Part No. 94819SL, Rev. C

Service Manual

Reelmaster® 5300-D

Preface

The purpose of this publication is to provide the service technician with information for troubleshooting, testing, and repair of major systems and components on the Reelmaster 5300-D

REFER TO THE REELMASTER 5300-D TRACTION UNIT AND CUTTING UNIT OPERATOR'S MANUALS FOR OPERATING, MAINTENANCE AND ADJUSTMENT INSTRUCTIONS. Space is provided in Chapter 2 of this book to insert the Operator's Manuals and Parts Catalogs for your machine. Replacement Operator's Manuals are available by sending complete Model and Serial Number of traction unit and cutting unit to:

The Toro Company
8111 Lyndale Avenue South
Bloomington, MN 55420

The Toro Company reserves the right to change product specifications or this publication 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.

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Chapter 1

Safety

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Safety Instructions

The Reelmaster 5300-D was tested and certified by TORO for compliance with the B71.4-1990 specifications of the American National Standards Institute's safety standards for riding mowers when 65 lbs. of ballast is added to rear wheels and a rear weight kit, part no. 75-6690 is installed. Although hazard control and accident prevention partially are dependent upon the design and configuration of the machine, these factors are also dependent upon the awareness, concern, and proper training of the personnel involved in the operation, transport, maintenance, and storage of the machine.

CAUTION

Improper operation, maintenance, troubleshooting, testing, adjustments or repairs of the machine can result in injury or death.To reduce the potential for injury or death, comply with the following safety instructions.

Before Operating

1. Read and understand the Operator's Manual before starting, operating, maintaining or repairing the machine. Become familiar with the controls and know how to stop the machine and engine quickly. Replacement Operator's Manuals are available by sending complete Model and Serial Number of traction unit and cutting units to:

The Toro Company
8111 Lyndale Avenue South
Minneapolis, MN 55420-1196

Use the Model and Serial Number when referring to your machine. If you have questions about this Service Information, please contact:

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

2. Never allow children to operate the machine. Do not allow adults to operate the machine without proper instruction. Only trained operators who have read the Operator's Manual should operate the machine.

3. Never operate the machine when under the influence of drugs or alcohol.

4. Keep all shields, safety devices and decals in place. If a shield, safety device or decal is defective or damaged, repair or replace it before operating the machine. Also tighten any loose nuts. bolts or screws to ensure machine is in safe operating condition.

5. Always wear substantial shoes. Do not operate machine while wearing sandals, tennis shoes, sneakers .or when barefoot. Do not wear lose fitting clothing that could get caught in moving parts and possibly cause personal injury. Wearing safety glasses, safety shoes, long pants and a helmet is advisable and required by some local ordinances and insurance regulations.

6. Assure interlock switches are adjusted correctly so engine cannot be started unless traction pedal is in NEUTRAL and cutting units are DISENGAGED.

7. Remove all debris or other objects that might be picked up and thrown by the reels or fast moving components from other attached implements. Keep all bystanders away from operating area.

8. Since diesel fuel is highly flammable, handle it carefully:

A. Use an approved fuel container.

B. Do not remove fuel tank cap while engine is hot or running.

C. Do not smoke while handling fuel.

D. Fill fuel tank outdoors and only to within an inch of the top of the tank, not the filler neck. Do not overfill.

E. Wipe up any spilled fuel.

While Operating

9. Sit on the seat when starting and operating the machine.

10. Before starting the engine:

A. Engage the parking brake.

B. Make sure traction pedal is in NEUTRAL and the ENABLE / DISABLE switch is in DISABLE.

C. After engine is started, release parking brake and keep foot off traction pedal. Machine must not move. If movement is evident, the neutral return mechanism is adjusted incorrectly; therefor, shut engine off and adjust until machine does not move when traction pedal is released.

11. Seating capacity is one person. Therefore, never carry passengers.

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

13. Check interlock switches daily for proper operation. If a switch fails, replace it before operation the machine. The interlock system is for your protection, so do not bypass it. Replace all interlock switches every two years.

14. Using the machine demands attention. To prevent loss of control:

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

B. Drive slowly.

C. Watch for holes or other hidden hazards.

D. Look behind machine before backing up.

E. Do not drive close to a sand trap, ditch, creek or other hazard.

F. Reduce speed when making sharp turns and turning on a hillside.

G. Avoid sudden stops and starts.

15. Traverse slopes carefully. Do not start or stop suddenly when traveling uphill.

16. Operator must be skilled and trained in how to drive on hillsides. Failure to use caution on slopes or hills may cause loss of control and vehicle to tip or roll possibly resulting in personal injury or death. On 4 wheel drive models, always use the seat belt and ROPS together.

17. If engine stalls or looses headway and cannot make it to the top of a slope, do not turn machine around. Always back slowly straight down the slope.

18. DON'T TAKE AN INJURY RISK! When a person or pet appears unexpectedly in or near the mowing area, STOP MOWING. Careless operation, combined with terrain angles, ricochets, or improperly positioned guards can lead to thrown object injuries. Do not resume mowing until area is cleared.

19. Do not touch engine, muffler or exhaust pipe while engine is running or soon after is stopped. These areas could be hot enough to cause burns.

20. If cutting unit strikes a solid object or vibrates abnormally, stop immediately, turn engine off, set parking brake and wait for all motion to stop. Inspect for damage. If reel or bedknife is damaged, repair or replace it before operating. Do not attempt to free blocked cutting unit by reversing its reel direction. Damage to the reel may result.

21. Before getting off the seat:

A. Move traction pedal to neutral.

B. Set parking brake.

C. Disengage cutting units and wait for reels to stop.

D. Stop engine and remove key from switch.

E. Do not park on slopes unless wheels are chocked or blocked.

While Doing Maintenance, Troubleshooting, Testing, Adjustments or Repairs

22. Before servicing or making adjustments, stop the engine and remove the key from the ignition switch.

23. Make sure machine is in safe operating condition by keeping all nuts, bolts and screws tight.

24. Frequently inspect all hydraulic line connectors and fittings. Make sure all hydraulic hoses and lines are in good condition before applying pressure to the system.

25. Keep body and hands away from pin hole leaks or nozzles that eject high pressure hydraulic fluid. Use cardboard or paper to find hydraulic leaks. Hydraulic fluid escaping under pressure can penetrate the skin and cause injury. Fluid accidentally injected into the skin must be surgically removed within a few hours by a doctor or gangrene may occur.

26. Before disconnecting, or performing any work on the hydraulic system, lower the cutting units to the ground and stop the engine so all pressure is relieved.

27. 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 your TORO Distributor.

28. To reduce potential fire hazard, keep engine area free of excessive grease, grass, leaves and dirt. Clean protective screen on front of engine frequently. Do not use flammable solvents for cleaning parts. Do not use diesel fuel, kerosene or gasoline.

29. 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 cutting units and other moving parts.

30. Do not overspeed the engine by changing governor setting.

31. Shut engine off before checking or adding oil to the engine crankcase.

32. Disconnect the cables from the battery before servicing the machine. If battery voltage is required for troubleshooting or test procedures, temporarily connect the battery.

33. Do not charge a frozen battery because it can explode and cause injury. Let the battery warm to 60^{o} F (15.5^{o} 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.

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

35. Failure to follow proper procedures when mounting a tire on a wheel or rim can produce an explosion which may result in serious injury. Do not attempt to mount a tire unless you have the proper equipment and experience to perform the job. Have it done by your Toro Distributor or a qualified tire service.

36. When changing attachments or performing other service, use the correct blocks and hoists. Always use jackstands to safely support the machine when it is raised by a jack or hoist.

37. Do not use your hand to prevent cutting unit reel from turning while servicing; this can result in personal injury. Use a 1-1/2 in. thick x 4 in. wide x 8 in. long piece of hardwood inserted into front of cutting unit between reel blades.

38. For optimum performance and safety, use genuine Toro replacement parts and accessories. Replacement parts and accessories made by other manufacturers may result in non-conformance with the safety standards, and the warranty may be voided.

Chapter 2

Product Records and Manuals

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Product Records

Record information about your Reelmaster 5300-D on the OPERATION AND SERVICE HISTORY REPORT form. Use this information when referring to your machine.

Insert Operator's Manuals and Parts Manuals for your Reelmaster 5300-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**		

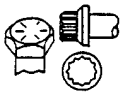
U.S to Metric Conversions

	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^{o} 2. Multiply by 5/9

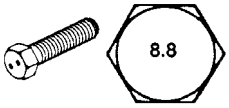
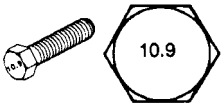
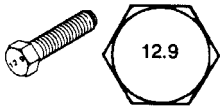
Torque Specifications

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

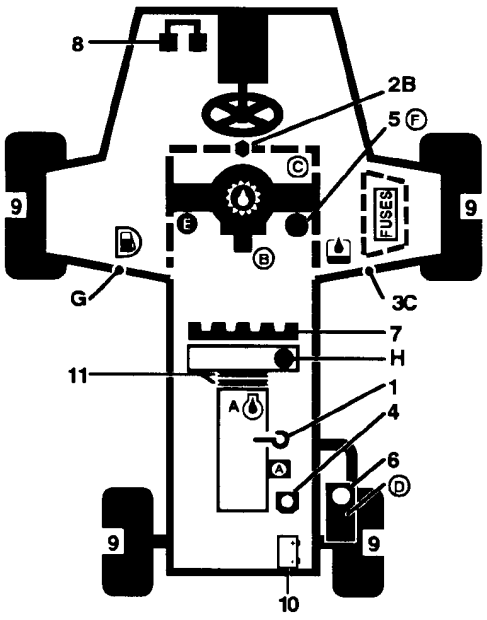
SAE Grade Number	5				8			
Capscrew Head Markings								
Capscrew Body Size	Capscrew Torque - Grade 5				Capscrew Torque - Grade 8			
	Cast Iron		Aluminum		Cast Iron		Aluminum	
	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm	ft-lb	Nm
1/4-20	7	9	6	8	11	15	9	12
-28	9	12	7	9	13	18	10	14
5/16-18	15	20	12	16	22	30	18	24
-24	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 mm	Capscrew Torque - Class 8.8				Capscrew Torque - Class 10.9				Capscrew Torque - Class 12.9			
	Cast Iron		Aluminum		Cast Iron		Aluminum		Cast Iron		Aluminum	
	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

Maintenance Interval Chart

REELMASTER 5100-D/5300-D
QUICK REFERENCE AID



CHECK/SERVICE (daily)

1. OIL LEVEL, ENGINE
2. OIL LEVEL, TRANSMISSION
3. OIL LEVEL, HYDRAULIC TANK
4. COOLANT LEVEL, RADIATOR
5. FUEL /WATER SEPARATOR
6. PRECLEANER – AIR CLEANER
7. RADIATOR SCREEN
8. BRAKE FUNCTION
9. TIRE PRESSURE
10. BATTERY
11. BELTS (FAN, ALT.)

GREASING – SEE OPERATOR'S MANUAL

FLUID SPECIFICATIONS/CHANGE INTERVALS

SEE OPERATOR'S MANUAL FOR INITIAL CHANGES.	FLUID TYPE	CAPACITY	CHANGE INTERVAL		FILTER PART NO.
			FLUID	FILTER	
A. ENGINE OIL	SAE 10W-30CD	3.9 QTS. † 4.0 QTS. ††	50 HRS.	100 HRS.	67-4330 † 93-4295 ††
B. TRANSMISSION OIL	MOBIL 424	5 QTS.*	800 HRS.	800 HRS.	75-1330
C. HYD. CIRCUIT OIL	MOBIL 424	8.5 GALS.*	800 HRS.	SEE INDICATOR	75-1310
D. AIR CLEANER				400 HRS.	27-7110
E. FUEL PUMP				400 HRS.	43-2550
F. WATER SEPARATOR				400 HRS.	63-8300
G. FUEL TANK	NO. 2-Diesel	10 GALS.	Drain and flush, 2 yrs.		
H. COOLANT	50/50 Ethylene glycol/water	7 QTS. † 9.6 QTS. ††	Drain and flush, 2 yrs.		

* INCLUDING FILTER

† REELMASTER 5100-D
†† REELMASTER 5300-D

93-3601

EQUIPMENT OPERATION AND SERVICE HISTORY REPORT
for
REELMASTER® 223-D, 5100-D, AND 5300-D

TORO 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.

REELMASTER® 223-D, 5100-D, and 5300-D Maintenance Schedule

Minimum Recommended Maintenance Intervals:

Maintenance Procedure	Maintenance Interval & Service				
	Every 50hrs	Every 100hrs	Every 200hrs	Every 400hrs	Every 800hrs
Check Battery Fluid Level Check Battery Cable Connections Lubricate All Grease Fittings Change Engine Oil Inspect Air Filter, Dust Cup, and Baffle	*A Level Service*				
† Check Fan and Altenator Belt Tension ‡ Replace Engine Oil Filter Inspect Cooling System Hoses		*B Level Service*			
Drain Moisture-Hyd. Tank Drain Moisture-Fuel Tank Check Reel Bearing Preload Adjustment † Torque Wheel Lug Nuts			*C Level*		
Service Air Filter Replace Electric Fuel Pump Filter Replace Fuel/WaterSeparator Filter Inspect Traction Linkage Movement ‡ Torque Head and Adjust Valves ‡ Check Engine RPM (idle and full throttle)				*D Level*	
Change Hydraulic Fluid Change Transmission Fluid † Replace Transmission Filter Check Rear Wheel Toe-in Rear Axle Service - pack Rear Wheel Bearings (2WD) - change Rear Axle Lubricant (4WD)					*E Level Service*

† Initial break in at 10 hours

‡ Initial break in at 50 hours

Replace Moving Hoses
Replace Safety Switches
Coolant System - Flush/Replace Fluid
Fuel Tank - Drain/Flush
Hydraulic Tank - Drain/Flush

Annual Recommendations:
Items listed are recommended every 1600 hours or 2 years whichever occurs first.

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

REELMASTER® 223-D, 5100-D and 5300-D 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							
✓ Brake Operation							
✓ Engine Oil & Fuel Level							
✓ Cooling System Fluid Level							
Drain Water/Fuel Separator							
✓ Air Filter/Pre-Cleaner Condition							
✓ Radiator & Screen for Debris							
✓ Unusual Engine Noises[1]							
✓ Unusual Operating Noises							
✓ Transmission Oil Level							
✓ Hydraulic System Oil Level							
✓ Hydraulic Filter Indicator[2]							
✓ Hydraulic Hoses for Damage							
✓ Fluid Leaks							
✓ Tire Pressure							
✓ Instrument Operation							
✓ Reel-to-Bedknife Adjustment							
✓ Height-of-Cut Adjustment							
✓ Cutting Units Shear Pin							
Lubricate All Grease Fittings[3]							
Touch-up damaged paint							

[1] = Check glow plugs and injector nozzles, if hard starting, excess smoke, or rough running is noted.

[2] = Check with engine running and oil at operating temperature.

[3] = Immediately after every washing, regardless of the interval listed.

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)

REELMASTER® 223-D, 5100-D, and 5300-D Supervisor Maintenance Work Order Date:_____

(duplicate this page for routine use)

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

Remarks:

A -Service (every 50 hours)

- ☐ Check Battery Fluid Level
- ☐ Check Battery Cable Connections
- ☐ Lubricate All Grease Fittings
- ☐ Change Engine Oil
- ☐ Inspect Air Filter, Dust Cup, and Baffle
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____

B -Service (every 100 hours)

- ☐ Check Fan and Altenator Belt Tension
- ☐ Replace Engine Oil Filter
- ☐ Inspect Cooling System Hoses
- ☐ **A-Service** required
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____

C -Service (every 200 hours)

- ☐ Drain Moisture-Hyd. Tank
- ☐ Drain Moisture-Fuel Tank
- ☐ Check Reel Bearing Preload
- ☐ Torque Wheel Lug Nuts
- ☐ **A** and **B Service** required
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____

D -Service (every 400 hours)

- ☐ Service Air Filter
- ☐ Replace Electric Fuel Pump Filter
- ☐ Replace Fuel/WaterSeparator Filter
- ☐ Inspect Traction Linkage Movement
- ☐ Torque Head and Adjust Valves
- ☐ Check Engine RPM (idle and full throttle)
- ☐ **A**, **B**, and **C Service** required
- ☐ _____
- ☐ _____

E -Service (every 800 hours)

- ☐ Change Hydraulic Fluid
- ☐ Change Transmission Fluid
- ☐ Replace Transmission Filter
- ☐ Check Rear Wheel Toe-in
- ☐ Pack Rear Wheel Brgs/Change 4WD Oil
- ☐ **A**, **B**, **C**, and **D Service** required
- ☐ _____
- ☐ _____
- ☐ _____

Other - Annual Service and Specials

- ☐ Replace Moving Hoses
- ☐ Replace Safety Switches
- ☐ Coolant System - Flush/Replace Fluid
- ☐ Fuel Tank - Drain/Flush
- ☐ Hydraulic Tank - Drain/Flush
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____

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

Chapter 3

Engine

Table of Contents

Introduction

This chapter gives information about specifications, maintenance, troubleshooting, testing and repair of the diesel engine used in the Reelmaster® 5300-D mower.

Most repairs and adjustments require tools which are commonly available in many service shops. Special tools are described in the Special Tools section. 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.

The engine used in the Reelmaster® 5300-D mower is manufactured by Mitsubishi Heavy Industries Limited. Service and repair parts for Mitsubishi engines are supplied through TORO Distributors. 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.

Specifications

Item	Specification
Make/Designation	Mitsubishi S3L2, 4 cycle, liquid cooled, vertical overhead valve diesel
Combustion Chamber	Swirl chamber type
Number of Cylinders	3
Bore x Stroke	78 x 92 mm
Total Displacement	1.318 Liter
Compression Ratio	3:1
Firing Order	1 - 3 - 2
Dry Weight (approximate)	125 kg (276 lb.)
Fuel	Diesel
Fuel Injection Pump	Bosch type ND-PFR-NC
Governor	Mechanical centrifugal weight type
Fuel Injector Nozzle	Nippon Denso 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	4.1 Liter (3.9 qt.)
Cooling System	Forced circulation, water cooling
Water Pump	Centrifugal type
Cooling System Capacity Total System (approximate)	10.1 Lliter (9.6 qt.)
Starter	Solenoid shift type 1.6 kW (12 volt)
Alternator	AC type 12 volt 50A
Glow Plug	Quick heat sheathed type

Special Tools

Order special tools from *TORO SPECIAL TOOLS AND APPLICATIONS GUIDE (Commercial Products)*. Some tools may be available from a local supplier.

Filter Cleaner

Filter cleaner (Fig. 1). Mix with water and use solution to wash the Donaldson air cleaner element.

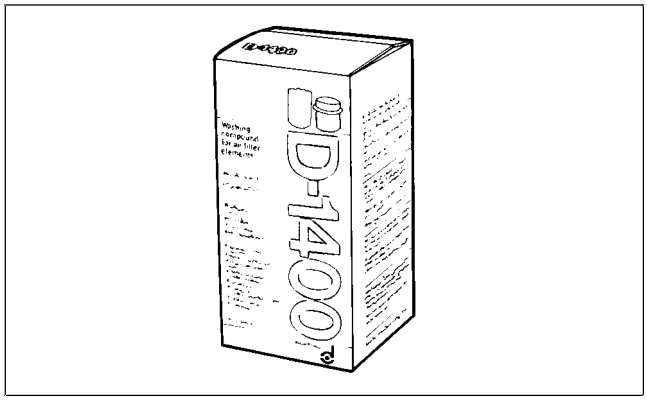


Figure 1

Diesel Engine Compression Test Kit

Diesel engine compression test kit (Fig. 2). 0-1000 PSI Gauge allows testing of diesel engines to check general operating condition of engine. Includes case, gauge with hose, glow plug hole adapters and instructions.

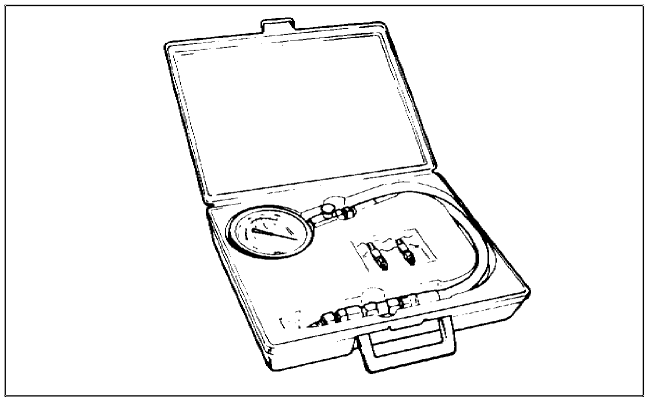


Figure 2

Piston Pin Tool

Piston pin tool (Fig. 3) is used to remove and install the wrist pin without distorting the piston. Includes an adapter for use with Mitsubishi and most other engines.

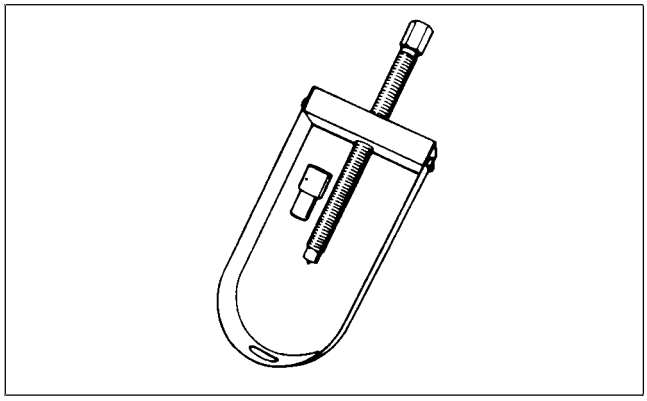


Figure 3

Nozzle Tester

Nozzle tester (Fig. 4). Tests condition and opening pressure of fuel injector nozzles.

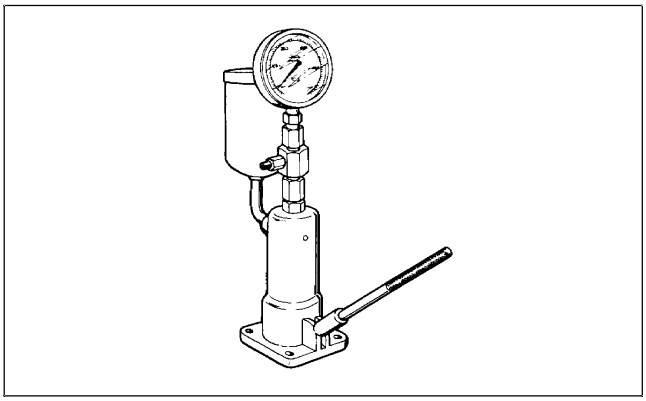


Figure 4

Nozzle Tester Adapter

Nozzle tester adapter (Fig.5) is required to test the fuel injection nozzles.

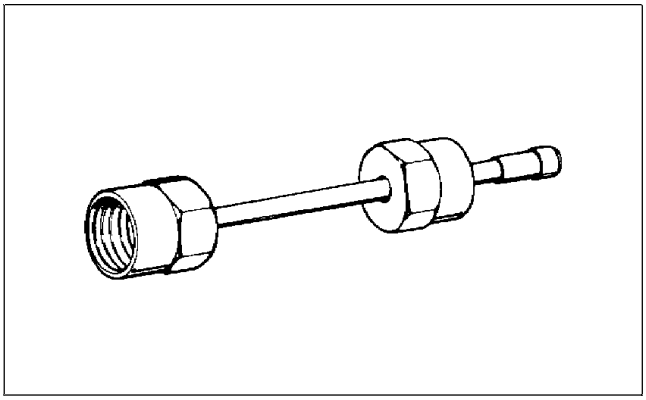


Figure 5

Adjustments

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.

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

Idle Speed (no load):	$1700\ ^{+50}_{-0}$ rpm
Maximum engine speed (no load):	$3200\ ^{+50}_{-0}$ rpm

See Engine Service Manual for Engine Speed Adjustment procedure.

Throttle Linkage Adjustment

1. Push the throttle lever forward until it stops against the slot in the seat base (Fig. 6).

2. Loosen the throttle cable connector on the lever arm at the injection pump (Fig. 7).

3. Hold the injection pump lever arm against the high idle stop and tighten the cable connector.

NOTE: When tightened, the cable connector must be free to swivel.

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

5. Tighten locknut on throttle lever pivot to 40 - 55 in-lb (Fig. 6). The maximum force required to operate the throttle lever should be 20 lb.

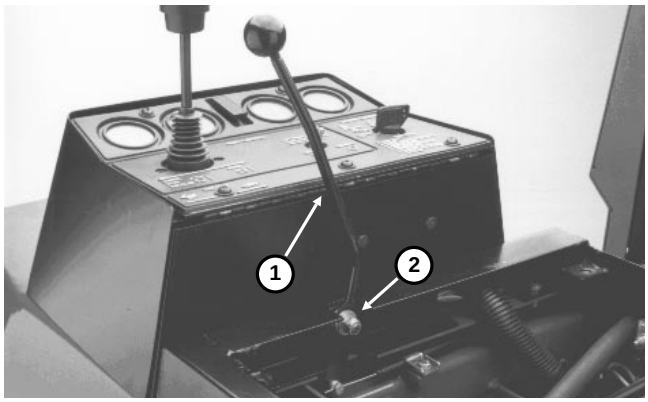


Figure 6

1. Throttle lever **2. Locknut**

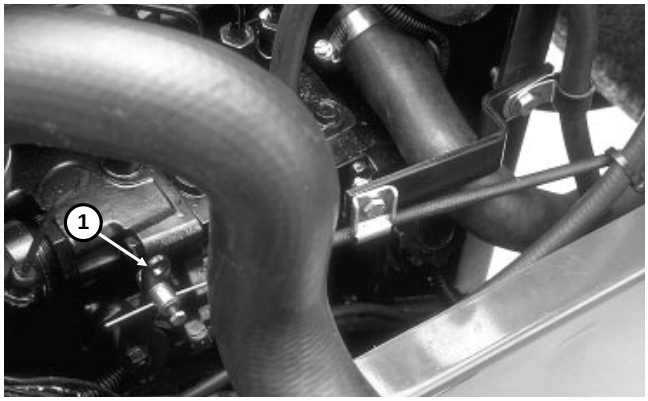


Figure 7

1. Injection pump lever arm

Fan Belt and Alternator Belt Replacement

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

2. Loosen locknut on belt tensioner lever (Fig. 8). If replacing alternator belt, loosen bolt securing alternator brace to engine and bolt securing alternator to brace (Fig. 9).

3. Remove three capscrews securing transmission drive shaft coupler to engine crankshaft pulley (Fig. 10). Do not disconnect drive shaft from transmission.

4. Move drive shaft out of the way so the belt(s) can be removed.

5. Install new belt(s).

6. Connect drive shaft coupler to engine crankshaft pulley with two capscrews and lockwashers.

7. Adjust belt tension:

Alternator belt: Insert pry bar between alternator and engine and carefully pry alternator out until proper tension is achieved. Belt should deflect 3/8 to 1/2 in. when 22 lb. of force is applied to belt midway between crankshaft pulley and alternator pulley. Tighten alternator and brace bolts to secure adjustment.

Cooling fan belt: Apply 5 - 10 lb. of force at end of lever. Tighten lock nut to secure adjustment.

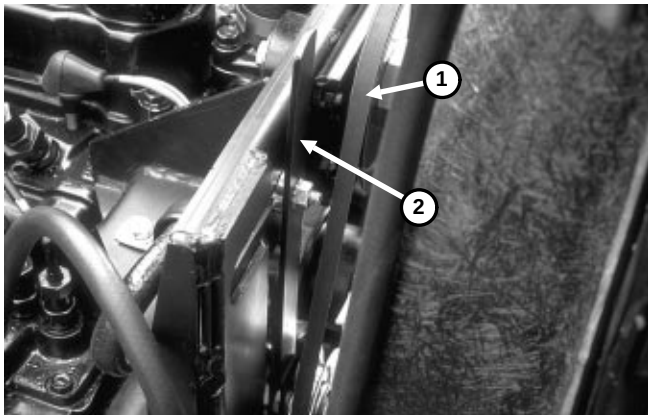


Figure 8

1. Fan belt **2. Tensioner lever**

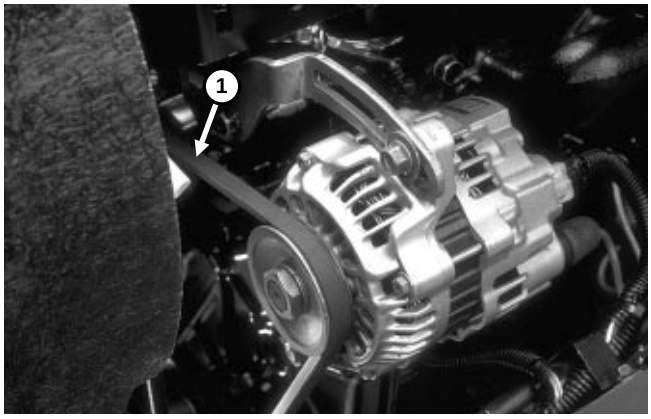


Figure 9

1. Alternator belt

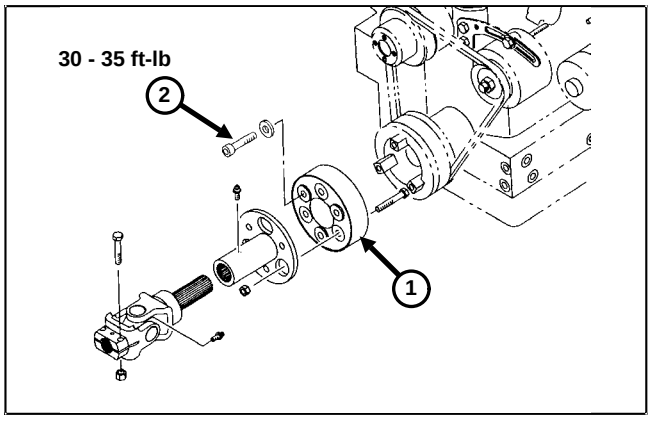


Figure 10

1. Drive shaft coupling **2. Capscrew & lockwasher (3)**

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. 11).

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. 12).

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).

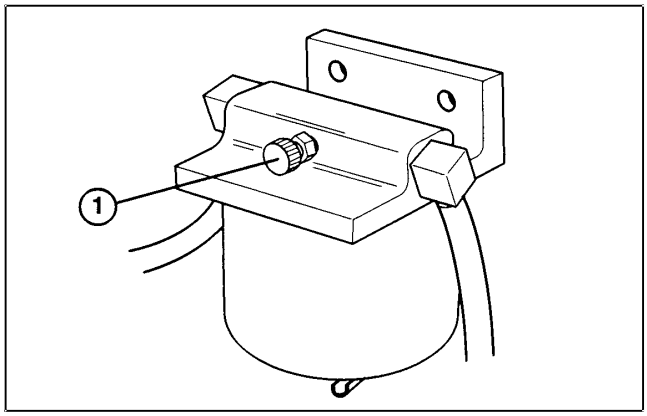


Figure 11

1. Bleed screw

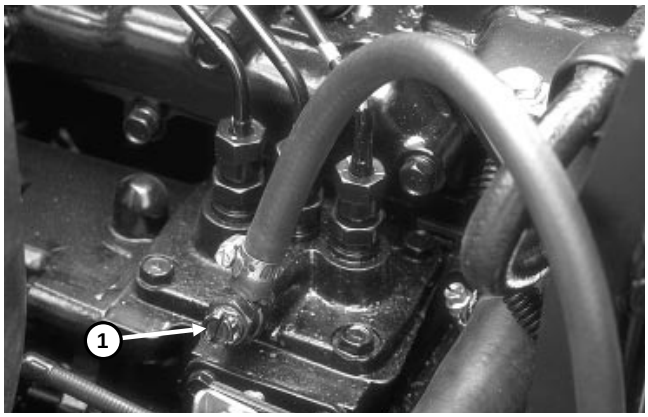


Figure 12

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. 13).

