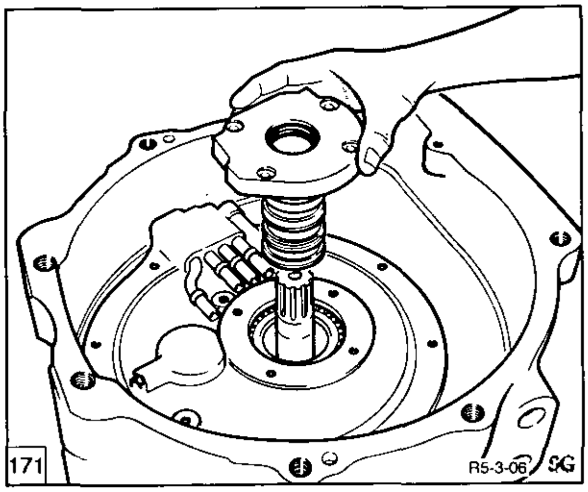


Installing Front Cover Plate (with Creeper shown)

1. Front Cover Plate
2. C1 Clutch Output Gear
3. Lube Tube 'O' Ring Seals
4. Front Bottom Shaft
5. Front Roller Bearing
6. Lube Oil Baffle
7. C1 Clutch Output Gear Needle Roller Bearing

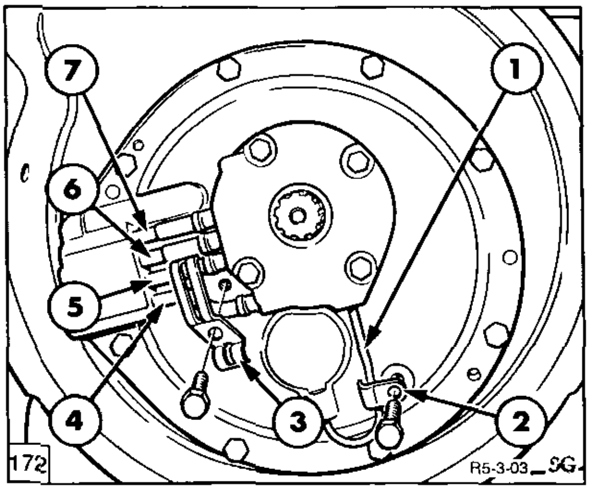
9. Ensure before fitting the C1/C2 clutch support shaft that the oil transfer tubes, shown in Figure 172, are in place in the front cover.

10. Coat the C1/C2 clutch support shaft clutch sealing rings with petroleum jelly, check that the front shaft oil seal and the shaft to cover 'O' ring are in place. Check that the C1/C2 clutch oil transfer tube seals and the front bottom shaft lube tube seal (rubber covered inserts) are installed in the shaft.



Installing C1/C2 Clutch Support Shaft

11. Carefully slide the support through the front cover and onto the PTO/input shaft Figure 171. Install the shaft retaining bolts and tighten evenly to 34–44 lbf. ft. (45–60 Nm).



Oil Transfer Tubes on Front Cover

1. Lower Front Shafts Lube Supply Tube
2. Retaining Bracket
3. Retaining Bracket
4. Top Shaft Lube & Supply to Bottom Shafts Tube
5. C1 Clutch Pressure Supply Tube
6. Clutch C1/C2 Lube Tube
7. C2 Clutch Pressure Supply Tube

12. Slide the C1/C2 clutch oil transfer tubes back into the C1/C2 clutch support shaft, install the front bottom shaft lube oil transfer tube and install the retaining brackets, Figure 172. Tighten the retaining brackets to 34–44 lbf. ft. (45–60 Nm).

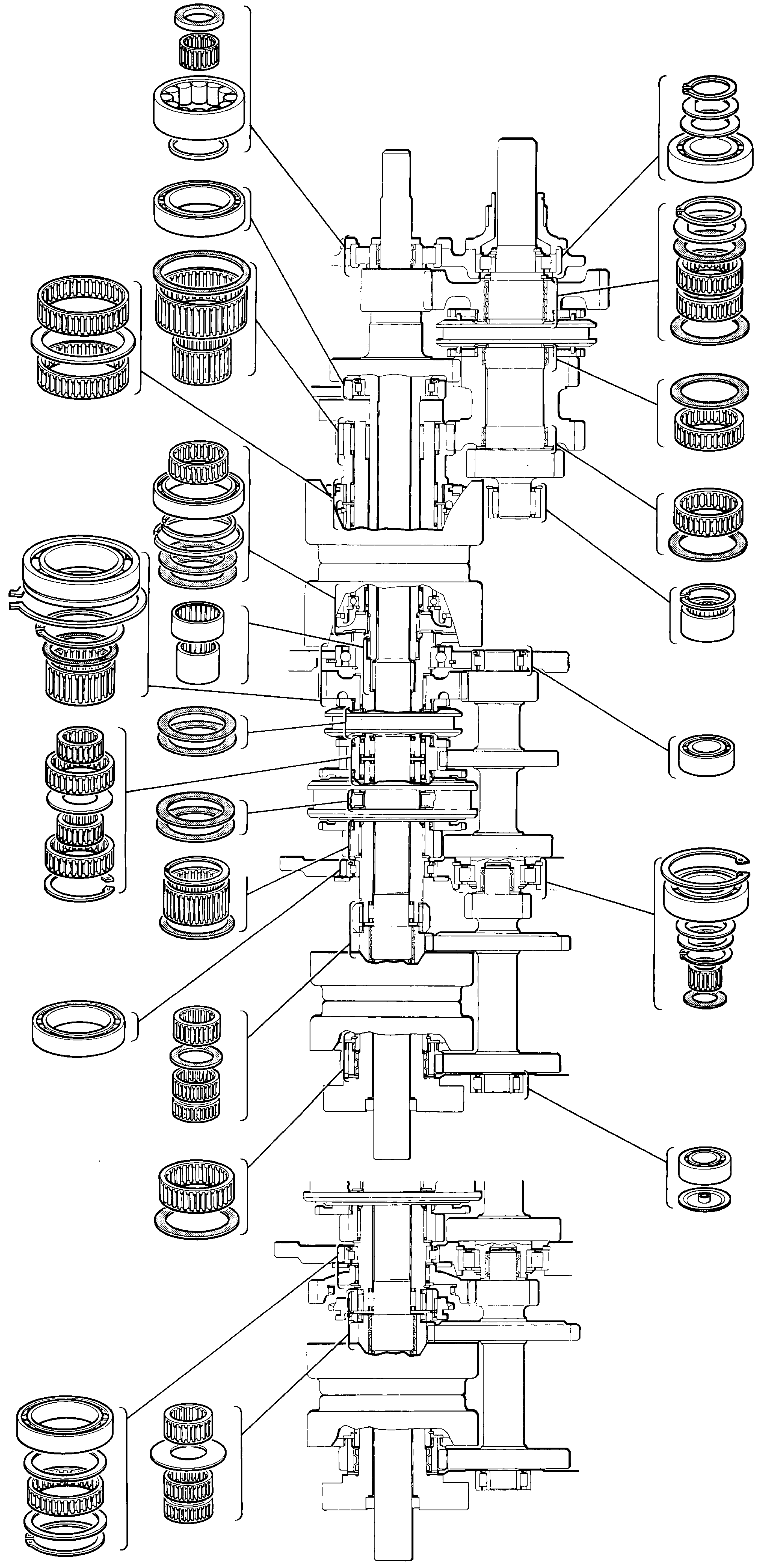
Synchroniser Centralisation

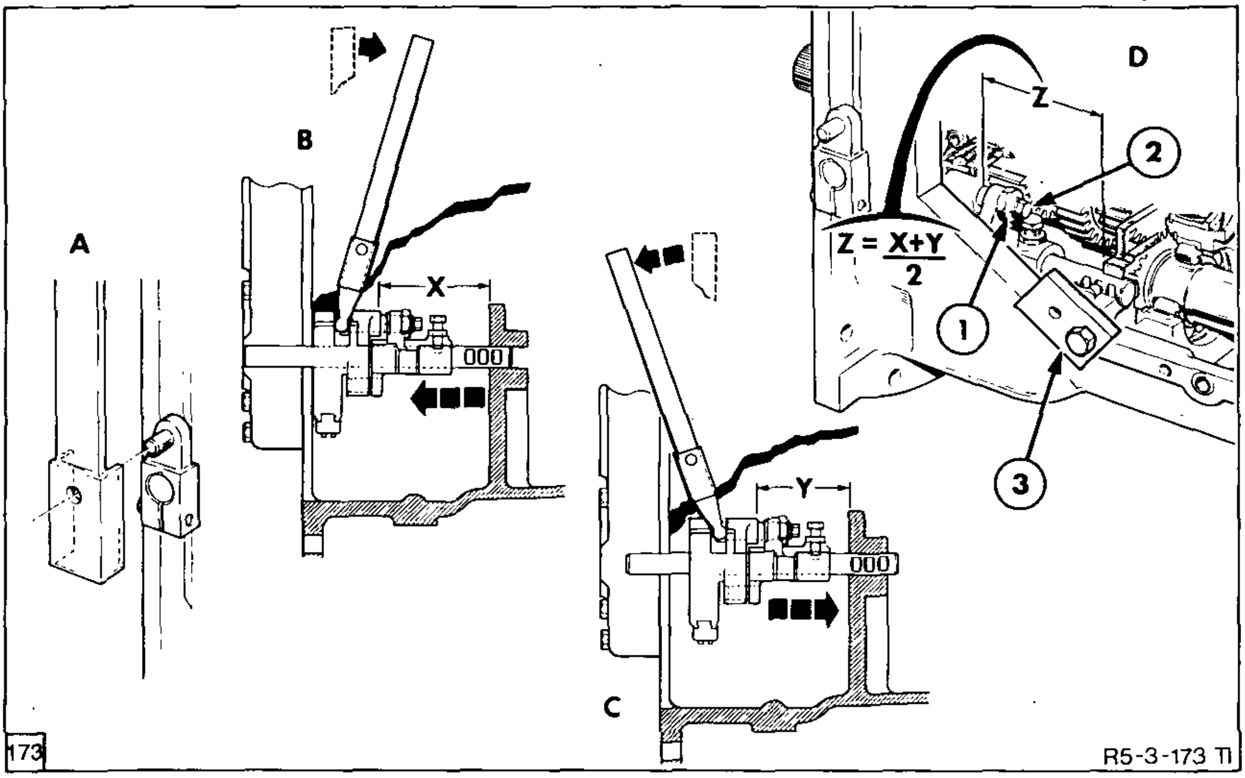
The forward/reverse, range and high/low synchronisers must be centralised midway between the movement limits. This adjustment is important as a badly centralised synchroniser will tend to wear and burn when in neutral. The high/low synchroniser adjustment is described in the following steps. As the gearshift cover must be re–installed to adjust the forward/reverse and main range synchronisers, this procedure is detailed in Section D.

Adjustment of the High/Low Synchroniser

1. Position the high/low synchroniser fork rail in neutral and install the rail detent ball, the ball actuator and the spring.
2. Fabricate a simple plate from 0.125 (3mm) strip steel so that the plate straddles the rail detent bore and allows the stem of the detent ball actuator to protrude (only the spring needs to be compressed). Bolt the plate across the control valve retaining bolt holes so that it compresses the detent spring and holds the rail in neutral, Figure 173.
3. Ensure the rail to fork set screw and locknut are installed and tightened. Also ensure that the adjustable high/low fork adjusting screw is tightened.
4. Using a suitable locally adapted lever to act on the high/low range selector shaft, shown at A in Figure 173, move the synchroniser backward and forward to engage the high and low ranges several times, in order to seat all the components.
5. Using the lever, move the fork and synchroniser into the engaged low range position, shown at B in Figure 173 and hold the lever fully hard in this position (beyond the natural point of detent). Establish a datum point and from that datum using a vernier caliper, measure the distance to the selector fork in the low range position. Record the measured distance, X in Figure 173.
6. Again using the lever move the fork and synchroniser into the fully engaged high range position, shown at C in Figure 173 and hold hard in that position (again possibly beyond the natural point of detent) and from the previously established datum point, measure the distance to the fork in the high range position. Ensure that the point of measurement on the fork is exactly the same as when the fork was measured in the low range position. Record this distance, Y in Figure 173.
7. Adding measurement X and Y together and dividing by 2 will establish the mid–point. This resultant measurement Z, shown in Figure 173, is the neutral position for the high/low synchroniser.
8. Move the fork and rail so that the neutral detented position is selected.
9. Loosen the adjustable fork adjusting screw locknut and by rotating the screw, adjust the position of the fork relative to the rail to achieve the previously calculated mid–point position. Tighten the adjuster locknut to 43–59 lbf. ft (58–80 Nm).
10. Move the fork and synchroniser in and out of high and low range several times and re–check the adjustment.

Installation of the internal transmission components is now complete. Install the control valve assembly as detailed in Section E, the gearshift cover as detailed in Section D and the gearshift control mechanism as detailed in Section C.



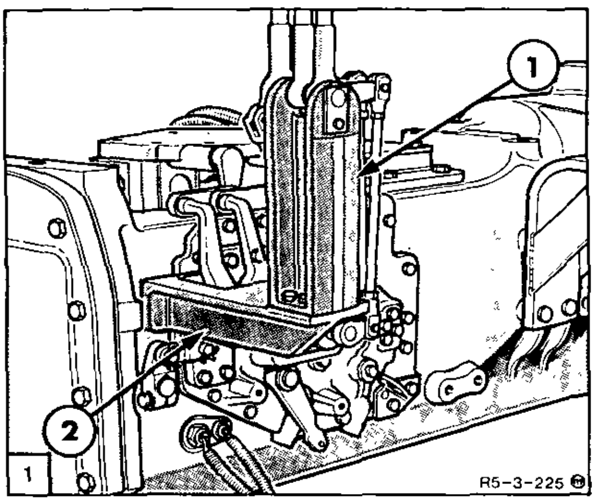


Centralising High/Low Range Synchroniser Selector Fork

A. Locally Fabricated Lever to Actuate High/low Fork Shaft
B. High/Low Fork Moved Fully Rearward
C. High/Low Fork Moved Fully Forward
D. High/Low Fork in Neutral and Adjusting Mid–Point

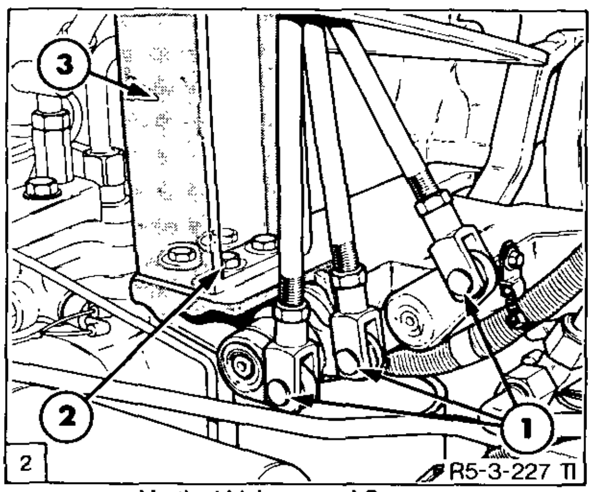
1. Adjuster Locknut
2. Adjuster Screw
3. Detent Ball Spring Retainer (**Note:** hole to allow stem of detent to protrude)

C. GEARSHIFT CONTROL LINKAGE – OVERHAUL



Gearshift Control Linkage

1. Vertical Support and Linkage Assembly
2. Horizontal Support and Linkage Assembly



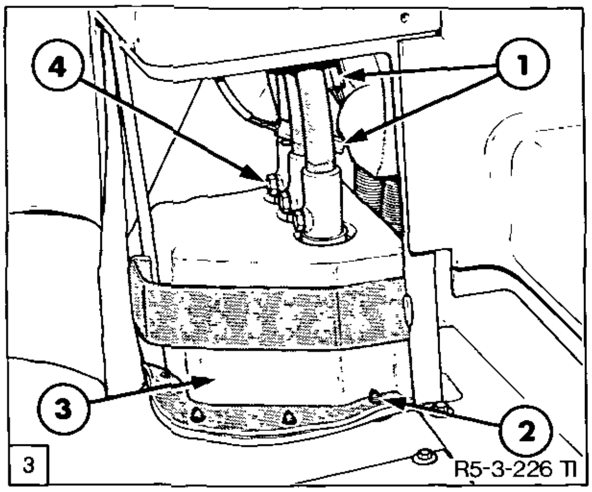
Vertical Linkage and Support

1. Control Rod Clevis Pins
2. Support Attaching Bolts (4 off)
3. Vertical Support

The gearshift linkage is located on the right hand side of the transmission, Figure 1. The linkage comprises of a vertical and horizontal support assembly containing the shafts, bellcranks and control rods. To prevent dirt ingress the linkage is protected by a three piece rubber boot.

Removal

1. From beneath the cab/platform separate the middle and lower section of the rubber boot and remove the clevis pins at the base of the three control rods, Figure 2.



Gearshift Lever Installation
(Console Covers Removed)

1. Electrical Connectors
2. Plastic Studs
3. Rubber Boot
4. Shift Lever Clamp Bolts

2. Remove the gear shift console and cover screws. Remove the lower gearshift cover and peel back the cab/deck floor mat, Figure 3.

3. Disconnect the shift lever electrical connectors.

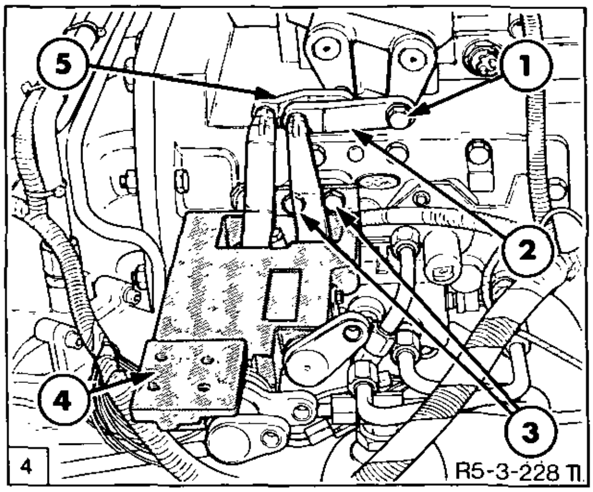
4. Loosen the shift lever clamp bolts.

5. Carefully raise the levers to disconnect them from the linkage. If the tractor is fitted with the in cab fast raise/lower switch, disconnect the wiring to the switch before fully removing the lever and console assembly.

6. Remove the plastic studs joining the upper and middle sections of the rubber boot. Refer to Figure 3.

7. Using a 13 mm socket and extension bar, inserted between the upper and middle sections of the rubber boot, remove the four bolts attaching the vertical and horizontal supports. Refer to Figure 2.

8. From beneath the cab, remove the vertical support and linkage assembly.

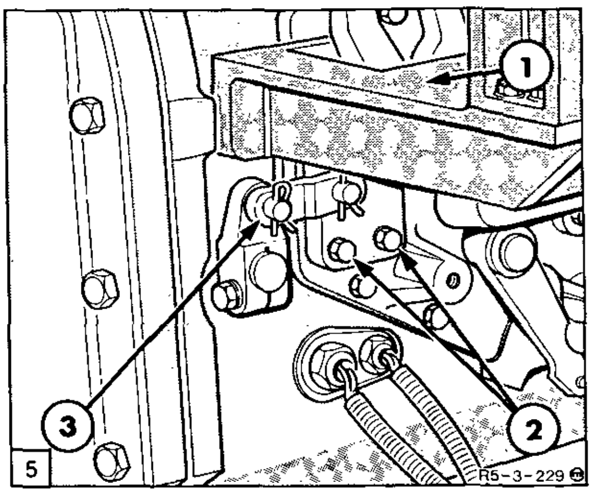


Horizontal Support and Linkage Installation

1. Pivot Bolt
2. Link Arm
3. Support Retaining Bolts
4. Horizontal Support
5. Link Arm

9. Remove the pivot bolt, *Figure* 4.

10. Remove the two support retaining bolts Figure 4.



Horizontal Support and Range Lever Link

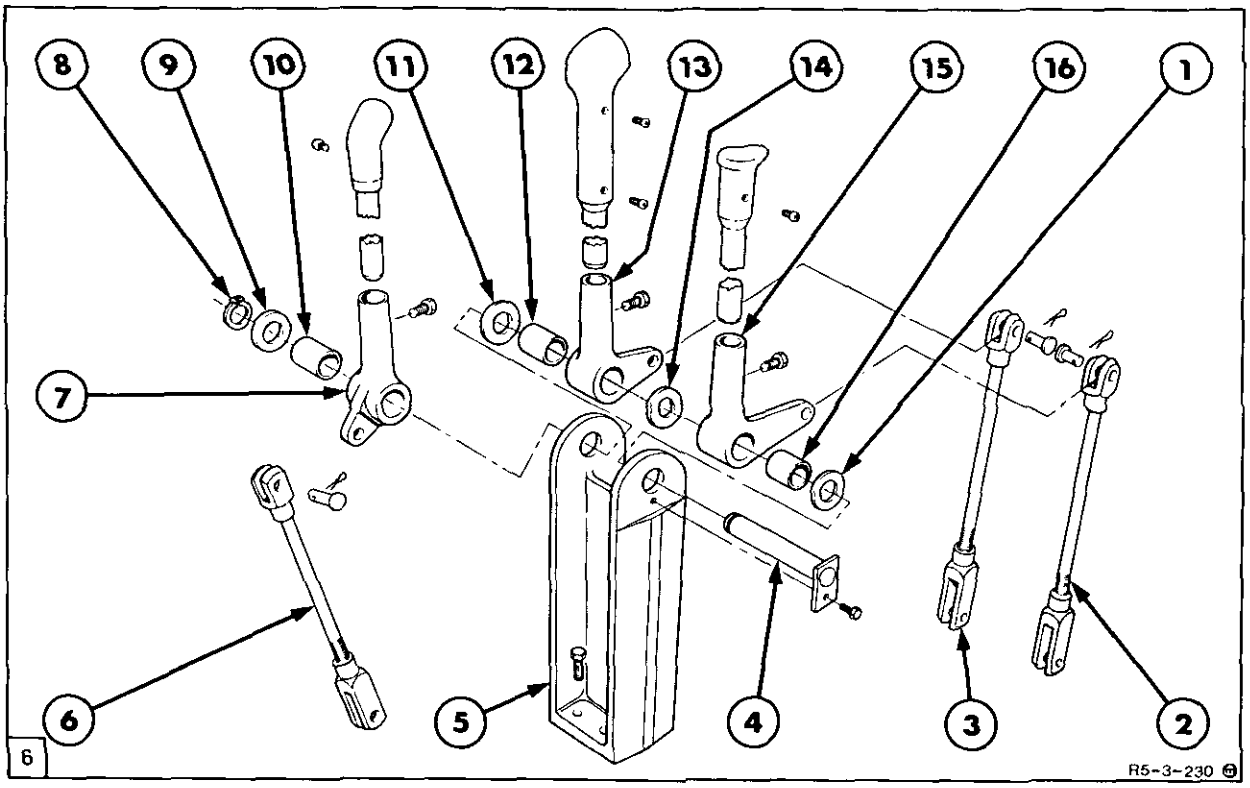
1. Support
2. Support Retaining Nuts
3. Range Lever Link

11. Disconnect the range lever link located beneath the horizontal support, Figure 5.

12. Remove the two nuts immediately beneath the support, Figure 5 and carefully lift the support from the side of the transmission.

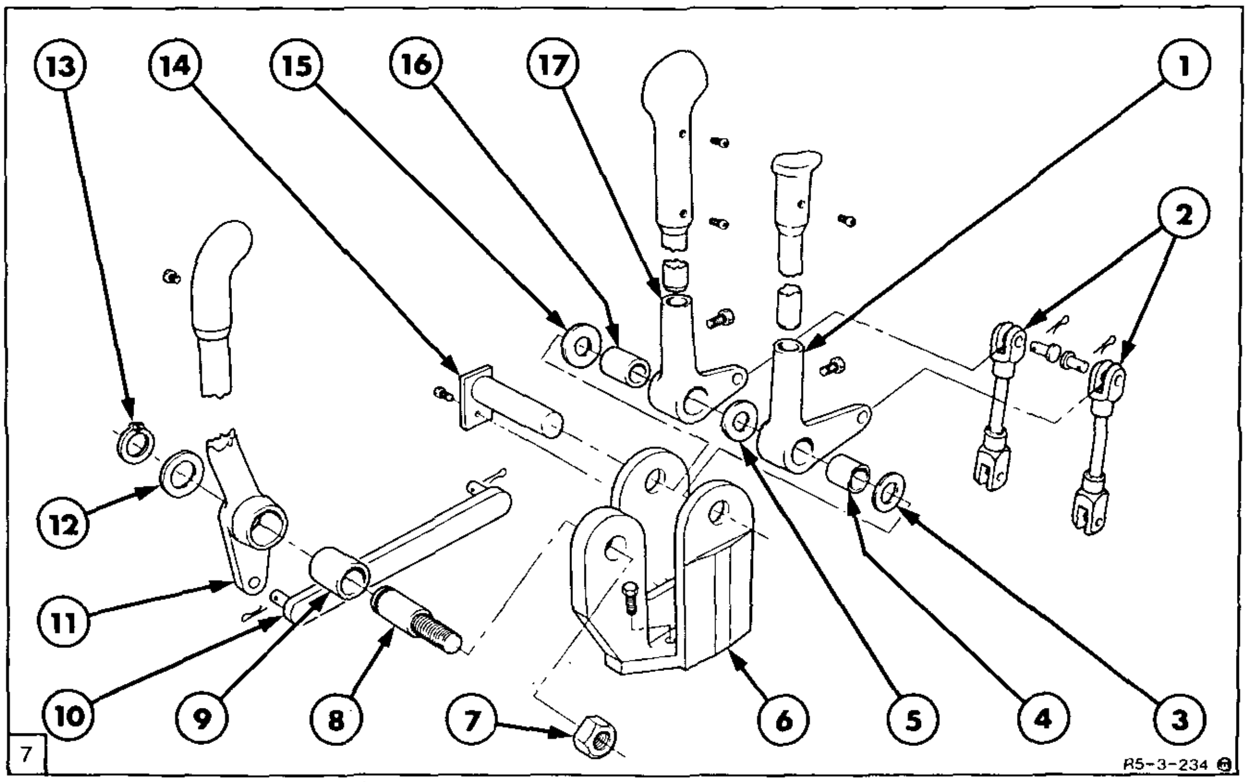
Disassembly

1. With reference to Figure 6 or Figure 7, disassemble the vertical linkage and support assembly.



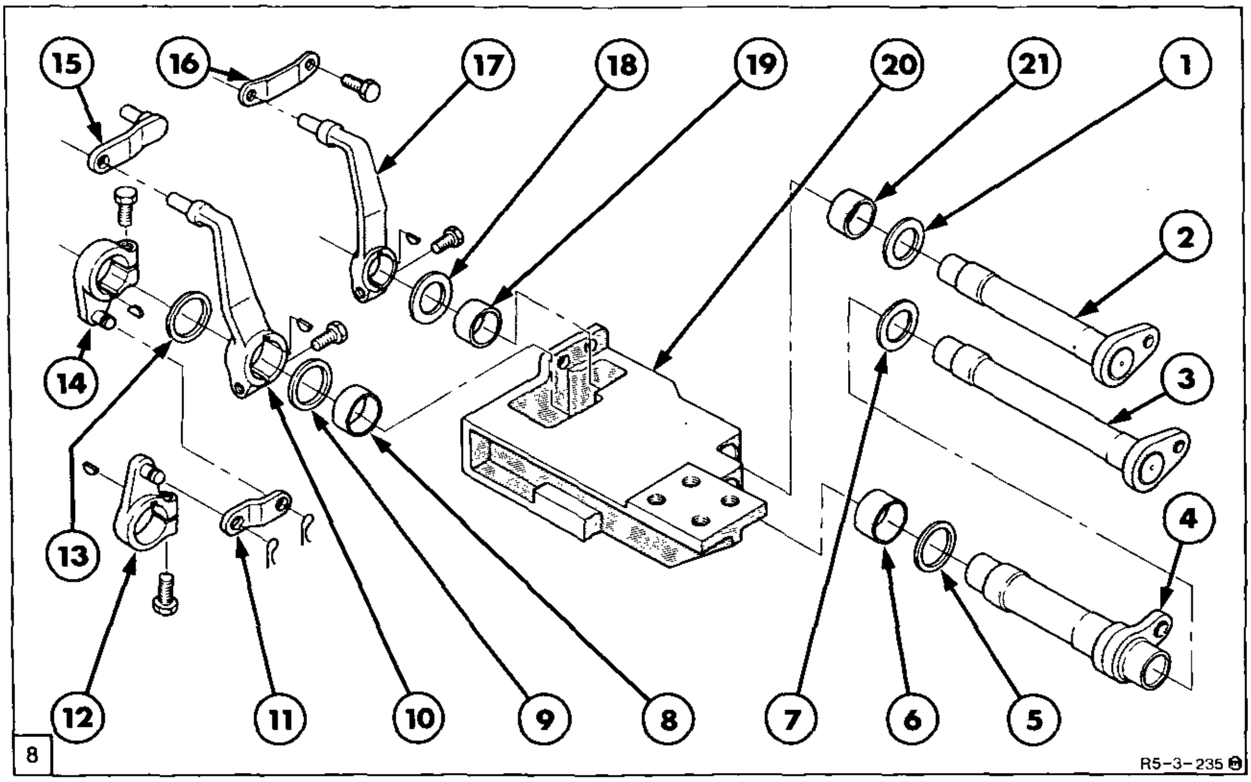
Vertical Support and Linkage Assembly (With Cab)

1. Plastic washer
2. Control Rod (green, 321 mm)
3. Control Rod (orange, 317 mm)
4. Shaft
5. Support
6. Control Rod (white, 299 mm)
7. Shuttle Lever
8. Snap Ring
9. Steel Washer
10. Bush
11. Plastic washer
12. Bush
13. Main Shift Lever
14. Plastic Washer
15. Range Lever
16. Bush



Vertical Support and Linkage Assembly (Less Cab)

1. Range Lever
2. Control Rods
3. Plastic Washer
4. Bush
5. Plastic Washer
6. Support
7. Nut
8. Shaft
9. Bush
10. Link
11. Shuttle Lever
12. Steel Washer
13. Snap Ring
14. Shaft
15. Plastic washer
16. Bush
17. Main Shift Lever



Horizontal Support and Linkage Assembly

1. Plastic Washer
2. Range Shaft
3. Forward/Reverse Shaft
4. Main Shaft
5. Plastic Washer
6. Bush
7. Plastic Washer
8. Bush
9. Plastic Washer
10. Main Arm
11. Link
12. Arm
13. Plastic Washer
14. Shuttle Arm
15. Link
16. Link
17. Range Arm
18. Plastic washer
19. Bush
20. Support
21. Bush

2. With reference to Figure 8, disassemble the horizontal support and linkage assembly.

3. Measure the length of each control rod. Each rod is colour coded and the dimensions in the key for Figure 6 are the specified measurements between the clevis pin hole centres.

Inspection

Inspection of the linkage follows established techniques.

1. Ensure excessive wear is not present in any of the pivots and that the shafts and bushings are not excessively worn.

2. Ensure that the linkage is free to move smoothly without binding.

Re–assembly

Re–assemble the linkages following the disassembly procedure in reverse.

1. Ensure all pivots are lubricated and greased where required.

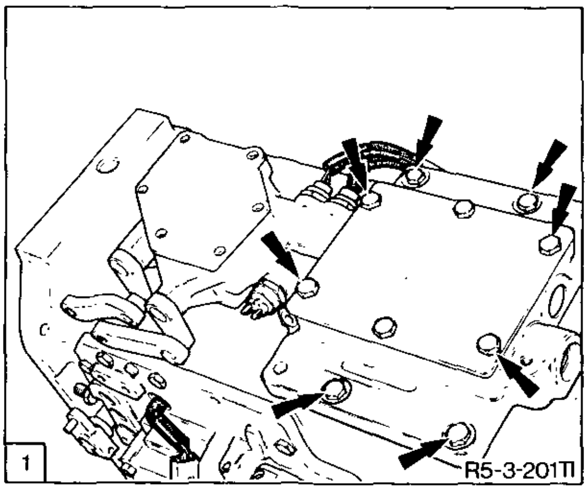
2. Tighten the arm pinch bolts to a torque of 15–19 lbf.ft (20.5–25.5 Nm).

Installation

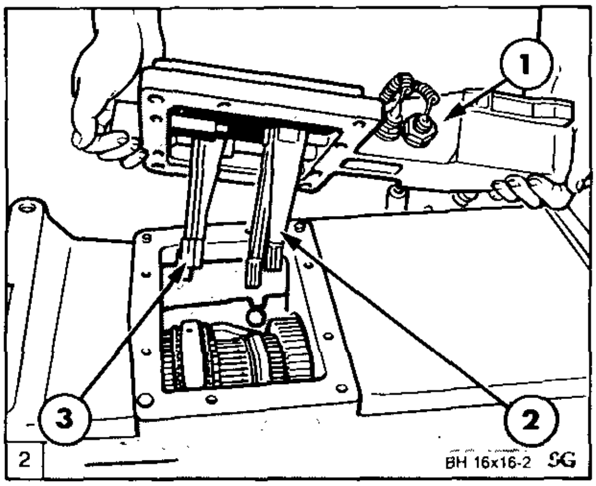
Installation of the gearshift control linkage follows the removal procedure in reverse. During installation observe the following:–

- Tighten the horizontal support retaining nuts and bolts to a torque of 30–37 lbf ft (40–51 Nm).
- Tighten the link pivot bolt, Figure 4, to a torque of 52–66 lbf ft (70–90 Nm).
- Tighten the four bolts attaching the vertical and horizontal linkage supports to a torque of 30–37 lbf ft (40–51 Nm).
- Tighten the shift lever retaining bolts to a torque of 15–19 lbf ft (20.5–25.5 Nm).
- On with cab tractors it may be necessary to re–adjust the length of the control rods to ensure that the levers align with the quadrant neutral position.
- Check the movement of the control levers through their total operating range to ensure that they do not foul the ends of the quadrant or console.

D. GEARSHIFT COVER – OVERHAUL



Gearshift Cover Retaining Bolts



Removing Gearshift Cover

1. Cover Assembly
2. Main Shift Fork
3. Forward reverse Shift Fork

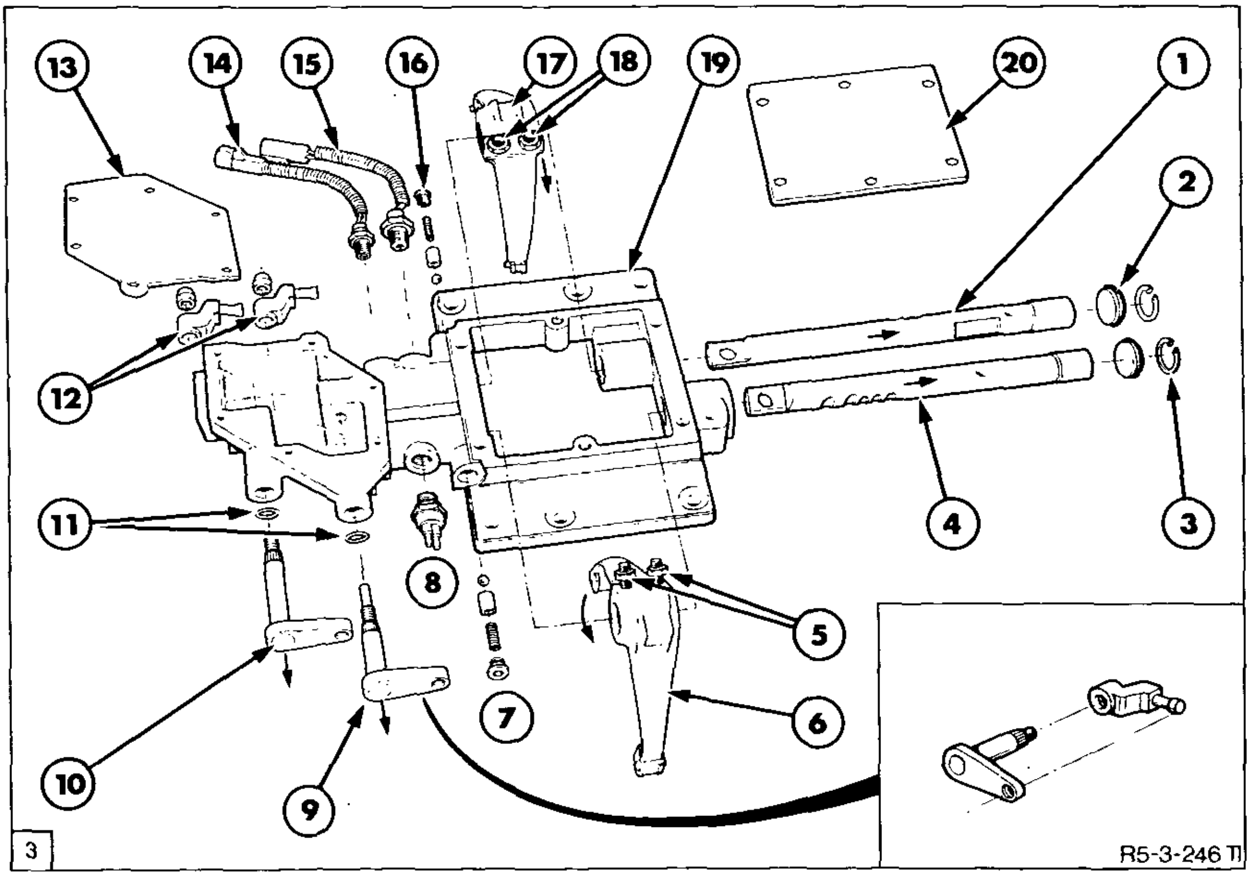
Removal

1. Ensure the transmission is in neutral.
2. Remove the eight cover retaining bolts, Figure 1.
3. Lift the cover from the transmission housing, Figure 2.

Disassembly

With reference to Figure 3.

1. Remove the front and rear cover plates.
2. Remove the detent ball, seat and spring from each shift rail.



Gearshift Cover Assembly Exploded View

1. Main Shift Rail (Long Rail)
2. Blanking Plug (4 off)
3. Snap Ring (4 off)
4. Forward/Reverse Shift Rail (Short Rail)
5. Set Screws
6. *Forward/Reverse Fork (Large Fork)*
7. Detent Ball, Seat, Spring and Plug
8. Neutral Start Switch
9. Forward/Reverse Shift Cross Lever
10. Main Shift Cross Lever
11. Cross Lever Seals
12. Rail Actuator Arms
13. Rear Cover Plate
14. 5–8 Range Switch
15. 1–4 Range Switch
16. *Detent Ball, Seat, Spring and Plug*
17. Main Shift Rail Fork (Small Fork)
18. Set Screws
19. Housing
20. Front Cover Plate

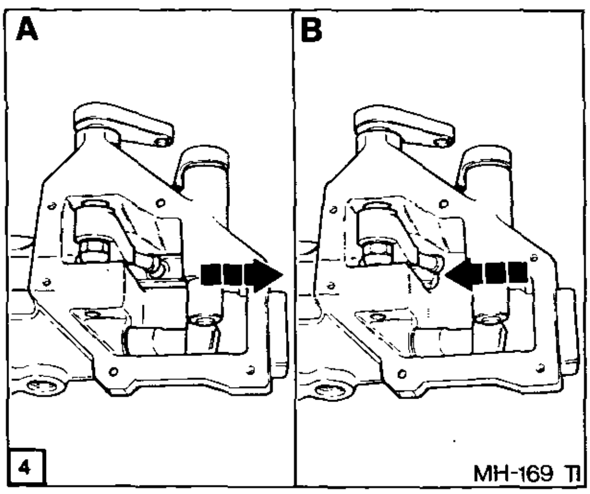
3. Remove the three switches.

4. Remove the snap rings and shift rail bore blanking plugs from the front end of the shift cover. It is not necessary to remove the blanking plugs from the rear of the cover unless oil leakage is apparent.

5. Remove the locknuts and set screws from each fork.

6. Push the forward/reverse shift rail toward the cross lever arm. Disconnect the ball on the arm from the slot in the rail and remove the rail from the front of the cover housing, Figure 4.

7. Remove the main shift rail.



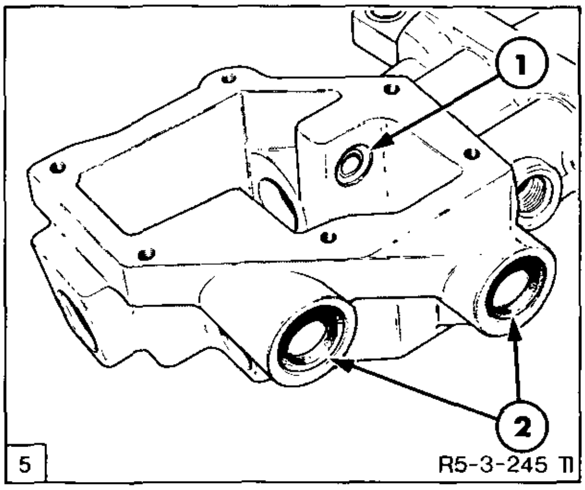
Forward/Reverse Shift Rail Removal

8. Unscrew the rail actuating arm retaining nuts and lever the arms from the cross lever splines.

9. Pull the cross levers from the selector housing.

Inspection

1. Thoroughly clean all parts and dry using a clean lint free cloth.



Cross Shaft Bushes and Seals

1. Bush
2. Bushes and Seals

2. Inspect the cross shaft to housing inner bushes for wear and replace if necessary, Figure 5.

3. Replace the cross shaft seals.

4. Inspect the detent springs for distortion by comparing with a new item.

5. Replace the 'O' ring seals.

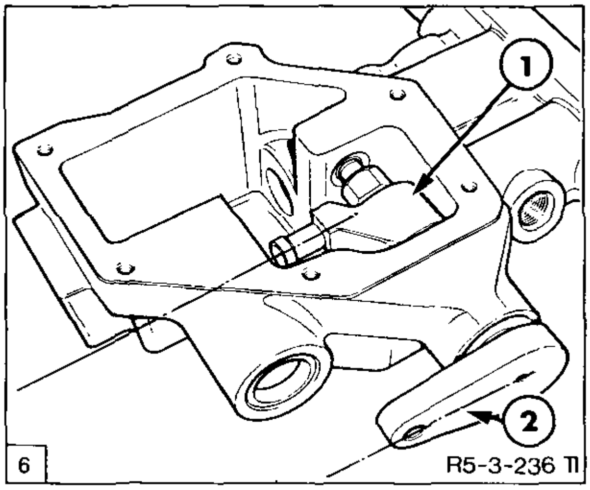
6. Inspect the forks and thrust pads on the tips of each fork for damage and wear.

7. Inspect the fork to rail set screw contact area for damage. If necessary dress the surface to ensure the set screws will positively grip in the correct position during re–assembly.

Re–assembly

Re–assembly of the gearshift cover follows the disassembly procedure in reverse.

1. Ensure all parts are lubricated with transmission/rear axle oil.



Aligning Cross Shaft Lever to Arm
(Arm and Lever Must be Parallel to Each Other)

1. Rail Actuating Arm
2. Cross Shaft Lever

2. Install the cross shaft levers and actuator arms. Ensure the arms are positioned parallel to the lever on the shaft. Refer to Figure 6.

3. Tighten the rail actuator arm nuts to a torque of 30–38 lbf.ft (40–50 Nm).

4. Install the shift rails and forks into the cover. **Do Not** tighten the fork setscrews, the forks must remain loose on the rails until after installation of the cover.

5. Position the rails in the neutral position and install the two detent balls, springs and plugs. Tighten the plugs to 13–18 lbf.ft (17–25 Nm).

6. Install the switches. Tighten the neutral and 5–8 range switches to a torque of 22–37 lbf.ft (30–50 Nm) and the 1–4 range switch to 15–21 lbf.ft (20–28 Nm).

7. Install the shift rail blanking plugs and snap rings.

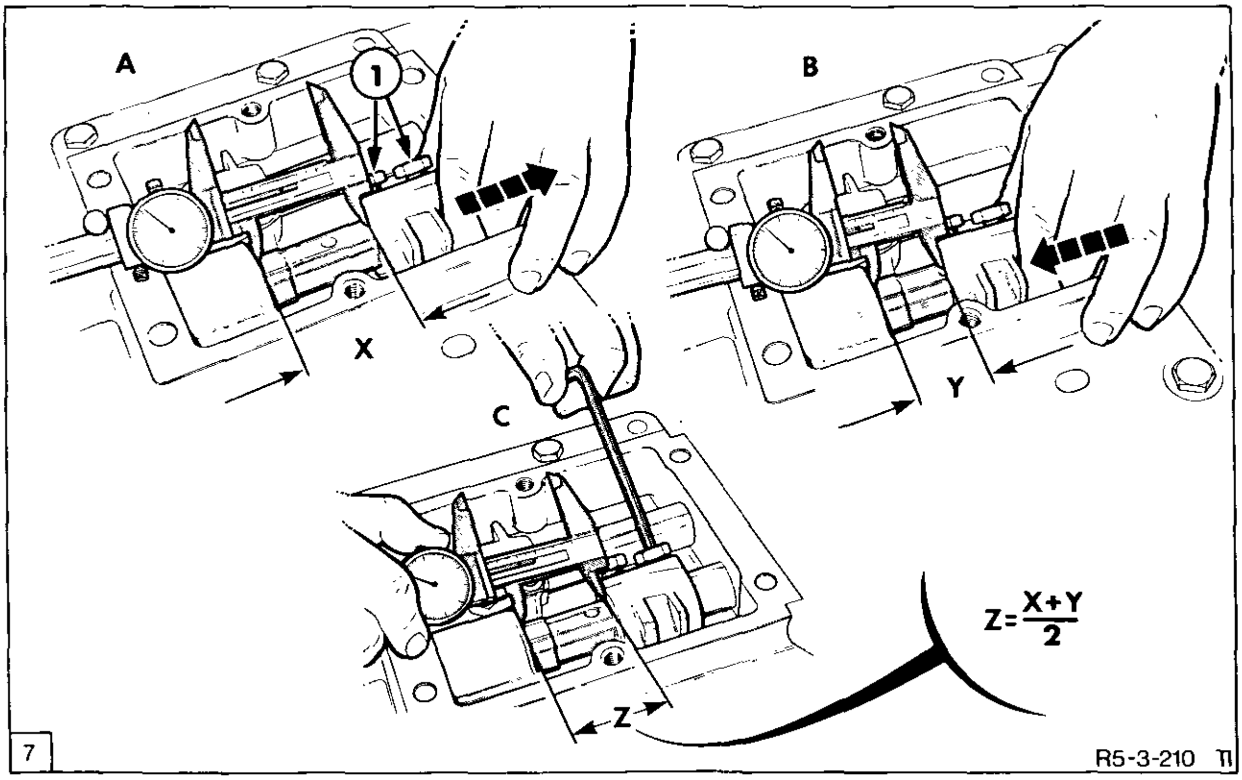
8. **Do Not** install the front and rear cover plates at this stage.

Installation

1. Apply liquid gasket ESE–M4G234–A1 (Loctite 515) to the transmission gearshift cover aperture.

2. Position the gearshift cover to the transmission housing taking care to align the pads on the forks with the synchronisers.

3. Install the four shift cover outer bolts and tighten to a torque of 26–40 lbf.ft. (35–55 Nm).



Centralising Forward/Reverse Synchroniser Selector Fork

A. Forward/Reverse Fork Moved Fully Forward
B. Forward/Reverse Fork Moved Fully Rearward
C. Setting Forward/Reverse Selector Fork at Mid–point
1. Fork to Rail Set Screws and Locknuts

Shift Fork Adjustment Procedure

With Reference to Figure 7.

1. Ensure both shift rails are in the neutral position (cross shaft levers vertical)

2. Move the forward reverse shift fork fully forwards and rearwards several times without moving the shift rail from the neutral detented position.

NOTE: *If the rail has a tendency to move from the neutral position, insert an additional ball beneath the rail detent seat. This will lock the rail in position, but care must be taken to ensure the ball is removed once the adjustment procedure has been completed.*

3. Without moving the shift rail, move the forward/reverse shift fork fully forwards to engage the synchroniser. While continuing to hold the fork in the fully forward position measure dimension "X".

4. Again without moving the shift rail from the neutral position move the forward/reverse shift fork fully rearwards to engage the synchroniser. While continuing to hold the fork in the fully rearward position measure dimension "Y".

5. Calculate the synchroniser neutral position "Z" using the formula $Z=\frac{(X+Y)}{2}$.

6. Without moving the shift rail position the shift fork to dimension "Z" and tighten the lock screws evenly to 18–23 lbf.ft (24–30 Nm). Tighten the locknuts to 14–19 lbf.ft (19–25 Nm).

IMPORTANT: *Ensure the fork does not wander from the established neutral position when tightening the setscrews.*

7. Repeat the above procedure for the main shift rail fork and synchroniser.

8. Install both shift cover plates using liquid gasket ESE–M4G234–A1 (Loctite 515). Tighten the forward cover plate retaining bolts to 26–40 lbf.ft (35–55 Nm) and the rear cover plate screws to 6–9 lbf.ft (7–13 Nm).

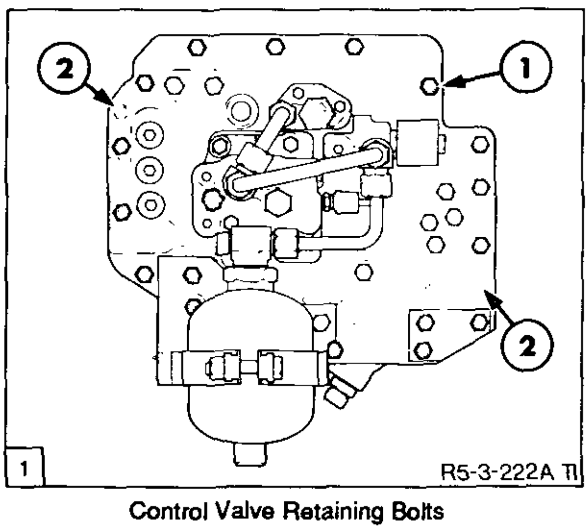
E. CONTROL VALVE – OVERHAUL

The following procedure treats the transmission as removed from the tractor. It is possible to remove the control valve from the transmission without removing the transmission from the tractor. Removal of the surrounding tubing, the accumulator and other peripheral hardware should be performed following conventional techniques to gain access to the control valve.

NOTE: *During removal of the control valve and the connecting hardware, it is essential that outside contaminant is not permitted to enter the inside of the transmission. If necessary steam clean the outside of the control valve area before proceeding to remove the valve assembly.*

The following overhaul details a complete disassembly, inspection and reassembly procedure. It will be rare in Service that a complete overhaul will be required. During fault finding, a particular area or component may be highlighted as being suspect and it will not be necessary to follow the complete overhaul procedure, but it is important to read this Section before repair is undertaken and to determine the level of disassembly required.

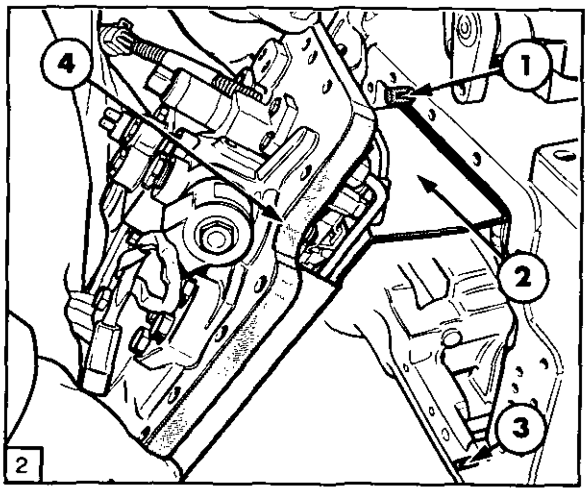
Control Valve Removal



Control Valve Retaining Bolts

1. Retaining Bolts – 16 off
2. Jacking Bolt Hole – 2 off

1. Remove the 16 control valve cover retaining bolts shown in Figure 1. Use two of the removed bolts in the jacking holes provided in the cover and carefully remove the control valve assembly from the transmission housing. As the control valve cover is withdrawn it will be necessary to tilt the bottom outwards and withdraw downwards to prevent the metal shield from catching on the internal pipework, the clutch cable arm will also need to be held up to prevent catching on the transmission casing.



Control Valve Assembly Removal

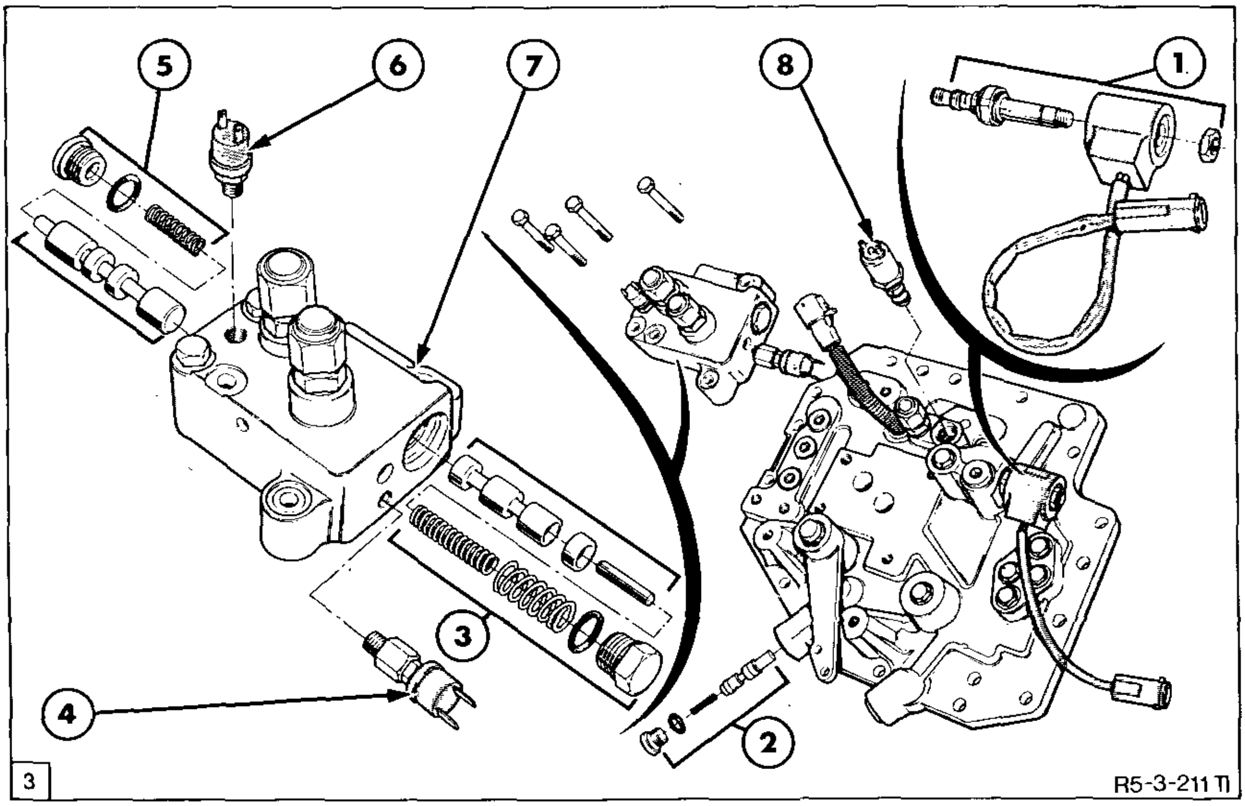
1. Location Dowel
2. Metal Shield
3. Location Dowel
4. Control Valve Assembly

Control Valve Disassembly

Absolute cleanliness is essential during disassembly and reassembly of the control valve. Ensure the working area is clean and not likely to be contaminated by other working operations being performed alongside. It is not recommended to disassemble the control valve in any place other than a clean, dust and dirt free environment.

During disassembly take care when removing components and note how 'easy' or 'hard' it is to remove spools. This will indicate if spools are possibly sticking or stuck or are excessively loose and therefore leaking pressure oil past the spool lands.

External Components

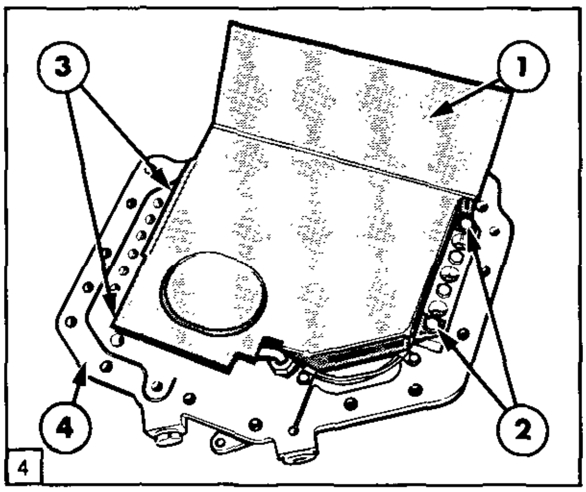


Hydraulic Control Valve – Externally Located Components

1. Creeper Solenoid and Valve
2. Creeper Interlock Piston
3. C1/C2 Sequencing Valve and Springs
4. C1/C2 Clutch Pressure Switch
5. Lube Combining Valve and Spring
6. C3/C4 Clutch Pressure switch
7. CALC Valve Body
8. PWM Solenoid Valve

1. Referring to Figure 3, remove the external components from the control valve.

2. Loosen the end plugs, items 3 and 5 of Figure 3, of the CALC (Clutch And Lubrication Control) valve and carefully remove the end plugs, springs, sequencing and lube combining spools.



Metal Shield Securing Bolts

1. Metal Shield
2. Securing Bolts
3. Securing Bolts
4. Control Valve Cover Assembly

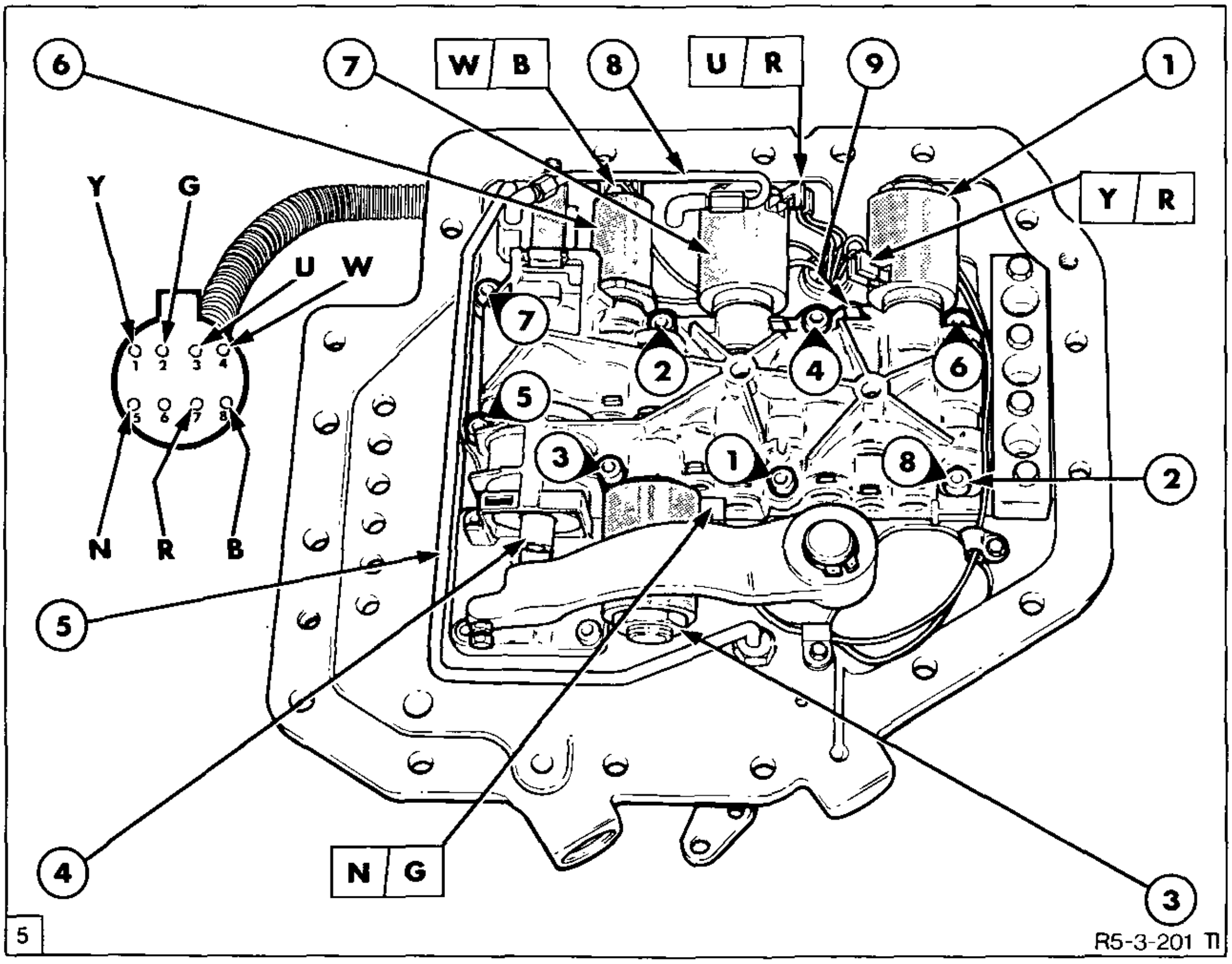
Internal Components

1. Remove the four bolts securing the metal shield to the cover assembly.

2. If creeper is fitted, remove the creeper interlock feed tube, item 5, Figure 5.

3. Remove the feed tube to the feathering valve from the PWM valve, item 7, Figure 5.

4. Remove the wiring from the solenoids noting the colour and location of the wires.



Control Valve Internal Components and Valve Body Tightening Sequence

1. S2 Solenoid – C3/C4 Clutch Selector
2. Valve Body Retaining Bolt with Tightening Sequence Number
3. S3 Solenoid – Neutral Dump Valve
4. Feathering Valve Mechanical Actuating Piston
5. Creeper Interlock Feed Tube
6. S4 Solenoid – FWD Valve
7. S1 Solenoid – C1/C2 Clutch Selector
8. PWM to Feathering Valve Tube
9. Valve Body

Wire Colours:
W= White
B= Black
U= Blue
R= Red
Y= Yellow
N= Brown
G= Green

5. Loosen and remove the eight hexagonal headed set screws retaining the valve body to the cover, using the reverse of the tightening sequence shown in Figure 5. Carefully lift away the valve body from the cover.

6. Referring to Figure 7, remove the remainder of the cover assembly components.

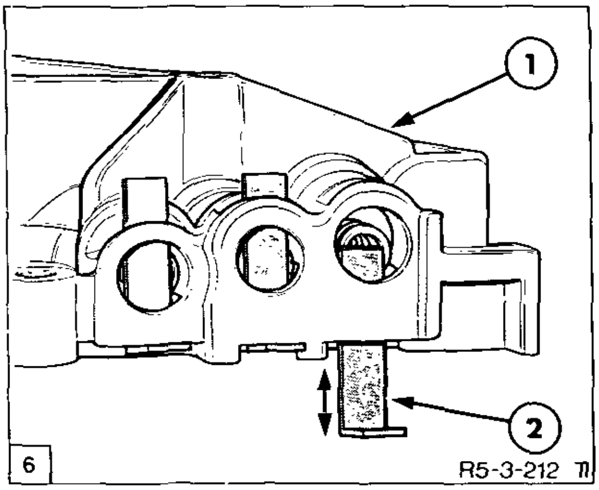
Valve Body Disassembly

With reference to Figure 8.

1. Loosen and remove the solenoid coil retaining nuts. Note the 'O' ring under the nuts. Loosen and remove the solenoid cores and push rods from the valve body. Carefully remove the valve spools and springs previously retained by the solenoid push rods. Refer to Figure 8, items 5, 7 and 10.

2. Remove the remaining spools by carefully withdrawing the spring keepers from the underside of the valve body, as

shown in Figure 6. Shield the orifice as the keeper is removed to ensure that injury is avoided and the springs are not lost.

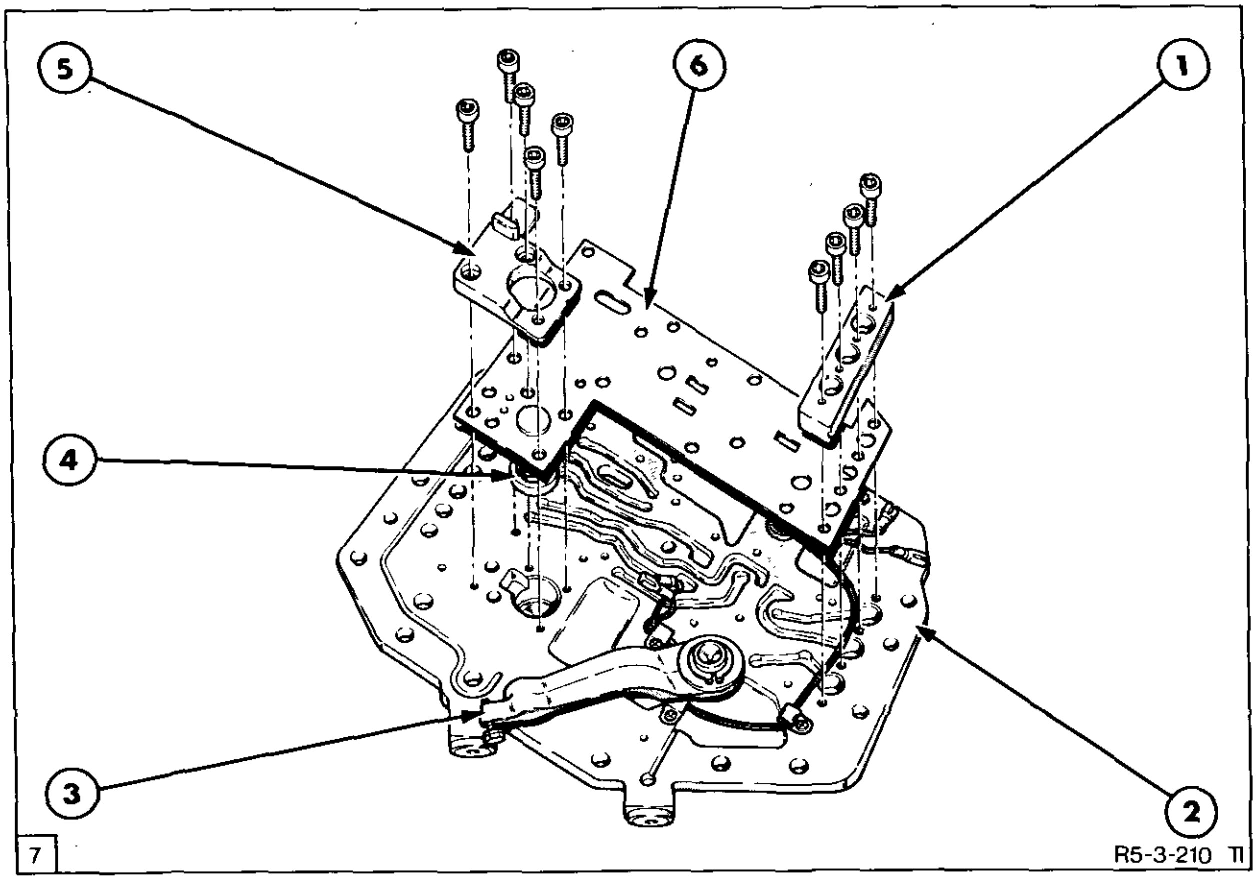


Spring Keeper Removal/Installation

1. Valve Body 2. Spring Keeper

3. To remove the spools use suitable long nose pliers, taking care not to cause damage to the spools. The lube shut off spool, item 6 Figure 8, can be removed by using external circlip pliers opened inside the spool.

IMPORTANT: *Do not strike the valve body to remove spools, damage or distortion to the valve body may result which will require the replacement of the complete valve body assembly.*



Control Valve Cover Assembly Internal Components

1. Oil Manifold
2. Control Valve Cover
3. Clutch Pedal Lever and Adjustable Stop
4. Lube Relief Valve
5. Lube Relief Valve Manifold
6. Plate

4. To remove the feathering valve, item 2 Figure 8, slacken the nut of the retaining screw. With the retaining screw sufficiently withdrawn, squeeze and rotate through 90° the horse shoe clamp, item 13, Figure 8, the manifold assembly

can now be removed. Note the 'O' ring on the underside of the manifold.

Component Inspection

1. Clean all of the disassembled components in a suitable cleaning solvent such as paraffin. Carefully observe whilst cleaning the oil galleries to see if any dirt particles have been flushed out. Any dirt in the valve body or cover assembly may have been causing an operational fault.

WARNING: *Cleaning solvents may be very flammable. When using cleaning solvents ensure that adequate safety precautions are taken to avoid personal injury. Ensure the area is well ventilated and that there are no naked flames or lit cigarettes.*

2. Inspect all of the spools for scoring or damage, which may have been caused by the ingress of dirt particles. If there are any indications of damage or wear replace the affected spools.

3. Inspect the valve body for similar damage as the spools. Also inspect for hairline cracks in the body between the spool galleries. If there is any damage or the valve body is in any way suspected of being faulty, a new valve body assembly should be installed. A valve body assembly will consist of the valve body, spools, springs and keepers and the solenoids. The valve body is not Serviced as a separate item.

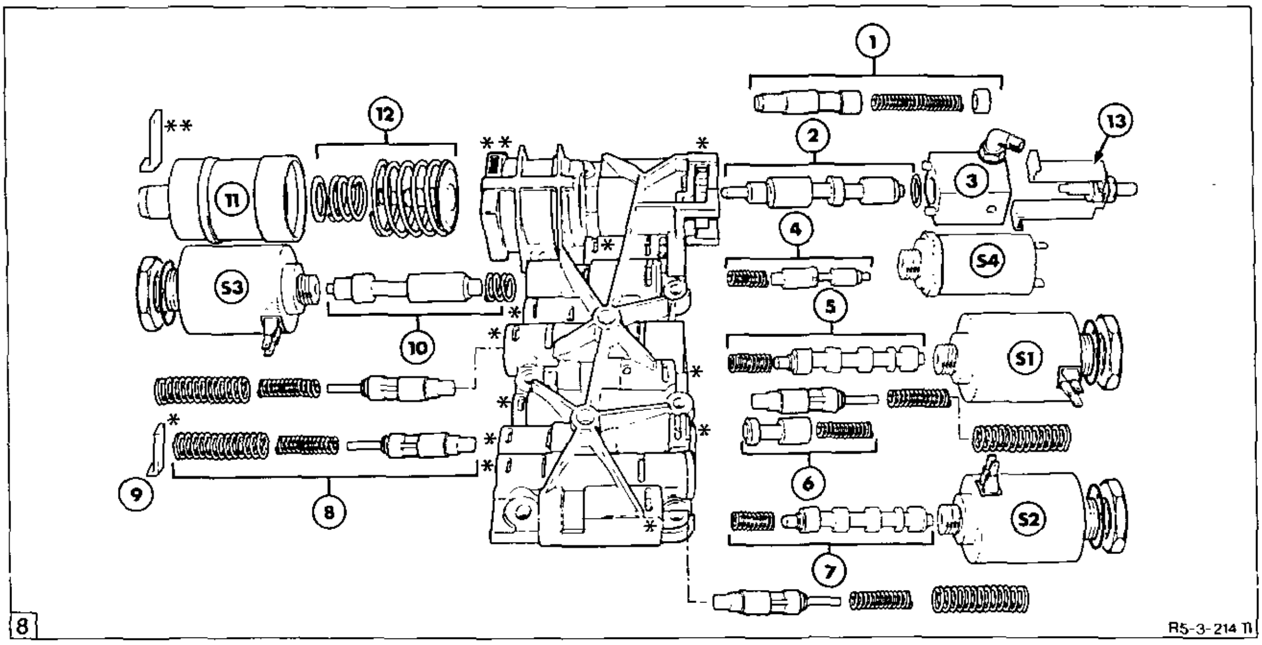
4. Inspect the valve solenoids and test the coils as described in the fault finding section. Replace faulty or suspect solenoid assemblies.

5. Inspect the wiring through the housing cover for chafing and check each wire for continuity, for short circuits to ground and short circuits between the other wires.

6. Inspect the spool return springs and replace damaged or broken springs as required.

7. Inspect the lube relief valve, item 4, Figure 7 and lube manifold, item 5, Figure 7. The relief valve should seat on the plate and create an oil tight seal. The valve should lift off its seat using moderate hand pressure. Inspect the manifold for flatness and for cracks in its casting. Replace if defects are found.

8. Inspect the valve cover for blocked galleries or cracking between the galleries.



8

Control Valve Exploded View

1. Safety Start Valve Assembly
2. Feathering Valve
3. PWM Oil Manifold
4. FWD Selector Valve Assembly
5. C1/C2 Selector Valve Assembly
6. Lube Shut off Valve Assembly
7. C3/C4 Selector Valve Assembly
8. Vent Delay Valve and Springs – 4 off
9. Spring Retainer (10 off)
10. Neutral Dump Valve
11. Feathering Valve Plunger Assy.
12. Feathering Valve Spring Assy.
13. Oil Manifold Retainer (Horse Shoe Clamp)

S1 C1/C2 Clutch Solenoid
S2 C3/C4 Clutch Solenoid
S3 Neutral Dump Solenoid
S4 FWD Solenoid

* Spring Retainer (short) – 10 off
** Feathering Valve Plunger Retainer – 1 off

Reassembly

1. Reassembly is the reversal of the disassembly, although the following points should be noted:

- With the individual spools lubricated with the correct grade of transmission oil, ensure that each spool is free to slide and rotate within the complete length of its respective bore.

- Replace all 'O' rings and gaskets with new ones during reassembly.

- Install the feathering valve manifold and 'horse shoe' clamp using the reversal of the disassembly procedure. Tighten the screw onto the manifold and lock into position with the locknuts on either side of the clamp.

- Tighten the valve body to the valve cover retaining bolts in the sequence shown in Figure 5. Tighten all bolts to a torque value of 3.7 lbf.ft (5 Nm) then to a final torque value of 9 lbf.ft (12 Nm).

- Ensure that the clutch pedal lever stop screw, item 3, Figure 7, is adjusted as follows:

Slacken the locknut of the screw and withdraw the screw several turns. Operate the the lever to fully depress the feathering valve, i.e. the valve bottoms out in the casting. Tighten the screw up to the stop and then an extra 3/4 to 1 turn inwards to ensure that the stop is effective before bottoming the valve. Lock the screw in position with the locknut.

- Reconnect the wiring to the solenoids, refer to Figure 5 for wire colour to solenoid reference.

- Reconnect the hydraulic tube from the feathering valve manifold to PWM valve and the creeper interlock feed tube on creeper transmissions items 7 and 5 of Figure 5.

- Install the metal shield tightening the four securing bolts to a torque value of 7.5 lbf.ft (10 Nm).

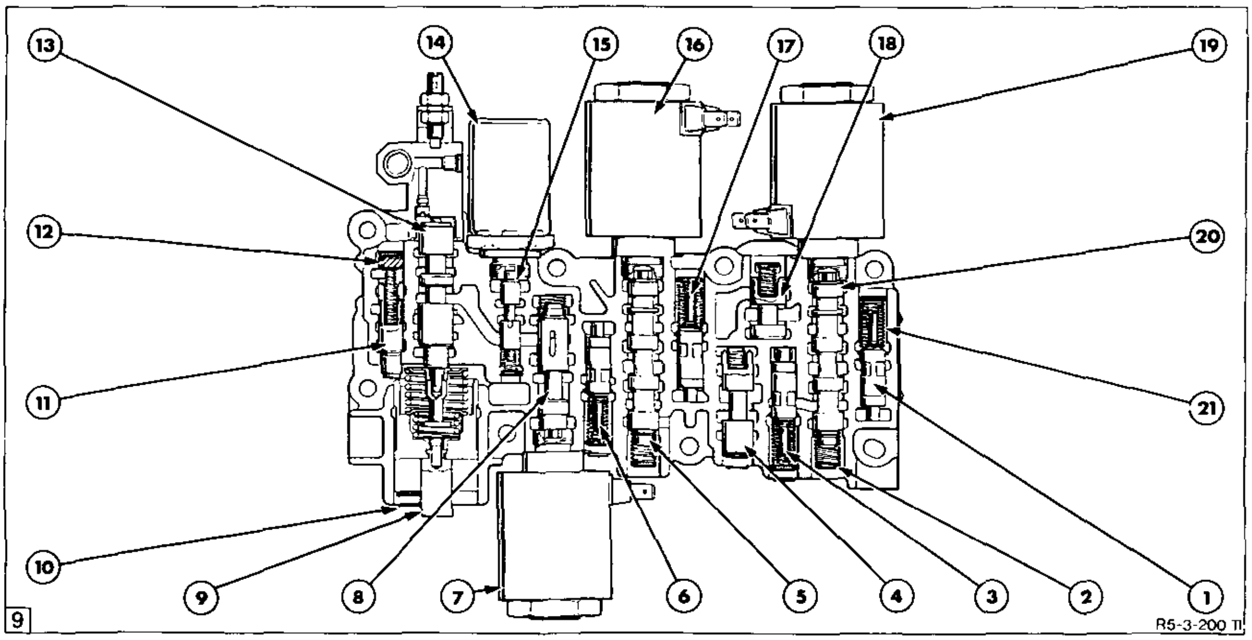
- Before replacing the assembled control valve cover assembly onto the transmission, ensure that both mating surfaces are clean and free from oil and previous sealant. Apply a thin bead of sealant, specification ESE–M4G234–A1 (Loctite 515), to the transmission casing. Do not apply an excessive quantity as the surplus may enter the transmission oil and return to the control valve, causing blocked oil galleries or sticking/stuck valve spools.

- Install the control valve onto the transmission and tighten the securing bolts to a torque value of 41 lbf.ft (56 Nm). reconnect the tubes, wiring, etc disconnected during removal.

- Ensure the clutch control cable is correctly adjusted using the following procedure:

  Remove the cable return spring, item 2, Figure 10. Remove the trim panel from the left hand side of the instrument console and disconnect the clutch pedal return spring, item 1, Figure 11.

  Loosen the upper and lower adjusting nuts and position them at opposite ends of the threaded section of the cable. Position a 1.23 in (31.25 mm) wide spacer between the fire wall and the clutch pedal as shown in Figure 11. With the clutch



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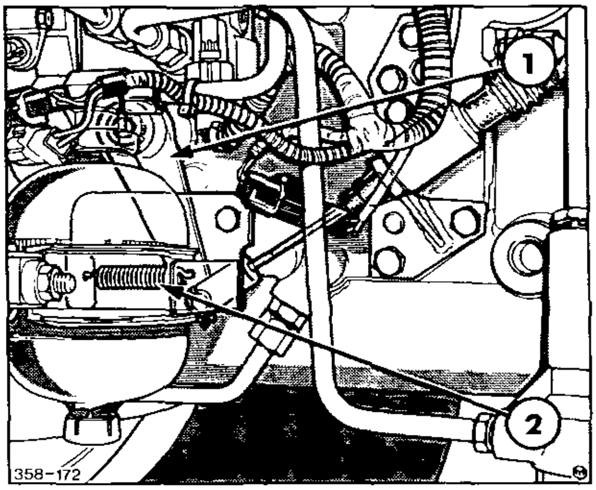
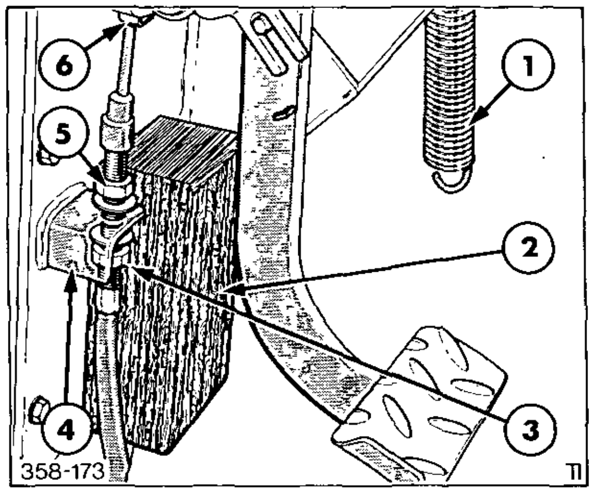
Transmission Control Valve Sectional View

1. Vent Delay Valve C3
2. Spring
3. Vent Delay Valve C3
4. Blocked Shuttle Valve
5. C1/C2 Selector Valve
6. Vent Delay Valve C1
7. Solenoid S3
8. Neutral Dump Valve
9. Pushrod
10. Plunger
11. Safety Start Valve
12. Valve Stop
13. Feathering Valve
14. Solenoid S4
15. FWD Valve
16. Solenoid S1
17. Vent Delay Valve C2
18. Lube Shut Off Valve
19. Solenoid S2
20. C3/C4 Selector Valve
21. Springs



Clutch Cable – Transmission Connection

1. Clutch Actuating Lever
2. Return Spring



Clutch Cable – Pedal Connection

1. Clutch Pedal Return Spring
2. Spacer
3. Lower Adjusting Nut/Washer
4. Cable Support Bracket
5. Upper Adjusting Nut/Washer
6. Clevis

pedal pulled down against the spacer, pull the outer cable down until the inner cable is tight against the clevis.

While holding the outer cable down, screw the lower adjusting nut up to the underside of the cable support bracket. At this point, release the outer cable and continue to hand tighten the lower adjusting nut against the bracket until the inner cable is lightly tensioned. Remove the spacer block, release the clutch pedal and reposition it against the upper stop.

Hand tighten the upper adjusting nut down onto the top of the cable support bracket. Using two wrenches, hold the upper nut while finally tightening the lower nut. Re–install the clutch pedal return spring and replace the trim. Reconnect the clutch actuating lever return spring.

- Fill the transmission/rear axle with the correct quantity and grade of transmission oil, specification ESN–M2C134–D and test drive the tractor.

NOTE: *It will be necessary to recalibrate the transmission clutches after an overhaul of the control valve, refer to section F, fault finding and calibration section of this chapter.*

F. CALIBRATION, FAULT FINDING, PRESSURE TESTING AND LIMP HOME PROCEDURES

Introduction

The transmission electronic management system has an inbuilt self diagnostic facility. This facility utilises the digital display to indicate, in coded format, any malfunction in the electrical and electronic circuitry and in the micro–processor. It should be noted that the self diagnostic capability is generally limited to diagnosis of the electrical and electronic circuitry and related components, however, there are some codes, such as E19 and E28, which can be generated if pressure switch circuits are not closed because of an actual lack of hydraulic pressure. Any malfunction of the mechanical and hydraulic components must be diagnosed using conventional techniques, performance characteristics and tooling, such as pressure testing equipment. Full guidance for both electrical self diagnosis and conventional diagnosis is contained within this section.

Trouble–shooting and fault finding should always be carried out in a logical and planned sequence, many apparent faults associated with electronic components are often hastily diagnosed and result in the replacement of expensive components. An extra few minutes confirming the apparent fault will result in a more positive and cost effective repair.

With the use of micro–processors it is often that this item is blamed for any malfunction but the real truth is that this item is usually sound and that the fault is due to poor contacts in the associated connectors.

Each connector illustrated and identified in the wiring diagrams in Part 3 and referred to in the following fault finding procedure, has the same identification reference. For example, the main ETC connector is referred to as Connector E3 in the illustration and also referred to as E3 in the fault finding procedure. Often in the fault finding flow chart the connector and pin are abbreviated and will read, for example, E3–38. The E3 refers to the connector and the 38 to the pin number.

Where the fault finding procedure requires checks for continuity a visual inspection of the wiring should be made prior to conducting tests to ensure that obvious 'mechanical' damage has not occurred to the harness or the connectors.

A good quality multi–meter is an essential item to perform fault finding. It should be capable of measuring resistance of at least 20,000 ohms and measuring voltage and current. When using the multi–meter it is good practice to select a high range and work downwards to avoid damaging the instrument.

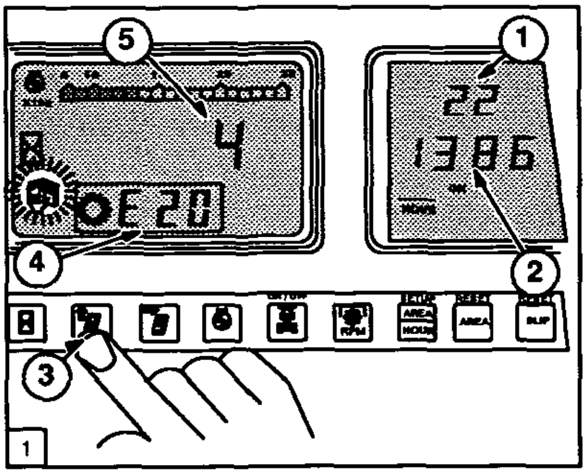
IMPORTANT: *Care should be used when using the multi–meter, only use the instrument as instructed to avoid damage to the internal elements of the micro–processor. When checking the continuity of wiring, sensors or switches it is necessary to isolate the electronic micro–processor and ensure the keystart is turned off to prevent possible further damage. The keystart should only be switched on and the processor connected where specifically instructed in the fault finding procedure.*

If it is found necessary to clean the connectors a contact spray should be used. DO NOT USE ANY OTHER METHOD FOR CLEANING TERMINALS. Do not use a cleaner that contains Trichloro–ethylene, this solvent will damage the plastic body of the connector. It is preferable to use a cleaner with a Freon T.F. base.

Error Code Recovery

The electronic instrument panel has a feature which stores and recalls the last ten error codes and the operating hours at which they occurred. This feature is useful in establishing a record of the last time that a particular error occurred on a tractor. To enter the Error Code Recovery mode proceed as follows:–

1. Hold down the DIGIT SET button on the electronic instrument panel and turn the keystart switch 'ON', Figure 1. **DO NOT** start the engine. The 'read your manual' symbol will flash and the most recent error to have occurred on the tractor will be displayed on the appropriate instrument panel display together with the hours at which the error last occurred.



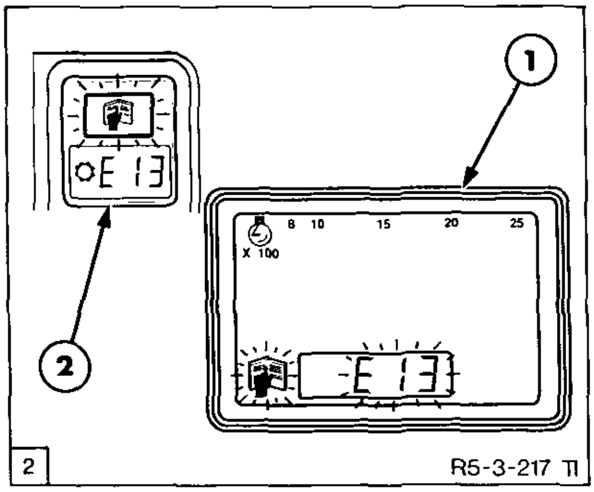
Error Code Recovery

1. Electronic Draft Control (EDC) Error Code
2. Hours of Error Occurrence
3. Digit Set Button
4. 16 x 16 Transmission Error Code
5. Electronic Instrument Cluster (EIC) Error Code

2. Press the DIGIT SET button and the next *most recent error code will occur.* This procedure can be repeated until a maximum of the last 10 error codes have been displayed.

3. To erase the memory of the stored error codes, hold down the DIGIT SET button for approximately 10 seconds while in the error code recovery mode.

The heading **Error Code Listing** gives the displayed message that will appear on the digital display should a fault occur in the electronic or electrical system. Note that if more than one fault exists the appropriate codes will be displayed until such time as all faults have been corrected.



Error Code Display

1. EIC Instrument Cluster Display
2. AEIC Instrument Cluster Display

IMPORTANT: *Upon completion of a repair it will be necessary to turn the keystart on and off to clear the code from the display and confirm that the repair was successful.*

Use the 'Fault Finding Flow Chart' for identification of specific areas within this section.

Clutch Calibration – General

The transmission C1 and C2 clutches are normally automatically calibrated by the micro–processor (ETC) and the associated inputs during tractor operation. This automatic calibration provides automatic compensation for C1/C2 clutch wear and in addition adjusts automatically the timing of engagement of the C1/C2 clutches when powershift changes are made involving the C1/C2 clutch combination (i.e. C1 going off and C2 coming on or vice–versa). This adjustment is continually monitored and is learnt by the ETC from the performance of previous shifts. It should be noted that no automatic calibration will occur during the first 15 minutes of tractor operation to prevent adapting to shifts made with oil which is not up to operating temperature. An alternative method of calibrating the C1 and C2 clutches, which bypasses the initial 15 minute operating period is also provided.

NOTE: *The alternative C1/C2 calibration is not provided on some early tractors which have an ETC module with a software release level prior to '06' installed.*

The C3 and C4 clutches are calibrated, again automatically but at the instigation and control of the service man. The process can be done from the operating seat and does not require the use of tools or test equipment.

There are two separate calibration routines:

1. **C3 and C4 Spring Pressure Calibration** The spring pressure calibration mode determines the 'kiss' pressure of the C3/C4 clutches. These pressures are then used as references by the ETC module when C3 or C4 clutch pressure is subsequently controlled during clutch pedal operation or powershifts. The most obvious symptom of incorrect spring pressure calibration is that the inching point on the clutch pedal is either abnormally high or low. This calibration should be performed after service has been carried out on the PWM valve, transmission control valve assembly, C3/C4 clutches or the ETC module.

2. **C3 and C4 Clutch Fill Time Calibration** The fill time calibration mode determines the time required to shift the C3/C4 selector and fill the C3 or C4 clutch during powershifts. This mode is used to compensate for wear of the C3 or C4 clutches. This routine should be performed if the quality of single clutch swap shifts is poor, particularly under load, for example, gear changes 1–2, 2–1, 3–4, 4–3, 5–6, 6–5, 7–8 and 8–7. The fill time calibration may also be required after service has been performed on the C3/C4 clutches.

In both of the above routines C3 and C4 clutches are measured separately.

There is a second procedure for adjusting the **fill time** for C3 and C4 clutches and can be used with, or in place of, the automatic calibration procedure. This second procedure allows for manual adjustment of the fill time to optimize the powershift quality for gear changes under specific loads and conditions. Refer to the heading 'Procedure for Manual Adjustment of the C3 and C4 Clutch Fill Time'.

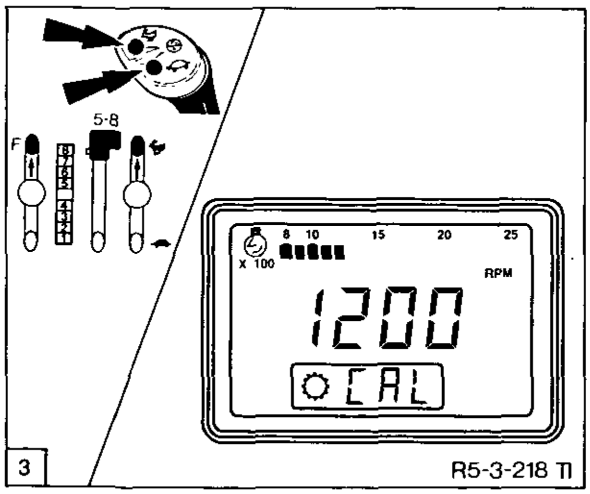
IMPORTANT: *Some early tractors which have an ETC module with a software release level prior to '06' may, during the following calibration procedures display a 'U99' error code. If this occurs refer to the heading 'U99 Correction Procedure'. Tractors with software level 06 (or higher) will display an 'E##' error code, if a fault is detected, which is preventing calibration from being performed.*

Procedure for Clutch C3 and C4 Spring Pressure Calibration

1. Apply the handbrake and ensure that the surrounding area is unrestricted. It is preferable to perform the calibration routine outside the workshop. If this is not possible, block all wheels and display a vehicle under test notice.

IMPORTANT: *Although the test procedure is controlled by the ETC it is prudent to make every safety precaution against unexpected tractor movement.*

2. With the engine switched off, depress the clutch pedal and depress and hold down both powershift buttons. With the buttons still depressed start the engine. The instrument cluster transmission display will now display 'CAL'.



Electronic Instrument Cluster – CAL Displayed

3. Release the switches.

4. Place all shift levers in the forward position to select forward, 5–8 and high range.

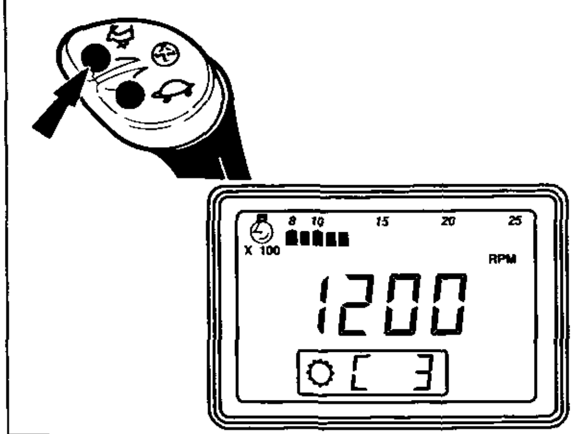
5. Release the clutch pedal (the tractor should not move).

6. Using the hand throttle set the engine speed to 1200 ± 100 rev/min.

IMPORTANT: *It is important during calibration that all additional equipment such as air conditioning, lights, etc., that could effect engine speed fluctuations, are turned off.*

The initial calibration set up is now complete. The calibration procedure that follows can be performed as many times as desired and in any order. When a clutch is correctly calibrated the old calibration value is erased from the ETC memory and replaced by the new value.

Upshift button depressed = C3 calibration.
Downshift button depressed = C4 calibration.



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Electronic Instrument Cluster – C3 Displayed

7. Depress and hold the upshift button and note that 'C3' is displayed. If the test conditions are not correct an error code will be displayed. This code will be prefixed by a 'U' and followed by two further digits. Refer to the following table for explanation of the error codes.

   a) From the point where the upshift button was depressed the actual calibration process managed by the ETC began.

   b) 'C3' was displayed while the base line engine rev/min. was being established by the ETC. This must remain steady before the calibration will begin.

   c) The ETC will begin to slowly increase the modulation pressure from an initial low level. A relative value will be displayed numerically and be seen to increase until the engine is speed is pulled down (initial application of the clutch) by 50 rev/min. below the initial base line measurement.

   d) The ETC will immediately recognise the decrease of 50 rev/min. and the pressure will be dumped. The resultant calibration value will be displayed and remain displayed for as long as the upshift button is depressed.

8. Repeat step 7, using the downshift button, note that 'C4' is now displayed.

It is good practice to record these calibration values and enter them with the tractors repair history file. They will be retained in the ETC memory (but could unintentionally be updated by another service man) and will serve purpose in possible future fault diagnosis.

C3 and C4 Clutch Spring Pressure Calibration Procedure – Error Codes

U20 Correct start up sequence was not used (depress and release pedal and repeat step 7 or 8).
U21 Engine rev/min. is too low.
U22 Engine rev/min. is too high.
U23 Forward/reverse lever is not in forward.
U24 Main lever is not in high range.
U25 High/low lever is not in high range.
U26 Clutch pedal is not fully released.
U27 C3 Calibration is too low. The initial test pressure was sufficient to pull down the engine.
U28 C3 Calibration is too high. The maximum test pressure was reached without causing the engine speed to decrease by 50 rev/min.
U29 C4 Calibration is too low. The initial test pressure was sufficient to pull down the engine.
U30 C4 Calibration is too high. The maximum test pressure was reached without causing the engine speed to decrease by 50 rev/min.
U31 Wheel motion detected during calibration. Handbrake not applied or the calibration threshold was too low such that initial test pressure was enough to cause slight wheel motion prior to pulling down the engine.
U99 System failure (refer to separate heading).

Procedure for Clutch C3 and C4 Fill Time Calibration

1. Allow the tractor to operate until working temperature is obtained, transmission oil temperature should exceed 65°C (150°F). A calibration procedure performed with cold oil will give erroneous results.

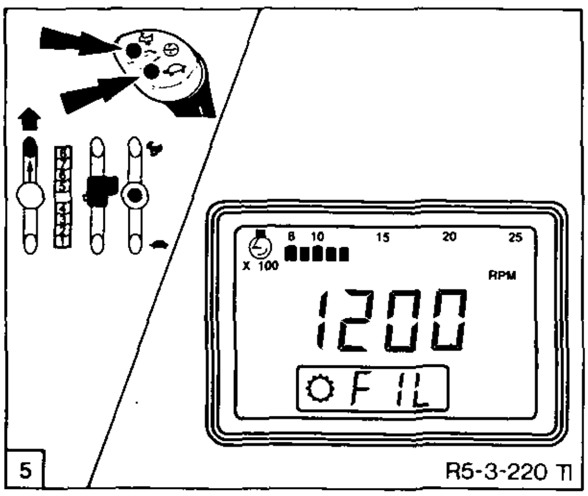
2. Apply the handbrake and ensure that the surrounding area is unrestricted. It is preferable to perform the calibration routine outside. If this is not possible, block all wheels and display a vehicle under test notice.

IMPORTANT: *Although the test procedure is controlled by the ETC it is prudent to make every safety precaution against unexpected tractor movement.*

3. With the engine switched off, depress the clutch pedal and depress and hold down both powershift buttons. With the buttons still depressed start the engine. The transmission display on the EIC will now display 'CAL'.

4. Release the switches.

5. Place all the main and high/low transmission levers in neutral and the forward reverse lever in forward. The transmission display will now display 'FIL'.



Electronic Instrument Cluster – FIL Displayed

6. Release the clutch pedal (the tractor should not move).

7. Using the hand throttle set the engine speed to at least 1100 rev/min.

The initial calibration set–up is now complete. The calibration procedure that follows can be performed as many times as desired and in any order. When a clutch is correctly calibrated the old calibration value is erased from the ETC memory and replaced by the new value.

Upshift button depressed = C3 calibration.
Downshift button depressed = C4 calibration.

8. Depress and hold the upshift button and note that 'C3' is displayed. If the test conditions are not correct an Error Code will be displayed. This code will be prefixed by a 'U' and followed by two further digits. refer to the following table for explanation of the error codes.

   a) From the point where the upshift button was depressed the actual calibration process managed by the ETC began with the display of C3 signifying that the calibration process is starting.

   b) The ETC will perform ten complete fill and empty cycles of the C3 clutch. During each cycle, the time taken to fill the clutch, in milliseconds, will flash on the display (ten numeric flashes will occur on the display).

   c) At the end of the first ten cycles a solid (non–flashing) number will appear on the display for approximately 2 seconds. This is the number of milliseconds that the C3 clutch timing will be advanced to account for the clutch fill time.

   d) The ETC will then automatically perform a series of ten up and down shifts to allow the C1/C2 clutches to adjust their timing to the new C3 clutch timing. During these shifts the timing for the upshifts for the C1/C2 clutches will flash on the display.

   e) When the shift sequence is complete the last C1/C2 clutch timing value will appear solid on the display. The upshift button may be released at this time. The whole procedure will take approximately 35 seconds to complete.

9. Repeat step 8, using the downshift button, note 'C4' is now displayed.

It is good practice to record these calibration values and enter them with the tractors repair history file. They will be retained in the ETC memory (but could unintentionally be updated by another service man) and will serve purpose in possible future fault diagnosis.

C3 and C4 Clutch Fill Time Calibration Procedure – Error Codes

U20 Correct start up sequence was not used (depress and release pedal and repeat step 8 or 9).
U21 Engine rev/min. is too low.
U23 Forward/reverse lever is not in forward.
U26 Clutch pedal is not fully released.
U31 Wheel motion detected during calibration. Handbrake not applied.
U32 Low pressure was not sensed by th *C3/C4 pressure switch at a time when* the pressure should have been low. Is oil hot?
U33 High pressure was not sensed by the C3/C4 pressure switch at a time when the pressure should have been high.
U34 Main lever is not in neutral.
U35 High/Low lever is not in neutral.
U36 Clutch fill time is too short.
U37 Clutch fill time is too long.
U38 C3/C4 spring pressure calibration procedure must be performed before fill time calibration.
U99 System failure (refer to separate heading).

U99 Error Code Display Correction Procedure (Tractors with ETC software prior to level '06' Installed)

If 'U99' is displayed during the calibration procedure it is an indication that there is a system failure which is preventing the calibration sequence. To detemine which component has failed, exit or leave the calibrated mode and return to normal operation which will then dis*play the respective 'E' prefixed error code on* the transmission display.

Because some error codes have longer delays before they are displayed, perform the following sequence to enable all codes.

1. Turn the keystart off.
2. Depress the clutch pedal.
3. Start the tractor engine with all levers in neutral. Do not enter the calibration mode.
4. Place the forward/reverse lever in forward. Leave the main and high/low levers in neutral.
5. Release the clutch pedal.
6. Error codes should be displayed within 10 seconds of releasing the clutch pedal.

If error codes E24, EC3 or EC4 are displayed then they will not allow the display to show the C1 and C2 pressure switch error codes (E28 and E29) if detected. However, if the display does not change during the above sequence and the audible alarm sounds 8 seconds after releasing the clutch pedal, then this is an indication that error E28 (C1/C2 pressure switch – short circuit) was detected. This alarm indi*cates that pressure is not present on the* C1/C2 clutches or that the C1/C2 pressure switch did not close at high pressure.

Procedure for Manual Adjustment of the C3 and C4 Clutch Fill Time

This procedure can be used in place of or in addition to the 'Procedure for Clutch C3 and C4 Fill Time Calibration'.

The serviceman can manually adjust the C3 *and C4 clutch selector valve timing.* This timing controls the time allowed to fill the clutch at high pressure before the PWM solenoid takes over and finitely modulates the final clutch application. The timing can be adjusted in one millisecond increments from 0–50 milliseconds. A long duration, for exam*ple 30 milliseconds, will allow a longer fill time* at the high pressure, compensating for the increased piston travel that will occur when the clutch has worn.

Both the C3 and the C4 clutches can be manually adjusted separately. The C3 adjustment controls all powershifts where the C3 clutch is applied and the C4 clutch is released. These are the shifts into even numbered gears which are 1st–2nd, 3rd–4th, 5th–6th, 7th–8th, 3rd–2nd and 7th–6th.

The C4 adjustment controls all powershifts where the C4 clutch is applied and the C3 clutch is released. These are the shifts into odd numbered gears which are 2nd–3rd, 6th–7th, 2nd–1st, 4th–3rd, 6th–5th and 8th–7th.

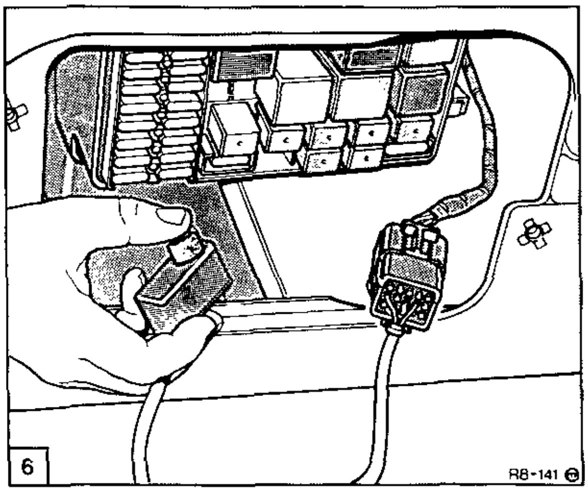
Perform the manual adjustment of the C3 and C4 clutch fill time as follows:–

1. Allow the tractor to operate until working temperature is obtained. A calibration procedure performed with cold oil will give erroneous results.

2. Observe the quality of the 5th–6th powershift and record the load or task being performed and the engine speed. The owner or driver may have complained or criticised the powershift quality on a specific task. Use this observation or experience at the end of the adjustment to gauge whether the adjustment has been successful or not.

3. Stop the tractor, apply the parking brake and turn the key–start off.

4. Install the diagnostic switch, Special Tool No. 4FT 950.

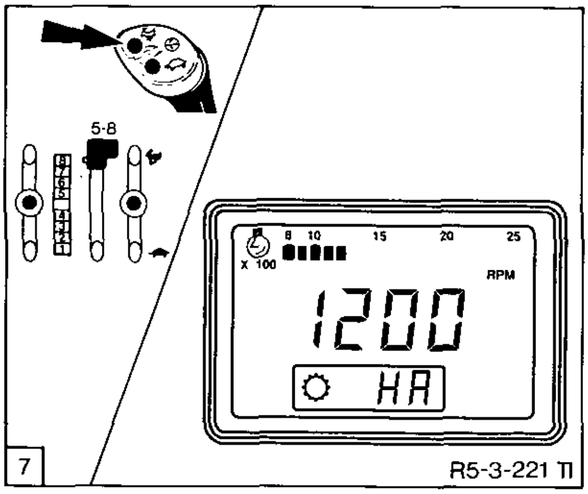


Diagnostic Switch Connected into Diagnostic Connector

5. Start the engine.

6. Using the diagnostic switch (Special Tool No. 4FT 950), enter into the diagnostic test routine 'HA'. The 'HA' routine follows 'H9'.

7. Move the main transmission lever into the high (5th–8th) range. The transmission display on the instrument cluster will display 'C3' for 2 seconds and will then be followed by the timing adjustment that is currently stored for the C3 clutch.



EIC 'HA' Displayed and Gear Lever Positions

8. Using the upshift button press the button to increase the number on the display by 8, (8 presses on the upshift button will increase the C3 timing by 8 milliseconds).

9. Depress the diagnostic switch to exit the 'HA' mode and enter the diagnostic routine 'H6'. The tractor may now be driven normally.

NOTE: *While in routine 'H6' the transmission display will not operate. Use the indicator lights next to the main lever for gear indication.*

10. Drive the tractor and compare the powershift quality of the 5th–6th gear change with the previous experience under the same conditions.

11. If the powershift has improved, stop the tractor then repeat steps 6 through to 10 until the 5th–6th gear change quality deteriorates or until 50 milliseconds is displayed. As each test is made record the value of clutch timing shown on the transmission display. Then reduce the displayed timing by pressing the downshift button until the value that produced the best gear change quality is obtained.

12. Adjustments smaller than 8 milliseconds can be attempted to fine tune the powershift quality if desired.

13. If the powershift quality has deteriorated after the first adjustment, decrease the displayed value by 8 milliseconds from the initial value. Repeat steps 6 through 10 except use the downshift button to decrease the displayed number by 8 rather than increasing the number.

14. Continue repeating steps 6 through to 10 until the powershift quality deteriorates (or until 0 is displayed), then increase the value to the displayed number that produced the best results. Adjustments smaller than 8 milliseconds can be attempted to fine tune the powershift quality if desired.

Adjustment of the C4 clutch is performed in the same manner with the following differences:–

1. Test the tractor to experience the powershift quality for a 6th–7th gear change instead of a 5th–6th change.
2. Shift the main lever into the low (1–4) range, when in the diagnostic test routine 'HA' to adjust C4 clutch timing.

IMPORTANT: *The 6th–7th powershift involves a double clutch change. This means that C1 clutch is being applied and C2 is being released. The timing of the C2–C1 clutch change also affects the powershift quality.*

The timing of C1 and C2 clutches is adjusted automatically in normal operation, but will be affected by manual adjustments to the timing of the C3 and C4 clutches. Several 6th–7th powershifts will need to be made after each C3 and C4 clutch timing adjustments to allow the C1 and C2 clutches to optimize and provide the best powershift quality.

Operating in 'H6' routine will allow C1 and C2 clutches to begin optimizing immediately without the normal 15 minute waiting period. The waiting period is designed to prevent clutch optimization occurring with cold transmission oil.

If the 6th–7th gear changing is performed following a key on and engine start up, even though the tractor is at normal operating temperature, the C1 and C2 clutch optimization will be delayed for 15 minutes by the micro processor. When the tractor is operated in the 'H6' routine, this waiting period is cancelled.

Pressure Testing

Pressure ports are provided on the transmission control valve cover to enable the transmission clutches the creeper and the four wheel drive systems to be tested to determine the correct function of a number of system components. Components such as selector valves, solenoids and the clutch pedal operation can be seen to be operating correctly by the results of pressure testing.

NOTE: *Prior to pressure testing, make certain that all the points detailed under the tractor preparation are carried out to ensure maximum safety.*

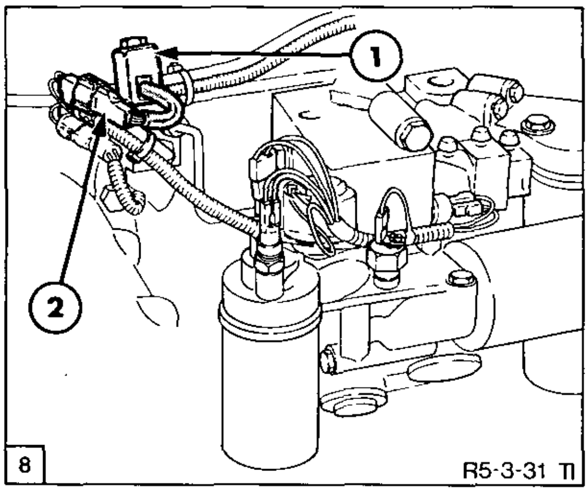
Tractor Preparation

1. Start the tractor and run until the transmission oil has reached its normal operating temperature of at least 60°C (140°F).

2. Apply the handbrake and remove the FWD shaft.

3. Raise the right hand rear wheel and place a suitable support under the axle casing. Remove the right hand wheel.

4. Disconnect the grey connector to the low range switch and install 'Switch By–Pass Connector', Tool No. 4FT 951, into the tractor harness end. By installing the connector, the ETC receives a signal indicating that low range is selected, although the **RANGE LEVER remains in NEUTRAL** throughout the testing.



Differential Lock Solenoid Connector

1. Differential Lock Solenoid
2. Connector

5. Disconnect the differential lock solenoid connector.

C1/C2 and C3/C4 Clutch Engagement and Disengagement

1. Install the pressure gauges. Ideally four gauges should be used, however, the testing can be carried out with two gauges using the following procedure:

- Connect to C1 and C2 test ports and carry out tests from powershift one through to four.

- Connect to C3 and C4 test ports and carry out tests from powershift one through to four.

- Connect to C2 and C3 test ports and carry out clutch feathering test.

2. Position the shuttle lever in **Forward,** the main lever into the **1–4 range** and leave the High/Low lever in **Neutral.** Set the engine speed to 1500 rev/min. Observe the reading on the gauges and compare with those in Table 1 as the gears are shifted and with those in Table 2 for the feathering tests.

Four Wheel Drive Pressure Testing (Follow previous tractor preparation. The FWD shaft must be removed).

1. Install gauge into FWD test port.

2. Disengage FWD, **DO NOT TOUCH FOOT BRAKES, shift all levers to neutral.** Start and run engine at 1200 rev/min. Pressure reading should be 15–18 bar.

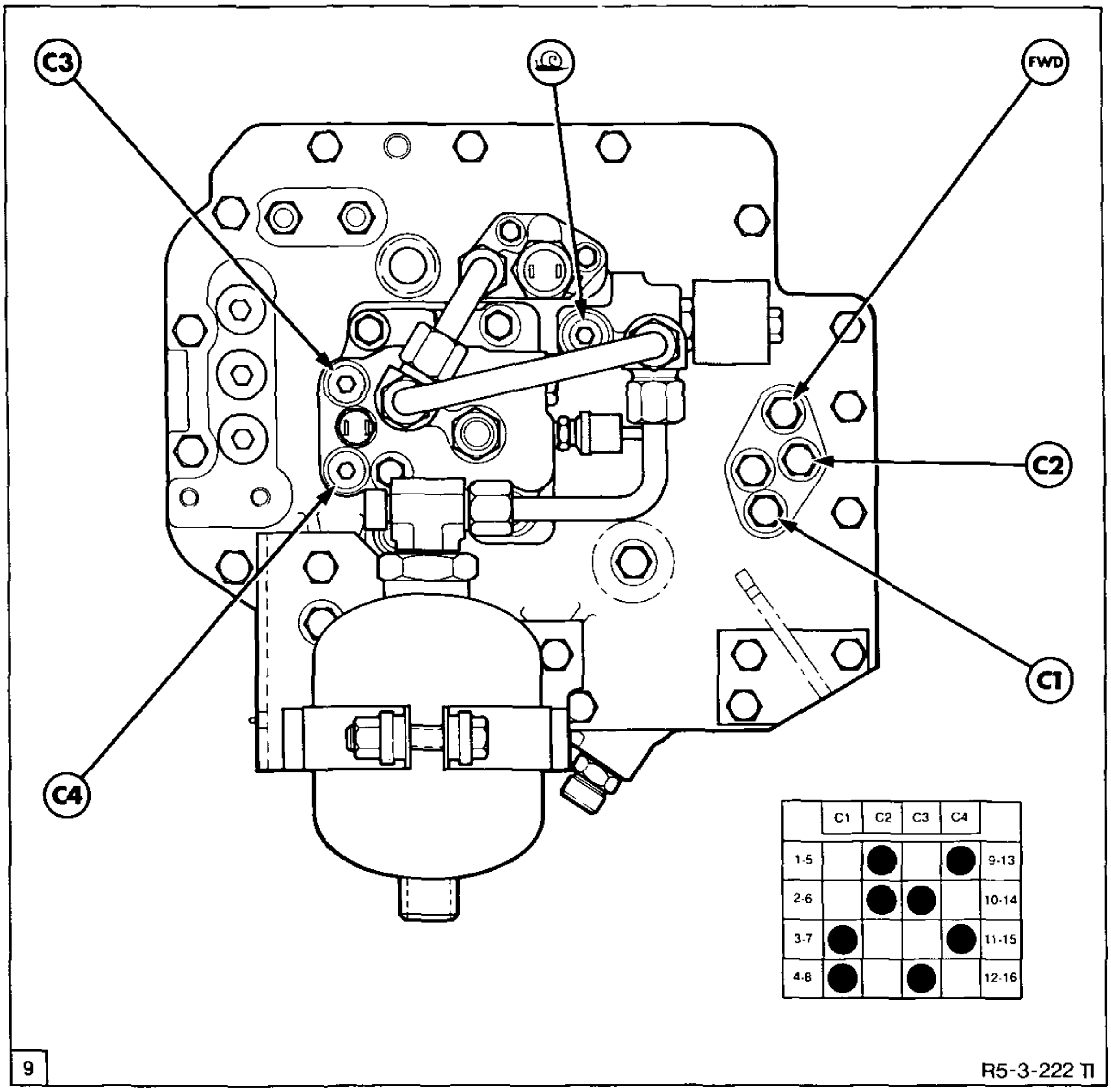
3. Engage FWD, pressure reading should drop to zero.

Creeper Pressure Testing (Follow previous tractor preparation

1. Install gauge into creeper test port.

2. Shift all levers into neutral. Start engine and run at 1200 rev/min.

3. Depress the clutch pedal, engage low range and select creeper. The pressure reading should be between 15–18 bar.



	C1	C2	C3	C4	
1-5		●		●	9-13
2-6		●	●		10-14
3-7	●			●	11-15
4-8	●		●		12-16

Pressure Test Ports
All Pressure Test Ports Accept 7/16 inch JIC Fitting

Table 1 – Pressure Testing – Clutch Selector Valve and Vent Delay Valve Operation

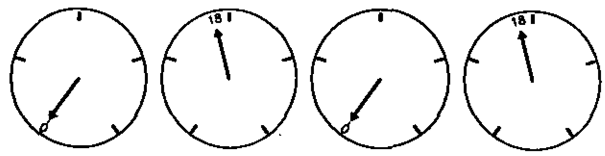
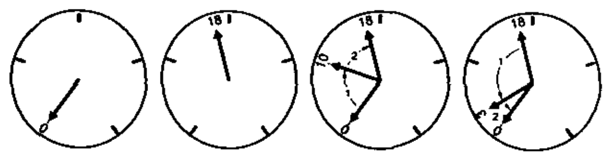
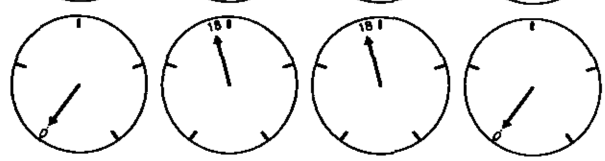
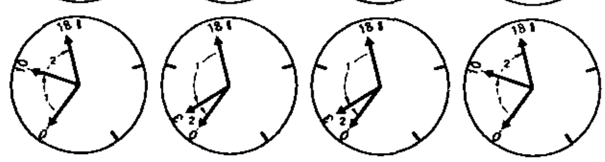
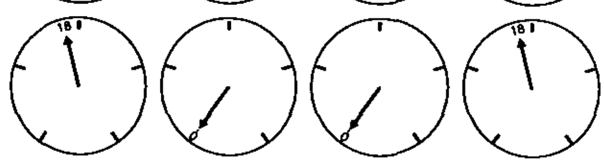
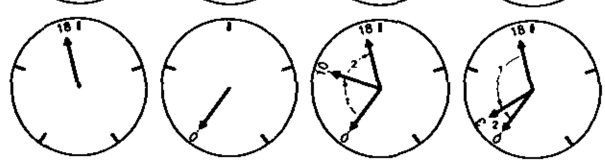
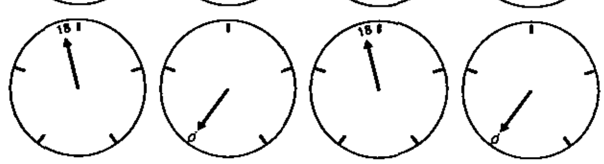
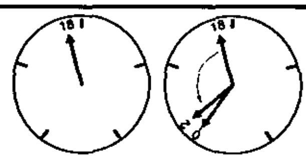
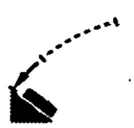
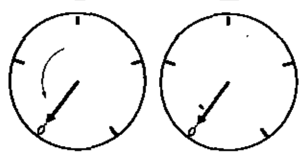
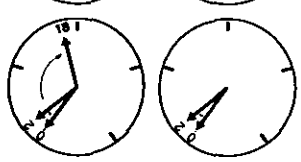
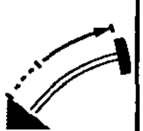
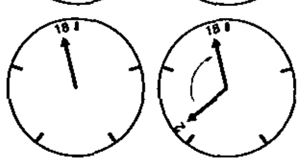
Clutch / Gear	C1 C2 C3 C4	Observations
1		C2 and C4 at Regulated Pressure
1 → 2		C2 Regulated Pressure C3 0 to 10 bar : 10 to 18 bar C4 18 to 3 bar ; 3 to 0 bar (Vent Delay Valve V4
2		C2 and C3 at Regulated Pressure
2 → 3		C1/C4 0 to 10 bar : 10 to 18 bar C2/C3 18 to 3 bar : 3 to 0 bar (Vent Delay Valves V2/V3) Change 3–2 to check Vent Delays V1/V4
3		C1 and C4 at Regulated Pressure
3 → 4		C1 Regulated Pressure C3 0 to 10 bar : 10 to 18 bar C4 18 to 3 bar : 3 to 0 bar (Vent Delay Valve V4)
4		C1 and C3 at Regulated Pressure

Table 2 – Powershift 2 Selected – Clutch Feathering Tests

Clutch Pedal	C2 C3	Observations
		Pressure on C3 should progressively reduce as clutch pedal is depressed. Indicates feathering and PWM valve functional.
		Fully depressing clutch pedal should zero C2/C3 pressures, indicating neutral dump valve operational.
		Releasing clutch pedal from fully depressed position should restore clutch 2 to full pressure and clutch 3 to feathering pressure.
		Pressure in C3 should progressively increase as clutch pedal is released indicating feathering and PWM valves are functioning.

Limp Home Procedure

In the unlikely event of an electrical fault developing within the powershift transmission that renders the tractor immobile, for example, failure of the wiring or supply voltage to the PWM valve, an emergency 'Limp Home Harness', Special Tool No. 4FT 952, is available to enable the tractor to be driven onto a transporter or hardstanding, in order that the repair can be carried out in a suitable location. The Limp Home device **is not and must not** be used as a means to continue operating the tractor in its work environment. If the fault is not within the PWM circuit, it may be possible to drive the tractor by disconnecting the 8 pin grey connector which will provide engagement of 2nd/6th/10th and 14th gears and still allow the clutch to provide a feathering function.

To engage and operate the 'Limp Home Harness' proceed as follows:–

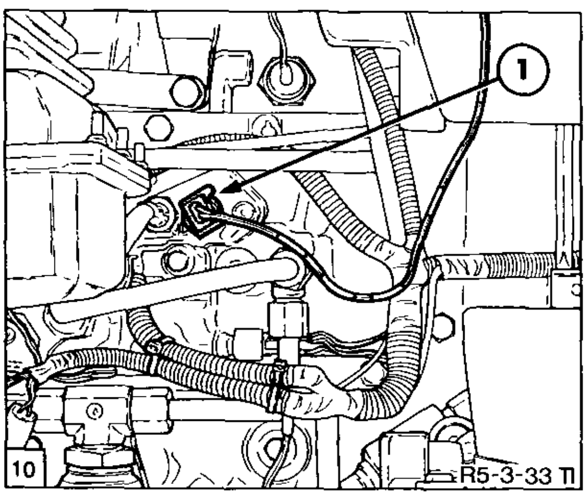
1. Apply the parking brake.
2. Stop the engine and turn keystart off.
3. Disconnect the PWM valve connector from the PWM valve located on the control valve cover and connect the Limp Home harness to the PWM valve.
4. Disconnect the 8 pin grey transmission connector.
5. Connect the other end of the Limp Home harness to the 'D1' diagnostic plug located adjacent to the fuse box.
6. Place the range lever into **Low Range** and the main lever into the **1–4 Range.** Ensure the forward/reverse lever is in **Neutral.**

NOTE: *It is important that only the lowest ranges are used when operating with the Limp Home Harness due to the feathering capability of the transmission being inoperative.*

7. Start the vehicle.
8. Select forward or reverse.
9. Cycle the clutch, depress and release clutch pedal to activate the safety start valve.
10. Operate the momentary switch of the Limp Home Harness to move the vehicle. If necessary, depress the foot throttle to increase engine speed.

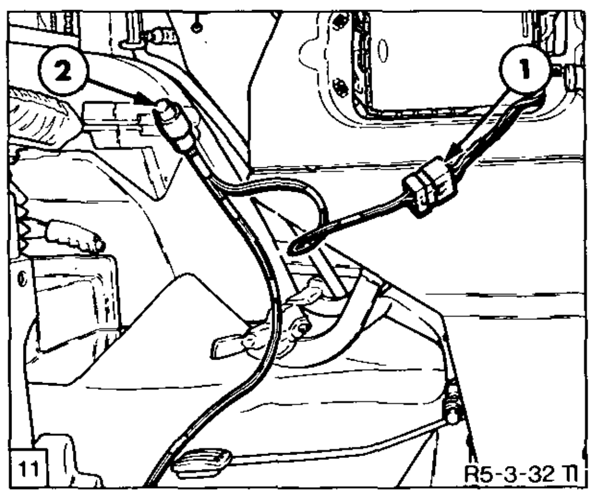
NOTE: *Operating the clutch pedal will still override the tractor operation, depressing the clutch pedal should, therefore, prevent tractor drive by preventing pressure oil to pass through the feathering valve.*

11. When the tractor has been delivered to the repair area, disconnect the Limp Home Harness and reconnect the PWM valve wires and proceed with diagnosing and repairing the fault.



Limp Home Harness
Connection to PWM Valve

1. Harness Connected to PWM Valve Solenoid



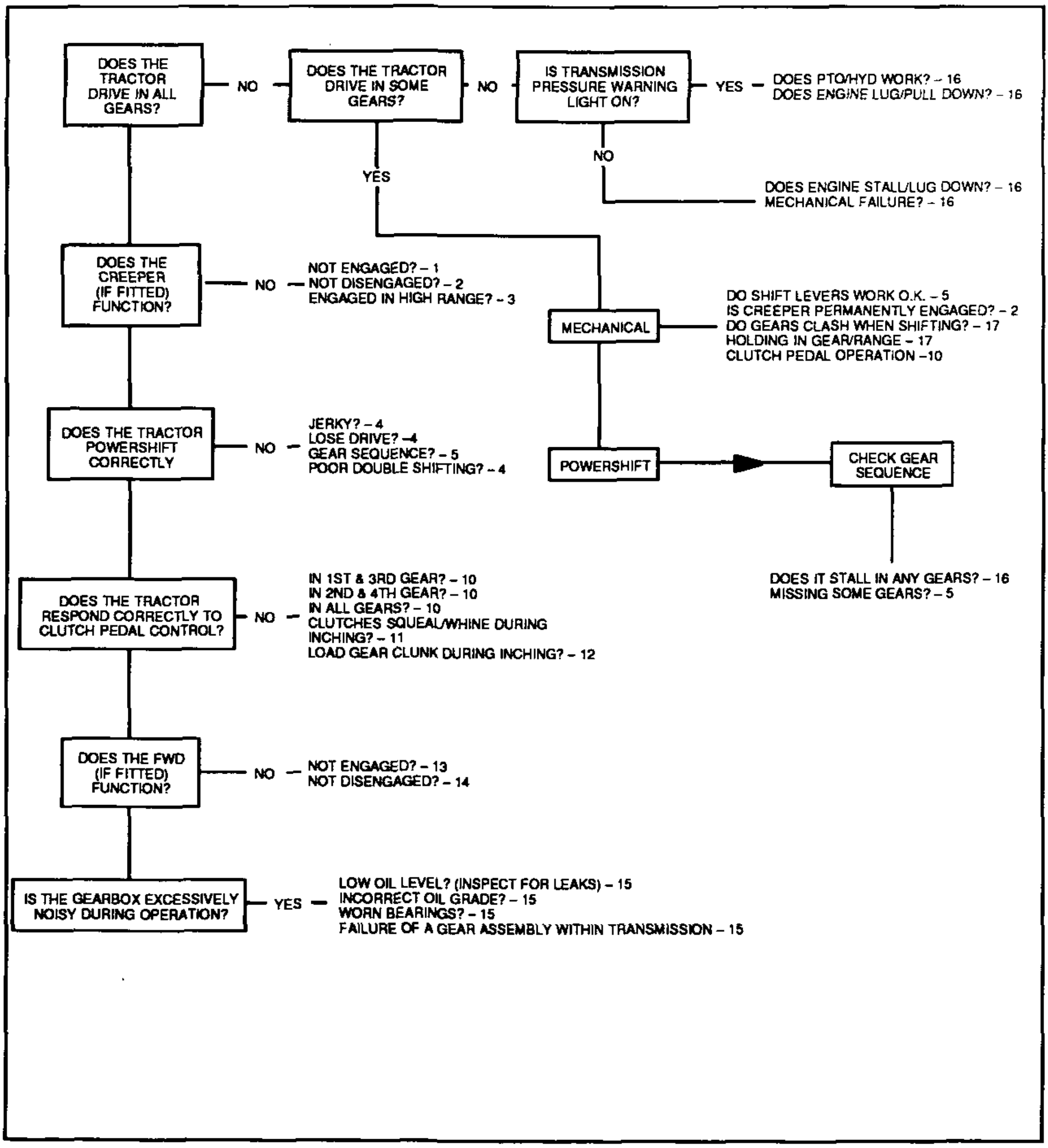
Limp Home Harness
Connection to 'D1' Plug

1. Harness Connected to Diagnostic Plug (D1)
2. Push Button Momentary Switch

Fault Finding

To determine the area of a transmission fault test drive the tractor and note the operation. Refer to the fault finding chart below. Follow the chart to the end of the respective fault line, the number at the end of the fault line refers to the appropriate, detailed, fault finding flow chart. Always start at the beginning of a flow diagram and go through each test procedure before going onto the next test, do not assume a component or circuit is correct without testing.

FAULT FINDING FLOW CHART



ERROR CODE LISTING

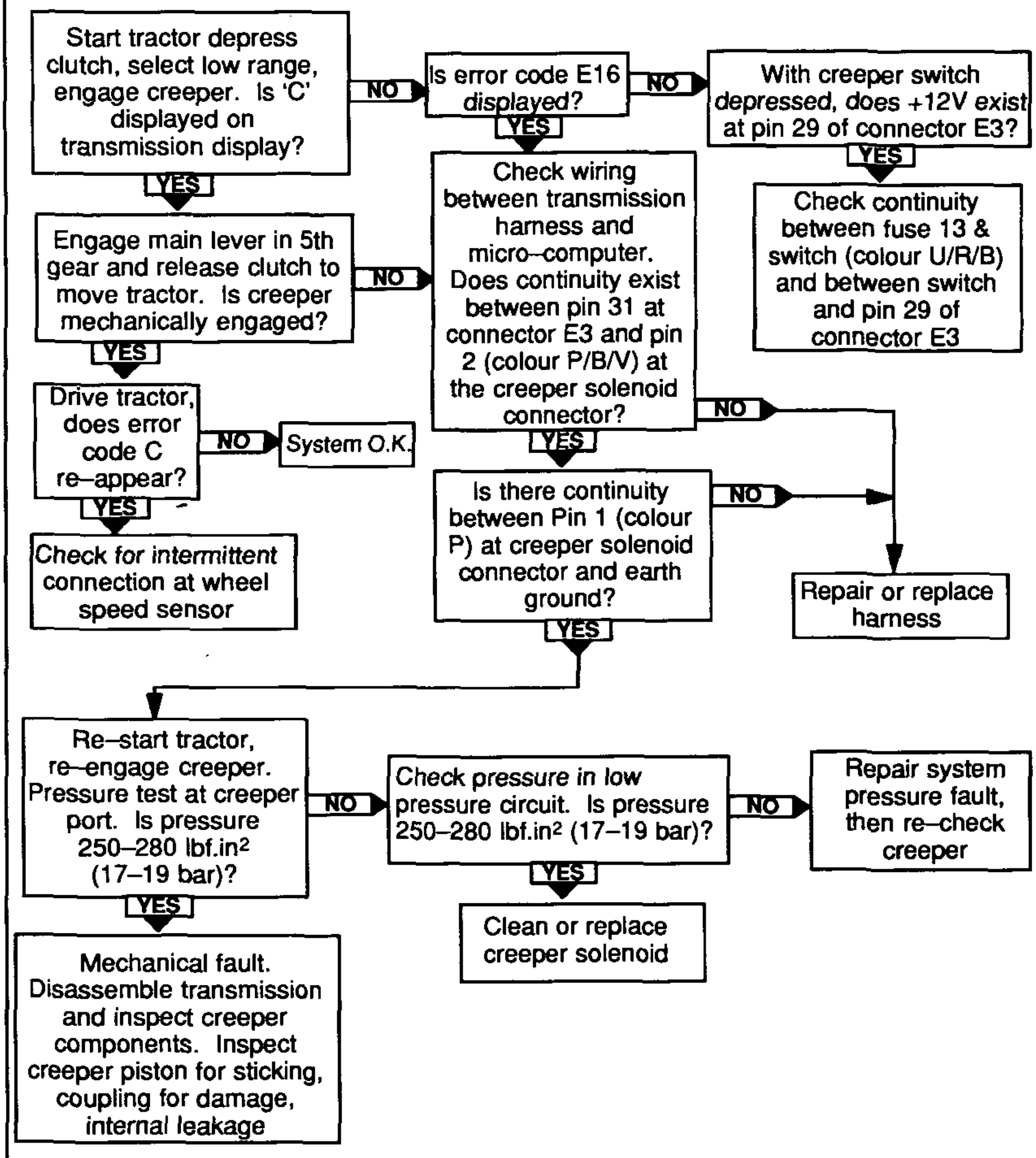
Code	Fault Condition	Possible Causes
E29	C1/C2 Pressure Switch Short Circuit (Switch does not indicate low pressure)	**Refer to Flow Diagram No. 7**
E28	C1/C2 Pressure Switch Open Circuit (Switch does not indicate high pressure)	**Refer to Flow Diagram No. 6**
E27	Engine rev/min. Signal not Present	i) Alternator belt broken ii) Alternator failure iii) Open or short circuit in alternator wiring **Refer to Flow Diagram No 18**
E26	Engine rev/min. too High	i) Alternator failure ii) Intermittent fault in wiring **Refer to Flow Diagram No. 19**
E25	Tractor Motion not Detected when Transmission is Engaged	**Refer to Flow Diagram No. 8**
E13	Up/Downshift Switches Both On	i) Switch failure ii) Short circuit in switch wiring **Refer to Flow Diagram No. 20**
E14	1–4 & 5–8 Switches Both On	i) Switch failure ii) Short circuit in switch wiring iii) Damaged transmission rail **Refer to Flow Diagram No. 21**
E15	High/Low Switches Both On	i) Switch failure ii) Short circuit in switch wiring iii) Damaged transmission rail **Refer to Flow Diagram No. 22**
E16	Creeper Solenoid Short Circuit Error or Attempt to Engage Creeper after Prior Creeper Error	**Refer to Flow Diagram No. 1**
EC4	C4 Clutch not Calibrated	Perform spring pressure calibration routine for C4 clutch
EC3	C3 Clutch not Calibrated	Perform spring pressure calibration routine for C3 clutch
E24	C3 and C4 Clutches not Calibrated	Perform spring pressure calibration *routine for C3 and C4 clutches*
E17	C3/C4 Solenoid Open or Short Circuit	i) Open or short circuit of control wire between C3/C4 solenoid and ETC pin 59 ii) Open or short circuit of power wire between C3/C4 solenoid and +12V (fuse 13) iii) Short or open circuit of C3/C4 solenoid coil **Refer to Flow Diagram No. 23**
E18	C1/C2 Solenoid Open or Short Circuit	i) Open or short circuit of control wire between C1/C2 solenoid and ETC pin 58 iii) Open or short circuit of power wire between C1/C2 solenoid and +12V (fuse 13) iii) Short or open circuit of C1/C2 solenoid and iv) Fuse 13 blown **Refer to Flow Diagram No. 24**

Code	Fault Condition	Possible Causes
CP	Depress Clutch Pedal to Re–Enable Transmission	i) Intermittent mechanical switching of neutral switch ii) Intermittent open or short circuit in neutral switch wiring iii) Intermittent fault in +12V or ground wiring to ETC module iv) Intermittent fault of power delay relay v) Loose connector in ETC/cab harness vi) Neutral to in–gear shift with pedal up vii) Engine re–started with shift lever in gear after stall **Refer to Flow Diagram No. 25**
ECC	Electrical Re–Set with Creeper Engaged (while tractor is moving)	i) Intermittent fault in +12V or ground wiring ii) Intermittent fault of power delay relay iii) Loose connector in ETC/cab harness **Refer to Flow Diagram No. 26**
HC	Range Shift too High with Creeper Engaged	**Refer to Flow Diagram No. 3**
C	Wheel Speed too High for Creeper Gear	i) Creeper not engaged ii) Wiring to creeper solenoid is short or open circuit, wiring disconnected iii) Creeper solenoid coil short or open circuit iv) Intermittent connection at wheel speed sensor, indicating higher speed than actual **Refer to Flow Diagram No. 1**
E11	Clutch Potentiometer Voltage Below Valid Range	i) Open or short circuit of potentiometer wiring ii) Potentiometer failed iii) Potentiometer is mechanically out of range **Refer to Flow Diagram No. 27**
E12	Clutch Potentiometer Voltage Above Valid Range	i) Open or short circuit of potentiometer wiring ii) Potentiometer failed iii) Potentiometer is mechanically out of range **Refer to Flow Diagram No. 27**
E19	Dump Solenoid Open or Short Circuit or C3/C4 Pressure Switch Open Circuit	**Refer to Flow Diagram No. 9**
E22	PWM Solenoid Current Below Valid Range	i) Short circuit of PWM coil ii) Open or short circuit in solenoid wiring **Refer to Flow Diagram No. 28**
E23	PWM Solenoid Current Above Valid Range	i) Short circuit of PWM coil ii) Short circuit of solenoid wiring **Refer to Flow Diagram No. 29**
E20	T1 Harness Disconnected	Error codes E17, E18 and E19 have been detected by the ETC module and assumes the T1 harness is disconnected
E21	T2 Harness Disconnected	Error codes E16, E17, E18 and E19 have been detected by the ETC module and assumes the T2 harness is disconnected
E32	Keep Alive Memory (KAM) Power Failure	i) Battery recently disconnected ii) The ETC module was recently disconnected iii) Fuse 20 failed iv) +12V to ETC pin No. 1 open or short circuit **Refer to Flow Diagram No. 30**

FLOW DIAGRAM 1: The tractor drives in all gears and in all ranges but has the following fault:

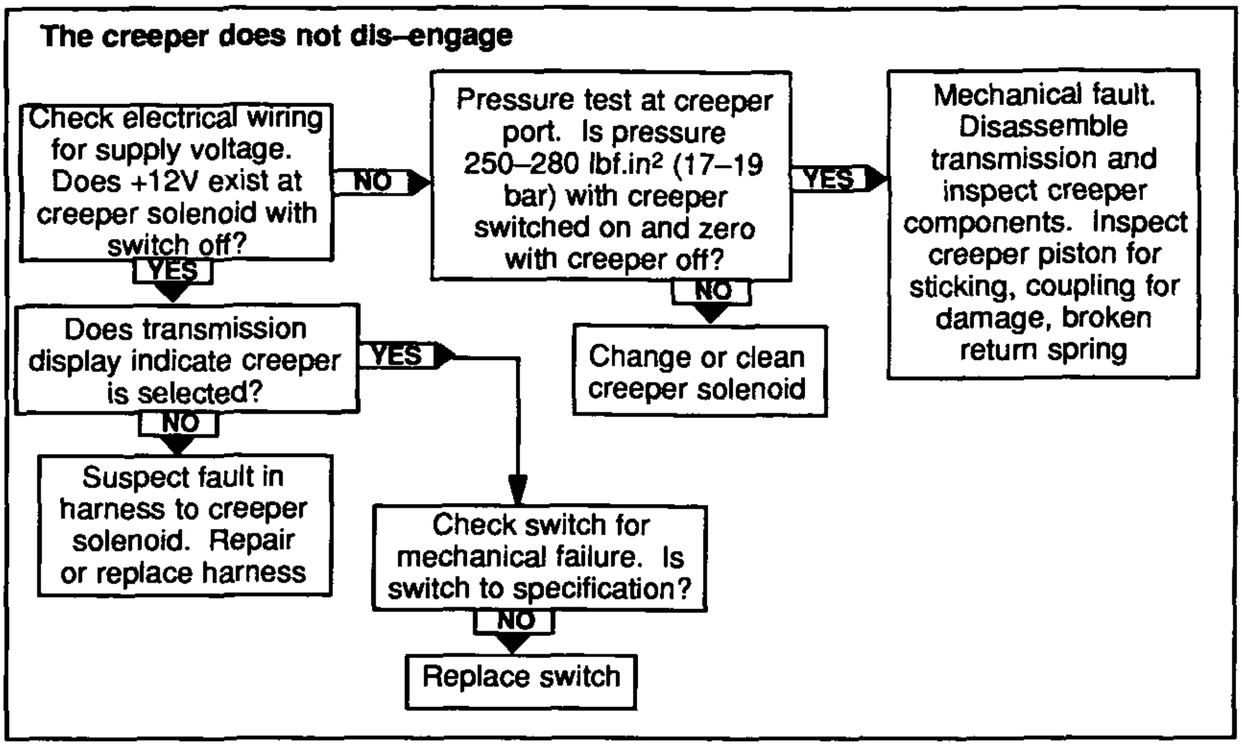
For transmission wiring diagram and connector location refer to the end of this Section.

The creeper does not engage in low range



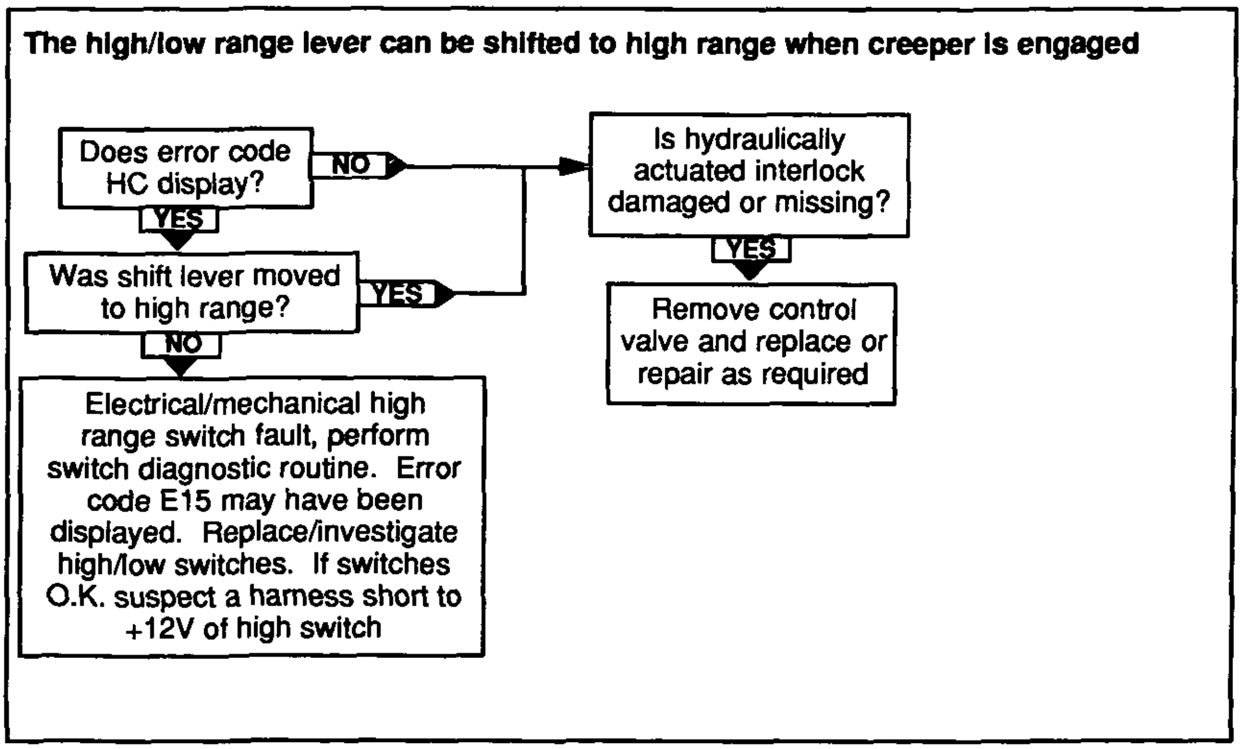
FLOW DIAGRAM 2: The tractor drives in all gears and in all ranges but has the following fault:

For transmission wiring diagram and connector location refer to the end of this Section.



