Part No. 88712SL, Rev. H

Service Manual

Groundsmaster 224 / 225 / 1000L / 228-D: (See notes in box below)

Groundsmaster® 220-D/223-D

Preface

This Service and Overhaul Manual was written to give the service technician information about the TORO Groundsmaster® 220-D/223-D mowers.

This manual is not designed to teach component theory. The purpose of this manual is to provide the service technician with a working guide for safe maintenance, troubleshooting, test, repair, and overhaul procedures.

The Toro Company has made every effort to make this service manual a useful and lasting addition to every service facility. To assure proper and effective service, and to provide the best performance for the life of the machine, you should read this manual carefully.

Read the complete sequence of instructions (example: steps 1 - 6) before performing a procedure.

The Toro Company reserves the right to change product specifications or this manual without notice.

This safety symbol means DANGER, WARNING, or CAUTION, PERSONAL SAFETY INSTRUCTION. When you see this symbol, carefully read the instructions that follow. Failure to obey the instructions may result in personal injury.

NOTE: A NOTE will give general information about the correct operation, maintenance, service, testing or repair of the machine.

IMPORTANT: The IMPORTANT notice will give important instructions which must be followed to prevent damage to systems or components on the machine.

Use this book along with the Toro Operator's Manual and Parts Catalog for the specific model and serial number of the machine, and the engine manual listed below:

Groundsmaster 224:
Mitsubishi GL3 Engine Service Guide
(Toro Part No. 91773SL).

Groundsmaster 1000L:
Kawasaki FD620 Engine Service Manual
(Toro Part No. 492-4713).

Groundsmaster 225:
Briggs-Daihatsu 3LC Engine Repair
Manual (Toro Part No. 99048SL).

Groundsmaster 228-D:
Kubota 05 Series Shop Manual
(Toro Part No. 01090SL).

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Chapter 1

Safety

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Safety Instructions

The Groundsmaster® 220-D has been tested and verified for compliance with the B71.4-1984 specifications of the American National Standards Institute (ANSI). However, improper use or maintenance by the owner or operator of the machine can result in personal injury.

CAUTION

Obey the following safety instructions. Read and understand these instructions before operating the Groundsmaster® 220-D or doing maintenance, troubleshooting, testing, adjustments or repairs. Failure to comply with the safety instructions may result in personal injury.

Before Operating

1. Read and understand the Operator's Manual before starting, operating, or repairing the machine. Become familiar with all controls and know how to stop the machine quickly. A replacement Operator's Manuals is available by sending complete Model and Serial Number to:

The Toro Company
8111 Lyndale Avenue South
Minneapolis, MN 55420

Use the model number and serial number when referring to your machine. If you have questions about this Service and Repair Manual please contact:

The Toro Company
Commercial Service Department
8111 Lyndale Avenue South
Minneapolis, MN 55420

2. Never allow children or adults unfamiliar with operation of this machine operate it. Keep everyone, especially children and pets, away from the area of operation.

3. Remove sticks, stones, wire and any other debris or other objects that might be picked up and thrown by the cutting unit blades or other attached implements. Keep all bystanders away from the area of operation.

4. Keep all shields and safety devices in place. If a shield, safety device or decal is missing, defective or damaged, repair or replace it before operating. Make sure the machine is in safe operating condition. Tighten any loose nuts, bolts, and screws.

5. Always wear long pants and sturdy shoes. Do not operate the machine while wearing sandals, tennis shoes, sneakers, or short pants. Do not wear loose clothing. Loose clothing can get caught in moving parts. Wearing safety glasses, safety shoes, and a helmet is recommended and also required by some local ordinances and insurance regulations.

6. Make sure that all the interlock switches operate correctly so the engine cannot be started unless the traction pedal is released (NEUTRAL position) and the P.T.O switch is OFF. Replace any failed switch before operating the machine.

7. Fill the fuel tank with diesel fuel before starting the engine. Avoid spilling any fuel. Fuel is very flammable. Handle fuel carefully. DO NOT SMOKE.

A. Use an approved fuel container.

B. Do not fill the fuel tank when the engine is hot or running.

C. Do not smoke while handling fuels or lubricants.

D. Fill the tank up to approximately one inch (25 mm) from the top of the tank, not the filler neck. Do not overfill.

E. Wipe up any spilled fuel. Install the fuel container cap and the machine fuel tank cap securely before starting the engine.

While Operating

8. Do not run the engine in a confined area without adequate ventilation. Exhaust fumes are hazardous and could possibly be deadly.

9. The maximum seating capacity is one person. Never carry passengers.

10. Sit on the seat when starting the engine and operating the machine.

11. When starting the engine:

A. Engage the parking brake.

B. Make sure the traction pedal is in the NEUTRAL position and the P.T.O. switch is OFF.

C. After the engine is started, release the parking brake and keep your foot off the traction pedal. The machine must not move. If the machine moves, the neutral return mechanism must be adjusted. Turn the engine OFF and adjust the neutral return mechanism so the machine does not move when the engine is running and the traction pedal is released. (See Chapter 4 - Hydraulic System.)

12. Be alert when operating. To prevent loss of control:

A. Operate only in daylight or when there is good artificial light.

B. Watch for holes or other hidden hazards.

C. Do not drive close to a sand traps, ditches, creeks, or other hazardous areas.

D. Reduce speed when making sharp turns and when turning on hill sides.

E. Avoid sudden stops and starts.

F. Before backing up, look to the rear to make sure no people or obstacles are behind the machine.

G. Watch out for traffic when near or going across roads. Always yield the right of way.

13. The grass deflector must always be installed on the cutting unit. If the cutting unit discharge area ever plugs, turn the P.T.O. switch OFF and turn the engine OFF. Use an object with a long handle to remove the obstruction.

14. Never raise the cutting unit or other attached implement while the blades or other parts are rotating.

15. If the cutting blades or other implement components strike a solid object, or if the machine vibrates abnormally, turn the P.T.O. switch OFF, move the throttle to SLOW, set the parking brake, and turn the engine OFF. Remove the key from the ignition switch to prevent the possibility of accidental starting. Check the cutting unit or other implement and traction unit for damage and defective parts. Repair any damage before restarting the engine and operating the cutting unit or other implement. Be sure the cutting unit blades are in good condition and the blade bolts are tightened to the correct torque.

16. Go across slopes carefully. Do not start or stop suddenly when traveling uphill or downhill.

17. Do not touch the engine, muffler, or radiator while the engine is running or soon after it has stopped. These areas could be hot enough to cause a burn.

18. Lower the cutting unit or other attached implement to the ground and remove the key from the ignition switch when the machine is left unattended.

19. Before getting off the seat:

A. Move the traction pedal to the NEUTRAL position and remove your foot from the pedal.

B. Move the throttle to the SLOW position.

C. Engage the parking brake and turn the P.T.O. switch OFF.

D. Turn the engine OFF and remove the key from the ignition switch. Wait for all movement to stop before getting off the seat.

While Doing Maintenance, Troubleshooting, Testing, Adjustments or Repairs

20. Remove the key from the ignition switch and disconnect the negative (–) cable from the battery. Secure the cable off to the side. This will prevent sparks, electrical shocks, or accidental starting of the engine when servicing, cleaning, adjusting, or storing the machine.

21. Be sure you understand a service procedure before working on the machine. Unauthorized modifications to the machine may impair the function, safety and life of the machine. If major repairs are ever needed, or assistance is desired, contact an Authorized TORO Distributor or Dealer.

22. To reduce potential fire hazards, keep the engine free of excessive grease, grass, leaves, and accumulation of dirt. Do not use flammable solvents for cleaning parts. Do not use diesel fuel, kerosene or gasoline.

23. Be sure the machine is in good operating condition. Keep nuts, bolts, and screws tight. Check all cutting blade mounting bolts frequently for the proper torque; 75 to 100 ft.lbs (10.4 to 13.8 KgM).

24. If the engine must be running to perform an inspection or procedure, use extreme caution. Always use two people, with the operator at the controls able to see the person doing the inspection or procedure. Keep hands, feet, clothing, and body away from the P.T.O. shaft, cutting unit blades, belts, cooling fan and other moving parts.

25. Do not overspeed the engine by changing the governor settings. The maximum engine speed (with no load and engine coupled to the transmission) is listed in Chapter 3 - Mitsubishi Diesel Engine.

26. The engine must be stopped before checking the oil level or adding oil to the crankcase.

27. Make sure all hydraulic line connectors are tight, and all hydraulic hoses and lines are in good condition before applying pressure to the system.

28. Keep body and hands away from pin hole leaks or nozzles that eject hydraulic fluid under high pressure. Use paper or cardboard, not hands, to search for leaks. Hydraulic fluid escaping under pressre can have sufficient force to penetrate skin and do serious damage. If fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type of injury or gangrene may result.

29. Before disconnecting or performing any work on the hydraulic system, all pressure in the system must be relieved by stopping the engine and lowering the implement to the ground.

30. Wear safety glasses, goggles or a face shield to prevent possible eye injury when using compressed air for cleaning or drying components.

31. At the time of manufacture, the Groundsmaster® 220-D conformed to safety standards in effect for riding mowers. To assure optimum performance and safety of the machine, always use genuine TORO replacement parts and accessories. NEVER USE “WILL FIT” REPLACEMENT PARTS AND ACCESSORIES MADE BY OTHER MANUFACTURERS. Using unapproved replacement parts and accessories could void the warranty of your TORO mower.

Safety and Instruction Decals

If a decal becomes damaged or illegible, replace it. The decals are shown and part numbers listed in the Operator’s Manual and Parts Catalog for your machine. Replacement decals can be ordered from your Authorized Toro Distributor or Dealer.

Chapter 2

Product Records and Manuals

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Product Records

Record information about your Groundsmaster 220–D or 223–D on the OPERATION AND SERVICE HISTORY REPORT form. Use this information when referring to your machine.

Insert Operator's Manuals and Parts Catalogs for your Groundsmaster 220–D or 223–D at the end of this section.

Equivalents and Conversions

Decimal and Millimeter Equivalents

Fractions	Decimals	mm	Fractions	Decimals	mm
1/64	0.015625	— 0.397	33/64	0.515625	— 13.097
1/32	0.03125	— 0.794	17/32	0.53125	— 13.494
3/64	0.046875	— 1.191	35/64	0.546875	— 13.891
1/16	0.0625	— 1.588	9/16	0.5625	— 14.288
5/64	0.078125	— 1.984	37/64	0.578125	— 14.684
3/32	0.9375	— 2.381	19/32	0.59375	— 15.081
7/64	0.109275	— 2.778	39/64	0.609375	— 15.478
1/8	0.1250	— 3.175	**5/8**	0.6250	— 15.875
9/64	0.140625	— 3.572	41/64	0.640625	— 16.272
5/32	0.15625	— 3.969	21/32	0.65625	— 16.669
11/64	0.171875	— 4.366	43/64	0.671875	— 17.066
3/16	0.1875	— 4.762	11/16	0.6875	— 17.462
13/64	0.203125	— 5.159	45/64	0.703125	— 17.859
7/32	0.21875	— 5.556	23/32	0.71875	— 18.256
15/64	0.234375	— 5.953	47/64	0.734375	— 18.653
1/4	0.2500	— 6.350	**3/4**	0.7500	— 19.050
17/64	0.265625	— 6.747	49/64	0.765625	— 19.447
9/32	0.28125	— 7.144	25/32	0.78125	— 19.844
19/64	0.296875	— 7.541	51/64	0.796875	— 20.241
5/16	0.3125	— 7.938	13/16	0.8125	— 20.638
21/64	0.328125	— 8.334	53/64	0.828125	— 21.034
11/32	0.34375	— 8.731	27/32	0.84375	— 21.431
23/64	0.359375	— 9.128	55/64	0.859375	— 21.828
3/8	0.3750	— 9.525	**7/8**	0.8750	— 22.225
25/64	0.390625	— 9.922	57/64	0.890625	— 22.622
13/32	0.40625	— 10.319	29/32	0.90625	— 23.019
27/64	0.421875	— 10.716	59/64	0.921875	— 23.416
7/16	0.4375	— 11.112	15/16	0.9375	— 23.812
29/64	0.453125	— 11.509	61/64	0.953125	— 24.209
15/32	0.46875	— 11.906	31/32	0.96875	— 24.606
31/64	0.484375	— 12.303	63/64	0.984375	— 25.003
1/2	0.5000	— 12.700	**1**	1.000	— 25.400
1 mm = 0.03937 in.			**0.001 in. = 0.0254 mm**		

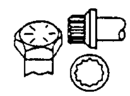
U.S to Metric Conversions

	To Convert	Into	Multiply By
Linear Measurement	Miles	Kilometers	1.609
	Yards	Meters	0.9144
	Feet	Meters	0.3048
	Feet	Centimeters	30.48
	Inches	Meters	0.0254
	Inches	Centimeters	2.54
	Inches	Millimeters	25.4
Area	Square Miles	Square Kilometers	2.59
	Square Feet	Square Meters	0.0929
	Square Inches	Square Centimeters	6.452
	Acre	Hectare	0.4047
Volume	Cubic Yards	Cubic Meters	0.7646
	Cubic Feet	Cubic Meters	0.02832
	Cubic Inches	Cubic Centimeters	16.39
Weight	Tons (Short)	Metric Tons	0.9078
	Pounds	Kilograms	0.4536
	Ounces (Avdp.)	Grams	28.3495
Pressure	Pounds/Sq. In.	Kilopascal	6.895
	Pounds/Sq. In.	Bar	0.069
Work	Foot-pounds	Newton-Meters	1.356
	Foot-pounds	Kilogram-Meters	0.1383
	Inch-pounds	Kilogram-Centimeters	1.152144
Liquid Volume	Quarts	Liters	0.9463
	Gallons	Liters	3.785
Liquid Flow	Gallons/Minute	Liters/Minute	3.785
Temperature	Fahrenheit	Celsius	1. Subract 32° 2. Multiply by 5/9

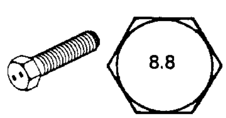
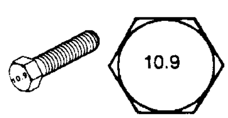
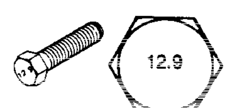
Torque Specifications

Use these torque values when specific torque values are not given. DO NOT use these values in place of specified values. Torque values listed are for lubricated threads. Plated threads are considered to be lubricated.

Capscrew Markings and Torque Values - U.S. Customary

SAE Grade Number	5				8			
Capscrew Head Markings								
Capscrew Body Size	Capscrew Torque - Grade 5				Capscrew Torque - Grade 8			
	Cast Iron		Aluminum		Cast Iron		Aluminum	
	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm
1/4-20	7	9	6	8	11	15	9	12
-28	9	12	7	9	13	18	10	14
5/16-18	15	20	12	16	22	30	18	24
-24	17	23	14	19	24	33	19	25
3/8-16	30	40	20	25	40	55	30	40
-24	30	40	25	35	45	60	35	45
7/16-14	45	60	35	45	65	90	50	65
-20	50	65	40	55	70	95	55	75
1/2-13	70	95	55	75	95	130	75	100
-20	75	100	60	80	110	150	90	120
9/16-12	100	135	80	110	140	190	110	150
-18	110	150	85	115	155	210	125	170
5/8-11	135	180	110	150	190	255	150	205
-18	155	210	120	160	215	290	170	230
3/4-10	240	325	190	255	340	460	270	365
-16	270	365	210	285	380	515	300	410
7/8-9	360	490	280	380	550	745	440	600
-14	390	530	310	420	610	825	490	660
1-8	530	720	420	570	820	1100	660	890
-14	590	800	480	650	890	1200	710	960

Capscrew Markings and Torque Values – Metric

Commercial Steel Class	8.8				10.9				12.9			
Capscrew Head Markings												
Thread Diameter	Capscrew Torque - Class 8.8				Capscrew Torque - Class 10.9				Capscrew Torque - Class 12.9			
	Cast Iron		Aluminum		Cast Iron		Aluminum		Cast Iron		Aluminum	
mm	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm
6	5	9	4	7	9	14	7	11	9	14	7	11
7	9	14	7	11	14	18	11	14	18	23	14	18
8	18	25	14	18	23	32	18	25	27	36	21	28
10	30	40	25	30	45	60	35	45	50	70	40	55
12	55	70	40	55	75	105	60	80	95	125	75	100
14	85	115	65	90	120	160	95	125	145	195	110	150
16	130	180	100	140	175	240	135	190	210	290	165	220
18	170	230	135	180	240	320	185	250	290	400	230	310

EQUIPMENT OPERATION AND SERVICE HISTORY REPORT
for
GROUNDSMASTER® 220-D, 223-D, 224

TORO Model and Serial Number: __________-__________

Deck Model and Serial Number: __________-__________

Engine Numbers: ____________________

Transmission Numbers: ____________________

Drive Axle(s) Numbers: ____________________

Date Purchased: ____________________ Warranty Expires__________

Purchased From: ____________________

____

____

Contacts: Parts ____________________ Phone__________________

Service ____________________ Phone__________________

Sales ____________________ Phone__________________

See your TORO *Distributor/Dealer for other Publications, Manuals, and Videos from* The TORO Company.

GROUNDSMASTER® 220-D, 223-D, 224 Maintenance Schedule

Minimum Recommended Maintenance Intervals:

Maintenance Procedure	Maintenance Interval & Service
Check Battery Fluid Level	50hrs — A Level Service
Check Battery Cable Connections	50hrs — A Level Service
Lubricate All Grease Fittings	50hrs — A Level Service
Lubricate Brake Cables	50hrs — A Level Service
Check Cutting Unit Gear Box Oil Level	50hrs — A Level Service
Clean Under Cutting Unit Belt Covers	50hrs — A Level Service
Check Cutting Unit Drive Belt Adjustment	50hrs — A Level Service
Change Engine Oil	50hrs — A Level Service
Inspect Air Filter, Dust Cup, and Baffle	50hrs — A Level Service
‡ Replace Engine Oil Filter	100hrs — B Level Service
Check Electric Clutch Gap Adjustment	100hrs — B Level Service
† Check PTO Belt Tension	100hrs — B Level Service
† Check Fan and Alternator Belt Tension	100hrs — B Level Service
Inspect Cooling System Hoses	100hrs — B Level Service
Service Air Filter	200hrs — C Level Service
Replace Gasoline Fuel Filter (gas unit)	200hrs — C Level Service
Check Rear Wheel Toe-In and Steering Linkage	200hrs — C Level Service
† Replace Transmission Filter	200hrs — C Level Service
† Torque Wheel Lug Nuts	200hrs — C Level Service
Drain and Clean Fuel Tank (diesel unit)	400hrs — D Level Service
Change Cutting Unit Gear Box Oil	400hrs — D Level Service
Change Electric Fuel Pump Filter	400hrs — D Level Service
Change Diesel/WaterSeparator Filter	400hrs — D Level Service
Rear Axle Service - pack rear wheel bearings (2WD) - change rear axle lubricant (4WD)	400hrs — D Level Service
Coat Transmission Bypass Pins with Grease	400hrs — D Level Service
Replace Spark Plugs (gasoline unit)	400hrs — D Level Service
‡ Torque Head, Adjust Valves, and Check Engine RPM	400hrs — D Level Service

† Initial break in at 10 hours

‡ Initial break in at 50 hours

	Annual Recommendations
Replace Moving Hoses	**Annual Recommendations:** *Items listed are recommended every 1000 hours or 2 years whichever occurs first.*
Replace Safety Switches	
Coolant System - Flush/Replace Fluid	
Change Hydraulic Oil	

(See Operator's and Service Manual for specifications and procedures)

GROUNDSMASTER® 220-D, 223-D, 224 Daily Maintenance Check List

Unit Designation:__________
Daily Maintenance:(duplicate this page for routine use) TORO ID#:_______-_______

Maintenance Check Item	Daily Maintenance Check For Week Of _______________						
	MON ______HRS	TUES ______HRS	WED ______HRS	THURS ______HRS	FRI ______HRS	SAT ______HRS	SUN ______HRS
✓ Safety Interlock Operation							
✓ Grass Deflector in Down Position							
✓ Brake Operation							
✓ Fuel Level							
✓ Engine Oil Level							
✓ Cooling System Fluid Level							
Drain Water/Fuel Separator[1]							
✓ Dust Cup and Baffle (Air Filter)							
✓ Radiator & Screen for Debris							
✓ Unusual Engine Noises[2]							
✓ Unusual Operating Noises							
✓ Transmission Oil Level							
✓ Hydraulic Hoses for Damage							
✓ Fluid Leaks							
✓ Tire Pressure							
✓ Instrument Operation							
✓ Condition of Blades							
Lubricate All Grease Fittings[3]							
Touch-up damaged paint							

[1] = Diesel units only.
[2] = Check diesel glow plug and injector nozzles, if hard starting, excess smoke, or rough running is noted.
[3] = Immediately after every washing, regardless of the intervals specified.

Notation for areas of concern: Inspection performed by:________________

Item	Date	Information
1		
2		
3		
4		
5		
6		
7		

(See Operator's and Service Manual for specifications and procedures)

GROUNDSMASTER® 220-D, 223-D, 224 Supervisor Maintenance Work Order

Date:______________

(duplicate this page for routine use)

Unit Designation:	TORO I.D. #: ________-________	Remarks:
Hours:	Service to perform (circle): **A B C D Other**	
Technician:		

A -Service (every 50 hours)

- ☐ Check Battery Fluid Level
- ☐ Check Battery Cable Connections
- ☐ Lubricate All Grease Fittings
- ☐ Lubricate Brake Cables
- ☐ Check Cutting Unit Gear Box Oil Level
- ☐ Clean Under Cutting Unit Belt Covers
- ☐ Check Cutting Unit Drive Belt Adjustment
- ☐ Change Engine Oil
- ☐ Inspect Air Filter, Dust Cup, and Baffle

B -Service (every 100 hours)

- ☐ Replace Engine Oil Filter
- ☐ Check Electric Clutch Gap Adjustment
- ☐ Check PTO Belt Tension
- ☐ Check Fan and Alternator Belt Tension
- ☐ Inspect Cooling System Hoses
- ☐ **A-Service** required
- ☐ ________
- ☐ ________
- ☐ ________

C -Service (every 200 hours)

- ☐ Service Air Filter
- ☐ Replace Gasoline Fuel Filter (gas unit)
- ☐ Check Rear Wheel Toe-In
- ☐ Check Steering Linkage
- ☐ Replace Transmission Filter
- ☐ Torque Wheel Lug Nuts
- ☐ **A** and **B Service** required
- ☐ ________
- ☐ ________

D -Service (every 400 hours)

- ☐ Drain and Clean Fuel Tank (diesel unit)
- ☐ Change Cutting Unit Gear Box Oil
- ☐ Replace Electric Fuel Pump Filter
- ☐ Replace Diesel/WaterSeparator Filter
- ☐ Pack Rear Wheel Brgs/Change 4WD Oil
- ☐ Coat Transmission Bypass Pins w/Grease
- ☐ Replace Spark Plugs (gasoline unit)
- ☐ Torque Head, Adjust Valves,✓Engine RPM
- ☐ **A**, **B**, and **C Service** required

Annual Service

- ☐ Replace Moving Hoses
- ☐ Replace Safety Switches
- ☐ Coolant System - Flush/Replace Fluid
- ☐ Change Hydraulic Oil
- ☐ ________
- ☐ ________
- ☐ ________
- ☐ ________
- ☐ ________

Additional Servicing Items

- ☐ ________
- ☐ ________
- ☐ ________
- ☐ ________
- ☐ ________
- ☐ ________
- ☐ ________
- ☐ ________
- ☐ ________

(See Operator's and Service Manual for specifications and procedures)

Form No. 95-841-SL

TORO®

Chapter 3

(For Groundsmaster 220-D/223-D only)

Diesel Engine

For Groundsmaster 228-D, use the Toro Operator's Manual and Parts Catalog along with the Kubota 05 Series Workshop Manual (Toro Part No. 01090SL).

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Introduction

This chapter gives information about specifications, maintenance, troubleshooting, testing and repair of the diesel engine used in the Groundsmaster® 220-D and Groundsmaster 223-D mowers.

Most repairs and adjustments require tools which are commonly available in many service shops. Special tools are described in the Special Tools section of this chapter. The use of some specialized test equipment is explained, however, the cost of the test equipment and the specialized nature of some repairs may dictate that the work be done at a qualified diesel engine repair facility.

This engine is manufactured by Mitsubishi Heavy Industries Limited. Service and repair parts for Mitsubishi engines are supplied through TORO Distributors and Commercial Equipment Dealers. Repair parts may be ordered by TORO Part Number. If no parts list is available be sure to provide your dealer or distributor with the TORO Model Number and Serial Number.

The engine model number is cast onto the injection pump side of the cylinder block (Fig. 1a). The serial number is stamped on the injection pump mounting surface of the crankcase (Fig. 1b). There is also a model and serial number decal on the valve cover.

IMPORTANT: Items listed in the Maintenance section of this chapter are necessary procedures to be performed in order to get maximum engine life, starting ability and performance.

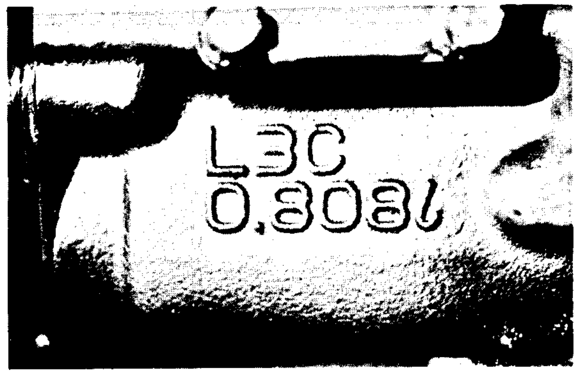


Figure 1a

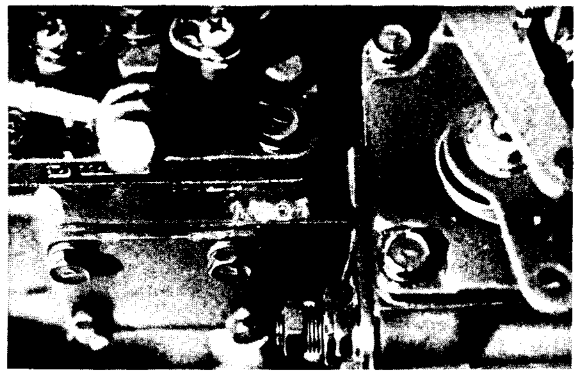


Figure 1b

Specifications

The illustrations (Figs. 2a and 2b) will give information about the general construction of the engine.

Refer to the specifications listed in this section when performing tests on the engine or examining parts for wear. Some specifications are included in the service procedures later in this chapter.

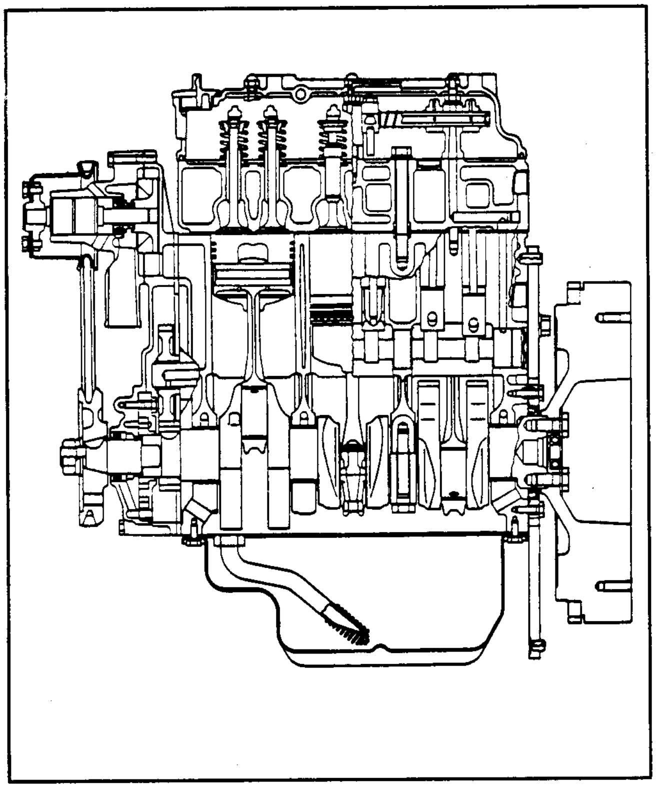


Figure 2a

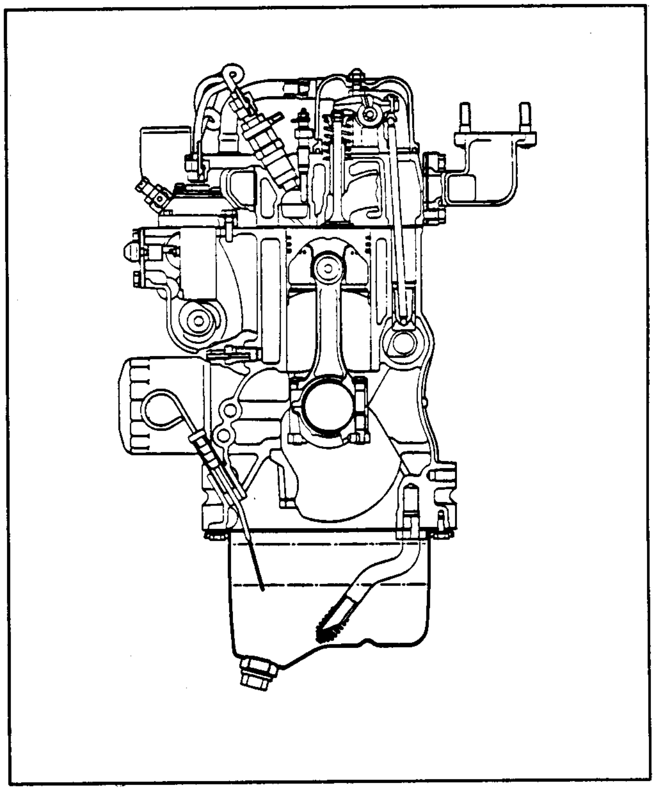


Figure 2b

General

Item	Specification
Make/Designation Groundsmaster 220-D Groundsmaster 223-D	 Mitsubishi L3C - 61TG Mitsubishi L3E - 61TG
Combustion Chamber	Swirl chamber type
Number of Cylinders	3
Bore x Stroke Groundsmaster 220-D Groundsmaster 223-D	 70 x 70 mm (2.76 x 2.76 in.) 76 x 70 mm (2.99 x 2.76 in.)
Total Displacement Groundsmaster 220-D Groundsmaster 223-D	 808 cc (49.3 $in.^3$) 952 cc (49.3 $in.^3$)
Compression Ratio	23:1
Firing Order	1 - 3 - 2
Dry Weight (approximate)	75 kg (165 lb.)
Fuel	Diesel
Fuel Injection Pump	Bosch type NC
Governor	Centrifugal weight type
Fuel Injector Nozzle	Throttle type
Fuel Injection Pressure	(140 kg/cm^2) 1990 psi
Lubrication System	Forced lubrication
Oil Pump	Gear type
Oil Filter	Paper element filter (full flow type)
Crankcase Oil Capacity: including filter of 0.5 liter (0.6 qt.) capacity - FULL / LOW	3.6 / 1.8 liter (3.8 / 1.9 qt.)
Cooling System	Forced circulation, water cooling
Water Pump	Centrifugal type
Cooling System Capacity Engine Only Total System (approximate)	 1.8 liter (1.9 qt.) 6.1 liter (7 qt.) with expansion tank
Starter	Solenoid shift type 1.6 kW (12 volt)
Alternator	AC type 12 volt 40A
Glow Plug	Sheathed type

Engine

Item	Standard Specification	Repair Limit	Service Limit
Operating Speed (no load)	3250 rpm		$^{+0}_{-50}$ rpm
Idle Speed (no load)	1700 rpm		$^{+50}_{-0}$ rpm
Compression	28 kg/cm^2 (398 psi) at 280 rpm	25 kg/cm^2 (356 psi)	22 kg/cm^2 (93 psi)
Pressure Difference Between Cylinders	2.5 kg/cm^2 (36 psi) max.		
Cylinder Injection Order	1 - 3 - 2		
Injection Timing	19° B.T.D.C. (at smoke set position) ± 1.5°	19° ± 2°	
Cylinder Head			
Bottom Surface Flatness (distortion)	Within 0.05 mm (0.002 in.)	0.1 mm (0.004 in.)	
Valve Guide I.D.	6.6 mm (0.26 in.)		
Valve Seat Angle	45°		
Valve Seat Width	1.3 - 1.8 mm (0.051 - 0.071 in.)	2.5 mm (0.1 .in.)	
Valve Seat Sinkage			–1 mm (–0.039 in.)
Valve Clearance (cold) (both intake and exhaust)	0.25 mm (0.0098 in.)		
Valves			
Valve Head Dia. (IN)	26.7 mm (1.051 in.)		
Valve Head Dia. (EX)	24.7 mm (0.972 in.)		
Overall Length	94 mm (3.701 in.)		
Valve Stem O.D.	6.6 mm (0.260 in.)		
Stem to Guide Clearance (IN)			0.10 mm (0.004 in.)
Stem to Guide Clearance (EX)			0.15 mm (0.006 in.)
Valve Seat Face Angle	45°		
Valve Head Thickness (margin width)	1 mm (0.039 in.)		0.5 mm (0.020 in.)
Valve Head Sinkage (from cyl. head bottom face)	0.5 mm (0.020 in.)		1.5 mm (0.06 in.)
Valve Spring			
Free Length	40.5 mm (1.595 in.)	39.3 mm (1.547 in.)	
Installed Load/Height (IN)	5.94 kg/35.5 mm (13.1 lb./1.4 in.)		–15%
Installed Load/Height (EX)	14.84 kg/28 mm (32.7 lb./1.1 in.)		–15%
Squareness	3°		3°
Rocker Arm I.D.	12 mm (0.472 in.)		
Rocker Arm to Shaft Clearance			0.2 mm (0.008 in.)
Cylinder Block			
Cylinder Bore	Groundsmaster 220-D: 70 mm (2.7559 in.) Groundsmaster 223-D: 76 mm (2.9921 in.)	+0.2 mm (0.0079 in.) +0.2 mm (0.0079 in.)	+0.45 mm (0.0177 in.) +0.45 mm (0.0177 in.)
Tolerance on Oversize Cylinder Bore	Each Oversize 0 to 0.03 mm (0.001 in.)		
Cylindricity	Within 0.01 mm (0.0004 in.)		
Gasket Fitting Surface Distortion	Within 0.05 mm (0.002 in.)	0.1mm (0.004 in.)	
Camshaft Hole Diameter			
Front	42 mm (1.654 in.) (ball bearing hole)		
No. 2	33 mm (1.299 in.)		
No. 3	33 mm (1.299 in.)		
Rear	33 mm (1.299 in.)		

Engine (cont.)

Item	Standard Specification	Repair Limit	Service Limit
Piston			
Type	Solid		
Material	Aluminum alloy		
Piston Outside Diameter (skirt end)	Groundsmaster 220-D: 70 mm (2.758 in.) Groundsmaster 223-D: 76 mm (2.99 in.)		
Piston to Cylinder Wall Clearance			0.3 mm (0.012 in.)
Oversize	0.25, 0.50 mm (0.01, 0.02)		
Protrusion from cylinder block top surface	0.9 mm (0.035 in.)		
Piston Pin			
Type	Semi-floating		
Outside Diameter	18 mm (0.709 in.)		
Pin to Piston Clearance			0.08 mm (0.003 in.)
Pin to Connecting Rod Clearance	Press-fit load: 1000 ± 500 kg (2200 ± 1100 lb.)		
Piston Rings			
Number of Rings			
2 Compression	No. 1: Chrome plated, semi-keystone type No. 2: Tapered		
1 Oil	Chrome plated ring with coil expander		
Compression Ring Width	2 mm (0.079 in.)		
Oil Ring Width	3 mm (0.118 in.)		
Compression Ring Side Clearance (No. 2)	0.05 - 0.09 mm (0.002 - 0.004 in.)		0.2 mm (0.008 in.)
Oil Ring Side Clearance	0.03 - 0.07 mm (0.001 - 0.003 in.)		0.2 mm (0.008 in.)
Ring Gap	0.15 - 0.40 mm (0.006 - 0.016 in.)		1.5 mm (.060 in.)
Connecting Rod			
Type	Forged I-beam		
Bend and Twist	Within 0.05 mm (0.002 in.)		0.15 mm (0.006 in.) max.
Big End Thrust Clearance	0.1 - 0.35 mm (0.004 - 0.014 in.)		0.5 mm (0.02 in.)
Connecting Rod Bearings			
Oil Clearance			0.15 mm (0.006 in.)
Undersize	0.25, 0.50 mm (0.01, 0.02 in.)		
Crankshaft			
Type	Fully counterbalanced		
Bend	Within 0.03 mm (0.001 in.)		0.05 mm (0.002 in.)
End Play	0.05 - 0.175 mm (0.002 - 0.007 in.)		
Journal O.D.	43 mm (1.693 in.)	– 0.15 mm (– 0.006 in.)	– 0.70 mm (– 0.028 .in)
Pin O.D.	40 mm (1.575 in.)	– 0.15 mm (– 0.006 in.)	– 0.70 mm (– 0.028 .in)
Finish Undersize			
Journal U.S. 0.25 mm (0.01 in.)	42.715 - 42.730 mm (1.6817 - 1.6823 in.)		
Journal U.S. 0.50 mm (0.02 in.)	42.465 - 42.480 mm (1.6719 - 1.6724 in.)		
Pin U.S. 0.25 mm (0.01 in.)	39.715 - 39.730 mm (1.5636 - 1.5642 in.)		
Pin U.S. 0.50 mm (0.02 in.)	39.465 - 39.480 mm (1.5537 - 1.5543 in.)		
Main Bearings			
Oil Clearance			0.10 mm (0.004 in.)
Undersize	0.25, 0.50 mm (0.01, 0.02 in.)		

Engine (cont.)

Item	Standard Specification	Repair Limit	Service Limit
Camshafts Drive System Front Journal Journal to Cylinder Block Hole Clearance Cam Lobe Major Diameter (both intake and exhaust) Cam Lobe Major Diameter (pump cam)	Gear Ball bearing 27.37 mm (1.078 in.) 30 mm (1.224 in.)		0.15 mm (0.006 in.) – 1.0 mm (– 0.0433 in.) – 0.7 mm (– 0.028 in.)
Tappets Outside Diameter Tappet to Cylinder Block Hole Clearance	19 mm (0.748 in.)		0.15 mm (0.006 in.)
Push Rod Bend	Within 0.3 mm (0.012 in.)		

Lubrication System

Item	Standard Specification	Repair Limit	Service Limit
Oil Capacity	3.6 liter (3.8 qt.) including oil filter		
API Service Class	CD		
Viscosity Above 68°F (20°C) 41°F to 68°F (5° to 20°C) Below 41°F (5°C)	SAE 30 or 10W-30 SAE 20 or 10W-30 SAE 10W-30		
Oil Pump Type Check Valve Opening Pressure Outer Rotor to Housing Clearance Outer Rotor Thrust Clearance	Gear type 3 $\pm$ 0.3 kg/cm^2 (42.66 $\pm$ 4.27 lb/in^2) at 1000 rpm 0.100 - 0.196 mm (0.004 - 0.008 in.) 0.04 - 0.10 mm (0.002 - 0.004 in.)	0.3 mm (0.012 in.) 0.25 mm (0.01 in.)	
Oil Pressure Switch Indicator Lamp Lighting Pressure	7.1 lbs/in^2 (0.5 kg/cm^2)		

Fuel System

Item	Standard Specification	Repair Limit	Service Limit
Fuel Pump Delivery Rate	225 cc (13.73 in^3) or more (15 sec., 12V)		
Fuel Injection Pump Model Injection Timing (B.T.D.C.)	 ND-PFR3NC $19^\circ \pm 1.5^\circ$ (at SS)	 $19^\circ \pm 2^\circ$	
Nozzles Type Injection Start Pressure	 Throttle type 140 kg/cm^2 (1992 psi)	 140 ± 10 kg/cm^2 (1992 ± 142 psi)	

Governor System

Item	Standard Specification	Repair Limit	Service Limit
Type	Centrifugal weight type		

Cooling System

Item	Standard Specification	Repair Limit	Service Limit
Coolant Capacity Engine Only Total System (approximate)	 1.8 liter (1.9 qt.) 6.1 liter (7 qt.) with expansion tank		
Thermostat Type Full Opening Valve Temperature Valve Lift	 Wax type $90^\circ \pm 1.5^\circ C$ ($194^\circ \pm 3^\circ F$) 8 mm (0.314 in.)		

Electrical System

Item	Standard Specification	Repair Limit	Service Limit
Starter			
Type	Solenoid shift type		
Nominal Output	1.6 kW - 12V		
Direction of Rotation	Clockwise as viewed from pinion side		
No-load Characteristics (Cold)			
Terminal Voltage	11.5V		
Current	100A or less		
Speed	3000 rpm or more		
Load Characteristics			
Terminal Voltage	7.7 V		11.5V
Current (torque)	300A (0.98 kg/m (6.7 ft-lb) or more)		0.7 kg/m (5 ft-lb)
Speed	980 rpm or more		
Height of Brush	17 mm (0.67 in.)		6 mm (0.24 in.)
Spring Pressure	3 kg (6.6 lb.)		
Commutator O.D.	38.7 mm (1.52 in.)		– 1.0 mm (– 0.4 in.)
Depth of Commutator Undercut	0.5 mm (0.02 in.)		0.2 mm (0.008 in.)
Pinion Gap	0.5 - 2.0 mm (0.02 - 0.08 in.)		
Thrust Gap	0.5 (0.02 in.) or less		
Alternator			
Nominal Output	12V - 40A		
Direction of Rotation	Clockwise as viewed from pulley side		
Output Characteristics - Hot			
Regulated Voltage	13.5V		
Current / Speed	21A / 2500 rpm 37A/5000 rpm		
Glow Plugs			
Rated Voltage	10.5V DC		
Rated Current (when rated voltage is applied for 30 seconds)	9.7A + 1.0A		
Resistance	0.16 ohm (at room temperature)		
Glow Plug Indicator			
Rated Current	29A		
Voltage Across Terminals (at 29A)	1.7V $\pm$ 0.2V		

Tightening Torque

The Mitsubishi diesel engine has many bolts and capscrews of special materials and sizes. It is very important that special care be used to replace all bolts and capscrews in their proper location during assembly of the engine. The torque specifications in American Standard and Metric as listed below MUST be followed in order to have the assembled engine conform to the original specifications.

Item	Specification
Cylinder Head Bolt,Main (Wet) Cylinder Head Bolt, Sub. (Wet)	7.5 - 8.5 KgM (54 - 62 ft-lb) 2.0 - 3.0 Kgm (15 - 22 ft-lb)
Connecting Rod Cap Nut	3.2 - 3.5 KgM (23 - 25 ft-lb)
Flywheel Bolt	8.5 - 9.5 KgM (62 - 69 ft-lb)
Crankshaft Pulley Nut	10.0 - 12.0 KgM (72 - 87 ft-lb)
Main Bearing Cap Bolt	5.0 - 5.5 KgM (36 - 40 ft-lb)
Rocker Stay Bolt	1.5 - 2.2 KgM (11 - 16 ft-lb)
Rocker Cover Nut	0.5 - 0.7 KgM (4 - 5 ft-lb)
Nozzle Holder (fitting to engine)	5.0 - 6.0 KgM (36 - 43 ft-lb)
Nozzle Union Collar Fixing Nut	2.5 - 3.0 KgM (18 - 22 ft-lb)
Nozzle Retaining Nut	3.5 - 4.0 KgM (25 - 29 ft-lb)
Fuel Injection Pipe Nut	2.5 - 3.5 KgM (18 - 25 ft-lb)
Delivery Valve Holder	3.5 - 3.9 KgM (25 - 28 ft-lb)
Injection Pump Hollow Screw	1.0 - 1.5 KgM (7 - 11 ft-lb)
Injection Pump Air Vent Screw	0.5 - 0.7 KgM (4 - 5 ft-lb)
Solenoid Locknut	4.0 - 5.0 KgM (29 - 36 ft-lb)
Water Temperature Gauge Joint	2.0 - 3.0 KgM (15 - 22 ft-lb)
Thermoswitch	1.9 - 2.7 KgM (14 - 20 ft-lb)
Thermo Gauge Unit	1.9 - 2.7 KgM (14 - 20 ft-lb)
Oil Filter	1.1 - 1.3 KgM (8 - 9 ft-lb)
Oil Relief Plug	4.0 - 5.0 KgM (29 - 36 ft-lb)
Oil Drain Plug	5.0 - 6.0 KgM (36 - 43 ft-lb)
Glow Plug	1.5 - 2.0 KgM (11 - 14 ft-lb)
Glow Plug Lead Wire Fitting Nut	10 - 15 KgCM (9 - 13 in-lb)

Special Tools

Filter cleaner (Fig. 3), TORO Part Number 27-7220. Mix with water and use solution to wash the Donaldson air cleaner element.

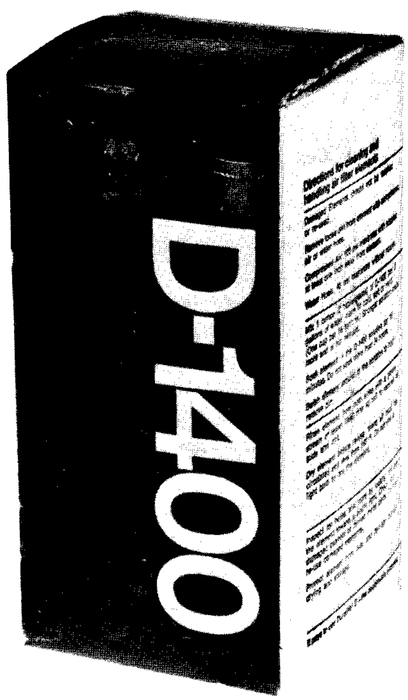


Figure 3

Compression gauge adapter (Fig. 4). Connects compression gauge into glow plug hole.

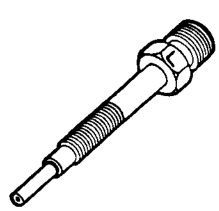


Figure 4

High pressure compression gauge (Fig. 5). Special high pressure gauge (0 - 1000 psi) (0 - 32 kg/cm^2) to test cylinder compression of Groundsmaster® 220-D diesel engine.

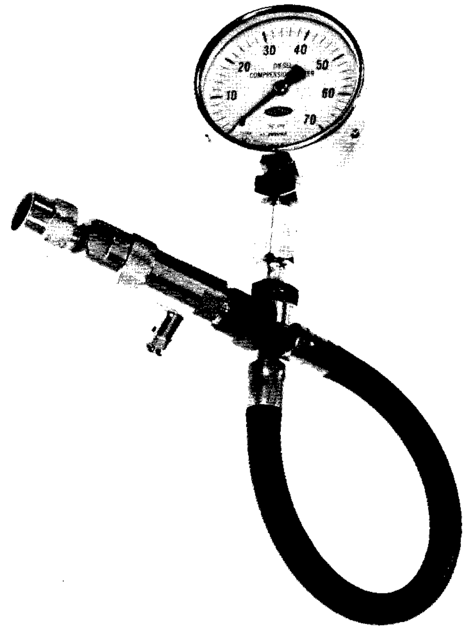


Figure 5

Piston pin tool (Fig. 6). For piston pin removal, the tool body is used with a 6000 lb (2700 kg) press. The tool body, push rod and appropriate guide are used with a press to install (set) the piston pin into the piston.

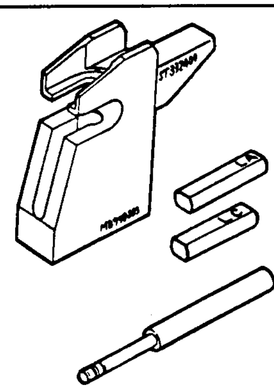


Figure 6

Nozzle tester (Fig. 7). Tests condition and opening pressure of fuel injector nozzles. Nozzle tester adapter (Fig. 8) is required to test Groundsmaster® diesel engine nozzles.

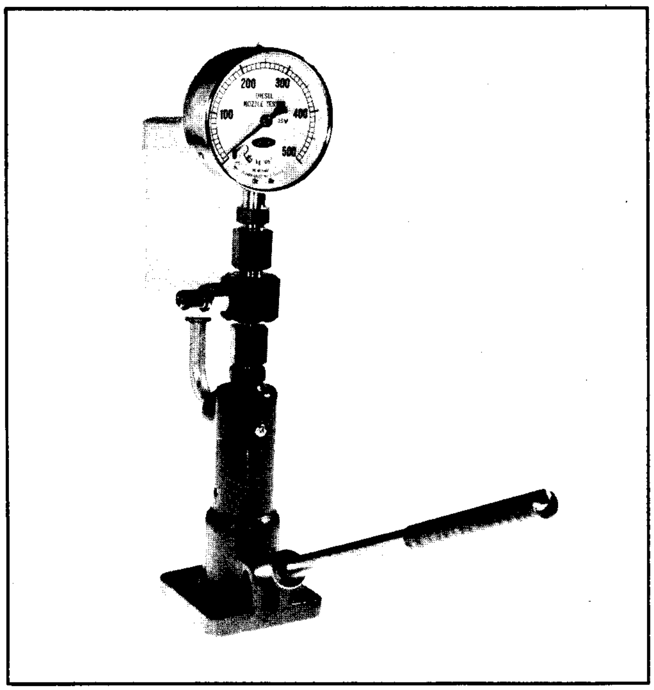


Figure 7

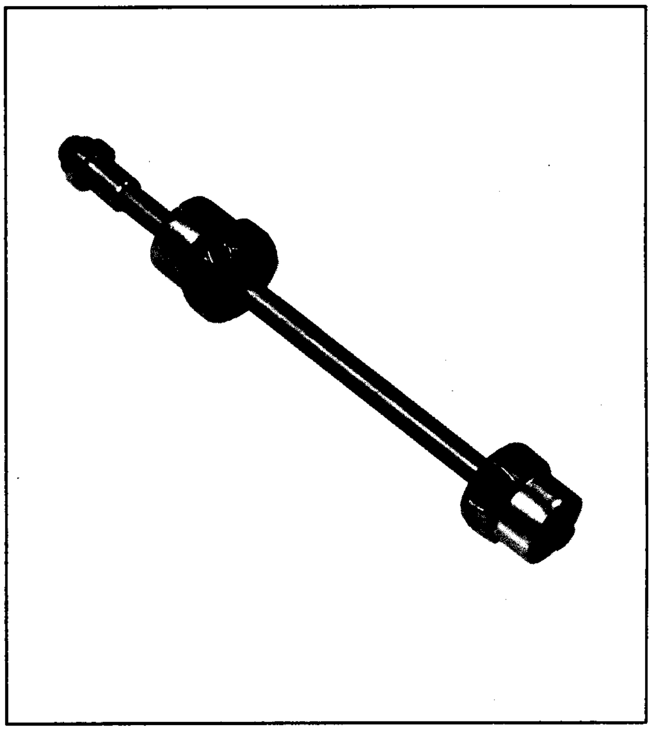


Figure 8

Maintenance

Fuel Requirements

The engine requires No. 1-D or 2-D automotive type diesel fuel with a minimum cetane rating of 40.

NOTE: Fuel with a higher cetane rating may be required if the machine is operated at high altitudes and/or low ambient temperatures.

Use No. 2-D diesel fuel at temperatures above 20°F (–7°C) and No. 1-D diesel fuel below 20°F (–7°).

Use of No. 1-D diesel fuel at low temperatures provides lower flash point and pour point characteristics. This improves starting and reduces the possibility of paraffin separating from the fuel and causing plugged filters.

Use of No. 2-D diesel fuel above 20°F (–7°C) will provide longer service life of the injection pump because of improved lubrication. DO NOT use furnace oils. Furnace oils usually contain heavy cracked distillates which are not suitable for diesel engines.

Store fuel outside of buildings in a convenient location. Tipping the front of the tank up slightly will allow contaminants to collect at the lower end away from the outlet. Never empty the tank to below 4 in. (100 mm) from the bottom of the tank to avoid picking up water and other contaminants that may have collect at the bottom. Dispose of the remaining fuel at the bottom of the tank periodically to prevent excessive build-up of contaminants.

Keep all fuel containers free of dirt, water, scale and other contaminants. Many engine problems can be the result of contaminated fuel.

Use only metal containers for fuel storage. DO NOT store the fuel in a galvanized metal container. A chemical reaction will result, which will plug the filters and cause possible fuel system damage.

To assure volatility, and to prevent contamination, do not buy more than a 6 month supply of diesel fuel.

Filling the Fuel Tank

Fill the fuel tank at the end of each day. This will prevent possible condensation inside the fuel tank. Let the engine cool down after operating before adding fuel.

CAUTION

Because diesel fuel is flammable, caution must be used when storing or handling it. Do not fill the fuel tank while the engine is running, hot or when the machine is in an enclosed area. Vapors may build up and be ignited by a spark or flame source many feet away. DO NOT SMOKE while filling the fuel tank to prevent the possibility of an explosion. Always fill the fuel tank outside and wipe up any spilled fuel before starting the engine. Use a funnel or spout to prevent spilling fuel before starting the engine. Fill the tank to approximately 1 inch (25 mm) below the top of the tank. Store diesel fuel in a clean safety-approved container and keep the cap in place on the container. Keep diesel fuel in a cool, well-ventilated place; never in an enclosed area such as a hot storage shed.

Figure 9

1. Fuel tank cap

1. Use a clean rag to clean the area around the fuel tank cap (Fig. 9).

2. Remove the cap from the fuel tank and fill the tank to 1 inch (25 mm) below the top of the tank with the proper diesel fuel. (See Fuel Requirements in this section of the book.) Install the fuel tank cap securely.

Fuel tank capacity: 8 gallons (34 liters).

3. Wipe up any diesel fuel that may have spilled to prevent a fire hazard. Remove the support from under the seat and allow the seat to pivot down to its normal position.

Fuel Tank Maintenance

Remove, drain and clean the fuel tank after every 400 hours of operation or annually, whichever comes first. Also, remove, drain and clean the tank if the fuel system becomes contaminated or if the machine is to be stored for an extended period of time. Use clean diesel fuel to flush out the tank.

Fuel Lines and Connections

Check the fuel lines and connections after every 400 hours of operation or annually, whichever comes first. Replace any parts that are deteriorated, worn or damaged. Tighten any loose connections.

Fuel Filter / Water Separator

Open the drain valve and let any water or other contamination flow out of fuel filter / water separator (Fig. 10) every day. Close the drain valve.

Replace the filter canister after every 400 hours of operation.

Replacing Fuel Filter / Water Separator Canister

1. Clean area where filter canister mounts to filter head.

2. Remove filter canister and clean mounting surface on filter head.

3. Lubricate gasket on filter canister with 10W-40 SF/CC oil.

4. Install filter canister by hand until gasket contacts mounting surface, than tighten an additional 1/2 turn.

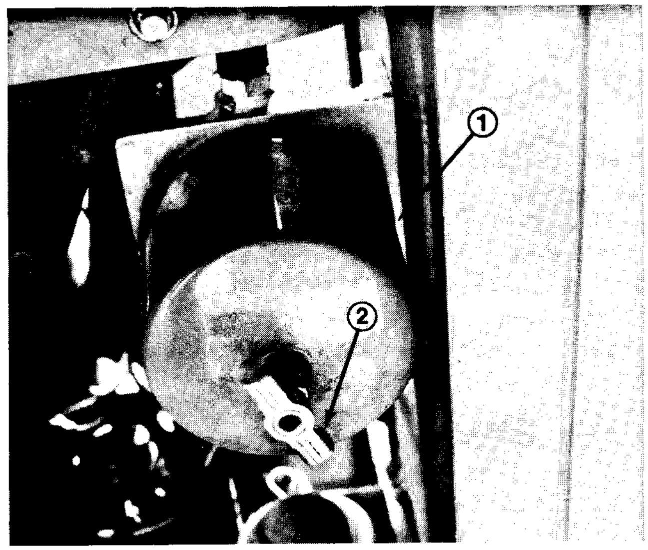


Figure 10

1. Fuel filter canister
2. Drain valve

Replacing Fuel Pump Filter

Replace the fuel pump filter after every 400 hours of operation.

1. The fuel pump is located on the inner frame at the right rear of the engine (Fig. 11).

2. Clean the outside of the fuel filter assembly.

3. Put a drain pan under the fuel pump. Use a 17 mm wrench to remove the cover from the fuel pump (Fig. 11). Take care not to damage the wire when removing the cover.

4. Pull the filter out of the pump body (Fig. 12).

5. Replace the filter with a new filter. If the filter must be replaced and you don't have a new one it can be cleaned. If the filter is to be cleaned, wash thoroughly in cleaning solvent and blow compressed air from the inside toward the outside of the element. Hold the air nozzle a minimum of 1 inch (25 mm) from the filter and move up and down while rotating the filter. Do not exceed 100 psi (689 kPa) to avoid filter damage.

IMPORTANT: Replace the filter if there is any visible dirt which cannot be washed out.

CAUTION

To prevent possible injury, wear eye protection during use of compressed air.

6. Inspect the two rubber gaskets; replace them if they are damaged.

7. Clean the magnet of any residue (Fig. 12), insert the filter into the body and install the cover.

8. Bleed the fuel system. (See Bleeding the Fuel System in the Fuel System Repairs section of this chapter.)

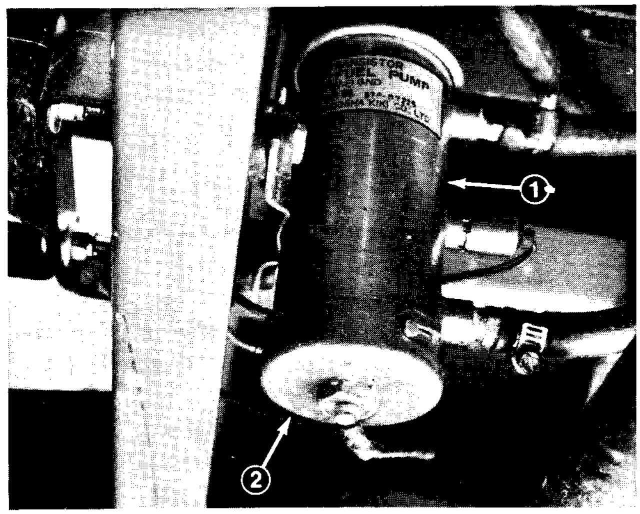


Figure 11

1. Fuel pump assembly
2. Fuel pump cover

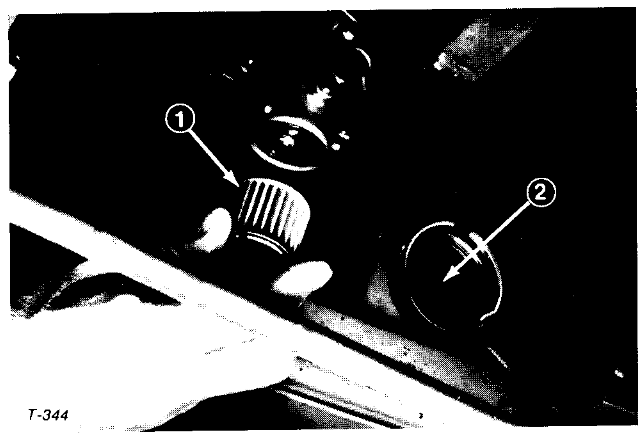


Figure 12

1. Filter
2. Magnet

Checking Engine Oil Level

Check the engine crankcase oil level before every day of operation. Check more often if necessary.

NOTE: If checking the oil level after the engine has been running, allow a minimum of 10 minutes after stopping the engine for the oil to drain down before checking.

1. Put the machine on a level surface. Stop the engine (see NOTE above).

2. Open the hood.

3. Remove the dipstick and wipe it with a clean rag. Put the dipstick into the tube and make sure it is seated fully. Remove the dipstick and check the oil level (Fig. 14). If the oil level is low, add enough oil to raise the level to the FULL (upper) mark on the dipstick.

NOTE: If the oil level is at the ADD (lower) mark on the dipstick, add 1 pint (0.47 L) of oil to raise the level to FULL. Do not overfill.

4. Pour the oil into the add hole until the level is at the FULL (upper) mark on the dipstick. The Mitsubishi engine uses high-quality detergent motor oil having the American Petroleum Institute (API) classification CD. Oil viscosity (weight) must be selected according to anticipated ambient temperatures. (See the chart on the following page.)

5. Install the cover on the engine oil add hole.

6. Install the dipstick. Make sure the dipstick is seated tightly in the tube to prevent oil leakage.

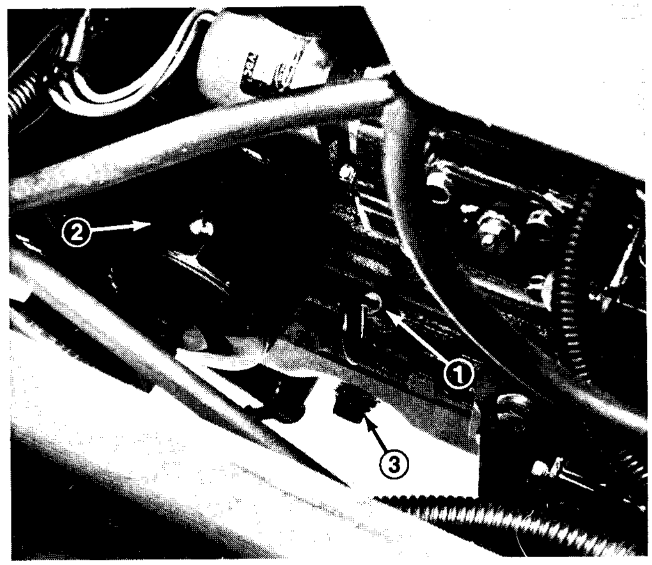


Figure 14

1. Engine oil dipstick
2. Engine oil filter
3. Engine oil drain plug

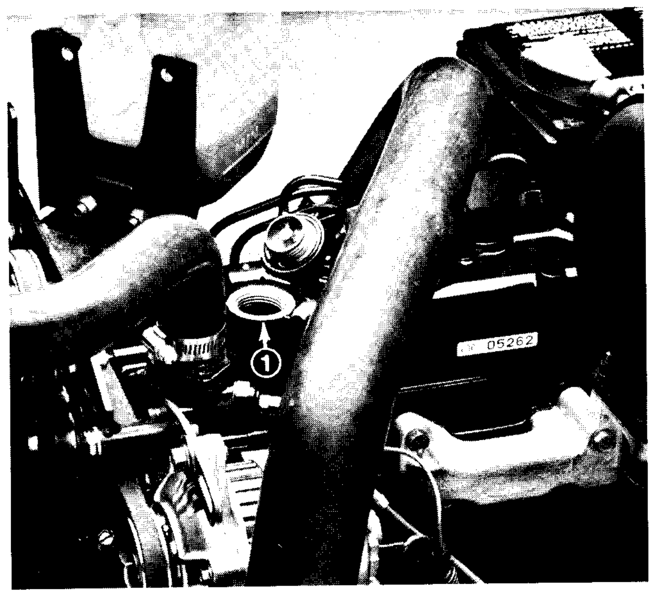


Figure 15

1. Engine oil add hole

	OIL SPECIFICATIONS AND CAPACITY	
Minimum API Service Classification	**Recommended SAE Oil Viscosity**	**Crankcase Capacity**
CD	Above 68°F (20°C): SAE 30 or 10W30 41° to 68°F (5° to 20°C): SAE 20 or 10W30 Below 41°F (5°C): SAE 10W30	3.8 quarts (3.6 L) with filter change 3.3 quarts (3.1 L) with no filter change

Changing Oil and Filter

Change the oil after every 50 hours of operation. Replace the oil filter after the first 50 hours of operation and every 100 hours of operation thereafter. Change the oil and filter more frequently when the engine is operated in dusty or sandy conditions.

1. Operate the engine until it is at operating temperature. Put the machine on a level surface and stop the engine.

2. Open the hood. Put a drain pan under the engine crankcase drain plug (Fig. 16).

3. Clean the area around the drain plug.

CAUTION

Hot oil can cause burns if it spilled or splashed on skin. Keep fingers and hands away from hot oil when removing the oil drain plug.

4. Remove the oil drain plug and let the oil flow into the drain pan. Remove and discard the oil filter (Fig. 16).

5. Clean the filter mounting surface. Apply a thin film of oil to the gasket on the new filter. Install the element by hand until the gasket just touches the mounting surface, then turn down an additional 1/4 to 1/2 turn. Do not over tighten.

6. After the oil is drained, install the plug.

7. Fill the crankcase with the correct oil. (See Checking Oil Level in this section of the book.) Wipe up any oil that may have spilled.

Engine oil capacity: 3.8 qt. (3.6 L) with filter change
3.3 qt. (3.1 L) without filter filter change

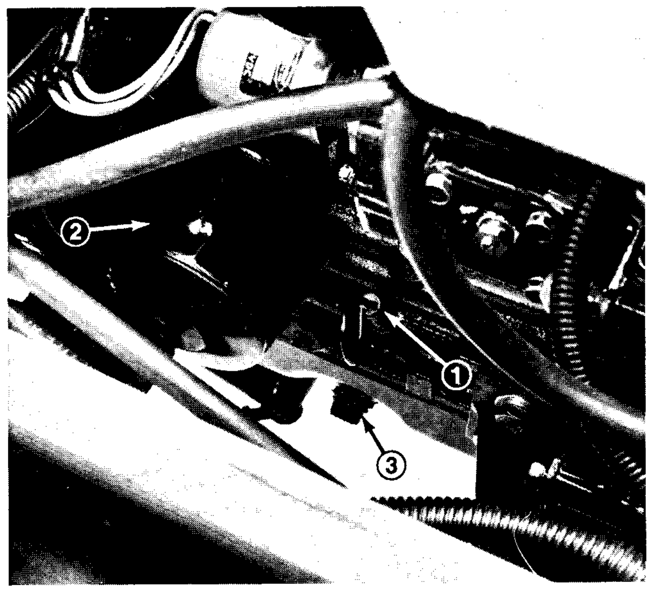


Figure 16

1. **Engine oil dipstick**
2. **Engine oil filter**
3. **Engine oil drain plug**

General Air Cleaner Maintenance

Inspect the air cleaner and hose periodically to maintain maximum engine protection and service life.

1. Make sure the hose between the air cleaner and carburetor is clamped securely. Replace the hose if it is cracked or punctured.

2. Check the air cleaner body for dents and other damage which could possibly cause an air leak. Replace a damaged air cleaner body.

3. Make sure the dust cup is sealing around the bottom of the air cleaner body.

4. Mounting screws and nuts holding the air cleaner in place must be tight.

5. The inlet cap must be free of obstructions.

Air Cleaner Dust Cup and Baffle

Inspect the dust cup and rubber baffle after every 50 hours of operation or once a week. Daily or more frequent inspection is required when operating conditions are extremely dusty and dirty. Never allow dust to build up closer than one inch (25 mm) from the rubber baffle.

NOTE: If conditions are extremely dusty and dirty, begin by checking the dust cup and baffle after each day of operation. Use this information to find out how long it takes before the dust cup should be emptied. Closer maintenance intervals for emptying the dust cup may be required when a rear discharge cutting unit is used.

1. Loosen the wing nut until the dust cup and baffle can be removed (Fig. 17). Separate the dust cup and baffle.

2. Dump the dust out of the dust cup. After cleaning the dust cup and baffle, assemble and reinstall both parts.

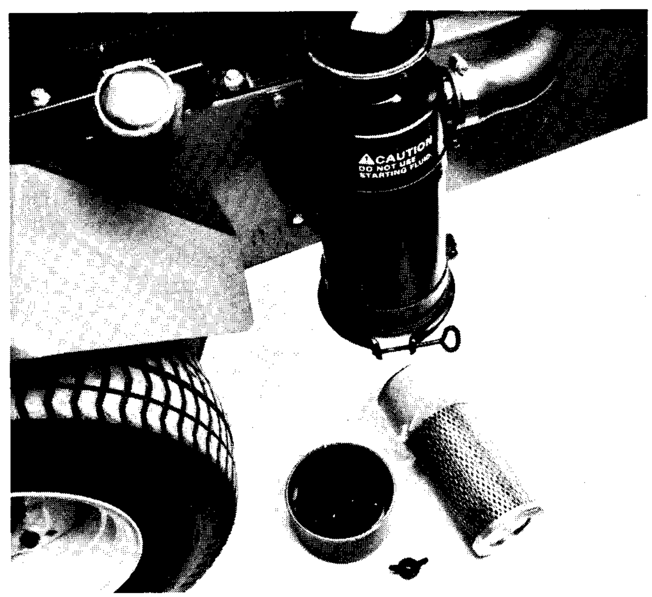


Figure 17

1. **Thumb screw**
2. **Dust cup**
3. **Baffle**
4. **Wing nut with gasket**
5. **Filter element**
6. **Air cleaner body**

Air Cleaner Filter

Service the air cleaner filter after each 250 hours of operation. Service more frequently in extreme dusty or dirty conditions. Replace the element after every six cleanings, 1500 hours of operation, or annually, whichever comes first.

1. Remove and service the dust cup. (See Dust Cup and Baffle in this section of the book.)

2. Remove the wing nut with gasket. Pull the filter element out of the air cleaner body (Fig. 18).

3. Clean the element by the washing method or compressed air method.

NOTE: The compressed air method is recommended when the element must be used immediately after servicing because a washed element must be dried before it is used. The washing method is a more complete method of cleaning. The filter MUST be washed when exhaust soot is plugging the filter pores.

Washing Method:

IMPORTANT: To prevent damage to the filter, do not remove the plastic fin assembly. Washing will remove dust from beneath fins.

A. Prepare a solution of filter cleaner (Toro Part No. 27-7720) and water. Soak the filter element approximately 15 minutes. Refer to the directions on the filter cleaner carton for complete information.

CAUTION

The filter cleaner may cause burns and is harmful if swallowed. Keep out of reach of children. Contains sodium metasilicate. Follow manufacturer's instructions.

B. After soaking the filter for 15 minutes, rinse it with clear water. Maximum water pressure must not exceed 40 psi (276 kPa) to prevent damage to the filter element.

C. Allow the element to air dry, or dry the filter element using warm, flowing air (160°F (71°C) maximum). Do not use compressed air or a light bulb to dry the filter element. This will damage the element. Inspect the element after it has dried. (See Inspecting Air Cleaner Filter Element in this section of the book.)

Compressed Air Method:

IMPORTANT: To prevent damage to the filter, do not remove the plastic fin assembly. Cleaning with compressed air removes dust from beneath the fins.

CAUTION

To prevent possible injury, wear eye protection during use of compressed air.

A. Blow compressed air from the inside to the outside of the dry filter element. Do not exceed 100 psi (689 kPa) and keep the air nozzle a minimum of 1 in. (25 mm) away from the element to prevent damage.

B. Keep the air hose nozzle at least one inch (25 mm) away from the pleated paper. Move the nozzle up and down while rotating the filter element. Inspect the element after dust and dirt are removed. (See Inspecting Air Cleaner Filter Element in this section of the book.)

4. Wipe the inside of the air cleaner body with a damp cloth to remove excess dust. Slide the filter into the air cleaner body. Install the wing nut and gasket.

5. Install the dust cup and baffle. Move the thumb screw so it is behind the air cleaner body and tighten it securely.

Figure 18

1. Thumb screw
2. Dust cup
3. Baffle
4. Wing nut with gasket
5. Filter element
6. Air cleaner body

Inspecting Air Cleaner Filter Element

Inspect the air cleaner every time it is cleaned.

1. Put a bright light inside the filter element.

2. Rotate the filter element slowly while checking for cleanliness, ruptures, holes and tears. Replace the element if it is damaged.

3. Check the fin assembly, gasket and screen for damage. Replace the element if any of these parts are damaged.

Checking Cooling System

The cooling system is filled with a 50/50 solution of water and ethylene glycol anti-freeze. Check the level of coolant in the radiator before starting the engine each day.

WARNING

Ethylene-glycol antifreeze is poisonous. Follow the antifreeze manufacturers warnings on the container.

1. Open the hood. Remove the radiator cap (Fig. 19).

WARNING

DO NOT open the radiator cap if the engine or radiator is hot. Pressurized, hot coolant can escape and cause burns.

2. Check the level of coolant in the radiator and expansion tank. The level of coolant should be to the top of the filler neck and the expansion tank filled to between the marks on its side.

3. If coolant level is low add a 50/50 solution of ethylene-glycol antifreeze and water as necessary. Do not overfill.

Cooling system capacity: approx. 7 quarts (6.1 L) (including expansion tank)

4. Install radiator cap and expansion tank cap.

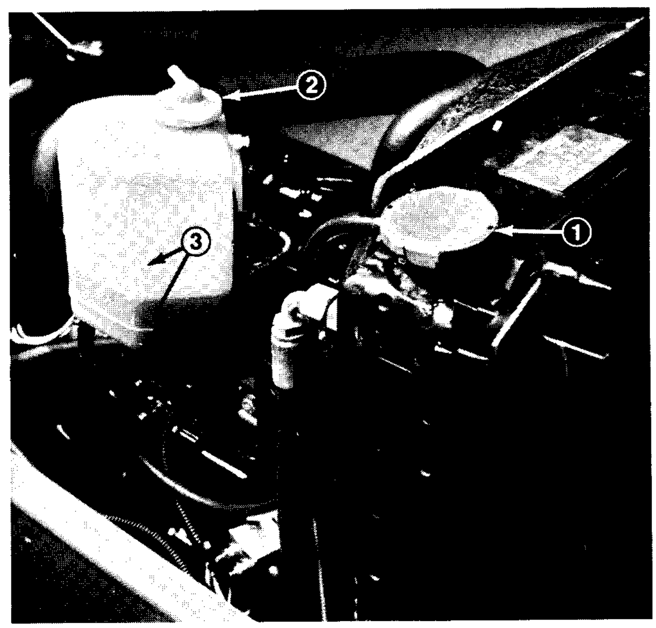


Figure 19

1. Radiator cap
2. Expansion tank cap
3. Expansion tank fill marks

Cleaning Radiator and Screen

Clean debris off screen and front of radiator every day (Fig. 20). Check and clean the radiator and screen more often if operating in extremely dry and dusty conditions.

1. Clean the screen and radiator by spraying with water, or blowing with compressed air from the fan side of the radiator and screen. Make sure the entire radiator is clean, including the corners.

> **CAUTION**
>
> **To prevent possible injury, wear eye protection during use of compressed air.**

IMPORTANT: High pressure water can bend the radiator fins and cause a loss of cooling efficiency.

2. Clean out all debris which has settled to the bottom between the screen and radiator. Remove debris from the channel before installing the screen.

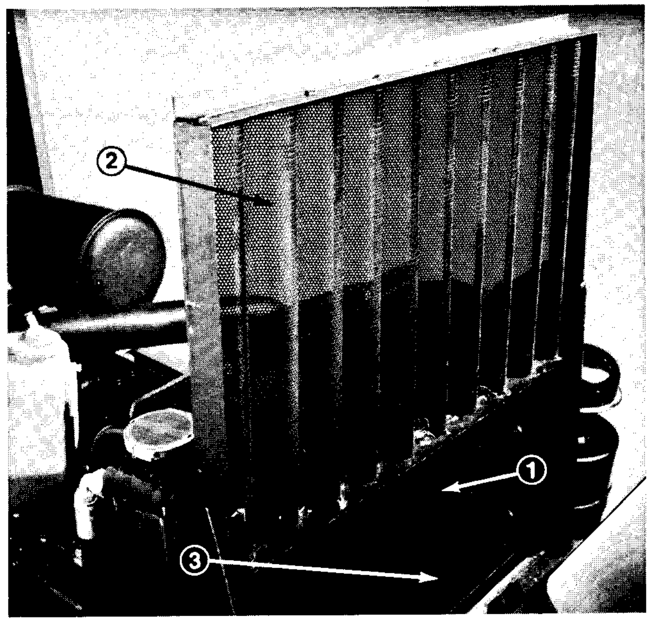


Figure 20

1. **Radiator**
2. **Radiator screen**
3. **Screen channel**

Spark Arrestor Muffler

Clean the carbon from the spark arrestor muffler after every 100 hours of operation.

> **CAUTION**
>
> **Be careful when working near exhaust system parts. Do not put your hand near or stand in line with the muffler clean-out port.**

1. Open the hood.

2. Remove the plug from the clean-out port at the lower side of the muffler.

3. Start the engine. Plug the muffler outlet with a block of wood or a metal plate so exhaust will be forced out of the cleaport. Keep the normal exhaust outlet plugged until carbon deposits stop coming out of the clean-out port.

4. Stop the engine and install the plug in the clean-out port.

5. Close the hood.

Changing Coolant

Drain and replace the coolant after every 2 years of operation.

> **WARNING**
>
> **DO NOT open the radiator cap or drain the coolant if the engine or radiator is hot. Pressurized, hot coolant can escape and cause burns.**
>
> **Ethylene-glycol antifreeze is poisonous. Follow the antifreeze manufacturers warnings on the container.**

1. Open the hood. Remove the radiator cap (Fig. 21a).

2. Drain the cooling system by opening the drain valve on the bottom of the radiator or disconnecting the lower radiator hose at the radiator (Fig. 21b).

3. Drain and flush the coolant expansion tank with clean water.

4. Check for damaged hoses and loose or damaged hose clamps. Replace as required.

5. Connect the lower radiator hose if it was disconnected.

6. Flush the cooling system with water or a commercially available cooling system flushing solution.

7. DO NOT install the radiator cap. Operate the engine for 5 minutes with the coolant temperature high enough to open the thermostat. Shut the engine off and drain the system.

8. Fill the system with water. DO NOT install the radiator cap. Repeat step 6 of this procedure.

9. Fill the system with a 50/50 solution of clean, soft water and ethylene glycol antifreeze.

   Cooling system capacity: approx. 7 quarts (6.1 L) (including expansion tank)

10. Operate the engine and check for coolant leaks.

11. Recheck the coolant level after the air has been purged from the system. The level of coolant should be to the top of the filler neck and the expansion tank filled to between the marks on its side. Add coolant if necessary. Install the radiator cap and expansion tank cap.

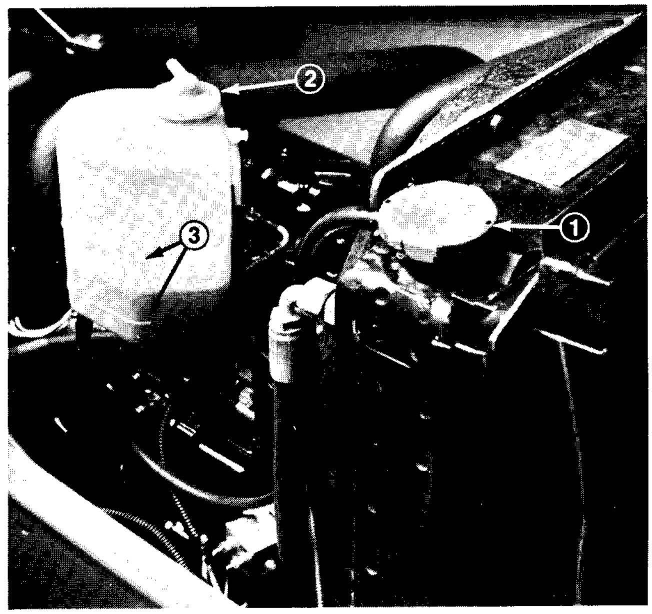


Figure 21a

1. Radiator cap
2. Expansion tank cap
3. Expansion Tank Fill Marks

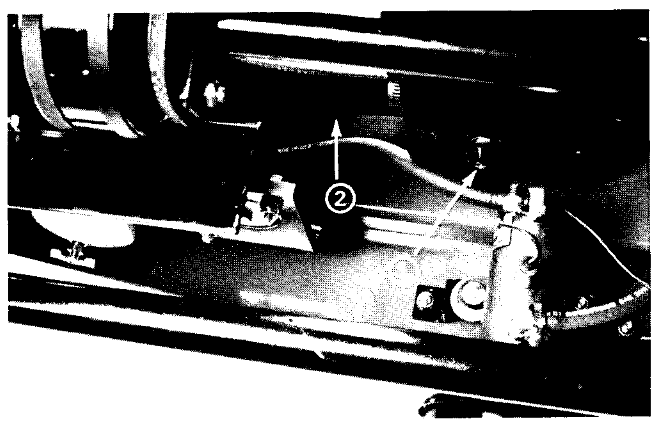


Figure 21b

1. Radiator drain valve
2. Lower radiator hose

Engine Belt Maintenance

Check the tension and condition of the engine belts after the first day of operation and every 100 hours after that. Replace any belts that are cracked, frayed, or glazed.

WARNING

Stop the engine before checking the belts. Keep clothing and body parts away from moving parts.

Adjustments

Alternator Belt

1. Open the hood.

2. Check the belt tension by pushing down on the belt midway between the alternator and crankshaft pulleys (Fig. 22). The belt should deflect 3/8 to 1/2 in. (10 - 12 mm) when a 22 lb. (10 kg) force is applied to the belt midway between the water pump pulley and alternator pulley.

3. To adjust the belt tension, loosen the alternator brace bolt (Fig. 23) and alternator support bolt.

4. Insert a pry bar between the alternator body and the engine. Apply only enough pressure to get the correct belt tension.

5. Hold the alternator in position and tighten the alternator brace bolt. Tighten the alternator support bolt.

6. Close the hood.

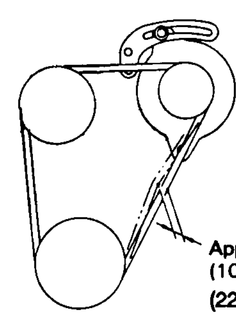


Figure 22

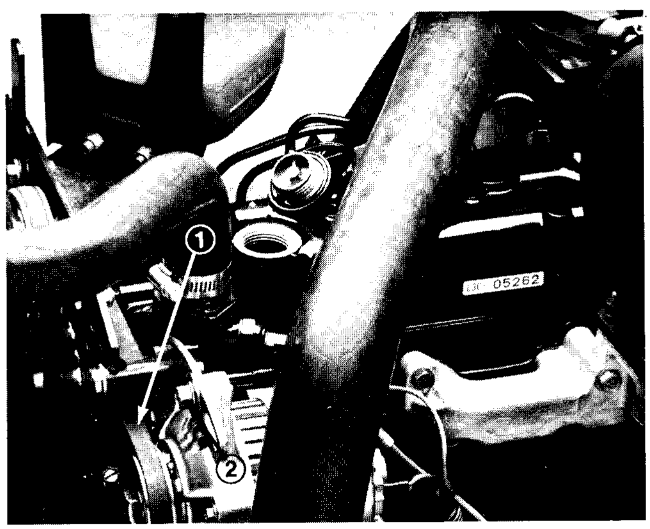


Figure 23

1. Alternator / water pump belt
2. Alternator brace bolt

Fan Belt

1. Open the hood.

2. To check and adjust the belt tension, loosen the two bolts securing the idler pulley lever to the bracket (Fig. 24). Put 10 lbs. (4.5 kg) of force on top of the idler pulley lever and tighten the upper bolt. Tighten the lower bolt.

3. Close the hood.

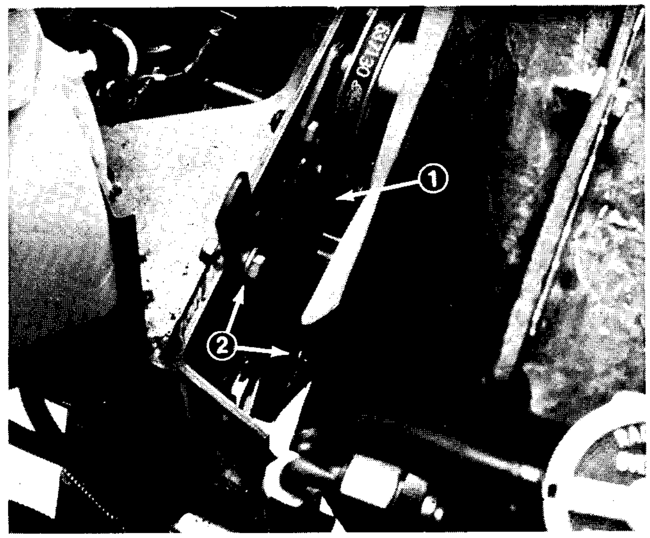


Figure 24

1. **Fan belt**
2. **Tension adjustment bolt**

Valve Clearance

Check the valve clearance after the first 50 hours of operation and every 400 hours of operation after that.

1. The engine must be cold when the valve clearance is checked.

2. Remove the air breather hose from the rocker cover.

3. Remove the rocker cover nuts and washers. Remove the rocker cover.

4. Tighten the cylinder head bolts to the proper torque. The rocker assembly must be removed before tightening the cylinder head bolts. When tightening the cylinder head bolts, lower the coolant level in the engine, loosen the bolts slightly and then re-tighten in the sequence shown (Fig. 25).

> **M10 head bolt torque: 7.5 - 8.5 KgM (54 - 62 ft-lb)**
> **M8 head bolt torque: 2.0 - 3.0 KgM (15 - 22 ft-lb)**
> **Rocker stay bolt torque: 1.5 - 2.2 KgM (11 - 16 ft-lb)**

5. Rotate the crankshaft until the TDC mark (located next to the injection timing mark(s) on the pulley lines up with the registration mark on the gear case (Fig. 26). This will be TDC on cylinder No. 1.

NOTE: There are two TDC positions (compression and intake strokes). At compression TDC the rocker arms will not move when the crankshaft pulley is rotated a small distance each way. Compression TDC is where the valves are to be adjusted.

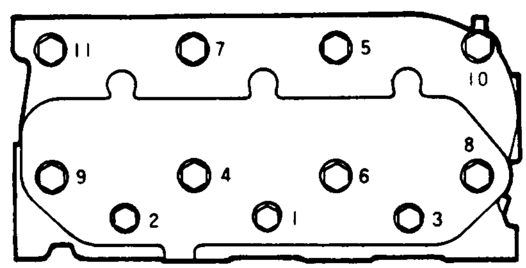


Figure 25

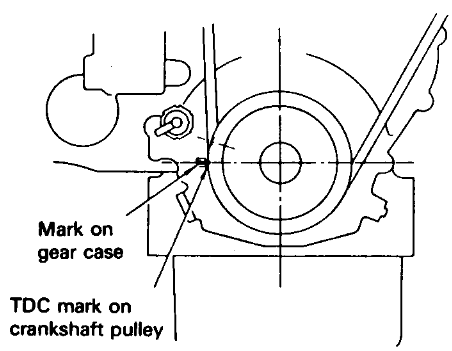


Figure 26

6. Measure the valve clearance by using a thickness gauge inserted between the valve stem and rocker arm. The correct valve clearance for both the intake and exhaust valves is 0.25 mm (0.01 in.).

7. To adjust the valve clearance, loosen the adjusting lock nut and turn the rocker arm adjusting screw clockwise or counterclockwise until you get the correct clearance (Fig. 27). Tighten the locknut securely. Check to make sure that the clearance was not changed while tightening the locknut.

8. Perform steps 6 and 7 of this procedure for cylinder No. 2 and 3 while at their TDC position. Turn the crankshaft 240° clockwise to get No. 3 cylinder TDC. Turn the crankshaft an additional 240° clockwise to get No. 2 cylinder TDC.

9. Install the rocker cover. Install the rocker cover nuts and washers. Install the air breather hose on the rocker cover.

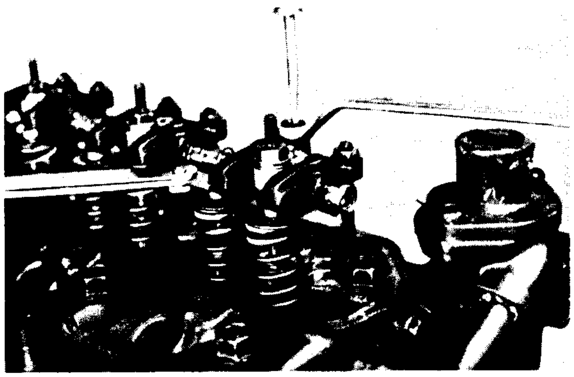


Figure 27

Engine Speed Adjustments

Adjustments to the engine speed settings are not normally necessary unless the throttle linkage, injection pump, or governor mechanism have been repaired, rebuilt, replaced or are not operating correctly.

Since there is no ignition system from which to power an electronic tachometer, a vibration-type tachometer must be used to set engine speed.

High Speed Adjustment

NOTE: Specified rpm is with no load on engine (fan drive and transmission coupler disconnected).

The high speed set bolt has been set properly and sealed at the factory. Never tamper with the seal unless necessary.

1. The engine should be at operating temperature. Make sure the parking brake is engaged.

2. Open the hood.

3. Loosen the lock nut on the high speed set bolt (Fig. 28a).

4. Adjust maximum engine speed to 3200 $^{+0}_{-50}$ rpm by rotating the high speed set bolt. Tighten the lock nut.

5. Install a wire and lead seal on the high speed set bolt.

Idle Speed Adjustment

NOTE: Specified engine rpm is with no load on engine (fan drive and transmission coupler disconnected).

1. The engine should be at operating temperature. Make sure the parking brake is engaged.

2. Move the throttle control lever to the idle position (against the stop plate). Open the hood.

3. Loosen the lock nut on the low speed set bolt (Fig. 28a).

4. Adjust idle speed to 1700 $^{+50}_{-0}$ rpm by rotating the low speed set bolt. Tighten the lock nut.

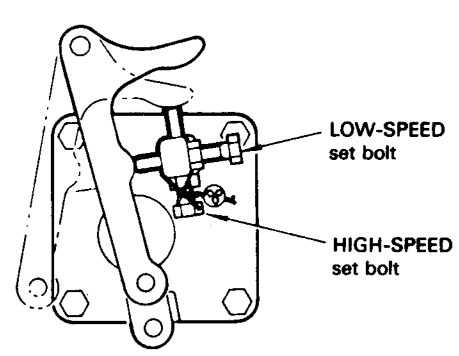


Figure 28a

Throttle Linkage Adjustment

The throttle lever (Fig. 28b) must not touch the end of the slot during the full range of motion from idle to full engine rpm. The throttle lever should be within 0.125 in. (3 mm) from the front of the slot with the governor lever touching the high speed set bolt (Fig. 28c).

1. Loosen the capscrew and nut securing the throttle cable to the governor lever.

2. Push the governor lever all the way back so it is contacting the high speed set screw.

3. Move the throttle lever so it is within 0.125 in. (3 mm) from the front of the slot.

4. Tighten the cap screw and nut securing the throttle cable to the governor lever.

5. Tighten the lock nut on the throttle lever pivot so 10 - 15 lb. (4.5 - 6.8 kg) of force is required to move the throttle lever.

6. Make sure the thottle cable conduit is against the outer frame and does not rub on the radiator.

7. Make sure the throttle cable conduit does not interfere with the full range of motion of the throttle lever or governor lever.

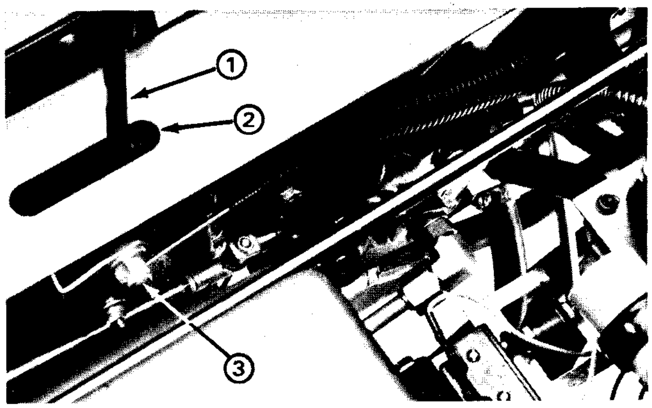


Figure 28b

1. Throttle lever
2. Slot
3. Lock nut

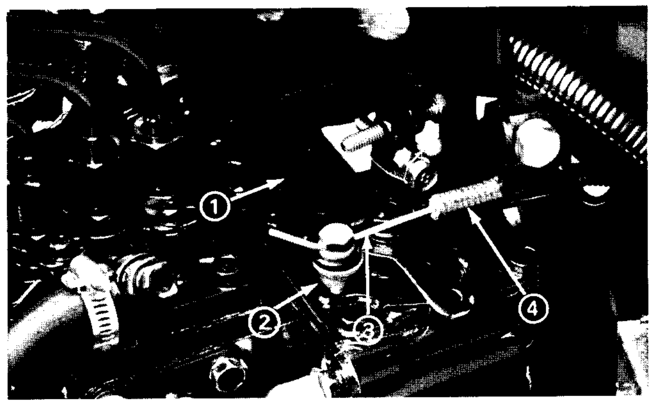


Figure 28c

1. Governor lever
2. Cap screw and nut
3. Throttle cable
4. Throttle cable conduit

Troubleshooting

Giving immediate attention to any indication of a problem can prevent major failures, and increase the life of the engine.

Never make more that one adjustment at a time, then locate the trouble by a process of elimination. Remember the cause is usually SIMPLE, rather than mysterious and complicated.

(1) Engine Fails to Start

Problem/Probable Cause	Possible Remedy
● Slow Cranking Speed	
1. Engine oil viscosity is too high.	Use correct oil.
2. Battery is discharged.	Charge the battery.
3. Battery plates sulfated.	Replace the battery.
4. Battery terminal dirty or poor connection.	Clean the terminals/repair or tighten cables.
5. Starter failure.	Repair or replace starter.

(1) Engine Fails to Start (continued)

Problem/Probable Cause	Possible Remedy
● Injection system	
1. Air in fuel line.	Purge air from the fuel system.
2. Fuel filter is clogged.	Clean/replace filters.
3. Injection pressure is low.	Adjust injection pressure of nozzle.
4. Poor nozzle spray.	Clean or replace the nozzle.
5. Poor injection pump pressure.	Repair or replace injection pump.
6. Incorrect fuel.	Use recommended fuel.
7. Injection timing is advanced.	Adjust injection timing.
● Low Compression	
1. Valve clearance is incorrect.	Adjust valve clearance.
2. Valve seat surface is rough, or burnt.	Finish surface by lapping. Replace valve and guide.
3. Valve spring is broken.	Replace the spring.
4. Leaking cylinder head gasket.	Replace the gasket.
5. Piston rings are seized.	Overhaul the engine.
6. Piston rings and cylinder are worn.	Overhaul the engine.
● Glow plug is burnt out.	Replace the glow plug.
● Glow plug does not glow red hot.	Poor wiring connection.
● Governor lever position incorrect.	Adjust governor lever.
● Governor spring broken or disconnected.	Repair governor spring.

(2) Low Power

Problem/Probable Cause	Possible Remedy
● Low Compression	Refer to "starting failure, low compression."
● Injection system faulty	
1. Injection timing is incorrect.	Adjust the injection timing.
2. Injection volume is insufficient.	Repair or replace pump.
3. Injection pressure is low.	Inspect the injection nozzle, adjust pressure.
● Lack of fuel	
1. Air in fuel system.	Inspect fuel line connections.
2. Filter is clogged.	Clean/replace filters.
3. Fuel tank is contaminated.	Clean the fuel tank.
● Air cleaner is clogged	Clean the air cleaner; replace the element if unserviceable.
● Engine overheats	
1. Low or incorrect coolant level.	Check coolant.
2. Improper belt tension.	Adjust belt tension.
3. Defective water pump.	Replace water pump.
4. Radiator clogged, or leaks pressure.	Clean/repair the radiator, inspect hoses and cap.
5. Injection timing is incorrect.	Adjust the injecting timing.
6. Engine oil is low.	Add engine oil.
7. Defective thermostat.	Replace thermostat.
● Carbon build-up in muffler.	Decarbon muffler.

(3) Excessive Oil Consumption

Problem/Probable Cause	Possible Remedy
● Oil leaks	
1. Oil seals worn.	Check for wear, and replace if worn.
2. Gaskets leaking.	Replace the gasket.
3. Loose fasteners.	Retighten fasteners.
4. Drain plug is loose.	Tighten the plug.
5. Pipe plugs at oil pump loose.	Tighten the plugs.
● Burning Oil	
1. Ring end gaps positioned wrong.	Stagger end gaps properly.
2. Connecting rod bent or twisted.	Overhaul engine.
3. Piston rings worn.	Replace the rings. Overhaul engine.
4. Piston and cylinder are worn.	Overhaul engine.
5. Faulty valve stem seal.	Replace valve stem seal.
6. Valves or valve guides worn.	Replace the valves or valve guides.

(4) Abnormal Engine Noises

Problem/Probable Cause	Possible Remedy
● Crankshaft and main bearing	
1. Worn crankshaft.	Repair or replace crankshaft; inspect bearings.
2. Worn or damaged bearings.	Replace bearings; inspect crankshaft.
● Connecting rod and bearings	
1. Connecting rod bearing worn.	Replace bearing; inspect crankshaft.
2. Worn crankpin.	Repair or replace crankshaft; inspect bearing.
3. Twisted connecting rod.	Replace connecting rod.
● Piston, piston pin, and piston rings	
1. Cylinder is worn.	Overhaul engine.
2. Piston pin is worn.	Replace piston and pin, inspect cylinder, rod, and rings.
● Rocker arm mechanism and relative parts	
1. Camshaft is worn.	Replace camshaft.
2. Excessive valve clearance.	Adjust the valve clearance.
3. Worn timing gear.	Replace the timing gear; inspect mating gears.
4. Worn fan shaft bearings.	Replace the bearing/shaft.

(5) Engine Runs Rough

Problem/Probable Cause	Possible Remedy
● Injection pump mechanism	
1. Irregular injection pump volume.	Repair or replace injection pump.
2. Faulty control rack function.	Repair or replace injection pump.
3. Worn delivery valve.	Replace the delivery valve.
4. Faulty injection nozzle.	Repair or replace nozzle.
● Governor mechanism	
1. Governor lever sticking.	Inspect/repair governor.
2. Stretched or weak governor spring.	Replace the spring.

Glow Plug Test

CAUTION

Be careful while handling or testing glow plugs. Glow plugs become extremely hot. Accidental contact with the heated plug tip could cause personal injury.

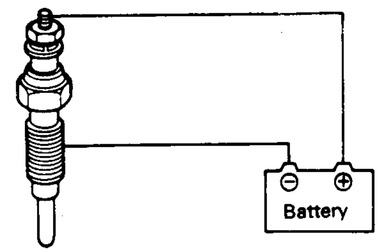


Figure 29

1. Disconnect the wire lead(s) to the glow plug.

2. Remove the glow plug.

3. Inspect the glow plug for signs of a burnt glow plug end tube.

NOTE: If the metal of the glow plug end is melted, it is a sign of cylinder overheating. (See Engine Overheats in the Troubleshooting section of this chapter.)

4. Connect the positive (+) battery terminal to the glow plug terminal, and the negative (–) battery terminal to the plug body (Fig. 29). If the glow plug glows red-hot, the glow plug is operating correctly.

5. Replace any glow plugs that do not operate correctly.

Compression Test

Normal cylinder compression is 28 kg/cm^2 (398 psi) at 280 rpm (normal cranking speed). The engine should be warm - coolant temperature of 50° C (120° F).

IMPORTANT: DO NOT put oil into the combustion chamber before performing a compression test. Damage may result because of "hydraulic" forces acting upon the piston and connecting rod.

1. Remove the glow plug lead wires and glow plugs from all three cylinders.

2. Insert the compression gauge adapter into the glow plug hole. (See the Special Tools section of this chapter.)

3. Connect the high pressure compression gauge to the adapter (Fig. 30a).

4. Disconnect the fuel stop solenoid electrical connector to prevent fuel delivery during the compression test (Fig. 30b). This will prevent wash-down of the cylinders and inaccurate readings.

5. Crank the engine with the starter motor until you get a stable gauge reading.

6. Normal compression is 28 - 32 kg/cm^2 (398 - 455 psi). If the pressure is less than 25 kg/cm^2 (356 psi) it will be necessary to find the cause of low compression. (See Engine Fails to Start - Low Compression in the Troubleshooting section of this chapter.)

7. Repeat the test for the other two cylinders. Difference between cylinders should be no more than 2.5 kg/cm^2 (36 psi).

8. Connect the fuel stop solenoid electrical connector.

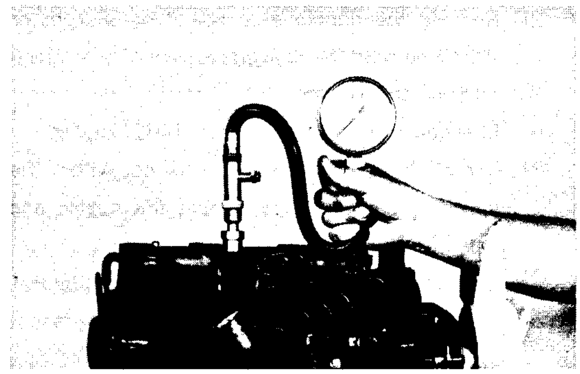


Figure 30a

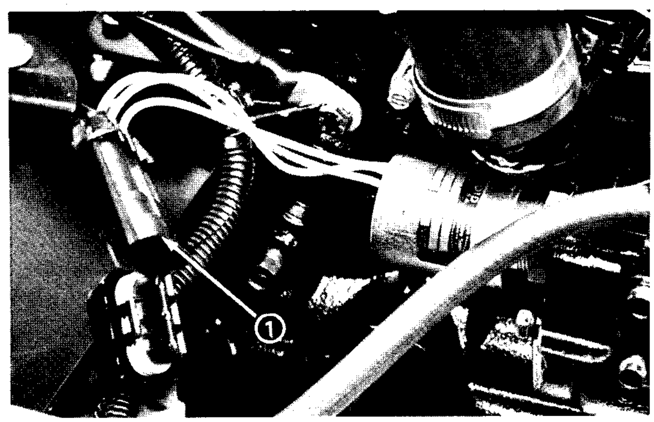


Figure 30b

1. Fuel stop solenoid electrical connector

Nozzle Tests

There are several tests to examine the condition of the injection nozzles. These tests require the use of a nozzle tester and nozzle tester adapter. (See the Special Tools section of this chapter.)

> **DANGER**
>
> **The nozzle tester forces fuel from the nozzle under extremely high pressure. Always point the nozzle tip away from yourself and any other personnel. Contact with the fuel stream, even though it appears to be a mist can cause fuel to penetrate clothing and skin. If fuel is injected into the skin get proper medical attention from a doctor immediately. A serious infection or other reaction can develop if the injury is not properly treated. Tighten all adapter fittings to prevent leaks. If a leak is suspected, use a piece of cardboard, not your hands to search for a leak.**

> **CAUTION**
>
> **To prevent possible injury, wear eye protection when operating the nozzle tester.**

IMPORTANT: Always use fresh filtered fuel in the nozzle tester. Use of dirty fuel can damage the precision parts of the injector nozzle. It is a good practice to:

1. Bolt the tester securely to the test bench.

2. Use a drain pan to catch fuel.

3. Flush the adapter by pumping the handle of the tester slowly several times before attaching the nozzle to be tested.

Injection Pressure Test

The diesel engine requires that fuel be sprayed into the combustion chamber at a precise point in the compression stroke. The point at which this fuel injection occurs is determined by the injection timing. If the nozzle is defective, damaged or adjusted incorrectly, starting failures, low power output, or engine knocking can occur.

1. Securely fasten the nozzle to the adapter.

2. Pump the handle several times to purge air from the nozzle mechanism.

3. Allow pressure to dissipate before performing the test.

4. Operate the pump handle slowly and observe the gauge to determine the pressure at which the nozzle opens and the fuel is sprayed.

5. Verify that starting pressure is within the following limits: Minimum starting pressure is 130 kg/cm^2 (1850 psi); Maximum starting pressure is 150 kg/cm^2 (2134 psi).

6. Starting pressure can be adjusted by adding or removing shims from the nozzle. (See Nozzle Service in the Fuel System Repairs section of this chapter.) A 0.1 mm shim will cause a 10 kg/cm^2 (140 psi) starting pressure difference. Shims are available from 1.25 mm to 1.7 mm thick in 0.5 mm increments.

7. Repeat the test after installing shim to verify that a correct starting pressure has been obtained.

Chattering Test

Proper and free operation of the nozzle valve can be determined by the chattering test.

1. Securely fasten the nozzle to be tested to the adapter.

2. Operate the pump handle slowly (ten strokes per minute). As the pump pressure reaches the starting pressure the nozzle valve will chatter as it opens and closes rapidly. A nozzle which does not chatter may be the result of a binding or bent nozzle valve.

Nozzle Leakage Test

A nozzle that leaks fuel from the nozzle orifice must be replaced.

1. Securely fasten the nozzle to the adapter.

2. Wipe all fuel from the nozzle.

3. Operate the pump until the pressure is approximately 108 kg/cm^2 (1500 psi). Maintain this pressure to the nozzle.

4. Watch for leaks where the threaded nozzle body threads into the retaining nut. Leaks in this area would indicate a bad seat between the distance piece and/or the body or nozzle assembly.

5. If leakage occurs, verify that the body is tightly fastened in the retaining nut. If the leak continues, replace the nozzle.

6. While pressure is being applied, watch for an accumulation of fuel at the tip of the nozzle (Fig. 31). A small amount of fuel may be present due to a previous chattering test - this would be normal. If the fuel accumulates and drips down during the test (about ten seconds) the nozzle assembly is defective and must be replaced.

Spray Test

For proper combustion, the nozzle must effectively atomize the injected fuel.

1. Operate the pump handle at a rate of 20 - 30 strokes per minute.

2. Observe the injector nozzle spray. The spray pattern should be finely atomized in a broad, straight stream (Fig. 32).

3. If the nozzle fails to spray properly, it must be cleaned, repaired or replaced. (See Nozzle Servicing in the Fuel System Repairs section of this chapter.)

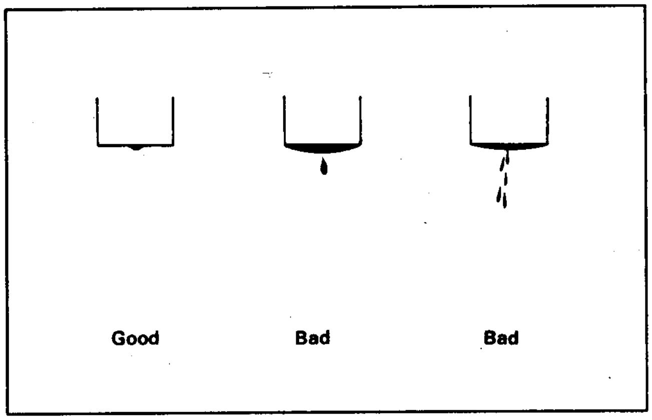


Figure 31

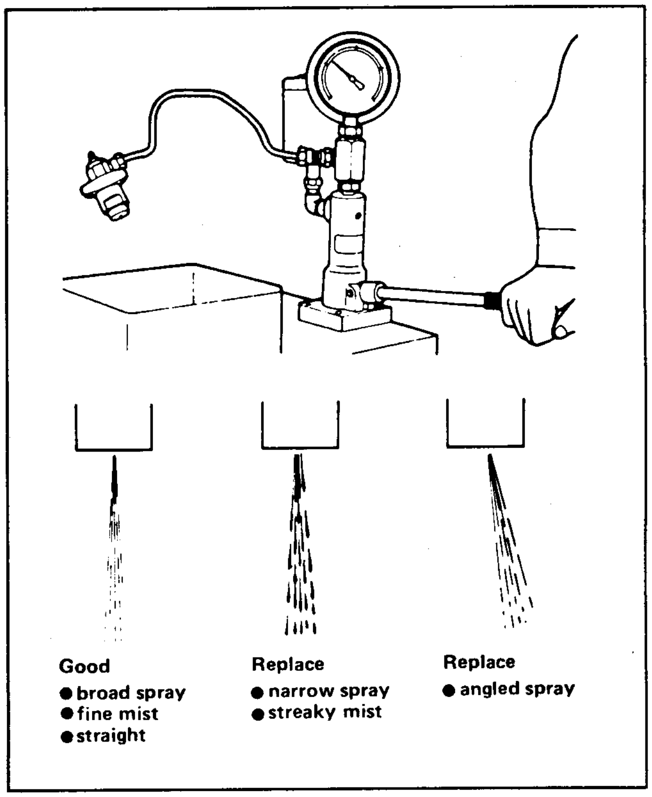


Figure 32

Injection Pump Test

Calibration of fuel delivery volumes, pressure and distribution between pump barrels should be performed by a professional diesel engine service shop. Special test fixtures and equipment are required.

It is possible to determine if the fuel injection pump requires service through a process of elimination using other fuel system tests. The following test procedure will help isolate fuel system difficulties.

1. Make sure that fuel is being supplied to the injector pump. (See Fuel Pump Test in this section and Bleeding Air From the Fuel System in the Fuel System Repairs section of this section.)

2. Check the operating condition of the injection nozzles to make sure that the injection pressure is correct. (See Injection Pressure Test in this section of the book.)

3. Make sure that the injection pump is providing sufficient fuel pressure to operate the nozzle by performing the following procedures:

A. Loosen the fuel delivery pipe from the number one nozzle.

B. Remove the nozzle from the cylinder head.

C. Connect the fuel delivery pipe to the nozzle assembly so the tip of the nozzle is pointed away from the engine. Tighten the fitting securely.

D. Put the throttle control in the FAST position. Turn the ignition key to the START position to crank the engine. Observe the nozzle.

DANGER

The injection pump forces fuel from the nozzle under extremely high pressure. Always point the nozzle tip away from yourself and any other personnel. Contact with the fuel stream, even though it appears to be a mist can cause fuel to penetrate clothing and skin. If fuel is injected into the skin get proper medical attention from a doctor immediately. A serious infection or other reaction can develop if the injury is not properly treated. Tighten all adapter fittings to prevent leaks. If a leak is suspected, use a piece of cardboard, not your hands to search for a leak.

If the nozzle produces an atomized mist of fuel the injector pump for that cylinder is operating properly. Failure of the nozzle to inject fuel can indicate a injection pump cylinder that is not operating correctly.

5. Repeat the test for the other cylinders.

Injection Timing Test

Injection timing can be adjusted by installing shims under the pump body. The timing is important because it determines when the fuel enters the combustion chamber.

The most accurate method of timing is done with an electronic diesel timing tester (available from major tool supply companies).

The following method is an initial setting for starting the machine.

1. Remove the number one injection pipe from both the pump and nozzle. (The number one cylinder is opposite from the flywheel end of the engine.)

2. Set up the injection pump for the test:

   A. Remove the delivery valve holder (Fig. 33). Remove the delivery valve and spring. The valve seat must remain in place.

   B. Replace the valve holder and tighten it in place.

   C. Connect the fuel injection pipe to the nozzle holder so the open end of the pipe will discharge fuel into a container.

3. Put the throttle control in the middle of its range of travel.

4. Slowly rotate the crankshaft counterclockwise from the flywheel end (normal rotation) until the IT marks (injection timing marks) on the crankshaft pulley are approximately 1/2 in. (21 mm) from alignment with the stationary pointer on the engine gear case (Fig. 34). Make sure the number one cylinder compression stroke is approaching by checking the push rods. Both push rods on the number one cylinder should be loose and the valves closed. If either push rod is tight, rotate the engine crankshaft one full revolution and inspect the push rods again.

5. Turn the ignition switch ON so the fuel pump will supply fuel through the injection pump and out the number one injection pipe.

6. Rotate the engine crankshaft slowly in the normal direction until the flow from the number one injection pipe just stops. This is the moment of actual injection timing. (A screwdriver inserted between the transmission drive hub and rubber coupler will provide control and leverage to slowly rotate the engine crankshaft.)

NOTE: Wear of the internal parts in the injection pump may allow the fuel to continue to drip from the injection pipe. If the slowest flow rate exceeds 1 drop in 5 seconds, repair of the pump should be considered.

7. Standard injection timing can be confirmed by the IT marks on the crankshaft pulley and the stationary pointer on the crankcase (Fig. 34).

The center mark on the pulley represents 19° BTDC; standard fuel injection timing. The outside marks represent 21° BTDC and 17° BTDC; the acceptable range of injection timing.

Shims are available in different sizes from 0.2 to 1.0 mm thick. Adding or removing a shim 0.1 mm thick will change injection timing by 1°. Increase shim thickness if injection is too early. Decrease shim thickness if injection is too late. (See Injection Pump Servicing in the Fuel System Repairs section of this chapter.)

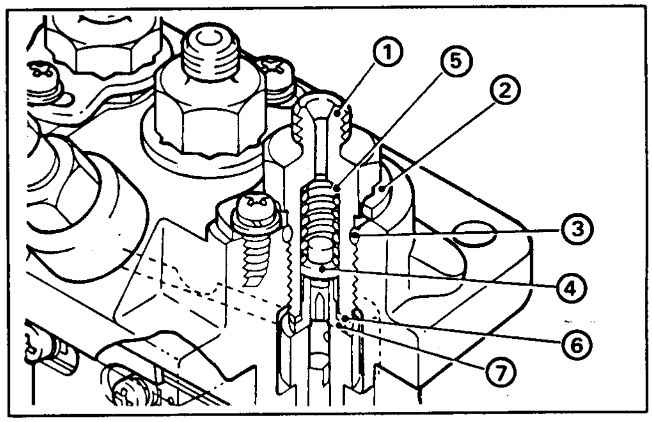


Figure 33

1. Delivery valve holder
2. Holder stopper
3. O-ring
4. Delivery valve
5. Spring
6. Gasket
7. Valve seat

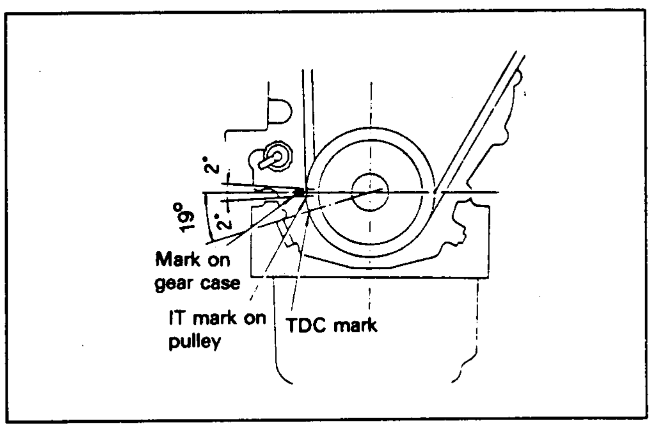


Figure 34

Fuel Pump Test

1. Turn the ignition switch to the ON position. Test for pump operation by listening for the pump oscillating sound, or by feeling for vibration which indicates the pump is operating.

2. If no pumping action occurs when the ignition switch is turned on, connect a 12 volt DC battery directly to the pump (Fig. 35). If the pump now operates, check for an electrical failure of the pump circuit, eg. fuses, connections, wires, etc.

3. The delivery of the fuel pump may be checked by disconnecting the fuel lines from the water separator and fuel filter and routing them to a can of filtered diesel fuel and a drain pan (Fig. 35). Activate the pump and measure the amount of fuel pumped in during a 15 second time interval. The standard pump rate is approximately 8 ounces (225 cc) in 15 seconds.

4. If the fuel delivery rate is below the standard value the pump should be disassembled and checked. (See Fuel Pump Service in the Fuel System Repairs section of this chapter.)

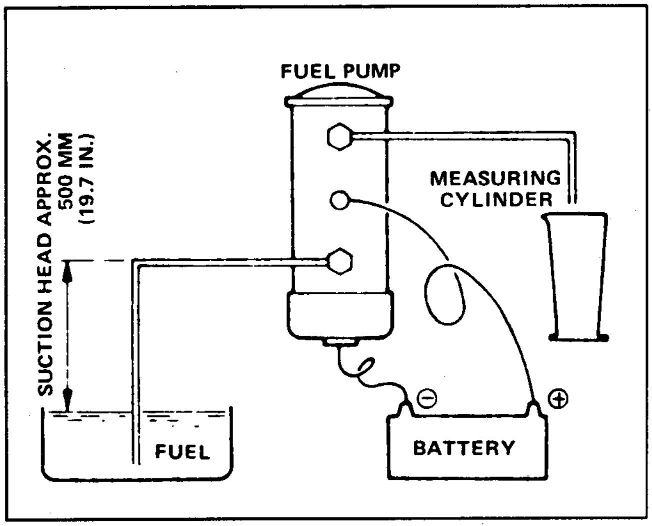


Figure 35

Thermostat Test

If the engine overheats and a faulty thermostat is suspected, the thermostat should be tested.

1. Remove the thermostat (see Thermostat Removal and Installation in the External Engine Component Repair section of this chapter).

2. Put the thermostat in a container of water with a thermometer and heat the water (Fig. 36).

Valve cracking temperature: 76.5° C (177° F).
Full-open temperature: 90° C (194° F)
Valve lift: 8 mm (0.314 in.)

3. If the thermostat fails to open, only partially opens, or sticks, it should be replaced.

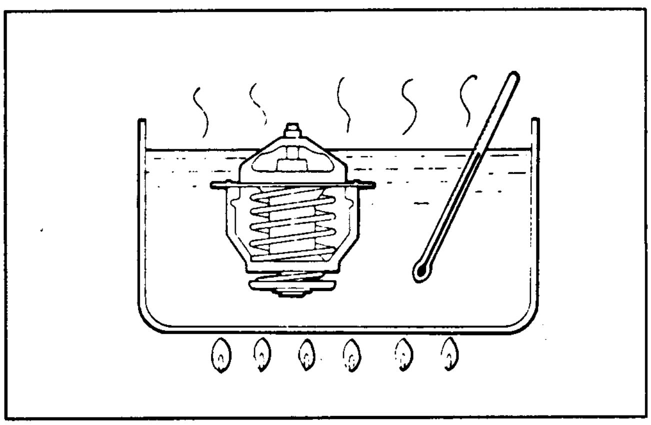


Figure 36

Preparation for Engine Repair

1. Before cleaning and disassembly, carefully check for problems that cannot be found after the engine has been cleaned or disassembled (e.g. oil leaks from cracked components, gaskets or loose fittings, damaged air cleaner or breather hoses that could cause cylinder wear, etc.). Make a note of any problems that you find.

2. Clean or wash the engine exterior thoroughly before disassembly.

IMPORTANT: Do not spray water on a hot engine. Injection pump seizure or other failures could result.

3. Do not disassemble or remove parts that do not require disassembly.

4. Disassemble the engine in proper order, arranging the parts the disassembled parts neatly. Apply clean engine oil to disassembled parts, as necessary to prevent rust.

5. Keep the work area clean; dirt causes engine failures.

6. Be very careful when working on fuel system components. Cover the work area with clean paper. Store components of the nozzles or injector pump in clean fuel oil. Do not allow components to strike each other or other objects. Wet hands with clean diesel fuel before handling these parts.

Engine Compression

The time interval to overhaul the engine can most accurately be determined by regular and systematic cylinder compression measurement. (See Compression Test in the Testing section of this chapter.)

Cylinder and Cylinder Block Overhaul

Before removing any parts, disassembly or overhaul of the Mitsubishi engine, it is very important to understand the nature and probable cause of the problem that made an overhaul necessary.

When the engine trouble is caused by worn cylinders, rings or valves, one or more of the following symptoms will occur:

1. Low engine power, and a decrease in compression pressure.

2. Increased fuel consumption.

3. Increased lubricating oil consumption.

4. Poor engine starting.

5. Loud noises in the engine.

It is important to find the cause of the engine failure before beginning repair. Symptoms 2 and 3 in the above list can be a result of excessive fuel injection, improper injection timing, or nozzle and injection pump wear. Poor starting may be a result of electrical problems. Noises may be associated with a mechanical part outside the engine. Excess fuel or oil consumption may be the result of leaks. (See the Troubleshooting section of this chapter.)

Another indicator of the need for an overhaul is oil consumption. Make sure the engine does not leak oil. when the oil consumption between the oil change maintenance interval is approximately 1-1/2 times normal (150%), engine overhaul should be considered.

With a good knowledge of how the engine operates, access to maintenance and compression test records, and information in the Troubleshooting section of this chapter, unnecessary disassembly and inspection can be eliminated.

External Engine Component Repair

Fan Belt Replacement

1. Put the machine on a level surface, engage the parking brake, turn the engine off and remove the key from the switch. Open the hood.

2. Loosen two nuts securing the idler pulley lever to the bracket (Fig. 37). Move the pulley away from the belt.

3. Remove two capscrews holding the transmission drive shaft coupler to the engine crankshaft pulley (Fig. 38). Do not remove the drive shaft from the transmission.

4. Bend the drive shaft out of the way so the belt can be removed. Remove the belt by carefully moving it around the fan blades.

5. Install the new belt.

6. To adjust belt tension, push the idler against the belt until there is 10 lbs. of force on top of the idler pulley lever. Tighten the upper nut. Tighten the lower nut.

7. Connect the drive shaft coupler to the engine crankshaft pulley.

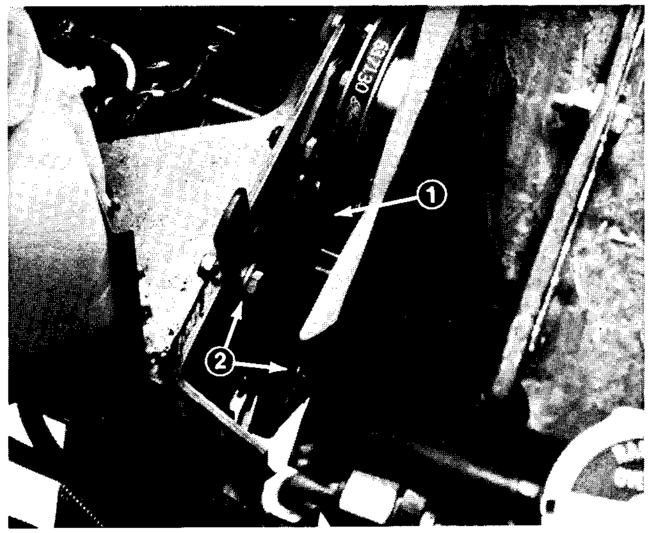


Figure 37

1. Fan belt
2. Tension adjustment bolt

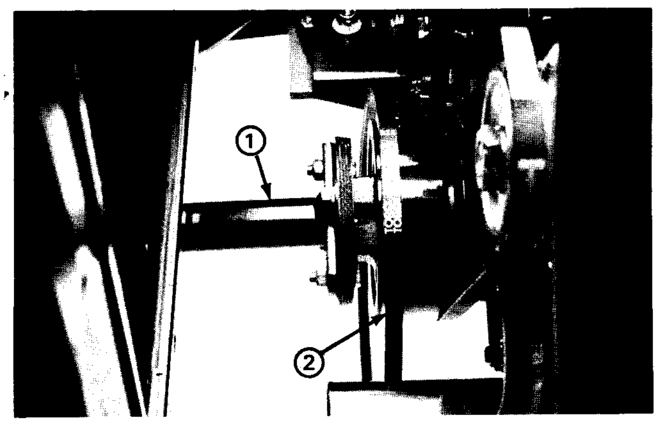


Figure 38

1. Transmission drive shaft coupler
2. Engine crankshaft pulley

Alternator / Water Pump Belt Replacement

1. Put the machine on a level surface, engage the parking brake, turn the engine off and remove the key from the switch. Open the hood.

2. Remove the fan belt (See Steps 1 - 4 of Fan Belt Replacement). Remove the fan and fan hub assembly. (See Steps 1 - 3 of Fan Removal and Disassembly).

3. Loosen alternator brace bolt and support bolt (Fig. 39). Push the alternator in towards the engine.

4. Bend the drive shaft out of the way so the belt can be removed. Remove the belt and install a new belt.

5. Insert a pry bar between the alternator and engine and pry out the alternator. Apply only enough pressure to get the correct belt tension.

6. Hold the alternator in position after you get proper belt tension and tighten alternator brace bolt. Tighten alternator support bolt. For proper tension, belt should deflect 7/16 in. (9 to 11 mm) when 10 Kg (22 lb.) of force is applied midway between alternator and crankshaft pulleys.

7. Install fan and fan hub assembly.

8. Install fan belt.

9. To adjust fan belt tension, push the idler against the belt until there is 10 lbs. of force on top of the idler pulley lever. Tighten the upper nut. Tighten the lower nut.

10. Connect the drive shaft to the engine crankshaft pulley.

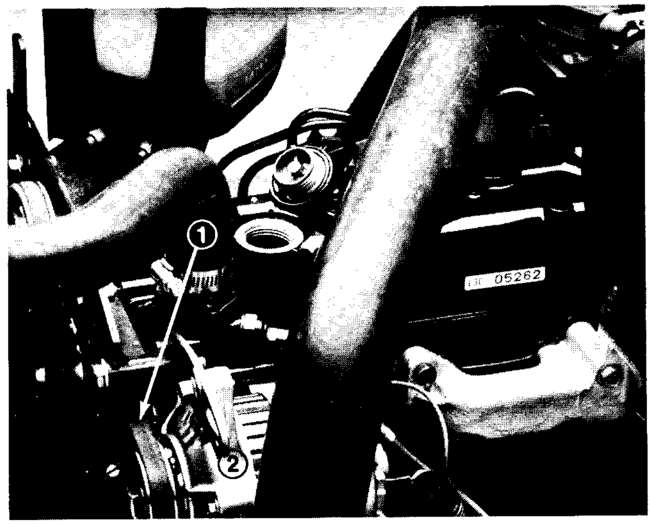


Figure 39

1. Alternator / water pump belt
2. Alternator brace bolt

Cooling Fan Service

The engine cooling fan is belt driven from the crankshaft pulley.

Fan Inspection

1. Put the machine on a level surface, engage the parking brake, turn the engine off and remove the key from the switch. Open the hood.

2. Inspect the fan for cracks or other damage. Replace the fan if it is damaged.

3. Check the conditions of the fan shaft bearings. With the belt removed, rotate the fan by hand. The fan should rotate smoothly and not have noticeable end play or side play. Repair or replace worn or damaged parts.

Fan Removal and Disassembly

1. Put the machine on a level surface, engage the parking brake, turn the engine off and remove the key from the switch. Open the hood.

2. Loosen two nuts securing the idler pulley lever to the bracket (Fig. 40). Move the pulley away from the belt.

3. Remove two (2) capscrews, securing the hub to the bracket. Remove the fan hub as assembly (Fig. 40, Items 1 - 6).

4. Remove the four (4) capscrews and lockwashers securing the fan and fan pulley to the fan hub.

6. Use a bearing puller to remove the fan hub from the shaft.

7. Remove the snap ring from the hub. Use an arbor press to push the shaft and bearing out of the hub.

NOTE: The shaft and bearing is serviced as an assembly.

Fan Assembly and Installation

1. Replace any worn or damaged parts when assembling the fan.

2. Use an arbor press to install the bearing and shaft into the hub. When doing the installation, PUSH ON THE OUTER RACE OF THE BEARING NOT THE SHAFT.

3. Install the snap ring in the hub.

4. Support the shaft through the hole in the hub. Push the fan hub onto the shaft to dimension shown in Figure 41.

5. Fasten fan pulley to fan hub with four (4) capscrews and lockwashers.

6. Put the fan assembly into the radiator shroud opening.

7. Install the hub to the bracket with two (2) capscrews and locknuts.

8. Install the belt.

9. To adjust belt tension, push the idler against the belt until there is 10 lbs. (4.5 kg) of force on top of the idler pulley lever. Tighten the upper nut. Tighten the lower nut.

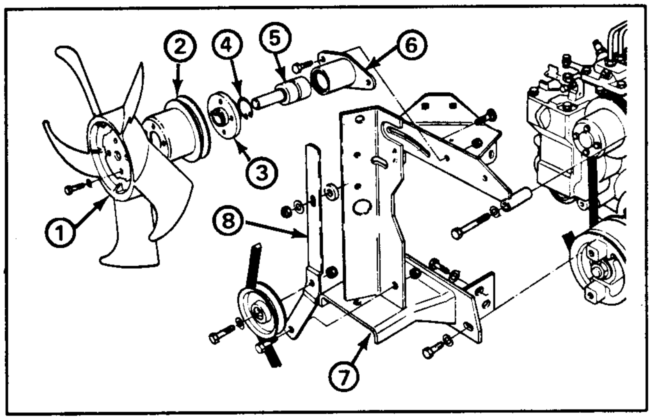


Figure 40

1. Fan
2. Fan Pulley
3. Fan hub
4. Snap ring
5. Shaft and bearing
6. Hub
7. Bracket
8. Idler pulley lever

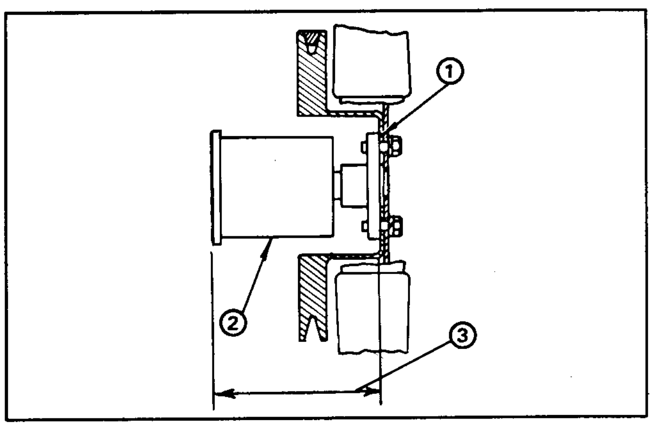


Figure 41

1. Fan hub
2. Hub
3. 2.72 in. (69 mm)

Alternator Removal and Installation

1. Disconnect the negative (–) cable from the battery.

2. Disconnect the wire from terminal "B" on the back of the alternator.

3. Disconnect the alternator wiring harness connector.

4. Loosen alternator brace bolt and alternator support bolt (Fig. 42). Push the alternator toward the engine and remove the belt.

5. Remove the alternator.

6. Reverse steps 1 - 5 to install the alternator. Make sure the spacer and shim is installed on the alternator support bolt between the alternator lower rear bracket and gear case bracket (Fig. 43).

7. Insert a pry bar between the alternator and engine and pry out alternator. Apply only enough pressure to get the correct belt tension.

8. Hold the alternator in position after you get proper belt tension and tighten the alternator brace bolt. Tighten the alternator support bolt. For proper tension, the belt should deflect 7/16 in. (9 to 11 mm) when 10 Kg (22 lb.) of force is applied midway between alternator and crankshaft pulleys.