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.

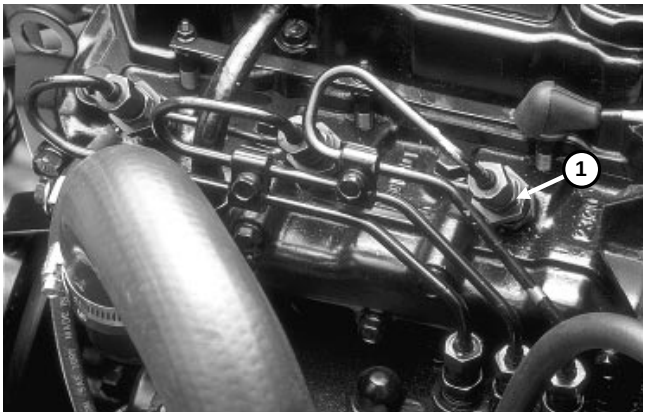


Figure 13

1. Fuel injector nozzle and holder (3)

Removing and Installing the Fuel Tank

1. Put machine on a level surface, lower the cutting units, stop the engine, engage the parking brakes and remove the key from the ignition switch.

2. Open drain fitting on bottom of fuel tank and drain fuel into a suitable container (Fig. 14).

3. Remove six capscrews securing the fender to the frame and remove the fender.

4. Disconnect fuel lines from fittings on top of fuel tank.

5. Disconnect electrical wire from fuel gauge sender.

6. Remove three capscrews, flat washers and lock-washers securing fuel tank to frame and remove fuel tank.

7. Reverse steps 2 - 6 to install the fuel tank and tank base. When installing the tank to the frame, tighten the screws to a torque of 30 - 60 in-lb (Fig. 15). Do not overtighten.

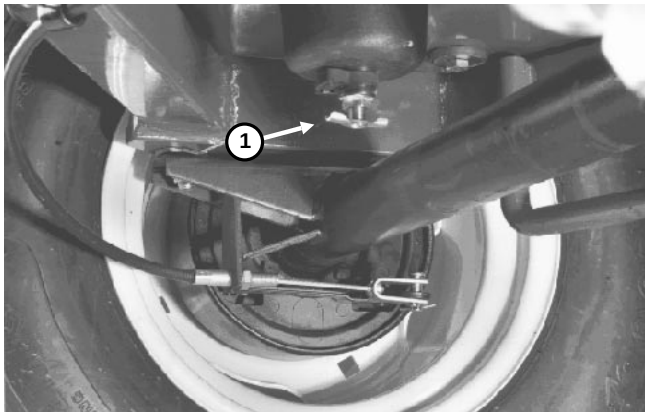


Figure 14

1. Fuel tank drain fitting

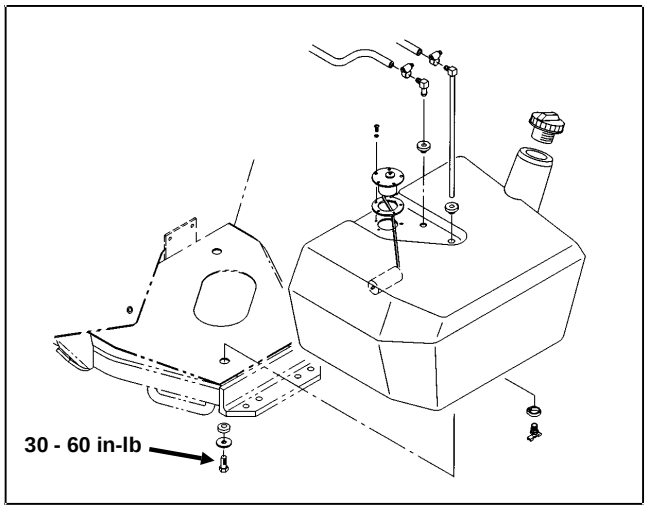


Figure 15

Replacing and/or Adjusting Engine Stop (ETR) 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 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. 16).

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. 17). 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 - 0.03 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. 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.

7. Connect the solenoid electrical connector.

8. Install the governor tie rod cover.

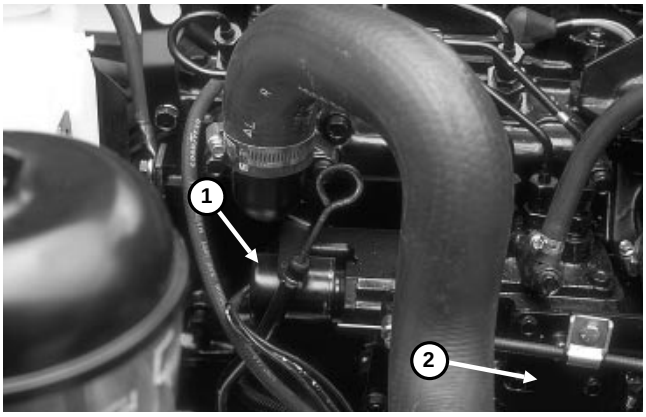


Figure 16

1. Fuel stop (ETR) solenoid
2. Governor tie rod cover

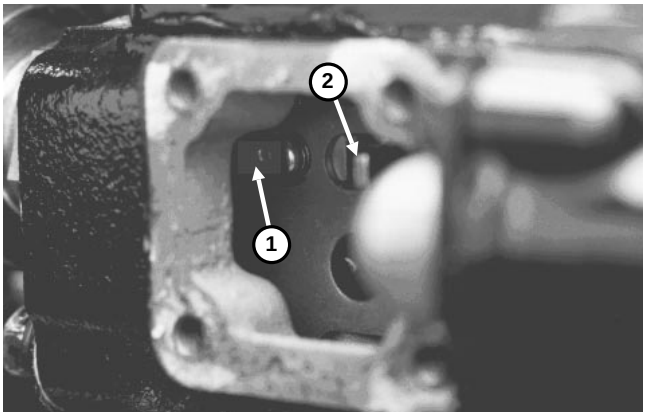


Figure 17

1. Solenoid plunger
2. Tie rod

Removing and Installing the Engine

Removing the Engine

Figure 18

1. Put machine on a level surface, lower the cutting units, stop the engine, engage the parking brakes and remove key from ignition switch. Allow engine and radiator to cool.

2. Open hood. Disconnect hood stop cable from frame. Lower hood. Remove left and right hinge plates. Lift hood off chassis.

3. Disconnect positive (+) and negative (–) battery cables from battery. Loosen battery securing bolt and remove battery.

4. Remove rear lift arm down pressure springs (see Chapter 8 - Cutting Units).

5. Open radiator cap. Put a drain pan under left side of radiator. Open radiator drain valve and allow coolant to drain into drain pan.

CAUTION

DO NOT open radiator cap or drain coolant if 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.

6. Loosen hose clamps and disconnect upper and lower radiator hoses from engine and radiator. Lift coolant expansion tank off of bracket.

7. Remove plug from right side cylinder block to drain coolant from engine.

8. Loosen hose clamps and disconnect air intake hose from engine and air cleaner.

9. Remove muffler. Keep muffler bracket on engine.

10. Loosen hose clamp and remove fuel hose from injector pump. Plug end of fuel line to prevent fuel leakage. Loosen hose clamp and remove fuel return hose from rear fuel injector on engine.

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

Alternator
Starter motor and solenoid
Ground cables
Oil pressure switch
Temperature gauge sender
Thermoswitch
Engine stop solenoid
Glow indicator

12. Remove two (2) capscrews and lockwashers to disconnect drive shaft coupler from engine crankshaft pulley.

13. Remove four (4) capscrews, washers and locknuts to remove fan shroud from radiator.

14. Loosen cap screw and nut to disconnect throttle cable from governor lever on engine. Loosen clamp and remove throttle cable and from fan bracket.

15. Remove locknut, flat washer, bolt and rebound washer securing engine to each of four (4) rubber engine mounts.

16. Attach a short section of chain between lifting holes in fan bracket and muffler bracket. Connect hoist or block and tackle chain at center of short section of chain. One person should operate hoist or block and tackle and the other person should help guide engine out of chassis. Remove engine from chassis. Be careful when removing engine to prevent damage to engine, radiator, fan or other parts. Mount engine in an engine rebuilding stand.

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

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 engine with the correct oil. Fill the cooling system with a 50/50 solution of ethylene glycol antifreeze and clean, soft water. Check for oil and coolant leaks and repair as necessary.

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

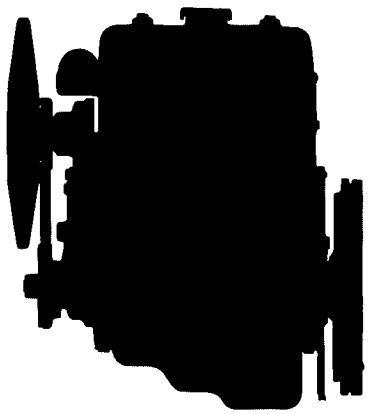
MITSUBISHI DIESEL ENGINES

SERVICE MANUAL

SL-SERIES

SWIRL CHAMBER TYPE

S3L,S3L2
S4L,S4L2



Jan. '94

Quality makes the Difference

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INTRODUCTION

This service manual has instructions and procedures for the subject on the front cover.

The information, specifications and illustrations in this manual are on the basis of the information that was current at the time this issue was written.

Correct servicing, test and repair procedures will give the engine a long service life. Before starting a test, repair or rebuild job, the serviceman must read the respective sections of this manual to know all the components he will work on.

Continuing improvement of product design may have caused changes to your engine which are not included in this manual.

Whenever a question arises regarding your engine, or this manual, consult your Mitsubishi dealer for the latest available information.

HOW TO USE THIS MANUAL

1. Exploded views

   In the exploded views, the component parts are separated but so arranged to show their relationship to the whole. Index numbering is used to identify the parts and to indicate a sequence in which the parts are to be removed for disassembly, or they are to be installed for assembly.

2. Symbols

   The following symbols are used in this manual to emphasize important and critical instructions:

   NOTE ..... Indicates a condition that is essential to highlight.

   CAUTION ..... Indicates a condition that can cause engine damage.

   WARNING ..... Indicates a condition that can cause personal injury or death.

3. Definition of locational terms

   The fan end is "front" and the flywheel end is "rear." The words "left" and "right" are as these directions would appear from the flywheel end.

4. Dimensional or specification terms

   Nominal size ..... Is the named size which has no specified limits of accuracy.

   Standard ..... Is the dimension of a part to be attained at the time of assembly, or the standard performance.

   Limit ..... Is the maximum or minimum permissible limit beyond which a part must be repaired or replaced.

5. Tightening torques

   Tighten bolts, nuts, etc. in a wet condition (apply oil to threads) when specified as [WET]. Tighten them in a dry condition unless so specified. Use the general torques unless otherwise specified.

INDEX

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GENERAL INFORMATION

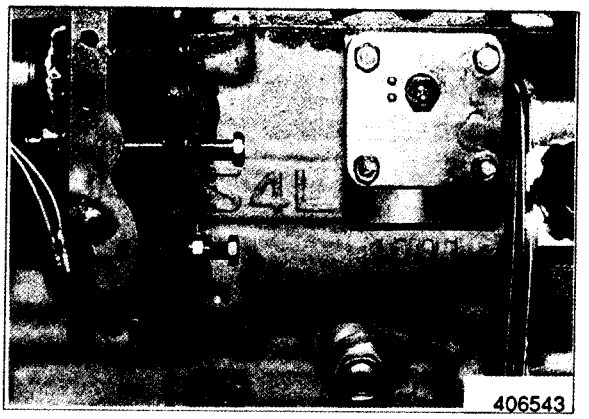
MODEL IDENTIFICATION AND SERIAL NUMBER LOCATION

1. Model identification location

(a) The model identification is embossed on the right side of the cylinder block, near the fuel injection pump mount.

(b) The model identifications and displacements of the engines in current production are as listed below:

	Displacement
S3L–61A	1.125 liters (68.7 cu in.)
S3L2–61A	1.318 liters (80.4 cu in.)
S4L–61A	1.500 liters (91.5 cu in.)
S4L2–61A	1.758 liters (107.3 cu in.)



Model identification location

(c) A scheme of coding used for identifying the engines in current production is as follows:

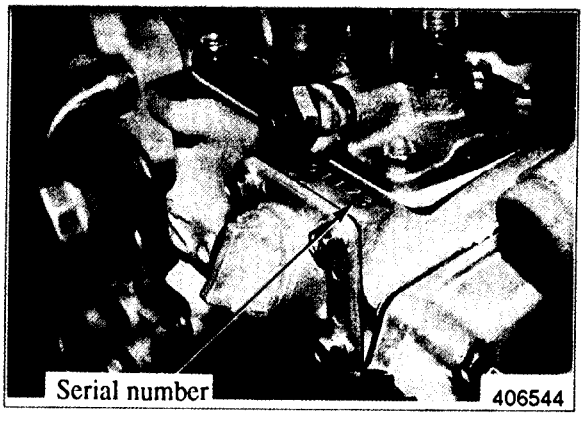
Example: Coded designation

S 4 L (2) – 61 A

- 61 A — Specification code
- (2) — Export code
- L — Stroke code (No code: 78.5 mm (3.09 in.), 2: 92 mm (3.62 in.)
- 4 — Series code [Bore: 78 mm (3.07 in.)]
- S — Number-of-cylinders code ["4" stands for four cylinders]
- Identification of "Sagamihara Machinery Works"

2. Serial Number Location

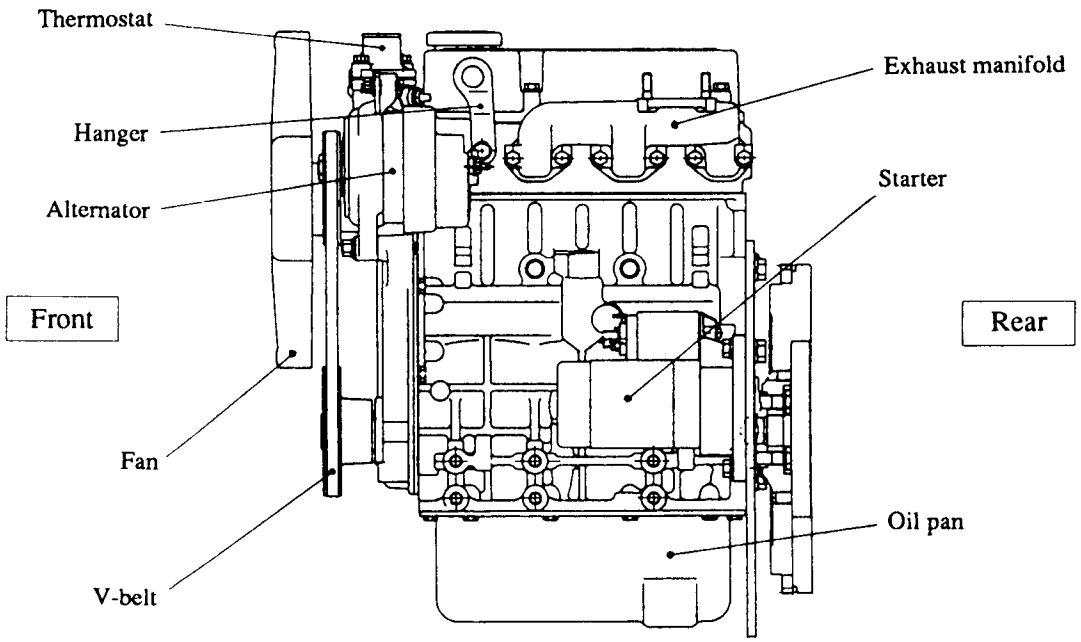
The serial number is punched on the cylinder block, near the fuel injection pump mount.



Serial number location

COMPONENT LOCATION

S3L/S3L2



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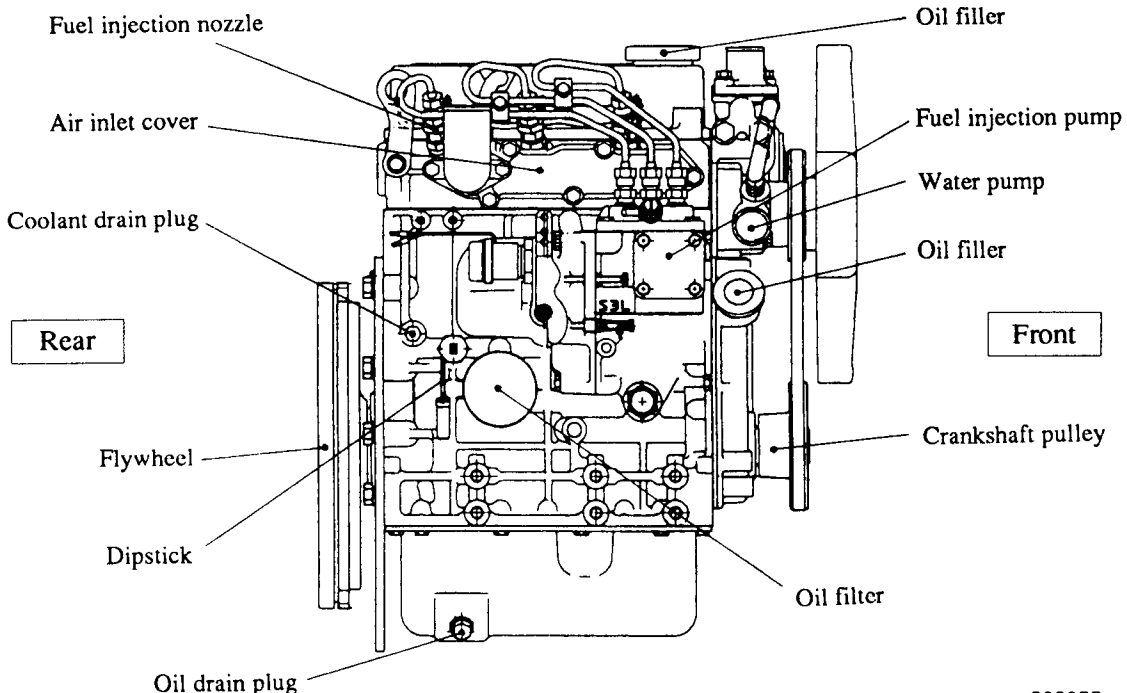
Left side



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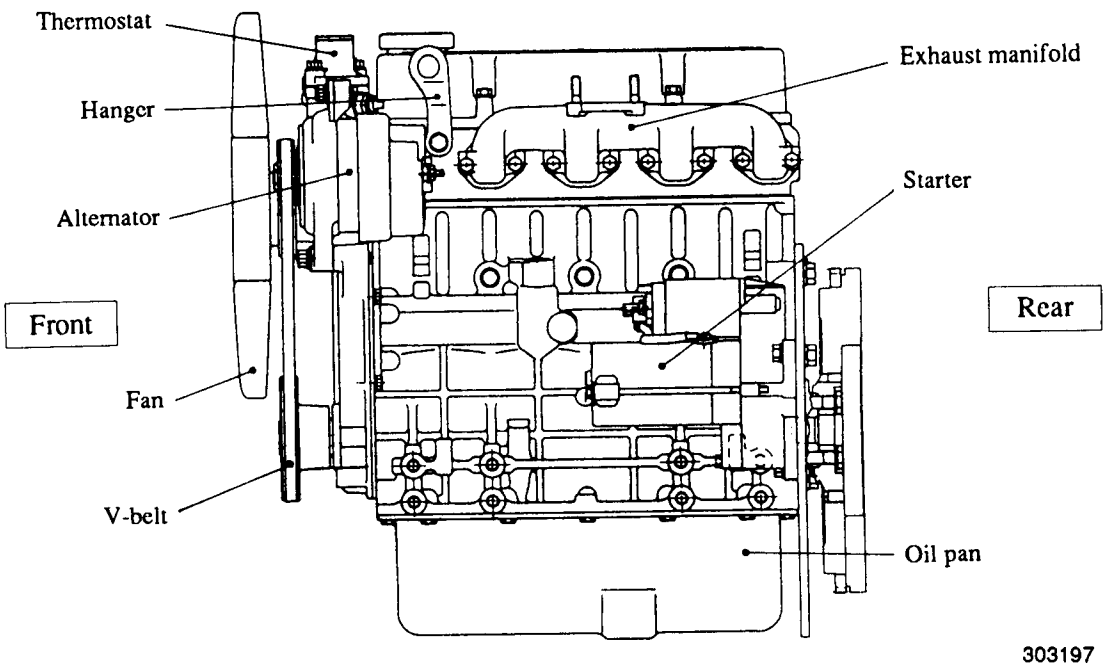
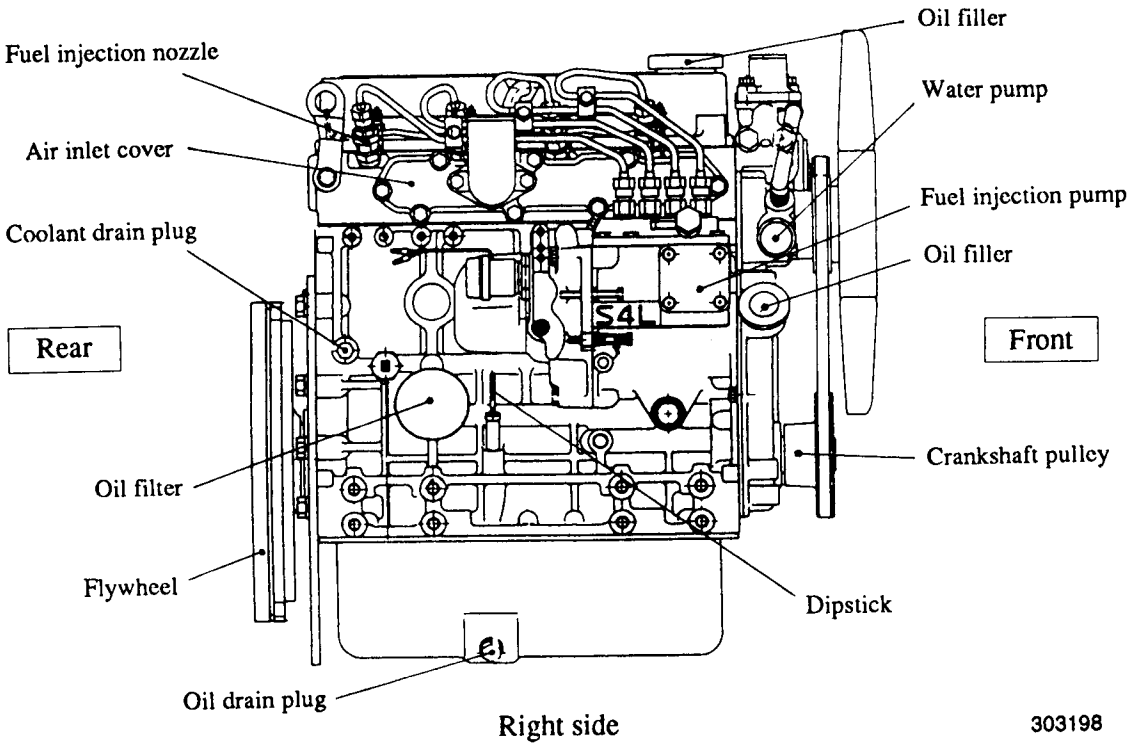
Right side

S4L/S4L2



Left side



Right side

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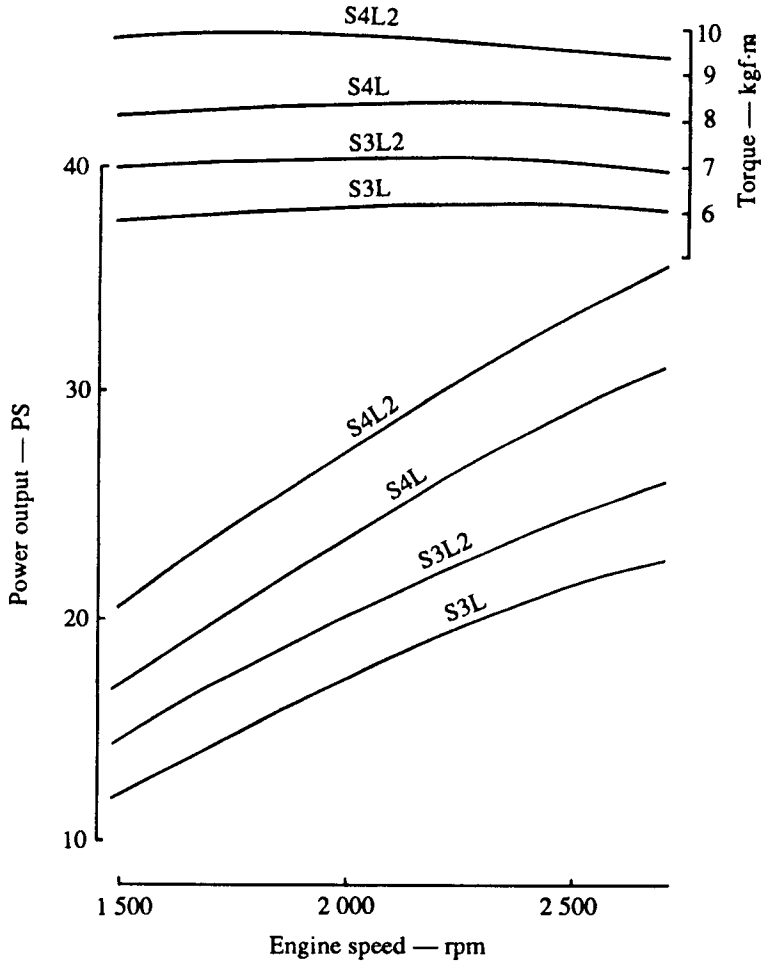
SPECIFICATIONS

Model		S3L–61A	S3L2–61A	S4L–61A	S4L2–61A
Type		Water-cooled, 4-stroke cycle, in-line diesel engine			
Firing order (injection sequence)		1 - 3 - 2		1 - 3 - 4 - 2	
Compression ratio		22			
Combustion chamber, type		Swirl			
Weight, kg (lb)		125 (276)		150 (331)	
No. of cylinders		3		4	
Bore x Stroke, mm (in.)		78 x 78.5 (3.07 x 3.09)	78 x 92 (3.07 x 3.62)	78 x 78.5 (3.07 x 3.09)	78 x 92 (3.07 x 3.62)
Displacement, liter (cu in.)		1.125 (68.7)	1.318 (80.4)	1.500 (91.5)	1.758 (107.3)
Fuel system	Injection pump, type	Bosch M			
	Injection nozzle, type	Throttle			
	Governor, type	Centrifugal flyweight			
	Fuel	ASTM No. 2-D			
Lubrication system	Type	Force feed (by trochoid pump)			
	Engine oil	API Service Classification CC			
	Oil filter	Paper-element (full-flow)			
	Capacity (high level excl. 0.5 liter (0.13 U.S. gal) of oil in oil filter), liter (U.S. gal)	5.7 (1.5) (with deep oil pan) 3.7 (1.0) (with standard oil pan)		7.7 (2.0) (with deep oil pan) 5.4 (1.4) (with standard oil pan)	
Cooling system	Type	Forced cooling			
	Capacity (approximate), liter (U.S. gal)	1.8 (0.5)		2.5 (0.7)	
Starter, V – kW		12 – 1.6		12 – 2.0	
Alternator, V – A		12 – 50			

PERFORMANCE CURVES (ONE-HOUR RATING, WITH FAN)



PRIME POWER OUTPUT CHART

Unit: PS

Rating \ Engine model / RPM		S3L	S3L2	S4L	S4L2
		With fan	With fan	With fan	With fan
One-hour (no overload)	1 500	12.0	14.5	17.0	20.5
	1 800	15.0	18.0	21.0	25.0
	2 000	17.0	20.0	23.5	27.5
	2 200	19.0	22.0	26.0	30.0
	2 500	21.5	24.5	29.0	33.5
Continuous	1 500	11.4	13.8	16.2	19.5
	1 800	14.3	17.1	20.0	23.8
	2 000	16.2	19.0	22.3	26.1
	2 200	18.1	20.9	24.7	28.5
	2 500	20.4	23.3	27.6	31.8

OVERHAUL INSTRUCTIONS

DETERMINING WHEN TO OVERHAUL THE ENGINE

Generally, when to overhaul the engine is to be determined by taking into account a drop in compression pressure as well as an increase in lube oil consumption and excessive blowby gases.

Lower power or loss of power, an increase in fuel consumption, a drop in lube oil pressure, hard starting and excessive abnormal noise are also troubles. These troubles, however, are not always the result of low compression pressure and give no valid reason for overhauling the engine.

The engine develops troubles of widely different varieties when the compression pressure drops in it. Following are the typical troubles caused by the compression pressure failure:

(1) Low power or loss of power

(2) Increase in fuel consumption

(3) Increase in lube oil consumption

(4) Excessive blowby through breather due to worn cylinders, pistons, etc.

(5) Excessive blowby due to poor seating of worn inlet and exhaust valves

(6) Hard starting or failure to start

(7) Excessive engine noise

In most cases, these troubles occur concurrently. Some of them are directly caused by low compression pressure, but others are not. Among the troubles listed above, (2) and (6) are caused by a fuel injection pump improperly adjusted with respect to injection quantity or injection timing, worn injection pump plungers, faulty injection nozzles, or poor care of the battery, starter and alternator.

The trouble to be taken into account as the most valid reason for overhauling the engine is (4): in actually determining when to overhaul the engine, it is reasonable to take this trouble into account in conjunction with the other ones.

COMPRESSION PRESSURE MEASUREMENT

1. Inspection

Check to make sure —

(1) The crankcase oil level is correct, and the air cleaner, starter and battery are all in normal condition.

(2) The engine is at the normal operating temperature.

2. Measurement

(1) Move the control lever to a position for shutting off fuel supply.

(2) Remove all glow plugs from the engine. Install the compression gauge and adaptor (ST332270) combination to a cylinder on which the compression pressure is to be measured.

(3) Turn the engine with the starter and read the gauge pressure at the instant the gauge pointer comes to stop.

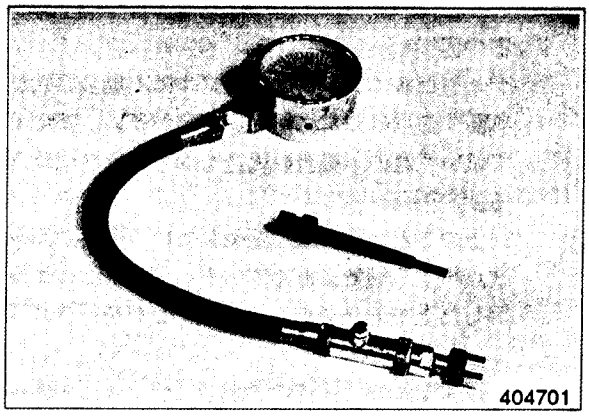
(4) If the gauge reading is below the limit, overhaul the engine.

⚠ CAUTION

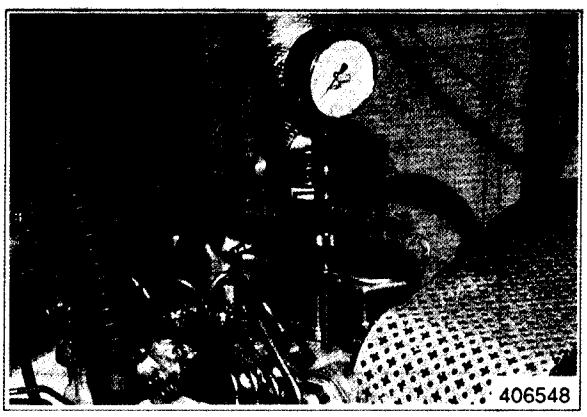
a) Be sure to measure the compression pressure on all cylinders.

b) The compression pressure varies with change of engine rpm. This makes it necessary to check engine rpm at the time of measuring the compression pressure.