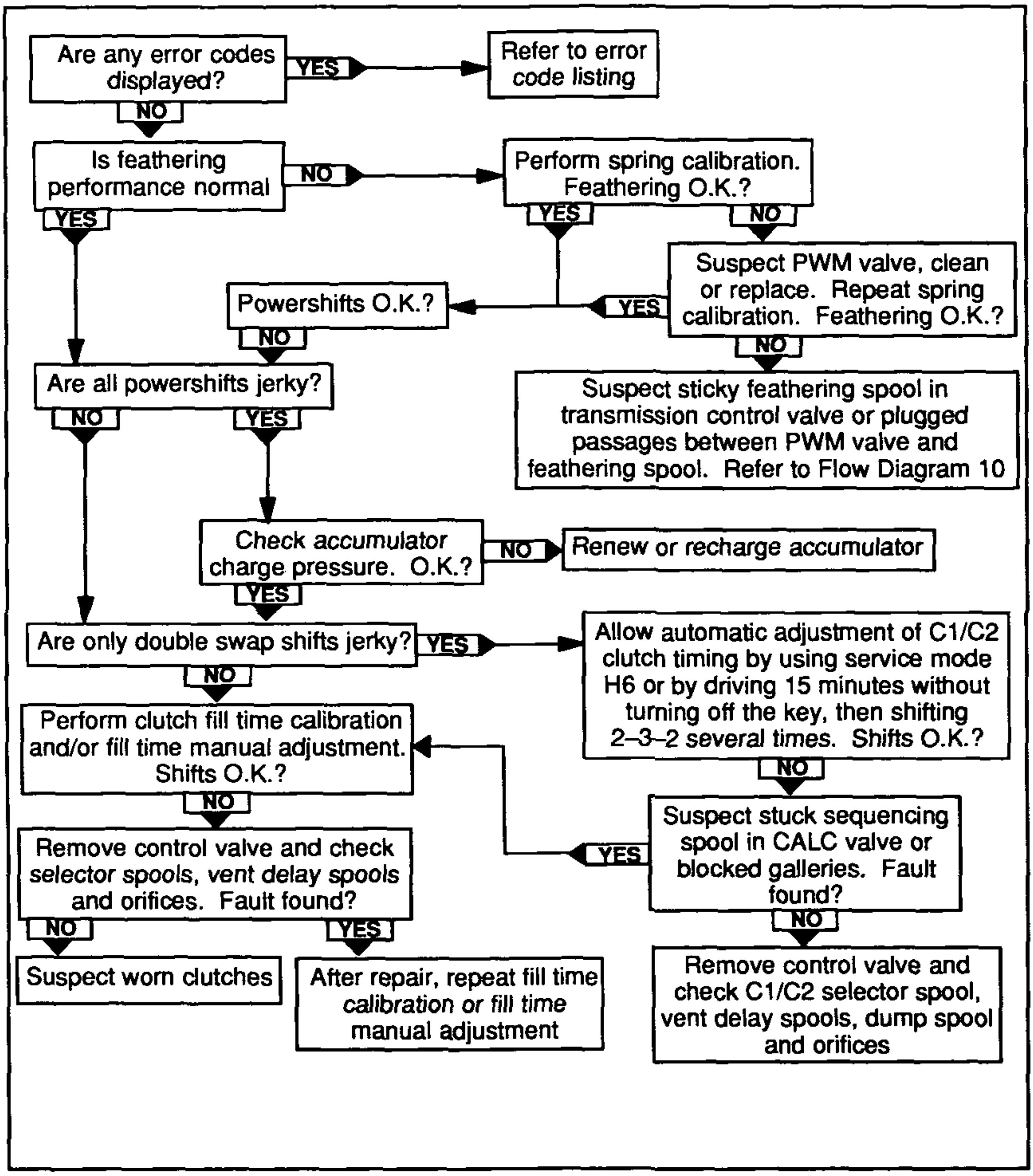
FLOW DIAGRAM 3: The tractor drives in all gears and in all ranges but has the following fault:

For transmission wiring diagram and connector location refer to the end of this Section.



FLOW DIAGRAM 4: The powershifts are not smooth or the tractor loses drive between *powershifts (in work, tractor stops or could be jerky)*

For transmission wiring diagram and connector location refer to the end of this Section.



FLOW DIAGRAM 5: The tractor drives in all ranges but has the following fault:
For transmission wiring diagram and connector location refer to the end of this Section.

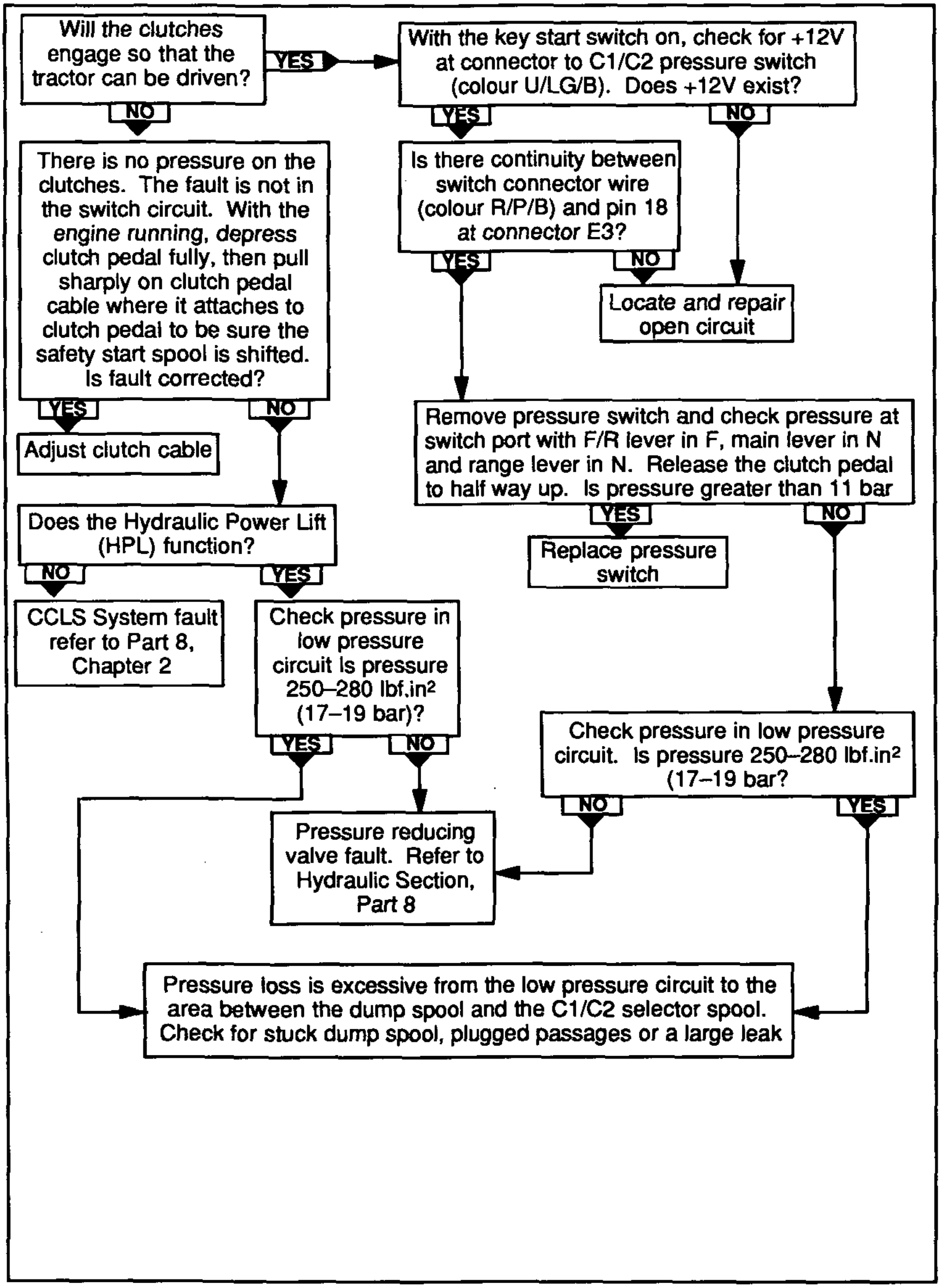
The powershift function operates but the sequence is incorrect or gears missing

1. Turn on key start switch without starting engine with FNR lever in neutral. Is an error code displayed?
   - YES → Refer to error code listing
   - NO ↓
2. Disconnect connector T5 from gear shift display module. Does the transmission function correctly?
   - YES → Replace gear shift display module
   - NO ↓
3. Does the shift sequence of the shift lamp display agree with the gear display on the instrument cluster?
   - NO → Check wiring to C1/C2 and C3/C4 selector valves using Flow Diagrams 23 and 24
   - YES ↓
4. Inspect the shift levers for correct operation. Inspect shift mechanism for damaged or disconnected links. Is fault found?
   - YES → Repair or adjust as required. Refer to 'Gearshift Control Mechanism' section
   - NO ↓
5. Check gear sequence chart. Pressure test at respective clutch port. Is pressure 250–280 lbf.in2 (17–19 bar) at the correct clutch?
   - YES → Suspect mechanical failure of clutches, shafts or gears.
   - NO ↓
6. Remove control valve and check related selector spool, vent dealy spool, orifices and CALC valve sequencing spool. Fault found?
   - NO ↓
7. Suspect clutches/seals

	C1	C2	C3	C4	
1-5		●		●	9-13
2-6		●	●		10-14
3-7	●			●	11-15
4-8	●		●		12-16

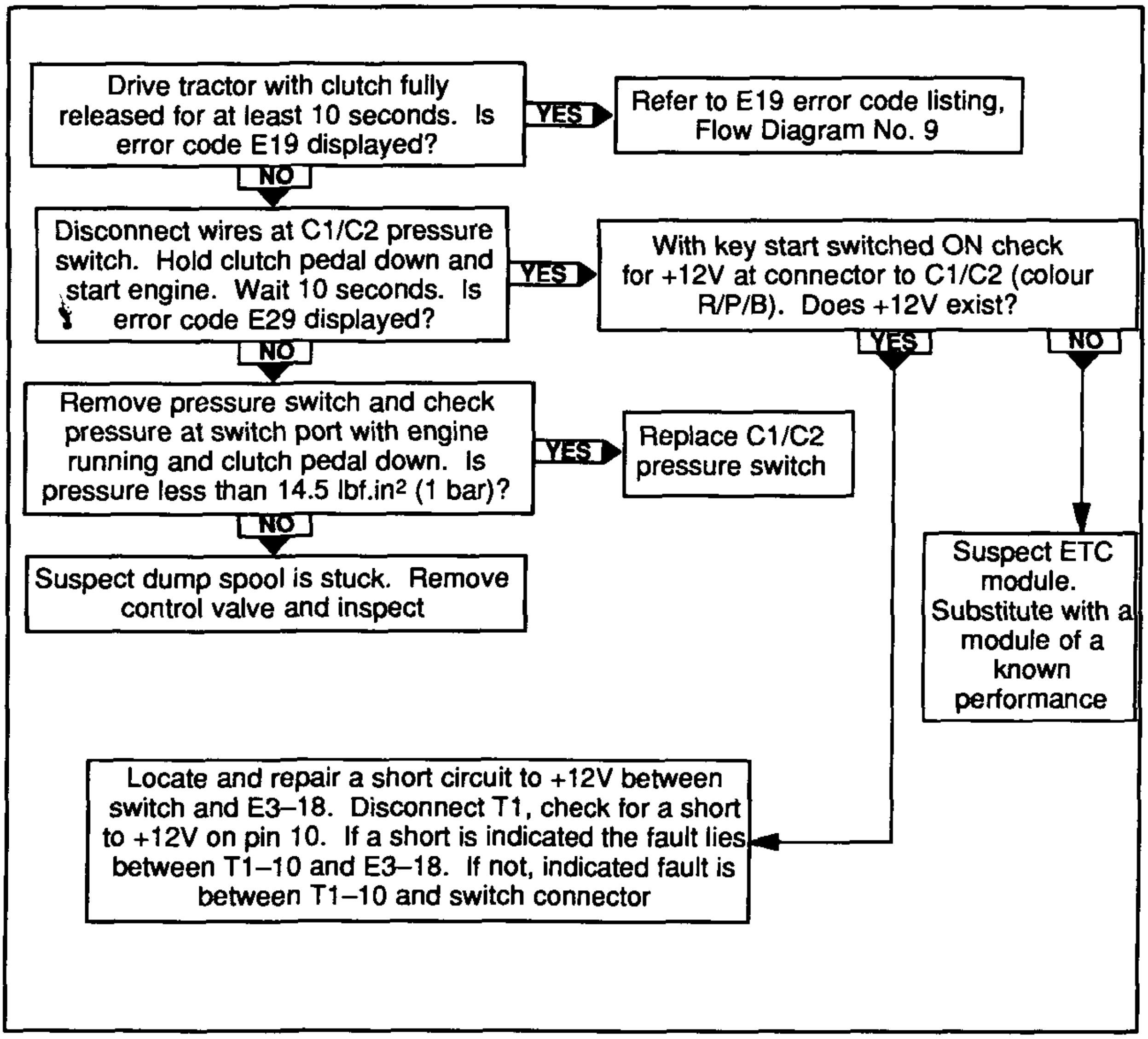
FLOW DIAGRAM 6: Error Code E28 displayed – C1/C2 clutch circuit pressure switch open circuit (switch does not indicate high pressure)

For transmission wiring diagram and connector location refer to the end of this Section.



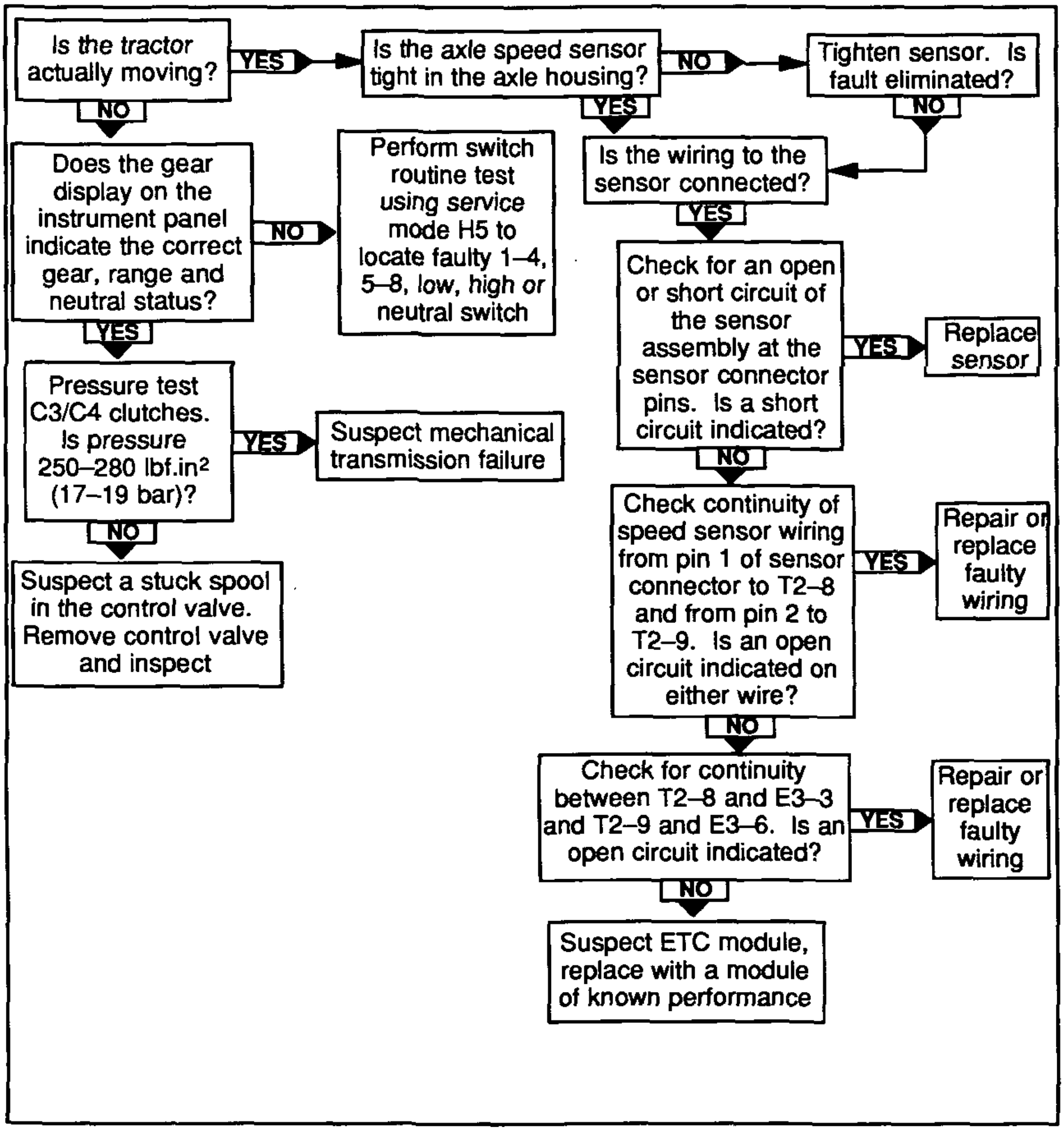
FLOW DIAGRAM 7: Error Code E29 displayed – C1/C2 clutch circuit pressure switch short circuit (switch does not indicate low pressure)

For transmission wiring diagram and connector location refer to the end of this Section.



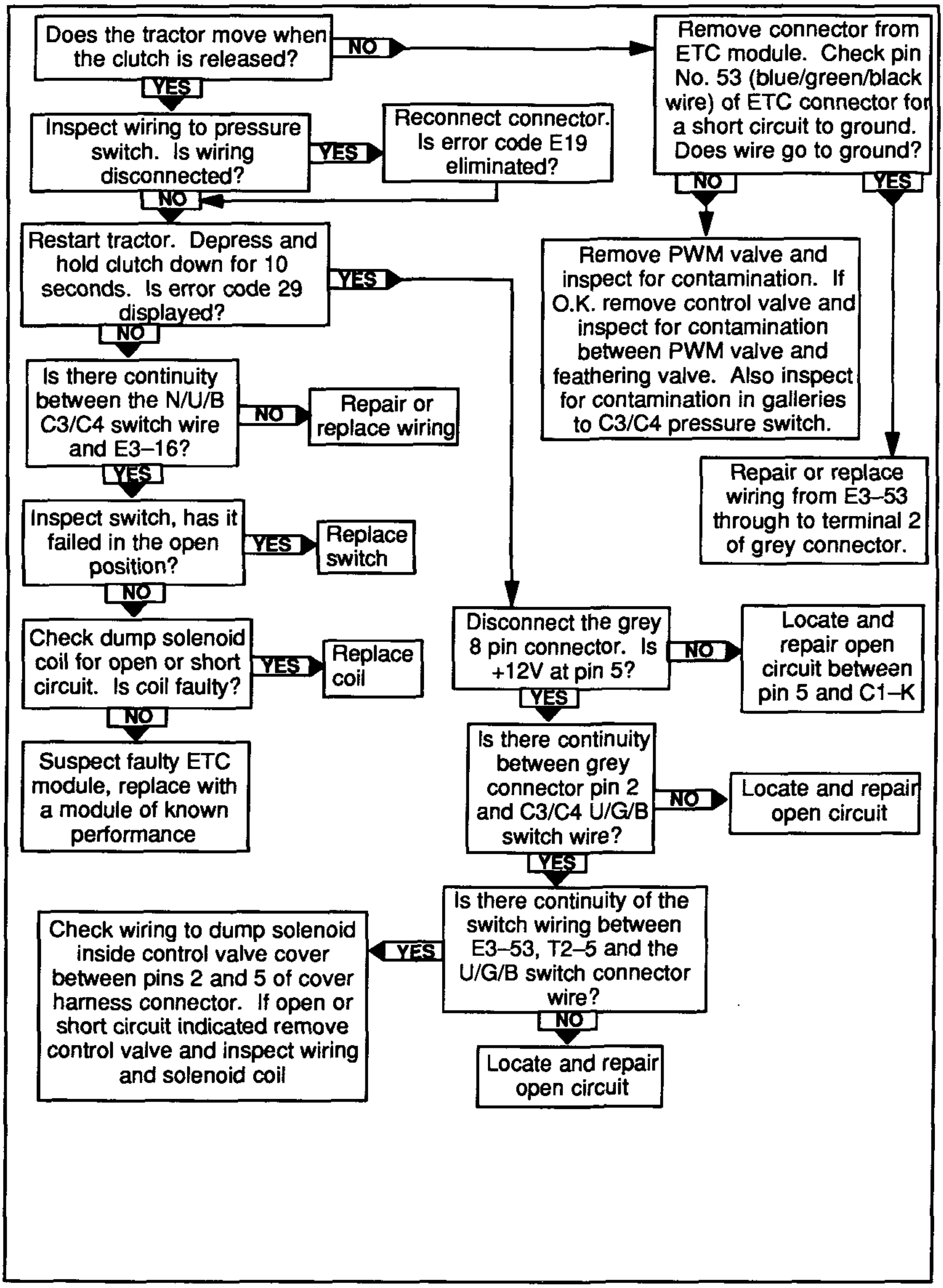
FLOW DIAGRAM 8: Error Code E25 displayed – Tractor motion not detected when transmission is engaged

For transmission wiring diagram and connector location refer to the end of this Section.



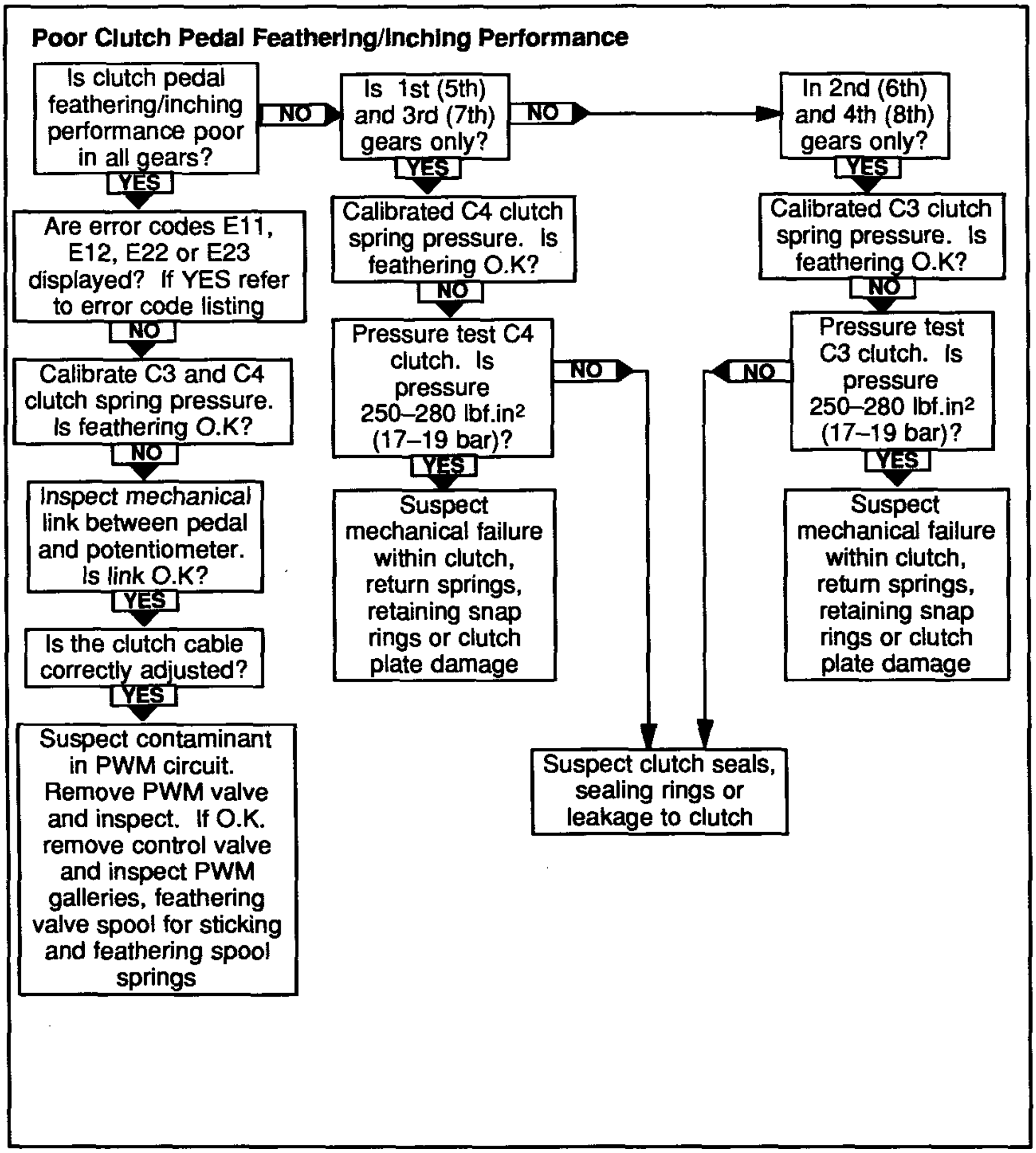
FLOW DIAGRAM 9: Error Code E19 displayed – Dump solenoid open or short circuit OR C3/C4 pressure switch open circuit

For transmission wiring diagram and connector location refer to the end of this Section.



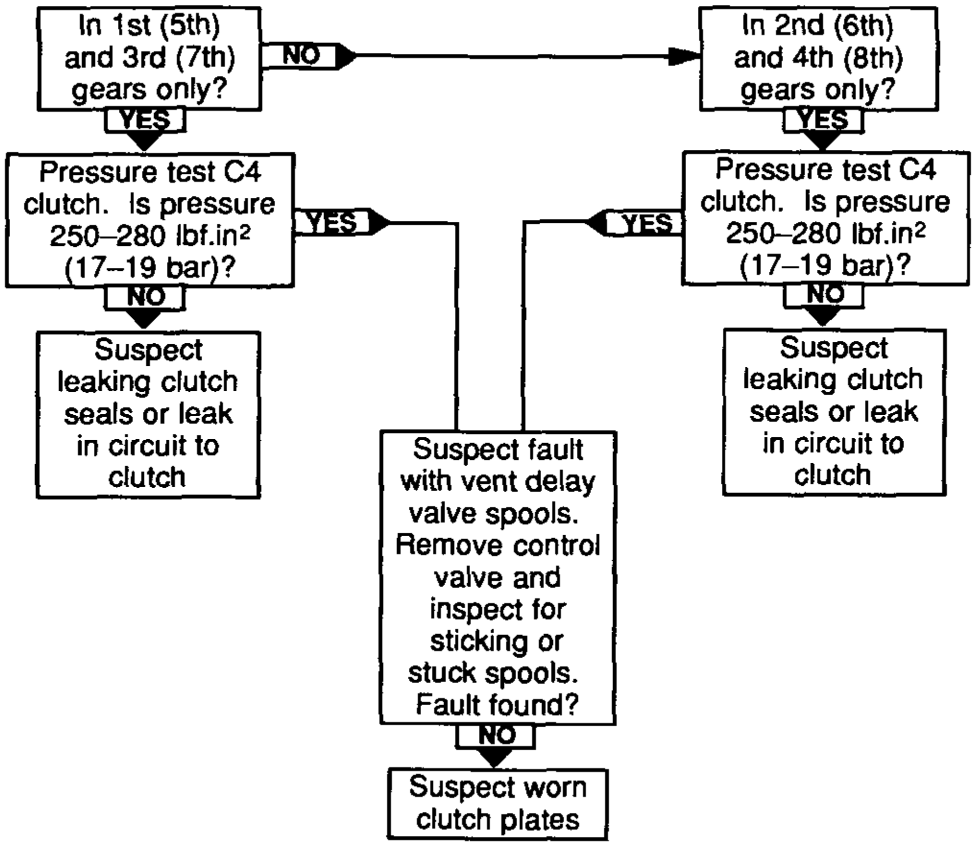
FLOW DIAGRAM 10: The tractor drives in all gears and ranges but has the following fault:

For transmission wiring diagram and connector location refer to the end of this Section.



FLOW DIAGRAM 11: The tractor drives in all gears and ranges but has the following fault:
For transmission wiring diagram and connector location refer to the end of this Section.

Clutches squeal/whine during inching



FLOW DIAGRAM 12: The tractor drives in all gears and ranges but has the following fault:
For transmission wiring diagram and connector location refer to the end of this Section.

Does transmission clunk during inching?

Suspect malfunction of CALC vavle. Remove CALC valve from control valve cover assembly and inspect spools for indications of sticking or being stuck and broken springs

FLOW DIAGRAM 13: ***The tractor drives in all gears and in all ranges but has the following fault:***
For transmission wiring diagram and connector location refer to the end of this Section.

Front Wheel Drive does not engage or engages slowly

- Pressure test at FWD test port in control valve cover. Does pressure gauge indicate 250–280 lbf.in2 (17–19 bar) when FWD switched off and zero pressure when switched on?
  - YES → Suspect mechanical failure of FWD output assembly, or transmission to FWD output assembly gear failure. If slow in engaging, carefully inspect the pilot check valve
  - NO → Test for correct operation of switch. Is switch O.K?
    - NO → Replace switch
    - YES → Disconnect wiring from switch check wiring for short circuit to +12V. Fault found?
      - NO → Suspect stuck solenoid spool. Remove control valve and inspect

FLOW DIAGRAM 14: ***The tractor drives in all gears and in all ranges but has the following fault:***
For transmission wiring diagram and connector location refer to the end of this Section.

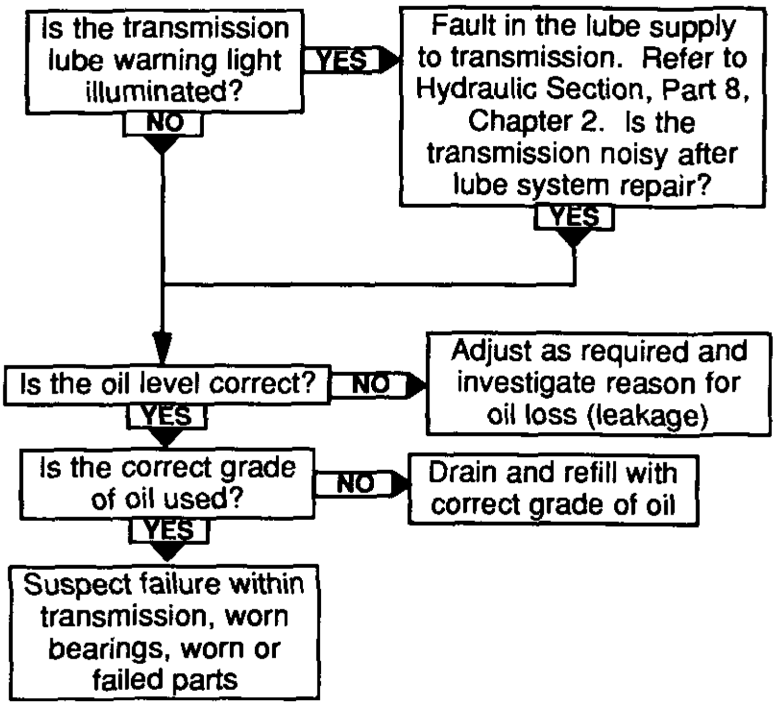
Front Wheel Drive does not disengage

- Pressure test at FWD test port in control valve cover. Does pressure gauge indicate 250–280 lbf.in2 (17–19 bar) when FWD switched off and zero pressure when switched on?
  - YES → Mechanical failure of FWD output assembly
  - NO → Test for correct operation of switch. Is switch O.K?
    - NO → Replace switch
    - YES → Disconnect wiring from switch check wiring for short circuit to ground or open circuit. Fault found?
      - NO → Suspect fault within control valve. Wiring to solenoid disconnected, solenoid faulty or struck solenoid spool. Fault found?
        - NO → Suspect oil leak, oil transfer tube leaking (missing), FWD output assembly clutch seals leaking

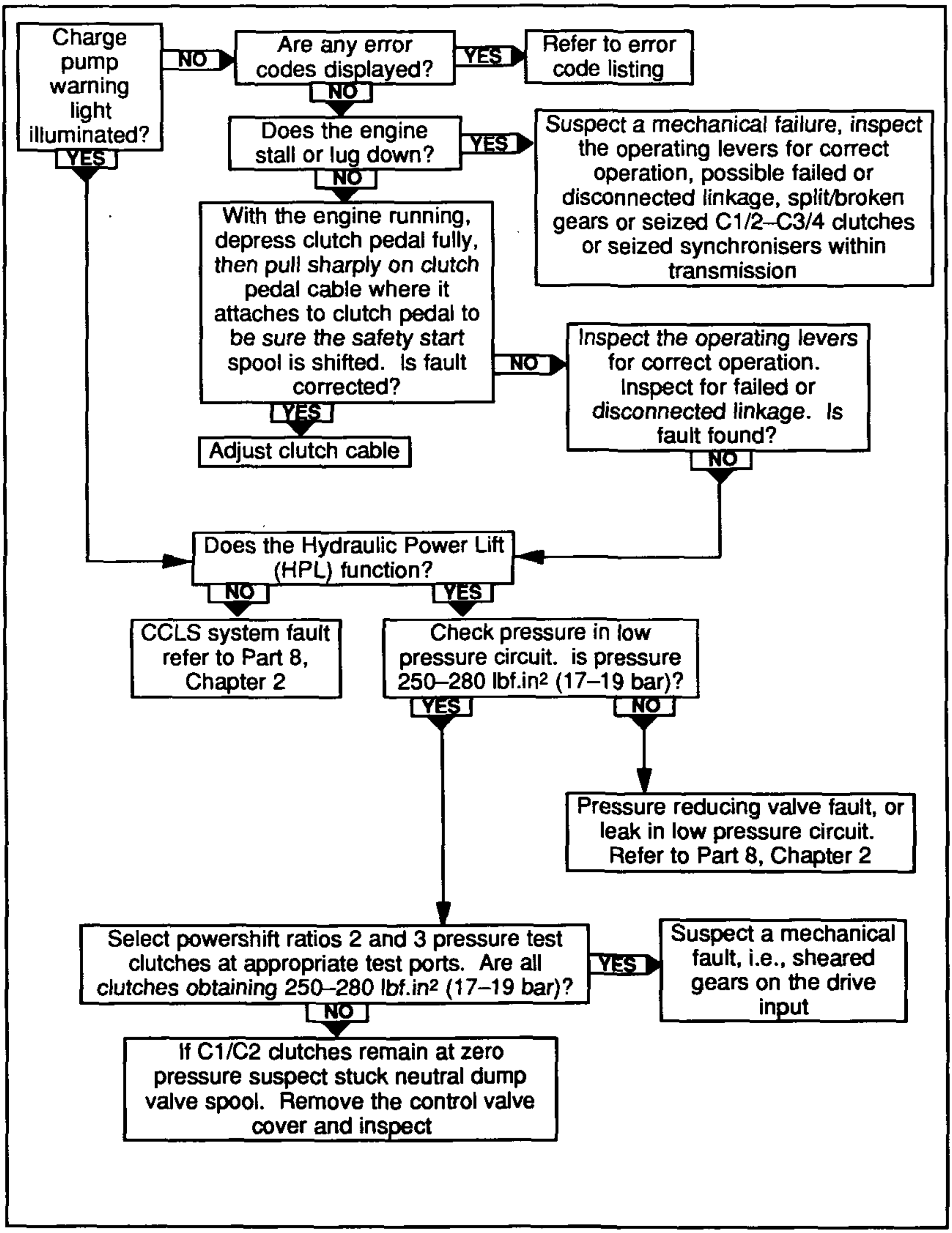
FLOW DIAGRAM 15: The tractor drives in all gears and in all ranges but has the following fault:

For transmission wiring diagram and connector location refer to the end of this Section.

Transmission is noisy in operation



FLOW DIAGRAM 16: Tractor does not drive (in any gear)
For transmission wiring diagram and connector location refer to the end of this Section.



FLOW DIAGRAM 17: The tractor drives in all gears and ranges but has the following fault:

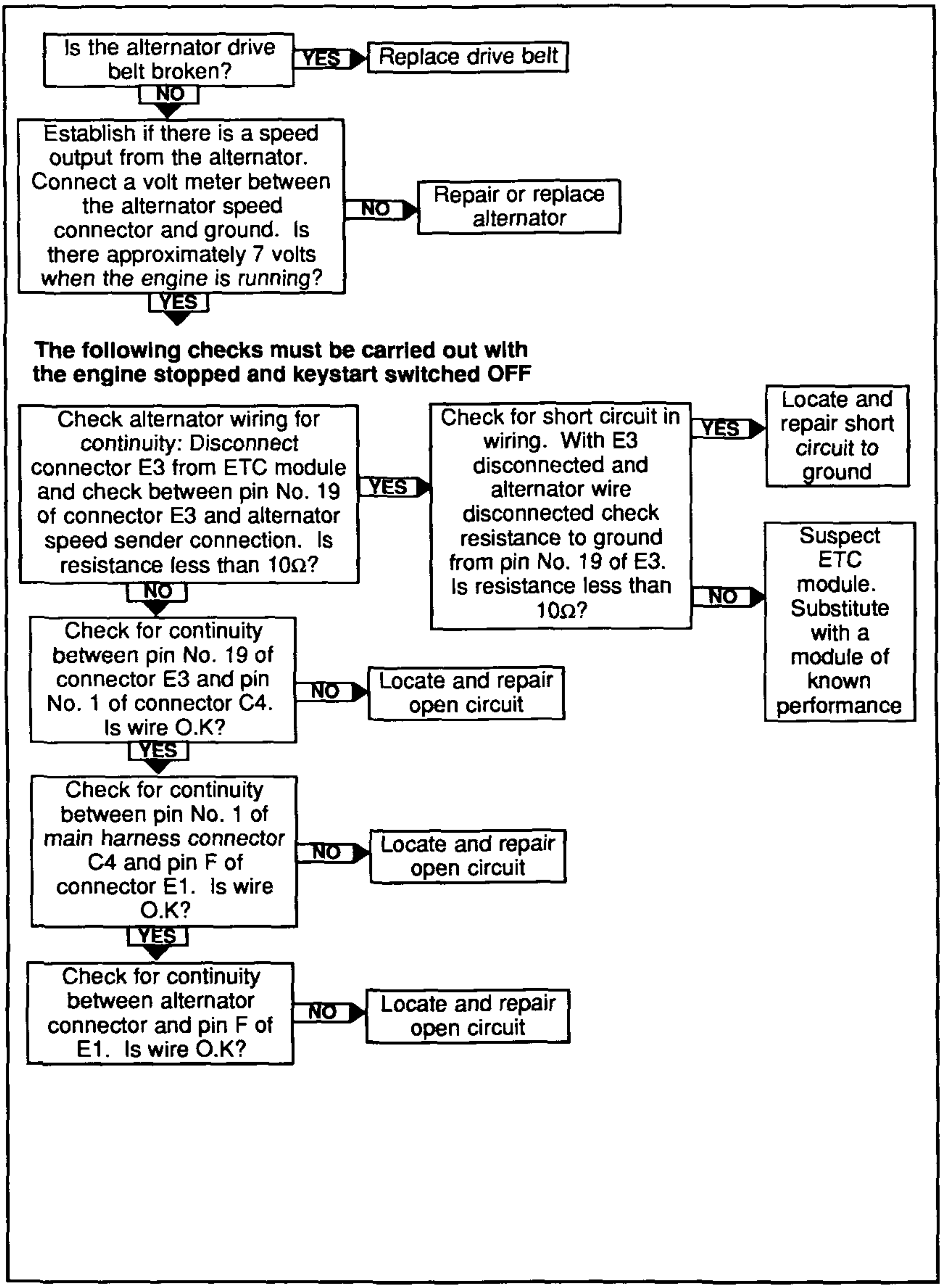
For transmission wiring diagram and connector location refer to the end of this Section.

Transmission jumps out of gear, holds in gear or gears clash when shifting

- Does transmission jump out of gear/range or gears clash when shifting?
  - NO → Does transmission hold in a range?
    - YES → Inspect control lever linkage. Is linkage damaged or maladjusted?
      - NO → Suspect mechanical fault within transmission. Synchroniser sleeve/couplers worn
      - YES → Repair or adjust as necessary
  - YES → Are any error codes stored in the EIC memory, indicating an intermittent electrical fault?
    - YES → Refer to Error Code Listing. Clear EIC memory of stored codes. Drive tractor until fault is repeated, immediately stop tractor and check for error code
    - NO → Is the gear fully engaging? Inspect and adjust shift lever linkage as required. Fault cured?
      - NO → For clashing gears during shifting, pressure test one of the C1/C2 clutches. Is the pressure dumped when the clutch is fully depressed?
        - NO → Dump solenoid not activated when clutch depressed, suspect fault in dump valve circuit, refer to Flow Diagram 9
        - YES → Pressure test C3/C4 clutches. Is pressure dumped when the clutch pedal is depressed?
          - NO → Check the clutch cable and adjust as necessary. If fault not cured, problem must lie in the feathering spool valve or circuit. Remove control valve and inspect
          - YES → Suspect a mechanical fault within the transmission, inspect the detents in the shift cover, if no fault found suspect either worn synchronisers or excessive end float of transmission components

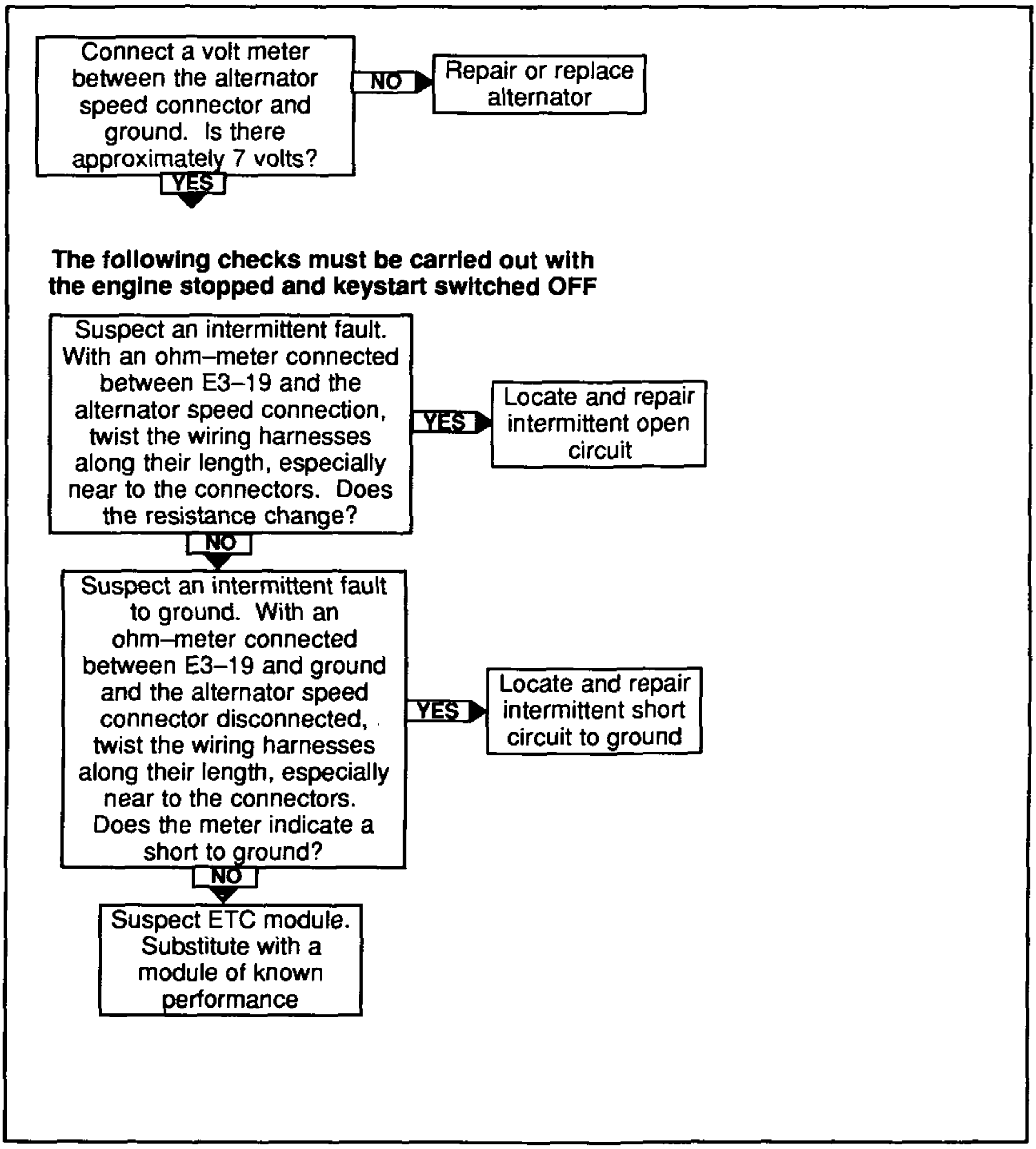
FLOW DIAGRAM 18: Error Code E27 displayed – ERPM signal not present

For transmission wiring diagram and connector location refer to the end of this Section.



FLOW DIAGRAM 19: Error Code E26 displayed – ERPM signal too high

For transmission wiring diagram and connector location refer to the end of this Section.



FLOW DIAGRAM 20: Error Code E13 displayed – up/downshift switches both on

For transmission wiring diagram and connector location refer to the end of this Section.

Check operation of switches. Disconnect connector T4 from switch wiring. Check for correct switch operation with a continuity meter between pin No. 1 (common) and pin Nos. 4 (down) and 5 (up). Do both switches function correctly?

NO → Replace faulty switch/switches

YES ↓

Disconnect connector E3 from the ETC module. With connector T4 disconnected, check for a short circuit between pin Nos. 9 (down) and 27 (up) of the E3 connector. Is a short circuit indicated?

YES → Locate and repair or replace faulty wiring

NO ↓

Check for a short circuit between pin No. 1 and pin No. 4 and between pin No. 1 and pin No. 5 of the T4 connector. Is a short circuit indicated?

YES → Locate and repair or replace faulty wiring

NO ↓

Suspect ETC module. Substitute with a module of known performance

FLOW DIAGRAM 21: Error Code E14 displayed – 1–4 & 5–8 switches both on

For transmission wiring diagram and connector location refer to the end of this Section.

Check operation of switches: Disconnect connector E3 from ETC module and remove fuse 13. With the keystart OFF, connect a continuity meter between E3–34 and output side of fuse, move main lever into 1–4 position. Repeat above operation from E3–15 and selecting 5–8 position on main lever. Does meter indicate switches operating correctly?

NO → Remove switch/switches and check operation. Do switches function correctly?

NO → Replace faulty switch/switches

YES ↓

Suspect damaged transmission rail. Remove transmission top cover and inspect.

YES ↓

Check for a short circuit between pin Nos. 34 and 15 of the connector E3. Is a short circuit indicated?

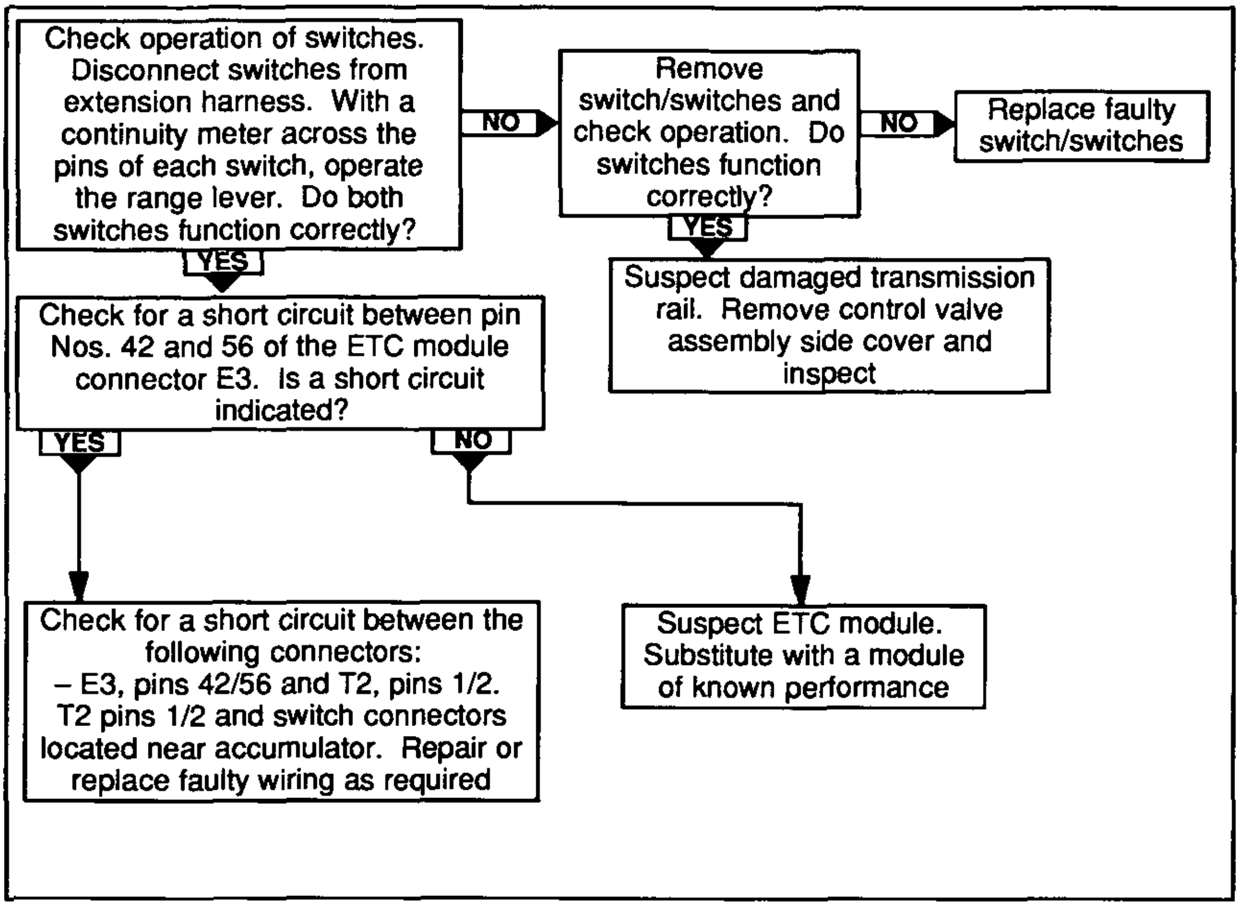
NO → Suspect ETC Module. Substitute with a module of known performance

YES ↓

Check for a short circuit between the following connectors:
– E3, pin Nos. 15/34 and T2 pin Nos. 6/7. T2 pin Nos. 6/7 and switch connectors located on transmission top cover. Repair or replace faulty wiring as required

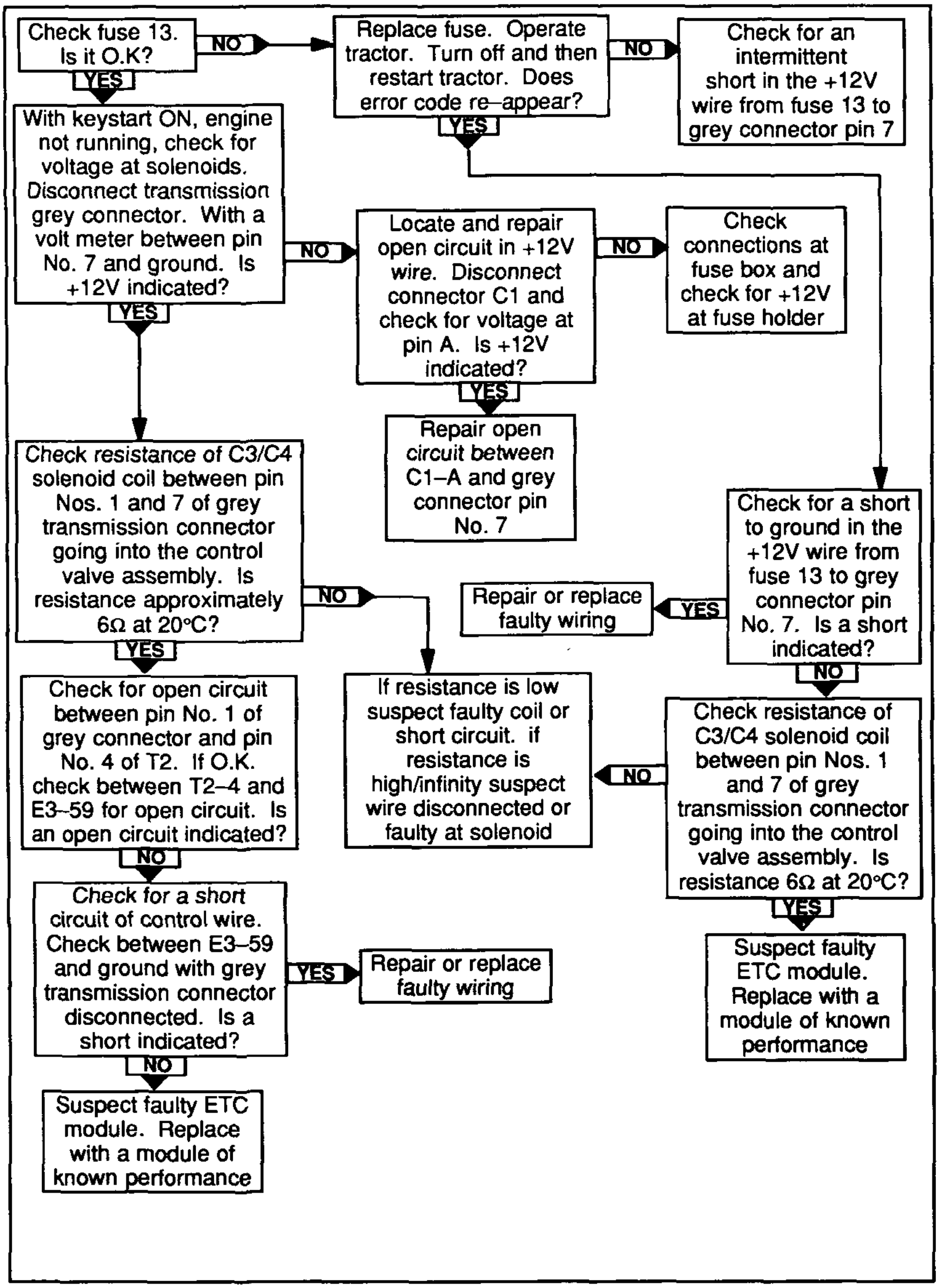
FLOW DIAGRAM 22: Error Code E15 displayed – high/low switches both on

For transmission wiring diagram and connector location refer to the end of this Section.



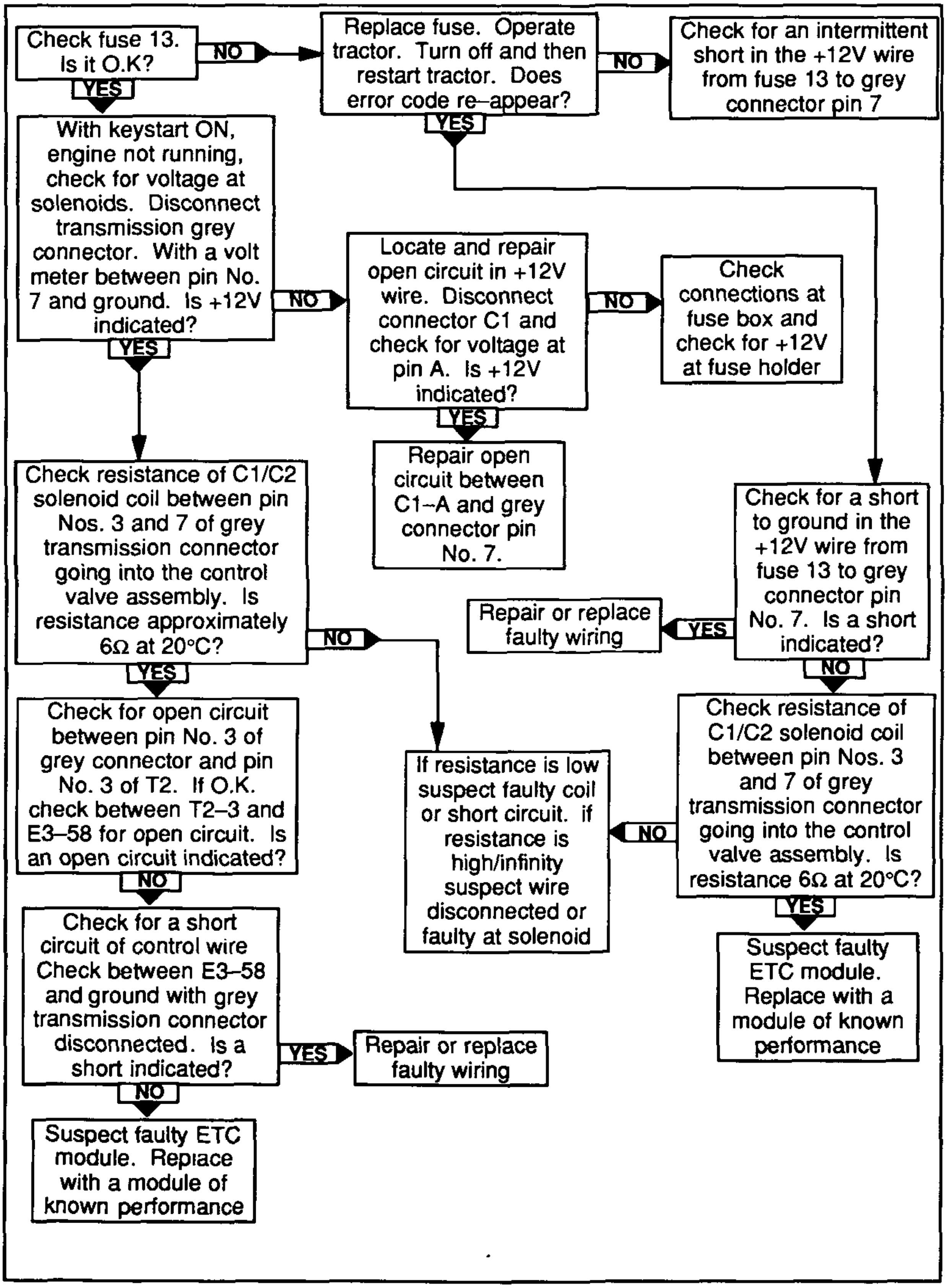
FLOW DIAGRAM 23: Error Code E17 displayed – C3/C4 solenoid open or short circuit

For transmission wiring diagram and connector location refer to the end of this Section.



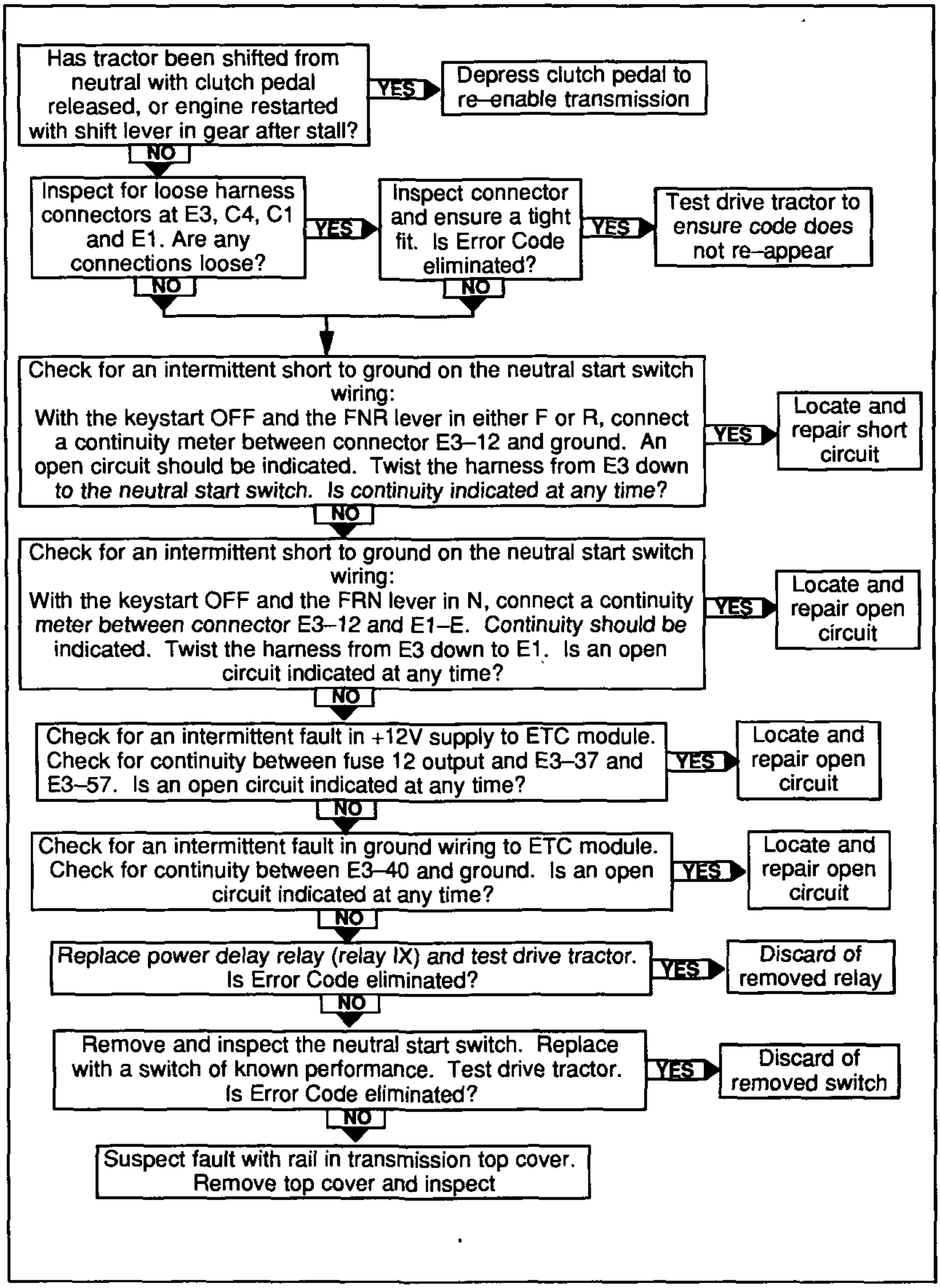
FLOW DIAGRAM 24: Error Code E18 displayed – C1/C2 solenoid open or short circuit

For transmission wiring diagram and connector location refer to the end of this Section.



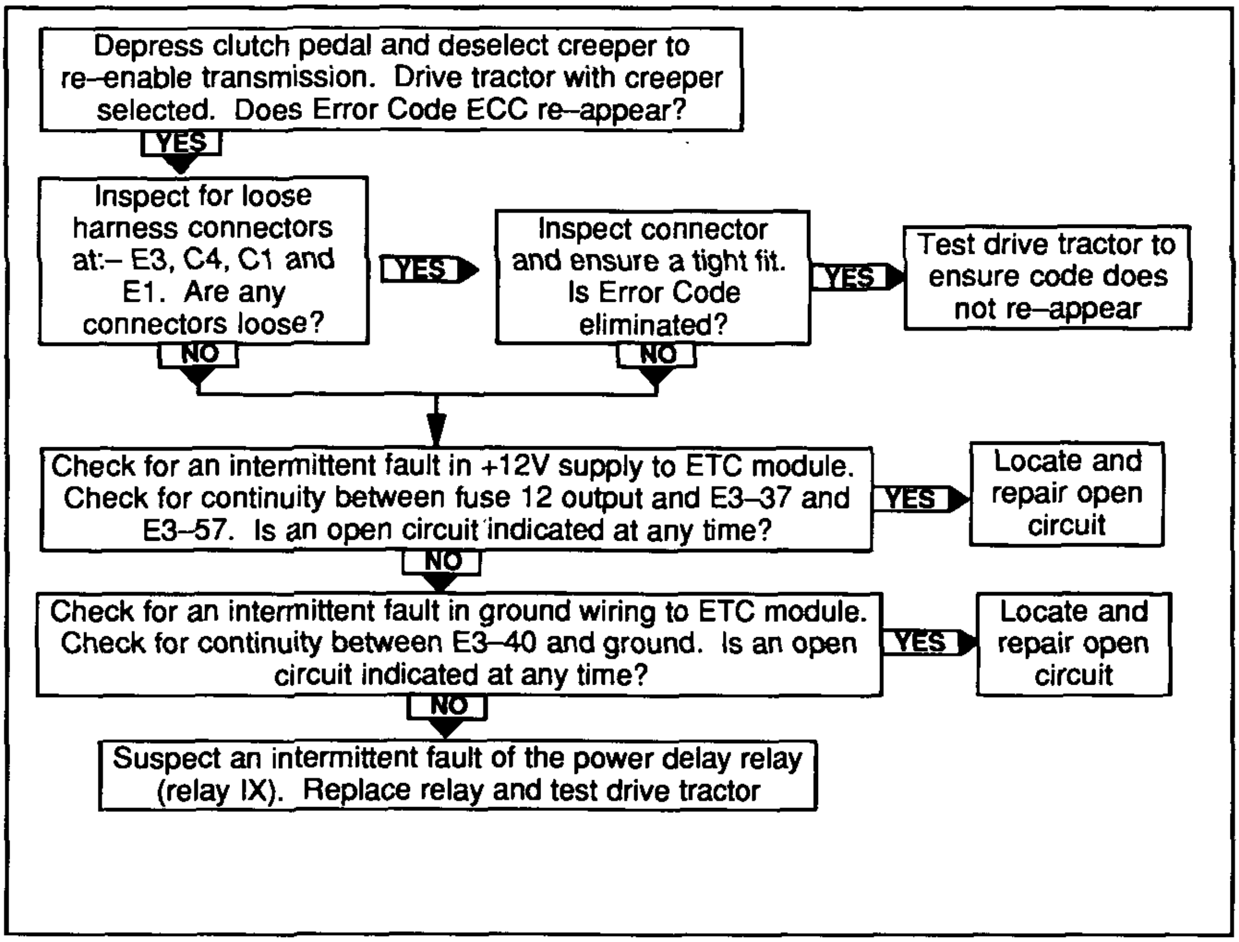
FLOW DIAGRAM 25: Error Code CP displayed – Depress clutch pedal to re–enable transmission

For transmission wiring diagram and connector location refer to the end of this Section.



FLOW DIAGRAM 26: Error Code ECC displayed – electrical re–set with creeper engaged (while tractor is moving)

For transmission wiring diagram and connector location refer to the end of this Section.



FLOW DIAGRAM 27: Error Code E11 Clutch Potentiometer voltage below valid range
Error Code E12 Clutch Potentiometer voltage above valid range

For transmission wiring diagram and connector location refer to the end of this Section.

Check operation of potentiometer. Remove left hand lower side panel below instrument cluster to expose potentiometer and wiring. Disconnect plug to potentiometer and check operation of potentiometer. With pedal released, is resistance between 3.1KΩ and 3.9kΩ, gradually changing to between 640Ω and 2.1kΩ as the clutch pedal is depressed?

- NO → Replace potentiometer as required
- YES ↓

Disconnect the ETC module and connect an ohm meter between pin No. 2 (tan) and pin No. 3 (black) of harness connector to potentiometer and between pin No. 1 (yellow/red/black) and pin Nos. 2 and 3. Is an open circuit indicated in every case?

- NO → Trace and repair short circuit
- YES ↓

Connect an ohm meter between pin No. 1 (yellow/red/black) of harness connector to potentiometer and ground. Is an open circuit indicated?

- NO → Trace and repair short to ground
- YES ↓

Connect an ohm meter between pin No. 2 (tan) of harness connector to potentiometer and ground. Is an open circuit indicated?

- NO → Trace and repair short to ground
- YES ↓

Connect an ohm meter between pin No. 3 (black) of harness connector to potentiometer and ground. Is an open circuit indicated?

- NO → Trace and repair short to ground
- YES ↓

Reconnect the ETC module. With the keystart ON, is the voltage at pin No. 2 (tan) 5 volts?

- NO → Check continuity of wire from pin No. 2 to E3–26
- YES ↓

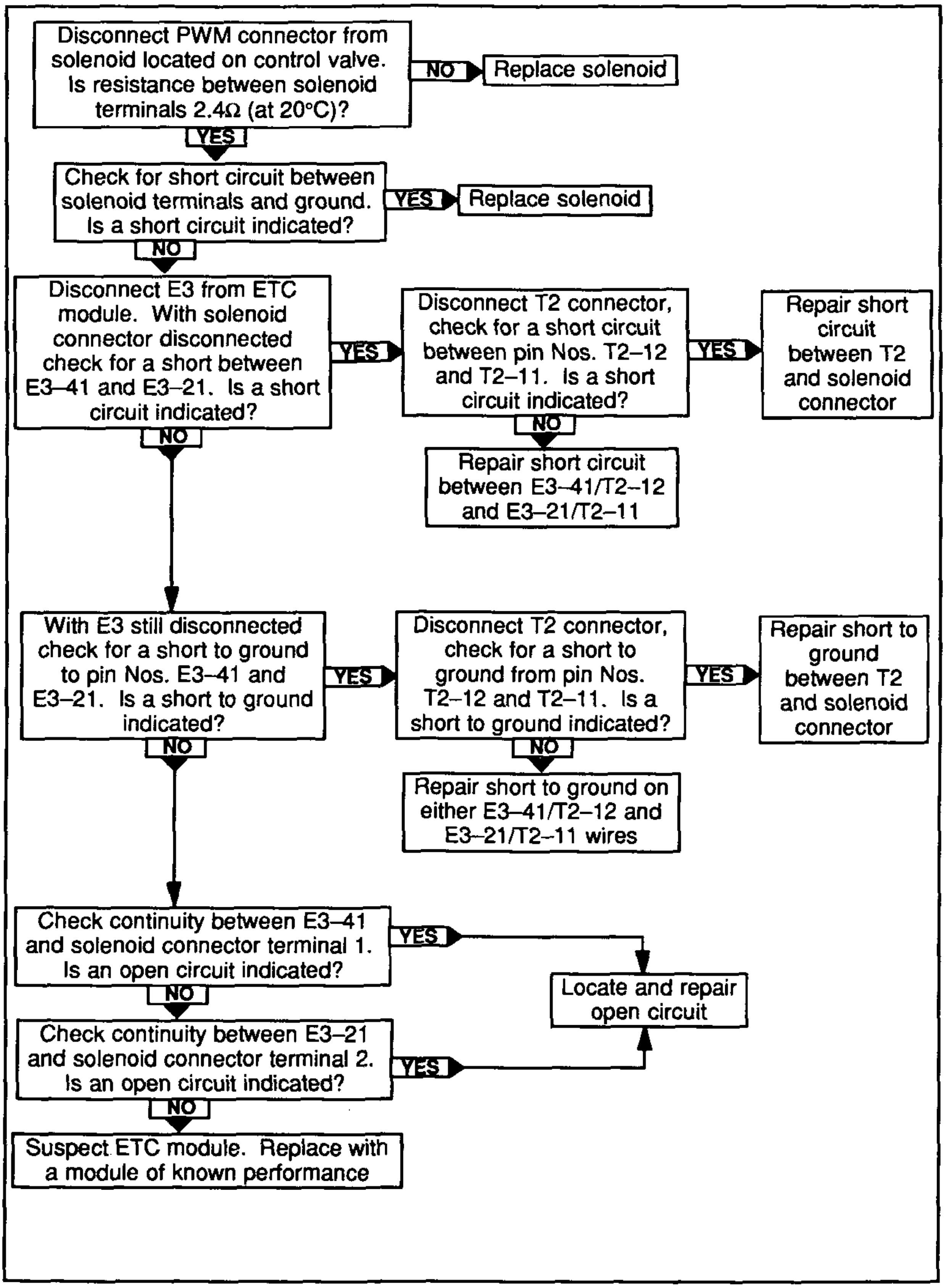
Check continuity of wire from pin No. 1 to E3–25 and continuity of wire from E3–46 to pin No. 3. Are both wires O.K?

- NO → Trace and repair open circuits as required
- YES ↓

Suspect faulty ETC module, replace with a module of known performance

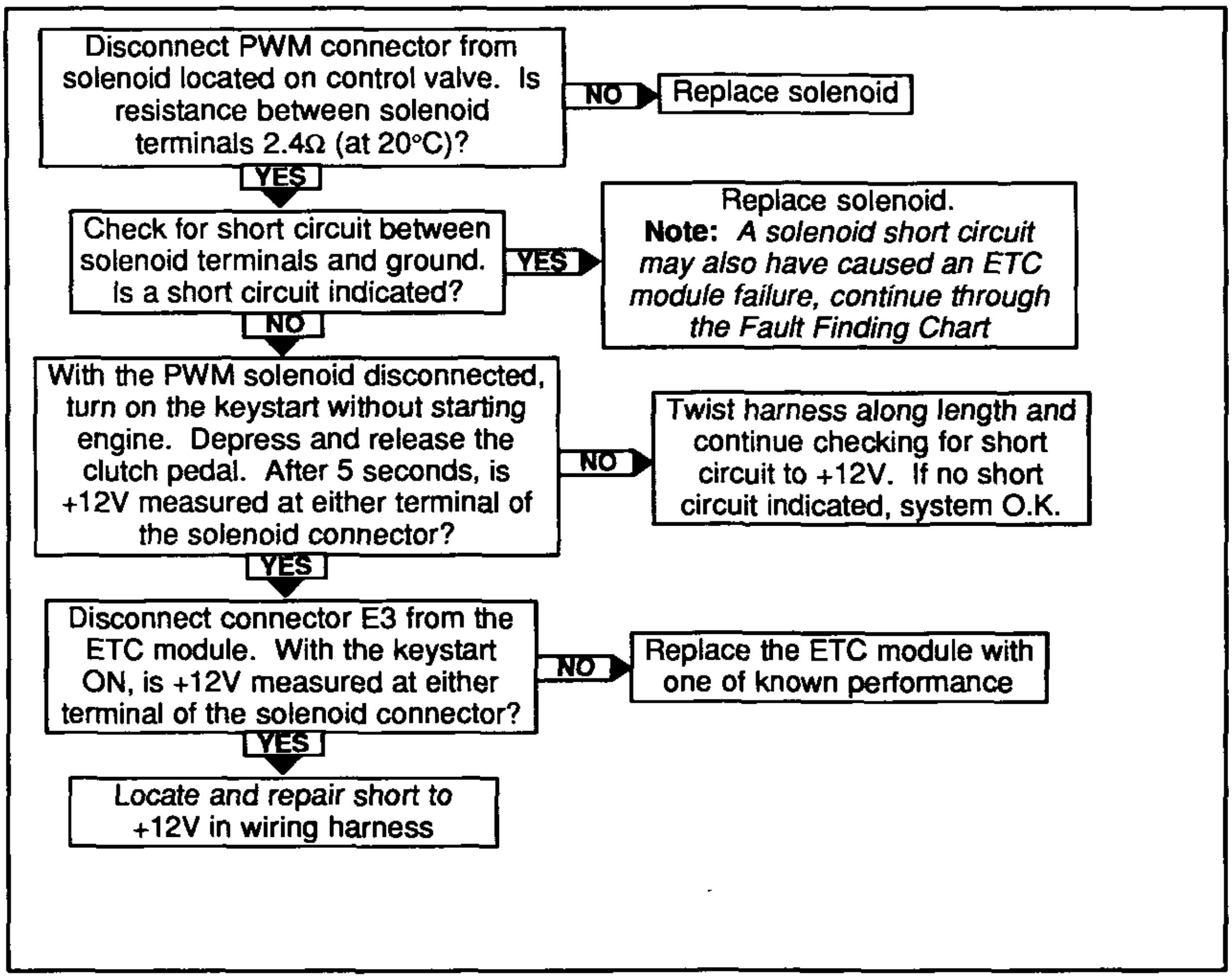
FLOW DIAGRAM 28: Error Code E22 displayed – PWM solenoid current below valid range

For transmission wiring diagram and connector location refer to the end of this Section.



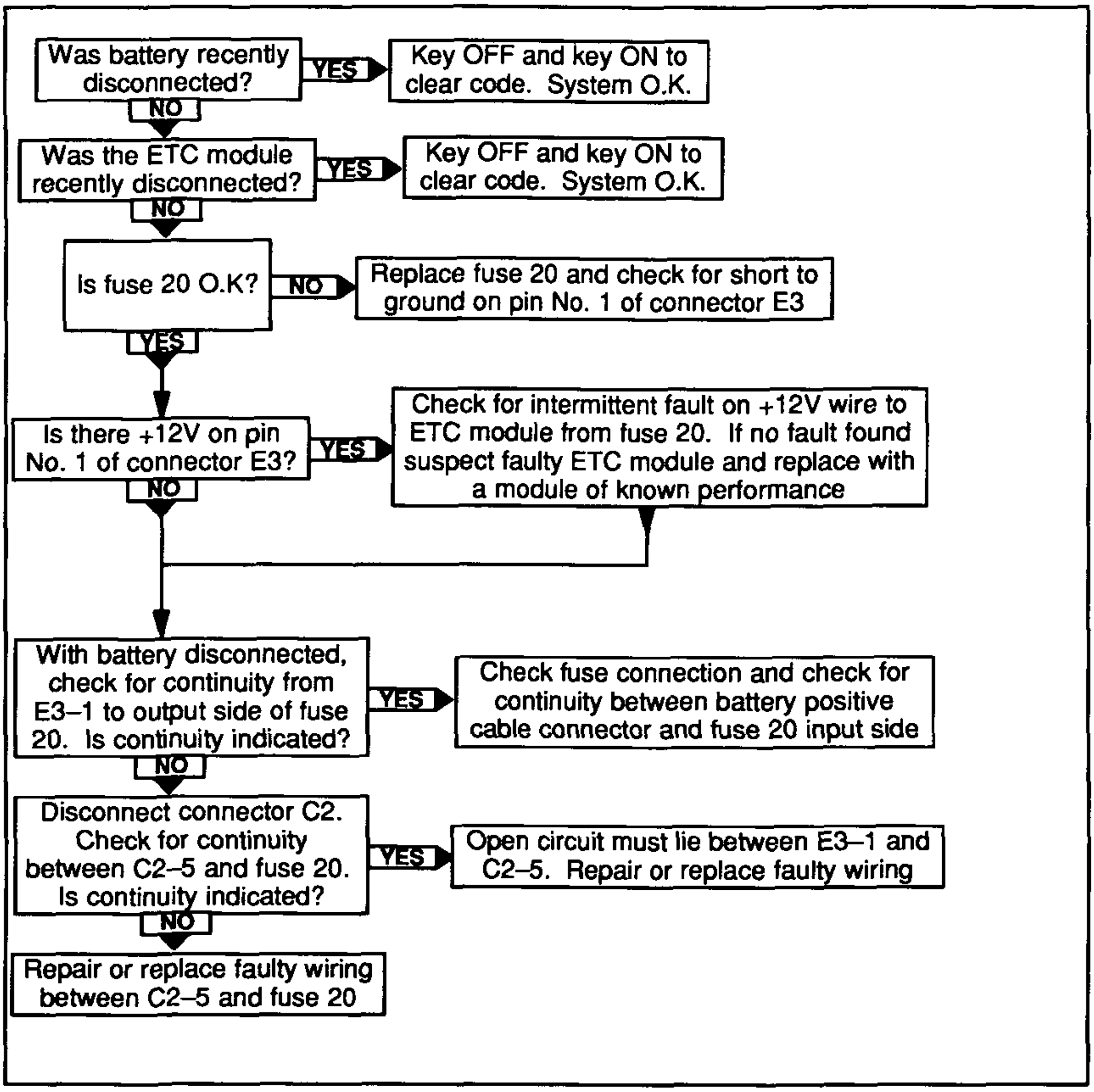
FLOW DIAGRAM 29: Error Code E23 displayed – PWM solenoid current above valid range

For transmission wiring diagram and connector location refer to the end of this Section.



FLOW DIAGRAM 30: Error Code E32 displayed – Keep Alive Memory (KAM) power failure

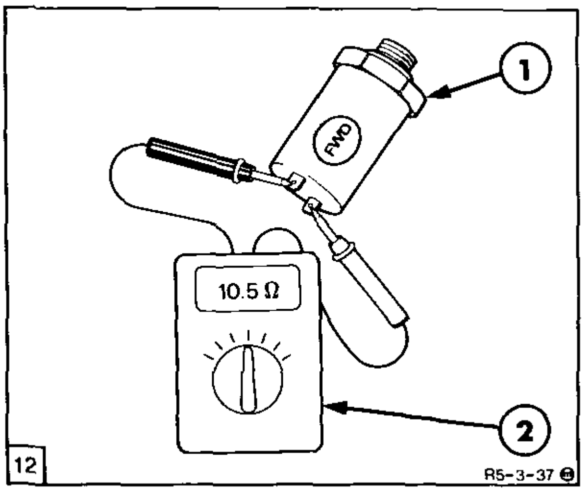
For transmission wiring diagram and connector location refer to the end of this Section.



Component Testing and Specifications:

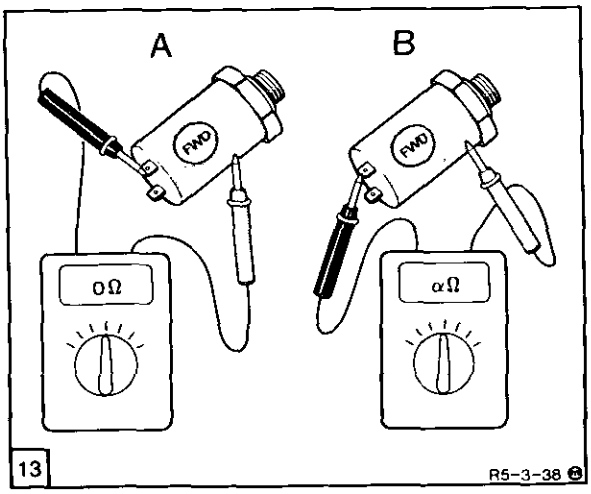
Electrical Components

The method of testing individual electrical components, for example, solenoid coils, speed sensors and potentiometers, is basically the same for each component. Each component has within it a coil or wire which has a specified resistance to electrical flow in order for it to function correctly. Therefore, to test a component the resistance of the coil must be checked, usually at 20°C, using a good quality multi–meter between the two coil wires. A potentiometer is a variable resistor which is dependent on mechanical movement, i.e., clutch pedal movement, to vary the resistance of the component and therefore, alter the output voltage. To check the correct operation of a potentiometer, the resistance should be measured at the minimum and maximum positions and the rise from the minimum to maximum must be smooth and gradual. Further to checking the resistance value, all components should also be checked for a short circuit between the component coil and the component's outer casing by connecting a multi–meter between the component terminals and its casing.



Resistance Testing of Component

1. Solenoid Coil
2. Multi–Meter



Testing for Short Circuit of Component

A Zero Ohms indicating Short Circuit
B Infinity Ohms, No Short Circuit indicated

Component Test Specifications:

Component	Nominal Resistance at 20°C
S1 (C1/C2 Selector Solenoid)	6Ω
S2 (C3/C4 Selector Solenoid)	6Ω
S3 (Dump Solenoid)	6Ω
S4 (FWD Solenoid)	10.5Ω
S5 (Creep Solenoid)	10Ω
S6 (PWM Valve Solenoid)	2.4Ω
Transmission Speed Sensor	2.5kΩ
Clutch Potentiometer	3.1KΩ – 3.9kΩ Pedal Up / 640Ω – 2.1kΩ Pedal Down, between Green and Black Wires

Hydraulic Accumulator

The hydraulic accumulator is a very reliable component requiring no maintenance or servicing. Where an accumulator is suspected of being faulty the following procedure will quickly determine if the unit is charged and therefore, functioning.

1. Apply the handbrake and disconnect the battery to ensure the engine cannot be started.

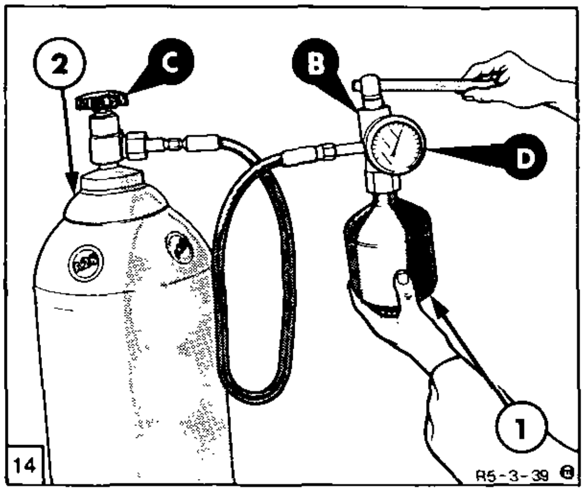
2. Position an oil drain tray under the accumulator to catch some residual oil in the pipes and remove the accumulator from the tractor. **NOTE:** *There will be no hydraulic oil pressure when the engine is not running, but a couple of minutes should be allowed after stopping the engine to allow the oil to depressurise.*

3. Using a rod of approximately 10 mm diameter with an end rounded off, insert into the accumulator onto the metal button. Use reasonable hand pressure to attempt to push the button down. An accumulator which is fully charged will not readily push down. If the button is easy to push down the accumulator has lost its charge.

4. Unless an accumulator has been tampered with, the usual reason for loss of charge will be due to failure of the diaphragm within the accumulator. The diaphragm is not a replaceable item and a new accumulator assembly will be required if this is the case.

A re–charging and testing kit is available by ordering through authorised 'Bosch' distributors. The kit, 'Bosch' reference number 0538–103–012, consists of a pressure gauge, hose with adaptor and filling and testing valves.

With reference to Figure 14, use the following procedure to test or re–charge a suspect accumulator.



Accumulator Testing and Re–Charging

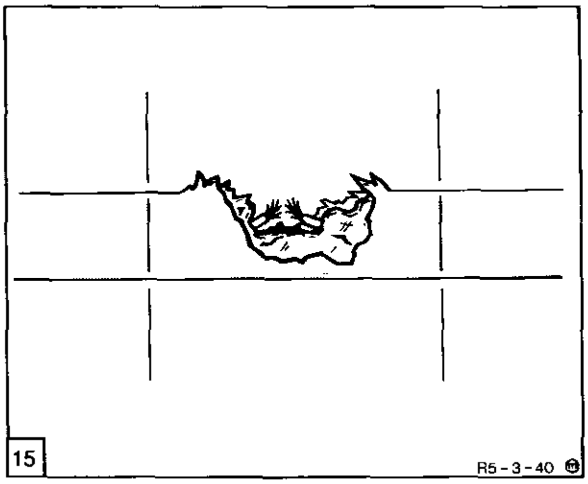
1. Accumulator
2. Nitrogen Bottle

In addition to the Bosch test kit, a bottle of nitrogen gas will be required which should be obtained from a local supplier.

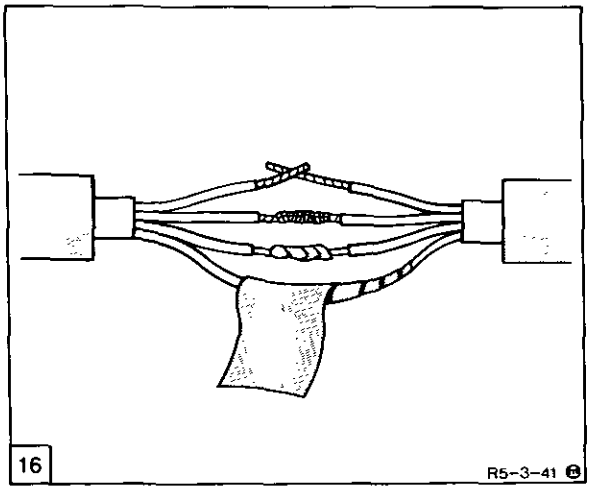
1. Remove the accumulator from the tractor as previously described.
2. Initially loosen the hexagon headed set screw of the accumulator just enough to break the film of the sealant used on the screw.
3. Connect the test kit to the accumulator and nitrogen bottle as shown in Figure 14.
4. Open valve 'B' and read the pressure registered on the gauge. If necessary, add nitrogen by gradually opening valve 'C' until the correct pressure, 10 bar (145 $lbf.in^2$) is obtained.
5. If necessary, bleed any excess pressure through valve 'D', valve 'C' closed. When the pressure is correct observe the gauge to see if the unit is loosing pressure, if so, it will need replacing.
6. Ensure that valves 'B' and 'C' are closed, bleed off pressure in the tool through valve 'D' and disconnect the test kit from the accumulator and nitrogen bottle. Fully tighten the hexagonal set screw in the accumulator.

Temporary Wiring Harness Repair

The following method to repair wiring is a temporary expedient only. Wiring should be replaced as soon as possible. Replacement of temporary repaired cables with new is particularly important if the tractor is to be used for spraying as chemicals can enter the repaired area, travel up the cable and damage


15 R5-3-40

Damaged Cable


16 R5-3-41

Repair Leads

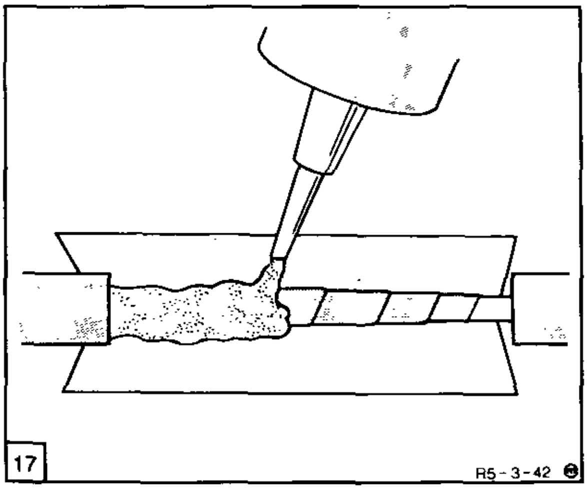
electrical components. Do not attempt to repair the wire on any system sensors as these are sealed and should only be replaced with a new component.

NOTE: *When conducting a cable repair it is important that only RESIN CORED SOLDER is used. Use of other types of solder may result in further cable damage.*

To carry out a temporary repair, proceed as follows:–

1. Locate damaged portion of cable then cut away outer protective cover on both sides of the damaged area, Figure 15.
2. Peel back the cable from both ends of the damaged area and carefully cut away the inner cable cover at the damaged area and strip about 1/2 inch (13 mm) of insulation from the wires. Do not cut away any wire strands.
3. Using a suitable solvent, clean about 2 inches (50 mm) from each cover end. Clean the grey cable cover and the individual leads.
4. Twist two bare leads together for each damaged lead, being careful to match wire colours, then solder the leads using resin cored solder. Tape each repaired lead with vinyl insulation tape, Figure 16.
5. Wind a layer of vinyl insulation tape up to the grey cable cover at each end of the repair section. Make a paper trough, Figure 17, then apply silicon rubber compound (non hardening sealant) over the repaired section up to the cover ends. Sufficient sealant must be used to fill the ends of the cut away area.
6. Allow the compound to cure then cover the area with insulating tape taking the tape well over each end of the repair. An overlap of at least 2 inches (50 mm) of tape at each end is necessary, Figure 18.
7. Check to ensure the repair is satisfactory and secure the repaired cable so that repeat damage is avoided.

NOTE: *This is a temporary repair only. Ensure the damaged cable is replaced as soon as possible to prevent ingress of water or chemicals.*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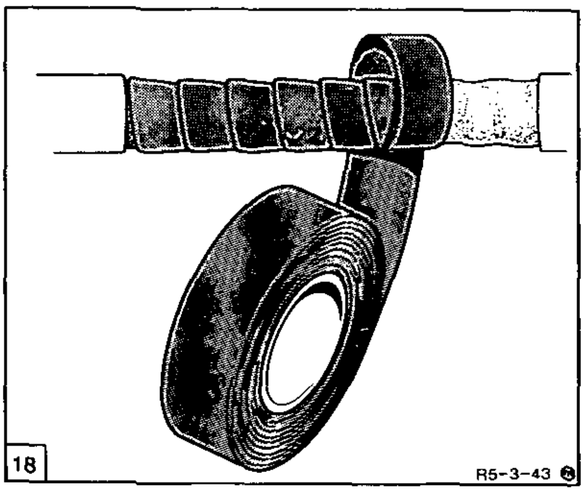
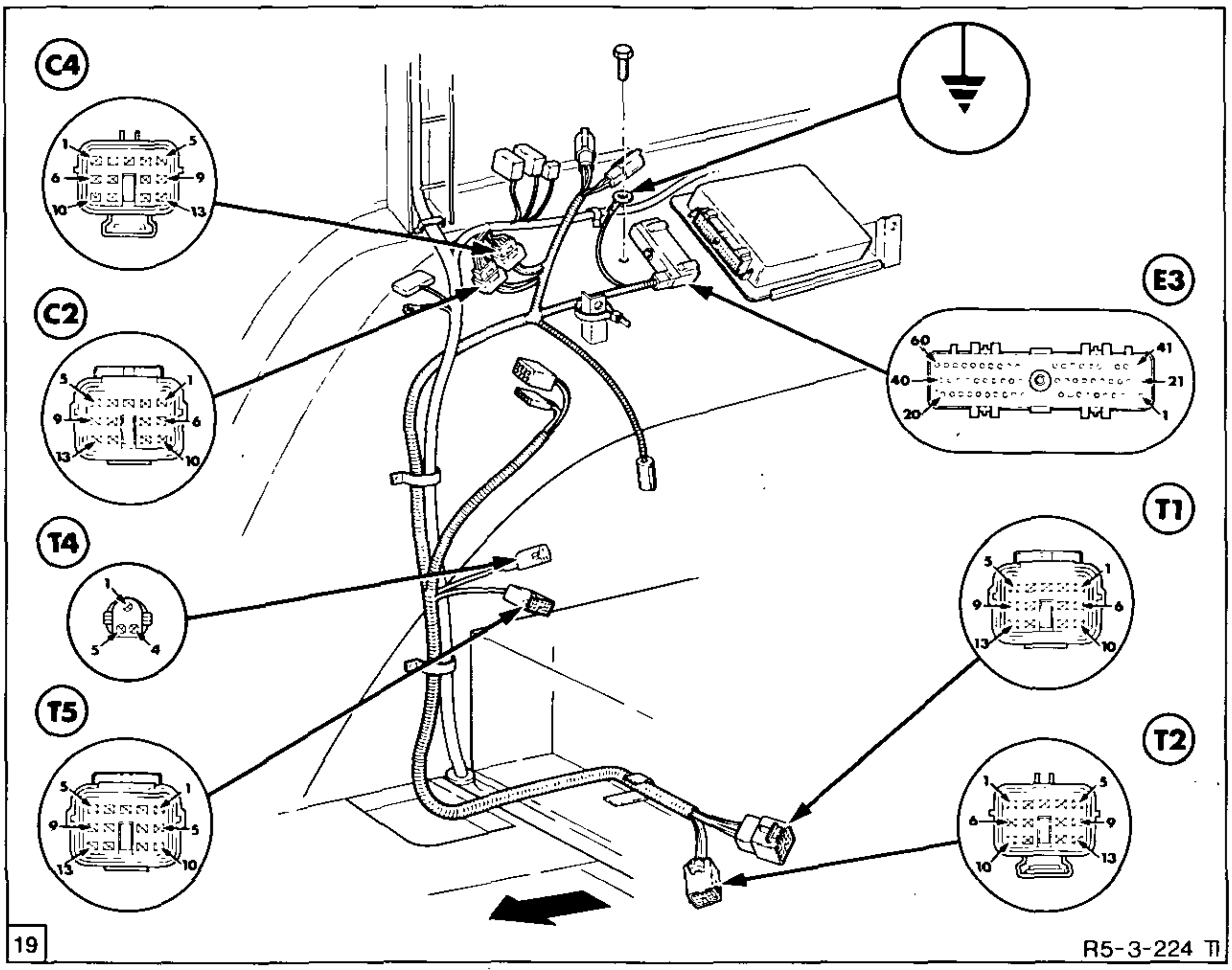
Apply Sealant


18 R5-3-43

Tape Over Repair

Shown in Figure 19, Figure 20 and Figure 21 are the 16 x 16 transmission harnesses with connector locations and connector pin identification. Use these illustrations in conjunction with the transmission wiring diagram at the end of this Section to aid fault finding of the transmission electrical system.



Arrow Denotes Front of Tractor
ETC (EEC IV) Harness 16 x 16 Transmission Connectors

E3 – ETC (EEC IV) Processor Connector

T4 – Gear Shift Connector

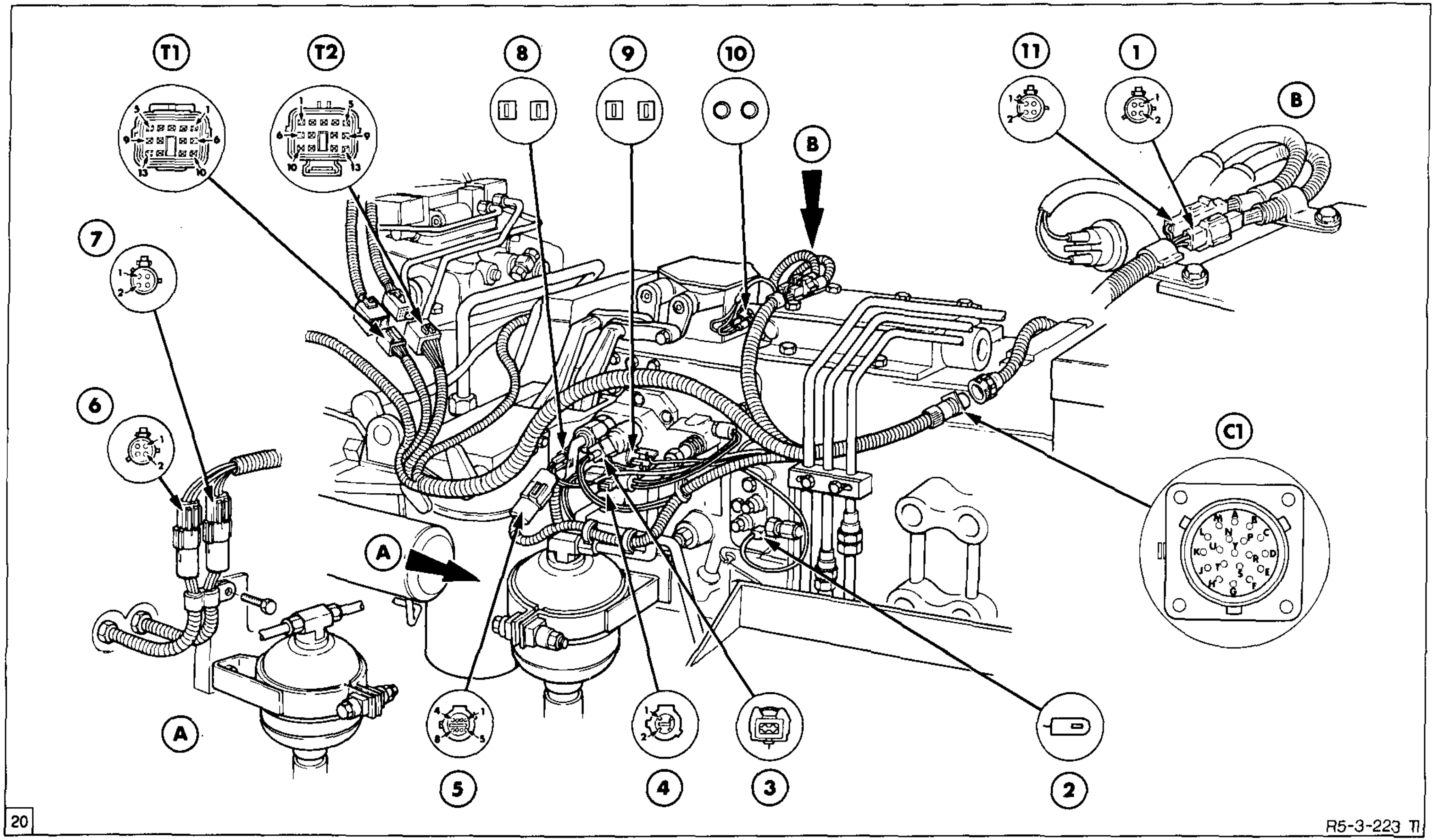
T1 – EDC Chassis Connector

C2 – Transmission/EDC Connector

T2 – ETC (EEC IV) Extension Harness Connector

C4 – Transmission/EDC Connector

T5 – Gear Shift Display Connector



16 x 16 Extension Harness Connectors

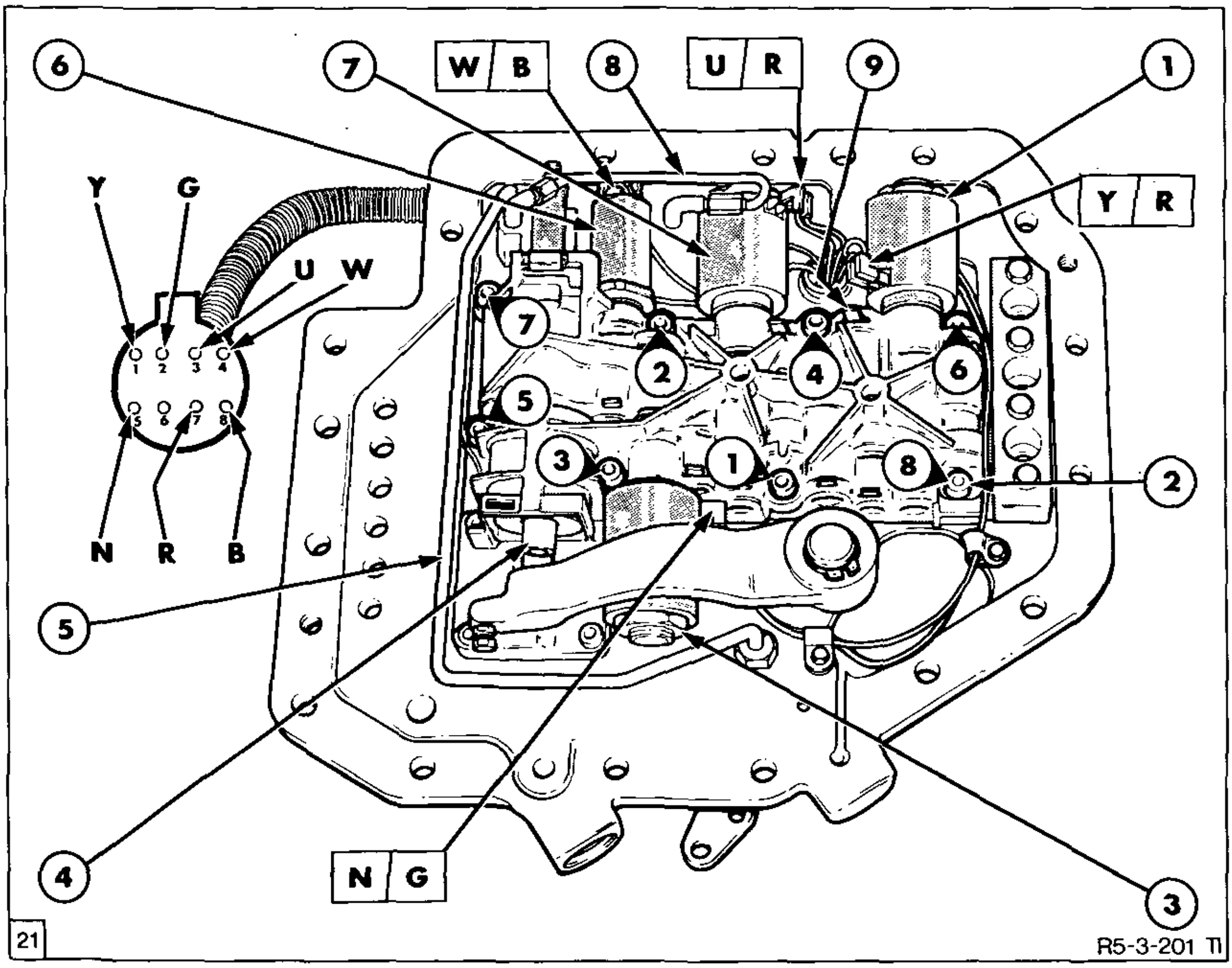
Figure 20 – 16 x 16 Extension Harness Connectors

1. 1–4 Range Switch Connector (Black)
2. Power Steering Pressure Switch Connector
3. PWM Valve Connector
4. Creeper Solenoid Connector (Black)
5. 8 Pin Transmission Connector (Grey)
6. High Range Switch (Black)
7. Low Range Switch (Grey)
8. C3/C4 Pressure (Brown/Blue/Black & Blue/Green/Black wires)
9. C1/C2 Pressure Switch (Red/Purple/Black & Blue/Light Green/Black wires)
10. Neutral Start Switch
11. 5–8 Range Switch Connector (Grey)

C1 – Extension Harness Connector

T1 – EDC Chassis Connector

T2 – ETC (EEC IV) Extension Harness Connector



Control Valve Solenoids and Wiring

1. S2 Solenoid, C3/C4 Clutch Selector
2. Valve Body Retaining Bolt
3. S3 Solenoid, Neutral Dump Valve
4. Feathering Valve Mechanical Actuating Piston
5. Creeper Interlock Feed Tube
6. S4 Solenoid, FWD Valve
7. S1 Solenoid, C1/C2 Clutch Selector
8. PWM Solenoid to Feathering Valve Tube
9. Valve Body

Wire Colours

B = Black

G = Green

N = Brown

R = Red

U = Blue

W = White

Y = Yellow

Key to Wiring Diagram

Fuses

F.S. 20 – Fuse 20, 5 Amp
F.S. 15 – Fuse 15, 15 Amp
F.S. 13 – Fuse 13, 15 Amp
F.S. 12 – Fuse 12, 10 Amp
F.S. 3 – Fuse 3, 10 Amp

Connectors

T1 – EDC Chassis Connector
T2 – ETC (EEC IV) Extension Harness Connector
T4 – Gear Shift Connector
T5 – Gear Shift Display Connector

C1 – Extension Harness Connector
C2 – Transmission/EDC Connector
C4 – Transmission/EDC Connector

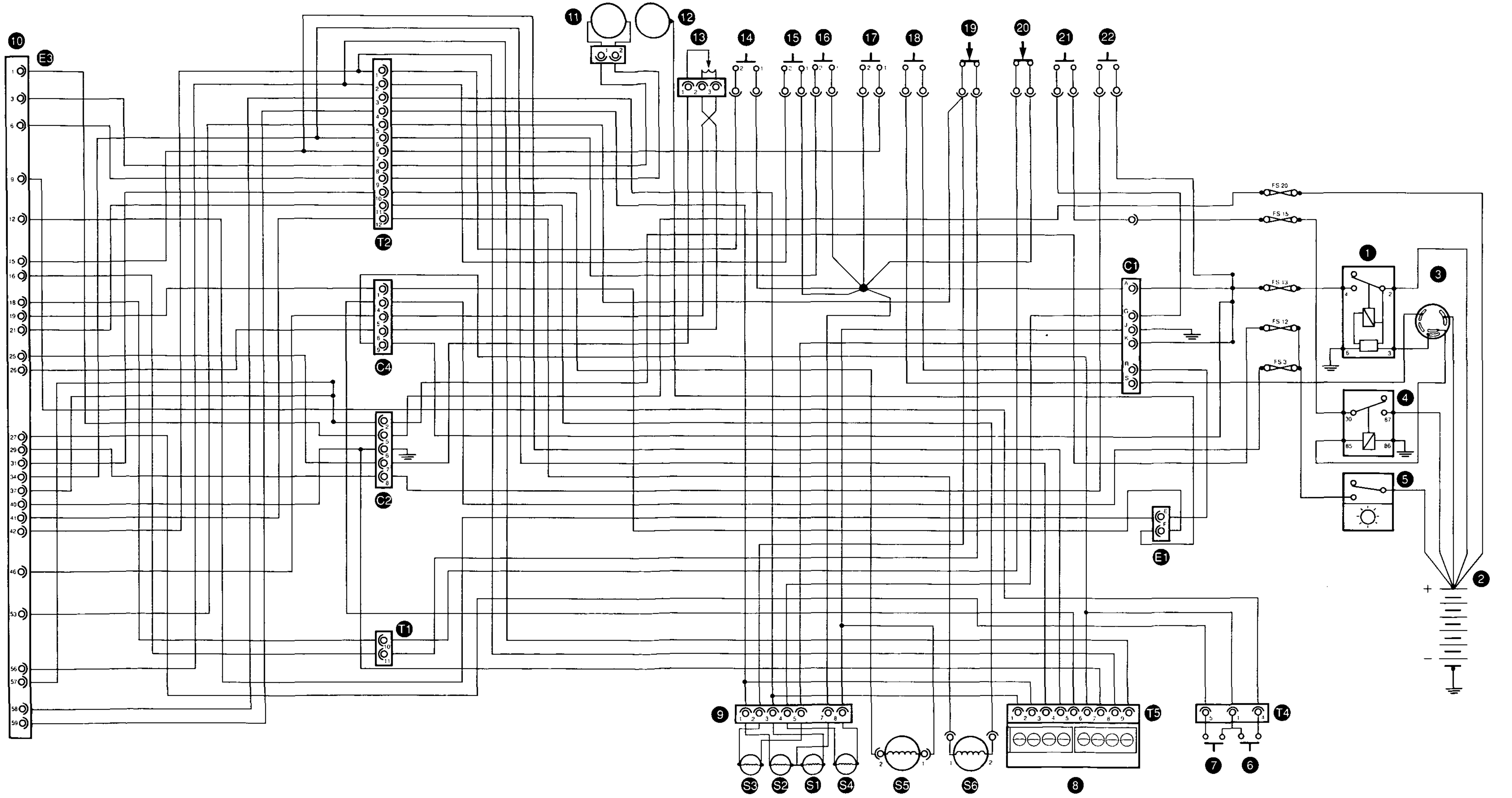
E1 – Engine Harness Connector
E3 – ETC Processor Connector

Solenoids

S1 – C1/C2 Selector Valve Solenoid
S2 – C3/C4 Selector Valve Solenoid
S3 – Dump Valve Solenoid
S4 – FWD Valve Solenoid
S5 – Creeper Valve Solenoid
S6 – PWM Valve Solenoid

Electrical Components

1. Power Delay (IX) Relay
2. Tractor Battery
3. Keystart Switch
4. Relay I, FWD
5. Main Light Switch
6. Down Shift Switch
7. Up Shift Switch
8. Gear Shift Display Module
9. Transmission Grey Connector
10. ETC (EEC IV) Module
11. Transmission Speed Sensor
12. Alternator
13. Clutch Potentiometer
14. High Range Switch
15. Low Range Switch
16. 1–4 Switch
17. 5–8 Switch
18. Neutral Switch
19. C3/C4 Pressure Switch
20. C1/C2 Pressure Switch
21. FWD Switch
22. Creeper Switch

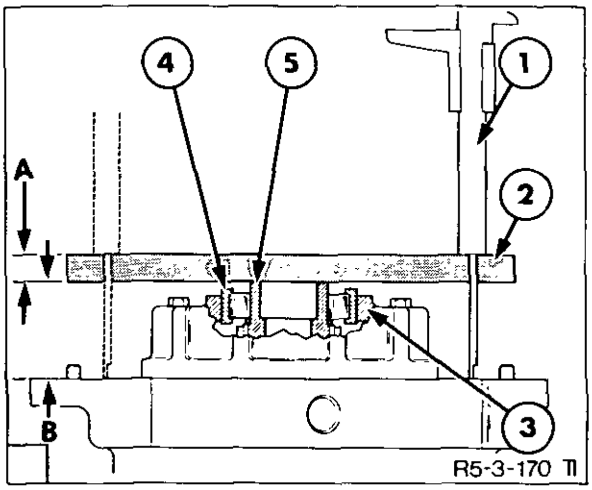


G. SPECIFICATIONS AND SPECIAL TOOLS

Transmission Type	16 forward and 16 reverse speeds using straight cut gears, four multi–plate wet powershift clutches, one foreward reverse friction plate synchroniser and one main range friction cone synchroniser
Control System	Electro–hydraulic with electronic management System
Clutch Hydraulic Operating Pressure	17–19 bar (250–280 lbf.in²) supplied from the CCLS Hydraulic PistonPump
Hydraulic Control Valve	
Type	Seperate Casting, multi spool with internal cast–in galleries
Control	By electrically operated solenoid coils signalled by electronic management System
Hydraulic Accumulator	
Type	Diaphragm type, nitrogen charged with 0.7 litre hydraulic oil capacity
Charge Pressure	10 bar (145 lbf.in²)
Multi–Plate Wet Clutches	
Type	Constant running, pressure lubricated, pressure applied, spring released.
C1 and C2 clutches Number of Friction Plates	4 in each clutch
Number of Steel Plates	4 in each clutch
C3 and C4 clutches	
Number of Friction Plates	7 in each clutch
Number of Steel Plates	4 in each clutch
Number of steel Plates with seperator springs	3 in each clutch
Number of Bellville Washers	4 pairs in each clutch
Bellville washer stack height	24 mm
Forward/Reverse friction plate synchroniser	
Number of friction plates internal splined	5 each side
Number of steel plates external splines	4 each side
Pressure Lubrication	Maximum 7 bar (100 lbf.in²) supplied by the steering gear pump
Lubricant Capacity Transmission/Rear Axle	U.S. Gallons 16.0 Imp. Gallons 13.3 Litres 60.6
Lubricant	ESN–M2C134–D
Lubricant operating temperature	65°C (150°F)

Output Shaft Component End Float	0.004–0.012 in	(0.10–0.30 mm)
Output Shaft 'D' Shaped Shim Washer Sizes	0.079–0.080 in. 0.085–0.086 in. 0.091–0.092 in. 0.097–0.098 in. 0.102–0.104 in.	(2.00–2.04 mm) (2.15–2.19 mm) (2.30–2.34 mm) (2.45–2.49 mm) (2.60–2.64 mm)

C3 Clutch Output Shaft to Transmission Rear Buckle Up Face:



Calculated Distance 'B' (mm)	Washer Thickness Required (mm)
58.82–59.15	6.20–6.25
59.16–59.40	5.95–6.00
59.41–59.65	5.70–5.75
59.66–59.90	5.45–5.50
59.91–60.17	5.20–5.25
60.18–60.52	4.85–4.90

Synchroniser Wear Check

Main Synchroniser

Minimum Gap Between Friction and Outer Cone	0.032 in	0.8 mm
Foreward/Reverse Synchroniser Minimum Gap Between End Plate and Housing	0.048 in	1.20 mm
High–Low Range Synchroniser Minimum Gap Between	0.060 in	1.50 mm
Clutch 3 and 4 Piston Travel	0.10–0.12 in	2.50–3.05 mm
Clutch 3 and 4 Seperator Plate Thicknesses	0.089–0.091 in	2.26–2.3 mm
	0.109–0.114 in	2.76–2.8 mm
Foreward/Reverse and Range Synchroniser Support Shaft Running Clearance	0.016–0.024 in	0.40–0.60 mm

Forward/Reverse Synchroniser Support Front
Bearing Retainer Plate Shim Sizes:

F0NN–7Z478–AA	0.040 in	1.00 mm
F0NN–7Z478–BA	0.012 in	0.30 mm
F0NN–7Z478–CA	0.004 in	0.10 mm
F0NN–7Z478–DA	0.002 in	0.05 mm

Gear Ratios
30 Km/hr Transmission

Gear	Forward Range	Transmission Ratio
1	Creeper	43.20
2	Creeper	35.36
3	Creeper	28.91
4	Creeper	23.66
5	Creeper	18.30
6	Creeper	14.98
7	Creeper	12.24
8	Creeper	10.02
1	L	8.51
2	L	6.97
3	L	5.69
4	L	4.66
5	L	3.30
6	L	2.95
7	L	2.41
8	L	1.97
1	H	2.74
2	H	2.25
3	H	1.84
4	H	1.50
5	H	1.16
6	H	0.95
7	H	0.78
8	H	0.64

	Reverse	
1	Creeper	43.60
2	Creeper	35.68
3	Creeper	29.17
4	Creeper	23.88
5	Creeper	18.46
6	Creeper	15.11
7	Creeper	12.36
8	Creeper	10.11
1	L	8.59
2	L	7.03
3	L	5.75
4	L	4.70
5	L	3.64
6	L	2.98
7	L	2.43
8	L	1.99
1	H	2.77
2	H	2.27
3	H	1.85
4	H	1.52
5	H	1.17
6	H	0.96
7	H	0.78
8	H	0.64

40 Km/hr Transmission

Gear	Forward Range	Transmission Ratio
1	Creeper	43.42
2	Creeper	35.36
3	Creeper	29.06
4	Creeper	23.66
5	Creeper	18.39
6	Creeper	14.98
7	Creeper	12.31
8	Creeper	10.02
1	L	8.55
2	L	6.97
3	L	5.72
4	L	4.66
5	L	3.62
6	L	2.95
7	L	2.42
8	L	1.97
1	H	2.08
2	H	1.69
3	H	1.39
4	H	1.13
5	H	0.88
6	H	0.72
7	H	0.59
8	H	0.48

	Reverse	
1	Creeper	43.82
2	Creeper	35.68
3	Creeper	29.32
4	Creeper	23.88
5	Creeper	18.55
6	Creeper	15.11
7	Creeper	12.42
8	Creeper	10.11
1	L	8.63
2	L	7.03
3	L	5.78
4	L	4.70
5	L	3.66
6	L	2.98
7	L	2.45
8	L	1.99
1	H	2.10
2	H	1.71
3	H	1.40
4	H	1.14
5	H	0.89
6	H	0.72
7	H	0.59
8	H	0.48

Low Pressure Hydraulic Circuit Pressure Regulating Valve	250–280 lbf/in² (17–19 bar)
Low Transmission Oil Pressure Switch	Closes @ 210–220 lbf/in² (14.5–15.2 bar) transmission oil pressure warning light comes 'On' Opens @ 240–250 lbf/in² (16.5–17.2 bar) transmission oil pressure warning light goes 'Off'
Maximum Operating Pressure	Low pressure circuit safety valve operates 400–415 lbf.in² (27.6–28.6 bars)

THREAD SEALANT

Thread Sealant	Ford Specification ESE–M4G140–A (Loctite 542).
Gasket Sealant	Ford Specification ESE–M4G234–A1 (Loctite 515).

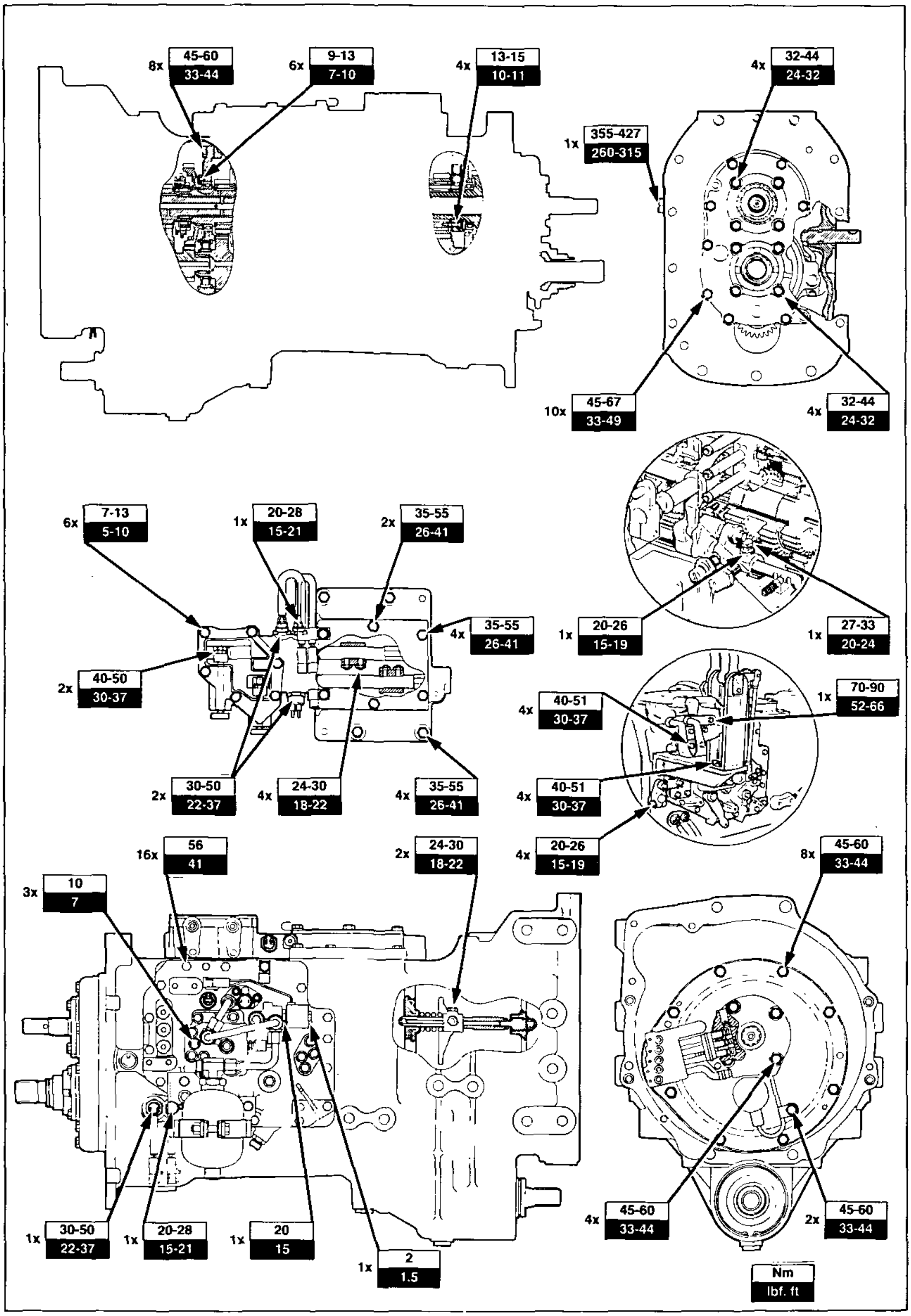
ELECTRICAL COMPONENT SPECIFICATIONS

Solenoids		Nominal Resistance at 20°C
S1 (C1/C2 Selector valve)		6Ω
S2 (C3/C4 Selector valve)		6Ω
S3 (Neutral/Dump valve)		6Ω
S4 (Four Wheel Drive valve)		10.5Ω
S5 (Creep valve)		10Ω
S6 (PWM Valve)		2.4Ω
Transmission Speed Sensor		2.5KΩ
Clutch Potentiometer		3100–3900Ω clutch pedal up 640–2100Ω clutch pedal down between green and black wires
C1/C2 and C3/C4 Pressure Switches Closing Pressure		160 lbf.in² (11 bar)
Transmission Fuses	Fuse 20	(5 Amp) – Keep Alive Memory Power
	Fuse 15	(15 Amp) – FWD Solenoid
	Fuse 13	(15 Amp) – Transmission Control
	Fuse 12	(10 Amp) – ETC +12V Supply
	Fuse 3	(10 Amp) – Gear Dynamic Display night light
Electrical Terminal/Component Cleaner		Freon T.F. base contact spray **(Do not use trichloro ethylene based cleaners)**

SPECIAL TOOLS

DESCRIPTION	TOOL NUMBER (V.L. Churchill Ltd.)	(FNH–A No.)
16 x 16 Transmission Overhaul Kit	4FT500	FNH–00865
Comprising of:–		
Handle (for use with resizer tool)	4FT501	FNH–00866
Tapered Sleeve, C3/C4 Piston Seal Expander	4FT502	FNH–00867
Tapered Sleeve, C1/C2 Piston Seal Expander	4FT503	FNH–00868
Piston Installer (Pusher)	4FT504	–
Tapered Sleeve C3/C4 Piston Seal Installer	4FT505	FNH–00869
Tapered Sleeve C1/C2 Piston Seal Installer	4FT506	FNH–00870
Seal Resizer C1/C2/C3/C4 Piston Seal	4FT507	FNH–00871
Clutch Piston Return Spring Compressor	4FT508	FNH–00872
FWD Transfer Tube Remover	4FT509	FNH–00873
Transmission Stand Bracket	4FT510	–
Gauge Rolled In Tube Replacement	4FT511	–
Gauge Rolled In Tube Expander	4FT512	–
Bypass Connector (Transmission Pressure Test)	4FT951	FNH–00875
Diagnostic Switch	4FT950	FNH–00874
Additional tools required not supplied in the above kit:		
Limp Home Harness	4FT952	–
Adaptor	Ford Part No 86298–S36	–
Slide Hammer	954C	–
Puller	951 or 9190	–
Pulling Attachment	1002 or 9198	–

Tightening Torque Values



PART 5
TRANSMISSION SYSTEMS
Chapter 2
12 x 12 SYNCHRO–SHIFT TRANSMISSION

A. DESCRIPTION AND OPERATION

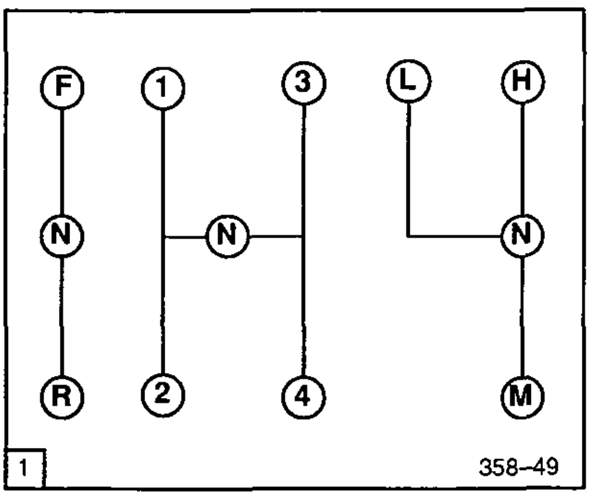
GENERAL

The 12x12 Synchro–Shift transmission provides twelve forward and twelve reverse speeds which are manually selected by three levers. The basic transmission can be specified with the following options:–

1. Four wheel drive (FWD) – consisting of an integral gear, clutch and output arrangement that provides an engageable coupling between the transmission and front axle. This four wheel drive output is available with two ratios to suit different tyre combinations. If two wheel drive is specified the output arrangement is deleted. Four wheel drive will automatically engage when both brakes are applied, providing 4 wheel braking.
2. 40 km/hr option may be specified in place of the standard 30 km/hr.

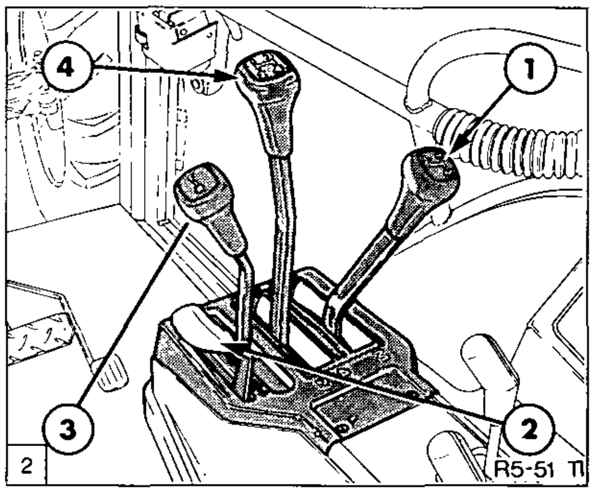
The transmission provides three selectable ranges. Within each of these ranges a further four ratios may be selected. This in effect provides a three times four (3x4=12) transmission resulting in 12 ratios. All shifts except down shifting into low range are synchronised.

The three shift levers shown in Figure 2, control the selection of the 12 forward and 12 reverse ratios. Figure 1 shows the gear shift lever pattern. The main shift lever, reference 4 Figure 2, operates in a conventional H–pattern and, in conjunction with the clutch pedal, is used to select any of four gear ratios, whether the tractor is stationary or moving. The range lever, reference 1, Figure 2, in conjunction with the clutch pedal, is used to select one of three ranges. The shuttle lever is used to select forward or reverse travel when any one of the twelve ratios is engaged, provided that the clutch pedal is depressed.



Gear Shift Pattern

F = Forward
N = Neutral
R = Reverse
L = Low Range
M = Medium Range
H = High Range



Transmission Levers

1. Range Lever
2. Hand Throttle Lever
3. Shuttle Lever
4. Main Shift Lever

NOTE: *An interlock mechanism prevents movement of the shuttle lever, unless the clutch pedal is depressed.*

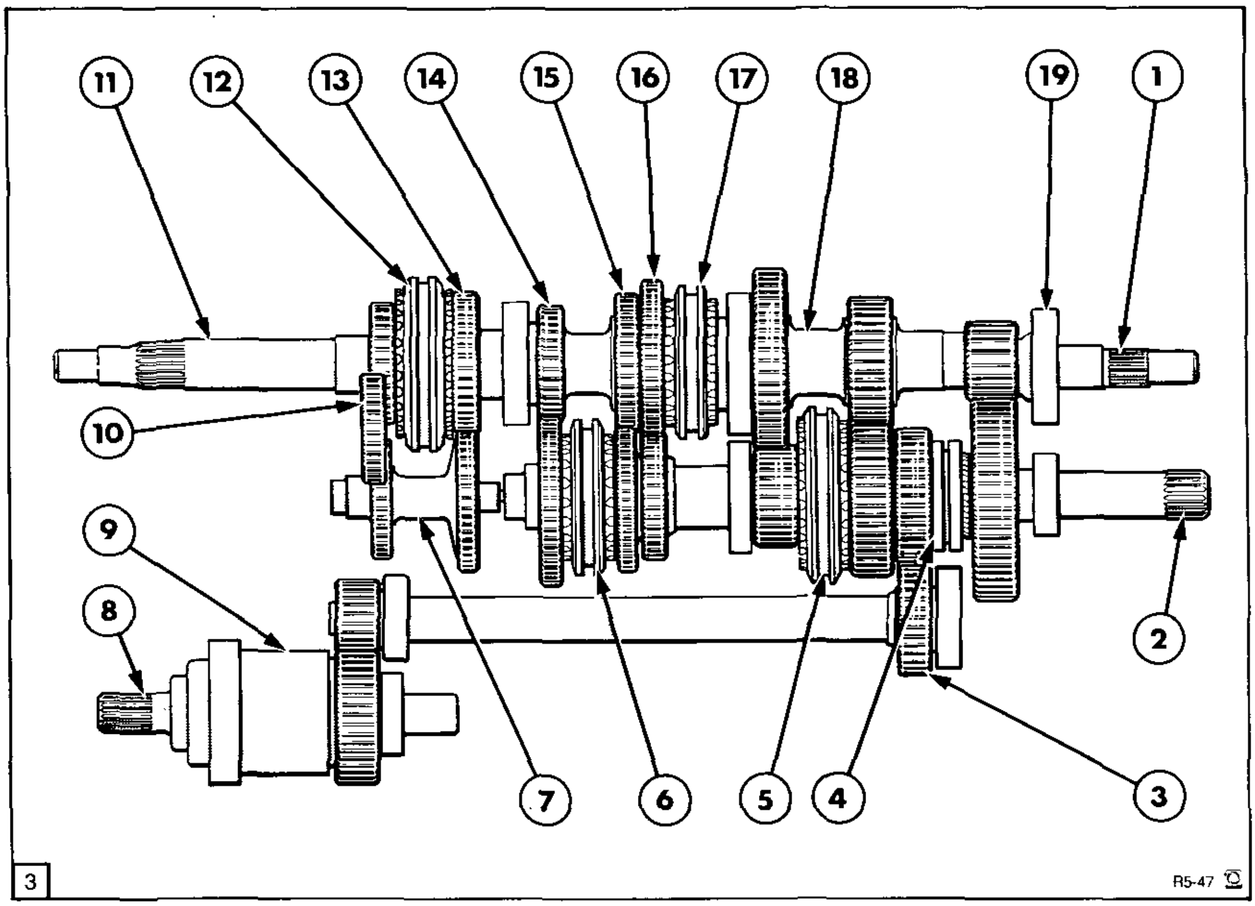
NOTE: *A neutral start switch prevents operation of the starting motor unless the shuttle (forward/reverse) lever is in neutral.*

Drive is transmitted from the engine to the transmission by a conventional solid centre dry plate clutch assembly.

IMPORTANT: *If it is necessary to tow the tractor, the range lever **must** be in the neutral position, otherwise damage to transmission components may occur.*

It is permissible to tow start the tractor.

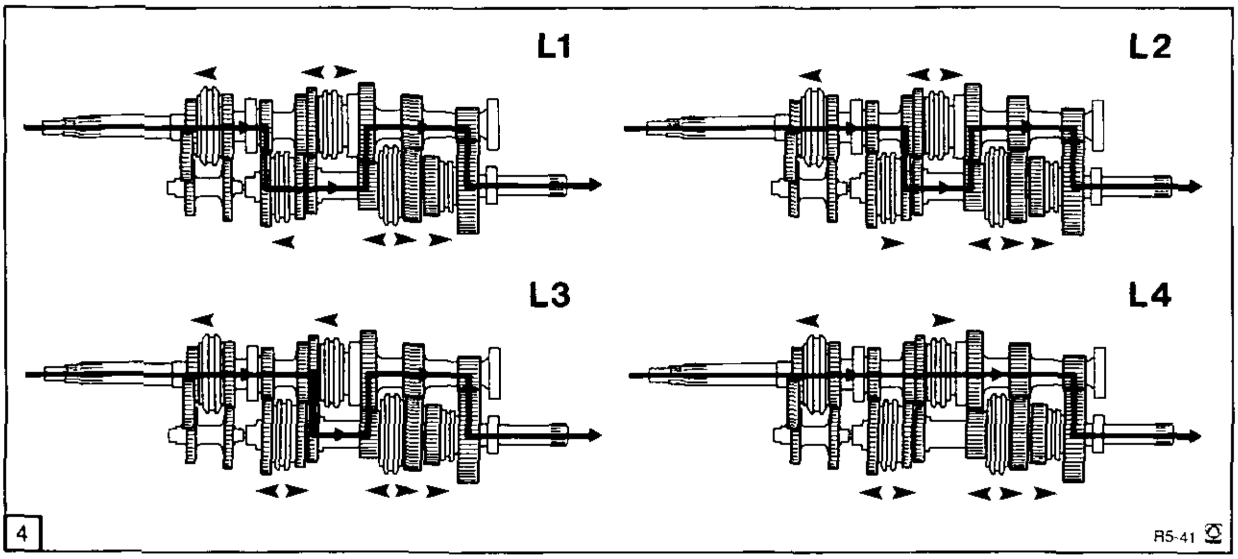
Oil supplied from the power steering motor, via the PTO valve and oil cooler, provides pressure lubrication for the synchronisers, bearings and output shaft. The transmission shares a common oil reservoir with the rear axle.



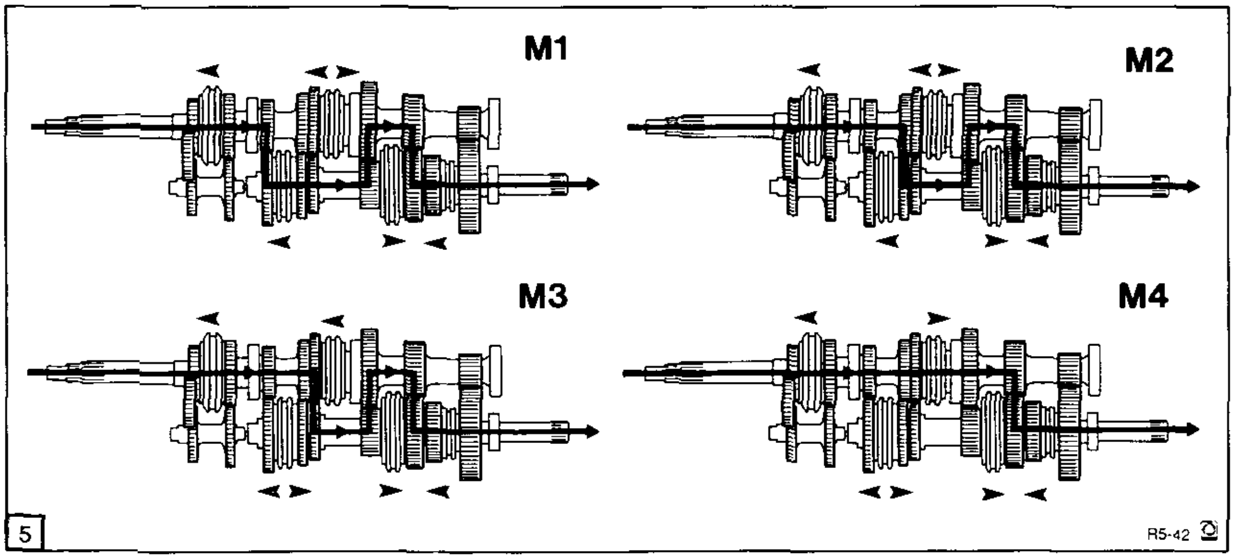
3

Transmission Assembly

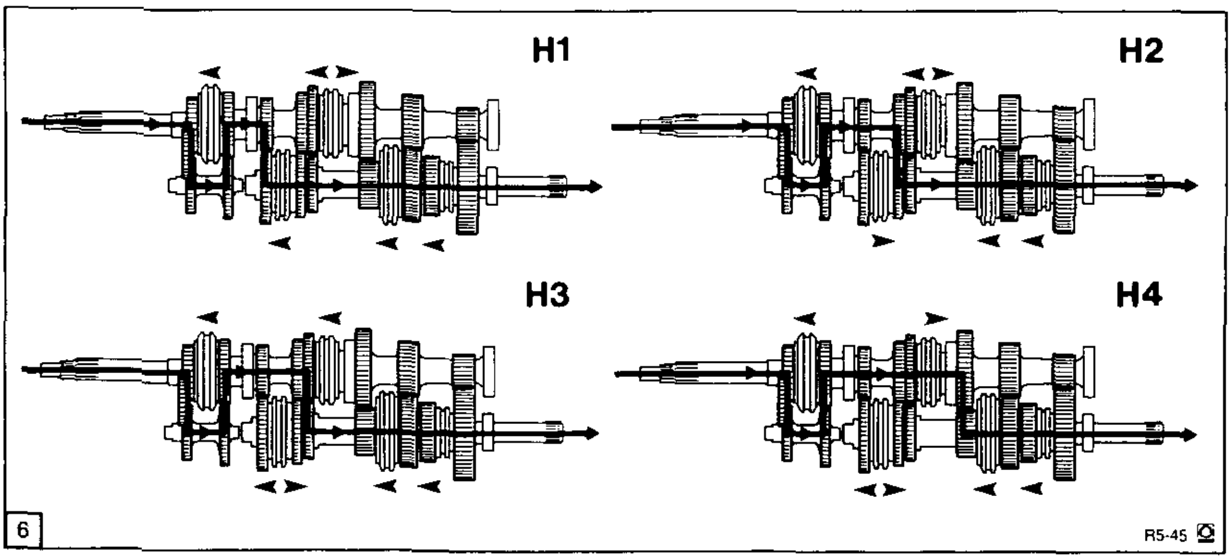
1. PTO Shaft
2. Output Shaft
3. Four Wheel Drive Front Axle Drive Shaft
4. Low Range Coupler
5. High and Medium Range Synchroniser
6. First/Second Gear Synchroniser
7. Reverse Gear Cluster
8. Four Wheel Drive Output Shaft
9. Four Wheel Drive Clutch
10. Reverse Gear Idler
11. Input Shaft
12. Forward/Reverse Synchroniser
13. Reverse Gear (free running on shaft)
14. 1st Ratio Gear
15. 2nd Ratio Gear (splined to shaft)
16. 3rd Ratio Gear (free running on shaft)
17. Third/Fourth Gear Synchroniser
18. Range Cluster Gear
19. Range Cluster Shaft Bearing



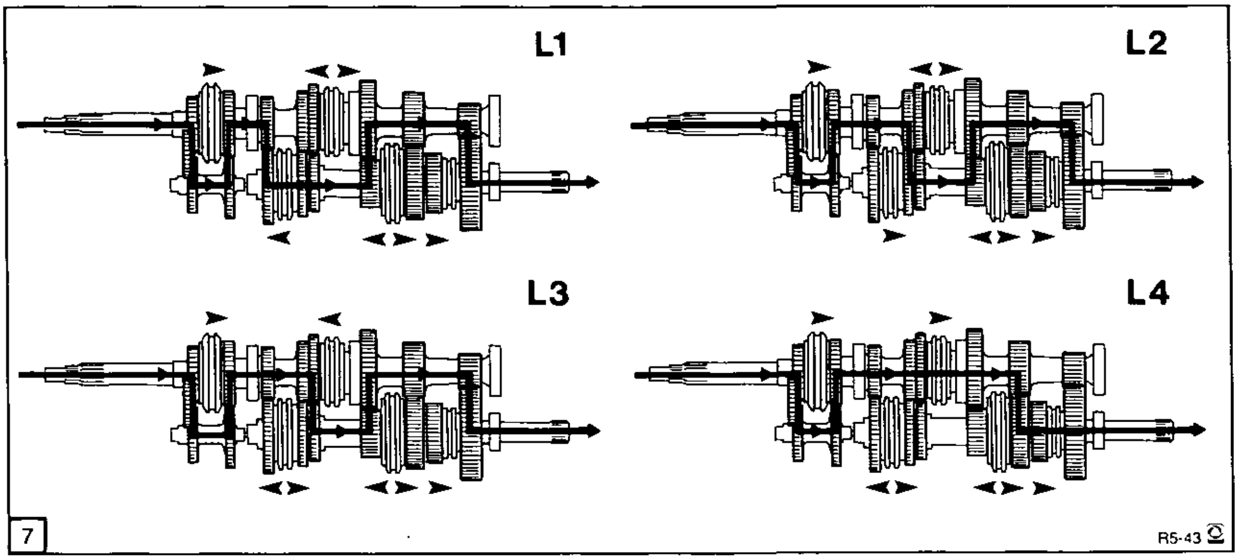
Power Flows Forward Low Range



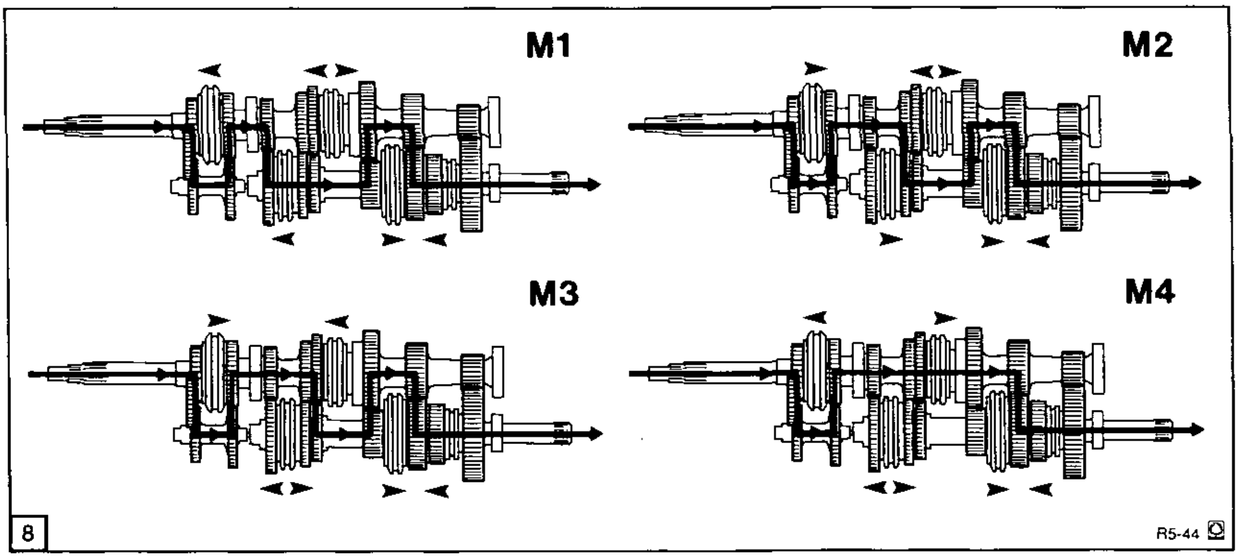
Power Flows Forward Medium Range



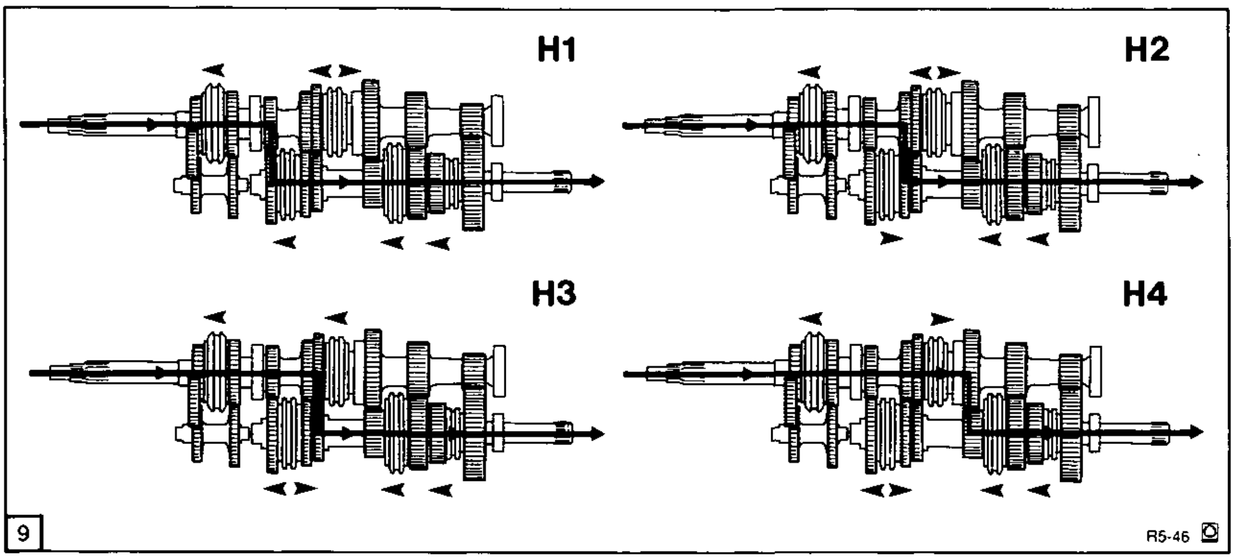
Power Flows Forward High Range



Power Flows Reverse Low Range



Power Flows Reverse Medium Range



Power Flows Reverse High Range

B. FAULT FINDING

GENERAL

The most important factor to consider in transmission system fault finding is verification of the problem by observing the system operation. Therefore, if possible, operate the transmission and note the operating characteristics.

