PURPOSE:
To advise potentially hazardous condition.

DETAIL:

It has been brought to our attention that 'Viton' material used in manufacture of oil seals and 'O' rings, produces a highly corrosive acid (Hydrofluoric) when subjected to temperatures above 315° C.

The resulting contamination can have extreme consequences on human tissue since it is almost impossible to remove after contact.

We therefore recommend the following procedure when it is necessary to inspect any equipment that has been subjected to a high temperature i.e. fire.

a. Visually inspect for any gaskets or seals which have suffered from heat; they will appear black and sticky.

b. If this is affirmed - **Do Not Touch**

c. Make enquiries to ascertain the material composition. Any Fluoro-elastomer (Viton, Fluorel or Tecmoflon) should be considered dangerous but natural rubber and nitrile are non-hazardous.

d. If Fluoro-elastomer seals have been used, then the affected area MUST be decontaminated before undertaking further work.

e. Disposable Heavy Duty Gloves (Neoprene) MUST be worn and the affected area decontaminated by washing thoroughly with Limewater (Calcium Hydroxide solution).

f. Any cloths, residue and gloves used MUST be safely discarded after use.

**Note:** Burning of the discarded items is NOT RECOMMENDED, except in an approved incineration process where the gaseous products are treated by alkaline scrubbing.
**IMPORTANT SAFETY NOTICE**

Proper service and repair is important to the safe, reliable operation of all motor vehicles. The service procedures recommended and described in this publication, are effective methods for performing service operations. Some of these service operations require the use of tools specially designed for the purpose. The special tools should be used when, and as recommended.

It is important to note that this publication contains various WARNINGS and NOTES which should be carefully read in order to minimize the risk of personal injury to personnel, or the possibility that improper service methods will be followed which may damage the vehicle or render it unsafe. It is also important to understand these WARNINGS and NOTES are not exhaustive. It is not possible to know, evaluate and advise the service trade of ALL conceivable ways in which service might be carried out, or, of the possible hazardous consequences of each way. Consequently, no such broad evaluation has been undertaken. Accordingly, anyone who uses a service procedure, or tool, which is not recommended, must first satisfy themselves thoroughly that neither their safety, nor vehicle safety, will be jeopardized by the service method he/she selects.

Two types of heading are used in this manual to attract your attention.

1. **WARNING** - This symbol is used when an operating procedure, practice, etc., which, if not correctly followed could result in personal injury or loss of life. Look for this symbol to point out important safety precautions. It means - **ATTENTION! BECOME ALERT! YOUR SAFETY IS INVOLVED!**

2. **Note** - This is used when an operating procedure, practice, etc., which, if not strictly observed, could result in damage to or destruction of equipment.

**WARNING**

Never use parts which are altered, modified, or weakened in operation. This can seriously jeopardize the integrity of the machine and could result in property damage or serious personal injury.
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* * * * *
GENERAL INFORMATION - TS14G Technical Data

Section 000-0000

ENGINE
Tractor
Engine Series ......................... Cummins QSB-30
Type ............................. 4 Cycle Diesel, Turbocharged, Electronic Management

Gross power at 2 200 rev/min .......... 138 kW (185 hp)
Net power at 2 200 rev/min .......... 131 kW (176 hp)

Note: Gross power rated to SAE J1995 June 90. Engine emission meets USA EPA/CARB MOH 40 CFR 89 and EU NRMM (non-road mobile machinery) directive.

Maximum Torque
at 1 600 rev/min ................. 720 Nm (531 lbf ft)
Number of cylinders/configuration .......... 6, Inline
Bore x Stroke .................. 102 x 120 mm (4.01 x 4.72 in)
Total Displacement ........... 5.9 litres (360 in³)

Air cleaner.............................. Dry, Aspirated
Starting ................................................ Electric
Maximum Speed (No load) ............. 2 390 rev/min
Maximum Speed (Full load) ........... 2 200 rev/min
Idle Speed .............................................. 750 rev/min
Safe Operating Angle ................... 30°/57% Grade

Scraper
Engine Series ......................... Cummins QSB-30
Type ............................. 4 Cycle Diesel, Turbocharged, Electronic Management

Gross power at 2 200 rev/min .......... 125 kW (167 hp)
Net power at 2 200 rev/min .......... 118 kW (158 hp)

Note: Gross power rated to SAE J1995 June 90. Engine emission meets USA EPA/CARB MOH 40 CFR 89 and EU NRMM (non-road mobile machinery) directive.

Dimensions in mm (ft-in)

Fig. 1 - Machine Dimensions

All vertical dimensions with bowl at 300 mm (12 in) carry position. Unit empty.
BRAKES
Full air operated drum brakes with automatic application on loss of air pressure. Secondary system can also be manually applied. Spring-applied parking brake actuators. Air drier standard.

Braking Lining:
- Diameter: 508 mm (20 in)
- Shoe Width: 152 mm (6 in)
- Lining Thickness: 19 mm (0.75 in)
- Lining Area - Each Axle: 3 355 cm² (520 in²)

WHEELS AND TYRES
- Wheel Rim Width: 25 in
- Standard Tyres: 29.5 R25** Radial
- Optional Tyres: 29.5-25 (28PR) E3

Note: Consult tyre manufacturers for optimum tyre selection and correct t-km/h (ton-mileh) capacity for application.

STEERING SYSTEM
Full hydraulic type provided by two interchangeable single stage, double acting steering cylinders. Steering cylinders are mounted below the gooseneck to aid stability.

System Pressure: 135 bar (1 950 lbf/in²) at 1 500 rev/min

STEERING CYLINDER:
- Bore and Stroke: 140 x 445 mm (5.5 x 17.5 in)
- Pump Type: Gear Drive
- Hydraulic Pump Capacity: 147 litre/min (38.7 US gal/min)

AXLES
Heavy duty axles with fully-floating axle shafts, single reduction bevel gear differential and planetary reduction in each wheel. A NoSpin differential is standard in the rear axle for improved traction in difficult conditions. A pedal controlled power-locking differential is optional in the front axle, operational in first gear only.

Ratios:
- Differential: 4.11:1
- Planetary: 5.33:1
- Total Reduction: 21.91:1

Maximum Torque:
- at 1 600 rev/min: 720 Nm (531 lbf ft)

Number of cylinders/configuration: 6, Inline
Bore x Stroke: 102 x 120 mm (4.01 x 4.72 in)
Total Displacement: 5.9 litres (360 in³)
Air cleaner: Dry, Aspirated
Starting: Electric

Maximum Speed (No load): 2 390 rev/min
Maximum Speed (Full load): 2 200 rev/min
Idle Speed: 750 rev/min
Safe Operating Angle: 30°/57% Grade

SPEEDS WITH STANDARD DIFFERENTIAL

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<td>7.2</td>
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| Ratio | 4.05 |
| km/h | 8.3 |
| mile/h | 5.1 |

Stall Speed: 2030-2090 rev/min
Torque Converter Ratio (front and rear): 2.408:1

HYDRAULICS AND CONTROLS
Hydraulic system is filtered and has one reservoir supplying a triple section gear pump for steering and scraper hydraulics.

Scraper Functions:
- Capacity at 2 200 rev/min: 270 litre/min (71.2 US gal/min)
- System Pressure: 127.5 bar (1 850 lbf/in²) at 1 500 rev/min
ELECTRICAL SYSTEM
Type ................................. 24 volt, Negative Ground.
Battery ............................... Two, 12 Volt, 165 Ah each
Accessories .......................... 24 Volt
Alternator ............................ 70 Amp

SERVICE CAPACITIES
Tractor
Cooling System ....................... 40 litres (10.6 US gal)
Fuel Tank .............................. 378 litres (100 US gal)
Engine Crankcase and filters (dry fill) ........................... 15 litres (4 US gal)
Transmission and Converter ...... 48.5 litres (12.8 US gal)
Hydraulic System ..................... 204 litres (54 US gal)
Drive Axle ............................ 17 litres (4.5 US gal)

Scraper
Cooling System ....................... 39 litres (10.3 US gal)
Fuel Tank .............................. 303 litres (80 US gal)
Engine Crankcase and filters (dry fill) ......................... 15 litres (4 US gal)
Transmission and Converter ...... 49 litres (12.9 US gal)
Drive Axle ............................ 17 litres (4.5 US gal)

VOLUMES
Struck (SAE) .......................... 10.7 m³ (14.0 yd³)
Heaped 1:1 (SAE) ..................... 15.3 m³ (20.0 yd³)

VEHICLE WEIGHTS
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<td>Gross Vehicle Weight</td>
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Welding

**WARNINGS**
Before any welding is done on a machine equipped with any electronic systems, disconnect the following (if applicable) in this order: Battery earth cable, battery supply cable, alternator earth cables, alternator supply cables and electrical connections at the engine ECM, transmission ECU, body control lever, hydraulics ECU and cab bulkhead to avoid damage to electrical components. Turn off battery master switch to isolate the batteries before disconnecting any components. After welding connect all of the above in the reverse order.

**Note:**
Always fasten the welding machines ground cable to the piece/frame being welded if possible.

Electric arc welding is recommended for all welded frame repairs. Since the nature and extent of damage to the frame cannot be predetermined, no definite repair procedure can be established. As a general rule however, if parts are twisted, bent or pulled apart, or a frame is bent or out of alignment, no welding should be done until the parts are straightened or realigned.

Successfully welded repairs will depend to a great extent upon the use of the proper equipment, materials and the ability of the welder. The Customer Support Department can be consulted regarding the feasibility of welding repairs.

**WARNING**
Welding and flame cutting cadmium plated metals produce odourless fumes which are toxic. Recommended industrial hygiene practice for protection of the welding operator from the cadmium fumes and metallic oxides requires enclosure ventilation specifically designed for the welding process. A respiratory protective device such as the M.S.A. ‘Gasfoe’ respirator with G.M.A. cartridge will provide protection against cadmium, fumes and metallic oxides. The ‘Gasfoe’ respirator has been approved by the U.S. Bureau of Mines: Approval number 23B-10, and is designed to protect against gases, vapours, and/or metal fumes.

**Note:**
The current from the welding rod always follows the path of least resistance. If, for example, the ground clamp is attached to the rear frame when welding is performed on the front frame, the current must pass a frame connection to return to the welding machine. Since the pivot coupling offers the least resistance but not a sound electrical connection, small electric arcs may be set up across the moving parts which may cause welding blotches on their wearing surfaces and increase the wear rate of these components.

**General Welding Procedure**
The following general procedure should be used for the repair of defects outwith the vicinity of alloy steel castings.

1. Completely ARC-AIR gouge or grind out the crack until sound metal is reached. If ARC-AIR method is employed, pre-heat area to 100° C (212° F), measure 3 - 4” either side of repair prior to gouging. On completion of gouging grind to remove thin carbon layer.

2. Apply dye-penetrant check to ensure crack has been completely removed.
General Information - Welding Procedure

Section 000-0010

3. Pre-heat area to 100° C (212° F), measured 3 - 4" either side of repair. Avoid local overheating.

4. Weld completely using E-7016 electrodes. Care must be taken to ensure electrodes are protected from moisture pick-ups at all times.

5. Allow repair weld to cool slowly.

6. Grind and blend repair to original contour. Paint heat damaged areas.

The following general procedure should be used for the repair of defects in alloy steel castings and in the welds joining steel castings.

1. Completely ARC-AIR gouge or grind out the crack until sound metal is reached. If ARC-AIR method is employed, pre-heat area to 200° C (392° F), measure 3 - 4" either side of repair prior to gouging. On completion of gouging grind to remove thin carbon layer.

2. Apply dye-penetrant check to ensure crack has been completely removed.

3. Pre-heat area to 200° C (392° F), measured 3 - 4" either side of repair. Avoid local overheating.

4. Weld completely using E-7016 electrodes. Care must be taken to ensure electrodes are protected from moisture pick-ups at all times.

5. On completion of welding, post-heat repair area to 400° C (752° F), measure 3 - 4" either side of repair.

6. If welding has to be interrupted for any reason, e.g. overnight, post-heat immediately as in Step 5.
DESCRIPTION
Numbers in parentheses refer to Fig. 1, unless otherwise stated.

The frame assembly (1) is constructed of heavy box-section side rails which are held in alignment by welded steel crossmembers.

An important feature of the frame’s construction is its integral drive axle banjo housings and spindles (2). These parts are welded to the box-section side rails. The banjo housing in this design becomes an important load-carrying and strengthening member of the chassis. The upper part of the banjo housing also serves as the pivot point for the steering assembly.

The engine supports, transmission supports and various other brackets are welded in position on the frame.

REMOVAL

**WARNING**
To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

To remove any of the components shown in Figs. 1, 2, 3 or 4 (or similar components) the following procedures should be carried out.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.
Chassis - Chassis, Hood and Fenders

Section 100-0010

2. Block all road wheels and place battery master switch in the 'Off' position.

3. Attach a suitable lifting device to the component and remove mounting hardware. Remove the component from the vehicle.

INSTALLATION

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

WARNING
To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

Using a suitable lifting device, align the component to be installed in position on the chassis. Secure the component securely to the chassis with mounting hardware removed during removal.

REPLACEMENT OF SPINDLE

Damaged spindles (2, Fig. 1), oil transfer tubes and banjo outer plates can be removed and new ones installed by following the procedures described in this section.

WARNING
To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place battery master switch in the 'Off' position.

3. Remove all components from the spindle to be replaced. Attach a suitable lifting device to the component and remove mounting hardware. Remove the component from the vehicle. Refer to Section 160-0050, WHEEL RIM AND TYRE, for tyre and wheel removal; Section 160-0040, PLANETARY GEARING, for axle and planetary removal; and Section 165-0031, BRAKE PARTS, for brake removal.

4. Remove sun pinion and axle shaft from the opposite side of the machine. Refer to Section 160-0040, PLANETARY GEARING, for procedure.

5. Remove differential from the banjo. Refer to Section 160-0020, DIFFERENTIAL.
Fig. 3 - Exploded View of Fenders and Mounting

1 - LH Fender Assembly
2 - Step Assembly
3 - Bolt
4 - Washer
5 - Locknut
6 - Retainer
7 - Screw
8 - Lockwasher
9 - Nut
10 - RH Fender Assembly
11 - Bolt
12 - Lockwasher
13 - Nut
14 - Bolt
15 - Hardened Washer

Fig. 4 - Radiator Guard and Mounting

1 - Radiator Guard
2 - Seal
3 - Grille
4 - Bolt
5 - Lockwasher
6 - Bolt
7 - Washer
8 - Nut
9 - Handle
Oil Transfer Tube
1. Burn off weld that fastens oil transfer tube to spindle.

2. Reaching into the banjo, burn off the weld that holds the oil transfer tube to the banjo housing.

3. Remove and discard oil transfer tube from the spindle.

4. Using a grinder, remove all burrs and slag from the spindle end and inside the banjo weld joint areas.

5. Thoroughly clean the spindle and banjo cavities to remove all metal chips.

6. Install new oil transfer tube in the spindle.

7. Weld all round the oil transfer tube at the spindle end and banjo end. Use E-70 low hydrogen weld rod and make a 1/16 in (1.6 mm) oil tight fillet weld all around the tube.

8. Install brakes, wheel, planetary and tyre assemblies on the spindle. Refer to Section 165-0031, BRAKE PARTS, for brake installation, Section 160-0040, PLANETARY GEARING, for planetary installation and Section 160-0050, WHEEL RIM AND TYRE, for tyre and wheel installation.

9. Pre-heat the weld joint to 149 - 205° C (360 - 400° F) and maintain the heat during the welding process.

10. Weld spindle to the banjo outer plate as shown in Fig. 5, using E-70 low hydrogen electrode.

11. If removed, install new bushings in spindle.

12. To install oil seal bushing, if removed, on spindle, heat the new bushing to 177 - 205° C (350 - 400° F) in oil to expand it for installation. If oil heating equipment is not available, heat the bushing evenly to 205° C (400° F). This takes about one minute using a torch with a heating tip. Use a templistik or other temperature gauge to make sure the bushing is hot enough. Slide heated bushing on spindle and tap lightly with a hammer to seat it.

Note: Do not apply flame directly to bushing. Place bushing on steel plate and direct flame to centre of plate to evenly distribute heat.

13. Install oil transfer tube in the spindle and banjo as described under the heading ‘Oil Transfer Tube’.

Spindle
1. Remove oil transfer tube as described under heading ‘Oil Transfer Tube’.

2. Attach a suitable lifting device to the spindle.

3. Burn off weld that fastens the spindle to the banjo outer plate and remove spindle.

4. If the spindle is to be reused, clean up the spindle as shown in Fig. 5.

5. With a grinder, clean up the weld area on the banjo outer plate.

6. Clean the spindle and banjo with a suitable solvent to remove chips and metal dust.

7. With a suitable lifting device, position the spindle on the banjo outer plate.

8. Install spindle alignment tool, which can be fabricated as shown in Fig. 6, through the spindles and banjo. Align the spindle to the dimensions shown in Fig. 5 and tighten alignment tool.

9. Pre-heat the weld joint to 149 - 205° C (360 - 400° F) and maintain the heat during the welding process.

10. Weld spindle to the banjo outer plate as shown in Fig. 5, using E-70 low hydrogen electrode.

11. If removed, install new bushings in spindle.

12. To install oil seal bushing, if removed, on spindle, heat the new bushing to 177 - 205° C (350 - 400° F) in oil to expand it for installation. If oil heating equipment is not available, heat the bushing evenly to 205° C (400° F). This takes about one minute using a torch with a heating tip. Use a templistik or other temperature gauge to make sure the bushing is hot enough. Slide heated bushing on spindle and tap lightly with a hammer to seat it.

Note: Do not apply flame directly to bushing. Place bushing on steel plate and direct flame to centre of plate to evenly distribute heat.

13. Install oil transfer tube in the spindle and banjo as described under the heading ‘Oil Transfer Tube’.

Banjo Outer Plate
1. Remove oil transfer tube as described under the heading ‘Oil Transfer Tube’.

2. Remove spindle as described under heading ‘Spindle’.

3. Burn off the weld that secures banjo outer plate to the banjo.

4. Using a grinder, grind off all burrs and slag from the end of the banjo.

5. Using a suitable solvent, clean the banjo thoroughly to remove all chips and metal dust.

6. Install a new banjo outer plate and seat firmly against the inner reinforcing plates.

7. Weld the banjo outer plate to the banjo as shown on Fig. 5, using E-70 low hydrogen welding rod.

8. Install the spindle to the banjo as described under heading ‘Spindle’.

9. Install the oil transfer tube as described under the heading ‘Oil Transfer Tube’.
Chassis - Chassis, Hood and Fenders

Section 100-0010

Fig. 5 - Tractor Spindle Installation

1 - Spindle
2 - Banjo Outer Plate
3 - Banjo
4 - Nut
5 - Washer
6 - Pilot
7 - Shaft
8 - Sleeve
9 - Fixture
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**Material Requirements**

SAE 1010 Steel

**Dimensions Concentric**

Within 0.002" TIR & Square Within 0.0004" With Back Face

**Break Outside Corners**

Washer, Shaft, Sleeve, Nut, Fixtures, Pilot.
MAINTENANCE

Inspection
Inspect the frame and attached parts at intervals not exceeding 250 hours for cracked or broken welds and bending/twisting of the frame. Any defects found should be repaired before they progress into major failures. Contact your dealer for recommended weld and repair instructions.

Straightening
Hydraulic straightening or aligning equipment should be used to straighten bent or twisted frames whenever possible. However, if heat must be applied, never heat the metal beyond a dull cherry red colour, as too much heat will weaken the metal. When it is necessary to heat the metal, apply heat uniformly over the area to be straightened and protect the heated surface from sudden cooling. Frame parts, that cannot be straightened should be replaced.

Welding

**WARNINGS**
Before any welding is done on a machine equipped with the HEUI electronic management system, disconnect the following in this order: Battery earth cable, battery supply cable, alternator earth cables, alternator supply cables, front & rear transmission ECU connectors (located behind access door below cab door) and front & rear engine ECU connectors (located on LH side of engine). Turn off battery master switch before disconnecting any components. After welding connect all of the above in the reverse order.

Welding and flame cutting cadmium plated metals produce odourless fumes which are toxic. Recommended industrial hygiene practice for protection of the welding operator from the cadmium fumes and metallic oxides requires enclosure ventilation specifically designed for the welding process. A respiratory protective device such as the M.S.A. 'Gasfoo' respirator with G.M.A. cartridge will provide protection against cadmium, fumes and metallic oxides. The 'Gasfoo' respirator has been approved by the U.S. Bureau of Mines: Approval number 23B-10, and is designed to protect against gases, vapours, and/or metal fumes.

**Note:** Prior to welding, switch off/disconnect the following in the order given. Failure to do so may seriously damage the machines electrical components.

a - Turn ignition keyswitch off  
b - Turn battery master switch off  
c - Battery earth cables  
d - Battery supply cables  
e - Alternator earth cables  
f - Alternator supply cables  
g - Transmission ECU connectors (front & rear)  
h - Engine ECU connectors (front & rear)

After welding, connect all of the above in the reverse order.

**Note:** Always fasten the welding machines ground cable to the piece/frame being welded if possible.

Electric arc welding is recommended for all welded frame repairs. Since the nature and extent of damage to the frame cannot be predetermined, no definite repair procedure can be established. As a general rule however, if parts are twisted, bent or pulled apart, or a frame is bent or out of alignment, no welding should be done until the parts are straightened or realigned.

Successfully welded repairs will depend to a great extent upon the use of the proper equipment, materials and the ability of the welder. The Service Department can be consulted regarding the feasibility of welding repairs.

Reinforcement
Frame reinforcement can be made with channel, angle, or flat structural stock. Whenever possible, the reinforcement should extend well beyond the bent, broken, or cracked area. The reinforcement stock thickness should not exceed that of the frame stock and the material should be of the same tensile strength.
Painting
A check of the condition of the paint should be made approximately twice a year and chassis repainted if necessary.

⚠️ WARNING
Welding, burning, heating or dressing surfaces previously painted using polyurethane paint produces fumes which are toxic. Surfaces must be prepared using paint stripper prior to area being reworked. Recommended Industrial Hygiene and Safety Rules should be followed for protection of the welding operator from fumes.

If painting of the actual frame of the unit is required, thoroughly clean the areas to be painted. Apply a primer coat of red oxide and then a finish coat of polyurethane enamel.

To keep rust and corrosion to a minimum, periodic painting of abrasions and other exposed metal areas on the frame is highly recommended.
DESCRIPTION AND OPERATION
Numbers in parentheses refer to Fig. 1.

The steering trunnion (1) is a heavy steel casting mounted on the main frame banjo housing with two trunnion mounting pins (6).

Upper and lower king pins mounted in the trunnion, connect scraper pull yoke to the tractor. Refer to Section 280-0020, PULL YOKE.

Steering cylinders are mounted to the trunnion by pins (13). Base assembly at rear of trunnion serves as a mount for flow reversing valve. Refer to Section 220-0010, STEERING LINES AND FITTINGS.

Stop block assemblies (11), prevent steering cylinder pistons from bottoming when cylinder rods are extended to their maximum strokes. Refer to Section 220-0010, STEERING LINES AND FITTINGS.

REMOVAL AND DISASSEMBLY
Numbers in parentheses refer to Fig. 1.

**WARNING**
To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Operate the treadle valve continuously relieve any pressure in the braking system.

3. Block all road wheels and place battery master switch in the 'Off' position.
Chassis - Steering Trunnion

Section 100-0130

4. Separate scraper from tractor. Refer to Section 280-0020, PULL YOKE.

5. Remove steering cylinders. Refer to Section 220-0120, STEERING CYLINDER.

6. Attach suitable lifting equipment to steering trunnion (1) before removing it from tractor frame.

7. Remove bolts (10), lockwashers (9) and nuts (8) from steering trunnion (1).

8. Slide pins (6) out of the steering trunnion (1) bores.

9. When pins (6) are released, washers (5) will be free for removal.

10. Remove steering trunnion (1) from the tractor frame.

11. While removing steering trunnion (1), be careful not to damage hydraulic lines, air lines and wiring.

**WARNING**
Make sure to use a soft drift and drive when removing bushing, to prevent personal injury from flying chips.

12. If necessary, drive bushing (2) from steering trunnion (1) with a soft drift and drive.

13. If necessary, remove lube fittings (7) from mounting pins (6).

14. If necessary, remove washer (3) by breaking weld.

**INSTALLATION AND ASSEMBLY**

Numbers in parentheses refer to Fig. 1.

**WARNING**
To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

**Note:** Tighten all fasteners, without special torques specified, to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. If removed, install bushing (2) in steering trunnion (1).

2. If removed, position washer (3) on steering trunnion (1) and weld as shown in Fig. 2.

3. Attach suitable lifting equipment to steering trunnion (1) and position it on tractor frame.

4. While installing steering trunnion (1), guide hydraulic lines, and hose containing air lines and wiring through the opening in the steering trunnion (1). Be careful not to damage lines and wiring during installation.

5. Install thrust washers (5) and mounting pins (6), attaching steering trunnion (1) to tractor frame.

6. Check clearance at thrust washers (5) by forcing the trunnion (1) rearward against the forward thrust washer on each mounting pin (6). With the rear washer on each pin positioned forward against the tractor frame mount, measure the gap between the rear washers and the trunnion. The gap should be 0.25 - 1.02 mm (0.010 - 0.040 inch). The standard thrust washers used are 13.59 - 13.72 mm (0.535 - 0.540 inch) thick. If the gap is more than specified above when using standard thrust washers, oversize thrust washers should be installed to obtain the specified clearance. Oversize thrust washers, 14.48 - 14.73 mm (0.570 - 0.580 inch) and 16.00 - 16.26 mm (0.630 - 0.640 inch) are available.

7. Secure mounting pins (6) with bolts (10), lockwashers (9) and nuts (8).

8. If removed, install lube fittings (7) in mounting pins (6).

9. Connect scraper to tractor. Refer to Section 280-0020, PULL YOKE.

10. Install steering cylinders. Refer to Section 220-0120, STEERING CYLINDER.

**SPECIAL TOOLS**

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of the general service tools required. These tools are available from your dealer.
Fig. 2 - Washer and Bushing Installation
DESCRIPTION

Numbers in parentheses refer to Fig. 1.

For engine make, model and specification, refer to Section 000-0000, GENERAL INFORMATION. For engine servicing and repair data refer to the engine manufacturers service manual.

The engine is mounted to the tractor frame at three points by a mounting bracket (6) at the front of engine (1) and two rear mounts (7 & 8). Rubber isolation mounts (9) through engine mounts provide sufficient flexibility to absorb varying engine vibration and torsional loads.

The spin-on type fuel filter (3) is remotely mounted on the right hand side of the frame in a downward position (1). REFER to section 200-0040 for remote fuel filter details. There is also an 'in-line' fuel filter mounted on the left hand side of the frame (see fig 2). The remote filter acts as a strainer / water separator and should be checked daily. REFER to fig. 2 for hose / line connections for the filters.
QUANTUM ELECTRONIC FUEL SYSTEM

Description
Refer to Fig. 3.

⚠️ WARNING
Before any welding is done on a machine equipped with the Quantum Electronic Fuel System, disconnect the following in this order: Battery earth cable, battery supply cable, alternator earth cables, alternator supply cables, front & rear electrical connections at the engine ECM connectors (located behind access door below cab door) and front & rear transmission ECU connectors (located on LH side of engine). Turn off battery master switch before disconnecting any components. After welding connect all of the above in the reverse order.

The engine is equipped with Quantum Electronic Fuel System which controls the timing and amount of fuel injection by the electronic fuel system injectors. The system also monitors several engine functions using electrical sensors which send electrical signals to the electronic control module (ECM). The ECM then computes the incoming data and determines the correct fuel output and timing for optimum power, fuel economy and emissions.

The Quantum Electronic Fuel System also takes action to prevent damage to the engine and, provides the serviceman with diagnostic capabilities so that problems can be corrected quickly and easily.

1. Electronic Control Module (ECM) - Receives electronic inputs from the driver as well as from mounted sensors that provide information electronically, such as oil pressure and temperature and intake manifold pressure. This information is used to control both the quantity of fuel injected and injection timing.

2. Programmable Read Only Memory (PROM) - Located in the ECM and encoded with the operating software. Additional information is programmed into the EEPROM. This information controls the horsepower rating, torque curve, maximum engine speed and engine protection devices. The ECM processes this information and sends electronic signals to the Electronic Fuel System Injectors where the precise amount of fuel is injected into the engine.

3. Electronic Fuel System Injectors - The injector is a lightweight, compact unit that injects diesel fuel directly into the combustion chamber. The amount of fuel injected and the beginning of injection timing is
determined by the ECM. The ECM sends a command pulse which activates the injector solenoid.

The injector performs four functions:

a - Creates the high fuel pressure required for efficient injection.
b - Meters and injects the exact amount of fuel required to handle the load.
c - Atomizes the fuel for mixing with the air in the combustion chamber.
d - Permits continuous fuel flow for component cooling.

Electronic fuel system injectors are self compensating and virtually eliminate engine tune-ups.

Note: Never apply 12 V directly to terminals on the injector as it will burn out. Before removing injectors, the fuel passages must be blown out to prevent fuel flow from entering the cylinder head.

4. Batteries - Two 12 volt maintenance free batteries supply the machine with electrical power to operate all electrical components.

5. Electronic Foot Pedal - The electronic foot pedal provides an electrical signal to the engine's fuel control system in proportion to the degree of pedal actuation.

Note: The engine MUST be started with foot 'OFF' the electronic foot pedal.

Do not place engine under FULL LOAD at FULL SPEED IMMEDIATELY after starting. ALWAYS allow the engine to fully circulate lubricant and warm up gradually before operating at full speed and full load.

Operate engine at top rated speed when maximum power is needed for the load. Operation of the engine below top rated speed can occur during gear shifting due to the difference of ratios between transmission gears, but engine operation MUST NOT be sustained more than 30 seconds at full throttle below top rated speed.

Under normal operating conditions, both engines should be accelerated equally to apply equal power to both the tractor and scraper wheels by depressing both engine accelerators at the same time. In a sharp turn however, use only front engine power, because the scraper wheels tend to push the tractor sideways.

NEVER idle the engine more than 5 minutes at a time; shut it off.
If any gauge operates outwith its normal operating range or a warning light illuminates, shut engine down immediately and report to service or maintenance personnel.

6. Stop Engine Light - When the 'Stop Engine' light comes on, the computer has detected a major malfunction in the engine that requires immediate attention. It is the operators responsibility to shut down the engine to avoid serious damage.

7. Check Engine Light - When the 'Check Engine' light comes on, the computer has detected a fault in the engine. The fault should be diagnosed and corrected at the earliest opportunity.

8. Engine Diagnostic switches - To check for active fault codes:
   a. - The igniton key switch to the ('1') position.
   b. - Press the diagnostic switch to the 'ON' position.
   If no active codes are recorded the 'Stop' and 'Check' lights will come on and stay on. The amber 'Check' and red 'Stop' lights will begin to flash the code of the recorded fault. Refer to pages 26-28 for details of the fault codes.

   Note: To access the rear scraper engine diagnostic code, ensure that the rear engine ignition switch is actuated.

   Note: If the switch is pressed 'ON' during normal operation, the stop light will illuminate, however, this does not indicate an engine malfunction and the light will go out when the switch is pressed 'OFF'.

9. Engine diagnostic request switches - When the engine is in diagnostic mode, this switch is used to search through a list of fault codes, i.e. pressing the top of the switch momentarily will advance to the next active fault code, pressing the bottom of the switch will go back to the previous code.

10. Diagnostic Test Point - Plug in connector for diagnostic data reader (DDR).

11. Maintenance Light - The maintenance light will illuminate when it is time to change the engine oil. The maintenance monitor continuously monitors the time the engine has been operating and the amount of fuel burned to determine when it is time to change oil.

   Note: Whenever an electrical fault has occurred, the maintenance monitor data can be inaccurate.

---

**Operation**

When the 'Stop' light on the dash panel illuminates, the computer has detected a major malfunction in the engine that requires immediate attention. It is the operators responsibility to shut down the engine to avoid serious damage.

The machine is equipped with an engine protection derate system, which records fault codes and illuminates appropriate warning lights when an out-of-range condition associated with any of the following sensors is found:

- Coolant temperature
- Coolant level
- Intake manifold temperature
- Oil pressure
- Oil temperature

The engine power and speed will be gradually reduced depending on the level of severity of the out-of-range condition. The operator MUST shut down the engine to avoid serious damage.

The engine should not be restarted after it has been shut down after activation of the engine protection derate system unless the problem has been diagnosed and corrected.

Whenever the 'Stop' or 'Check' light comes on, the Electronic Fuel System computer will determine where the problem is and will store this information in its memory. If the malfunction is intermittent, the lights will come on and go off as the computer senses the changing engine condition.

A special diagnostic data reader (INSITE) is available that can be plugged into the engine computer memory to extract information related to the cause of the problem. Once the malfunction has been corrected, the Electronic Fuel System will return the engine to normal operation. The data reader can now distinguish between active codes and those stored in the historic code memory (inactive codes). Inactive codes can only be viewed using the data reader. The fault code recorded in the ECM memory will remain until it is erased by a technician.

The operator can check for active faults on the front Tractor unit by turning the ignition key switch to the 'OFF' position, switching the diagnostic switch 'ON' and then turning the ignition key switch to position '1'.

The procedure for the rear Scraper unit is the same, with the additional step of also pressing the Engine ignition switch (Scraper) on the right hand side of the main switch bank.
If no active fault codes are recorded, both (‘Stop’ & ‘Check’) lights will come on and stay on. If active codes are recorded, both lights will come on momentarily. The amber (‘Check’) and red (‘Stop’) lights will begin to flash the code of the recorded fault. The fault codes flash in the following sequence: the amber light flashes once, then there is a pause where both lights are off. Then the numbers of the recorded fault code flash in red. There is a pause between each number. When the code is flashed, the amber light flashes again. e.g. amber flashes once - pause - red flashes twice - pause - red flashes three times - pause - red flashes five times - pause - amber flashes once, indicates fault code 235. The number will repeat in the same sequence until the system is advanced to the next active fault code or the diagnostic switch is switched to the ‘OFF’ position. To go to the next fault code, press top of diagnostic engine request switch. To step back to the previous code, press bottom of diagnostic engine request switch. If only one code is active, the system will continuously display the same fault code. Refer to ‘Electronic Fuel System Diagnostic Codes’ table (pages 24-26) for fault code descriptions.

⚠️ WARNINGS
The operator of a Quantum - equipped vehicle must not attempt to use or read a DDR (INSITE) of any kind while the vehicle is operating. Doing so can result in loss of control, which may cause vehicle damage and may result in personal injury.

⚠️ When engine or electronics system diagnosis is required on a Quantum - equipped vehicle, this must be done by a person other than the operator. The operator must maintain control of the moving vehicle while the assistant performs the diagnosis.
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### ELECTRONIC FUEL SYSTEM DIAGNOSTIC CODES

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<tr>
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<td>432</td>
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<td>Red</td>
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<tr>
<td>433</td>
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<td>Battery Voltage High - Warning</td>
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<tr>
<td>443</td>
<td>Accelerator Pedal Position Sensor Supply Voltage - Circuit shorted low</td>
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<td>444</td>
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<td>488</td>
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<tr>
<td>2195</td>
<td>Auxiliary Equipment Sensor Input #3 (OEM Switch) Engine Protection - Critical</td>
<td>Red</td>
</tr>
</tbody>
</table>
REMOVAL

Tractor

Numbers in parentheses refer to Fig. 1.

Note: Tag all cables, harnesses, lines and pipes disconnected during removal to aid in installation.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering circuit.

2. Block all road wheels and place the battery master switch in the 'Off' position.

3. Disconnect battery cables from terminal posts (earth cable first).

4. Remove hood assembly, and on tractors, the side panel on the operator’s side. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS.

5. Disconnect electrical cables from headlights and reverse alarm. Remove mounting hardware and radiator guard from machine. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS.

6. Remove muffler and exhaust system from the engine.

7. Remove mounting hardware securing air cleaner assembly to right hand fender. Slacken mounting clamp at air cleaner intake pipe and draw air cleaner, complete with rubber hose, away from intake pipe. Disconnect air cleaner intake pipe and remove from the engine. Cover open ends to prevent entry of dirt.

8. If the machine is equipped with an air conditioning system, evacuate refrigerant from the system and disconnect air conditioner lines at the engine compressor. Refer to Section 260-0130, AIR CONDITIONING.

9. With a suitable container in position, open drain cock on the radiator assembly and drain the coolant.

10. Remove the radiator assembly from the vehicle. Refer to Section 210-0040, RADIATOR AND MOUNTING.

11. Support guard plate under the engine with suitable blocking and remove mounting hardware securing guard plate to the frame. Remove guard plate from the frame.

12. Place a suitable container under the engine drain port, remove drain plug and drain the oil. After draining, reinstall drain plug in engine sump and tighten securely.

13. Identify hydraulic hoses (3, Fig. 2) for ease of installation and disconnect from the engine. Cover engine inlet ports to prevent entry of dirt.

14. Identify heater lines for ease of installation and with a suitable container in position, disconnect heater lines from the engine. Cap open line ends and fittings.

15. Identify fuel lines for ease of installation and with a suitable container in position, disconnect fuel lines from the engine. Cap open line ends and fittings.

16. Identify all electrical harnesses and cables for ease of installation and disconnect from the engine.

17. Disconnect clips securing items to the engine that cannot be removed with the engine.
18. Disconnect driveline from the engine coupling and secure clear of the engine. Refer to Section 130-0010, DRIVELINE.

19. Support hydraulic pump with suitable lifting equipment and remove mounting hardware securing pump to the power takeoff assembly. Refer to Section 235-0050, TRIPLE PUMP. Pump can remain attached to hoses, if laid carefully aside.

20. Attach suitable lifting equipment to the lifting brackets on the engine and raise lifting equipment to take up the slack.

21. Remove locknuts (13), washers (12), spacers (11) and bolts (10) securing engine (1) to the frame through front mounting.

22. Remove locknuts (13), washers (12), spacers (11) and bolts (10) securing engine (1) to the frame through rear mounting brackets (7 & 8).

23. Check to make certain that all necessary line and electrical disconnections have been made before lifting engine (1).

24. Carefully lift engine (1) clear of the frame, remove to a suitable work area and mount securely on a work stand.

Scrapers
Use the same procedure to remove the scraper engine as described under tractor engine, except omit steps 8, 14 & 19.

DISASSEMBLY
Numbers in parentheses refer to Fig. 1.

1. Identify rear mounts (7 & 8) to aid in assembly then remove bolts (15 & 16) and lockwashers (18) securing rear mounts to engine (1). Remove mounts (7 & 8).

2. If required, remove rubber isolation mounts (9) from rear mounts (7 & 8) and front mounting bracket (6) on engine (1).

3. Remove bolts (14) securing fan (5) to engine (1) then remove fan (5).

4. Remove mounting hardware securing power takeoff from tractor engine, or flywheel cover from scraper engine, whichever applies. Refer to Section 110-0130, POWER TAKEOFF - TRACTOR or Section 110-0130, FLYWHEEL COVER GROUP - SCRAPER.

5. Remove mounting hardware securing dipstick assembly to engine (1). Remove dipstick assembly from engine (1).

6. Remove mounting hardware securing oil filler assembly to engine (1). Remove oil filler assembly from engine (1).

7. Remove filter (2) from engine (1) and fuel filter (3) from remote mounting on frame as described in 'Maintenance'. Discard filters. Cover engine inlet ports to prevent entry of dirt.

8. Refer to 'Engine Manufacturers Service Manual' if engine service or repair is required.

Note: Remove engine coupling at this stage for checking, by removing required bolts.

INSPECTION
Numbers in parentheses refer to Fig. 1.

1. Inspect rubber isolation mounts (9) for damage and replace if required.

2. Check rear mounts (7 & 8), front mounting bracket on engine (1) and mounting brackets on the frame for cracks and/or damage. Repair or replace as necessary.

ASSEMBLY
Numbers in parentheses refer to Fig. 1.

Note: Tighten all fasteners without special torques specified to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. Remove covers from engine filter ports and install new lube oil filter (2) on engine (1) and fuel filter (3) to remote mounting, as described in 'Maintenance'.

2. Install oil filler assembly on engine (1) and secure with mounting hardware as removed at Disassembly.

3. Install dipstick assembly on engine (1) and secure with mounting hardware as removed at Disassembly.

4. If removed, install coupling (8) to engine with bolts (23) as follows:
   a. Clean and degrease mating faces of engine
Engine - Engine and Mounting

Section 110-0030

flywheel and coupling. Apply Loctite retaining compound to coupling face.

b. Screw two locating pins, which can be fabricated as shown in Fig. 3, to engine flywheel housing and locate coupling (24).

c. Clean bolts (23) and tapped holes with Loctite Primer "T" and apply Loctite Retaining Compound to the bolt (23) threads.

d. Secure coupling (24) to engine using six bolts (23). Torque tighten bolts (22) to 57 Nm (42 lbf ft), working in a diagonal pattern.

e. Remove locating pins and secure remaining two bolts following procedures c and d.

Note: If coupling (24) needs to be removed, the flywheel requires to be heated to a temperature of 160°C in order to break the Loctite bond.

5. If removed, assemble power take-off assembly on tractor engine, or flywheel cover on scraper engine, whichever applies. Refer to Section 110-0130, POWER TAKEOFF - TRACTOR or Section 110-0130, FLYWHEEL COVER GROUP - SCRAPER.

6. Position fan (5) to fan pulley on engine (1) and secure with bolts (14). Tighten bolts in a star shaped pattern to a torque of 34 Nm (25 lbf ft).

7. If removed, install rubber isolation mounts (9) to front mounting bracket on engine (1).

8. If removed, install rubber isolation mounts (9) in rear mounts (7 & 8). Secure rear mounts (7 & 8) to engine (1) with bolts (15 & 16) and lockwashers (18).

INSTALLATION

Numbers in parentheses refer to Fig. 1.

Note: Tighten all fasteners without special torques specified to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

WARNING

To prevent personal injury and property damage, be sure lifting device is properly secured and of adequate capacity to do the job safely.

1. Attach suitable lifting equipment to engine (1) lifting brackets and carefully position engine (1) assembly in the tractor frame.

2. Secure engine (1) assembly to frame mounting brackets with bolts (10 & 14), snubbing washers (11) washers (12) and locknuts (13) as shown in Fig. 1. Torque tighten front mounting bolts (6) to 149 Nm (110 lbf ft). Torque tighten rear mounting bolts (23) to 176 Nm (130 lbf ft).

3. Connect driveline to engine (1) assembly. Refer to Section 130-0010, DRIVELINE.

4. Install hydraulic pump on power takeoff assembly. Refer to Section 235-0050, TRIPLE PUMP.

5. Remove caps from heater lines and fittings and connect heater lines to engine (1) as identified at removal.

6. Remove caps from fuel lines and fittings and connect fuel lines to engine (1) as identified at removal.

7. Remove caps from hydraulic hoses (3, Fig. 2) and fittings and ports on engine (1) as identified at removal.

8. Connect all electrical harnesses and cables to engine (1) (with the exception of battery connections) as identified at removal.

9. Install radiator assembly on the vehicle. Refer to Section 210-0040, RADIATOR AND MOUNTING.

10. Ensure all cooling lines to radiator assembly, engine (1) are correctly connected. Refer to Section 210-0040, RADIATOR AND MOUNTING.

11. Connect air conditioner lines at the compressor as identified at removal. On completion of engine installation the air conditioning system will require to be charged. Refer to Section 260-0130, AIR CONDITIONING.

12. Install muffler and exhaust system to the engine.

13. Remove covers from air cleaner intake pipe and rubber hose on the air cleaner inlet then locate the rubber hose on air cleaner assembly to the inlet pipe. Install air cleaner intake pipe to engine.

14. Secure air cleaner assembly to the right hand fender and rubber hose to the inlet pipe with mounting hardware removed during removal.

15. Connect battery positive connections to battery terminals. Connect battery earth connections to battery terminals.
16. Ensure all lines, harnesses and cables are secured with clips and clamps as removed during removal. Ensure no lines are chaffing on sharp edges or resting against areas where heat will be evident.

17. Ensure drain cock at the bottom of the radiator assembly and drain cocks on engine (1) water jacket are securely closed.

18. Fill the cooling system with coolant. Refer to Section 300-0020, LUBRICATION SYSTEM.

19. Fill the engine with lubricant through oil filler to the top mark on dipstick. Refer to Section 300-0020, LUBRICATION SYSTEM for oil specification.

20. Check all line and pipe connections for leaks prior to starting the vehicle. Tighten as required.

21. Switch the battery master switch to the 'On' position, start up the engine and check for leaks. Tighten lines, pipes and fittings and top up all systems as required.

22. Install hood assembly and side panel on the vehicle. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS.

23. Using suitable lifting equipment position engine guard under the engine and secure to the frame with mounting hardware removed during removal.

24. Remove wheel blocks from all road wheels.

Scraper
Use the same procedure to install the scraper engine as described under tractor engine, except omit steps 4, 5 & 11.

MAINTENANCE
Numbers in parentheses refer to Fig. 1.

Note: Carry out the following maintenance procedures in conjunction with additional procedures listed in Section 300-0020, LUBRICATION SYSTEM.

Every 10 Hours (Daily)
Engine (1): Visually check engine for damage, loose or frayed belts and listen for any unusual noises. Check the turbocharger for leaks.

Engine (1) Oil Level Check - Position the vehicle on a level work area, apply the parking brake, shut off the engine and wait at least five minutes (to allow oil to drain to the oil pan) before checking the oil level. The oil level should be between the low (L) and high (H) marks on the dipstick. Add oil if low. Refer to Section 300-0020, LUBRICATION SYSTEM for oil specification.

Note: Never operate the engine with oil level below the low (L) or above the high (H) mark on the dipstick.

Fuel Filter/Water Separator (4) - Drain the water and sediment from the separator daily. Position the vehicle on a level work area, apply the parking brake, shut off the engine and, with a suitable container below the drain valve to catch spillage, open the drain valve by hand. Turn the valve anticlockwise approximately 1.5 - 2 turns until draining occurs. Drain the filter sump until clear fuel is visible. Turn the valve clockwise to close the drain valve.

Note: Do not overtighten the drain valve as overtightening can damage the threads.

Cooling System - Check coolant level add if low - Add coolant to the top of the filler neck.

Drive Belts - Visually inspect all drive belts daily. Replace belts that are cracked or frayed and adjust belts that have a glazed or shiny surface which indicates belt slippage. Correctly installed and tensioned belts will show even pulley and belt wear.

Every 500 Hours
Engine (1): Drain engine oil and refill. Refer to Section 300-0020, LUBRICATION SYSTEM for oil specification.

Engine Water Pump: Inspect water pump drain hole and clean if required.

Engine Oil Filter (2): Replace oil filter as follows:
1. Using filter wrench, remove and discard oil filter (2) from engine (1). Inspect the sealing surface of the filter to ensure that the seal ring stayed with the filter. If not, remove it from the filter adaptor.

2. Clean the filter adaptor with a clean, lint free cloth.

3.lightly coat new oil filter (2) seal with clean engine oil as specified in Section 300-0020, LUBRICATION SYSTEM.
4. Start a new oil filter (2) on the filter adaptor and tighten it by hand until the seal touches the adaptor filter head. Tighten an additional 2/3 of a turn after contact.

**Note:** Mechanical tightening of oil filter (2) is not necessary and will distort or crack the adaptor. Tighten oil filters by hand only.

5. Start and run the engine for a short period and check for oil leaks. If any leaks are noted, have them corrected.

6. After the engine has been stopped long enough (approximately 20 minutes) for the oil from various parts of engine (1) to drain back to the crankcase, check oil level and add oil to bring it to the proper level on the dipstick. Refer to Section 300-0020, LUBRICATION SYSTEM for oil specification.

**Fuel Filter (4):** Replace fuel filter (4) as follows:

1. Close shut off valve at fuel filter (4) and, using filter wrench, remove and discard fuel filter (4) from engine (1).

2. Fill the replacement filter and coat the gasket slightly with clean fuel oil as specified in Section 300-0020, LUBRICATION SYSTEM.

3. Start new fuel filter (4) on the filter adaptor and tighten it by hand until the gasket contacts the adaptor fully with no side movement of the filter evident. Tighten an additional 1/2 of a turn.

**Note:** Mechanical tightening of fuel filters (4) is not recommended, and may result in seal and/or cartridge damage. Tighten fuel filter by hand only.

4. Start the engine and check for leaks. If any leaks are noted, have them corrected.

**Coolant Filter (3):** Check condition of coolant inhibitor as described in Engine 'Operation and Maintenance Manual'. Replace coolant filter (3) as follows:

1. Close shut off valves at coolant filter (3) inlet and outlet lines and, using filter wrench, remove and discard coolant filter (3) from engine (1).

2. Clean the filter adaptor with a clean, lint free cloth.

3. Lightly coat new coolant filter (3) seal with clean engine oil as specified in Section 300-0020, LUBRICATION SYSTEM.

4. Start coolant filter (3) on the filter adaptor and tighten it by hand until the seal touches the adaptor filter head. Tighten an additional 2/3 of a turn after contact.

**Note:** Mechanical tightening of coolant filter (3) is not necessary and will distort or crack the adaptor. Tighten oil filters by hand only.

5. Open shut off valves at coolant filter (3) inlet and outlet lines.

6. Start the engine and check for leaks. If any leaks are noted, have them corrected. Add coolant as required. Refer to Section 300-0020, LUBRICATION SYSTEM.
SPECIAL TOOLS
Refer to Section 300-0070, SERVICE TOOLS, for part numbers of service tools which should be used in conjunction with procedures outlined in the engine manufacturers service manual, and, general service tools required. These tools are available from your dealer. The locating pins used in the installation of the engine damper can be fabricated as shown in Fig. 4.

Material:
Make from 13017, 13040 or 13083

SPECIAL TORQUE SPECIFICATIONS

<table>
<thead>
<tr>
<th>FIG. NO.</th>
<th>ITEM NO.</th>
<th>ITEM NAME</th>
<th>TORQUE</th>
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<tr>
<td></td>
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<td>Fan Hub Mounting Bolts</td>
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* * * *
DESCRIPTION

Numbers in parentheses refer to Fig. 1, unless otherwise specified.

There are two dual dry element type air cleaner assemblies fitted to the machine, one for the tractor engine and one for the scraper engine. The tractor air cleaner is mounted off the platform to the right hand side of the machine, the scraper air cleaner is mounted under the hood adjacent to the rear right hand fender. The air cleaner prolongs engine life by removing grit, dust and water from the air as it enters the engine. Grit and dust combined with engine oil, forms a highly abrasive compound which can destroy the engine in a comparatively short period of time.

A rubber vacuator valve (6) attached to cover assembly (4) in a downward position, ejects grit, dust and water while the engine is running. Vacuator valve (6) minimizes the need for daily servicing. Even though vacuator valve (6) is normally under a slight vacuum when the engine is running, pulsing of the vacuum opens and closes vacuator valve (6) expelling grit, dust and water as they collect. When the engine is stopped, vacuator valve (6) opens and expels any accumulated grit, dust or water.

A mechanical air restriction gauge (12, Fig. 2) is mounted externally and indicates when the system air flow is being restricted. A red band gradually rises in the gauge window as air restriction increases. The red band is locked when maximum allowable restriction level is reached. When the red band locks at the top of the gauge window, primary element (2) should be serviced. Air restriction gauge (12, Fig. 2) should be reset by pushing the button on the gauge, holding it for several seconds and then releasing it.

While the air restriction gauge (12, Fig. 2) indicates the need for servicing, it does not give as precise a measurement as a water manometer or vacuum gauge. Refer to 'Measuring Air Restriction'.

Safety element (3) is installed in the air cleaner assembly inside of primary element (2). This element increases the reliability of the air cleaner’s protection of the engine from airborne dirt. It protects the engine from dirt admitted by a damaged primary element (2), or dirt that might be dropped into the air cleaner assembly while servicing primary element (2).
MAINTENANCE

Numbers in parentheses refer to Fig. 1, unless otherwise specified.

WARNING
Always shutdown the engine before servicing air cleaner.

Check air restriction gauge (12, Fig. 2) daily. The air cleaner elements should be serviced only when the maximum allowable restriction has been reached, as indicated by air cleaner restriction gauge (12, Fig. 2). The elements should not be serviced on the basis of visual observation as this would lead to over service. When restriction readings finally indicate a change, remove primary element (2) carefully and clean/replace as required. Refer to 'Primary Element'.

Never attempt to clean safety element (3). Change safety element (3) after every third primary element (2) service.

Make sure vacuator valve (6) is not damaged or plugged and that the joint with cover assembly (4) is not broken. If vacuator valve (6) is lost or damaged, replace it to maintain pre-cleaner efficiency and normal filter element service life.

Check condition of clamps (7, Fig. 2), hump hose (5, Fig. 2) and elbows (2 & 3, Fig. 2). Tighten/replace as necessary.

Air Cleaner Assembly
Numbers in parentheses refer to Fig. 1, unless otherwise specified.

Note: Air cleaner body (1) should be thoroughly cleaned twice a year. Do not apply heat in any form to air cleaner body (1).

1. Release latches (5) on cover assembly (4) and remove cover assembly from air cleaner body (1).

2. Remove primary element (2) and safety element (3) from air cleaner body (1).
3. Slacken clamp (6, Fig. 2) and disconnect elbow (3, Fig. 2) from air cleaner body (1).

4. Remove nuts (16, Fig. 2), lockwashers (15, Fig. 2) and bolts (14, Fig. 2) securing the air cleaner assembly to mounting bracket (1, Fig. 2).

5. Remove the air cleaner assembly from the machine for cleaning.

6. Open clamps (6) and remove from air cleaner body (1). Open clamp on cap assembly (7) and remove cap assembly from air cleaner body (1).

7. Blank off air cleaner body (1) outlets with tape or cardboard. Reach inside body with a compressed air nozzle or brush and remove dust from the body.

8. Remove all loose dust from air cleaner body (1) and remove tape or cardboard from body outlets.

**Note:** Assembly and installation of the air cleaner assembly is the reverse of disassembly and removal.

### Primary Element

Numbers in parentheses refer to Fig. 1.

Although a paper primary element (2) is used, it is possible to clean it so that it can be reused. The number of times one element can be reused depends on the type of dirt on the element and the care exercised in cleaning.

The life of a properly cleaned element will be approximately as long as that of a new element for the first one or two cleanings. After that, the life of the element will gradually decrease with each cleaning; however, it should perform satisfactorily through approximately six cleanings, providing it does not rupture.

Visually determine the condition of primary element (2) and choose either the compressed air or washing method.

1. Release latches (5) on cover assembly (4) and remove cover assembly from air cleaner body (1).

2. Remove primary element (2) from air cleaner body (1).

3. Using a damp cloth and a suitable solvent, wipe out all excess dust from air cleaner body (1) and allow to dry.

4. If the major contaminant on primary element (2) is light dust, direct a jet of compressed air, not exceeding 6.9 bar (100 lbf/in²), against the pleats of the element. The air jet should be directed in the opposite direction of normal operating air flow. Move the air jet up and down the pleats, holding the air nozzle 25 mm (1.0 in) away from the pleats, to prevent rupturing the element with either the nozzle or air jet.

5. In cases where the dust cake on primary element (2) contains oil or carbon, air will not clean effectively. Using manufacturers recommended solution and warm water, not exceeding 48° C (120° F), soak primary element (2) for fifteen minutes. Element should be gently agitated to assist cleaning process.

**Note:** It is possible to modify an old agitator type washing machine for primary element (2) cleaning. Do not soak or agitate primary element (2) in the solution for more than fifteen minutes. Prolonged exposure softens vertical seams in the element.

6. Rinse washed element thoroughly with a low pressure stream of water, not exceeding 0.7 bar (10 lbf/in²), opposite from the normal air flow, until rinse water runs clear.

7. Air dry primary element (2) thoroughly before returning it to service. Drying is a slow process which may be hastened by exposing element to slowly circulating heated air. Heated air temperature should not exceed 46° C (115° F). Drying time can be reduced to about three hours with heated air. DO NOT use a light bulb for drying. DO NOT use compressed air on a wet element.

**Note:** Replace paper elements after six cleanings or two years in service, whichever comes first. Mark each cleaned element to show total cleanings to date.

8. After primary element (2) is thoroughly dried, inspect for damage or ruptures, especially close to the end caps. To detect paper ruptures, place a bright light bulb inside the element and rotate element slowly. Inspection of element on the outside will disclose any holes where concentrated light shines through. Even the smallest hole will pass dust to the engine and may result in costly engine repairs.

9. Install primary element (2) in air cleaner body (1).

10. Install cover assembly (4) on air cleaner body (1) and secure with latches (5).
Secondary Element
Numbers in parentheses refer to Fig. 1.

Since safety element (3) is protected from contamination by primary element (2), it needs no periodic cleaning and should be replaced only after every third primary element (2) service.

1. With primary element (2) removed from air cleaner body (1), remove safety element (3).

2. Remove any dust dislodged into air cleaner body (1) outlet and, using a damp cloth and a suitable solvent, wipe out all excess dust from air cleaner body (1) and allow to dry.

3. Install new safety element (3) followed by primary element (2) in air cleaner body (1)

4. Install cover assembly (4) on air cleaner body (1) and secure with latches (5).

Recommendations
Numbers in parentheses refer to Fig. 2.

1. Under no condition should the vehicle be operated without both filter elements in each air cleaner assembly.

2. It is very important that hump hose (5) and elbows (2 & 3) from the air cleaner assembly to the engine be airtight or the purpose of the air cleaner will be completely defeated. All clamps (4 & 6) should be checked frequently and tightened to prevent leaks.

3. Keep new or cleaned filter elements on hand for replacement to prevent unnecessary downtime of the vehicle.

MEASURING AIR RESTRICTION
Numbers in parentheses refer to Fig. 2.

As a dry air cleaner element becomes loaded with dust, the vacuum on the engine side of the air cleaner (air cleaner outlet) increases. This vacuum is generally measured as ‘restriction in mm (inches) of water’.

The recommended maximum allowable intake restrictions at rated speed and load are as follows:

a. 380 mm-H₂O (15 in-H₂O) with clean filter elements.
b. 635 mm-H₂O (25 in-H₂O) with dirty filter elements.

While the air restriction gauge sends a signal to indicate the need for servicing, it does not give as precise a measurement as a water manometer or vacuum gauge.

Water Manometer
a. Remove air restriction gauge (12) from port in air cleaner assembly.

b. Hold water manometer vertically and fill both legs approximately half full of water. Connect one of the upper ends to port by means of a flexible hose.

c. With the manometer held vertically and the engine drawing maximum air, the difference in height of the water columns in the two legs is measured as the air cleaner restriction.

d. If the restriction exceeds the levels indicated, engine performance will be affected. Primary filter element should be cleaned or replaced.

Vacuum Gauge
a. Remove air restriction gauge (12) from port in air cleaner assembly.

b. Connect the hose from the vacuum gauge to port and, with the engine drawing maximum air, take a note of the reading on the gauge.

c. If the restriction exceeds the levels indicated, engine performance will be affected. Primary filter element should be cleaned or replaced.

SERVICE TOOLS
Refer to Section 300-0070, SERVICE TOOLS for part numbers of service tools referenced in this section and general service tools required. These tools are available from your dealer.

* * * *
DESCRIPTION AND OPERATION

Numbers in parentheses refer to Fig. 1.

The function of the power takeoff (PTO), as the name implies, is to provide the means of mounting and driving an auxiliary component. The triple pump for the bowl hydraulic system and steering system is mounted to PTO cover (10) and its input shaft is meshed with the internal splines in the hub of driven gear (28). Refer to Section 235-0050, TRIPLE PUMP.

The major components of the PTO assembly are; flywheel cover case (2), PTO cover (10), driveshaft (6), drive gear (5) and driven gear (28).

As driveshaft (6) is driven by the engine crankcase, drive gear (5) turns the driven gear (28). The triple pump driveshaft, meshed in the hub of driven gear (12), turns with driven gear (12) to operate the triple pump which, in turn, supplies hydraulic oil to the steering system and bowl hydraulic system. Refer to Section 235-0050, TRIPLE PUMP.

REMOVAL

Numbers in parentheses refer to Fig. 1.

WARNING

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Turn steering wheel several times to relieve any pressure in the steering circuit.

2. Block all road wheels and place the battery master switch in the 'Off' position.

3. Disconnect driveline from flange (18) at the PTO assembly. Refer to Section 130-0010, DRIVELINE.

4. Drain oil from power takeoff housing by removing
drain plug (30) from PTO cover (10). Reinstall drain plug (30) securely.

5. Match mark triple pump mounting flange and PTO cover (10) so that the pump can be installed in the same position at installation.

6. With suitable blocking or lifting equipment, support the pump before loosening attaching nuts. Remove nuts and lockwashers from pump mounting studs and secure pump clear of the PTO assembly.

7. Match mark engine flywheel housing and flywheel cover case (2) so that the PTO assembly can be installed in the same position at 'Installation'.

8. Attach a suitable lifting device to the PTO assembly and remove bolts (3 & 37) and lockwashers (22 & 26) securing PTO assembly to the engine flywheel housing. Carefully lower PTO assembly and spacer (31) from the flywheel housing and move to a clean work area for disassembly.

9. Remove spacer (31) and Damper assembly (32 & 33) from the PTO assembly.

**DISASSEMBLY**

Numbers in parentheses refer to Fig. 1.

1. Remove cotter pin (15), locknut (16) and hardened washer (17) from driveshaft (6). Pull flange (18) from driveshaft (6).

2. Remove bolts (8 & 24) from PTO cover (10). Pull PTO cover (10) and gasket (26) from flywheel cover case (2). Discard gasket (26).

3. Place PTO cover (10) flange side up on a work bench. Pry oil seal (19) from PTO cover (10) and discard.

4. Remove snap rings (21) from pump and driveshaft bores. Drive bearings (7 & 27) from PTO cover (10) with a sleeve or soft steel drift. Drive on the outer race of bearings (7 & 27) taking care not to damage the bearings.

5. Slide drive gear (5) from driveshaft (6) and pull driven gear (28) from flywheel cover case (2).

6. Pull driveshaft (6) from flywheel cover case (2). Pry oil seal (1) from flywheel cover case (2).

7. Pull bearings (4 & 29) from flywheel cover case (2) with a suitable bearing puller.

8. If necessary, note locations and remove dowel pins (25) from flywheel cover case (2) and breather assembly (11, 12, 13 & 14) from PTO cover (10).

**INSPECTION**

Numbers in parentheses refer to Fig. 1.

1. Wash all parts thoroughly in a suitable solvent and dry all but bearings (4, 7, 27 & 29) with compressed air. Dry bearings (4, 7, 27 & 29) with a clean lint free cloth.

2. Check the condition of splines and teeth on gears (5 & 28), driveshaft (6), flange (18) and Damper (33) for burrs or signs of wear.

3. Lubricate bearings (4, 7, 27 & 29) with oil and check operation by spinning bearings by hand. DO NOT spin bearings with compressed air. Inspect bearing bores for out of roundness or irregular wear patterns. Replace bearings, if required.

4. Inspect flywheel cover case (2) and PTO cover (10) for cracks. If either flywheel cover case (2) or PTO cover (10) are damaged, both parts must be replaced as an assembly.

5. Visually check oil seal lip contact surfaces on driveshaft (6) and flange (18) for nicks, dents, scratches, wear, or corrosion. Replace as necessary.

**ASSEMBLY**

Numbers in parentheses refer to Fig. 1.

*Note:* Prior to assembly, lubricate all seal lips and surfaces with lubricant specified in Section 300-0020, LUBRICATION SYSTEM.

*Note:* Tighten all fasteners without special torques specified to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

**WARNING**

To prevent personal injury and property damage, be sure lifting device is properly secured and of adequate capacity to do the job safely.

1. If removed, install dowel pins (25) in flywheel cover case (2) and breather assembly (11, 12, 13 & 14) in PTO cover (10), as noted at disassembly.
2. Using suitable lifting equipment, position triple pump over its mounting studs and secure with nuts and lockwashers removed during removal.

3. Reconnect driveline to flange (18). Refer to Section 130-0010, DRIVELINE.

4. Remove oil level plug from PTO cover (10) and fill PTO assembly with lubricant specified in Section 300-0020, LUBRICATION SYSTEM, until oil flows from the oil level port. Install oil level plug in PTO cover (10) and tighten securely.

5. Place the battery master switch in the 'On' position, start the engine and bring oil to correct operating temperature. Check for leaks and correct as necessary.

6. Remove wheel blocks from all road wheels.

MAINTENANCE

Numbers in parentheses refer to Fig. 1.

Note: Refer to Section 300-0020, LUBRICATION SYSTEM for recommended check and drain intervals and lubricant specifications.

Oil Level Check

Remove oil level plug from the PTO cover (10) and, if oil level is below the bottom of the filler hole, add lubricant until it flows from the filler hole. Reinstall oil level plug and tighten securely.

Drain and Refill

To drain: Remove drain plug (30) from PTO cover (10) and drain oil into a suitable container. Reinstall drain plug (30) securely when draining is complete.

To refill: Remove oil level plug from the PTO cover (10) and fill PTO assembly with lubricant specified in Section 300-0020, LUBRICATION SYSTEM, until oil flows from the oil level port. Install oil level plug in PTO cover (10) and tighten securely.

SPECIAL TOOLS

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.
### SPECIAL TORQUE SPECIFICATIONS

<table>
<thead>
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<th>FIG. NO.</th>
<th>ITEM NO.</th>
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<th>TORQUE lbf ft</th>
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<td>16</td>
<td>Locknut</td>
<td>950 - 1 085</td>
<td>700 - 800</td>
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</table>

* * * * *
Section 110-0130

REMOVAL

Numbers in parentheses refer to Fig. 1.

**WARNING**

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Turn steering wheel several times to relieve any pressure in the steering circuit.

2. Block all road wheels and place the battery master switch in the 'Off' position.

3. Disconnect driveline from yoke (4) at the flywheel assembly. Refer to Section 130-0010, DRIVELINE.

4. Match mark flywheel cover case (2) and engine flywheel housing so that the flywheel cover case (2) can be installed in the same position at 'Installation'.

5. Attach a suitable lifting device to the flywheel cover case (2) assembly and remove bolts (18) and lockwashers (19) securing assembly and spacer (1) to the engine flywheel housing. If necessary pry flywheel cover case (2) and spacer (1) assembly away from engine flywheel housing.

6. Carefully lower flywheel cover case (2) and spacer (1) assembly from the flywheel housing and move to a clean work area for disassembly.

7. Remove spacer (1) from the flywheel cover case (2) assembly.

---

**Fig. 1 - Exploded View of Flywheel Cover and Driveshaft**

1 - Spacer  6 - Snap Ring  11 - Oil Seal  16 - Cotter Pin
2 - Flywheel Cover Case  7 - Snap Ring  12 - Lockwasher  17 - Grease Fitting
3 - Driveshaft  8 - Bearing  13 - Bolt  18 - Bolt
4 - Yoke  9 - Spacer  14 - Washer  19 - Lockwasher
5 - Oil Seal  10 - Cover  15 - Slotted Nut  20 - Bearing
Engine - Flywheel Cover Group - Scraper
Section 110-0130

DISASSEMBLY
Numbers in parentheses refer to Fig. 1.

1. Remove cotter pin (16), slotted nut (15) and washer (14) from driveshaft (3). Pull yoke (4) from driveshaft (3).

2. Remove bolts (13) and lockwashers (12) from cover (10). To remove the cover (10) from the flywheel cover case (2), tap it with a soft hammer. Oil seal (11) is removed with the cover. Remove oil seal (11) with a soft drift and hammer.

3. Slide spacer (9) from driveshaft (3).

4. Install a thread protector onto the threaded end of driveshaft (3). Drive the shaft through flywheel cover (2) assembly. The oil seal (5) and bearing (8) are removed in the process.

5. Remove snap rings (6 & 7) and press bearing (8) off of driveshaft (3).

6. With a soft drift and hammer, tap bearing (20) out of flywheel cover case (2).

INSPECTION
Numbers in parentheses refer to Fig. 1.

1. Wash all parts thoroughly in a suitable solvent and dry all but bearings (8 & 20) with compressed air. Dry bearings (8 & 20) with a clean lint free cloth.

2. Check the condition of splines on driveshaft (3) and yoke (4) for burrs or signs of wear.

3. Lubricate bearings (8 & 20) with oil and check operation by spinning bearings by hand. DO NOT spin bearings with compressed air. Inspect bearing bores for out of roundness. Replace bearings, if required.

4. Inspect flywheel cover case (2) for cracks. If damaged, flywheel cover case (2) must be replaced.

5. Visually check oil seal lip contact surfaces on driveshaft (3) and yoke (4) for nicks, dents, scratches, wear, or corrosion. Replace as necessary.

ASSEMBLY
Numbers in parentheses refer to Fig. 1.

Note: Prior to assembly, lubricate all seal lips and surfaces with lubricant specified in Section 300-0020, LUBRICATION SYSTEM.

Note: Tighten all fasteners without special torques specified to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

**WARNING**
To prevent personal injury and property damage, be sure lifting device is properly secured and of adequate capacity to do the job safely.

1. Install new oil seal (5) in bore of flywheel cover case (2). Be sure the seal is seated against the shoulder in the flywheel cover (2) face, then install snap ring (6).

2. Press bearing (8) on driveshaft (3), then install snap ring (7).

3. Install assembled driveshaft (3) and bearing (8) in flywheel cover case (2).

4. Press bearing (20) over driveshaft (3) and into bore in flywheel cover case (2). Be sure the bearing snap ring is seated against cover.

5. Slide spacer (9) onto driveshaft (3) with chamfered side towards the bearing (20).

6. Press seal (11) into bore in cover (10), with the seal lip facing towards yoke (4). Be sure seal (11) is seated against the shoulder in the cover (10).

7. Install assembled cover (10) to flywheel cover case (2). Secure with bolts (13) and lockwashers (12) torqued to 8 - 11 Nm (6 - 8 lbf ft) lubricated.

8. Install yoke (4), washer (14) and slotted nut (15) on driveshaft (3) end. Tighten nut (15) to a torque of 970 - 1 243 Nm (715 - 917 lbf ft) lubricated and install cotter pin (16).
INSTALLATION
Numbers in parentheses refer to Fig. 1.

Note: When reassembling flywheel cover assembly to engine flywheel housing, be sure to align match marks inscribed during disassembly.

Note: Tighten all fasteners without special torques specified to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. Install spacer (1) on flywheel assembly and, using suitable lifting equipment, position flywheel assembly on engine flywheel housing. Secure the flywheel assembly and spacer (1) to the engine flywheel housing with bolts (18) and lockwashers (19) torqued to 57 - 75 Nm (42 - 55 lbf ft) lubricated.

2. Reconnect driveline to yoke (4). Refer to Section 130-0010, DRIVELINE.

3. Lubricate grease fitting (17) with lubricant specified in Section 300-0020, LUBRICATION SYSTEM. Do NOT overgrease.

4. Place the battery master switch in the 'On' position, start the engine and bring oil to correct operating temperature. Check for leaks and correct as necessary.

5. Remove wheel blocks from all road wheels.

MAINTENANCE
Numbers in parentheses refer to Fig. 1.

Note: Refer to Section 300-0020, LUBRICATION SYSTEM for recommended check and drain intervals and lubricant specifications.

SPECIAL TOOLS
There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.

<table>
<thead>
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<td></td>
<td></td>
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<tr>
<td>1</td>
<td>18</td>
<td>Bolt</td>
<td>57 - 75</td>
</tr>
</tbody>
</table>
DESCRIPTION

Numbers in parentheses refer to Fig. 1.

For transmission make, model and specification, refer to Section 000-0000, GENERAL INFORMATION. For transmission servicing and repair data refer to transmission manufacturers service manual.

The transmission is supported by left hand mounting bracket (1) and right hand mounting bracket (2) which are bolted to the transmission and attached to front frame mounting brackets through isolation mounts (6). Isolation mounts (6) provide sufficient flexibility to absorb varying transmission vibration and torsional loads.

The transmission assembly, used in both the tractor and scraper, is a countershaft-type gearbox with integral torque converter. Signalled by electric shift control the transmission has seven forward speeds and one reverse. Automatic converter lockup in the top six forward gears. The rear transmission is equipped with an alarm to warn the operator in event of a malfunction. Refer to Section 120-0070, TRANSMISSION ELECTRONIC CONTROLS.
Transmission - Transmission and Mounting

Section 120-0010

REMOVAL

Numbers in parentheses refer to Fig. 1.

Note: Tag all lines, cables and linkages disconnected during removal to aid in installation.

**WARNINGS**

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

High electrical current can cause sparks and personal injury from burns. Turn battery master switch to the 'Off' position before disconnecting any components.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and the battery master switch in the 'Off' position.

3. Disconnect the following cables and connectors in the order given, to prevent serious damage to the vehicles electrical components.
   a - Battery earth cables
   b - Battery supply cables
   c - Alternator earth cables
   d - Alternator supply cables
   e - Transmission ECU connector

4. Place a suitable container under the transmission drain port, remove drain plug and drain oil. After draining, reinstall plug and tighten securely.

Note: If anti-spill drain plug is fitted, remove cap from connection, install drain tube connection and drain oil into a suitable container. Remove drain tube connection and reinstall cap.

5. Open drain cocks on air tanks and drain all air from the system. Close drain cocks securely after draining.

6. With a suitable container in position under the hydraulic tank drain port, remove drain plug and drain oil. After draining, reinstall plug and tighten securely.

7. Remove air tanks and mounting bracket from the machine. Refer to Section 250-0170, AIR TANKS AND MOUNTING.

8. Disconnect driveline connected to the transmission and secure clear of the transmission. Refer to Section 130-0010, DRIVELINE.

9. Identify, tag and disconnect all electrical harnesses and connections from the transmission.

10. Identify and tag oil cooler lines (3 & 4, Fig. 2) to aid installation. Disconnect oil cooler lines (3 & 4, Fig. 2) and cap open ends and tee pieces (10 & 12, Fig. 2) to prevent entry of dirt.

11. Identify and tag oil filter hose assemblies (1, 2 & 5, Fig. 2) to aid installation. Disconnect hose assemblies (1, 2 & 5, Fig. 2) and cap open ends and tee piece (12, Fig. 2) and adaptors (6 & 8, Fig. 2) to prevent entry of dirt.

12. Disconnect air lines at transmission differential lock cylinder. Cap lines and ports to prevent entry of dirt.

13. Identify, tag and disconnect all remaining lines and fixtures necessary to allow removal of the transmission from the vehicle.

14. Attach suitable lifting equipment to the lifting points on transmission and raise lifting equipment to take up the slack.

15. Remove bolts (3) and lockwashers (4) securing LH bracket (1) to transmission.

16. Remove bolts (5) and lockwashers (4) securing RH bracket (2) to transmission.

17. Check to make certain that all necessary line and cable disconnections have been made before lifting the transmission.

18. Carefully raise the transmission ensuring that no lines, cables or components foul during removal. When the transmission is clear of the frame assembly, move to a suitable work area and mount securely on a work stand.
DISASSEMBLY
Numbers in parentheses refer to Fig. 1, unless otherwise specified.

1. Remove bolts (9), washers (10), spacers (7), snubbing washers (8), locknuts (11) and LH bracket assembly (1) from the frame mounts. Remove isolation mounts (6) from frame mount and replace if required.

2. Remove bolts (9), washers (10), spacers (7), snubbing washers (8), locknuts (11) and RH bracket assembly (2) from the frame mounts. Remove isolation mounts (6) from frame mount and replace if required.

3. If required, remove mounting hardware securing dipstick tube assembly to transmission. Remove dipstick tube assembly and gasket from the transmission.

4. If required, identify and tag all electrical connections, sensors and senders and remove from the transmission.

5. Refer to transmission manufacturers service manual if transmission service or repair is required.
Transmission - Transmission and Mounting

Section 120-0010

INSPECTION
Numbers in parentheses refer to Fig. 1.

1. Check LH bracket assembly (1), RH bracket assembly (2) and frame mounting brackets for cracks and damage. Repair or replace as required.

2. Check general condition of transmission assembly for wear and damage. Check for worn or damaged driveline flanges and excessive wear on mounting holes.

3. Check condition of all electrical harnesses and connections and repair/replace as required. Check condition of all hydraulic lines on the transmission and replace if damaged.

ASSEMBLY
Numbers in parentheses refer to Fig. 1, unless otherwise specified.

Note: Tighten all fasteners without special torques specified to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. Install new gasket on dipstick tube assembly and secure assembly to the transmission with mounting hardware as removed at Disassembly.

2. If removed, install all senders and sensors in the transmission. Tighten all electrical connections securely.

3. Secure LH bracket assembly (1) to the transmission with bolts (3) and lockwashers (4).

4. Secure RH bracket assembly (2) to the transmission with bolts (5) and lockwashers (4).

INSTALLATION
Numbers in parentheses refer to Fig. 1, unless otherwise specified.

Note: Tighten all fasteners without special torques specified to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

Note: Tighten all hydraulic lines fitted with ORFS connections, as described in Section 220-0000, STEERING SYSTEM SCHEMATIC. Renew all ‘O’ rings where used.

WARNING
To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

Note: Isolation mounts (6) are colour coded to aid in installation. Front isolation mounts are green and white whereas rear isolation mounts are blue and white.

1. Lubricate isolation mounts (6) with water or a suitable rubber lubricant and install in frame mounts, with spigots to the underside of the mounts.

2. Attach suitable lifting equipment to transmission lifting points and carefully position the transmission assembly in the frame. Take care to avoid snagging any lines, harnesses or components attached to the transmission.

3. Secure LH bracket assembly (1) to frame mounts with bolts (9), washers (10), spacers (7), snubbing washers (8) and locknuts (11), as shown in Fig. 1. Tighten bolts (9) to a torque of 271 Nm (200 lbf ft).

4. Secure RH bracket assembly (2) to frame mounts with bolts (9), washers (10), spacers (7), snubbing washers (8) and locknuts (11), as shown in Fig. 1. Tighten bolts (9) to a torque of 271 Nm (200 lbf ft).