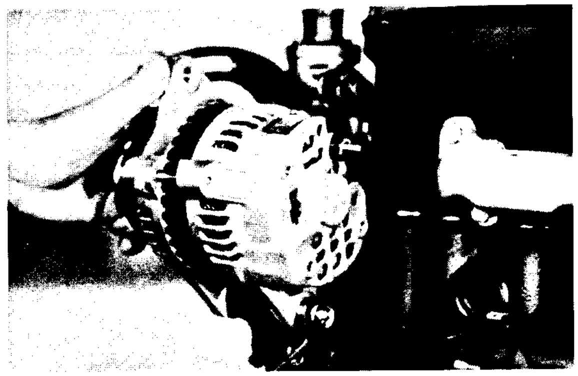


Figure 42

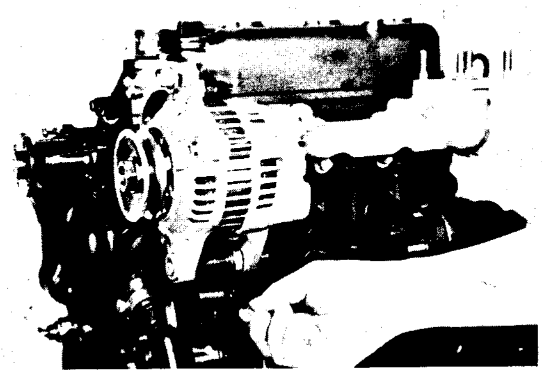


Figure 43

Starter Removal and Installation

1. Disconnect the negative (–) cable from the battery.

2. Disconnect the wires from the starter solenoid (Fig. 44).

3. Remove the two cap screws and washers securing the starter to the bracket.

4. Remove the starter.

5. Reverse steps 1 - 4 to install the starter.

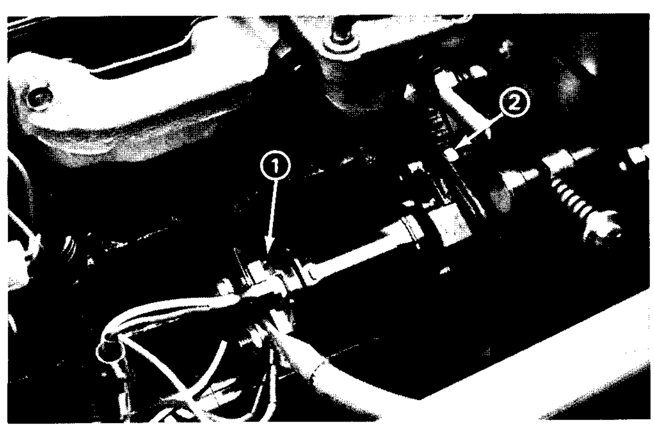


Figure 44

1. Starter solenoid **2. Cap screw and washer (2)**

Replacing and/or Adjusting Engine Stop Solenoid

See Chapter 5 - Electrical System for information about testing the engine stop solenoid.

An improperly adjusted stop solenoid can result in failure of the engine to stop when the key switch is turned off or could cause injection pump damage or malfunction.

Removing the Stop Solenoid

1. Stop the engine. If the engine will not stop when the ignition key switch is turned off, manually push the stop lever (Fig. 45) toward the rear of the machine until the engine stops.

2. Disconnect the solenoid electrical connector.

3. Loosen the nut securing the solenoid to the engine and unscrew the solenoid.

4. If you will be installing a new solenoid, remove the gasket and nut from the old solenoid and install them on the new solenoid. Thread the nut completely on the new solenoid.

Installing and/or Adjusting the Stop Solenoid

1. Remove the governor tie rod cover (Fig. 45).

2. Apply thread sealant to the solenoid threads.

3. Thread the solenoid into the engine.

4. Thread the solenoid into the engine while moving the tie rod back and forth (Fig. 46). Stop screwing the solenoid into the engine when there is no free play in the tie rod.

5. Turn the solenoid outward (counterclockwise) 1/4 to 1/2 turn. There should be a small amount of free play in the injector pump control rack 0.01 - 0.3 in. (0.3 - 0.7 mm).

IMPORTANT: No free play in the control rack with the solenoid de-energized (plunger out) may cause injection pump damage or malfuntion. Excess free play 0.04 in. (1 mm) or more will prevent the engine from stopping when the solenoid is de-energized.

6. Remove the cover cap screw from the engine to get access to the solenoid nut (Fig. 45).

7. Hold the solenoid body to prevent it from turning and tighten the nut against the engine to secure the adjustment. Do not over tighten the nut. If the nut is over tightened, the solenoid may become distorted and will not operate correctly.

8. Install the cover cap screw that was removed from the engine in step 6.

9. Connect the solenoid electrical connector.

10. Install the governor tie rod cover.

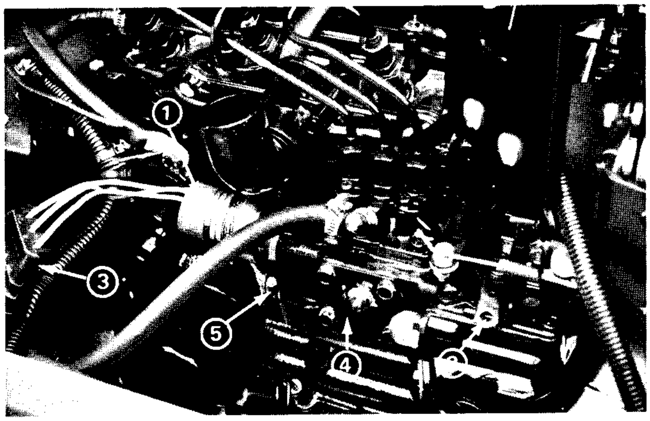


Figure 45

1. **Stop solenoid**
2. **Stop lever**
3. **Solenoid electrical connector**
4. **Governor tie rod cover**
5. **Cover cap screw**

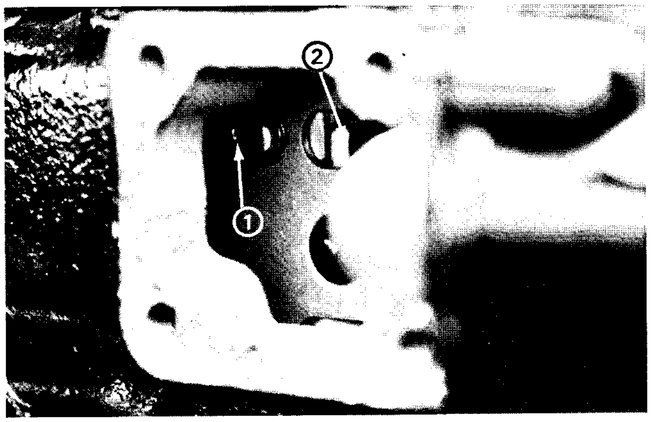


Figure 46

1. **Solenoid plunger**
2. **Tie rod**

Glow Plug Replacement

Replace the glow plug(s) if they do not operate correctly. (See Glow Plug Test in the Testing section of this chapter.)

1. Remove the nut and lead wire.

2. Clean the area around the glow plug. This will prevent dirt or other contamination from falling through the glow plug hole into the cylinder.

3. Remove the glow plug.

4. Install a new glow plug. Tighten the glow plug to a torque of 11-14.5 ft-lb (1.5-2 KgM).

5. Install the lead wire and nuts.

Oil Pressure Switch Replacement

The engine is equipped with an oil pressure switch (Fig. 47). This switch activates a lamp on the control panel and a buzzer if the oil pressure drops below safe levels during operation.

Pressure switch ON pressure: 0.5 kg/cm^2 (7 psi)

Replace the switch if it is not operating correctly. Before installing the switch put a small amount of LOCTITE #567 Thread Sealant (or equivalent) on the switch threads. When installing the switch make sure the sealant does not block the oil hole in the switch.

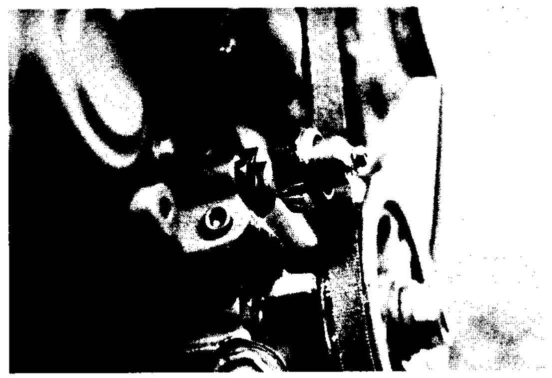


Figure 47

Thermostat Removal and Installation

1. Lower the coolant level to below the thermostat.

2. Loosen the hose clamp and disconnect the hose from the water outlet fitting.

3. Remove the water outlet fitting and gasket (Fig. 48).

4. Replace the thermostat if necessary (See Thermostat Test in the Testing section of this chapter).

5. Do not allow the thermostat flange to protrude from the water outlet fitting joint. Do not place thermostat stay in the direction of thermoswitch hole. Use a new gasket when installing the water outlet fitting.

6. Check for damaged hoses or damaged hose clamps. Replace as required. Install the hose on the water outlet fitting and tighten the hose clamp.

7. Fill the cooling system to the proper level with a 50/50 solution of clean, soft water and ethylene glycol antifreeze (See Checking the Cooling System and Changing Coolant in the Maintenance section of this book.).

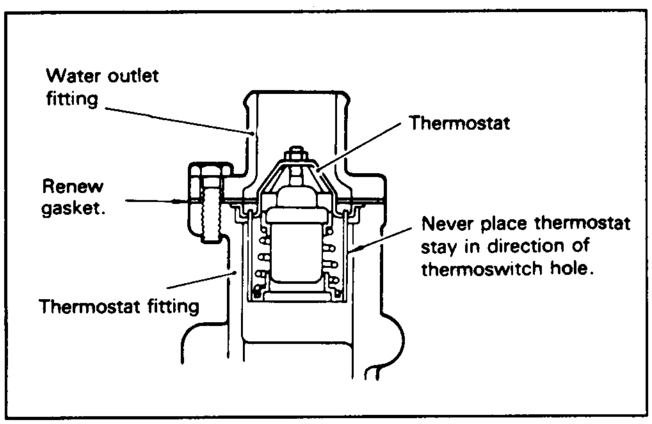


Figure 48

Water Pump Service

1. Drain the cooling system (see Changing Coolant in the Maintenance section of this chapter).

2. Remove the drive belt from the water pump and alternator.

3. Loosen the hose clamp and disconnect the hose from the water pump.

4. Remove the water pump (Fig. 49).

5. Check the water pump for cracks or leaks. Rotate the water pump shaft by hand. If the bearings do not rotate smoothly, or are noisy replace the water pump with a new water pump. There are no replaceable parts in the water pump.

6. Install the water pump and a new gasket onto the cylinder block.

7. Check for damaged hoses or damaged hose clamps. Replace as required. Install the hoses on the water pump and tighten the hose clamps.

8. Install the alternator / water pump drive belt.

9. Insert a pry bar between the alternator and engine and pry out alternator. Apply only enough pressure to get the correct belt tension.

10. Hold the alternator in position after you get proper belt tension and tighten the alternator brace bolt. Tighten alternator the support bolt. For proper tension, belt should deflect 7/16 in. (9 to 11 mm) when 10 Kg (22 lb.) of force is applied midway between alternator and crankshaft pulleys.

11. Fill the cooling system with a 50/50 solution of clean, soft water and ethylene glycol antifreeze. (See Checking the Cooling System and Changing Coolant in the Maintenance section of this book.)

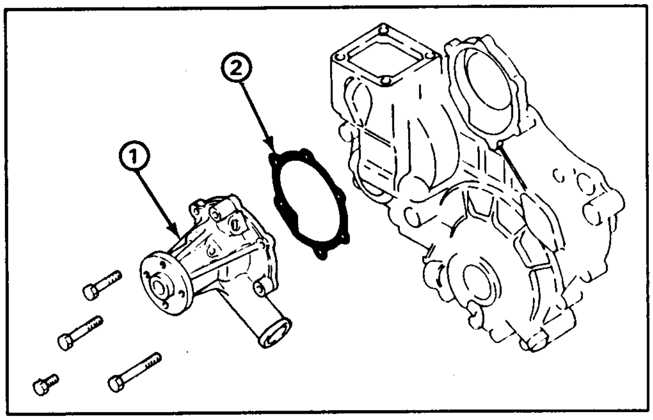


Figure 49

1. Water pump
2. Gasket

Governor System Repairs

Governor Operation

The governor keeps the engine operating at a constant speed by balancing the centrifugal force acting on the governor weights and the governor spring tension. As the engine picks up speed, the governor weights open to move the sliding shaft forward. The shaft pushes on the governor lever to move the injector control rack and decrease the fuel injection rate. At the same time the governor spring is pulled by the governor lever until the spring force is balanced with the centrifugal force of the governor weights, thus maintaining constant engine speed.

When the speed control lever is pulled toward high speed, the governor spring is pulled. The spring pulls on the governor lever to move the governor control rack and increase the fuel injection rate. As engine speed increases, the governor weight centrifugal force also increases until it is balanced with the governor spring force, thus maintaining a constant engine speed.

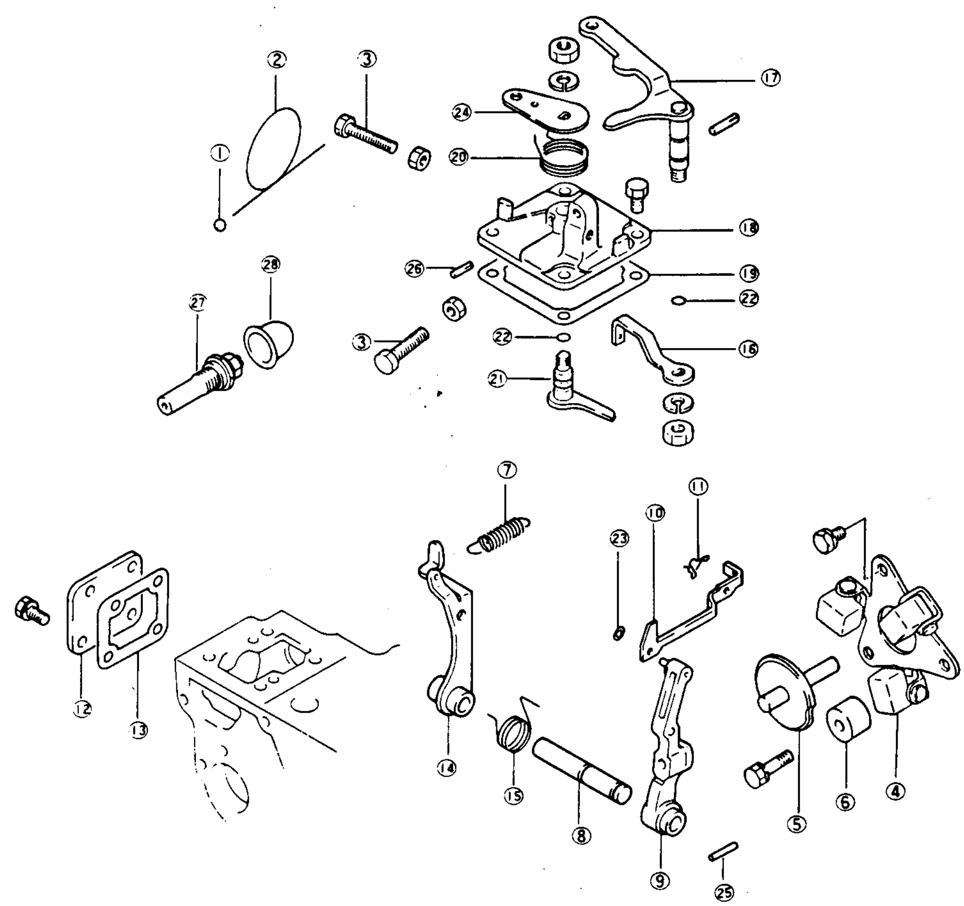


Figure 50

1. Sealing metal
2. Sealing wire
3. Speed adjustment screw
4. Governor weight assembly
5. Sliding shaft
6. Stopper
7. Governor spring
8. Governor shaft
9. Governor lever
10. Tie rod
11. Tie rod clip
12. Tie rod cover
13. Tie rod cover gasket
14. Tension lever
15. Start spring
16. Governor spring lever
17. Speed control lever ass'y
18. Governor cover gasket
19. Governor cover gasket
20. Return spring
21. Stop lever assembly
22. O-ring
23. Snap ring
24. Stop lever
25. Grooved pin (3 x 20 mm)
26. Grooved pin (3 x 14 mm)
27. Torque spring set
28. Sealing cap

Governor Inspection

A governor failure can cause engine starting failure, loss of engine speed control, or engine surging (hunting). Before removal and disassembly of the engine the following inspections are recommended:

1. Stop the engine, lower the implement and engage the parking brake. Open the engine hood.

2. Remove the governor tie rod cover (Fig. 45).

3. While holding the stop lever (Fig. 50) in the stop position (towards the rear of the machine) turn the ignition key switch quickly to the START position and release it to the ON positon. This will retract the stop solenoid plunger, allowing movement of the injection pump control rack.

4. Push the tie rod forward only with only enough force to overcome the spring pressure and operate the speed control lever (or throttle lever). You should feel the governor lever, under spring tension, move the tie rod and control rack as the lever is operated.

5. If the control rack does not move move correctly, disconnect the tie rod from the injection pump control rack. Make sure the injection pump control rack moves freely. If it does not, check for injection pump problems.

6. Failure of the speed control lever or governor lever to move when the tie rod is disconnected may indicated a problem with internal parts of the governor.

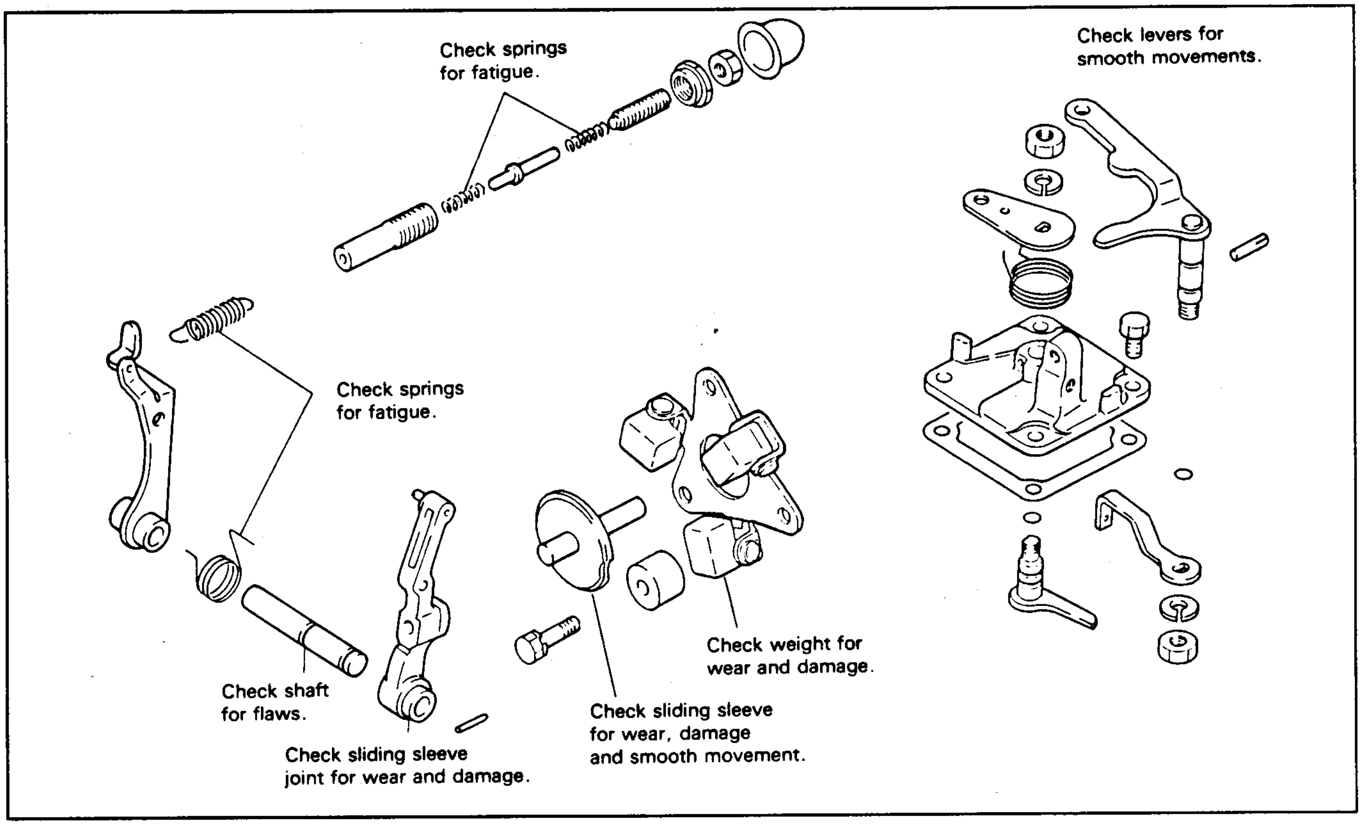


Figure 51

Governor Service

1. Remove the tie rod cover (Fig. 50).

2. Remove the tie rod clip and disconnect the tie rod from the injection pump control rack.

3. Disconnect the governor spring from the tension lever.

4. Remove the cover assembly.

5. Removing the levers:

A. To remove the levers, pull out the grooved pins from the governor lever, stop lever and speed control lever.

B. Loosen the bolts securing the levers and shafts.

6. Installing the levers:

A. Coat the o-rings with oil before installation.

B. Install the levers and shafts. After press fitting each grooved pin, check the shaft for smooth operation.

C. Install the governor spring lever and speed control lever so there is a minimum play of angle between levers (Fig. 52).

D. The governor spring should not deflect more than 20 mm (0.8 in.) when installed.

9. Inspect all parts for wear or damage and smooth operation.

10. Reverse steps 1 - 4 to reassemble. After assembly, make sure that the governor mechanism operates smoothly.

NOTE: Further governor repairs require removal of the gear case (See Gear Case and Oil Pump in the Cylinder Block Overhaul section of this chapter).

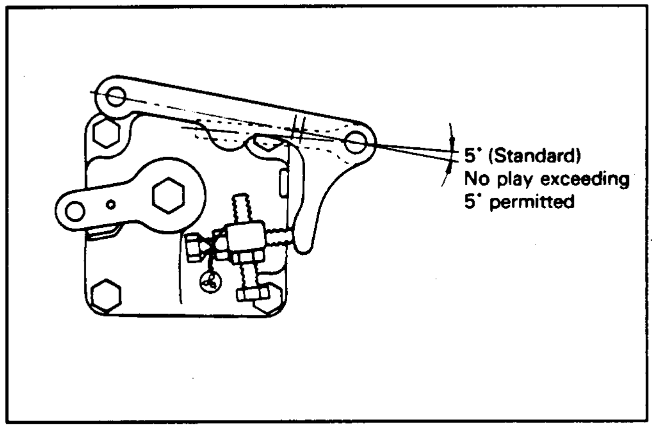


Figure 52

Installation of Torque Spring Set

IMPORTANT: Torque spring set adjustment has been done and sealed at the factory. Do not remove, disassemble or adjust this device unless necessary. The torque spring set adjustment is very sensitive. Improper adjustment can vary fuel delivery to under power or over fuel the engine.

1. Engage the parking brake. Make sure the high speed set bolt is adjusted to the correct engine speed of 3200 $^{+50}_{-0}$ rpm (See Adjusting Engine Speed in the Maintenance section of this chapter).

NOTE: Specified rpm is with no load on engine (fan drive and transmission coupler disconnected).

2. Operate the engine at high idle speed.

3. Turn the torque spring set (Fig. 53) clockwise until engine speed drops approximately 50 rpm from high idle speed.

4. From this position, turn the back the torque spring set (counterclockwise) "N" turns (2.5 turns). Lock the torque spring set in position with the special nut.

5. Install the sealing cap.

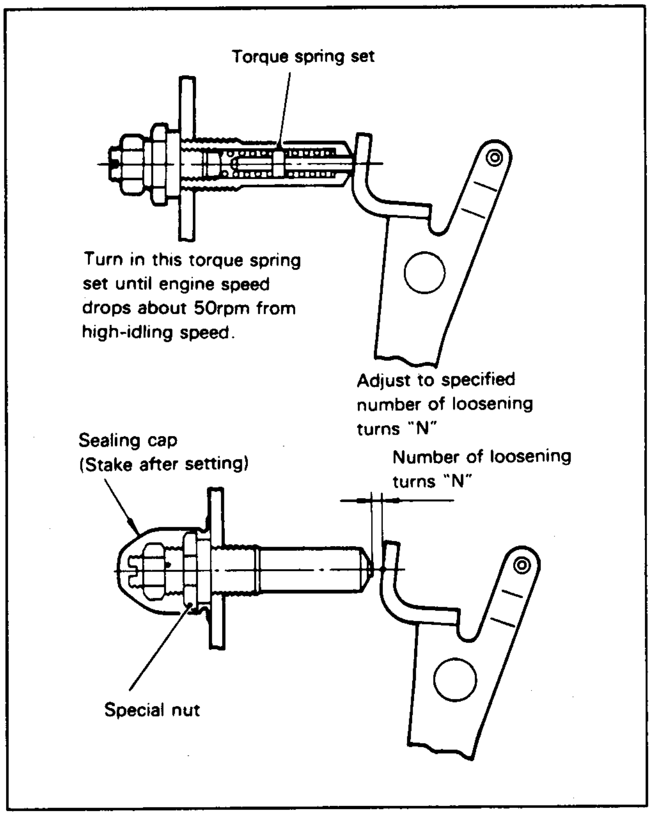


Figure 53

Assembly of Torque Spring Set (Groundsmaster 223-D)

If the torque spring set has been disassembled or parts replaced, reassemble and adjust the torque spring set using the following procedure.

IMPORTANT: The torque spring set has been adjusted and sealed at the factory. Do not remove, disassemble or adjust this device unless necessary. The torque spring set adjustment is very sensitive. Improper adjustment can vary fuel delivery to under power or over fuel the engine.

1. Assemble the torque spring set as shown in Figure 54A.

2. Use a screwdriver operated by fingertips to lightly tighten adjustment screw until resistance to rotation is felt. Lightly lock the screw in position with locknut.

3. Set dial on spring scale to zero (0). Tighten spring case until a value of 970^{+10}_{-0} grams is obtained. Lock the spring case in that position with special nut.

4. Temporarily loosen adjustment screw until to get a value of 770 grams then retighten the screw until a value of 970^{+10}_{-0} grams is attained. Lock the adjustment screw in position with locknut.

5. To inspect torque spring set for proper adjustment, use a test set up as shown (Fig. 55A). Gradually push scale against torque spring set until stopper is moved (or pointer of dial indicator moves). Check that load applied to torque spring at that moment is 950^{+20}_{-30} grams.

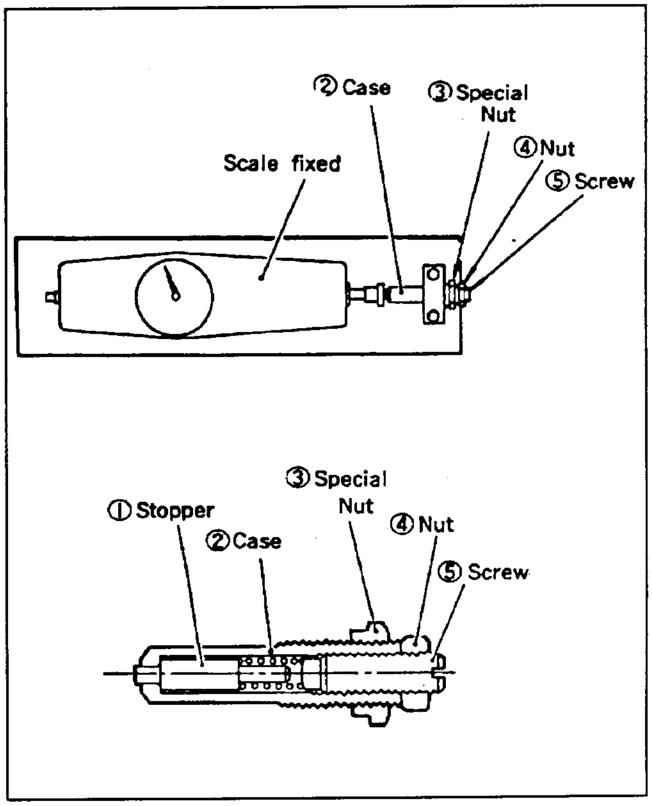


Figure 54A

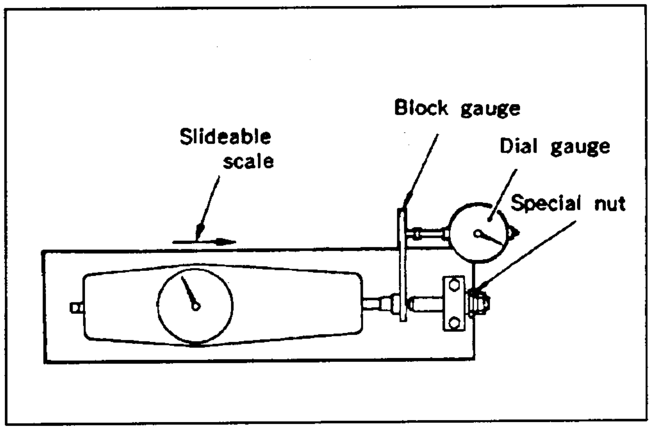


Figure 55A

Assembly of Torque Spring Set (Groundsmaster 220-D)

If the torque spring set has been disassembled or parts replaced, reassemble and adjust the torque spring set using the following procedure.

IMPORTANT: Torque spring set adjustment has been done and sealed at the factory. Do not remove, disassemble or adjust this device unless necessary. The torque spring set adjustment is very sensitive. Improper adjustment can vary fuel delivery to under power or over fuel the engine.

1. Assemble the torque spring set as shown in Figure 54. Use the adjusting screw to adjust the projection of the torque spring stopper from the spring case.

2. To measure the projection, keep the torque spring set in a vertical position as shown in Figure 55. Put the dial indicator probe against the center of the spring stopper face. Use a sensitive dial indicator that will not compress the torque spring when the measuring probe is against the spring stopper end.

3. Measure the difference in height between the spring case and spring stopper (Fig. 55). Make the measurement three times to confirm accurate measurement. Adjust the projection as necessary by turning the adjusting screw.

Spring stopper projection: 0 to – 0.4 mm (0 to – 0.016 in.)

4. After adjustment, tighten the nut to a torque of 0.8 to 1.2 Kgm (6 to 9 ft-lb)

5. Check to make sure the spring stopper can be depressed smoothly and that the end of the stopper can become flush with the end face of the spring case.

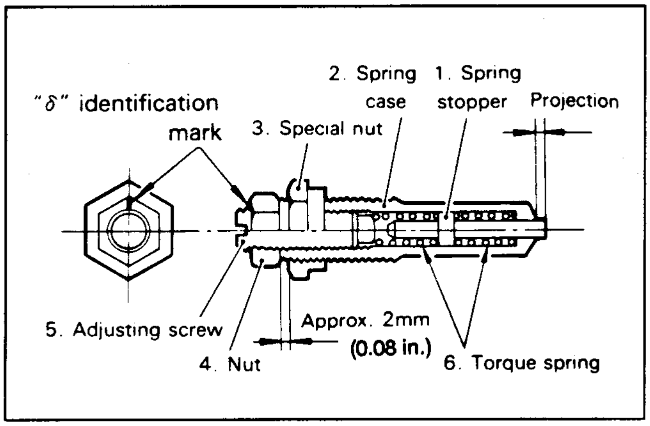


Figure 54

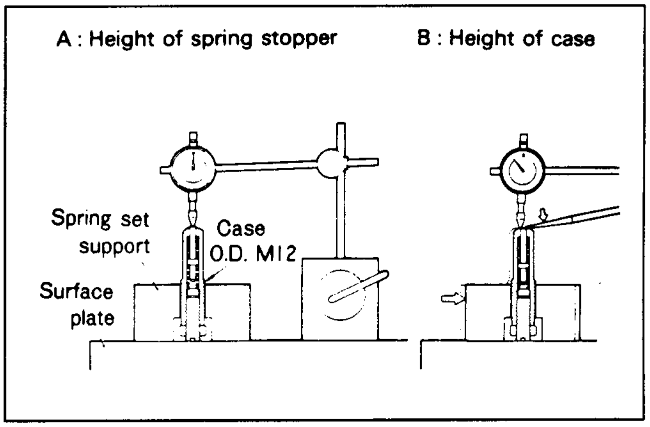


Figure 55

Fuel System Repairs

When cleaning the engine, DO NOT spray water onto a hot injection pump. This could cause the fuel pump to seize and be damaged.

When working on the fuel system, ALWAYS make sure that the equipment and work area is clean. The close tolerance parts of the fuel system can be easily damaged by dirt.

Wash fuel system parts in clean fresh diesel fuel. If parts are removed for a period of time, store them in containers of clean diesel fuel to prevent corrosion.

Bleeding the Fuel System

1. Stop the engine and engage the parking brake. Open the hood.

2. Loosen the air bleed screw on the fuel filter / water separator (Fig. 56a).

3. Turn the ignition key switch to the ON position. The electric fuel pump will begin to operate and force fuel out around the screw loosened in step 2. Fuel will fill the filter bowl and then flow out around the screw. When a solid stream of fuel flows out around the screw, tighten the screw and turn the key switch OFF.

4. Open the air vent screw on the fuel injection pump (Fig. 56b).

5. Turn the ignition key switch to the ON position. The electric fuel pump will begin to operate and force fuel out around the injection pump air vent screw. When a solid stream of fuel flows out around the screw, tighten the screw and turn the key switch OFF.

NOTE: Normally the engine should start after this procedure. If the engine does not start, air may be trapped between the injection pump and injectors (See Bleeding Air From the Injectors in this section of the book.)

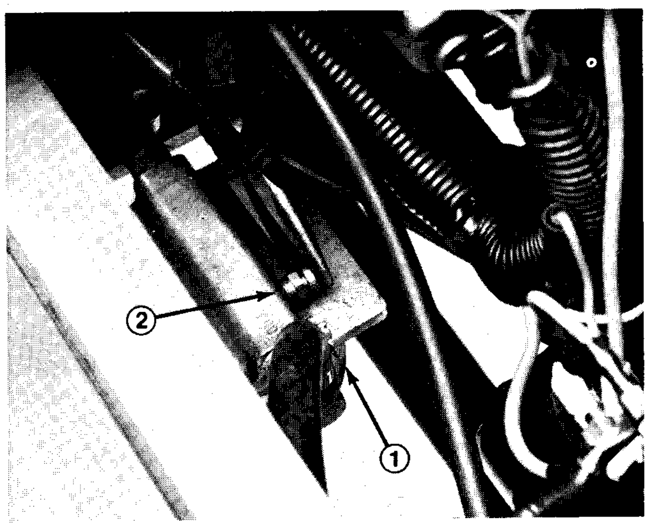


Figure 56a

1. Fuel filter
2. Air bleed screw

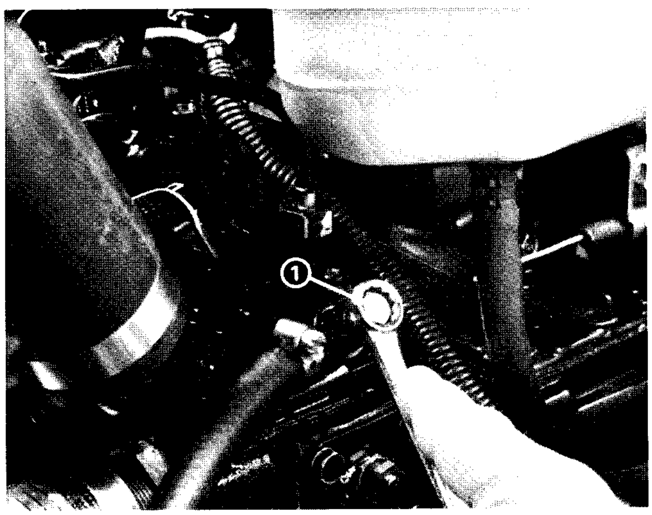


Figure 56b

1. Fuel injection pump air vent screw

Bleeding Air From the Injectors

This procedure should only be used if the fuel system has been purged of air. (See Bleeding the Fuel System in this section of the book.)

1. Loosen the pipe connection at the number one nozzle and holder assembly on the cylinder head (Fig. 57).

2. Move the throttle control to the FAST position.

3. Turn the ignition key to the START position to crank the engine and pump fuel to the nozzles. Turn the ignition key to the OFF position when a steady stream of fuel flows out of the loose pipe connection.

4. Tighten the pipe connector.

5. Repeat steps 1 - 4 for the No. 2 and No. 3 injector nozzle and holder.

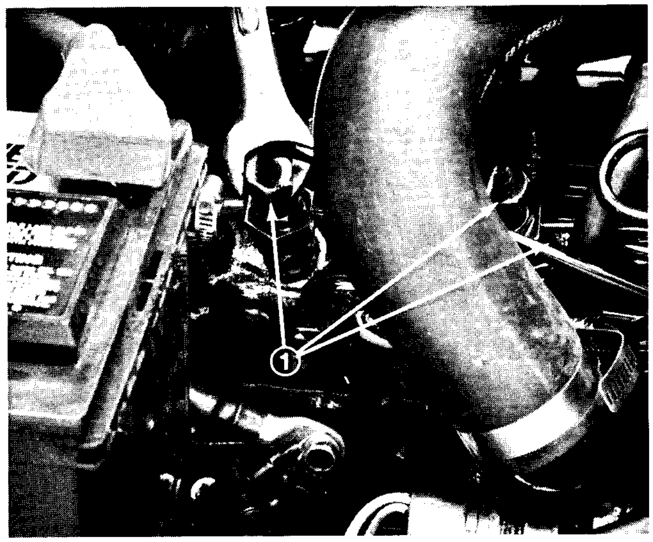


Figure 57

1. Fuel injector nozzle and holder (3)

Fuel Pump Service

The only serviceable parts of the fuel pump are the magnet, filter, and the gaskets on each end of the filter.

1. Disconnect the fuel pump wires from the wiring harness and ground connection.

2. Disconnect the fuel hoses from the pump. Plug the fuel lines.

3. Remove the two screws which secure the pump to the frame.

4. Use a 17 mm wrench to remove the cover from the fuel pump (Fig. 58). Remove the gasket, magnet and filter element.

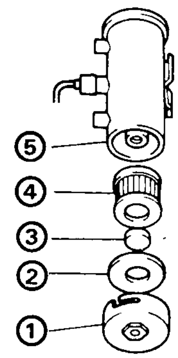


Figure 58

1. Cover
2. Cover gasket
3. Magnet
4. Filter
5. Body

5. Carefully remove the spring retainer from the end of the plunger tube (Fig. 59). Remove the washer, o-ring, valve, plunger spring and plunger.

IMPORTANT: Be careful not to bend or deform the plunger tube while disassembling the fuel pump. If the plunger tube is bent, the fuel pump plunger will bind and the pump will need to be replaced.

6. Install the plunger (valve side out), plunger spring, valve, o-ring, washer and spring retainer. Make sure the plunger operates freely.

7. Install the filter and cover gaskets, magnet, filter and cover. Tighten the cover to prevent air leaks.

8. Install the fuel pump to the frame. Connect the fuel lines and electrical wires.

9. Bleed the fuel system. (See Bleeding the Fuel System in this section of the book.)

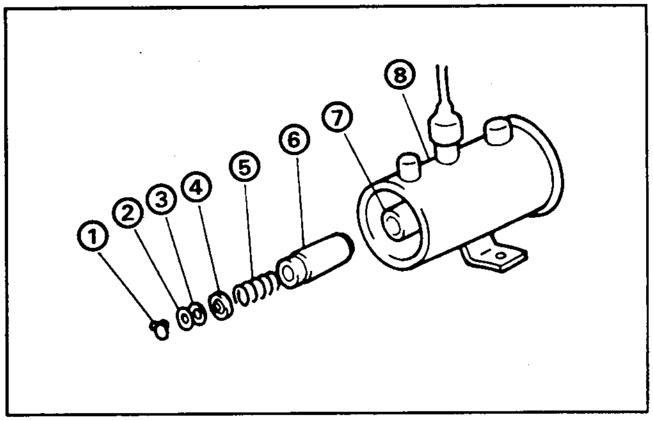


Figure 59

1. Spring retainer
2. Washer
3. O-ring
4. Valve
5. Plunger spring
6. Plunger
7. Plunger tube
8. Body

Injection Pump Service

Do not attempt the disassemble the injection pump unless it is necessary. If the pump is damaged or defective, it is recommended to replace the pump.

IMPORTANT: Clean the injection pump and the area near the injection pump before removing or servicing it. DO NOT spray water onto a hot injection pump.

Removing and Installing the Injection Pump

1. Remove the engine stop solenoid (Fig. 60a). (See Replacing and/or Adjusting Engine Stop Solenoid in the External Engine Component Repair section of this chapter.)

2. Disconnect the fuel pipes from the injector nozzles and injection pump delivery valve holders. Loosen the hose clamp and disconnect the fuel hose.

3. Remove the tie rod cover. Remove the tie rod clip and disconnect the tie rod from the injection pump control rack (Fig. 60b).

4. Remove the four (4) injection pump mounting bolts. Remove the injection pump from the cylinder block. Make a note of the number and thickness of the adjusting shims under the pump. (The shims determine the injection timing.)

5. Reverse steps 1 - 4 to install the injection pump. Make sure the Engine Stop Solenoid is adjusted correctly. (See Replacing and/or Adjusting Engine Stop Solenoid in the External Engine Component Repair sectoin of this chapter.)

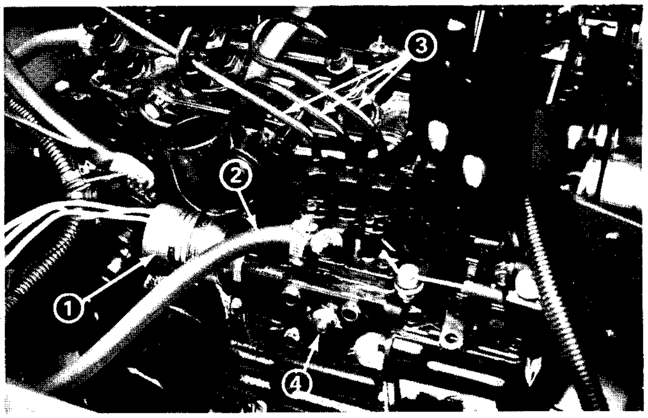


Figure 60a

1. Engine stop solenoid
2. Fuel hose
3. Fuel pipes
4. Tie rod cover

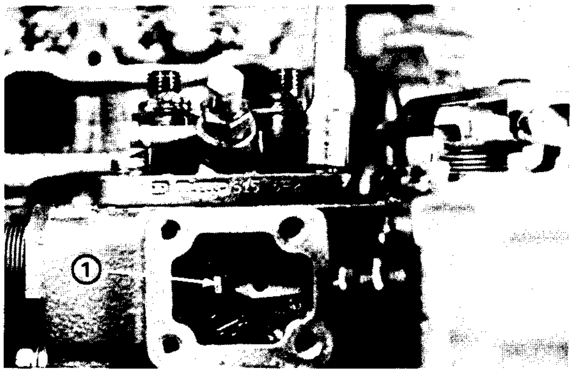


Figure 60b

1. Tie rod (disconnected)

Injection Pump Disassembly

IMPORTANT: Do not mix the delivery valves, delivery valve seats, plungers or plunger barrels from one cylinder to another. These are parts are "matched sets". Handle these parts carefully. Place the parts in a container of clean diesel fuel to prevent corrosion.

1. Remove the stopper holder. Remove the delivery valve holder (Fig. 61).

2. Remove the valve spring, delivery valve and o-ring. Remove the gasket and valve seat.

3. Remove the tappet roller and stopper pin. Remove the tappet and adjusting shim.

4. Remove the lower seat from the plunger. Remove the plunger spring and upper seat

5. Remove the two screws securing the bracket to the pump housing. Remove the control rack.

IMPORTANT: DO NOT loosen the adjusting screws on the control rack for each cylinder. If these parts are removed, it is necessary to measure fuel injection quantity with a pump tester and cam box.

7. Remove the sleeve and plunger. Remove the plunger barrel upward from the pump housing.

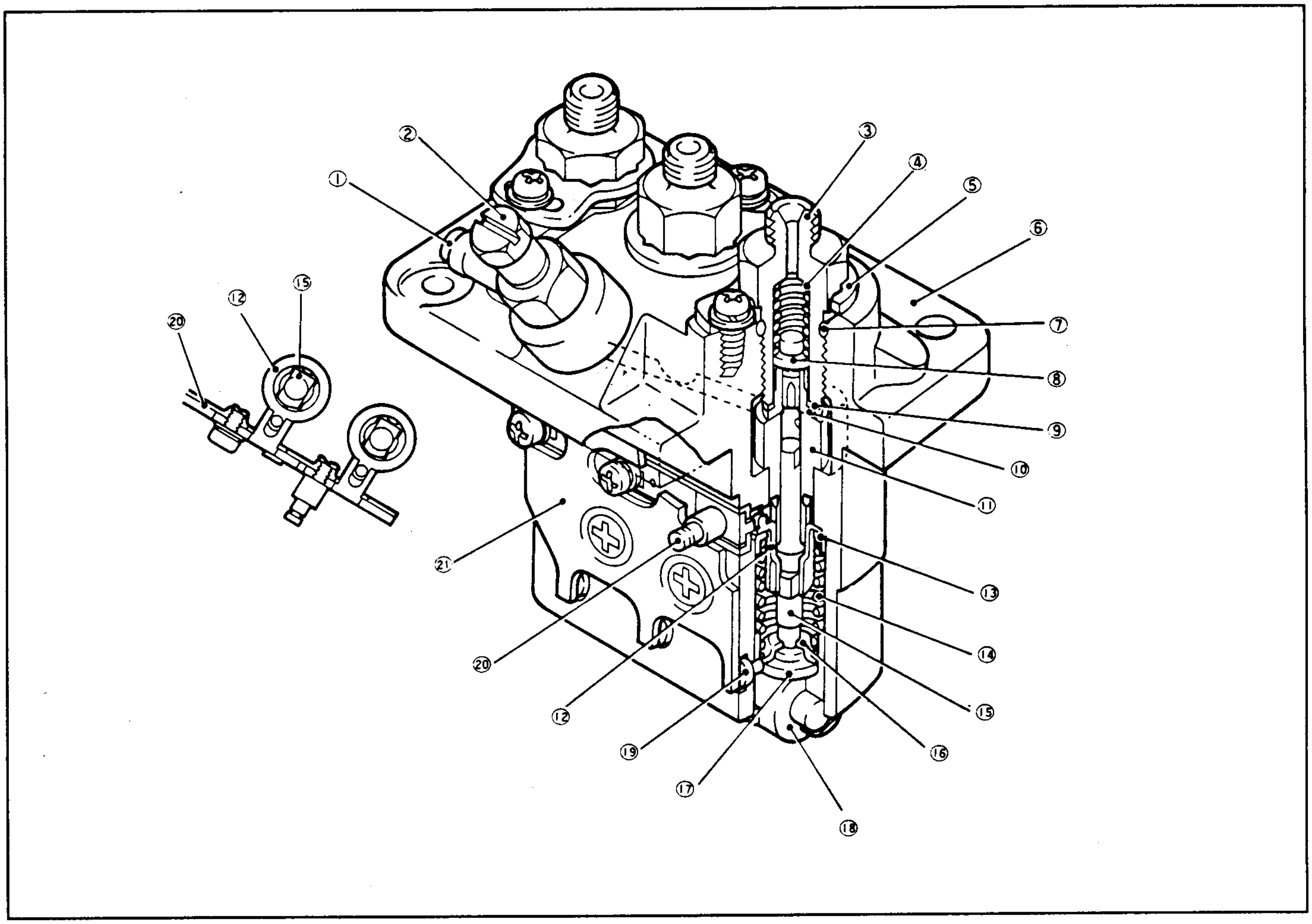


Figure 61

1. Union collar	**8. Delivery valve**	**15. Plunger**
2. Air vent screw	**9. Gasket**	**16. Lower seat**
3. Delivery valve holder	**10. Valve seat**	**17. Adjusting shim**
4. Valve spring	**11. Plunger barrel**	**18. Tappet roller**
5. Holder stopper	**12. Sleeve**	**19. Pin**
6. Housing	**13. Upper seat**	**20. Control rack**
7. O-ring	**14. Plunger spring**	**21. Bracket**

Injection Pump Inspection

Inspect the injection pump parts for proper operation, wear, corrosion, seizure, etc. (Fig. 62). Replace worn or damaged parts.

Injection Pump Assembly

1. Insert the plunger barrel into the housing.

2. Install the delivery valve seat, gasket, delivery valve and valve spring. Install the o-ring on the delivery valve holder. Temporarily tighten the delivery valve holder.

3. Insert the control rack. Insert the sleeve. Align the match mark on the rack with that on the pinion (sleeve).

4. Insert the upper seat. Insert the plunger spring.

5. Fit the lower seat to the plunger. Insert the plunger into the barrel (Fig. 63).

6. Push in the tappet roller assembly and install the stopper pin.

7. Tighten the delivery valve holder to a torque of 3.5 - 3.9 Kgm (25 - 28 ft-lb). Install the holder stopper.

9. Before installing the injection pump, make sure the control rack slides smoothly, with little resistance. If the control rack binds, it is assembled incorrectly or parts are dirty. The pump must then be reassembled correctly and/or cleaned.

10. Install the injection pump to the cylinder block. Make sure that the same number and size shims that were under the pump when it was removed are installed.

11. Install the fuel line and delivery pipes.

12. Bleed air from the fuel system. (See Bleeding the Fuel System and Bleeding Air From the Injectors in this section of the book.)

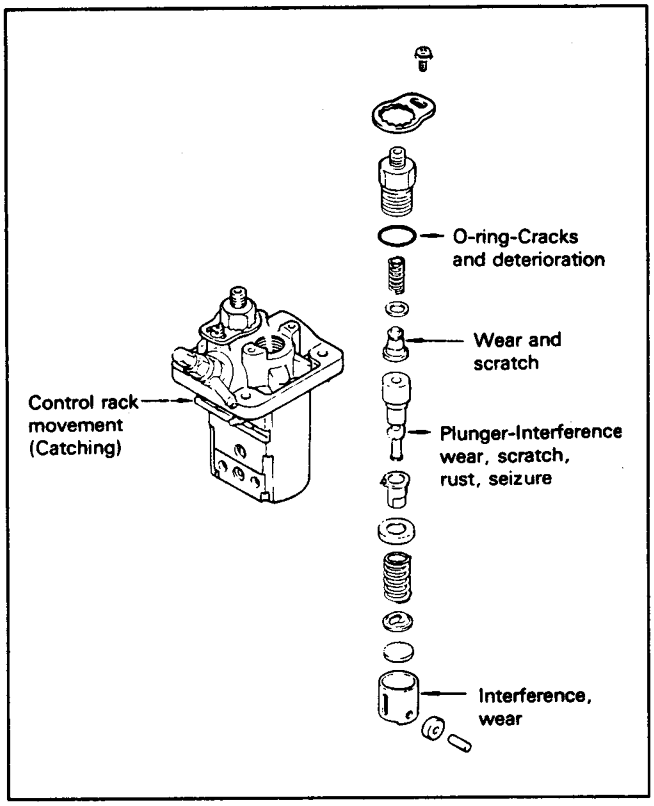


Figure 62

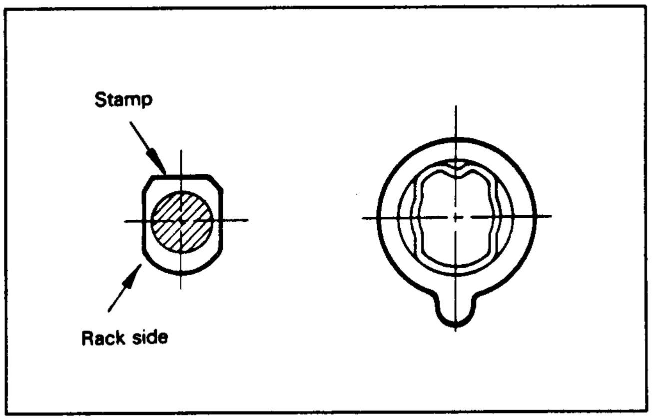


Figure 63

Nozzle Service

IMPORTANT: When servicing the injection nozzles make sure that the engine and fuel delivery pipes are clean to prevent dirt from entering cylinder or nozzle. Do not mix components of one nozzle with the other.

Nozzle Removal and Disassembly

1. Disconnect the injection pipes and fuel return pipe.

2. Remove the injector nozzle from the cylinder head.

NOTE: Further disassembly of the nozzle is not required for the nozzle to be tested. (See Nozzle Tests in the Testing section of this chapter.)

3. Secure the nozzle holder in a vise that has aluminum or brass jaw plates. To prevent deformation do not clamp the vise onto the retaining nut (Fig. 64).

4. Remove the retaining nut, shim washer, spring, pin, and distance piece.

6. Remove the nozzle assembly from the retaining nut. If it is difficult to remove, tap it lightly with a rubber or wooden mallet. IMPORTANT: Be careful not to hit or damage the protruding tip of the nozzle needle valve.

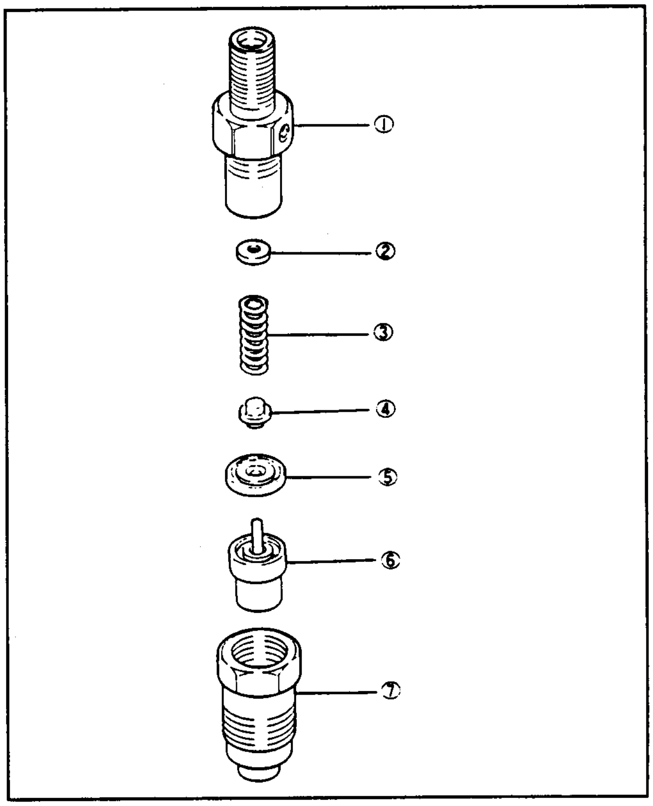


Figure 64

1. Body
2. Shim washer
3. Pressure spring
4. Pin
5. Distance piece
6. Nozzle assembly
7. Retaining nut

Nozzle Inspection and Cleaning

1. Clean the inside and outside of the retaining nut in clean diesel fuel or kerosene to remove carbon or fuel deposits. Inspect the lower seating surface for rust or damage. The sealing area may be restored with emery cloth.

2. Remove carbon or lacquer deposits from the nozzle by cleaning in clean diesel fuel or kerosene. Stubborn deposits can be removed with a brass wire brush.

IMPORTANT: Do not use a steel brush, steel wool, etc. Take special care not to scratch the needle valve in the nozzle assembly.

3. Clean the body, shim, spring, pin and distance piece in clean diesel fuel or kerosene.

4. Inspect the removed parts (Fig. 65). Replace any worn or damaged parts.

Nozzle Assembly and Testing

1. Install the nozzle assembly, distance piece and pin into the retaining nut.

2. Install the shim and pressure spring the body. Assemble the body to the retaining nut. Put the nozzle holder in a vise. Tighten the body and nut to a torque of 3.5 - 4.0 KgM (25 - 29 ft-lb) (Fig. 66).

3. Test the nozzle for proper operation. (See Nozzle Tests in the Testing section of this chapter.)

Nozzle Installation

1. Clean the nozzle holder fitting surface on the cylinder head. Install a new nozzle holder gasket onto the nozzle.

2. Install the nozzle holder into the cylinder head and tighten to a torque of 5.0 - 6.0 KgM (36 - 43 ft-lb).

3. Install the fuel return pipe. Tighten the retaining nut to a torque of 2.5 - 3.0 KgM (18 - 22 ft-lb) (Fig. 66).

4. Install the fuel injection pipes. Tighten the nut to a torque of 2.5 - 3.5 KgM (18 - 25 ft-lb).

5. Bleed air from the fuel system (See Bleeding the Fuel System and Bleeding Air From the Injectors in this section of the book.)

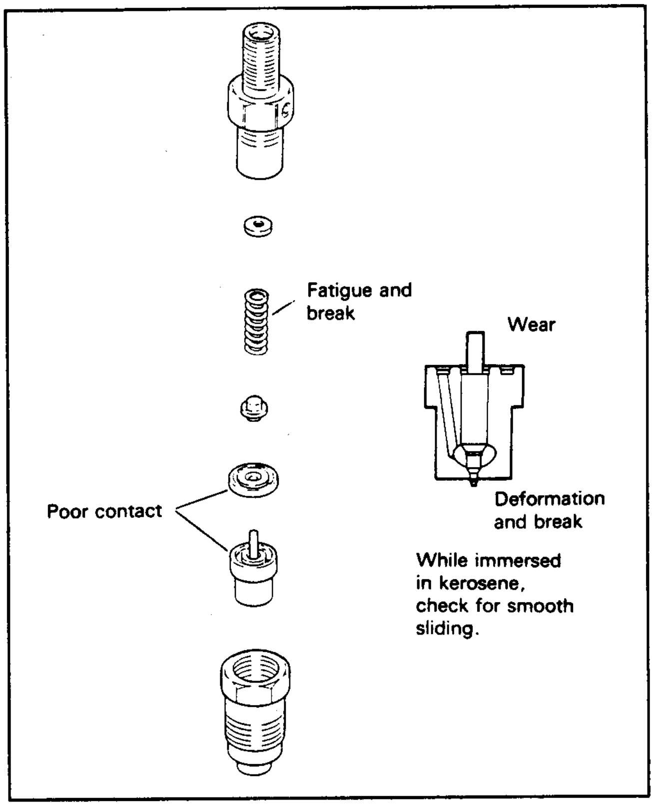


Figure 65

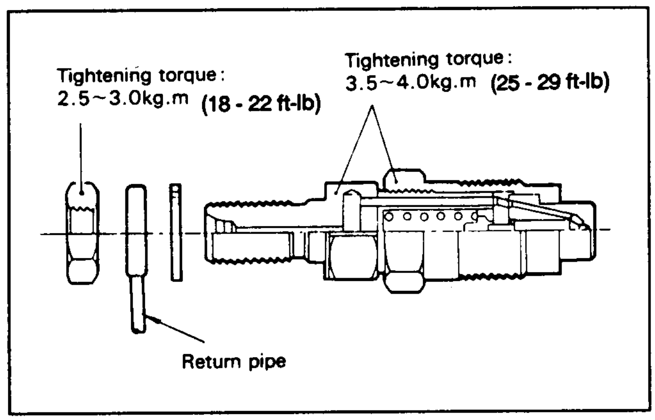


Figure 66

Removing and Installing the Fuel Tank

1. Stop the engine and engage the parking brake.

2. Remove the negative (–) cable from the battery.

3. Lift the seat mounting plate by removing the hair pin and pulling back on the locking spring flap. Disconnect the support rod from the seat plate and carefully lower the seat plate (Fig. 61).

4. Remove the capscrews and nuts from the hinges on the front of the seat plate (Fig. 63). Lift the seat and seat mounting plate off the frame.

6. Disconnect the wiring connectors from the two (2) electrical relays (Fig. 62). Remove the seat switch bracket from the seat frame. Leave all wires connected. Remove the cap screw and lock nut securing the fuel hose and wiring harness clamp to the rear of the seat frame.

7. Remove the knobs from the throttle lever and lift control lever. Remove the eight (8) capscrews and washers securing the seat frame to the chassis (Fig. 63).

8. Remove the four (4) socket head screws securing the instrument panel to the instrument box. Lift the instrument panel up and disconnect the wiring harness (Fig. 63).

9. Remove the two (2) cap screws and washers securing the instrument box to the seat frame (Fig. 63). Remove the ground wire from the cap screw. Pull the wiring harness through the opening to the inside of the seat frame. Open the tool box and remove the two (2) cap screws and washers securing the tool box to the seat frame.

10. Lift the seat frame off the chassis.

11. Remove the three (3) capscrews, lockwashers and flatwashers securing the fuel tank to the chassis (Fig. 63).

12. Disconnect the wires from the fuel sender (Fig. 63). Loosen the clamps holding both fuel lines on the fuel tank fittings. Pull the fuel lines off the fittings.

13. Lift the fuel tank up and remove it from the chassis.

14. Reverse steps 2 - 13 to install the fuel tank Tighten the fuel tank mounting cap screws to a torque of 70 - 80 in-lb (81 - 92 KgCm). Do not over tighten.

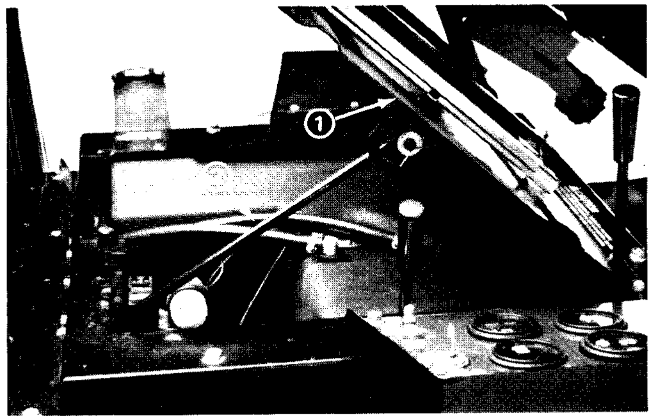


Figure 61

1. Seat mounting plate
2. Support rod

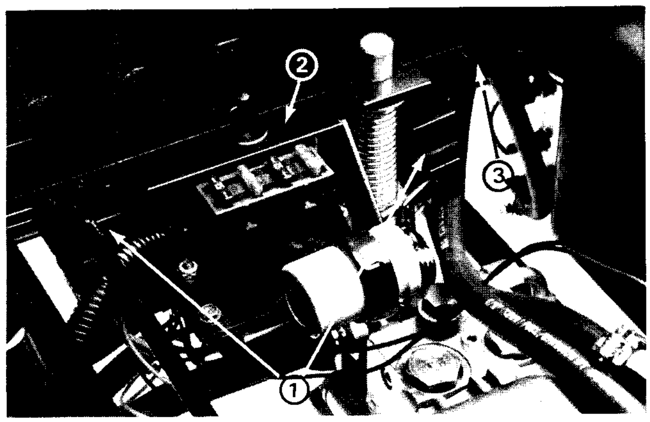


Figure 62

1. Relays (2)
2. Seat switch bracket
3. Clamp

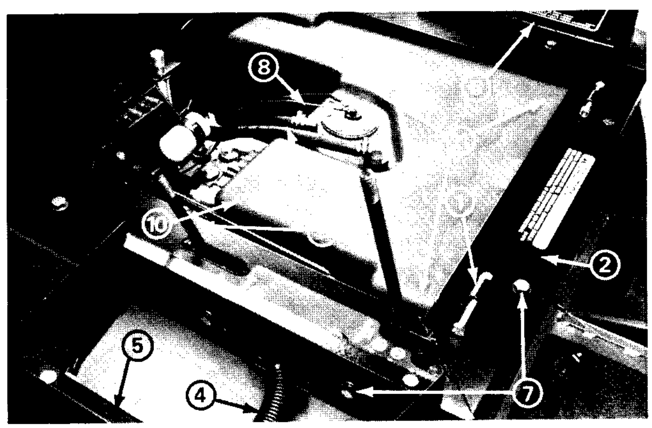


Figure 63

1. Hinge
2. Seat frame
3. Control levers
4. Wiring harness
5. Instrument box
6. Tool box
7. Capscrews & washers (12)
8. Fuel sender wires
9. Fuel lines
10. Fuel tank
11. Location of capscrews below fuel tank (3).

Removing and Installing the Engine

Removing the Engine

1. Put the machine on a level surface and engage the parking brake. Turn the engine OFF and remove the key from ignition switch. Allow the engine and radiator to cool.

2. Open the hood. Disconnect the hood stop cable from the muffler bracket (Fig. 64). Lower the hood. Remove the left and right hinge plates. Lift the hood off the chassis.

3. Disconnect both the positive (+) and negative (–) battery cables from the battery (Fig. 65). Loosen the battery securing bolt and remove the battery. Remove the battery mounting plate.

4. Open the radiator cap (Fig. 19). Put a drain pan under the left side of the radiator. Open the radiator drain valve or loosen the hose clamp and disconnect the lower radiator hose from the radiator (Fig 66). Allow the coolant to drain into the drain pan.

> **CAUTION**
>
> **DO NOT open the radiator cap or drain the coolant if the engine or radiator is hot. Pressurized, hot coolant can escape and cause burns.**
>
> **Ethylene-glycol antifreeze is poisonous. Dispose of it properly or store in a properly labeled container away from children or pets.**

5. Loosen the hose clamps and disconnect the upper radiator hose from the engine and radiator (Fig. 67). Lift the coolant expansion tank from the bracket and put it on top of the radiator.

6. Remove the plug from the cylinder block to drain coolant from the engine (Fig. 67).

7. Loosen the hose clamps and disconnect the air intake hose from the engine and air cleaner (Fig. 67).

8. Loosen the hose clamp and remove the fuel hose from the injector pump (Fig. 67). Plug the end of the fuel line to prevent fuel leakage. Loosen the hose clamp and remove the fuel return hose from the rear fuel injector on the engine.

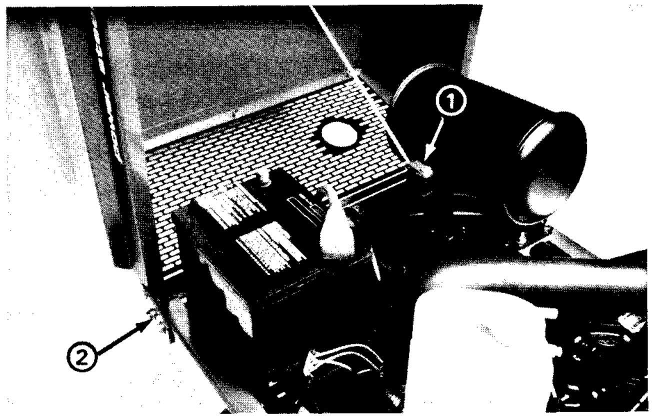


Figure 64

1. **Hood stop cable** 2. **Hinge plate**

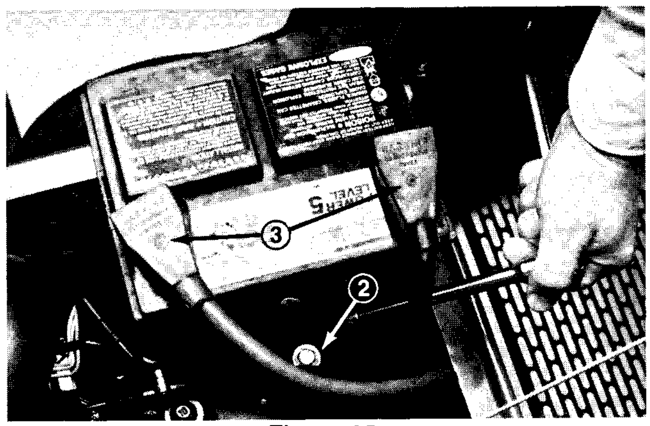


Figure 65

1. **Battery**
2. **Battery securing bolt (2)**
3. **Rubber boots (over battery posts)**

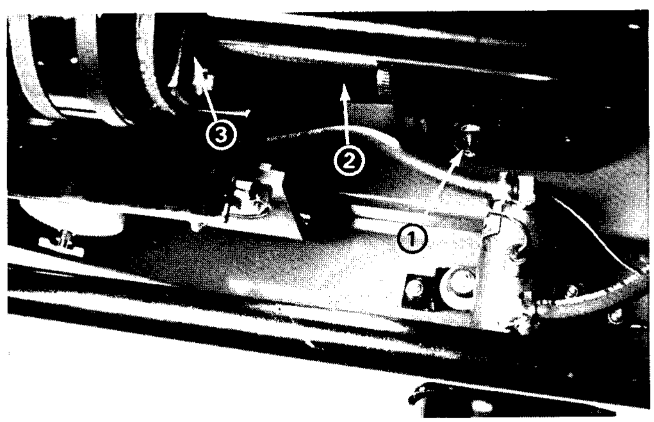


Figure 66

1. **Radiator drain valve**
2. **Lower radiator hose**
3. **Engine to trans. coupler**

9. Disconnect and tag wires that attach to the engine or engine components:

Alternator
Starter motor and solenoid
Ground cable
Oil pressure switch
Temperature gauge sender
Thermoswitch
Engine stop solenoid
Glow indicator
P.T.O. clutch

10. Loosen the jam nut on the P.T.O. adjusting bolt. Unscrew and remove the bolt, washer, spring and pin (Fig. 68). Remove the P.T.O. belt

11. Disconnect the engine to transmission coupler from the engine crankshaft pulley (Fig. 66). (See Removing Drive Coupling in the Repair section of Chapter 10 - Engine to Transmission Coupler.)

12. Remove the cooling fan. (See Cooling Fan Service in the External Engine Component Repair section of this chapter.)

13. Loosen the cap screw and nut to disconnect the throttle cable from the speed control lever on the engine (Fig. 67). Loosen the clamp and remove the throttle cable and from the engine bracket.

14. Remove four (4) cap screws washers securing the P.T.O. pivot plate to the engine (Fig. 69).

15. Remove the locknut, flat washer, bolt and rebound washer securing the engine to each of three (3) rubber engine mounts (Fig. 69).

16. Attach a short section of chain (approximately 13 inches (330 mm) between the two lifting holes in the engine brackets (Fig. 67). Connect the hoist or block and tackle chain at the center of the short section of chain. One person should operate the hoist or block and tackle and the other person should help guide the engine out of the chassis. Remove the engine from the chassis. Be careful when removing the engine to prevent damage to the engine, radiator or other parts. Mount the engine in an engine rebuilding stand.

17. Remove the muffler, brackets and accessories from the engine as necessary. Drain the oil from the engine and remove the engine oil filter.

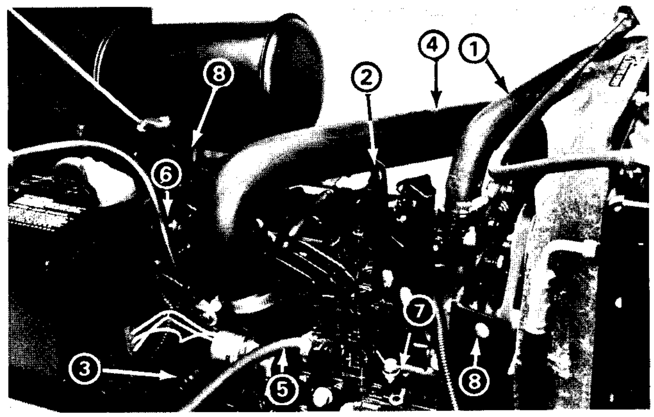


Figure 67

1. Upper radiator hose
2. Expansion tank bracket
3. Drain plug
4. Air intake hose
5. Fuel hose
6. Fuel return hose
7. Throttle cable
8. Lifting holes

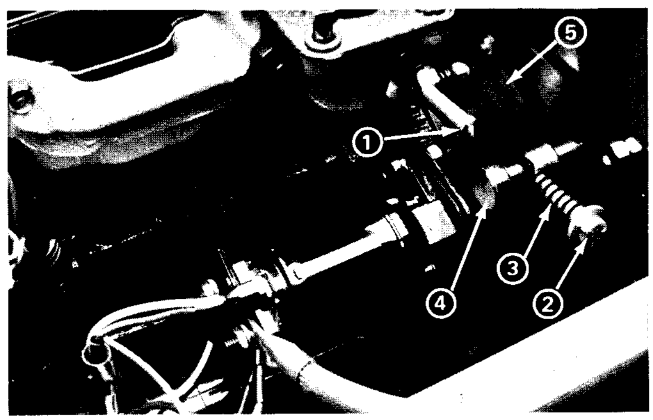


Figure 68

1. Jam nut
2. P.T.O. adjusting bolt
3. Spring
4. Pin
5. P.T.O. belt

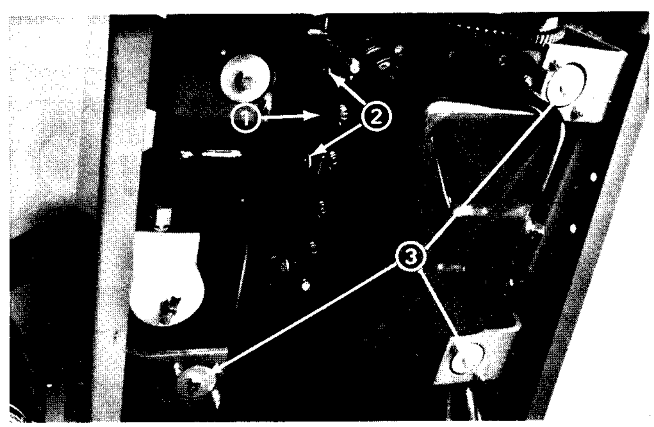


Figure 69

1. P.T.O. pivot plate
2. Cap screws & washers (4)
3. Engine mounts (3)

Installing the Engine

1. To install the engine, perform steps 2-17 of Removing the Engine in reverse order.

2. Install a new engine oil filter. Fill the engine with the correct oil. (See Checking Oil Level in the Maintenance section of this chapter.) Fill the cooling system with a 50/50 solution of ethylene glycol antifreeze and clean, soft water (see Checking Cooling System in the Maintenance section of this chapter). Check for oil and coolant leaks and repair as necessary.

3. Adjust the throttle linkage (See Throttle Linkage Adjustment in the Adjustments section of this chapter).

Cylinder Head Overhaul

Cylinder Head Removal

1. If the engine will not be removed from the traction unit, lower the coolant level in the engine. Loosen the hose clamp and remove the upper radiator hose from the thermostat housing. Disconnect the coolant bypass hose from the thermostat housing.

2. Remove the plug from the cylinder block (Fig. 67) to drain the coolant from the head and cylinder block.

3. Remove the muffler.

4. Remove the alternator (see Alternator Removal and Installation in the External Engine Component Repair section of this chapter).

5. Remove the glow plug lead wires.

6. Remove the fuel injection pipes and return pipe.

7. Remove the rocker cover and gasket.

8. Loosen the rocker stay attaching bolts. Remove the rocker assembly (Fig. 70a).

9. Loosen the cylinder head bolts. Use the sequence shown in Figure 70b. Remove the cylinder head assembly including the intake and exhaust manifolds.

10. Remove the cylinder head gasket. Use a scraper tool to remove the cylinder head gasket from the cylinder head and cylinder block. Make sure all of the gasket material is removed. Do not damage or scratch the cylinder head or cylinder block surfaces.

11. Remove the intake and exhaust manifolds from the cylinder head. Remove thermostat housing and thermostat.

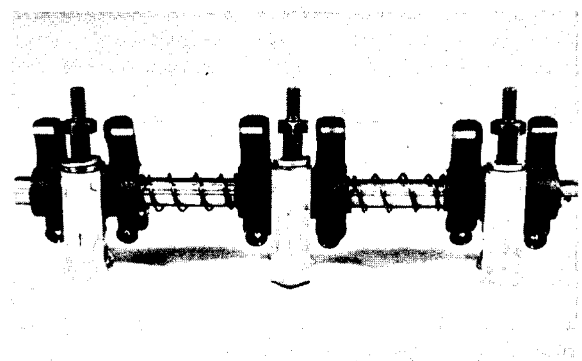


Figure 70a

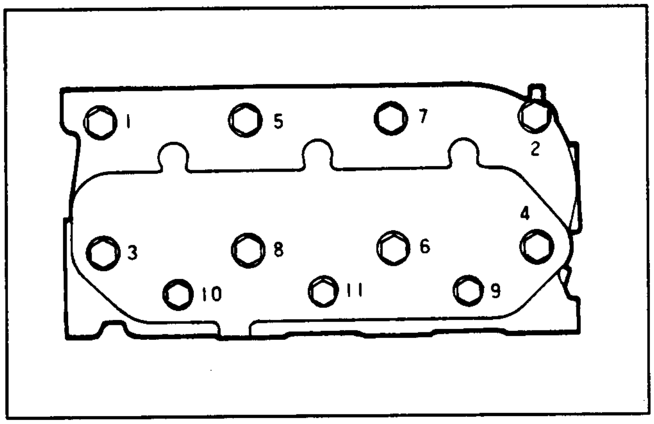


Figure 70b

Cylinder Head Service

1. Use a valve lifter tool to compress the valve spring (Fig. 71). To remove each valve retainer, depress the retainer against the valve spring and remove the retainer lock (Fig. 72). Remove the valve retainer, spring and valve. Keep each valve and other parts for each cylinder separate so they can be reinstalled in the same cylinder.

2. Examine each valve for burning, pitting, heavy carbon deposits or wear. The condition of the valves can give important information about other components that may require service (example: improper valve clearance, worn valve guides, damaged seals, etc.). Remove the valve seals.

3. Inspect the cylinder head for coolant leaks or damage before cleaning.

4. Remove all of the carbon deposits from the combustion chamber using a scraper and wire brush.

5. Clean the cylinder head thoroughly with solvent or degreasing solution and allow it to dry. Inspect carefully for cracks.

6. Remove all carbon deposits from the valve guide bores with a valve guide cleaner. Use a valve guide bristle brush to remove loosened carbon deposits in the valve guide. Push a solvent soaked cloth through the valve guides to remove all foreign material.

7. Use compressed air to clean out the oil passages. Make sure the oil passages are not plugged.

CAUTION

Warn other personnel in the area before using compressed air. To prevent injury, wear safety glasses, goggles or a face shield.

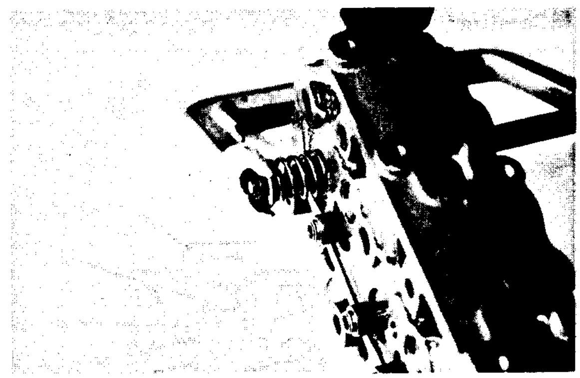


Figure 71

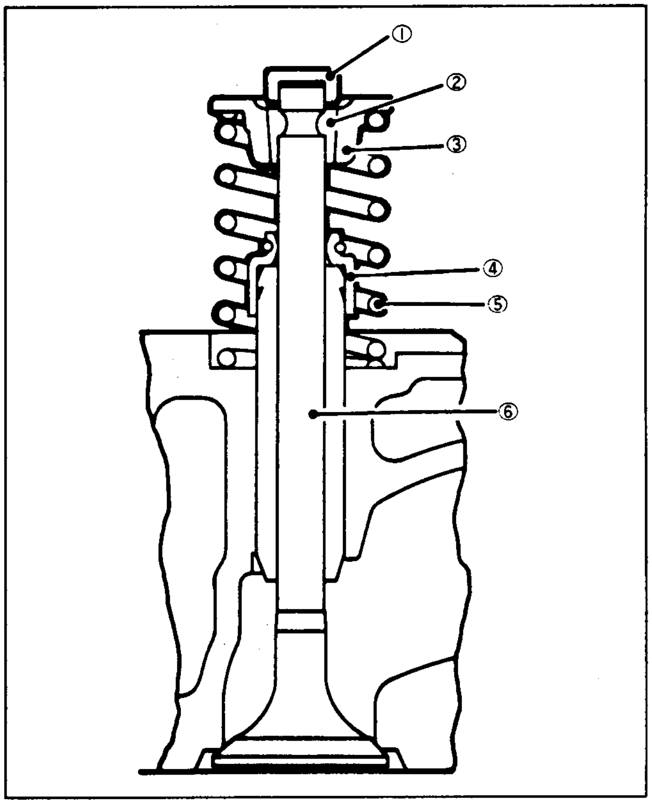


Figure 72

1. Valve stem cap
2. Retainer lock
3. Valve spring retainer
4. Valve stem seal
5. Valve spring
6. Valve

8. Use a straight edge and feeler gauge to check the flatness of the cylinder head lower surface (Fig. 73). Be sure to check the surface variation crosswise, lengthwise, and diagonally. If the variation in surface flatness exceeds (0.05 mm) 0.002 in., the cylinder head or cylinder block must be replaced or resurfaced.

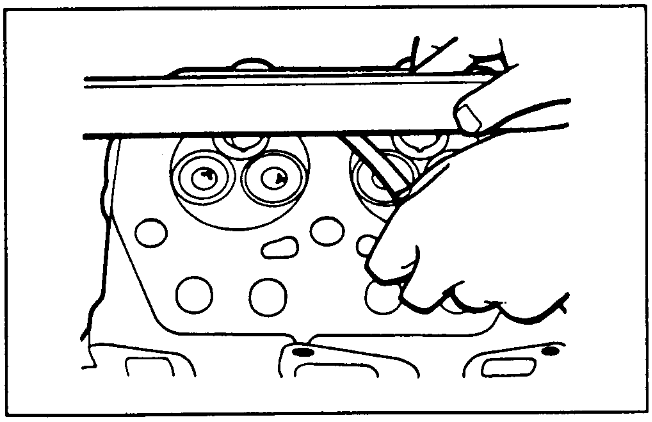


Figure 73

Valve Guides

1. Use a micrometer and a small hole gauge to check the valve guide to valve stem clearance. The valve and valve guide should be replaced if the clearance exceeds the following limits:

Valve guide to valve stem clearance

Intake valve: 0.10 mm (0.004 in.)
Exhaust valve: 0.15 mm (0.006 in.)

2. Use a valve guide removing mandrel with a pilot section to remove the valve guide. Push the valve guide up from the bottom of the cylinder head.

3. To install the new valve guide press it in from the top of the cylinder head, using the valve guide mandrel. Install the valve guide so the installed height is 13.5 - 14.5 mm (0.531 - 0.571 in.) above the cylinder head (Fig. 74).

4. After installing the new valve guide, check the valve guide to stem clearance. If the clearance is smaller than standard, it will be necessary to ream the valve guide bore to get the proper clearance.

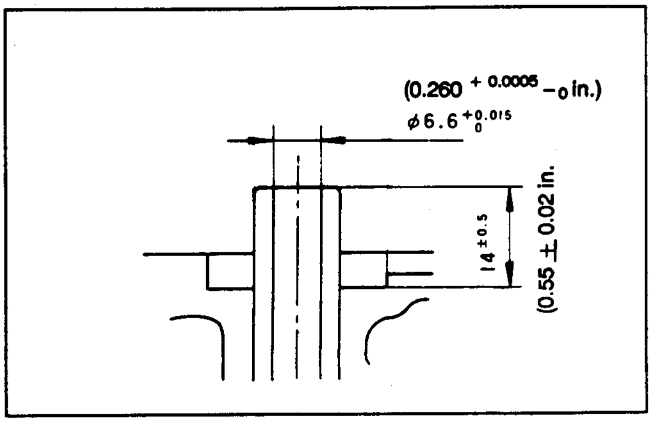


Figure 74

Valves

1. Carefully clean each valve with a wire wheel to remove all carbon deposits.

2. Check the valve face and valve stem for excessive wear, damage, cracks or deformation. If any of these conditions exist, the valve must be replaced. It is possible to reface the valve if the valve head thickness (margin width) is not less than the service limit (Fig.75). If the margin of the resurfaced valve is less than the service limit, replace the valve.

Minimum valve head thickness (margin width):
0.5 mm (0.020 in.)

3. Check the tip of the valve stem for wear or pitting. Replace the valve if the tip is worn.

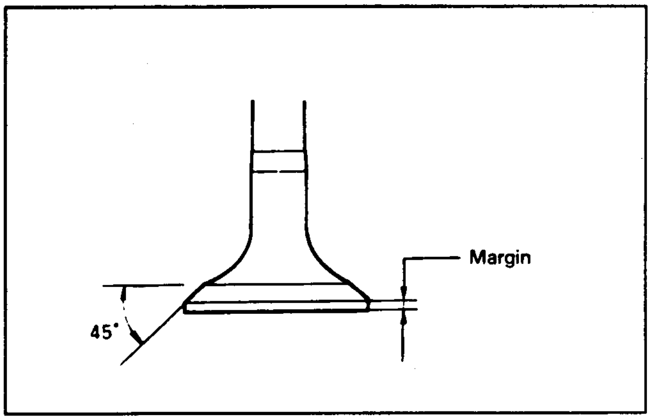


Figure 75

Valve Seats

1. Check the valve seats for damage and indications of incorrect contact (Fig. 76).

Maximum valve sinkage: 1.5 mm (0.06 in.)

2. The valve seat can be resurfaced (Fig. 77). Resurface the valve seat so it contacts the mid-portion of the valve face.

3. After cutting new valve seats, use lapping compound to lap the valve to the seat. After lapping, thoroughly clean the valve seat and valve areas to remove any traces of lapping compound.

4. Put a light coat of Prussion blue dye on the valve seat area. Install the valve. Hold the valve down and rotate it 1/4 turn, then turn the valve back to the original position. Remove the valve and examine the valve seat. The valve seat should show an even wear pattern from contact with the valve. Examine the valve. The dye should be evenly distributed around the valve and in the center of the valve face.

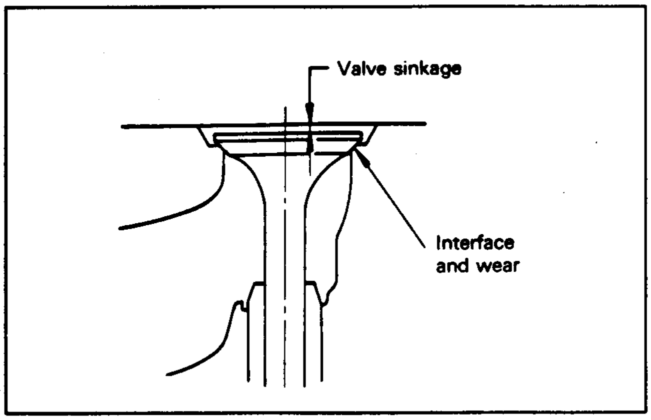


Figure 76

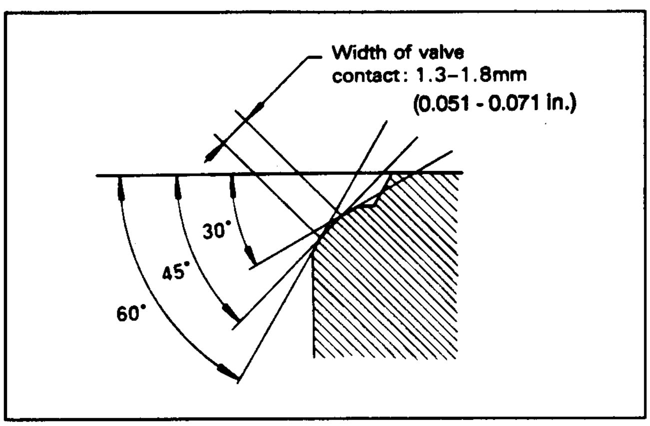


Figure 77

Valve Springs

1. Check the valve springs for rust, pitting, cracks or other damage.

2. Check the squareness of the valve spring by putting it upright on a level surface. Any spring that is 3° or more out of square must be replaced.

3. Measure the spring free length. Any spring that has a free length of 39.3 mm (1.55 in.) or less must be replaced.

4. Over a period of time, valve springs can lose some of their tension. The spring must be replaced if the tension is less than the service limit. (Fig. 78)

Minimum Installed Load/Height

(IN) 5.05 kg / 35.5 mm (11 lb. / 1.4 in.)
(EX) 12.61 kg / 28 mm (27 lb. / 1.1 in.)

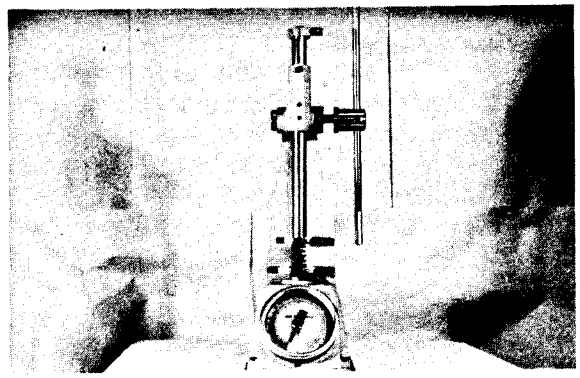


Figure 78

Rocker Arm and Rocker Shaft

1. Remove the snap ring on each end of the rocker shaft. Remove the rocker arm stay bolts. Remove rocker arm stays, spring and rocker arms from the shaft (Fig. 79).

2. Inspect each rocker arm for wear at the valve tip and push rod contact surfaces. Replace any worn or damaged rocker arms.

3. Inspect the rocker shaft for wear or damage. Replace the rocker shaft if it is worn or damaged.

4. Measure the rocker arm inside diameter and the shaft outside diameter. Replace the shaft if the rocker arm to shaft clearance is more than 0.02 mm (0.008 in.).

5. Make sure the oil passages in the rocker shaft and rocker arms are open. Clean if necessary.

IMPORTANT: When assembling the rocker assembly, make sure the identification mark near the end of the shaft is at the front and facing the valve side.

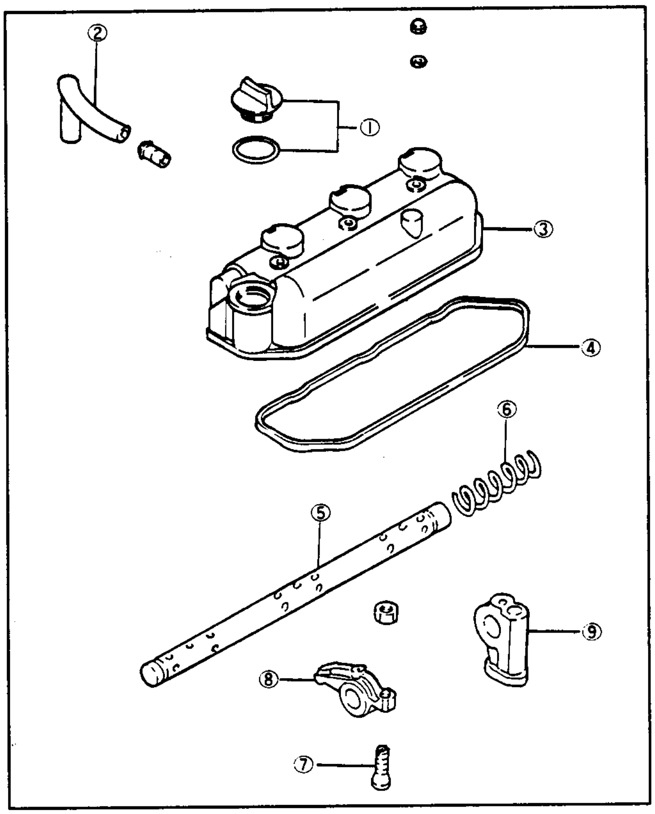


Figure 79

1. Oil filler cap
2. Breather hose
3. Rocker cover
4. Rocker cover gasket
5. Rocker shaft
6. Rocker spring
7. Adjusting screw
8. Rocker arm
9. Rocker stay

Cylinder Head Assembly and Installation

1. Install the thermostat housing. Use a new gasket.

2. Install the intake and exhaust manifolds. Use new gaskets.

3. Make sure the valve guides are properly installed (Fig. 74).

4. Install new valve stem seals onto the valve guides (Fig. 80). DO NOT install used seals.

5. Apply a coating of oil to the valve stems and insert them in proper order, into the valve guides. Install the valve springs and valve retainers. Compress the spring with a valve lifter, then install the retainer lock.

IMPORTANT: Be careful not to damage the spring and stem seal by over compressing the spring during installation.

6. Install the nozzle holders in the cylinder head and tighten to a torque of 5.0 - 6.0 KgM (36 - 43 ft-lb).

7. Install the glow plugs in the cylinder head and tighten to a torque of 5.0 - 6.0 KgM (36 - 43 ft-lb).

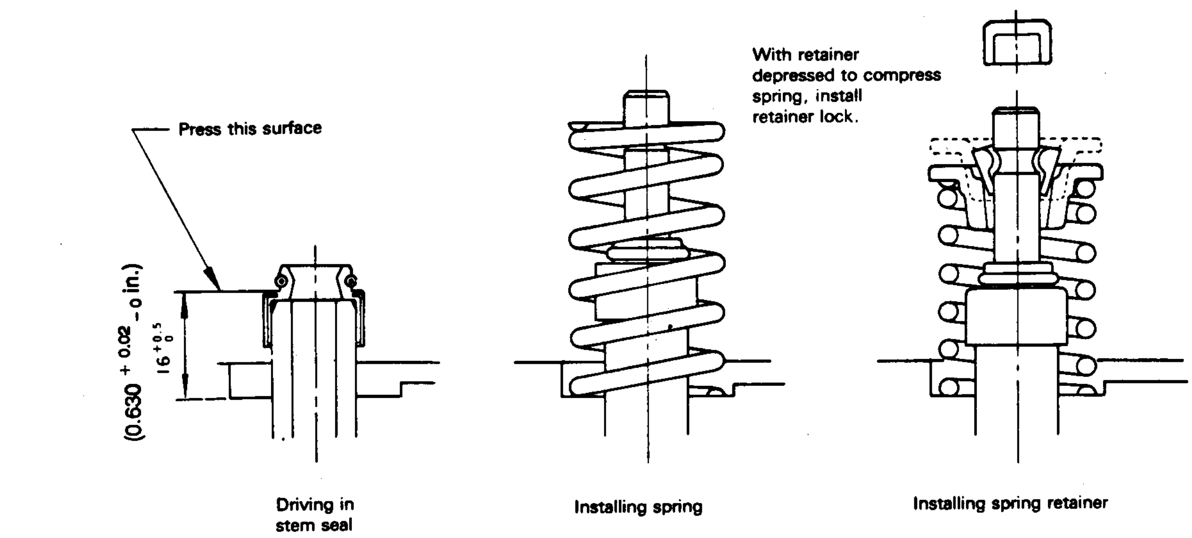


Figure 80

8. Make sure that the cylinder head and cylinder block surfaces are clean. Put a new gasket on the cylinder head. Insert dowel pins into two cylinder head bolt holes to assist in mounting the head onto the block. Carefully put the cylinder head into position on the cylinder block. Remove the dowel pins. Insert the cylinder head bolts.

IMPORTANT: Do not put any sealant on the cylinder head gasket.

9. Tighten the cylinder head bolts in the order shown in Figure 81. Tighten the bolts to approximately one-third the specified torque, then two-thirds and finally to the final specified torque.

M10 head bolt torque: 7.5 - 8.5 KgM (54 - 62 ft-lb)
M8 head bolt torque: 2.0 - 3.0 KgM (15 - 22 ft-lb)

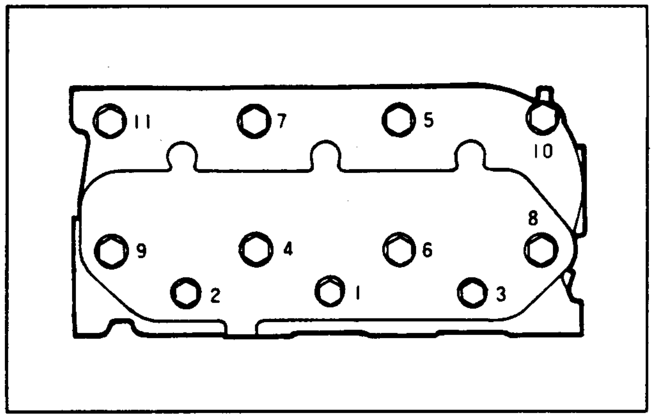


Figure 81

10. Install the fuel return pipe. Install the fuel delivery pipes. When tightening the nut on each end of the pipe hold the delivery valve holder or nozzle holder with a wrench to prevent turning.

11. Apply engine oil to the inside surface of the rocker arm bushings. Install the rocker arms, spring and rocker arm stays on the rocker shaft. Install the rocker shaft so the identification mark (small drilled hole near the end of the shaft) is at the front and facing the valve side. Install the bolts through each stay and into the shaft. Install the snap ring on each end of the shaft.

12. Install the rocker arm and shaft assembly on the cylinder head. Tighten the rocker arm stay bolts to a torque of 1.5 - 2.2 KgM (11 - 16 ft-lb)

13. Adjust the valve clearance. (See Checking and Adjusting Valve Clearance in the Maintenance section of this chapter.)

14. Install the rocker cover and gasket. Install the breather hose to the rocker cover and intake manifold.

15. Install the glow plug lead wires.

16. Install the alternator.

17. Install the muffler.

18. Install the upper radiator hose and tighten the hose clamps. Install the coolant bypass hose to the thermostat housing and tighten the hose clamps.

19. Fill the cooling system with a 50/50 solution of ethylene glycol antifreeze and clean, soft water (see Checking Cooling System in the Maintenance section of this chapter). Check for oil and coolant leaks and repair as necessary.

Cylinder Block Overhaul

NOTE: The engine must be removed from the traction unit chassis and put in an engine stand. (See the Removing and Installing The Engine section of this chapter.)

Gear Case and Oil Pump

1. Remove the crankshaft pulley.

2. Remove the fuel injection pump. (See Injection Pump Service in the Fuel System Repairs section of this chapter.)

3. Disconnect the governor spring from the tension lever. Remove the governor cover assembly from the gear case. (See the Governor System Repairs section of this chapter.)

4. Remove the water pump. (See Water Pump Service in the External Engine Component Repair section of this chapter.)

5. Remove the alternator. (See Alternator Removal and Installation in the External Engine Component Repair section of this chapter.)

6. Remove the gear case assembly (Fig. 82).

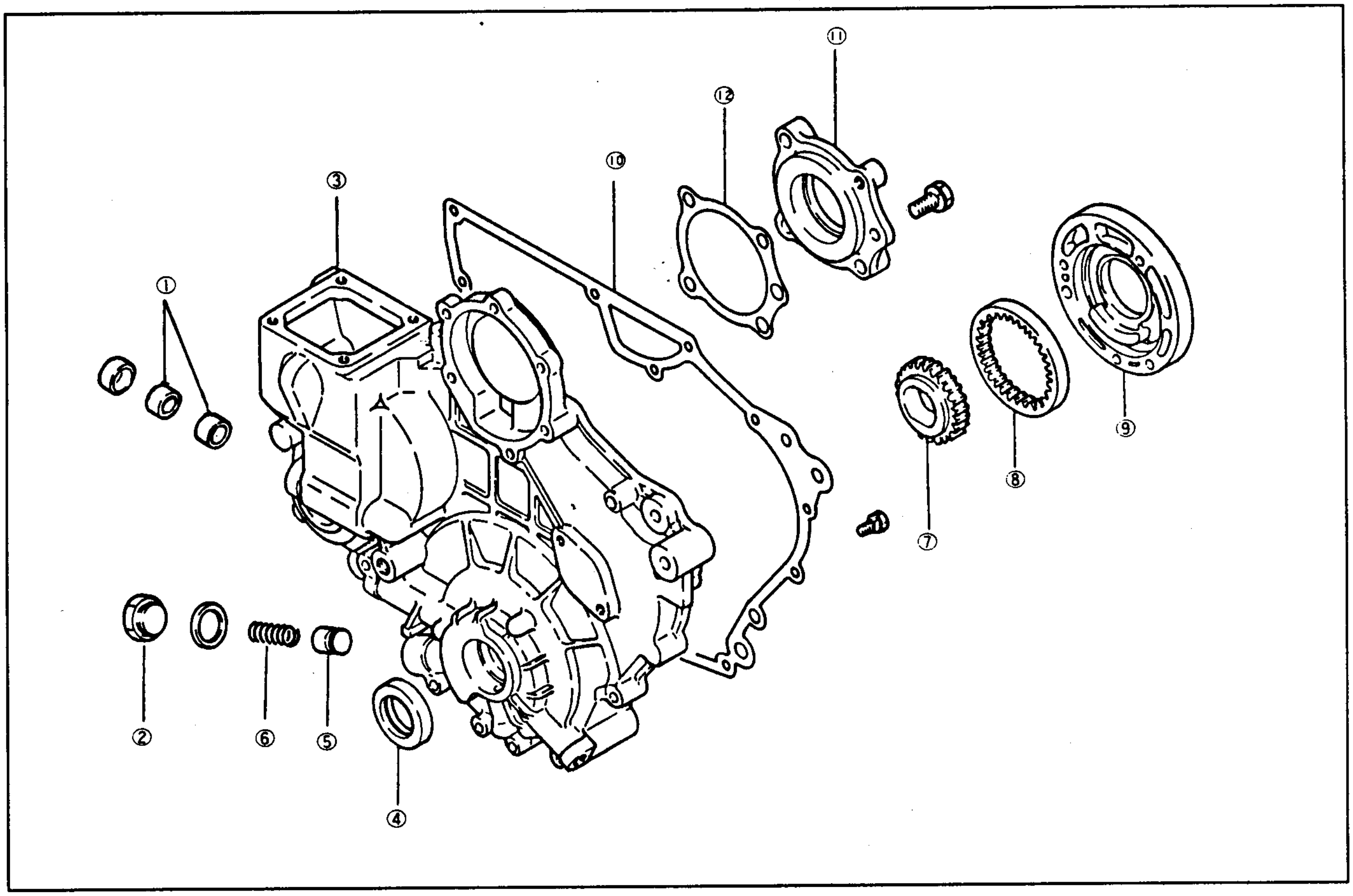


Figure 82

1. Bushings
2. Plug
3. Gear case
4. Front oil seal
5. Relief plunger
6. Relief spring
7. Oil pump inner gear
8. Oil pump outer gear
9. Oil pump housing
10. Gear case gasket
11. High pressure pump gear housing
12. Housing gasket

7. Check removed parts for wear or damage (Fig. 83). Replace parts as necessary.

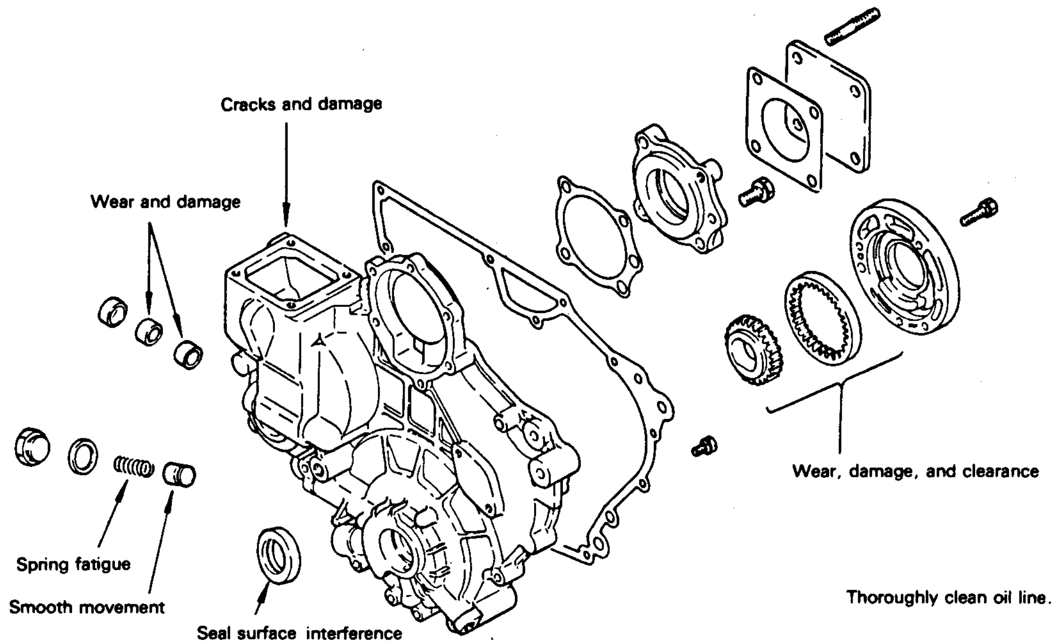


Figure 83

8. Check the governor parts for wear or damage (Fig 84). Replace parts as necessary.

A. Remove the expansion plug (Fig 85). Be careful to not scratch the gear case.

B. Pull out the grooved pin.

C. Remove the shaft, spring and levers.

D. If necessary replace the governor bushings (Fig. 86).

E. Install the shaft, spring and levers. Press fit the expansion plug into the hole in the gear case.

9. Reverse steps 1 - 6 to reassemble the gear case. Use new gaskets when assembling the gear case.

IMPORTANT: Install a new front oil seal before installing the gear case. Apply a thin coat of oil to the circumference and lip of the oil seal.

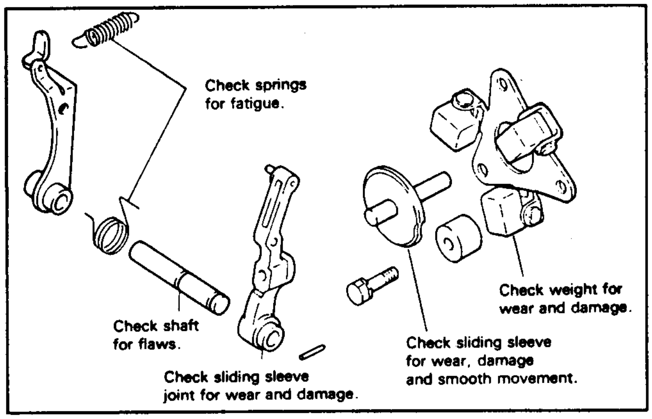


Figure 84

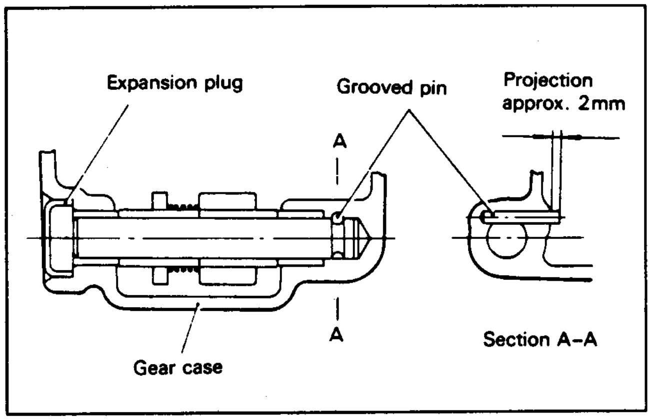


Figure 85

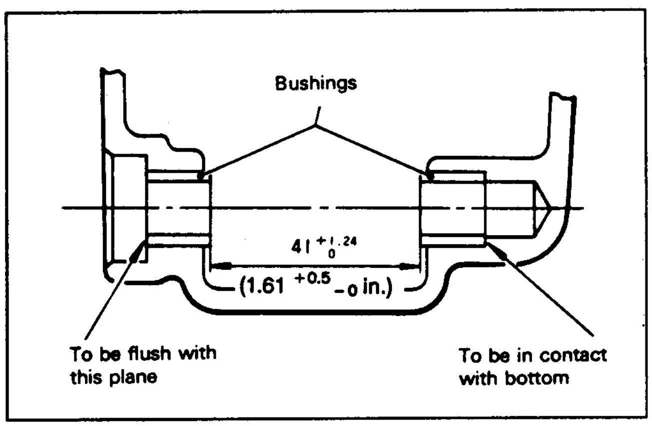


Figure 86

Timing Gears and Camshafts

1. Remove the cylinder head (see Cylinder Head Removal in the Cylinder Head Overhaul section of this chapter).

2. Remove the gear case (see Gear Case and Oil Pump in this section).

3. Remove the snap ring and remove the idle gear (Fig. 87).

4. To remove the injection pump camshaft:

   A. Remove the governor weight assembly (Fig. 50).

   B. Remove camshaft rear cover.

   C. Remove the stopper bolt (Fig. 88).

   D. Pull out the camshaft from the front of the cylinder block.

5. To remove the valve camshaft:

   A. Pull the push rods and tappets out of the cylinder block.

   B. Remove the camshaft stopper bolt.

   C. Pull the camshaft out of the cylinder block (Fig 89).

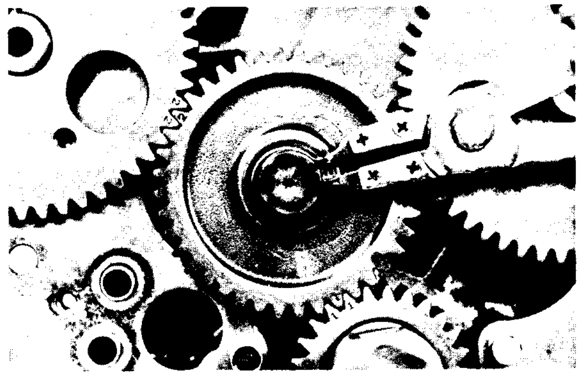


Figure 87

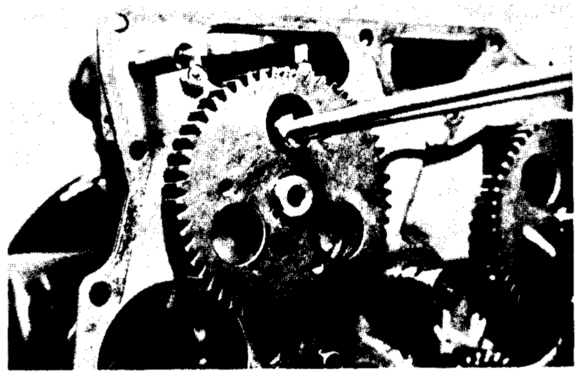


Figure 88

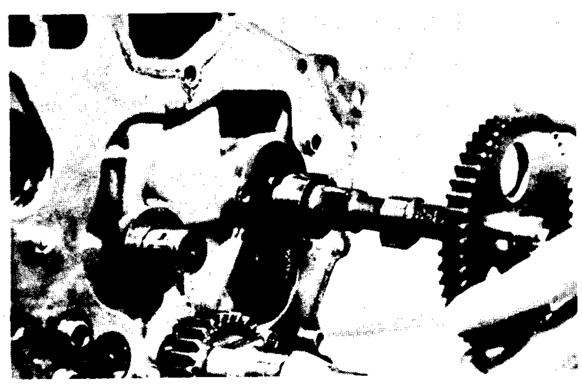


Figure 89

6. Check the gears for incorrect tooth contact, wear and damage. Replace any gears that are badly worn or damaged.

Maximum idle gear bushing to shaft clearance:
0.2 mm (0.008 in.)

Maximum backlash between gears in mesh:
0.3 mm (0.012 in.)

7. Inspect the camshaft parts (Fig. 90). Replace any parts that are worn or damaged.

Major diameter of cam:
Injection pump cam: 29.3 - 30 mm (1.154 - 1.181 in.)
Valve cam: 26.37 - 27.37 mm (1.038 - 1.078 in.)

Push rod bend: within 0.3 mm (0.012 in.)

Tappet to cylinder block hole clearance:
0.15 mm (0.006 in.) maximum

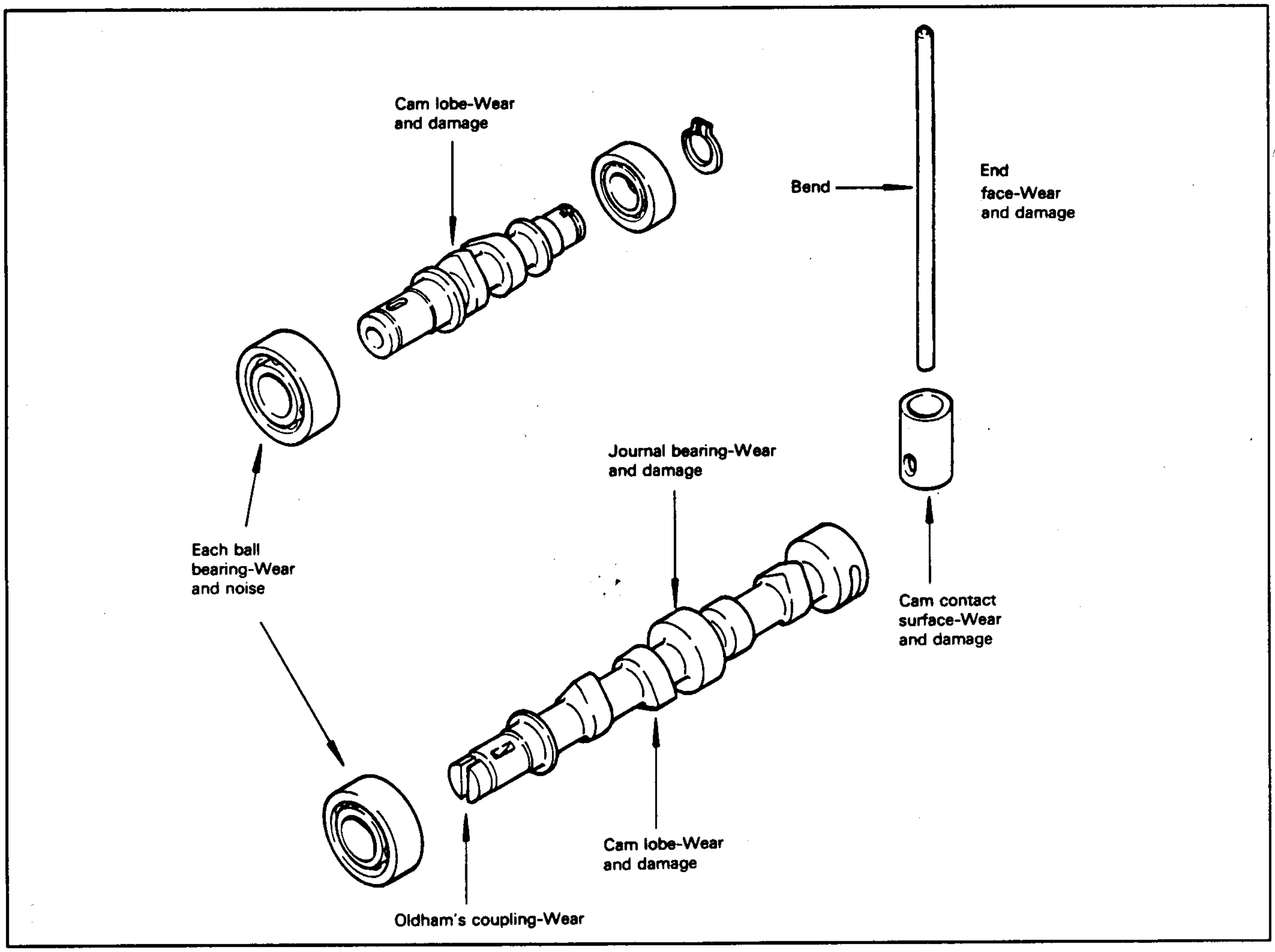


Figure 90

8. Before installing the camshafts and timing gears, turn the crankshaft to set the No. 1 cylinder to top dead center (TDC) of the compression stroke. Reverse steps 1 - 5 to install the camshafts and timing gears (Fig. 91).

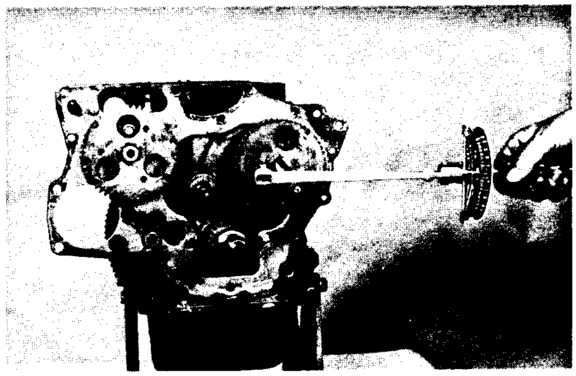


Figure 91

9. With the crankshaft set to No. 1 cylinder TDC, install the idle gear so the timing marks on all the gears are in alignment (Fig. 92).

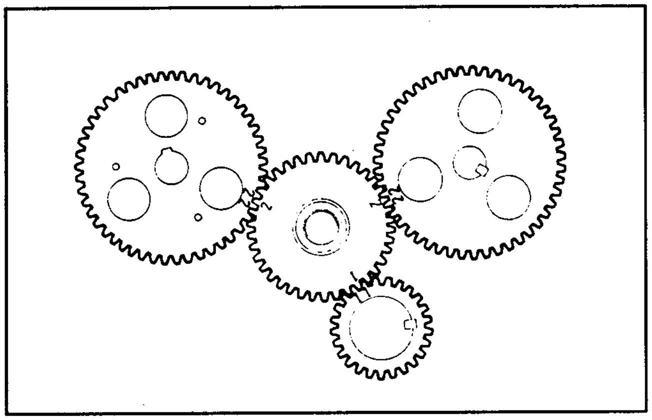


Figure 92

Piston and Connecting Rod

1. Remove the cylinder head (see Cylinder Head Removal in the Cylinder Head Overhaul section of this chapter).

2. Remove the oil pan and gasket.

3. Remove the oil screen

NOTE: Before removing the pistons, mark the number of the cylinder onto the top of each piston and on the side face of each connecting rod (on the large end). When the piston and connecting rod is removed be careful to prevent damage to the piston or bearing surfaces.

4. Use a ridge removing tool to remove the ring ridge from each cylinders. This will prevent damage to the rings and pistons.

5. Remove the connecting rod end caps and bearings (Fig 93). Keep these parts in cylinder number order so they can be reinstalled in the same cylinder. Use a wood block to push the pistons and connecting rods up out from the bottom of the block. Take care not to scratch the crankshaft pin and cylinder.

6. Check each piston for wear, signs of seizure or nicks. Replace the piston if it is damaged.

7. Thoroughly clean the carbon deposits from the piston and ring grooves. A ring groove cleaner, or piece of discarded ring may be used to clean the ring grooves.

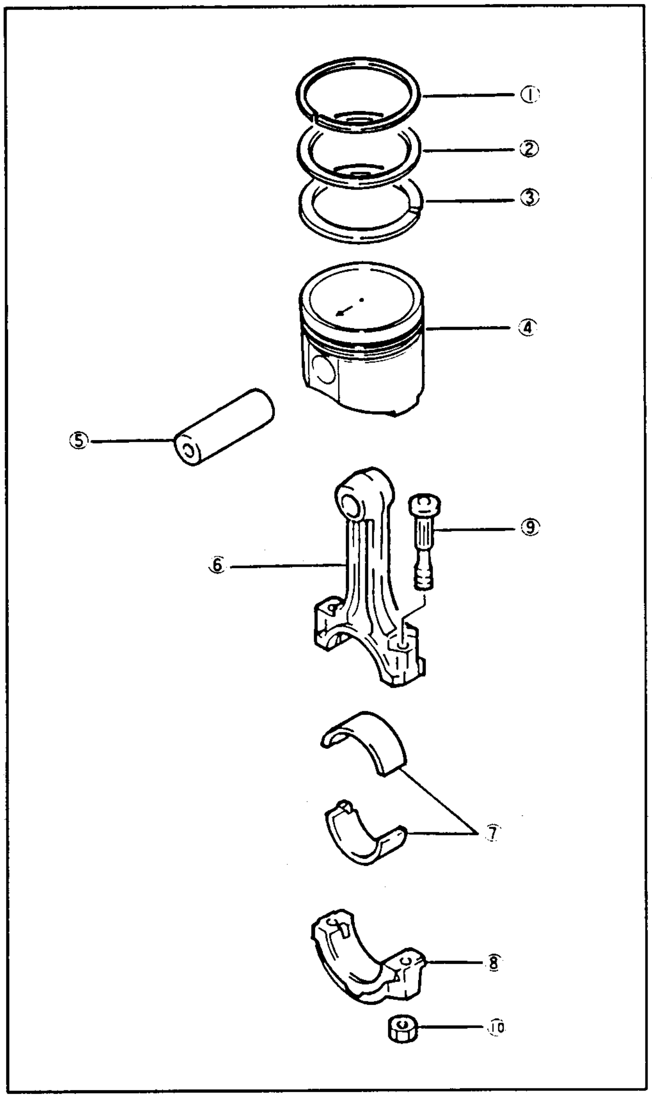


Figure 93

1. Piston ring No. 1
2. Piston ring No. 2
3. Oil ring
4. Piston
5. Piston pin
6. Connecting rod
7. Connecting rod bearing
8. Connecting rod cap
9. Connecting rod bolt
10. Connecting rod nut

8. Measure the piston outside diameter (Fig. 94). (See Cylinder Block in this section).

Maximum piston to cylinder wall clearance:
0.3 mm (0.012 in.)

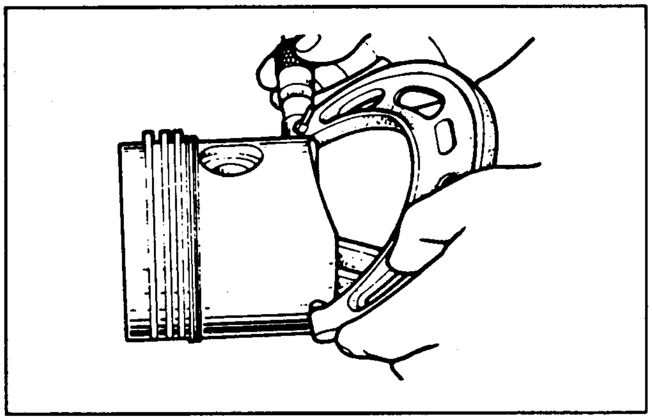


Figure 94

9. Use a thickness gauge to check the piston ring side clearance (Fig. 95).

If the piston ring side clearance exceeds the service limit, the ring must be replaced. If the clearance still does not meet specifications with a new ring the piston must be replaced. (See the Specifications section of this chapter.)

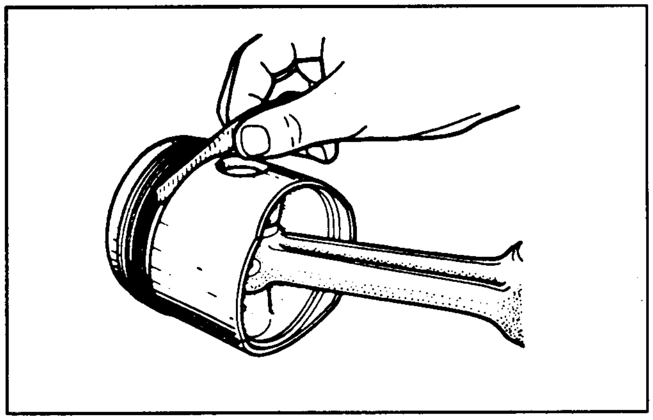


Figure 95

10. Measure the piston ring end gap. Insert the ring into the least worn area of the cylinder by pushing it into place with the piston (Fig. 96). If the gap exceeds 1.5 mm (0.060 in.) the ring must be replaced.

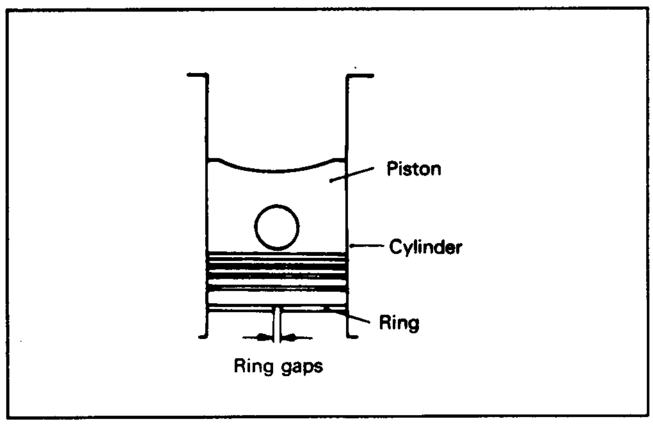


Figure 96

11. To remove the piston from the connecting rod press the piston pin from each piston. Use the piston setting tool (Fig. 97).

IMPORTANT: Do not attempt to remove the piston pins by driving then out with a hammer. A stuck piston pin, requiring excessive pressure to remove, should be replaced. Standard pin removal force is 500 - 1500 kg (1100 - 3300 lb.).

CAUTION

Do not put a load of more than 3000 kg (6600 lb.) on the piston pin setting tool.

12. Check for bending or distortion of the connecting rod. The service limit for bend and distortion is 0.15 mm (0.006 in.). Replace the connecting rod if damaged or out of specification.

13. To assemble the piston to the connecting rod, press the piston pin into the set position. Use the piston pin setting tool (Fig. 98). Make sure the identification mark of the rod and the arrow mark on the piston head are directed up.

Pin press fitting force: 500 - 1500 kg (1100 - 3300 lb.)

14. Assemble each connecting rod and bearing to the crankshaft in proper order. Use a feeler gauge to measure the side clearance between the connecting rod end and crankshaft (Fig. 99). Replace the connecting rod assembloy if the side clearance is more than the specified amount.

Maximum connecting rod side clearance: 0.5 mm (0.02 in.)

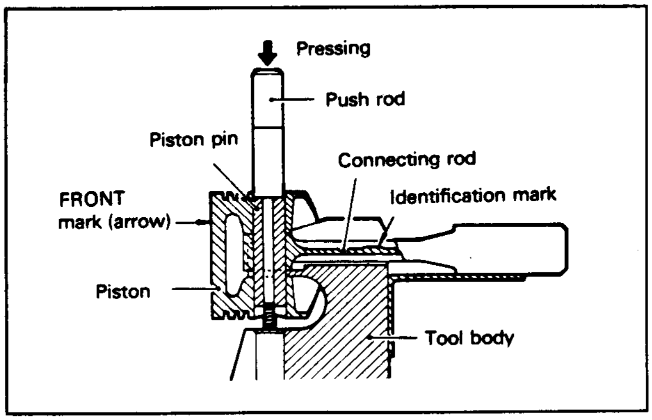


Figure 97

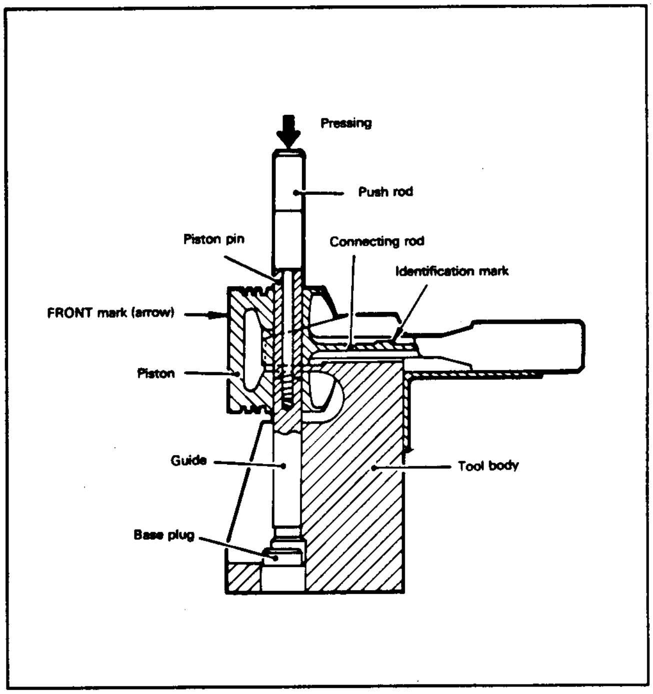


Figure 98

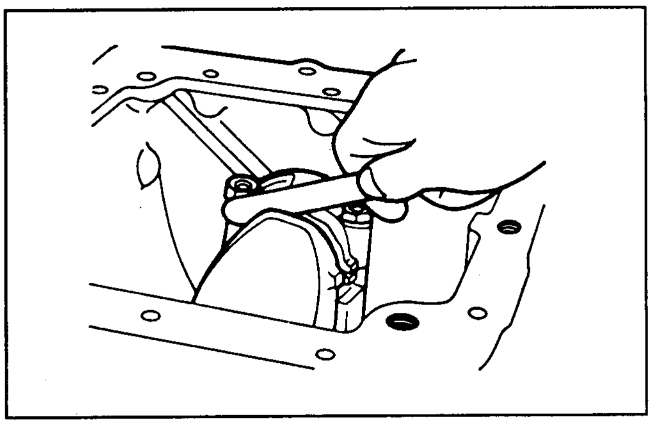


Figure 99

15.Install the piston rings. Each piston ring has different shape. Make sure they are installed in the proper position and with the ring gaps in the directions as illustrated (Fig. 100).

16. Insert the piston and connecting rod assembly into the cylinder block using a ring compressor and a wooden block. Make sure the arrow mark on top of the piston is facing toward the front of the engine.

17. Install the connecting rod bearings and end caps. Make sure the notches on the bearings and connecting rod are aligned. Tighten the end cap retaining bolts to a torque of 3.2 - 3.5 KgM (23 - 25 ft-lb).