PROBLEM	POSSIBLE CAUSES	REMEDY
1. **Noisy Gearbox**	1. Low oil level	1. Adjust as required
	2. Incorrect oil grade	2. Determine oil grade, drain and refill as necessary
	3. Worn bearings **Note:** Check the pressure lubrication feed to the transmission. Part 8, Chapter 2.	3. End float of output shaft out of specification. Check and replace bearings as required, reset endfloat.
2. **Lubricant leak from split pin in transmission case bottom**	1. Engine crankshaft rear oil seal/housing gasket leakage	1. Replace rear seal/ gasket. Refer to Part 1 Engine System
	2. Worn or damaged input shaft oil seal, PTO drive shaft seal, transmission front plate gasket, reverse idler bolt seal leakage	2. Inspect and replace seals/gaskets as necessary
	3. Hydraulic release bearing seal leakage (reservoir level requires regular topping up)	3. Replace seals in release bearing assembly
3. **Difficult / failure to engage gears**	1. Incorrect linkage adjustment or worn linkage	1. Adjust linkage, replace worn parts as required
	2. Damaged linkage	2. Inspect, repair/replace as required
	3. Damaged/worn shift forks	3. Inspect shift forks and rails for wear and distortion. Replace as required.
	4. Worn synchronisers	4. Inspect synchroniser ring rubbing surfaces. Renew as required if worn

PROBLEM	POSSIBLE CAUSES	REMEDY
3. Difficult/failure to engage gears (continued)	5. Excessive output shaft end float – worn bearings 6. Incorrect clutch operation	5. Inspect bearings, replace as required. Reset end float 6. Air in hydraulic system, faulty clutch cover plate
4. Failure to change between forward and reverse	1. Clutch interlock adjustment incorrect or assembly inoperative	1. Check cable adjustment 2. Inspect cable and lever components.
5. Jumping out of gear	1. Gear not fully engaging 2. Detents in shift covers faulty 3. Worn synchroniser 4. Excessive output shaft end float (bearing wear)	1. Check linkage adjustment 2. Remove shift covers and inspect detent balls and springs 3. Inspect teeth of synchroniser assy. 4. Check bearings and reset end float to specification
6. Holding in gear	1. Worn sliding sleeve/ coupler 2. Locked linkage	1. Inspect and replace as required 2. Adjust linkage and replace worn parts as required.

C. INTRODUCTION TO OVERHAULING THE TRANSMISSION

GENERAL

The arrangements of the procedures in this section permit the servicing of the 12 x 12 Synchro–Shift transmission with the minimum of disassembly.

The procedures are separated into five groups, detailed below, listing the components serviceable in each group.

GROUP 1
Assemblies Serviced with Transmission Installed. Refer to Section D.

- Gearshift Covers, Including Levers, Forks and Mechanism.
- Neutral Start Switch.
- Four Wheel Drive Output Assembly and Solenoid.
- Clutch Interlock.

GROUP 2
Assemblies Serviced from Transmission Front End, Engine Removed. Refer to Section E.

- Release Bearing Assembly and Hydraulic Tubes
- Front Cover, including Seal and Reverse Idler.
- Input Shaft and bearing
- Forward/Reverse Synchroniser
- Reverse Cluster Gear

GROUP 3
Assemblies Serviced from Transmission Rear End, Rear Axle Removed. Refer to Section E.

- PTO shaft, Bearing and Seal
- High/Medium Range Synchroniser
- Low Range Coupler
- Range Cluster Gear and Bearing
- Output Shaft Assembly

GROUP 4
Assemblies Serviced with Transmission Removed from Tractor – Complete Overhaul. Refer to Section E.

- Mainshaft Assembly, Including 3rd/4th Synchroniser
- Countershaft Assembly, Including 1st/2nd Synchroniser
- Four Wheel Drive Shaft and Bearings

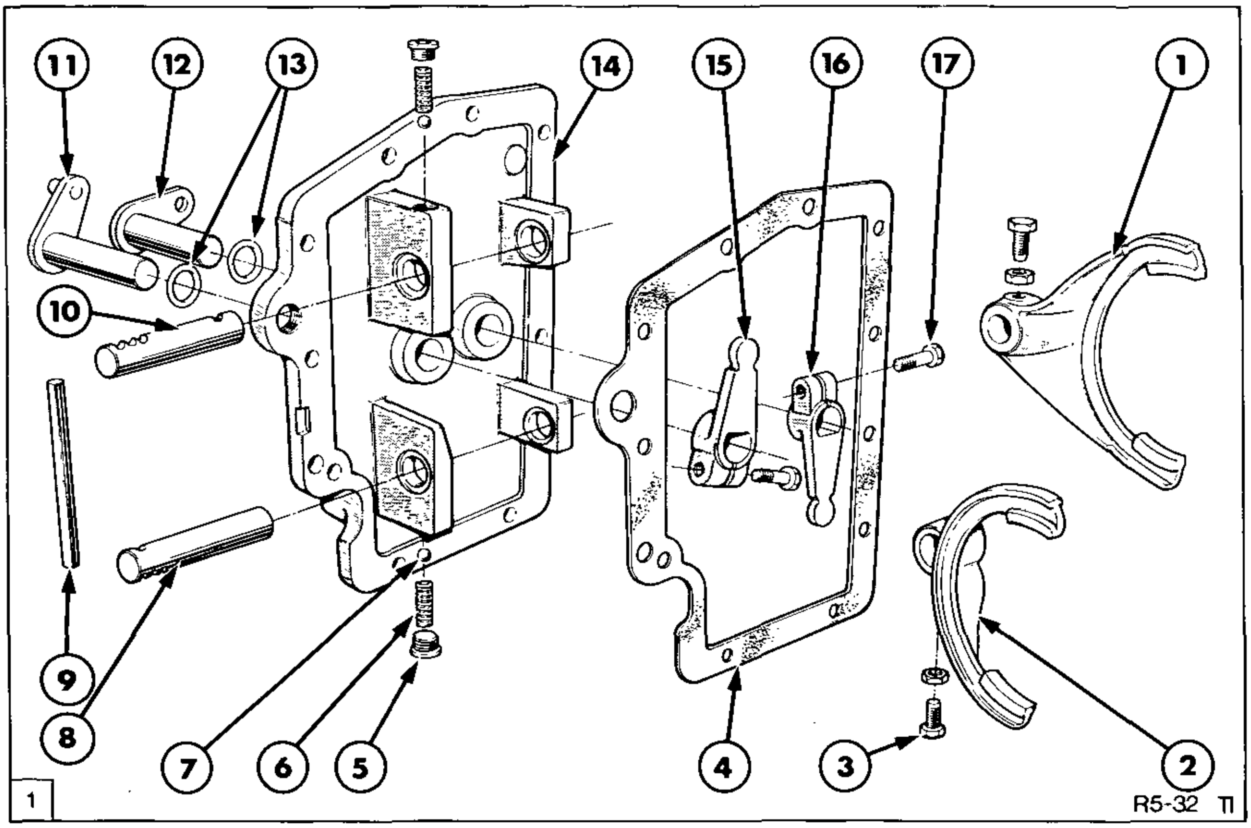
GROUP 5
Component Inspection and Repair (Sub–Assembly Overhaul). Refer to Section F.

When servicing the transmission always work in clean surroundings and with clean tools. Thoroughly clean the transmission case to prevent entry of dirt. Use lint free cloths when wiping parts or your hands. Lay cleaned parts out on clean paper so a thorough inspection can be made.

When installing the transmission components, do not use force. If parts do not assemble freely, examine them for the cause of difficulty and coat them with a film of clean petroleum jelly or transmission oil to facilitate assembly. Lubricate all shafts, bearings, oil seals and gears with a film of clean transmission oil before installing them into the transmission.

D. TRANSMISSION INSTALLED – SERVICEABLE COMPONENTS

Main Shift (Forward) Side Cover



Main Shift (Forward) Side Cover

1. 3rd/4th Synchroniser Fork
2. 1st/2nd Synchroniser Fork
3. Fork Locking Bolt
4. Cover Gasket
5. Detent Cap
6. Detent Spring
7. Detent Ball
8. 1st/2nd Synchroniser Fork Shaft
9. Interlock Pin
10. 3rd/4th Synchroniser Fork Shaft
11. 3rd/4th Shaft and Lever Assy.
12. 1st/2nd Shaft and Lever Assy.
13. Cover Oil Seals
14. Cover Body
15. 3rd/4th Shaft Lever
16. 1st/2nd Shaft Lever
17. Locking Bolt

Disassembly (Refer to Figure 1)

1. Remove the interlock cap, spring and ball and remove the pin.
2. Remove one of the lever locking bolts. Punch the lever shaft out of the cover and remove the lever.
3. Remove the corresponding fork locking bolt, slide out the shaft and remove the fork.
4. Repeat the above operations on the other fork assembly.

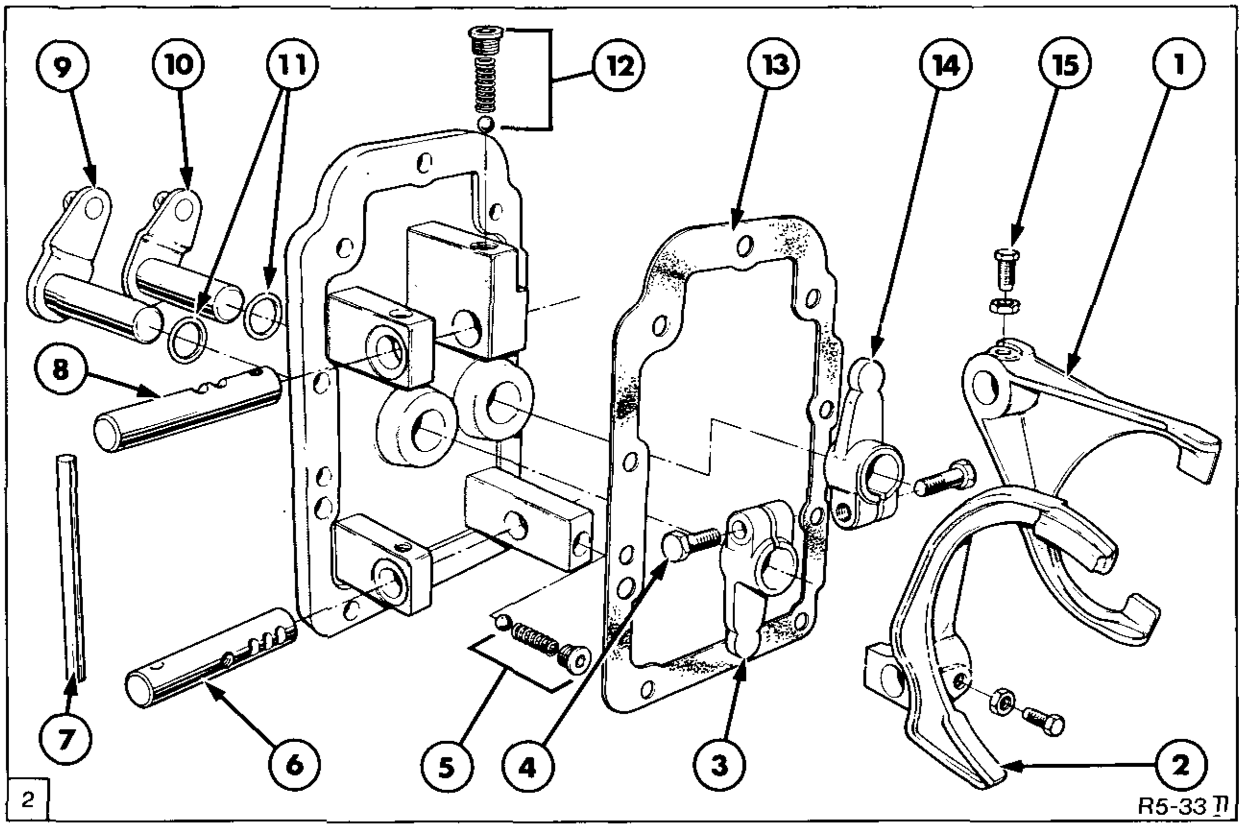
Inspection

1. Inspect and if necessary, install new seals into the cover bores, lubricate seals with grease.
2. Inspect fork ends, shafts and levers for wear and damage replacing components as required.

Assembly

1. Assembly of the cover is the reversal of the disassembly.

Range Shift (Rear) Side Cover



Range Shift (Rear) Side Cover

1. Low Range Coupler Fork
2. Hi/Med. Synchroniser Fork
3. Hi/Med. Shaft Lever
4. Lever Locking Bolt
5. Hi/Med. Detent Assembly
6. Hi/Med. Shaft
7. Interlock Pin
8. Low Range Coupler Shaft
9. Hi/Med. Shaft and Lever Assy
10. Low Coupler Shaft and Lever Assembly
11. Cover Oil Seals
12. Low Coupler Detent Assembly
13. Cover Gasket
14. Low Coupler Shaft Lever
15. Fork Locking Bolt

Disassembly (Refer to Figure 2)

1. Remove the detent plug, followed by the ball and spring for the low range fork, from the cover detent bore.

2. Remove the low range fork locking bolt. Slide out the rail and remove fork.

3. Remove interlock pin.

4. Remove the detent plug, ball and spring from the Hi–Med. fork cover detent bore.

5. Remove the locking bolt from the fork and slide out the rail. Remove the fork.

6. To remove the levers remove the locking bolts and punch the shafts out of the cover assembly. Remove levers from cover.

Inspection

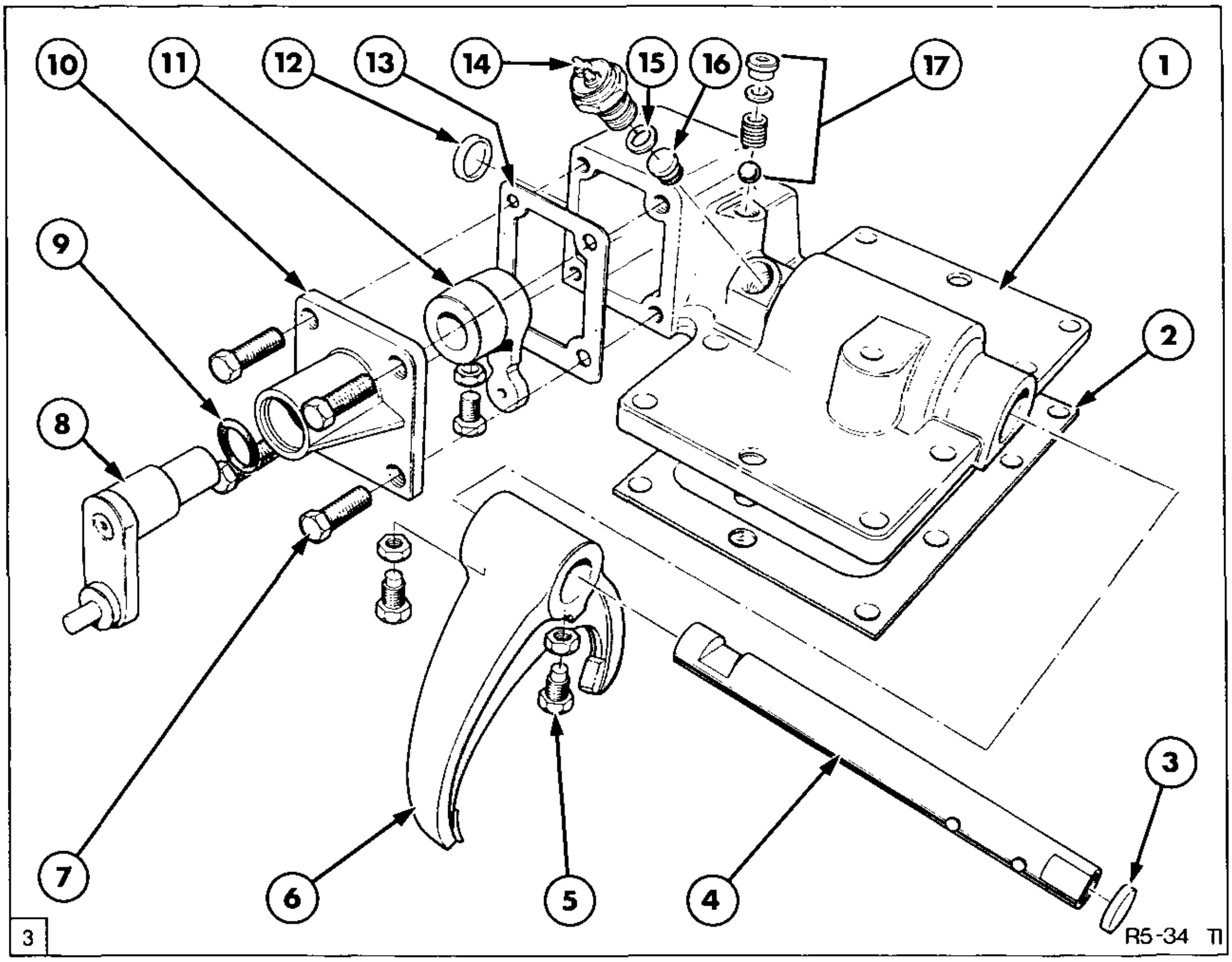
1. Inspect and if necessary install new seals into bores of cover assembly. Lubricate seals with grease.

2. Inspect fork ends, shafts and levers for wear and damage, replace components as required.

Assembly

1. Assembly of the cover is the reversal of the disassembly.

Top Cover



Top Cover

1. Top Cover Body
2. Gasket
3. End Plug
4. Fork Shaft
5. Fork Locking Bolt
6. Fork
7. Housing Retaining Bolt
8. Operating Shaft Assembly
9. Housing Seal
10. Operating Shaft/Lever Housing
11. Operating Lever
12. Cover Body End Plug
13. Housing Gasket
14. Neutral Start Switch
15. Seal
16. Plunger
17. Detent Assembly

Disassembly (Refer to Figure 3)

1. Remove the detent plug, followed by ball and spring.
2. Remove the neutral start switch and operating plunger.
3. Remove the housing cover assembly.
4. Remove the lever locking bolt and remove the lever from the shaft.
5. Using a suitable drift, punch the rail end plug into the housing of the cover.
6. Remove the fork locking bolts, and through the bore of the removed plug punch out the rail and remove the fork.

Inspection

1. Inspect the seals and replace where necessary.
2. Inspect the fork, levers and shaft for wear and damage, replace components as required.

Assembly

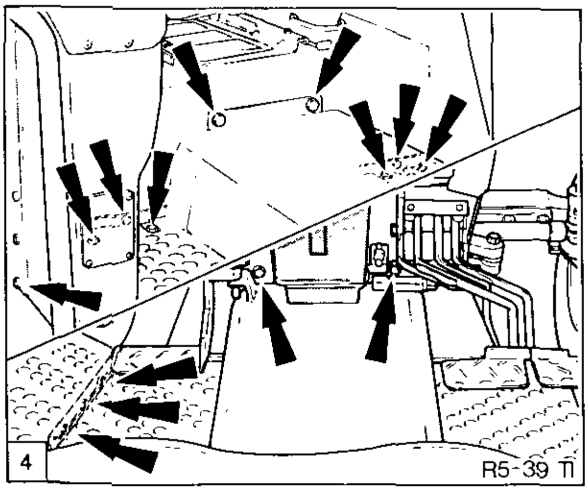
1. Assembly of the cover is the reversal of the disassembly.

Gear Shift Levers and Linkage

WARNING: *The bracket assembly is heavy. Either obtain assistance or use suitable lifting equipment to aid removal.*

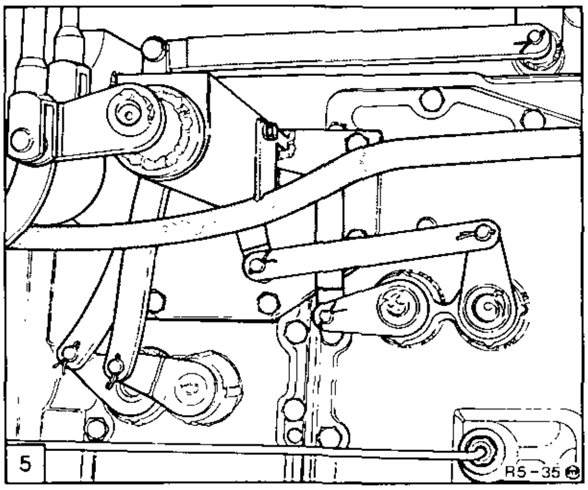
Removal – Less Cab

1. Remove the knobs from the levers.
2. Remove the shroud from around the top of the linkage.
3. Remove the locking screws from the main shift and range levers, tap out the lever pivot pins and remove the levers.
4. Remove the snap ring retaining the forward/reverse lever and remove lever.



Platform Securing Bolts

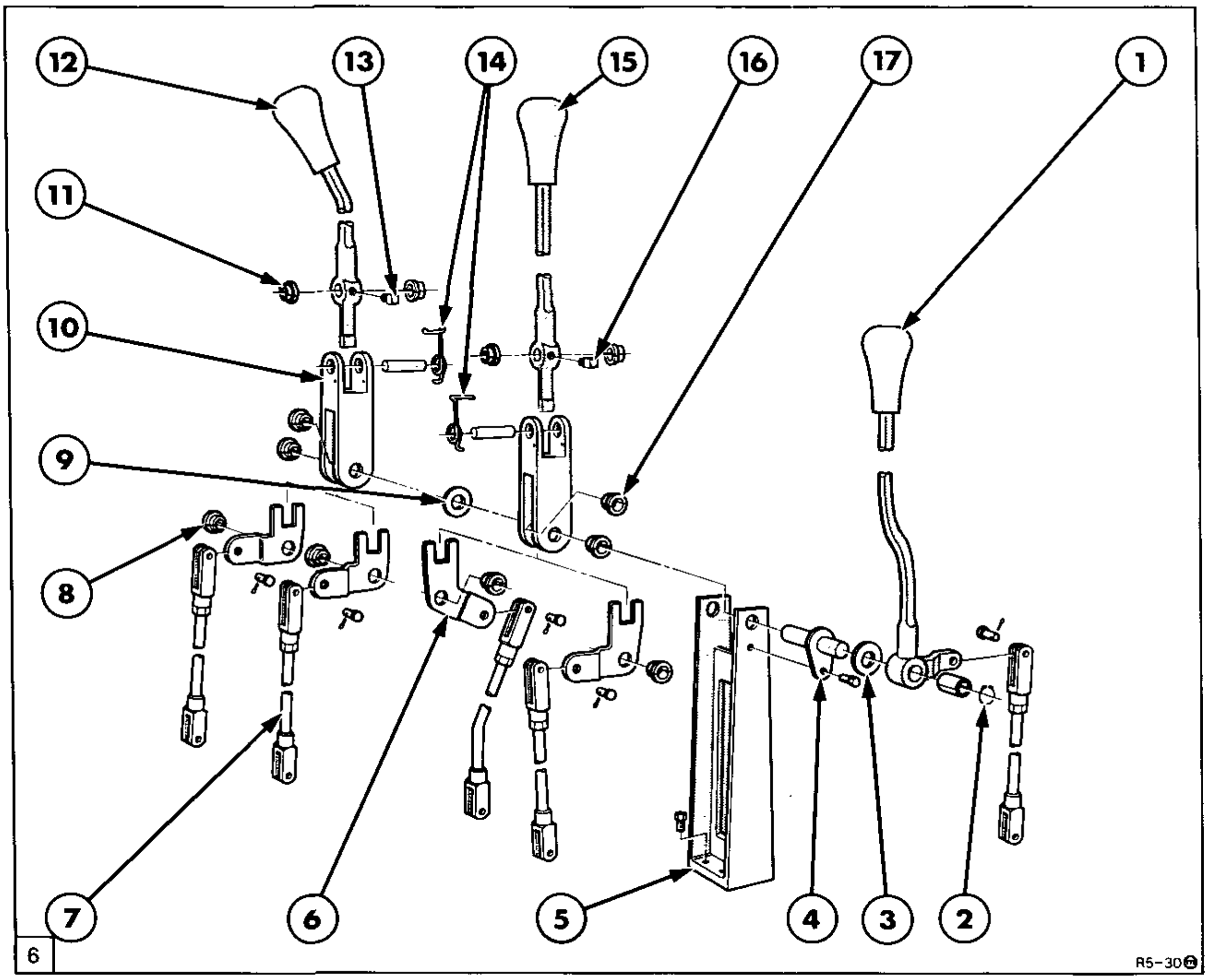
5. Disconnect the throttle pedal and remove the platform securing bolts, Figure 4 and slightly raise the platform.
6. Disconnect the links between the bracket assembly and the transmission.
7. Remove the metal casing carrying the wiring loom, from the linkage bracket and remove the five bolts securing the bracket assembly to the transmission casing, Figure 5. Carefully remove the assembly. It may be necessary to raise or lower the platform during the removal procedure.



Transmission Bracket and Retaining Bolts

Removal – With Cab

1. Remove the knobs from the levers.
2. Remove the shroud from around the top of the linkage.
3. Remove the locking bolts from the main shift and range levers and tap out the *lever pivot pins.*
4. Remove the protective rubber boot and disconnect the links between the bracket assembly and the transmission.
5. Remove the metal casing carrying the wiring loom, from the linkage bracket and *remove the five bolts securing the bracket* assembly to the transmission casing. Carefully remove the assembly.

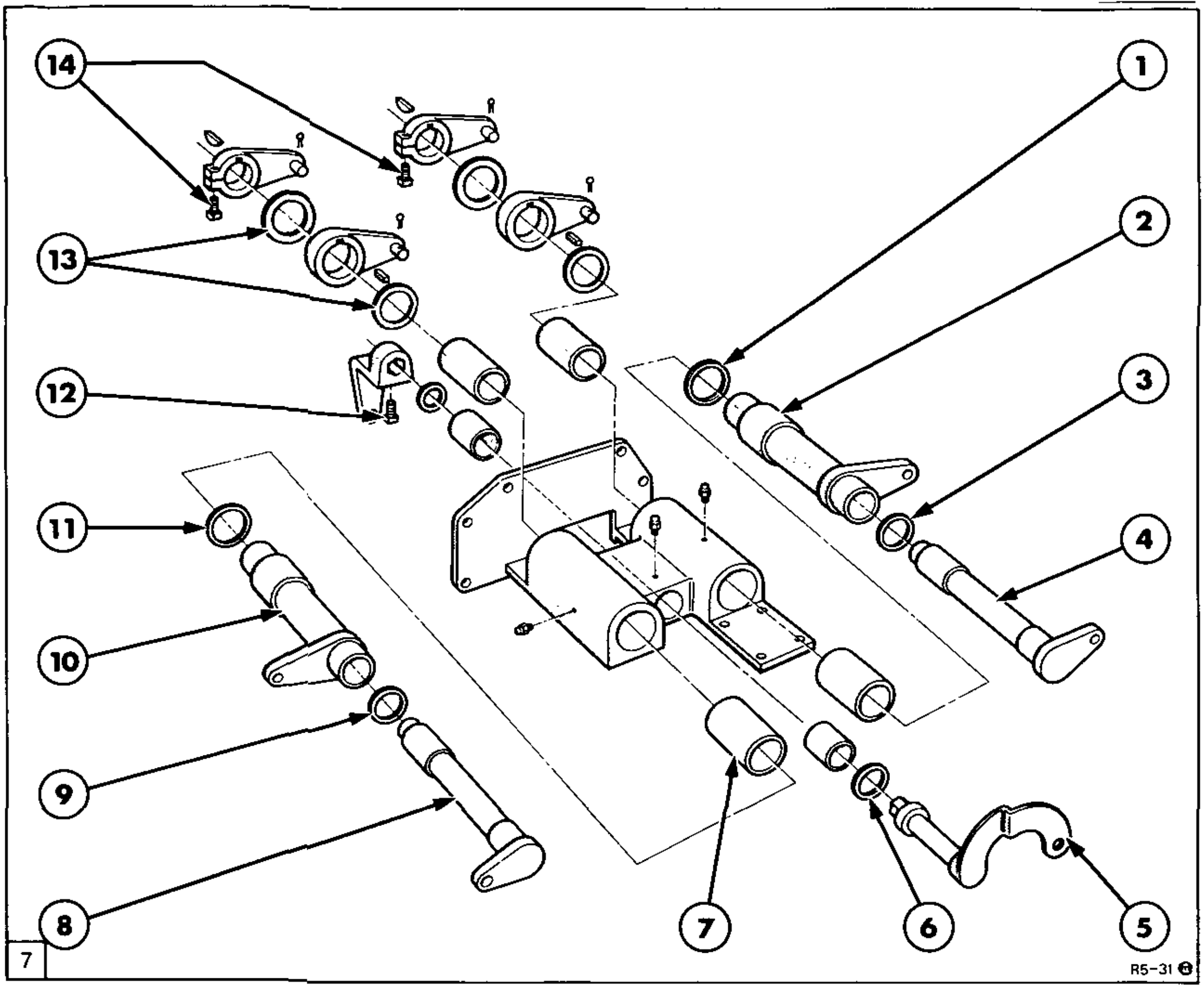


Gear Lever Linkage – Top End

1. Forward/Reverse Lever
2. Snap Ring
3. Nylon Washer
4. Pivot Bracket Shaft
5. Support Assembly
6. Operating arm
7. Operating Rod
8. Operating Arm Bush – 4 off
9. Nylon Washer
10. Pivot Bracket
11. Pivot Bracket Top Bush – 4 off
12. Range Lever
13. Locking Screw
14. Lever Return Spring
15. Main Shift Lever
16. Locking Screw
17. Pivot Bracket Lower Bushes – 4 off

Disassembly

1. Remove the rods located between the lower bracket assembly and the upper arms. Note their positions for re–assembly.
2. Remove the support assembly, reference 5, Figure 6, by removing the 4 securing bolts.
3. The operating arms and pivot bracket may be removed by withdrawing the shaft, reference 4, Figure 6, secured by a single bolt.
4. Removal of the bushes from the pivot bracket will allow the operating arms to be removed.



7

Gear Lever Linkage – Bracket Assembly
(Shown off the vehicle and upside down for clarity)

1. Nylon Washer
2. Outer Shaft (Hi–Med. Range)
3. Nylon Washer
4. Inner Shaft (Low Coupler)
5. Centre Shaft (Forward/Reverse)
6. Nylon Washer
7. Bushing
8. Inner Shaft (1st/2nd Ratio)
9. Nylon Washer
10. Outer Shaft (3rd/4th Ratio)
11. Nylon Washer
12. Locking Screw
13. Nylon Washer
14. Locking Screw

5. Remove locking screws reference 14, Figure 7.

6. Remove the shaft assemblies references 2 and 10, Figure 7.

7. Withdraw the inner shaft from the outer shaft.

8. Remove the locking screw reference 12, Figure 7, from the centre shaft operating arm and withdraw the shaft.

Inspection And Repair

1. Inspect the bushes, shafts and clevis pins, if wear is evident or there is excessive play between components, renew parts as necessary.

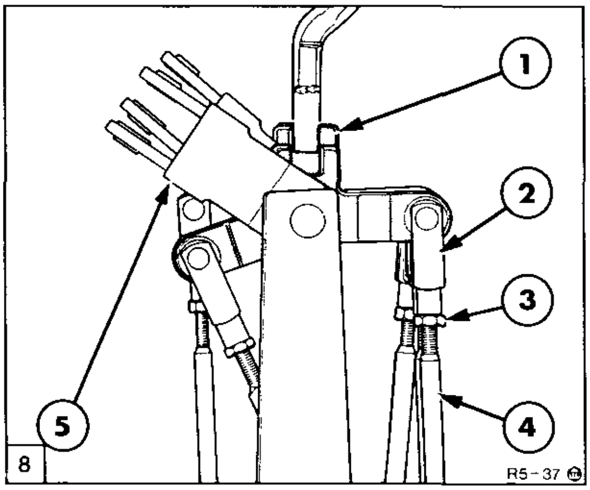
2. Ensure that the grease fittings and the bracket channels are free of blockages to allow correct lubrication.

Assembly

1. *Assemble using the reverse of the* disassembly procedure. Smear some grease onto the shafts and bushes as they are being assembled.

Installation

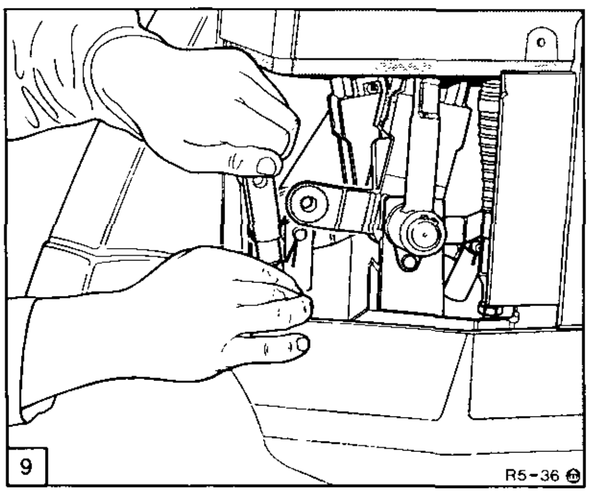
1. Replace the assembled bracket and linkage to the tractor, using the reverse of the removal procedure.



Operating Arm Alignment

1. Operating Arm Slots Aligned
2. Clevis
3. Locknut
4. Rod
5. Pivot Brackets moved for Clarity

2. It will be necessary after disassembly to check that the linkages are correctly adjusted. Linkage adjustment should be conducted with all transmission shift levers in neutral. Correct adjustment is when all the operating arms are in the vertical position and are perfectly aligned, Figure 8.

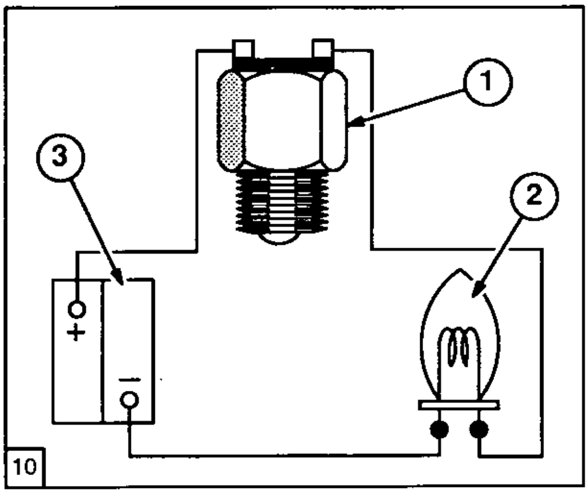


Rod Adjustment

3. To adjust, disconnect the relevant link from the transmission, this allows access to the clevis pin which must be removed to allow the clevis to be rotated, Figure 9.

4. Check operation of the levers after adjustment.

Neutral Start Switch Inspection



Switch Test

1. Switch
2. Lamp
3. Battery

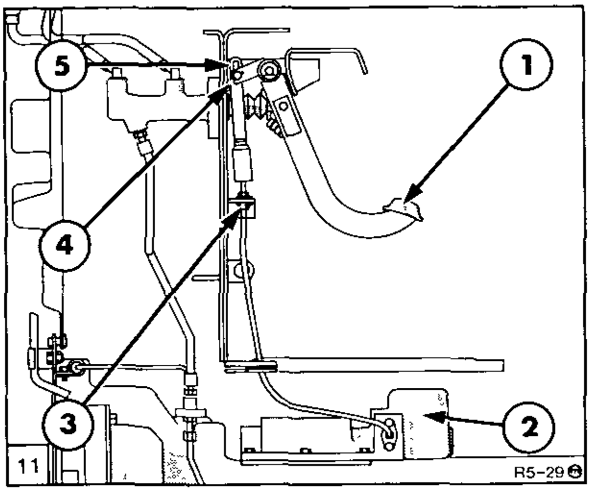
1. Inspect the conical ends of the switch plunger for nicks and burrs. If either of these cannot be removed by polishing, install a new plunger.

2. Check the switch operation by connecting to a suitable lamp and battery as shown in Figure 10.

3. Operating the switch should illuminate the lamp with the ball depressed and extinquish when released. Replace switch if operation is faulty.

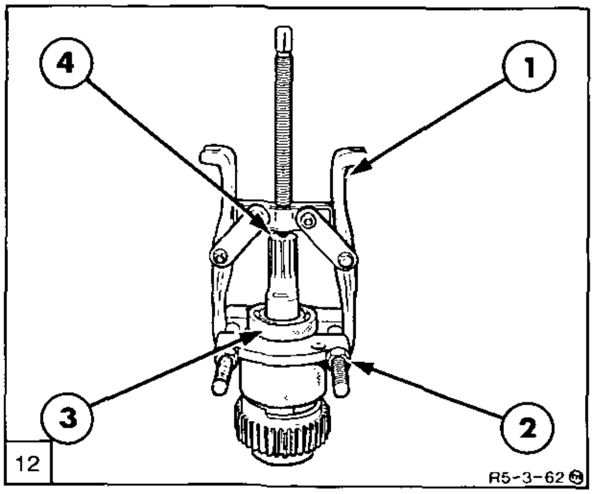
Clutch Interlock

An interlock mechanism is provided on the transmission top cover to prevent shifts between forward and reverse travel, unless the clutch pedal is depressed.



Clutch Interlock

1. *Clutch Pedal*
2. Top Cover
3. Adjusting Nuts
4. *Clutch Pedal Pin*
5. Cable End Slot



Removing FWD Output Assy Front Bearing

1. *Puller 951 or 9190*
2. Pulling Attachment 1002 or 9198
3. *Front Bearing*
4. Shaft Protector

The interlock mechanism consists of a control cable, which is connected at one end to the clutch pedal assembly and the other to the transmission top cover through a bore in the housing, Figure 11.

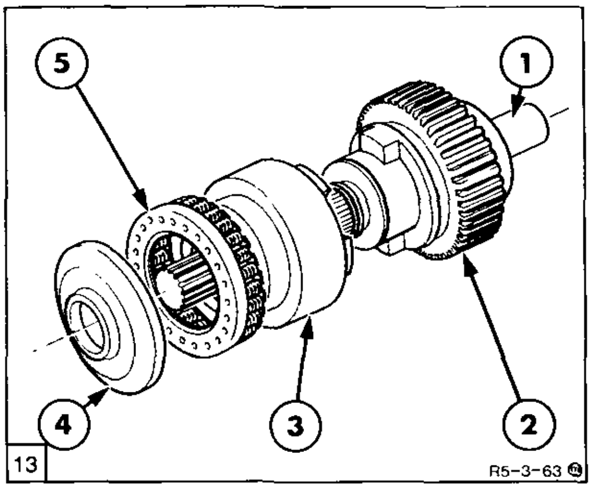
A plunger, connected to the control cable, engages with a slot in the forward/reverse rail to prevent rail movement. When the clutch pedal is depressed the plunger is moved free of the slot to allow shifting.

Adjustment

1. To ensure correct operation of the interlock, adjust the cable so that the pin in the clutch pedal lever contacts the upper end of the cable slot and provides 6–8mm of cable movement at the end of the pedal stroke.

Front Wheel Drive Output Assembly – Disassembly (Removal is described in Section E)

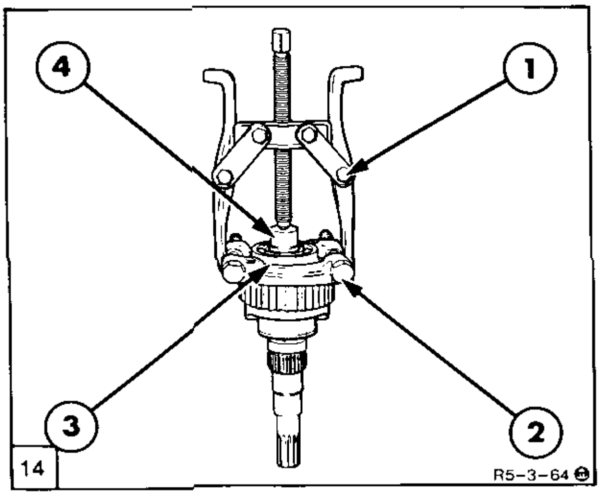
1. Remove the front cover plate by gently bumping the output shaft to free the front cover from the bearing.
2. Remove the front bearing snap ring, reference 7 in Figure 17, and using Tool numbers 951 or 9190 and 1002 or 9198 with a suitable shaft protector, pull off the front bearing, Figure 12.



Removing FWD Clutch Spring Keeper

1. Drive Shaft Assy.
2. Clutch Half
3. Sliding Front Clutch
4. Spring Keeper
5. Engagement Spring

3. Lift off the spring keeper and engagement spring assembly and slide the front half of the clutch from the shaft, Figure 13.



Removing FWD Output Assy Rear Bearing

1. Puller 951 or 9190
2. Pulling Attachment 1002 or 9198
3. Rear Bearing
4. Shaft Protector

4. Remove the rear bearing snap ring, reference 21 in Figure 17, and using Tool numbers 951 or 9190 and 1002 or 9198 with a suitable shaft protector pull off the rear bearing reference 3, Figure 14.

5. Remove the gear/rear half of the clutch and collect the two bearings, references 15 and 17 with the two spacer washers references 16 and 19 in the exploded view of the FWD transfer output shaft assembly shown in Figure 17.

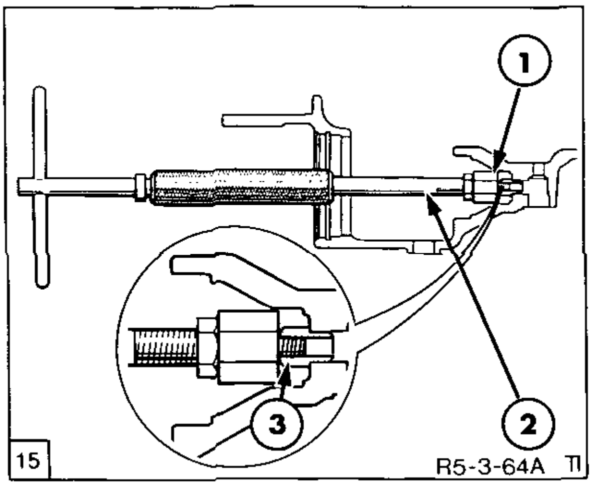
6. The oil transfer tube supplies pressure oil to the FWD clutch. This transfer tube is a tight fit in the transmission housing. It should be removed and the polyamide thrust seal renewed. Remove the tube by threading an M10–1.5 bolt into the centre of the tube and using a conventional slide hammer and suitable adapter, withdraw the tube, Figure 15. Alternatively use Tool No. 4FT 509 with slide hammer, part of Tool No. 954C.

Front Wheel Drive Output Assembly – Inspection

Use the sectional view in Figure 18 to aid component identification.

1. Inspect all snap rings and their grooves for deformation and damage.

2. Inspect the internal drive shaft gear, the shaft front gear and the gear on the clutch half, examining the teeth for wear or pitting.



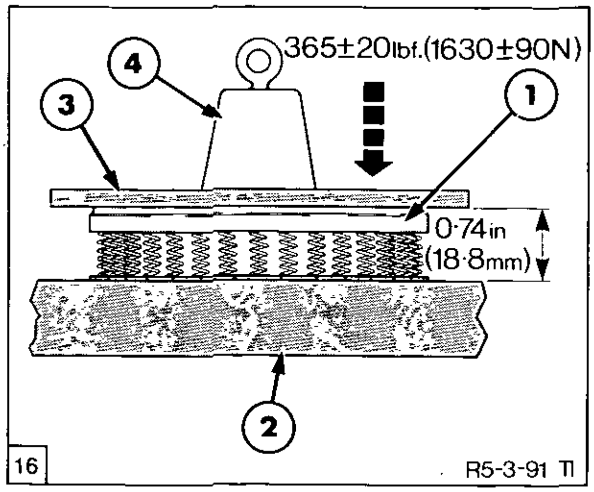
Removing FWD Clutch Oil Supply Transfer Tube

1. Special Tool No. 4FT 509
2. Part of Slide Hammer Tool No. 954C
3. Oil Transfer Tube

3. Carefully inspect all bearings for wear, pitting and damage.

4. Install new inner and outer seals, references 13 and 25, Figure 18, to the output shaft.

5. Carefully prise out the output shaft lip seal, reference 19, Figure 18, from the cover plate and press in a new seal using a suitable step plate or adaptor. Renew the outer 'O' ring seal.



Checking Compressed Height of Clutch Piston Return Spring Assemblies

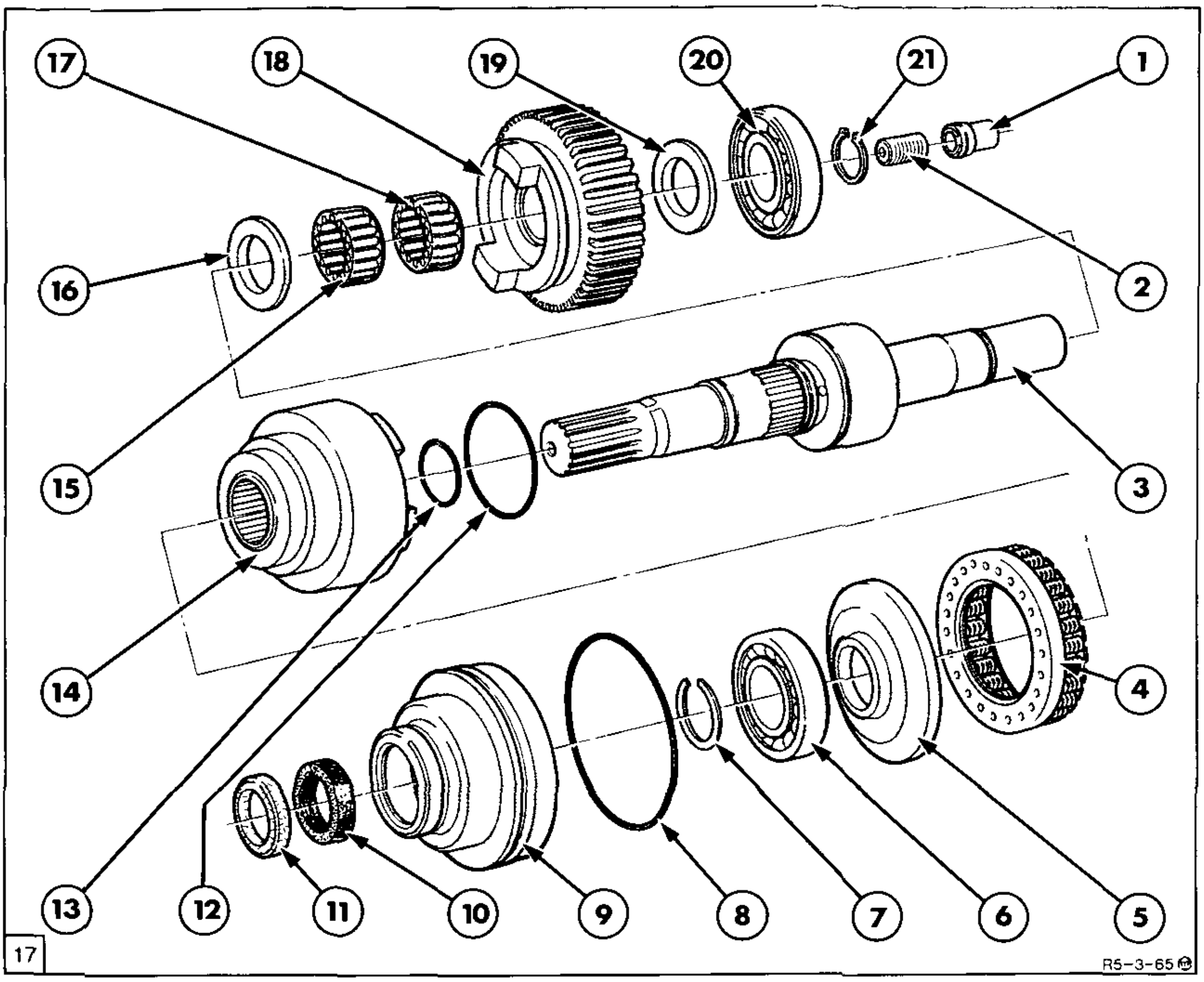
1. Piston Return Spring Assembly
2. Base Plate
3. Load Spreader (flat disc)
4. Weight (or load)

6. Inspect the clutch engagement spring assembly for cracked coils or deformation. Check the spring assembly loaded height as shown in Figure 16, or by comparing it with a new reference. If any doubt exists renew the spring assembly.

7. Inspect the inner surfaces of the front half of the clutch for damage, ensure that the sealing area is unmarked.

8. Examine the clutch dog teeth for damage and wear.

9. Inspect the splined areas of the front half of the clutch, the output shaft and the internal drive shaft for damage and fretting.



Front Wheel Drive Output Transfer Assembly – Exploded View

1. Oil Transfer Tube
2. Pilot Valve Assembly
3. Output Shaft
4. Engagement Spring Assembly
5. Spring Keeper
6. Front Bearing
7. Snap Ring
8. Oil Seal
9. Front Cover
10. Inner Seal
11. Outer Seal
12. Quad Seal
13. Quad Seal
14. Clutch Half
15. Needle Roller Bearing
16. Spacer
17. Needle Roller Bearing
18. Gear/Clutch Half
19. Spacer
20. Rear Bearing
21. Snap Ring

Front Wheel Drive Output Drive Assembly – Re–Assembly

1. Use the sectional illustration in Figure 18 to aid re–assembly and note the following references, giving them special attention.

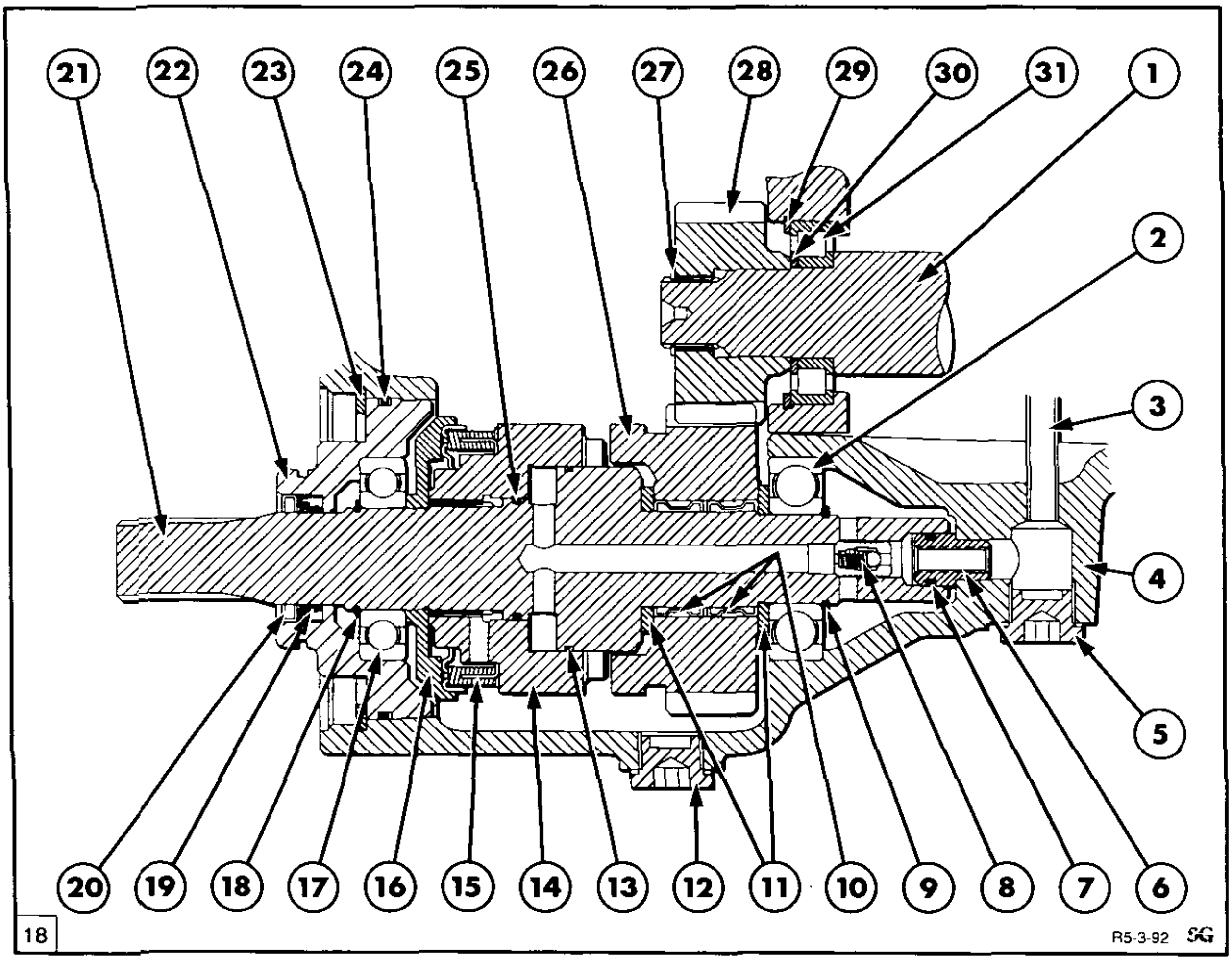
2. Re–assembly of the front wheel drive output transfer assembly follows the disassembly procedure in reverse.

3. Coat the shaft seals with transmission fluid prior to re–assembly and allow the seals to resize before assembling the sliding clutch half.

4. Use a suitable press and sleeve to install the front and rear bearings, ensure when installing the front bearing that the sliding clutch half, the spring assembly and the keeper plate do not become misaligned and damage the seals.

5. Ensure the two washers, reference 11, Figure 18, are positioned either side of the driven clutch half.

6. In order for the dog clutch to perform correctly, it is essential that the pilot valve assembly, reference 8, Figure 18, is assembled with the ball facing rearwards.

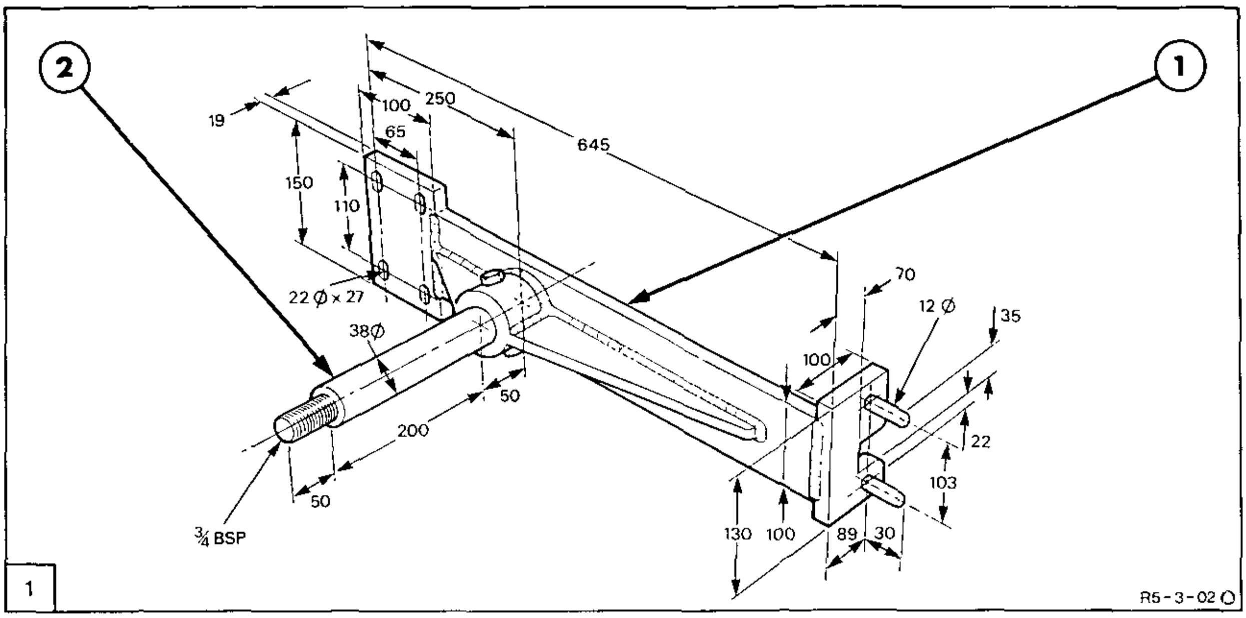


Front Wheel Drive Output Assembly – Sectional View

1. Shaft (from transmission output)
2. Output Shaft Rear Bearing
3. Oil Pressure Supply Tube
4. Transmission Housing
5. Plug (Pressure Supply)
6. Oil Transfer Tube
7. Oil Transfer Tube Polyamide Seal
8. Pilot Valve Assembly
9. Bearing Retaining Snap Ring
10. Needle Roller Bearings
11. Steel Washers
12. Transmission Drain Plug
13. Outer Piston Seal
14. Sliding Clutch Half
15. Engagement Spring Assembly
16. Spring Keeper
17. Output Shaft Front Bearing
18. Snap Ring
19. Oil Seal
20. Output Shaft
21. Dust Seal
22. Cover Plate
23. Cover Plate Retaining Snap Ring
24. Cover Plate 'O' Ring Seal
25. Inner Piston Seal
26. Clutch Half/Gear
27. Snap Ring
28. Drive Gear (from transmission output)
29. Bearing Thrust Washer
30. Snap Ring
31. Bearing Assembly

E. TRANSMISSION OVERHAUL

Transmission Stand Bracket

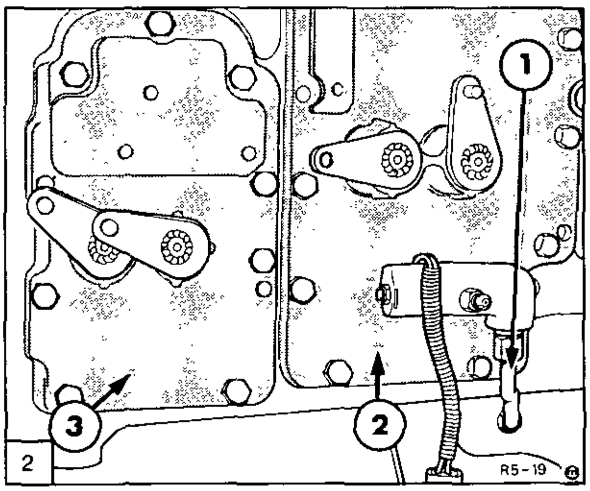


Transmission to Stand Attachment Bracket – Constructional Detail
(*Dimensions in millimetres unless stated*)

1. Bracket Assembly
2. Stand Support Shaft

Although it is not necessary to mount the transmission in a rotating stand to carry out an overhaul, the bracket detailed above in Figure 1, which is also suitable for 16x16 transmissions, may be fabricated to mount the transmission to existing stands to aid *overhaul and transporting of the transmission.*

The stand support shaft reference 2, Figure 1, will enable the bracket to be coupled to existing V.L. Churchill Ltd stands. If a V.L. Churchill stand is not available a suitable support shaft will have to be fabricated.



Transmission Side Covers
Gear Selectors in Neutral Position

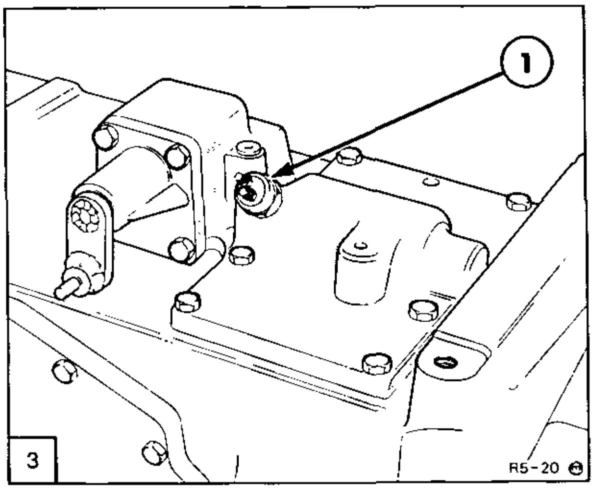
1. FWD Solenoid to Output Assembly Hydraulic Tube
2. Ratio Shift Cover
3. Range Shift Cover

DISASSEMBLY

Removal of Covers

1. Remove the tube from the side cover to the FWD connector.
2. Place all transmission levers to neutral, shown in Figure 2.
3. Remove the 8 securing bolts and withdraw the range shift side cover, reference 3, Figure 2, from the transmission.

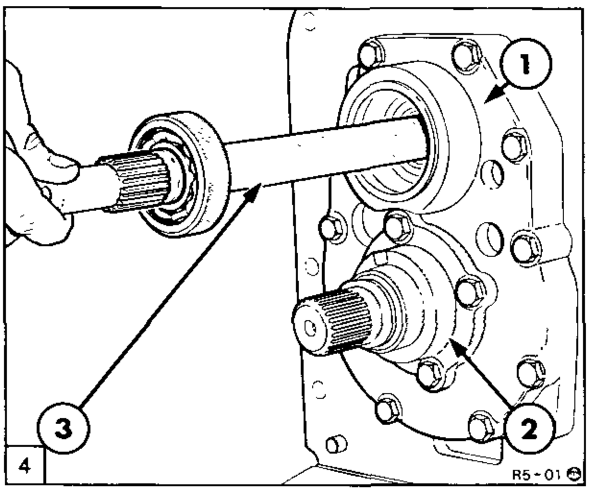
4. Remove the 10 securing bolts and withdraw the ratio shift cover, reference 2, Figure 2, from the transmission.



Top Cover

1. Neutral Start Switch

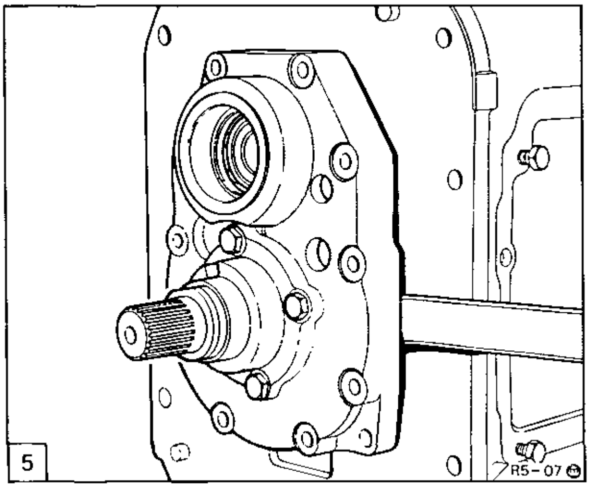
5. Remove the neutral start switch to gain access to one of the bolts and remove the 8 securing bolts from the top cover and withdraw the top cover, Figure 3.



Rear Plate Assembly

1. Rear Plate Assembly
2. Retainer
3. PTO Shaft and Bearing

6. Remove snap ring retaining PTO shaft bearing, pull out PTO shaft and bearing, Figure 4.

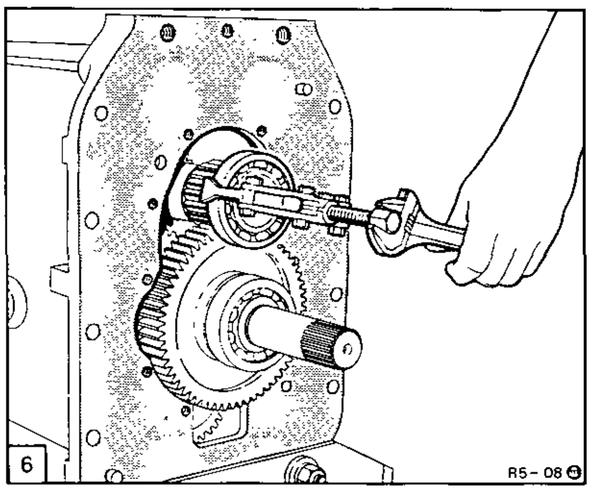


Rear Plate Removal

7. Remove the rear plate assembly, (10 bolts), Figure 5.

8. Remove the 4 bolts securing the output shaft retainer and remove the retainer and shims.

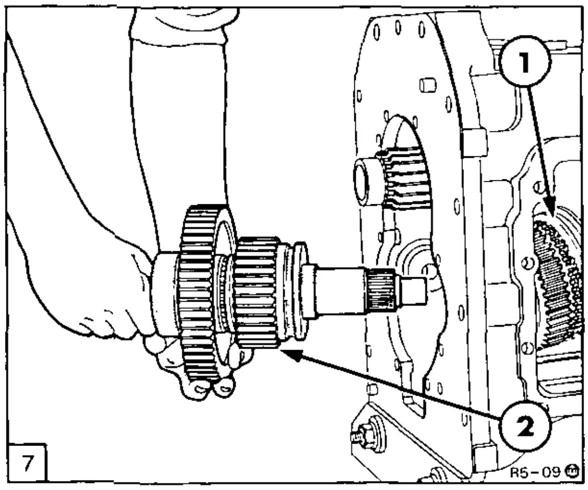
Removal of Transmission Rear End Components



Range Cluster Bearing Removal

1. Remove bearing from the range cluster gear assembly using a suitable puller, Figure 6.

2. Remove the output shaft assembly through the rear of the transmission, Figure 7.

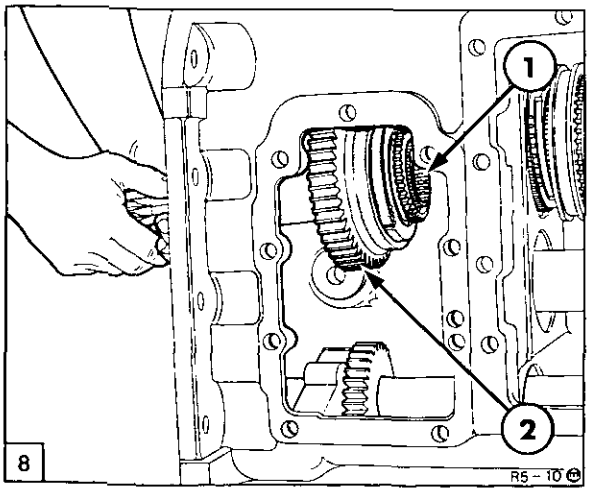


Output Shaft Removal

1. Medium Range Gear and Synchroniser
2. Output Shaft Assembly

3. Remove the medium range gear and synchroniser assembly through the side of the gearbox.

NOTE: *It may be necessary to move the FWD gear rearward slightly, by removing the outer circlip from the bearing.*

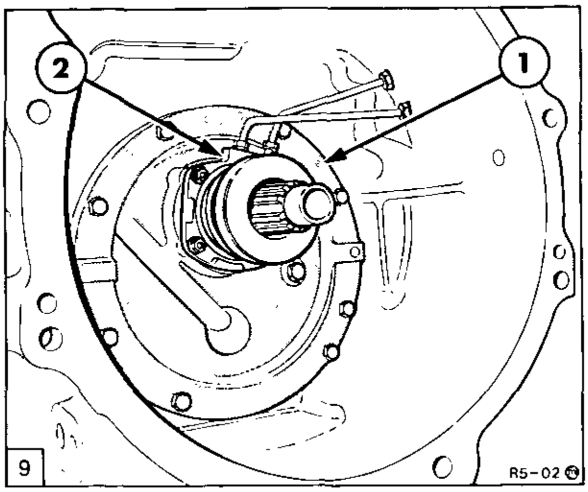


Range Cluster Removal

1. Needle Bearing
2. Range Cluster Assy.

4. Remove the range cluster gear assembly, taking care not to damage the needle roller bearing, Figure 8.

Removal of Transmission Front End Components

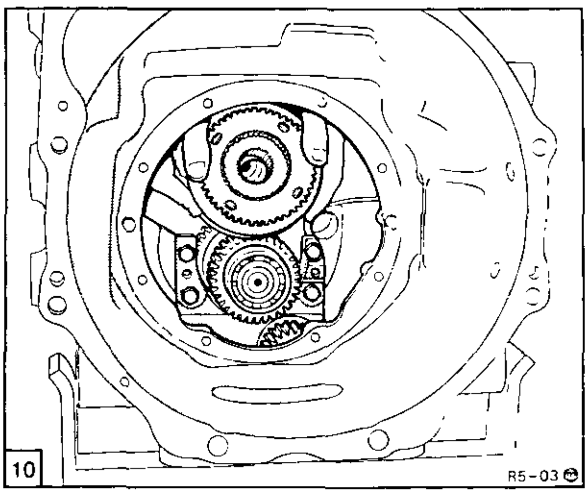


Transmission Front View

1. Front Plate Assy.
2. Release Bearing

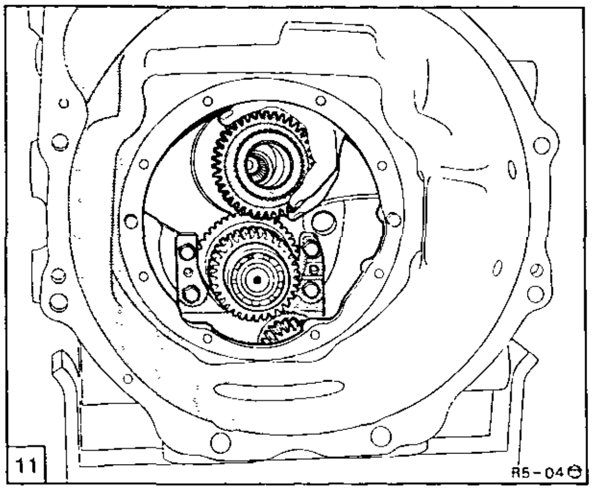
1. At the front of the transmission, remove the two tubes for the hydraulic release bearing, Figure 9.
2. Remove the hydraulic bearing assembly. (3 bolts), Figure 9.
3. Remove front plate assembly, (8 bolts), Figure 9. To assist removal, use a suitable drift through the top cover aperture onto the rear face of the front cover. Progressively tap the cover near to the dowels, until the cover is free.

NOTE: *The reverse idler gear, front cover oil tube and transmission input shaft are also removed in this operation.*



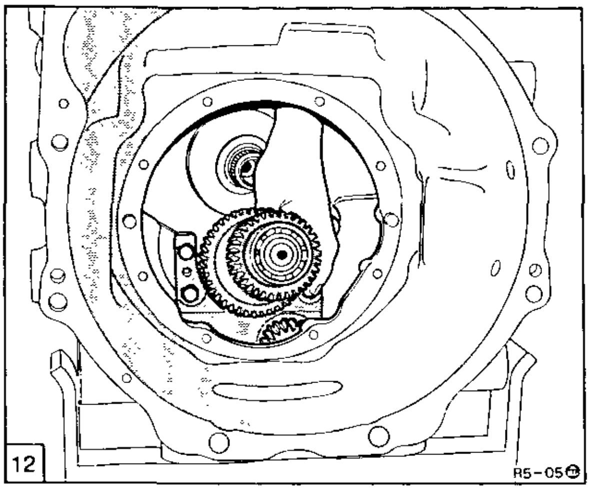
Forward/Reverse Synchroniser Removal

4. Remove snap ring from (top) mainshaft. Move the reverse cluster forward slightly and slide off the forward/reverse synchroniser assembly, Figure 10.



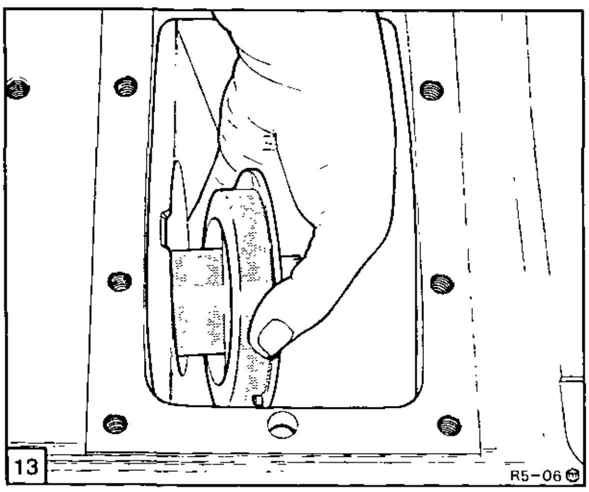
Reverse Gear Removal

5. Slide off reverse gear, Figure 11.



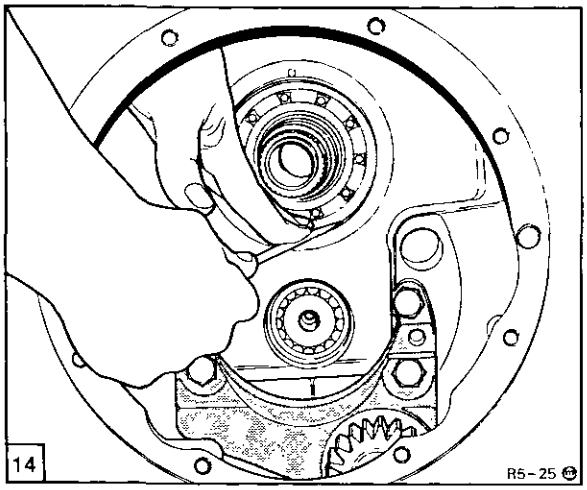
Reverse Cluster Gear Removal

6. Remove the reverse cluster gear assembly, Figure 12.



Oil Manifold Removal

7. Lever out and remove the oil manifold, Figure 13.



Mainshaft Bearing Snap Ring Removal

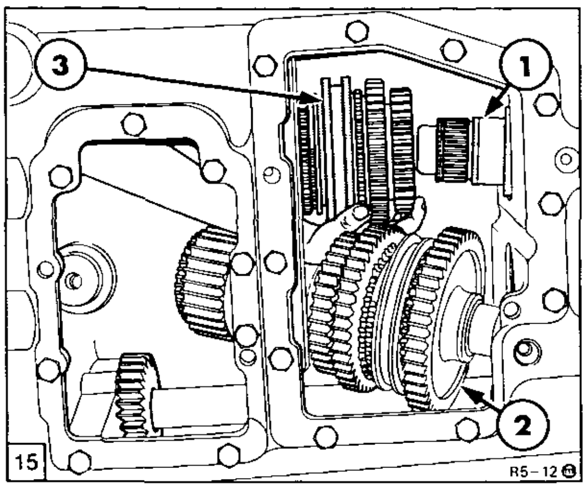
8. Remove snap ring from mainshaft front bearing, Figure 14.

Removal of Transmission Centre Components

1. *Remove snap ring from rear of mainshaft* assembly (retains 3rd/4th synchroniser).

2. Pull back and drop the countershaft down out of the way, Figure 15.

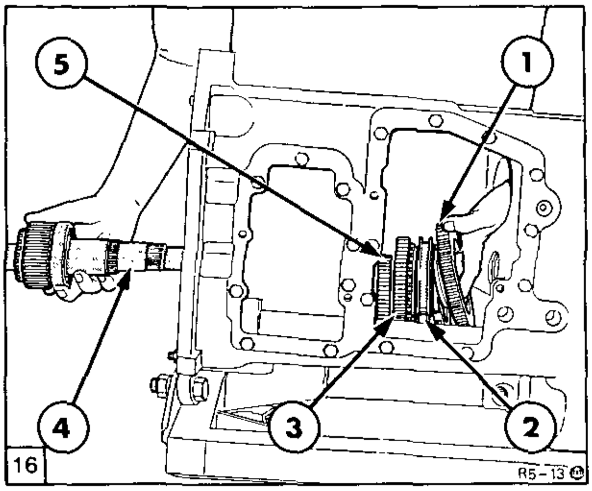
3. Remove mainshaft from front of box (countershaft moved out of way), Figure 15 and remove 3rd/4th synchroniser, 3rd ratio gear and 2nd ratio gear (splined), from the side of the transmission.



Mainshaft Removal

1. Mainshaft
2. Countershaft Assembly
3. 1st/2nd/3rd gears and 3rd/4th Synchroniser

4. Remove snap ring from countershaft front end.



Countershaft Removal

1. 1st Gear
2. 1st/2nd Synchroniser
3. 2nd Gear
4. Countershaft
5. 3rd Gear

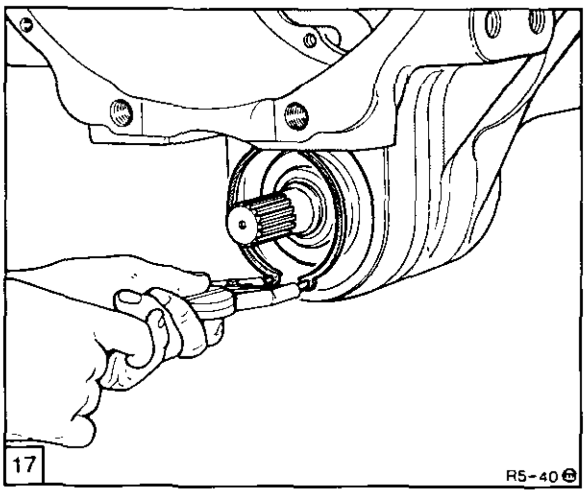
5. Slide the countershaft assembly shaft out from the rear of the transmission casing, Figure 16.

6. Remove the following as an assembly, (from side window):–

   3rd ratio gear,
   2nd ratio gear,
   1st/2nd synchroniser assembly,
   1st ratio gear.

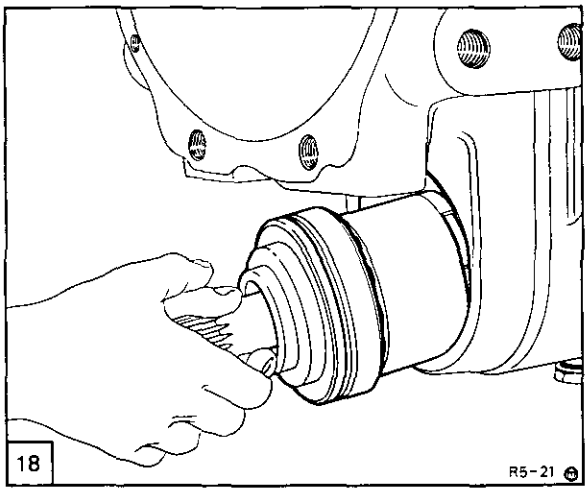
7. Remove the snap ring retaining the front countershaft bearing into the casing and punch out bearing.

FWD Output Assembly and Driveshaft Removal



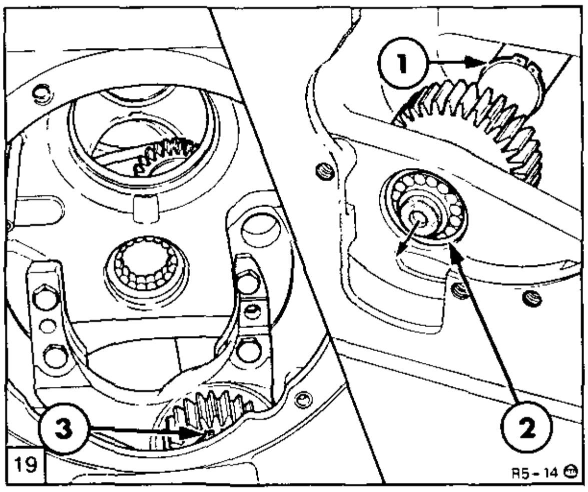
FWD Output Assembly
Retaining Snap Ring Removal

1. Remove the FWD output assembly cover snap ring, Figure 17.



FWD Output Removal

2. To assist removal, apply a suitable lever to pry points on the cover and lever against the transmission case to pull out assembly, Figure 18.



FWD Shaft Removal

1. Rear Gear Snap Ring
2. Rear Bearing Outer Snap Ring
3. Front Gear Snap Ring

NOTE: *Remove FWD shaft from rear end.*

3. Remove snap ring from front end of shaft, retaining front gear assembly, Figure 19.

4. Remove outer snap ring retaining rear bearing (if not already removed), Figure 19.

5. Remove snap ring from the groove in front of the rear gear. Allow snap ring to hang loose on shaft, Figure 19. Remove shaft and rear bearing as an assembly.

6. To remove the front FWD shaft bearing, remove the four bolts securing the FWD shaft bearing support assembly to the transmission casing. Remove the snap rings from either side of the bearing and push out the bearing.

RE-ASSEMBLY

FWD Shaft Installation

1. Install the FWD shaft front bearing to the support assembly and secure with snap rings on either side.

2. Install the support to the transmission casing, secure with the four retaining bolts.

3. Ensure the rear snap ring for the rear bearing is installed into the transmission casing.

4. Position the front FWD gear between the shaft support assembly and the casing.

5. Ensure the rear gear rear snap ring is installed onto the shaft. Position and retain the rear bearing onto the shaft. Feed the shaft and bearing from the rear of the transmission casing, picking up the rear gear and its front snap ring, front bearing and front gear. Install the front gear snap ring.

NOTE: *Take care not to damage the front bearing rollers when installing the shaft.*

6. Retain the rear bearing with outer (casing) snap ring.

Centre Components Installation

1. Install snap ring into groove of transmission bore (front countershaft).

2. Install from the front the countershaft front needle bearing into the transmission casing.

3. Install through the transmission side window, successively, the following parts, as shown in Figure 20:–

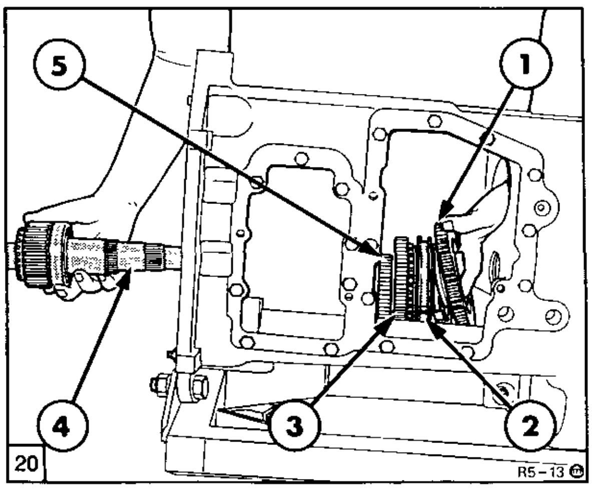
   i) 1st ratio gear,

   ii) 1st/2nd Synchroniser assembly,

   iii) 2nd ratio gear,

   iv) Splined 3rd ratio gear.

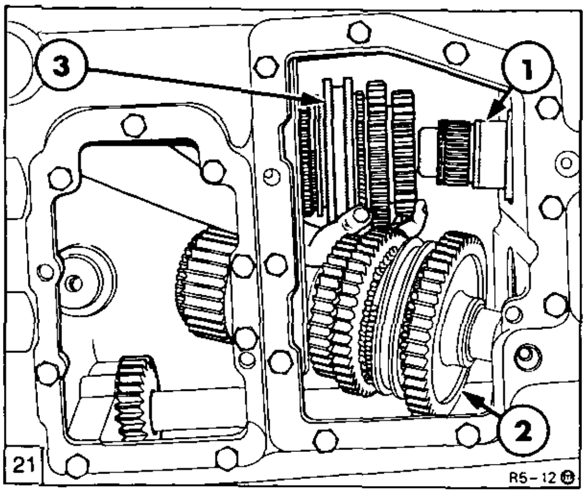
   Engage 1st ratio gear (i) and 2nd ratio gear (iii) with splines of synchroniser.



Countershaft Installation

1. 1st Gear
2. 1st/2nd Synchroniser
3. 2nd Gear
4. Countershaft
5. 3rd Gear

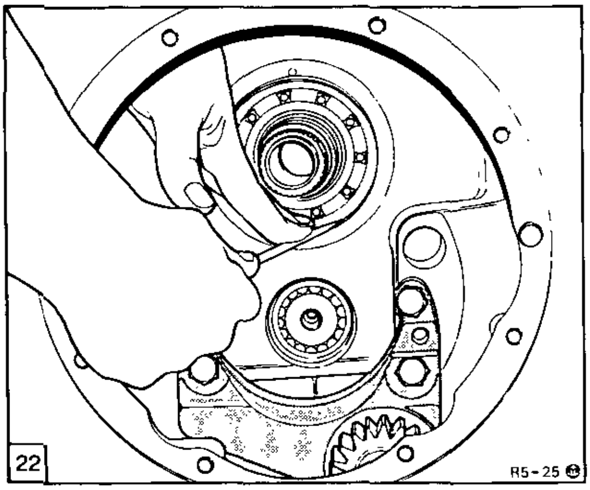
4. Slide countershaft from rear end, through parts installed during previous operation. Push shaft fully home, install washer and lock with snap ring.



Mainshaft Installation

1. Mainshaft
2. Countershaft Assembly
3. 1st/2nd/3rd gears and 3rd/4th Synchroniser

5. Install mainshaft, with front bearing installed, from the front end of the transmission, picking up the 3rd and 2nd ratio gear assemblies and complete 3rd/4th ratio synchroniser assembly, Figure 21.



Mainshaft Bearing Snap Ring Installation

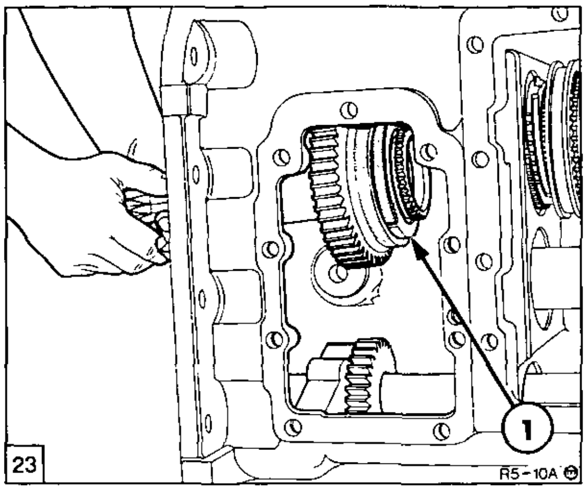
6. Align bearing on shaft to transmission bore and push in sufficiently to allow snap ring to be installed in casing bore, Figure 22.

7. Lock gears and synchroniser assembly to mainshaft with the rear snap ring.

8. Pull the mainshaft assembly rearwards slightly and locate the countershaft assembly into the front bearing, install a wooden wedge between the FWD shaft and a countershaft gear to hold in position. Push the the mainshaft forward, contacting the front bearing with the snap ring.

9. Install the needle roller bearing onto the rear of the mainshaft assembly.

Rear End Components



Range Cluster Installation

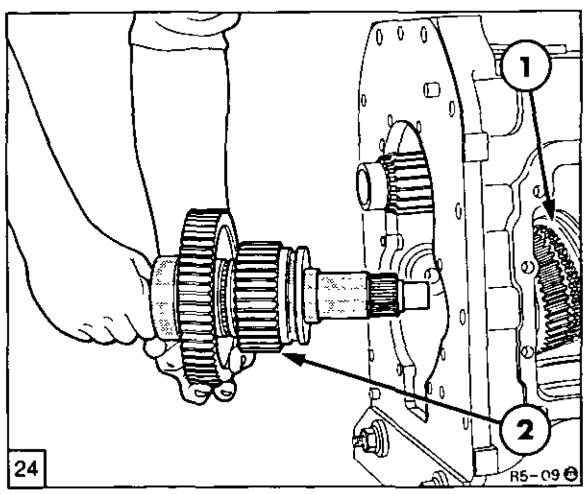
1. Washer in Position

1. Ensure the washer is positioned onto the range cluster gear assembly, Figure 23, and install assembly, picking up mainshaft needle bearing and engaging on splines of 3rd/4th synchroniser. Ensure assembly is fully seated.

2. Assemble medium range gear with Hi/Med. range synchroniser.

3. Insert gear/synchroniser assembly through rear side window and engage with splines of countershaft.

NOTE: *It may be necessary to move the FWD gear rearward slightly, by removing the outer circlip from the bearing. Ensure that the snap ring is replaced before the output shaft is installed.*



Output Shaft Installation

1. Medium Range Gear and Synchroniser
2. Output Shaft

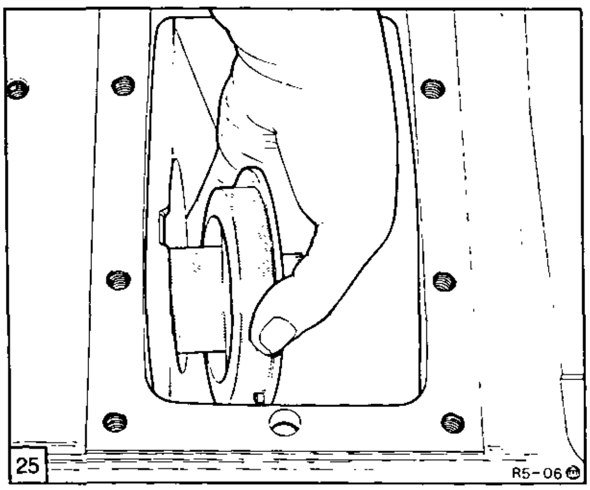
4. Install output shaft assembly engaging gear and synchroniser assembly previously installed, Figure 24.

5. Install end bearing onto range cluster gear. Heat bearing to a maximum temperature of 125°C (257°F) and push up to shoulder of gear.

6. Assemble rear cover assembly to transmission case and secure (10 bolts).

7. Install retainer over output shaft to rear cover, (temporarily, to keep output shaft in position).

Front End Components



Oil Manifold Installation

1. Install oil manifold assembly over mainshaft into casing bore, Figure 25. Align pegs with transmission case bores, and ensure oil hole alignment. Push fully home.

2. Install reverse cluster gear assy. DO NOT push fully home.

3. Slide onto the mainshaft the reverse gear and the forward/reverse synchroniser assembly.

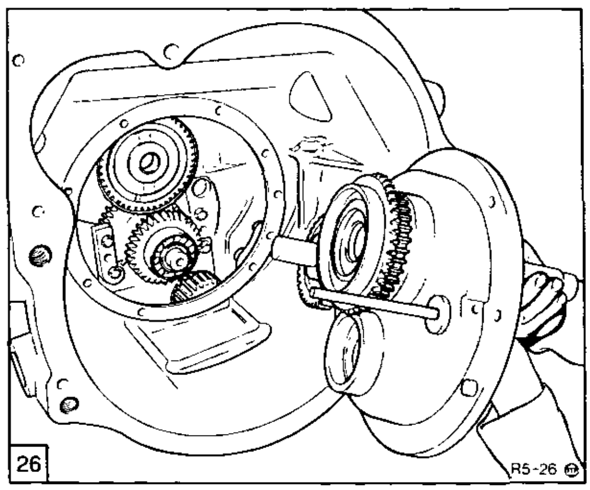
4. With synchroniser engaged on mainshaft splines, move synchroniser, together with reverse cluster gear, into place.

NOTE: *If necessary shift synchroniser to forward position to allow assembly. Return to neutral when correctly installed.*

5. Retain components on mainshaft with snap ring.

6. Apply a suitable gasket sealant (see Specifications, Section G) to the front cover face and locate the gasket. Apply sealant to the gasket face to ensure an oil tight joint.

7. Install the input shaft assembly and the reverse idler assembly into the front cover, secure the idler shaft with the retaining bolt and a new 'O' ring seal. Install the cover to the transmission, Figure 26, ensuring that the oil tube from the front cover to the transmission casing is correctly located.



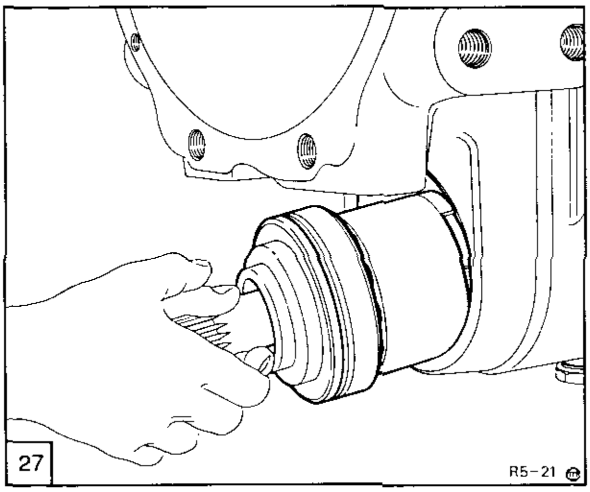
Front Cover Installation

8. Secure the cover with the 8 retaining bolts.

9. Assemble the hydraulic release bearing assembly to the front plate, secure with the 3 bolts.

10. Install hydraulic tubes.

FWD Output

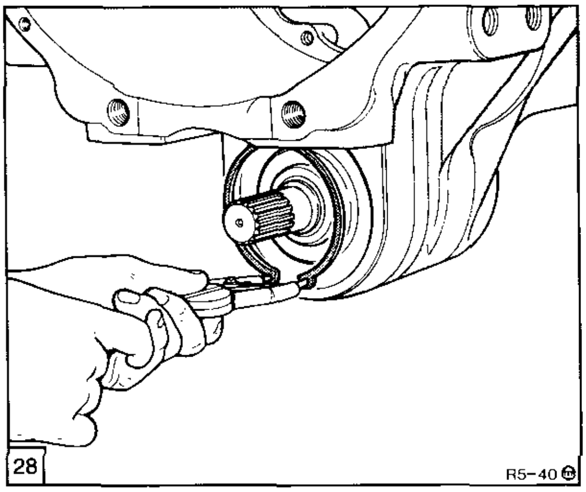


FWD Output Installation

1. If FWD is fitted, position the FWD transfer assembly oil supply tube, complete with polyamide thrust seal, in the transmission housing. The tube is a press fit in the housing and should carefully be driven into its location using a suitable drift.

2. Place the FWD clutch quick release check valve in its bore, with the ball end facing rearward. Using a suitable driver, firmly strike the end of the rear of the valve to force the front of the valve against the internal oil gallery in the FWD shaft, this will seat or 'coin' the face, to ensure an effective oil seal during operation. Retain the valve with petroleum jelly.

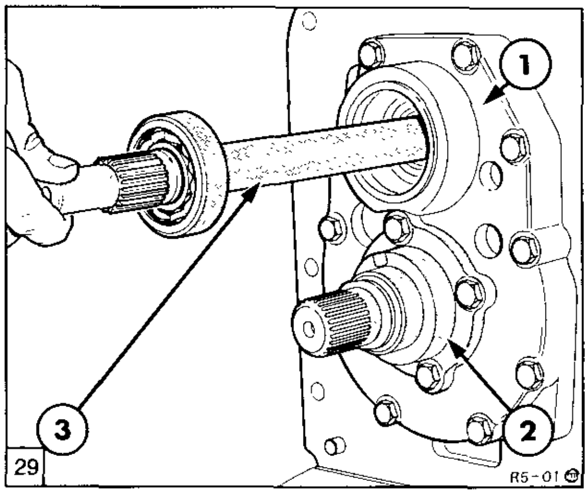
3. Align the gear of the FWD output assembly with the drive gear in the transmission casing and install, Figure 27.



FWD Output Assembly
Installing Retaining Snap Ring

4. Install the FWD cover and secure with the snap ring, Figure 28. The use of suitable heavy duty snap ring pliers is recommended.

PTO Shaft



Rear Plate Assembly

1. Rear Plate Assembly
2. Retainer
3. PTO Shaft and Bearing

1. Grease and slide the PTO shaft assembly seal up to the shaft shoulder.

2. Install the PTO shaft into the transmission, Figure 29. Secure with snap ring.

Output Shaft End Float

1. Check that the output shaft end float is between 0.001 – 0.003 in (0.0254 – 0.0762 mm) using the following procedure:

2. Remove the retainer assembly held in position with 2 bolts.

   Install a number of shims, Figure 31, of known dimensions, and re–install the retainer, torque to correct specification. Rotate the transmission several times to settle assembly. Using a suitable lever under the FWD output gear and a dial indicator gauge on the output shaft end face, Figure 30, measure the end float. From the figure read on the gauge, deduct the required amount to obtain an end float of between 0.001 – 0.003 in (0.0254 – 0.0762 mm).

NOTE: *Increasing shim thickness increases the end float. Reducing shim thickness reduces end float.*

3. Install the output shaft bearing retainer ensuring that the oil slot faces towards the top.

4. Check free running of:–

   Input shaft,
   PTO shaft,
   Output shaft,
   FWD shaft.

5. Verify that there is clearance between gears and synchroniser cones.

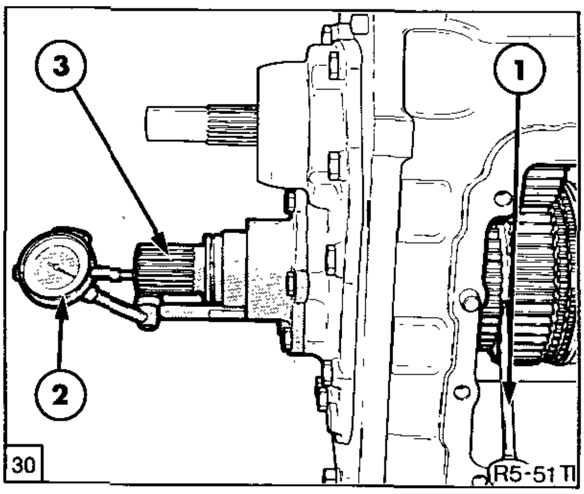
6. Ensure all synchronisers are in neutral.

7. Install a new top cover gasket and install the top cover, with forks in neutral position, to the transmission assembly. Retain with 8 bolts. Install the neutral start switch after the cover has been tightened down.

8. Refit the ratio shifting cover using a new gasket, ensuring forks are in neutral. Secure with 10 bolts.

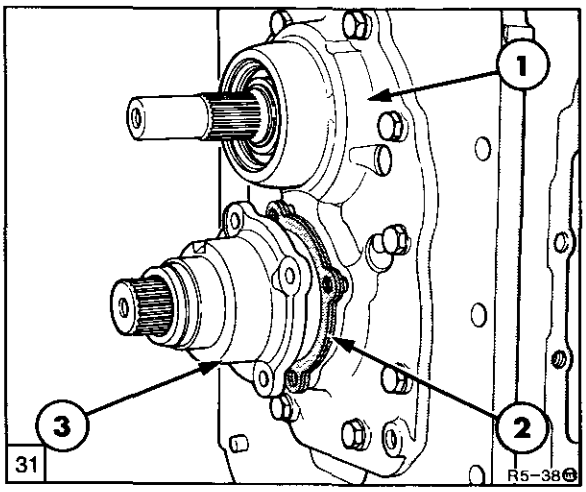
9. Refit the range shift cover, using a new gasket, ensure forks are in neutral, secure with 8 bolts.

10. Assemble the FWD to shift cover tube assembly.



Measuring Output Shaft End Float

1. Lever
2. Dial Gauge
3. Output Shaft



Output Shaft Shims

1. Rear Plate Assembly
2. Shims
3. Retainer

F. TRANSMISSION COMPONENT ASSEMBLIES

GENERAL INSPECTION AND REPAIR

Inspect oil seals for wear and damage. If any doubt exists as to the condition of any seal, replace with a new seal. Apply a film of clean transmission oil to the sealing lip of any seal prior to installation.

Clean bearings in a suitable cleaning solvent and inspect. If wear is evident or a bearing is not free running, replace with a new bearing.

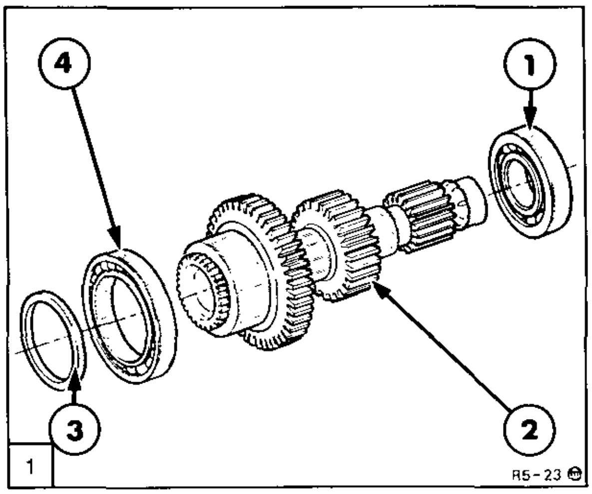
Inspect the gears for wear and chipped teeth. Inspect the shafts for wear and ensure that oil galleries are free from obstruction. Replace gears or shafts that are damaged or worn. If any taper roller bearings or cups are found to be unserviceable these must be replaced in matching sets.

If the transmission case has been completely disassembled, clean the case internally and externally. Inspect the case for damage or cracks.

Prior to assembly of components into the transmission, ensure components are free from dirt or other contamination. When assembling components to the transmission casing lubricate bearings and shafts with clean transmission oil.

NOTE: *The following component assembly instructions detail the level of assembly required prior to transmission re-assembly.*

RANGE CLUSTER GEAR ASSEMBLY



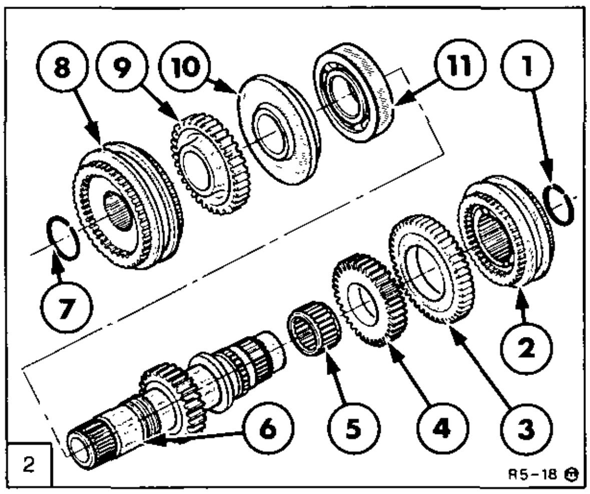
Range Cluster

1. Rear Bearing
2. Cluster Gear
3. Washer
4. Front Bearing

Assembly

1. Using a press with suitable adaptors install front bearing and washer, Figure 1.

MAINSHAFT ASSEMBLY



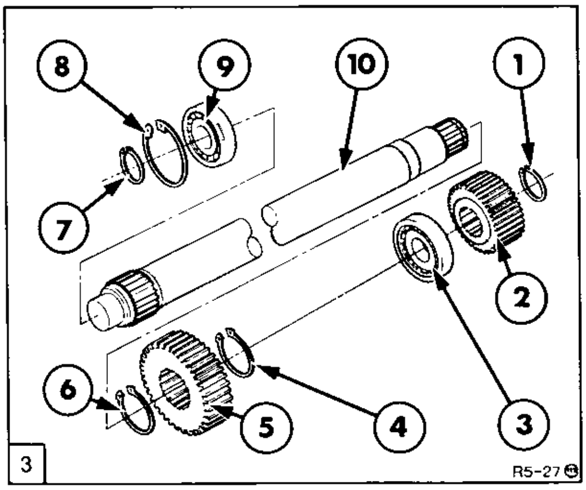
Mainshaft

1. Snap Ring
2. 3rd/4th Synchroniser
3. 3rd Ratio Gear
4. 2nd Ratio Gear
5. Bearing
6. Shaft
7. Snap Ring
8. Forward/Reverse Synchroniser
9. Reverse Gear
10. Oil Manifold
11. Bearing

Assembly

1. Using a press with suitable adaptors install bearing, reference 11, Figure 2, onto mainshaft assembly.

FWD COUNTERSHAFT



FWD Countershaft Components

1. Snap Ring
2. Output Drive Gear
3. Front Bearing (Installed into Front Support)
4. Snap Ring
5. Shaft Driven Gear
6. Casing Snap Ring
7. Snap Ring, Bearing To Shaft Retaining
8. Casing Snap Ring
9. Rear Bearing
10. Shaft

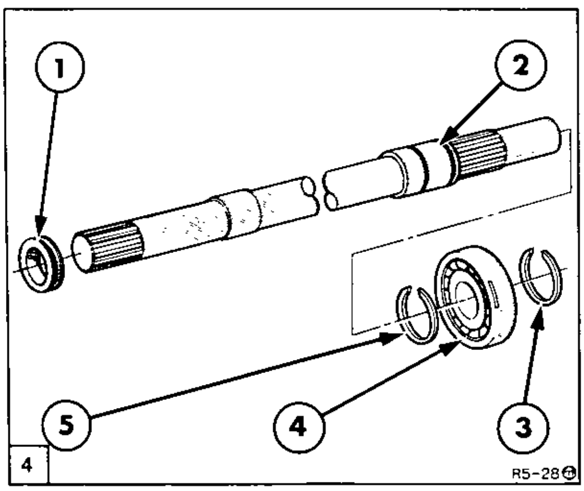
Assembly

1. Install snap ring, reference 6, Figure 3 onto shaft.

2. Install rear bearing, reference 9, Figure 3, and retaining snap ring reference 7, Figure 3.

3. Install front bearing, reference 3, Figure 3, into transmission casing.

PTO DRIVE SHAFT ASSEMBLY



PTO Shaft

1. Seal
2. Shaft
3. Snap Ring
4. Bearing
5. Snap Ring

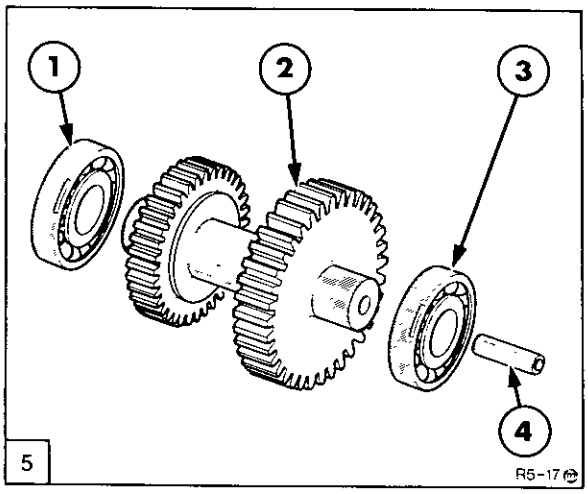
Assembly

1. Install snap ring, reference 5, Figure 4, to shaft.

2. Press on bearing, reference 4, Figure 4, and lock into position with snap ring, reference 3, Figure 4.

3. Slide seal up to shoulder of shaft.

REVERSE CLUSTER GEAR ASSEMBLY



Reverse Cluster Gear

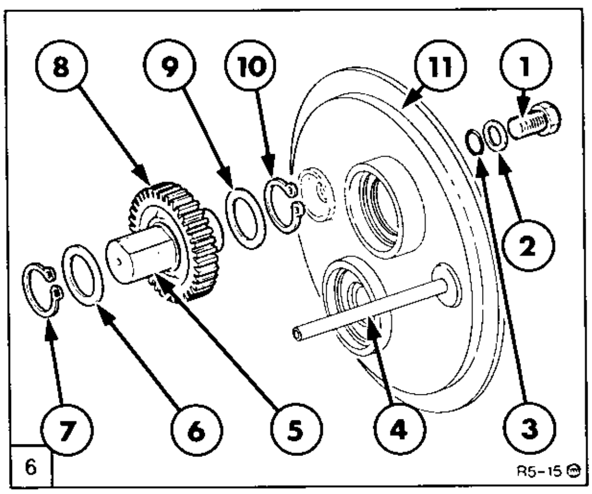
1. Front Bearing
2. Gear Cluster
3. Rear Bearing
4. Hollow Pin

Assembly

1. Install Hollow pin, reference 4, Figure 5. It is important that this pin is installed correctly as it supplies lubricating oil to the front bearing.

2. Press on the two end bearings using suitable adaptors.

REVERSE IDLER ASSEMBLY



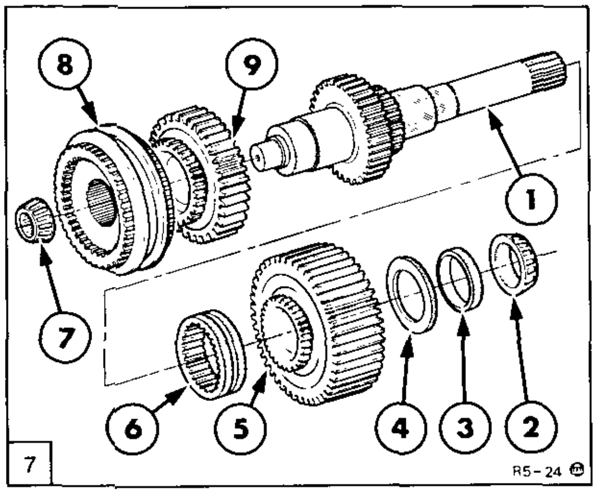
Reverse Idler Components

1. Bolt
2. Washer
3. 'O' Ring
4. Oil Transfer Tube
5. Shaft
6. Washer
7. Snap Ring
8. Idler Gear
9. Washer
10. Snap Ring
11. Front Plate

1. Assemble the idler gear, reference 10, Figure 6 and washers to the shaft and retain with snap rings, references 5 and 8, Figure 6.

2. Secure the gear and shaft assembly to the front cover using the bolt and washer with a new 'O' ring seal.

OUTPUT SHAFT ASSEMBLY



Output Shaft Components

1. Shaft
2. Rear Bearing
3. Spacer
4. Washer
5. Low Range Gear
6. Low Range Coupler
7. Front Bearing
8. Hi/Med. Range Synchroniser
9. Medium range Gear

Assembly

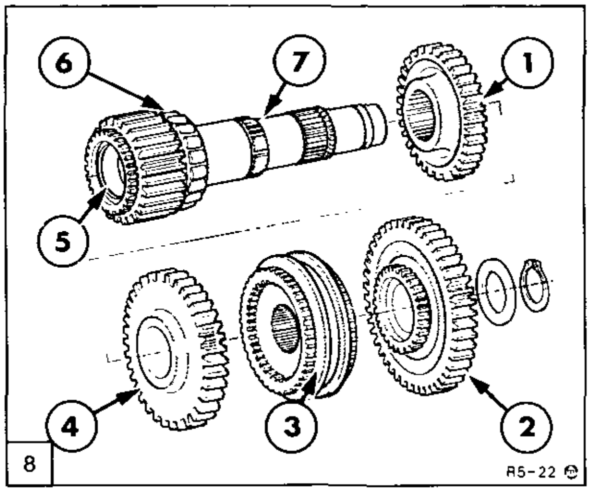
1. Install onto the shaft the following components in the sequence listed:–

   Low range coupler, reference 6 Figure 7,
   Low range gear, reference 5, Figure 7,
   Washer, reference 4, Figure 7,
   Spacer, reference 3, Figure 7,
   Rear cone and roller bearing reference 2, Figure 7.

   Ensure that the coupler is a free sliding fit on the shaft and that the gear is free to rotate.

2. Install the cone and roller bearing assembly on the opposite end, reference 7, Figure 7.

MAIN COUNTERSHAFT



Countershaft Assembly

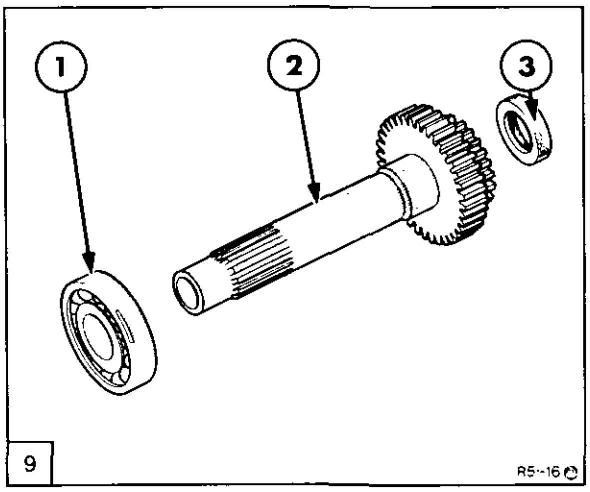
1. 3rd Gear
2. 1st Ratio Gear
3. 1st/2nd Synchroniser
4. 2nd Ratio Gear
5. Bearing Cup
6. Bearing
7. Shaft

Assembly

1. Press on bearing, reference 6, Figure 8, using suitable adaptors.

2. Press in the bearing cup, reference 5, Figure 8.

INPUT SHAFT



Input Shaft Components

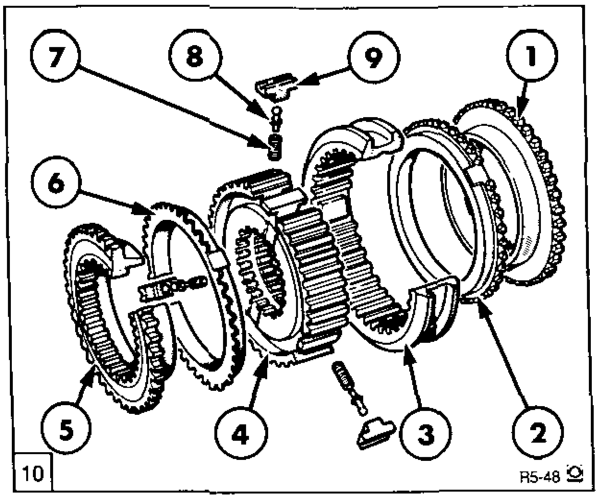
1. Bearing
2. Shaft
3. PTO Shaft Seal

Assembly

1. Install bearing, reference 1 onto shaft, reference 2, Figure 9.

2. Install seal, reference 3, Figure 9, into rear of shaft. Grease lip prior to assembly.

SYNCHRONISER ASSEMBLIES



Synchroniser Assembly

1. Clutch Body
2. Synchroniser Ring
3. Sliding Sleeve
4. Synchroniser Body
5. Synchroniser Ring
6. Clutch Body
7. Spring
8. Guide
9. Plunger

The 12x12 Synchro–Shift transmission incorporates four baulk ring type synchronisers, their locations shown in Figure 3.

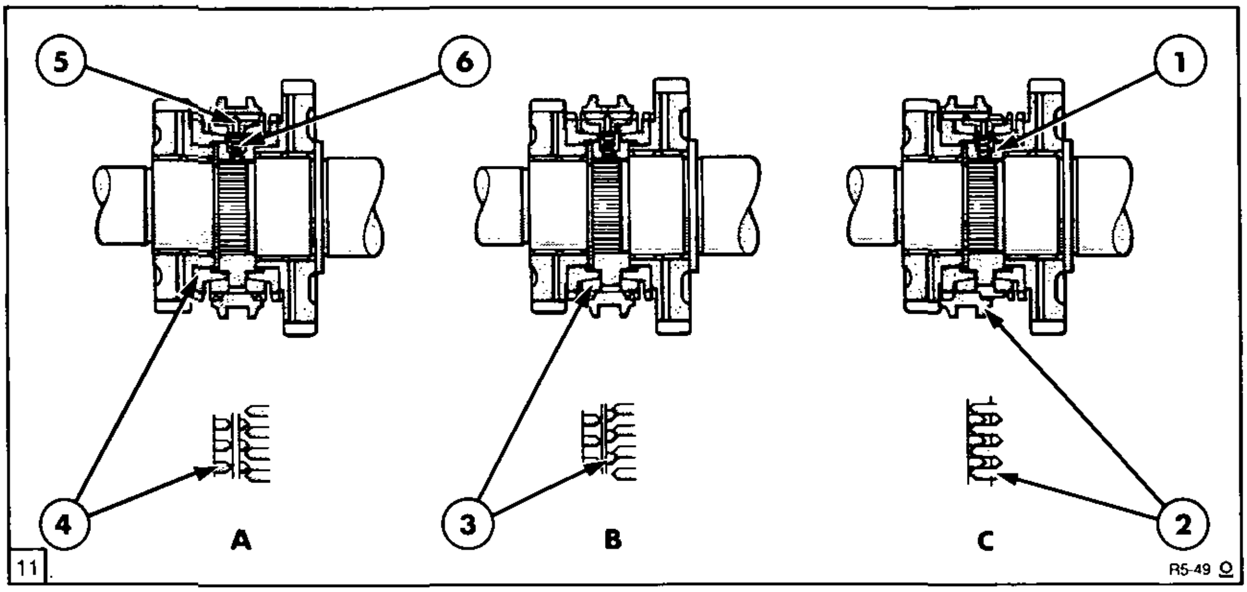
Synchroniser operation:

In the neutral position the plungers are pressed into the V–shaped recesses in the sliding sleeve. The gears are free to rotate on the shaft. See 'A' Figure 11.

As the sliding sleeve is moved from neutral towards the gear to be selected, the synchroniser ring is pressed against the clutch body. Any difference in speed of the parts to be engaged causes the synchroniser ring rotate. This rotation, which is limited by stops, causes the chamfered teeth of the synchroniser ring to be pressed against those of the sliding sleeve and prevent any further movement of the sliding sleeve, see 'B' Figure 11.

Further shift pressure causes the synchroniser ring and clutch body to eventually rotate at the same speed and the shaft and gear speeds are synchronised.

After synchronisation, no rubbing exists between the clutch body and synchroniser ring. The force on the chamfered teeth of these components is relaxed, allowing the sliding sleeve to move past the synchroniser ring and engage on the gear driving tooth, See 'C' Figure 11.



Synchroniser Operation

1. Synchroniser Body
2. Sliding Sleeve
3. Synchroniser Ring
4. Clutch Body
5. Plunger
6. Spring

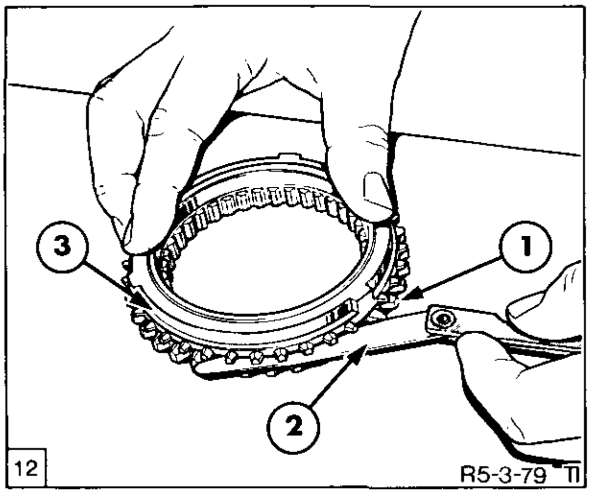
Synchroniser Inspection

1. Inspect the sliding sleeve, ensuring that wear is even around the circumference of the sleeve. If wear is uneven or there is evidence of fork pick up, replace the sleeve and inspect the shift forks.
2. Inspect the friction material on the synchroniser ring. Replace the ring if friction material is missing, there is visually uneven wear or the material is excessively worn, as determined in the following test:

Synchroniser Ring Wear

Place the synchroniser ring over the synchroniser clutch body. Rotate the ring several times over the clutch body to ensure correct seating.

Using a feeler gauge determine the gap between the ring and clutch body. Insert the gauge at three equally spaced points around the circumference, as shown in Figure 12. From Table 1 determine if the synchroniser ring is still serviceable. Replace the synchroniser if the gap is at or below the minimum specified.



Synchroniser Ring Wear

1. Synchroniser Clutch Body
2. Feeler Gauge to be Inserted at Three Points Around Circumference
3. Synchroniser Ring

Table 1

Synchroniser	New Gap mm (Inches)	Minimum Gap mm (Inches)
Forward/Reverse	2.0 (0.079)	0.8 (0.032
High/Medium	1.8 (0.071)	0.8 (0.032)
1/2 3/4	1.6 (0.063)	0.8 (0.032)

G. SPECIFICATIONS AND TIGHTENING TORQUE VALUES

Specifications

Lubricant Capacity Transmission/Rear Axle	U.S. Gallons Imp.Gallons Litres	15 12.5 56.8
Lubricant	ESN–M2C134–D	
Gasket Sealant	Ford Specification ESE–M4G234–A1 (Loctite 515)	
Output Shaft End Float	0.001 – 0.003 in (0.0254 – 0.0762 mm)	
Shims Available for Output shaft End Bearing Retainer	0.003 in (0.0762 mm) 0.005 in (0.1270 mm) 0.012 in (0.3048 mm) 0.030 in (0.7620 mm)	

Gear Ratios

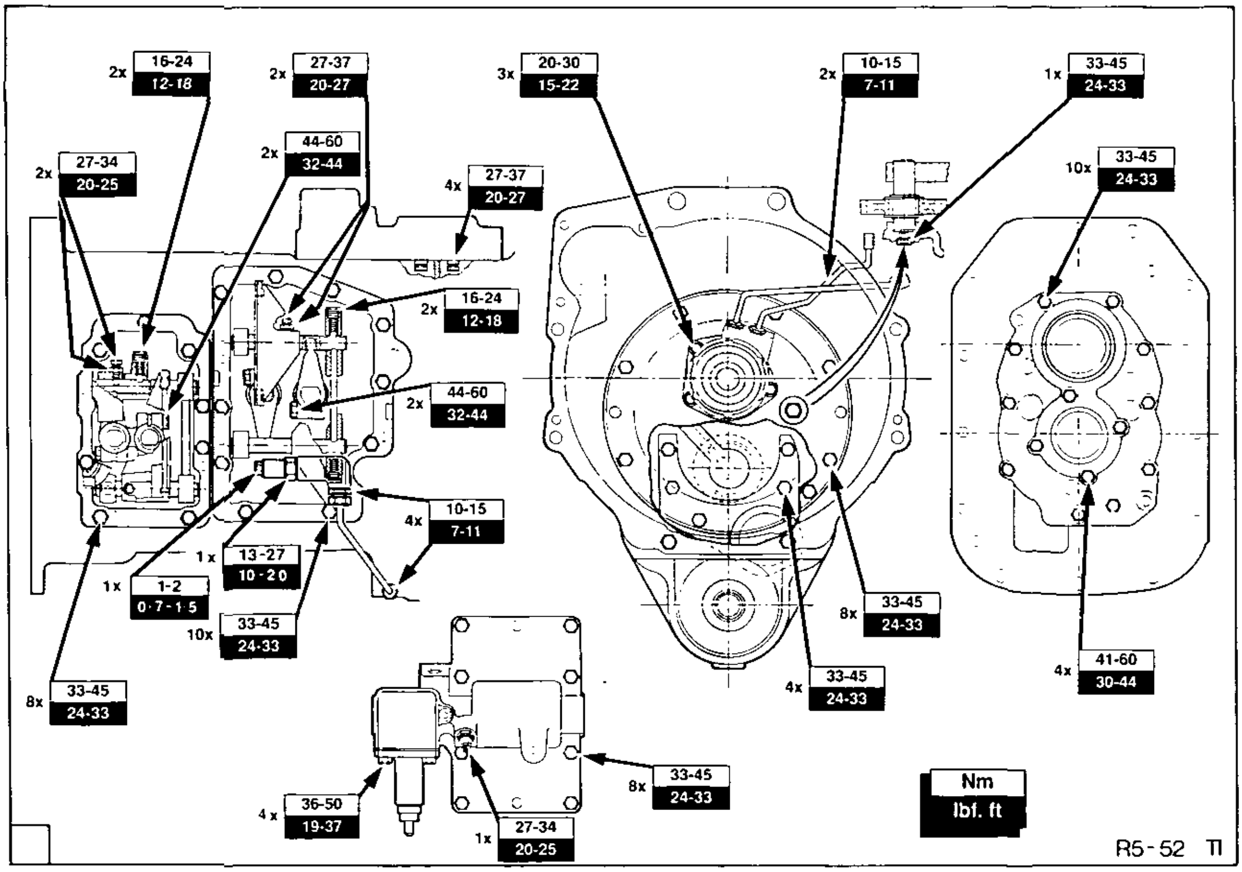
30 Km/hr Transmission

F1	9.61
F2	6.61
F3	4.87
F4	3.16
F5	4.24
F6	2.92
F7	2.15
F8	1.39
F9	1.93
F10	1.32
F11	0.97
F12	0.63
R1	9.37
R2	6.44
R3	4.75
R4	3.08
R5	4.14
R6	2.84
R7	2.09
R8	1.36
R9	1.88
R10	1.29
R11	0.95
R12	0.62

40 Km/hr Transmission

F1	9.61
F2	6.56
F3	4.59
F4	3.16
F5	3.83
F6	2.61
F7	1.83
F8	1.26
F9	1.58
F10	1.08
F11	0.76
F12	0.52
R1	9.37
R2	6.40
R3	4.48
R4	3.08
R5	3.73
R6	2.55
R7	1.78
R8	1.23
R9	1.54
R10	1.05
R11	0.74
R12	0.51

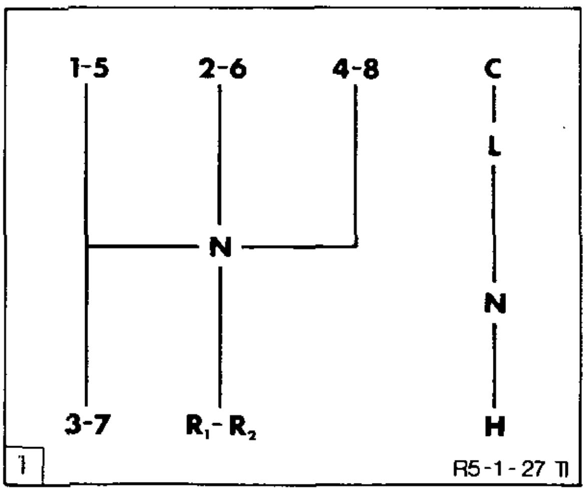
Tightening Torque Values



PART 5
TRANSMISSION SYSTEMS
Chapter 3
EIGHT SPEED NON–SYNCHROMESH TRANSMISSION

A. TRANSMISSION – DESCRIPTION AND OPERATION

The non–synchromesh transmission is of a constant mesh design and provides eight forward and two reverse speeds which are manually selected by two levers. The main gear lever selects any one of four forward or one reverse speeds whilst a second shorter lever is used to select an overall high or low ratio.



Gear Shift Lever Positions
(With Optional Creeper Gears)

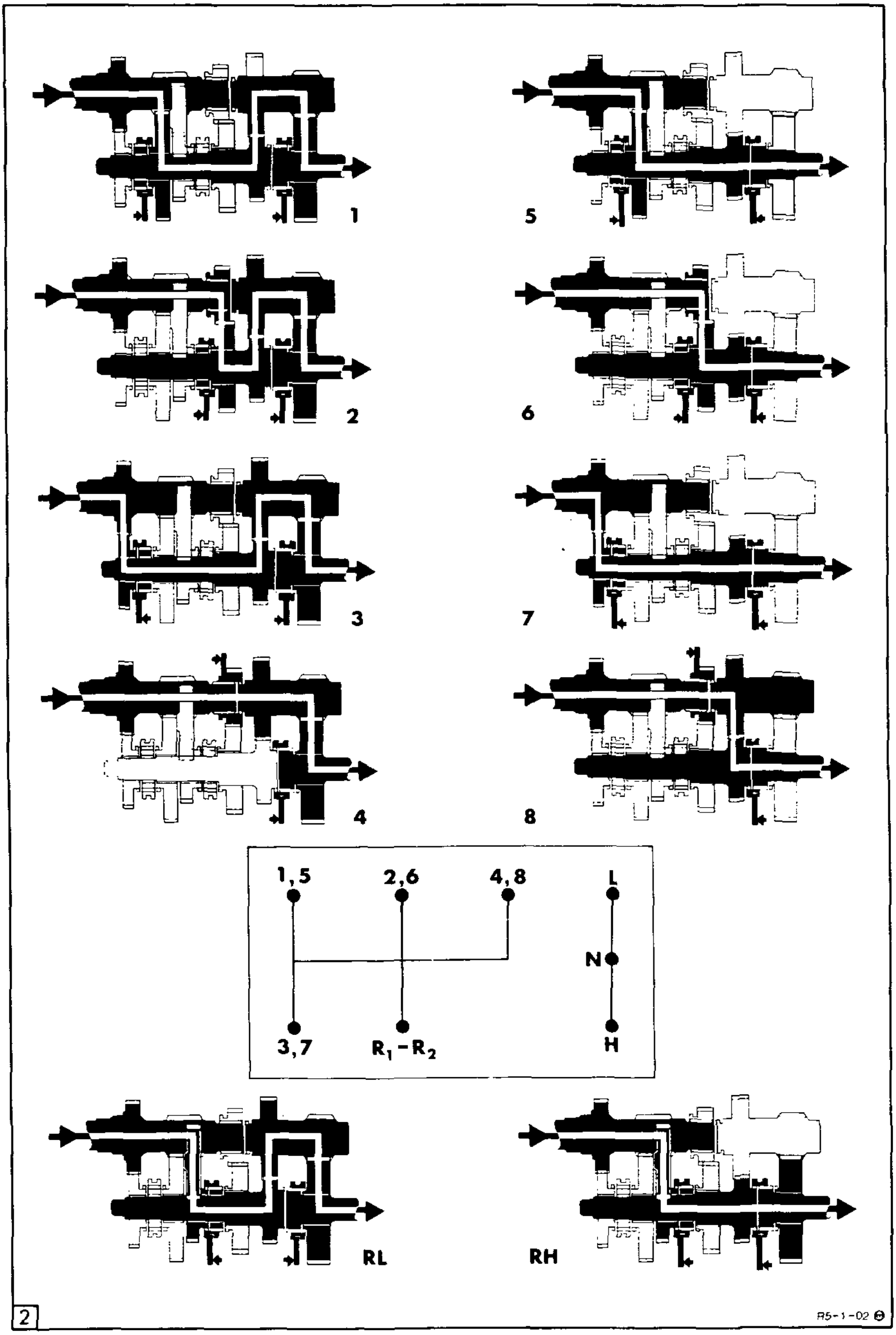
L = Low Range
H = High Range
N = Neutral
R = Reverse
C = Creeper gears

The transmission incorporates a safety starter switch which allows the tractor starter motor only to be operated when the secondary (range) lever is in the neutral position.

The gears are all in constant mesh and gear connections are made by sliding couplings. The transmission mainshaft is located in the top drive line and the main countershaft and output shaft are located in the bottom drive line. The transmission is available with Independent single or two speed P.T.O., not shiftable. Refer to "POWER TAKE–OFF" – Part 6 for further details of the P.T.O. drive line.

The transmission features straight cut type gears on all gears. Roller bearings are used throughout the transmission, except on the output shaft assembly where taper roller bearings are used. Shims between the output shaft end cover and bearing retainer provide the method of controlling output shaft end float.

The low pressure hydraulic system oil is utilised to effect pressure lubrication of the front transmission. A proportion of the low pressure hydraulic oil is fed, by means of external pipework, to an oil cooler located at the front of the tractor from which the cooled oil is directed to the front of the transmission.



Power Flow and Gear Shift Positions

L. Low
H. High
N. Neutral
R. Reverse

A hollow main countershaft and output shaft are utilised to accept oil from the cooler. Cross drillings in the main countershaft and output shaft allow the oil to lubricate and cool the transmission gears.

The hydraulic return oil flows through the front transmission back to the rear axle and tractor hydraulic system. The front transmission, rear axle and hydraulic system, therefore, form a common oil reservoir.

A Dual Power option which consists of a planetary gear set installed directly between the clutch and input shaft of the standard transmission is available. The planetary gear set provides either a direct drive or an underdrive in each gear ratio of the standard transmission. Refer to "Dual Power Transmission" Part 5, Chapter 4.

B. INTRODUCTION TO TRANSMISSION OVERHAUL

To assist in overhauling the transmission, the following notes on component accessibility should be noted:–

Components Accessible With Transmission Installed:

- Dual Power Control Valve
- Gear shift Levers
- Gear Shift Cover Assembly
- Safety Start Switch

Components Accessible With Engine Removed Only:

All items above, plus the following,

- Clutch assembly
- Clutch release shaft, fork and bearing assembly
- Dual Power assembly
- Main Input Shaft
- Front upper and lower shaft front bearings
- Front end oil seal

Components Accessible With Transmission Removed:

All items above, plus the following,

- Rear cover assembly
- PTO drive shaft
- Selector rails, forks, detent components and interlocks
- Output shaft assembly
- Range cluster gear
- Front upper shaft components
- Front lower shaft components
- Reverse idler components

C. GEAR SHIFT LEVERS AND COVERS – OVERHAUL

REMOVAL

1. If the tractor is equipped with a cab, lift up the floor mats and remove the floor panel in order to gain access to the shift cover.

2. Place the gear shift levers in neutral.

3. Disconnect the Battery negative cable.

4. Disconnect the safety start switch wires from the harness connection.

5. Remove the gearshift cover retaining bolts and partially lift the cover from the transmission casing. With the cover raised, disconnect the safety start switch wires from the switch and remove the shift cover assembly from the transmission.

DISASSEMBLY

1. Remove the oil baffle plate retaining bolts from the underside of the shift cover and remove the plate and washers.

2. Unscrew and remove the gear shift lever knobs.

3. Use a hacksaw to partially cut the lever retaining snap rings. If possible place the gear shift lever into the jaws of a vice as close to the snap ring as possible. Then using a chisel, finally break off the rings. During this operation ensure the retaining rings are not dangerously ejected from the grooves on the levers. Slowly release the vice and remove the springs, ball retainers and levers.

NOTE: *There is no need to attempt to remove the lever locating pins in the cover assembly as the levers are slotted.*

INSPECTION

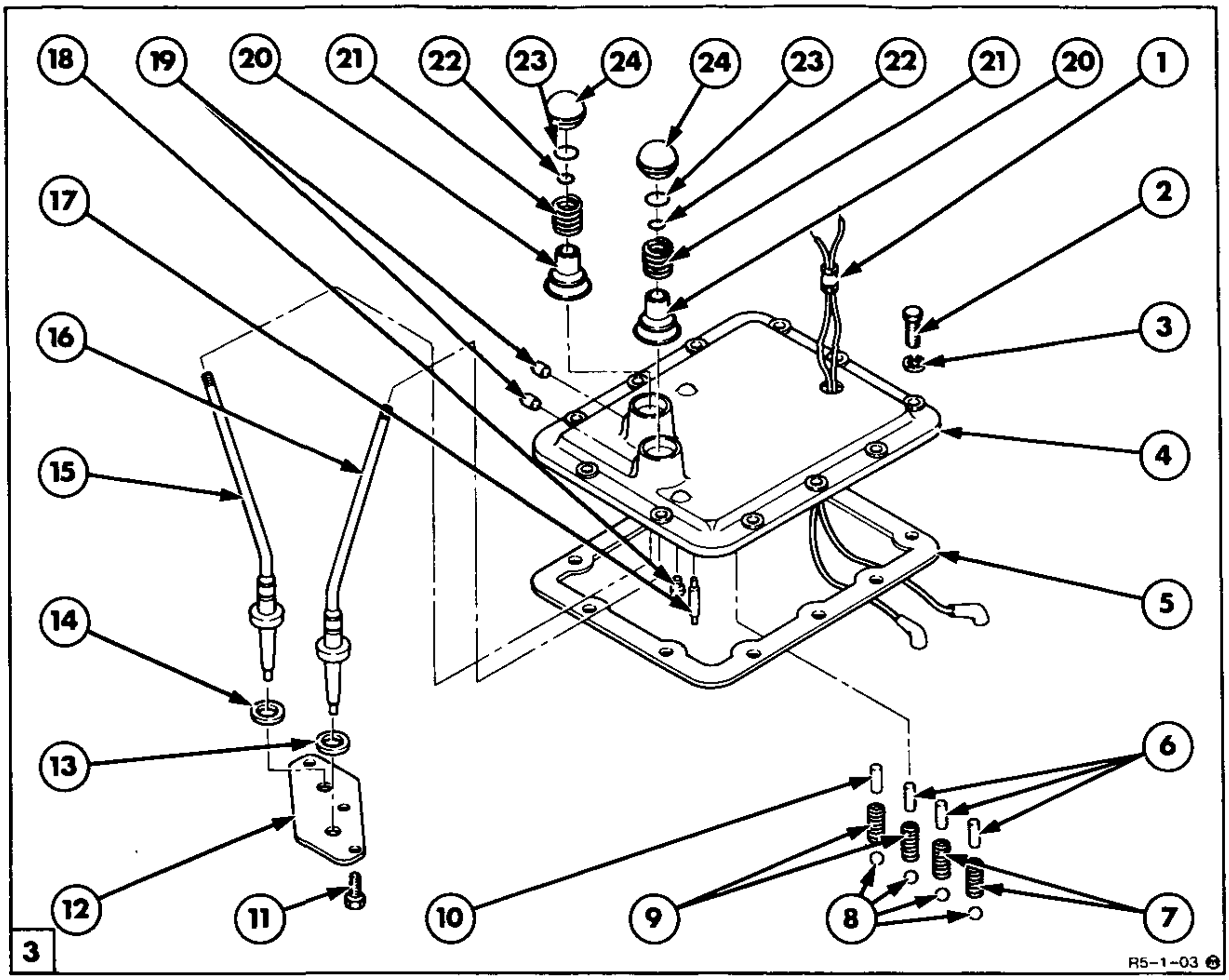
1. Wash the shift cover and shift lever assemblies in a suitable solvent and dry with a clean, lint free cloth or compressed air.