Item	Standard		Limit
Engine speed, rpm	290		—
Compression pressure, kgf/cm² (psi) [kPa]	SL	30 (427) [2 942]	23 (327) [2 256]
	SL2	32 (455) [3 138]	25 (356) [2 452]
Maximum permissible difference between average compression pressure of all cylinders in one engine, kgf/cm² (psi) [kPa]	3 (42.7) [294]		—



Compression gauge and adaptor



Measuring compression pressure

⚠ CAUTION

a) It is important to measure the compression pressure at regular intervals to obtain the data on the gradual change of the compression pressure.

b) The compression pressure would be slightly higher than the standard in a new or overhauled engine owing to breaking-in of the piston rings, valve seats, etc. It drops as the engine components wear down.

TROUBLESHOOTING

1. General

The diagnosis of troubles, especially those caused by a faulty fuel injection pump or injection nozzles, or low compression pressure, can be difficult. It requires a careful inspection to determine not which item is the cause, but how may causes are contributing to the trouble, someone of which is the primary cause. Several causes may be contributing to a single trouble.

On the following pages, there are trouble-shooting charts on which engine troubles can be traced to their causes. Each chart has items to be verified ahead and suggested inspection procedure.

Diesel engines exhibit some marked characteristics during operation. Knowing these characteristics will help minimize time lost in tracing engine troubles to their source. Following are the characteristics of diesel engines you should know about for diagnosis:

- Combustion knock (diesel knock)
- Some black exhaust smoke (when the engine picks up load)
- Vibration (due to high compression pressure and high torque)
- Hunting (when the engine speed is quickly decreased)
- Some white exhaust smoke (when the engine is cold, or shortly after the engine has been started)

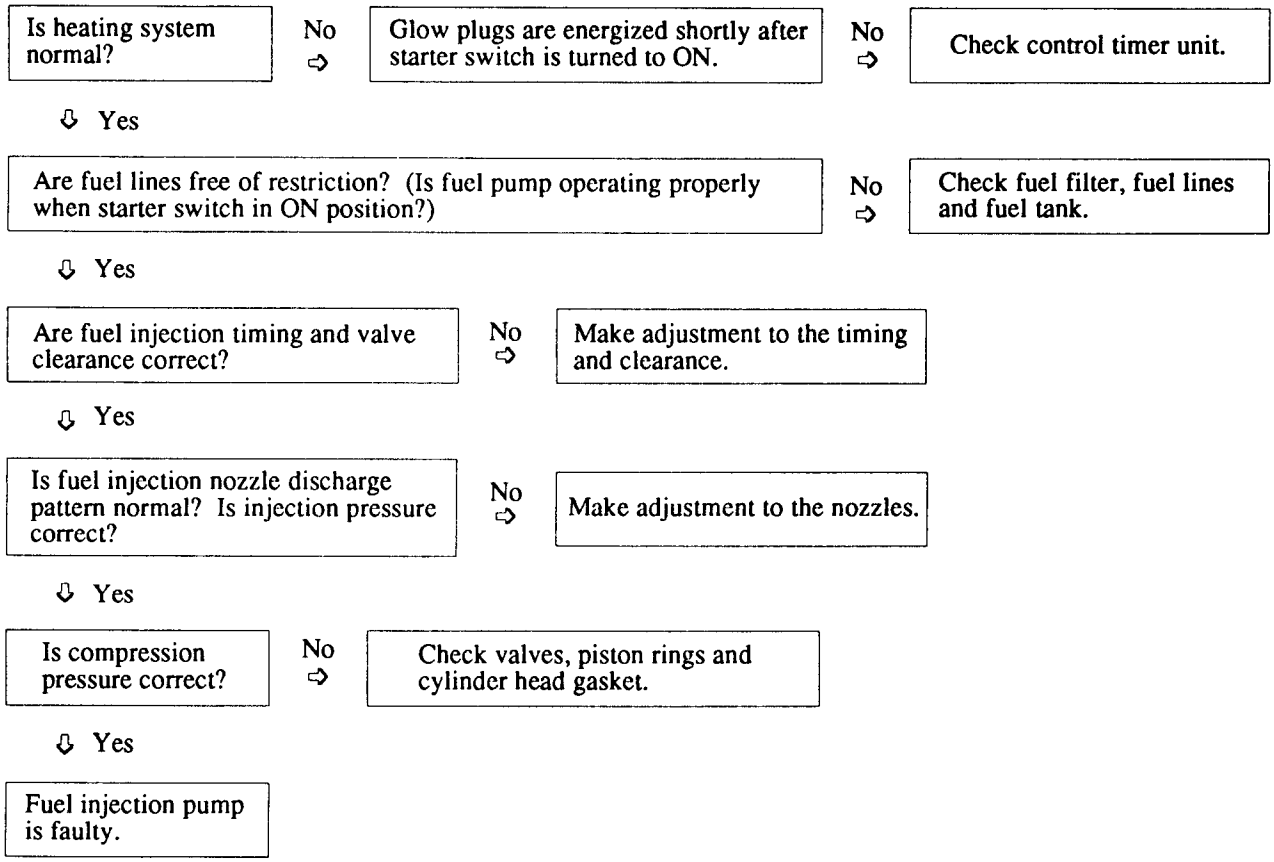
2. Engine troubleshooting

Problem 1: Hard starting

(1) Items to be checked for ahead

- Clogged air cleaner
- Wrong oil grade for weather conditions
- Poor quality fuel
- Low cranking speed

(2) Inspection procedure



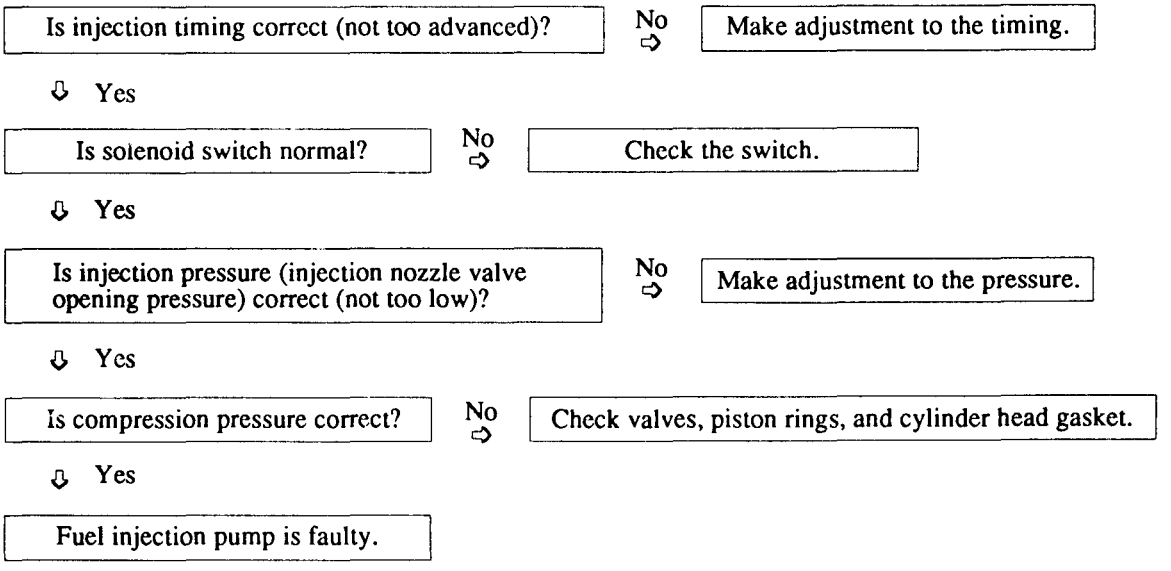
Problem 2: Fuel knock

More or less fuel knock occurs in diesel engines. This may be caused either by an excessively large delay period or by a too fast rate of fuel injection.

(1) Items to be checked for ahead

- Clogged air cleaner
- Poor quality fuel

(2) Inspection procedure



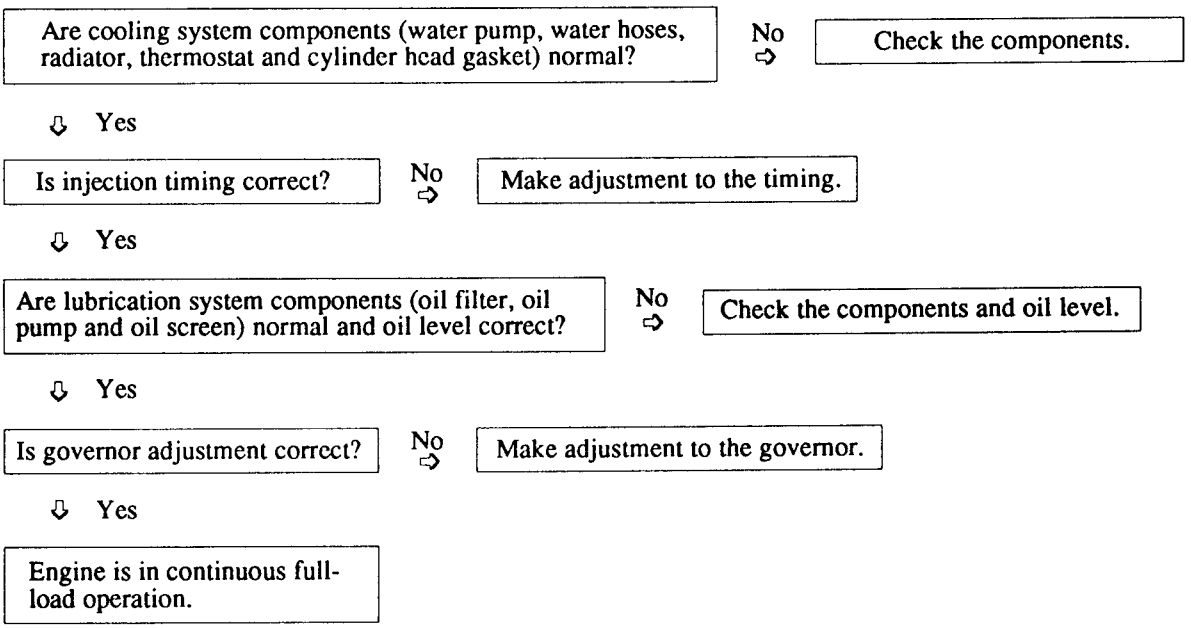
Problem 3: Overheating

(1) Items to be checked for ahead

Overheating might also be caused by abnormal operating conditions. If the engine is overheating but its cooling system is not contributing to this trouble, it is necessary to check the difference between the ambient temperature and coolant temperature when the engine is in normal operation (with the thermostat fully open). If the ambient temperature is higher than the normal coolant temperature by more than 60°C (108°C), investigate other items than those related to the engine cooling system.

- Insufficient coolant and exterior coolant leaks
- Loose fan belt
- Radiator core openings plugged with dirt

(2) Inspection procedure



Problem 4: Black exhaust smoke

(1) Items to be checked for ahead

- Clogged air cleaner
- Poor quality fuel

(2) Inspection procedure

Are valve clearance and injection timing correct? → No → Make adjustment to the clearance and timing.

↓ Yes

Is injection nozzle discharge pattern normal? Is injection pressure correct (not too high)? → No → Make adjustment to the nozzles.

↓ Yes

Is compression pressure correct? → No → Check valves, piston rings and cylinder head gasket.

↓ Yes

Fuel injection pump is faulty.

Problem 5: Erratic idle speeds

(1) Items to be checked for ahead

- Maladjusted engine control
- Wrong oil grade for weather conditions
- Poor quality fuel

(2) Inspection procedure

Are valve clearance and injection timing correct? → No → Make adjustment to the clearance and timing.

↓ Yes

Is injection nozzle discharge pattern normal? Is injection pressure constant? → No → Make adjustment to the nozzles.

↓ Yes

Is compression pressure correct (no difference in compression pressure between cylinders)? → No → Check valves, piston rings and cylinder head gasket.

↓ Yes

Fuel injection pump is faulty.

Problem 6: Low power or loss of power

(1) Items to be checked for ahead

- Stuck running parts
- Wrong oil grade for weather conditions
- Poor quality fuel
- Clogged air cleaner
- Restricted exhaust line
- Faulty power take-off

(2) Inspection procedure

Are valve clearance and injection timing correct? → No → Make adjustment to the clearance and timing.

↓ Yes

Are fuel lines free from restriction? (Is fuel pump operating properly when starter switch is in ON position?) → No → Check fuel tank, fuel filter and fuel lines.

↓ Yes

Is governor adjustment correct? → No → Make adjustment to the governor.

↓ Yes

Is injection nozzle discharge pattern normal? Is injection pressure correct? → No → Make adjustment to the nozzles.

↓ Yes

Is compression pressure correct? → No → Check valves, piston rings and cylinder head gaskets.

↓ Yes

Fuel injection pump is faulty.

3. Starting system troubleshooting

Burned starter

- Overruns at low speed → Make reference to "Overrun."
- Faulty starter motor
  - Burned contact points in switch → Burned motor coil or switch coil
  - Layer shorted or grounded field coil → Burned field coil
  - Layer shorted or grounded armature coil → Burned coil in armature
  - Mechanical problems
    - Misaligned armature
    - Machining fault of parts
    - Worn bearings

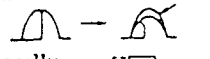
    → Burned motor coil (evidence of rubbing)
  - Pinion gap too large. → Switch will not turn off only when engine fails to fire, resulting in damage to motor.
- Prolonged cranking
  - Hard starting at low temperatures
    - Wrong starting system
    - High resistance in main circuit
    - Poor quality fuel
    - Mechanical problems in engine
    - Very low ambient temperature
  - Troubles in engine
  - No fuel

  → Burned motor coil
- Excessive load
  - Engine directly coupled to load
  - Reverse torque due to incorrect injection timing
  - Mechanical problems in engine
  - Starter abused (for moving equipment)

No cranking

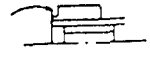
- Pinion fails to shift
  - Battery run-down
  - Loose battery terminals
  - Defective key switch
  - Poor S connector contact
  - S connector missing
  - Open circuit in engine switch coil
  - Worn starter brushes
  - Defective contact points in auxiliary switch
  - Open circuit in auxiliary switch coil
- Pinion shifts but will not spin
  - High resistance in S circuit → This trouble is likely to occur during heating
  - Voltage applied to starter too high
  - Contact points defective in starter switch
  - Pinion and ring gear improperly chamfered
- Pinion butts ring gear instead of meshing
  - Battery rating too high
  - Pinion chamfered insufficiently or wrong
  - Ring gear chamfered insufficiently or wrong
  - Ring gear end face badly worn (ring gear not hardened properly)
  - Pinion will not shift
    - Pinion metal jammed with dirt
    - Overrunning clutch jammed with foreign matter
    - Shift lever jammed
    - Solenoid switch plunger jammed
    - Shift lever broken
  - Contact points close too early
    - Shift lever spring weak
    - Pinion gap too large
    - Pinion shifted excessively
  - Pinion is forced into mesh with ring gear again when starter is coasting → Overrunning clutch shell peeled
  - Starter is turned on while engine is running → Pinion is chipped

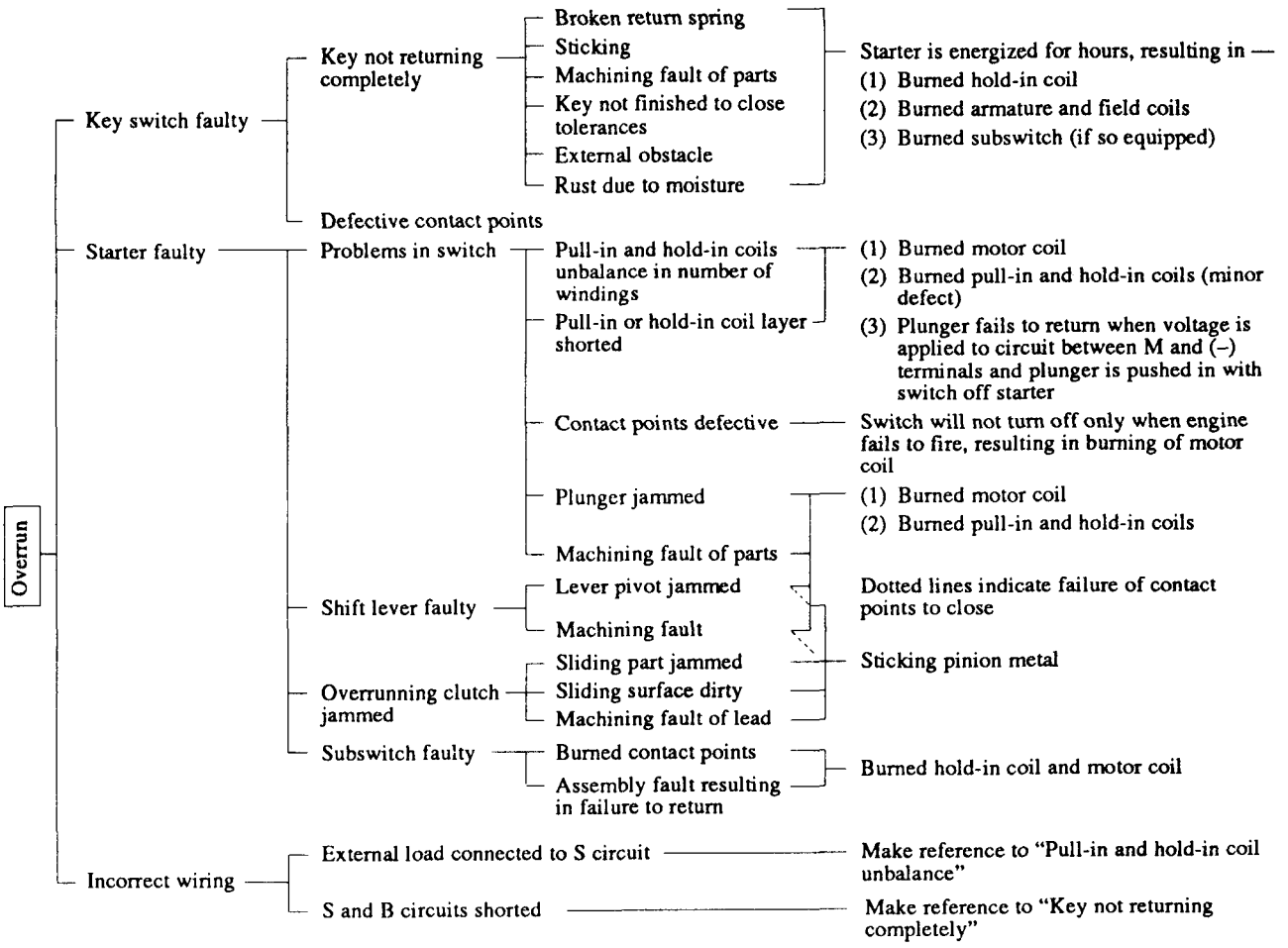
→ Pinion tooth worn round



→ Ring gear locally chipped

→ Four or five teeth chipped





[Other possibility is sticking pinion metal in case of overrun trouble.]

BASIC PRECAUTIONS FOR DISASSEMBLY AND ASSEMBLY

This section outlines basic precautions recommended by Mitsubishi that should always be observed.

1. Disassembly

(1) Always use tools that are in good condition and be sure you understand how to use them before performing any job.

(2) Use an overhaul stand or a work bench, if necessary. Also, use bins to keep engine parts in order of removal.

(3) Parts must be restored to their respective components from which they were removed at disassembly. This means that all parts must be set aside separately in groups, each marked for its component, so that the same combination or set can be reproduced at assembly.

(4) Pay attention to marks on assemblies, components and parts for their positions or directions. Put on marks, if necessary, to aid assembly.

(5) Carefully check each part or component for any sign of faulty condition during removal or cleaning. The part will tell you how it acted or what was abnormal about it more accurately during removal or cleaning.

(6) When lifting or carrying a part too heavy or too awkward for one person to handle, get another person's help and, if necessary, use a jack or a hoist.

2. Assembly

(1) Wash all parts, except for oil seals, O-rings, rubber sheets, etc., with cleaning solvent and dry them with pressure air.

(2) Always use tools that are in good condition and be sure you understand how to use them before performing any job.

(3) Use only good-quality lubricants. Be sure to apply a coat of oil, grease or sealant to parts as specified.

(4) Be sure to use a torque wrench to tighten parts for which torques are specified.

(5) Any time the engine is assembled, new gaskets and O-rings must be installed.

DISASSEMBLY

PREPARATION FOR DISASSEMBLY

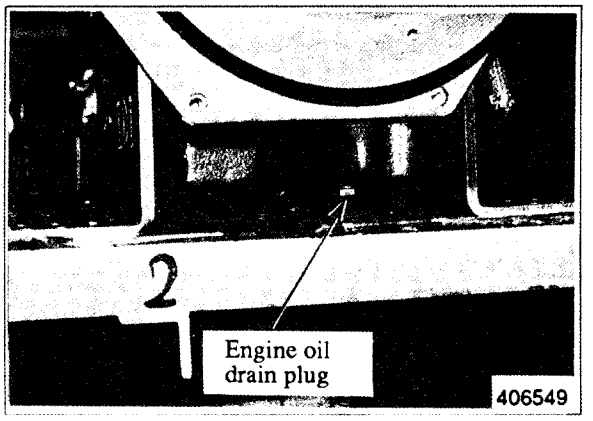
1. Engine oil draining

Remove the drain plug from the bottom of the oil pan and allow the oil to drain.

Refill capacities (high level excl. 0.5 liter (0.13 U.S. gal) of oil in oil filter, liter (U.S. gal)	S3L/S3L2: 5.7 (1.5) (with deep oil pan) 3.7 (1.0) (with standard oil pan) S4L/S4L2: 7.7 (2.0) (with deep oil pan) 5.4 (1.4) (with standard oil pan)

⚠ WARNING

Hot oil and components can cause personal injury. Do not allow hot oil or components to contact skin.



Draining engine oil

2. Coolant draining

Loose the drain plug on the right side of the cylinder block and allow the coolant to drain.

Refill capacities, liter (U.S. gal)	S3L/S3L2: 1.8 (0.5) S4L/S4L2: 2.5 (0.7)

Draining coolant

ELECTRICAL SYSTEM

1. Starter

1.1. Testing before disassembly

(1) Clearance between pinion and housing (pinion clearance)

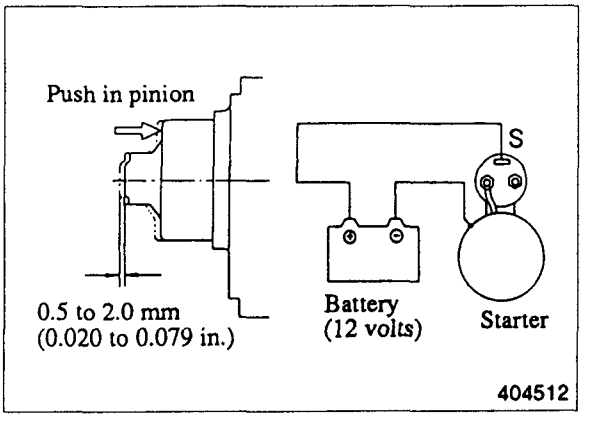
(a) Connect the starter to a 12 volt battery as shown in the illustration to cause the pinion to shift into cranking position and remain there.

⚠ CAUTION

Due to the amount of current being passed through the solenoid series winding, this test must be made within 10 seconds.

(b) Push the pinion toward the commutator end by hand to measure its free movement (pinion clearance).

(c) The pinion clearance must be 0.5 to 2.0 mm (0.020 to 0.079 in.). If the clearance is out of this range, make an adjustment to it by adding or removing the packings on the magnetic switch. Adding the packings will decrease the clearance.

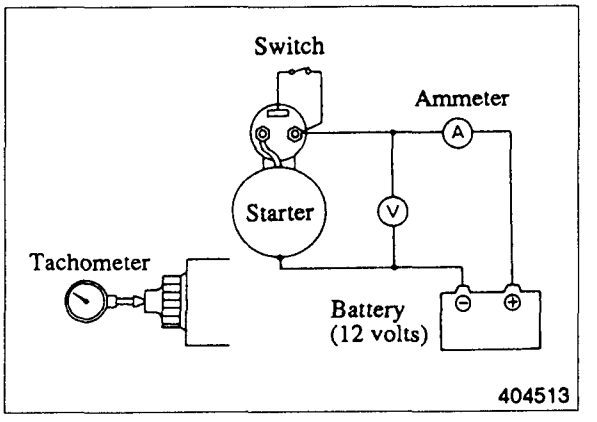


Connections for measuring pinion clearance

(2) No-load characteristics

(a) Connect the starter to a 12 volt battery with an ammeter capable of indicating several hundred amperes as shown in the illustration.

(b) Close the switch to make sure the pinion shifts into cranking position properly and the starter runs at speeds higher than is specified. If the current draw and/or operating speed is out of the standard, disassemble the starter for inspection and repairs.



Connections for testing no-load characteristics

⚠ CAUTION

a) The size of wires used for this test must be as large as possible. Tighten the terminals securely.

b) This starter has a reduction gear. Do not confuse gear noise with some abnormal noise else.

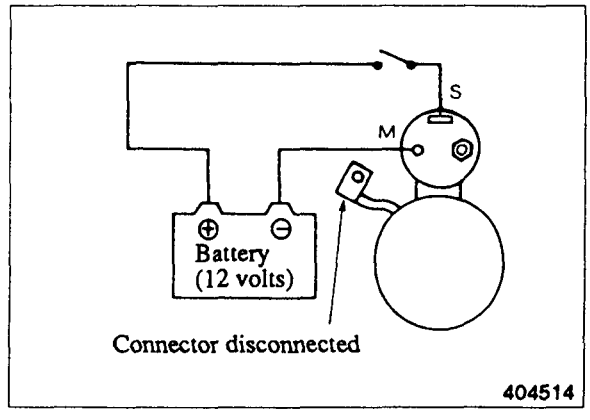
c) When measuring the starter speed at the end of the pinion, be ready for accidental shifting of the pinion.

Item		Standard	
Model		M2T56272	M2T50381
Nominal output, V – kW		12 – 2.0	12 – 1.6
No-load characteristics	Terminal voltage, V	11	11.5
	Current draw, A	130, maximum	100, maximum
	Speed, rpm	3 850, minimum	3 000, minimum

(3) Magnetic switch

(a) Disconnect the connector from the M terminal of the magnetic switch.

(b) Connect the magnetic switch to a 12 volt battery with a switch as shown in the illustration to test the pull-in coil. Close the switch to see if the pinion shifts. If the piston fails to shift, the magnetic switch is faulty.

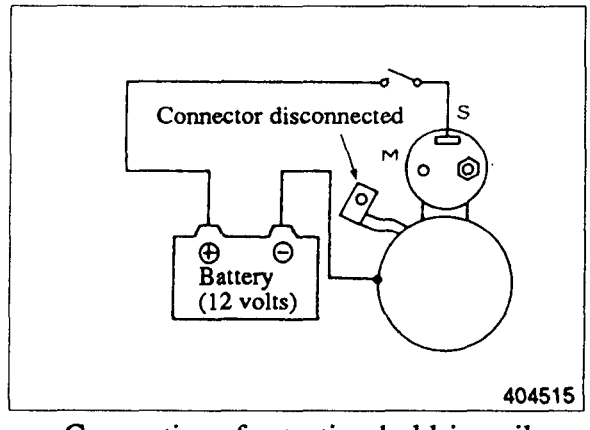


Connections for testing pull-in coil

⚠ CAUTION

Due to the amount of current being passed through the solenoid series winding, this test must be made within 10 seconds.

(c) Connect the magnetic switch to a 12 volt battery with a switch as shown in the illustration to test the hold-in coil. Close the switch and pull the pinion away from the commutator end by hand. Release the pinion to see if it remains there. If the pinion returns, the magnetic switch is faulty.

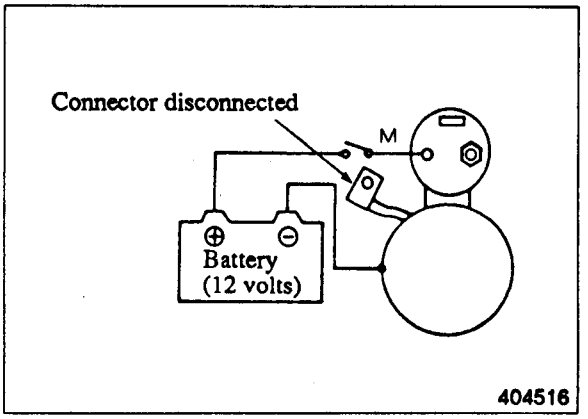


Connections for testing hold-in coil

⚠ CAUTION

Due to the amount of current being passed through the solenoid series winding, this test must be made within 10 seconds.

(d) Connect the magnetic switch to a 12 volt battery with a switch as shown in the illustration to make a pinion return test. Close the switch and pull the pinion away from the commutator end by hand. Release the pinion to see if it returns immediately when released. If the pinion fails to so return, the magnetic switch is faulty.



Connections for pinion return test

⚠ CAUTION

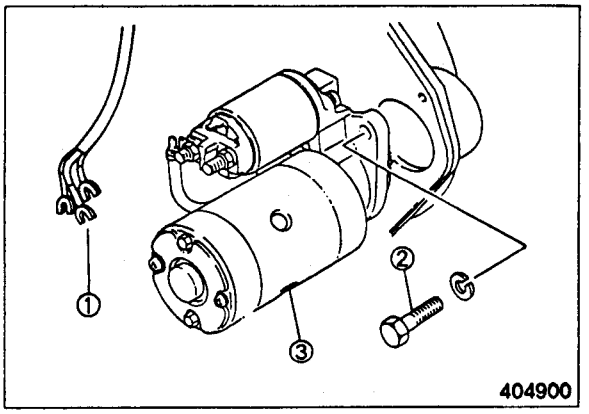
Due to the amount of current being passed through the solenoid series winding, this test must be made within 10 seconds.

1.2. Removal

(1) Disconnect the battery wires. Disconnect the negative (–) wire first.

(2) Disconnect wire (1) from the starter.

(3) Loosen bolts (2) (two) holding starter (3) in position and remove the starter.



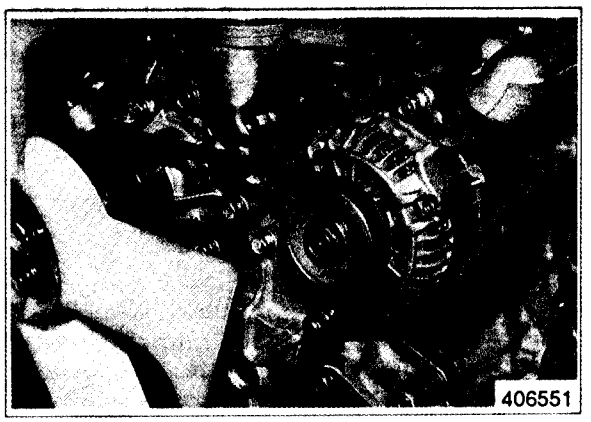
Removing starter

2. Alternator

2.1. Inspection before removal

The correct diagnosis of the charging system requires a careful inspection with the alternator on the engine to determine whether or not it is necessary to remove the alternator from the engine for further inspection. The following chart, in which two troubles are listed with four possible causes of each, will help locate the cause of the trouble:

Alternator charge too high	Voltage regulator setting too high
	Ground return circuit defective
	Wiring incorrect
	Series resistor or winding open-circuited
Alternator gives no charge	Alternator drive belt loose
	Voltage regulator setting too low
	Alternator output low
	Brushes worn



Alternator on engine

2.2. Precautions for removal

Following is a list of basic precautions that should always be observed for removal:

(1) When installing the battery, care must be used to make sure the negative (–) terminal is grounded.

(2) Do not use a megger (an instrument for high resistance of electrical materials).