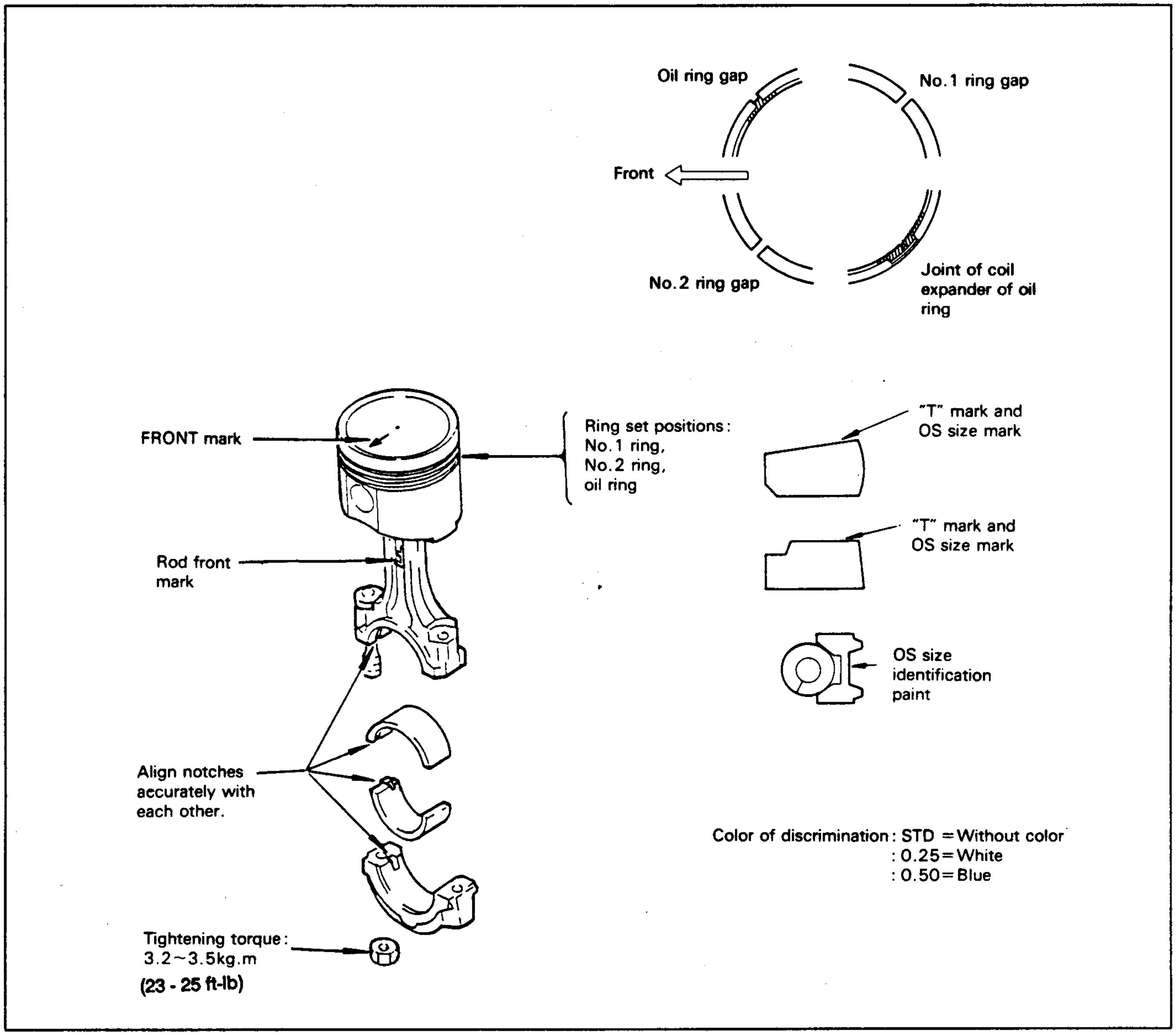


Figure 100

Crankshaft

1. Perform steps 1 - 5 under Piston and Connecting Rod in this section.

2. Remove the flywheel.

3. Remove the rear oil seal case.

4. Remove the main bearing caps (Fig. 101). Keep each set of bearings together with its bearing cap.

5. Remove the crankshaft.

6. Inspect the removed parts. Repair or replace any worn or damaged parts (Fig. 102).

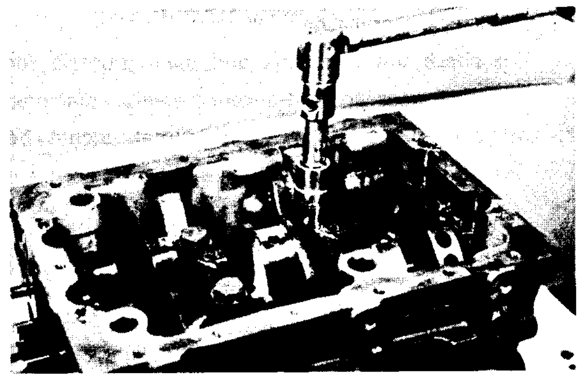


Figure 101

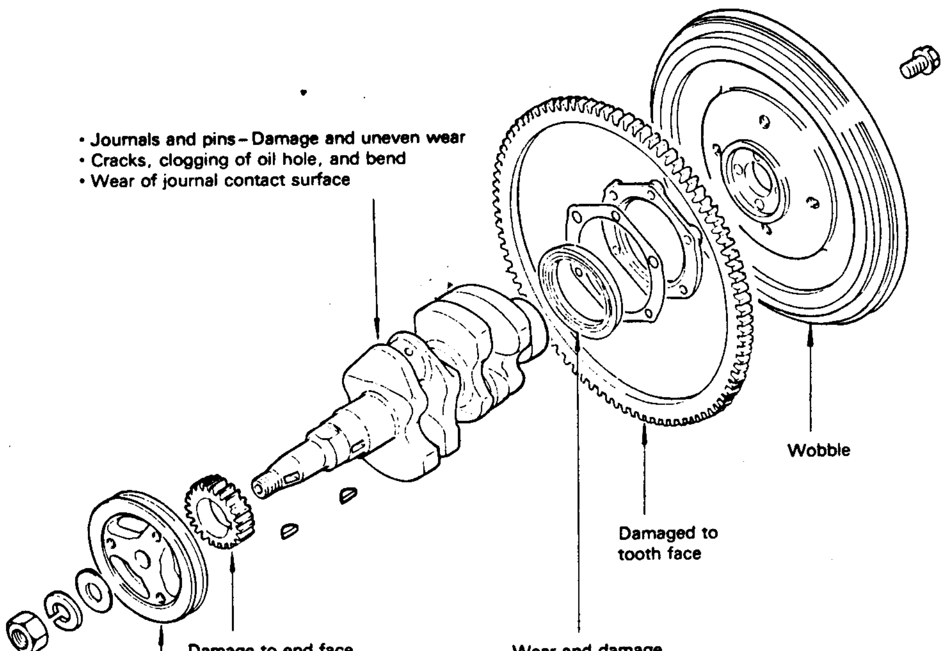


Figure 102

6. Measure the crankshaft for "run-out" (bend). Mount the crankshaft in a pair of V-blocks (or live centers) and use a dial indicator to measure the run-out in the crankshaft (Fig. 103). The maximum allowable crankshaft run-out is 0.05 mm (0.002 in.).

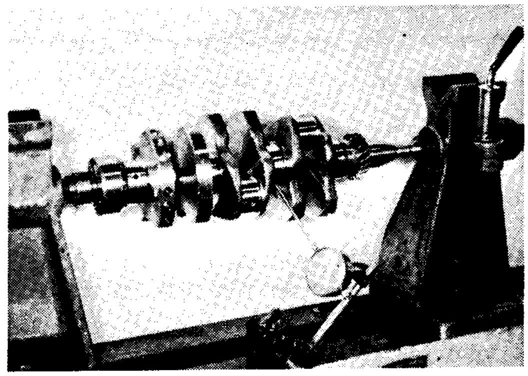


Figure 103

7. Check the crank journals and crankpins for damage, out of round wear or tapering wear. The diameter of each crankpin or main journal should be measured at two places, "1" and "2", in two directions, "A" and "B" (Fig. 104).

Main journal diameter: 42.3 mm (1.665 in.) minimum
Crankpin diameter: 39.3 mm (1.547 in.) minimum

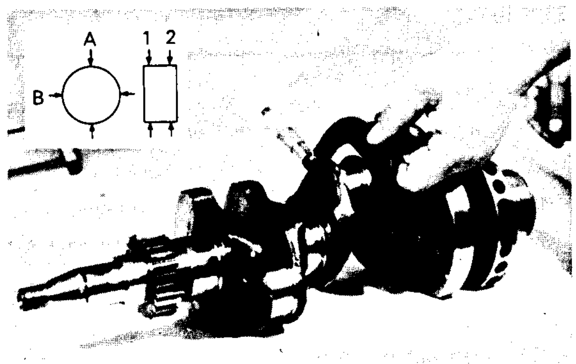


Figure 104

8. Check the crankshaft oil clearance. Oil clearance is calculated by subtracting the diameter of the main journal or crankpin from the inside diameter of the main bearing or rod bearing. The inside diameter of each crankpin or main journal should be measured at two places, "1" and "2", in two directions, "A" and "B" (Fig. 105) after the bearing cap is installed at the proper torque. If the oil clearance exceeds the service limits, install a new bearing. If installing the new bearing does not reduce the clearance to within service limits, the crankshaft must be reground and oversize bearings installed.

Tightening Torque:
Main bearing cap bolt: 5.0 - 5.5 KgM (23 - 25 ft-lb)
Rod bearing cap nut: 3.2 - 3.5 KgM (36 - 40 ft-lb)

Crankpin oil clearance: 0.15 mm (0.006 in.)
Journal oil clearance: 0.10 mm (0.004 in.)

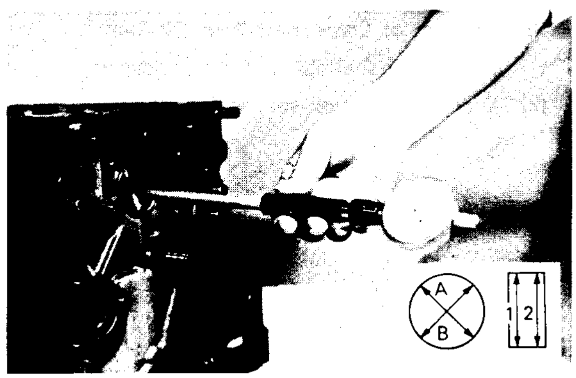


Figure 105

NOTE: If using Plastigauge to measure the oil clearance, put a piece of Plastigauge onto the crankpin or journal, and tighten the bearing cap (with bearing) in place. DO NOT rotate connecting rod or crankshaft when the Plastigauge is in place. Rotating will destroy the Plastigauge. Remove the bearing cap and measure the width of the Plastigauge to determine the clearance. If the oil clearance exceeds the service limits, install a new bearing. If installing the new bearing does not reduce the clearance to within service limits, the crankshaft must be reground and oversize bearings installed.

9. To install a new oil seal, pry the seal out with a screwdriver and drive a new seal into the oil seal case.

10. Reverse steps 1 - 5 to install the crankshaft (Fig. 107). When installing the No. 1 and No. 4 bearing caps, apply sealant (Permatex No. 2 or equivalent) to the upper surface that meets with the cylinder block.

11. Use a dial indicator to measure the crankshaft end play. If end play exceeds specifications, replace all the main bearings.

Crankshaft end play: 0.05 - 0.175 mm (0.002 - 0.007 in.)

12. Apply sealant (Permatex No. 2 or equivalent) to the outside surface of the side seals. Install the side seals with the radius towards the outside of the engine (Fig. 106).

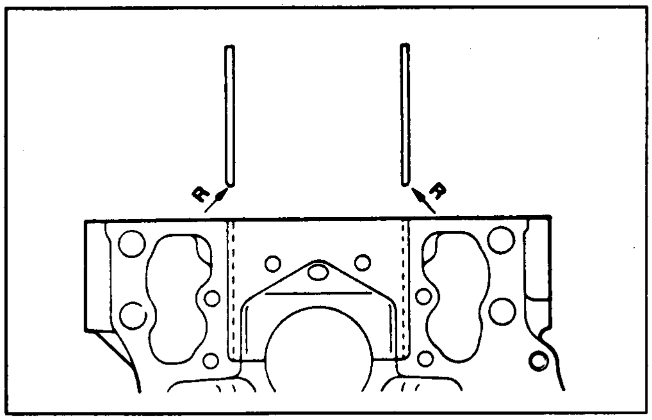


Figure 106

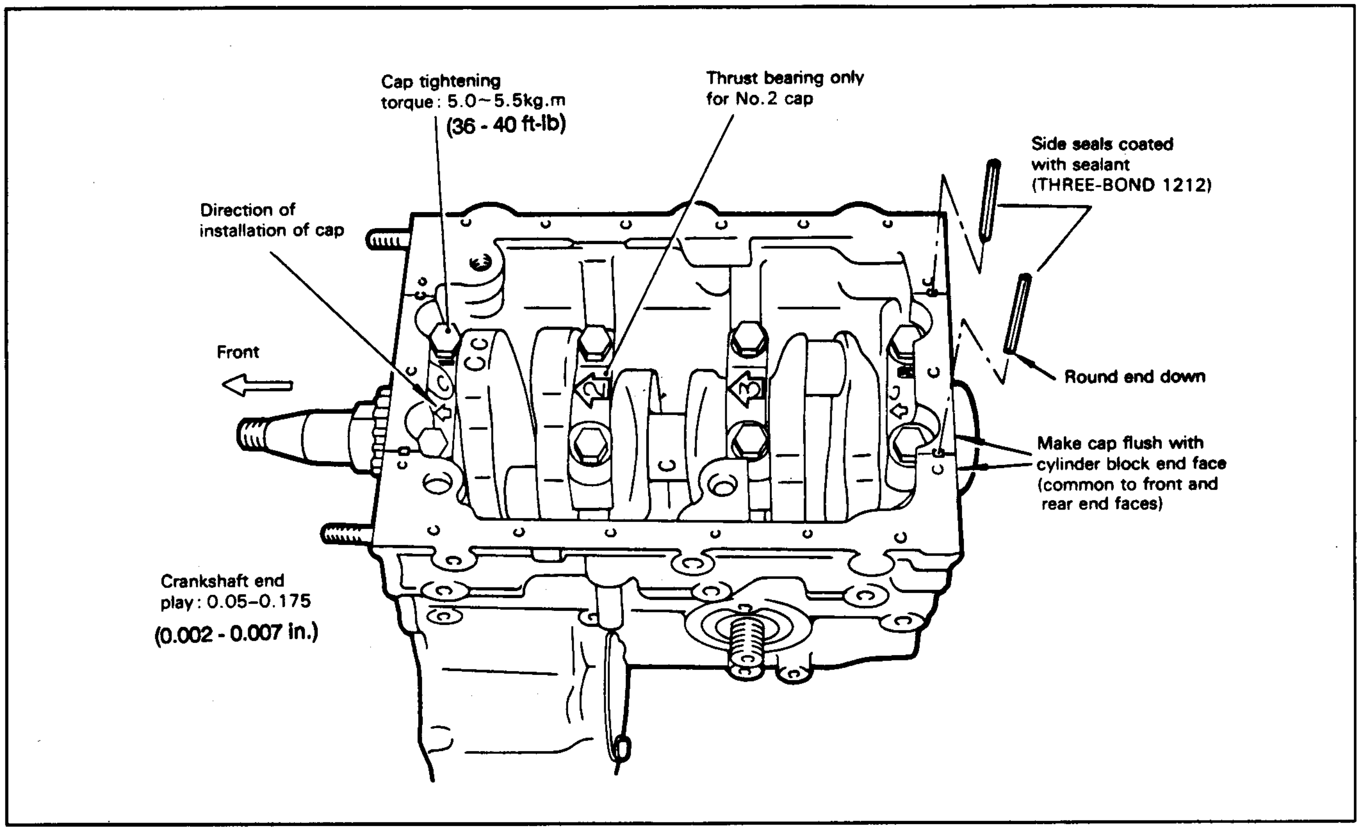


Figure 107

Cylinder Block

Before cleaning check the cylinder block for coolant leaks, oil leaks or damage. Clean all parts to remove dirt, oil, carbon deposits and water scale.

Check the cylinder block for cracks or other damage. Check the water jacket for water scale and rust. Replace the cylinder block if necessary.

Measure each cylinder bore size in six locations (Fig. 108).

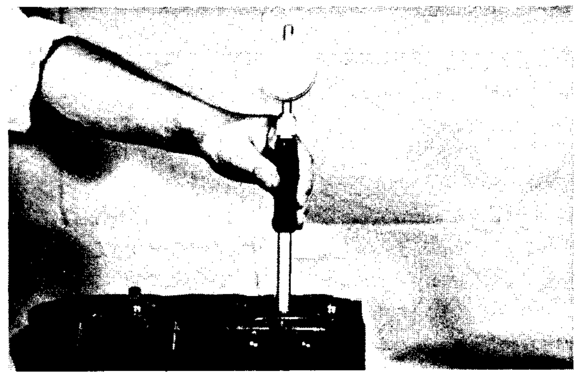
Standard bore diameter:	
Groundsmaster 220-D	70 mm (2.7559 in.)
Groundsmaster 223-D	76 mm (2.9921 in.)

The cylinder must be rebored and over-sized piston and rings installed if the diameter exceeds the standard by 0.2 mm (0.0079 in.). Examine the cylinder bore diameter readings to determine the amount of taper in the cylinder. If the taper exceeds 0.01 mm (0.0004 in.), the cylinder must be rebored and oversized piston and rings installed.

IMPORTANT: If one cylinder is rebored, all cylinders must be rebored to the same specifications.

NOTE: See the Specifications section of this chapter for oversize finishing sizes. After machining, install the piston and piston rings corresponding to the reworked cylinder size.

NOTE: When the cylinder bore is worn a small amount and the only the piston rings require replacement, check for groove wear in the upper part of the cylinder. Hone the cylinder if necessary.



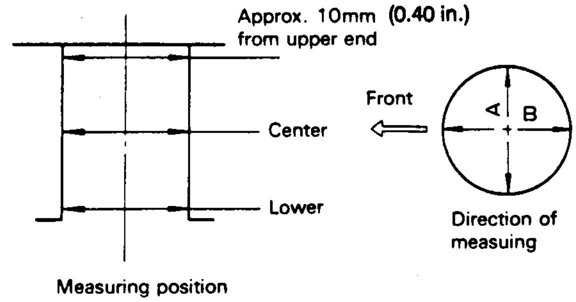


Figure 108

Reboring Cylinder

1. Select a piston:

   0.25, 0.50 mm (0.01, 0.02.) oversize

2. Measure the piston diameter (Fig. 94).

3. Reboring finish dimension = (Piston O.D.) + (Clearance) – (Honing allowance).

   Clearance: 0.071 - 0.084 mm (0.0028 - 0.0033 in.)
   Honing allowance = 0.02 mm (0.0008 in.)

Chapter 4

Hydraulic System

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Introduction

This chapter describes the maintenance, testing, adjustment and repair of the hydraulic system used on the Groundsmaster® 220-D

See **Chapter 8 - Steering System** for information about testing, troubleshooting and repairing the power steering valve and cylinder.

A U-type hydrostatic transmission (Fig. 1), provides an infinitely variable forward/reverse drive by the simple movement of a foot control.

Power from the hydrostatic transmission is transmitted to the Dana GT-20 drive axle through a spur gear set. The differential assembly then transfers the power to the wheels through the two axle shafts (Fig. 2).

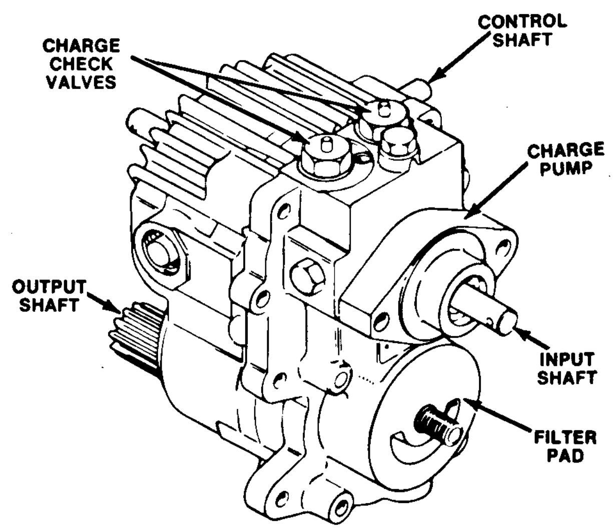


Figure 1

This Sundstrand, Series 15 transmission operates with a closed-loop main system circuit (Fig. 3). Charge pump oil in excess of that required to supply the closed-loop main circuit (traction system only) is diverted to the steering control valve. Oil not required for steering goes to the auxiliary implement and cooling circuit.

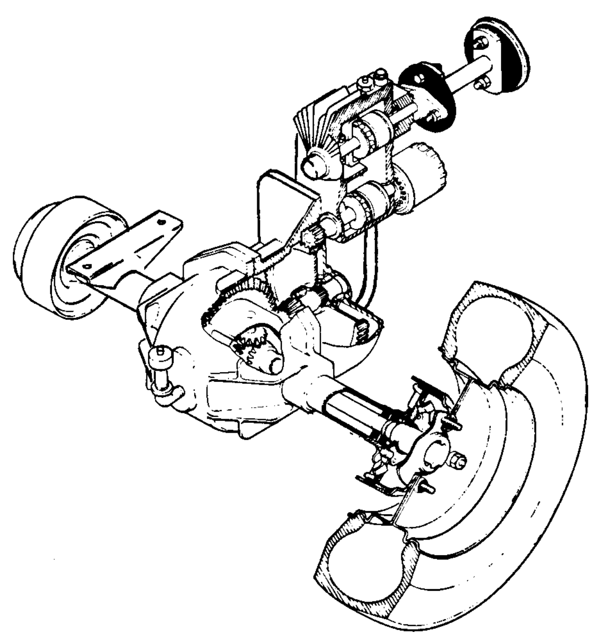


Figure 2

Hydraulic Schematic

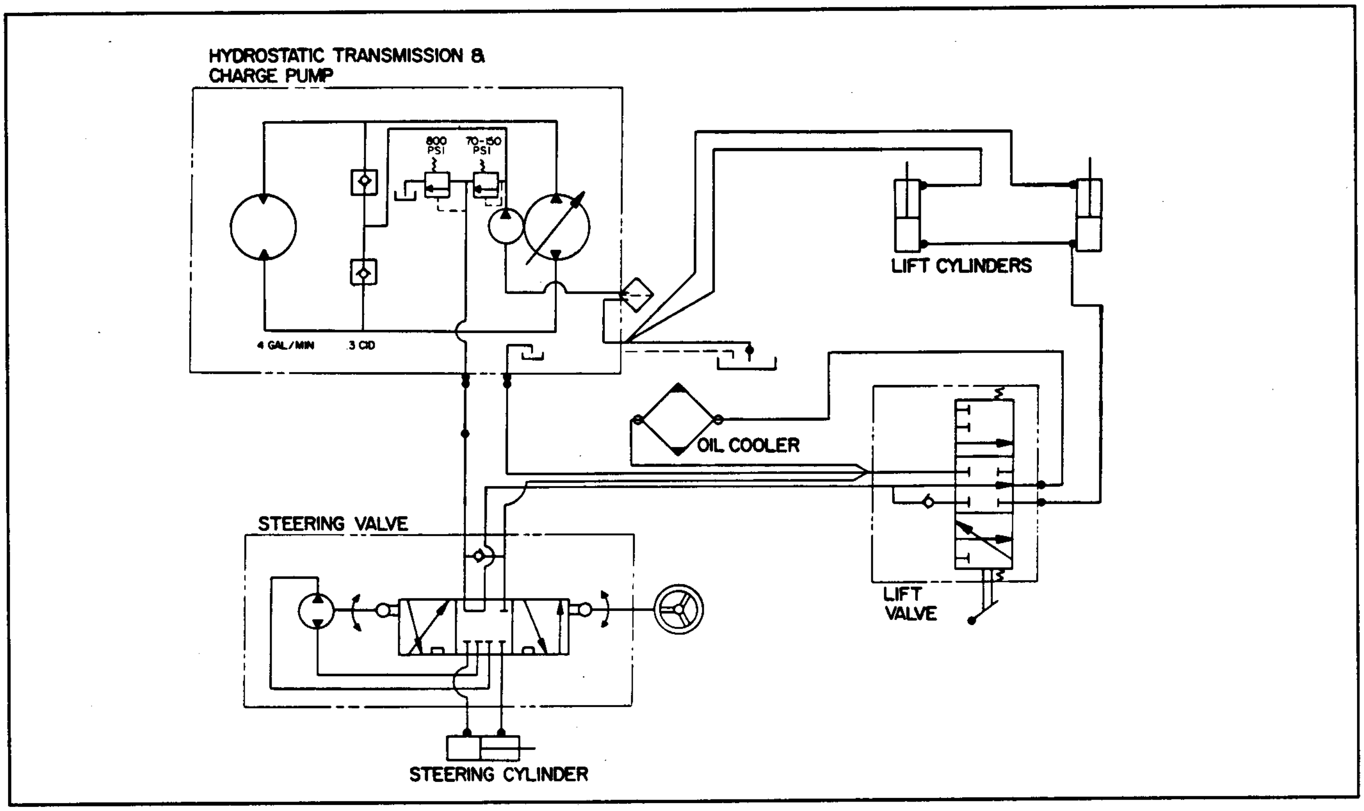


Figure 3

Specifications

Item	Description	Standard
Sundstrand Hydrostatic Transmission	Pump displacement Pump input speed (maximum) Motor displacement Motor output speed Maximum normal operating pressure Charge pump displacement Charge relief pressure Maximum inlet vacuum Maximum case pressure Implement relief pressure	12.6 gal/min (47.9 L/min) @ 3200 rpm 3200 ± 50 rpm 12.6 gal/min (47.9 L/min) @ 3200 rpm 0 - 3300 rpm 3000 psi (20685 kPa) 4.6 gal/min (17.3 L/min) @ 3200 rpm 70 - 150 psi (453 - 1034 kPa) 5 in. of Hg (16.9 kPa) 15 psi (103 kPa) 700 - 800 psi (4826 - 5516 kPa) @ 3200 rpm
Hydraulic oil	Above 32° F (0° C) Below 32° F (0° C)	10W-30 engine oil or Type A automatic transmission oil Type A automatic transmission oil or 5W-20 engine oil
Lift Control Valve	Four way, three position, open center	
Reservoir	Differential housing	5 qt. (4.7 liter) capacity
Oil filter	Transmission mounted (TORO P/N 23-2300)	25 micron screw-on type

Special Tools

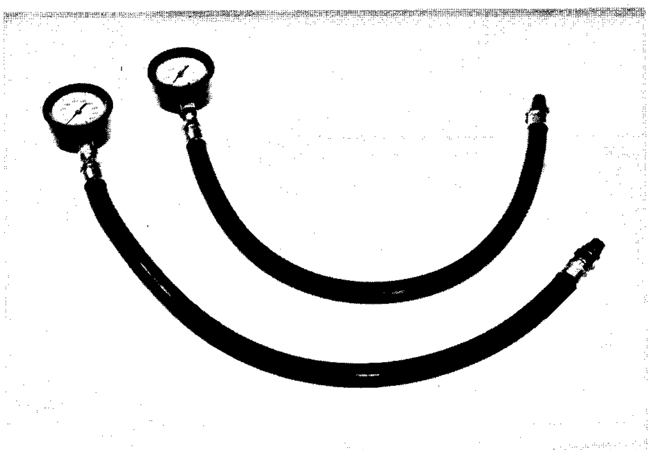


Figure 4

High and Low Pressure Test Gauges

Low pressure gauge 0 - 1000 psi (0 - 6895 kPa), high pressure gauge 0 - 5000 psi (0 - 34475 kPa), and associated hoses and fittings (Fig. 4).

Use the low pressure gauge to check charge pressure and implement relief pressure. Use ONLY the high pressure gauge during the Testing Traction Pressure procedure.

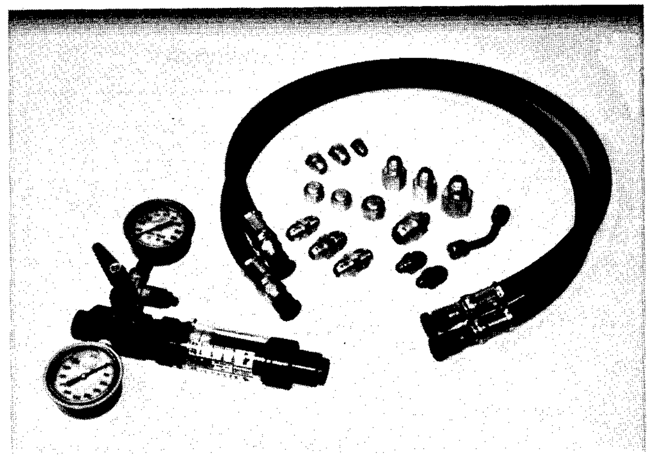


Figure 5

Tester with Pressure and Flow Capabilities.

NOTE: You must have o-ring face seal (ORFS) adapter fittings for this tester to use it on the Groundsmaster® 220-D.

Two tests may be made with this tester (Fig. 5): checking the charge pump flow and checking the implement relief setting; traction pressure CANNOT be tested.

INLET HOSE: Hose connected from the system circuit to the inlet side of the hydraulic tester.

LOAD VALVE: If required, upon turning the valve to restrict flow, a simulated working load is created in the circuit.

LOW PRESSURE GAUGE: Low range gauge to provide accurate reading at low pressure, 0 - 1000 psi (0 - 6895 kPa).

This gauge has a protector valve which cuts out when pressure is about to exceed the normal range for the gauge. The cutout pressure is adjustable.

HIGH PRESSURE GAUGE: High range gauge to accommodate pressure beyond the capacity of the low pressure gauge, 0 - 5000 (0 - 34475 kPa).

FLOW METER: This meter measures actual oil flow in the operation circuit. The reading is given in gallons per minute (GPM) and liters per minute (LPM) with a gauge rated at 15 GPM (57 LPM).

OUTLET HOSE: Hose from the outlet side of the hydraulic tester to be connected to the hydraulic system circuit.

Hydraulic System Oil

Oil must be selected according to the anticipated ambient temperature. Temperature/viscosity recommendations are:

Above 32°F (0° C) use SAE 10W-30 or 10W-40 engine oil. Type A automatic transmission fluid may be used as a substitute.

Below 32° F (0° C) use type A automatic transmission fluid. SAE 5W-20 engine oil may be used as a substitute.

IMPORTANT: Do not mix engine oil and automatic transmission fluid; hydraulic system component damage may result. When changing from one type of fluid to another, be sure to completely drain the old fluid and change the filter. DO NOT use Dexron II ATF.

The axle housing acts as the reservoir for the system. The hydraulic system is filled at the factory with SAE 10W-30 engine oil. Check the transmission oil level before the engine is first started and daily after that.

Checking Oil Level

1. Put the machine on a level surface and engage the parking brake. Put all controls in the neutral position and start the engine. Run the engine at lowest possible rpm to remove air from the system. DO NOT engage the PTO. Turn the steering wheel several times fully to the left and right. Raise the cutting unit to extend the lift cylinders. Turn the steering wheel so the rear wheels are in the straight ahead position and turn the engine OFF.

2. To prevent contamination, clean the area around the dipstick cap. Unscrew and remove the dipstick cap (Fig. 6) from the filler neck and wipe it with a clean rag. Screw the dipstick cap FINGER TIGHT ONLY onto the filler neck. Unscrew the dipstick and check the level of the oil. If the level is not within 1/2 inch (13mm) from the groove in the dipstick (Fig. 7), add enough oil to raise the level to the groove mark. DO NOT OVERFILL.

IMPORTANT: When adding oil to the hydraulic system, use a funnel with a fine wire screen (200 mesh). Make sure that the funnel and oil are very clean to prevent accidental contamination of the hydraulic system.

3. Screw the dipstick fill cap finger-tight onto the filler neck. DO NOT tighten the cap with a wrench.

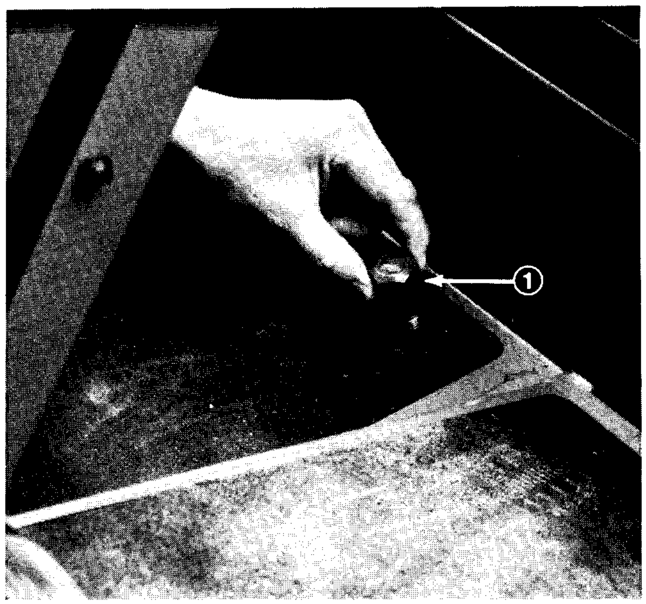


Figure 6

1. Hydraulic reservoir dipstick / fill cap

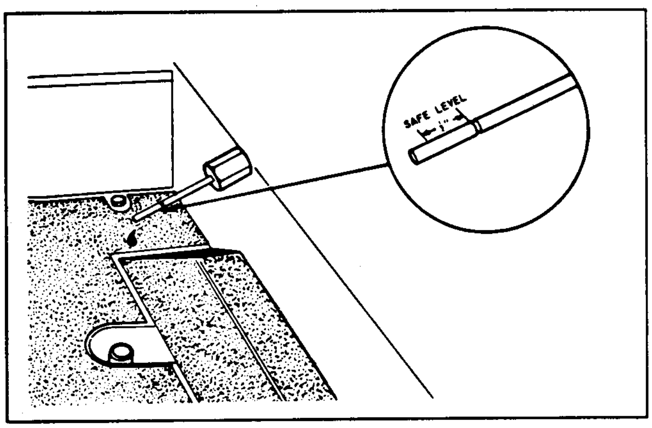


Figure 7

Inspecting Hydraulic Lines and Fittings

A daily inspection of the lines and fittings should include:

1. Check for clearances; hoses or tube lines should not rub against another line or part.

2. Check for poor physical condition; look for cracks, abrasions, swelling, and deterioration.

3. Check for bends, dents, and kinks; too much fluid flow restriction may cause overheating and slow operation.

4. Look for signs of oil leakage.

Replace any hoses, tube lines and fittings that are worn or damaged. The correct method for tightening hydraulic fittings should be followed at all times. (See Hydraulic Hoses and Hydraulic Fitting Installation in the Repairs section of this chapter.)

WARNING

Keep body and hands away from pin hole leaks or nozzles that eject hydraulic fluid under high pressure. Use paper or cardboard, not hands, to search for leaks. Hydraulic fluid escaping under pressure can have sufficient force to penetrate skin and do serious damage. If fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type of injury or gangrene may result.

Before disconnecting or performing any work on the hydraulic system, all pressure in the system must be relieved by stopping the engine and lowering the implement to the ground.

Replacing Hydraulic Oil and Filter

Change the oil and filter after the first 5 hours of engine operation, and after every 250 hours of operation or yearly, whichever comes first.

The axle housing is the reservoir for the hydraulic oil and its capacity is approximately 5 U.S. quarts (4.7 L).

The transmission uses a TORO 25 micron filter that spins onto the back of the transmission (Fig. 8). An oil filter wrench may be used to remove the filter.

1. Park the machine on a level surface, lower the cutting unit to the shop floor, set the parking brake, and turn the engine OFF. Block the two front wheels.

2. Clean the area around the hydraulic oil filter. Remove the filter from the back of the transmission.

3. Remove the transmission suction hose that connects the axle housing to the transmission. Let the oil flow into a drain pan.

4. Put a light coating of oil on the rubber gasket of the new hydraulic oil filter. Install the filter onto the transmission.

5. Install the transmission suction hose between the axle housing and transmission.

6. Fill the axle (reservoir) to the proper level. (See Checking Oil Level in this section of the book.)

7. Start the engine and cycle the steering and lift cylinders. Check for oil leaks. Allow the engine to run for approximately 5 minutes. Turn the steering wheel so the rear wheels are pointing straight ahead. Turn the engine OFF.

8. Allow the machine to sit for approximately 2 minutes. Check the level of the oil in the axle. If the level is low, add oil to achieve the proper level. If the level is too high, drain out some of the oil until it is at the correct level. (See Checking Oil Level in this section of the book.)

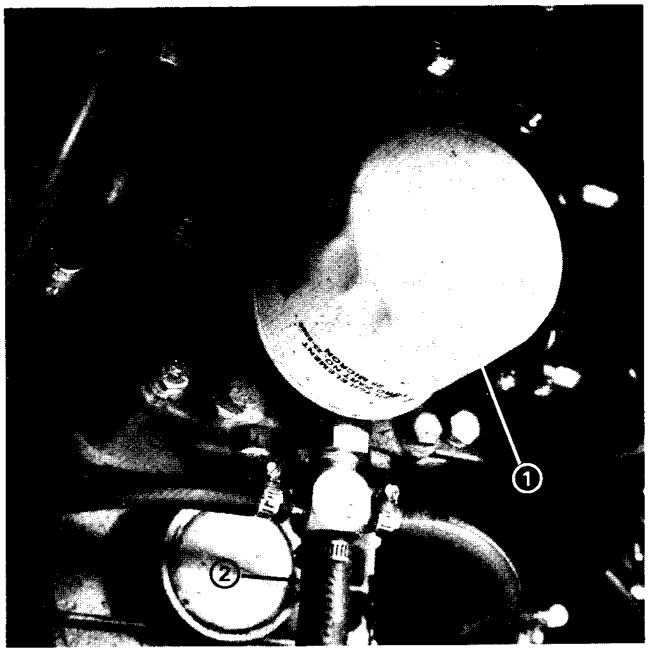


Figure 8

1. Filter 2. Transmission suction hose

Servicing Bypass Valves

In some situations it is necessary to bypass hydraulic oil within the transmission so that the mower can be moved (pushed) short distances WITHOUT running the engine. To bypass hydraulic oil within the transmission the by-pass buttons (Fig. 9) are pushed in and held in that position. These by-pass valve buttons should have a liberal coating of No. 2 grease applied over them after each 500 hours of machine operation, or yearly, to prevent the buttons from sticking. Should these buttons stick in the down (bypass) position and unit operation is continued, the hydraulic system may overheat and possibly result in severe damage to internal transmission components.

1. Stop the engine and engage the parking brake. Remove the hair pin, pull back on the locking spring flap and tilt the seat forward. Put the seat support rod in the detent position.

2. Clean any dirt or grass clippings off of the bypass buttons (Fig. 9).

3. Apply a liberal coat of No. 2 grease over the by-pass buttons.

4. Lower the seat and install the hair pin. Resume operation.

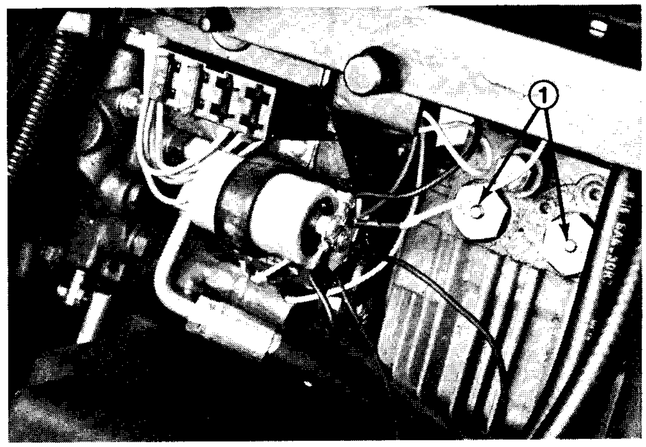


Figure 9

1. By-pass buttons

Checking Transmission for Neutral

- The front drive wheels must not rotate when the traction pedal is in the neutral position. The common name for this is "creeping".

Check the machine for creep each time the Groundsmaster® 220-D is used. After the hydraulic oil has had sufficient time to warm up (about two minutes), bring the machine to a complete stop. With the engine running at full throttle, and while the machine is stopped on level ground, the unit should remain stationary with the traction pedal in neutral and all brakes released.

If the vehicle moves, adjustment of the neutral return mechanism (mounted to control shaft of transmission) is necessary. (See Adjusting Traction Control For Neutral in the Adjustments section of this chapter.)

Checking for Full Traction Speed

With the engine stopped (OFF), depress the traction pedal fully. There must be a 1/8 - 1/4 inch (3 - 6 mm) gap between the front edge of the traction pedal and the floorboard.

The absence of a gap at this point is most likely caused by worn linkage points on the traction control rod or, linkage that is out of adjustment. (See Adjusting Traction Control Rod in the Adjustments section of this chapter.)

Inspecting Traction Pedal Friction Wheel

The traction pedal friction wheel is designed to reduce transmission oscillation by deterring rapid back and forth foot movements against the traction pedal (Fig. 10). This is most noticeable while operating over bumpy terrain.

Occasionally inspect the friction wheel for wear by looking at the wheel-to-pedal contacting surfaces. Should the friction wheel be flat (worn) at this point, the wheel should be turned to a new position to restore contact with the foot pedal. (See Adjusting Traction Pedal Friction Wheel in the Adjustments section of this chapter.)

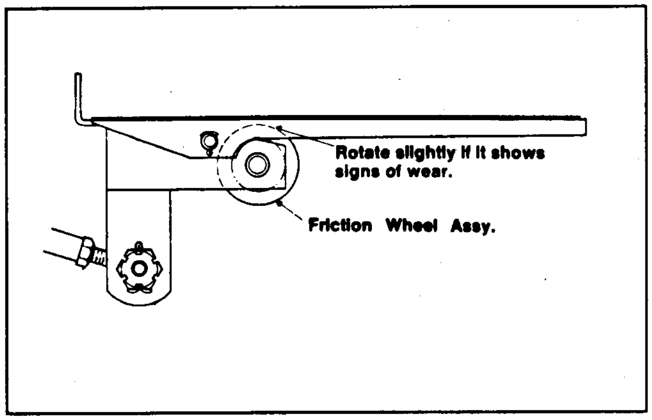


Figure 10

Lubricating Traction Pedal

Periodically lubricate the traction pedal pivot shaft bushings with a good grade of lubricating oil (Fig. 10A).

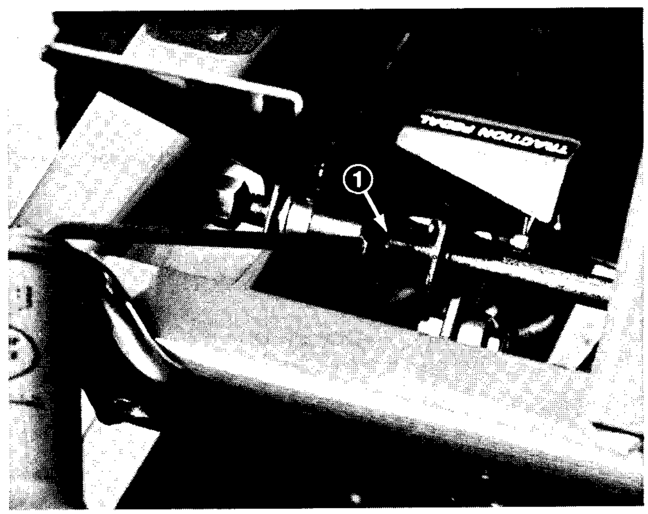


Figure 10A

1. Lubricate traction pedal

Checking Drive Coupling Alignment

Refer to Chapter 10 - Engine to Transmission Coupler, for procedures to achieve proper coupling alignment.

Inspecting the Lift Valve

Periodically inspect the lift valve for any signs of leakage, wear, or binding.

Leakage from this control valve may be repaired by overhauling the control valve. During inspection of the valve, check the spool for worn areas which would cause the valve to leak, or bypass oil to the reservoir, rather than directing it to the lift cylinder.

Binding in the valve could be caused by a bent spool or a sticking mechanical link (i.e. lift lever).

A small amount of oil will usually free sticking linkage. If the valve had just been overhauled or replaced, and sluggishness or binding is occurring, it may be found that the mounting surfaces of the valve or frame may not be flat and the valve body could have a twisting effect being applied to it. For control valve overhaul procedures, refer to Servicing the Lift Control Valve in the Repair section of this chapter.

Inspecting the Lift Cylinders

Proper care of the lift cylinders is important. Dirt and rust may cause a cylinder to fail rapidly. Contaminated hydraulic oil and filters will cause a cylinder's internal packing to become damaged.

A periodic inspection of the lift cylinders would include:

1. Checking for external leaks.

2. Looking for rust, burrs, or abrasions on the piston rod.

3. Checking for loose mounting brackets or pins.

4. Inspecting for proper alignment.

5. Testing for proper operation.

To test a lift cylinder for internal leaks, see Checking Hydraulic Cylinders for Hold in the Testing section of this chapter.

Checking the Hydrostatic Transmission

The hydrostatic transmission creates the flow of fluid for traction, steering and implement circuits. If the transmission fails, the entire machine is disabled. It is important to make a simple check of the transmission each time the machine is to be used. This inspection could eliminate a major breakdown by locating a broken or loose component, or by finding potential causes of failure (i.e. a leaking oil filter).

Proceed with the inspection of:

1. Checking for oil leaks.

2. Listening for excessive noise.

3. Looking for loose or broken parts.

4. Checking operation of traction and implement circuits.

Performing specific hydraulic tests, and overhaul or repair of the hydrostatic transmission will be described in the appropriate sections which follow.

Troubleshooting

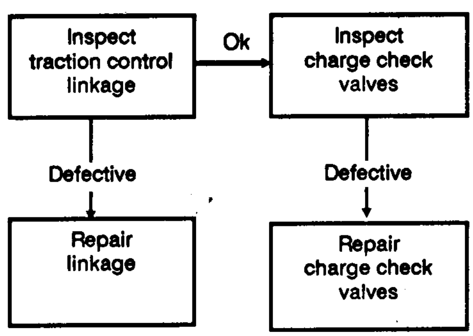
The cause of an improperly functioning hydraulic system is best diagnosed with the use of proper testing equipment (Fig. 4 and 5) and a thorough understanding of the complete hydraulic system (Fig. 3).

A hydraulic system with an excessive increase in heat or noise is a potential failure. Should either of these conditions be noticed, immediately stop the machine, turn off the engine, locate the cause of the trouble, and correct it before allowing the machine to be used again. Continued use of an improperly functioning hydraulic system could lead to extensive internal component damage.

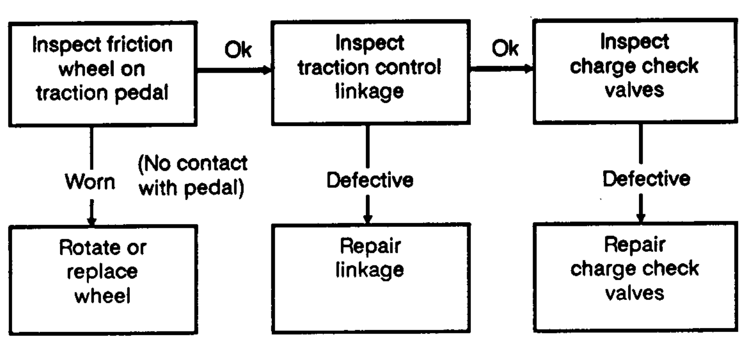
The charts that follow contain detailed information to assist in troubleshooting. There may possibly be more than one cause for a machine malfunction. All causes should be checked in the order in which they are listed on the charts; do not deviate from this procedure.

Refer to the Testing section of this chapter for precautions and specific test procedures.

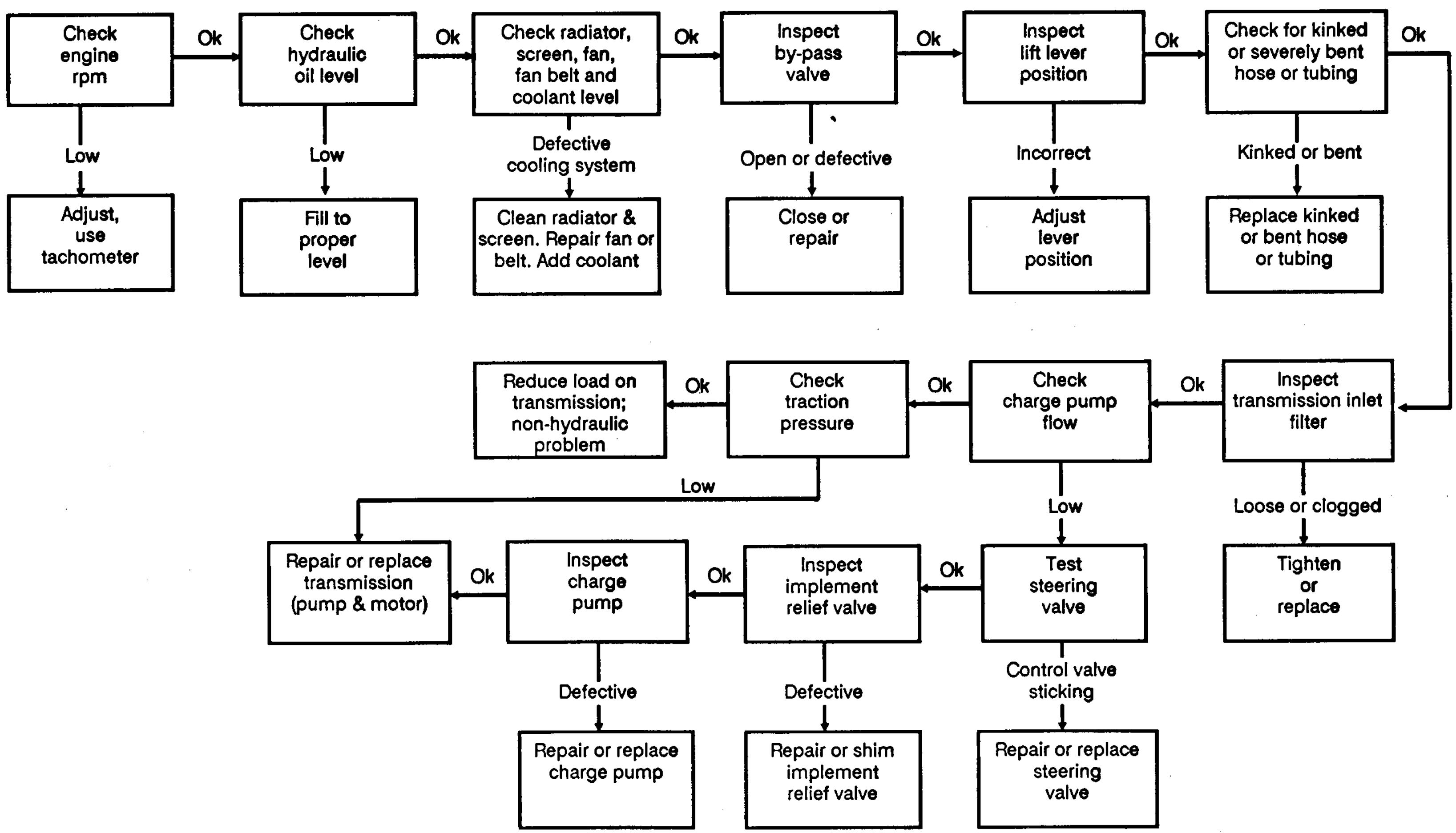
System Operates in Only One Direction



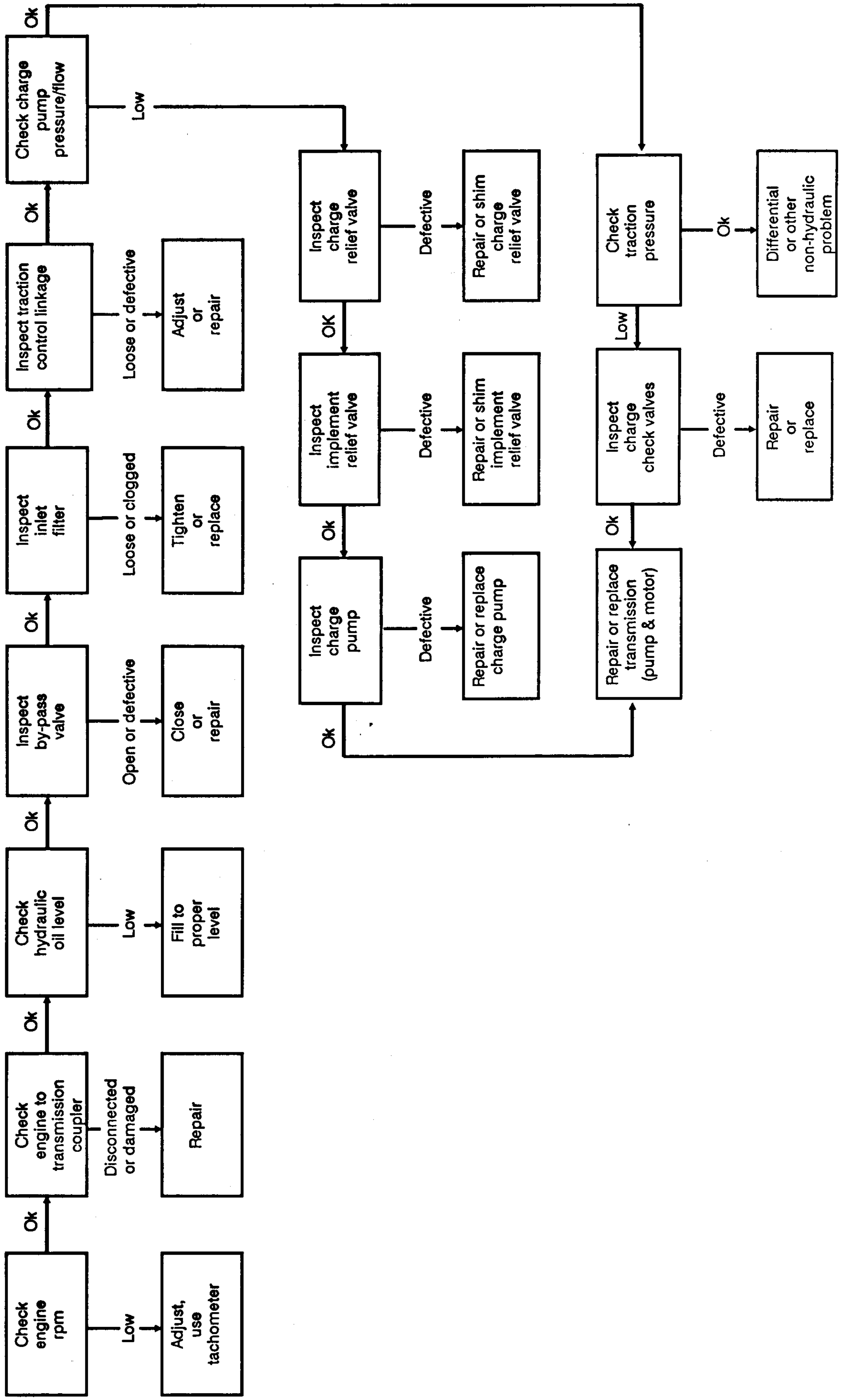
System Jerky When Starting



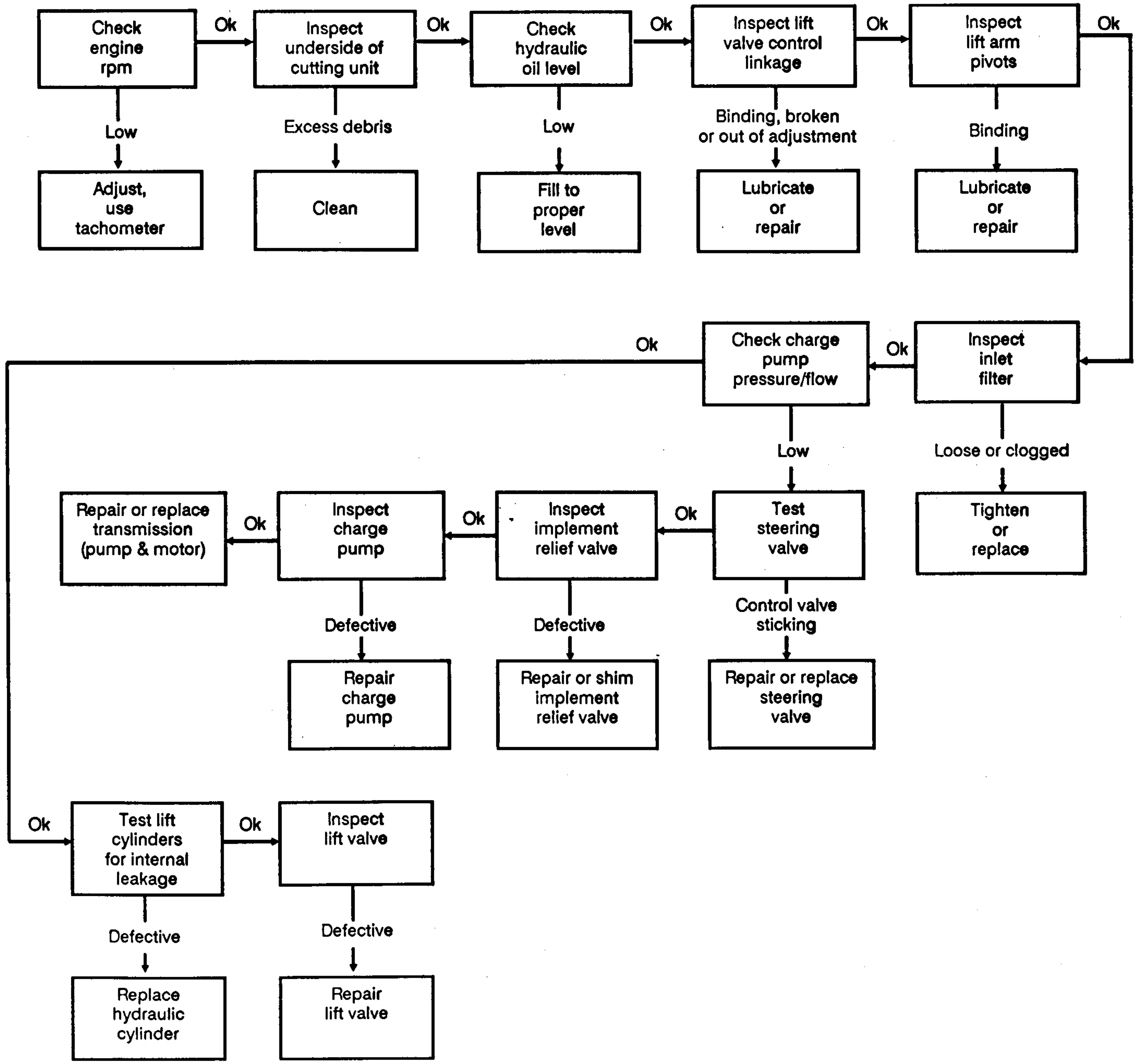
System Operates Hot



Loss of Power or Unit Will Not Operate In Either Direction



Cutting Unit Will Not Lift or Lifts Slowly



Testing

The most effective method for isolating troubles in the hydraulic system is by using hydraulic test equipment such as pressure gauges and flow meters in the circuits during various operational checks. (See the Special Tools section in this chapter.)

Hydraulic testers may vary significantly in size, construction, accuracy, and cost. The decision as to which tester to purchase should be influenced by what type of tests will be performed on all of the hydraulically-powered equipment in the shop.

All obvious areas such as oil supply, filter, binding linkage, loose fasteners, or improper adjustments must be checked before assuming that a hydraulic component is the source of the problem being experienced.

WARNING

Before disconnecting or performing any work on the hydraulic system, all pressure in the system must be relieved by stopping the engine and lowering the implement to the ground.

Keep body and hands away from pin hole leaks or nozzles that eject hydraulic fluid under high pressure. Use paper or cardboard, not hands, to search for leaks. Hydraulic fluid escaping under pressure can have sufficient force to penetrate skin and do serious damage. If fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type of injury or gangrene may result.

Before Performing Hydraulic Tests

1. Thorough clean the machine before disconnecting or disassembling any hydraulic components. Always keep in mind the need for cleanliness when working on hydraulic equipment.

2. Put caps or plugs on any hydraulic lines left open or exposed during testing or removal of components.

3. The engine must be in good operating condition. ALWAYS use a tachometer when making a hydraulic test. Engine speed will affect the accuracy of the tester readings.

4. To prevent damage to the tester or components, the inlet and the outlet hoses must be properly connected, and not reversed (tester with pressure and flow capabilities).

5. To minimize the possibility of damaging the components, completely open the load valve by turning it counterclockwise (tester with pressure and flow capabilities).

IMPORTANT: The charge pump used on the Groundsmaster® 220-D is a positive displacement type. If its output flow is completely restricted or stopped, damage to the hydrostatic transmission could occur.

6. Install fittings finger tight, far enough to insure that they are not cross-threaded, before tightening with a wrench.

7. Position the tester hoses so that rotating machine parts will not make contact with them and result in hose or tester damage.

8. Check the oil level in the reservoir. (See Checking Oil Level in the Maintenance section of this chapter.)

9. Check the control linkage for improper adjustment, binding or broken parts.

10. Inspect the by-pass valves (Fig. 9). If open, close the valves by pulling the buttons up; the buttons should move up by hydraulic pressure when the engine is started. If the valves are defective, repair or replace the valves.

11. All hydraulic tests should be made with the hydraulic oil at normal operating temperature (hoses warm to the touch).

Charge Pressure Test

Using a low pressure gauge,
0 – 1000 psi (0 – 6895 kPa)

1. Engage the parking brake and block the front wheels to prevent movement of the machine. Lower the cutting deck or implement to the floor and turn the engine OFF.

2. Raise and support the seat.

CAUTION

Before opening hydraulic system, operate all hydraulic controls to relieve system pressure and avoid injury from pressurized hydraulic oil.

3. Thoroughly clean the area around the pipe plug located on the top of the transmission between the charge check valves (Fig. 11). Remove plug from the transmission.

4. Connect a 0 to 1000 PSI (0 to 6895 kPa) hydraulic pressure gauge to the transmission opening. Use only clean, hydraulic fittings.

5. Start engine and move the throttle to SLOW so that the engine idles. Use a tachometer to verify that the engine is running at 1700 $\pm$ 50 rpm. The engine must idle at this speed to provide sufficient charge pump flow and pressure to lubricate the internal parts of the transmission. Check for any hydraulic leakage from test connections and correct before proceeding with test.

6. Allow engine to run for approximately 5 minutes so the hydraulic oil reaches normal operating temperature.

7. Increase the engine speed to the FULL throttle setting and use a tachometer to verify that the engine is running at 3200 $\pm$ 50 RPM.

8. Observe the pressure measurement on the pressure gauge. The pressure reading should be 70 to 150 psi (453 to 1034 kPa). Record test results.

NOTE: A higher reading may be obtained due to the back pressure in the system. This is acceptable.

9. If the pressure is below 70 psi (453 kPa), adjust the charge relief valve in the transmission by adding the required amount of shims from the shim pack (see Charge Relief Valve Service in the Repairs section of this chapter).

NOTE: For every 0.010 in. (0.254 mm) of shim thickness, there is an approximate 2 PSI (50 kPa) change in charge relief pressure.

10. Perform a dynamic charge pressure test to identify possible hydrostat (pump or motor) problems as follows:

A. With pressure gauge still connected, sit in the operator seat, start engine and press the traction pedal to forward.

B. While machine is moving straight ahead on level ground (no turning or deck lifting), monitor the pressure reading on the pressure guage. Record test results.

C. The pressure should drop no more than 15% from initial test reading (Step 8 above). A pressure drop of more than 15% may indicate a traction circuit leak (e.g. check valve not seating, worn or damaged hydrostat).

11. If adding shims to the relief valve does not increase pressure or if charge pressure drops more than 15% in dynamic test, inspect the condition of the charge pump gerotor and internal housing (See Charge Pump Service in the Repairs section of this chapter).

If the charge pump is in good condition (no scoring, scratches or excessive wear), the general condition of the transmission's piston pump and piston motor might be suspected of wear and inefficiency.

A lack of minimum charge pressure could be due to the fact that the charge pump is having to direct all of its flow to the main traction circuit (piston pump and motor). When this occurs, charge pressure may not increase to the 70 to 150 psi (453 to 1034 kPa) pressure necessary to open the charge relief valve; therefore, no oil can flow to the steering and implement circuit.

12. Disconnect pressure gauge from the transmission. Install pipe plug back in the transmission. Check hydraulic oil level in reservoir (front axle).

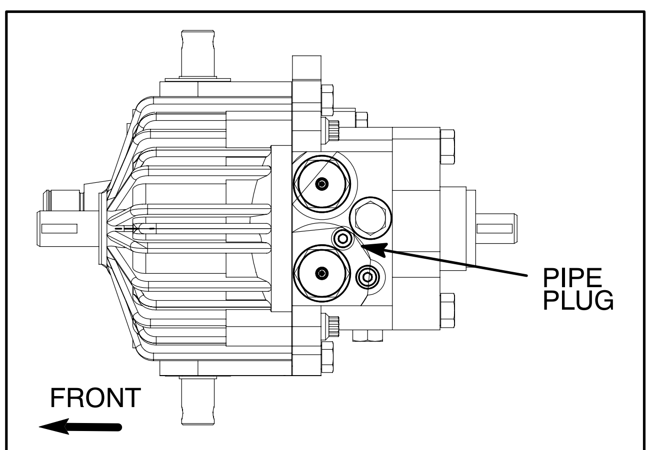


Figure 11

Implement Relief Pressure Test

**Using a low pressure gauge,
0 – 1000 psi (0 – 6895 kPa)**

1. Perform steps 1 through 7 of the Charge Pressure Test.

2. With the engine running at 3200 RPM, move the lift control lever to the RAISE position and allow the cutting unit or implement to fully raise. Continue to hold the lever in the RAISE position and observe the pressure gauge. The pressure reading should be from 700 to 800 PSI (4826 to 5516 kPa) as the implement relief valve lifts.

3. Move the lift control lever to the LOWER position to lower the cutting deck (or implement) to the ground. Shut off engine. Record test results.

4. If the implement relief pressure is below 700 PSI (4826 kPa), adjust the implement relief valve in the transmission by adding the required amount of shims from the shim pack (see Implement Relief Valve Service in the Repairs section of this chapter).

NOTE: For every 0.010 in. (0.254 mm) of shim thickness, there is an approximate 50 PSI (340 kPa) change in implement relief pressure.

CAUTION

The Implement Relief pressure must not exceed 800 psi (5516 kPaa).

If adding shims to the relief valve does not increase pressure, inspect the condition of the charge pump gerotor and internal housing (see Charge Pump Service in the Repairs section of this chapter).

If the charge pump is in good condition (no scoring, scratches or excessive wear), the general condition of the transmission's piston pump and piston motor might be suspected of wear and inefficiency. A lack of minimum implement relief pressure could be due to the charge pump having to direct all flow to the main traction circuit (piston pump and piston motor).

NOTE: If the implement relief pressure is 700 to 800 PSI (4826 to 5516 kPa) and a steering or lift problem occurs, inspect for a problem unrelated to the hydraulic circuit (e.g. binding steering or lift system components, debris build–up on/under the cutting deck). Check and repair other items before continuing with hydraulic tests.

5. Disconnect pressure gauge from the transmission. Install pipe plug back in the transmission. Check hydraulic oil level in reservoir (front axle).

At this point, a traction pressure test could be used to determine whether the hydrostatic transmission has excessive piston group leakage and needs to be repaired (see Testing Traction Pressure).

Traction Pressure Test

Using a high pressure gauge,
0 - 5000 psi (0 - 34475 kPa)

> **CAUTION**
>
> **Failure to use a high pressure gauge 0 - 5000 psi (0 - 34475 kPa) during this traction pressure test could result in damage to the gauge and possible personal injury due to leaking, hot oil.**

1. Before beginning the traction test, drive the machine to an open area, lower the cutting unit, turn the engine OFF and engage the parking brake. Connect a chain to the rear frame tie down brackets (Fig. 12). Connect the other end of the chain to an immovable object and remove all slack from the chain.

2. Place a drain pan on the floor beneath the transmission. Remove the hex head plug located on the bottom right-hand side of the transmission (Fig. 13a).

3. Connect the high pressure hydraulic gauge hose to the gauge port (Fig. 13b). Use only clean, hydraulic fittings.

4. Start the engine and allow it to run for approximately 5 minutes so that the hydraulic oil reaches normal operating temperature.

5. Increase the engine speed to the FULL throttle setting and use a tachometer to achieve 3200 $\pm$ 50 rpm.

6. Sit on the seat, and with the brakes locked, slowly depress the top of the traction pedal. While pushing the top of the traction pedal down, look at the pressure reading on the gauge. The gauge should show 4000 - 4500 psi (27580 - 31028 kPa).

7. If the traction pressure is lower than 4000 psi (27580 kPa), check the charge check valves. (See Charge Check Valve Service in the Repairs section of this chapter.) If the charge check valves are in good condition, overhaul the transmission because either the pump, motor, or both piston groups are at fault.

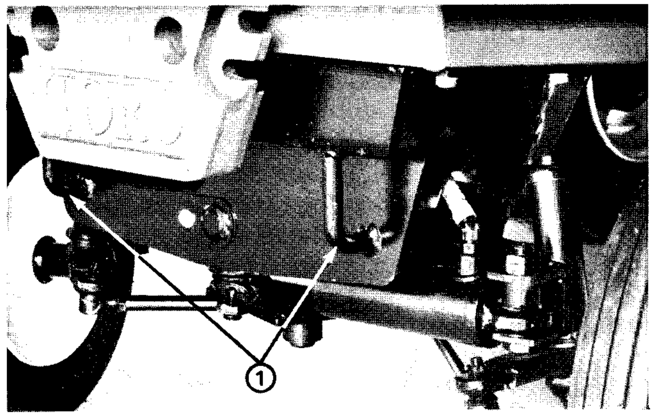


Figure 12

1. Rear frame tie down brackets

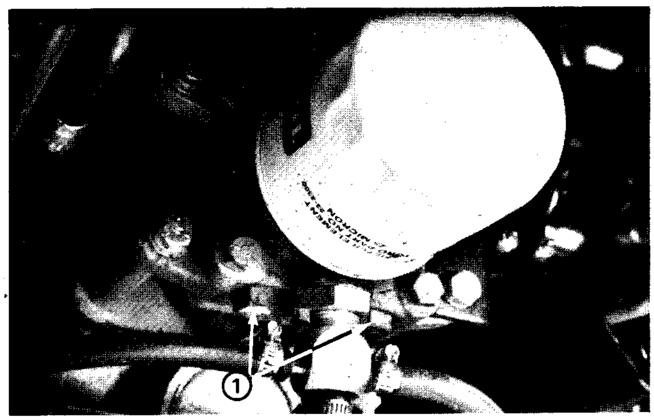


Figure 13a

1. Hex plug (pressure gauge port)

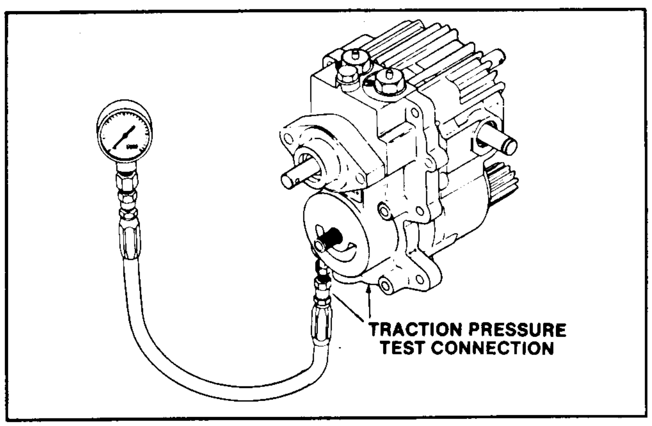


Figure 13b

Charge Pump Flow and Implement Relief Pressure Test

Using a hydraulic tester with flow meter

1. Engage the parking brake and block the front wheels to prevent movement of the machine. Lower the cutting unit or implement to the floor and turn the engine OFF.

2. Raise and support the seat or remove the seat and seat mounting plate.

3. Put a drain pan below the transmission. Disconnect the hydraulic hose from the charge pump outlet (pressure) fitting on the transmission (Fig. 14).

4. Connect the inlet hose of the tester to the fitting on the transmission. Connect the tester outlet hose to the hose that was disconnected in step 3.

NOTE: To remove the steering valve from the test circuit, connect the inlet hose of the tester to the fitting on the transmission as described in steps 3 and 4. Disconnect the tube line from the inlet fitting on the lift valve (port marked "IN"). Connect the tester outlet hose to the lift valve fitting.

IMPORTANT: Make sure that the oil flow indicator arrow on the flow gauge is showing that the oil will flow through the tester from the pump to the steering valve (or lift valve).

5. Make sure that the tester load valve is fully open (counterclockwise). Start the engine and allow it to run for approximately 5 minutes so that the hydraulic oil reaches normal operating temperature.

6. Increase the engine speed to the FULL throttle setting and use a tachometer to verify that the engine is running at 3200 $\pm$ 50 rpm.

7. While watching the flow and pressure gauges, slowly close the flow control valve (load valve) until the flow gauge reads 1.0 GPM (3.8 LPM).

8. If the pressure is below 700 psi (4827 kPa) or 1.0 GPM could not be achieved, adjust the implement relief valve by adding the required amount of shims from the shim pack. (See Implement Relief Valve Service in Repairs section of this chapter.)

Shim size	Approximate Pressure Change
0.005 in. (0.127 mm)	25 psi (170 kPa)
0.010 in. (0.254 mm)	50 psi (340 kPa)
0.015 in. (0.381 mm)	75 psi (520 kPa)
0.020 in. (0.508 mm)	100 psi (690 kPa)

NOTE: For every 0.010 in. (0.254 mm) of shim thickness, there is approximately a 50 psi (340 kPa) change in implement relief pressure.

CAUTION

The implement relief pressure must not exceed 800 psi (5516 kPa).

If adding shims to the relief valve does not increase the pressure, inspect the condition of the charge pump gerotor and internal housing. (See Charge Pump Service in the Repairs section of this chapter.)

If the charge pump is in good condition (no scoring, scratches, or excessive wear), the general condition of the transmission's piston pump and piston motor might be suspected of wear and inefficiency.

A lack of sufficient implement pressure could be due to the fact that the charge pump is having to direct most of its flow to the main traction circuit (piston pump and piston motor). When this occurs, oil pressure may not increase to the 700 - 800 psi (4826 - 5516 kPa) pressure necessary to raise the heavy implement.

At this point, a traction pressure test could be used to determine whether the hydrostatic transmission has excessive piston group leakage and needs to be repaired. (See Testing Traction Pressure.)

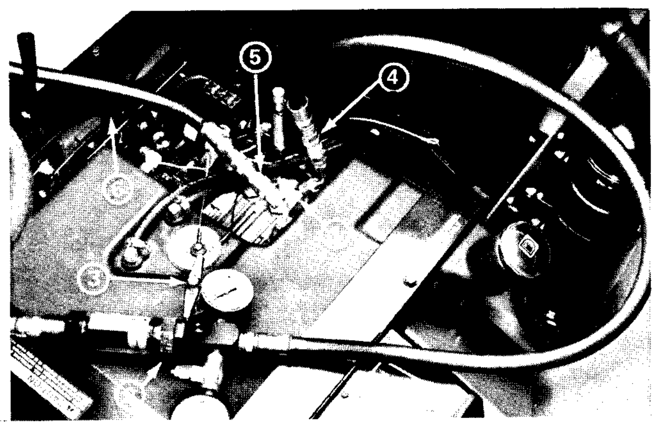


Figure 14

1. Transmission
2. Tester
3. Load valve
4. Inlet line to tester
5. Outlet line from tester
6. Lift valve

Hydraulic Lift Cylinder Internal Leakage Test

1. Make sure the machine is on a level surface and the parking brake is engaged.

2. Start the engine and pull the lift control lever back to raise the cutting unit or implement as far as it will go. Put blocks under the cutting unit or implement, or use an overhead hoist to secure it in the raised position. Turn key switch OFF to stop the engine.

3. Put an empty drain pan below the lift cylinder that you think may have internal leakage. Loosen the hose clamp and disconnect the cylinder return hose from the bottom of the lift cylinder (Fig. 15). Leave the other end of the hose connected to the fitting on the bottom of the transmission.

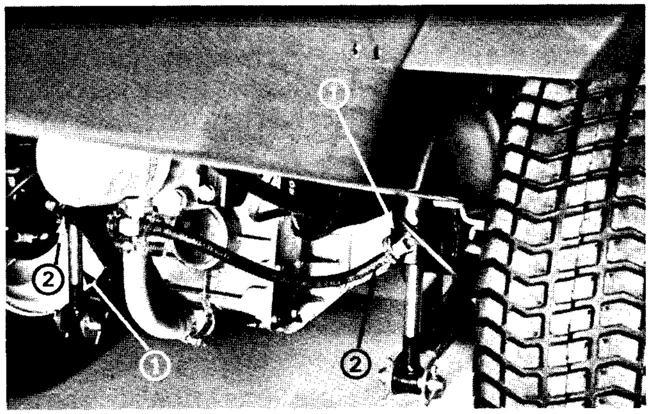


Figure 15

1. Lift cylinder
2. Cylinder return hose

4. Securely plug the open end of the cylinder return hose to prevent hydraulic oil leakage and suction of air by the transmission.

5. Remove all hydraulic oil from drain pan.

6. Start the engine and briefly hold the lift control lever in the RAISE position so the lift cylinders are pressurized. Turn the key switch OFF to stop the engine.

7. Check to see if oil has leaked into the drain pan from the open fitting on the bottom of the lift cylinder. If there is oil in the drain pan, the lift cylinder has internal leakage and must be replaced. (See Lift Cylinder Removal and Installation in the Repairs section of this chapter.)

8. If the lift cylinder is not leaking internally, install the cylinder return hose on the lift cylinder and tighten the hose clamp.

9. Repeat steps 3 - 8 for the other lift cylinder.

10. Start the engine and operate the lift cylinders through several up and down cycles. Stop the engine and inspect the lift cylinders, hoses and fittings for leaks.

Adjusting Traction Control for Neutral

The front wheels of the Groundsmaster® 220-D must not rotate when the traction pedal and pump lever are in the neutral position. If the wheels rotate, adjustment of the neutral return device is required.

1. Park the vehicle on a level surface, turn the engine OFF, and engage the parking brake. Lower the cutting unit or implement to the floor. Raise and support the seat to gain access to the neutral return device located on the right-hand side of the transmission.

2. Actuate the pump lever (foot pedal) to make sure that the neutral return assembly is properly connected and operates freely; the ball bearing must follow the V-shaped notch in the pump lever (Fig. 17).

3. Correct any problems such as a seized bearing, broken leaf springs, or a loose pump lever mounting.

4. Block the right front tire and both rear tires so that the vehicle cannot roll forward or backward during this adjustment process.

5. Jack up the frame of the machine so that the left front wheel is off of the shop floor approximately 2 inches (5 cm). Support the frame with jackstands to prevent it from falling accidentally.

IMPORTANT: Do not place the jack or the jackstands under the differential or the axle tubes, or damage to those components may result.

6. Start the engine and move the throttle to SLOW so that the engine idles. Allow the engine to idle for approximately 5 minutes so that the hydraulic oil reaches normal operating temperature.

7. While the engine is still running at idle speed (SLOW), release the parking brake, and watch the left front wheel of the machine; the wheel should not be rotating. If the wheel is rotating, proceed to step 8 for adjustment procedures. If the wheel is not rotating, verify correct adjustment by moving the throttle control to the FAST position. If the wheel begins to rotate while the engine speed is fast, proceed to step 8. If the wheel does not rotate, the neutral return adjustment is correct.

8. Because the wheel is rotating, the transmission pump's swash plate is not positioned exactly perpendicular to the pump's pistons, so the pistons are pumping oil to the motor group, causing the wheel rotation.

To correct this condition, the swash plate must be adjusted so that it returns to a true neutral (perpendicular) position when the traction pedal is released. This is accomplished by adjusting the position of the pump plate (Fig. 16):

A. Move the throttle to the SLOW position and stop the engine. Slightly loosen the two cap screws that attach the pump plate to the its mounting bracket on the right-hand side of the transmission (Fig. 16).

B. Start the engine and make sure the throttle is in the SLOW position. If the wheel is/was rotating in the direction allowing forward vehicle movement, VERY LIGHTLY tap the bottom of the pump plate in a COUNTERCLOCKWISE direction until the wheel stops rotating. If the wheel is/was rotating in the direction allowing reverse vehicle movement, VERY LIGHTLY tap the bottom of the pump plate in a CLOCKWISE direction until the wheel stops rotating. Stop the engine. Tighten the two cap screws to secure the pump plate and its mounting bracket to the side of the transmission. Verify the correct adjustment with the engine running and the throttle in the SLOW and FAST positions.

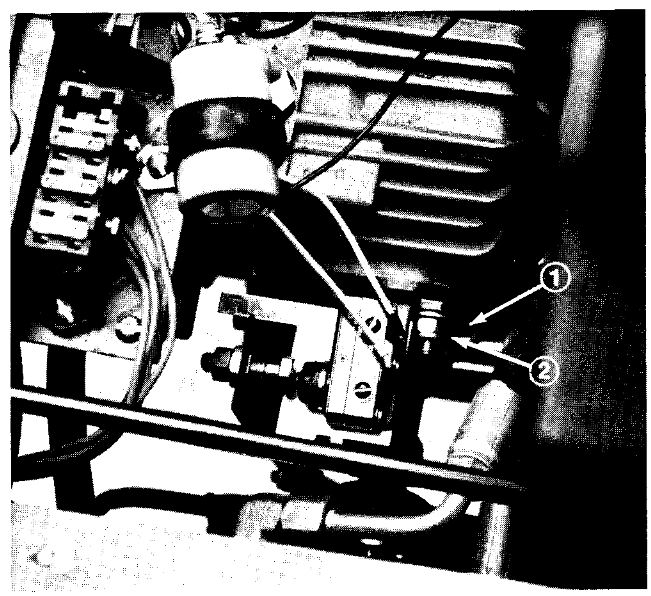


Figure 16

1. Pump plate
2. Cap screw

8. Should the front wheels continue to rotate or the machine "creep" after a proper adjustment has been made, check for the following (Fig. 17):

A. Ball bearing is loose or worn out.

B. The plunger of the interlock switch is sticking or adjustment screw is out of adjustment.

C. Loose or missing fasteners.

D. Worn bolt or hole where bolt secures the pump lever to the transmission control shaft.

E. The pump lever is loosely mounted to the transmission control shaft. Correct by applying Loctite 271 or Loctite 601 to the shaft and pump lever mating surfaces.

F. Weak or damaged return leaf springs.

9. With the engine turned off, remove the jackstands and lower the machine to the shop floor. Lower the seat.

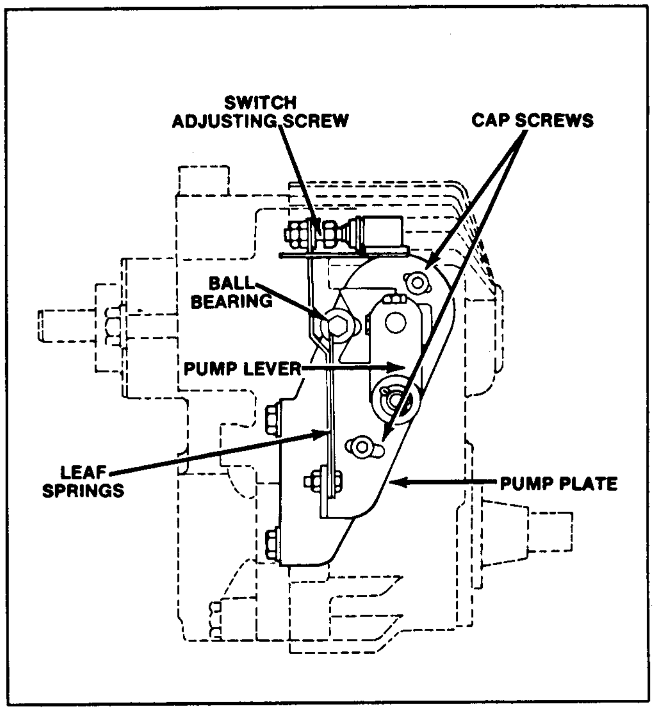


Figure 17

Adjusting Traction Control Rod

1. Check the traction drive neutral position to make sure that the front wheels do not "creep" (See Adjusting Traction Control For Neutral in this section of the book.)

2. With the engine OFF, depress the traction pedal fully. There must be a 1/8 - 1/4 inch (3 - 6 mm) gap between the inside, top front edge of the traction pedal and the floorboard (Fig. 18). If the distance is as specified, the control rod is adjusted correctly. If the distance is not as specified, proceed to step 3 for adjustment procedures.

3. Disconnect the pump control rod from the foot pedal (traction pedal) by removing the lock nut and cap screw.

4. Adjust the length of the control rod by loosening the jam nut and turning the threaded rod end into or out of the control rod tube. Connect the pump control rod to the traction pedal pivot mount with the cap screw. Depress the traction pedal and again measure the gap between the floorboard and the foot pedal. Continue adjusting the length of the control rod until the correct gap is achieved.

5. Secure the rod end to the traction pedal pivot mount with the cap screw and lock nut.

6. Tighten the jam nut against the front of the control rod tube. Make sure that the control rod has the freedom to pivot slightly when all the fasteners are tight and does not contact anything in its range of motion. If necessary, loosen the jam nut, pivot the control rod to the middle of its normal arc of movement, and tighten the jam nut.

NOTE: Adjusting the control rod prevents the traction pedal from bottoming out against the floorboard during forward movement before the pump has reached full stroke.

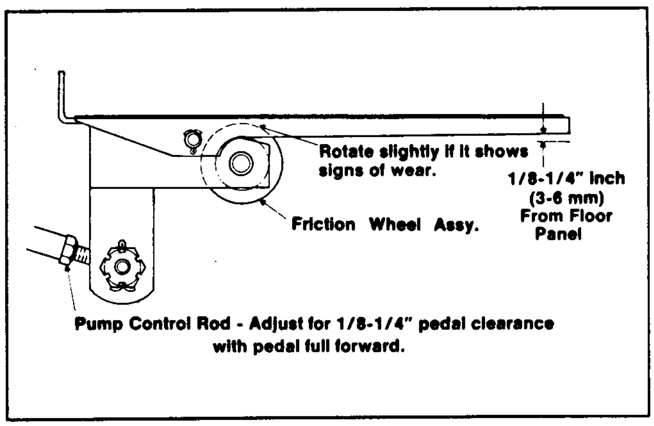


Figure 18

Adjusting Traction Pedal Friction Wheel

1. Loosen the two hex nuts securing the right-hand side of the traction pedal shaft to the frame (Fig 19).

2. Rotate the shaft to relocate the worn surface of the friction wheel away from the underside of the traction pedal (Fig. 20).

3. Tighten the two hex nuts to secure the traction pedal shaft and the friction wheel into its new position.

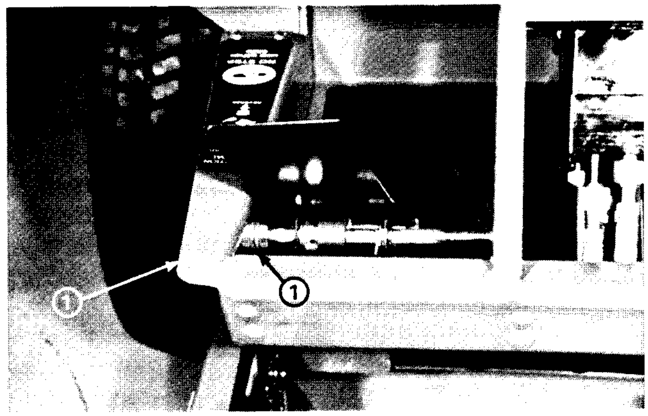


Figure 19

1. Hex nuts

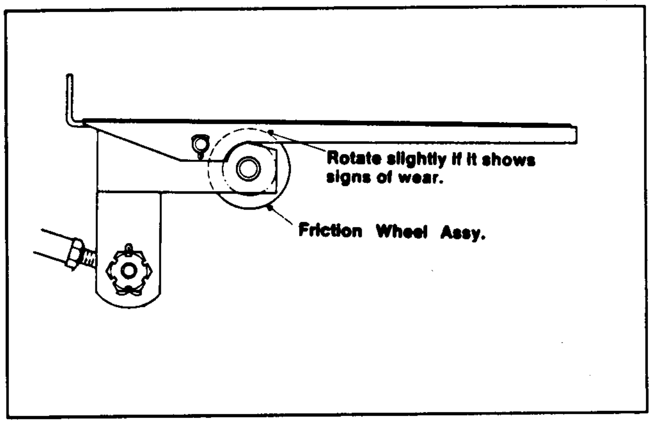


Figure 20

Hydraulic Hoses

Failure of the flexible hydraulic hoses most often occurs because of damage, but can also be the result of weather, chemicals, or storage conditions where the machine is stored in an extremely warm environment. A preventative maintenance replacement program that has hydraulic hoses replaced at the first sign of damage should prove beneficial when lines are not protected from sunlight, chemicals, or physical damage.

When replacing a hydraulic hose, be sure that the hose is straight (not twisted) before tightening the fittings. This can be done by observing the imprint on the hose. Use two wrenches; one to hold the hose straight and one to tighten the hose swivel nut onto the fitting.

WARNING

Before disconnecting or performing any work on the hydraulic system, all pressure in the system must be relieved by stopping the engine and lowering the implement to the ground.

Hydraulic Fitting Installation

O-Ring Face Seal

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches, or any foreign material (Fig. 20).

2. Make sure the O-ring is installed and properly seated in the groove. It is recommended that the O-ring be replaced any time the connection is opened.

3. Lubricate the O-ring with a light coating of oil.

4. Put the tube and nut squarely into position on the face seal end of the fitting and tighten the nut until finger tight.

5. Mark the nut and fitting body (Fig. 21). Hold the body with a wrench. Use another wrench to tighten the nut to the correct flats from finger tight (F.F.F.T.). The markings on the nut and fitting body will verify that the connection has been tightened.

Size	F.F.F.T.
4 (1/4 in. tubing O.D., hose I.D.)	.75 ± .25
6 (3/8 in. tubing O.D.)	.75 ± .25
8 (1/2 in. tubing O.D.)	.75 ± .25
10 (5/8 in. tubing O.D.)	1.00 ± .25
12 (3/4 in. tubing O.D.)	.75 ± .25
16 (1 in. tubing O.D.)	.75 ± .25

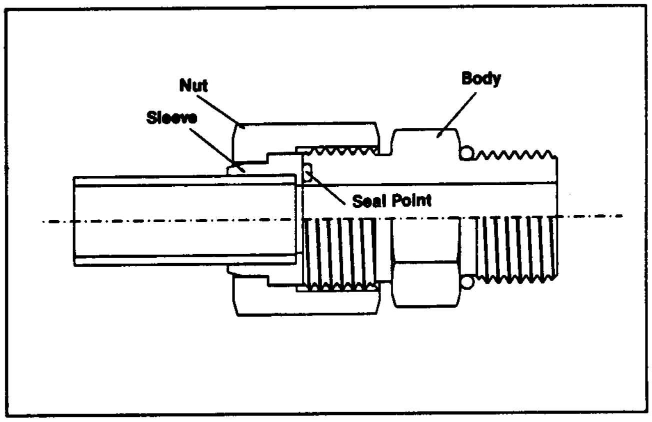


Figure 20

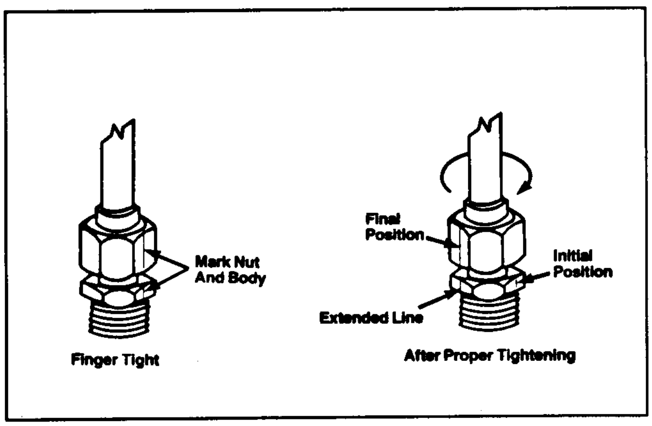


Figure 21

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SAE Straight Thread O-Ring Port (Non-adjustable)

SAE Straight Thread O-Ring Port (Non-adjustable)

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches, or any foreign material.

2. Always replace the O-ring seal when this type of fitting shows signs of leakage.

3. Lubricate the O-ring with a light coating of oil.

4. Install the fitting into the port and tighten it down full length until finger tight (Fig. 22).

5. Tighten the fitting to the correct flats from finger tight (F.F.F.T.).

Size	F.F.F.T.
4 (1/4 in. tubing O.D., hose I.D.)	1.00 ± .25
6 (3/8 in. tubing O.D.)	1.50 ± .25
8 (1/2 in. tubing O.D.)	1.50 ± .25
10 (5/8 in. tubing O.D.)	1.50 ± .25
12 (3/4 in. tubing O.D.)	1.50 ± .25
16 (1 in. tubing O.D.)	1.50 ± .25

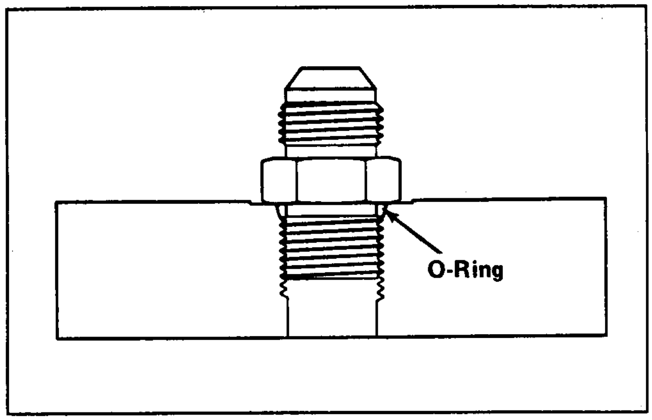

Figure 22

SAE Straight Thread O-Ring Port (Adjustable)

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches, or any foreign material (Fig. 23).

2. Always replace the O-ring seal when this type of fitting shows signs of leakage.

3. Lubricate the O-ring with a light coating of oil.

4. Turn back the jam nut as far as possible. Make sure the back up washer is not loose and is pushed up as far as possible (Fig. 24, Step 1).

5. Install the fitting into the port and tighten finger tight until the washer contacts the face of the port (Fig. 24, Step 2).

6. To put the fitting in the desired position, unscrew it by the required amount, but no more than one full turn (Fig. 24, Step 3).

7. Hold the fitting in the desired position with a wrench and turn the jam nut with another wrench to the correct flats from finger tight (F.F.F.T.) (Fig. 24, Step 4)

Size	F.F.F.T.
4 (1/4 in. tubing O.D., hose I.D.)	1.00 ± .25
6 (3/8 in. tubing O.D.)	1.50 ± .25
8 (1/2 in. tubing O.D.)	1.50 ± .25
10 (5/8 in. tubing O.D.)	1.50 ± .25
12 (3/4 in. tubing O.D.)	1.50 ± .25
16 (1 in. tubing O.D.)	1.50 ± .25

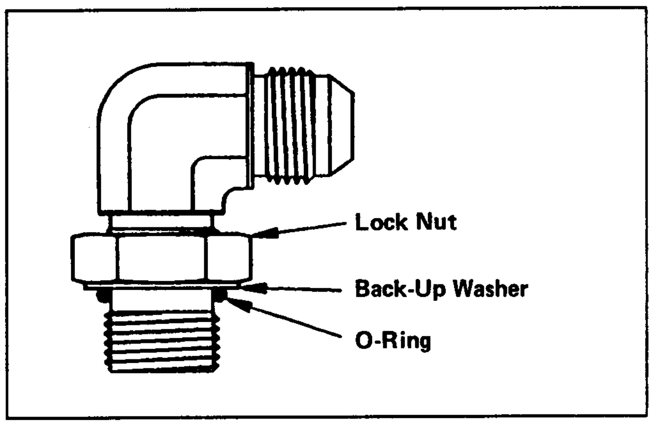

Figure 23

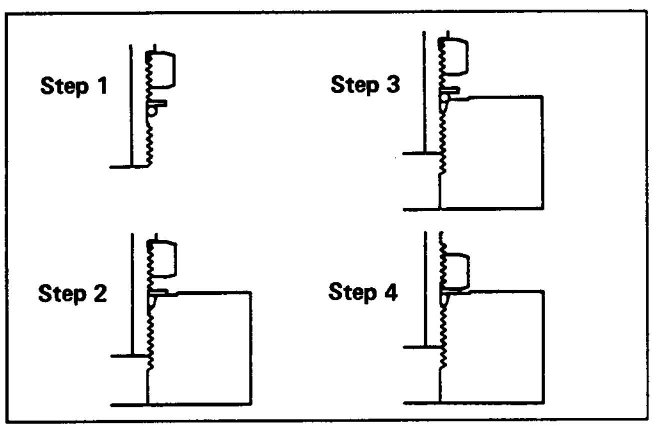

Figure 24

Hydrostatic Transmission Removal and Installation

1. Put the machine on a level surface in a clean area of the workshop. Block all four wheels of the unit to prevent it from moving.

2. Lower the cutting unit or implement to the shop floor and turn the engine OFF.

3. Disconnect the battery cable from the negative (–) battery terminal.

4. Remove the fuel tank. (See Removing and Installing the Fuel Tank in the Fuel System Repairs section of Chapter 3 - Mitsubhishi Diesel Engine.)

5. To prevent contamination of the hydraulic system during removal, thoroughly clean the exterior of the transmission and differential.

6. Put a drain pan below the differential and transmission. Disconnect the transmission suction hose from the fitting on the bottom of the transmission and allow the hydraulic oil to drain (Fig. 25). Disconnect the lift cylinder return hoses. Disconnect pressure hose and return hose from the transmission (Fig. 26). Put caps or plugs on the fittings, ports and hoses to prevent contamination.

7. Disconnect the engine to transmission coupler from the transmission (Fig. 25). (See Removing Drive Coupling in the Repairs section of Chapter 10 - Engine to Transmission Coupler.)

8. Disconnect and remove the traction pedal control rod where it connects to the pump lever on the right-hand side of the transmission (Fig. 27).

9. Disconnect the electrical wires from the safety interlock switch located on the right-hand side of the transmission. Note the position of these wires and the terminals of the switch to which they were connected.

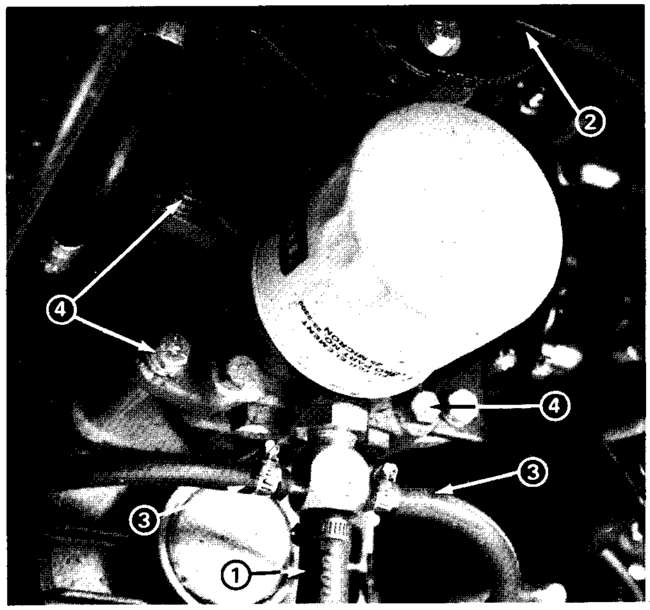

Figure 25

1. **Transmission suction hose**
2. **Transmission coupler**
3. **Lift cylinder return hoses**
4. **Transmission mounting cap screws**

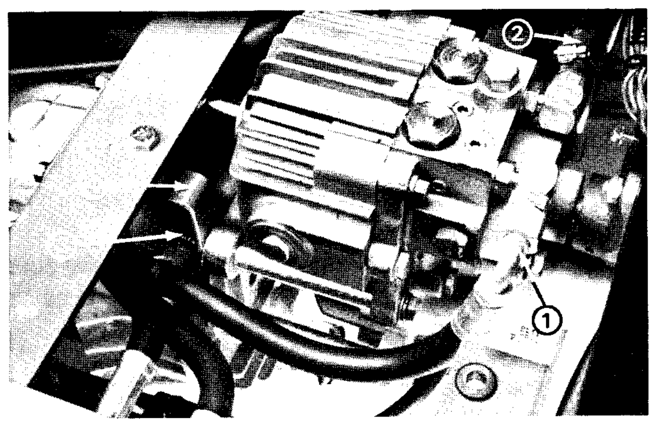

Figure 26

1. **Pressure hose**
2. **Return hose**
3. **Hex nut**
4. **Transmission anchor**

10. Remove the hex nut that secures the transmission anchor on the front of the differential mounting flange (Fig. 26). This nut is threaded onto the upper left transmission mounting cap screw.

11. Support the transmission to prevent it from falling while carefully removing the four cap screws that secure the transmission to the differential (Fig. 25). Carefully pull the transmission out of the differential and lower it out of the frame.

12. Remove the gasket that fits between the transmission and the differential (Fig. 27). Carefully clean the area of the differential where the new or rebuilt transmission will be installed.

NOTE: If the machine is going to be stored until the transmission is repaired or a new transmission is purchased, cover the hole in the differential with weatherproof tape to prevent contamination of the reservoir.

13. Reverse steps 1 - 12 to reinstall the transmission. Use a new gasket between the transmission and differential. Use Loctite 271 on the cap screws that hold the hydrostatic transmission to the differential. Also refer to "Removing And Replacing Pump Lever And Neutral Return Device Of Transmission" in this section.

14. Check the engine to transmission coupler alignment. (See Aligning Engine To Transmission in the Adjustments section of Chapter 10 - Engine to Transmission Coupler.)

NOTE: The transmission anchor prevents the weight of the transmission from causing the differential housing to rotate downward (pivoting at the axle tubes). Should this happen, the engine to transmission coupler would get out of alignment and cause coupler damage. It is important to leave the transmission anchor loose until the coupler is properly aligned, and then tighten the jam nuts against the anchor. DO NOT TIGHTEN THE JAM NUTS SO THAT A PUSHING OR PULLING FORCE IS APPLIED AGAINST THE TRANSMISSION.

15. Install a new hydraulic oil filter and prime the transmission (see Priming After Transmission Overhaul or Replacement in this section).

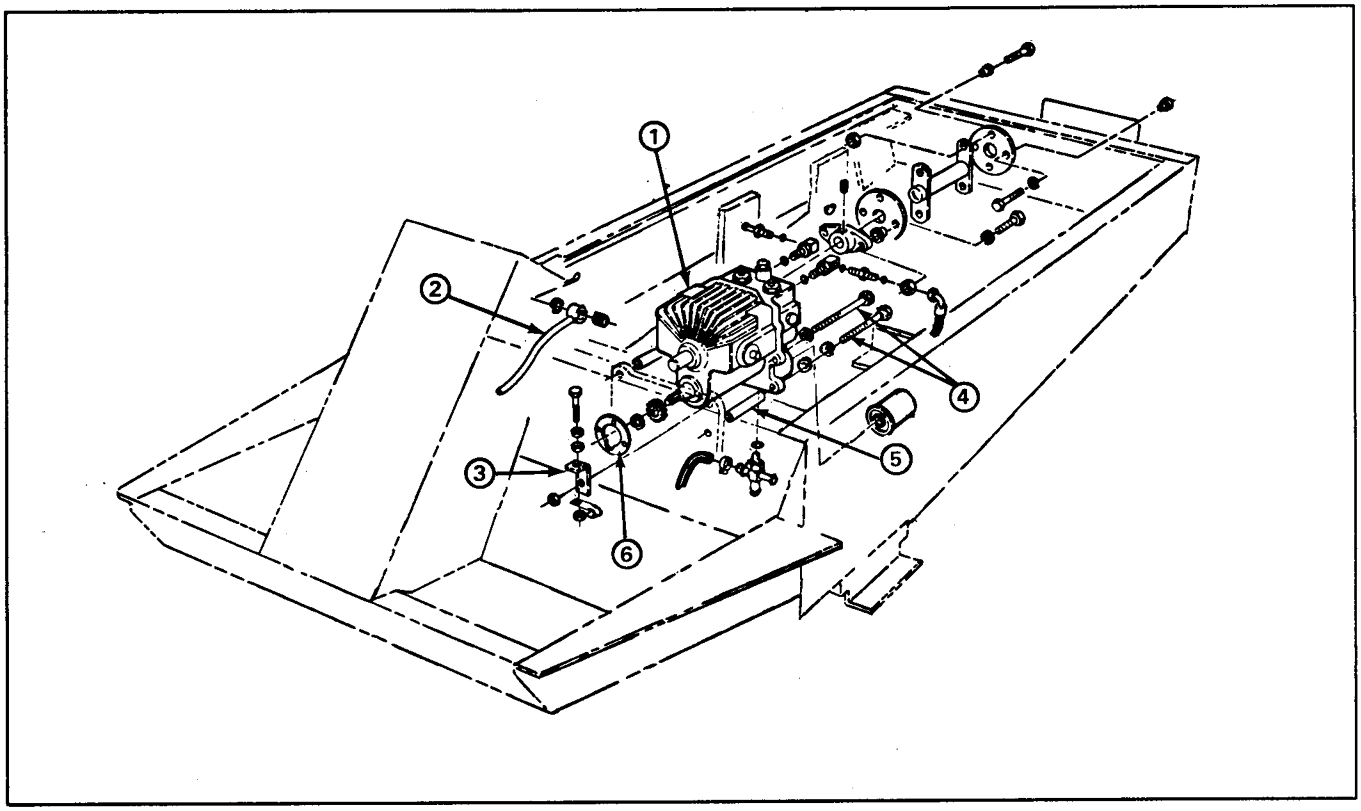

Figure 27

1. Transmission
2. Traction pedal control rod
3. Transmission anchor
4. Transmission mounting capscrews
5. Mounting spacer
6. Gasket

Pump Lever and Transmission Neutral Return Device Removal and Installation

The pump lever located on the right-hand side of the transmission is attached to the transmission using "Loctite". Damage to the pump shaft and/or transmission may result if the proper removal procedures are not followed.

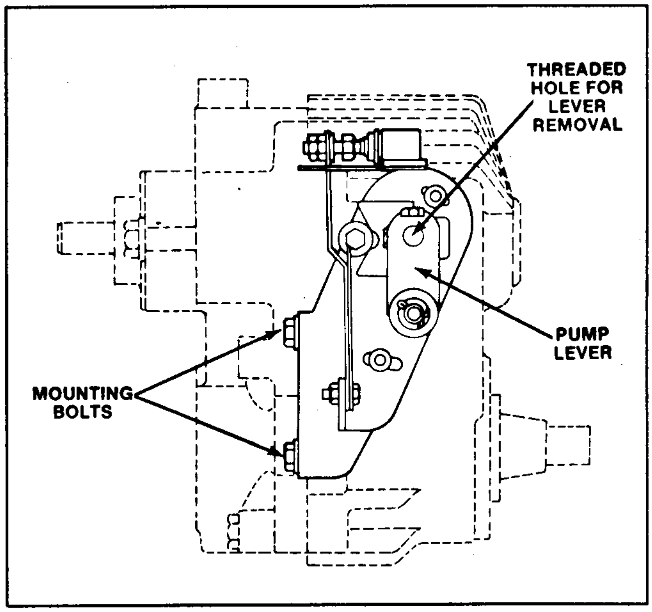

Figure 28

1. Park the machine on a level surface, engage the parking brake and turn the engine OFF. Lower the cutting unit or implement to the ground. Disconnect the battery cable from negative (–) terminal on the battery.

2. Remove the seat plate and seat from the seat frame to get access to the transmission.

3. Disconnect the traction pedal control rod from the transmission pump lever.

4. Remove the cap screw and locknut that secure the pump lever to the control shaft on the right-hand side of the transmission.

5. Carefully thread a two inch long, 3/8 - 16 NC cap screw into the threaded hole in the end of the pump lever (Fig. 28). Turn the cap screw clockwise to pull the pump lever off of the transmission control shaft. DO NOT STRIKE THE PUMP LEVER WITH A HAMMER because damage to the transmission's internal components could result.

6. Disconnect the two electrical wires that are attached to the safety interlock switch located on the right-hand side of the transmission. To ease reassembly, note the position of these wires and the terminals of the switch to which they were connected.

7. Remove the two mounting bolts (Fig. 28) that attach the neutral return device/transmission interlock assembly to the transmission.

8. Remove the neutral return assembly from the transmission.

9. Reverse steps 2 - 7 to reinstall the neutral device. Before reinstalling the pump lever onto the transmission control shaft, apply Loctite 271 onto the mating surfaces of the control shaft and pump lever.

10. Adjust the neutral return assembly. (See Adjusting Traction Control For Neutral in the Adjustments section of this chapter.) Adjust the traction safety interlock switch. (See Replacing the Traction Switch in the Repairs section of Chapter 5 - Electrical System.)

11. Reinstall the seat plate and seat to the seat frame.

Lift Control Valve Removal and Installation

1. Lower the cutting unit or implement to the ground, turn the engine OFF, and engage the parking brake. Disconnect the battery cable from the negative (–) terminal on the battery.

2. Remove the seat and seat plate from the seat frame to get better access to the lift control valve.

3. Remove the cap screw and disconnect the ball joint from the control valve (Fig. 29).

4. Disconnect the hydraulic lines that are attached to the control valve. Put caps or plugs on all the fittings and hoses to prevent contamination.

NOTE: To ease reassembly, tag each of the hoses to show their correct position on the lift valve.

5. Remove the cap screws lock washers and flat washers that secure the control valve to the frame.

6. Remove the control valve.

7. Reverse steps 1 - 6 to install the control valve. Bleed the hydraulic system (see Bleeding the Hydraulic System in this section).

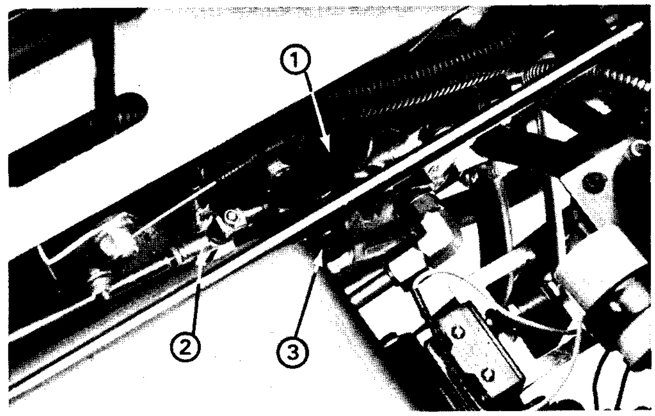

Figure 29

1. Control valve
2. Ball joint
3. Cap screw, lockwasher and flatwasher

Lift Control Valve Service

1. After removing the control valve from the machine, plug all ports and clean the outside of the valve.

2. Carefully mount the control valve into a vise so a control valve mounting pad is against the jaws of the vise.

3. Remove the slotted plug from the side of the valve body. Within the valve body, beneath the hex cap plug, there is a spring and plunger; remove these parts (Fig. 30). Remove the hex plug. Remove the O-rings from the plugs.

4. Remove the cap. DO NOT remove the retaining ring from the spool.

5. Carefully remove the control valve spool from the valve body.

6. Remove the wiper seal.

7. Use a hooked scribe or thin screwdriver to remove the O-rings from the inside bore of the valve body (be careful not to scratch the valve bore finish).

8. Wash the parts in safe solvent. Dry the parts with compressed air. DO NOT wipe them dry with a cloth or paper as lint and dirt may remain.

9. Inspect all parts of the control valve for wear, paying special attention to the valve spool. Signs of wear on one side of the spool may indicate a bent spool.

NOTE: If the spool or valve body is damaged the entire lift control valve must be replaced.

10. Before assembling the control valve, coat all of the O-rings and seals with oil. Make sure you use new O-rings and seals.

11. Install the spool into the valve body before installing the plunger, spring and slotted plug.

12 Complete the reassembly by reversing these procedures.

Cap tightening torque: 20 - 25 ft-lb (2.8 - 3.5 KgM)

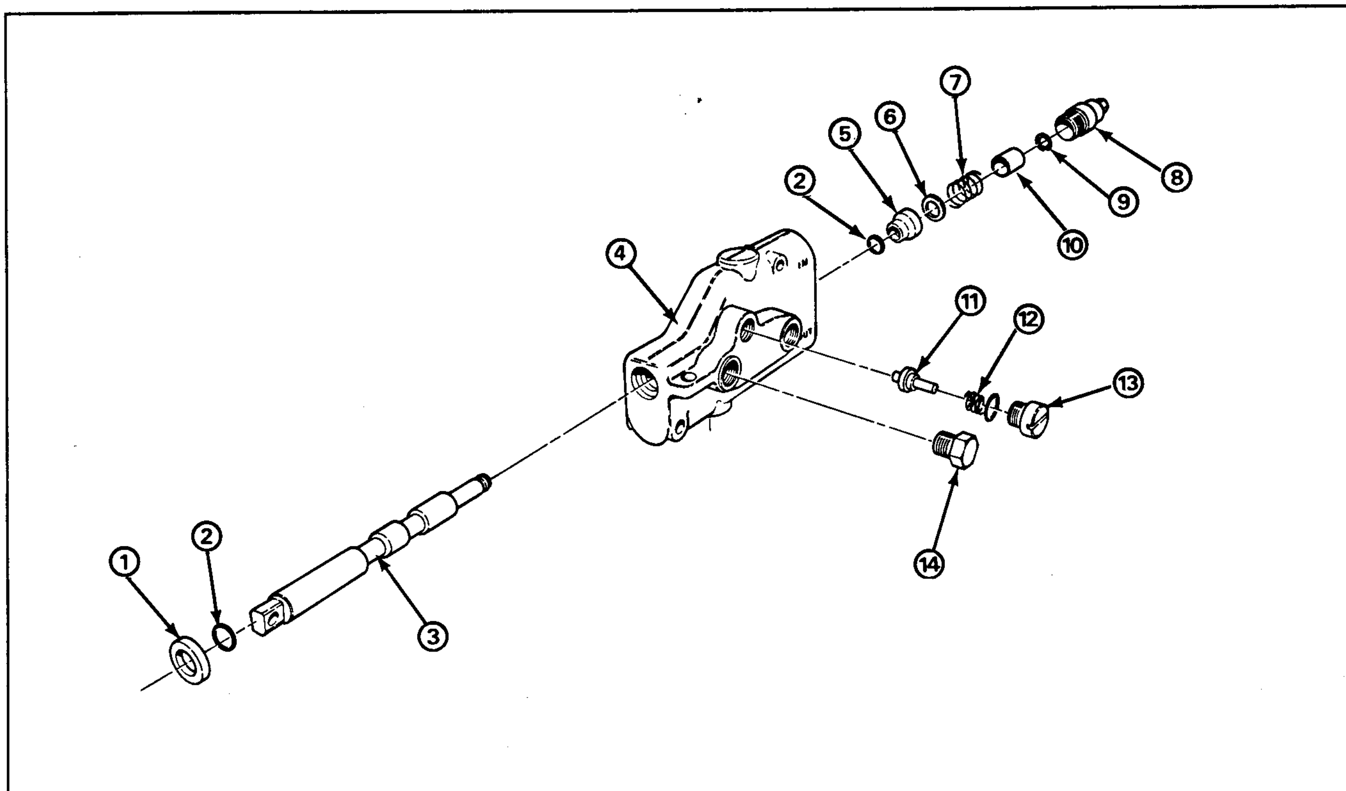

Figure 30

1. Wiper seal
2. O-ring
3. Spool
4. Body
5. Bushing
6. Washer
7. Spring
8. Cap
9. Retaining ring
10. Spacer
11. Plunger
12. Spring
13. Slotted plug
14. Hex plug

Lift Cylinder Removal and Installation

NOTE: The lift cylinder cannot be repaired. If the lift cylinder is damaged or defective it must be replaced.

1. Lower the cutting unit or implement to the ground, turn the engine OFF, and engage the parking brake. Disconnect the battery cable from negative (–) terminal on the battery.

2. Remove the cotter pins and cylinder pin (Fig. 31) that attach the lift cylinder piston rod to the lift arm.

3. Put a drain pan below the lift cylinder that is to be replaced. Disconnect the hydraulic hoses from the lift cylinder. Put caps and plugs on the hoses and fittings to prevent contamination of the hydraulic system.

4. Remove the lock nut and cap screw securing the barrel end of the cylinder to the traction unit frame.

5. Install the lift cylinder by reversing steps 2 - 4 and installing new cotter pins in place of the old ones.

6. Check the level of the hydraulic oil in the reservoir to be sure that it is up to the proper level. (See Checking Oil Level in the Maintenance section of this Chapter.)

7. Bleed the hydraulic system (see Bleeding the Hydraulic System in this section of the book).

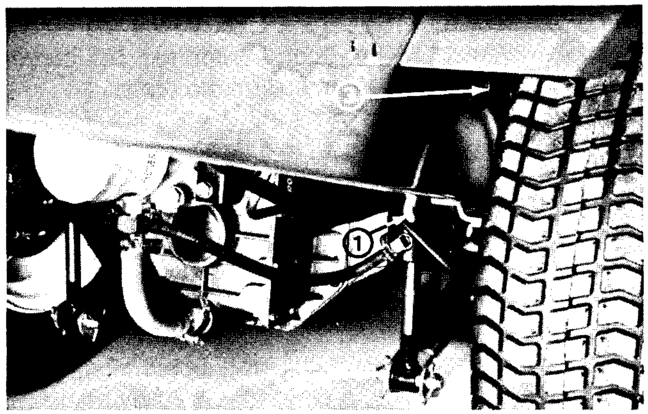

Figure 31

1. Lift Cylinder
2. Cotter pin and cylinder pin
3. Cap screw and lock nut

Charge Relief Valve Service

1. Park the machine on a level surface, engage the parking brake, and turn the engine OFF. Lower the cutting unit or implement to the floor. Disconnect the battery cable from negative (–) terminal on the battery.

2. Raise and support the seat to gain access to the transmission.

3. Place a drain pan below the charge relief valve.

4. Remove the charge relief plug and O-ring from the side of the pump housing (Fig. 32). Pull the shim pack, spring, and cone out of the housing. Some oil may flow out of the transmission. A small magnet may be helpful in removing the spring and cone from the transmission.

NOTE: The shims may remain inside the cap plug, being held in by an oil film. Count the shims when they are removed. The same number and thickness of shims must be installed when reassembling the parts. Do not interchange the charge relief shims with the implement relief shims.

5. Remove the O-ring from the cap plug.

6. Inspect the plug and pump housing for stripped threads. Replace any part that is damaged. Also check the seat inside the pump housing for damage and foreign material.

7. Check the spring for damage and correct specifications. Replace the spring if its condition is doubtful. Spring specifications are listed in the table below.

Charge Relief Spring

Number or coils	14
Outside diameter	0.244 - 0.256 in. (6.20 - 6.50 mm)
Pounds per inch	13.8 (2.5 kg/cm)

8. To install the charge relief valve, slide a new O-ring onto the charge relief plug.

9. In sequence, insert the cone and spring into the pump housing. Install the shim pack into the plug and replace the plug in the transmission to retain the parts in place.

10. Since some oil may have drained out of the transmission when the charge relief valve was removed, check the oil level in the axle housing. (See Checking Oil Level in the Maintenance section of this chapter.) Start the engine and let it run for one to two minutes. Then turn the engine OFF and recheck the oil level in the axle housing. Also check the charge relief plug area for oil leaks.

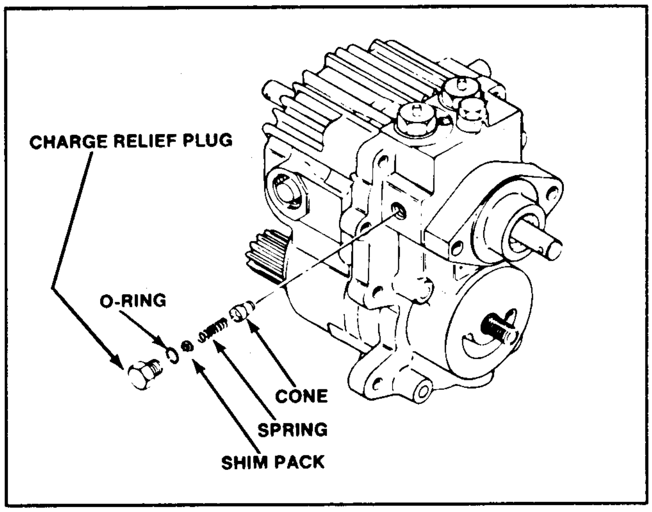

Figure 32

Implement Relief Valve Service

1. Park the machine on a level surface, engage the parking brake, and turn the engine OFF. Lower the cutting unit or implement to the floor. Disconnect the battery cable from negative (–) terminal on the battery.

2. Raise and support the seat to gain access to the transmission.

3. Place a drain pan below the implement relief valve area of the transmission.

4. Remove the implement relief plug and O-ring from the top of the pump housing (Fig. 33). Pull the shim pack, spring, and cone out of the housing. Some oil may flow out of the transmission. A small magnet may be helpful in removing the spring and cone from the transmission.

NOTE: The shims may remain inside the cap plug, being held in by an oil film. Count the shims when they are removed. The same number and thickness of shims must be installed when reassembling the parts. Do not interchange the implement relief shims with the charge relief shims.

5. Remove the O-ring from the cap plug.

6. Inspect the plug and pump housing for stripped threads. Replace any part that is damaged. Also check the seat inside the pump housing for damage and foreign material.

7. Inspect the relief valve cone for noticeable damage. If the cone is damaged, replace it.

8. Check the spring for damage and correct specifications. Replace the spring if its condition is doubtful. Spring specifications are listed in the table below.

Implement Relief Spring

Number or coils	10
Outside diameter	0.256 - 0.266 in. (6.50 - 6.76 mm)
Pounds per inch	339 (60.5 kg/cm)

9. To install the implement relief valve, slide a new O-ring onto the implement relief plug.

10. In sequence, insert the cone and spring into the pump housing. Install the shim pack into the plug and replace the plug in the transmission to retain the parts in place.

11. Since some oil may have drained out of the transmission when the implement relief valve was removed, check the oil level in the axle housing. (See Checking Oil Level in the Maintenance section of this chapter.) Start the engine and let it run for one to two minutes. Then turn the engine OFF and recheck the oil level in the axle housing. Also check the implement relief plug area for oil leaks.

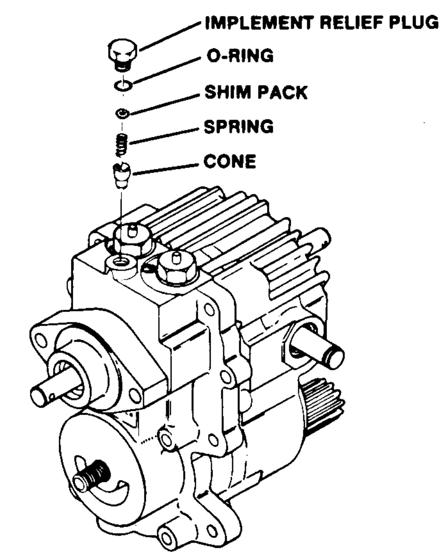

Figure 33

Charge Pump Service

1. Park the machine on a level surface, engage the parking brake, and turn the engine OFF. Lower the cutting unit or implement to the floor. Disconnect the battery cable from negative (–) terminal on the battery.

2 Remove the drive coupling from between the engine pulley and the transmission hub. (See Removing Drive Coupling in the Repairs section of Chapter 10 - ENGINE TO TRANSMISSION COUPLER.)

3. Examine the transmission pump shaft and remove all burrs, sharp edges, and residue to prevent possible damage to the charge pump lip seal.

NOTE: Disassembly of the charge pump is not necessary when the lip seal is the only part that must be replaced (see step 4 below). Servicing any other part of the charge pump requires disassembly (see step 5 below).

4. If the charge pump seal (Fig. 34) is the only part being serviced, pull the seal out of the charge pump housing using an oil seal puller or similar tool. Do not scratch the pump shaft. Since oil flows out of the transmission when the seal is removed, use a drain pan to catch the oil; however, do not use this oil again. Use a seal protector on the pump shaft and slide the new lip seal into place.

NOTE: In place of a seal protector, use cellophane or a similar material to wrap the pump shaft. This protects the seal from possible damage when sliding it onto the pump shaft. Apply transmission oil on the cellophane to make the seal slide freely.

5. If the charge pump must be disassembled, scribe a mark on the charge pump housing and adjacent pump housing to assure correct installation when the parts are reassembled.

NOTE: The charge pump housing and the transmission case have a flat edge on the side where the two parts meet (Fig. 34). These flat edges must be installed next to each other on the left-hand side of the transmission during reassembly.

6. Remove the cap screws holding the charge pump housing against the adjacent pump housing (Fig. 34). Using a seal protector, slide the charge pump housing and gerotor wheel off of the pump shaft. The O-ring will probably stay in the groove on the inside of the pump housing.

NOTE: If a seal protector is not used, wrap the pump shaft with waxed paper or cellophane to protect the seal. When sliding the housing and gerotor wheel off of the pump shaft, the drive pin may drop out of the pump shaft. Do not lose the pin because it is the only part that drives the gerotor wheel. Without the pin, the gerotor wheel will not rotate; therefore, no "charge pressure" and no hydraulic functions will be available.

7. Examine the gerotor wheel (Fig. 34) and the inside of the charge pump housing for excessive wear patterns, scratches, or score marks. If a part is damaged beyond repair, replace it.

IMPORTANT: If either the gerotor wheel or the charge pump housing is damaged, replace both parts. Never replace only one part because the charge pump housing and gerotor wheel have a definite wear-in characteristic. A new drive pin should also be installed.

8. Examine the bearing in the charge pump housing for damage and free rotation. If the bearing is damaged, replace the bearing and seal.

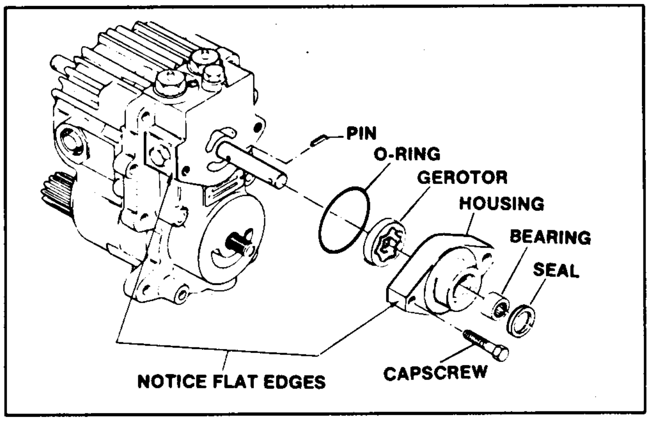

Figure 34

9. To assemble the charge pump, install a new O-ring into the groove in the charge pump housing.

10. Apply oil on the gerotor wheel and on the inside of the charge pump housing. Slide the drive pin through the hole in the pump shaft. (It is helpful to have this hole positioned horizontally, as shown in Fig. 34, to keep the pin in place during reassembly.) Then slide the gerotor wheel onto the pump shaft and over the drive pin so that positive engagement results.

11. Using a seal protector for the lip seal, slide the charge pump housing onto the pump shaft and against the face of the transmission housing. Align the scribe marks on both housings to assure proper assembly and to prevent damage to the transmission.

NOTE: In place of a seal protector, use cellophane or a similar material to wrap the pump shaft. This protects the seal from possible damage when sliding it onto the pump shaft. Apply transmission oil on the cellophane to make the seal slide freely.

The charge pump housing is marked with a flat edge. This is used to denote which side of the charge pump is mounted towards the left-hand side of the transmission for a given direction of engine rotation (eg. clockwise). The Groundsmaster 220-D mower application requires that the flat edge be toward the left-hand side of the transmission (see Fig. 34). Having the flat edge toward the right-hand side of the transmission will result in a complete loss of hydraulic functions.

12. Secure the charge pump housing against the transmission housing with the two cap screws. Tighten the cap screws to 13 - 15 ft-lb (1.7 - 2.1 KgM).

13. Install the drive coupling and the transmission hub to the engine pulley. (See Installing Drive Couplings in the Repairs section of Chapter 10 - ENGINE TO TRANSMISSION COUPLER.)

14. Prime the transmission (see Priming After Transmission Overhaul or Replacement).

Charge Check Valve Service

1. Park the machine on a level surface, engage the parking brake, and turn the engine OFF. Lower the cutting unit or implement to the floor. Disconnect the battery cable from negative (–) terminal on the battery.

2. Remove each valve assembly from the center section of the transmission by unscrewing it counterclockwise (Fig. 35). Some oil may flow into the drain pan. Clean the valves in clean solvent.

3. Inspect the threads of each valve. Replace the valve if the threads are damaged.

4. Check the O-rings and back up ring of each valve for damage. If the rings are damaged, replace them.

5. If the O-rings or back up washer must be replaced:

   A. Install the large O-ring fully into the groove, just below the hex head of the valve, taking care not to damage the O-ring on the sharp threads.

   B. Install the small back up washer and then the small O-ring into the groove located between the valve ports.

6. Press the bypass button to ensure that there is a slight spring pressure. If the button sticks severely, replace the valve assembly.

7. With the bypass button released and the check ball seated, stand the valve upright and load a small amount of solvent into one of the upper series of holes (Fig. 35). Allow the solvent to remain for 15 minutes, during which time there should be no leakage of solvent from the valve. Since these valves have no internal repair parts available, replace any leaking valves.

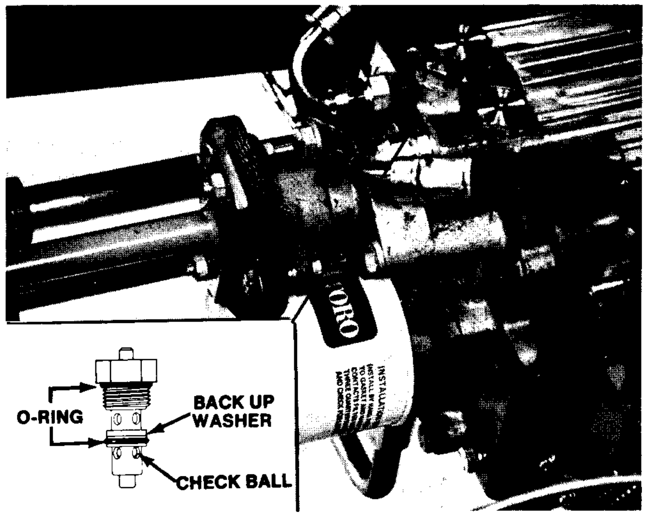

Figure 35

Trunnion Shaft Lip Seal Service

1. Park the machine on a level surface, engage the parking brake, and turn the engine OFF. Lower the cutting unit or implement to the floor. Disconnect the battery cable from negative (–) terminal on the battery. Place a drain pan below the transmission.

2. Remove the control lever and the interlock switch assembly from the control shaft on the right-hand side of the transmission. (See Removing And Replacing Pump Lever And Neutral Return Device Of Transmission in this section of the book.)

3. Remove the snap ring from the control shaft and slide the flat washer off of the shaft (Fig. 36). Using a seal puller, pull the seal out of the transmission housing. Do not mar or scratch the shaft.

NOTE: Since oil drains out of the transmission when the seal is removed, use the drain pan to catch the oil. However, do not use this oil again.

4. Examine the control shaft and remove all burrs, sharp edges, and residue.

5. Using a seal protector, press a new seal into the transmission housing until it is fully seated into the counterbore.

NOTE: In place of a seal protector, use cellophane or a similar material to wrap the control shaft. This protects the seal from possible damage when sliding it onto the shaft. Apply transmission oil on the cellophane to make the seal slide freely.

6. Slide the flat washer onto the shaft and install the snap ring into the groove in the shaft. Do not use a flat washer that is bent.

7. Remove the snap ring from the end of the trunnion shaft (left-hand side) and slide the flat washer off of the shaft (Fig. 36). Using a seal puller, pull the seal out of the transmission housing. Do not mar or scratch the shaft.

8. Examine the trunnion shaft and remove all burrs, sharp edges, and residue.

9. Using a seal protector, press a new seal into the transmission housing until it is fully seated into the counterbore.

NOTE: In place of a seal protector, use cellophane or a similar material to wrap the trunnion shaft. This protects the seal from possible damage when sliding it onto the shaft. Apply transmission oil on the cellophane to make the seal slide freely.

10. Slide the flat washer onto the shaft and install the snap ring into the groove at the end of the shaft. Do not use a flat washer that is bent.

11. Install the interlock switch assembly and the control lever onto the control shaft on the right-hand side of the transmission. Adjust the traction pedal control rod and linkage for neutral. (See Adjusting Traction Control For Neutral in the Adjustments of this chapter.)

12. Prime the transmission (see Priming after Transmission Overhaul or Replacement). Inspect the lip seals on the trunnion shafts for signs of leakage.

13. Check the operation and adjustment of the transmission safety interlock switch assembly to be sure that the engine will start ONLY when the traction pedal is in the neutral position. If switch assembly adjustment is required, see Replacing the Traction Switch in the Repairs section of Chapter 5 - ELECTRICAL SYSTEM.)

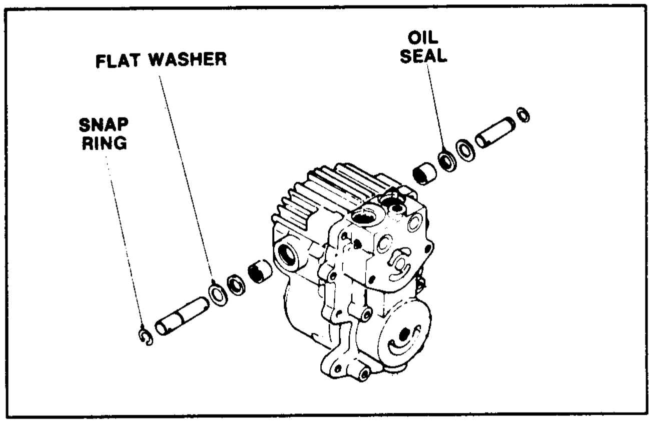

Figure 36

General Transmission Overhaul Information

Wash parts in safe solvent. Dry the parts with compressed air. DO NOT wipe them dry with a cloth or paper as lint and dirt may remain.