2. Inspect the shift cover for cracks or other damage. Renew the cover where necessary.

3. Inspect the shift lever ball seats and ends for wear and the lever locating pins in the cover. Renew the pins if worn or damaged. New pins should be pressed into the cover.

4. Inspect the lever retaining springs for cracks or distortion, also inspect the retaining snap ring grooves on the levers.

5. Inspect the safety start switch wiring harness for damage. Renew the harness if damaged.



Top Cover Assembly

1. Safety Start Switch Wiring Harness
2. Shift Cover Bolt
3. Washer
4. Cover
5. Gasket
6. Pin
7. Spring
8. Ball
9. Spring
10. Pin
11. Baffle Plate Retaining Bolt – 3 off
12. Baffle Plate
13. Washer
14. Washer
15. Range (High/Low) Lever
16. Main Gear Lever
17. Pin, Safety Start Switch
18. Dowel
19. Lever Locating Pins
20. Retainer
21. Lever Spring
22. Seal
23. Snap Ring
24. Gear Lever Knob

REASSEMBLY

1. Lubricate the ball seats with a good quality grease and pass the shift levers through the shift cover.

2. Assemble the ball retainers and springs, compress the springs and install new retaining snap rings.

3. Reassemble the two oil baffle washers to the underside of the shift cover, the oil baffle plate and the retaining bolts.

INSTALLATION

1. Install a new shift cover gasket to the cover assembly, hold in place with a suitable grease to aid assembly. Re–install the cover following the removal procedure in reverse, observing the following points:

- Ensure the safety start actuator housing is aligned with the locating pin in the shift cover.

- Tighten the cover retaining bolts to 41 lbf.ft (56 Nm).

SAFETY START SWITCH

REMOVAL

1. Remove the shift cover as previously described.

2. Unscrew the safety start switch from the housing.

INSPECTION

1. Inspect the safety start switch for wear or damage. Renew as necessary.

REASSEMBLY AND INSTALLATION

1. Reassembly and installation of the safety start switch follows the removal procedure in reverse.

2. Test the switch operation by connecting a test bulb in series with the switch terminals and a battery. Move the switch actuator housing along the high/low shift rail and away from the centre line of the actuating dowel. The test bulb should only light when the actuator housing is centred over the actuating dowel.

NOTE: *Do not move the actuator housing more than 0.25 in (6 mm) from the actuating dowel centre line or the dowel may come out of the shift rail.*

D. TRANSMISSION FRONT END – OVERHAUL

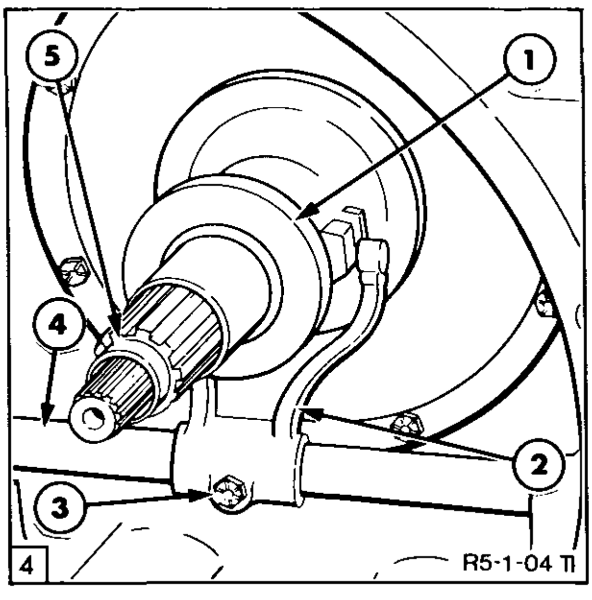
REMOVAL

1. Separate the engine from the transmission, see "SEPARATING THE TRACTOR".

2. Remove the gear shift levers and cover as previously described in this Chapter.

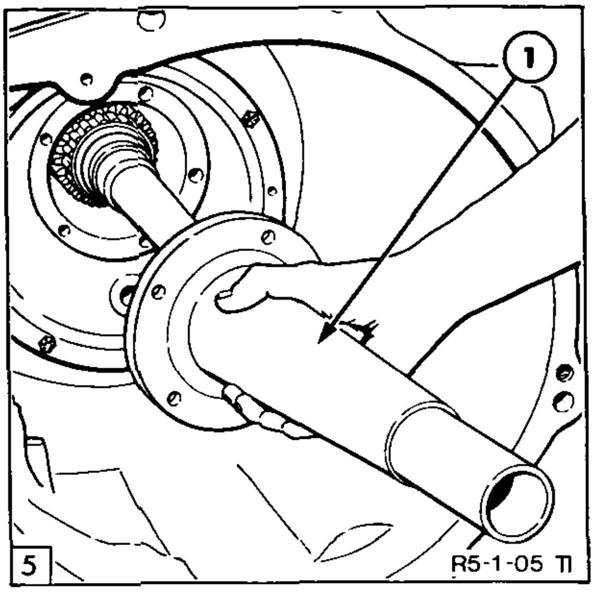
DISASSEMBLY

1. Remove the clutch release fork retaining bolt, Figure 4 and withdraw the clutch release shaft from the casing. Remove the clutch release fork from the transmission. Slide the clutch release bearing and hub from the clutch release hub support.



Clutch Release Bearing Installation

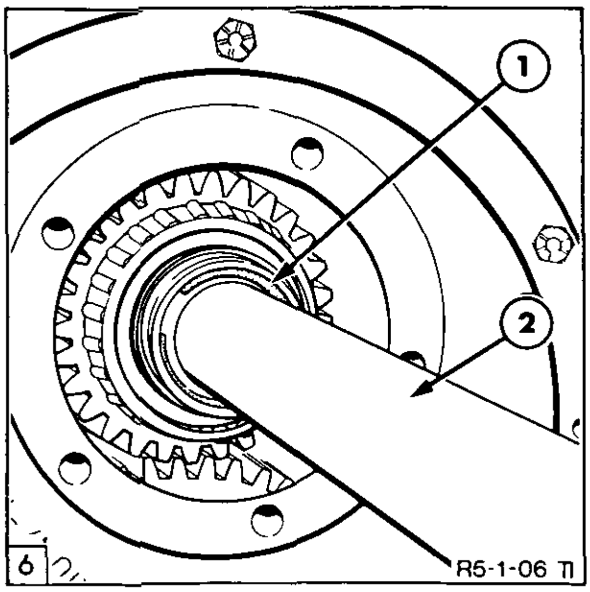
1. Clutch Release Bearing
2. Clutch Release Fork
3. Retaining Bolt
4. Clutch Release Shaft
5. Main Drive Input Shaft



Clutch Release Bearing Hub Support Removal

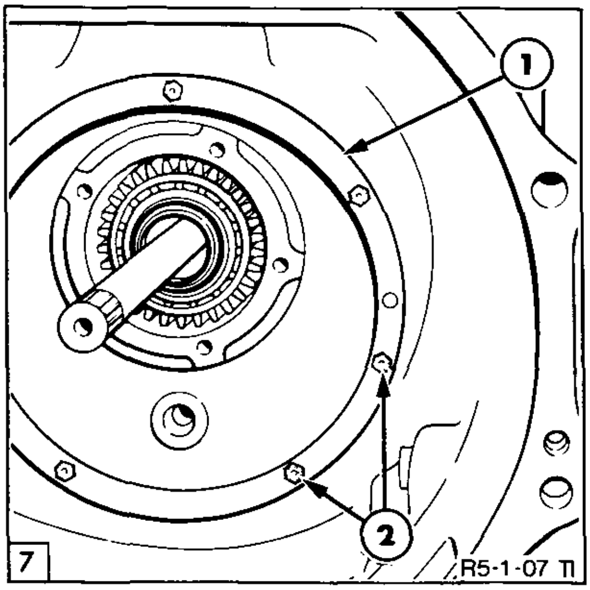
1. Hub Support

2. Transmissions With Dual Power: Disassemble the Dual Power unit as described in Chapter 4. Remove the Dual Power housing retaining bolts and lift the housing from the transmission casing. Take care not to lose the anti–spin washer located between the transmission mainshaft front gear and front bearing if the bearing comes away with the dual power housing.



Input Shaft Retaining Snap Ring

1. Retaining Snap Ring
2. Main Drive Input Shaft

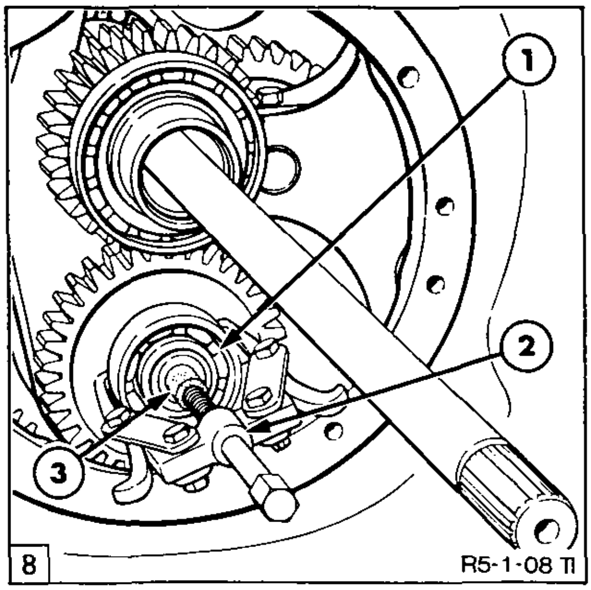


Front Support Plate Installation

1. Front Support Plate
2. Support Plate Retaining Bolts

Transmissions Less Dual Power: Disconnect the low pressure lubrication lines from the clutch release bearing hub support and the front support plate. Remove the hub support, Figure 5. Remove the snap ring retaining the main drive input shaft to the transmission mainshaft, Figure 6 and withdraw the input shaft.

3. Remove the front support plate retaining bolts, Figure 7 and withdraw the plate from the housing. If necessary, drive the plate from the housing using a suitable drift inserted into the main transmission compartment.



Countershaft Front Bearing removal

1. Countershaft Front Bearing
2. Puller, Tool No. 1001 or 9196
3. Shaft Protector, Tool No. 625A or 9212

INSPECTION AND REPAIR

1. Inspect the clutch release components for wear, see "CLUTCHES" – Part 4.

   Transmission Less Dual Power: Inspect the mainshaft front oil seal located in the clutch release bearing hub support, and if necessary, use Slide Hammer, Tool No. 943S or 9567, to remove the seal. Use a Step Plate, Tool No. 630S and sleeve of suitable diameter to install a new seal, with the sealing lip facing rearwards. Lubricate the sealing lip with a suitable grease prior to installation.

2. Examine the main drive input shaft and retaining snap ring and replace if worn or damaged.

3. Inspect the main countershaft front bearing and if worn or damaged, use puller, tool No. 1001 or 9196 and a shaft protector, tool No. 625A or 9212, to remove the bearing from the shaft, Figure 8.

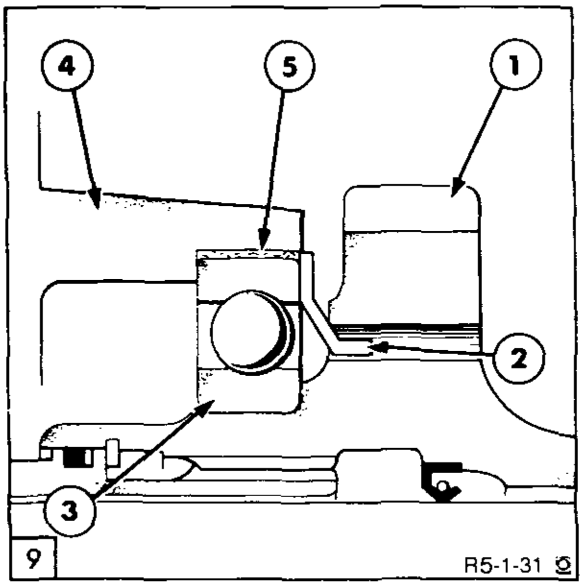
   Use a sleeve of 1.25 in (32mm) internal diameter and 1.62 in (41mm) external diameter to install a new bearing onto the countershaft.

RE-ASSEMBLY

1. Install the front support plate to the transmission case using a new gasket. If necessary, lift the mainshaft and main countershaft to align the countershaft front bearing. Install the retaining bolts and tighten to 32 lbf.ft (44 Nm).

   Transmissions With Dual Power: Re-assemble the Dual Power components as detailed in Chapter 4.

NOTE: *Ensure the anti-spin washer is installed between the mainshaft front gear and front bearing if the bearing has come away with the dual power unit during disassembly. If the bearing has remained on the mainshaft, coat the outer edge of the bearing with a suitable adhesive, such as Loctite 648, to ensure the bearing does not rotate in the dual power housing, prior to reassembly, Figure 9.*



9

Anti Spin Washer – Dual Power Transmissions

1. Mainshaft Assembly
2. Anti-spin Washer
3. Bearing
4. Dual Power Housing
5. Adhesive Location

Transmission Less Dual Power: Install the main drive input shaft into the forward end of the transmission mainshaft and secure with the snap ring. Place studs in two of the five bolt holes to ensure correct alignment of the clutch release hub on assembly. This will prevent damage to the release hub oil seal. Position a new gasket on the front support plate and slide the clutch release hub support over the studs. Drive the support into position with the drain hole downwards. Remove the studs, install the retaining bolts and tighten to 49 lbf.ft (67 Nm).

2. Install the clutch release bearing and hub assembly onto the hub support.

3. Locate the release fork fingers into the slots in the hub and install the release shaft through the casing and release fork. Install the fork retaining bolt and tighten to 35 lbf.ft (47 Nm).

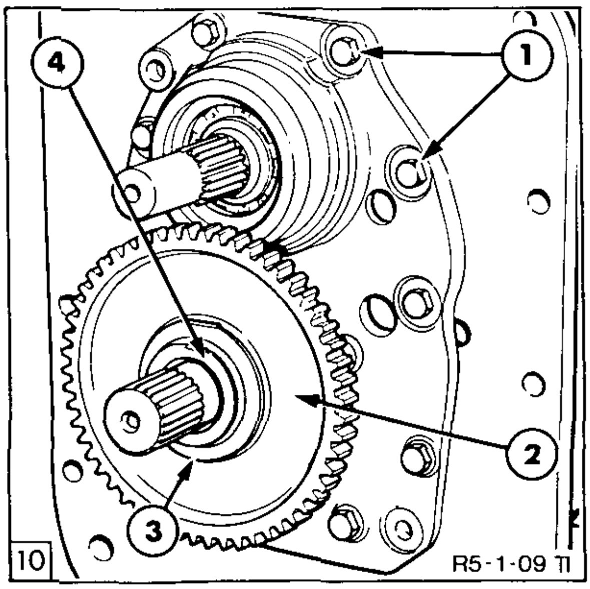
E. COMPLETE TRANSMISSION OVERHAUL

DISASSEMBLY

1. Remove the clutch operating mechanism, clutch release hub support, Dual Power transmission (where fitted), front support plate and main drive input shaft assembly as previously described in this Chapter.

2. Remove the shift levers and cover assembly as previously outlined in this Chapter, together with the safety starter switch from the high/low shift rail.

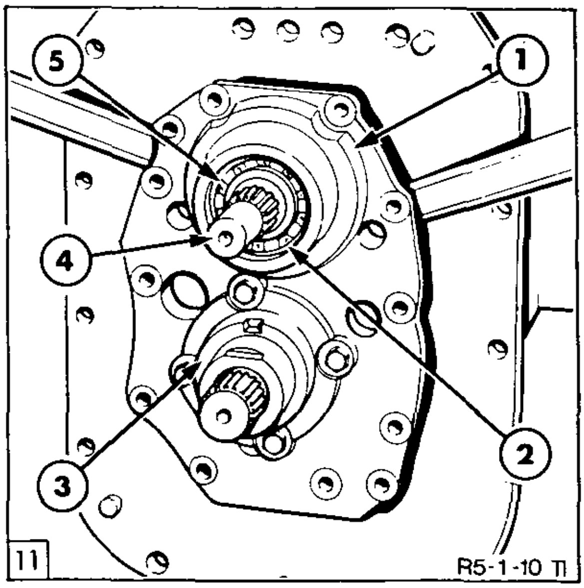
3. Remove the snap ring, the thrust washer and the hydraulic pump idler gear, located on the output shaft retainer, Figure 10.



Hydraulic Pump Idler Gear Installation

1. Rear Support Plate Retaining Bolts
2. Hydraulic Pump Idler Gear
3. Thrust Washer
4. Snap Ring

4. Remove the rear support plate retaining bolts and using a soft faced mallet drive the forward end of the P.T.O. drive shaft rearwards. This will separate the rear support plate from the transmission casing. If necessary, lever the rear support plate from the casing and withdraw the plate complete with the P.T.O. drive shaft, Figure 11.



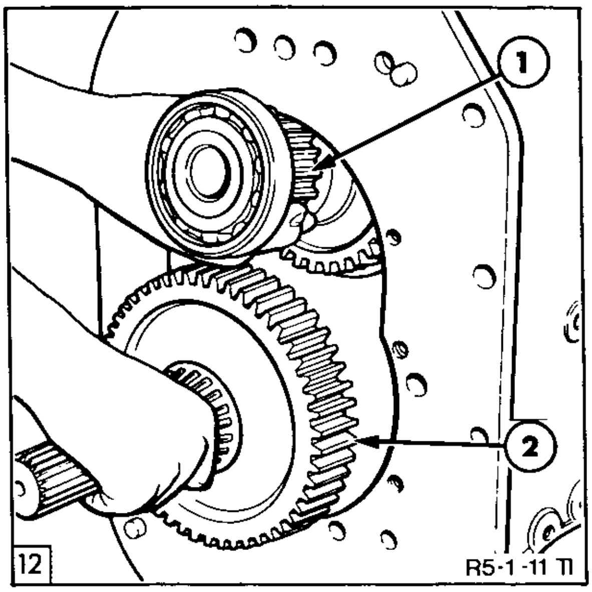
Rear Support Plate Removal

1. Rear Support Plate
2. Bearing Retaining Snap Ring
3. Output Shaft Bearing Retainer
4. P.T.O. Drive Shaft
5. P.T.O. Drive Shaft Bearing

5. Remove the snap ring retaining the P.T.O. drive shaft rear bearing and drive the shaft and bearing out of the support plate.

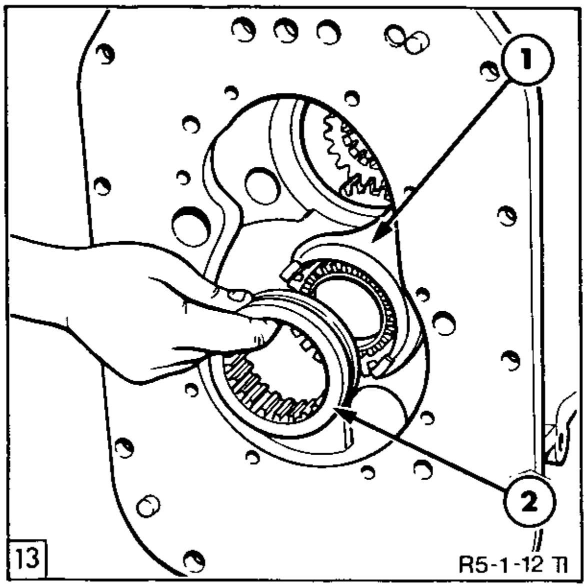
6. Remove the bolts securing the output shaft retainer to the rear support plate and withdraw the retainer and shims from the rear support plate.

7. Partially withdraw the secondary countershaft assembly until the front bearing is out of the location. Lift the secondary countershaft to allow the output shaft assembly to be removed from the rear compartment, Figure 12, followed by removal of the secondary countershaft.



Output Shaft Removal

1. Secondary Countershaft (Range Cluster gear)
2. Output Shaft Assembly



High/Low Coupling Removal

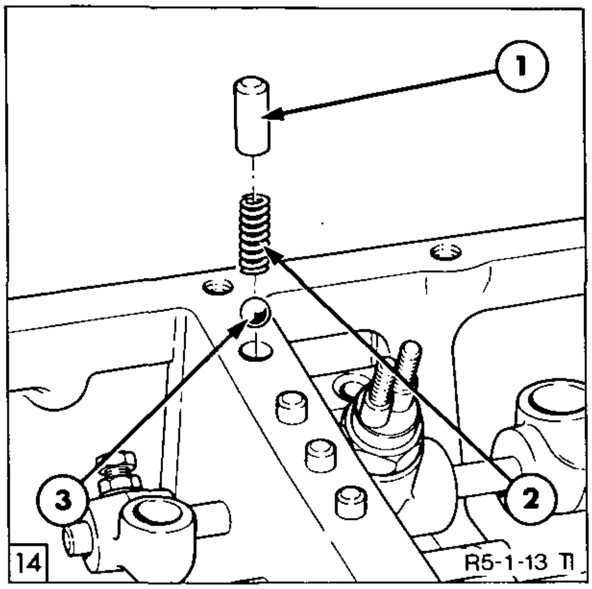
1. High/Low Shift Fork
2. High/Low Sliding Coupling

8. Remove the high/low sliding coupling from the rear of the main countershaft, Figure 13.

GEAR SHIFT MECHANISM

1. Remove the four detent plungers and springs. The detent balls located below the springs should be collected as each shift rail is removed, Figure 14.

2. Unscrew the safety start switch from the housing. Loosen the locknut and remove the bolt locking the high/low range fork to the shaft. Remove the range lever connector from the shaft and slide the rail out from the rear of the gearbox. Place a clean cloth beneath the safety start switch actuator housing. Take care to ensure the ball, spring and actuating dowel are collected from the housing and rail. Lift the high/low shift fork from the rear compartment.



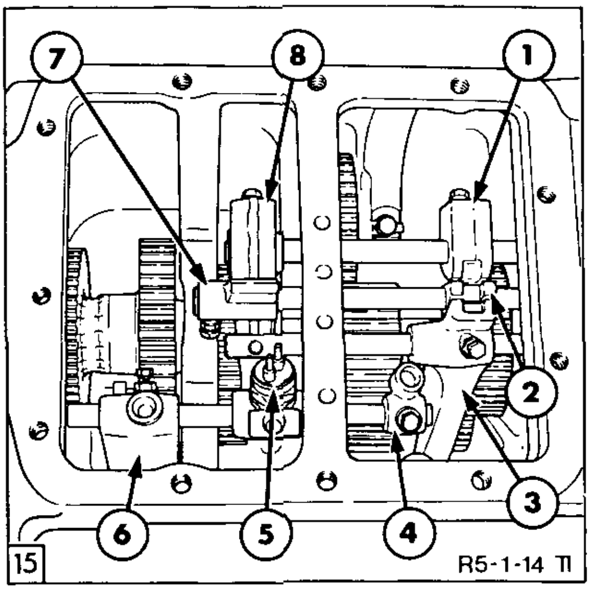
Gear Shift Detent

1. Detent Plunger
2. Spring
3. Ball

3. Unscrew the locknut and retaining screw from the 1st–5th/3rd–7th shift fork at the front of the shift rail. Drive the rail forward from the transmission casing pushing the sealing plug out with the end of the rail. Remove the shift connector and fork.

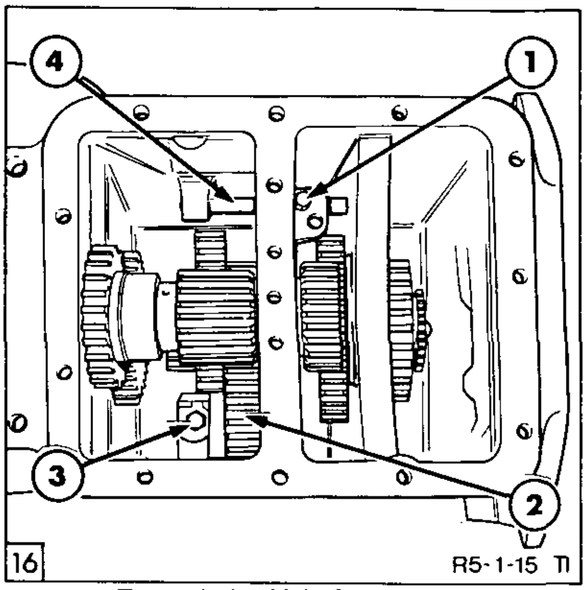
4. Unscrew the locknut and retaining screws from the 4th–8th shift fork and connector and push the shift rail rearwards from the transmission case. Remove the fork and the connector.

5. Unscrew the locknut and retaining screw from the Reverse/2nd–6th shift arm and connector and slide the top rail out rearwards. Lift the shift arm and the connector from the transmission case.



Gear Shift Mechanism

1. 4th–8th Shift Rail Connector
2. Rev/2nd–6th Shift Rail Connector
3. 1st–5th/3rd–7th Shift Fork
4. High/Low Shift Connector
5. Safety Start Switch
6. High/Low Shift Fork
7. Rev/2nd–6th Shift Arm
8. 4th–8th Shift Fork



Transmission Main Compartment

1. Reverse/2nd–6th Shift Fork Retaining Bolt
2. Reverse Idler
3. Reverse Idler Shaft Retaining Bolt
4. Lower Shift Rail

6. Remove the locknut and screw retaining the Reverse/2nd–6th shift fork to the lower shift rail, Figure 16 and push out the rail rearwards. Remove the shift fork from the transmission casing.

7. Remove the interlock plungers from the cross bore in the transmission case. If necessary, remove the bore plug situated on the left-hand side of the case to facilitate removal of the plungers.

REVERSE IDLER ASSEMBLY

1. Bend down the locktab and remove the bolt retaining the reverse idler shaft to the transmission case, Figure 16.

2. Drive the shaft out forwards and lift out the reverse idler gear.

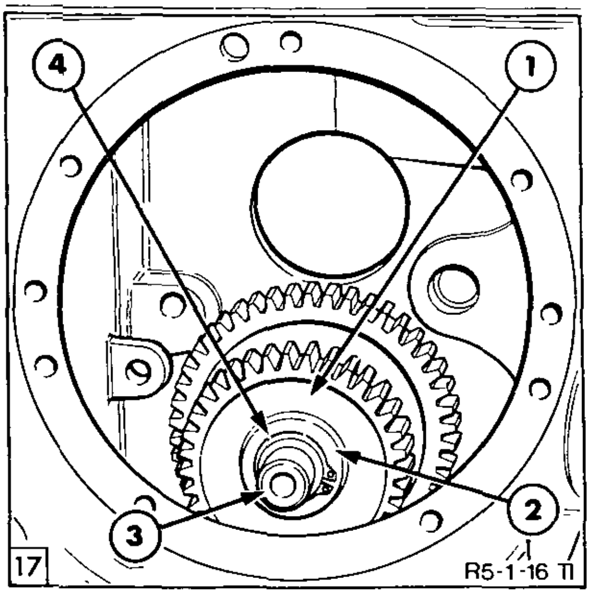
MAINSHAFT ASSEMBLY

1. Position a Step Plate, Tool No. 630S or 9210, in the bore at the rear of the mainshaft.

2. Drive the shaft forwards, using a suitable drift, from the transmission case and remove the 4th–8th coupling gear.

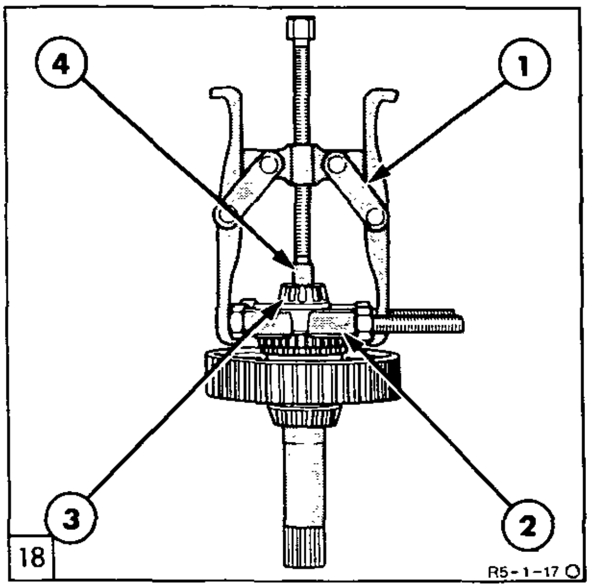
MAIN COUNTERSHAFT ASSEMBLY

1. If not previously removed, use puller, tool No. 1001 or 9196 and step plate, tool No. 630S or 9210, to remove the main countershaft front bearing. remove the snap ring located behind the bearing, Figure 17 and remove the thrust washer.



Main Countershaft (Lower Shaft) Installation

1. 3rd–7th Gear
2. Thrust Washer
3. Main Countershaft
4. Retaining Snap ring



Output Shaft Front Pilot Bearing Removal

1. Puller, Tool No. 1002 or 9198
2. Pulling Attachment, Tool No. 951 or 9190
3. Front Pilot Bearing
4. Shaft Protector Tool No. 625A or 9212

2. Withdraw the main countershaft rearwards removing the gears, couplings and thrust washer. Store these components in the order of removal to aid correct re–assembly.

NOTE: *The inner and outer sections of the sliding couplings are matched in manufacture and should not be separated.*

INSPECTION AND REPAIR

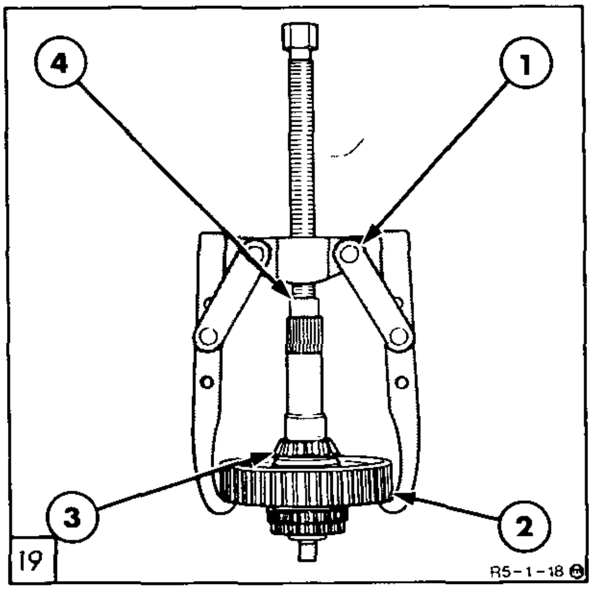
REAR END COMPONENTS

1. Inspect the P.T.O. drive shaft and bearing assembly. If the bearing is worn or damaged, use Puller, Tool No. 1003 or 9516, Pulling Attachment, Tool No. 951 or 9190 and Shaft Protector, Tool No. 625A or 9212, to effect removal. Use a convenient length of sleeve 1.44 in. (37 mm) internal diameter and 1.75 (44 mm) external diameter to install a new bearing.

2. Inspect the output shaft retainer and rear bearing cup for wear or damage. If necessary, remove the cup from the retainer using a suitable punch.

   Use Step Plate, Tool No. 630S or 9210 and a suitable punch to install the new bearing cup.

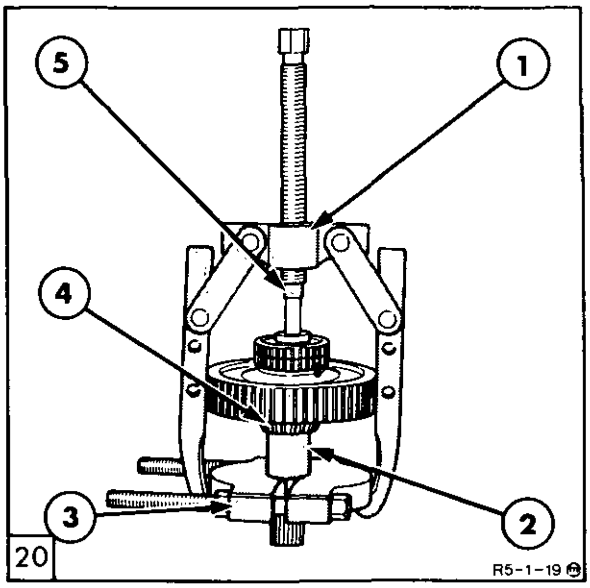
3. Examine the output shaft assembly for wear or damage. If necessary, use Puller, Tool No. 1002 or 9198, Puller Adaptor, Tool No. 951 or 9190 and Shaft Protector, Tool No. 625A or 9212, to remove the front pilot bearing cone and roller assembly, Figure 18. Use Puller, Tool No. 1003 or 9516 and Shaft Protector, Tool No. 625A or 9212, to remove the gear, rear bearing and thrust washer in one operation, Figure 19.



Output Shaft Rear Bearing Removal

1. Puller, Tool No. 1003 or 9516
2. Output Shaft Gear
3. Rear Bearing
4. Shaft Protector, Tool No. 625A or 9212

4. Inspect the output gear bushing for wear and replace the gear and bushing assembly if necessary.



Output Shaft Rear Bearing Installation

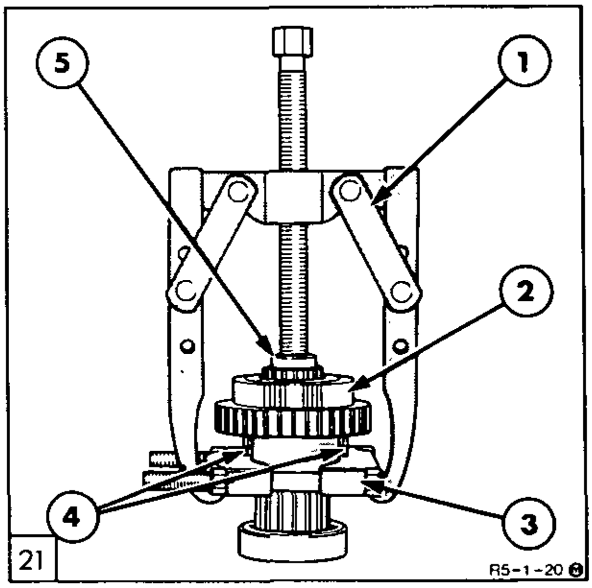
1. Puller, Tool No. 1003 or 9516
2. Sleeve
3. Pulling Attachment, Tool No. 952 or 9526
4. Rear Bearing
5. Shaft Protector, Tool No. 625A or 9212

5. Install the steel thrust washer aligning the flats on the washer with the flats on the shaft and position the rear bearing on the output shaft, Figure 30, page 18, component E. Use Puller, Tool No. 1003 or 9516, Pulling Attachment, Tool No. 952 or 9526, Shaft Protector, Tool No. 625A or 9212 and a suitable sleeve of 1.5 in. (40 mm) internal diameter, 2.00 in. (50 mm) external diameter, to pull the bearing into position, Figure 20.

6. Inspect the secondary countershaft assembly for wear or damage. If necessary, use Puller, Tool No. 1003 or 9516, Pulling Attachment, Tool No. 952 or 9526 and Step Plate, Tool No. 630S or 9210, to remove the rear bearing.

7. If necessary, remove the secondary countershaft front bearing using two steel rods 0.18 in. (48 mm) diameter and 2.0 in. (50 mm) long inserted through the two holes in the driving gear. Use Puller, Tool No. 1003 or 9516, Pulling Attachment, Tool No. 951 or 9190 and Step Plate, Tool No. 630S or 9210, to push the bearing from the countershaft, Figure 21.

8. Use Puller, Tool No. 1003 or 9516, Pulling Attachment, Tool No. 951 or 9190 and Step Plate, Tool No. 630S or 9210, to install both front and rear bearings.



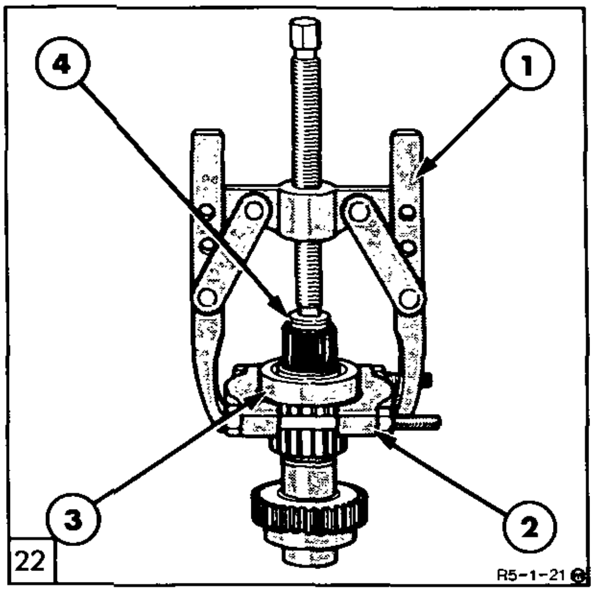
Secondary Countershaft Front Bearing Removal

1. Puller, Tool No. 1003 or 9516
2. Front Bearing
3. Pulling Attachment , Tool No. 951 or 9190
4. Steel Rods
5. Step Plate, Tool No. 630S or 9210

MAINSHAFT ASSEMBLY

1. Inspect the mainshaft assembly, the front and rear bearings and P.T.O. drive shaft oil seal located inside the forward end of the shaft.

2. If necessary, use Puller, Tool No. 1003 or 9516, Pulling Attachment, Tool No. 951 or 9190, to remove the mainshaft rear bearing, Figure 22. If necessary, remove the front bearing using two pieces of steel rod 0.18 in. (4.8 mm) diameter and 2.0 in. (50 mm) long inserted through the two holes in the main driving gear together with Puller, Tool No. 1003 or 9516, Pulling Attachment, Tool No. 951 or 9190 and Step Plate, Tool No. 630S or 9210.



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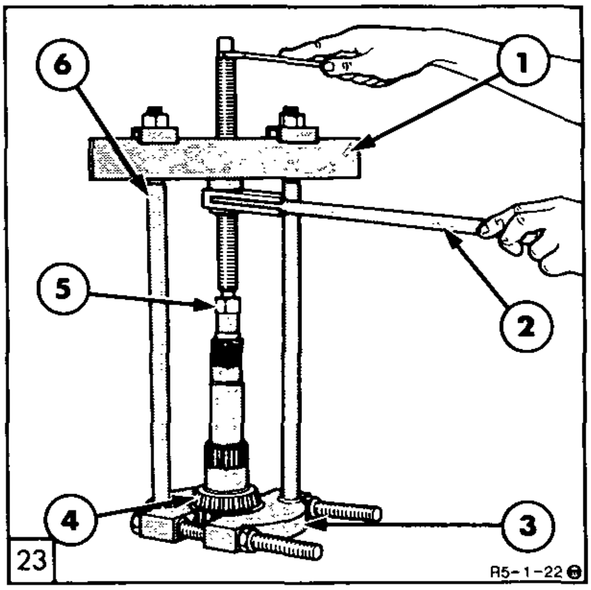
Mainshaft Rear Bearing Removal

1. Puller, Tool No. 1003 or 9516
2. Pulling Attachment, Tool No. 951 or 9190
3. Rear Bearing
4. Step Plate, Tool No. 630S or 9210



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Main Countershaft Rear Bearing Removal

1. Puller, Tool No. 938 or 9506
2. Ratchet, Tool No. P61 or 9162
3. *Pulling Attachment, Tool No. 952 or 9526*
4. Rear Bearing
5. Shaft Protector, Tool No. 625A or 9212
6. Puller Legs, Tool No. 930B or 9521

3. Use Puller, Tool No. 1003 or 9516, Pulling Attachment, Tool No. 952 or 9526 and Step Plate, Tool No. 630S or 9210 to install a new rear bearing. A new front bearing should be installed using the above tools together with a sleeve 2.5 in. (64 mm) internal diameter and 3.0 in. (76 mm) external diameter of convenient length.

4. When removing and installing the mainshaft front bearing of transmissions installed with Dual power, note that there is an anti–spin washer between the mainshaft front gear and bearing assembly. Ensure the washer is in good condition prior to reassembly.

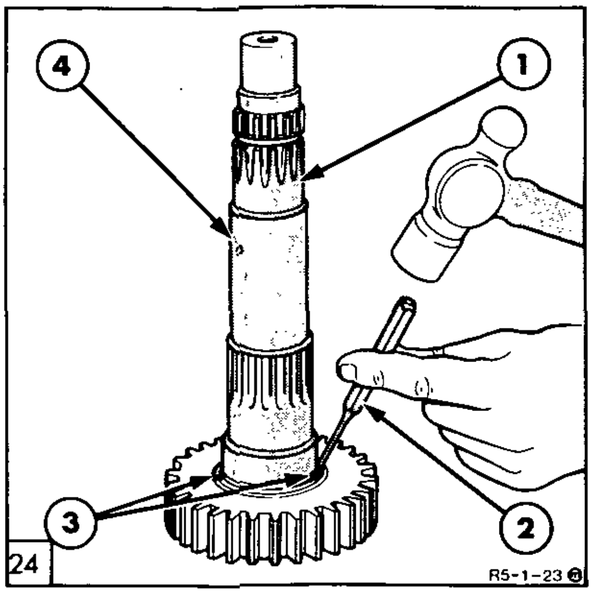
5. Inspect the P.T.O. drive shaft oil seal located within the mainshaft and remove if worn or damaged. Install a new seal, after lightly greasing the sealing lip, with the sealing lip facing rearwards. Use a Step Plate, Tool No. 630S or 9210 and sleeve of convenient size to drive the seal into location.

MAIN COUNTERSHAFT ASSEMBLY

1. Inspect the main countershaft assembly and if necessary, use Puller, Tool No. 938 or 9506, puller legs, Tool No. 930B or 9521, Ratchet, Tool No. P61 or 9162, Pulling Attachment, Tool No. 952 or 9526 and Shaft Protector, Tool No. 625A or 9212, to pull the rear bearing from the countershaft, Figure 23.

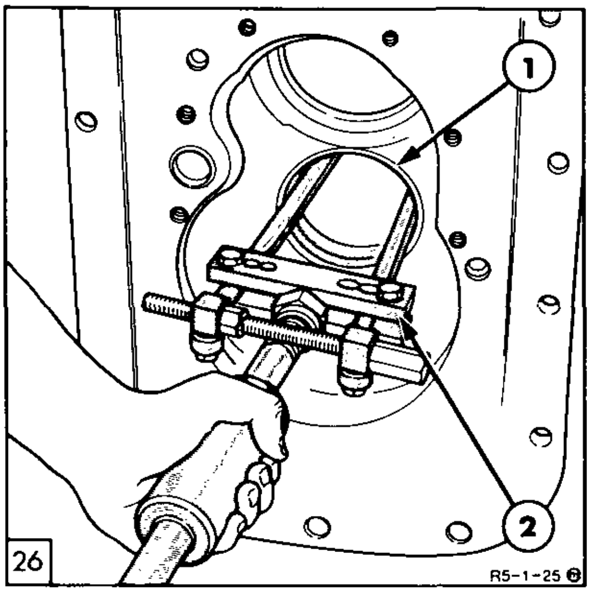
2. Examine the output shaft pilot bearing cup located in the end of the main countershaft. If necessary, remove the bearing cup using a suitable punch inserted through the two holes in the gear, Figure 24.

3. Use a suitable Step Plate, Tool No. 630S or 9210 and Puller, Tool No. 1003 or 9516, to install a new output shaft pilot bearing cup into the rear of the main countershaft.



Output Shaft Pilot Bearing Cup Removal

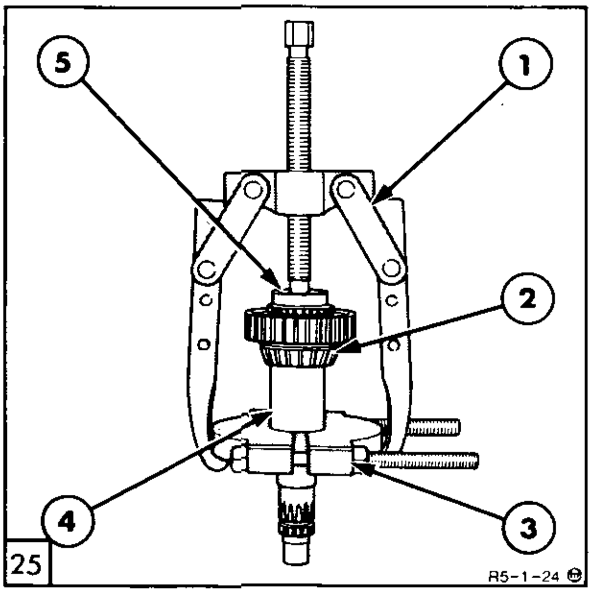
1. Main Countershaft
2. Punch
3. Access Holes
4. Lubrication Holes



Main Countershaft Rear Bearing Cup Removal

1. Rear Bearing Cup
2. Slide Hammer Tool No. 943S or 9567

4. Use Puller, Tool No. 1003 or 9516, Pulling Attachment, Tool No. 952 or 9526, Step Plate, Tool No. 630S or 9210 and a sleeve 2.00 in. (50 mm) internal diameter and 3.21 in. (58 mm) external diameter of convenient length, to install a new rear bearing onto the main countershaft, Figure 25.



Main Countershaft Rear Bearing Installation

1. Puller, Tool No. 1003 or 9516
2. Rear Bearing
3. Pulling Attachment, Tool No. 952 or 9526
4. Sleeve
5. Step Plate, Tool No. 630S or 9210

5. Inspect all gears which are mounted on the main countershaft for damage and wear. Mount the gears on the countershaft and check the bushings for free play. If any gear or bushing is worn, a new gear and bushing assembly must be installed. Similarly, examine the reverse idler gear and bushing assembly and replace if necessary.

6. Inspect the main countershaft rear bearing cup situated in the transmission case and if damaged or worn, use Slide Hammer, Tool No. 943S or 9567, to effect removal, Figure 26. Install a new cup using a suitable drift.

7. Examine the countershaft front bearing, previously removed from the front of the countershaft, for wear and damage. If necessary, install a new bearing on re–assembly.

8. Inspect all components with internal splines, external splines or gear teeth and if worn or damaged, replace on re–assembly. Ensure the lubrication oil drillings in the main countershaft are free from obstruction.

GEAR SHIFT MECHANISM

1. *Check the gear shift forks, rails, arms and* connectors for wear or distortion. Examine the detent on the shift rails and replace the shift rail if the detents are worn.

2. Renew all worn and damaged components.

TRANSMISSION CASE

1. Wash out the transmission case with a suitable solvent to remove all particles of metal and dirt. Dry with a clean, lint free cloth or compressed air.

2. Inspect the case for cracks or other damage and if beyond repair, re–assemble the transmission components into a new case.

RE–ASSEMBLY, Refer to Figure 30 during transmission re–assembly unless otherwise stated.

MAIN COUNTERSHAFT ASSEMBLY

1. Pass the main countershaft through the rear compartment and assemble the gears in the following sequence:

a) 2nd–6th Gear (dog–teeth forward).

b) Reverse/2nd–6th sliding coupling and connector.*

c) Phosphor–bronze thrust washer.

d) Reverse gear (dog–teeth rearward).

e) Phosphor–bronze thrust washer.

f) 1st–5th Gear (dog–teeth forward).

g) 3rd–7th/1st–5th Sliding coupling and connector.*

h) 3rd–7th Gear (dog–teeth rearward).

i) Thrust washer

j) *Snap ring.*

k) Front bearing.

* **NOTE:** *These connectors have a chamfer on one side of the inside diameter. This chamfer must face the rear of the transmission to allow the connector to seat correctly on the main countershaft splines. The sliding coupling and connector are matched in manufacture and should be installed with the etched marks aligned.*

2. Support the main countershaft during reassembly and ensure the rear bearing is seated squarely in the bearing outer track.

3. Position the high/low sliding coupling on the rear of the main countershaft.

MAINSHAFT ASSEMBLY

1. Ensure the snap ring retaining the mainshaft rear bearing is in position in the transmission casing.

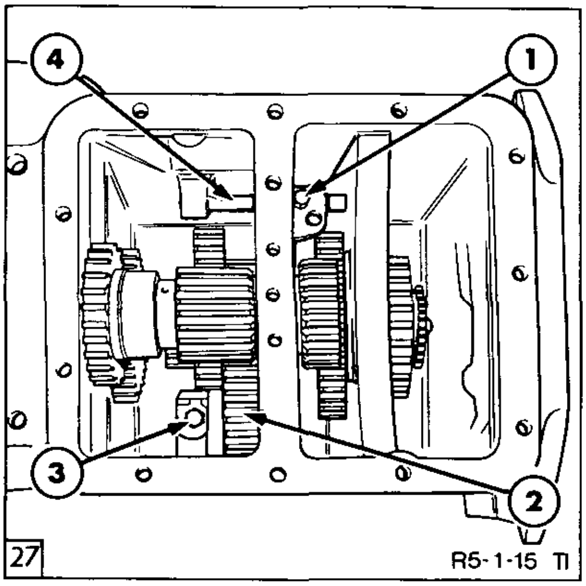
2. Install the 4th–8th coupling gear on the rear of the mainshaft with the shift fork groove to the front.

3. Position the mainshaft assembly in the transmission casing.

4. Drive the mainshaft assembly rearwards to seat the rear bearing in the location within the casing.

REVERSE IDLER ASSEMBLY

1. Position the reverse idler gear between the supporting lugs, Figure 27, with the extended hub of the gear towards the front of the transmission.



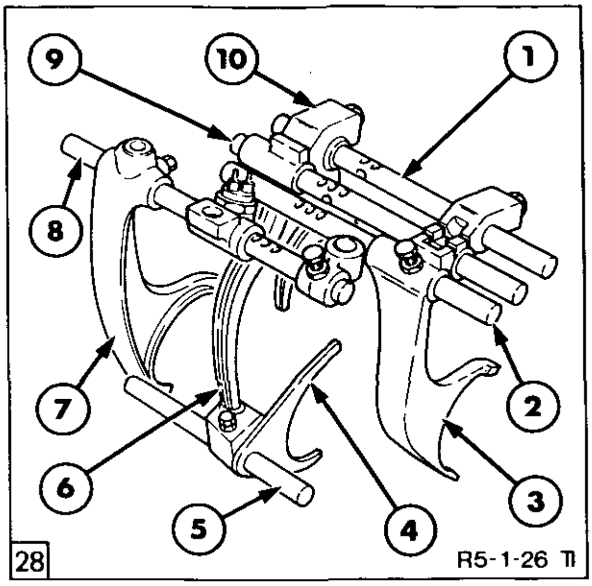
Transmission Main Compartment

1. Reverse/2nd–6th Shift Fork Retaining Bolt
2. Reverse Idler
3. Reverse Idler Shaft Retaining Bolt and Lock Tab
4. Lower Shift Rail

2. Install the reverse idler shaft from the rear compartment with the retaining bolt hole forwards. Install the retaining bolt and locktab, tighten the bolt to 17 lbf.ft (24 Nm) and bend up the locktab.

GEAR SHIFT MECHANISM

1. Locate the Reverse/2nd–6th shift fork onto the appropriate sliding coupling on the main countershaft and install the lower shift rail from the rear compartment with the fork retaining hole to the rear of the shift rail, Figure 28. Install the fork retaining screw and lock nut then tighten the screw to 23 lbf.ft (31 Nm). Secure with the lock nut.



Gear Shift Mechanism

1. 4th–8th Shift Rail
2. 1st–5th/3rd–7th Shift Rail
3. 1st–5th/3rd–7th Shift Fork
4. Reverse/2nd–6th Shift Fork
5. Lower Shift Rail
6. Reverse/2nd–6th Shift Arm
7. High/Low Shift Fork
8. High/Low Shift Rail
9. Reverse/2nd–6th Shift Rail
10. 4th–8th Shift Fork

2. Insert the two interlock plungers into the bore from the left–hand side of the transmission case and install the screwed plug. Position each plunger between the three shift rail bores.

3. Position the 4th–8th shift fork on the sliding coupling. Install the shift rail from the rear, with the oil relief groove rearwards and pass through the bore in the shift fork. Install the retaining screw and locknut and tighten to 23 lbf.ft (31 Nm).

NOTE: *When installing the remaining top shift rails, ensure the rails already installed are in the neutral position so the interlock plungers do not prevent the rail from entering the front support bore.*

4. Position the lower end of the Reverse/2nd–6th shift arm into the locating hole in the Reverse/2nd–6th shift fork. Pass the Reverse/2nd–6th top shift rail in from the rear with the oil relief groove rearwards. With the shift rail correctly located in the shift arm, install the retaining screw and locknut then tighten to 23 lbf.ft (31 Nm).

5. Position the 1st–5th/3rd–7th shift fork in the sliding coupling located at the front of the main countershaft. Install the 1st–5th/3rd–7th shift rail from the front of the transmission. Correctly locate the rail in the shift fork and secure with the retaining screw. Install the shift connector to the rear of the rail and secure with the retaining screw. Tighten the retaining screws and lock nuts to 23 lbf.ft (31 Nm). Install the sealing plug at the front of the rail.

6. Position the high/low shift fork in the groove of the high/low sliding coupling located on the output shaft. Install the high/low shift rail and correctly locate in the shift fork. Secure the shift fork with the retaining screw and tighten the screw and lock nut to 23 lbf.ft (31 Nm).

7. Install the four shift rail detent balls, springs and plungers. Ensure the balls and plungers slide freely in the bores.

NOTE: *The shorter plunger is located in the vertical bore above the high/low shift rail.*

REAR END COMPONENTS

1. Ensure the snap ring located immediately in front of the secondary countershaft front bearing is in position in the transmission casing bore.

2. Place the secondary countershaft assembly in the approximate location and hold the assembly at the top of the rear compartment whilst the output shaft assembly is installed. Align the secondary countershaft and drive forwards until the front bearing seats against the locating snap ring in the transmission case.

3. Locate the rear support plate, less the output shaft retainer assembly, on the transmission rear face. Drive the plate into position on the dowels then install the retaining bolts and tighten to 32 lbf.ft (44 Nm).

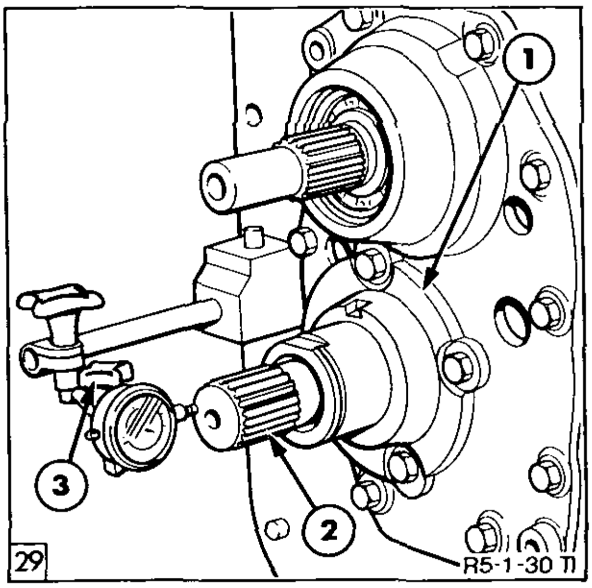
4. Install the P.T.O. drive shaft and rear bearing through the transmission from the rear and use a soft–faced mallet to drive the shaft and bearing into position. Secure the rear bearing with the snap ring.

5. To obtain the specified end play in the output shaft taper roller bearings, shims of appropriate thickness have to be installed between the rear support plate and the output shaft bearing retainer according to the following procedure:

(i) Install shims to a thickness of approximately 0.06 in. (1.6 mm) and locate the output shaft bearing retainer assembly on the rear support plate.

(ii) Install the four retaining bolts and tighten to 32 lbf.ft (44 Nm).

(iii) Position the plunger of a dial indicator gauge against the end face of the output shaft, Figure 29. Lever the shaft in and out and note the end play reading. If no end play is registered, add additional shims to produce a gauge reading.



Checking Output Shaft End Play

1. Output Shaft Bearing Retainer
2. Output Shaft
3. Dial Indicator

(iv) Remove the indicator gauge and the four retainer bolts. Withdraw the retainer and shims.

(v) Remove a number of shims to obtain an end float between 0.0015 in (0.038 mm) and 0.0034 (0.086 mm)

NOTE: *Shims are available in thicknesses of 0.003 in., 0.005 in. and 0.012 in. (0.076 mm, 0.127 mm and 0.305 mm).*

(vi) Having selected the correct shims, install the bearing retainer, with the oil slot to the top, shims and bolts. Tighten the bolts to 32 lbf.ft (44 Nm). Re–position the dial indicator gauge and re–check for end play.

6. Install the hydraulic pump idler gear, thrust washer and snap ring.

Re–assembly of the front end components follows the procedure detailed in Section D of this Chapter.

Installation of the shift levers and cover and the safety start switch follows the procedure detailed in Section C of this Chapter.

INSTALLATION

1. Re–connect the transmission to the engine and rear axle, see "SEPARATING THE TRACTOR".

2. Refill the transmission/rear axle with the correct grade and quantity of oil, meeting Ford New Holland specification ESN–M2C134–D.

Key to Figure 30

Transmission Components

A – Input Shaft Assembly

1. Clutch Release Bearing Hub Support
2. 'O' Ring Seal
3. Input Shaft Seal
4. Input Shaft Retaining Clip
5. Seal
6. Input Shaft
7. Seal

B – Top Shaft (Mainshaft)

1. Input Cluster Gear Front Bearing
2. Anti–Spin Washer – With Dual Power Only
3. Input Cluster Gear
4. Input Cluster Gear Rear Bearing
5. Casing Snap Ring
6. 4th–8th Connector Gear

C – Secondary Countershaft (Range Cluster)

1. Casing Snap Ring
2. Secondary Countershaft Front Bearing
3. Secondary Countershaft Gear Cluster
4. Secondary Countershaft Rear Bearing

D – Main Countershaft

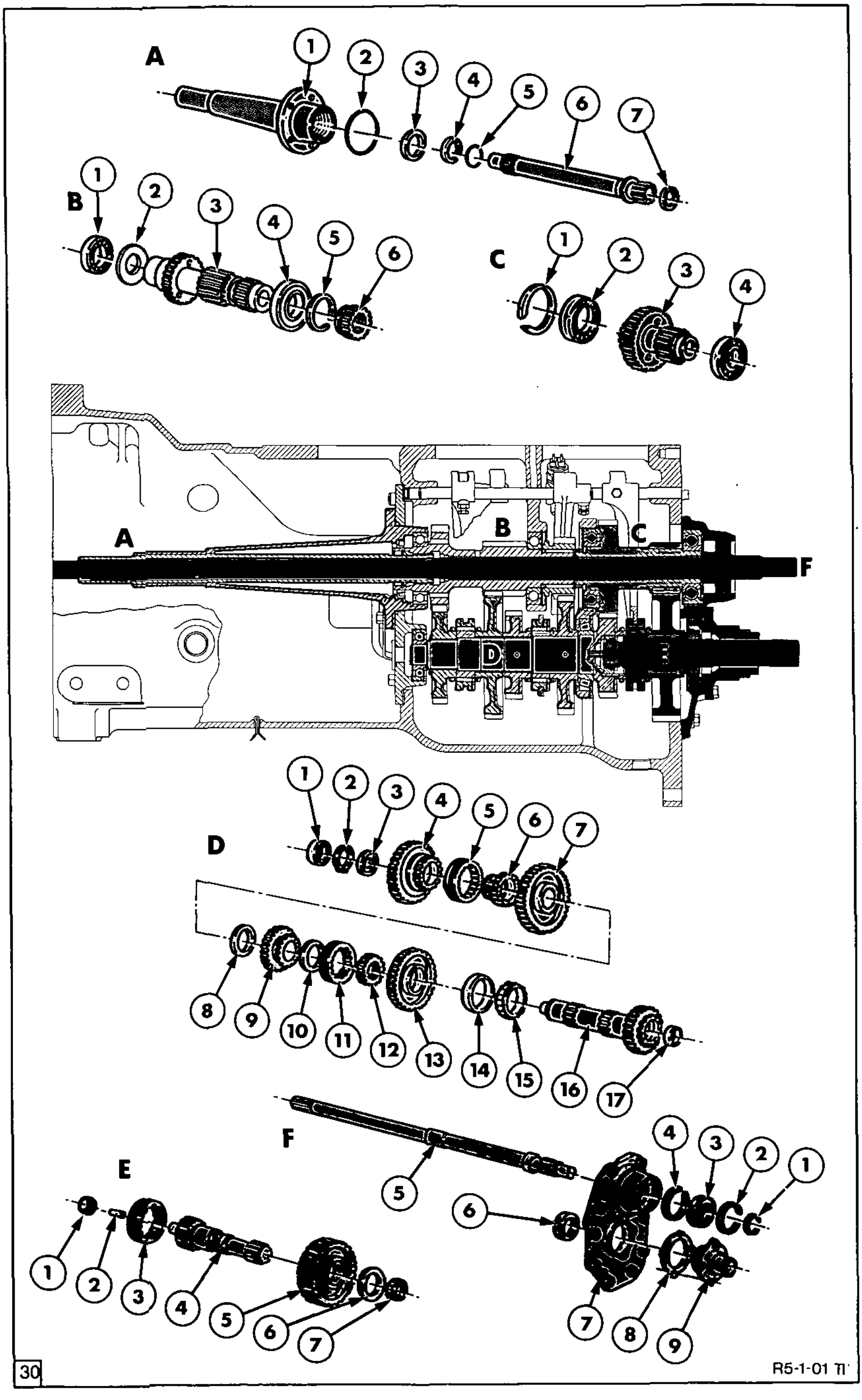
1. Main Countershaft Front Bearing
2. Snap Ring
3. Washer
4. 3rd – 7th Gear
5. *Coupling Matched With Connector, item 6*
6. Connector Matched With Coupling, Item 5
7. 1st – 5th Gear
8. Washer
9. Reverse Gear
10. Washer
11. Coupling Matched With Connector, Item 12
12. Connector Matched With Coupling, Item 11
13. 2nd – 6th Gear
14. Bearing Outer Cup
15. Taper Bearing
16. Countershaft
17. Bearing Outer Cup

E – Output Shaft Assembly

1. Taper Bearing
2. Lube Oil Transfer Tube
3. High/Low range Coupling
4. Output Shaft
5. Low Range Gear
6. Thrust Washer
7. Taper Bearing

F – End Cover Assembly

1. Snap Ring
2. Snap Ring
3. P.T.O. Shaft Bearing
4. Snap Ring
5. P.T.O. Shaft
6. Bearing Outer Cup
7. End Cover
8. Shims
9. Output Shaft Retainer


A
1
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B
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D
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R5-1-01 TI

F. SPECIFICATIONS, TIGHTENING TORQUES AND SPECIAL TOOLS

SPECIFICATIONS

Output Shaft End float	0.0015 – 0.0034 (0.038 – 0.086 mm)
Output Shaft End Float Shims Available	0.003 in (0.076 mm) 0.005 in (0.127 mm) 0.012 in (0.305 mm)
Oil Capacity	Common With Rear Axle
Imp. gallons U.S. gallons Litres	14.5 17.4 66.0
Transmission/Rear Axle Oil Specification	Ford ESN–M2C134–D

Ground Speed Charts

The charts on the two following pages show the ground speeds in MPH and km/h. The charts are for tractors fitted with Dual Power and creeper gears. If your tractor does not have either of these features, then the lines on the chart that are preceded by 'C' or 'Power' should be ignored. The road speeds in the charts relate to tractors with 16.9 – 34 rear tyres. If the rear tyres of your tractor are of a different size, then **multiply** each of the ground speeds shown in the printed charts by the following conversion factors:

Rear tyre size	Conversion factor
13.6 – 36 13.6 – 38	0.960 0.993
16.9 – 30 16.9 – 38	0.933 1.067
18.4 – 26 18.4 – 30 18.4 – 34 18.4 – 38	0.899 0.966 1.033 1.101
20.8 – 38	1.148

Ground Speeds in Miles per Hour (16.9 – 34 Rear Tyres)

Main Shift Lever	Range Lever	Dual Power	Miles per hour Engine Speed (rev/min) 1500	1900	2100	2200	Trans Gear Ratio
1	C	Power	0.16	0.20	0.23	0.24	67.08
1	C	Direct	0.21	0.27	0.30	0.31	52.18
2	C	Power	0.20	0.26	0.29	0.30	53.75
2	C	Direct	0.26	0.33	0.37	0.38	41.81
3	C	Power	0.36	0.46	0.50	0.53	30.63
3	C	Direct	0.46	0.59	0.65	0.68	23.82
4	C	Power	0.48	0.61	0.68	0.71	22.50
4	C	Direct	0.63	0.80	0.88	0.92	17.50
1	L	Power	0.93	1.18	1.31	1.37	11.74
1	L	Direct	1.20	1.52	1.69	1.76	9.13
2	L	Power	1.17	1.49	1.64	1.72	9.41
2	L	Direct	1.51	1.91	2.11	2.21	7.32
3	L	Power	2.05	2.60	2.88	3.01	5.36
3	L	Direct	2.64	3.34	3.70	3.87	4.17
4	L	Power	2.80	3.54	3.91	4.10	3.94
4	L	Direct	3.59	4.55	5.03	5.27	3.06
1	H	Power	3.35	4.25	4.69	4.92	3.29
1	H	Direct	4.30	5.45	6.03	6.31	2.56
2	H	Power	4.18	5.29	5.85	6.13	2.63
2	H	Direct	5.38	6.81	7.53	7.89	2.05
3	H	Power	7.34	9.29	10.27	10.76	1.50
3	H	Direct	9.44	11.95	13.20	13.84	1.17
4	H	Power	9.99	12.65	13.98	14.65	1.10
4	H	Direct	12.84	16.26	17.98	18.83	0.86
R	C	Power	0.31	0.39	0.33	0.45	46.67
R	C	Direct	0.36	0.46	0.42	0.53	36.30
R	L	Power	1.35	1.71	1.89	1.98	8.17
R	L	Direct	1.73	2.19	2.42	2.54	6.35
R	H	Power	4.81	6.10	6.74	7.06	2.29
R	H	Direct	6.19	7.84	8.67	9.08	1.78

Ground Speeds in Kilometers per Hour (16.9 – 34 Rear Tyres)

Main Shift Lever	Range Lever	Dual Power	Kilometers per hour Engine Speed (rev/min) 1500	1900	2100	2200	Trans Gear Ratio
1	C	Power	0.27	0.34	0.37	0.39	67.08
1	C	Direct	0.34	0.47	0.48	0.50	52.18
2	C	Power	0.33	0.41	0.46	0.48	53.75
2	C	Direct	0.42	0.54	0.59	0.62	41.81
3	C	Power	0.58	0.73	0.81	0.85	30.63
3	C	Direct	0.74	0.94	1.04	1.09	23.82
4	C	Power	0.78	0.99	1.10	1.15	22.50
4	C	Direct	1.01	1.28	1.42	1.48	17.50
1	L	Power	1.51	1.91	2.11	2.21	11.74
1	L	Direct	1.94	2.45	2.72	2.84	9.13
2	L	Power	1.88	2.38	2.64	2.76	9.41
2	L	Direct	2.42	3.07	3.39	3.55	7.32
3	L	Power	3.31	4.19	4.63	4.85	5.36
3	L	Direct	4.25	5.38	5.95	6.23	4.17
4	L	Power	4.50	5.70	6.30	6.60	3.94
4	L	Direct	5.78	7.32	8.10	8.48	3.06
1	H	Power	5.39	6.83	7.55	7.91	3.29
1	H	Direct	6.93	8.77	9.70	10.16	2.56
2	H	Power	6.73	8.52	9.42	9.87	2.63
2	H	Direct	8.65	10.96	12.11	12.69	2.05
3	H	Power	11.81	14.96	16.63	17.32	1.50
3	H	Direct	15.18	19.23	21.25	22.27	1.17
4	H	Power	16.07	20.36	22.50	23.57	1.10
4	H	Direct	20.67	26.18	28.93	30.31	0.86
R	C	Power	0.38	0.48	0.53	0.56	46.67
R	C	Direct	0.49	0.62	0.68	0.72	36.30
R	L	Power	2.17	2.75	3.04	3.18	8.17
R	L	Direct	2.79	3.53	3.90	4.09	6.35
R	H	Power	7.75	9.81	10.85	11.36	2.29
R	H	Direct	9.96	12.62	13.95	14.61	1.78

TIGHTENING TORQUES

	Lbf.ft	Nm
Clutch Release Bearing Hub Support Bolts	49	67
Clutch Release Fork Bolt	35	47
Front Support Plate Bolts	32	44
Gear Shift Cover Assembly Bolts	41	56
Gear Shift Forks and Connectors (Bolts and Locknuts)	23	31
Output Shaft Retainer Bolts	32	44
Rear Support Plate Bolts	32	44
Reverse Idler Shaft Retaining Bolt	17	24
Safety Start Switch	30	40

SPECIAL TOOLS

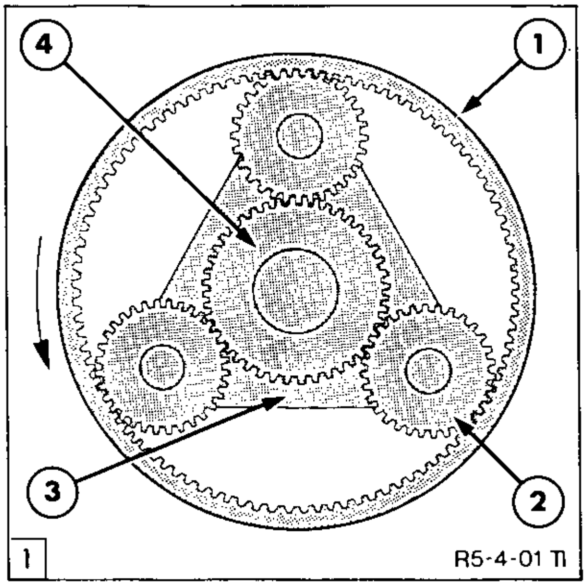
DESCRIPTION	V.L. CHURCHILL LTD TOOLS	NUDAY TOOLS
Heavy Duty Ratchet	P61	9162
Slide Hammer	MS.284	9567
Shaft Protectors	625A	9212
Step Plates	630S	9210
Puller Legs	930B	9521
Puller	938	9506
Internal/External Puller	943	9507
Slide Hammer	943S	9567
Pulling Attachments:		
Small	951	9190
Large	952	9526
Pullers:		
Small	1001	9196
Medium	1002	9198
Large	1003	9516

PART 5
TRANSMISSION SYSTEMS
Chapter 4
DUAL POWER TRANSMISSION

A. DUAL POWER TRANSMISSION – DESCRIPTION AND OPERATION

The Dual Power transmission consists of a planetary gear set installed directly between the clutch and the input shaft of the transmission.

The planetary gear set incorporates two hydraulically operated clutches which lock an element or elements of the planetary gear system together to produce either a normal direct drive to the transmission or a power underdrive which lowers the speed but increases the torque.



Dual Power Planetary Gear Set – Normal Direct Drive Operation

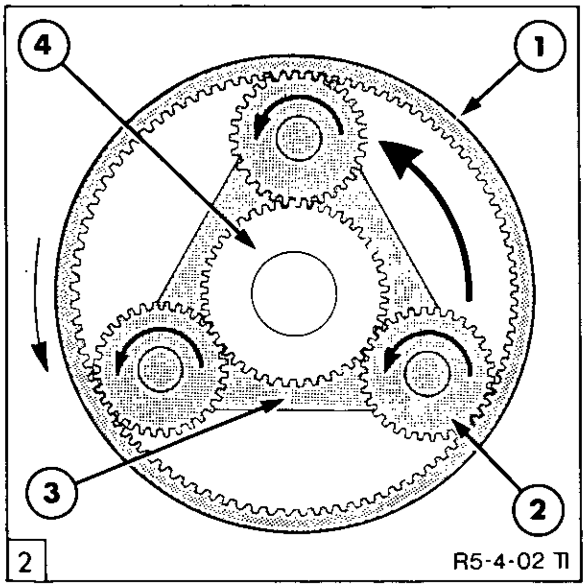
1. Ring Gear
2. Pinion
3. Planetary Carrier
4. Sun Gear

Normal Direct Drive

With reference to Figure 1.

Locking any two members of a planetary gear system together results in a direct drive with no change in speed or direction of rotation.

Compressing the direct drive clutch plates locks the sun gear to the planetary carrier which is the output member of the system. Applying power to the ring gear results in a normal direct drive.



Dual Power Planetary Gear Set – Power Underdrive Operation

1. Ring Gear
2. Pinion
3. Planetary Carrier
4. Sun Gear

Power Underdrive

With reference to Figure 2.

Compressing the underdrive clutch plate, locks the sun gear to the planetary housing. Applying power to the ring gear forces the pinions to rotate on their own axis and 'walk' around the sun gear, taking the planetary carrier with them. The planetary carrier is the output members of the system and turns in the same direction as the ring gear but at a lower speed with a resultant increase in torque. This condition produces a power underdrive.

The Dual Power transmission is operated by a two–position control valve, located on the side of the planetary gear set housing, which directs oil from the steering section of the tandem hydraulic system pumps, to engage either the direct drive or the underdrive clutch assembly. The oil pressure is regulated by the low pressure regulating and lubrication circuit relief valves housed within the PTO valve assembly.

The ground speeds in normal direct drive are unchanged from the previous 8–speed transmission ground speeds.

The Dual Power transmission ratios and corresponding gear shift lever positions are shown in the Specifications of Chapter 3.

Oil Flow to the Direct Drive Clutch

With reference to Figure 3.

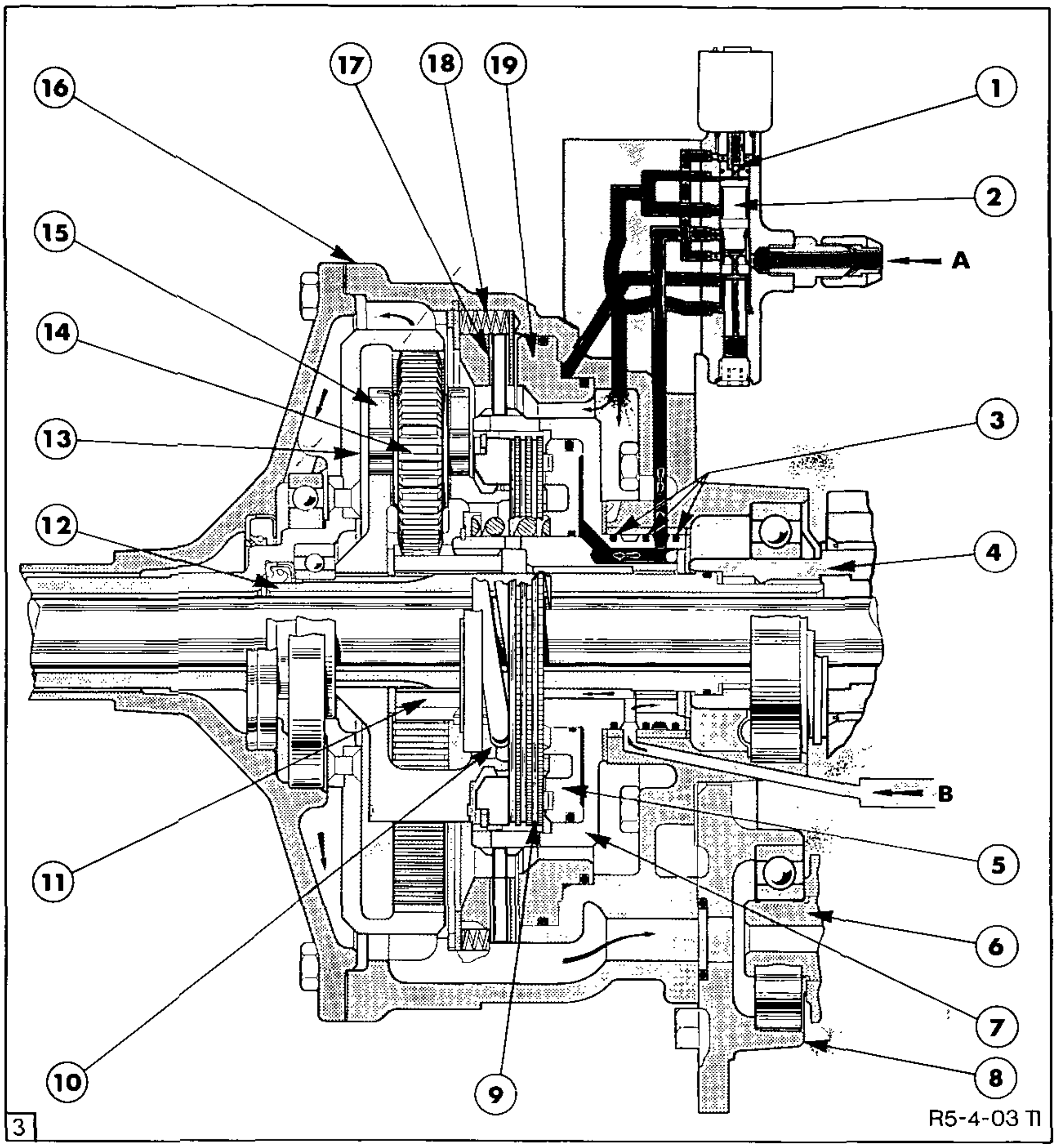
The control valve, which has no neutral position, is moved by means of a solenoid operated pilot valve. The solenoid is controlled by a switch located on the instrument panel.

When the Dual Power control switch is moved to the normal (direct drive) position, electric current flows to the control valve solenoid and so energises the solenoid coil.

The effect of energising the solenoid is to close the pilot valve, thereby preventing the oil supplied at port 'A' from acting on the top of the control valve. Supply oil can, however, still pass through the centre of the control valve and act under the control valve spool.

The hydraulic pressure acting under the control valve lifts the spool upwards, directing supply oil between the lands to the gallery drilled in the planetary housing which connects with the gap between the second and third sealing rings on the direct drive clutch hub. A drilled passage in the clutch hub allows the oil to act behind the direct drive clutch piston. The pressure moves the piston, compresses the piston spring and locks the direct drive clutch plate together so engaging the direct drive clutch.

Hydraulic oil from the rear of the underdrive clutch piston is exhausted and eventually returns to sump via the control valve and the planetary housing. Exhaust oil in the control valve also returns to the planetary housing via a connecting passage in the control valve housing.



3

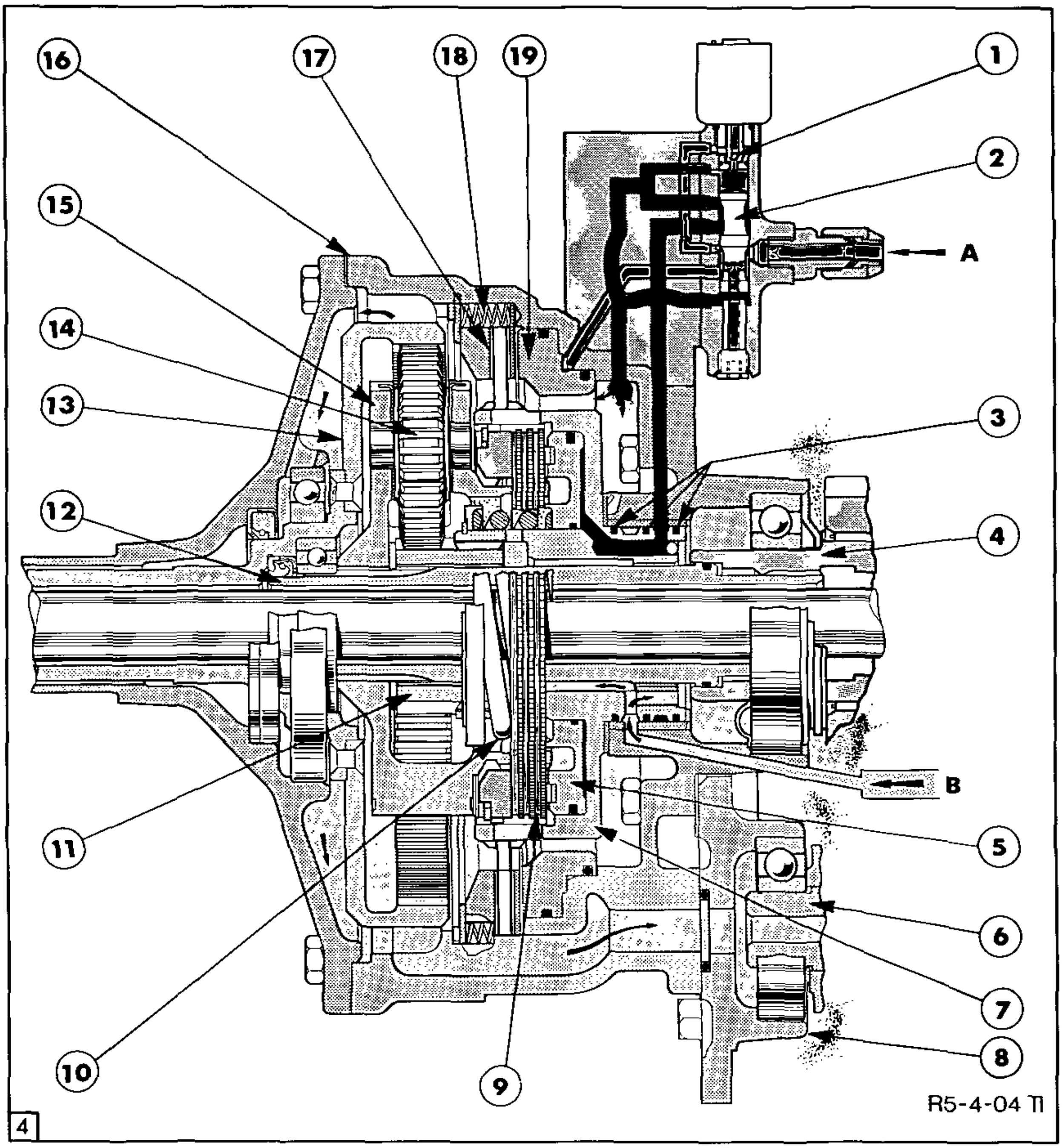
Oil Flow to Direct Drive Clutch

Pressure Oil

Lubrication Oil

Reservoir and Exhaust Oil

1. Pilot Valve
2. Control Valve Spool
3. Sealing Rings
4. Transmission Input Shaft
5. Direct Drive Clutch Piston
6. Transmission Countershaft
7. Direct Drive Clutch Housing
8. Hub Support Plate
9. Direct Drive Clutch Plates
10. Direct Drive Clutch Piston Return Spring
11. Sun Gear
12. Centre Shaft
13. Ring Gear and Input Shaft
14. Pinion
15. Planetary Carrier
16. Planetary Housing
17. Underdrive Clutch Plate
18. Underdrive Clutch Piston Return Springs
19. Underdrive Clutch Piston



Oil Flow to Underdrive Clutch

Pressure Oil

Lubrication Oil

Reservoir and Exhaust Oil

1. Pilot Valve
2. Control Valve Spool
3. Sealing Rings
4. Transmission Input Shaft
5. Direct Drive Clutch Piston
6. Transmission Countershaft
7. Direct Drive Clutch Housing
8. Hub Support Plate
9. Direct Drive Clutch Plates
10. Direct Drive Clutch Piston Return Spring
11. Sun Gear
12. Centre Shaft
13. Ring Gear and Input Shaft
14. Pinion
15. Planetary Carrier
16. Planetary Housing
17. Underdrive Clutch Plate
18. Underdrive Clutch Piston Return Springs
19. Underdrive Clutch Piston

Engaging the direct drive clutch locks the planetary carrier to the sun gear, which is splined to the direct drive clutch housing. When any two members of the planetary assembly are locked together a direct drive results with no change in speed or direction of rotation. Therefore, as the planetary carrier and the sun gear are locked together, power input at the ring gear is passed directly to the planetary carrier which is splined via a connecting shaft to the input shaft of the transmission.

Oil Flow to the Underdrive Clutch

With reference to Figure 4.

When the Dual Power control switch is moved to the power (underdrive) position, the electrical connection to the solenoid is broken and the solenoid becomes de–energised, which opens the pilot valve.

Supply oil from port 'A' can now act on both the upper and lower surfaces of the control valve. However, the area of the top of the control valve is greater than the area of the bottom, which results in the control valve being pushed down by the greater force acting on the top.

Oil from port 'A' is now directed by the control valve spool through a drilled passage in the planetary housing to the underdrive clutch piston. The pressure moves the piston, compresses the piston return springs and locks the underdrive clutch plates together so engaging the underdrive clutch.

Hydraulic oil from the rear of the direct drive clutch piston is exhausted and eventually returns to sump via the control valve and the planetary housing. Exhaust oil in the control valve also returns to the planetary housing via a connecting passage in the control valve housing.

Engaging the underdrive clutch locks the direct drive clutch housing to the planetary housing. As the sun gear is splined to the inner hub of the direct drive clutch assembly, it is also locked to the planetary housing. Applying power to the ring gear and holding the sun gear, causes the pinions of the planetary carrier to rotate on their own axis and 'walk' around the sun gear taking the carrier with them.

The carrier, being the output member of the system, turns in the same direction but at a slower speed than the ring gear, thereby producing an underdrive with a resultant decrease in speed and increase in torque.

Lubrication Oil Flow

Lubrication oil is supplied by the low pressure hydraulic system. This oil is directed via tubing through a transmission oil cooler, before entering a passage in the control valve body shown schematically at 'B' in Figure 3 and Figure 4.

The oil passes through a drilled passage in the planetary housing between the first and second sealing rings on the direct drive clutch hub and through a drilled passage in line with the direct drive clutch plates. The oil flows around the clutch plates and through the planetary assembly. As the members of the planetary assembly rotate, oil is thrown off to lubricate the bearings and other components in the housing. Oil in the bottom of the housing is directed through a tube connecting the housing with the main countershaft bearing in the hub support plate.

Excess oil in the housing flows directly into the transmission case to lubricate the transmission gears and bearings. Oil entering the hub support plate flows into the centre passage of the countershaft and lubricates the bearings and gears through cross drillings in the shaft. As the components on the countershaft and output shaft revolve, oil is carried to the input shaft and range cluster gear to lubricate the upper gears and bearings in the transmission case. Excess oil in the countershaft flows directly into the transmission casing through a slot in the front support plate.

Oil collected in the transmission case is allowed to flow into the rear axle centre housing, with which it forms a common oil reservoir, through passages in the transmission output shaft retainer.

B. FAULT FINDING

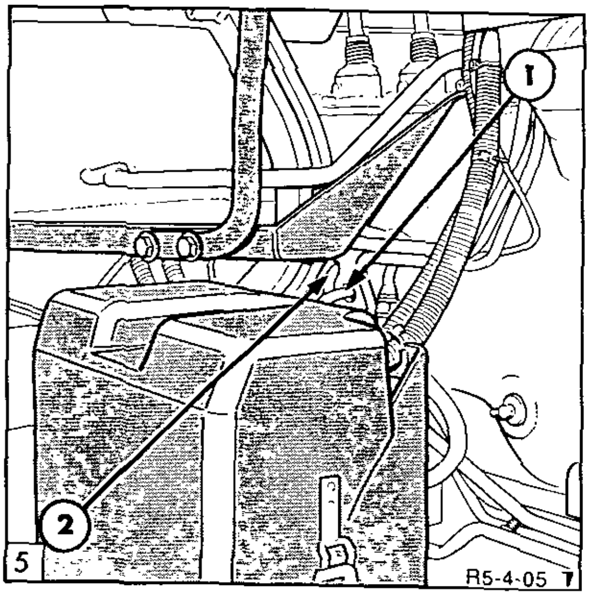
IMPORTANT: *Whenever effecting a repair the reason for the cause of the concern must be investigated and corrected to avoid repeat failures.*

The following table lists problems and their possible causes with recommended remedial action.

PROBLEM	POSSIBLE CAUSE	REMEDY
Dual power system pressure below specification in normal drive only	1. Direct drive clutch snap ring displaced 2. Damaged or leaking control valve body gasket 3. Leaking sealing rings on direct drive clutch housing hub or worn dual power housing 4. Leaking inner or outer seals on direct drive clutch piston 5. Broken or cracked direct drive clutch piston or housing	1. Replace snap ring and other damaged parts 2. Replace gasket 3. Replace sealing rings and/or dual power housing 4. Replace seals 5. Replace piston or housing
Dual power system pressure below specification in power drive only	1. Damaged or leaking control valve body gasket 2. Leaking inner or outer seals on under drive clutch piston 3. Broken or cracked underdrive clutch piston	1. Replace gasket 2. Replace seals 3. Replace piston
Dual power system pressure below specification in both normal drive and power drive	1. Fault in low pressure hydraulic circuit	1. Refer to Hydraulic Systems, Pressure Testing, Part 8, Chapter 5, Section E.
Dual power system pressure above specification in both normal drive and power drive	1. Fault in low pressure hydraulic circuit	1. Refer to Hydraulic Systems, Pressure Testing, Part 8, Chapter 5, Section E.
No power to rear wheels when normal drive engaged (power drive operative)	1. Low dual power system pressure in direct drive clutch circuit 2. Scorred, burred or binding direct drive clutch piston 3. Control valve spool jammed in underdrive position 4. Worn or defective direct drive clutch plates 5. Direct drive clutch pressure plate snap ring out of groove or broken	1. Refer to first problem 2. Replace piston 3. Check control valve spool 4. Replace clutch plates 5. Install snap ring correctly or replace

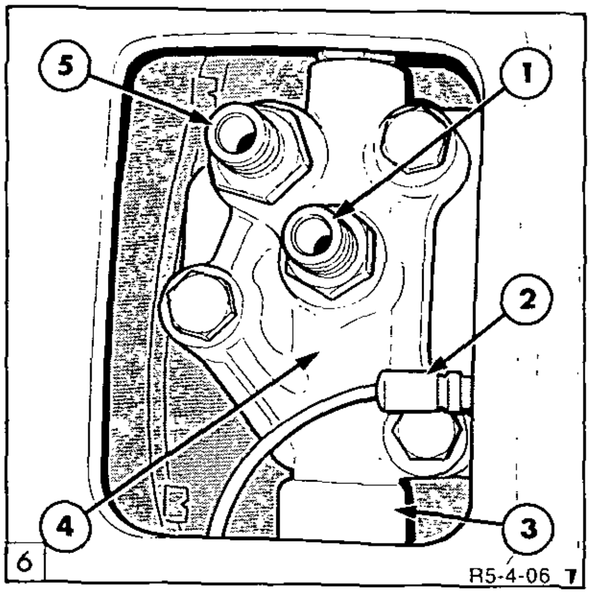
PROBLEM	POSSIBLE CAUSE	REMEDY
No power to rear wheels when power drive engaged (normal drive operative)	1. Low dual power system pressure in underdrive clutch circuit 2. Scorred, burred or binding underdrive clutch piston 3. Control valve spool jammed in direct drive position 4. Worn or defective underdrive clutch plates	1. Refer to second problem on page 6 2. Replace piston 3. Check control valve spool 4. Replace clutch plates
No power to rear wheels when dual power is engaged in normal drive or power drive	1. Low dual power system pressure 2. Defective planetary gear set ring gear, planetary carrier, sun gear, shaft or mainshaft splines 3. Main transmission or rear axle problem 4. Clutch problem	1. Check system pressure 2. Check components and replace as necessary 3. Check and overhaul as necessary 4. Overhaul clutch
Engine stalls or lugs when shifting from power drive to normal drive	1. Scorred, burred or binding underdrive clutch piston 2. Broken or defective underdrive clutch piston return springs 3. Warped or defective underdrive clutch plates	1. Replace piston 2. Replace springs 3. Replace clutch plates
Engine stalls or lugs when shifting from normal drive to power drive	1. Scorred, burred or binding direct drive clutch piston 2. Broken or defective direct drive clutch piston return springs 3. Warped or defective direct drive clutch plates	1. Replace piston 2. Replace springs 3. Replace clutch plates
Lubrication pressure below specification	1. Weak or broken cooler / lubrication valve spring, or valve stuck open 2. Blocked or restricted oil cooler	1. Overhaul cooler / lubrication valve 2. Replace oil cooler
Lubrication pressure above specification	1. Incorrect cooler / lubrication valve spring or valve stuck closed	1. Overhaul cooler / lubrication valve

C. PLANETARY GEAR SET – OVERHAUL



Dual Power Lubrication and Pressure Line Tube Connections

1. Lubrication Tube
2. Pressure Line



Dual Power Control Valve Solenoid

1. Lubrication Tube Connector
2. Solenoid Wire
3. Solenoid
4. Control Valve Body
5. Pressure line Tube Connector

REMOVAL

1. Drain the oil from the transmission and rear axle centre housings.

2. Disconnect the wiring harness from the wire assembly at the plug connector located above the transmission bell–housing. It is not necessary to take the wire assembly out of the transmission plug.

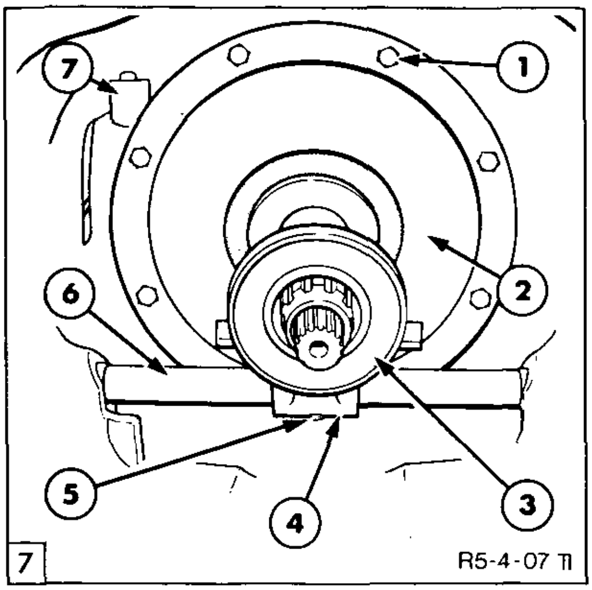
3. Pull the large rubber plug free from the transmission bell–housing and disconnect the lubrication and pressure control lines from the control valve body, Figure 5.

4. Unplug the wire assembly from the dual power solenoid wire.

5. Withdraw the bolts securing the valve body to the planetary housing and remove the valve body.

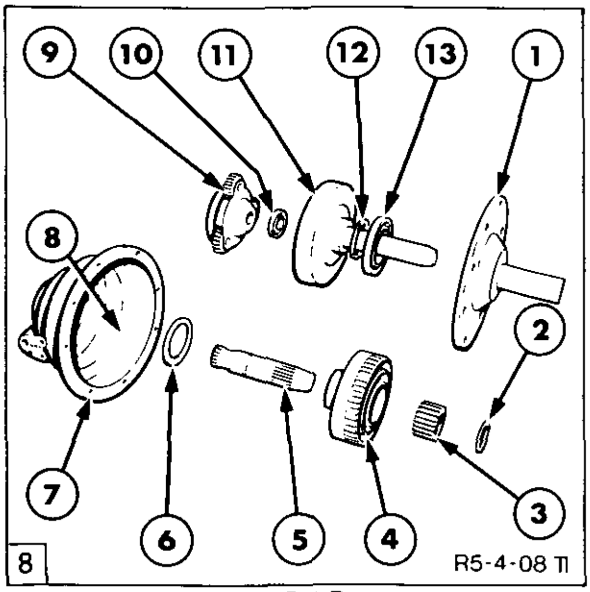
6. Remove the gasket from the valve body.

7. Remove the pressure line connector and lubrication line connector from the valve body and remove the 'O' ring seals from the connectors.



Dual Power Planetary Gear Set Installed

1. Retaining Bolts
2. Planetary Cover
3. Clutch Release Bearing
4. Clutch Release Fork
5. Clutch Release Fork Retaining Pin
6. Clutch Release Cross-Shaft
7. Control Valve



Planetary Gear Set Components – Exploded View

1. cover
2. Thrust Washer
3. Sun Gear
4. Direct Drive Clutch
5. Shaft
6. Thrust Washer
7. Planetary Housing
8. Underdrive Clutch Assembly
9. Planetary Carrier
10. Pilot Bearing
11. Ring Gear and Shaft Assembly
12. Shim
13. Ring Gear Bearing

8. Separate the engine from the transmission as described in "SEPARATING THE TRACTOR.

9. Disconnect the rod between the clutch pedal and the clutch release cross-shaft lever by removing the clevis pin at the lever end.

10. Remove the clutch release fork retaining pin, Figure 7, support the fork and withdraw the clutch release cross-shaft.

11. Remove the fork and release bearing assembly.

12. Remove the bolts from the planetary cover.

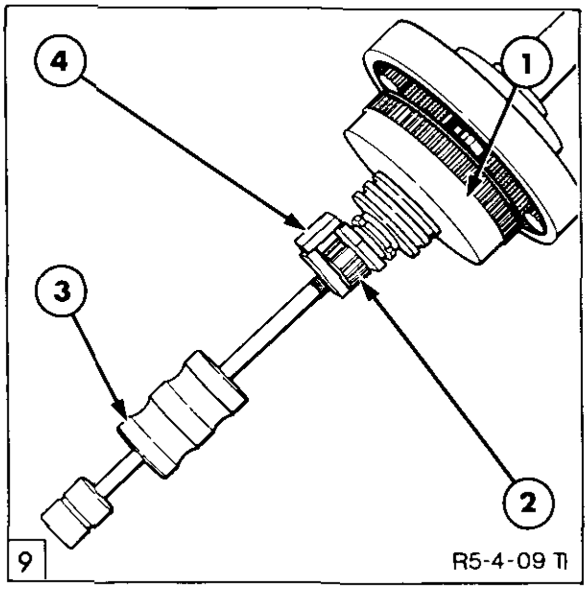
13. Carefully remove the cover from the planetary housing.

14. Remove the gasket from the cover.

15. Remove the ring gear and shaft assembly, Figure 8, from the housing.

16. Carefully remove the planetary carrier, shaft, sun gear and direct drive clutch assembly as a complete unit.

NOTE: *Removal of the ring gear may also withdraw the Dual Power reduction gear set and direct drive clutch unit from the transmission due to the shaft being a tight fit in the ring* *gear bearing. In these cases the shaft may be extracted from the ring gear bearing by means of a Slide Hammer, Tool No. MS.284 or 9567 and the Planetary Shaft Puller Tool No. FT.5004 or 4721 placed over the rear of the shaft, Figure 9.*



Dual Power Shaft Removal

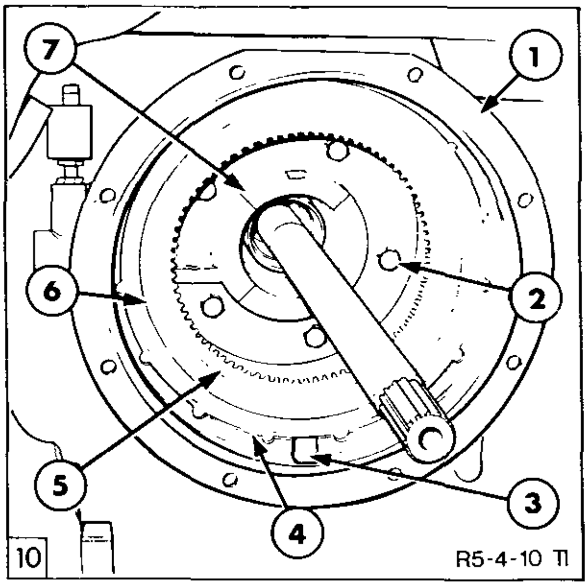
1. Direct Drive Clutch
2. Shaft
3. Slide Hammer, Tool No. MS.284 or 9567
4. Planetary Shaft Puller, Tool No. FT.5004 or 4721

17. If necessary, remove the pilot bearing from the shaft using Puller, Tool No. 1002 or 9198, Pulling Attachment, Tool No. 951 or 9190 and Step Plate, Tool No. 630–S/4 or 9210/4.

18. Remove the shaft and separate the planetary carrier from the direct drive clutch assembly.

19. Remove the sun gear from the inner splines of the direct drive clutch assembly.

20. Carefully remove the bolts securing the planetary housing to the transmission case, Figure 10.



Underdrive Clutch Assembly Installation

1. Planetary Housing
2. Retaining Bolts
3. Lubrication Supply Port
4. Snap Ring
5. Friction Plate
6. Pressure Plate
7. Thrust Washer

21. Remove the planetary housing from the case.

NOTE: *Take care not to lose the anti–spin washer located between the transmission mainshaft front gear and front bearing if the bearing comes away with the dual power housing.*

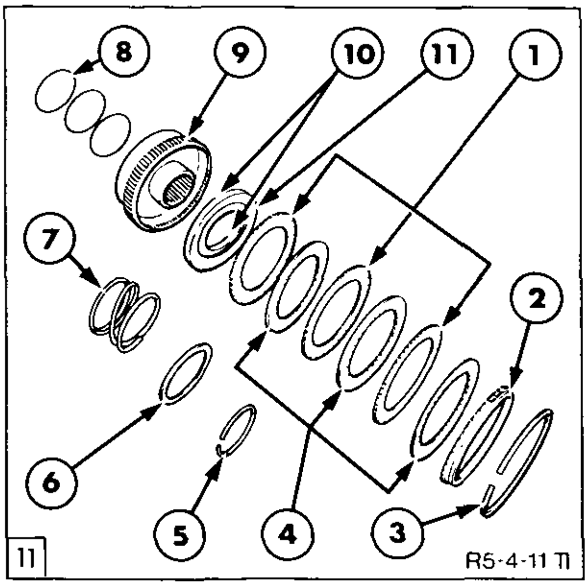
22. Remove and discard the gasket on the rear hub of the planetary housing.

23. Remove the 'O' ring between the planetary housing and the transmission front plate.

DISASSEMBLY

Direct Drive Clutch

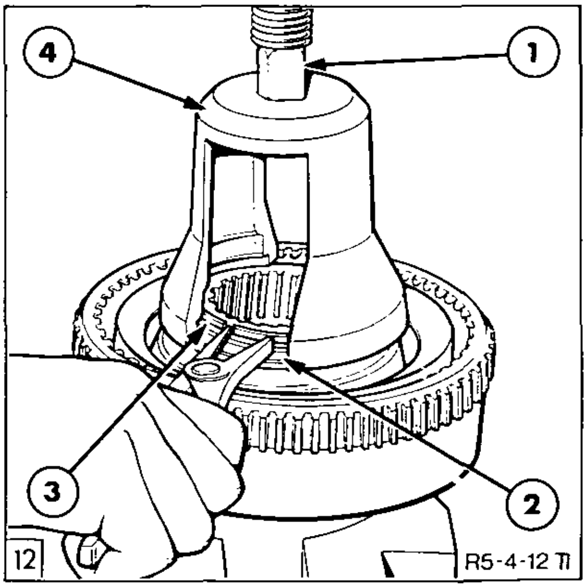
1. Remove the sealing rings, Figure 11, from the rear hub of the direct drive clutch housing.



Direct Drive Clutch Assembly – Exploded View

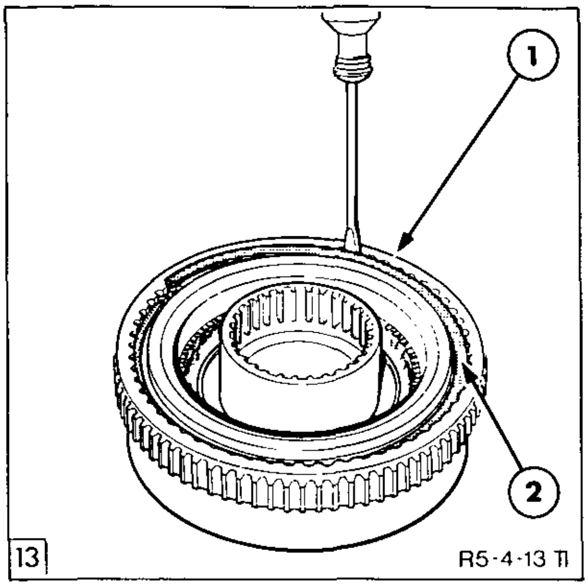
1. Steel Plates
2. Pressure Plate
3. Snap Ring
4. Friction Plates
5. Snap Ring
6. Spring Retainer
7. Piston Return Spring
8. Sealing Rings
9. Direct Drive Clutch Housing
10. Piston Seals
11. Piston

2. Depress the piston return spring and remove the snap ring from the inner hub using Clutch Compressor, Tool No. N–775 or 1312 and either Puller, Tool No. 1003 or 9516 or a press, Figure 12.



Direct Drive Clutch Piston Return Spring Snap Ring – Removal and Installation

1. Press Ram
2. Spring Retainer
3. Snap Ring
4. Clutch Compressor, Tool No. N–775 or 1312



Direct Drive Clutch Pressure Plate Snap Ring – Removal and Installation

1. Direct Drive Clutch Housing
2. Pressure Plate Snap Ring

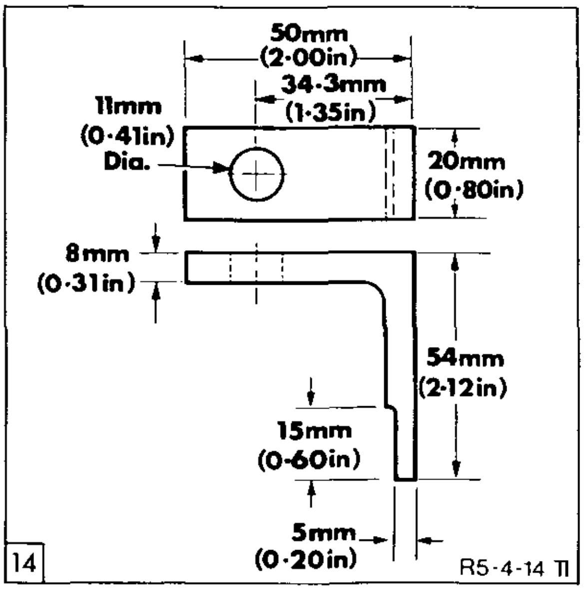
3. Release the pressure and ensure the spring retainer does not enter the snap ring groove.

4. Remove the spring retainer and spring.

5. Remove the clutch pressure plate snap ring, as shown in Figure 13.

6. Remove the pressure plate, the friction and steel plates from the clutch housing.

IMPORTANT: *Note the order in which the clutch plates were removed.*



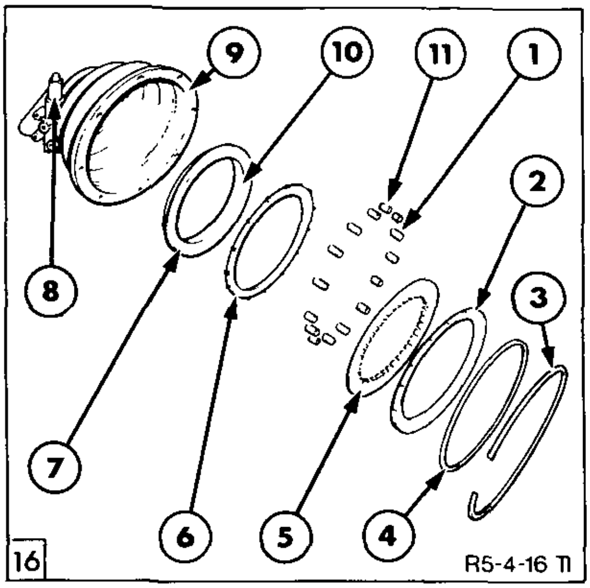
Restraining Clamp for Removal of Underdrive Clutch Snap Ring

7. Place an air hose nozzle in the hole between the middle and rear sealing ring

grooves in the clutch housing hub and blow out the piston.

IMPORTANT: *For safety, position the direct drive clutch housing with the front face down on the bench so the piston cannot cause injury when expelled.*

8. Remove the piston inner and outer seals.



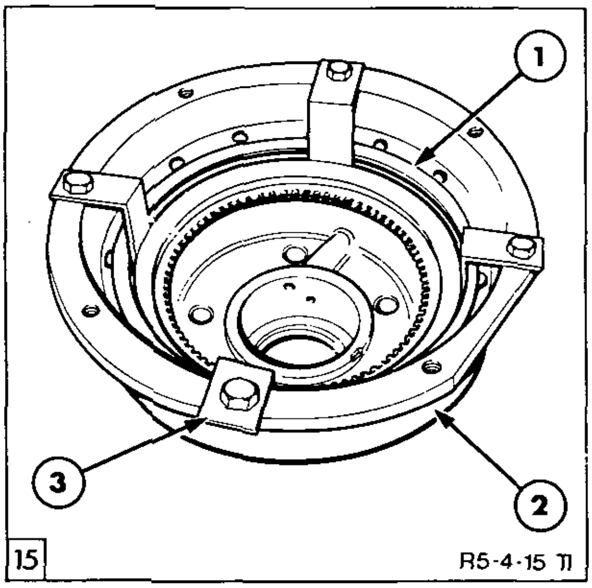
Underdrive Clutch Assembly – Exploded View

1. Piston Return Springs
2. Pressure Plate
3. Snap Ring
4. Spring Retainer
5. Friction Plate
6. Rear Plate
7. Piston Seals
8. Control Valve Body
9. Planetary Housing
10. Piston
11. Dowel Pins

Underdrive Clutch

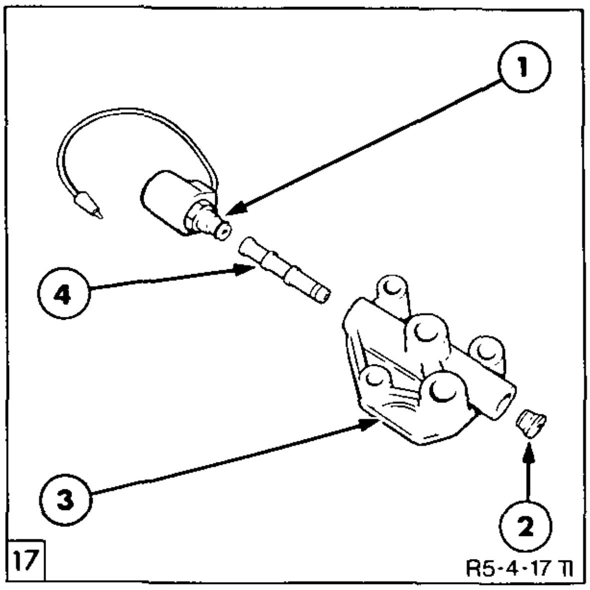
1. Remove the large snap ring from the inner surface of the planetary housing.

NOTE: *To remove the snap ring it is recommended that four restraining clamps be made as shown in Figure 14. Equispace the four clamps, Figure 15, around the rim of the planetary housing and secure with the housing bolts.*



Underdrive Clutch Snap Ring – Removal and Installation

1. Snap Ring
2. Planetary Housing
3. Restraining Clamp



Control Valve Assembly

1. Solenoid and Pilot Valve Assembly
2. Plug
3. Valve Body
4. Valve Spool

2. After removing the snap ring, gradually release the restraining clamps.

3. Remove the spring retainer, pressure plate and friction plate.

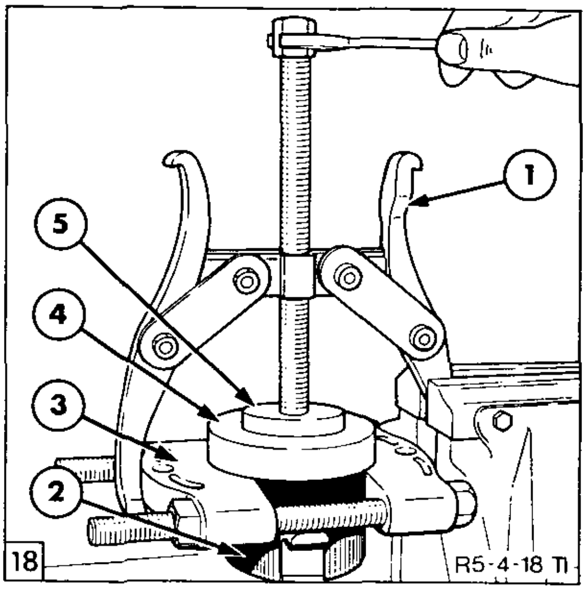
IMPORTANT: *Note the order in which the clutch plates were removed.*

4. Remove the piston return springs, locating dowel pins and rear plate.

5. Place an air hose nozzle in the pressure supply port of the control valve housing and carefully blow out the underdrive piston.

IMPORTANT: *Position the planetary housing so that the underdrive piston cannot cause injury when expelled.*

6. Remove the inner and outer seals from the piston.



Removing Clutch Release Bearing from Hub

1. Puller, Tool No. 1002 or 9198
2. Hub
3. Pulling Attachment, Tool No. 951 or 9190
4. Release Bearing
5. Step Plate, Tool No. 630–S/10 or 9210/10

Control Valve Assembly

With reference to Figure 17.

1. Remove the plug located in the control valve at the opposite end to the solenoid.

2. Remove the solenoid and pilot valve assembly.

3. Remove the control valve spool.

INSPECTION AND REPAIR

1. Clean all parts in a suitable solvent and dry thoroughly with a dry, lint–free cloth or compressed air.

2. Examine the lubrication inlet tube, the pressure inlet tube and the lubrication oil tube for damage or distortion. Discard any defective tubes.

3. Examine the control valve solenoid cable for damage or loose connections.

4. Examine the clutch release hub and bearing for excessive wear or damage. If necessary, remove the bearing from the hub with Pulling Attachment, Tool No. 951 or 9190, Step Plate, Tool No. 630–S/10 or 9210/10 and either a press or Puller, Tool No. 1002 or 9198, see Figure 18. Press a new bearing onto the hub ensuring the thrust face of the bearing faces away from the shoulder on the hub.

5. Pack the recess in the bearing hub bore with a high melting point grease.

6. Inspect the clutch release fork for cracks or excessive wear and replace as necessary.

7. Examine the cross–shaft and lever for distortion or excessive wear and install a new assembly, if damage is evident. Inspect the shaft bushings for excessive wear and replace if found to be defective. Bushings should be driven into the housing until they are flush with the outside edges of the cross–shaft locating bores.

8. Inspect the planetary cover for damage or distortion. Check the face of the cover and the mating surface for nicks or burrs and remove any imperfections with an abrasive stone.

9. Inspect the planetary carrier and gears, planetary shaft, pilot bearing and thrust washer for damage or wear. Install new parts where necessary.

10. Inspect the sun gear for excessive wear or damaged teeth.

11. Inspect the sealing rings from the rear hub of the direct drive clutch assembly for damage, distortion or cracks.

   If new seals are to be installed, insert the seals in a 2.38 in. (60 mm) internal diameter test bore for a period of 10 minutes prior to assembly. This procedure ensures the seals obtain the correct amount of pre-tension to avoid damage on assembly. Install the new seals using a suitable grease to hold the seals in position during re-assembly and ensure the seals do not protrude above the lands of the direct drive housing.

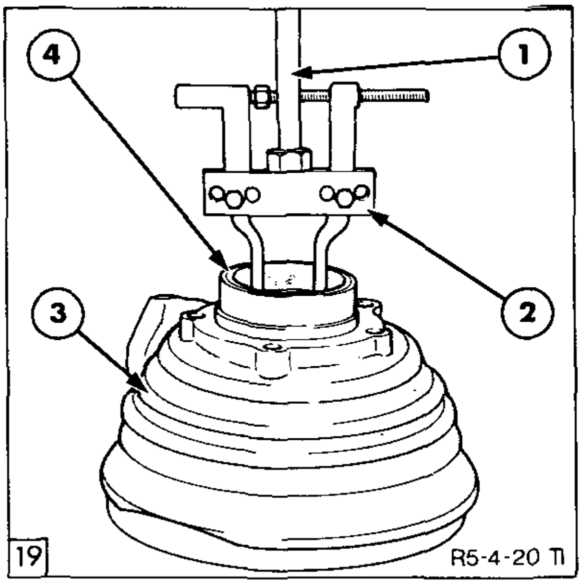
12. Examine the bore in the hub of the planetary housing where the direct drive sealing rings locate. If wear or damage is evident the planetary housing must be replaced.

13. Examine the direct drive clutch housing both externally for cracks or damage and internally for wear and piston scuffing. Inspect the housing external splines for cracked, broken or missing teeth.

14. Inspect the direct drive clutch piston, friction plates, steel plates, pressure plate and snap ring and install new piston seals. Any defective parts must be replaced during re-assembly.

15. Examine the direct drive clutch piston return spring, spring retainer and snap ring for damage.

16. Examine the thrust washer for damage or distortion.



Transmission Input Shaft Bearing Removal

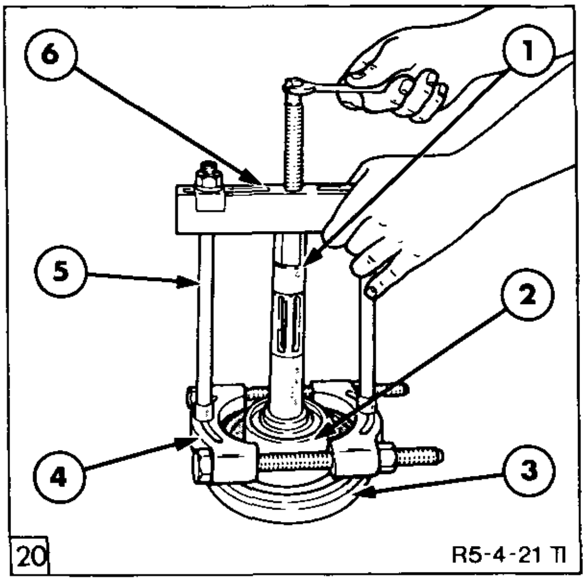
1. Slide Hammer, Tool No. 943S or 9567
2. Puller, Tool No. 943 or 9507
3. Planetary Housing
4. Input Shaft Bearing

17. Inspect the planetary housing for cracks or damage. Examine the underdrive clutch piston, locating dowel pins, springs, rear plate, friction plate, pressure plate, spring retainer and snap ring and install new piston seals. Discard and replace any cracked, damaged or badly worn parts.

18. Examine the transmission input shaft front bearing in the hub of the planetary housing, if removed with the dual power housing assembly, for excessive wear or damage. If necessary, use Puller, Tool No. 943 or 9507 and Slide Hammer, Tool No. 943S or 9567 to remove the bearing, Figure 19. Press in a new bearing.

19. Inspect the ring gear and shaft assembly for damage or wear. Inspect the shaft splines for damage. If necessary, install a new ring gear and shaft assembly.

20. Examine the ring gear bearing for wear or damage. If necessary, remove the bearing with Puller, Tool No. 938 or 9506, Puller Legs, Tool No. 930B or 9521, Pulling Attachment, Tool No. 952 or 9526 and Step Plate, Tool No. 630S/4 or 9210/4, as shown in Figure 20. Take care not to damage the shim located behind the bearing. Ensure the shim is placed against the step on the ring gear shaft and then press the new bearing onto the shaft, using a convenient length sleeve of 3.25 in. (82.6 mm) internal diameter and 3.75 in. (95.3 mm) external diameter.



Ring Gear Bearing Removal

1. Step Plate, Tool No. 630S/4 or 9210/4
2. Bearing
3. Ring Gear and Shaft Assembly
4. Pulling Attachment, Tool No. 952 or 9526
5. Puller Legs, Tool No. 930B or 9521
6. Puller, Tool No. 938 or 9506

IMPORTANT: *The shim located behind the ring gear bearing governs the planetary gear set end play. If any of the major components of the planetary gear set are changed, refer to 'Planetary Gear Set Shimming Procedure' in this Chapter, to determine the correct size shim to be installed.*

21. Examine the valve spool bore in the valve body for damage or wear.

22. Inspect the valve spool lands for scratches, wear or other damage. Minor burrs or scratches may be removed with a fine abrasive material but parts must be washed and dried prior to re–assembly.

23. Check the solenoid for cracks or damage. if any doubt exists as to the serviceability of this component, replace with a new solenoid assembly.

RE–ASSEMBLY

Re–assembly of the direct drive clutch, the underdrive clutch and control valve follows the disassembly procedure in reverse.

NOTE:

(i) *When re–assembling the solenoid to the valve, apply a proprietary thread sealant on the pilot valve assembly threads and tighten the nut to 4 lbf.ft (5.4 Nm)*

(ii) *Ensure the gap of the underdrive clutch retaining snap ring is placed in line with the lubrication port of the Dual Power Housing.*

PLANETARY GEAR SET SHIMMING PROCEDURE

IMPORTANT: *This procedure must be followed whenever a new cover, bearing, ring gear, planetary carrier, sun gear, direct drive clutch or planetary housing is installed.*

Free play among the components of the planetary housing is governed by means of a shim located between the bearing and the step on the ring gear shaft.

The free play should be between 0.004–0.020in (0.10–0.51mm). For free play available shims, see Specifications, Section E.

Determine the shim required to give the specified free play as follows:–

1. Install the sun gear in the inner splines of the direct drive clutch assembly.
2. Place the thrust washer in the planetary carrier and align the splines.
3. Install the planetary carrier and thrust washer onto the sun gear and ensure the splines of the planetary carrier are engaged with all of the direct drive clutch friction plates.
4. Hold the components tightly together and install the planetary shaft from the rear. Tap the shaft, if necessary, to ensure full engagement.
5. Press the pilot bearing onto the shaft using a sleeve of 1.62 in (41.2 mm) internal diameter and 1.88 in (47.8 mm) external diameter.
6. Position the planetary housing (with underdrive clutch installed) on a bench.

NOTE: *Support the housing on blocks so that the rear of the planetary shaft does not foul the workbench when the direct drive clutch and planetary gear set is fully installed.*

7. Place the thrust washer in the housing with the tab up and towards the rear of the transmission.
8. Install the direct drive clutch and planetary gear set assembly in the housing. Ensure the assembly is fully seated in the housing.
9. Install the ring gear and shaft assembly (without the ring gear bearing or shim) in the housing. Place the Ring Gauge, Tool No. FT.5000 or 1303, on the step of the ring gear shaft.
10. Position the cover on the planetary housing without the gasket.

IMPORTANT: *Ensure all components are properly seated in the housing.*

11. Measure the distance between the face of the cover and the face of the housing at three conveniently spaced intervals. Average the three measurements. If the average measurement is between 0.046–0.060in (1.17–1.52mm) the free play is within the required limits and no shims are necessary.
12. If the average measurement is less than the range stated, determine the shim thickness required by referring to the relevant chart in Specifications Section E.
13. Remove the cover and the ring gear and shaft assembly from the planetary housing. Remove the ring gauge and place the appropriate shim(s) on the step of the ring gear shaft. Press the bearing onto the ring gear using a convenient length sleeve of 3.25 in. (82.6 mm) internal diameter and 3.75 in. (95.3 mm) external diameter).
14. Remove the components from the planetary housing and retain in order for final installation.

INSTALLATION

NOTE: *If it is necessary to install a new cover, bearing, ring gear, planetary carrier, sun gear, direct drive clutch or planetary housing, refer to 'Planetary Gear Set Shimming Procedure' in this Chapter, before installing the planetary components in the transmission case.*

Installation of the planetary gear set and control valve follows the removal procedure in reverse. Pay particular attention to the following important points:

(i) If all components are correctly installed, the cover should easily seat in the housing. Any need for force indicates incorrect re–assembly.

(ii) Install new 'O' ring seals on the lubrication oil transfer tube.

(iii) Coat all tube joints with a proprietary sealing compound.

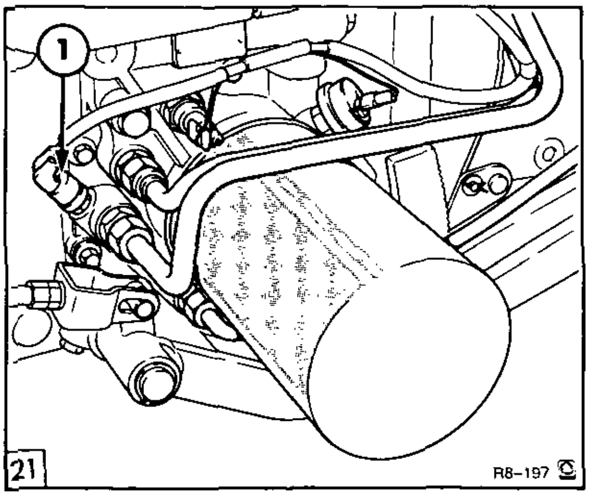
(iv) Install new 'O' ring seals on the control valve pressure line and lubrication line connections.

(v) Take care to avoid damage to the control valve solenoid and wire and ensure the grommet is firmly in place to protect the solenoid wire.

D. PRESSURE TESTING

For the following tests ensure the tractor hydraulic oil is at operating temperature, the transmission and hydraulic system are in neutral and the power take–off is disengaged.

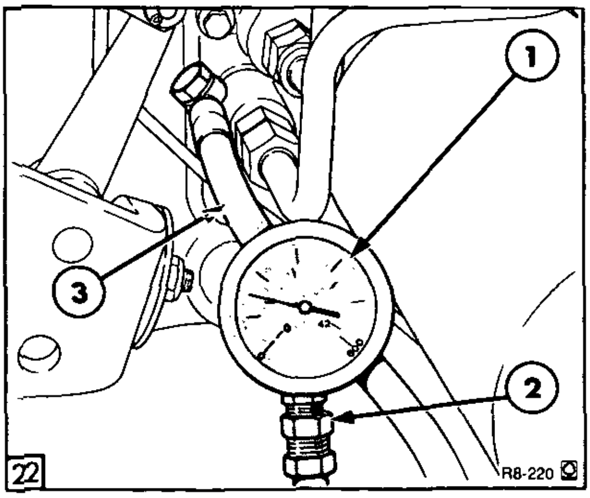
DUAL POWER SYSTEM PRESSURE TEST
(Low Pressure Hydraulic Circuit Test)



Pressure Switch for Low Pressure Circuit

1. Pressure Switch – Low Pressure Circuit

1. Remove the pressure switch for the low pressure hydraulic circuit, Figure 21.



Checking Low Pressure Circuit

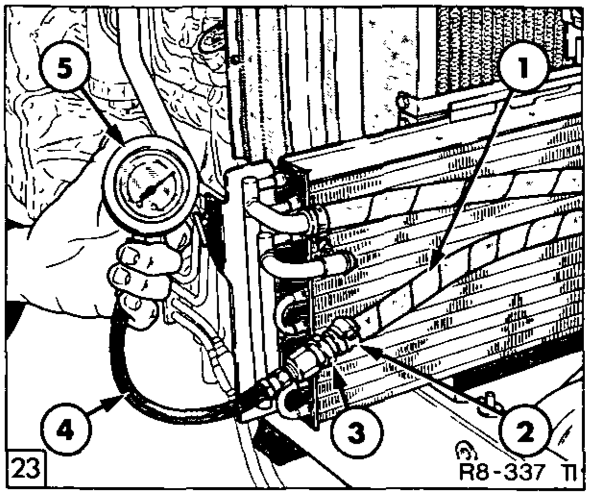
1. Pressure Gauge FT.8616 or FNH 06653
2. Adaptor FT.8503–8 or FNH 00705
3. Test Hoses E1NN–F493–AA (Finis Code 3936707) and E0NN–2N353–AB (Finis Code 3926717)

2. Install a 0–400 lbf.in² (0–30 bar) pressure gauge, FT.8616, Figure 22.

3. Set the engine speed to 2100 rev/min. and observe the pressure reading. A reading of 170–200 lbf.in² (11.7–13.8 bar) should be recorded.

TRANSMISSION LUBRICATION PRESSURE TEST

1. Operate the tractor and set the engine speed to 1000 rev/min. Stop the engine but do not re–adjust the throttle.



Lubrication Circuit Relief Valve Check

1. Oil Cooler Inlet Hose
2. Hose Clamp
3. Suitable 7/16 in JIC Adaptor to Connect Test Hose to Inlet Hose
4. Test Hose E1NN–F493–AA (Finis Code 3936707)
5. Pressure Gauge FT.8616or FNH 06653

2. Using a test hose, part number, E1NN–F493–AA with adaptor FT.8503–8 and a suitable 7/16 in. JIC adaptor, which must be a tight fit inside the oil cooler inlet hose, connect the 400 lbf.in² pressure gauge, FT.8616, to the cooler inlet hose, Figure 23.

3. Using an assistant to start the engine, observe the reading on the pressure gauge. Do Not run the tractor longer than is necessary to observe the pressure gauge reading.

The pressure recorded should be 73–123 lbf.in² (5.3–8.5 bar), depending on engine speed. 73–123 lbf.in² (5.0–8.5 bar) is the minimum operating pressure of the lubrication circuit relief valve located in the PTO valve and clutch assembly.

E. SPECIFICATIONS, TIGHTENING TORQUES AND SPECIAL TOOLS

SPECIFICATIONS

Planetary Gear Set Free Play	0.004–0.020 in (0.10–0.51 mm)	
Planetary Gear Set Free Play Shims Available	0.013 in. (0.33 mm) 0.032 in. (0.81 mm)	
Planetary Cover to Housing Shimming Gap	0.046–0.060 in. (1.17–1.52 mm)	
Planetary Gear Set Free Play Shimming Chart	Average Planetary cover to Housing Gap	Shim Thickness to be added
	0.001–0.013 in. (0.025–0.33mm)	0.045in. (1.14mm)
	0.014–0.026in. (0.34–0.66mm)	0.032in. (0.81mm)
	0.027–0.032in. (0.67–0.81mm)	0.026in. (0.66mm)
	0.033–0.045in. (0.82–1.14 mm)	0.013in. (0.33mm)
	0.046–0.0060in. (1.15–1.52mm)	None
Dual Power System Pressures	220–260 lbf.in2 (15.2–17.9 bar)	
Lubrication System Pressure	Run lubrication pressure test, a pressure within the following range should be recorded. 73–123 lbf.in2 (5.0–8.5 bar)	

TIGHTENING TORQUES

Components	lbf.ft	Nm
Control Valve Spool Plug	28	38
Control Valve Body Retaining Bolts	32	44
Planetary Housing Retaining Bolts	77	105
Planetary Cover Retaining Bolts	35	47
Lubrication Tube Connector	13	17.5
Pressure Line Control Tube Connector	9	12

SPECIAL TOOLS

Description	V.L. Churchill Ltd Tools	Nuday Tools
Slide Hammer	MS.284	9567 (943S)
Step Plates	630S	9210 (630S)
PTO Clutch Compressor	N–775	1312 (N–775)
Puller Legs	930B	9521 (930B)
Puller	938	9506 (938)
Internal / External Puller	943	9507 (943)
Slide Hammer	943S	9567 (943S)
Pulling Attachment		
Small	951	9190 (6951)
Large	952	9526 (962)
Puller		
Medium	1002	9198 (1002)
Large	1003	9516 (1003)
Spacer Gauge – Dual Power	FT.5000(SW523)	1303 (SW523)
Planetary Shaft Puller	FT.5004	4721
Pressure Gauge	*FT.8616*	*FNH 06653*
Adaptor	FT.8503	FNH 00705

PART 5
TRANSMISSION SYSTEM
Chapter 5
REDUCTION GEARBOX ASSEMBLY

A. REDUCTION GEARBOX – DESCRIPTION AND OPERATION

The reduction gearbox, which is available as an option on the 8x2, with or less dual power, non–synchromesh transmission, provides an extra reduction ratio below the standard low range. The reduction being obtained through the use of an epicyclic gear set which is mounted on the transmission output shaft.

When installed the reduction gearbox provides an additional creep range of four forward and one reverse speed, which increases the total number of ratios available to twelve forward and three reverse. On transmissions fitted with dual power, an additional eight forward and two reverse speeds are provided increasing the total ratios available to 24 forward and six reverse.

Alternative epicyclic gear sets are available for the reduction gearbox to give a reduction ratio below the low range of either 5.7:1 or 10.0:1 as required.

All reduction gearboxes consist basically of an epicyclic gear set mounted in place of the transmission output shaft gear used on the standard transmission.

A cross section of the reduction gearbox is shown in Figure 1.

The epicyclic gear set consists of:

(i) An outer ring gear which is fixed in relation to the transmission housing.

(ii) Planetary gears mounted in the carrier, the rear gear teeth engaging the outer ring gear.

(iii) The carrier, which has teeth formed on the outside diameter to act as the output shaft gear.

(iv) Intermediate ring gear which engages the front teeth of the planetary gears.

(v) The coupling, which is splined to and drives the output shaft, which may engage the carrier or intermediate ring gear.

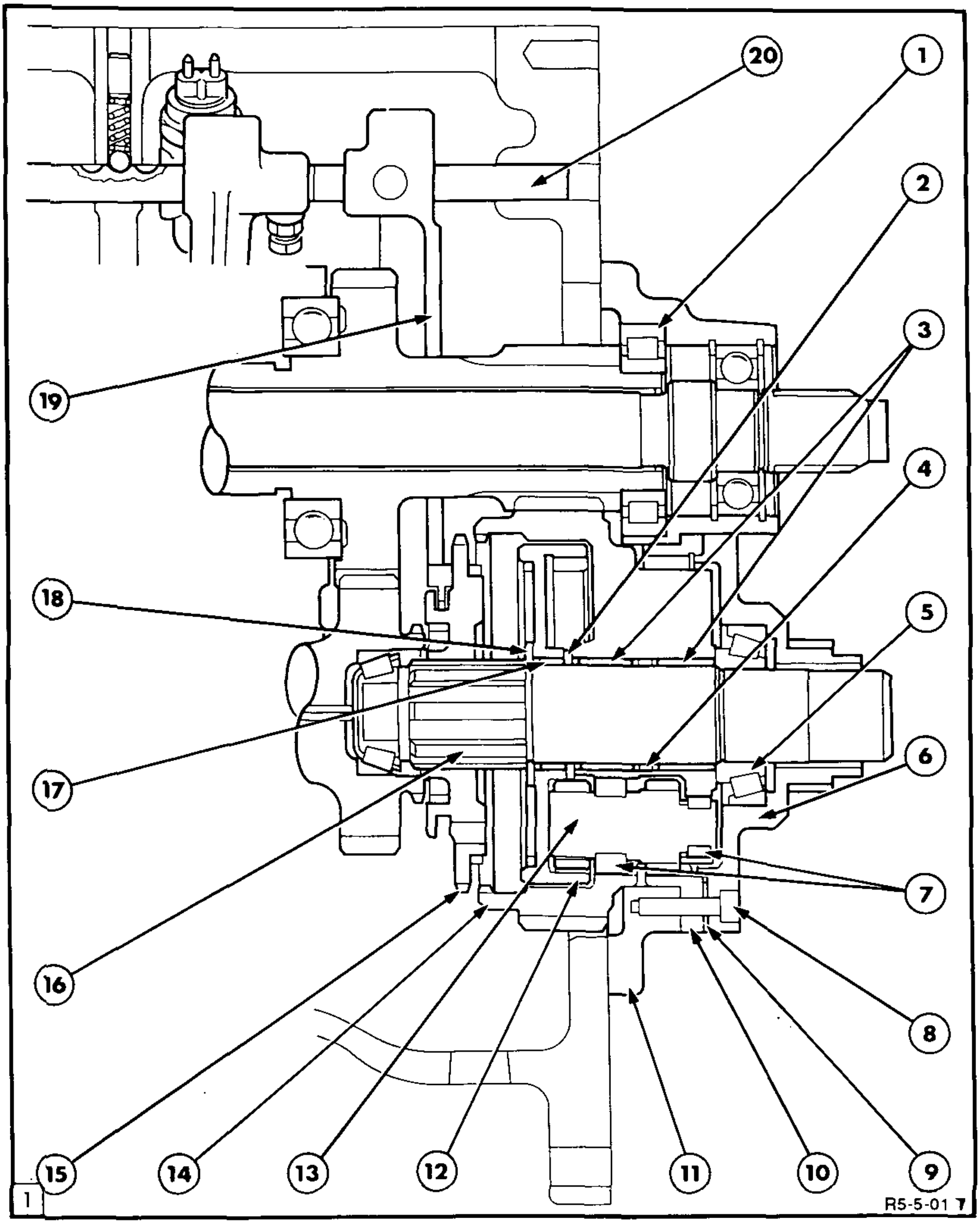
The coupling is moved by means of the selector fork and gear shift rail.

In the neutral position, as shown in Figure 1, the coupling does not engage any component of the reduction gear set and so the coupling and output shaft cannot be driven.

The transmission low range is selected by sliding the gear shift rail rearwards to the detent position adjacent to neutral. The movement of the rail, through the selector fork, causes the coupling to engage the reduction gear set carrier. Power is now transmitted from the secondary countershaft, via the carrier and coupling to the output shaft. The carrier has the same number of gear teeth on the outside diameter as the output shaft gear utilised on standard transmission, therefore, the ground speeds obtained in the low range are identical to those of a standard transmission.

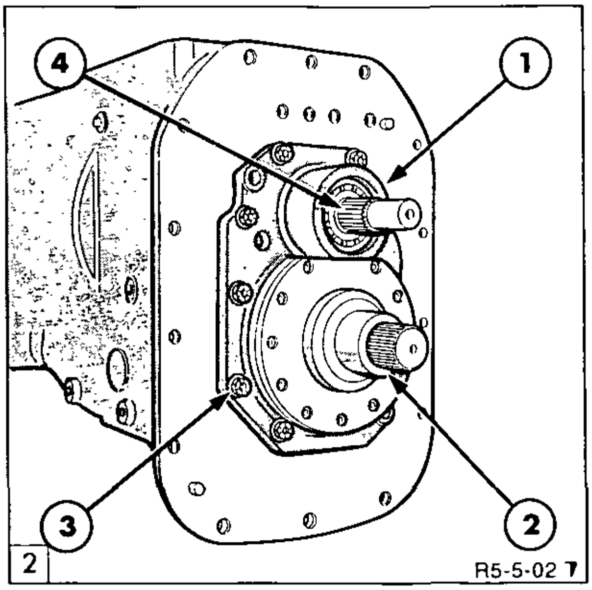
The creep range is selected by sliding the gear shift rail and fork further rearward to the final detent position. The coupling is moved by the selector fork inside the carrier assembly to engage the intermediate ring gear. Power is now transmitted from the secondary countershaft to the coupling via the planetary gear set.

The planetary gear set is designed so that the carrier is driven and causes the planetary gears to rotate with the rear teeth engaged in the stationary ring gear. The forward teeth of the planetary gears engage and drive the intermediate ring gear at reduced speed. The coupling, which now engages the intermediate ring gear, therefore, drives the output shaft at a reduced speed to obtain the required creep range.



Reduction Gearbox

1. Roller Bearing
2. Thrust Washer
3. Needle Roller Bearing
4. Spacer
5. Taper Roller Bearing
6. Output Shaft Retainer
7. Roller
8. Socket Head Screw
9. Shim(s)
10. Outer Ring Gear
11. Support Plate
12. Intermediate Ring Gear
13. Planetary Gear
14. Carrier
15. Coupling
16. Output Shaft
17. Needle Roller Bearing
18. Thrust Washer
19. Selector Fork
20. Gear Shift Rail



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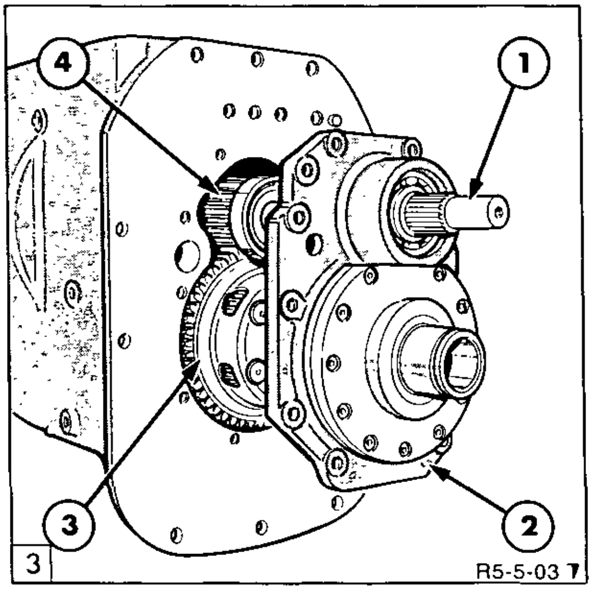
Reduction Gear Set Installed

1. Rear Support Plate
2. Output Shaft Retainer
3. Retaining Bolt
4. P.T.O. Drive Shaft



3

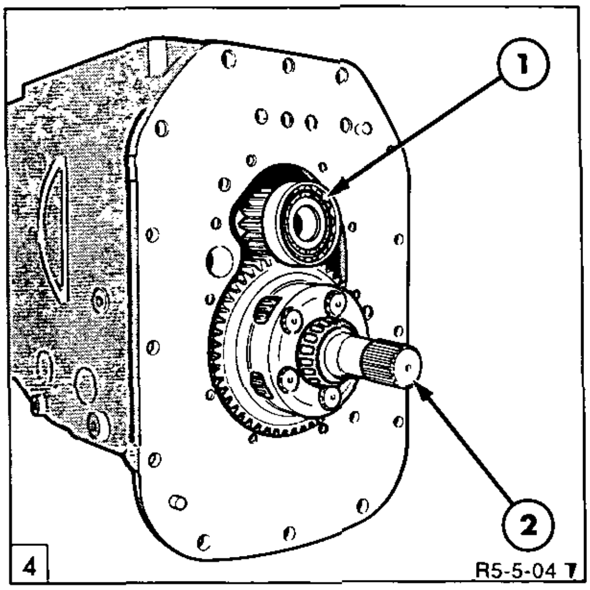
Reduction Gear Set Removal

1. P.T.O. Drive Shaft
2. Rear Support Plate
3. Reduction Gear Set
4. Secondary Countershaft

B. REDUCTION GEARBOX OVERHAUL

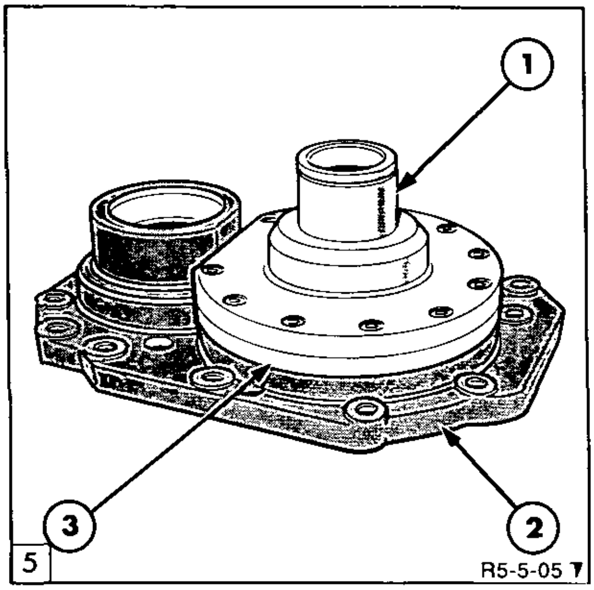
REMOVAL

1. Drain the oil from the transmission.
2. Separate the rear axle from the transmission, see "SEPARATING THE TRACTOR".
3. Remove the gear shift cover as described in Chapter 3.
4. Remove the snap ring, thrust washer and hydraulic pump idler gear, located on the output shaft retainer.
5. Remove the rear support plate retaining bolts and lever the support plate away from the transmission, Figure 2.
6. Remove the rear support plate and the P.T.O. countershaft as an assembly, Figure 3.