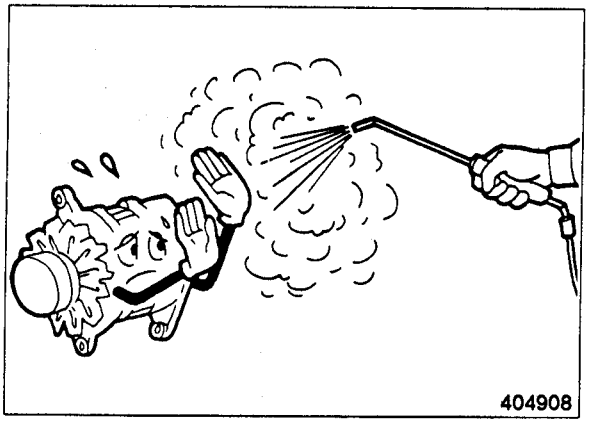
(3) Disconnect the battery cables before charging the battery.

(4) Do not attempt to disconnect the lead from the B terminal of the alternator when the engine is running.

(5) Battery voltage is being applied to the B terminal of the alternator. Do not ground it.

(6) Do not short or ground the L terminal of the alternator with a built-in IC regulator.

(7) Do not blow a spray from the steam cleaner nozzle at the alternator.



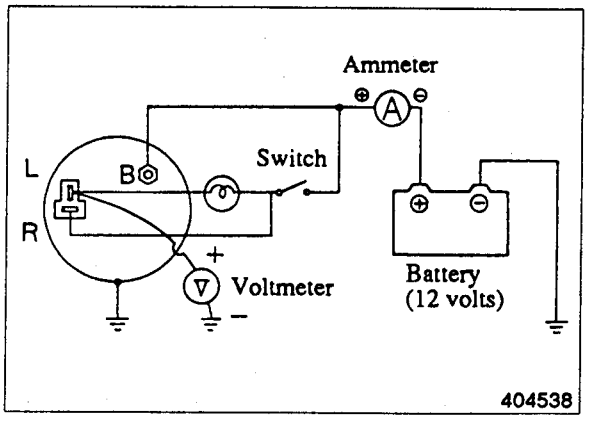
2.3. Testing voltage setting

(1) Connect the alternator to a 12 volt battery with an ammeter, a voltmeter and a switch as shown in the illustration.

(2) The voltmeter reading must be zero (0) when the starter switch is in OFF position. It must be lower than the battery voltage when the switch is in ON position (the engine will not start).

(3) With one ammeter lead short-circuited, start the engine.

(4) Read the voltmeter when the ammeter reading is below five amperes and the engine is running at 1800 rpm and also at 2500 rpm with all electrical loads turned off. The voltage setting varies with alternator temperature. Generally, the higher the alternator temperature, the lower the voltage setting.



Connections for testing voltage setting

Item	Standard
Voltage setting [at 20°C (68°F)]	14.7 ± 0.3 V

2.4. Testing output characteristics

(1) Disconnect the battery ground (negative) cable.

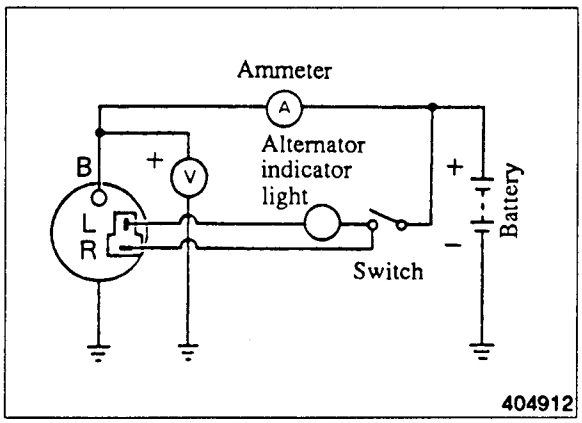
(2) Connect one ammeter lead to the B terminal of the alternator and the other lead to the positive terminal of the battery. Connect one voltmeter lead to the B terminal and the other lead to the ground.

(3) Connect the battery ground cable.

(4) Start the engine.

(5) Turn on all electrical loads.

(6) Increase the engine speed. Measure the maximum output current at the specified alternator speed when the voltmeter reading is 13.5 volts.



Connections for testing output characteristics (alternator with built-in regulator)

Item	Model	Standards	
		Terminal voltage/ current	Speed
Output characteristics (at normal temperature)	A7T02071	13.5 V/33 A	2 500 rpm, maximum
		13.5 V/47 A	5 000 rpm, maximum

2.5. Removal

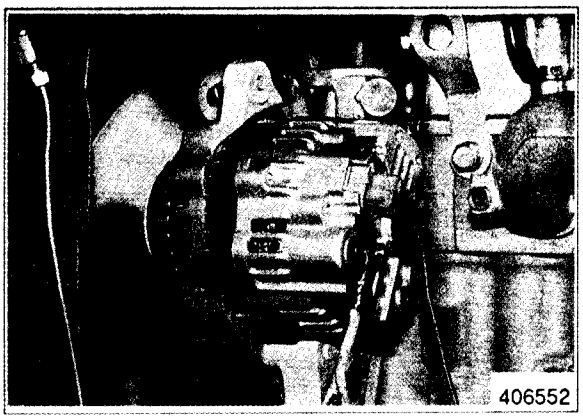
(1) Disconnect the battery cables.

(2) Disconnect the lead from the B terminal of the alternator.

(3) Disconnect the connector from the alternator.

(4) Loosen the brace and support bolts. Move the alternator toward the engine and remove the drive belt.

(5) Remove the alternator.



Removing alternator

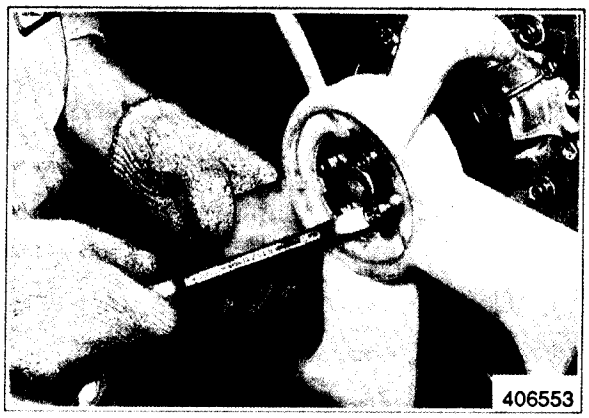
COOLING SYSTEM

1. Cooling fan removal

Hold the fan by one hand and remove the four bolts that hold the fan in position. Remove the fan and spacers.

NOTE

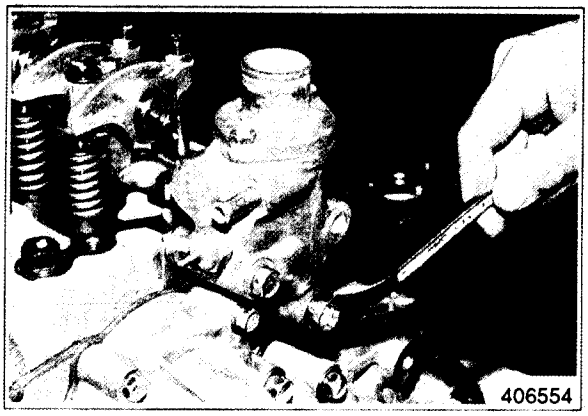
Keep the spacers with the fan for installation.



Removing cooling fan

2. Thermostat case removal

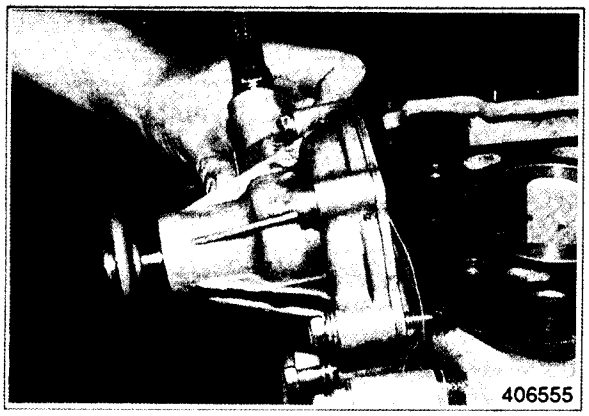
Remove the thermostat case assembly containing thermostat.



Removing thermostat assembly

3. Water pump assembly removal

Remove the water pump assembly.



Removing water pump assembly

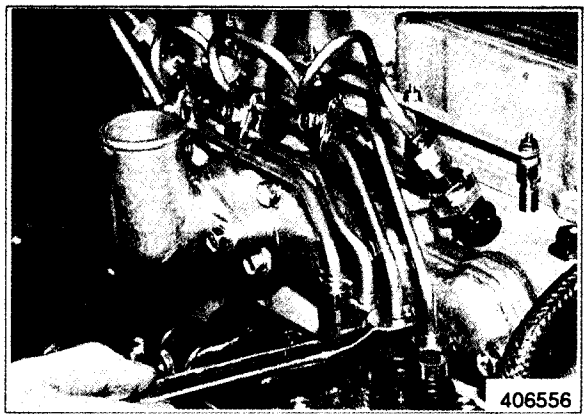
FUEL SYSTEM

1. Fuel injection pipe removal

Disconnect the fuel injection pipes and fuel leak-off pipe from the fuel injection pump and nozzles.

NOTE

Put plugs or caps on the openings of the injection pump and nozzle connectors.



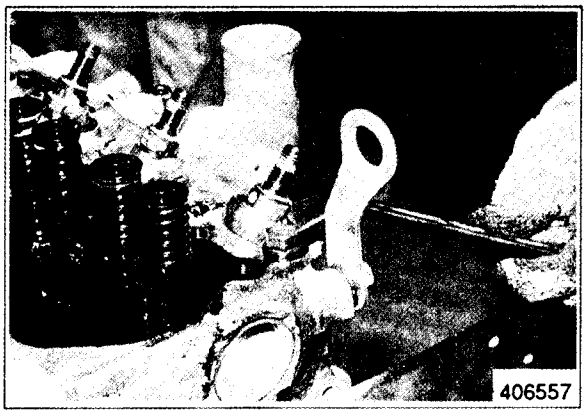
Removing fuel injection pipes

2. Fuel injection nozzle removal

Loosen the fuel injection nozzles with a wrench. Remove the nozzles and gaskets from the cylinder head.

NOTE

Remove the gaskets from the cylinder head with a screwdriver or the like. Discard defective gaskets.



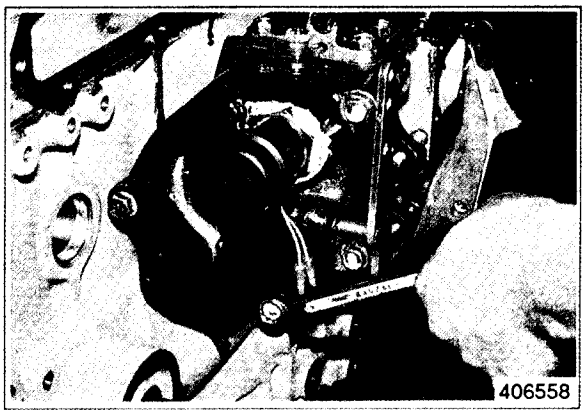
Removing fuel injection nozzles

3. Governor assembly removal

(1) Remove the tie rod cover.

(2) Remove the spring from the tie rod with a pliers to disconnect the tie rod from the fuel injection pump.

(3) Remove the governor assembly.

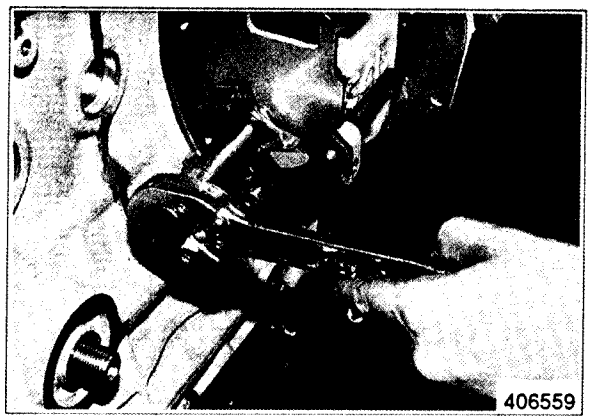


Removing governor assembly

4. Governor weight removal

(1) Remove the sliding sleeve.

(2) Remove the sliding sleeve shaft and governor weights.

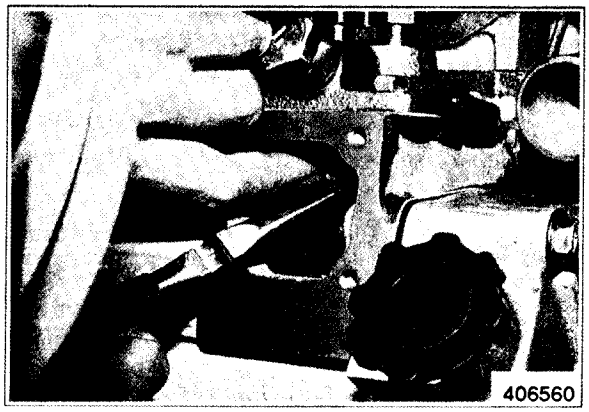


Removing governor weights

5. Fuel injection pump removal

(1) Remove the tie rod cover.

(2) Remove the spring from the tie rod with a pliers to disconnect the tie rod from the fuel injection pump.

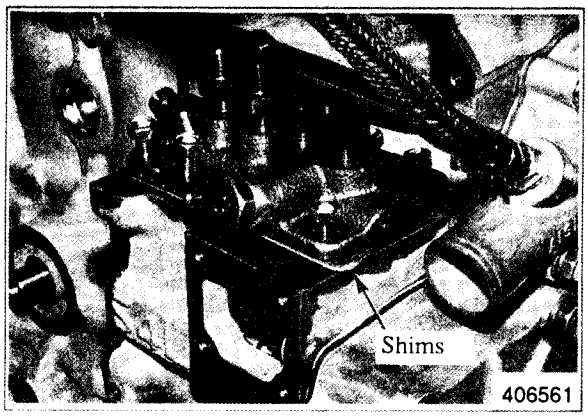


Removing tie rod

(3) Remove the fuel injection pump.

NOTE

Keep a record of the thickness of shims for installation.



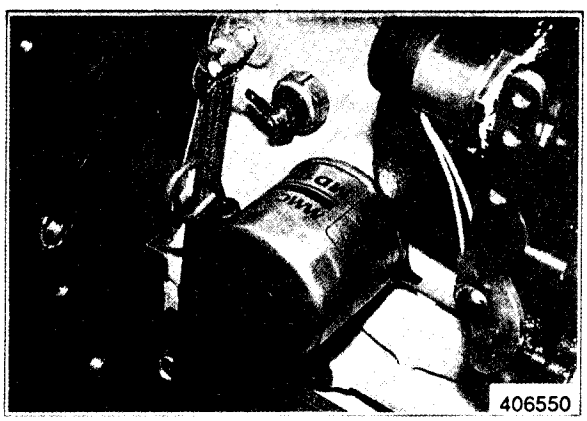
Removing fuel injection pump

LUBRICATION SYSTEM

1. Oil filter removal

(1) Put a container under the oil filter to catch the oil.

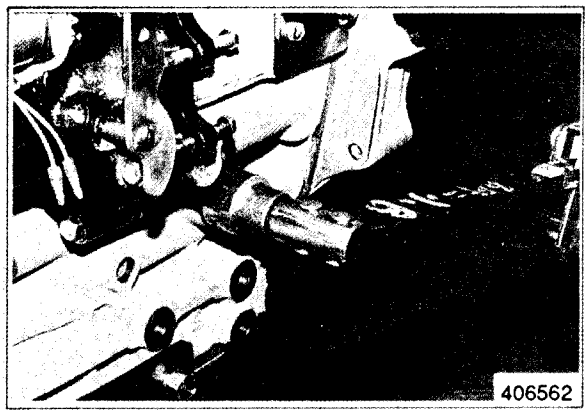
(2) Remove the oil filter from the cylinder block with a filter wrench.



Removing oil filter

2. Pressure relief valve removal

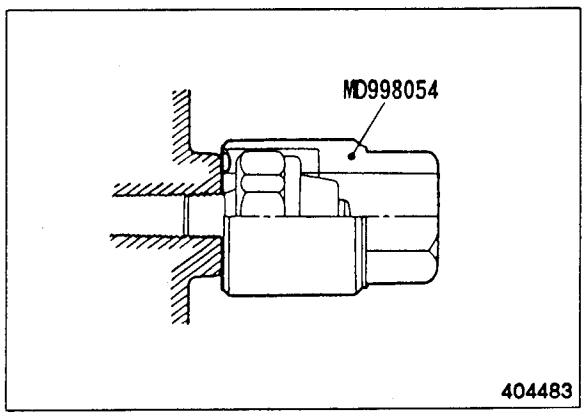
Remove the pressure relief valve from the cylinder block.



Removing pressure relief valve

3. Oil pressure switch removal

Remove the oil pressure switch with Oil Pressure Switch Socket Wrench (MD998054) (special tool).

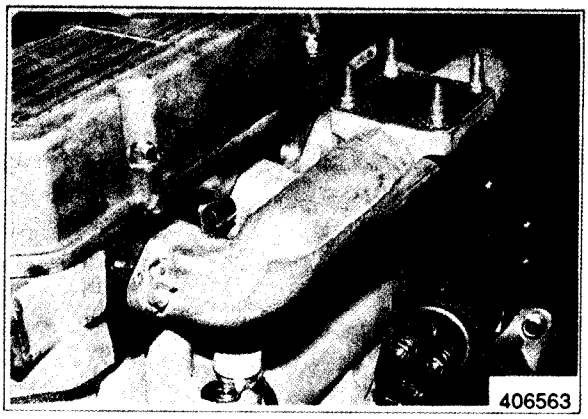


Removing oil pressure switch

AIR INLET SYSTEM AND EXHAUST SYSTEM

1. Exhaust manifold removal

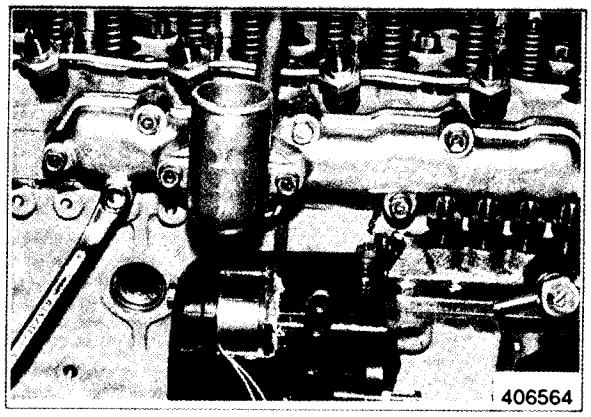
Remove the exhaust manifold from the cylinder head.



Removing exhaust manifold

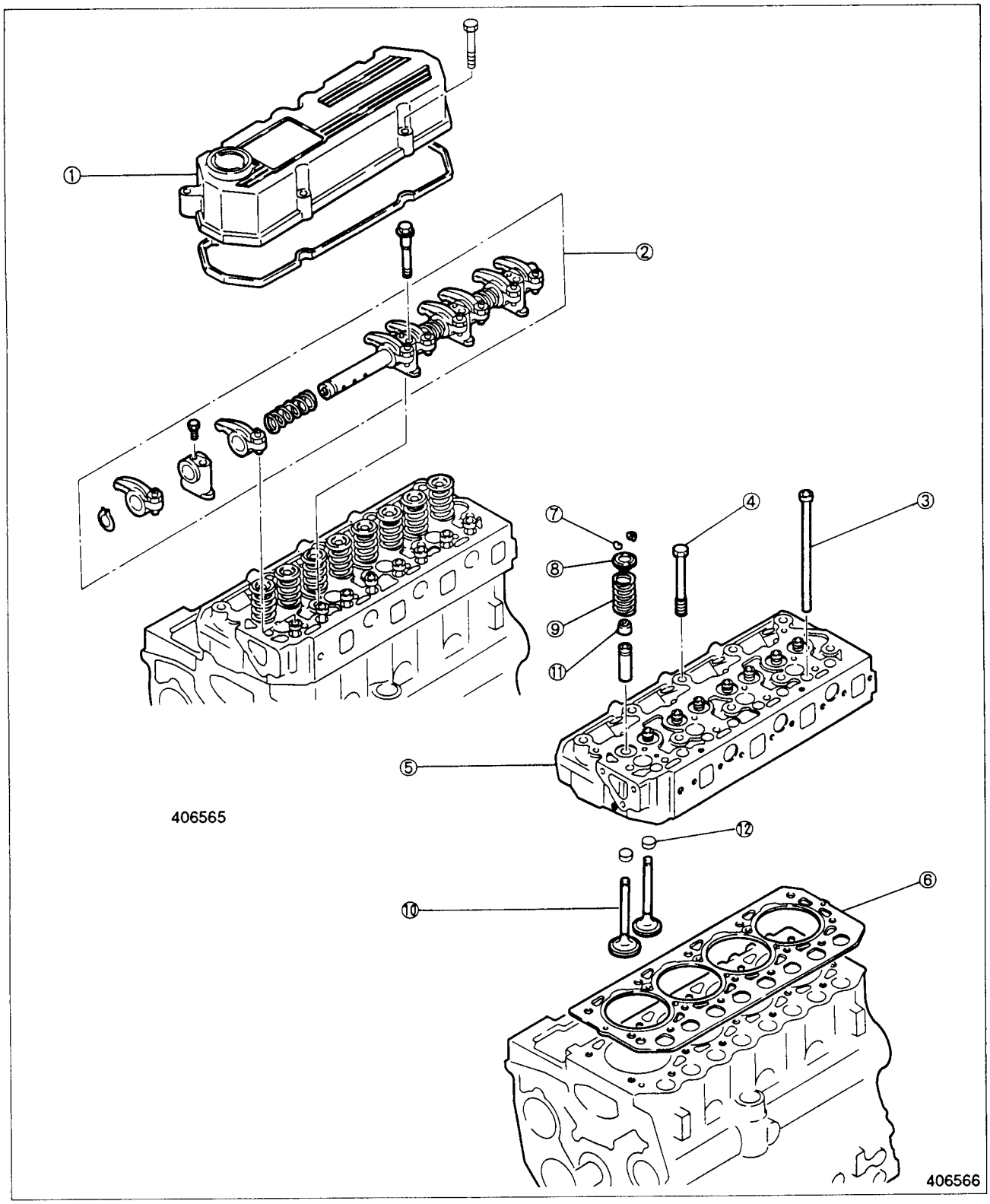
2. Air inlet cover removal

Remove the air inlet cover from the cylinder head.



Removing air inlet cover

CYLINDER HEAD AND VALVE MECHANISM



① Rocker cover
② Rocker shaft assembly
③ Valve push rod
④ Cylinder head bolt
⑤ Cylinder head
⑥ Cylinder head gasket
⑦ Valve lock
⑧ Valve retainer
⑨ Valve spring
⑩ Valve
⑪ Valve stem seal
⑫ Valve cap

1. Rocker shaft assembly removal

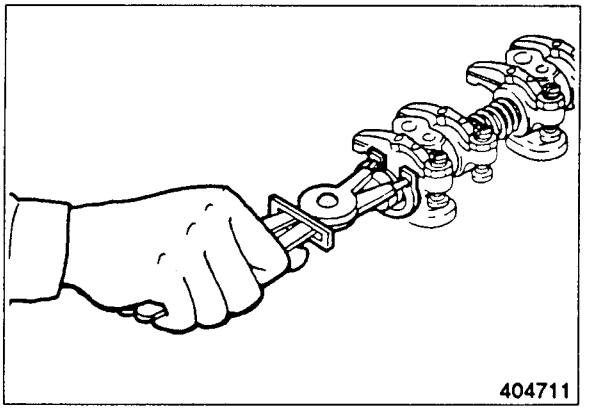
(1) Remove the bolts that hold the rocker stays in position and remove the rocker shaft assembly.

(2) Remove the valve caps.

Removing rocker shaft assemblies

2. Rocker shaft disassembly

Put identification on each rocker arm as to its location on the rocker shaft.



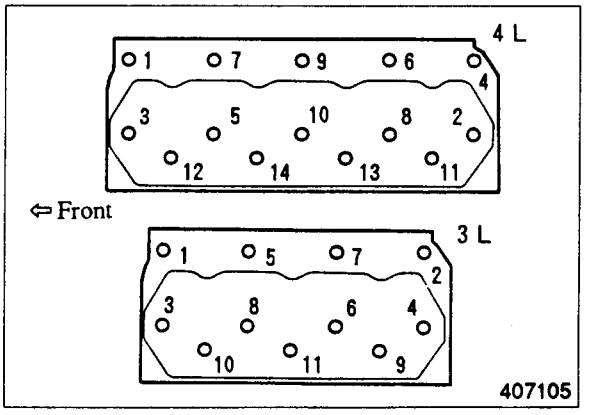
Disassembling rocker shaft assembly

3. Cylinder head bolt removal

Loosen the cylinder head bolts in two or three steps in the sequence shown.

NOTE

If any parts on the cylinder head are faulty, check the cylinder head bolts for tightness with a torque wrench before loosening them.



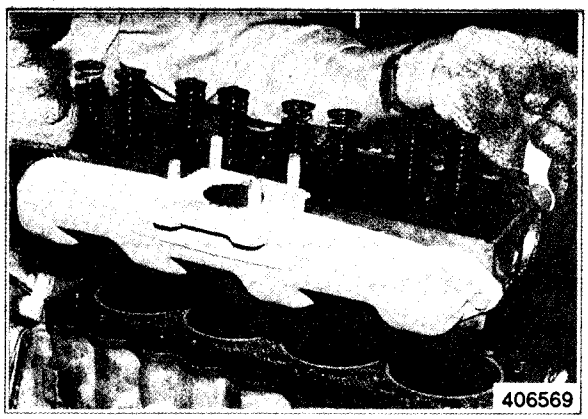
Cylinder head bolt loosening sequence

4. Cylinder head assembly removal

Lift the cylinder head straight up with a hoist.

NOTE

If the gasket is seized and the cylinder head cannot be separated from the cylinder block, tap around the thick side portion of the cylinder head with a plastic hammer.



Removing cylinder head assembly

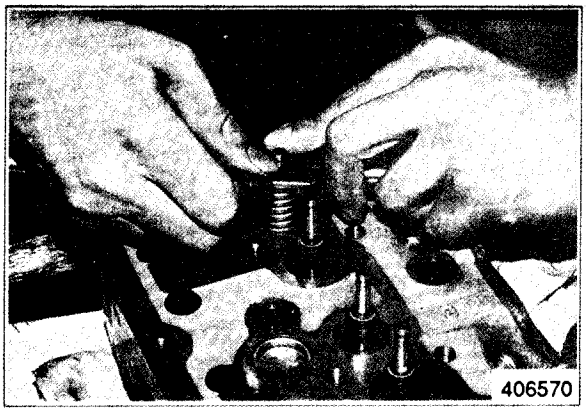
5. Valve and valve spring removal

(1) Compress the valve spring with a valve lifter and remove the valve lock.

(2) Remove the retainer, spring and valve.

NOTE

The valves, retainers, springs and valve locks must be set aside separately in groups, each tagged for cylinder number, for correct installation.



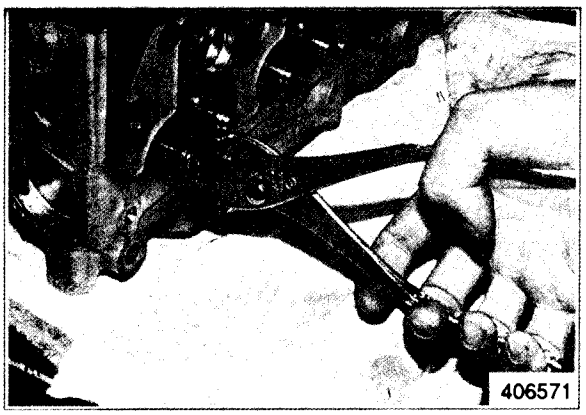
Removing valve springs

6. Valve stem seal removal

Remove the valve stem seals with a pliers.

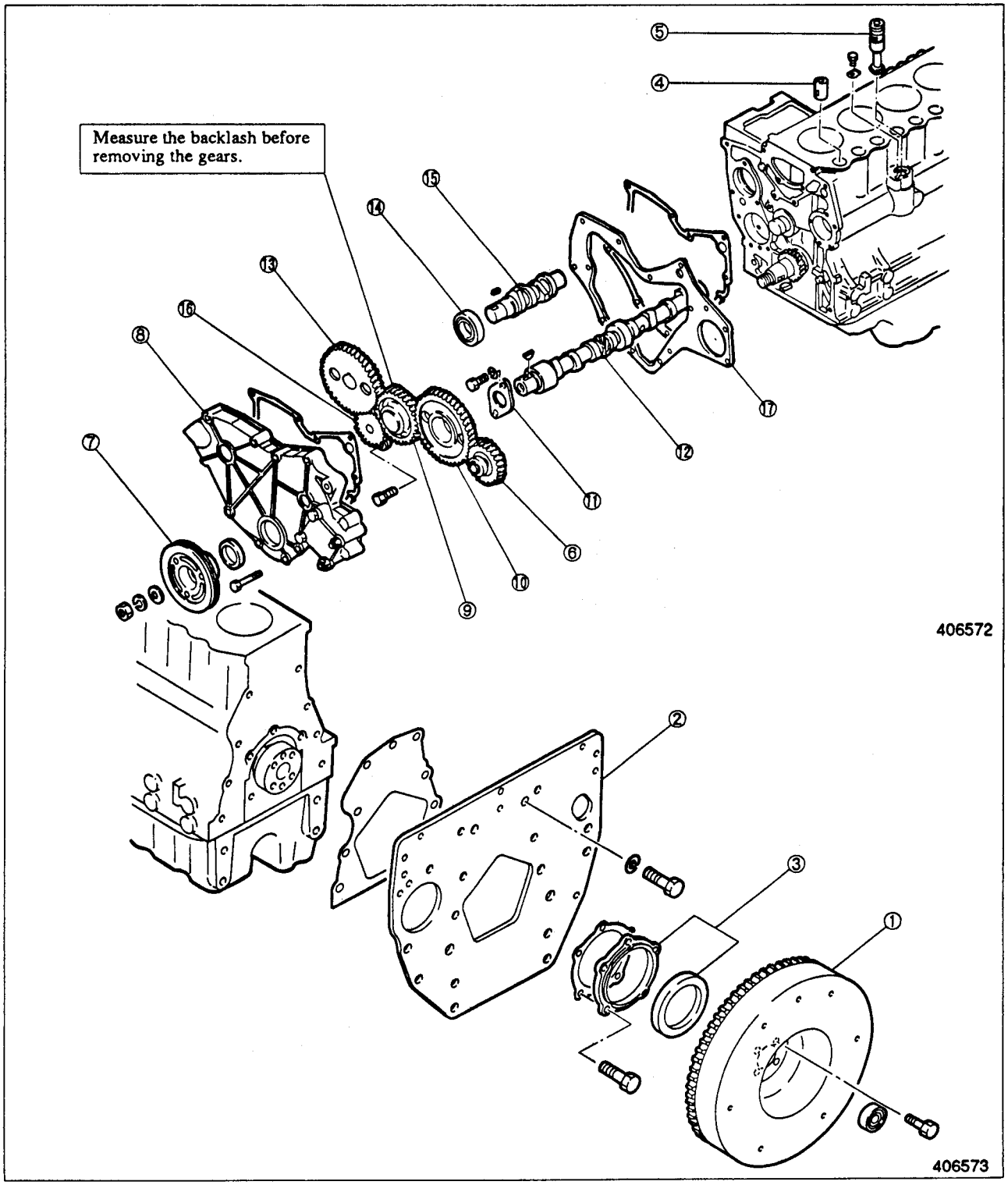
NOTE

Do not reuse the valve stem seals.