As the transmission components are removed for service and inspection, it should be noted that nominal wear to the components is acceptable. Critical contact surfaces (charge pump gerotor, piston slippers, etc.) must be in good condition or the hydraulic system will be inefficient.

When components have circumferential scratches or grooves noted on the running surfaces, it is an indication of foreign material in the oil.

When scratches or grooves can be detected by "feel" with a fingernail or lead pencil, the part should be replaced. Polishing or touch lapping can be accomplished using 4/0 grit sandpaper on a flat lapping table (table must be kept flat). Polish parts using polishing solvent or equivalent. Do not polish parts dry.

IMPORTANT: Lapping plate must be flat within .00005 inch (0.00127 mm).

Separating the Transmission Into Sections

1. Remove the transmission from the machine. (See Removing and Replacing the Hydrostatic Transmission in this section of the book.)

2. Remove the neutral return device/transmission interlock assembly and the pump lever from the control shaft of the transmission.

3. Put a drain pan under the transmission. Remove and discard the transmission hydraulic oil filter. Drain as much oil as possible from the transmission into the drain pan (from the filter mount hole).

4. Thoroughly clean the outside of the transmission to prevent contamination of the internal components during disassembly and repair.

5. Put the transmission on a clean work surface which has been covered with clean kraft paper.

6. Remove the charge pump from the transmission. (See Servicing the Charge Pump in this section of the book.)

7. Perform this step while working over a clean drain pan. Begin separating the two transmission sections by evenly, and in small increments, loosening the eight cap screws that secure the center section to the main transmission housing. As the cap screws are loosened, oil will drain from between the sections. Allow all the oil to drain into the drain pan.

NOTE: When the cap screws are first loosened, internal spring loads will cause the sections to separate slightly.

8. Put the transmission onto the clean work surface with the pump shafts in a vertical position. Remove the eight cap screws and pull the center section away from the main housing (Fig. 37). Do not let the internal parts fall out of the housing or off of the center section because damage may result.

NOTE: The pump and motor valve plates may adhere to the side of the center section when it is removed. Be careful not to let these fall off of the center section.

9. Remove the gasket from the main housing or center section.

10. Remove the valve plates. These plates will either be in position on the center section or adhered to its mating piston group. Set these plates aside, noting each plate's position (pump or motor) and keeping the two plates separate (they are not interchangeable). This will also allow easier reassembly, and in the case of component damage, allow better diagnosis of the cause of failure.

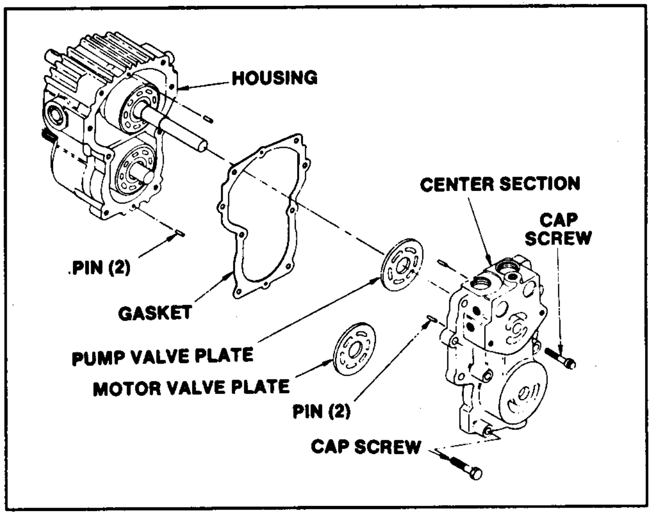

Figure 37

Transmission Overhaul

Disassembly and Inspection

The pump section is the top piston group located in the upper chamber of the transmission housing (Fig. 38).

1. Lift the pump cylinder block assembly out of the transmission (Fig. 38). The pistons may come out of the cylinder bores during removal, however, there is no special order of pistons to bores within the cylinder block. Set the piston group aside, near the pump valve plate.

NOTE: Since the entire cylinder block assembly must be replaced as a unit if it is defective, do not disassemble the spring and other parts from the center bore of the cylinder block. Cylinder block components from one assembly are not interchangeable with those of another assembly.

2. Remove the thrust plate from the counterbore of the variable position swash plate and place it near the pump piston group.

The motor section is the bottom piston group located in the lower chamber of the transmission housing (Fig. 39).

3. Lift the motor cylinder block assembly out of the transmission (Fig. 39). The pistons may come out of the cylinder bores during removal, however, there is no special order of pistons to bores within the cylinder block. Set the piston group aside, near the motor valve plate.

NOTE: Since the entire cylinder block assembly must be replaced as a unit if it is defective, do not disassemble the spring and other parts from the center bore of the cylinder block. Cylinder block components from one assembly are not interchangeable with those of another assembly.

4. Remove the two cap screws that secure the fixed position swash plate into the housing. Lift the swash plate out of the counterbore of the main housing. Place the swash plate near the motor piston group.

5. The pump shaft and motor shaft may now be removed from the transmission housing by pressing them out through the large cavity of the housing (Fig. 40).

IMPORTANT: Do not remove the shafts from the transmission housing by using a hammer or similar device. Impact against these parts could cause damage to the shafts and to their bearing seats.

6. If the motor shaft bearing is suspected as faulty, remove the bearing from the transmission by pressing it out towards the front (outside) of the housing.

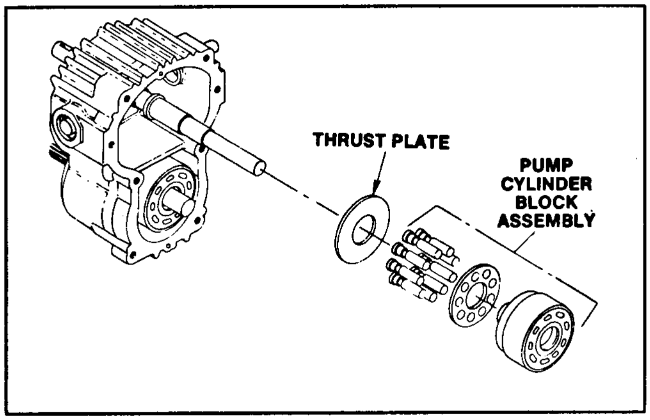

Figure 38

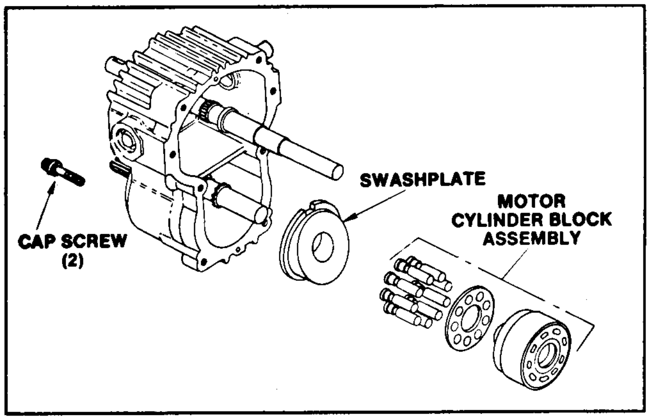

Figure 39

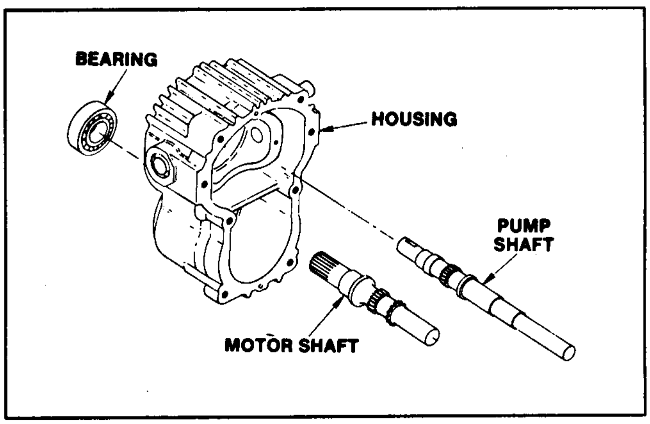

Figure 40

7. If the needle bearings located in the center section are suspected as being faulty, they may be removed by pressing them out of the center section (Fig. 41).

8. To remove the variable position swash plate and trunnion shafts, place the transmission housing onto the work surface with the large cavity up (Fig. 42). Mark the control shaft and housing so that the shaft can be reinstalled correctly during reassembly.

Remove the small retaining rings that secure the lip seal and washer into each side of the transmission case at the trunnion shaft and the control shaft. Remove the lip seals and washers.

Place a 3/16 inch (4.6 mm) diameter pin punch into the hole in the control shaft and tilt the swash plate to its full angle (15° full forward). Use a second 3/16 inch pin punch to drive out the single pin in the trunnion shaft until the pin contacts the transmission housing. DO NOT CONTINUE TO DRIVE THE PIN; damage may result

Drive both pins out of the control shaft until the first pin contacts the housing. Then twist the swash plate (control shaft) back towards neutral. The first control shaft pin and the pin on the trunnion shaft side should fall into the housing.

Tilt the swash plate back to its full angle (15 °) and drive the second pin out of the control shaft until it hits the housing. Note the orientation of the swash plate within the housing and mark the parts accordingly to insure proper reassembly. Rotate the control shaft back towards neutral and the last pin should fall out.

NOTE: There are two spring pins in the control shaft and one pin in the trunnion shaft. The control shaft must have two pins because of the continuous "applied force" from the traction pedal during normal operation of the mower.

9. Drive the control shaft out of the swash plate bore towards the outside of the housing. Remove the trunnion shaft in the same manner. The swash plate may now be removed from the transmission housing.

10. If the pump shaft bearing (located in the transmission housing) is suspected as being faulty, it may be removed by pressing it out towards the inside of the housing cavity (Fig. 43). The oil seal may be pressed out of the housing towards the outside (front).

11. Inspect the control shaft needle bearings to determine whether they should be removed and replaced. To remove these bearings, press them out towards the outside of the transmission housing (Fig. 43).

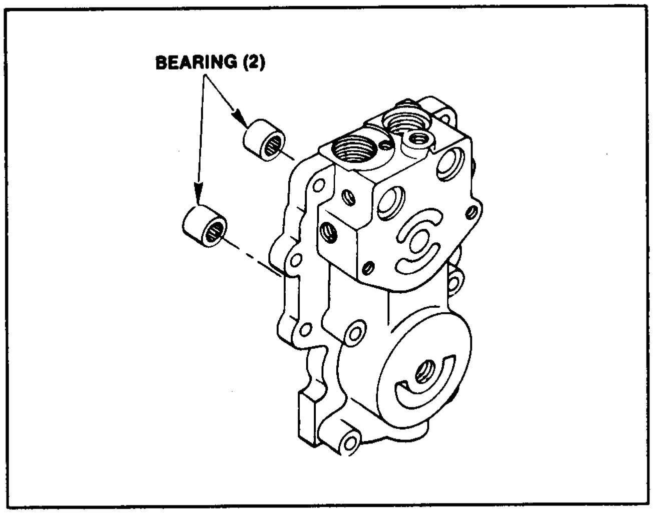

Figure 41

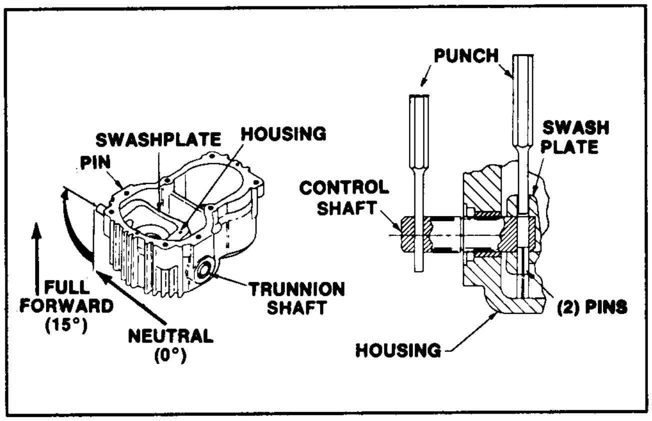

Figure 42

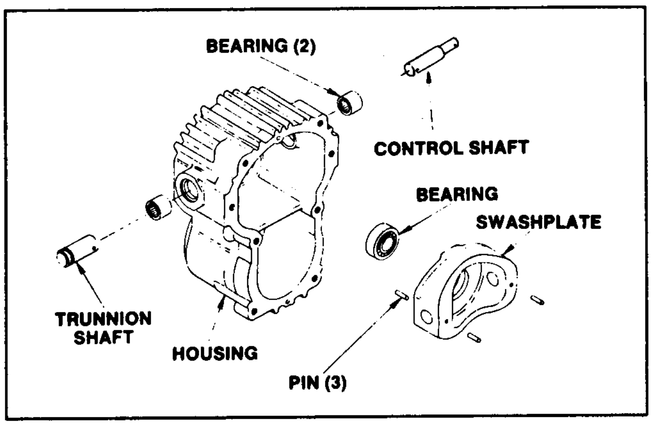

Figure 43

12. Clean and inspect the following parts as described:

A. Thrust Plate - Check both sides for damage such as severe scratches, heat discoloration, or metal transfer. The plate must be perfectly flat.

B. Fixed Position Swash Plate - Check the smooth (inclined plane) side for damage such as severe scratches, heat discoloration, or metal transfer.

C. Variable Position Swash Plate - Inspect for damage or any noticeable imperfections. If the mating thrust plate was severely damaged, this plate could also be damaged.

D. Cylinder Block Assemblies - Check the steel piston surfaces for wear, scratches, scoring, and freedom of movement within the cylinder block bores. Also check the brass-colored piston slippers for damage such as heat discoloration, severe scratches, cracks where the slipper is attached to the piston, and severe wear. DO NOT DISASSEMBLE THE SPRING AND OTHER PARTS FROM THE CENTER BORE OF THE CYLINDER BLOCK.

E. Bearings - Check for free rotation, damaged/pitted rollers or balls, cracked races, and heat discoloration.

F. Pump and Motor Shafts - Check for scratches, scoring, damaged splines, and burrs near the keyway.

G. Control and Trunnion Shafts - Check for wear, scratches, and burrs. The pump lever mounting hole in the control shaft must not be oblong; this will create "free play" at the traction pedal, after reassembly.

H. Valve Plates - Inspect for heat discoloration, severe scratches in the critical contact surfaces (especially small grooves between the ports), flatness, and metal transfer.

13. Replace any defective part. Remember that the cylinder block assemblies must be replaced as complete components, not as individual parts.

Interchanging parts between the pump cylinder block assembly and the motor cylinder block assembly will cause the transmission to malfunction and inevitably lead to the failure of certain internal components.

Assembly of Transmission

The reassembly instructions that follow consider that the transmission has been completely disassembled. If certain components were not removed during the overhaul (eg. center section bearings, etc.), omit that instruction and proceed to the next step.

1. The needle bearings mounted into the center section have two functions. First, to provide the shafts with a friction-reduced means to rotate, and their secondary purpose is to pilot the pump and motor valve plates into their proper position. It is therefore very important that these bearings be reinstalled as described (Fig. 44).

Protect the charge pump facing area of the center section from scratches by placing a soft lint-free shop towel against its surface. Lay the center section onto the bed of an arbor press with the towel-protected side face down. Press the needle bearings (one each) into the appropriate holes of the center section leaving 3/32 - 1/8 inch (2.3 - 3.0 mm) of bearing protruding beyond the face of the center section.

2. Reinstall the motor shaft bearing by pressing it into the main transmission housing, from the outside towards the rear of the housing, until it seats fully into the housing (Fig. 45).

3. Reinstall the pump shaft bearing by pressing it into the main transmission housing, from the inside to the front of the housing, until it seats fully into the housing (Fig. 46).

4. Install a new pump shaft seal into the main housing, from the outside towards the rear of the housing, until the rim of the seal is flush with the transmission case.

5. The control shaft and trunnion shaft needle bearings are reinstalled into the housing by pressing them in from the outside, towards the inside of the transmission case. Press them in until they are flush, to 1/16 inch (1.6 mm) below, the counterbore for the lip seals.

6. Place the variable position swash plate into the transmission housing with the counterbore for the thrust plate facing towards the rear of the transmission. Refer to the previously made assembly marks to insure the proper orientation of the swash plate in the housing. Slide the control shaft and trunnion shaft through the needle bearings and into the swash plate, being certain that the control shaft is on the right-hand side of the transmission.

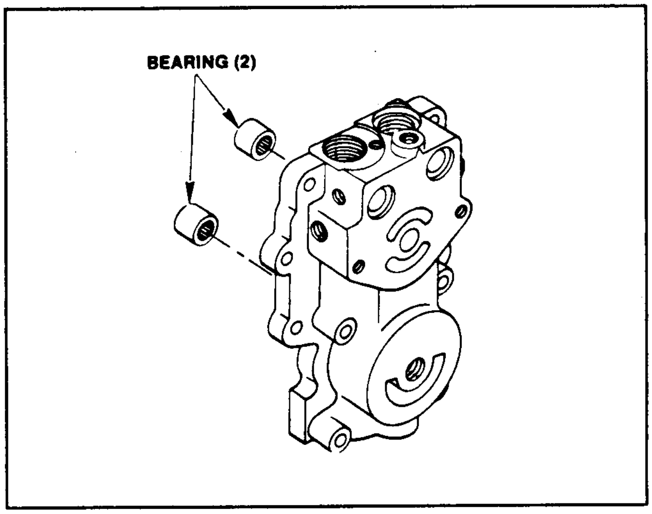

Figure 44

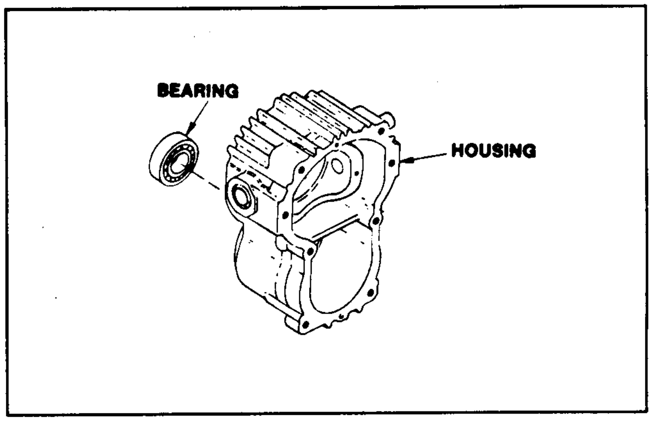

Figure 45

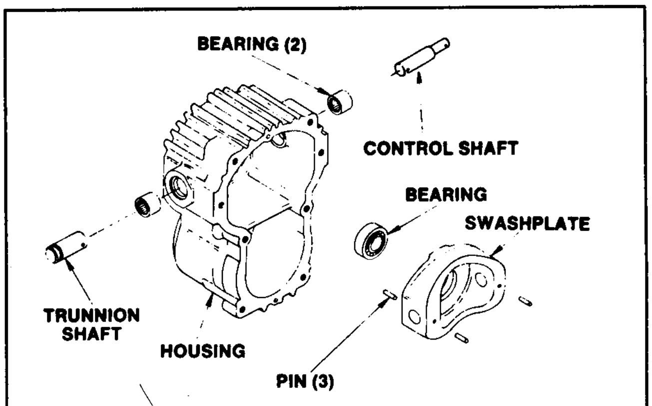

Figure 46

7. Install new spring pins through the swash plate and shafts, using two pins on the control shaft side (Fig. 47). Drive the pin into the trunnion shaft with a pin punch until the pin is 1/4 inch (6 mm) below the swash plate. To install the two pins in the control shaft, install the first pin until the second pin can be started, then drive both pins together until the last pin is 1/4 inch (6 mm) below the swash plate.

The swash plate should be capable of rotating freely in the pump housing. If not, determine the cause and repair before proceeding with the transmission reassembly.

8. Using a seal protector for the lip seals, slide the seals onto the control and trunnion shafts and into the counterbore of the transmission housing. Place a washer onto each shaft, against the lip seals, and secure the seals with the retaining rings.

NOTE: In place of a seal protector, use cellophane or a similar material to wrap the shafts. This protects the seals from possible damage when sliding them onto the shafts. Apply transmission oil on the cellophane to make the seals slide freely.

9. Guide the pump shaft through the center of the variable position swash plate and into the bearing previously installed into the transmission housing. Press the pump shaft into the bearing until it is fully seated (Fig. 48).

10. Press the motor shaft fully into the bearing previously installed into the transmission housing until it protrudes from .170 to .190 inch (4.3 - 4.8 mm) outside of the housing (Fig. 48).

11. Install the fixed position swash plate into the counterbore of the transmission housing (Fig. 49). Orient the swash plate so that the notch is at the top (high point of the cam angle is toward the bottom) and install the cap screws through the transmission case to secure it in place.

12. Assemble the cylinder block parts, if necessary, and lubricate them with clean SAE 10W30 or 10W40 SE, SF oil. Keep in mind that although there is no special order of pistons to bores with a given cylinder block assembly, do not interchange parts from another cylinder block group. Place the transmission housing assembly in a horizontal position (Fig. 49). Slide the motor piston group over the motor shaft and engage the splines. Be certain that the pistons remain in place within the cylinder group.

When properly installed, a slight spring tension can be felt when pushing against the cylinder block.

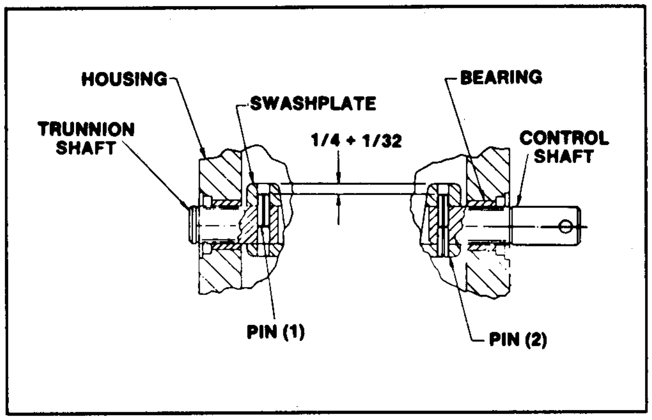

Figure 47

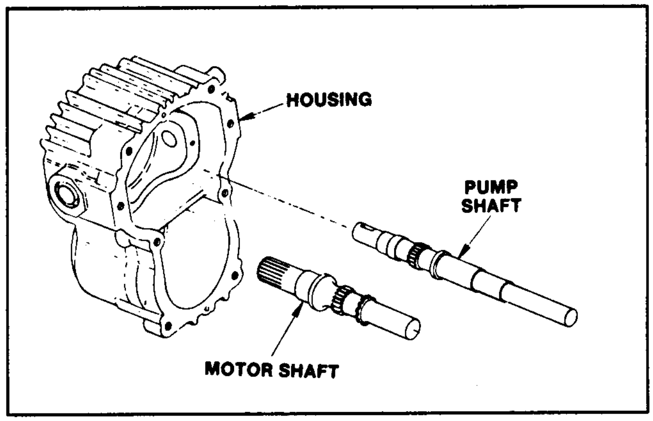

Figure 48

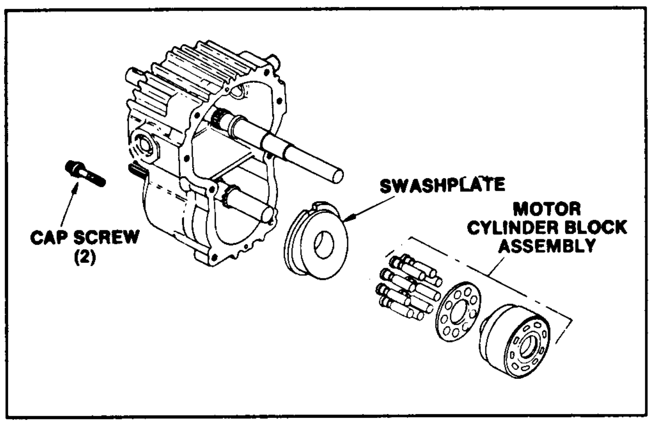

Figure 49

13. Lubricate the thrust plate and insert it into the counterbore of the variable position swash plate (Fig. 50). Slide the pump piston group over the pump shaft and engage the splines. Be certain that the pistons and the thrust plate remain in place. When properly installed, a slight spring tension can be felt when pushing against the cylinder block.

14. Lubricate the exposed faces of the cylinder block assemblies and the slotted sides of the pump and motor valve plates with clean 10W30 or 10W40 SE, SF oil.

15. Position the motor valve plate onto the center section (bottom position), over the protruding needle bearing, so that the slot on the steel side of the valve plate keys on the small locating pin. The brass colored side of the valve plate should be in position to contact the back of the piston group.

NOTE: The motor valve plate and the pump valve plate are not interchangeable. Identify the motor valve plate by the four (4) V-notches in the kidney-shaped grooves (Fig. 51). The pump valve plate has two (2) notches in the grooves.

16. Position the pump valve plate onto the center section (top section), over the protruding needle bearing, so that the slot on the steel side of the valve plate keys on the small locating pin. The brass colored side of the valve plate should be in position to contact the back of the piston group.

17. Place the new housing gasket in place on the center section while using a small amount of oil to hold it in place.

18. Carefully position the center section onto the transmission housing so that the valve plates and cylinder block assemblies remain in place. Insert the eight (8) cap screws and tighten them equally in small increments to a torque of 25 to 30 ft-lbs (3.5 to 4.1 KgM). Check for proper internal assembly by slowly rotating the pump, motor, and control shafts while tightening these screws.

19. Install a new oil filter onto the transmission. (See Replacing Hydraulic Oil Filter in the Maintenance section of this chapter.)

20. Replace the transmission into the mower. (See Removing and Replacing the Hydrostatic Transmission in this section of the book.)

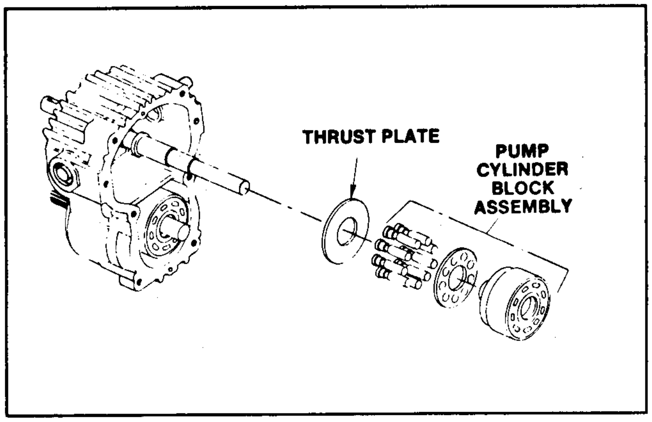

Figure 50

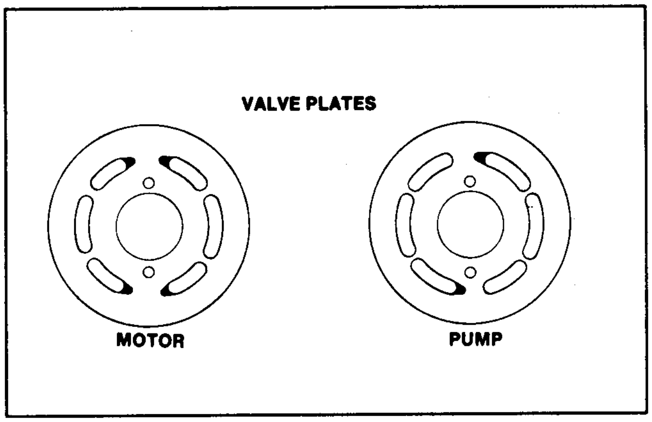

Figure 51

Priming After Transmission Overhaul or Replacement

Before starting the engine after the transmission is overhauled or replaced::

1. After the transmission has been installed in the machine, pour a quantity of the correct hydraulic oil into the transmission through one of the hose ports on top of the transmission. Connect the hose to the transmission.

   Above 32°F (0° C) use SAE 10W-30 or 10W-40 engine oil. Type A automatic transmission fluid may be used as a substitute.

   Below 32° F (0° C) use type A automatic transmission fluid. SAE 5W-20 engine oil may be used as a substitute.

IMPORTANT: Do not mix engine oil and automatic transmission fluid; hydraulic system component damage may result. When changing from one type of fluid to another, be sure to completely drain the old fluid and change the filter. DO NOT use Dextron II ATF.

2. Unscrew and remove the dipstick cap from the filler neck and add the correct oil so the oil level is to the mark on the dipstick (Fig. 52). Install the dipstick cap and tighten finger tight.

   Capacity: approximately 5 U.S. qt. (4.7 L)

3. Start the engine and let it idle for 5 - 10 minutes. Run the engine at high idle for 1 minute.

4. Turn the steering wheel fully left and right several times.

5. Operate the traction system in forward while making some full left and right turns. Operate the traction system in reverse.

6. Raise and lower the cutting unit or implement several times. Raise the cutting unit or implement to extend the lift cylinders. Turn the steering wheel so the rear wheels are in the straight ahead position. Engage the parking brake and turn the engine OFF.

7. Check for leaks. Check the oil level again. Add enough oil to raise the level to the groove mark on the dipstick. DO NOT OVERFILL.

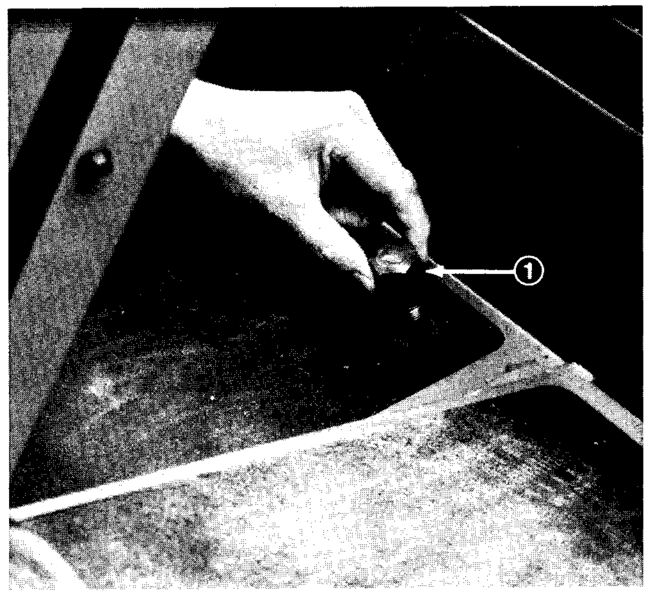

Figure 52

1. Hydraulic reservoir dipstick / fill cap

Bleeding the Hydraulic System

Perform this procedure after removing and installing any parts in the hydraulic system to make sure air is removed from the system.

1. Start the engine and let it idle for 5 - 10 minutes. Run the engine at high idle for 1 minute.

2. Turn the steering wheel fully left and right several times.

3. Operate the traction system in forward while making some full left and right turns. Operate the traction system in reverse.

4. Raise and lower the cutting unit or implement several times. Raise the cutting unit or implement to extend the lift cylinders. Turn the steering wheel so the rear wheels are in the straight ahead position. Engage the parking brake and turn the engine OFF.

5. Check for leaks. Check the oil level hydraulic oil level. Add enough oil to raise the level to the groove mark on the dipstick. DO NOT OVERFILL.

Towing

In an emergency, the traction unit may be pushed or towed for very short distances. However, The Toro Company does not recommend this as standard procedure.

IMPORTANT: Do not push or tow the traction unit faster than 2 to 3 mph (3 to 4 km/hr) because the transmission may become damaged. If the traction unit must be moved a considerable distance, transport it on a trailer. Whenever the traction unit is pushed or towed, the bypass valves (Fig. 53) must be held in the open (down) position.

1. Raise and support the seat to get access to the bypass buttons located on the top of the transmission.

2. Push and hold the buttons down while the mower is being pushed (onto the trailer).

3. After the machine has been repaired and the engine has just been restarted, make sure that the bypass buttons return to their closed (up) position.

IMPORTANT: Running the Groundsmaster® with the bypass valves open will cause the transmission to overheat.

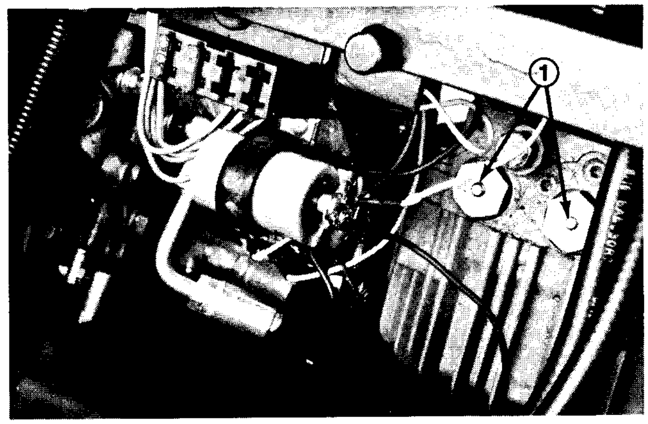

Figure 53

1. By-pass buttons

TORO®

Chapter 5

Electrical System

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Introduction

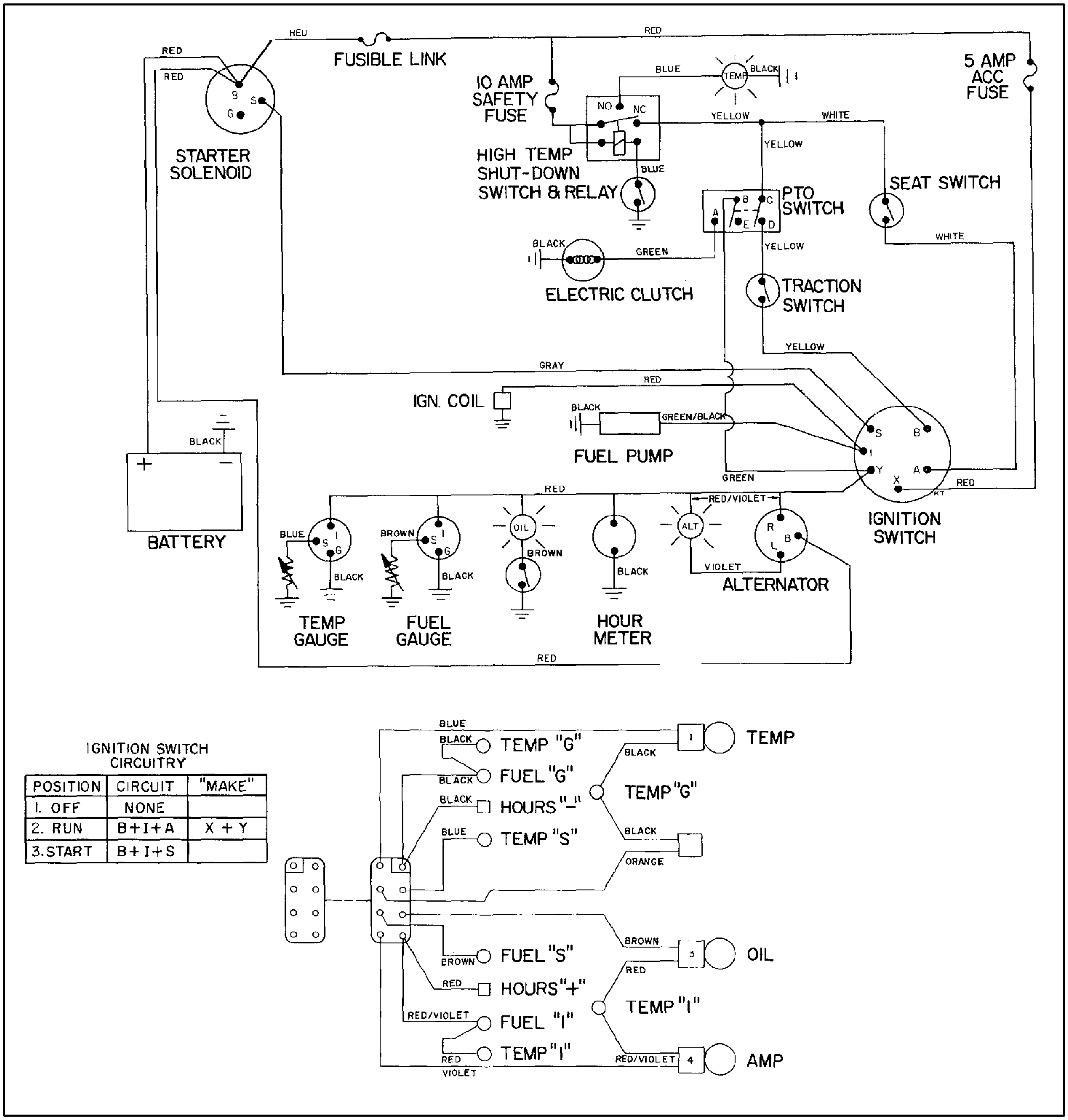
The Groundsmaster® 220-D/223-D electrical system is a combination of several functional systems. These systems are: the starting (or cranking) circuit, the run circuit and the accessories circuit. Within these functional circuits are several interdependent circuits that are called "interlocks". These work to provide safety protection for the operator and limited damage protection to some major machine components.

See **Chapter 3 - Mitsubishi Diesel Engine** for information about removal and installation of glow plugs, oil pressure switch, alternator, starter and engine stop solenoid. Also see Chapter 3 for testing of electric fuel pump and glow plugs and servicing the fuel pump.

See **Chapter 11 - P.T.O. System** for information about adjusting, replacement and repair of the electric P.T.O. clutch.

Wiring Schematics

Groundmaster 224

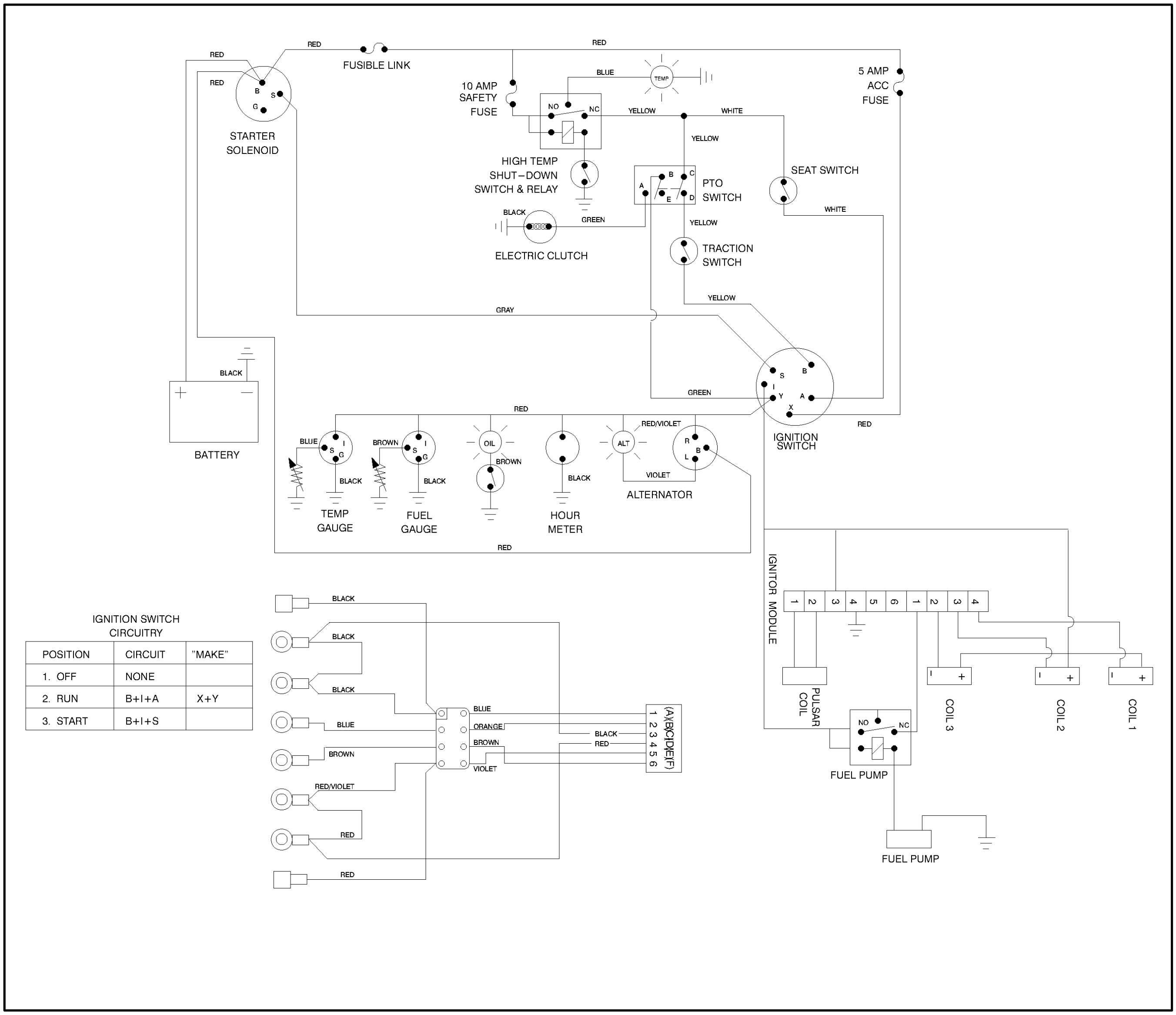


IGNITION SWITCH CIRCUITRY

POSITION	CIRCUIT	"MAKE"
1. OFF	NONE	
2. RUN	B+I+A	X + Y
3. START	B+I+S	

Figure 1

Groundmaster 225 (Serial Numbers 60001 to 200999999)



POSITION	CIRCUIT	"MAKE"
1. OFF	NONE	
2. RUN	B+I+A	X+Y
3. START	B+I+S	

Figure 2a

Groundmaster 225 (Serial Numbers higher than 21000000)

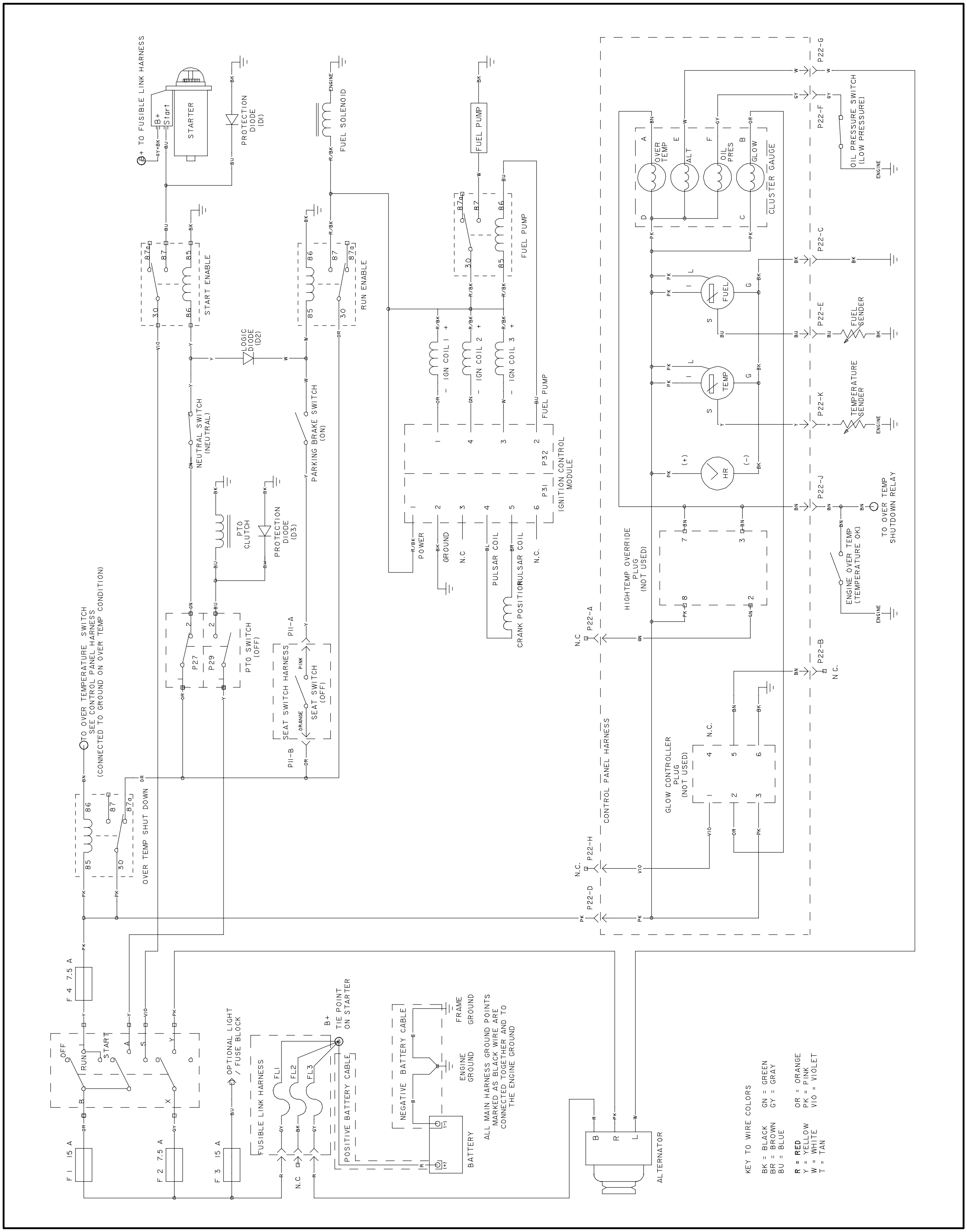


Figure 2b

Groundmaster 1000L

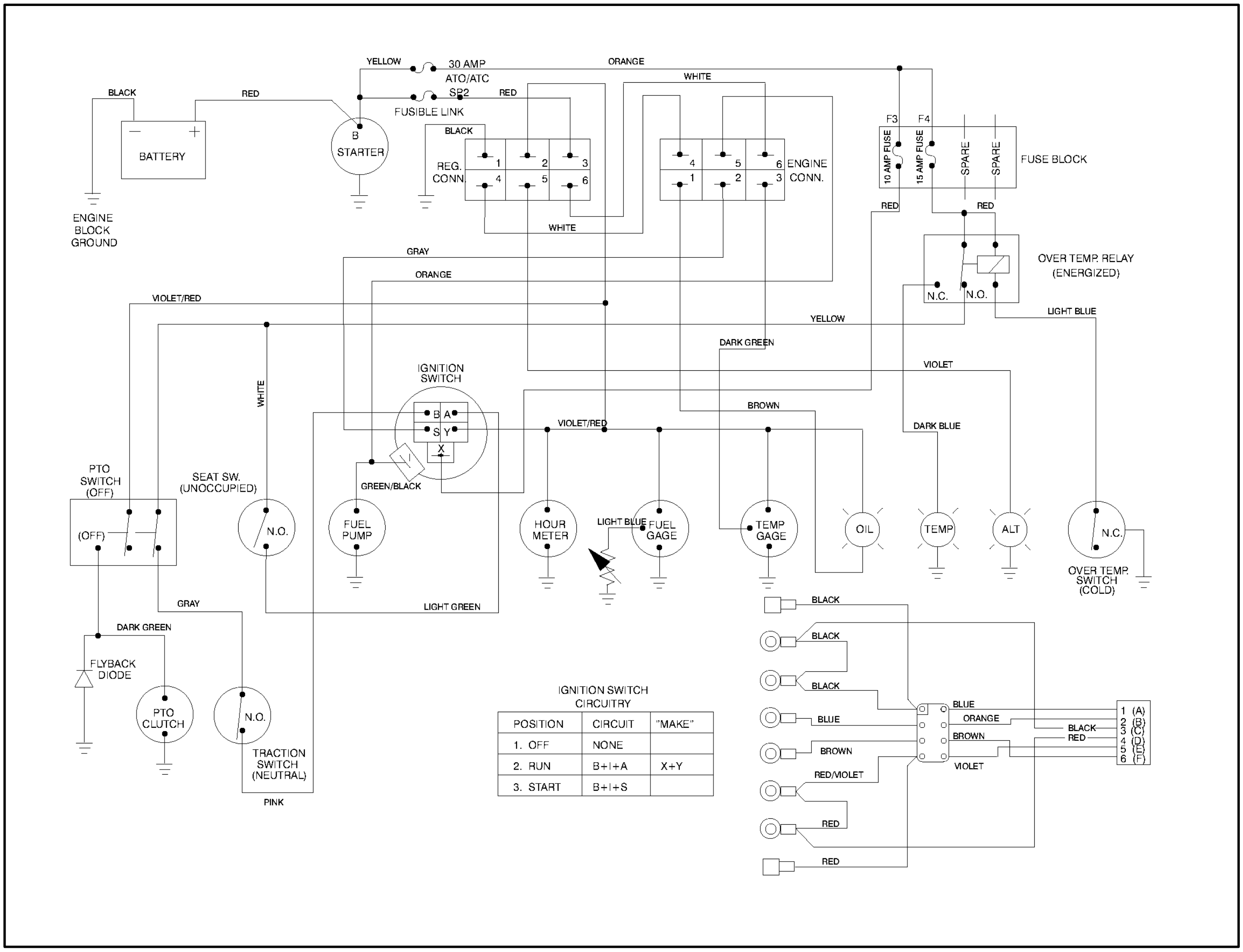


Figure 2c

Groundmaster 220–D (All Serial Numbers except 80000001 to 90000349)
Groundsmaster 223–D 2WD (All Serial Numbers)
Groundsmaster 223–D 4WD (Serial Numbers 300001 to 90499)

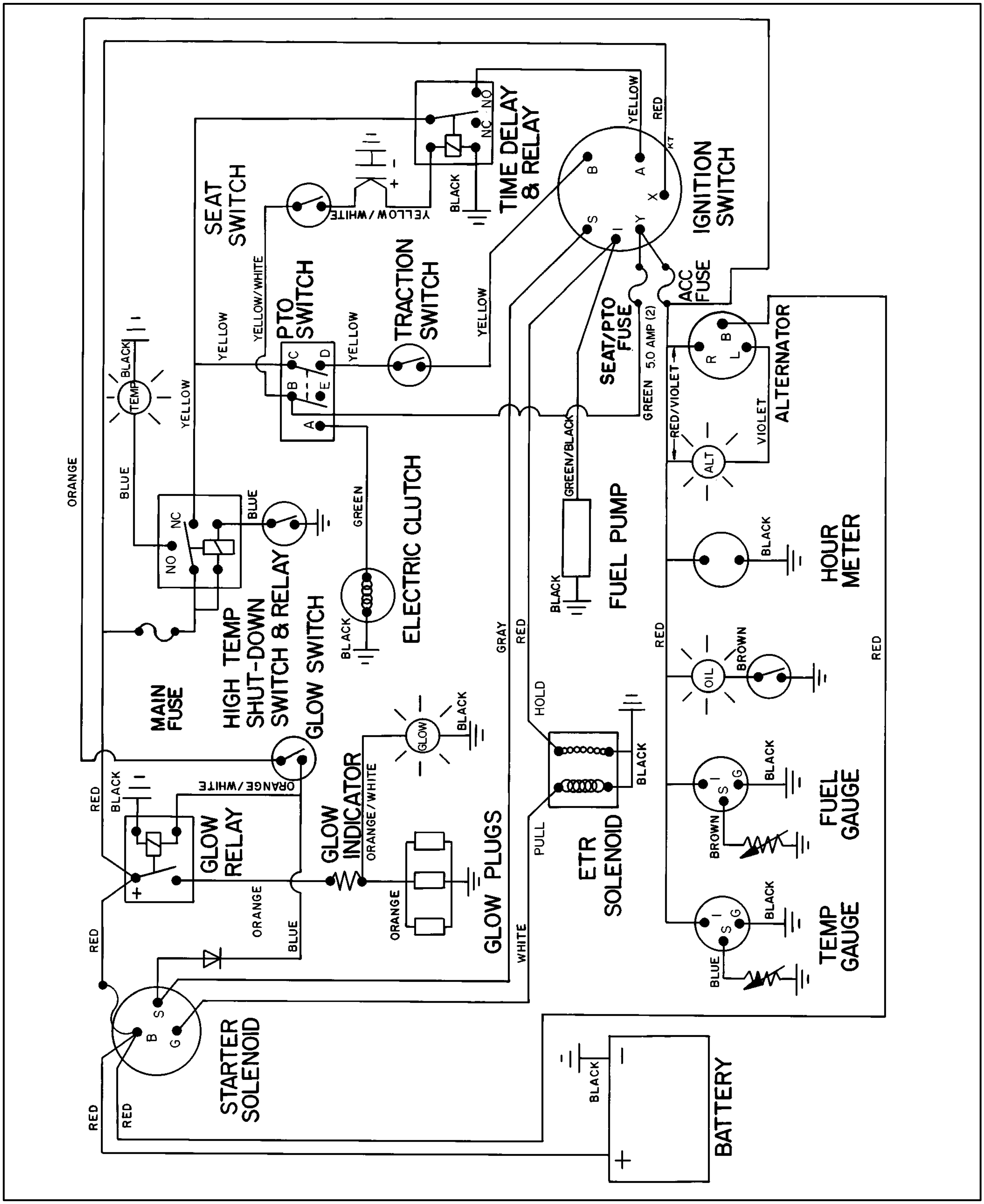


Figure 2d

Groundmaster 220–D (Serial Numbers 80000001 to 90000349)
Groundsmaster 223–D 4WD (Serial Numbers 90500 and higher)

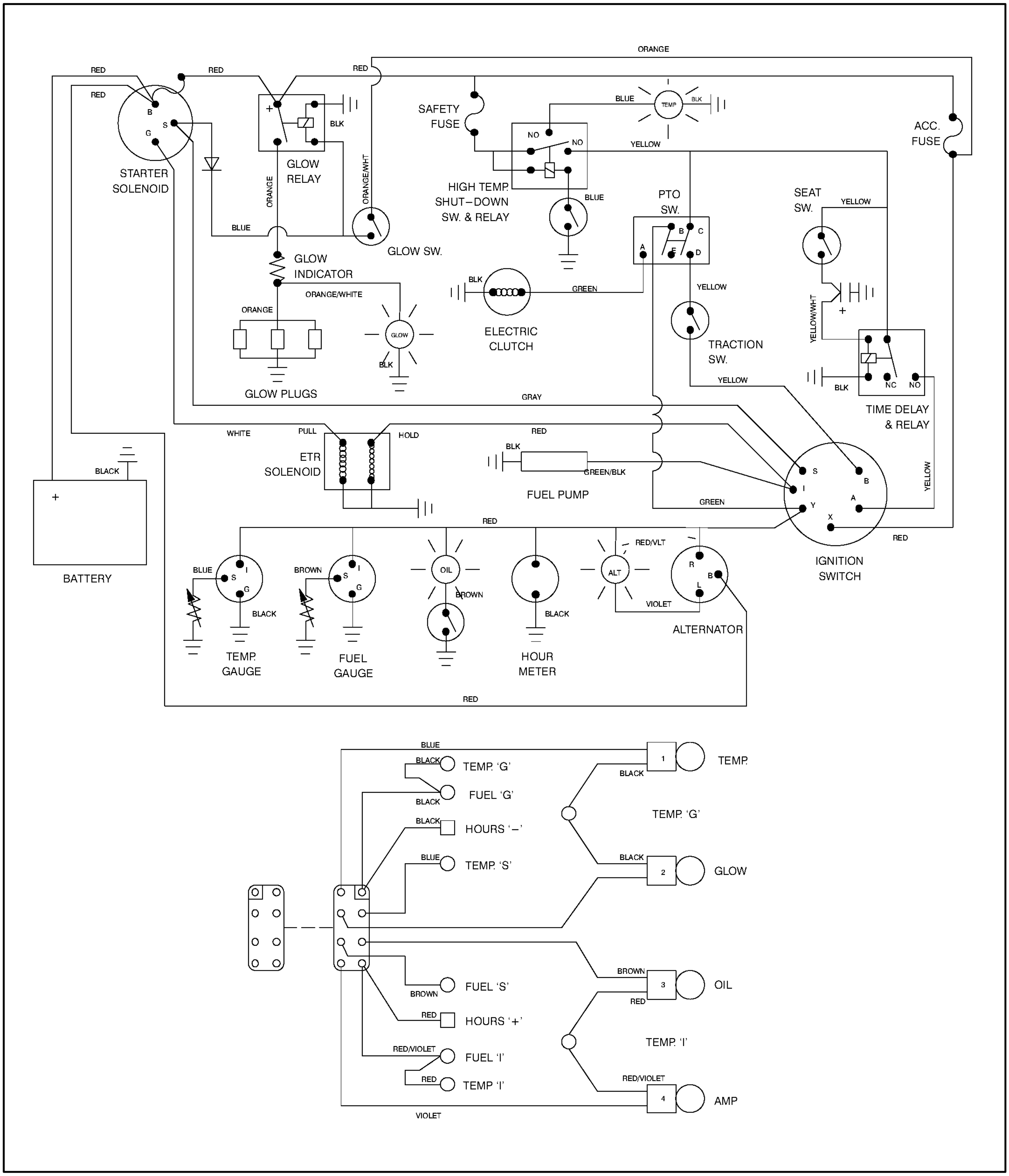


Figure 2e

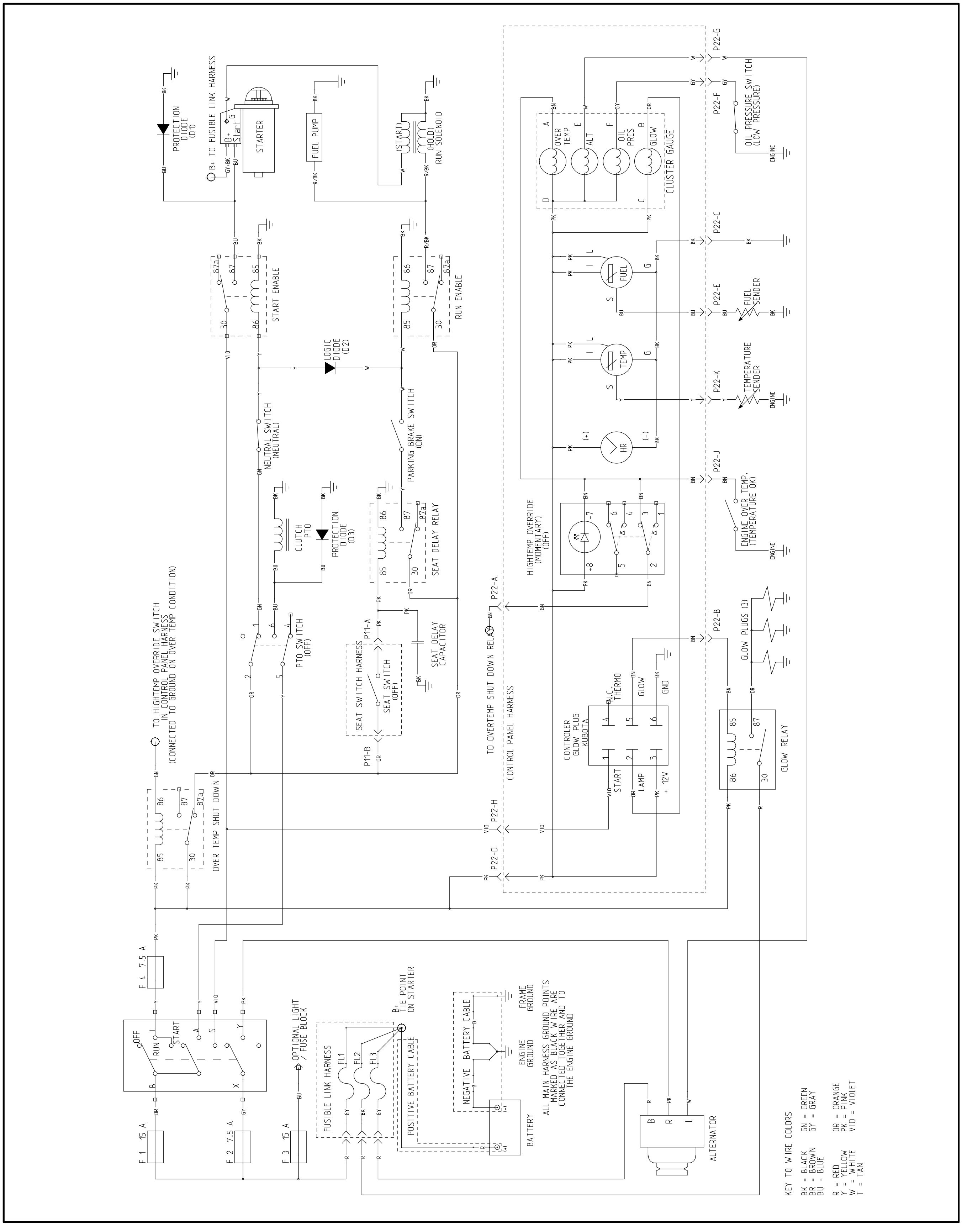

PROTECTION DIODE (D1)
B+ TO FUSIBLE LINK HARNESS
STARTER
FUEL PUMP
RUN SOLENOID
CLUSTER GAUGE
OVER TEMP
ALT
OIL PRES
GLOW
OIL PRESSURE SWITCH (LOW PRESSURE)
START ENABLE
RUN ENABLE
LOGIC DIODE (D2)
FUEL SENDER
TEMPERATURE SENDER
NEUTRAL SWITCH (NEUTRAL)
PARKING BRAKE SWITCH (ON)
ENGINE OVER TEMP. (TEMPERATURE OK)
CLUTCH PTO
PROTECTION DIODE (D3)
SEAT DELAY RELAY
HIGHTEMP OVERRIDE (MOMENTARY) (OFF)
TO HIGHTEMP OVERRIDE SWITCH IN CONTROL PANEL HARNESS (CONNECTED TO GROUND ON OVER TEMP CONDITION)
PTO SWITCH (OFF)
SEAT SWITCH HARNESS
SEAT SWITCH (OFF)
SEAT DELAY CAPACITOR
TO OVERTEMP SHUT DOWN RELAY
CONTROL PANEL HARNESS
GLOW PLUGS (3)
CONTROLER GLOW PLUG KUBOTA
GLOW RELAY
OVER TEMP SHUT DOWN
OPTIONAL LIGHT / FUSE BLOCK
B+ TIE POINT ON STARTER
FUSIBLE LINK HARNESS
POSITIVE BATTERY CABLE
NEGATIVE BATTERY CABLE
FRAME GROUND
ENGINE GROUND
ALL MAIN HARNESS GROUND POINTS MARKED AS BLACK WIRE ARE CONNECTED TOGETHER AND TO THE ENGINE GROUND
BATTERY
ALTERNATOR
F 1 15 A
F 2 7.5 A
F 3 15 A
F 4 7.5 A
KEY TO WIRE COLORS
BK = BLACK
BR = BROWN
BU = BLUE
GN = GREEN
GY = GRAY
R = RED
Y = YELLOW
W = WHITE
T = TAN
OR = ORANGE
PK = PINK
VIO = VIOLET

Figure 2f

Special Tools

Continuity Tester

Battery powered test lamp which is helpful in testing for continuity of circuits and electrical components when the current is off (Fig. 5).

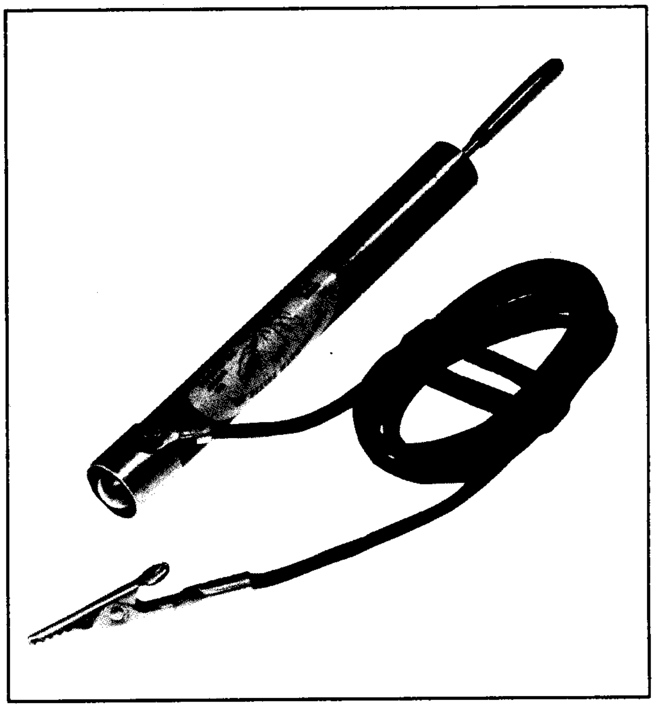


Figure 5

Skin-Over Grease

TORO Part Number 505-47

Special non-conductive grease which forms a light protective skin to help waterproof electrical switches and contacts. Recommended for all Groundsmaster® 220-D interlock system connections. Available in 1/2 pint (.2 L) can (Fig. 6).

Figure 6

Volt - Ohm - Amp Meter

The meter (Fig. 7) can test electrical components and circuits for current, resistance, or voltage draw.

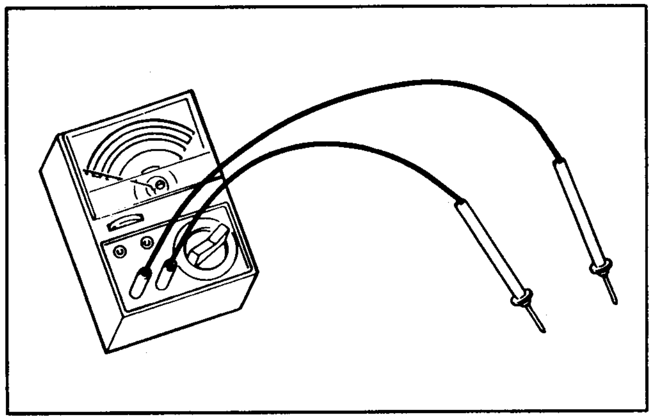


Figure 7

Battery

IMPORTANT: Before welding on the machine, disconnect the negative (-) battery cable from the battery to prevent damage to the electrical system (Fig. 8a).

IMPORTANT: To prevent damage to the electrical components, do not operate the engine with the battery cables disconnected.

Check the battery condition every week or after every 50 hours of operation (Fig. 8a). Keep the terminals and entire battery case clean. To clean the battery, wash the entire case with a solution of baking soda and water. Rinse with clear water. Do not get the soda solution into the battery because damage to the battery will result. Coat the battery posts and cable connectors with skin-over grease, or petroleum jelly to prevent corrosion.

Check the battery hold-down. A loose battery may crack or cause the container to wear and leak acid.

Check the electrolyte solution to make sure the level is above the plates (Fig. 8b). If the level is low (but above the plates inside the battery), add water so the level is to the bottom of the cap tubes. If the level is below the plates, add water only until the plates are covered and then charge the battery. After charging, fill the battery to the proper level.

Electrolyte Specific Gravity

Fully charged: 1.250 - 1.280
Discharged: less than 1.240

WARNING

Do not charge a frozen battery because it can explode and cause injury. Let the battery warm to 60° F (15.5° C) before connecting to a charger.

Charge the battery in a well-ventilated place so that gases produced while charging can dissipate. Since the gases are explosive, keep open flame and electrical spark away from the battery; do not smoke. Nausea may result if the gases are inhaled. Unplug the charger from the electrical outlet before connecting or disconnecting the charger leads from the battery posts.

Battery Specifications

BCI Group 26 Battery
530 Amp Cranking Performance at 0° F (-17 ° C)
85 min. Reserve Capacity at 80° F (27 ° C)

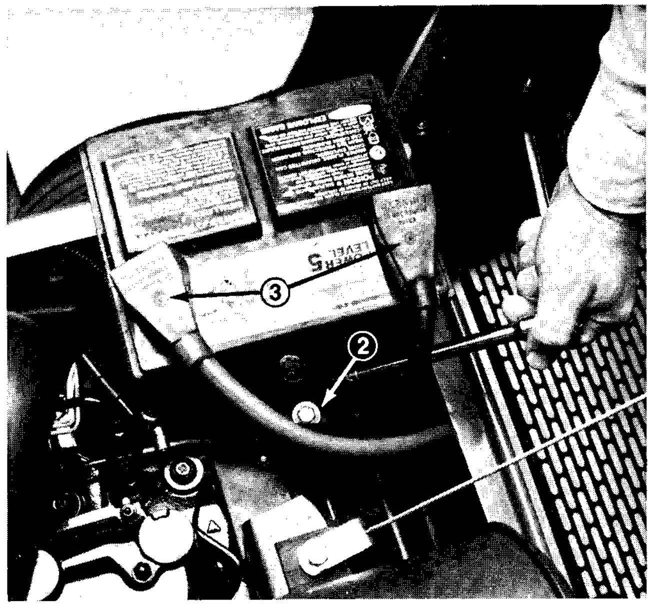


Figure 8a

1. **Battery**
2. **Battery securing bolt (2)**
3. **Rubber boots over battery posts**

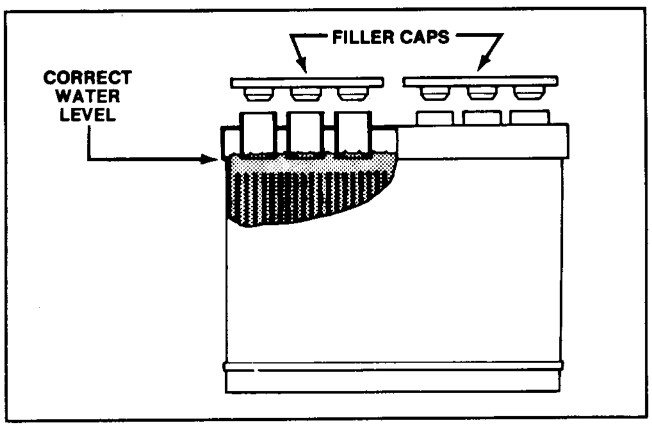


Figure 8b

Verify Interlock System Operation

The Groundsmaster® 220-D has interlock switches in the electrical system. The system is designed to stop the engine when the operator is off of the seat, while either the PTO switch is on or the traction pedal is depressed. This system also prevents the engine from starting in the same situation.

> **CAUTION**
>
> **Do not disconnect or bypass the interlock switches. Check the operation of the switches daily to assure that the interlock system is operating correctly. If a switch is defective, replace it before operating the machine. To assure maximum safety, replace all interlock switches every two years or 1000 hours, whichever comes first.**

Refer to the Troubleshooting section of this chapter to locate the cause of defects in the electrical system.

To check the operation of the interlock switches:

1. Move the machine to an open area that is free of obstructions, debris and bystanders. Lower the cutting unit or implement to the ground and stop the engine.

2. Sit on the seat and engage the parking brake. Make sure the PTO switch is OFF and remove your foot from the traction pedal.

3. Try to start the engine. If the engine cranks, go to step 4. If the engine does not crank, there may be a defect in the electrical system.

> **WARNING**
>
> **Do not operate the machine when the implement is removed unless the PTO universal drive shaft has also been removed.**

4. Stop the engine. Remove your foot from the traction pedal. Move the PTO switch to ON position and try to the start the engine. The engine should not crank. If the engine cranks, there is a defect in the safety interlock system. If the engine does not crank, go to step 5.

5. Stop the engine. Make sure the PTO switch is OFF and the parking brake is engaged. Push down on the traction pedal and try to start the engine. The engine should not crank. If the engine cranks, there is a defect in the safety interlock system. If the engine does not crank, go to step 6.

6. Remove your foot from the traction pedal. Make sure the PTO switch is OFF and the parking brake is engaged. Start the engine. With the engine running, raise off of the seat and move the PTO switch to the ON position. The engine should stop. If the engine does not stop, there is a defect in the safety interlock system.

NOTE: There is a 1 - 2 second delay between rising off the seat and engine shut off.

7. If the safety interlock system operated correctly, the machine can resume operation.

Troubleshooting

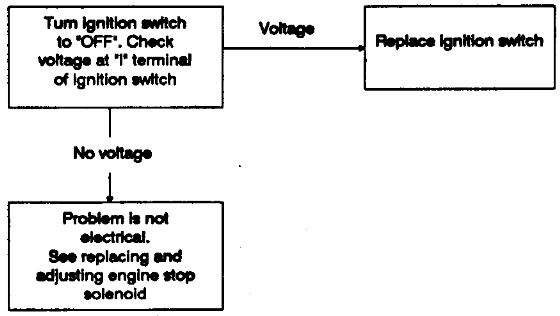
> **CAUTION**
>
> **Remove all jewelry, especially rings and watches, before doing any electrical troubleshooting. Disconnect the battery cables unless the test requires battery voltage.**

For effective troubleshooting and repairs, you must have a good understanding of the electrical circuits and components used. Tools such as a volt/ohm multimeter will help find problems in the circuitry.

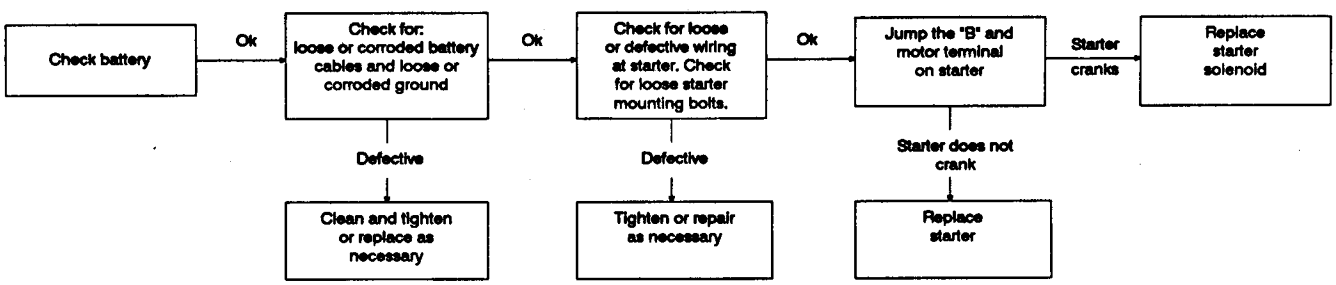
Studying the operating characteristics preceding an electrical failure will help in identifying the area of difficulty. Try to isolate the failure to a specific functional system; then check that area, repairing one component at a time. Attempting to repair two systems at once will lead to confusion.

NOTE: The interlock switches are described as normally open (NO) or normally closed (NC). The NC-NO description indicates the switch contact position with the switch installed in the machine with the PTO OFF, the TRANSMISSION in NEUTRAL, and OPERATOR OFF the seat. Should the machine being repaired have these components by-passed, they should be reconnected for proper troubleshooting and safety.

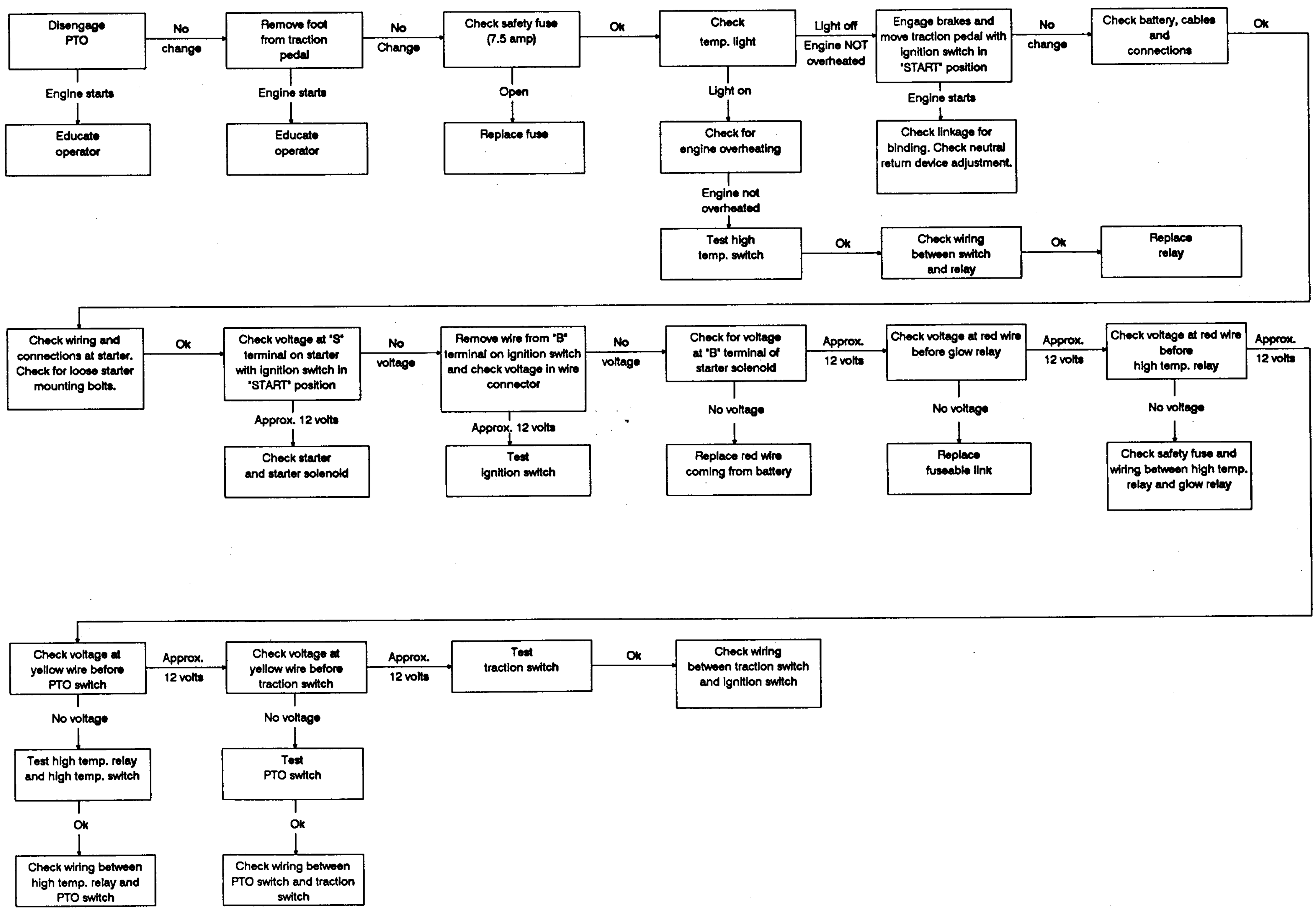
Engine Continues To Run, But Should Not When Ignition Key Switch Is Turned Off



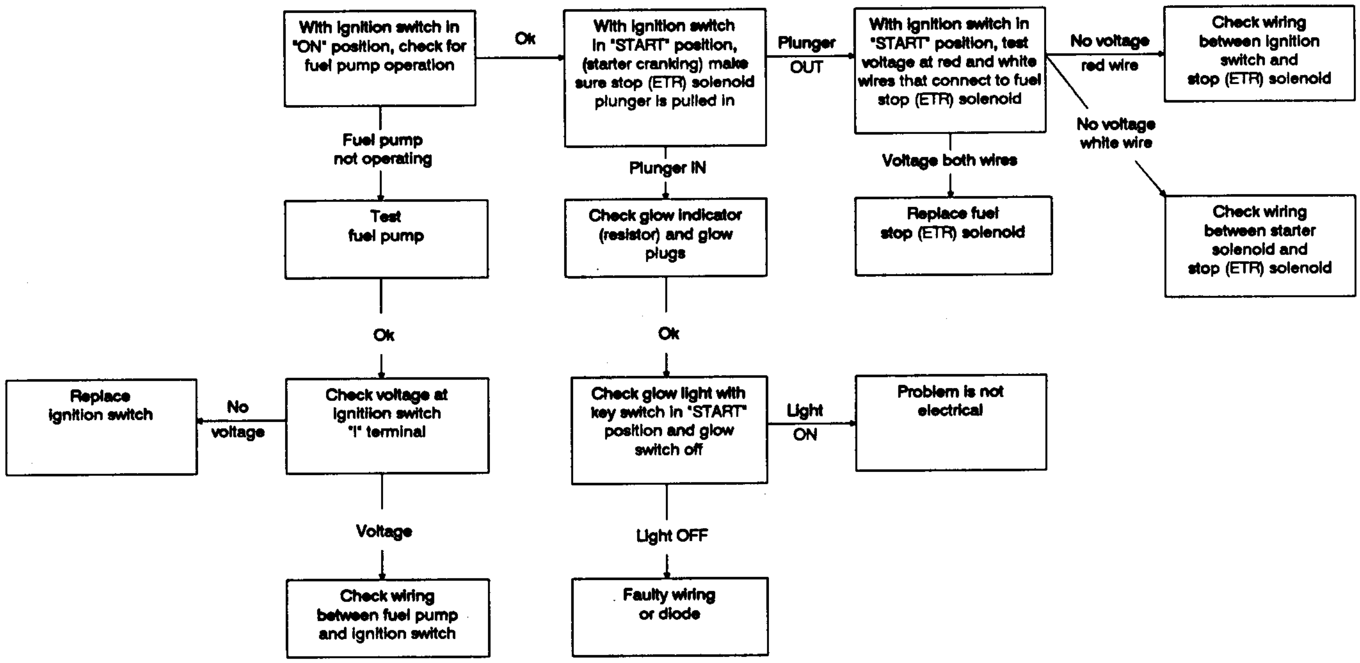
Starter Solenoid Clicks, But Starter Will Not Crank
(If solenoid clicks, interlock circuit is not at fault)



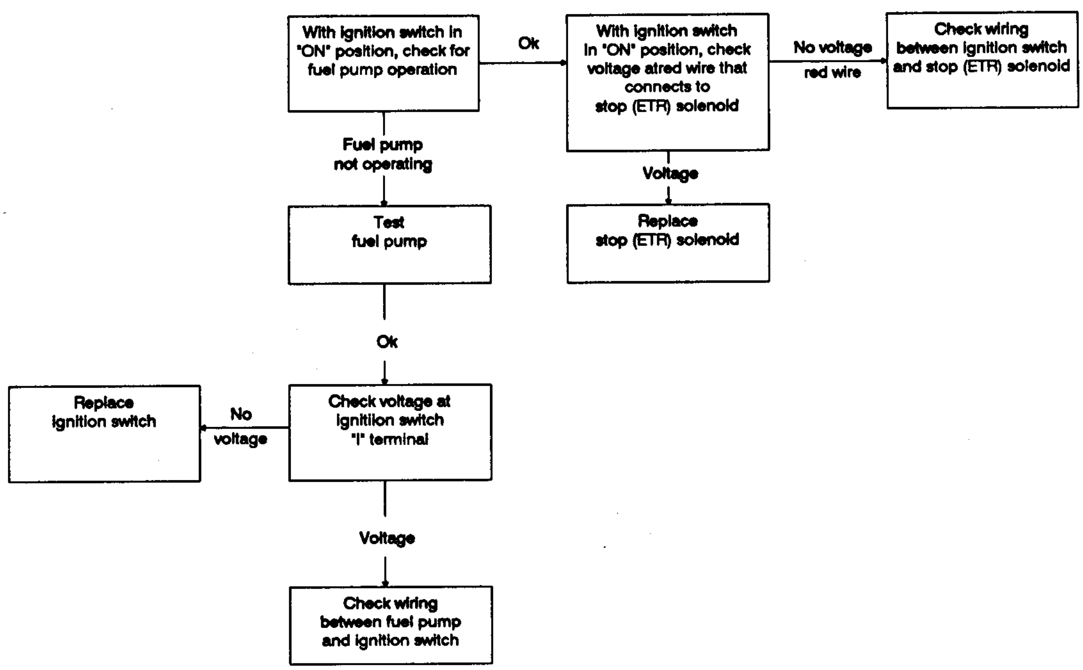
Nothing Happens When Start Attempt Is Made



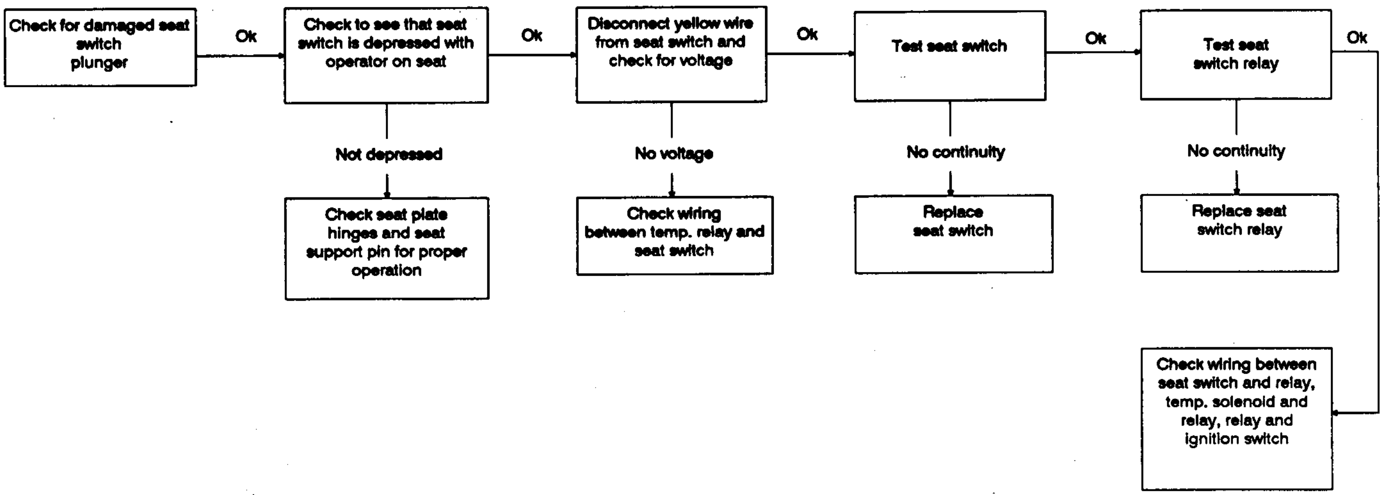
Starter Cranks, But Engine Will Not Start
(Glow light and glow indicator work when glow switch is ON)
(If starter cranks, interlock circuit is not at fault)



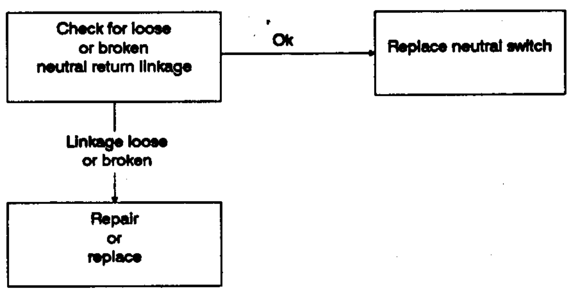
Engine Starts, But Kills Immediately When Ignition Switch Returns To "ON" Positon
(Operator on seat, traction pedal and P.T.O. disengaged, engine not overheated)



Engine Starts, But Kills When Traction Pedal or P.T.O. Is Engaged
(Operator on seat and engine not overheated)

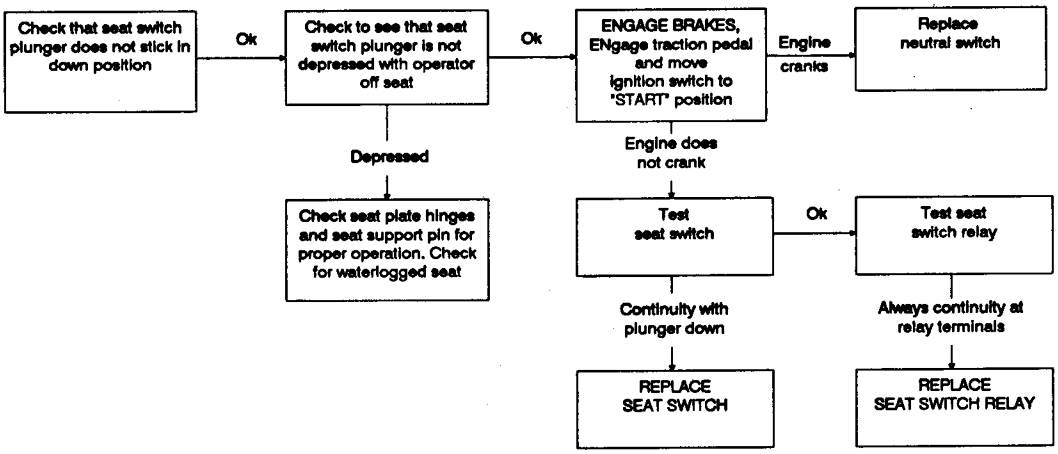


Starter Cranks, But Should Not When Traction Pedal Is Depressed

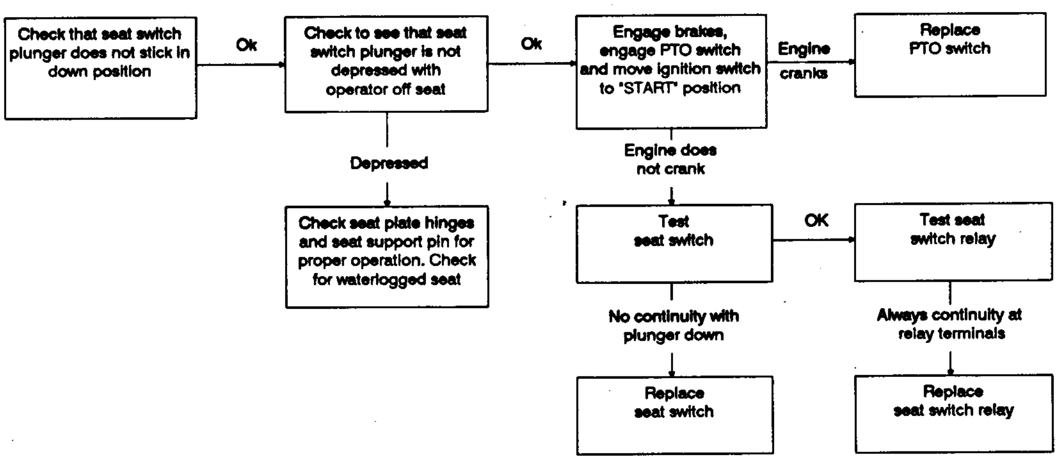


Starter Cranks, But Should Not When P.T.O. Switch is ON

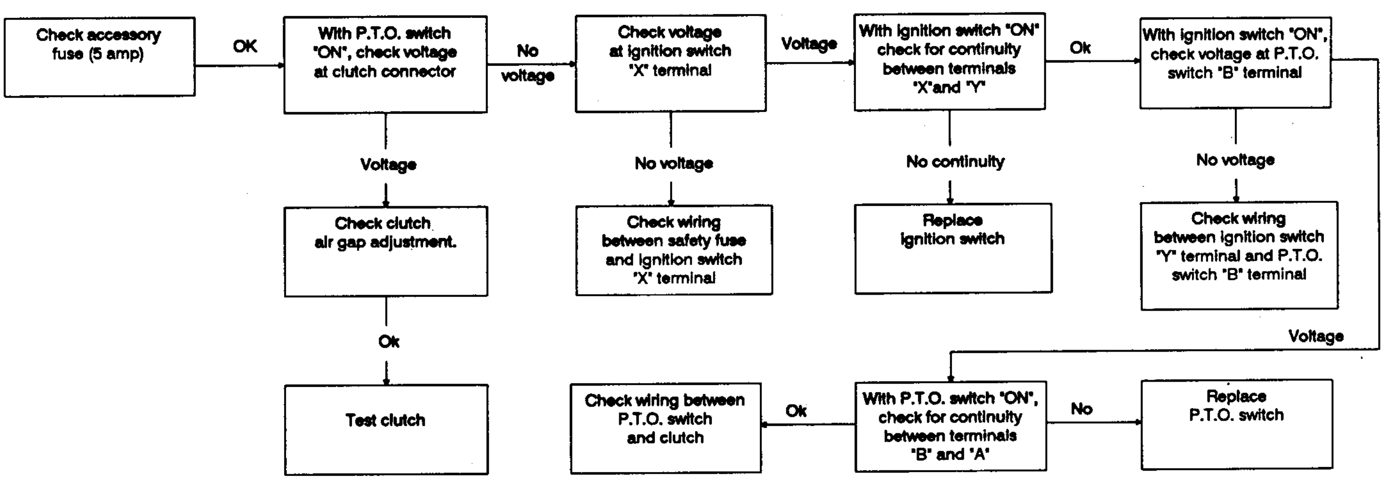
Engine Continues To Run, But Should Not, When Traction Pedal Is Engaged With No Operator On Seat
(Neutral return device working properly)



Engine Continues To Run, But Should Not, When P.T.O. is Engaged With No Operator On Seat
(Neutral return device working properly)



P.T.O. Clutch Will Not Engage
(Engine runs with operator on seat and P.T.O. switch ON)



Testing

It is often to the technician's advantage to leave the components intact in the electrical system, and by studying the electrical troubleshooting charts and schematics, determine which component is at fault. However, this section will define given components, and the tests that can be performed on those components, when those parts are isolated from the electrical system.

For accurate resistance and/or continuity checks, electrically disconnect the component being tested from the circuit (e.g. unplug the PTO switch connector before doing a continuity check).

> **CAUTION**
>
> **When testing electrical components with a volt-ohm meter or continuity tester, make sure that power to the circuit has been disconnected.**

Ignition Key Switch

The ignition (key) switch has three positions (OFF, START and RUN). The terminals are marked as shown in Figure 9a.

The circuitry of the ignition switch is shown in the chart (Fig. 9b). With the use of a continuity tester, the switch functions may be tested to determine whether all circuits are being completed while the key is moved to each position.

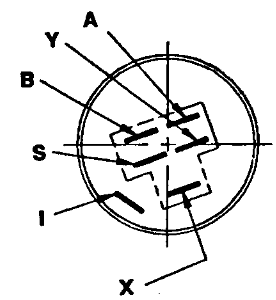


Figure 9a

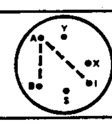
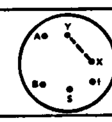
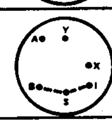
POSITION	CONTINUITY AMONG TERMINALS	OTHER CIRCUITS MADE
1. OFF	NONE	NONE
2. RUN	 B + I + A	 X + Y
3. START	 B + I + S	NONE

Figure 9b

Seat Switch, Time Delay and Relay

The seat switch (Fig. 10a) is a normally open (NO) switch. With no operator on the seat there is an open circuit to the time delay (capacitor) and relay coil. If the PTO switch or traction switch is open with no operator on the seat the engine will stop after a delay of approximately 2 seconds.

Check the seat switch by engaging the brakes, then with the engine running, engage the PTO switch or traction pedal. When you raise off the seat, the engine should stop after an approximately 2 second delay. If there is no time delay, the capacitor is faulty or the capacitor wires are touching.

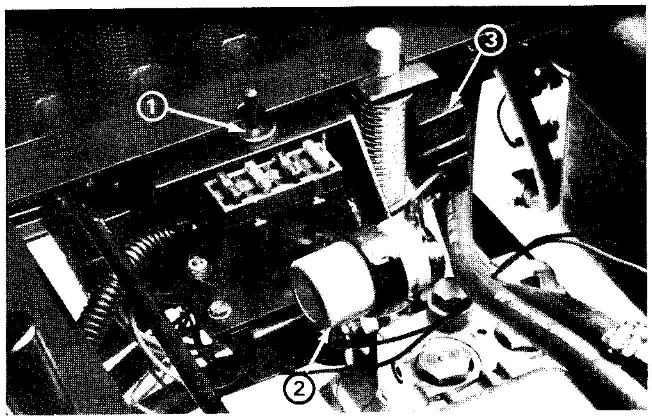


Figure 10a

1. **Seat switch**
2. **Time delay (capacitor)**
3. **Seat switch relay**

Seat Switch Test

Disconnect the seat switch wire connector and install a continuity tester between the two leads of the seat switch. Lower the seat. Have the operator sit on the seat, slowly depressing the seat switch. The continuity tester should indicate a reading as the seat approaches the bottom of its travel.

NOTE: Make sure the compression spring and pin hold the seat up off the seat switch when there is on operator on the seat.

Relay Test

Disconnect the relay wire connector and install a continuity tester between the relay terminals (terminals 30 and 87) (Fig. 10b). The relay should make and break continuity as 12 V.D.C. connected and disconnected between the winding terminals (terminals 85 and 86).

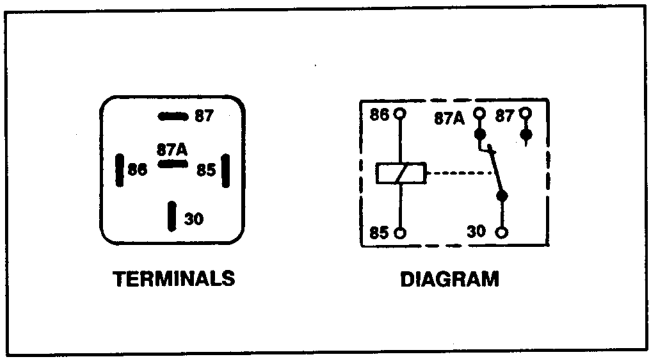


Figure 10b

Seat switch relay and high temp. shut-down relays

Glow Relay and High Temperature Shut-Down Relay

To test the relay (Fig. 11), disconnect the wire connector and install a continuity tester between the relay terminals. The relay should make and break continuity as 12 V.D.C. is connected and disconnected betweeen the winding terminals.

The circuitry of the high temperature shut-down relay is shown in Figure 10b. The circuitry of the glow relay is shown in the Electrical Schematics section of this chapter.

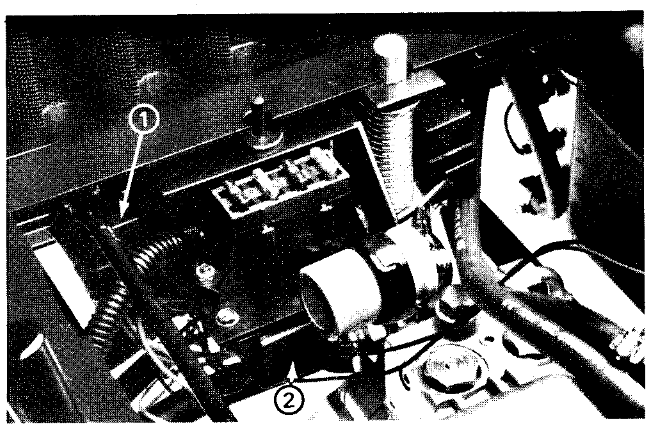


Figure 11

1. **High temperature shut-down relay**
2. **Glow relay**

PTO Switch

To test the PTO switch (Fig. 12a) independent of wiring harness disconnect the wire connector from the terminals. When the switch is in the ON position, there should be continuity between terminals A – B only (Fig. 12b). Terminals C – D and B – E should show continuity with the switch in the OFF position.

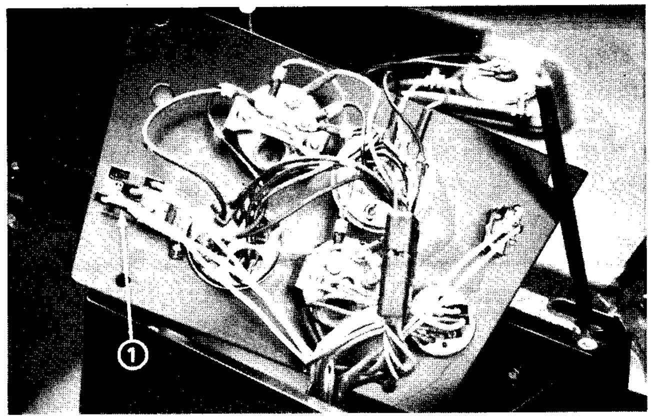


Figure 12

1. PTO Switch

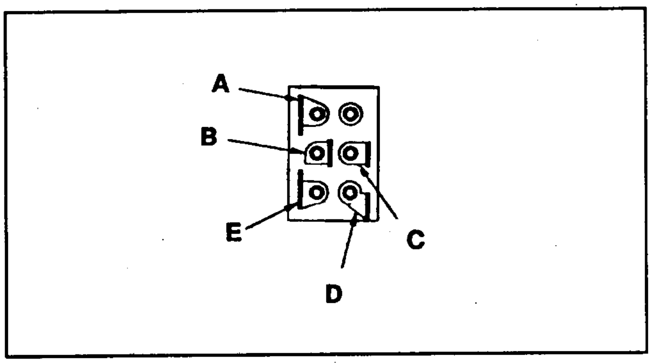


Figure 12b

PTO switch terminals

Traction (Neutral) Switch

A traction switch is a normally closed (NC) switch (traction pedal in neutral) located on the right-hand side of the hydrostatic transmission (Fig. 13). It is activated by the traction control lever located on the side of the transmission.

IMPORTANT: The traction switch has three (3) terminals. Make sure the wires are connected to the "COMMON" and "NO" terminals.

Test the switch by connecting a continuity tester across the two terminals that have wires connected. With the engine turned off, slowly push the traction pedal in a forward and reverse direction while watching the continuity tester. There should be indications that the traction switch is making and breaking contact. (See Replacing the Traction Switch in the Repairs section of this chapter for replacement and adjustment procedures.)

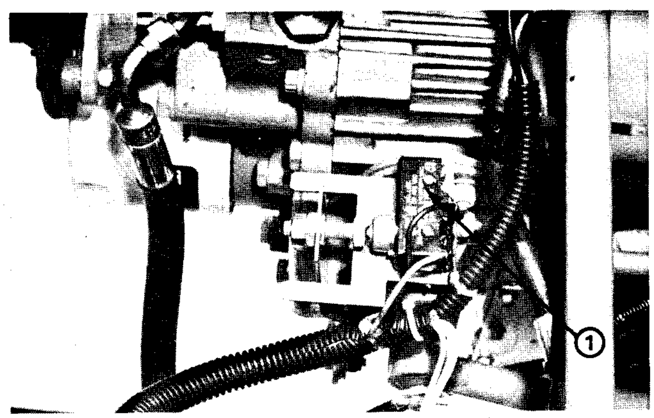


Figure 13

1. Traction switch

Battery

Terminal Voltage Test

1. Use a volt-ohm meter to measure the voltage between the battery terminals.

2. If the voltage is less than 12.3 V.D.C., the battery should be charged.

Indicator Lights

Oil Pressure Light

Oil pressure lamp should come on when the ignition key switch is in the RUN position with the engine not running or if the oil pressure switch closes during operation - oil pressure below 7 psi (0.5 kg/cm^2).

Test the lamp by disconnecting the wires and applying 12 V.D.C. between the terminals.

Amp Light

The amp light should come on when the ignition key switch is in the RUN position with the engine not running or if the charging circuit is not operating properly during operation.

Test the lamp by disconnecting the wires and applying 12 V.D.C. between the terminals.

Glow Light

The glow light should be on when the glow switch is ON or the ignition key switch is in the START position.

Test the lamp by disconnecting the wires and applying 12 V.D.C. between the terminals.

Temperature Light

The temperature light should come on only if the high temperature shut-down switch and relay has stopped the engine - coolant temperature above 225° F (108° C). The light will remain on if the engine is overheated whether the ignition key switch is ON or OFF.

Test the lamp by grounding the wire that is connected to the high temperature shut-down switch (Fig. 14). The light should come on when the wire is grounded.

Hourmeter

Test the hourmeter by disconnecting the wires and applying 12 V.D.C. between the terminals.

Gauges (Temperature and Fuel Level)

To test a gauge, use a commercial gauge tester. If a commercial gauge tester is not available, substitute a new gauge or test the sending unit.

High Temperature Shut-Down Switch

1. Lower the coolant level in the engine and remove the high temperature shut-down switch (Fig. 14).

2. Put the switch in a container of oil with a thermometer and heat the oil (Fig. 15).

3. The switch is normally open (NO) and should close at 226 - 237° F (108 - 114° C).

Switch ON (closed) temperature 226 - 237° F (108 - 114° C)

CAUTION

Handle hot oil with special care to prevent personal injury or fire.

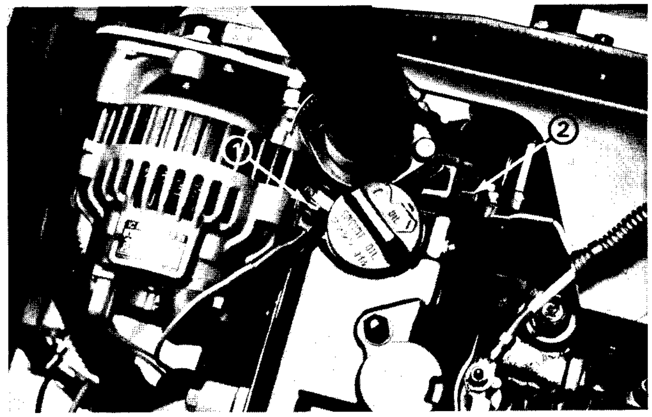


Figure 14

1. High temperature shut-down switch
2. Temperature gauge sender

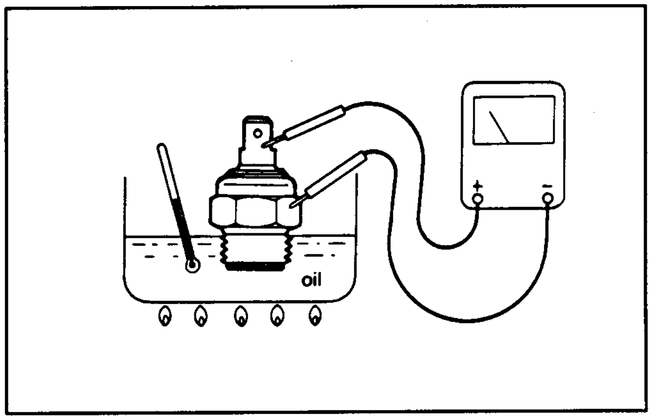


Figure 15

Temperature Gauge Sender

1. Lower the coolant level in the engine and remove the temperature gauge sender (Fig. 14).

2. Put the switch in a container of oil with a thermometer and heat the oil (Fig. 16).

90.5 - 117.5 ohm at 160° F (70° C)
21.3 - 26.3 ohm at 207° F (115° C)

CAUTION

Handle hot oil with special care to prevent personal injury or fire.

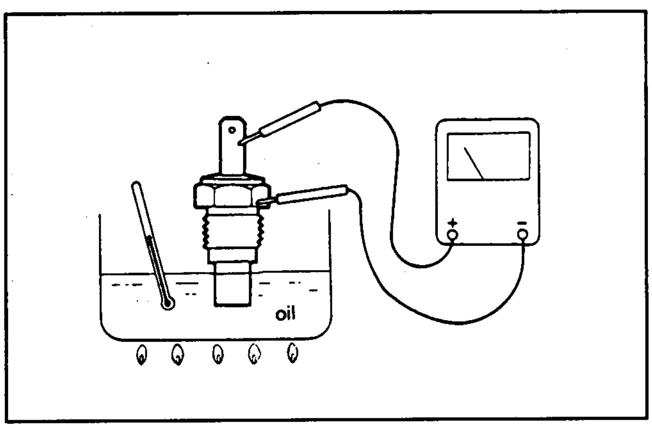


Figure 16

Fuel Gauge Sender

1. Remove the fuel gauge sender from the fuel tank (Fig. 17).

2. Install an ohm meter between the terminal and base. Check the resistance while moving the sender arm up and down. Resistance should increase as the arm is moved up and decrease as the arm is moved down.

> **CAUTION**
>
> **Make sure the sending unit is completely dry (no fuel on it) before testing. Perform test away from fuel tank to prevent an explosion or fire from sparks.**

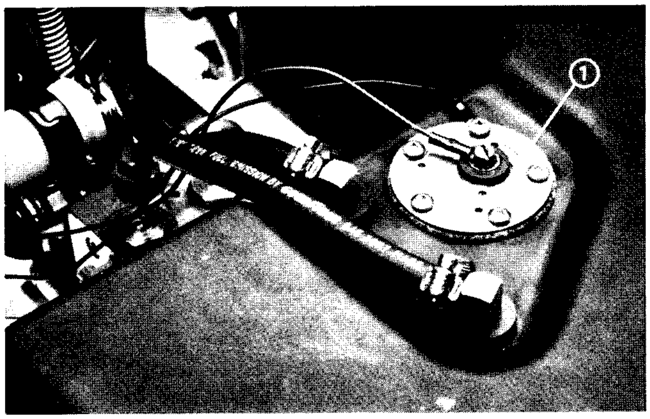


Figure 17

1. Fuel gauge sender

P.T.O. Clutch

Disconnect the clutch connector from the wire harness (Fig. 18). There should be continuity between the two terminals in the clutch connector. Resistance measured through the clutch coil should be approximately 3 ohms. If continuity is not present, replace the clutch or electromagnet part of the clutch (See Chapter 11 - P.T.O. System).

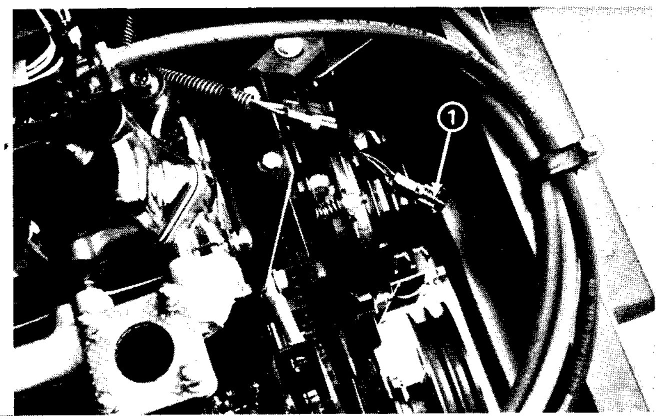


Figure 18

1. Clutch connector

Fuel Stop (ETR) Solenoid

The Groundsmaster® 220-D has an energize-to-run (ETR) fuel stop solenoid. The solenoid will stop injector pump fuel delivery with any electrical failure in the RUN circuit.

1. Disconnect the wire connector and remove the fuel stop solenoid from the engine (Fig. 19).

2. Connect a 12 volt battery so the positive (+) battery terminal is connected to terminals A (hold) and B (pull) (Fig. 20). Connect the negative (–) battery terminal to solenoid terminal C (common). The plunger should retract to the dimension shown.

IMPORTANT: Do not connect terminal B (pull) for more than 30 seconds or damage to the solenoid coil could result.

3. With the battery connected the same as step 2, disconnect the battery from solenoid terminal B (pull). The plunger should remain pulled in.

4. Disconnect the battery from terminal A (hold). The plunger should return to the extended position.

5. Check the solenoid internal spring tension. The spring must have 9.2 lbs (4.2 kg) minimum force with the plunger in the extended position.

Replace the fuel stop solenoid if it fails any of the above tests. (See Replacing and/or Adjusting Stop Solenoid in the External Engine Component Repair section of Chapter 3 - MITSUBISHI ENGINE.)

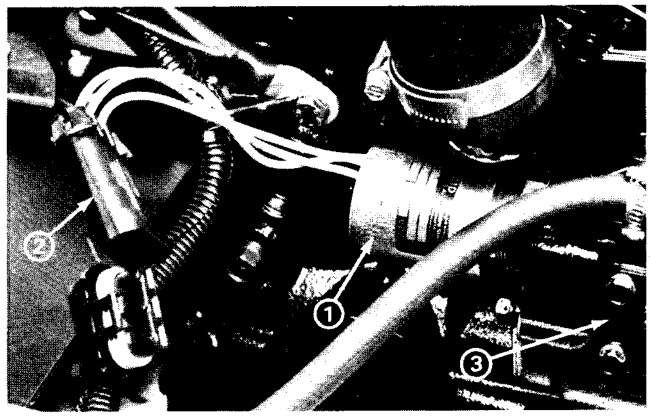


Figure 19

1. Fuel stop (ETR) solenoid
2. Wire connector
3. Governor tie rod cover

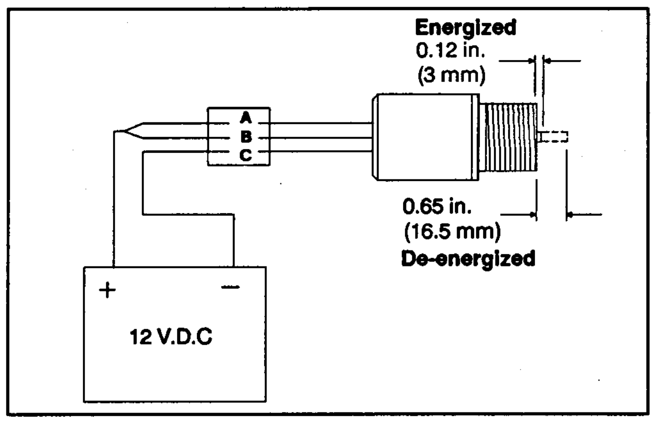


Figure 20

A. Hold
B. Pull
C. Common (ground)

To Test While Connected to Wire Harness

1. Remove the governor tie rod cover so you can observe the solenoid plunger.

2. Hold the manual fuel stop lever back to prevent fuel delivery. Turn the key switch to the START position and quickly return it to the ON position. The solenoid plunger should be retracted.

3. Turn the key switch to the OFF position. The solenoid plunger should extend.

Checking Starter Pinion Gap

1. Install 12 volt battery between the "S" terminal and the starter body (Fig. 21). The pinion should protrude and stop.

IMPORTANT: Never apply battery voltage to the starter for longer than 10 seconds.

2. Lightly push the pinion back and measure the return stroke (called pinion gap).

3. If the pinion gap is not within standard range of 0.5 - 2.0 mm (0.02 - 0.08 in.), adjust it by increasing or decreasing the number of packings on the magnetic switch. The gap is decreased as the number of packings increases.

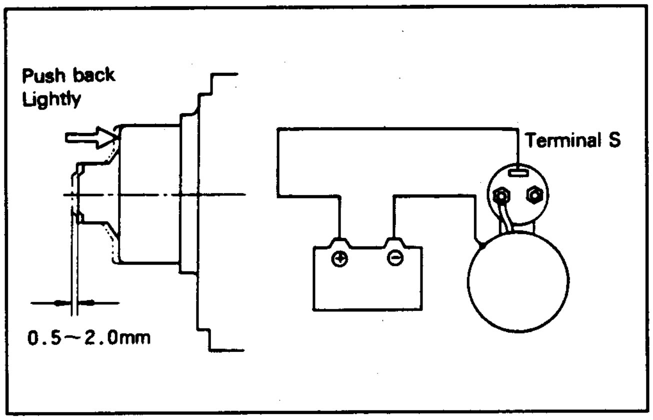


Figure 21

Starter No-Load Test

1. Connect a 12 volt battery, ammeter and voltmeter to the starter as shown (Fig. 22).

2. When terminals "S" and "B" are connected the pinion should protrude and the starter should run smoothly.

Terminal voltage: 11.5V
Current: 100 A
Speed: 3000 rpm

No-Load Test Results

Low speed and high current draw:

- High friction (faulty bearings, bent armature shaft).
- Shorted armature.
- Grounded armature or fields.

Failure to operate with high current draw:

- Direct ground in terminals or fields.
- "Frozen" bearings.

Failure to operate with no current draw:

- Open field circuit.

Low speed and low current draw:

- Open armature coils - check commutator for badly burned bars after disassembly.

High speed and high current draw:

- Poor contact between brushes and commutator (broken brush springs, worn brushes, high insulation between commutator bars).
- High internal resistance (poor connections, defective leads, dirty commutator or open field circuit). Shorted fields.

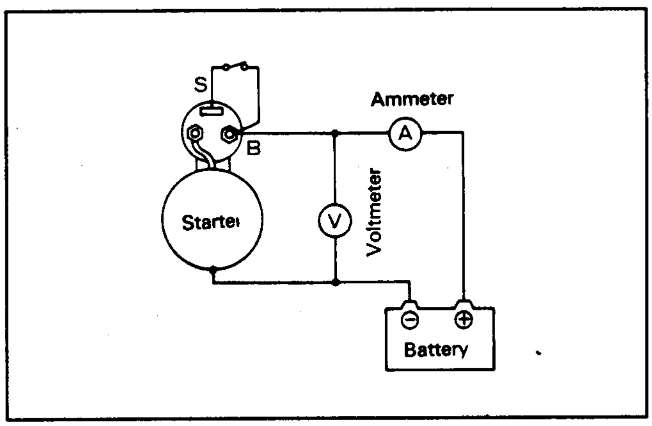


Figure 22

Magnetic Switch (Solenoid) Attraction Test

1. Disconnect the wire from terminal "M" (Fig. 23).

2. Connect a 12 volt battery to the magnetic switch terminals "S" and "M". The pinion must protrude.

IMPORTANT: Never apply battery voltage to the starter for longer than 10 seconds.

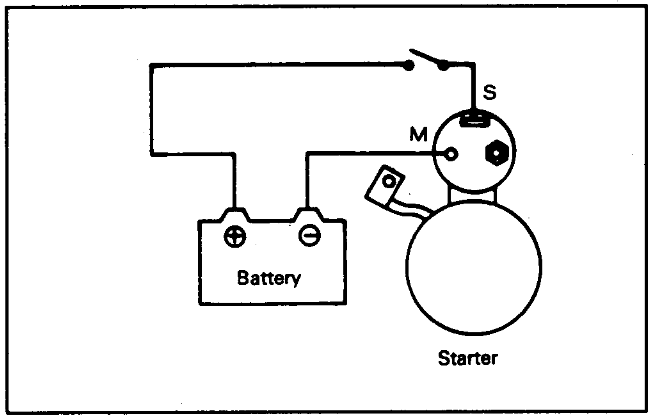


Figure 23

Magnetic Switch (Solenoid) Holding Test

1. Disconnect the wire from terminal "M" (Fig. 24).

2. Connect a 12 volt battery to the magnetic switch terminal "S" and the starter body. Pull out the pinion fully. The pinion must remain at that position even when released.

IMPORTANT: Never apply battery voltage to the starter for longer than 10 seconds.

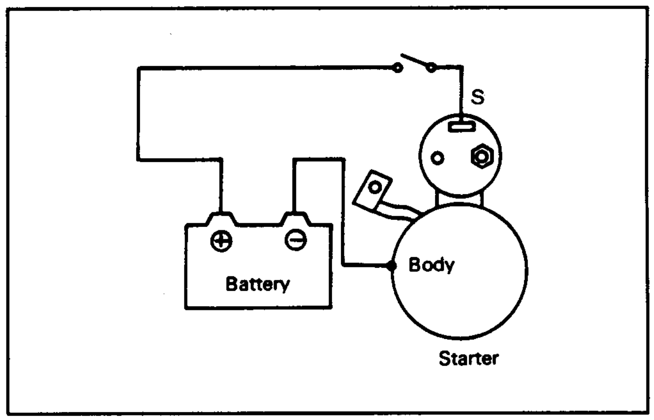


Figure 24

Magnetic Switch (Solenoid) Return Test

1. Disconnect the wire from terminal "M" (Fig. 25).

2. Connect a 12 volt battery to the magnetic switch terminal "M" and the starter body. Pull out the pinion fully. The pinion must return to its original position when released.

IMPORTANT: Never apply battery voltage to the starter for longer than 10 seconds.

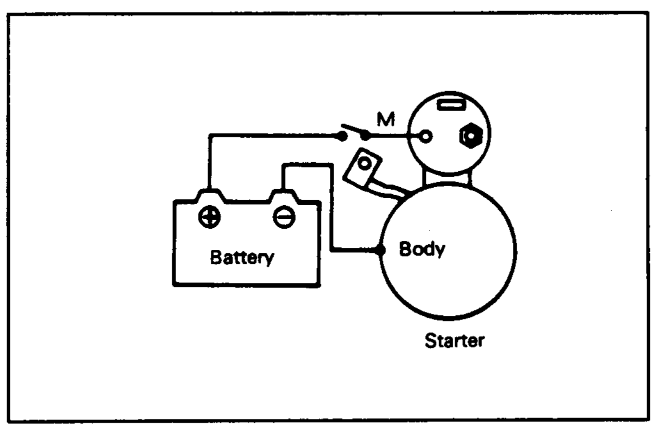


Figure 25

Alternator Regulated Voltage Test

1. Install an ammeter between the positive (+) terminal of the battery and terminal "B" of the alternator (Fig. 26).

2. Ground alternator terminal "L" through a voltmeter.

3. Note that the voltmeter shows 0 volts when the ignition key switch is in the OFF position. The voltmeter will show voltage lower than battery voltage when the ignition key switch is in the ON position (engine not running).

4. Start the engine.

5. Run the engine with the alternator at 1300 and 2500 rpm and observe the voltmeter with all accessories OFF, Ammeter below 5 A. Regulated voltage will decrease slightly as alternator temperature increases.

Regulated voltage: 13.5 V

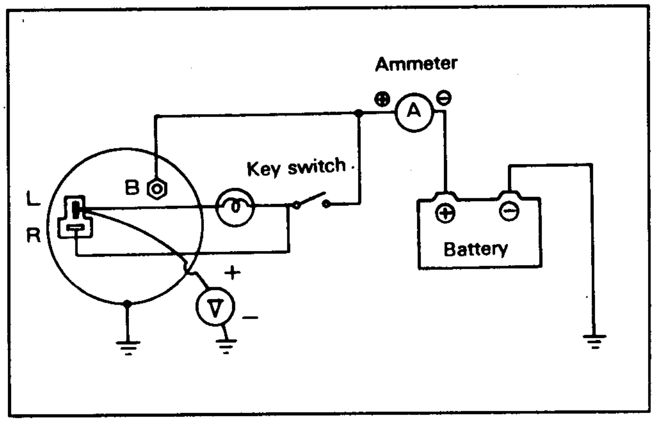


Figure 26

Alternator Output Test

1. Disconnect the battery ground (–) cable.

2. Install an ammeter between the positive (+) terminal of the battery and terminal "B" of the alternator (Fig. 27).

3. Ground alternator terminal "B" through a voltmeter.

4. Connect the battery ground (–) cable.

5. Start the engine.

6. Run the engine with the alternator at 2500 and 5000 rpm and observe the voltmeter with all electrical load applied. Read the maximum indication on the ammeter with the voltmeter showing 13.5 V.

Output Characteristics (Hot):

21 A at 2500 rpm
37 A at 5000 rpm

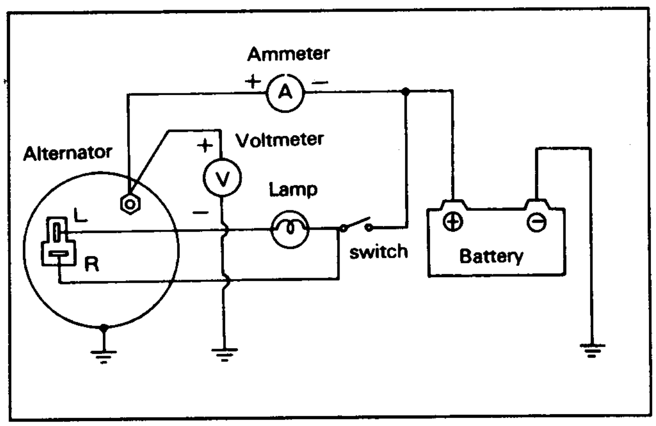


Figure 27

Diode (Glow Plug)

There is a diode in the starting circuit to energize the glow plug relay when the starter is cranking. If the glow plug functions correctly when holding the glow switch, but does not heat when the engine is cranking the diode may be causing an open circuit.

Repairs

Fuse Replacement

Raise and support the seat to get access to the fuses (Fig. 28, 28A).

NOTE: Spare fuses can be kept in the open holes of the fuse block.

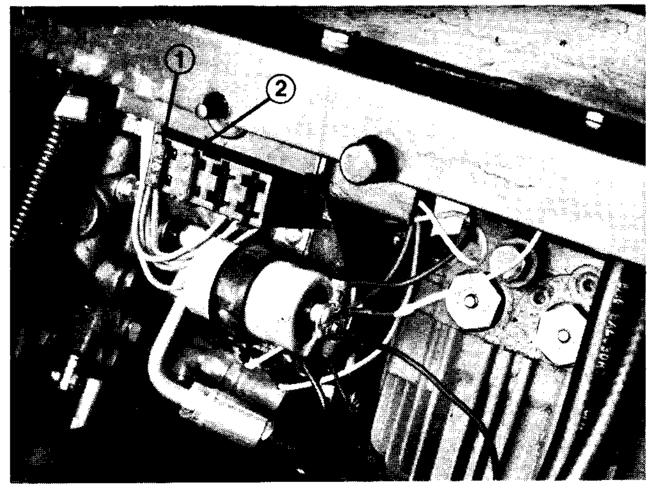


Figure 28
(Groundsmaster 220-D — S/N 90349 & Below)

1. Safety switches and operations fuse
2. Accessories and PTO fuse

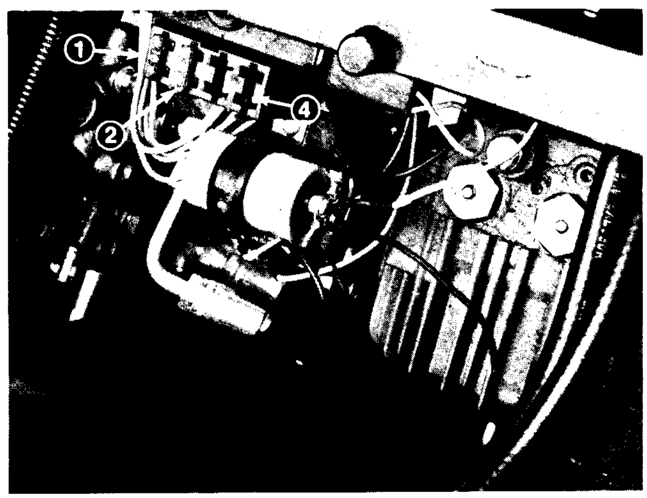


Figure 28A
(Groundsmaster 220-D — S/N 90350 & Up)
(Groundsmaster 223-D — S/N 20001 & Up)

1. Accessories fuse (5A)
2. Safety swtiches fuse (5A)
3. Main fuse (7.5 A)
4. Spare fuse

Replacing the Traction (Neutral) Switch

1. Raise the operator seat and remove the seat support cover.

2. Disconnect the negative battery cable from the battery.

3. Remove the two wires that are connected to the traction switch (right side of transmission) (Fig. 29).

4. Have a helper push the traction pedal down into either the FORWARD or REVERSE position; this will take the switch adjusting screw tension off of the switch. Remove the switch from the pump plate (Fig. 29).

5. Install the new switch onto the pump plate with the two screws. DO NOT over-tighten the screws as the switch case could break.

NOTE: Have a helper hold the traction pedal down while installing the switch.

6. Reconnect the two wires to the new switch. Make sure that one wire is connected to the "COMMON" terminal, and one wire is connected to the "NORMALLY OPEN" terminal.

IMPORTANT: The traction switch has three (3) terminals. If the two (2) wires are not connected to the "COMMON" and "NORMALLY OPEN" (NO) terminals, the engine will be unable to start and the safety interlock circuit will not function properly.

CAUTION

If the wires are not correctly installed to the switch, the engine could start with the traction pedal in forward or reverse.

7. Liberally coat the switch connectors with skin-over grease.

8. Check the adjustment of the transmission for neutral. (See Adjusting Traction Control for Neutral in the Adjustments section of Chapter 4 - HYDRAULIC SYSTEM.

9. Actuate the pump lever to assure that all of the parts are operating freely and are seated properly. Return the traction pedal to neutral.

10. Rotate the switch adjusting screw (Fig.) until there is a gap between the head of the screw and the switch button.

11. Rotate the adjusting screw until it contacts the switch button. Continue to rotate the screw until the circuit is completed (switch "clicks"). After the switch clicks, rotate the adjusting screw an additional 1/2 turn.

12. Actuate the traction pedal in both FORWARD and REVERSE to assure that the switch "clicks" in both directions.

13. Replace the seat cover, lower the seat and connect the battery.

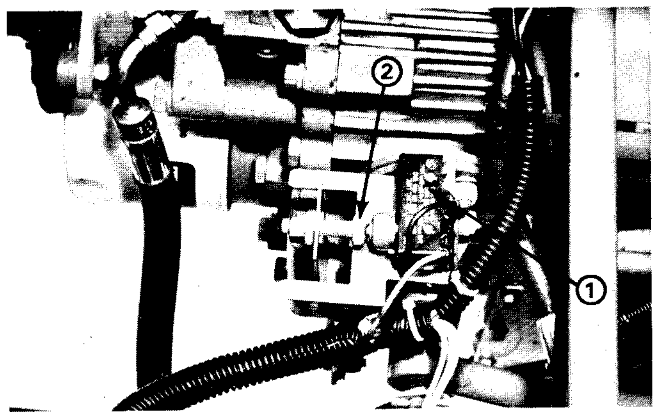


Figure 29

1. Traction switch **2. Adjusting screw**

Wiring Harness Service

Prevent corrosion of the wiring terminals by applying skin-over grease to the inside of all harness connectors whenever the harness is disconnected.

Always disconnect the battery cables, negative (-) cable first, to prevent possible wiring damage from short-outs whenever working with the electrical system.

Starter Service

Disassembly and Inspection

1. Remove the starter from the engine (see Starter Removal and Installation in the External Engine Component Repair section of Chapter 3 - Mitsubishi Diesel Engine).

2. Disconnect wire from magnetic switch terminal "M".

3. Loose two screws securing the magnetic switch (Fig. 30). Remove the magnetic switch.

4. Remove two through bolts and screws securing the brush holder. Remove the rear bracket.

5. With the two brushes in the floating state, remove the yoke and brush holder assembly. Pull the armature out.

6. Remove the cover, pry the snap ring out and remove the washer.

7. Unscrew the bolts and remove the center bracket. As the bracket is removed, washers for pinion shaft end play adjustment will come off.

8. Pull out the reduction gear lever and lever spring from the front bracket.

9. Pry the snap ring out on the pinion side and pull out the pinion and pinion shaft.

10. Remove the ball bearings from each end of the armature with a bearing puller. The bearing that is press-fitted in the front bracket cannot be removed. Replace the bracket assembly if the bearing is worn or damaged.