5. Remove lifting equipment from lifting points on transmission.

6. Remove blanking caps from hose assemblies (3 & 4, Fig. 2) and tee pieces (10 & 12, Fig. 3) and connect hose assembly to the tee pieces as identified at Removal.

7. Remove blanking caps from hose assemblies (7 & 12, Fig. 2), tee piece (12, Fig. 2) and adaptors (6 & 8, Fig. 2). Connect hose assemblies to the tee piece and adaptors as identified at Removal.

8. Connect all electrical cables, harnesses and connections to the transmission, as identified at removal.
9. Connect driveline to the transmission and secure with mounting hardware removed during removal. Refer to Section 130-0010, DRIVELINE.

10. Install air tanks and mounting bracket to the machine. Refer to Section 250-0170, AIR TANKS AND MOUNTING.

11. Fill hydraulic tank with hydraulic oil specified in Section 300-0020, LUBRICATION SYSTEM. Refer to Section 230-0040, HYDRAULIC TANK for fill level and procedure.

12. Fill transmission with engine oil specified in Section 300-0020, LUBRICATION SYSTEM. Check the oil level as described under ‘Oil Level Check’.

13. Connect the following cables and connectors in the order given to prevent serious damage to the engines electrical components.

   a - Transmission ECU connector
   b - Alternator supply cables
   c - Alternator earth cables
   d - Battery supply cables
   e - Battery earth cables

14. Turn the battery master switch to the ‘On’ position, start the engine and make an operational check of all lines and electrical connections disconnected during removal. Check for leaks and tighten lines and fittings as required. Allow transmission to warm up and recheck all connections for leaks.

15. Ensure parking brake is applied and remove wheel blocks from all road wheels.

16. Check for correct operation of the transmission, shift selector and warning lights.

MAINTENANCE

Periodic Inspections

For easier inspection, the transmission should be kept clean. Make periodic checks for loose mounting bolts and leaking air and oil lines. Check the condition of electrical harnesses and connections regularly.

Transmission breather should be checked on a regular basis, and as frequently as necessary, depending on operating conditions. A badly corroded or plugged breather restricts proper breathing and causes a buildup of condensation and subsequent oil deterioration.

Oil Level Check

**WARNING**

When checking the oil level, be sure that the parking brake is applied and all road wheels are securely blocked.

Check the transmission oil level and add oil if low, every 10 hours/daily. Use only oil specified in Section 300-0020, LUBRICATION SYSTEM.

Because the transmission oil cools, lubricates and transmits hydraulic power it is important that the proper oil level be maintained at all times. If the oil level is too low, the converter and clutches will not receive an adequate supply of oil. If the oil level is too high, the oil will aerate and the transmission will overheat. It is absolutely necessary that the oil put into the transmission is clean.

Cold Oil Level Check

This check is made only to determine if the transmission contains sufficient oil for safe starting. Make sure there is some oil showing on dipstick. Add oil if low.

Hot Oil Level Check

1. Position the vehicle on a level work area, apply the parking brake and block all road wheels securely.

2. With the transmission in neutral and the engine running, allow the machine to idle for approximately 20 seconds (until normal operating temperature of 80° C (176° F) is achieved).

3. With parking brake applied, foot on service brake, engine idling and transmission operating at normal temperature, select each gear position in turn. Allow the transmission to remain in each gear for 5 - 10 seconds.

4. Return gear selector to neutral and, with the engine idling, check the oil level on dipstick. Oil level should be up to, but not over, the upper mark on the dipstick. Add oil if low.

Oil and Filter Change

After the first 50 hours of operating a new or rebuilt transmission, the transmission oil and filter cartridges (14, Fig. 2) should be changed. Internal filter and finger magnet at the lower front left hand of the sump should be removed and cleaned.

The transmission oil and filter cartridges should be
Transmission - Transmission and Mounting

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changed every 1,000 hours, or sooner, depending on operating conditions. Clean oil filter head (13, Fig. 2) when changing filter cartridges (14, Fig. 2). Also, the oil must be changed whenever there are traces of dirt or evidence of high temperature indicated by discoloration or strong odour.

The internal filter and finger magnet at the lower front left hand of the sump should be removed and cleaned with mineral spirits at each oil and filter change. Metal particles in the oil (except for the minute particles normally trapped in the oil filters) indicate damage has occurred in the transmission. When these particles are found in the filters, the cause must be established and rectified immediately to prevent damage to the transmission.

At each oil change, examine the used oil for evidence of dirt or water. A normal amount of condensation will emulsify in the oil during transmission operation. However, if there is evidence of water or engine coolant in the oil, the cause must be established and rectified immediately to prevent damage to the transmission.

SERVICE TOOLS

There are no special tools required for the procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of service tools which should be used in conjunction with procedures outlined in the transmission manufacturers service manual, and, general service tools required. These tools are available from your dealer.

<table>
<thead>
<tr>
<th>FIG. NO.</th>
<th>ITEM NO.</th>
<th>ITEM NAME</th>
<th>TORQUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
<td>Bolt</td>
<td>271 Nm 200 lbf ft</td>
</tr>
</tbody>
</table>

* * * *
DESCRIPTION
This machine is fitted with a Funk DF158 Powershift transmission equipped with the Funk DF158 Electronic Control Unit (ECU), to operate the transmission. Upshifting, downshifting and control of the disconnect are the main functions of the ECU. Another function of the ECU is the capability to communicate with a panel mounted gear/diagnostic display unit.

WARNING
Before any welding is done on the machine, disconnect battery cables from terminal posts (ground cables first) and electrical connections at the ECU to avoid damage to electrical components. Turn off the battery master switch before disconnecting any components.

General Theory of Operation
The transmissions performance is determined by the various inputs to the ECU. Based upon these inputs the ECU commands the transmission so that maximum performance can be achieved under the present operating conditions. All functions of the ECU are under software control.

Switching the vehicle's ignition to the 'On' position supplies power to the ECU and related system components from the batteries, through the transient voltage protection (TVP) module. At this point the ECU begins to monitor all inputs and outputs. If a known conflict in inputs or a fault condition is detected, the ECU will command the transmission to stay in Neutral regardless of the shift lever position. A flashing error code will be displayed on the gear/diagnostic display unit, and will remain displayed until the error has been corrected and the shift lever cycled back through the Neutral position.

If no error conditions are detected, the ECU will calculate a speed ratio between the engine speed (derived from the engine speed MPU signal) and the transmission output speed (derived from the transmission output speed MPU).

Based upon this speed ratio and the combination of inputs from the shift lever and any other applicable inputs, the ECU will select the proper transmission gear and command the transmission to shift to this gear. The gear/diagnostic display unit will show the actual gear selected.

The transmission uses electrohydraulic valves to control the operation of the transmission. The solenoids controlling the transmission clutches (solenoids A through D and 1 through 4) are driven by a pulse width modulated (PWM) signal that produces proportional pressure/flow changes. This is achieved by pulsing the solenoid at a constant frequency and varying the 'on time' of each cycle. The ratio of 'on time' to cycle time is called duty cycle. These transmission solenoids are driven with a maximum duty cycle considerably less than this and ramped up to full on. The initial duty cycle is dependant upon several factors and is not a preset value. The process of modulating these clutches greatly enhances shift quality.

SYSTEM COMPONENTS
Description and Operation
1. Electronic Control Unit (ECU) - There are two electronic control units located beneath the cab. The ECU is the brain of the system. It is responsible for the logic, computation, and decision making processes and the control of the transmission based on these calculations. How the ECU performs is determined by software programmed into the ECU's memory. The ECU’s application is specific, therefore ECU’s from different vehicles are not interchangeable.

2. Transient Voltage Protection (TVP) Module - The TVP module is responsible for supplying electrical power to the system and protecting the systems electrical components. It provides 40 volt limiting during an electrical load dump malfunction and protection from reverse battery connection. Protection is provided only while the ignition is switched on, thus energizing an internal relay which provides an electrical connection between vehicle power and the protection device inside the module.

3. Engine Speed Magnetic Pickup (MPU) - The engine speed MPU is located in the input housing of the transmission. The MPU provides a signal to the ECU which represents engine speed. This signal is of a sinusoidal nature, varying in amplitude and frequency relative to engine speed. The ECU conditions this signal and converts it into pulses. It then measures the width of these pulses in microseconds, and based on a preprogrammed value in the ECU which represents the number of pulses per revolution of the engine, calculates the engine speed.
4. Transmission Output Speed MPU - The transmission output speed MPU is located in the rear housing of the transmission and provides a signal to the ECU which represents transmission output speed. This signal is of a sinusoidal nature, varying in amplitude and frequency relative to output speed. The ECU conditions this signal and converts it into pulses. It then measures the width of these pulses in microseconds, and based on a preprogrammed value in the ECU which represents the number of pulses per revolution of the transmission output, calculates output speed.

5. Gear Shift Lever - The transmission provides seven forward ranges, one reverse gear and a neutral position. The lever is detented in the Forward, Neutral and Reverse positions with a positive lock only in the Neutral position.

The gear shift lever is spring loaded to the centre position. ‘Bumping’ the shift lever to the upshift or downshift direction sends a corresponding signal to the ECU.

6. Wiring Harness - The wiring harness consists of the various wires needed to provide electrical connections between the components of the system. All connectors in the system are sealed to protect the connections from the environment and to prevent corrosion of the contacts, which would eventually result in a failure.

7. Gear/Diagnostic Display Unit - A dash mounted gear/diagnostic display unit provides the operator with information about the system. Under normal operating conditions the display shows the actual forward or reverse transmission gear and the state of the disconnect.

When an error has occurred, the display will flash an error code indicating that a problem has been detected in the system. This error code will continue to flash until the shift lever has been placed in Neutral. Once the ECU has detected a legal Neutral condition, the error will clear and ‘NEU’ will be displayed. Once the shift lever is moved out of Neutral the error will once more begin to flash. This condition will continue until the error has been corrected and the shift lever cycled through Neutral again. If the error is related to the Neutral signal making it impossible for the ECU to see a legal Neutral signal, the error will continue to flash even in the Neutral position until it is resolved.

8. Diagnostic Test Points - There are two diagnostic test points located at the front of the fuse box, under the dash panel, one for the tractor transmission and the other for the scraper transmission.

GENERAL TRANSMISSION OPERATION

Watch for wide deviations from normal readings on the transmission oil temperature gauge during machine operation. If the transmission oil temperature gauge shows oil temperature consistently rising above the green zone under normal operating conditions; check for external causes. If none are evident shift to Neutral (N) and operate the engine at 1 200 - 1 500 rev/min. If the transmission oil temperature does not decrease into the green zone within 2 or 3 minutes, the cause of the overheating should be corrected before the machine is operated further. Watch the oil temperature gauge when operating on upgrades, also. If the oil temperature goes into the yellow zone, select the range which will limit upshifts to the highest range in which the transmission will operate within the normal temperature range (green zone). If upshifting must be consistently limited to ranges lower than normal for the loads and the grades encountered to prevent overheating the transmission oil, the causes should be determined and corrected.

WARNING
Do not allow the vehicle to coast in Neutral. This practice can result in severe transmission damage.

When Reverse is selected an audible alarm sounds. This feature warns personnel to the immediate rear of the machine that the operator has shifted the transmission to Reverse.

WARNING
Always select Neutral and apply the parking brake before leaving the operator’s seat.
## POWERSHIFT TROUBLESHOOTING

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Problem</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Erratic oil pressure.</strong></td>
<td>Low oil level.</td>
<td>Add oil to proper level.</td>
</tr>
<tr>
<td></td>
<td>Suction tube fitting.</td>
<td>Replace 'O' ring fitting.</td>
</tr>
<tr>
<td></td>
<td>Suction manifold 'O' ring not sealing.</td>
<td>Replace 'O' ring.</td>
</tr>
<tr>
<td></td>
<td>Foreign object in suction port.</td>
<td>Remove object and check for other contamination.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Excessive oil pressure.</strong></td>
<td>Sticking main regulator valve.</td>
<td>Replace main regulator valve.</td>
</tr>
<tr>
<td></td>
<td>Faulty spring.</td>
<td>Replace main regulator.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Low oil pressure in all gears.</strong></td>
<td>Sticking main regulator valve.</td>
<td>Replace main regulator valve.</td>
</tr>
<tr>
<td></td>
<td>Control valve body gasket leaking.</td>
<td>Replace gaskets.</td>
</tr>
<tr>
<td></td>
<td>Charge pump defective.</td>
<td>Replace pump.</td>
</tr>
<tr>
<td></td>
<td>Internal disconnect seal damage or</td>
<td>Replace seal and install correctly.</td>
</tr>
<tr>
<td></td>
<td>installed incorrectly.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Faulty main regulator valve.</td>
<td>Replace main regulator valve.</td>
</tr>
<tr>
<td></td>
<td>Control valve body cracked.</td>
<td>Replace control valve body.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Low pressure in one gear but all right in other gears.</strong></td>
<td>Contaminated proportional solenoid.</td>
<td>Replace proportional solenoid. *Check suction screen for contamination.</td>
</tr>
<tr>
<td></td>
<td>Broken wire to one solenoid, or dirty connection.</td>
<td>Repair wire.</td>
</tr>
<tr>
<td></td>
<td>Broken seal ring on input end of clutch assembly.</td>
<td>Replace seal ring.</td>
</tr>
<tr>
<td></td>
<td>Bore sleeve worn.</td>
<td>Replace bore sleeves.</td>
</tr>
<tr>
<td></td>
<td>Outer or inner piston seal leaking.</td>
<td>Replace seals.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vehicle will not move.</strong></td>
<td>Voltage to wrong solenoids on control valve. (See schematic.)</td>
<td>Check wiring and connectors.</td>
</tr>
<tr>
<td></td>
<td>Converter damage.</td>
<td>Rebuild converter.</td>
</tr>
<tr>
<td></td>
<td>No voltage to all solenoids.</td>
<td>Check wiring, controller and connectors.</td>
</tr>
<tr>
<td></td>
<td>Voltage to more than two solenoids.</td>
<td>Check wiring and controller.</td>
</tr>
<tr>
<td></td>
<td>Proportional solenoid stuck.</td>
<td>Replace solenoid.</td>
</tr>
</tbody>
</table>
# POWERSHIFT TROUBLESHOOTING - Continued

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Problem</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low or no converter pressure (Converter in pressure).</strong></td>
<td>Converter bypass valve defective.</td>
<td>Replace converter bypass valve.</td>
</tr>
<tr>
<td></td>
<td>Converter hub seal ring not sealing.</td>
<td>Replace seal ring.</td>
</tr>
<tr>
<td></td>
<td>Check converter offset dimension.</td>
<td>Correct offset dimension.</td>
</tr>
<tr>
<td><strong>Filter or filter oil lines blow out.</strong></td>
<td>Hose bends too sharp.</td>
<td>Reroute hoses.</td>
</tr>
<tr>
<td></td>
<td>Defective hose.</td>
<td>Replace hose.</td>
</tr>
<tr>
<td></td>
<td>Main regulator valve faulty.</td>
<td>Change valve and change filter and oil.</td>
</tr>
<tr>
<td></td>
<td>System plumbing incorrect.</td>
<td>Correct plumbing.</td>
</tr>
<tr>
<td></td>
<td>Filter 'O' ring faulty.</td>
<td>Replace filter.</td>
</tr>
<tr>
<td><strong>Excessive noise.</strong></td>
<td>Charge pump defective.</td>
<td>Replace pump.</td>
</tr>
<tr>
<td></td>
<td>Excessive backlash in gear train.</td>
<td>Replace bearings and inspect for defective gears.</td>
</tr>
<tr>
<td></td>
<td>Auxiliary driven pump bad.</td>
<td>Remove pump and check for noise.</td>
</tr>
<tr>
<td><strong>Blows oil out of breather or dipstick tube.</strong></td>
<td>Transmission over filled with oil.</td>
<td>Establish proper oil level. Check front seal on auxiliary driven hydraulic pump if equipped.</td>
</tr>
<tr>
<td></td>
<td>Converter seal ring damaged.</td>
<td>Remove transmission and install new seal ring on converter hub.</td>
</tr>
<tr>
<td><strong>Transmission overheating.</strong></td>
<td>Converter stalling.</td>
<td>Shift to lower gear.</td>
</tr>
<tr>
<td></td>
<td>Oil level too high.</td>
<td>Establish proper oil level. Check front seal on auxiliary driven hydraulic pump if equipped.</td>
</tr>
<tr>
<td></td>
<td>Engine overheating.</td>
<td>Check engine coolant.</td>
</tr>
<tr>
<td></td>
<td>Water lines defective on heat exchanger.</td>
<td>Replace lines.</td>
</tr>
<tr>
<td></td>
<td>Heat exchanger dirty.</td>
<td>Clean heat exchanger.</td>
</tr>
<tr>
<td></td>
<td>Clutch slipping.</td>
<td>Check clutch pressure.</td>
</tr>
</tbody>
</table>
POWERSHIFT TROUBLESHOOTING - Continued

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Problem</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low or no converter pressure.</td>
<td>Converter bypass valve defective.</td>
<td>Replace converter bypass valve.</td>
</tr>
<tr>
<td>Transmission pressure checks okay, but has no power and possibly overheating.</td>
<td>Converter sprag clutch damaged or installed wrong.</td>
<td>Disassemble and inspect converter.</td>
</tr>
<tr>
<td>Transmission pressure checks okay, but has no power and possibly overheating.</td>
<td>Converter relief valve broken.</td>
<td>Replace relief valve.</td>
</tr>
<tr>
<td>Oil leaking from engine flywheel and/or weep hole in transmission bell housing.</td>
<td>Converter front cover seal leaking.</td>
<td>Replace seal.</td>
</tr>
<tr>
<td>Oil leaking from engine flywheel and/or weep hole in transmission bell housing.</td>
<td>Converter hub seal or 'O' ring damaged.</td>
<td>Replace seal.</td>
</tr>
<tr>
<td>Oil leaking from engine flywheel and/or weep hole in transmission bell housing.</td>
<td>Converter not properly positioned within bell housing, causing converter and seal to leak.</td>
<td>Check engine flywheel offset dimensions and converter pilot bushing length against vehicle manufacture standards.</td>
</tr>
</tbody>
</table>

ELECTRONIC CONTROL UNIT

Troubleshooting Introduction

This introduction is written to initiate an understanding of a strategy which can be used toward solving problems in the driveline system. The preferred technique used in solving problems is to exchange components. However, a very important element necessary to the timely and successful conclusion of this activity is the selection of the malfunctioning component. An understanding of the total system and an elimination process leading to the component is absolutely necessary before starting the exchange activity.

The DF transmission system as installed consists of various components linked together to form a functioning system.

- Gear shift control
- Wiring harnesses
- Electronic control units
- Transmission control valve.
- Transmission hydraulic system (pump, relief valves, lines, etc.)
- Transmission mechanical system (clutches, gears, shafts, seals, etc.)

The most desirable strategy in a trouble shooting plan is to reduce the random exchange of components by carefully analysing the symptoms and then conducting tests which will help determine which of the elements in the system is likely to be the problem. The technician should use the above list as a guide in locating the problem.

As a result of being a new component and unfamiliar to most people, the ECU is usually the first component which is targeted for exchange. However, the malfunction of an ECU is extremely rare and therefore, it should be the last component considered for replacement. In fact the ECU has an internal ability to diagnose itself and the connections which are attached to it. This information can be very helpful in indicating the problem area. Therefore, if the ECU is responding to commands and not giving diagnostics which indicate an internal problem, the likelihood of the problem being internal to the ECU is very remote.

ANALOG ERROR CODES

Note: The following is a list of the errors that are detectable;

Diagnostic code: 20
Error type: Driver 1 cannot get up to requested current.
Error: Open or short ground in Solenoid 1 circuit from output pin J3-A3 to return pin J3-B1.

Diagnostic code: 21
Error type: Driver 2 cannot get up to requested current.
Error: Open or short ground in Solenoid 2 circuit from output pin J3-B2 to return pin J3-B3.
Diagnostic code: 22  
Error type: Driver 3 cannot get up to requested current.  
Error: Open or short ground in Solenoid 3 circuit from output pin J3-C1 to return pin J3-C2.

Diagnostic code: 23  
Error type: Driver 4 cannot get up to requested current.  
Error: Open or short ground in Solenoid 4 circuit from output pin J3-C3 to return pin J3-D1.

Diagnostic code: 24  
Error type: Driver 5 cannot get up to requested current.  
Error: Open or short ground in Solenoid A circuit from output pin J3-D2 to return pin J3-D3.

Diagnostic code: 25  
Error type: Driver 6 cannot get up to requested current.  
Error: Open or short ground in Solenoid B circuit from output pin J3-E1 to return pin J3-E2.

Diagnostic code: 26  
Error type: Driver 7 cannot get up to requested current.  
Error: Open or short ground in Solenoid C circuit from output pin J3-E3 to return pin J3-F1.

Diagnostic code: 27  
Error type: Driver 8 cannot get up to requested current.  
Error: Open or short ground in Solenoid D circuit from output pin J3-F2 to return pin J3-F3.

Diagnostic code: 28  
Error type: Driver 9 cannot get up to requested current.  
Error: Open or short ground in Solenoid 1 circuit from output pin J3-G1 to return pin J3-G2.

Diagnostic code: 29  
Error type: Driver 10 cannot get up to requested current.  
Error: Open or short ground in Torque Converter Lock Up circuit from output pin J3-G3 to return pin J3-H1.

Diagnostic code: 30  
Error type: Driver 1 cannot get down to requested current.  
Error: Short or positive in Solenoid 1 circuit from output pin J3-A3 to return pin J3-B1.

Diagnostic code: 31  
Error type: Driver 2 cannot get down to requested current.  
Error: Short or positive in Solenoid 2 circuit from output pin J3-B2 to return pin J3-B3.
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Diagnostic code: 32
Error type: Driver 3 cannot get down to requested current.
Error: Short or positive in Solenoid 3 circuit from output pin J3-C1 to return pin J3-C2.

Diagnostic code: 33
Error type: Driver 4 cannot get down to requested current.
Error: Short or positive in Solenoid 4 circuit from output pin J3-C3 to return pin J3-D1.

Diagnostic code: 34
Error type: Driver 5 cannot get down to requested current.
Error: Short or positive in Solenoid A circuit from output pin J3-D2 to return pin J3-D3.

Diagnostic code: 35
Error type: Driver 6 cannot get down to requested current.
Error: Short or positive in Solenoid B circuit from output pin J3-E1 to return pin J3-E2.

Diagnostic code: 36
Error type: Driver 7 cannot get down to requested current.
Error: Short or positive in Solenoid C circuit from output pin J3-E3 to return pin J3-F1.

Diagnostic code: 37
Error type: Driver 8 cannot get down to requested current.
Error: Short or positive in Solenoid D circuit from output pin J3-F2 to return pin J3-F3.

Diagnostic code: 38
Error type: Driver 9 cannot get down to requested current.
Error: Short or positive in circuit from output pin J3-G1 to return pin J3-G2.

Diagnostic code: 39
Error type: Driver 10 cannot get down to requested current.
Error: Short or positive in Torque Converter Lock Up circuit from output pin J3-G3 to return pin J3-H1.

Diagnostic code: 40
Error: Request for an undefined shift being made.

Diagnostic code: 41
Error: ECU has not seen a legal Neutral (input pin J2-A1) since initial power up of system.

Diagnostic code: 42
Error type: Bottom of Clutch input on J1-K2 is passive.
Error: Application does not utilize inching. Input at J1-K2 must be connected to system voltage.

Diagnostic code: 43
Error: NOT PARK (input pin J1-K1) and PARK (input pin J2-B3) are both passive at ECU.
Legal conditions are: 1 NOT PARK active and PARK passive.
Legal conditions are: 2 NOT PARK passive and PARK active.

Diagnostic code: 44
Error: NOT PARK (input pin J1-K1) and NEUTRAL (input pin J2-A1) are both passive at ECU.
Legal conditions are: 1 NOT PARK active and NEUTRAL passive.
Legal conditions are: 2 NOT PARK passive and NEUTRAL active.

Diagnostic code: 45
Error: PARK (input pin J2-B3) is active but NEUTRAL (input pin J2-A1) is passive at ECU.

Diagnostic code: 46
Error: NOT PARK (input pin J1-K1) passive and FORWARD (input pin J1-J1) active at ECU.
Legal conditions are: 1 NOT PARK and FORWARD both active.
Legal conditions are: 2 NOT PARK and FORWARD both passive.

Diagnostic code: 47
Error: NOT PARK (input pin J1-K1) passive and REVERSE (input pin J1-J2) active at ECU.
Legal conditions are: 1 NOT PARK and REVERSE both active.
Legal conditions are: 2 NOT PARK and REVERSE both passive.

Diagnostic code: 48
Error: NOT PARK (input pin J1-K1) and PARK (input pin J2-B3) are both active at ECU.
Legal conditions are: 1 NOT PARK active and PARK passive.
Legal conditions are: 2 NOT PARK passive and PARK active.

Diagnostic code: 49
Error: Handle signal is park but PARK PRESSURE (input pin J2-B3) is passive at ECU.
Diagnostic code: 50
Error: UPSHIFT (input pin J1-H2) and DOWNSHIFT (input pin J1-H3) are both active at ECU.

Diagnostic code: 51
Error: FORWARD (input pin J1-J1) and REVERSE (input pin J1-J2) are both active at ECU.

Diagnostic code: 52
Error: FORWARD (input pin J1-J1) and NEUTRAL (input pin J2-A1) and REVERSE (input pin J1-J2) are all passive at ECU.

Diagnostic code: 54
Error: Program variable REQUIRED GEAR has taken on an invalid value.

Diagnostic code: 56
Error: NEUTRAL (input pin J2-A1) and FORWARD (input pin J1-J1) are both active at ECU.
Legal conditions are: 1 NEUTRAL active and FORWARD passive.
Legal conditions are: 2 NEUTRAL passive and FORWARD active.

Diagnostic code: 57
Error: NEUTRAL (input pin J2-A1) and REVERSE (input pin J1-J2) are both active at ECU.
Legal conditions are: 1 NEUTRAL active and REVERSE passive.
Legal conditions are: 2 NEUTRAL passive and REVERSE active.

Diagnostic code: 58
Error: START (input pin J2-B2) went active at ECU disabling internal solenoid power.

Diagnostic code: 59
Error: Invalid 5 bit selector code.

Diagnostic code: 60
Error type: Valve driver supply voltage (ECU pin J3-A1) too low.
Error: Must be above 8 volts on a 12 volt system or above 17 volts on a 24 volt system.

Diagnostic code: 80
Error: Engine MPU (input pin J1-B1) missing or frequency is too low.

Diagnostic code: 82
Error: Output MPU (input pin J1-A3) signal missing or frequency is too low.

Diagnostic code: 84
Error: Illegal or undefined vehicle mode code.

Diagnostic code: 85
Error: PARK (input pin J2-B3) is active but NEUTRAL (input pin J2-A1) is passive at ECU.

Diagnostic code: 86
Error: Inching pedal TOP OF CLUTCH signal (input pin J1-K3) is closed but BOTTOM OF CLUTCH (input pin J1-K2) is open.

Diagnostic code: 87
Error: PARK (input pin J2-B3) and FORWARD (input pin J1-J1) are both active at ECU.

Diagnostic code: 88
Error: PARK (input pin J2-B3) and REVERSE (input pin J1-J2) are both active at ECU.

Diagnostic code: 89
Error: PARK (input pin J2-B3) and NOT PARK (input pin J1-K1) are both passive at ECU.

Diagnostic code: 90
Error: PARK (input pin J2-B3) and NOT PARK (input pin J1-K1) are both active at ECU.

Diagnostic code: 91
Error: Seat switch (input pin J2-C3) and NEUTRAL (input pin J2-A1) are both passive at ECU.

Diagnostic code: 92
Error: Engine speed is at or near manufacturers warranty void level.

Diagnostic code: 93
Error: CARRIER CAB and UPPER CAB inputs are both active at ECU.

Diagnostic code: 94
Error: CARRIER CAB and UPPER CAB inputs are both passive at ECU.

Diagnostic code: 95
Error code: Handle code not neutral.
Error: NEUTRAL (input pin J2-A1) is passive while switching cab modes.

Diagnostic code: 96
Error: Upper cab mode selected but transmission gear is not a legal gear range for upper cab mode.
Transmission - Transmission Electronic Controls

Diagnostic code: 97  
Error: Upper cab mode selected but FORWARD, NEUTRAL and REVERSE inputs are all passive at ECU.

Diagnostic code: 98  
Error: WHEELS-UP (input pin J1-H1) and WHEELS-DOWN (input pin J1-H2) are both active.

Diagnostic code: 99  
Error: Attempt to change wheels-up wheels-down mode while in an out-of-neutral condition.

Diagnostic code: 100  
Error: Sump temperature (input J1-C3) is too low for calibration.

Diagnostic code: 101  
Error: Engine speed is too high for calibration.

Diagnostic code: 102  
Error: Engine speed is too low for calibration.

Diagnostic code: 103  
Error: Output speed detected during calibration.

Diagnostic code: 104  
Error: No cylinder speed detected during calibration.

Diagnostic code: 105  
Error: Incorrect forward cylinder speed ratio during calibration.

Diagnostic code: 106  
Error: Incorrect reverse cylinder speed ratio during calibration.

Diagnostic code: 107  
Error: Cylinder speed will not drop below the start count speed.

Diagnostic code: 108  
Error: Holding clutch pressure exceeds 90 psi.

Diagnostic code: 109  
Error: Clutch 1 fast fill time exceeds 300 ms.

Diagnostic code: 110  
Error: Clutch 2 fast fill time exceeds 300 ms.

Diagnostic code: 111  
Error: Clutch 3 fast fill time exceeds 300 ms.

Diagnostic code: 112  
Error: Clutch 4 fast fill time exceeds 300 ms.

Diagnostic code: 113  
Error: Clutch A fast fill time exceeds 300 ms.

Diagnostic code: 114  
Error: Clutch B fast fill time exceeds 300 ms.

Diagnostic code: 115  
Error: Clutch C fast fill time exceeds 300 ms.

Diagnostic code: 116  
Error: Clutch D fast fill time exceeds 300 ms.

Diagnostic code: 117  
Error: Clutch hold pressure is above 90 psi.

Diagnostic code: 118  
Error: Clutch R fast fill time exceeds 300 ms.

Diagnostic code: 119  
Error: Clutch L fast fill time exceeds 300 ms.

Diagnostic code: 120  
Error: Clutch M fast fill time exceeds 300 ms.

Diagnostic code: 121  
Error: Clutch H fast fill time exceeds 300 ms.

Diagnostic code: 122  
Error: Clutch hold pressure is above 90 psi.

Diagnostic code: 126  
Error: Cylinder deceleration time is inconsistent.

Diagnostic code: 127  
Error: Attempt to calibrate with PARK (input pin J2-B3) input passive at ECU.

Diagnostic code: 144  
Error: Low air pressure.

Diagnostic code: 145  
Error: Analog inching voltage is too low.

Diagnostic code: 146  
Error: Temperature sensor circuit (J1-C3) SENSE or (J1-D1) GROUND shorted or open.

Diagnostic code: 147  
Error: Analog input (J1-D3) shorted or open.

Diagnostic code: 148  
Error: Analog inching voltage (J1-F3) is too high.
Diagnostic code: 149
Error: Vehicle system voltage (J3-A1) is too high.

Diagnostic code: 150
Error: Transmission temperature (J1-C3) is too high.

Diagnostic code: 154
Error: Engine MPU circuit (J1-B1) open.

Diagnostic code: 155
Error: Output MPU circuit (J1-A3) open.

Diagnostic code: 160
Error: Cannot get shift constants from eeprom.

Diagnostic code: 161
Error: Group one enable low should be high.

Diagnostic code: 162
Error: Group two enable low should be high.

Diagnostic code: 163
Error: Group three enable low should be high.

Diagnostic code: 164
Error: Pointer in capcom20 gets too big.

Diagnostic code: 165
Error: Safety FET A failed OFF.

Diagnostic code: 166
Error: Safety FET A failed ON.

Diagnostic code: 167
Error: Safety FET B failed OFF.

Diagnostic code: 168
Error: Safety FET B failed ON.

Diagnostic code: 169
Error: Safety FET C failed OFF.

Diagnostic code: 170
Error: Safety FET C failed ON.

Diagnostic code: 171
Error: Group one enable high should be low.

Diagnostic code: 172
Error: Group two enable high should be low.

Diagnostic code: 173
Error: Group three enable high should be low.

Diagnostic code: 174
Error: EEprom check sum error.

Diagnostic code: 175
Error code: Driver 11 cannot get up to requested current.
Error: Open or short to ground in circuit from output pin J3-H2 to return pin J3-H3.

Diagnostic code: 176
Error code: Driver 12 cannot get up to requested current.
Error: Open or short to ground in circuit from output pin J3-J1 to return pin J3-J2.

Diagnostic code: 177
Error code: Driver 13 cannot get up to requested current.
Error: Open or short to ground in circuit from output pin J3-J3 to return pin J3-K1.

Diagnostic code: 178
Error code: Driver 11 cannot get down to requested current.
Error: Short to positive in circuit from output pin J3-H2 to return pin J3-H3.

Diagnostic code: 179
Error code: Driver 12 cannot get down to requested current.
Error: Short to positive in circuit from output pin J3-J1 to return pin J3-K1.

Diagnostic code: 180
Error code: Driver 13 cannot get down to requested current.
Error: Short to positive in circuit from output pin J3-J3 to return pin J3-K1.

Diagnostic code 198
Error: CCD communications link failure between master ECU and slave ECU on (CCD BUS- (J2-E3)) and (CCD BUS+ (J2-B2)).

Diagnostic code 199
Error: This is a non-functional base ECU. No application specific software has been programmed into it.
Transmission - Transmission Electronic Controls

Section 120-0070

GLOSSARY

Analog: A signal which has a continuous range of possible voltages.

Active: The high voltage (+12V / +24V) state of a digital input. Dependant upon vehicle system voltage.

Actual Gear: The actual physical gear of the transmission, regardless of shift lever position or controller operation.

Bus: Serial communications link which interconnects intelligent electronic modules.

Come-Home: A hardware function which allows limited vehicle motion in the event of failure of certain components.

Commanded Gear: The gear selected by the combination of the shift lever position and the state of the Forward, Reverse, Neutral, and Not Neutral inputs. The ‘destination’ gear.

Current Gear: The gear the controller is currently attempting to drive the transmission into by the application of commands to the valves.

Digital: A signal which consists of only two voltage levels - usually 0 volts and +5 volts. On/Off type signals are also considered to be digital.

Downshift Inhibit: The prohibiting of downshifting, by the ECU, to prevent harsh and abrupt shifts or possible over speed conditions of the engine. The downshift will be inhibited until the current speed ratio will permit the shift to take place.

Fault: An abnormal condition which results in a perceived performance change or in a loss of function which may result in performance loss or system damage.

Intershift Pause Time: The minimum time delay between shifts. A value preprogrammed into the ECU.

Neutral Recoverable: The process where a detected fault is maintained and displayed by the ECU until the shift lever is cycled to neutral and the ECU detects the proper combination of inputs for a legal neutral condition, at which time the displayed fault will be cleared. The fault code will still be maintained in ECU memory for future recall.

Next Gear: The next gear the controller plans to enter. The next gear will become the current gear if no faults are detected and all conditions for entering the next gear are met.

Nonvolatile Memory: Memory that retains its data even though power to the system has been removed.

Passive: The low voltage (0V) state of a digital input.

Previous Direction: The direction of vehicle motion before a shuttle shift is initiated.

Previous Gear: The previous current gear.

Sequence Shift: The type of shift which consists of shifting from a gear to an adjacent gear.

Sequential Shifting: Multiple sequence shifts with no delay between shifts other than the programmed intershift pause time.

Shuttle Shift: A shift to a gear in the opposite direction of vehicle travel made by moving the shift lever between the Forward and Reverse positions without hesitation in the Neutral position long enough for the controller to obtain a legal neutral condition.
ABBREVIATIONS USED IN ECU GROUP

ECU: Electronic Control Unit

PMW: Pulse Width Modulated

MPU: Magnetic Pickup Sensor

GND: Ground

RPM: Revolutions Per Minute

REV: Reverse

FOR: Forward

NEU: Neutral

P: Park

DC: Direct Current

TOC: Top of Clutch

BOC: Bottom of Clutch

V: Volt

CYL: Cylinder

ENG: Engine

TEMP: Temperature

CAN: Control Area Network

SOL: Solenoid

POT: Potentiometer

* * * *
DESCRIPTION

Numbers in parentheses refer to Fig. 1, unless otherwise specified.

The function of the driveline is to transmit rotating power from one point to another in a smooth and continuous action while allowing a degree of movement or misalignment of the components it connects.

The drivelines must operate through constantly changing relative angles between the components they are mounted to and must also be capable of changing length while transmitting torque.

A typical driveline consists of universal joints which allow some misalignment and permit the driveline to pivot in any direction, and, a light rigid hollow slip yoke and splined shaft assembly forming a slip joint.

The slip joint accommodates length variations generated during operation, preventing tension or compression loads from causing serious damage to the components.

**Note:** Extra care should be taken when handling the drivelines since chips, dents, burrs or deformity on any rotating mass creates vibration and excessive wear during any operation.

Numbers in parentheses refer to Fig. 1, unless otherwise stated.

There are two driveline assemblies installed between various components in the Tractor and Scraper units. In each unit, the component installation is the same.

Driveline assembly (1) is connected between the Tractor/Scraper engine drive and transmission input drive.

Driveline assembly (5) is connected between the Tractor/Scraper Front axle drive flange and transmission final drive.
Drivelines - Front and Rear Drivelines
Section 130-0010

For details of Front Driveline assembly refer to Fig. 2, for details of Rear Driveline assembly refer to Fig. 4.

Again note as shown in Fig. 3, the Scraper unit is orientated the opposite way round from the Tractor unit, when in position.

REMOVAL

Note: Extra care should be taken when handling drivelines since carelessness can result in premature failure of the components. Chips, dents, burrs, or any other deformity of universal joints will prevent accurate mating. This will cause misalignment which is accompanied by vibration and excessive wear.

WARNINGS

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

To prevent serious injury or death, DO NOT go under the vehicle when the engine is running. Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc..
1. Position the vehicle in a level work area, apply the parking brake and switch off the engine.

2. Block all road wheels and place the battery master switch in the 'Off' position.

**Note:** Access to remove driveline assembly (1) can be obtained by tilting the cab. Refer to Section 260-0010, CAB AND MOUNTING.

**Note:** The following procedure for removal of the Front and Rear drivelines is the same for both the Tractor and Scraper units.

Numbers in parentheses refer to Fig. 2, unless otherwise stated.

3. For removal of the Front Driveline assembly (1), it is necessary to remove the anti flail guards (5 & 6) first.

4. Remove the bolts (7), Lockwashers (8), and washers (9) securing anti-flail guards (5 & 6) to the frame. Remove anti-flail guard (5 & 6).

5. Match mark universal joints (2) and their mating surfaces to ensure correct mating alignment when installing the Driveline assembly (1).

6. Support the Front driveline assembly (1) with suitable lifting equipment and remove bolts (4) securing universal joints (2) to their mating components. Remove driveline assembly (1). If necessary tap driveline assembly (1) from its mating components with a soft faced hammer.

**Note:** Access to the Rear driveline assemblies can be obtained from underneath the vehicle.

Numbers in parentheses refer to Fig. 4, unless otherwise stated.

7. Match mark universal joints (2) and their mating surfaces to ensure correct mating alignment when installing Rear driveline assemblies (1).

8. Remove Bolts (4 & 5) securing universal joints (2) to their mating components and remove Rear driveline assembly (1). If necessary tap Rear driveline assembly (1) from its mating components with a soft faced hammer.
**DISASSEMBLY**

**Universal Joint**
Numbers in parentheses refer to Fig. 1, unless stated otherwise.

*Note:* The procedure for removal of Universal joints is the same for both Tractor and Scraper units.

1. Place the **yoke** end of Front driveline assembly (1) in a soft jawed vice, clamping on the tube of shaft.

*Note:* Do not distort the tube with excessive grip.

2. Remove bolts (3) and universal joint (2) from Front driveline assembly (1).

3. Place the **shaft** end of driveline assembly (1) in a soft jawed vice.

4. Remove bolts (3) and universal joint (2) from Front driveline assembly (1).

5. Repeat steps 1 to 4 for Rear drivelines (5) by removing bolts (7) and universal joints (6) from both ends of the rear driveline.

**INSPECTION**

1. Clean all metal parts in a suitable solvent, and dry all parts with compressed air.

2. Inspect splines of shaft and yoke for nicks, burrs and excessive wear. Replace if wear is excessive or splines are nicked. Burrs may be removed with a fine file or medium India stone.

3. Check the surfaces of the components that universal joints mate against for parallelism. Refer to Fig. 5.

4. Check condition of mounting Bolts and replace if required.

**ASSEMBLY**

**Universal Joint**
Numbers in parentheses refer to Fig. 2, unless stated otherwise.

1. Place the **yoke** end of the Front driveline assembly (1) in a soft jawed vice, clamping on the tube of shaft.

*Note:* Do not distort the tube with excessive grip.

2. Install universal joint (2) to yoke end of Front driveline assembly (1) and secure with Bolts (3).

3. Place the shaft end of Front driveline assembly (1) in a soft jawed vice.

4. Install universal joint (2) to shaft end of driveline assembly (1) and secure with bolts (3).

**INSTALLATION**

Numbers in parentheses refer to Fig. 1, unless otherwise specified.

*Note:* Tighten all fasteners without special torques specified to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

*Note:* Extra care should be taken when handling drivelines since carelessness can result in premature failure of the components. Chips, dents, burrs, or any other deformity of wing bearings will prevent accurate mating. This will cause misalignment which is accompanied by vibration and excessive wear.

---

**WARNINGS**

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

To prevent serious injury or death, DO NOT go under the vehicle when the engine is running. Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc..
1. Position Front driveline assembly (1) on the engine end as shown and align match marks on universal joints (2) with those on its mating surfaces.

2. Apply Loctite 648 to the threads of bolts (4) and secure universal joints (2) to its mating surfaces with bolts (4). Tighten bolts (4) to a torque of 153 Nm (113 lbf ft).

3. Position Front driveline assembly (1) on the Transmission end as shown and align match marks on universal joint (2) with those on its mating surface.

4. Apply Loctite 648 to the threads of bolts (4) and secure universal joints (2) to its mating surfaces with bolts (4). Tighten bolts (4) to a torque of 153 Nm (113 lbf ft).

5. Position rear driveline assembly (5) on the axle end as shown and align match marks on universal joint (6) with those on its mating surfaces.

6. Apply Loctite 648 to the threads of bolts (4) and secure universal joints (6) to its mating surfaces with bolts (4). Tighten bolts (4) to a torque of 153 Nm (113 lbf ft).

7. Position rear driveline assembly (5) on the transmission end and align match marks on universal joint (6) with those of its mating surface.

8. Apply loctite 648 to the threads of bolts (8) and secure universal joint (6) to its mating surfaces with the bolts (8). Tighten bolts (8) to a torque of 153 Nm (113 lbf ft).

13. Lower the cab, place the battery master switch in the 'On' position, ensure the parking brake is applied and start the engines by following the correct procedure, REFER to Operators Handbook for the correct starting procedure. Remove wheel blocks from all road wheels.

MAINTENANCE

Every 500 hours, check the universal joints for wear and replace if required.

Every 2 000 hours, check drivelines for leaks and damage, and replace if required.

Periodic Inspection

Use a small pry bar to check the companion flange yokes for looseness. If loose, drop one end of the driveline and twist the yoke to check the backlash between the splines and yokes. Replace any yoke that does not fit snugly.

With the pry bar, check the universal joints for play. If loose, replace the universal joints. Check the splines at the slip joint and replace the yoke if excessively worn.

SERVICE TOOLS

There are no special tools required for the procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools and adhesives required. These tools and adhesives are available from your dealer.
DRIVELINE DIAGNOSIS CHART

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>REASON</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration or noise</td>
<td>Driveline bent or out of balance</td>
<td>Clean driveline in a suitable solvent. Inspect for contact with adjacent parts. If driveline is distorted or sprung, replace. If driveline does not run smoothly, and vibration is felt, remove driveline and dynamically balance the assembly.</td>
</tr>
<tr>
<td>Driveline loose at yoke/flange</td>
<td></td>
<td>Check driveline mounting capscrews for tightness. If loose, replace capscrews and torque tighten to the proper specification.</td>
</tr>
<tr>
<td>Worn or dry bearings</td>
<td></td>
<td>Test driveline by hand. If crosses are loose, replace cross and bearings as an assembly. Also, see below.</td>
</tr>
<tr>
<td>Excessive wear of universal joints</td>
<td>Lack of lubrication</td>
<td>Replace cross and bearings as an assembly. Lubricate cross assembly so that lubricant appears at ALL bearing and cross seals.</td>
</tr>
<tr>
<td>Poor yoke/flange alignment and/or run-out</td>
<td></td>
<td>Check yoke/flange for alignment, run-out and balance. Repair or replace as required.</td>
</tr>
<tr>
<td>Driveline imbalance</td>
<td></td>
<td>Check to see if balance weights are missing or if driveline is distorted. If driveline is distorted, replace; if weights are missing, check balance of driveline dynamically and rebalance.</td>
</tr>
</tbody>
</table>

SPECIAL TORQUE SPECIFICATIONS

<table>
<thead>
<tr>
<th>FIG. NO.</th>
<th>ITEM NO.</th>
<th>ITEM NAME</th>
<th>TORQUE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nm</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
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<td>153</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>Bolt</td>
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</tr>
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<td>3</td>
<td>Bolt</td>
<td>153</td>
</tr>
<tr>
<td>2</td>
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</tr>
<tr>
<td>4</td>
<td>5</td>
<td>Bolt</td>
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</tbody>
</table>

* * * *
DESCRIPTION AND OPERATION

Numbers in parentheses refer to Fig. 1.

The differential performs three functions; it multiplies torque delivered by the driveline; it transmits this torque to the axle shafts; and it allows the drive wheels to rotate at different speeds.

When the vehicle is making a turn, one drive wheel must travel a greater distance than the other. If the wheels were connected by a single axle shaft, the wheel turning the larger radius of the turn circle would have to override the wheel making the shorter turn. Thus, one wheel would have to skip or hop causing tyre scuffing and strain on the power train.

The differential eliminates wheel skip by allowing separate axle shafts inserted into side gears (6 & 10) to rotate at different speeds as the drive wheels rotate. Spider (9) and spider pinion gears (8) are meshed with side gears (6 & 10). This assembly is enclosed in plain case (4) and flanged case (14).
which are bolted to ring gear (13). Thus, ring gear (13), plain case (4) and flanged case (14) rotate as an assembly when driven by input pinion gear (28). However, side gears (6 & 10), into which each axle shaft is inserted, are free to rotate independently about spider pinion gears (8) with which they are meshed. Therefore, as each drive wheel travels through a different arc as the truck makes a turn, side gears (6 & 10) rotate about spider pinion gears (8) to provide the required differential action.

REMOVAL

WARNINGS

To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

A come-a-long or chain fall with a minimum capacity of one ton is required for removal and installation of a differential assembly.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place the battery master switch in the ‘Off’ position.

3. Drain the lubricant from the differential banjo housing and planetary assemblies.

Note: When the differential is removed from the rear drive axle housing, it may be necessary to raise the frame above the drive axle housing to ensure proper clearance between the differential carrier housing and the frame crossmember. When the differential is removed from the front axle housing, it will be necessary to remove the main hydraulic valve mounting bolts and raise the control valve (with hoses connected) out of the way.

4. If required, use suitable lifting equipment to lift the frame off the drive axle housing far enough to facilitate removal of the differential without interference, and block the frame securely in this position.

5. Remove the driving flange cover from each wheel. Refer to Section 160-0040, PLANETARY GEARING.

6. Pull the axle shaft and sun pinion gear assembly of each driving wheel at least 305 mm (12 in) out of the wheel housing so that the inner axle shaft splines will be disengaged from the splines of the differential side gears (6 & 10). See Fig. 2.

7. Identify the relationship of the differential pinion yoke flange (33) with that of the driveline companion flange using punch marks.

8. Uncouple driveline at differential yoke flange (33), then lower the driveline.

9. Install a suitable chain fall or come-a-long to the differential assembly.

10. Support the weight of the differential assembly with suitable lifting device.

11. Remove mounting hardware which secures the differential carrier housing (26) to the axle banjo housing.

12. Pull the differential assembly away from the banjo until it clears the studs of the axle banjo housing, then carefully lower the differential assembly.
Section 140-0060

Pinion Cage Group

Note: Before disassembling, punch identifying marks on pinion bearing cage (39) and carrier housing (26) for assembly purposes.

1. Remove bolts (37) and lockwashers (38) securing pinion bearing cage (39) and shims (40) to carrier housing (26).

2. With carrier housing (26) as shown in Fig. 4, drive cage (39) assembly out of the housing. During this operation, be careful not to let cage assembly fall on yoke flange (33). Wire shims (40) together to aid in 'Assembly'.

3. Clamp yoke flange (33) in a soft-jawed vice with bearing cage (39) assembly attached and remove nut (32) from pinion gear (28) shaft. Drive the pinion gear shaft out of the yoke.

4. Hold the pinion gear and cage assembly in both hands with pinion gear (28) facing upward. Bump the splined end of the pinion gear shaft against a block of wood until bearing cage (39), containing outer cone (35), outer cup (36), inner cup (30) and seal (34) fall free of the pinion gear shaft.

5. Using a soft-jawed vice with the jaws opened slightly wider than bearing cage (39) OD, place bearing cage (39) in the vice so that the flange is resting on top of the jaws with seal (34) facing downward. Tap out outer bearing cup (36), outer bearing cone (35) and seal (34) with a soft-faced...
hammer. Be careful not to damage the inside machined surface of bearing cage (39) when removing these components.

6. Invert bearing cage (39) in the vice and tap out inner bearing cup (30).

**Note:** If the bearing races are still serviceable, wire the cups and corresponding cones together for proper mating in assembly. Bearing assembly is replaceable as a unit only. If any component is defective, the complete assembly must be replaced.

7. Remove washers (31) from pinion gear (28).

8. Using a bearing puller similar to that shown in Fig. 5, remove pinion inner cone (29) from the splined end of pinion gear (28) shaft.

9. Remove the staked area on the end of pinion gear (28) shaft, then with the aid of a bearing puller, see Fig. 5, remove end bearing (27) from the stub end of pinion gear (28) shaft.

**Differential and Ring Gear**

1. Remove and tag bearing cups (2 & 24) from the differential assembly.

2. Before separating, make identifying punch marks on plain case (4) flanged case (14) and ring gear (13) to show their relationship for assembly purposes.

3. Place the differential assembly on a bench so that plain case (4) is facing upwards. Cut lockwire (41) and remove bolts (42) from plain case (4). Lift plain case (4) off flanged case (14). Refer to Fig. 6.

4. Remove thrust washer (5) and side gear (6), then lift spider (9), spider pinion gears (8) and thrust washers (7) out of flanged case (14).

5. Remove four thrust washers (7) from the spider journals then separate the four spider pinion gears (8) from spider (9).

6. Remove remaining side gear (10) and thrust washer (11) from flanged case (14).

7. Remove bolts (12) and nuts (15) from ring gear (13) and flanged case (14).

8. Turn flanged case (14) and ring gear (13) assembly over on a block of wood approximately 50 mm (2 in) thick.

**Note:** Make sure that identifying marks are stamped on the side of ring gear (13) and flanged case (14) for assembly purposes.

9. Separate flanged case (14) from ring gear (13) by tapping the edge of ring gear (13) with a soft-faced hammer. See Fig. 7.

10. Using a bearing puller, remove cone (3) from plain case (4) and cone (25) from flanged case (14). Match up cones with cups (2 & 24) previously removed.
INSPECTION

Numbers in parentheses refer to Fig. 1.

The importance of careful and thorough inspection cannot be stressed enough. Thorough inspection and necessary replacement of parts now, may eliminate costly and avoidable trouble later.

1. Clean all parts in a suitable solvent.

2. Immediately after cleaning, dry all parts, except bearings, with compressed air, or lint-free cloth. Bearings are better left to air dry, then inspected and oiled thoroughly with gear lubricant for protection from corrosion.

3. With the parts cleaned, coat parts immediately with light oil to prevent corrosion. If parts are not to be assembled immediately, treat them with a good rust preventative and wrap them with treated paper or other suitable material designed to prevent corrosion.

4. Replace all gaskets, ‘O’ rings and seals with new parts.

5. Before installing the differential assembly to the banjo, clean the inside and outside of the banjo housing to remove any foreign material.

6. Inspect all gears, pinions and splines for cracked or broken teeth, excessive wear, and pitted or scored surfaces. Repair or replace as necessary.

**Note:** If either ring gear (13) or pinion gear (28) is defective, both gears must be replaced, because they are serviced only as a matched set. This set is identified by a serial number on the OD of the ring gear and outer face of the pinion gear. It is also advisable to replace side gears (6 & 10) or spider pinion gears (8) in matched sets only, because a newer gear installed to operate in conjunction with an older, worn gear tends to carry an uneven portion of the load. This creates an excessive amount of stress on the new gear.

7. Check for pitted, scored or worn thrust surfaces of differential case halves, spider trunnions and thrust washers. It is also advisable to replace thrust washers in sets, as the use of a combination of old and new washers may cause premature failure.

8. Inspect all housings (4, 14 & 26) and bearing cage (39) for bore damage, cracks and wear. Replace as necessary.

9. Check the amount of run-out on the machined surfaces of bearing cage (39). The outer machined surface on the hub of the bearing cage must be concentric with the bearing cup bore within 0.05 mm (0.002 in) total indicator reading (T.I.R.).

10. The machined mating surfaces of plain case (4) and flanged case (14) must be square with the axis of the cases within 0.05 mm (0.002 in) T.I.R.. The mating diameters of the cases must also be concentric within 0.08 mm (0.003 in) T.I.R..

11. Check the depth that the bearing rollers have worn into the wear surfaces. If the thrust face at the large end of the roller, which is ground and polished, is chipped or worn down to the centre area, or if the separator has become worn enough to drag on the cone, discard the bearing.

ASSEMBLY

Numbers in parentheses refer to Fig. 1.

**WARNING**

To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

Assembly of Differential and Ring Gear

1. Align identification marks that were made during ‘Disassembly’ on ring gear (13) and flanged case (14).

2. Install bolts (1) through ring gear (13) and flanged case (14) and secure with nuts (15). Torque tighten to 260 - 270 Nm (190 - 200 lbf ft), lubricated.
Front Axle - Differential

Section 140-0060

3. Press cone (3) on plain case (4) and press cone (25) on flanged case (14).

4. Lubricate inner walls of flanged case (14), plain case (4) and all component parts with gear lubricant. Refer to Section 300-0020, LUBRICATION SYSTEM, for proper lubricant.

5. Position thrust washer (11) in bore of flanged case (14).

6. Install side gear (10) into thrust washer (11) and flanged case (14).

7. Install pinions (8) and thrust washers (7) over spider (9).

8. Lay complete spider assembly (7, 8 & 9) in pinion grooves in face of flanged case (4).

9. Install side gear (6) and thrust washer (5) on spider assembly (7, 8 & 9).

10. Assemble plain case (4) to ring gear (13) and flanged case (14) assembly. Turn plain case (4) until the mating mark made during disassembly lines up with the mark made on flanged case (14) and tap into place using a soft faced mallet.

11. Install four bolts (42), equally spaced to secure plain case (4) to flanged case (14).

12. Check assembly for free gear rotation and correct if necessary. Install remaining bolts (42). Torque tighten bolts (42) to 185 - 210 Nm (135 - 155 lbf ft). Install lockwire (41) in bolts (42) and secure lockwire.

Assembly of Cage and Pinion

Note: During assembly and installation, make sure that mated, punch-marked or otherwise identified parts are returned to their original positions, if still serviceable.

Note: The bore of the inner race of the end bearing (27) has a radius on one side and a chamfer on the other. The bearing must be installed with the radius toward the pinion gear teeth.

1. Press end bearing inner race (27) firmly against pinion gear (28) stub shaft shoulder with a suitable sleeve that will bear only on the inner bearing race. Stake stub shaft in six places 0.15 mm (0.06 in) from ID of inner race to hold the race securely in place, as shown in Fig. 8.

2. Press inner cone (29) of pinion bearing assembly against shoulder of the splined end of pinion gear (28).

3. Install spacer (31) and two washers (32) on the splined end of pinion gear (28), spacer first.

4. Press outer cup (36) into bearing cage (39). Invert bearing cage and press inner cup (30) into bearing cage, making certain that both cups are fully seated in the bearing cage.

5. Lubricate cups (30 & 36) and cone (29) with gear lubricant as specified in Section 300-0020, LUBRICATION SYSTEM.

6. Install pinion gear (28) shaft into bearing cage (39) until inner cone (29) on the pinion shaft, is seated in the inner cup (30) in the bearing cage.

7. Lubricate outer cone (35) with gear lubricant. Press outer cone (35) onto the splined end of pinion gear (28) shaft until it seats into outer cup (36). DO NOT install seal (34) at this time.

8. Position pinion gear (28) in a soft-jawed vice with the splines upwards. Install yoke flange (33) on the splines of pinion gear (28) shaft. Install nut (32) on pinion shaft and torque tighten to 1 140 - 1 380 Nm (840 - 1 020 lbf ft). Tighten nut while rotating bearing cage in both directions to ensure normal bearing contact. Refer to Fig. 9.

9. If inner and outer cones (29 & 35) should start to seize as nut (32) is being tightened, the assembly must be taken apart enough to permit removal of washers (31) and new washers which have a greater total thickness, installed and reassembled as described in Step 8.

10. With the bearings lightly oiled, there should be a
noticable drag or preload on the pinion bearings when yoke nut (32) is tightened to the torque specified.

**Note:** The preload should be held within a torque range of 2 - 4 Nm (15 - 35 lbf in), lubricated.

11. To check pre-load torque, place pinion gear (28) in a soft-jawed vice, yoke (33) up. Wrap several turns of soft wire around body of cage (39) and form a small loop at the free end. Insert the hook of a suitable spring scale into the wire loop and pull on a line tangent to the outer flange face. Refer to Fig. 10. The scale reading should be taken while cage (39) is being rotated. The starting torque may be higher and therefore misleading, depending upon the tightness of the bearings.

The pull in Newtons (lbf) as indicated by the scale, multiplied by the cage body radius in metres (inches) (measured at the point where wire was wrapped) equals the Newton metres - Nm (lbf in) of torque.

For example: if the cage body radius is 0.103 18 m (4.0625 in) and the scale pull registered 40.03 N (9 lbf), then 0.103 18 x 40.03 = 4.13 Nm (4.0625 x 9 = 36.5625 lbf in) torque. This is 0.18 Nm (1.56 lbf in) over the high limit. The bearing preload would be too great.

If the preload is too much, use a combination of two washers (31) that is thicker. If the preload is not enough, use a combination of two washers that is thinner.

Continue checking the preload and changing washers as required until the proper fit of 2 - 4 Nm (15 - 35 lbf in) is obtained, with the bearings and washers under the full torque specified for nut (32).

12. Remove nut (32) and remove yoke (33) from pinion gear (28). If any difficulty is experienced removing the yoke use a suitable puller, DO NOT hammer the yoke.

13. Install seal (34) into bearing cage (39).


15. Install nut (32) on pinion gear (28) and torque tighten nut to 1 140 - 1 380 Nm (840 - 1 020 lbf ft).

16. Remove wire from shim (40) pack and set shims in place against flange of bearing cage (39).

17. Position bearing cage (39) and pinion gear (28) assembly to carrier housing (26) assembly and secure with bolts (37) and lockwashers (38). Torque tighten to 230 - 260 Nm (170 - 190 lbf ft).
Front Axle - Differential

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Ring Gear Assembly to Carrier Housing

Bearing adjusters (1 & 23) have two basic functions: pre-loading bearings (2, 3 & 24, 25); and positioning ring gear (13) to obtain the correct backlash between the ring gear and pinion gear (28). See Fig. 11. Bearing adjuster (23) located on the same side of pinion gear (28) as ring gear (13), pushes the ring gear toward the pinion gear. Bearing adjuster (1), located on the opposite side of the drive pinion than the ring gear, pushes the ring gear away from the drive pinion. The ring gear assembly must be installed onto carrier housing (26) so that side bearings (2, 3 & 24, 25) are properly pre-loaded; correct backlash exists between ring gear (13) and pinion gear (28); and satisfactory tooth pattern is established between ring gear and pinion gear.

These conditions can be obtained by using the following procedures:

1. Install cups (2 & 24) on their respective cones (3 & 25) and install ring gear (13) and differential assembly on carrier housing (26). Make sure that side bearing cups (2 & 24) are properly positioned on side bearing cones (3 & 25). Install bearing caps (19) over cups (2 & 24) then secure bearing caps to differential housing with washers (18) and bolts (17). Secure bolts snugly, but do not tighten them to torque specifications at this time.

Note: Each bearing cap (19) is mated to carrier housing (26), therefore, they must be returned to their original positions by aligning the identification marks made during ‘Disassembly’.

2. Install bearing adjusters (1 & 23) in their respective bearing caps (19).

3. Install a dial indicator on the assembly fixture as shown in Fig. 11.

4. Loosen bearing adjuster (1) until one thread is exposed. This is the adjuster on the same side as ring gear (13) teeth.

5. Tighten bearing adjuster (23) until there is a zero backlash on the dial indicator.

6. Rotate ring gear (13), checking backlash clearances at various tooth sections. This will determine any run-out or binding point that may exist and also help seat the bearings. If a run-out condition exists, the backlash must be adjusted from this point.

7. Loosen bearing adjuster (23) one notch and tighten bearing adjuster (1) until bearing cup (2) is contacted. Seat cup (2) by tightening and loosening adjuster (1) two notches each way.

8. When bearing cup (2) is seated, locate the point where adjuster (1) just contacts cup (2). From this point continue to tighten adjuster (1) two or three notches. Ring gear (13) should be positioned within the specified 0.15 - 0.41 mm (0.006 - 0.016 in) backlash.

9. When the proper backlash adjustment is reached, the correct side bearing preload will be established.

10. Torque tighten bearing cap bolts (17) to 440 - 520 Nm (320 - 380 lbf ft), lubricated, and again measure the ring gear backlash to make sure it is still within the specified limits.

11. When a satisfactory backlash tolerance has been established, check the gear tooth pattern as described under the heading ‘Adjustments’.

12. If gear tooth pattern is not correct, some correction can be made by systematically loosening and tightening bearing adjusters (1 & 23), as previously described, but in every instance re-check the backlash tolerance. If a favourable gear tooth pattern cannot be established within the backlash tolerance, it will be necessary to alter, add or remove, shims (40) between pinion cage assembly (39) and carrier housing (26).

13. The procedures for keeping differential side bearing pre-load, backlash and favourable gear tooth pattern within specifications is strictly a ‘try, check, and try again’ method.

14. After a satisfactory pre-load, backlash and gear...
tooth pattern is obtained, make certain that pinion bearing cage bolts (37) are torque tightened to 230 - 260 Nm (170 - 190 lbf ft). Again check backlash tolerance and gear tooth pattern.

15. Install adjuster locks (21) and secure with cotter pins (20).

16. Install lockwire (16) in bearing cap bolts (17). Each pair of bolts must be tied with lockwire (16). The lockwire passes over the top of bearing cap (19) and through the 'V' groove in adjuster locks (21).

**ADJUSTMENTS**

When adjusting a noisy differential that has been in service for some time, more harm than good can result. Changes in adjustment will frequently concentrate the bearing area on a small portion of the teeth which often results in failure. Therefore, it is advisable to know exactly what the end result will be before adjustments are made in an old differential.

**Note:** A rebuilt differential or one that has not worn excessively may be adjusted as previously described.

The following suggestions are offered to make gear tooth pattern analysis and identification easier.

1. Paint twelve ring gear teeth with Prussian Blue, oiled red lead, or some other easily removed paint or dye. When the pinion is rotated, the paint is squeezed away by the contact of the teeth, leaving bare areas the exact size, shape and location of the contacts.

2. Make this check by rotating the ring gear clockwise and counter-clockwise several times.

3. Gear tooth patterns can be interpreted by referring to Figs. 12 thru 18.

A. If a contact pattern similar to that shown in Fig. 12 is obtained, the adjustment is correct.

B. If the contact area is on the inner side of the ring gear teeth, see Fig. 13, move ring gear away from pinion by turning bearing adjusters equal amounts until the proper bearing pattern is obtained.

C. If the contact area is on the outer part of the ring gear teeth, see Fig. 14, move ring gear toward pinion by turning bearing adjusters equal amounts.

D. If the contact area is along the root of the ring gear
teeth, see Fig. 15, move the pinion out by adding shims.

E. If the contact area is along the top edge of the ring gear teeth, see Fig. 16, move the pinion in by removing shims.

INSTALLATION

**WARNINGS**

To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

A come-a-long or chain fall with a minimum capacity of one ton is required for removal and installation of a differential assembly.

**Note:** Tighten all fasteners without special torques specified, to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. Clean mating surfaces of the banjo and differential assembly with a hydrocarbon solvent to remove dirt, oil, grease, or other foreign matter. Wipe cleaned surfaces dry. Apply a pliable non-hardening seal material to the mounting surface of the banjo for a leakproof seal. The seal is installed by pressing it in place around the bolt circle on the banjo. The two beads of the seal should be separated at each stud and the seal slipped over the studs to make an effective seal when the differential assembly is bolted in place on the banjo.

2. Position the differential assembly under the vehicle in front of the banjo housing.

3. Install chain fall or come-a-long to a suitable lifting device and lift the differential assembly and carefully position it on the studs of the banjo housing.

4. Install the lockwashers, stud nuts and bolts on differential assembly and torque tighten to 300 - 320 Nm (220 - 240 lbf ft).

5. Recouple the driveline to yoke (33), aligning marks made at 'Removal'. Refer to Section 130-0010, DRIVELINE.
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7. Install the axle shafts, then install and secure the driving flange cover to the wheels. Refer to Section 160-0040, PLANETARY GEARING.

8. If removed, lower frame onto the drive axle housing and install bolts and nuts securing the drive axle to the frame.

9. Fill the drive axle, planetary reservoirs, and differential with the proper grade and quantity of lubricant specified in Section 300-0020, LUBRICATION SYSTEM.

MAINTENANCE

Periodic Inspection
Inspect regularly the flange yoke mounting bolts, pinion shaft nut, pinion cage and seal retainer bolts, and differential stud nuts for tightness. Tighten the stud nuts and flange bolts weekly until they 'set' or show that they no longer need tightening. Keep the nuts tight to reduce the possibility of differential or driveline failure due to excessive vibration or wear. Replace any mounting studs which have become stripped or broken.

Jack up the drive axle to 'test run' the differential and listen for noises which may indicate the need for adjustment or replacement of worn parts. When doing this, lift BOTH wheels off the ground. Both wheel brakes should be free to allow both wheels to rotate at approximately the same speed.

**Note:** Do not operate with only one wheel jacked up. Excessive operation in this manner will overheat the differential spider and cause galling or shearing of the spider trunnions and bearings.

If differential is excessively noisy, it should be removed from the banjo and disassembled for inspection.

Lubrication
The differential is splash-lubricated with an extreme pressure lubricant. The fill-level plug is located on the rear of the banjo housing.

The differential should be checked and periodically drained and filled to the bottom of the fill-level hole, or to no more than 13 mm (1/2 in) below the fill level, with new lubricant as recommended. Refer to Section 300-0020, LUBRICATION SYSTEM. When the lubricant is drained, remove any chips of steel particles that may be attached to the magnetic drain plug located in the bottom of the banjo housing.

After draining and refilling an axle, the planetary gearing should be checked after 10 hours of operation.

1. Check the level in planetaries at oil level plug. If the oil level is low, add oil. This check point is a minimum check point only. If the oil level is above the check point, do not drain off oil.

2. Add oil if needed. The oil level is correct when oil flows from the lube level check plug in the banjo. These checks should be made every 10 hours until oil level in the differential is maintained.

DIFFERENTIAL DIAGNOSIS

Noises and vibrations originating in the tyres, transmission, planetaries and drivelines are easily transmitted and may be erroneously attributed to the differential. Therefore all possible sources of noise should be investigated before the differential is taken apart.

Differential noises may be located by jacking up both drive axles of the machine so that the tyres are clear of the ground, then run the power train in a high gear at a moderate engine speed. Be sure to jack up all wheels of the drive axles to prevent damage to the differentials.

Whenever noises such as grating or rattle are heard coming from the differential, stop the machine immediately. One tooth from a gear can cause damage to all gears and bearings. When the differential is definitely at fault, pull the drive axles before moving the machine. Refer to Section 160-0040, PLANETARY GEARING.

SPECIAL TOOLS
Refer to Section 300-0070, SERVICE TOOLS, for part numbers of special tools outlined in this section and general service tools required. These tools are available from your dealer.
**DIAGNOSIS CHART**

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>REASON</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration</td>
<td>Broken gear teeth</td>
<td>Replace damaged gear</td>
</tr>
<tr>
<td></td>
<td>Excessive run-out of pinion or flanged case</td>
<td>Disassemble, correct or replace faulty part</td>
</tr>
<tr>
<td>Continual noise</td>
<td>Bearing worn</td>
<td>Replace worn parts</td>
</tr>
<tr>
<td></td>
<td>Gears damaged or worn</td>
<td>Replace gears</td>
</tr>
<tr>
<td>Noise on drive</td>
<td>Ring and pinion gear adjustment tight</td>
<td>Adjust</td>
</tr>
<tr>
<td>Noise on coast</td>
<td>Bearing damaged</td>
<td>Replace bearings</td>
</tr>
<tr>
<td></td>
<td>Loose ring and pinion gear adjustment</td>
<td>Adjust gears</td>
</tr>
<tr>
<td></td>
<td>Excessive pinion gear end play</td>
<td>Adjust</td>
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<tr>
<td>Noise on turns</td>
<td>Worn spider gears or side gears</td>
<td>Replace gears</td>
</tr>
<tr>
<td></td>
<td>Worn or damaged spider bushings</td>
<td>Replace bushings</td>
</tr>
<tr>
<td>Loss of lubricant</td>
<td>Oil seals worn</td>
<td>Replace seal</td>
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<tr>
<td></td>
<td>Loose nuts</td>
<td>Tighten nuts to correct torque</td>
</tr>
<tr>
<td></td>
<td>Cracked housing</td>
<td>Repair or replace housing</td>
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**SPECIAL TORQUE SPECIFICATIONS**

<table>
<thead>
<tr>
<th>FIG. NO.</th>
<th>ITEM NO.</th>
<th>PART NAME</th>
<th>TORQUE</th>
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<td>Screw</td>
<td>440 - 520</td>
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<tr>
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<td>32</td>
<td>Locknut</td>
<td>1 140 - 1 380</td>
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<td>37</td>
<td>Bolt</td>
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<tr>
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<td></td>
<td></td>
<td>Differential-to-Banjo Nuts</td>
<td>300 - 320</td>
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</tbody>
</table>
DESCRIPTION AND OPERATION

Numbers in parentheses refer to Fig. 1.

The differential performs three functions; it multiplies torque delivered by the driveline; it transmits this torque to the axle shafts; and it allows the drive wheels to rotate at different speeds.

When the vehicle is making a turn, one drive wheel must travel a greater distance than the other. If the wheels were connected by a single axle shaft, the wheel turning the larger radius of the turn circle would have to override the wheel making the shorter turn. Thus, one wheel would have to skip or hop causing tyre scuffing and strain on the power train.

The differential eliminates wheel skip by allowing separate axle shafts inserted into side gears (6 & 10) to rotate at different speeds as the drive wheels rotate. Spider (9) and spider pinion gears (8) are meshed with side gears (6 & 10). This assembly is enclosed in plain case (4) and flanged case (14).
Rear Axle - Differential
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which are bolted to ring gear (13). Thus, ring gear (13), plain case (4) and flanged case (14) rotate as an assembly when driven by input pinion gear (28). However, side gears (6 & 10), into which each axle shaft is inserted, are free to rotate independently about spider pinion gears (8) with which they are meshed. Therefore, as each drive wheel travels through a different arc as the truck makes a turn, side gears (6 & 10) rotate about spider pinion gears (8) to provide the required differential action.

REMOVAL

⚠️ WARNINGS
To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

⚠️ A come-a-long or chain fall with a minimum capacity of one ton is required for removal and installation of a differential assembly.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place the battery master switch in the ‘Off’ position.

3. Drain the lubricant from the differential banjo housing and planetary assemblies.

Note: When the differential is removed from the rear drive axle housing, it may be necessary to raise the frame above the drive axle housing to ensure proper clearance between the differential carrier housing and the frame crossmember. When the differential is removed from the front axle housing, it will be necessary to remove the main hydraulic valve mounting bolts and raise the control valve (with hoses connected) out of the way.

4. If required, use suitable lifting equipment to lift the frame off the drive axle housing far enough to facilitate removal of the differential without interference, and block the frame securely in this position.

5. Remove the driving flange cover from each wheel. Refer to Section 160-0040, PLANETARY GEARING.

6. Pull the axle shaft and sun pinion gear assembly of each driving wheel at least 305 mm (12 in) out of the wheel housing so that the inner axle shaft splines will be disengaged from the splines of the differential side gears (6 & 10). See Fig. 2.

7. Identify the relationship of the differential pinion yoke flange (33) with that of the driveline companion flange using punch marks.

8. Uncouple driveline at differential yoke flange (33), then lower the driveline.

9. Install a suitable chain fall or come-a-long to the differential assembly.

10. Support the weight of the differential assembly with suitable lifting device.

11. Remove mounting hardware which secures the differential carrier housing (26) to the axle banjo housing.

12. Pull the differential assembly away from the banjo until it clears the studs of the axle banjo housing, then carefully lower the differential assembly.
DISASSEMBLY
Numbers in parentheses refer to Fig. 1.

⚠️ WARNING
To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

1. Make identifying punch marks on bearing caps (19) and plain and flanged cases (4 & 14), so that the bearing caps can be returned to their original position in assembly.

2. Scribe an identifying line on the bearing adjusters (1 & 23) and carrier housing (26) bores for correct location of adjuster locks (21) during assembly.

3. Remove cotter pins (20) and locks (21) from bearing caps (19). Remove lockwire (16), screws (17) and washers (18) from bearing caps (19). Remove bearing caps (19) and bearing adjusters (1 & 23) from carrier housing (26).

4. Place a suitable rod through differential assembly and attach suitable lifting equipment to the rod. Tilt ring gear (13) away from pinion gear (28) and lift the differential assembly out of carrier housing (26). Refer to Fig. 3.

Pinion Cage Group
Note: Before disassembling, punch identifying marks on pinion bearing cage (39) and carrier housing (26) for assembly purposes.

1. Remove bolts (37) and lockwashers (38) securing pinion bearing cage (39) and shims (40) to carrier housing (26).

2. With carrier housing (26) as shown in Fig. 4, drive cage (39) assembly out of the housing. During this operation, be careful not to let cage assembly fall on yoke flange (33). Wire shims (40) together to aid in ‘Assembly’.

3. Clamp yoke flange (33) in a soft-jawed vice with bearing cage (39) assembly attached and remove nut (32) from pinion gear (28) shaft. Drive the pinion gear shaft out of the yoke.

4. Hold the pinion gear and cage assembly in both hands with pinion gear (28) facing upward. Bump the splined end of the pinion gear shaft against a block of wood until bearing cage (39), containing outer cone (35), outer cup (36), inner cup (30) and seal (34) fall free of the pinion gear shaft.

5. Using a soft-jawed vice with the jaws opened slightly wider than bearing cage (39) OD, place bearing cage (39) in the vice so that the flange is resting on top of the jaws with seal (34) facing downward. Tap out outer bearing cup (36), outer bearing cone (35) and seal (34) with a soft-faced...
hammer. Be careful not to damage the inside machined surface of bearing cage (39) when removing these components.

6. Invert bearing cage (39) in the vice and tap out inner bearing cup (30).

**Note:** If the bearing races are still serviceable, wire the cups and corresponding cones together for proper mating in assembly. Bearing assembly is replaceable as a unit only. If any component is defective, the complete assembly must be replaced.

7. Remove washers (31) from pinion gear (28).

8. Using a bearing puller similar to that shown in Fig. 5, remove pinion inner cone (29) from the splined end of pinion gear (28) shaft.

9. Remove the staked area on the end of pinion gear (28) shaft, then with the aid of a bearing puller, see Fig. 5, remove end bearing (27) from the stub end of pinion gear (28) shaft.

**Differential and Ring Gear**

1. Remove and tag bearing cups (2 & 24) from the differential assembly.

2. Before separating, make identifying punch marks on plain case (4) flanged case (14) and ring gear (13) to show their relationship for assembly purposes.

**Note:** If the differential is equipped with the NoSPIN® element (44), disregard Steps 3 thru 6 and remove the NoSPIN® element (44) as described in Section 160-0080, NOSPIN ELEMENT.

3. Place the differential assembly on a bench so that plain case (4) is facing upwards. Cut lockwire (41) and remove bolts (42) from plain case (4). Lift plain case (4) off flanged case (14). Refer to Fig. 6.

4. Remove thrust washer (5) and side gear (6), then lift spider (9), spider pinion gears (8) and thrust washers (7) out of flanged case (14).

5. Remove four thrust washers (7) from the spider journals then separate the four spider pinion gears (8) from spider (9).

6. Remove remaining side gear (10) and thrust washer (11) from flanged case (14).

7. Remove bolts (12) and nuts (15) from ring gear (13) and flanged case (14).

8. Turn flanged case (14) and ring gear (13) assembly over on a block of wood approximately 50 mm (2 in) thick.

**Note:** Make sure that identifying marks are stamped on the side of ring gear (13) and flanged case (14) for assembly purposes.

9. Separate flanged case (14) from ring gear (13) by tapping the edge of ring gear (13) with a soft-faced hammer. See Fig. 7.
10. Using a bearing puller, remove cone (3) from plain case (4) and cone (25) from flanged case (14). Match up cones with cups (2 & 24) previously removed.