Removing valve stem seals

TIMING GEARS AND FLYWHEEL



① Flywheel
② Rear plate
③ Oil seal case; oil seal
④ Tappet
⑤ Speedometer driven gear
⑥ P.T.O. gear
⑦ Crankshaft pulley
⑧ Timing gear case
⑨ Idler gear
(Remove ⑩ thru ⑫ as an assembly.)
⑩ Camshaft gear
⑪ Thrust plate
⑫ Camshaft
(Remove ⑬ thru ⑮ as an assembly.)
⑬ Fuel injection pump camshaft gear
⑭ Bearing
⑮ Fuel injection pump camshaft
⑯ Oil pump
⑰ Front plate

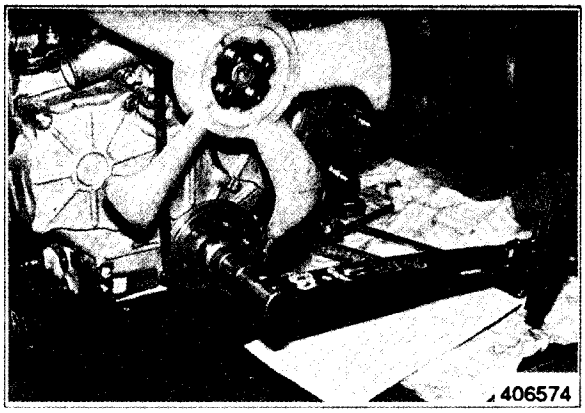
1. Flywheel removal

(1) Have someone hold the crankshaft pulley with a wrench to prevent the flywheel from rotating.

(2) Remove one of the bolts that hold the flywheel in position.

⚠ WARNING

Always signal each other to prevent possible personal injury.



Holding flywheel

(3) Install a safety bar (M12 x 1.25) into the threaded hole in the flywheel from which the bolt was removed in Step (2). Remove the remaining bolts.

(4) Hold the flywheel by hands and withdraw it from the crankshaft. Joggling the flywheel back and forth will facilitate removal.

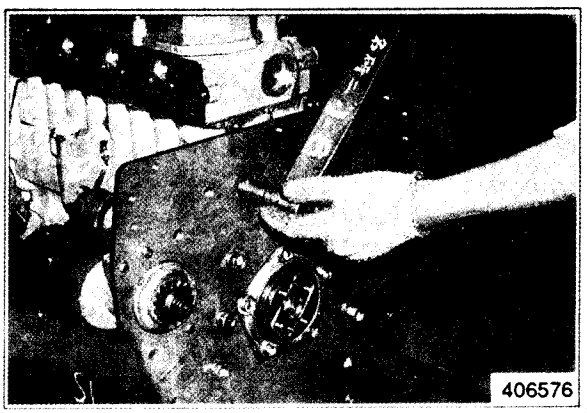
⚠ WARNING

When removing the flywheel, wear heavy gloves to avoid hand injury.

Removing flywheel

2. Rear plate removal

The rear plate is doweled in position. Pull the plate as straight as possible when removing it.



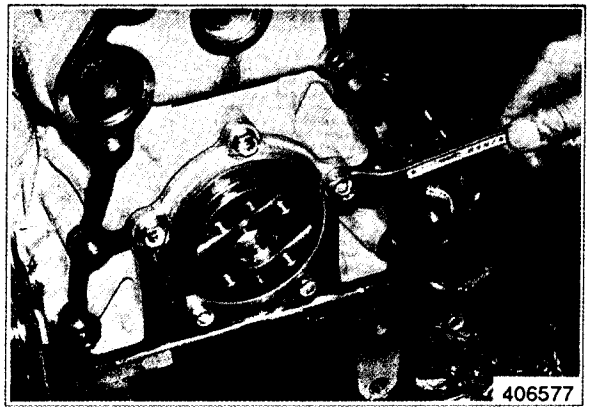
Removing rear plate

3. Oil seal case removal

Remove the bolts that hold the oil seal case in position. Remove the case from the cylinder block with a screwdriver or the like.

⚠ CAUTION

Do not cause damage to the oil seal.



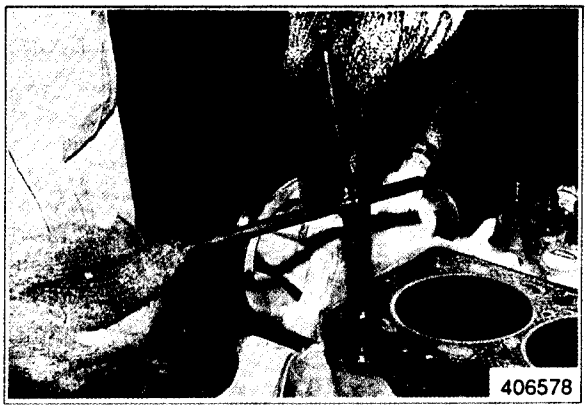
Removing oil seal case

4. Tappet removal

Remove the tappets from the cylinder block with a valve push rod.

NOTE

The tappers will fall into the oil pan if the camshaft is removed before the tappets are removed.



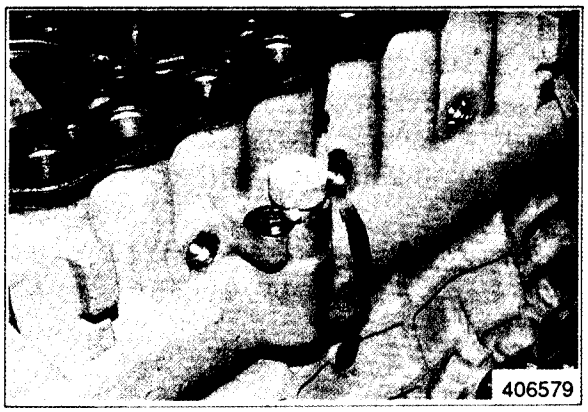
Removing tappets

5. Speedometer driven gear removal

Remove the lock plate and speedometer driven gear in that order.

NOTE

Unless the speedometer driven gear is removed, the camshaft cannot be removed.



Removing speedometer driven gear

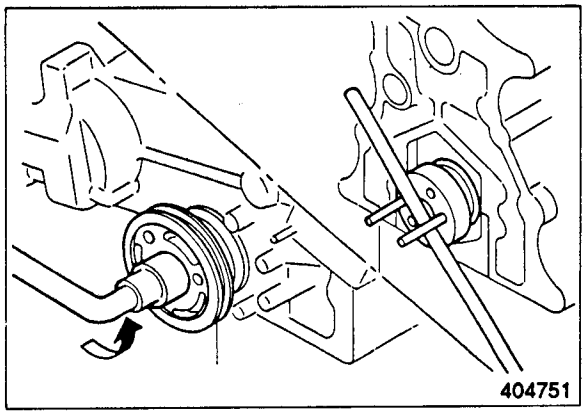
6. Crankshaft pulley removal

(1) Install two safety bars (M12 x 1.25) into the threaded holes in the rear end of the crankshaft. Put a bar between the safety bars to hold the crankshaft to prevent it from rotating.

(2) Remove the crankshaft pulley.

⚠ WARNING

When removing the crankshaft pulley, be prepared to stop the job in case the bar slips off the crankshaft to prevent injury.



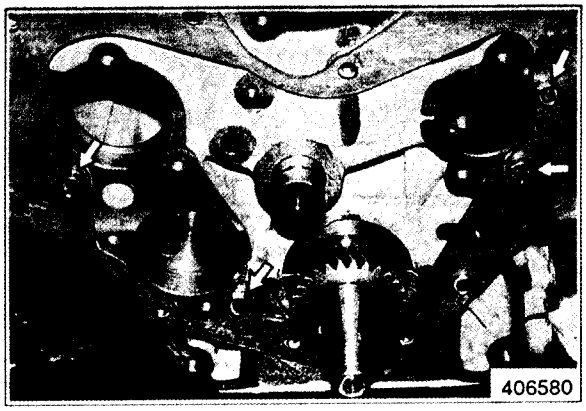
Removing crankshaft pulley

7. Timing gear case removal

Remove the bolts that hold the timing gear case in position and remove the case.

⚠ CAUTION

The front plate is bolted inside the timing gear case. Do not attempt to remove this plate along with the timing gear case by tapping.



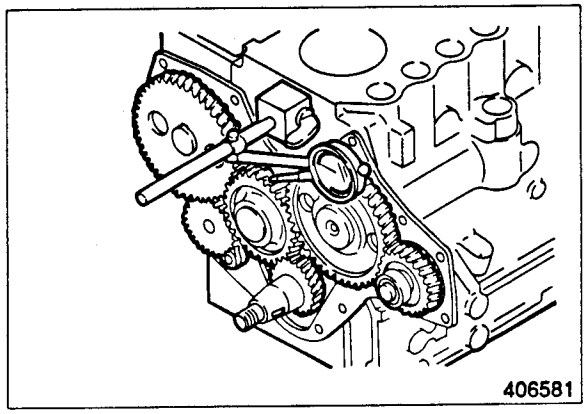
Front plate attaching bolts

8. Timing gear backlash measurement

Measure the backlash of each gear and keep a record of it for correct installation. Replace the gears if the backlash exceeds the limit.

Unit: mm (in.)

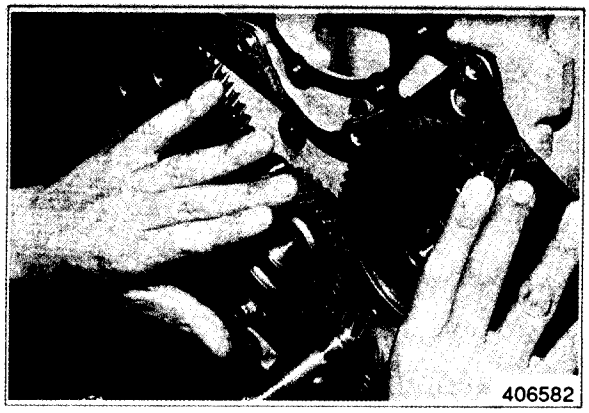
	Item	Standard	Limit
Timing gear backlash	Crankshaft gear and idler gear	0.04 to 0.12 (0.001 6 to 0.004 7)	0.30 (0.011 8)
	Idler gear and camshaft gear		
	Idler gear and fuel injection pump camshaft gear		
	Camshaft gear and P.T.O. gear	0.08 to 0.19 (0.003 1 to 0.007 5)	
	Fuel injection pump camshaft gear and oil pump gear	0.07 to 0.20 (0.002 8 to 0.007 9)	



Measuring timing gear backlash

9. Idler gear removal

To remove the idler gear, rotate the gear in a direction of the helix of the teeth to pull it out of mesh.



Removing idler gear

10. Camshaft removal

(1) Remove the bolts that hold the thrust plate.

(2) Pull the camshaft out of the cylinder block.

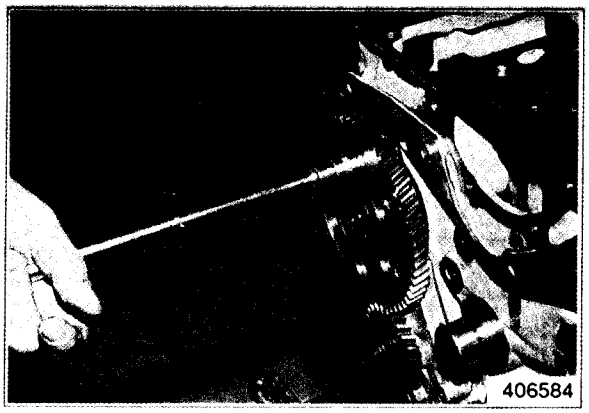
⚠ CAUTION

Do not cause damage to the lobes or bearing journals when removing the camshaft.

Removing camshaft

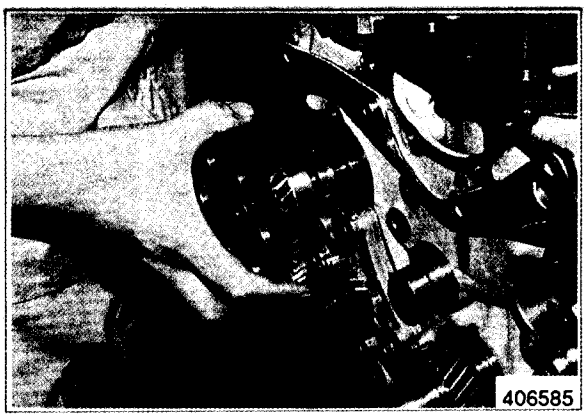
11. Fuel injection pump camshaft removal

(1) Remove the stopper bolt.



Removing camshaft stopper bolt

(2) Tap the rear end of the camshaft with a copper bar to push it out of the front side of the cylinder block.



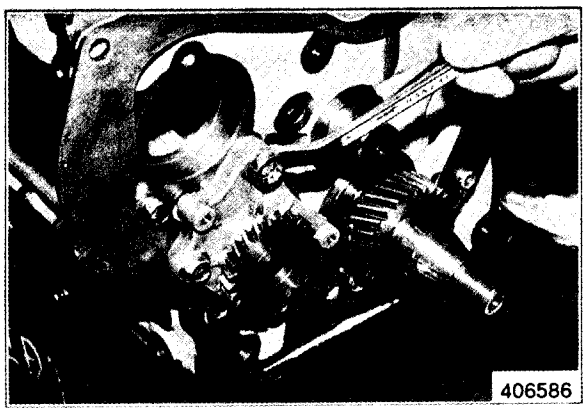
Removing fuel injection pump camshaft

12. Gear removal (when required)

To remove the gears from the camshaft and fuel injection pump camshaft, use an arbor press.

13. Oil pump removal

Remove the bolts that hold the oil pump to the cylinder block and remove the pump.



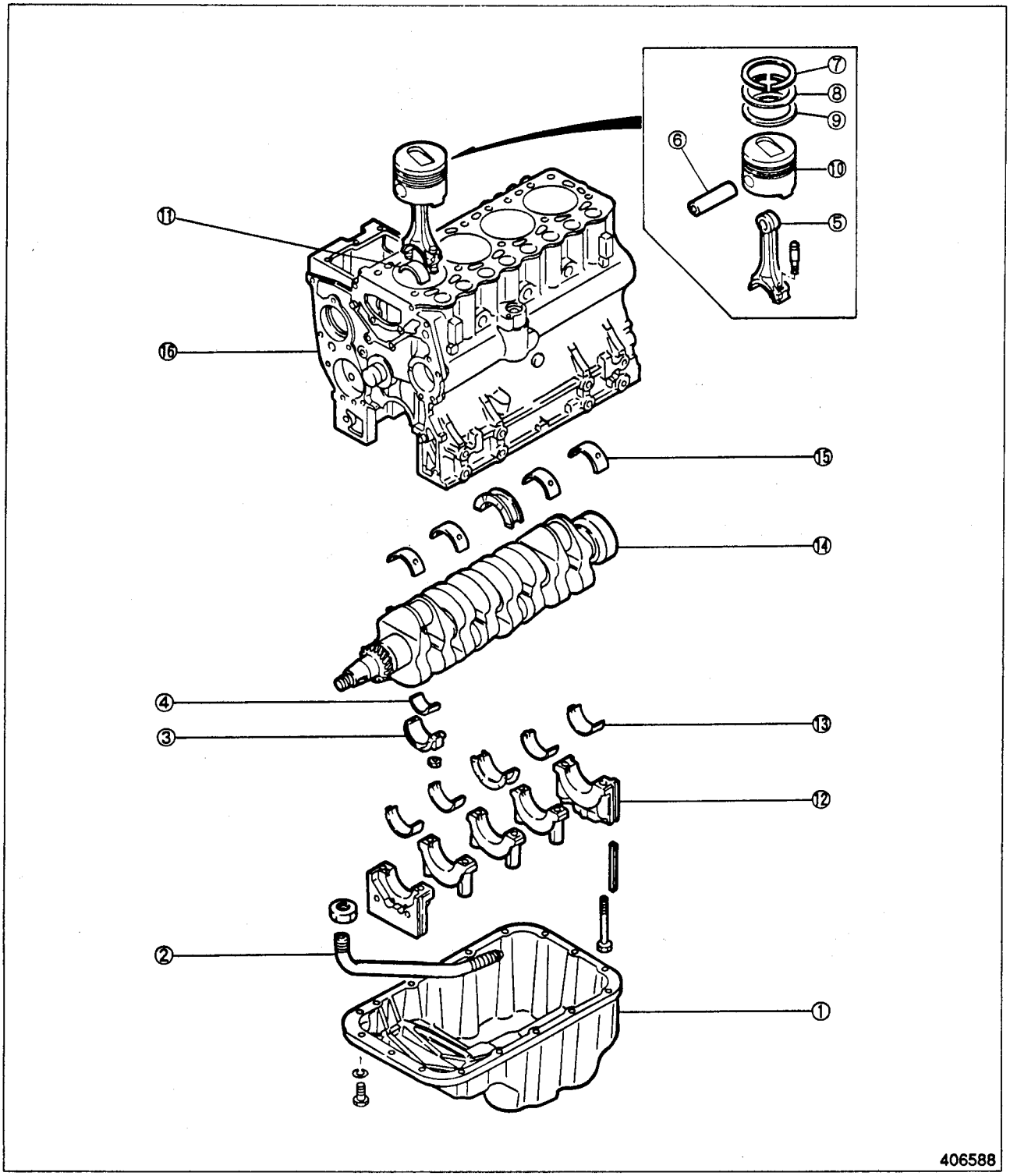
Removing oil pump

14. Front plate removal

Remove four bolts that hold the front plate in position. Tap the plate lightly with a plastic hammer to separate the gasket.

Removing front plate

CYLINDER BLOCK, CRANKSHAFT, PISTONS AND OIL PAN



① Oil pan
② Oil screen
③ Connecting rod cap
④ Connecting rod bearing (lower half)
(Remove ⑤ thru ⑩ as an assembly.)
⑤ Connecting rod
⑥ Piston pin
⑦ No. 1 ring
⑧ No. 2 ring
⑨ Oil ring
⑩ Piston
⑪ Connecting rod bearing (upper half)
⑫ Main bearing cap
⑬ Main bearing (lower half)
⑭ Crankshaft
⑮ Main bearing (upper half)
⑯ Cylinder block

NOTE: When the cylinder block is to be discarded, remove the components (pressure relief valve, etc.) from the block for reuse.

1. Oil pan removal

(1) Turn the engine upside down.

(2) Tap the bottom corners of the oil pan with a plastic hammer to remove the oil pan.

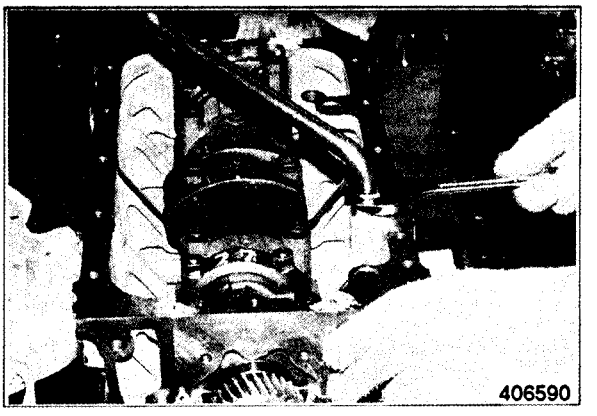
⚠ CAUTION

Do not attempt to pry off the oil pan by inserting a screwdriver or a chisel between the oil pan and cylinder block. Damage to the oil pan can be the result.

Removing oil pan

2. Oil screen removal

Loosen the nut that holds the oil screen in position and remove the screen.



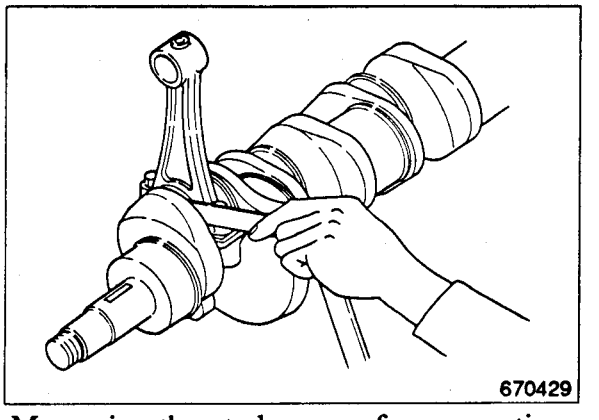
Removing oil screen

3. Thrust clearance measurement for connecting rod big end

Install the connecting rod to its crankpin and tighten the cap nuts to the specified torque. Measure the thrust clearance with a feeler gauge. If the clearance exceeds the limit, replace the connecting rod.

Unit: mm (in.)

Item	Standard	Limit
Thrust clearance for connecting rod big end	0.10 to 0.35 (0.003 9 to 0.013 8)	0.50 (0.019 7)



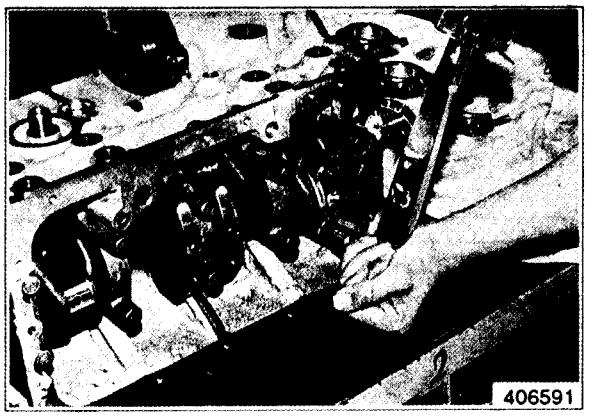
Measuring thrust clearance for connecting rod big end

4. Connecting rod cap removal

(1) Lay the cylinder block on its side.

(2) Put identification on each connecting rod and cap combination as to its location in the engine.

(3) Remove the caps.

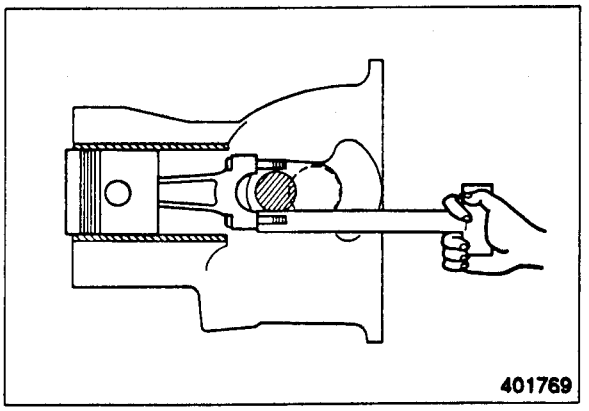


Removing connecting rod caps

5. Piston removal

(1) Turn the crankshaft until the piston is at top center.

(2) Push the piston and connecting rod away from the crankshaft with the handle of a hammer or the like until the piston rings are above the cylinder. Remove the piston and connecting rod. Do Steps (1) and (2) for the removal of the other pistons.



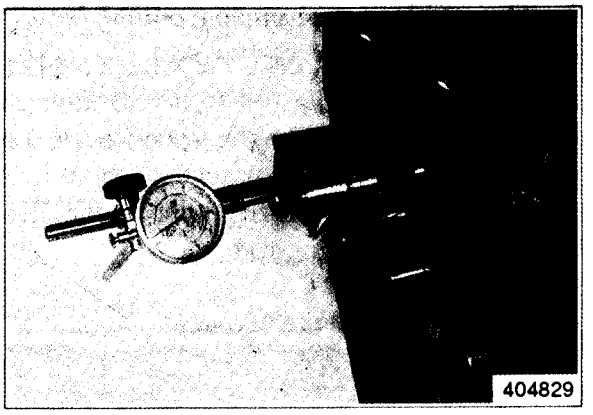
Removing piston

6. End play measurement for crankshaft

Set a dial indicator so that it will touch the end of the crankshaft and measure the end play. If the end play exceeds the limit, replace No. 3 flanged bearing.

Unit: mm (in.)

Item	Standard	Limit
End play for crankshaft end play	0.050 to 0.175 (0.001 97 to 0.006 89)	0.500 (0.019 69)



Measuring end play for crankshaft

7. Main bearing cap removal

(1) Lay the cylinder block with its bottom (oil pan) side up.

(2) Remove the bolts that hold the main bearing caps in position. Remove the caps.

(3) Remove the front and rear bearing caps with a sliding hammer.

Removing main bearing caps

8. Crankshaft removal

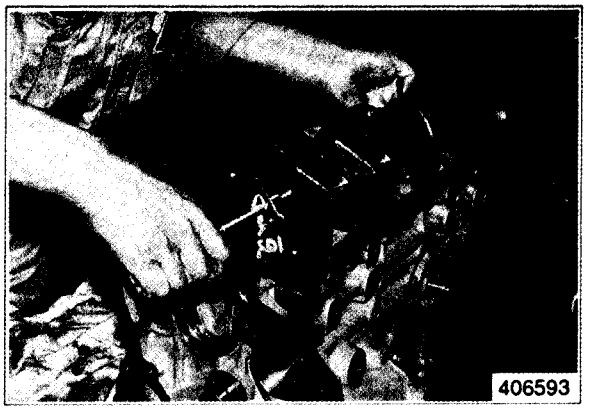
Remove the crankshaft.

⚠ CAUTION

Do not cause damage to the bearings.

NOTE

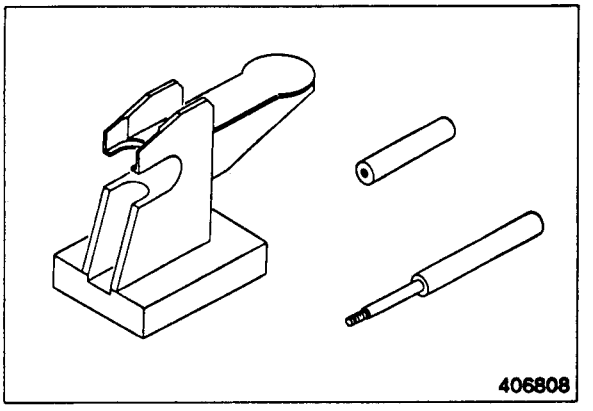
Put identification on each main bearing as to its location in the engine.



Removing crankshaft

9. Piston separation from connecting rod

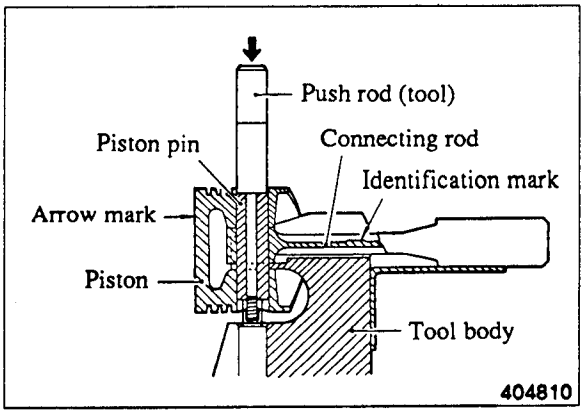
(1) Use Piston Pin Setting Tool (31A91-00100) (special tool) to separate the piston from the connecting rod.



Piston pin setting tool

(2) Insert the push rod of the tool into the bore in the piston for the piston pin and, using an arbor press, remove the piston pin.

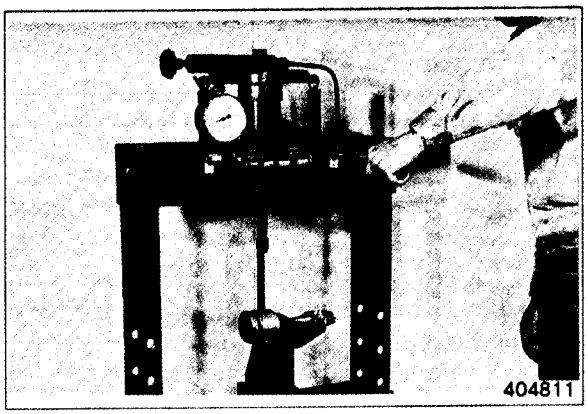
(3) Use this Piston Pin Setting Tool to install the connecting rod to the piston.



Removing piston pin (1)

⚠ CAUTION

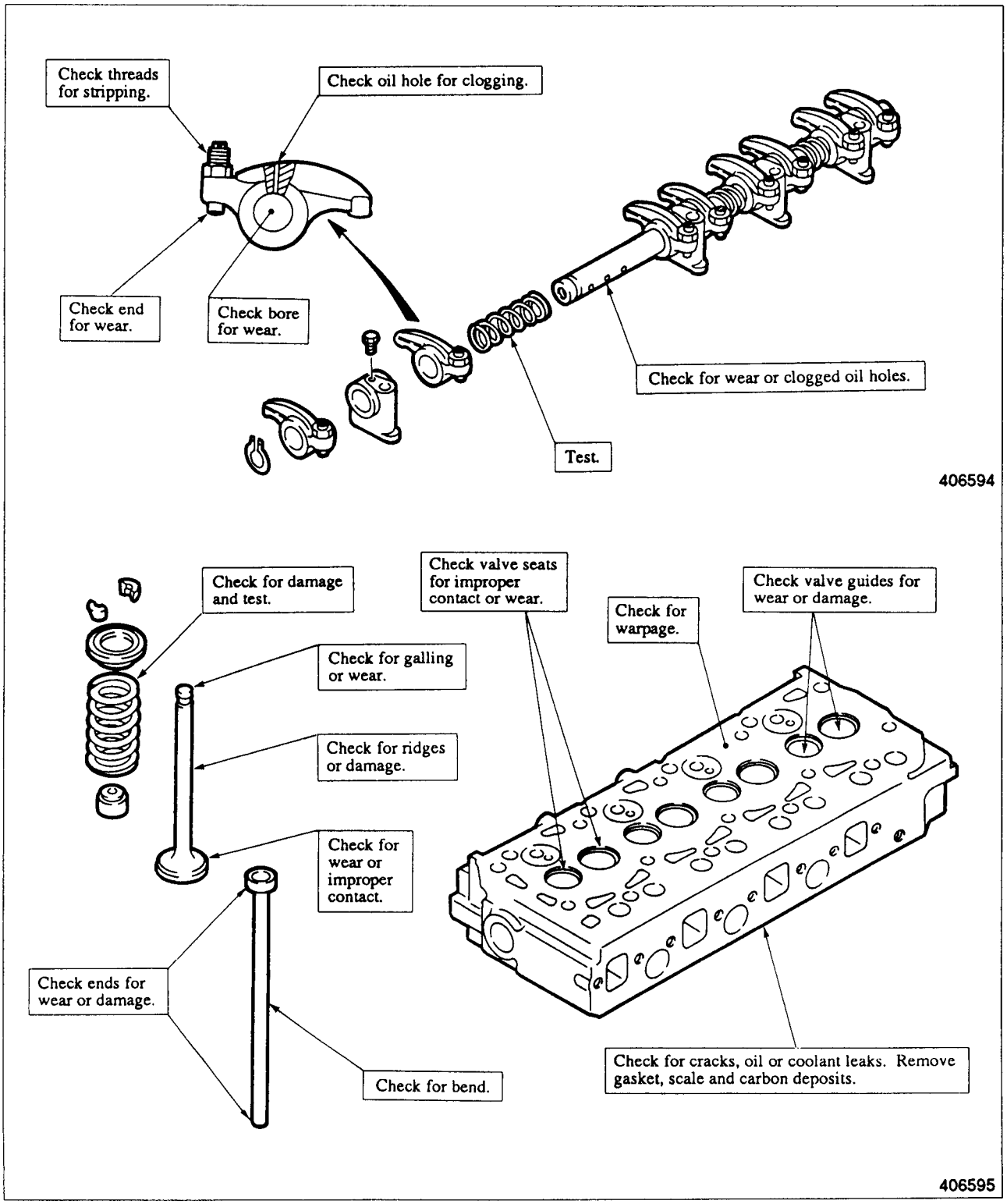
Do not attempt to remove the piston pin by tapping. Replace a piston pin which needs a greater force for removal.