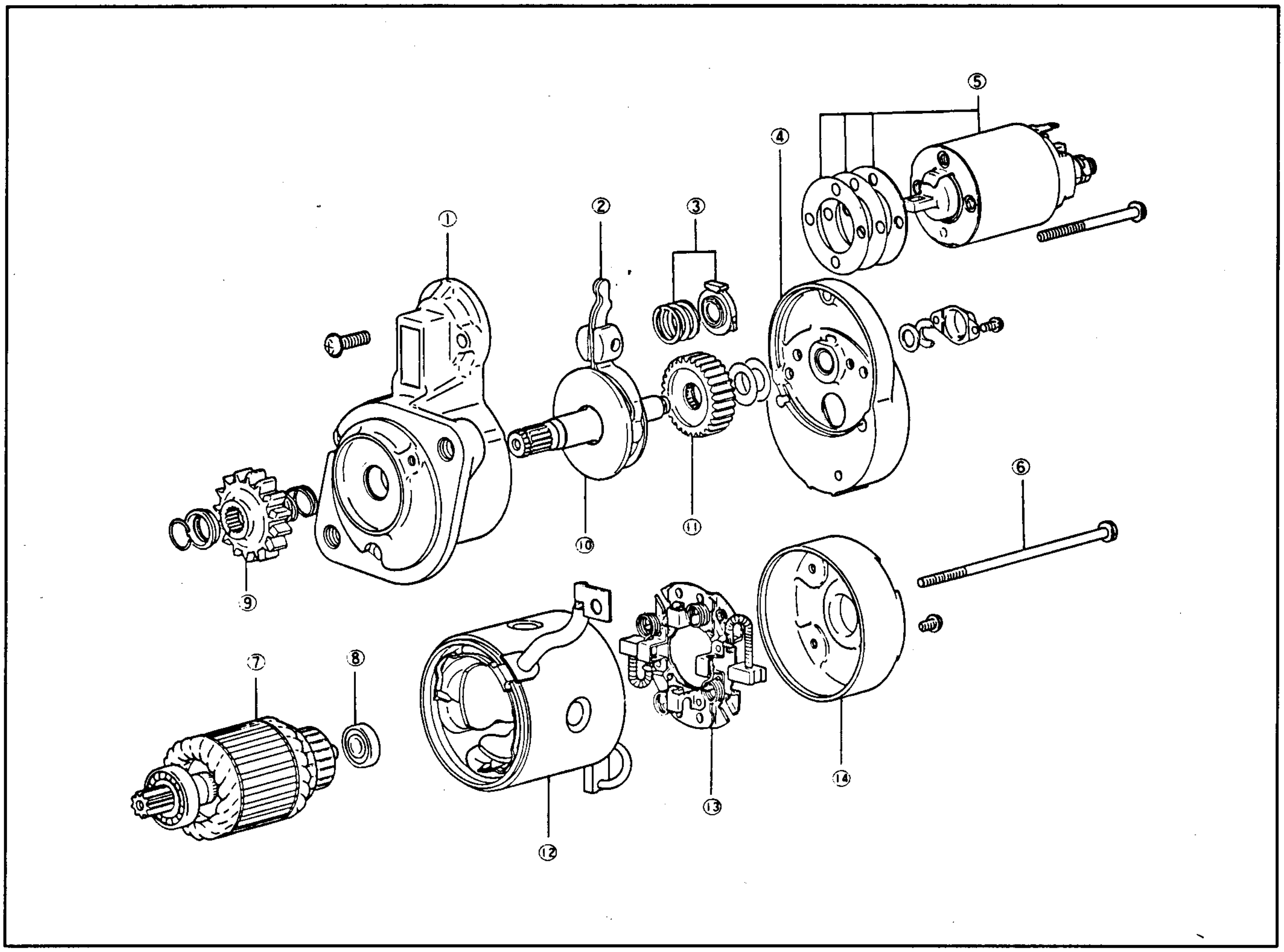


Figure 30

1. Front bracket assembly
2. Lever assembly
3. Spring set
4. Center bracket assembly
5. Switch assembly
6. Through bolt
7. Armature
8. Rear bearing
9. Pinion
10. Pinion shaft assembly
11. Gear
12. Yoke assembly
13. Brush holder assembly
14. Rear bracket

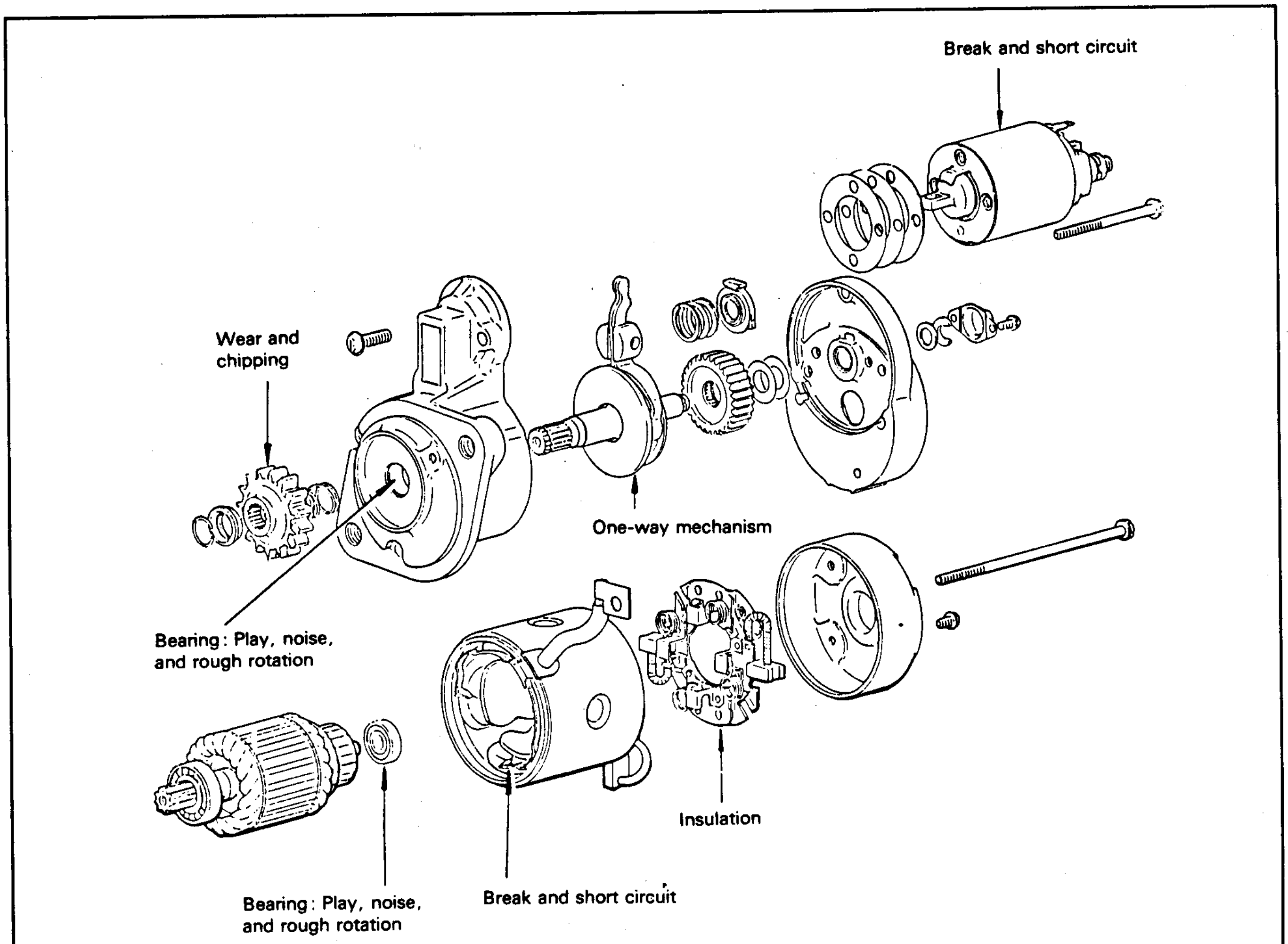


Figure 31

10. Check the magnetic switch for continuity between terminals "S" and "M" and between terminals "S" and body (Fig. 32). If there is continuity (or zero ohm is indicated), replace the magnetic switch.

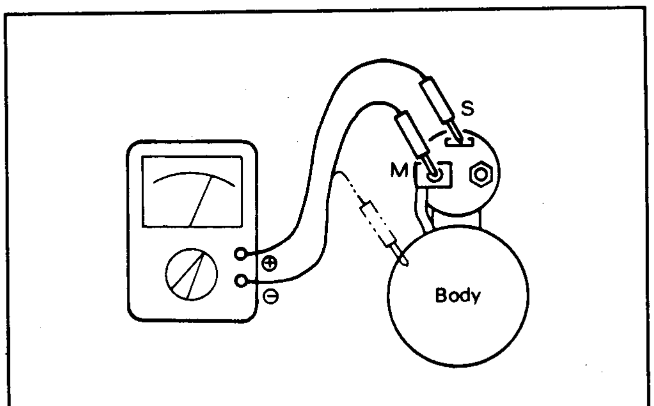


Figure 32

11. Put the armature on a growler tester to check for a shorted armature (Fig. 33). A burned commutator bar is an indication of a shorted armature. With the growler turned on, put a thin strip of steel or a hacksaw blade on the armature as it is slowly rotated. If the metal strip vibrates over a winding, that winding is short circuited. Short circuited windings are sometimes caused by metal in the commutator bridging the gap from on commutator bar to the next. By removing the bridged metal, this condition can be corrected. If this does not correct the short replace the armature.

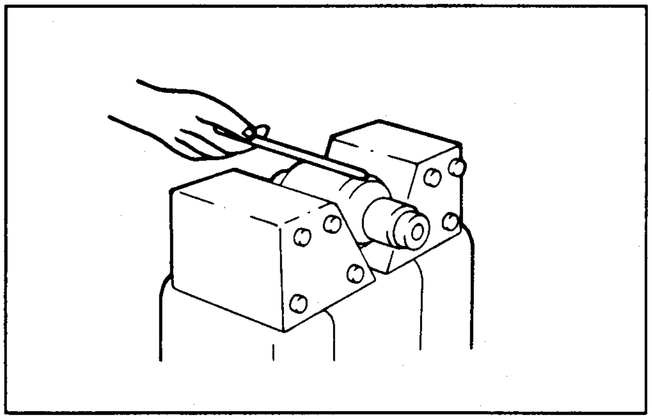


Figure 33

12. Measure the commutator O.D. and depth of undercut. Repair or replace if the service limit is exceeded. Check the commutator outside surface for dirt and roughness. If rough, polish the commutator with fine (00 or 000) sandpaper. DO NOT use emery cloth.

Item	Standard	Service Limit
Commutator O.D.	38.7 mm (1.52 in.)	- 1.0 mm (- 0.4 in.)
Depth of Undercut	0.5 mm (0.02 in.)	0.2 mm (0.008 in.)

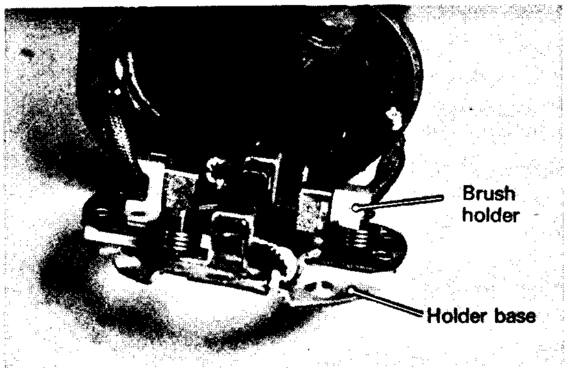


Figure 34

13. Check the brushes (Fig. 34). Replace if worn beyond the service limit. Check the brush spring tension. Replace the springs if tension is less than the service limit. Check for insulation between the positive brush holder and holder base. If poorly insulated, replace the holder assembly. Check the brush holders for proper staking.

Item	Standard	Service Limit
Height of Brush	17 mm (0.67 in.)	6 mm (0.24 in.)
Spring Pressure	3 kg (6.6 lb.)	

14. Check for continuity between one end of field coil (brush) and yoke (Fig. 35). There should be no continuity. Check for continuity between both ends of coil (brushes). There should be continuity if the field coil is good. Check the poles and coil for tightness.

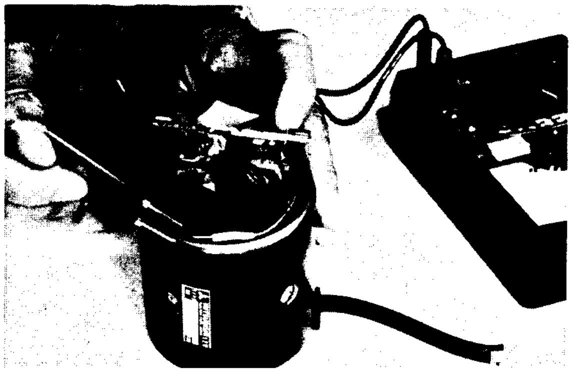


Figure 35

Assembly and Adjustment of Starter

1. Reverse steps 1 - 10 under Disassembly and Inspection and also following the following instructions:

2. Set the pinion shaft end play (thrust gap) to 0.5 mm (0.02 in.) or less by inserting an adjusting washer between the center bracket and reduction gear (Fig. 36).

   A. Fit the pinion shaft, reduction gear washer and snap ring to the center bracket.

   B. Measure end play by moving the pinion shaft in and out. If end play exceeds 0.5 mm (0.02 in.), increase the number of adjusting washers.

3. Put grease on the following parts whenever the starter has been overhauled:

   Armature shaft gear and reduction gear
   All bearings
   Bearing shaft washers and snap rings
   Bearing sleeves
   Pinion
   Sliding part of lever

IMPORTANT: Never put grease on terminals, brushes, commutator or surface that mounts to the engine.

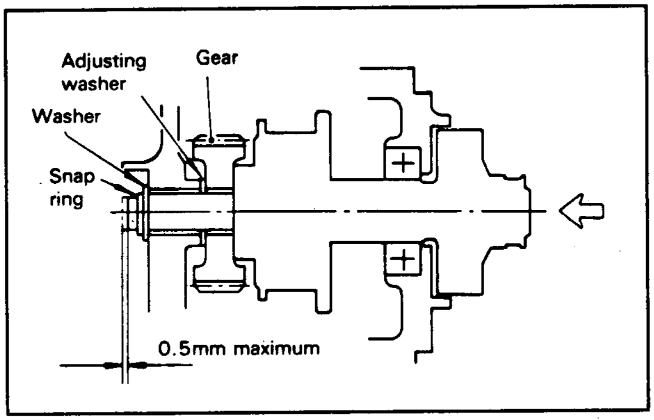


Figure 36

Alternator Service

Disassembly and Inspection

1. Remove the alternator from the engine (see Alternator Removal and Installation in the External Engine Component Repair section of Chapter 3 - Mitsubishi Diesel Engine).

2. Remove the three through bolts (Fig. 37).

3. Use a solder iron to heat the rear bracket around the rear bearing to 120 - 140° F (50 - 60° C). Separate the front and rear brackets by prying with a screwdriver blade inserted between the brackets.

IMPORTANT: Be careful not to insert the blade too far causing damage to the windings.

4. Put the rotor in a vise. Remove pulley nut and pull off the pulley and spacer.

5. Pull the rotor assembly from the front bracket.

6. Unsolder the stator core lead wires. Remove the stator assembly.

IMPORTANT: To prevent damage to the diodes, heat the stator core lead wires only long enough to remove.

7. Disconnect the capacitor from terminal "B".

8. Loosen the screws securing the rectifier and remove the rectifier.

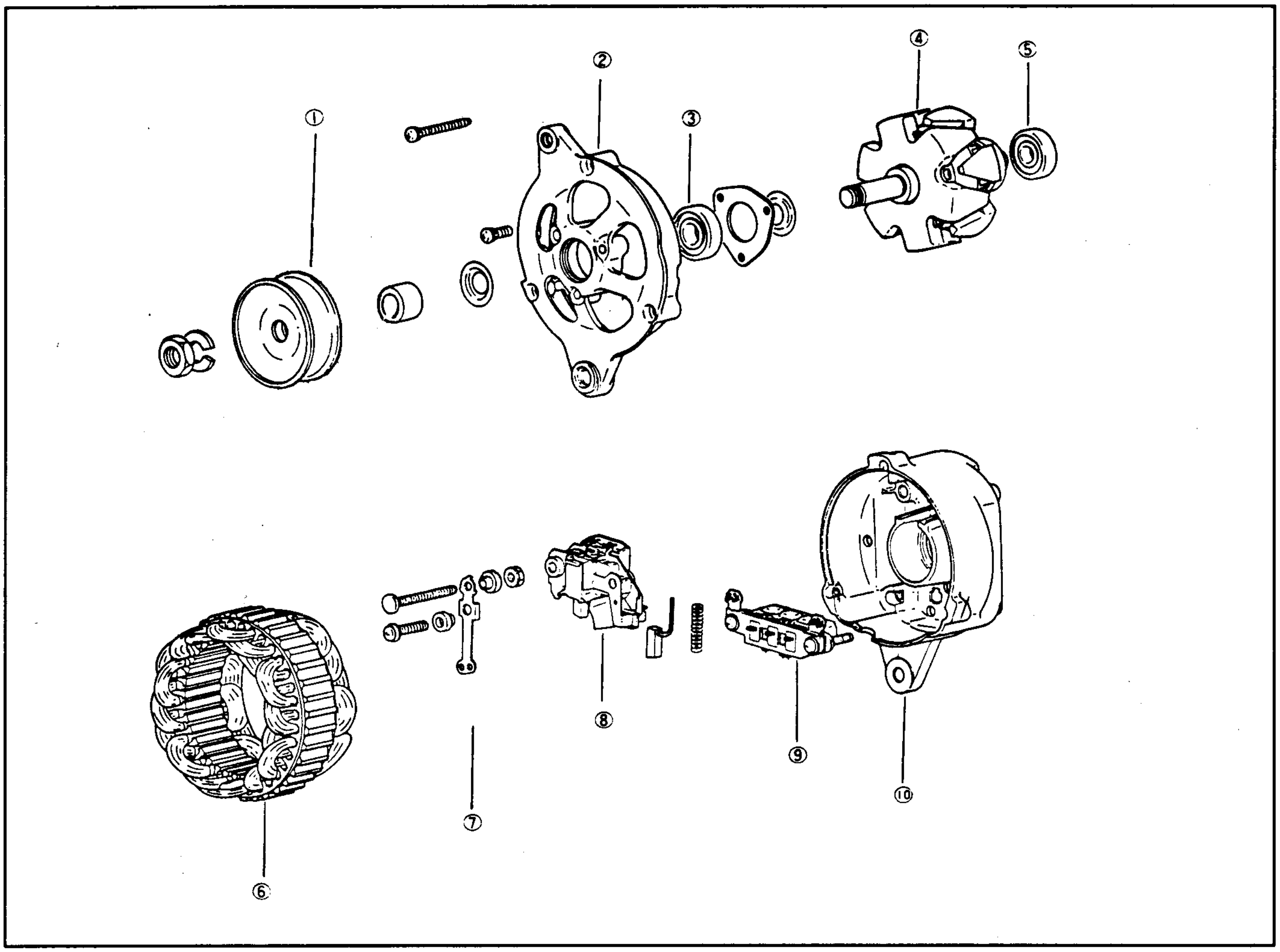


Figure 37

1. Pulley
2. Front bracket assembly
3. Front bearing
4. Rotor assembly
5. Rear bearing
6. Stator
7. Terminal set assembly
8. Regulator assembly
9. Rectifier assembly
10. Rear bracket assembly

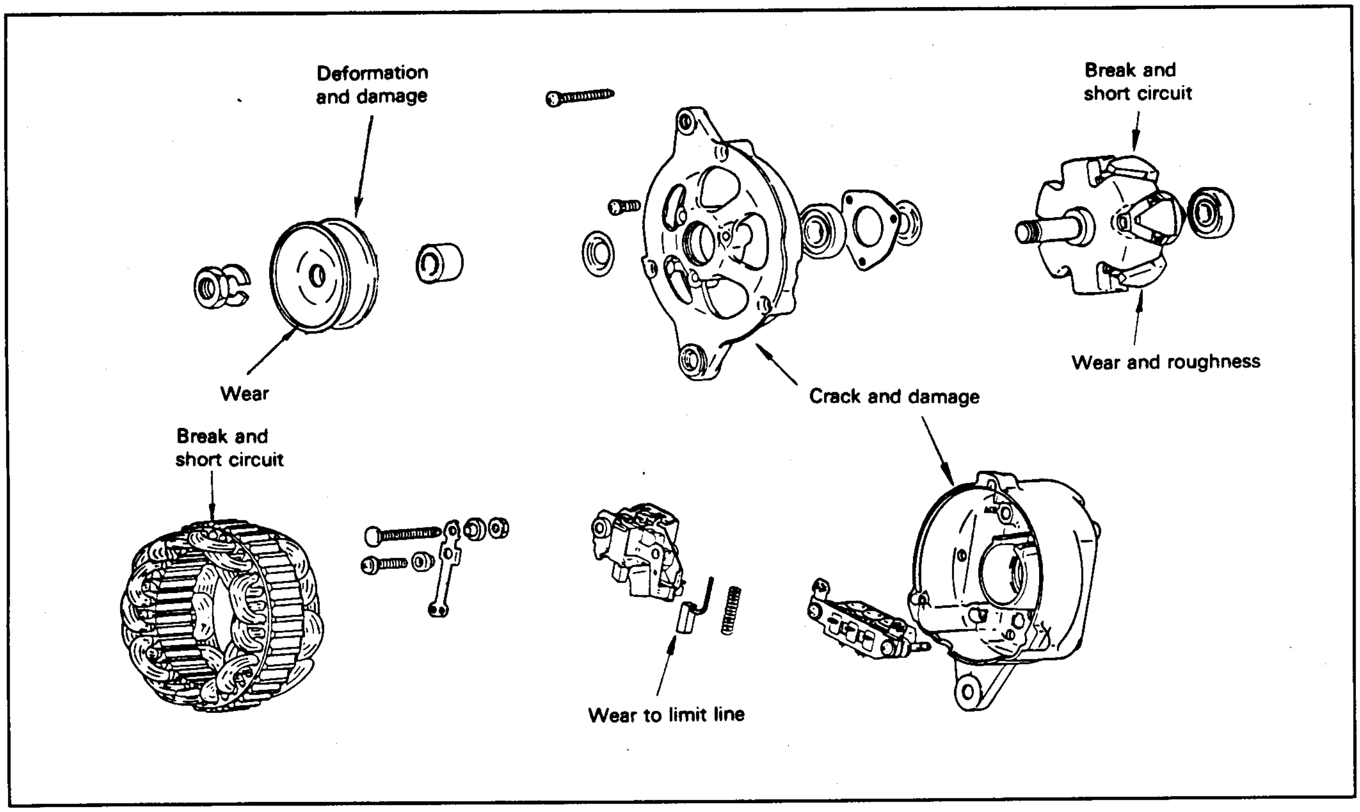


Figure 38

9. Check each diode in the rectifier for conduction (Fig. 39). Connect an ohm meter across the lead wire and diode case. The diode is normal if its resistance is large in one direction and small in the reverse direction. If there is equal resistance in both directions the diode is defective. Replace the rectifier assembly if a diode is defective.

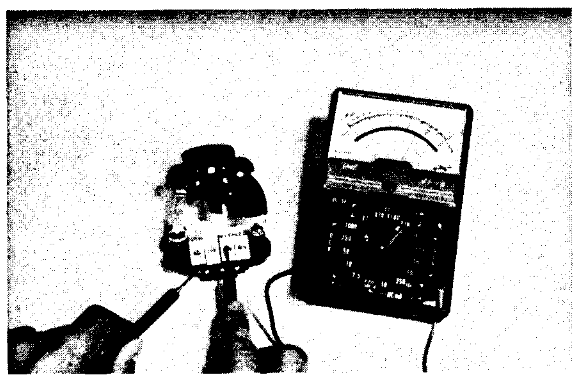


Figure 39

10. Check the field coil for continuity between the slip rings (Fig. 40). If there is no continuity, replace the field coil.

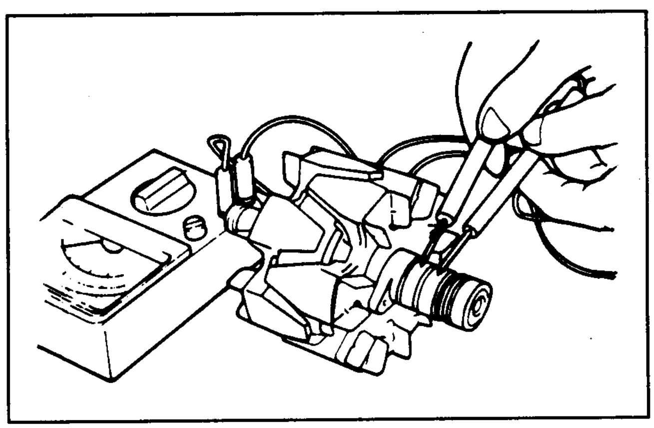


Figure 40

11. Check for continuity between a slip ring and shaft (core) (Fig. 41). Replace the field coil if there is continuity.

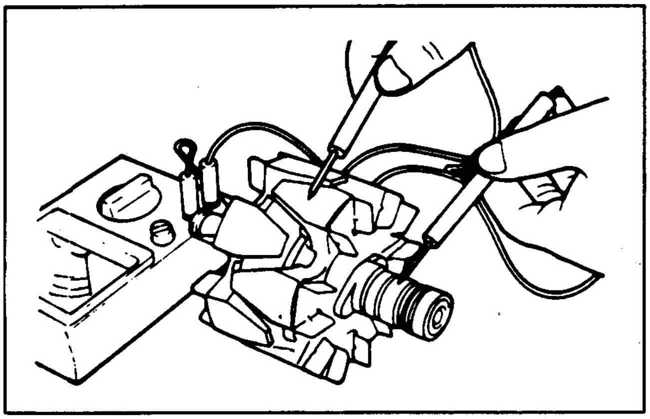


Figure 41

12. Check for continuity between lead wires of the stator coil (Fig. 42). Replace the stator coil if there is no continuity.

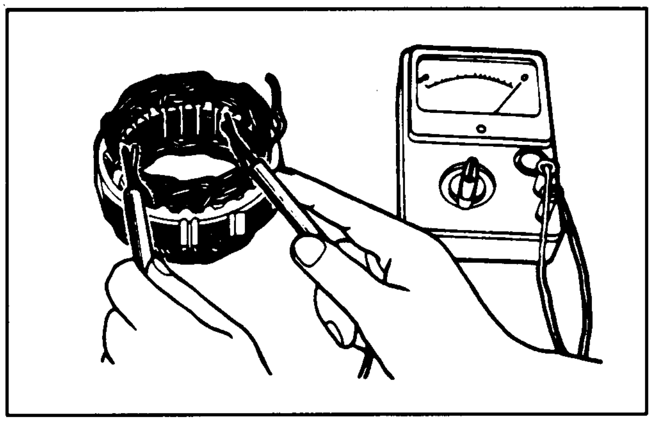


Figure 42

13. Check for continuity between each lead wire and stator core (Fig.43). Replace the stator coil if there is continuity.

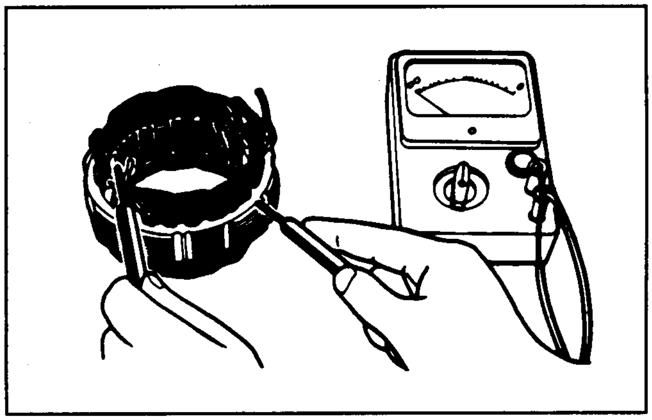


Figure 43

Assembly of Alternator

1. Reverse steps 1 - 8 under Disassembly and Inspection and also following the following instructions:

2. The rear bearing has an eccetric groove. Install the snap ring so its projection fits in the deepest part of the groove.

3. When installing a new rear bearing, press fit the bearing with its groove facing the slip ring side.

4. Heat the rear bracket when press fitting the rear bearing into the bracket.

IMPORTANT: Put a wire through the small hole in the rear bracket to lift the brushes before installing the rotor to the rear bracket (Fig. 44). Remove the wire after the rotor is installed.

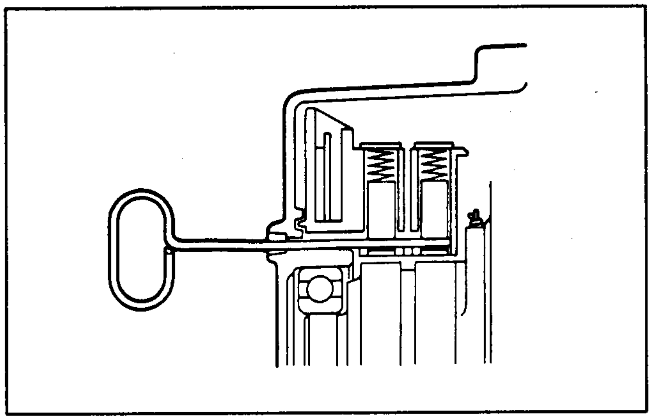


Figure 44

Chapter 6

Differential Axle

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Introduction

Groundsmaster® 200 Series traction units are equipped with a Dana Hydrostatic Axle, model GT-20. The differential and axle form the final drive of the power train (Fig. 1A).

The differential has a heavy duty case with automotive type, cut gears that rotate on tapered roller bearings. Single-row, pre-set, tapered roller bearings are used on the outside ends of the axle shafts.

The entire drive line of the axle assembly is made of alloy steel. The axle has a die-cast aluminum housing that also serves as the hydraulic oil reservoir.

Power is transmitted from the transmission output gear to the pinion spur gear. The pinion spur gear transmits power directly to the differential drive gears, to turn the axles and the wheels.

The differential axle has a one-piece axle shaft with the flange being part of the axle stem (Fig. 1B).

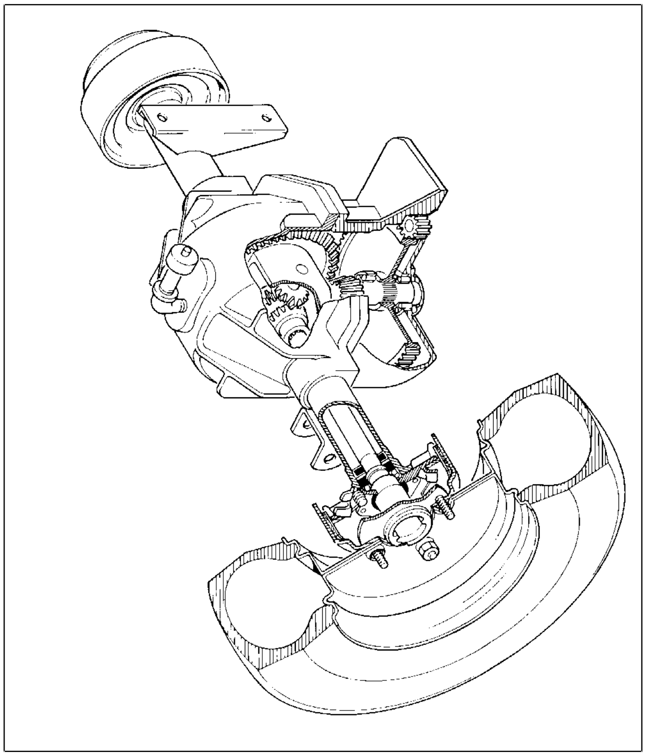

Figure 1A

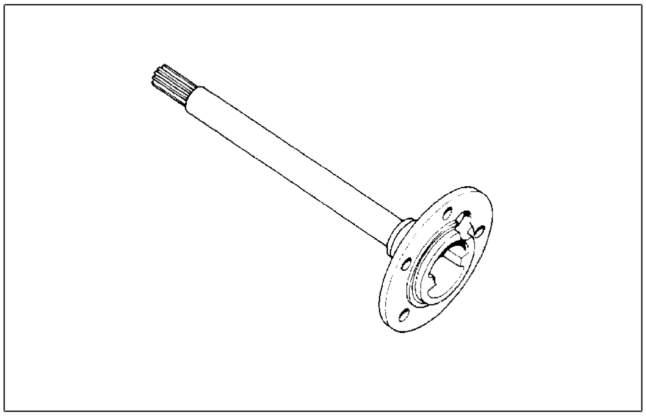

Figure 1B

Specifications

Item	Specification
Front wheel lug nut torque	45 to 55 ft-lb
Front to rear housing torque	18 to 28 ft-lb
Transmission to axle torque	25 to 30 ft-lb
Differential bearing caps torque	30 to 45 ft-lb
Ring gear to differential case torque	45 to 65 ft-lb
Fill pipe torque	20 to 30 ft-lb
Side plate (gear cover) torque	25 to 40 in-lb
Axle shaft bearing retainer (nut) torque With hex head screw With socket head screw (newer models)	 37 to 45 ft-lb 16 to 20 ft-lb
Ring gear to pinion gear backlash	0.003 to 0.007 in.
Pinion gear end play	0.00 to 0.005 in.

Special Tools

NOTE: Order special tools from the *TORO SPECIAL TOOLS AND APPLICATIONS GUIDE (COMMERCIAL PRODUCTS)*. Some tools may be listed in the Parts Catalog for your Toro equipment. Some tools may also be available from a local supplier.

Differential Gear Holder

Remove gear cover from right hand side of differential and bolt this tool in place to lock spur gear in position when removing nut that secures drive shaft flange for 4WD drive shaft.

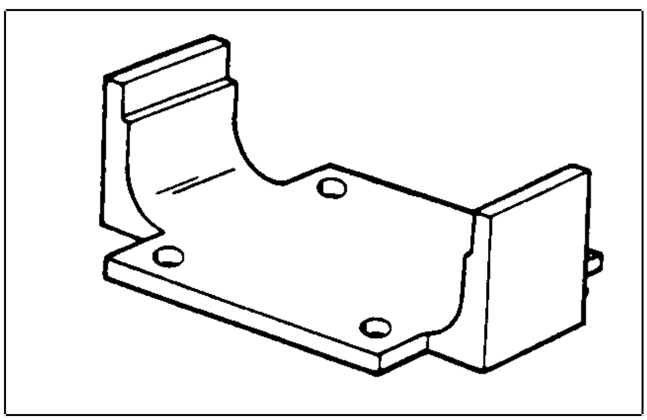

Figure 2

Axle Removal and Installation

1. Disconnect the battery cable from the negative (–) battery post.

2. Remove the cutting unit from the suspension frame. Remove the cutting unit suspension frame from the traction unit. (See the Repairs section of Chapter 12 - Cutting Units.)

3. Remove the fuel tank. (See Removing and Installing the Fuel Tank in the Fuel System Repairs section of Chapter 3 - Mitsubishi Diesel Engine.)

4. Remove the hydrostatic transmission. (See Hydrostatic Transmission Removal and Installation in the Repairs section of Chapter 4 - Hydraulic System.) Cap or plug all hydraulic lines and fittings to prevent oil contamination.

5. Remove the carrier brackets (Fig. 3A).

6. Slightly loosen all of the front wheel lug nuts.

7. Jack both of the front wheels off of the ground and install jackstands or blocks under the traction unit frame (not the axle tubes) to prevent the machine from falling.

8. Remove both of the front wheels.

9. If unit is equipped with 4WD, remove nut (Fig. 3B, Item 47), washer (Item 27) and flange (Item 26) from differential axle pinion (Item 12). Use Differential Gear Holder tool to hold gears when removing nut.

10. Put a jack or blocking under the differential to hold it in place. Remove the cap screws and lock nuts securing the axle mounting pads to the frame. Carefully lower the differential axle and pull it out from under the traction unit.

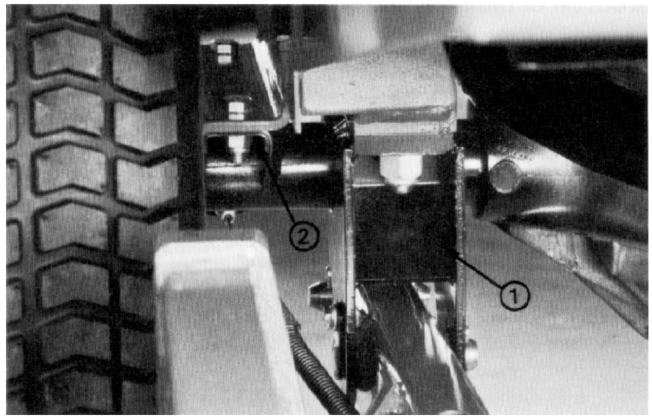

Figure 3A

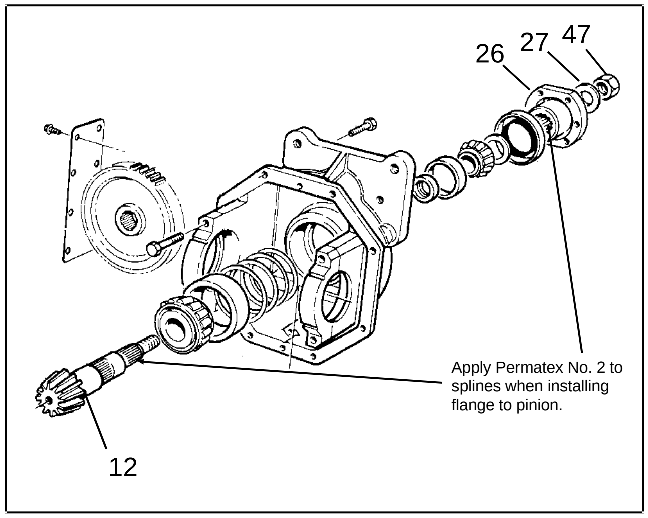

Figure 3B

Installation

NOTE: Before installing flange (for 4WD drive shaft), apply Permatex No. 2 to external splines of pinion and internal splines of flange. Tighten lock nut to secure pinion coupler 75 - 90 ft-lb (102 - 122 N-m)..

1. To install axle, reverse steps 1 - 10 above. Be sure to refill the differential with the proper oil before operation.

2. Check the engine to transmission coupler alignment. (See Drive Coupling Alignment in the Adjustments section of Chapter 10 - Engine to Transmission Coupler.

Axle Shaft Disassembly and Wheel Bearing Service

NOTE: When servicing the bearing and seal area of the axle shaft, it is recommended that you replace hex head screws and flange nuts with socket head screws (94-6934), washers (94-6936) and nuts (94-6935). See Figure 18.

1. After the wheel has been removed, slide the brake drum off of the axle flange (Fig. 5).

NOTE: It may be necessary to loosen the brake shoes by turning the star wheel inside the brake drum assembly. (See Chapter 7 - Steering and Brakes.)

Figure 5

2. Line up the hole in the axle shaft flange and remove the backing plate nuts which hold the axle shaft assembly to the axle housing. Use a 1/2 inch socket wrench (Fig. 6).

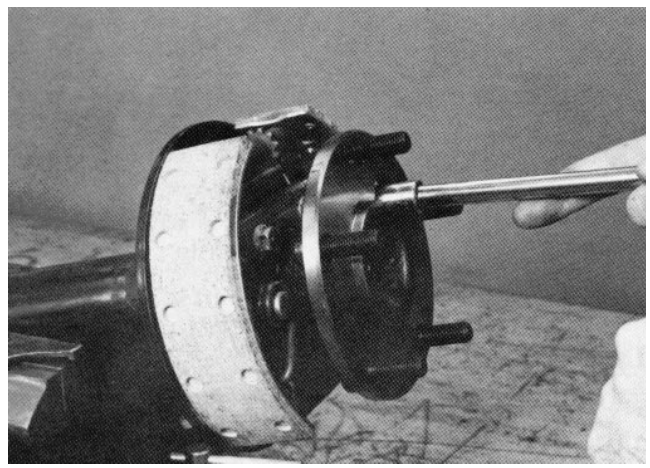

Figure 6

3. Pull out the axle shaft and brake assembly (Fig. 7).

NOTE: Bearing races and retainer ring are cemented together with an epoxy adhesive. If the bearing and race come apart, remove the bearing cup from the housing with a puller.

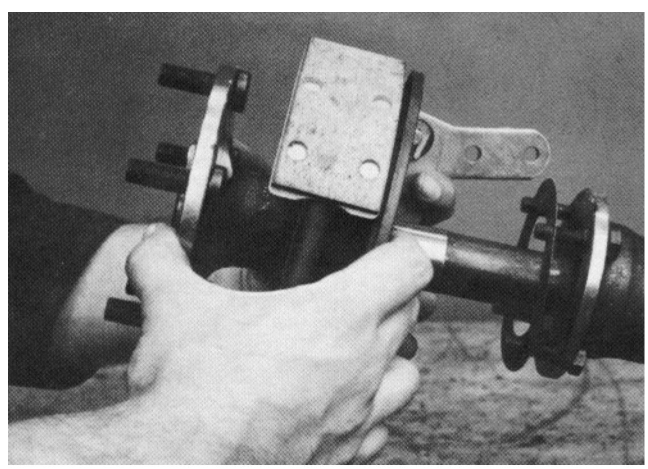

Figure 7

4. Remove the inner axle shaft seal (Fig. 8). Discard the seal and replace with a new one at the time of assembly.

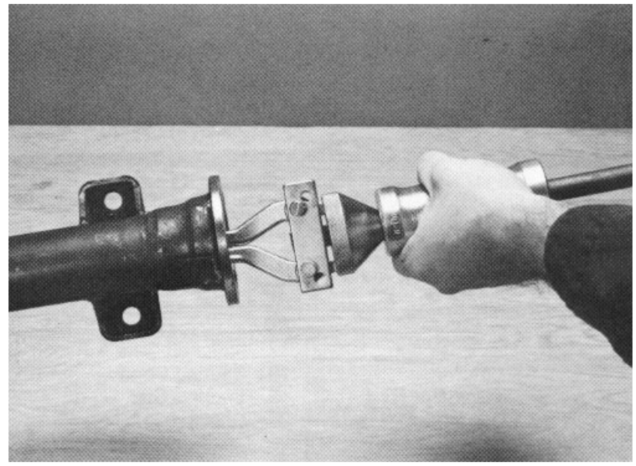

Figure 8

5. Center punch the outside of the retaining ring (Fig. 9).

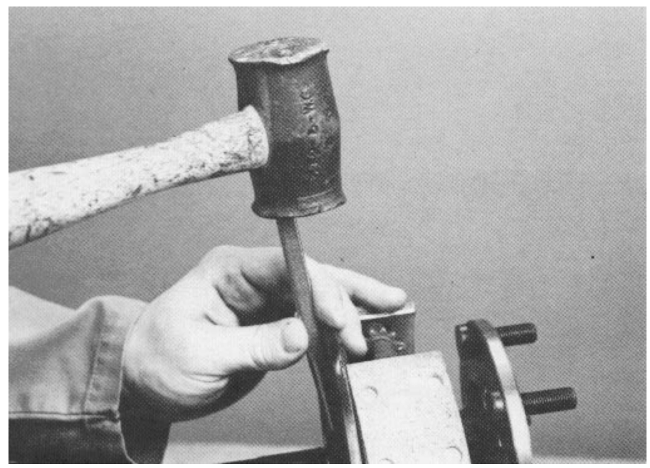

Figure 9

6. Drill a 1/4 inch hole (approximate) into the outside of the retainer ring to a depth of about 3/4 the thickness of the ring (Fig. 10).

IMPORTANT: Drilling completely through the retainer ring could damage the shaft.

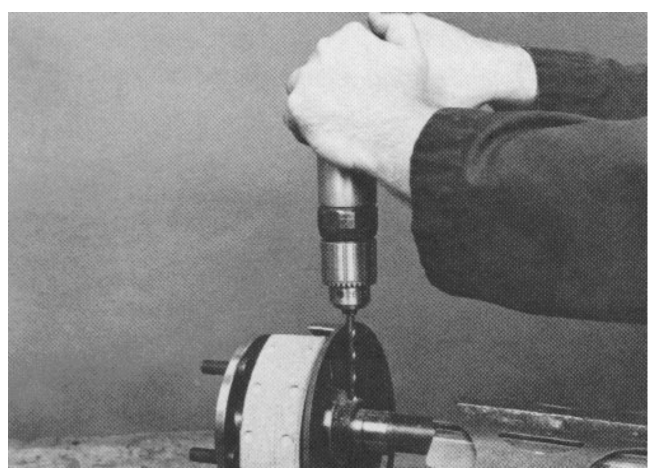

Figure 10

7. After drilling, put a chisel in position across the hole and strike sharply to break the ring. Replace with a new ring at time of reassembly (Fig. 11).

WARNING

Wear protective safety goggles when breaking the retaining ring. Personal injury could result from flying metal particles. Keep all personnel away during this procedure.

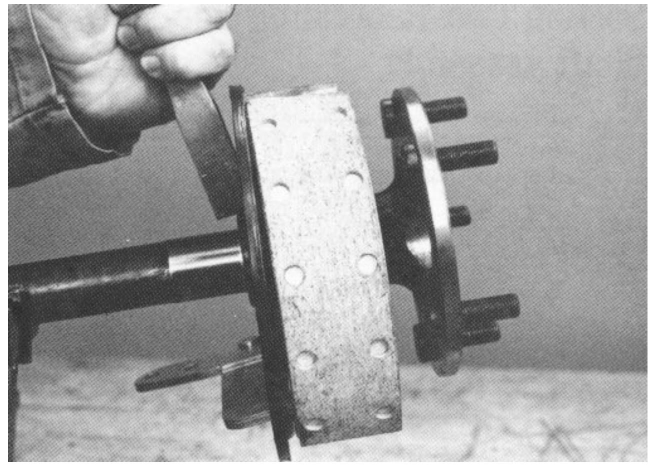

Figure 11

8. Inspect the shaft for possible damage (Fig. 12). Inspect the sealing surface of the hub and shaft. Replace it if the seal has grooved the surface more that 1/64 inch (0.4 mm).

9. Put a new grease seal, brake assembly, and a new grease packed bearing (in that order) onto the axle shaft.

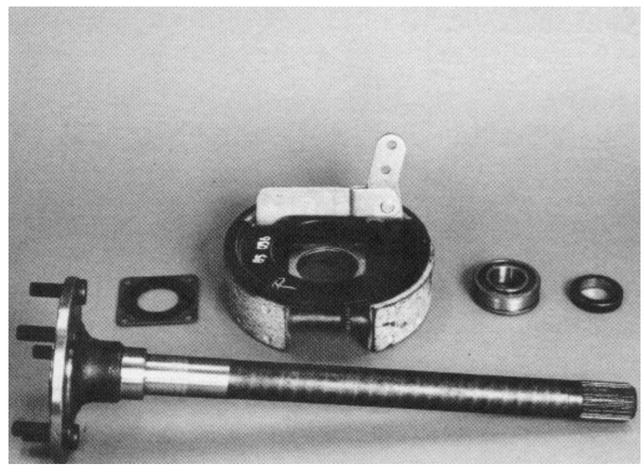

Figure 12

10. Press the assembly until the bearing is firmly seated against the axle shaft shoulder (Fig. 13).

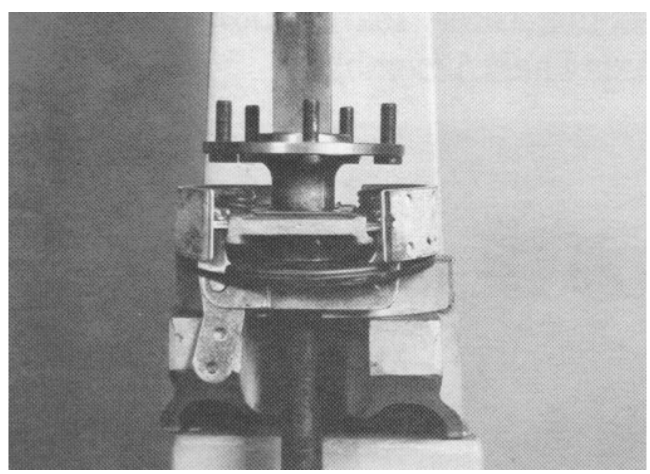

Figure 13

11. Slide a new retaining ring on the axle shaft and support the shaft and ring in a suitable press (Fig. 14). Press the retaining ring firmly against the bearing.

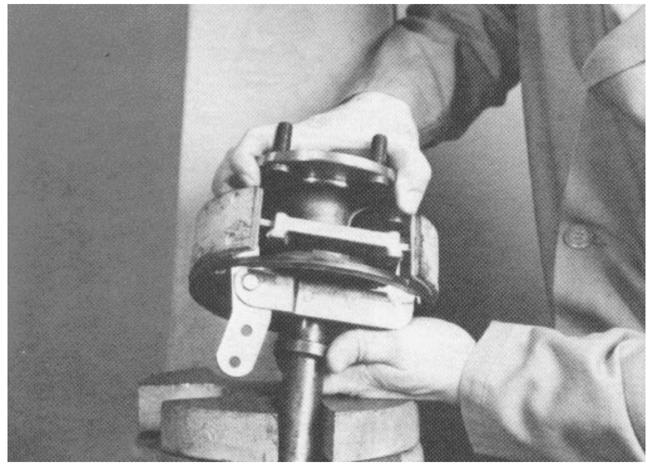

Figure 14

12. Put a light coating of No. 1 Permatex on the outside diameter of a new grease seal (surface that contacts the axle housing). Install the new seal to a depth of 1.218 in. into the housing (Fig. 15, 16). After the seal has been assembled, put grease on the lip of the seal.

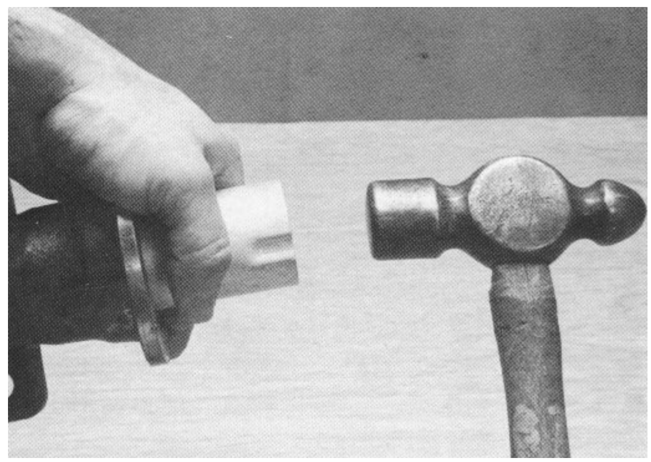

Figure 15

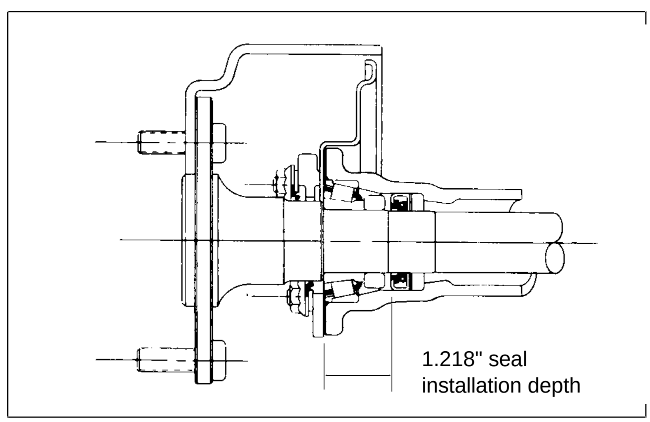

Figure 16

13. Assemble the bearing retainer bolts to the axle housing. Apply a 0.625 in. (16 mm) bead of gasket material to flange on end of axle housing, then install the axle shaft assembly into the axle housing. Be careful not to damage the oil seal and bearing. Line up the holes of the brake assembly and oil seal. Push the axle shaft as far as possible into the axle housing (Fig. 17).

Wheel end gasket material: P/N 92-8775 Liquid Gasket Kit
(Kit contains Loctite Ultra-Gray gasket eliminator and instructions.

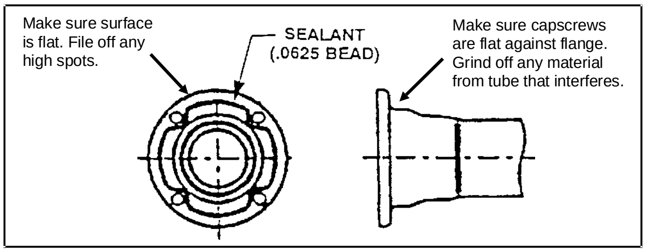

Figure 17

14. Start the nuts by hand. Tighten the nuts so the bearing assembly is drawn evenly into the axle housing (Fig. 18). **NOTE:** It is recommended that you replace hex head screws and flange nuts with socket head screws, washers and nuts (Fig. 18). If installing socket head screws, tighten the nuts to a torque of 16 - 20 ft.-lb. (2 - 3 Kgm). If reinstalling hex head screws, tighten the nuts to a torque of 37 - 45 ft.-lb. (5 - 6 Kgm).

IMPORTANT: Hold the socket head screw or hex head screw when tightening the nut to prevent the head from turning into the tube radius.

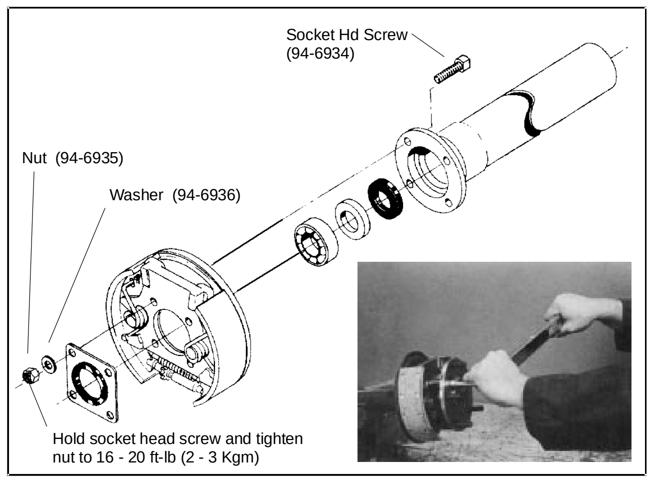

Figure 18

Differential and Housing Disassembly

1. Remove the right and left-hand axle assemblies. (See Axle Shaft Disassembly and Wheel Bearing Service in this section of the book.)

Remove the eight (8) housing cap screws and separate the upper and lower axle housings (Fig. 19). Clean the gasket material from the mating surfaces before reassembly.

NOTE: A complete Upper Housing Assembly for Differential repairs is available. Using this assembly eliminates the need for “trial and error” shimming procedures to establish the correct contact pattern between ring and pinion gears.

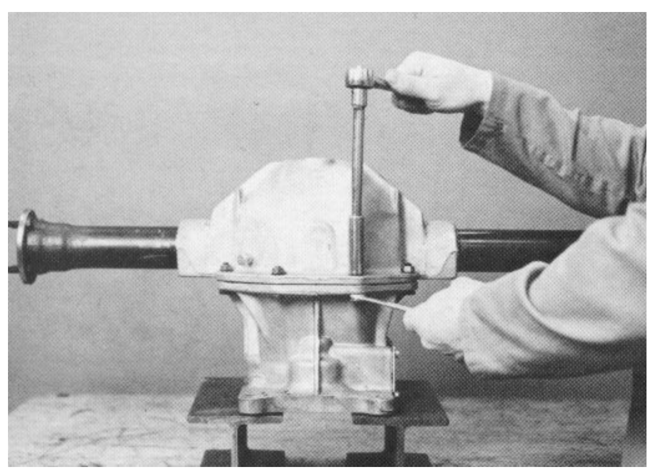

Figure 19

2. Remove the four bearing cap screws and remove the caps. Place the caps in a safe place to avoid damaging their machined surfaces (Fig. 20).

The bearing caps are marked for identification. The letters or numbers are in horizontal and vertical positions. When reassembling, place them back in the same position.

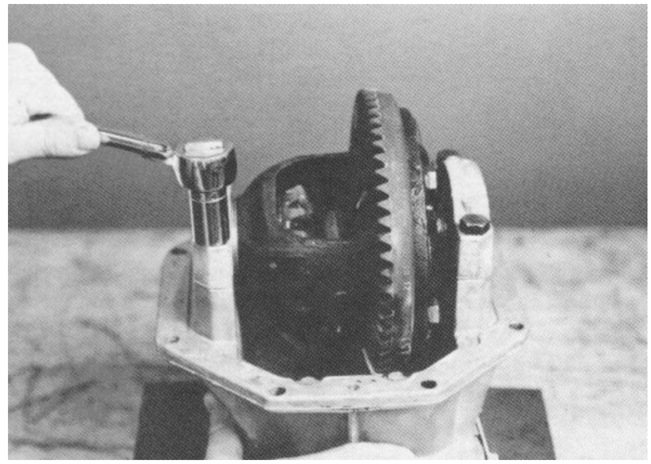

Figure 20

3. To remove the differential assembly, place two wooden devices (i.e. hammer handles) under the differential case and pry firmly upward. The bearing cups must be kept with their mating cones (Fig. 21).

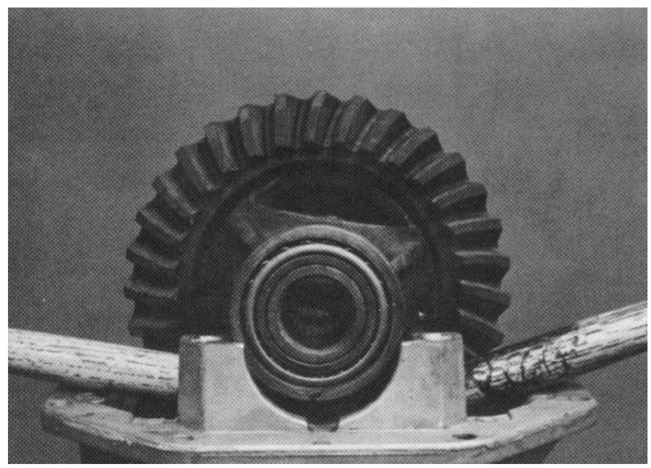

Figure 21

4. Remove the ring gear cap screws. Using a hard wooden block and a hammer, drive the ring gear off of the differential case. Be prepared to protect the ring gear when removing it from the differential case; this will avoid damage of the ring gear teeth (Fig. 22).

NOTE: It is recommended that whenever the ring gear screws are removed, they are to be replaced with new screws.

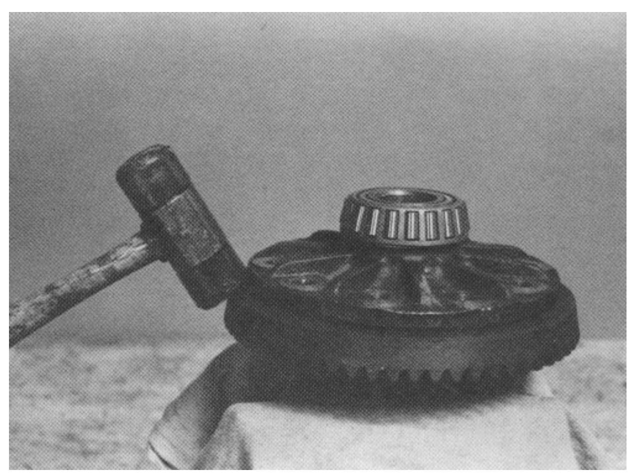

Figure 22

5. Do not remove the bearings from the differential case unless bearing failure is evident. It is recommended that whenever bearings are removed (regardless of usage) they must be replaced with new ones. Remove the case side bearing with a puller as shown (Fig. 23).

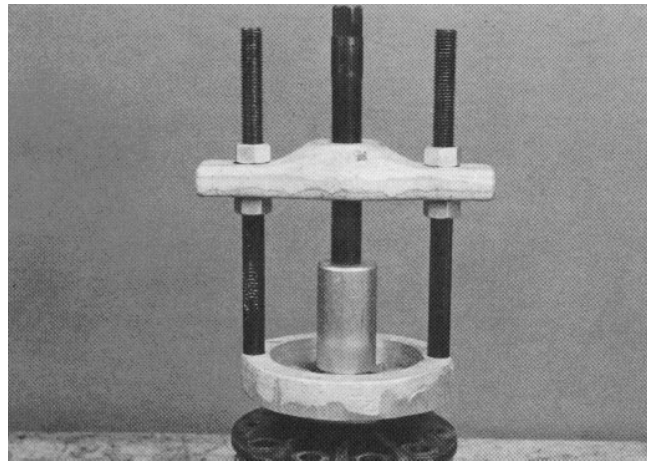

Figure 23

6. Put the case in a vise. Drive the lock pin out of the pinion shaft (Fig. 24). Use a small drift punch as shown.

WARNING

To prevent personal injury, always wear a face shield or safety goggles when striking a drift punch with a hammer.

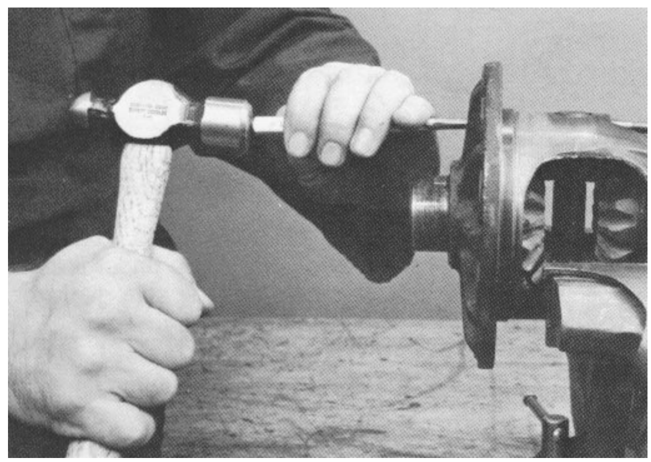

Figure 24

7. While supporting the differential in a vise, drive the pinion mate shaft from the differential with a long drift punch (Fig. 25).

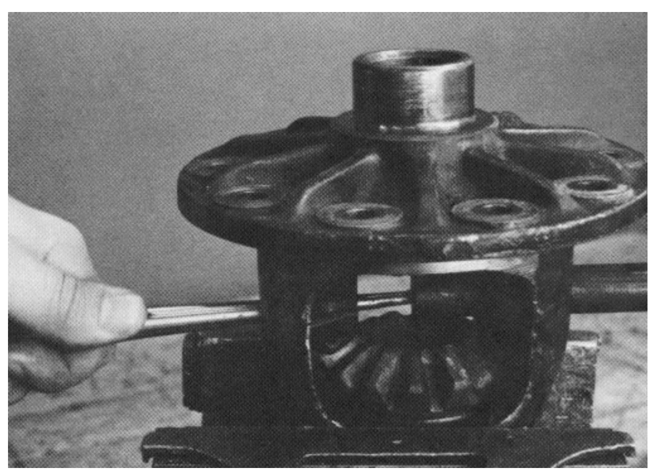

Figure 25

8. To remove the side gears and pinion mate gears, rotate the side gears. This will allow the pinion mate gears to turn to the opening of the case (Fig. 26). Remove the pinion mate gears and the spherical washers behind the gears.

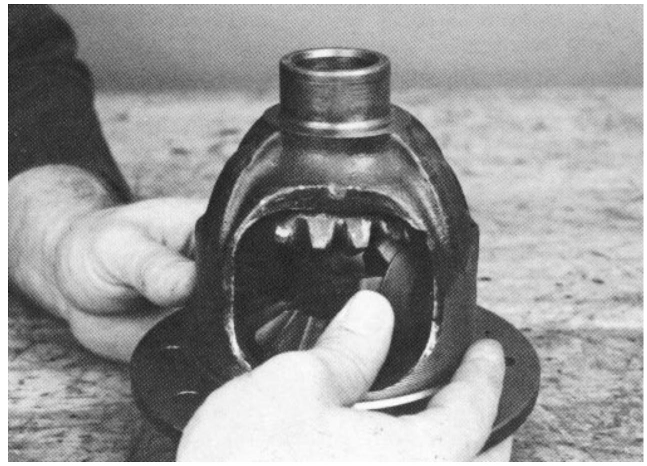

Figure 26

9. Remove the eight side cover capscrews. Remove the the side cover from the carrier assembly (Fig. 27). Clean the gasket material from the mating surfaces before reassembly.

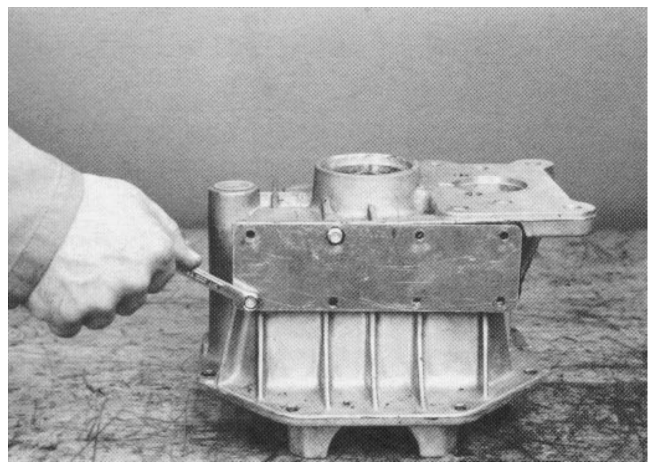

Figure 27

10. If unit has an expansion plug, remove it by driving a pointed punch through the plug about 3/8 inch (10 mm) from the outer edge. When the hole is large enough, insert a large screwdriver through it and pry the plug outward (Fig. 28).

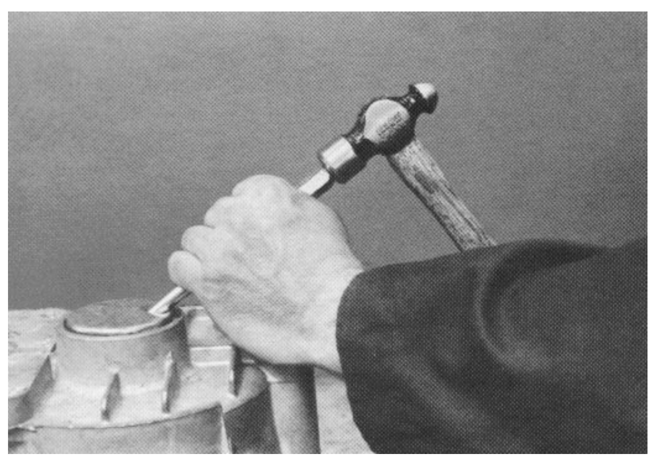

Figure 28

11. Before pressing pinion out of housing:

If unit was equipped with an expansion plug (removed in step 10), remove the snap ring and shim from the end of the pinion (Fig. 29).

If unit is equipped with a flange for 4WD (no expansion plug), nut, washer and flange (Fig. 3C) must be removed before pressing pinion out of housing.

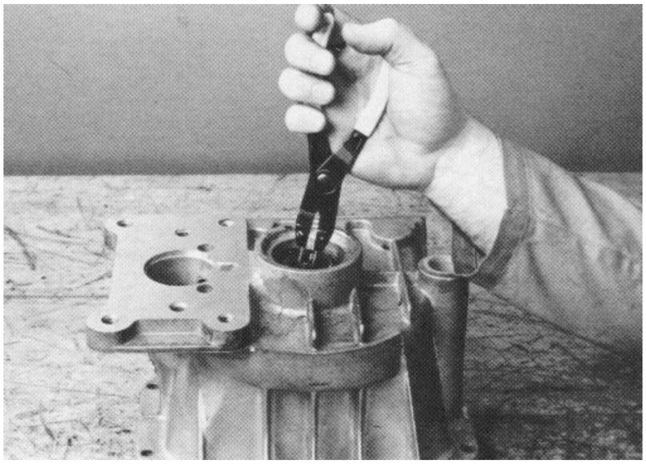

Figure 29

12. Position the housing assembly on a suitable press. Place a 1/8 inch (3 mm) piece of steel or a screwdriver blade under the edge of the spur gear. This will prevent the spur gear from cocking and possibly cracking the housing (Fig. 30).

When the pinion is close to being pressed completely out of the bearing, reach under the housing and catch the pinion in your hand to prevent any damage to the pinion.

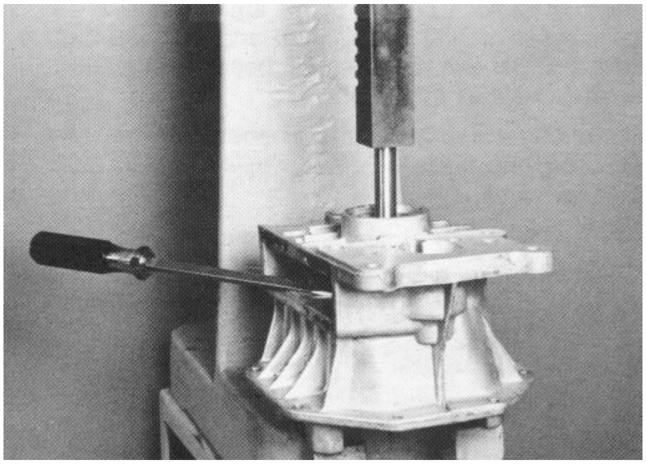

Figure 30

Removing the drive pinion releases the spur gear, spacer, and outer pinion bearing for removal (Fig. 31).

If unit was equipped with a flange for 4WD (no expansion plug), remove oil seal from housing (Fig. 3B).

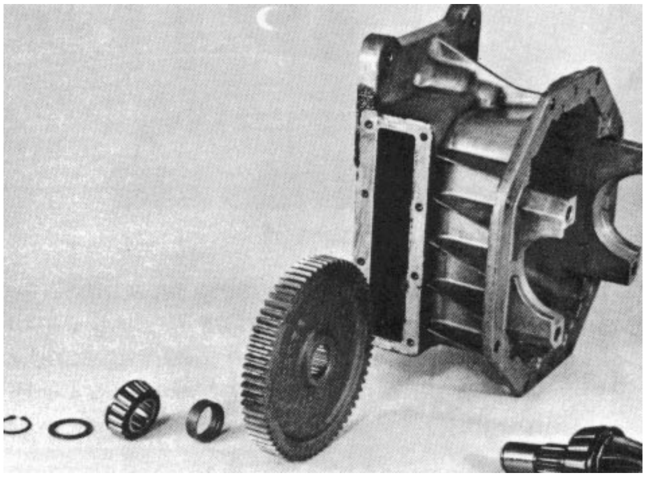

Figure 31

13. Clamp the inner pinion bearing with a universal bearing remover (Fig. 32). Position the unit in a press and carefully push the drive pinion out of the bearing.

DO NOT allow the pinion to drop on the floor - damage will result.

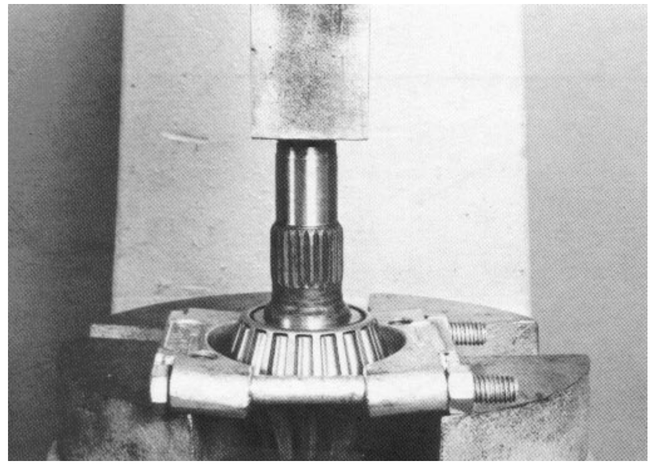

Figure 32

14. To remove the outer pinion bearing cup, position the housing in a press. Place a press plate of the proper size against the cup. Press the cup out of the housing (Fig. 33).

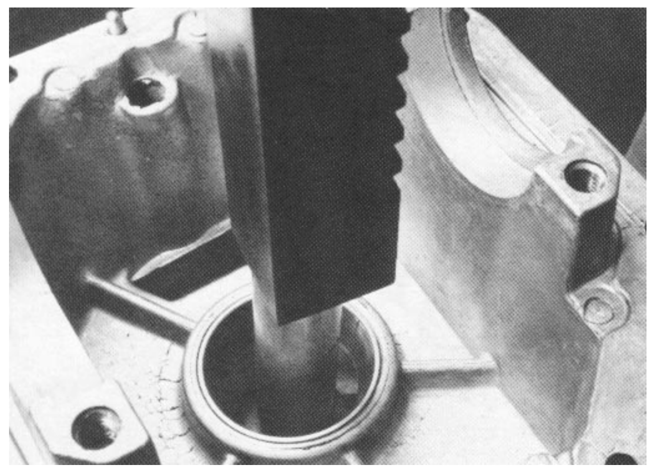

Figure 33

15. Position the front housing on a press bed with the bearing saddles resting on the press bed. Protect the bearing saddles with a strip of wood if the press bed is rough.

Insert a press plate of the proper size and press the bearing cup toward the inside of the housing. Retain the shims located under the bearing cup (Fig. 34). If the shims are damaged, replace with new shims of the same thickness.

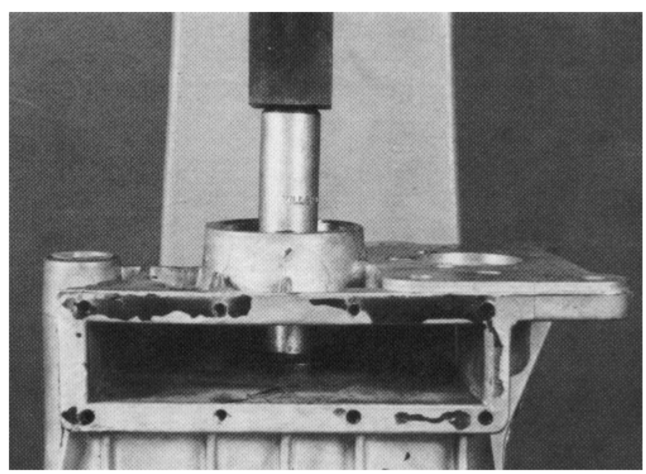

Figure 34

Differential and Housing Reassembly

1. Inspect the differential parts for damage before assembling.

A. If any bearings are damaged they must be replaced with new ones.

B. Check the ring, pinion, and spur gear for abnormal wear and damage; replace worn components.

C. Inspect the housings for cracks and external damage that could affect the operation of the axle assembly.

D. Inspect the differential case for wear in the side gear and pinion mate area. Replace the case if its machined areas are scored or if the pinion mate shaft fits loosely in the bore.

2. Press the inner pinion bearing onto the pinion drive gear. Support the bearing on the inner cup of the bearing ONLY WHEN INSTALLING (Fig. 35).

3. Put the front housing on a press. Using a press plate, push the outer pinion bearing cup into the housing until it bottoms in the housing (Fig. 36).

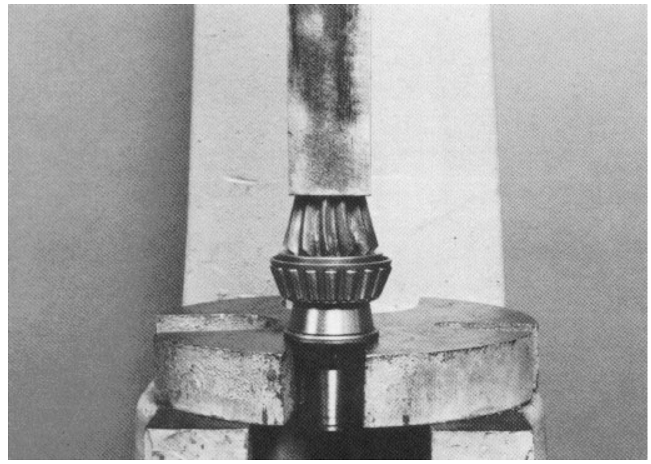

Figure 35

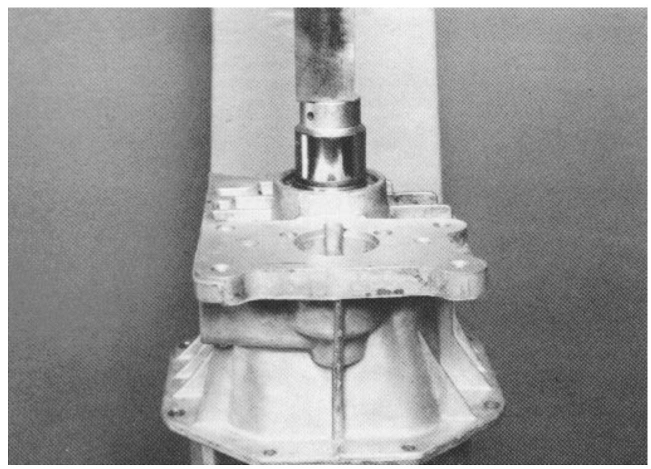

Figure 36

Ring and Pinion Set

Rings gears and pinions are supplied in matched sets only. Matching numbers are etched on both the pinion and ring gear (Fig. 37).

The mounting distance from the bottom of the differential bearing bores to the button end of the pinion is 1.210 in.

On the button end of each pinion there is a plus (+) or minus (–) number, or a (0) number. This number indicates the best running position for each particular gear set. This dimension is controlled by the shimming behind the inner bearing cup.

For example, if a pinion is etched +3, this pinion would require 0.003 in. less than a pinion etched “0". This means that by removing shims, the mounting distance of the pinion is increased to 1.213 in., which is just what +3 indicates. Or if a pinion is etched –3, we would want to add 0.003 in. shims, the mounting distance of the the pinion was decreased to 1.207 in., which is just what a –3 etching indicates.

If a new gear set is being used, notice the (+) or (–) etching on both the old and new pinion and adjust the thickness of the new shim pack to compensate for the difference of these two numbers.

For example: If the old pinion reads +2 and the new pinion is –2, add .004 in. shims to the original shim pack.

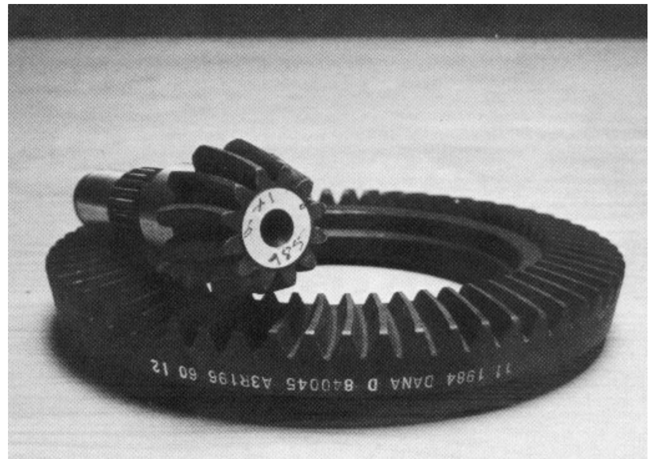

Figure 37

4. Install a new inner bearing cup using a press plate of proper diameter. Reuse the original shims or use new shims of the same thickness. Push the bearing cup into the housing until it bottoms against the housing (Fig. 38).

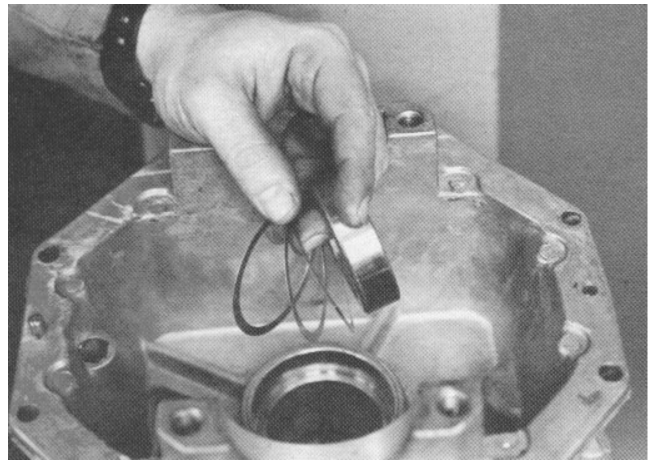

Figure 38

5. Insert the pinion into the housing.

NOTE: A number marked on the new ring and pinion set is used to establish the proper amount of shims required prior to installing the pinion gear (see page 15). The final pinion position will be verified by using the gear contact pattern method as described on page 21of this chapter.

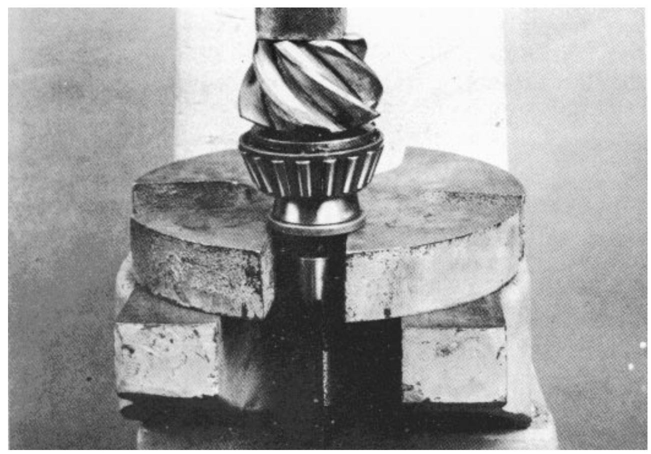

Figure 39

6. Insert the spur gear into the front housing with the chamfered area of the center spline toward the drive pinion. Install the drive pinion with a soft mallet to engage the splines in the spur gear (Fig. 40).

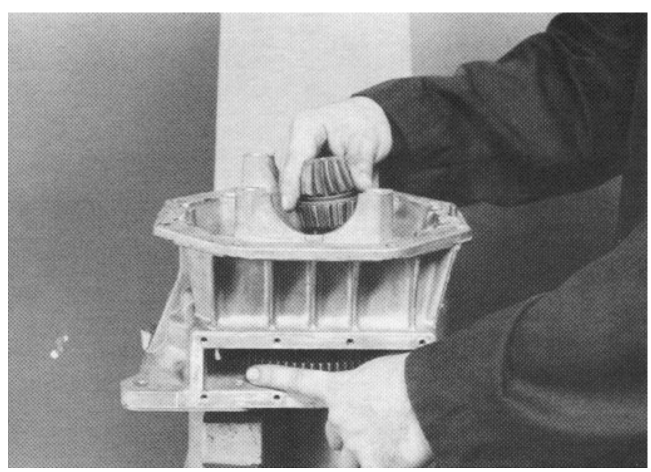

Figure 40

7. Support the drive pinion in a suitable press (Fig. 41).

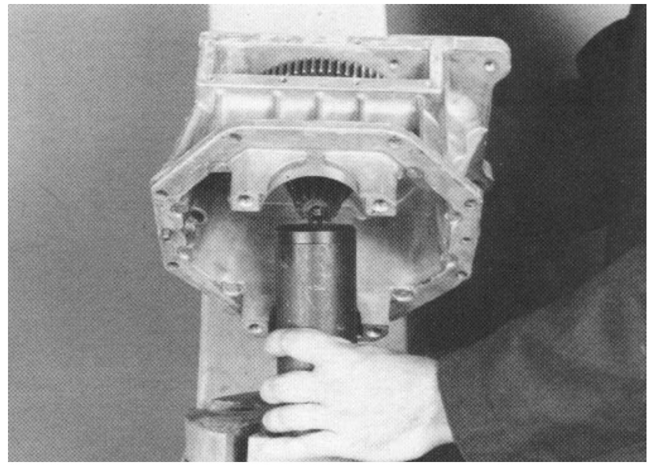

Figure 41

8. Install the outer pinion spacer with the chamfer towards the pinion splines and install the new outer pinion bearing cone (Fig. 42).

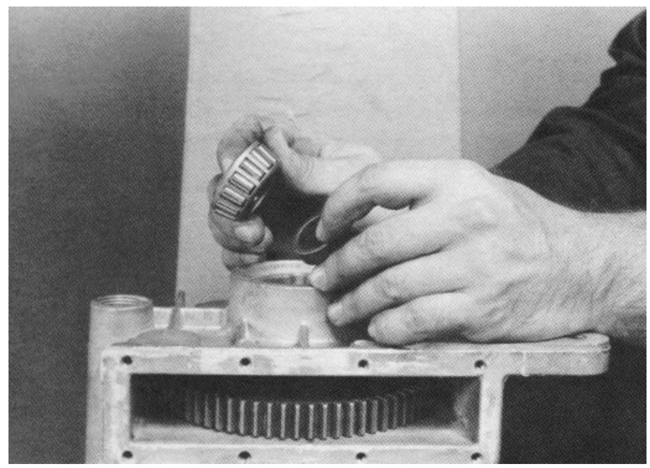

Figure 42

9. With a hollow press sleeve of proper diameter, press on the outer bearing cone race until the drive pinion seats in the carrier and a slight drag is noticed when the gear is rotated by hand (2-13 in.-lb. torque to rotate) (Fig. 43). If the drag is to severe, tap the pinion shaft with a soft mallet until the drag is reduced.

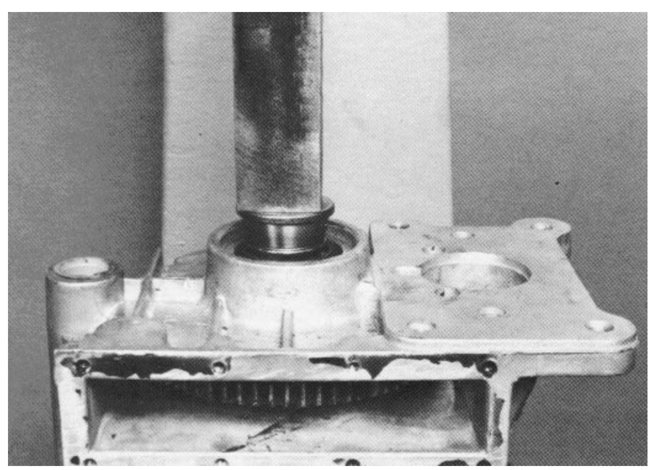

Figure 43

10. Install the shim and snap ring onto the end of the pinion shaft. Use the thickest shim possible which will permit installation of the snap ring (Fig. 44). Limit the end play to 0.000 - 0.005 inch (0.000 - 0.127 mm).

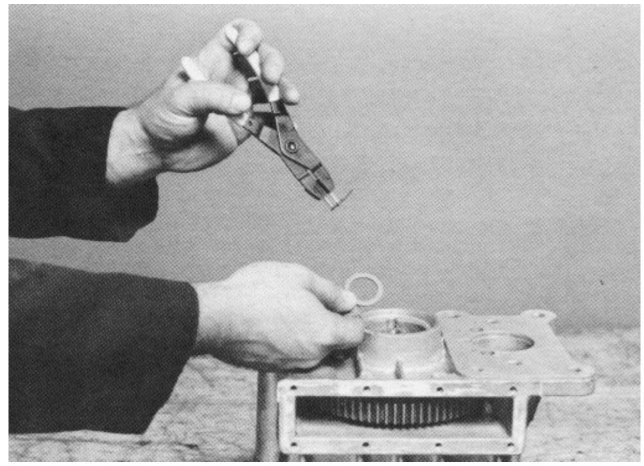

Figure 44

11. Apply a small bead of Permatex No. 2 or silicone sealant to the outer edge of the carrier bore. Install the expansion plug (or seal if equipped with flange for 4WD) into carrier until plug or seal seats firmly in carrier bore (Fig. 45).

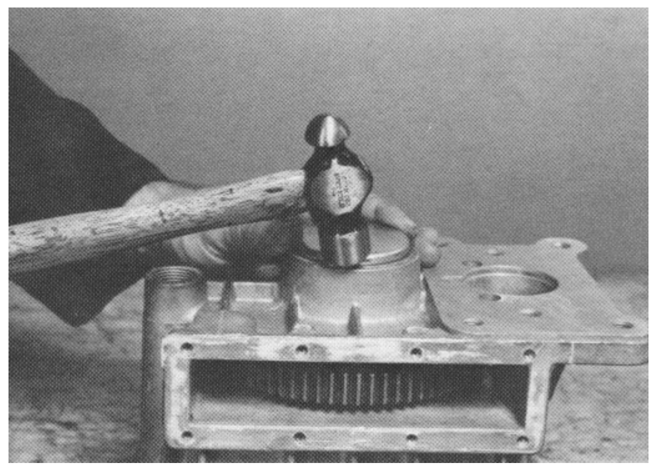

Figure 45

12. Install the spur gear cover. Use Permatex No. 2 or silicone sealant when installing the cover. Tighten the capscrews to a torque of 25 - 40 in.-lb. (Fig. 46).

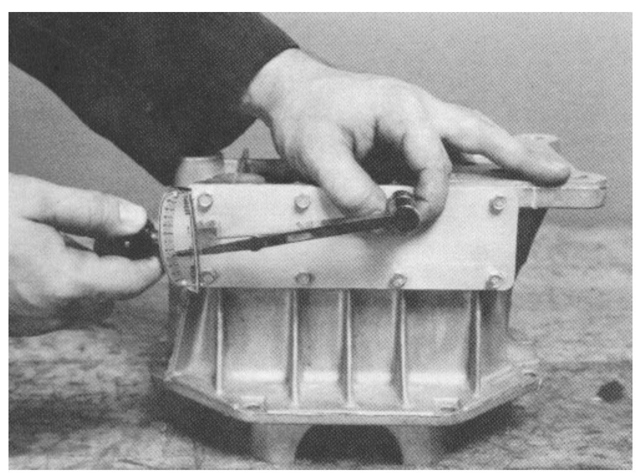

Figure 46

13. Place the differential case in a vise as shown (Fig. 47). Apply grease to new side gear thrust washers and hubs of the side gears. Apply grease to new pinion mate spherical washers and pinion mate gears. Place the side gears and thrust washers in the case. Install the pinion gears while holding the side gears in place.

Rotate the side gears until the holes of the washers and pinion gears line up with the holes of the case. If the gears cannot be rotated by hand, install one of the axle shafts into the side gear spline and use a pipe wrench to turn the shafts.

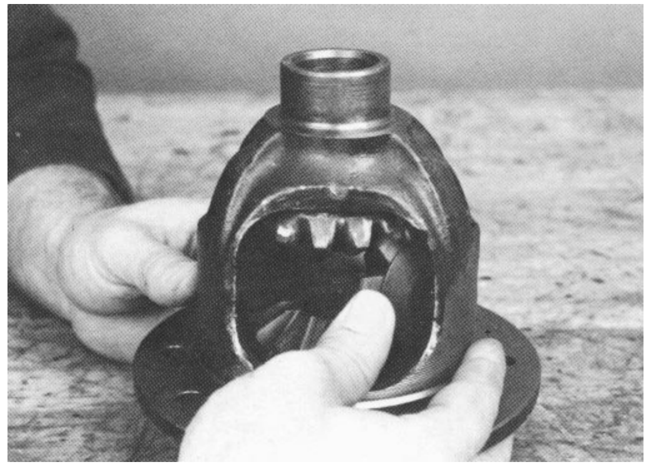

Figure 47

14. Install the pinion shaft. Grease the shaft to aid assembly. Be sure the hole in the pinion shaft lines up with the hole in the differential case (Fig. 48).

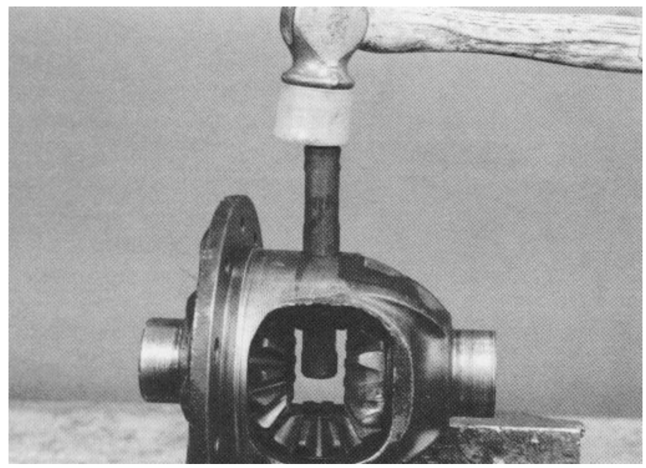

Figure 48

15. Assemble the lock pin. Drive the pin to the approximate center location of the pinion mate shaft. Peen the metal of the case to lock the pin in place (Fig. 49).

Figure 49

16. Put the ring gear onto the differential case and start the new capscrews into the gear with your fingers. Tighten the screws, alternating back and forth across the gear to allow the gear to be pulled evenly into place. Tighten the cap screws to a torque of 45 - 65 ft-lb (6.2 - 9.0 KgM) (Fig. 50).

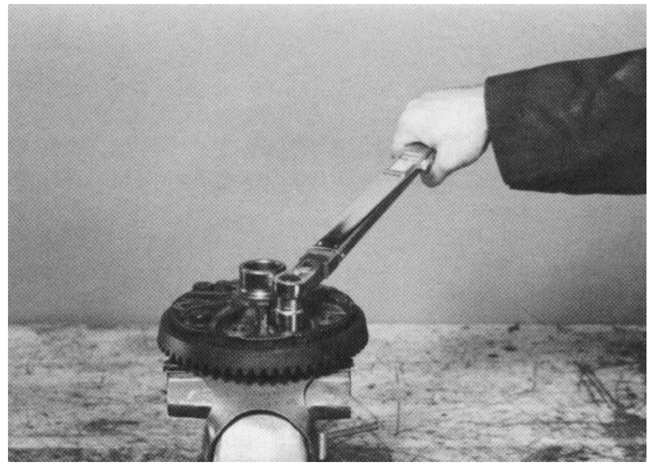

Figure 50

17. When installing new differential bearings, reuse the original shims or use new shims of the same thickness. Press the bearing onto the differential case. If a new differential case is being installed, start with a .020 inch pack of shims under each differential bearing. Shims are available in .003, .005, .010, and .030 inch sizes (Fig. 51).

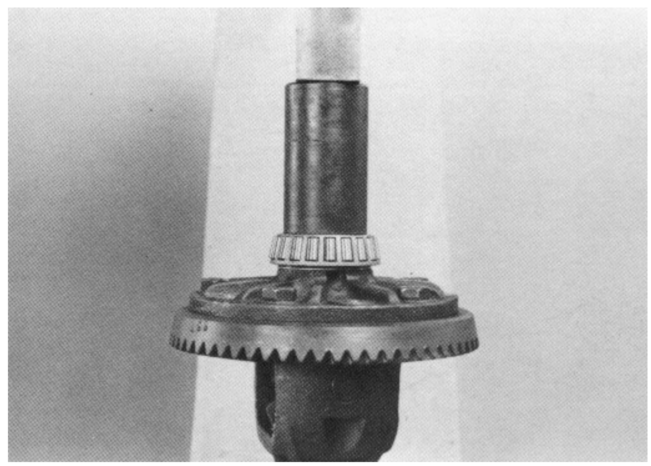

Figure 51

18. Assemble new differential bearing cups to differential bearing cones. Seat differential assembly with drive gear on proper side of carrier into carrier bearing cradles.

NOTE: Groundsmaster 220-D/223-D application requires that the ring gear teeth face away from the spur gear cover.

The bearing cradles are designed to apply a slight preload to the bearings. It is important to push both of the bearing assemblies simultaneously into their saddles.

Bearing caps must be installed with indexing marks “P” adjacent to indexing marks “P” in case. Install the bearing caps into their original position as previously marked. Tighten the cap screws to a torque of 30 - 45 ft-lb (4.1-6.2 KgM) (Fig. 52).

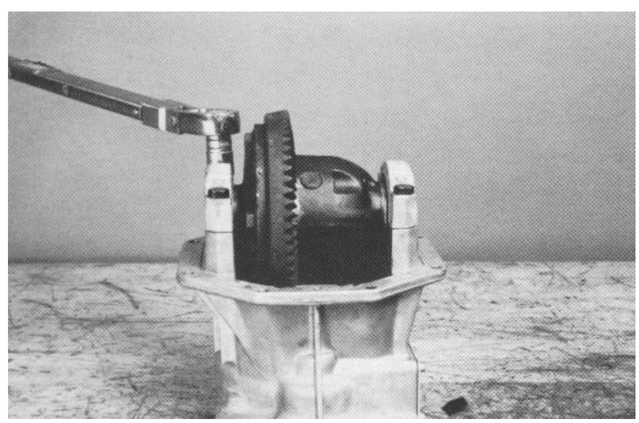

Figure 52

19. Using a dial indicator, check the ring gear backlash in three equally spaced points. Ring gear backlash should be .003 - .007 inch (.076 - .178 mm) and must not vary more than .002 in. between points checked (Fig. 53).

If the backlash is not in this range, move the shims which are located beneath the differential bearings, from one side to the other until the correct backlash is attained.

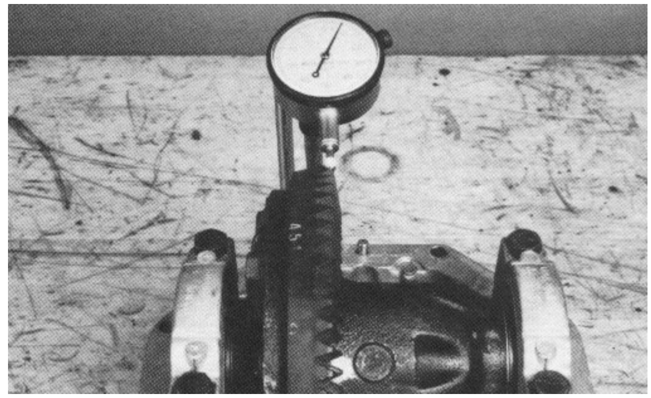

Figure 53

Checking Ring Gear Pattern

Final position of pinion is verified by using the gear contact pattern method as described in the following procedure.

Gear tooth **Toe** - the portion of the tooth surface at the end towards the center.
Gear tooth **Heel** - the portion of the gear tooth at the outer end.
Gear tooth **Top Land** - top surface of tooth.

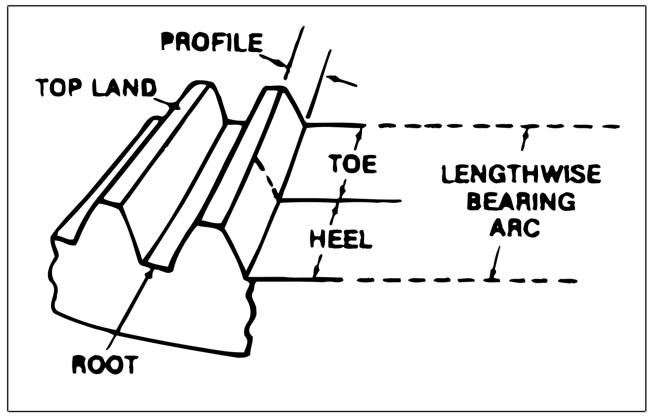

Figure 54

Every gear has a characterisitc pattern. The illustrations show typical patterns only and explaing how patterns shift as gear location is changed. When making pinion position changes, shims should be changed in the range of .002 inch to .004 inch until a correct pattern has been obtained.

When a change in backlash is required, backlash shims should be changed in the range of 1-1/2 times the amount of backlash required to bring the gears into specification. For example, if the backlash needed to be changed by .004 inch, the shim pack should be changed by .006 inch as a starting point.

High backlash is corrected by moving the ring gear closer to the pinion. Low backlash is corrected by moving the ring gear away from the pinion. These corrections are made by switching shims from one side of the differential case to the other.

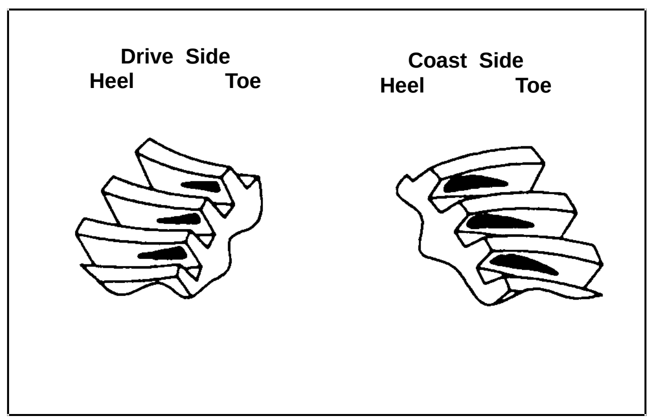

Figure 54A

To check the ring gear and pinion pattern:

1. Paint the teeth of the ring gear, both drive and coast side, with a gear marking compound, such as DyKem Steel Blue.

2. While applying a light load to the ring gear, rotate the pinion gear until the ring gear has made one complete revolution. Study the patterns in the following illustrations and correct as necessary.

The preferred pattern is shown in Figure 54A. The drive side pattern should be located at the toe portion of the tooth. The coast pattern should also be at the toe portion of the tooth.

NOTE: When making changes, note that two variables are involved. Example: If you have the backlash set correctly to specifications and you change the pinion position shim, you may have to readjust backlash to the correct specification before checking the pattern.

Backlash correct. Thicker pinion position shims required.

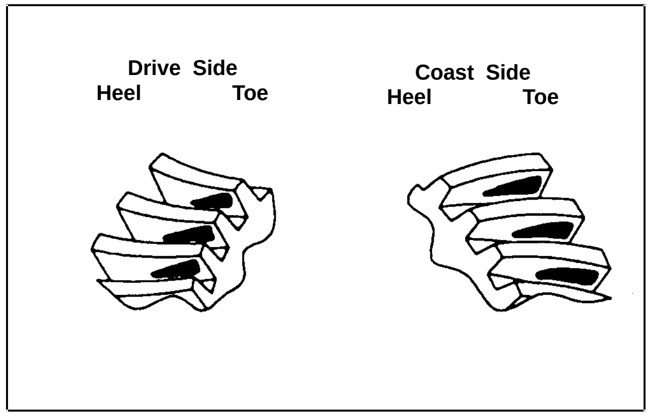

Figure 55

Backlash correct. Thinner pinion position shims required.

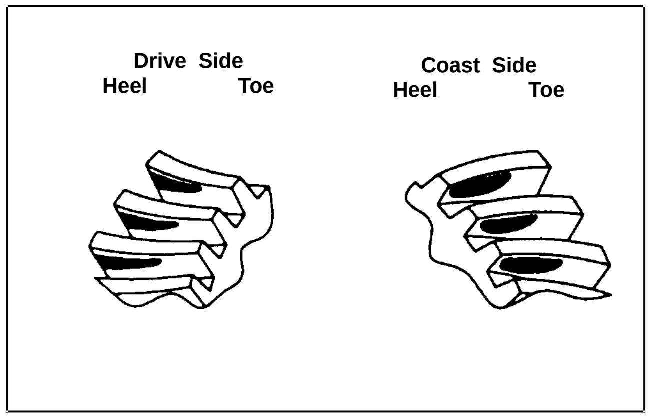

Figure 56

Backlash incorrect. Thinner pinion position shim required. Adjust backlash to match.

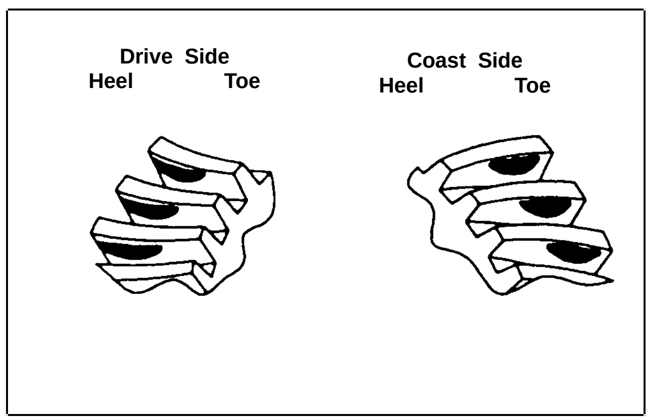

Figure 57

Gear Pattern Movements Summary

1. Decreasing backlash moves the ring gear closer to the pinion.

Drive pattern (convex side of gear) moves lower and toward the toe.

Coast pattern (concave side of gear) moves slightly higher and toward the heel.

2. Increasing backlash moves the ring gear away from the pinion.

Drive pattern moves higher and toward the heel.

Coast pattern moves slightely lower and toward the toe.

3. Thicker pinion position shim with the backlash constant moves the pinion closer to the ring gear.

Drive pattern moves deeper on the tooth (flank contact) and slightly toward the toe.

Coast pattern moves deeper on the tooth and toward the heel.

4. Thinner pinion position shim with backlash constant moves the pinion further from the ring gear.

Drive pattern moves toward the top of the tooth (face contact) and toward the heel.

Coast pattern moves toward the top of the tooth (face contact) and toward the heel.

Apply silicone sealant between the front and rear axle housings and install the eight housing cap screws. Tighten the cap screws to a torque of 18 - 23 ft-lb (2.5 - 3.2 KgM) (Fig. 58).

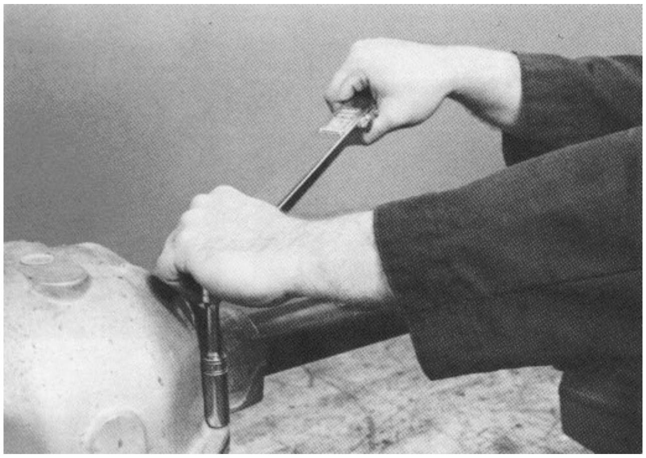

Figure 58

Chapter 7

Wheels and Tires

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Specifications

Standard	Item	Description
Traction Unit		
Tire Front	4-ply rating, tubeless extra traction tread	23" x 8.50 - 12
Tire, Rear	4-ply rating, tubeless ribbed tread	16" x 6.50 - 8
Rim, Front	Demountable	12 inches (305 mm)
Rim, Rear	Welded, stamped steel	8 inches (203 mm)
Wheel Base	——	46 inches (1168 mm)
Tread Width, Front Wheels	Centerline	35.25 inches (895 mm)
Tread Width, Rear Wheels	Centerline	33.5 inches (851 mm)
Wheel Bearings, Front and Rear	Tapered roller	.002 - .005 inch (.051 - .127 mm) end play
Tire Pressure, Front and Rear	——	10-15 psi (69-103 kPa)
Lug Nut Torque	——	45 - 55 ft-lb (6.2 - 7.6 Kgm)
Toe-In	Measurement taken at front and rear of REAR tires	0 - .125 inch (0 - 3 mm)
Cutting Unit		
Wheels, Front Castor	Hard plastic with greaseable roller bearings	8.0 inches (203 mm)
	Optional, pneumatic with greasable roller bearings	8.62 inches (219 mm)
Rim, Pneumatic Castor	Demountable	4 inches (102 mm)
Tire, Pneumatic Castor	4-ply rating w/tube, sawtooth tread	8.62" x 2.80/2.50
Tire Pressure, Pneumatic Castors	——	10-15 psi (69-103 kPa)
Deck Rollers, Front	Hard plastic	3.0 inches (76 mm)
Deck Rollers, Rear	Hard plastic	3.0 in. x 6.1 in. (76 mm x 155 mm)

Traction Unit Maintenance

Front Wheel Bearings (Axle Shaft Bearings)

The front wheel bearings (axle shaft bearings) are lubricated at the factory and do not require maintenance.

Rear Wheel Bearings

Disassemble, clean, repack and adjust the rear wheel bearings after each 500 hours of operation or once a year. (See the Traction Unit Repair section of this chapter.)

Tires

Inspect the front and rear tires for wear and proper inflation after each 25 hours of operation. Inflate both the front and rear tires to 10-15 psi (69-103 kPa) air pressure.

Lug Nuts

Check the front wheel lug nuts for the proper torque after the initial 10 and 100 hours of operation. Check the torque after the initial 250 hours of operation and every 250 hours after that. The front wheels are secured with 1/2"-20 nuts tightened to a torque of 45 - 55 ft-lb (6.2 - 7.6 KgM).

Toe-in

Check the rear wheel toe-in after each 250 hours of use and adjust as necessary. (See Traction Unit Repairs in this chapter.)

Traction Unit Repair

Repairing Flat Tires or Blow-Outs

If there is a tire failure, standard tubeless tire repair or replacement procedures should be followed. In certain operating environments, it may be desirable to use inner tubes or a urethene tire filling material, such as B.F. Goodrich "Tyrfill". Contact the local B.F. Goodrich representative for further information

Front Wheel Bearing Service

See Axle Shaft Dissassembly and Wheel Bearing Service in the Repairs section of Chapter 6 - Differential.

Replacing or Repacking Rear Wheel Bearings

Disassemble, clean, repack and adjust the rear wheel bearings after each 500 hours of operation or once a year. Use No. 2 general purpose lithium base grease containing E.P. additive. If operating conditions are extremely dusty and dirty, it may be necessary to perform this maintenance more often.

1. Jack up the rear of the machine until the tire is off the floor. Support the machine with jack stands or blocks to prevent it from falling.

2. Remove the dust cap from the end of the wheel spindle (Fig. 1).

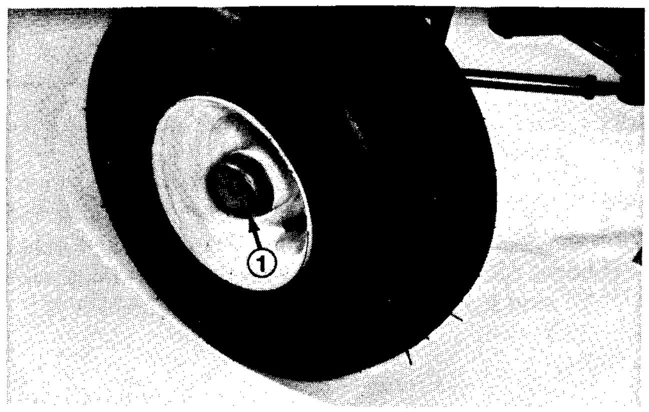

Figure 1

1. Dust cap

3. Remove the cotter pin, slotted nut, and washer. Slide the wheel off spindle shaft (Fig. 2).

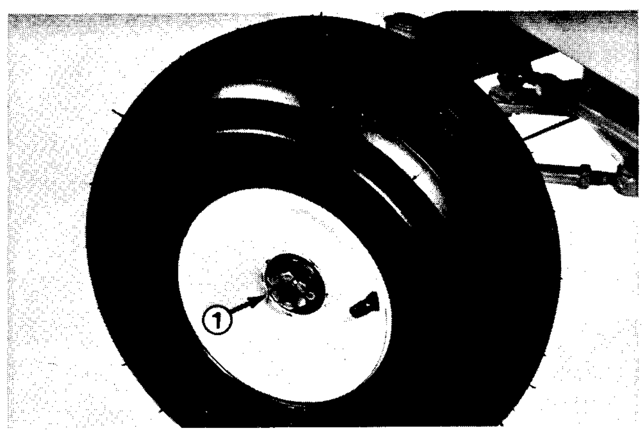

Figure 2

1. Cotter pin and slotted nut

4. Pull the seal out of the wheel hub (Fig. 3).

5. Remove the bearings from both sides of the wheel hub. Clean the bearings in solvent. Make sure the bearings are in good operating condition. Clean the inside of the wheel hub. Check the bearing cups for wear, pitting or other noticeable damage. Replace worn or damaged parts.

6. If bearing cups were removed from the wheel hub, press them into the hub until they seat against the shoulder. (Fig. 4)

7. Pack both bearings with grease. Install one bearing into the cup on inboard side of the wheel hub. Lubricate the inside of the new lip seal and press it into the wheel hub (Fig. 3).

IMPORTANT: The lip seal must be pressed in so it is flush with the end of the hub. The lip of the seal must be toward the bearing.

8. Pack inside of wheel hub with some grease (not full). Install remaining bearing into the bearing cup.

9. Slide the wheel onto the spindle shaft and secure it in place with the flatwasher and slotted nut (Fig. 2). DO NOT tighten the nut or install the cotter pin.

10. Adjust preload on the wheel bearings. (See steps 3-5 under Adjusting Rear Wheel Bearings.)

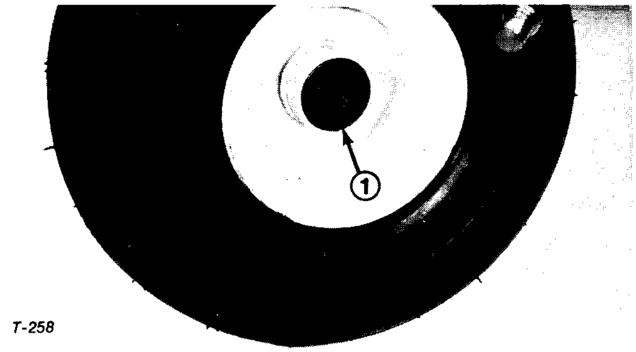

Figure 3

1. Seal

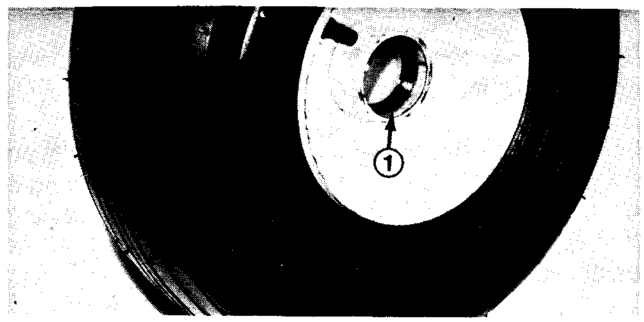

Figure 4

1. Bearing cup

Adjusting Rear Wheel Bearings

1. Jack up rear of machine until wheel is off the floor. Support the machine with jack stands or blocks to prevent it from falling.

2. Remove dust cap from end of wheel spindle. Also remove cotter pin retaining slotted nut in place (Fig. 1).

3. Rotate the wheel by hand and tighten the slotted nut (Fig. 5) until the bearing binds SLIGHTLY. Then, loosen the nut until the nearest slot and hole in the spindle line up. Reinstall the cotter pin to retain the slotted nut in place. NOTE: The correct end play of the adjusted assembly is .002 -. 005 inches (.051-.127 mm).

4. Remove jack stands or blocks and lower machine to floor.

5. Put a coating of grease on the inside of the dust cap. Install dust cap on the end of the wheel spindle (Fig. 1).

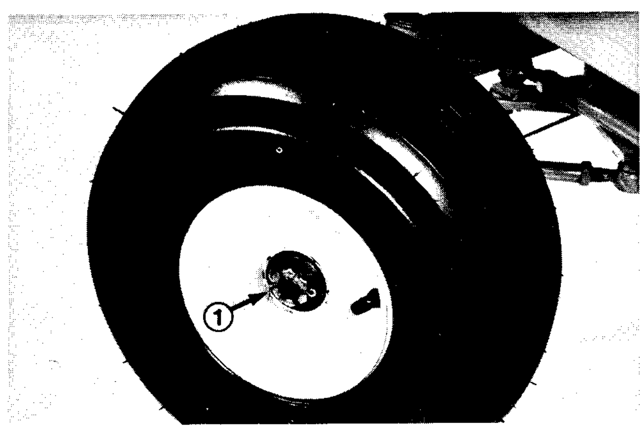

Figure 5

1. Cotter pin and slotted nut

Adjusting Rear Wheel Toe-In

The rear wheels should have 0 to 1/8 of an inch (3 mm) toe-in when they are pointed straight ahead. To check toe-in, measure the center-to-center distance, at wheel hub height, in front and in back of the rear tires. If toe-in is not within specifications, an adjustment is required.

1. Rotate the steering wheel so the rear wheels are straight ahead.

2. Loosen the jam nuts on both tie rods. Adjust both tie rods until center-to-center distance at front of rear wheels is 0 - 1/8 of an inch (0 - 3 mm) less than at the back of the rear wheels (Fig. 6).

3. When toe-in of rear wheels is correct, tighten jam nuts against tie rods (Fig. 6).

4. Turn the steering wheel full left (counterclockwise) so the steering cylinder is retracted all the way. The right rear spindle should be 1/16" (1.5 mm) to just touching the axle stop (Fig. 7). Loosen the jam nuts on the right tie rod and adjust as necessary.

5. Turn the steering wheel full right (clockwise) so the steering cylinder is extended all the way. The left rear spindle should be 1/16" (1.5 mm) to just touching the axle stop. Loosen the jam nuts on the left tie rod and adjust as necessary.

6. Check the toe-in again and adjust as necessary.

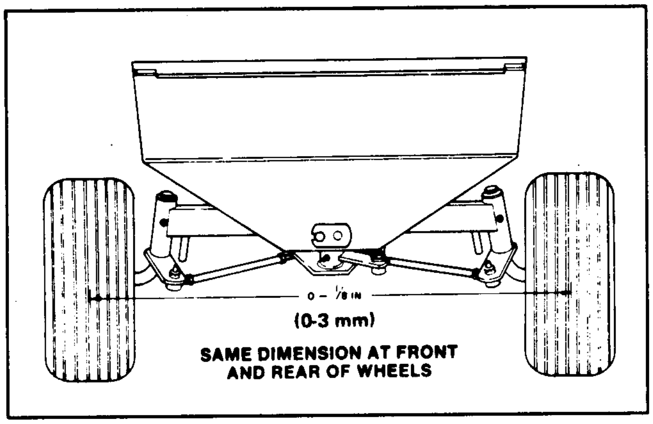

Figure 6

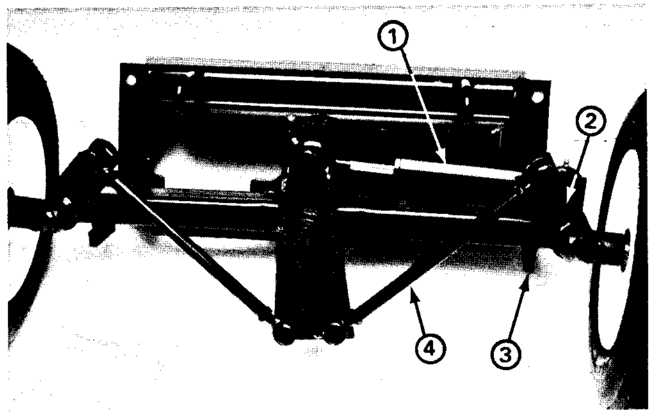

Figure 7

1. Steering cylinder
2. Spindle
3. Axle stop
4. Tie rod

Cutting Unit Maintenance

Lubrication

If the machine is operated under normal conditions lubricate the castor wheel bearings and castor spindle bearings after every 8 hours of operation or daily (Fig. 8). Use No. 2 general purpose lithium base or molybdenum base grease.

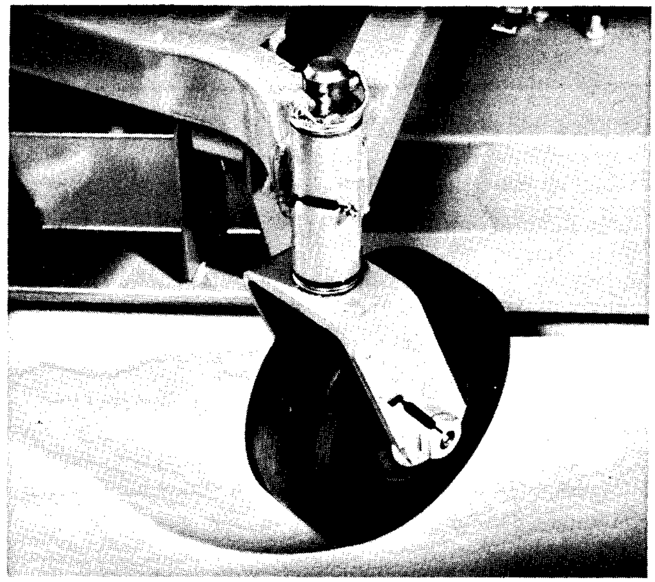

Figure 8

Castor Wheels (Solid Plastic)

Solid plastic castor wheels that are excessively worn must be replaced. (See Servicing Solid Plastic Castor Wheels in this chapter.) Castor wheels that are worn may be replaced with new wheels, using the old bearings, or the wheel and bearings may be replaced as one unit.

Castor Wheels (Pneumatic)

The tires should be inspected for wear and proper inflation after each 25 hours of use. Proper air pressure is 10-15 psi (69-103 kPa).

Tires that are excessively worn or damaged may be replaced with a new tire only, or the tire, wheel and bearings may be replaced as one unit. (See Servicing Pneumatic Castor Wheels in this chapter.)

Deck Rollers

Check the rollers periodically for free movement and no significant decrease in diameter. These rollers must rotate freely on their axle shafts to prevent damage to the grass. Replace any worn or damaged rollers or shafts. (See Servicing Deck Rollers in this chapter.)

Cutting Unit Repair

Tires (Pneumatic Castor Wheels)

In the event of a tire failure, standard tire and tube repair or replacement procedures should be followed.

Castor Wheel Repair (Solid Plastic)

Failure to keep the bearings lubricated will cause rapid wear. A wobbly castor wheel usually indicates a worn bearing.

1. Remove locknut from castor wheel axle. Hold castor wheel and pull axle out of fork (Fig. 9).

NOTE: Account for the two bearing retainers and thrust washers.

2. Tip wheel to the side and allow roller bearing and spanner bushing to fall out (Fig. 9).

3. Inspect the bearing, spanner bushing and inside of wheel hub for wear. Replace worn or damaged parts.

4. Slide the spanner bushing into the bearing. Pack the bearing with No. 2 grease. Insert the bearing with spanner bushing into the wheel.

5. Slide bearing retainer and thrust washer onto spanner bushing. Hold the castor wheel assembly between the mounting fork and install the axle and locknut. Tighten the axle and locknut until the spanner bushing bottoms against the inside of the fork.

6. Lubricate the castor wheel bearing through the grease fitting located on either the axle or wheel hub, using No. 2 general purpose grease (Fig. 8).

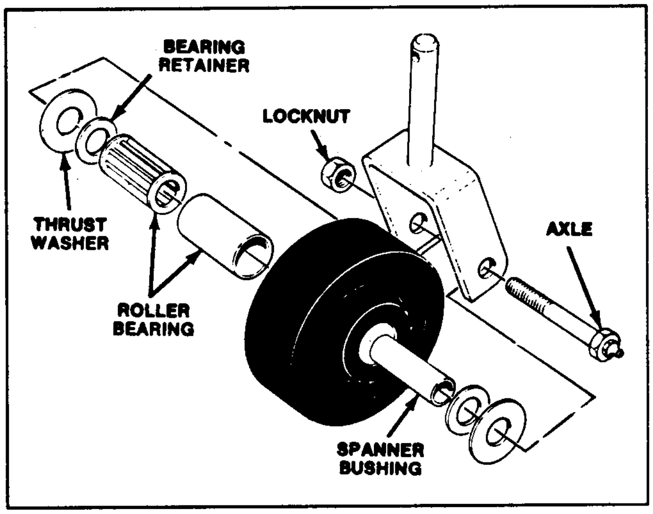

Figure 9

Castor Wheel Service (Pneumatic)

Failure to keep the bearings lubricated will cause rapid wear. A wobbly castor wheel usually indicates a worn bearing.

1. Remove locknut from castor wheel axle. Hold castor wheel and pull axle out of fork (Fig. 10).

NOTE: Account for the two bearing retainers

2. Tip wheel to the side and allow roller bearing and spanner bushing to fall out (Fig. 10).

3. Inspect the bearing, spanner bushing and inside of wheel hub for wear. Replace worn or damaged parts.

4. Slide the spanner bushing into the bearing. Pack the bearing with No. 2 grease. Insert the bearing with spanner bushing into the wheel.

5. Slide bearing retainer and thrust washer onto spanner bushing. Hold the castor wheel assembly between the mounting fork and install the axle and locknut. Tighten the axle and locknut until the spanner bushing bottoms against the inside of the fork.

6. Lubricate the castor wheel bearing through the grease fitting located on wheel hub, using No. 2 general purpose grease (Fig. 8).

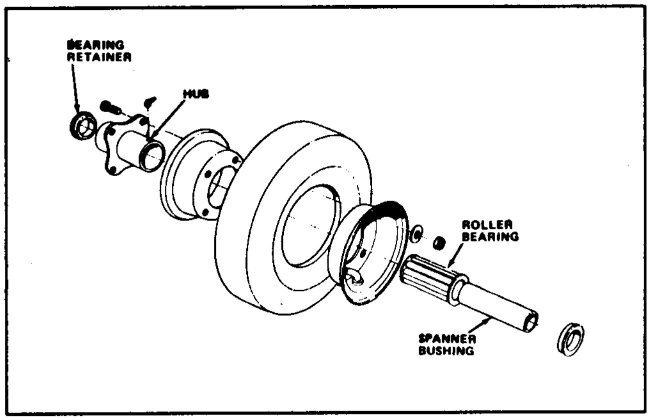

Figure 10

Deck Roller Service

1. Raise the cutting unit to its highest position, engage the parking brake, and turn the engine OFF.

2. Make sure the P.T.O. lever is in the DISENGAGED position. Support the cutting unit with blocks to prevent it from falling.

3. Remove one of the cotter pins that secure the roller shaft in place on the deck. Pull the roller shaft out of the deck through the roller(s) (Fig. 11).

4. Inspect the roller(s) and shafts(s) for wear and straightness. Replace any worn or damaged parts.

5. Hold the roller(s) between the mounting brackets and insert the shaft. Install the cotter pin.

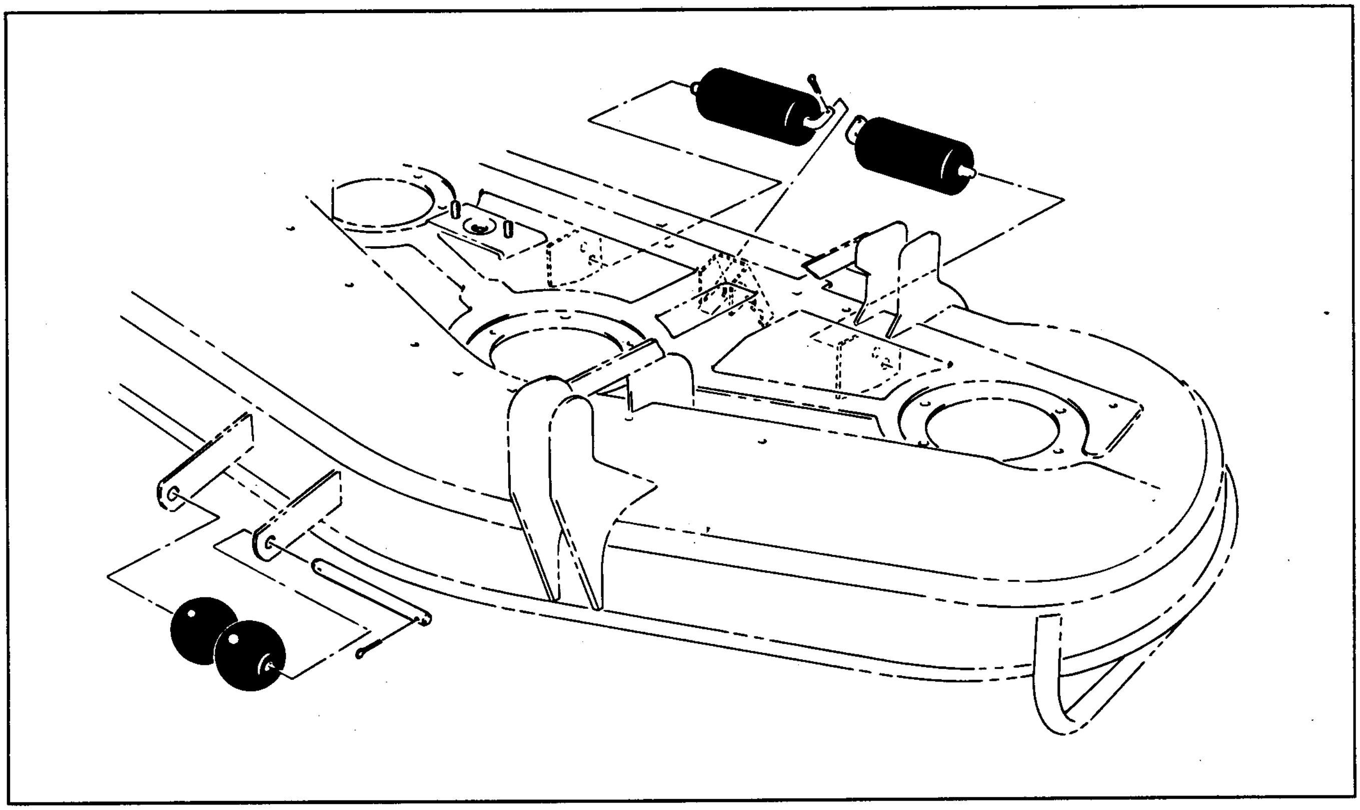

Figure 11

Steering System

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Introduction

The Groundsmaster® 220-D is equipped with power steering. The power steering valve is enclosed in the steering tower at the front of the traction unit. As the steering wheel is turned, the steering valve meters hydraulic fluid to the double-acting steering cylinder on the rear axle and turns the wheels. Hydraulic fluid flow for power steering is supplied by the hydrostatic transmission charge pump. The steering valve is designed so that it provides priority flow for steering.

The Model HGF Hydraguide ™ steering valve (Fig 1.) is manufactured by TRW, Ross Gear Division.

NOTE: Because the steering cylinder has different displacements when extended and retracted, the steering wheel will not return to its original position after making a turn.

NOTE: The steering system will operate with the engine off if necessary (with increased effort).

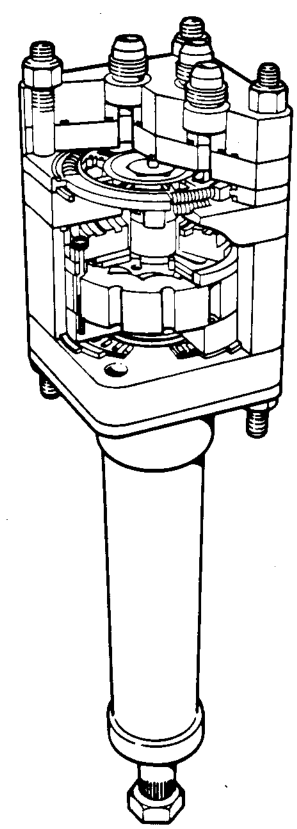

Figure 1

Schematics

When the steering wheel is turned to the right (Fig. 2), the control valve within the steering valve shifts to close the "AUX" port. This directs oil supplied by the hydrostatic transmission charge pump to the metering section of the steering valve. As the steering wheel is turned, system oil is metered out port "RT" to the steering cylinder. Oil displaced by the other end of the steering cylinder returns to the steering valve through port "LT" and is directed out port "OUT" back to reservoir.

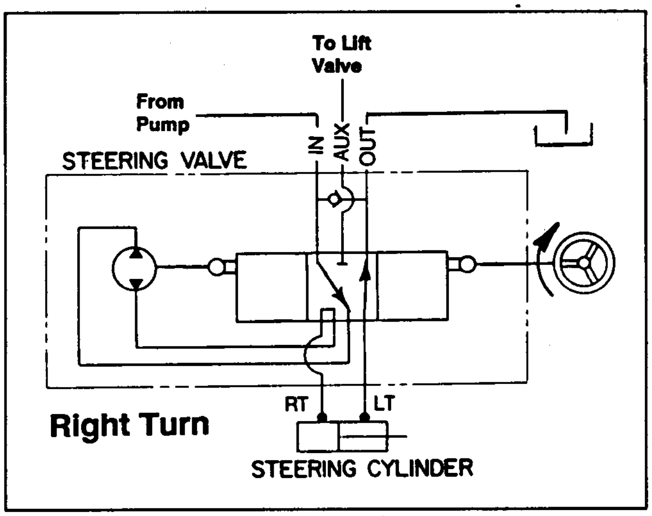

Figure 2

When the steering wheel is stationary, the control valve within the steering valve shifts back to neutral (Fig. 3), allowing system oil to flow through the steering valve and out the "AUX" port to the implement and cooling circuit. Oil in the rest of the steering circuit is then trapped.

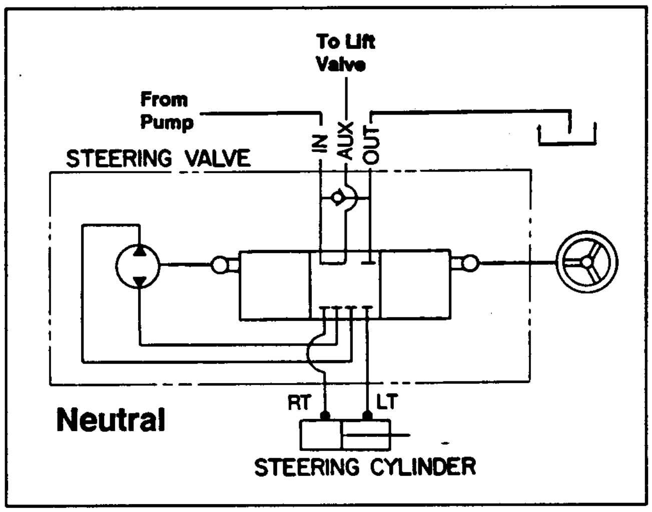

Figure 3

When the steering valve is turned to the left (Fig. 4) oil is metered out port "LT" to the steering cylinder. Oil displaced by the other end of the cylinder returns to the steering valve through port "RT" and is directed out port "OUT" back to reservoir.