**INSPECTION**

Numbers in parentheses refer to Fig. 1.

The importance of careful and thorough inspection cannot be stressed enough. Thorough inspection and necessary replacement of parts now, may eliminate costly and avoidable trouble later.

**Note:** If the differential is equipped with the NoSPIN® element (44), refer to Section 160-0080, NOSPIN ELEMENT for inspection of the NoSPIN® components.

1. Clean all parts in a suitable solvent.

2. Immediately after cleaning, dry all parts, except bearings, with compressed air, or lint-free cloth. Bearings are better left to air dry, then inspected and oiled thoroughly with gear lubricant for protection from corrosion.

3. With the parts cleaned, coat parts immediately with light oil to prevent corrosion. If parts are not to be assembled immediately, treat them with a good rust preventative and wrap them with treated paper or other suitable material designed to prevent corrosion.

4. Replace all gaskets, ‘O’ rings and seals with new parts.

5. Before installing the differential assembly to the banjo, clean the inside and outside of the banjo housing to remove any foreign material.

6. Inspect all gears, pinions and splines for cracked or broken teeth, excessive wear, and pitted or scored surfaces. Repair or replace as necessary.

**Note:** If either ring gear (13) or pinion gear (28) is defective, both gears must be replaced, because they are serviced only as a matched set. This set is identified by a serial number on the OD of the ring gear and outer face of the pinion gear. It is also advisable to replace side gears (6 & 10) or spider pinion gears (8) in matched sets only, because a newer gear installed to operate in conjunction with an older, worn gear tends to carry an uneven portion of the load. This creates an excessive amount of stress on the new gear.

7. Check for pitted, scored or worn thrust surfaces of differential case halves, spider trunnions and thrust washers. It is also advisable to replace thrust washers in sets, as the use of a combination of old and new washers may cause premature failure.

8. Inspect all housings (4, 14 & 26) and bearing cage (39) for bore damage, cracks and wear. Replace as necessary.

9. Check the amount of run-out on the machined surfaces of bearing cage (39). The outer machined surface on the hub of the bearing cage must be concentric with the bearing cup bore within 0.05 mm (0.002 in) total indicator reading (T.I.R.).

10. The machined mating surfaces of plain case (4) and flanged case (14) must be square with the axis of the cases within 0.05 mm (0.002 in) T.I.R.. The mating diameters of the cases must also be concentric within 0.08 mm (0.003 in) T.I.R..

11. Check the depth that the bearing rollers have worn into the wear surfaces. If the thrust face at the large end of the roller, which is ground and polished, is chipped or worn down to the centre area, or if the separator has become worn enough to drag on the cone, discard the bearing.

**ASSEMBLY**

Numbers in parentheses refer to Fig. 1.

⚠️ **WARNING**

To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.
Rear Axle - Differential

Assembly of Differential and Ring Gear

1. Align identification marks that were made during 'Disassembly' on ring gear (13) and flanged case (14).

2. Install bolts (1) through ring gear (13) and flanged case (14) and secure with nuts (15). Torque tighten to 260 - 270 Nm (190 - 200 lbf ft), lubricated.

3. Press cone (3) on plain case (4) and press cone (25) on flanged case (14).

4. Lubricate inner walls of flanged case (14), plain case (4) and all component parts with gear lubricant. Refer to Section 300-0020, LUBRICATION SYSTEM, for proper lubricant.

Note: If the differential is equipped with the NoSPIN® element (44), disregard Steps 5 thru 10 and install the NoSPIN® element (44) as described in Section 160-0080, NOSPIN ELEMENT.

5. Position thrust washer (11) in bore of flanged case (14).

6. Install side gear (10) into thrust washer (11) and flanged case (14).

7. Install pinions (8) and thrust washers (7) over spider (9).

8. Lay complete spider assembly (7, 8 & 9) in pinion grooves in face of flanged case (4).

9. Install side gear (6) and thrust washer (5) on spider assembly (7, 8 & 9).

10. Assemble plain case (4) to ring gear (13) and flanged case (14) assembly. Turn plain case (4) until the mating mark made during disassembly lines up with the mark made on flanged case (14) and tap into place using a soft faced mallet.

11. Install four bolts (42), equally spaced to secure plain case (4) to flanged case (14).

12. Check assembly for free gear rotation and correct if necessary. Install remaining bolts (42). Torque tighten bolts (42) to 185 - 210 Nm (135 - 155 lbf ft). Install lockwire (41) in bolts (42) and secure lockwire.

Assembly of Cage and Pinion

Note: During assembly and installation, make sure that mated, punch-marked or otherwise identified parts are returned to their original positions, if still serviceable.

Note: The bore of the inner race of the end bearing (27) has a radius on one side and a chamfer on the other. The bearing must be installed with the radius toward the pinion gear teeth.

1. Press end bearing inner race (27) firmly against pinion gear (28) stub shaft shoulder with a suitable sleeve that will bear only on the inner bearing race. Stake stub shaft in six places 0.15 mm (0.06 in) from ID of inner race to hold the race securely in place, as shown in Fig. 8.

2. Press inner cone (29) of pinion bearing assembly against shoulder of the splined end of pinion gear (28).

3. Install spacer (31) and two washers (32) on the splined end of pinion gear (28), spacer first.

4. Press outer cup (36) into bearing cage (39). Invert bearing cage and press inner cup (30) into bearing cage, making certain that both cups are fully seated in the bearing cage.

5. Lubricate cups (30 & 36) and cone (29) with gear lubricant as specified in Section 300-0020, LUBRICATION SYSTEM.

6. Install pinion gear (28) shaft into bearing cage (39) until inner cone (29) on the pinion shaft, is seated in the inner cup (30) in the bearing cage.

7. Lubricate outer cone (35) with gear lubricant. Press outer cone (35) onto the splined end of pinion gear (28) shaft until it seats into outer cup (36). DO NOT install seal (34) at this time.

8. Position pinion gear (28) in a soft-jawed vice with the splines upwards. Install yoke flange (33) on the splines of pinion gear (28) shaft. Install nut (32) on pinion shaft and torque tighten to 1 140 - 1 380 Nm
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(840 - 1,020 lbf ft). Tighten nut while rotating bearing cage in both directions to ensure normal bearing contact. Refer to Fig. 9.

9. If inner and outer cones (29 & 35) should start to seize as nut (32) is being tightened, the assembly must be taken apart enough to permit removal of washers (31) and new washers which have a greater total thickness, installed and reassembled as described in Step 8.

10. With the bearings lightly oiled, there should be a noticeable drag or preload on the pinion bearings when yoke nut (32) is tightened to the torque specified.

**Note:** The preload should be held within a torque range of 2 - 4 Nm (15 - 35 lbf in), lubricated.

11. To check pre-load torque, place pinion gear (28) in a soft-jawed vice, yoke (33) up. Wrap several turns of soft wire around body of cage (39) and form a small loop at the free end. Insert the hook of a suitable spring scale into the wire loop and pull on a line tangent to the outer flange face. Refer to Fig. 10.

The pull in Newtons (lbf) as indicated by the scale, multiplied by the cage body radius in metres (inches) (measured at the point where wire was wrapped) equals the Newton metres - Nm (lbf in) of torque.

For example: if the cage body radius is 0.103 18 m (4.0625 in) and the scale pull registered 40.03 N (9 lbf), then 0.103 18 x 40.03 = 4.13 Nm (4.0625 x 9 = 36.5625 lbf in) torque. This is 0.18 Nm (1.56 lbf in) over the high limit. The bearing preload would be too great.

If the preload is too much, use a combination of two washers (31) that is thicker. If the preload is not enough, use a combination of two washers that is thinner.

Continue checking the preload and changing washers as required until the proper fit of 2 - 4 Nm (15 - 35 lbf in) is obtained, with the bearings and washers under the full torque specified for nut (32).

12. Remove nut (32) and remove yoke (33) from pinion gear (28). If any difficulty is experienced removing the yoke use a suitable puller, DO NOT hammer the yoke.

13. Install seal (34) into bearing cage (39).

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15. Install nut (32) on pinion gear (28) and torque tighten nut to 140 - 1380 Nm (840 - 1020 lbf ft).

16. Remove wire from shim (40) pack and set shims in place against flange of bearing cage (39).

17. Position bearing cage (39) and pinion gear (28) assembly to carrier housing (26) assembly and secure with bolts (37) and lockwashers (38). Torque tighten to 230 - 260 Nm (170 - 190 lbf ft).

Ring Gear Assembly to Carrier Housing

Bearing adjusters (1 & 23) have two basic functions: pre-loading bearings (2, 3 & 24, 25); and positioning ring gear (13) to obtain the correct backlash between the ring gear and pinion gear (28). See Fig. 11. Bearing adjuster (23) located on the same side of pinion gear (28) as ring gear (13), pushes the ring gear toward the pinion gear. Bearing adjuster (1), located on the opposite side of the drive pinion than the ring gear, pushes the ring gear away from the drive pinion. The ring gear assembly must be installed onto carrier housing (26) so that side bearings (2, 3 & 24, 25) are properly pre-loaded; correct backlash exists between ring gear (13) and pinion gear (28); and satisfactory tooth pattern is established between ring gear and pinion gear.

These conditions can be obtained by using the following procedures:

1. Install cups (2 & 24) on their respective cones (3 & 25) and install ring gear (13) and differential assembly on carrier housing (26). Make sure that side bearing cups (2 & 24) are properly positioned on side bearing cones (3 & 25). Install bearing caps (19) over cups (2 & 24) then secure bearing caps to differential housing with washers (18) and bolts (17). Secure bolts snugly, but do not tighten them to torque specifications at this time.

Note: Each bearing cap (19) is mated to carrier housing (26), therefore, they must be returned to their original positions by aligning the identification marks made during ‘Disassembly’.

2. Install bearing adjusters (1 & 23) in their respective bearing caps (19).

3. Install a dial indicator on the assembly fixture as shown in Fig. 11.

4. Loosen bearing adjuster (1) until one thread is exposed. This is the adjuster on the same side as ring gear (13) teeth.

5. Tighten bearing adjuster (23) until there is a zero backlash on the dial indicator.

6. Rotate ring gear (13), checking backlash clearances at various tooth sections. This will determine any run-out or binding point that may exist and also help seat the bearings. If a run-out condition exists, the backlash must be adjusted from this point.

7. Loosen bearing adjuster (23) one notch and tighten bearing adjuster (1) until bearing cup (2) is contacted. Seat cup (2) by tightening and loosening adjuster (1) two notches each way.

8. When bearing cup (2) is seated, locate the point where adjuster (1) just contacts cup (2). From this point continue to tighten adjuster (1) two or three notches. Ring gear (13) should be positioned within the specified 0.15 - 0.41 mm (0.006 - 0.016 in) backlash.

9. When the proper backlash adjustment is reached, the correct side bearing preload will be established.

10. Torque tighten bearing cap bolts (17) to 440 - 520 Nm (320 - 380 lbf ft), lubricated, and again measure the ring gear backlash to make sure it is still within the specified limits.

11. When a satisfactory backlash tolerance has been established, check the gear tooth pattern as described under the heading ‘Adjustments’.

12. If gear tooth pattern is not correct, some correction can be made by systematically loosening and tightening bearing adjusters (1 & 23), as previously described, but in every instance re-check the backlash tolerance. If a favourable gear tooth pattern cannot be established within the backlash...
tolerance, it will be necessary to alter, add or remove, shims (40) between pinion cage assembly (39) and carrier housing (26).

13. The procedures for keeping differential side bearing pre-load, backlash and favourable gear tooth pattern within specifications is strictly a ‘try, check, and try again’ method.

14. After a satisfactory pre-load, backlash and gear tooth pattern is obtained, make certain that pinion bearing cage bolts (37) are torque tightened to 230 - 260 Nm (170 - 190 lbf ft). Again check backlash tolerance and gear tooth pattern.

15. Install adjuster locks (21) and secure with cotter pins (20).

16. Install lockwire (16) in bearing cap bolts (17). Each pair of bolts must be tied with lockwire (16). The lockwire passes over the top of bearing cap (19) and through the ‘V’ groove in adjuster locks (21).

**ADJUSTMENTS**

When adjusting a noisy differential that has been in service for some time, more harm than good can result. Changes in adjustment will frequently concentrate the bearing area on a small portion of the teeth which often results in failure. Therefore, it is advisable to know exactly what the end result will be before adjustments are made in an old differential.

**Note:** A rebuilt differential or one that has not worn excessively may be adjusted as previously described.

The following suggestions are offered to make gear tooth pattern analysis and identification easier.

1. Paint twelve ring gear teeth with Prussian Blue, oiled red lead, or some other easily removed paint or dye. When the pinion is rotated, the paint is squeezed away by the contact of the teeth, leaving bare areas the exact size, shape and location of the contacts.

2. Make this check by rotating the ring gear clockwise and counter-clockwise several times.

3. Gear tooth patterns can be interpreted by referring to Figs. 12 thru 18.

A. If a contact pattern similar to that shown in Fig. 12 is obtained, the adjustment is correct.

B. If the contact area is on the inner side of the ring
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gear teeth, see Fig. 13, move ring gear away from pinion by turning bearing adjusters equal amounts until the proper bearing pattern is obtained.

C. If the contact area is on the outer part of the ring gear teeth, see Fig. 14, move ring gear toward pinion by turning bearing adjusters equal amounts.

D. If the contact area is along the root of the ring gear teeth, see Fig. 15, move the pinion out by adding shims.

E. If the contact area is along the top edge of the ring gear teeth, see Fig. 16, move the pinion in by removing shims.

INSTALLATION

⚠️ WARNINGS
To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

⚠️ A come-a-long or chain fall with a minimum capacity of one ton is required for removal and installation of a differential assembly.

**Note:** Tighten all fasteners without special torques specified, to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. Clean mating surfaces of the banjo and differential assembly with a hydrocarbon solvent to remove dirt, oil, grease, or other foreign matter. Wipe cleaned surfaces dry. Apply a pliable non-hardening seal material to the mounting surface of the banjo for a leakproof seal. The seal is installed by pressing it in place around the bolt circle on the banjo. The two beads of the seal should be separated at each stud and the seal slipped over the studs to make an effective seal when the differential assembly is bolted in place on the banjo.

2. Position the differential assembly under the vehicle in front of the banjo housing.

3. Install chain fall or come-a-long to a suitable lifting device and lift the differential assembly and carefully position it on the studs of the banjo housing.
4. Install the lockwashers, stud nuts and bolts on differential assembly and torque tighten to 300 - 320 Nm (220 - 240 lbf ft).

5. Recouple the driveline to yoke (33), aligning marks made at 'Removal'. Refer to Section 130-0010, DRIVELINE.

7. Install the axle shafts, then install and secure the driving flange cover to the wheels. Refer to Section 160-0040, PLANETARY GEARING.

8. If removed, lower frame onto the drive axle housing and install bolts and nuts securing the drive axle to the frame.

9. Fill the drive axle, planetary reservoirs, and differential with the proper grade and quantity of lubricant specified in Section 300-0020, LUBRICATION SYSTEM.

MAINTENANCE

Periodic Inspection
Inspect regularly the flange yoke mounting bolts, pinion shaft nut, pinion cage and seal retainer bolts, and differential stud nuts for tightness. Tighten the stud nuts and flange bolts weekly until they 'set' or show that they no longer need tightening. Keep the nuts tight to reduce the possibility of differential or driveline failure due to excessive vibration or wear. Replace any mounting studs which have become stripped or broken.

Jack up the drive axle to 'test run' the differential and listen for noises which may indicate the need for adjustment or replacement of worn parts. When doing this, lift BOTH wheels off the ground. Both wheel brakes should be free to allow both wheels to rotate at approximately the same speed.

Note: Do not operate with only one wheel jacked up. Excessive operation in this manner will overheat the differential spider and cause galling or shearing of the spider trunnions and bearings.

If differential is excessively noisy, it should be removed from the banjo and disassembled for inspection.

Lubrication
The differential is splash-lubricated with an extreme pressure lubricant. The fill-level plug is located on the rear of the banjo housing.

The differential should be checked and periodically drained and filled to the bottom of the fill-level hole, or to no more than 13 mm (1/2 in) below the fill level, with new lubricant as recommended. Refer to Section 300-0020, LUBRICATION SYSTEM. When the lubricant is drained, remove any chips of steel particles that may be attached to the magnetic drain plug located in the bottom of the banjo housing.

After draining and refilling an axle, the planetary gearing should be checked after 10 hours of operation.

1. Check the level in planetaries at oil level plug. If the oil level is low, add oil. This check point is a minimum check point only. If the oil level is above the check point, do not drain off oil.

2. Add oil if needed. The oil level is correct when oil flows from the lube level check plug in the banjo. These checks should be made every 10 hours until oil level in the differential is maintained.

DIFFERENTIAL DIAGNOSIS
Noises and vibrations originating in the tyres, transmission, planetaries and drivelines are easily transmitted and may be erroneously attributed to the differential. Therefore all possible sources of noise should be investigated before the differential is taken apart.

Differential noises may be located by jacking up both drive axles of the machine so that the tyres are clear of the ground, then run the power train in a high gear at a moderate engine speed. Be sure to jack up all wheels of the drive axles to prevent damage to the differentials.

Whenever noises such as grating or rattle are heard coming from the differential, stop the machine immediately. One tooth from a gear can cause damage to all gears and bearings. When the differential is definitely at fault, pull the drive axles before moving the machine. Refer to Section 160-0040, PLANETARY GEARING.

Note: If the differential is equipped with the NoSPIN® element (44) in place of the spider, spider gears and side gears, refer to Section 160-0080, NOSPIN ELEMENT for diagnosis of the NoSPIN® element.
Rear Axle - Differential

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SPECIAL TOOLS
Refer to Section 300-0070, SERVICE TOOLS, for part numbers of special tools outlined in this section and general service tools required. These tools are available from your dealer.

### DIAGNOSIS CHART

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<th>REMEDY</th>
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<td>Vibration</td>
<td>Broken gear teeth</td>
<td>Replace damaged gear</td>
</tr>
<tr>
<td></td>
<td>Excessive run-out of pinion or flanged case</td>
<td>Disassemble, correct or replace faulty part</td>
</tr>
<tr>
<td>Continual noise</td>
<td>Bearing worn</td>
<td>Replace worn parts</td>
</tr>
<tr>
<td></td>
<td>Gears damaged or worn</td>
<td>Replace gears</td>
</tr>
<tr>
<td>Noise on drive</td>
<td>Ring and pinion gear adjustment tight</td>
<td>Adjust</td>
</tr>
<tr>
<td>Noise on coast</td>
<td>Bearing damaged</td>
<td>Replace bearings</td>
</tr>
<tr>
<td></td>
<td>Loose ring and pinion gear adjustment</td>
<td>Adjust gears</td>
</tr>
<tr>
<td></td>
<td>Excessive pinion gear end play</td>
<td>Adjust</td>
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<tr>
<td>Noise on turns</td>
<td>Worn spider gears or side gears</td>
<td>Replace gears</td>
</tr>
<tr>
<td></td>
<td>Worn or damaged spider bushings</td>
<td>Replace bushings</td>
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<tr>
<td>Loss of lubricant</td>
<td>Oil seals worn</td>
<td>Replace seal</td>
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<tr>
<td></td>
<td>Loose nuts</td>
<td>Tighten nuts to correct torque</td>
</tr>
<tr>
<td></td>
<td>Cracked housing</td>
<td>Repair or replace housing</td>
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### SPECIAL TORQUE SPECIFICATIONS

<table>
<thead>
<tr>
<th>FIG. NO.</th>
<th>ITEM NO.</th>
<th>PART NAME</th>
<th>TORQUE</th>
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<td>Nm</td>
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<tr>
<td>1</td>
<td>15</td>
<td>Nut</td>
<td>260 - 270</td>
</tr>
<tr>
<td>1</td>
<td>17</td>
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<tr>
<td>1</td>
<td>32</td>
<td>Locknut</td>
<td>1 140 - 1 380</td>
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<tr>
<td>1</td>
<td>37</td>
<td>Bolt</td>
<td>230 - 260</td>
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<tr>
<td>1</td>
<td>42</td>
<td>Bolt</td>
<td>185 - 210</td>
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<td>-</td>
<td>-</td>
<td>Differential-to-Banjo Nuts</td>
<td>300 - 320</td>
</tr>
</tbody>
</table>

* * * *
DESCRIPTION
The planetary assemblies are located in the outer portion of the wheels to provide final torque multiplication at the wheels. This allows greater portion of engine power to be transferred to the wheel to move larger payloads. The planetary assembly consists of an axle shaft, sun gear, planet pinions, ring gear and planetary carrier.

OPERATION
Numbers in parentheses refer to Fig. 2, unless otherwise stated.

Power from the differential is transmitted through full floating axle shaft (1) to sun gear (2) which is splined to the axle shaft. As sun gear (2) rotates in a clockwise direction, the planet pinions (3) meshed with the sun gear, rotate in a counterclockwise direction on pins (11, Fig. 1). Ring gear (4) is splined to the spindle and does not rotate but causes planet pinions (3) which are meshed with the ring gear, to move around ling gear (4) in the direction of arrow (A). Driving flange (5) assembly contains the planet pinions and is bolted to the wheel. Movement of the planet pinions (3) in the direction of arrow (A) causes the driving flange and wheel to rotate in a clockwise direction. This causes the machine to move in the direction shown by arrow (B) in Fig. 2.

To determine the amount of torque multiplication provided by this type of gear set, divide the number of teeth in the ring gear by the number of teeth in the sun gear and add 1. For example, a ring gear of 30 teeth and a sun gear of 10 teeth should produce a torque multiplication of 4.

PLANETARY GEARING
Towing
Numbers in parentheses refer to Fig. 1.

If the machine is to be towed, as in the case of a breakdown, axle shaft (18) and sun gear (8) should be removed from the planetary assemblies. Removal will prevent possible damage to the power train components during towing.

The axle shafts and sun gears can be removed easily by taking off driving flange cover (17) and simply sliding the axle shaft, together with the sun gear, out of each planetary assembly by hand. Be certain the driving flange covers are installed to protect the planetary assemblies from road dust and dirt while towing is in progress.
Removal and Disassembly
Numbers in parentheses refer to Fig. 1.

WARNING
Heavy assembly. To prevent personal injury and property damage, be sure lifting device is of sufficient capacity and properly secured to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine.

2. Turn the steering wheel in both directions several times to relieve pressure in the steering system. Place the battery master switch in the 'Off' position.

3. Using suitable equipment, jack or lift the machine until the weight is no longer resting on the tyres and block machine in this position.

Note: It is not necessary to remove the tyre assembly of this machine to safely remove the driving flange.

4. Drain lubricant from planetary gear reservoir by turning wheel until drain plug (14) is in lowest point of travel and remove plug.

5. Remove bolts (15), cover (17) and gasket (16) from planetary assembly. Discard gasket (16).

6. Pull out sun gear (8) and axle shaft (18). Remove sun gear from axle shaft by removing snap ring (19) and sliding off gear. Remove thrust washer (2) from axle shaft. Ring gear (1) may be removed, if necessary, by removing snap ring (7), after removing planetary carrier (13).

7. The driving flange and planetary gear assembly (13) can now be pulled from the wheel by removing thread protectors and threading bolts into exposed holes. A hoist should be used, as shown in Fig. 4, to support the assembly during removal. Remove bolts (20) and hardened washers (21) and remove the planetary assembly.

8. Remove and discard ‘O’ ring (12) and place planetary assembly on a clean work surface with gear side up. Remove lockwire (3) and bolts (4) from pinion pin retainers (5). Remove pin retainers (5). The planet pins (11) may be removed by threading bolts into their end holes and lifting out. Recover the washers (6), planet gears (9) and bearings (10) as the pins are removed.
Inspection
Numbers in parentheses refer to Fig. 1.

Thorougly clean all the parts with suitable solvent and air dry. Inspect all parts for damage or excessive wear. In addition, check pinion bearings (10) for free fit in gears (9) and on planet pins (11). Replace any parts which are in questionable condition.

The planet pinion wear washers (6) also should be inspected to see that they are free of burrs, and absolutely flat. These washers must rest solidly against the spot-faced surfaces of the driving flange and planetary carrier.

Assembly and Installation
Numbers in parentheses refer to Fig. 1.

**WARNING**
Heavy assembly. To prevent personal injury and property damage, be sure lifting device is of sufficient capacity and properly secured to do the job safely.

**Note:** Tighten all fasteners without special torques specified, to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. Build up the driving flange assembly in the following manner. Lay driving flange (13) gear side up, on a clean surface. Thoroughly oil bearings (10) and slide bearings planet gears (9). Place a washer (6), planet gear (9) and another washer (6) in line with each pinion bore. Oil pins (11) with light oil and slide into their respective bores. Make sure they are firmly seated. Secure pins (11) in place with retainers (5) and bolts (4), then lockwire (3) bolts (4). Check the pinion gears for free rotation. If these gears bind, look for dirt or metal chips between the washer of driving flange and carrier.

2. Install ring gear (1), if removed, and secure with snap ring (7). Position thrust washer (2) in bore at end of spindle and tap in place.

3. Install new 'O' ring (12) in its groove in driving flange (13); then place the planetary assembly in position on the wheel. Mesh planet gears (9) with ring gear (1) and push the planetary assembly into place. Install bolts (20) and hardened washers (21).

4. If sun gear (8) was removed during 'Disassembly', slide sun gear over splines of axle shaft (18) and install snap ring (19). Insert axle shaft into the spindle and
Rear Axle - Axle Planetary Gearing

banjo housing, pushing the shaft part way into the differential side gear. Mesh the sun gear with ring gear and pinions.

5. Push axle shaft (18) and sun gear (8) inward as far as they will go. With a steel rule and straight edge, measure from cover (17) mounting surface on driving flange (13) to axle shaft (18). Note as dimension 'A'. See Fig. 5.

6. Next, lay the driving flange cover (17) on flat surface and again use a straight edge and steel rule to measure the height of the inside raised surface of the cover (17). Note as dimension 'B'. See Fig. 6. Subtract dimension 'B' from dimension 'A' the clearance should be within 3.58 - 5.11 mm (0.141 - 0.201 in).

Note: If the end play is too small, the axle shaft is not pushed completely into the differential side gear. If the end play is greater then the allowable maximum, either the axle shaft end or the driving flange thrust cover, or both are excessively worn. To correct this, replace the cover first. If the end play is still too great, a new axle shaft must be installed.

7. Reinstall drain plug (14) and fill the planetary reservoir with lubricant specified in Section 300-0020, LUBRICATION SYSTEM, through the driving flange opening until the correct level is reached. Spread sealing compound on surface of cover (17) which contacts driving flange (13). Position new gasket (16) and install cover on driving flange using bolts (15). Be sure to reinstall any thread protectors (14) which have been removed.

MAINTENANCE
Proper lubrication of the axle group is essential if axles are to deliver the service intended. Section 300-0020, LUBRICATION SYSTEM gives full information on the proper lubrication intervals and the lubricant which should be used.

AXLE DIAGNOSIS
Noises originating in the tyres, transmission or driveline might be attributed by mistake to the axle. Therefore, all possible sources of noise should be investigated before deciding the axle is at fault.

True axle noises may be located by lifting or jacking machine until all tyres of drive wheels are clear of the floor or ground. Securely block machine in this position. Run power train at moderate speed. Be certain all drive wheel tyres are off the ground and to prevent damage to the differential, see that neither rear brake drags.

SPECIAL TOOLS
Refer to Section 300-0070, SERVICE TOOLS, for part numbers of special tools outlined in this section and general service tools required. These tools are available from your dealer.

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>REASON</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise</td>
<td>Insufficient or incorrect lubricant</td>
<td>Check level; fill with proper type and grade lubricant</td>
</tr>
<tr>
<td></td>
<td>Wheel bearings scored or rough</td>
<td>Replace bearings</td>
</tr>
<tr>
<td></td>
<td>Gear teeth in planetary chipped</td>
<td>Replace gear</td>
</tr>
<tr>
<td>Loss of lubricant</td>
<td>Lubricant level too high</td>
<td>Drain and fill to proper level</td>
</tr>
<tr>
<td></td>
<td>Lubricant foams excessively</td>
<td>Drain and fill with correct type and grade lubricant</td>
</tr>
<tr>
<td></td>
<td>Worn or broken oil seal</td>
<td>Replace oil seal</td>
</tr>
<tr>
<td></td>
<td>Restricted breather vent</td>
<td>Clean vents</td>
</tr>
<tr>
<td></td>
<td>Loose nuts or bolts</td>
<td>Tighten nuts or bolts</td>
</tr>
<tr>
<td>Gain of lubricant</td>
<td>Restricted differential housing vent</td>
<td>Clean vent</td>
</tr>
<tr>
<td>Planetaries running hot</td>
<td>Insufficient or incorrect lubricant</td>
<td>Check level; fill with proper type and grade lubricant</td>
</tr>
<tr>
<td></td>
<td>Pinion bearings seized</td>
<td>Replace bearings</td>
</tr>
</tbody>
</table>

* * * *
DESCRIPTION AND OPERATION

The wheel and rim is of welded construction and consists of a hub assembly, inner and outer flange, 'O' ring, bead seat band and lock ring. The wheel is mounted on the axle spindle with two tapered roller bearings mounted in the hub.

The tyre and rim may be removed from the machine as an assembly and transported to a more suitable location for removing the tyre from the rim.

Procedures for removing tyre and rim assembly from machine, and dismounting tyre from rim, the use of hand, hydraulic, and special tools, are described in this section.

When dismounting a tyre and rim assembly from the machine, special equipment and careful handling are required because of the size and weight of the tyres.

One of the following pieces of hoisting equipment should be used to lift the tyre and rim: chain block and tackle, overhead crane, fork lift truck, boom truck, or tripod tyre changing tool.

PREPARATION FOR SERVICING

⚠️ WARNING
Before performing any service on the tyres or rim components, to prevent personal injury and property damage, completely deflate the tyre by removing the valve cap and core. Insert a thin wire through valve to be sure valve is not plugged. Even a flat tyre, in some cases, will retain sufficient air pressure to blow off a rim component with enough force to cause bodily injury or death.
DISMOUNTING TYRE FROM RIM

Numbers in parentheses refer to Fig. 1, unless otherwise specified.

**Note:** The following instructions apply to use of hand tools. For procedures and tooling required to dismount the tyre from the rim using hydraulic tools, contact the relevant tyre manufacturer.

---

⚠️ **WARNINGS**

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

⚠️ When lifting tyre from the rim, be sure the equipment is of sufficient capacity and properly secured to do the job safely.

---

1. Position the vehicle in a level work area, apply the parking brake and shutdown the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels, except the one to be raised, and place the battery master switch in the 'Off' position.

3. For tyre to be removed, set up jack to support machine weight, but do not raise machine.

4. Completely deflate tyre by removing valve cap and valve core and leave valve open to prevent trapping of air in tyre. Check valve stem by running a piece of wire through the stem to make sure it is not plugged. See warning under 'Preparation For Servicing'. Tape valve threads for protection.

5. Break outer tyre bead loose with pry bar shown in Fig. 2.

6. Insert flat hooked end of pry bar into breaking slots between bead seat band (17) and outer flange (15). See Fig. 3. A pipe over the straight end of the pry bar will increase leverage.

7. Twist pry bar toward tyre to break bead.

8. A second pry bar may be inserted in the space between bead seat band (17) and outer flange (15). Twist the second pry bar to maintain the space gained by the first pry bar.

9. Move the first pry bar around wheel rim, twisting and following with the second pry bar, until the outer tyre bead is loose.

10. Pry bead seat band (17) away from lock ring (18) by placing hooked end of pry bar in the groove of wheel (6), between ends of lock ring (18), and prying up with the pry bar. Using two pry bars, as in Step 8, work completely around wheel (6).

11. Pry lock ring (18) out in the same manner by starting at prying notch in wheel (6) assembly, and work all the way around wheel (6) with two pry bars.

12. Remove and discard 'O' ring (16).

13. Remove lock ring (18) then pry out and remove bead seat band (17). Outer flange (15) may now be removed.

14. Breaking slots are provided inside the rims. The inner bead may be broken as described in Steps 4 through 8. If the tyre and rim assembly is on the vehicle, the following procedure may be used for breaking the inner bead.

15. Place jack between inner flange (15) and vehicle
frame. Extend jack until tyre bead is broken. Continue around the rim until tyre bead is broken at all points.

16. Using suitable lifting equipment, remove tyre from rim. This completes the removal of the tubeless tyre.

17. If necessary, remove inner flange (15).

Note: If tyre rim is on the vehicle, and no tyre lifting equipment is available, ‘walk’ the tyre off the rim as follows:

Force bottom of tyre outward as far as possible; lower jack enough to allow weight of tyre to rest on ground; force top of tyre out as far as possible; raise jack to original height and repeat the above until the tyre is off the rim.

INSPECTION

Tyre
Check the interior surface of the tyre to determine its condition. Inspect for cuts or fabric breaks that have penetrated the tyre body. The casing should be inspected closely for any sharp, pointed object that may have penetrated the tyre body but is invisible from the outside. All dust, dirt, water or other foreign matter should be cleaned from the inside of tyre.

Wheel Assembly
Overloading, improper tyre inflation, rough terrain, high speed, accidents, dirt accumulation, and corrosion all tend to reduce the service life of rims and rim components. It is recommended that rims be inspected, as below, not less often than at every tyre change and that, as the warranty limit approaches, consideration be given to periodic replacement.

The wheel and its components are designed with built-in safety factors, to prevent the components from flying off with killing force during inflation. Check components for cracks, bends, distortion, or other damage. If damage is found, the component must be replaced.

WARNING
Never mix components of one manufacturer’s rims with those of another. Using the rim base of one manufacturer with the lock ring of another or vice versa is dangerous. The lock ring of one may not fully engage with the lock ring groove of the other. Always consult the rim manufacturer for proper matching and assembly instructions. Also, use and servicing of damaged, worn out, or improperly assembled rim assemblies is a very dangerous practice. Failure to comply with the above warnings could result in explosions from tyre pressure causing serious personal injury and property damage.

Clean all rust and dirt from the wheel parts and wheel and apply a coat of good grade primer paint. Allow the paint to dry thoroughly before remounting tyre.

The rim parts used with tubeless tyres form an important part of the air chamber. Therefore, they should be carefully checked for distortion or mutilation that would prevent an effective air seal when the tyre and rim are reassembled.

Rubber ‘O’ rings are air seals for tubeless tyre and rim assemblies and therefore should be carefully handled to provide an airtight seal when the tyre is remounted on the rim. Always use new ‘O’ rings when mounting a tubeless tyre.

Note: Handle ‘O’ rings carefully, as damage will prevent an airtight seal for tyre inflation.

MOUNTING TYRE ON RIM

Numbers in parentheses refer to Fig. 1, unless otherwise specified.

For mounting a tyre with rim on or off machine, the procedure is basically the same.

WARNING
When lifting tyre onto the rim, be sure the equipment is of sufficient capacity and properly secured to do the job safely.

1. For off-machine installation, lay wheel (6) on blocks or mounting stand with ‘O’ ring groove up. Wheel (6) should be off the floor enough to allow tyre to rest on rim and not the floor. Blocks are not to extend more than 13 mm (0.50 in) beyond rim base.
2. If removed, install inner flange (15) over wheel (6).

3. Lubricate tyre beads and new 'O' ring (16), with a thin solution of vegetable base soap and water.


5. Install outer flange (15) on wheel (6).

6. Align lock ring driver notch in bead seat band (17) with notch in wheel (6) rim, and install bead seat band on rim.

7. Install lock ring (18) in groove of wheel (6) rim so that lock ring lug engages both notches. Notches and lock ring lug must line up correctly. If necessary, use only a soft hammer to rotate the lug. Use pry bar for installing lock ring (18), as shown in Fig. 4.

8. Force bead seat band (17) past 'O' ring groove in wheel (6) rim by prying, or with lift truck forks. Use blocking between the forks and tyre to prevent damage. Insert a new 'O' ring (16) in groove of the rim behind lock ring (18). Lubricate area of front taper of bead seat band (17) adjacent to 'O' ring (16), with a thin solution of soap and water or another approved lubricant which is not harmful to rubber. Avoid using an excessive amount of lubricant.

9. Lift the tyre upwards to effect a seal between bead seat band (17) and 'O' ring (16). In some cases the tyre will automatically spring out, making this step unnecessary. When mounting tyre on wheels installed on machine, use a length of cable around tyre and a 'come-a-long' to seal tyre to the bead seat band (17).

10. Install the valve core (13) in the valve assembly (12). Refer to heading, 'Tyre Inflation' in this section for the proper procedure for inflating the tyre.

**WHEEL**

**Removal and Disassembly**

Numbers in parentheses refer to Fig. 1.

---

**WARNING**

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of sufficient capacity to do the job safely.

---

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Place battery master switch in the 'Off' position and block all road wheels, except the one to be raised.

3. Release parking brake.

4. Deflate tyre completely, and remove the tyre and rim assembly from the wheel. Follow instructions under 'Dismounting Tyre from Rim'.

5. Drain differential and planetary gear lubricant and remove planetary gear assembly from the wheel. Refer to Section 160-0040, PLANETARY GEARING.

6. Remove locking capscrews (11) from spindle nut (10). Attach fishtail assembly (See Special Tools) to wheel assembly (6) with a bolt removed from the planetary assembly.

7. Install a tool, which can be fabricated as shown in Fig. 5, across wheel assembly and secure to wheel (6).
with a bolt removed from the planetary assembly.

8. Apply a suitable wrench to the fabricated tool and rotate wheel assembly (6) to back off spindle nut (10).

9. With suitable lifting equipment, pull wheel assembly (6) off of spindle, taking care to prevent damage to spindle threads. Remove outer bearing cone (9) from wheel assembly (6) to prevent it from dropping as the wheel is drawn from the spindle.

**Note:** Brake drum is bolted to the inner face of wheel assembly (6). When wheel assembly (6) is removed, the brake drum will also be removed.

10. If brake drum is to be separated from wheel (6), remove mounting hardware and drum to separate these parts.

11. Remove snap ring (1) from wheel (6). Remove seal (2), washer (3) and bearing cone (4) from wheel (6).

12. If required, drive out inner and outer bearing cups (5) from wheel (6), using a soft drift and drive.

**Note:** Bearing cups and cones must always be replaced as a matched set, never separately.

**Inspection**

1. Thoroughly clean all metal components, except bearing cones, in a suitable solvent. Dry with compressed air and coat all threaded components with light oil to facilitate assembly.

2. Clean bearings in volatile mineral spirits and wipe dry with a lint free cloth. Lubricate lightly with light oil and spin by hand, to check for wear and roughness. Replace with new bearings if excessively worn, or if operation is rough or noisy.

3. Inspect all machined surfaces of all parts for scoring, pitting, corrosion and burring. Resurface or replace with new parts as necessary.

4. Inspect all threaded components, and repair or replace as necessary.

5. Discard seal (2) and replace with a new one.

6. Oil seal (2) rides on a special bushing which is shrunk on the axle spindle to provide a smooth contact surface for the seal. If after removal of the wheel the bushing is found to be rough or worn, remove it by splitting with a chisel and install a new bushing. Heat the new bushing to 177° C (350° F) in oil to expand it for installation. If oil heating equipment is not available, heat the bushing evenly to 177° C (350° F). Use a Templistik or other temperature gauge to make sure the bushing is hot enough. Slide heated bushing on spindle and tap lightly with a hammer to seat it.

**Assembly and Installation**

Numbers in parentheses refer to Fig. 1.

**Note:** Tighten all fasteners without special torques specified, to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

**WARNINGS**

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of sufficient capacity to do the job safely.

Be sure to use a soft drift and take care when driving in bearing cups with a drift, to avoid personal injury from chips or fragments.

1. If removed, install bearing cups (5) in their respective wheel bearing bores with care to avoid damaging their raceways. Installation by press fit at ambient temperature is best. Note that the cups must seat fully against the shoulders of the cup bores in the wheel hub to assure retention of bearing adjustment. If
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carbon dioxide, or dry ice, freezing of the cup is used, remember to permit the cup and hub to warm to ambient temperature after insertion and then to tap them with a soft steel drift and hammer to seat.

2. Lubricate inner bearing cone (4) with lubricant specified in Section 300-0020, LUBRICATION SYSTEM and install in wheel (6). Place washer (3) on bearing, drive or press new seal (2) into position, and install snap ring (1). Install seal with lip towards bearing. Apply a light coat of gear oil to seal lips and special seal bushing on spindle.

Note: If new ‘Buna’ seal is used, be sure it is installed in the wheel bore with the dirt seal (square lip) toward the machine frame. Pack seal valley with EP grease. Install snap ring (1).

3. If removed, install brake drum on wheel (6) and secure with mounting hardware as removed at ‘Removal’. Make sure brake drum and wheel (6) are clean where they contact each other, so that the drum will run true.

4. Wrap spindle threads carefully with masking tape to protect the seal and threads. With suitable lifting equipment slide wheel (6) and drum assembly onto the spindle carefully to avoid damaging spindle threads. Remove protective tape from spindle threads.

5. Lubricate outer bearing cone (9) with lubricant specified in Section 300-0020, LUBRICATION SYSTEM. Install outer bearing cone (9) on spindle and seat in outer bearing cup (5).

6. Apply a smear of oil or grease to the threads of spindle and install spindle nut (10) on spindle. Make sure nut turns freely for full thread length. If nut binds, either replace with new nut or chase the threads so nut will turn freely.

7. Attach fishtail assembly (See Special Tools) to wheel (6) assembly and fabricated tool assembly across wheel (6) assembly, as described during disassembly.

8. Rotate wheel (6) assembly and tighten spindle nut (10) to a seating torque of 1 360 Nm (1 000 lbf ft), or until wheel starts to bind, while rotating and bumping wheel (6) assembly to ensure adequate seating of the wheel bearings.

9. Back off spindle nut (10) until the wheel turns freely (approximately 1/2 turn).

10. Start the wheel rotating and torque tighten spindle nut (10) to 740 Nm (550 lbf ft).

Note: Always rotate wheel when tightening spindle nut (4), see Section 160-0050, WHEEL, RIM AND TYRE, ‘Bearing Adjustment’, for explanation.

11. Secure spindle nut (10) with screws (11).

12. Install planetary gear assembly and fill planetary and differential assemblies with lubricant specified in Section 300-0020, LUBRICATION SYSTEM. Refer to Section 160-0040, PLANETARY GEARING.

13. Install tyre on wheel as described under ‘Mounting Tyre on Wheel’.

TYRE INFLATION

WARNING
To prevent personal injury and property damage, the tyre and rim assembly should be placed in a safety cage before inflating. If no safety cage is available or tyre is on the machine, the tyre and rim assembly should be wrapped with safety chains or with lash cables before inflating.

Even with these precautions remember that air-blast is a potential hazard. Tyre inflation should be carried out away from busy working areas.

WARNING
To avoid personal injury and property damage, never stand or sit in front of a mounted tyre during tyre inflation. Use a clip-on air chuck with a long hose and stand to one side while the tyre is being inflated.

WARNING
To prevent personal injury and property damage, always prevent flammable vapours that could produce tyre explosions, from being pumped into tyres during inflation, by observing the following precautions:

A. Use an air compressor and reservoir located inside a heated building, when available, so that alcohol, methanol, or other flammable antifreeze liquids are not needed in the air tanks to prevent moisture freezing in the tank and lines in subfreezing outside temperatures.
B. Make sure that paints, lacquers, paint thinners, or similar materials that produce volatile, flammable vapours are not used or stored near the air intake of the compressor that supplies the air for inflating tyres. The compressor should be isolated from all such sources of flammable vapours.

C. Be sure to thoroughly flush and blow off all flammable solvents used for cleaning the air compressor inlet screen before using the compressor for tyre inflation, or any other purpose.

D. Do not charge batteries, either in or out of a machine, near the air inlet of a compressor used for inflating tyres. Charging batteries produces highly explosive hydrogen gas which can be readily drawn into a nearby compressor inlet and pumped into the tyre.

E. Never exceed the specified concentration of alcohol when adjusting the alcohol vaporizer, or adding alcohol to the auxiliary air tank, used on machine air systems to prevent freezing or moisture condensate in below-freezing temperatures. Excessive alcohol, added to the machines air tanks in this manner can produce flammable vapours that will be pumped into a tyre when this air supply is used for tyre inflation if the tyre inflation kit is not equipped with a moisture filter. Alcohol added to machine air systems in recommended concentration to prevent condensate freezing are below hazardous levels for tyre inflation.

F. Another source of hazardous flammable vapours in tyres is the tyre bead lubricant. Always use bead lubricants that do not introduce flammable vapours into the tyre.

Inflation

Note: Always use tyre inflation equipment with an air filter that removes moisture from the air supply, when available, to prevent moisture corrosion of internal rim parts.

1. Inflate tyre to 1 bar (15 lbf/in²) initially to seat components and tap lock ring lightly to ensure correct seating. Visually check that all components are in place, then continue inflation observing all safety precautions. (See Step 2).

2. If the tyre is off the machine, place it in a safety cage after initially inflating to 1 bar (15 lbf/in²) to seat components. See Fig. 6.

3. Inflate tyres to 5.2 bar (75 lbf/in²) to seat beads and seal the 'O' ring, then adjust to the recommended inflation pressure.

4. For recommended operating air pressure, refer to chart under the heading, 'Tyre Inflation Pressures'.

NITROGEN TYRE INFLATION

Note: All Warnings and procedures under 'Tyre Inflation' will apply, except for differences covered by this passage.

In certain environments it is recommended that tyres be inflated with dry nitrogen gas, and that the resulting oxygen content of the inflation does not exceed 5%. All machines whose tyres are factory inflated with dry nitrogen gas will be identified by a decal on the body or frame.

Nitrogen gas improves tyre pressure retention, increases tyre life by reducing carcass oxidation from within, minimizes rim rust and has no detrimental effects on the tyre. It also reduces the potential of a
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tyre explosion because it is an inert gas and will not support combustion inside the tyre.

The same tyre inflation pressure used for air inflation should be used for nitrogen inflation. Tyre valves formerly used with air inflation are entirely satisfactory for use with nitrogen gas.

Nitrogen Tyre Inflation Kit

![Fig. 7 - Nitrogen Tyre Inflation Kit](image)

<table>
<thead>
<tr>
<th>WARNINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO NOT USE charging assembly, Part No. 9359489, for tyre inflation because this assembly does not include a pressure regulator, safety relief valve, and adequate pressure gauging which is mandatory for tyre inflation purposes. Tyre volume is as much as 90 times greater than the average accumulator volume and hence it takes very much longer to inflate a tyre - up to 40 minutes or more for very large tyres.</td>
</tr>
<tr>
<td>Nitrogen gas cylinders used to inflate tyres are generally charged to approximately 152 bar (2 200 lbf/in²). A tyre blowout and/or rim failure could occur if inflation equipment is not properly used. Proper nitrogen charging equipment and personnel training for its use is a must to avoid over inflation.</td>
</tr>
</tbody>
</table>

1. A nitrogen tyre inflation kit is available from your dealer and consists of the following. Refer to Fig. 7.

   a. Pressure regulator, 0 - 13 bar (0 - 200 lbf/in²), with two dual pressure gauges.
   
   b. Safety relief valve, 8.6 bar (125 lbf/in²), that will assure an upper limit to the pressure available for tyre inflation.

   c. A 15.2 m (50 ft) length of flexible hose with interconnecting fittings. On the tyre end of the hose is a large bore quick connect/disconnect clip-on chuck.

2. The pressure regulator is connected to a nitrogen compressed gas cylinder available from local suppliers.

3. The usual procedure for using this type of equipment is as follows:

   a. Connect nitrogen tyre inflation kit to nitrogen compressed gas supply. DO NOT connect clip-on chuck to the tyre valve at this time.

b. Open valve on nitrogen supply.

   c. With flexible hose and clip-on chuck connected to nitrogen tyre inflation kit assembly but not connected to the tyre, adjust pressure regulator so that its output pressure is not more than 1.4 bar (20 lbf/in²) higher than the desired tyre inflation pressure.

   d. Connect clip-on chuck to the tyre valve. The tyre will now inflate. Tyre pressure can be monitored by observing the gauge at the pressure regulator. STAY AWAY FROM THE TYRE.

   e. When desired inflation pressure has been achieved, back off the regulator or close the valve on the compressed gas cylinder.

   f. Remove the clip-on chuck and adjust the tyre pressure with the tyre gauge in the usual manner.

Re-inflation of a Mounted Tyre

To re-inflate a tyre with dry nitrogen gas which is now inflated with air, proceed as follows:

1. Exhaust the tyre until only air at atmospheric pressure remains in the tyre.
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2. Re-inflate the tyre using only dry nitrogen gas to 4.15 bar (60 lbf/in²) gauge as a minimum, or to bead-seating pressure as a maximum.

3. Adjust to the service inflation pressure required:
   a. If the required service inflation pressure is LESS than 4.1 bar (60 lbf/in²), remove the clip-on chuck and adjust the pressure with the tyre gauge in the usual manner.
   b. If the required service inflation pressure is greater than 4.1 bar (60 lbf/in²), further inflate, with dry nitrogen gas only, to the pressure level required. Then remove the clip-on chuck and adjust the pressure with the tyre gauge in the usual manner.

New Tyre Mounts and Remounts
To newly mount or remount a tyre to its rim, use only dry nitrogen gas; this includes the pressure required to seat the beads. After seating the tyre beads, remove the clip-on chuck and adjust the pressure with the tyre gauge in the usual manner.

Note: Although a little more nitrogen gas is used to seat beads than that used for re-inflation of a mounted tyre, refer to 'Re-inflation of a Mounted Tyre', its cost is generally negligible in comparison to the time and labour saving and, longer tyre life achievable with the reduced oxygen content which results.

HYDRAULIC BEAD BREAKING TOOL
The hydraulic bead breaking tool illustrated in Fig. 8 is specifically designed to break tyre beads on rusted rims, and is available from your dealer. Refer to Special Tools. It can be used on rims having pry bar slots. The recommended procedure for using this tool is described below.

1. Prepare the vehicle for dismounting the tyre by following the necessary steps outlined under the headings 'Preparation for Servicing' and 'Dismounting Tyre from Rim'.

2. Before using the tool, make sure the tyre has been completely deflated by removing the valve core. Refer to the Warning under 'Preparation for Servicing'. Tape valve threads to protect from damage, leaving valve end open to avoid the possibility of trapping air inside the tyre.

3. Place the lip of the hydraulic tool in one of four breaking slots between the bead seat band and the rim flange.

4. Adjust the locking screw to a position which will hold the tool in a line perpendicular to the face of the rim.

5. Close valve on the hydraulic pump and apply pressure to take up the slack in the tool and rim parts. This will cause the tool to tilt slightly downward. Release pressure and adjust the screw again so that the tool will be perpendicular to the rim when under pressure.

6. Apply enough pressure to move the flange back approximately 13 mm (0.5 in) and hold this distance by dropping a nut, or similar object, in the space between the flange and bead seat band.

7. Release pressure and move the tool about 300 mm (12 in) around the rim in either direction. Insert lip of tool between bead seat band and flange. Repeat cycle until 3/4 of the rim circumference has been covered. Apply pressure at this point until bead breaks loose.

8. Remove lock ring, bead seat band and rim flange as described previously in this section under 'Dismounting Tyre from Rim'.

9. After lock ring, bead seat band and rim flange have been removed, inner bead must be broken loose by following the procedure outlined for the outer bead, (steps 3 through 7).
TYRE EXPLOSION HAZARD

⚠️ WARNING
Whenever a machine’s tyre(s) is (are) exposed to excessive heat such as a machine fire or extremely hot brakes the hazard of a subsequent violent tyre explosion must be recognized. All persons must avoid approaching the machine so as not to be physically endangered in the event of an explosion of the tyre and rim parts.

⚠️ The machine should be moved to a remote area, but only when this can be done with complete safety to the operator operating or towing the machine. All other persons should stay clear of the machine. The fire or overheated brakes, wheel, etc. should be extinguished or cooled from a safe distance. Do not attempt to extinguish the fire or cool the machine by use of hand-held fire extinguishers.

⚠️ If it is absolutely necessary to approach a machine with a suspect tyre, approach only from the front or the back. Stay at least 15 m (50 ft) from the tread area. Keep observers out of the area and at least 460 m (1 500 ft) from the tyre sidewall. Refer to Fig. 8. The tyre(s) should be allowed at least eight (8) hours cooling time after the machine is shut down or the fire extinguished before approaching closer.

⚠️ There is always a possibility of a tyre explosion whenever the smell of burning rubber or excessively hot brakes is detected. The danger is also present when a fire on the machine reaches the tyre and wheel area. Under such conditions, all personnel must avoid approaching the machine in a manner that could result in injury should an explosion actually occur. Move the machine to a remote area only if it can be done without endangering the operator or other personnel in the area.

⚠️ WARNING (cont.)
DO NOT WELD ON OR HEAT RIM COMPONENTS. For several years the company and tyre and rim manufacturers have warned users never to weld rim components with the tyre mounted on the rim. The gases that build up inside the tyre during arc welding or heating on rim components can ignite, resulting in one of these explosive-like failures of the tyre and rim. This warning also applies to nitrogen inflated tyres. Ignition will not occur in the nitrogen atmosphere, but the pressure buildup from the heat of welding may be sufficient to cause a blowout severe enough to injure or kill. It is recommended to scrap the part if heat is necessary to repair any rim component.

TYRE AND WHEEL MAINTENANCE

Tyre Repairs
Prompt repair of tyre injuries will prevent small injuries from enlarging and causing tyre failure. Use the best tyre facilities available. If good repair facilities are not available, have the nearest dealer make the necessary repairs.

Minor cuts, snags, or punctures should be repaired upon discovery. Skive with a sharp pointed knife around any cut in the tyre tread area that is of sufficient depth or shape to hold pebbles or dirt. The
angle of the skive should be no more than sufficient to expel all foreign material and should extend no deeper than the breaker. The skive should go to the bottom of the hole. Tyres with shallow cuts, if treated promptly, may be allowed to continue in service. If the cut extends deeper into the tyre carcass, the tyre should be removed for repair.

The tyre must be removed from the rim to repair larger punctures or cuts. Irregular shaped punctures or cuts less than 13 mm (0.50 in) in size can be repaired with a plug and hot patch. Insert a repair plug into the hole to keep out moisture and to back up the hot patch. Trim the plug off flush with the inside of the casing, buff, and apply the hot patch according to the instructions supplied with the hot patch equipment.

Punctures 13 mm (0.50 in) or larger, large cuts, or bruise breaks require sectional or reinforced vulcanized repair. Cover the repair patch with a layer of cushion gum after application to the tubeless tyre to ensure an airtight repair. Any cords of the inside ply that are exposed in buffing and are not covered with repair patch must be coated with cushion gum to prevent air leakage into the carcass plies on tubeless tyres.

Recapping and Retreading
There are two general methods employed in restoring the tread surface of off-the-highway tyres: recapping and retreading.

A recapped tyre has a new tread cured right over the old tread surface.

A retreaded tyre has the old tread removed entirely and a new tread cured directly onto the body of the tyre. A tyre can be recapped or retreaded if the cord body is free of cuts, bruises and separation, and is thoroughly sound, including previous repairs.

TYRE CARE
To obtain maximum service from off-highway tyres, the following common-sense precautions should be followed.

Maintain Correct Inflation
The most common cause of tyre damage is improper inflation. Both over-inflation and under-inflation are detrimental to tyre life. Tyre pressure should be checked daily, preferably before the machine is placed in operation. Refer to ‘Tyre Inflation Pressures’ table.

The valve cores should be checked for leaks. Keep in mind that valve cores are delicate mechanisms that wear out in service; therefore, they should be replaced with new ones when they become worn. Each tyre should be equipped with a valve cap to prevent dirt from damaging the valve core and causing air leakage.

Maintain Good Haul Roads
Because haul roads are considered temporary roads they are frequently neglected. The better the haul road, the longer the tyre and machine life of off-highway machines.

Although it takes time and effort to maintain good haul roads, the delay and cost of tyres and machine breakdowns caused by poor haul roads is many times greater.

Inspect Tyres Regularly
A systematic plan for tyre inspection will more than pay for itself in lowered tyre costs per hour of operation. All tyres should be checked regularly for cuts, bruises, ply material breaks, excessive or uneven wear, embedded foreign matter, and any other damage which can be repaired. A considerable increase in tyre service can be realized if tyre injuries are repaired before they have progressed to the irreparable stage.

The rim mounting nuts should also be checked periodically and tightened to the torque specified.

Prevent Overloading
Off-highway machines are designed to carry a maximum allowable payload. Excessive loading will overstress both the machine and tyres and shorten the life of both.

Prevent Contact with Oil
Prevent tyre contact with petroleum products. Rubber that is exposed to oil, gasoline, or grease becomes soft and spongy and deteriorates rapidly. Always avoid driving machine through a puddle of gasoline, fuel oil, lubricating oil, or grease. Never let a tyre stand in an oil or grease spot overnight.

Store Tyres Properly
The best of care given to tyres in service by operators and maintenance personnel can be completely nullified by careless storage. Time is not the only
contributing factor to the deterioration of rubber products. Therefore, tyres that are to be stored must be protected from light, heat, oils, dirt, moisture, and ozone. Stored tyres should be carefully covered with a tarpaulin or some other suitable material, such as opaque plastic sheeting, to prevent contact with the contaminants listed above.

Proper Handling of Tyres and Wheel Rim Parts
Tyres should be stored vertically. Horizontal stacking may compress the tyre walls, making inflation difficult. If tyres are stored in racks, the lower supporting members should provide as broad a surface as possible to the tyre tread to avoid a concentration of load.

The beads of tubeless tyres must be protected from damage or a faulty air seal will result. Do not use hooks, cables, or chains in contact with the tyre beads when lifting these tyres. If forklift trucks are used for handling, they should be equipped with broad, well-rounded arms to distribute the load and prevent damage to the tyre bead. When handling tyres with the fork truck do not scrape the fork across the bead.

Tubeless tyre rims perform an important function as part of the assembly air seal. Proper care, therefore, must be taken not to distort or mutilate the rim parts because they must mate properly to form part of the basic air chamber. Since the rim base and bead seat band are mating surfaces, distortion may prevent easy assembly as well as possibly resulting in no seal.

Never drop, tumble, or roll rim parts.

If rim parts are stored outdoors, they should be given a protective coat of a good commercial primer.

Similar parts should be stacked neatly to prevent distortion.

Babbit or lead hammers, not sledge hammers, should be used in assembling rim parts.

'O' rings are seals and should be carefully stored in a cool, dry place where they will not be injured or damaged.

Valve cores should also be stored in a cool, dry and clean place.

TYRE INFLATION PRESSURES
The inflation pressures listed should be regarded as nominal only. Specific job conditions, terrain, haul road maintenance and length, maximum and workday average speed, job t-km/h (ton-mile/h) required and tyre t-km/h (ton-mile/h) capacity, etc., may require an increase in inflation pressure. It is recommended that for tyres both listed and unlisted the user consult the tyre manufacturer and evaluate all job conditions in order to make the proper selection.

SERVICE TOOLS
Refer to Section 300-0070, SERVICE TOOLS, for part numbers of special tools outlined in this section and general service tools required. These tools are available from your dealer.

TYRE INFLATION PRESSURES (BRIDGESTONE)

<table>
<thead>
<tr>
<th>TYRE SIZE</th>
<th>FRONT</th>
<th></th>
<th>REAR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>bar</td>
<td>lbf/in²</td>
<td>bar</td>
</tr>
<tr>
<td>Bridgestone 29.5 R 25**</td>
<td>4.8</td>
<td>70</td>
<td>4.35</td>
</tr>
<tr>
<td>Michelin 29.5R25**</td>
<td>4.2</td>
<td>61</td>
<td>3.8</td>
</tr>
</tbody>
</table>
**TUBELESS TYRE LEAK DIAGNOSIS**

Occasionally a tubeless off highway tyre/rim assembly may leak in field service. To determine cause of leakage, the entire assembly including valve hardware, multi-piece rim assembly, 'O' ring and tyre should be checked using a soap solution.

This table lists various causes of air loss and possible remedy.

<table>
<thead>
<tr>
<th>CAUSE</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defective valve</td>
<td>Tighten parts. Replace defective parts. Use valve caps.</td>
</tr>
<tr>
<td>Cracked rim or weld</td>
<td>Replace defective part</td>
</tr>
<tr>
<td>Twisted or damaged 'O' ring</td>
<td>Replace 'O' ring (lubricate)</td>
</tr>
<tr>
<td>Tyre cuts and snags</td>
<td>Repair tyre damage</td>
</tr>
<tr>
<td>Bead area awl holes</td>
<td>Repair inner liner (preferred)</td>
</tr>
</tbody>
</table>
| Leakage between tyre bead trim | With tyre removed from rim:  
                                        | Clean tyre beads in rim contact area  
                                        | Clean rim with wire brush  
                                        | Inspect 5 degree tapered bead seat band and the rim base in the bead seating area to determine if the transverse weld trims are flat or concave.  
                                        | Replace defective part(s).  
                                        | **Note:** Weld trim should follow rim contour.  
                                        | Mount tyre using a lubricant such as Murphy's Tyre and tube Mounting Compound, or equivalent, on tyre beads and rim bead seat area. |

* * * *
DESCRIPTION

The NoSPIN® element is an automatic locking device which provides positive drive to both wheels. It eliminates individual wheel spinning that is common in conventional gear type differentials, while it allows each drive wheel to revolve at a different speed when the machine negotiates a turn, or is manoeuvred over different road conditions.

This section covers the silent-type NoSPIN® differential, which differs from the standard-type only in the fact that either of the driven clutch and ‘holdout’ ring assemblies may overrun continuously when required and then automatically return to full locked engagement. The continuous over-running feature is made possible by using ‘holdout’ rings as part of the driven clutch assembly. During overrun operation of the standard type NoSPIN® element, the driven clutch will slide away from the spider and then back into engagement after each tooth, causing a slight indexing noise. As shown in Fig. 1 & 2, the NoSPIN® element may use an external spring or an internal spring, however, operation is the same.

OPERATION

Numbers in parentheses refer to Figs. 1 & 2.

Straight Forward

When the machine is driven in a straight forward direction, the clutch teeth of both driven clutch and ‘holdout’ ring (2) assemblies are fully engaged with the clutch teeth and cams of the spider and cam assembly (1). Full engagement is assured by the pressure of springs (3). When the spider is rotated forward by the action of the ring gear, the clutch teeth of the spider, now meshed with the clutch teeth of the driven clutches, are held in a positive locked position by the mating undercuts on the driving faces of all clutch teeth. The assembly then rotates as a unit, and each output shaft must turn at ring gear speed. Refer to Fig. 3.

When the machine is driven in a straight rearward direction, engagement of the clutch teeth is the same, except the spider rotates in the reverse direction and shifts and driving force to the opposite side of all driving clutch teeth.

Right Hand Turn

When making a right-hand turn in a forward direction under power, the driven clutch of the right-hand clutch and ‘holdout’ ring assembly (2) remains fully engaged with the spider clutch teeth and cams of the centre cam. When the left-hand driven clutch and ‘holdout’ ring assembly (2) is required to rotate faster to make the right turn through the over-running action of the left wheel, it is free to ride up and over the cams of the centre cam. Refer to Fig. 4. As the ‘holdout’ ring begins to rotate forward, the end of the ‘holdout’ ring slot engages the spider key, refer to Figs. 5 & 6. On those NoSPIN® units using a ‘holdout’ ring with cams (see Fig. 5), this action sets...
the cams of the ‘holdout’ ring between the cams of the driven clutch, thus preventing the driven clutch from returning to engagement so long as it rotates faster than the spider and centre cam assembly. On those units using a “holdout” ring with lugs, movement of the ‘holdout’ ring moves the lugs ahead of the slots in the centre cam, which prevents the driven clutch from returning to engagement as long as it rotates faster than the spider and centre cam is being driven. Refer to Figs. 6, 7 & 8.

When the over-running movement ceases and the relative speed of the spider and over-running driven clutch become the same there is a slight reversal of rotation so that the left ‘holdout’ ring rotates back away from the spider key. When this happens, the cams or lugs of the ‘holdout’ ring, whichever type is used, become realigned with the centre cam, permitting the left driven clutch and ‘holdout’ ring to return to full engagement with the spider and centre cam.

**Left-Hand Turn**

When making a left-hand turn, in a forward direction under power, the left-hand driven clutch, of driven clutch and ‘holdout’ ring (2), remains fully engaged with the spider clutch teeth and the right-hand wheel then turns faster than ring gear speed. The cam action is the same as for right-hand turn except, the cam action is on the opposite side of the NoSPIN® element.
Rough, Uneven or Choppy Road Conditions
When the machine is travelling at moderate speed over a rough road, it will be found that constant differentiation will be required of the NoSPIN® differential. In other words, the NoSPIN® differential will go through its complete unlocking and locking cycle in rapid succession as required by such road conditions.

Should one driving wheel, however, encounter soft and slippery road conditions, both driving wheels will remain locked and revolve at ring gear speed, thus preventing wheel spin and undue scuffing of the tyre.
Rear Axle - No SPIN® Element

Section 160-0080

REMOVAL

**WARNINGS**

To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

A come-a-long or chain fall with a minimum capacity of one ton is required for removal and installation of a differential assembly.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Turn the steering wheel in both directions several times to relieve pressure in the steering system.

2. Block all road wheels and place the battery master switch in the 'Off' position.

3. Remove the differential carrier from the drive axle. If an axle shaft has failed, be sure all fragments of the shaft are removed to avoid serious damage of the pinion and ring gear, or NoSPIN® element. Refer to Section 160-0020, DIFFERENTIAL, for removal of differential carrier.

4. Do not remove the ring gear from differential carrier case unless the ring gear or case are to be replaced or it is necessary for separation of the inner and outer flanged case halves.

5. Mark the plain case and flanged case with a centre punch so they can be reassembled in the original position when repairs or inspection is completed.
6. A retaining bolt and washers should be used to keep the NoSPIN® assembly intact when removing it from differential case. Refer to Fig. 9. Insert bolt with washer and install other washer and nut or wing nut. Turn nut or wing nut tight. Note that washers should be small enough to pass through the case ends (Dim. A), yet large enough to restrain the side gears (Dim. B.)

7. Remove the NoSPIN® element, from the differential as described in Section 160-0020, DIFFERENTIAL.

**DISASSEMBLY**

Numbers in parentheses refer to Figs. 1 & 2, unless otherwise stated.

⚠ **WARNING**

To prevent personal injury and property damage, be careful when disassembling the NoSPIN® element, because spring (3) tension can cause parts to fly apart.

1. Release the retaining wing nut, bolt and washer assembly, holding the NoSPIN® assembly firmly to absorb the sudden release of spring (3) pressure.

2. Separate side gears (5), springs (3), spring retainers (4), driven clutches and ‘holdout’ rings (2) and spider and cam assembly (1).

3. Using a suitable pair of snap ring expanders, expand the ‘holdout’ rings slightly and remove from driven clutches (2).
Rear Axle - No SPIN® Element

Section 160-0080

INSPECTION

Numbers in parentheses refer to Figs. 1 & 2, unless otherwise stated.

1. Inspect the splines on the side gears (5) and clutches, of the driven clutches and ‘holdout’ rings (2). Remove any burrs or small chipped edges with an abrasive stone or electric burr grinder. If the spline is broken or twisted, replace the part. Check side gear (5) hubs for fractures.

2. Be sure the ‘holdout’ ring rotates on the clutch with only a little resistance. Check ring for fractures and chipping, or excessive wear of teeth.

3. Check the centre cam for free movement. It must be free to rotate within the limits of the key in the spider. If either the spider or cam is excessively worn or damaged, replace the complete spider and cam assembly (1).

4. Teeth on the centre cams or driven clutches must not be excessively chipped. A smooth wear pattern up to 50% of the tooth face width is acceptable.

5. Inspect the clutch teeth on the spider. Slight chips can be touched up with an abrasive stone. If excessively chipped or rounded, the part should be replaced.

Note: If a part is replaced due to the chipped teeth, always replace the mating part as it may have invisible fractures.

6. Check the spring (3) operating height at the applicable load. Replace spring if it does not meet specifications. Refer to following table for spring, load requirements.

<table>
<thead>
<tr>
<th>OPERATING HEIGHT</th>
<th>LOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>in.</td>
</tr>
<tr>
<td>26.4</td>
<td>1.04</td>
</tr>
</tbody>
</table>

ASSEMBLY

Numbers in parentheses refer to Figs. 1 & 2, unless otherwise stated.

WARNING
To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

WARNING
Incorrect assembly of the spring retainer can limit the spring movement and prevent proper NoSPIN® operation.

1. Using the same retaining bolt and washers as used during disassembly, place the ground hub of side gear (5) over the retaining bolt. Refer to Fig. 10.

2. If the NoSPIN® element uses an external spring (3), assemble spring retainer (4) over side gear (5) splines, with the side gear flange firmly seated into the cupped section of the spring retainer. If an internal spring (3) is used, assemble spring (3) over side gear (5) inner hub.

3. If an external spring (3) is used, place spring over side gear (5) inner hub against spring retainer (4). If spring (3) is an internal spring, seat spring retainer (4) on spring. Refer to Fig. 1.

4. If removed, install ‘holdout’ rings in driven clutches with cams or lugs facing out.

5. Assemble clutch and ‘holdout’ ring assembly (2) over spring (3) or spring retainer (4), whichever applies, with clutch teeth up. Check to see if the spring is functioning freely by compressing the clutch over the side gear (5) splines. Be sure spring is not binding and coils do not overlap and there is good

Note: Lightly lubricate all parts before assembly.
contact between the end coil and the spring retainer when the clutch and side gear splines are fully engaged. Refer to Fig. 11.

6. Place spider and centre cam assembly (1) on the driven clutch and ‘holdout’ ring assembly (2), carefully mating clutch teeth and spider cams.

**Note:** Be sure the gap in the ‘holdout’ ring mates with spider key. Refer to Figs. 5 & 6.

**Note:** On some NoSPIN® assemblies it is necessary to mate lugs of ‘holdout’ rings with slots in centre cam.

7. Install remaining driven clutch and ‘holdout’ ring assembly (2) on spider and cam assembly (1), properly mating clutch teeth and spider cams.

8. If the NoSPIN® element uses an external spring (3), position remaining spring (3) over driven clutch and ‘holdout’ ring assembly (2) with larger end of the spring over the clutch. If an internal spring (3) is used, install spring retainer (4) in driven clutch and ‘holdout’ ring assembly (2).

9. If the NoSPIN® element uses an external spring (3), position remaining spring (3) over driven clutch and ‘holdout’ ring assembly (2) with larger end of the spring over the clutch. If an internal spring (3) is used, install spring retainer (4) in driven clutch and ‘holdout’ ring assembly (2).

10. If the NoSPIN® element uses an external spring (3), install remaining spring retainer (4) on remaining side gear (5), cup side up. Assemble spring retainer and side gear assembly over spring (3). Install retaining washer and wing nut on retaining bolt and tighten to keep the NoSPIN® assembly intact. If an internal spring (3) is used, position spring over hub of side gear (5) and assemble spring and side gear as an assembly in driven clutch and ‘holdout’ ring (2), and spring retainer (4). Install retaining washer and wing nut on retaining bolt and tighten to keep the NoSPIN® assembly intact.

**INSTALLATION**

**WARNINGS**

To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

A come-a-long or chain fall with a minimum capacity of one ton is required for removal and installation of a differential assembly.

**Note:** Tighten all fasteners without special torques specified, to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. Install NoSPIN® element in differential carrier, and differential carrier in banjo housing as described in Section 160-0020, DIFFERENTIAL.

**TESTING NOSPIN® DIFFERENTIAL OPERATION**

**WARNING**

To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

A simple test for proper operation of a NoSPIN® unit in the differential assembly will help determine if the NoSPIN® is assembled and installed correctly. This test checks for proper meshing of the NoSPIN® to allow one wheel to rotate while the opposite wheel remains locked to the differential ring gear. It can be
Rear Axle - No SPIN® Element

Section 160-0080

easily performed by following the steps illustrated below:

<table>
<thead>
<tr>
<th>WARNING</th>
</tr>
</thead>
<tbody>
<tr>
<td>To prevent personal injury and property damage, make sure both wheels are off ground. Both wheels are driving wheels even if one is off ground.</td>
</tr>
</tbody>
</table>

1. Raise the axle to be tested so that both tyres are free to rotate. Block up the axle securely.

2. With the aid of an assistant, rotate both wheels forward as far as possible (they should stop after only a 25 - 75 mm (1 - 3 inches) movement). If differential gearing and transmission gearing resistance do not stop wheel rotation after a few inches of movement, insert a suitable soft bar into a driveline universal joint so that it will rest against a chassis rail, etc., to prevent wheel rotation.

3. Hold the left wheel securely in the forward position and rotate the right wheel in the reverse direction, while listening for regular clicking or meshing of the NoSPIN® unit. The clicking will be very faint - almost inaudible. The left wheel must be held firmly forward against the stop or the right wheel will not disengage freely.

4. Rotate both wheels rearward as far as possible (they should stop after only a few inches movement).

5. Hold the left wheel firmly against the stop in the rearward position and rotate the light wheel in the forward direction. Listen for the clicking that indicates meshing of the NoSPIN® during wheel rotation. The left wheel must be firmly against the stop or the right wheel will not rotate freely.

6. Repeat Steps 2 thru 5, while holding the right wheel and testing the left wheel for rotation in the forward and reverse directions.

If the NoSPIN® unit is properly assembled and installed in the differential, free rotation of each wheel will produce very faint clicking sounds as the unit meshes. If either wheel does not rotate or cam freely in both directions, check for dragging brake shoes on both service and parking brakes, and for faulty NoSPIN® assembly and installation.

SPECIAL TOOLS

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools and adhesives required. These tools are available from your dealer.

### DIAGNOSIS CHART

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>REASON</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of drive to wheel</td>
<td>Both sides gears jammed, preventing differential action</td>
<td>Remove differential and repair NoSPIN® element</td>
</tr>
<tr>
<td></td>
<td>One axle always cammed out and will not drive. The axle splined to the jammed side will always drive</td>
<td>Remove differential and repair NoSPIN® element</td>
</tr>
<tr>
<td>Loud snap and severe jerk under heavy torque loads</td>
<td>Worn clutch teeth</td>
<td>Replace worn NoSPIN® components</td>
</tr>
<tr>
<td>Loss on differential action or wheel scuffing</td>
<td>Locked NoSPIN® element</td>
<td>Disassemble and replace damaged components</td>
</tr>
<tr>
<td>Continuous indexing or clicking sound on straight forward driving</td>
<td>Unequal radii of tyres or defective NoSPIN®</td>
<td>Use tyres with same radii or repair NoSPIN®</td>
</tr>
</tbody>
</table>

* * * *
DESCRIPTION AND OPERATION
Numbers in parentheses refer to Fig. 1.

The brakes are air actuated to slow or stop wheel rotation. When the brake treadle in the operator’s compartment is depressed, air pressure is applied to the brake chamber which forces the slack adjuster to rotate camshaft (2). The camshaft cam then forces brake shoes (5 & 19) outward against brake drum (15) through rollers (11) which are pinned to the brake shoes. The wedging action of the brake shoes, which are pinned to the spindle at the opposite ends, against the brake drum slow or stop wheel rotation. The force applied by brake shoes (5 & 19) against brake drum (15) is directly proportional to the degree to which the brake treadle is depressed. As pressure is relaxed, the brake shoes are returned to their released position by return spring (12). Refer to Section 250-0000, AIR BRAKING SYSTEM SCHEMATIC, for operation of the air system and Section 165-0060, SLACK ADJUSTER for operation of the slack adjuster.
REMOVAL AND DISASSEMBLY
Numbers in parentheses refer to Figure 1.

**WARNINGS**
When servicing wheel brake parts do not create dust by grinding or sanding brake linings or by cleaning wheel brake parts with a dry brush or with compressed air. A water dampened cloth should be used. Many wheel brake parts contain asbestos fibres which can become airborne if dust is created during servicing. Breathing dust containing asbestos fibres may cause serious bodily harm.

Use extreme caution to prevent personal injury when removing wheels, The exact procedure must be followed as described in Section 160-0050, WHEEL, RIM AND TYRE.

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of sufficient capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Place battery master switch in the 'Off' position and block all road wheels, except the one to be raised.

3. Open air tank drain cocks and drain air tanks completely.

4. Back off brake slack adjuster to remove all tension on the brake chamber push rod. Refer to Section 165-0060, SLACK ADJUSTER.

5. Drain differential and planetary gear lubricant and remove planetary gear assembly from the wheel. Refer to Section 160-0040, PLANETARY GEARING.

6. Remove wheel and brake drum as described in Section 160-0050, WHEEL, RIM AND TYRE.

7. Lay wheel down with brake drum (15) up. Using suitable lifting equipment attached to drum (15) remove mounting hardware and lift drum from wheel.

8. Remove bolts (21), lockwashers (22), washer (23), bar (24) and guards (25) from spindle.

9. Remove brake return springs (12) from brake shoes (5 & 18).

10. Remove snap rings (14) and anchor pin link (13). Pull off brake shoes (5 & 18).

11. Remove brake linings (16) by removing nuts, lockwashers, screws and plugs (17).

12. Crack weld and remove pins (6) and rollers (11) if rollers are worn. Rollers should be replaced in pairs to make sure both shoes will be expanded an equal amount.

13. To remove the slack adjuster, remove snap ring (1) from camshaft (2). Disconnect slack adjuster from brake chamber by removing cotter pin and clevis pin (3) from brake chamber clevis. Pull the slack adjuster off the camshaft.

14. Remove camshaft (2) from spindle by pulling the camshaft from the outboard side.

15. To remove pins (20) from spindle, remove lube fittings (7), nuts and lockwashers (8) from pins (20). Drive pins (20) from spindle with a soft drift.

**Note:** After removing the brake drum, visually check the drum and lining for wear conditions shown in Fig. 2.
INSPECTION
Numbers in parentheses refer to Fig. 1.

**WARNING**
Do not allow solvents to come in contact with brake shoe linings. If brake shoe linings are soaked with solvents, they must be replaced.