Removing piston pin (2)

INSPECTION

CYLINDER HEAD AND VALVE MECHANISM



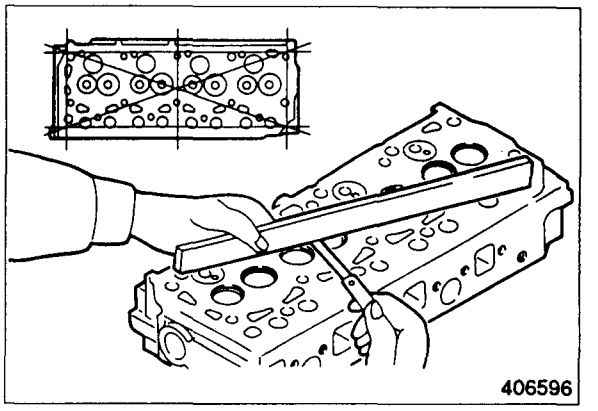
Inspection points

1. Cylinder head

Using a heavy accurate straight edge and a feeler gauge, check the bottom face for warpage in three positions lengthwise, two crosswise and two widthwise as shown in the illustration. If warpage exceeds the limit, reface the bottom face with a surface grinder.

Unit: mm (in.)

Item	Standard	Limit
Warpage of cylinder head bottom face	0.05 (0.002 0) maximum	0.10 (0.003 9)



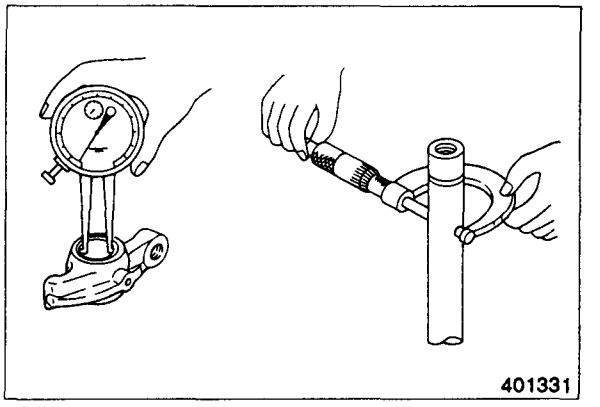
Checking cylinder head bottom face for warpage

2. Rocker arms and rocker shaft

Measure the bore in the rocker arm for the rocker shaft and the diameter of the rocker shaft to find the clearance between the arm and shaft. If the clearance has reached the limit, replace the rocker arm. If it exceeds the limit, replace both arm and shaft.

Unit: mm (in.)

Item	Nominal size	Standard	Limit
Bore in rocker arm for shaft	18.9 (0.744)	18.910 to 18.930 (0.744 49 to 0.745 27)	—
Diameter of shaft for arm	18.9 (0.744)	18.880 to 18.898 (0.743 31 to 0.744 01)	—
Clearance between rocker arm and shaft	—	0.012 to 0.050 (0.000 47 to 0.001 97)	0.200 (0.007 87)



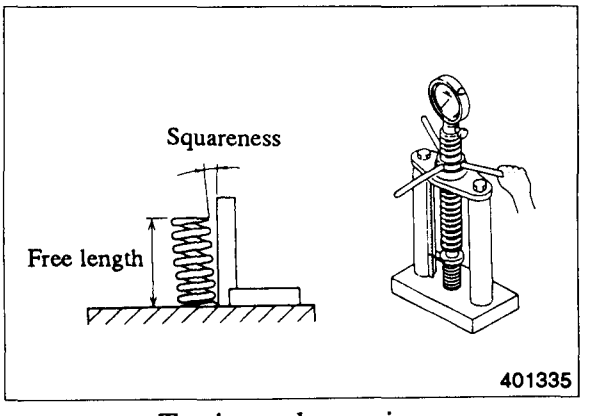
Measuring rocker arm and rocker shaft

3. Valve springs

Check the squareness and free length. If the squareness and/or free length exceeds the limit, replace the spring.

Unit: mm (in.)

Item		Standard	Limit
Free length		47 (1.85)	46 (1.81)
Squareness		1.5° maximum	
Test force, kgf (lbf) [N]	Length under test force: 39.1 (1.54)	13.9 ± 0.7 (30.6 ± 1.5) [136 ± 7]	-15%
	Length under test force: 30.5 (1.20)	29 ± 2 (64 ± 4.4) [284 ± 20]	



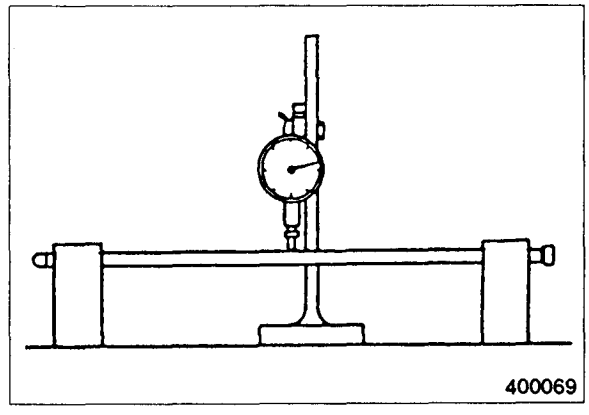
Testing valve spring

4. Valve push rods

Using V-blocks and a dial indicator, check for bend. If the bend exceeds the limit, replace the push rod.

Unit: mm (in.)

Item	Limit
Bend (dial indicator reading) of valve push rod	0.3 (0.012) maximum



Checking bend of valve push rod

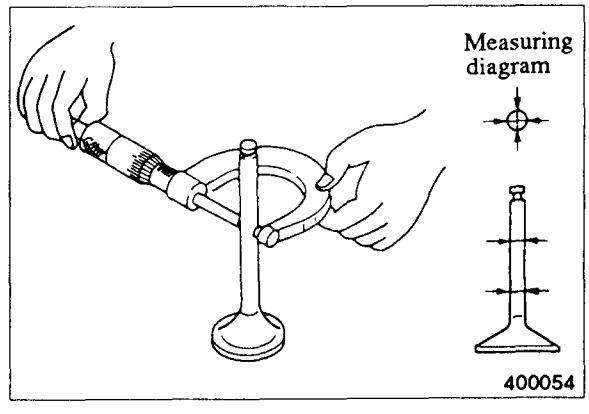
5. Valves, valve guides and valve seats

(1) Diameter of valve stem

Measure the diameter of the valve stem as shown in the illustration. If the stem is worn beyond the limit, or if it is abnormally worn, replace the valve.

Unit: mm (in.)

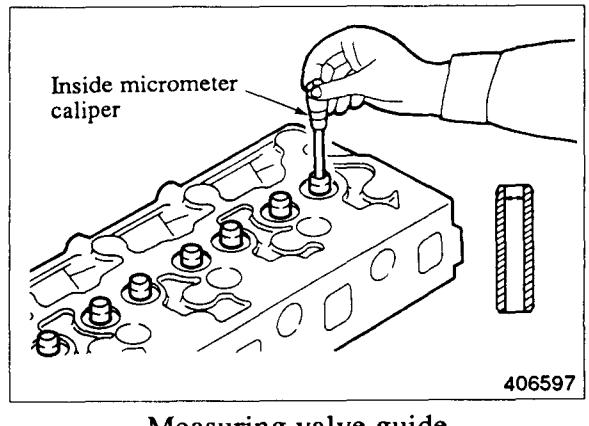
Item		Nominal size	Standard	Limit
Diameter of valve stem	Inlet valve	6.6 (0.260)	6.565 to 6.580 (0.258 46 to 0.259 05)	6.500 (0.255 91)
	Exhaust valve	6.6 (0.260)	6.530 to 6.550 (0.257 09 to 0.257 87)	



Measuring valve stem

(2) Clearance between valve stem and valve guide

The valve guide wears more rapidly at its both ends than at any other parts. Measure the bore in the guide for the stem at its ends with an inside micrometer caliper to find the clearance between the stem and guide. If the clearance exceeds the limit, replace the guide or valve whichever is badly worn.



Measuring valve guide

Unit: mm (in.)

Item		Nominal size	Standard	Limit
Clearance between valve stem and valve guide	Inlet valve	—	0.02 to 0.05 (0.000 8 to 0.002 0)	0.10 (0.003 9)
	Exhaust valve	—	0.05 to 0.085 (0.002 0 to 0.003 35)	0.15 (0.005 9)
Height to top of valve guide		10 (0.39)	9.5 to 10.5 (0.374 to 0.413)	—

NOTE

Before measuring the valve guides, clear the guides of lacquer and carbon.

(3) Valve guide replacement

(a) Remove the guide from the cylinder head by pushing it with a tool and an arbor press from the bottom side of the head.

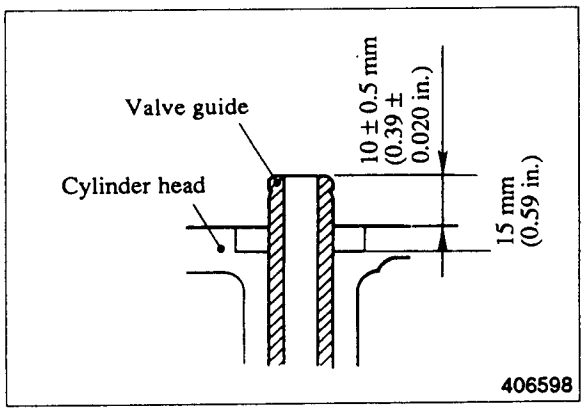
(b) Install a new guide into the cylinder head by pushing it with an arbor press from the upper side of the head until the specified height to the top of the guide is obtained.

(c) Insert a new valve into the guide and make sure the valve slides in the guide freely.

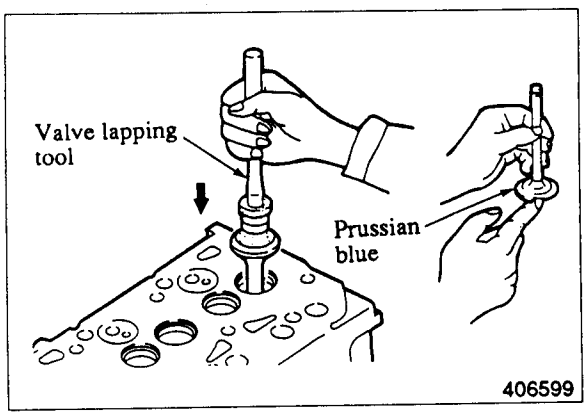
(d) After the valve guide has been replaced, check the valve contact with its seat.

(4) Valves

(a) Put a small amount of Prussian blue or read lead on the valve face. Hold the valve with a valve lapping tool (commercially available) and press it against the seat to check its contact.

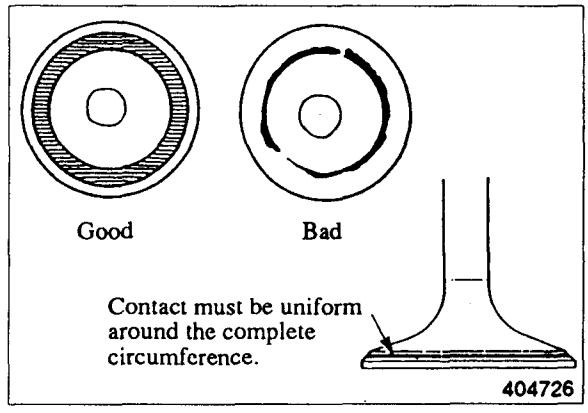


Height to top of valve guide



Checking valve contact with seat

(b) The width of contact must be uniform all the way around both seat and valve. If the contact is bad, reface the valve and seat.

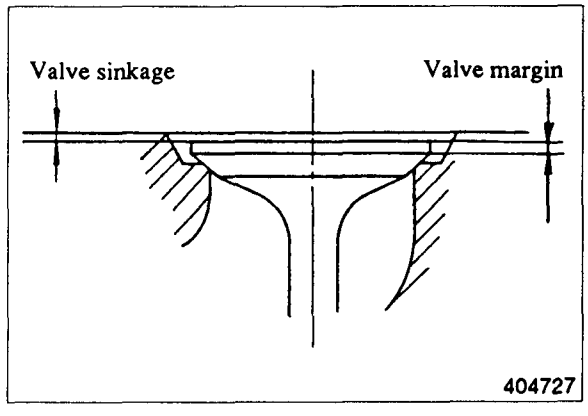


Valve and valve seat contact

(c) If the valve margin (valve lip thickness) exceeds the limit, replace the valve.

Unit: mm (in.)

Item	Standard	Limit
Valve margin (lip thickness)	1.0 (0.039)	0.5 (0.020)



Valve margin and sinkage

(d) If the valve sinkage (the dimension from the top of a closed valve to the face of cylinder head) exceeds the limit, recondition the valve seat or replace the cylinder head assembly.

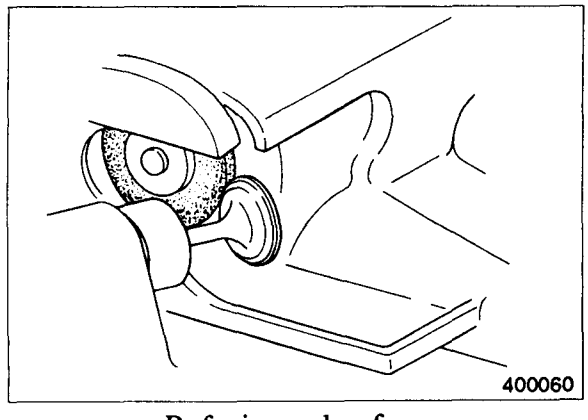
Unit: mm (in.)

Item	Standard	Limit
Valve sinkage (dimension from top of closed valve to face of head)	0.5 ± 0.25 (0.020 ± 0.009 8)	1.5 (0.059)

(5) Valve refacing

(a) Set the valve refacer at an angle of 45° and grind the valve.

(b) The valve margin must be not less than the limit. If the margin seems to be less than the limit when the valve is refaced, replace the valve.

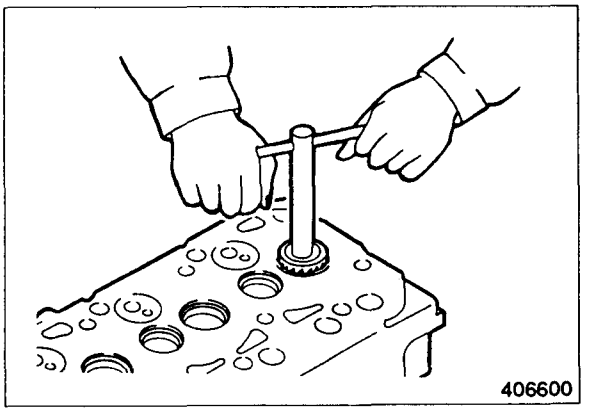


Refacing valve face

(6) Valve seat refacing

(a) Before refacing the valve seat, check the clearance between the valve and guide, and replace the guide if necessary.

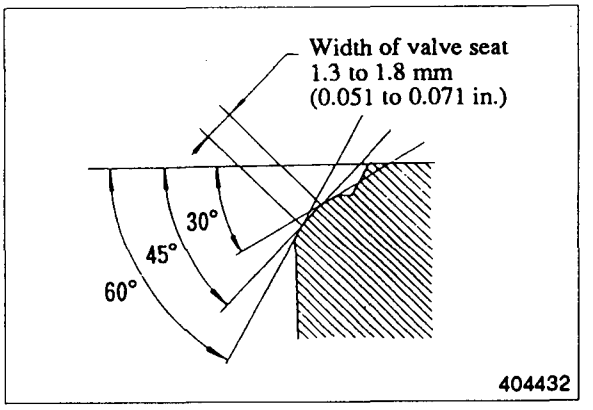
(b) Cut the valve seat with a valve seat cutter (commercially available), or grind it with a valve seat grinder, and finish the width of valve seat and the angle of seat face to the correct values.



Refacing valve seat

Unit: mm (in.)

Item	Standard	Limit
Angle of seat face	45°	—
Width of valve seat	1.3 to 1.8 (0.051 to 0.071)	2.5 (0.098)



Valve seat width and valve face angle

(c) After refacing the valve seat, put lapping compound on the valve face and lap the valve in the valve seat.

(7) Valve lapping

Be sure to lap the valves in the seats after refacing or replacing the valves or valve seats.

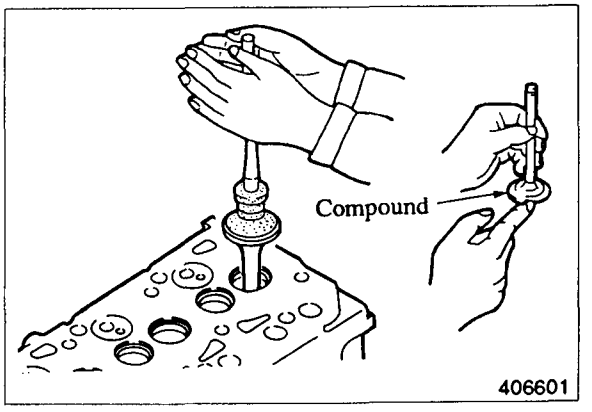
(a) Put a small amount of lapping compound on the valve face.

NOTE

a) Do not put lapping compound on the valve stem.

b) Use a lapping compound of 120 to 150 mesh for initial lapping and a compound of finer than 200 mesh for finish lapping.

c) Mixing the compound with a small amount of engine oil will help put the compound on the valve face uniformly.



Lapping valve in seat

(b) Using a lapping tool, hold the valve against the seat and rotate it only a part of a turn, then raise the valve off its seal,

rotating it to a new position. Press the valve against the seal for another part of a turn. Repeat this operation until the compound wears and loses its cutting property.

(c) Wash the valve and valve seat with dry cleaning solvent.

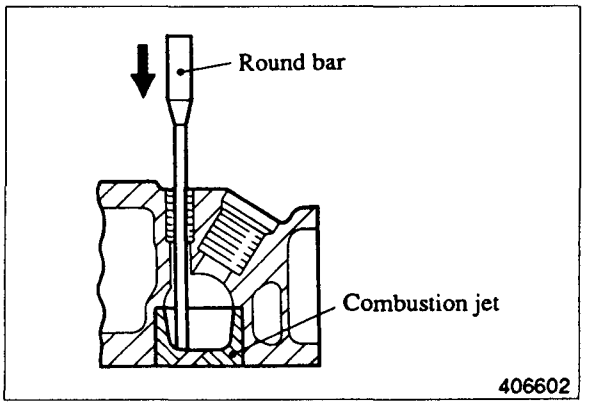
(d) Apply engine oil to the valve and lap it in the seat.

(e) Check the valve face for contact.

6. Combustion jet replacement

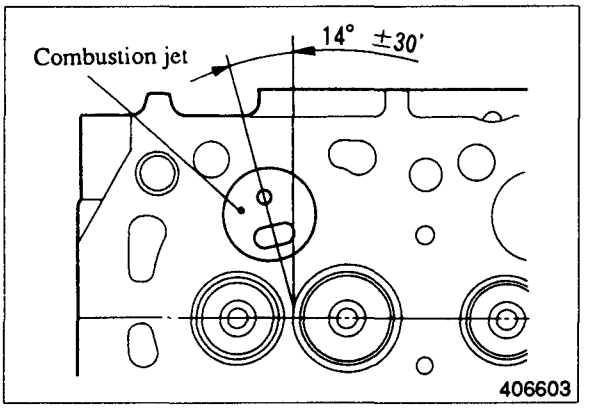
Replace the combustion jets only when they are cracked or defective.

(1) To remove the jet, insert a 6 mm (0.24 in.) diameter round bar through the bore in the cylinder head for the glow plug and tap around the jet.



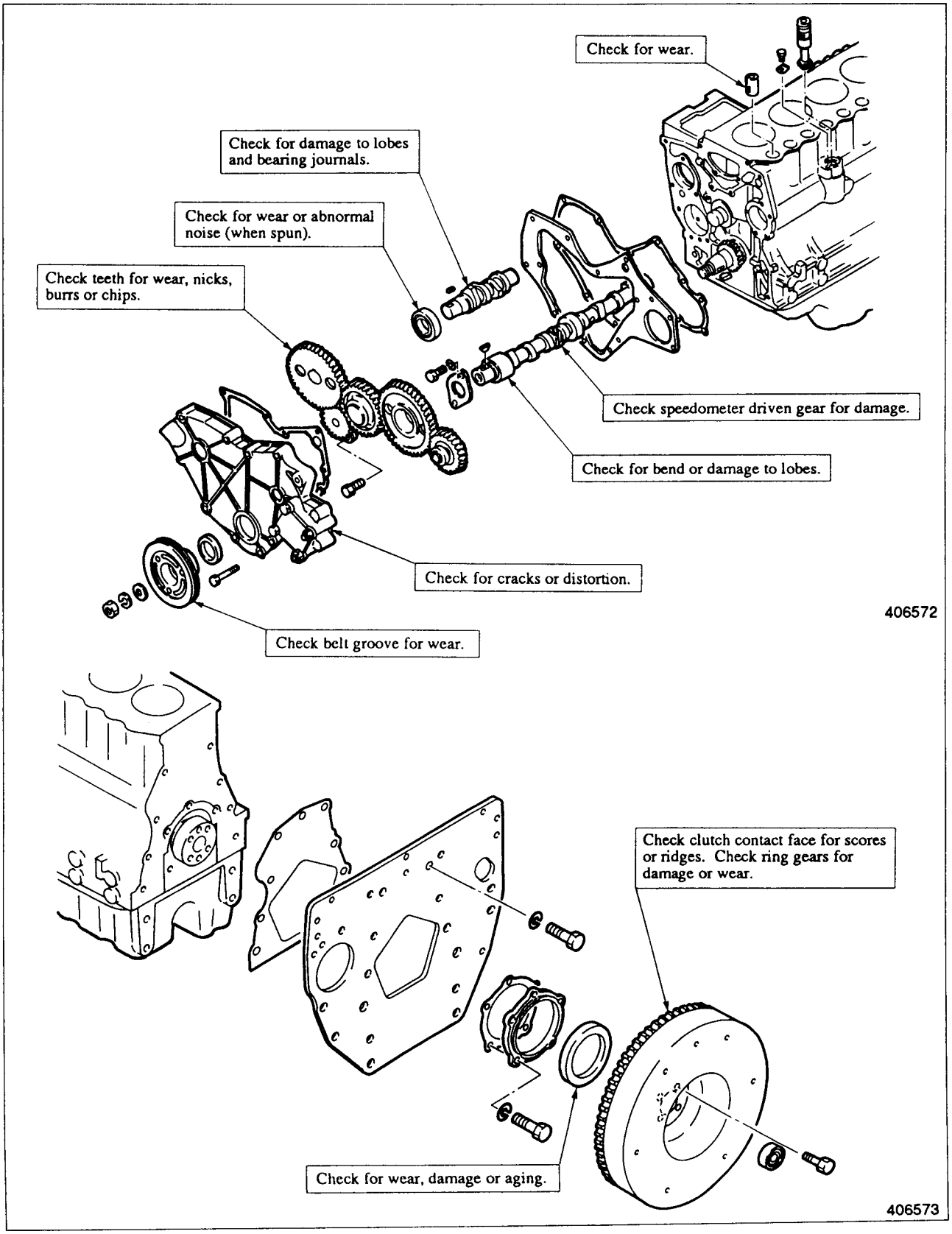
Removing combustion jet

(2) To install a new jet, put the jet in position in the head with its tangential orifice in alignment with the center of the main chamber and tap it with a plastic hammer.



Installing combustion jet

TIMING GEARS AND FLYWHEEL



Inspection points

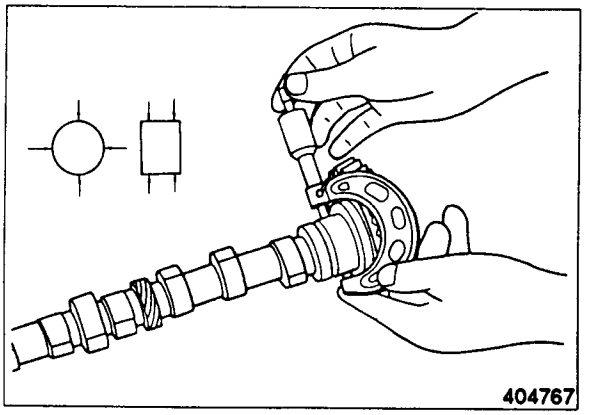
1. Camshaft

(1) Clearance between journal and bushing

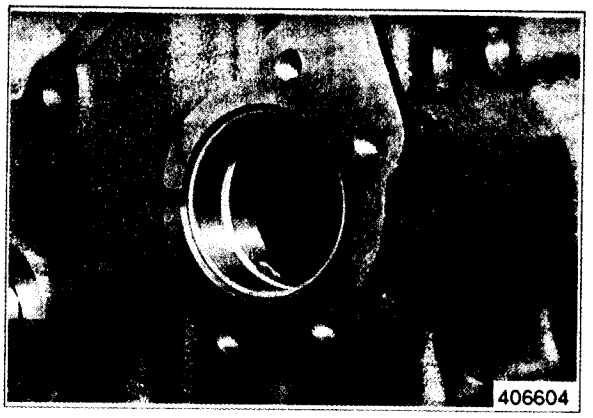
Measure the diameter of the journal and the bore in the bushing for the shaft to find the clearance as shown in the illustration. If the clearance exceeds the limit, replace the bushing.

Unit: mm (in.)

Item	Standard
Clearance between camshaft journal and bushing	0.15 (0.005 9)



Measuring camshaft journal



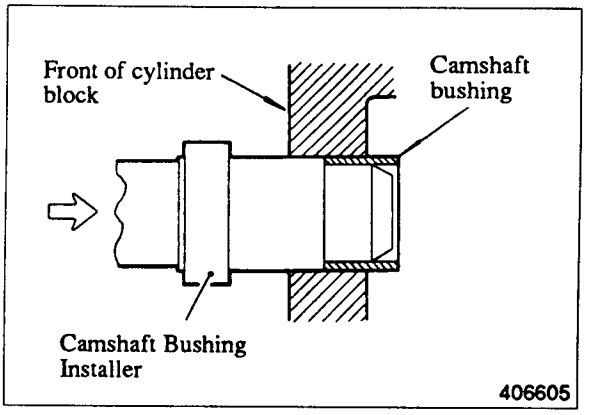
Measuring bore in camshaft bushing

(2) Bushing replacement

Use Camshaft Bushing Installer (ST332340) (special tool) for camshaft bushing replacement.

(a) Removal

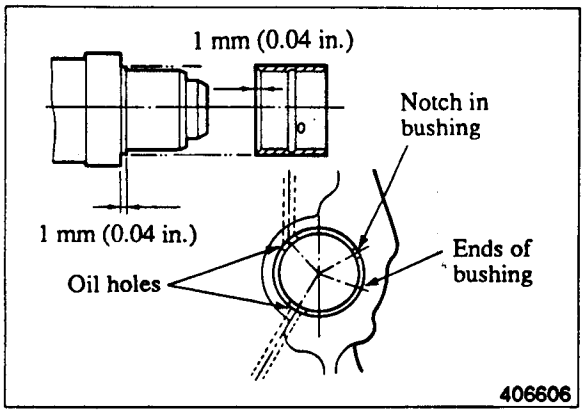
Remove the oil pan. Using a "remover" end of the Installer, push out the bushing into the cylinder block. Crush and take out the bushing from the block.



Removing camshaft bushing

(b) Installation

Install a new bushing in position with its oil holes in alignment with those of the oil gallery.



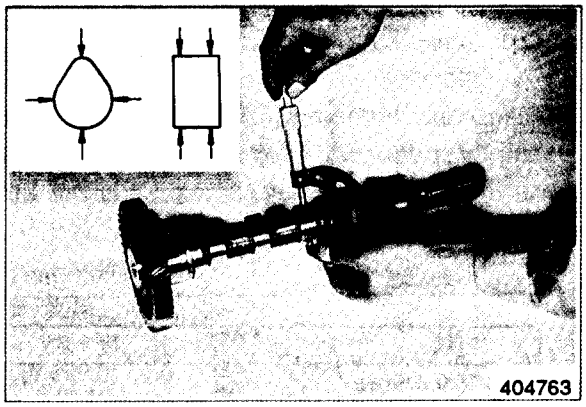
Installing camshaft bushing

(3) Lobe lift

Measure the lobe height and base circle as shown in the illustration. Subtract the base circle from the lobe height to find the lobe life. If the lobe lift exceeds the limit, replace the camshaft.

Unit: mm (in.)

Item	Standard	Limit
Lobe height of camshaft	35.72 (1.406 3)	34.72 (1.366 9)



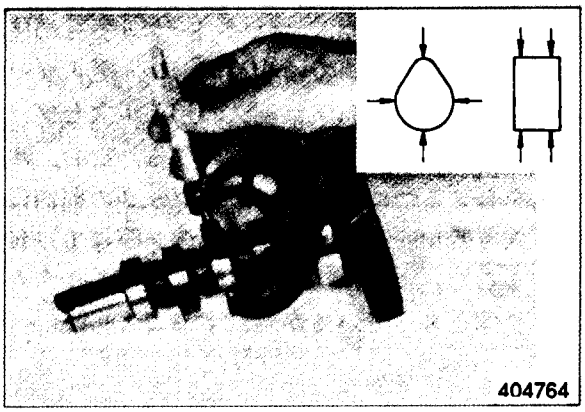
Measuring lobe height of camshaft

2. Fuel injection pump camshaft

Measure the lobe height and base circle as shown in the illustration. Subtract the base circle from the lobe height to find the lobe life. If the lobe lift exceeds the limit, replace the camshaft.

Unit: mm (in.)

Item	Standard	Limit
Lobe height of fuel injection pump camshaft	44 (1.73)	43 (1.69)

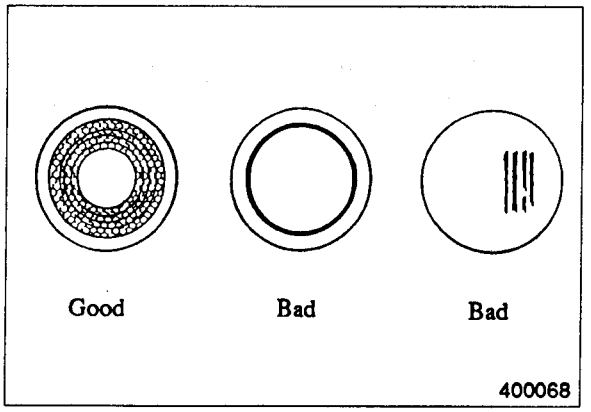


Measuring lobe height of fuel injection pump camshaft

3. Tappets

(1) Cam contact face

Check the cam contact face of each tappet for abnormal wear. Replace the tappet if the face is defective.



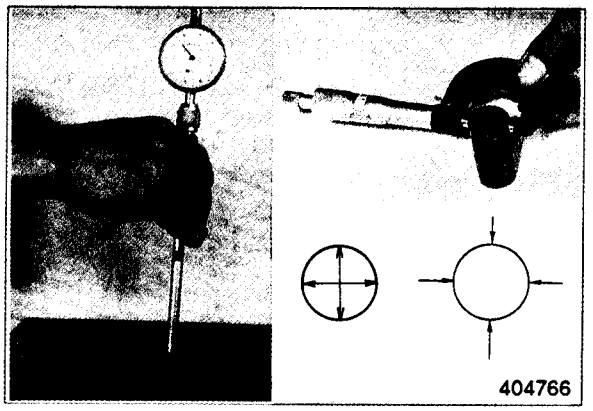
Cam contact face of tappet

(2) Clearance between tappet and cylinder block

Measure the diameter of the tappet and the bore in the cylinder block for the tappet to find the clearance. If the clearance exceeds the limit, replace the tappet.

Unit: mm (in.)

Item	Standard
Clearance between tappet and cylinder block	0.15 (0.005 9)



Measuring tappet and bore in cylinder

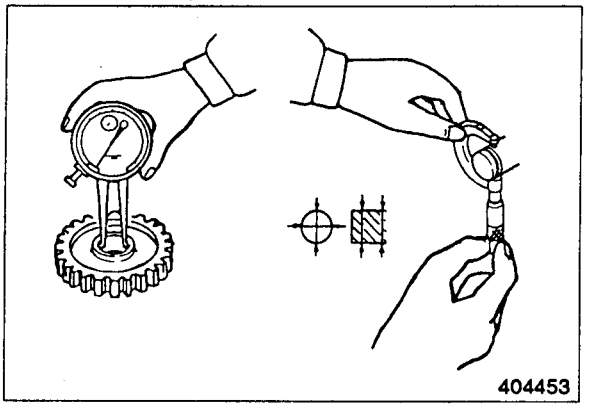
4. Idler gear

(1) Clearance between idler gear and shaft

Measure the bore in the idler gear for the shaft and the diameter of the shaft to find the clearance. If the clearance exceeds the limit, replace the gear or shaft whichever is badly worn.