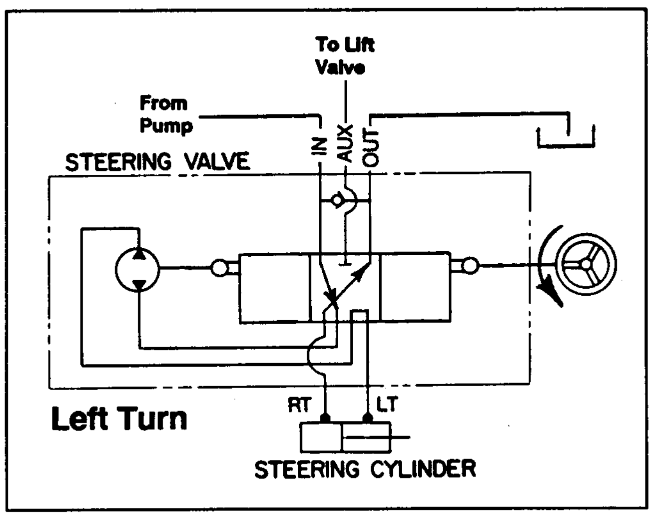

Figure 4

Special Tools

Steering Valve Service Fixture

To avoid distorting or damaging the steering valve when repairing, do not clamp it directly into a vise. Fabricate a service fixture (Fig. 5) and use it as instructed (See Steering Valve Service in the Repairs section of this chapter).

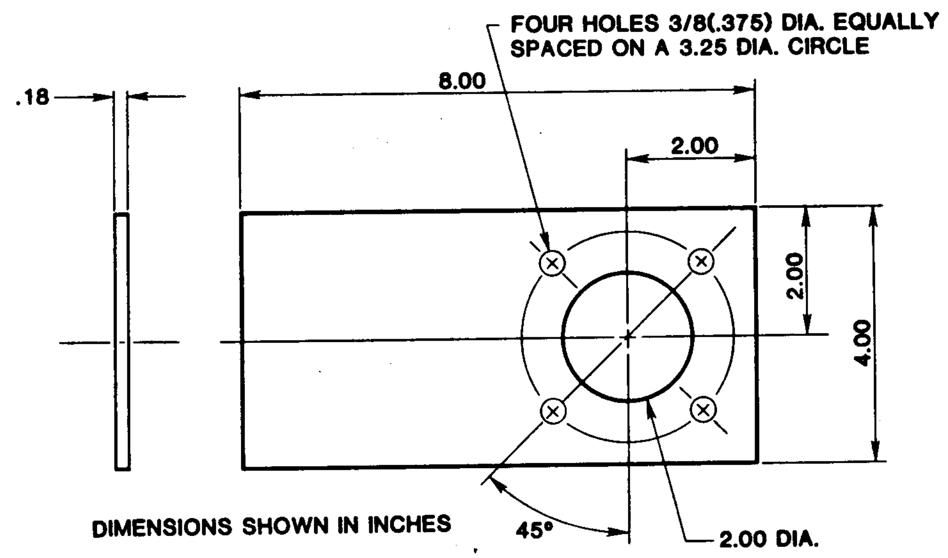

Figure 5

Maintenance

Lubrication

Lubricate the rear axle pivot, steering pivot, spindles and steering cylinder at the fittings shown after each 25 hours of operation (Fig. 6 and 7). Clean grease fittings before adding grease. Add grease until lubricant begins to seep out. Wipe off excess grease. Use No. 2 general purpose lithium-base grease.

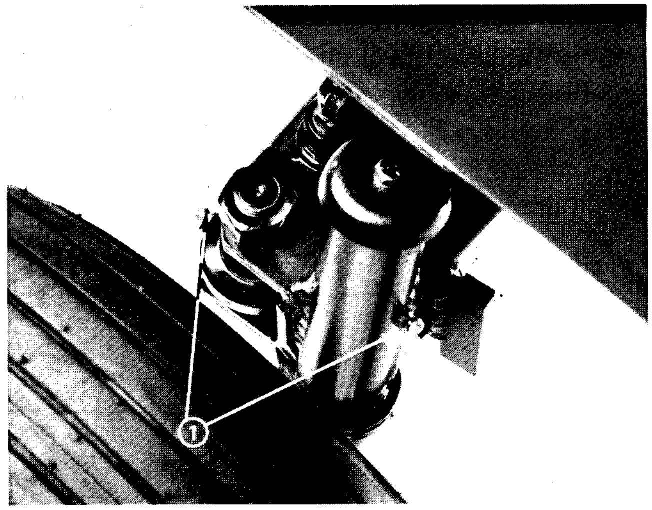

Figure 6

1. Spindle and steering cylinder

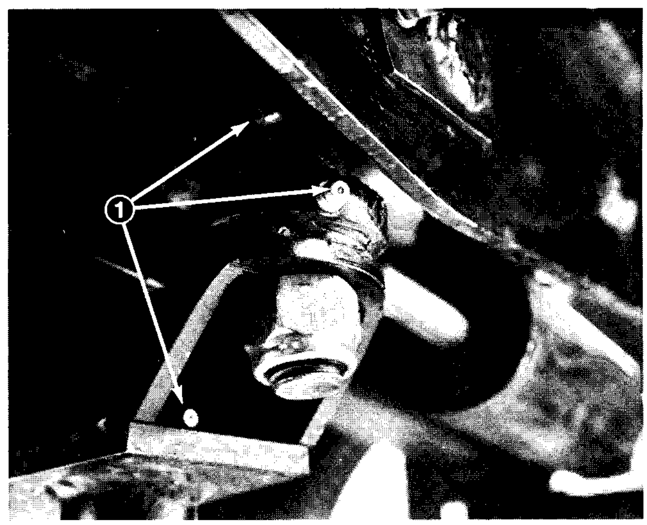

Figure 7

1. Rear axle pivot, steering pivot and cylinder

Inspection

Check the following items for excessive wear after each 250 hours of operation:

1. Rear wheel toe-in. (See Chapter 7 - Wheels and Tires).

2. Rear wheel bearings. (See Chapter 7 - Wheels and Tires.)

3. Steering pivot bushings.

4. Spindle bushings.

Repair or replace worn or damaged parts as necessary.

Troubleshooting

Problem	Possible Causes
Steering Wander	Tire pressure incorrect or unequal left to right. Loose or worn steering linkage. Improperly adjusted or worn rear wheel bearings. Rear wheels out of alignment; toe-in / toe-out. Internal leakage of steering cylinder.
Poor or No Returnability (Recovery)	Improper rear wheel alignment; toe-in. Steering linkage binding. Low tire pressure. Steering column binding or out of alignment.
Shimmy	Steering linkage loose, worn or out of adjustment. Wheel bearings out of adjustment. Air in hydraulic system. Internal leakage of steering cylinder.
High Steering Effort in One Direction	Low hydraulic system pressure. Excessive heat causing steering valve plate valve to stick (See Excessive Heat in this section).
High Steering Effort in Both Directions	Low hydraulic fluid level. Low flow or pressure from hydrostatic transmission charge pump. Steering linkage binding. Restriction in hydraulic return line.

Problem	Possible Causes
Steering Wheel Lash (Free Movement)	Steering wheel loose on column. Steering linkage loose or worn. Steering valve loose at mounting. Air in hydraulic system. Internal leakage in hydraulic cylinder.
Excessive Heat in Hydraulic System	Undersized replacement hose or tube line. Kinked or severely bent hose or tube line. Restricted oil cooler. Restricted recentering of steering valve control valve plate. Lift control valve linkage out of adjustment.

Steering Valve Test (Control Valve Section)

1. Engage the parking brake and block the front wheels to prevent movement of the machine. Lower the cutting unit or implement to the floor and turn the engine OFF.

2. Raise the seat and secure with the seat support rod. For better access, disconnect the seat support rod and remove the seat and seat mounting plate.

3. Place a drain pan on the floor beneath the hydrostatic transmission. Disconnect the hydraulic hose at the charge pump outlet (pressure) fitting (Fig. 8).

4. Connect the inlet hose of the tester to the hydraulic fitting on the transmission and the outlet hose of the tester to hose that was disconnected in step 2.

IMPORTANT: Make sure that the oil flow indicator arrow on the flow gauge is showing that the oil will flow through the tester from the charge pump to the steering valve.

5. Make sure that the tester load valve is fully open (counterclockwise). Start the engine and allow it to run for approximately 5 minutes so that the hydraulic oil reaches normal operating temperature.

6. With the tester load valve fully open (counterclockwise) run the engine at full throttle.

7. Turn the steering wheel all the way to the right (clockwise) and hold it against the right stop. Look at the flow meter. There should be no flow as the steering wheel is held against the right stop. Flow should be approximately 3 gpm when the steering wheel is released. Repeat this procedure with the steering wheel all the way to the left (counterclockwise). If flow does not return to approximately 3 gpm when the steering wheel is released the control valve within the steering valve may be sticking.

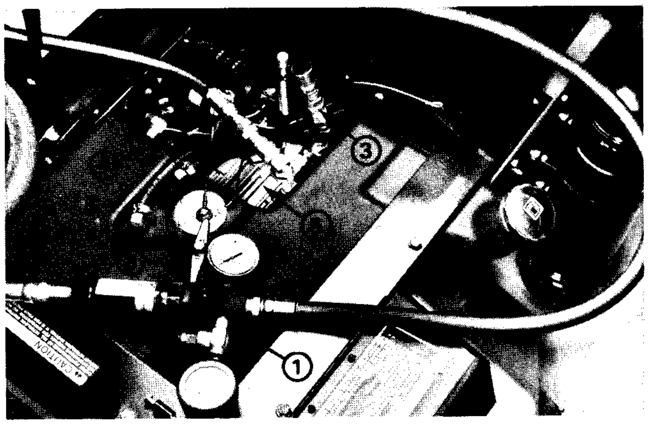

Figure 8

1. Tester
2. Load valve
3. Inlet line to tester
4. Return line from tester
5. Hydrostatic transmission

If a Hydraulic Tester is Not Available

1. Engage the parking brake.

2. Run the engine at full throttle.

3. Turn the steering wheel all the way to the right (clockwise) and hold it against the stop. Pull the lift control lever back to raise the implement while holding the steering wheel against the stop. The implement should NOT raise until the steering wheel is released. Repeat this procedure with the steering wheel turned all the way to the left (counterclockwise). If the implement raises slowly, or not at all when the steering wheel is released, the control valve within the steering valve may by sticking. When turning the steering wheel, the wheels must move from stop to stop. The wheels must move smoothly in both directions.

Steering Cylinder Internal Leakage Test

1. Engage the parking brake.

2. Turn the steering wheel all the way to the left (counterclockwise) so the steering cylinder rod is retracted all the way.

3. Turn the engine OFF.

4. Disconnect the hydraulic hose from the fitting on the barrel end of the cylinder (Fig. 9). Put a plug in the end of the hose to prevent contamination.

5. With the engine off, continue turning the steering wheel to the left (counterclockwise) against the stop and observe the open fitting on the steering cylinder. If oil comes out of the fitting while turning the steering wheel to the left, the steering cylinder has internal leakage and must be repaired or replaced.

NOTE: DO NOT turn the steering wheel to the right (clockwise) or the steering valve will meter oil out the disconnected hydraulic hose.

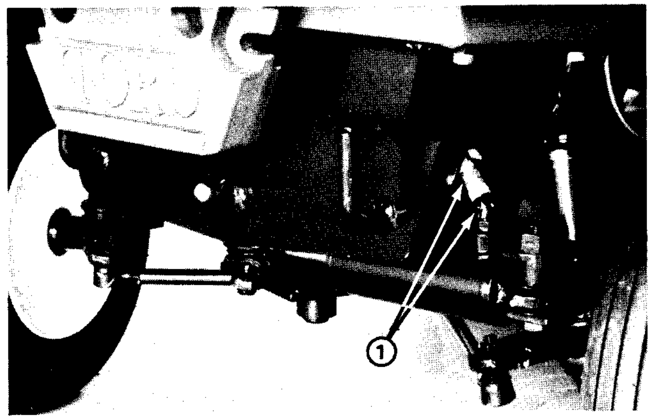

Figure 9

1. Hydraulic hose and fitting

Steering Wheel Removal and Installation

Removing the Steering Wheel

Remove the cover from the steering wheel hub. Remove the locknut that secures the steering wheel to the shaft (Fig. 8). Pull the steering wheel off the shaft.

NOTE: It may be necessary to use a jaw-type puller to remove the steering wheel from the steering shaft.

IMPORTANT: DO NOT hit the steering shaft with a hammer. This could damage the steering valve components.

Installing the Steering Wheel

1. Use the steering wheel to put the rear wheels in the straight ahead position.

2. Slide the steering wheel onto the steering shaft.

3. Secure the steering wheel in place with the lock nut (Fig. 10). Tighten the nut to 70 ft-lb (9.7 KgM).

4. Insert the tab on the decorative cover into the cutout in the steering wheel hub. Press the cover into the groove in the hub. A thin screwdriver may be helpful in seating the cap into the groove.

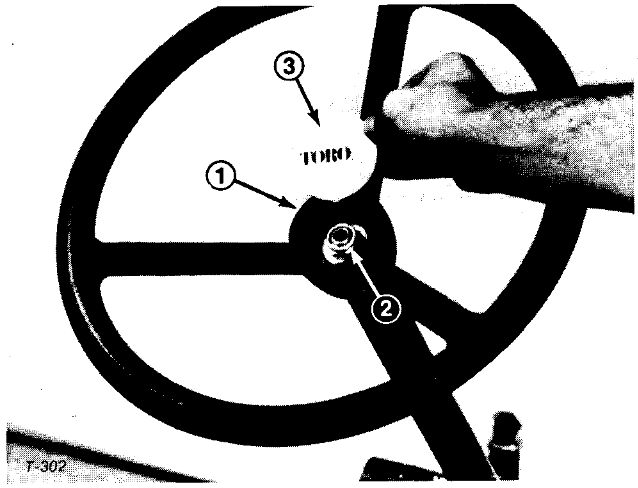

Figure 10

1. Cutout
2. Lock nut
3. Steering wheel cover

Axle Bushing Service

The rear axle must be held in place snugly by the axle pin. Excessive movement of the axle, which is characterized by erratic steering, usually indicates worn bushings. To correct the problem, replace the bushings.

1. Disconnect the hydraulic hoses from the steering cylinder. Put caps or plugs on all the fittings and hoses to prevent contamination.

NOTE: To ease reassembly, tag each of the hoses to show their correct position on the steering cylinder.

2. Remove the large lock nut from the end of the rear axle pin (Fig. 11).

3. Remove the cap screw securing the outside of the axle pin to the chassis.

4. Jack up the frame (just ahead of the rear wheels) until pressure is taken off the axle pin. Support the machine with jack stands to prevent it from falling.

5. Pull the axle pin out. This will release the rear axle and washer(s) from the frame. Carefully pull the entire axle and wheel assembly out from under the machine.

NOTE: Several washers may have been installed between the axle pivot tube and frame during manufacture. Make sure the same number of washers are installed during reassembly.

6. Use a drift punch and hammer to drive both bushings out of the axle. Clean the inside of the axle pivot tube to remove dirt and foreign material.

7. Apply grease to the inside and outside of the new bushing. Use an arbor press to install the bushings into the top and bottom of the axle pivot tube. Bushings must be flush with the axle tube.

8. Wipe the rear axle pin with a rag to remove dirt and grease. Inspect the pin for wear or damage and replace as necessary.

9. Mount the axle to the frame with the axle pin. The washer(s) must be positioned between the rear end of the pivot tube and the frame (see the NOTE after step 5). Secure the axle pin in place with the cap screw.

10. Install the lock nut on the end of the axle pin. Tighten the lock nut until the shoulder of the axle pin bottoms out. The axle must be free to pivot.

11. Remove the jackstands and lower the machine to the floor.

12. Install the hydraulic hoses to the steering cylinder.

13. Lubricate the rear axle bushings through the grease fitting on the rear axle (Fig. 7).

Steering Pivot Bushing Service

The steering pivot must fit snugly onto the mounting pin. Excessive movement of the steering pivot may indicate worn bushings or tie rod ball joints.

1. Remove the lock nut and cap screw securing the steering cylinder rod end to the steering pivot (Fig. 11).

2. Remove the cotter pins and slotted nuts from the tie rod ends that connect to the steering pivot. Separate the tie rod ends from the steering pivot. Inspect all tie rod end ball joints for wear or damage and replace as necessary.

3. Remove the snap ring and washers. Slide the steering pivot off of the mounting pin on the bottom of the axle.

4. Use a drift punch and hammer to drive both bushings out of the steering pivot. Clean the inside of the steering pivot to remove dirt and foreign material. Also clean the mounting pin on the bottom of the rear axle.

5. Apply grease to the inside and outside of the new bushings. Use an arbor press to install the bushings into the top and bottom of the steering pivot tube. Bushings must be flush with the end of the tube.

6. Slide the steering pivot onto the mounting pin. Secure the plate in place with the washer, flat washer and snap ring.

NOTE: If end play of more than 0.060 in. (1.5 mm) is evident between steering pivot tube and axle, put another washer (part no. 5-1226) between the snap ring and flat washer.

7. Slide the tie rod ends through appropriate holes in the steering pivot and secure the parts together with the slotted nuts. Tighten each nut to a torque of 25 - 33 ft-lb (3.5 - 4.6 KgM). Tighten each nut further if necessary until a slot in the nut lines up with the hole in the tie rod end. Install a new cotter pin through each nut and tie rod end.

8. Install the lock nut and cap screw to secure the steering cylinder rod end to the steering pivot. Tighten the nut to 200 - 220 ft-lb (28 - 30 KgM).

9. Lubricate the bushings through the grease fitting on the steering pivot (Fig. 7).

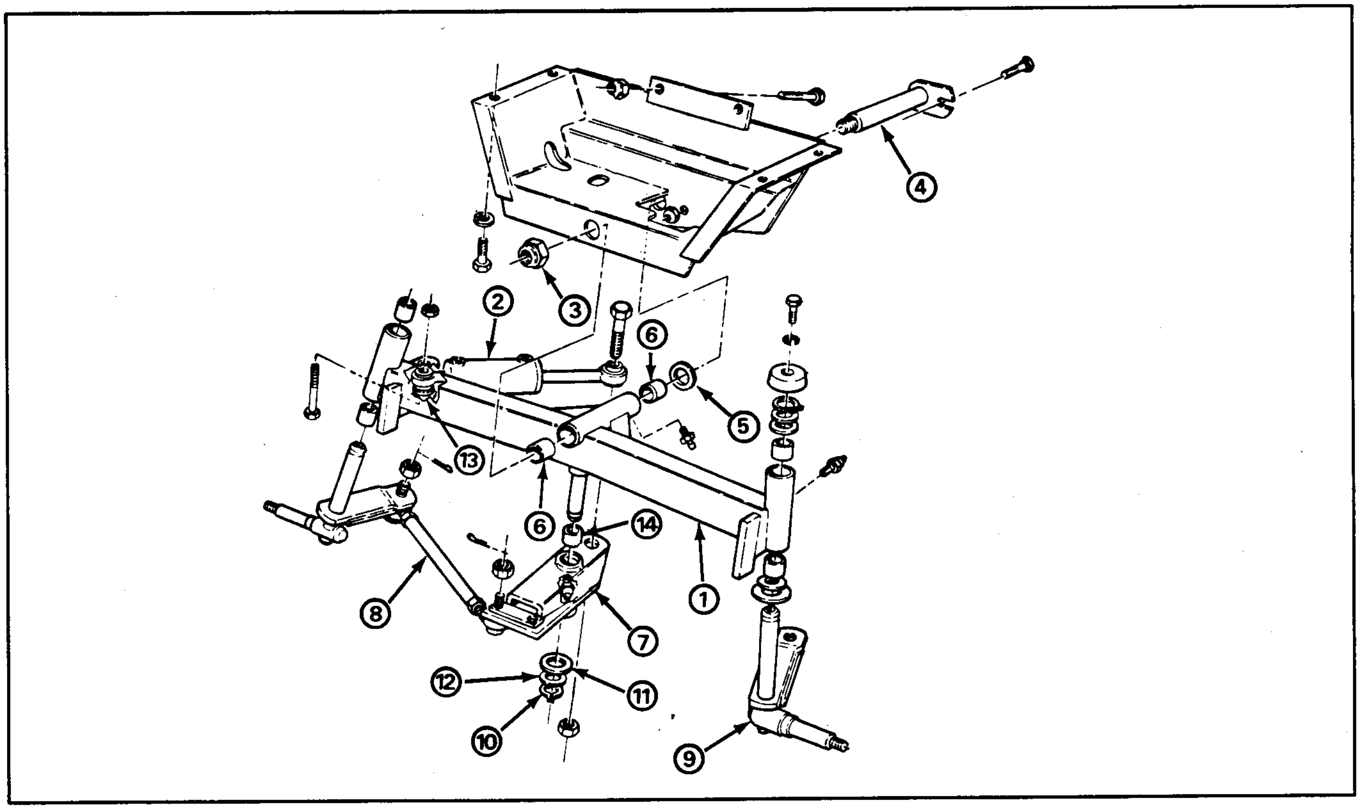

Figure 11

1. Rear axle
2. Steering cylinder
3. Lock nut
4. Rear axle pin
5. Washer
6. Axle bushings
7. Steering pivot
8. Tie rod
9. Wheel spindle
10. Snap ring
11. Washer
12. Flat washer (P/N 5-1226)
13. Cylinder spacer
14. Steering pivot bushings

Rear Wheel Spindle Bushing Service

The rear wheel spindles must fit snugly in the rear axle. Excessive movement of the spindle in the axle indicates that the bushings are probably worn and must be replaced.

1. Disconnect the hydraulic hoses from the steering cylinder. Put caps or plugs on the fittings and hoses to prevent contamination.

NOTE: To ease reassembly, tag each of the hoses to show their correct position on the steering cylinder.

2. Remove the large lock nut from the end of the axle pivot pin (Fig. 12).

3. Remove the cap screw that secures the outside of the axle pin to the chassis.

4. Jack up the frame (just ahead of the rear wheels) until pressure is taken off the axle pin. Support the machine with jackstands to prevent it from falling. Pull the axle pin out to release the rear axle and washer(s) from the frame.

NOTE: Several washers may have been installed between the axle pivot tube and frame during manufacture. Make sure the same number of washers are installed during reassembly.

5. Carefully roll the entire rear axle and wheel assembly out from under the machine.

6. Remove the cotter pin and slotted nut that connects the tie rod end to the wheel spindle arm. Separate the tie rod end from the spindle arm.

7. Remove the cover from the top of the spindle.

8. Remove the snap ring and washers that secure the wheel spindle into the axle tube. Slide the spindle and wheel assembly out of the axle tube to expose the bushings.

9. Use a punch and hammer to drive both bushings out of the axle tube. Clean the inside of the axle tube to remove any dirt and foreign material.

10. Apply grease to the inside and outside of the new bushings. Use an arbor press to install the bushings into the top and bottom of the axle tube. The bushings must be flush with the axle tube.

11. Wipe the spindle shaft with a rag to remove any dirt and grease. Inspect the spindles for wear and replace as necessary.

12. Install a washer onto the spindle shaft and push the shaft through the axle tube. Hold the wheel and spindle shaft assembly in place and install the washer flat washer and snap ring onto the end of the spindle shaft.

13. Install the cover on top of the spindle with the cap screw and lock washer.

14. Connect the tie rod end to the spindle bracket with the slotted nut. Tighten the nut to a torque of 25 - 33 ft-lb (3.5 - 4.6 KgM). Tighten the nut further if necessary until a slot in the nut lines up with the hole in the tie rod end. Install a new cotter pin through the nut and tie rod end.

15. Mount the axle to the frame with the axle pin. The washer(s) must be positioned the between the rear end of the pivot tube and the frame (see the NOTE after step 4). Secure the axle pin in place with the cap screw.

16. Install the large locknut on the end of the axle pin. Tighten the locknut until shoulder of the axle pin bottoms out. The axle must be free to pivot.

17. Remove the jackstands and lower the machine to the shop floor.

18. Install the hydraulic hoses to the steering cylinder.

19. Lubricate the steering spindle and rear axle pivot (Fig. 6 and 7).

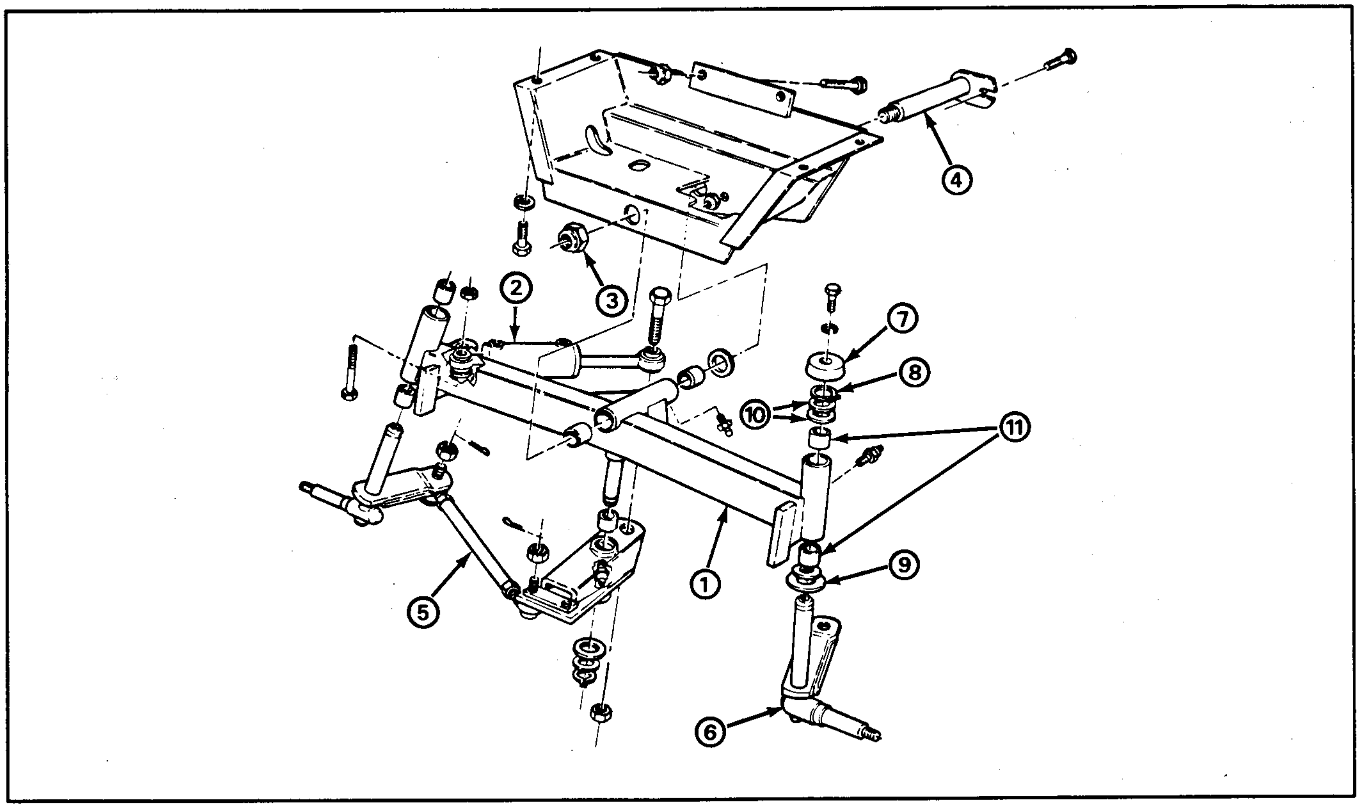

Figure 12

1. Rear axle
2. Steering cylinder
3. Lock nut
4. Rear axle pin
5. Tie rod
6. Wheel spindle
7. Cover
8. Snap ring
9. Washer
10. Flat washer (P/N 5-1226)
11. Bushings

Rear Wheel Bearing Service

See Chapter 7 - Wheels and Tires.

Steering Cylinder Removal and Installation

1. Disconnect the hydraulic hoses from the steering cylinder. Put caps or plugs on all the fittings and hoses to prevent contamination.

NOTE: To ease reassembly, tag each of the hoses to show their correct position on the steering cylinder.

2. Remove the lock nut and cap screw securing the rod end of the cylinder to the steering pivot (Fig. 13).

3. Remove the lock nut, cap screw and spacer securing the barrel end of the cylinder to the rear axle.

4. Remove the cylinder.

5. Reverse steps 1 - 4 to install the steering cylinder. Tighten the cap screw and nut securing the rod end of the cylinder to the steering pivot to 200 - 220 ft-lb (28 - 30 KgM).

6. After installing the cylinder, bleed the hydraulic system. (See Bleeding the Hydraulic System in the Repairs section of Chapter 4 - Hydraulic System.)

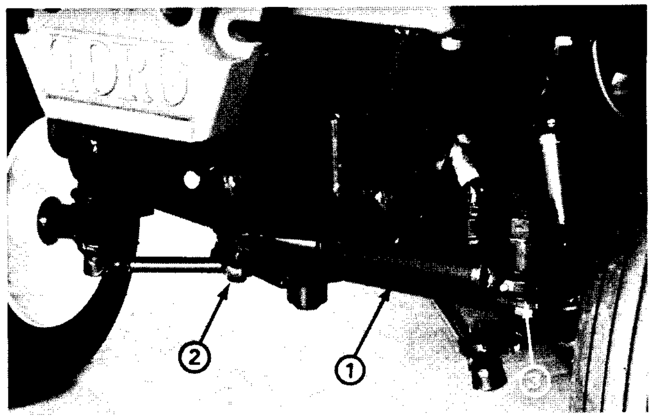

Figure 13

1. Steering cylinder
2. Lock nut and cap screw
3. Cylinder spacer

Steering Cylinder Service

IMPORTANT: To prevent damage when clamping the cylinder barrel or rod in a vise, clamp only on the pivot ends.

1. After removing the cylinder, pump the oil out of the cylinder into a drain pan by SLOWLY moving the cylinder's piston in and out of the cylinder bore.

2. Plug the ports and clean the outside of the cylinder.

3. Mount the cylinder in a vise so the rod end of the cylinder is tilted up slightly. Do not close the vise so firmly that the cylinder tube could become distorted.

4. Use a spanner wrench to unscrew (counterclockwise) the gland from the cylinder tube (Fig. 14).

5. Grasp the large end of the piston rod and use a twisting and pulling motion to carefully extract the piston, rod, and gland from the cylinder tube.

7. Securely mount the piston, rod, and gland into the vise so that the large nut is easily accessible for removal. Remove the nut by turning it counterclockwise.

IMPORTANT: Do not clamp the vise jaws against the smooth piston rod surface; the rod will become damaged.

8. Remove the piston. Slide the gland off of the piston rod.

9. Remove all seals and O-rings.

10. Wash the parts in a safe solvent. Dry the parts with compressed air. DO NOT wipe them dry with a cloth or paper as lint and dirt may remain.

11. Carefully inspect the internal surface of the tube for damage (deep scratches, out-of-round, etc.). Replace the tube if damaged. Inspect the gland, rod, and piston for evidence of excessive scoring, pitting, or wear. Replace any defective parts.

12. Put a light coating of oil on all new seals, and O-rings. Install the new seals and O-rings.

12. Install the gland onto the piston rod.

13. Install the piston onto the rod and tighten the hex nut to 30 - 34 ft-lb (4.1 - 4.7 KgM).

14. Put a light coating of oil on all cylinder parts to ease assembly.

15. Slide the piston rod assembly into the cylinder tube.

16. Install the gland into the tube and tighten by hand to properly engage the threads. Tighten the gland with a spanner wrench.

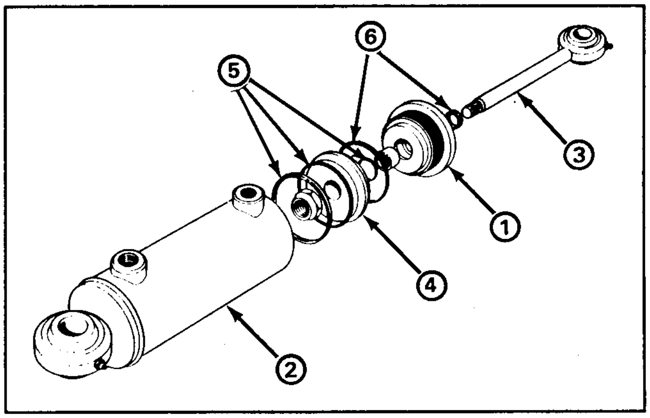

Figure 14

1. Gland	**4. Piston**
2. Cylinder tube	**5. Piston seals**
3. Piston rod	**6. Gland seals**

Steering Valve Removal and Installation

1. Remove the cutting unit from the carrier frame (see Separating Cutting Unit From Traction Unit in the Repairs section of Chapter 13 - Cutting Units).

2. Remove the cap screws from the steering tower covers and remove the covers from the steering tower.

3. Clean the outside of the steering valve and the area around the hydraulic fittings. Disconnect the hydraulic hoses and tube lines from the steering valve (Fig. 15). Put caps or plugs on all the fittings and hoses and tubes to prevent contamination.

NOTE: To ease reassembly, tag each of the hoses and tube lines to show their correct position on the steering valve.

4. Remove the steering wheel (see Steering Wheel Removal and Installation in this section of the book.)

5. Remove the u-bolt securing the steering column to the steering tower.

6. Remove the four nuts and washers securing the steering valve to the steering tower.

7. Carefully move the hydraulic lines to the side and pull the steering valve and column out through the bottom of the steering tower.

8. Reverse steps 1 - 7 to install the steering valve.

9. After installing the steering valve, bleed the hydraulic system. (See Bleeding the Hydraulic System in the Repairs section of Chapter 4 - Hydraulic System.)

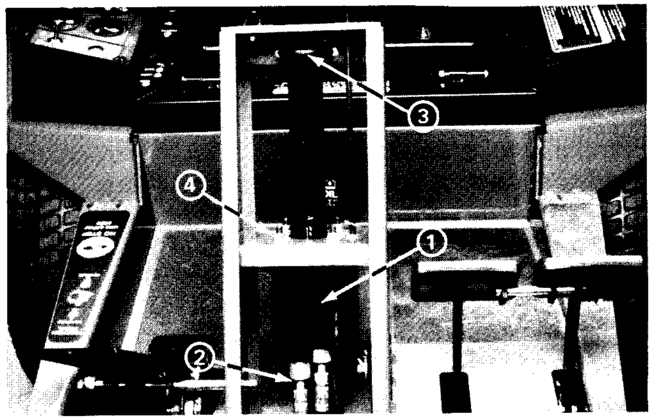

Figure 15

1. Steering valve
2. Hydraulic lines
3. U-bolt
4. Nuts and washers

Chapter 9

Brake System

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Brake Cable Replacement 7
Parking Brake Rack Replacement 7

Introduction

The Groundsmaster® 220-D is equipped with Bendix 7 inch diameter x 1-3/4 inch wide mechanical drum brakes on the front wheels (Fig. 1).

Two pedals are used to control the brakes. When used separately, the pedals can control each wheel brake to assist steering. The two pedals may be locked together with the brake lock arm (Fig. 2). When the lock arm is engaged both wheels will brake equally and act as a service brake or parking brake.

The brake pedals operate the brakes through a cable system to a strut and lever on the brake shoes.

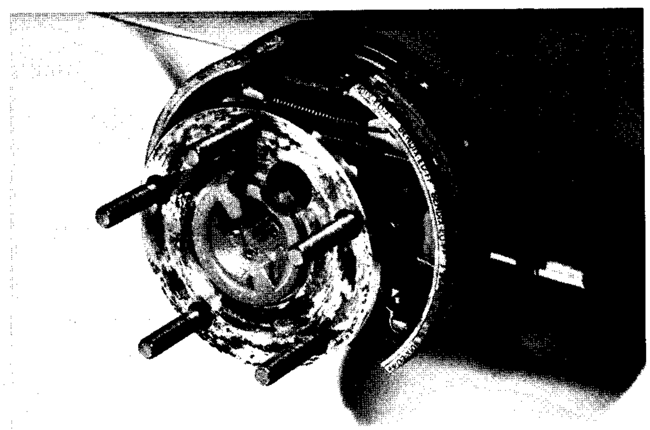

Figure 1

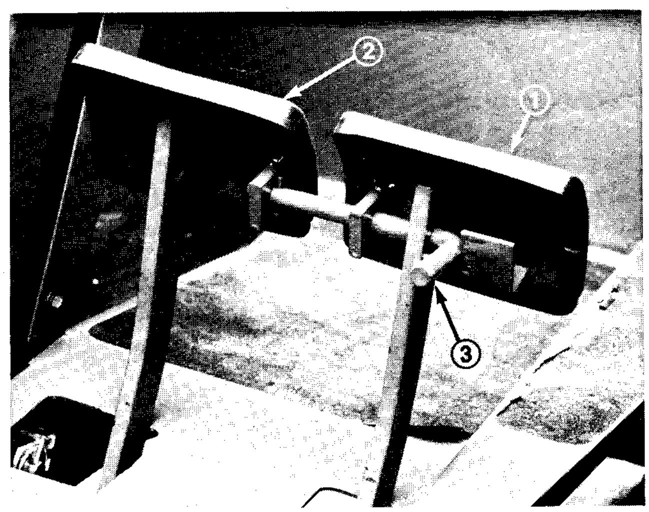

Figure 2

1. Left brake pedal
2. Right brake pedal
3. Lock arm

Maintenance

Lubrication

Lubricate the brake pedal pivot bushings after every 25 hours of operation (Fig. 3). Apply grease to the exposed cable wire and cable ends at pedals and brakes. Clean grease fittings before adding grease. Add grease to bushings until lubricant begins to seep out. Wipe off excess grease. Use No. 2 general purpose lithium-base grease.

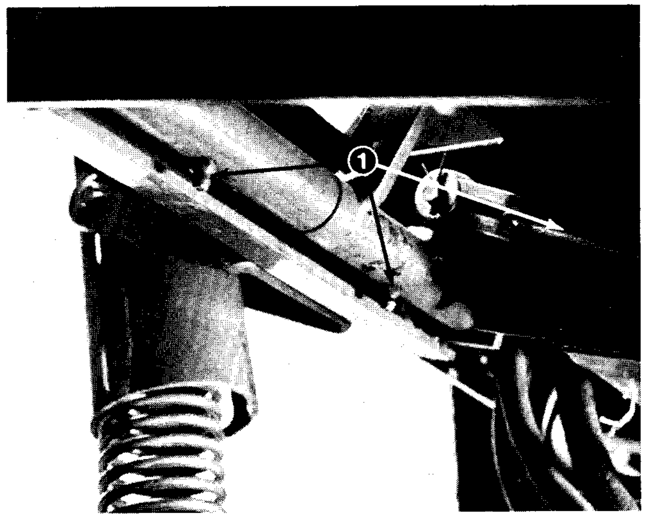

Figure 3

1. Apply grease to both ends of both cables

Adjusting Brakes

Check the brakes for proper adjustment after the first 25 hours of operation. Check the brakes periodically for proper adjustment after the initial adjustment. Adjust the service brakes when there is more that one inch (25 mm) of "free travel" of the brake pedals, or when the brakes do not work effectively. Free travel is the distance the brake pedal moves before braking resistance is felt (Fig. 4).

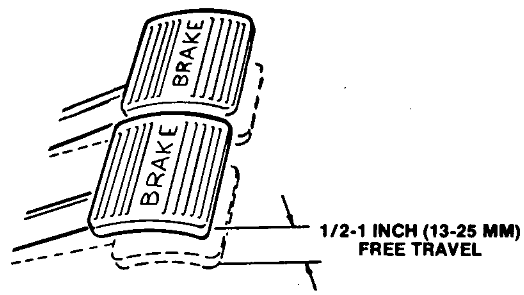

Figure 4

The adjustments can be performed where the brake cables connect to the bottom of the brake pedals. When the cable is no longer adjustable, the star nut on the inside of the brake drum must be adjusted to move the brake shoes outward. The brake pedals must be adjusted again after the star nut is adjusted.

1. Disengage the lock arm from the left brake pedal so both pedals work independently of each other (Fig. 2).

2. To reduce free travel of the brake pedals, tighten the brakes:

A. Loosen the front nut on the threaded end of the brake cable (Fig. 5).

B. Tighten the rear nut to move the cable toward the rear until the brake pedals have 1/2 to 1 in. (13 mm to 25 mm) of free travel.

C. Tighten the front nut after the brakes are adjusted correctly.

3. When the brake cables cannot be adjusted to get free travel within 1/2 to 1 in. (13 to 25 mm), the star nut inside the brake drum must be adjusted. Before adjusting the star nut, loosen the brake cable nuts to prevent unnecessary strain on the cables.

4. Loosen (do not remove) the five (5) wheel nuts holding the wheel and tire assembly on the wheel studs.

5. Jack up the machine until the front wheel is off the floor. Use jack stands or block the machine to prevent it from falling accidentally.

6. Remove the wheel nuts and slide the wheel and tire assembly off the studs. Rotate the brake drum until the adjusting slot is at the top and centered over the star-nut that adjusts the brake shoes (Fig. 6).

7. Use a brake adjusting tool or a screwdriver to rotate the star nut until the brake drum locks because of outward pressure of the brake shoes (Fig. 7).

8. Loosen the star nut approximately 12 to 15 notches or until the brake drum rotates freely.

9. Install the wheel and tire assembly on the studs with five (5) wheel nuts. Tighten the wheel lug nuts.

10. Remove the jack stands or blocking and lower the machine to the floor. Tighten the wheel lug nuts to a torque of 45 - 55 ft-lb (6.2 - 7.6 KgM).

11. Adjust the brake cables (see step 2 of this procedure).

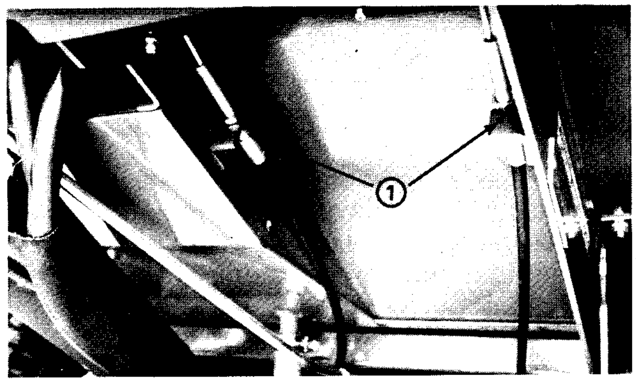

Figure 5

1. Jam nuts

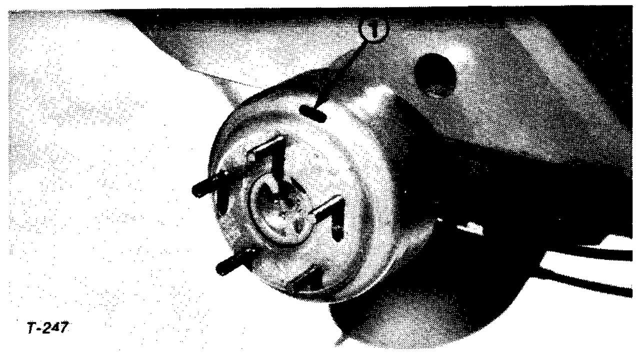

Figure 6

1. Brake adjusting slot

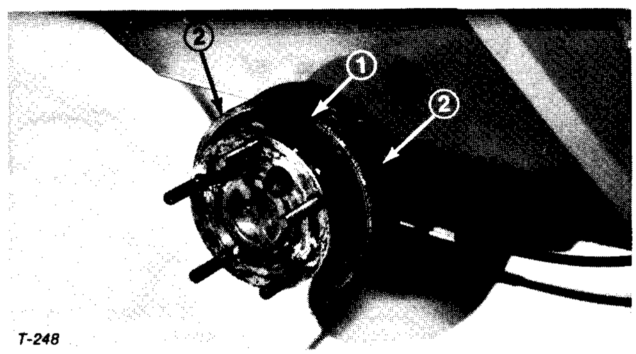

Figure 7

1. Star nut 2. Brake shoe

Brake Pedal Pivot Bushing Replacement

The brake pedals must be held in place snugly by the brake pivot pin. Excessive movement of the brake pedal, other than brake pedal free travel, usually indicates worn bushings. To correct the problem, replace the bushings.

1. Loosen the brake cable jam nuts (Fig. 8).

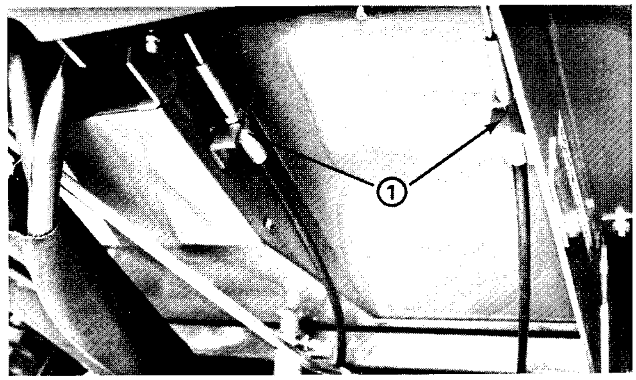

Figure 8

1. Jam nuts

2. Remove the cotter pins, clevis pins and flat washers to disengage the brake cables from the brake pedals (Fig. 9).

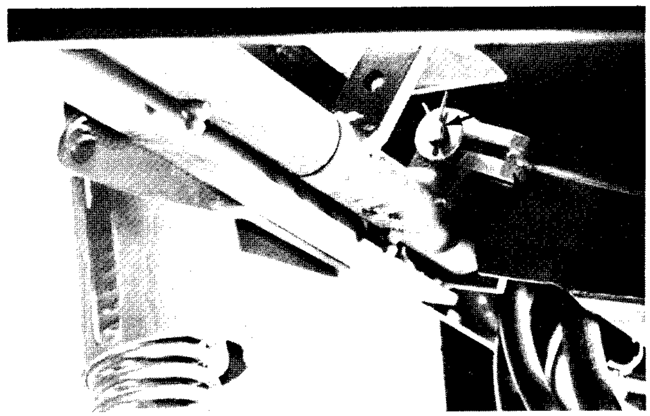

Figure 9

1. Cotter pin, clevis pin and flat washer
2. Brake cable

3. Remove the cap screw and lock nut securing the brake pedal pivot pin to the frame (Fig. 10). Pull the pivot pin out so the brake pedals can be removed. Remove the brake pedals.

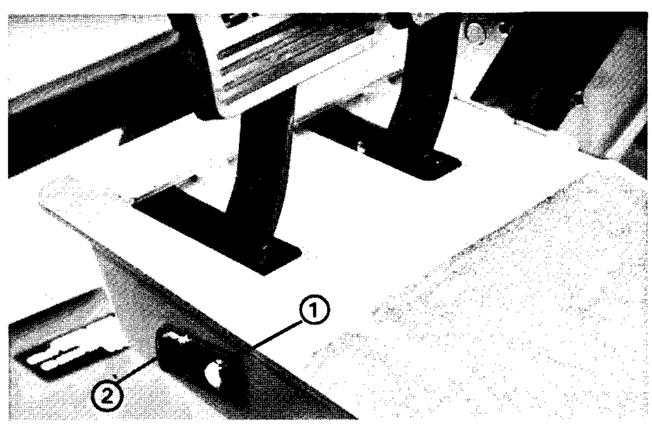

Figure 10

1. Cap screw and lock nut
2. Brake pedal pivot pin

4. Use a pin punch and hammer to drive both bushings out of the brake pivot (Fig. 11). Clean the inside of the brake pivot to remove any dirt and foreign material.

5. Put grease on the inside and outside of the new bushings. Use an arbor press to install the new bushings into both ends of the brake pivot. The bushings must be flush with the ends of the brake pivot.

6. Clean the brake pivot pin to remove dirt and grease. Hold the left brake pedal in position and install the pivot pin through the side of the frame and brake pivot. Hold the right brake pedal in position and push the pin through the brake pivot and opposite side plate. Install the cap screw and lock nut to secure the pivot pin (Fig. 10).

7. Connect the brake cables to the brake pedals (Fig. 9). Adjust the brakes (see Adjusting Brakes in the Maintenance section of this chapter).

8. Lubricate the brake pivot bushings through the grease fittings (Fig. 3). Use No. 2 grease.

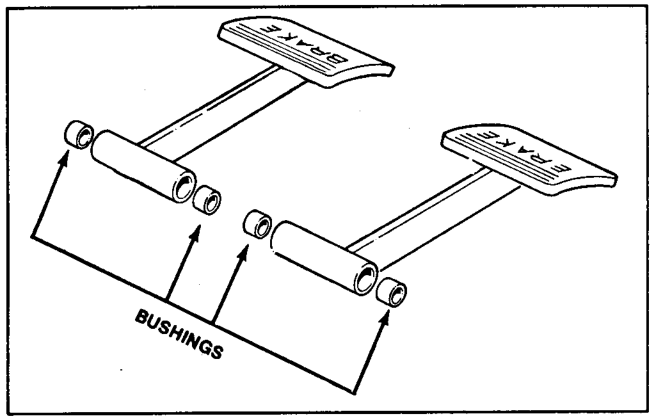

Figure 11

Brake Pedal Return Spring Replacement

1. Disengage the spring from the slotted hole on the cutting unit suspension frame (Fig. 12).

2. Remove the end of the spring from brake arm.

3. To install the new spring, install the short end of the spring into the hole in the brake arm.

4. Use a vise grip pliers to install the long end of the spring through the slotted hole in the cutting unit suspension frame.

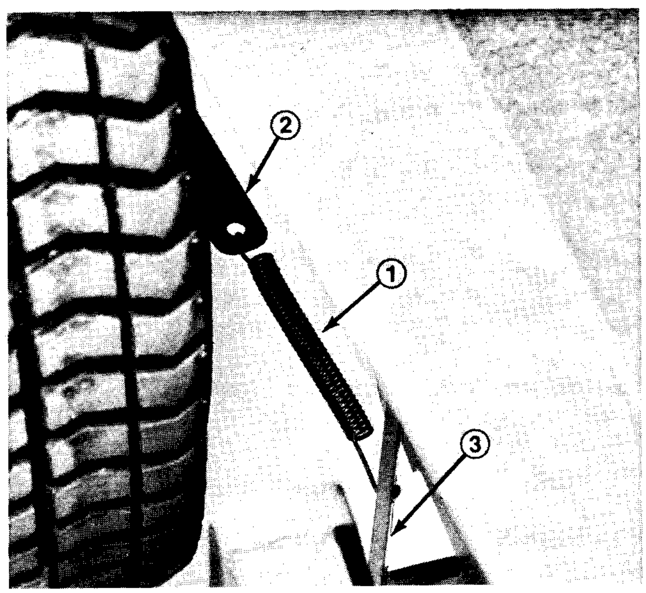

Figure 12

1. Brake pedal return spring
2. Brake arm
3. Cutting unit frame

Brake Shoe Replacement

1. Remove the brake pedal return springs (Fig. 12).

2. Loosen the five (5) wheel lug nuts holding the wheel and tire assembly on the wheel studs.

3. Jack up the machine until the front wheel that is being repaired is off the floor. Use jackstands to prevent the machine from falling accidentally.

4. Remove the wheel lug nuts and slide wheel and tire assembly off the studs.

5. Remove the brake drum. If the drum will not come off easily, the brake shoes may have to be retracted with the star nut (see Adjusting Brakes in the Maintenance section of this chapter).

6. If the brake shoes are worn down to the rivets, they must be replaced. Replace the brake drum if it is severely scored.

WARNING

Wear a face shield when removing the brake return spring (Fig. 13). The spring is under tension and could possibly slip during removal.

7. Remove the brake shoe return spring (Fig. 13) by prying the end of the spring up and over its retaining boss. Use a brake spring pliers or flat blade screwdriver.

8. Remove the brake lever retainers (cotter pins) with a slip joint pliers.

9. Pull the strut and lever from the brake shoes. Remove the brake shoes by sliding them both on one motion straight down off the cast-iron spider.

10. Remove the adjusting screw spring and star wheel assembly.

11. Install new brake shoes (reverse steps 1 - 10).

12. Install the wheel and tire assembly on the studs with five (5) wheel nuts. Tighten the wheel lug nuts.

13. Remove the jack stands or blocking and lower the machine to the floor. Tighten the wheel lug nuts to a torque of 45 - 55 ft-lb (6.2 - 7.6 KgM).

14. Install the brake pedal return springs (Fig. 12).

15. Adjust the brakes (see Adjusting Brakes in the Maintenance section of this chapter).

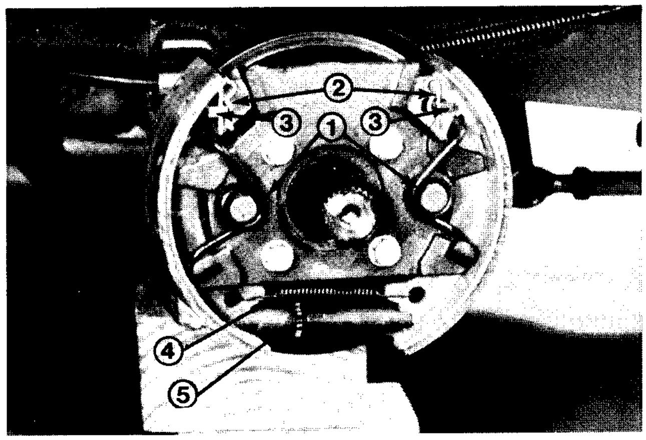

Figure 13

1. Return spring
2. Cotter pins
3. Strut and lever
4. Adjusting screw spring
5. Star wheel assembly

Brake Cable Replacement

1. Remove brake pedal return spring (Fig. 12).

2. Loosen the jam nuts on both ends of the brake cable (Fig. 8, 14).

3. Remove the cotter keys and clevis pins attaching the brake cable to the brake strut (Fig. 14) and brake pedal (Fig. 9).

4. Remove the cable.

5. Install the new cable (reverse steps 1-4).

6. Adjust the brakes (see Adjusting Brakes in the Maintenance section of this chapter).

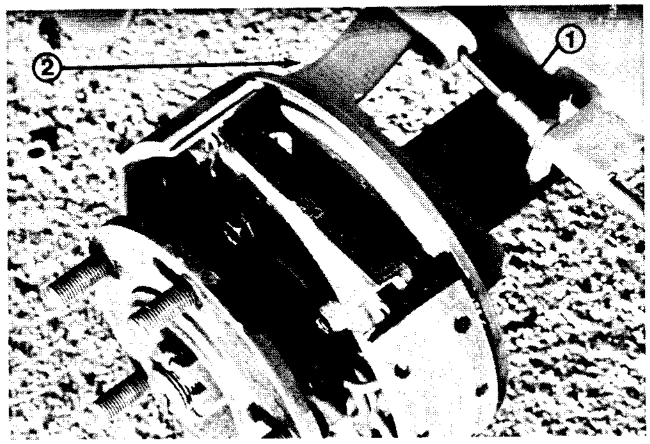

Figure 14

1. Brake cable
2. Strut and lever

Parking Brake Rack Replacement

1. Remove the self tapping screws the hold the front steering tower cover in place. Remove the cover.

2. Remove the two (2) cotter pins and the flat washer from the lower end of the parking brake rod (Fig. 15). Remove the cotter pin and flatwasher securing the rack to the pivot pin. Pull the rod out of the rack. Pull the rack off the pivot pin.

3. Install the new rack onto the pivot pin. Secure the rack with the flat washer and cotter pin.

4. Install the rod into the rack. Secure the rod with the flat washer and cotter pins.

5. Install the steering tower cover with the self tapping screws.

Figure 15

1. Parking brake rod
2. Parking brake rack

Chapter 10

Engine to Transmission Coupler

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Introduction

Engine power is transmitted from the engine through flexible couplings and a drive shaft to the hydrostatic transmission.

The drive coupling consists of three main components. The components are: a metal drive shaft, a rubber coupling bolted to each end of the shaft, and the pump hub.

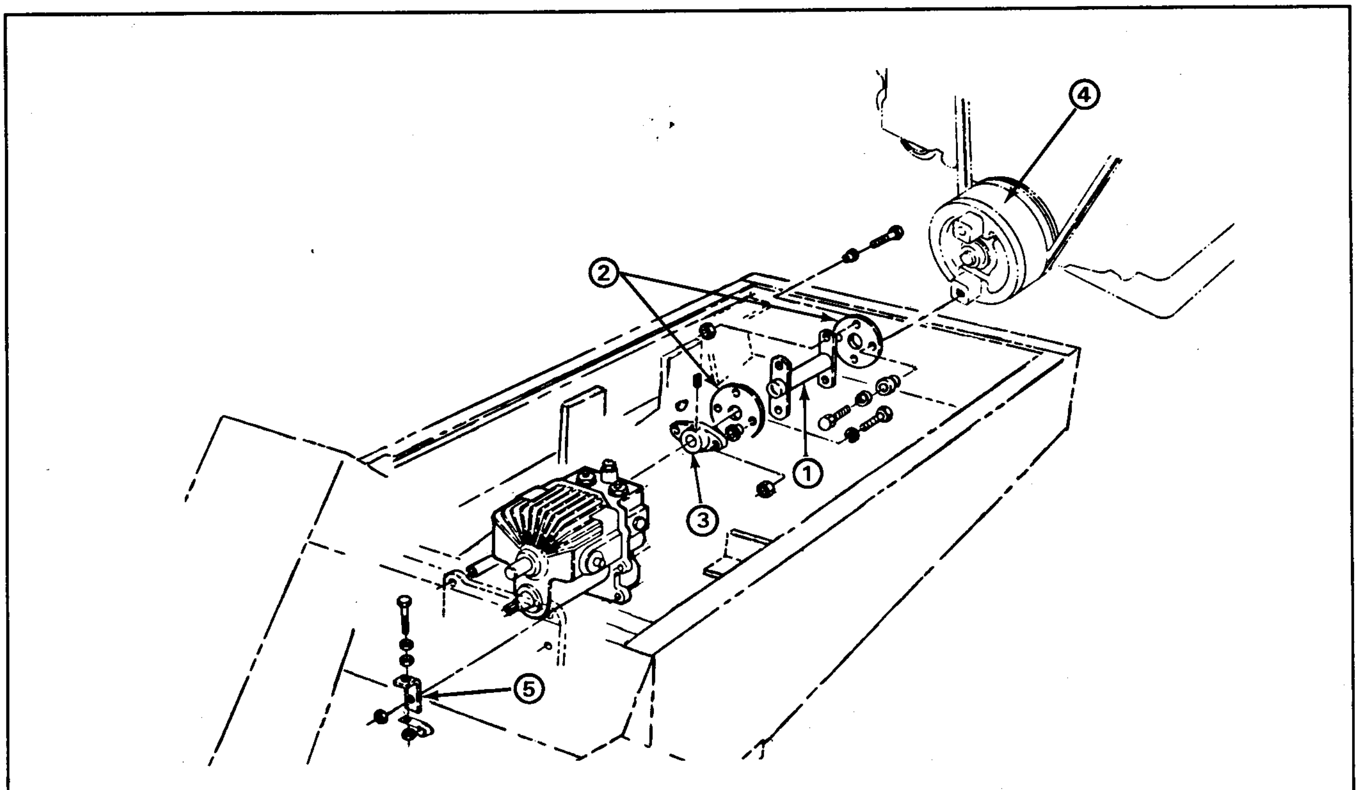

Figure 1

1. Drive shaft
2. Rubber coupling
3. Transmission hub
4. Engine crankshaft pulley
5. Transmission anchor

Maintenance

Rubber Couplings

Once each year the rubber couplings should be inspected for deterioration, wear, or damage. Replace any defective or worn parts.

Fasteners

Periodically inspect all of the coupling fasteners for tightness. Tighten any loose fasteners. Replace fasteners that are no longer serviceable.

Checking Drive Coupling Alignment

When ever the hydrostatic axle or the engine has been removed, the alignment of the drive coupling must be checked and readjusted if necessary. The alignment is checked and adjusted after all components except the coupler have been installed. Any abnormal vibration in the coupler area usually indicates that misalignment is more than 1/8 inch (3 mm) from one end of the coupler shaft to the other. (See Adjusting Drive Coupling Alignment in the Adjustments section of this chapter.)

Troubleshooting

Problem	Possible Causes
Excessive drive coupling vibration, premature rubber couplng wear or damaged pump hub .	Drive shaft bent or deformed. Loose fasteners. Coupler not aligned correctly.

Adjustments

Drive Coupling Alignment

The centerlines of the engine crankshaft and the transmission input shaft must be aligned to within 1/8 inch (3 mm) of each other.

1. Lower the implement to the shop floor, turn the engine OFF, and engage the parking brake. Remove the cable from the negative (–) terminal of the battery.

2. Remove the drive coupling. (See Removing Drive Coupling in the Repairs section of this chapter.)

3. Remove the rubber couplings and fasteners from the drive shaft.

4. Verify that the drive shaft is straight. Verify that the shaft end plates are perpendicular to the tube and are not bent.

5. Loosen the special knurled cup-point setscrews securing the hub to the transmission.

6. Secure the drive shaft to the engine crankshaft pulley with the two (2) 8 mm cap screws (Fig. 2).

7. Pull the transmission hub out closer to the coupler shaft.

8. Use the holes in the drive shaft mounting plate and transmission hub to check the alignment. Put two (2) 5/16 in. cap screws through the holes in the drive shaft mounting plate to get a better indication of the alignment. Check the alignment with the shaft mounting plate and transmission hub in the horizontal and vertical positions.

9. If adjustment is necessary, loosen the transmission anchor nuts (Fig. 3).

NOTE: Loosen the carrier bracket if necessary before installing shims between the frame and axle mounting pad.

10. A transmission that is too high at the drive coupling end may be lowered by installing an Axle Shim (Toro part 42-6080) between the rear of the differential mounting pad and the bottom of the frame (Fig. 4). A transmission that is too low is corrected by installing a spacer between the front of the mounting pad and the bottom of the frame.

11. If the spacers must be added to the front of the mounting pad, REMOVE the front cap screws and LOOSEN the back ones. Do just the opposite to add spacers at the rear of the mounting pads.

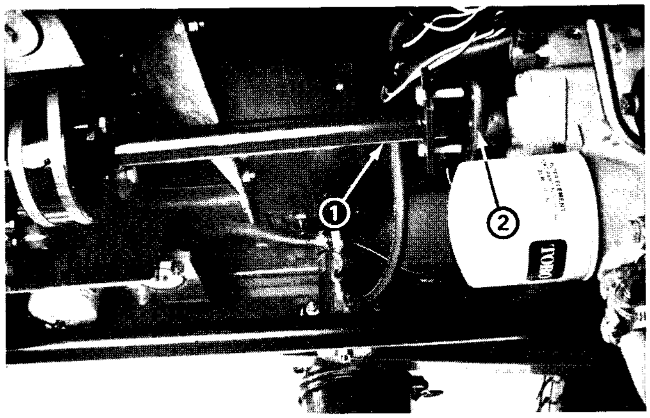

Figure 2

1. Drive shaft 2. Transmission hub

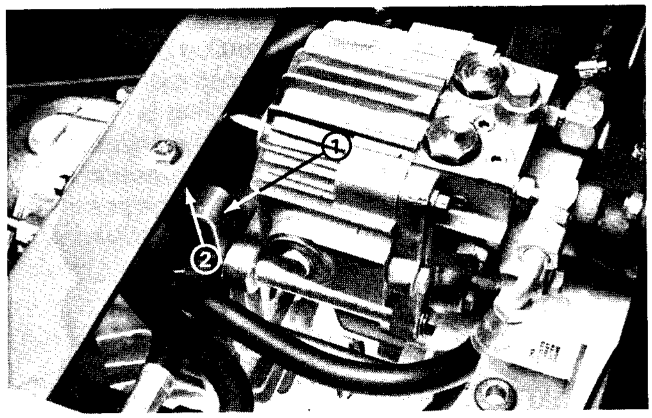

Figure 3

1. Transmission anchor 2. Nut

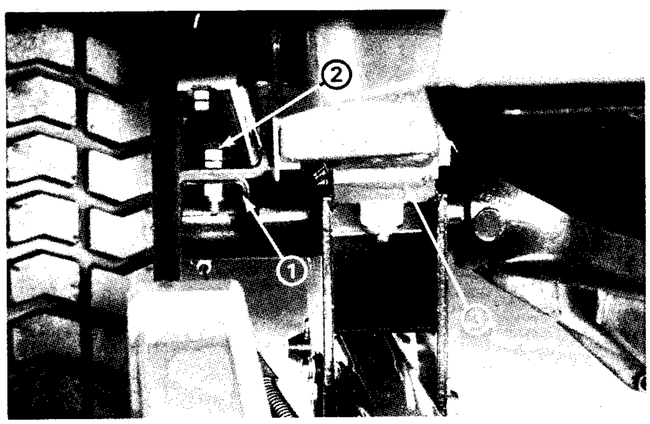

Figure 4

1. Mounting pad
2. Cap screws & lock nuts
3. Carrier bracket

12. After adding the spacers, install the final two cap screws and tighten all four cap screws and lock nuts to secure the axle in place.

13. Continue to check the alignment and add shims as required. When the alignment is correct, tighten the axle nuts to a torque of 45 ft-lb (6.5 KgM). Tighten the rear nut the until it contacts the frame, then tighten the front nut. Secure the rear nut last.

14. Reinstall the drive coupling assembly. (See Installing Drive Coupling in the Repairs section of this chapter.)

NOTE: The transmission anchor prevents the weight of the transmission from causing the differential housing to rotate downward (pivoting at the axle tubes). Should this happen, the engine to transmission coupler would become misaligned and cause coupler damage. It is important to leave the transmission anchor loose until the coupler is properly aligned and then tighten the anchor jam nuts against the anchor (Fig. 3). DO NOT TIGHTEN THE JAM NUTS SO THAT A PUSHING OR PULLING FORCE IS APPLIED AGAINST THE TRANSMISSION.

NOTE: After installing the drive coupling assembly, the rubber coupling must not be deformed more than .250 in (6mm) either direction. If the coupling is deformed, correct the condition by loosening the transmission pump hub setscrews and changing the position of the pump hub. The end of the pump hub must be positioned .060 - .250 in. (1.5 - 6mm) away from the transmission face (Fig. 5). Tighten the setscrews on the transmission hub to a torque of 12 ft-lb (1.7 KgM).

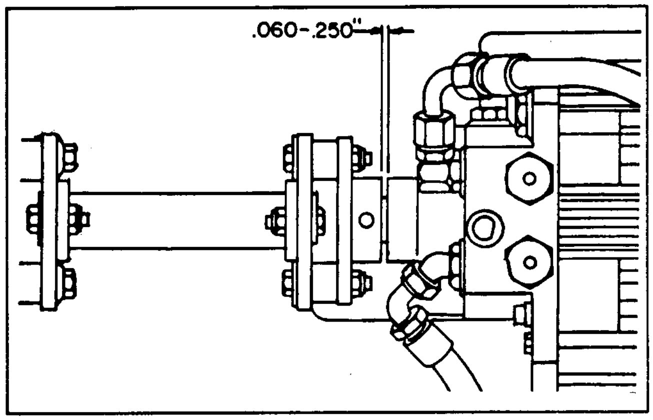

Figure 5

Removing the Drive Coupling

The drive coupling must be removed whenever the transmission or the engine will be removed from the chassis.

1. Lower the implement to the shop floor, turn the engine OFF, and engage the parking brake. Remove the cable from the negative (–) terminal of the battery.

2. Remove the cap screws, flat washers, spacers and locknuts securing the drive coupling assembly to the transmission hub (Fig. 6).

3. Remove the cap screws, lock washers and spacers securing the drive coupling assembly to the engine crankshaft pulley (Fig. 7). Remove the drive coupling assembly from between the hub and the pulley.

4. Examine the rubber coupling. Replace the coupling if it is severely cracked or worn.

5. It recommended that you check the alignment of the drive coupling before reassembly. (Drive Coupling Alignment in the Adjustments section of this chapter.)

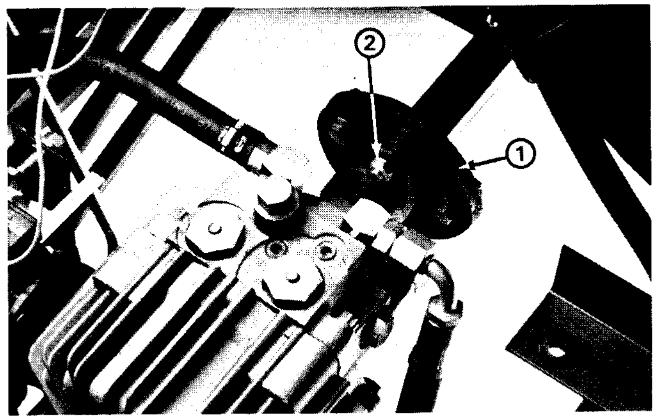

Figure 6

1. Drive coupling
2. Capscrews, flat washers, spacers and locknuts

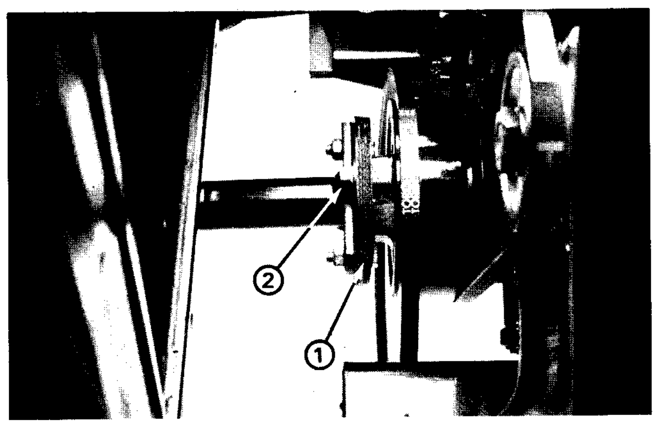

Figure 7

1. Drive coupling
2. Capscrews, lock washers and spacers

Installing the Drive Coupling

1. It recommended that you check the alignment of the drive coupling before reassembly. (Drive Coupling Alignment in the Adjustments section of this chapter.)

2. Insert the large spacers into the holes in the rubber couplings so the spacers are between the rubber coupling and transmission hub (Fig. 6). Insert the cap screws with flat washers through the rubber coupling, spacer and transmission hub. Install the lock nuts to secure the coupling the transmission hub.

3. Insert the small spacers into the holes in the rubber coupling so the small end of the spacer is facing the engine pulley. Secure the rubber coupling to the engine pulley with the 8 mm cap screws and lock washers (Fig. 7).

NOTE: After installing the drive coupling assembly between the engine and transmission, the rubber coupling must not be deformed more than .250 in (6mm) either direction. If coupling is deformed, correct the condition by loosening the transmission pump hub setscrews and changing the position of the pump hub. However, the end of the pump hub must be positioned 0.060 - 0.250 in. (1.5 - 6mm) away from the transmission face (Fig. 8). Tighten the setscrews on the pump hub to a torque of 12 ft-lb (1.7 KgM).

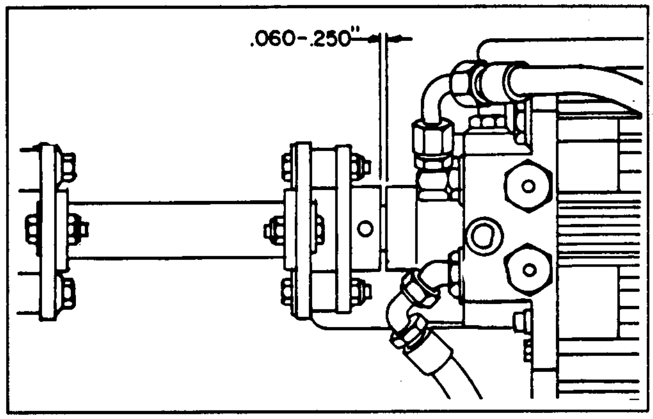

Figure 8

TORO®

Chapter 11

P.T.O. System

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Introduction

The power take-off (PTO) system (Fig. 1) transmits power from the engine to the cutting unit or other implement. The operator controls the PTO by operating an electrical switch on the control panel.

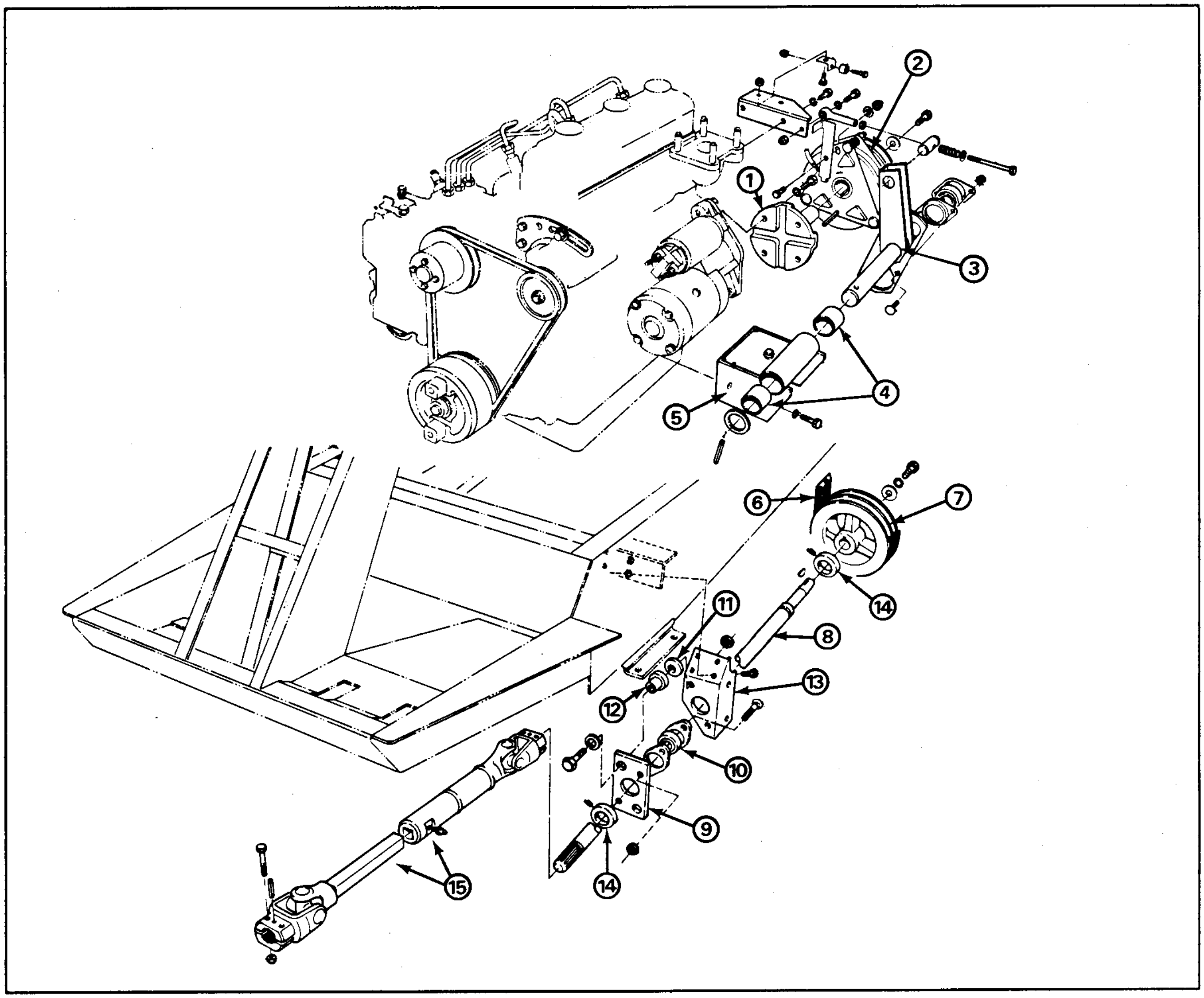

Figure 1

1. Engine shaft
2. Clutch
3. PTO tension shaft
4. Bushing (2)
5. PTO pivot plate
6. PTO belt
7. PTO pulley
8. PTO shaft
9. PTO bearing bracket
10. Bearing (2) & bearing flanges (4)
11. PTO spacer (2)
12. Mount (2)
13. Bushing support plate
14. Locking collar
15. Universal drive shaft

Lubrication

Lubricate the PTO shaft (Fig. 2) and PTO tension pivot (Fig. 3) after every 25 hours of operation. Use No. 2 general purpose lithium base grease. Clean grease fittings before adding grease. Add grease until lubricant begins to seep out. Wipe off excess grease.

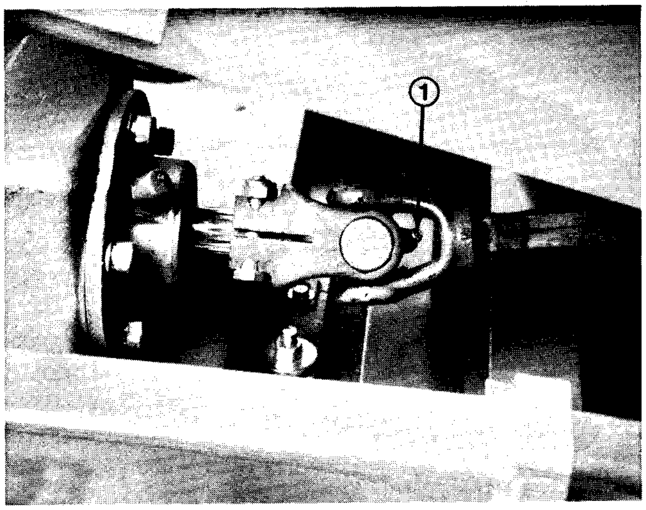

Figure 2

1. PTO shaft lubrication (3 places on shaft)

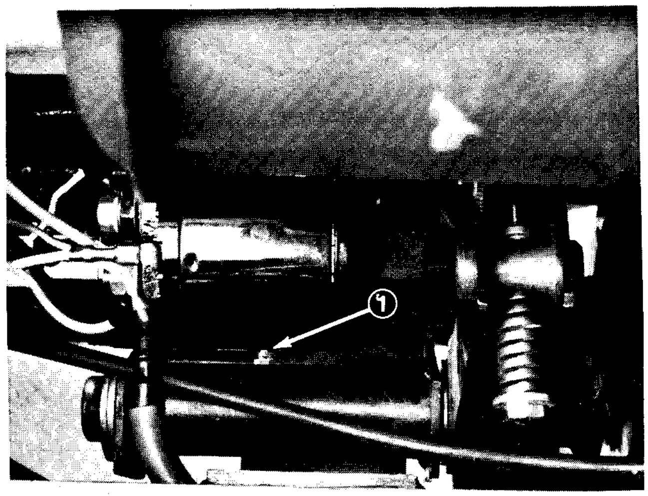

Figure 3

1. PTO tension pivot lubrication

Belt Inspection

Check the PTO belt condition (wear, deterioration, fraying of material, glazing) and tension at 50 hour intervals. Replace the belt as needed. The belt has proper tension when the tensioning spring is 1-1/2 in. (38 mm) long (Fig. 4) (See Belt Adjustment in the Adjustments section of this chapter.)

Clutch Inspection

Check the clutch for proper adjustment after each 100 hours of operation. Insert a feeler gauge through the slots next to the flange studs (Fig. 5).

The proper disengaged clearance between the clutch lining and friction plate is 0.012 - 0.018 in. (0.31 - 0.45 mm). It is necessary to check the clearance at each of the three slots to make sure the plates are parallel to each other. (See Clutch Adjustment in the Adjustments section of this chapter.)

NOTE: The clutch also functions as a PTO brake. Proper air gap adjustment must be maintained to quickly stop the cutting unit blades.

Troubleshooting

Problem	Possible Cause
PTO belt jumps off.	Pulleys not properly aligned.
Machine vibrates excessively.	Engine to transmission coupler not properly aligned. P.T.O. shaft or universal drive shaft damaged or bent.
PTO universal drive shaft does not telescope properly.	Worn bearings in U-Joints or lack of lubrication on sliding tube.
Galling of U-Joint journal cross ends.	Drive shaft rpm too high.
Abrasive wear on PTO universal drive shaft.	Extreme low angle of operation of PTO shaft.
Broken U-Joint journal.	Excessive shock loading to PTO shaft.
Clutch will not engage.	See Troubleshooting section of Chapter 5 - Electrical System.

Adjustments

Belt Adjustment

1. Turn the engine OFF and engage the parking brake. Lower the implement to the ground. Remove the key from the ignition switch.

2. Loosen the tension rod jam nut (Fig. 4).

3. Tighten or loosen the tension adjusting bolt to get a tensioning spring length of 1-1/2 in. (38 mm).

4. Tighten the jam nut.

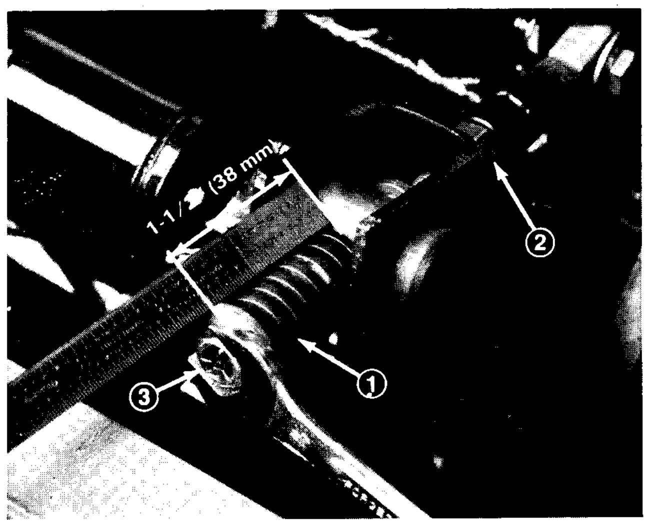

Figure 4

1. Tensioning spring
2. Tensioning rod jam nut
3. Tension adjusting bolt

Clutch Adjustment

1. Turn the engine OFF and engage the parking brake. Lower the implement to the ground. Remove the key from the ignition switch.

2. Disconnect the clutch electrical connector.

3. Remove the left-hand clutch retainer bracket nut and bolt to remove the rubber bumper (Fig. 5).

4. Adjust the air gap so a 0.015 in. feeler gauge slides in between the clutch lining and friction plate with light pressure. the gap can be decreased by tuning the adjusting nut clockwise.

5. Rotate the clutch by hand and adjust the air gap in all three (3) locations. After all three (3) air gaps have been set, check all three (3) again. Adjusting one gap can affect the others.

6. Install the rubber bumper with the bracket retaining nut and bolt. Connect the clutch electrical connector.

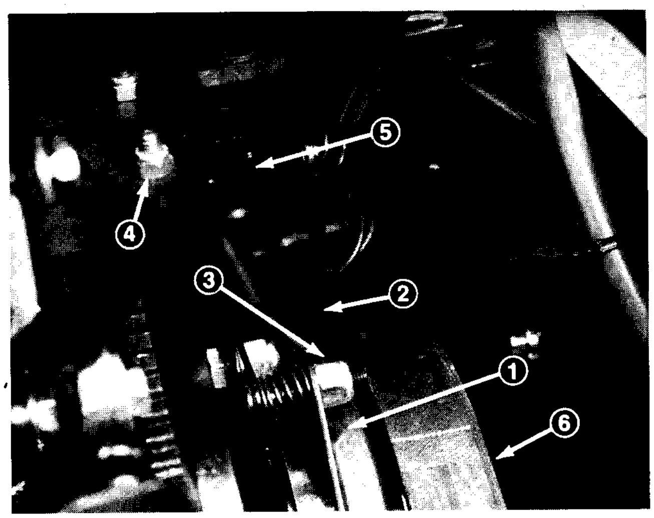

Figure 5

1. Clutch
2. 0.015 in. air gap (3)
3. Adjusting nut (3)
4. Left retainer bracket nut & bolt
5. Electrical connector
6. PTO belt

Aligning the PTO Pulley and Clutch Pulley

1. Turn the engine OFF, engage the parking brake. Lower the implement to the ground. Remove the key from the ignition switch.

2. Remove the rear frame and axle assembly:

A. Disconnect the two hydraulic hoses from the fittings on the steering cylinder (Fig. 6). Put caps on the hoses and fittings to prevent contamination.

B. Remove the two (2) cap screws and nuts at the rear of the chassis. Remove the counter weight (if equipped).

C. Jack up the rear of the machine until the rear tires are just off the ground. Put jack stands under the chassis.

D. Remove the four (4) cap screws securing the rear frame to the chassis. Carefully move the rear frame and axle assembly out from under the machine.

3. With the PTO belt installed and the rear PTO bearing flanges finger tight, tighten the belt tension screw until the compression spring begins to compress (Fig. 4).

4. The clutch pulley and PTO pulley grooves must be in line within 1/16 in. (1.6 mm). Measure near the bottom of the pulleys with the belt lightly tensioned (Fig. 7).

NOTE: The pulley faces will not be in alignment since they have a different thickness.

5. If the pulley grooves are not aligned within 1/16 in. (1.6 mm) the lock collars must be loosened and the PTO shaft moved to get proper alignment.

6. Remove the fuel tank to get access to the front lock collar. (See Removing and Installing the Fuel Tank in the Fuel System Repairs section of Chapter 3 - Mitsubishi Diesel Engine.)

7. Loosen the setscrews in the lock collars (Fig. 7, 8). Use a punch and hammer to loosen the collars by driving them clockwise (as viewed while facing forward). Shift the position of the shaft and pulley until proper alignment is achieved.

8. Rotate the lock collars counterclockwise (as viewed while facing forward) to lock. Tighten the set screws. Check the alignment again to make sure it did not change when tightening the lock collars and set screws.

9. Install the fuel tank. Install the rear axle frame (reverse A - E in step 1). Adjust the PTO belt. (See PTO Belt Adjustment in this section of the book.)

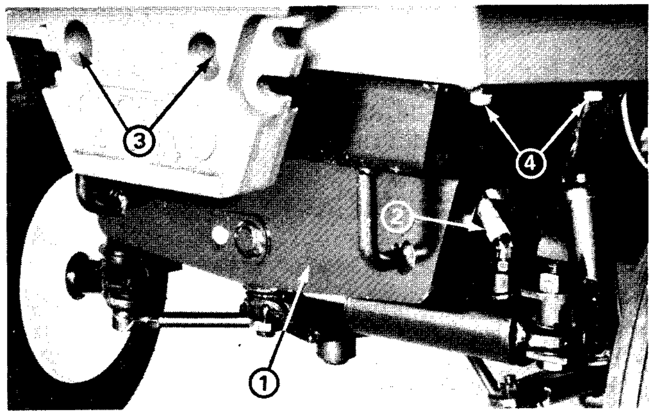

Figure 6

1. Rear frame
2. Hydraulic hose (2)
3. Cap screws and nuts (2)
4. Cap screws and lock washers (4)

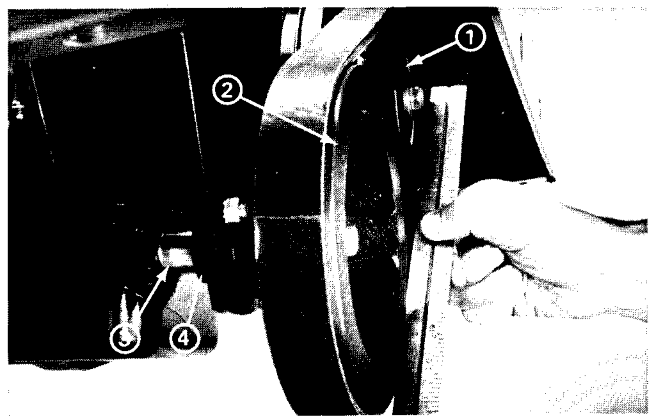

Figure 7

1. Clutch pulley
2. PTO pulley
3. PTO shaft
4. Lock collar

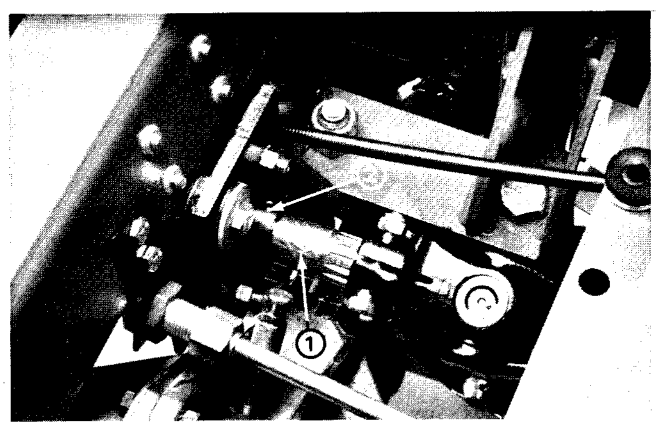

Figure 8

1. PTO shaft
2. Lock collar

Belt Replacement

1. Turn the engine OFF and engage the parking brake. Lower the implement to the ground. Remove the key from the ignition switch.

2. Loosen the tensioning rod jam nut (Fig. 9).

3. Loosen the tension adjusting bolt all the way.

4. Push the PTO pulley toward the clutch pulley and remove the belt.

5. Install the new belt and tighten the tension adjusting bolt to get a tensioning spring length of 1-1/2 in. (38 mm).

6. Tighten the jam nut.

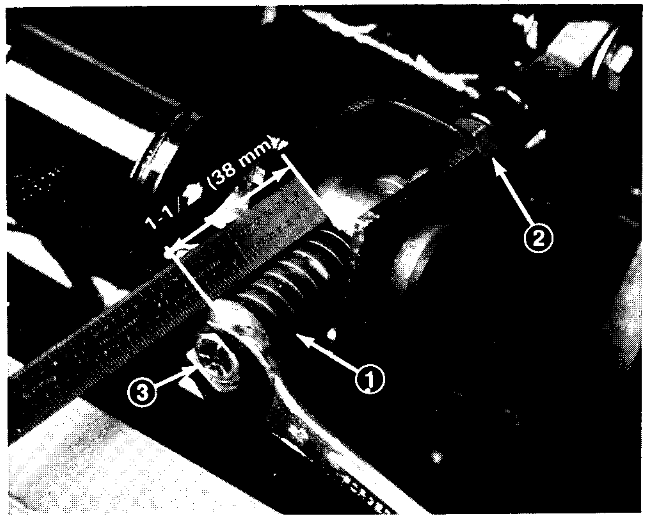

Figure 9

1. **Tensioning spring**
2. **Tensioning rod jam nut**
3. **Tension adjusting bolt**

Clutch Removal and Installation

Removing the Clutch

1. Remove the PTO belt. (See Belt Replacement above.)

2. Disconnect the clutch electrical connector.

3. Remove the cap screw and spacer securing the clutch to the engine shaft (Fig. 10). Hold a long screwdriver through the coupler at the front of the engine to prevent the crankshaft from rotating (Fig. 11).

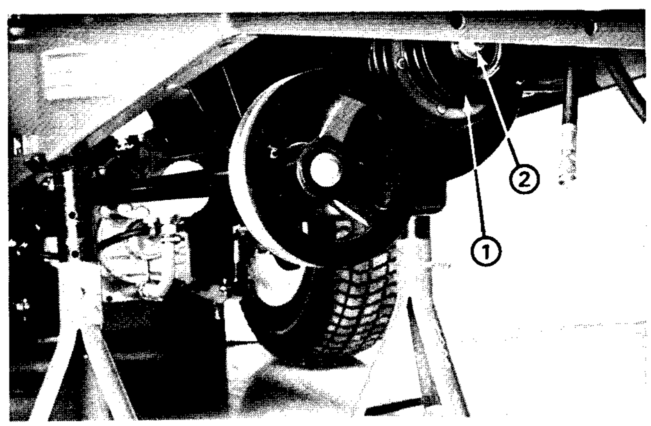

Figure 10

(Shown with rear frame and axle removed)

1. Clutch **2. Cap screw and spacer**

4. Use a pry bar to carefully loosen the clutch from the engine shaft (Fig. 12).

5. Remove the clutch. If necessary, remove the rear frame and axle assembly so the clutch can be removed from the engine shaft:

A. Disconnect the two hydraulic hoses from the fittings on the steering cylinder (Fig. 13). Put caps on the hoses and fittings to prevent contamination.

B. Remove the two (2) cap screws and nuts at the rear of the chassis. Remove the counter weight (if equipped).

C. Jack up the rear of the machine until the rear tires are just off the ground. Put jack stands under the chassis.

D. Remove the four (4) cap screws securing the rear frame to the chassis. Carefully move the rear frame and axle assembly out from under the machine.

Installing the Clutch

1. Apply anti-seize compound to the engine shaft before installing the clutch.

2. Make sure the key is installed in the shaft keyway. Make sure the keyways in the clutch and pulley are aligned and install the clutch onto the engine shaft. Make sure the clutch retainer is between the two rubber bumpers on the retainer bracket.

3. Apply a small amount of Locktite 242 or equivalent to the cap screw threads. Secure the clutch to the engine shaft with the cap screw and spacer. Hold a long screwdriver through the coupler at the front of the engine to prevent the crankshaft from rotating. Tighten the capscrew to a torque of 60 ft-lb (80 Nm).

4. Install the rear frame and axle assembly if it was removed (reverse A - E in step 5 of Removing the Clutch).

5. Install the PTO belt. (See Belt Removal and Installation in this section of the book.)

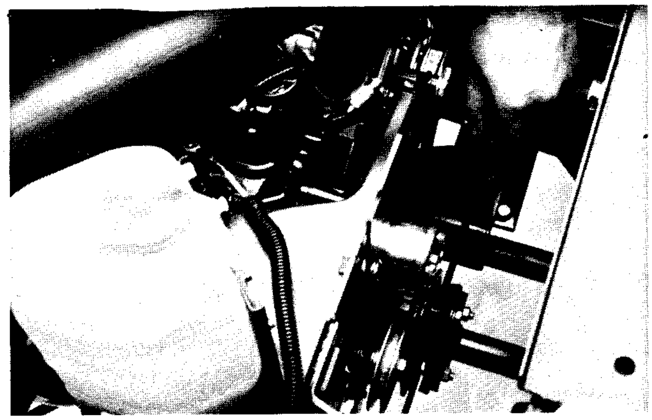

Figure 11

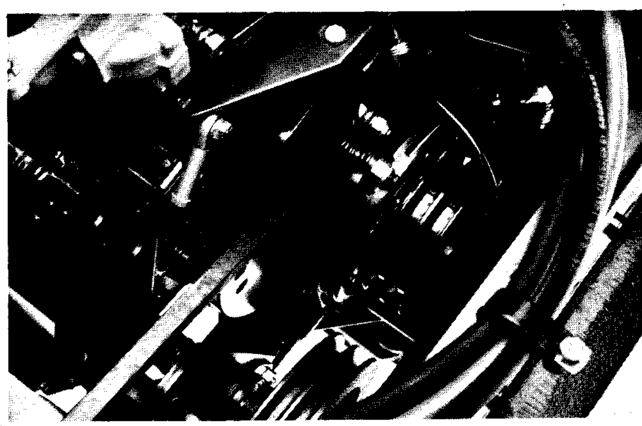

Figure 12

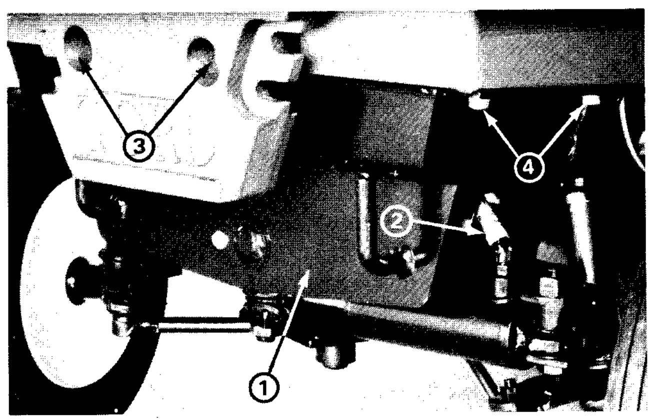

Figure 13

1. **Rear frame**
2. **Hydraulic hose (2)**
3. **Cap screws and nuts (2)**
4. **Cap screws and lock washers (4)**

PTO Shaft and Bearing Service

1. Remove the PTO belt. (See Belt Replacement in this section of the book.)

2. Remove the rear frame and axle assembly:

   A. Disconnect the two hydraulic hoses from the fittings on the steering cylinder (Fig. 14). Put caps on the hoses and fittings to prevent contamination.

   B. Remove the two (2) cap screws and nuts at the rear of the chassis. Remove the counter weight (if equipped).

   C. Jack up the rear of the machine until the rear tires are just off the ground. Put jack stands under the chassis.

   D. Remove the four (4) cap screws securing the rear frame to the chassis. Carefully move the rear frame and axle assembly out from under the machine.

3. Remove the cap screw and washers from the PTO pulley (Fig. 15). Use a puller tool to remove the PTO pulley from the PTO shaft.

4. Remove the carriage bolts and lock nuts securing the rear bearing flange to the PTO pivot shaft. Replace the bearing if necessary.

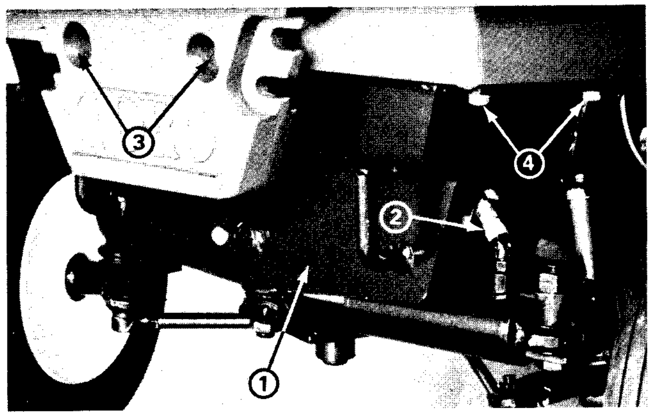

Figure 14

1. **Rear frame**
2. **Hydraulic hose (2)**
3. **Cap screws and nuts (2)**
4. **Cap screws and lock washers (4)**

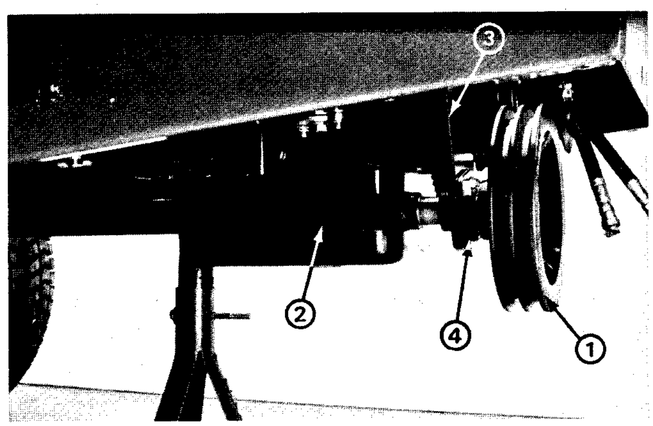

Figure 15

1. **PTO pulley**
2. **PTO shaft**
3. **PTO pivot shaft**
4. **Rear bearing flange and bearing**

NOTE: Do not perform Steps 5 - 12 if replacing only the rear bearing.

5. Remove the fuel tank. (See Removing and Installing the Fuel Tank in the Fuel System Repairs section of Chapter 3 - Mitsubishi Diesel Engine.)

6. Loosen the setscrew on the front locking collar (Fig. 16). Use a punch and hammer to rotate the collar clockwise (as viewed while facing the front of the machine).

7. Drive the roll pin out of the yoke on the PTO universal drive shaft (Fig. 16). Loosen the clamping bolts and lock nuts. Disconnect the yoke from the PTO shaft.

8. Disconnect the two (2) hydraulic hoses from the "tee" fitting on the left-hand lift cylinder (Fig. 17). Put caps and plugs on the fitting and hoses to prevent contamination of the hydraulic system. This will give better access to the four (4) cap screws securing the bearing bracket to the chassis (Fig. 16).

9. Remove the four (4) cap screws securing the bearing bracket to the chassis.

10. Pull the PTO shaft back through the hole in the PTO pivot shaft to get access to the front bearing.

11. Separate the PTO bearing bracket from the bushing support plate by removing the two (2) capscrews, washers and lock nuts (Fig. 18).

12. Remove the carriage bolts and lock nuts securing the front bearing flanges to the bushing support plate. Replace the bearing and PTO shaft if necessary.

13. Inspect the rubber mounts for wear or damage and replace if necessary (Fig. 1).

IMPORTANT: When installing the rubber mounts between the bushing support plate and bearing bracket, make sure the small end of the rubber mounts go through the holes in the bearing bracket. As the cap screws are tightened, the small end of the rubber mount should flatten out evenly between the flat washer and the front face of the bearing bracket (Fig 18). Tighten the cap screws until the bracket bottoms against the internal spacers in the rubber mounts.

14. Reverse steps 1 - 13 to reassemble. Align the PTO pulley and clutch pulley. (See Aligning the PTO Pulley and Clutch Pulley in the Adjustments section of this chapter.)

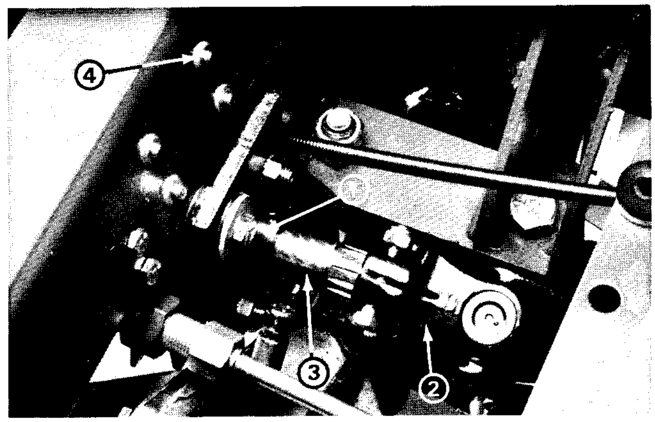

Figure 16

1. Locking collar
2. PTO universal drive shaft yoke
3. PTO shaft
4. Cap screws (4)

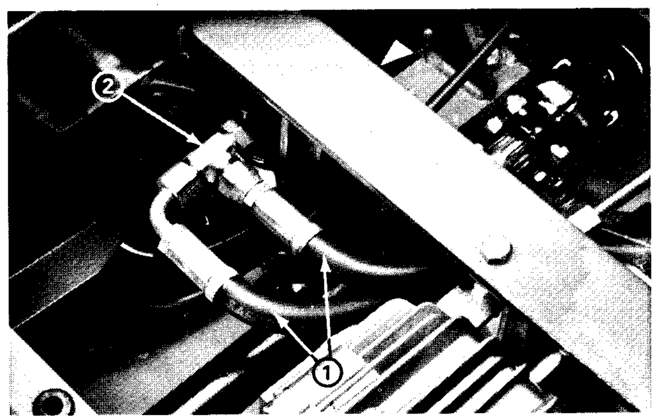

Figure 17

1. Hydraulic hoses (2)
2. Tee fitting

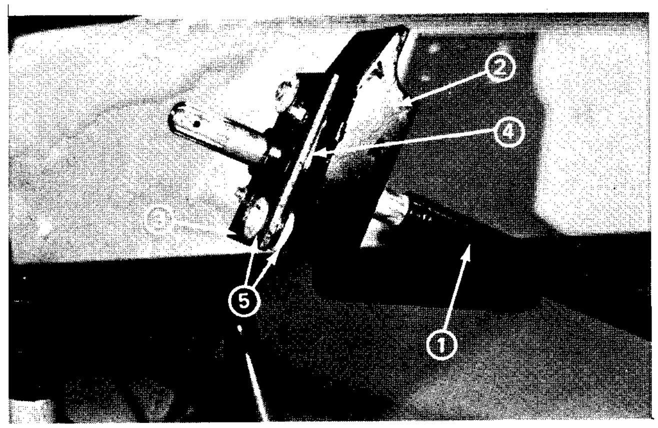

Figure 18

1. PTO shaft
2. Bushing support plate
3. Bearing bracket
4. Bearing flange
5. Rubber mount

PTO Universal Drive Shaft Removal and Installation

> **DANGER**
>
> **Do not start the engine and engage the PTO switch when the PTO universal drive shaft is disconnected from the cutting unit or implement. If the engine is started and the PTO shaft is allowed to rotate, serious injury could result. Disconnect the clutch electrical connector whenever the PTO universal drive shaft is disconnected from the cutting unit or implement.**

1. Turn the engine OFF and engage the parking brake. Lower the implement to the ground. Remove the key from the ignition switch.

2. If the rear universal joint (Fig. 19) must be removed, remove the fuel tank (See Removing and Installing the Fuel Tank in the Fuel System Repairs section of Chapter 3 - Mitsubishi Diesel Engine.)

3. Drive the roll pin out of the yoke (Fig. 19, 20). Loosen the clamping bolts and lock nuts. Disconnect the yoke(s) from the PTO shaft and/or implement input shaft.

4. When installing the PTO universal drive shaft, the tube part attaches to the PTO shaft on the traction unit and the square shaft part attaches to the implement input shaft (Fig. 21). Align the roll pin hole in the yoke with the hole on the PTO shaft and/or implement input shaft. Drive a new roll pin through the hole(s). Tighten the clamping bolts and lock nuts.

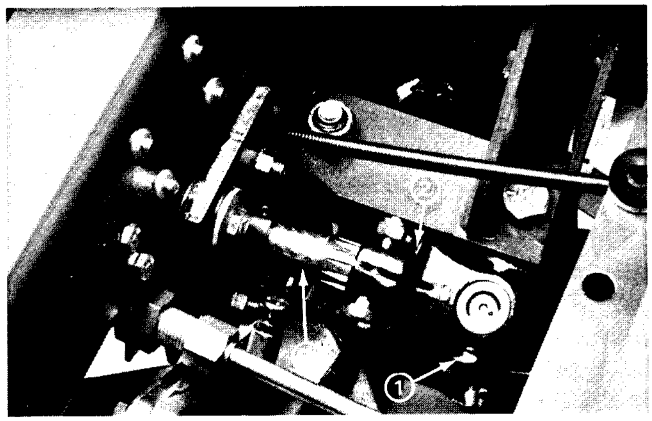

Figure 19

1. Rear universal joint
2. Yoke
3. PTO shaft

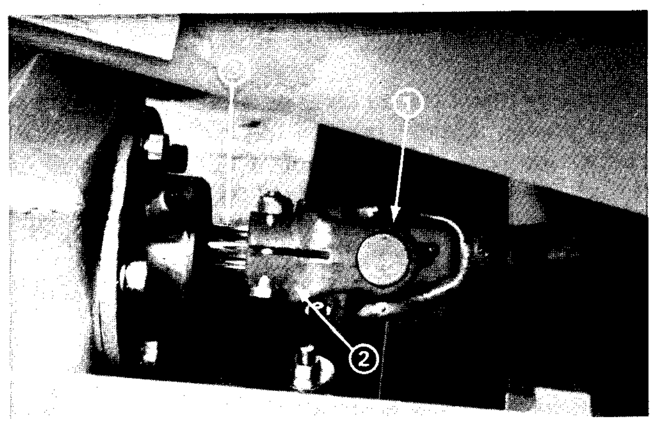

Figure 20

1. Front universal joint
2. Yoke
3. Implement input shaft

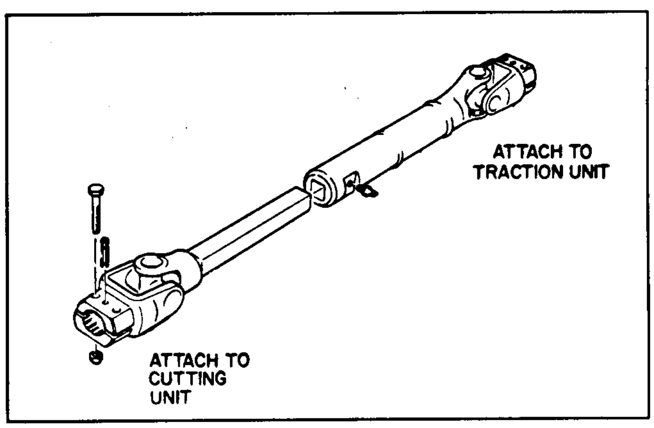

Figure 21

Universal Joint Repair

1. Remove the PTO universal drive shaft. (See PTO Universal Drive Shaft Removal and Installation in this section of the book.)

2. Separate the two sections of the PTO shaft.

3. Mount the section to be repaired in a vise so that the U-joint is pointing up.

IMPORTANT: When clamping in the vise, clamp the solid part of the U-joint. If the yoke must be clamped, clamp lightly. Use jaw covers. Avoid clamping the tube part of the propeller shaft as it is thin and easily crushed. Never clamp the tube part, even lightly, when it is necessary to hammer on the yoke. Support the free end of the propeller shaft to remove some of the strain from the clamped end.

4. Use two thin screwdrivers to remove the "C" shaped snap ring from each of the U-joint rollers (located on inside of each yoke). Remove the shaft from the vise.

5. The vise may now be used as a press by placing a small socket against one roller and a large socket against the yoke on the opposite side. As the vise is closed, the small socket will force the cross to push the opposite roller part way into the large socket (Fig. 22).

6. When the roller is forced partway out, grasp the roller and strike the yoke to complete removal. DO NOT spill the needle bearings.

7. Follow steps 5 and 6 to complete the removal of the U-joint from the PTO shaft.

8. When replacing the U-joint, pack the roller bearings with the recommended lubricant (multi-purpose grease). Pack carefully to eliminate trapped air. Install seals.

9. Start one of the rollers in the yoke. Insert from the bottom with the open side of the roller up to prevent loss of the needles. Make sure that each roller contains all of the needles.

10. Insert one of the cross trunnions into the roller. Start the other roller making certain it slips over the trunnion (Fig. 23).

11. When partially seated, put the two rollers between the vise jaws. Squeeze until FLUSH with the yoke. Stop when flush; DO NOT OVER-TIGHTEN.

12. Tap one of the rollers (use a brass punch the full width of the roller) through the yoke until the snap ring can be inserted. Insert the snap ring. Use new snap rings. Make sure the snap ring is seated to full depth.

13. Support the cross and strike the yoke to force the snap ring against the inner face of the yoke. Always seat the roller using this method to prevent improper centering of the cross.

14. Install the other snap ring or rings and seat the rollers against the rings.

15. Grease the fitting SLOWLY until it starts to show at the seals. Use a low pressure hand grease gun or a power gun equipped with a pressure relief valve. A high pressure grease gun can blow the rollers out of the yokes with the tremendous pressure; seals may also be damaged.

16. Test the action of the assembled joint. It should move throughout its range without binding. If a slight bind exists, rap the yoke lugs with a soft hammer. this will usually free the joint. If it does not, disassemble and check for the source of binding.

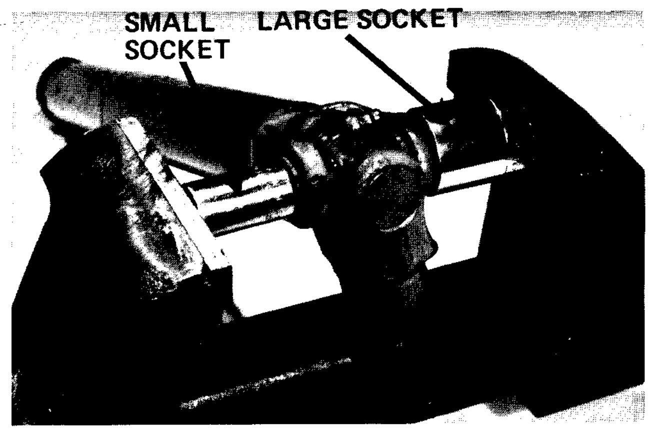

Figure 22

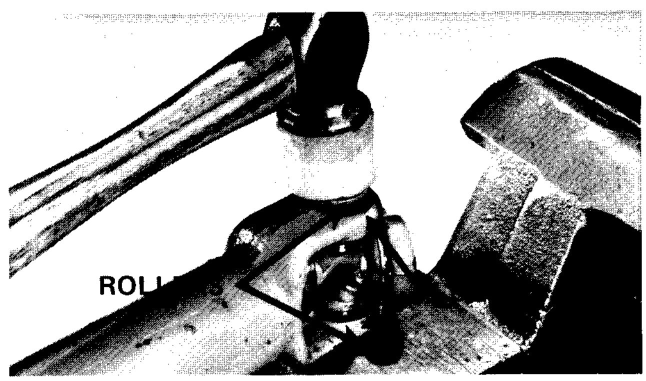

Figure 23

Clutch Service

The clutch has a rotor that is driven by the engine shaft. When the PTO switch is moved to the ON position, an electromagnet pulls the armature into contact with the rotor to drive the pulley.

Failure to get clutch engagement would likely be caused by a clutch air gap that is to large (see Clutch Adjustment in the Adjustments section of this chapter), a circuit fault in the clutch electromagnet, or other electrical problem (see the Troubleshooting section of Chapter 5 - Electrical System).

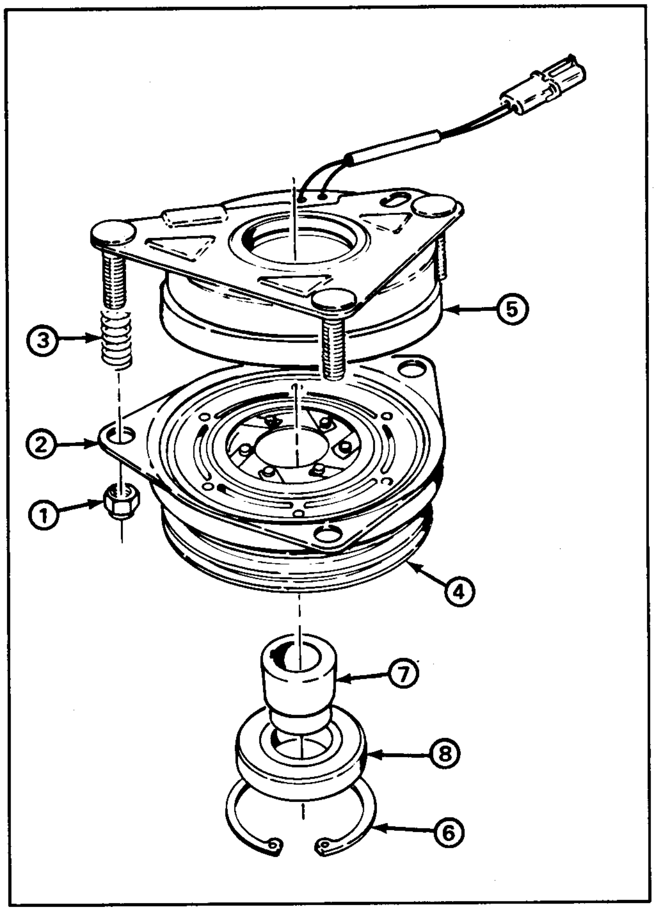

Figure 24

1. Lock nut (3)
2. Brake plate
3. Spring (3)
4. Armature & pulley assy.
5. Field rotor assy.
6. Retaining ring
7. Bearing collar
8. Bearing

1. Remove the clutch (see Clutch Removal and Installation in this section of the book).

2. Remove the clutch anchor lever (Fig. 25). Note the position of the flat washer. When reinstalling the lever make sure the washer is between the anchor lever and clutch (Fig. 26).

Figure 25

1. Anchor lever

3. Remove the three (3) lock nuts (Fig. 26). Remove the brake plate and three (3) springs.

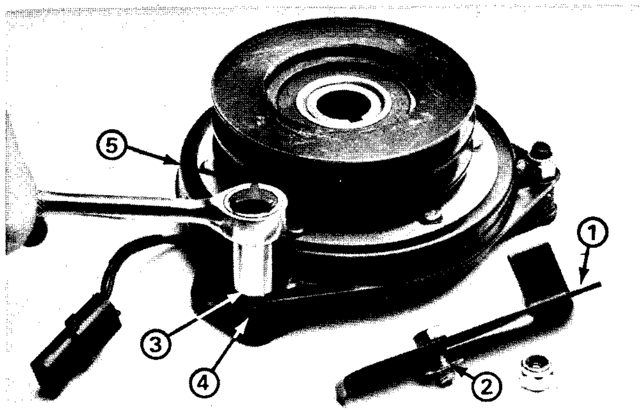

Figure 26

1. Anchor lever
2. Washer
3. Lock nut (3)
4. Spring (3)
5. Brake plate

4. Separate the armature & pulley assembly from the field rotor assembly (Fig. 27).

NOTE: The parts in the field rotor assembly are not serviceable and must be replaced as an assembly.

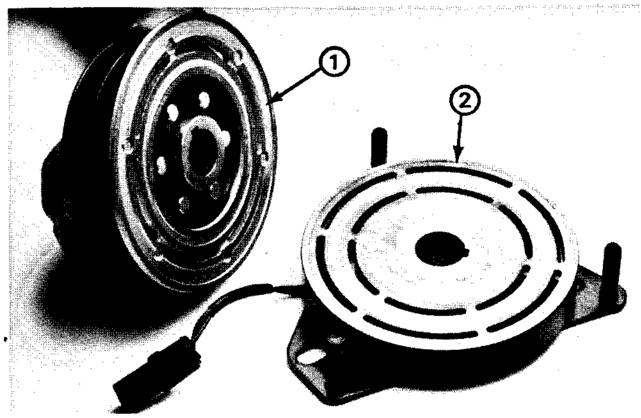

Figure 27

1. Armature & pulley assembly
2. Field rotor assembly

5. To replace the pulley bearing:

A. Remove the retaining ring (Fig. 28).

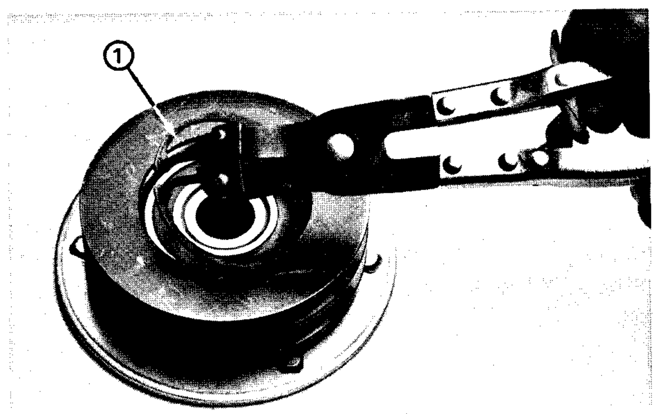

Figure 28

1. Retaining ring

B. Put the armature & pulley assembly, pulley side down, in an arbor press. Press on the bearing collar to remove the bearing and collar (Fig. 29). If the bearing is removed, it MUST be replaced with a new one.

C. Press the collar out of the bearing.

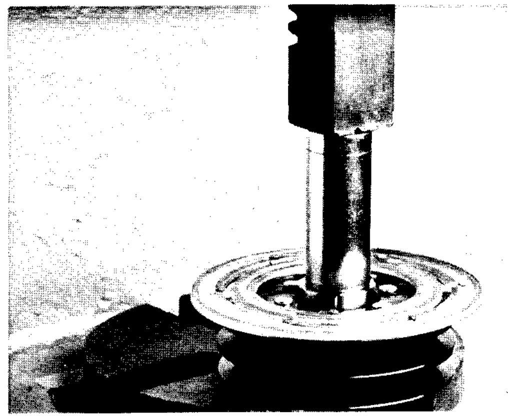

Figure 29

D. Replace the bearing collar if it is damaged. Make sure both the inside and outside race of the new bearing is on a flat surface and press the collar into the new bearing (Fig. 30).

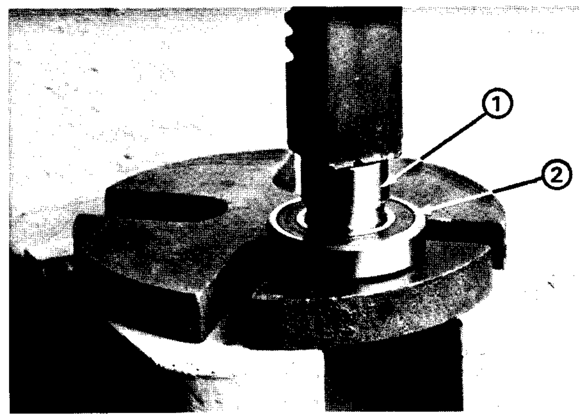

Figure 30

1. Bearing collar **2. Bearing**

E. Put the armature & pulley assembly in the arbor press, pulley side up. Put spacers in three (3) locations between the pulley and armature plate to prevent damage to the springs (Fig. 31). Three (3) stacks of flat washers can be used for spacers. Make sure the extended part of the collar is facing down and press on the outer bearing race to install the bearing and collar.

F. Install the retaining ring (Fig. 28).

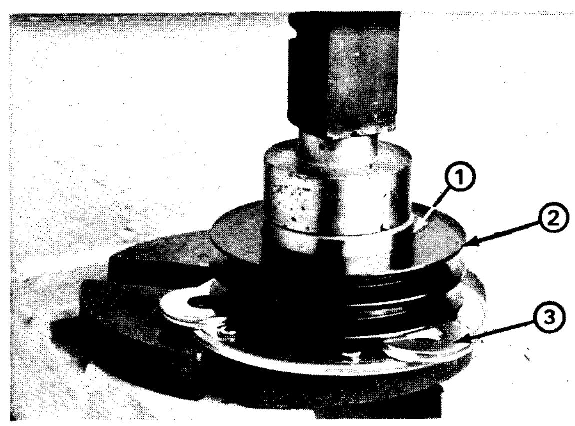

Figure 31

1. Bearing and collar
2. Armature & pulley assembly
3. Spacers (3 sets of washers)

6. Reverse steps 2 - 5 to assemble the clutch.

7. Install the clutch on the engine shaft, making sure the anchor lever is between the two rubber bumpers on the retainer bracket (see Clutch Removal and Installation in this section of the book). Connect the clutch electrical connector. Adjust the clutch air gap after the clutch is installed (see Clutch Adjustment in the Adjustments section of this chapter).

IMPORTANT: Apply anti-seize compound to the engine shaft before installing the clutch. Apply a small amount of Loctite 242 or equivalent to the cap screw threads before installing it in the engine shaft.

Chapter 12

Cutting Units

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Introduction

The cutting units used on the Groundsmaster® 220-D/223-D are identified by a model number and serial number. These numbers are stamped into a metal plate on the cutting unit frame (Fig. 1).

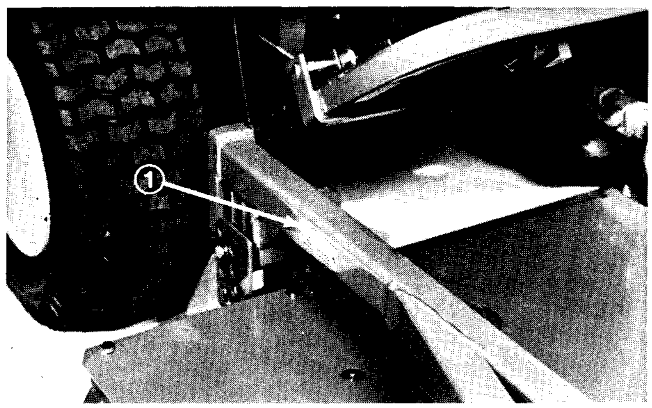


Figure 1

1. Model and serial number

Cutting unit models covered in this book are as follows (Figs. 2a - 2e):

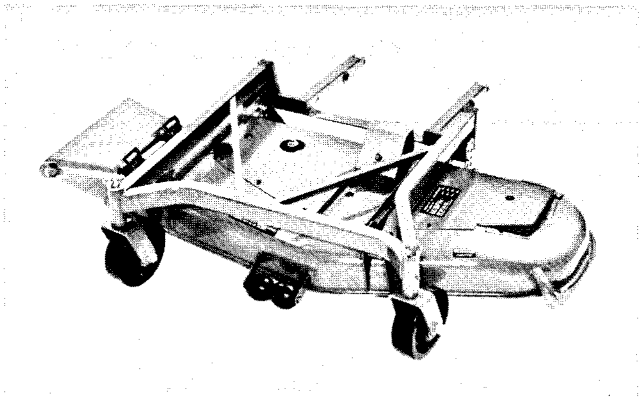


Figure 2a

Model 30555
52" Side Discharge

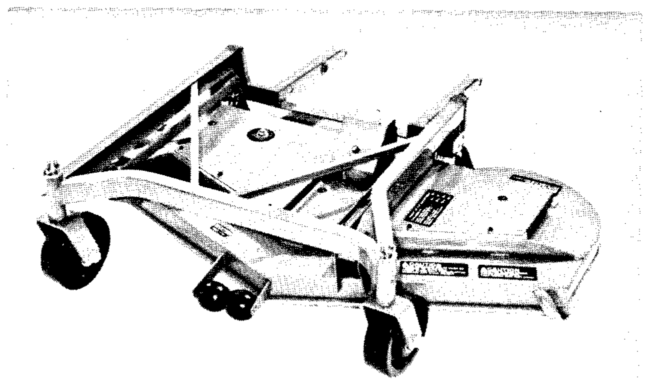


Figure 2b

Model 30568
52" Rear Discharge
(IMPORTANT: Requires Model 30567 Shield Kit)

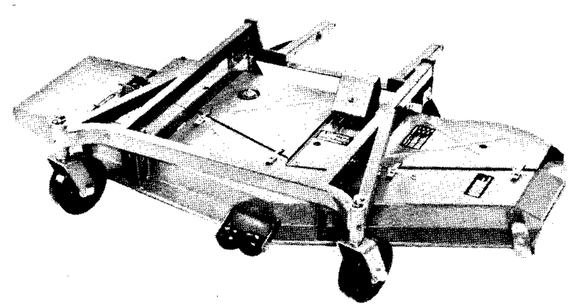


Figure 2c

Model 30562
62" Side Discharge

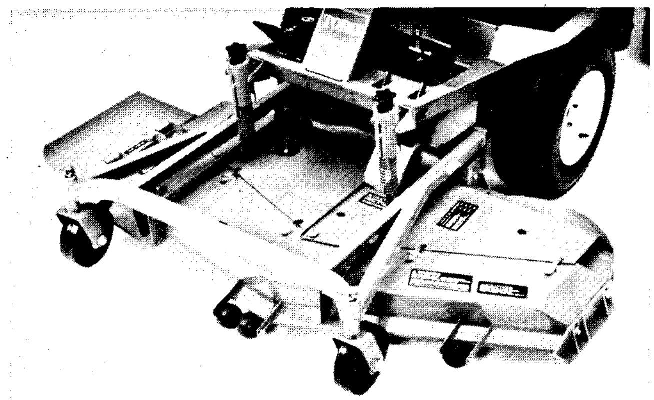


Figure 2d

Model 30564
62" Side Discharge

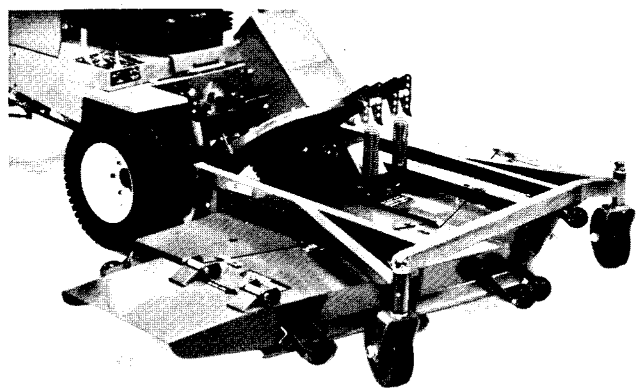


Figure 2e

Model 30575
72" Side Discharge

Specifications

Model	30555	30568	30562	30564	30575
Height of Cut	1 to 4 in. (25 to 102 mm) Adjustable in .5 in. (13 mm) increments				
Width of Cut	51.75 in (131 cm)		61.675 in (157 cm)		71.625 in (184 cm)
Gearbox Endplay Output Shaft Input Shaft	0.001 - 0.005 in. (0.025 - 0.127 mm) 0.005 - 0.010 in. (0.127 - 0.254 mm)				
Gearbox Lubrication	(Aluminum gearbox) 10W30 or 10W40, SE or SF motor oil (Cast iron gearbox) SAE 80W90 API GL-5 gear lube				
Spindles Shaft	1 in.				
Bearings	Two greaseable tapered roller bearings				
Lubricant	No. 2 general purpose lithium base grease				
Blades Length	18 in. (457 mm)		21.5 in. (546 mm)		24.75 in. (629 mm)
Speed Engine at 3250 rpm	3290 rpm		2820 rpm		2580 rpm
Tip Speed Engine at 3250 rpm	15,500 ft/min (78.7 m/sec)		15,850 ft/min (80.5 m/sec)		16,750 ft/min (85.1 m/sec)
Castor Wheels	(See Chapter 7 - Wheels and Tires)				
Castor Forks	5/16 in. (8 mm) steel				
Weight	200 lb. (91 kg)	200 lb. (91 kg)	285 lb. (129 kg)	285 lb. (129 kg)	360 lb. (163 kg)

Maintenance

Gearbox

Check gearbox oil level after every 50 hours of operation. Change the oil after every 500 hours of operation or annually, whichever comes first.

Gearbox lubricant:
(Toro aluminum gearbox – Fig. 3) 10W30 or 10W40, API SE/SF
(Curtis cast iron gearbox – Fig. 3A) SAE 80W90 API GL-5

Check oil level with cutting unit lowered so castor wheels are on a level surface (Fig. 3). Remove check plug. The oil should be level with the check plug hole.

Add oil as necessary. Wipe any metal particles off of the filler plug before installing.

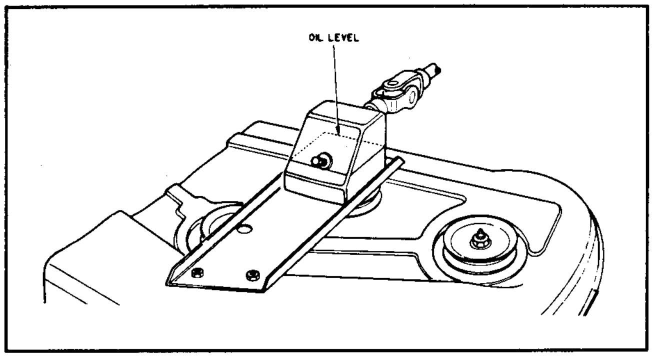


Figure 3

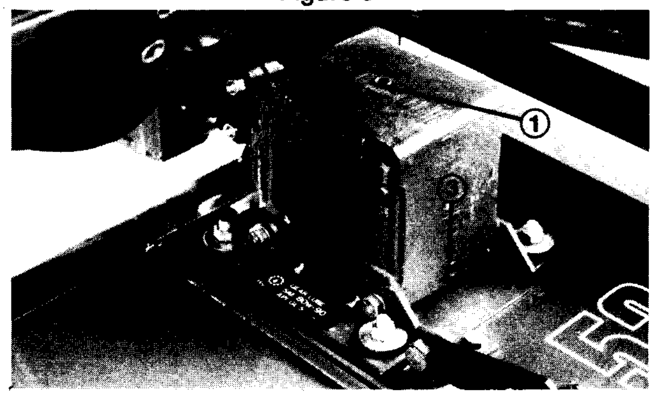


Figure 3A

1. Filler plug 2. Check plug 3. Drain plug

Frame Pivot Bushings

Lubricate the frame pivot bushings after every 25 hours of operation (Fig 4). Use No. 2 general purpose lithium grease.