1. Thoroughly clean all parts, except linings, in a suitable solvent. Dry with compressed air or wipe dry with a lint free cloth.

2. Ensure lube passages in pins (20) are open.

3. Check camshafts (2) for flat spots. Flat spots on cams can cause serious pulling, especially in the tractor drive brakes.

4. Check for bent camshafts (2). Bent camshafts will tend to bind in the bushings, push the shoes open at an angle, tending to bend the anchor pins (20) or cause a taper wear pattern of the brake lining.

5. Check camshaft bushings in spindle and anchor pin bushings (19) in brake shoes for excessive wear and replace if worn.

6. Check brake drums for cracks, distortion and scored surfaces. Severely scored brake drums may be salvaged by reboring. The maximum the drums can be rebored is 5 mm (3/16 inch). Drums should be bolted to the hub of wheel when being rebored. With rebored drums, an oversized lining should be used. When using oversized linings, each shoe must have added to the original thickness ONE HALF the amount removed from the drum.

7. Check brake shoe rollers (11) for binding. If they bind, clean and oil; if they still bind the rollers and pins (6) should be checked for excessive wear. If necessary, break the weld on pins (6) and replace with new pins and rollers.

8. Clean all rust off face of brake shoes and smooth down bolt or rivet holes so lining will fit snugly.

9. When installing linings, always replace all linings on an axle to equalise wear and prevent the brakes from pulling.

ASSEMBLY AND INSTALLATION
Numbers in parentheses refer to Fig. 1.

**Note:** Tighten all fasteners without special torques specified, to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

**WARNINGS**
To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of sufficient capacity to do the job safely.

1. If camshaft bushings in spindle were removed, install new bushings in spindle bore. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS.

2. Install camshaft (2) in spindle. Install slack adjuster and snap ring (1) on camshaft (2). Connect brake chamber to slack adjuster by replacing clevis pin and cotter pin (3).

3. If pins (20) were removed, install pins in spindle. Secure pins (20) to spindle with nuts and lockwashers (8). Install lube fittings (7) in pins, if removed.

4. Install rollers (11) and pins (6) in brake shoes (5 & 18). Re-weld both ends of pin to the shoe to prevent it from working out.

5. Install linings (16) on brake shoes (5 & 18) and secure with screws, lockwashers and nuts (17). Torque tighten nuts to 20 - 27 Nm (15 - 20 lbf ft).
Install plugs (18) in linings over screw heads, and grind plugs flush with linings.

**Note:** Install blue edge linings on leading brake shoe (5) and yellow edge linings on trailing brake shoe (18), refer to Fig. 3.

6. Install brake shoes (5 & 19). Install anchor pin link (13) and snap rings (14) on anchor pins (21).

7. Install brake return springs (12) in holes in brake shoes (5 & 19).

8. Using suitable lifting equipment, position brake drum (16) into wheel assembly and secure using mounting hardware as removed at Removal.

9. Position guards (25) on spindle and secure with bar (24), washer (23), lockwashers (22) and bolts (21).

**BRAKE BALANCING**

The brakes should be balanced prior to final reassembly of the relined brake shoes. Brake balancing is checking to see that all brake shoe linings are contacting the drums at the same time and each brake assembly is performing its share of the work.

There are two steps involved in checking the brake balance.

1. Install a low pressure air gauge into the air line leading into each wheel. Depress the treadle valve to allow enough air into the lines to just start a movement of the cams. The difference should be not more than 0.5 lbf/in² between wheels. Also there should be not more than a 3 lbf/in² difference between axles.

2. The next step is to measure the amount of air necessary to move each brake chamber push rod 25 mm (one inch). The air pressure difference should be the same as in Step 1, although the pressure necessary to move the push rods will be slightly higher. A large difference in air pressure between the wheels or axles indicates bad springs in the brake chambers or an obstructed air line. Make a thorough inspection of the entire braking system if the brake chambers prove to be satisfactory.

10. Install wheel assembly on vehicle as described in Section 160-0050, WHEEL, RIM AND TYRE.

11. Install planetary gear assembly and fill planetary and differential assemblies with lubricant specified in Section 300-0020, LUBRICATION SYSTEM. Refer to Section 160-0040, PLANETARY GEARING.
ADJUSTMENT

Push Rod and Slack Adjuster Angle
Numbers in parentheses refer to Fig. 4.

Adjustment must be such as to keep brake chamber push rod travel at a minimum while still maintaining the necessary clearance between the brake shoes and brake drum. Also brake chamber push rod (1) and slack adjuster (2) must form an angle of slightly more than 90°, with brakes applied. If the angle is less than 90°, depress the locking sleeve (5) and turn adjusting screw (4) and worm gear (3) until brake shoe linings contact brake drum. Back out adjusting screw two flats (1/3 turn). If the angle is still less than 90°, further adjustment must be made at the brake chamber push rod and clevis. If push rod and clevis need adjustment, release brakes and disconnect brake chamber push rod (1) clevis from slack adjuster. Back off jam nut on push rod and adjust clevis by turning. If adjustment of slack adjuster is also necessary, depress locking sleeve (5) and turn adjusting screw (4) and worm gear (3) until proper angle is established. After proper angle has been established, make sure locking sleeve returns to the locked position and that the brake shoes are not dragging. Tighten jam nut on push rod against clevis. Connect push rod clevis to slack adjuster. Apply brake and check angle between push rod and slack adjuster.

Brake Shoe Clearance
To adjust brake shoe clearance, refer to Section 165-0060, SLACK ADJUSTER.

SERVICE TOOLS
Refer to Section 300-0070, SERVICE TOOLS, for part numbers of special tools outlined in this section and general service tools required. These tools are available from your dealer.

SPECIAL TORQUE SPECIFICATIONS

<table>
<thead>
<tr>
<th>FIG. NO.</th>
<th>ITEM NO.</th>
<th>ITEM NAME</th>
<th>TORQUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17</td>
<td>Nut</td>
<td>Nm</td>
</tr>
<tr>
<td>1</td>
<td>17</td>
<td>Nut</td>
<td>lbf ft</td>
</tr>
<tr>
<td>1</td>
<td>17</td>
<td>Nut</td>
<td>20 - 27</td>
</tr>
</tbody>
</table>
DESCRIPTION AND OPERATION

Numbers in parentheses refer to Fig. 1.

The slack adjuster connects the air brake chamber push rod to the brake assembly camshaft to rotate the cam. The slack adjuster consists of worm (11) and adjusting shaft (7) which engages worm gear (9) that is splined to the brake camshaft. Turning adjusting shaft (7) rotates worm gear (9) and the camshaft. This movement changes the clearance between the brake lining and brake drum.

A locking sleeve (6) and spring (5) is used to lock adjusting shaft (7) in place.

ADJUSTMENT

Brake Shoe Clearance

Numbers in parentheses refer to Fig. 2.

Before brake shoe clearance can be adjusted brake chamber push rod (1) and slack adjuster (2) must form an angle of slightly more than 90°, with brakes applied. Make certain the angle is identical on all
Brake Parts - Slack Adjuster

Section 165-0060

Wheels to obtain even braking on all wheels. If adjustment is necessary, refer to Section 165-0031, BRAKE PARTS for adjustment procedure.

To adjust brake shoe clearance, release brakes and depress locking sleeve (5) enough to allow adjusting shaft (4) and worm gear (3) to be turned. Turn the adjusting shaft and worm gear in the direction that causes slack adjuster to turn cam shaft toward brake apply position. Turn until tight, then back off one third of a turn (two flats). If new shoes have been installed, back off one half turn (three flats). Make sure locking sleeve (5), returns to the locked position and that the brake shoes are not dragging.

LUBRICATION

The slack adjuster is permanently lubricated, eliminating the need periodic lubrication.
## COMPONENT DESIGNATIONS

<table>
<thead>
<tr>
<th>Component</th>
<th>Designation</th>
<th>Component</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A4 - Radio/Cassette</td>
<td>K1 - Starter Relay</td>
<td>A5 - Radio/Cassette Speaker</td>
<td>K4 - Dir Ind Clutch</td>
</tr>
<tr>
<td>B7 - Coolant Level Sender</td>
<td>K5 - Air Cond Clutch</td>
<td>B9 - Air Pressure Sender</td>
<td>K14 - Start Interlock Relay</td>
</tr>
<tr>
<td>B13 - Rotational Speed Sensor</td>
<td>K15 - Headlamp Relay</td>
<td>B15 - Air Temp Sender</td>
<td>K17 - Reverse Relay</td>
</tr>
<tr>
<td>B19 - Throttle Position Sender</td>
<td>K21 - Trans Shift Clutch</td>
<td>B21 - Trans Oil Temp Sender</td>
<td>K22 - Lockup Clutch</td>
</tr>
<tr>
<td>B33 - Air Cond Temp Sender</td>
<td>K23 - Ignition Air Cond</td>
<td>B34 - Barometric Air Press Sender</td>
<td>K23 - Ignition Wipers</td>
</tr>
<tr>
<td>E3 - Interior Light</td>
<td>K23 - Ignition Engine</td>
<td>E7 - Instrument Panel Lights</td>
<td>K34 - Horn Relay</td>
</tr>
<tr>
<td>E11 - Side Marker Light, L</td>
<td>K44 - Trans Start Relay</td>
<td>E12 - Taillight, L</td>
<td>K45 - Engine Alarm Relay</td>
</tr>
<tr>
<td>E13 - Side Marker Light, R</td>
<td>K46 - Rear Starter Inhibit</td>
<td>E14 - Taillight, R</td>
<td>K47 - Intermittent Wipe Relay</td>
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<tr>
<td>E15 - High/Low Beam H'lamp, L</td>
<td>K53 - Grid Heater Power Relay</td>
<td>E16 - High/Low Beam H'lamp, R</td>
<td>L3 - Reverse Alarm</td>
</tr>
<tr>
<td>E21 - Rotating Beacon</td>
<td>L4 - Buzzer</td>
<td>E23 - Work Light</td>
<td>L5 - Horn Solenoid</td>
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<tr>
<td>E26 - High Beam H'lamp, L</td>
<td>M1 - Starter Motor</td>
<td>E27 - High Beam H'lamp, R</td>
<td>M3 - Cab Vent Blower Motor</td>
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<tr>
<td>E36 - Cutting Edge Light Switch</td>
<td>M4 - Washer Motor, F</td>
<td>G1 - Generator</td>
<td>M5 - Wiper Motor, F</td>
</tr>
<tr>
<td>G2 - Battery</td>
<td>M6 - Wiper Motor, B</td>
<td>G2 - Battery</td>
<td>M7 - Washer Motor, B</td>
</tr>
<tr>
<td>H2 - Warning Light</td>
<td>M10 - Cab Fan Motor</td>
<td>H5 - Direction Indicator w/l</td>
<td>N3 - Voltage Convertor 12V</td>
</tr>
<tr>
<td>H6 - Direction Indicator; F, L</td>
<td>N3 - Voltage Convertor 12V</td>
<td>H7 - Direction Indicator; B, L</td>
<td>P2 - Tachometer/Hourmeter</td>
</tr>
<tr>
<td>H8 - Direction Indicator; F, R</td>
<td>P6 - Air Press Gauge</td>
<td>H9 - Direction Indicator; B, R</td>
<td>P8 - Trans Temp Gauge</td>
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<tr>
<td>H10 - Brake Light, L</td>
<td>R7 - Cigar Lighter</td>
<td>H11 - Brake Light, R</td>
<td>S1 - Battery Master Switch</td>
</tr>
<tr>
<td>H12 - High Beam w/l</td>
<td>S1 - Battery Master Switch</td>
<td>H23 - Engine Check w/l</td>
<td>S2 - Starter Keyswitch</td>
</tr>
<tr>
<td>H24 - Engine Stop w/l</td>
<td>S3 - Rear Engine Start Switch</td>
<td>H28 - Service Engine w/l</td>
<td>S4 - W/L Test Switch</td>
</tr>
<tr>
<td>H30 - Water in Fuel w/l</td>
<td></td>
<td>H31 - Wait To Start w/l</td>
<td></td>
</tr>
</tbody>
</table>

### Wire Colours

- B - Black
- N - Brown
- O - Orange
- U - Blue
- Y - Yellow
- R - Red
- P - Purple
- G - Green
- W - White
- L - Light Green
- S - Slate
- K - Pink

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Section 190-0000

Electrical System - Circuit Diagrams
NOTEs:
1. ENGINE MANAGEMENT WIRE NUMBERS ARE IN ( ).
2. SOME ENGINE MANAGEMENT HARNESSES ARE SHEILDED FROM ELECTRO MAGNETIC INDUCTION WHERE THEY RUN CLOSE TO OTHER VEHICLE SYSTEMS.
3. CABLES R/B (916B), U (417), B (952B) & Y (542) TWISTED 32 TURNS/METRE.
4. CABLES R/B (916B (A)), U (417 (A)), B (952B (A)) & Y (542 (A)) TWISTED 32 TURNS/METRE.

CALIBRATION PLUGS FOR FRONT AND REAR TRANSMISSIONS
## Electrical System - Circuit Diagrams

### FUSES

<table>
<thead>
<tr>
<th>Location</th>
<th>Fuse No.</th>
<th>Circuit</th>
<th>Current Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>Ignition Sensed Relay Wipers</td>
<td>30A</td>
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<tr>
<td></td>
<td>2</td>
<td>Keyswitch</td>
<td>15A</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Spare</td>
<td>-</td>
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<tr>
<td></td>
<td>4</td>
<td>Rear Wash/Wipe</td>
<td>10A</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Horn, Front Wash/Wipe</td>
<td>10A</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Spare</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Lights Switch</td>
<td>10A</td>
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<td></td>
<td>8</td>
<td>Main Beam</td>
<td>10A</td>
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<td>9</td>
<td>Wiper Park Front and Rear</td>
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<td></td>
<td>10</td>
<td>Hazards</td>
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<td></td>
<td>11</td>
<td>Rear Starter Solenoid</td>
<td>3A</td>
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<td></td>
<td>12</td>
<td>Reverse System, Cutting Edge Light</td>
<td>7.5A</td>
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<td>13</td>
<td>Brake Lights</td>
<td>5A</td>
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<td></td>
<td>14</td>
<td>Interior Light, Handlamp, Cigar Lighter</td>
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<td>Direction Indicators/Rocker Switch Lights</td>
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<td>16</td>
<td>Alarm Engines/Transmissions</td>
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<td>17</td>
<td>Warning Lights</td>
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<td>18</td>
<td>Bowl Drop</td>
<td>3A</td>
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<td></td>
<td>19</td>
<td>Gauges/Ignition Sensed Relay Coils</td>
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<tr>
<td></td>
<td>20</td>
<td>Spare</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>Front Starter Solenoid</td>
<td>3A</td>
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<tr>
<td></td>
<td>22</td>
<td>Washers, Front</td>
<td>3A</td>
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<tr>
<td></td>
<td>23</td>
<td>Washers, Rear</td>
<td>3A</td>
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<tr>
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<td>24</td>
<td>Horn</td>
<td>3A</td>
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<td>25</td>
<td>Ignition Sensed Relay Contacts (Air Cond, TVP, Opt.)</td>
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<td></td>
<td>26</td>
<td>Air Conditioning System</td>
<td>15A</td>
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<td></td>
<td>27</td>
<td>Transmission Ignition Supply</td>
<td>15A</td>
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<td></td>
<td>28</td>
<td>Ignition Auxiliary Supply Option</td>
<td>10A</td>
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<tr>
<td></td>
<td>29</td>
<td>Work Lights</td>
<td>15A</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>Rotating Beacon</td>
<td>5A</td>
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<td></td>
<td>31</td>
<td>Cab Fan</td>
<td>3A</td>
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<td></td>
<td>32</td>
<td>Spare</td>
<td>-</td>
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<td>33</td>
<td>Bowl Suspension</td>
<td>3A</td>
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<td>Alternator Drive Signal</td>
<td>3A</td>
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<tr>
<td></td>
<td>35</td>
<td>Spare</td>
<td>-</td>
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<tr>
<td></td>
<td>36</td>
<td>Spare</td>
<td>-</td>
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<tr>
<td>Radio Harness</td>
<td>38</td>
<td>Radio/Cassette Supply (Glass Fuse)</td>
<td>7A</td>
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<td></td>
<td>39</td>
<td>Radio/Cassette Supply (Glass Fuse)</td>
<td>1A</td>
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</table>

### Front Frame Fuse Box

|              | 43  | Front ECM Battery Supply                      | 10A            |
|              | 44  | Front ECM Battery Supply                      | 10A            |
|              | 45  | Front ECM Battery Supply                      | 7.5A           |
|              | 46  | Front ECM Battery Supply                      | 7.5A           |
|              | 47  | Front ECM Battery Supply                      | 7.5A           |
|              | 48  | Front ECM Ignition Supply                     | 5A             |
|              | 49  | Transmission Start Relay                      | 15A            |
|              | 50  | Transmission TVP Battery Supply               | 15A            |
|              | 51  | Transmission TVP Battery Supply               | 15A            |

### Rr Frame Fuse Box

|              | 55  | Rear Engine Battery Supply                    | 10A            |
|              | 56  | Rear Engine Battery Supply                    | 10A            |
|              | 57  | Rear Engine Battery Supply                    | 7.5A           |
|              | 58  | Rear Engine Battery Supply                    | 7.5A           |
|              | 59  | Rear Engine Battery Supply                    | 7.5A           |
## Electrical System - Circuit Diagrams

### FUSES

<table>
<thead>
<tr>
<th>Location</th>
<th>Fuse No.</th>
<th>Circuit</th>
<th>Current Rating</th>
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</thead>
<tbody>
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<td>Rr Frame Fuse Box</td>
<td>60</td>
<td>Rear Engine Ignition Supply</td>
<td>5A</td>
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<tr>
<td>L.H rail Power Box</td>
<td>61</td>
<td>Vehicle System supply</td>
<td>100A</td>
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<tr>
<td></td>
<td>62</td>
<td>Alternator Charge System Supply</td>
<td>100A</td>
</tr>
<tr>
<td>Front Engine Bay</td>
<td>63</td>
<td>Front Grid Heater Supply</td>
<td>125A</td>
</tr>
<tr>
<td>Rear Engine Bay</td>
<td>64</td>
<td>Rear Grid Heater Supply</td>
<td>125A</td>
</tr>
</tbody>
</table>
Electrical System - Circuit Diagrams

Section 190-0000

* * * *
ELECTRICAL SYSTEM - Switches and Sensors

Section 190-0270

1 - Front Brake Low Air Pressure Sw
2 - Rear Brake Low Air Pressure Sw
3 - Front Brake Stop Light Pressure Sw
4 - Rear Brake Stop Light Pressure Sw
5 - Starter Solenoid
6 - Grid Heater Relay
7 - Transmission Oil Temperature Sender
8 - Transmission Oil Pressure Switch
9 - Engine Coolant Level Sender
10 - Parking Brake Low Air Pressure Sw
11 - Trans. Parking Brake Pressure Sw
12 - Air Cleaner Restriction Indicator
13 - Convertor Drive Pressure Switch
14 - Air Pressure Sender

DESCRIPTION

Numbers in parentheses refer to Fig. 1 & 2, unless otherwise specified.

This section describes the location and function of various switches and sensors fitted to the vehicle to monitor all major components and systems. Gauges and warning lights located in the dash panel, relay this information to the operator.

Note: Always make sure all gauges, warning lights and controls are working properly before operating the vehicle.

Engine

The Quantum Electronic fuel system monitors the engines at all times and sends a signal to the engine check lights (5 & 19, Fig. 3) and engine stop lights (6 & 20, Fig. 3) on the dash panel to alert the operator of a fault in the engine circuit. An audible alarm also sounds when the engine stop lights illuminate. Refer to Section 110-0030, ENGINE AND MOUNTING.

Starter Solenoid (5) - The starter solenoid powers up the starter motor when the key switch is turned.

Grid Heaters Relay (6) - The relay powers up the grid heaters in both the Tractor and Scraper engine units.
Engine Coolant Level Senders (9) - Located in the radiator top tank, the sender sends a signal to engine stop light (6 or 20, Fig. 3) indicating that the engine coolant level is low.

Tachometer/Hourmeter (1, Fig. 3) - Driven from the alternator, the tachometer indicates the number of engine crankshaft revolutions per minute (rev/min). Never accelerate the engine to speeds indicated by the red zone on the dial face. A digital hourmeter is incorporated in the tachometer to record total hours of engine operation.

Transmission
The FUNK DF 158 transmission management system monitors the transmissions at all times and sends a signal to the display unit on the dash panel to alert the operator of a fault in the transmission circuit.

Converter Drive Pressure Switch (13) - Located on the top rear of the transmission, sends a signal to illuminate transmission converter indicator light (9, Fig. 3) to indicate when the transmission is in torque converter drive.

Transmission Oil Pressure Switch (8) - Located in a tee at the front of the transmission, sends a signal to illuminate transmission oil pressure warning light (8 & 18, Fig. 3) to indicate when the transmission oil pressure is low.

Transmission Oil Temperature Sender (7, Fig. 1) & Transmission Oil Temperature Sender/Switch (7, Fig. 2) - The temperature switch (only on scraper) sends a signal to illuminate transmission oil temperature warning light (17, Fig. 3) when the scraper transmission oil temperature rises above the safe operating temperature.

The temperature senders sends a signal to the Transmission Oil Temperature Gauge (2 & 4, Fig. 2) to indicate converter-out oil temperature. The gauge should read in the green zone during normal operation.

Watch for wide deviations from normal readings on the...
Braking System

Transmission Parking Brake Pressure Switch (11) -
The pressure switch is located in a tee from the parking/emergency brake control valve. The pressure switch sends a signal to transmission indicating that the parking brake is applied.

Stop Light Pressure Switches (3 & 4) - There are two normally open (NO) pressure switches, one for the front brake circuit and one for the rear brake circuit. These are connected in parallel and are located in the treadle valve. As brake apply pressure increases to 0.28 bar (4 lbf/in²) and above, the circuit closes and sends a signal to illuminate the brake lights at the rear of the vehicle. As pressure drops below 0.28 bar (4 lbf/in²) the circuit opens and the brake lights go out.

Air Pressure Sender (14) - Located in a tee in port ‘23’ of the pressure protection valve, the air pressure sender sends a signal indicating air reservoir pressure on air pressure gauge (3, Fig. 3).
Air Pressure Gauge (3, Fig. 3) - Indicates air reservoir pressure. During normal operation, the needle in this gauge should be showing in or approaching the centre of the green zone. Do not operate the vehicle if the needle remains in the red zone.

**WARNING**

Never release the parking brake or move the vehicle until the needle is at least approaching the centre of the green zone.

Low Air Pressure Switch (1, 2 & 10) - There are 3 normally open (NO) pressure switches located in air system. One located in port ‘4’ of the manifold plate and two in the treadle valve. The switches send a signal to illuminate low brake air pressure warning light (15, Fig. 3) if there is a loss of air pressure in the following circuits:

- Switch (10) - Park/emergency brake circuit air pressure falls below 5.5 bar (80 lbf/in²).
- Switch (1) - Front service circuit air pressure falls below 4.1 bar (60 lbf/in²).
- Switch (2) - Rear service circuit air pressure falls below 4.1 bar (60 lbf/in²).

If the warning light illuminates, stop the machine, apply the parking brake and investigate the cause.

Air Cleaner

Air Cleaner Restriction Gauge (14) - Mounted externally on the air cleaner pipes, the restriction gauge indicates the degree of air cleaner element restriction as the red band rises in the gauge window. The filter elements should be replaced if the red band locks in place when the engine is shut down. Reset the gauge by pressing the button on the gauge with the engine running.
FUEL SYSTEM - Fuel Tanks, Lines and Mounting

Section 200-0040

DESCRIPTION
Numbers in parentheses refer to Fig. 1 & 2, unless otherwise stated.

The tractor fuel tank is mounted on the chassis at the front of the cab assembly. The scraper fuel tank is mounted on the scraper chassis at the rear of the bowl assembly. Both fuel tanks are secured with bolts (14 & 18), washers (15 & 19), lockwashers (13 & 16) and locknuts (11 & 17).

Both fuel tanks have an integral fuel strainer (12) which helps prevent foreign particles from entering the fuel tank during filling.

Note: Refer to Section 300-0020, LUBRICATION SYSTEM for fuel tank capacity and fuel specifications.

OPERATION
Numbers in parentheses refer to Fig. 3 & 4, unless otherwise specified.

Fuel is drawn from fuel tank through fuel line (4 & 21), inline filters and fuel filters (35 & 36) by fuel pump. Leaving fuel pump under pressure, the fuel flows to the fuel injectors in the cylinder head through passages integral with the cylinder head. Surplus fuel exits from the cylinder head, just above the fuel inlet, and returns...
WARNING
To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

REMOVAL
Numbers in parentheses refer to Fig. 1 & 2, unless otherwise specified.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place the battery master
1. A switch in the 'Off' position.

3. Remove padlock (20) and remove filler cap (2) assembly from fuel tank (1).

4. Remove fuel strainer (12) from fuel tank (1) and clean with clean diesel fuel.

5. With a suitable container in position, remove drain plug (9) from the underside of fuel tank (1) and drain fuel from fuel tank (1). Reinstall drain plug (9) and tighten securely when fuel tank (1) is completely drained.

6. Identify and tag fuel lines (4, 5, 21 & 30, Figs. 3 & 4) and, with a suitable container available to catch leakage, disconnect fuel lines (4, 5, 21 & 30, Figs. 3 & 4). Cap open line ends, connectors (2 & 19 Figs. 3 & 4) and elbows (1 & 18, Figs. 3 & 4) to prevent entry of dirt.

7. Remove locknuts (11 & 17), bolts (14 & 18), lockwashers (13 & 16) and washers (15 & 19) securing fuel tank (1) assembly to the frame. Using a suitable lifting device, remove fuel tank (1) assembly from the vehicle.
Fuel System - Fuel Tanks, Lines and Mounting

Section 200-0040

INSTALLATION

Numbers in parentheses refer to Fig. 1 & 2, unless otherwise specified.

**WARNING**

To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

1. Using suitable lifting equipment, position fuel tank (1) assembly on the frame.

2. Secure the fuel tank (1) assembly to the frame with bolts (14 & 18), washers (15 & 19), lockwashers (13 & 16) and locknuts (11 & 17), as shown.

3. Remove blanking caps and secure fuel lines (4, 5, 21 & 30 Figs. 3 & 4) to connectors (2, 19 Figs. 3 & 4) and elbows (1 & 18 Figs. 3 & 4), as identified at removal.

4. Install fuel strainer (12) in fuel tank (1).

5. Fill fuel tank (1) assembly with clean diesel fuel specified in Section 300-0020, LUBRICATION SYSTEM.

6. Install filler cap (2) assembly on fuel tank filler neck. Tighten filler cap (2) securely and secure in place with padlock (20).

7. Place the battery master switch in the 'On' position, start the engine and run for a few minutes to ensure fuel is being supplied to the engine. Check for leaks at fuel lines (4, 5, 21 & 30, Fig. 3 & 4) and tighten if required.

8. Remove wheel blocks from all road wheels.

MAINTENANCE

Numbers in parentheses refer to Fig. 1 & 2, unless otherwise specified.

**WARNING**

To prevent personal injury and property damage, be sure wheel blocks and blocking materials are properly secured and of adequate capacity to do the job safely.

General

Refill fuel tank (1) at the end of each day's operation to prevent condensation from contaminating the fuel. Ensure vent hole in filler cap (2) is clear to prevent a vacuum from building up in fuel tank (1).

When filling fuel tank (1), check that there is no buildup of dirt and sludge at fuel strainer (12) and filler cap (2). Remove and clean fuel strainer (12) and filler cap (2) as required.

Every 10 Hours/Daily

Make a visual check for fuel leaks at all fuel lines and connections. Make sure that fuel lines (4, 9, 18 & 25, Figs. 3 & 4) are not resting on or touching rotating components, heated surfaces including exhaust manifolds, or sharp edges. If fittings have loosened or cracked, or if lines have ruptured or worn through, take corrective action immediately.

Every 500 Hours

Remove drain plug (9) from the underside of fuel tank (1) and drain off any water or sediment which has gathered. Check condition of filler cap (2) and clean fuel strainer (12) and filler cap (2) with clean fuel. Check the condition of all fuel lines and replace if required.

Diesel Fuel Oil

The sulphur content of diesel fuel oil should be as low as possible to avoid premature wear of piston rings and line, excessive deposit formation, and minimise sulphur dioxide exhausted into the atmosphere. Limited amounts can be tolerated, but the amount of sulphur in the fuel and engine operating conditions can influence corrosion and deposit formation tendencies. The use of diesel fuel oil with a MAXIMUM sulphur content of 0.5% is recommended for use. Refer to Section 300-0020, LUBRICATION SYSTEM.

SERVICE TOOLS

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.
DESCRIPTION

Numbers in parentheses refer to Fig. 1.

There are two electronic foot pedals mounted on the cab floor. The electronic foot pedals provide an electrical signal to the engine's fuel control system in proportion to the degree of pedal actuation. The right hand pedal operates the tractor engine and the left hand pedal operates the scraper engine. The right hand (tractor) accelerator pedal can be operated individually when only the tractor engine is running, however, when both engines are running, it is recommended that both pedals are depressed at the same time to provide equal power to both engines. This action is obtained by depressing the left hand accelerator pedal which, by means of linking bar (10), also depresses the right hand pedal.

**Note:** The electronic controlled engine will override the electronic foot pedal position until the engine is warmed up to the correct operating temperature. The engine MUST be started with the foot ‘OFF’ the electronic foot pedal.
Fuel System - Electronic Foot Pedal
Section 200-0051

REMOVAL
Numbers in parentheses refer to Fig. 1.

**WARNING**
To prevent personal injury and property damage, be sure wheel blocks are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Turn steering wheel several times to relieve any pressure in the steering circuit.

2. Block all road wheels and place the battery master switch in the ‘Off’ position.

3. Disconnect electrical harnesses (2) from the mating engine harnesses.

4. Move cab floor mat back and clear from pedal assemblies (1) and mounting plates.

5. Remove mounting bolts (17) and lockwashers (18) securing pedal assemblies (1) to cab floor plate. Remove pedal assemblies (1).

INSTALLATION
Numbers in parentheses refer to Fig. 1.

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. Position pedal assemblies (1) on cab floor and secure with mounting bolts (17) and lockwashers (18) removed during removal.

2. Connect electrical harnesses (2) to the mating engine harnesses.

3. Position floor mat on cab floor and ensure that pedal assemblies (1) are free to operate.

4. Switch the battery master switch to the ‘On’ position and start the engine. Ensure that pedal assemblies (1) operate correctly.

**Note:** The engine MUST be started with the foot ‘OFF’ pedal assemblies (1).

5. Remove wheel blocks.

MAINTENANCE
Limited repair of the electronic foot pedal assembly is by replacement of parts only. Refer to vehicle Parts Book for part numbers of overhaul kits.

* * * *
COOLING SYSTEM - Radiator and Mounting

Section 210-0040

REMOVAL

Numbers in parentheses refer to Fig. 1, unless otherwise specified.

⚠️ WARNING
Do not remove radiator filler cap or drain the coolant until the engine has cooled to below 50° C (120° F). When removing filler cap, always release pressure from the system by depressing the pressure relief button on the filler cap. Remove filler cap slowly, as the sudden release of pressure from a heated cooling system can result in a loss of coolant and possible personal injury.

⚠️ To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate steering right and left several times to relieve pressure in the steering system.

2. Block all road wheels and place the battery master switch in the ‘Off’ position.

3. Remove mounting hardware securing hood assembly to the machine and, using suitable lifting equipment, remove hood assembly. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS.

4. Depress pressure relief button on filler cap (18) and remove the filler cap (18) from filler neck (17).

5. With a suitable container in position, remove drain plug (2) at the bottom of radiator assembly (28) and drain the cooling system. Reinstall drain plug (2) and tighten securely when coolant is completely drained.
6. Remove bolts (3) and washers (4) securing fan guard (1) to radiator shroud (20). Remove fan guard (1) from the machine.

7. Slacken clamps (5, Fig. 2) and slide silicon hose (3, Fig. 2) away from the radiator top tank connection. Cap open ends to prevent entry of dirt.

8. Disconnect deaeration line (9, Fig. 2) from adaptor (8, Fig. 2) in radiator top tank and cap open ends to prevent entry of dirt.

9. Slacken clamps (5, Fig. 2) and slide silicon hose (4, Fig. 2) away from the radiator bottom tank connection. Cap open ends to prevent entry of dirt.

10. Ensure all coolant lines have been disconnected from radiator assembly (28).

11. Remove bolts (11), lockwashers (12), washers (15) and bracket (10) from radiator assembly (28).

12. Attach suitable lifting equipment to radiator assembly (28) and remove nuts (25), washers (24), springs (23) securing radiator assembly (1) to the machine. Remove radiator assembly (1), studs (22) and pads (21) from the machine.

Note: The thin fins and tubes of the radiator core are easily damaged, therefore, handle radiator assembly (28) with care.
DISASSEMBLY

Numbers in parentheses refer to Fig. 3, unless otherwise specified.

Note: Position radiator assembly on wooden blocks with radiator shroud (20, Fig. 1) up to protect radiator core during ‘Disassembly’.

1. Remove bolts (8, Fig. 1), lockwashers (9, Fig. 1) and washers (4, Fig. 1) securing radiator shroud (20, Fig. 1) to radiator assembly (28, Fig. 1). Remove radiator shroud from radiator assembly.

2. Remove mounting hardware, clip (7, Fig. 1) and overflow tube (16, Fig. 1) from filler neck (17, Fig. 1) on radiator top tank (1).

3. Remove bolts (11), lockwashers (12) and nuts (7) securing side columns (3 & 4) to top tank (1) and bottom tank (2). Remove side columns (3 & 4).

4. Remove nuts (7), washers (12) and bolts (11) securing top tank (1) to core assembly (5).

5. Remove top tank (1) from core assembly (5) and discard gasket (6).

6. Remove bolts (19, Fig. 1) securing filler neck (17, Fig. 1) to radiator top tank (1). Remove filler neck (17, Fig. 1) and discard gasket (6, Fig. 1).

7. Remove nuts (7), washers (12) and bolts (11) securing bottom tank (2) to core assembly (5).

8. Remove bottom tank (2) from core assembly (5). Discard gasket (6).

9. If required, remove drain plug (2, Fig. 1) and studs (22, Fig. 1) from bottom tank (2).
Cooling System - Radiator and Mounting

Section 210-0040

INSPECTION

Numbers in parentheses refer to Fig. 3.

1. Steam clean all parts thoroughly.

2. Examine core assembly (5) carefully for possible damage. Repair any damage discovered, if equipped to do so, or have repairs made at a reputable radiator repair shop.

3. Clean top tank (1) and bottom tank (2) of all traces of corrosion, scale and old gasket material.

ASSEMBLY

Numbers in parentheses refer to Fig. 3, unless otherwise specified.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE.

Note: Use a gasket sealer such as Permatex No. 2, or equivalent, during assembly to ensure leakproof joints.

1. If removed, install drain plug (2, Fig. 1) and studs (22, Fig. 1) in bottom tank (2).

2. Install new gasket (6, Fig. 1), coated with sealer, and filler neck (17, Fig. 1) on top tank (1). Secure filler neck to top tank with bolts (19, Fig. 1).

3. Install new gasket (6), coated with sealer, to top tank (1). Position side columns (3 & 4) to core assembly (5) and attach top tank (1) to core assembly (5) and side columns (3 & 4) with bolts (11), washers (12) and nuts (7).

5. Install new gasket (6), coated with sealer, to bottom tank (2). Position side columns (3 & 4) to core assembly (5) and attach bottom tank (2) to core assembly (5) and side columns (3 & 4) with bolts (11), washers (12) and nuts (7).

Note: Tighten top tank (1) and bottom tank (2) to core assembly (5) from the centre out to ensure an evenly spread load.

6. Install overflow tube (16, Fig. 1) to filler neck (17, Fig. 1) on radiator top tank (1). Secure tube with clips (7, Fig. 1) and mounting hardware as removed at Disassembly.

7. Install radiator shroud (20, Fig. 1) to radiator assembly (1, Fig. 1) and secure with bolts (8, Fig. 1), lockwashers (9, Fig. 1) and washers (4, Fig. 1).

INSTALLATION

Numbers in parentheses refer to Fig. 1.

Note: Tighten all fasteners, without special torques specified, to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE.

⚠️ To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

1. Using suitable lifting equipment, position radiator assembly (28) on mounting brackets with pads (21). Install a spring (23), washer (24) and nut (25) to each mounting stud (22). Preload spring by tightening nut until spring is compressed to a length of 42.9 mm (1.69 inch). Refer to Fig. 4, Dimension ‘A’.

Note: The thin fins and tubes of the radiator core are easily damaged, therefore, handle radiator assembly (1) with care.

2. Remove blanking cap from deaeration line (9, Fig. 2) and tighten securely to adaptor (8, Fig. 2).

3. Remove blanking cap and slide silicon hose (3, Fig. 2) over radiator top tank connection and secure with clamp (5, Fig. 2).

4. Remove blanking cap and slide silicon hose
(3, Fig. 2) over radiator bottom tank connection and secure with clamp (5, Fig. 2).

5. Install fan guard (1) to radiator shroud (20) and secure with bolts (3), washers (4).

6. Using a suitable lifting device, install hood assembly and radiator guard on the machine and secure with mounting hardware, as removed at 'Removal'. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS.

7. Connect all electrical connections to lights in radiator guard assembly.

**Note:** Do not secure hood assembly on the vehicle until vehicle has been started and checked for leaks. Refer to 'Initial Fill and Start-up'.

**Initial Fill and Start-up**
Numbers in parentheses refer to Fig. 1.

1. Refer to Engine 'Operation and Maintenance Manual' for correct selection of heavy duty coolant.

2. Ensure drain plug (2) is tightened securely and fill the cooling system through filler neck (17). Fill with coolant until coolant reaches the bottom of filler neck (17) and holds at that level.

3. Check all line connections for leaks prior to starting the vehicle. Tighten as required.

4. Place the battery master switch 'On', start the engine and check for leaks. Tighten lines and fittings and top up coolant level as required. Fit filler cap (18).

5. Using suitable lifting equipment, position hood assembly on the vehicle and secure with mounting hardware, as removed at 'Removal'. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS.

6. Remove all wheel blocks.

**MAINTENANCE**
Refer to Section 210-0000, COOLING SYSTEM, for recommended preventive maintenance procedures and coolant specifications.

**Internal Cleaning - Water Tubes**
If scale deposits are present inside the water tubes of the radiator, it is necessary to use a suitable scale remover such as 'Powdered Scale Solvent', or equivalent. This material is a free-flowing powder, inhibited to prevent attack on the cooling system materials.

**WARNING**
Take care to avoid contact of skin or eyes with the solvent. If contact is made it should be washed off immediately with clean water and medical advice should be taken.

For general cleaning use it is recommended to use a concentration of 50 - 100 kg/m³ of water at a temperature of up to 60° C. Rapid circulation or agitation with compressed air will reduce the time for cleaning.

**Note:** If scale deposits within the radiator are exceptionally heavy, concentrations up to 200 kg/m³ may be used.

The most convenient method of use is to prepare a concentrated solution by mixing the powder in hot water in a tank and then adding the concentrated solution to water contained in the radiator.

**Note:** The solvent must always be added carefully to water, not water to solvent.

**External Cleaning**

**Note:** If a build up of dirt is apparent during routine inspection, the following cleaning procedure should be adopted.

1. Direct a steam jet at 100 - 300 kN/m², or compressed air at 500 - 700 kN/m² on to the faces of the radiator core.

2. Liberally brush a liquid detergent on to those surfaces which were not satisfactorily cleaned at step 1. Leave to soak for at least 1 hour.

3. Apply a high pressure steam jet at 100 - 300 kN/m² on to the treated surfaces, forcing the fouling material out from the radiator core.

4. Leave radiator core to dry before re-installing the cooling equipment.

**Note:** In the case of grossly fouled surfaces which are not cleaned adequately in steps 1 through 4, the following procedure may be used.

5. Ensure that the radiator core is dry.
6. Liberally brush on to both sides of the radiator core an emulsifying cleaner such as 'Gunk', or equivalent, and leave to soak for at least 1 hour.

7. Apply a high pressure steam jet at 100 - 300 kN/m² on to the treated surfaces, from several different angles, forcing the fouling material out from the radiator core.

8. For surfaces with stubborn deposits, it may be necessary to repeat steps 5 through 7, brushing the surfaces between stages using a stiff bristle brush.

9. Leave radiator core to dry before re-installing the cooling equipment.

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**SPECIAL TOOLS**

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.
COOLING SYSTEM - Transmission Oil Cooler

Section 210-0060

DESCRIPTION AND OPERATION

Numbers and letters in parentheses refer to Fig. 1.

The transmission oil cooler is connected in the cooling and transmission oil circuits, between the radiator and transmission. The purpose of the transmission oil cooler is to maintain transmission oil within its required operating temperature range. Refer to Section 120-0010, TRANSMISSION AND MOUNTING and Section 210-0000, COOLING SYSTEM.

Coolant is drawn from port ‘D’, through coolant outlet pipe (6) by the engine water pump. It then circulates through the engine water jacket and, when thermostats are open, returns through coolant inlet pipe (5) at port ‘A’. Coolant circulates through cooler tubes in heat exchanger (1), cooling transmission oil around the tubes, and exits at port ‘D’.

Transmission oil to be cooled enters heat exchanger (1), through oil inlet line (14) at port ‘C’, circulates around cooler tubes, exits at port ‘B’ through oil return line (15) to the transmission.

Note: Oil flow must always flow in the opposite direction to coolant flow through transmission oil cooler.

REMOVAL

Numbers in parentheses refer to Fig. 1.

WARNING

To prevent personal injury and property damage, be sure wheel blocks and lifting equipment are properly secured and of adequate capacity to do the job safely.
Cooling System - Transmission Oil Cooler
Section 210-0060

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place the battery master switch in the 'Off' position.

3. Remove mounting hardware securing hood assembly to the machine and, using suitable lifting equipment, remove hood assembly. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS.

4. Open drain cock on the underside of the radiator and drain the coolant into a suitable container. Refer to Section 210-0000, COOLING SYSTEM.

5. Remove drain plug from underside of the transmission and drain the transmission oil into a suitable container. Refer to Section 120-0010, TRANSMISSION AND MOUNTING.

6. Loosen clamps (8) and slide coolant inlet pipe (5) from connection at port 'A'. Drain coolant from coolant inlet pipe (5) and cooler flange (2) into a suitable container.

7. Loosen clamps (12) and slide coolant outlet pipe (6) from connection at port 'D'. Drain coolant from coolant outlet pipe (6) and cooler flange (2) into a suitable container.

8. Remove drain plug from underside of heat exchanger (1) and drain oil into a suitable container. Reinstall drain plug in heat exchanger (1).

9. Remove oil inlet line (14) from elbow (24) at port 'C' on heat exchanger (1). Drain any oil in the line into a suitable container.

10. Remove oil return line (15) from elbow (7) at port 'B' on heat exchanger (1). Drain any oil in the line into a suitable container.

11. Support transmission oil cooler assembly with a suitable lifting device and remove bolts (18), washers (26) and lockwashers (19). Remove transmission oil cooler assembly from the frame mounts.

CLEANING AND DISASSEMBLY
Numbers in parentheses refer to Fig. 1.

Note: In the event of a major mechanical failure, the transmission oil cooler assembly should be cleaned thoroughly or replaced. Do not attempt to clean cooler cores after a transmission failure in which metal particles from worn or broken parts are released into the oil. Replace the cooler cores.

In many areas, raw water is extremely corrosive or scale forming and should be treated to prevent damage to the transmission oil cooler. A properly maintained cooling system will significantly reduce cleaning intervals. Refer to Section 210-0000, COOLING SYSTEM.

Cleaning Oil Side

![WARNING]
Dangerous fumes. To prevent personal injury, use trichloroethane only in the open or in a well ventilated room.

1. Clean transmission oil cooler before sludge hardens. After transmission oil cooler is completely drained, circulate a solution of trichloroethane through the passages surrounding the cooler tubes in heat exchanger (1) to remove sludge.

2. If cooler tubes are badly clogged, circulate an oakite or alkaline solution through heat exchanger (1). Solution should be circulated through heat exchanger (1), in the reverse direction to normal flow, for approximately 15 minutes, after soaking for 10 minutes. The duration of circulation depends on how badly clogged the cooler tubes are. Flush thoroughly with clean hot water.

Cleaning Water Side

1. Match mark cooler flanges (2) and heat exchanger (1) to aid in assembly.

2. Remove bolts (4) securing cooler flanges (2) to heat exchanger (1). Remove cooler flanges (2) from heat exchanger (1) and discard viton seals (3).
3. Make up a solution composed of 1/3 muriatic acid and 2/3 water. To each 9.5 litres (2.5 gal) of solution, add 227 g (0.5 lb) of oxalic acid.

4. Immerse heat exchanger (1) in the cleaning solution. Cleaning action is noticeable by bubbling and foaming. The process must be carefully observed and when bubbling stops, usually between 30 - 60 sec., remove heat exchanger (1) from cleaning solution and flush thoroughly with clean, hot water. After cleaning, dip heat exchanger (1) in light oil.

**Note:** Severely fouled cooler tubes can be cleaned by use of a rotary brush if normal cleaning is not sufficient.

**ASSEMBLY**

Numbers in parentheses refer to Fig. 1.

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. Install new viton seals (3) to cooler flanges (2) and align cooler flanges to heat exchanger (1), as match marked at disassembly.

2. Secure cooler flanges (2) to heat exchanger (1) with bolts (4). Tighten bolts (4) alternately to give an even seal around cooler flange area.

**INSTALLATION**

Numbers and letters in parentheses refer to Fig. 1.

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

**Note:** Tighten all hydraulic lines fitted with ORFS connections, as described in Section 220-0000, STEERING SYSTEM SCHEMATIC. Renew all ‘O’ rings where used.

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**WARNING**

To prevent personal injury and property damage, be sure wheel blocks and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Using suitable lifting equipment, position transmission oil cooler assembly on frame mounting brackets and secure with bolts (18), washers (24) and lockwashers (19).

2. If removed, install elbow (7) in port ‘B’ and install elbow (7) in port ‘C’ on heat exchanger (1). Install oil inlet line (14) on elbow (7) in port ‘C’, and oil outlet line (15) on elbow (7) in port ‘B’.

3. Install coolant outlet pipe (6) on connection at port ‘D’ and secure with sleeve (9) and clamps (12).

4. Install coolant inlet pipe (5) on connection at port ‘A’ and secure with sleeve (9) and clamps (8).

5. If removed, install drain plug in underside of transmission and fill transmission with lubricant, as specified in Section 300-0020, LUBRICATION SYSTEM.

6. Ensure drain cock on underside of radiator is closed and fill radiator with coolant specified in Section 210-0000, COOLING SYSTEM.

7. Place the battery master switch in the ‘On’ position, start the engine and check for leaks. Tighten lines and fittings as required.

8. Using a suitable lifting device, install hood assembly on the machine and secure with mounting hardware, as removed at ‘Removal’. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS.

9. Remove wheel blocks from all road wheels.

**SERVICE TOOLS**

There are no special service tools required for the procedures outlined in this Section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.

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* * * *
DESCRIPTION

Numbers in parentheses refer to Fig. 1.

The operation of the steering system is hydrostatic. That is to say, there is no mechanical connection between the steering column and the steered wheels. Instead there are hydraulic pipes and lines between the steering components and the steering cylinders. Actuating pressure for steering operation is supplied by triple pump (2).

When the steering wheel is turned, steering valve (3) meters an oil volume proportional to the amount of turn. This volume of oil flows to the appropriate side of steering cylinders (6). Steering valve (3) returns automatically to its neutral position when turning is completed.

A brief description of the individual components shown in the steering system are listed below. Detailed service and operating instructions for the individual components can be found in their relative component sections in this manual.

Hydraulic Tank (1)

Refer to Section 235-0040, HYDRAULIC TANK.

The hydraulic tank is the common oil reservoir for the steering and bowl hydraulic systems.

Integral with the tank assembly is a suction screen, filter element, relief valve, adaptor plate, access covers and filler neck assembly. Two sight gauges on the side of the tank assembly indicate hydraulic oil level. Located on top of the tank assembly is a breather assembly.

Triple Pump (2)

Refer to Section 235-0050, TRIPLE PUMP.

The triple pump supplies hydraulic oil for operating the steering and bowl hydraulic systems.

The triple pump is a multiple gear type pump consisting of three separate sections connected together as one assembly.

One section of the pump draws hydraulic oil from the hydraulic tank (1) then pumps the oil to the steering valve (3) where, depending on the spool position, oil is directed to the right or left hand steering cylinders (6) via the double relief valve (4) and flow reversing valve (5).

The remaining two pump sections draw hydraulic oil from the hydraulic tank (1) then pumps the oil to the bowl hydraulic circuit.

The triple pump operates in the one direction only (it is assembled for right hand (clockwise) rotation, as viewed from the driveshaft end).

Note: Never drive a pump in the wrong direction of rotation, as pump seizure may result.

Steering Valve (3)

Refer to Section 220-0090, STEERING VALVE.

Mounted off the underside of the cab floor, the steering valve is connected to the steering column via the steering gear and linkage and controls hydraulic oil flow to the steering cylinders.

The steering valve is equipped with an integral relief valve, a check valve and a flow control valve. The relief valve prevents excessive pressure build up and the check valve prevents a reverse flow of oil from the cylinders back to the pump. The integral flow control valve modulates the pressure applied to the steering cylinders, maintaining smooth steering action.

The relief valve pressure setting is 134 bar (1 950 lbf/in²).

There are four ports on the steering valve housing as follows:

- Port ‘P’ - Supply from pump
- Port ‘T’ - Return to tank
- Port ‘A’ - Cylinder supply
- Port ‘B’ - Cylinder supply
Fig. 1 - Steering System Schematic Diagram

1 - Hydraulic Tank
2 - Triple Pump
3 - Steering Valve
4 - Double Relief Valve
5 - Flow Reversing Valve
6 - Steering Cylinders
Section 220-0000

Steering System - Steering Schematic

Double Relief Valve (4)
Refer to Section 220-0130, DOUBLE RELIEF VALVE.

The double relief valve is mounted to the top face of the flow reversing valve (5). The valve is installed in the lines between the steering valve (4) and steering cylinders (6). The purpose of the double relief valve is to relieve shock loads on the steering cylinders by transferring the excessive pressure applied to the oil by the road shock, to the opposite end of the cylinders. This shock, if left unchecked, might damage steering linkage components.

The double relief valve pressure setting is 145 bar (2 100 lbf/in²).

Flow Reversing Valve (5)
Refer to Section 220-0160, FLOW REVERSING VALVE.

Mounted on the rear of the steering frame between the two steering cylinders, the flow reversing valve distributes the oil to the steering cylinders and also reverses the flow of oil to the cylinders, when one of the pistons is pushed into the housing.

Steering Cylinders (6)
Refer to Section 220-0120, STEERING CYLINDER.

There are two single stage, double acting steering cylinders on the machine. The cylinder base end is connected to the steering trunnion, and, the piston rod end is connected to the pull yoke. Single stage double acting means that the piston rod can have oil applied to either side, extending or retracting the piston rod.

Cylinder mounting is by pins, secured with bolts, lockwashers and nuts. Bushings permit a limited amount of cylinder misalignment when travelling over rough terrain.

Diagnostic Test Point
The steering system has one diagnostic test point which enables the service engineer to obtain an accurate steering system pressure reading.

'O' RING FACE SEALS (ORFS)
Where hydraulic lines are fitted with ORFS connections, the following procedure should be carried out during 'Installation'. Refer to Fig. 2.

a. Ensure ‘O’ ring/seal is in place and that the joining surfaces are clean. If necessary, retain ‘O’ ring/seal in place with a light coating of grease or vaseline.

b. Initially, the nuts should be tightened by hand.

c. Where a hose is fitted, ensure that it is not twisted or kinked when the nuts are tightened so that it is allowed to adopt a natural position.

d. Where a tube is fitted, ensure that the connection is aligned correctly.

e. Tighten the nut a further 1/4 to 1/2 a turn using the correct size spanner (wrench).

f. Check that a satisfactory hose or tube routing has been achieved.

Fig. 2 - Assembly of Typical ORFS Connector
FILLING AND BLEEDING THE STEERING SYSTEM

1. Fill hydraulic tank to maximum level. Be ready to add oil when the engine is started. Do not let oil drop below the pump suction line to prevent air entering the system.

2. Start engine and let it idle. Immediately add oil to the tank as required. When no more oil can be added and oil is clear, proceed as follows:

   a. Turn the steering wheel from lock to lock to bleed the air in the steering cylinders and lines.

   Note: Immediately upon valve spool actuation oil must be added to the hydraulic tank to replenish the oil moving into the circuit.

   b. When the oil in the tank is clear (not cloudy or creamy), the system is free of air.

   Note: Slight creep or drift of the steering wheel is normal.

   c. Fill hydraulic tank to the recommended level and install the filler cap.

Hydraulic Oil

The steering system should be kept filled with hydraulic oil as listed in Section 300-0020, LUBRICATION SYSTEM.

MAINTENANCE

Maintenance instructions, intervals and warnings, in the individual steering and body hydraulic component sections of this manual, should be adhered to at all times.

Relieving Pressure In Steering System

⚠️ WARNING
Dangerous pressure. Turn steering wheel several times in each direction to relieve pressure in the system. Failure to relieve pressure as stated can result in personal injury and property damage.

SERVICE TOOLS

It is recommended that the following service tools are used when carrying out pressure and temperature checks during maintenance procedures. These tools, along with other general service tools, are available from your dealer. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of these tools.

Multi-Gauge

The multi-gauge is basically four pressure gauges in one. Continuous system pressure readings are indicated on one of three simultaneously reading gauges through a pressure range of 30 in of vacuum to 5 000 lbf/in².

Non-contact Infrared Thermometer

The infrared thermometer can be used to spot heat problems early in electrical, mechanical and hydraulic systems. Hand held and easy to use, you simply aim, pull the trigger, and read the temperature. Since there is no need to touch what you are measuring, temperatures of hard-to-reach or moving components can be taken without getting burned or shocked.
DESCRIPTION
Numbers in parentheses refer to Fig. 1.

The steering valve (1) is equipped with an integral relief valve and a check valve. The relief valve prevents excessive pressure build-ups and the check valve prevents a reverse flow of oil from the cylinders back to the pump.

Bolted to the top face of the flow reversing valve (5) is the double relief valve (4). Its primary purpose is to bypass oil from one steering cylinder to the other cylinder when a shock load is placed on the piston rod.

The cored passages of both valves form a direct connection when they are bolted together.

Adding the flow reversing valve (5) and reversing mechanism into the steering system permits the machine to make a 90° turn in either direction.

Oil flow through the steering valve (1) to the cylinders is controlled by the movement of the steering valve spool, 'in' or 'out' of the housing.

Detailed service and operating instructions for the individual components can be found in their relative component sections in this manual.
OPERATION AND FLOW

Numbers in parentheses refer to Fig. 1, unless otherwise specified.

Oil is drawn from the oil tank (7) through line (B) into the suction side of the steering pump (2). Pressurized oil leaves the pump and flows through line (A) to the inlet port of the steering valve (1). Should the pressure exceed 135 bar (1 950 lbf/in²) at the steering valve, the inlet oil will be diverted back to tank (7) by way of the integral relief valve and tank return line (L).

Neutral

In a neutral position, both ports leading from the steering valve (1) to the flow reversing valve (5) and double relief valve (4) are closed and the steering cylinders (3 & 6) hold their positions. The oil flows through the steering valve and is directed back to tank (7) through return line (L).

With the steering valve spool in this position any oil in the cylinders is retained there by the closing of the ports in the steering valve. If a road shock is sustained by a wheel, when the machine is not being steered, the oil in the base or rod end of the steering cylinders (3 & 6) is pressurized as is the oil in the lines to that end from the flow reversing valve and from the double relief valve to the steering valve. If pressure exceeds 145 bar (2 100 lbf/in²) the double relief valve opens and allows a small amount of oil to pass to the opposite ends of the steering cylinders to relieve the excessive pressure.
The right cylinder (3) and retracts the left-cylinder (6) pivoting the machine to the right.

Return oil from the cylinders (3 & 6) flows through lines (G & K), reversing valve (5), double relief valve (4), into line (C) to the steering valve (1) through the lower forward cylinder port. The oil then returns to tank (7) by way of the tank return line (L).

When the left cylinder (8, Fig. 2) reaches its minimum retracted length or when points A, B, and C (Fig. 2) are in line, the flow of oil to left cylinder (8, Fig. 2) is reversed. This is accomplished by the roller of the left reversing mechanism (7, Fig. 2) riding over the cam (9, Fig. 2) of the left cylinder (8, Fig. 2). Cam action pushes the spool into the valve housing, aligning cored
passages which reverse the flow of oil. The reversed flow of oil to the left cylinder is as follows: Oil flows into the base of the cylinder (8, Fig. 2) through line (K), extending the cylinder. Oil returns to the reversing valve (5) through line (J) and returns to the tank (7) as described previously.

With both cylinders extending, the necessary hydraulic force is exerted on the steering frame, enabling the machine to make a 90° right turn.

Left Turn
Numbers and letters in parentheses refer to Fig. 3 unless otherwise specified.

In a left turn the steering valve spool is pushed inward by the steering gear linkage. This allows pressurized oil to flow from the lower forward cylinder port through line (C, Fig. 1) to the right side port of the double relief valve (6). This port is connected to cored passages in the flow reversing valve (5) which, in turn, connect the base end of the left steering cylinder (3) and to the rod end of the right cylinder (8).

Oil flows through the valves (5 & 6) and is simultaneously directed to the base end of left cylinder (3) through line (K, Fig. 1) and to the rod end of right cylinder (8) through line (G, Fig. 1). Oil pressure extends the left cylinder (3) and retracts the right cylinder (8), pivoting the machine to the left.

Return oil from cylinders (3 & 8) flows through lines (H & J, Fig. 1), reversing valve (5), double relief valve (6), into line (D, Fig. 1) and into the steering valve through the lower rear cylinder port. The oil then returns to tank (7, Fig. 1) by way of the tank return line (L, Fig. 1).

The flow of oil to the right cylinder is reversed when the cylinder reaches its minimum retracted position or when points A, B and C (Fig. 3) are in line. This is accomplished by the roller of the right reversing mechanism (7) riding over the cam (9) on the right cylinder (8). The cam action pushes the spool into the valve housing, which aligns cored passages, reversing the oil flow. The reversed flow of oil to the right cylinder is as follows: Oil flows into the base end of the cylinder (8) through line (H, Fig. 1). Return oil flows into the reversing valve (5) through line (G, Fig. 1) and back into the tank (7, Fig. 1) as described previously.

With both cylinders extending, the necessary hydraulic force is exerted on the steering frame, enabling the machine to make a 90° left turn.

Line (E, Fig. 1) is a bleed line for the double relief valve (6), and the flow reversing valve (5) is vented to the tank (7, Fig. 1) through line (F, Fig. 1).

Double Relief Valve
Numbers in parentheses refer to Fig. 1.

The double relief valve (4) goes into operation when a shock load is placed on either of the steering cylinder piston rods. In some instances the shock load can be caused by striking a boulder or a hole. When this occurs the oil that is displaced flows through the cored passages of the flow reversing valve (5) and into the double relief valve (4). The excessive pressure activates a piston in the valve (4) which aligns certain cored passages and allows the oil to flow into the other cylinder or flow back to the tank. This relieves the high pressure caused by the shock load. The relief valve cartridges are preset by the vendor at 145 bar (2 100 lbf/in²) and are lockwired, so no adjustments are necessary.

To check the pressure setting, remove the pipe plug which is located near the main inlet port on the steering valve and install a pressure gauge. Remove the set screw cap and loosen the locknut on the relief valve in the steering valve. Operate the steering system by turning the steering wheel all the way in either direction. Keep the wheel turned all the way and quickly turn relief valve adjusting screw in to increase pressure above the rated setting of the double relief valve. Raise the pressure until the valve relieves.

DO NOT APPLY EXCESSIVE PRESSURE TO THE VALVE TOO LONG; the shock load on the double relief valve in actual service, is instantaneous, so the pressure check should be made the same way.

CAUTION
Be sure to adjust the regular relief valve pressure back to the proper setting after checking the double relief valve.

Steering Cams
1. Steer the machine until the retracting cylinder reaches a position where points A, B & C of Fig. 2 or 3 are in line.

2. With the retracting cylinder in this position, the reversing valve roller is just contacting the steering cam and the reversing valve spool is pushed 10.3 mm (0.406 in) (half of the piston stroke) into the valve
housing. Total piston travel is 20.6 mm (0.812 in). One way of checking spool travel is to mark the spool in its normal position and then mark it again when the above conditions are met. Then measure the distance between the two marks; it should be 10.3 mm (0.406 in).

3. To make this adjustment, either install shims behind the steering cam or change the length of the link assembly.

4. Repeat the above procedure when adjusting the other steering cam.

5. Check the steering operation after adjusting the steering cam. Machine must steer 90° in each direction and the flow reversing valve pistons must travel 20.6 mm (0.812 in) into the valve housing from neutral.

**Steering Stop Blocks**

Steering stop blocks are welded to the steering frame to prevent the steering cylinder pistons from bottoming when the steering cylinders are extended to their maximum strokes (Fig. 4). When these stop blocks become worn, the cylinders may be damaged when the scraper is turned a full 90°, so the maximum strokes of the steering cylinders should be adjusted as follows:

1. Turn the tractor until one cylinder is extended to within 3.2 mm (0.125 in) of the maximum eye-to-eye dimension of 1 274.1 mm (50.16 in), which is dimension 'A' shown in Fig. 4.

2. If there is a gap, due to wear, between the king pin section and the steering frame stop block, measure the distance between the king pin section and the steering frame. Refer to Fig. 4.

3. Burn off the weld and remove the worn stop block. Weld a new stop block to the steering frame according to the welding direction given in Fig. 4. The new blocks, which range in thickness from 6.4 to 19.1 mm (0.25 to 0.75 in) in 3.2 mm (0.125 in) increments, should be slightly thicker than the measured gap.

4. Swing the tractor 180° in the opposite direction and repeat steps 1, 2 and 3.

**Note:** A minimum block thickness of 6.4 mm (0.25 in) is required, regardless of the maximum eye-to-eye dimension.
DESCRIPTION
Numbers in parentheses refer to Figs. 1 & 2.

The steering valve consists of spool (47), lock plunger (18) with poppets (17), cross-over relief valve assemblies (4) and main relief valve assembly (20 thru 36). Shifting spool (47) allows oil to flow to one steering cylinder to extend it while allowing oil to return to the hydraulic oil tank from the opposite cylinder which is contracting. Cross-over relief valve assemblies (4) allow steering cylinders to compensate for road shocks and main relief valve assembly (20 thru 36) relieves oil pressure in excess of 134 bar (1 950 lbf/in²) in the steering valve.

NEUTRAL POSITION
Numbers in parentheses refer to Fig. 2.

Oil enters the steering valve at the inlet port, flows through spool (47) bore and back out of the valve through return-to-tank passages and the return-to-tank port. Oil pressure in the valve is not enough to cause poppets (17) to shift, therefore, ports ‘A’ and ‘B’ remain closed.
Steering System - Steering Valve

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Fig. 2 - Cutaway View of Typical Steering Valve

1 - Seat
2 - 'O' Ring
3 - 'O' Ring
4 - Cross-over Relief Valve
5 - Spring
6 - Valve Body
7 - 'O' Ring
8 - Plug
9 - Cover
10 - Cap
11 - 'O' Ring
12 - Retaining Ring
13 - 'O' Ring
14 - Plug
15 - Spring
16 - Lockwasher
17 - Poppet
18 - Lock Plunger
19 - Cap
20 - Nut
21 - Jam Nut
22 - Washer
23 - Screw
24 - Cap
25 - 'O' Ring
26 - Spring
27 - Poppet
28 - Seat
29 - 'O' Ring
30 - Spring
31 - Check
32 - Seat
33 - Check
34 - Spring
35 - 'O' Ring
36 - Cap
37 - Shims
38 - Nut
39 - Washer
40 - Washer
41 - Spacer
42 - Spring
43 - Plate
44 - Shims
45 - Washer
46 - Seal
47 - Spool
48 - Wiper
49 - Plate
50 - Lockwasher
51 - Bolt
52 - Plug
53 - Capscrew
54 - Poppet

* - Shown on Fig. 1
**SPOOL IN POSITION**

Numbers in parentheses refer to Fig. 2.

Movement of spool (47) inward in the control valve causes pressure to increase in the control valve. Oil travels through the centre passage and enters lock plunger (18) where it forces poppets (17) outward in the lock plunger. Oil flows through passage (A), lock plunger (18), around poppet (17) and back out the lock plunger to port ‘A’. The oil then flows to the flow reversing valve and the steering cylinder. As the cylinder piston is forced outward, oil in the opposite steering cylinder is forced out of the cylinder. Oil from the steering cylinder enters the steering valve at port ‘B’, enters lock plunger (18), flows around poppet (17) and enters passage (B). Oil flows around spool (47) and into the return-to-tank passage where it returns to the tank through return-to-tank port. Centering spring (42) returns the spool (47) to ‘Neutral’ position when the steering wheel is straightened out.

**SPOOL OUT POSITION**

Numbers in parentheses refer to Fig. 2.

When spool (47) is moved outward in the steering valve, oil pressure builds up and the pressure in the centre passages causes poppets (17) to move outward in lock plunger (18). Oil flows through passage (B) into lock plunger (18), around poppet (17) and out port ‘B’ to the flow reversing valve then to the steering cylinder. As the cylinder piston is forced outward, the oil in the opposite cylinder is forced out of the cylinder by the inward movement of the piston rod. This oil enters port ‘A’, travels around poppet (17) in lock plunger (18) and enters the return-to-tank passage. The oil exits the steering valve at the return-to-tank port, then returns to the hydraulic oil tank. Returning the steering wheel to straight ahead position, allows centering spring (42) to bring spool (47) to the ‘Neutral’ position.

**CROSS-OVER RELIEF VALVE ASSEMBLIES**

Numbers in parentheses refer to Fig. 2.

Rough steering due to road shocks is prevented by cross-over relief valve (4) assemblies. A wheel hitting an obstruction or chuck hole will cause one piston rod in a steering cylinder to move outward and the piston rod in the other steering cylinder to move inward. The piston rod moving outward creates a void in the steering cylinder and the piston rod moving inward creates a high pressure on the oil in the cylinder. To relieve this situation the cross-over relief valve assemblies add to oil in a steering cylinder or relieve excess pressure in the cylinder.

If the steering cylinder connected to port ‘B’ receives a road shock, oil is forced out of the cylinder and pressure builds up at port ‘B’. Oil travels from port ‘B’ to the cross-over relief valve where excess oil pressure forces poppet (54) off its seat, allowing oil to flow through the cross-over relief valve and into passage (B) where the oil joins with the other oil and returns to the hydraulic oil tank through return-to-tank port. The steering cylinder connected to port ‘A’ begins to cavitate because the piston rod is being forced outward in the cylinder. This drop in pressure behind poppet (17) allows oil pressure in passage (A) to push poppet (17) back. Oil flows from passage (A) past poppet (17) to port ‘A’. The oil flows out of port ‘A’ and into the steering cylinder to fill the cavity left by the steering cylinder piston rod moving outward in the cylinder.

Should the other steering cylinder receive the shock, the above actions would take place but in reverse.

**MAIN RELIEF VALVE**

Numbers in parentheses refer to Fig. 2.

Oil pressure in the steering valve is normally 134 bar (1950 lbf/in²). When oil pressure rises above the setting, oil in the centre passage forces check (31) off its seat. Movement of check (31) compresses oil behind the check, causing poppet (27) to be unseated and allow excess oil behind the check to flow into the return-to-tank passage and then to the hydraulic oil tank through return-to-tank port. Unseating check (31) allows excess oil to flow through seat (32) and unseat check (33). Excess oil flows around check (33) and back to the hydraulic oil tank through return-to-tank passage and return-to-tank port. As pressure returns to normal, the springs behind checks (31 & 33) seat the checks and a spring behind poppet (27) returns the poppet to its seated position.
Steering System - Steering Valve

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REMOVAL

Numbers in parentheses refer to Fig. 1.

WARNINGs

Hydraulic fluid pressure will remain within the system after engine shutdown. To prevent personal injury and property damage, turn steering wheel several times in each direction to relieve pressure in the system.

To prevent personal injury and property damage, be sure wheel blocks are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, ensure bowl and apron are fully lowered. Apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Place the battery master switch in the 'Off' position and block all road wheels.

3. Thoroughly clean the exterior of the steering valve and its surrounding area to prevent dirt from entering the valve ports or hydraulic lines during removal.

Note: If steering valve is being serviced to correct a suspected spool seal leak, the condition of nut (20) and washer (22) should be inspected before removing the steering valve. Replace nut (20) and washer (22), if defective. Nut (20) should be torque tightened to 50 Nm (35 lbf ft), lubricated. If valve continues to leak, further servicing is indicated.

4. Identify and tag all hydraulic oil lines, to aid in installation. With a suitable container available to catch spillage, disconnect hydraulic lines from steering valve. Cap all lines and plug all ports of the steering valve to prevent ingress of dirt.

5. Disconnect the link bar and rod end from steering valve spool (47).

6. Remove mounting hardware from steering valve and transfer steering valve to a clean area for disassembly.

DISASSEMBLY

Numbers in parentheses refer to Fig. 1 & 2.

1. If required, remove fittings from steering valve and identify to aid in assembly.

2. Remove seat (1) and ‘O’ rings (2 & 3) from valve body (6). Shake out cross-over relief valve (4) assembly and spring (5) being careful not to damage valve. Discard ‘O’ rings (2 & 3). Repeat process for other cross-over relief valve (4) assembly.

Note: Do not disassemble cross-over relief valve (4) assemblies. Valves are pressure set at 145 bar (2 100 lbf/in²) at assembly. If cross-over relief valve (4) is defective it must be replaced with a new assembly.

3. Remove cap (19) and ‘O’ ring (11) from valve body (6). Discard ‘O’ ring (11).

4. Remove plunger cap (10) and ‘O’ ring (11) from opposite side of valve body (6). Discard ‘O’ ring (11). Tap lock plunger (18) assembly out cap (10) side, using a soft drift and drive.

5. Remove cap screws (53) and lockwashers (50). Remove plate (49) and wiper (48). Discard wiper (48), if damaged.

6. Hold the link bar end of the control spool (47) securely across the flats and loosen nut (38) on the opposite end. Back the nut off slowly to release the compression of spring (42). Remove nut (38), washer (39), first washer (40), spacer (41), spring (42) and second washer (40). Lift off shims (37 & 44) and plate (43). Discard the shims (37 & 44) if they are damaged. Remove washer (45) and seal (46) from valve body (6) bore. Discard seal (46).

7. Remove bolts (51) and lockwashers (50). Remove plate (49) and wiper (48). Discard wiper (48), if damaged.

8. Pull spool (47) out of valve body (6) being careful not to nick or scratch the surface of the spool. Remove and discard seal (46) from groove in valve body (6) bore.
9. Remove plug (8) and ‘O’ ring (7) from valve body (6). Discard ‘O’ ring (7).

10. Remove nut (20) and one washer (22). Loosen jam nut (21) and back off adjusting screw (23) to release compression of spring (26), then remove adjusting screw (23), jam nut (21), second washer (22) and cap (24). Remove poppet spring (26) and poppet (27) from valve body (6). Remove and discard ‘O’ ring (25) from cap (24).

11. Remove cap (36), spring (34) and check (33) from valve body (6). Remove and discard ‘O’ ring (35) from cap (36).

12. Insert a soft metal rod, with a diameter of 6.4 mm (0.25 inches) into valve body (6) from cap (36) side, through bore in seat (32) and push out check (31), spring (30) and seat (28). Remove and discard ‘O’ ring (29) from seat (28). Insert rod through cap (24) side of valve body (6) and push out plunger seat (32).

13. Clamp lock plunger (18) in a soft-jawed vice and remove retaining ring (12), plugs (14), springs (15) and poppets (17) from ends of lock plunger. Remove and discard ‘O’ rings (13) from plugs (14).

**INSPECTION**
Numbers in parentheses refer to Figs. 1 & 2.

1. Clean all parts with a suitable solvent and dry with a clean lint free cloth or compressed air.

2. Inspect valve and poppet seat for scoring, eroding, or out-of-round. The seat must have sharp edges. Check the seating surfaces on valves and poppets for defects that may cause leakage. Replace if the surfaces are eroded or show excessive wear and prevent proper seating.

3. Inspect the valve body (6) bores, spool (47) and lock plunger (18) for grooves, deep scoring, or wear. Check the spool and plunger for flaking of the chrome plating. For inspection purposes, coat them with clean hydraulic oil and install them in their respective bores in the valve body (6). While rotating them, work the spool and plunger in and out as in actual operation to determine the extent of wear and to see if they fit without binding. If the fit is too loose or if there is damage, valve body and plungers MUST be replaced as an assembly.

**ASSEMBLY**
Numbers in parentheses refer to Fig. 1 & 2.

**Note:** Lubricate the bore of steering valve body (6) and all parts with hydraulic oil to facilitate assembly. Refer to Section 300-0020, LUBRICATION SYSTEM for oil specification.

1. Clamp lock plunger (18) horizontally in a soft-jawed vice.

2. Install poppet (17) and spring (15) in retaining groove end of lock plunger (18). Install new ‘O’ ring (13) on plug (14). Position plug (14) over spring (15) and install into lock plunger (18). Install retaining ring (12) in lock plunger. Repeat for opposite end of lock plunger (18).

3. Coat lock plunger (18) with hydraulic oil and install in valve body (6).

4. Install new ‘O’ ring (11) on cap (10) and thread cap (10) into valve body (6). Tighten cap (10) until it bottoms against the housing.

5. Install new ‘O’ ring (11) on cap (19) and thread cap (19) into valve body (6). Make sure that plug (14) seats properly in lock plunger (18). Tighten cap (19) until it bottoms against the housing.

6. Clamp spool (47) in a soft-jawed vice with the link bar end down.

7. Position one washer (40), spring (42), spacer (41), second washer (40) and washer (39) over end of spool (47). Clean threads of spool and nut (38) making sure the threads are free of oil and apply Loctite, or suitable equivalent to the threads. Install nut (38) on spool (47) and torque tighten to 70 - 80 Nm (50 - 60 lbf ft), lubricated.

8. Install new seal (46) and washer (45) in groove on cover (9) side of valve body (6) and new seal (46) on wiper (48) side of valve body (6).

9. Remove spool (47) from vice and coat with hydraulic oil. Slide plate (43) and shims (37 & 44) over link bar end of spool (47) until they contact washer (40). Carefully slide spool (47), link bar end first, through bore in valve body (6) making sure seal (46) and washer (45) are not dislodged from their grooves.
10. Fully depress spool (47) at nut end, until it bottoms, check dimension B as shown in Fig. 3. If dimension B is 31.2 mm (1.23 inch), for example, the thickness taken by shims B, Fig. 3, must be reduced by 0.51 mm (0.020 inch) to obtain the correct 31.8 mm (1.25 inch) dimension. If dimension B exceeds 31.8 mm (1.25 inch), the thickness taken by shims B must be increased. Shims B, Fig. 3, are available in 0.050, 0.13, 0.25, 0.50 and 0.64 mm (0.002, 0.005, 0.010, 0.020 and 0.025 inch) sizes. Do not use a shim A in place of a shim B.

11. Line up the cap screw holes in shims, plate and valve body (6). Install new plug (52) into cover (9) over end of spool (47) and secure to valve body (6) with four cap screws (53) and lockwashers (16). Torque tighten cap screws (53) to 40 - 50 Nm (30 - 40 lbf ft), lubricated.

12. Fully depress spool (47) into cover (9) and check dimension A as shown in Fig. 3. If, for example, dimension A is 19.6 mm (0.77 inch), the thickness taken by shims A, Fig. 3, must be increased by 0.50 mm (0.02 inch) to obtain the correct 19.1 mm (0.75 inch) dimension. If dimension A is less than 19.1 mm (0.75 inch), the thickness taken by shims A must be reduced. Shims A, Fig. 3, are available in 0.05, 0.13 and 0.25 mm (0.002, 0.005 and 0.010 inch) sizes. Do not use a shim B in place of a shim A.

13. Check the dimension shown in Fig. 3 with spool in 'Neutral and Hold' position. If the 25.4 mm (1.00 inch) dimension is not obtained, re-check dimensions A and B, Fig. 3, and adjust as required.

14. Install wiper (48) over link bar end of spool (47) and into groove in valve body (6). Secure wiper with plate (49) and two bolts (51) and lockwashers (50).

15. Place new ‘O’ ring (7) on plug (8) and thread plug into valve body (6) until it bottoms.

16. Install new ‘O’ rings (2 & 3) on seat (1).

17. Place one spring (5) in bore on side of valve body (6), followed by cross-over relief valve (4) assembly and seat (1). Screw seat (1) into valve body (6) until it bottoms against housing. Repeat this step for other cross-over relief valve (4) assembly in opposite side of valve body (6).

18. Using a soft metal rod with a diameter of 12.7 mm (0.50 inch), press or tap seat (32) into bore of valve body (6).

19. Install new ‘O’ ring (35) on cap (36). Position spring (34) in opening of cap (36) and check (33) in spring (34) and into cap (36). Install check and cap assembly into valve body (6). Make sure check is in proper position on seat (32) and secure cap to valve body (6).

20. Insert check (31) into opposite side of valve body (6) and against seat (32) in housing. Install spring (30) in open end of check (31) in valve body (6).

21. Install new ‘O’ ring (29) on seat (28). Insert seat into valve body (6) against spring (30). Make sure spring is positioned in embossment on inner face of seat.

22. Install new ‘O’ ring (25) on cap (24). Thread adjusting screw (23) through cap (24). Position spring (26) and poppet (27) on boss end of adjusting screw and install cap (24) in valve body (6). Make sure poppet (27) is guided into seating surface of seat (28). Thread cap into valve body (6) until it bottoms on housing.