Unit: mm (in.)

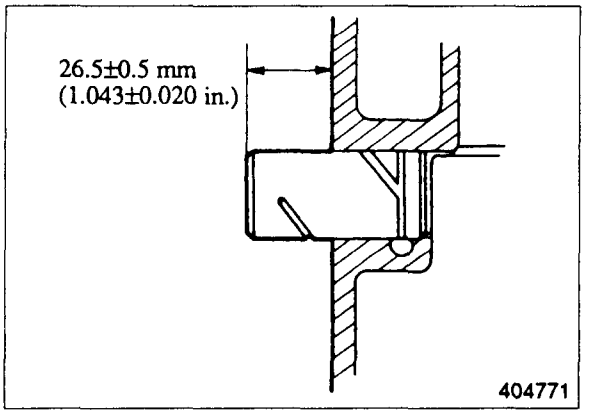
Item	Standard	Limit
Clearance between idler gear and shaft	0.03 to 0.07 (0.001 2 to 0.002 8)	0.20 (0.007 9)



Measuring idler gear and shaft

(2) Idler shaft replacement

Install a new idler shaft to the cylinder block so that its dimension from the face of the block is 26.5±0.5 mm (1.043±0.020 in.).



Idler shaft dimension

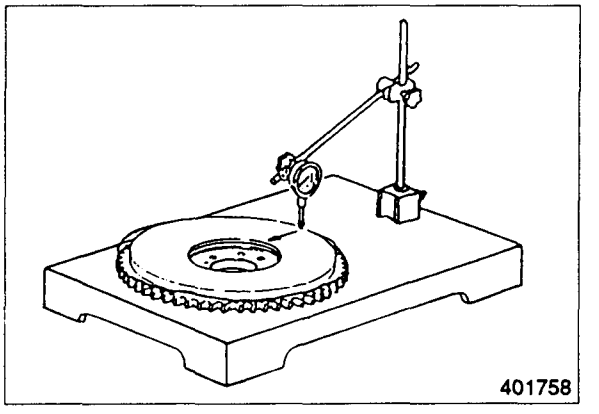
5. Flywheel and ring gear

(1) Flatness (difference between lower and higher measurements) of flywheel

Put the flywheel on the surface plate. Set a dial indicator at one side of the friction (clutch contact) face and move it over to the opposite side of the face as shown in the illustration to find the flatness. If the flatness exceeds the limit, grind the face.

Unit: mm (in.)

Item	Standard	Limit
Flatness of flywheel	0.15 (0.005 9) maximum	0.50 (0.019 7)



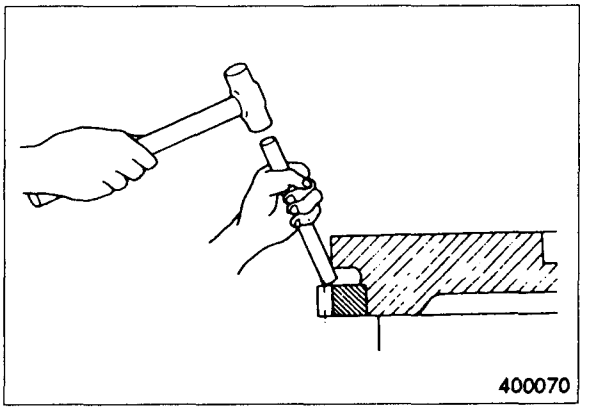
Measuring flywheel flatness

(2) Ring gear replacement

Check the ring gear and replace it if its teeth are abnormally worn or chipped.

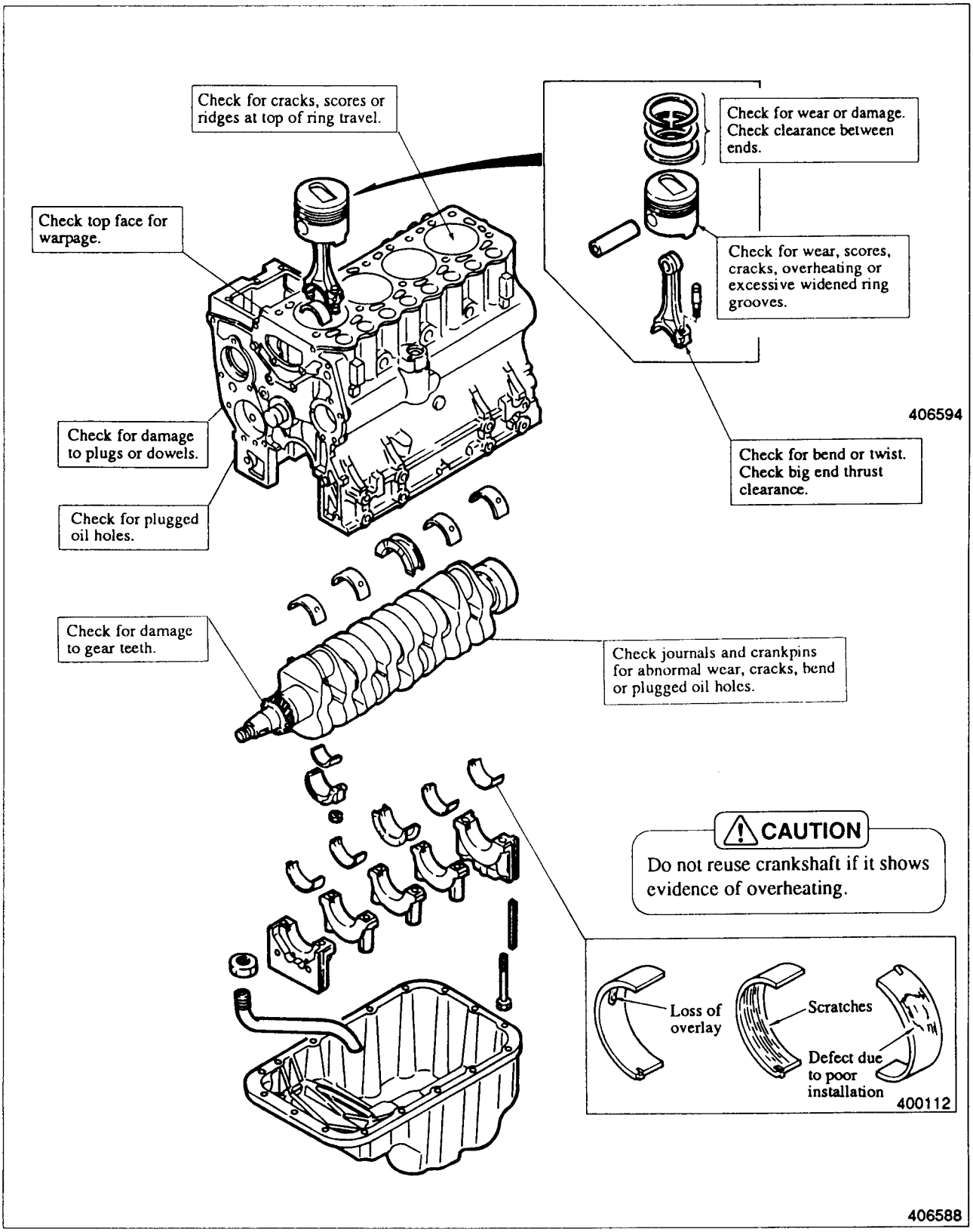
(a) Removal
Heat the ring gear evenly with an acetylene torch. Tap the ring gear all the way around with a bar and a hammer as shown in the illustration to remove it from the flywheel.

(b) Installation
Heat a new ring gear up to a temperature of 150°C (302°F) with a piston heater and install it to the flywheel with its unchamfered side foremost.



Removing ring gear

CYLINDER BLOCK, CRANKSHAFT, PISTONS AND OIL PAN



Inspection points

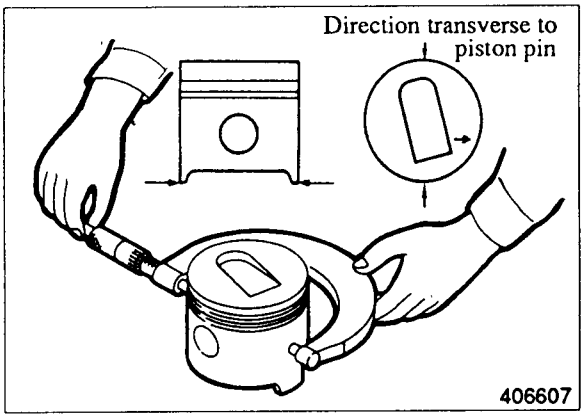
1. Pistons, Piston Rings and Piston Pins

(1) Diameter of piston

Measure the diameter of the piston at its skirt in a direction transverse to the piston pin with a micrometer as shown in the illustration. If the diameter exceeds the limit, replace the piston. Select a new piston so that the difference between average weight of all pistons in one engine does not exceed the standard.

Unit: mm (in.)

Item		Nominal size	Standard	Limit
Diameter of piston	Standard	78.00 (3.070 9)	77.93 to 77.95 (3.068 1 to 3.068 9)	77.80 (3.063 0)
	0.25 (0.009 8) oversize	78.25 (3.080 7)	78.18 to 78.20 (3.077 9 to 3.078 7)	78.05 (3.072 8)
	0.50 (0.019 7) oversize	78.50 (3.090 5)	78.43 to 78.45 (3.087 8 to 3.088 6)	78.30 (3.082 7)
Maximum permissible difference between average weight of all pistons in one engine, g (oz)			5 (0.18)	—



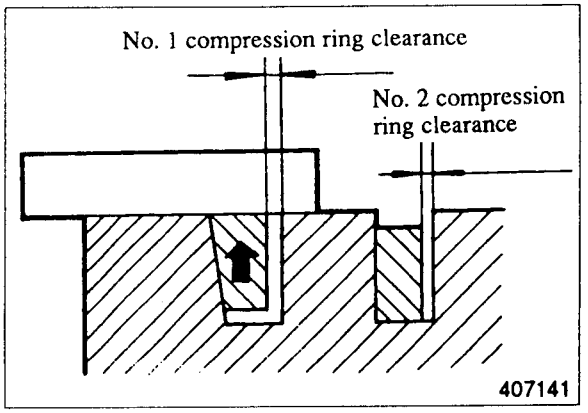
Measuring diameter of piston

(2) Clearance between piston ring and groove

(a) Measure the clearance between the groove and piston with a straight edge and a feeler gauge as shown in the illustration. If the clearance exceeds the limit, replace the ring.

Unit: mm (in.)

Item	Standard	Limit
No. 1 compression ring	0.06 to 0.10 (0.002 4 to 0.003 9)	0.30 (0.011 8)
No. 2 compression ring	0.05 to 0.09 (0.002 0 to 0.003 5)	0.20 (0.007 9)
Oil ring	0.03 to 0.07 (0.001 2 to 0.002 8)	0.20 (0.007 9)



Measuring clearance between piston ring and groove

(b) If the clearance still exceeds the limit after new piston rings have been installed, replace the piston.

(3) Clearance between ends of piston ring

Put the piston ring in a gauge or in the bore in a new cylinder block and measure the clearance between the ends of the ring with a feeler gauge as shown in the illustration. If the clearance exceeds the limit, replace all the rings.

Inside diameter of gauge

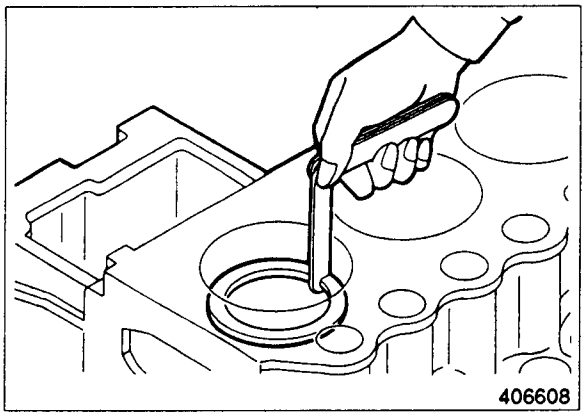
Standard: $78^{+0.03}_{0}$ mm ($3.07^{+0.001\,2}_{0}$ in.)

0.25 mm (0.0098 in.) oversize:

$78.25^{+0.03}_{0}$ mm ($3.08^{+0.001\,2}_{0}$ in.)

0.50 mm (0.0197 in.) oversize:

$78.50^{+0.03}_{0}$ mm ($3.09^{+0.001\,2}_{0}$ in.)



Measuring clearance between ends of piston ring

NOTE

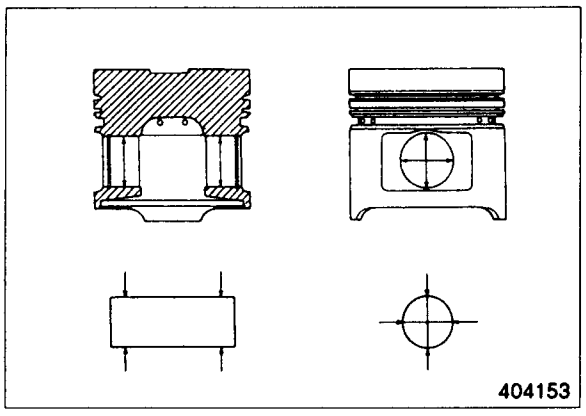
Put the piston ring in the gauge or cylinder squarely with the piston.

Unit: mm (in.)

Item		Standard	Limit
Clearance between ends of piston ring	No. 1 compression ring	0.15 to 0.30 (0.005 9 to 0.011 8)	1.50 (0.059 1)
	No. 2 compression ring	0.15 to 0.35 (0.005 9 to 0.013 8)	
	Oil ring	0.20 to 0.40 (0.007 9 to 0.015 7)	

(4) Clearance between piston pin and piston

Measure the diameter of the piston pin and the bore in the piston for the pin as shown in the illustration to find the clearance. If the clearance exceeds the limit, replace the piston or pin whichever is badly worn.



Measuring piston pin and bore in piston for pin

Unit: mm (in.)

Item	Nominal size	Standard	Limit
Diameter of piston pin	23 (0.91)	22.994 to 23.000 (0.905 27 to 0.905 51)	
Clearance between piston pin and piston	—	0.006 to 0.018 (0.000 24 to 0.000 71)	0.050 (0.001 97)

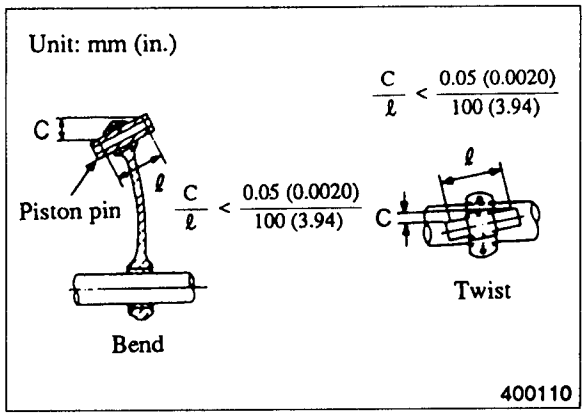
2. Connecting rods

Check the connecting rod for bend or twist as follows:

(a) Measure "C" and "ℓ." If "C" exceeds 0.05 mm (0.0020 in.) per 100 mm (3.94 in.) of "ℓ," straighten the connecting rod with a press.

Unit: mm (in.)

Item	Standard	Limit
Bend or twist of connecting rod	0.05/100 (0.002 0/3.94) maximum	0.15/100 (0.005 9/ 3.94)

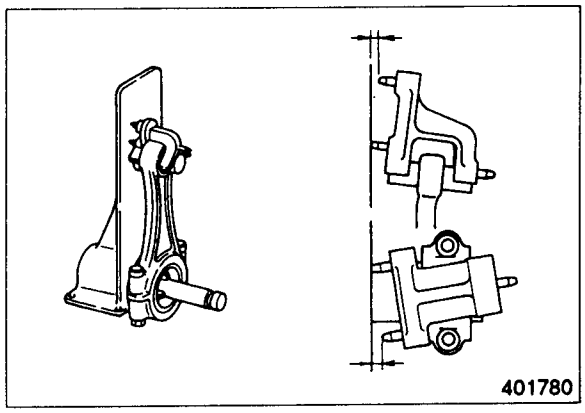


Checking connecting rod for bend or twist

(b) Generally, a connecting rod aligner is used to check the connecting rod for bend or twist.

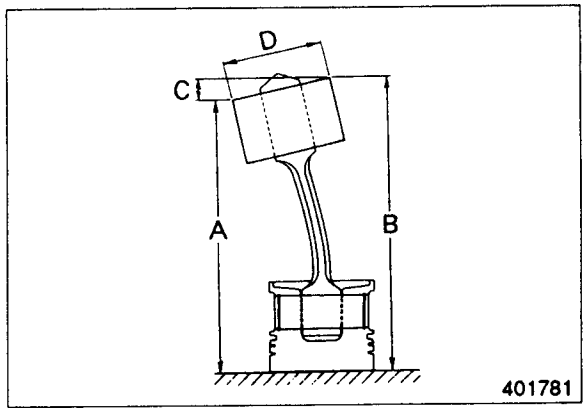
NOTE

To check the rod for bend, install the cap to the connecting rod and tighten the cap nuts to the specified torque.



Check connecting rod on a connecting rod aligner

(c) To check the connecting rod fitted to the piston for bend, put the connecting rod and piston on the surface plate as shown in the illustration, insert a round bar having a diameter equal to that of the crankpin into the bore in the big end of the rod and measure "A" and "B" with a dial indicator. Subtract "A" from "B" to find the bend ("C").



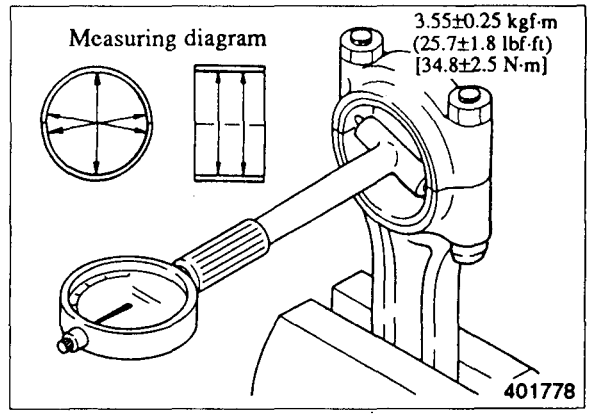
Checking connecting rod for bend with a dial indicator

3. Crankshaft

(1) Clearance between crankpin and connecting rod bearing

(a) Install the bearing (upper and lower halves) and cap to the big end of the connecting rod and tighten the cap nuts to the specified torque. Measure the bore in the bearing for crankpin as shown in the illustration.

Tightening torque	3.55 ± 0.25 kgf·m (25.7 ± 1.8 lbf·ft) [34.8 ± 2.5 N·m]

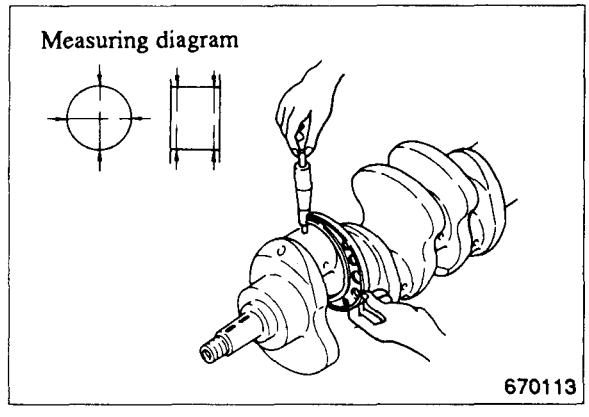


Measuring bore in connecting rod bearing

(b) Measure the diameter of the crankpin as shown in the illustration to find the clearance between the crankpin and connecting rod bearing.

Unit: mm (in.)

Item	Nominal size	Standard	Limit
Diameter of crankpin (standard)	48 (1.89)	47.950 to 47.965 (1.887 79 to 1.888 38)	—
Clearance between crankpin and connecting rod bearing	—	0.025 to 0.072 (0.000 98 to 0.002 83)	0.150 (0.005 91)



Measuring diameter of crankpin

(c) If the clearance exceeds the limit, install a new bearing and check the clearance again.

(d) If the clearance still exceeds the limit, grind the crankpin to 0.25 mm (0.0098 in.), 0.50 mm (0.0197 in.) or 0.75 mm (0.0295 in.) undersize and use undersize connecting rod bearing.

Crankpin undersizes

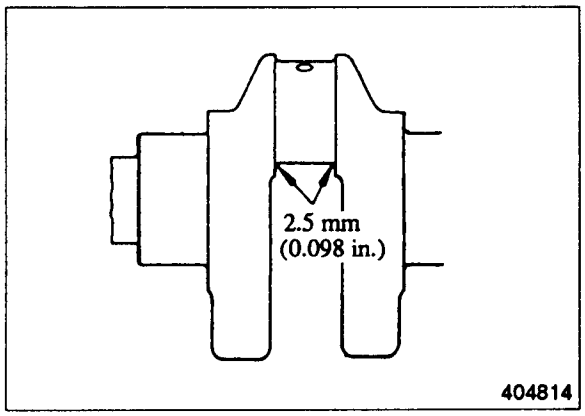
Unit: mm (in.)

Item	Undersize	Finish
Crankpin	0.25 (0.009 8)	$47.75^{-0.035}_{-0.050}$ ($1.879\,9^{-0.001\,38}_{-0.001\,97}$)
	0.50 (0.019 7)	$47.50^{-0.035}_{-0.050}$ ($1.870\,1^{-0.001\,38}_{-0.001\,97}$)
	0.75 (0.029 5)	$47.25^{-0.035}_{-0.050}$ ($1.860\,2^{-0.001\,38}_{-0.001\,97}$)

⚠ CAUTION

a) Grind all the crankpins of one crankshaft to the same undersize.

b) Finish the crankpin fillets to a radius of 2.5 mm (0.098 in.).

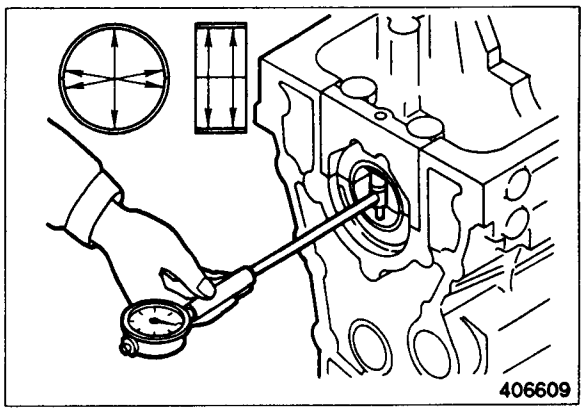


Crankpin fillet radius

(2) Clearance between journal and main bearing

(a) Install the main bearing (upper and lower halves) and cap to the cylinder block and tighten the cap bolts to the specified torque. Measure the bore in the bearing for the journal as shown in the illustration.

Tightening torque	5.25 ± 0.25 kgf·m (38 ± 1.8 lbf·ft) [51.5 ± 2.5 N·m]

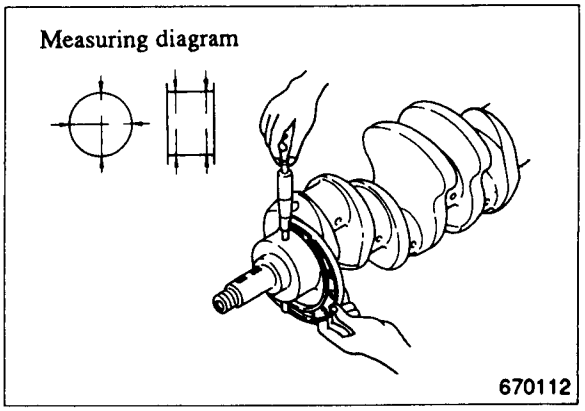


Measuring bore in main bearing

(b) Measure the diameter of the journal as shown in the illustration to find the clearance between the journal and main bearing.

Unit: mm (in.)

Item	Nominal size	Standard	Limit
Diameter of journal (standard)	52 (2.05)	51.985 to 52.000 (2.046 65 to 2.047 24)	—
Clearance between journal and main bearing	—	0.030 to 0.077 (0.001 18 to 0.003 03)	0.100 (0.003 94)



Measuring diameter of journal

(c) If the clearance exceeds the limit, install a new bearing and check the clearance again.

(d) If the clearance still exceeds the limit, grind the journal to 0.25 mm (0.009 8 in.), 0.50 mm (0.019 7 in.) or 0.75 mm (0.029 5 in.) undersize and use undersize main bearing.

Journal undersizes

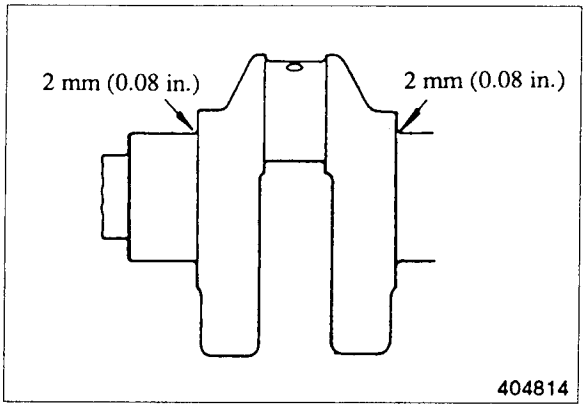
Unit: mm (in.)

Item	Undersize	Finish
Journal	0.25 (0.009 8)	$51.75^{0}_{-0.015}$ ($2.037\,4^{0}_{-0.000\,59}$)
	0.50 (0.019 7)	$51.50^{0}_{-0.015}$ ($2.027\,6^{0}_{-0.000\,59}$)
	0.75 (0.029 5)	$51.25^{0}_{-0.015}$ ($2.017\,7^{0}_{-0.000\,59}$)

⚠ CAUTION

a) Grind all the journals of one crankshaft to the same undersize.

b) Finish the journal fillets to a radius of 2 mm (0.08 in.).



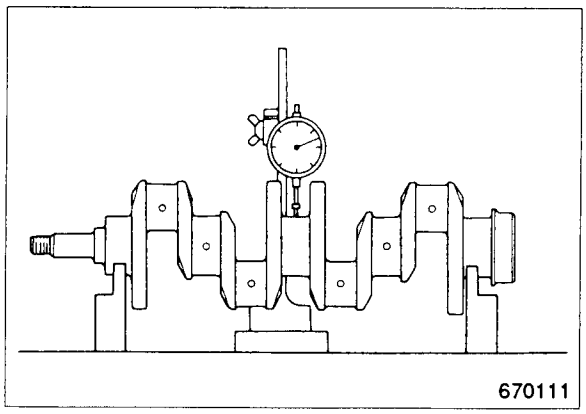
Journal fillet radius

(3) Runout

Support the crankshaft on its front and rear journals in V-blocks or in a lathe and check runout at the center journal with a dial indicator as shown in the illustration. Depending on the amount of runout, repair the crankshaft by grinding or by straightening with a press. If runout exceeds the limit, replace the crankshaft.

Unit: mm (in.)

Item	Standard	Limit
Crankshaft runout	0.025 (0.000 98)	0.05 (0.002 0)



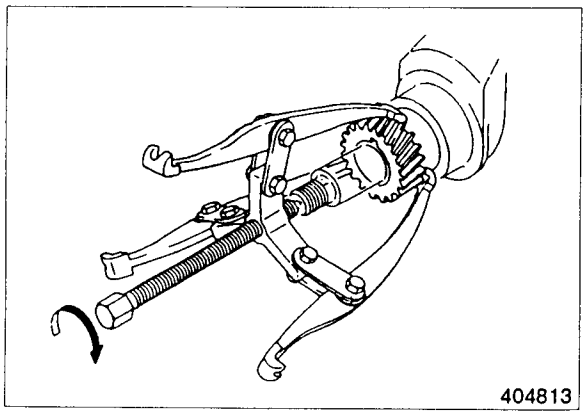
Checking crankshaft runout

(4) Crankshaft gear removal

Use a gear puller to remove the gear from the crankshaft.

NOTE

Do not remove the gear unless the gear or crankshaft is defective.

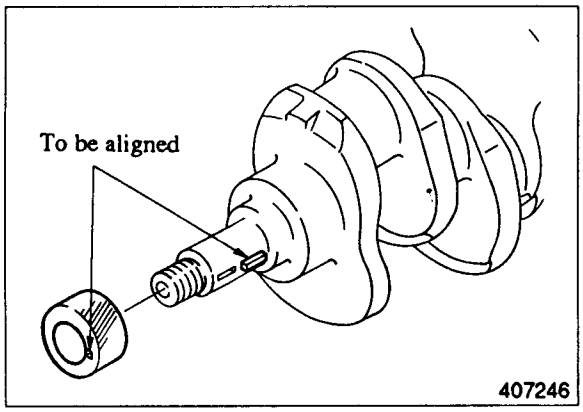


Removing crankshaft gear

(5) Crankshaft gear installation

(a) Install the key in position on the crankshaft.

(b) Install the gear in position with its keyway in alignment with the key as shown in the illustration.



Installing crankshaft gear

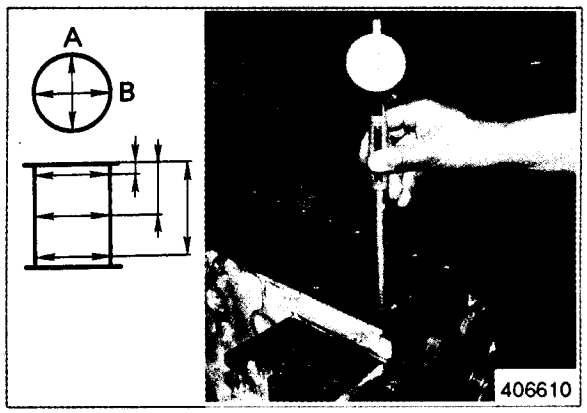
4. Cylinder block

(1) Bore

Measure the bore at the top, middle and bottom points on axes A and B with a cylinder bore gauge as shown in the illustration. If any one of the cylinders exceeds the limit, hone out all the bores for oversize pistons.

Unit: mm (in.)

Piston and piston ring		Bore	
Size	Size code	Standard	Limit
Standard	STD	$78^{+0.03}_{0}$ ($3.07^{+0.001\,2}_{0}$)	Standard: +0.2 (+0.008)
0.25 (0.009 8) oversize	25	$78.25^{+0.03}_{0}$ ($3.080\,7^{+0.001\,2}_{0}$)	
0.50 (0.019 7) oversize	50	$78.50^{+0.03}_{0}$ ($3.090\,5^{+0.001\,2}_{0}$)	
Taper and out-of-round		0.01 (0.000 4) maximum	—



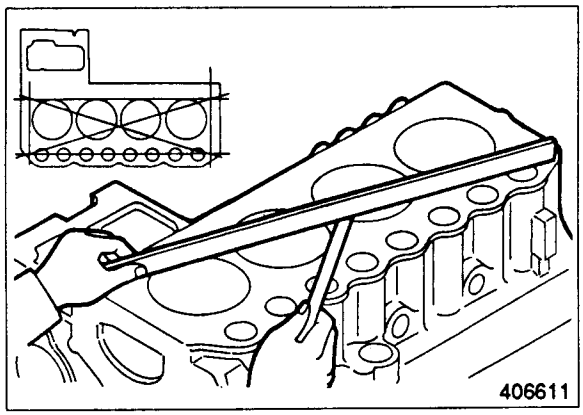
Measuring bore in cylinder block

(2) Warpage of top face

Using a heavy accurate straight edge and a feeler gauge, check the top face for warpage in two positions lengthwise, two crosswise and two widthwise as shown in the illustration. If warpage exceeds the limit, reface the top face with a surface grinder.