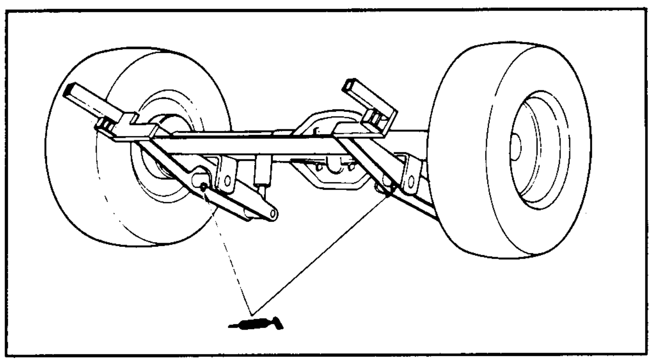


Figure 4

Cleaning

Wash cutting unit with water after each day's use. Always turn engine OFF before attempting to clean mower. Removing grass and grit from around castor wheels and spindles will prolong service life. Lubricate cutting unit after mower is cleaned.

After every 50 hours of use, remove deck belt covers and clean out any debris (eg. grass clippings) that may have accumulated. If left unattended, a buildup of debris in this area may cause belt slippage, belt wear, bearing damage or rust.

Blade Spindles

Grease the three (3) blade spindles after every 25 hours of operation (one grease fitting per spindle) (Fig. 5). Use No. 2 general purpose lithium base grease.

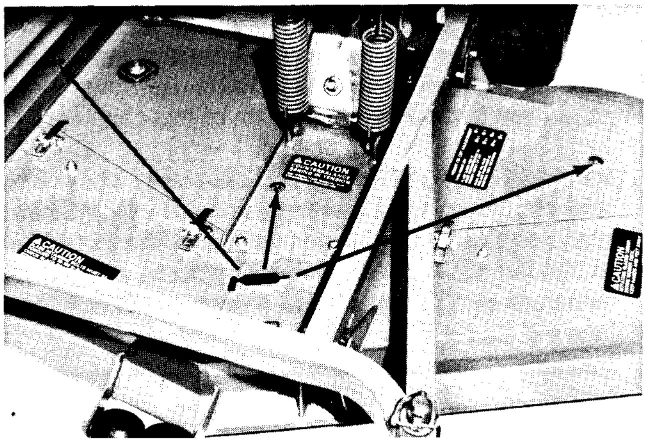


Figure 5

Castor Forks and Castor Wheels

Lubricate all four castor fork and castor wheel bushings and bearings after every eight hours of operation (Fig. 6). Use No. 2 general purpose lithium or molybdenum-based grease.

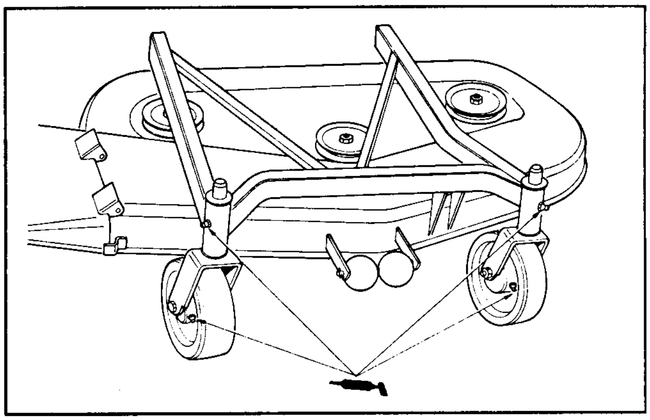


Figure 6

Fasteners

All fasteners should be checked periodically for tightness. The blade mounting bolts should be checked often. The correct blade mounting bolt torque is 75 - 100 ft-lbs (10.37 - 13.83 KgM).

Blade Inspection and Sharpening

The blades may be inspected without removing them from the cutting unit. Should removal be necessary, use the procedures described in Blade Removal and Replacement, in the Repairs section of this chapter.

1. Examine the sails of the blades, especially where the flat and curved parts of the blade meet (Fig. 7). Since sand and abrasive material can wear away the metal between the flat and curved parts of the blade, check the blade before using the machine. If any wear is noticed, replace the blade.

> **WARNING**
>
> **If the blade is allowed to wear, a slot will form between the sail and flat part of the blade (Fig. 7). Eventually, a piece of the blade may break off and be thrown from under the housing. This could result in serious injury to yourself or a bystander.**

2. Examine the cutting edges of all blades. Sharpen the cutting edges if they are dull or nicked. Sharpen only the top side of the cutting edge and maintain the original cutting angle to assure sharpness (Fig. 8). The blade will remain balanced if the same amount of metal is removed from both cutting edges. However, it is recommended that all blades be checked for balance prior to reinstalling them onto the cutting unit. Balance blades by removing metal from the top (cutting edge) of the blade only. Do not remove metal from the sail or bottom of the blade.

3. To check the blade for being straight and parallel, lay the blade on a level surface and check its ends. The ends of the blade must be slightly lower than the center and the cutting edge must be lower than the heel of the blade. This blade will produce a good quality of cut and will require minimal power from the engine. By contrast, a blade that is higher at the ends than the center, or the cutting edge is higher than the heel, is warped or bent and must be replaced.

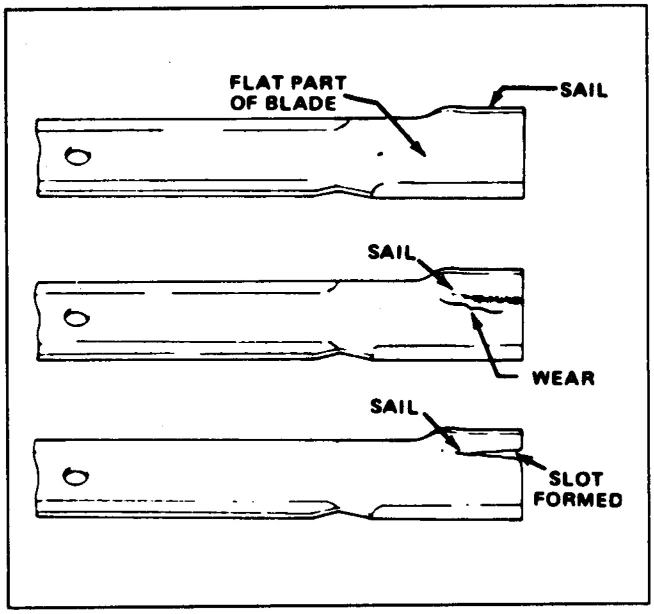


Figure 7

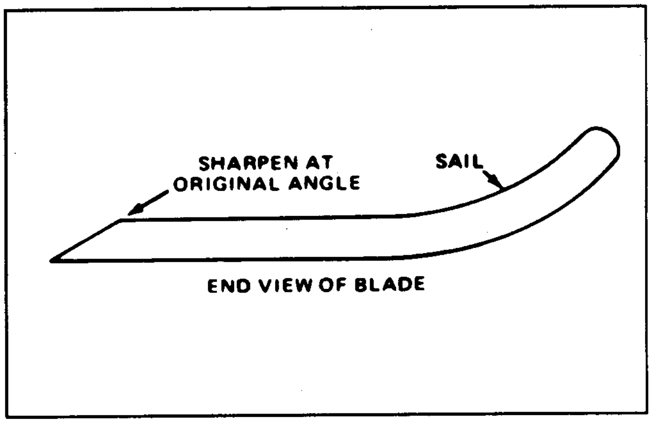
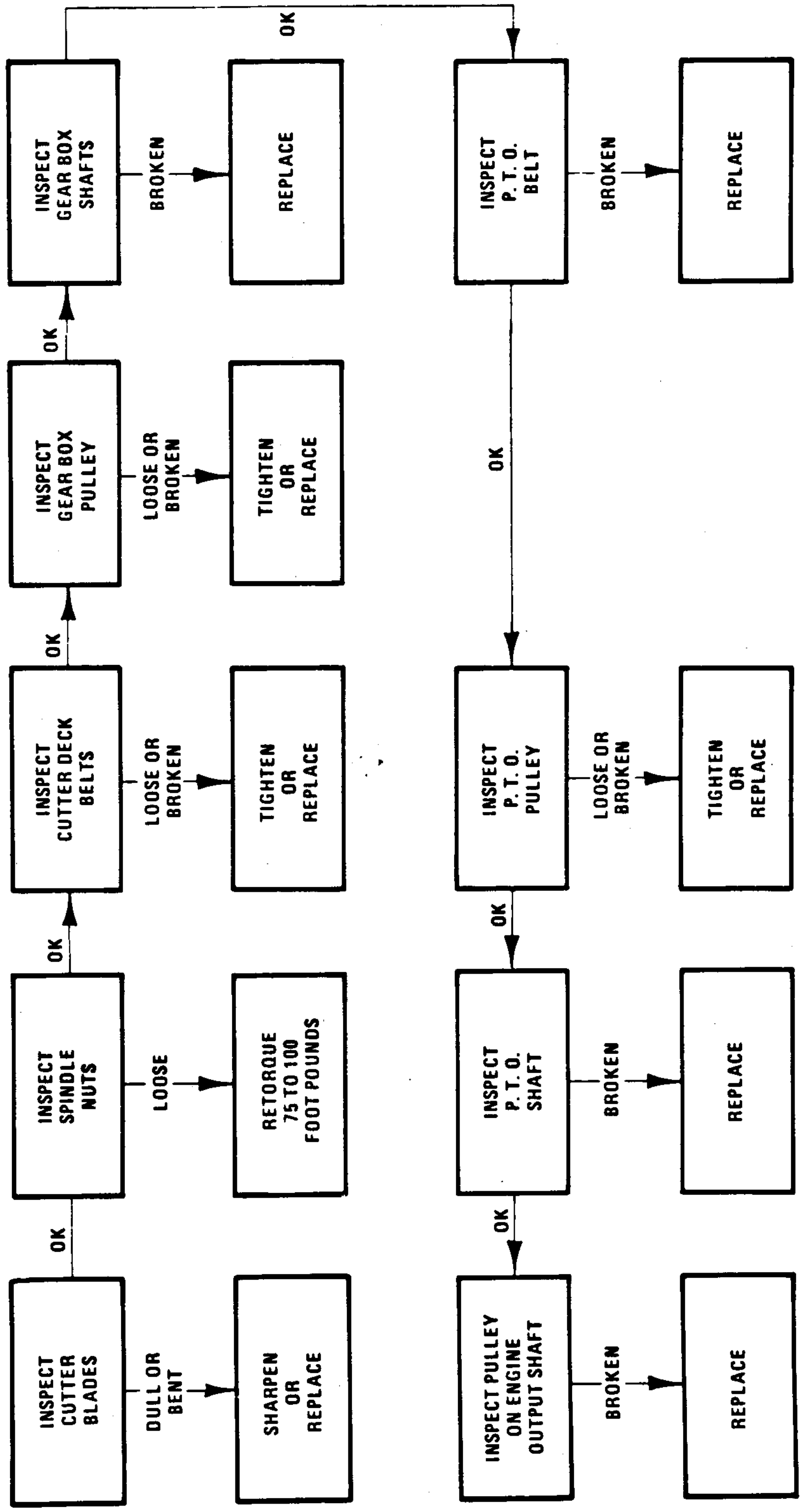


Figure 8

Troubleshooting

UNIT WILL NOT CUT OR CUTS POORLY



Adjustments

Height of Cut Adjustment

The height of cut is adjustable from 1 to 4 inches (25 to 102 mm) in 1/2 inch (13 mm) increments. The adjustment is made by relocating four clevis pins in different hole locations in brackets at each corner of the cutting unit (Fig. 9).

NOTE: All four pins should be in identical hole locations for proper operation.

NOTE: If a side discharge cutting unit is to be used in either the 1 inch (25 mm) or 1-1/2 inch (38 mm) height of cut setting, the rear rollers (Fig. 10, 11) must be repositioned in the top bracket holes.

HEIGHT OF CUT ADJUSTMENT

TURN ENGINE OFF.

PLACE CLEVIS PINS IN HOLES CORRESPONDING TO DESIRED HEIGHT OF CUT.

MAKE SURE ALL FOUR PINS ARE POSITIONED IN IDENTICAL HOLE LOCATIONS.

● 1"
● 1½"
● 2"
● 2½"
● 3"
● 3½"
● 4"

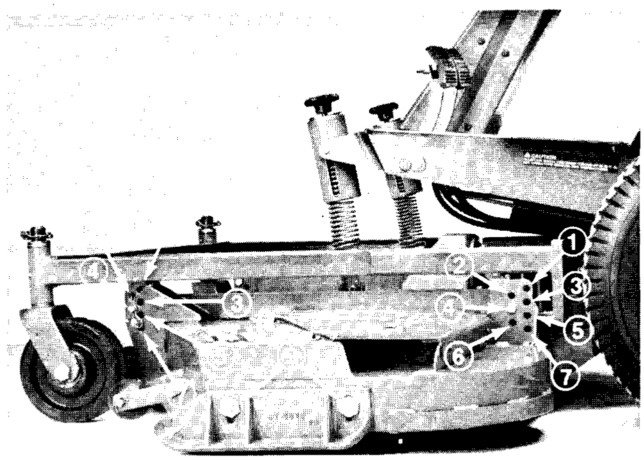


Figure 9

1. 1 in. (25 mm)
2. 1-1/2 in. (38 mm)
3. 2 in. (51 mm)
4. 2-1/2 in. (64 mm)
5. 3 in. (76 mm)
6. 3-1/2 in. (89 mm)
7. 4 in. (102 mm)
8. Skid
9. Flange nuts (2)

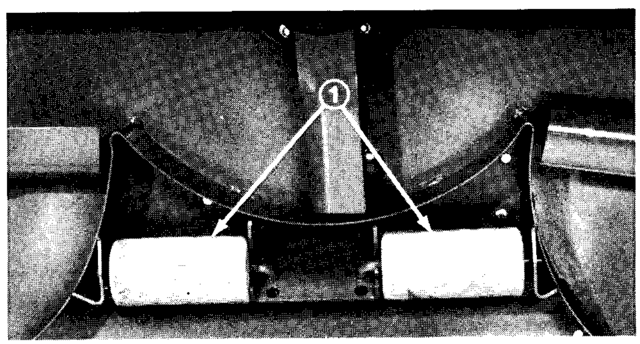


Figure 10

1. Rear rollers

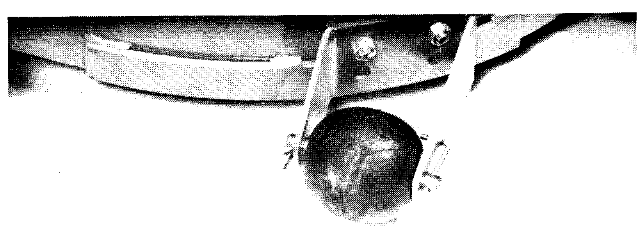


Figure 11

1. Rear roller (Model 30575 only)

Adjusting Skid (Model 30562, 30564 and 30575 Only)

After adjusting height of cut, the deck skid should also be adjusted (Fig. 9).

1 in. H.O.C. - Skid all the way up.
1-1/2 to 2 in. H.O.C. - Skid 1/4 to 3/8 in. off ground.
2-1/2 and higher H.O.C. - Skid all the way down.

Adjust the skid by loosening the flange nuts, positioning the skid as desired, and retightening the flange nuts.

Weight Transfer Adjustment

The cutting unit will give the best performance when spring tension is adjusted so that the cutting unit does not ride too heavily on flat turf while not bouncing excessively in uneven conditions.

If the cutting unit scalps the turf and/or gives an uneven cut from one side to the other, there is too much weight on the deck and weight needs to be transferred to the traction unit (tighten the springs up).

The deck will flop around and give an uneven cut if too much weight is transferred to the traction unit (loosen the springs down).

Initial weight transfer settings:

Adjust to lower range of setting for 1 to 1-1/2 inch cut.
Adjust to middle range of setting for 2 to 3 inch cut.
Adjust to higher range of setting for 3-1/2 to 4 inch cut.

CAUTION

Counterbalance spring(s) are in tension when the cutting unit is in the lowered position. Always raise the cutting unit before adjusting or removing the spring(s).

1. Engage the parking brake, raise the cutting unit and stop the engine.

2. Adjust the weight transfer tension:

   If equipped with adjustment knobs, turn knob to adjust (Fig. 12).

   If not equipped with adjustment knobs, remove hair pin cotter from clevis pin and remove clevis pin. Align top spring end hole with new hole selected in spring cover, insert clevis pin and secure with hair pin cotter. (Fig. 12A)

3. Resume operation. If further adjustments are necessary, refer to steps 1, 2.

Figure 12

1. Weight transfer adjust knobs
2. Spring tension gauge
3. Spring tension range
A. 4 in. cut
B. 2-1/2 in. cut
C. 1 in. cut

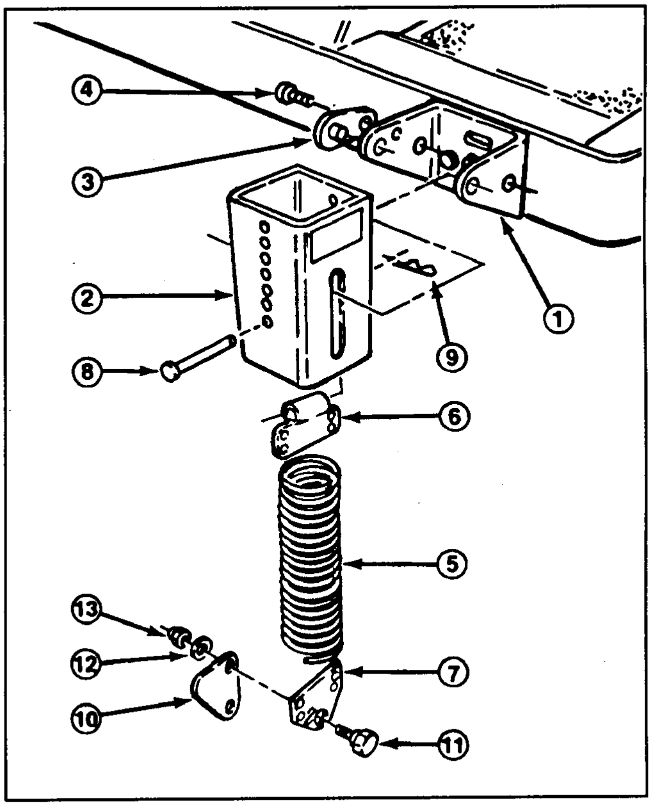


Figure 12A

1. Mounting bracket
2. Spring cover
3. Lock pin
4. Self-tapping screw
5. Extension spring
6. Top spring end
7. Bottom spring end
8. Clevis pin
9. Hair pin cotter
10. Knee link
11. Shoulder bolt
12. Flatwasher
13. Locknut

Checking and Correcting Blade Mismatch

If there is a mismatch between the blades, the grass may appear streaked or at different heights when it is cut. These problems can be corrected by making sure that the blades are straight and that all blades are cutting on the same plane.

Use a 3 ft. long (1 m) carpenter's level or straight edge to find a flat work surface on the shop floor. The best correction for mismatch can be obtained on this flat surface.

1. Lower the cutting unit onto the level surface and engage the parking brake. Be sure that the traction pedal is in NEUTRAL and the P.T.O. switch is OFF. Turn the engine OFF and remove the key from the key switch. Make sure tire pressure is equal in all tires.

2. Raise the height of cut to the 4 inches (102 mm) height of cut position. (See Height of Cut Adjustment in this section of the book.)

3. Rotate the blades so that the tips line up with one another. The tips of the adjacent blades must be within 1/8 inch (3 mm) of each other. If the tips are not within 1/8 inch (3 mm) of each other, proceed to step 8 and add shims between the spindle housing and the bottom of the cutting unit.

4. Position all three blades in the "A" position (Fig. 13) and measure the distance from the level surface to the bottom of the tip end of each blade (Fig. 14).

5. Note measurement attained at "A", rotate the blades to position "B" (Fig. 13), and measure the distance from all of the blade tips to the level surface (Fig. 14), noting the dimensions.

6. Following the same procedures as in steps 4 and 5 above, rotate the blades to the "C" position. Measure and note the distances measured (Figs.13 and 14).

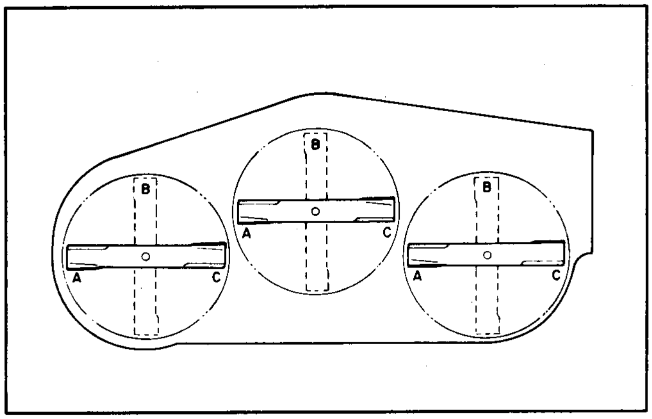


Figure 13

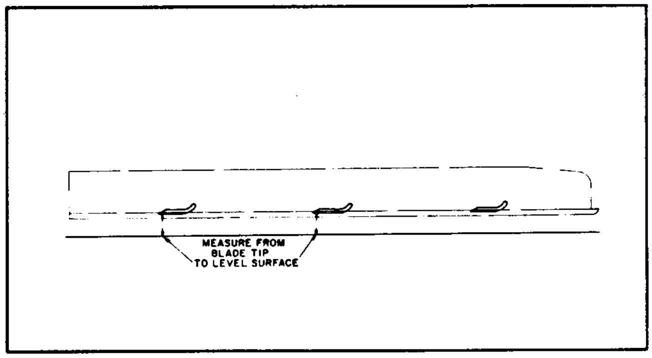


Figure 14

7. Equalize the side to side measurements as follows:

A. Cutting units that are operated at 1 to 2 inches (25 - 51 mm) height of cut should have the low side of the cutting unit raised. Remove the lynch pin securing the castor wheel on the low end (Fig. 15) and remove the castor assembly.

B. Transfer one thrust washer from the top side of the castor shaft to the lower side, install the castor assembly, and compare the blade height of all of the blades; refer to steps 3 - 6. Continue adding thrust washers if the height still does not meet requirements.

C. If the cutting unit is operated between 2 to 4 inches (51 - 102 mm) height of cut, lower the high side of the cutting unit. Remove the lynch pin of the castor wheel at the high end of the cutting unit and remove the castor assembly (Fig. 15).

D. Transfer one thrust washer from the lower side of the castor fork shaft to the top side, reinstall the castor assembly, and compare the blade height of all of the blades; refer to steps 3 - 6. Repeat the procedure if the height still does not meet the requirements.

E. If the height is within the specified dimension, reinstall the lynch pin and set the height of cut to the desired height.

8. Check to make sure that the front height of cut pins are fully contacting against the frame cushions (Fig. 16). If either of the pins is not touching the cushion in one of the front brackets, place a shim or shims under the cushion to raise the cushion until the height of cut pin and the cushion fully contact one another.

9. Compare the measurements taken at the various positions. All of the dimensions must be equal within 1/4 inch (6 mm) of each other. If the difference between measurements exceeds 1/4 inch (6 mm), proceed to step 10 and add shims between the spindle housing and the bottom of the cutting unit.

10. Remove the cap screws, flat washers, lockwashers and nuts from the outer spindle in the area where the shims must be added. To raise or lower the blade, add a shim (TORO Part Number 3256-24) between the spindle housing and the bottom of the cutting unit. Continue to check the alignment of each blade and add shims until the tips of the blades are within the required dimensions.

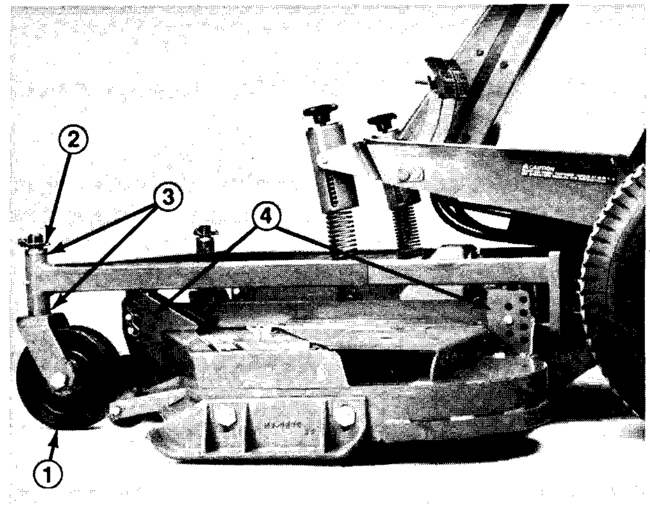


Figure 15

1. **Castor wheel (2)**
2. **Lynch pin (2)**
3. **Thrust washers (6 on each castor wheel)**
4. **Height of cut setting (4)**

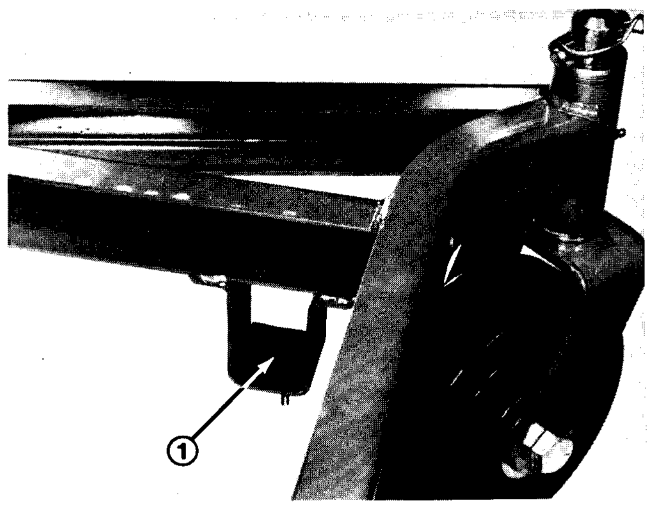


Figure 16

1. **Frame cushions**

Adjusting Blade Belt Idler Pulley Tension

Adjusting Blade Belt Idler Pulley Tension (Model 30555 and 30568)

The idler pulley applies force against the blade belt so that power can be transmitted to the blade pulleys. If the idler is not tensioned against the belt with sufficient force, maximum power will not be transmitted to the pulleys.

Initial tension on a new belt requires 25 to 30 ft-lb (3.5 to 4.1 Kgm) of torque on the large nut, which applies force against the belt. As the belt wears and loosens, 20 to 25 ft-lb (2.7 to 3.4 KgM) of torque on the nut is required. If the idler is not adjusted to these specifications, readjustment is necessary.

1. Lower the cutting unit and engage the parking brake. Be sure that the traction pedal is in NEUTRAL and the P.T.O. switch is OFF. Turn the engine OFF and remove the key from the key switch.

2. Remove the capscrews and lockwashers securing the right hand cover to the top of the cutting unit. Remove the cover from the cutting unit.

3. Loosen the two nuts securing the idler plate in place (Fig. 17). Using a socket and torque wrench, tighten the idler adjusting nut until the proper torque value is achieved.

4. Hold the torque against the belt and tighten the two nuts so that the idler plate is held securely in that position (Fig. 17). Release the idler adjusting nut and install the belt cover with the cap screws and lock washers.

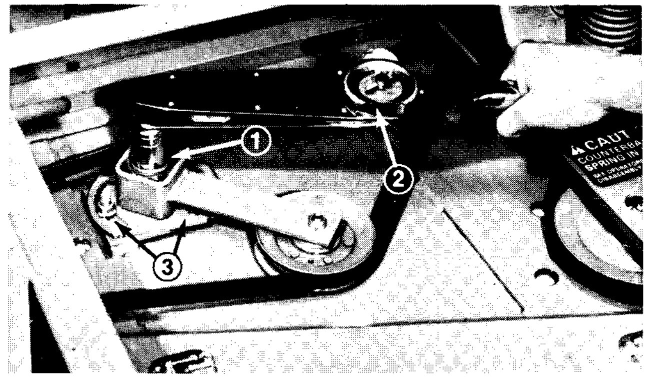


Figure 17

1. Idler adjusting nut
2. Torque wrench
3. Nuts (2)

Adjusting Blade Belt Idler Pulley Tension (Model 30562, 30564 and 30575)

The idler pulley applies force against the blade belt so that power can be transmitted to the blade pulleys. If the idler is not tensioned against the belt with sufficient force, maximum power will not be transmitted to the pulleys.

Model 30562 and 30564: Initial tension on a new belt requires 35 to 40 ft-lb (4.8 to 5.5 Kgm) of torque on the large nut, which applies force against the belt. As the belt wears and loosens, 30 to 35 ft-lb (4.1 to 4.8 KgM) of torque on the nut is required.

Model 30575: Tension on the belt requires 40 to 50 ft-lb (5.5 to 6.9 Kgm) of torque on the large nut, which applies force against the belt.

If the idler is not adjusted to these specifications, readjustment is necessary.

1. Lower the cutting unit and engage the parking brake. Be sure that the traction pedal is in NEUTRAL and the P.T.O. switch is OFF. Turn the engine OFF and remove the key from the key switch.

2. Remove the center cover from the top of the cutting unit (Fig. 18).

3. Loosen the two nuts securing the idler plate in place (Figs. 19). Use a torque wrench to tighten the idler adjusting nut until the proper torque value is achieved.

4. Hold the torque against the belt and tighten the two nuts so that the idler plate is held securely in that position (Figs. 19). Release the idler adjusting nut and install the belt cover.

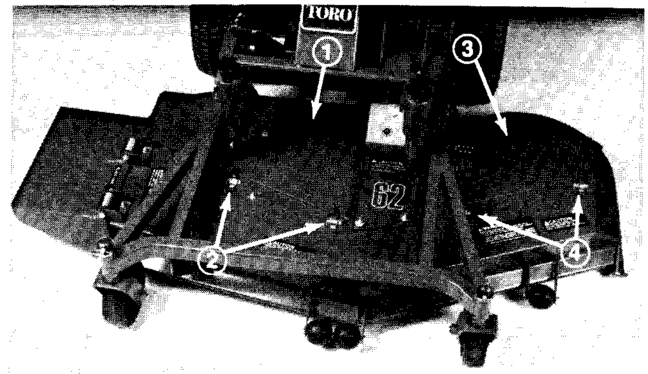


Figure 18

1. **Center cover**
2. **Latches (2)**
3. **Left cover**
4. **Latches (2)**

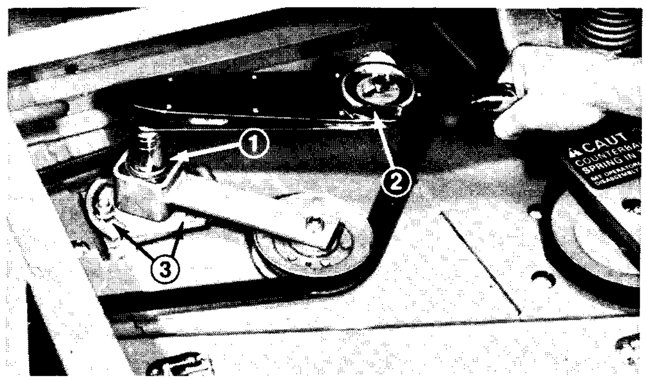


Figure 19

1. **Idler adjusting nut**
2. **Torque wrench**
3. **Nuts (2)**

Castor Wheels

See Chapter 7 - Wheels and Tires, for service and repair information.

Blade Removal and Installation

A cutter blade must be replaced if a solid object is hit, if the blade is out-of-balance, or if the blade is worn or bent. Always use genuine TORO replacement blades to provide the maximum blade safety possible.

CAUTION

Do not try to straighten a blade that is bent. Never weld a broken or cracked blade. Always use the proper, new TORO replacement blade when the condition of the original blade is doubtful.

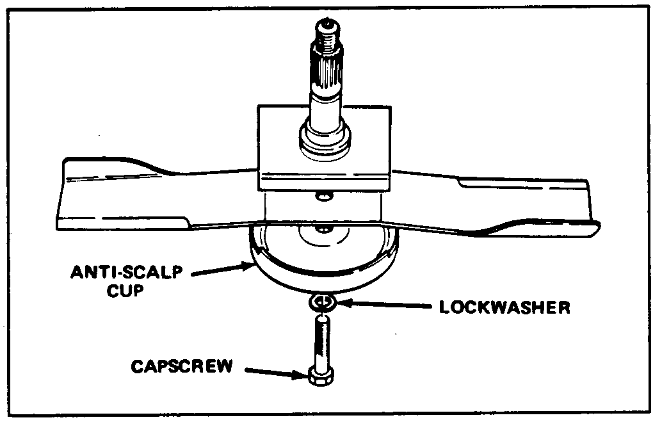


Figure 20

1. Raise the cutting unit to its highest position and engage the parking brake. Be sure that the traction pedal is in NEUTRAL and the P.T.O. switch is OFF. Turn the engine OFF. Block the cutting unit to prevent it from falling accidentally.

2. Grasp the end of the blade using a rag or thickly padded glove. Remove the blade bolt, lock washer, anti-scalp cup, and blade from the spindle shaft (Fig. 20).

3. In sequence, install the blade, with the sail facing toward the cutting unit, and the anti-scalp cup. Secure the parts in place with the blade bolt and lock washer. Tighten the blade bolt to 75 - 100 ft-lb (10.4 - 13.8 KgM).

Checking for Bent Blade

1. Raise the cutting unit and engage the parking brake. Be sure that the traction pedal is in NEUTRAL and the P.T.O. switch is OFF. Turn the engine OFF and remove the key from the key switch. Block the cutting unit to prevent it from falling accidentally.

2. Rotate the blade until the ends face forward and backward. Measure from the inside of the cutting unit to the cutting edge at the front of the blade (Fig. 21); note this dimension.

3. Rotate the opposite end of the blade forward. Measure between the cutting unit and the cutting edge of the blade at the same position described in step 2. The difference between dimensions obtained in steps 2 and 3 must not exceed 1/8 inch (3 mm). If the dimension exceeds 1/8 inch (3 mm), replace the blade because it is bent. See Blade Removal and Replacement in this section of the book.)

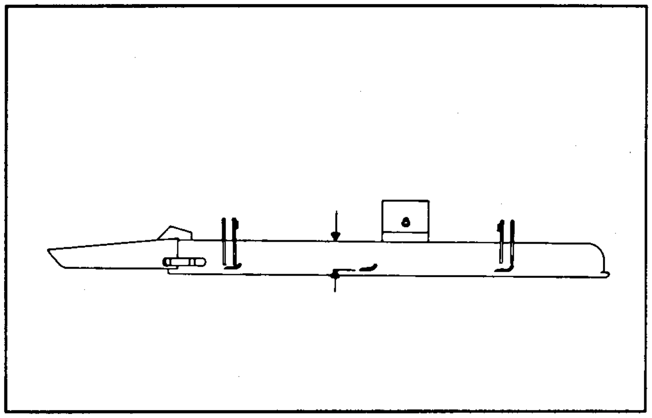


Figure 21

Separating Cutting Unit From Traction Unit

1. Position the machine on a level surface, RAISE the cutting unit, and engage the parking brake. Be sure that the traction pedal is in the NEUTRAL position and the P.T.O. switch is OFF. Turn the engine OFF and remove the key from the switch.

> **CAUTION**
>
> **Counterbalance spring(s) are in tension when the cutting unit is in the lowered position. Always raise the cutting unit before adjusting or removing the spring(s).**

2. Remove the lower shoulder bolt from each weight transfer spring (Fig. 22).

3. Lower the cutting unit to the floor. Remove the pins from the (4) height of cut brackets (Fig 23).

4. Start the engine and move the lift lever to the RAISE position to raise the cutting unit suspension frame.

5. Turn the engine OFF. Slide the cutting unit away from the traction unit and frame, separating the male and female section of the PTO universal drive shaft (Fig. 24). Lower the cutting unit frame to the ground.

6. Cover the male portion of the P.T.O. universal drive shaft (attached to the cutting unit gearbox) with a heavy plastic bag to prevent it from becoming contaminated with dirt.

> **DANGER**
>
> **Do not start the engine and engage the P.T.O. switch while both portions of the P.T.O. shaft are not connected to the gearbox of the cutting unit. If the engine is started and the disconnected P.T.O. shaft is allowed to rotate, serious injury could result.**

If the traction unit will be used without the cutting unit attached, completely remove the P.T.O. universal drive shaft from the traction unit. (See Chapter 11 - P.T.O. System.) The deck suspension frame must be removed if the traction unit will be used with any other accessory. (See Deck Suspension Frame Removal and Installation in this section of the book.)

7. Reverse steps 1 - 6 to install the cutting unit.

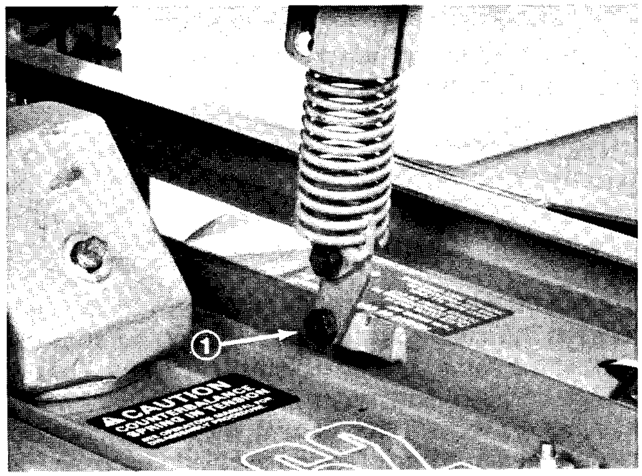


Figure 22

1. Lower shoulder bolt

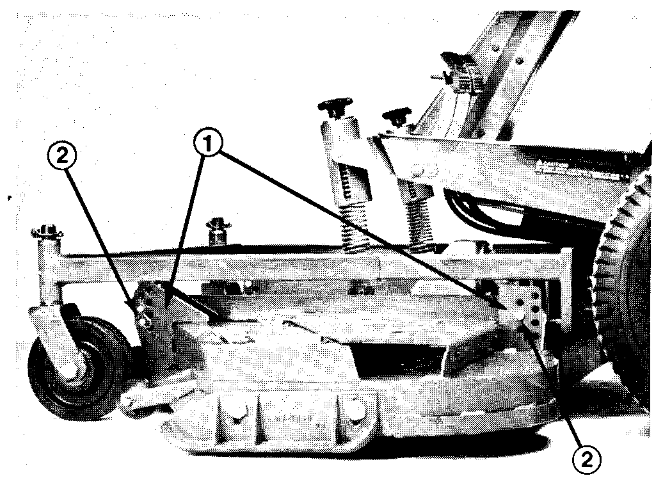


Figure 23

1. Height of cut brackets (4)
2. Pins (4)

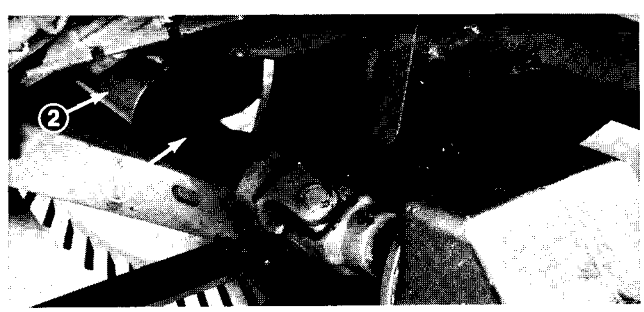


Figure 24

1. Male PTO shaft
2. Female PTO shaft

Suspension Frame Removal and Installation

1. Remove the cutting unit from the suspension frame. (See Separating Cutting Unit From Traction Unit in this section of the book.)

2. Use a pair of locking pliers to remove the end of the brake springs from the slotted holes in the suspension frame (Fig. 25).

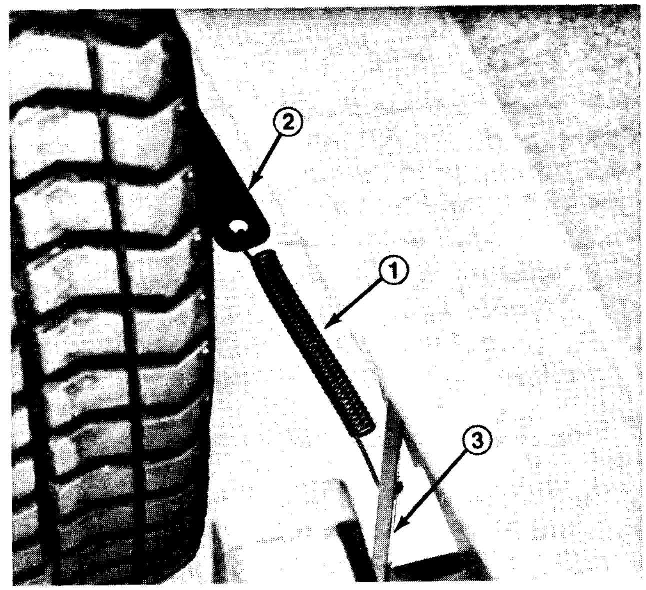


Figure 25

1. Brake return spring (2)
2. Brake arm
3. Suspension frame

3. Remove the cotter pin from each cylinder pin (Fig. 26). Push the cylinder pins out of the frame to disconnect the lift cylinders.

4. Remove the cotter pin from each pivot pin.

5. Remove the cap screw and washer from each pivot pin. Remove the pivot pins from the carrier bracket and frame. Pull the suspension frame out from under the traction unit.

6. Reverse steps 1 - 5 to install the cutting unit suspension frame.

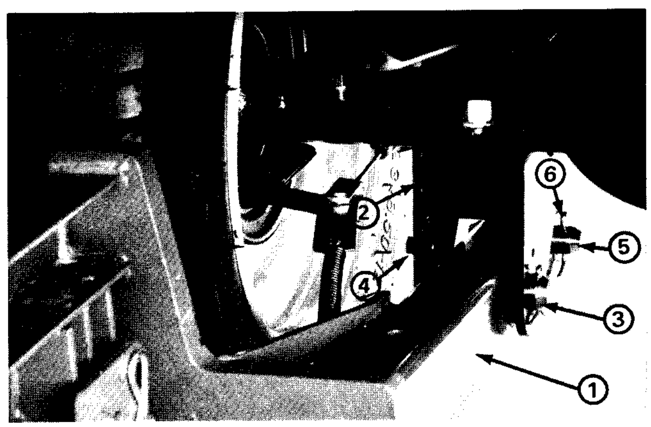


Figure 26

1. Frame
2. Carrier bracket
3. Pivot pin
4. Capscrew
5. Cylinder pin
6. Cotter pins

Weight Transfer System Service

> **CAUTION**
>
> **The counterbalance spring(s) are in tension when the cutting unit is in the lowered position. Always raise the cutting unit before adjusting or removing the spring(s).**

1. Fully raise the cutting deck, engage the parking brake, turn the engine OFF and remove the key from the ignition switch. Put blocks under the cutting deck to prevent it from dropping during the repairs.

2. Disassemble and replace parts as necessary.

3. Assemble the parts as shown in the Parts Catalog and Figures 27 and 28. When installing a spring, thread it through the holes in the spring ends until the spring passes through all four holes.

NOTE: 62" cutting decks use a heavy rate extension spring on the left hand side (large diameter spring wire) and a light rate extension spring on the right (small diameter spring wire).

IMPORTANT: The top hole in the knee link bracket(s) must be towards the rear (Fig. 27). If installed incorrectly, the extension spring could fold incorrectly, going under the traction frame when the deck is raised all the way.

4. Adjust the counterbalance spring tension. (See Weight Transfer Adjustment in the Adjustments section of this chapter.)

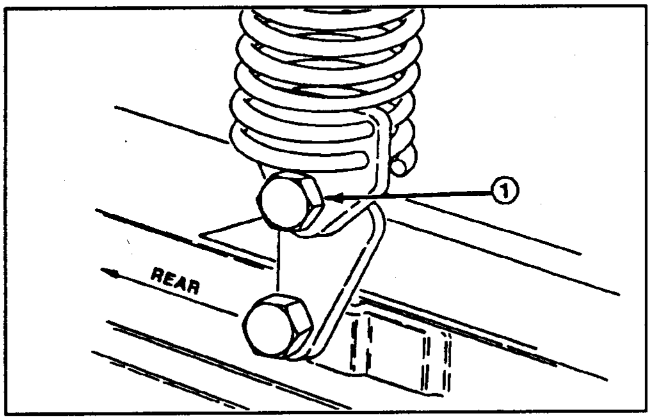


Figure 27

1. Top knee link hole toward rear

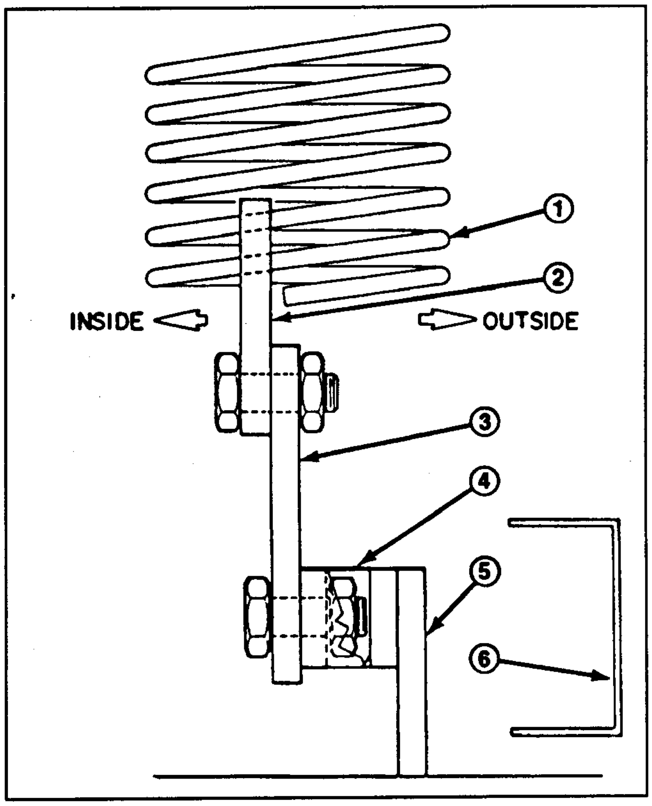


Figure 28

1. Weight transfer spring
2. Spring end plate
3. Knee link bracket
4. Deck bracket
5. Deck frame
6. Floatation frame

Replacing Blade Drive Belt

The blade drive belt, tensioned by an adjustable idler, is very durable when the proper belt tension is maintained. However, after many hours of use, the belt will show signs of wear.

Signs of a worn belt are: a squealing sound while the belt is rotating, blades slipping when cutting grass, or damage to the belt such as frayed edges, burn marks, or cracks. Replace the belt if any of these conditions are evident.

1. Lower the cutting unit and engage the parking brake. Be sure that the traction pedal is in NEUTRAL and the P.T.O. switch is OFF. Turn the engine OFF and remove the key from the key switch.

2. Remove the covers from the top of the cutting unit.

3. Loosen the two nuts securing the idler plate in place and remove the old belt from the pulleys (Fig. 29).

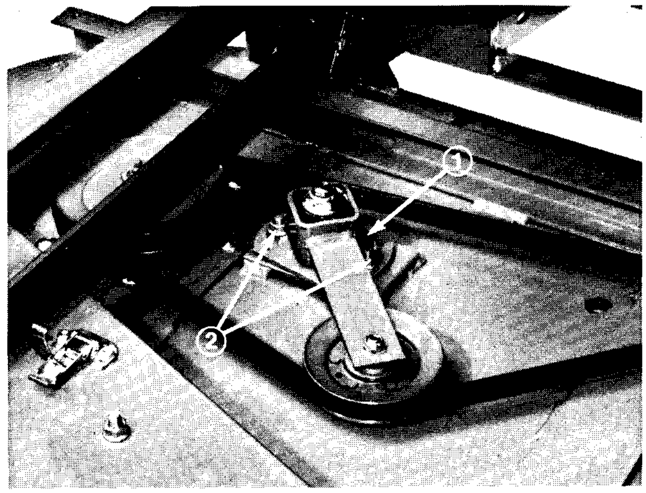


Figure 29

1. Idler plate
2. Flange nut

4. To install a new belt, the gearbox base must be removed. Remove the four carriage bolts, nuts and washers holding the gearbox base to the deck housing (Fig. 30).

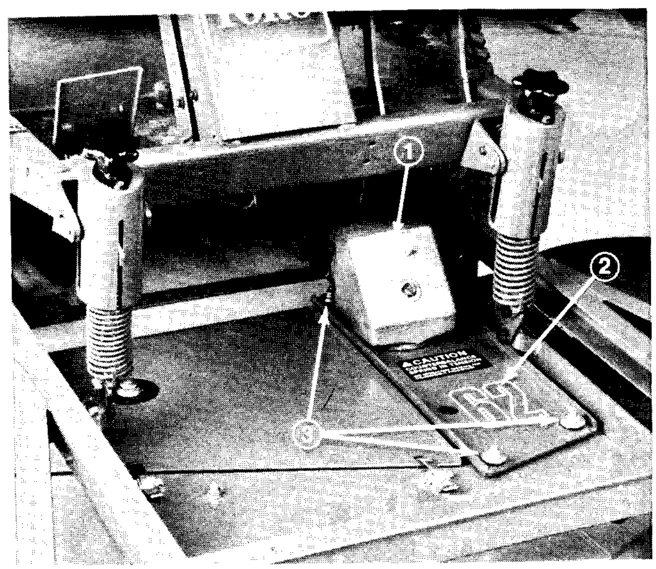


Figure 30

1. Gearbox
2. Gearbox base
3. Carriage bolts, nuts and washers

5. Install a new belt around the gearbox pulley, spindle pulleys, and idler pulley (Fig. 31).

6. Install the gearbox base to the deck housing with the carriage bolts, washers and nuts.

7. Use a torque wrench to adjust the tension of the idler pulley against the belt. (See Adjusting Blade Belt Idler Pulley Tension in the Adjustments section of this chapter.)

8. Install the belt covers.

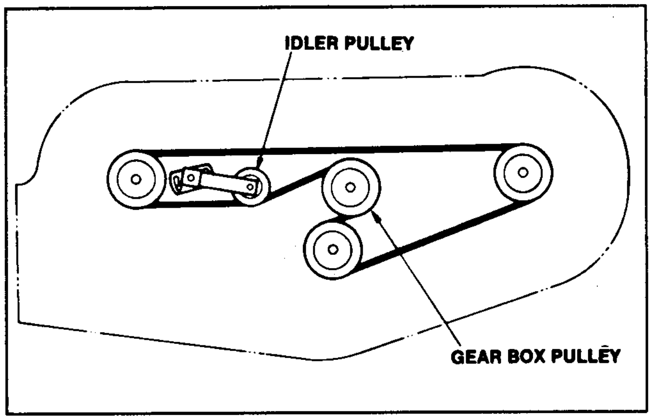


Figure 31

Castor Arm and Castor Fork Bushing Service

The castor arms have bushings pressed into the top and bottom portion of the tube. To check the condition of the bushings, raise the deck or suspension frame and move the castor fork back and forth and from side to side. If the castor spindle is loose inside the bushings, the bushings are worn and must be replaced.

1. Raise the cutting unit and block up the suspension frame and turn the engine OFF. Remove the key from the key switch.

2. Remove the lynch pin and thrust washers from the top of the castor spindle.

3. Pull the castor spindle out of the mounting tube. Allow the thrust washers to remain on the castor fork spindle (Fig. 32).

4. Use a pin punch to drive the bushings out of the tube (Fig. 32). Clean the inside of the tube to remove any dirt.

5. Apply grease to the inside and outside of the new bushings. Using a hammer and a flat plate, carefully drive the bushings into the mounting tube.

6. Inspect the castor spindle for wear and replace it if it is damaged or worn.

7. Push the castor spindle through the bushings and mounting tube. Slide the spacers onto the spindle. Install the lynch pin through the castor spindle to retain all of the parts in place. Remove the blocks supporting the deck.

IMPORTANT: When bushings are installed, the inside diameter of the bushing may collapse slightly; this may not allow the castor spindle to be installed. If the castor spindle does not slide through the new bushings and mounting tube, ream both bushings to an inside diameter of 1.126 inches (28.60 mm).

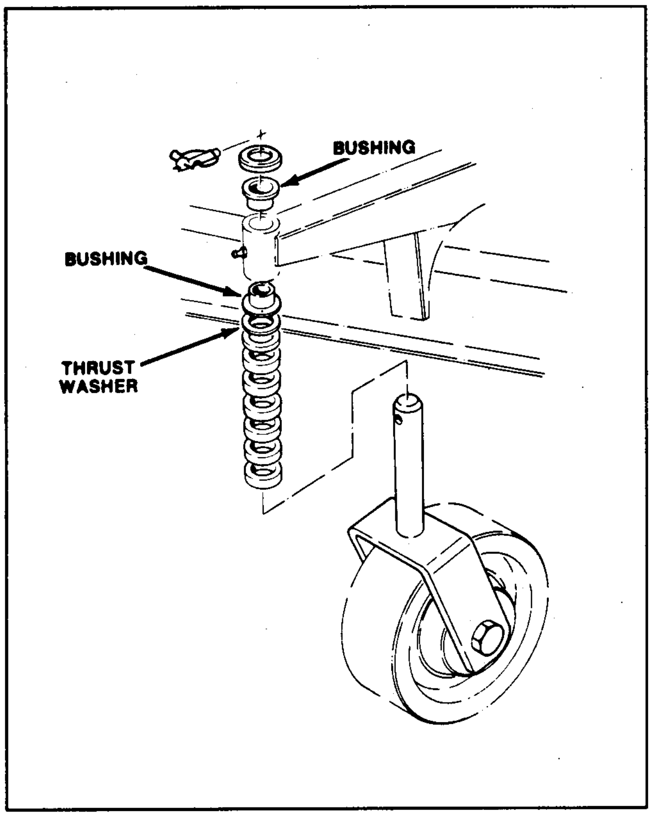


Figure 32

Belt Idler Pulley, Arm and Plate Service

1. Lower the cutting unit and engage the parking brake. Be sure that the traction pedal is in NEUTRAL and the P.T.O. switch is OFF. Turn the engine OFF and remove the key from the key switch.

2. Remove the right-hand belt cover from the top of the cutting unit.

3. Loosen the two nuts securing the idler plate to the deck housing (Fig. 33). The belt tension will be released when the nuts are loosened.

4. Remove the large nut and flat washer that retain the idler arm onto the idler plate shaft (Fig. 34). Slide the arm off of the shaft and account for the square key.

5. Remove the cap screw and lock washer that hold the idler pulley and arm together (Fig. 34).

6. Inspect the idler pulley for concentricity and its bearing for smooth operation. Replace the idler pulley if it is damaged.

7. To reinstall the idler pulley, mount the pulley against the bottom of the idler arm with the cap screw and nut. Tighten the locknut securely.

NOTE: The head of the cap screw must be toward the bottom of the cutting unit when the idler assembly is installed on the idler plate shaft (Fig. 34).

8. Remove the two nuts, lock washers and flat washers that hold the slotted idler plate in place (Fig. 34).

9. To install the idler plate, slide the idler plate and flat washers onto the threaded studs. Thread the nuts onto the studs but do not tighten them.

10. Install the key into the keyway in the idler plate shaft. Slide the idler arm socket onto the shaft and retain it in place with the large nut. Tighten the locknut to 30 ft-lb (4.1 KgM).

11. Reinstall the belt into all of the pulleys as shown in Figure 35.

12. Adjust the idler pulley tension against the belt. (See Adjusting Blade Belt Idler Pulley Tension in the Adjustments section of this chapter.)

13. Install the belt cover.

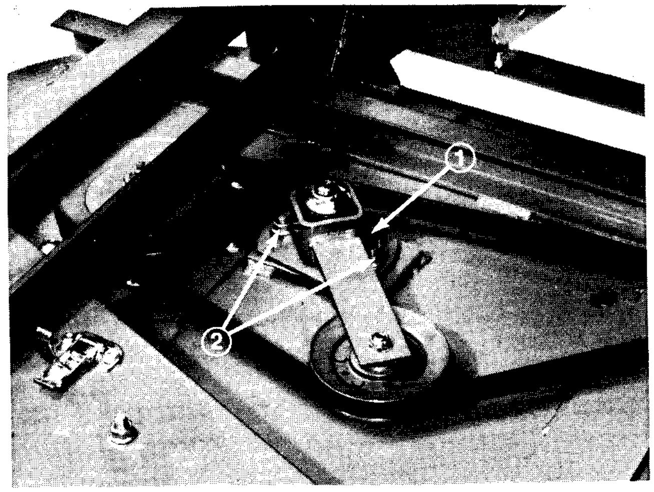


Figure 33

1. Idler plate 2. Flange nut (2)

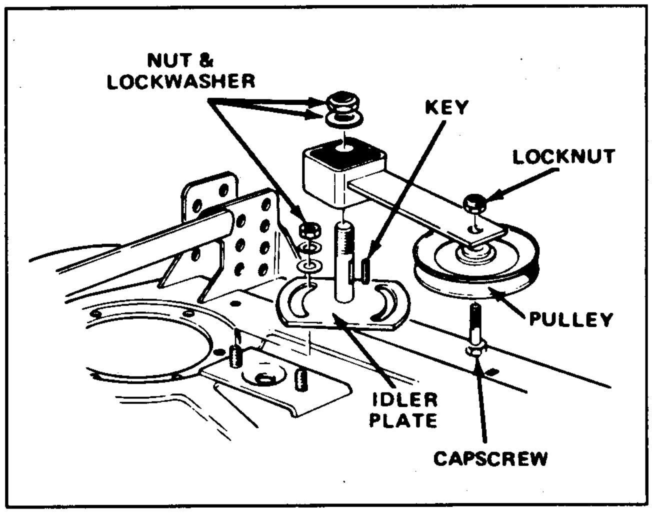


Figure 34

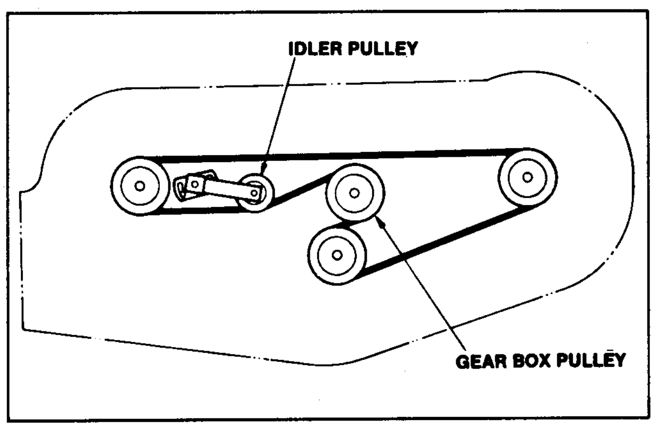


Figure 35

Replacing Spindle Pulley

1. Lower the cutting unit and engage the parking brake. Be sure that the traction pedal is in NEUTRAL and the P.T.O. switch is OFF. Turn the engine OFF and remove the key from the key switch.

2. Remove the belt covers from the top of the cutting unit.

3. Loosen the two nuts securing the idler plate in place so that the tension of the idler pulley against the belt is released (Fig. 33). Remove the belt from the spindle pulley that will be replaced.

4. Raise the cutting unit to it highest position and engage the parking brake. Be sure that the traction pedal is in the NEUTRAL position and the P.T.O. switch is in the DISENGAGE position. Turn the engine OFF and remove the key from the key switch. Block the cutting unit up to prevent it from accidentally falling.

5. Remove the six carriage bolts and flange nuts holding the spindle housing assembly and support ring against the cutting unit deck housing (Fig. 36). Slide the spindle housing assembly out through the bottom of the cutting unit.

6. Remove the locknut and flat washer that retain the pulley onto the spindle shaft. Pull the pulley off of the shaft; use caution not to bend the pulley.

7. Check the splines on the inside of the pulley and the pulley flanges for straightness. If the splines are damaged or the flanges bent, replace the pulley. When installing a new pulley, check the splines on the end of the spindle shaft for damage. If splines are damaged, the spindle shaft must be replaced before the pulley is installed.

8. Install the pulley onto the spindle shaft with the flat washer and locknut. Tighten the nut to 100 ft-lb (13.8 KgM).

9. Slide the pulley end of the spindle housing assembly up through the hole in the cutting unit. Loop the belt around the pulley and idler. Mount the spindle assembly in place with support ring and six carriage bolts and flange nuts (Fig. 36).

10. Remove the blocking and lower the cutting unit.

11. Adjust the idler pulley tension against the belt. (See Adjusting Blade Belt Idler Pulley Tension in the Adjustments section of this chapter.)

12. Install the belt covers.

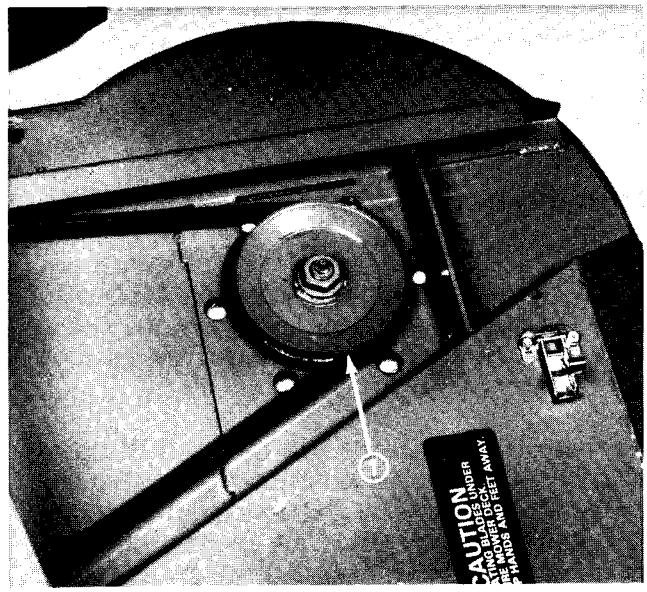


Figure 36

1. Spindle housing assembly

Gearbox and Pulley Assembly Removal and Installation

Removing Gearbox and Drive Pulley

1. Lower the cutting unit and engage the parking brake. Be sure that the traction pedal is in NEUTRAL and the P.T.O. switch is OFF. Turn the engine OFF and remove the key from the key switch.

2. Remove the belt covers from both sides of the gearbox base.

3. Loosen the two nuts securing idler plate in place so that the tension of the idler pulley against the belt is released. Remove the belt from about the gearbox pulley.

4. Remove the four carriage bolts, washers and nuts securing the gearbox base to the top of the cutting unit (Fig. 37). Slide the gearbox and base forward until the P.T.O. shaft separates. Place the gearbox base assembly on a workbench.

> **DANGER**
>
> **Do not start the engine and engage the P.T.O. switch when the P.T.O. shaft is not connected to the gearbox. If engine is started and the P.T.O. shaft is allowed to rotate, serious injury could result.**

5. Remove the set screws from the taper lock bushing (Fig. 38). Install one setscrew into the hole that is threaded on the side of taper lock. Tighten the setscrew until the taper lock is loose from the inside of the pulley hub.

NOTE: Only one setscrew is used to loosen the taper lock.

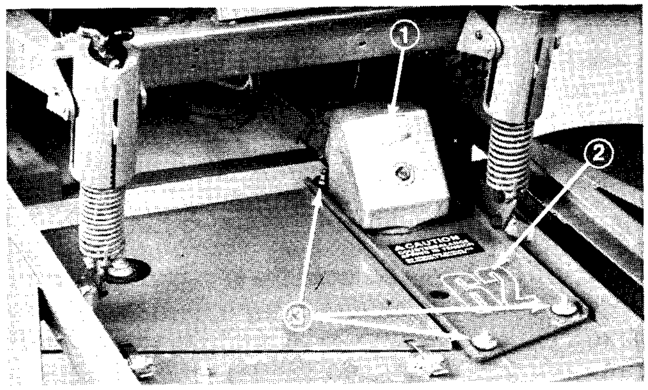


Figure 37

1. Gearbox
2. Gearbox base
3. Carriage bolts, nuts and washers

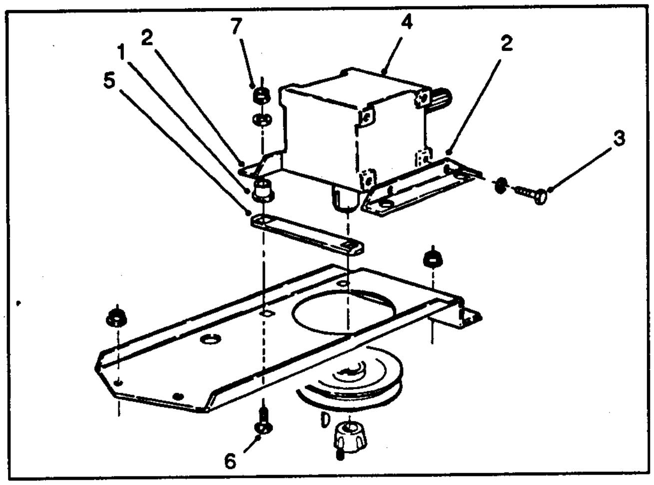


Figure 37A

1. Isolation mounts
2. Brackets
3. Capscrews & lockwashers
4. Gearbox
5. Strap
6. Carriage bolts
7. Flatwashers & nuts

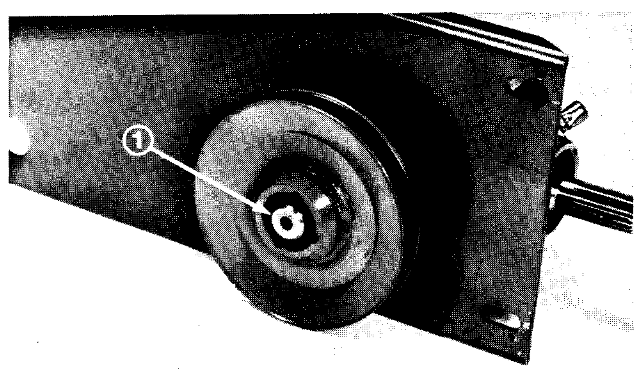


Figure 38

1. Taper lock bushing

6. Slide the gearbox pulley and taper lock off of the gearbox output shaft. Account for the woodruff key that positions the pulley on the shaft, and remove the setscrew from the side of the taper lock.

7. Disconnect the P.T.O. universal shaft yoke from the gearbox input shaft.

8. Remove gearbox from gearbox base plate:

Alumuinum Gearbox (Fig. 37)

A. Remove the five (5) cap screws securing gearbox to base plate.

Cast Iron Gearbox (Fig. 37A)

A. Remove the four nuts, flat washers and carriage bolts securing gearbox and isolation mounts to base plate.

B. Remove four (4) capscrews and lockwashers securing brackets to each side of gearbox.

Installing Gearbox and Drive Pulley

1. Install gearbox to baseplate:

Aluminum Gearbox (Fig. 37)

A. To install the gearbox, secure it to the base plate with the capscrews.

Cast Iron Gearbox (Fig. 37A)

A. Install four (4) isolation mounts into two (2) brackets. Use water or lubricant to ease installation. Install mounts from bottom of bracket.

B.Install bracket on each side of gearbox with capscrews and lockwashers. Tighten capscrews to a torque of 20 - 26 ft-lb.

C. Align holes in thin metal strip with the two front gearbox mounting holes on base plate.

D. Mount gearbox with brackets onto base plate. Insert four (4) carriage bolts up from bottom of base plate and install flatwasher and nut on each bolt to secure gearbox to base plate. Tighten nuts to 20 - 26 ft-lb.

2. To install the pulley, lay the pulley on the workbench with the hub side up. Then slide the taper lock - small end first - into the pulley hub.

3. Insert the woodruff key into the keyway in the gearbox shaft. Slide the pulley with the taper lock onto the gearbox shaft while aligning the key and keyway.

NOTE: The large hub on the pulley must face away from the gearbox, and like the taper lock, the pulley must contact the shoulder on the gearbox shaft.

4. Rotate the pulley to get the non-threaded holes in the taper lock to line up with the two threaded holes in the hub of the gearbox pulley. Start threading the setscrews into the two holes and tighten them alternately and evenly until both setscrews are tight.

5. Using a brass drift pin or sleeve and a hammer, hit the taper lock firmly. Now tighten the setscrews to 55 in-lb (63 KgCm). Continue to hit the taper lock and tighten the set screws until the 55 in-lb (63 KgCm) of torque will not turn the setscrews.

6. Check the alignment of the gearbox with a spindle pulley. Loosen and relocate the taper lock to adjust, if necessary.

7. Fill the recessed socket head in each setscrew, and the other taper lock holes, with grease to prevent dirt from packing into the holes.

8. Loop the blade drive belt around the gearbox pulley and mount the gearbox base on top of the cutting unit with the four carriage bolts, lock washers and nuts.

9. Assemble the two pieces of the P.T.O. universal drive shaft by sliding them together. Align the holes of the P.T.O. U-joint and the gearbox input shaft and secure them together with a new roll pin.

10. Lubricate the P.T.O. shaft. Also check the gearbox oil level and replenish as needed.

11. Install the belt around the spindle pulleys and idler pulley. Adjust the idler pulley tension against the belt. (See Adjusting Blade Belt Idler Pulley Tension in the Adjustments section of this chapter.).

Gearbox Repair (Aluminum Gearbox)

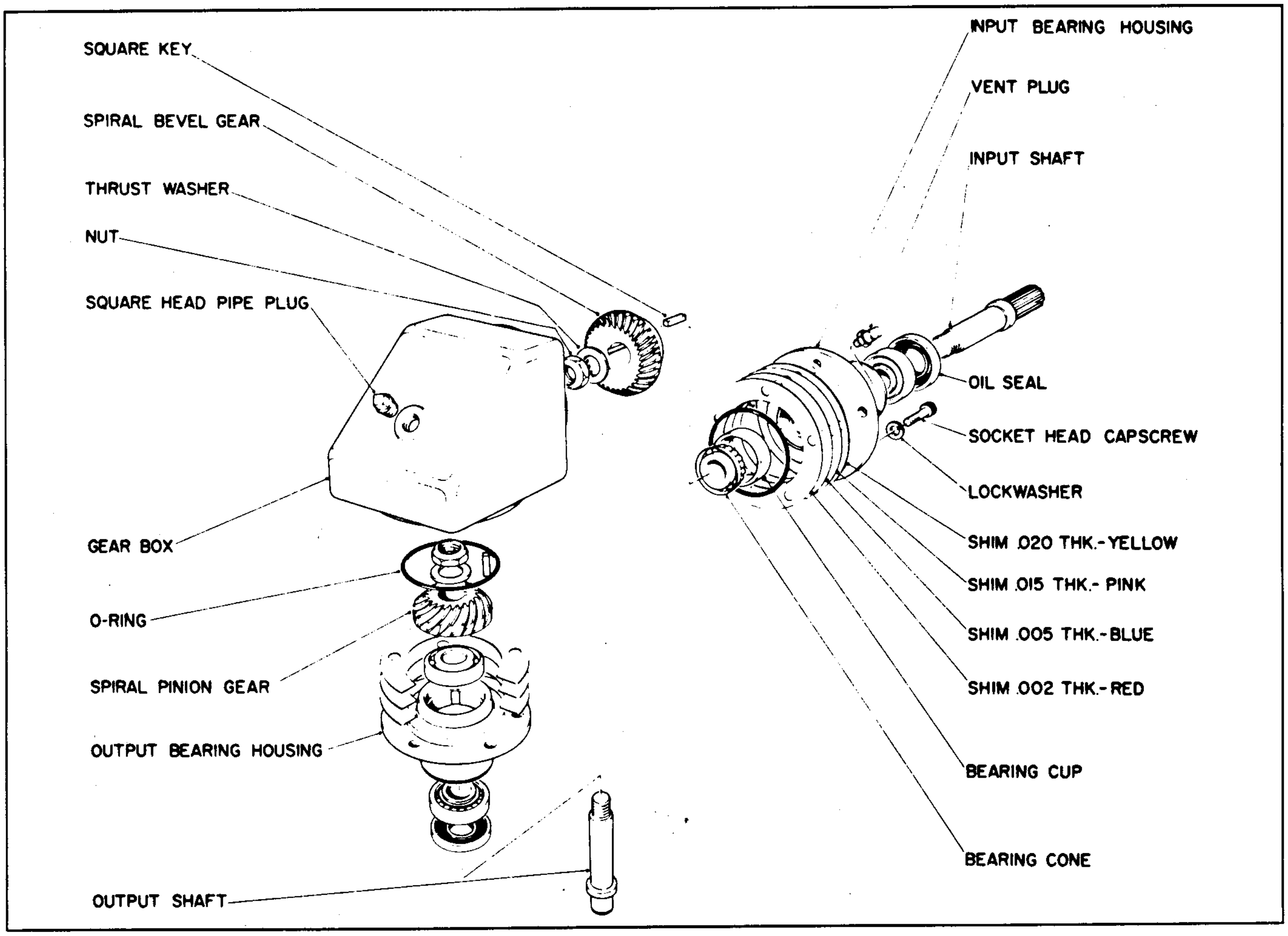


Figure 40

1. Remove the gearbox and the pulley from the machine. (See Removing And Replacing Gearbox and Pulley Assembly, steps 1 - 8.)

2. Remove the pipe plug from the gearbox and drain the oil out of the gearbox.

3. Scribe a mark on the input and output shaft housings and gearbox to aid assembly operation (Fig. 39).

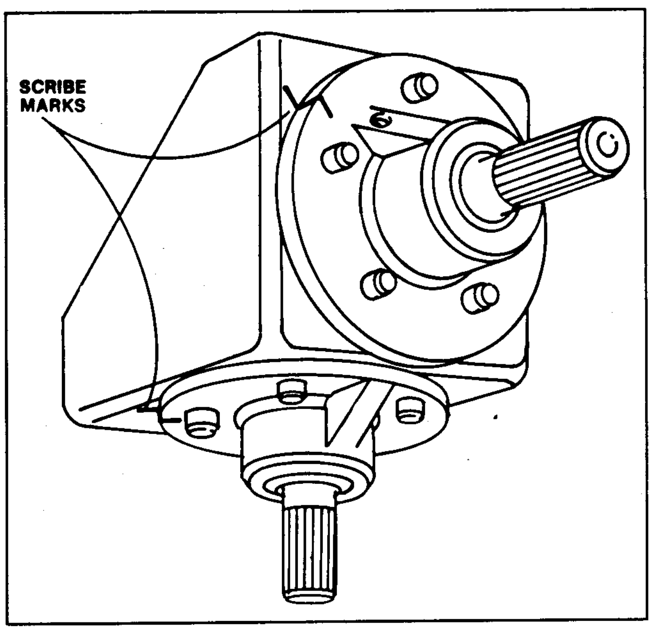


Figure 39

Input And Output Shaft Removal

1. Remove the five cap screws securing the input bearing housing assembly to the gearbox. Tap the input housing with a soft-faced hammer while pulling on the input shaft to remove it from the gearbox (Fig. 40).

2. Remove the five cap screws securing the output bearing housing assembly to the gearbox. Tap the input housing with a soft-faced hammer while pulling on the output shaft to remove it from the gearbox.

NOTE: Keep track of the number and color of shims used in each bearing housing assembly. Remember the position of the vent plug to be sure the input housing is in the correct position during reassembly.

IMPORTANT: The input and output bearing housing cap screws are of different lengths. Do not intermix them.

3. Mount the input shaft and bearing housing assembly into a soft-jawed vise. Remove the nut and thrust washer from the input shaft.

4. Use a bearing separator to remove the gear from the shaft. Remove the square key.

5. Support the mounting flange of the input bearing housing in an arbor press and press the shaft, threaded end up, out of the housing (Fig. 40).

6. One complete bearing and one bearing cup will remain in the housing. Remove the remaining bearing cone and drive both cups out of the housing with a drift punch and hammer. Press the other bearing cone off of the shaft.

7. Use procedures 3 - 6 above to disassemble the output shaft and bearing housing assembly (Fig. 40).

8. Discard the shaft nut, shaft seal, and housing O-ring for both assemblies and replace these items with new parts.

9. Inspect the input and output shafts for straightness, possible wear at the seal area, damaged keyways, and chipped or damaged threads. Discard and replace all worn and damaged parts.

10. Examine the bearings and cups for any signs of discoloration, pitting, or wear. Replace these parts as necessary.

11. Inspect the pinion gear and bevel gear for chipped or extremely worn teeth. Also check the wear pattern in the profile of the teeth. A properly shimmed and lubricated gearbox assembly will be evident by a smooth, even wear pattern centered in the teeth of the two gears.

It is recommended that both gears be replaced if either shows signs of excess wear or damage.

12. Examine the gearbox and bearing housings for cracks, damaged threads, and poor mounting or sealing surfaces. Repair or replace these components as needed.

Input And Output Shaft Reassembly

NOTE: Use the following procedures to assemble both of the input and output shafts to their respective bearing housings. Use an arbor press when installing bearings, seals, etc (Fig. 40).

1. Press the bearing cups into the bearing housing with the smallest inside diameter of the cups toward the inside of the housing.

2. Press a bearing cone onto the shaft and insert the shaft into the housing.

3. Press on the remaining bearing cone. Install the square key into the shaft keyway. Press the gear onto the shaft. Apply a light coating of Loctite 242 or 601 onto the shaft and inside the gear. Install the thrust washer and nut onto the shaft (Fig. 40).

4. Clamp the shaft end into a soft-jawed vise and rotate the bearing housing while tightening the nut to insure that the bearings are matched with the races. Tighten the nut until the shaft and bearing assembly has .001 - .005 inch (0.025 - 0.127 mm) of end play.

5. Apply No. 2 Permatex to the outer surface of the seal. Apply oil onto the seal lips and press the new seal into the bearing housing with the seal lips facing in toward the gearbox (Fig. 40).

Installing Input And Output Shaft Into Gearbox

IMPORTANT: It is recommended that the shims be replaced during shaft assembly reinstallation. However, if only the bearings, shafts, or gears have been replaced, use the same number and size shims as were used originally. If the gearbox or bearing housing has been replaced, install a .020 inch (0.51 mm) shim as a beginning shim; alignment to the correct dimensions (gear backlash) will be required.

1. Install the shims onto the housing (Fig. 40).

2. Oil the O-rings, install them into the housing and insert both shaft assemblies into the gearbox (Fig. 40).

3. Install the mounting plate, insert the mounting cap screws and torque them to 20 - 25 ft-lb (2.8 - 3.5 KgM) in both shaft and bearing assemblies.

4. Clamp the output shaft of the gearbox in a soft-jawed vise. Lightly clamp a pair of locking pliers onto the input shaft. Mount a dial indicator with magnetic base to the vise so that the dial indicator touches against the pliers (Fig. 41). Move the locking pliers up and down to check the input gear backlash. Backlash should be .005 - .010 inch (0.13 - 0.25 mm) with the dial indicator positioned one and one-half inches (38 mm) from the center of the shaft (Fig. 41).

If the backlash is incorrect, remove the input bearing housing assembly and add or subtract shims as necessary to achieve the specified backlash. Repeat the procedures until the correct backlash is obtained. Shims are available in Red .002 inch, Blue .005 inch, Pink .015 inch, and Yellow .020 inch (0.051, 0.13, 0.38, and 0.51 mm) sizes (Fig. 40).

5. After the correct backlash has been achieved, check the input and output gear pattern to assure that the proper gear mesh has been attained. To accomplish this, remove both shaft assemblies and coat the gear teeth with DyKem steel blue or an equivalent compound. Reinstall both assemblies into the gearbox. Insure that the same number shims are used as established in step 4.

6. Rotate the shafts to establish a wear pattern in the gear pattern compound on the gear teeth and disassemble the input shaft and the bearing housing assembly from the gearbox.

7. Inspect the wear pattern on the gear teeth, compare them to the patterns indicated in Figure 42. Add or remove shims from the output bearing housing to correct any misalignment.

8. Repeat steps 1 - 6 until the desired wear pattern is established. Reassemble the output bearing housing assembly into the gearbox, tighten the cap screws, and fill the gearbox to the bottom of the gearbox plug with SAE 10W40 engine oil.

9. Install the gearbox pulley. (See Removing And Replacing Gearbox And Pulley Assembly, steps 9 - 19.)

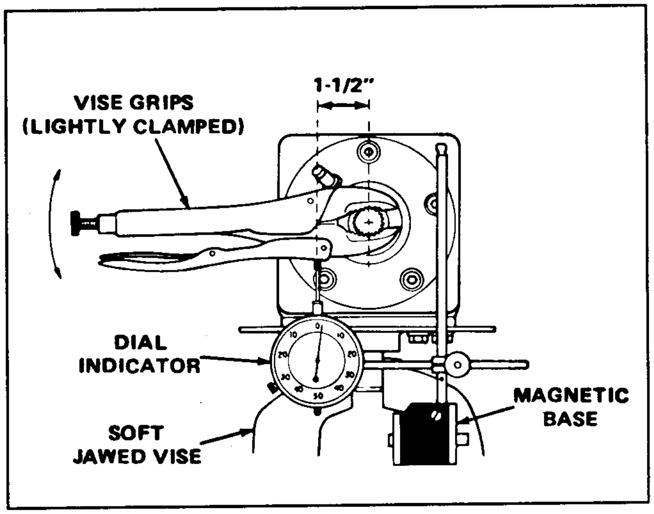


Figure 41

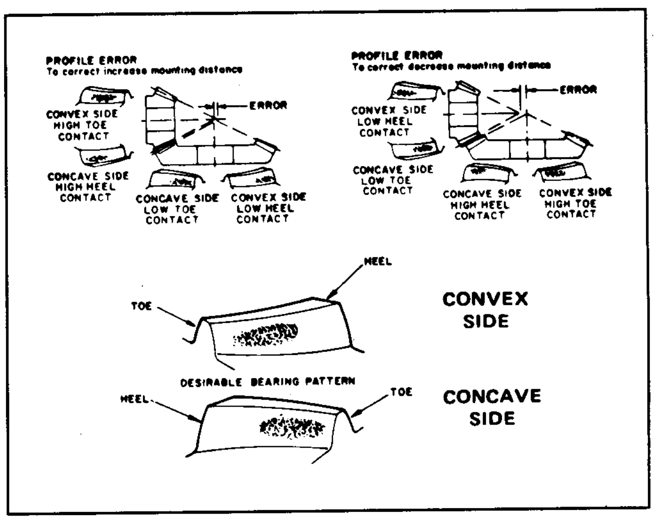


Figure 42

Gearbox Repair (Cast Iron Gearbox)

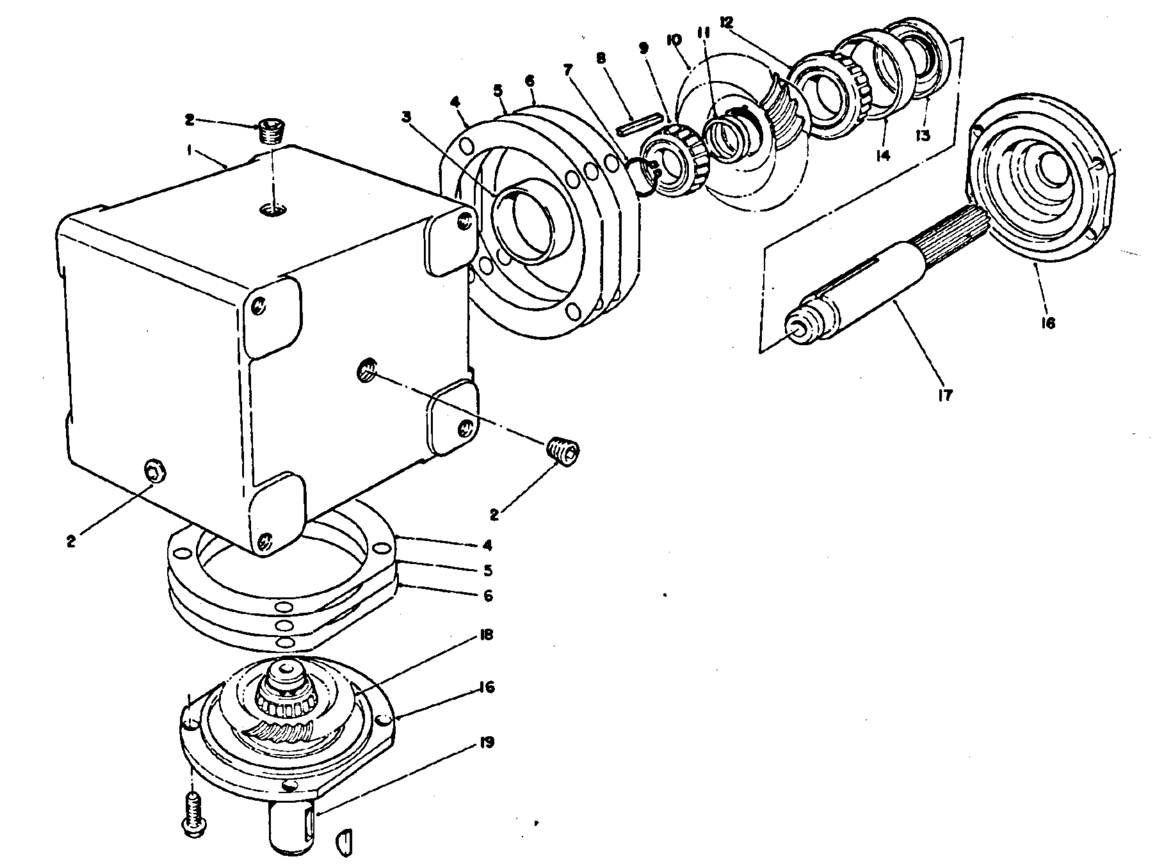


Figure 42A

Disassembly (Fig. 42A)

1. Drain lubricant from gearbox.

2. Remove capscrews and lift out shaft and cap assemblies.

3. Remove cap assemblies and bearing cones (Item 12) from shafts (Item 17, 19).

NOTE: Mark each gear (Item 10 and 18) so they are installed on the proper shaft (Item 17 or 19) when re-assembled.

4. Remove retaining rings (Item 7).

5. Press shafts (Item 17, 19) back through bearing cones (Item 9). When bearing cone is free, gears (Item 10, 18), keys (Item 8) and shims (Item 11) may be removed from the shaft.

6. Remove bearing cups (Item 14) from cap by putting a punch through the shaft bore and through the seal and then tapping against the back of the bearing cup until driven out of the cap.

7. If the oil seal (Item 13) is removed, it will be destroyed. To remove the oil seal, cut it out of the bore with a screw driver or chisel.

8. To remove the bearing cups (Item 3) from the housing a slide hammer puller may be used, or if this is not available, the bearing cups may be knocked out with a punch by coming down through the opposite cap bore and tapping against the back side of the bearing cup until it comes out.

9. Remove the plugs (Item 2) from the housing.

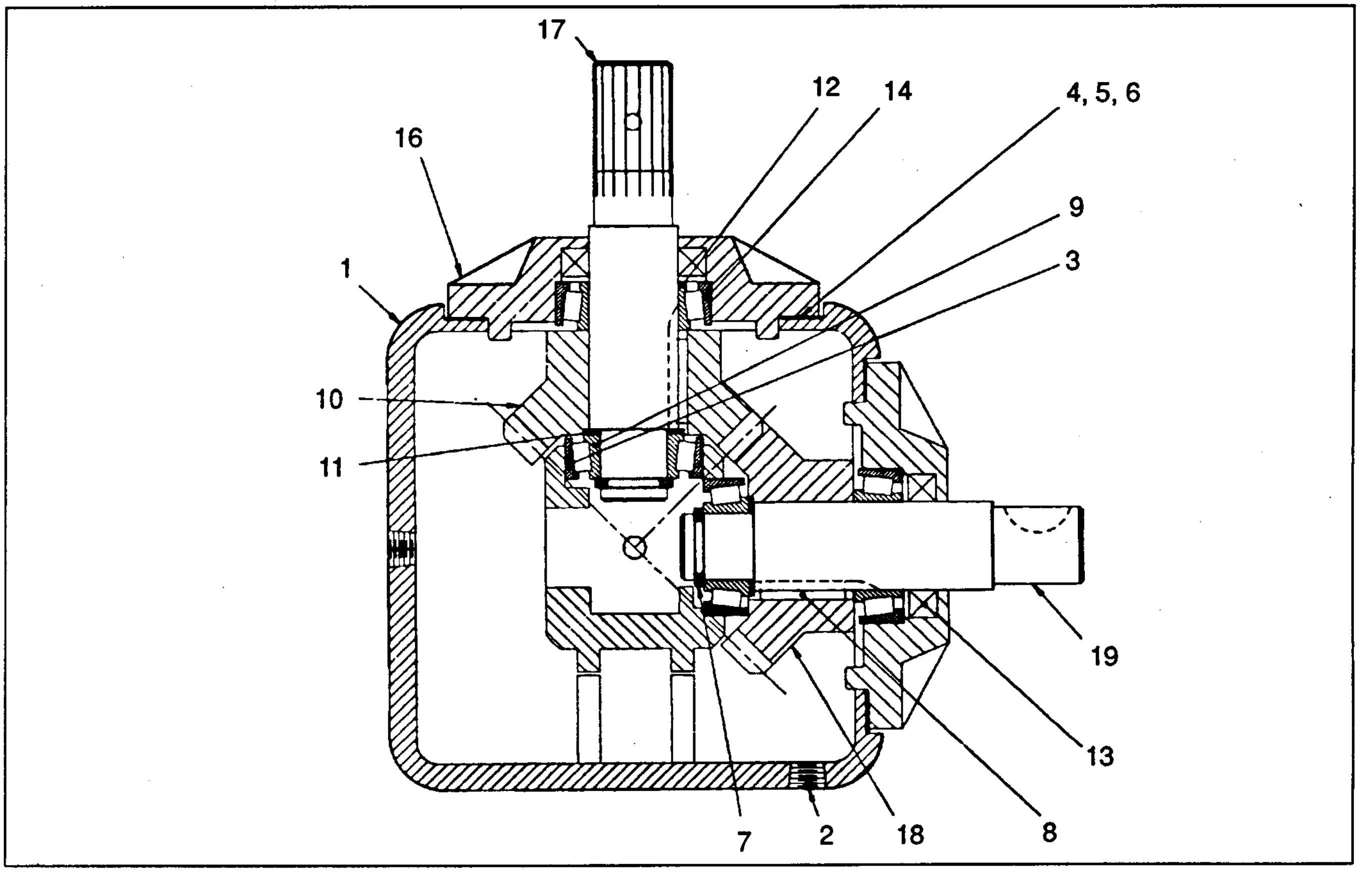


Figure 42B

Pre-Assembly (Fig. 42A, 42B)

1. Start with one of the shafts (Item 17) and put one of the gears (Item 10) over the shaft so the tooth side is towards the turned end of the shaft. Align the keyway in the gear with the keyway in the shaft and install one of the keys (Item 8) in the keyway.

2. Install one set of shims (Item 11) onto the turned end of the shaft. Press one of the bearing cones (Item 9) over the turned end of the shaft. Be sure the bearing cone is installed as shown in the illustration (Fig. 42B). Install a retaining ring (Item 7) on the turned end of the shaft.

3. Put one of the bearing cones (Item 12) over the other end of the shaft and down against the hub side of the gear. Be sure the bearing cone is installed as shown in the illustration.

4. Repeat steps 1 - 3 with the other set of parts to complete the assembly.

5. Put one of the caps (Item 16) down, with the machined surface facing up. Install a new seal (Item 13) into the cap with the open side toward the machined side of the cap.

6. Install the bearing cup (Item 14) into the cap. Make sure the bearing cup is installed as shown in the illustration.

7. Repeat steps 5 - 6 with the other set of parts to complete the two cap assemblies.

8. Take one of the shaft and gear assemblies and wrap the end of the shaft with a piece of shim stock to keep from cutting the oil seal on the keyway or splines. Put the cap assembly down over the shaft so the bearing cone (Item 12) on the shaft mates with the bearing cone (Item 14) in the cap. Remove the shim stock from the shaft that was used to protect the seal.

9. Press the bearing cups (Item 3) into both bearing bores in the housing (Item 1). Make sure the cups are installed as shown in the illustration. Install the plugs (Item 2) into the tapped holes in the housing.

Final Assembly (Fig. 42A, 42B)

1. Bearing drag is adjusted by the amount of gaskets (Item 4, 5, 6) used between the cap and housing machined surfaces.

2. Put two 0.015 in. gaskets on the machined surface of the housing, then install the shaft and cap assembly in the housing so the bearing cone (Item 9) on the shaft assembly and bearing cup (Item 3) in the housing are mating. Align the holes in the cap with the holes in the gaskets and housing.

3. Install capscrews and tighten.

4. The shaft should have a very slight amount of bearing drag. If the shaft turns hard, the cap must be removed and gasket(s) need to be added. If the shaft has no bearing drag, or has end play, the cap must be removed and gasket(s) taken out. The cap must be adjusted to where the shaft has no end play and only a slight amount of bearing drag.

5. Repeat steps 1 - 4 with the other shaft and cap assembly.

6. After installing the gearbox on the cutting unit, fill it with SAE 80W90 API GL-5 lubricant to the level of the check plug (see Maintenance section in this chapter).

Blade Spindle Service

Removing Spindle And Bearings From Spindle Housing

1. Lower the cutting unit and engage the parking brake. Be sure that the traction pedal is in NEUTRAL and the P.T.O. switch is OFF. Turn the engine OFF and remove the key from the key switch.

2. Remove belt cover on top of the spindle housing to be serviced. Also remove the right-hand belt cover and loosen the two nuts securing the (blade belt tension) idler plate in place (Fig. 33). This will release the tension on the drive belt.

3. Remove the belt from the spindle to be serviced.

4. Start the engine and raise the cutting unit. Turn the engine OFF and remove the key from the key switch. Block up the cutting unit so it cannot fall accidentally.

5. Remove the six carriage bolts and flange nuts holding the spindle housing assembly and the support ring against the cutting unit (Fig. 43). Slide the spindle housing assembly out the bottom of the cutting unit.

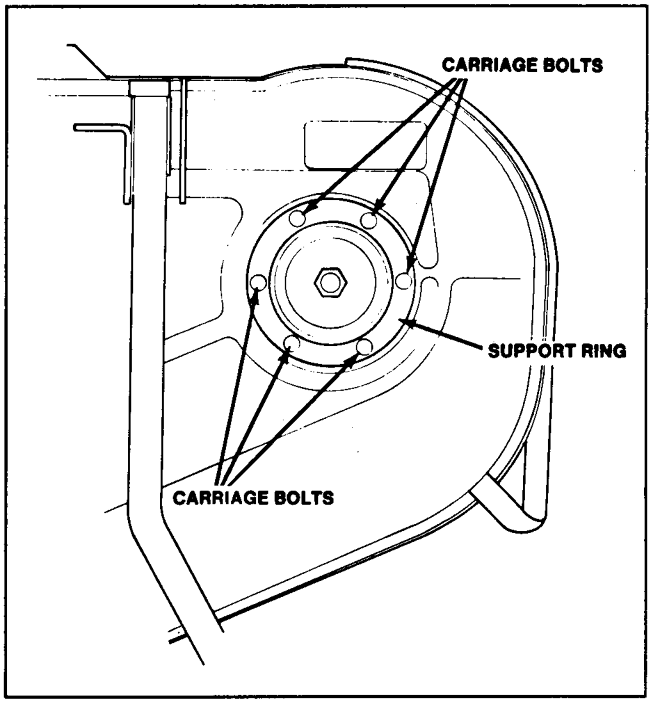


Figure 43

6. Remove the nut and flat washer retaining the spindle pulley on the spindle shaft. Slide the pulley off of the shaft.

7. If the spindle shaft will be replaced, remove the blade bolt, lock washer, anti-scalp cup and the blade from the spindle shaft (Fig. 44). Otherwise, the blade and its other associated parts may be left on the spindle shaft.

8. Press the spindle shaft out of the spindle housing using an arbor press. The bearing spacer remains on the spindle shaft as the shaft is being removed.

9. The seals will be removed next; however, notice the lip of the seal. The lip of the upper seal faces inward, and the lip of the lower seal faces outward (Fig. 44). Therefore, new seals must always be installed with the lip facing in the proper direction. Now remove the seals from spindle housing.

10. Allow the bearings and small thick spacer to fall out of the spindle housing.

11. Using a punch and hammer, drive both of the bearing cups out of the spindle housing. Also drive the large spacer out of the housing.

12. A large snap ring is still inside the spindle housing and it should remain there because it cannot be easily removed.

IMPORTANT: If new bearings will be installed into a used spindle housing that has the original snap ring installed, discard the large snap ring that came with the bearings because it is not needed. However, new bearings with their matched spacer and snap ring must always be installed when the spindle housing is being replaced. Replacement bearings are sold only with a matched snap ring and spacer set. These parts cannot be purchased separately.

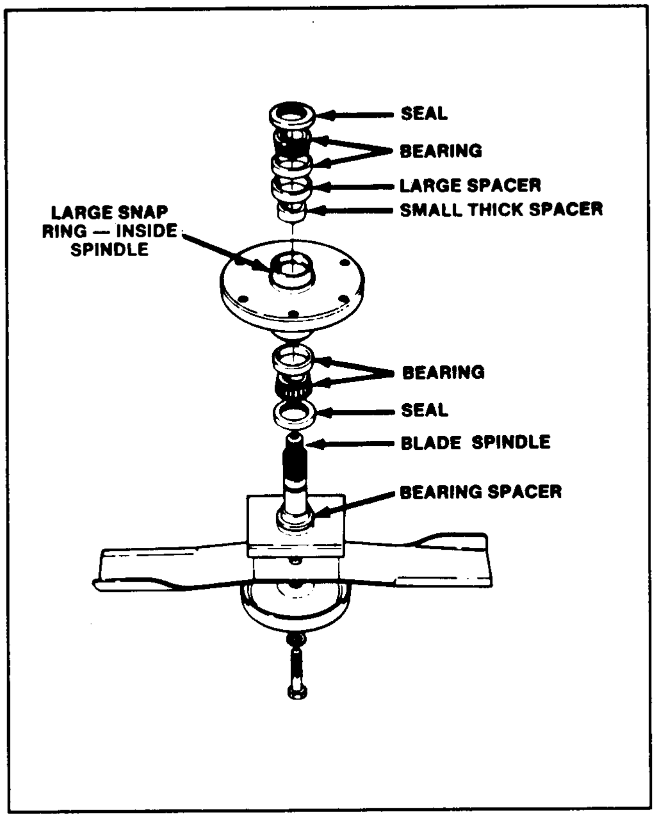


Figure 44

Installing Spindle, Bearings, And Seals Into Spindle Housing

IMPORTANT: If a new spindle housing is being used, new bearings and the matched snap ring set must be installed; refer to step 1 below. Never use the old bearings, spacer, and snap ring with a new spindle housing. By contrast, use only new bearings with cups and spacer - not the large snap ring because it is not required - when installing bearings into a used spindle housing that still has a snap ring installed: refer to step 2 below.

1. Install the large snap ring into the groove in the bore of the spindle housing (Fig. 44). Assure the snap ring is seated in the groove.

2. Using an arbor press, push the large spacer into the top of the spindle housing; tightly against the snap ring. The spacer must contact the snap ring to be sure of the correct assembly of the parts.

3. Thoroughly oil the bearing cups and using an arbor press, push the bearing cups - smallest inside diameter first - into the top and bottom of the spindle housing (Fig. 45). The top bearing cup must contact the spacer that was installed in step 2, and the bottom bearing cup must contact the snap ring to be sure of the correct assembly of parts. Insure that the assembly is correct by supporting the first cup and pressing the second against it (Fig. 46).

4. Apply a film of grease on the lips of both seals, then install the bearing and the seal into the bottom of the spindle housing. Remember, the bottom seal must have the lip facing outward (Fig 44), not toward the inside of the spindle housing.

5. Check the spindle shaft to make sure it is free of burrs and nicks that could possibly cut the seals and thoroughly lubricate both the shaft and seal lips.

6. Slide the small, thick spacer into the spindle housing. Then install the bearing and seal into the top of the spindle housing. The lip of the seal must face inward.

7. Slide the bearing spacer onto the spindle shaft. Carefully slide the spindle shaft through the spindle housing. The bottom seal and bearing spacer fit together when the spindle is installed (Fig. 45).

8. Push the pulley onto the splines of the spindle shaft and retain the parts together with the large flat washer and nut. Tighten the nut to 100 - 120 ft-lb (13.8 - 16.6 KgM) and rotate the spindle shaft to be sure that the shaft rotates freely.

9. Slide the pulley end of the spindle assembly through the hole in the cutting unit. Mount the spindle assembly in place with the support ring and six carriage bolts and flange nuts (Fig. 43).

10. Adjust the idler pulley tension against the belt. (See Adjusting Blade Belt Idler Pulley Tension in the Adjustments section of this chapter.)

11. Reinstall the belt covers with the cap screws and lock washers.

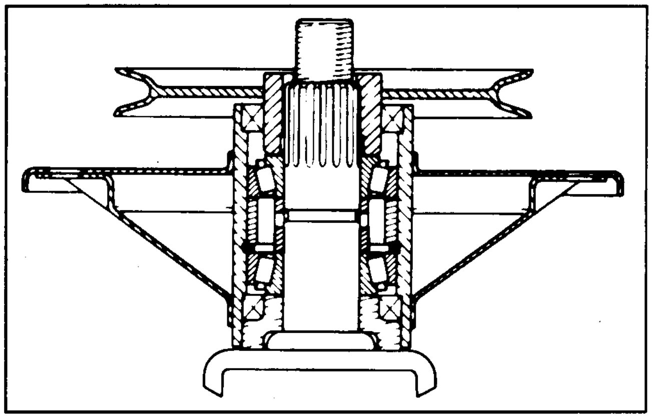


Figure 45

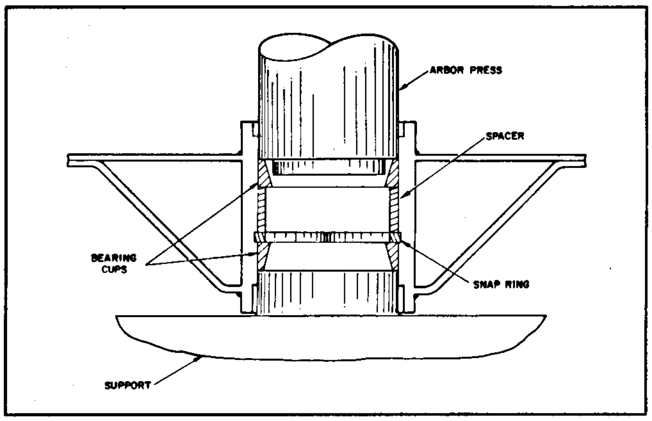


Figure 46

Grass Deflector

DANGER

The grass deflector (Fig. 46) is a safety device that diverts grass and other foreign objects being discharged in a downward direction. Without the deflector mounted in place on the cutting unit, and the carriage bolts holding the deflector in down position, the blades could hurl grass and/or foreign objects out of the discharge opening with enough force to cause bodily injury or property damage. If the grass deflector or hinges are worn, broken, or damaged, repair or replace the affected part(s). Never operate the cutting unit without the deflector mounted on the cutting unit. Always be sure the deflector chute is in the lowest possible position.

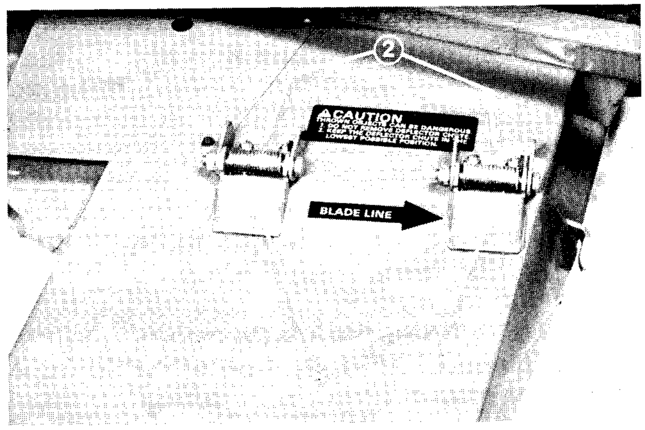


Figure 46

1. Deflector mounts
2. Pivot brackets
3. Pivot springs

Replacing Grass Deflector

1. Raise the cutting unit and engage the parking brake. Be sure that the traction pedal is in NEUTRAL and the P.T.O. switch is OFF. Turn the engine OFF and remove the key from the key switch. Block the cutting unit to prevent it from falling accidentally.

2. Remove the two cap screws, locknuts, and springs securing the deflector mounts to the pivot brackets (Fig. 46).

3. To remove the pivot brackets, remove the carriage bolts, lock washers and nuts (Fig. 46).

4. Reinstall the pivot brackets onto the top of the discharge opening with the carriage bolts, lock washers and nuts. The head of the carriage bolts must be on the inside of the cutting unit.

5. Position the deflector mounts onto the pivot brackets and secure the parts together with the cap screws, locknuts, and springs.

Both locknuts must face each other. Tighten the locknuts until they are flush against the deflector pivots. Lift the deflector and allow it to drop to check the spring tension. The deflector must be held firmly in the full downward position by spring tension; correct the mountings if necessary.

6. Remove the blocking from the cutting unit and lower the deck to the floor.

Chapter 13

Cleaning and Seasonal Storage

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Cleaning

When cleaning the paint finish and seat upholstery, always use a mild common detergent mixed with water. Industrial strength soaps or degreasers do an excellent job of removing dirt, grass stains, and grease, however these cleaners contain chemicals that may cause premature paint oxidation and damage to the vinyl material used on the seat.

IMPORTANT: When using a high pressure washer or steam cleaner, do not direct the discharge at oil seal areas. The cleaning solution, when used under high pressure, can be forced past the seals and contaminate the lubricants.

IMPORTANT: Do not direct water or cleaning solution, especially when under pressure, at or on the instrument panel. This could cause condensation inside the gauges and result in early failure of the gauges.

IMPORTANT: High pressure water can bend radiator fins. This will result in loss of engine cooling efficency.

Periodically clean the traction and cutting units with water and detergent. After washing, automotive type waxes can be used on painted surfaces.

The seat material may be cleaned using a mild detergent. Rinse thoroughly after cleaning. Cream type hand cleaner is also a very effective as an upholstery cleaner.

After cleaning, make sure all safety and operation decals are intact and that the foot pad (no slip surface) is in good condition. Replace any decals that are damaged or missing.

Seasonal Storage

Traction and Cutting Unit

1. Thoroughly clean the traction unit, cutting unit and engine. Give special attention to the following areas:

    A. Engine and engine compartment.

    B. Under the cutting unit.

    C. Under the cutting unit belt covers.

    D. P.T.O. shaft assembly.

    E. All grease fittings and pivot points.

    F. Radiator and screen.

2. Check the tire pressure. Inflate all traction unit tires to 10-15 psi (69-103 kPa). Inflate cutting unit pneumatic caster wheel tires to 10-15 psi (69-103 kPa).

3. Remove, sharpen and balance the cutting unit blades. Reinstall the blades and torque the blade fasteners to 75 to 100 ft-lbs (10.4 to 14.8 KgM).

4. Check all fasteners for looseness. Tighten as necessary.

5. Grease or oil all grease fittings and pivot points. Wipe off any excess lubricant.

6. Lightly sand and apply touch up paint on painted areas that are scratched, chipped, or rusted. Repair any dents or other damage to the sheetmetal.

7. Service the battery and cables as follows:

A. Remove the battery cable terminals from the battery posts.

B. Clean the battery, terminals and posts with a baking soda and water solution. IMPORTANT: Do not get baking soda solution into the battery cells.

C. Check the battery electrolyte level. Add water or electrolyte as necessary. IMPORTANT: Do not add water if freezing temperatures are expected unless the battery is going to be charged.

D. Coat the cable terminals and battery posts with Grafo 112X skin-over grease (Toro Part Number 505-47), or petroleum jelly to prevent corrosion.

E. Slowly recharge the battery every 60 days for 24 hours to prevent lead sulfation of the battery.

8. Put a corrosion inhibitor on metal surfaces that are not painted (hydraulic cylinder rods, control linkages, etc.).

9. Service the air cleaner assembly.

10. Check the engine coolant for anti-freeze protection down to the expected minimum temperature.

Diesel Engine

NOTE: See the Maintenance section of Chapter 3 - Mitsubishi Diesel Engine for maintenance instructions.

1. Run the engine until is reaches normal operating temperature. Stop the engine.

2. Remove the drain plug from the oil pan and let the oil flow out into a drain pan.

3. Remove and discard the oil filter. Install a new oil filter.

4. Fill the engine with with 3.8 quarts (3.6 L) of SAE 10W30 motor oil. Use API classification CD motor oil.

5. Start the engine and run at idle speed for approximately two minutes.

6. Stop the engine.

7. Remove the fuel tank and drain the fuel through the filler neck into a suitable container. (See the Fuel System Repairs section of Chapter 3 - Mitsubishi Diesel Engine.)

8. Drain all fuel from the fuel lines. Replace the fuel filter / water separator canister and fuel pump filter.

9. Flush the tank with fresh, clean diesel fuel. Install the fuel tank, fuel lines and clamps.

10. Remove P.T.O. belt tension so the belt does not take a "set".

11. Remove the key from the ignition key switch.

12. Seal the air cleaner inlet, and exhaust outlet with weather proof tape.

Before Operating After Storage

1. Remove covering from air cleaner inlet and exhaust outlet.

2. Check the tire pressure. Inflate all traction unit tires to 10-15 psi (69-103 kPa). Inflate cutting unit pneumatic caster wheel tires to 10-15 psi (69-103 kPa).

3. Check the battery and service as necessary. Make sure the battery has a full charge.

4. Connect the battery cables.

5. Make sure that all fuel lines and fittings are secure.

6. Fill the fuel tank with the proper fuel.

7. Check the oil level in the engine and hydraulic reservoir. Add the correct oil as necessary. Check the coolant level in the radiator and coolant recovery tank.

8. Bleed the fuel system. (See the Fuel System Repairs section of Chapter 3 - Mitsubishi Diesel Engine.)

9. Start the engine and check for leaks in fuel system or around oil filter.

Chapter 14

Groundsmaster 223-D with Inasaka axle

4WD Rear Axle

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Specifications

Item	Specification
Lubricant (Fig. 1, 2, 3)	SAE 80W90 gear lube
Rear wheel toe-in	1/8 inch
Wheel nut torque	45 - 55 ft-lb

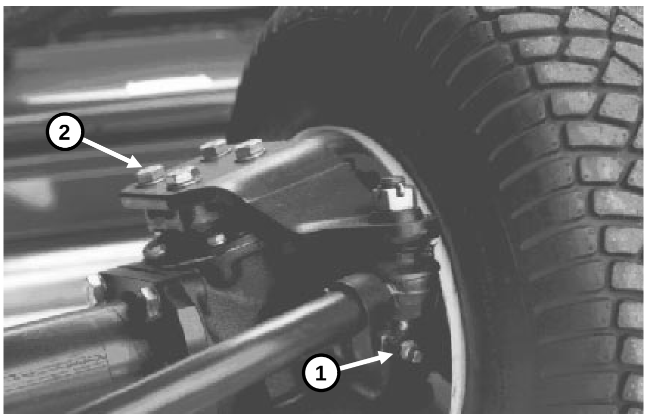

Figure 1
(Right-hand end of axle shown)

1. Check plugs (2) **2. Mounting bolts**

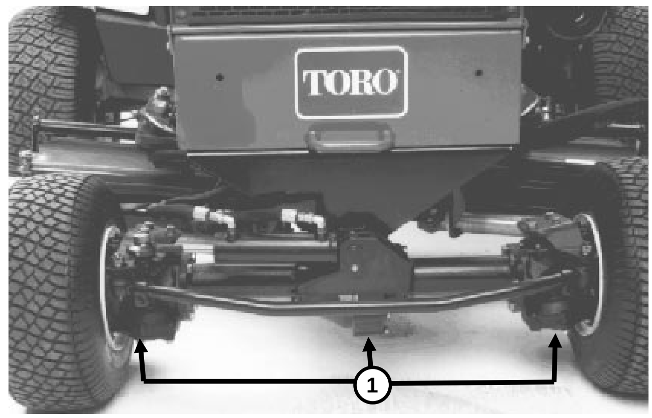

Figure 3

1. Drain plugs

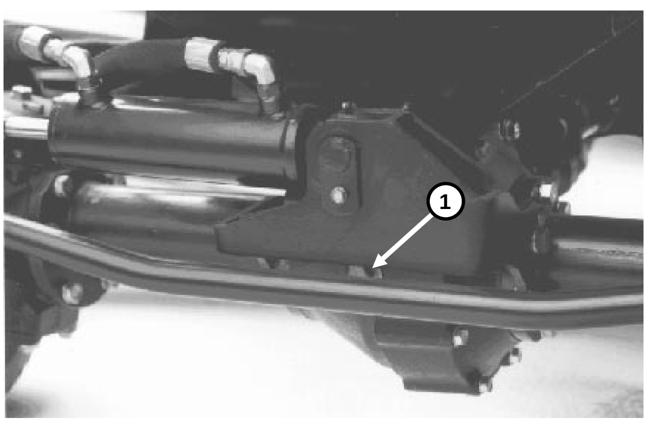

Figure 2

1. Check/fill plug

General Information

Four-Matic™ 4WD Over-Running Clutch Operation

A drive shaft connected to the front axle provides power for the rear 4WD drive axle. The drive shaft tor the rear axle incorporates an OVER-RUNNING (ROLLER) CLUTCH THAT TRANSMITS POWER ONLY IN THE FORWARD DIRECTION.

Front and rear axle gear ratios and tire sizes were carefully selected so that during normal operation, the REAR AXLE PINION SHAFT TURNS SLIGHTLY FASTER THAN THE REAR AXLE DRIVE SHAFT.

Any time the front wheels begin to slip (such as when climbing a steep hill), the forward movement of the traction unit slows. This causes the rear axle pinion speed to slow down. As soon as the rear axle pinion is turning the same speed as the drive shaft, the roller clutch will engage and power will be transmitted from the drive shaft to the rear wheels – four wheel drive.

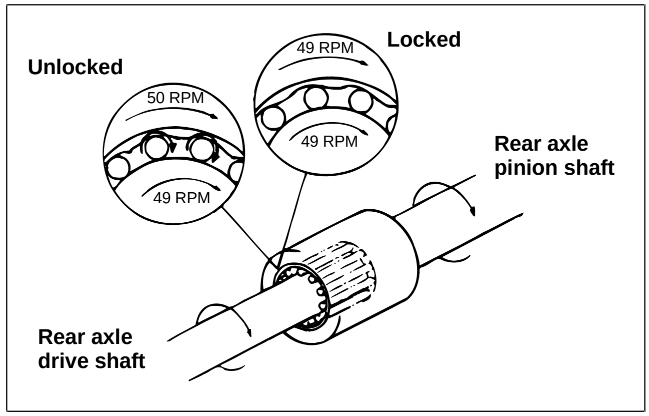

Figure 4a

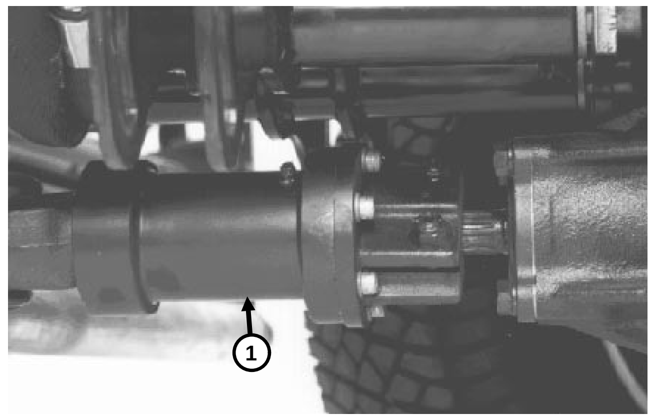

Figure 4b

1. Over-running clutch

When the traction unit is turning, the rear wheels swing out in a larger arc and must travel faster than the front wheels. In this condition, the rear wheels and axle pinion shaft are turning faster than the drive shaft and the roller clutch is disengaged.

NOTE: The Four-Matic four wheel drive system may not operate properly if the tires are replaced by different size tires, or if proper tire pressure is not maintained.

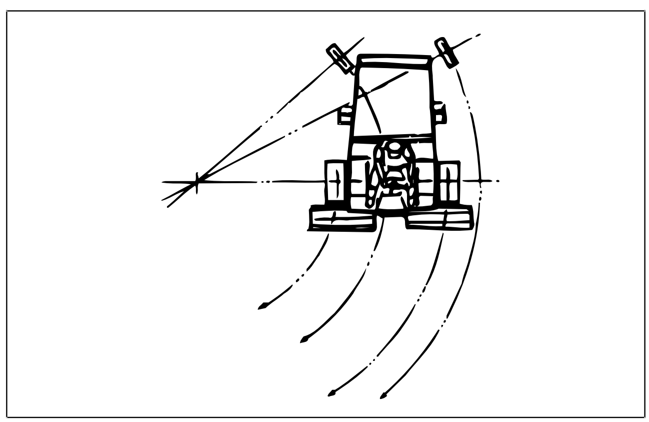

Figure 5

Adjustments

Rear Wheel Toe-in

1. Measure center–to–center distance (at axle height) at front and rear of steering tires. Front measurement must be 1/8 in. less than rear measurement.

2. To adjust, loosen clamps at both ends of tie rod.

3. Rotate tie rod to move front of tire inward or outward.

4. Tighten tie rod clamps when adjustment is correct.

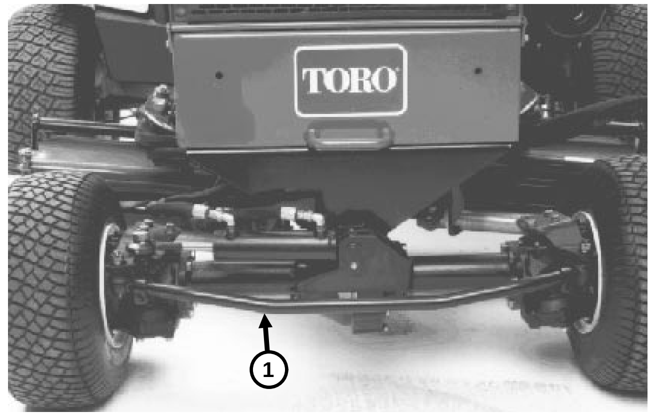

Figure 6

1. Tie rod

Steering Stop

The rear axle steering stops help prevent over travel of the steering cylinder in case of impact on rear wheels. The stops should be adjusted so there is 0.090 in. clearance between bolt head and knuckle on axle when steering wheel is completely turned left or right.

1. Thread bolt in out out unitl 0.090 in. clearance is attained (Fig. 7)

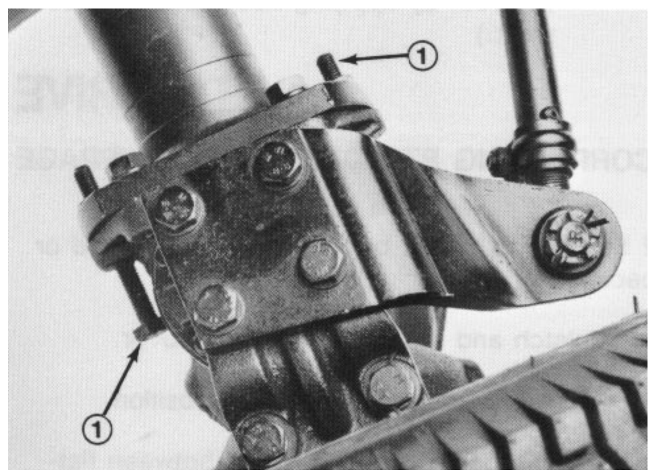

Figure 7

1. Tie rod

Drive Shaft Service

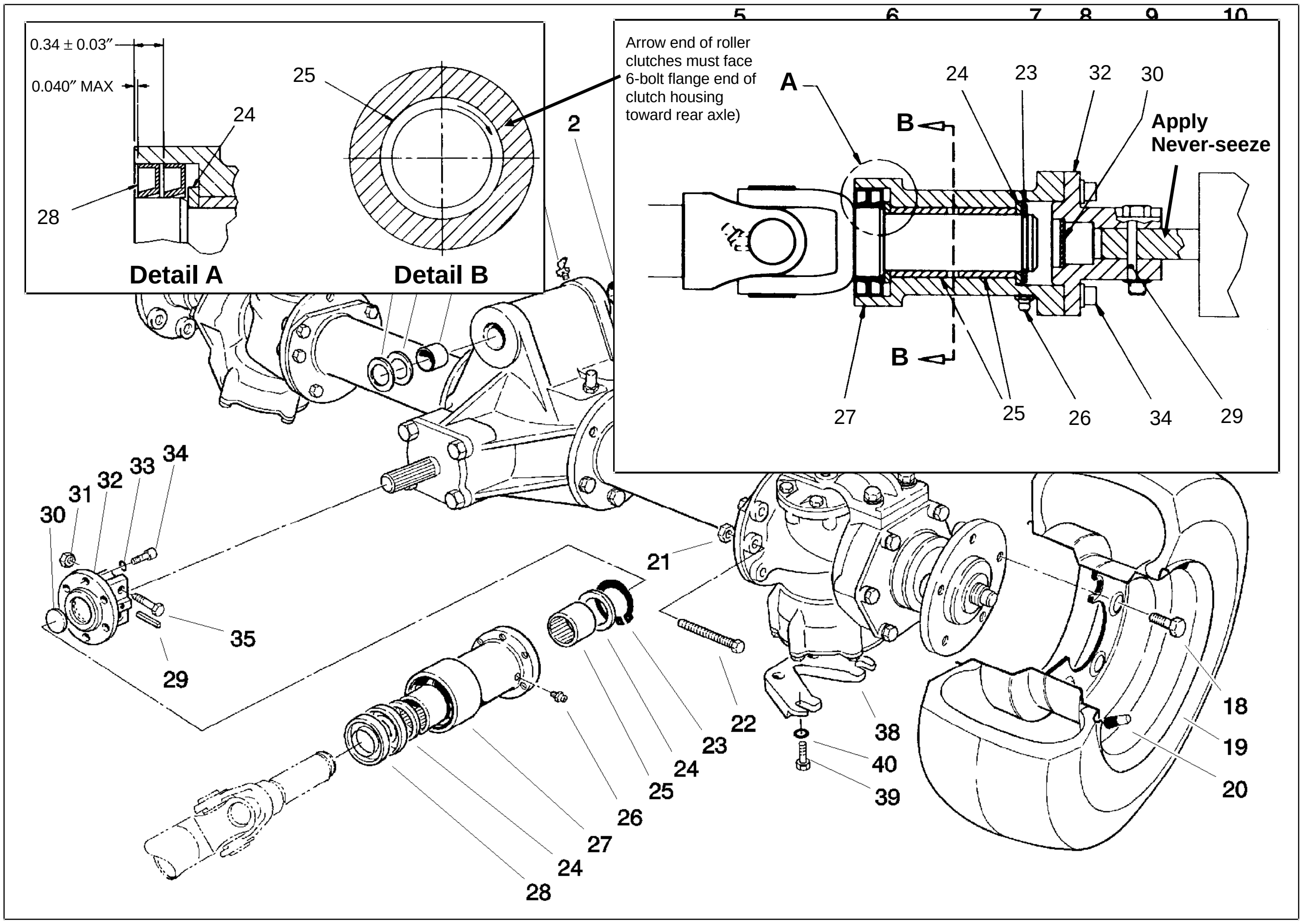

Figure 8

Removing Drive Shaft

1. Put machine on a level surface, lower cutting unit, stop the engine and remove the key from the ignition switch. Block the rear wheels to prevent the machine from moving.

2. Use a hammer and punch to drive roll pin (Fig. 8, Item 29) out of axle coupling (Item 32) and rear axle shaft. Loosen two (2) capscrews and locknuts securing coupling to axle shaft. Slide coupling off of shaft.

3. Remove six (6) socket head capscrews and lockwashers securing drive shaft yoke flange to flange on front axle differential (not shown).

Clutch Service

1. To disassemble clutch, remove six (6) capscrews (Item 34) and lockwashers (Item 33). Remove axle coupling (Item 32) from clutch housing (Item 27).

2. Remove retaining ring (Item 23). Clutch housing (Item 27), along with thrust washers (Item 24), roller clutches (Item 25) and seals (Item 28) can now be removed from yoke shaft.

3. Inspect parts and replace as necessary.

4. Roller clutches (Item 25) must be installed into housing so end is flush to 0.040 in. inset with shoulder at each end of housing bore. Both roller clutches must be installed with arrow end toward 6-bolt flange end of housing as shown in view B - B.

5. Put thrust washer (Item 24) in housing adjacent to roller clutch as shown. Press both seals (Item 28) into end of housing to dimensions shown. Seals must be installed with lip facing out.

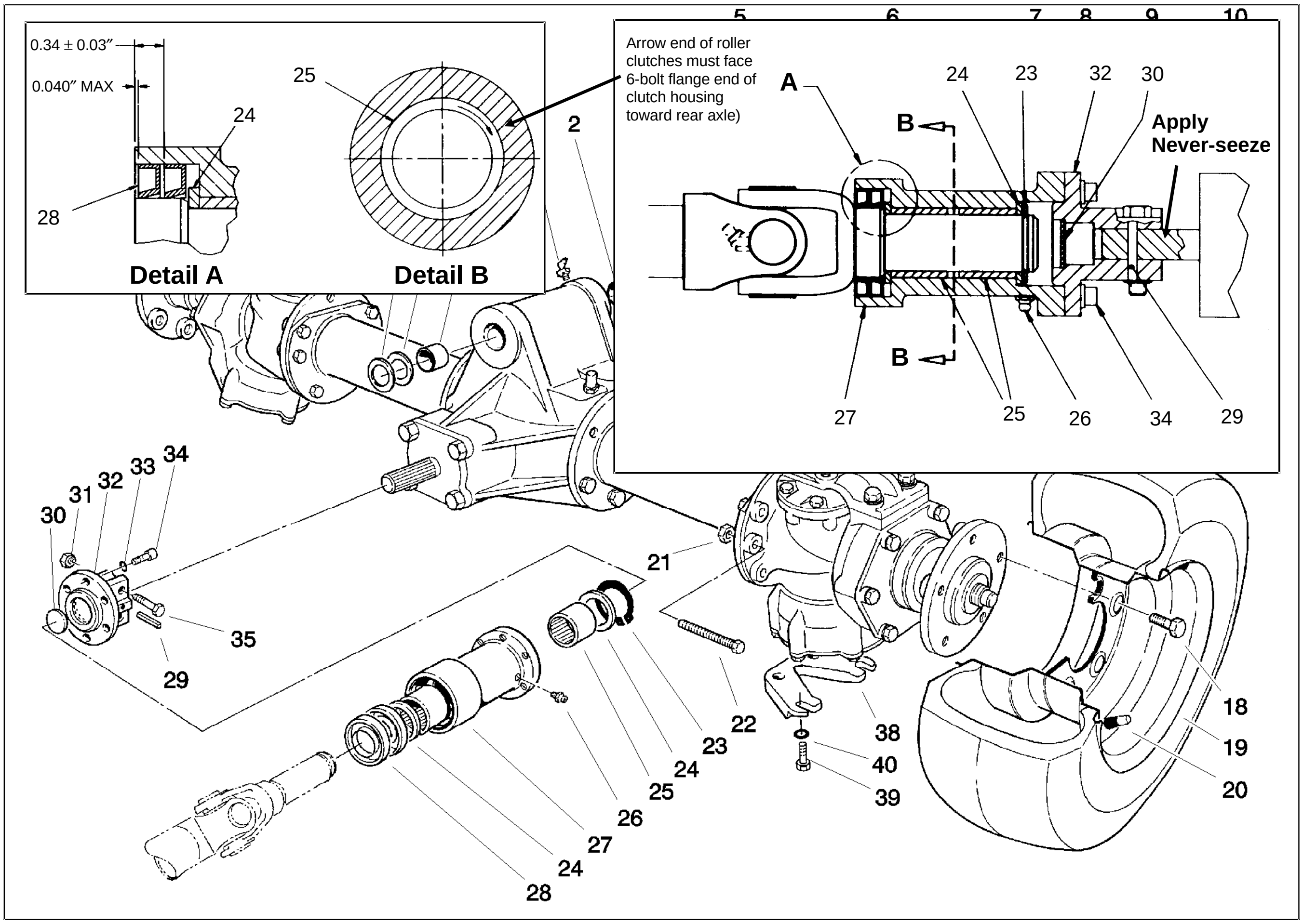

Figure 9

6. Install clutch assembly onto yoke shaft, then install other thrust washer. Install retaining ring (Item 23) to secure clutch assembly to shaft. Install axle coupling (Item 32) to clutch housing with six (6) capscrews and lockwashers, then tighten capscrews evenly.

7. Lubricate clutch through grease fitting with No. 2 General Purpose Lithium Grease.

Installing Drive Shaft.

1. Apply never-seize to splines of traction shaft and axle input shaft.

2. Slide clutch end of drive shaft onto rear axle shaft spline, aligning roll pin hole in shaft with hole in axle coupling. Install roll pin (Item 29) through coupling and shaft.

3. Tighten two (2) capscrews (Item 35) and locknuts (Item 31) to secure coupling to shaft.

4. Secure drive shaft yoke flange to flange on front axle differential with six (6) socekt head capscrews and lockwashers (not shown).

Rear Axle Removal and Installation

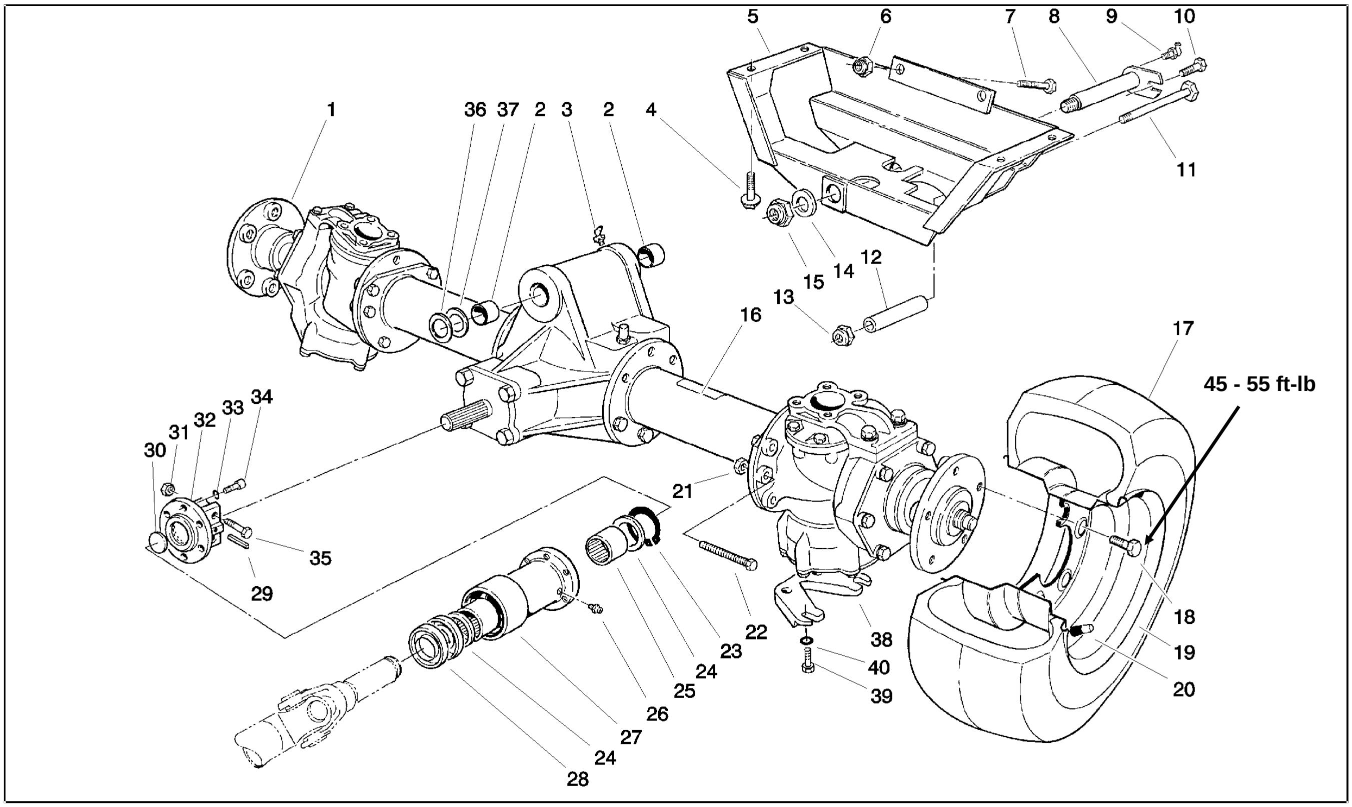

Figure 10

1. Remove drive shaft (see Drive Shaft Service).

2. Thoroughly clean around hydraulic hoses connections to steering cylinder. Mark hoses so they will be installed correctly during reassembly. Disconnect hoses from fittings on steering cylinder. Put plugs or caps on open hoses and fittings to prevent contamination of hydraulic system.