Reduction Gear Set Removal

1. Secondary Countershaft
2. Output Shaft and Reduction Gear Set Assembly



Output Shaft Retainer Removal

1. Output Shaft Retainer
2. Rear Support Plate
3. Outer Ring Gear

7. Partially withdraw the secondary countershaft assembly until the front bearing is out of the location. Lift the secondary countershaft to allow the output shaft and reduction gear set assembly to be removed from the rear compartment, Figure 4. Remove the secondary countershaft.

8. Remove the high/low/creep coupling from the rear of the transmission, or the output shaft, as required.

DISASSEMBLY

1. Remove the output shaft retainer from the rear support plate, Figure 5.

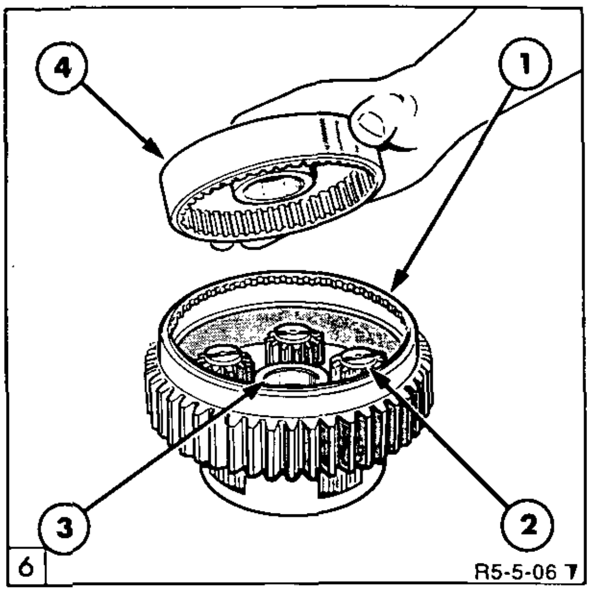
2. Remove the outer ring gear from the rear support plate.

3. Remove the output shaft from the reduction gear set assembly. If necessary, use a soft faced hammer to drive the output shaft forwards out of the assembly, Figure 7. Ensure the intermediate ring gear remains inside the reduction gear set.

NOTE: *Removal of the output shaft will push the bearing off the rear of the output shaft.*

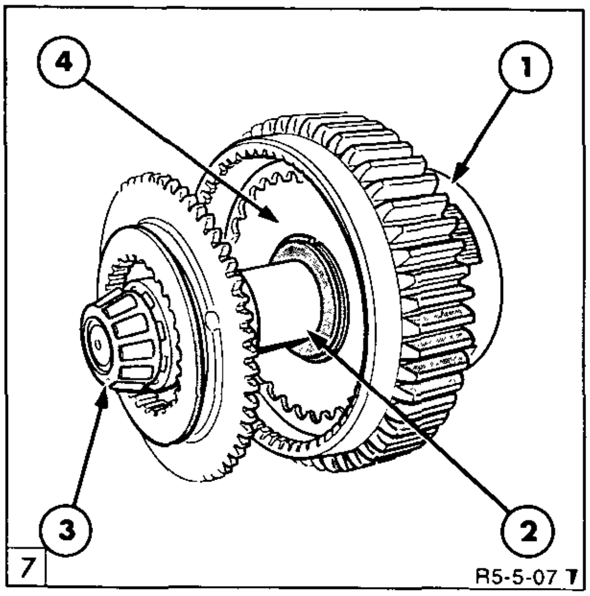
4. Remove the thrust washer and needle roller bearing from the output shaft (or intermediate ring gear should these components remain inside the gear set assembly).

5. Lay the epicyclic gear set on the bench with the intermediate ring gear uppermost. Withdraw the intermediate ring gear, Figure 6.



Intermediate Ring Gear Removal

1. Carrier
2. Planetary Gear
3. Thrust Washer
4. Intermediate Ring Gear



Output Shaft Removal

1. Gear Set Assembly
2. Output Shaft
3. Bearing
4. Intermediate Ring Gear

6. Remove the thrust washer, needle roller bearing, spacer and second needle roller bearing from the carrier.

7. Remove the planetary gears from the carrier.. Take care to retain the bearing rollers.

INSPECTION AND REPAIR

1. Inspect the output shaft retainer and rear bearing cup for wear or damage. If necessary, use Pulling Attachment, Tool No. 943 or 9507 and Slide Hammer, Tool No. 943S or 9567 to remove the cup from the retainer. Use a suitable Step Plate, Tool No. 630S or 9210 to install a new bearing cup.

2. Inspect the output shaft and pilot bearing. Replace worn or damaged components.

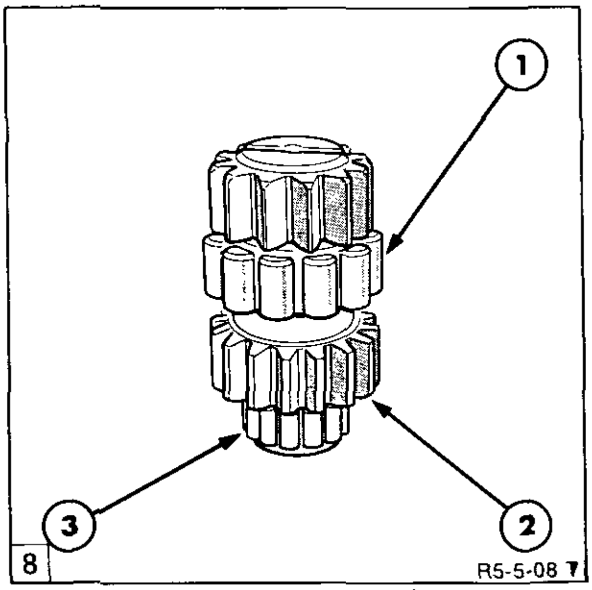
3. Examine the rear support plate for wear or damage and replace if necessary.

4. Check the secondary countershaft and P.T.O. drive shaft bearings located in the rear support plate. Replace any unserviceable bearing with a suitable Step Plate, Tool No. 630S or 9210.

5. Examine all needle roller bearings and thrust washers. Replace any unserviceable items.

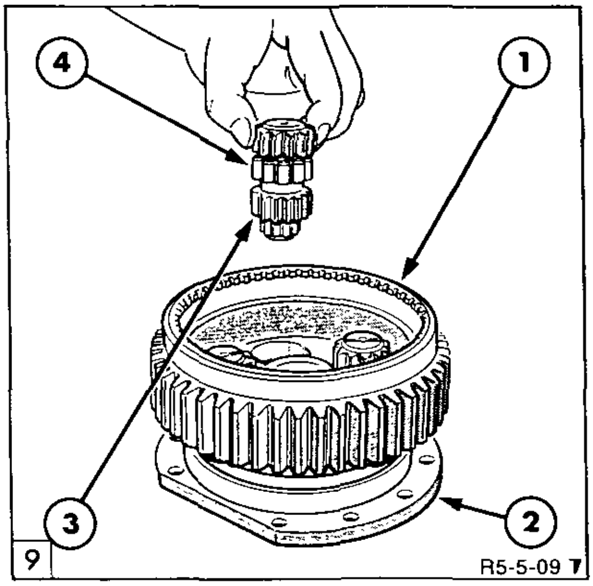
6. Inspect the planetary gear set carrier, ring gears and planetary gears and replace any worn or damaged components on re–assembly. However, if several components are worn, the complete reduction gear set should be replaced.

7. Examine the coupling and gear shift mechanism. Replace any unserviceable components.



Planetary Gear Assembly

1. 9 mm Diameter Rollers
2. Planetary Gear
3. 5 mm Diameter Rollers



Planetary Gear Installation

1. Carrier
2. Outer Ring Gear
3. Planetary Gear
4. Rollers

RE–ASSEMBLY

1. Use high quality grease to position the thirteen 5 mm diameter rollers and eleven 9 mm diameter rollers around the planetary gears, Figure 8.

2. Install the planetary gears with their rollers in the carrier which must rest inside the outer ring gear which acts as an assembly gauge, Figure 9.

IMPORTANT: *During installation, turn each gear until the master tooth (marked with a punched dot) points towards the centre of the carrier.*

3. 5.7:1 Reduction Ratio only:
   With reference to Figure 11 and viewed from the front, four pairs of gear teeth are in alignment. Identify the right–hand tooth of any aligned pair on the 12 teeth gear as the master tooth.

   10:1 Reduction Ratio only:
   With reference to Figure 12 and viewed from the front, only one pair of gear teeth are in alignment. Identify the tooth opposite the aligned pair on the 13 teeth gear as the master tooth.

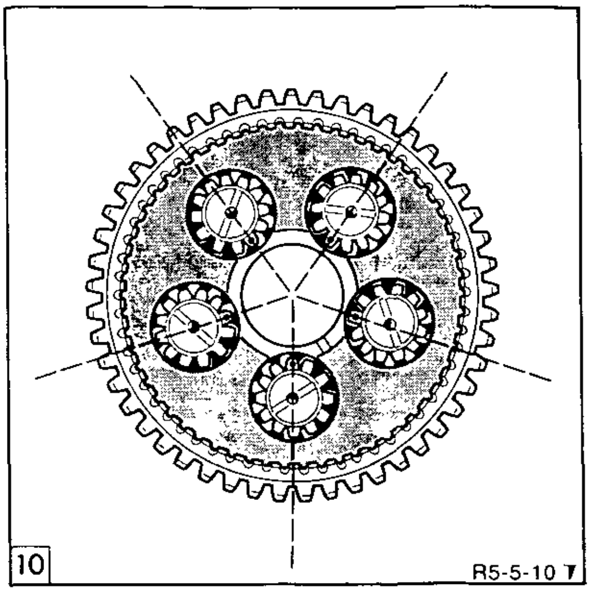
4. Locate the smaller diameter thrust washer, chamfered side up, on the carrier hub before installing the intermediate ring gear into the carrier to fully engage with the planetary gears, .

5. Place the gear coupling, groove to the front, on the output shaft.

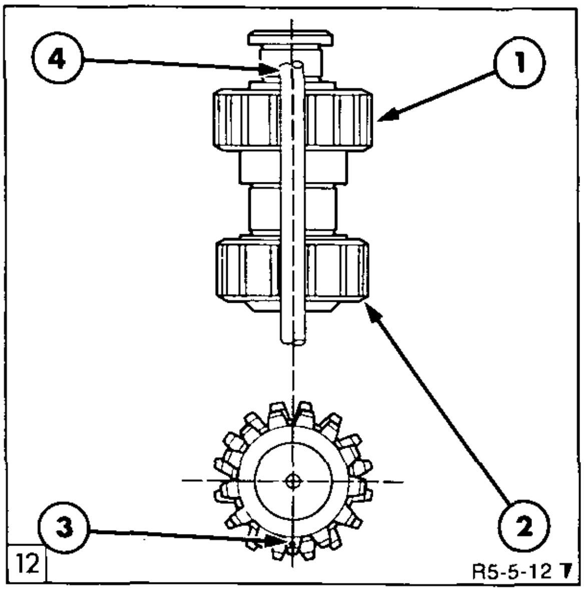
6. Position the larger diameter washer on the output shaft with the chamfered side facing the coupling Figure 14.

   (i) Lubricate the needle roller bearings with high quality grease and install the narrow needle roller bearing in the intermediate ring gear. Install the two wide needle roller bearings, with the spacer between them, in the carrier.

   (ii) Hold the previously assembled output shaft vertically and locate the carrier assembly on the output shaft.

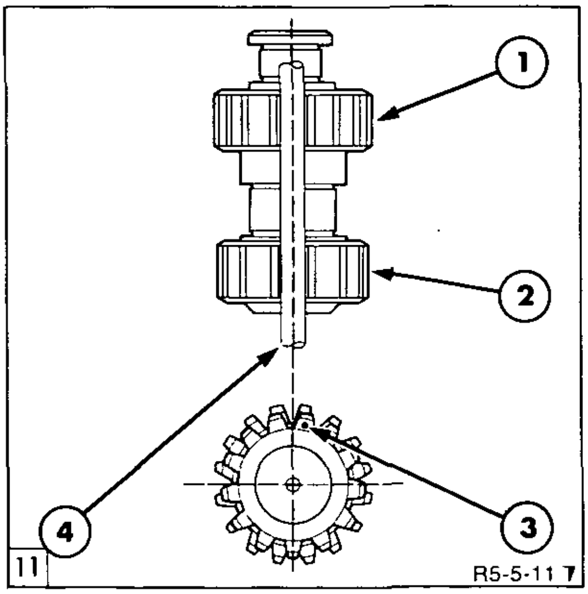


Planetary Gear to Carrier Relationship



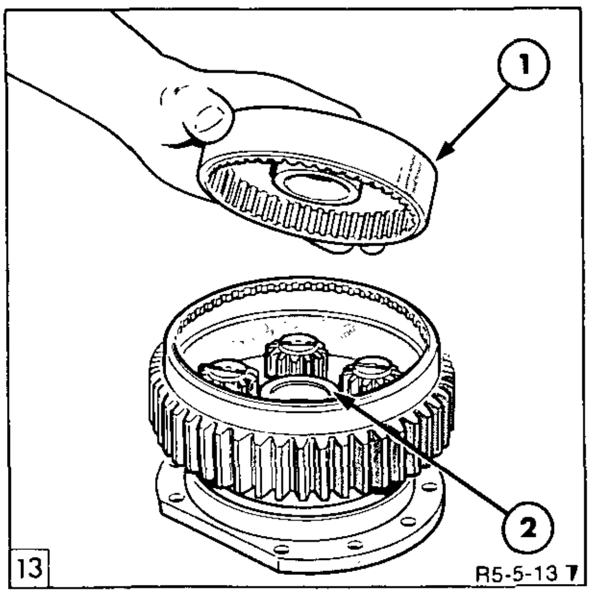
Identification of Master Tooth on 10:1 Reduction Ratio Planetary Gear

1. 16 Teeth Gear
2. 13 Teeth Gear
3. Master Tooth on 13 Teeth Gear
4. Rod Used to Establish Alignment of Gear Teeth



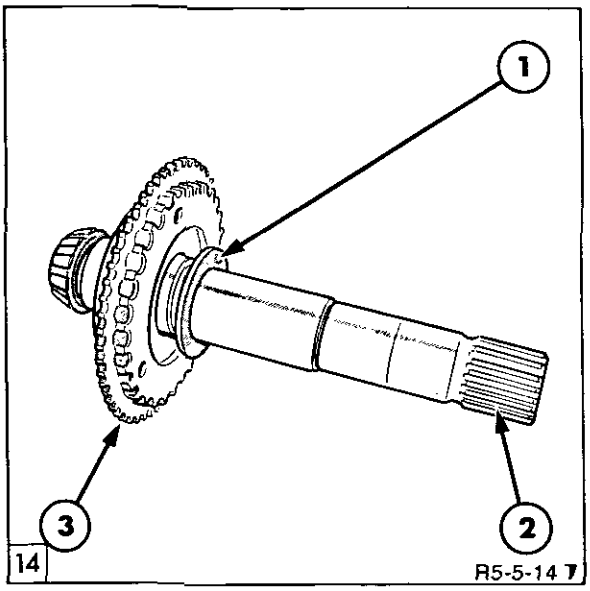
Identification of Master Tooth on 5.7:1 Reduction Ratio Planetary Gear

1. 16 Teeth Gear
2. 12 Teeth Gear
3. Master Tooth on 12 Teeth Gear
4. Rod Used to Establish Alignment of Gear Teeth



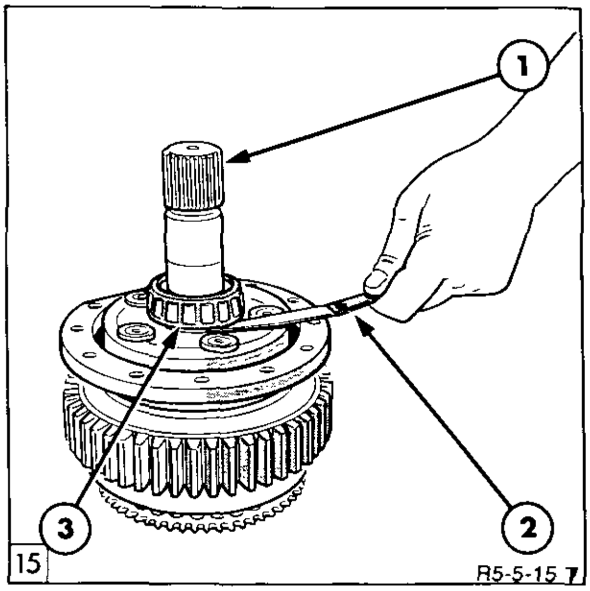
Intermediate Ring Gear Installation

1. Intermediate Ring Gear
2. Thrust Washer



Output Shaft Assembly

1. Washer
2. Output Shaft
3. Coupling



Checking Carrier End Float

1. Output Shaft
2. Feeler Gauges
3. Bearing

NOTE: *When the carrier is fully located, the output shaft should protrude above the carrier rear thrust face.*

(iii) Push the output shaft rear bearing against the output shaft shoulder.

(iv) Use feeler gauges to check the clearances between the bearing and the carrier. The gap should be 0.012–0.032 in. (0.3–0.8 mm), Figure 15.

INSTALLATION

1. Install the assembled carrier and output shaft unit in the transmission. Ensure the coupling engages the selector fork.

2. Remove the outer ring gear from the reduction gear set assembly.

3. Install the rear cover plate on the transmission.

4. Install the support plate retaining bolts and tighten to a torque value of 35 lbf.ft (47 Nm).

5. Locate the outer ring gear into the rear cover.

6. Replace the shims and bolt the output shaft retainer to the support plate so that the ring gear is also supported. Tighten the socket head screws to a torque value of 23 lbf.ft (31 Nm).

7. Using a pull scale and string wound around the output shaft, check the output shaft torque pre–load. With the transmission in neutral the pull scale should read between 9.5–16 lbf.in. Add or subtract shims from between the output shaft retainer to obtain the correct pre–load

   Alternatively, if a pull scale is not available, add or subtract shims to obtain an output shaft *end float* of between 0.0015–0.0034 in. (0.038–0.086 mm).

8. Install the hydraulic pump idler gear and thrust washer and retain with the snap ring.

9. Replace the gear shift cover as described in Chapter 3.

10. Reconnect the transmission and rear axle assemblies, see "SEPARATING THE TRACTOR".

11. Fill the transmission with the correct grade and quantity of oil, see 8x2 transmission, Part 5, Chapter 3, Section F Specifications.

C. SPECIFICATIONS, TIGHTENING TORQUES AND SPECIAL TOOLS

SPECIFICATIONS

Reduction Ratio	5.7:1 or 10.0:1
Output Shaft End Float with Reduction Gearbox	0.0015–0.0034 in (0.038–0.086 mm)
Output Shaft Pre–Load with Reduction Gearbox	Pull required to turn the output shaft with string wound around output shaft splines 9.5–16 lbf. (1.0–1.8 N)
Output Shaft Pre–Load Shims Available for Reduction Gear-box	0.004 in. (0.10 mm) 0.006 in. (0.15 mm) 0.020 in. (0.50 mm)

TIGHTENING TORQUES

Components	lbf.ft	Nm
Rear Support Plate Retaining Bolts	35	47
Output shaft Retainer Socket Head Screws	23	31

SPECIAL TOOLS

Description	V.L. Churchill Ltd Tools	Nuday Tools
Step Plates	630S	9210 (630S)
Internal / External Puller	943	9507 (943)
Slide Hammer	943S	9567 (943S)

PART 5
TRANSMISSION SYSTEMS

Chapter 6
12x12 DUAL POWER SYNCHRO–SHIFT TRANSMISSION

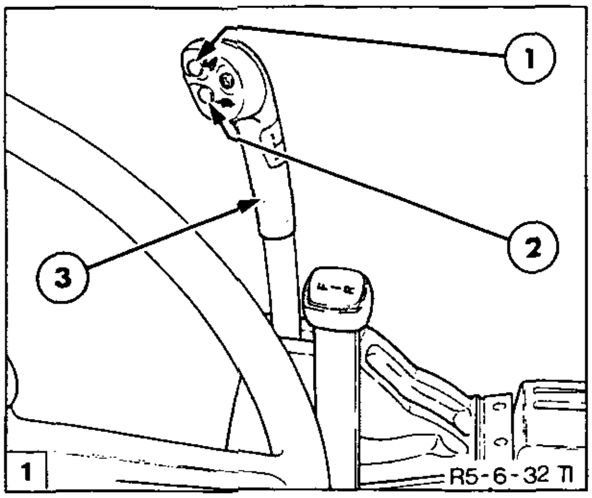
A. Description and Operation

General

The 12x12 transmission Dual Power assembly consists of a dual, multi plate wet clutch assembly, known as C1 and C2, located directly between the flywheel damper and input shaft of the transmission. The conventional clutch of the standard 12x12 transmission is not required.

The Dual Power unit provides an under drive to all of the standard, direct drive ratios, reducing road speed by 18% and increasing torque by 22%, providing the transmission with 24 forward and 24 reverse gears.

Selection of either under drive or direct drive modes is by switches located on the main shift lever knob, Figure 1. The actual selection is controlled by an electro–hydraulic system, the operation of which is described in greater detail later in this section.



Dual Power Switch Location

1. Direct Drive Switch
2. Under Drive Switch
3. Main Shift Lever Knob

Under Drive (UD) Operation–Mechanical

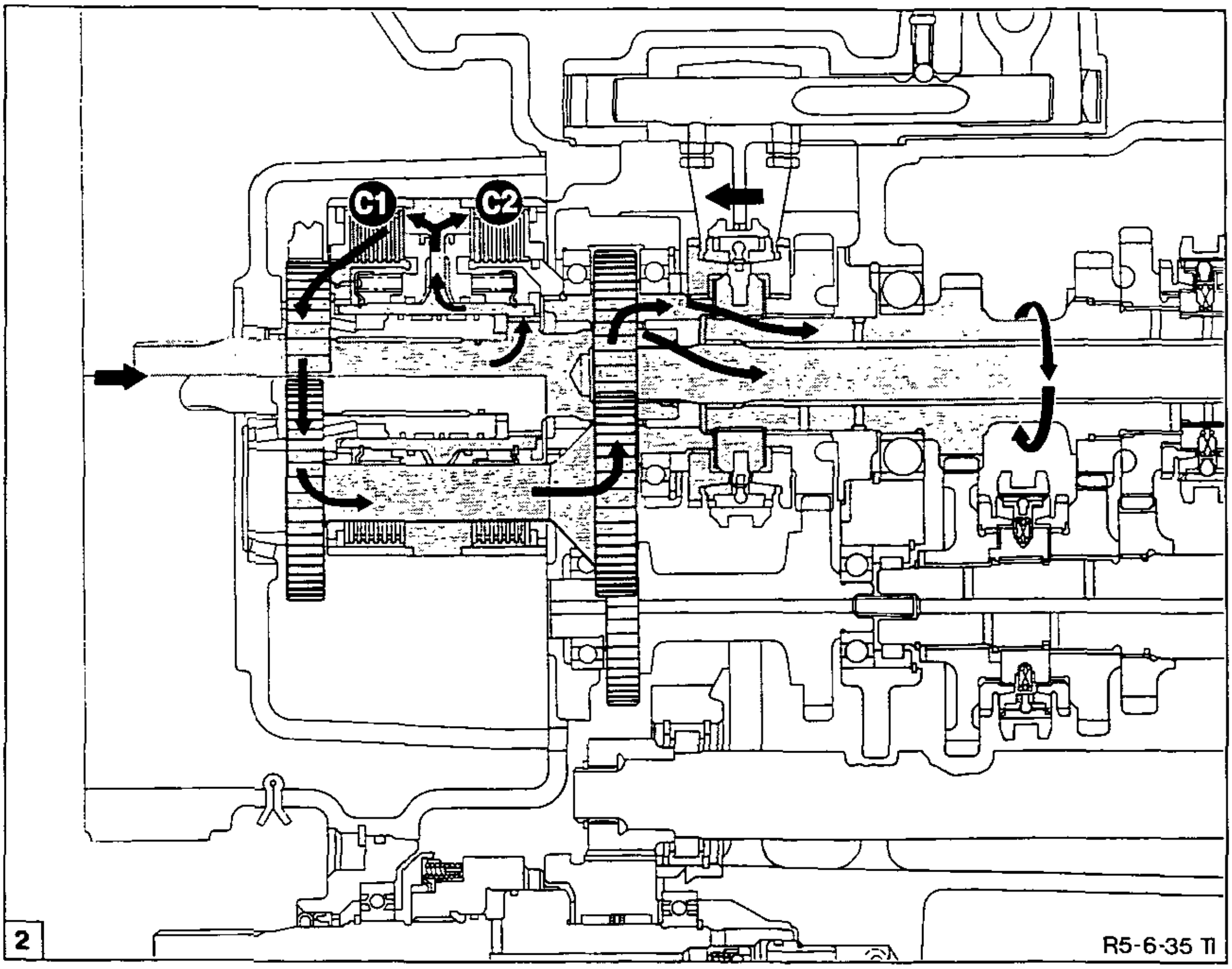
With reference to Figure 2 and Figure 3.

At tractor start up the transmission will automatically default to under drive operation. Oil pressure from the control valve assembly is directed to the C1 (front) clutch assembly. The drive is then taken down through the underdrive gear assembly and onto the transmission input shaft, the underdrive gear ratios providing the 18% drop in input speed to the transmission.

Direct Drive (DD) Operation – Mechanical

With reference to Figure 4 and Figure 5.

When the momentary switch on the main shift lever knob is energised the oil pressure from the control valve assembly is directed to the C2 (rear) clutch assembly and drive is straight through the C2 clutch assembly to the transmission input shaft.



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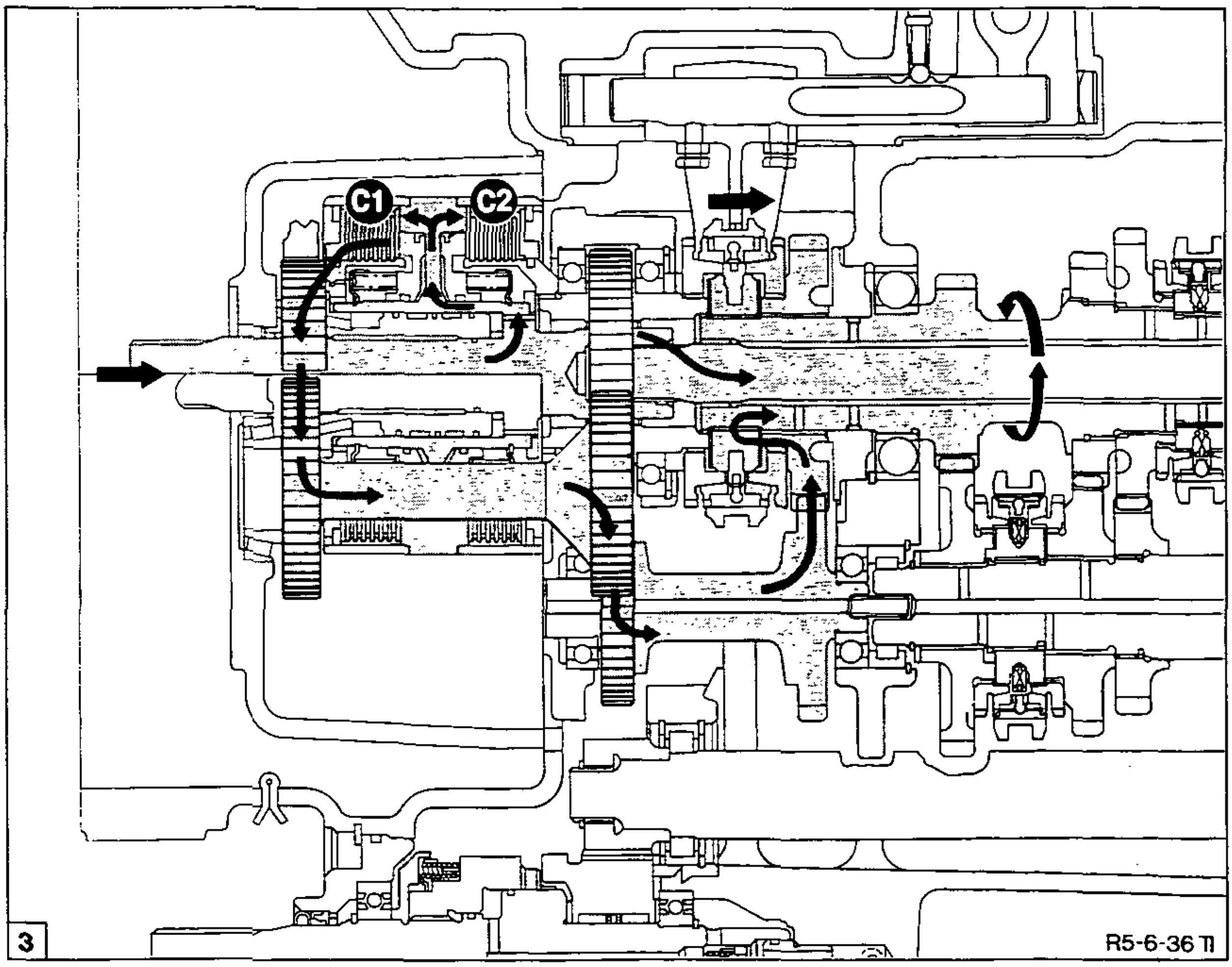
Under Drive Power Flow – Forward



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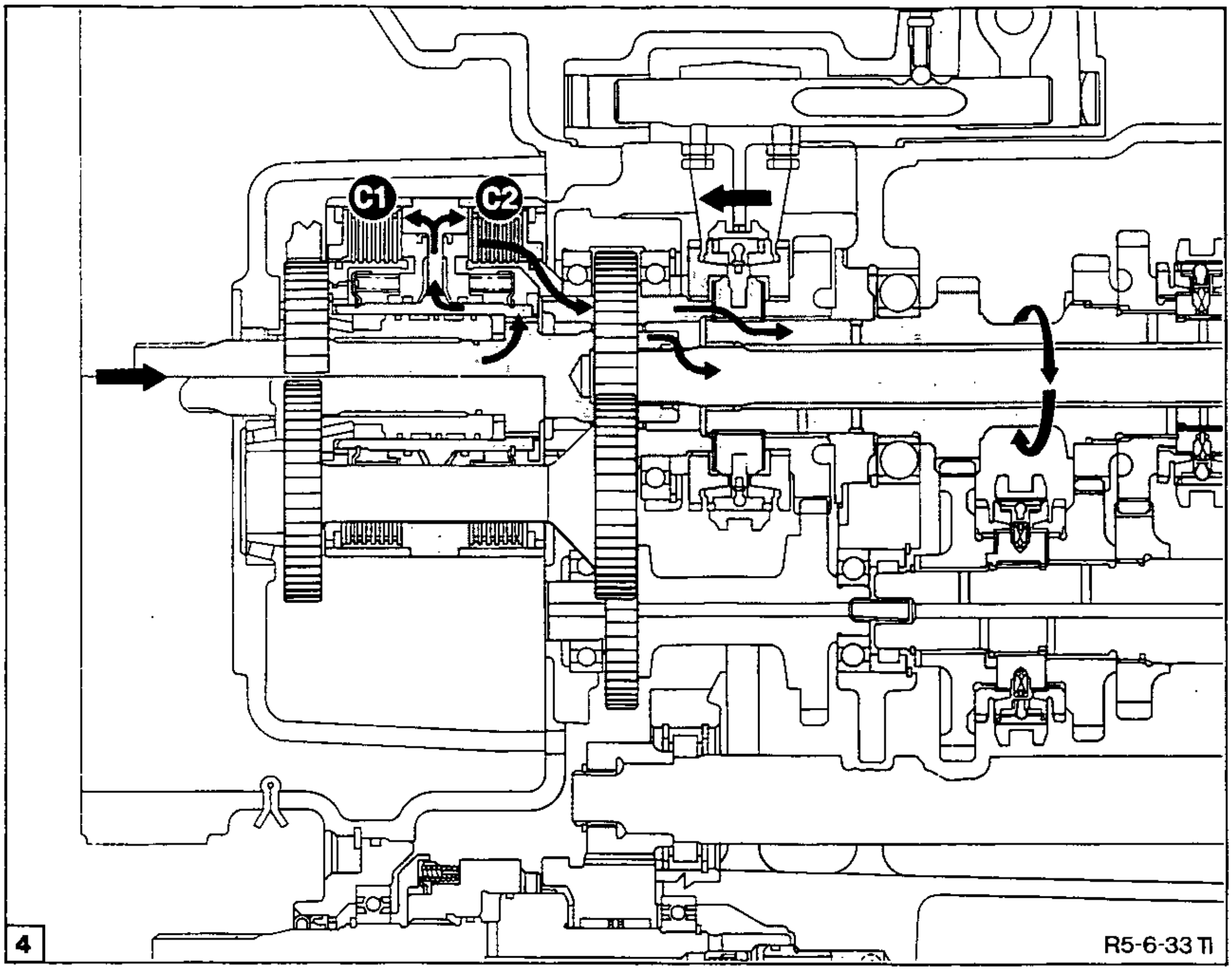
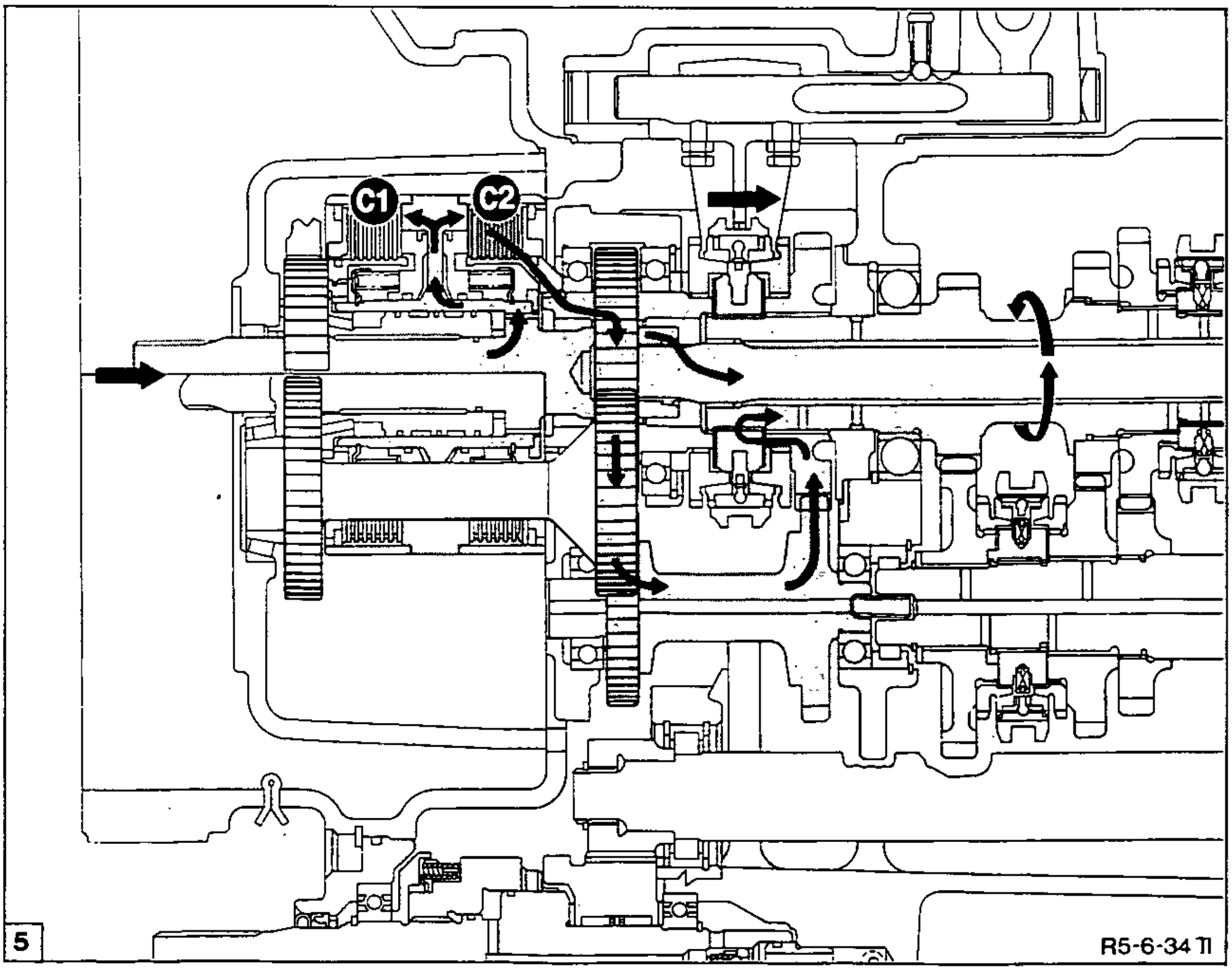
Under Drive Power Flow – Reverse

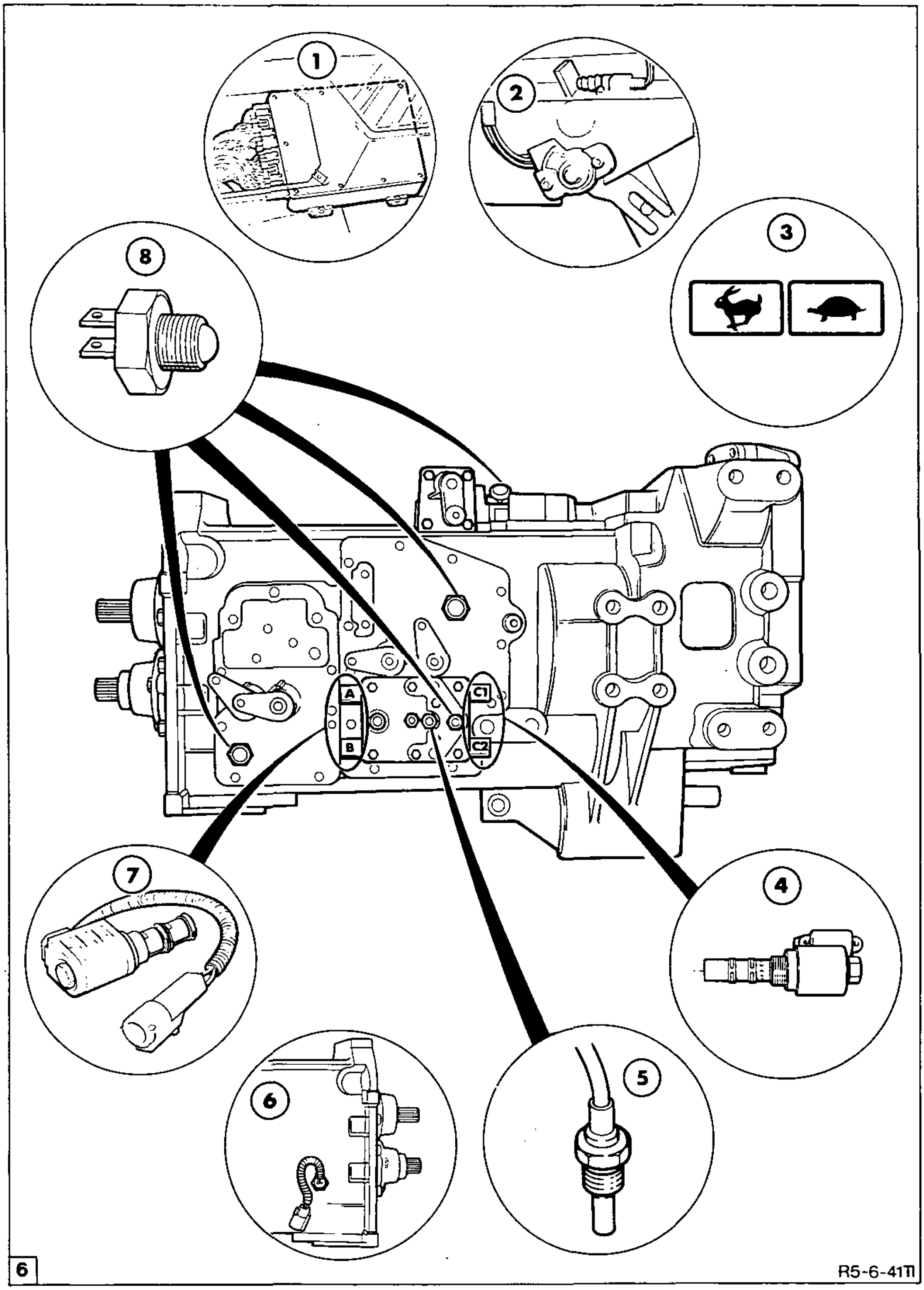


Direct Drive Power Flow – Forward



Direct Drive Power Flow – Reverse

ELECTRICAL SYSTEM



Components	Fig.6 Ref.	Function (In Dual Power Circuit)
Micro Processor	1	Controls engagement/disengagement of C1/C2 clutches, via PWM and transmission dump solenoids from inputs of various switches and senders. Also monitors system for electrical faults, providing error codes for the instrument cluster.
Clutch Pedal Potentiometer	2	Provides information to micro processor to determine current provided to PWM solenoids.
Clutch Pedal Switch	2	Operates when the clutch pedal is fully depressed, de–activating the transmission dump solenoid and PWM solenoids.
Transmission Status Switches	8	Provides transmission status to micro processor. Prevents tractor drive if levers are accidentally engaged without depressing the clutch pedal. Replaces the interlock cable of standard 12x12 transmission. Forward/Reverse neutral switch prevents tractor start up if not in the neutral position.
Oil Temperature Sender	5	Provides the micro processor with oil temperature information to compensate for pressure changes with variation in oil temperature within the PWM solenoid operated hydraulic valves, this ensures a consistent clutch engagement.
Transmission Speed Sensor	6	Detects tractor motion for micro processor.
Transmission Dump Solenoid	7A	Deadheads pressure oil feed from the hydraulic pump to the PWM solenoids, when transmission is in neutral or clutch pedal fully depressed.
PWM Solenoid Valves	4	Directs and controls the oil from the hydraulic pump, via the dump solenoid, to the C1/C2 clutches. Input is from the micro processor from information provided by the clutch pedal potentiometer and shift lever UD/DD switches.
Four Wheel Drive Solenoid	7B	Directs oil from the pump to the FWD assembly.
Instrument Panel Indicator Lights	3	Illuminates to indicate UD or DD selection.

Electrical Operation

Neutral

The forward/reverse shuttle lever must be in neutral to allow engine start up. The other status switches, located on the Hi/Medium, 1/2 and 3/4 shift rails provide the micro processor with the transmission status. Drive will not be permitted if any of the shift levers are engaged without the clutch pedal being depressed. With the transmission in neutral the dump valve solenoid is not energised and prevents pump oil from reaching the PWM valves. The electronics always default the transmission to the Under Drive selection on start up.

Gear Selection

The clutch pedal must be depressed prior to any shift lever engagement, if not error code 'CP' will be displayed on the instrument cluster and drive will not be permitted by the micro processor. When the clutch pedal is fully depressed and a gear/range/direction selection is made, the dump valve remains de–energised by action of the fully depressed clutch pedal operating the switch. The PWM solenoid operated valves are also deenergised with the clutch pedal fully depressed.

Inching/Feathering

As the clutch pedal is raised from the fully depressed position the dump valve solenoid becomes energised, allowing pressure oil from the pump to the PWM solenoid valve. With the system in the default, under drive mode, the PWM 1 solenoid becomes energised. As the clutch pedal is raised the clutch potentiometer provides increased voltage to the micro processor, the micro processor in turn provides increased current to the PWM 1 solenoid which regulates the pressure to the C1 clutch. As the clutch pedal and therefore current, is raised the pressure to the C1 clutch is raised correspondingly until full pressure/engagement is achieved.

Gear Shifting

As the clutch is depressed drive is disengaged between the engine and transmission as the dump valve is de–energised. Shifts are completed in the normal manner and drive is gradually re–established as the pedal is raised as described in 'inching /feathering.' The system has an electronic override feature where if the clutch is released to quickly or accidentally the micro processor will take over and control the engagement speed of the clutch to prevent sudden and possibly damaging engagements.

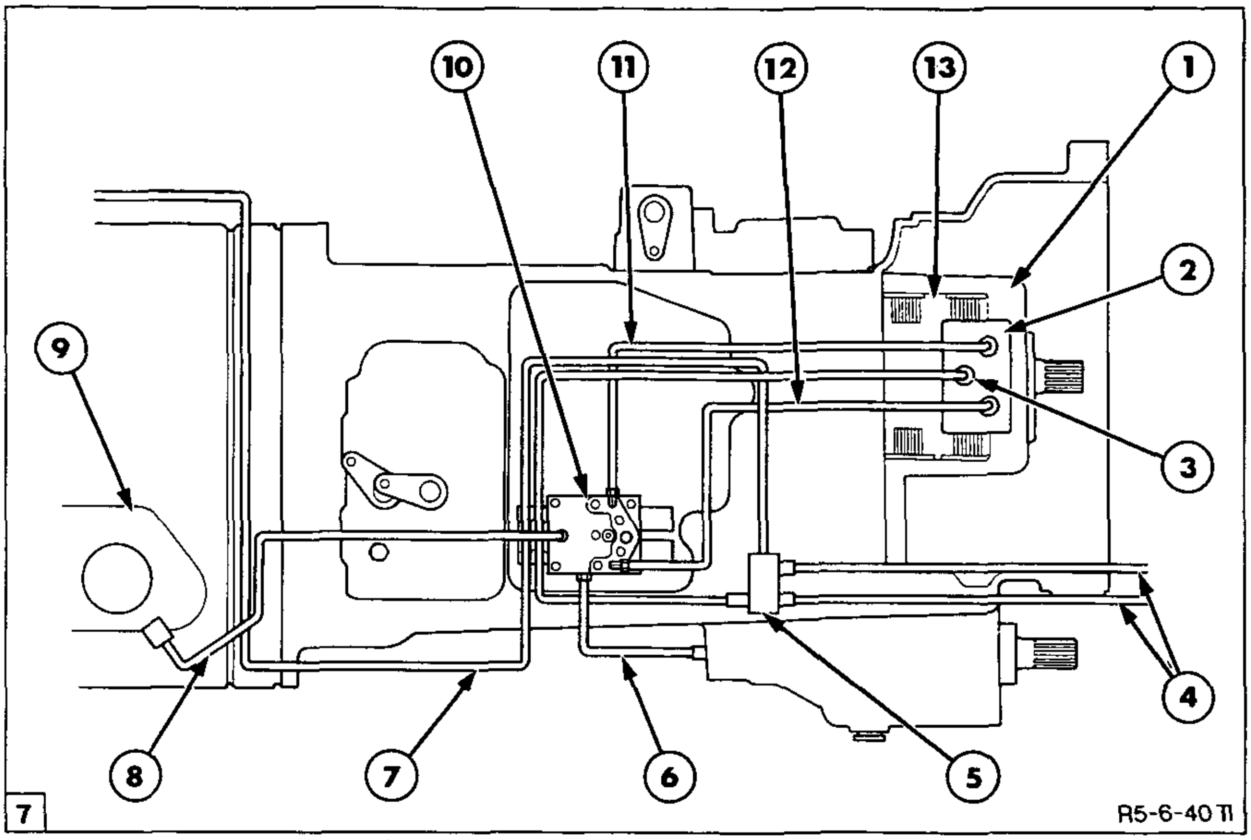
Drive

During continuous drive mode, clutch pedal fully released, the PWM 1 valve is fully open allowing full unrestricted pressure to the C1 clutch.

Under Drive to Direct Drive

Operation of the direct drive switch, located on the main shift lever, deselects the PWM 1 solenoid and energises the PWM 2 solenoid, pressure oil is switched to the C2 clutch. The clutch engagement time is still controlled by the micro processor during this changeover to ensure a smooth shift.

HYDRAULIC SYSTEM



Dual Power Hydraulic System

1. Dual Power Assembly
2. Lube Control Valve
3. Lube Control Valve, Lube Feed
4. Oil Cooler Tubes
5. Oil Cooler By–pass Valve
6. Four Wheel Drive Feed Tube
7. Oil Cooler By–pass Valve Feed from PTO Valve Pack
8. Transmission Control Valve Feed from Pump
9. Fixed Displacement Hydraulic Pump Assembly
10. Transmission Control Valve Assembly
11. C1 Clutch Assembly Feed Tube
12. C2 Clutch Assembly Feed Tube
13. C1/C2 Clutch Assemblies

Components	Fig.7 Ref.	Function (In Dual Power Circuit)
Fixed Displacement Pump	9	Supplies pressure oil at 220–260 lbf.in² (15.0–18.0 bar) at 2100 engine rev/min. from the low pressure side of the pump to the transmission control valve.
Transmission Control Valve	10	Receives oil from the pump. Houses PWM solenoid valves, dump and four wheel drive (where fitted) solenoids. Provides hydraulic outlets to dual power assembly. Also houses 1/2 shift rail staus switch and transmission oil temperature sender.
Lube Control Valve	3	Proportions the transmission lube oil depending on the operating state of the C1/C2 clutches. Ensures adequate lube to the clutches especially during inching/feathering mode.
C1/C2 Clutch Assembly	2	A dual multi plate wet clutch assembly providing either direct drive to transmission or under drive via the under drive gear assembly
Oil Cooler By–pass	5	Provides pressure regulated lube oil for the C1/C2 clutches and the transmission bearings and synchronisers.

Hydraulic Operation

Neutral
Pressure oil supplied by the pump enters the transmission control valve. The oil is channeled directly to the dump valve solenoid, which, with the transmission in neutral, is de–energised (closed), preventing pressure oil from going through to the PWM valves.

Inching/Feathering (Under Drive)
With the clutch pedal depressed and the *gear/range/direction* selected the transmission is still immobilised due to the dump valve remaining de–energised by the action of the clutch pedal in the fully depressed position. As the clutch pedal is raised the dump valve is energised allowing pump oil to the PWM valves. Further lifting of the clutch pedal provides a corresponding increase in oil flow through the PWM 1 valve, in this case, and a gradual engagement of the clutches in the C1 assembly.

Drive
With the clutch fully released full pressure is allowed to operate on the clutches to provide direct drive.

Gear Shifting
When shifting gear the action of fully depressing the clutch de–energises dump valve solenoid, the oil pressure to the PWM valves is cut, hence disconnecting drive between engine and transmission. As the clutch is raised hydraulic pressure is progressively restored to the clutch to continue driving.

Under Drive to Direct Drive
Operation of the direct drive switch (hare symbol), located on the main shift lever, deselects the PWM 1 solenoid and energises the PWM 2 solenoid, pressure oil is switched to the C2 clutch. The clutch engagement time is still controlled by the micro processor during this changeover to ensure a smooth shift.

LUBE CONTROL VALVE OPERATION

With reference to Figure 8.

The lube control valve consists of a lube selector spool, a direct drive cut–off valve and an under drive cut–off valve. The lube selector spool is energised by oil pressure bled from either the C1 or C2 supply oil and is *centred neutral by springs. The direct drive* and under drive cut–off valves are also activated by pressure oil bled from C1 for the under drive valve or C2 for the direct drive valve. Both are held in the disengaged position by a central return spring.

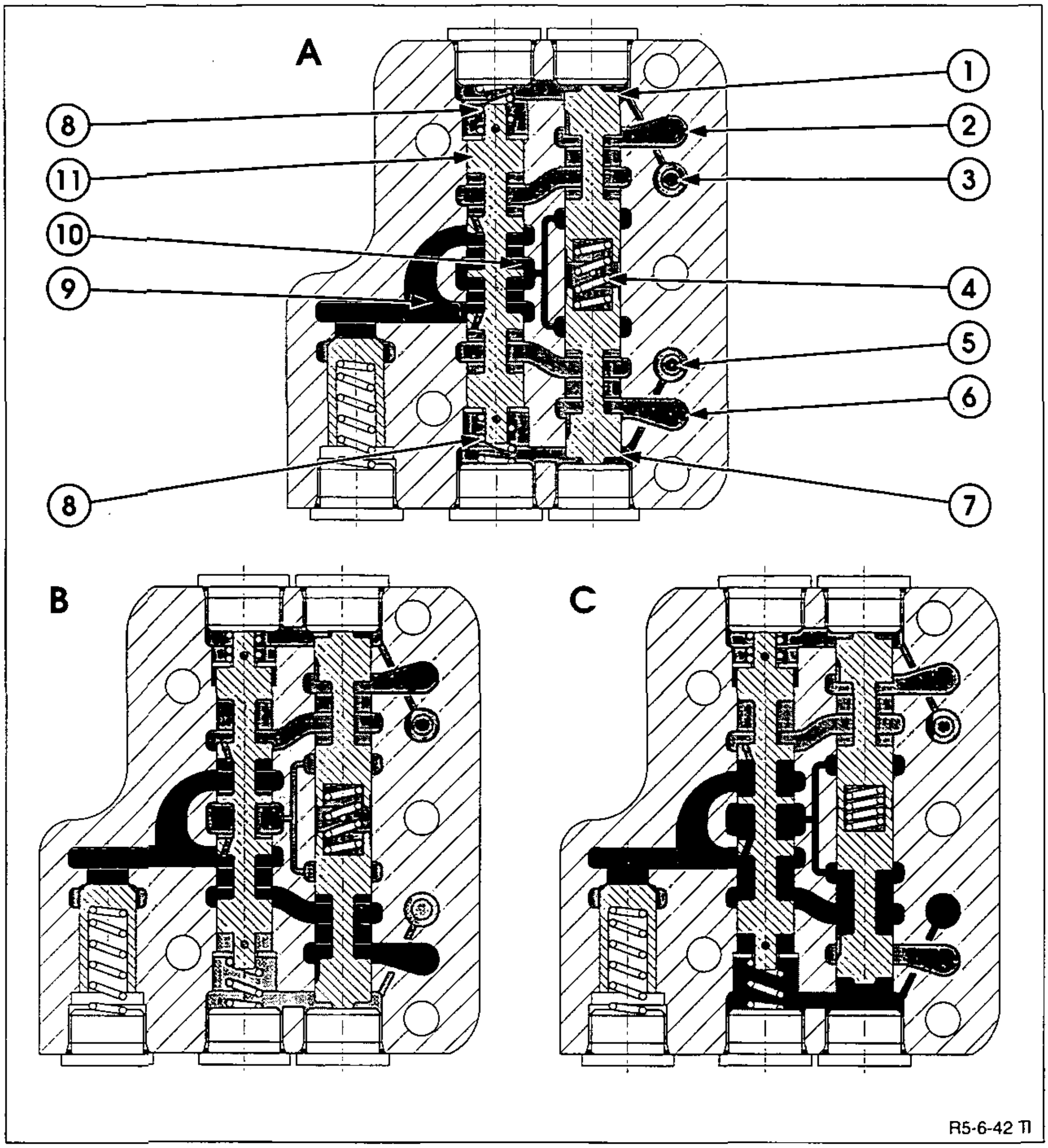
Early production models incorporate a relief valve within the lube control valve. This valve has no function and was removed shortly after Job 1. The relief valve for the transmission lubrication circuit is located in the P.T.O. valve pack. The relief valve operates if the pressure in the lube circuit exceeds approximately 100lbf.in^2 (6.9 bar).

Neutral – Diagram A
The dump valve solenoid is de–energised, therefore no oil pressure is in either the C1 or C2 clutches. The lube selector is held in its neutral state by the 20lb springs and both of the direct drive and under drive cut–off valves are in the disengaged state. Oil from the oil cooler by–pass valve passes through the selector valve and in this neutral condition, restricted oil flows to both direct drive and under drive clutches. Unrestricted oil is allowed to flow through the selector spool through to the transmission synchronisers and bearings.

Inching/feathering (Direct Drive) – Diagram B
As the clutch pedal is released and oil pressure to the C2 clutch assembly and subsequently the lube selector valve, begins to increase, the lube selector spool moves across against the neutralising spring, at approximately 20lbf.in^2 the selector spool is fully engaged. In this position full lubricating oil flow is directed to the direct drive (C2) lube cut–off valve. The lube cut–off valve is in the open position until a pressure of 110–120lbf.in^2 is attained in the C2 clutch line. Therefore between 20lbf.in^2 and 110–120lbf.in^2 the clutches in the C2 clutch receives the majority of the lube oil, which is during the inching/feathering period when the oil is most required. During this period a small amount of restricted lube oil is directed to the transmission synchronisers and bearings and to the under drive assembly.

Drive – Diagram C
When the clutch pedal is raised sufficiently, to provide the tractor with full drive, the oil pressure to the clutch assembly will exceed 120lbf.in^2. At this point the direct drive lube cut–off valve spool moves across to the cut–off position, providing the transmission synchronisers with unrestricted oil flow and restricted oil to the now fully engaged C2 *clutch and disengaged C1 clutch.*

The oil distribution is reversed when under drive is selected. i.e, C1 receives the unrestricted flow during inching/feathering.



LUBRICATION CONTROL VALVE OPERATION

Lubrication Inlet From Oil Cooler By-pass Valve

Restricted Lubrication Oil

Oil To Dump

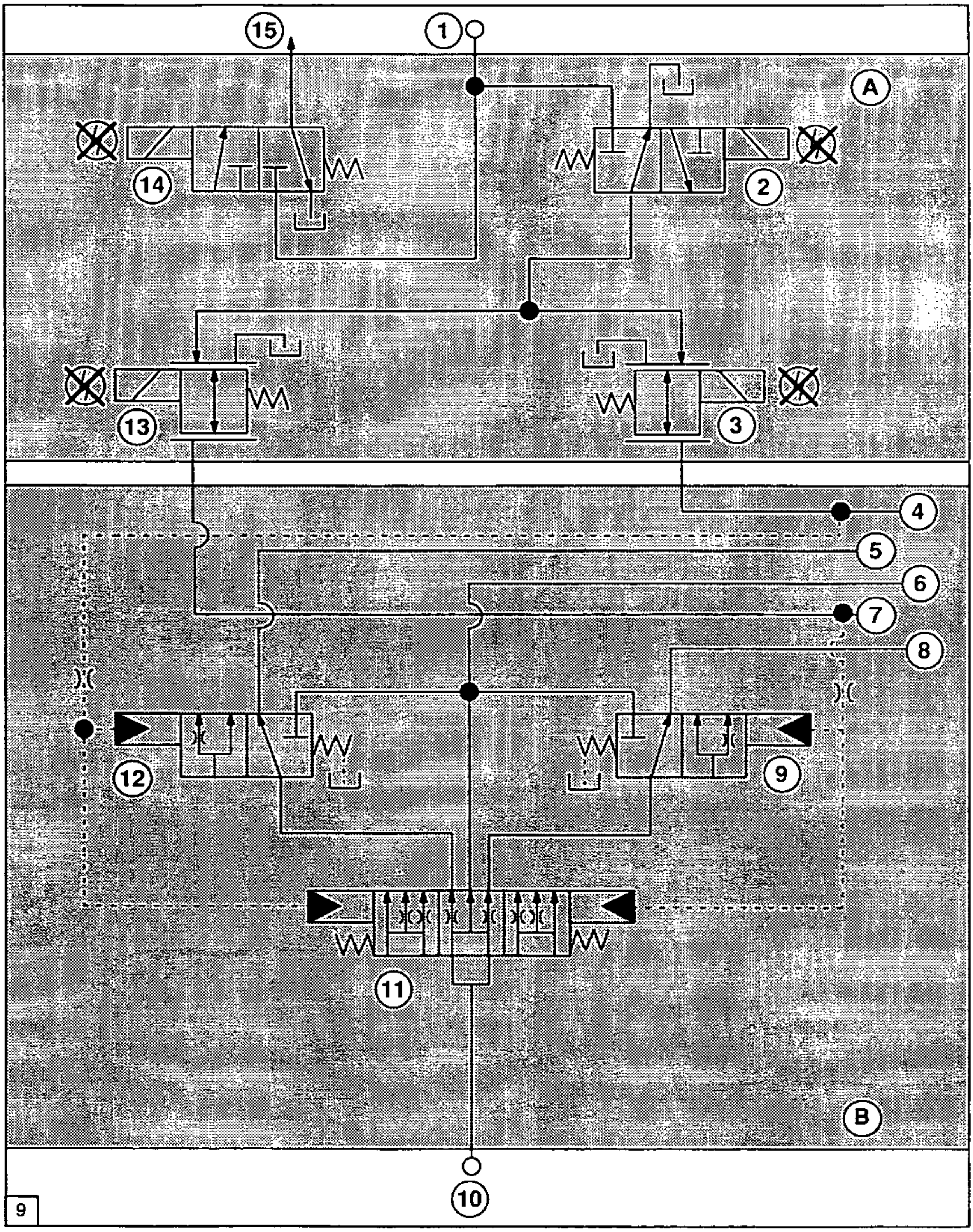
C1/C2 Clutch Oil Greater Than 120lbf.in² (8.3 bar)

C1/C2 Clutch Oil Less Than 120lbf.in² (8.3 bar) But Greater Than 20lbf.in² (1.4 bar)

A Transmission In Neutral
B Direct Drive, Inching/Feathering
C Direct Drive, Driving

1. C1 Lubrication Cut-off Valve Spool
2. C1 Lubrication Feed
3. Pressure Bleed From C1 Clutch
4. Spring – 120 lb.
5. Pressure Bleed From C2 Clutch
6. C2 Lubrication Feed
7. C2 Lubrication Cut-off Valve Spool
8. Selector Spool Centralising Spring
9. Lubrication Feed From Oil Cooler By-pass Valve
10. Transmission Bearing And Synchroniser Feed
11. Selector Valve Spool

DUAL POWER HYDRAULIC SYSTEM –TRANSMISSION IN NEUTRAL (FWD ENGAGED)

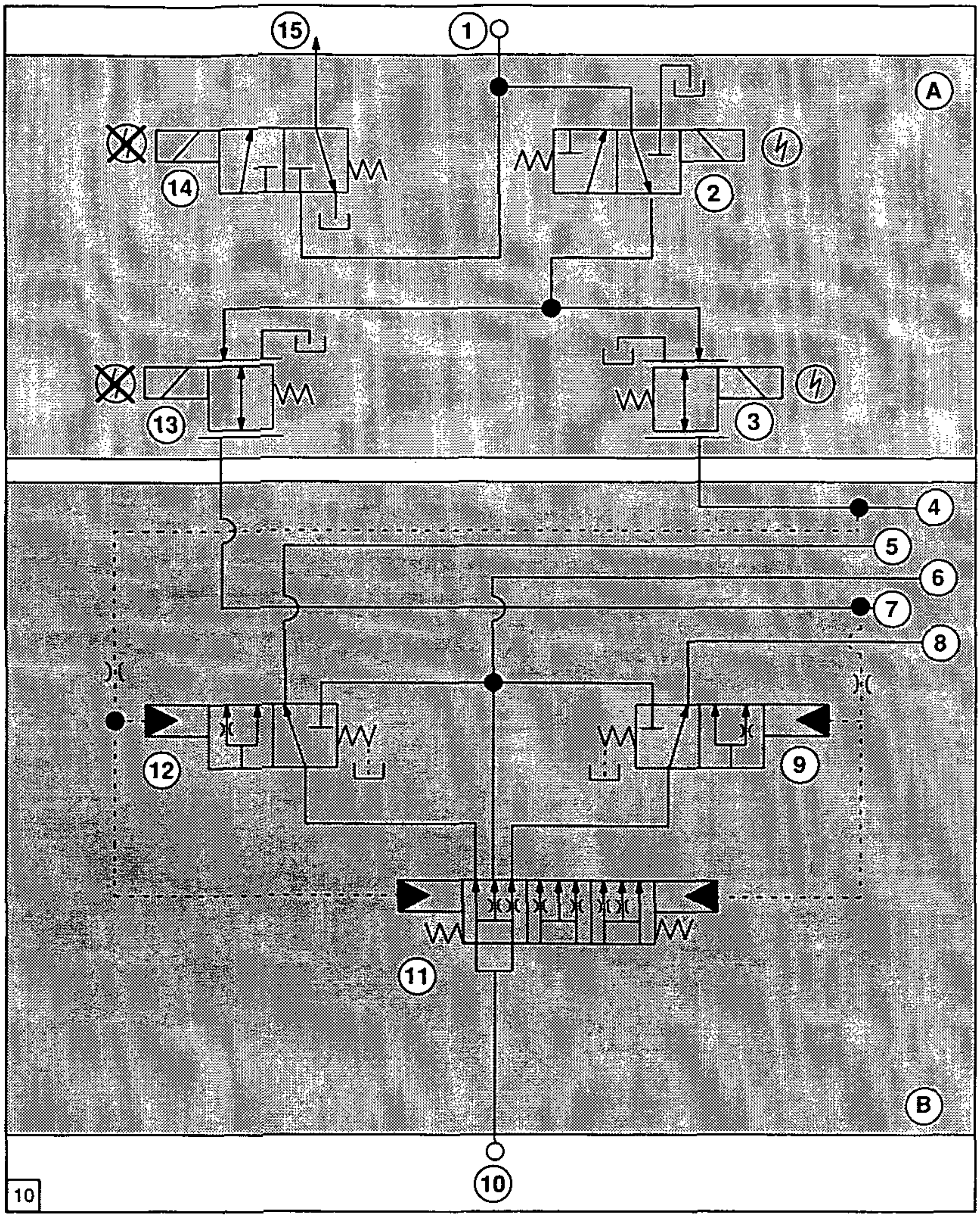


A. Transmission Control Valve

B. Lube Control Valve

1. Regulated oil feed from low pressure side of the fixed displacement pump.
2. Dump solenoid
3. PWM 2 solenoid
4. Direct drive (C2) clutch pressure feed
5. Direct drive (C2) clutch lube oil
6. Lube oil feed to transmission bearings and synchronisers
7. Under drive (C1) clutch pressure feed
8. Under drive (C1) clutch lube oil
9. Under drive lube cut–off valve
10. Lube oil feed from oil cooler by–pass valve
11. Lube selector valve
12. Direct drive lube cut–off valve
13. PWM 1 solenoid
14. Four wheel drive solenoid
15. Outlet to four wheel drive assembly

DUAL POWER HYDRAULIC SYSTEM –TRANSMISSION IN DIRECT DRIVE, INCHING/FEATHERING (FWD ENGAGED)

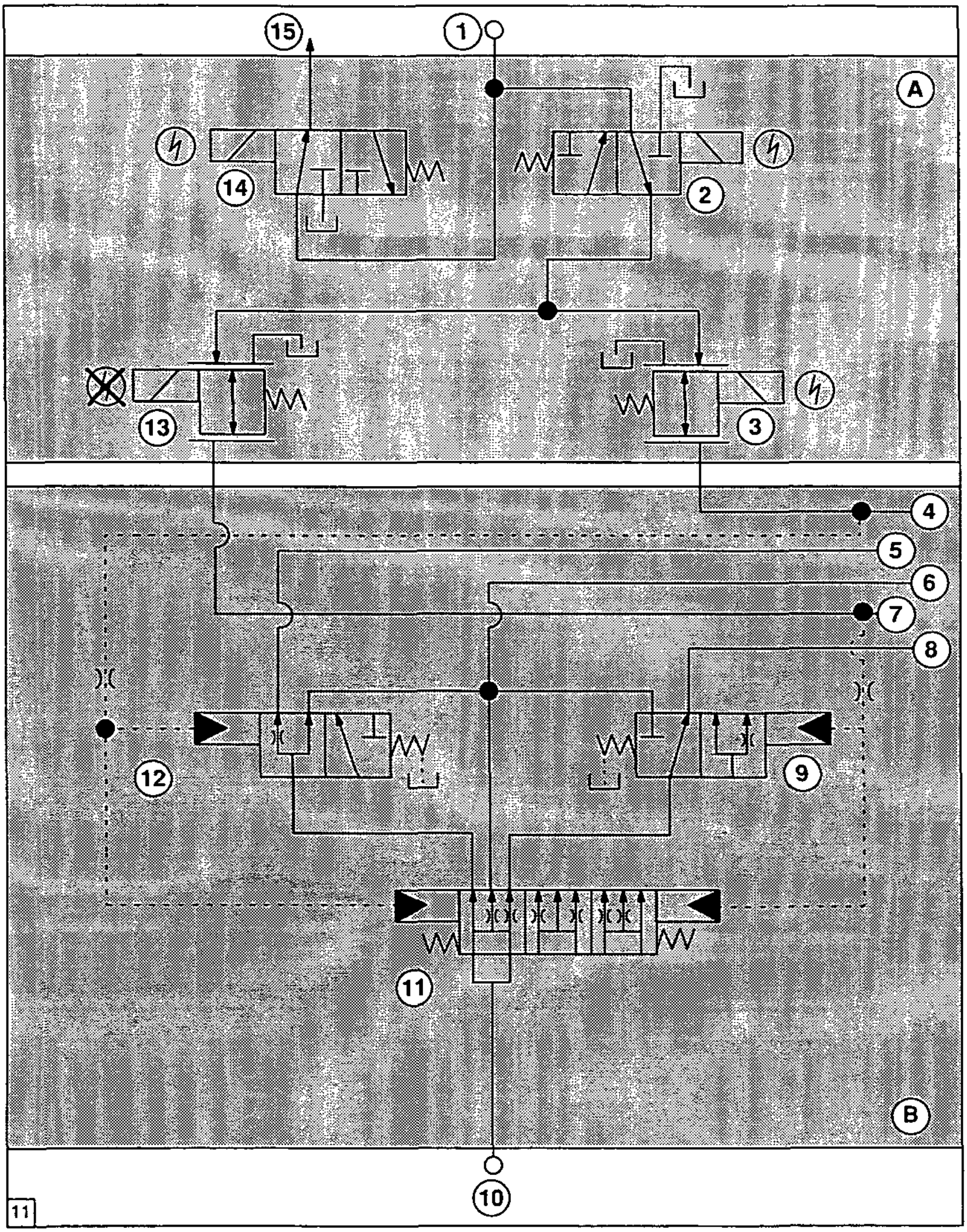


A. Transmission Control Valve

B. Lube Control Valve

1. Regulated oil feed from low pressure side of the fixed displacement pump.
2. Dump solenoid
3. PWM 2 solenoid
4. Direct drive (C2) clutch pressure feed
5. Direct drive (C2) clutch lube oil
6. Lube oil feed to transmission bearings and synchronisers
7. Under drive (C1) clutch pressure feed
8. Under drive (C1) clutch lube oil
9. Under drive lube cut–off valve
10. Lube oil feed from oil cooler by–pass valve
11. Lube selector valve
12. Direct drive lube cut–off valve
13. PWM 1 solenoid
14. Four wheel drive solenoid
15. Outlet to four wheel drive assembly

DUAL POWER HYDRAULIC SYSTEM – TRANSMISSION IN DIRECT DRIVE, DRIVE MODE (FWD DISENGAGED)

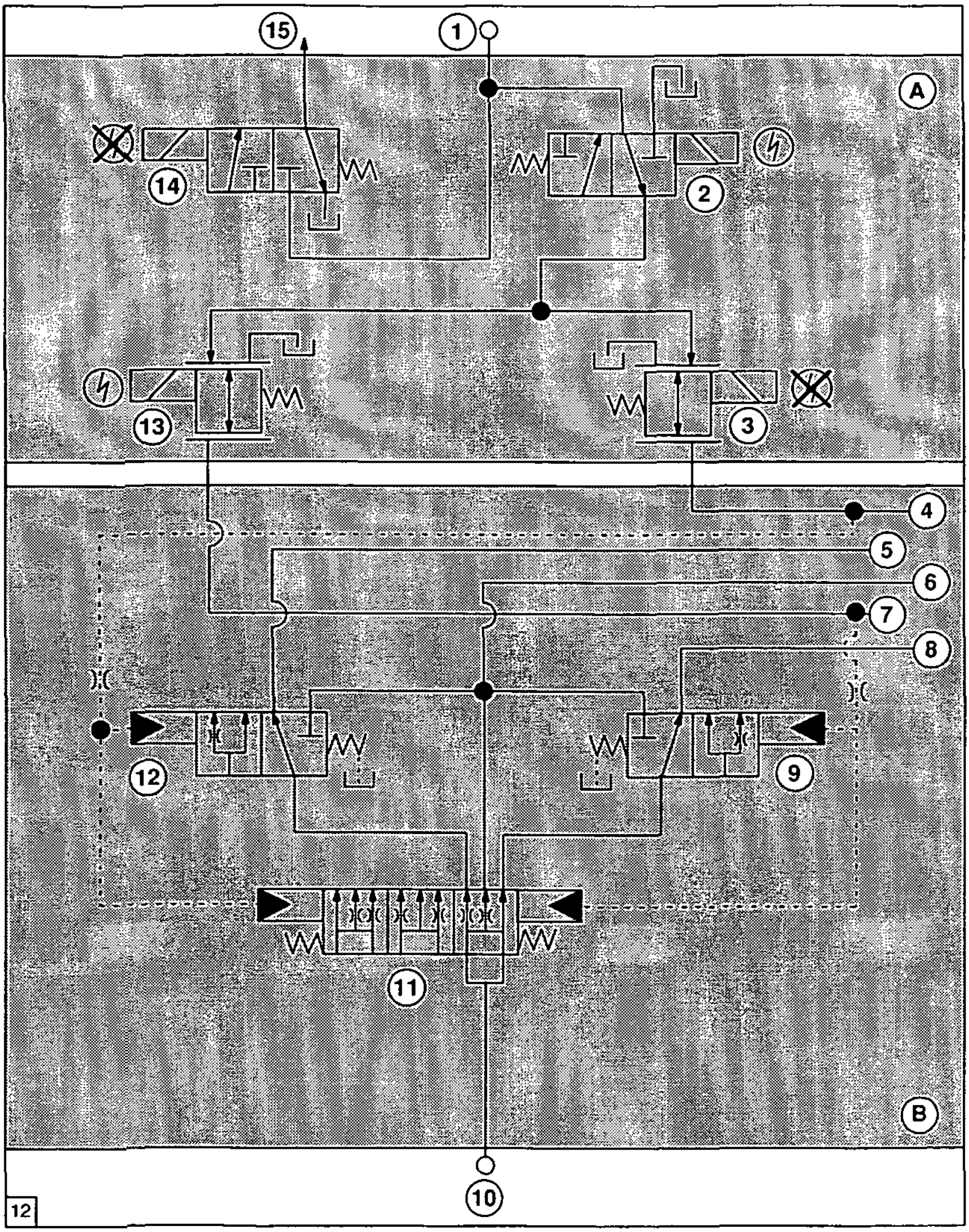


A. Transmission Control Valve

B. Lube Control Valve

1. Regulated oil feed from low pressure side of the fixed displacement pump.
2. Dump solenoid
3. PWM 2 solenoid
4. Direct drive (C2) clutch pressure feed
5. Direct drive (C2) clutch lube oil
6. Lube oil feed to transmission bearings and synchronisers
7. Under drive (C1) clutch pressure feed
8. Under drive (C1) clutch lube oil
9. Under drive lube cut–off valve
10. Lube oil feed from oil cooler by–pass valve
11. Lube selector valve
12. Direct drive lube cut–off valve
13. PWM 1 solenoid
14. Four wheel drive solenoid
15. Outlet to four wheel drive assembly

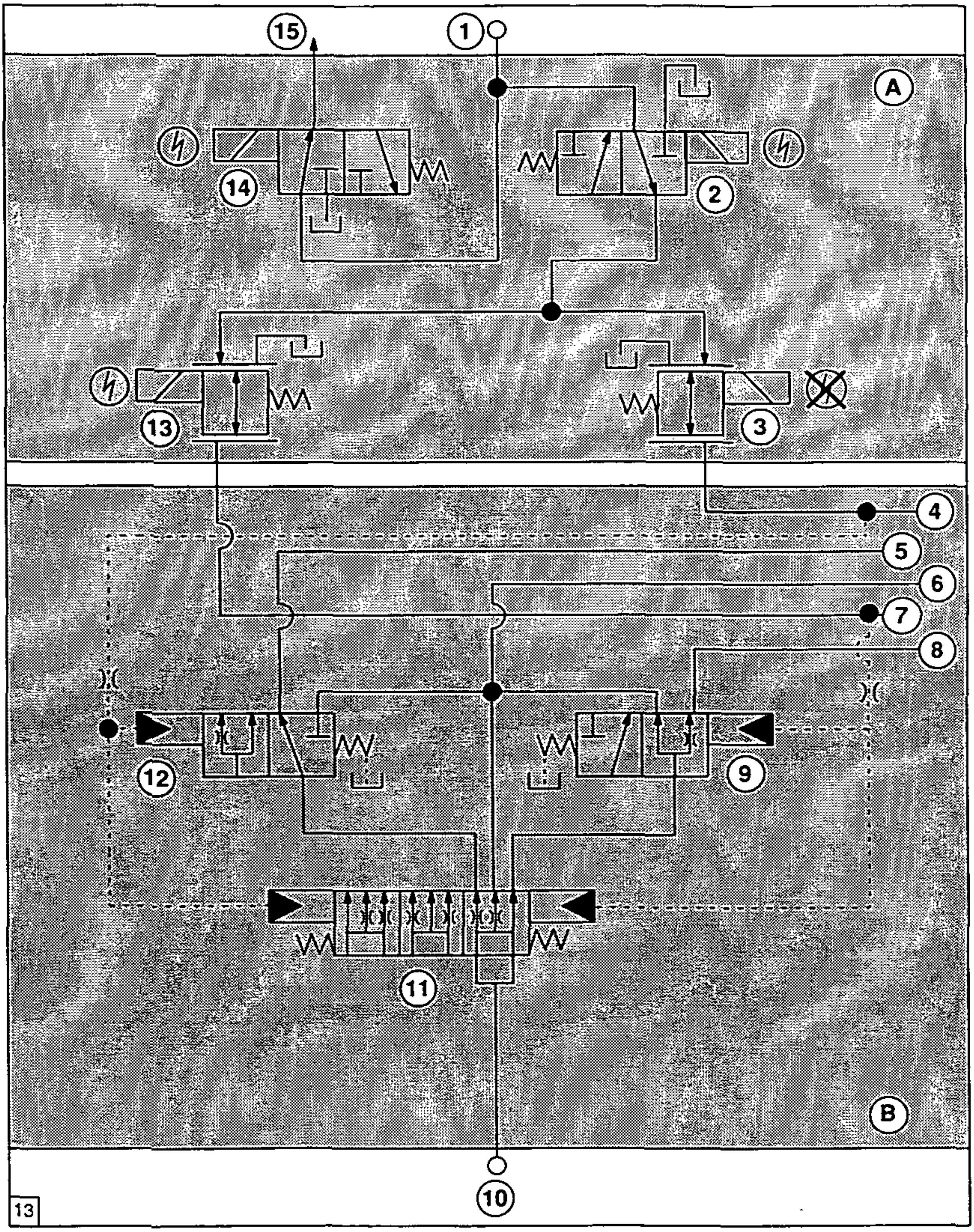
DUAL POWER HYDRAULIC SYSTEM –TRANSMISSION IN UNDER DRIVE, INCHING/FEATHERING (FWD ENGAGED)



A. Transmission Control Valve
B. Lube Control Valve

1. Regulated oil feed from low pressure side of the fixed displacement pump.
2. Dump solenoid
3. PWM 2 solenoid
4. Direct drive (C2) clutch pressure feed
5. Direct drive (C2) clutch lube oil
6. Lube oil feed to transmission bearings and synchronisers
7. Under drive (C1) clutch pressure feed
8. Under drive (C1) clutch lube oil
9. Under drive lube cut–off valve
10. Lube oil feed from oil cooler by–pass valve
11. Lube selector valve
12. Direct drive lube cut–off valve
13. PWM 1 solenoid
14. Four wheel drive solenoid
15. Outlet to four wheel drive assembly

DUAL POWER HYDRAULIC SYSTEM – TRANSMISSION IN UNDER DRIVE, DRIVE MODE (FWD DISENGAGED)



A. Transmission Control Valve

B. Lube Control Valve

1. Regulated oil feed from low pressure side of the fixed displacement pump.
2. Dump solenoid
3. PWM 2 solenoid
4. Direct drive (C2) clutch pressure feed
5. Direct drive (C2) clutch lube oil
6. Lube oil feed to transmission bearings and synchronisers
7. Under drive (C1) clutch pressure feed
8. Under drive (C1) clutch lube oil
9. Under drive lube cut–off valve
10. Lube oil feed from oil cooler by–pass valve
11. Lube selector valve
12. Direct drive lube cut–off valve
13. PWM 1 solenoid
14. Four wheel drive solenoid
15. Outlet to four wheel drive assembly

B. CLUTCH CALIBRATION, FAULT FINDING AND PRESSURE TESTING

Introduction

The transmission electronic management system has an inbuilt self diagnostic facility. This facility utilises the digital display to indicate, in coded format, any malfunction in the electrical and electronic circuitry and in the micro–processor. It should be noted that the self diagnostic capability is generally limited to diagnosis of the electrical and electronic circuitry and related components. Any malfunction of the mechanical and hydraulic components must be diagnosed using conventional techniques, performance characteristics and tooling, such as pressure testing equipment.

Trouble–shooting and fault finding should always be carried out in a logical and planned sequence, many apparent faults associated with electronic components are often hastily diagnosed and result in the replacement of expensive components. An extra few minutes confirming the apparent fault will result in a more positive and cost effective repair.

With the use of micro–processors it is often that this item is blamed for any malfunction but the real truth is that this item is usually sound and that the fault is due to poor contacts in the associated connectors.

Where the fault finding procedure requires checks for continuity a visual inspection of the wiring should be made prior to conducting tests to ensure that obvious 'mechanical' damage has not occurred to the harness or the connectors.

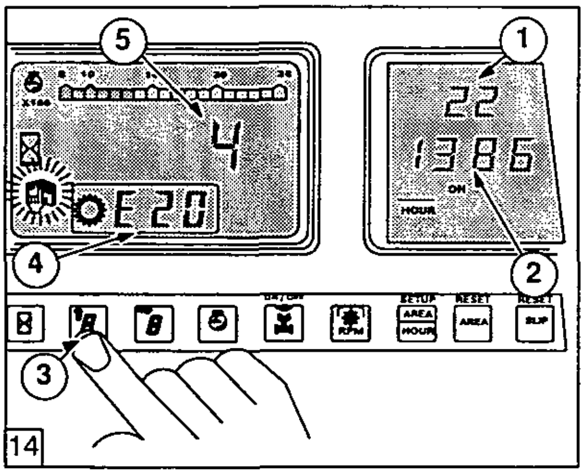
A good quality multi–meter is an essential item to perform fault finding. It should be capable of measuring resistance of at least 20,000 ohms and measuring voltage and current. When using the multi–meter it is good practice to select a high range and work downwards to avoid damaging the instrument.

If it is found necessary to clean the connectors a contact spray should be used. DO NOT USE ANY OTHER METHOD FOR CLEANING TERMINALS. Do not use a cleaner that contains Trichloro–ethylene, this solvent will damage the plastic body of the connector. It is preferable to use a cleaner with a Freon T.F. base.

Error Code Recovery – Electronic Instrument Cluster Only

The electronic instrument panel has a feature which stores and recalls the last ten error codes and the operating hours at which they occurred. This feature is useful in establishing a record of the last time that a particular error occurred on a tractor. To enter the Error Code Recovery mode proceed as follows:–

1. Hold down the DIGIT SET button on the electronic instrument panel and turn the keystart switch 'ON', Figure 14. **DO NOT** start the engine. The 'read your manual' symbol will flash and the most recent error to have occurred on the tractor will be displayed on the appropriate instrument panel display together with the hours at which the error last occurred.



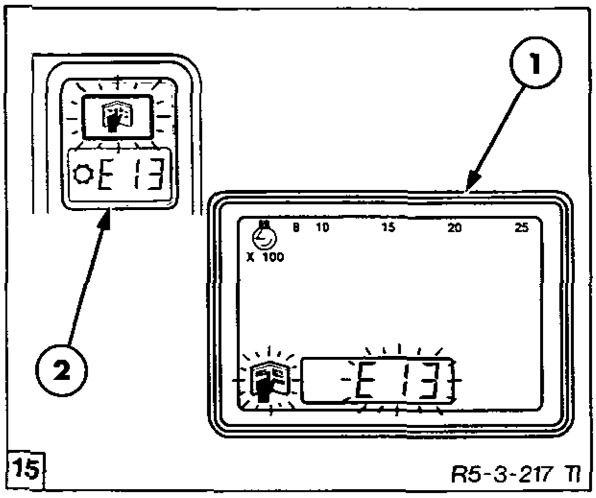
Error Code Recovery

1. Electronic Draft Control (EDC) Error Code
2. Hours of Error Occurrence
3. Digit Set Button
4. 12 x 12 Transmission Error Code
5. Electronic Instrument Cluster (EIC) Error Code

2. Press the DIGIT SET button and the next most recent error code will occur. This procedure can be repeated until a maximum of the last 10 error codes have been displayed.

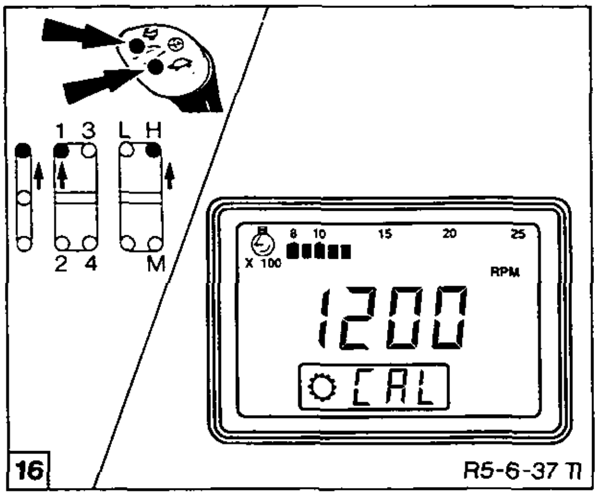
3. To erase the memory of the stored error codes, hold down the DIGIT SET button for approximately 10 seconds while in the error code recovery mode.

The heading **Error Code Listing** gives the displayed message that will appear on the digital display should a fault occur in the electronic or electrical system. Note that if more than one fault exists the appropriate codes will be displayed until such time as all faults have been corrected.



Error Code Display

1. EIC Instrument Cluster Display
2. AEIC Instrument Cluster Display



Electronic Instrument Cluster – CAL Displayed

IMPORTANT: *Upon completion of a repair it will be necessary to turn the keystart on and off to clear the code from the display and confirm that the repair was successful.*

CALIBRATION PROCEDURE

IMPORTANT: *In service the dual power clutch packs (C1 and C2) will require calibration as the clutches wear. In addition this calibration must be carried out following repair work to the PWM valves or following replacement of the microprocessor.*

Position the tractor in a suitable location on level ground.

1. Set the handbrake into full hold position.
2. Depress and hold both up and down switches (located on the main shift lever) while the engine is started.
   The instrument panels transmission display will display 'CAL'. Release the shift switches.
3. Depress the clutch pedal and then place all shift levers in the forward position to select forward, 1st gear and High Range.
4. Release the clutch pedal.
5. Set the engine speed to 1200 rev/min ±100 rev/min

NOTE: *Ensure the Air Conditioner is turned off to prevent uncontrolled changes in the engine speed.*

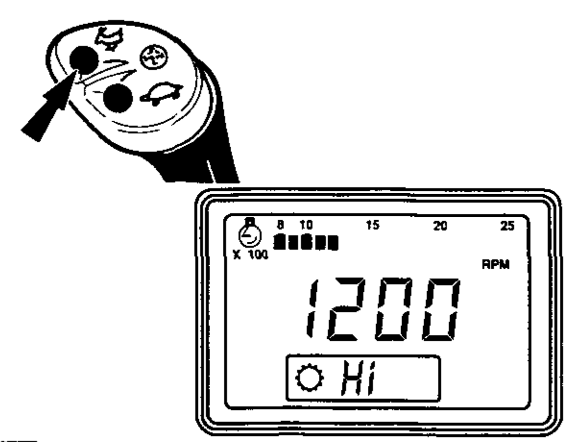
The initial set up is complete, the shift buttons can now be used to calibrate:–

C2 (Hi) – Upshift (direct drive) clutches.
C1 (Lo) – Downshift (underdrive) clutches.

NOTE: *Although only one calibration is required the calibration procedures in steps 6 to 9 can be repeated many times and in any order.*
In addition every time the clutch is successfully calibrated the old value is overwritten in memory. This memory is retained when power is disconnected.

C2 (Hi) Clutch Calibration

6. Depress and hold the upshift switch (hare symbol) on the main shift lever. If the test conditions are not correct an error code signified by a 'U' and two digits will be displayed, refer to the following, Clutch Spring Pressure Calibration Error Codes, on the following page.



17 R5-6-38 TI

Electronic Instrument Cluster – Hi Displayed

7. Under the normal calibration process Hi will be displayed while the base line engine rev/min is determined. Base engine rev/min must be held steady ±10 rev/min for 1 second before the calibration process will continue. The microprocessor will then begin to slowly increase the modulation pressure beginning at low pressure. The pressure will be displayed during calibration.

8. The clutch pressure will continue to increase until the engine rev/min decreases 50 rev/min below the base measurement. The clutch pressure will then be dumped and the calibration pressure will continue to be displayed until the shift switch is released.

C1 (Lo) Clutch Calibration

9. Depress the downshift switch (tortoise symbol) on the main shift lever and repeat the steps as for C2 (Hi) clutch calibration.

NOTE: *Typical calibration values can vary between 120 and 160.*

Store Calibration

In order to store the calibration turn the ignition key off and then on again.

Clutch Spring Pressure Calibration Error Codes

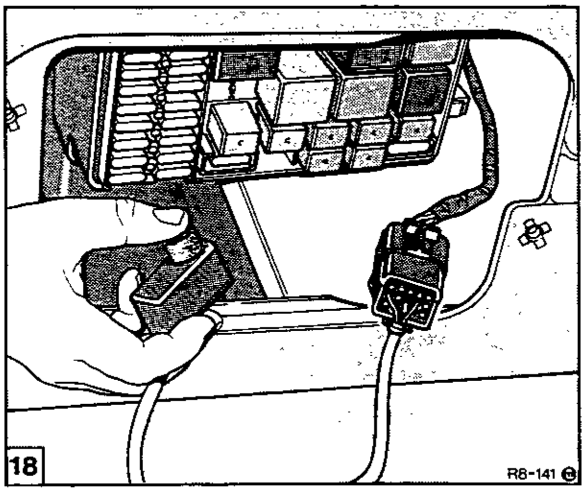
Code	Possible Cause
U20	Correct start up sequence not used – Depress and release the clutch pedal, repeat calibration procedure.
U21	Engine rev/min is too low (1200 rev/min ±100 rev/min
U22	Engine rev/min is too high (1200 rev/min ±100 rev/min
U23	Forward/Reverse shuttle lever is not in forward
U24	Main range lever is not in gear
U25	High/Medium range lever is not in gear
U26	Clutch pedal is not fully released
U27	C2 (Hi) clutch calibration is too low – The beginning test pressure was sufficient to lug the engine
U28	C2 (Hi) clutch calibration is too high – The maximum test pressure was reached without causing the engine speed to decrease 50 rev/min
U29	C1 (Lo) clutch calibration is too low – The beginning test pressure was sufficient to lug the engine
U30	C1 (Lo) clutch calibration is too high – The maximum test pressure was reached without causing the engine speed to decrease 50 rev/min
U31	Wheel motion detected during calibration – Handbrake was not set or the calibration threshold was too low such that initial pressure was enough to cause slight wheel motion prior to lugging the engine.

CLUTCH FILL TIME CALIBRATION

IMPORTANT: *Care must be taken when making this adjustment, over adjustment can make the clutch engagement very jerky. It may be necessary to perform this calibration in service as the clutches wear.*
If the delay in engaging drive when inching or during power shift seems excessive (clutch fill time is too long) or if the clutch performance is jerky when inching (clutch fill time is too short).

C1 (Lo) Clutch Fill Time Calibration

1. Connect the diagnostic plug, Tool No.4FT 950, to the tractor.



Diagnostic Switch Connected into Diagnostic Connector

2. With the tractor parked on a level surface, with the handbrake on, start the engine and set to 1500 rev/min.

3. The display will read HH, depress the test switch until H6 is selected on the display. After 4 seconds this will disappear and the currently stored C1 (Lo) clutch fill time value will be indicated.

NOTE: *This is set to 10 during manufacture. The value 10 represents 100 milliseconds, a value of 15 represents 150 milliseconds.*

4. Operate the tractor until the driveline oil has reached normal operating temperature. A method of warming the oil quickly and safely is to install a flow meter into the remote valves and restrict the flow for several minutes. Error code F1 will be displayed if the oil temperature is to cool for calibration.

NOTE: *Do Not Calibrate if F1 is displayed at any time. The oil temperature will seriously affect the calibration.*

Code	Possible Cause
F1	Oil temperature too cool for calibration

5. Depress the clutch pedal and select forward, first gear and medium range.

6. Release the clutch pedal slowly before the inching point is reached (about 20% of travel) and note if the tractor 'moves' as the pedal is released to this point.

7. If the tractor did not move or moves very slightly on releasing the clutch then go to step 10.

8. If the tractor motion is unacceptably jerky on releasing the clutch then go to step 9, if okay go to step 1, Hi clutch calibration.

9. Repeat step 6 after operating the gearshift "shiftdown" button and decreasing the quickfill number by one count on the display.

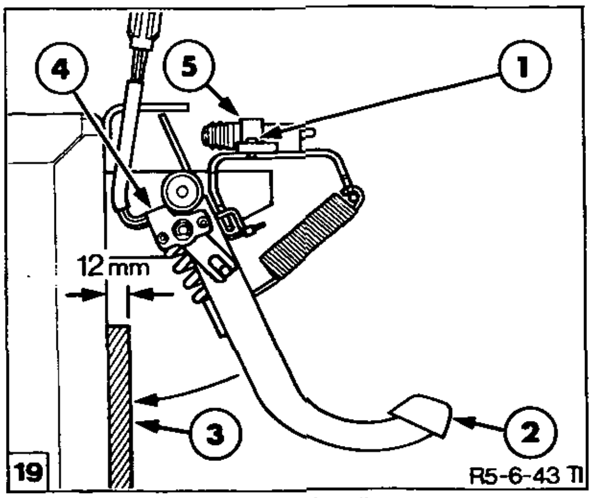
10. Repeat step 6 after operating the gearshift "shiftup" button and increasing the quickfill number by one count on the display.

C2 (Hi) Clutch Fill Time Calibration

1. Depress the diagnostic test switch until H7 is selected on the display, after 4 seconds this will disappear and the currently stored C2 (Hi) clutch fill time value will be indicated.
   Repeat steps 5 to 9 as for C1 (Lo) clutch to calibrate the C2 (Hi) clutch fill time.

2. Turn the ignition key off and disconnect the tractor diagnostic plug.

Clutch Pedal Switch Adjustment



Clutch Pedal Switch Adjustment

1. Switch Retaining Screw – 2 off
2. Clutch Pedal
3. 12 mm Spacer
4. Potentiometer
5. Clutch Pedal Switch Assembly

1. Loosen the two screws retaining the switch assembly. With a suitable 12mm spacer against the steering support, depress the clutch pedal until it contacts the spacer. Slide the switch against the pedal, at the point of the switch actuating tighten the retaining screws to lock the switch in position.

12x12 Dual Power Error Codes

Error Code	Fault Condition for 12x12 Dual Power Transmission	Priority	Disable Trans	Display Mode
E21	Chassis harness disconnected	1	Disable	Latched
E34	Fuse 13 blown	2	Disable	Latched
E36	12X12 Dump solenoid open circuit	3	Disable	Latched
E35	12x12 Dump solenoid closed circuit	4	Disable	Latched
E53	5 Volt Reference failed, shorted to 12 volts	5	Disable	Latched
E54	5 Volt Reference failed, shorted to ground	6	Disable	Latched
E12	12X12 Clutch pedal potentiometer signal too high	7	Disable	Latched
E11	12X12 Clutch pedal potentiometer signal too low	8	Disable	Latched
E37	12X12 Clutch disconnect switch open circuit	9	Disable	Latched
CP	Depress clutch pedal to enable transmission	10	Disable	Latched
E39	12X12 C2 (High) clutch solenoid open circuit	11	Disable	Latched
E38	12X12 C2 (High) clutch solenoid short circuit	12	Disable	Latched
E41	12X12 C1 (Low) clutch solenoid open circuit	13	Disable	Latched
E40	12X12 C1 (Low) clutch solenoid short circuit	14	Disable	Latched
E46	12X12 Fuse 12 blown	15	Enabled	Latched
E47	12x12 Clutch disconnect switch misadjusted high	16	Enabled	Latched
E48	12X12 Clutch disconnect switch short circuit misadjusted	17	Enabled	Latched
E51	Transmission temperature sensor open circuit	18	Enabled	Latched
E52	Transmission temperature sensor short circuit	19	Enabled	Latched
E24	Both clutches not calibrated	20	Enabled	Latched
E Hi	C2 (Hi) clutch not calibrated	21	Enabled	Latched
E Lo	C1 (Lo) clutch not calibrated	22	Enabled	Latched
E13	Up and down switches both on	23	Enabled	Temp
E49	Wheel speed sensor circuit open or short circuit	24	Enabled	Temp
E26	Engine rev/min speed too high	25	Enabled	Temp
E27	Engine rev/min speed too low	26	Enabled	Temp

Error Code Table Explanations:

Priority – The error codes are listed in a priority order. Number 1 priority being the most serious fault and number 26 being considered the least serious of errors, i.e, if more than two errors occur the highest priority error will be displayed.

Disable Trans – This column of the table indicates whether the transmission is either **disabled**, i.e, not allowed to function or **enabled**, i.e, there is a fault within the transmission but it is still allowed to function.

Display Mode – This refers to the instrument panel display. **Latched** means that the error code will remain displayed until the fault is rectified. **Temp** (Temporary) means the error code will display temporarily and will then extinquish, but *will be stored in the error code memory for retrieval at a later stage.*

ERROR CODE WIRING CIRCUITS

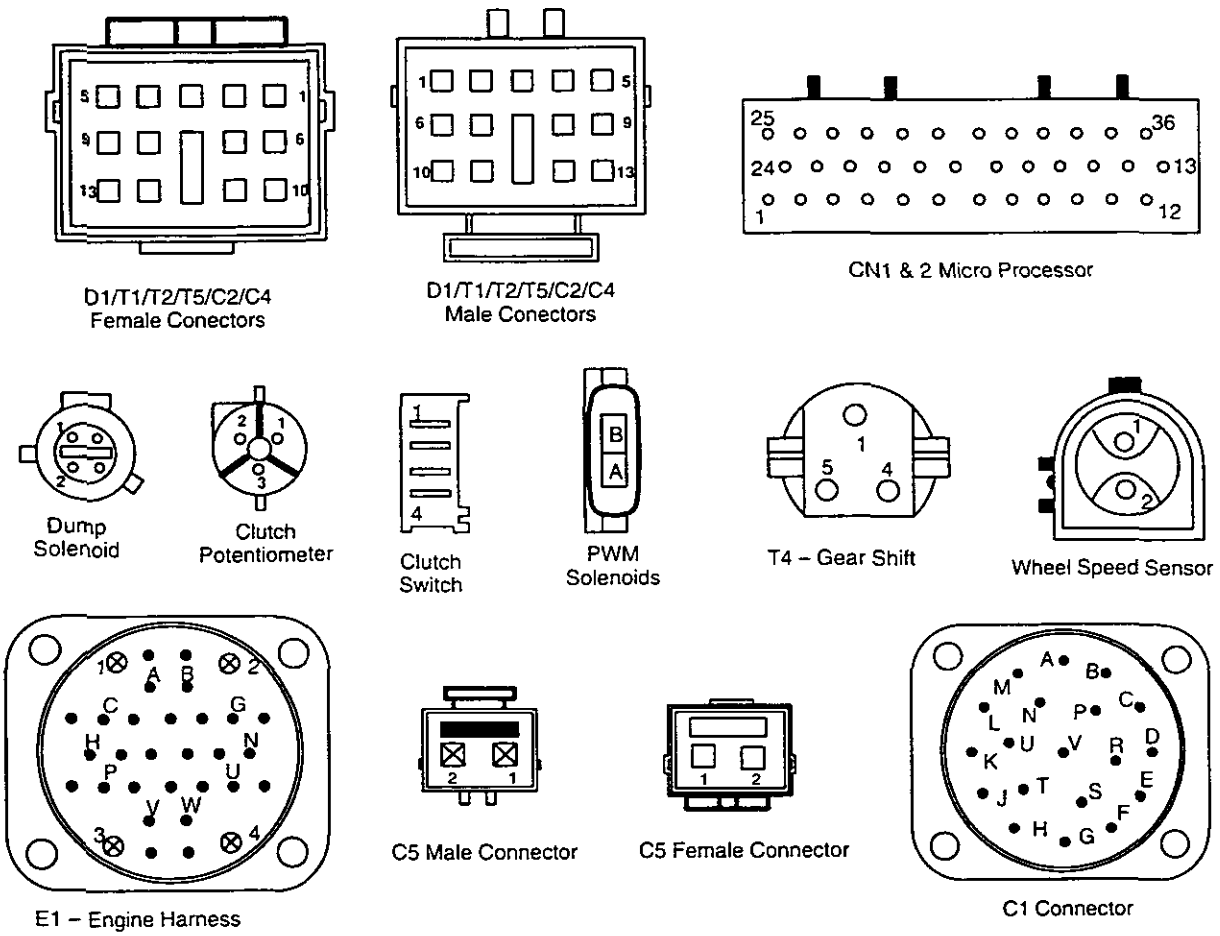
Key To Colours

B	Black	G	Green
N	Brown	LG	Light Green
LN	Tan	U	Blue
S	Slate	TQ	Turquoise
R	Red	P	Purple
O	Orange	K	Pink
Y	Yellow	W	White

Abbreviations used in wiring Circuits:

K.S. = Key Start Switch
FS = Fuse
CN1 or 2 = Micro Processor Connectors
D.S. = Dump Solenoid
C.Pot = Clutch Potentiometer
C.P.S. = Clutch Pedal Switch
N.C. = Normally Closed
W.S.S. = Wheel Speed Sensor
S.M.R. = Starter Motor Relay
N.S.S. = Neutral Start Switch
T.S. = Transmission Temperature Sender

Connector Identification:



D1/T1/T2/T5/C2/C4 Female Conectors

D1/T1/T2/T5/C2/C4 Male Conectors

CN1 & 2 Micro Processor

Dump Solenoid

Clutch Potentiometer

Clutch Switch

PWM Solenoids

T4 – Gear Shift

Wheel Speed Sensor

E1 – Engine Harness

C5 Male Connector

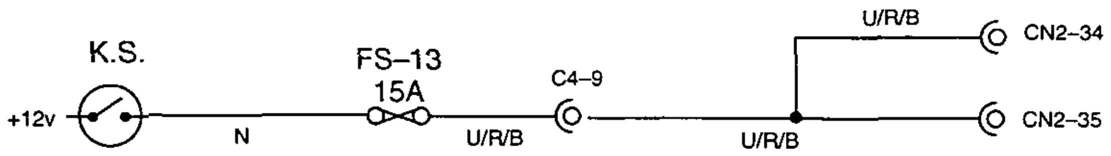
C5 Female Connector

C1 Connector

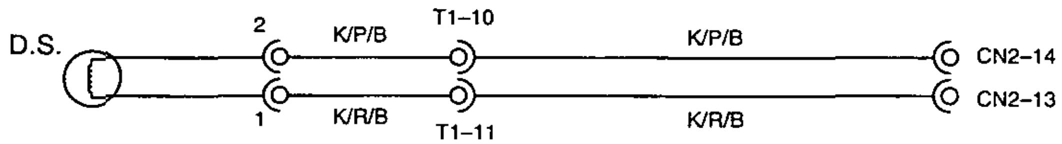
Error Code E21 displayed – Chassis Harness Disconnected

Inspect main harness connectors

Error Code E34 displayed – Fuse 13 Blown



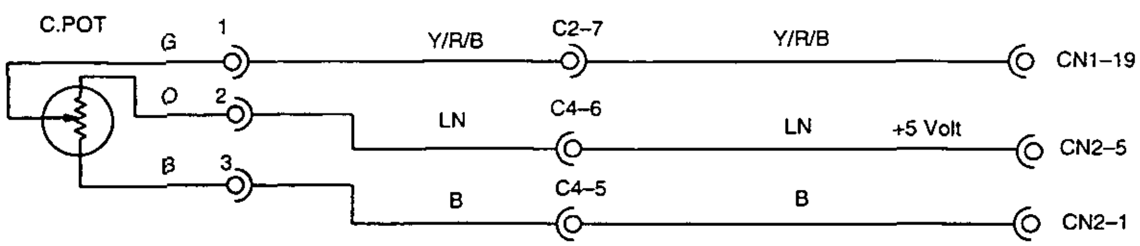
Error Code E35 displayed – Dump Solenoid Closed Circuit
Error Code E36 displayed – Dump Solenoid Open Circuit



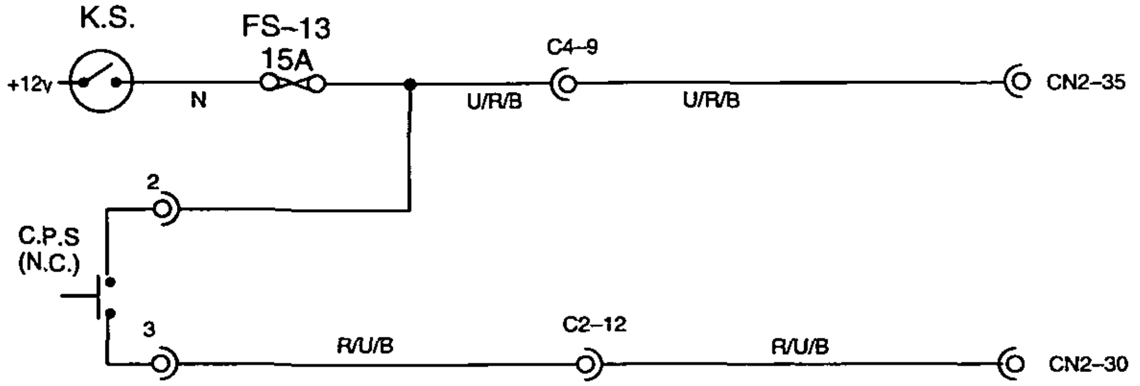
Error Code E53 displayed – 5 Volt Reference Failed, Shorted to +12V
Error Code E54 displayed – 5 Volt Reference Failed, Shorted to Ground

Error Code E12 displayed – Clutch Pedal Potentiometer Signal to high
Error Code E54 displayed – Clutch Pedal Potentiometer Signal to Low

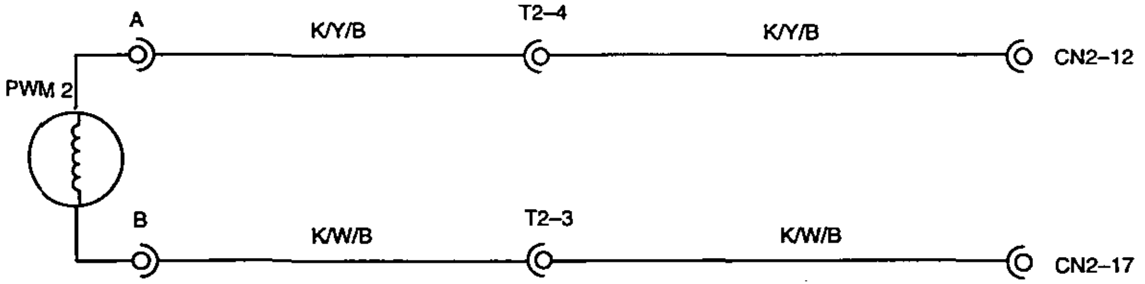
1. Inspect circuit connectors for corrosion, high resistance, (E54)
2. Inspect circuit for short circuit to +12volt (E12)
3. Inspect circuit for short circuit to ground (E54)
4. Disconnect potentiometer and check operation with an ohm meter.



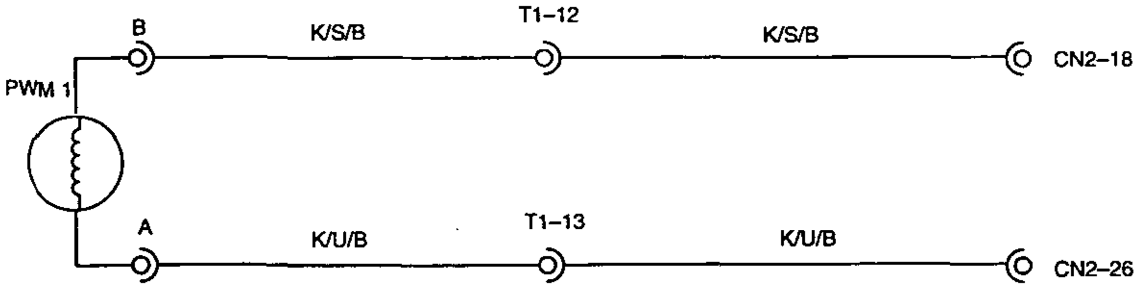
Error Code E37 displayed – Clutch Disconnect Switch Open Circuit
Error Code E48 displayed – Clutch Disconnect Switch Short Circuit
Error Code E47 displayed – Clutch Disconnect Switch Misadjusted High (Adjust Switch)



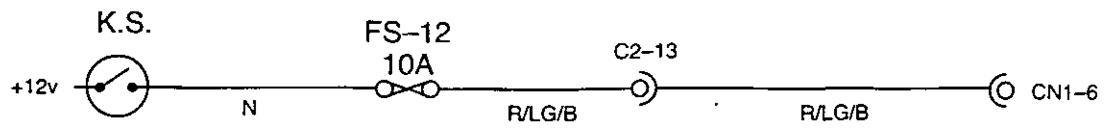
Error Code E38 displayed – C2 (PWM 2) Solenoid Short Circuit
Error Code E39 displayed – C2 (PWM 2) Solenoid Open Circuit



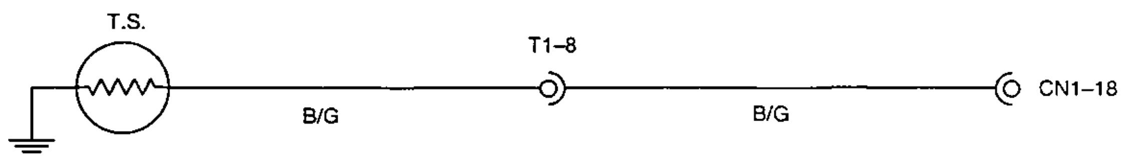
Error Code E40 displayed – C1 (PWM 1) Solenoid Short Circuit
Error Code E41 displayed – C1 (PWM 1) Solenoid Open Circuit



Error Code E46 displayed – Fuse 12 Blown



Error Code E51 displayed – Transmission Temperature Sensor Open Circuit
Error Code E52 displayed – Transmisson Temperature Sensor Short Circuit



Error Code E24 displayed – Both Clutches Not Calibrated

1. Perform spring pressure calibration on both clutches

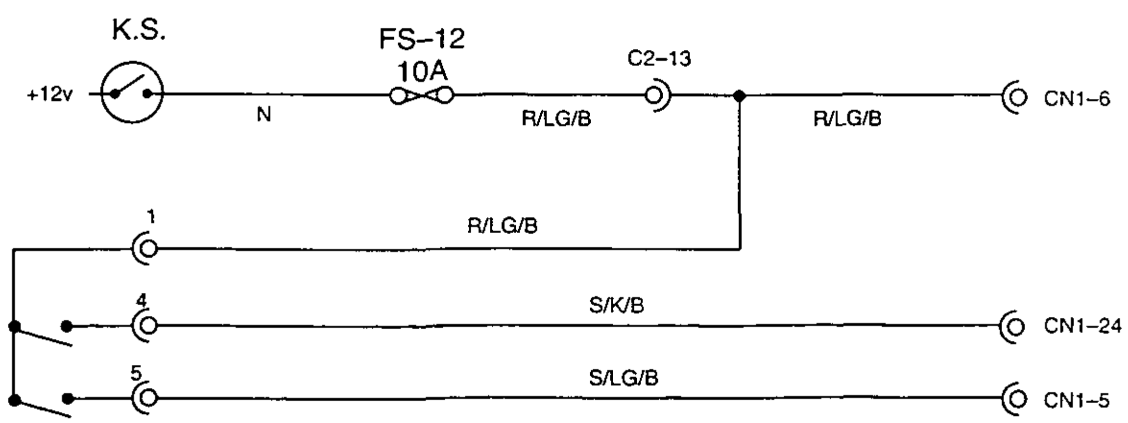
Error Code EHi displayed – Hi (C2) Clutch Not Calibrated

1. Perform spring pressure calibration on Hi (C2) clutch

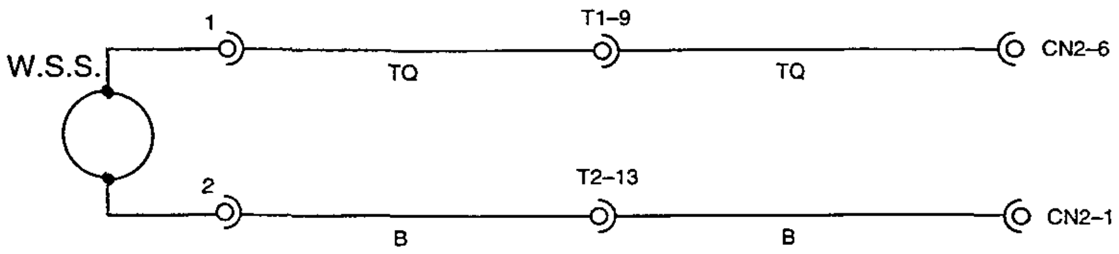
Error Code ELo displayed – Lo (C1) Clutch Not Calibrated

1. Perform spring pressure calibration on Lo (C1) Clutch

Error Code E13 displayed – Direct Drive / Under Drive Switches Both On

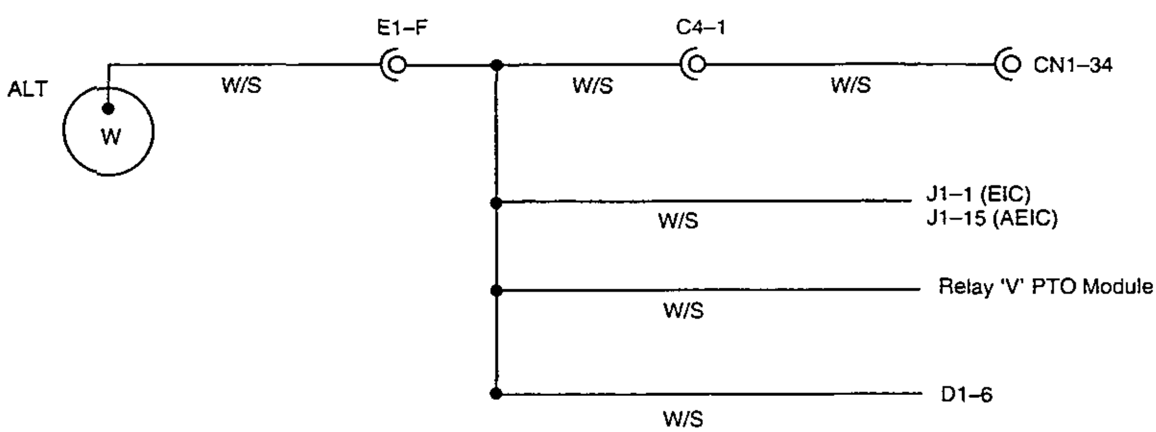


Error Code E49 displayed – Wheel Speed Sensor Circuit, Open or Short Circuit

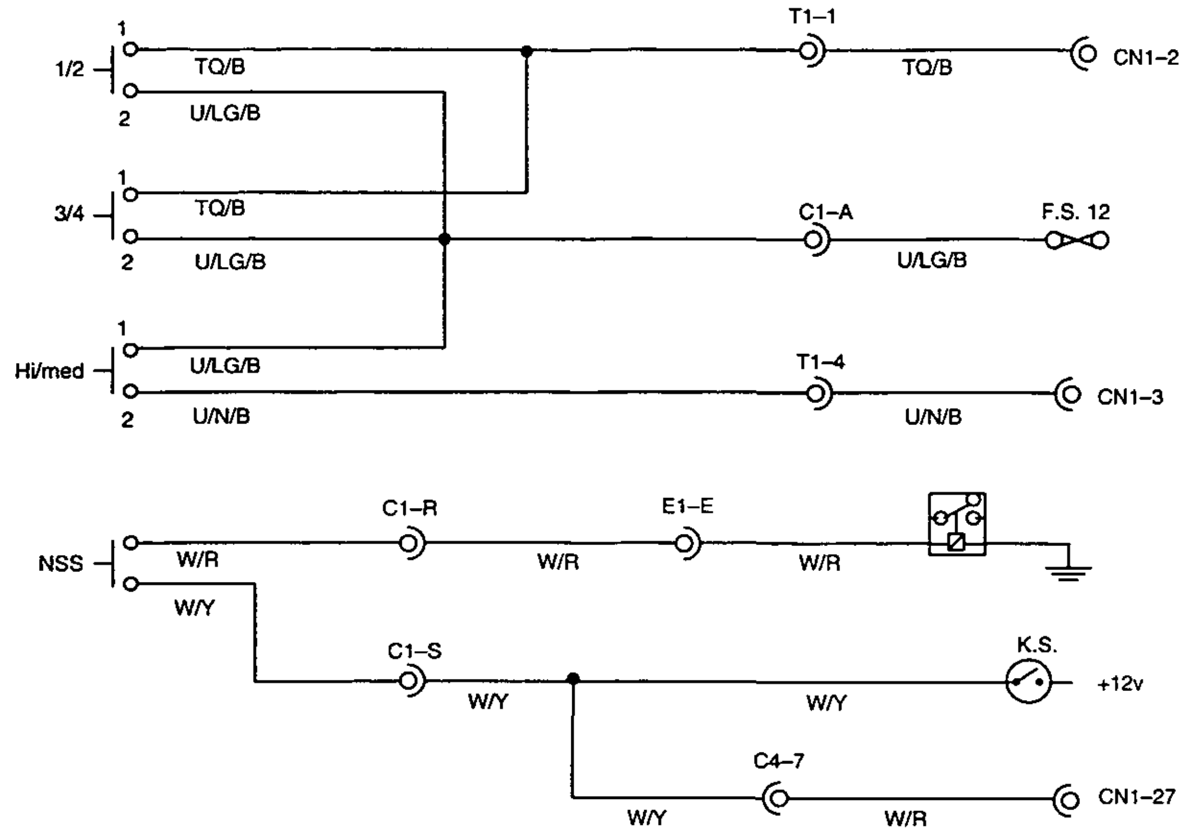


Error Code E26 displayed – Engine Rev/min to High
Error Code E27 displayed – Engine Rev/min to Low

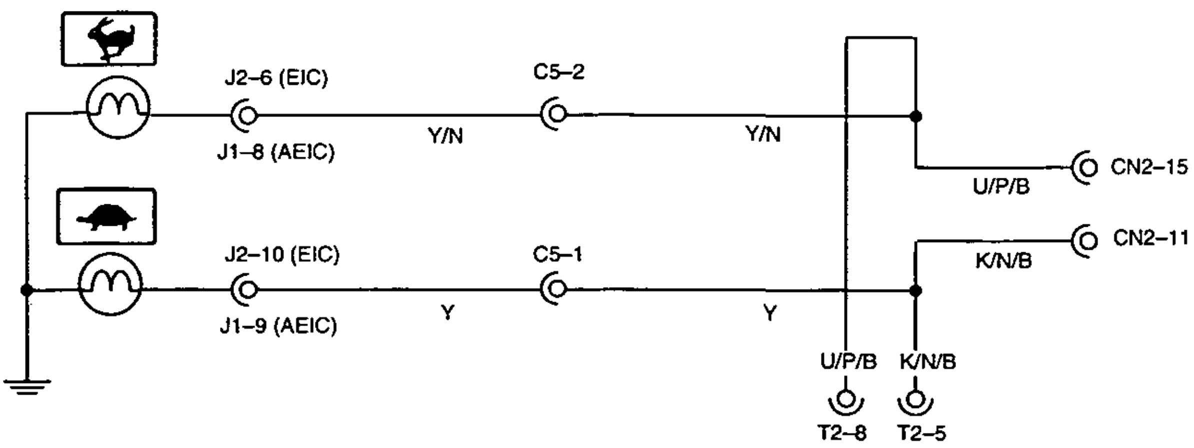
1. Check the alternator drive belt tension. (E27)
2. Faulty alternator – check voltage output at terminal 'W' of alternator, this should be approximately 7 volts. (E26 or E27)
3. Inspect wiring for intermittent open or short circuit (E26 or E27)

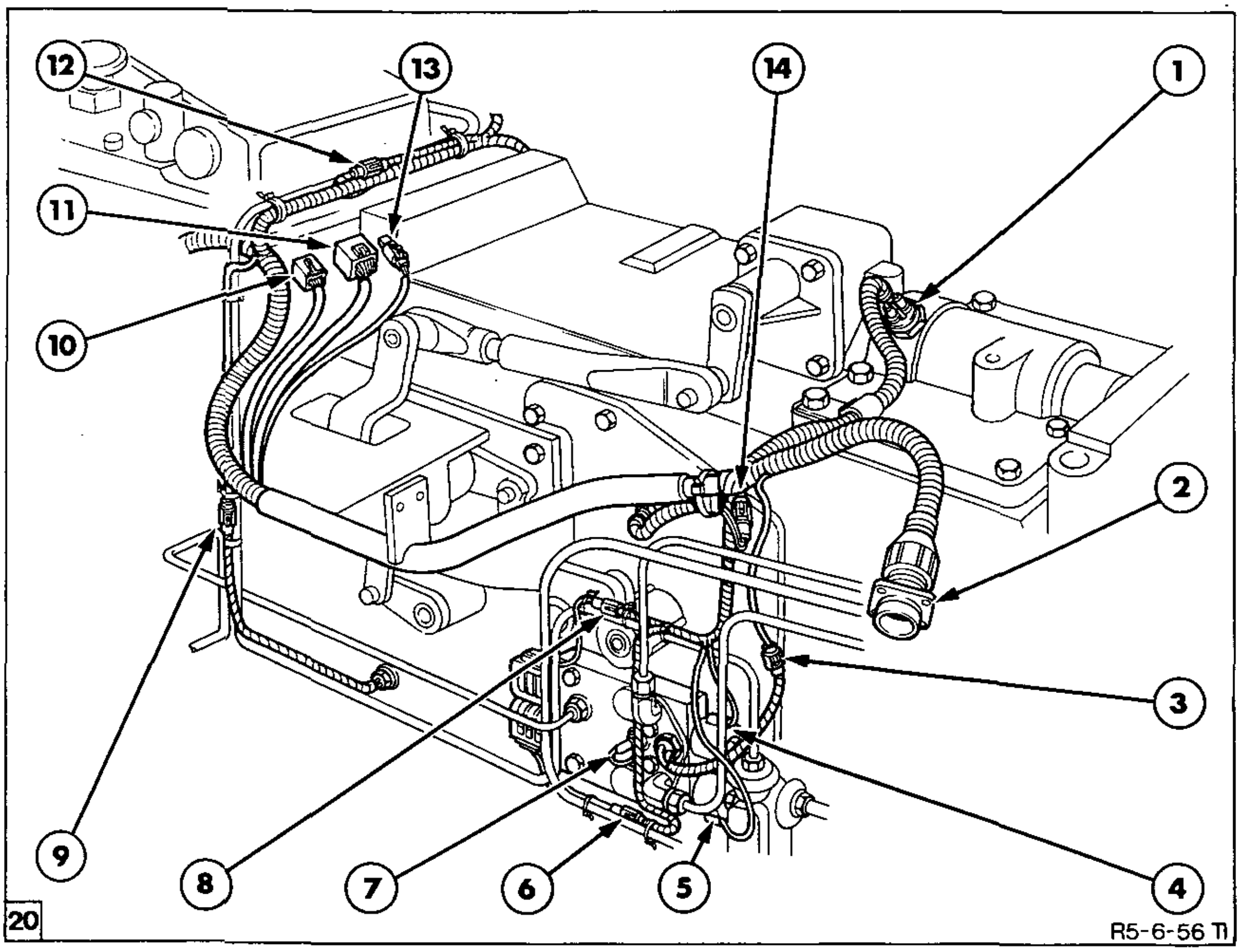


Transmission Status Switches Wiring Circuits

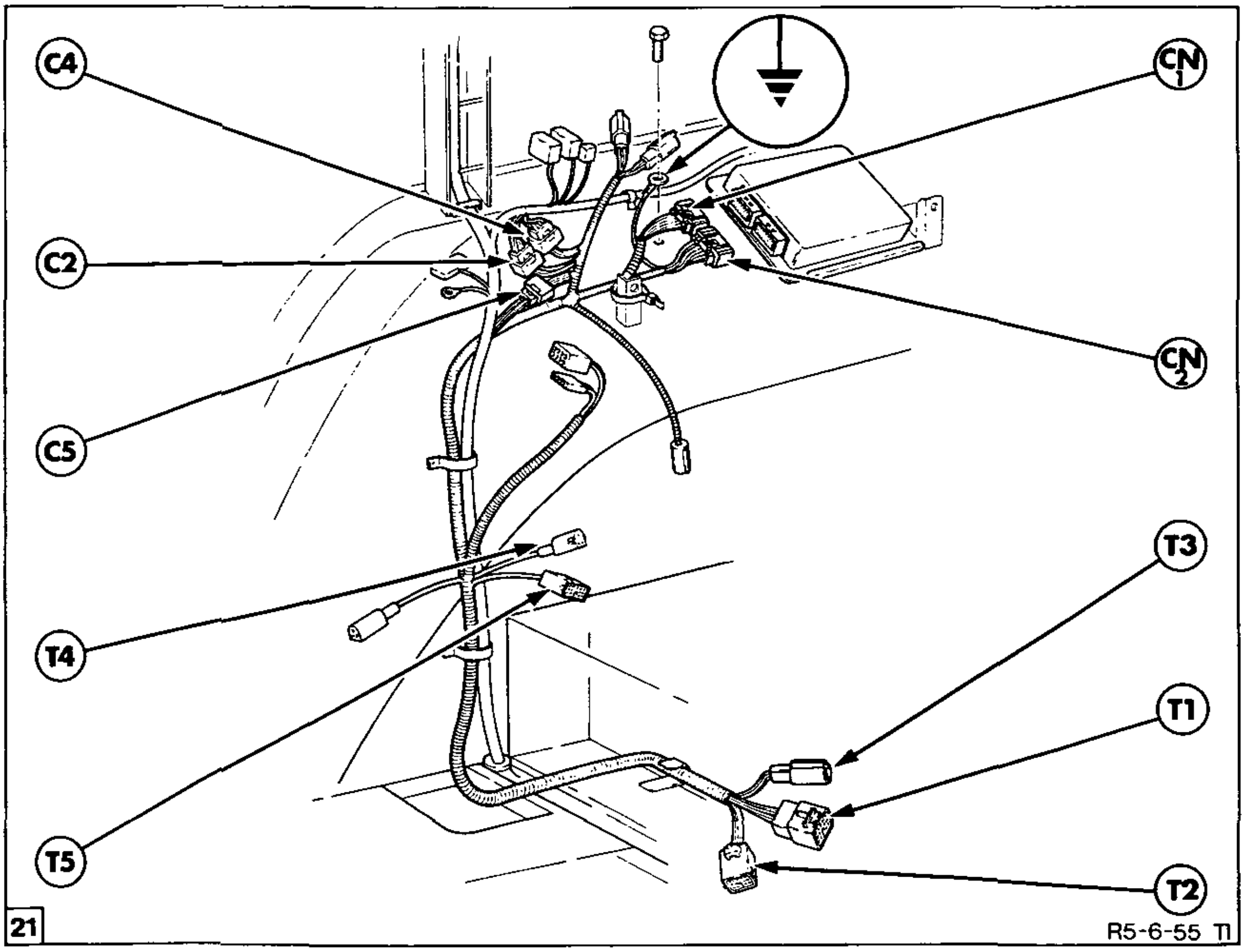


Instrument Panel Indicator Lamps





Extension Harness Connector Locations



Micro Processor Harness Connector Locations

Figure 20 – Extension Harness Connector Locations

1. Forward/Neutral/Reverse Safety Start Switch
2. C1 Connector
3. 1/2 Gear Status Switch Connector
4. PWM 1 Solenoid Connector
5. PWM 2 Solenoid Connector
6. Four Wheel Drive Solenoid Connector
7. Transmission Oil Temperature Sender
8. Dump Solenoid Connector
9. Hi/Medium Status Switch Connector
10. T1 Connector
11. T2 Connector
12. Speed Sensor Connector (Large Blue)
13. T3 Connector
14. 3/4 Gear Status Switch Connector

Diagnostic Test Routines

These diagnostic test routines supplement the automatic diagnostic error codes previously described. Access to these test modes is via the tractor diagnostic connector located near the fuse box. By connecting the diagnostic switch, Tool No. 4FT.950, to this connector and then switching the key start on, the instrument panel will display 'HH'. Pressing the tool switch button will increment through the menu modes. The menu modes are as follows:

Select Switch	Display	Transmission Status	12x12 Dual Power Test Routine
Power Up	HH	Disabled	–
Press	H1	Enabled	Transmission clutch spring pressure calibration routine
Press	H2	Disabled	Transmission clutch spring calibration value display
Press	H3	Disabled	Not Used
Press	H4	Disabled	Software revision display
Press	H5	Disabled	Switch diagnostic mode
Press	H6	Enabled	C1 (Lo) clutch quick fill duration modify mode
Press	H7	Enabled	C2 (Hi) clutch quick fill duration modify mode
Press	H8	Disabled	Micro–processor Non–Volatile Memory Reset
Press	H9	Enabled	Vehicle sensors operation display
Press	HA	Enabled	Clutch pedal percent display
Press	HB	Enabled	PWM valve temperature compensation adjustment

H1 Menu Mode

H1 provides access to the transmission clutch spring pressure calibration routines.

H2 Menu Mode

H2 displays the transmission spring pressure calibration values.

H3 Menu Mode

Not Used.

H4 Menu Mode

H4 indicates the software design level.

H5 Menu Mode

H5 provides access to the manual switch diagnostic mode. This is described in greater detail later in this section.

H6 Menu Mode

H6 allows adjustment of the C1 (Lo) clutch quickfill pulse duration as described in the calibration section of this chapter.

H7 Menu Mode

H7 allows adjustment of the C2 (Hi) clutch quickfill pulse duration as described in the calibration section of this chapter.

H8 Menu Mode

H8 allows calibrations to be cleared from the micro processor.

H9 Menu Mode

H9 provides access to the electronic reading from the vehicle sensors to check for correct operation. This mode is described in greater detail later in this section.

HA Menu Mode

HA provides access to the clutch pedal percentage position display.

HB Menu Mode

HB Provides PWM valve temperature compensation adjustment. This in effect matches the transmission oil temperature sender output to the PWM valves, via the micro processor, to maintain a constant clutch pedal height across all operating temperatures. This is factory set to a value of 16 and should not require adjustment in service.

Switch Diagnostic Mode

To assist in trouble shooting switch/switch circuit failures a switch diagnostic mode can be initiated. There are two ways to enter the switch diagnostic mode:

1. Via the service diagnostics connector switch, using H5 menu mode.

2. By depressing and holding the 'DIGIT SELECT' switch on tractors with 'EIC' during key on, without starting the engine.

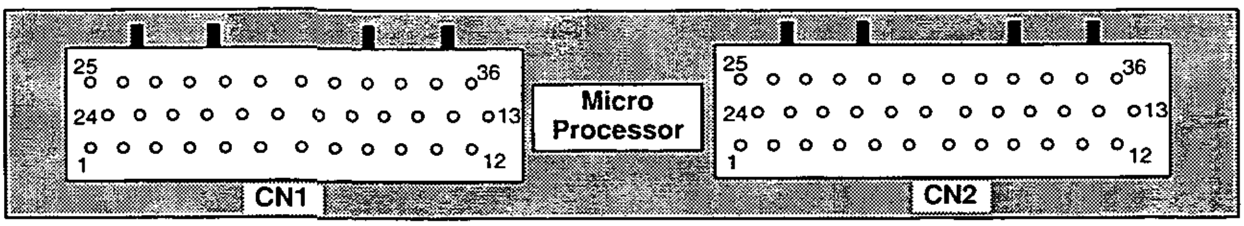
Following entry, the letter 'd' and a zero are displayed in the transmission portion of the instrument cluster display. At this point movement of the shift levers, clutch pedal and where fitted, Electronic draft control switches, results in an audible tone and the display of a numeric code which corresponds to a particular switch. Returning the switch to its original state will return the display to zero. The micro processor switch diagnostic mode display codes are as follows:

Switch Code	Switch Description
d1	External Lower Switch (EDC)
d2	External Raise Switch (EDC)
d3	Work Switch Transition (EDC)
d4	Raise Switch Transition (EDC)
d74	Dual Power Downshift Switch (12x12)
d75	Dual Power Upshift Switch (12x12)
d81	High / Medium in Gear Switch
d82	Main in Gear Switch – 1/2 and 3/4 Gear Switches
d85	Neutral Safety Start Switch
d71	Clutch pedal Switch
d92	Hydraulic Oil Temperature Switch
d93	Fuse 12 Sense

H9 – Vehicle Sensor Operation

This mode allows service personnel to verify the operation of various potentiometers, voltage supplies and the PWM current sense circuitry. In this mode both the transmission display and EDC display initially show a channel number and then follow by indicating a number in the 0–99 range which corresponds to the voltage that is sensed on that channel. The channel number can be incremented by depressing either the upshift switch, or if present, a transition of the raise/work switch from work to raise. The channel number can be lowered by depressing the downshift switch. The channel numbers, corresponding signal and typical signal values are as follows:

Channel Number	Description	Typical Approximate Values	Pin	Voltage
0	Clutch Pedal Position	91 released, 26 depressed	CN1–19	4.6 / 1.3
1	Transmission Oil Temperature	75 at 40°C	CN1–18	3.75
2	40°C Hydraulic Oil Switch	96 > 40°C	CN1–32	4.8
		2 < 40°C	CN1–32	0.1
3	Fuse 12 Sense	96	CN1–6	12
4	Not Applicable to Service	–	–	–
5	5 Volt Reference (Transmission Control)	49	CN2–5	5
6	12 Volt Vf input	42	CN2–34	12
7	12 Volt Vd input	43	CN2–30	12
8	12 Volt Vh input	43	CN2–29	12
9	8 Volt reference (EDC Control)	79	CN2–25	8
10	Not Used	–	–	–
11	Not Applicable to Service	–	–	–
12	Not Applicable to Service	–	–	–
13	Not Applicable to Service	–	–	–
14	Not Used	–	–	–
15	Dump Solenoid Current Sense	0 clutch engaged, out of gear	CN2–13	0
		97 clutch engaged, in gear	CN2–13	0.3
16	C1 Clutch Solenoid Current Sense	0 clutch engaged, out of gear	CN2–26	0
		82 clutch pedal released in underdrive	CN2–26	0.15
17	C2 Clutch Solenoid Current Sense	0 clutch engaged, out of gear	CN2–12	0
		82 clutch pedal released in direct drive	CN2–12	0.15
18 to 35	EDC Sensors	Refer to Part 8 Chapter 9	–	–



EXPLANATIONS AND NOTES:

If during fault finding, a channel value is not within ±5% of that shown in the above table, a voltage check should be carried out at the micro processor connector pin indicated in the right hand column. The connectors, CN1 (black) and CN2 (red), must remain installed to the micro processor. The negative probe of the volt meter should be inserted into CN2–32 (processor negative), and the positive probe to the appropriate pin. If the voltage at the pin is not as specified the fault can be considered to be within the wiring harness or a component within that circuit. If the voltage at the pin is correct the fault may lie between the micro processor connector, or if this appears to be okay, the processor itself should be replaced by a unit of known performance.

Channel 6: Vf input, this is the input voltage into the micro–processor for transmission components not directly affected by the clutch pedal switch, i.e, the direct drive and under drive indication lamps and the dump solenoid.

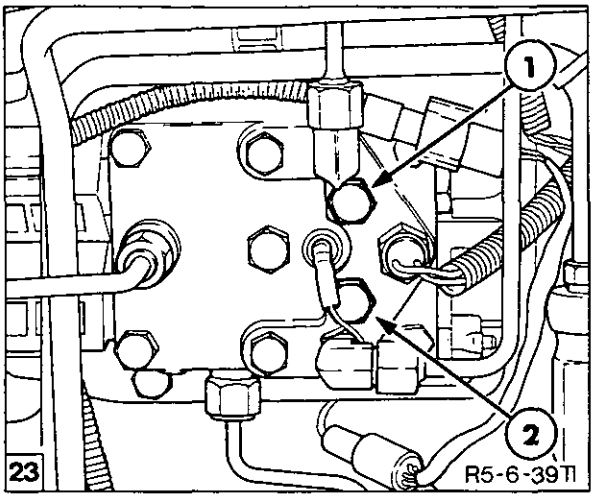
Channel 7: Vd input, this is the input voltage into the micro–processor for transmission components which are affected by the clutch pedal switch operation, i.e, the PWM valve solenoids.

Channel 8: Vh input, this is the input voltage into the micro–processor for the EDC components, i.e, raise and lower solenoids.

Pressure Testing

Pressure ports are provided on the transmission control valve to enable the transmission clutches to be tested to determine the correct function of a number of system components. Components such as solenoids and the clutch pedal operation can be seen to be operating correctly by the results of pressure testing.

NOTE: *Prior to pressure testing, make certain that all the points detailed under the tractor preparation are carried out to ensure maximum safety.*



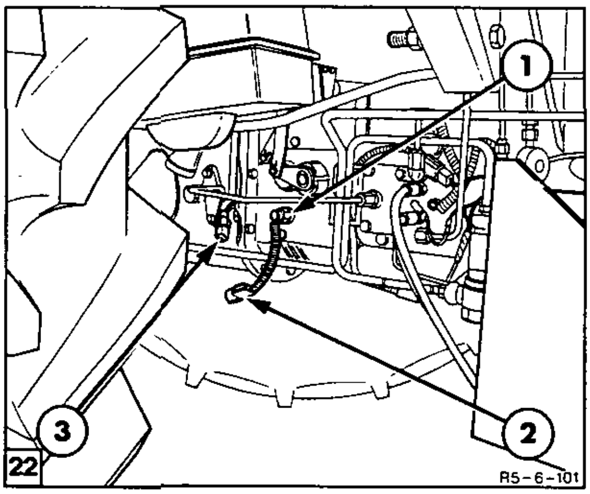
Pressure Test Ports

1. C1 Clutch 7/16–20 UNF Test Port
2. C2 Clutch 7/16–20 UNF Test Port

Tractor Preparation

1. Start the tractor and run until the transmission oil has reached its normal operating temperature of at least 60°C (140°F).

2. Ensure the handbrake is firmly applied.



High/Medium Status Switch

1. High/Medium Switch
2. Switch side Connector
3. Harness Side Connector to be Bridged

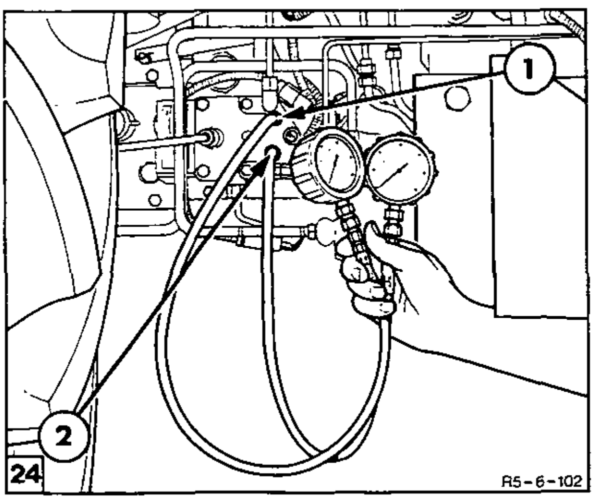
3. Disconnect the connector to the High/medium status switch and install a suitable bridging wire between the two connector pins on the harness side. With a bridging wire installed, the ETC receives a signal indicating that either high or medium is selected, although the **HIGH/MEDIUM RANGE LEVER remains in NEUTRAL** throughout the testing.