23. Install one washer (22), jam nut (21), second washer (22) and nut (20) on adjusting screw (23). Do not tighten nut (20) until relief valve adjustment is set.
**INSTALLATION**

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

**Note:** Tighten all hydraulic lines fitted with ORFS connections, as described in Section 220-0000, STEERING SYSTEM SCHEMATIC.

1. Make certain, area of installation is clean. Position steering valve onto mounting bracket on frame and secure in place with mounting hardware as removed at Removal. Tighten bolts equally so that the valve body is not distorted.

2. Remove blanking caps from hydraulic lines and install lines to steering valve as identified during removal.

3. Attach the end rod and link bar to the steering valve spool. Refer to Section 220-0180, STEERING GEAR AND LINKAGE, for attachment of link bar.

4. Check oil level in the hydraulic tank and add oil if required. Refer to Section 235-0040, HYDRAULIC TANK for correct fill level, and, Section 300-0020, LUBRICATION SYSTEM for oil specification.

5. Place the battery master switch in the 'On' position, start the engine and bring hydraulic oil to operating temperature.

6. Turn steering wheel lock to lock several times and check steering valve and hydraulic line connections for leaks and tighten as required.

7. Stop the engine and turn the steering wheel several times to bleed oil pressure. Check the hydraulic oil tank level. Replenish if required.

8. Remove wheel blocks.

**ADJUSTING RELIEF VALVE**

Numbers in parentheses refer to Figures 2 and 8.

Remove plug from gauge port of steering valve and fit a 0 - 207 bar (0 - 3 000 lbf/in²) pressure gauge.

Start engine and allow hydraulic oil to warm up to normal operating temperature. Steer the machine a full 90° and lock brakes. With steering cylinder at end of stroke, keep steering wheel turned. This will keep steering valve control spool in an operating position and allow pressure to build up.

With machine operating at 1 500 rpm, the relief valve should open at 134 bar (1 950 lbf/in²).

If pressure is above or below recommended pressure setting, adjust the relief valve as follows:

1. Remove nut (20) and washer (22).

2. Loosen jam nut (21).

3. Turn adjusting screw (23) in to increase pressure or out to decrease pressure.

4. Tighten jam nut (21) after completing adjustments.

5. Reinstall washer (22) and nut (20). Torque tighten nut to 50 Nm (35 lbf ft), lubricated.

6. Shut off engine and release oil pressure in the system by turning the steering wheel back and forth. Remove pressure gauge and reinstall plug in steering valve.

**SPECIAL TOOLS**

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.

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**SPECIAL TORQUE SPECIFICATIONS**

<table>
<thead>
<tr>
<th>FIG NO</th>
<th>ITEM NO</th>
<th>DESCRIPTION</th>
<th>TORQUE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nm</td>
</tr>
<tr>
<td>1 &amp; 2</td>
<td>20</td>
<td>Nut</td>
<td>50</td>
</tr>
<tr>
<td>1 &amp; 2</td>
<td>38</td>
<td>Nut</td>
<td>70 - 80</td>
</tr>
<tr>
<td>1</td>
<td>53</td>
<td>Capscrew</td>
<td>40 - 50</td>
</tr>
</tbody>
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* * * *
DESCRIPTION
Numbers in parentheses refer to Fig. 1.

There are two single stage, double acting steering cylinders on the machine. The cylinder base end is connected to the steering trunnion, and, piston rod (20) end is connected to the pull yoke. Single stage double acting means that piston rod (20) can have oil applied to either side, extending or retracting the piston rod.

Cylinder mounting is by pins, secured with bolts, lockwashers and nuts. Bushings (5) permit a limited amount of cylinder misalignment when travelling over rough terrain.

OPERATION
When the operator turns the steering wheel for a steering operation, movement of the piston rod generates force required to pivot the tractor frame.

In the neutral position, with the steering valve centralized, oil movement between the steering cylinders and the steering valve is stopped. Trapped oil in the system locks both steering cylinders and the angle of steering set by the operator is maintained. Refer to Section 220-0090, STEERING VALVE, for operation of the steering valve.
Steering System - Steering Cylinder

Section 220-0120

REMOVAL
Numbers in parentheses refer to Fig. 1.

⚠️ WARNINGS
Turn steering wheel several times in each direction to relieve any pressure in the system. Failure to release pressure as stated can result in personal injury and property damage.

⚠️ To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate steering right and left several times to relieve pressure in the steering system.

2. Block all road wheels and place the battery master switch in the 'Off' position.

3. Identify and tag all hydraulic lines on one steering cylinder. With a suitable container available to catch spillage, disconnect hydraulic lines. Cap all lines and fittings to prevent ingress of dirt.

4. Support steering cylinder with a suitable lifting device.

5. Remove bolt, lockwasher and nut securing pin at piston rod (20) end of the cylinder. Remove pin securing piston rod (20) end to the pull yoke.

6. Remove bolt, lockwasher and nut securing pin at base end of the cylinder tube (1). Remove pin securing base end to the steering trunnion.

7. Remove cylinder assembly from the machine.

8. Remove cylinder assembly to a clean area for disassembly. Drain oil from cylinder assembly into a suitable container.

9. Repeat steps 3 through 8 for opposite steering cylinder assembly.

DISASSEMBLY
Numbers in parentheses refer to Fig. 1.

⚠️ WARNING
To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

1. Ensure clean working conditions, remove any port plugs thus allowing easy entry of air into the cylinder, preventing a vacuum when parts are withdrawn from cylinder tube (1).

2. Match mark end cap (2) and cylinder tube (1) for correct alignment during assembly. Remove bolts (10) and washers (11) securing end cap (2) to cylinder tube (1).

3. Pull end cap (2), piston rod (20) and piston (3) out of cylinder tube (1) as an assembly.

4. Position eye end of piston rod (20) in a soft-jawed vice and remove locking screw (4).

5. Pull piston (3) assembly off piston rod (20) and remove and discard piston seal (13), wear ring (12) and 'O' ring (19) from piston (3).

6. Pull end cap (2) assembly off piston rod (20). Remove and discard backup ring (15) and 'O' ring (14) from outer groove of end cap (2). Remove and discard wear rings (21), rod seal (16), nylon ring (18) and wiper (17) from inner grooves of end cap (2).

7. If the piston rod bushing (5) is damaged, drive it out of the rod eye and discard it. Do not remove steering cam (6) unless it is damaged and has to be replaced.
INSPECTION

Numbers in parentheses refer to Fig. 1

1. Clean all parts of the cylinder with a suitable solvent and dry with clean, lint-free cloths. Clean all grooves carefully to remove any foreign material.

2. Check cylinder tube (1) bore, outer diameter of piston (3) and piston grooves for scratches, cracks or other signs of damage. Remove ridges, nicks and scratches with a fine stone and re-clean. Replace any components which cannot be repaired.

3. Inspect piston rod (20) for distortion, cracks or other defects. Replace piston rod (20) if defective area is irreparable.

4. Check bushings (5) for wear and replace if necessary.

ASSEMBLY

Numbers in parentheses refer to Fig. 1.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

Note: To facilitate assembly, lubricate all internal sliding or wearing surfaces prior to assembly with the same hydraulic oil that is used in the system.

WARNING
To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

1. If necessary, press new bushing (5) into eye end of piston rod (20).

2. Install new rod seal (16) in bore of end cap (2) with the lip pointing towards the internal face of the end cap (2). Install new nylon ring (18) behind rod seal (16) in groove.

3. Install new wiper (17) and new wear rings (21) into bore of end cap (2).

4. Install new backup ring (15) and new 'O' ring (14) on outer groove on end cap (2).

5. Guide end cap (2) assembly onto piston rod (20).

6. Install piston seal (13) and wear ring (12) into piston (3) external grooves. Install 'O' ring (19) into internal groove of piston (3).

7. Install piston (3) on piston rod (20) and tighten to a torque of 1 355 Nm (1 000 lbf ft).

8. Install new locking screw (4) into piston (10) and tighten to a torque of 48 Nm (36 lbf ft).

9. Ensure bore of cylinder tube (14) is well lubricated with hydraulic oil. Carefully insert piston rod (20), piston (3) and end cap (2) assembly into the cylinder tube (1), making certain that piston seal (13) is compressed correctly, and backup ring (15) and 'O' ring (14) are in place on the end cap (2).

10. Align end cap (2) and cylinder tube (1) as marked during Disassembly. Install bolts (10) and washers (11) and secure end cap (2) to cylinder body (1). Tighten bolts (10) to a torque of 260 - 280 Nm (190 - 210 lbf ft). Use feeler gauge to check the gap variation between the cap and cylinder which must not exceed 0.38 mm (0.015 inch) when measured at four equally spaced points on the circumference.

INSTALLATION

Numbers in parentheses refer to Fig. 1.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

Note: Tighten all hydraulic lines fitted with ORFS connections, as described in Section 220-0000, STEERING SYSTEM SCHEMATIC. Renew all 'O' rings where used.

WARNING
To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

1. Install a suitable strap, or other lifting device, around one cylinder assembly and position cylinder assembly on the vehicle, with base end of cylinder ready for mounting.
2. Install pin through base end of cylinder tube (1) and steering trunnion. Secure pin with bolt, lockwasher and nut as removed at Removal.

3. Install pin through pull yoke and piston rod (20) end of the cylinder. Secure pin with bolt, lockwasher and nut as removed at Removal.

4. Connect hydraulic lines to steering cylinder ports, as tagged during Removal.

5. Repeat steps 1 through 4 for installation of opposite steering cylinder.

6. Check oil level in hydraulic tank and add oil if low. Refer to Section 230-0040, HYDRAULIC TANK, for correct fill level. Refer to Section 300-0020, LUBRICATION SYSTEM, for the type of oil used.

7. Remove wheel blocks.

8. Place the battery master switch in the 'On' position, start the engine and operate the steering, from lock to lock several times, to purge air out of the hydraulic lines. Check hydraulic lines and fittings for leaks. Tighten lines and fittings as required.

**MAINTENANCE**

Inspect steering cylinders regularly for leaks or damage, repair as required. Lubricate cylinder pins every 50 hours, as specified in Section 300-0020, LUBRICATION SYSTEM.

**SPECIAL TOOLS**

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools and adhesives required. These tools and adhesives are available from your dealer.

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### SPECIAL TORQUE SPECIFICATIONS

<table>
<thead>
<tr>
<th>FIG. NO.</th>
<th>ITEM NO.</th>
<th>ITEM NAME</th>
<th>TORQUE</th>
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<tbody>
<tr>
<td></td>
<td>3</td>
<td>Piston</td>
<td>1 355 1 000</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Locking Screw</td>
<td>48 36</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Bolt</td>
<td>260 - 280 190 - 210</td>
</tr>
</tbody>
</table>

* * * *
DESCRIPTION AND OPERATION

Numbers in parentheses refer to Fig. 1.

The double relief valve is an oil by-passing device with two spring loaded pistons which are set and sealed in the relief valve cartridges.

The double relief valve is used to relieve shock loads transmitted to the steering cylinders by the machine striking a boulder, hole or other similar object. When this occurs, the oil that is displaced, flows through the cored passage of the flow reversing valve and into the double relief valve. The excessive pressure unseats the cartridge piston and feeds the pressurized oil to the opposite steering cylinder which stabilizes the steering.
Normal Oil Flow

Normally, oil flows from the steering valve through one of the ports and into the double relief valve. It then flows through the valve and directly into the flow reversing valve. Displaced oil from the steering cylinder and flow reversing valve flows through the double relief valve and then continues on to the steering valve.

For information concerning the oil flow through the flow reversing valve, refer to Section 220-0160, FLOW REVERSING VALVE.

By-Passing Oil Flow

Numbers in parentheses refer to Fig. 1.

This by-passing operation is the same regardless of which cylinder by-passes the oil.

When shock impact creates excessive pressure against the steering cylinder, the pressurized oil will enter the double relief valve at ‘P-1’ port. The oil will flow behind the poppet (7) and around the exposed end of the spring loaded piston in the cartridge assembly (2). If the pressure exceeds the rated bar (lbf/in²) setting of the cartridge assembly (2), the piston will be forced off its seat and allow oil to enter the passageway between the cartridge assembly (2) and the poppet (7). Pressure against the face of the poppet and the cavitation action on the poppet from the other cylinder will unseat the poppet and allow oil to flow out ‘P-2’ port to the opposite cylinder. When excessive pressure is dissipated, spring pressure overcomes the hydraulic pressure and returns the cartridge piston and poppet to their normal closed positions. The surplus oil flows out of the ‘Return Port’ and returns to the hydraulic tank.

REMOVAL

Numbers in parentheses refer to Fig. 2.

**WARNINGS**

Hydraulic fluid pressure will remain within the system after engine shutdown. To prevent personal injury and property damage, turn steering wheel several times in each direction to relieve pressure in the system.

To prevent personal injury and property damage, be sure wheel blocks are properly secured and of adequate capacity to do the job safely.

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1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure the steering system.

2. Place the battery master switch in the 'Off' position and block all road wheels.

3. Before removal of double relief valve (2) from the machine, clean exterior of the valve and hydraulic oil lines to prevent ingress of dirt.

4. Identify and tag all hydraulic oil lines, to aid in installation. With a suitable container available to catch spillage, disconnect hydraulic lines from double relief valve (2). Cap all lines and plug all ports of the double relief valve (2) to prevent ingress of dirt.

5. Index mark the double relief valve (2) and flow reversing valve (5) to aid installation. Remove bolts and lockwashers (1) securing double relief valve (2) to the flow reversing valve (5). Lift off double relief valve (2) and transfer to a clean area for disassembly. Remove and discard ‘O’ rings (3) from flow reversing valve (5).
**DISASSEMBLY**

Numbers in parentheses refer to Fig. 1.

1. If required, remove elbows from double relief valve and identify to aid in assembly.

2. Carefully remove cartridge assemblies (2) from valve body (1). Remove and discard ‘O’ rings (3 & 4).

3. Carefully remove poppet plugs (5) from valve body (1). Remove ‘O’ rings (8), springs (6) and poppets (7) from valve body (1). Discard ‘O’ rings (8).

   **Note:** To remove spring (6) and poppet (7) from valve body (1), it is necessary to turn valve body on its end and tap down on a work bench, or other suitable area, to release the parts.

4. If necessary, remove plugs (10) from valve body (1).

5. Check condition of valve cartridges (2). Insert a blunt nose drift or punch in cartridge end and depress piston.

   **Note:** If piston does not move freely or hangs up, replace cartridge. Cartridge should also be replaced if lead seal has been removed and cartridge adjustment has been tampered with.

**ASSEMBLY**

Numbers in parentheses refer to Fig. 1.

1. If removed, install plugs (10) in valve body (1).

2. Install springs (6) in end of poppet plugs (5) and insert in poppets (7). Install new ‘O’ rings (8) on poppet plugs (5) and install plug assemblies in valve body (1).

3. Install new ‘O’ rings (3 & 4) on valve cartridges (2). Lubricate threaded end of cartridge (2) and install in valve body (1).

4. If removed, install elbows on double relief valve as tagged at disassembly.

**INSPECTION**

Numbers in parentheses refer to Fig. 1.

**Note:** There is a seal kit available to replace all of the seals in the valve. Refer to the Parts Book for part number of the seal kit.

1. Clean all parts with a suitable solvent and dry with compressed air.

2. Inspect all threaded parts for stripped or damaged threads.

3. Inspect valve body (1) bores and poppets (7) for excessive wear, scratches or deep grooves. If either valve body (1) or poppets (7) are damaged beyond repair, the complete valve assembly must be replaced.

4. Inspect springs (6) for breaks, lack of tension or other damage. Replace if required.

5. Check condition of valve cartridges (2). Insert a blunt nose drift or punch in cartridge end and depress piston.

   **Note:** If piston does not move freely or hangs up, replace cartridge. Cartridge should also be replaced if lead seal has been removed and cartridge adjustment has been tampered with.

**INSTALLATION**

Numbers in parentheses refer to Fig. 2.

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

**Note:** Tighten all hydraulic lines fitted with ORFS connections, as described in Section 220-0000, STEERING SYSTEM SCHEMATIC.

1. Make certain, area of installation is clean. Position new ‘O’ rings (3) and double relief valve (2) onto flow reversing valve (5), as per index marks and secure in place with bolts and lockwashers (1). Tighten bolts (1) to a torque of 80 Nm (58 lbf ft), lubricated.

   **Note:** If a new double relief valve (2) is being installed, be sure to line up the ports in the bottom face of the double relief valve (2) housing with the ports of the flow reversing valve (5).
2. Remove blanking caps from hydraulic lines and install lines to double relief valve as identified during removal.

3. Check oil level in the hydraulic tank and add oil if required. Refer to Section 235-0040, HYDRAULIC TANK for correct fill level, and, Section 300-0020, LUBRICATION SYSTEM for oil specification.

4. Place the battery master switch in the 'On' position, start the engine and bring hydraulic oil to operating temperature.

5. Check double relief valve and hydraulic line connections for leaks and tighten as required.

6. Remove wheel blocks.

**SPECIAL TOOLS**

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.

<table>
<thead>
<tr>
<th>FIG NO</th>
<th>ITEM NO</th>
<th>DESCRIPTION</th>
<th>TORQUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1</td>
<td>Bolt</td>
<td>80 Nm</td>
</tr>
</tbody>
</table>

* * * *
DESCRIPTION AND OPERATION

Letters in parentheses refer to Fig. 1.

The flow reversing valve distributes the oil to the steering cylinders and also reverses the flow of oil to the cylinders, when one of the pistons is pushed into the housing. The valve is mounted on the rear of the steering frame between the two cylinders.

In Fig. 1, channel ‘A’ is connected to ‘C’ by the cored passage ‘B’. Channel ‘C’ is connected to the base of the right steering cylinder and the rod end of the left steering cylinder. Channel ‘D’ is connected to the base of the left steering cylinder and the rod end of the right steering cylinder.

Channels ‘E’ are connected together by a horizontally drilled passage, not shown in the illustration. They act as vent passages for high pressure oil to protect the seals.

OIL FLOW

Right Turn

Letters in parentheses refer to Fig. 1.

Oil flows into the valve housing through the top left port (not shown) into channel ‘A’. Oil flows around the land of the left plunger through channel ‘B’ and into channel ‘C’. From ‘C’ the oil flow simultaneously into the base of the right cylinder and into the rod end of the left cylinder.

In an extremely sharp right turn, the oil flow to the left steering cylinder is reversed by the left plunger being pushed 20.638 mm (0.8125 inch) into the valve housing. Refer to Section 220-0010, STEERING LINES AND FITTINGS. The lower part of the channel ‘C’ is blocked by the large land of the left plunger. Channel ‘A’ and the lower part of channel ‘D’ are now connected, allowing oil to flow into the base of the left steering cylinder.
Steering System - Flow Reversing Valve

Section 220-0160

Oil enters the valve housing through the top right port (not shown) and flows into channel ‘D’. The oil flows through channel ‘D’ and into the base of the left steering cylinder and the rod end of the right steering cylinder.

In an extremely sharp left turn, the oil flow to the right steering cylinder is reversed by the right plunger being pushed 20.638 mm (0.8125 inch) into the valve housing. Refer to Section 220-0010, STEERING LINES AND FITTINGS. The small middle land of the right plunger blocks the passage to the rod end of the right cylinder. Channel ‘D’ is now connected to the upper part of channel ‘C’. This allows oil to flow into the base end of the right steering cylinder.

**Left Turn**
Letters in parentheses refer to Fig. 1.

**REMOVAL**
Numbers in parentheses refer to Fig. 3.

**WARNINGS**
Hydraulic fluid pressure will remain within the system after engine shutdown. To prevent personal injury and property damage, turn steering wheel several times in each direction to relieve pressure in the system.

To prevent personal injury and property damage, be sure wheel blocks are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.
2. Place the battery master switch in the 'Off' position and block all road wheels.

3. Remove double relief valve (2) from the machine. Refer to Section 220-0130, DOUBLE RELIEF VALVE.

4. Before removal of flow reversing valve (5) from the machine, clean exterior of the valve and hydraulic oil lines to prevent ingress of dirt.

5. Disconnect the reversing linkage from the eye of the plungers.

6. Identify and tag all hydraulic oil lines, to aid in installation. With a suitable container available to catch spillage, disconnect hydraulic lines from flow reversing valve (5). Cap all lines and plug all ports of the flow reversing valve (5) to prevent ingress of dirt.

7. Remove bolts and lockwashers (4) securing flow reversing valve (5) to the steering trunnion. Remove flow reversing valve (5) and transfer to a clean area for disassembly. Remove and discard 'O' rings (3).

**DISASSEMBLY**
Numbers in parentheses refer to Fig. 2.

1. If required, remove fittings from flow reversing valve and identify to aid in assembly.

2. Remove plunger stop plugs (4 & 6) from valve body (1). Remove and discard 'O' rings (5).

3. Match mark plungers (2) to their respective bores in valve body (1). Pull both plungers (2) out from valve body (1).

4. Pry seals (3) out of plunger stop plugs (4). Discard seals (3).

5. If required, remove plugs (7 & 8) from valve body (1).

**INSPECTION**
Numbers in parentheses refer to Fig. 1.

**Note:** There is a seal kit available to replace all of the seals in the valve. Refer to the Parts Book for part number of the seal kit.

1. Clean all parts with a suitable solvent and dry with compressed air.

2. Inspect all threaded parts for stripped or damaged threads.

3. Inspect valve body (1) bores and plungers (2) for excessive wear, scratches or deep grooves. If either valve body (1) or plungers (7) are damaged, they must be replaced.

**ASSEMBLY**
Numbers in parentheses refer to Fig. 2.

1. If removed, install plugs (7 & 8) in valve body (1).

2. Install new seal (3) in plunger stop plug (4) with lip facing in. When assembled, the seal should be recessed approximately 3.0 mm (0.12 inch) from the face of the plunger stop plug (4).

3. Install new 'O' rings (5) on plunger stop plugs (6). Install plunger stop plugs (6) in valve body (1).
**Steering System - Flow Reversing Valve**

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4. Insert plungers (2) into valve body (1), as marked at Disassembly.

**Note:** If the same plungers that were removed from the valve are being installed, be sure the plungers are replaced in the same bore from which they were removed.

5. Carefully position plunger stop plugs (4) over plungers (2), taking care not to damage oil seals (3). Tighten plunger stop plugs (4) securely.

**INSTALLATION**

Numbers in parentheses refer to Fig. 3.

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

**Note:** Tighten all hydraulic lines fitted with ORFS connections, as described in Section 220-0000, STEERING SYSTEM SCHEMATIC.

1. Make certain, area of installation is clean. Position flow reversing valve (5) onto steering frame and secure in place with bolts and lockwashers (4).

2. Remove blanking caps from hydraulic lines and install lines to flow reversing valve as identified during removal.

3. Connect the reversing linkage to the eye of the plungers.

4. Position new 'O' rings (3) onto flow reversing valve (5) and install double relief valve (2) onto flow reversing valve (5). Refer to Section 220-0130, DOUBLE RELIEF VALVE.

5. Check oil level in the hydraulic tank and add oil if required. Refer to Section 235-0040, HYDRAULIC TANK for correct fill level, and, Section 300-0020, LUBRICATION SYSTEM for oil specification.

6. Place the battery master switch in the 'On' position, start the engine and bring hydraulic oil to operating temperature.

7. Check flow reversing valve (5) and hydraulic line connections for leaks and tighten as required.

8. Remove wheel blocks.

**SPECIAL TOOLS**

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.
DESCRIPTION AND OPERATION

Numbers in parentheses refer to Fig. 1.

The steering linkage consists of a bell crank (1), link assembly (7 thru 13), compression spring (14) and roller assembly (16). The bell crank is bolted to the steering frame and the link assembly is connected to the eye end of the flow reversing valve spool and to the bell crank. A grease fitting (15) is installed in each bell crank (1) to lubricate the roller shaft.

The function of the steering linkage is to push the flow reversing valve spool into the valve housing at the appropriate time, reversing the flow of oil to the steering cylinder. Refer to Section 220-0010, STEERING LINES AND FITTINGS, for detailed oil flow operation.
**WARNING**

To prevent personal injury and property damage, be sure wheel blocks are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate steering in both directions several times to relieve any pressure in steering system.

2. Turn tractor wheels to the straight forward position equalising compression on springs (9 & 14).

3. Place the battery master switch in the 'Off' position and block all road wheels.

4. Hold steering linkage securely and remove cotter pin (11) from clevis pin (12). Remove clevis (10) from flow reversing valve. Slowly release compression spring (14).

5. Remove spring (14) from steering trunnion.

6. Remove stop nut (17), bolt (5) and bell crank (1) from steering trunnion.

7. Remove steering linkage from machine.

8. Remove cotter pin (3) from clevis pin (4). Remove bushing (2) and clevis (7) from bell crank (1).

9. Remove clevis (7), spring guides (8) and clevis (10) from bolt (13).

10. Remove nut (6) and star washer (18) from roller assembly (16). Remove roller assembly (16) from bell crank (1).

11. If required, remove grease fitting (15) from bell crank (1).

**INSPECTION**

Numbers in parentheses refer to Fig. 1.

1. Clean all parts with a suitable solvent and dry with compressed air.

2. Inspect roller assembly (16), springs (9 & 14), bushing (2) and clevis pins (4 & 12) for wear or damage. Replace worn parts if necessary.

3. Inspect all threaded parts for worn or damaged threads. Replace all damaged parts.

**ASSEMBLY AND INSTALLATION**

Numbers in parentheses refer to Fig. 1.

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. If removed, install grease fitting (15) in bell crank (1).

2. Install roller assembly (16) on bell crank (1) with star washer (18) and nut (6).

3. Assemble link bolt (13), clevis (10), spring guides (8), spring (9) and clevis (7). Install bushing (2) in bell crank (1). Install clevis pin (4) in bell crank (1) and clevis (7) and secure with cotter pin (3).

4. Attach bell crank (1) assembly onto steering trunnion with bolt (5) and stop nut (17).

5. Install compression spring (14) between bell crank (1) retainer and retainer on steering trunnion.

6. Install steering linkage onto flow reversing valve with clevis pin (12) and cotter pin (11).

7. Place the battery master switch in the 'On' position and remove wheel blocks.

**SPECIAL TOOLS**

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.
The bowl hydraulic, servo control and steering hydraulic systems are operated by a triple pump. The systems use the same oil supply tank and pump but are operated independently of each other.

A brief description of the individual components shown in the bowl hydraulic and servo control systems are listed below. Detailed service and operating instructions for the individual components can be found in their relative component sections in this manual.

**Hydraulic Tank (1)**
Refer to Section 235-0040, HYDRAULIC TANK.

The hydraulic tank is the common oil reservoir for the bowl hydraulic and steering systems.

Integral with the tank assembly is a suction screen, filter element, relief valve, adaptor plate, access covers and filler neck assembly. Two sight gauges on the side of the tank assembly indicate hydraulic oil level. Located on top of the tank assembly is a breather assembly.

**Triple Pump (2)**
Refer to Section 235-0050, TRIPLE PUMP.

The triple pump supplies hydraulic oil for operating the bowl hydraulic and steering systems.

The triple pump is a multiple gear type pump consisting of three separate sections connected together as one assembly.

Two of the pump sections draw hydraulic oil from the hydraulic tank (1) then pump the oil to the servo control valve (8) and the bowl control valve (9).

The remaining section of the pump draws hydraulic oil from the hydraulic tank (1) then pumps the oil to the steering system.

The triple pump operates in the one direction only (it is assembled for right hand (clockwise) rotation, as viewed from the driveshaft end).

**Note:** Never drive a pump in the wrong direction of rotation, as pump seizure may result.

**Relief Valve (7)**
Refer to Section 235-0120, RELIEF VALVE.

The direct acting relief valve is mounted at the right hand side of the cab below the bowl drop valve (10). The valve is installed in the lines between the triple pump (2) and servo control valve (8).

The relief valve pressure setting is 17 bar (250 lbf/in²).

**Servo Control Valve (8)**
Refer to Section 235-0160, SERVO CONTROL VALVE.

The servo control valve (8), located on the right hand dash panel, is a mechanically actuated spool type valve controlling and directing signal oil pressure supplied by the main control valve (9). The valve spools are operated by levers connected to the spool ends. Operation of control levers moves the spools to open and close the inlet port to the signal ports to control movement of the valve spools.

Good control of the main hydraulic valve spools is attained by matching the pressure gain through the servo valve to the resistance of the main hydraulic control valve spool centering springs. As the servo valve spool is shifted from neutral, some signal oil is directed to the appropriate main hydraulic control valve spool, and some oil is directed back to the tank from the other side of the spool. As the servo valve spool is shifted farther through its stroke, so more oil is directed to the main hydraulic control valve spool, moving it farther through its stroke in direct proportion to the servo valve spool movement.

The ejector and apron spools have a mechanical detent in the lower position.

**Bowl Control Valve (9)**
Refer to Section 235-0060, BOWL CONTROL VALVE.

The bowl control valve (9) is used to direct hydraulic oil to the cylinders (14, 15 or 16) for raising or lowering the apron, ejector or bowl depending on the position of the control spools within the valve. The position of control spools is controlled by the servo control valve (8).

The main components of the bowl control valve assembly are three control spools, main pressure relief valve and three check valve assemblies.
Bowl Hydraulic System - Hydraulic System Schematic

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Fig. 1 - Bowl Hydraulic System Schematic

1 - Hydraulic Tank
2 - Triple Pump
7 - Relief Valve
8 - Servo Control Valve
9 - Bowl Control Valve
10 - Bowl Drop Valve
11 - Solenoid Valve
12 - Accumulator
13 - Solenoid Valve
14 - Bowl Cylinder
15 - Apron Cylinder
16 - Ejector Cylinder
17 - Pressure Reducing Valve
The main pressure relief valve permits by-passing hydraulic oil back to the tank (1), should oil pressure exceed 127.5 bar (1850 lbf/in²). Check valves in the spools prevent return oil flow from cylinders until supply oil pressure at the spools is sufficient to move the loads. Thus they prevent unexpected movement (dropping) of a load until oil pressure is sufficient to hold or raise it.

**Note:** The bowl spool in the control valve used with a power down bowl is a double acting type and contains two load check valves and springs. The apron spool in the control valve used with a power apron is a double acting type and contains two load check valves and springs. The ejector spool is a single acting type containing one check valve and spring.

**Bowl Drop Valve (10)**

The bowl drop valve (10) is mounted at the right hand side of the cab adjacent to the servo control valve (8). When the solenoid is energised, by operating the bowl drop switch inside the cab, the valve cartridge moves across allowing oil to return to tank. This allows the bowl to be lowered to ground under its own weight when the engine is switched ‘Off’.

**Solenoid Valves (11 & 13)**

There are two solenoid valves installed in the bowl hydraulic system, one (11) between the accumulator (12) and the base end of the bowl cylinders (14), the other (13) between the bowl control valve (9) and the rod end of the bowl cylinders (14). When the solenoids are energised, by operating the bowl suspension switch inside the cab, the valve cartridges move across allowing oil to return to tank. This allows the piston rod to have oil applied to either side, extending or retracting the piston rod. Cylinder mounting is by pins, secured with bolts and lockwashers. Bushings permit a limited amount of cylinder misalignment when travelling over rough terrain.

**Accumulator (12)**

Refer to Section 235-0070, ACCUMULATOR.

The accumulator (12) is mounted off the hood mounting bracket inboard of the right hand fender. The accumulator is of the piston type and is precharged with nitrogen to 27.5 bar (400 lbf/in²). It consists of a charging valve assembly, cylinder assembly and a piston. The charging valve is equipped with a locking feature which, when opened, will allow the precharge to be checked or the accumulator charged. The piston acts as a separator dividing the cylinder into two sections. The section nearest the charging valve contains the nitrogen precharge. The other section receives the hydraulic oil from the pump, via the bowl control valve (9).

**Bowl Cylinders (14)**

Refer to Section 235-0020, BOWL CYLINDER.

There are two single stage, double acting bowl cylinders (14) on the machine, mounted between the bowl and pull yoke. Single stage double acting means that the piston rod can have oil applied to either side, extending or retracting the piston rod. Cylinder mounting is by pins, secured with bolts, lockwashers and nuts. Bushings permit a limited amount of cylinder misalignment when travelling over rough terrain.

**Apron Cylinders (15)**

Refer to Section 235-0035, APRON CYLINDER.

There are two single stage, double acting apron cylinders (15) on the machine, mounted vertically between the pull yoke and lever. Single stage double acting means that the piston rod has oil applied to either side, extending or retracting the piston rod. Cylinder mounting is by pins, secured with bolts, lockwashers and nuts. Bushings permit a limited amount of cylinder misalignment when travelling over rough terrain.

**Ejector Cylinder (16)**

Refer to Section 235-0030, EJECTOR CYLINDER.

There is one single stage, single acting ejector cylinder (16) on the machine, mounted horizontally between the tail frame and ejector lever. Single stage single acting means that the piston rod has oil applied to one side, extending the piston rod and it retracts by gravity under its own weight. Cylinder mounting is by pins, secured with bolts, lockwashers and nuts. Bushings permit a limited amount of cylinder misalignment when travelling over rough terrain.
**Diagnostic Test Point**

The hydraulic system has one diagnostic test point (A) which enables the service engineer to obtain an accurate system pressure reading.

**'O' RING FACE SEALS (ORFS)**

Where hydraulic lines are fitted with ORFS connections, the following procedure should be carried out during 'Installation'. Refer to Fig. 2.

![](image)

**Fig. 2 - Assembly of Typical ORFS Connector**

a. Ensure 'O' ring/seal is in place and that the joining surfaces are clean. If necessary, retain 'O' ring/seal in place with a light coating of grease or vaseline.

b. Initially, the nuts should be tightened by hand.

c. Where a hose is fitted, ensure that it is not twisted or kinked when the nuts are tightened so that it is allowed to adopt a natural position.

d. Where a tube is fitted, ensure that the connection is aligned correctly.

e. Tighten the nut a further 1/4 to 1/2 a turn using the correct size spanner (wrench).

f. Check that a satisfactory hose or tube routing has been achieved.

---

**MAINTENANCE**

Maintenance instructions, intervals and warnings, in the individual component sections of this manual, should be adhered to.

**Hydraulic Oil**

The hydraulic tank should be kept filled with hydraulic oil as specified in Section 300-0020, LUBRICATION SYSTEM. Refer to Section 235-0040, HYDRAULIC TANK for correct fill level and procedure.

**SERVICE TOOLS**

It is recommended that the following service tools are used when carrying out pressure and temperature checks during maintenance procedures. These tools, along with other general service tools, are available from your dealer. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of these tools.

**Multi-Gauge**

The multi-gauge is basically four pressure gauges in one. Continuous system pressure readings are indicated on one of three simultaneously reading gauges through a pressure range of 30 in of vacuum to 5 000 lbf/in².

**Non-contact Infrared Thermometer**

The infrared thermometer can be used to spot heat problems early in electrical, mechanical and hydraulic systems. Hand held and easy to use, you simply aim, pull the trigger, and read the temperature. Since there is no need to touch what you are measuring, temperatures of hard-to-reach or moving components can be taken without getting burned or shocked.
DESCRIPTION
Refer to Section 235-0000, HYDRAULIC SYSTEM SCHEMATIC for details of hydraulic schematic and a brief description of the individual components shown in the bowl hydraulic and servo control systems.

The hydraulic, servo control and steering hydraulic systems are operated by a triple pump. The systems use the same oil supply tank and pump but are operated independently of each other.

This section refers to the hydraulic system with servo controls which operate the scraper bowl, apron and ejector.

Refer to Section 220-0010, STEERING LINES AND FITTINGS for details of the steering hydraulic system.

OPERATION
Neutral (Hold) Position
When the control levers (servo control valve) are in a neutral position, oil is drawn from the tank by the pump. From the pump the oil flows through the central passage in the control valve and back to the tank. Oil is also pumped through the servo valve and servo relief valve. If the pressure exceeds 17 bar (250 lbf/in²) the servo relief valve diverts oil back to the tank.

Bowl
Numbers in parentheses refer to Fig. 1.

The scraper bowl is operated by two single stage, double acting cylinders (2). The cylinder base ends are attached to the pull yoke and the piston rods are attached to the two bowl lift levers (1). The bowl lift levers (1) are hinged at the forward end and the other ends are connected to the two lift rods (3) which are, in turn, connected to the scraper bowl.

To describe the operation of the scraper, it is assumed that the bowl control lever is in the 'NEUTRAL' position and the bowl cutting edge is touching the ground. When the servo control bowl lever is pushed into the 'LOWER' position, a passage in the control valve is opened and oil flows from the pump into the control valve. Oil from the control valve flows into the bowl cylinder rod ends. The oil pressure in the cylinder rod ends, forces the piston rods to retract. As the piston rods retract, the levers are pulled down causing the bowl to lower, forcing the cutting edge into the ground. As the bowl cylinders are retracting, any oil trapped in the base ends is forced out through the control valve and back into the tank.

Oil also flows into the bowl drop valve where it is dead headed.

The bowl can be lowered with the engine stopped by pressing the bowl drop switch, located on the switch panel on the dash. Hold the switch until the bowl is completely lowered. This opens the bowl drop valve, which allows oil in the base of the bowl cylinders to flow through the drop valve back into the tank. The bowl cylinders retract which lowers the bowl.

To raise the bowl, the servo control bowl lever is pulled into the 'RAISE' position. This shifts the control valve bowl spool into the raise position. Oil leaves the control valve and flows into the bowl cylinder base ends. Oil pressure extends the cylinders which raises the bowl. Any oil trapped in the cylinder rod ends is forced through the control valve and back to the tank.

Apron
The scraper apron is operated by two single stage, double acting cylinders mounted on the outside of the scraper bowl. The cylinder base ends are attached to the bowl assembly and the piston rods are attached to the two apron arms.
The apron cylinders are actuated by the apron control lever on the servo valve. Oil flows into and out of the apron cylinders to raise or lower the apron.

When the servo control apron lever is pushed into the 'LOWER' position, a passage in the control valve is opened and oil flows from the pump into the control valve. Oil from the control valve flows into the apron cylinder rod ends. The oil pressure in the cylinder rod ends, forces the piston rods to retract. As the piston rods retract, the apron arms are pulled back causing the apron to power down. As the apron cylinders are retracting, any oil trapped in the base ends is forced out through the control valve and back into the tank.

To raise the apron, the servo control bowl lever is pulled into the 'RAISE' position. This shifts the control valve apron spool into the raise position. Oil leaves the control valve and flows into the apron cylinder base ends. Oil pressure extends the cylinders which raises the apron. Any oil trapped in the cylinder rod ends is forced through the control valve and back to the tank.

**Ejector**

The scraper ejector is operated by the ejector cylinder which is mounted to the tail assembly of the scraper and to a lever that is hinged at one end to the upper cross member of the bowl. The lower end of this lever has a roller which rolls on a wear plate welded to the ejector.

The oil which flows into and out of the ejector cylinder is the same as that for the apron and bowl cylinders.

The ejector cylinder is actuated by the ejector control lever on the servo valve. As the cylinder is extended, a force is transmitted to the ejector through the lever and roller which causes the ejector to pivot forward. The ejector is returned to the 'LOWER' position by the force of its weight creating an opposite action on the lever and cylinder. A detent mechanism in the servo valve holds the ejector control spool in the 'LOWER' position, allowing the ejector to 'FLOAT' down to the loading position, after the material is dumped from the bowl, without further attention from the operator. The control lever will remain in the 'LOWER' position until manually moved to the 'NEUTRAL' position.

**TIMING TEST**

As a general field test, the correct operation of the hydraulic system can be checked by timing the lift of the scraper bowl. If the scraper bowl can be lifted in the correct time, it can be assumed that the ejector and apron are operating at peak efficiency.

The test should be performed with the scraper bowl empty and blades resting on the ground, the engine and hydraulic oil heated to normal operating temperatures, and the engine running at top rev/min. With these conditions, the scraper bowl should be raised to its fully raised position in 5.8 seconds. If the timing test is in excess of 5.8 seconds, check the following items in sequence:

1. Check oil level in the tank.
2. Visually check for apparent leaks, faulty pump, cylinders or control valves.
3. Check pivot mechanism for binding.
4. Check hydraulic oil pressure/relief valve adjustment (see below).

**CHECKING AND ADJUSTING RELIEF VALVE PRESSURE**

The relief valve, incorporated in the control valve, is set at the factory for a maximum oil pressure of 127.5 bar (1,850 lbf/in²). Do not adjust the valve setting unless it has been determined that the maximum pressure is above or below 127.5 bar (1,850 lbf/in²).

**Note:** Do not change the setting to increase pressure above 127.5 bar (1,850 lbf/in²) to compensate for overloading the scraper with extra heavy materials.

To check the relief valve adjustment, the bowl must be empty, hydraulic oil and engine at normal operating temperatures. Remove cap from connector or plug in the face of the control valve and install a 207 bar (3,000 lbf/in²) capacity pressure gauge. Operate the engine at 1,500 rev/min and raise the bowl until the related cylinders are fully extended. Hold the bowl control lever in the raise position and keep the engine accelerated at 1,500 rev/min while...
watching the pressure gauge. The maximum reading on the gauge will indicate the pressure at which the valve is opening. If the reading is above or below 127.5 bar (1 850 lbf/in²), adjust the relief valve as follows:

1. Remove acorn nut and loosen adjusting screw jam nut.

2. Adjust valve by turning adjusting screw clockwise to increase pressure or counter-clockwise to decrease pressure.

**Note:** This is a pilot operated relief valve which is sensitive to adjustment. One complete turn of the adjusting screw will change the pressure setting approximately 55 - 69 bar (800 - 1 000 lbf/in²).

3. After the adjustment is completed, tighten jam nut and replace acorn nut.

4. Re-check the system pressure to make certain that it did not change when tightening the jam nut. If the pressure setting is correct, remove the pressure gauge and replace the cap or plug.

**CHECKING AND ADJUSTING SERVO SYSTEM RELIEF VALVE PRESSURE**

1. Install a 345 bar (5 000 lbf/in²) capacity pressure gauge at the pressure check port located in the servo relief valve housing.

2. Start the engine and observe the pressure gauge. It should read 17 bar (250 lbf/in²) when the servo relief valve opens. Adjust the relief valve if the pressure is not correct.

3. Remove the acorn nut and one seal washer. Loosen the jam nut. Turn the adjusting screw clockwise to raise the pressure or counter-clockwise to decrease the pressure. Turn the adjusting screw in small increments.

4. When the correct pressure setting is obtained, hold the adjusting screw with a screwdriver and tighten the jam nut securely.

5. Re-check the pressure and, if it is correct, install the outer seal washer and acorn nut and tighten.

6. Remove the pressure gauge from the relief valve housing and replace the plug and seal washer.

**MAINTENANCE**

Maintenance instructions, intervals and warnings, in the individual hydraulic component sections of this manual, should be adhered to at all times.

**SERVICE TOOLS**

It is recommended that the following service tool is used when carrying out pressure checks during maintenance procedures. This tool, along with other general service tools, are available from your dealer. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of these tools.

**Multi-Gauge**

The multi-gauge is basically four pressure gauges in one. Continuous system pressure readings are indicated on one of three simultaneously reading gauges through a pressure range of 30 in of vacuum to 5 000 lbf/in².
## HYDRAULIC SYSTEM DIAGNOSIS

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>REASON</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scraper Bowl, Apron or Ejector inoperative or operates too slowly.</td>
<td>Insufficient oil pressure.</td>
<td>Check pressures as described earlier.</td>
</tr>
<tr>
<td></td>
<td>Pump is not being driven or receiving.</td>
<td>Check pump drive or intake line.</td>
</tr>
<tr>
<td></td>
<td>Faulty control valve operation.</td>
<td>Check valve plunger travel and relief valve adjustment.</td>
</tr>
<tr>
<td></td>
<td>Faulty cylinder operation.</td>
<td>Check for leaks in cylinder. Check oil pressure at cylinder. If pressure is low, check for restrictions in lines and check pressure at control valve.</td>
</tr>
<tr>
<td>Bowl, Apron or Ejector will not lower.</td>
<td>Bent piston tube or jammed cylinder.</td>
<td>Replace faulty parts.</td>
</tr>
<tr>
<td></td>
<td>Obstruction or bind on ejector.</td>
<td>Remove obstruction or repair bound part.</td>
</tr>
<tr>
<td>Ejector will not return over its centre.</td>
<td>Bent cylinder.</td>
<td>Replace damaged parts.</td>
</tr>
<tr>
<td>Apron and Ejector plungers do not stay in Pushed In position.</td>
<td>Weak or broken detent springs.</td>
<td>Replace detent springs.</td>
</tr>
<tr>
<td>Oil leaks on either end of plunger.</td>
<td>Defective 'O' ring in valve body.</td>
<td>Replace 'O' ring.</td>
</tr>
<tr>
<td>Plungers do not return to neutral.</td>
<td>Broken return springs.</td>
<td>Replace springs.</td>
</tr>
</tbody>
</table>

* * * *
DESCRIPTION

Numbers in parentheses refer to Figs. 1 & 2.

There are two single stage, double acting bowl cylinders on the machine, mounted between the bowl and pull yoke. Single stage double acting means that piston rod (3) can have oil applied to either side, extending or retracting the piston rod.

Cylinder mounting is by pins, secured with bolts and lockwashers. Bushings (14) permit a limited amount of cylinder misalignment when travelling over rough terrain.

Main components of the cylinder include the piston rod (3) and piston (4) which slides within Cylinder assembly (1). Pressure oil in the tube is retained by seal (12) on the rod-eye end of Cylinder assembly (1). Seal (15) and 'O' ring (11) prevent oil in the base end of tube from flowing around piston (4).

OPERATION

Numbers in parentheses refer to Figs. 1 & 2.

Raise Position

In the raise position, oil from the scraper control valve flows into Port B at the cylinder base end. Oil pressure acting on the piston (4) and the Cylinder assembly (1), forces the tube to extend causing the lift levers to raise the bowl.

Any oil on the other side of the piston (4) is forced out of Port A and returns to the tank by way of the scraper control valve.
Raise Position

In the lower position, oil from the scraper control valve flows into Port A at the cylinder rod end. Oil pressure acting on the piston (4) and rod (3) forces the rod into the Cylinder assembly (1). Also the lift levers are pulled down which in turn lowers the bowl and forces the cutting edge into the ground.

Any oil in the base end is forced out Port B flows through the scraper control valve and back into the tank.

REMOVAL

Numbers in parentheses refer to Figs. 1 & 2.

⚠️ WARNING

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area and ensure bowl, apron and ejector are completely lowered. Apply the parking brake and switch off the engine.
2. Operate steering right and left several times to relieve pressure in the steering system. Block all road wheels and place the battery master switch in the 'Off' position.

3. Identify and tag all hydraulic lines on one bowl cylinder. With a suitable container available to catch spillage, disconnect hydraulic lines. Cap all lines and fittings to prevent ingress of dirt.

4. Support bowl cylinder with a suitable lifting device.

5. Remove bolt and lockwasher securing mounting pin at piston rod (3) end of the cylinder. Remove pin from piston rod (3) end of the cylinder.

6. Remove bolt and lockwasher securing mounting pin at base end of the cylinder. Remove pin from base end of the cylinder.

7. Remove cylinder assembly from the machine.

8. Transfer cylinder assembly to a clean area for disassembly. Drain oil from cylinder assembly into a suitable container.

9. Repeat steps 3 through 8 for opposite bowl cylinder assembly.

DISASSEMBLY
Numbers in parentheses refer to Figs. 1 & 2.

WARNING
To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

1. Ensure clean working conditions, remove any port plugs thus allowing easy entry of air into the cylinder, preventing a vacuum when parts are withdrawn from cylinder body (1).

2. Taking a suitable 'C' spanner unscrew Retainer (2) and carefully remove Piston rod (3), 'O'-Ring (10) and Retainer(2) from the Cylinder assembly (1). The Piston (4) will also be removed at this time as it is attached to the Piston Rod (3).

3. Place the above items on a suitable surface and remove the constituent parts as follows.

4. Remove 'O'-ring (11), Seal (15) and Wear ring (7) from the Piston (4).

Remove piston (4) from piston rod (3) by unscrewing grub screw (6) from the piston (4).

6. Now slide the Retainer (2) off Piston rod (3) and remove Seal (9), 'O'-Ring (5), Seal (12), 'O'-Ring (8) and Back up ring (13) from the Retainer (2).

7. Remove bushing (14) from Piston rod (3) and Cylinder assembly (1) if they are worn or damaged.

INSPECTION
Numbers in parentheses refer to Figs. 1 & 2.

1. Clean all parts of the cylinder with a suitable solvent and dry with clean, lint-free cloths. Clean all grooves carefully to remove any foreign material.

2. Check Cylinder assembly (1) bore and outer diameter of Piston (4) for scratches, cracks or other signs of damage. Remove ridges, nicks and scratches with a fine stone and re-clean. Replace any components which cannot be repaired.

3. Inspect Piston rod (3) for distortion, cracks or other defects. Replace piston rod (3) if defective area is irreparable.

4. Check bushings (14) for wear and replace if necessary.

ASSEMBLY
Numbers in parentheses refer to Figs. 1 & 2.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

Note: To facilitate assembly, lubricate all internal sliding or wearing surfaces prior to assembly with the same hydraulic oil that is used in the system.

WARNING
To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

1. If necessary, press Bushing (14) into eye end of Piston rod (3) and Cylinder assembly (1).

2. Install Seals (9 & 12), 'O'-Ring (5), Backup ring (13) and 'O'-Ring (8) into Retainer (2) and carefully slide Piston rod (3) into the bore of Retainer (2).
Bowl Hydraulic System - Bowl Cylinder

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3. Apply Loctite 243 to first two threads of piston (4). Screw piston (4) onto the mating end of Piston rod (3) and tighten to a torque of 1356 Nm (1000 lbf ft).

4. Insert grub screw through wear ring (7) groove in piston (4) and into groove machined on piston rod (3). Tighten grub screw to a torque of 49 Nm (36 lbf ft). Ensure top face of grub screw is below the level of the wear ring groove (7).

5. Install Seal (15) and Wear ring (7) on outer grooves of Piston (4) as shown.

6. Now move 'O'-Ring (11) into position on recess between Piston (4) and Piston rod (3).

7. Ensure bore of Cylinder assembly (1) is well lubricated with hydraulic oil. Sling the assembled piston rod (3) and carefully offer it into the bore of Cylinder assembly (1) with Piston (4) end face inserted first. Take care not to damage seal (15) on cylinder assembly (1) threads.

8. After piston (4) is inserted into cylinder assembly (1) push the piston rod assembly into the bore, mating coincidental centre lines of piston rod and cylinder body.

9. Before piston rod (3) is fully home and with slings taking some of the piston rod (3) weight, engage the male threads of the retainer (2) with female thread form of the cylinder assembly (1) and screw home. Take care not to damage 'O'-Rings (5 & 8) and backup ring (13).

10. Push piston rod (3) to fully retracted position and tighten retainer to a torque of 237 Nm (175 lbf ft).

**INSTALLATION**

Numbers in parentheses refer to Figs. 1 & 2.

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

**Note:** Tighten all hydraulic lines fitted with ORFS connections, as described in Section 235-0000, HYDRAULIC SYSTEM SCHEMATIC.

**WARNING**

To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

1. Install a suitable strap, or other lifting device, around one cylinder assembly and position cylinder assembly between the bowl and pull yoke, with base end of cylinder ready for mounting.

2. Install pin through base end of Cylinder assembly (1) and secure pin with bolt and lockwasher as removed at Removal.

3. Install pin through piston rod (3) end of the cylinder. Secure pin with bolt and lockwasher as removed at Removal.

4. Remove caps and connect hydraulic lines to steering cylinder ports, as tagged during Removal.

5. Repeat steps 1 through 4 for installation of opposite bowl cylinder.

6. Check oil level in hydraulic tank and add oil if low. Refer to Section 235-0040, HYDRAULIC TANK, for correct fill level. Refer to Section 300-0020, LUBRICATION SYSTEM, for the type of oil used.

7. Place the battery master switch in the ‘On’ position, start the engine and operate the bowl. Check hydraulic lines and fittings for leaks. Tighten lines and fittings as required.

8. Remove wheel blocks.

**MAINTENANCE**

Inspect bowl cylinders regularly for leaks or damage, repair as required. Lubricate cylinder pins every 50 hours, as specified in Section 300-0020, LUBRICATION SYSTEM.
REMOVAL
Numbers in parentheses refer to Fig. 1.

**WARNING**
To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area and ensure ejector is completely lowered. Apply the parking brake and switch off the engine.

2. Operate steering right and left several times to relieve pressure in the steering system. Block all road wheels and place the battery master switch in the 'Off' position.

3. With a suitable container available to catch spillage, disconnect hydraulic line from base end of cylinder. Cap hose and port to prevent ingress of dirt.

4. Support ejector cylinder with a suitable lifting device. Remove nut, lockwasher and bolt securing mounting pin to base end of cylinder and mounting bracket on tail frame. Using a soft drift, drive and remove the mounting pin.

5. Remove nut, lockwasher and bolt securing mounting pin to piston tube end of cylinder and ejector lever. Using a soft drift, drive and remove mounting pin from the cylinder rod end and ejector lever.

6. Lower cylinder until eye ends of rod and outer cylinder clear mounting brackets and remove cylinder.

7. Remove cylinder assembly from the machine and transfer to a clean area for disassembly.
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**Bowl Hydraulic System - Ejector Cylinder**

**DISASSEMBLY**
Numbers in parentheses refer to Fig. 1.

**WARNING**
To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

1. Ensure clean working conditions, remove plug from port at the base of cylinder and drain oil from cylinder assembly into a suitable container.

2. Place cylinder assembly in an upright position, with piston tube (2) facing up and clamp securely.

3. Remove lock ring (12) from between outer cylinder (1) and end cap (13).

4. Un螺丝 end cap (13) and pull end cap (13) and piston tube (2) out of cylinder body (1) as an assembly.

5. Position piston tube (2) in a soft-jawed vice and remove and discard wear ring (5).

   **Note:** Provide adequate protection to chrome surface to prevent any damage.

6. Remove retainer (3) and pull end cap (13) assembly off piston tube (2). Remove and discard backup ring and 'O' rings (9 & 10) from outer grooves of end cap (13). Remove and discard wear rings (6), rod seal (7), nylon ring (11) and wiper seal (8) from inner grooves of end cap (13).

7. Remove bushing (4) from piston tube (2) and outer cylinder (1) if they are worn or damaged.

**ASSEMBLY**
Numbers in parentheses refer to Fig. 1.

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

**Note:** To facilitate assembly, lubricate all internal sliding or wearing surfaces prior to assembly with the same hydraulic oil that is used in the system.

**WARNING**
To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

1. If necessary, press bushing (4) into eye end of piston tube (2) and outer cylinder (1).

2. Replace guide ring (3) on piston tube (2) and install piston tube in outer cylinder (4).

3. Install rod seal (7) into bore of end cap (13) with the lip pointing towards the internal face of end cap (13). Install nylon ring (11) behind rod seal (7) in groove. Install wiper seal (8) and wear rings (6) into bore of end cap (13).

4. Install back up ring and 'O' rings (9 & 10) in outer grooves of end cap (13).

5. With the piston tube (2) in a vertical position, guide end cap (13) assembly onto piston tube (2). Ensure leading chamfer on plunger is clean and free from nicks or rust.

6. Install piston wear ring (5).

7. Ensure bore of outer cylinder (1) is well lubricated with hydraulic oil. Carefully insert piston tube (2) and end cap (13) assembly into outer cylinder (1).
8. Engage end cap (13) and outer cylinder (1) thread and screw up fully. Tighten end cap (13) to a torque of 338 - 407 Nm (250 - 300 lbf ft).

9. Re-drill location hole for lock ring (12), diameter 3.175 mm (0.125 in) x 10 mm (0.394 in) maximum depth. Install lock ring (12).

INSTALLATION

Ejector Cylinder

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

**Note:** Tighten all hydraulic lines fitted with ORFS connections, as described in Section 235-0000, HYDRAULIC SYSTEM SCHEMATIC.

**WARNING**

To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

1. Install a suitable strap, or other lifting device, around cylinder assembly and position cylinder in tail assembly, ready for mounting.

**Note:** Oil inlet port must be towards the ground.

2. Secure piston tube end of cylinder to the ejector lever and the base end of cylinder to the bracket on the tail frame with mounting pins and secure with bolts, lockwashers and nuts.

3. Remove caps from cylinder port and hose end and install new ‘O’ ring on hose. Install hose to cylinder inlet port.

4. Lubricate mounting pins at lube fittings. Refer to Section 300-0020, LUBRICATION SYSTEM.

5. Check oil level in hydraulic tank and add oil if low. Refer to Section 235-0040, HYDRAULIC TANK, for correct fill level. Refer to Section 300-0020, LUBRICATION SYSTEM, for the type of oil used.

6. Place the battery master switch in the ‘On’ position, start the engine and operate the ejector controls. Check hydraulic lines and fittings for leaks. Tighten lines and fittings as required.

7. Remove wheel blocks.

MAINTENANCE

Inspect ejector cylinder regularly for leaks or damage, repair as required. Lubricate cylinder pins every 50 hours, as specified in Section 300-0020, LUBRICATION SYSTEM.

SPECIAL TOOLS

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools and adhesives required. These tools and adhesives are available from your dealer.

### SPECIAL TORQUE SPECIFICATIONS

<table>
<thead>
<tr>
<th>FIG. NO.</th>
<th>ITEM NO.</th>
<th>ITEM NAME</th>
<th>TORQUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13</td>
<td>End Cap</td>
<td>338 - 407 Nm (250 - 300 lbf ft)</td>
</tr>
</tbody>
</table>

* * * *
**BOWL HYDRAULIC SYSTEM - Apron Cylinder**

**Fig. 1 - Cutaway View of Apron Cylinder**

1. Cylinder Body  
2. Piston  
3. Piston Rod  
4. Retainer  
5. Cushion Sleeve  
6. Cushion Sleeve  
7. Piston Seal  
8. Wear Ring  
9. ‘O’ Ring  
10. Locking Screw  
11. Rod Seal  
12. ‘O’ Ring  
13. ‘O’ Ring  
14. Lock Ring  
15. Back Up Ring  
16. Wiper Seal  
17. Circlip  
18. End Cap

**REMOVAL**

Numbers in parentheses refer to Fig. 1.

**WARNING**

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area and ensure apron and bowl are completely lowered. Apply the parking brake and switch off the engine.

2. Operate steering right and left several times to relieve pressure in the steering system. Block all road wheels and place the battery master switch in the ‘Off’ position.

3. Identify and tag all hydraulic lines on one apron cylinder. With a suitable container available to catch spillage, disconnect hydraulic lines. Cap all lines and ports to prevent ingress of dirt.

4. Support apron cylinder with a suitable lifting device.

5. Remove bolt and lockwasher securing mounting pin at piston rod (3) end of the cylinder. Remove mounting pin from piston rod (3) end of the cylinder.

6. Remove bolt and lockwasher securing mounting pin at base end of the cylinder. Remove mounting pin from base end of the cylinder.

7. Remove cylinder assembly from the machine and transfer to a clean area for disassembly. Drain oil from cylinder assembly into a suitable container.

8. Repeat steps 3 through 7 for opposite apron cylinder.
DISASSEMBLY
Numbers in parentheses refer to Figs. 1 & 2.

1. Ensure clean working conditions, remove any port plugs thus allowing easy entry of air into the cylinder, preventing a vacuum when parts are withdrawn from cylinder body (1).

2. Place cylinder assembly in an upright position, with piston rod (3) facing up and clamp securely.

3. Remove lock ring (14) from between cylinder body (1) and end cap (18).

4. Unscrew end cap (18) and pull end cap (18), piston rod (3) and piston (2) out of cylinder body (1) as an assembly.

5. Position eye end of piston rod (3) in a soft-jawed vice and remove locking screw (10).

6. Pull piston (2) assembly off piston rod (3) and remove and discard piston seal (7) and wear ring (8) from piston (2).

7. Remove and retain cushion sleeve (6) from piston rod (3). Remove and discard three ‘O’ rings (9) from piston rod (3).

8. Pull end cap (18) assembly off piston rod (3). Remove and discard backup ring (15), retainer (4) and ‘O’ rings (12 & 13) from outer grooves of end cap (18). Remove and retain circlip (17) and cushion sleeve (5) from end cap (18). Remove and discard rod seal (11) and wiper seal (16) from inner grooves of end cap (18).

INSPECTION
Numbers in parentheses refer to Figs. 1.

1. Clean all parts of the cylinder with a suitable solvent and dry with clean, lint-free cloths. Clean all grooves carefully to remove any foreign material.

2. Check cylinder body (1) bore, outer diameter of piston (2) and end cap (18) for scratches, cracks or other signs of damage. Remove ridges, nicks and scratches with a fine stone and re-clean. Replace any components which cannot be repaired.

3. Inspect piston rod (3) for distortion, cracks or other defects. Replace piston rod (3) if defective area is irreparable.

4. Use new oil seals and ‘O’ rings whenever the cylinder is disassembled.

5. Discard all scored, deeply scratched or excessively worn parts and replace with new ones.

ASSEMBLY
Numbers in parentheses refer to Figs. 1.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

Note: To facilitate assembly, lubricate all internal sliding or wearing surfaces prior to assembly with the same hydraulic oil that is used in the system.

1. Install new rod seal (11) in bore of end cap (18) with the lip pointing towards the internal face of the end cap (18). Install new wiper seal (16) into bore of end cap (18).

2. Install cushion sleeve (5) and circlip (17) into bore of end cap (18). See Fig. 1 for proper installation.

3. Install new backup ring (15), new ‘O’ rings (12 & 13) and retainer (4) on outer groove on end cap (18).

4. Guide end cap (18) assembly onto piston rod (3).

5. Install three new ‘O’ rings (9) in the external grooves on piston rod (3). Install cushion sleeve (6) onto piston rod (3).

6. Install piston seal (7) into external groove on piston (2).

7. Install piston (2) on piston rod (3) and tighten to a torque of 1 355 Nm (1 000 lbf ft).
8. Install locking screw (10) into piston (2) and tighten to a torque of 48 Nm (36 lbf ft). Install wear ring (8) into external groove on piston (2).

9. Ensure bore of cylinder tube (14) is well lubricated with hydraulic oil. Carefully insert piston rod (3), piston (2) and end cap (18) assembly into the cylinder body (1).

10. Engage end cap (18) and cylinder body (1) thread and screw up fully. Tighten end cap (18) to a torque of 203 - 270 Nm (150 - 200 lbf ft).

11. Re-drill location hole for lock ring (14), diameter 3.175 mm (0.125 in) x 10 mm (0.394 in) maximum depth. Install lock ring (14).

### INSTALLATION

Numbers in parentheses refer to Figs. 1 & 2.

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

**Note:** Tighten all hydraulic lines fitted with ORFS connections, as described in Section 235-0000, HYDRAULIC SYSTEM SCHEMATIC.

---

**WARNING**

To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

---

1. Ensure apron is held in raised position by suitable lifting equipment. Install a suitable strap, or other lifting device, around one cylinder assembly and position cylinder assembly on vehicle, ready for mounting.

2. Attach cylinder base end to bowl assembly with mounting pin. Secure mounting pin with bolt and lockwasher as removed at Removal.

3. Attach piston rod (3) end to apron arm with mounting pin. Secure mounting pin with bolt and lockwasher as removed at Removal.

4. Remove caps and connect hydraulic lines to apron cylinder ports, as tagged during Removal.

5. Repeat steps 1 through 4 for installation of opposite apron cylinder.

6. Lubricate mounting pins at lube fittings. Refer to Section 300-0020, LUBRICATION SYSTEM.

7. Check oil level in hydraulic tank and add oil if low. Refer to Section 235-0040, HYDRAULIC TANK, for correct fill level. Refer to Section 300-0020, LUBRICATION SYSTEM, for the type of oil used.

8. Place the battery master switch in the 'On' position, start the engine and operate the apron controls. Check hydraulic lines and fittings for leaks. Tighten lines and fittings as required.

9. Remove wheel blocks.

### MAINTENANCE

Inspect apron cylinders regularly for leaks or damage, repair as required. Lubricate cylinder pins every 50 hours, as specified in Section 300-0020, LUBRICATION SYSTEM.

### SPECIAL TOOLS

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools and adhesives required. These tools and adhesives are available from your dealer.

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### SPECIAL TORQUE SPECIFICATIONS

<table>
<thead>
<tr>
<th>FIG. NO.</th>
<th>ITEM NO.</th>
<th>ITEM NAME</th>
<th>TORQUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>Piston</td>
<td>1 355 1 000</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>Locking Screw</td>
<td>48 36</td>
</tr>
<tr>
<td>1</td>
<td>18</td>
<td>End Cap</td>
<td>203 - 270 150 - 200</td>
</tr>
</tbody>
</table>

* * * *
**DESCRIPTION**

Numbers in parentheses refer to Fig. 1.

The hydraulic tank is the common oil reservoir for the steering and bowl hydraulic systems. It is mounted to the tractor frame, at the rear of the cab and is secured with bolts (24), washers (25), lockwashers (26) and nuts (27).

Integral with tank assembly (1) are filter assembly (14) with in built relief valve assembly, suction screen (17), access covers (6 & 8) and filler neck assembly. Two sight gauges (20) on the side of tank assembly (1) indicate hydraulic oil level. Breather (21) is mounted off the top of the hydraulic tank (1) via adaptor (22) and allows any air entering the tank to be released to atmosphere, preventing a pressure build up in the tank assembly (1).

**MAINTENANCE**

Numbers in parentheses refer to Fig. 1.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

⚠️ **WARNING**

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of sufficient capacity to do the job safely.
Bowl Hydraulic System - Hydraulic Tank

Section 235-0040

Checking Oil Level

1. Operate the bowl hydraulic and steering systems several times to bring the oil to correct operating temperature.

2. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate steering right and left several times to relieve pressure in the steering system.

3. Check oil level and add oil if low. Oil should show in the bottom of top sight gauge (20). If oil is required, remove filler cap (2) and fill tank assembly (1) with hydraulic oil as specified in Section 300-0020, LUBRICATION SYSTEM. Install filler cap (2) on filler neck assembly.

Replacing Hydraulic Oil

The hydraulic tank should be drained, cleaned and hydraulic oil changed every 1800 hours. Refer to Section 300-0020, LUBRICATION SYSTEM, for hydraulic oil used in the system.

Replacing Filter Element

Clean filter housing and install new filter assembly element (14) when hydraulic oil filter warning light illuminates, or after every 1800 hours of operation, whichever comes first.

Note: When hydraulic oil in tank assembly (1) is being replaced due to a hydraulic failure, or at recommended change interval, filter element (14) should be replaced.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place the battery master switch in the 'Off' position.

3. With a suitable container in position, remove drain plug (23), and drain hydraulic oil to below the level of filter assembly (14). Reinstall drain plug (23).

4. Remove bolts (10) and lockwashers (11) securing access cover (8) to tank (1). Remove and discard gasket (7) from tank (1).

5. Remove wing nuts (16) from rods (15). Slide Filter element (14) assembly and gasket (18) over rods (15) and remove from tank assembly (1). Discard filter element (14) and gaskets (18).

6. Clean out filter element (14) compartment in tank assembly (1) with a suitable solvent and dry with compressed air.

7. If damaged, remove and replace rods (15) from tank assembly (1).

8. Install new gasket (18), new filter element (14) and relief valve assembly, over rods (15) and into filter element compartment in tank assembly (1). Secure Filter element assembly (14) in position with wing nuts (16).

9. Install new gaskets (7) on access cover (8) mounting flange. Secure access cover (8) to tank assembly (1) with bolts (10) and lockwashers (11).

10. Refill tank assembly (1) with hydraulic oil, as specified in Section 300-0020, LUBRICATION SYSTEM. Install filler cap (2) and gasket (3) on filler neck assembly.

11. Place the battery master switch in the 'On' position, remove wheel blocks, start the engine and operate steering and bowl hydraulic systems to circulate the hydraulic oil.

12. Switch off the engine and check for leaks. Tighten lines and fittings as required. Check hydraulic oil tank level as described under 'Checking Oil Level'.

Replacing or Cleaning Suction Screens

Suction screens (17) should be cleaned every time tank assembly (1) is fully drained for any reason. Refer to 'Replacing Hydraulic Oil' for oil change interval.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place the battery master switch in the 'Off' position.

3. Remove bolts (9) and lockwashers (11) securing access cover (6) to tank assembly (1). Remove and discard gasket (5) from tank assembly (1).
Section 235-0040

Bowl Hydraulic System - Hydraulic Tank

2. Block all road wheels and place the battery master switch in the 'Off' position.

3. With a suitable container in position, remove drain plug (23), and drain hydraulic oil from tank. Reinstall drain plug (23).

4. Tag and disconnect all lines and fittings attached to tank assembly (1), to aid in 'Installation'. Cap all lines and fittings to prevent ingress of dirt.

5. Secure a suitable lifting device on tank assembly (1) and remove bolts (24), washers (25), lockwashers (26) and nuts (27) securing tank assembly (1) to tank mountings.

6. Carefully remove tank assembly (1) from the vehicle to a clean area for disassembly.

Disassembly

1. Remove internal components from tank assembly (1) as previously described under 'Maintenance'.

2. Remove breather (21) from top of tank assembly (1).

3. Remove sight gauges (20) from tank assembly (1).

4. With a suitable container in position, remove drain plug (23), and drain hydraulic oil to below the level of suction screens (17). Reinstall drain plug (23).

5. Remove suction screen (17) from the interior of tank assembly (1).

6. Clean Suction screen (17) in a suitable solvent and dry with compressed air.

7. Inspect suction screen (17) for damage and replace if required.

8. Install suction screen (17) and secure.

9. Install new gasket (5) on access cover (6) mounting flange. Secure access cover (6) to tank (1) assembly with bolts (9) and lockwashers (11).

10. Refill tank assembly (1) with hydraulic oil, as specified in Section 300-0020, LUBRICATION SYSTEM. Install filler cap (2) filler neck assembly.

11. Place the battery master switch in the 'On' position, remove wheel blocks, start the engine and operate steering and bowl hydraulic systems to circulate the hydraulic oil.

12. Switch off the engine and check for leaks. Tighten lines and fittings as required. Check hydraulic oil tank level as described under 'Checking Oil Level'.

Inspection

1. Clean tank assembly (1) and components with a suitable solvent and dry with compressed air.

2. Inspect tank assembly (1) for weld cracks and security of internal pipes and weld fitments.

3. Clean Suction screen (17) in a suitable solvent and dry with compressed air.

4. Inspect Suction screen (17) for damage and replace if required.

5. Install Suction screen (17) and secure.

6. Install new gasket (5) on access cover (6) mounting flange. Secure access cover (6) to tank (1) assembly with bolts (9) and lockwashers (11).

7. Refill tank assembly (1) with hydraulic oil, as specified in Section 300-0020, LUBRICATION SYSTEM. Install filler cap (2) filler neck assembly.

8. Place the battery master switch in the 'On' position, remove wheel blocks, start the engine and operate steering and bowl hydraulic systems to circulate the hydraulic oil.

9. Switch off the engine and check for leaks. Tighten lines and fittings as required. Check hydraulic oil tank level as described under 'Checking Oil Level'.

10. Renew all gaskets and install all internal components in tank assembly (1), as previously described under 'Maintenance'.

11. Install breather (21) on top of tank assembly (1).

12. Install sight gauges (20) on tank assembly (1).
Bowl Hydraulic System - Hydraulic Tank

Section 235-0040

Installation

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

**Note:** Tighten all hydraulic lines fitted with ORFS connections, as described in Section 235-0000, HYDRAULIC SYSTEM SCHEMATIC.

**WARNING**

To prevent personal injury and property damage, be sure lifting equipment is properly secured and of adequate capacity to do the job safely.

1. Using a suitable lifting device, position tank assembly (1) carefully in position on the vehicle.

2. Secure tank assembly (1) to tank mounting brackets with bolts (24), washers (25), lockwashers (26) and nuts (27).

3. Install all lines and fittings to tank assembly (1) as tagged at 'Removal'.

4. Remove filler cap (2) from filler neck assembly and refill tank assembly (1) with hydraulic oil, as specified in Section 300-0020, LUBRICATION SYSTEM. Install filler cap (2) on filler neck assembly.

5. Place the battery master switch in the 'On' position, remove wheel blocks, start the engine and operate steering and bowl hydraulic systems to circulate the hydraulic oil.

6. Switch off the engine and check for leaks. Tighten lines and fittings as required. Check hydraulic oil tank level as described under 'Checking Oil Level'.

**SERVICE TOOLS**

There are no special tools required for the procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.
BOWL HYDRAULIC SYSTEM - Triple Pump

Section 235-0050

DESCRIPTION
Numbers in parentheses refer to Fig. 1.

The triple pump supplies hydraulic oil for operating the bowl hydraulic and steering systems.

This is a multiple gear type pump consisting of three separate pumping units connected together as one assembly. The first pump unit consists of driveshaft & gear (12), driven gear (13) and gear housing (15). Drive gear (20), driven gear (21) and gear housing (22) make up the second pump unit. Drive gear (25), driven gear (26) and gear housing (27) make up the third pump unit. Connecting shafts (17 & 23) connect the second and third pump units to driveshaft and gear (12).

OPERATION
Numbers in parentheses refer to Fig. 1. Refer to Fig. 2 for the operation of a typical gear type hydraulic pump. Refer to Fig. 3 for hydraulic schematic of the triple pump operation.

One pump unit supplies hydraulic oil to the steering system. The remaining two pump units supply hydraulic oil to the bowl hydraulic system.

As the drive gear rotates, the driven gear rotates in the opposite direction. The pockets between the gear teeth carry oil from the inlet port around the gear housing ID to the pump outlet port. As the gear teeth re-mesh, this oil is forced out of the outlet port of the gear housing. The maximum oil delivery rate of each section of the triple pump is fixed by the width of its respective gear set and the speed at which driveshaft (12) is turned.

Fig. 1 - Cutaway View of Triple Pump

1 - Snap Ring  9 - Bearings  17 - Connecting Shaft  25 - Drive Gear
2 - Spacer  10 - Pocket Seals  18 - Bearing Carrier  26 - Driven Gear
3 - Seal Retainer  11 - Thrust Plates  19 - Plug *  27 - Gear Housing
4 - 'O' Ring *  12 - Driveshaft & Gear  20 - Drive Gear  28 - End Cover
5 - Seal *  13 - Driven Gear  21 - Driven Gear  29 - Washers *
6 - Shaft End Cover  14 - Seals  22 - Gear Housing  30 - Studs *
7 - Plug *  15 - Gear Housing  23 - Connecting Shaft  31 - Nuts
8 - Ring Seals  16 - Seals  24 - Bearing Carrier  32 - Pins (if used) *

* Shown on Fig. 6.
REMOVAL

**WARNING**
To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in accumulator and steering system.

2. Block all road wheels and place the battery master switch in the 'Off' position.

3. With a suitable container in position, remove the drain plug from the hydraulic tank and drain the oil. Reinstall the drain plug in the hydraulic tank and tighten securely.

4. Clean pump housing and tag and disconnect inlet and outlet lines from pump. Make sure pump is supported when removing line flange bolts which also secure pump support bracket. When flange bolts are removed, pump support bracket will also be disconnected at the pump. Drain oil in lines into a suitable container. Cap lines and pump ports to prevent ingress of dirt.

5. With suitable blocking or lifting equipment, support pump before loosening attaching nuts. Remove nuts and lockwashers from pump mounting studs. Move pump to a suitable work area for disassembly.

DISASSEMBLY

Numbers in parentheses refer to Fig. 6.

1. Place pump in a soft-jawed vice, driveshaft (12) down. Match mark all pump sections with a punch to aid assembly. See Fig. 4.

**Note:** Do not clamp vice on pump machined surfaces at any time.

2. Remove nuts (31) and washers (29) from studs (30). See Fig. 5. Remove studs (30) from pump assembly.
Bowl Hydraulic System - Triple Pump

Section 235-0050

Fig. 6 - Exploded View Of Triple Pump

1 - Snap Ring
2 - Spacer
3 - Seal Retainer
4 - 'O' Ring
5 - Seal
6 - Shaft End Cover
7 - Plug
8 - Ring Seals
9 - Bearings
10 - Pocket Seals
11 - Thrust Plates
12 - Driveshaft & Gear
13 - Driven Gear
14 - Seals
15 - Gear Housing
16 - Seals
17 - Connecting Shaft
18 - Bearing Carrier
19 - Plug
20 - Drive Gear
21 - Driven Gear
22 - Gear Housing
23 - Connecting Shaft
24 - Bearing Carrier
25 - Drive Gear
26 - Driven Gear
27 - Gear Housing
28 - End Cover
29 - Washers
30 - Studs
31 - Nuts
32 - Pins (if used)
3. Tap end cover (28) with a soft hammer and separate from gear housing (27). If end cover (28) must be pried off, use care to avoid damaging machined surfaces of the cover and housing. See Fig. 7. If thrust plate (11) stays with gear housing (27), it can be tapped out later. Do not damage or distort thrust plate (11).

4. Separate gear housing (27) from bearing carrier (24) and lift off. See Fig. 8. If it must be pried loose, use care to prevent damage to machined surfaces. Tap or pry out thrust plate (11) carefully, if it remained with gear housing (27).

5. Mark three meshed gear teeth with a dab of Prussian blue, or similar dye, and lift out matched gears (25 & 26). See Fig. 9. Keep these gears together. Do not interchange with other gear sets.

6. Loosen bearing carrier (24) with a plastic hammer and lift or pry off with care to avoid damaging machined surfaces. Separate thrust plate (11) from bearing carrier (24) carefully to avoid distortion. See Fig. 10.

7. Remove connecting shaft (23) from drive gear (20). See Fig. 11.
8. Repeat Steps 4 through 7 to remove gear housing (22), matched gear set (20 & 21), bearing carrier (18) and connecting shaft (17).

9. Separate and lift off gear housing (15) with care. See Fig. 12. Remove thrust plate (11) as in Step 4.

10. Mark three meshed gear teeth with a dab of Prussian blue, or similar dye, and remove matched driveshaft and gear (12) and driven gear (13) set. See Fig. 13.