3. Loosen rear wheel capscrews (Item 18).

4. Block front tires and jack up rear of machine until there is approximately one inch clearance between rear tires and the ground. SECURELY BLOCK FRAME.

5. Remove rear wheels.

6. Remove capscrew (Item 10) from pin (Item 8). Remove pin from axle support, allowing axle to be lowered to floor and removed.

7. Reverse steps 1 - 7 to install axle.

Install washers (Items 36, 37) as necessary between axle and axle support.

Apply medium strength locktite to capscrew (Item 10) before installing to secure pin (Item 8).

Rear Axle Repair

Before disassembling axle, remove hydraulic cylinder (Fig. 9, Item 28), cylinder support (Item 17), tie rod tube and clamp assembly (Item 12) and steering arms (Items 46, 31).

Disassembly

1. Remove drain plugs (Fig. 11) and let oil drain out into containers.

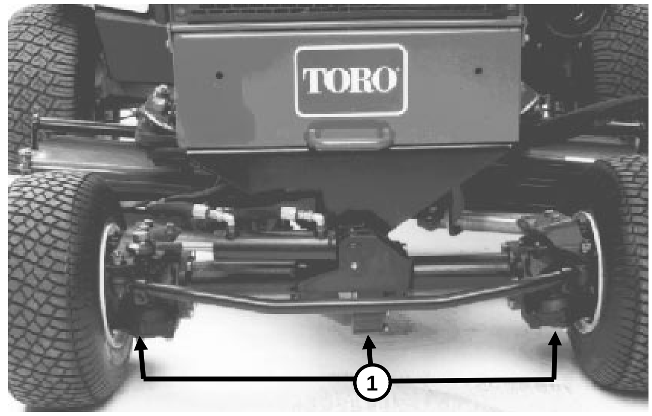

Figure 11

1. Drain plugs

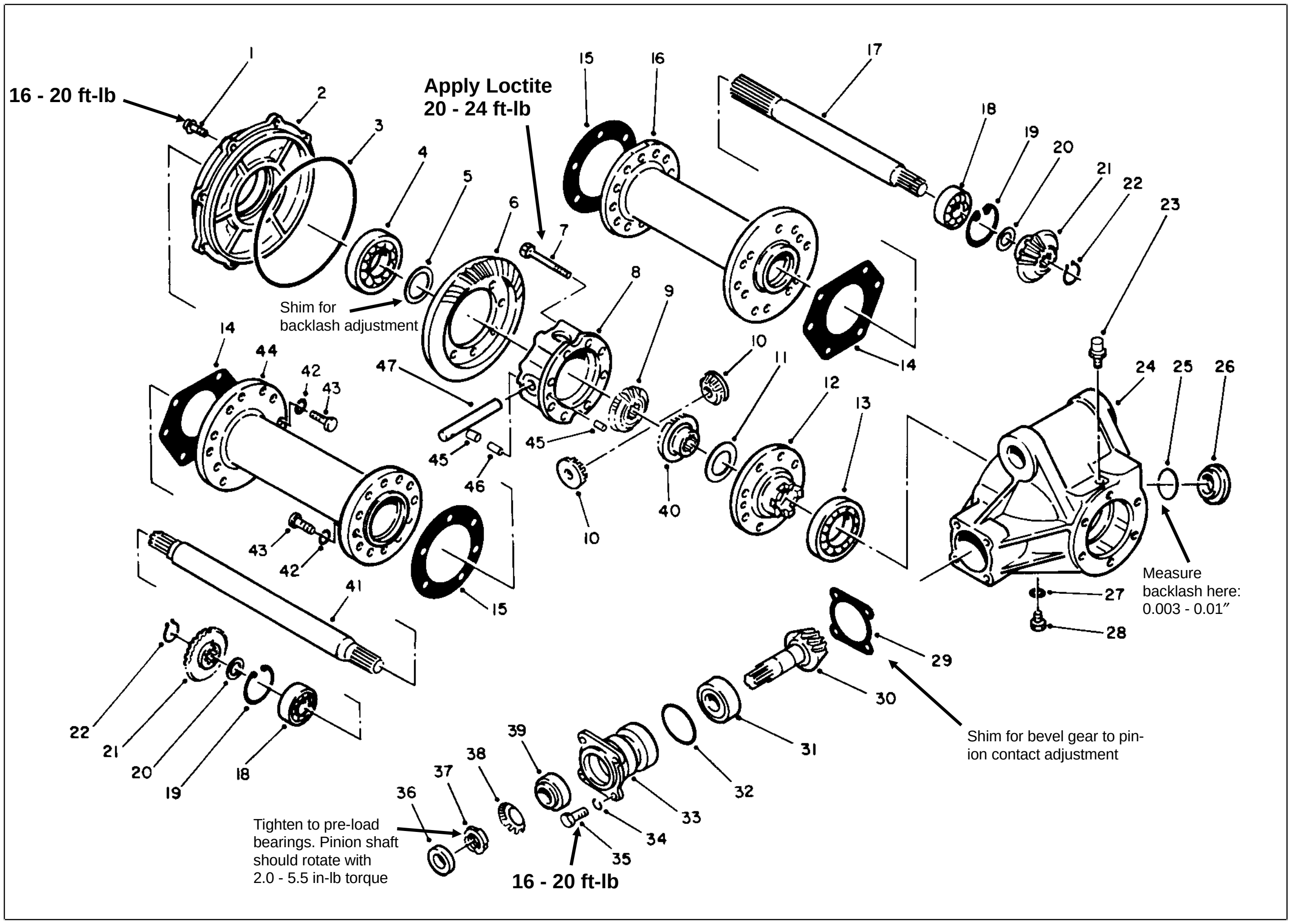

Figure 12

2. Remove bolts (Fig. 12, Item 43) securing axle tubes (Item 16, 44) to differential case (Item 24). Separate axle tubes and axles from differental case.

3. Remove bolts (Fig. 12, Item 43) securing axle tubes (Item 16, 44) to gearbox housings (Fig. 12, Item 23) of knuckle assemblies. Separate axle tubes and axles from knuckle assemblies.

4. Disassemble knuckle assembly (Fig .13):

A. Remove bolts (Item 28, 39) securing covers (Item 30, 26) to knuckle case (Item 28).

B. Pull out outer axle shaft (Item 35) and bevel gear (Item 5).

C. Remove capscrews (Item 10) securing knuckle arm (Item 8) to knuckle case (Item 28). Pull off knuckle arm toward upper side and pull off case toward bottom.

D. Remove capscrews (Item 13) and remove bearing retainer (Item 15). Remove bevel gear (Item 18) and knuckle pin (Item 20).

5. Disassemble differential case (Fig. 12):

A. Remove bolts (Item 35) and remove bearing case (Item 33) and pinion gear (Item 30) from differential case (Item 24).

B. Remove bolts (Item 1) and remove cover (Item 2). Remove differential assembly from differential case.

C. Remove bolts (Item 7) to disassemble differential.

Inspection

Inspect shaft splines, gears and bearings for wear and damage. Replace parts as necessary. Use suitable bearing pullers and an arbor press when replacing bearings.

NOTE: Ring gear (Item 6) and pinion (Item 30) are a matched set that must be replaced together.

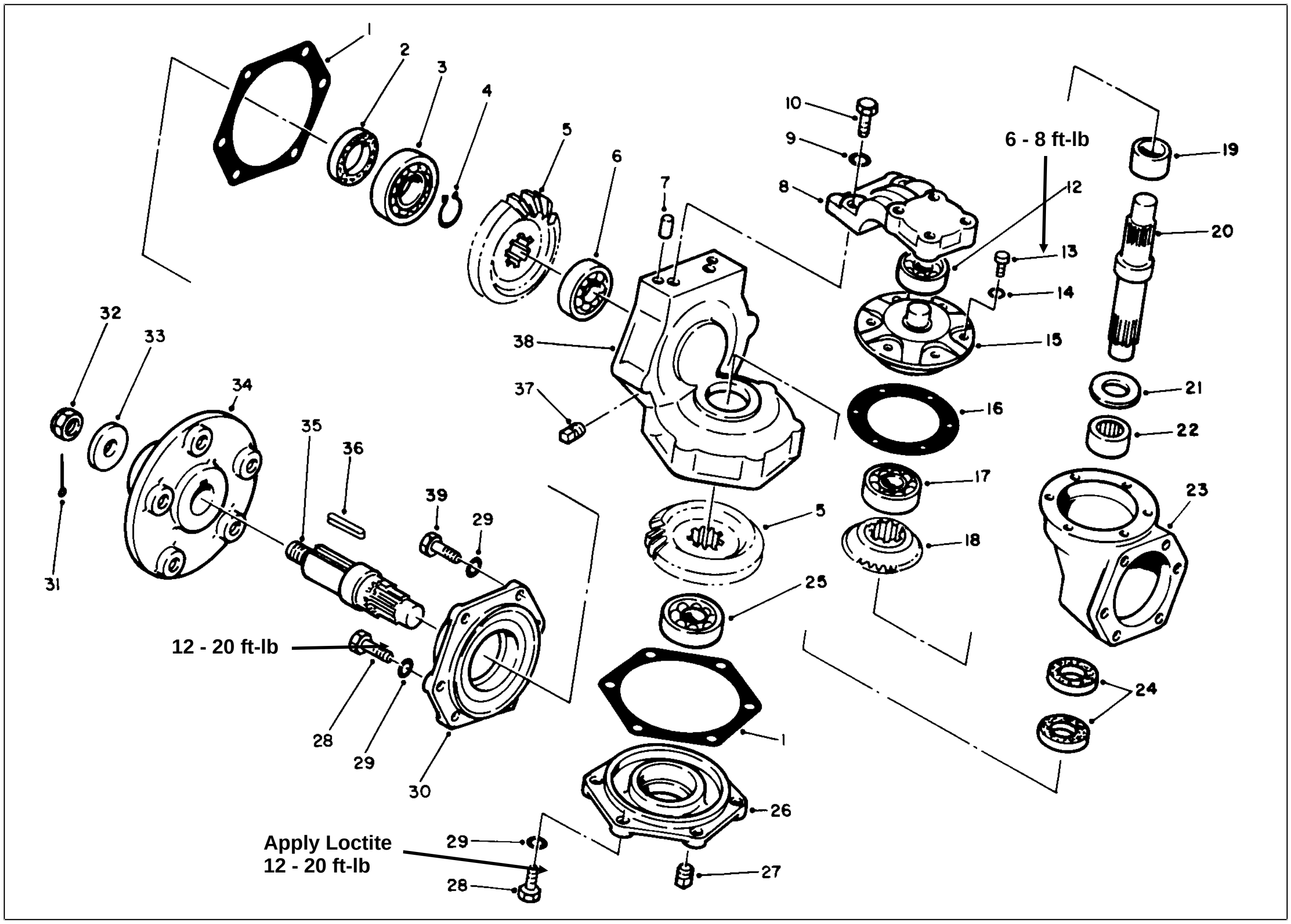

Figure 13

Assembly

1. Use new gaskets and seals when reassembling axle.

2. Assemble differential case (Fig. 12):

A. Assemble differential. Use medium strength Loctite on bolts (Item 7) and tighten evenly to a torque of 20 - 24 ft-lb (270-330 Kg-Cm).

B. Assemble pinion gear (Item 30) and bearing case (Item 33). Tighten bearing nut (Item 37) to pre-load tapered roller bearings. Tighten so pinion shaft will rotate with 2 - 5.5 in-lb (2.0 - 6.5 Kg-Cm) of torque. Bend washer (Item 38) to prevent nut from loosening. Install oil seal (Item 36).

C. Adjust tooth contact of bevel gear (Item 6) to pinion (Item 30). Use shims (Item 29) to make good contact with light load between bevel gear and pinion (Fig. 13).

D. After adjusting tooth contact, use shims (Item 5) to make backlash 0.003 - 0.01 in. (0.08 - 0.25 mm). Check backlash through plug hole (Item 26) with a dial indicator.

E. Tighten bolts (Item 1, 35) to a torque of 16 - 20 ft-lb (220-280 Kg-Cm).

3. Assemble knuckle assembly (Fig. 13):

A. Insert needle bearing (Item 22), washer (Item 21), knuckle pin (Item 20), spacer (Item 19) and bevel gear (Item 18) into axle gear box (Item 23). Fasten bearing retainer (Item 15) with bolts (Item 13) and tighten bolts evenly to a torque of 6 - 8 ft-lb (80-120 Kg-Cm).

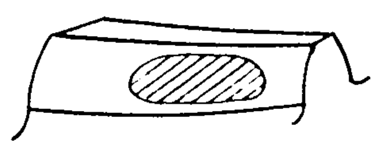

Figure 14

B. Assemble knuckle pin (Item 20) and knuckle case (Item 38) to match knuckle arm (Item 8) with knuckle pin. Fasten capscrew (Item 10) temporarily (will be removed to fill with lubricant).

C. Assemble wheel shaft (Item 35) to cover (Item 30).

D. Assemble gear (Item 5) to wheel shaft and install cover and wheel shaft assembly to knuckle case (Item 38). Note that top two (2) capscrews (Item 39), securing cover (Item 30) are a shorter length.

E. Install bevel gear (Item 5) to knuckle pin and install cover (Item 26) to knuckle case (Item 38). Use medium strenght Loctite on capscrews (Item 28) securing cover (Item 26).

F. Evenly tighten capscrews (Item 28, 39) securing covers to a torque of 12 - 20 ft-lb (170-280 Kg-Cm).

4. Install axle on machine (see Rear Axle Removal and Installation).

5. Fill axle with proper lubricant to level of check plugs (see Specifications).

Chapter 14.1

Groundsmaster 228–D with Dae Dong Axle

4WD Rear Axle

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NOTE: For machines with Mitsubishi axle, see Chapter 14 “4WD Rear Axle” in this manual.

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Specifications

Item	Specification
Wheel lug nut torque (font and rear)	45–55 ft-lbs. (61 to 75 Nm)
Rear wheel toe-in	0.000 to 0.125 in. (0.0 to 3.0 mm)
Tire pressure (front and rear)	20 psi (138 kPa)
Axle lubricant	SAE GL-5 80W90 gear lube
Bi–directional clutch lubricant	Mobil 424 hydraulic fluid

Adjustments

Steering Stop Bolt Adjustment

The rear axle steering stop bolts help prevent over–travel of the steering cylinder in case of impacts on rear wheels. When the steering cylinder is fully extended, a gap of 1/16” (1.6 mm) should exist between left side bevel gear case casting and stop bolt (Fig. 1). When the steering cylinder is fully retracted, a gap of 1/16” (1.6 mm) should exist between right side bevel gear case casting and stop bolt.

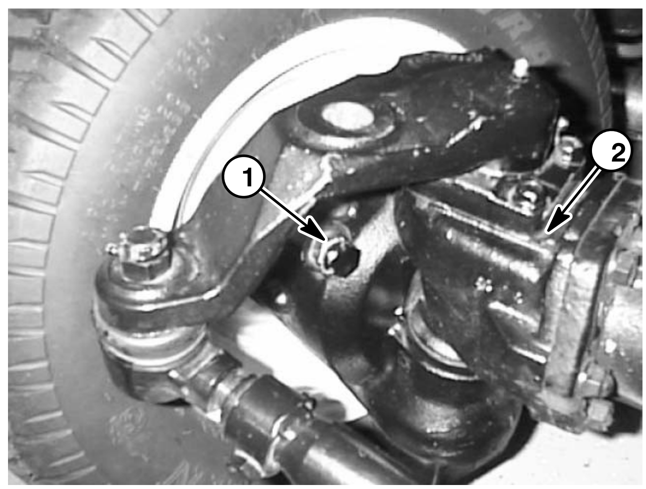

Figure 1

1. Steering stop bolt **2. Bevel gear case (LH)**

Service and Repairs

See Operators Manual for Maintenance intervals and instructions.

Bevel Gear Case and Axle Case

The following procedures assume the rear axle assembly has been removed from the machine.

Removal

1. Remove the mounting screws, nuts, and lock washers. Remove the bevel gear case/axle case assembly and O-ring from the axle support (Fig. 1).

2. Mark both right and left bevel gear case/axle case assemblies.

IMPORTANT: Do not interchange right and left bevel gear case/axle case assemblies.

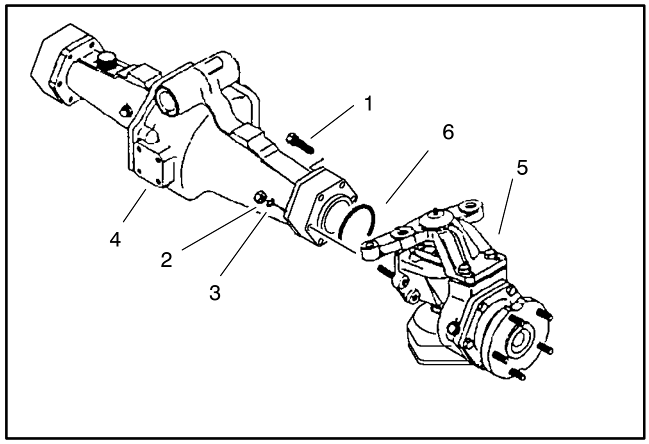

Figure 1

1. **Cap screw**
2. **Lock nut**
3. **Lock washer**
4. **Axle support**
5. **Bevel gear case/axle case assembly**
6. **O-ring**

3. Remove the axle cover mounting screws. Remove the axle cover from the axle case as an assembly (Fig. 2).

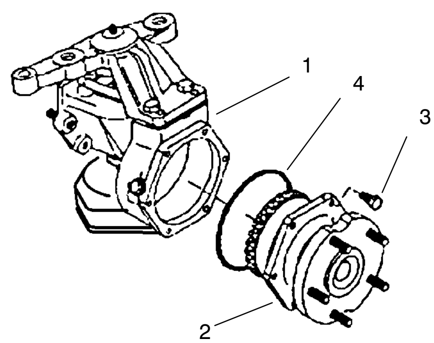

Figure 2

1. **Axle case**
2. **Axle cover assembly**
3. **Mounting screw**
4. **O-ring**

4. Remove the axle case support mounting screws, the axle case support, and the support shims (Fig. 3).

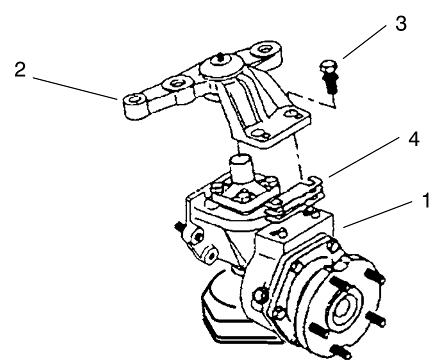

Figure 3

1. **Axle case**
2. **Axle case support**
3. **Mounting screw**
4. **Support shim**

5. Remove the knuckle pin mounting screws and the knuckle pin. Remove the gasket and any remaining gasket material from either mating surface (Fig. 4).

6. While holding the bevel gear case, lightly tap the upper end of the bevel gear shaft out of the upper bearing and upper bevel gear.

7. Pull the bevel gear case from the axle case and remove the upper bevel gear, collar, spacer, and thrust washer from the gear case.

8. Remove the axle case cover screws, cover, and the O-ring from the axle case.

9. Remove the plug and sealing washer from the center of the axle case cover. While holding the axle case cover, lightly tap the lower end of the bevel gear shaft out of the lower bearing and lower bevel gear.

10. Remove and discard bevel gear shaft seals from bevel gear case and axle case (Fig. 4).

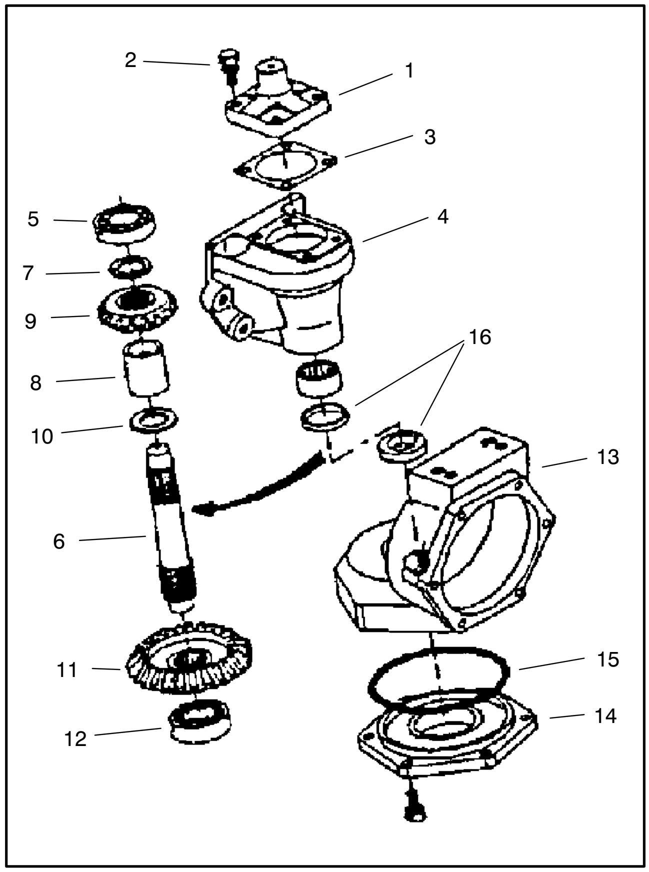

Figure 4

1. **Knuckle pin**
2. **Mounting screw**
3. **Gasket**
4. **Bevel gear case**
5. **Upper bearing**
6. **Bevel gear shaft**
7. **Collar**
8. **Spacer**
9. **Upper bevel gear**
10. **Thrust washer**
11. **Lower bevel gear**
12. **Lower bearing**
13. **Axle case**
14. **Axle case cover**
15. **O-ring**
16. **Shaft seals**

Inspection

1. Measure the knuckle pin O.D. and the axle case support bushing I.D. to determine the bushing to pin clearance (Fig. 5). Replace components as necessary.

BUSHING TO PIN CLEARANCE:
0.002 to 0.016 in. (0.05 to 0.40 mm)

KNUCKLE PIN O.D. (Factory Spec.):
0.982 to 0.983 in. (24.95 to 24.98 mm)

AXLE CASE SUPPORT BUSHING I.D. (Factory Spec.):
0.984 to 0.987 in. (25.00 to 25.08 mm)

2. Inspect all gears, shafts, bearings, cases, and covers for damage and wear. Replace components as necessary.

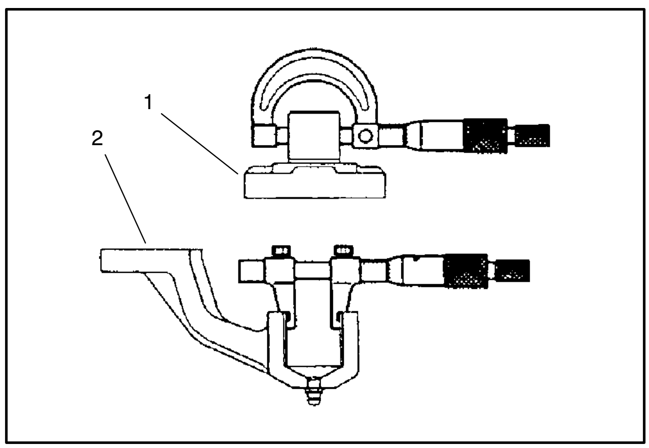

Figure 5

1. **Knuckle pin**
2. **Axle case support**

Installation

1. Coat new shaft seals with grease and install in axle case and bevel gear case as shown (Fig. 6).

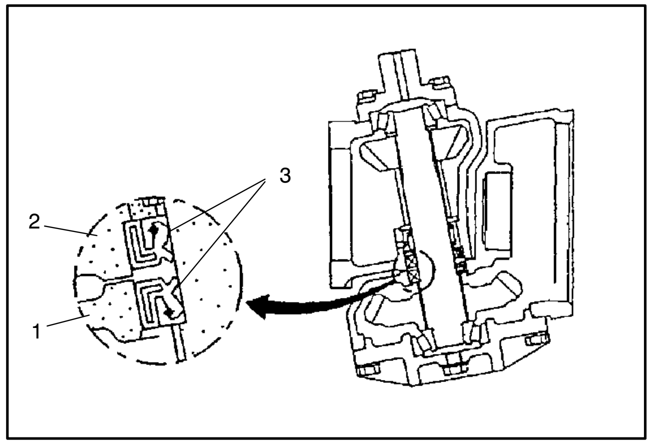

Figure 6

1. **Axle case**
2. **Bevel gear case**
3. **Shaft seal**

2. Install the lower bevel gear, and bevel gear shaft in the axle case cover. Coat a new O-ring with grease and install the axle case cover (Fig. 7). Tighten cover screws to 17 to 20 ft-lbs. (23 to 27 Nm).

3. Slide the bevel gear case over the bevel gear shaft and install the thrust washer, spacer, bevel gear, and collar. Make sure the bevel gear shaft is completely seated in the upper and lower bearings (Fig. 7).

4. Install the knuckle pin. Use medium strength Loctite thread locker and tighten the knuckle pin mounting screws to 17 to 20 ft-lbs. (23 to 27 Nm).

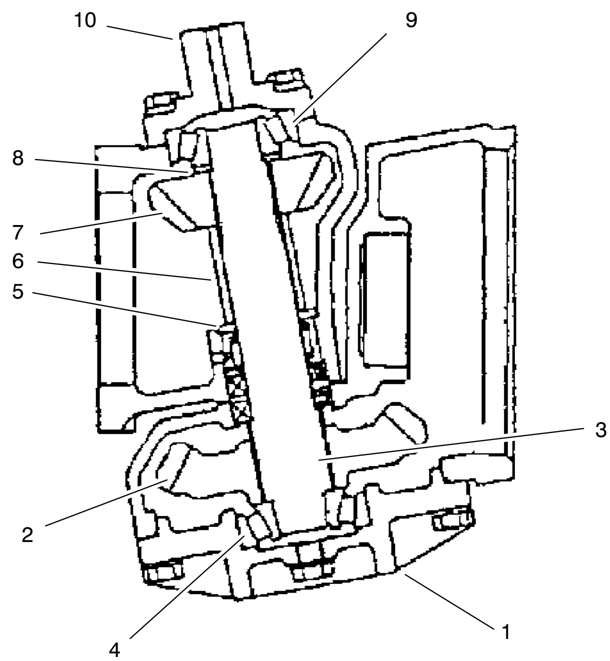

Figure 7

1. **Axle case cover**
2. **Lower bevel gear**
3. **Bevel gear shaft**
4. **Lower bearing**
5. **Thrust washer**
6. **Spacer**
7. **Upper bevel gear**
8. **Collar**
9. **Upper bearing**
10. **Knuckle pin**

5. Determine necessary quantity of support shims.

A. Lubricate the axle case support bushing with a thin coat of grease and slide axle case support onto knuckle pin.

B. Position support shims that were removed during disassembly between axle case support and axle case. Install mounting screws into axle case. Slowly tighten screws while frequently checking for clearance (vertical endplay) between axle case support and knuckle pin. If binding of components is noted before screws are fully tightened, add additional support shims. Torque screws from 57 to 67 ft–lb (77 to 91 N–m).

C. Use dial indicator to measure vertical endplay of axle case (Fig. 8).

AXLE CASE ASSEMBLY ENDPLAY:
0.001 to 0.008 in. (0.02 to 0.20 mm)

D. Adjust endplay by increasing or reducing number of axle case support shims.

NOTE: Axle case support shims are available in 0.004 in. (0.1 mm), 0.008 in. (0.2 mm), and 0.016 in. (0.4 mm) thickness.

6. After correct support shims have been determined, remove mounting screws, apply heavy strength thread–locking compound to screw threads, reinstall screws, and torque from 57 to 67 ft–lb (77 to 91 N–m).

IMPORTANT: Correct engagement between bevel gears is critical to axle performance and durability.

7. Temporarily install the bevel gear case/axle case assembly on the axle support. Position a dial indicator at the tooths center. Prevent the axle from turning and measure the upper bevel gear to differential shaft gear backlash (Fig. 9).

UPPER BEVEL GEAR BACKLASH:
0.004 to 0.016 in. (0.10 to 0.40 mm)

8. Adjust backlash by increasing or reducing axle bearing shim thickness (see Differential Shafts in this section of this manual).

NOTE: Axle bearing shims are available in 0.004 in. (0.1 mm), 0.008 in. (0.2 mm), and 0.020 in. (0.5 mm) thickness.

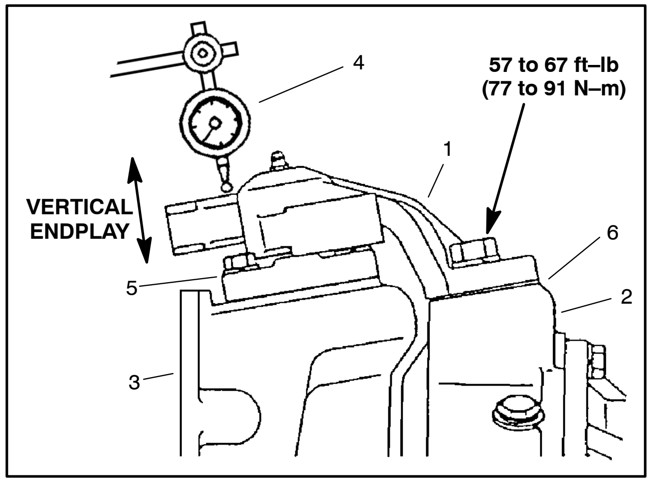

Figure 8

1. **Axle case support**
2. **Axle case**
3. **Bevel gearcase**
4. **Dial indicator**
5. **Knuckle pin**
6. **Support shim location**

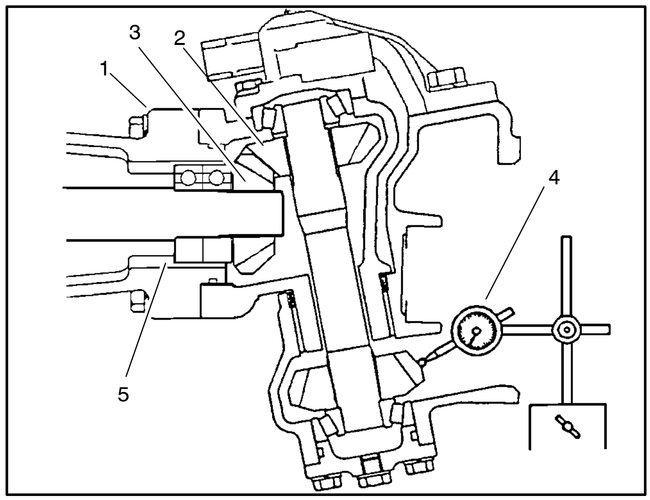

Figure 9

1. **Axle support**
2. **Upper bevel gear**
3. **Differential shaft gear**
4. **Dial indicator**
5. **Axle bearing shims**

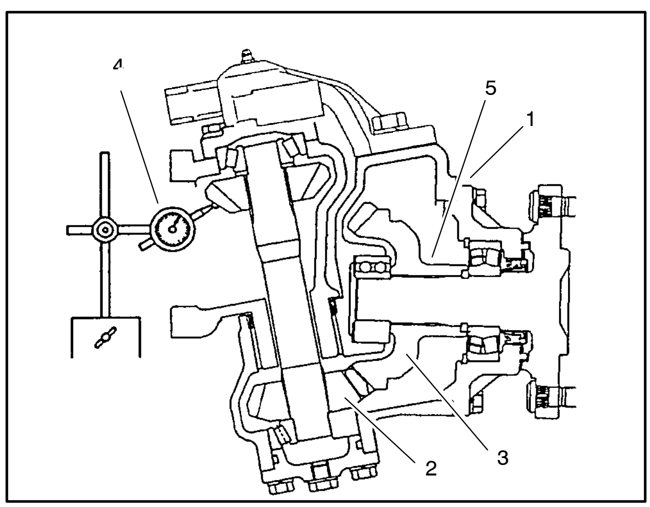

Figure 10

1. **Axle cover assembly**
2. **Lower bevel gear**
3. **Axle gear**
4. **Dial indicator**
5. **Axle bearing shims**

9. Remove the bevel gear case/axle case assembly from the axle support. Coat a new O-ring with grease and temporarily install the axle cover assembly. Position a dial indicator at the tooths center. Prevent the axle from turning and measure the lower bevel gear to axle gear backlash (Fig. 10).

LOWER BEVEL GEAR BACKLASH:
0.004 to 0.016 in. (0.10 to 0.40 mm)

10. Adjust backlash by increasing or reducing axle bearing shim thickness (see Axle Shafts in this section of this manual).

NOTE: Axle bearing shims are available in 0.008 in. (0.2 mm), 0.012 in. (0.3 mm), and 0.020 in. (0.5 mm) thickness.

11. Tighten axle cover screws from 17 to 20 ft-lb (23 to 27 N–m).

12. Coat a new O-ring with grease and install the bevel gear case/axle case assembly on the axle support. Tighten mounting screws and nuts from 35 to 41 ft-lb (47 to 56 N–m) (Fig. 11).

Differential Shafts

The following procedures assume the rear axle assembly has been removed from the machine.

Removal

IMPORTANT: Do not interchange right and left differential shafts assemblies.

1. Remove the mounting screws, nuts, and lock washers. Remove the bevel gear case/axle case assembly and O-ring from the axle support (Fig. 11).

2. Mark and pull the differential shaft assembly from the axle support.

3. Remove the retaining ring and bevel gear (Fig 12).

4. Drive the differential shaft out of the bearings. Remove the bearings and bearing shims.

5. Inspect all gears, shafts, bearings, and cases for damage and wear. Replace components as necessary.

Installation

1. Press bearings onto differential shaft. Place correct combination of bearing shims in axle support and drive differential shaft and bearing assembly into axle support.

2. Install bevel gear and retaining ring.

3. Coat new O-ring with grease. Align differential shaft splines with differential gear assembly and slide differential shaft assembly onto axle support.

4. Install bevel gear case/axle case assembly (see Bevel Gear Case/Axle Case Assembly in this section of this manual).

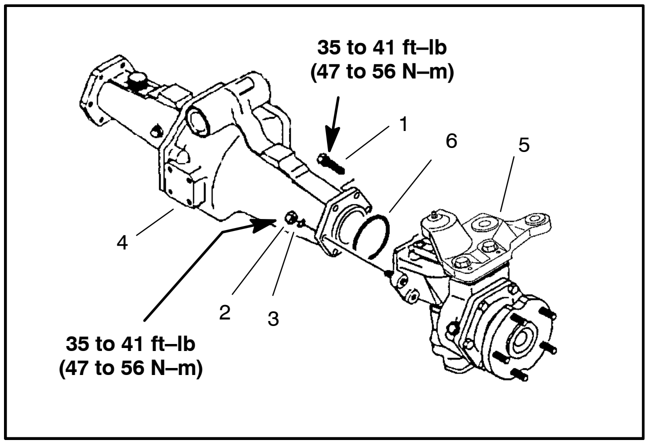

Figure 11

1. **Cap screw**
2. **Lock nut**
3. **Lock washer**
4. **Axle support**
5. **Bevel gear case/axle case assembly**
6. **O-ring**

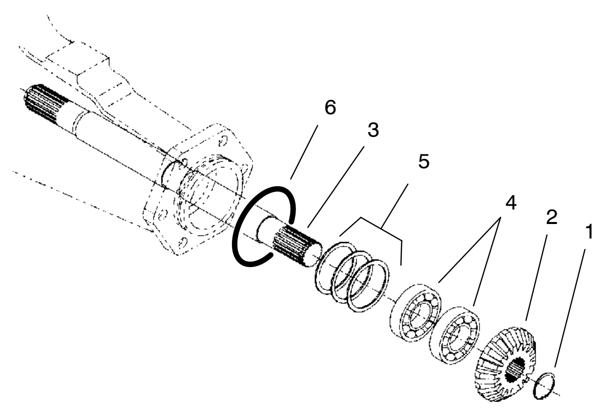

Figure 12

1. **Retaining ring**
2. **Bevel gear**
3. **Differential shaft**
4. **Bearing**
5. **Bearing shims**
6. **O-ring**

Axle Shafts

The following procedures assume the rear axle assembly has been removed from the machine.

Removal

1. Remove the axle cover mounting screws. Remove the axle cover from the axle case as an assembly (Fig. 13).

2. Use a bearing puller to remove the bearing and bevel gear as shown (Fig. 14).

3. Remove the shims, spacer, and retaining ring. Drive the axle out of the bearing and cover. Remove and discard the axle shaft seal.

4. Inspect all gears, shafts, bearings, spacers, and cases for damage and wear. Replace components as necessary.

Installation

1. Coat new axle shaft seal with grease and install in axle cover as shown (Fig. 15).

2. Press the axle cover and bearing assembly onto the axle shaft. Press only on the inner race of the cover bearing (Fig. 15).

3. Install retaining ring, spacer, and correct combination of bearing shims. Install bevel gear and bearing.

4. Coat a new O-ring with grease and install the axle cover assembly. Tighten axle cover screws to 17 to 20 ft-lbs. (23 to 27 Nm).

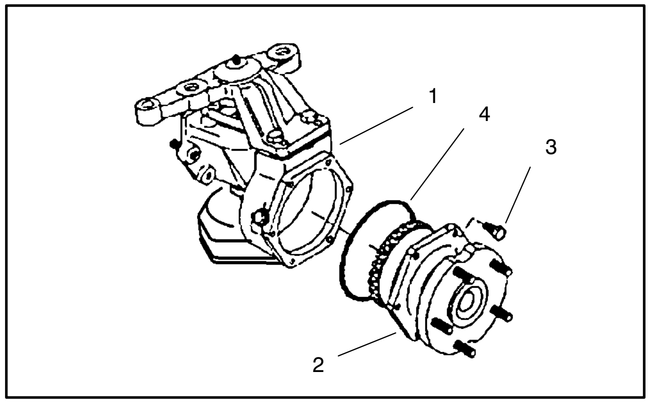

Figure 13

1. **Axle case**
2. **Axle cover assembly**
3. **Mounting screw**
4. **O-ring**

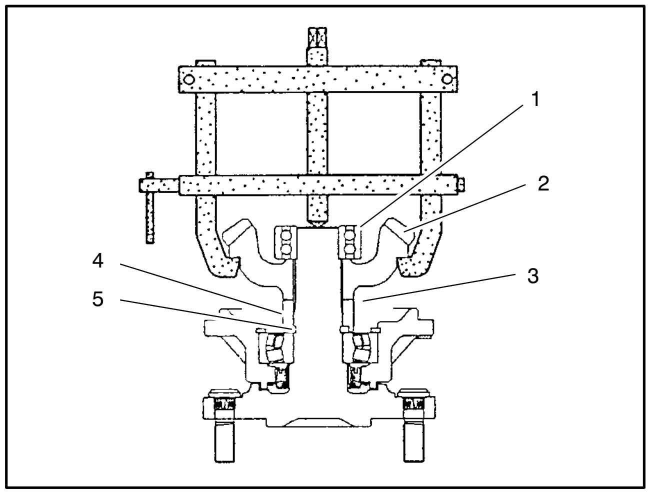

Figure 14

1. **Bearing**
2. **Bevel gear**
3. **Shims**
4. **Spacer**
5. **Retaining ring**

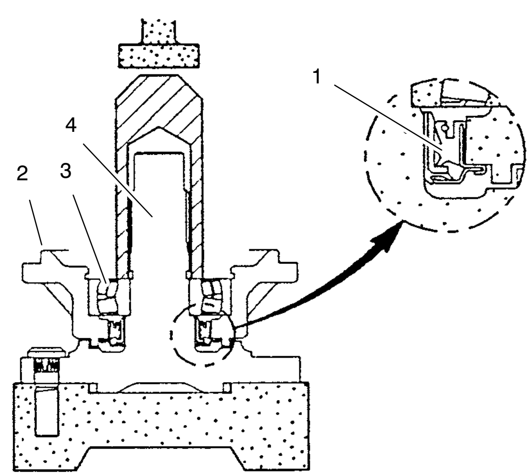

Figure 15

1. **Axle shaft seal**
2. **Axle cover**
3. **Bearing**
4. **Axle shaft**

Input Shaft/Pinion Gear

The following procedures assume the rear axle assembly has been removed from the machine.

Removal

1. Remove input shaft/pinion gear assembly from the axle support. Remove the shims and bearing case O-ring.

2. Release the stake washer and remove the locknut. Remove and discard the stake washer (Fig. 16).

3. Drive the input shaft/pinion gear out from the outer bearing cone and bearing case. Remove and discard the oil seal and O-ring.

4. Inspect all gears, shafts, bearings, spacers, and cases for damage and wear. Replace components as necessary.

NOTE: Replacement input shaft/pinion gears are only available in matched ring and pinion sets.

Installation

NOTE: When installing new bearing cones, press only on the inner race of the bearing cone.

1. If the inner bearing cone was removed, press a new bearing cone all the way onto the input shaft/pinion gear.

2. Place the shaft and bearing assembly in the bearing case and install the outer bearing cone.

NOTE: The bearings must be completely seated. There should be no input shaft/pinion gear end play.

3. Coat a new oil seal with grease and install as shown (Fig. 17).

4. Coat a new O-ring with grease. Install O-ring in the oil seal collar, and install the collar.

5. Install a new stake washer. Install the lock nut finger tight.

6. Set the bearing preload be securing the bearing case in a vise. Thread a M12 x 1.5 hex. hd. capscrew into the splined end of the input shaft/pinion gear.

7. Slowly tighten the locknut until 4.0 to 6.0 in-lbs. (0.4 to 0.7 Nm) of force is required to rotate the input shaft/pinion gear in the bearing case.

8. Secure the lock nut with the stake washer.

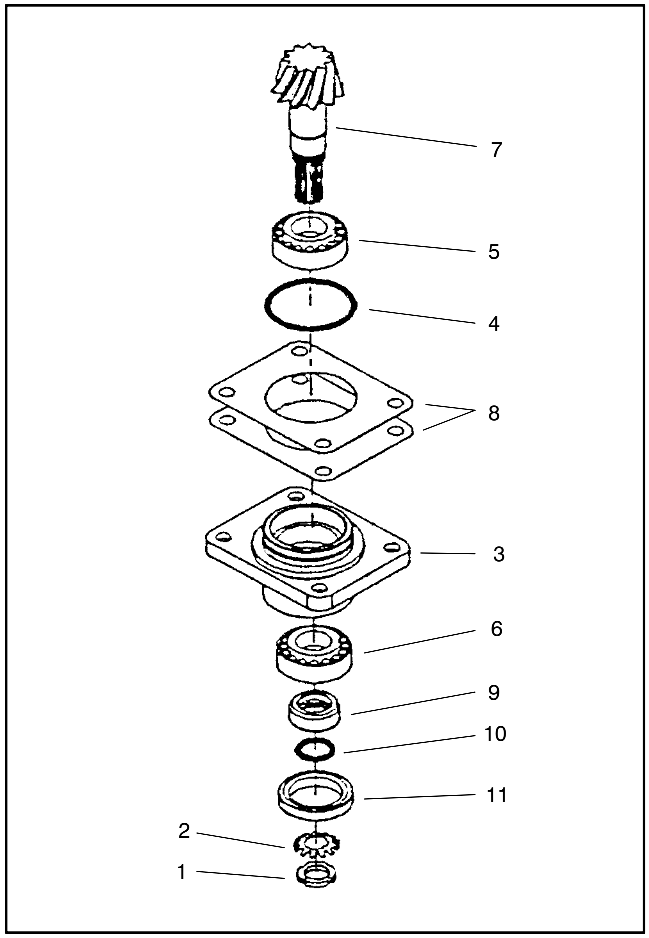

Figure 16

1. **Lock nut**
2. **Stake washer**
3. **Bearing case**
4. **Bearing case O-ring**
5. **Inner bearing**
6. **Outer bearing**
7. **Input shaft/pinion gear**
8. **Bearing case shims**
9. **Seal collar**
10. **O-ring**
11. **Oil seal**

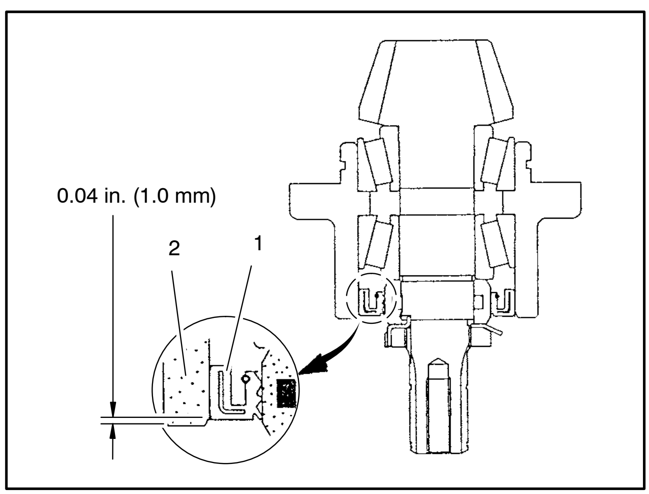

Figure 17

1. **Oil seal**
2. **Bearing case**

9. Use a depth gauge to measure the distance from the end face of the input shaft/pinion gear to the mating surface of the bearing case. Subtract the “Design Cone Center Distance” from this distance to determine initial shim thickness (Fig. 18).

DESIGN CONE CENTER DISTANCE
(distance from mating surface of axle support to end face of pinion gear):
1.870 $\pm$ 0.002 in. (47.5 $\pm$ 0.05 mm)

NOTE: Bearing case shims are available in 0.004 in. (0.1 mm) and 0.008 in. (0.2 mm) thickness.

10. Coat a new O-ring with grease. Place shims on the bearing case and temporarily install input shaft/pinion gear assembly into axle case. Tighten mounting screws to 35 to 41 ft-lbs. (47 to 56 Nm).

11. Insert a screwdriver through the drain plug hole to hold ring gear and measure the pinion gear to ring gear backlash (Fig. 19).

PINION GEAR TO RING GEAR BACKLASH:
0.004 to 0.016 in. (0.10 to 0.40 mm)

12. Adjust backlash by increasing or reducing bearing case shim thickness.

13. Check pinion gear to ring gear engagement (see Pinion Gear to Ring Gear Engagement in this section of this manual.

14. Place the correct combination of shims on the bearing case. Tighten mounting screws to 35 to 41 ft-lbs. (47 to 56 Nm).

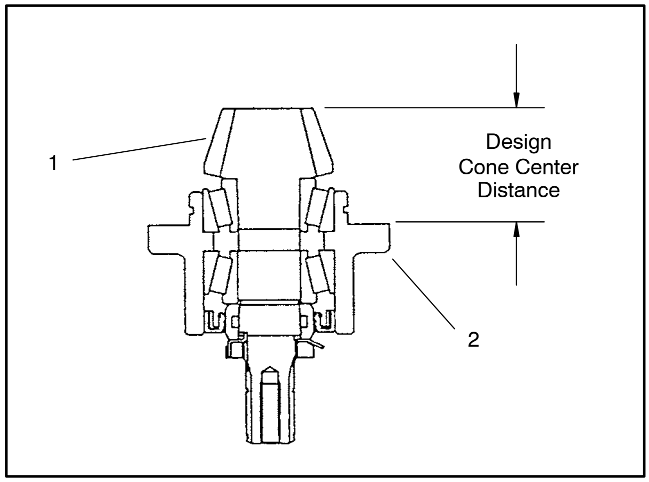

Figure 18

1. Input shaft/pinion gear **2. Bearing case**

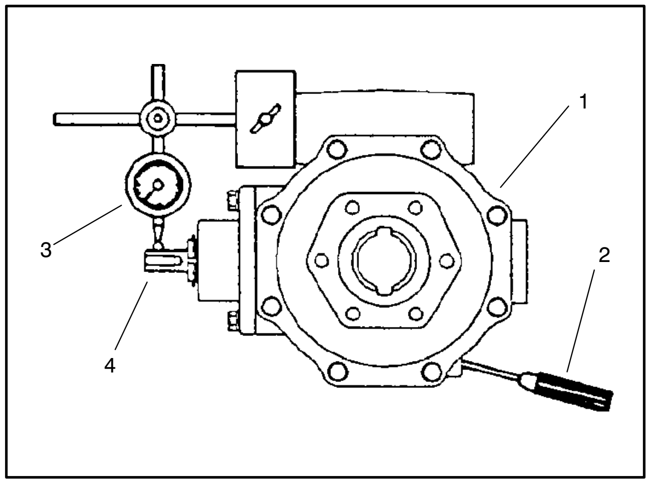

Figure 19

1. Axle case
2. Screwdriver
3. Dial indicator
4. Input shaft/pinion gear

Differential Gear

The following procedures assume the rear axle assembly has been removed from the machine.

Removal

1. Remove bevel gear case/axle case assemblies (see Bevel Gear Case/Axle Case Assembly in this section of this manual).

IMPORTANT: Do not interchange right and left differential shafts assemblies.

2. Mark and pull the differential shaft assemblies from the axle support.

3. Remove input shaft/pinion gear assembly, shims, and O-ring from the axle support (Fig. 20).

4. Remove the axle support case screws. Separate the axle support halves and remove the O-ring.

5. Remove the differential gear assembly, bearings, and adjusting shims from the axle case.

6. Drive the spring pin from the differential case with a punch and hammer. Discard the spring pin (Fig. 21).

NOTE: Mark and arrange all components so they can be reassembled in their original position.

7. Remove the differential pinion shaft, pinion gears, and pinion washers. Remove the differential side gears and side gear shims. Remove the ring gear only if it will be replaced (Fig. 22).

NOTE: Replacement ring gears are only available in matched ring and pinion sets.

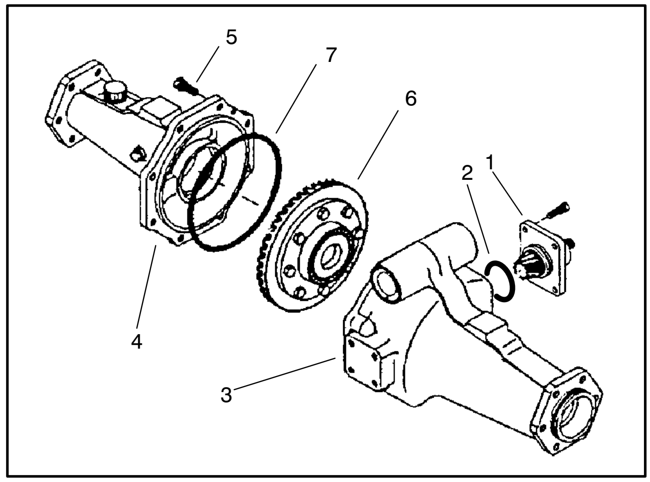

Figure 20

1. **Pinion gear**
2. **O-ring**
3. **Axle support (right)**
4. **Axle support (left)**
5. **Case screws**
6. **Differential gear**
7. **O-ring**

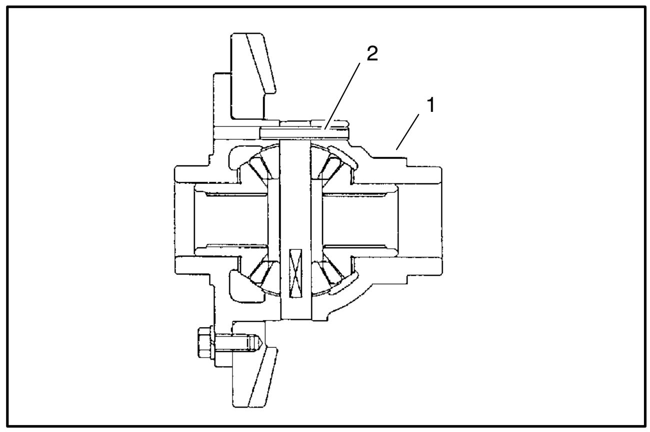

Figure 21

1. **Differential case**
2. **Spring pin**

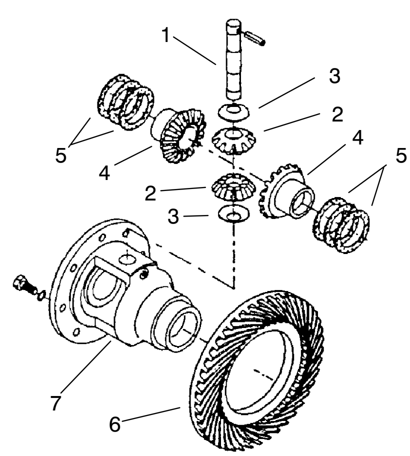

Figure 22

1. **Differential pinion shaft**
2. **Pinion gear**
3. **Pinion washer**
4. **Side gear**
5. **Side gear shims**
6. **Ring gear**
7. **Differential case**

Inspection

1. Measure the differential side gear O.D. and the differential case I.D. to determine the side gear to case clearance (Fig. 23). Replace components as necessary.

SIDE GEAR TO CASE CLEARANCE:
0.002 to 0.012 in. (0.05 to 0.30 mm)

SIDE GEAR O.D. (Factory Spec.):
1.335 to 1.337 in. (33.91 to 33.95 mm)

DIFFERENTIAL CASE I.D. (Factory Spec.):
1.339 to 1.341 in. (34.00 to 34.06 mm)

2. Measure the differential pinion shaft O.D. and the pinion gear I.D. to determine the pinion shaft to pinion gear clearance (Fig. 24). Replace components as necessary.

PINION SHAFT TO PINION GEAR CLEARANCE:
0.001 to 0.010 in. (0.03 to 0.25 mm)

PINION SHAFT O.D. (Factory Spec.):
0.550 to 0.551 in. (13.97 to 13.10 mm)

PINION GEAR I.D. (Factory Spec.):
0.551 to 0.552 in. (13.10 to 14.02 mm)

3. Inspect all gears, shafts, bearings, cases, and covers for damage and wear. Replace components as necessary.

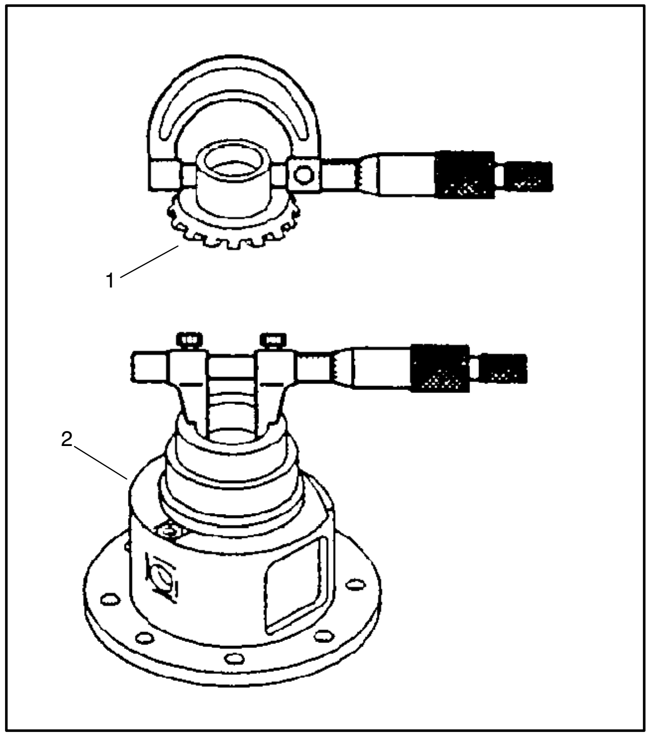

Figure 23

1. **Side gear** 2. **Differential case**

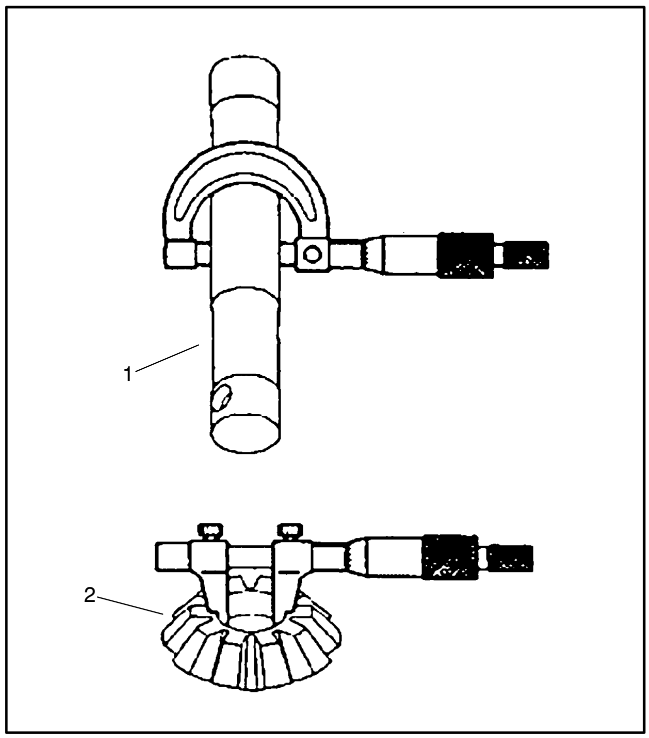

Figure 24

1. **Pinion shaft** 2. **Pinion gear**

Installation

1. If the ring gear was removed, use medium strength Loctite thread locker and tighten the mounting screws to 22 to 25 ft-lbs. (30 to 34 Nm).

2. Apply molybdenum disulfide to the splines and bearing surfaces of the differential pinion gears, pinion washers, and side gears.

3. Install the side gear shims and side gears in their original location in the differential case.

4. Place the differential pinion gears and pinion washers in their original location in the differential case. Temporarily install the differential pinion shaft.

5. Secure the differential case in a vise. Position a dial indicator at the tooths center and measure the differential pinion gear to side gear backlash (Fig. 25).

PINION GEAR TO SIDE GEAR BACKLASH:
0.004 to 0.016 in. (0.10 to 0.40 mm)

6. Adjust backlash by increasing or reducing side gear shim thickness.

NOTE: Side gear shims are available in 0.043 in. (1.1 mm), 0.047 in. (1.2 mm), and 0.051 in. (1.3 mm) thickness.

7. Apply gear marking compound, such as DyKem® Steel Blue lightly over several gear teeth.

8. While applying a light load to either side gear, rotate either pinion gear until the side gears have made one complete revolution.

9. Ideal tooth contact should cover more than 35% of each tooth surface. The contact area should be in the center of each tooth and extend 1/3 to 1/2 way across each tooth from the toe (small) end (Fig. 26).

10. Adjust side gear shims if necessary to correct tooth contact. Recheck differential pinion gear to side gear backlash if any changes are made.

11. After backlash and tooth contact have been adjusted, align the hole in the differential pinion shaft with the hole in the differential case and install a new spring pin.

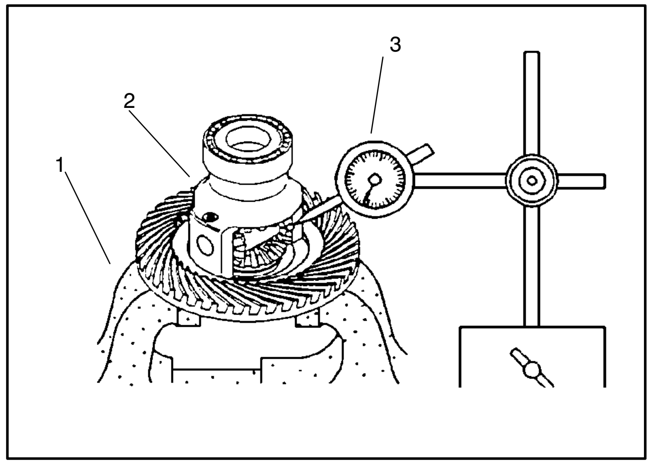

Figure 25

1. **Vise**
2. **Differential gear case**
3. **Dial indicator**

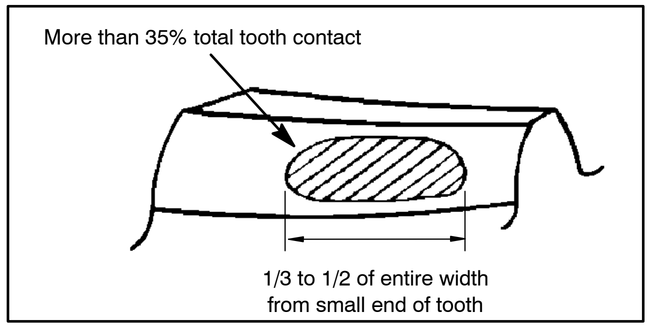

Figure 26

12. Install differential gear assembly in right side axle support half.

13. Coat a new O-ring with grease and install left side axle support half. Tighten axle support case screws to 35 to 41 ft-lbs. (47 to 56 Nm).

14. Install input shaft/pinion gear assembly (see Input shaft/Pinion in this section of this manual).

15. Coat new O-rings with grease, align differential shaft splines with differential gear assembly, and slide differential shaft assemblies onto axle support.

16. Install bevel gear case/axle case assemblies (see Bevel Gear Case/Axle Case Assembly in this section of this manual).

Pinion Gear to Ring Gear Engagement

The final position of the pinion gear is verified by using the gear contact pattern method as described in the following procedure.

GEAR TOOTH DEFINITIONS (Fig. 27):

Toe – the portion of the tooth surface at the end towards the center.

Heel – the portion of the gear tooth at the outer end.

Top Land – top surface of tooth.

1. Paint the teeth of the ring gear, both drive and coast side, with a gear marking compound, such as DyKem® Steel Blue.

2. Install the input shaft/pinion gear assembly into axle case.

3. While applying a light load to the ring gear, rotate the pinion gear in the direction of forward travel until the ring gear has made one complete revolution.

Ideal tooth contact observed on the ring gear should cover more than 35% of each tooth surface. The contact area should be in the center of each tooth and extend 1/3 to 1/2 way across each tooth from the toe end (Fig. 28).

Adjustments to the gear contact position are made by moving the input shaft/pinion gear (bearing case shims) or by moving the differential gear case (differential bearing shims) (Fig. 29).

NOTE: Bearing case shims are available in 0.004 in. (0.10 mm) and 0.008 in. (0.20 mm) thickness.

NOTE: Differential bearing shims are available in 0.004 in. (0.10 mm), 0.008 in. (0.20 mm) and 0.016 in. (0.40 mm) thickness.

Study the different contact patterns (Figs. 30 and 31) and correct gear engagement as necessary.

NOTE: When making changes, note that two variables are involved (see Gear Pattern Movement Summary in this section of this manual).

Example: If the pinion gear to ring gear backlash is set correctly to specifications and the bearing case shim is changed to adjust tooth contact, it may be necessary to readjust backlash to the correct specification before checking the contact pattern.

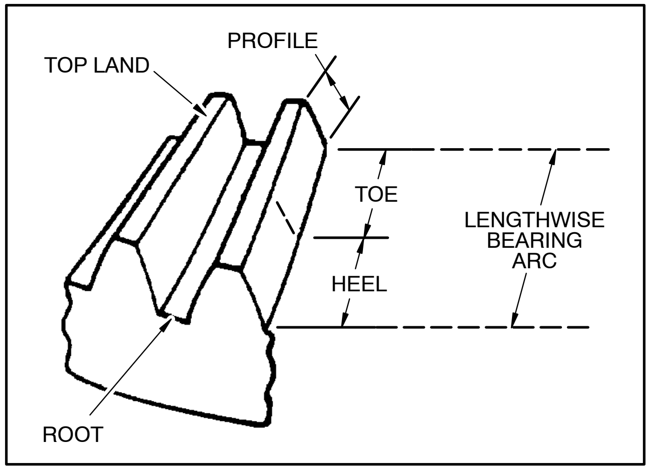

Figure 27

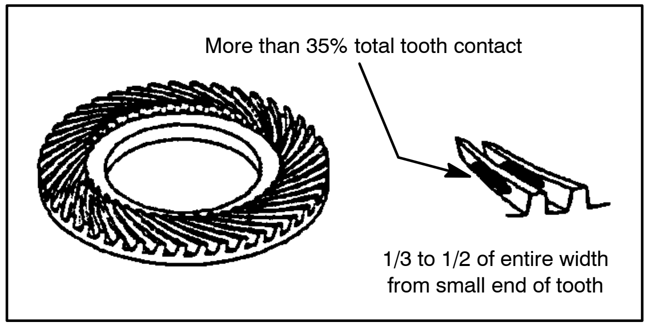

Figure 28

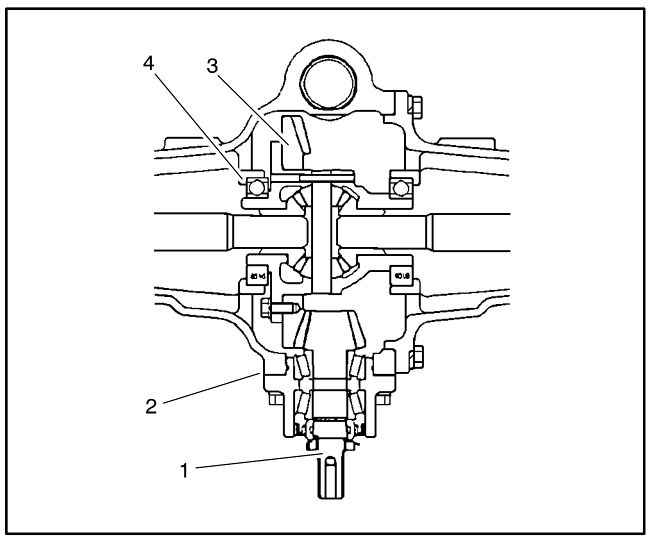

Figure 29

1. **Input shaft/pinion gear**
2. **Bearing case shims**
3. **Differential gear case**
4. **Differential bearing shims**

Gear Pattern Movement Summary

Every gear has a characteristic pattern. The illustrations show typical patterns only and explain how patterns shift as gear location is changed.

1. If contact is toward the heel or base of the gear (Fig. 30):

   A. Install thicker or additional bearing case shim(s) to move pinion shaft toward ring gear.

   B. Install thinner or remove differential bearing shim(s) to move ring gear backward.

   C. Repeat until proper tooth contact and pinion gear to ring gear backlash are correct.

2. If contact is toward the toe or tip of the gear (Fig. 31):

   A. Install thinner or remove bearing case shim(s) to move pinion shaft away from ring gear.

   B. Install thicker or additional differential bearing shim(s) to move ring gear forward.

   C. Repeat until proper tooth contact and pinion gear to ring gear backlash are correct.

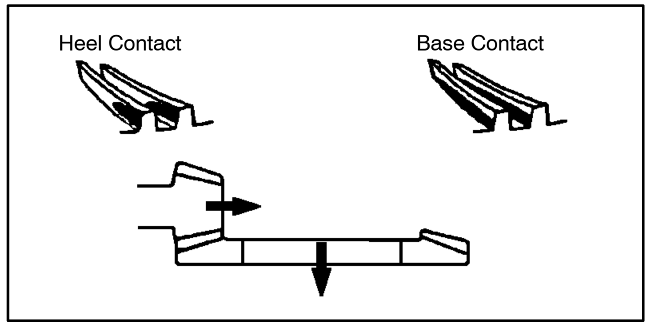

Figure 30

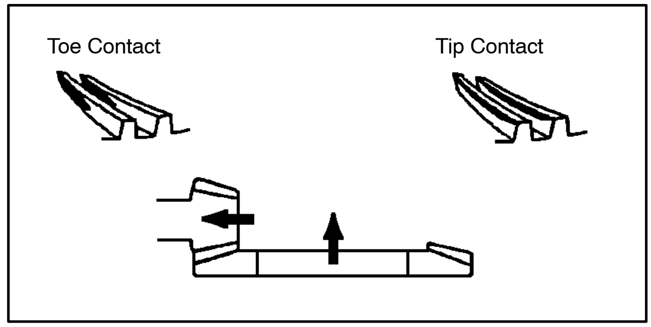

Figure 31

Chapter 15

Guardian® 62″ Recycler® Cutting Unit

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CAUTION

- **Engine could start accidentally.**
- **Accidental starting of engine could cause serious injury to operator or bystanders.**
- **Shut engine off and remove key from ignition switch before performing any maintenance or adjustments.**

Specifications

Width of Cut: 62 in.

Height–of–Cut: Adjustable from 1–1/2” to 4–1/2” in 1/2” increments.

Cutter Housing: 4” deep housing is made of 12 gauge steel and reinforced with 10 gauge channel and plates.

Cutting Unit Drive: Isolation mounted gear box on cutting unit is driven by PTO shaft. Power is transmitted to the blades by one hex ”AA” section belt. Spindle shafts are 1 inch diameter and supported by two greaseable, tapered roller bearings.

Cutting Unit Blades: Three 21–3/4” long and 1/4” thick heat treated steel, Recycler blades .

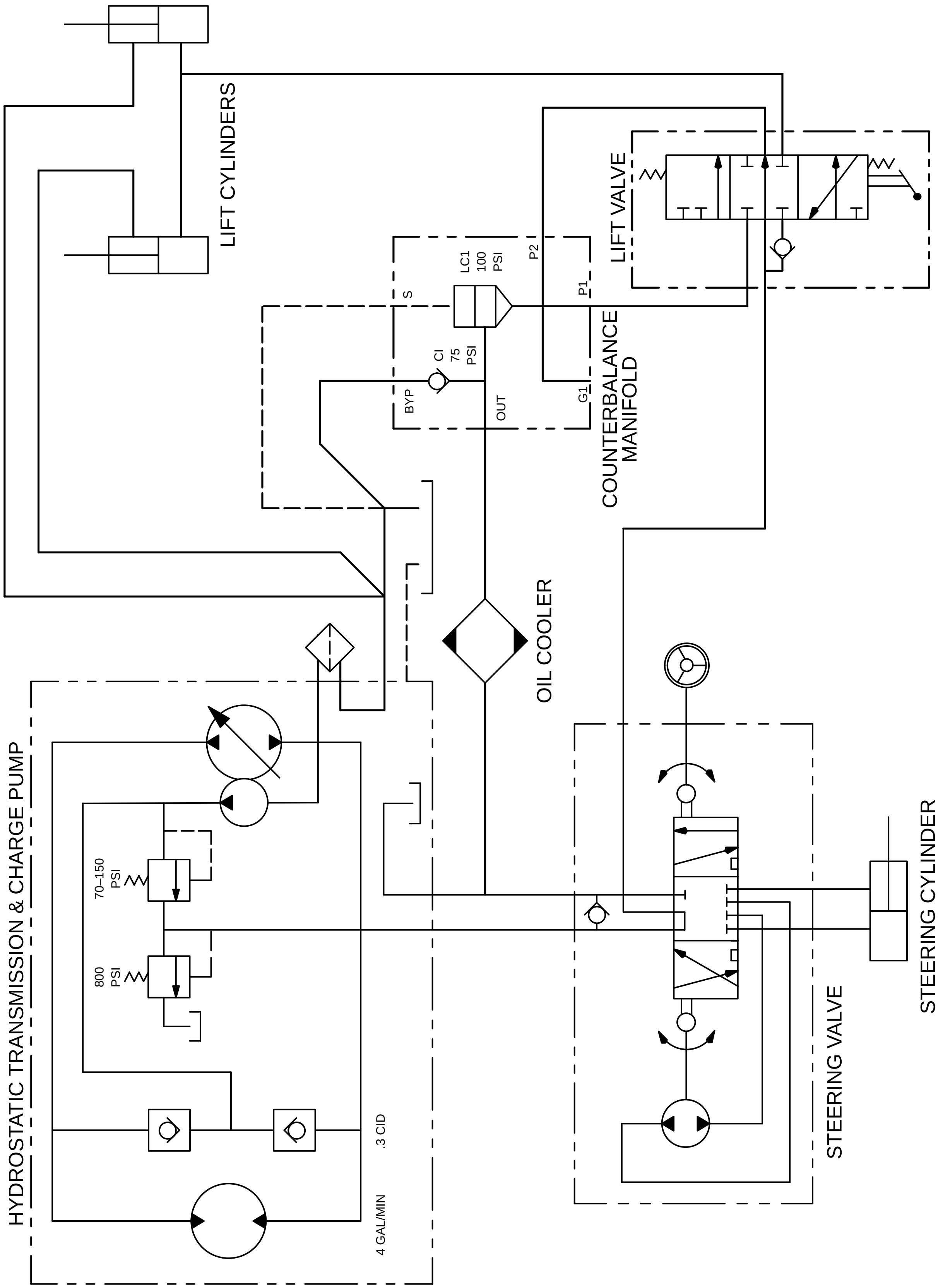
Castor Wheels: Front and rear castor wheels have 8 in. x 3.50 in. hard rubber tires and roller bearings.

Cutting Unit Lift: Independent lift arms and hydraulic weight transfer provide deck flotation.

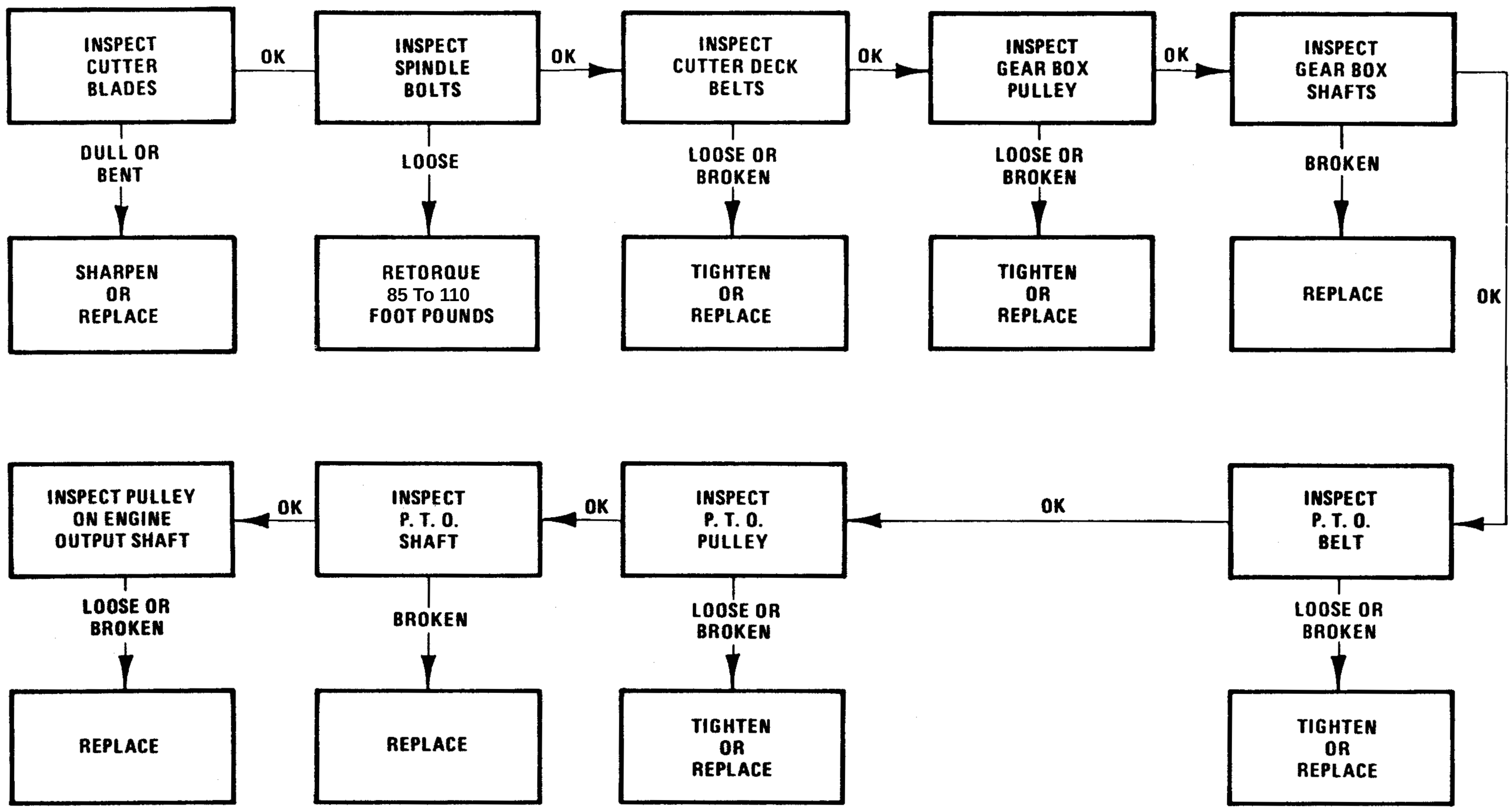
Weight: 340 lb.

Specifications and design subject to change without notice.

Schematic


LIFT CYLINDERS
LIFT VALVE
S
LC1
100
PSI
P2
P1
CI
75
PSI
BYP
OUT
G1
COUNTERBALANCE
MANIFOLD
OIL COOLER
HYDROSTATIC TRANSMISSION & CHARGE PUMP
70–150
PSI
800
PSI
.3 CID
4 GAL/MIN
STEERING VALVE
STEERING CYLINDER

UNIT WILL NOT CUT OR CUTS POORLY



Adjustments

Height of Cut Adjustment

The height–of–cut is adjustable from 1–1/2 to 4–1/2 inches in 1/2 inch increments, by adding or removing an equal number of spacers from the front and rear castor forks. The height–of–cut chart below gives the combinations of spacers to use for all height–of–cut settings.

Height–of–Cut Chart

Height–of–Cut Setting	**Spacers Below Castor Arm**	
	Front	**Rear**
1–1/2 inch	0	0
2 inch	1	1
2–1/2 inch	2	2
3 inch	3	3
3–1/2 inch	4	4
4 inch	5	5
4–1/2 inch	6	6

1. Start the engine and raise the cutting unit so height–of–cut can be changed. Stop engine after cutting unit is raised.

Note: 1" height–of–cut can be attained by modifying the castor forks as follows:

A. Remove front and rear castor forks from cutting deck and remove wheels from forks.

B. Drill out .438" dia. holes (Fig. 1 & 2) in each side of castor forks to .500" or .516" dia.

C. Using new holes, reinstall castor wheels to forks and install forks to deck.

Note: Height–of–cut decal will now be off by 1/2" for spacer placement and height–of–cut will be 1" to 4".

Front Castor Wheels

1. Remove tensioning cap from spindle shaft and slide spindle out of front castor arm. Remove washer from spindle shaft. Slide spacers onto spindle shaft to get desired height–of–cut, then slide washer onto shaft.

2. Push castor spindle through front castor arm, install other thrust washer and remaining spacers onto spindle and install tensioning cap to secure assembly .

Rear Castor Wheels

1. Remove tensioning cap from spindle shaft.

Note: Rear castor fork assembly does not need to be removed from castor arm to change height–of–cut.

2. Remove or add "C" shaped spacers at the narrow portion of the spindle shaft, below castor arm, to get desired height–of–cut. Make sure thrust washers – not the spacers – contact the top and bottom of the castor arm.

3. Install tensioning cap to secure assembly .

4. Assure all four castor wheels are set at same height–of–cut.

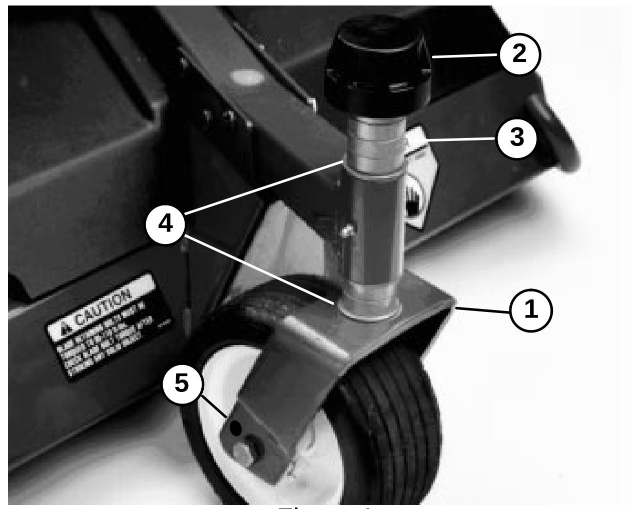


Figure 1

1. Front Castor Wheel
2. Tensioning cap
3. Spacers
4. Thrust Washers
5. .438" dia hole

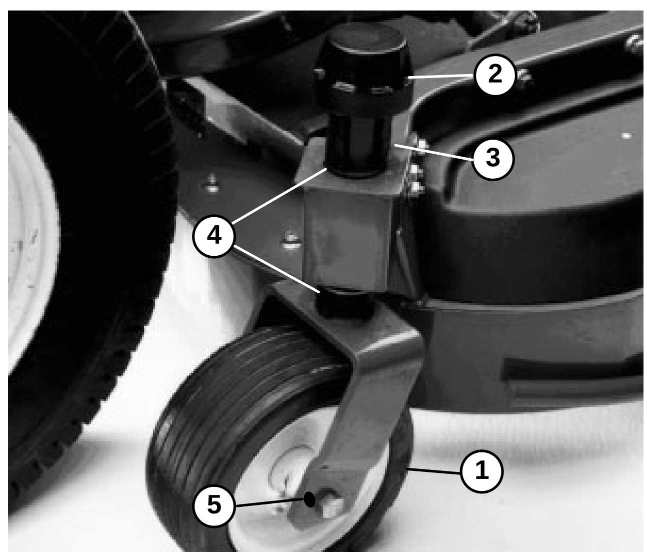


Figure 2

1. Rear Castor Wheel
2. Tensioning cap
3. Spacers
4. Thrust Washers
5. .438" dia. hole

Roller Adjustment

Note: If cutting unit is to be used in the 1” or 1–1/2” height–of–cut setting, cutting unit rollers must be repositioned in the top bracket holes.

To adjust front and rear rollers:

1. Remove cotter pins securing roller shafts to underside of deck.

2. Slide shafts out of lower bracket holes, align rollers with top holes and install shafts.

3. Install cotter pins to secure assemblies.

Skid Adjustment

Adjust skids by removing flange nuts, positioning skids at desired position and reinstalling flange nuts.

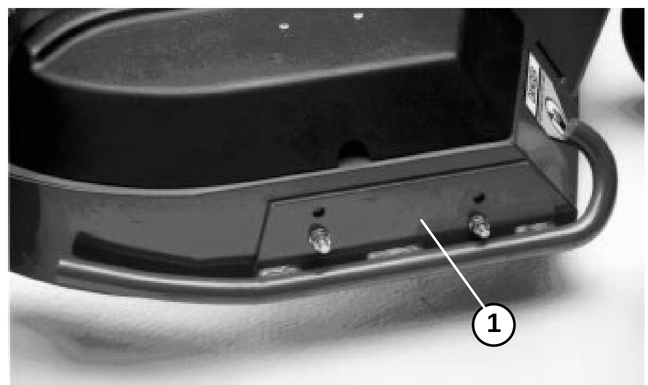


Figure 3
1. Skid

Service and Repairs

Lubrication

The cutting unit must be lubricated regularly. If machine is operated under normal conditions, lubricate castor bearings and bushings with No. 2 general purpose lithium base grease or molybdenum base grease, after every 8 hours of operation or daily, whichever comes first **NOTE:** Lubricate immediately after washing, regardless of the service interval listed.

The cutting unit has bearings and bushings that must be lubricated, and these lubrication points are: front castor spindle bushings (Fig. 5); rear castor spindle shaft (Remove shaft from castor arm and coat hex shaft with designated grease every 50 hours (Fig. 6); castor wheel bearings (Fig. 5 & 6); blade spindle bearings (Fig. 7) and right and left push arm ball joints (Fig. 7).

Figure 5

Figure 6

Figure 7

Checking and Correcting Blade Mismatch

If there is mismatch between the blades, the grass will appear streaked when it is cut. This problem can be corrected by making sure the blades are straight and all blades are cutting on the same plane.

1. Using a 3 foot long carpenters level, find a level surface on the shop floor.

2. Raise height–of–cut to the highest position: refer to Adjusting Height–Of–Cut.

3. Lower cutting unit onto flat surface. Remove covers from top of cutting unit.

4. Loosen flange nut securing idler pulley to release belt tension.

5. Rotate blades until the ends face forward and backward. Measure from floor to front tip of cutting edge and remember this dimension. Then rotate same blade so opposite end is forward and measure again. The difference between dimensions must not exceed 1/8 of an inch. If dimension exceeds 1/8 of an inch, replace the blade because it is bent. Make sure to measure all blades.

6. Compare measurements of outer blades with the center blade. Center blade must not be more than 3/8 of an inch lower than the outer blades. If center blade is more than 3/8 of an inch lower than the outer blades. proceed to step 7 and add shims between spindle housing and bottom of cutting unit.

7. Remove capscrews, flatwashers, lockwashers and nuts from outer spindle in the area where shims must be added. To raise or lower the blade, add a shim, Part No. 3256–24, between spindle housing and bottom of cutting unit. Continue to check alignment of blades and add shims until tips of blades are within the required dimension.

IMPORTANT: Do not use more than three shims at any one hole location. Use decreasing numbers of shims in adjacent holes if more than one shim is added to any one hole location.

8. Readjust idler pulley. Reinstall belt covers.

Counterbalance Adjustment

NOTE: The test port is used to check hydraulic circuit pressure. Check pressure with lift lever in FLOAT position, engine running at high idle and hydraulic oil at its normal operating temperature (Fig. 4).

NOTE: The counterbalance has been pre–set at the factory and should not require adjusting. Rotating manifold screw to increase or decrease pressure will increase or decrease counterbalance (Fig. 4).

Normal counterbalance setting is 100 psi. Adjustment range is 80 – 130 psi.

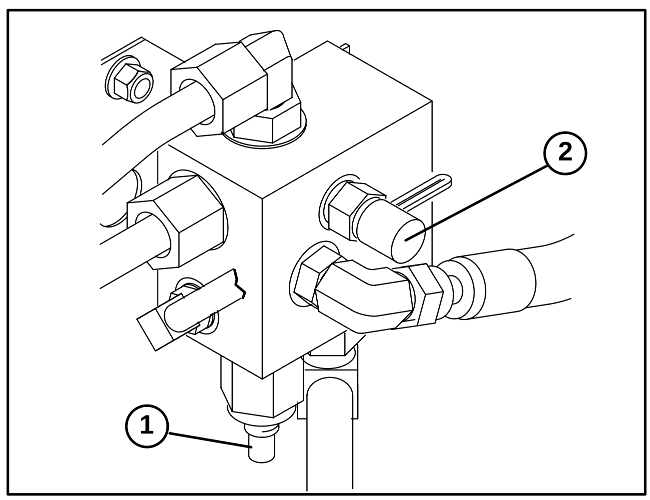


Figure 4

1. Adjusting screw
2. Test port

Checking Gearbox Lubricant

The gear box in designed to operate on SAE 80–90 wt. gear lube. Although the gear box is shipped with lubricant from the factory, check the level before operating the cutting unit.

1. Position the machine and cutting unit on a level surface.

2. Remove check plug from side of gear box and make sure lubricant is up to bottom of hole. If level of lubricant is low, remove fill plug on top of gear case and add enough lubricant to bring it up to bottom of hole in side.

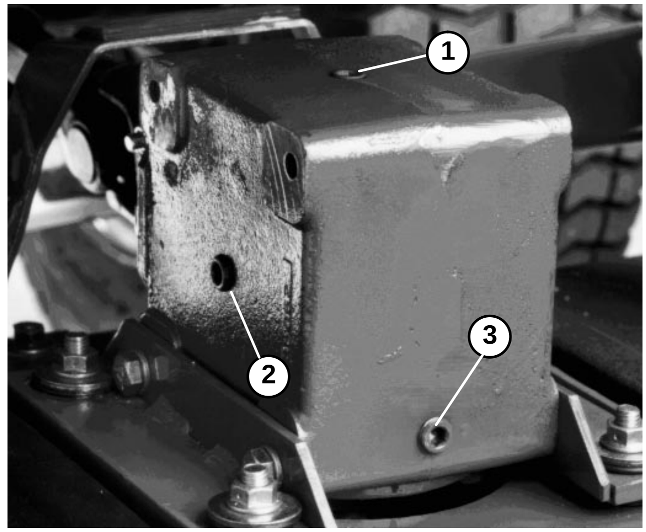


Figure 8

1. Filler Plug
2. Check Plug
3. Drain Plug

Separating Cutting Unit From Traction Unit

1. Position machine on level surface, lower cutting unit to floor, move lift lever to float position, shut engine off and engage parking brake.

2. Remove the capscrews, flatwashers and locknuts securing the ball joint mounts to castor arms on cutting unit.

3. Roll cutting unit away from the traction unit separating male and female sections of PTO shaft.

DANGER

- **Starting engine and engaging PTO lever when PTO shaft is not connected to cutting unit gear box may result in serious personal injury.**
- **Do not start engine and engage PTO lever when PTO shaft is not connected to gear box on cutting unit.**

Figure 9
1. PTO Shaft

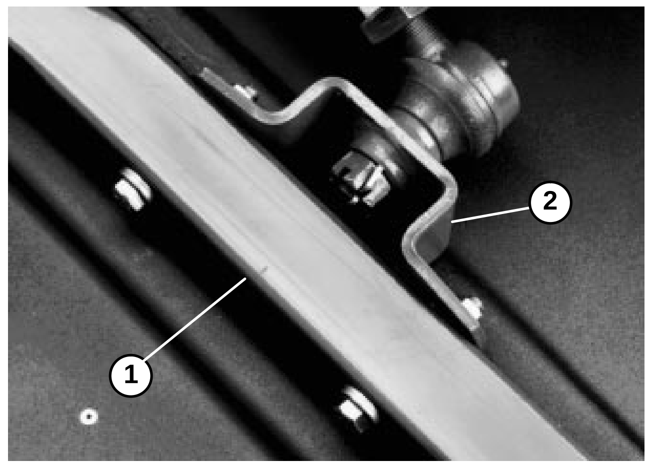


Figure 10
1. Castor Arm
2. Ball Joint Mount

Mounting Cutting Unit to Traction Unit

1. Position machine on a level surface and shut engine off.

2. Move cutting unit into position in front of traction unit.

3. Slide male PTO shaft into female PTO shaft.

4. Move lift lever to FLOAT position. Push lift arms down until holes in ball joint mounts line up with holes in castor arms.

5. Secure ball joint mounts to castor arms with capscrews, flatwashers and flange nuts. Flatwashers to be positioned to outside of castor arm.

Installing Lift Arms to Traction Unit

1. Mount lift arms to pivot brackets and lift cylinders with pivot pins and 3/32" x 1–1/4" lg. cotter pins, supplied with traction unit. Lift arms to be mounted with ball joint ends positioned outward.

2. Hook brake return springs to holes in traction unit lift arms.

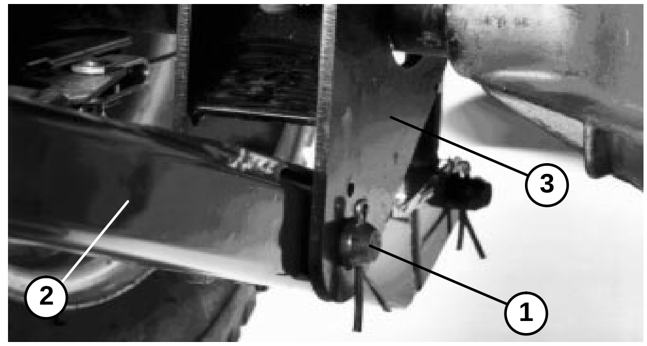


Figure 11

1. Pivot pin
2. Lift arm
3. Lift arm pivot bracket

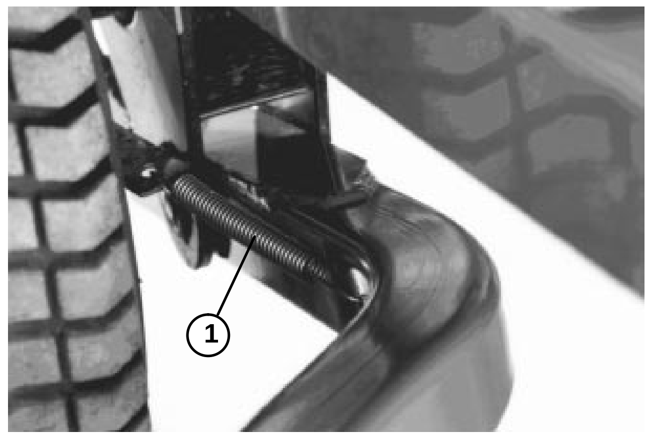


Figure 12

1. Brake return spring

Connecting Lift Arms to Cutting Unit

1. Move cutting unit into position in front of traction unit.

2. Measure distance from end of each lift arm to center of ball joint (grease fitting). Distance should be 2.25”. If distance is not 2.25”, loosen jam nut securing ball joint to lift arm and rotate ball joint in or out until distance is attained. Do not tighten jam nuts at this time.

3. Move lift lever to FLOAT position. Push lift arms down until holes in ball joint mounts line up with holes in castor arms.

4. Secure ball joint mounts to each castor arm with (2) 7/16 – 14 x 3” lg. capscrews, 15/32” I.D. x 59/64” O.D. flatwashers and 7/16 – 14 flange nuts. Flatwashers to be positioned to outside of castor arm (FIg. 14).

Note: Ball joint mount to be above castor arm when assembled.

5. Tighten large jam nut securing ball joint to lift arm (FIg. 5). When tightening jam nut, hold ball joint straight to permit proper oscillation during raising and lowering of cutting unit.

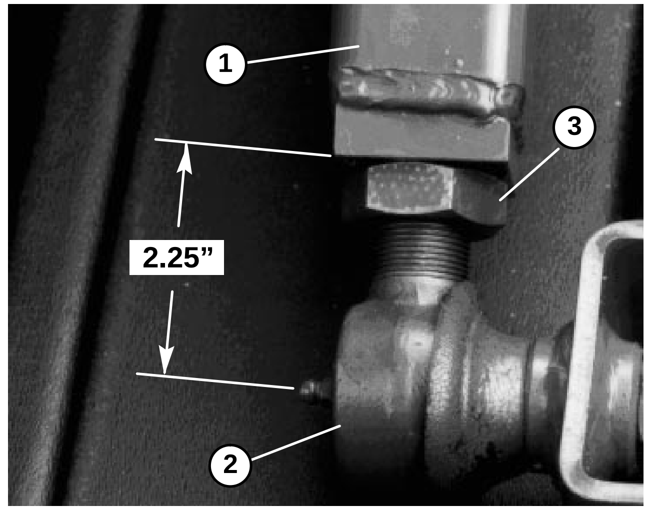


Figure 13

1. Lift Arm 2. Ball Joint 3. Jam Nut

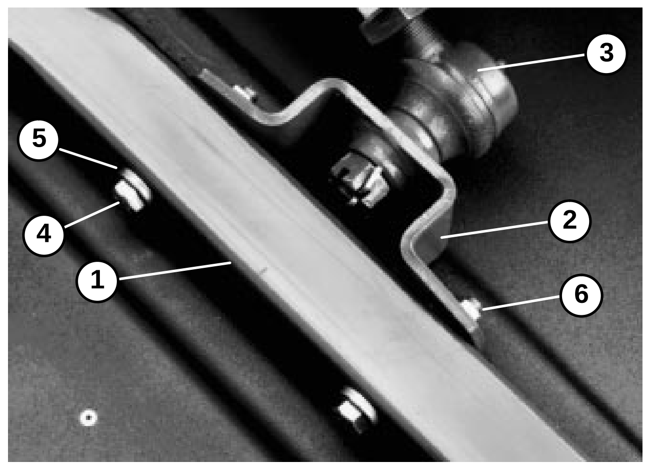


Figure 14

1. Castor Arm
2. Ball Joint Mount
3. Ball Joint
4. Capscrew
5. Washer
6. Flangenut

Connecting PTO Shaft to Cutting Unit Gearbox

1. Slide male PTO shaft into female PTO shaft. Align mounting holes in gear case input shaft with holes in PTO shaft and slide together. Secure with roll pin.

Note: On Groundsmaster 223–D (Diesel) or GM 224 also tighten bolts and locknuts.

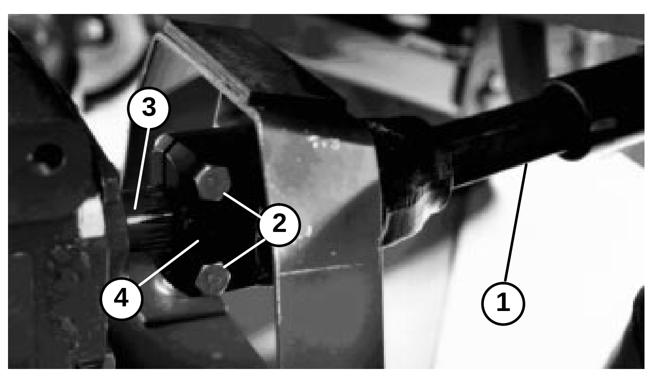


Figure 15

1. PTO shaft
2. Bolts and locknuts
3. Gearcase input shaft
4. Roll pin

Replacing Drive Belt

The blade drive belt, tensioned by the stationary idler pulley, is very durable. However, after many hours of use, the belt will show signs of wear. Signs of a worn belt are: squealing when belt is rotating, blades slipping when cutting grass, frayed edges, burn marks and cracks. Replace the belt if any of these conditions are evident.

1. Lower cutting unit to the shop floor. Remove belt covers from top of cutting unit and set covers aside.

2. Loosen flange nut securing idler pulley to deck. Move pulley away from belt to release belt tension.

3. Remove carriage bolts and flange nuts securing gear box plate to deck. Lift gear box plate and gear box off deck and lay it on top of deck.

4. Remove old belt from around spindle pulleys and idler pulley.

5. Route new belt around spindle pulleys and idler pulley assembly, as shown in figure 18.

6. Reposition gear box plate on deck while routing belt around gear box pulley. Mount gear box plate to deck with carriage bolts and flange nuts previously removed.

7. Using approximately 50 lbs. of force, slide idler pulley against belt.

8. Hold pulley in position and tighten nut.

9. Reinstall belt covers.

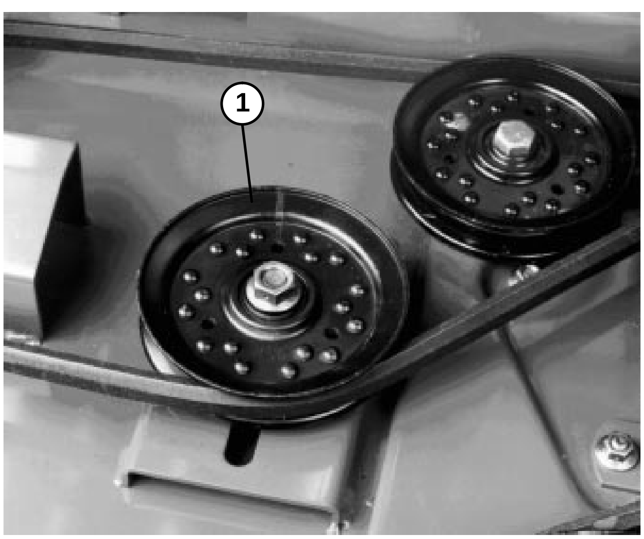


Figure 16

1. Idler pulley

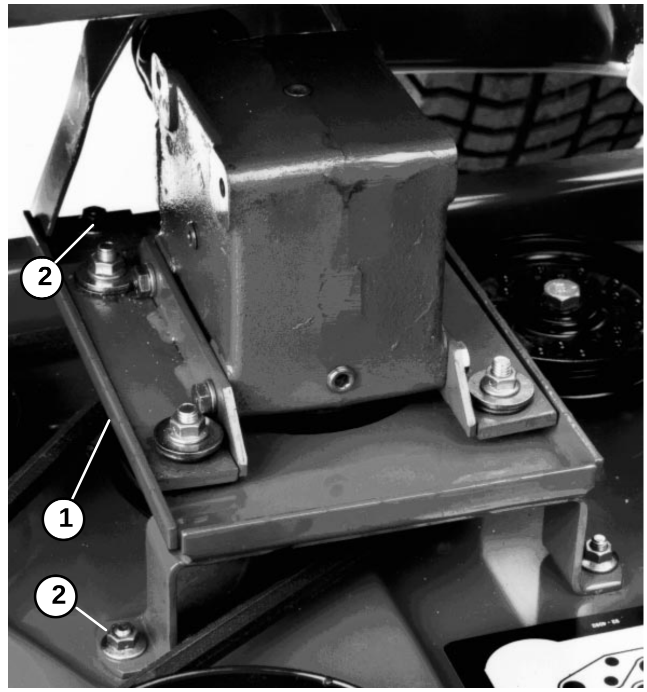


Figure 17

1. Gear Box Plate
2. Capscrews & Nuts

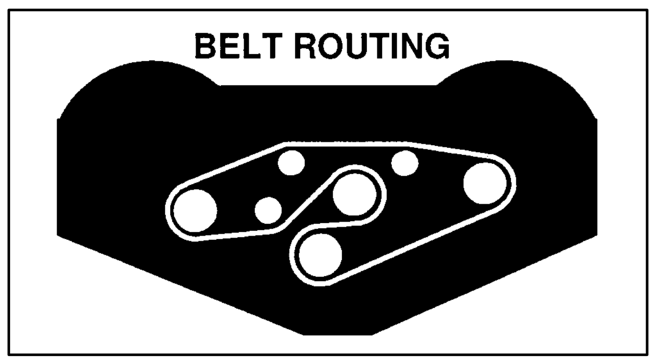


Figure 18

Servicing Front Castor Arm Bushings

The castor arms have bushings pressed into the top and bottom of the tube and after many hours of operation, the bushings will wear. To check the bushings, move castor fork back and forth and from side to side. If castor spindle is loose inside the bushings, bushings are worn and must be replaced.

1. Raise cutting unit so wheels are off floor and block it so it cannot fall accidentally.

2. Remove tensioning cap, spacer(s) and thrust washer from top of castor spindle.

3. Pull castor spindle out of mounting tube. Allow thrust washer and spacer(s) to remain on bottom of spindle.

4. Insert pin punch into top or bottom of mounting tube and drive bushing out of tube. Also drive other bushing out of tube. Clean inside of tubes to remove dirt.

5. Apply grease to inside and outside of new bushings. Using a hammer and flat plate, drive bushings into mounting tube.

6. Inspect castor spindle for wear and replace it if damaged.

7. Push castor spindle through bushings and mounting tube. Slide thrust washer and spacer(s) onto spindle. Install tensioning cap on castor spindle to retain all parts in place.

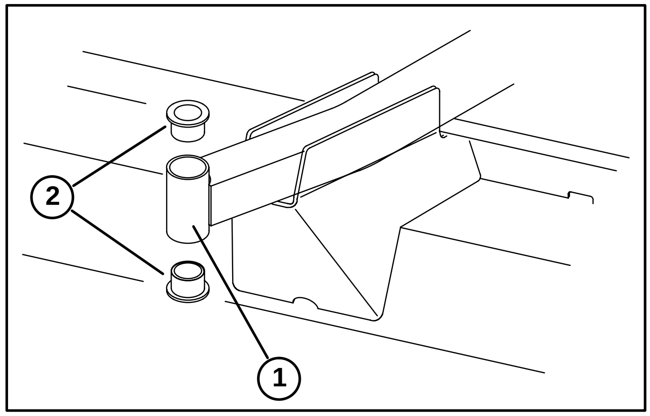


Figure 19

1. Front Castor Arm Tube
2. Bushings

Servicing Castor Wheels and Bearings

The castor wheel rotates on a high–quality roller bearing and is supported by a spanner bushing. Even after many hours of use, provided that the bearing was kept well–lubricated, bearing wear will be minimal. However, failure to keep bearing lubricated will cause rapid wear. A wobbly castor wheel usually indicates a worn bearing.

1. Remove locknut from capscrew holding castor wheel assembly between castor fork. Grasp castor wheel and slide capscrew out of fork.

2. Pull spanner bushing out of wheel hub.

3. Remove bushing from wheel hub and allow bearing to fall out. Remove bushing from opposite side of wheel hub.

4. Check the bearing, spanner and inside of wheel hub for wear. Replace defective parts.

5. To assemble the castor wheel, push bushing into wheel hub. Slide bearing into wheel hub. Push other bushing into open end of wheel hub to captivate the bearing inside the wheel hub.

6. Carefully slide spanner through the bushings and the wheel hub.

7. Install castor wheel assembly between castor fork and secure in place with capscrew, washers and locknut.

8. Lubricate castor wheel bearing through grease fitting, using No. 2 general purpose lithium base grease.

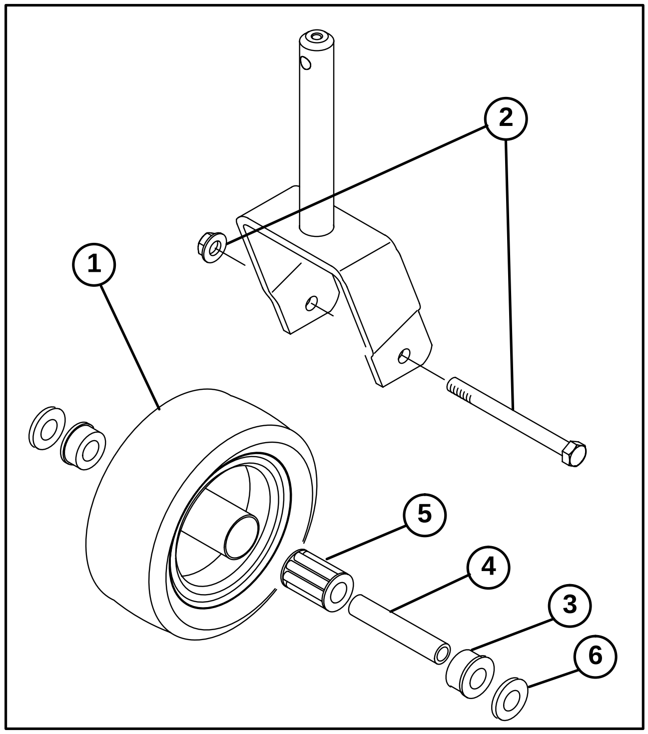


Figure 20

1. Castor wheel
2. Capscrew & Locknut
3. Bushing (2)
4. Spanner Bushing
5. Roller Bearing
6. Washer (2)

Removing Blade

The blade must be replaced if a solid object is hit, the blade is out–of–balance or if the blade is bent. Always use genuine TORO replacement blades to be sure of safety and optimum performance. Never use replacement blades made by other manufacturers because they could be dangerous.

1. Raise cutting unit to highest position, shut the engine off and engage the parking brake. Block cutting unit to prevent it from falling accidentally.

2. Grasp end of blade using a rag or thickly padded glove. Remove blade bolt, lockwasher, anti–scalp cup and blade from spindle shaft.

3. Install blade—sail facing toward cutting unit with anti–scalp cup, lockwasher and blade bolt. Tighten blade bolt to 85–110 ft–lb.

CAUTION

- **Trying to straighten a blade that is bent or welding a broken or cracked blade may result in serious personal injury and/or discontinued safety certification of the product.**
- **Do not try to straighten a blade that is bent, and never weld a broken or cracked blade.**
- **Always replace a damaged blade.**

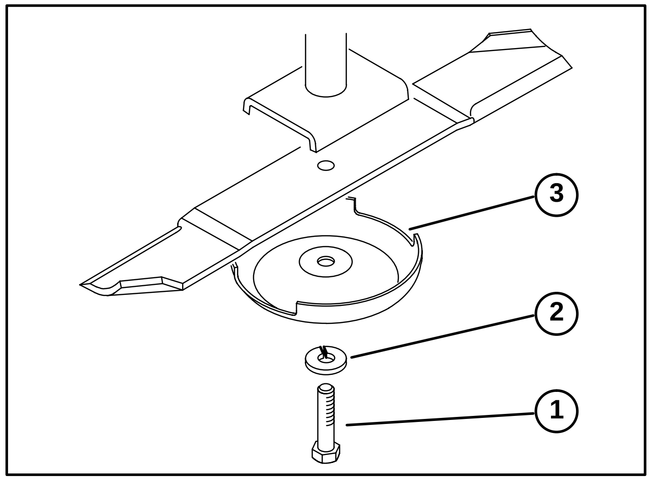


Figure 21

1. Blade bolt
2. Lockwasher
3. Anti–Scalp Cup

Inspecting and Sharpening Blades

1. Raise cutting unit to highest position, shut the engine off and engage the parking brake. Block cutting unit to prevent it from falling accidentally.

2. Examine cutting ends of the blade carefully, especially where the flat and curved parts of the blade meet (Fig. 22–A). Since sand and abrasive material can wear away the metal that connects the flat and curved parts of the blade, check the blade before using the machine. If wear is noticed (Fig. 22–B), replace the blade: refer to Removing Cutter Blade.

DANGER

- **A worn or damaged blade could break and a piece of blade could be thrown into operator's or bystander's area.**
- **A thrown piece of blade could cause serious personal injury or death to operator or bystanders.**
- **Inspect blade periodically for wear or damage.**
- **Replace a worn or damaged blade.**

3. Inspect cutting edges of all blades. Sharpen the cutting edges if they are dull or nicked. Sharpen only the top of the cutting edge and maintain the original cutting angle to make sure of sharpness (Fig. 23). The blade will remain balanced if same amount of metal is removed from both cutting edges.

4. To check blade for being straight and parallel, lay blade on a level surface and check its ends. Ends of blade must be slightly lower than the center, and cutting edge must be lower than the heel of the blade. This blade will produce good quality of cut and require minimal power from the engine. By contrast a blade that is higher at the ends than the center, or if cutting edge is higher than the heel, the blade is bent or warped and must be replaced.

5. Install blade—sail facing toward cutting unit with anti–scalp cup, lockwasher and blade bolt. Tighten blade bolt to 85–110 ft–lb.

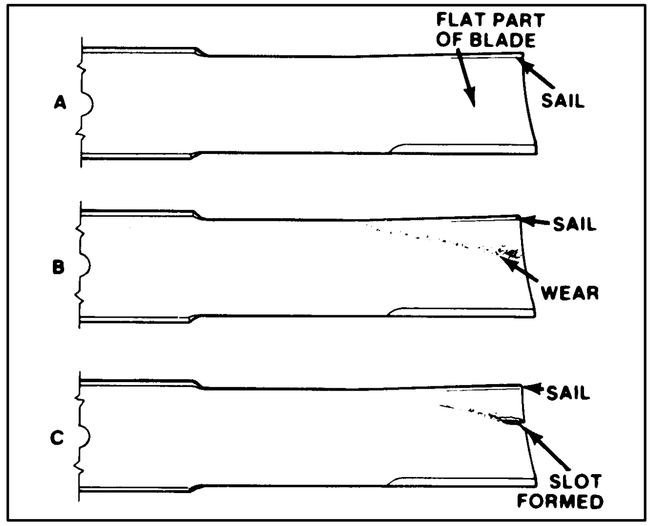


Figure 22

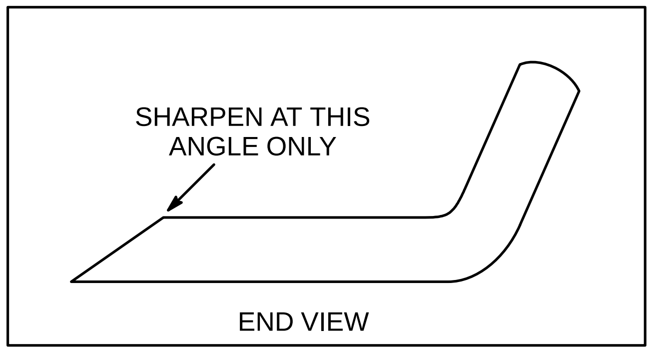


Figure 23

Gearbox Repair

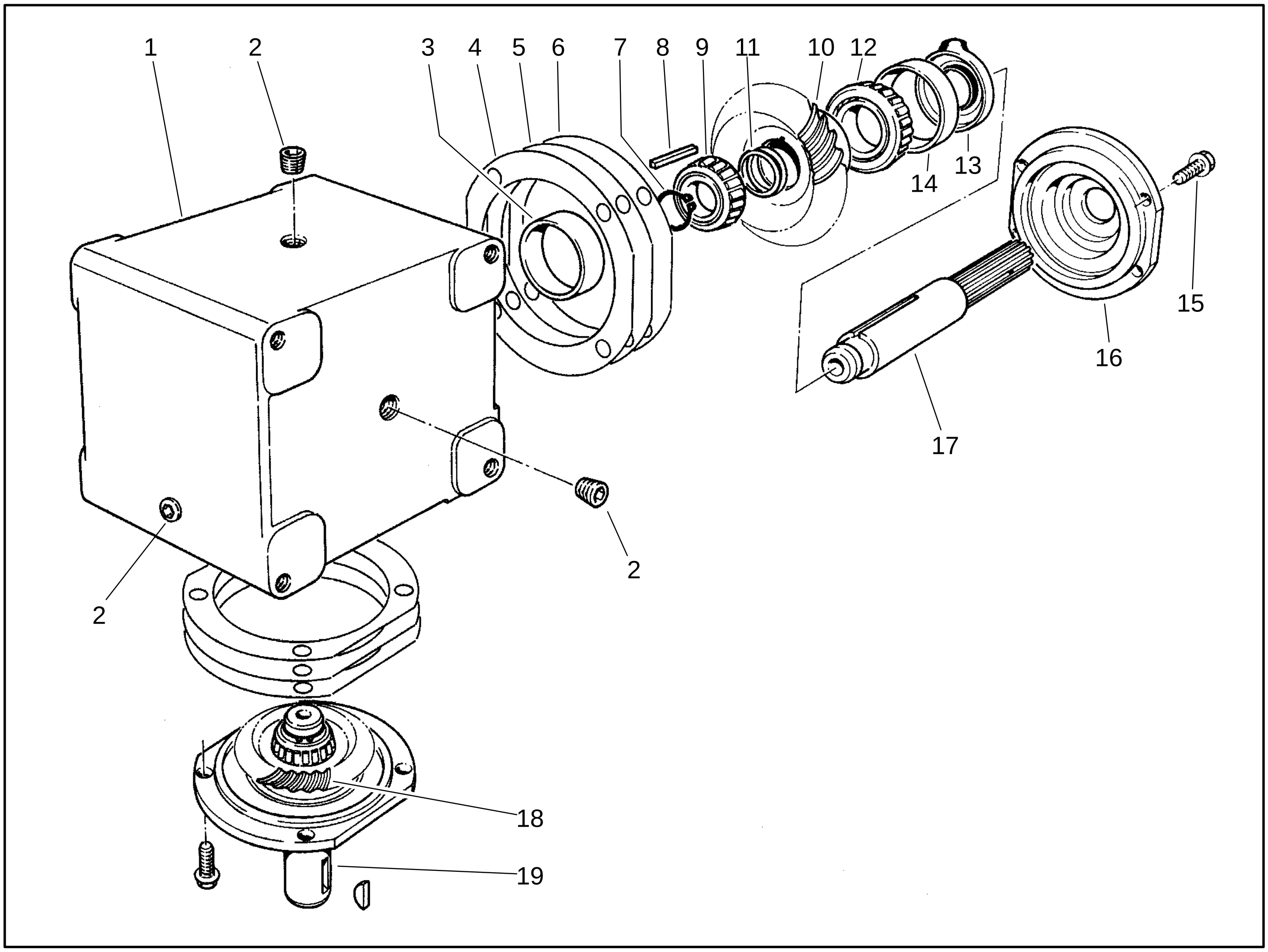


Figure 24

Gear Box Disassembly

1. Drain lubricant from gear box.

2. Remove capscrews and lift out shaft and cap assemblies.

3. Remove cap assemblies and bearing cones (Item 12) from shafts (Item 17, 19).

NOTE: Mark each gear (Item 10 and 18) so they are installed on the proper shaft (Item 17 or 19) when re–assembled.

4. Remove retaining rings (Item 7).

5. Press shafts (Item 17, 19) back through bearing cones (Item 9). When bearing cone is free, gears (Item 10, 18), keys (Item 8) and shims (Item 11) may be removed from the shaft.

6. Remove bearing cups (Item 14) from cap by putting a punch through the shaft bore and through the seal and then tapping against the back of the bearing cup until driven out of the cap.

7. If the oil seal (Item 13) is removed, it will be destroyed. To remove the oil seal, cut it out of the bore with a screw driver or chisel.

8. To remove the bearing cups (Item 3) from the housing a slide hammer puller may be used, or if this is not available, the bearing cups may be knocked out with a punch by coming down through the opposite cap bore and tapping against the back side of the bearing cup until it comes out.

9. Remove the plugs (Item 2) from the housing.

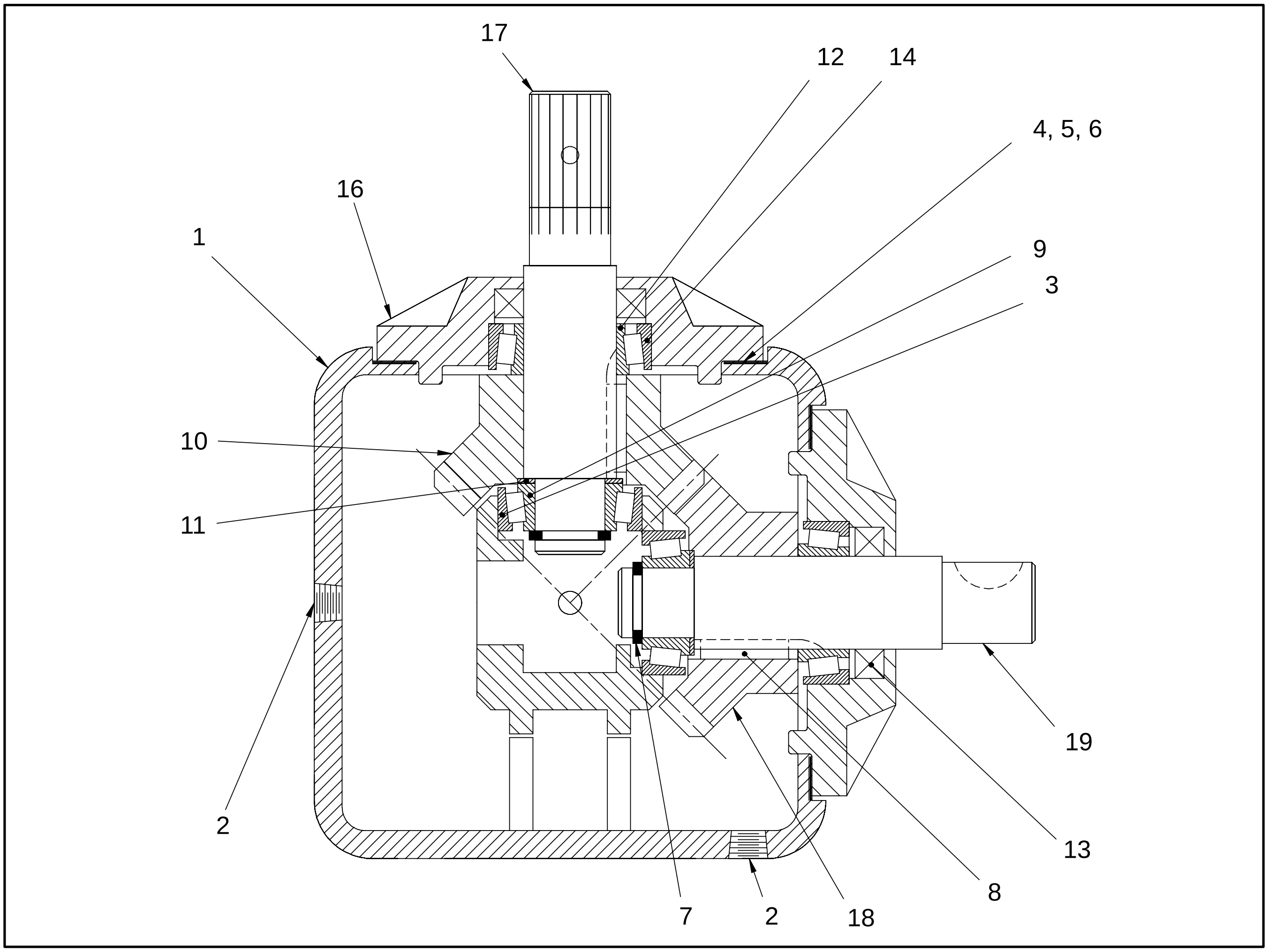


Figure 25

Gear Box Pre–Assembly

1. Start with one of the shafts (Item 17) and put one of the gears (Item 10) over the shaft so the tooth side is towards the turned end of the shaft. Align the keyway in the gear with the keyway in the shaft and install one of the keys (Item 8) in the keyway.

2. Install one set of shims (Item 11) onto the turned end of the shaft. Press one of the bearing cones (Item 9) over the turned end of the shaft. Be sure the bearing cone is installed as shown in the illustration (Fig. 42B). Install a retaining ring (Item 7) on the turned end of the shaft.

3. Put one of the bearing cones (Item 12) over the other end of the shaft and down against the hub side of the gear. Be sure the bearing cone is installed as shown in the illustration.

4. Repeat steps 1 – 3 with the other set of parts to complete the assembly.

5. Put one of the caps (Item 16) down, with the machined surface facing up. Install a new seal (Item 13) into the cap with the open side toward the machined side of the cap.

6. Install the bearing cup (Item 14) into the cap. Make sure the bearing cup is installed as shown in the illustration.

7. Repeat steps 5 – 6 with the other set of parts to complete the two cap assemblies.

8. Take one of the shaft and gear assemblies and wrap the end of the shaft with a piece of shim stock to keep from cutting the oil seal on the keyway or splines. Put the cap assembly down over the shaft so the bearing cone (Item 12) on the shaft mates with the bearing cone (Item 14) in the cap. Remove the shim stock from the shaft that was used to protect the seal.

9. Press the bearing cups (Item 3) into both bearing bores in the housing (Item 1). Make sure the cups are installed as shown in the illustration. Install the plugs (Item 2) into the tapped holes in the housing.

Gear Box Final Assembly

1. Bearing drag is adjusted by the amount of gaskets (Item 4, 5, 6) used between the cap and housing machined surfaces.

2. Put two 0.015 in. gaskets on the machined surface of the housing, then install the shaft and cap assembly in the housing so the bearing cone (Item 9) on the shaft assembly and bearing cup (Item 3) in the housing are mating. Align the holes in the cap with the holes in the gaskets and housing.

3. Install capscrews and tighten.

4. The shaft should have a very slight amount of bearing drag. If the shaft turns hard, the cap must be removed and gasket(s) need to be added. If the shaft has no bearing drag, or has end play, the cap must be removed and gasket(s) taken out. The cap must be adjusted to where the shaft has no end play and only a slight amount of bearing drag.

5. Repeat steps 1 – 4 with the other shaft and cap assembly.

6. After installing the gear box on the cutting unit, fill it with SAE 80W90 API GL–5 lubricant to the level of the check plug (see Maintenance section in this chapter).

Blade Spindle Service

Removing Spindle Housing Assembly

1. Lower the cutting unit, shut the engine off and engage the parking brake.

2. Remove deck covers from top of cutting unit. Release belt tension. Remove belt from spindle to be serviced.

3. Start the engine and raise the cutting unit. Turn the engine OFF and remove the key from the key switch. Block up the cutting unit so it cannot fall accidentally.

4. Using a rag or thickly padded glove, grasp end of blade. Remove blade screw, flat washer, anti–scalp cup and blade from spindle assembly.

5. Remove flange nuts and carriage bolts securing spindle housing to deck. Slide spindle housing assembly out the bottom of the cutting unit.

Disassembly

1. Remove lock nut retaining the spindle pulley on spindle shaft. Slide pulley off of shaft.

2. Press the spindle shaft out of the spindle housing using an arbor press. The bearing spacer remains on the spindle shaft as the shaft is being removed.

3. Remove seals from spindle housing.

4. Allow the bearings and small thick spacer to fall out of the spindle housing.

5. Using a punch and hammer, drive both of the bearing cups out of the spindle housing. Also drive the large spacer out of the housing.

6. A large snap ring is still inside the spindle housing and it should remain there because it cannot be easily removed.

IMPORTANT: If new bearings will be installed into a used spindle housing that has the original snap ring installed, discard the large snap ring that came with the bearings because it is not needed. However, new bearings with their matched spacer and snap ring must always be installed when the spindle housing is being replaced. Replacement bearings are sold only with a matched snap ring and spacer set. These parts cannot be purchased separately.

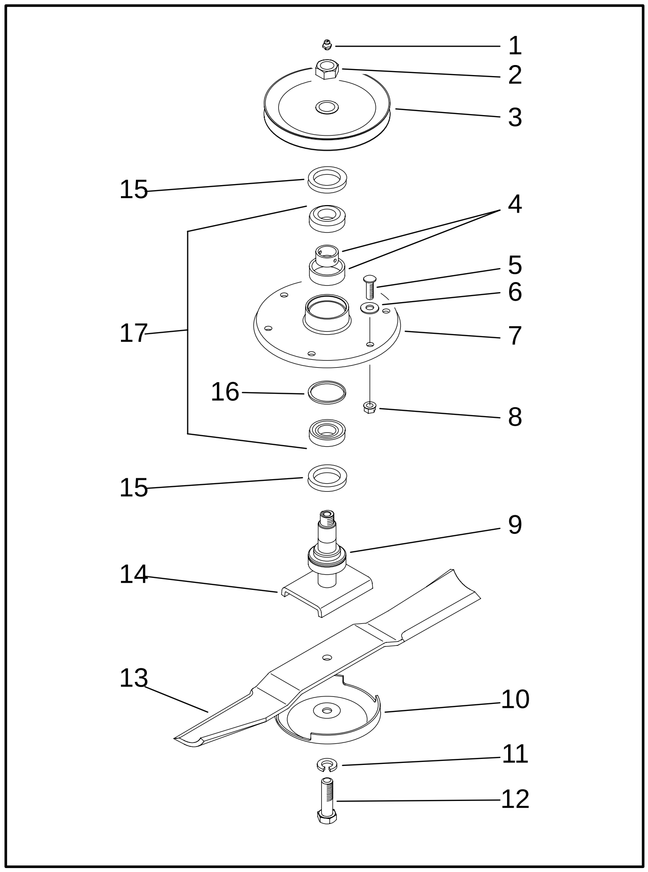


Figure 26

1. Grease fitting
2. Locknut
3. Pulley
4. Spacer set
5. Carriage bolt
6. Flat washer
7. Spindle housing
8. Locknut
9. Spindle spacer
10. Anti–scalp cut
12. Blade bolt
13. Blade
14. Spindle
15. Oil seal
16. Spacer
17. Bearing assembly (Incl. Ref. #16)

Installing Spindle, Bearings and Seals Into Spindle Housing

IMPORTANT: If a new spindle housing is being used, new bearings and matched snap ring set must be installed; see step 1 below. Never use old bearings, spacer, and snap ring with a new spindle housing. If installing bearings into a used spindle housing that still has a snap ring installed, use only new bearings with cups and spacer – not the large snap ring because it is not required; see step 2 below.

1. Install large snap ring into groove in bore of spindle housing. Make sure snap ring is seated in groove.

2. Using an arbor press, push large spacer into top of spindle housing; tightly against snap ring. The spacer must contact the snap ring to be sure of the correct assembly of the parts.

3. Thoroughly oil the bearing cups and using an arbor press, push the bearing cups, smallest inside diameter first, into the top and bottom of the spindle housing. The top bearing cup must contact the spacer that was installed in step 2, and the bottom bearing cup must contact the snap ring to be sure of the correct assembly of parts. Insure that the assembly is correct by supporting the first cup and pressing the second against it.

4. Apply a film of grease on lips of both seals, then install bearing and seal into bottom of spindle housing. Remember, the BOTTOM SEAL MUST HAVE THE LIP FACING OUTWARD, not toward the inside of the spindle housing.

5. Check the spindle shaft to make sure it is free of burrs and nicks that could possibly cut the seals and thoroughly lubricate both the shaft and seal lips.

6. Slide small, thick spacer into spindle housing, then install bearing and seal into top of spindle housing. LIP OF UPPER SEAL MUST FACE INWARD.

7. Slide bearing spacer onto spindle shaft. Carefully slide spindle shaft through spindle housing. The bottom seal and bearing spacer fit together when the spindle is installed.

8. Push pulley onto splines of spindle shaft and retain the parts together with the large flat washer and nut. Tighten the nut to 100 – 120 ft–lb and rotate the spindle shaft to be sure that the shaft rotates freely.

9. Slide pulley end of spindle assembly through hole in cutting unit. Mount the spindle assembly in place with the carriage bolts and flange nuts.

10. Install the belt and adjust belt tension.

11. Reinstall the belt covers.

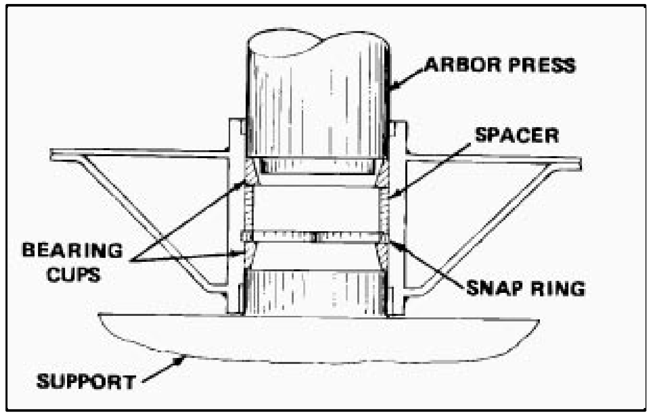


Figure 27

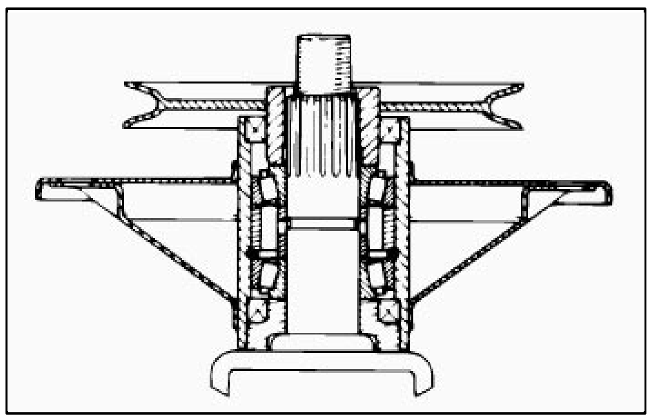


Figure 28

Commercial Products