C1/C2 Clutch Engagement and Disengagement

1. Install pressure gauges into the C1 and C2 test ports.

2. Leave the High/Low/Medium range lever in **NEUTRAL**, position the main shift lever into **1st GEAR** and the shuttle lever in **FORWARD**. Set the engine speed to 1500 rev/min. Observe the reading on the gauges.

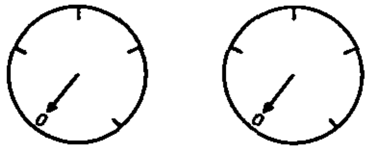
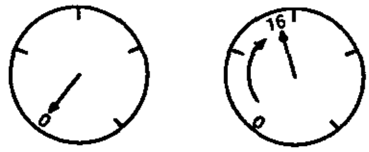
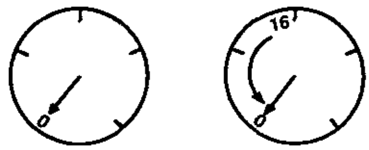
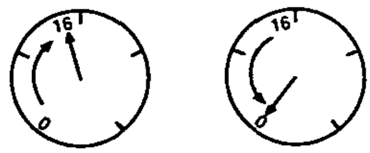
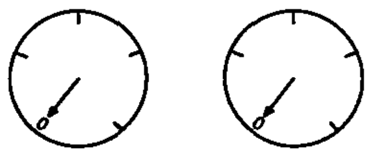
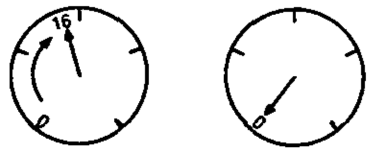
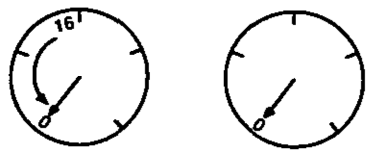
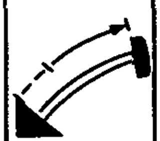
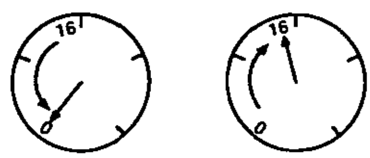
NOTE: *For observing the system operation set the engine speed to 1500 rev/min. For Testing for maximum pressure in each clutch set the engine speed to 2100 rev/min.*



Pressure Gauges Installed

1. C1 (U.D.) Clutch Pressure Test Port
2. C2 (D.D.) Clutch Pressure Test Port

Table 1 – Dual Power Pressure Testing

Clutch Pedal	C1 C2	Observations
		**Direct Drive Selected** Pressure on C1 and C2 should be zero. Indicates dump valve solenoid operational
		Releasing clutch pedal from fully depressed position should smoothly and gradually restore clutch 2 to full pressure. Clutch 1 should remain at zero. Indicates correct PWM 2 and clutch pedal potentiometer operation.
		Depressing clutch pedal should progressively reduce pressure in C2, until with pedal fully depressed zero pressure should be indicated. Indicates correct PWM 2, clutch potentiometer and dump valve solenoid operation.
		**Switch from Direct Drive to underdrive** C2 pressure should reduce to zero, C1 pressure should rise to full pressure. This should appear to be an instantaneous operation with just a slight overlap of pressure between the clutches. Indicates correct operation of both PWM valve solenoids
		**Under Drive Selected** Pressure on C1 and C2 should be zero. Indicates dump valve solenoid operational
		Releasing clutch pedal from fully depressed position should smoothly and gradually restore clutch 1 to full pressure. Clutch 2 should remain at zero. Indicates correct PWM 1 and clutch pedal potentiometer operation.
		Depressing clutch pedal should progressively reduce pressure in C1, until with pedal fully depressed zero pressure should be indicated. Indicates correct PWM 1, clutch potentiometer and dump valve solenoid operation.
		**Switch from Underdrive to Direct Drive** C1 pressure should reduce to zero, C2 pressure should rise to full pressure. This should appear to be an instantaneous operation with just a slight overlap of pressure between the clutches. Indicates correct operation of both PWM valve solenoids

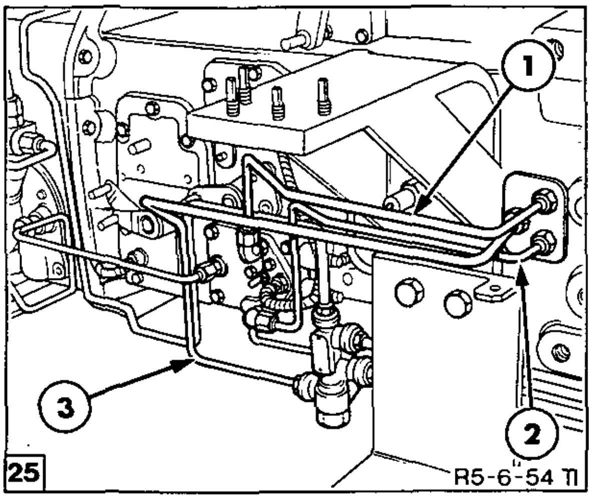
Pressure Testing Notes:

1) Maximum pressure should be between 220–260 lbf.in^2 (15.0–18.0 bar). If maximum pressure is attained in only one of the clutches, suspect a fault in that clutch circuit, e.g. leaking clutch seals, faulty PWM valve. The pressure at 1500 rev/min. should be between 200–240 lbf.in^2 (13.8–16.5 bar).
2) If the pressure is low on both clutches this may indicate a faulty dump solenoid valve or a fault in the hydraulic supply circuit.
3) Sudden, irregular rises or drops in pressure as the clutch pedal is operated may indicate a faulty clutch potentiometer if it occurs in both underdrive and direct drive, or a faulty PWM valve if it occurs in only one of the drives.
4) If the pressure comes on suddenly as the clutch pedal is raised this may indicate that the clutch pedal switch is incorrectly adjusted.
5) If the pressure is not at absolute zero with the clutch pedal fully depressed this may also indicate a maladjusted clutch switch or a possible fault with the dump solenoid valve.

C. DUAL POWER REMOVAL

NOTE: *To remove the dual power unit, the tractor must be separated between front transmission and the engine, refer to, 'Separating the Tractor,' Part 12, Chapter 2,*

Disconnect the three dual power oil feed pipes through the aperture at the right hand side of the front transmission, Figure 25

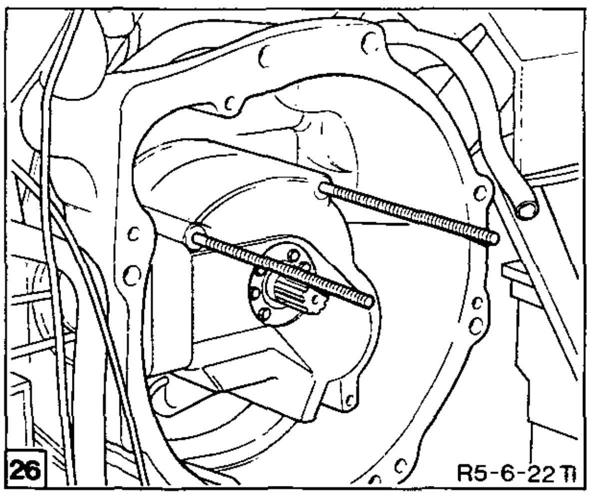


Oil Feeds To Lubrication Valve

1. C1 Clutch Assembly Feed Tube
2. C2 Clutch Assembly Feed Tube
3. Lubrication Control Valve Lube Feed Tube

Remove the top two dual power attaching bolts and install 2 off studs (M10) threads approximately 12 in (304mm) long, into the bolt holes,Figure 26.

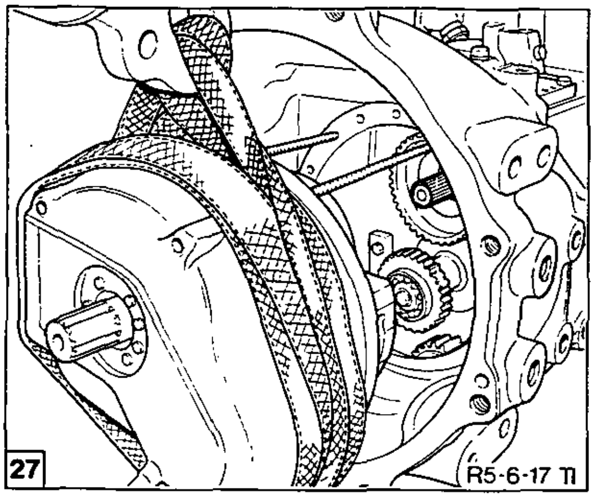
NOTE: *The gearbox top cover will require removal to ensure the synchroniser and cone are not dropped or damaged as they may fall loose from the rear of the dual power unit during removal, Figure 28.*



Dual Power Installed

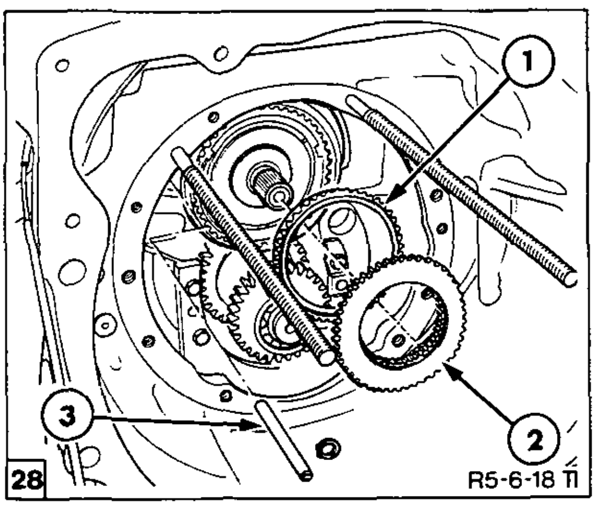
NOTE: *The oil lubrication tube is a tight fit in the dual power body and may remain in position in the dual power on removal from the vehicle. It is recommended that this is removed to avoid damage during disassembly of the Dual Power.*

Remove the remaining 4 attaching bolts and pull the dual power unit forward sufficiently to attach a lifting strop and hoist, Figure 27.



Dual Power Removal

Carefully remove the dual power unit (using the hoist and strop) from the transmission.



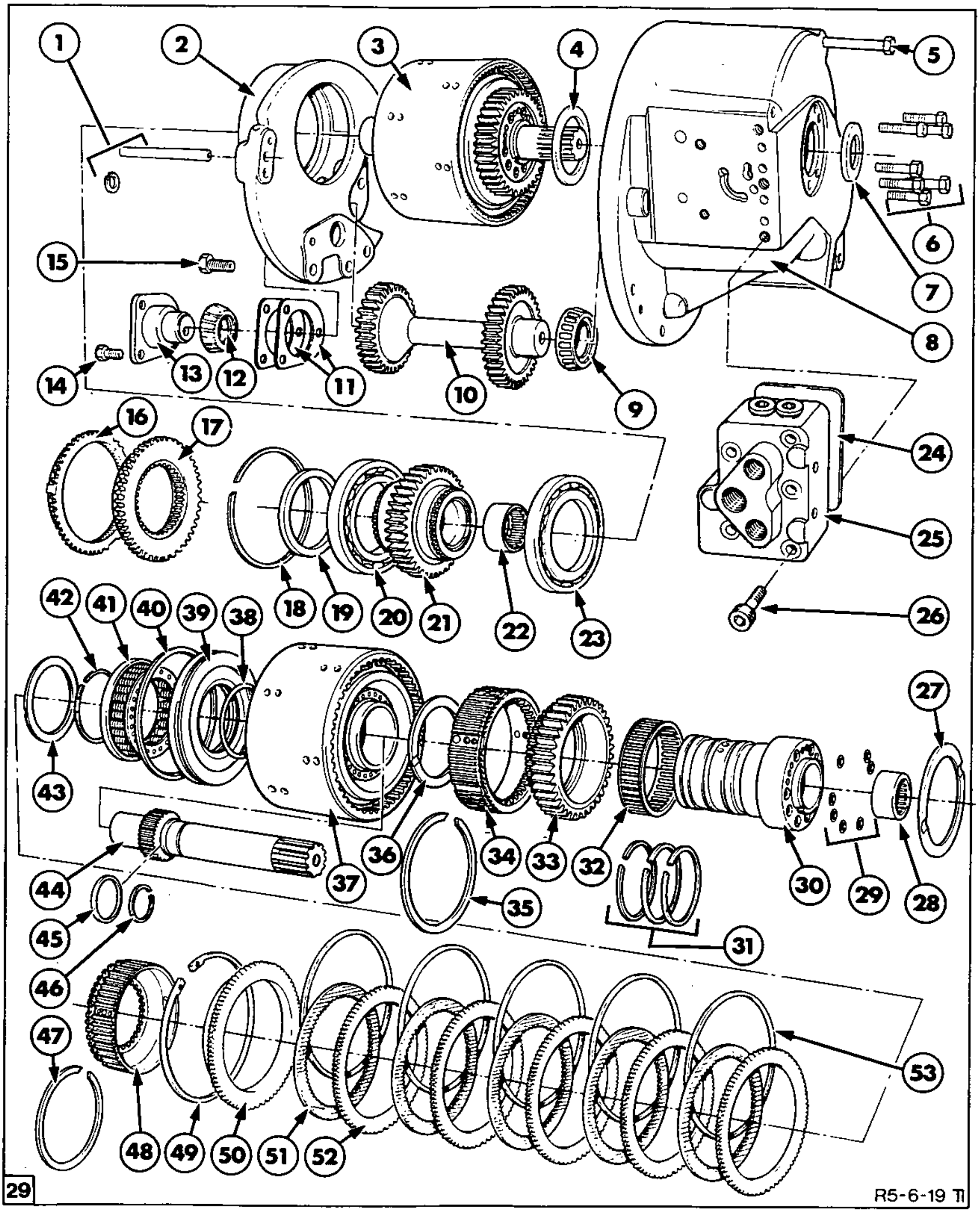
Synchroniser

1. Reverse/Forward Cone
2. Reverse/Forward Synchroniser
3. Oil Lubrication Tube and 'C' Clip

D. DUAL POWER OVERHAUL

Dual Power Components refer to, Figure 29

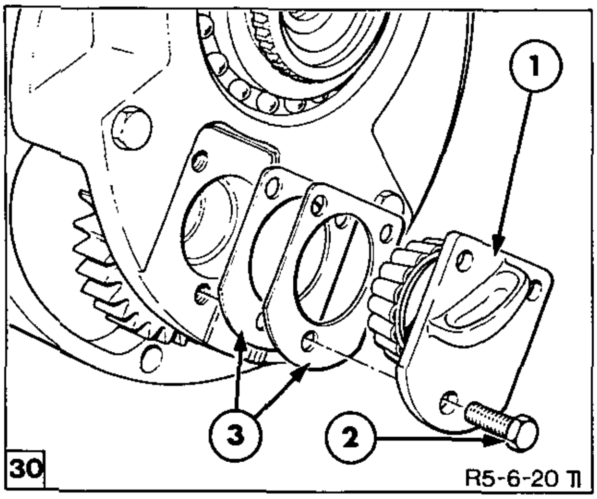
1. Lubrication Tube with 'C' Clip
2. Backplate
3. C1/C2 Clutch Body
4. Polyimide Washer
5. Housing Attaching Bolt 6 off
6. Support Shaft Attaching Bolts 7 off
7. Centre Shaft Seal
8. Housing
9. Bearing
10. UnderDrive Gear Assembly
11. Pre Load Bearing Shims
12. Pre Load Bearing
13. Pre Load Bearing Support
14. Attaching bolts 3 off
15. Backplate Attaching Bolts 4 off
16. Reverse/Forward Synchroniser Cone
17. Reverse/Forward Synchroniser Gear
18. 'C' Clip
19. Spacer
20. Bearing
21. Underdrive Gear Assembly
22. Needle Bearing
23. Bearing
24. Gasket
25. Lubrication Valve
26. Attaching Hardware
27. Polyimide Washer (Item 4)
28. Needle Bearing
29. 'O' Rings
30. Support Shaft
31. Support Shaft Sealing Rings
32. Roller Bearings
33. Underdrive Output Gear
34. C1 Hub
35. C1 Hub Sealing Ring
36. Thrust Washer (with lubrication groove outboard)
37. Clutch Pack Assembly
38. Piston internal 'O' Ring
39. Piston
40. Piston External Sealing Ring
41. Spring Pack
42. 'C' Clip
43. Thrust Washer (Position lip to clutch plate face, lubrication groove outboard)
44. Drive Shaft
45. Spacer
46. Sealing Ring
47. C2 Hub Sealing Ring
48. C2 Hub
49. 'C' Clip Clutch pack Retaining
50. End Plate
51. Friction Disc
52. Steel Disc
53. Separator



Dual Power Exploded View

NOTE: *Items 1, 16 and 17 are located between the Dual Power Unit and the Gear Box Mating Parts*

With the dual power unit positioned on a work bench remove the rear plate bolts, (Note various bolt lengths) and remove the bearing/ shim assembly, Figure 30.

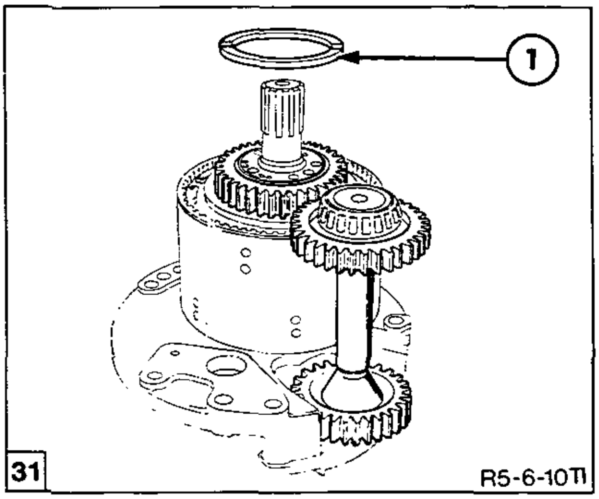


Bearing/Shim Assembly

1. Bearing Assembly
2. Attaching Bolts
3. Shims

Place the unit on its rear face and remove the support shaft bolts, from the outer housing.

Lift outer housing from backplate to expose clutch pack assembly and underdrive gear, Figure 31, note polyimide washer.



Rear Housing Removed

UNDER DRIVE GEAR ASSEMBLY

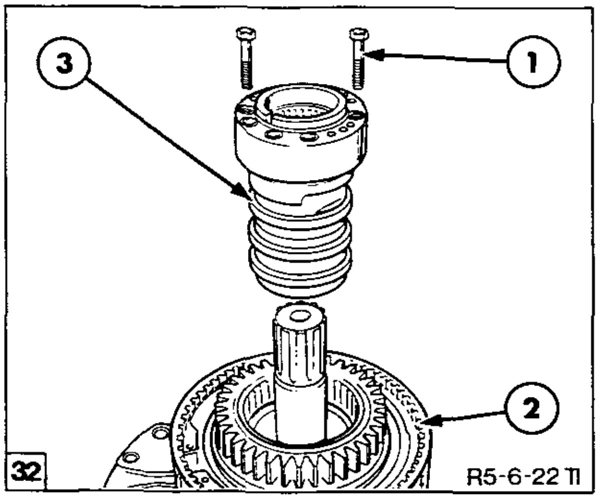
Overhaul

With the under drive gear cluster removed inspect for damage, nicks or burrs to the gears. Heavy damage or wear will result in fitting a new under drive gear assembly.

Inspect the bearing for wear or damage and replace with new if required. The bearing can be pulled from the shaft using a suitable puller if it is to be replaced.

SUPPORT SHAFT ASSEMBLY

To remove support shaft, install bolts in the end of the shaft and withdraw from the clutch pack, Figure 32.



Support Shaft Removal

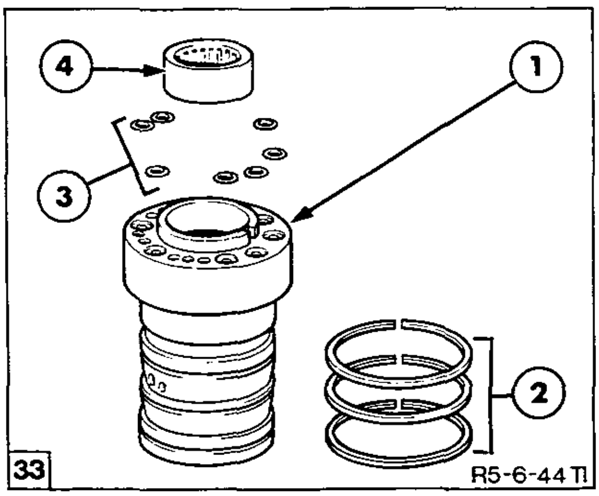
1. Attaching Bolts
2. Clutch Body
3. Support Shaft

Overhaul

1. Remove the seal rings from the support and inspect for wear and damage, renew parts as required, Figure 33.

NOTE: *The internal needle bearing may be damaged when removed for inspection. When replacing push the bearing upto within 0.125in (3.2mm) of the internal shoulder.* ***Do not push*** *bearing upto to the shoulder as the bearing may be distorted.*

2. Refit new sealing rings and 'O' Rings upon re–assembly.



Support Shaft

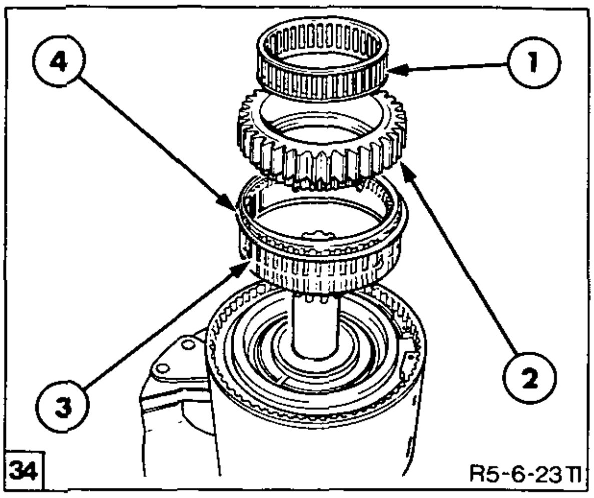
1. Support Shaft
2. Seals
3. 'O' Rings
4. Internal Bearing

Withdraw the following as per, Figure 34.

- Needle roller bearing

- Underdrive Output Gear

- Centre Hub



Disassembly

1. Needle Bearing
2. Underdrive Output Gear
3. Centre Hub
4. Centre Hub Seal

C1 – CLUTCH PACK DISASSEMBLY (UNDER DRIVE SIDE OF THE CLUTCH)

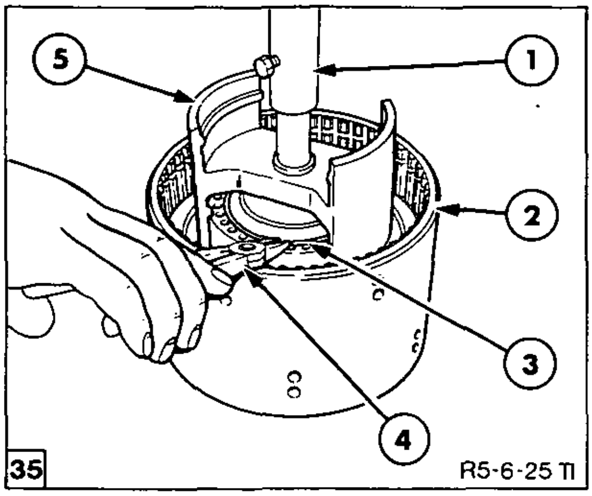
Lift the clutch housing from the backplate ensuring clutch hub does not fall out and become damaged, remove centre shaft and place clutch on a workbench.

Disassemble the clutch pack by removing the 'C' Clip and remove all of the steel discs, friction discs and spring separators.

Spring Pack

With the clutch pack removed, the piston spring pack can be removed in the following manner:

Place clutch assembly on press bench and using tool FT 508, apply sufficient pressure to allow removal of the clutch spring pack retaining ring. Remove ring, ease pressure off and remove spring pack, Figure 35.



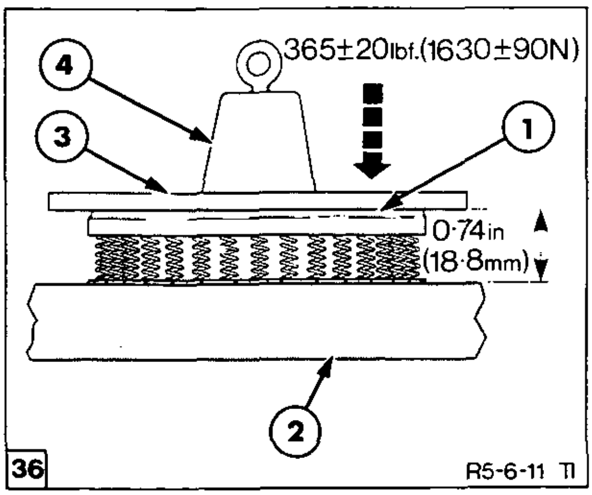
Spring Pack Removal

1. Press Tool
2. Clutch Body
3. Circlip
4. Circlip Pliers
5. Compressing Tool 4FT 508

Overhaul

Inspect the spring assemblies for cracked coils or deformation of the assembly, **especially the pressed steel endcap**.

The spring tension can be checked by applying a load to the assembly as in, Figure 36, or comparison with a new one. If in doubt renew the spring assembly.

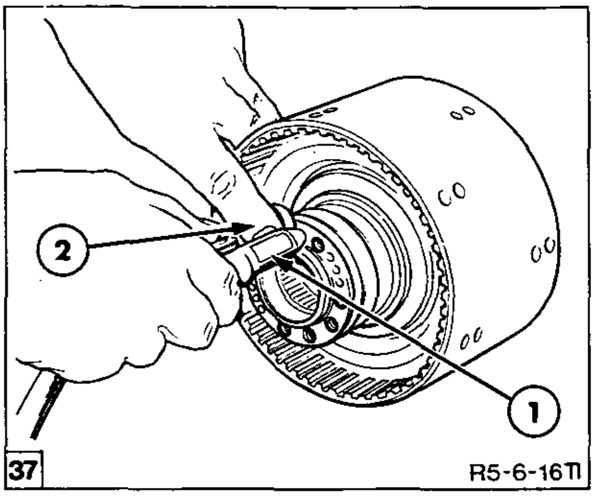


Checking Compressed Height of Clutch Piston Return Spring Assembly

1. Piston Return Spring Assembly
2. Base Plate
3. Load Spreader (flat Disc)
4. Weight (or load)

Piston Removal

1. To remove the piston from the housing place the support shaft back into the housing. Position an air line nozzle into an *oil feed hole in the support shaft and* blanking the exhaust port with a plug apply sufficient air pressure to push the piston from the housing, Figure 37.



Piston Removal

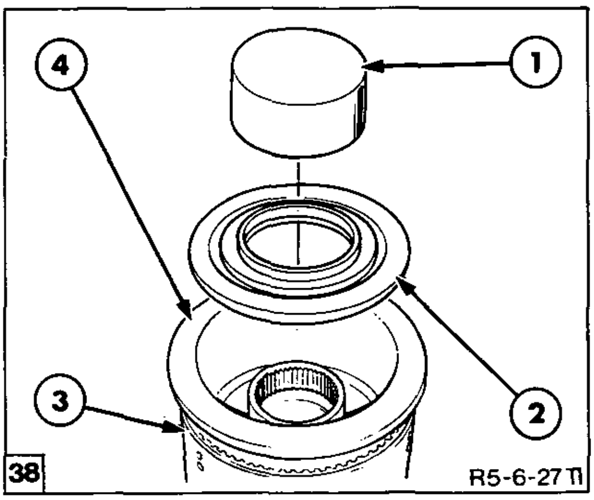
1. Air Line
2. Blanking Off Exhaust Port

Overhaul

Ensure seal face is free of nicks or damage, *repair or renew the piston if damage is evi*dent. Renew inner and outer piston seals.

Re–Assembly

1. Lubricate the piston with M2C134D oil and using guide tool 4FT 505, push the piston into the guide body, Figure 38.



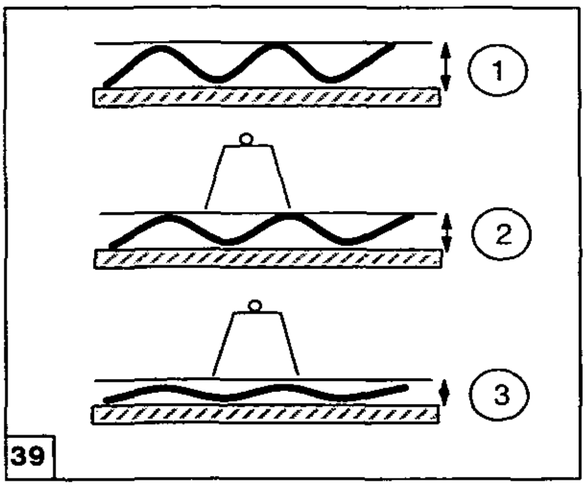
Piston Re–Assembly

1. Hand Tool – 4FT 504
2. Piston
3. *Clutch Housing*
4. Guide Tool – 4FT 505

C1 – Overhaul

Check plates and discs for wear, damage, scoring, flatness or discolouring renew if in doubt.

The spring separators can be checked by measuring free height and compressed height by application of weights on a parallel surface, as shown in, Figure 39.

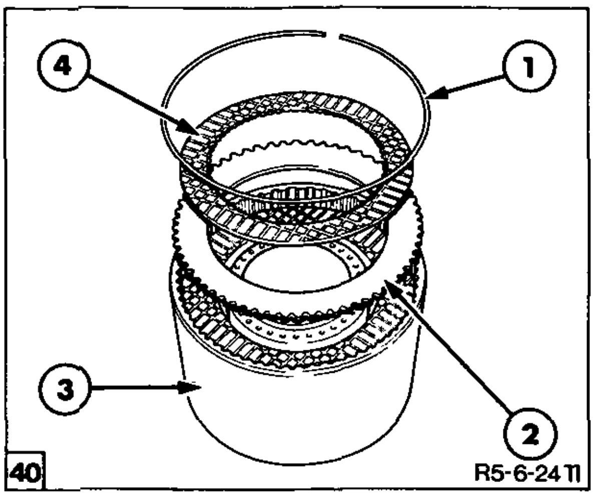


Spring Separators

1. **Free Height** = 0.200ins (5.08mm)
2. **Load Height** = 0.105ins (2.67mm)
   With a weight of 40lbs (18kgs)
3. **Load Height** = 0.073ins (1.88mm)
   With a weight of 95lbs (43kgs)

If the separators are not to specification as listed in, Figure 39, they must be replaced.

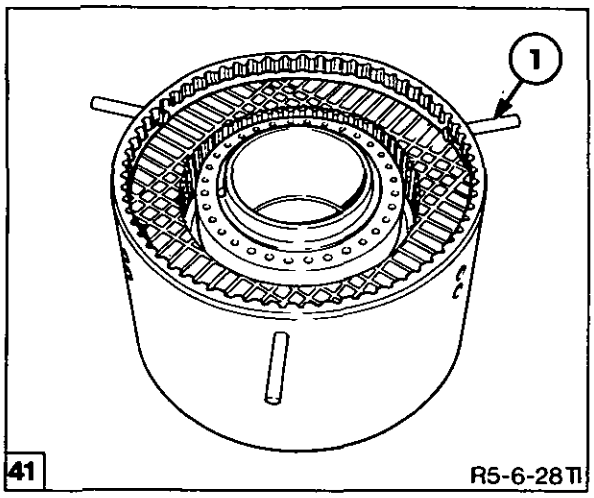
1. Using press tool as previously described for disassembly, re–assemble the spring pack into housing and refit the retaining clip.
2. Re–assemble discs (5 off each) in order: *Steel disc, friction disc and spring* separator.



Disc Re–Assembly

1. Seperator
2. Steel Disc
3. Clutch Body
4. Friction Disc

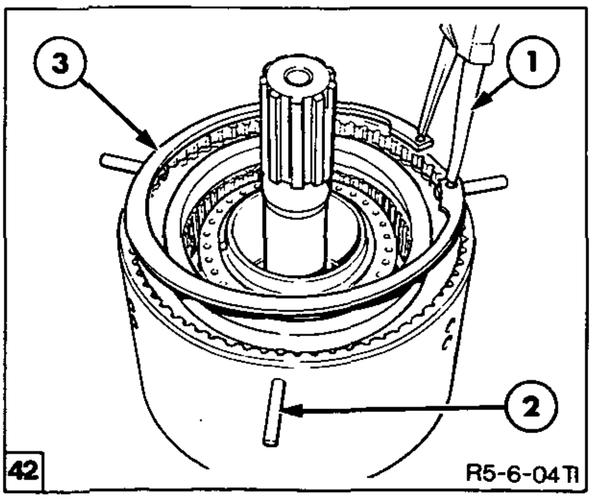
- Continue up to and including the fifth steel Plate.
- Compress the plates by hand and hold in place by inserting three rods in the upper most lubrication outlet holes, Figure 41.



Friction Disc Re–assembly

1. Retaining Rods

- Fit the the fifth friction disc separating spring and end plate on top of rods and secure the assembly with the retaining clip, Figure 42.



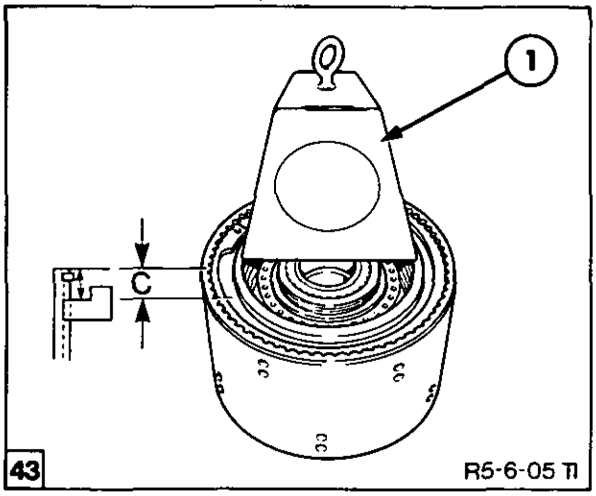
Clutch Plate Retaining Clip

- Remove the rods.

Clutch Pack Setting Procedure

With the clutch pack re–assembled, the clearance of pack to housing under load, will require checking, as follows:–

1. Using a weight of 90–100 lbs (40–45kgs) applied to the end pack, measure using a dial indicator or depth gauge the distance from the top face of the end plate to the edge of the housing, Figure 43.



Measuring the Pack Clearance

1. Clutch Pack Face
2. Clutch Housing Reference Point 'C'

2. Release the pack and measure the distance again, the difference 'C' of these two readings should be should be between 0.088–0.110 in (2.25–2.8mm).
3. If not to specification disassemble the pack, stack the 0.069 in (1.75mm) separator plates and measure their combined thickness. Swap them for 0.079 in (2.0mm) spring separators to achieve the specification, depending on original clearance.

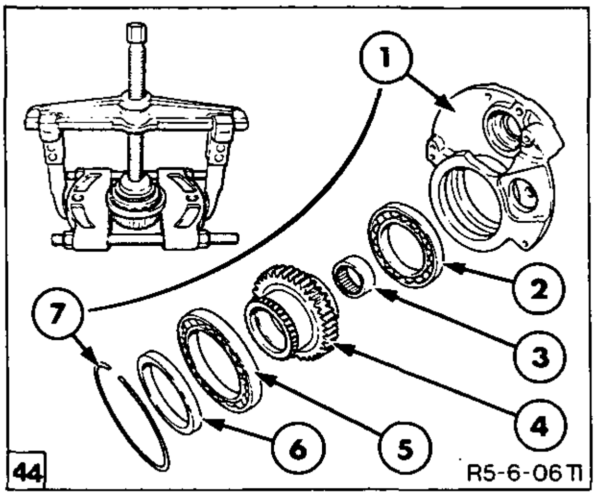
C2 – CLUTCH DISASSEMBLY (DIRECT DRIVE SIDE OF THE CLUTCH)

Disassembly, re–assembly and setting of the clutch pack is the same as for C1 clutch.

BACK PLATE ASSEMBLY

1. *To disassemble the bearing assembly* from the end plate remove the circlip and push the bearing assembly out, Figure 44.

2. The bearing can be fully disassembled by using a suitable pulling attachment, Tool No. 951 or similar between the gear and bearings.



Back Plate Assembly

1. Back Plate
2. External Bearing
3. Needle Bearing
4. Bearing Support
5. External Bearing
6. Spacer
7. Circlip

Overhaul

1. Check the bearing assembly for signs of wear, scoring or damage and renew as required.

2. Check back plate for damage or distortion and repair or renew as required.

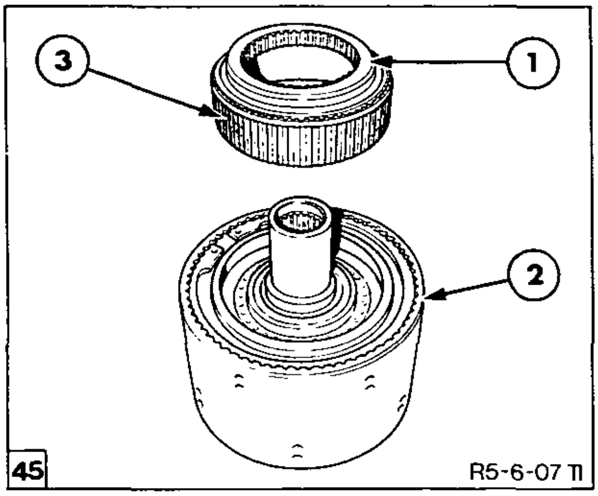
Re–assembly

1. Rebuild the bearing assembly and push into the back plate, refit the bearing retaining circlip.

CLUTCH PACK ASSEMBLY TO BACK PLATE

1. Fit a new seal and spacer and tap the input shaft into the clutch spline until mating end-faces are flush. Support the assembly with the C2 (DD) clutch facing upwards.

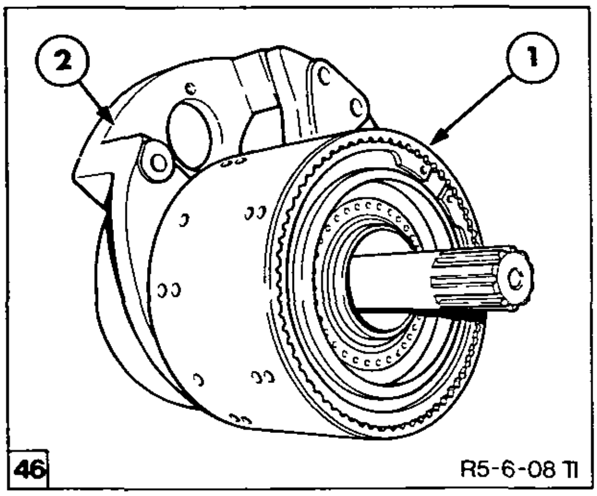
2. With the clutch assembly supported on wood place thrust washer (with oil lubrication slot facing outboard) on piston face, fit a new seal to the hub and insert into the clutch plates, it may be necessary to rotate the hub back and forth to locate the hub splines into the clutch splines, Figure 45.



Hub into C2 Clutch

1. Hub
2. Clutch Housing
3. Hub Seal

3. With the end plate assembly on its side, position the clutch onto the backplate to allow engagement between clutch hub and the rear bearing gear spline, Figure 46.



Clutch to Backplate

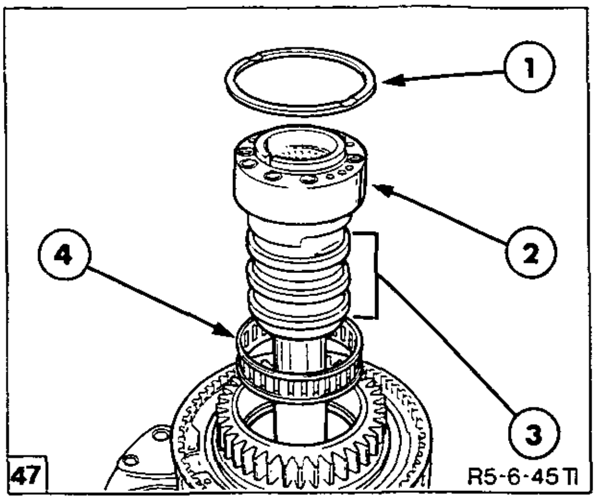
1. Clutch Assembly
2. Backplate

Turn the entire assembly over onto the back plate assembly.

4. Install the thrust washer over the spring pack retaining ring (with the shoulder down), Figure 49.

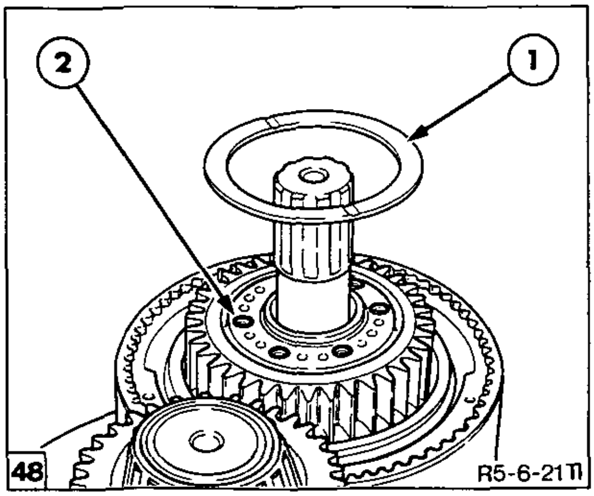
5. Fit seal to hub and place hub into clutch pack, rotating back and forth to align the splines.

6. Refit the gear to hub, place needle bearing into gear and refit support shaft (taking care not to damage the support shaft seal rings), Figure 47.



Support Shaft Re–Assembly

1. Polyimide Washer
2. Support Shaft
3. Sealing Rings
4. Roller Bearing



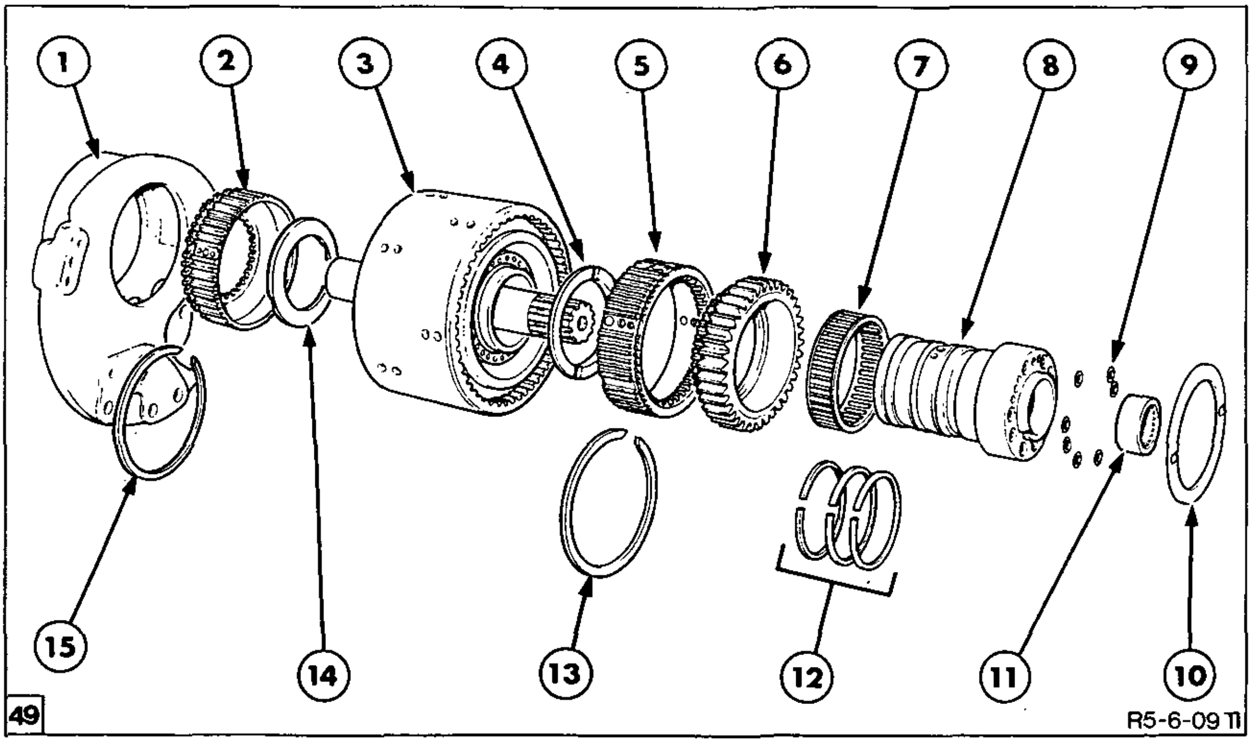
Support Shaft Sealing

1. Polyimide Washer
2. 'O' Rings 7 off

7. Place the under drive gear cluster in position.

8. Fit 7 off new 'O' Rings onto the support shaft bolt hole counter bores, Figure 48.

9. Using grease to prevent movement place the polyimide bearing washer in position on the (DD) gear face between the support shaft and outer housing.



Clutch Re–Assembly

1. Back plate
2. C2 Direct Drive Hub
3. Clutch Housing
4. Thrust Washer (Oil Groove Facing Outboard)
5. C1 Underdrive Hub
6. Underdrive Output Gear
7. Roller Bearing
8. Support Shaft
9. 'O' Rings – 7 off
10. Polyimide Washer
11. Needle Bearing
12. Support Shaft Sealing Rings
13. C1 Hub Seal
14. Thrust Washer (Lip to Clutch Face, oil groove facing outboard)
15. C2 Hub Seal

DUAL POWER HOUSING

NOTE: *It is recommended the output shaft seal in the main cover be renewed upon re–assembly of the cover.*

1. To assist assembly of the cover orientate the oil drain cutout in the support shaft to align as close as possible to the oil slot in the main casting.

2. Lower the main casting over the dowels lining up the M6 bolt holes in the support shaft, then fit and torque the 7 off M6 screws to, 7–10 lbs ft (9–13Nm).

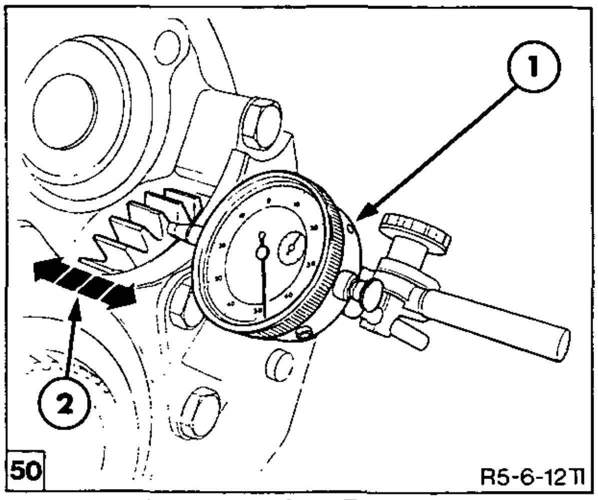
3. Install and tighten the M10 x 40mm bolt to, 25–33 lbs ft (33–45Nm) then carefully turn the assembly over onto a support block, fit and torque the remaining M10 x 55, 70 and 90mm bolts, 25–33 lbs ft (33–45Nm).

BEARING AND SHIM ASSEMBLY

With the bearing retainer bolts torqued down, a pre load should be achieved on the under drive cluster. This pre load can be achieved in the following manner.

1. Install bearing retainer with excess shims of approximately, 0.040 in (1.0mm) and torque the retainer bolts to 30–44 lbs ft (40–60Nm).

2. Attach a dial indicator to the housing in a position to contact the gear face and measure end float, Figure 50.



Under drive Gear End Float

1. Dial Indicator
2. Gear Face End Float

3. Calculate the shims required using the following guide:–

Shim Thickness Required =
(Excess Shims – End Float) – Pre Load

Excess Shims = 0.047 in (1.19mm)
End Float = 0.015 in (0.38mm)
Minus
Average. Pre Load = 0.002 in (0.05mm)

Shim Thickness Required = 0.030 in (0.76mm)

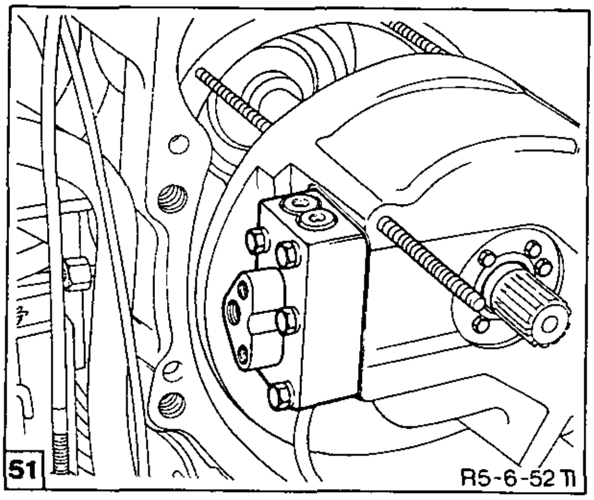
4. With the correct shims in place refit the bearing assembly and torque the M10 X 20mm bolts to 30–44lbs ft (40–60Nm).

OIL LUBRICATION TUBE

1. Tap the oil lubrication tube into the dual power housing until fully seated, or does not protrude from the dual power end face beyond 4.590 in (116.5mm).

IMPORTANT: *If the oil lubrication tube is not fully seated, once reassembled the tube may protrude too far into the oil gallery in the gearbox and restrict the oil flow.*

DUAL POWER ASSEMBLY INTO GEAR BOX



Dual Power Into Gear Box

NOTE: *All 'O' Rings, seals and gaskets should be renewed on re–assembly.*

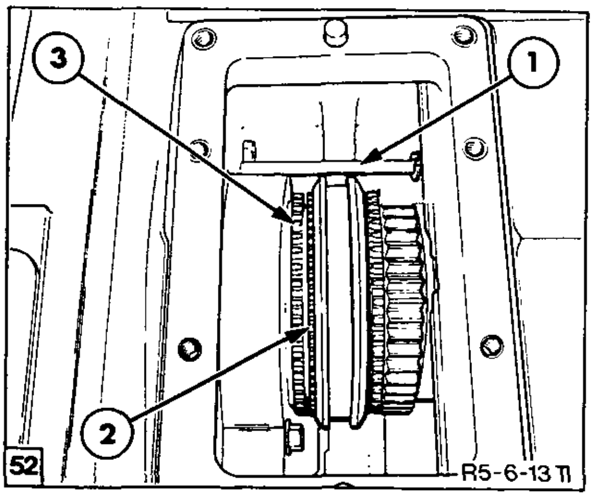
1. With the dual power re–assembled and using a strop and hoist move the unit to the gear box.

2. Apply grease to the three lugs on the forward reverse gear synchroniser and place into position in the gear box, grease the synchronizer cone and position on the dual power drive gear end.

3. Apply grease to the gear box mounting face and adhere the gasket.

NOTE: *The gearbox top cover will require removal to ensure correct engagement of the reverse gear cluster and to aid assembly of the oil lubrication tube.*

4. Carefully guide the dual power unit onto the studs in the gear box aligning the rear gear cluster and oil tube with 'C' clip upto to the face of the gear box, Figure 52.

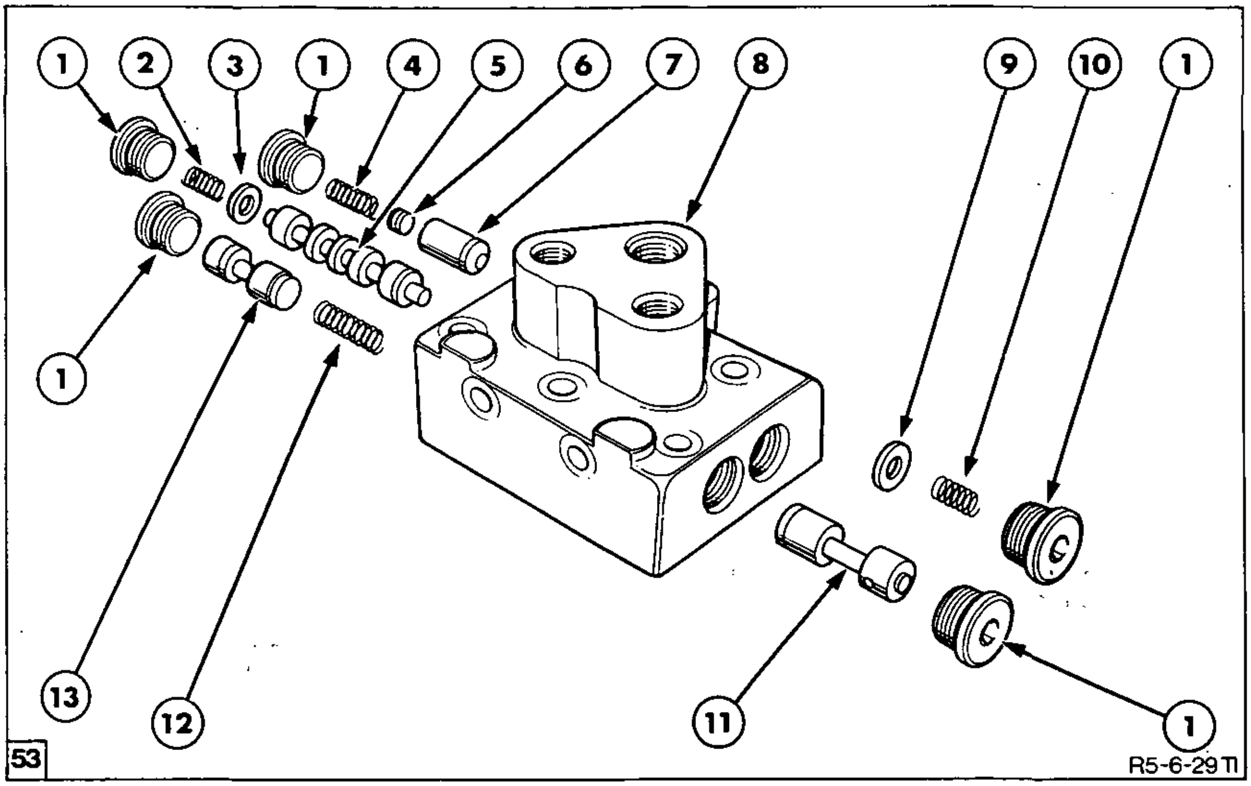


Mating Dual Power To Gear Box

1. Oil Lubrication Tube
2. Synchroniser Cone
3. Synchroniser

5. Install the attaching bolts and torque to 25–33 lbs ft (33–45Nm).

E. LUBRICATION VALVE REMOVAL AND OVERHAUL



Lubrication Valve

1. End Plugs
2. Spring
3. *Shim*
4. Spring
5. Selecter Spool
6. Pressure Relief Valve Shims
7. Pressure Relief Valve
8. Lubrication Valve
9. Shim
10. Spring
11. Lubrication Cut Out Valve Spool C1
12. *Spring*
13. Lubrication Cut Out Valve Spool C2

NOTE: *Items 1,4,6 and 7 have no function and will be deleted on later units.*

Removal

NOTE: *The lubrication valve can only be accessed once the vehicle is separated between the engine and front transmission.*

Remove the valve 5 attaching bolts and withdraw the valve from the dual power.

Overhaul

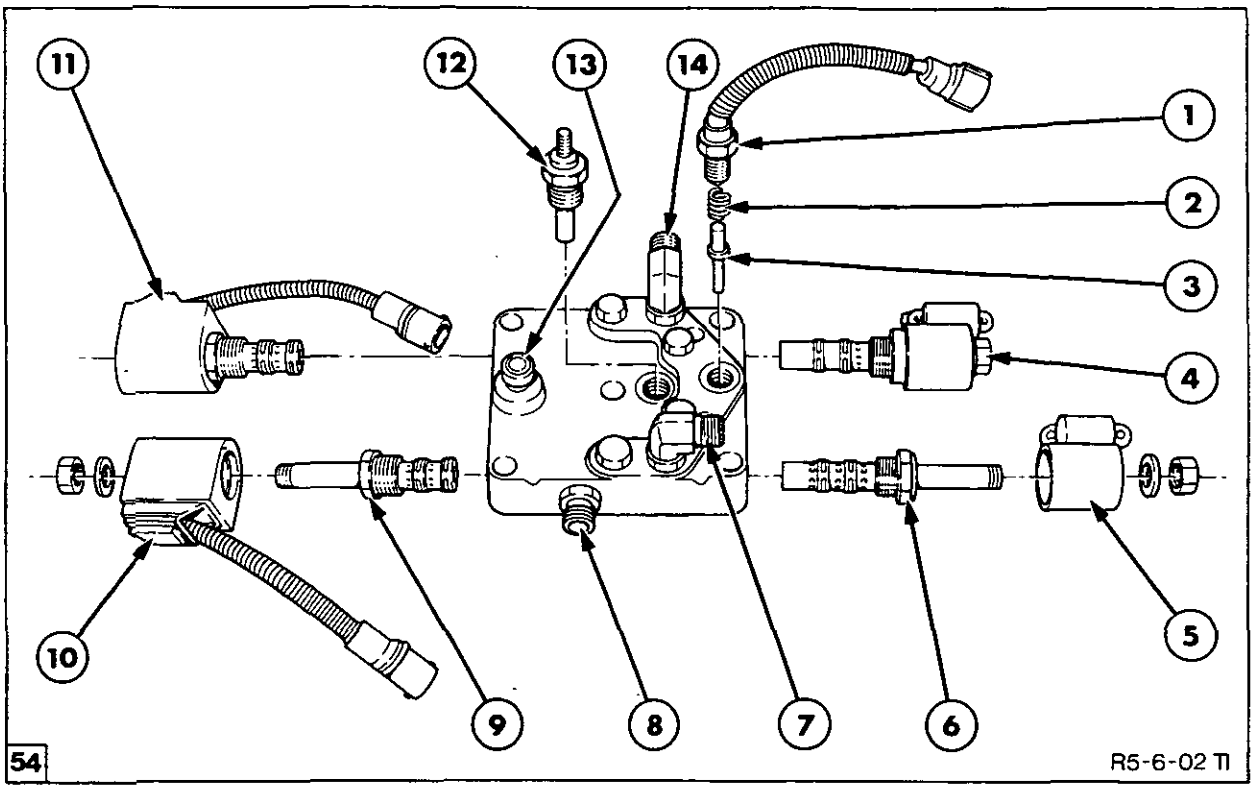
With the valve disassembled as in, Figure 53, inspect all parts for signs of wear or scoring and renew any suspect parts.

Re–Assembly

NOTE: *All 'O' Rings, seals and gaskets should be renewed on re–assembly*

1. Re–assemble the lubrication valve as shown in, Figure 53, ensuring all parts are clean and free of debris.
2. Tighten the end plugs to a torque of 11–16lbs ft (15–22Nm)
3. Refit the valve to the dual power and torque attaching bolts 11–16lbs ft (15–22Nm).

F. TRANSMISSION CONTROL VALVE REMOVAL AND OVERHAUL



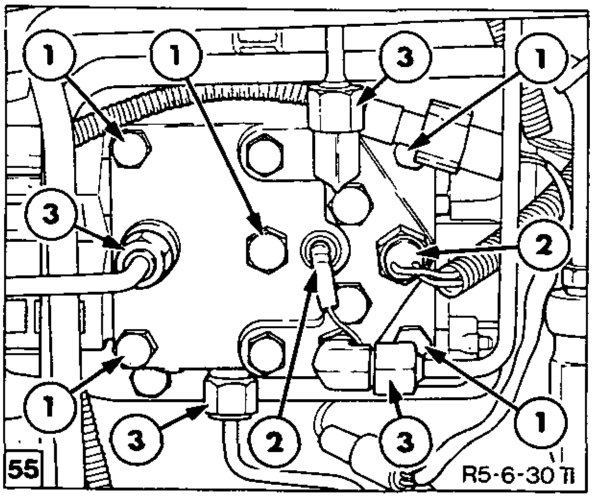
Transmission Control Valve

1. 1/2 status Switch
2. Spring
3. Plunger
4. Pulse Width Modulation Solenoid C1 Clutch (UD)
5. PWM Solenoid C2 Clutch (DD)
6. PWM Valve C2 Clutch (DD)
7. Direct Drive Oil Supply
8. Four Wheel Drive Oil Feed
9. Four Wheel Drive Valve
10. Four Wheel Drive Solenoid
11. Dump Valve
12. Temperature Sender
13. Oil Feed From Pump
14. Oil Supply (UD)

Removal

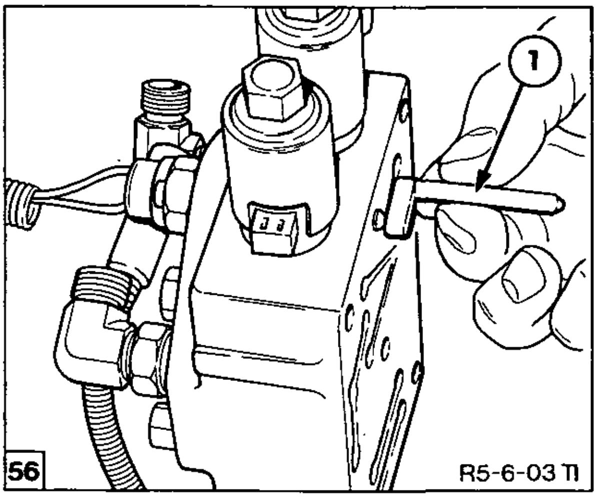
1. To remove the transmission control valve mounted on the right hand side of the transmission, disassemble the oil tube connections and solenoid electrical connections, Figure 55.

2. Remove the 5 attaching bolts from the valve body and withdraw from the transmission, Figure 55.



Transmission Control Valve Installed

1. Attaching Bolts (5 off)
2. Electrical Connections
3. Oil Tubes



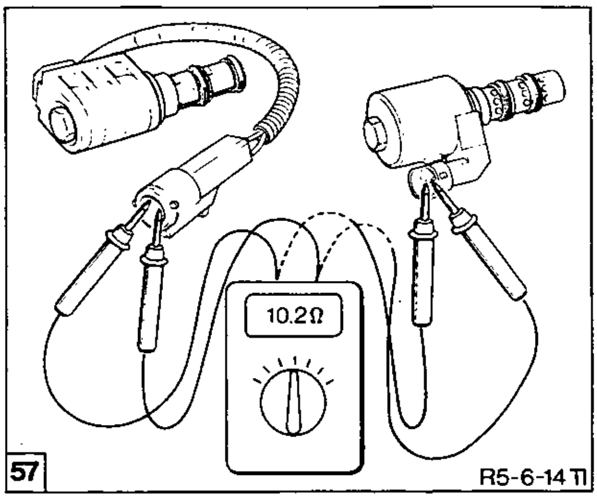
Status Switch Plunger

1. 'L' Plunger

3. Withdraw the 'L' shaped plunger from the position in the transmission and check for sticking, wear or damage, replace if in doubt, Figure 56.

Electrical Testing of Solenoid Valves

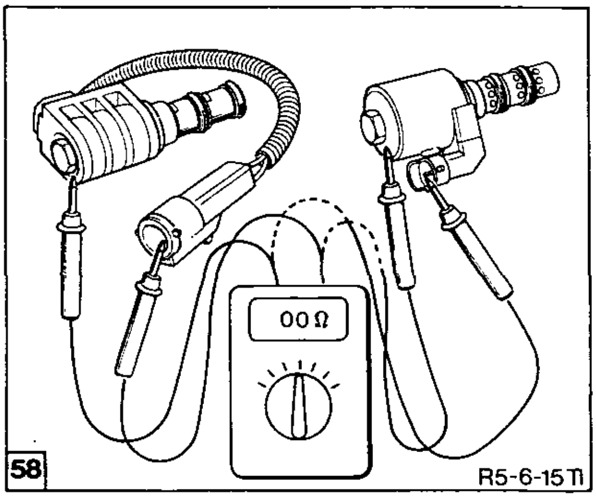
Each valve has within it a coil or wire which has a specified resistance to electrical flow in order for it to function correctly. Therefore to test a component the resistance of the coil must be checked, usually at 20°C, using a good quality multi meter between the two coil wires, Figure 57.



Resistance Testing of Component

Component	Nominal Resistance in Ohms at 20°C
PWM Valve C1	10.2 Ω
PWM Valve C2	10.2 Ω
FWD Valve	7. 2 Ω
Dump Valve	7. 2 Ω

Further to checking the resistance value, all components should be checked for a short circuit between the component coil and the components outer casing, by connecting a multi meter between the component terminals and its casing, Figure 58.



Testing for Short Circuit of Component

Zero ohms = short circuit
Infinity ohms = no short circuit

Providing the valves meet the electrical requirements they can be re–installed, if in any doubt replace with new.

Disassembly and visual inspection of the solenoid valves and body can be carried out as shown in, Figure 54. All parts must be clean and free of dirt or debris.

Re–Assembly

NOTE: *All 'O' Rings, seals and gaskets should be renewed, upon re–assembly.*

1. Refit the valve with a new gasket, torque attaching bolts to, 24–26lbs ft (33–35Nm

IMPORTANT: *To avoid damage to the solenoid body (coil) on reassembly it is recommended that the valve is fitted independently of the coil, as follows.*

- Refit the solenoid valves (less body) to the control valve and torque nut to 25–33lbs ft (34–45Nm)
- Re–assemble the (solenoid body to valve) and torque attaching nut to 1.3–1.4lbs ft (1.7–1.8Nm).

1. Reconnect the solenoid valve harness connectors.
2. Refit the oil tube connectors to the transmission control valve body and torque to 24–26lbs ft (33–35Nm).
3. Attach the oil feed tubes to the connectors and torque to 24–26lbs ft (33–35Nm).

G. SPECIFICATIONS, SPECIAL TOOLS AND TIGHTENING TORQUES

Control System	Electro–hydraulic with electronic management System
Clutch Hydraulic Operating Pressure	15–18 bar (220–260 lbf.in²) at 2100 engine rev/min, supplied from the low pressure side of pump
Pressure Lubrication	Maximum 7.6 bar (110 lbf.in²) supplied by the steering gear pump
Lubricant Capacity Transmission/Rear Axle	U.S. Gallons 15.4 Imp. Gallons 12.8 Litres 58.5
Lubricant	ESN–M2C134–D
Lubricant operating temperature	65°C (150°F)
Hydraulic Control Valve	
Type	Separate Casting, with internal cast–in galleries
Control	By electrically operated solenoid coils signaled by electronic management System
Multi–Plate Wet Clutches	
Type	Constant running, pressure lubricated, pressure applied, spring released.
Number of Friction Plates	5 in each clutch
Number of Steel Plates	5 in each clutch
Number of Separator Springs	5 in each clutch

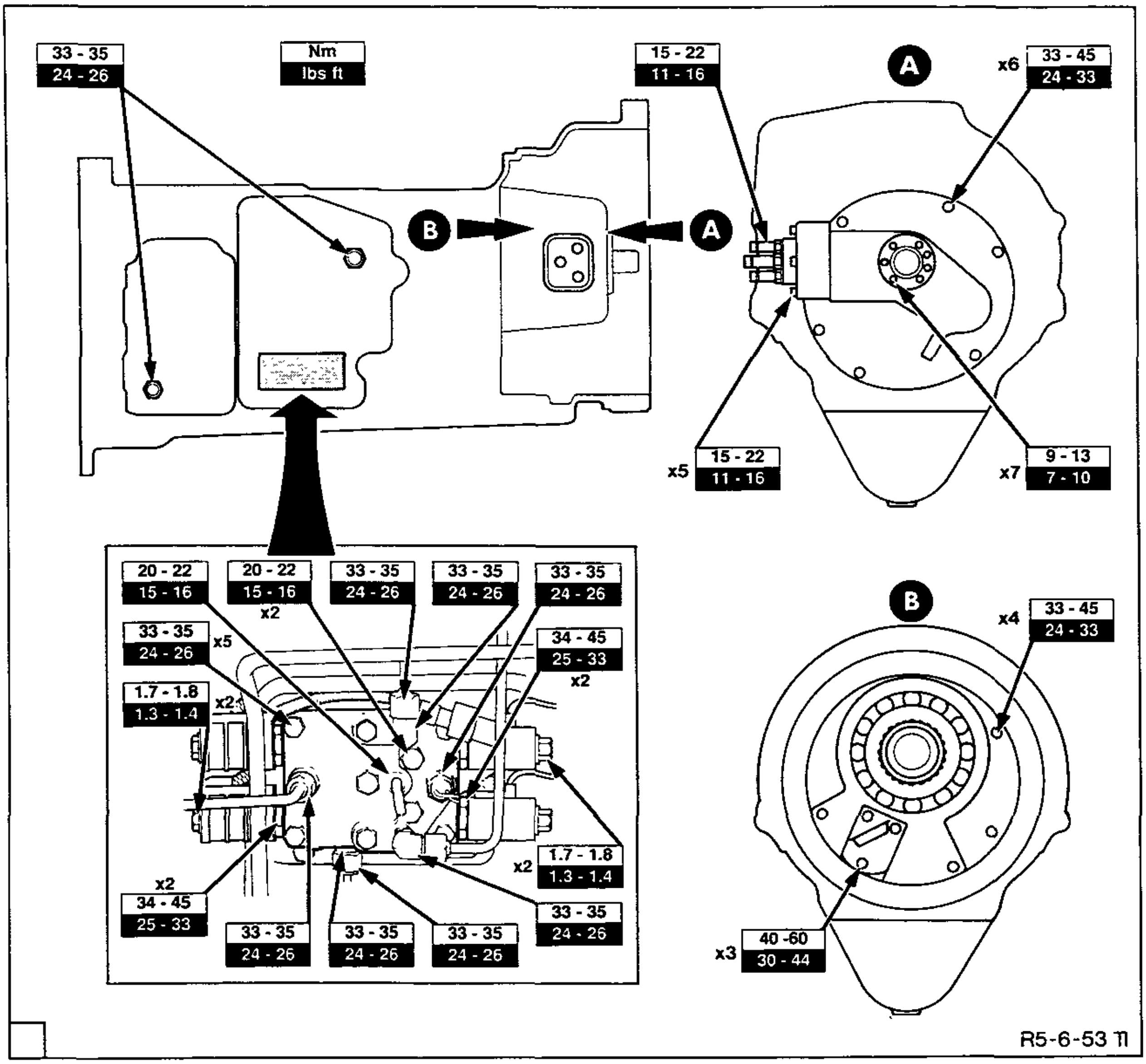
ELECTRICAL COMPONENT SPECIFICATIONS

Solenoids		Nominal Resistance at 20°C
Dump		7.2Ω
Four Wheel Drive		7.2Ω
PWM's (1 and 2)		10.2Ω
Transmission Speed Sensor		2.5KΩ
Clutch Potentiometer		3100–3900Ω clutch pedal up 640–2100Ω clutch pedal down between green and black wires
Transmission Fuses	Fuse 20	(5 Amp) – Keep Alive Memory Power
	Fuse 14	(10 Amp) – EDC Control
	Fuse 13	(15 Amp) – Transmission Control
	Fuse 12	(10 Amp) – Dual Power Switches (All Status and Hi/Lo Switches)
	Fuse 9	(10 Amp) – EIC
	Fuse 8	(10 Amp) – Fuel Shut off Solenoid
Electrical Terminal/Component Cleaner		Freon T.F. base contact spray **(Do not use trichloro ethylene based cleaners)**

SPECIAL TOOLS

Description	Tool Number (V.L. Churchill Ltd.)	(FNH–A No.)
Piston Installer (Pusher)	4FT504	–
Tapered Sleeve C1/C2 Piston Seal Installer	4FT505	FNH–00869
Clutch Piston Return Spring Compressor	4FT508	FNH–00872
Diagnostic Switch	4FT950	FNH–00874
M10 Studding (I metre)	Purchase Locally	
Silver Steel Rod 0.236 in (6mm)Dia x 6 in (152mm) long 3 off	Purchase Locally	

TIGHTENING TORQUES



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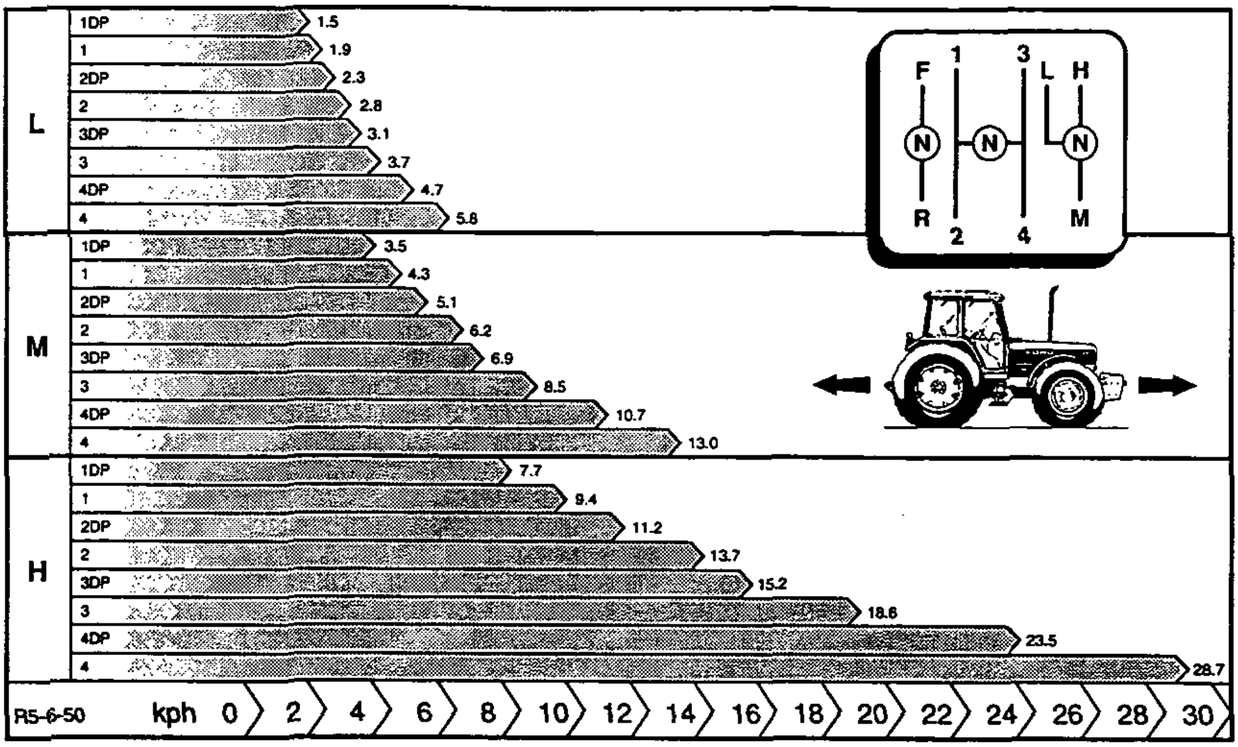
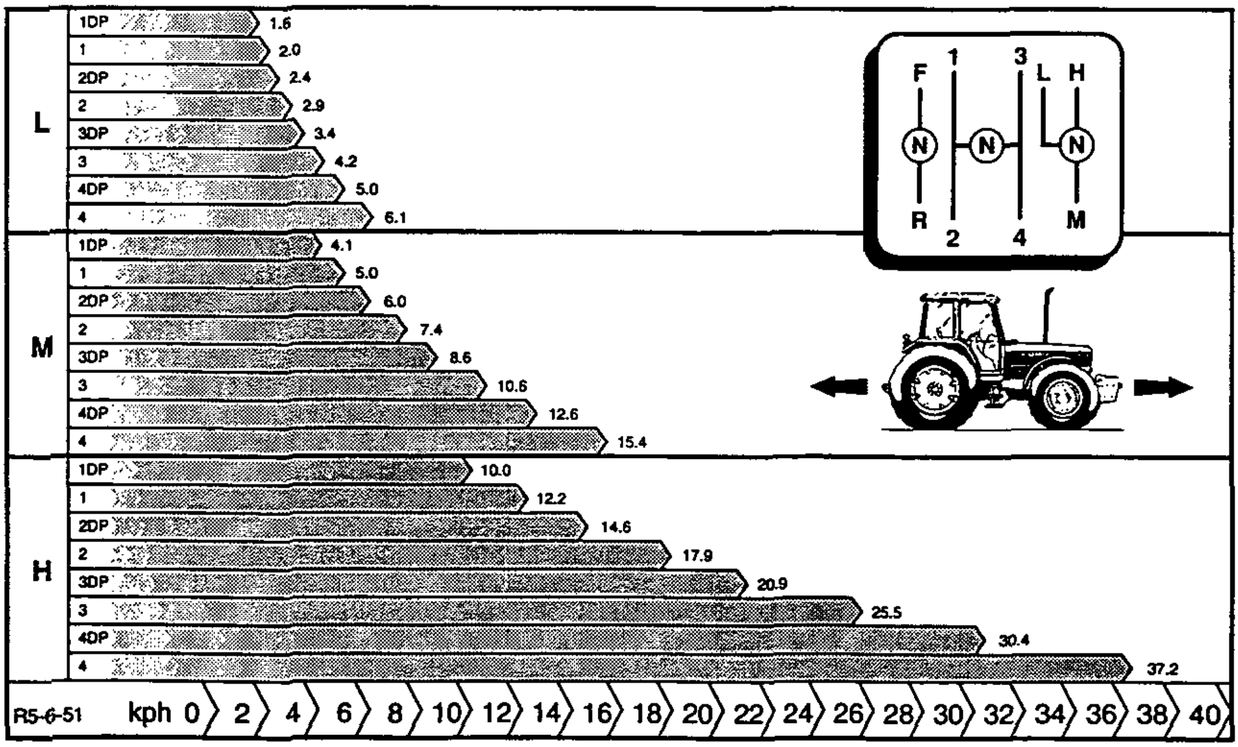
GROUND SPEEDS – 12x12 DUAL POWER TRANSMISSIONS AT MAXIMUM RATED ENGINE SPEED



30 kph Transmissions
L = Low Range M = Medium Range H = High Range
UD = Underdrive



40 kph Transmissions
L = Low Range M = Medium Range H = High Range
UD = Underdrive

PART 5
TRANSMISSION SYSTEMS
Chapter 7
16 x 16 'Quad Mod' Transmission
(16x16 Transmissions Post September 1993)

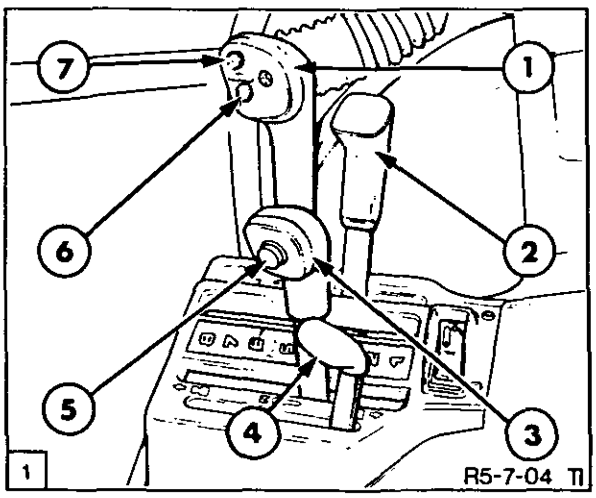
A. DESCRIPTION AND OPERATION

Description

From September 1993 the 16 x 16 powershift transmission was improved with the incorporation of a new transmission control valve side cover and cable control for the shift levers. The new side cover incorporates 4 PWM solenoid valves, hence the term 'Quad Mod', which totally control clutch engagement/disengagement, via signals from the micro processor. The 4 PWM solenoid valves replace all the previous side cover internals.

The 'Quad Mod' transmission incorporates all of the operating features of the original 16 x 16 transmission, with the addition of the following new features:

Clutchless Shuttle Shifting – Figure 1



Powershift Transmission Controls

1. Main shift lever
2. Range lever
3. Shuttle lever
4. Hand throttle
5. 'Dump' switch
6. Powershift down button
7. Powershift up button

N – Neutral

A transmission 'dump' switch is now provided on the shuttle lever. The switch enables gear engagement and drive off, without using the clutch pedal and is particularly useful for shuttle operations.

When the dump switch button is depressed, drive is instantly disengaged. When the button is released, transmission output speed and clutch pack engagement are automatically monitored to take up the drive smoothly.

NOTE: *To prevent inadvertent shuttle lever engagement, an electronic interlock is provided. If the tractor is stationary with the shuttle lever in neutral the following procedure must be used to drive away from a standstill:*

Depress and release the dump switch then, within one second, depress and hold in the switch. Move the shuttle lever into gear. The drive will engage when the button is released. If this sequence is not followed a warning 'bleeper' will sound and the fault code 'CP' will appear in the digital display.

To change from forward to reverse motion, press the dump button, apply the brakes to slow the tractor, move the shuttle lever fully rearward, release the button and control tractor speed by means of the throttle.

IMPORTANT: *To reduce clutch damage caused by shuttle shifting in too high a gear or at too high a speed, a warning 'bleeper' will be heard and a symbol 'H' will appear in the instrument cluster under the following conditions:*

- *In high range: ratios 5 – 8. Shuttle shifting while the tractor is still rolling.*

- *30 km/h transmission: In high range: ratios 3 – 4. Shuttle shifting while the tractor is still rolling at more than 5 MPH (9 km/hr).*

- *40 km/h transmission: In high range: ratios 2 – 4. Shuttle shifting while the tractor is still rolling at more than 5 MPH (9 km/hr).*

The shuttle shift will continue to operate under these warning conditions.

Speed Matching – Figure 1

When travelling on the road in high range, ratios 5 to 8, the transmission will automatically select a ratio to match engine speed to road speed if the following method is adopted:

To upshift: Depress the inching pedal (or depress the dump switch) then decrease engine speed with the foot throttle. When the inching pedal or dump switch is released, the transmission will automatically select a higher gear ratio (provided 8th. speed is not already selected) to approximately match engine speed to road speed.

To downshift: Decrease engine speed, depress the inching pedal (or press the dump switch), simultaneously increasing engine speed by pressing the foot throttle further down. When the inching pedal or dump switch is released, the transmission will automatically select a lower gear ratio (provided 5th. speed is not already selected) to approximately match engine speed to road speed.

Speed matching allows shifting from low to high range to be more easily accomplished. For example, if it is necessary to hill start with a heavy trailer in low range then, when 8th. speed is reached, change to the high range, the transmission will automatically speed match to the lowest ratio (5th.) in the high range.

When starting off in the highest range, the speed matching feature will always try to set off in 5th. gear. If required, this feature may be overridden and a higher gear selected by partially releasing the clutch then Powershifting up to the required ratio before the clutch 'bite' point is reached.

Sequential Powershifting – Figure 1

It was previously necessary to press the Powershift up or down buttons on the main shift lever once, twice or three times to make one, two or three consecutive ratio changes. Now, if a Powershift button is held depressed, the transmission will make sequential ratio changes at 1.75 second intervals until the button is released.

COMPONENT CHANGES

Component changes from the original 16 x 16 transmission are as follows:

- A completely new side cover assembly.
- A new micro processor
- New processor, transmission extension and main cab harnesses.
- Cable control for the shift levers, replacing the original rod linkage.
- A modified top cover which has an increase in height and new shift rails to accept the new shift cables. As a result of the increased height longer synchroniser selector forks are also used.
- Shuttle dump switch on forward/reverse lever.
- Clutch pedal disconnect switch.
- C1/C2 clutch assembly piston now of a one piece construction, similar to that used in the C3/C4 clutch assembly.

Other system changes include improved electronic diagnostic codes and modified clutch calibration procedures to provide calibration of all four clutches. The clutch pedal cable has also been deleted, its function being replaced by electronic control.

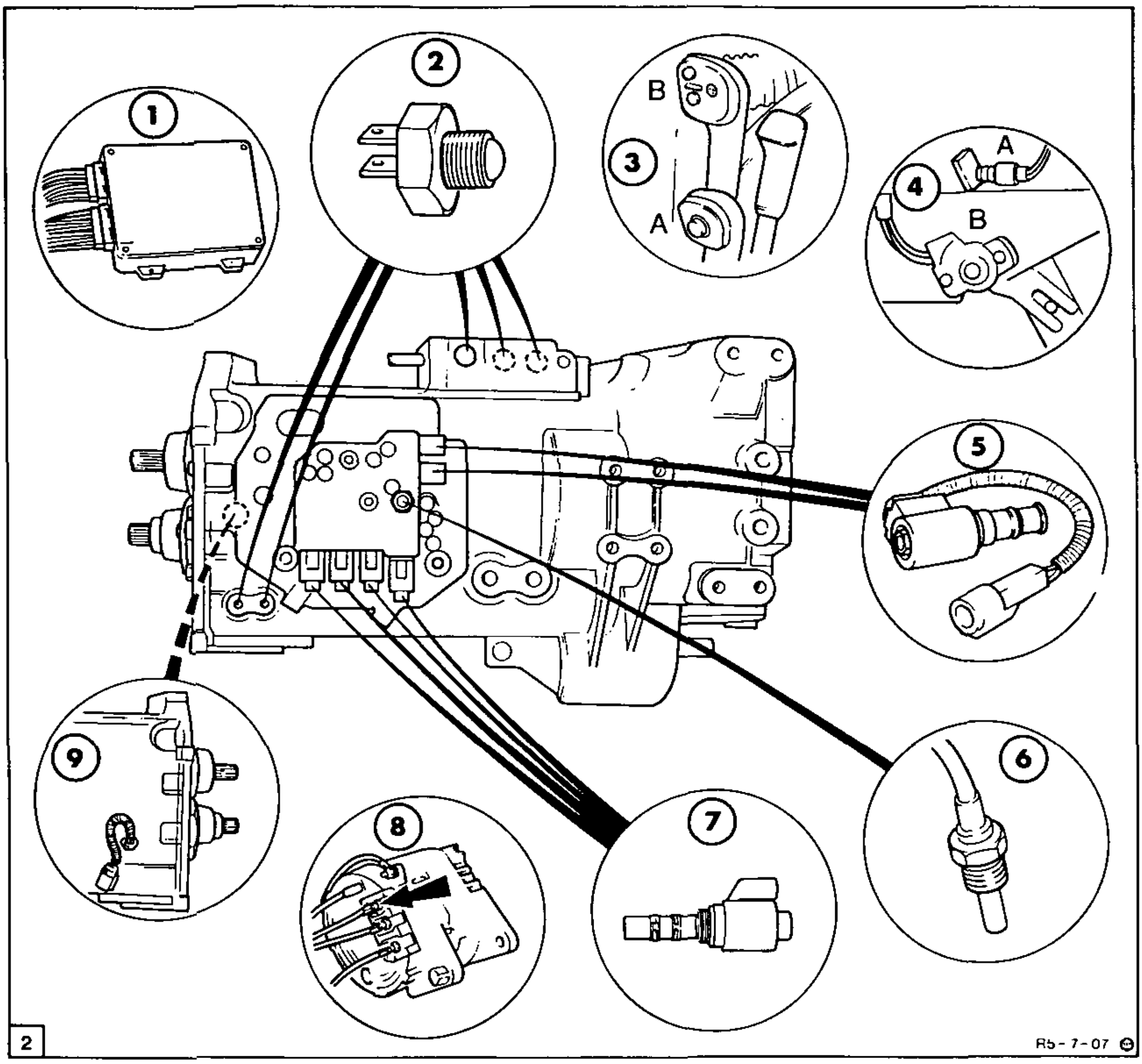
Operation

The transmission clutch engagements/disengagements are now controlled totally by the micro processor. The four PWM (pulse width modulation) solenoid valves, one for each clutch, C1/C2/C3/C4, react to signals from the processor to totally control the oil flow to the clutches and hence clutch engagement/disengagement. The creeper and four wheel drive operation is unchanged from the original 16x16 transmission.

The micro processors signal to the PWM solenoid valves is determined by the information returned from the following switches and senders:

- Clutch pedal disconnect switch
- Forward/reverse shuttle dump switch
- Clutch pedal potentiometer
- Transmission speed sensor

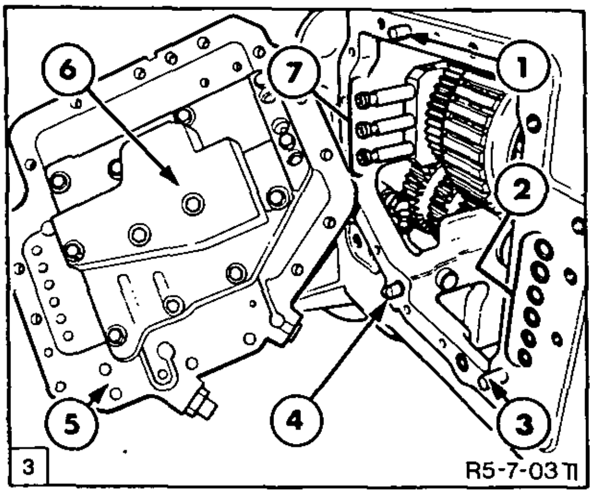
- 1–4 range, 5–8 range, neutral, high range and low range transmission switches.
- Engine speed signal from the alternator
- Transmission oil temperature sender
- Up shift / down shift switches on main shift lever



Transmission Related Electrical Components

1. Micro Processor
2. Transmission Switches
   A: Forward/Reverse
   B: 5–8 Range
   C: 1–4 Range
   D: Low Range
   E: High Range
3. Shift Lever Switches
   A: Shuttle Dump
   B: Up/Down Shift
4. Clutch Pedal
   A: Clutch Disconnect Switch
   B: Clutch Potentiometer
5. Creeper and FWD Solenoids
   A: Creeper
   B: FWD
6. Transmission Oil Temperature Sender
7. PWM Solenoid Valves
   A: C1 Clutch
   B: C2 Clutch
   C: C3 Clutch
   D: C4 Clutch
8. Alternator – Engine Speed
9. Transmission Speed Sensor

Transmission Lubrication



Side Cover Assembly

1. Dowel
2. 'O' Ring
3. Dowel
4. High/Low Detent
5. Side Cover
6. Lube Control Valve
7. C3/C4 Supply Tubes

The clutch lubrication is controlled by a new 'lube control valve' assembly which is located on the rear face of the side cover, Figure 3.

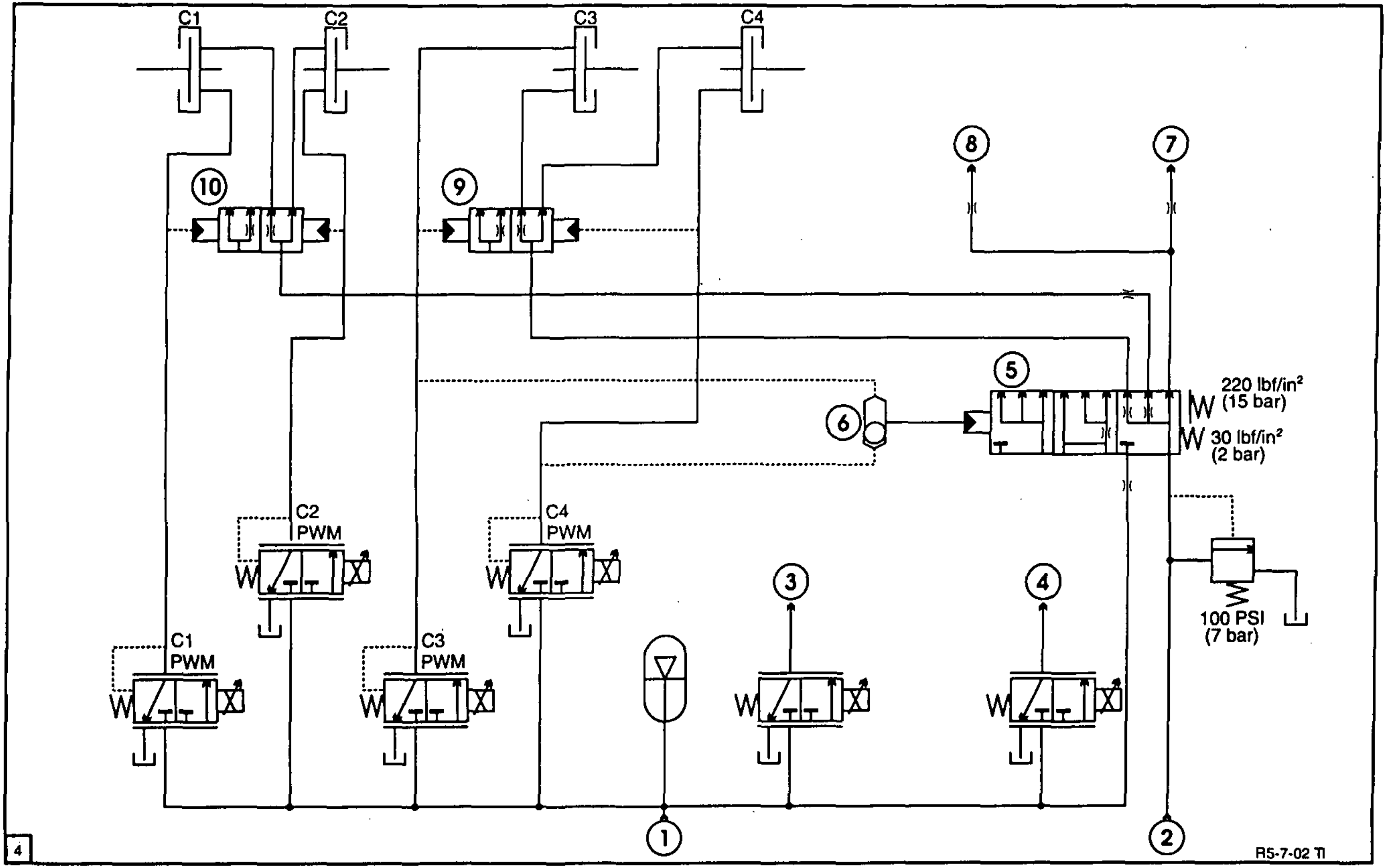
With reference to Figure 4, hydraulic schematic circuit. The lube control valve is shown with the clutch pedal in the depressed position. It can be seen on the illustration that lube oil is allowed to pass unrestricted to the transmission and rear axle bearings with restricted oil going to the drive clutches, which are disengaged with the clutch pedal depressed.

As the clutch pedal is raised the increase in oil pressure to either the C3 or C4 clutch, depending on which gear is selected, passes through the shuttle valve and acts on the lube control valve. As the pressure increases to between 30–220 lbf.in2 (2.0–15.0 bar), the transmission is in inching mode, the control valve spool is moved to the central position and allows combining of the regulated low pressure system oil with the normal lube supply, to provide the additional oil while the tractor is inching. The clutches are not fully engaged at this point and will be slipping, hence the extra lube oil requirement.

When the pedal is fully released, or the pressure in the clutch pack (C3 or C4) exceeds 220 lbf.in2 (15.0 bar), this pressure acting on the lube control valve spool over comes the spool spring and allows the spool to move fully to the right. The regulated oil pressure is now cut off from the lube oil and normal lube oil flows unrestricted through the lube control valve spool to all the clutches and the transmission and rear axle bearings.

Key to 16 x 16 'Quad Mod' Transmission Hydraulic Schematic (Figure 4)

1. Regulated Low Pressure Oil Supply from Variable Displacement CCLS Pump
2. Lube Oil Supply from Steering Motor Return Side
3. Creeper Solenoid Valve Oil Outlet
4. Four Wheel Drive Solenoid Valve Oil Outlet
5. *Lube Control Valve Spool*
6. Lube Shuttle Valve Located Within Lube Valve Assembly
7. Lube to Rear Axle
8. Lube to Transmission Bearings and Synchronisers
9. *C3/C4 Lube Shuttle Valve*
10. C1/C2 Lube Shuttle Valve



16 x 16 Quad Mod Transmission Hydraulic Schematic

B. CALIBRATION, FAULT FINDING AND PRESSURE TESTING

Introduction

The principle of fault finding on the 'Quad–mod' 16x16 transmission is the same as that used for the previous level of transmission. This Section details areas of fault finding which are unique to the new control System. The following items have been changed:

- Revised Clutch Spring Pressure Calibration Procedure, To Include All Four Clutches.
- Automatic Clutch Fill Time Calibration Deleted, New Manual Fill Time Procedure
- Calibration Error Codes Revised
- Transmission Pressure Testing
- Additional Switch Diagnostic Codes
- Transmission Error Codes Revised

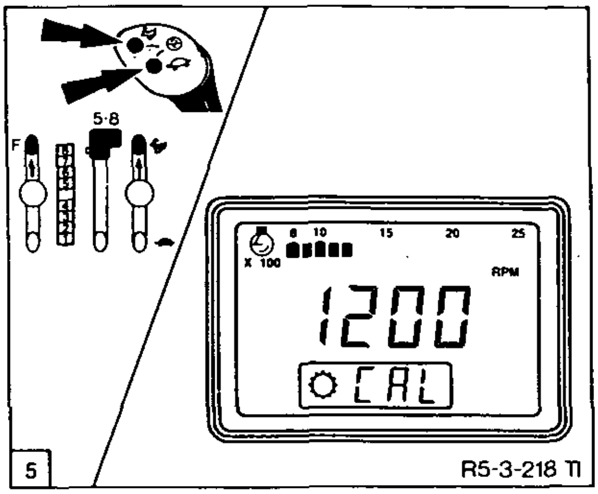
Clutch Spring Pressure Calibration

- **C3 and C4 Clutches**

1. Apply the handbrake and ensure that the surrounding area is unrestricted. It is preferable to perform the calibration routine outside the workshop. If this is not possible, block all wheels and display a vehicle under test notice.

IMPORTANT: *Although the test procedure is controlled by the ETC it is prudent to make every safety precaution against unexpected tractor movement.*

2. With the engine switched off, depress the clutch pedal and depress and hold down both powershift buttons. With the buttons still depressed start the engine. The instrument cluster transmission display will now display 'CAL'.



Electronic Instrument Cluster – CAL Displayed

3. Release the switches.

4. Place all shift levers in the forward position to select forward, 5–8 and high range.

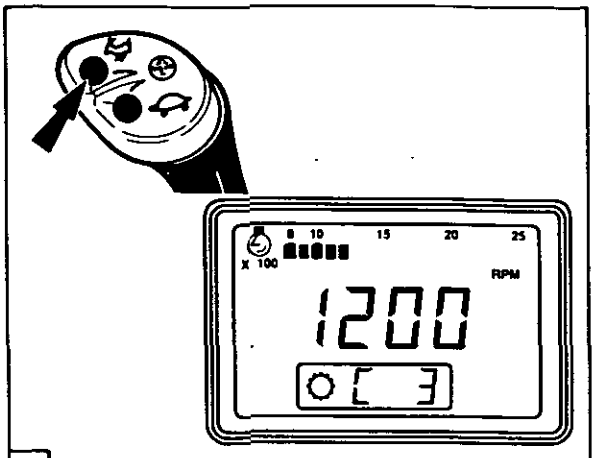
5. Release the clutch pedal (the tractor should not move).

6. Using the hand throttle set the engine speed to 1200 ± 100 rev/min.

IMPORTANT: *It is important during calibration that all additional equipment such as air conditioning, lights, etc., that could effect engine speed fluctuations, are turned off.*

The initial calibration set up is now complete. The calibration procedure that follows can be performed as many times as desired and in any order. When a clutch is correctly calibrated the old calibration value is erased from the ETC memory and replaced by the new value.

Upshift button depressed = C3 calibration.
Downshift button depressed = C4 calibration.



6

R5-3-219 TI

Electronic Instrument Cluster – C3 Displayed

7.Depress and hold the upshift button and note that 'C3' is displayed. If the test conditions are not correct an error code will be displayed. This code will be prefixed by a 'U' and followed by two further digits. Refer to the following table for explanation of the error codes.

a) From the point where the upshift button was depressed the actual calibration process managed by the ETC began.

b) 'C3' was displayed while the base line engine rev/min. was being established by the ETC. This must remain steady before the calibration will begin.

c) The ETC will begin to slowly increase the modulation pressure from an initial low level. A relative value will be displayed numerically and be seen to increase until the engine speed is pulled down (initial application of the clutch) by 50 rev/min. below the initial base line measurement.

d) The ETC will immediately recognise the decrease of 50 rev/min. and the pressure will be dumped. The resultant calibration value will be displayed and remain displayed for as long as the upshift button is depressed.

8.Repeat step 7, using the downshift button, note that 'C4' is now displayed.

It is good practice to record these calibration values and enter them with the tractors repair history file. They will be retained in the ETC memory (but could unintentionally be updated by another service man) and will help in possible future fault diagnosis.

- **C1 and C2 Clutches**

The Calibration of the C1 and C2 clutches follows the same procedure as above, except that in item (4) the **high/low** shift lever should be positioned in **neutral.** The **Forward/Neutral/Reverse** and **1–4/5–8** levers should be positioned **forward** to select Forward and 5–8 range.

NOTE: *Calibration of C1 and C2 clutches can be performed immediately following C3 and C4 clutches. Depress the clutch pedal, select the neutral position of the high/low lever and depress either the upshift or downshift button to calibrate C1 or C2.*

When the upshift button is depressed and held, item (7), C1 will be displayed, indicating that C1 clutch is being calibrated. When the downshift button is held C2 will be displayed indicating that C2 clutch is being calibrated.

Upshift button depressed = C1 calibration.
Downshift button depressed = C2 calibration.

NOTE : *During the calibration of the C1 or C2 clutch, both C3 and C4 clutches are engaged to lock the transmission shafts.*

Typical Clutch Spring Calibration Values:

Clutch	Typical Value
C1/C2/C3/C4	120–180

Clutch Spring Pressure Calibration Procedure – Error Codes

U20 Correct start up sequence was not used (depress and release pedal and repeat step 7 or 8).
U21 Engine rev/min. is too low.
U22 Engine rev/min. is too high.
U23 Forward/reverse lever is not in forward.
U24 Main lever is not in high range (5–8).
U25 High/low lever is not in neutral.
U26 Clutch pedal is not fully released.
U27 C3 Calibration is too low. The initial test pressure was sufficient to pull down the engine.
U28 C3 Calibration is too high. The maximum test pressure was reached without causing the engine speed to decrease by 50 rev/min.

U29 C4 Calibration is too low. The initial test pressure was sufficient to pull down the engine.

U30 C4 Calibration is too high. The maximum test pressure was reached without causing the engine speed to decrease by 50 rev/min.

U31 Wheel motion detected during calibration. Handbrake not applied or the calibration threshold was too low such that initial test pressure was enough to cause slight wheel motion prior to pulling down the engine.

U32 C1 calibration is too low. The beginning test pressure was sufficient to lug the engine.

U33 C1 calibration is too high. The maximum test pressure was reached without causing the engine speed to decrease.

U34 C2 calibration is too low. The beginning test pressure was sufficient to lug the engine.

U35 C2 calibration is too high. The maximum test pressure was reached without causing the engine speed to decrease.

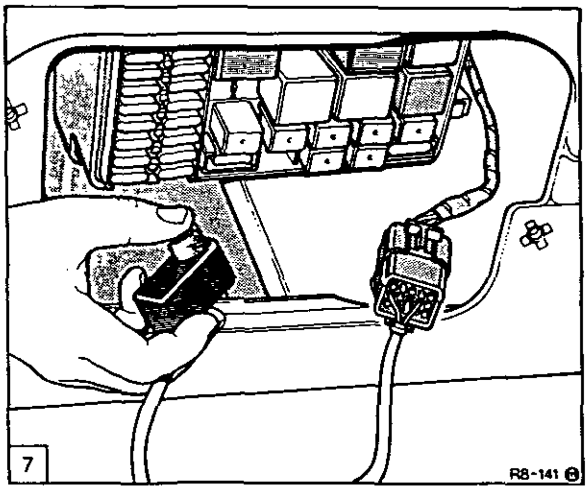
CLUTCH FILL TIME CALIBRATION (USING HC to HF DIAGNOSTIC MODE)

IMPORTANT: *Care must be taken when making this adjustment, over adjustment can make the clutch engagement very jerky. It may be necessary to perform this calibration in service as the clutches wear.*
A sign that the C3/C4 clutches require fill time adjustment is if the delay in engaging drive when inching or during power shift seems excessive (clutch fill time is too short) or if the clutch performance is jerky when inching (clutch fill time is too long). An indication that the C1/C2 clutches require fill time adjustment is if a 'clunk' occurs while raising the clutch pedal.

C1 and C2 Clutch Fill Time Calibration

1. Operate the tractor until the driveline oil has reached normal operating temperature. A method of warming the oil quickly and safely is to install a flow meter into the remote valves and restrict the flow for several minutes

2. Connect the diagnostic plug, Tool No.4FT 950, to the tractor.



Diagnostic Switch Connected into Diagnostic Connector

3. With the tractor parked on a level surface, with the handbrake on, start the engine and set to 1200 ± 100 rev/min.

4. The display will read HH, depress the test switch until HC is selected on the display.

NOTE: *After 4 seconds this will disappear and a 'U' error code will appear. Ignore the error code at this stage and proceed to step 6.*

5. Error code F1 will be displayed if the oil temperature is too cool for calibration.

NOTE: *Do Not Calibrate if F1 is displayed at any time. The oil temperature will seriously affect the calibration. The F1 display will also disappear after 4 seconds. Do Not ignore. Return to step 1 until oil is at operating temperature.*

6. Depress the clutch pedal and select forward, 5–8 range and neutral of the high / low range. Release the clutch pedal. The display may show a 'U' error code if the calibration set–up was incorrect.

7. After the setup is completed correctly, C1 will be displayed for several seconds. During this time the C3/C4 clutches are smoothly engaged to full pressure to 'brake' the internal transmission shafts.

8. After the C3/C4 clutches have fully engaged, the currently stored C1 clutch fill time value will be displayed.

NOTE: *This is set at 3, for C1/C2 and at 4 for C3/C4 during manufacture. The value 3 represents 30 milliseconds, a value of 4 represents 40 milliseconds.*

9. Depress and release the shuttle dump switch and listen for a 'clunk.' If a 'clunk' is evident reduce the fill time by a value of 2, using the powershift 'down' button.

10.If a clunk is not evident increase the fill time value, using the powershift 'up' button. Depress and release the dump switch and repeat this until a clunk is evident. At this point reduce the the fill time value by 2 to obtain the correct calibration. There should not be a 'clunk' now when the shuttle dump switch is operated.

11.When C1 is satisfactory go back to step 3, using the diagnostic switch select HD and repeat steps 4 to 7 for clutch C2.

C3 and C4 Clutch Fill Time Calibration

IMPORTANT: *Ensure adequate safety precautions are taken. This procedure allows the vehicle to move forward several feet. Keep the front of the vehicle clear of obstruction and warn other workshop personnel of the operation being performed.*

1.Repeat steps 1 and 2 of C1/C2 procedure. Set the engine speed to 1200 rev/min and position the handbrake in the OFF position. Using the diagnostic switch in step 4 select HE (C3).

2.Depress the clutch pedal and select forward, 5–8 range and High range. Release the clutch pedal

3. Depress and release the dump switch. If a jerk is evident or the tractor starts to creep reduce the fill time by a value of 2. If no jerk/creep is evident increase fill time value to obtain a jerk/creep and then reduce value by 2.

4.Repeat above procedure, selecting 'HF' for C4 clutch.

5.Turn the ignition key off and disconnect the tractor diagnostic plug.

NOTE: *If conditions are not correct for calibration to be performed a 'U' error code will be displayed. These are the same as those used for clutch spring calibration.*

PRESSURE TESTING

Pressure ports are provided on the transmission control valve cover, detailed in Figure 9, to enable the transmission clutches, the creeper and the four wheel drive systems to be tested to determine the correct function of a number of system components. Components such as solenoids, clutch pedal operation and micro–processor can be seen to be operating correctly by the results of pressure testing.

NOTE: *Prior to pressure testing, make certain that all the points detailed under the tractor preparation are carried out to ensure maximum safety.*

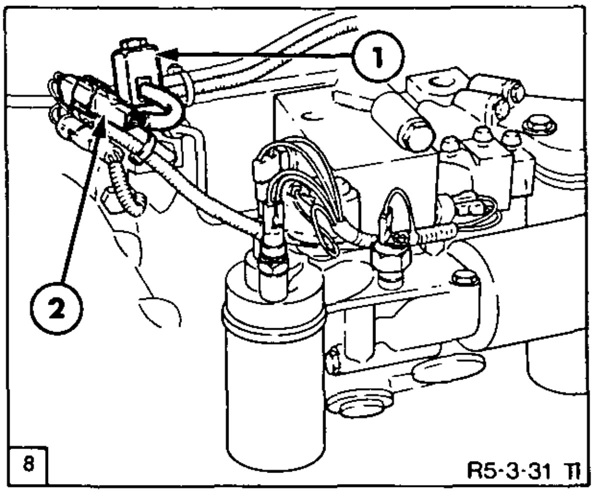
Tractor Preparation

1.Start the tractor and run until the transmission oil has reached its normal operating temperature of at least 40°C (104°F).

2.Apply the handbrake and remove the FWD shaft.

3.Raise the right hand rear wheel and place a suitable support under the axle casing. Remove the right hand wheel.

4.Disconnect the grey connector to the low range switch and install 'Switch By–Pass Connector', Tool No. 4FT 951, into the tractor harness end. By installing the connector, the ETC receives a signal indicating that low range is selected, although the **RANGE LEVER remains in NEUTRAL** throughout the testing.



Differential Lock Solenoid Connector

1. Differential Lock Solenoid
2. Connector

5.Disconnect the differential lock solenoid connector.

C1/C2 and C3/C4 Clutch Engagement and Disengagement

1.Install the pressure gauges. Ideally four gauges should be used, however, the testing can be carried out with two gauges using the following procedure:

- Connect to C1 and C2 test ports and carry out tests from powershift one through to four.
- Connect to C3 and C4 test ports and carry out tests from powershift one through to four.
- Connect to C2 and C3 test ports and carry out clutch feathering test.

2.Position the shuttle lever in **Forward,** the main lever into the **1–4 range** and leave the High/Low lever in **Neutral.** Set the engine speed to 1500 rev/min. Observe the reading on the gauges and compare with those in Table 1 as the gears are shifted and with those in Table 2 for the feathering tests.

Four Wheel Drive Pressure Testing (Follow previous tractor preparation. The FWD shaft must be removed).

1.Install gauge into FWD test port.

2.Disengage FWD, **DO NOT TOUCH FOOT BRAKES, shift all levers to neutral.** Start and run engine at 1500 rev/min. Pressure reading should be 18–20 bar.

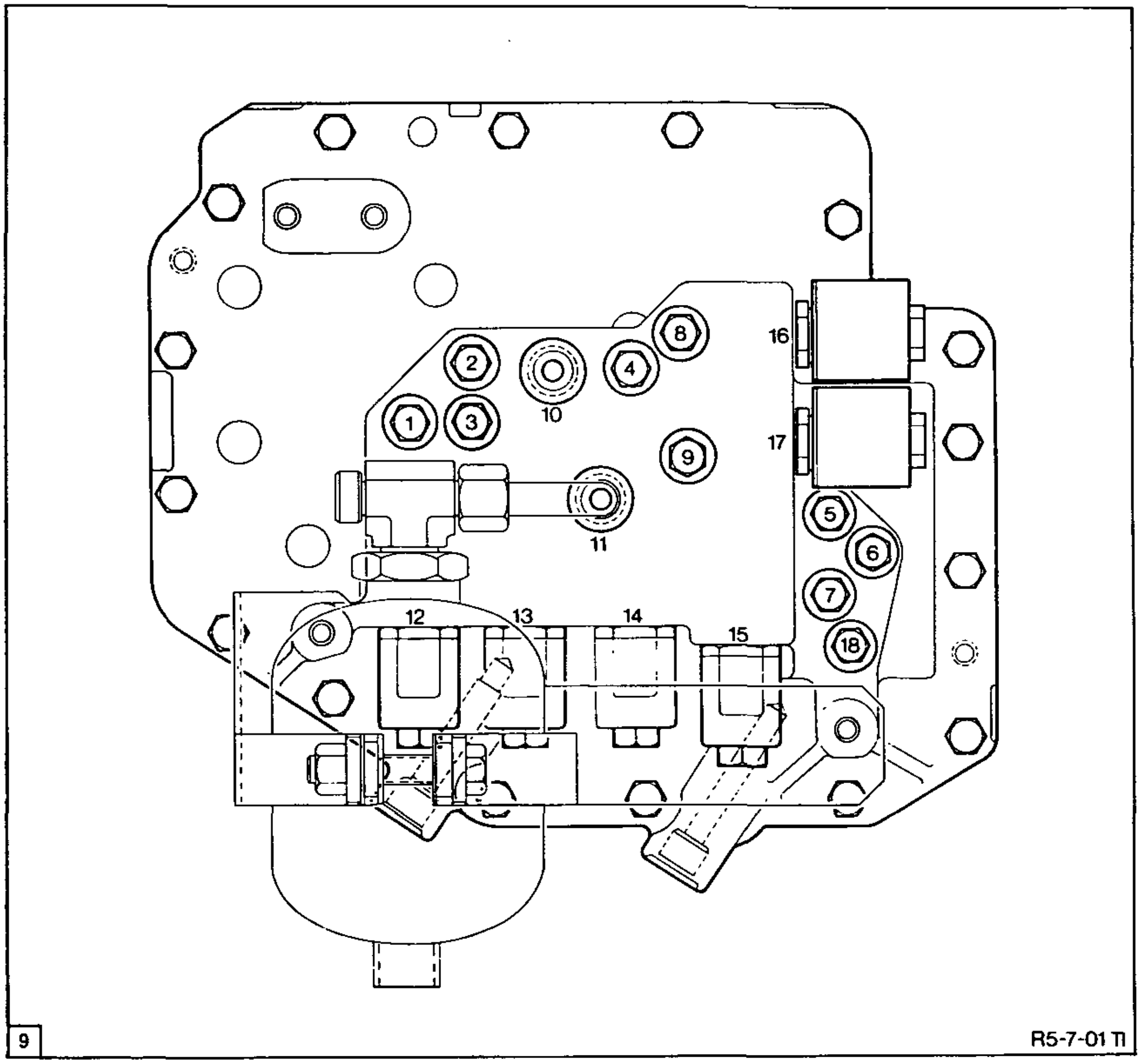
3.Engage FWD, pressure reading should drop to zero.

Creeper Pressure Testing (Follow previous tractor preparation

1.Install gauge into creeper test port.

2.Shift all levers into neutral. Start engine and run at 1500 rev/min.

3.Depress the clutch pedal, engage low range and select creeper. The pressure reading should be between 18–20 bar.



Pressure Test Ports
All Pressure Test Ports Accept $^{7}/_{16}$ inch JIC Fitting

1. C4 Pressure
2. C3 Pressure
3. C3/C4 Lube Pressure
4. Lube Supply Pressure
5. C2 Pressure
6. C1/C2 Lube Pressure
7. C1 Pressure
8. Creeper Pressure
9. FWD Pressure
10. Lube Inlet Connector
11. Regulated Pressure Inlet
12. C4 PWM Solenoid Valve
13. C3 PWM Solenoid Valve
14. C2 PWM Solenoid Valve
15. C1 PWM Solenoid Valve
16. Creeper Solenoid Valve
17. FWD Solenoid Valve
18. Transmission Bearing / Synchroniser Lube Pressure

Table 1 – Pressure Testing – Clutch PWM Solenoid Operation

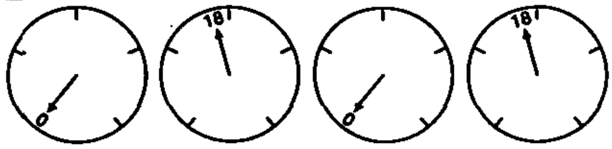
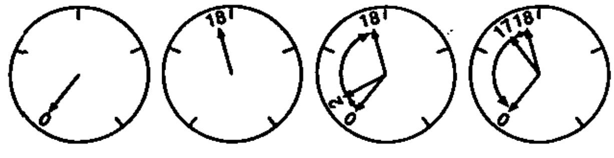
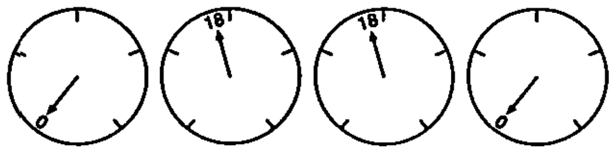
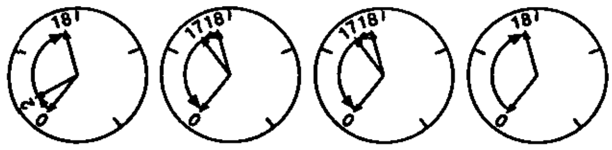
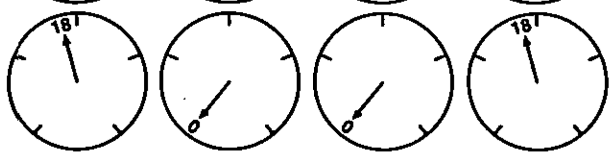
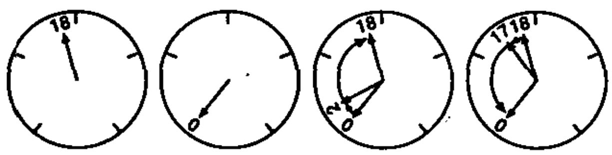
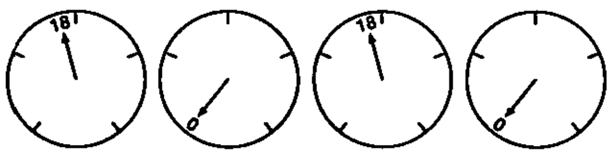
Clutch / Gear	C1	C2	C3	C4	Observations
1					C2 and C4 at Full Pressure
1 → 2					C2 Full Pressure C3 0 to 2 bar : 2 to 18 bar C4 18 to 17 bar ; 17 to 0 bar
2					C2 and C3 at Full Pressure
2 → 3					C1 0 to 2 bar : 2 to 18 bar C2/C3 18 to 17 bar : 17 to 0 bar C4 0 to 18 bar
3					C1 and C4 at Full Pressure
3 → 4					C1 Full Pressure C3 0 to 2 bar : 2 to 18 bar C4 18 to 17 bar : 17 to 0 bar
4					C1 and C3 at Full Pressure

Table 2 – Powershift 2 Selected – Clutch Feathering Tests

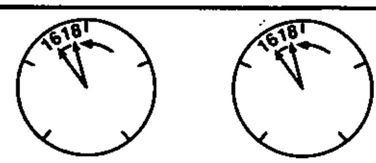
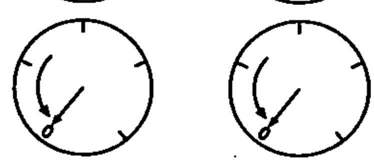
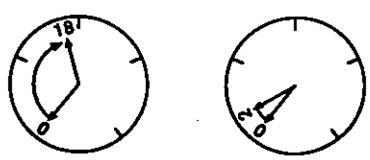
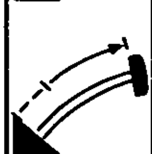
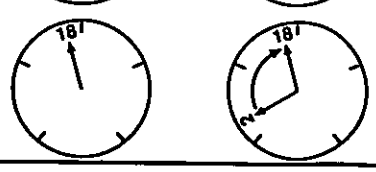
Clutch Pedal	C2	C3	Observations
			When clutch pedal is initially depressed Pressure in both C2 and C3 reduce from the fully engaged pressure by approximately 2 bar.
			Fully depressing clutch pedal should zero C2/C3 pressures.
			Releasing clutch pedal from fully depressed position should restore clutch 2 to full pressure, minus approx. 2bar and clutch 3 to feathering pressure.
			Pressure in C3 should progressively increase as clutch pedal is released indicating PWM valve and clutch potentiometer are functioning correctly.

Table 3 – Forward/Neutral/Reverse Shuttle Switch – 1st Powershift Selected

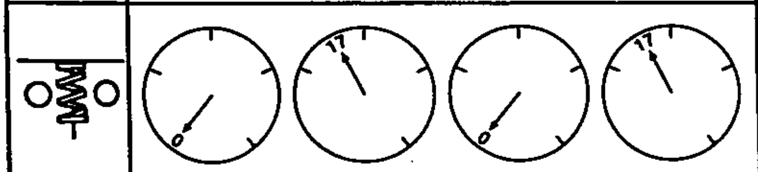
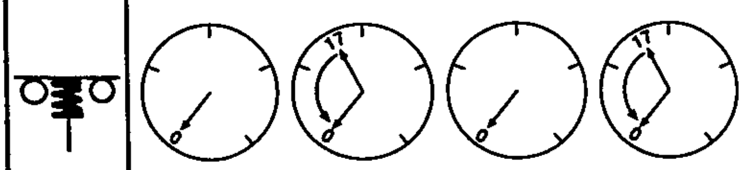
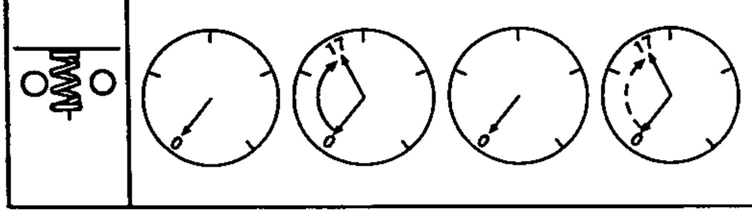
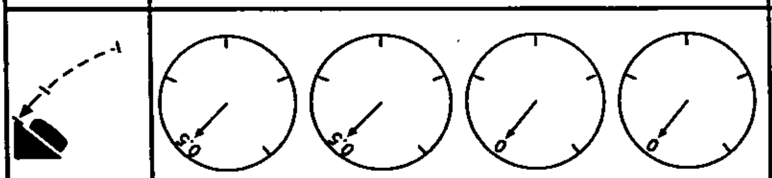
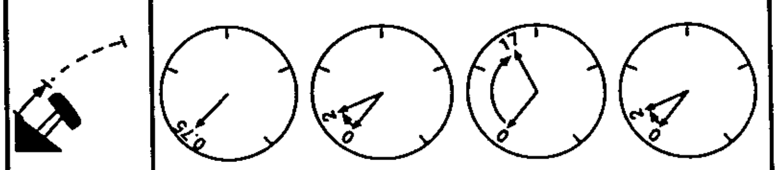
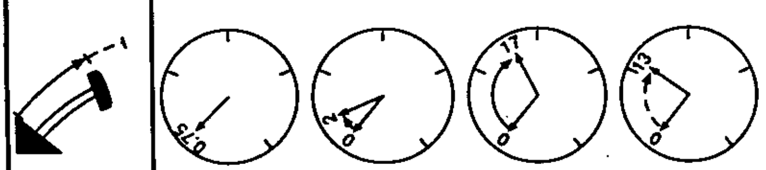
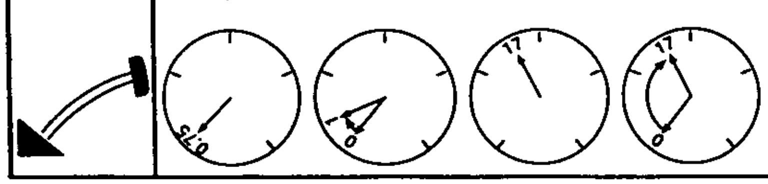
Switch Position	C1	C2	C3	C4	Observations
					C2 and C4 at Full Pressure
					C2/C4 17 to 0 bar
					C2 Immediate full Pressure restored C4 Controlled engagement to full pressure

Table 4 – Powershift 1 Selected – Clutch Lube Tests

Clutch Pedal	C1/2 Lube	C3/4 Lube	C2	C4	Observations
					C2/C4 Zero pressure C1/C2 Lube Approx 0.5 bar C3/C4 Lube Approx 0.5 bar
					C2 Full pressure C4 0–2 bar C1/C2 Lube Approx 0.75 bar C3/C4 Lube Approx 2 bar
					C2 Full pressure C4 Rising to Full pressure C1/C2 Lube Approx 0.75 bar C3/C4 Lube Approx 2 bar
					C2 Full pressure C4 Full pressure C1/C2 Lube Approx 0.75 bar C3/C4 Lube Reduced to 1 bar

Limp Home Procedure

In the unlikely event of an electrical fault developing within the powershift transmission that renders the tractor immobile, for example, failure of the wiring or supply voltage to the PWM valves, the emergency 'Limp Home Harness', Special Tool No. 4FT 952A, for 'Quad –Mod' transmissions, is available to enable the tractor to be driven onto a transporter or hard standing, in order that the repair can be carried out in a suitable location. The Limp Home device **is not and must not** be used as a means to continue operating the tractor in its work environment.

To engage and operate the 'Limp Home Harness' proceed as follows:–

1. Apply the parking brake.

2. Stop the engine and turn keystart off.

3. Disconnect all of the PWM valve connectors. Connect the Limp Home harness extension connectors to the C2 and C3 PWM valves.

4. Connect the other end of the Limp Home harness to the 'D1' diagnostic plug located adjacent to the fuse box.

5. Place the range lever into **Low Range** and the main lever into the **1–4 Range.** Ensure the forward/reverse lever is in **Neutral.**

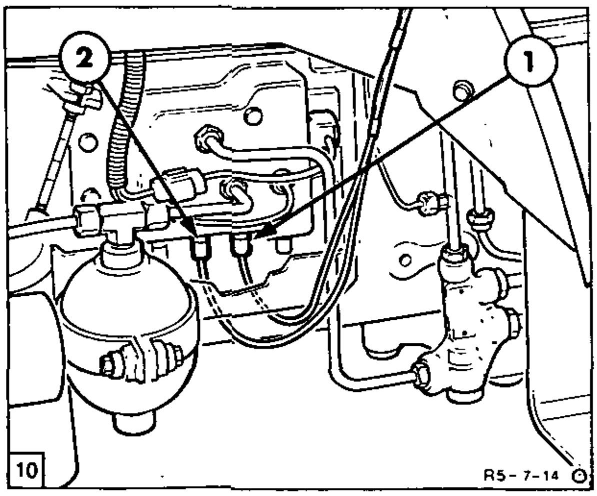
NOTE: *It is important that only the lowest ranges are used when operating with the Limp Home Harness due to the feathering capability of the transmission being inoperative.*

6. Start the vehicle.

7. Select forward or reverse.

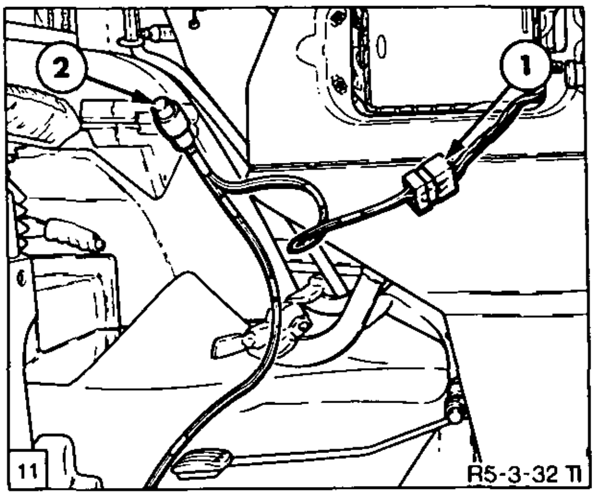
8. Operate the momentary switch of the Limp Home Harness to move the vehicle. If necessary, depress the foot throttle to increase engine speed.

9. When the tractor has been delivered to the repair area, disconnect the Limp Home Harness and reconnect the PWM valve connectors and proceed with diagnosing and repairing the fault.



Limp Home Harness
Connection to PWM Valve

1. Harness Connected to C2 PWM Valve Solenoid
2. Harness Connected to C3 PWM Valve Solenoid



Limp Home Harness
Connection to 'D1' Plug

1. Harness Connected to Diagnostic Plug (D1)
2. Push Button Momentary Switch

16x16 'Quad–Mod' Transmission Error Codes

Error Code	Fault Condition	Priority	Disable Trans	Display Mode
E21	Chassis harness disconnected	1	Disable	Latched
E34	Fuse 13 blown (**Note:** *Will not be displayed*)	2	Disable	Latched
E53	5 Volt Reference failed, shorted to 12 volts	3	Disable	Latched
E54	5 Volt Reference failed, shorted to ground	4	Disable	Latched
E12	Clutch pedal potentiometer signal too high	5	Disable	Latched
E11	Clutch pedal potentiometer signal too low	6	Disable	Latched
E39	C4 clutch solenoid open circuit	7	Disable	Latched
E38	C4 clutch solenoid short circuit	8	Disable	Latched
E41	C3 clutch solenoid open circuit	9	Disable	Latched
E40	C3 clutch solenoid short circuit	10	Disable	Latched
E43	C2 clutch solenoid open circuit	11	Disable	Latched
E42	C2 clutch solenoid short circuit	12	Disable	Latched
E45	C1 clutch solenoid open circuit	13	Disable	Latched
E44	C1 clutch solenoid short circuit	14	Disable	Latched
C	Wheel speed too high for creeper gear	15	Recover	Latched
HC	Range shift to high with creeper engaged	16	Recover	Latched
E37	Clutch disconnect switch open circuit	17	Recover	Latched
CP	Depress clutch pedal to enable transmission	18	Recover	Latched
E46	Fuse 12 blown	19	Enabled	Latched
E47	Clutch disconnect switch misadjusted high	20	Enabled	Temp
E48	Clutch disconnect switch short circuit misadjusted, always closed	21	Enabled	Temp
E51	Transmission temperature sensor open circuit	22	Enabled	Latched
E52	Transmission temperature sensor short circuit	23	Enabled	Latched
E24	All clutches not calibrated	24	Enabled	Latched
EC4	C4 clutch not calibrated	25	Enabled	Latched
EC3	C3 clutch not calibrated	26	Enabled	Latched
EC2	C2 clutch not calibrated	27	Enabled	Latched
EC1	C1 clutch not calibrated	28	Enabled	Latched
E16	Creeper solenoid open/short circuit, or attempt was made to engage creeper after prior creeper error	29	Enabled	Temp
E15	High/low range lever switches both on	30	Enabled	Temp
E14	1–4/5–8 Range lever switches both on	31	Enabled	Temp
E13	Up and down switches both on	32	Enabled	Temp
E49	Wheel speed sensor circuit open or short circuit	33	Enabled	Temp
E26	Engine rev/min speed too high	34	Enabled	Temp
E27	Engine rev/min speed too low	35	Enabled	Temp
H	Clutchless shuttle operation attempted at too high a speed and in too high a gear	36	Enabled	Temp

Error Code Table Explanations:

Priority – The error codes are listed in a priority order. Number 1 priority being the most serious fault and number 36 being considered the least serious of errors, i.e, if more than two errors occur the highest priority error will be displayed.

Disable Trans – This column of the table indicates whether the transmission is either **disabled**, i.e, not allowed to function, **enabled**, i.e, there is a fault within the transmission but it is still allowed to function, or the fault is **Recoverable**, i.e, performing a specific operation will clear the error code and recover the tractor.

Display Mode – This refers to the instrument panel display. **Latched** means that the error code will remain displayed until the fault is rectified. **Temp** (Temporary) means the error code will display temporarily and will then extinguish, but will be stored in the error code memory for retrieval at a later stage.

Key to Fault Finding Diagrams

Diagrams 1 to 11 – Not related to error codes

1. Tractor Does Not Drive In Any Gear
2. Incorrect Gear Shift Sequence or Gears Missing
3. Powershifts Jerky / Loss of Drive
4. Poor Clutch Feathering
5. Clutch Potentiometer Calibration Check
6. Holding in Gear / Jumping Out of Gear / Clashing
7. Four Wheel Drive Engages Slowly or Does Not Engage
8. Four Wheel Drive Does Not Disengage
9. Creeper Does Not Disengage
10. Clutches Squeal / Whine During Inching
11. Transmission is Noisy in Operation
12. Transmission 'Clunks' During Inching
13. Engagement of the Clutchless Shuttle is Delayed or Aggressive

Diagrams 14 onwards, error code related:

14. Error Code E21
15. Error Code E34
16. Error Codes E11 and E12
17. Error Codes E53 and E54
18. Error Codes E37, E47 and E48
19. Error Codes E38,E39 / E40,E41 / E42,E43 / E44,E45
20. Error Codes C and E16 – Creeper Does Not Engage in Low Range
21. Error Code HC
22. Error Code CP
23. Error Code E46
24. Error Codes E51 and E52
25. Error Codes E24, EC4, EC3, EC2 and EC1
26. Error Code E15
27. Error Code E13
28. Error Code E14
29. Error Code E49
30. Error Code E26
31. Error Code E27
32. Error Code Symbol 'H'

DIAGRAM 1: Tractor does not drive (in any gear)
For transmission wiring diagram and connector location refer to the end of this Section.

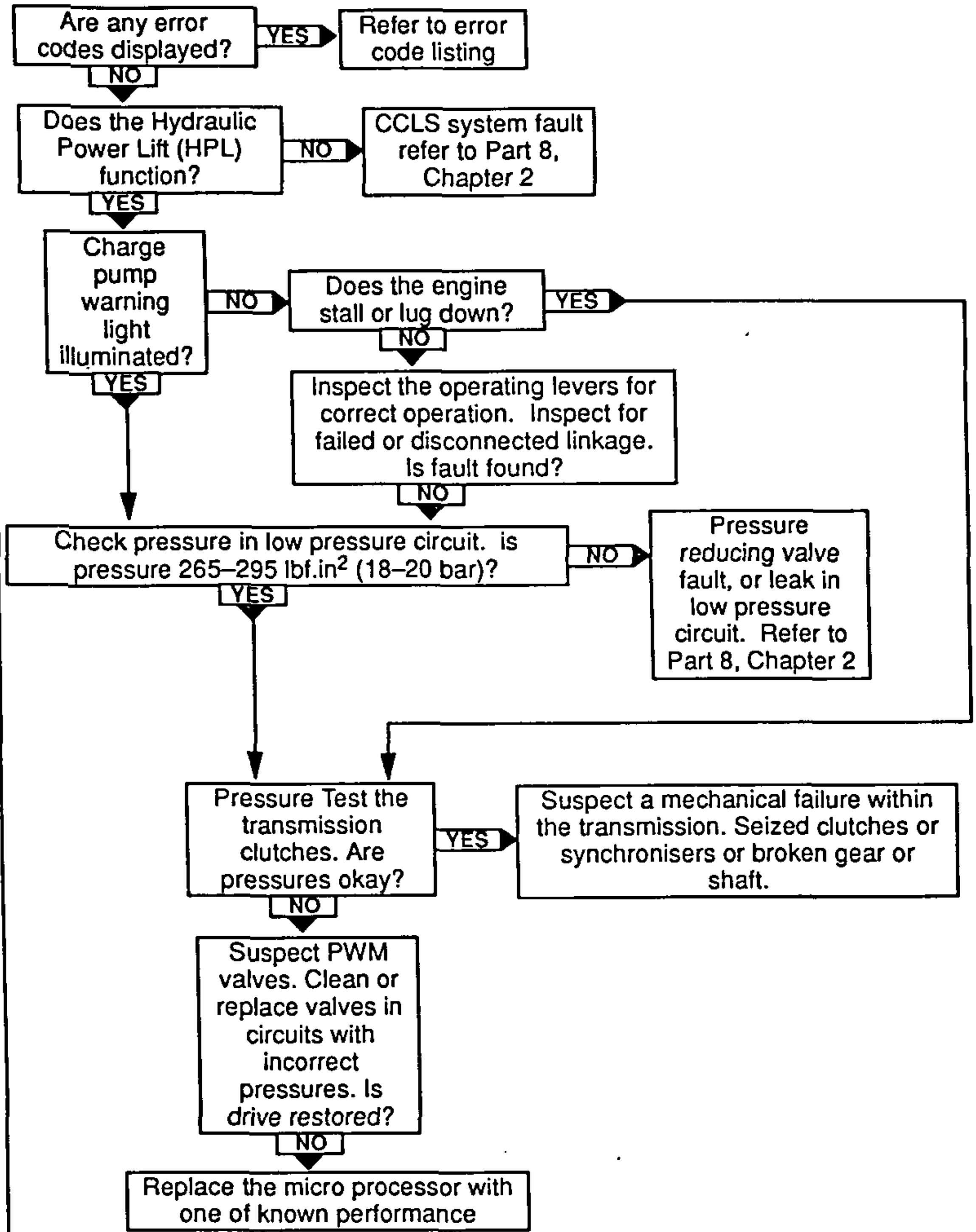


DIAGRAM 2: The tractor drives in all ranges but has the following fault:
For transmission wiring diagram and connector location refer to the end of this Section.

The powershift function operates but the shift sequence is incorrect or gears missing

Turn on key start switch without starting engine with FNR lever in neutral. Is an error code displayed?
- YES → Refer to error code listing
- NO ↓

Is the wiring correct to the PWM solenoids?
- NO → Using the wiring diagram, ensure the correct harness connector is on the appropriate PWM solenoid
- YES ↓

Inspect the shift levers for correct operation. Inspect shift mechanism for damaged or disconnected links. Is fault found?
- YES → Repair or adjust as required. Refer to 'Gearshift Control Mechanism' section
- NO ↓

Check gear sequence chart. Pressure test at respective clutch port. Is pressure 250–280 $lbf.in^2$ (17–19 bar) at the correct clutch?
- YES → Suspect mechanical failure of clutches, shafts or gears.
- NO ↓

Substitute the respective PWM solenoid valve for one of known performance

	C1	C2	C3	C4	
1-5		●		●	9-13
2-6		●	●		10-14
3-7	●			●	11-15
4-8	●		●		12-16

DIAGRAM 3: The powershifts are not smooth or the tractor loses drive between powershifts (In work, tractor stops or could be jerky)

For transmission wiring diagram and connector location refer to the end of this Section.

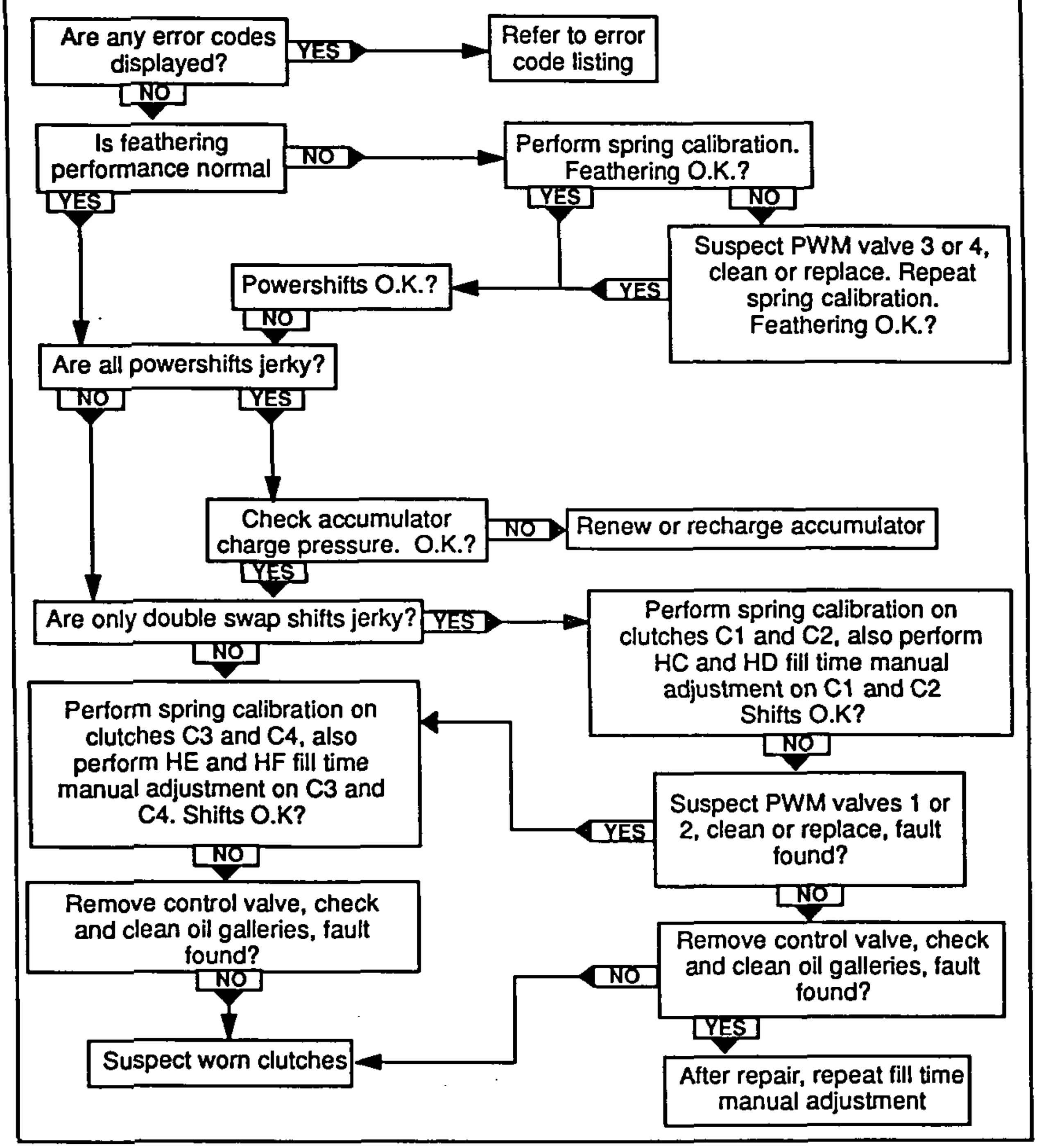


DIAGRAM 4: The tractor drives in all gears and ranges but has the following fault:
For transmission wiring diagram and connector location refer to the end of this Section.