11. Pry thrust plate (11) from shaft end cover (6) carefully to avoid distortion. See Fig. 14.

12. Clamp shaft end cover (6) in vice, mounting face up. Remove snap ring (1) with snap ring pliers. See Fig. 15.

13. Pull spacer (2) from shaft end cover (6) with a bearing puller. See Fig. 16.

14. Remove seal retainer (3) and seal (5) from shaft end cover (6). See Fig. 17. The seal retainer removal tool can be fabricated as shown in Fig. 37. Remove and discard ‘O’ ring (4).

15. Tap seal (5) from seal retainer (3). See Fig. 18. The tool shown in Fig. 37 can be fabricated to separate these parts.
Section 235-0050

Bowl Hydraulic System - Triple Pump

6. Check gears carefully for wear. Scoring, grooving or burring of the gear teeth OD requires gear replacement. Nicked, grooved or fretted gear tooth mating surfaces also require gear replacement. Any wear of gear hubs in excess of 0.05 mm (0.002 in), or detectable by touch, requires gear replacement. Since both drive and driven gears of a set are matched, both gears must be replaced if one is worn or damaged.

7. Check the centre of thrust plates (11) at the point of meshing of gears (12 & 13), (20 & 21) and (25 & 26). Erosion indicates contaminated oil. Pitted thrust plates indicate cavitation or aeration of the oil supply. Discoloured thrust plates are a sign of pump overheating. Thrust plate side wear permits oil to bypass gears and allows internal oil slippage and reduced pump efficiency. Check thrust plate surface wear against the size of new thrust plates. If worn more than 0.05 mm (0.002 in), replace the thrust plates.

8. Bearings (9) should fit into their bores with a light press fit. A tight hand fit is allowable. If the bearings can fall out of their bores, the bores might be distorted or oversize. When gears are replaced, their bearings must also be replaced.

9. Check driveshaft and gear (12) for wear or damage to splines, and seal areas. Replace the driveshaft and driven gear matched set if wear is detectable by touch or measures in excess of 0.05 mm (0.002 in) at the seal or drive areas. Excessive spline wear requires driveshaft and matching gear replacement.

10. Smooth all machined surfaces with a medium-grit stone. See Fig. 21. Deburr all bearing bores if required.

16. If necessary, remove bearings (9) and ring seals (8) from shaft end cover (6), bearing carriers (18 & 24), gear housings (15 & 22) and end cover (28). See Figs. 19 & 20.

17. Remove and discard all pocket seals (10) from thrust plates (11), and, seals (14 & 16) from gear housings (15, 22 & 27).

18. Remove plug (7) only if damaged.

INSPECTION

Numbers in parentheses refer to Fig. 6.

1. Clean all parts in suitable solvent and dry all but bearings with compressed air.

2. Dry bearings with a clean, lint-free cloth.

3. Examine all bearings (9) carefully for scoring, spalling or pitting. Lightly oil the bearings and spin by hand to check for roughness of operation. Replace bearings if necessary.

4. Check ring seals (8) for wear or damage and replace if necessary.

5. Check gear housings (15, 22 & 27) carefully for wear. Hydraulic pressure forces the gears against the low pressure side of the housing. As the bearings and gear hubs wear, the housing gear bores wear. Excessive bore cutout, particularly in a short period, indicates excessive pump loading or dirty oil. Place a straight edge across the cutout area of the gear bore. If a 0.13 mm (0.005 in) feeler gauge can be slipped between the straight edge and the worn area of the gear bore, replace the gear housing.

Fig. 19 - Removing Bearings

Fig. 20 - Removing and Installing Seals

Fig. 21 Cleaning Gear Housing
11. Clean parts in a suitable solvent and dry with compressed air after smoothing surfaces.

ASSEMBLY

Numbers in parentheses refer to Fig. 6.

**Note:** Tighten all fasteners without special torques specified to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. If removed, install new plug (7) in shaft end cover (6). Be sure to install plug in the outlet side of shaft end cover (6). The unplugged drain hole must be on the inlet side of shaft end cover (6). Turn plug (7) in until one thread of the hole is visible. Secure plug (7) by staking around the hole with a punch.

2. If removed, install ring seals (8) into the bearing bores in shaft end cover (6), bearing carriers (18 & 24) and end cover (28). The notch in the ring seal must be visible. See Fig. 20.

3. If removed, press new bearings (9) into the bearing bores of shaft end cover (6), bearing carriers (18 & 24) and end cover (28) with an arbor press. See Fig. 22.

4. For each thrust plate (11) using pocket seals (10), cut two pocket seals 9 mm (0.34 in) long from a new seal strip. Coat with grease and insert seals into the centre slots of thrust plates (11). See Fig. 23.

5. Place thrust plate (11) over bearings (9) in shaft end cover (6), bearing carriers (18 & 24) and end cover (28). With seals facing bearings, tap thrust plate with a soft hammer to about 0.8 mm (0.031 in) from machined surface. See Fig. 24.

6. For each thrust plate (11) using pocket seals (10), cut four pocket seals 11 mm (0.44 in) long from a new seal strip. Insert one pocket seal into each of the outer slots in the thrust plates. Push each seal into the thrust plate slot so that it touches bearing (9). Tap thrust plate (11) down against the machined surface with a soft hammer. Trim the exposed ends of pocket seals (10) square and flush with thrust plate (11) using a razor blade or sharp knife. See Fig. 25.

7. With shaft end cover (6) clamped in a soft-jawed vice, insert driveshaft and gear (12) into the shaft end cover bore and push down until the gear is snug.
against thrust plate (11). Install matched driven gear (13) hub into its bearing (9) so that the three teeth marked at 'Disassembly' will mesh. See Fig. 26.

8. Coat new seals (14 & 16) with grease and insert them into their grooves in both sides of gear housings (15, 22 & 27). See Fig. 27.

9. Slide gear housing (15) over gears (12 & 13) and, with match marks made at 'Disassembly' aligned, tap gear housing (15) with a soft hammer until it rests snugly against shaft end cover (6). See Fig. 28. If a new gear housing is used, make sure the large oil port will be toward the inlet, and the small port toward the outlet side of the pump assembly. Be sure seal (14) is not pinched or dislodged. Coat gears (12 & 13) with hydraulic fluid for initial lubrication when the pump is started.

10. With match marks aligned, position bearing carrier (18) on gear housing (15) so that bearings (9) will receive the journals of the drive and driven gears (12 & 13). Tap bearing carrier (18) down tight with a soft hammer. See Fig. 29.

Note: The drain hole plug (19) must be on the inlet side of the pump.

11. Insert connecting shaft (17) into the spline of driveshaft and gear (12). See Fig. 30.

12. Insert the matched set of drive and driven gears (20 & 21) into their respective bores of bearings (9) in bearing carrier (18) so that the three teeth marked at 'Disassembly' will mesh. See Fig. 31. Push the gears down tightly against thrust plate (11).

13. Repeat Steps 9 through 12 to assemble gear housing (22), bearing carrier (24), connecting shaft (23), drive gear (25) and driven gear (26).

14. Slide gear housing (27) over gears (25 & 26) and,
with match marks made at 'Disassembly' aligned, tap gear housing (27) with a soft hammer until it rests snugly against bearing carrier (24). Refer to Fig. 28. If a new housing is used, make sure the large oil port will be toward the inlet, and the small port toward the outlet side of the pump assembly. Be sure seal (14) is not pinched or dislodged. Coat gears (25 & 26) with hydraulic fluid for initial lubrication when pump is started.

15. With match marks aligned, position end cover (28) over gear (25 & 26) journals. Tap end cover (28) lightly with a soft hammer to seat on gear housing (27). See Fig. 32. Be careful not to pinch seal (16).

16. Insert eight studs (30) through the pump assembly and thread into shaft end cover (6). Install washers (29) and nuts (31). Tighten opposite nuts alternately until snug. See Fig. 33. Rotate driveshaft (12) with a 150 mm (6 in) wrench and check carefully for pump binding. If the pump rotates freely, torque tighten alternate nuts (31) to 271 Nm (200 lbf ft). If the pump binds, the cause should be determined and corrected before completing the assembly. Check for burrs on shafts, housings, bearings, etc., or similar causes.

17. Coat the OD of seal (5) with Loctite Seal retainer or equivalent. Press seal (5), metal side down, into seal retainer (3) on an arbor press using a 70 mm (2.75 in) diameter bar. See Fig. 34. Be careful not to damage the lip of seal (5).

18. Clamp pump assembly in a soft-jawed vice, driveshaft (12) up.

19. Coat a new 'O' ring (4) with grease and install on seal retainer (3). Oil a suitable seal installation sleeve and twist into the seal ID carefully. Slide the sleeve and seal over driveshaft (12) and seat seal (5) and seal retainer (3) assembly firmly in shaft end cover (6) bore. Remove seal installation sleeve. See Fig. 35.

20. Insert spacer (2) over driveshaft (12) and install into
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4. Fill hydraulic tank to the proper level. Refer to Section 235-0040, HYDRAULIC TANK for correct oil level and, Section 300-0020, LUBRICATION SYSTEM for oil specification.

5. Operate the pump at least two minutes at zero pressure at engine idle speed. During this break-in period, it should run free and not develop excessive heat. If the pump becomes hot to touch, it is binding and might seize. The pump will then have to be rebuilt with extra care to avoid binding. If the pump runs properly, speed and pressure can be increased to normal operating values.

6. Check pump mounting and line connections for leaks. Remove wheel blocks.

LUBRICATION

All pump parts are lubricated by the hydraulic oil. The oil, therefore, must be kept clean to minimize pump wear. Whenever there is a hydraulic system failure, the oil should be drained, the entire system flushed, oil filters replaced, oil screens thoroughly cleaned and fresh hydraulic oil installed to eliminate all metal particles or foreign matter.

Refer to Section 300-0020, LUBRICATION SYSTEM, for recommended periodic oil drain periods and oil specifications.

SPECIAL TOOLS

The special tools shown in use in Figs. 17 & 18 can be fabricated as shown in Fig. 37. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools and adhesives required. These tools and adhesives are available from your dealer.

1. Coat the pump driveshaft spline with high grade plating-type molybdenum disulphide grease 15% minimum (typical).

2. With suitable lifting equipment position pump on mounting studs. Secure with lockwashers and nuts.

3. Fill all pump ports with clean hydraulic oil and connect lines to pump, as tagged during removal. Be sure pump support bracket is installed on pump at same location from which it was removed. Use the two longer flange bolts at this location.

INSTALLATION AND RUN-IN

Note: Tighten all fasteners without special torques specified to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

Note: Tighten all hydraulic lines fitted with ORFS connections, as described in Section 235-0000, HYDRAULIC SYSTEM SCHEMATIC.

A WARNING

To prevent personal injury and property damage, be sure blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

<table>
<thead>
<tr>
<th>FIG. NO.</th>
<th>ITEM NO.</th>
<th>ITEM NAME</th>
<th>TORQUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 &amp; 6</td>
<td>31</td>
<td>Nut</td>
<td>271</td>
</tr>
</tbody>
</table>

* * * *
DESCRIPTION
Numbers in parentheses refer to Fig. 1.

The control valve is used to direct hydraulic oil to the cylinders for raising or lowering the apron, ejector or bowl depending on the position of the control spools (60, 61 & 62). The position of control spools (60, 61 & 62) is controlled by the servo control valve, located on the right hand dash panel, by means of hydraulic oil pressure and springs. Refer to Section 235-0160, SERVO CONTROL VALVE.

The main components of the control valve assembly are three control spools (60, 61 & 62), main pressure...
relief valve (5), three check valve assemblies (18 to 28) and valve housing (3).

The main pressure relief valve permits bypassing hydraulic oil back to the tank, should oil pressure exceed 127.5 bar (1 850 lbf/in²). Check valves in the spools prevent return oil flow from cylinders until supply oil pressure at the spools is sufficient to move the loads. Thus they prevent unexpected movement (dropping) of a load until oil pressure is sufficient to hold or raise it.

Note: The bowl spool in the control valve used with a power down bowl is a double acting type and contains two load check valves and springs. The apron spool in the control valve used with a power apron is a double acting type and contains two load check valves and springs. The ejector spool is a single acting type containing one check valve and spring.

OPERATION

Neutral
With no signal oil pressure applied, the spools are held in their neutral positions by centering springs at either end. Oil supply through the inlet port flows through the central passage around spool grooves to the outlet port, and through the oil return hose to tank. Since valve oil ports connected to the cylinder supply hoses are blocked by the spools, no oil can flow to or from the cylinders. The cylinders are therefore held in their position by oil trapped on their pistons.

Ejector - Raise
When signal oil pressure is applied to the end of the spool, the spool shifts. This action aligns the spool lands to block the supply oil flow from the valve inlet channel to the outlet port.

Supply is now directed through the spool holes and bore to unseat the spool check valve and then flow to the cylinder forcing it to extend.

Power Apron - Raise
When signal pressure is applied to the end of the apron spool, it shifts into the raise position. Oil flows out of the housing apron port and enters the apron cylinder base end ports. This extends the apron cylinders which raises the apron. Oil forced out of the apron cylinder rod ends flows into the control valve housing and back into the tank. The purpose of the load check valves inside the apron spool is to prevent the apron cylinders from moving when the apron spool is shifted from neutral to raise.

Power Down Bowl - Raise
When signal pressure is applied to the end of the bowl spool, it shifts into the raise position. Oil flows out of the housing bowl port and enters the bowl cylinder base end ports. This extends the bowl cylinders which raises the bowl. Oil forced out of the bowl cylinder rod ends flows into the control valve housing and back into the tank. The purpose of the load check valves inside the bowl spool is to prevent the bowl cylinders from moving when the bowl spool is shifted from neutral to raise.

Ejector - Lower
When signal oil pressure is applied to the end of the spool, the spool shifts. This action aligns ports in the spool with ports in the valve so that oil can return through the same port that it left and then unseat the check valve and return through an outer channel in the valve and back to tank. Main oil pressure is still allowed to flow through the centre of the valve since the spool does not totally block its flow.

Power Apron - Lower
When signal oil pressure is applied to the opposite end of the apron spool, it is shifted in the opposite direction into the lower position. Oil flows out the opposite housing port and flows into the apron cylinder rod ends. This retracts the apron cylinders which lowers the apron. Oil from the cylinder base ends returns to the valve housing return port and back into the tank.

Power Down Bowl - Lower
When signal oil pressure is applied to the opposite end of the bowl spool, it is shifted in the opposite direction into the lower position. Oil flows out the opposite housing port and flows into the bowl cylinder rod ends. This retracts the bowl cylinders which lowers the bowl and cutting edge into the ground. Oil from the cylinder base ends returns to the valve housing return port and back into the tank.
REMOVAL
Numbers in parentheses refer to Fig. 1.

**WARNING**
To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Place the battery master switch in the 'Off' position and block all road wheels.

3. With suitable containers available to catch spillage, open drain cock at the bottom of the hydraulic tank and drain hydraulic oil. Close drain cock.

4. Clean control valve housing (3) and surrounding area with a suitable solvent. Identify and tag all hydraulic and servo control lines connected to control valve, to aid in 'Installation'.

5. With suitable containers available to catch spillage, disconnect hydraulic and servo control lines from control valve. Drain the oil from the lines into the container and discard all 'O' rings. Cap hydraulic lines and control valve ports to prevent ingress of dirt.

6. Support control valve and remove mounting bolts and lockwashers securing control valve to its mounting bracket. Remove control valve to a clean area for disassembly.

DISASSEMBLY
Numbers and letters in parentheses refer to Fig. 1.

**WARNING**
Spring loaded parts. Use care when removing end cap, retainers and plugs to prevent sudden release of spring tension behind these parts. Personal injury or property damage could result if care is not taken.

**Note:** Clean entire control valve assembly with a suitable solvent and dry thoroughly prior to disassembly.

Control Spool
1. Clean the entire control valve assembly with a suitable solvent and dry thoroughly. Remove caps from valve housing (3) ports.

2. If required, clamp control valve assembly in a soft jawed vice. Take care to avoid damaging valve housing (3) machined surfaces.

**Note:** When removing spring cap (18) and spring assemblies, remove the light spring assemblies first, i.e. the caps fitted on the same side as the plug (1). The heavy spring assemblies should only be removed with the spool secured in a spool clamp.

3. Remove screws (15), lockwashers (16) and end cover (17) from valve housing (3).

4. Using an Allen key in the spring cap (18), sharply tap the key to break the grip of the Loctite. Unscrew cap (18) and remove spring (22), spacer (21), spring retainer (20 & 23), seal retainer (25) and seal rings (24 & 26). Remove spring (27) and check valve (28) from the apron spool (61).

5. Carefully remove screws (15), lockwashers (16) and end cover (39) from valve housing (3) and withdraw spool assembly (29 to 38) from valve housing (3). Note the direction of withdrawal and label the spool to facilitate reassembly.

6. Secure the spool assembly (29 to 38 & 61) in a spool clamp. Using an Allen key in the spring cap (38), sharply tap the key to break the grip of the Loctite. Unscrew cap (38) and remove spring (35), spacer (36), spring retainer (34 & 37), seal retainer (32) and seal rings (31 & 33). Remove spring (30) and check valve (29) from the apron spool (61).

7. Repeat steps 3, 4, 5 and 6 for the remaining spools.

Relief Valve
1. Clean the entire control valve assembly with a suitable solvent and dry thoroughly. Remove caps from valve housing (3) ports.

2. If desired, clamp control valve assembly in a soft jawed vice. Take care to avoid damaging valve housing (3) machined surfaces.

3. Remove acorn nut (14), jam nut (12) and seal washers (11 & 13).

4. Slacken adjusting screw (10) until loose. Remove
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adjusting cap (9) and seal ring (8), poppet spring (7) and poppet (6).

5. Remove plug (1) and seal ring (2) from the opposite end of valve housing (3). Discard seal ring (2).

6. Using a suitable piloted bronze or brass drift, drive or press out relief valve (5) assembly and seal ring (4) from bore in valve housing (3). Discard seal ring (4).

Valve Body
1. If required, remove plugs (63 & 65) and ‘O’ rings (64 & 66) from valve housing (3). Discard ‘O’ rings (64 & 66).

2. If required, remove adaptor (69) and ‘O’ ring (70) from valve housing (3). Discard ‘O’ ring (70). If required, remove plug (67) and ‘O’ ring (68) from adaptor (69). Discard ‘O’ ring (68).

INSPECTION
Numbers in parentheses refer to Fig. 1.

1. Remove and discard all ‘O’ rings and seals. Clean all parts thoroughly in a suitable solvent and examine for wear and/or damage.

2. Examine the poppet and relief valve cartridge poppet seat for signs of wear or damage. If either unit is faulty, both components should be replaced. The relief valve assembly can only be serviced as a complete unit. The relief valve adjusting screw (10) and its mating threads in the adjusting cap (9) must be in good condition to ensure accurate pressure relief adjustment.

3. Examine valve housing (3) bores and seal recesses, and if they are badly scored or damaged, the complete valve assembly should be replaced.

4. Examine the spool check valves (28, 29 & 59), springs (27, 30 & 58) and spring caps (18, 38, 41 & 50) for wear or damage. Fit replacement items as required.

ASSEMBLY
Numbers and letters in parentheses refer to Fig. 1.

Note: Lightly lubricate all components with hydraulic oil. Refer to Section 300-0020, LUBRICATION SYSTEM, for recommended oil specifications.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

Valve Body
1. If removed, install new ‘O’ rings (64 & 66) on plugs (63 & 65) and install in valve housing (3).

3. If removed, install new ‘O’ ring (68) on plug (67) and install in adaptor (69). Install new ‘O’ ring (70) on adaptor (69) and install in valve housing (3).

Relief Valve
1. Install relief valve (5) assembly with seal ring (4) into relief valve bore in valve housing (3).

Note: Drive relief valve (5) assembly with a brass or bronze drift until the snap ring on the outer sleeve locates in the recess in the relief valve bore.

2. Install plug (1) and seal ring (2) in valve housing (3).

3. Lightly oil the poppet (6) and spring (7) and assemble these items with the adjusting cap (9) and seal (8). Install assembly in valve housing (3).

Note: Do not grind or lap poppet (6) to its seat as both components have a ground finish.

4. Install adjusting screw (10) in adjusting cap (9). Loosely fit the seal washers (11 & 13), nut (12) and acorn nut (14).

5. Leave adjusting screw loose prior to pressure setting. Refer to ‘Adjustments’ for correct pressure setting.

Control Spool
1. Secure spool (61) in a spool clamp and install the check valve (29) and spring (30) in the heavy spring end.

2. Install seal rings (31 & 33) to seal retainer (32) and fit the seal retainer to spool (61).

3. Install spring retainer (34), spring (35), spacer (36) and spring retainer (37) to spool (61).

4. Fit new seal to the spring cap (38) and apply Loctite to the threads. Install spring cap (38) in spool (61).
5. Install spool (61) assembly in valve housing (3) bore.

6. Repeat steps 1 to 5 for the opposite end of spool (61).

7. Secure end covers (17 & 39) to valve housing (3) using screws (15) and lockwashers (16).

8. Repeat steps 1 to 7 for spools (60 & 62).

**INSTALLATION**

Numbers in parentheses refer to Fig. 1.

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

**Note:** Tighten all hydraulic lines fitted with ORFS connections, as described in Section 235-0000, HYDRAULIC SYSTEM SCHEMATIC.

---

**WARNING**

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

---

1. Using a suitable lifting device, position control valve in place on the machine. Secure control valve in place with mounting bolts and lockwashers as removed at 'Removal'.

2. Reconnect all servo control and hydraulic lines to control valve, as tagged at 'Removal'.

**Note:** Be sure to use new 'O' rings with the fittings.

3. Fill hydraulic oil tank with hydraulic oil as specified in Section 300-0020, LUBRICATION SYSTEM. Refer to Section 235-0040, HYDRAULIC TANK, for hydraulic oil levels.

4. Adjust the system relief valve according to the instructions in 'Adjustments'.

---

**ADJUSTMENTS**

Numbers in parentheses refer to Fig. 1.

**Relief Valve Adjustment**

The relief valve, incorporated in the control valve, is set at the factory for a maximum oil pressure of 127.5 bar (1 850 lbf/in²). Do not adjust the valve setting unless it has been determined that the maximum pressure is above or below 127.5 bar (1 850 lbf/in²).

**Note:** Do not adjust the setting to increase pressure above 127.5 bar (1 850 lbf/in²) to compensate for over loading the scraper with extra heavy materials.

**Note:** If adjustment only is to be carried out, the procedure for blocking the machine as described in 'Removal, must be strictly adhered to, ensuring the bowl is completely empty.

---

**WARNING**

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Remove plug (67) from adaptor (69) and connect a hydraulic gauge, capable of recording a pressure of 0 - 207 bar (0 - 3 000 lbf/in²), to diagnostic pressure point.

2. Start engine, operate at 1 500 rev/min and the bowl until the related cylinders are fully extended.

3. Hold the bowl control lever in the raise position and keep the engine accelerated at 1500 rev/min while watching the pressure gauge. The maximum reading on the gauge will indicate the pressure at which the valve is opening. If the reading is above or below 127.5 bar (1 850 lbf/in²), the relief valve requires adjustment.

4. Remove acorn nut (14) and loosen adjusting screw jam nut (12).

5. Adjust valve by turning adjusting screw (10) clockwise to increase pressure or counter-clockwise to decrease pressure.
Note: This is a pilot operated relief valve which is sensitive to adjustment. One complete turn of the adjusting screw will change the pressure setting approximately 55 - 69 bar (800 - 1 000 lbf/in²).

6. After the adjustment is completed, tighten jam nut (12) and replace acorn nut (14).

7. Re-check the pressure to make certain that it did not change when tightening the jam nut. If the pressure setting is correct, remove the pressure gauge and replace plug (67).

8. Check control valve assembly and hydraulic lines for leaks. Tighten as required.

9. Remove all blocking from road wheels.

MAINTENANCE
Relief valve pressure should be checked on a regular basis to ensure correct operating pressures are being maintained. Limited repair of the control valve is with replacement of parts only.

SERVICE TOOLS
There are no special tools required for the procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools and adhesives. These tools and adhesives are available from your dealer.
DESCRIPTION

Numbers in parentheses refer to Fig. 1.

The bowl hydraulic accumulator can be identified as item 12 in Section 235-0000, BOWL HYDRAULIC SYSTEM SCHEMATIC.

The accumulator is mounted off the hood mounting bracket inboard of the right hand fender. The accumulator is of the piston type and is precharged with nitrogen to 27.5 bar (400 lbf/in²). It consists of charging valve (1), end cap (10), cylinder (12) and piston (5). Charging valve (1) is equipped with a locking feature. Loosening locknut (1D) will open the valve so that the precharge can be checked or the accumulator charged.

OPERATION

Numbers in parentheses refer to Fig. 1.

Piston (5) acts as a separator dividing cylinder (12) into two sections. The section nearest charging valve (1) contains the nitrogen pre-charge. Hydraulic oil from the triple pump flows through the bowl control valve and into the lower section of the accumulator via solenoid valve.

TESTING

WARNING

 Accumulator is charged with Nitrogen. The service pressure is 27.5 bar (400 lbf/in²) at 21°C (70°F). Do not attempt to remove any valves or fittings until all nitrogen pressure is completely relieved to prevent personal injury and property damage.

Testing Charging Valve For Leakage

Numbers in parentheses refer to Fig. 1.

1. Remove screws (2), lockwashers (3), protector (4) and pads (11) from accumulator.

2. Remove valve cap (1A) from charging valve (1) and loosen locknut (1D). Coat open end of charging valve with soapy water. Bubbles indicate leaky valve core (1B). Attempt to reseat the valve core by depressing and releasing it quickly once or twice. Recheck for leakage, if leakage continues then discharge the accumulator as described under 'Discharging Nitrogen' in this section, then replace the valve core. Torque tighten locknut (1D) to 11 Nm (100 lbf in) and replace valve cap (1A) finger tight.
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Section 235-0070

Testing Pre-charge Pressure
Numbers in parentheses refer to Fig. 2, unless otherwise specified.

Note: The nitrogen pressure in an accumulator is directly affected by changes in nitrogen temperature. The cylinder pressure will increase or decrease proportionally with temperature changes. An accumulator pressure reading can vary about 4.3 bar (62 lbf/in²) with 22° C (72° F) temperature change. Such temperature changes could easily occur between noon and midnight of the same day. Refer to the table at the end of this section for Nitrogen pressures at ambient temperatures of other than 21° C (70° F).

To test accumulator pre-charge pressure or to charge the accumulator, a charging assembly tool can be used. See Fig. 2.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine.

2. Operate the bowl hydraulic controls continuously to discharge the bowl hydraulic accumulator. Block all road wheels and place the battery master switch in the 'Off' position.

3. Check accumulator mounting to be sure the accumulator is held tightly in position.

4. Remove cap (1A, Fig. 1) from accumulator charging valve (1, Fig. 1). Attach charging line (1) to charging valve by rotating 'T' handle of valve chuck (2) anticlockwise until it stops. Screw the swivel nut down on the valve until it seats. Loosen charging valve locknut (1D, Fig. 1) by turning anticlockwise one to two turns.

5. Turn 'T' handle clockwise until charging valve core is depressed. Be sure bleeder valve (10) is tight and does not leak, and valves (4 & 6) are closed.

6. To read accumulator precharge pressure, slowly open accumulator valve (4). Pressure gauge (5) will register pre-charge pressure, it should be 27.5 bar (400 lbf/in²) at 21° C (70° F) ambient temperature. Refer to the table at the end of this section for Nitrogen pressures at ambient temperatures of other than 21° C (70° F).

7. Close accumulator valve (4) and open bleeder valve (10) to dissipate gauge pressure. Close bleeder valve (10) after pressure is relieved. If accumulator needs charged, leave line and chuck attached to charging valve and charge the accumulator as described under 'Charging The Accumulator'.

8. If precharge is 27.5 bar (400 lbf/in²) at 21° C (70° F), rotate 'T' handle anticlockwise until it stops, then torque tighten locknut (1D, Fig. 1) on charging valve (1, Fig. 1) to 11 Nm (100 lbf in). Loosen the swivel nut and remove the gauging head.

9. Install valve cap (1A, Fig. 1) on charging valve (1, Fig. 1) and tighten finger tight.

CHARGING THE ACCUMULATOR
Numbers in parentheses refer to Fig. 2, unless otherwise specified.

Either oil or water pumped nitrogen can be used to charge the accumulator. Both types are readily available from a local compressed gas dealer.
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1. Attach line (1) and the swivel nut to charging valve (1, Fig. 1) as described in Steps 1 through 4 under the heading 'Testing Pre-charge Pressure'. Be sure valves (4 & 6) are closed.

2. Attach gauging head to nitrogen bottle by screwing down on gland nut (8).

3. Open tank valve (6) slowly; pressure shown on gauge (5) is tank pressure.

4. Open accumulator valve (4) slowly and charge accumulator to 27.5 bar (400 lbf/in²) at 21°C (70°F) ambient temperature, closing valve occasionally. Refer to the table at the end of this section for the Nitrogen pressures at ambient temperatures of other than 21°C (70°F).

5. To check accumulator charge, close tank valve (6), relieve pressure between tank and gauge by opening bleeder valve (10) momentarily. This will allow gauge needle to settle, thus giving correct pressure reading of accumulator charge.

6. When the correct pressure for the ambient temperature has been reached, close valves (4 & 6) tightly. Bleed pressure off pressure gauge (5) by opening bleeder valve (10). Close bleeder valve when all pressure is bled off the gauge.

7. Unscrew gland nut (8) from nitrogen bottle.

8. Rotate 'T' handle of valve chuck (2) anticlockwise until it stops, torque tighten charging valve locknut (1D, Fig. 1) to 11 Nm (100 lbf in), loosen the swivel nut and remove gauging head.

9. Check accumulator charging valve (1, Fig. 1) for leakage using soapy water. Reinstall valve cap (1A, Fig. 1) and tighten finger tight.

DISCHARGING NITROGEN
Numbers in parentheses refer to Fig. 1, unless otherwise specified.

Make sure charging valve (1) is closed internally by turning locknut (1D) clockwise. Remove valve cap (1A) and valve core (1B) from charging valve assembly (1). Slowly turn the locknut (1D) anticlockwise to open the charging valve assembly (1).

DO NOT remove charging valve (1) until all the gas has been completely evacuated.

REMOVAL
Numbers in parentheses refer to Fig. 3.

WARNINGS
Do not try to discharge the accumulator by depressing the charging valve core (1B, Fig. 1).

WARNINGS
Do not use Oxygen or any gas other than Nitrogen to charge an accumulator. Oxygen under pressure coming into contact with oil or grease will cause a violent explosion. Always double check to make sure you are using Nitrogen to prevent personal injury and property damage.

A high pressure nitrogen pressure regulator must be used with the charging assembly. Failure to use pressure regulator could cause property damage, personal injury or death.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine.

2. Operate the bowl hydraulic controls continuously to discharge the bowl hydraulic accumulator. Block all road wheels and place the battery master switch in the 'Off' position.

3. Remove screws (2, Fig. 1), lockwashers (3, Fig. 1) and protector (4, Fig. 1).

4. Discharge nitrogen from accumulator. Refer to previous section on 'Discharging Nitrogen' for correct procedure.

5. Disconnect hydraulic line from solenoid valve at bottom of accumulator. Drain oil and cap the line and solenoid valve port to prevent ingress of dirt.

WARNINGS
Make sure that lifting equipment, blocking materials and wheel blocks are properly secured and of adequate capacity to prevent personal injury and property damage.

Accumulator is charged with Nitrogen. The service pressure is 27.5 bar (400 lbf/in²) at 21°C (70°F). Be sure all Nitrogen pressure has been relieved before removing accumulator from the vehicle. Sudden release of pressure may cause personal injury.
Bowl Hydraulic System - Accumulator

Section 235-0070

6. Support the accumulator using an adequate sling and lifting device. Remove nuts (7) and lockwashers (6) securing clamps (2) to mounting positions. Remove accumulator and clamp assemblies (2).

DISASSEMBLY
Numbers in parentheses refer to Fig. 1.

1. Make sure all nitrogen gas has been released before starting to disassemble the accumulator. Refer to section on 'Discharging Nitrogen'.

2. If required, remove bolts (3, Fig. 3), washers (4, Fig. 3), locknuts (5, Fig. 3) and clamps (2, Fig. 3) from accumulator.

3. Remove solenoid valve and connectors, if required, from bottom port on accumulator.

4. Remove charging valve (1) from end cap (10).

5. With accumulator lying horizontal, hold accumulator cylinder (12) with a strap wrench.

6. Install pins in three equally spaced holes in end cap (10), then use a long bar working against the pins to remove end cap from cylinder (12). Remove and discard 'O' ring (9).

7. Grip cast web of piston (5) with pliers and while rotating, pull piston from cylinder (12). Remove and discard wear rings (8), backup rings (6) and 'V' section ring (7).

INSPECTION
Numbers in parentheses refer to Fig. 1.

1. Wash metal components with a suitable solvent and thoroughly air dry.

2. Inspect piston (5) for cracks or burrs. Replace piston (5) if excessively scored or worn.

3. Use an inspection lamp to check the bore of accumulator cylinder (12) for scratches or scoring. Minor nicks, scratches or light scoring of the bore can be removed by using crocus cloth. Dress the bore until all apparent imperfections have been removed. Replace complete accumulator assembly if the inside of cylinder (12) is excessively scored or worn.

4. Inspect threads in end cap (10) and threads in cylinder (12) for damage. Replace all parts worn or damaged beyond repair.

ASSEMBLY
Numbers in parentheses refer to Fig. 1.

1. Lubricate 'O' ring (9), wear rings (8), backup rings (6), 'V' section ring (7) and inside of cylinder (12) with hydraulic oil prior to assembly.

2. Install new 'V' section ring (7), backup rings (6) and wear rings (8) on piston (5).

3. Insert piston (5) into cylinder (12) with cupped end facing the open end of the cylinder. Do not let 'V' section ring (7) drag on cylinder threads. Use a hammer and wood block to tap piston into place until all of piston is 50 mm (2.0 in) below beginning of honed bore. Keep pressure against piston while tapping 'V' section ring (7) through the bore chamfer,
otherwise piston will bounce back, damaging the 'V' section ring.

4. Install new 'O' ring (9) on end cap (10) and install end cap (10) in cylinder (12). Tighten cap so that it is flush with the end of cylinder (12) within 1.6 - 2.4 mm (0.062 - 0.094 in) above or below.

5. Install charging valve (1). Torque tighten locknut (1D) clockwise to 11 Nm (100 lbf in) to close charging valve, insert valve core (1B), replace valve cap (1A) and tighten finger tight.

6. If removed, install connectors and solenoid valve to bottom port on accumulator.

7. If removed, install clamps (2, Fig. 3) on accumulator and secure with bolts (3, Fig. 3), washers (4, Fig. 3) and locknuts (5, Fig. 3).

8. Test accumulator hydraulically for leakage or failure at 255 - 276 bar (3 700 - 4 000 lbf/in²). Discharge after testing.

INSTALLATION
Numbers in parentheses refer to Fig. 3.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

Note: Tighten all hydraulic lines fitted with ORFS connections, as described in Section 235-0000, BOWL HYDRAULIC SYSTEM SCHEMATIC. Renew all 'O' rings where used.

**WARNING**
Make sure that lifting equipment, blocking materials and wheel chocks are properly secured and of adequate capacity to prevent personal injury and property damage.

1. Position accumulator on mounting bracket with the oil inlet port downward.

2. Attach clamps (2) securely with lockwashers (6) and nuts (7).

3. Remove caps installed at 'Removal' to prevent dirt entering the hydraulic line and accumulator port.

4. Install hydraulic line securely to the oil inlet port on solenoid valve fitted at the bottom of the accumulator.

5. Charge the accumulator with Nitrogen gas as described under the heading 'Charging the Accumulator' in this section.

6. Check oil level in hydraulic tank and add oil if required. Refer to Section 235-0040, HYDRAULIC TANK for correct fill level, and, use only oil as specified in Section 300-0020, LUBRICATION SYSTEM.

7. Place the battery master switch in the 'On' position and remove the wheel blocks. Start the engine and bring hydraulic oil to operating temperature.

8. Check for oil leaks as the oil pressure increases. Tighten line connections and fittings as necessary.

MAINTENANCE
Inspect the accumulator regularly for any signs of leakage or damage.

**Every 500 hours**
Check the Nitrogen precharge pressure at the accumulator, prior to checking bowl hydraulic system pressure. Refer to 'Testing Pre-charge Pressure', in this section.

SPECIAL TOOLS
Refer to Section 300-0070, SERVICE TOOLS, for part numbers of special tools referenced in this section and general service tools required. These tools are available from your dealer.

### SPECIAL TORQUE SPECIFICATIONS

<table>
<thead>
<tr>
<th>FIG. NO.</th>
<th>ITEM NO.</th>
<th>ITEM NAME</th>
<th>TORQUE</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>1D</td>
<td>Locknut</td>
<td>11 Nm</td>
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<table>
<thead>
<tr>
<th></th>
<th>lbf in</th>
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### AMBIENT TEMPERATURE - NITROGEN PRE-CHARGE PRESSURE

<table>
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<th>°F</th>
<th>bar</th>
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<td>0</td>
<td>23.7</td>
<td>344</td>
</tr>
<tr>
<td>-12</td>
<td>10</td>
<td>24.2</td>
<td>351</td>
</tr>
<tr>
<td>-7</td>
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<tr>
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<td>54</td>
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<td>442</td>
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</tbody>
</table>

⚠️ **WARNING**

This vehicle is equipped with a precharged nitrogen gas cylinder of more than 2.8 bar (40 lbf/in²). Special permits may be required when transporting the vehicle or cylinder by any method while cylinder is charged. For shipment, contact the appropriate agency in the country involved. Consult your dealer for further permit information.
DESCRIPTION

Numbers in parentheses refer to Fig. 1.

The direct acting relief valve is located in the hydraulic lines between the triple pump and servo control valve. Relief valve pressure setting is 17 bar (250 lbf/in²).

REMOVAL

Numbers in parentheses refer to Fig. 1.

⚠️ WARNING

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.
Bowl Hydraulic System - Relief Valve

Section 235-0120

2. Place the battery master switch in the 'Off' position and block all road wheels.

3. With suitable containers available to catch spillage, open drain cock at the bottom of the hydraulic tank and drain hydraulic oil. Close drain cock.

4. Clean relief valve housing (16) and surrounding area with a suitable solvent. Identify and tag hydraulic lines connected to relief valve, to aid in 'Installation'.

5. With suitable containers available to catch spillage, disconnect hydraulic lines from relief valve. Drain the oil from the lines into the container and discard all 'O' rings. Cap hydraulic lines and relief valve ports to prevent ingress of dirt.

6. Support relief valve and remove bolts (17), washers (18), lockwashers (20) and nuts (21) securing relief valve to its mounting. Remove relief valve to a clean area for disassembly.

DISASSEMBLY

Numbers and letters in parentheses refer to Fig. 1.

WARNING

Spring loaded parts. Use care when removing end cap, retainers and plugs to prevent sudden release of spring tension behind these parts. Personal injury or property damage could result if care is not taken.

1. Clean the entire relief valve assembly with a suitable solvent and dry thoroughly. Remove caps from valve housing (16) ports.

2. If required, clamp relief valve assembly in a soft jawed vice. Take care to avoid damaging valve housing (16) machined surfaces.

3. Remove acorn nut (1) and seal washer (2) from adjusting screw (4).

4. Hold adjusting screw (4) with a screwdriver and slacken jam nut (3). Remove jam nut (3), inner seal washer (2) and adjusting screw (4) from relief valve.

5. Remove relief valve cap (5) and seal ring (6). Discard seal ring (6).

6. Withdraw spring (8), spring guide (7) and relief valve plunger (9) from bore in valve housing (16).

7. Remove plug (15) and seal ring (14) from valve housing (16). Discard seal ring (14).

8. Remove blanking screw (13) and seal washer (12). Using an Allen key, unscrew set screw (11) until seat (10) is free. Push or tap seat (10) from bore in valve housing (16).

INSPECTION

Numbers in parentheses refer to Fig. 1.

1. Clean all parts thoroughly in a suitable solvent and examine for wear and/or damage.

2. Inspect all parts for signs of wear, corrosion, distortion or damage. Remove any burrs from plunger (9) with a fine stone.

3. Inspect mating faces of plunger (9) and seat (10). If they are damaged, both parts should be replaced with new or reconditioned parts. DO NOT grind or lap parts to renew the seating.

4. Remove and discard all 'O' rings and seals.

5. Check condition of rubber mounts (19) and replaced if necessary.

ASSEMBLY

Numbers and letters in parentheses refer to Fig. 1.

Note: Lightly lubricate all components with hydraulic oil. Refer to Section 300-0020, LUBRICATION SYSTEM, for recommended oil specifications.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. Insert valve seat (10), closed end first. Push or tap it into position ensuring that it is fully located in the bore.

2. Using an Allen key, turn setscrew (11) in a clockwise direction until it beds firmly onto seat (10). DO NOT over-tighten the setscrew.

3. Place seal washer (12) on blanking screw (13) and install screw (13) in the valve housing (16).

4. Grip valve housing (16) in a soft-jawed vice with open end uppermost. Insert plunger (9) full end foremost, into seat (10). Install spring (8) and spring guide (7).
5. Install a new seal ring (6) on cap (5) install cap in valve housing (16) and tighten.

6. Fit adjusting screw (4) and screw in until spring (8) is under light compression.

7. Install seal washer (2) with jam nut (3). Tighten nut only sufficiently to secure until correct pressure setting is made. Refer to 'Adjustments' for correct pressure setting.

8. Fit new seal ring (14) to plug (15) and install in valve housing (16).

**INSTALLATION**

Numbers in parentheses refer to Fig. 1.

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

**Note:** Tighten all hydraulic lines fitted with ORFS connections, as described in Section 235-0000, HYDRAULIC SYSTEM SCHEMATIC.

**WARNING**

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. If removed, install rubber mounts (19) to mounting bracket. Secure relief valve in place with bolts (17), washers (18), lockwashers (20) and nuts (21).

2. Reconnect hydraulic lines to relief valve, as tagged at 'Removal'.

**Note:** Be sure to use new 'O' rings with the fittings.

3. Fill hydraulic oil tank with hydraulic oil as specified in Section 300-0020, LUBRICATION SYSTEM. Refer to Section 235-0040, HYDRAULIC TANK, for hydraulic oil levels.

4. Adjust the system relief valve according to the instructions in 'Adjustments'.

**ADJUSTMENTS**

Numbers in parentheses refer to Fig. 1.

**Relief Valve Adjustment**

This type of relief valve is very sensitive to adjustment. Relief valve setting and adjustment can be carried out as follows:

**Note:** If adjustment only is to be carried out, the procedure for blocking the machine as described in 'Removal, must be strictly adhered to.

**WARNING**

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Remove plug and connect a hydraulic gauge, capable of recording a pressure of 0 - 207 bar (0 - 3 000 lbf/in²), to the pressure check port in relief valve housing.

2. Start the engine and watch the pressure gauge. It should read 17 bar (250 lbf/in²) when the relief valve opens. Adjust the relief valve if the pressure is not correct.

3. Remove acorn nut (1) and seal washer (2). Loosen adjusting screw jam nut (3).

4. Adjust valve by turning adjusting screw (4), clockwise to increase pressure or counter-clockwise to decrease pressure. Turn the adjusting screw in small increments.

5. After the adjustment is completed, hold adjusting screw (4) with a screwdriver and tighten jam nut (3) securely.

7. Re-check the pressure to make certain that it did not change when tightening the jam nut. If the pressure setting is correct, install the outer seal washer (2) and acorn nut (1) and tighten.

8. Check relief valve assembly and hydraulic lines for leaks. Tighten as required.

9. Remove all blocking from road wheels.
MAINTENANCE
Relief valve pressure should be checked on a regular basis to ensure correct operating pressures are being maintained. Limited repair of the control valve is with replacement of parts only.

SERVICE TOOLS
There are no special tools required for the procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools and adhesives. These tools and adhesives are available from your dealer.
Fig. 1 - Cutaway View of Servo Control Valve

1 - Knob
2 - Flexible Cover
3 - Lever
4 - Spool Actuator
5 - Strap
6 - Bolt
7 - Washer
8 - Pivot Block
9 - Pin
10 - Pin
11 - Screw
12 - Dowel Pin
13 - Lever Plate
14 - Mounting Flange
15 - Screw
16 - Wiper Seal
17 - Retainer
18 - Seal
19 - Valve Housing
20 - Seal
21 - Retainer
22 - Spool
23 - Spring Retainer
24 - Spring
25 - Spring Retainer
26 - Spool End
27 - End Cover
28 - Washer
29 - Screw
30 - Dust Cover
31 - Spacer
32 - Spool
33 - Spring Retainer
34 - Spacer
35 - Spring
36 - Spacer
37 - Spool End
38 - Ball Housing
39 - Ball
40 - Detent Cover
41 - Detent Slide
42 - Spacer
43 - Adjustment Housing
44 - Spring
45 - Adjustment Screw
46 - Snap Ring
47 - Spring Retainer
48 - Retainer
Section 235-0160

Bowl Hydraulic System - Servo Control Valve

DESCRIPTION

The servo control valve is mechanically actuated spool type valve controlling and directing signal oil pressure supplied by the main control valve. The valve spools are operated by levers connected to the spool ends. Operation of control levers moves the spools to open and close the inlet port to the signal ports to control movement of the valve spools.

Good control of the main hydraulic valve spools is attained by matching the pressure gain through the servo valve to the resistance of the main hydraulic control valve spool centering springs. As the servo valve spool is shifted from neutral, some signal oil is directed to the appropriate main hydraulic control valve spool, and some oil is directed back to the tank from the other side of the spool. As the servo valve spool is shifted farther through its stroke, so more oil is directed to the main hydraulic control valve spool, moving it farther through its stroke in direct proportion to the servo valve spool movement.

The ejector and apron spools have a mechanical detent in the lower position.

OPERATION

Neutral

When the levers are in the neutral position, the spools are held in the centered positions by centering springs. The lands on the valve spools block ports A, B, C, D, E and F from the oil inlet, and since this valve is a closed centre component, excess oil pressure goes over the relief valve, and back to the tank.

Raising and Lowering

When any lever is moved to the raise position, the attached valve spool is moved downwards and oil will flow through ports B, D and F to stroke the respective main hydraulic control valve spool. Oil on the other side of the main hydraulic control valve is displaced through nylon tubing back to the servo valve and through ports A, C and E back to tank.

In the lower position, oil will flow through ports B, D or F when the attached spool is moved upwards. This action will stroke the respective spool to give a lower condition.

REMOVAL

WARNING

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Place the battery master switch in the 'Off' position and block all road wheels.

3. Remove screws and washers securing cover to right hand side dash panel.

4. Identify and tag all nylon control lines connected to servo control valve, to aid in 'Installation'.

5. With suitable container available to catch spillage, disconnect nylon control lines from servo control valve. Drain the oil from the lines into the container. Cap lines and valve ports to prevent ingress of dirt.

6. Remove mounting hardware securing servo control valve to its mounting on right hand dash panel. Lift valve out from dash panel and remove to a clean area for disassembly.

DISASSEMBLY

Numbers in parentheses refer to Figs. 1 & 2.

WARNING

Spring loaded parts. Use care when removing end cap, retainers and plugs to prevent sudden release of spring tension behind these parts. Personal injury or property damage could result if care is not taken.

Note: Clean entire servo control valve assembly with a suitable solvent and dry thoroughly prior to disassembly.

1. Remove caps from valve housing (19) ports.

2. If required, clamp servo control valve assembly in a soft jawed vice. Take care to avoid damaging valve housing (19) machined surfaces.
3. Unscrew knobs (1) and remove from levers (3). Remove strap (5) and slide flexible cover (2) off of levers (3).

4. Identify and tag each lever (3). Make reference marks on lever plate (13), mounting flange (14) and valve housing (19) to ensure correct location when reassembling.

5. Remove bolts (6) and lockwashers (7) from blocks (8). Separate levers (3) from blocks (8) and spools (22 & 32). Pull pins (9 & 10) from blocks. The dowel pins (12) need not be withdrawn if undamaged.

6. Remove screws (11) from lever plate (13). Remove lever plate (13) from valve housing (19).
7. Remove screws (15) from mounting flange (14). Remove mounting flange (14) from valve housing (19).

8. Remove wiper seals (16), retainers (17) and seals (18) from valve housing (19).

9. From the other side of valve housing (19), remove snap ring (46) and detent components (41 thru 45).

10. Remove detent cover (40) and ball housing (38) taking care not to lose ball (39).

11. Remove spacer (31), seal (20) and retainer (21) from valve housing (19).

12. Remove screws (29), washers (28) and end cover (27) from valve housing (19).

13. Remove seal (20) and retainer (48) from valve housing (19).


15. Secure spool assembly in a suitable spool clamp and withdraw from bore in valve housing (19). DO NOT interchange spools with bores.

16. Repeat steps 14 and 15 for the remaining spools.

Note: DO NOT interchange spools with bores.

INSPECTION
Numbers in parentheses refer to Fig. 1 & 2.

1. Remove and discard all non-metallic seals. Clean all parts thoroughly in a suitable solvent and examine for wear and/or damage.

2. Inspect spools and spool bores for wear or damage. Polish any small nicks or burrs. Excessive wear of components will necessitate valve replacement.

3. Check condition of detent diameter on spool end (37). If badly rounded it should be replaced. Replace detent balls (39). Replace ball housing (38) if the holes are elongated. Replace detent slide (41) if taper edge is badly worn.

ASSEMBLY
Numbers in parentheses refer to Fig. 1 & 2.

Note: Lightly lubricate all components with hydraulic oil. Refer to Section 300-0020, LUBRICATION SYSTEM, for recommended oil specifications.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. Assemble springs (24 & 35), retainers (23, 25, 33 & 47) and spacers (34 & 36) to spools (22 & 32), as shown in Fig. 2. With spool held in a spool clamp, secure these components with spool ends (26 & 37).

2. Clamp servo control valve assembly in a soft jawed vice. Install seals (20) and retainers (21) in valve housing (19).

3. Install detent spool assemblies (32) in valve housing (19). Fit spacer (31) in position. Use a small amount of grease or vaseline to retain balls (39) in housing (38) and fit over spool end (37). Fit detent covers (40), and carefully assemble parts (41 to 46), taking care not to dislodge balls (39) from their housing (38).

4. Install spool assembly (22) in valve housing (19). Fit end cover (27) complete with dust cover (30) and secure with screws (29) and washers (28).

5. On the other side of valve housing (19), fit seals (18), retainers (17) and wiper seals (16).

6. Secure mounting flange (14) to valve housing (19) with screws (15). Secure lever plate (13) to mounting flange (14) with screws (11).

7. If removed, refit dowel pins (12) to lever plate (13).

8. Assemble levers (3) and spool actuators (4) to pivot blocks (8) with pins (9 & 10). Make sure spool actuators (4) slip over ball ends of spools and pivot blocks (8) fit on to dowels (12). Secure pivot blocks (8) with bolts (6) and washers (7).

9. Slide flexible cover (2) over lever (3) and secure in place with strap (5). Screw knobs (1) onto levers (3).

10. Check for smooth operation of levers and for good detent action on the apron and ejector spools.
INSTALLATION
Numbers in parentheses refer to Figs. 1 & 2.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

Note: Tighten all hydraulic lines fitted with ORFS connections, as described in Section 235-0000, HYDRAULIC SYSTEM SCHEMATIC.

**WARNING**
To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Using a suitable lifting device, position control valve in place on the machine. Secure control valve in place with mounting bolts and lockwashers as removed at 'Removal'.

2. Reconnect all nylon control lines to servo control valve, as tagged at 'Removal'.

3. Fill hydraulic oil tank with hydraulic oil as specified in Section 300-0020, LUBRICATION SYSTEM. Refer to Section 235-0040, HYDRAULIC TANK, for hydraulic oil levels.

4. Place battery master switch in the 'On' position, start the engine and check servo control valve operation. Check servo control valve and hydraulic lines for leaks. Tighten as required.

5. Secure cover to right hand dash panel using mounting hardware as removed at 'Removal'.

6. Remove all blocking from road wheels.

MAINTENANCE
Limited repair of the servo control valve is with replacement of parts only. Refer to vehicle parts book for list of kits available.

SERVICE TOOLS
There are no special tools required for the procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.
DESCRIPTION
The air brake system is used to supply air pressure for operating the front and rear brake chambers which in turn, actuate the slack adjusters applying the front and rear brakes. The air system also supplies pressure for operating air actuated accessories such as the air suspension seat and the air horn.

The safety air brake system on the machine has the following features:

1. Low air pressure warning light which illuminates when air pressure drops below a predetermined level.
2. Separate front and rear braking circuits.
3. Air released - spring applied parking brake controlled by the park/emergency control valve. Parking brake is applied when the control valve lever is in the ‘PARK’ position.

AIR SYSTEM AUXILIARY COMPONENTS
Numbers in parentheses refer to Fig. 1.

The following is a list of auxiliary components used in the air system, with a brief description of each:

Pressure Protection Valve (6) - Supplies air to all air tanks for the service brakes, secondary braking and accessory devices. Refer to Section 250-0290, PRESSURE PROTECTION VALVE, for detailed operating and servicing procedures.

Air Horn Solenoid (12) - Electric solenoid valve is activated by the horn button, allowing air pressure to the air horn.

Air Horn (13) - Provides effective warning signal.

Air Pressure Gauge - Located on the instrument panel it indicates system air pressure.

OPERATION
Numbers in parentheses refer to Figs. 1.

Air from the engine driven air compressor (1) travels through air drier kit (2) and into primary tank (3).

When pressure in primary tank (3) reaches 6.2 bar (90 lb/in²), pressure protection valve (6) opens. The valve allows air to flow to the air suspension seat and air horn (13) via the air horn solenoid (12).

Air compression is controlled by unloader valve on air drier (2) stopping and starting delivery of air from air compressor (1), when maximum 8.4 bar (122 lb/in²) and minimum 6.5 bar (95 lb/in²) pressures are reached.

The pressure in the system should not exceed 8.4 bar (122 lb/in²) if the system is operating normally. However, if unloader valve malfunctions and the pressure continues to rise, safety valve on air drier (2) will open to protect the air system by relieving the pressure at 13 bar (190 lb/in²).

AIR BRAKING SYSTEM COMPONENTS
Numbers in parentheses refer to Fig. 1.

The following is a list of air control devices in the air safety brake system, with a brief description of each:

Air Compressor (1) - Delivers air, through the air drier kit, to the air tanks to operate brake and air operated accessories. The air compressor is mounted on the engine.

Air Drier Kit (2) - Filters the air from the compressor to remove any oil and moisture in the air system. The integral unloader valve controls supply of air to the system, by stopping and starting delivery of air by the compressor when maximum and minimum pressures are reached. The purge reservoir stores dried air to purge the air drier desiccant bed as part of a regeneration process. Refer to Section 250-0200, AIR DRIER, for detailed operating and servicing procedures.

Air Tanks (3, 4, 17 & 18) - Store compressed air until it is needed for brake or accessory operation. Secondary tanks maintain an air supply for normal brake application or for automatic safety brake application, if pressure drops in the primary tanks. Air pressure in the tanks is indicated on the air system pressure gauge on the instrument panel in the operators compartment. Refer to Section 250-0170, AIR TANKS AND MOUNTING, for detailed operating and servicing procedures.

Relay Emergency Valves (7 & 20) - Speeds the application and release of air pressure to and from tractor and scraper brake chambers. Refer to Section 250-0280, RELAY EMERGENCY VALVE, for detailed operating and servicing procedures.
Fig. 1 - Air Braking System Schematic - Tractor

1 - Air Compressor
2 - Air Drier Kit
3 - Front Primary Tank
4 - Front Secondary Tank
5 - Drain Cock

6 - Pressure Protection Valve
7 - Relay Emergency Valve
8 - Park/Emergency Control Valve
9 - Treadle Valve
10 - Brake Chamber

11 - Quick Release Valve
12 - Air Horn Solenoid
13 - Air Horn
14 - Manifold
15 - Test Point
16 - Tilt Drain Valve
Braking System - Air Braking System Schematic

Fig. 1 - Air Braking System Schematic

- 17 - Rear Primary Tank
- 18 - Rear Secondary Tank
- 19 - Relay Valve
- 20 - Relay Emergency Valve
- 21 - Brake Chamber
- 22 - Quick Release Valve
- 23 - Drain Cock
- 24 - Test Point
Braking System - Air Braking System Schematic

Section 250-0000

Park/Emergency Control Valve (8) - Controls air pressure delivery to the relay emergency valve for actuation of brake chambers to apply the brakes. In the 'PARK' position it exhausts the air from the spring applied brake chambers, to apply the parking brake. Refer to Section 250-0190, PARK/EMERGENCY CONTROL VALVE, for detailed operating and servicing procedures.

c. Park/emergency brake circuit air pressure falls below 5.5 bar (80 lbf/in²).

If light illuminates while operating, stop the machine, apply the parking brake and do not operate until the fault has been corrected.

OPERATION

Numbers in parentheses refer to Fig. 1.

Air from the engine driven air compressor (1) travels through air drier kit (2) via pressure protection valve (6) and into all four air tanks (3, 4, 17 & 18).

Air flows to the front primary tank (3) and service brakes via port '21' of the pressure protection valve (6). Air is supplied to the rear primary tank (16) and service brakes via port '22' of the pressure protection valve (6). Air is supplied to the front and rear secondary tanks (5 & 18) and park/emergency brake valve (8) via port '23' of the pressure protection valve (6). Air is supplied to the auxiliary components via port '24' of the pressure protection valve (6).

Air compression is controlled by unloader valve on air drier stopping and starting delivery of air from air compressor when maximum 8.4 bar (122 lbf/in²) and minimum 6.5 bar (95 lbf/in²) pressures are reached.

The pressure in the system should not exceed 8.4 bar (122 lbf/in²) if the system is operating normally. However, if unloader valve malfunctions and the pressure continues to rise, safety valve on air drier will open to protect the air system by relieving the pressure at 13 bar (190 lbf/in²).

Service Brake

Depressing treadle valve (9) allows air to flow directly to the service ports of the front brake chambers to apply the service brakes. Refer to Section 250-0280, RELAY VALVE, for detailed operating and servicing procedures.

The amount of air that flows to brake chambers (10 & 21) depends on how far the treadle pedal is depressed. The farther the pedal is depressed the greater the air pressure in the brake chambers (10 & 21) and the greater the braking force.

The brakes are released when the treadle pedal is released. Air pressure is exhausted through treadle valve exhaust port.
Park/Emergency Brake Control Valve
Air line from port '23' of pressure protection valve (6) directs a constant supply of air to park/emergency control brake valve (8).

With park/emergency brake control valve (8) lever in the 'RELEASE' position, the inlet and exhaust ports in the valve are closed. As a result, air pressure flows to the brake chambers (10 & 21) via the relay emergency valves (7 & 20), preventing the spring in the actuator from applying the parking brake. The park/emergency brake control lever should always be in the 'RELEASE' position when driving the machine.

With the park/emergency control valve (8) lever in the 'PARK' position, air pressure is vented through the exhaust ports in the quick release valves (11 & 22), allowing the spring brake chambers (10 & 21) to apply the parking brake.

BRAKE SYSTEM SAFETY PRECAUTIONS
When working on or around brake systems and components, the following precautions, should be observed:

1. Always block vehicle wheels. Stop engine when working under a vehicle. Keep hands away from actuator push rods and slack adjusters; they may apply as air system pressure drops.

2. Always carry out ALL servicing operations in conjunction with WARNINGS and procedures outlined in the individual component sections.

3. Always ensure there is no pressure in the air system before attempting to replace brake pads or shoes; the brakes will automatically apply as air pressure drops.

4. Never connect or disconnect a pipe or line containing pressure; it may whip. Never remove a component or pipe plug unless you are certain all system pressure has been released.

5. Never exceed recommended pressure and always wear safety glasses when working.

6. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all safety precautions pertaining to use of those tools.

7. Use only genuine factory replacement parts and components.
   a) Only components, devices and mounting and attaching, specifically designed for use in hydraulic brake systems, should be used.
   b) Replacement hardware, tubes, lines, fittings, etc. should be of equivalent size, type and strength as the original equipment.

8. Devices with stripped threads or damaged parts should be replaced. Repairs requiring machining should not be attempted.

BRAKE FUNCTION CHECKS
WARNING
Make sure the area around the machine is clear of personnel and obstructions before carrying out these checks.

Note: The following checks are not intended to measure maximum brake holding ability. If NEW brake pads are fitted, they MUST be burnished as per the manufacturers recommendations before carrying out the checks.

Service Brake Holding Ability
1. With the bowl in the 'Fully Raised' position, depress service brake treadle pedal and move transmission gear shift selector to 1st gear.

2. Move park/emergency control lever to the 'RELEASE' position.

3. Depress front engine accelerator control and accelerate engine to 1 350 rev/min. The machine should not move.

4. Decelerate engine, shift transmission to 'NEUTRAL' and apply the park/emergency brake before releasing the service brake.
Braking System - Air Braking System Schematic

Section 250-0000

Park/Emergency Brake Holding Ability

1. With the bowl in the ‘Fully Raised’ position, move park/emergency control lever to ‘PARK’ position and move transmission gear shift selector to 1st gear.

2. Depress front engine accelerator control and accelerate engine to 1 350 rev/min. The machine should not move.

3. Decelerate engine, shift transmission to ‘NEUTRAL’ and apply the park/emergency brake.

General

Note: Brake holding effort required to hold a machine stationary at a specific rev/min can vary from machine to machine due to differences in engine performance, powertrain efficiency, etc., as well as differences in brake holding ability.

Note: As an indication of system deterioration, the engine rev/min at which point the machine moved, with the service or park/emergency brakes applied, can be compared against the engine rev/min your specific machine was able to hold to on a previous check.

MAINTENANCE

General

Perform all maintenance as outlined in individual air component sections, at the service intervals specified in those sections.

Every Year

Check accuracy of air pressure gauge on the instrument panel with a test gauge. Replace if difference is more than 0.3 bar (5 lbf/in²).

Every 2 000 hours/12 months replace air dryer desiccant cartridge.

Braking System Diagnosis

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>REASON</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadequate braking</td>
<td>Low air pressure in brake system only</td>
<td>Trace brake lines by referring to Fig. 1. Install a test gauge at various points in the system to determine location of trouble. Test operation of faulty components as outlined in air brake control component sections. Repair or replace, as recommended. Check brake air lines for leaks.</td>
</tr>
<tr>
<td>Treadle valve delivery pressure below normal</td>
<td>Check operation of air compressor, air drier, unloader and safety valve. Check air lines for leaks.</td>
<td></td>
</tr>
<tr>
<td>Brake pads need replaced</td>
<td>Refer to Section 165-0031, BRAKE PARTS.</td>
<td></td>
</tr>
<tr>
<td>Brakes do not apply with normal treadle valve application</td>
<td>No air pressure in brake system</td>
<td>Trace brake lines by referring to Fig. 1. Install a test gauge at various points in the system to determine location of trouble. Test operation of faulty component as outlined in air brake control component sections. Check brake air lines for leaks.</td>
</tr>
<tr>
<td>Restricted or broken tubing or hose line</td>
<td>Replace tubing or hose line.</td>
<td></td>
</tr>
</tbody>
</table>

WARNING

If the machine moves during the above checks, stop the machine, apply the parking brake and do not operate until the fault has been corrected.
<table>
<thead>
<tr>
<th>CONDITION</th>
<th>REASON</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brakes do not apply with normal treadle valve application</td>
<td>Defective treadle valve</td>
<td>Repair or replace faulty component as recommended in Section 250-0070, TREADLE VALVE.</td>
</tr>
<tr>
<td></td>
<td>Defective relay emergency valve</td>
<td>Repair or replace faulty component as recommended in Section 250-0280, RELAY EMERGENCY VALVE.</td>
</tr>
<tr>
<td>Brakes apply too slowly</td>
<td>Low air pressure in the brake system</td>
<td>Trace brake lines by referring to Fig. 1. Install a test gauge at various points in the system to determine location of trouble. Test operation of faulty component as outlined in air brake control component sections. Repair or replace, as recommended. Check brake air lines for leaks.</td>
</tr>
<tr>
<td></td>
<td>Treadle valve delivery pressure below normal</td>
<td>Check operation of air compressor, air dryer unloader valve and safety valve. Check air lines for leaks.</td>
</tr>
<tr>
<td></td>
<td>Excessive leakage with brakes applied</td>
<td>Trace brake lines by referring to Fig. 1. Install a test gauge at various points in the system to determine location of trouble. Test operation of faulty component as outlined in air brake control component sections. Repair or replace, as recommended. Check brake air lines for leaks.</td>
</tr>
<tr>
<td></td>
<td>Restriction in tubing or hose line</td>
<td>Replace tubing or hose lines.</td>
</tr>
<tr>
<td>Brakes do not release</td>
<td>Defective brake chambers</td>
<td>Repair or replace faulty component as recommended in Section 250-0260, BRAKE CHAMBER.</td>
</tr>
<tr>
<td></td>
<td>Defective quick release valves</td>
<td>Repair or replace faulty component as recommended in Section 250-0180, QUICK RELEASE VALVE.</td>
</tr>
<tr>
<td></td>
<td>Treadle valve not in fully released position</td>
<td>Repair or replace faulty component as recommended in Section 250-0070, TREADLE VALVE.</td>
</tr>
<tr>
<td></td>
<td>Restriction in tubing or hose line</td>
<td>Replace tubing or hose lines.</td>
</tr>
<tr>
<td>Brakes grab or pull</td>
<td>Faulty operation of one or more brake air control components</td>
<td>Trace brake lines by referring to Fig. 1. Install a test gauge at various points in the system to determine location of trouble. Test operation of faulty component as outline in air control component sections. Repair or replace, as recommended. Check brake air lines for leaks.</td>
</tr>
<tr>
<td></td>
<td>Calliper pistons binding</td>
<td>Check calliper operation as described in Section 165-0031, BRAKE PARTS.</td>
</tr>
<tr>
<td>Air pressure too high</td>
<td>Pressure gauge registering incorrectly</td>
<td>Replace gauge and/or gauge sender unit.</td>
</tr>
<tr>
<td></td>
<td>Faulty air drier, unloader valve</td>
<td>Repair of replace faulty component. Refer to Section 250-0200, AIR DRIER.</td>
</tr>
</tbody>
</table>
### BRAKING SYSTEM DIAGNOSIS (Continued)

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>REASON</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air pressure too low</td>
<td>Pressure gauge registering incorrectly</td>
<td>Replace gauge and/or gauge sender unit.</td>
</tr>
<tr>
<td></td>
<td>Defective compressor</td>
<td>Repair or replace air compressor. Refer to ENGINE MAINTENANCE MANUAL.</td>
</tr>
<tr>
<td></td>
<td>Excessive leakage</td>
<td>Trace brake lines by referring to Fig. 1. Install test gauge at various points in the system to determine location of trouble. Test operation of faulty component as outlined in air brake control component sections. Repair or replace, as recommended. Check brake air lines for leaks.</td>
</tr>
<tr>
<td>Air tank drain cock open or leaking</td>
<td></td>
<td>Tighten or install new drain cock.</td>
</tr>
<tr>
<td>Faulty air drier unloader valve</td>
<td></td>
<td>Repair or replace air drier unloader valve. Refer to Section 250-0200, AIR DRIER.</td>
</tr>
<tr>
<td>Compressor knocks continuously or intermittently</td>
<td>Excessive backlash in drive gears or drive coupling</td>
<td>Correct backlash. Refer to ENGINE MAINTENANCE MANUAL.</td>
</tr>
<tr>
<td>Worn or burnt out bearings</td>
<td></td>
<td>Replace faulty components or compressor. Refer to ENGINE MAINTENANCE MANUAL.</td>
</tr>
<tr>
<td>Excessive carbon deposits in compressor cylinder head</td>
<td></td>
<td>Remove the compressor head and clean. Refer to ENGINE MAINTENANCE MANUAL.</td>
</tr>
<tr>
<td>Brakes release too slowly</td>
<td>Defective brake chamber</td>
<td>Repair or replace faulty component as recommended in Section 250-0260, BRAKE CHAMBER.</td>
</tr>
<tr>
<td>Treadle valve not returning to fully released position</td>
<td></td>
<td>Repair or replace faulty component as recommended in Section 250-0070, TREADLE VALVE.</td>
</tr>
<tr>
<td>Exhaust port of treadle valve or relay valve restricted or plugged</td>
<td></td>
<td>Repair or replace faulty component as recommended in Section 250-0070, TREADLE VALVE and 250-0280, RELAY EMERGENCY VALVE.</td>
</tr>
<tr>
<td>Air pressure drops quickly with engine stopped and brakes released</td>
<td>One or more faulty air control components in brake air line, or leak in lines</td>
<td>Trace brake lines by referring to Fig. 1. Install test gauge at various points in the system to determine location of trouble. Test operation of faulty component as outlined in air brake control component sections. Repair or replace, as recommended. Check brake air lines for leaks.</td>
</tr>
<tr>
<td>Air pressure rises to normal reading too slowly</td>
<td>Excessive leakage</td>
<td>Trace brake lines by referring to Fig. 1. Install test gauge at various points in the system to determine location of trouble. Test operation of faulty component as outlined in air brake control component sections. Repair or replace, as recommended. Check brake air lines for leaks.</td>
</tr>
<tr>
<td>Engine speed too slow</td>
<td></td>
<td>Correct condition. Refer to ENGINE MAINTENANCE MANUAL.</td>
</tr>
</tbody>
</table>
### BRAKING SYSTEM DIAGNOSIS (Continued)

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>REASON</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air pressure rises to normal reading too slowly</td>
<td>Worn compressor</td>
<td>Repair or replace. Refer to ENGINE MAINTENANCE MANUAL.</td>
</tr>
<tr>
<td></td>
<td>Excessive carbon in compressor cylinder head or discharge line.</td>
<td>Clean the head and lines. Refer to ENGINE MAINTENANCE MANUAL.</td>
</tr>
<tr>
<td>Safety valve 'blows off'</td>
<td>Safety valve out of adjustment</td>
<td>Adjust as recommended in Section 250-0200, AIR DRIER.</td>
</tr>
<tr>
<td></td>
<td>Air pressure in system above normal</td>
<td>Check air drier unloader valve, adjust as recommended. Refer to Section 250-0200, AIR DRIER.</td>
</tr>
<tr>
<td>Excessive oil or water in the system</td>
<td>Air tanks not being drained often enough</td>
<td>Drain all air tanks every 10 hours.</td>
</tr>
<tr>
<td></td>
<td>Compressor passing excessive oil</td>
<td>Service compressor as recommended in ENGINE MAINTENANCE MANUAL.</td>
</tr>
<tr>
<td></td>
<td>Air drier not performing adequately</td>
<td>Check desiccant cartridge, replace if required. Refer to Section 250-0200, AIR DRIER.</td>
</tr>
<tr>
<td>Air pressure drops quickly with engine stopped and brakes fully applied</td>
<td>One or more faulty air control components in brake air lines, or leak in lines</td>
<td>Trace brake lines by referring to Fig. 1. Install test gauge at various points in the system to determine location of trouble. Test operation of faulty component as outlined in air control component sections. Repair or replace, as recommended. Check brake air lines for leaks.</td>
</tr>
</tbody>
</table>
DESCRIPTION

The treadle valve is mounted alongside the accelerator pedals and bolted to the cab floor. The treadle valve is the left hand pedal.

The treadle valve directs and controls air to the front brake chambers and rear relay valve which controls air delivery to the rear brake chamber.

There are 9 ports on the treadle valve as follows:

- Port 'A' - Supply line from rear primary tank service circuit
- Port 'B' - Delivery to rear service brakes
- Port 'C' - Low pressure switch - rear
- Port 'D' - Stop light switch - rear
- Port 'E' - Supply line from front primary tank service circuit
- Port 'F' - Delivery to front service brakes
- Port 'G' - Low pressure switch - front
- Port 'H' - Stop light switch - front
- Port 'J' - Exhaust port

OPERATION

Numbers in parentheses refer to Fig. 1.

When treadle (1) is depressed, the brake force is transmitted through plunger (24) and spring via the

Fig. 1 - Cutaway View of Treadle Valve
Braking System - Treadle Valve
Section 250-0070

The system is 'Lapped' with inlet valve (10) and exhaust passage (32) closed. This balance is maintained until the Treadle (1) is depressed further or released.

When the operator releases the treadle, to reduce the application of braking force. This causes piston (3) to rise. With the valve (5) closed, the piston seat (4) will open exhaust passage (32) causing the air in supply port 1 to be exhausted till the pressure falls sufficiently to balance the force on the piston (3).

At which time the piston (3) and its seat (4) will move down, closing the exhaust passage (32). As the pressure within the upper circuit falls, piston (8) will rise. With valve (10) remaining closed and piston seat (15) rising to uncover the exhaust passage (32) air pressure from supply port 2 will fall to balance the forces on the piston (8). At which time piston (8) and its seat (15) will move down closing the exhaust passage (32) once again.

The pressures within the upper and lower circuits are thus maintained at levels proportionate to the degree of mechanical force exerted by the driver on the treadle. The self lapping action takes place whenever the brake application force is increased or decreased.

3. Depress treadle (1) to several positions between fully released position and fully depressed position and check to be sure the delivered air pressure registered by the test gauge varies in accordance with the position in which the treadle (1) is held. The treadle valve must control all delivery pressures between 0.34 bar (5 lbf/in²) and upper limit of the air system.

4. With treadle (1) fully released, coat exhaust port 'J' with soap suds to check for leakage. Leakage in excess of a 25 mm (1 in) soap bubble in one second is not permissible in either of these tests. If excessive leakage is found, the treadle valve must be repaired or replaced.

REMOVAL AND DISASSEMBLY
Numbers in parentheses refer to Fig. 1.

**WARNING**
To prevent personal injury and property damage, be sure wheel blocks are properly secured and of adequate capacity to do the job safely.
Braking System - Treadle Valve

Section 250-00070

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine.

2. Operate the steering in both directions several times to relieve any pressure in the steering system. Block all road wheels.

3. Open drain cocks on air tanks and drain air from four main tanks and auxiliary air tank. Close drain cocks on air tanks when air is exhausted.

4. Ensure all air lines connected to the treadle valve are identified for ease of installation and disconnect air lines from the treadle valve assembly.

5. Remove electrical connection to stop light pressure switch.

6. Release and remove mounting hardware securing treadle valve assembly to the cab floor.

7. Remove treadle valve assembly from the vehicle.

8. If required, separate valve body (26 & 31) assembly and treadle (1) assembly.

**Note:** The treadle valve assembly should not be disassembled further as replacement of parts is by treadle (1) assembly and/or valve body (26 & 31) assembly only. Refer to 'Maintenance' procedures.

**ASSEMBLY AND INSTALLATION**

Numbers in parentheses refer to Fig. 1.

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. If removed, install treadle (1) assembly on valve body (26 & 31) assembly.

2. Secure treadle valve assembly to the cab floor with mounting hardware, as removed at 'Removal and Disassembly'.

3. Install all air lines to the treadle valve assembly, as tagged at removal.

4. Connect electrical connection to stop light pressure switch.

5. Start the engine and allow air pressure in the tanks to build up to correct operating pressure. Check for leaks at air lines and tighten as required.

6. Remove wheel blocks from all road wheels.

**ADJUSTMENTS**

Numbers in parentheses refer to Fig. 1.

If the treadle valve does not release promptly or does not fully release, it indicates that exhaust valve is not opening sufficiently. This can be caused by:

1. Lack of lubrication in valve body causing piston and spring assembly to bind.

2. Dirt or other foreign matter between the heel of treadle (1) and mounting plate (17).

If the treadle valve does not apply promptly, or does not apply fully, it indicates that inlet valve (5) is not opening sufficiently. Check for correct operation and replace valve assembly, if required.
DESCRIPTION AND OPERATION
There are four air tanks in the air system; tractor primary tank, tractor secondary tank and scraper primary tank, scraper secondary tank. The tractor air tanks are located on the rear left hand side and right hand side of the frame respectively. The scraper air tanks are located on the left hand side of the trailer frame, forward of the frame cross channel.

Air tanks store compressed air from the engine compressor until it is required for brake or accessory operation. Brake tanks maintain an air supply for normal brake application or for automatic safety brake application, if pressure drops in the primary tank.

Air pressure in the tanks is indicated on the air system pressure gauge located on the instrument panel in the operators compartment.

REMOVAL
Numbers in parentheses refer to Fig. 1.

1. Position the vehicle in a level work area, apply the parking brake and shutdown the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place the battery master switch in the 'Off' position.

3. Open drain cocks and drain air from all four air tanks.

4. Tag all air lines attached to air tanks for easy identification at 'Installation'. Remove all air lines from air tanks.

5. Horizontally mounted air tank (1)- Remove bolts (22) and nuts (21) securing air tank (1) to clamp assembly (2). Using suitable lifting aid, remove air tank (1) from assembly.

6. Remove bolts (5), washers (6) and nuts (7) securing clamp assemblies (2) to bracket assembly (3) and plate assembly (4). Remove clamp assemblies (2).

7. Support air drier assembly and remove bolts (13)
and lockwashers (14) securing air drier assembly to the plate assembly (4). Secure air drier clear from plate assembly (4).

8. Using suitable lifting equipment, support Bracket assembly (3) and remove bolts (8) and lockwashers (9) securing bracket assembly (3) to frame assembly. Remove bracket assembly (3) from the machine.

9. Using suitable lifting equipment, support Plate assembly (4) and remove bolts (10), washers (11) and nuts (12) securing plate assembly (4) to the frame assembly. Remove plate assembly from the machine.

10. Vertically orientated tank- Remove bolts (22) and nuts (21) securing air tank to clamp assembly (2). Using suitable lifting aid remove air tank (1) from assembly.
11. Remove bolts (5), washers (6) and nuts (7) securing clamp assemblies (2) to bracket assembly (15). Remove clamp assemblies.
12. Remove bolts (16) and lockwashers (9) securing bracket assembly (15) to frame assembly. Using suitable lifting equipment remove bracket assembly (15).