Poor Clutch Pedal Feathering/Inching Performance

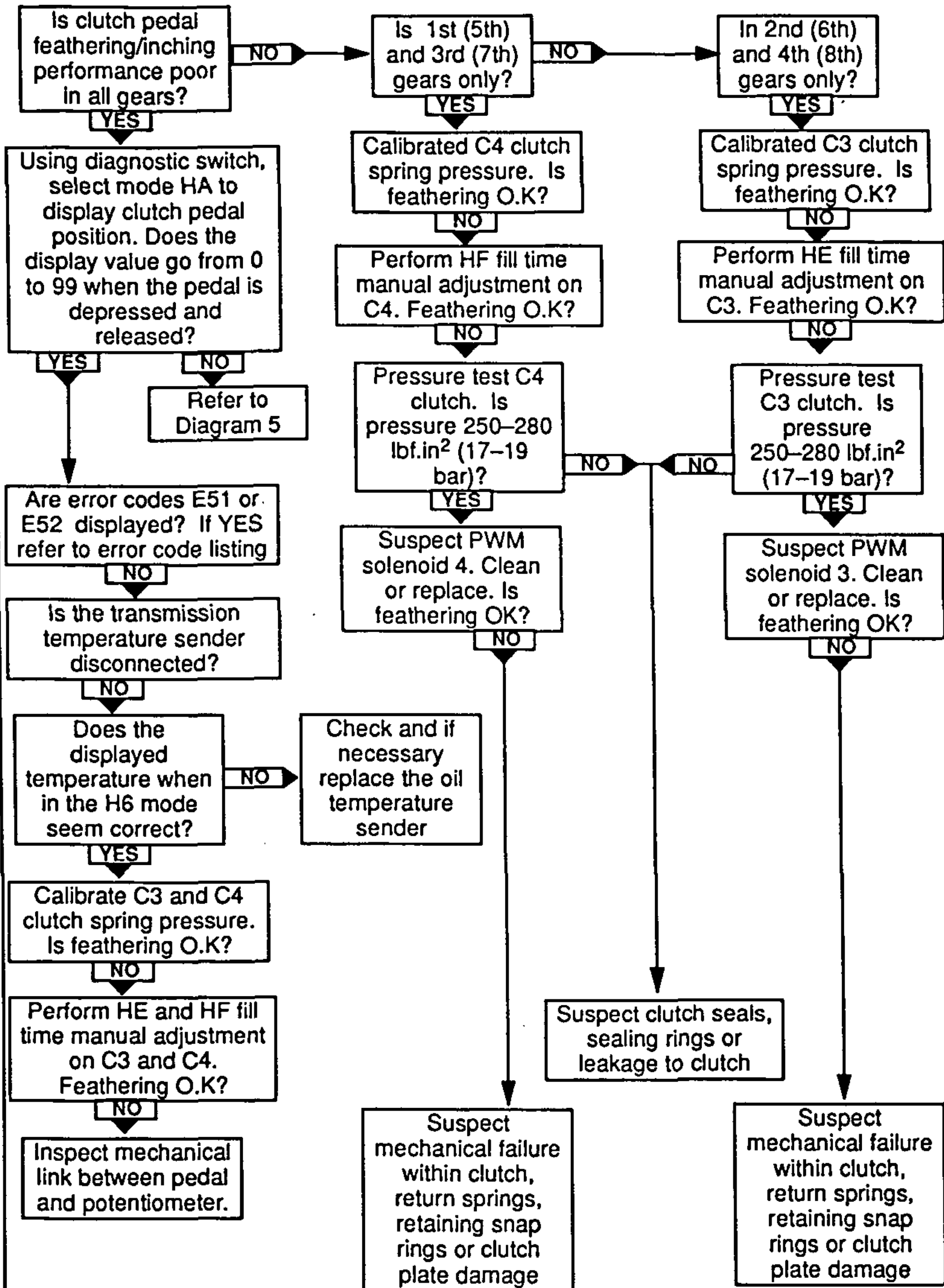


DIAGRAM 5: Clutch Pedal Potentiometer Calibration Check

Using the service diagnostic switch select mode HA to display the clutch pedal position. Does the transmission display value change smoothly from 0 to 99 when the clutch pedal is depressed and released?

YES → Clutch pedal potentiometer is okay.

NO ↓

With the key start switch OFF, disconnect the potentiometer connector. Turn the key start switch ON to produce error code E11. Turn the key start OFF and reconnect the potentiometer. Retest in HA mode. Does the display value change smoothly from 0 to 99?

YES → Clutch pedal potentiometer is okay.

NO ↓

Inspect the linkage to the potentiometer. If the linkage or potentiometer is damaged replace the affected parts. Disconnect the potentiometer, turn the key start ON to produce E11. Turn the key start OFF and reconnect the potentiometer. Retest in HA mode. Does the display value change smoothly from 0 to 99?

YES → Clutch pedal potentiometer is okay.

NO ↓

Substitute the micro processor module for one of known performance.

DIAGRAM 6: The tractor drives in all gears and ranges but has the following fault:
For transmission wiring diagram and connector location refer to the end of this Section.

Transmission jumps out of gear, holds in gear or gears clash when shifting

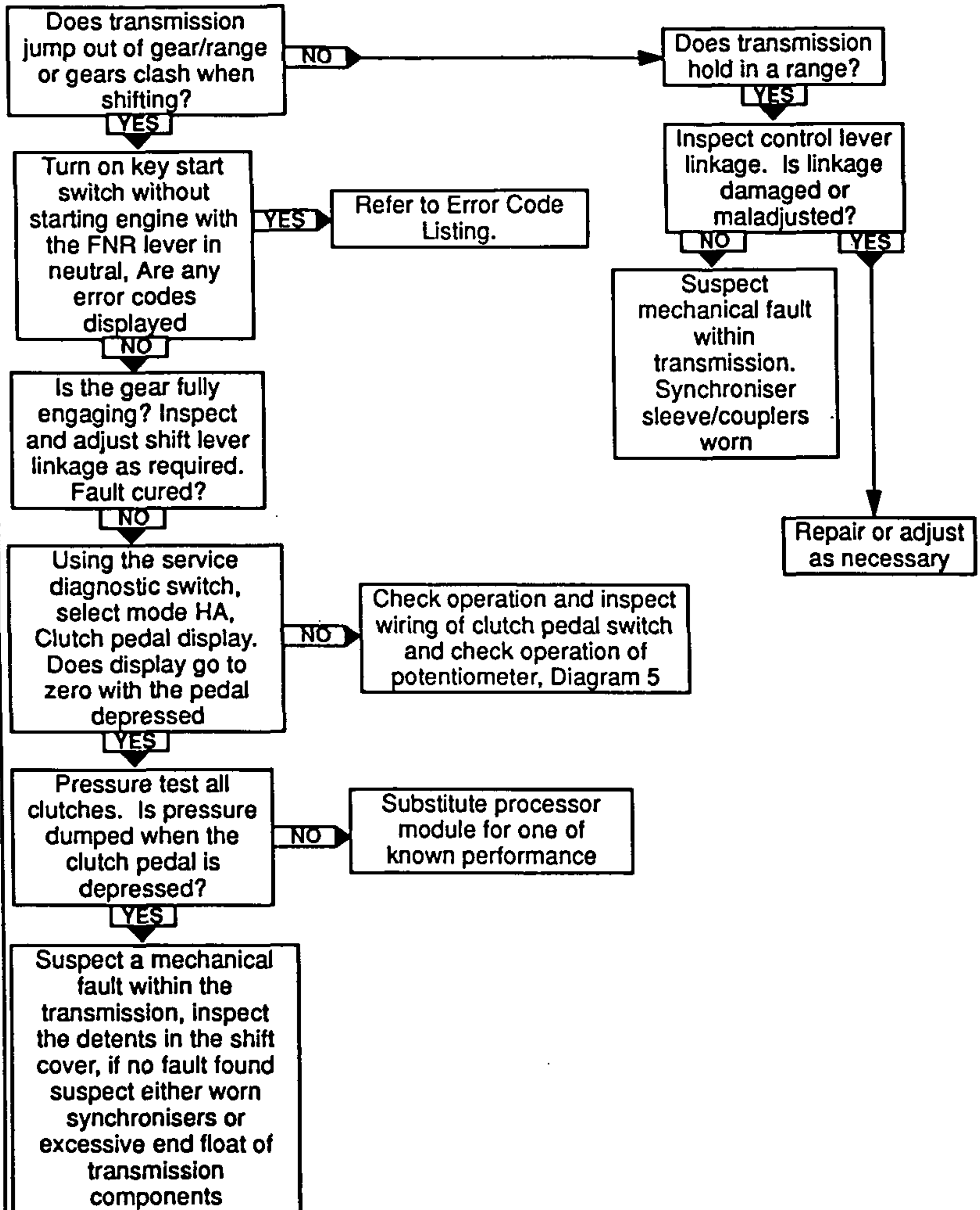
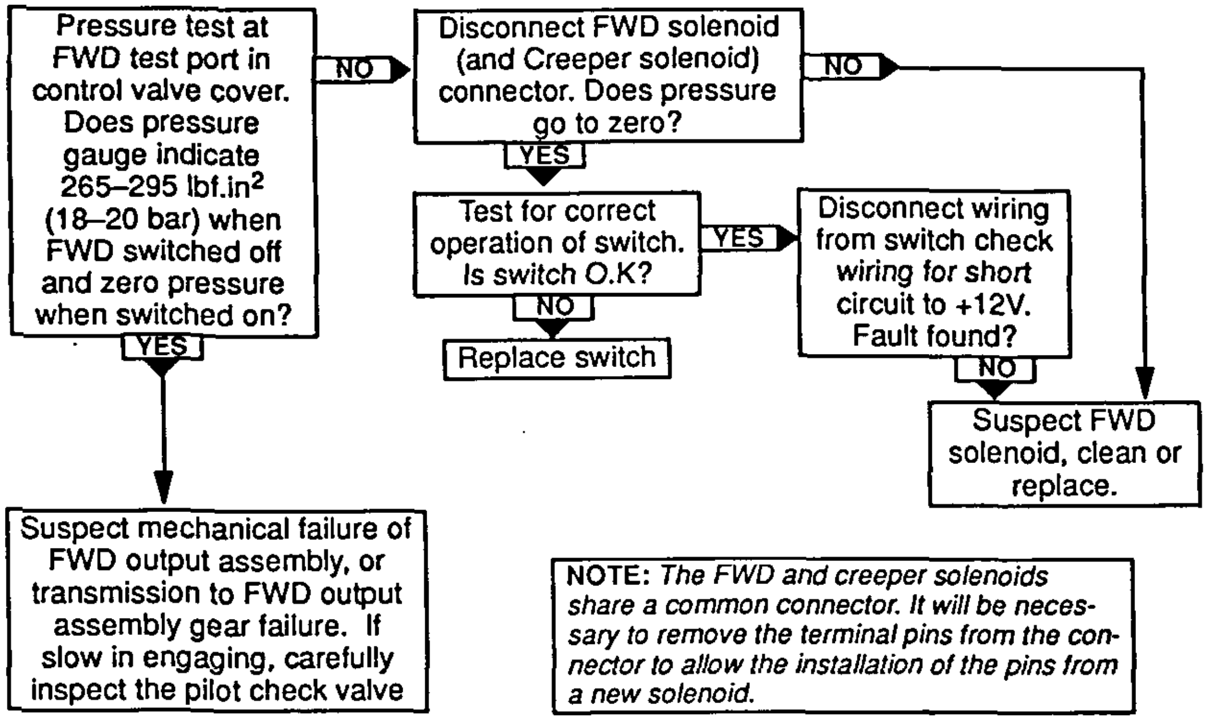


DIAGRAM 7: The tractor drives in all gears and in all ranges but has the following fault:
For transmission wiring diagram and connector location refer to the end of this Section.

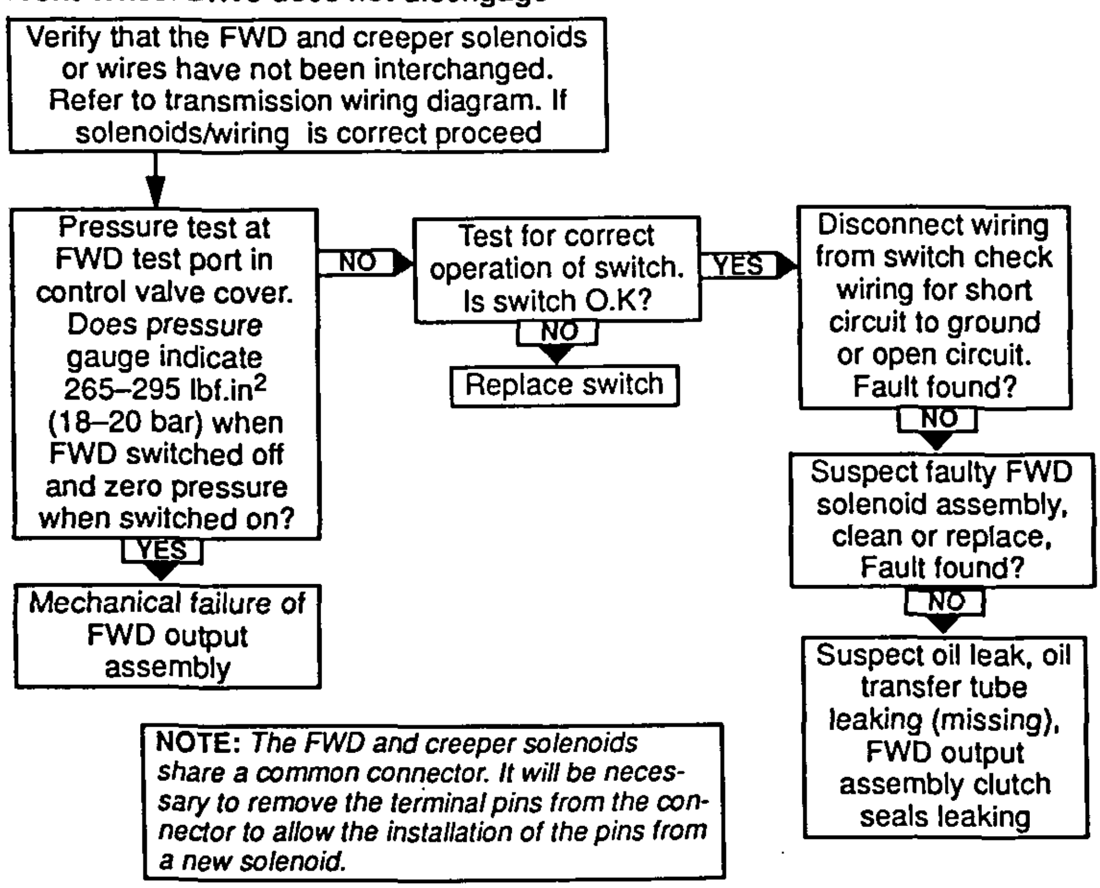
Front Wheel Drive does not engage or engages slowly



NOTE: *The FWD and creeper solenoids share a common connector. It will be necessary to remove the terminal pins from the connector to allow the installation of the pins from a new solenoid.*

DIAGRAM 8: The tractor drives in all gears and in all ranges but has the following fault:
For transmission wiring diagram and connector location refer to the end of this Section.

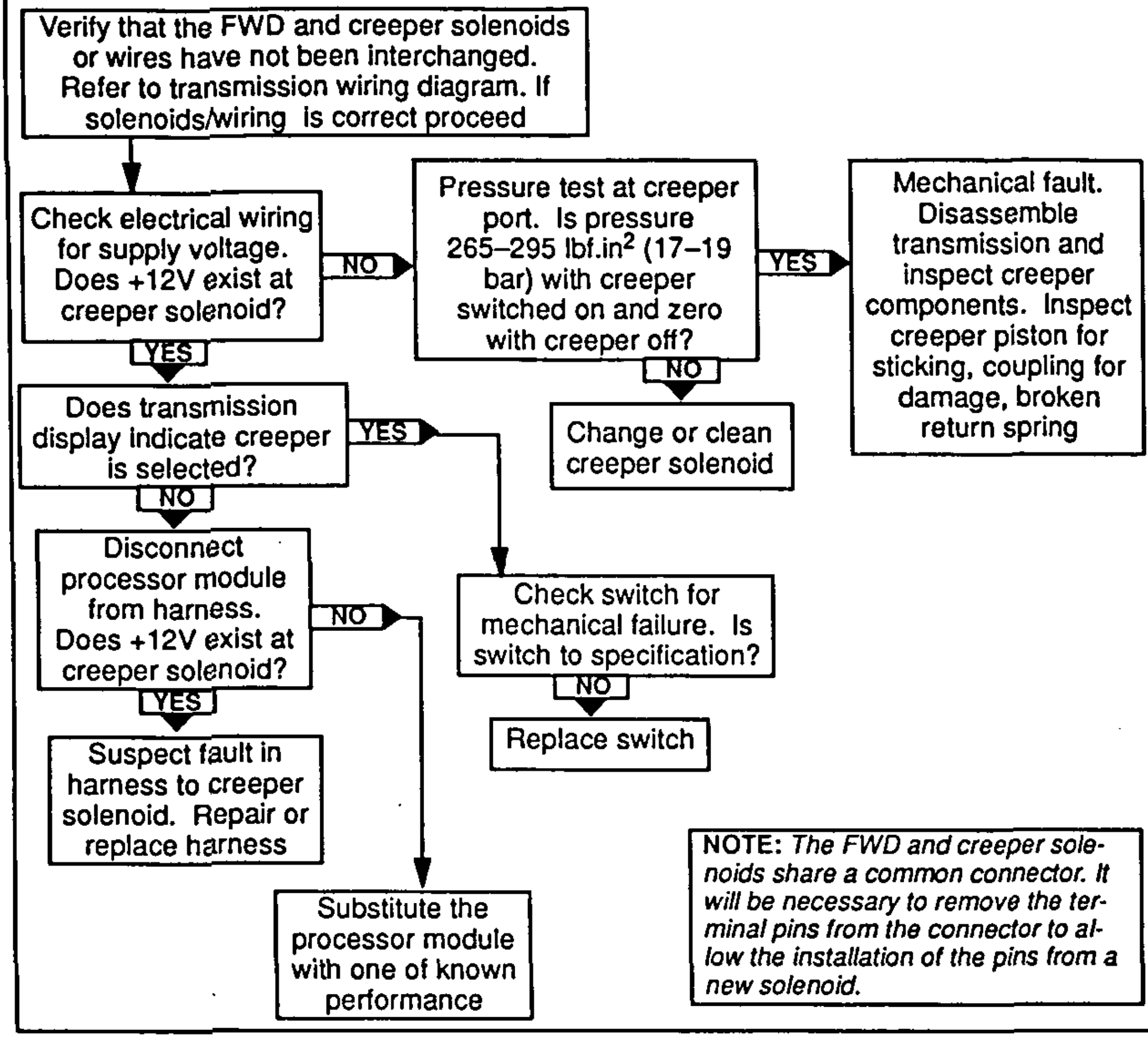
Front Wheel Drive does not disengage



NOTE: *The FWD and creeper solenoids share a common connector. It will be necessary to remove the terminal pins from the connector to allow the installation of the pins from a new solenoid.*

DIAGRAM 9: The tractor drives in all gears and in all ranges but has the following fault:
For transmission wiring diagram and connector location refer to the end of this Section.

The creeper does not dis–engage



FLOW DIAGRAM 10: The tractor drives in all gears and ranges but has the following fault:
For transmission wiring diagram and connector location refer to the end of this Section.

Clutches squeal/whine during inching

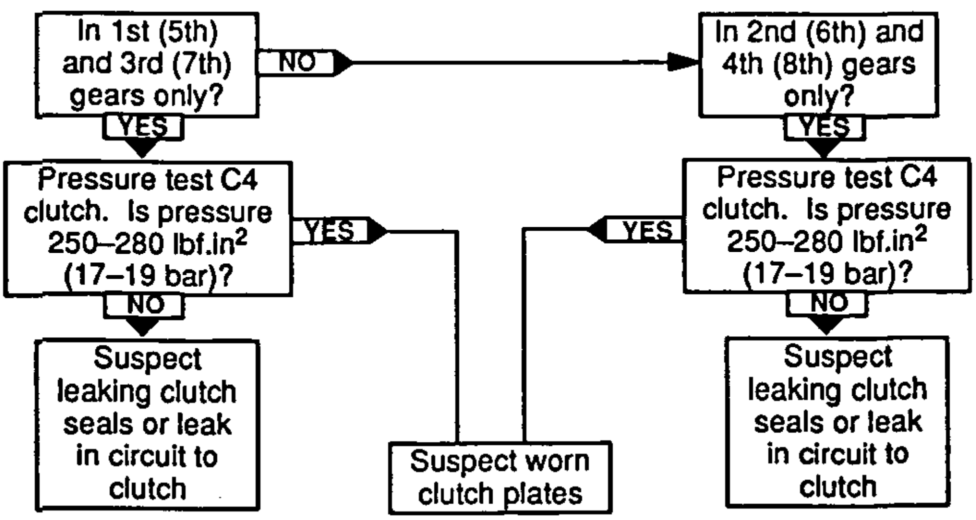


DIAGRAM 11: The tractor drives in all gears and in all ranges but has the following fault:
For transmission wiring diagram and connector location refer to the end of this Section.

Transmission is noisy in operation

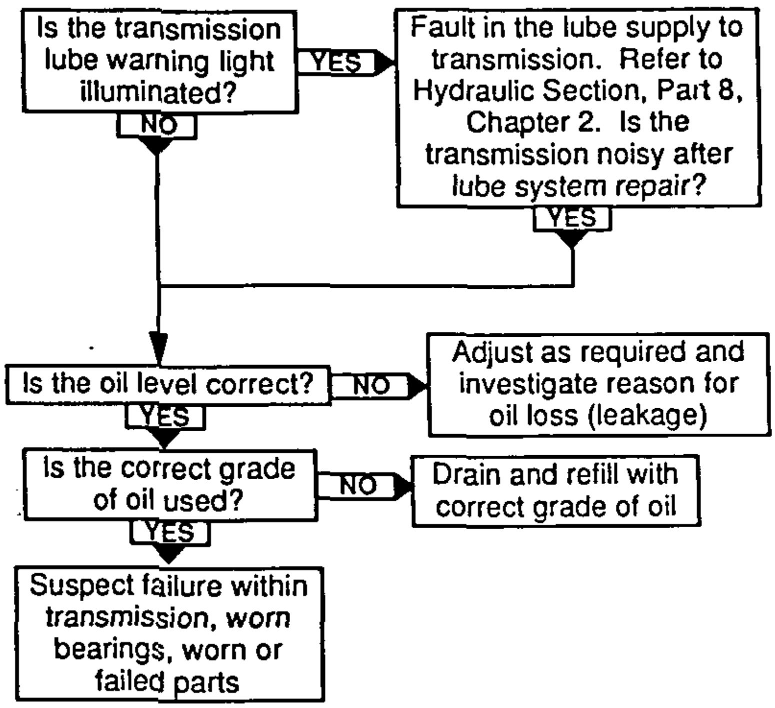


DIAGRAM 12: The tractor drives in all gears and ranges but has the following fault:
For transmission wiring diagram and connector location refer to the end of this Section.

Transmission clunks during inching

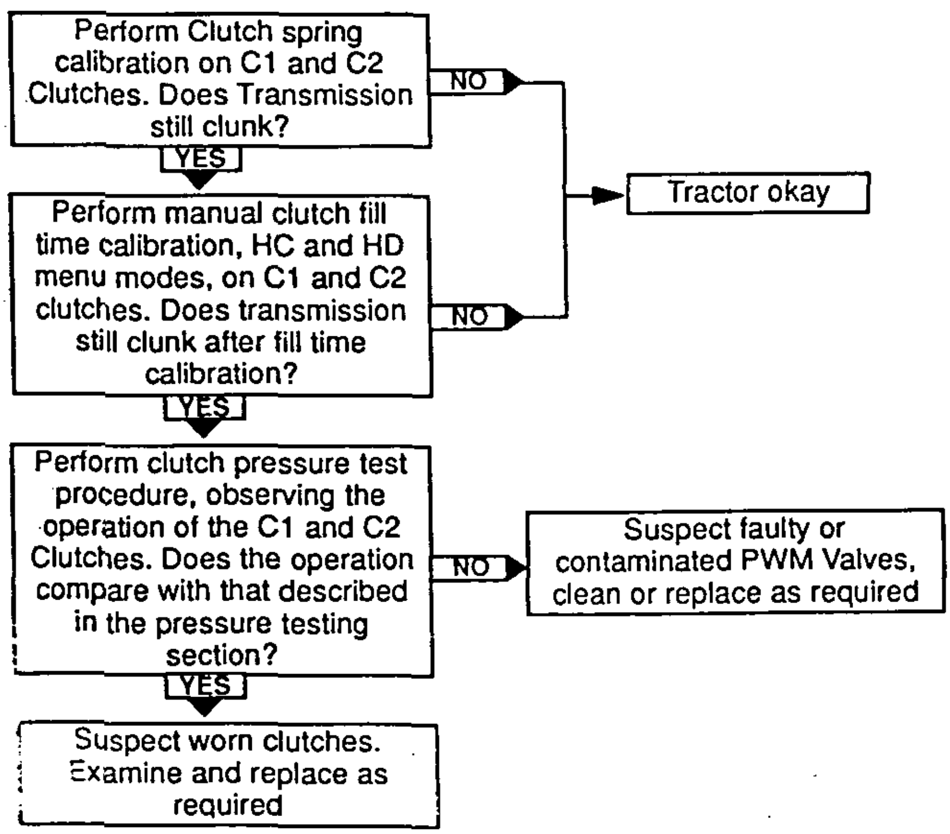


DIAGRAM 13

The Engagement of the Clutchless Shuttle Is Delayed or Aggressive

Is Transmission Error Code E49 displayed when the key start is switched ON?

- YES → Diagnose Transmission Error Code E49 using Diagram 29
- NO → Diagnose using fault finding Diagram for "Poor Clutch Feathering" (Diagram 4)

DIAGRAM 14

For transmission wiring diagram and connector location refer to the end of this Section.

Error Code E21 displayed – Harness Disconnected

Inspect processor to extension harness connectors T1 and T2

DIAGRAM 15

For transmission wiring diagram and connector location refer to the end of this Section.

Error Code E34 (NOTE: *This will not be displayed*) – Fuse 13 Blown

Replace Fuse 13 (15 Amp) Operate tractor. Does fuse blow again?

- NO → Fuse possibly failed due to fatigue. Examine wiring as detailed below to ensure okay.
- YES → With key–start off, disconnect CN2 from the processor. Check with a multi–meter between CN2–34 and Earth and CN2–35 and Earth. Is a short circuit indicated in either instance?
  - YES → Disconnect C4 connector. Repeat previous tests. Is a short circuit indicated?
    - YES → Locate short circuit between CN2 and C4 connectors
    - NO → Locate short circuit between C4–9 and Fuse 13. Note, Clutch pedal switch, pin 2 is also part of the circuit
  - NO → Suspect faulty processor module, replace with one of known performance

DIAGRAM 16: Error Code E11 Clutch Potentiometer voltage below valid range
Error Code E12 Clutch Potentiometer voltage above valid range

For transmission wiring diagram and connector location refer to the end of this Section.

1. Check operation of potentiometer. Remove left hand lower side panel below instrument cluster to expose potentiometer and wiring. Disconnect plug to potentiometer and check operation of potentiometer between the orange and green wires. With pedal released, is resistance between 3.1KΩ and 3.9kΩ, gradually changing to between 640Ω and 2.1kΩ as the clutch pedal is depressed?
   - NO → Replace potentiometer as required
   - YES ↓
2. Disconnect the processor module connectors CN1 and CN2 and connect an ohm meter between pin No. 2 (tan) and pin No. 3 (black) of harness connector to potentiometer and then between pin No. 1 (yellow/red/black) and pin Nos. 2 and 3. Is an open circuit indicated in every case?
   - NO → Trace and repair short circuit
   - YES ↓
3. Connect an ohm meter between pin No. 1 (yellow/red/black) of harness connector to potentiometer and ground. Is an open circuit indicated?
   - NO → Trace and repair short to ground
   - YES ↓
4. Connect an ohm meter between pin No. 2 (tan) of harness connector to potentiometer and ground. Is an open circuit indicated?
   - NO → Trace and repair short to ground
   - YES ↓
5. Connect an ohm meter between pin No. 3 (black) of harness connector to potentiometer and ground. Is an open circuit indicated?
   - NO → Trace and repair short to ground
   - YES ↓
6. Reconnect the processor module. With the keystart ON, is the voltage at pin No. 2 (tan) 5 volts?
   - NO → Check continuity of wire from pin No. 2 to CN2–5
   - YES ↓
7. Check continuity of wire from pin No. 1 to CN1–19 and continuity of wire from CN2–1 to pin No. 3. Are both wires O.K?
   - NO → Trace and repair open circuits as required
   - YES ↓
8. Suspect faulty ETC module, replace with a module of known performance

DIAGRAM 17: Error Code E53 5 volt Reference Failed, Shorted to 12 volts
Error Code E54 5 volt Reference Failed, Shorted to Earth

For transmission wiring diagram and connector location refer to the end of this Section.

Disconnect the clutch pedal potentiometer. Does the error code clear?
- YES → Replace the clutch potentiometer or diagnose using fault finding diagrams for transmission error codes E11 and E12.
- NO ↓

Disconnect the EDC control knob panel. Does the error clear?
- YES → Replace the EDC control panel
- NO ↓

Disconnect the EDC rockershaft potentiometer. Does the error code clear?
- YES → Replace the rock shaft potentiometer or diagnose using diagrams for EDC error codes 27 and 28. Refer to Part 8 of the Repair Manual.
- NO ↓

Disconnect quadrant potentiometer. Does the error code clear?
- YES → Replace the rock shaft potentiometer or diagnose using diagrams for EDC error codes 25 and 26. Refer to Part 8 of the Repair Manual.
- NO ↓

Replace the micro processor module with a unit of known performance. Does the error code clear?
- YES → Replace the Micro processor module. Clear the modules memory using Service mode H8. Recalibrate the transmission and EDC systems.
- NO ↓

Trace and repair a short circuit to either earth or 12 volts, in the harness between CN2–5 and either the Clutch pedal potentiometer, EDC quadrant potentiometer or the EDC rock shaft potentiometer

DIAGRAM 18

For transmission wiring diagram and connector location refer to the end of this Section.

Error Code E37 displayed – Clutch Disconnect Switch Open Circuit

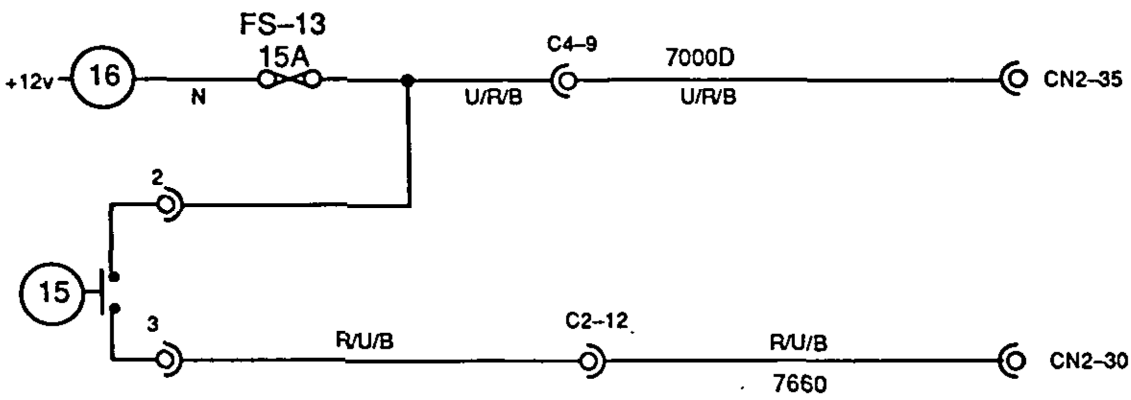
- Check switch adjustment and switch operation, if okay trace break in wiring (open circuit)

Error Code E48 displayed – Clutch Disconnect Switch Short Circuit

- Check switch adjustment and switch operation, if okay trace short circuit in wiring.

Error Code E47 displayed – Clutch Disconnect Switch Misadjusted High (Adjust Switch)

- Check switch adjustment and operation of switch.



NOTE: With each of these error codes also check that the clutch potentiometer operates over the full range using Service mode HA. If the range is not 0–99 then refer to 'Clutch Potentiometer calibration' Diagram 5.

DIAGRAM 19 – Circuit Faults, PWM Solenoids
For transmission wiring diagram and connector location refer to the end of this Section.

Error Code E38 Displayed – C4 PWM solenoid wiring short circuit
Error Code E39 Displayed – C4 PWM solenoid Wiring open circuit
Error Code E40 Displayed – C3 PWM solenoid wiring short Circuit
Error Code E41 Displayed – C3 PWM solenoid wiring open circuit
Error Code E42 Displayed – C2 PWM solenoid wiring short circuit
Error Code E43 Displayed – C2 PWM solenoid wiring open circuit
Error Code E44 Displayed – C1 PWM solenoid wiring short circuit
Error Code E45 Displayed – C1 PWM solenoid wiring open circuit

Error codes E38 through to E45 indicate either a short or open circuit in the wiring of one of the PWM solenoids. Using a suitable multi–meter check the wiring from the PWM solenoid back to the processor module. Locate the short/open circuit, repair or replace wiring as necessary.

If wiring is okay disconnect the PWM solenoid from the harness and check that the resistance of the PWM coil is approximately 10Ω at 20°C. If not, replace the PWM solenoid.

If wiring and PWM solenoids are okay replace the micro processor with one of known performance.

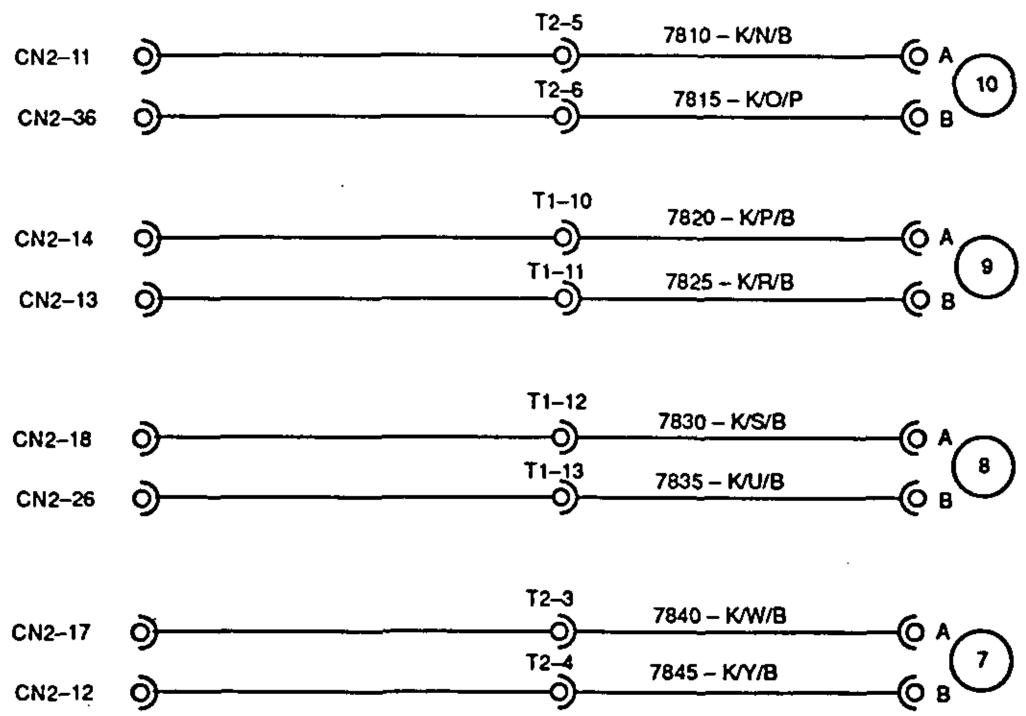
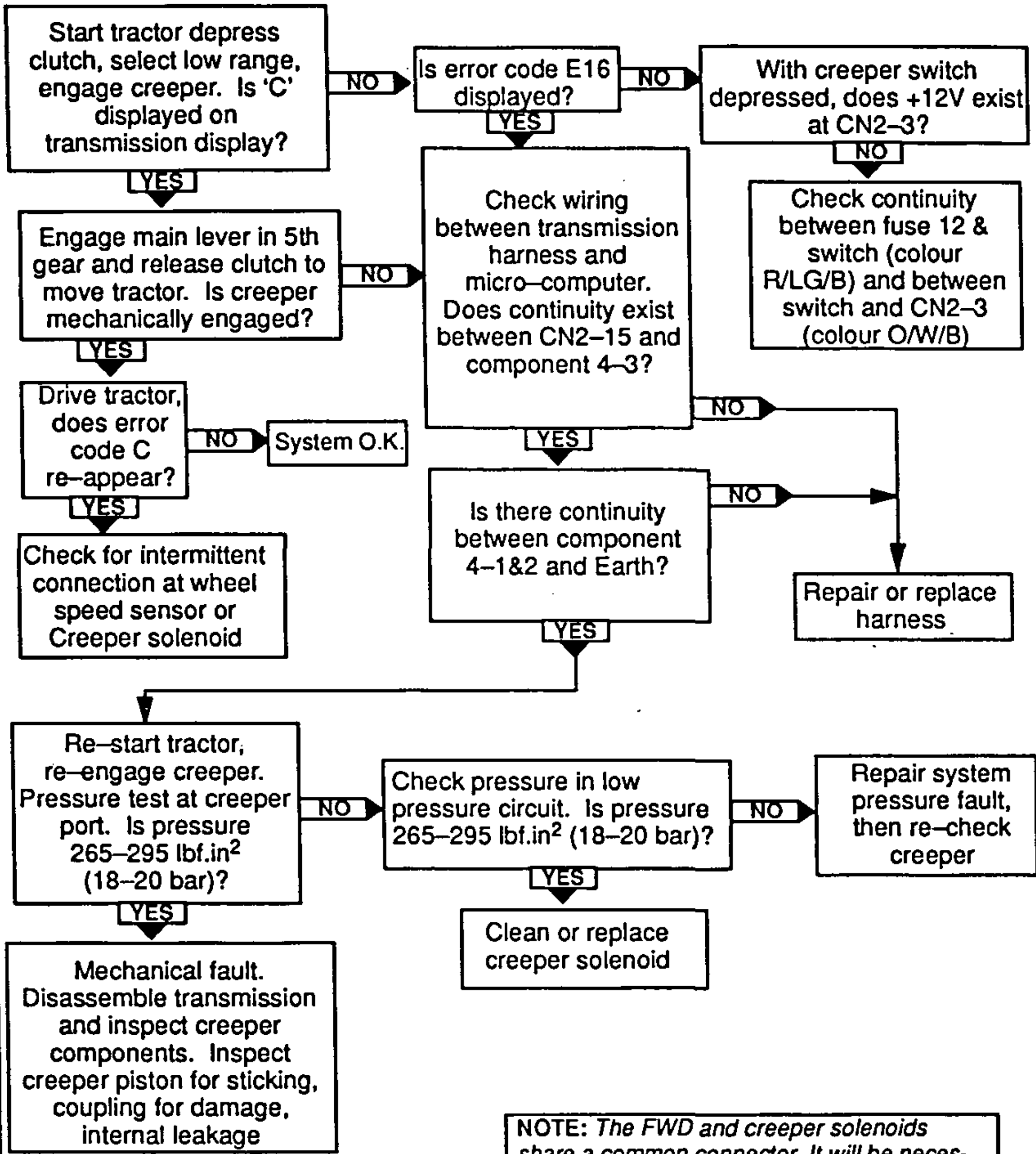


DIAGRAM 20: The creeper does not engage in low range – Possibly Error Code E16 or Symbol 'C' Displayed

For transmission wiring diagram and connector location refer to the end of this Section.



NOTE: *The FWD and creeper solenoids share a common connector. It will be necessary to remove the terminal pins from the connector to allow the installation of the pins from a new solenoid.*

DIAGRAM 21: The high/low range lever can be shifted to high range when creeper is engaged Error Code 'HC' Possibly Displayed

For transmission wiring diagram and connector location refer to the end of this Section.

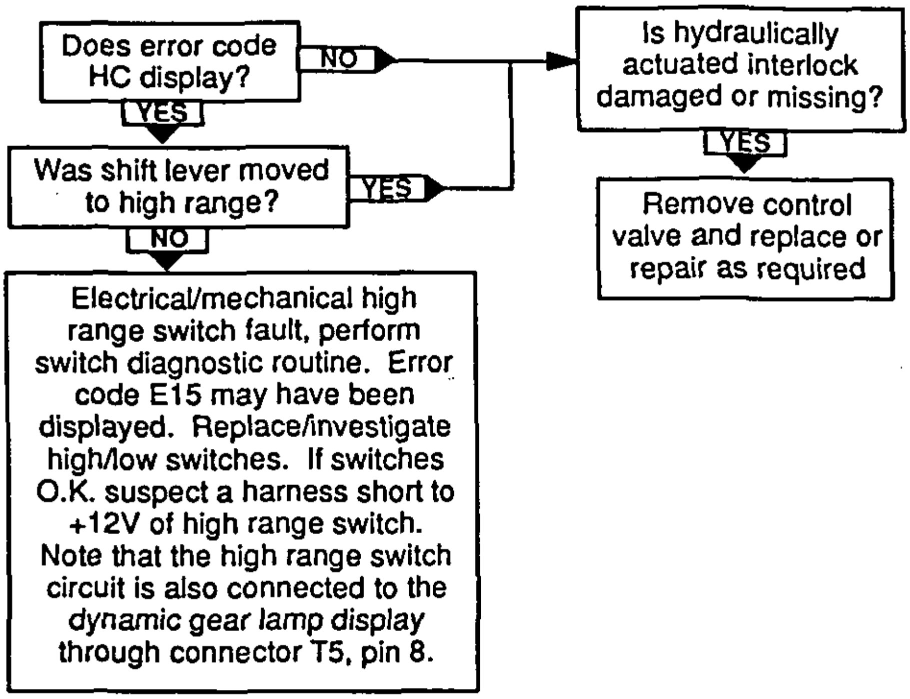


DIAGRAM 22: Error Code CP displayed – Depress clutch pedal to re–enable transmission

For transmission wiring diagram and connector location refer to the end of this Section.

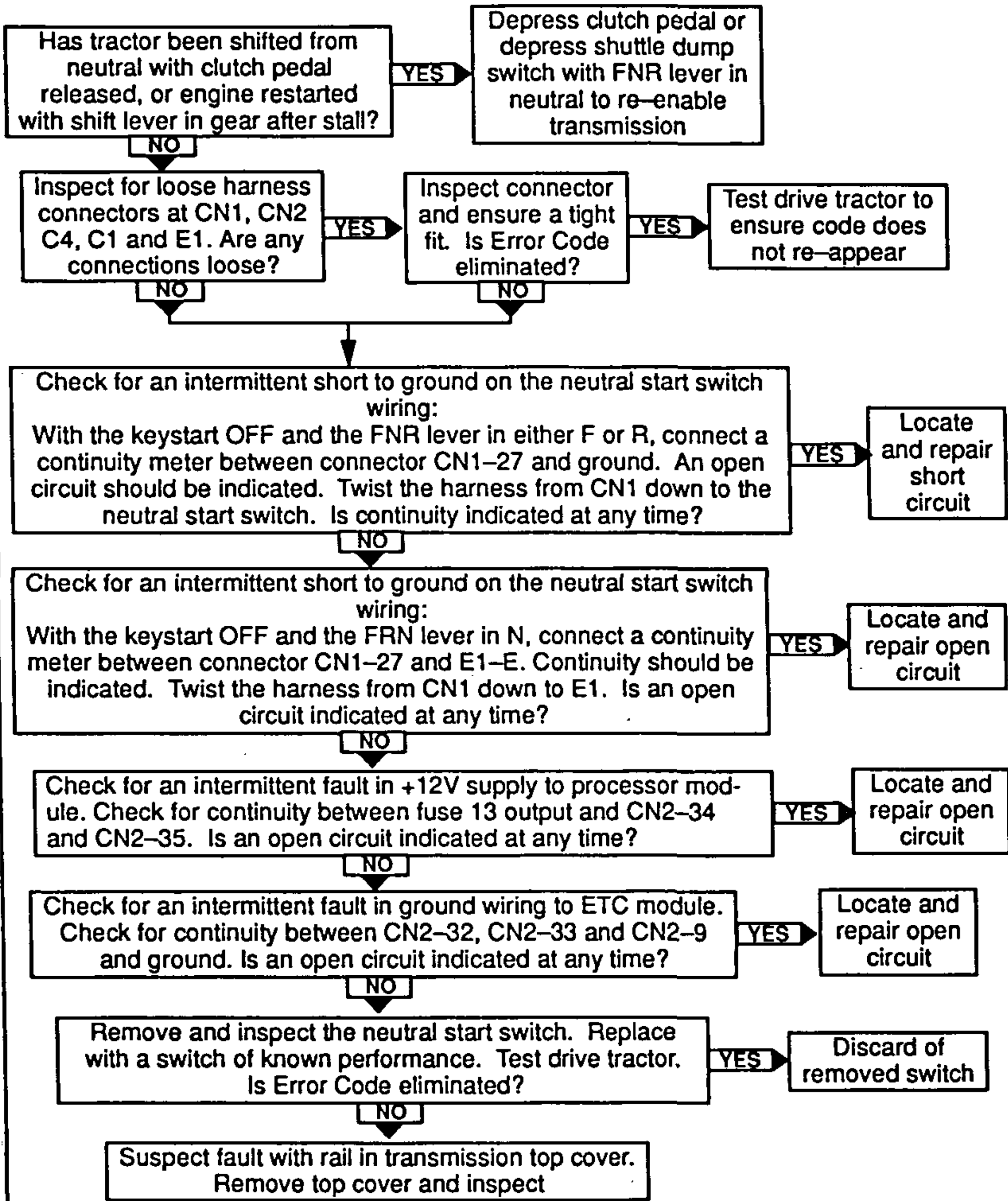


DIAGRAM 23 – Error Code E46 Displayed – Fuse 12 Blown

For transmission wiring diagram and connector location refer to the end of this Section.

No power to switches, 1–4/5–8/shuttle dump/high range/low range/powershift up–down and gearshift display module.

Is Fuse 12 blown?

- NO → Disconnect CN1 from the processor and confirm continuity between Fuse 12 and CN1–6. If no continuity exists trace and repair the open circuit.
- YES ↓

Replace Fuse 12 (10 Amp) Operate tractor. Does fuse blow again?

- NO → Fuse may have failed through fatigue, check wiring wiring to ensure there is no intermittent fault
- YES ↓

Ensure Key start is off and fuse 12 is removed. Disconnect CN1 from the processor. With a suitable multi–meter check between CN1–6 and earth, is a short circuit indicated?

- NO → Inspect harness, twist harness with meter still connected to ensure no intermittent fault. If no intermittent fault found, check with meter between CN1–6 and other CN1/CN2 terminals. An open circuit should be indicated in all cases. If a short circuit is indicated trace and repair the fault in the harness.
- YES ↓

Disconnect connector C2, is a short circuit still indicated between CN1–6 and earth?

- YES ↓ With the multi–meter still connected between CN1–6 and earth and C2 disconnected, disconnect connectors T5, T4 and the shuttle dump switch connector (13). Observe the meter as disconnecting, if continuity to earth is broken after a connector is disconnected, fault lies within that circuit. If continuity still exists, fault lies in harness. Inspect harness, repair or replace faulty wiring.
- NO ↓ Connect meter between C2–13 and earth. Is continuity indicated?
  - NO → Inspect connector, ensure it is clean and undamaged
  - YES ↓ Disconnect C1 connector is continuity still indicated?
    - NO → Trace and repair short between C1–A and switches
    - YES ↓ Trace and repair short between C2–13/C1–A and fuse 12.

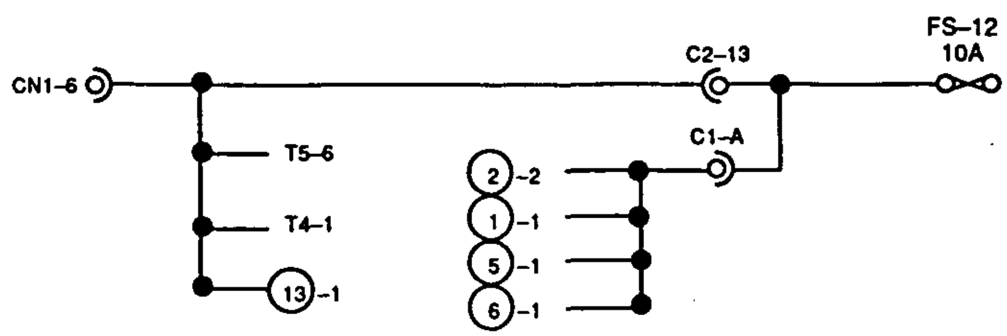


DIAGRAM 24 – Error Codes E51 and E52 Displayed

For transmission wiring diagram and connector location refer to the end of this Section.

Transmission oil temperature wiring, open or short circuit

With a suitable multi–meter check the oil temperature sender wiring for open/short circuit, repair / replace wiring as required.

If wiring is okay verify that the oil temperature sender resistance is correct as detailed in the specification section.

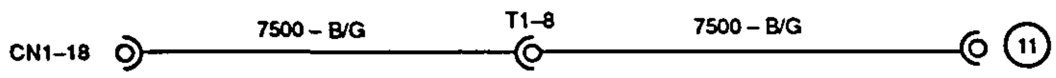


DIAGRAM 25 – Error Code E24 All clutches not calibrated
Error Code EC4 – Clutch 4 not calibrated
Error Code EC3 – Clutch 3 not calibrated
Error Code EC2 – Clutch 2 not calibrated
Error Code EC1 – Clutch 1 not calibrated

Perform spring calibration procedure to clear error

DIAGRAM 26: Error Code E15 displayed – high/low switches both on

For transmission wiring diagram and connector location refer to the end of this Section.

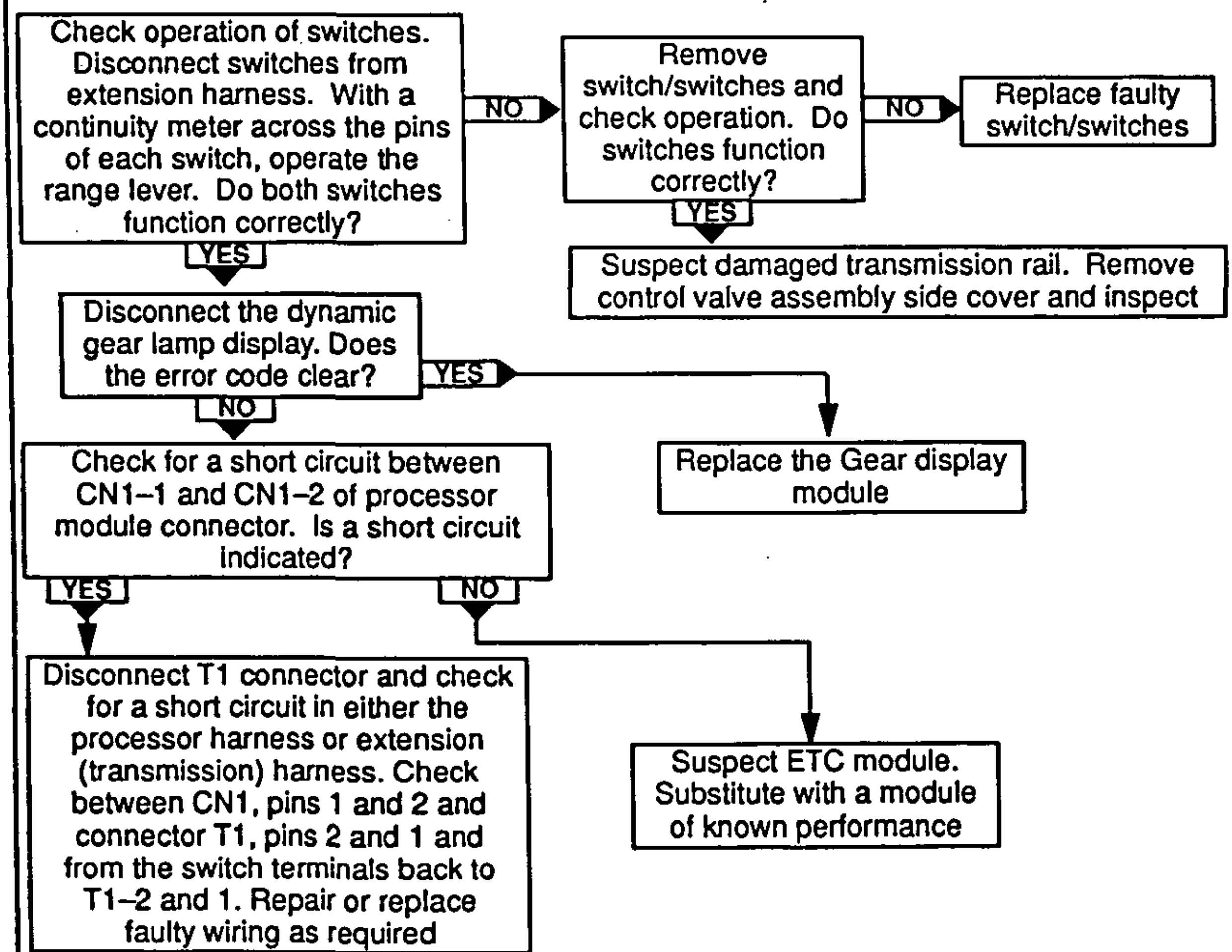


DIAGRAM 27: Error Code E13 displayed – up/downshift switches both on

For transmission wiring diagram and connector location refer to the end of this Section.

- Check operation of switches. Disconnect connector T4 from switch wiring. Check for correct switch operation with a continuity meter between pin No. 1 (common) and pin No. 4 (down) and 5 (up). Do both switches function correctly?
  - NO → Replace faulty switch/switches
  - YES ↓
- Disconnect connector CN1 from the processor module. With connector T4 disconnected, check for a short circuit between CN1–24 (down) and CN1–5 (up). Is a short circuit indicated?
  - YES → Locate and repair or replace faulty wiring
  - NO ↓
- Check for a short circuit between pin No. 1 and pin No. 4 and between pin No. 1 and pin No. 5 of the T4 connector. Is a short circuit indicated?
  - YES → Locate and repair or replace faulty wiring
  - NO ↓
- Suspect ETC module. Substitute with a module of known performance

DIAGRAM 28: Error Code E14 displayed – 1–4 & 5–8 switches both on

For transmission wiring diagram and connector location refer to the end of this Section.

- Check operation of switches: Disconnect connector CN1 from processor module and remove fuse 12. With the keystart OFF, connect a continuity meter between CN1–3 and output side of fuse, move main lever into 1–4 position. Repeat above operation from CN1–4 and selecting 5–8 position on main lever. Does meter indicate switches operating correctly?
  - NO → Remove switch/switches and check operation. Do switches function correctly?
    - NO → Replace faulty switch/switches
    - YES ↓ Suspect damaged transmission rail. Remove transmission top cover and inspect.
  - YES ↓
- Disconnect the dynamic gear lamp display. Does the error code clear?
  - YES → Replace the Gear display module
  - NO ↓
- Check for a short circuit between CN1–3 and CN1–4 Is a short circuit indicated?
  - NO → Suspect ETC Module. Substitute with a module of known performance
  - YES ↓
- Disconnect T1 connector and check for a short circuit in either the processor harness or extension (transmission) harness. Check between CN1, pins 3 and 4 and connector T1, pins 4 and 5 and from the switch terminals back to T1–4 and 5. Repair or replace faulty wiring as required

DIAGRAM 29 – Error Code E49

For transmission wiring diagram and connector location refer to the end of this Section.

Wheel speed sender open or short circuit

Disconnect processor connectors, CN1 and CN2 and disconnect the wheel speed sender connector. Test the wiring for open / short circuit and repair as required. If wiring checks out okay test wheel speed sender.

↓

With the sender installed in the transmission, check for a short to earth on each sender terminal, check resistance of the sender, which should be approximately 2500 ohms at 20°C. Replace if outside specification

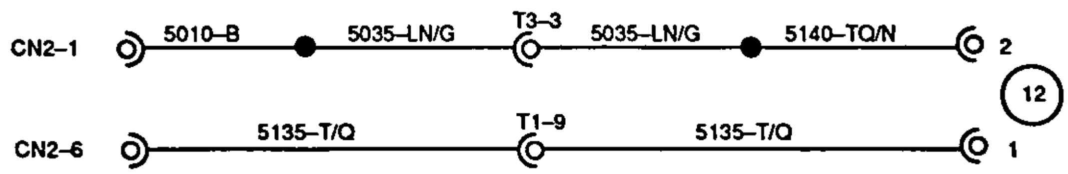


DIAGRAM 30: Error Code E26 displayed – ERPM signal too high

For transmission wiring diagram and connector location refer to the end of this Section.

Connect a volt meter between the alternator speed connector and ground. Is there approximately 7 volts?

- NO → Repair or replace alternator
- YES ↓

The following checks must be carried out with the engine stopped and keystart switched OFF

Suspect an intermittent fault. With an ohm–meter connected between CN1–34 and the alternator speed connection, twist the wiring harnesses along their length, especially near to the connectors. Does the resistance change?

- YES → Locate and repair intermittent open circuit
- NO ↓

Suspect an intermittent fault to ground. With an ohm–meter connected between CN1–34 and ground and the alternator speed connector disconnected, twist the wiring harnesses along their length, especially near to the connectors. Does the meter indicate a short to ground?

- YES → Locate and repair intermittent short circuit to ground
- NO ↓

Suspect ETC module. Substitute with a module of known performance

DIAGRAM 31: Error Code E27 displayed – ERPM signal not present

For transmission wiring diagram and connector location refer to the end of this Section.

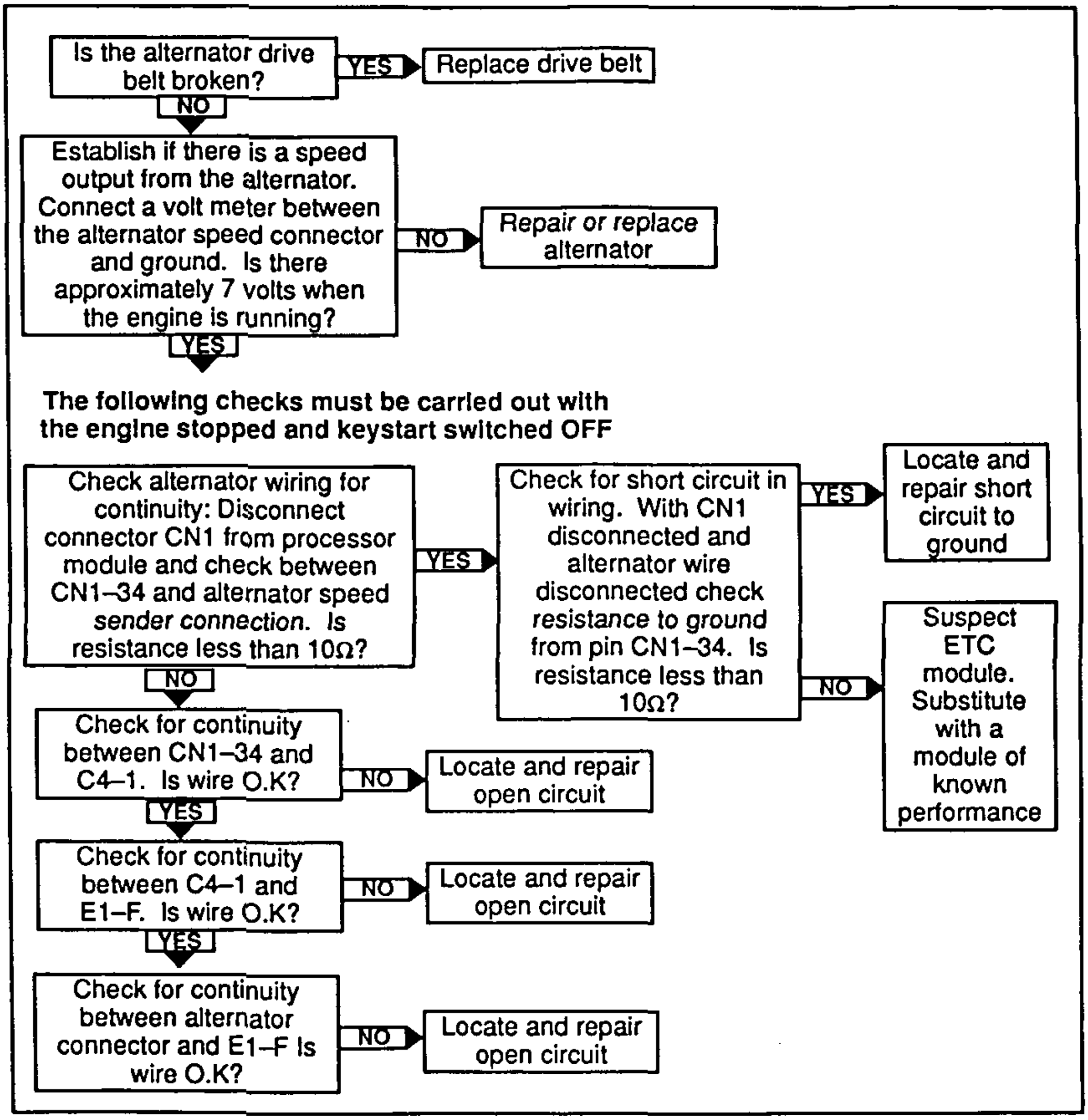


DIAGRAM 32 – Error Code H

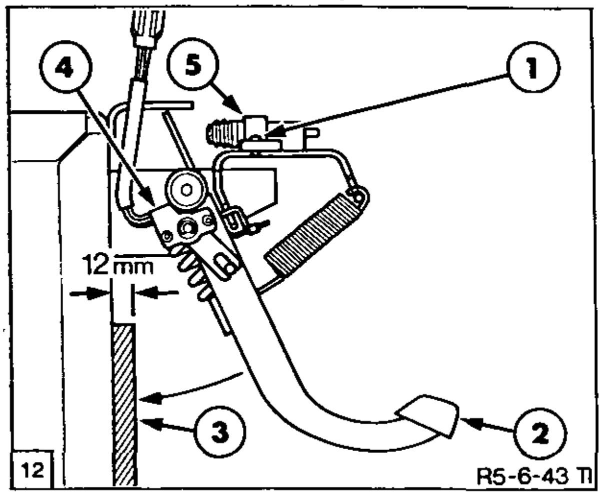
Clutchless shuttle operation attempted at too high a speed and in too high a gear

To reduce clutch damage from shifting in too high a gear or at too higher speed a warning bleeper and symbol 'H' are activated under the following conditions:

- In high range 5–8 gears, shuttling while tractor is still rolling.
- In high range 2–4 gears, shuttling while tractor is rolling faster than 9 Km/h (5.5 mph)

Important: *The clutchless shuttle will still operate under the warning conditions*

Clutch Pedal Switch Adjustment

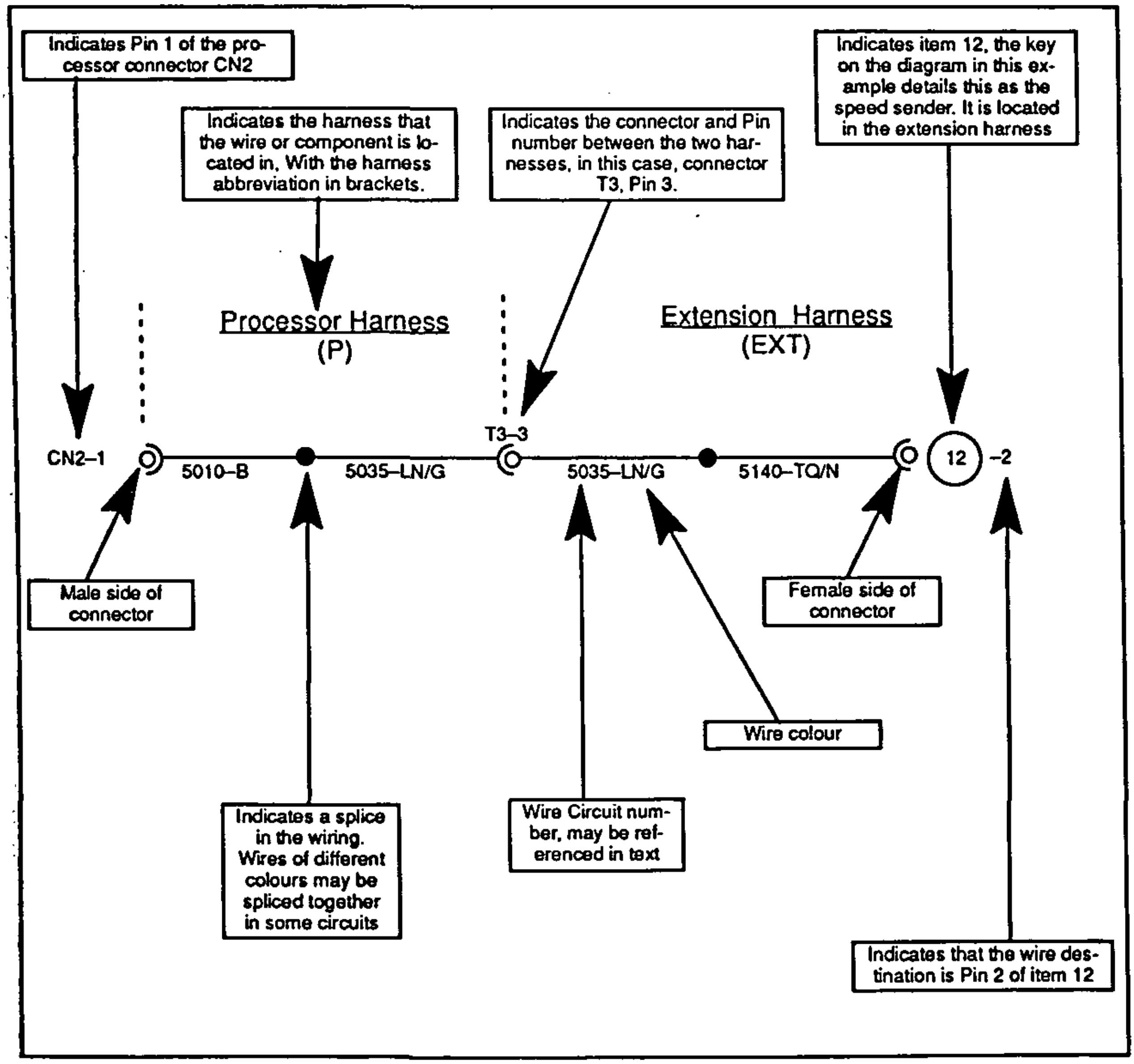


Clutch Pedal Switch Adjustment

1. Switch Retaining Screw – 2 off
2. Clutch Pedal
3. 12 mm Spacer
4. Potentiometer
5. Clutch Pedal Switch Assembly

1. Loosen the two screws retaining the switch assembly. With a suitable 12mm spacer against the steering support, depress the clutch pedal until it contacts the spacer. Slide the switch against the pedal, at the point of the switch actuating tighten the retaining screws to lock the switch in position.

Using The 16x16 'Quad–Mod' Wiring Diagram

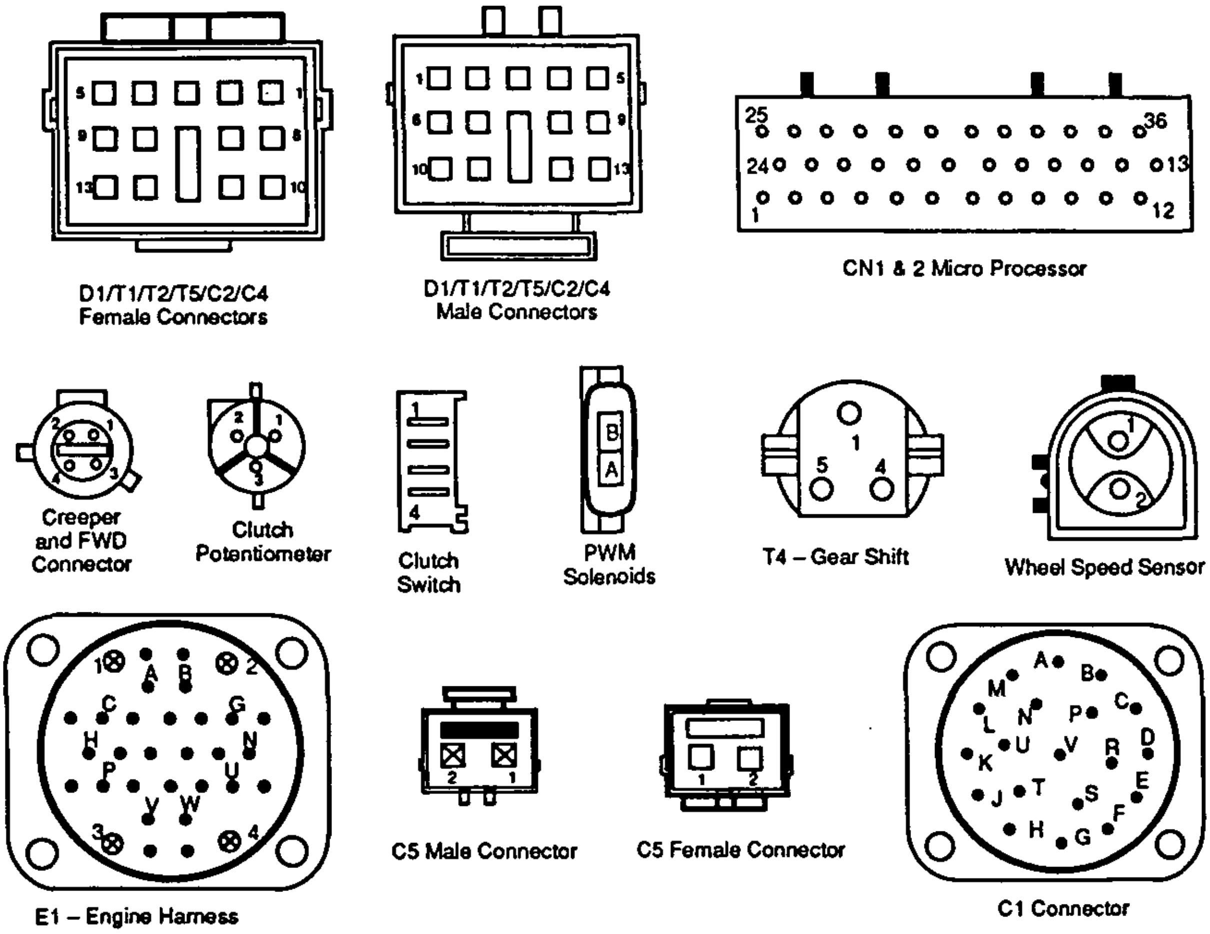


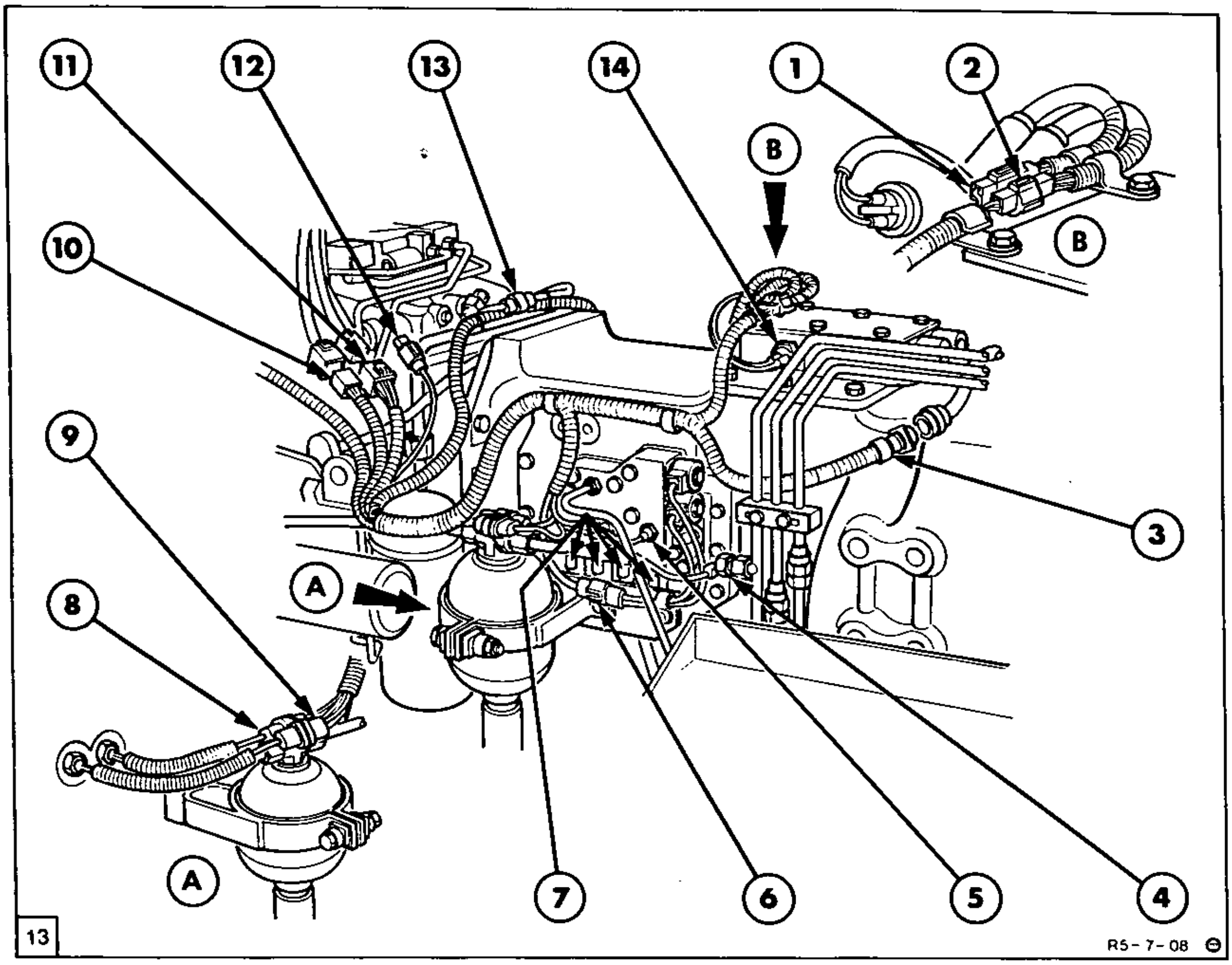
WIRING CIRCUITS

Key To Colours

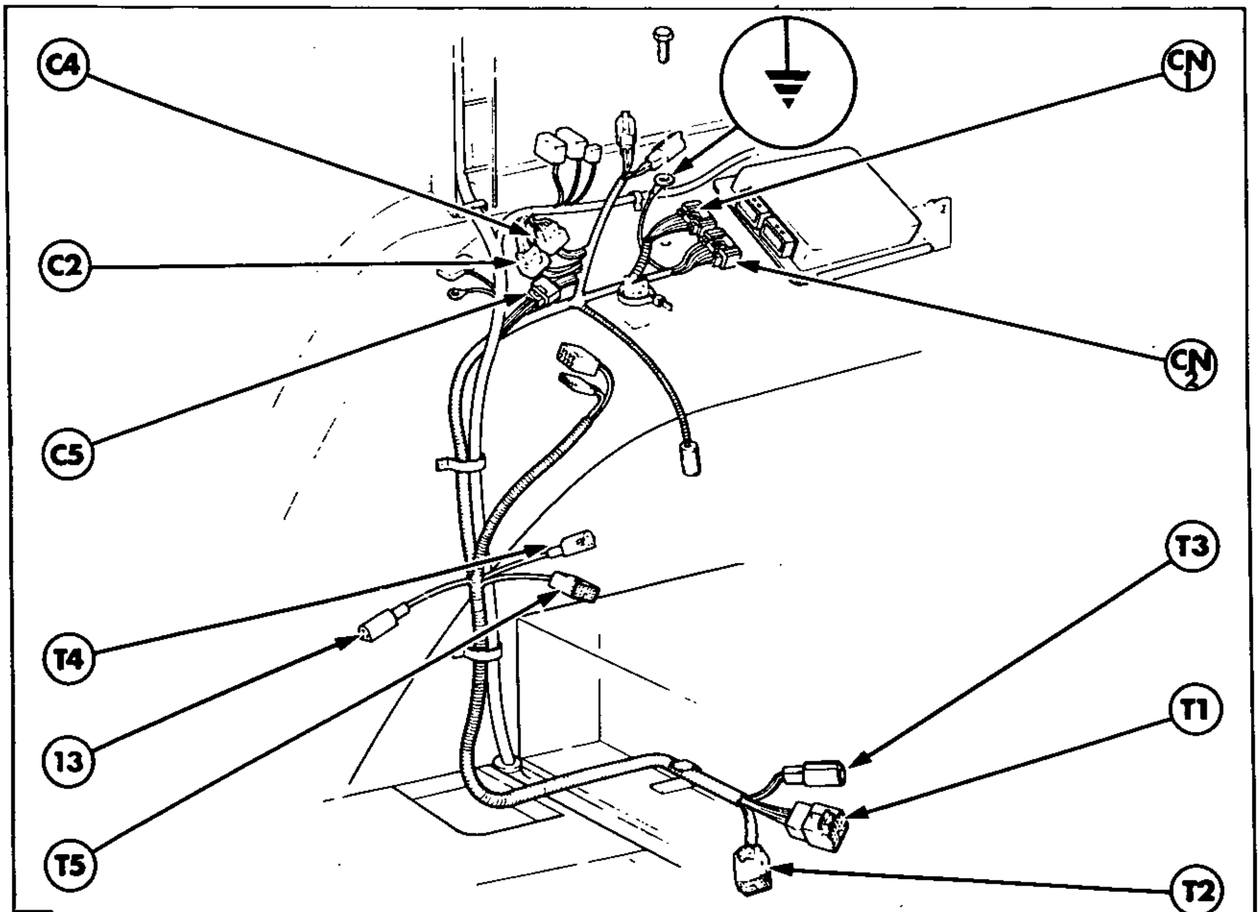
B – Black	G – Green
N – Brown	LG – Light Green
LN – Tan	U – Blue
S – Slate	TQ – Turquoise
R – Red	P – Purple
O – Orange	K – Pink
Y – Yellow	W – White

Harness Connector Identification:





Extension Harness Connector Locations



Micro Processor Harness Connector Locations
Refer to Wiring Diagram for Connector Descriptions

Figure 13 – Extension Harness Connector Locations

1. 5–8 Range Switch Connector
2. 1–4 Range Switch Connector
3. C1 Connector
4. Steering Pressure Switch
5. Transmission Oil Temperature Sender
6. Four Wheel Drive Solenoid and Creeper Solenoid Connector
7. PWM Solenoid Valve Connectors
8. High Range Switch Connector (Black)
9. Low Range Switch Connector (Grey)
10. T1 Connector
11. T2 Connector
12. T3 Connector
13. Speed Sensor Connector (Large Blue)
14. Forward/Neutral/Reverse Safety Start Switch

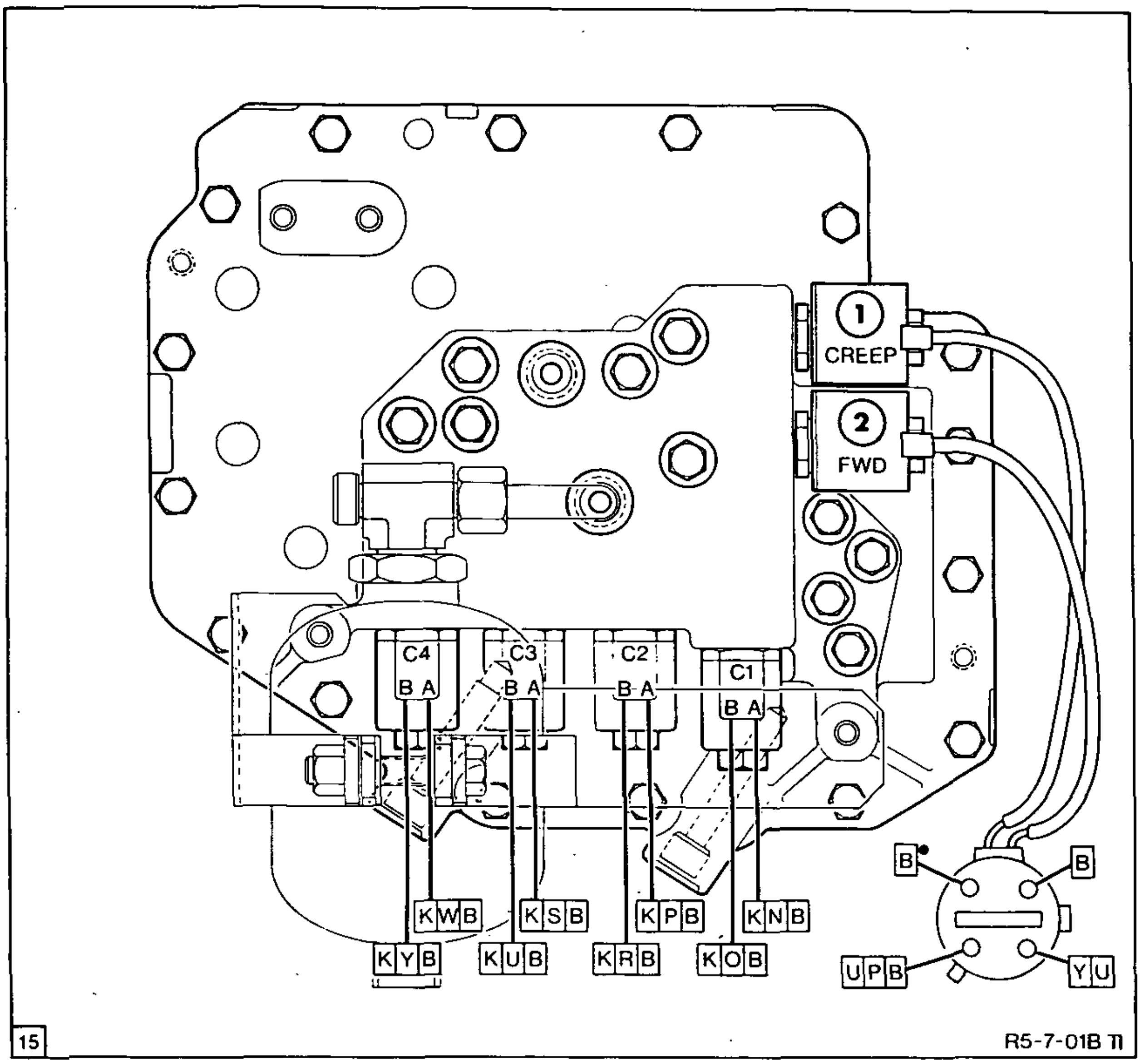
PWM Solenoid, Creeper Solenoid and FWD Solenoid Check–Out Procedure

The Quad Mod system for 16x16 transmission uses four identical PWM valves with integral electrical connectors to control the four transmission clutches. The side cover casting and the wiring harness are both labeled C1/C2/C3/C4, but it is still possible to mix up the connections. THIS IS NOT DETECTABLE BY THE MICRO PROCESSOR. Mixing the connections will lead to improper operation, which can include engagement of both C1 and C2 at the same time. This can cause clutch burn out in a matter of seconds, particularly at high engine rev/min. IT WILL NOT ALWAYS STALL THE ENGINE.

The Quad Mod system also uses identical solenoid valves for creeper and four wheel drive. These are wired into a single four pin connector, so that disconnecting and reconnecting the connector will result in proper connections. However the solenoids are interchangeable on the valves and the valves are interchangeable in the cavities in the transmission side cover. If the solenoids are switched, the FWD circuit will shift the transmission in and out of creeper. Since the FWD can be shifted on the move and automatically engages when the brake pedals are depressed, this could result in serious damage to the transmission.

To be sure of correct connections after any of the solenoid coils have been disconnected or removed, the following procedure should be used. This should be performed BEFORE performing spring calibration on any clutch, as the calibration may not work properly if the connections are mixed.

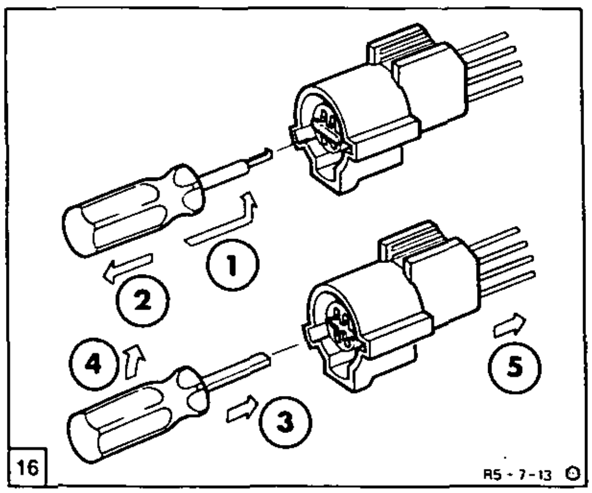
1. Turn the key start switch to the 'run' position without starting the engine and check for error codes. Correct any errors.
2. If the tractor has FWD and creeper turn FWD 'ON' to prevent the brake pedal switches from shifting FWD 'ON' and 'OFF'.
3. Check the area around the tractor to be sure it can be driven without hitting anyone or anything.
4. Start the engine and set engine speed to LOW IDLE. Release the handbrake.
5. During the following steps, 6 to 9, if the engine lugs or stalls, or if the tractor stops or does not move, or if the transmission downshifts when it should upshift, depress the clutch pedal within 5 seconds then stop the engine and correct the PWM valve connections.
6. Depress the clutch pedal, select 1st gear, low range, forward or reverse and fully release the clutch pedal. The tractor should move within 3 seconds.
7. Powershift to 2nd gear. Tractor speed should increase slightly.
8. Powershift to 3rd gear. Tractor speed should increase slightly.
9. Powershift to 4th gear. Tractor speed should increase slightly.
10. If the tractor is equipped with creeper, powershift back to 1st gear, depress the clutch pedal, stop the tractor and select creeper. Release the clutch pedal and verify that the transmission is in creeper. If the transmission is not in creeper correct the fault before checking FWD operation.
11. If the tractor is equipped with FWD, check FWD operation.



Control Valve Side Cover Solenoid Wiring

1. Creeper Solenoid
2. Four Wheel Drive Solenoid

NOTE: *The Creeper and Four Wheel Drive solenoids share a common connector to the harness. The solenoids are also identical and the same part number services both solenoids. The solenoid is supplied with the connector attached and the terminal pins in the position for the* ***FWD solenoid.*** *If the solenoid is to be used on the creeper valve the terminal pins* ***must be removed*** *from the connector and either repositioned within the new connector or installed in the original connector in the correct location as shown above.*



FWD / Creeper Connector
Terminal Removal/Installation

1. Insert, special tool M.S.1562 under the terminal pin separator plate
2. Withdraw the separator
3. Insert special tool M.S.1575 into the Separator slot
4. Angle the tool to depress the terminal pin tang
5. Withdraw the wire from the rear of the connector

To install a new wire/terminal pin, simply push the terminal in from the rear of the connector until the tang is in sufficiently to not allow withdrawal.
Special tools quoted above are part of 'Electrical Repair Kit', Tool No. 4FT–953.

Diagnostic Test Routines

These diagnostic test routines supplement the automatic diagnostic error codes previously described. Access to these test modes is via the tractor diagnostic connector located near the fuse box. By connecting the diagnostic switch, Tool No. 4FT.950, to this connector and then switching the key start on, the instrument panel will display 'HH'. Pressing the tool switch button will increment through the menu modes. The menu modes are as follows:

Select Switch	Display	Transmission Status	16x16 Quad Mod Test Routine
Power Up	HH	Disabled	–
Press	H1	Enabled	Transmission clutch spring pressure calibration routine
Press	H2	Disabled	Transmission clutch spring calibration value display
Press	H3	Disabled	Not Used
Press	H4	Disabled	Software revision display
Press	H5	Disabled	Switch diagnostic mode
Press	H6	Enabled	Temperature/pressure compensation – display
Press	H7	Enabled	Oil temperature display
Press	H8	Disabled	Micro–processor Non–Volatile Memory Reset
Press	H9	Enabled	Vehicle sensors operation display
Press	HA	Enabled	Clutch pedal percent display
Press	HB	Disabled	PWM valve temperature compensation adjustment
Press	HC to HF	Enabled	Quickfill duration adjustment mode

H1 Menu Mode

H1 provides access to the transmission clutch spring pressure calibration routines.

H2 Menu Mode

H2 displays the transmission spring pressure calibration values.

H3 Menu Mode

Not Used.

H4 Menu Mode

H4 indicates the software design level.

H5 Menu Mode

H5 provides access to the manual switch diagnostic mode. This is described in greater detail later in this section.

H6 Menu Mode

H6 displays the pressure offset from PWM valve solenoids in relation to the oil temperature. As the oil temperature changes the pressure is compensated to maintain the same operating characteristics, i.e, clutch pedal operating height is maintained.

H7 Menu Mode

H7 displays the temperature of the transmission oil. The normal transmission display is replaced by a value from 0–99 indicating the oil temperature in degrees Celsius.

H8 Menu Mode

H8 allows calibrations to be cleared from the micro processor.

H9 Menu Mode

H9 provides access to the electronic reading from the vehicle sensors to check for correct operation. This mode is described in greater detail later in this section.

HA Menu Mode

HA provides access to the clutch pedal percentage position display.

HB Menu Mode

HB Provides PWM valve temperature compensation adjustment. This in effect matches the transmission oil temperature sender output to the PWM valves, via the micro processor, to maintain a constant clutch pedal height across all operating temperatures. This is factory set to a value of 16 and should not require adjustment in service.

HC to HF Menu Mode

A manual adjustment mode is provided to independently change the duration of the quickfill pulse for each of the four clutches. This adjustment is only required to compensate for clutch wear. The adjustment procedure is described in greater detail in the calibration procedure of this section. HC=C1, HD=C2, HE=C3, HF=C4.

Switch Diagnostic Mode

To assist in trouble shooting switch/switch circuit failures a switch diagnostic mode is available. To enter the switch diagnostic mode the service diagnostic switch must be connected and mode H5 initiated.

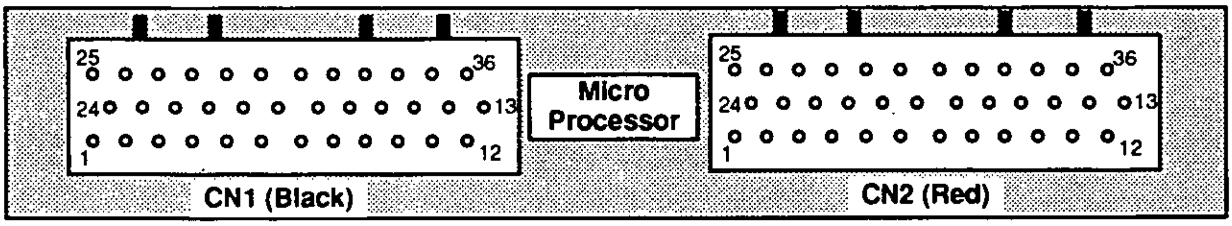
Following entry, the letter 'd' and a zero are displayed in the transmission portion of the instrument cluster display. At this point movement of the shift levers, clutch pedal and where fitted, Electronic draft control switches, results in an audible tone and the display of a numeric code which corresponds to a particular switch. Returning the switch to its original state will return the display to zero. The micro processor switch diagnostic mode display codes are as follows:

Switch Code	Switch Description
d1	External Lower Switch (EDC)
d2	External Raise Switch (EDC)
d3	Work Switch Transition (EDC)
d4	Raise Switch Transition (EDC)
d71	Clutch Pedal Switch
d74	Down shift Switch
d75	Upshift Switch
d77	5–8 Range Lever Switch
d81	1–4 Range Lever Switch
d82	Low Range Switch
d83	High Range Switch
d85	Neutral Safety Start Switch
d91	Shuttle Dump Switch
d92	40°C Oil Temperature Switch
d93	Fuse 12 Sense

H9 – Vehicle Sensor Operation

This mode allows service personnel to verify the operation of various potentiometers, voltage supplies and the PWM current sense circuitry. In this mode both the transmission display and EDC display initially show a channel number and then follow by indicating a number in the 0–99 range which corresponds to the voltage that is sensed on that channel. The channel number can be incremented by depressing either the upshift switch, or if present, a transition of the raise/work switch from work to raise. The channel number can be lowered by depressing the downshift switch. The channel numbers, corresponding signal and typical signal values are as follows:

Channel Number	Description	Typical Approximate Values	Pin	Voltage
0	Clutch Pedal Position	91 released, 26 depressed	CN1–19	4.6 / 1.3
1	Transmission Oil Temperature	75 at 40°C	CN1–18	3.75
2	Transmission 40°C Oil Switch	96 > 40°C	CN1–32	12
		2 < 40°C	CN1–32	0.1
3	Fuse 12 Sense	96	CN1–6	12
4	Not Applicable to Service	–	–	–
5	5 Volt Reference (Transmission Control)	49	CN2–5	5
6	12 Volt Vf input (Fuse 13)	42	CN2–34	12
7	12 Volt Vd input (Clutch Switch)	43	CN2–30	12
8	12 Volt Vh input (Fuse 14)	43	CN2–29	12
9	8 Volt reference (EDC Control)	79	CN2–25	8
10	Not Used	–	–	–
11	Not Applicable to Service	–	–	–
12	Not Applicable to Service	–	–	–
13	Not Applicable to Service	–	–	–
14	C1 Valve Current Sense	92 engaged	CN2–36	0.15
		0 not engaged	CN2–36	0
15	C2 Valve Current Sense	92 engaged	CN2–13	0.15
		0 not engaged	CN2–13	0
16	C3 Valve Current Sense	92 engaged	CN2–26	0.15
		0 not engaged	CN2–26	0
17	C4 Valve Current Sense	92 engaged	CN2–12	0.15
		0 not engaged	CN2–12	0
20	Wheel Speed Sensor Sense	64	CN2–6	2.3
18 to 35	EDC Sensors			



EXPLANATIONS AND NOTES:

If during fault finding, a channel value is not within ±5% of that shown in the above table, a voltage check should be carried out at the micro processor connector pin indicated in the right hand column. The connectors, CN1 (black) and CN2 (red), must remain installed to the micro processor. The negative probe of the volt meter should be inserted into CN2–32 (processor negative), and the positive probe to the appropriate pin. If the voltage at the pin is not as specified the fault can be considered to be within the wiring harness or a component within that circuit. If the voltage at the pin is correct the fault may lie between the micro processor connector, or if this appears to be okay, the processor itself should be replaced by a unit of known performance.

Channel 6: Vf input, this is the input voltage into the micro–processor for transmission components not directly affected by the clutch pedal switch, i.e, PWM valve solenoids C1 and C2 and the creeper solenoid.

Channel 7: Vd input, this is the input voltage into the micro–processor for transmission components which are affected by the clutch pedal switch operation, i.e, PWM valve solenoids C3 and C4.

Channel 8: Vh input, this is the input voltage into the micro–processor for the EDC components, i.e, raise and lower solenoids.

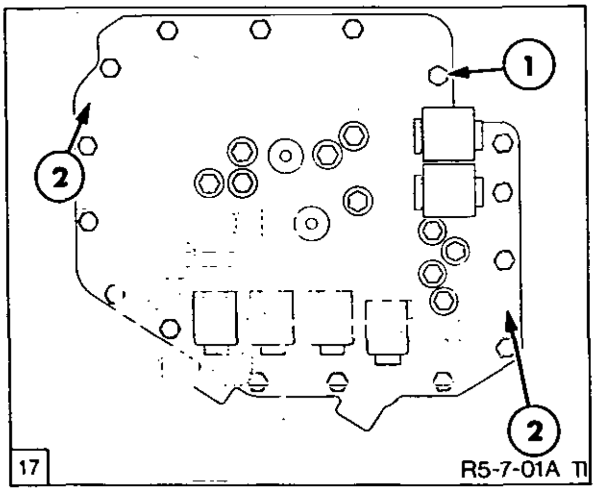
C. CONTROL VALVE – OVERHAUL

The following procedure treats the transmission as removed from the tractor. It is possible to remove the control valve assembly from the transmission without removing the transmission from the tractor. Removal of the surrounding tubing, the accumulator and other peripheral hardware should be performed following conventional techniques to gain access to the control valve.

It should be noted that unless contaminant is suspected to be within the control valve cover oil galleries or there is a suspected fault within the lube control valve, it is not necessary to remove the valve cover to remove any of the PWM solenoids or four wheel drive and creeper solenoids.

NOTE: *During removal of the control valve and the connecting hardware, it is essential that outside contaminant is not permitted to enter the inside of the transmission. If necessary steam clean the outside of the control valve area before proceeding to remove the valve assembly.*

Control Valve Removal

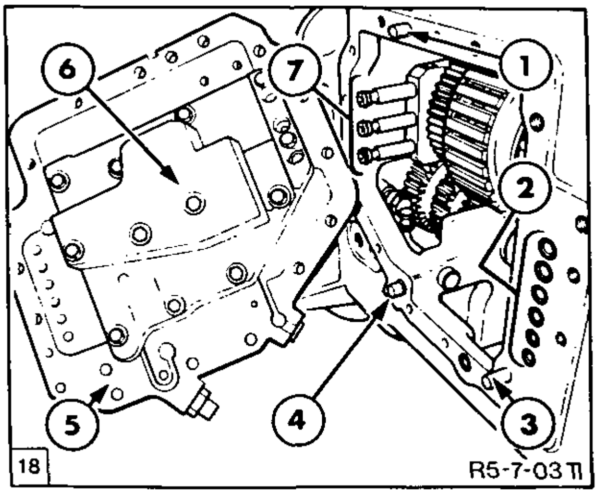


Control Valve Retaining Bolts

1. Retaining Bolts – 16 off
2. Jacking Bolt Hole – 2 off

1. Drain the transmission/rear axle oil into a suitable container.

2. Remove the 16 control valve cover retaining bolts shown in Figure 17. Use two of the removed bolts in the jacking holes provided in the cover and carefully remove the control valve assembly from the transmission housing.



Side Cover Assembly Removal

1. Dowel
2. 'O' Ring
3. Dowel
4. High/Low Detent
5. Side Cover
6. Lube Control Valve
7. C3/C4 Supply Tubes

Control Valve Assembly Overhaul

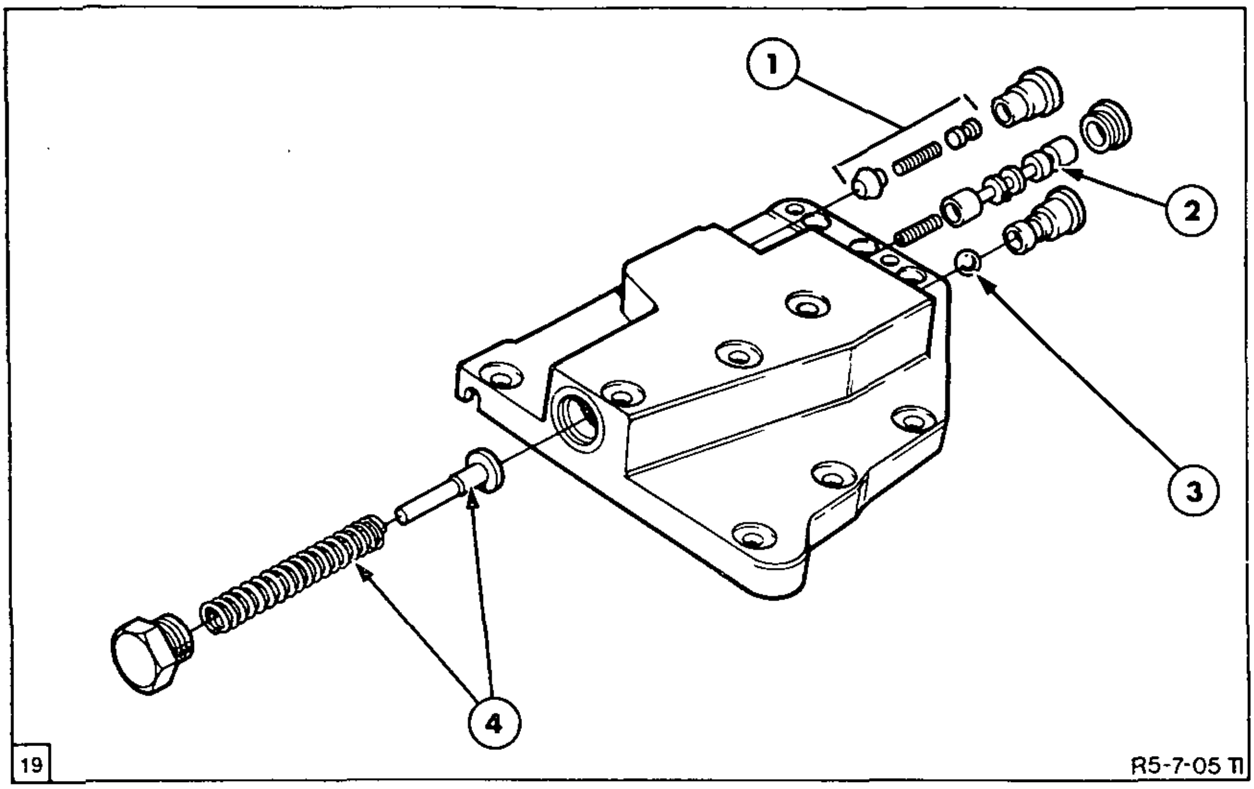
Absolute cleanliness is essential during disassembly and reassembly of the control valve. Ensure the working area is clean and not likely to be contaminated by other working operations being performed alongside. It is recommended that only a clean, dust free environment is used for the overhaul.

Lube Valve Removal and Disassembly

1. Place the control valve face down on a clean surface and remove the 12 bolts retaining the lube valve assembly to the side cover. Carefully lift off the Lube valve, noting the gasket between the two castings.

2. Remove the end plugs and withdraw the spools and springs as shown in Figure 19. During dissassembly note how easy 'easy' or 'hard' it is to remove spools. This will indicate if spools are possibly sticking or stuck or excessively loose and therefore leaking oil past the spool lands.

Lube Valve Inspection and Reassembly



Lube Valve Assembly

1. Lube Pressure Relief Valve
2. Lube Control Valve Spool
3. Lube Shuttle Valve Ball
4. Lube Valve Spool Spring (220 lb) and Plunger

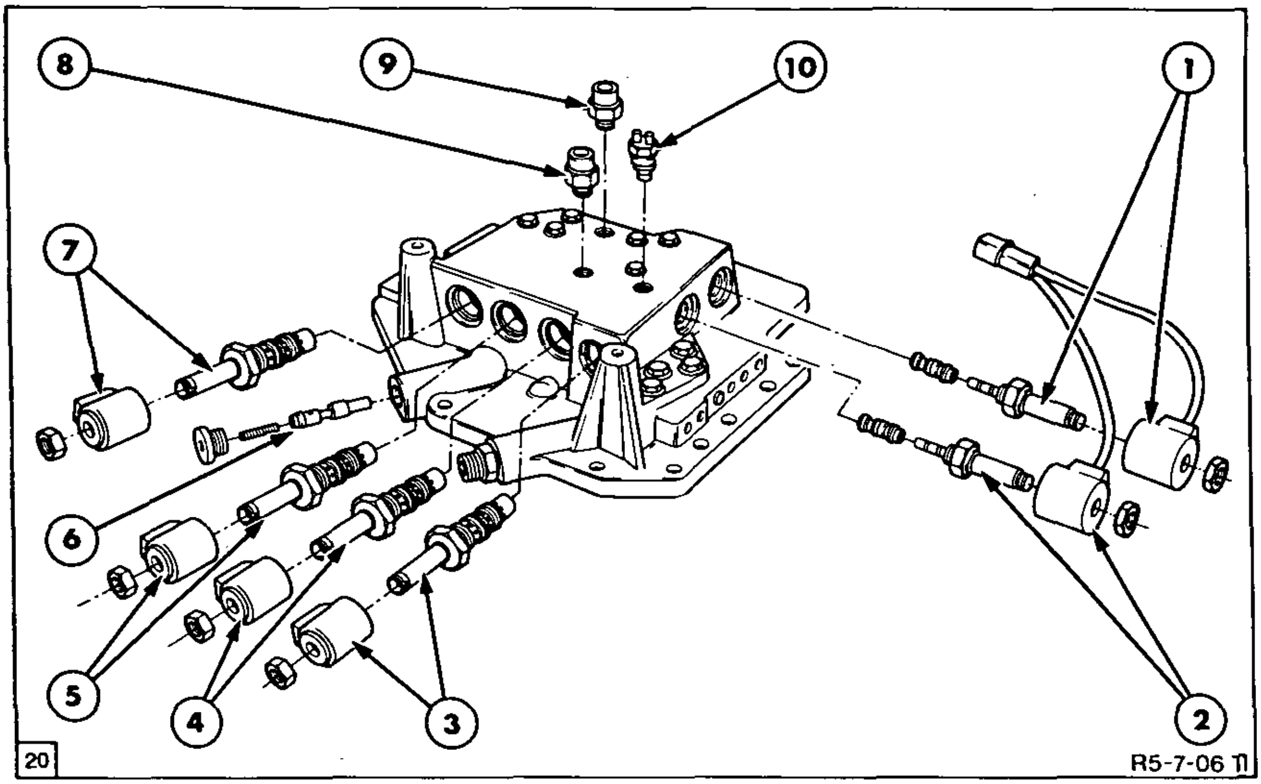
1. Clean the valve body in a suitable cleaning solvent and use pressure air to dry. Note during cleaning if contaminant is expelled which may have caused an oil blockage or stuck spool.
2. Examine the spools and bores for wear or damage, replace as required.
3. Reassembly is the reverse of the disassembly. Coat all components with clean transmission oil of the correct specification just prior to assembly.
4. Prior to assembling the lube valve to the cover, ensure the mating faces are clean and that a new gasket is available for installation. Do not use a liquid gasket sealant between these surfaces.

Control Valve Cover Dissassembly

1. With reference to Figure 20, remove the four PWM solenoid valves, the creeper interlock piston, the oil temperature sender and the four wheel drive and creeper solenoids, if fitted.

Control Valve Cover Inspection and Reassembly

1. Clean the cover in a suitable cleaning solvent and dry with pressure air. Note during cleaning if contaminant is expelled which may have caused an oil blockage.
2. Carefully examine the cover for hairline cracks or other damage which may have caused oil leakage. Replace the cover if any damage or cracks are found, do not attempt a repair.
3. Clean the complete PWM valve assemblies, less the solenoids, in a suitable cleaning solvent. It is not recommended to dissassemble the PWM valves further to clean. If the performance of the valve is suspect and no contaminant is found during cleaning, but the solenoid is within specification, the valve should be replaced with a new one.
4. Clean the FWD and creeper valves in the same manner as the PWM valves.
5. Reassembly is the reverse of the disassembly. Ensure the 'O' rings of all the solenoid valve assemblies are in good condition prior to installation. Coat the valve components with clean transmission oil of the correct specification prior to assembly.
6. Tighten the 12 retaining bolts to a torque value of 27 Nm (20 lbf.ft).



Control Valve Assembly

1. Creeper Solenoid and Valve Assembly
2. Four Wheel Drive Solenoid and Valve Assembly
3. C1 PWM Solenoid and Valve Assembly
4. C2 PWM Solenoid and Valve Assembly
5. C3 PWM Solenoid and Valve Assembly
6. Creeper Interlock Piston
7. C4 PWM Solenoid and Valve Assembly
8. RegulatedPressure Supply Inlet Connector
9. Lube Supply Inlet Connector
10. Transmission Oil Temperature Sender

Installation of Control Valve Cover onto Transmission

1. Before replacing the assembled control valve cover assembly onto the transmission, ensure that both mating surfaces are clean and free from oil and previous sealant. Apply a thin bead of sealant, specification ESE–M4G234–A1 (Loctite 515), to the transmission casing. Do not apply an excessive quantity as the surplus may enter the transmission oil and return to the control valve, causing blocked oil galleries or sticking spools.

2. Ensure the 6 'O' rings seals. located to the right of the cover aperture, are in position in the transmission casing and the three tubes, located to the left, are in position with 'O' rings installed.

3. Install cover assembly onto the transmission and tighten the 16 retaining bolts to a torque value of 56 Nm (41 lbf.ft). Reconnect the tubes, wiring etc disconnected during removal.

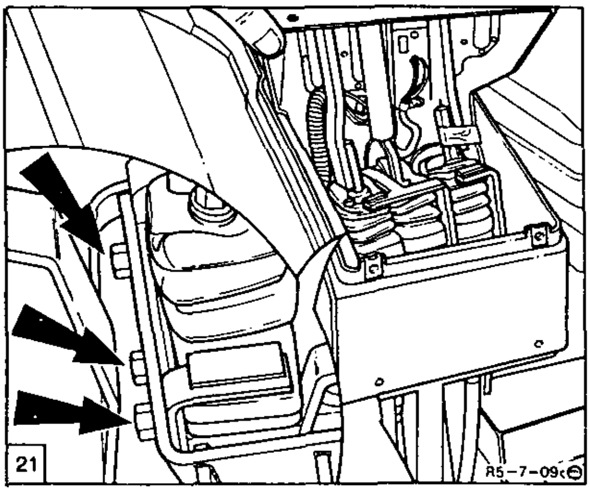
4. Fill the transmission/rear axle with the correct quantity and grade of transmission oil, specification ESN–M2C134–D and test drive the tractor.

NOTE: *If the PWM valves have been cleaned or replaced it will be necessary to recalibrate the transmission clutches as detailed in Section B of this Chapter.*

D. GEARSHIFT CONTROL CABLES

The Forward/Reverse shuttle lever, the 1–4/5–8 main shift lever and the high/low lever each have a cable link to the transmission casing. Use of cable control provides a more durable and efficient link compared to the rod type linkage system and requires less maintenance.

Cable Removal and Replacement



Shift Lever Console Removal

1. Remove the securing screws and the knobs of all the gear levers and the hand throttle.

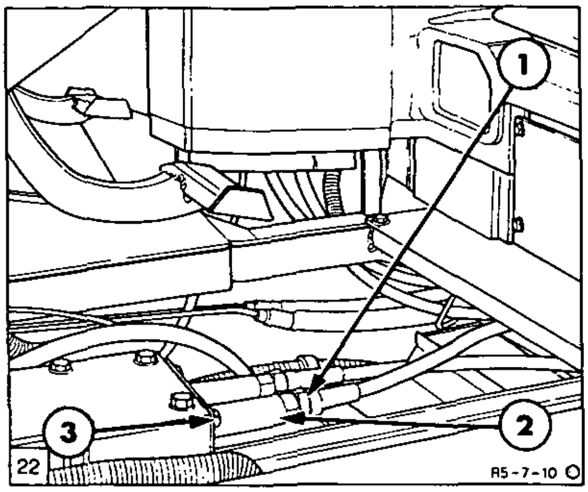
2. Remove the screws retaining the lower gearshift cover and remove the cover.

3. Remove the screws retaining the gear shift console and the screws retaining the console for the hydraulic remote valve levers. Lift the consoles high enough to allow access to the three bolts retaining the cable to lever connection box.

4. To remove a single cable, loosen the grub screw retaining the lever to the box. Withdraw the lever from the box. Remove the nuts from the three through bolts and withdraw the bolts sufficient enough to allow the cable box to come free of the support.

5. If removing either the Forward/Reverse or 1–4/5–8 range control cables remove the rubber floor mat and the floor plate to gain access to the top of the transmission.

6. Loosen the locknut of the cable to be removed so that the locknut is free to slide up the cable outer covering.



Transmission Top Cover – 1–4/5–8 Cable Access

1. Adjustment Sleeve Locknut
2. Adjustment Sleeve
3. Sleeve Flange Locknut

7. Loosen and remove the two bolts securing the cable end sleeve flange to the transmission top cover. Unscrew the sleeve sufficient to allow the cable to shift rail connecting pin to be removed. The cable assembly can now be removed from the tractor.

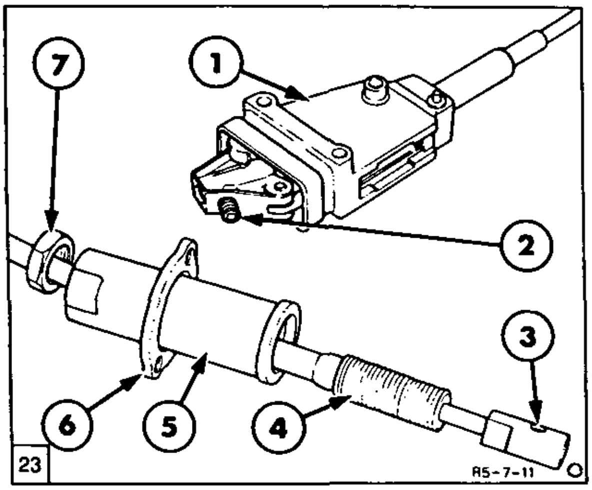
8. To remove the high/low control cable it is not necessary to lift the cab floor. Disconnect the cable to transmission operating link clip and withdraw the pin to allow the cable to disconnect. Loosen and remove from the thread the lower locknut of the cable. Lift the cable until it is able to slide free of the mounting bracket. The cable assembly can now be removed from the tractor.

9. Replacement is the reversal of the removal assembly.

Cable Adjustment

NOTE: *To adjust the Forward/Reverse and 1–4/5–8 lever control cables it is necessary to gain access to the transmission top cover. Remove the cab floor mat and floor plate.*

Forward/Reverse and 1–4/5–8 Cables



1–4 and 5–8 Shift Cable

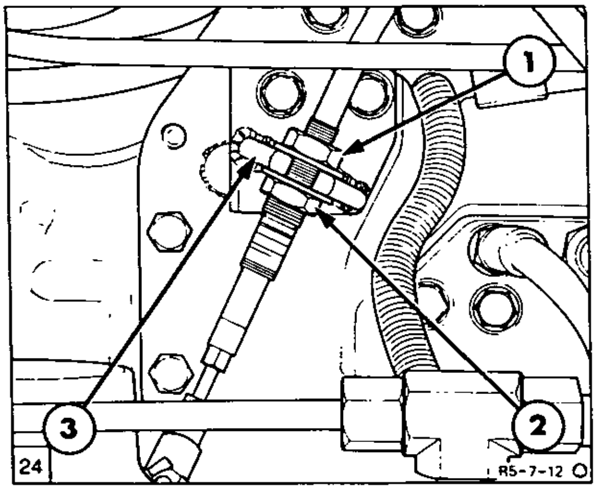
1. Cable, Shift Lever End
2. Shift Lever Retaining Screw
3. Cable End Connector to Shift Rail
4. Cable Outer Cover Adjustment Thread
5. Sleeve
6. Sleeve Locking Flange
7. Sleeve Locknut

1. Ensure the transmission has all ranges in neutral.

2. With the cable installed and routed correctly. Loosen the bolts retaining the cable end sleeve flange just sufficient to allow the sleeve to be rotated.

3. Rotate the sleeve until, initially, the lever in the cab is positioned centrally in the console slot. Tighten the sleeve flange bolts and the sleeve locknut. Operate the lever and ensure that the synchronisers are fully engaged. If the lever travel is too far one way, i.e, the lever is contacting or almost contacting the end of the console slot, re–adjust the cable as previously described until an equal gap is obtained between the lever and console slot at both ends of its travel.

High/Low Range cable



High/Low Cable Adjustment

1. Upper Cable Locknut
2. Lower Cable Locknut
3. Cable Mounting Bracket

1. The adjustment procedure is the same as detailed for the forward/reverse and 1–4/5–8 lever cables, except that it is not necessary to remove the cab floor and the adjustment is carried out using the locknuts either side of the cable mounting bracket shown in Figure 24.

E. SPECIFICATIONS

Solenoids	Nominal Resistance at 68° F (20° C)
PWM 1	10 Ω
PWM 2	10 Ω
PWM 3	10 Ω
PWM 4	10 Ω
Four Wheel Drive	10 Ω
Creeper Valve	10 Ω

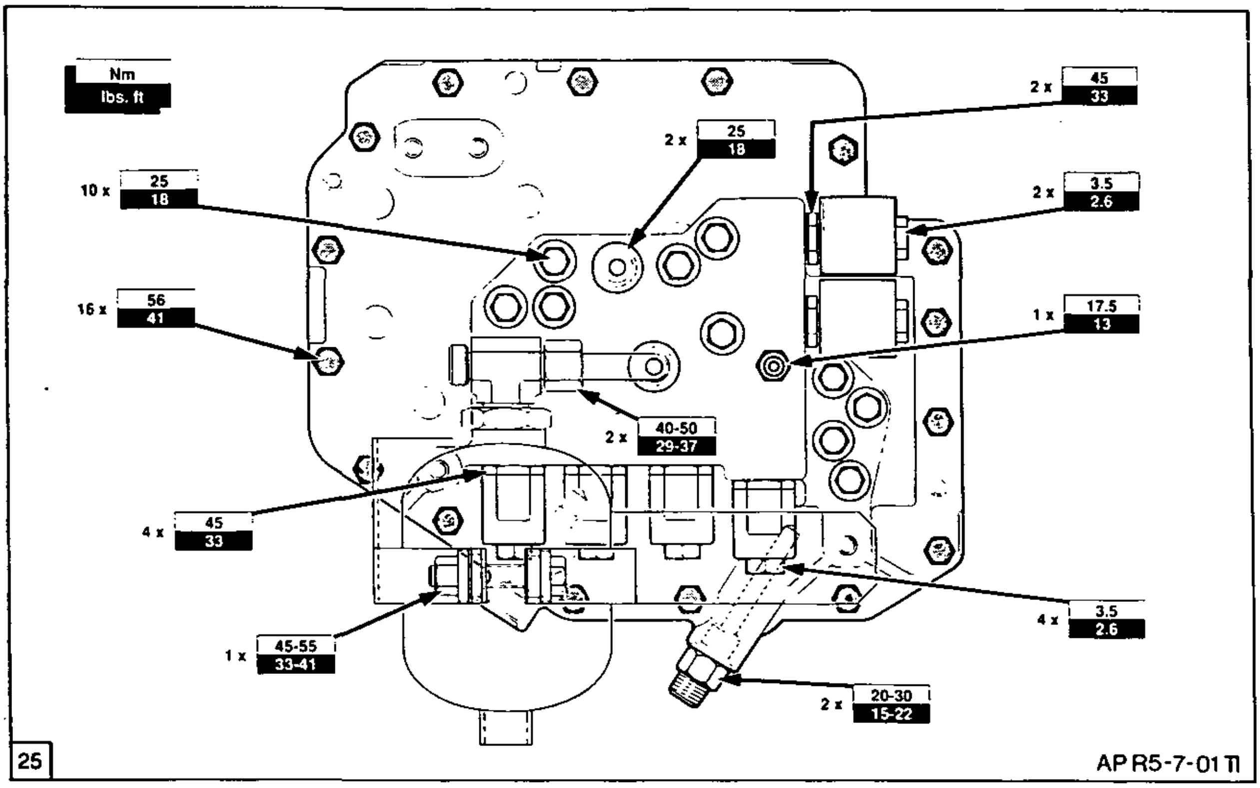
Transmission Fuses	Amperage
Fuse 12 – Module switches	10 Amp
Fuse 13 – ETC + 12 V Supply and Clutch Solenoids	15 Amp

Temperature Sender

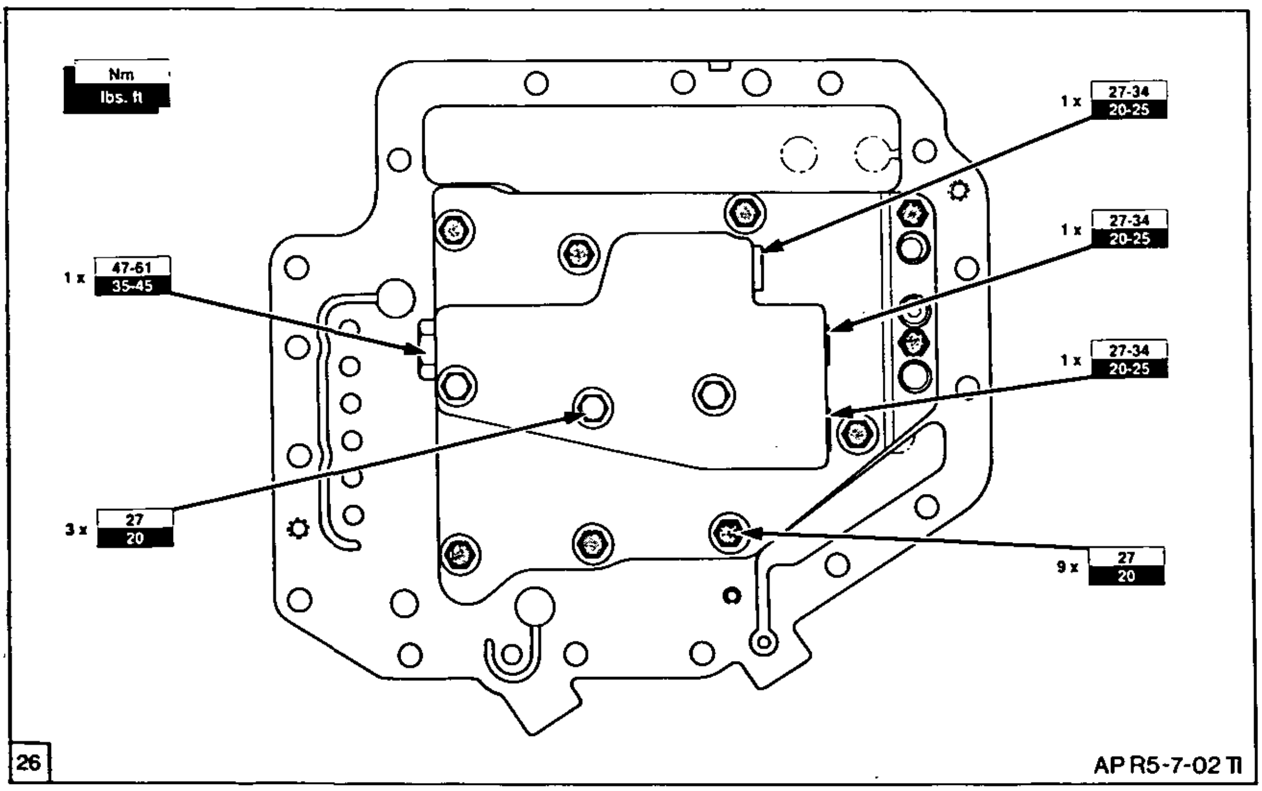
NOTE: When testing the sender a maximum test current of (1 Miliamp) should be used.

Temperature F°	65	70	75	80	85	90	95	100	180	250	270
Temperature C°	18.3	21.1	23.9	26.7	29.4	32.2	35.0	37.8	82.2	121.1	132.2
Resistance Ω	3795	3338	2939	2594	2293	2030	1802	1600	508.9	97.39	72.7

F. TIGHTENING TORQUES



Side Cover (External View)



Side Cover (Internal View)

G. SPECIAL TOOLS

	V.L Churchill	FNH–A
Quad Mod Limp Home Harness	4FT–952A	——
Electrical Repair Kit	4FT–953	——

PART 5
TRANSMISSION SYSTEM

Chapter 8
Fault Finding And Calibrations
(16x16 Quad–Mod and 12x12 Dual Power Post November 1995)
Software levels: 07 for 16x16 and 09 for 12x12 Dual Power

CONTENTS

A. INTRODUCTION

With the introduction of new wiring harnesses, which incorporate new connectors and revised wiring details, the fault finding charts for the 16x16 Quad–Mod transmission and 12x12 Dual Power transmission have been updated to reflect the wiring level of tractors from Unit Date Code 5L01 (November 1st 1995).

Where revisions to calibration routines and diagnostics have been made these are also included within this chapter. Where a specific item is not mentioned in the Contents table above this indicates that the procedure is unchanged from prior level models and reference should be made to the original Chapters.

B. 16 x 16 QUAD MOD FAULT FINDING CHARTS

16 x 16 'QUAD-MOD' Transmission Error Codes

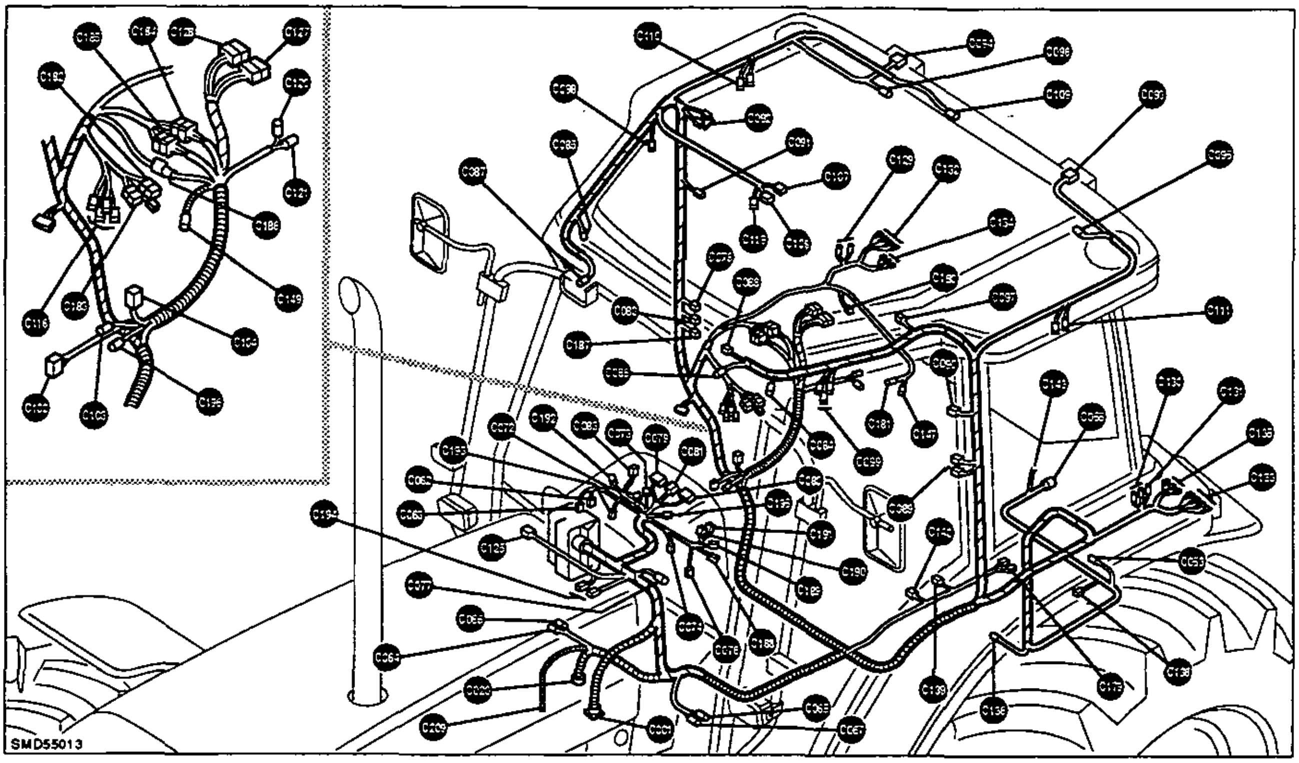
Error Code	Fault Condition	Flow Diagram	Disable Trans	Display Mode
E21	Chassis harness disconnected	14	Disable	Latched
E34	Fuse 13 blown (Note: will not be displayed)	15	Disable	Latched
E53	5 volt Reference failed, shorted to 12 volts	17	Disable	Latched
E54	5 volt Reference failed, shorted to ground	17	Disable	Latched
E12	Clutch pedal potentiometer signal too high	16	Disable	Latched
E11	Clutch pedal potentiometer signal too low	16	Disable	Latched
E39	C4 clutch solenoid open circuit	19	Disable	Latched
E38	C4 clutch solenoid short circuit	19	Disable	Latched
E41	C3 clutch solenoid open circuit	19	Disable	Latched
E40	C3 clutch solenoid short circuit	19	Disable	Latched
E43	C2 clutch solenoid open circuit	19	Disable	Latched
E42	C2 clutch solenoid short circuit	19	Disable	Latched
E45	C1 clutch solenoid open circuit	19	Disable	Latched
E44	C1 clutch solenoid short circuit	19	Disable	Latched
C	Wheel speed too high for creeper gear	20	Recover	Latched
HC	Range shift too high with creeper engaged	21	Recover	Latched
E37	Clutch disconnect switch open circuit	18	Recover	Latched
CP	Depress clutch pedal to enable transmission	22	Recover	Latched
E46	Fuse 12 blown	23	Enabled	Latched
E47	Clutch disconnect switch misadjusted high	18	Enabled	Temp
E48	Clutch disconnect switch short circuit misadjusted, always closed	18	Enabled	Temp
E51	Transmission temperature sensor open circuit	24	Enabled	Latched
E52	Transmission temperature sensor short circuit	24	Enabled	Latched
E24	All clutches not calibrated	25	Enabled	Latched
EC4	C4 clutch not calibrated	25	Enabled	Latched
EC3	C3 clutch not calibrated	25	Enabled	Latched
EC2	C2 clutch not calibrated	25	Enabled	Latched
EC1	C1 clutch not calibrated	25	Enabled	Latched
E16	Creeper solenoid open/short circuit or attempt was made to engage creeper after prior creeper error	20	Enabled	Temp
E15	High/low range lever switches both on	26	Enabled	Temp
E14	1-4/5-8 range lever switches both on	28	Enabled	Temp
E13	Up and down switches both on	27	Enabled	Temp
E49	Wheel speed sensor circuit open or short circuit	29	Enable	Temp
E26	Engine rev/min speed too high	30	Enabled	Temp
E27	Engine rev/min speed too low	31	Enabled	Temp
H	Clutchless shuttle operation attempted at too high a speed and in too high a gear	32	Enabled	Temp

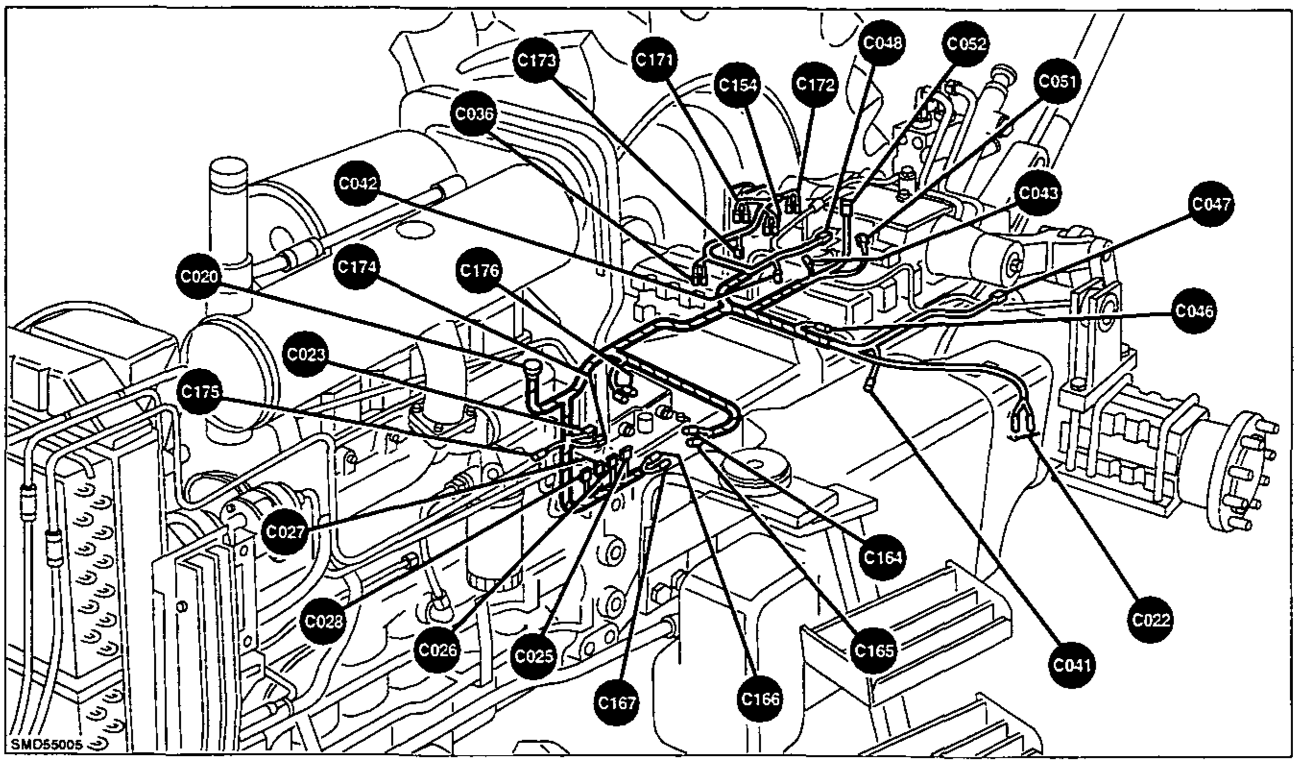
Error Code Table Explanations:

Priority - The error codes are listed in a priority order. Number 1 priority being the most serious fault and number 36 being considered the least serious of errors, i.e, if more than two errors occur the highest priority error will be displayed.

Disable Trans - This column of the table indicates whether the transmission is either **disabled**, i.e, not allowed to function, **enabled**, i.e, there is a fault within the transmission but is still allowed to function, or the fault is **recoverable**, i.e, performing a specific operation will clear the error code and recover the tractor.

Display Mode - This refers to the instrument panel display. **Latched** means that the error code will remain displayed until the fault is rectified. **Temp** (Temporary) means the error code will display temporarily and will then extinguish, but will be stored in the error code memory for retrieval at a later stage.





Harness Connector Identification

Key to Fault Finding Diagrams

Diagrams 1 to 11 - Not related to Error Codes

1. Tractor does not drive in any gear
2. Incorrect gear shift sequence or gears missing
3. Powershifts jerky / loss of drive
4. Poor clutch feathering
5. Clutch potentiometer calibration check
6. Holding in gear / jumping out of gear / clashing
7. Four wheel drive engages slowly or does not engage
8. Four wheel drive does not disengage
9. Creeper does not disengage
10. Clutches squeal / whine during inching
11. Transmission is noisy in operation
12. Transmission 'clunks' during inching
13. Engagement of the clutchless shuttle is delayed or aggressive

Diagrams 14 onwards, Error Code related

14. Error code E21
15. Error code E34
16. Error codes E11 and E12
17. Error codes E53 and E54
18. Error codes E37, E47 and E48
19. Error codes E38, E39 / E40, E41 / E42, E43 / E44, E45
20. Error codes C and E16 - Creeper does not engage in low range
21. Error code HC
22. Error code CP
23. Error code E46
24. Error codes E51 and E52
25. Error codes E24, EC4, EC3, EC2 and EC1
26. Error code E15
27. Error code E13
28. Error code E14
29. Error code E49
30. Error code E26
31. Error code E27
32. Error code symbol 'H'

Diagram 1: Tractor does not drive (in any gear)

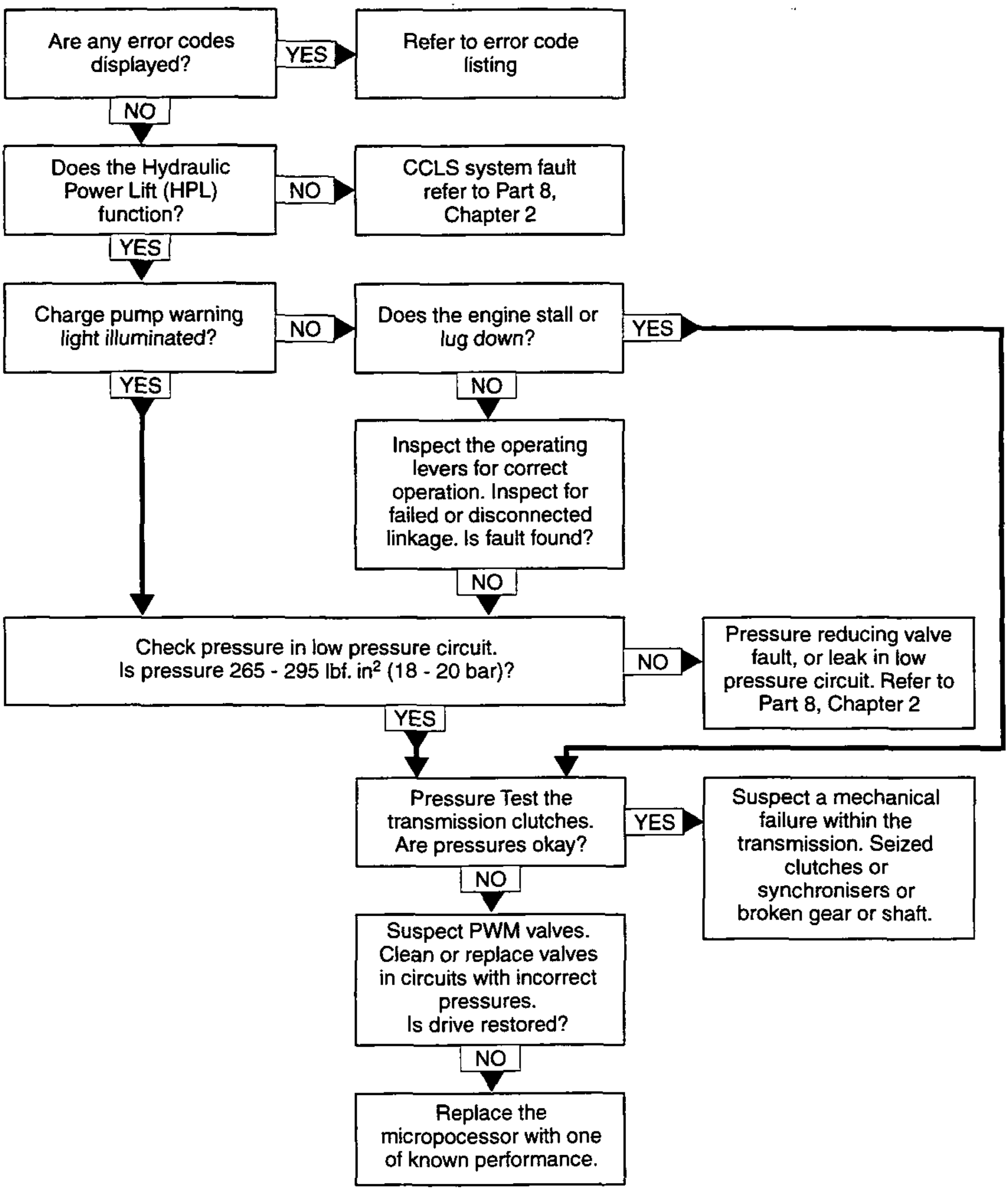


Diagram 2: Tractor drives in ranges but has the following fault:

The Powershift function operates but the shift sequence is incorrect or gears missing

Turn on key start switch without starting engine with FNR *lever in neutral.* Is an error code displayed?
- YES → Refer to error code listing
- NO ↓

Is the wiring correct to the PWM solenoids?
- NO → CCLS system fault refer to Part 8, Chapter 2
- YES ↓

Charge pump warning light illuminated?
- NO → Using the wiring diagram, ensure the correct harness connector is on the appropriate PWM solenoid.
- YES ↓

Inspect the shift levers for correct operation. Inspect shift mechanism for damaged or disconnected links. Is fault found?
- YES → Repair or adjust as required. Refer to 'Gearshift Control Mechanism' section.
- NO ↓

Check gear sequence chart. Pressure test at respective clutch port? Is pressure 265 - 295 lbf. in^2 (18 - 20 bar) at the correct clutch?
- YES → Suspect mechanical failure of clutches, shafts or gears.
- NO ↓

Substitute the respective PWM *solenoid valve for one* of known performance.

		Clutch used				
		C1	C2	C3	C4	
Gear Obtained	1 - 5		●		●	9 - 13
	2 - 6		●	●		10 - 14
	3 - 7	●			●	11 - 15
	4 - 8	●		●		12 - 16

Diagram 3: The powershifts are not smooth or the tractor loses drive between powershifts (in work, tractor stops or could be jerky)

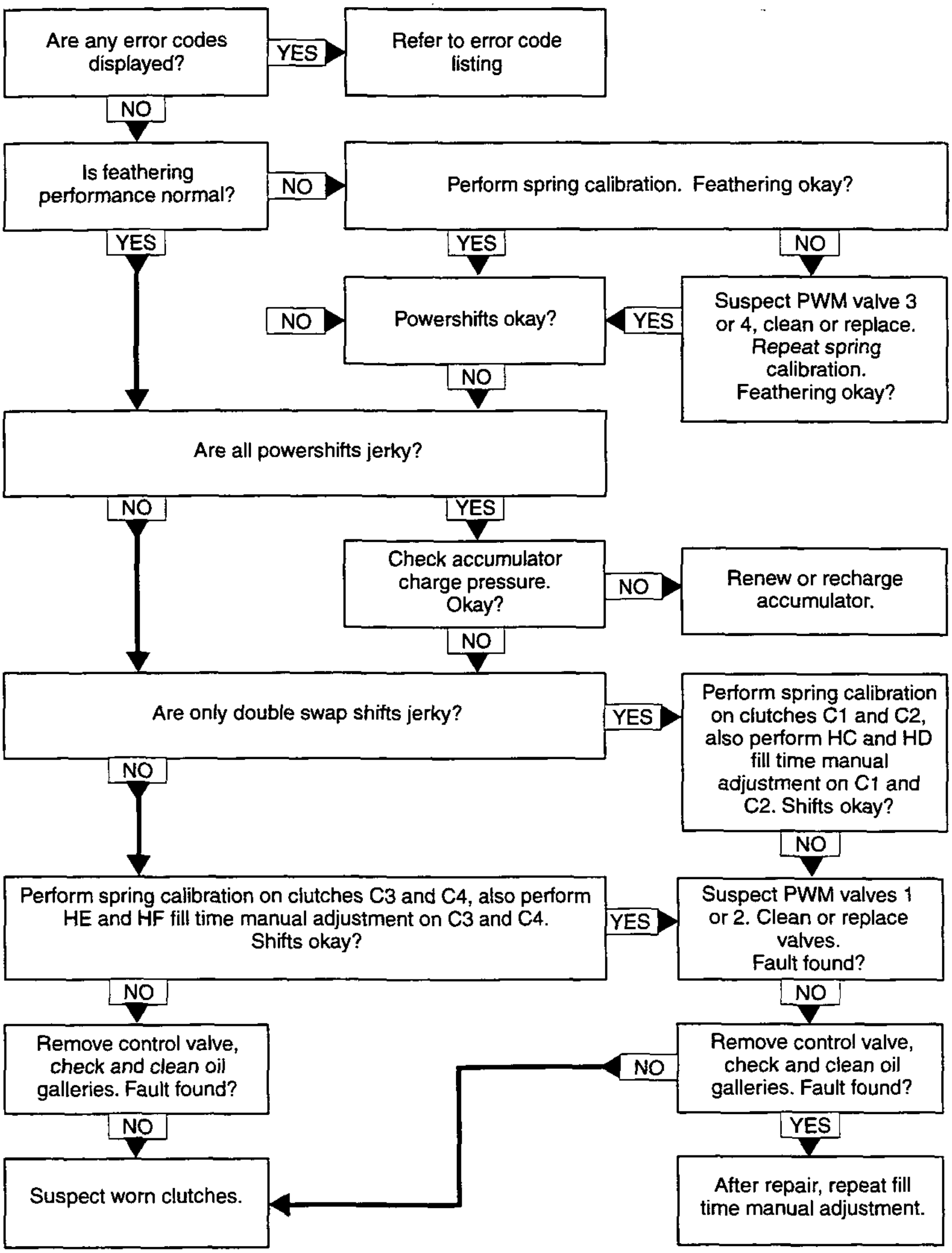


Diagram 4: The tractor drives in all gears but has the following fault.

Poor clutch pedal feathering/inching performance.

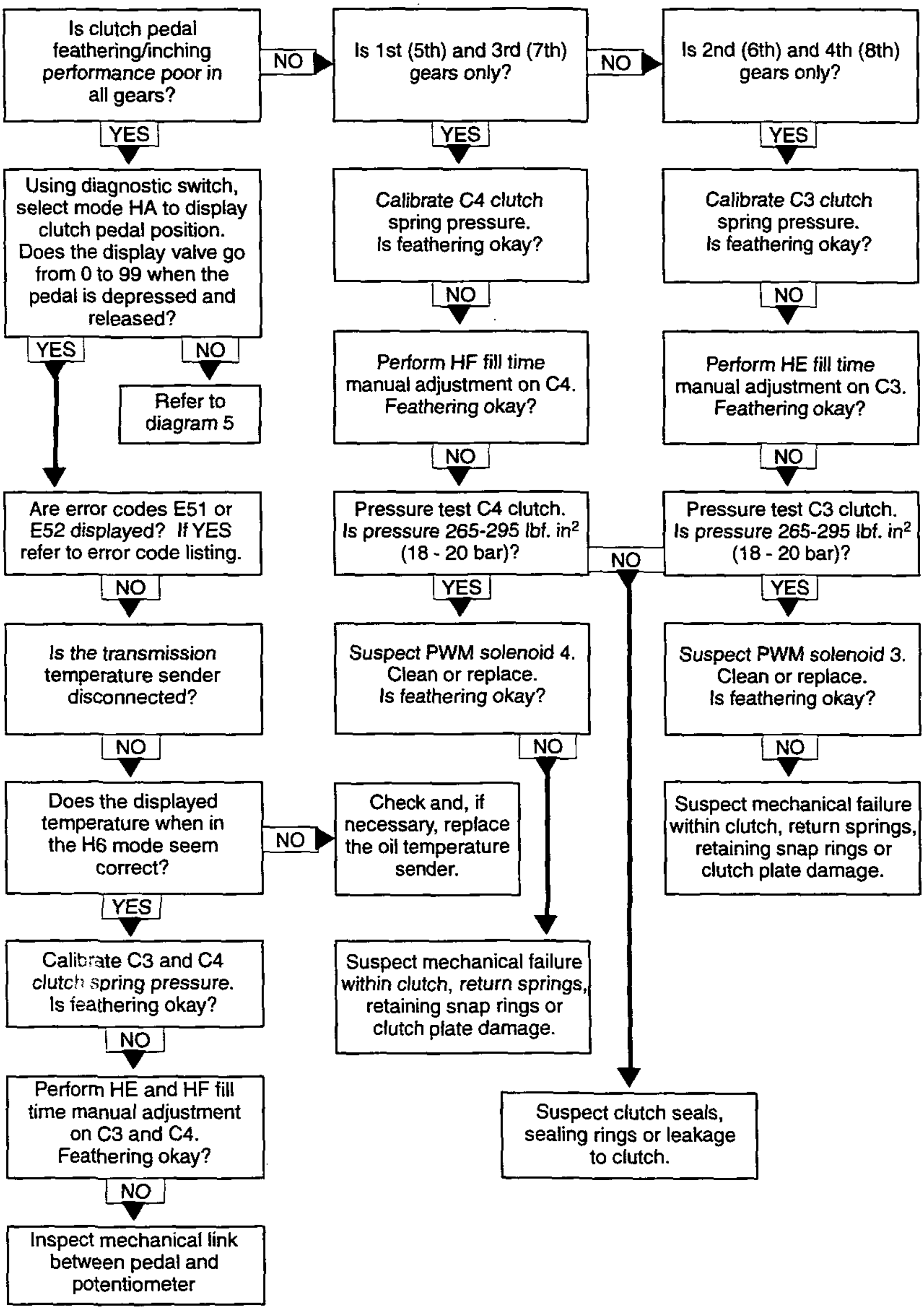


Diagram 5: Clutch pedal potentiometer calibration check

Using the service diagnostic switch select mode HA to display the clutch pedal position.
Does the transmission display value change smoothly from 0 to 99 when the clutch pedal is depressed and released?

YES ▶ Refer to error code listing

NO ▼

With the key start switch OFF, disconnect the potentiometer connector. Turn the key start switch ON to produce error code E11. Turn the key start switch OFF and reconnect the potentiometer. Reset in HA mode.
Does the display value change smoothly from 0 to 99?

YES ▶ Clutch pedal potentiometer is okay.

NO ▼

Inspect the linkage to the potentiometer. If the linkage or potentiometer is damaged replace the affected parts. Disconnect the potentiometer, turn the key start switch ON to produce E11. Turn the key start switch OFF and reconnect the potentiometer. Reset in HA mode.
Does the display value change smoothly from 0 to 99?

YES ▶ Clutch pedal potentiometer is okay.

NO ▼

Substitute the microprocessor module for one of known performance.

Diagram 6: The tractor drives in all gears and in all ranges but has the following fault.

Transmission jumps out of gear, holds in gear or gears clash when shifting.

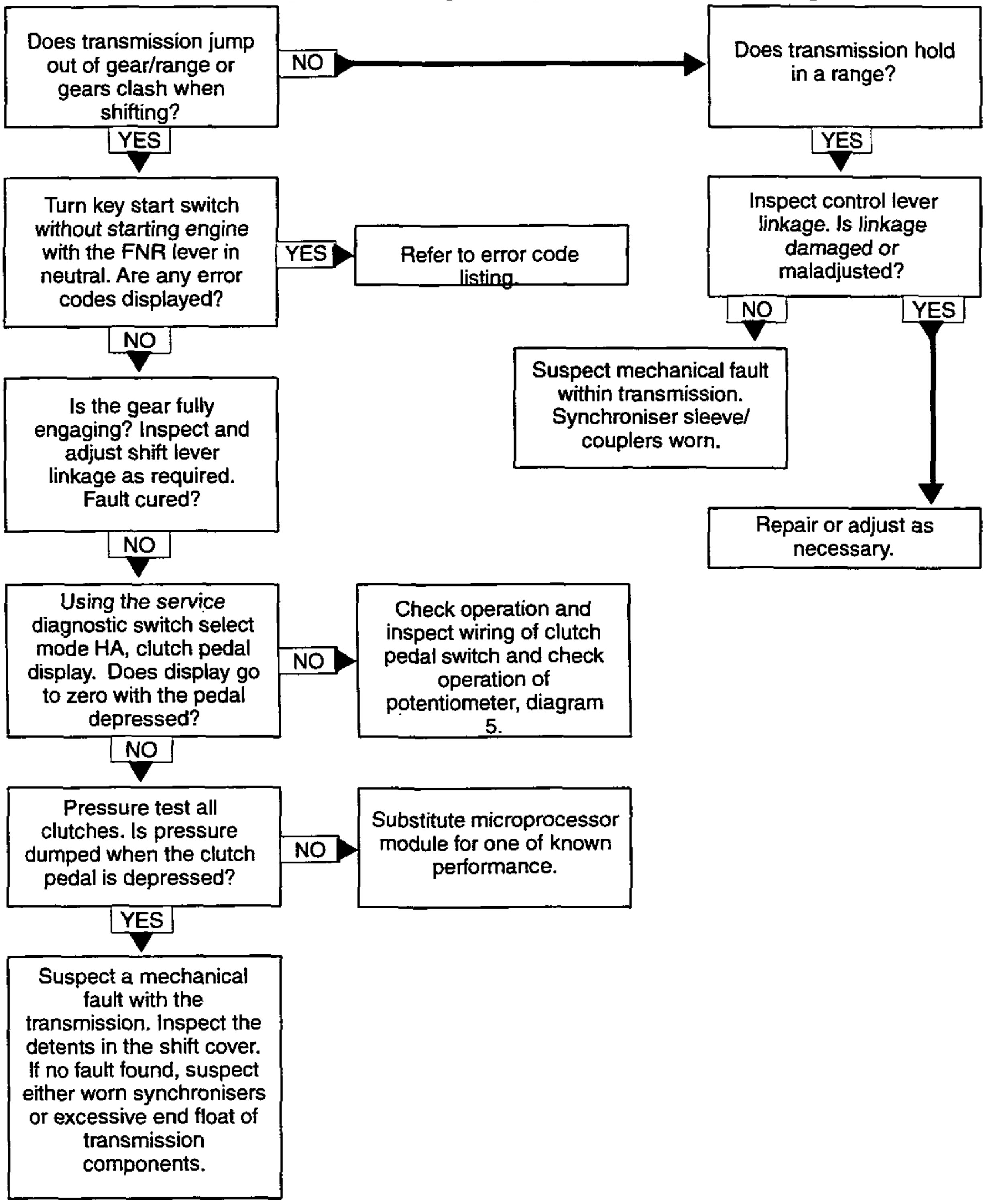


Diagram 7: The tractor drives in all gears and in all ranges but has the following fault.

Front wheel drive does not engage or engages slowly.

Pressure test at FWD test port in control valve cover. Does pressure gauge indicate 265-295 lbf.in^2 (18-20 bar) when FWD switched off and zero pressure when switched on??

YES

Suspect mechanical failure of FWD output assembly or transmission to FWD output assembly gear failure. If slow in engaging, carefully inspect the pilot check valve.

NO

Disconnect FWD solenoid (and creeper solenoid) connector. Does pressure go to zero?

YES

Test for correct operation of switch. Is switch okay?

NO

Replace switch.

YES

Disconnect wiring from switch, check wiring for short circuit to +12v. Fault found?

NO

Suspect FWD solenoid, clean or replace.

NOTE: *The FWD and creeper solenoids share a common connector. It will be necessary to remove the terminal pins from the connector to allow the installation of the pins from a new solenoid.*

Diagram 8: The tractor drives in all gears and in all ranges but has the following fault.

Front wheel drive does not disengage.

Verify that the FWD and creeper solenoids or wires have not been interchanged. refer to transmission wiring diagram. If solenoids/wiring is correct proceed.

Pressure test at FWD test port in control valve cover. Does pressure gauge indicate 265-295 lbf.in^2 (18-20 bar) when FWD switched off and zero pressure when switched on??

YES

Mechanical failure of FWD output assembly.

NO

Test for correct operation of switch. Is switch okay?

NO

Replace switch.

YES

Disconnect wiring from switch, check wiring for short circuit to ground or open circuit. Fault found?

NO

Suspect faulty FWD solenoid assembly, clean or replace. Fault found?

NO

Suspect oil leak, oil transfer tube leaking (missing), FWD output assembly clutch seals leaking.

NOTE: *The FWD and creeper solenoids share a common connector. It will be necessary to remove the terminal pins from the connector to allow the installation of the pins from a new solenoid.*

Diagram 9: The tractor drives in all gears and in all ranges but has the following fault.

The creeper does not disengage.

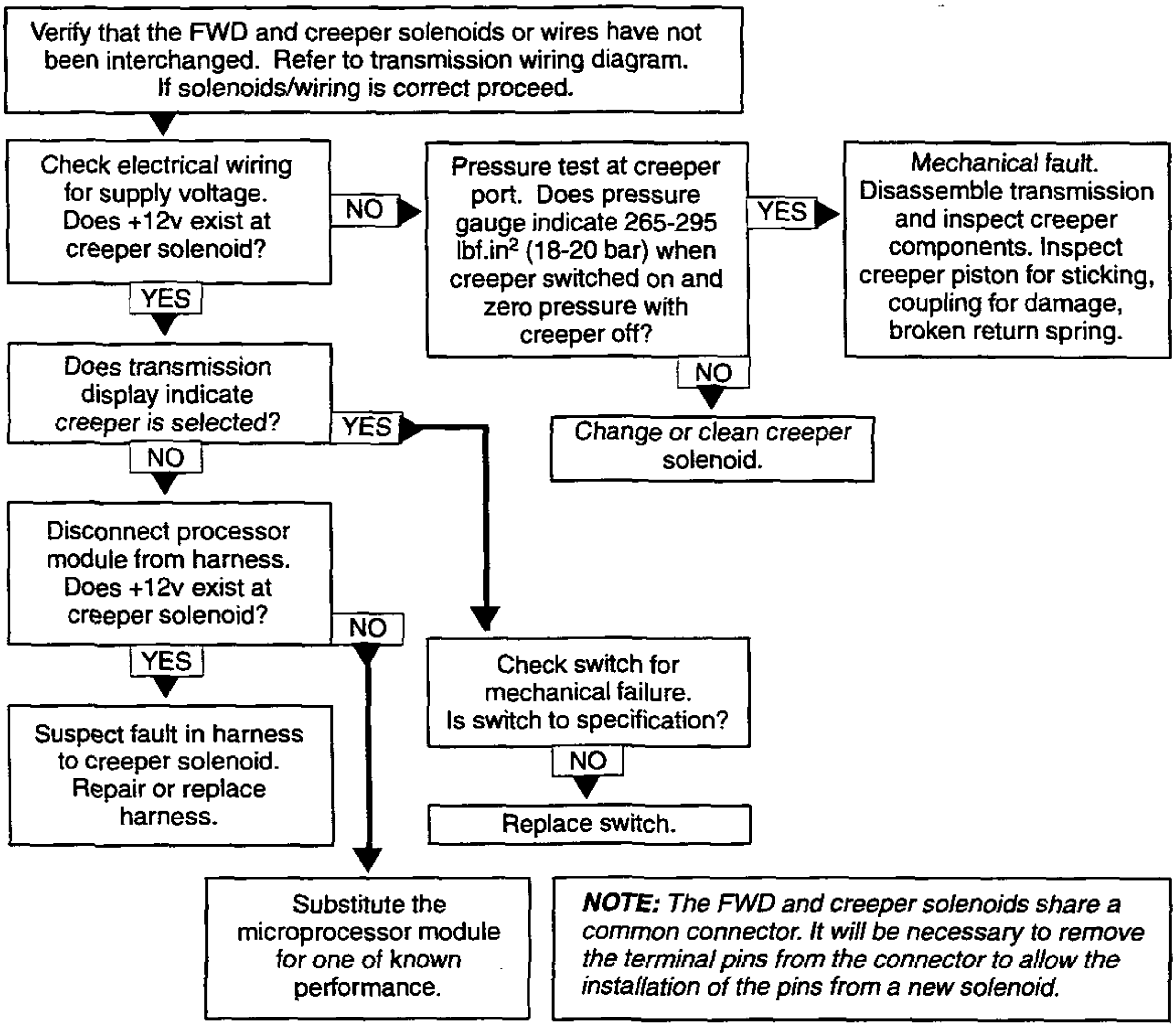


Diagram 10: The tractor drives in all gears and all ranges but has the following fault.

Clutches squeal/whine during inching.

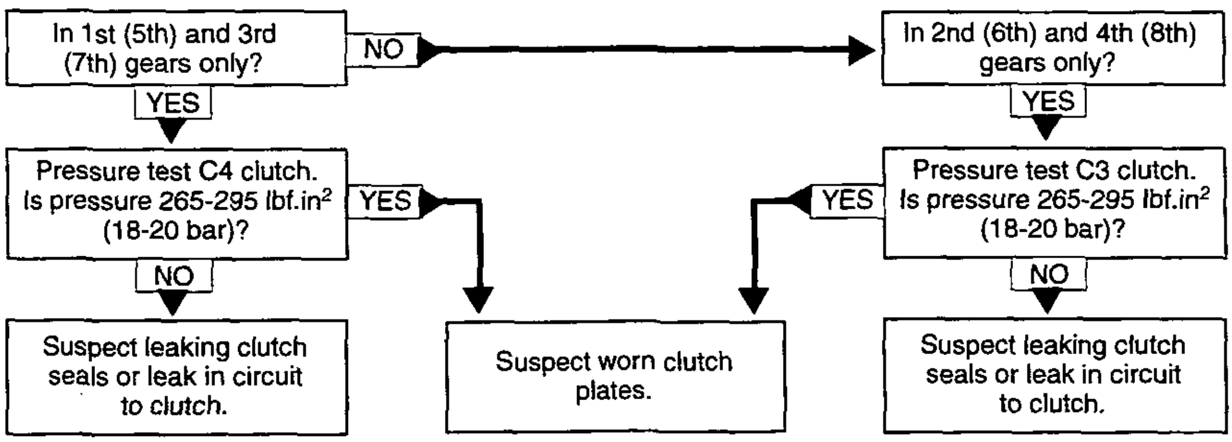


Diagram 11: The tractor drives in all gears and all ranges but has the following fault.

The transmission is noisy in operation.

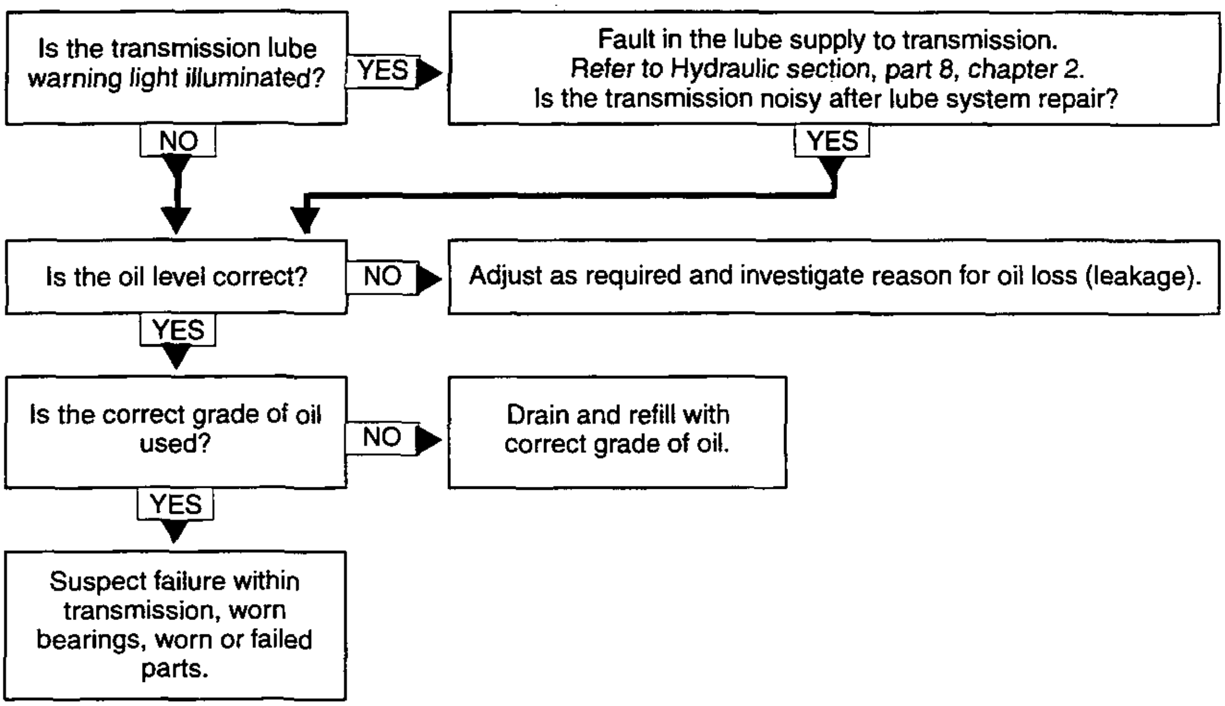


Diagram 12: The tractor drives in all gears and all ranges but has the following fault.

Transmission clunks during inching.

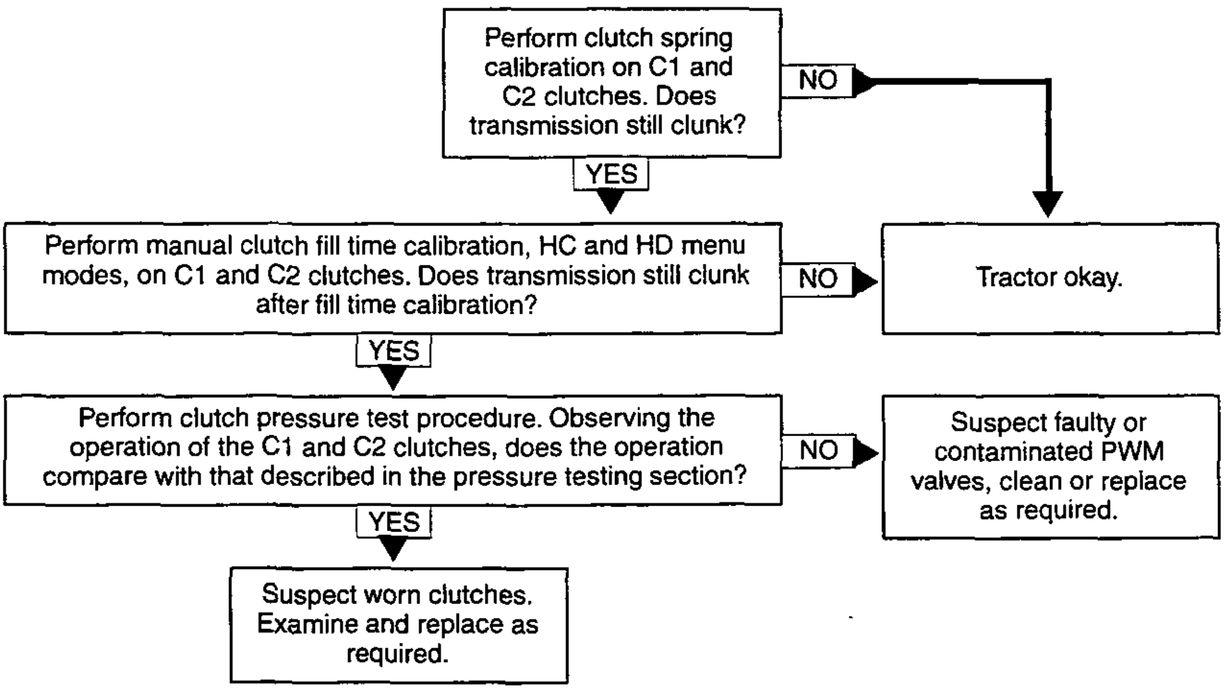


Diagram 13: The engagement of the clutchless shuttle is delayed or aggressive.

Is Transmission Error Code E49 displayed when the key start is switched ON?

YES → Diagnose Transmission Error Code E49 using diagram 29.

NO → Diagnose using fault finding diagram for "Poor Clutch Feathering" (Diagram 4).

Diagram 14: Error Code E34 displayed - Harness disconnected

Inspect processor to extension harness connector C20.

Diagram 15: Error Code E34 *(NOTE: this will not be displayed)* - Fuse 13 blown

Replace Fuse 13 (15 amp). Operate tractor. Does fuse blow again?

NO → Fuse possibly failed due to fatigue. Examine wiring as detailed below to ensure okay.

YES → With key start OFF, *disconnect C127 from the* processor. Check with a multimeter between C127-34 (U/R/B) and Earth. Is a short circuit indicated in either instance?

NO → Suspect faulty processor module. Replace with one of known performance.

YES → Disconnect C185 connector. Repeat previous tests. Is a short circuit indicated?

YES → Locate short circuit between C127 and C185 connectors.

NO → Locate short circuit between C185-9 (B/LN) and Fuse 13. Note; clutch pedal switch, pin 2 is also part of the circuit.

Diagram 16: Error Code E11 - Clutch potentiometer voltage below valid range
Error Code E12 - Clutch potentiometer voltage above valid range

	NO
Check operation of potentiometer, remove left hand lower side panel below instrument cluster to expose potentiometer and wiring. Disconnect plug to potentiometer and check operation of potentiometer between the orange and green wires. With pedal released, is resistance between 3.1kΩ and 3.9kΩ gradually changing to between 640Ω and 2.1kΩ as the clutch pedal is depressed?	Replace potentiometer as required.
YES ▼	
Disconnect the processor module connectors C127 and C128 and connect an ohmmeter between pin 2 (tan) and pin 3 (black) or harness connector to potentiometer and then between pin 1 (yellow/red/black) and pins 2 and 3. Is an open circuit indicated?	Trace and repair short circuit.
YES ▼	
Connect an ohmmeter between pin 1 (yellow/red/black) of harness connector to potentiometer and ground. Is an open circuit indicated?	Trace and repair short to ground.
YES ▼	
Connect an ohmmeter between pin 2 (tan) of harness connector to potentiometer and ground. Is an open circuit indicated?	Trace and repair short to ground.
YES ▼	
Connect an ohmmeter between pin 3 (black) of harness connector to potentiometer and ground. Is an open circuit indicated?	Trace and repair short to ground.
YES ▼	
Reconnect the processor module. With the key start ON, is the voltage at pin 2 (tan) 5 volts?	Check continuity of wire from pin 2 to C127-5 (LN).
YES ▼	
Check continuity of wire from pin 1 to C128-19 (Y/R/B) and continuity of wire from C128 -1 (S/N/B) to pin 3. Are both wires okay?	Trace and repair open circuits as required.
YES ▼	
Suspect faulty EDC module. Replace with a module of known performance.	

Diagram 17: Error Code E53 - 5 volt reference failed, shorted to 12 volts
Error Code E54 - 5 volt reference failed, shorted to earth

	YES
Disconnect the clutch pedal potentiometer. Does the error code clear?	Replace the clutch pedal potentiometer or diagnose using fault finding diagrams for transmission error codes E11 and E12.
NO ▼ Disconnect the EDC control knob panel. Does the error code clear?	Replace the EDC control panel.
NO ▼ Disconnect the EDC rocker shaft potentiometer. Does the error code clear?	Replace the rocker shaft potentiometer or diagnose using diagrams for EDC error codes 27 and 28. Refer to part 8 of the Repair Manual.
NO ▼ Disconnect quadrant potentiometer. Does the error code clear?	Replace the rocker shaft potentiometer or diagnose using diagrams for EDC error codes 25 and 26. Refer to part 8 of the Repair Manual.
NO ▼ Replace the micro processor module with a unit of known performance. Does the error code clear?	Replace the micro processor module. Clear the module's memory using service mode H8. Recalibrate the transmission and EDC systems.

NO ▼

Trace and repair a short circuit to either earth or 12 volts, in the harness between C127-5 (LN) and either the clutch pedal potentiometer, EDC quadrant potentiometer or the EDC rock shaft potentiometer.

Diagram 18:

Error Code E37 displayed - Clutch disconnect switch open circuit

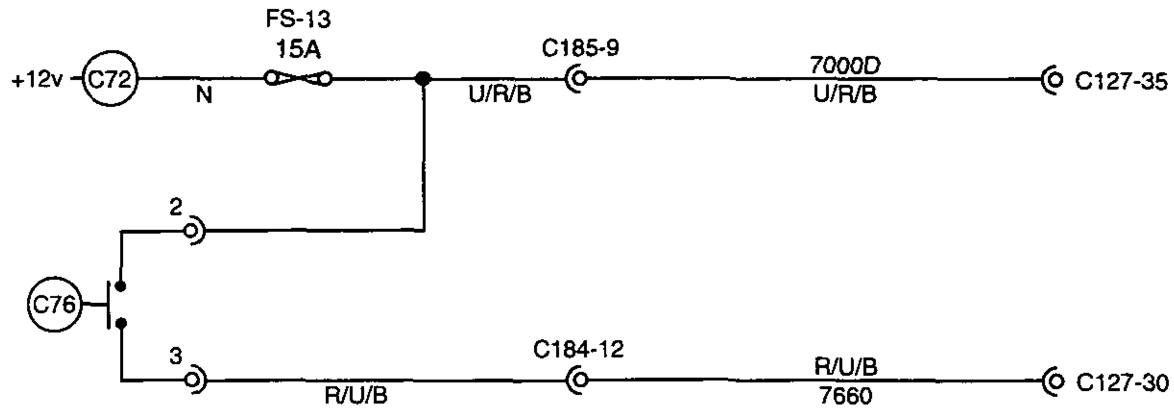
Check switch adjustment and switch operation, if okay trace break in wiring (open circuit).

Error Code E48 displayed - Clutch disconnect switch short circuit

Check switch adjustment and switch operation, if okay trace short circuit in wiring.

Error Code E47 displayed - Clutch disconnect switch maladjusted high

Check switch adjustment and operation of switch.



NOTE: *With each of these error codes also check that the clutch potentiometer operates over the full range using service mode HA. If the range is not 0-99 then refer to 'Clutch Potentiometer Calibration' diagram 5.*

Diagram 19: Circuit Faults - PWM Solenoids

Error Code E38 displayed - C4 [C25] PWM solenoid wiring short circuit
Error Code E39 displayed - C4 [C25] PWM solenoid wiring open circuit
Error Code E40 displayed - C3 [C26] PWM solenoid wiring short circuit
Error Code E41 displayed - C3 [C26] PWM solenoid wiring open circuit
Error Code E42 displayed - C2 [C27] PWM solenoid wiring short circuit
Error Code E43 displayed - C2 [C27] PWM solenoid wiring open circuit
Error Code E44 displayed - C1 [C28] PWM solenoid wiring short circuit
Error Code E45 displayed - C1 [C28] PWM solenoid wiring open circuit

Error codes E38 through to E45 indicate either a short or open circuit in the wiring of one of the PWM solenoids. Using a suitable multi-meter check the wiring from the PWM solenoid back to the processor module. Locate the short/open circuit and repair or replace wiring as necessary.

If wiring is okay, disconnect the PWM solenoid from the harness and check that the resistance of the PWM coil is approximately 10 ohms at 20°C. If not, replace the PWM solenoid.

If wiring and PWM solenoids are okay, replace the microprocessor with one of known performance.

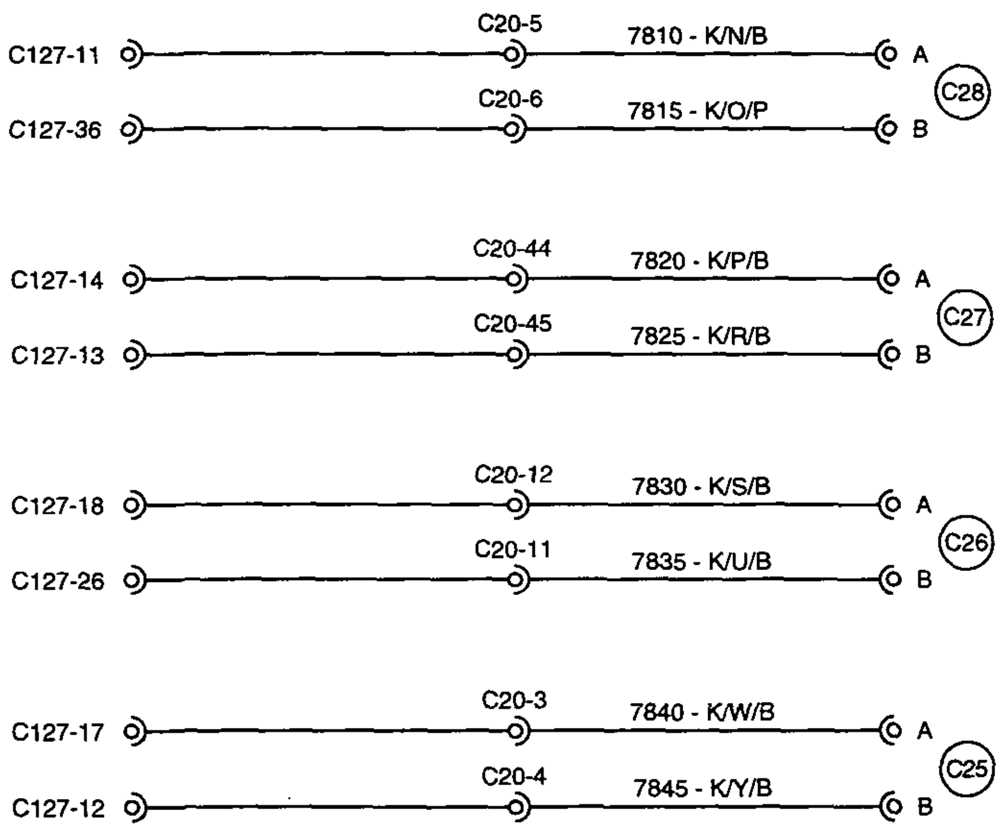
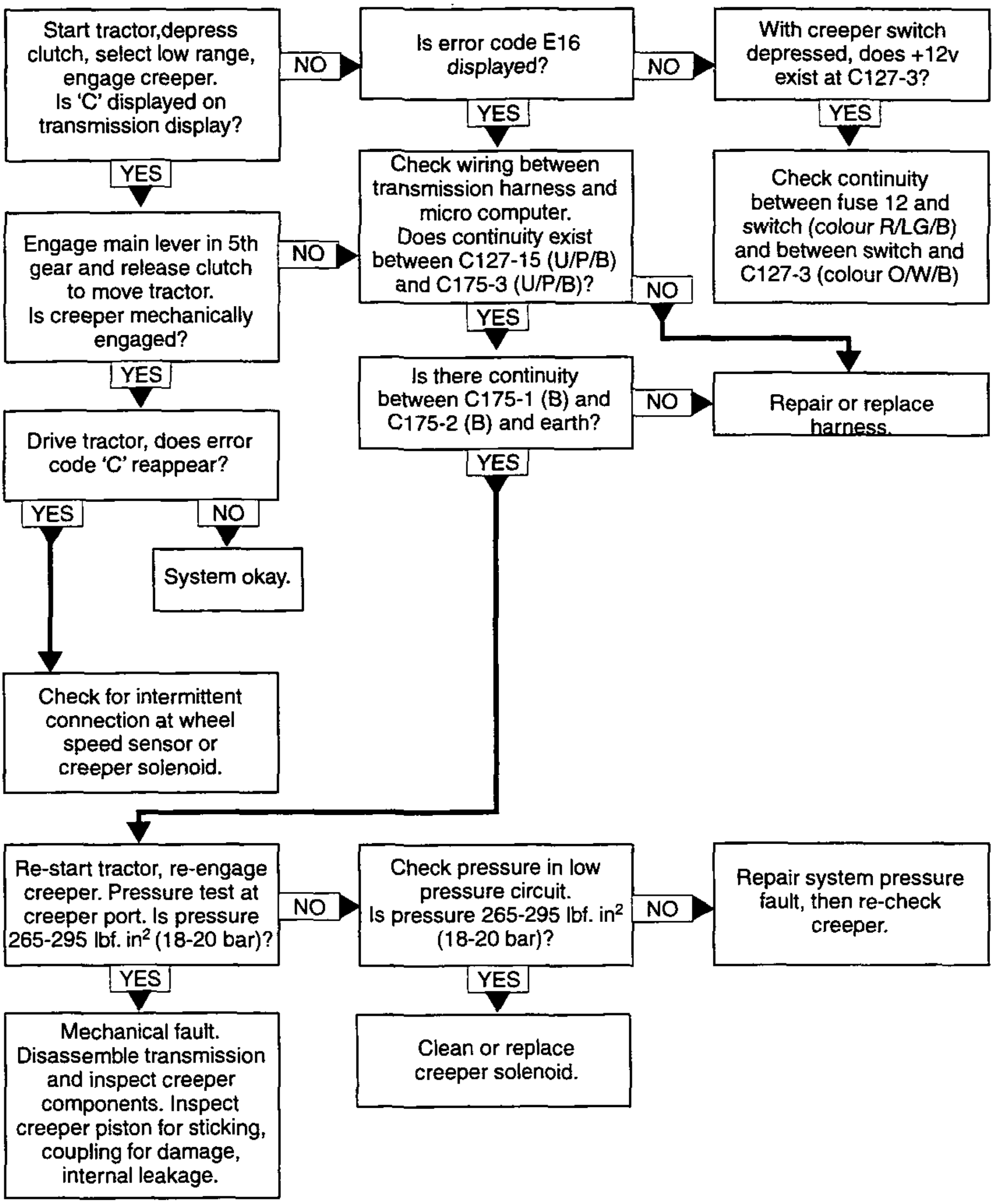


Diagram 20: The creeper does not engage in low range - possibly error code E16 or Symbol 'C' displayed



NOTE: *The FWD and creeper solenoids share a common connector. It will be necessary to remove the terminal pins from the connector to allow the installation of the pins from a new solenoid.*

Diagram 21: The high/low range lever can be shifted to high range when creeper is engaged - possibly error code HC displayed

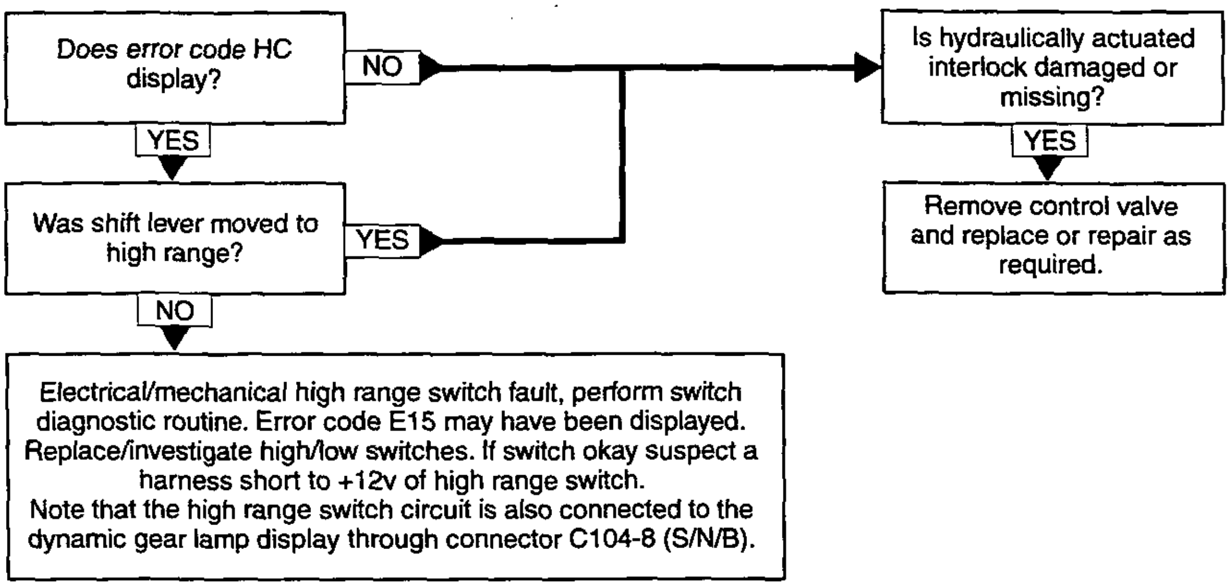


Diagram 22: Error code CP displayed - depress clutch pedal to re-enable *transmission.*

Has tractor been shifted from neutral with clutch pedal released, or engine restarted with shift lever in gear after stall?

YES → Depress clutch pedal or depress shuttle dump switch with FNR lever in neutral to re-enable transmission.

NO ↓

Inspect for loose harness connectors at C127, C128, C185, C20 and C1. Are any connections loose?

YES → Inspect connector and ensure a tight fit. Is error code eliminated?

- YES → Test drive tractor to ensure error code does not re-appear.
- NO ↓

NO ↓

Check for an intermittent short to ground on the neutral start switch wiring:
With the key start OFF and the FNR lever in either F or R, connect a continuity meter between connector C128-27 (W/R) *and ground. An open circuit should be indicated. Twist the* harness from C128 and down to the neutral start switch.
Is continuity indicated at any time?

YES → Locate and repair short circuit.

NO ↓

Check for an intermittent short to ground on the neutral start switch wiring:
With the key start OFF and the FNR lever in N, connect a continuity meter between connector C128-27 (W/R) and C1-E (W/R). Continuity should be indicated.
Twist the harness from C128 down to C1.
Is an open circuit indicated at any time?

YES → Locate and repair open circuit.

NO ↓

Check for an intermittent fault in +12v supply to processor module. Check for continuity between fuse 13 output and C127-34 (U/R/B) and C127-35 (U/R/B). Is an open circuit indicated at any time?

YES → Locate and repair open circuit.

NO ↓

Check for an intermittent fault in ground wiring to ETC module. Check for continuity between C128-32 (LN/O/B), C128-33 (LN/LG) and C127-9 (B) and ground. Is an open circuit indicated at any time?

YES → Locate and repair open circuit.

NO ↓

Remove and inspect the neutral start switch. Replace with a switch of known performance. Test drive tractor.
Is error code eliminated?

YES → Discard removed switch.

NO ↓

Suspect fault with rail in transmission top cover.
Remove top cover and inspect.

Diagram 23: Error code E46 displayed - Fuse 12 blown.

No power to switches, 1-4/5-8/shuttle dump/high range/low range/powershift up-down and gearshift display module.

Is fuse 12 blown?

- NO → Disconnect C128 from the processor and confirm continuity between fuse 12 and C128-7 (R/LG/B). If no continuity exists, trace and repair the open circuit.
- YES ↓

Replace fuse 12 (10 amp). Operate tractor. Does fuse blow again?

- NO → Fuse may have failed through fatigue, check wiring to ensure *there is no intermittetr fault.*
- YES ↓

Ensure key start is OFF and fuse 12 is removed. Disconnect C128 from the processor. With a suitable multi-meter check between C128-7 (R/LG/B) and earth. Is a short circuit indicated?

- NO → Inspect harness, twist harness with meter still connected to ensure no intermittent fault. If no intermittent fault is found, check with meter between C128-7 (R/LG/B) and other C127/ C128 terminals. If an open circuit is indicated, trace and repair the fault in the harness.
- YES ↓

Disconnect connector C184, is a short circuit still indicated between C128-6 and earth?

- YES ↓ With the multi-meter still connected between C128-7 and earth, and C184 disconnected, disconnect connectors C104, C103 and the shuttle dump switch connector C196. Observe the meter while disconnecting, if continuity to earth is broken after a connector is disconnected, fault lies within that circuit. If continuity still exists, fault lies in harness. Inspect harness, repair or replace faulty wiring.
- NO ↓ Connect meter between C184-13 and earth. Is continuity indicated?
  - NO → Inspect connector, ensure it is clean and undamaged.
  - YES ↓ Disconnect C20 connector. Is continuity still indicated?
    - NO → Trace and repair short circuit between C20-12 (U/LG/B) and switches.
    - YES ↓ Trace and repair short between C184-13 (R/LG/B) C20-12 (U/LG/B) and fuse 12.

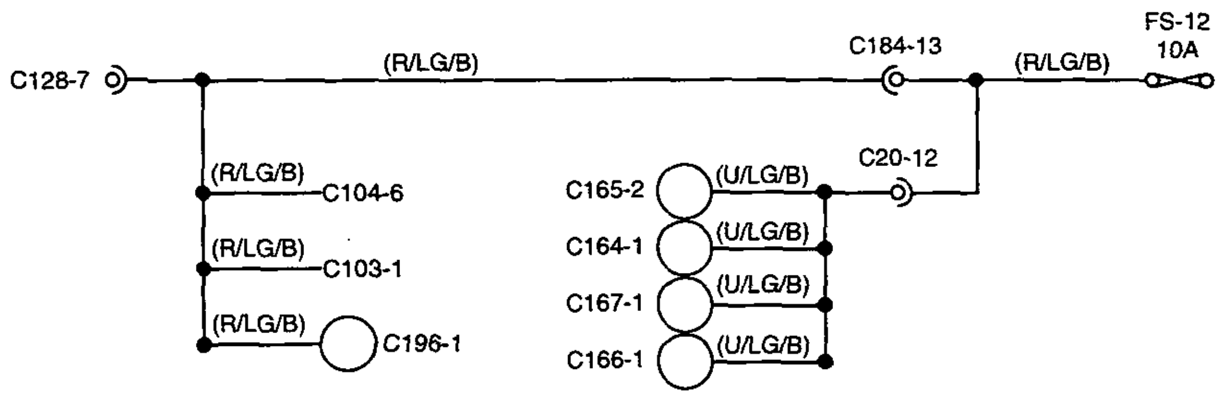


Diagram 24: Error Codes E51 and E52 displayed

Transmission oil temperature wiring open circuit or short circuit.

With suitable multi-meter check oil temperature sender wiring for open/short circuit. repair/replace wiring as required.

If wiring is okay, verify that the oil temperature sender resistance is correct as detailed in the specification section.

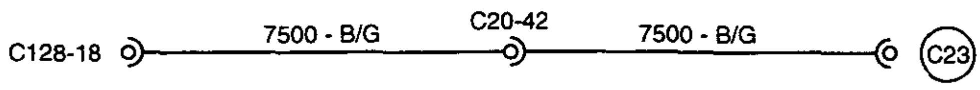


Diagram 25: Error Code E24 - all clutches not calibrated
Error Code EC4 - clutch 4 not calibrated
Error Code EC3 - clutch 3 not calibrated
Error Code EC2 - clutch 2 not calibrated
Error Code EC1 - clutch 1 not calibrated

Perform spring calibration procedure to clear error.

Diagram 26: Error code E15 displayed - high/low switches both on

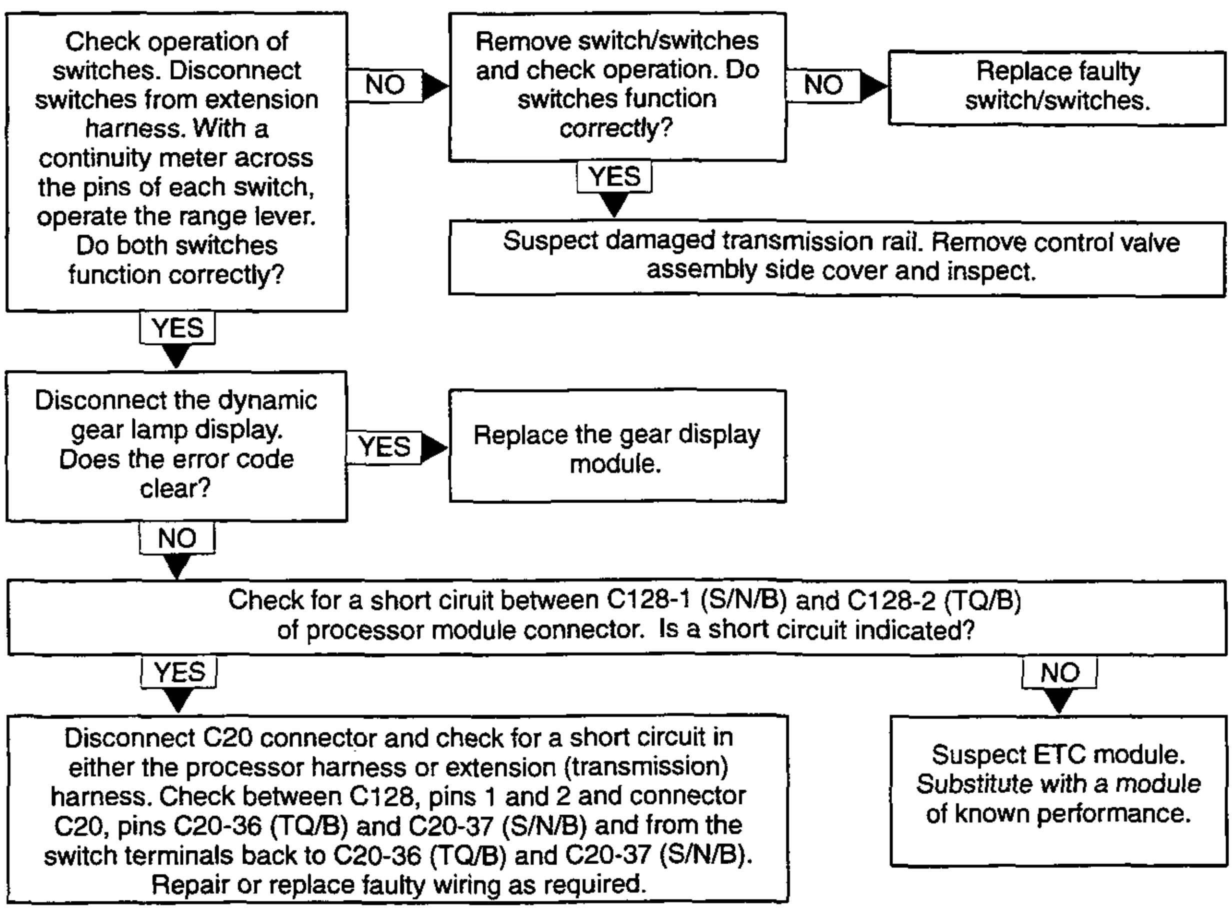


Diagram 27: Error code E13 displayed - up/downshift switches both on

Check operation of switches. Disconnect connector C103 from switch wiring. Check for correct switch operation with a continuity meter between pin 1 (common) and pin 4 (down) and 5 (up). Do both switches function correctly?

YES → Replace faulty switch/switches.

NO ↓

Disconnect connector C128 from the processor module. With connector C103 disconnected, check for a short cicuit between C128-24 (S/K/B)[down] and C128-5 [up]. Is a short circuit indicated?

YES → Locate and repair or replace faulty wiring.

NO ↓

Check for a short circuit between pin 1 and pin 4 and between pin 1 and pin 5 of the C103 (S/LG/B) connector. Is a short circuit indicated?

YES → Locate and repair or replace faulty wiring.

NO ↓

Suspect ETC module. Substitute with a module of known performance.

Diagram 28: Error code E14 displayed - 1-4/5-8 switches both on

Check operation of switches. Disconnect connector C128 from processor module and remove fuse 12. With the key start OFF connect a continuity meter between C128-3 (U/N/B) and output side of fuse, move main lever into 1-4 position. Repeat above operation from C128-4 (U/N/B) and selecting 5-8 position on main lever. Does meter indicate switches operating correctly?

NO → Remove switch/switches and check operation. Do switches function correctly?

- NO → Replace faulty switch/switches.
- YES ↓ Suspect damaged transmission rail. Remove transmission top cover and inspect.

YES → Disconnect the dynamic gear lamp display. Does the error code clear?

- YES → Replace the gear display module.
- NO ↓

Check for a short ciruit between C128-3 and C128-4. Is a short circuit indicated?

YES ↓ Disconnect C20 connector and check for a short circuit in either the processor harness or extension (transmission) harness. Check between C128-3 and C128-4 and connector C20-4 (K/Y/B) and C20-5 (K/N/B) and from the switch terminals back to C20-4 and C20-5. Repair or replace faulty wiring as required.

NO ↓ Suspect ETC module. Substitute with a module of known performance.

Diagram 29: Error Codes E49

Wheel speed sensor open or short circuit

Disconnect processor connectors C128 and C127 and disconnect the wheel speed sender connector. Test the wiring for open/short circuit and repair as required. If wiring checks out okay, test wheel speed sender.

▼

With the sender installed in the transmission, check for a short to earth on each sender terminal, check resistance of the sender, which should be approximately 2500 ohms at 20°C. Replace if outside specification.

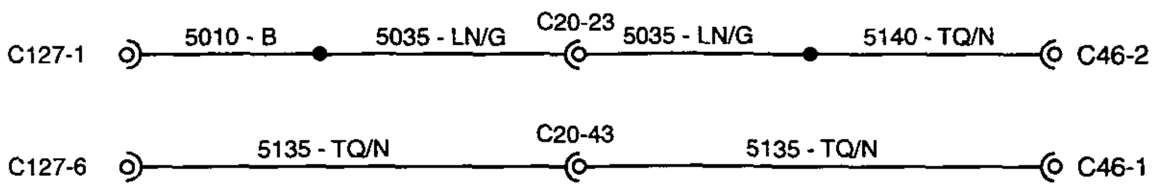


Diagram 30: Error code E26 displayed - ERPM signal too high

Connect a volt meter between the alternator speed connector and ground. Is there approximately 7 volts?

NO ▶ Repair or replace alternator.

YES ▼

The following checks must be carried out with the engine stopped and key start switched OFF.

Suspect an intermittent fault. With an ohm meter connected between C128-34 (W/S) and the alternator speed connection, twist the wiring harnesses along their length, especially near to the connectors. Does the resistance change?

YES ▶ Locate and repair intermittent short circuit to ground.

NO ▼

Suspect an intermittent fault to ground. With an ohm meter connected between C128-34 (W/S) and ground and the alternator speed connector disconnected, twist the wiring harnesses along their length, especially near to the connectors. Does the meter indicate a short to ground?

YES ▶ Locate and repair intermittent short circuit to ground.

NO ▼

Suspect ETC module, substitute with a module of known performance.

Diagram 31: Error code E27 displayed - ERPM signal not present

Is the alternator drive belt broken?
YES → Replace drive belt.
NO ↓

Establish if there is a speed output from the alternator. *Connect a volt meter between the alternator speed connector* and ground. Is there approximately 7 volts when the engine is running?
NO → Repair or replace alternator.
YES ↓

The following checks must be carried out with the engine stopped and key start switched OFF.

Check alternator wiring for continuity: Disconnect connector C128 from processor module and check between C128-34 (W/S) and alternator speed sender connection. Is resistance less than 10 *ohms?*
YES → Check for short circuit in wiring. With C128 disconnected and alternator wire disconnected, check resistance to ground from pin C128-34 (W/S). Is resistance less than 10 ohms?
- YES → Locate and repair short circuit to ground.
- NO → Suspect ETC module. Substitute with a module of known performance.

NO ↓

Check for continuity between C185-1 (W/S) and C1-F (W/S). Is wire okay?
NO → Locate and repair open circuit.
YES ↓

Check for continuity between alternator connector and C1-F (W/S). Is wire okay?
NO → Locate and repair open circuit.

Diagram 32 - Error Code H

Clutchless shuttle operation attempted at too high a speed and in too high a gear.

To reduce clutch damage from shifting in too high a gear or at too high a speed, a warning bleeper and symbol 'H' are activated under the following conditions:

- In high range 5-8 gears, shuttling while tractor is still rolling.
- In high range 2-4 gears, shuttling while tractor is rolling faster than 9 km/h (5.5 mph)

Important: *The clutchless shuttle will still operate under the warning conditions.*

Limp Home Procedure

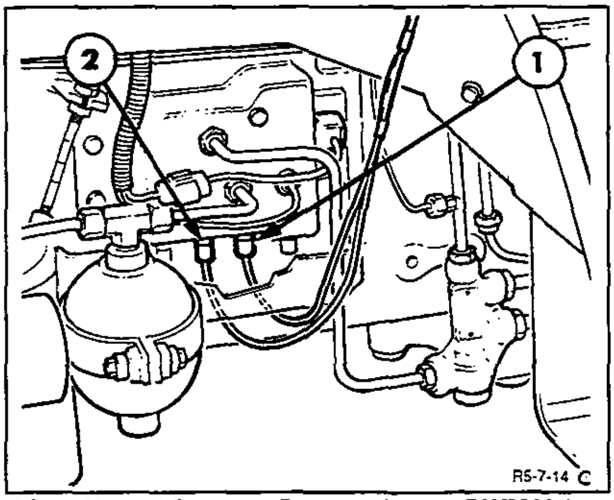
In the unlikely event of an electrical fault developing within the powershift transmission that renders the tractor immobile, for example, failure of the wiring or supply voltage to the PWM valves, the emergency "Limp Home Harness", Special Tool No. 4FT 952A, for 'Quad-Mod' transmissions, is available to enable the tractor to be driven onto a transporter or hard standing, in order that the repair can be carried out in a suitable location. The Limp Home device is not, and must not be used as, a means to continue operating the tractor in its work environment.

To engage and operate the 'Limp Home Harness' proceed as follows:-

1. Apply the parking brake.
2. Stop the engine and turn the key start OFF.
3. Disconnect all of the PWM valve connectors. Connect the 'Limp Home Harness' extension connectors to the fuse box.
4. Connect the other end of the 'Limp Home Harness' to the 'C125' diagnostic plug located adjacent to the fuse box.
5. Place the range lever into Low Range and the main lever into the 1-4 Range. Ensure the forward/reverse lever is in neutral.

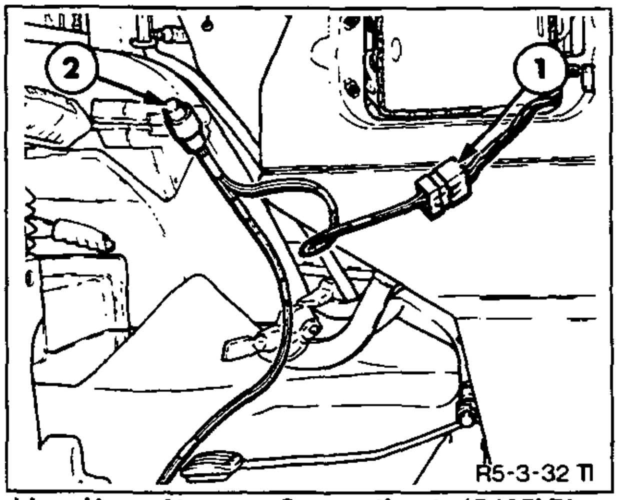
NOTE: *It is important that only the lowest ranges are used when operating with the 'Limp Home Harness' due to the feathering capability of the transmission being inoperative.*

6. Start the vehicle.
7. Select forward or reverse.
8. Operate the momentary switch of the 'Limp Home Harness' to move the vehicle. If necessary, depress the foot throttle to increase engine speed.
9. When the tractor has been delivered to the repair area, disconnect the 'Limp Home Harness' and reconnect the PWM valve connectors and proceed with diagnosing and repairing the fault.



Limp Home Harness Connection to PWM Valve

1. Harness connected to C2 [C27] PWM Valve Solenoid
2. Harness connected to C3 [C26] PWM Valve Solenoid



Limp Home Harness Connection to 'C125' Plug

1. Harness connected to Diagnostic Plug C125
2. Push Button Momentary Switch

C. 12 x 12 DUAL POWER FAULT FINDING CHARTS

12 x 12 Dual Power Error Codes

Error Code	Fault Condition for 12 x 12 Dual Power Transmission	Priority	Disable Trans	Display Mode
E21	Chassis harness disconnected	1	Disable	Latched
E34	Fuse 13 blown	2	Disable	Latched
E36	12 x 12 dump solenoid open circuit	3	Disable	Latched
E35	12 x 12 dump solenoid closed circuit	4	Disable	Latched
E53	5 volt reference failed, shorted to 12 volts	5	Disable	Latched
E54	5 volt reference failed, shorted to ground	6	Disable	Latched
E12	12 x 12 clutch pedal potentiometer signal too high	7	Disable	Latched
E11	12 x 12 clutch pedal potentiometer signal too low	8	Disable	Latched
E37	12 x 12 clutch disconnect switch open circuit	9	Disable	Latched
CP	Depress clutch pedal to enable transmission	10	Disable	Latched
E39	12 x 12 C2 (High) clutch solenoid open circuit	11	Disable	Latched
E38	12 x 12 C2 (High) clutch solenoid short circuit	12	Disable	Latched
E41	12 x 12 C1 (Low) clutch solenoid open circuit	13	Disable	Latched
E40	12 x 12 C1 (Low) clutch solenoid short circuit	14	Disable	Latched
E46	12 x 12 fuse 12 blown	15	Enabled	Latched
E47	12 x 12 clutch disconnect switch misadjusted high	16	Enabled	Latched
E48	12 x 12 clutch disconnect switch short circuit	17	Enabled	Latched
E51	Transmission temperature sensor open circuit	18	Enabled	Latched
E52	Transmission temperature sensor short circuit	19	Enabled	Latched
E24	Both clutches not calibrated	20	Enabled	Latched
E Hi	C2 (Hi) clutch no calibrated	21	Enabled	Latched
E Lo	C1 (Lo) clutch not calibrated	22	Enabled	Temp
E13	Up and down switches both on	23	Enabled	Temp
E49	Wheel speed sensor ciurcuit open or short circuit	24	Enabled	Temp
E26	Engine rev/min speed too high	25	Enabled	Temp
E27	Engine rev/min speed too low	26	Enabled	Temp

Error Code Table Explanations:

Priority - The error codes are listed in a priority order. Number 1 priority being the most serious fault and number 26 being considered the least serious of errors, i.e, if more than two errors occur the highest priority error will be displayed.

Disable Trans - This column of the table indicates whether the transmission is either **disabled,** i.e, not allowed to function or **enabled**, i.e, there is a fault within the transmission but it is still allowed to function.

Display Mode - This refers to the instrument panel display. **Latched** means that the error code will remain displayed until the fault is rectified. **Temp** (Temporary) means the error code will display temporarily and will then extinguish, but will be stored in the error code memory for retrieval at a later stage.

Error Code Wiring Circuits

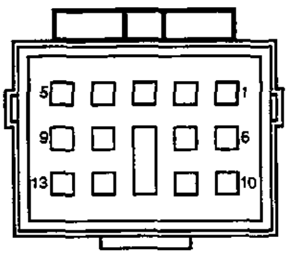
Key to Colours

B	Black	G	Green
N	Brown	LG	Light Green
LN	Tan	U	Blue
S	Slate	TQ	Turquoise
R	Red	P	Purple
O	Orange	K	Pink
Y	Yellow	W	White

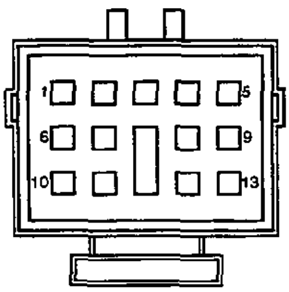
Abbreviations used in wiring circuits

K.S.	= Key Start Switch
FS	= Fuse
CN1 or 2	= Microprocessor Connectors
D.S.	= Dump Solenoid
C.Pot	= Clutch Potentiometer
C.P.S.	= Clutch Pedal Switch
N.C.	= Normally Closed
W.S.S.	= Wheel Speed Sensor
S.M.R.	= Starter Motor Relay
N.S.S.	= Neutral Start Switch
T.S.	= Transmission Temperature Sender

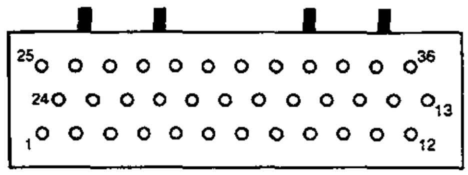
Connector Identification



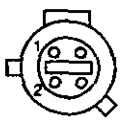
C19, C20, C104, C125, C184, C185
Female Connectors



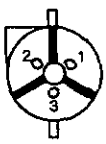
C19, C20, C104, C125, C184, C185
Male Connectors



C127 & C128 Micro-processor



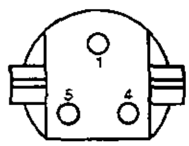
Dump
Solenoid



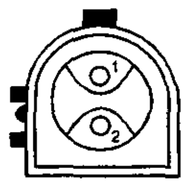
Clutch
Potentiometer

Clutch
Switch

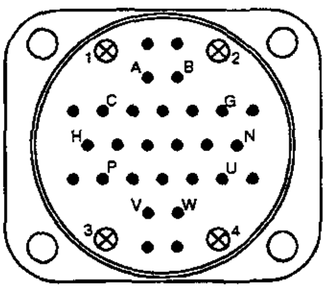
PWM
Solenoids



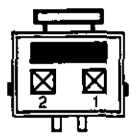
C103 - Gear Shift



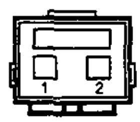
C046 - Wheel Speed Sensor



C1 - Engine Harness



C121 Male Connector

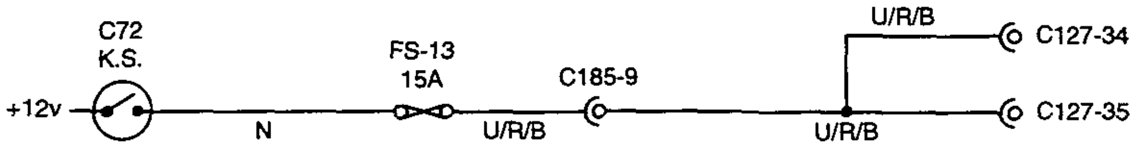


C121 Female Connector

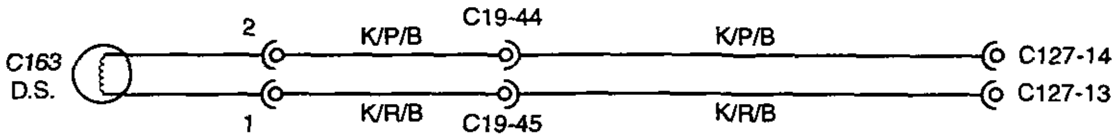
Error Code E21 displayed - Chassis Harness Disconnected

Inspect main harness connectors

Error Code E34 displayed - Fuse 13 Blown



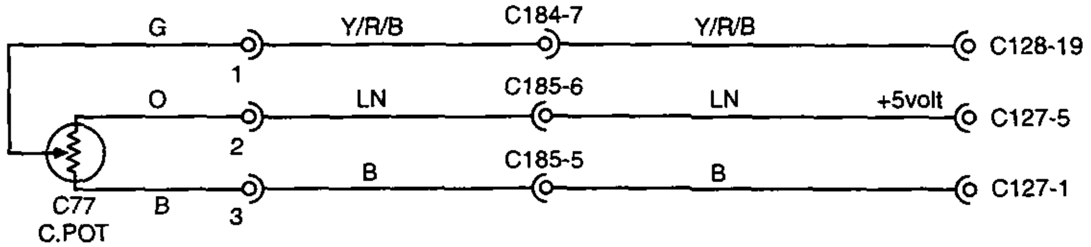
Error Code E35 displayed - Dump Solenoid Closed Circuit
Error Code E36 displayed - Dump Solenoid Open Circuit



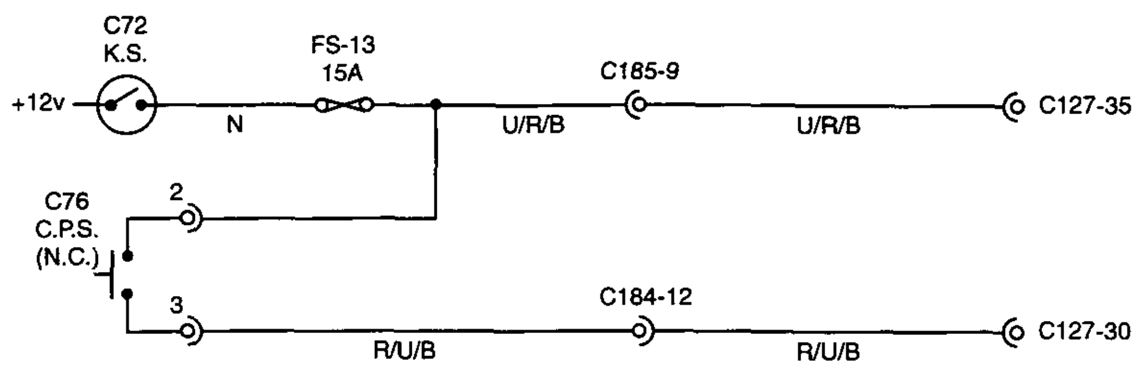
Error Code E53 displayed - 5 Volt Reference Failed, Shorted to +12 v
Error Code E54 displayed - 5 Volt Reference Failed, Shorted to Ground

Error Code E12 displayed - Clutch Pedal Potentiometer Signal Too High
Error Code E11 displayed - Clutch Pedal Potentiometer Signal Too Low

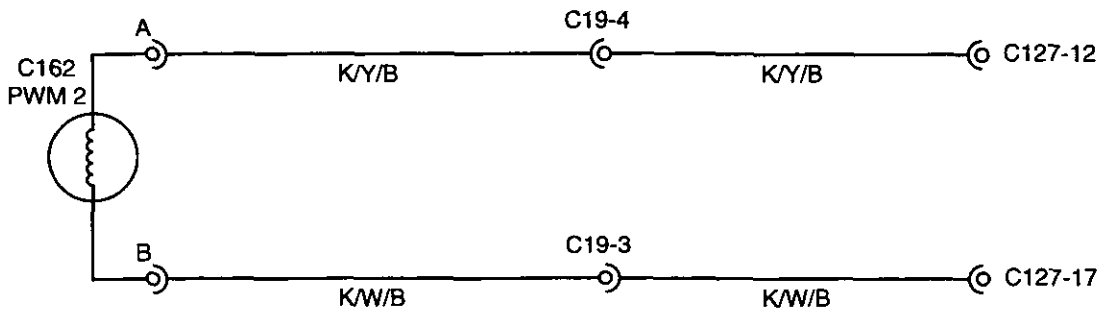
1. Inspect circuit connectors for corrosion, high resistance, (E54)
2. Inspect circuit for short circuit to +12 volt (E53)
3. Inspect circuit for short circuit to ground (E54)
4. Disconnect potentiometer and check operation with an ohm meter.



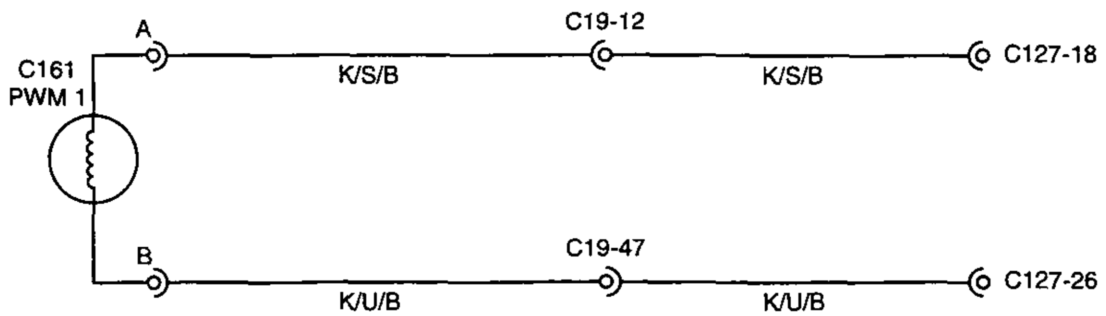
Error Code E37 displayed - Clutch Disconnect Switch Open Circuit
Error Code E48 displayed - Clutch Disconnect Switch Short Circuit
Error Code E47 displayed - Clutch Disconnect Switch Misadjusted High (Adjust Switch)



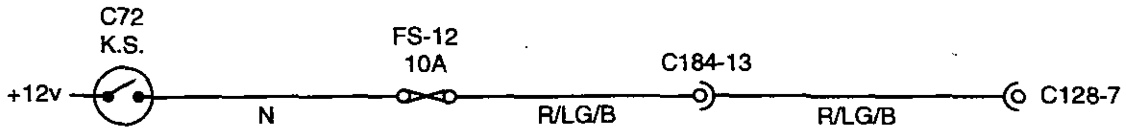
Error Code E38 displayed - C2 (PWM 2) Solenoid Short Circuit
Error Code E39 displayed - C2 (PWM 2) Solenoid Open Circuit



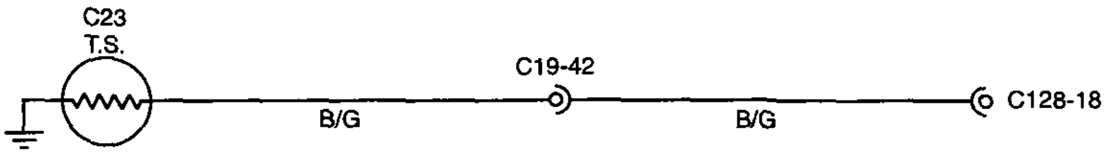
Error Code E40 displayed - C1 (PWM 1) Solenoid Short Circuit
Error Code E41 displayed - C1 (PWM 1) Solenoid Open Circuit



Error Code E46 displayed - Fuse 12 Blown



Error Code E51 displayed - Transmission Temperature Sensor Open Circuit
Error Code E52 displayed - Transmission Temperature Sensor Short Circuit



Error Code E24 displayed - Both Clutches Not Calibrated

1. Perform spring pressure calibration on both clutches

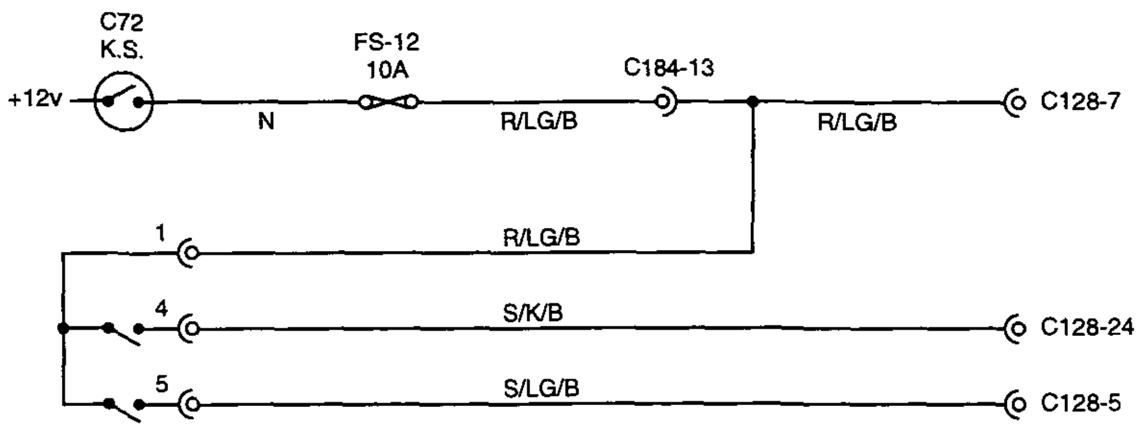
Error Code E Hi displayed - Hi (C2) Clutch Not Calibrated

1. Perform spring pressure calibration on Hi (C2) clutch

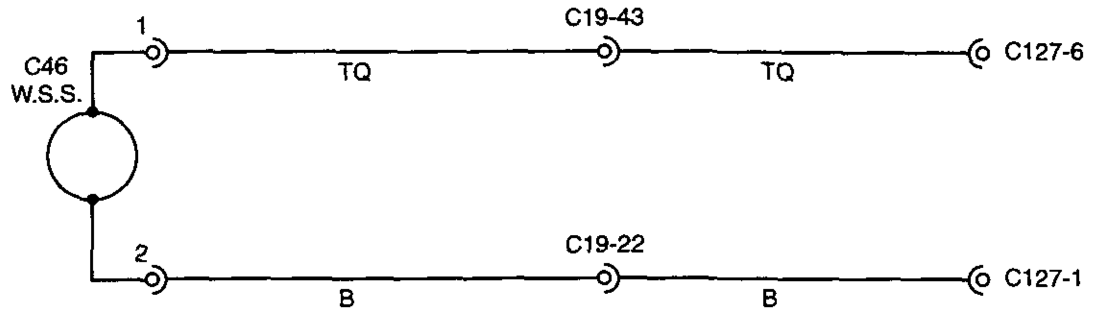
Error Code E Lo displayed - Lo (C1) Clutch Not Calibrated

1. Perform spring pressure calibration on Lo (C1) clutch

Error Code E13 displayed - Direct Drive / Under Drive Switches Both ON

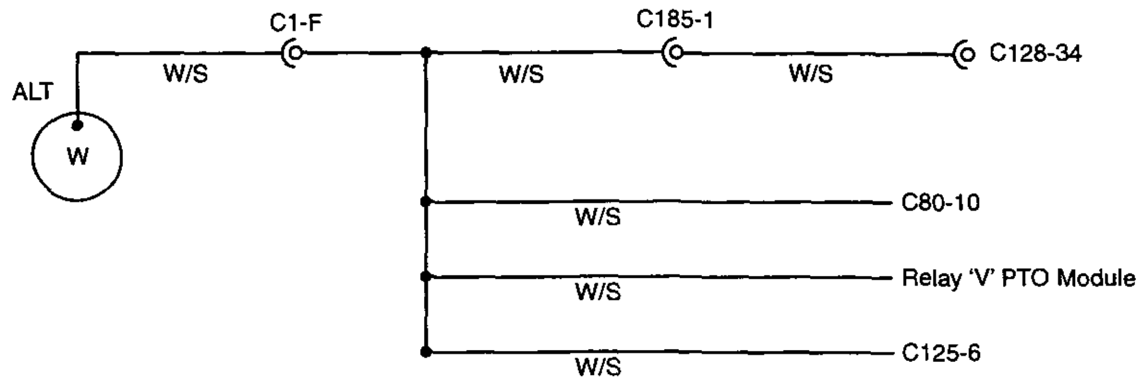


Error Code E49 displayed - Wheel Speed Sensor Circuit, Open or Short Circuit

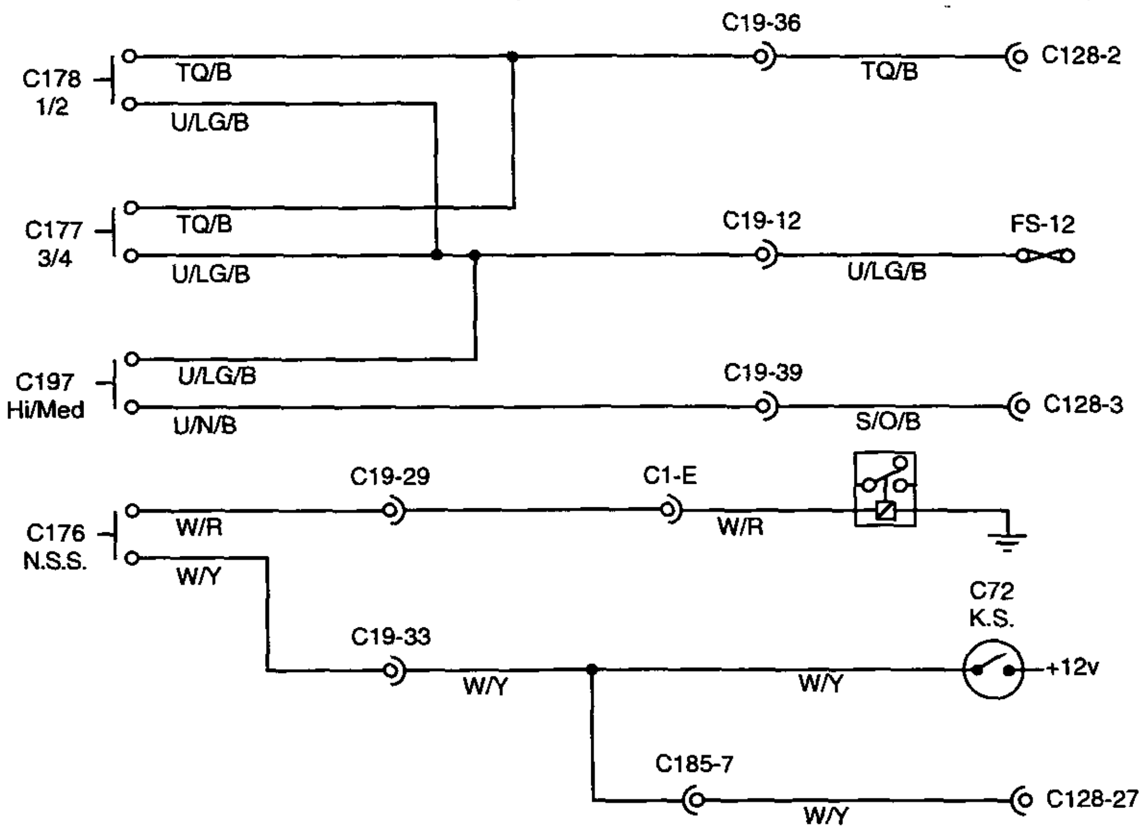


Error Code E26 displayed - Engine rev/min Too High
Error Code E27 displayed - Engine rev/min Too Low

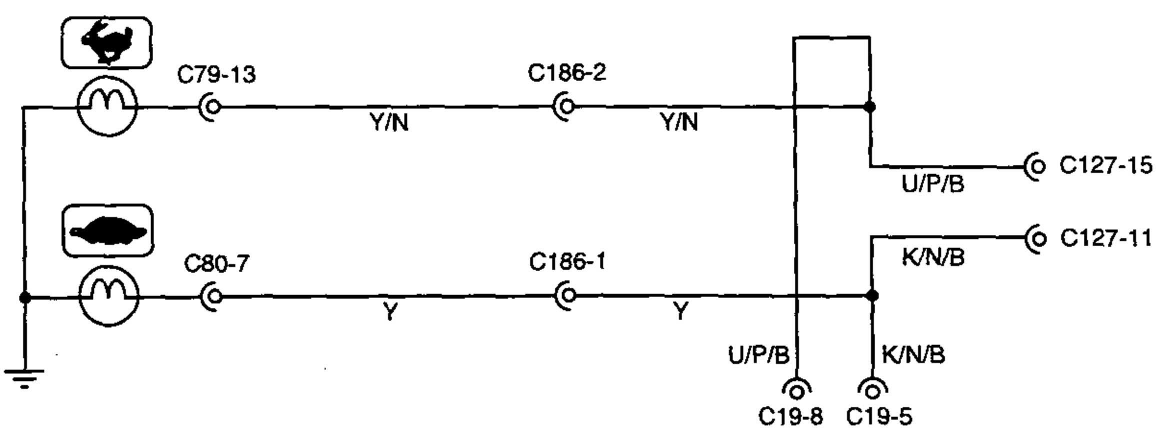
1. Check the alternator drive belt tension (E27).
2. Faulty alternator - check voltage output at terminal 'W' of alternator, this should be approximately 7 volts (E26 or E27).
3. Inspect wiring for intermittent open or short circuit (E26 or E27).

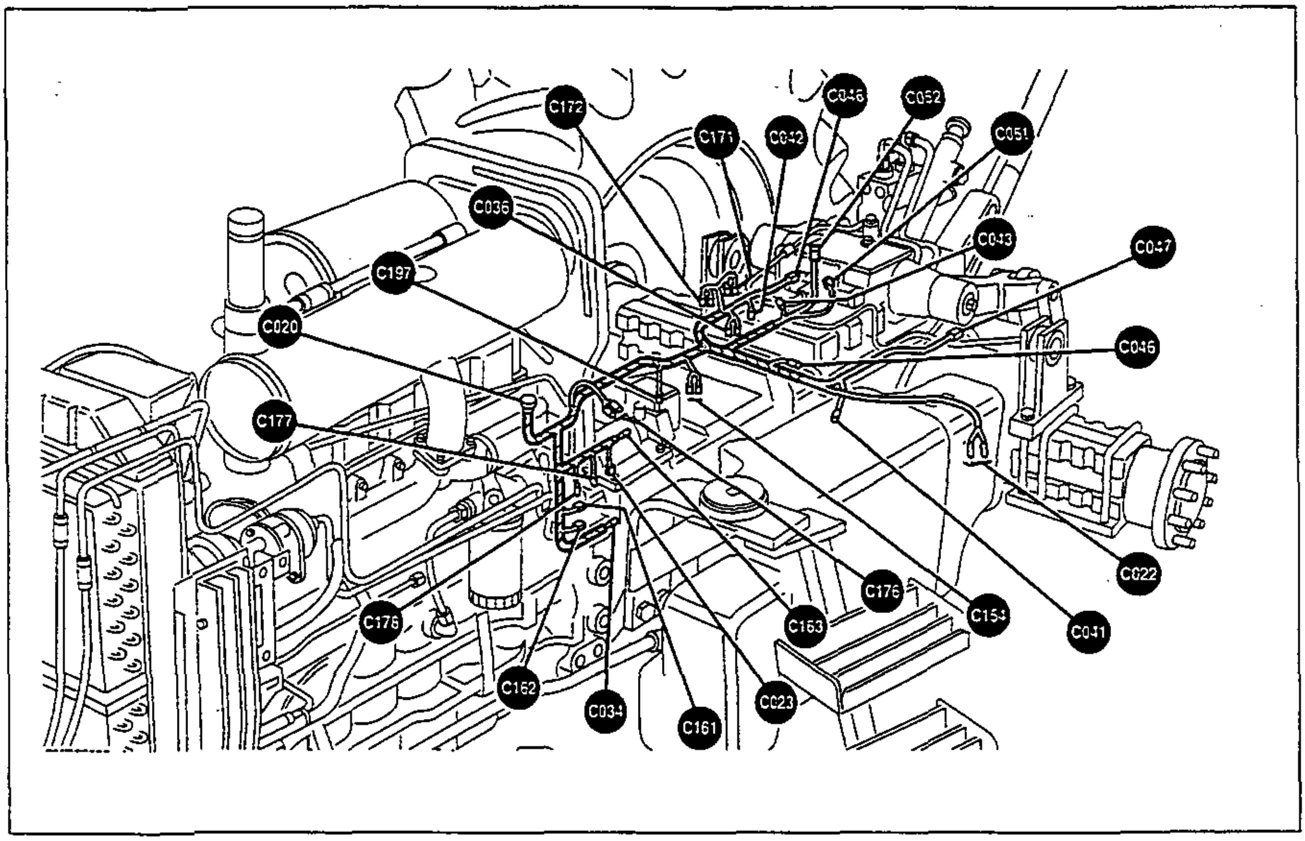


Transmission Status Switches Wiring Circuits



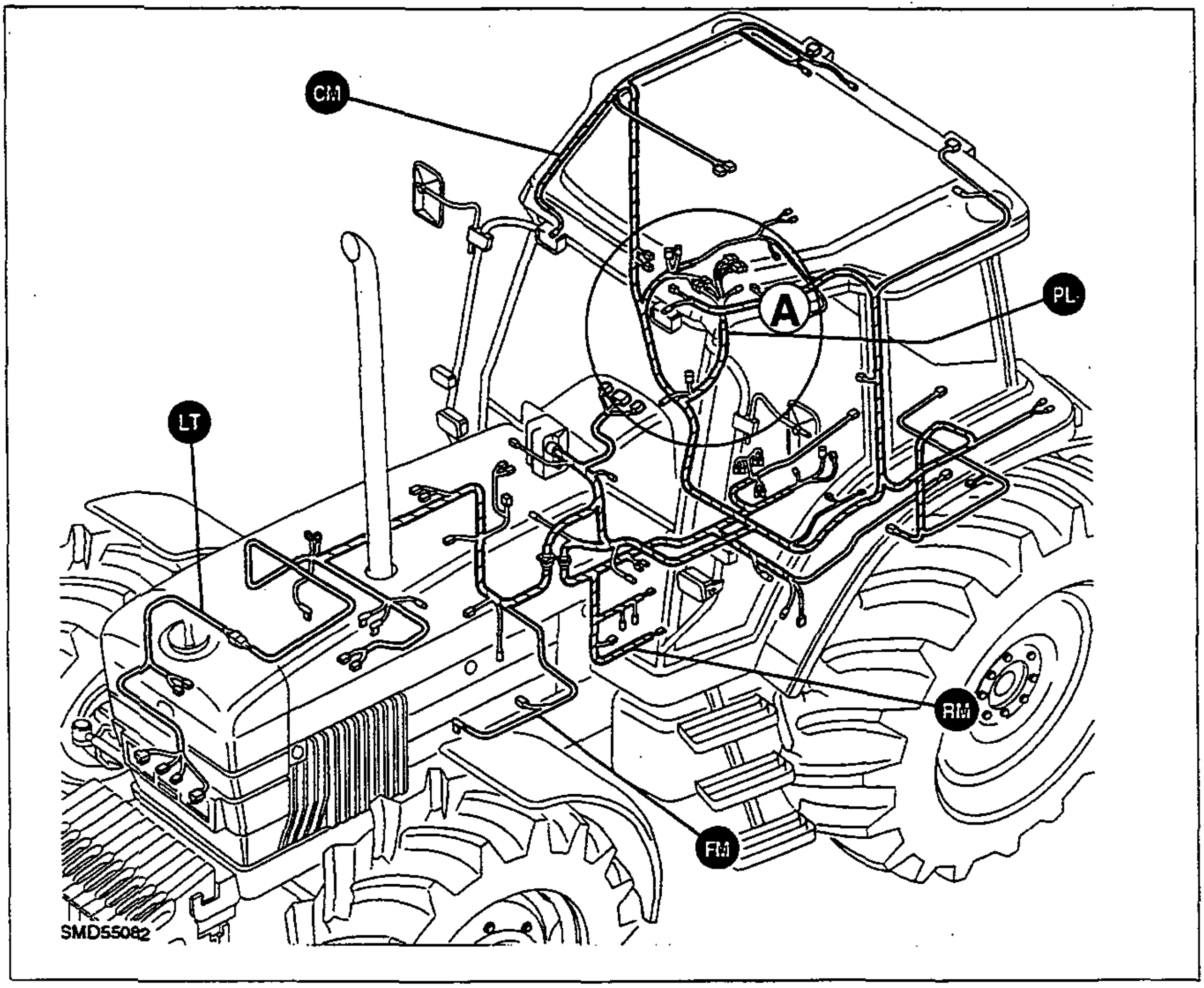
Instrument Panel indicator Lamps

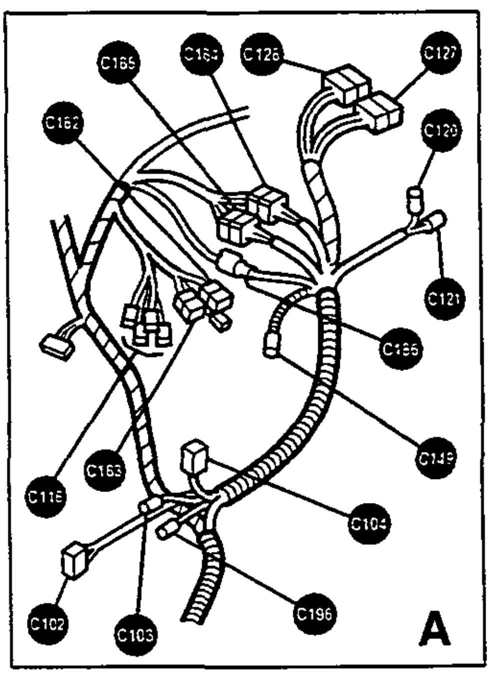




Extension Harness Connector Locations

C020	Cab to Chassis Connector
C022	Auxillary fuel tank Connector
C023	Trans Oil Temp Sender
C036	Oil Pressure Switch
C042	Diff Lock Switch
C043	Diff Lock Switch
C046	Axle Speed Sensor
C047	L\H Draft Pin
C048	R\H Draft Pin
C051	EDC Valve Connector
C052	Rock Shaft Pot
C154	HPL Vacuum Switch
C161	Low PWM
C162	Hi Pwm
C163	Dump Solenoid
C171	Temp Switch
C172	Temp Switch
C176	Start Inhibitor Switch
C177	Neutral Switch 3/4 Rail
C197	Neutral Switch Hi\Med Rail





Microprocessor Harness Connector Locations

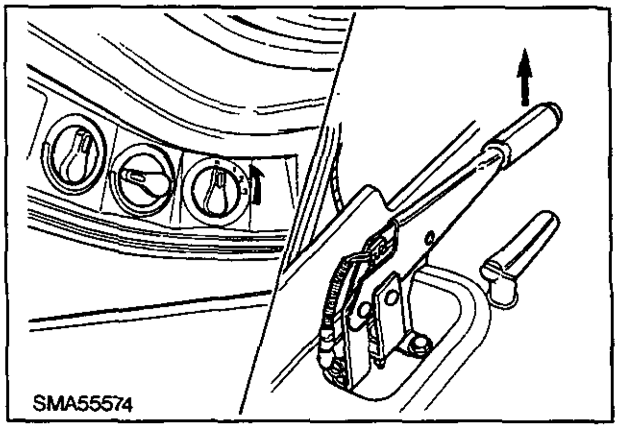
D. 12 x 12 DUAL POWER CALIBRATIONS

CLUTCH CALIBRATION ROUTINES: Dual Power Auto Clutch Spring Pressure Calibration.

Apply handbrake.

Turn off air conditioning.

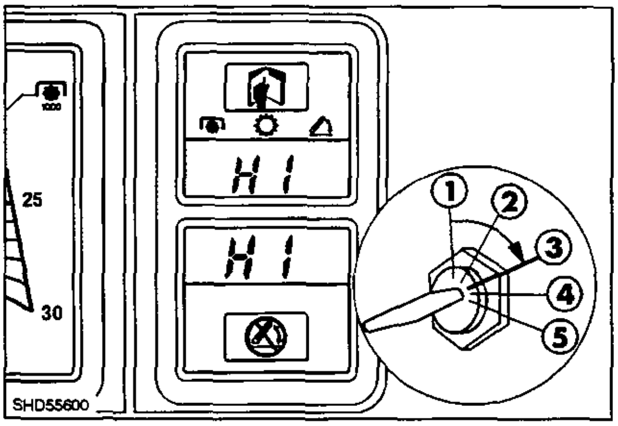
Gearshift levers in neutral.



Install diagnostic tool 4FT. 950.

Start engine.

Select H1 by depressing the diagnostic switch once.

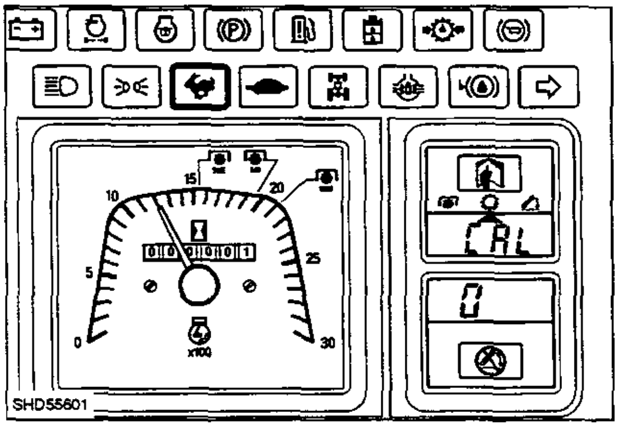


Transmission display will show "CAL".

Fully depress clutch pedal.

Place shift levers into:
FORWARD
1st
HIGH.

Set engine speed to 1200 ± 100 ERPM.



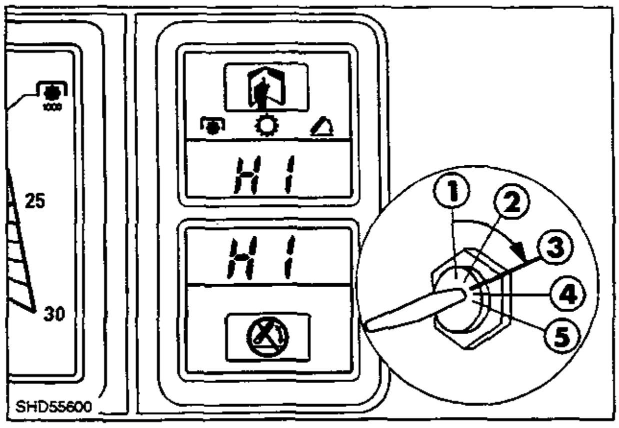
C2 (Hi) clutch calibration

Press and hold upshift button.

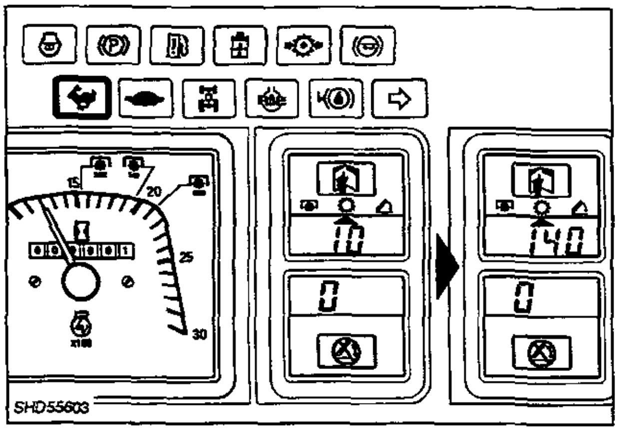
If the set up procedure was incorrect a "U" error code will display.

Refer to Part 5 Chapter 6 Page 17 of Repair Manual SE 4840.

The display will change to show "Hi" whilst the processor determines the engine baseline RPM.

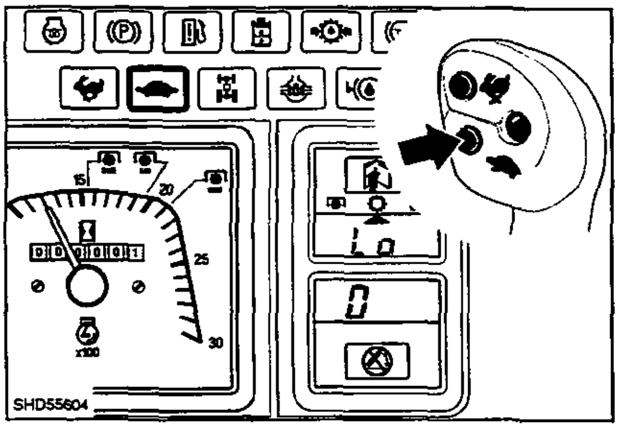


A calibration value appears and increases whilst the processor gradually applies pressure to the clutch, until the engine speed is dragged down by 50 ERPM, when the microprocessor will release the pressure.



C1 (Low) clutch calibration

The same procedure is used as for C2 except the downshift button is used.



Clutch fill time (bump point) calibration

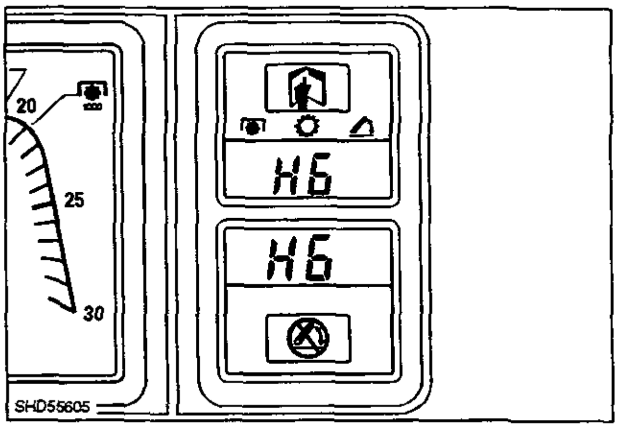
Connect diagnostic test connector 4FT 950.

Start engine.

C1 (Lo) clutch

Set engine speed to 1200 ± 100 ERPM.

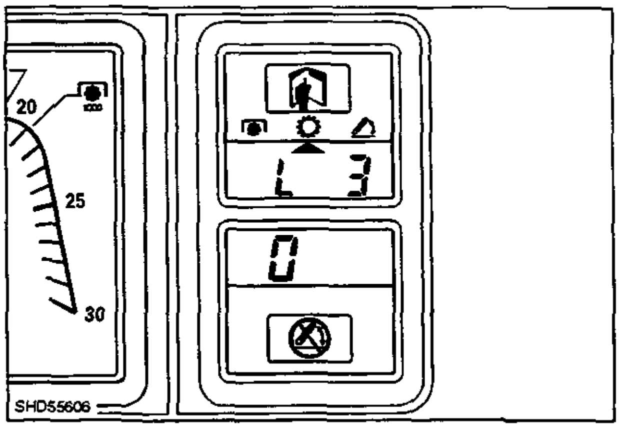
Pulse switch until H6 is selected, after 4 seconds the currently stored fill time value will display. (If F1 appears at any stage, stop calibrating and operate tractor normally to heat the oil).



Release the handbrake.

Select Forward, 1st Gear, High Range.

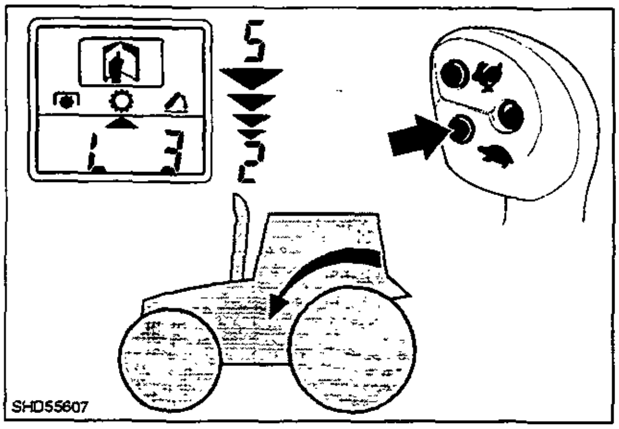
SLOWLY release clutch pedal until the tractor "moves" (approx 20% of pedal travel).



Adjust the value using the upshift/ downshift buttons until only the slightest movement can be detected.

WARNING: *Exercise extreme caution when adjusting the value higher than the factory set 3. Tractor take-off will become very harsh and unexpected.*

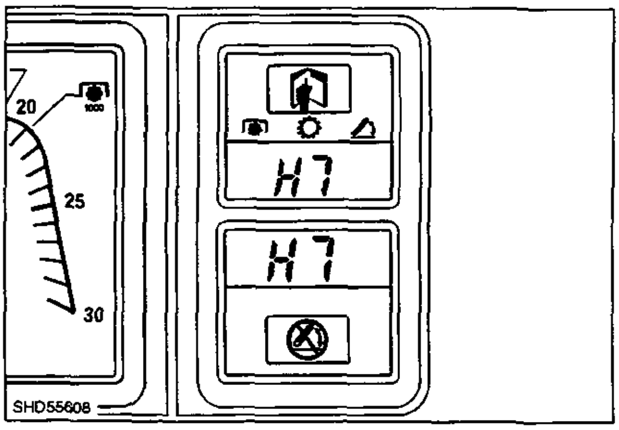
Ensure the area the test is being performed in is free of personnel.



C2 (Hi) clutch

Pulse diagnostic test switch to H7 and repeat steps for C1 clutch.

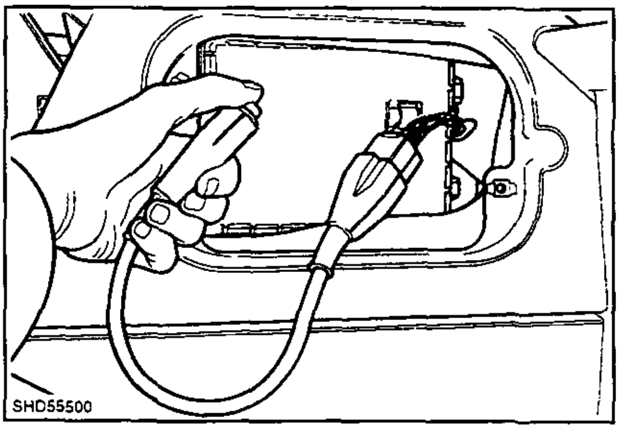
Place shift levers in neutral.



Manual Clutch Calibration - Clutch Bite Point

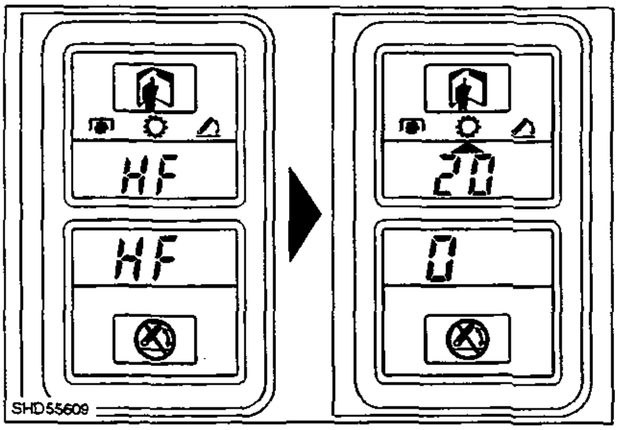
Connect diagnostic test connector 4FT 950.

Start engine.



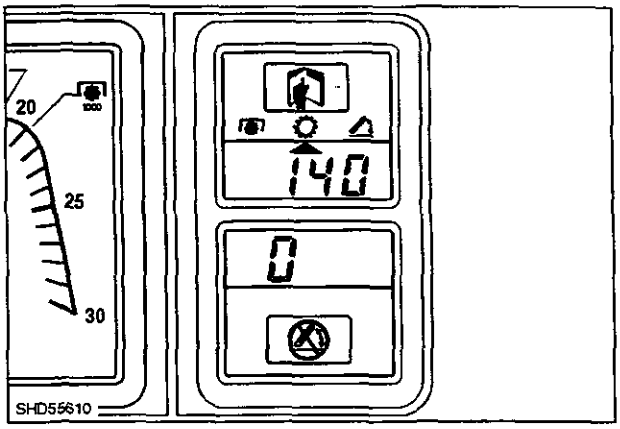
C1 (Lo) clutch

Pulse diagnostic test switch to HF, after 4 seconds the transmission oil temperature will be displayed.



Depress the clutch pedal.

The previously stored C1 spring pressure calibration figure will be displayed.



Select:
2nd Gear, Mid Range, with either Forward or Reverse.

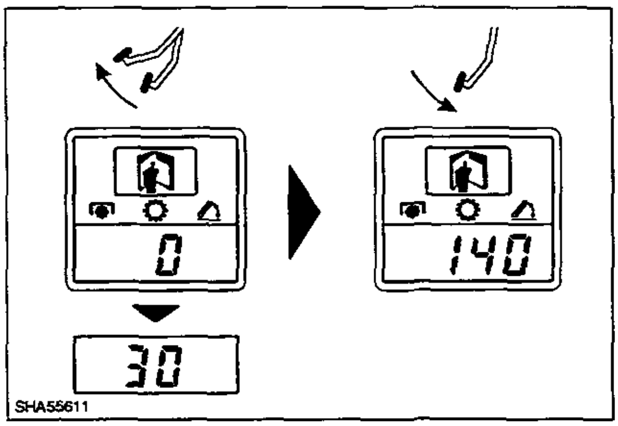
Slowly release the clutch pedal, the display will now show % movement, past the "bump" (20%) until the tractor begins to roll forward.

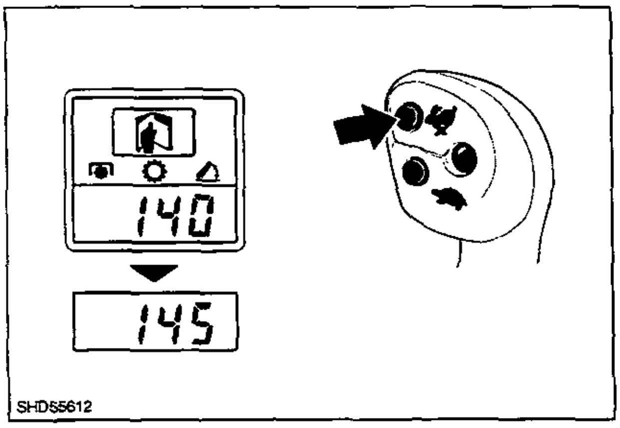
This should be between 30-35% of pedal movement.

Depress the clutch.

If the bite point was too high, above 35%, increase the spring pressure calibration value using the upshift button.

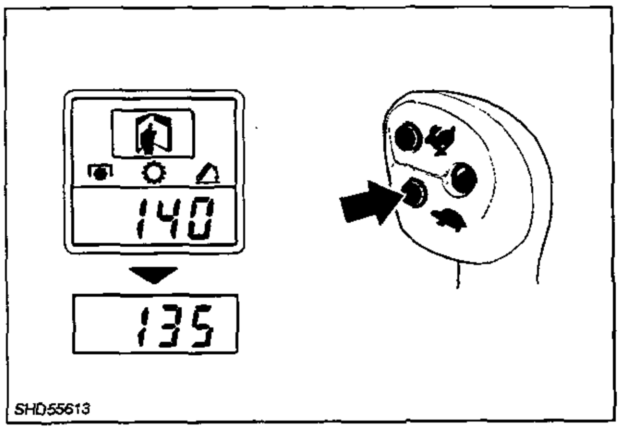
Retry pedal movement.





If the bite point was too low, below 30%, decrease the spring pressure calibration value using the downshift button.

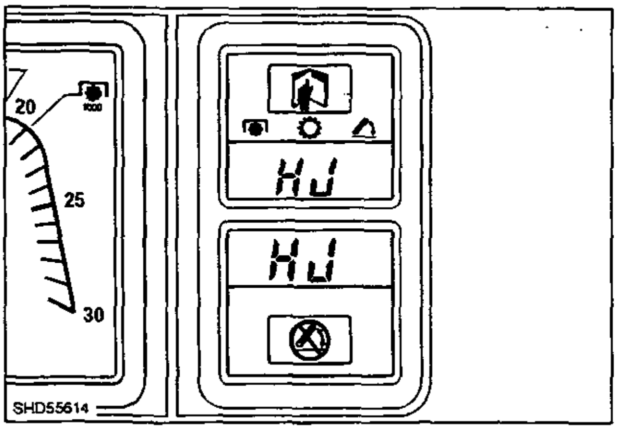
Retry pedal movement.



C2 (Hi) clutch

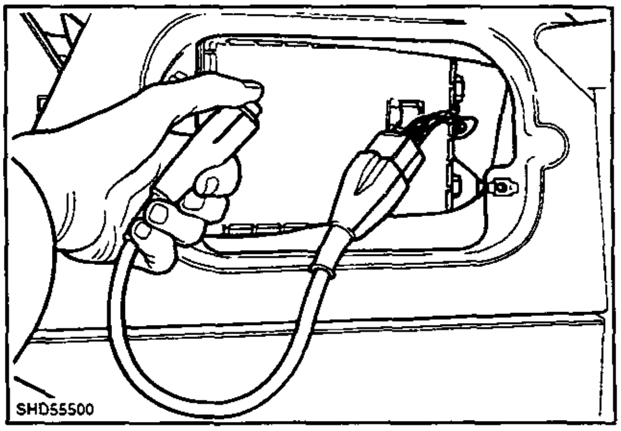
Pulse diagnostic test switch to HJ and repeat calibration as for C1 (Lo) clutch.

Turn key OFF, stop engine, shift levers in neutral.



E. 12 x 12 DUAL POWER DIAGNOSTIC 'H' MENUS

To access the 'H' menu system plug the test switch, 4FT950 in to the diagnostic connector.

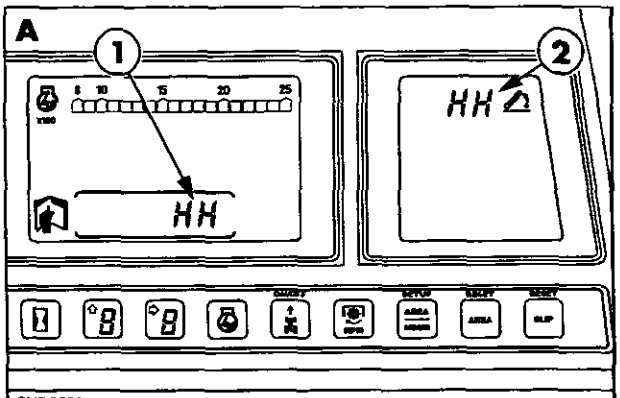


SHD55500

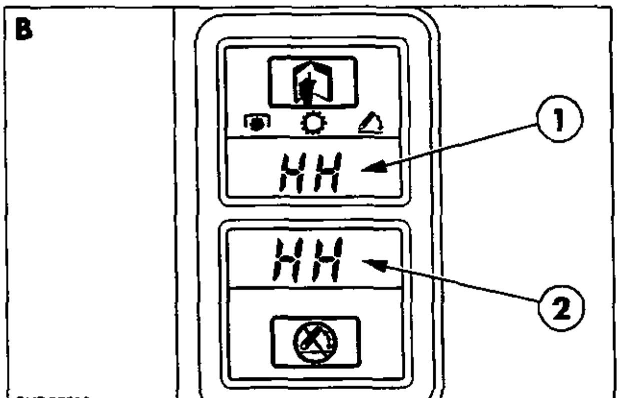
Turn the keystart switch ON, and the display will show "HH". This is the *diagnostic menu.*

The system is available to tractors fitted with either the full EIC (A) or the AEIC (B) instrument clusters.

1. Transmission Display
2. EDC Display



SHD55501



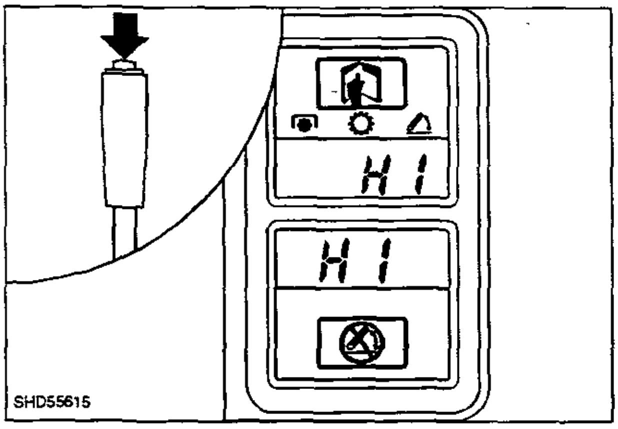
SHD55502

HH	**Transmission Display (1)**	**EDC Display (2)**
H1	transmission clutch spring pressure calibration	
H2	transmission clutch calibration value review	EDC valve calibration review
H3	*not used*	*as transmission*
H4	software revision level	as transmission
H5	diagnostic switch test	as transmission
H6	lo clutch quick fill adjustment	right hand draft pin display
H7	hi clutch quick fill adjustment	left hand draft pin display
H8	non volatile memory reset	as transmission
H9	vehicle sensor operation display	as transmission
HA	clutch pedal position percentage display	
HB	PWM temperature compensation value	
HC	not used	
HD	not used	
HE	transmission temperature	
HF	hi clutch manual adjust	
HJ	lo clutch manual adjust	
HL	not used	
HP	not used	

Transmission 'H' Menu

H1 Transmission Clutch Spring Pressure Calibration

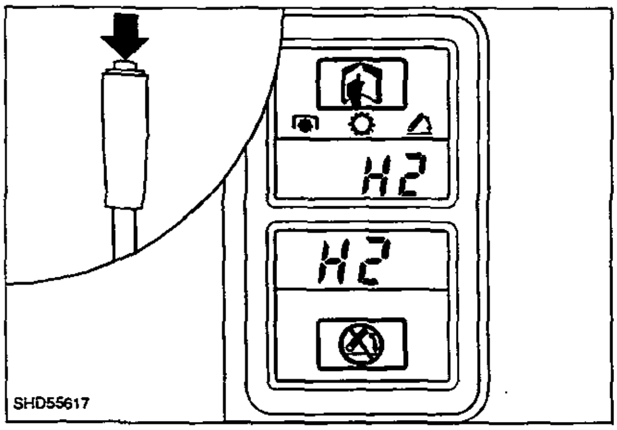
See Calibration Section.



SHD55615

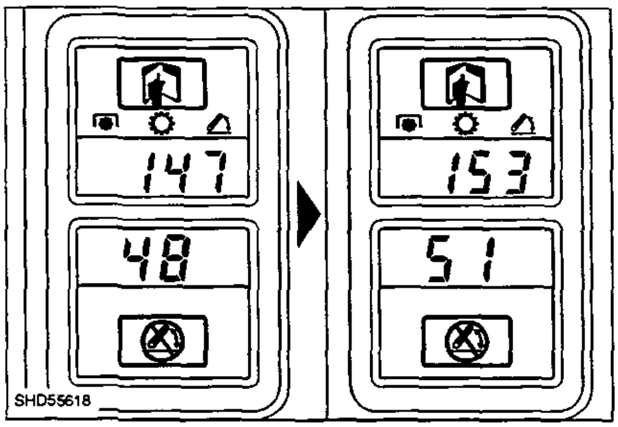
H2 Transmission Clutch Calibration Value Review

Select H2 with the test switch.



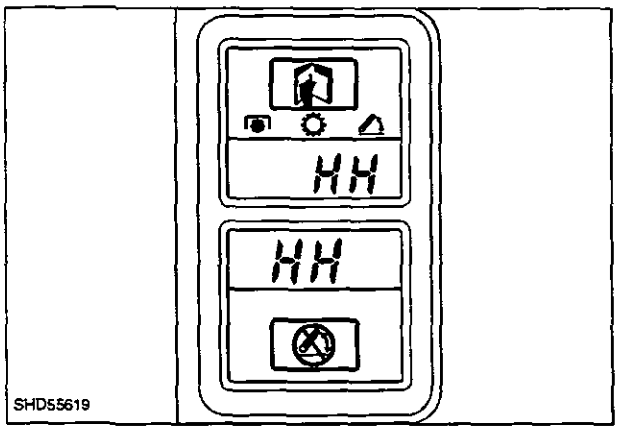
SHD55617

The display will change to show first the Hi clutch stored calibration value and then the Lo clutch value.



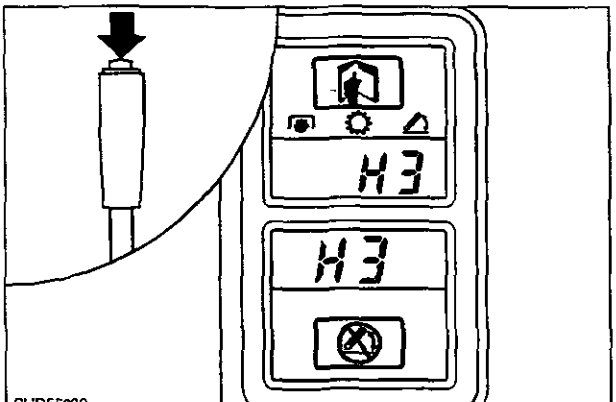
SHD55618

The display automatically returns to HH.



SHD55619

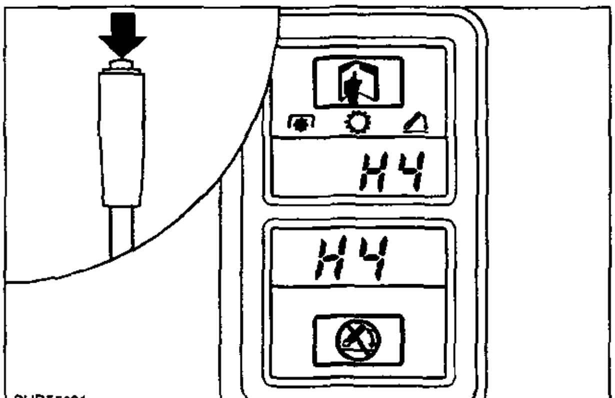
H3 Not used in service



SHD55620

H4 Software Revision Level

Select H4 with the test switch.

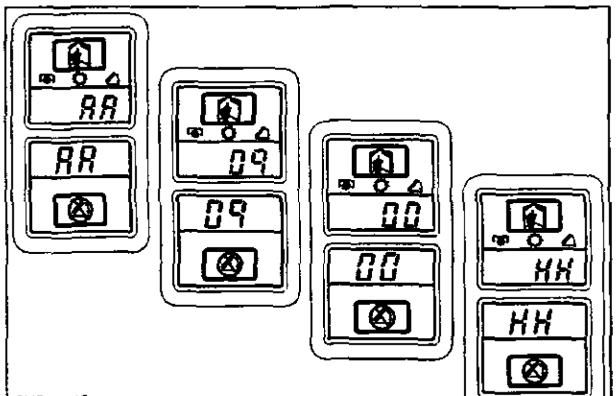


SHD55621

The display will automatically display;

AA	12 x 12 dual power transmission
09	Software level
00	Prototype software (if any)

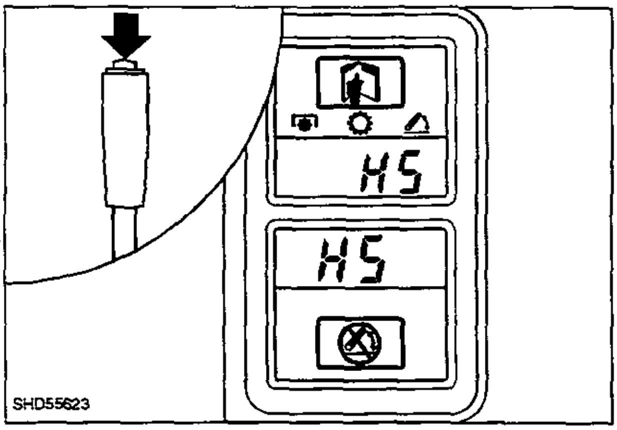
and then return to "HH" screen.



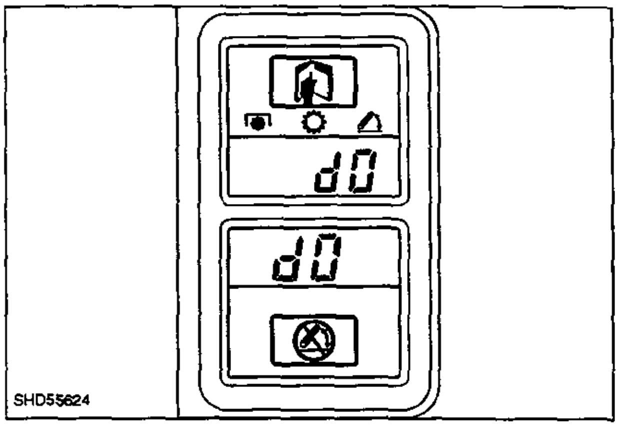
SHD55645

H5 Transmission/EDC Switch Test

Select H5 with the test switch.

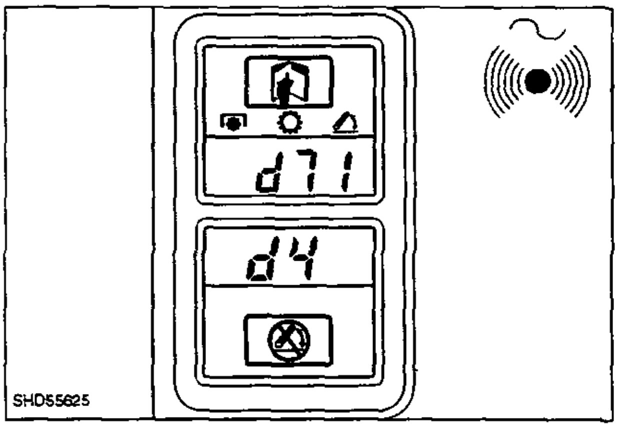


The display will then show "d0".



If a transmission or EDC switch is operated a code number will be displayed along with an audible tone to indicate correct operation.

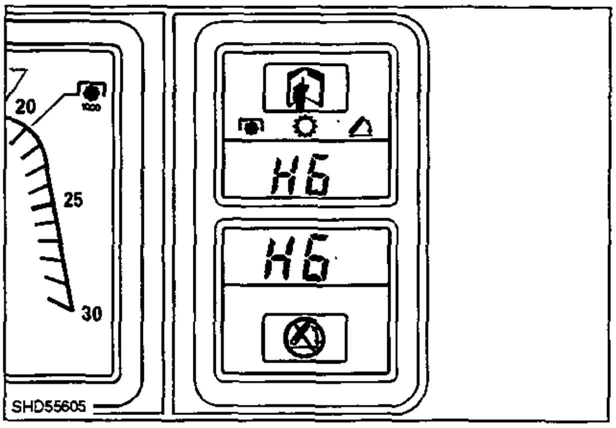
If the code number and tone do not operate, the switch could be at fault.



Switch Code	Switch Description
d1	External Lower Switch (EDC)
d2	External Raise Switch (EDC)
d3	Work Switch Transition (EDC)
d4	Raise Switch Transition (EDC)
d71	Clutch Pedal Switch
d74	Dual Power Downshift Switch
d75	Dual Power Upshift Switch
d81	High/medium In Gear Switch
d82	Main In Gear Switch - 1/2 and 3/4 Gear Switches
d85	Neutral Start Switch
d92	Hydraulic Oil Temperature Switch
d93	Fuse No.12 Sense

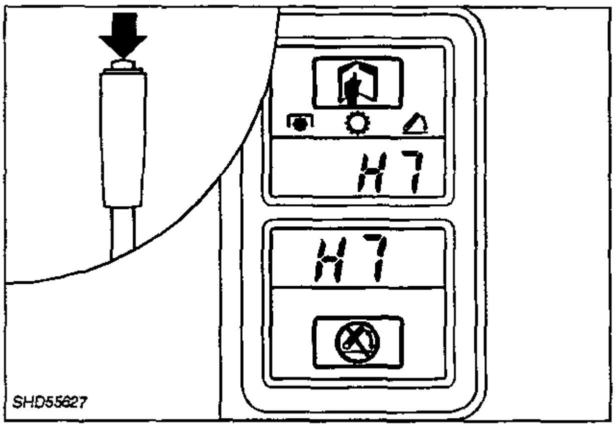
H6 Lo Clutch Quickfill Adjustment

See Calibration Section.



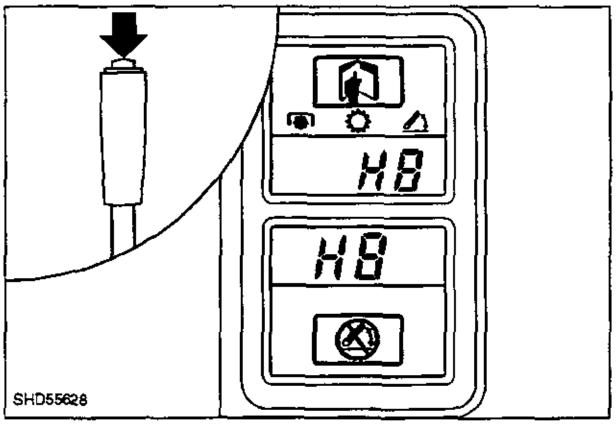
H7 Hi Clutch Quickfill Adjustment

See Calibration Section.

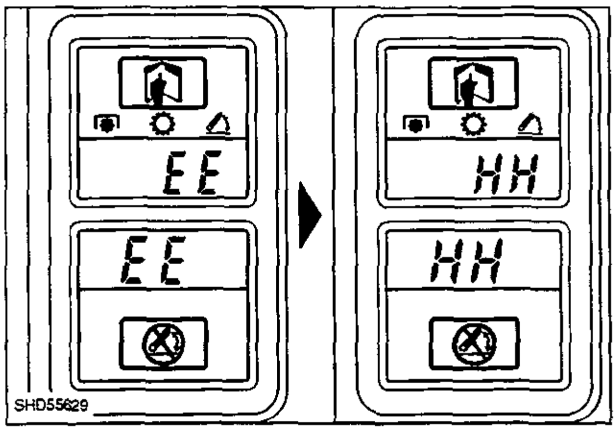


H8 Non Volatile Memory Reset

Select H8 with the test switch.



The display will change to show "EE" (Erase EPROM) and then return to the "HH" screen.

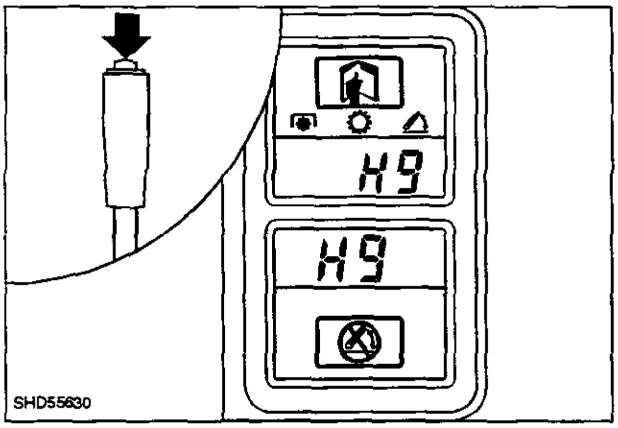


WARNING!
THIS OPERATION WILL ERASE ALL TRANSMISSION AND EDC CALIBRATION VALUES.

H9 Vehicle Sensor Operation Display

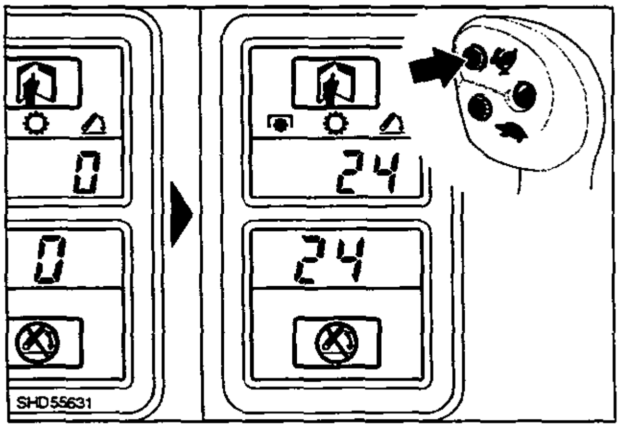
Select H9 with the test switch.

H9 allows various signals to solenoids, potentiometers etc to be checked for both transmission and EDC systems.



The required channel can be selected by using the up/downshift switches.

The display will show the channel number followed by the sensor value.

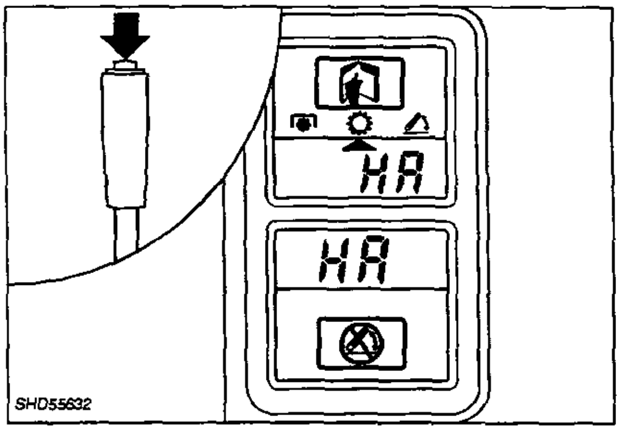


Channel Number	Description	Typical Approximate Values
0	Clutch Pedal position	91 Released, 26 Depressed
1	Transmission Oil Temperature	75 at 40°C
2	40°C Hydraulic Oil Switch	96 > 40°C, 2 < 40°C
3	Fuse 12 Sense	96
4	*Not applicable to service*	-
5	5 Volt Reference (Transmission Control)	49
6	12 Volt Vf Input (Fuse 13)	42
7	12 Volt Vd Input (Clutch Switch)	43
8	12 Volt Vh Input (Fuse 14)	43
9	8 Volt Reference (EDC Control)	79
10	Not used	-
11	*Not applicable to service*	-
12	Not applicable to service	-
13	Not applicable to service	-

Channel Number	Description	Typical Approximate Values
14	Not used	-
15	Dump Solenoid Current Sense	0 Clutch engaged, out of gear 97 Clutch engaged, in gear
16	C1 Clutch Solenoid Current Sense	0 Clutch engaged, out of gear 82 Clutch pedal released in underdrive
17	C2 Clutch Solenoid Current Sense	0 Clutch engaged, out of gear 82 Clutch pedal released in direct drive
18	EDC Valve Raise Solenoid Current	0 - 66
19	EDC Valve Lower Solenoid Current	0 - 66
20	Ground Speed Signal	64
21	Not used	-
22	Not used	-
23	Not used	-
24	Not used	-
25	Implement Status Lamp Sense	7 when Illuminated
26	Wheel Slip Lamp Sense	7 when Illuminated
27	Not used	-
28	Lift Arm Posisiton Sensing Potentiometer	33 Lift Lowered 83 Lift Raised
29	Lift Control Lever Potentiometer	27 Fully Lowered 83 Fully Raised
30	Drop Rate Control Potentiometer	84 Turned Fully Clockwise 14 Turned Fully Counter Clockwise
31	Height Limit Control Potentiometer	84 Turned Fully Clockwise 14 Turned Fully Counter Clockwise
32	Position/Draft Sensitivity Potentiometer	84 Turned Fully Clockwise 14 Turned Fully Counter Clockwise
33	Slip Limit Control Potentiometer	84 Turned Fully Clockwise 14 Turned Fully Counter Clockwise
34	Right Hand Load Sensing Pin	48 When Implement Not Being Used
35	Left Hand Load Sensing Pin	48 When Implement Not Being Used

HA Clutch Pedal Position Percentage Display

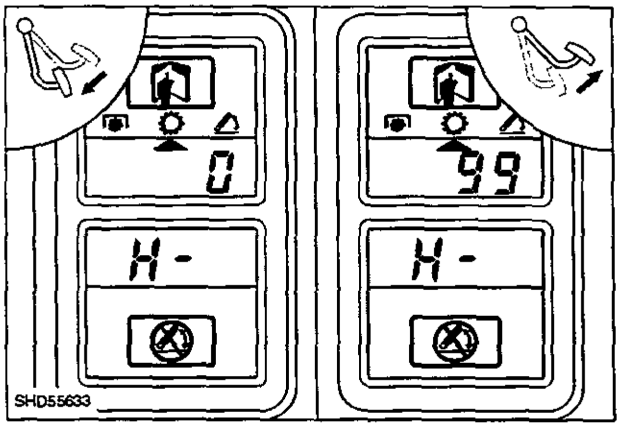
Select HA with the test switch



The display will show the position of clutch pedal as a percentage:

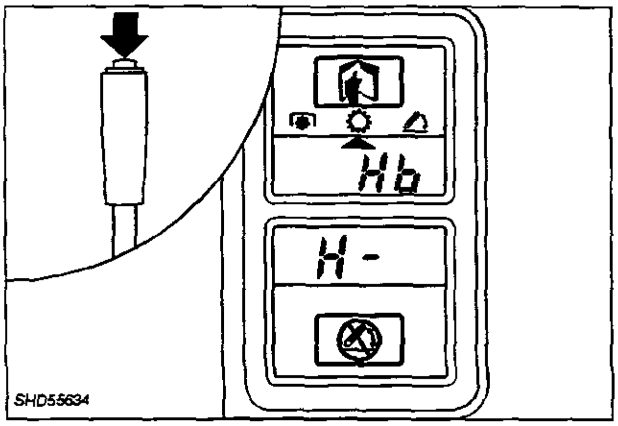
0 Fully down

99 Fully up

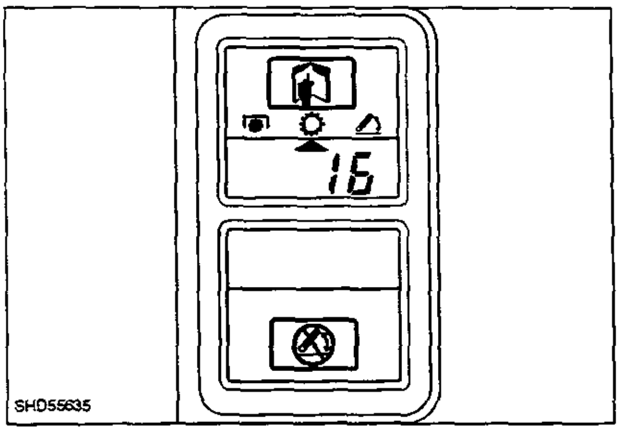


HB PWM Temperature Compensation Value

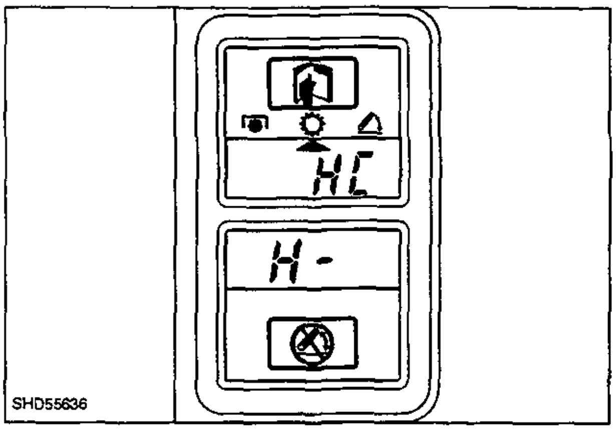
Select HB with the test switch.



Set to 16.

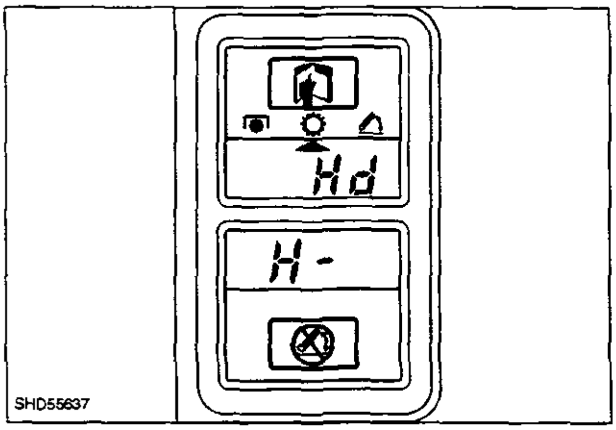


HC Not used in service



SHD55636

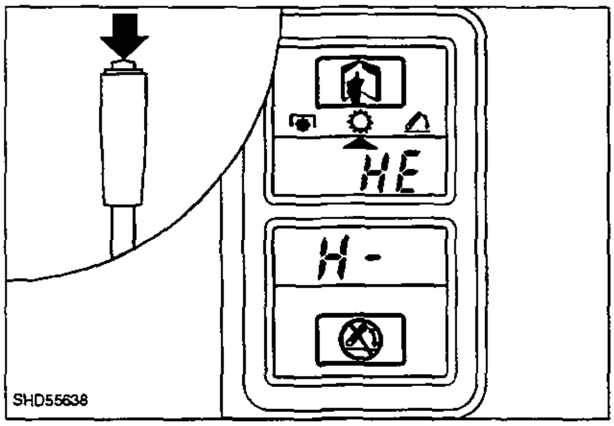
HD Not used in service



SHD55637

HE Transmission Oil Temperature

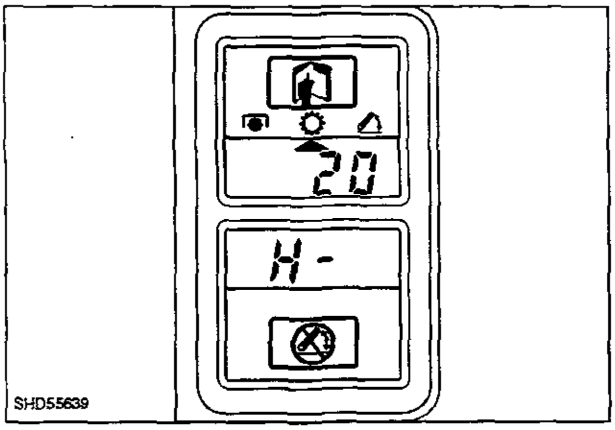
Select HE with the test switch.



SHD55638

The display will show transmission oil temperature in degrees Celsius.

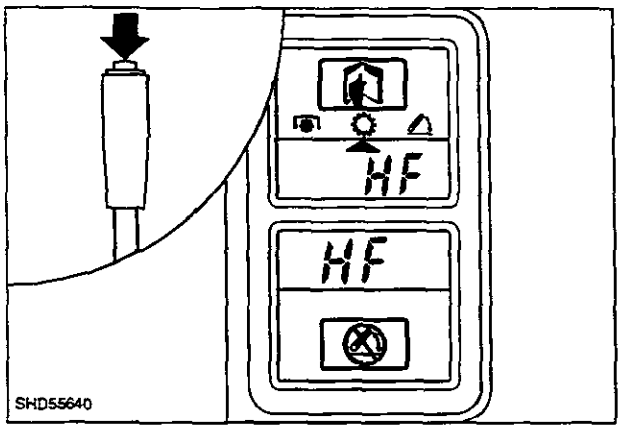
The tractor can be driven in this mode and the temperature monitored.



SHD55639

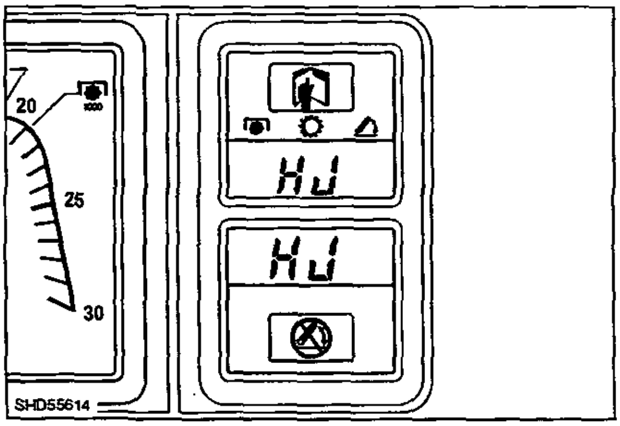
HF Hi Clutch Manual Adjustment

See Calibration Section.



HJ Lo Clutch Manual Adjustment.

See Calibration Section.



HL & HP Not used