**Scraper** : Numbers in parentheses refer to Fig. 2

10. Support air tanks (1) and remove nuts and U bands from clamp assemblies (2). Remove air tanks (1) from the machine.

11. Remove bolts (3), washers (5), and nuts (4) securing clamp assemblies (2) to mounting bracket (6). Remove clamp assemblies (2).

12. Using suitable lifting equipment, support mounting brackets (6) and remove bolts (7), washers (9) and nuts (8) securing mounting bracket (6) to frame assembly. Remove mounting bracket from the machine.

**INSTALLATION**

Numbers in parentheses refer to Fig. 1 & 2.

**Note:** Tighten all fasteners to standard torques listed in
Section 300-0020, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

**Tractor:**

1. Vertically orientated tank- Install clamp assemblies (2) onto bracket assembly (15) using bolts (5), washers (6) and nuts (7).

2. Using suitable lifting equipment, position bracket assembly (15) on frame assembly. Secure to frame using bolts (16) and lockwashers (9).

3. Install air tank (1) in place on bracket assembly (15) and secure with bolts (22) and nuts (21).

4. Horizontal mounted tank- Install clamp assemblies (2) to plate assembly (4) and bracket assembly (3) using bolts (5), washers (6) and nuts (7).

5. Using suitable lifting equipment, position plate assembly on frame assembly and secure in place using bolts (10), washers (11) and nuts (12).

6. Using suitable lifting equipment, position air drier on plate assembly (4) and secure in position using bolts (13), and lockwashers (14).

7. Using suitable lifting equipment, position bracket assembly (3) on frame assembly and secure in place using bolts (8) and lockwashers (9).

8. Using suitable lifting equipment, install air tank (1) in place on bracket / plate assemblies (3 & 4) and secure to clamp assemblies (2) using bolts (22) and nuts (21).

**Scraper:**

9. Using suitable lifting equipment, position mounting bracket (6) on frame assembly and secure in place with bolts (7), washers (9) and nuts (8).

10. Install air tanks (1) in place on mounting bracket (6) and secure using clamp assemblies (2)

5. Install all air lines to air tanks (1), as tagged at 'Removal'.

11. Now that all four air tanks are installed- Place battery master switch in the 'On' position, start the engine and allow air pressure in the tanks to build up to correct operating pressure. Check for leaks at air lines and tighten as required.

7. Remove all wheel blocks.

**MAINTENANCE**

Before starting the shift make sure that drain cocks are tightly closed.
DESCRIPTION
There are two quick release valves fitted to the vehicle, one in the tractor lines and the other in the scraper lines. The quick release valves can be identified as items 11 and 21 in Section 250-0000, AIR BRAKING SYSTEM SCHEMATIC.

The front quick release valve is mounted off the rear left hand side of the tractor frame, adjacent to the pressure protection valve. The rear quick release valve is mounted off the rear fuel tank left hand side mounting bracket.

The quick release valves are installed in the air braking system adjacent to the brake chambers to hasten the exhaust of the air from the chambers when the applied pressure is released, thus speeding up the application of the brakes.

OPERATION
Refer to Fig. 3
When air is supplied to the supply port at A, the diaphragm (2) is pushed away from the seat (1) and against the exhaust seat (3) sealing the exit to port C. The air now flows around the edge of the circular flexible diaphragm (2) and passes out of the delivery ports B and D, to the brake chambers. Refer to Fig. 3.

Refer to Fig. 4
As the applied pressure at A is reduced, the pressure present in the brake chambers and therefore under the diaphragm (2) will be greater. The diaphragm (2) lifts away from seat (3), allowing the air in the brake chambers to exhaust completely and quickly to atmosphere through port C. Refer to Fig. 4.

REMOVAL/INSTALLATION
Numbers in parentheses refer to Figs. 1 and 2, unless otherwise specified.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

WARNING
To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place the battery master switch in the 'Off' position. Open drain cocks on air tanks and drain air from all four air tanks. Close drain
Braking System - Quick Release Valve

Section 250-0180

cocks on air tanks when air is exhausted.

3. Clean quick release valve (1) and surrounding area with a suitable solvent. Ensure all lines connected to quick release valve (1) are identified for ease of installation and disconnect lines. Fit blanking caps to all open lines and ports.

4. Remove bolts (2), washers (3) and locknuts (4, Fig. 1 only) and quick release valve (1) from mounting bracket.

5. Note location of adaptors (5), elbow (6) and reducer (4, Fig. 2 only) and remove from quick release valve (1) for use on the new valve.

6. Install adaptors (5), elbow (6) and reducer (4, Fig. 2 only) in new quick release valve (1) ports as removed from the old valve.

7. Secure quick release valve (1) to mounting bracket with bolts (2), washers (3) and locknuts (4, Fig. 1 only).

8. Remove blanking caps from air lines and install lines to quick release valve (1) as identified during removal.

9. Place master switch in the 'On' position, start the engine and allow air pressure in the tanks to build up to correct operating pressure. Check for leaks at air lines and tighten as required.

10. Remove wheel blocks.

**MAINTENANCE**

Inspect the quick release valve regularly for any signs of leakage or damage and repair/replace as required.

**Note:** Limited repair of the quick release valve is by replacement of parts only. Refer to vehicle Parts Book for part numbers of kits.

**Leak Checking**

Block all road wheels, ensure air tanks are fully charged and apply the parking brake. Apply a soap solution to the exhaust port and valve housing and check for leakage. No leakage is permitted from the valve housing and any leakage from the exhaust port must not exceed a 25 mm (1.0 in) diameter soap bubble in 1 second.

**SPECIAL TOOLS**

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.
DESCRIPTION
The park/emergency brake control valve can be identified as item 8 in Section 250-0000, AIR BRAKING SYSTEM SCHEMATIC.

The park/emergency brake control valve is mounted on the right hand side dash panel in the operators compartment.

The valve controls air pressure delivery to the relay emergency valve for actuation of brake chambers to apply the brakes. In the 'PARK' position it exhausts the air from the spring applied brake chambers, to apply the parking brake.

OPERATION
Numbers in parentheses refer to Fig. 1.

When control lever (27) is in the 'Release' position, the vehicle spring brakes are held off by the maintenance of air pressure in the brake chambers.

Cam (21) has pushed down cam follower (19) and plunger (16) against spring (17) to close exhaust passage (9). The existing delivery pressure in chamber (18) has pushed down piston assembly (6) against graduating spring (5) to close inlet valve seat (15) on inlet/exhaust valve (8). The valve is now 'lapped', ie. both the inlet and exhaust valves are closed.
closed. A constant pressure is being maintained in chamber (18) and in the spring brake chambers.

When the control lever (27) is moved against torsion spring (24) towards the vehicle 'Park' position, the diminishing profile of nylon cam (21) allows spring (17) to lift valve plunger (16), thus uncovering exhaust passage (9). Since exhaust valve (8) remains seated on valve seat (15), the air pressure in the spring brake chambers and in chamber (18) commences to exhaust to atmosphere through exhaust passage (9).

If the control lever (27) movement is halted between brakes 'Release' and vehicle 'Park', the falling pressure in chamber (18) allows graduating spring (5) to lift piston assembly (6) until valve plunger (16) closes exhaust passage (9). Since exhaust valve (8) remains seated on valve seat (15), the valve is again lapped, although with a lower air pressure in chamber (18) and in the spring brake chambers.

In the vehicle 'Park' position, valve plunger (16) has made a full upstroke so that air pressure in the spring brake chambers and chamber (18) is completely exhausted through exhaust passage (9). This allows graduating spring (5) to lift piston assembly (6) to the top of its stroke. However, exhaust passage (9) remains open and as inlet/exhaust valve (8) is still seated on valve seat (15), no supply air can enter chamber (18) and the vehicle brakes are now held on by the springs in the brake chambers.

When the control lever (27) is moved from vehicle 'Park' towards brakes 'Release', the increasing profile of nylon cam (21) depresses cam follower (19) and valve plunger (16) until exhaust passage (9) is closed and inlet/exhaust valve (8) is unseated from valve seat (15). An increasing air pressure is then admitted to chamber (18) and the spring brake chambers to release the vehicle brakes. The maximum delivered pressure is limited by the setting of graduating spring (5).

REMOVAL
Numbers in parentheses refer to Fig. 1.

WARNING
To prevent personal injury and property damage, be sure wheel blocks are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, move control lever (1) to the 'Park' position and switch off the engine.

2. Block all road wheels and place the battery master switch in the 'Off' position. Open drain cocks on air tanks and drain air from all four air tanks. Close drain cocks on air tanks when air is exhausted.

3. Clean valve (1) and surrounding area with a suitable solvent. Support valve body and remove mounting hardware securing valve body to dash panel.

4. Ease valve body up from the dash panel. Tag and disconnect air lines and electrical connection from valve body, to aid in installation. Fit blanking caps to all open lines and ports.

5. Remove valve body from the dash panel.

INSTALLATION
Numbers in parentheses refer to Fig. 1.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATION.

1. Position valve on dash panel and install air lines and electrical connection to valve body, as tagged at 'Removal'.

2. Secure valve body to dash panel using mounting hardware as removed at 'Removal'.

3. Start engine and allow air pressure in the tanks to build up to correct operating pressure. Check for leaks at air lines and tighten as required.

4. Check operation of park/emergency control valve for correct operation in both positions.
TESTING
Numbers in parentheses refer to Fig. 1.

Block all road wheels and ensure air tanks are fully charged. With control lever (27) in the 'Park' position, there should be no pressure at the delivery ports. When control lever (27) is moved to the 'Release' position, the delivered air pressure rises in proportion to the amount of handle movement. At the 'Release' position, the delivered air pressure should be at the specified maximum setting.

When testing for air leaks, apply a soap solution to the exhaust port and valve housing and check for leakage. No leakage is permitted from the valve housing or exhaust port when the control lever is in the 'Release' position or 'Park' position.

If the valve is found to be leaking, it must be replaced.

MAINTENANCE
The park/emergency control valve is a non-serviceable item and should be replaced completely if damaged.

SPECIAL TOOLS
There are no special tools required for procedures outlined in this section. Refer to Section 300-0020, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.
DESCRIPTION
Numbers in parentheses refer to Fig. 1.

The air drier is mounted off the air tank mounting bracket at the rear left hand side of the tractor frame, with the purge tank located inboard of the left hand frame rail.

The purpose of the air drier is to filter the air from the compressor to remove any oil and moisture before it enters the primary air tank.

Note: An air system maintained to proper specification can lead to prolonged component life. It is important therefore to follow the servicing procedures contained in this section.

The external components of the air drier system are air compressor (2), purge tank (8) and air drier (1).

Contained in air drier (1) body is a safety valve (3), unloader valve (4), desiccant cartridge (5) and orificed check valve (6 & 7).

Safety valve (3) limits the maximum system pressure to 13 bar (191 lbf/in²).

Air drier unloader valve (4) controls the supply of air to the system by stopping and starting delivery of air by the compressor (2), when maximum and minimum system pressures are reached.

Orificed check valve (6 & 7) meters compressed air flowing into purge tank (8) and traps air in the primary air tank during the purging cycle.

OPERATION
Delivery Air Flow
Numbers in parentheses refer to Fig. 1.

Air from air compressor (2) enters air drier (1) inlet port 1, flows past safety valve (3), through desiccant cartridge (5), orificed check valve (6 & 7) through port 22 into purge tank (8) and air tank reservoirs via the pressure protection valve.

Humid air from the compressor passes up and down the air drier cartridge. The dirt in the air is collected in the filter and water molecules adhere to the desiccant. Air flows through the desiccant and out of air drier (1) which results in clean dry air flowing into purge tank (8) and the air reservoirs.
Purging Air Flow
Numbers in parentheses refer to Fig. 1.

When system pressure reaches 8.4 bar (122 lbf/in²), the air pressure overcomes spring tension in purge valve which forces the spool down. This unloads air compressor (2) by opening unloader valve (4) and allowing the air to flow out of purge tank (8), through orifice (7), unloader valve (4) and air drier (1) drain to atmosphere.

Numbers in parentheses refer to Fig. 2.

When air pressure reaches 8.4 bar (122 lbf/in²), air enters unloader valve (4) moving the piston allowing air through to purge valve (7). Once the purge valve (7) is open, the air compressor now pumps air at low pressure directly to atmosphere. Dirt and water collected around unloader valve (4) flows out of exhaust port (C) to atmosphere.

Dry air from purge tank (1) flows through the purge choke (6) and desiccant (2) carrying the water molecules out of exhaust port (C) to atmosphere.

This purging process continues until purge tank (1) pressure is zero or until unloader valve (4) closes at 7.5 bar (109 lbf/in²) and once again compressed air passes through the desiccant cartridge.
REMOVAL

**WARNING**
To prevent personal injury and property damage, be sure wheel blocks are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Place the battery master switch in the 'Off' position, block all road wheels, open drain valves on air tanks and drain air from all four air tanks. Close drain valves on air tanks when air is exhausted. Carefully loosen the union nut at purge port (22, Fig. 3) and delivery port 1 on air drier to relieve any trapped air.

3. Tag and carefully disconnect all air lines from the air drier body ports.

**Note:** All ports on air drier have numbers cast into housing for identification purposes.

4. Remove mounting hardware attaching the air drier to the air tank mounting bracket. Move the air drier assembly to a clean work area for 'Disassembly'.

5. Remove desiccant cartridge and 'O' ring from air drier body. Discard 'O' ring.

UNLOADER VALVE

Disassembly / Assembly
Unloader valve components should be replaced as a complete assembly when removed from air drier assembly. Do not reassemble using old components.

The entire body assembly should be cleaned using a suitable cleaning fluid and thoroughly dried.

SAFETY VALVE

Description
The safety valve protects the air brake system against excessive air pressure build up. It is a spring loaded valve subjected to reservoir pressure which will permit air to exhaust reservoir pressure to atmosphere if reservoir pressure rises above the valves' pressure setting. The safety valve is set to open at a pressure of 13 bar (191 lbf/in²).

Operation
Numbers in parentheses refer to Fig. 1.

When primary tank air pressure under valve (3) exceeds the maximum valve setting of 13 bar (191 lbf/in²), the valve is forced off its seat, permitting air to escape through exhaust port '3' to atmosphere.

Testing
Operating Test - The valve must open (exhaust) when the pressure applied at the supply port 'P-1' is above 13 bar (191 lbf/in²). The valve should exhaust sharply, with a 'pop' action.

Leakage Test - With the air system at operating pressure, test for leakage by applying soap suds to valve body and exhaust port. If leakage exceeds a 25 mm soap bubble in 5 seconds, replace the valve assembly.

ASSEMBLY/INSTALLATION
Numbers in parentheses refer to Fig. 2.

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATION.

1. Install new 'O' ring on desiccant cartridge (2).

2. Install desiccant cartridge (2) assembly on drier body- Tighten by hand to approx 15 Nm (11 lbf ft).

**Note:** The new desiccant cartridge (2) must be kept in its plastic bag until it is installed. If not the desiccant will absorb moisture and lose its efficiency.

3. Position air drier assembly on air tank mounting bracket and secure in place with mounting hardware as removed at 'Removal'.

4. Connect all air lines to the air drier body, as tagged at 'Removal'.

5. Start the engine and allow the air pressure in the air tanks to build up to correct operating pressure. Refer to Section 250-0000, AIR BRAKING SYSTEM SCHEMATIC. Check for leaks at air lines and tighten as required.

CHECKING AIR DRIER OPERATION
1. Charge the air system until the unloader valve cutout pressure is reached. Refer to Section 250-0000, AIR BRAKING SYSTEM SCHEMATIC. At this point the air
drier unloader valve opens allowing air compressor output, purge tank air and collected water, dirt and oil to flow out of the drain at the bottom of the air drier. If this does not happen, then check for a plugged drain, unloader valve pressure setting.

2. The unloading phase continues until the unloader valve cut-in pressure is reached. Refer to Section 250-0000, AIR BRAKING SYSTEM SCHEMATIC. This closes the unloader valve and the compressor starts charging the air system again. At this point air flow coming out of the air drier drain stops. If air flow does not stop, check for a partially open unloader valve or check cut-in pressure setting.

3. Every 2,000 hours/12 months replace the desiccant cartridge. The desiccant cartridge service life is determined by the air quality delivered by the air compressor and the compressor charging time. Polluted air and long charging times reduce desiccant cartridge service life.

4. If water is present, the desiccant cartridge must be replaced and the components in the air drier body checked for proper operation.

**AIR DRIER DIAGNOSIS**

The following table lists some of the conditions which could prove responsible for air drier malfunctioning. The reasons and remedies to correct these conditions are listed opposite each condition.

**WARNING**

Always shut off the engine, completely drain the air system, and make sure the air drier is completely purged of all air pressure before loosening air lines or fittings to prevent personal injury.

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>REASON</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air continually blows out of drain port while compressor is pumping</td>
<td>Unloader valve held open by foreign particles on the valve seat</td>
<td>Disassemble and clean unloader valve assembly.</td>
</tr>
<tr>
<td></td>
<td>Faulty unloader valve</td>
<td>Disconnect pilot line from the unloader valve. If leak stops and air is being expelled from the unloader valve line, unloader valve is the problem. Repair or replace unloader valve.</td>
</tr>
<tr>
<td>Leakage occurs while air compressor is unloaded: A. Continuous leakage</td>
<td>Faulty check valve at air drier</td>
<td>Replace air drier.</td>
</tr>
<tr>
<td>B. Pulsating leakage</td>
<td>Faulty unloader valve</td>
<td>Clean, rebuild or replace unloader valve.</td>
</tr>
<tr>
<td>Continuous on-off purge cycle</td>
<td>No/Faulty check valve at air drier</td>
<td>Install or replace air drier.</td>
</tr>
<tr>
<td></td>
<td>Primary tank drain valve open</td>
<td>Close drain cock</td>
</tr>
<tr>
<td></td>
<td>Unloader valve malfunction</td>
<td>If cycling occurred when air compressor was unloaded, check unloader valve for by-pass leakage. Check unloader valve high-low limits.</td>
</tr>
<tr>
<td>Air drier not purging or cycling</td>
<td>Signal line hooked up to wrong unloader valve port or at air drier</td>
<td>Check lines. Line must go from air drier to unloader valve unloaded port.</td>
</tr>
<tr>
<td></td>
<td>Signal line plugged blockage.</td>
<td>Remove signal line and check for</td>
</tr>
<tr>
<td>Large amount of water in primary tank</td>
<td>Desiccant cartridge plugged</td>
<td>Replace desiccant cartridge.</td>
</tr>
<tr>
<td></td>
<td>Desiccant saturated with water</td>
<td>Not enough cooling of air. Check for air line too near engine exhaust, etc.</td>
</tr>
</tbody>
</table>

* * * *
To release the vehicle brake, the park/emergency brake valve is operated to readmit compressed air to the power spring chamber (11). The spring (18) is then 'held off' by the maintenance of air pressure in the chamber. If the vehicle needs to be moved when air pressure is unavailable, the power spring (18) force on the brake push rod (2) can be relieved by unscrewing the release bolt (20) in the end of the actuator.

DESCRIPTION
Numbers in parentheses refer to Fig. 1.

The spring brake actuator combines the functions of normal service braking with those of a parking and secondary brake. Parking and secondary braking is effected by the park/emergency brake valve which releases compressed air from the power spring chamber (11) portion of the actuator. This allows the power spring (18) to expand and transmit its force to the vehicle brakes through the service brake push rod (2).
Braking System - Brake Chamber

Section 250-0260

OPERATION

Normal Driving
In its ‘OFF’ position, the park/emergency brake valve maintains a constant air pressure on the spring brake piston. The resulting compression of the power spring holds off the vehicle brake. This system ensures that the vehicle cannot be moved until sufficient air pressure is available to hold off the power spring. Refer to Fig. 2.

Parking Brake
Moving the park/emergency brake valve from the ‘OFF’ position towards the ‘PARK’ position gradually releases the air pressure from the spring brake chamber and allows the power spring to extend. Progressive secondary braking is provided by the increasing spring pressure on the service brake push rod. At ‘PARK’ the air pressure has been fully exhausted and the vehicle brake is held on by the force of the power spring alone. Refer to Fig. 4.

Service Brake
The service brake chamber is of the conventional diaphragm type. The vehicle service braking effort is controlled by the foot operated treadle brake valve. The valve supplies a graduable air pressure to the service brake chamber while the spring brake continues to be held off by air pressure from the park/emergency brake valve. Refer to Fig. 3.

Manual Release
The readily accessible brake spring release bolt allows the vehicle to be moved in the absence of air pressure and permits the safe and speedy servicing of the actuator and foundation brake. Refer to Fig. 5.
REMOVAL
Numbers in parentheses refer to Fig. 1.

⚠️ WARNING
To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place the battery master switch in the 'Off' position.

3. Open drain cocks on air tanks and drain air from all four air tanks. Close drain cocks on air tanks when air is exhausted.

4. Release spring pressure on brake chambers by removing snap-on cap (21) and loosening release bolt (20). Refer to Fig. 5.

5. Remove cotter pin and clevis pin from clevis and slack adjuster.

6. Ensure air lines are identified for ease of installation and disconnect air lines from brake chamber. Fit blanking caps to all open lines and ports.

7. Support brake chamber and remove nuts and lockwashers from mounting studs (1). Remove brake chamber from mounting bracket.

INSTALLATION
Numbers in parentheses refer to Fig. 1.

⚠️ WARNING
To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

Note: Tighten all fasteners without special torques specified, to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. Install brake chamber on mounting bracket and secure using mounting hardware as removed at 'Removal'.

2. Connect clevis assembly to slack adjuster with pin and cotter pin as removed at 'Removal'.

3. Remove plugs from air lines and connect to brake chamber as tagged at 'Removal'.

4. Tighten release bolt (20) and install snap-on cap (21).

5. Start engine and allow air pressure in the tanks to build up to correct operating pressure. Check for leaks at air lines and tighten as required.

6. Check operation of brake chamber for correct operation in both positions.

SERVICING
Numbers in parentheses refer to Fig. 1.

EVERY 300 HOURS brakes should be adjusted at the slack adjuster. Push-rod travel should be as short as possible without brakes dragging. Excessive travel not only shortens the normal service life of the diaphragm but gives slow braking response and wastes air. Push rod to slack adjuster alignment should be checked in both the applied and released position. The rod should move out and return promptly without binding. Check the angle formed by the slack adjuster arm and push rod. It should be 90° or greater when the actuator is in the applied position when brakes are properly adjusted.

TESTING
Numbers in parentheses refer to Fig. 1.

1. Position the vehicle in a level work area and block all road wheels.

2. With brakes in released position, make several service brake applications. Push rod (2) should extend and retract freely.

3. Actuate park/emergency brake control lever and check to see if push rod (2) extends. Drain air reservoirs, and check to see that push rod remains extended. Close air reservoir drain, and fully charge air system. Make a full service brake application by depressing treadle valve, and hold about 5 seconds. Push rod should retract freely when treadle valve is released.
Braking System - Brake Chamber

Section 250-0260

Leak Checking

Ensure all road wheels are chocked. Detach tube (23) from elbow (22) at the head (19). Apply a soap solution liberally to the service chamber vents, push rod opening, the open end of tube (23), clamp ring (8) and open elbow (22).

Apply full air pressure in turn to the service and spring brake chambers. Watch closely for any soap bubbles indicating air leakage. With service chamber air applied no leakage is permitted at the service chamber vents, push rod opening or tube end. Only slight frothing is permitted at the clamp ring. With spring chamber air applied, any leakage at the open elbow (22) must not exceed a 25 mm (1 inch) diameter soap bubble in 10 seconds.

MAINTENANCE

Inspect the brake chambers regularly for any signs of leakage or damage and repair/replace as required.

Note: Limited repair of the brake chambers is by replacement of parts only. Refer to vehicle Parts Book for part numbers of kits.

SPECIAL TOOLS

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.
DESCRIPTION

There are two relay emergency (anti-compounding) valves fitted to the vehicle, one in the tractor lines and the other in the scraper lines. The relay emergency valves can be identified as items 7 and 19 in Section 250-0000, AIR BRAKING SYSTEM SCHEMATIC.

The front relay emergency valve is mounted off the rear left hand side of the tractor frame, in front of the air tanks. The rear relay emergency valve is mounted off the left hand side of the bowl and tail frame, adjacent to the fuel tank.

The relay emergency valves speed the application and release of air pressure to and from tractor and scraper brake chambers. The relay emergency valves are also used as a means of preventing the force from the spring brake and service diaphragm being applied to the foundation brake at the same time.
Braking System - Relay Emergency Valve

Section 250-0280

OPERATION

Numbers in parentheses refer to Fig. 2.

Pressure from the park/emergency control valve is supplied via port 42 to chamber C where it acts upon piston (1). Under the action of the pressure in chamber C, piston (1) moves down and contacts the back of piston (2); they then move down together and close the exhaust seat (7). The application of further pressure causes pistons (1 & 2) to move the inlet/exhaust valve (4) down again and open the inlet seat (6) thereby permitting air to flow from the supply port 1 into chamber A and out through delivery port 2 to the spring brake chambers. The pressure in chamber A acts on the underside of piston (2) and forces the pistons up until the inlet/exhaust valve (4), under the action of spring (5), is in a lapped condition (both the inlet (6) and exhaust (7) seats closed).

When the pressure from the park/emergency control valve is reduced the pressure in chamber C falls and the pressure in chamber A forces pistons (1 & 2) up and the exhaust seat (7) is opened allowing air from the delivery port and the spring brake chambers to flow out of the exhaust port 3. The pressure in chamber A continues to fall until the pressure in chamber C is sufficient to close the exhaust seat (7).

When the vehicle is running the power spring in the spring brake chamber is held compressed by air pressure from the relay emergency valve and, when the vehicle is required to be parked, the park/emergency control valve delivery is vented and pressure in the spring brake is exhausted through the relay emergency valves allowing the force from the power spring to apply the vehicle foundation brakes. Should the service brake be applied in this condition then air pressure is supplied from the treadle valve to both the service diaphragm of the spring brake chamber and to chamber B of relay emergency valve via port 41. This forces piston (2) down to close exhaust seat (7) and open inlet seat (6) thereby reinstating air pressure to the spring brake chambers to compress the power spring and prevent its force compounding that from the service brake diaphragm. If the service brake pressure from the treadle valve is released then the pressure in the spring brake will be exhausted through the relay valves and the parking brake will be reapplied.
**REMOVAL/INSTALLATION**

Numbers in parentheses refer to Figs. 3 & 4.

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

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**WARNING**

To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place the battery master switch in the 'Off' position. Open drain cocks on air tanks and drain air from all four air tanks. Close drain cocks on air tanks when air is exhausted.

3. Clean relay emergency valve (1) and surrounding area with a suitable solvent. Ensure all lines connected to relay emergency valve (1) are identified for ease of installation and disconnect lines. Fit blanking caps to all open lines and ports.

4. Support valve body and remove nuts (3) and lockwashers (2) securing relay emergency valve (1) to its mounting. Remove relay emergency valve (1) from vehicle.

5. Note location of adaptor (4), elbow (5), reducer (6) and tee piece (7) and remove from relay emergency valve (1) for use on the new valve.

6. Replace all ‘O’ rings and install adaptor (4), elbow (5), reducer (6) and tee piece (7) in new relay emergency valve (1) ports as removed from the old valve.

7. Secure relay emergency valve (1) to mounting bracket using nuts (3) and lockwashers (2).

8. Remove blanking caps from air lines and install lines to relay emergency valve (1) as identified during removal.

9. Place master switch in the 'On' position, start the engine and allow air pressure in the tanks to build up to correct operating pressure. Check for leaks at air lines and tighten as required.

10. Remove wheel blocks.

**MAINTENANCE**

Inspect the relay emergency valve regularly for any signs of leakage or damage and repair/replace as required.

**Note:** Limited repair of the relay emergency valve is by replacement of parts only. Refer to vehicle Parts Book for part numbers of kits.

**Leak Checking**

Block all road wheels, ensure air tanks are fully charged and apply the parking brake. Apply a soap solution to the valve housing and pipe joints and check for leakage. No leakage is permitted from the valve housing or joints.

**SPECIAL TOOLS**

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.
DESCRIPTION
The relay valve can be identified as item 18 in Section 250-0000, AIR BRAKING SYSTEM SCHEMATIC.

Mounted off the rear fuel tank right hand mounting bracket, the relay valve is located in the air lines between the treadle valve and rear brake chambers. The relay valve speeds the application and release of air pressure to and from tractor and scraper brake chambers.

OPERATION
Numbers in parenthesis refer to Fig. 2.

When a signal pressure is applied to port D air flows into chamber C between the cover A and the top of the piston B. A relatively small applied pressure reacts quickly over the large area of piston B, which is forced down. This movement of the piston closes the exhaust passage as the valve seat N seals against the inlet/exhaust valve G, which is also moved down against the return spring K and opens the inlet at L. Air now flows from the reservoir port F past the open valve chamber M, and from there it passes out of one of the delivery ports. This flow continues until the combined forces of the piston and valve return springs and the air pressure beneath the piston balance the force of the applied air pressure above the piston. The piston now lifts sufficiently to allow the valve to rise and close the inlet at L. The valve is now in the 'lapping' condition with both the inlet and the exhaust closed.

If the signal pressure is reduced at D, the forces below the piston are now greater and the piston rises until the valve seat N is lifted clear of the valve, allowing air to exhaust through the hollow in the piston at J, and out to atmosphere past the rubber flap at H.

The exhaustion continues until the force below the piston is reduced to balance that above the piston and the exhaust closes again, lapping the valve.

These procedures are repeated instantly the applied pressure at port D is varied, either up or down, the valve being self-lapping under all conditions.
Braking System - Relay Valve
Section 250-0280

REMOVAL/INSTALLATION
Numbers in parentheses refer to Fig. 1.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

⚠️ WARNING
To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place the battery master switch in the 'Off' position. Open drain cocks on air tanks and drain air from all four air tanks. Close drain cocks on air tanks when air is exhausted.

3. Clean relay valve (1) and surrounding area with a suitable solvent. Ensure all lines connected to relay valve (1) are identified for ease of installation and disconnect lines. Fit blanking caps to all open lines and ports.

4. Support valve body and remove bolts (2) and lockwashers (3) securing relay valve (1) to it's mounting. Remove relay valve (1) from vehicle.

5. Note location of adaptor (4), elbow (5), reducer (6) and tee piece (7) and remove from relay valve (1) for use on the new valve.

6. Replace all 'O' rings and install adaptor (4), elbow (5), reducer (6) and tee piece (7) in new relay valve (1) ports as removed from the old valve.

7. Secure relay valve (1) to mounting bracket using bolts (2) and lockwashers (3).

8. Remove blanking caps from air lines and install lines to relay valve (1) as identified during removal.

9. Place master switch in the 'On' position, start the engine and allow air pressure in the tanks to build up to correct operating pressure. Check for leaks at air lines and tighten as required.

10. Remove wheel blocks.

MAINTENANCE
Inspect the relay valve regularly for any signs of leakage or damage and repair/replace as required.

Note: Limited repair of the relay valve is by replacement of parts only. Refer to vehicle Parts Book for part numbers of kits.

Leak Checking
Block all road wheels, ensure air tanks are fully charged and apply the parking brake. Apply a soap solution to the valve housing and pipe joints and check for leakage. No leakage is permitted from the valve housing or joints.

SPECIAL TOOLS
There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.
DESCRIPTION

The 4 way pressure protection valve can be identified as item 6 in Section 250-0000, AIR BRAKING SYSTEM SCHEMATIC.

Mounted off the rear left hand side of the tractor frame, adjacent to the primary air tank, the pressure protection valve is located in the air compressor and air drier delivery line, immediately prior to the air tanks.

The pressure protection valve supplies air to all four tanks for the service brakes, secondary braking and accessory air devices, such as the air seat and air horn. If a pressure drop or failure is experienced in one circuit of the air system, the valve closes, isolating the circuit, enabling the compressor to continue to recharge the unfailed circuits.

OPERATION

Numbers in parenthesis refer to Fig. 1.

Air from the compressor enters the valve through port '1'. While valves are seated, air flow through delivery ports '21', '22', '23' and '24' are restricted and pressure is exerted on pistons. When air pressure reaches the predetermined settings, pistons move upward, valves are unseated and air flows through delivery ports '21', '22', '23' and '24'. Valve remains open until air pressure at port '1' drops below the predetermined setting. At this point, piston return springs and valve return springs return pistons and valves to the closed position.

MAINTENANCE

Numbers in parentheses refer to Fig. 1.

The pressure protection valve is a non-serviceable item and should be replaced completely, if damaged, as follows:

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

WARNING

To prevent personal injury and property damage, be sure wheel blocks are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place the battery master switch in the 'Off' position. Open drain cocks on air tanks and drain air from all four air tanks. Close drain cocks on air tanks when air is exhausted.

3. Tag and disconnect air lines and electrical connection from pressure protection valve (1), to aid in installation.
4. Support valve body and remove locknuts (4) and lockwashers (3) securing pressure protection valve (1) to mounting bracket (2). Remove pressure protection valve (1) from vehicle.

5. If required, remove elbows (5 & 9), reducer (10), adaptors (6 & 11), tee pieces (7) and pressure switch (8) from pressure protection valve (1) ports.

6. If removed, replace all ‘O’ rings and install elbows (5 & 9), reducer (10), adaptors (6 & 11), tee pieces (7) and pressure switch (8) to pressure protection valve (1) ports.

7. Secure pressure protection valve (1) to mounting bracket (2) using locknuts (4) and lockwashers (3).

8. Install air lines and electrical connection to pressure protection valve (1), as tagged at 'Removal'.

9. Place master switch in the ‘On’ position, start the engine and allow air pressure in the tanks to build up to correct operating pressure. Check for leaks at air lines and tighten as required.

10. Remove wheel blocks.

SPECIAL TOOLS
There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of general service tools required. These tools are available from your dealer.
DESCRIPTION AND OPERATION

Numbers in parentheses refer to Fig. 1.

The air horn is mounted on a bracket off the front fuel tank and is operated when the horn control is pressed in. This action activates the electrically activated horn solenoid which allows air to pass from the primary air tank and into horn body (3). Air pressure forces the diaphragms upwards and air pressure flows through projectors (1 & 2) to provide an effective warning sound.

Refer to Section 250-0000, AIR BRAKING SYSTEM SCHEMATIC for air lines. Refer to Section 190-0000, CIRCUIT DIAGRAMS, for electrical operation of the horn solenoid.

The air horn consists of a long projector (1), short projector (2), horn body (3), cover (4), two diaphragms (5), screw (6), mounting pad (7), mounting stem (8) and washer (9).

Diaphragms (5) can be removed by removing six screws (6) and cover (4).

MAINTENANCE

Check horn application on a regular basis for correct and audible operation.

* * * *
DESCRIPTION

Numbers in parentheses refer to Fig. 1.

The cab is fully insulated and mounted on rubber isolation mounts (4) which damp structure borne noise and vibration. The cab conforms with ISO/SAE, ROPS (Roll Over Protective Structure) and FOPS (Falling Object Protective Structure) safety legislation.

ROPS - ISO 3471, SAE J1040 APR 88
FOPS - ISO 3449, SAE J231

WARNING

The protection offered by the ROPS & FOPS protective structure may be impaired if it has been subjected to any modification or damage. Unauthorized modification will void certification.

Cab assembly (13) is spacious and offers outstanding visibility through large areas of tinted safety glass. Access to cab assembly (13) is from the left hand side.
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The cab interior, trimmed with noise-absorbant material, is extensively thermally insulated and a heater and demisting unit keeps internal air fresh and dust free. Sliding windows provide additional ventilation. An air conditioning unit is also fitted. Refer to Section 260-0130, AIR CONDITIONING.

Note: Access from the cab, in case of an emergency, can be gained by breaking any of the windows using the hammer provided (mounted on the right hand cab pillar).

REMOVAL
Numbers in parentheses refer to Fig. 1.

Note: Identify and tag all cables, harnesses, lines and pipes disconnected from cab assembly (13) during removal to aid in installation.

3. Disconnect the electrical cables in the following order to prevent damage to the electrical components.
   a. Disconnect battery equalizer ground cables.
   b. Disconnect battery cables from terminal posts (ground cables first).
   c. Disconnect battery equalizer positive cables.
   d. Disconnect electrical connections at the ECU.

4. Disconnect all remaining electrical connections attached to cab assembly (13).

5. Open drain cocks on air tanks and drain air from tanks. Close drain cocks on air tanks when air is exhausted.

6. With a suitable container in position, drain the cooling system. Refer to Section 210-0040, RADIATOR AND MOUNTING.

7. Ensure all steering and bowl hydraulic lines connected to the cab are identified for ease of installation, and with suitable containers available to catch leakage, disconnect all lines. Fit blanking caps to all open lines and fittings.

8. If the vehicle is equipped with air conditioning, evacuate the system and disconnect air conditioning lines. Refer to Section 260-0130, AIR CONDITIONING. Fit blanking caps to all open lines and fittings.

9. Ensure heater lines are identified for ease of installation, and with suitable containers available to catch leakage, disconnect heater lines. Fit blanking caps to open lines and fittings.

10. Ensure all connections to cab assembly (13) have been removed, prior to removal.

11. Attach suitable lifting equipment to cab assembly (13) and take up the slack.

Note: Use padded spreader bars when removing cab assembly (13) with overhead lifting equipment to
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prevent damage from concentrated loads at cab lifting points with hooks, chains, cables etc..

12. Remove locknuts (8), washers (7), snubbing washers (6) and bolts (5 & 9) securing the cab assembly (13) to cab mounting supports (1, 2 & 3) on the tractor frame.

13. Lift cab assembly (13) carefully from the cab supports (1, 2 & 3) and remove to suitable stands. Remove rubber isolation mounts (4) from cab mounting supports (1, 2 & 3).

14. If required, remove bolts (10) and washers (11) securing cab supports (1, 2 & 3) to tractor frame. Remove cab mounting supports (1, 2 & 3) from tractor frame.

INSTALLATION

Numbers in parentheses refer to Fig. 1.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

WARNING
To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. If removed, secure cab mounting supports (1, 2 & 3) to tractor frame using bolts (10) and washers (11).

2. Inspect rubber mounts (4) for damage and replace if necessary. If installing new rubber mounts (4), lubricate them with water or a suitable rubber lubricant and install in cab mounting supports (1, 2 & 3). Use a driver of the same diameter as the internal metal sleeve in rubber mount (4) to drive the mounts fully home.

3. Attach suitable lifting equipment (with padded spreader bars) and position cab assembly (13) to cab mounting supports (1, 2 & 3). Take care when positioning cab assembly (13) to prevent snagging of lines and components on the underside of cab assembly (13).

4. Secure cab assembly (13) to mounting supports (1, 2 & 3) with bolts (5 & 9), snubbing washers (6), washers (7) and locknuts (8). Tighten bolts (5 & 9) to a torque of 271 Nm (200 lbf ft).

5. Remove blanking caps from all bowl hydraulic lines and connect lines as identified at removal. Tighten all lines securely.

6. Remove blanking caps from all steering lines and connect lines as identified at removal. Tighten all lines securely.

7. Connect all electrical connections with the exception of battery cables, battery equalizer cables and ECU connections, as identified at removal.

8. Remove blanking caps from heater lines and fittings and connect lines as identified at removal. Tighten heater lines securely.

WARNING
Before connecting any air conditioner lines, refer to Section 260-0130, AIR CONDITIONING. Refrigerant will rapidly freeze all objects with which it comes into contact. It can cause serious and permanent damage to the eyes and skin.

9. If the vehicle is equipped with air conditioning, connect the lines to the evaporator and charge the system. Refer to Section 260-0130, AIR CONDITIONING.

10. Connect electrical cables in the following order:
   a. Connect all electrical connections removed at the ECU.
   b. Connect battery equalizer positive connections.
   c. Connect battery cables to terminal posts (positive cables first).
   d. Connect battery equalizer ground cables.

11. Check cab assembly (13) and be sure that all lines, cables and harnesses removed at removal have been reconnected.

12. Fill hydraulic tank with hydraulic oil specified in Section 300-0020, LUBRICATION SYSTEM. Fill the cooling system with coolant specified in Section 300-0020, LUBRICATION SYSTEM.

13. Place the battery master switch in the ‘On’ position, start the engine and check for leaks. Tighten lines and fittings as required. Allow the vehicle to warm to normal operating temperatures and check all connections for leaks. Ensure electrical systems and gear shift are functioning properly.
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14. Ensure parking brake is applied and remove wheel blocks from all road wheels.

REPLACING GLASS

Numbers in parentheses refer to Fig. 1.

Note: When replacing broken glass, it is the user’s responsibility to ensure that replacement glass meets the required specifications.

Front glasses, rear glasses and side glass panels are held in place by a bonding adhesive. The front and rear glasses also have corner covers.

To replace a glass assembly, proceed as follows:

Note: Ensure the glass is supported adequately before starting to cut the adhesive seal.

1. If necessary, remove corner covers.

2. Using a pointed tool, pierce a hole in the adhesive seal, it is advisable to start at the top edge of the glass. Unscrew one handle of the special tool and feed the wire through the opening. Pierce a second hole in the adhesive on the side directly opposite the first.

3. From inside the cab pull the wire through and feed it back out through the second hole.

4. Re-fit the handle on the special tool. Pull both handles outwards until wire is taut.

5. Manoeuvre the special tool around the edge of the glass, keeping the wire taut, to cut the adhesive seal. Ensure the glass is supported adequately before completing the cut. Remove glass from window aperture.

6. Clean the remains of the adhesive from the edge of the panel opening using a suitable solvent.

7. Coat the edge of the replacement glass with primer and apply adhesive around the lip of the window aperture, as per the manufacturers recommendations.

8. Position glass onto panel opening, pressing firmly so that adhesive bonds sufficiently to allow the glass to be moved or straightened up as required.

9. Ensuring the glass is adequately supported, allow the sealing adhesive to set properly.

10. Clean off any excess adhesive using a suitable solvent.

11. If removed, re-fit corner covers.

Water Leaks

Test for leaks by directing a stream of water along the adhesive seal, while an assistant marks the spot of leakage inside the cab. Care should be taken to note whether the leak is between adhesive and glass. Then apply a sealing compound from the outside. Start from a point near the leak and continue applying the sealer until well beyond the suspected point of entry.

This should stop the leak immediately, but since some sealing compounds should be allowed to set before getting wet, wait a few minutes before testing.

SPECIAL TOOLS

Refer to Section 300-0070, SERVICE TOOLS, for part numbers of special tools referenced in this section and general service tools required. These tools are available from your dealer.

SPECIAL TORQUE SPECIFICATIONS

<table>
<thead>
<tr>
<th>FIG. NO.</th>
<th>ITEM NO.</th>
<th>ITEM NAME</th>
<th>TORQUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>Bolt</td>
<td>271 Nm</td>
</tr>
<tr>
<td>1</td>
<td>9</td>
<td>Bolt</td>
<td>271 Nm</td>
</tr>
</tbody>
</table>

* * * *
DESCRIPTION
Numbers in parentheses refer to Fig. 1.

WARNING
By Law, seat belts must be provided. Always wear seat belts when travelling in the vehicle.

The driver seat is secured to the cab floor with bolts (24 & 25) and lockwashers (26). The seat assembly (1) consists of a seat cushion (7) and back cushion (5) mounted to seat frame (2). Seat frame (2) is attached to seat base (27) by means of a suspension assembly. The air seat only reacts when the driver sits on the seat. When unoccupied, the seat sinks to the lowest.
position to allow easier access. The incorporated block out maintains the seat in position for driving.

A retractable lap belt (21) is secured to the seat assembly using bolts and lockwashers. A lift lever buckle allows quick release of lap belt (21).

The following is the list of controls to adjust the seat:
A. Height and slope adjustment, front.
B. Height and slope adjustment, rear.
C. Backrest angle adjustment.
D. Weight adjustment.
E. Horizontal adjustment (sliderails).
F. Lumber support adjustment (5 positions).
G. Armrest adjustment.

WARNING
Do not attempt to adjust the seat or seat belt while the machine is moving. Loss of control may result. Stop the machine; apply the brakes; then adjust.

REMOVAL AND DISASSEMBLY
Numbers in parentheses refer to Fig. 1.

**WARNINGS**
To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.
2. Block all road wheels and place the battery master switch in the 'Off' position.
3. Open drain cocks on air tanks and drain air from tanks. Close drain cocks on air tanks when air is exhausted.
4. Disconnect air line at floor plate at the rear of the seat.
5. Push the control valve button (D) in to release the air from the seat air suspension system.
6. Remove bolts (24 & 25) and lockwashers (26) securing complete seat assembly to the cab floor. Remove seat assembly from vehicle.
7. Remove bolts and lockwashers securing lap belt (21) to seat assembly. Remove lap belt (21).
8. Remove bolts (28), washers (29), lockwashers (30) and nuts (31) securing seat base (27) to seat assembly. Remove seat base (27) from seat assembly.
9. If required, remove pop-out button and pull back suspension cover (16) to allow access to suspension assembly (13).
10. If required, remove mounting hardware securing dampers (12) to suspension assembly (13). Remove dampers (12).

INSPECTION
Numbers in parentheses refer to Fig. 1.

1. Inspect air lines, control valve (D), dampers (12) and air spring (15) for leaks and damage and replace if required.
2. Check all brackets and frame for cracks and/or damage. Repair or replace as necessary.
3. Check springs (11) for fatigue or damage and replace as required.

ASSEMBLY AND INSTALLATION
Numbers in parentheses refer to Fig. 1.

**Note:** Tighten all fasteners without special torques specified to torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. If removed, secure dampers (12) to suspension assembly (13) using mounting hardware as removed at Removal.
2. If required, install suspension cover (16) over suspension assembly (13) and refit pop-out button.
3. Install seat base (27) to seat assembly and secure using bolts (28), washers (29), lockwashers (30) and nuts (31).
4. Position lap belt (21) to seat assembly and secure using bolts and lockwashers as removed at Removal.

5. Position seat assembly on the cab floor and secure with bolts (24 & 25) and lockwashers (26).

6. Reconnect air line at floor plate to the port at the rear of the seat.

7. Place battery master switch in the 'On' position, start the engine and charge the air system. Pull out control valve button (D) to allow air into seat suspension system and check seat for proper operation.

8. Remove wheel chocks from road wheels.

**MAINTENANCE**

Numbers in parentheses refer to Fig. 1.

The care of the upholstery on seat cover (8) and back cover (6) is a relatively simple, but important matter.

Accumulation of dirt on the surface eventually turns into a hard gritty substance which cuts into the surface of the upholstery.

To clean seat cover (8) and back cover (6), use warm water and a mild soap, such as Castile. Work up thin soap suds on a piece of soft cloth and rub the upholstery briskly. Remove the suds with a damp cloth, using no soap, and finish by wiping the upholstery dry with a soft, dry cloth.

Lap belt (21) assembly should be inspected by the user on a regular basis. Replace lap belt (21) immediately if hardware is worn or damage, straps are nicked or frayed, buckle is not functioning correctly, loose stitching is found, or if the strap material has lost strength due to the effects of ultraviolet rays.

**Note:** Regardless of appearance, lap belt (21) must be removed and replaced at least once every three years.
DESCRIPTION

Temperature Control Switch
A thermostat switch senses the temperature of the evaporator and engages or disengages the compressor clutch. The control for this switch is located in the cab.

Compressor
The compressor is designed to compress vapour and can be damaged by non-compressibles such as dirt, moisture, liquid refrigerant (R-134a), etc. The compressor draws vaporized R-134a from the evaporator (which maintains the low pressure necessary for proper evaporation) and compresses the vapour to a high pressure, which is necessary for condensation. The high pressure vapour then moves into the condenser where heat can be radiated to change the R-134a back to liquid.

Note: R-134a designates the type of refrigerant used in heavy duty vehicle air conditioning systems.

Compressor Drive Clutch
The R-134a compressor systems use an electronically actuated clutch to engage and disengage drive to the compressor. The 'V' belt pulley is mounted on a bearing and is free to rotate without turning the compressor crankshaft any time electrical power is disconnected. The compressor is not operating when the pulley is freewheeling. The field coil is energized by supplying electrical current to the exposed wire. The other end of the coil winding is grounded to the compressor and equipment frame. Energizing the coil creates a magnetic force that locks the driven disk to the pulley and drives the compressor.

Condenser
The purpose of the condenser is to radiate enough heat energy from the compressed high pressure vaporized R-134a so that the R-134a changes from vapour to liquid. During normal operation all the high pressure section of the system will be warm or hot, but large quantities of heat should be radiating from the condenser. Nothing should be permitted to stop or slow
down this radiation of heat. Cooling fins are located on the condenser tubes and fans are used to circulate cool air around the condenser tubes. Keep all leaves, paper, dirt, etc. clear from the condenser and condenser filter. The cooling fins should be straight to permit free flow of air. The condenser is sometimes located ahead of the engine radiator and blockage of air flow through the radiator also affects the condenser. Bent fan blades, slipping fan drive, inoperable condenser fan motors, or any other fault that lessens the amount of cool air circulated through the condenser, should be corrected. The oil, dirt, or antifreeze will act as an insulator that will inhibit the radiation of heat.

Since the purpose of the condenser is to radiate heat energy, anything that prevents or inhibits this action may affect cooling, but the temperature and pressure of the R-134a raise and lower together. Heat energy that has not been radiated will remain in the R-134a and the result will be pressure that is too high. The condenser, hoses, connections and seals can be damaged by the high pressure. Pressure sensing safety switches may be activated by the high pressure caused by the condenser not radiating enough heat.

Receiver Drier
The high pressure liquid R-134a moves from the condenser to the receiver drier, where the R-134a is stored and filtered. Moisture is the major enemy of the air conditioning system and the desiccant inside the receiver drier will absorb only a small amount. The container of desiccant inside the receiver drier may break open and contaminate the system if any attempt is made to dry the desiccant, or, if more moisture is inside the system than the desiccant can absorb.

Every effort should be made to remove all moisture from the system and install a new receiver drier if its condition is questionable. Installation of a new receiver drier is recommended each time any part of the R-134a system is open to the atmosphere. The receiver drier is equipped with a moisture indicator at the sight glass. When moisture is in the system, the indicator turns yellow. A dry system is indicated by a green colour. Bubbles are observed in the sight glass on top of the receiver drier during the charging procedure.

A filter screen is located in the receiver drier to stop solid contaminates from leaving the unit. Blockage of the filter will result in a drop in pressure that will be indicated by a drop in temperature. Connections of the new receiver drier should be securely capped before installation to prevent the entrance of moisture (air) while in storage.

Thermostatic Expansion Valve
An expansion valve is installed in the system to lower the pressure before the R-134a enters the evaporator. The reduction in pressure is done by passing the R-134a through a small hole (orifice). The size of the orifice must be controlled to compensate for changes in pressure and temperature. The temperature of R-134a leaving the evaporator is sensed by a thermal bulb and capillary tube that moves the valve seat via a diaphragm and actuating pins. Externally equalized expansion valves have a line connected to the outlet from the evaporator, and R-134a pressure passes through this line to push against the diaphragm and actuate the valve.

Evaporator - Heat/Cool
The evaporator is the low pressure, low temperature component where liquid R-134a absorbs heat from surrounding air. The expansion valve bleeds high pressure R-134a into the low pressure evaporator. The R-134a expands rapidly in the evaporator and its temperature is quickly reduced. The R-134a absorbs heat from the air when the blower fan circulates air over the evaporator coil fins. The exchange of heat from the air to the R-134a depends upon the difference in temperature. During high heat load, such as usually encountered when the system is first turned on, the temperature difference is great and the R-134a will absorb heat quickly. The blower fan can be set at its highest setting to circulate large quantities of warm air around the evaporator. After the cab has cooled, the fan speed should be reduced so that the already cool air will have a longer time to yield heat to the R-134a as it passes the evaporator coils. The heater circuits utilize engine coolant at approximately 82° C (180° F).

High Pressure and Low Pressure Switches
The pressure switches are electric switches that monitor air conditioner operation. The high pressure and low pressure switches are activated at preset pressures and engage and disengage the compressor clutch.
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REMOVAL

Numbers in parentheses refer to Fig. 2, unless otherwise stated.

**WARNINGS**

Always wear goggles or glasses to protect your eyes when working around R-134a. R-134a boils at sea level temperatures of -29.8° C (-21.6° F), which means that direct contact with your skin will produce frostbite. Exercise extreme care when handling R-134a.

If you get the slightest trace of R-134a in your eye, flood the eye immediately with cool water; then treat with mineral oil or clear petroleum jelly followed by boric acid rinse. Report to a hospital or doctor as soon as possible.

The chemicals of R-134a change when burned and become a poison phosgene gas that will damage the respiratory system if inhaled. NEVER SMOKE in an area where R-134a is used or stored. Use hot water or an approved heated charge cylinder as a heat source if required to force R-134a into the system. If using water, do not exceed 52° C (125° F). Never use direct flame or electric heaters in direct contact with the R-134a container. High temperatures may result in raising the pressure to a dangerous level.

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place the battery master switch in the ‘Off’ position.

3. Remove hood assembly and side panel from vehicle to gain access to air conditioning components. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS.

4. Disconnect electrical cables from headlights and reverse alarm. Remove mounting hardware and radiator guard from machine. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS.

5. Discharge the air conditioning system as described under ‘Discharging The System’.

6. Remove mounting hardware securing cover on air conditioner unit (1) to gain access to refrigerant hosing and control cable (32).

7. When satisfied that the system is completely discharged, tag refrigerant hoses (21 & 23) to aid in installation and carefully disconnect hoses from air conditioner unit (1) and cab bulkhead. Cap fittings and refrigerant hoses (21 & 23) to prevent foreign matter from entering the system.

8. Remove fastener (31) and lock (30) and unhook control cable (32) from water valve (29). Disconnect harness.

9. Tag refrigerant hoses (22 & 24) to aid in installation and carefully disconnect hoses from cab bulkhead. Cap fittings and refrigerant hoses (22 & 24) to prevent foreign matter from entering the system.

10. Tag refrigerant hoses (24 & 5) to aid in installation and carefully disconnect hoses from receiver/drier (6). Cap receiver/drier (6) fittings and refrigerant hoses (24 & 5) to prevent foreign matter from entering the system.

11. Slacken band clamps (9) and remove receiver/drier (6) from mounting bracket (7). If necessary, remove mounting hardware and mounting bracket (7) from vehicle.

12. Tag refrigerant hoses (5 & 10) to aid in installation and carefully disconnect hoses at condenser (33). Cap condenser (33) fittings and refrigerant hoses (5 & 10) to prevent ingress of foreign matter.

13. If required, support air conditioner condenser (33) and mounting bracket (34) and remove Screws (28), lockwashers (27), washers (26) securing condenser (33) and mounting bracket (34) to radiator assembly. Remove condenser (33) from vehicle.

14. Tag refrigerant hoses (10 & 22) to aid in installation and carefully disconnect hoses from compressor (2). Cap compressor (2) fittings and refrigerant hoses (10 & 22) to prevent foreign matter from entering the system.

15. Disconnect electrical connection from compressor (2) clutch.
Fig. 2 - Air Conditioner Lines and Mounting
1 - Air Conditioning Unit
36 - Blower Unit
37 - Evaporator Matrix
38 - Expansion Valve
39 - Heater Matrix
40 - Clamp
41 - Hose (Drain)
42 - Clamp
43 - Duct - Flexible
44 - Filter Element

Fig. 3 - Air Conditioner Lines and Mounting
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16. Back of Bolts (13) enough to allow gentle pivot motion of compressor unit (2) onto outer brackets (35) to release tension on 'V' belt (4).

17. 'V' belt (4) should now be free to slide off the groove in compressor (2).

18. Support compressor (2) and remove bolts (18) and lockwashers (14 & 15) and nuts (16) (from both sides) securing compressor (2) to bracket assembly (35). Carefully remove compressor (2) from the vehicle.

Note: If 'V' belt (4) does not require replacement do not remove from engine fan pulley. If 'V' belt (2) requires replacement, proceed with steps 19 and 20.

19. If required, remove mounting hardware securing fan guard assembly to radiator shroud assembly. Refer to SECTION 210-0040, RADIATOR AND MOUNTING.

20. Release tension on Poly 'V' fan belt and remove from fan pulley. Remove compressor 'V' belt (4) from the rear groove of the fan pulley. Refer to Section 110-0030, ENGINE AND MOUNTING.

21. If required, remove bolts (31), washers (30), and bracket (35).

22. If required, disconnect all clamps and clips securing refrigerant hoses and harnesses to the vehicle. Remove hoses and harnesses from the vehicle.

23. If necessary to gain access to blower unit (36, Fig. 3), evaporator matrix (37, Fig. 3), heater matrix (39, Fig. 3) and expansion valve (38, Fig. 3) remove mounting hardware and slide cover from air conditioning unit.

INSTALLATION

Numbers in parentheses refer to Fig. 2, unless otherwise stated.

Note: Tighten all fasteners to standard torques specified in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. If removed, slide air conditioner cover into position inside the cab and secure cover with mounting hardware as removed at Removal.

2. Attach control cable (32) to water valve (29) and secure in place with fastener (31) and lock (30). Connect harness.

3. Remove caps from end of refrigerant hoses (4 & 5) and ports on air conditioner (1) and cab bulkhead and connect hoses to ports as tagged at Removal.

4. Position front cover and filter assemblies on air conditioner (1) unit and secure using mounting hardware as removed at Removal.

5. If removed, route refrigerant hoses and secure in place with clamps removed during Removal.

6. If removed, secure mounting bracket (15) in place using mounting hardware as removed at Removal. Install receiver/drier (14) to mounting bracket (15) and secure with band clamps (16).

7. Remove caps from end of refrigerant hoses (6 & 9) and ports on receiver/drier (14) and connect hoses to ports as tagged at Removal.

8. If removed, install condenser unit (10) and mounting bracket (11) to radiator assembly and secure with bolts (12) and washers (13).

9. Remove caps and connect refrigerant hoses (8 & 9) to condenser unit (10) ports as tagged at Removal.

10. If removed, install mounting bracket (35) and secure using bolts (31) and washers (30).

11. Fit compressor (2) to outer mounting brackets (35) and secure with bolts (17) and washers (14).

12. Take the assembly from step 11. and arrange Spacers (11 & 12), Bolts (13), washers (14), Lockwashers (15) and nuts (16) in the correct orientation as shown (fig 1.) to enable the compressor and outer mounting brackets to be fitted to the main bracket (35).

Note: Do not tighten bolts (13) and nuts (16) fully at this stage, to allow for fitting and adjustment of Poly 'V' belt.

Note: If fan guard, Poly 'V' fan belt and compressor 'V' belt (4) were removed, proceed with steps 12 & 13.

WARNING

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.
12. Install new ‘V’ belt (4) onto rear groove on engine fan pulley and fit to rear groove on compressor (2).

13. Refit Poly ‘V’ fan belt and adjust tension. Refer to Section 110-0030, ENGINE AND MOUNTING. Refit fan guard and secure with mounting hardware as removed during removal. Refer to Section 210-0040, RADIATOR AND MOUNTING.

14. Adjust tension of compressor ‘V’ belt until there is approximately an inward deflection of 10 mm (0.4 in) at the centre of ‘V’ belt (18). When tension correct, tighten bolts (13) and nuts (16) to fix location of compressor (2) relative to belt. Fully tighten all mounting hardware.

15. Remove caps from end of refrigerant hoses (10 & 22) and ports on compressor (2) and connect hoses to ports as tagged at Removal.

16. Connect electrical connection to compressor (2) clutch.

17. Secure all lines with clips and clamps as removed during removal. Ensure no lines are chaffing on sharp edges or resting against areas where heat will be evident.

18. Charge the air conditioning system as described under ‘Charging Procedure’.

19. Switch the battery master switch to the ‘On’ position, start up the engine and check for correct operation of the air conditioning system.

20. Install hood assembly and side panel to vehicle. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS. Install radiator guard to vehicle and connect electrical cables to headlights and reverse alarm. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS.

21. Remove wheel chocks.

**MAINTENANCE**

**WARNING**
Always wear goggles or glasses to protect your eyes when working around R-134a. R-134a boils at sea level temperatures of -29.8° C (-21.6° F), which means that direct contact with your skin will produce frostbite. Exercise extreme care when handling R-134a.

If you get the slightest trace of R-134a in your eye, flood the eye immediately with cool water; then treat with mineral oil or clear petroleum jelly followed by boric acid rinse. Report to a hospital or doctor as soon as possible.

**WARNING**
The chemicals of R-134a change when burned and become a poison phosgene gas that will damage the respiratory system if inhaled. NEVER SMOKE in an area where R-134a is used or stored. Use hot water or an approved heated charge cylinder as a heat source if required to force R-134a into the system. If using water, do not exceed 52° C (125° F). Never use direct flame or electric heaters in direct contact with the R-134a container. High temperatures may result in raising the pressure to a dangerous level.

1. Periodically clean the condenser coil of debris and dirt using water or air pressure. A partially blocked condenser coil can reduce the life of the compressor belt and/or clutch.

2. If the system has a heater in the same location as the air conditioning evaporator core, heater valves should be closed.

3. To check the refrigerant level, run the engine at 1 200 rev/min with fans on high speed and thermostat fully open for a minimum of five minutes. If the clutch is engaged in this situation, there should be very few bubbles visible in the receiver-drier sight glass.

**Note:** Unit can operate with some bubbles visible, but not milky looking.
Operators Compartment - Air Conditioning

Section 260-0130

4. Ensure all hoses and hose clamps are free from contact with sharp metal, moving parts or near to manifolds.

5. Inspect condensation drain lines for debris, sharp bends or breaks.

6. Inspect the clutch wire from the thermostat for bare spots.

7. Inspect bolts and nuts on the compressor and mounting bracket for proper tightness.

8. Inspect and clean outside and inside cab air filters periodically, depending on dust conditions. Replace the outside filter when it becomes saturated to the point it won't come clean.

Maintenance of 'V' belt Drives

1. Listen for 'ticking' sound - they mean interference with the belts. Visually inspect for bent or damaged belt guards.

2. Replace all belts in a mismatched set at one time to ensure even load distribution.

3. Periodically check tension and keep belts tight.

   - The ideal tension is the lowest tension at which the belt will not slip under peak load conditions.
   - Check belt tension frequently during the first 24 - 48 hours of run-in operation.
   - Initial belt tension should be 445 N (100 lbf) dropping to 334 N (75 lbf) after the first 48 hours.
   - There should be a freeplay of 10 mm in the 'V' belt.
   - Do not over tension belts.
   - Keep belts free from foreign material that may cause slippage.
   - Inspect the V-drive periodically. Re-tension belts if they are slipping.
   - Maintain sheave alignment with a strong straight edge tool while tensioning belts.

4. Never attempt to correct belt slippage by using a belt dressing. The dressing may cause softening and deterioration.

5. If belt slips, even when properly tensioned, check for overload, worn sheave grooves or oil or grease on the belts.

6. Never pry a 'V' belt or force it into the sheave groove. Loosen the 'V' belt tighter prior to installation.

7. A belt that has operated while rolled over in the sheave groove may be damaged - replace it.

8. Store belts in a cool, dry place. If stored on a machine, relieve all belt tension by loosening the 'V' belt tightener.

9. Never attempt to check or adjust belts while they are running.

System Leak Testing

Recommended Equipment Required:
Halogen Leak Detector

Switch off the engine and check all connections throughout the system for leaks. A large leak point will have an oily or greasy appearance. The refrigerant carries compressor oil with it and deposits it around the leak area. Check all such points for loose connections and tighten.

Using a suitable leak detector, search for leaks around all joints, connections, seals and control devices. If a leak is located, purge the system of refrigerant and repair. Fully evacuate and charge the system to make it operational.

DISCHARGING THE SYSTEM

Note: Refer to all WARNINGS listed under 'Maintenance' prior to discharging the system.

Recommended Equipment Required:
Portable High Vacuum Charging Station
Suitable Canister

To eliminate system contaminants from an air conditioning system requires discharging the entire system. This means removing all of the refrigerant and cleansing all contamination (air and moisture) from the system components. If any of the major system components are to be repaired or replaced, the system must also be completely discharged.

⚠️ WARNING
The vehicle must not be running during this procedure. Be sure to have adequate ventilation during this operation. Do not discharge refrigerant near an open flame.
1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place the battery master switch in the ‘Off’ position.

3. If necessary, remove hood assembly and side panel from vehicle to gain access to air conditioning components. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS.

4. Tighten down (turn clockwise) both high and low side valves on the gauge manifold to the closed position. Remove protective caps from the service ports on the compressor.

5. Connect both service hoses from the two fittings in the bottom of the manifold to the two service ports on the compressor. High side (red) to compressor discharge valve, low side (blue) to compressor suction valve, and centre service hose (yellow) vented to a suitable canister (canister on charging station).

6. Open the low side hand valve on the manifold very slowly. Watch the centre service hose for evidence of any refrigerant oil in the canister. Carefully adjust low side hand valve to prevent oil from escaping.

7. When the high side manifold gauge reading moves below 3.5 bar (50 lbf/in²), open high side hand valve very slowly. The refrigerant should flow at a fairly even rate from both high and low sides of the system. As necessary, continue to monitor the hand valves to prevent any oil leakage.

8. When 0 bar (0 lbf/in²) is reached on both gauges, close both hand valves. The system should now be completely discharged and may be opened for service.

9. If removed, install hood assembly and side panel to vehicle. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS.

10. Remove wheel blocks.

**For New Or Completely Empty System**

**Note:** The charging procedure must be done in ambient temperatures above 15.5°C (60°F) with the R-134a canister temperature equal to the outside ambient temperature.

1. Shut off engine and block all road wheels.

2. If necessary, remove hood assembly and side panel from vehicle to gain access to air conditioning components. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS.

3. Remove protective caps from ‘Schraeder’ valves on rear of compressor.

4. Connect low pressure gauge hose (blue hose and gauge) to suction side or low side fitting on compressor. The suction side can be identified by the size of the hose connected to the fitting. This will be the largest diameter hose of the system.

5. Connect the high pressure gauge hose (red hose and gauge) to discharge or high side fitting on compressor.

6. Connect yellow supply hose to suction port on vacuum pump.

7. Open both sides of gauges, low and high, completely.

8. Start vacuum pump to evacuate the complete air conditioning system.

9. Run vacuum pump for approximately 30 minutes. Ideal gauge readings should be 29.92 inches of mercury. The pressure will vary with altitude; it will be approximately 0.03 bar (0.5 lbf/in²) less for each 305 m (1000 ft) of elevation.

10. Before disconnecting power supply from vacuum pump, close both high and low side gauges. Remove yellow hose from vacuum pump and connect to R-134a source.

11. Open R-134a source. Loosen, but do not remove, yellow supply hose at manifold on gauges to remove all air in the yellow supply hose, replacing the air with R-134a. This is done in a few seconds. Tighten yellow supply hose.

12. Open low side of R-134a gauges slowly. When gauge reads zero open both sides completely. Vacuum in the system will draw R-134a gas into the system. Hold until both gauge readings equalize.
Note: Never charge with liquid R-134a. Charge on the low pressure side only.

**Final Charging Of The System**

1. Start the engine and run at engine idle speed.

2. Turn the air conditioning system on with the thermostat set on maximum cooling, fan on high speed and toggle switch set to air conditioning.

3. At this point a visual inspection must be made of the sight glass on top of the receiver-drier. As charging continues, the sight glass will appear milky coloured as the bubbles in the system circulate. As the system continues the charging process, the regularity of the bubbles in the sight glass will gradually diminish. When no bubbles are seen in the sight glass, close the low pressure valve (blue side) completely.

4. Increase the engine idle speed while observing the sight glass. If many bubbles are seen resulting from the increased engine speed, open the low pressure side valve. Allow the system to continue the charging procedure until the sight glass is clear. If the sight glass remains clear, with the increased engine speed, do not add any more R-134a.

Note: Occasionally bubbles are noticed during clutch cycling or system start-up. This is a normal condition.

5. With the system completely charged, shut off the engine. Close the valve on the R-134a canister and remove the yellow supply hose. Remove both the low pressure (blue) hose and high pressure (red) hose from the filling ports on the compressor.

Note: Some R-134a will escape as the hoses are being removed. Replace protective caps on hoses.

6. If removed, install hood assembly and side panel to vehicle. Refer to Section 100-0010, CHASSIS, HOOD AND FENDERS.

7. Remove wheel blocks.

**SPECIAL TOOLS**

Refer to Section 300-0070, SERVICE TOOLS, for part numbers of special tools referenced in this section and general service tools and sealants required. These tools and sealants are available from your dealer.
## AIR CONDITIONING DIAGNOSIS

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>PROBLEM</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Belt Trouble</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slipping</td>
<td>Loose</td>
<td>Adjust belt to 12 mm (0.5 in) depression</td>
</tr>
<tr>
<td></td>
<td>Overcharge</td>
<td>Correct the charge</td>
</tr>
<tr>
<td></td>
<td>Air in system</td>
<td>Evacuate and re-charge</td>
</tr>
<tr>
<td>Excessive wear</td>
<td>Pulley not aligned</td>
<td>Align Pulley</td>
</tr>
<tr>
<td></td>
<td>Belt too tight</td>
<td>Adjust or replace</td>
</tr>
<tr>
<td></td>
<td>Bad idler bearing</td>
<td>Replace idler bearing</td>
</tr>
<tr>
<td></td>
<td>Belt wrong width</td>
<td>Replace with correct belt</td>
</tr>
<tr>
<td><strong>2. Vibration/Noise in Compressor area</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration/noise</td>
<td>Stuck compressor or clutch</td>
<td>Replace</td>
</tr>
<tr>
<td></td>
<td>Overcharge</td>
<td>Correct the charge</td>
</tr>
<tr>
<td></td>
<td>Air in system</td>
<td>Evacuate system and re-charge</td>
</tr>
<tr>
<td></td>
<td>Compressor mounting or belts loose</td>
<td>Tighten</td>
</tr>
<tr>
<td></td>
<td>Drive pulley loose</td>
<td>Tighten</td>
</tr>
<tr>
<td></td>
<td>Belt tension incorrect</td>
<td>Correct tension</td>
</tr>
<tr>
<td></td>
<td>Faulty compressor</td>
<td>Replace compressor</td>
</tr>
<tr>
<td>Noise with clutch engaged</td>
<td>Faulty clutch bearing</td>
<td>Replace bearing</td>
</tr>
<tr>
<td>Noise with clutch engaged or disengaged</td>
<td>Clutch loose</td>
<td>Tighten</td>
</tr>
<tr>
<td>Noise</td>
<td>Clutch rubbing field coil</td>
<td>Align clutch</td>
</tr>
<tr>
<td></td>
<td>Faulty belt</td>
<td>Replace belt</td>
</tr>
<tr>
<td></td>
<td>Compressor oil level low</td>
<td>Add oil</td>
</tr>
<tr>
<td>Chatter/Knock</td>
<td>Valve plate broken</td>
<td>Repair or replace</td>
</tr>
</tbody>
</table>
### AIR CONDITIONING DIAGNOSIS (continued)

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>PROBLEM</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3. Noise - Evaporator</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rubbing/scraping</td>
<td>Fan blade or blower</td>
<td>Repair or replace</td>
</tr>
<tr>
<td>Hissing</td>
<td>Low charge/leak</td>
<td>Correct charge/repair leak</td>
</tr>
<tr>
<td>Chatter/Knocking</td>
<td>Air in system</td>
<td>Evacuate and re-charge</td>
</tr>
<tr>
<td>Noisy case</td>
<td>Loose brackets/screws</td>
<td>Tighten</td>
</tr>
<tr>
<td>Motor squeal</td>
<td>Dry bearings</td>
<td>Replace</td>
</tr>
</tbody>
</table>

| **4. Air Conditioning Inadequate After Short Period Of Operation** | | |
| Cooling quits | Moisture in system | Replace thermostat |
| | Thermostat | Correct the charge |
| | Clutch | Check pull-in of clutch or replace |
| Cooling intermittent | Moisture in system | Replace drier |

<p>| <strong>5. Electrical Trouble</strong> | | |
| Blower motor or condenser fan motor inoperable | Defective circuit breaker or bad wiring connections | Replace, Clean and tighten connections |
| | Tight motor bearing | Repair or replace motor |
| | Switch open or shorted | Repair or replace switch |
| Slow running blower | Shaft binding | Replace motor - worn bearings |
| | Wheel misaligned | Replace |
| | Bad blower switch | Replace blower |
| | Insufficient current | Install larger alternator |
| Clutch inoperable | Defective circuit breaker | Replace |
| | Loose connection | Clean and tighten connection |
| | Broken wire - ground | Repair wire |
| | Shorted or open field | Replace field |</p>
<table>
<thead>
<tr>
<th>CONDITION</th>
<th>PROBLEM</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6. Air Conditioning System Trouble - Gauges must be connected</strong></td>
<td>Overcharge of refrigerant</td>
<td>Purge system as necessary</td>
</tr>
<tr>
<td>High head pressure</td>
<td>Air in system</td>
<td>Correct charge/repair leak</td>
</tr>
<tr>
<td></td>
<td>Condenser clogged</td>
<td>Clean condenser</td>
</tr>
<tr>
<td></td>
<td>Defective condenser fan motor</td>
<td>Check electrical connections before replacing fan motors</td>
</tr>
<tr>
<td>Low head pressure</td>
<td>Undercharge of refrigerant</td>
<td>Complete charge</td>
</tr>
<tr>
<td></td>
<td>Bad compressor valve plate or gasket</td>
<td>Repair or replace</td>
</tr>
<tr>
<td></td>
<td>Restriction in drier</td>
<td>Replace drier</td>
</tr>
<tr>
<td>Low suction pressure</td>
<td>Restriction in lines</td>
<td>Clean lines</td>
</tr>
<tr>
<td></td>
<td>Restriction in expansion valve</td>
<td>Replace expansion valve and drier</td>
</tr>
<tr>
<td></td>
<td>Improper expansion valve in charge</td>
<td>Replace expansion valve</td>
</tr>
<tr>
<td></td>
<td>Damaged expansion valve cap tube - valve remains closed</td>
<td>Replace expansion valve</td>
</tr>
<tr>
<td></td>
<td>Refrigerant leak</td>
<td>Inspect lines and fittings. Tighten, repair or replace</td>
</tr>
</tbody>
</table>
DESCRIPTION AND OPERATION

Numbers in parentheses refer to Fig. 1.

The bowl (1) assembly is the portion of the scraper in which the load is carried. The front of the bowl is supported by bowl cylinders connected to the lift beam brackets (26) and pull yoke. The pivot point (ball and socket joint) on both sides is approximately at the centre of the load. The bowl is of single wall construction with channel reinforcement on the outside. This form of construction provides an all welded, torsion resisting structure.
becomes an important load-carrying and strengthening member of the scraper.

**Bowl**

The bowl (1) operated by two single stage, double acting cylinders which are pinned to the pull yoke drawbar. The rod ends of the cylinders are connected to the lift beam of the scraper bowl. When the cylinders extend, the bowl is lowered. To raise the bowl, the action is reversed, as the cylinders retract, the bowl is raised. See Fig. 3.

### REPLACEMENT OF SPINDLE

Damaged spindles (2, Fig. 1) and oil transfer tubes (4,5 Fig. 1) can be removed and new ones installed by following the procedures described in this section.

**WARNING**

To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place battery master switch in the 'Off' position.

3. Remove all components from the spindle to be replaced. Attach a suitable lifting device to the component and remove mounting hardware. Remove the component from the vehicle. Refer to Section 160-0050, WHEEL RIM AND TYRE, for tyre and wheel removal; Section 160-0040, PLANETARY GEARING, for axle and planetary removal; and Section 165-0031, BRAKE PARTS, for brake removal.

4. Remove sun pinion and axle shaft from the opposite side of the machine. Refer to Section 160-0040, PLANETARY GEARING, for procedure.

5. Remove differential from the banjo. Refer to Section 160-0020, DIFFERENTIAL.

### Oil Transfer Tube

1. Burn off weld that fastens oil transfer tube to spindle.

2. Reaching into the banjo, burn off the weld that holds the oil transfer tube to the banjo housing.
Section 280-0010

Body - Scraper Bowl and Tail

3. Remove and discard oil transfer tube from the spindle.

4. Using a grinder, remove all burrs and slag from the spindle end and inside the banjo weld joint areas.

5. Thoroughly clean the spindle and banjo cavities to remove all metal chips.

6. Install new oil transfer tube in the spindle.

7. Thoroughly clean the spindle and banjo cavities to remove all metal chips.

8. Install brakes, planetary, wheel and tyre assemblies on the spindle. Refer to Section 165-0031, BRAKE PARTS, for brake installation, Section 160-0040, PLANETARY GEARING, for planetary installation and Section 160-0050, WHEEL RIM AND TYRE, for tyre and wheel installation.

Spindle

1. Remove oil transfer tube as described under heading 'Oil Transfer Tube'.

2. Attach a suitable lifting device to the spindle.

3. Burn off weld that fastens top and bottom plates (view A-A, Fig. 4) to frame and spindle. Discard the plates.

4. Burn off weld that fastens the spindle to the banjo end plate. See fig. 4. Remove spindle from the banjo.

5. With a grinder, clean up the weld area on the tail assembly and banjo housing.

6. Thoroughly clean the banjo housing with a suitable solvent and dry. Make sure there are no chips and metal dust in the differential cavity of the banjo housing.

7. With a suitable lifting device, position the spindle on the banjo end plate.

8. Install spindle alignment tool, which can be fabricated as shown in Fig. 5, through the spindles and banjo. Align the spindle to the dimensions shown in Fig. 4 and tighten alignment tool.

9. Pre-heat the weld joint to 149 - 205°C (360 - 400°F) and maintain the heat during the welding process.

10. Weld spindle to the banjo end plate with a 9.5 mm (3/8 inch) fillet weld all around using E-70 low hydrogen electrode.

11. Position the top and bottom plates, as shown in Fig. 3 and tack weld in place. Re-check position.

12. Weld the top and bottom plates to the tail assembly and banjo. See View A-A, Fig. 4.

13. Remove the alignment tool from the spindles and banjo.

14. If removed, install new bushings in spindle (2, Fig. 1).

15. To install oil seal bushing, if removed, on spindle, heat the new bushing to 177 - 205°C (350 - 400°F) in oil to expand it for installation. If oil heating equipment is not available, heat the bushing evenly to 205°C (400°F). This takes about one minute using a torch with a heating tip. Use a templistik or other temperature gauge to make sure the bushing is hot enough. Slide heated bushing on spindle and tap lightly with a hammer to seat it.

Note: Do not apply flame directly to bushing. Place bushing on steel plate and direct flame to centre of plate to evenly distribute heat.

17. Install oil transfer tube in the spindle and banjo as described under the heading 'Oil Transfer Tube'.
Fig. 4 - Spindle Alignment and Installation
MAINTENANCE

Inspection
Inspect the frame and attached parts at intervals not exceeding 250 hours for cracked or broken welds and bending/twisting of the frame. Any defects found should be repaired before they progress into major failures. Contact your dealer for recommended weld and repair instructions.

Straightening
Hydraulic straightening or aligning equipment should be used to straighten bent or twisted frames whenever possible. However, if heat must be applied, never heat the metal beyond a dull cherry red colour, as too much heat will weaken the metal. When it is necessary to heat the metal, apply heat uniformly over the area to be straightened and protect the heated surface from sudden cooling. Frame parts, that cannot be straightened should be replaced.

Welding

WARNINGS
Before any welding is done on a machine equipped with the HEUI electronic management system, disconnect the following in this order: Battery earth cable, battery supply cable, alternator earth cables, alternator supply cables, front & rear transmission ECU connectors (located behind access door below cab door) and front & rear engine ECU connectors (located on LH side of engine). Turn off battery master switch before disconnecting any components. After welding connect all of the above in the reverse order.

Welding and flame cutting cadmium plated metals produce odourless fumes which are toxic. Recommended industrial hygiene practice for protection of the welding operator from the cadmium fumes and metallic oxides requires enclosure ventilation specifically designed for the welding process. A respiratory protective device such as the M.S.A. 'Gasfoe' respirator with G.M.A. cartridge will provide protection against cadmium, fumes and metallic oxides. The 'Gasfoe' respirator has been approved by the U.S. Bureau of Mines: Approval number 23B-10, and is designed to protect against gases, vapours, and/or metal fumes.

Note: Prior to welding, switch off/disconnect the following in the order given. Failure to do so may seriously damage the machines electrical components.

a - Turn ignition keyswitch off
b - Turn battery master switch off
c - Battery earth cables
d - Battery supply cables
e - Alternator earth cables
f - Alternator supply cables
g - Transmission ECU connectors (front & rear)
h - Engine ECU connectors (front & rear)

After welding, connect all of the above in the reverse order.

Note: Always fasten the welding machines ground cable to the piece/frame being welded if possible.

Electric arc welding is recommended for all welded frame repairs. Since the nature and extent of damage to the frame cannot be predetermined, no definite repair procedure can be established. As a general rule however, if parts are twisted, bent or pulled apart, or a frame is bent or out of alignment, no welding should be done until the parts are straightened or realigned.

Successfully welded repairs will depend to a great extent upon the use of the proper equipment, materials and the ability of the welder. The Service Department can be consulted regarding the feasibility of welding repairs.

Patching
There are two methods to be used when patching a hole. On the outside surfaces where no moving parts will come in contact with the patch, trim off the curved edges of the hole and place a patch, of the same thickness and type of steel, over the hole. This patch should overlap the hole at least 51 mm (2 inches) all around. Tack weld the patch in a few places to hold it in place, and then weld around the edges of the patch.

When patching a hole where moving parts must pass over the patch, the hole should be trimmed with a cutting torch and a patch of the same shape and
contour as the panel placed in the hole. Before welding the patch, tack weld a piece of strap steel across it to provide a grip and to keep the patch in the proper position. Next weld around the patch enough to hold it firmly in place and remove the strap steel. After removing the strap, complete the weld and grind it down to finish the job.

If the hole is completely through the panel of the wall, each side can be mended in the manner suggested. See Fig. 6.

Reinforcement
Frame reinforcement can be made with channel, angle, or flat structural stock. Whenever possible, the reinforcement should extend well beyond the bent, broken, or cracked area. The reinforcement stock thickness should not exceed that of the frame stock and the material should be of the same tensile strength.

Painting
A check of the condition of the paint should be made approximately twice a year and chassis repainted if necessary.

⚠️ WARNING
Welding, burning, heating or dressing surfaces previously painted using polyurethane paint produces fumes which are toxic. Surfaces must be prepared using paint stripper prior to area being reworked. Recommended Industrial Hygiene and Safety Rules should be followed for protection of the welding operator from fumes.

If painting of the actual frame of the unit is required, thoroughly clean the areas to be painted. Apply a primer coat of red oxide and then a finish coat of polyurethane enamel.

To keep rust and corrosion to a minimum, periodic painting of abrasions and other exposed metal areas on the frame is highly recommended.
DESCRIPTION AND OPERATION
The pull yoke assembly consists of a torque tube, a drawbar and two pull arms. The assembly is fabricated from steel plates and is welded together to form a strong, rigid pull yoke. One end of the drawbar is welded to the torque tube and the other end to the king pin housing. The pull arms are welded to the ends of the torque tube and are fastened to the bowl by means of ball and socket joints. The ball cylinders base ends are pinned at the ears of the pull yoke at the drawbar. The pull yoke is designed to provide sufficient turning clearance for the tractor, with stability, whether the scraper is excavating, hauling, or ejecting its load.

DISCONNECTING SCRAPER FROM TRACTOR

**WARNING**
To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, lower the scraper bowl and apron. Return ejector completely, apply the parking brake and switch off the engine.

2. Operate steering in both directions several times to relieve any pressure in the steering system. Block all road wheels and place the battery master switch in the 'Off' position.
3. With a suitable container in position, remove drain plug from hydraulic tank and drain the hydraulic system. Reinstall drain plug and tighten securely.

4. Open drain cocks on air tanks and drain all air from the system. Close drain cocks securely after draining.

5. Disconnect battery cables from terminal posts (earth cable first).

**Disconnecting Hydraulic Lines**

1. Remove bolts, lockwashers and clamps from top of pull yoke.

2. With a suitable container in position to catch any spillage, tag and disconnect bowl hose assembly from bowl manifold. Cap line and manifold port to prevent entry of dirt.

3. With a suitable container in position to catch any spillage, tag and disconnect apron hose assembly from scraper apron cylinder line. Cap lines and ports to prevent entry of dirt.

4. With a suitable container in position to catch any spillage, tag and disconnect ejector hose assembly from scraper ejector hose assembly. Cap lines and ports to prevent entry of dirt.

5. Move lines clear of the pull yoke so they will not be damaged when pull yoke is separated from tractor.

**Disconnecting Air Lines**

1. Remove bolts and clamps from inner right side of pull yoke.

2. Tag and disconnect at the pull yoke, four tractor and scraper brake air lines. Cap lines and ports to prevent entry of dirt.
Disconnecting Electrical Wiring
1. Disconnect frame harness and rear transmission harness from separation point on the gooseneck.

2. Tag and disconnect three heavy cables, (starter, engine supply and engine earth) from separation point on the gooseneck.

Removing King Pin
Numbers in parentheses refer to Fig. 2.

1. Block up the front end of the tractor with timber or heavy-duty stands. Support the pull yoke with an overhead crane or other suitable lifting equipment.

2. With a suitable container in position to catch any spillage, disconnect the steering hoses from steering cylinders and remove the steering cylinders. Refer to Section 220-0120, STEERING CYLINDER, for removal procedure for steering cylinders and attaching components (4, 5, 6 & 7). Cap all hoses and ports to keep out dirt.

3. Remove bolt (1), lockwasher (2), and nut (3) from steering trunnion and upper king pin (9). Remove upper king pin from pull yoke.

4. Using suitable lifting equipment, lift the scraper and lower king pin (8) up and away from the tractor. While removing pull yoke, carefully guide air and electrical lines out of pull yoke.

5. If required, remove lower king pin from pull yoke.

Inspection
Numbers in parentheses refer to Fig. 1.

Check lower and upper king pins (5 & 14) for excessive wear and replace as necessary. Check king pin bores, and bushing (6) and replace worn or damaged parts. If bushing (6) is to be replaced, make sure the grease groove in the bushing, when installed, will be in fine with the grease hole in the upper king pin.

Disconnecting Pull Yoke from Bowl
Numbers in parentheses refer to Fig. 1.

1. Support pull yoke (1) using suitable lifting equipment. With a suitable container in position to catch any spillage, tag and disconnect all necessary hydraulic and air lines at the bowl, and cap lines to keep dirt out.

2. Tag and disconnect electrical wires at bowl.

3. Remove bowl cylinder from lift beam of the bowl. Refer to Section 235-0020, BOWL CYLINDER.

4. Remove bolts (3) and nuts (4) securing ball seats (2) and pull yoke arms to the pull yoke arm balls on bowl. Remove both ball seats (2) from pull yoke arms.

5. Slide pull yoke assembly forward to free it from the pull yoke arm balls. Remove pull yoke assembly from scraper bowl.

6. Remove lifting device from pull yoke.

Inspection
Numbers in parentheses refer to Fig. 1.

Check socket assembly on the end of the pull yoke arm and ball seat (2) for wear, burrs and out of roundness. Check pull yoke arm ball on bowl for wear. Replace any parts that show signs of wear.
CONNECTING PULL YOKE TO BOWL

Numbers in parentheses refer to Fig. 1.

**WARNING**
To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

**Note:** Tighten all fasteners, without special torques specified, to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. With suitable lifting equipment attached to pull yoke (1), align pull yoke arms with pull yoke arm balls on bowl and install ball seats (2). Install bolts (3) and nuts (4) to secure ball seats and pull yoke arms to bowl.

2. Connect bowl lift rods to bowl. For proper installation procedure refer to Section 280-0040, BOWL LINKAGE.

3. Remove caps from air and hydraulic lines and connect at bowl as tagged at removal. Connect electrical wires at bowl, as tagged at removal, and remove lifting device used.

CONNECTING SCRAPER TO TRACTOR

Installing King Pins

Numbers in parentheses refer to Fig. 2.

**WARNING**
To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

**Note:** Tighten all fasteners, without special torques specified, to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. Block tractor wheels. Attach an overhead crane to the scraper pull yoke.

2. If removed, install lower king pin (8) in pull yoke. Make sure the lube passage in the side of the king pin faces forward.

3. Align the pull yoke and king pin (6) with the steering trunnion of the tractor and carefully lower pull yoke, inserting lower king pin into steering trunnion bore.

**Note:** When installing lower king pin and pull yoke to steering trunnion, it may be necessary to lift the front end of the tractor with crane, forklift truck or other suitable lifting device to align the angle of bore in the steering trunnion with the angle of entry of the lower king pin.

4. Install upper king pin (9) through bushing in upper bore of pull yoke and steering trunnion. Be sure that the upper king pin bolt holes lines up with the hole in the steering trunnion.

5. Install bolt (1) through steering trunnion and king pin (9). Secure the bolt (1) with lockwasher (2) and nut (3).

6. Install steering cylinders. Refer to Section 220-0120, STEERING CYLINDER, for installation procedures.

7. Guide air hoses and wiring through the pull yoke.

Connecting Wiring

1. Connect three heavy cables, (starter, engine supply and engine earth) at separation point on the gooseneck.

2. Connect frame harness and rear transmission harness at separation point on the gooseneck.

Connecting Air Lines

1. Remove caps and connect the tractor brake air lines to the corresponding scraper brake lines.

**Note:** Tractor brake lines can only be connected to scraper brake lines in the correct manner.

2. Install clamps and bolts to secure tubes to pull yoke.
Connecting Hydraulic Lines
2. Remove dirt caps and connect bowl, apron and ejector hose assemblies as tagged during removal.
3. Install clamps, lockwashers and bolts to secure hoses to pull yoke.
4. Connect negative battery cable to the battery.
5. Close all air reservoir drain cocks.
6. Install the anti-syphon plug in the hydraulic oil tank.
7. Check hydraulic oil level and replenish, if necessary.
8. Place the battery master switch in the ‘On’ position, start the engine and bring air and hydraulic systems to operating temperature and pressure.
9. Remove all blocking from the machine and operate hydraulic and brake systems controls. Check for leaks and tighten fittings, if required.
10. Shut down engine and check hydraulic oil level. Replenish, if necessary.

* * * *
REMOVAL

Apron

Numbers in parentheses refer to Fig. 1.

**WARNING**

To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, lower apron (1) completely, apply the parking brake and switch off the engine.

2. Operate the steering in both directions several times to relieve any pressure in the steering system.

3. Block all road wheels and place battery master switch in the ‘Off’ position.

4. Disconnect apron cylinders. Refer to Section 235-0035, APRON CYLINDER.

5. Remove locking bolts (7) from apron mounting pin (6) and remove pin (6) from Pin (9) and apron arm (2). Repeat for second apron arm (3).

6. Using suitable lifting equipment secured to lifting bar, welded to centre of apron (1), remove apron (1) from scraper bowl.

7. If required, remove bushing (4 & 5) from apron arms (2 & 3).
Bowl - Apron and Ejector

Section 280-0030

INSPECTION

Apron
Numbers in parentheses refer to Fig. 1.

1. Check condition of bushings (4 & 5). If bushings (4 & 5) are scored, out of round, worn or damaged in any way, they must be replaced.

2. Check bores of apron arms (2 & 3) and apron mounting pins (6) for wear or damage and repair or replace parts as necessary.

3. Check apron arms (2 & 3) and apron (1) for cracks or bends and repair or straighten parts as necessary. Refer to 'Maintenance' for correct procedure to follow.

INSTALLATION

Apron
Numbers in parentheses refer to Fig. 1.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. If removed, press bushings (4 & 5) into bores on apron arms (2 & 3).

2. Using suitable lifting equipment attached to lifting bar, position apron (1) on vehicle and align the bores of the apron arms (2 & 3) with those of the bowl. Install pins (9) and locate apron mounting pins (6) and secure with bolts (7).

3. Install apron cylinders. Refer to Section 235-0035, APRON CYLINDER, for proper procedure.

4. Place the battery master switch in the 'On' position, start the engine and check the operation of the apron and bowl.

5. Ensure parking brake is applied and remove wheel blocks from all road wheels.

REMOVAL

Ejector
Numbers in parentheses refer to Fig. 1.

WARNING
To prevent personal injury and property damage, be sure wheel chocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, lower ejector completely, apply the parking brake and switch off the engine.

2. Operate the steering in both directions several times to relieve any pressure in the steering system.

3. Block all road wheels and place battery master switch in the 'Off' position.

4. Using suitable lifting equipment, secured to lifting bar (11), support ejector assembly (10).

5. Cut off cover plates welded over ejector hinge opening. Drive one ejector hinge rod (14) out slightly by tapping with a drift or punch against the other rod. Pull hinge rod (14) out from hinge tubes (12). Remove other hinge rod (14) in the same manner.

6. When hinge rods (14) are removed, remove ejector assembly (10) from scraper bowl.

INSPECTION

Ejector
Numbers in parentheses refer to Fig. 1.

1. Check ejector hinge tubes (12) for cracks and replace or reweld as necessary.

2. Check ejector assembly (10) for cracks or bends and repair or straighten parts as necessary. Refer to 'Maintenance' for correct procedure to follow.
INSTALLATION

Ejector
Numbers in parentheses refer to Fig. 1.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. Using suitable lifting equipment attached to lifting bar (11), position ejector assembly (10) on vehicle. When properly aligned, drive ejector hinge rods (14) through hinge tubes (12).

2. Weld the cover plates over ejector hinge openings. Refer to 'Welding' section for proper procedure.

3. Place the battery master switch in the 'On' position, start the engine and check the operation of the apron and bowl linkage.

4. Ensure parking brake is applied and remove wheel blocks from all road wheels.

MAINTENANCE

Inspection
Inspect the apron and ejector assemblies periodically for cracked or broken welds and bending/twisting. Any defects found should be repaired before they progress into major failures. Moving parts, such as levers, apron arms and ejector hinges should be checked for wear and for binding. Worn parts should be replaced before they break and cause considerable damage to the vehicle.

Straightening
Hydraulic straightening or aligning equipment should be used to straighten bent or twisted components whenever possible. However, if heat must be applied, never heat the metal beyond a dull cherry red colour, as too much heat will weaken the metal. When it is necessary to heat the metal, apply heat uniformly over the area to be straightened and protect the heated surface from sudden cooling. Any parts buckled sufficiently to show cracks or signs of strain after cold straightening should be reinforced or replaced.

Welding

WARNINGS
Before any welding is done on a machine equipped with the HEUI electronic management system, disconnect the following in this order: Battery earth cable, battery supply cable, alternator earth cables, alternator supply cables, front & rear transmission ECU connectors (located behind access door below cab door) and front & rear engine ECU connectors (located on LH side of engine). Turn off battery master switch before disconnecting any components. After welding connect all of the above in the reverse order.

Welding and flame cutting cadmium plated metals produce odourless fumes which are toxic. Recommended industrial hygiene practice for protection of the welding operator from the cadmium fumes and metallic oxides requires enclosure ventilation specifically designed for the welding process. A respiratory protective device such as the M.S.A. 'Gasfow' respirator with G.M.A. cartridge will provide protection against cadmium, fumes and metallic oxides. The 'Gasfow' respirator has been approved by the U.S. Bureau of Mines: Approval number 23B-10, and is designed to protect against gases, vapours, and/or metal fumes.

Note: Prior to welding, switch off/disconnect the following in the order given. Failure to do so may seriously damage the machines electrical components.

- Turn keyswitch off
- Turn battery master switch off
- Battery earth cables
- Battery supply cables
- Alternator earth cables
- Alternator supply cables
- Transmission ECU connectors (front & rear)
- Engine ECU connectors (front & rear)

After welding, connect all of the above in the reverse order.
Note: Always fasten the welding machines ground cable to the piece/frame being welded if possible.

Electric arc welding is recommended for all welded repairs. Since the nature and extent of damage to the apron and ejector cannot be predetermined, no definite repair procedure can be established. As a general rule however, if parts are twisted, bent or pulled apart, or is bent or out of alignment, no welding should be done until the parts are straightened or realigned.

Successfully welded repairs will depend to a great extent upon the use of the proper equipment, materials and the ability of the welder. The Service Department can be consulted regarding the feasibility of welding repairs.

Patching
Refer to Fig. 2.

There are two methods to be used when patching a hole. On the outside surfaces where no moving parts will come in contact with the patch, trim off the curved edges of the hole and place a patch, of the same thickness and type of steel, over the hole. This patch should overlap the hole at least two inches all around. Tack weld the patch in a few places to hold it in place, and then weld all around the edge of the patch.

When patching a hole where moving parts must pass over the patch, the hole should be trimmed with a cutting torch and a patch of the same shape and contour as the panel placed in the hole. Before welding the patch, tack weld a piece of strap steel across it to provide a grip and to keep the patch in the proper position. Next, weld around the patch enough to hold it firmly in place and remove the strap steel. After removing the strap, complete the weld and grind it down to finish the job.

If the hole is completely through both panels of the wall, each side can be mended in the manner suggested. In order to obtain the original strength of the wall when the hole is completely through it, the ‘I’ reinforcing spacers must be repaired if they are damaged.

Painting
A check of the condition of the paint should be made approximately twice a year.

⚠️ WARNING
Welding, burning, heating or dressing surfaces previously painted using polyurethane paint produces fumes which are toxic. Surfaces must be prepared using paint stripper prior to area being reworked. Recommended Industrial Hygiene and Safety Rules should be followed for protection of the welding operator from fumes.

If painting of the unit is required, thoroughly clean the areas to be painted. Apply a primer coat of red oxide and then a finish coat of polyurethane enamel.

To keep rust and corrosion to a minimum, periodic painting of abrasions and other exposed metal areas on the frame is highly recommended.

If the unit is to be stored for any length of time, the interior of the apron and ejector should painted with a primer coat of red oxide to prevent formation of rust.
OPERATION
Numbers in parentheses refer to Fig. 1.

When the ejector cylinder is actuated, the ejector lever pivots at the top and the ejector roller (4) pushes against the ejector. The ejector raises and pushes the material up and out of the scraper bowl.

REMOVAL
Numbers in parentheses refer to Fig. 1.

**WARNING**
To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, lower ejector completely until it rests on ejector stops, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.
2. Block all road wheels and place the battery master switch in the 'Off' position.

3. Identify lube hoses (16 & 17) for ease of installation and disconnect from elbows (15) on ejector lever (1) and mounting pin (5). Cap ends to prevent entry of dirt. Remove elbows (15) from ejector lever (1) and mounting pin (5).

4. Using suitable blocking equipment, support ejector cylinder and remove bolt (9), washer (10) and mounting pin (5) from ejector lever (1).

5. Using suitable lifting equipment, support ejector lever (1), remove bolt (7) and nut (8) and drive lever mounting pin (2) from ejector lever (1). Remove ejector lever (1) from vehicle.

6. Remove grease fitting (14) from mounting pin (6). Support roller (4) and remove bolt (9), washer (10) and mounting pin (6) from ejector lever (1). Remove roller (4) from vehicle.

7. If required, remove bushing (3) from ejector lever (1).

**INSPECTION**

Numbers in parentheses refer to Fig. 1.

1. Check ejector lever (1) for cracks or bends and repair or replace as necessary.

2. Check bushing (3), bores of ejector lever (1) and pins (5 & 6) for excessive wear and replace parts as necessary.

3. Check roller (4) for wear, and out of roundness. Replace roller (4) if it shows signs of wear.

**INSTALLATION**

Numbers in parentheses refer to Fig. 1.

**Note:** Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. If removed, press bushing (3) into ejector lever (1) bore.

2. Support roller (4) and install mounting pin (6) through bore. Secure with bolt (9) and washer (10). Check roller (4) turns freely and does not bind. Install grease fitting (14) in mounting pin (6).

3. Using suitable lifting equipment, position ejector lever (1) on vehicle and install lever mounting pin (2) through bowl mounting brackets and ejector lever (1) bore. Secure mounting pin (2) with bolt (9) and nut (8).

4. Align ejector lever (1) with ejector cylinder eye and install mounting pin (5). Secure mounting pin (5) with bolt (9) and washer (10).

5. Install elbows (15) in ejector lever (1) and mounting pin (5). Remove caps and connect lube hoses (16 & 17) to elbows (15) as identified at Removal.

6. Place the battery master switch in the 'On' position, start the engine and check the operation of the apron and bowl linkage.

7. Ensure parking brake is applied and remove wheel blocks from all road wheels.

**SPECIAL TOOLS**

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of the general service tools required. These tools are available from your dealer.

* * * *
REMOVAL
Numbers in parentheses refer to Fig. 1.

**WARNING**
To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, ensure scraper bowl and apron is completely lowered, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place the battery master switch in the 'Off' position.

3. Disconnect lift rods (14) and roller (12), if used, from bowl by removing bolts (5), nuts (10) and lockwashers (9) and driving out pins (13). Remove grease fitting (6) before removing pins.

4. Remove bolts (5), nuts (11) and grease fittings (6) from pins (4). Support lift rods (14) and drive out pins (4) separating lift rods (14) from levers (7).

5. Support cylinders and disconnect levers (7) from cylinders by removing cylinder pin locking bolts (5), nuts (10), lockwashers (9) and grease fittings (6) and driving out pins (4).
6. Support levers (7), with suitable lifting equipment, to keep them from falling and to take weight off lever pin (1). Remove cotter pin (2) from pin (1). Drive pin (1) out and remove spacers (3). Remove levers (7) and place in a suitable working area.

7. Remove bushings (8) if scored or scratched.

INSPECTION
Numbers in parentheses refer to Fig. 1.

1. Check levers (7) for cracks or bends and repair or replace as necessary.

2. Check bushing (8), pins (1, 4 & 13), bores in levers (7) and lift rods (14) and roller (12), if used, for excessive wear and replace parts as necessary.

3. Inspect all bolts and nuts for stripping or bends and replace as necessary.

INSTALLATION
Numbers in parentheses refer to Fig. 1.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

1. If removed, press bushing (8) into bowl levers (7).

2. If removed, press bushing (8) into bowl levers (7). Secure support levers (7) to bowl cylinders by installing pins (4) and securing with bolts (5), lockwashers (9) and nuts (10). Install grease fittings (6) in pins (4).

3. Support levers (7) with a suitable lifting device and drive lever mounting pin (1) through bores containing bushings (8) of bowl levers and spacers (3). Install cotter pin (2) on each end of pin (1).

4. Install levers (7) to bowl cylinders by installing pins (4) and securing with bolts (5), lockwashers (9) and nuts (10). Install grease fittings (6) in pins (4).

5. Connect lift rods (14) to bowl levers (7) by installing pins (4) and securing with bolts (5) and nuts (11). Install grease fittings (6) in pins (4).

6. Position lift rods (14) and rollers (12), to brackets on bowl and secure with pins (13). Secure pins (13) with bolts (5), lockwashers (9) and nuts (10). Replace grease fittings (6).

SPECIAL TOOLS
There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of the general service tools required. These tools are available from your dealer.

*   *   *   *
REMOVAL

Numbers in parentheses refer to Fig. 1.

**WARNING**

To prevent personal injury and property damage, be sure wheel blocks, blocking materials and lifting equipment are properly secured and of adequate capacity to do the job safely.

1. Position the vehicle in a level work area, apply the parking brake and switch off the engine. Operate the steering in both directions several times to relieve any pressure in the steering system.

2. Block all road wheels and place the battery master switch in the 'Off' position.

3. Remove nuts (2) and plow bolts (1) securing cutting edges (7) to blade base (3). Remove cutting edges (7) from vehicle.

4. Remove nuts (6) and plow bolts (4) securing side blades (5) to bowl frame. Remove side blades (5) from vehicle.
Bowl - Cutting Edges and Side Blades

Section 280-0050

INSTALLATION

Numbers in parentheses refer to Fig. 1.

Note: Tighten all fasteners to standard torques listed in Section 300-0080, STANDARD BOLT AND NUT TORQUE SPECIFICATIONS.

Note: The plow bolts used to attach the scraper cutting edges and side blades must be tightened correctly if the blades are to stay in place. The plow bolts have square shoulders which fit into square holes in the blades to keep the bolts from turning. If the bolt shoulders are not seated properly the bolts cannot be tightened adequately and the blades will eventually work loose. To make sure the bolts are torqued to the recommended 750 - 820 Nm (550 - 600 lbf ft), strike the heads with a suitable hammer while tightening the nuts with a torque wrench. When the torque on the nuts cannot be reduced below 750 Nm (550 lbf ft) by additional striking on bolts heads, the bolts are then properly seated and tightened correctly.

1. Inspect cutting edges (7) for damage and replace if necessary. Position cutting edges (7) to blade base (3) and secure with plow bolts (1) and nuts (2).

2. Inspect side blades (5) for damage and replace if necessary. Position side blades (5) to bowl frame and secure with plow bolts (4) and nuts (6).

3. Place the battery master switch in the 'On' position and remove blocks from all road wheels.

BLADE ARRANGEMENTS

Numbers in parentheses refer to Fig. 2.

The scraper cutting edges (blades) and scraper blade base are designed so that one type of edge can be used for various edge arrangements. In addition, the edges are reversible which prolongs the useful life of the edges. The use of the proper edge arrangement for certain types of cut or soil conditions can save a great deal of money in edge replacement and labour. Scraper edges should never be allowed to wear to the point where the blade base is doing the cutting.

The 100 mm (4 in) drop centre arrangement is recommended for hard, rock-free soils when a maximum drop centre and centre heaped loads is required. To renew this arrangement after one edge is worn, reverse all edges and interchange the outer pair of edges (1 & 4) with the inner pair (2 & 3).

The straight edge arrangement is recommended whenever a level cut or a level fill is required. To renew this arrangement after one edge is worn, reverse all edges and interchange the outer pair of edges (1 & 4) with the inner pair (2 & 3).

The maximum overhang arrangement is recommended for fast, easy loading in rock-free soils and for maximum edge wear life. When working in rocky soils, the minimum overhang edge arrangement is recommended. For beginning scraper cuts on side slopes or to crown a scraper cut, the one side cutting edge is recommended. These three edge arrangements cannot be renewed by reversing the edge when one edge is worn, however, the edges can be used with the 100 mm (4 in) drop centre and straight edge arrangements.

SPECIAL TOOLS

There are no special tools required for procedures outlined in this section. Refer to Section 300-0070, SERVICE TOOLS, for part numbers of the general service tools required. These tools are available from your dealer.

### SPECIAL TORQUE SPECIFICATIONS

<table>
<thead>
<tr>
<th>FIG. NO.</th>
<th>ITEM NO.</th>
<th>ITEM NAME</th>
<th>TORQUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>Nut</td>
<td>750 - 820 Nm (550 - 600 lbf ft)</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>Nut</td>
<td>750 - 820 Nm (550 - 600 lbf ft)</td>
</tr>
</tbody>
</table>
Section 280-0050

Bowl - Cutting Edges and Side Blades

Fig. 2 - Various Cutting Edge Arrangements

* * * *
SAFETY PRECAUTIONS

Do not allow unauthorized personnel to service or maintain this vehicle. Study the Operator’s Handbook and Maintenance Manual before starting, operating or servicing this vehicle. Always follow procedures and safety precautions detailed throughout this manual.

Always attach a ‘DO NOT OPERATE’ or similar warning sign to the ignition switch or a prominent control before cleaning, lubricating or servicing the vehicle.

Never allow anyone to work on the vehicle while it is moving. Make sure there is no one on the vehicle before working on it.

Do not work under or near any unblocked or unsupported linkage, part or vehicle.

Always relieve pressure before servicing any pressurized system. Follow the procedures and safety precautions detailed in the relevant Maintainance Manual section.

When changing oil in the engine, transmission and hydraulic systems, or removing hydraulic lines, remember that the oil may be hot and can cause burns to unprotected skin.

When working on or around exhaust components, remember that the components may be hot and can cause burns to unprotected skin.

Always deflate the tyre before attempting to remove any embedded objects or removing the tyre and rim assembly from the vehicle.

Always use a self-attaching chuck with a long airline, and, stand to one side while the tyre is inflating. Refer to Section 160-0050, WHEEL RIM AND TYRE.

WARNING

These vehicles are equipped with engine and transmission oil pans which permit operation on longitudinal slopes up to 30° (57%). For operation on steeper slopes, the factory should be consulted.

LUBRICATION AND SERVICE

Lubrication and Service Chart

Small circles on the following illustration represent points at which lubrication and/or servicing must take place, at the intervals indicated on the left hand side of the lubrication and service chart. The numbered circles on the illustration contain reference numbers which correspond to the reference numbers in the ‘Ref. Points’ column of the lubrication and service chart.

Note: At each scheduled maintenance interval, perform all previous checks in addition to the ones specified.
## LUBRICATION AND SERVICE CHART - Tractor

<table>
<thead>
<tr>
<th>Interval Hours</th>
<th>Ref. Points</th>
<th>Identification</th>
<th>Service Instructions</th>
<th>No. of Points</th>
<th>Lubricant</th>
<th>Service/Quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1</td>
<td>Engine</td>
<td>Check oil level. Add if low</td>
<td>1</td>
<td>EO</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>2 Transmisson</td>
<td>Hydraulic Oil Tank</td>
<td>Check oil level. Add if low</td>
<td>1</td>
<td>HTF</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>Coolant Level</td>
<td>Check coolant level. Add if low</td>
<td>1</td>
<td>HO</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>Fuel Tank</td>
<td>Check coolant level. Add if low</td>
<td>1</td>
<td>Antifreeze</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>- Fuel Filter/Water Separator</td>
<td>Cooling Fan</td>
<td>Check coolant level. Add if low</td>
<td>1</td>
<td>Antifreeze</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>Drive Belts</td>
<td>Check coolant level. Add if low</td>
<td>1</td>
<td>Antifreeze</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>Air Reservoirs</td>
<td>Check coolant level. Add if low</td>
<td>1</td>
<td>Antifreeze</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>- Air Cleaner Restriction</td>
<td>Air/Water Separator</td>
<td>Check coolant level. Add if low</td>
<td>1</td>
<td>Antifreeze</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>Tyres</td>
<td>Check coolant level. Add if low</td>
<td>1</td>
<td>Antifreeze</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>- Controls and Instruments</td>
<td>General Inspection</td>
<td>Check coolant level. Add if low</td>
<td>1</td>
<td>Antifreeze</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>- General Inspection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>3</td>
<td>Steering Frame Pins</td>
<td>Lube</td>
<td>2</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td></td>
<td>4 Steering Cylinder Pins</td>
<td>Lube</td>
<td></td>
<td>4</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td></td>
<td>5 Reversing Valve Rollers</td>
<td>Lube</td>
<td></td>
<td>2</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td></td>
<td>- Remote Lubrication Points</td>
<td>Lube</td>
<td></td>
<td>3</td>
<td>EP, NLGI</td>
<td>See Note 1 &amp; Page 4</td>
</tr>
<tr>
<td></td>
<td>- Basic Parts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Cooling System</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Planetary Assemblies</td>
<td>Lube</td>
<td></td>
<td>2</td>
<td>EPL</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>- Differential</td>
<td>Lube</td>
<td></td>
<td>1</td>
<td>EPL</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>- Driveline Slip Joints</td>
<td>Lube</td>
<td></td>
<td>2</td>
<td>EP, NLGI</td>
<td>Refer to Section 130-0010</td>
</tr>
<tr>
<td></td>
<td>- Universal Joints</td>
<td>Lube</td>
<td></td>
<td>4</td>
<td>EP, NLGI</td>
<td>Refer to Section 130-0010</td>
</tr>
<tr>
<td></td>
<td>- Brake Cam Shafts</td>
<td>Lube</td>
<td></td>
<td>2</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td></td>
<td>- Brake Shoe Anchor Pins</td>
<td>Lube</td>
<td></td>
<td>4</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
</tbody>
</table>

**Fig. 1 - Lubrication Points - Tractor**

- **Note 1**: Refer to Section 130-0010
- **Note 2**: Refer to Section 130-00010
## LUBRICATION AND SERVICE CHART - Tractor (Continued)

<table>
<thead>
<tr>
<th>Interval Hours</th>
<th>Ref. Points</th>
<th>Identification</th>
<th>Service Instructions</th>
<th>No. of Points</th>
<th>Lubricant</th>
<th>Service/Quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>13</td>
<td>Steering Gear</td>
<td>Lube</td>
<td>1</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Differential Breather</td>
<td>Clean</td>
<td>1</td>
<td>EP, NLGI</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Remote Lubrication Points</td>
<td>Lube</td>
<td>1</td>
<td>EP, NLGI</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Brake Parts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Transmission Input Bearing</td>
<td>Lube</td>
<td>1</td>
<td>EP, NLGI</td>
<td>See Page 5</td>
</tr>
<tr>
<td>300</td>
<td>1</td>
<td>Engine</td>
<td>Drain oil and refill</td>
<td>1</td>
<td>EO</td>
<td>24.6 litres (6.5 US gal)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Engine Lube Oil Filters</td>
<td>Replace</td>
<td></td>
<td></td>
<td>Ref. Engine Manual</td>
</tr>
<tr>
<td>500</td>
<td>16</td>
<td>Transmission Oil Filter</td>
<td>Replace</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>600</td>
<td></td>
<td>- Fuel Filters and Strainer</td>
<td>Replace filters and clean housings</td>
<td>-</td>
<td>-</td>
<td>Ref. Engine Manual</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Drive Belts</td>
<td>Check tension. Adjust if required</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Hydraulic Filter</td>
<td>Change filter element</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Hydraulic Tank Breather</td>
<td>Clean</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Air Compressor Governor</td>
<td>Clean or replace filters</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Coolant Inhibitor</td>
<td>Replenish</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1 000</td>
<td>2</td>
<td>Transmission</td>
<td>Drain oil and refill</td>
<td>1</td>
<td>HTF</td>
<td>48.5 litres (12.8 US gal)</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>Transmission Oil Filter</td>
<td>Replace</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1 200</td>
<td>6</td>
<td>Engine Power Takeoff</td>
<td>Drain oil and refill</td>
<td>1</td>
<td>EPL</td>
<td>See Page 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Engine Air Cleaner</td>
<td>Clean inlet hood and tubes</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Engine Crankcase Breather</td>
<td>Replace element</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Planetary Assemblies</td>
<td>Drain oil and refill</td>
<td>2</td>
<td>EPL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Differential</td>
<td>Drain oil and refill</td>
<td>1</td>
<td>EPL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Cooling System</td>
<td>Drain coolant and refill</td>
<td>1</td>
<td>Antifreeze</td>
<td>40 litres (10.6 US gal)</td>
</tr>
<tr>
<td>1 800</td>
<td></td>
<td>- Hydraulic System</td>
<td>Drain oil and refill</td>
<td>-</td>
<td>HO</td>
<td>204 litres (54 US gal)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Hydraulic Oil Tank Screen</td>
<td>Remove and clean</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2 000</td>
<td></td>
<td>- Air Drier</td>
<td>Replace dessicant cartridge</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2 400</td>
<td></td>
<td>- Engine Cooling System</td>
<td>Drain coolant and refill. Replace filters</td>
<td>1</td>
<td>Antifreeze</td>
<td>40 litres (10.5 US gal)</td>
</tr>
</tbody>
</table>

**Note:** Capacities given are approximate, work to dipstick, sight gauges or level plugs. Use chart in conjunction with 'Recommended Lubricants' table.

**Note 1:** Lubricate slowly until excess lube is seen.

**EO** - Engine Oil. Refer to 'Recommended Lubricants' table.

**EO** - Engine Oil. Refer to 'Recommended Lubricants' table.

*** - Refer to 'Recommended Lubricants' table.**

EPL - Extreme Pressure Gear Lubricant spec. MIL-L-2105D.

HTF - Hydraulic Transmission Fluid Type C-4. Refer to 'Recommended Lubricants' table.

HO - Hydraulic Transmission Oil. Refer to 'Recommended Lubricants' table.

EP, NLGI - Extreme Pressure Lithium No. 2 Grease. Refer to 'Recommended Lubricants Table'.

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Remote Lubrication Points

For improved accessibility, remote lube lines are run to manifold blocks mounted on the front right hand side engine cover and the front left hand side of the bowl. These lines should be inspected periodically for damage.

Apply sufficient grease into each nipple until there is clear evidence of grease emerging from one or two of the clearly visible connected bearing points.

Do not over grease the brake system.

When a component is lubricated, the general condition of the component should also be visually checked. Look for cracked parts, loose fasteners, excessive wear, or improper clearance as applicable to the component being lubricated.

Operation

The distributor manifolds progressively and positively distribute the total lubricant input into each of the single grease points to all connected bearing points on the scraper, via internal reciprocating pistons, without reliance on springs, valves or seals.

The progressive distribution of the lubricant throughout the system is absolutely positive. Such that should any connected bearing point not be able to accept the individually measured quantity of lubricant from the system for any reason, the distribution will progressively cease to function until a 'pressure stall' situation occurs. This situation will be clearly evident to the operator as the lever gun or air gun will stop operating, and no more lubricant will enter the system.

Should a pressure stall condition occur, this indicates that one or more of the connected bearing points cannot receive its measured quantity of grease. The following procedure should be followed in order to quickly identify which of the connected points is the cause of the problem.

With the grease gun applied to the single nipple in question, maintain pressure on the system. Remove and refit each outlet of the distributor manifold in turn, until grease appears and the distributor can operate once again. This indicates which bearing point is causing the problem, trace the feed line to the bearing point and rectify the problem.
MISCELLANEOUS SERVICING

WHEN REQUIRED

Seat Belts - Inspect seat belts and replace if damaged.

Note: Replace seat belts at least once every three years, regardless of appearance.

Windscreen Wipers and Washers - Inspect wiper blades and replace if damaged. Top up washer reservoir.

EVERY 10 HOURS OF OPERATION (DAILY)

Walk Around Inspection - Inspect the machine as described in Section 4 of the Operators Handbook.

Engine - Visually check engine for damage, loose or frayed belts and listen for any unusual noises.

Engine Air Cleaner - Change air cleaner element only when air restriction gauge locks up in the red. Service dust cup daily.

Note: Service air cleaners more often when operating under extremely dusty conditions.

Engine Crankcase - Check oil level and add oil if low. With the engine off, the oil should be between the 'Low' and 'Full' marks on the dipstick, up to the 'Full' mark is preferable.

Transmission - Adjust bowl height to level the transmission and, with the engine running and oil at normal operating temperature, check oil level. Add oil if the level is below the 'FULL' line on the dipstick. Do not overfill.

Hydraulic Tank - With the bowl on the ground, apron down, ejector returned and the engine off, check oil level. Oil level should be between the 'Cold' and 'Hot' marks on the sight gauge. Add oil if low.

Cooling System - Check coolant level, add if low. Add coolant to the top of the filler neck.

AFTER FIRST 50 HOURS OF OPERATING NEW OR REBUILT COMPONENTS

Transmission - Drain oil, replace filter and refill.

AFTER FIRST 150 HOURS OF OPERATING NEW OR REBUILT COMPONENTS

Differential - Drain oil and refill.

Planetaries - Drain oil and refill.

EVERY 150 HOURS OF OPERATION

General Inspection - Check entire scraper for leaks, loose bolts and nuts or damaged parts. Examine the scraper, particularly the chassis, for cracks or broken welds. Repair where necessary.

Drive Belts - Visually check the belts and replace if they are cracked or frayed. Adjust belts that have a glazed or shiny surface which indicates belt slippage. Correctly installed and tensioned belts will show even pulley and belt wear. Refer to 'Engine Operation and Maintenance Manual' for drive belt tension and adjustment of new and used belts.

Note: The fan belt is maintained to the correct belt tension by a spring loaded idler arm, therefore, there is no need to adjust belt tension.

Oil Can Points - Oil brake treadle rollers, hinges and other working parts with engine oil.

Transmission Input Bearing - Lubricate through the lube fitting with a hand grease gun, 3-4 shots of grease. Do not overgrease

Note: Failure to lubricate with a No. 2 Consistency grease could cause premature failure of the input bearing.

EVERY 250 HOURS OF OPERATION

Cooling Fan - Visually check fan for cracks, loose rivets, and bent or loose blades. Check fan mounting and tighten if required. Replace any fan that is damaged.

EVERY 600 HOURS OF OPERATION

Coolant Inhibitor - Check and replenish coolant inhibitor as described in Engine 'Operation and Maintenance Manual'.

EVERY 1 200 HOURS OF OPERATION

Engine Power Takeoff - Drain and refill. Remove bottom pipe plug in PTO cover and drain oil into a suitable container. Reinstall pipe plug and refill to level of check cock.

EVERY 1 800 HOURS OF OPERATION

Hydraulic Oil Tank - Drain tank, remove and clean filter screen assembly and discard filter element. Reinstall filter screen, new filter element and refill with clean hydraulic oil. Refer to Section 235-0040, HYDRAULIC TANK.
**Miscellaneous - Lubrication System**

**Section 300-0020**

**ENGINES AND TRANSMISSION**

All information contained in the ‘Lubrication and Service Chart’ was extracted from the relevant manufacturers Operators Manual and was correct at time of publication. User should ensure that information contained in this chart, regarding the Engine and Transmission, reflects the information shown in the relevant manufacturers Operators Manuals, supplied with the machine. Maintenance procedures should be carried out in conjunction with any additional procedures contained in the relevant manufacturers ‘Operation and Maintenance Manual’, at the intervals specified.

### RECOMMENDED LUBRICANTS

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>LUBRICANT</th>
<th>VISCOSITY (See Note 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine</td>
<td>Engine oil with 1.00% ash is recommended. Sulphated ash must not exceed 1.85% limit. Classification is as follows: API Classification CG-4 or CF-4 Military Specifications MIL-L-2104E SAE Grade 15W-40</td>
<td>Ambient Recommendation -30° to 30° C SAE 0W-20 (Arctic) -25° to 30° C DEXRON-III -15° to 30° C SAE 10W -10° to 30° C SAE 15W -5° to 50° C SAE 30 0° to 50° C SAE 40</td>
</tr>
<tr>
<td>Transmission</td>
<td>Hydraulic Transmission Oil, Type C-4. See Note 3.</td>
<td>Continuous use of low viscosity oils can decrease engine life due to wear.</td>
</tr>
<tr>
<td>Differential, Planetary Gears, Power Takeoff, Steering Gear</td>
<td>Multipurpose Extreme Pressure type gear oil meeting MIL-L-2105C Specifications (No Zinc Additive).</td>
<td>SAE 80W-90 at ambient temperatures of -18° to 32°C</td>
</tr>
<tr>
<td>Grease Fittings</td>
<td>Multipurpose Extreme Pressure Lithium Grease with a typical melting point of 190° C.</td>
<td>No. 2 Consistency</td>
</tr>
<tr>
<td>Cooling System</td>
<td>Antifreeze, Ethylene Glycol</td>
<td></td>
</tr>
<tr>
<td>Fuel Tank</td>
<td>Diesel Fuel Oil with maximum sulphur 0.5%</td>
<td>DIN EN590</td>
</tr>
<tr>
<td>Hydraulic System</td>
<td>Hydraulic Transmission Oil meeting MIL-L-2104C Specifications or API Service Code CC or CD/SC</td>
<td>SAE 10W at ambient temperatures of -18° to 32°C</td>
</tr>
<tr>
<td>Drivelines, Steering Column</td>
<td>Multipurpose Extreme Pressure Lithium Grease (without ‘Molybdenum’), with a typical melting point of 190° C.</td>
<td>No. 2 Consistency</td>
</tr>
</tbody>
</table>

**Note** - For temperature conversions to degrees Fahrenheit (°F) refer to the table on page 11.

**Note 1** - Consult your lubricant supplier for the correct viscosity of lubricant to use when ambient temperatures are consistently above or below those listed.

**Note 2** - Detroit Diesel does not recommend any specific brand of engine oil but the use of oils that meet API categories. Detroit Diesel recommends use of only the multi-graded viscosity oils shown for the various ambient temperatures listed.

**Note 3** - Preheat is required below minimum temperatures shown. Operation below the minimum temperatures listed for the oil used without proper preheat or warm-up results in greatly reduced transmission life. Proper warm-up requires 20 minutes minimum operation in neutral (with engine at part throttle) before operating the transmission in gear. Hydraulic Transmission Oil meeting Specification EMS19058 may also conform to the Allison C-4 requirements. Consult your lubricant supplier for confirmation.
### LUBRICATION AND SERVICE CHART - Scraper

<table>
<thead>
<tr>
<th>Interval Hours</th>
<th>Ref. Points</th>
<th>Identification</th>
<th>Service Instructions</th>
<th>No. of Points</th>
<th>Lubricant</th>
<th>Service/Quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1</td>
<td>Engine</td>
<td>Check oil level. Add if low</td>
<td>1</td>
<td>EO</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Transmission</td>
<td>Check oil level. Add if low</td>
<td>1</td>
<td>HTF</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coolant Level</td>
<td>Check coolant level. Add if low</td>
<td>1</td>
<td>Antifreeze</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fuel Tank</td>
<td>Drain water</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fuel Strainer</td>
<td>Drain water and sediment</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fuel/Water Separator</td>
<td>Drain water and sediment</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cooling Fan</td>
<td>Visually inspect for debris &amp; damage</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drive Belts</td>
<td>Visually inspect all belts</td>
<td>-</td>
<td>-</td>
<td>See Page 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air Reservoirs</td>
<td>Drain all air tanks</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air Cleaner Restriction</td>
<td>Check gauge. Replace element if reqd</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tyres</td>
<td>Check condition. Check pressures when tyres are cold</td>
<td>2</td>
<td>-</td>
<td>Refer to Section 160-0050</td>
</tr>
<tr>
<td></td>
<td></td>
<td>General Inspection</td>
<td>Check for leaks and damaged parts. Repair/Replace as reqd</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>50</td>
<td>3</td>
<td>Ejector Lever Roller Pin</td>
<td>Lube</td>
<td>1</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Lower Kingpin Thrust Bearing</td>
<td>Lube</td>
<td>1</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Lower Kingpin Bushing</td>
<td>Lube</td>
<td>1</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Upper Kingpin</td>
<td>Lube</td>
<td>1</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Lever Mounting Pins</td>
<td>Lube</td>
<td>3</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Bowl Cylinder Mounting Pins</td>
<td>Lube</td>
<td>6</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Lift Rod Mounting Pins</td>
<td>Lube</td>
<td>4</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Apron Sheave Pin</td>
<td>Lube</td>
<td>1</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Apron Cable Roller</td>
<td>Lube</td>
<td>2</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Pull Yoke Ball Joint</td>
<td>Lube</td>
<td>2</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Ejector Lever Mounting and</td>
<td>Lube</td>
<td>3</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ejector Cylinder Pins</td>
<td>Lube</td>
<td>1</td>
<td>EP, NLGI</td>
<td>See Note 1 &amp; Page 9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remote Lubrication Points</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Basic Parts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3 - Lubrication Points - Scraper
### LUBRICATION AND SERVICE CHART - Scraper (Continued)

<table>
<thead>
<tr>
<th>Interval Hours</th>
<th>Ref. Points</th>
<th>Identification</th>
<th>Service Instructions</th>
<th>Service Instructions</th>
<th>Lubricant</th>
<th>Service/Quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td></td>
<td>- Cooling System</td>
<td>Check antifreeze concentration</td>
<td>-</td>
<td>-</td>
<td>Ref. Engine Manual</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>- Planetary Assemblies</td>
<td>Check oil level. Add if low</td>
<td>2</td>
<td>EPL</td>
<td>As required</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>- Differential</td>
<td>Check oil level. Add if low</td>
<td>1</td>
<td>EPL</td>
<td>As required</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>- Driveline Slip Joints</td>
<td>Lube</td>
<td>2</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>- Universal Joints</td>
<td>Lube</td>
<td>4</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>- Brake Cam Shafts</td>
<td>Lube</td>
<td>2</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td>19</td>
<td></td>
<td>- Brake Shoe Anchor Pins</td>
<td>Lube</td>
<td>4</td>
<td>EP, NLGI</td>
<td>See Note 1</td>
</tr>
<tr>
<td>-</td>
<td></td>
<td>- Differential Breather</td>
<td>Clean</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td></td>
<td>- Remote Lubrication Points</td>
<td>Lube</td>
<td>1</td>
<td>EP, NLGI</td>
<td>See Note 1 &amp; Page 9</td>
</tr>
<tr>
<td>-</td>
<td></td>
<td>- Brake Parts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
<td>- Transmission Input Bearing</td>
<td>Lube</td>
<td>1</td>
<td>EP, NLGI</td>
<td>See Page 10</td>
</tr>
<tr>
<td>300</td>
<td>1</td>
<td>- Engine</td>
<td>Drain oil and refill</td>
<td>1</td>
<td>EO</td>
<td>24.6 litres (6.5 US gal)</td>
</tr>
<tr>
<td>-</td>
<td></td>
<td>- Engine Lube Oil Filter</td>
<td>Replace</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td></td>
<td>- Transmission Oil Filter</td>
<td>Replace</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>600</td>
<td></td>
<td>- Fuel Filters and Strainer</td>
<td>Replace filters and clean housings</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td></td>
<td>- Coolant Inhibitor</td>
<td>Replace filters and clean housings</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td></td>
<td>- Drive Belts</td>
<td>Replace filters and clean housings</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td></td>
<td>- Coolant Inhibitor</td>
<td>Replace filters and clean housings</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>900</td>
<td></td>
<td>- Engine Coolant Filter</td>
<td>Replace filter/conditioner element</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1 000</td>
<td>2</td>
<td>- Transmission</td>
<td>Drain oil and refill</td>
<td>1</td>
<td>HTF</td>
<td>49 litres (12.9 US gal)</td>
</tr>
<tr>
<td>-</td>
<td></td>
<td>- Transmission Oil Filter</td>
<td>Replace</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1 200</td>
<td></td>
<td>- Engine Power Takeoff</td>
<td>Drain oil and refill</td>
<td>1</td>
<td>EPL</td>
<td>See Page 10</td>
</tr>
<tr>
<td>-</td>
<td></td>
<td>- Engine Air Cleaner</td>
<td>Clean inlet hood and tubes</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>- Planetary Assemblies</td>
<td>Drain oil and refill</td>
<td>1</td>
<td>EPL</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>- Differential</td>
<td>Drain oil and refill</td>
<td>2</td>
<td>EPL</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td></td>
<td>- Fuel Tank</td>
<td>Clean filler neck screen</td>
<td>1</td>
<td>EPL</td>
<td></td>
</tr>
<tr>
<td>2 400</td>
<td></td>
<td>- Cooling System</td>
<td>Drain coolant and refill</td>
<td>1</td>
<td>Antifreeze</td>
<td>39 litres (10.3 US gal)</td>
</tr>
</tbody>
</table>

**Note:** Capacities given are approximate, work to dipstick, sight gauges or level plugs. Use chart in conjunction with 'Recommended Lubricants' table.

Note 1 - Lubricate slowly until excess lube is seen.

**EO** - Engine Oil. Refer to 'Recommended Lubricants' table.

***** - Refer to 'Recommended Lubricants' table.

**EPL** - Extreme Pressure Gear Lubricant spec. MIL-L-2105D.

**HTF** - Hydraulic Transmission Fluid Type C-4. Refer to 'Recommended Lubricants' table.

**HO** - Hydraulic Transmission Oil. Refer to 'Recommended Lubricants' table.

**EP, NLGI** - Extreme Pressure Lithium No. 2 Grease. Refer to 'Recommended Lubricants Table'.
Remote Lubrication Points
For improved accessibility, remote lube lines are run to a manifold block mounted on the rear right hand side of the engine cover. These lines should be inspected periodically for damage.

Apply sufficient grease into each nipple until there is clear evidence of grease emerging from one or two of the clearly visible connected bearing points.

Do not over grease the brake system.

When a component is lubricated, the general condition of the component should also be visually checked. Look for cracked parts, loose fasteners, excessive wear, or improper clearance as applicable to the component being lubricated.

Operation
The distributor manifolds progressively and positively distribute the total lubricant input into each of the single grease points to all connected bearing points on the scraper, via internal reciprocating pistons, without reliance on springs, valves or seals.

The progressive distribution of the lubricant throughout the system is absolutely positive. Such that should any connected bearing point not be able to accept the individually measured quantity of lubricant from the system for any reason, the distribution will progressively cease to function until a 'pressure stall' situation occurs. This situation will be clearly evident to the operator as the lever gun or air gun will stop operating, and no more lubricant will enter the system.

Should a pressure stall condition occur, this indicates that one or more of the connected bearing points cannot receive its measured quantity of grease. The following procedure should be followed in order to quickly identify which of the connected points is the cause of the problem.

With the grease gun applied to the single nipple in question, maintain pressure on the system. Remove and refit each outlet of the distributor manifold in turn, until grease appears and the distributor can operate once again. This indicates which bearing point is causing the problem, trace the feed line to the bearing point and rectify the problem.
MISCELLANEOUS SERVICING

Every 10 hours of Operation (Daily)

Walk Around Inspection - Inspect the machine as described in Section 4 of the Operators Handbook.

Engine - Visually check engine for damage, loose or frayed belts and listen for any unusual noises.

Engine Air Cleaner - Change air cleaner element only when air restriction gauge locks up in the red. Service dust cup daily.

Note: Service air cleaners more often when operating under extremely dusty conditions.

Engine Crankcase - Check oil level and add oil if low. With the engine off, the oil should be between the 'Low' and 'Full' marks on the dipstick, up to the 'Full' mark is preferable.

Transmission - Adjust bowl height to level the transmission and, with the engine running and oil at normal operating temperature, check oil level. Add oil if the level is below the 'FULL' line on the dipstick. Do not overfill.

Cooling System - Check coolant level, add if low. Add coolant to the top of the filler neck.

AFTER FIRST 50 HOURS OF OPERATING NEW OR REBUILT COMPONENTS

Transmission - Drain oil, replace filter and refill.

AFTER FIRST 150 HOURS OF OPERATING NEW OR REBUILT COMPONENTS

Differential - Drain oil and refill.

Planetaries - Drain oil and refill.

EVERY 150 HOURS OF OPERATION

General Inspection - Check entire scraper for leaks, loose bolts and nuts or damaged parts. Examine the scraper, particularly the chassis, for cracks or broken welds. Repair where necessary.

Oil Can Points - Oil brake treadle rollers and other working parts with engine oil.

Drive Belts - Visually check the belts and replace if they are cracked or frayed. Adjust belts that have a glazed or shiny surface which indicates belt slippage. Correctly installed and tensioned belts will show even pulley and belt wear. Refer to 'Engine Operation and Maintenance Manual' for drive belt tension and adjustment of new and used belts.

Note: The fan belt is maintained to the correct belt tension by a spring loaded idler arm, therefore, there is no need to adjust belt tension.

Transmission Input Bearing - Lubricate through the lube fitting with a hand grease gun, 3-4 shots of grease. Do not overgrease.

Note: Failure to lubricate with a No. 2 Consistency grease could cause premature failure of the input bearing.

EVERY 250 HOURS OF OPERATION

Cooling Fan - Visually check fan for cracks, loose rivets, and bent or loose blades. Check fan mounting and tighten if required. Replace any fan that is damaged.

EVERY 600 HOURS OF OPERATION

Coolant Inhibitor - Check and replenish coolant inhibitor as described in Engine 'Operation and Maintenance Manual'.

EVERY 1 200 HOURS OF OPERATION

Engine Power Takeoff - Drain and refill. Remove bottom pipe plug in PTO cover and drain oil into a suitable container. Reinstall pipe plug and refill to level of check cock.

ENGINE AND TRANSMISSION

All information contained in the 'Lubrication and Service Chart' was extracted from the relevant manufacturers Operators Manual and was correct at time of publication. User should ensure that information contained in this chart, regarding the Engine and Transmission, reflects the information shown in the relevant manufacturers Operators Manuals, supplied with the machine. Maintenance procedures should be carried out in conjunction with any additional procedures contained in the relevant manufacturers 'Operation and Maintenance Manual', at the intervals specified.
RECOMMENDED LUBRICANTS

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>LUBRICANT</th>
<th>VISCOSITY (See Note 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine</td>
<td>Engine oil with 1.00% ash is recommended. Sulphated ash must not exceed 1.85% limit. Classification is as follows: API Classification CG-4 or CF-4 Military Specifications MIL-L-2104E SAE Grade 15W-40</td>
<td>The use of low viscosity oils, such as 10W or 10W-30, can be used to aid in starting the engine and providing sufficient oil flow at ambient temperatures below -5°C (23°F). Continuous use of low viscosity oils can decrease engine life due to wear.</td>
</tr>
<tr>
<td>Transmission</td>
<td>Hydraulic Transmission Oil, Type C-4. See Note 3.</td>
<td>Ambient Recommendation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-30° to 30° C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-25° to 30° C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-15° to 30° C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-10° to 30° C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-5° to 50° C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0° to 50° C</td>
</tr>
<tr>
<td>Differential, Planetary Gears</td>
<td>Multipurpose Extreme Pressure type gear oil meeting MIL-L-2105C Specifications (No Zinc Additive).</td>
<td>SAE 80W-90 at ambient temperatures of -18° to 32°C</td>
</tr>
<tr>
<td>Grease Fittings Ejector Rollers</td>
<td>Multipurpose Extreme Pressure Lithium Grease with a typical melting point of 190° C.</td>
<td>No. 2 Consistency</td>
</tr>
<tr>
<td>Cooling System</td>
<td>Antifreeze, Ethylene Glycol</td>
<td></td>
</tr>
<tr>
<td>Fuel Tank</td>
<td>Diesel Fuel Oil with maximum sulphur 0.5%</td>
<td>DIN EN590</td>
</tr>
<tr>
<td>Drivelines</td>
<td>Multipurpose Extreme Pressure Lithium Grease (without 'Molybdenum'), with a typical melting point of 190° C.</td>
<td>No. 2 Consistency</td>
</tr>
</tbody>
</table>

**Note** - For temperature conversions to degrees Fahrenheit (°F) refer to the table below.

**Note 1** - Consult your lubricant supplier for the correct viscosity of lubricant to use when ambient temperatures are consistently above or below those listed.

**Note 2** - Detroit Diesel does not recommend any specific brand of engine oil but the use of oils that meet API categories. Detroit Diesel recommends use of only the multi-graded viscosity oils shown for the various ambient temperatures listed.

**Note 3** - Preheat is required below minimum temperatures shown. Operation below the minimum temperatures listed for the oil used without proper preheat or warm-up results in greatly reduced transmission life. Proper warm-up requires 20 minutes minimum operation in neutral (with engine at part throttle) before operating the transmission in gear. Hydraulic Transmission Oil meeting Specification EMS19058 may also conform to the Allison C-4 requirements. Consult your lubricant supplier for confirmation.

<table>
<thead>
<tr>
<th>Temperature Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td>° Celsius</td>
</tr>
<tr>
<td>° Fahrenheit</td>
</tr>
<tr>
<td>-26 -22 -17 -13 -4 0 5 14 23 32 50 59 77 90 95 100 122 200</td>
</tr>
</tbody>
</table>

* * *
**INTRODUCTION**

Contained in this section are recommended service tools and equipment required for maintenance, overhaul and troubleshooting. In certain instances, both Metric and Imperial equivalents of the same tools are listed.

**Note:** A tool may be of one piece construction or consist of a number of parts.

**General**

*15269784* - Multi-Gauge - Pressure range of 30 in of vacuum to 5 000 lbf/in²  
15269785 - Non-contact Infrared Thermometer  
15268968 - Strap Type Filter Wrench  
15268969 - Socket Type Filter Wrench  
15268970 - Universal Belt Tension Gauge  
15270180 - Belt Tension Gauge - Poly 'V' Belt  
15269858 - Digital Tachometer  
15269859 - Multimeter  
15269813 - Water Manometer  
15269802 - Dial Indicator Gauge - Metric  
15269803 - Dial Indicator Gauge - Imperial  
15269804 - Magnetic Base for Dial Indicator Gauge  
15269805 - Micrometer - 0 to 25 mm  
15269806 - Micrometer - 0 to 1 in  
15269860 - 92 Piece Heavy Equipment Tool Kit  
15269861 - Torque Wrench - 3/8 in drive, 20 - 100 Nm (15 - 80 lbf ft) range  
15269862 - Torque Wrench - 1/2 in drive, 60 - 330 Nm (45 - 250 lbf ft) range  
15269863 - Torque Wrench - 3/8 in drive, 4 - 20 Nm (40 - 180 lbf in) range  
15269864 - Torque Wrench - 3/4 in drive, 300 - 1 000 Nm (200 - 750 lbf ft) range  
15269865 - Torque Wrench - 3/4 in drive, 700 - 1 500 Nm (500 - 1 000 lbf ft) range  
15269866 - Torque Multiplier - 1/2 in to 1 in drive, 25:1 Ratio, 3 000 Nm (2 200 lbf ft) range

* - The following items should be added to the multi-gauge to enable the gauge to be used on diagnostic test points:  
15018226 - Diagnostic Coupling  
00118748 - Connector (2 off)  
15004085 - Hose Assembly (-4 HP, 84 in long)

**Engine**

The following tools are recommended for Engine Maintenance Procedures. These tools should be used in conjunction with procedures outlined in the engine manufacturers service manual.

15273106 - Sled Gauge  
15273107 - Nozzle Tester with Adapter  
15273105 - PRO-LINK 9000  
15270310 - Adaptor Cable for DDR  
15273084 - Multi Protocol Cartridge  
15273101 - Navistar RAM Card  
15273123 - Pressure Test Kit  
15273110 - Crankshaft Front Oil Seal Wear Sleeve Installer  
15273122 - Orifice Restrictor Tool  
15273121 - Piston Groove Wear Measuring Tool  
15273119 - Valve Seat Installer  
15273120 - Camshaft Bushing Service Set  
15273109 - Plunger Pin (to check timing)  
15273111 - Crankshaft Rear Oil Seal Installer  
15273112 - Valve Guide Removal Tool  
15273113 - Nozzle Puller  
15273108 - Idler Nut Socket  
15273089 - Fuel Injector Sleeve Remover  
15273090 - Fuel Injector Remover Tool  
15273091 - Fuel Injector Sleeve Installer  
15273092 - Engine Harness Repair Kit  
15273093 - Terminal Release Tool Kit  
15273100 - ECM Terminal Crimping Plier  
15273094 - Cylinder Sleeve Holding Adapters  
15273095 - Guide Stud Set  
15273096 - Oil Cooling Plate  
15273099 - Injector Test Harness  
15273097 - Cylinder Head Magnet Intake Shield  
15273098 - Valve Guide Installer  
15273102 - CEC Breakout Box  
15273103 - ICP Breakout "T" Harness  
15273104 - ICP Adapter Plug Kit
Miscellaneous - Service Tools

Section 300-0070

Axles and Differentials
15269893 - Pin Spanner - M95 x 1.5
15269894 - Wheel Bolt Puller - Basic Set
15269895 - Insert - M22 x 1.5
15269896 - Driver
15269897 - Driver
15269898 - Driver Handle
15269899 - Hot Air Blower - 220 V, 50 Hz
15269900 - Hot Air Blower - 127 V, 60 Hz
15269928 - Back-off Screw - M14
15269929 - Lifting Pliers
15269930 - Grab Sleeve
15269931 - Sleeve
15269932 - Basic Set Rollex 1
15269933 - Grab Sleeve ‘Super’
15269934 - Measuring Shaft
15269935 - Thrust Washer
15269936 - Measuring Piston
15269937 - Shims - 120 mm Diameter
15270204 - Driver
15269939 - Measuring Ring
15269940 - Driver
15269941 - Driver
15269942 - Driver Handle
15269943 - Spanner
15269944 - Hook Spanner
15269945 - Insert
15269946 - Puller Set
15269947 - Shims
15269948 - Straightedge - 600 mm
15269949 - Pry Bars - Set of 2
15269950 - Driver

Nitrogen Charging/Inflation
15269121 - Nitrogen Tyre Inflation Kit
09359489 - Charging Assembly

Cooling and Air Conditioning
15269814 - DCA4 Test Kit - Metric Version
15269815 - DCA4 Test Kit - US gallon Version
15269816 - Refractometer - °C Scale
15269817 - Refractometer - °F Scale
15269844 - Portable High Vacuum Charging Station - R-134a Gas
15269845 - Halogen Leak Tester

Cab
15271016 - Glass Removal Tool
15271017 - Bonding Kit (Quick Dry)

Adhesives and Sealants
15269103 - Loctite 221
09362529 - Loctite 225
09029849 - Loctite 243
09244598 - Loctite 270
09985300 - Loctite 271
15269104 - Loctite 275
15269245 - Loctite 277
15233715 - Loctite Prism 406
15269111 - Loctite Prism 410
15269105 - Loctite 515
09007209 - Loctite 574 (50 ml)
09379518 - Loctite 574 (160 ml)
15269106 - Loctite 577 (Superflex)
15270244 - Loctite 592 - Pipe Sealer with Teflon
15023696 - Loctite 635
09371048 - Loctite 638
15269107 - Loctite 641
15269108 - Loctite Superclean Safety Solvent 706
15304830 - Loctite 5205
15229541 - Loctite Activator ‘N’
09243825 - Loctite Activator ‘T’
09175039 - General Adhesive
15269114 - Tectyl 280 Wax Based Rust Preventive
09380475 - Hylosil RTV Silicone Compound
15303808 - Silicon Grease (Dielectric)

Fabricated Tools
The service tools shown in Fig. 1 through 5 can be fabricated as shown.
**Miscellaneous - Service Tools**

Section 300-0070

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**Fig. 1 - Flywheel Damper Locating Pin**
*(Section 110-0030, ENGINE AND MOUNTING)*

**Fig. 2 - Typical Fabricated Wheel Tool**
*(Section 160-0050, WHEEL, RIM AND TYRE)*

**Fig. 3 - Seal Retainer Removal Tool**
*(Section 235-0050, TRIPLE PUMP)*

**Fig. 4 - Unloader Valve Adjusting Bush Installation Tool**
*(Section 250-0200, AIR DRIER)*

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Material:
Make from 13017, 13040 or 13083

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**Machined**

- **Length:**
  - 1.00 in
  - 0.75 in
  - 0.938 in

- **Diameter:**
  - ø 0.403 in
  - ø 3/8 x 16 UNCPTHD.
  - ø 0.50 in
  - ø 0.218 in
  - ø 0.480 in

- **Pins to be:**
  - 0.072 in dia.

- **Shank:**
  - Should be about 8 in long
  - Fitted with Tee handle approx. 4 in long

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**CAUTION:** Dimensions are approximate. Measure distance diagonally between wheel studs before fabrication.

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**SM - 2055**

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**SM - 2169**

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**SM - 372**

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**SM - 386**

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**SM - 1953**

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**SM 1802 Rev 1 10-99**

3
### Table 1

<table>
<thead>
<tr>
<th>INCHES</th>
<th>mm</th>
</tr>
</thead>
<tbody>
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<td>0.0004</td>
<td>0.010</td>
</tr>
<tr>
<td>0.002</td>
<td>0.05</td>
</tr>
<tr>
<td>0.153</td>
<td>3.89</td>
</tr>
<tr>
<td>0.213</td>
<td>5.41</td>
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<tr>
<td>0.50</td>
<td>12.7</td>
</tr>
<tr>
<td>0.656</td>
<td>16.66</td>
</tr>
<tr>
<td>0.75</td>
<td>19.05</td>
</tr>
<tr>
<td>1.50</td>
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WARNING
Some fasteners are important attaching parts which could affect the performance of vital components and systems, and/or, could result in major repair expense. Fasteners should be replaced with parts of the same part number, or with equivalent parts, if replacement becomes necessary. Do not use replacement parts of lesser quality or substitute design. The torque values shown in the following tables should be used in all cases, unless otherwise specified elsewhere in this manual, in order to avoid possible personal injury or property damage.

The following torque specification tables are based on GM Standard Materials for bolts, nuts, studs and self-locking fasteners based on SAE bolt steel classifications, or, prevailing torque specifications for self-locking fasteners.

To prevent the threaded bolts and nuts used on this equipment from being overstressed during assembly, and to establish a uniform value to which these fasteners can be safely tightened, the following torque tables have been compiled.

The torque values listed in the tables have been established over a period of years and cover all conditions of assembly. The maximum torque values for standard bolts and nuts are based on 75% of the specified minimum proof strength of the bolt steel in order to provide a safety factor to compensate for the variation in the accuracy of torque wrenches, skill of the assembler, and variance in fractional conditions. All torque values are for lubricated threads. The term 'lubricated' includes the application of thread lubricants, cadmium plating or the use of hardened washers.

To provide a quick method for determining the GM material classification of a particular standard bolt or nut, compare the bolt head markings to those in the appropriate tables, then locate the maximum torque value for that bolt size in the column under that marking.

### MISCELLANEOUS - Standard Bolt and Nut Torque Specifications

Section 300-0080

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### RECOMMENDED MAXIMUM TORQUES (IMPERIAL) ± 10%

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# Miscellaneous - Standard Bolt and Nut Torque Specifications

## Section 300-0080

### RECOMMENDED MAXIMUM TORQUES (IMPERIAL) ± 10%

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Note: Where materials other than GM Standards are used, refer to the conversion table below.

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<th>Rockwell Hardness Range</th>
<th>Applicable Torque Values</th>
<th>SAE Bolt Head Symbols</th>
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| Plain Medium Carbon (eg. SAE 1035, 1038 & 1045) | Rockwell "C" 19-30 | GM 280-M               |

| Medium Carbon Alloy (eg. SAE 4140, 8642 & 5157) | Rockwell "C" 28-34 | GM 290-M               |

| Medium Carbon Alloy (eg. SAE 4140, 8642 & 5147) | Rockwell "C" 32-38 | GM 300-M               |
## RECOMMENDED MAXIMUM TORQUES (METRIC) ± 10%

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<td>1 433</td>
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<td>M 36.0 - 3.00</td>
<td>2 102</td>
<td>1 517</td>
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</table>
SELF-LOCKING FASTENERS
Self-locking fasteners develop a measured gripping action or torque and provide a renewed locking action after being removed and reinstalled to their original mating part. The self-locking fasteners used on this equipment meet specifications necessary to allow the fasteners to be reused up to five times. Whenever a self-locking fastener is removed, the head of the fastener should be deeply scribed or otherwise marked to record the number of times the fastener has been used. Do not use a self-locking fastener more than five times.

The following table shows the minimum torque specifications allowed to remove self-locking fasteners after the initial break-away torque has been achieved. Any self locking fastener that can be removed with less than the prevailing torque value shown in the table should be discarded, even if the fastener has not yet been reused five times.

**MINIMUM PREVAILING TORQUE - REMOVAL**

<table>
<thead>
<tr>
<th>Size</th>
<th>Lockscrews</th>
<th>Locknuts</th>
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<tr>
<td></td>
<td>SAE Grade 5 &amp; 8 and ASTM A-574</td>
<td>SAE Grade 5</td>
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<tr>
<td></td>
<td>Nm</td>
<td>lbf in</td>
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<tr>
<td>0.25 - 20</td>
<td>0.3</td>
<td>3</td>
</tr>
<tr>
<td>0.25 - 28</td>
<td>0.3</td>
<td>3</td>
</tr>
<tr>
<td>0.31 - 18</td>
<td>0.6</td>
<td>5</td>
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<td>0.31 - 24</td>
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<td>0.38 - 24</td>
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<tr>
<td>1.00 - 12</td>
<td>9.6</td>
<td>85</td>
</tr>
<tr>
<td>1.00 - 14</td>
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</tr>
</tbody>
</table>

* * * *
GENERAL

The storage of machines for short periods of time or during the off-season is an important item if major damage to components is to be avoided. Failure to take the necessary steps to protect the various assemblies while the machine is being stored can result in an expensive overhaul job and delay in returning the machine to work.

TEMPORARY STORAGE

When storing a machine for a period of 30 days or less, the following precautions must be taken:

1. INSPECTION AND REPAIR - Thoroughly inspect and test the machine and make any necessary repairs or adjustments which may be necessary to prepare the machine for service. This will enable you to put the machine back into use immediately at the end of the storage period.

2. LUBRICATION - Lubricate the machine completely according to the instructions given in Section 300-0020, LUBRICATION SYSTEM of this manual.

3. PARKING - After thoroughly cleaning the entire machine, park it on a hard, dry, level surface that is free from grease and oil. The oil and grease would cause tyre deterioration. Apply the parking brake.

4. BATTERIES - Where moderate temperatures are expected, the batteries may be left in the machine. Up to 30 days, the batteries may require a boost at the end of the storage period. Preferably place the batteries in the shop where they can be inspected, brought up to full charge and placed on a trickle charge to keep them at full charge. In very cold or hot climates, store the batteries where they will be protected from temperature extremes.

5. RUST PREVENTION - Remove all evidence of rust from the machine and repaint. In addition, cover all exposed machine surfaces with a good rust preventive.

6. SUPPLY TANKS - Fill fuel and hydraulic tanks to prevent moisture condensation within the tanks.

7. TYRES - Inflate all tyres to correct pressure. During storage, check inflation pressure approximately once every two weeks.

8. ENGINE - Consult the relevant Engine Maintenance Manual for complete information on storing the engine for periods shorter than 30 days.

9. TRANSMISSION - Fill transmission sumps to the proper level.

EXTENDED STORAGE - Under Six Months

When storing a machine for periods of longer than 30 days, but under six months, the following procedure must be followed:

1. INSPECTION AND REPAIR - Same as Step 1 given under 'Temporary Storage'.

2. LUBRICATION - Same as Step 2 given under 'Temporary Storage'.

3. PARKING - Same as Step 3 given under 'Temporary Storage'. Machines should be blocked up so the tyres are off the ground or floor.

4. BATTERIES - Remove batteries from the machine and store them in a suitable place where they can be inspected and charged at least every 30 days or placed on a trickle charger.

5. RUST PREVENTION - Same as Step 5 given under 'Temporary Storage'.

6. SUPPLY TANKS - Same as Step 6 given under 'Temporary Storage'.

7. TYRES - With the machine on blocks, as called for in Step 3, deflate the tyres to 0.7 bar (10 lbf/in²) pressure. Remove all traces of grease and oil and protect the tyres from direct sunlight and water with a suitable cover.

8. TRANSMISSION - Consult the relevant Transmission Maintenance Manual for storage data involving periods longer than 30 days.

9. ENGINE - Consult the relevant Engine Maintenance Manual for storage data involving periods longer than 30 days.

10. VENTS AND BREATHERS - Remove all vents and breathers and plug openings with pipe plugs. If it is not possible to do this, seal vents and breathers with waterproof tape.
EXTENDED STORAGE - Over Six Months

When a machine is to be stored for a period over SIX MONTHS, the following procedure must be followed:

**Note:** These steps are in addition to those given previously under 'Extended Storage - Under Six Months'.

1. **LUBRICATION** - Completely lubricate the machine according to the instructions contained in Section 300-0020, LUBRICATION SYSTEM of this manual.

2. **WHEEL BEARING** - Remove, clean, inspect and repack all wheel bearings.

**Note:** The above steps must be repeated for every Six Month period the machine is in storage.

REMOVAL FROM EXTENDED STORAGE

**General**

1. **LUBRICATION** - Completely lubricate the machine according to the instructions in Section 300-0020, LUBRICATION SYSTEM of this manual.

2. **BATTERIES** - Install batteries and check for a full charge. Charge batteries as required.

3. **TYRES** - Inflate tyres to the proper pressures. Refer to Section 140-0040, WHEEL RIM AND TYRE, of this manual.

4. **FUEL AND HYDRAULIC TANKS** - Drain off condensation and fill tanks to proper level, remove breather covers and install air breathers. Be sure breathers are clean before installation.

5. **VENTS AND BREATHERS** - Remove seals and plugs from all breather openings, then install all breathers and vents.

6. **ENGINES** - Consult the relevant Engine Maintenance Manual for instructions on removing an engine from storage.

7. **PAINT** - Check machine for rust. Remove all rust spots and repaint rusted areas.

8. **TRANSMISSION** - Consult the relevant Transmission Maintenance Manual for instructions on removing from storage.

* * * *