⚠ CAUTION

The maximum permissible amount of stock to be removed from the cylinder head and block by grinding is 0.2 mm (0.008 in.) in total.



Checking cylinder block top face for warpage

Unit: mm (in.)

Item	Standard	Limit
Warpage of cylinder block top face	0.05 (0.002 0) maximum	0.10 (0.003 9)

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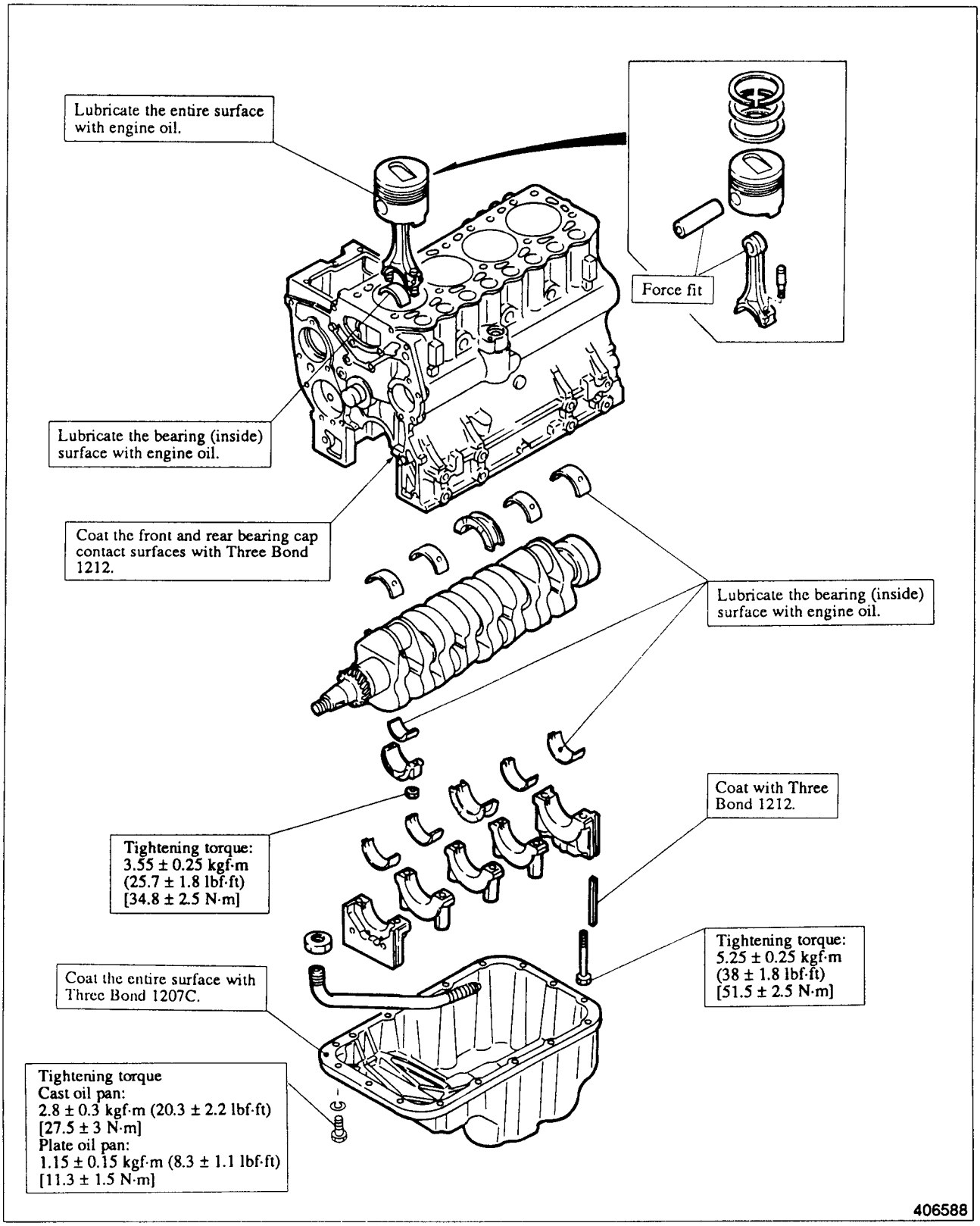
ASSEMBLY

CYLINDER BLOCK, CRANKSHAFT, PISTONS AND OIL PAN



Inspection points

1. Main bearing installation

(1) Install the upper halves of the main bearings in the cylinder block and the lower halves in the main bearing caps so their tabs fit into the notches in the cylinder block and the main bearing caps.

(2) Install the flanged bearing in the No. 3 journal.

(3) Lightly lubricate the inside surfaces of the bearings with engine oil.

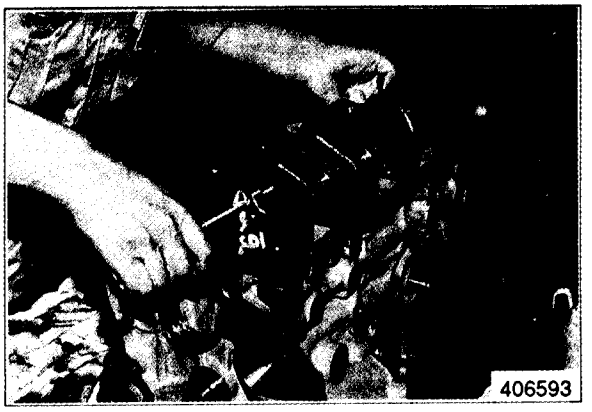
Installing main bearings

2. Crankshaft installation

(1) Clean the crankshaft with cleaning solvent and blow dry with compressed air.

(2) Fasten a hoist to the crankshaft and hold it in horizontal position. Carefully put the crankshaft in position in the cylinder block.

(3) Lightly lubricate the crankshaft journals with engine oil.



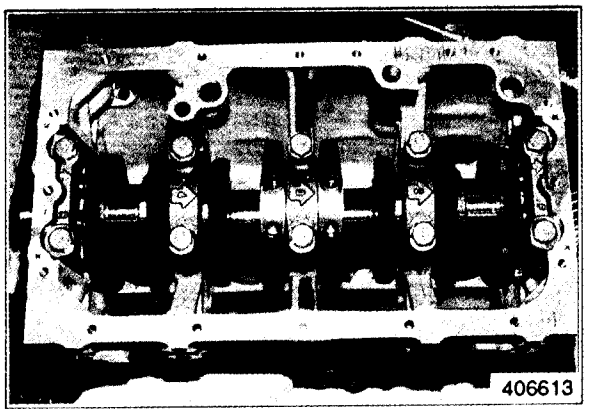
Installing crankshaft

3. Main bearing cap installation

(1) Coat the mating surfaces of the rear bearing cap and cylinder block with Three Bond 1212.

(2) Install the main bearing caps in position. Make sure the number (arrow head) on the main bearing cap is toward the front of the engine.

(3) Tighten the main bearing cap bolts finger tight only.



Main bearing caps installed

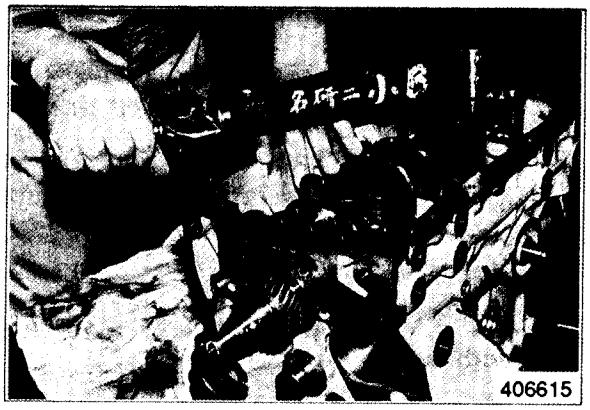
⚠CAUTION

Install the front and rear bearing caps in position so their end faces are even with the end faces of the cylinder block.

Installing front and rear bearing caps

(4) Tighten the bolts holding the main bearing caps in steps to the specified torque.

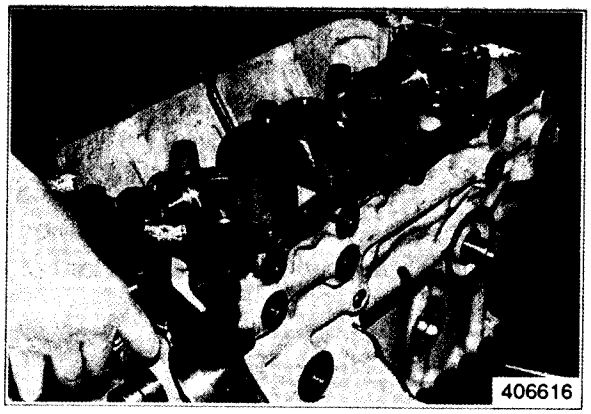
Tightening torque	5.25 ± 0.25 kgf·m (38 ± 2 lbf·ft) [51.5 ± 2.5]



Tightening bolts holding main bearing caps

(5) Make sure the crankshaft rotates freely without binding or catching.

(6) Measure the end play for the crankshaft. Make reference to "End play measurement for crankshaft" (page 42). If the end play is incorrect, loosen the bolts holding the main bearing caps once and tighten them again.

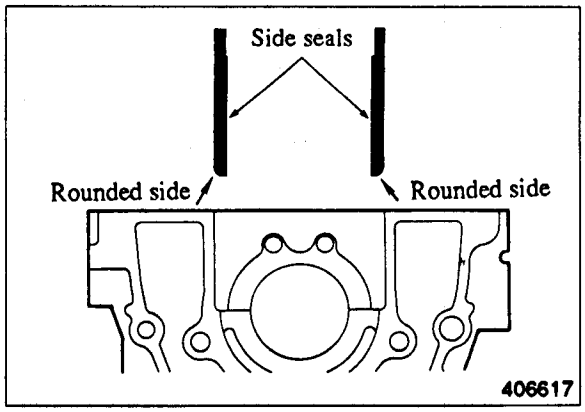


Checking crankshaft for rotation

4. Side seal installation

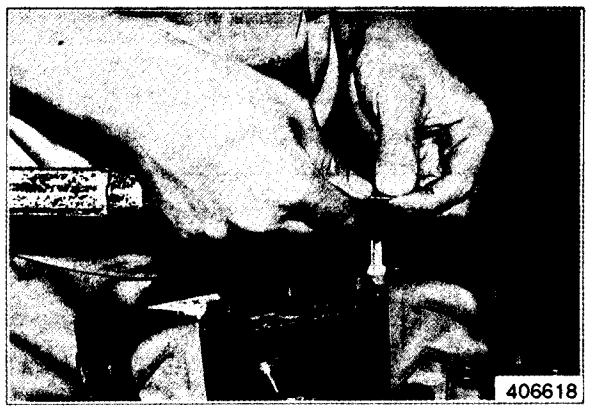
(1) Coat the side seals with Three Bond 1212.

(2) Insert the side seals between the cylinder block and the front and rear caps and push in them by hand as far as possible, with their rounded side toward the outside of the cylinder block.



Side seals

(3) Using a flat plate, push the seals into position, taking care not to bend them.

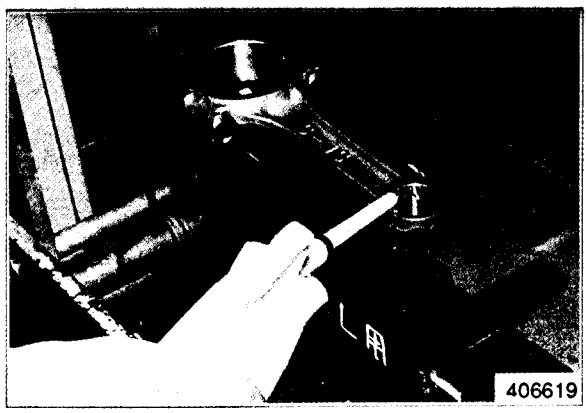


Installing side seals

5. Piston assembling to connecting rod

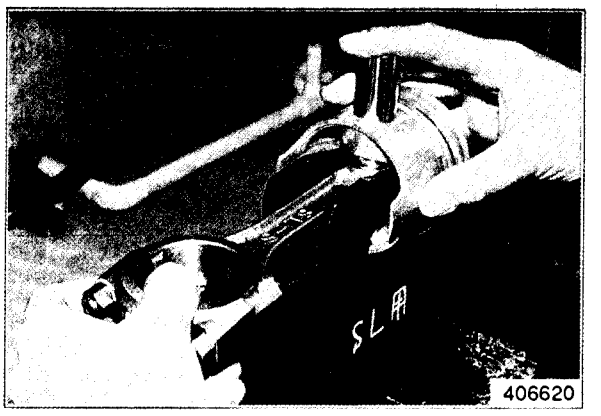
(1) Set Piston Setting Tool (31A91-00100) (special tool) in a hydraulic press.

(2) Put the connecting rod on the Tool and lubricate the bore in the rod for the piston pin with engine oil.



Connecting rod on Piston Setting Tool

(3) Put the piston in position on the connecting rod, making sure the model identification on the rod is on the same side as the arrow head on the top of the piston. Put the piston pin in position.

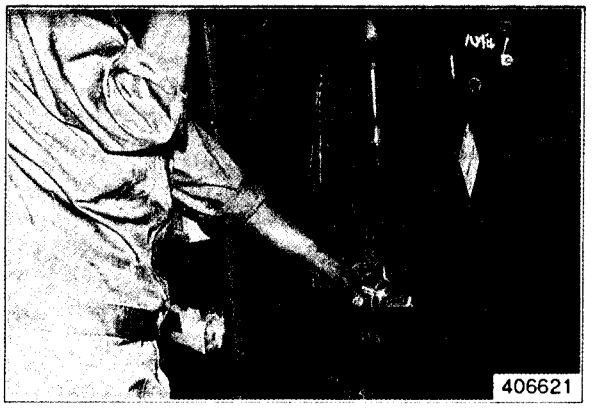


Installing piston pin

(4) Insert the push rod of the Tool into the bore in the piston for the piston pin and press the pin with the press.

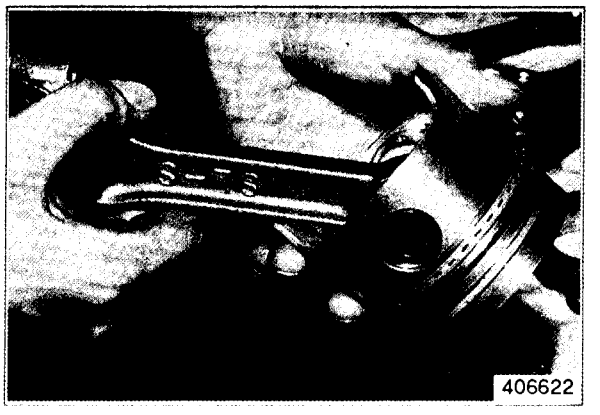
⚠ CAUTION

Observe the indicator of the press when pressing the piston pin. If the force of the press is ready to exceed 50 kgf (110 lbf) [490 N], stop pressing the pin and check the bores in the piston and connecting rod for alignment.



Pressing piston pin

(5) After assembling the piston and connecting rod, make sure the connecting rod moves freely.



Checking piston and connecting rod

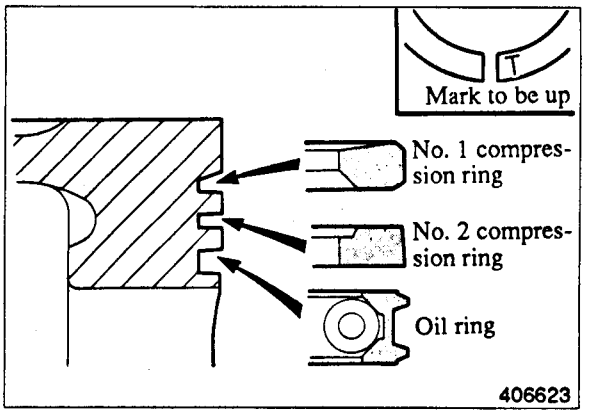
6. Piston ring installation

Using a piston ring pliers, install the piston rings on the piston.

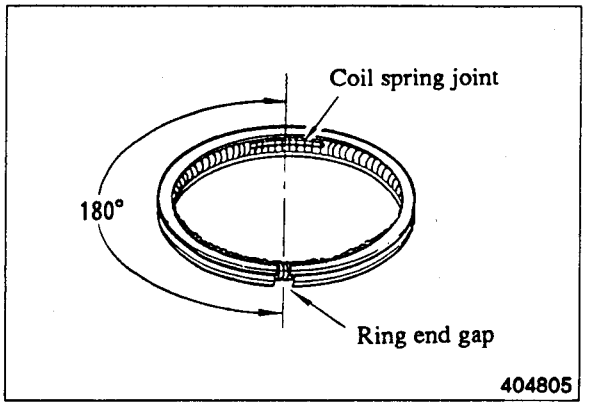
NOTE

a) The piston rings must be installed with the side that has the mark "T" toward the top of the piston.

b) The oil ring must be installed with the ring end gap 180° apart from the coil spring joint.



Piston rings



Oil ring

7. Piston and connecting rod installation

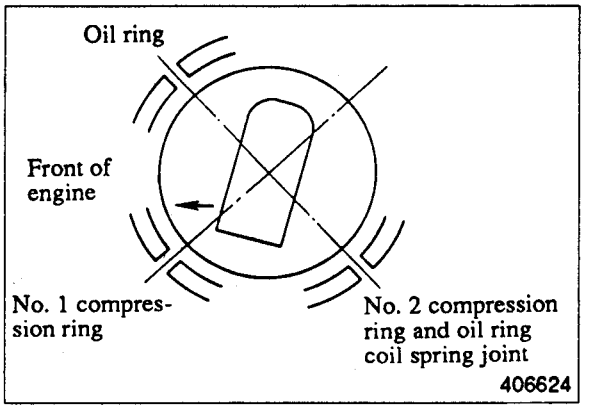
(1) Lubricate the piston and piston rings with engine oil.

(2) Move the piston rings on the piston so that the end gaps are apart from a direction parallel to, or transverse to, the piston pin.

(3) Install the connecting rod bearing (upper half) to the rod, making sure the tab in the back of the bearing is in the notch of the connecting rod.

(4) Turn the crankshaft until the crankpin for the piston and connecting rod to be installed is at the top center.

(5) Hold the piston and connecting rod with "FRONT" mark (arrow head) on the top of the piston toward the front (timing gear case side) of the engine.



Relative location of piston ring end gaps

(6) Using a piston guide (commercially available), put the piston and connecting rod into the cylinder from the top of the cylinder block.

⚠CAUTION

Do not hit the piston with a hammer to install the piston and connecting rod. This will put force on the piston and connecting rod and cause damage to the piston rings and crankpin.

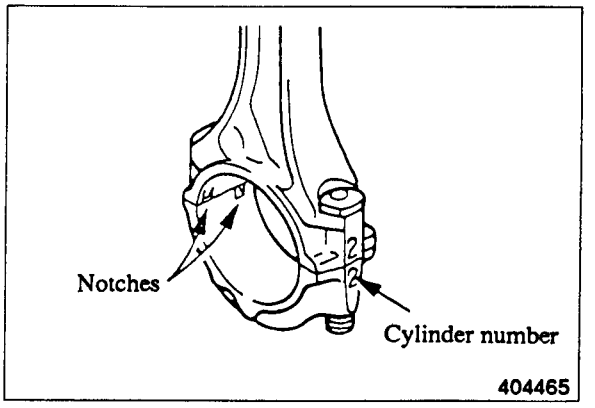
Installing piston and connecting rod

8. Connecting rod cap installation

(1) Push the piston into position until the big end of the connecting rod is put into position over the crankpin. Then turn the crankshaft 180° while pushing on the top of the piston.

(2) Install the lower half of the connecting rod bearing in the connecting rod cap, making sure the tab in the back of the bearing is in the notch of the cap.

(3) Install the bearing cap to the connecting rod.

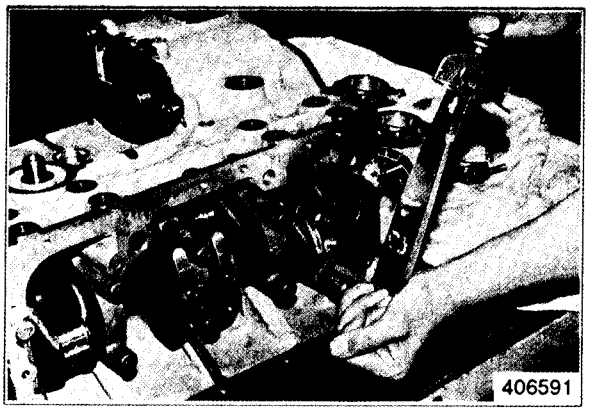


Installing connecting rod cap

NOTE

a) Make sure the number on the cap is the same as the number on the connecting rod.

b) In case of a new connecting rod having no cylinder number, install the cap to the rod with the notches on the same side.



Tightening connecting rod cap nuts

(4) Tighten the connecting rod cap nuts in steps to the specified torque.

Tightening torque	3.55 ± 0.25 kgf·m (25.7 ± 2 lbf·ft) [34.8 ± 2.5 N·m]

(5) Check the thrust clearance for the connecting rod big end.

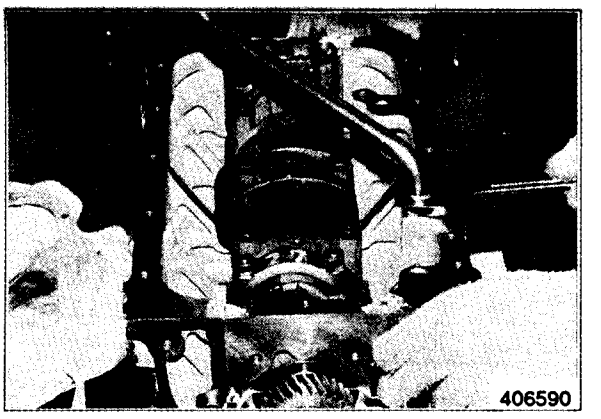
9. Oil screen installation

(1) Lay the cylinder block with the bottom (oil pan side) up.

(2) Install the oil screen in position.

NOTE

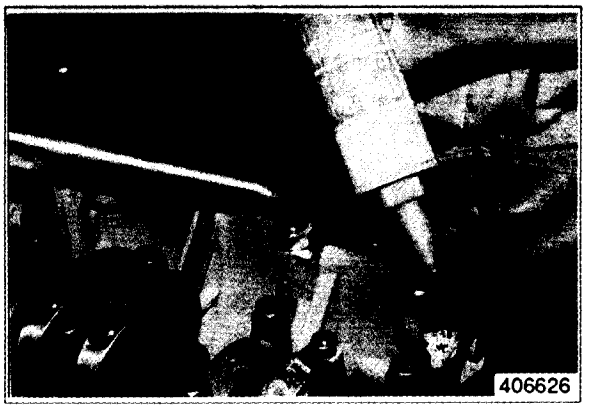
The oil screen must be installed in position so that it is below the oil level line and away from the oil pan.



Installing oil screen

10. Oil pan installation

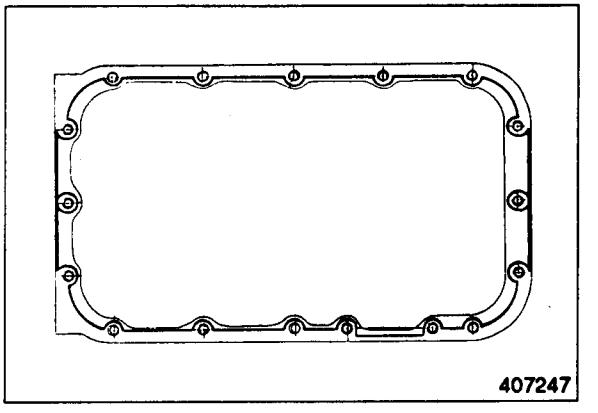
(1) Clean the mating surfaces of the oil pan and cylinder block and coat them with Three Bond 1207C.



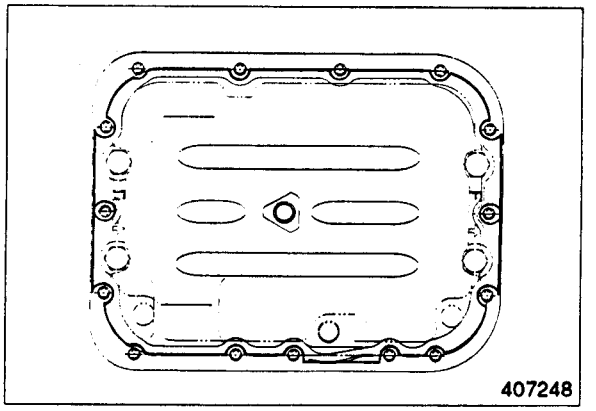
Coating mating surfaces with adhesive

NOTE

Squeeze out a 4 mm (0.2 in.) thick bar of sealing compound (Three Bond) from the tube and put it on the flange of the oil pan as shown.

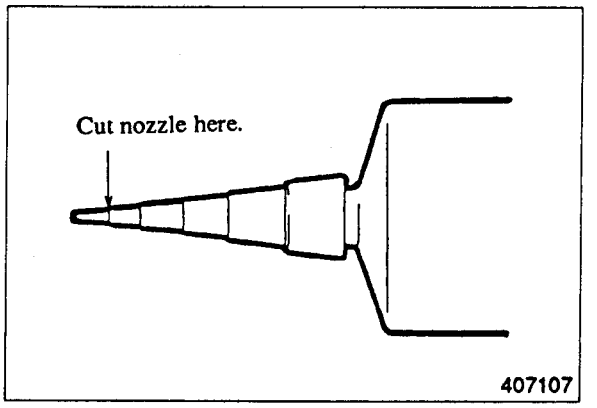


Oil pan for S4L and S4L2 engines



Oil pan for S3L and S3L2 engines

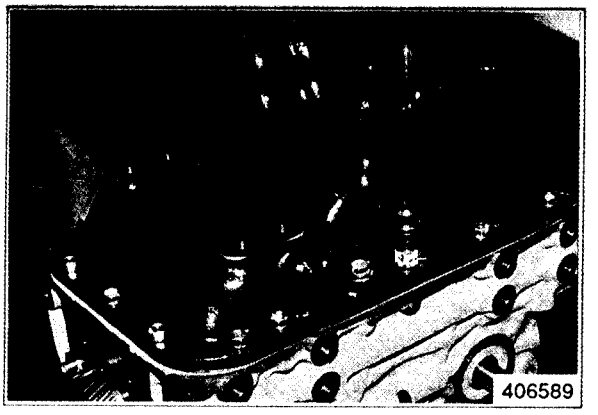
To squeeze out a 4 mm (0.2 in.) thick bar, cut the nozzle of the tube as shown.



Cutting sealing compound tube nozzle

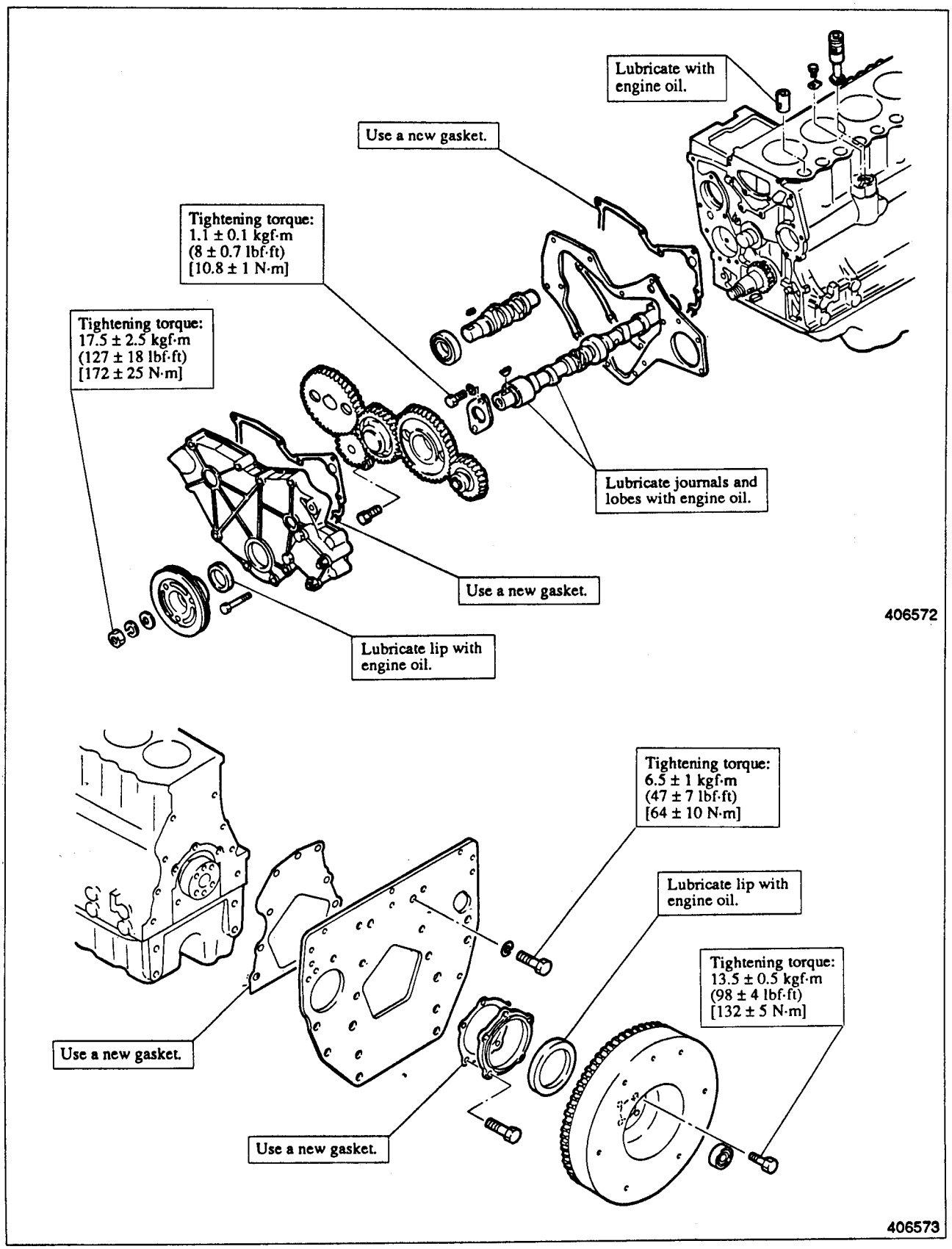
(2) Tighten the bolts that hold the oil pan to the cylinder block in a crisscross pattern to the specified torque.

Tightening torque	Cast oil pan: 2.8 ± 0.3 kgf·m (20.3 ± 2.2 lbf·ft) [27.5 ± 3 N·m] Plate oil pan: 1.15 ± 0.15 kgf·m (8.3 ± 1.1 lbf·ft) [11.3 ± 1.5 N·m]



Tightening oil pan bolts

TIMING GEARS AND FLYWHEEL



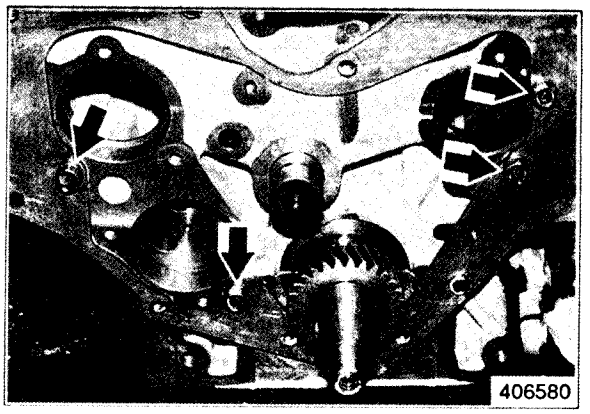
Inspection points

1. Front plate installation

(1) Scrape the gasket from the cylinder block and front plate.

(2) Coat the gasket contact surface of cylinder block with adhesive and put a new gasket in position, making sure the holes in the gasket are all in alignment with the holes in the cylinder block.

(3) Put the front plate in position. Install four bolts and tighten them.



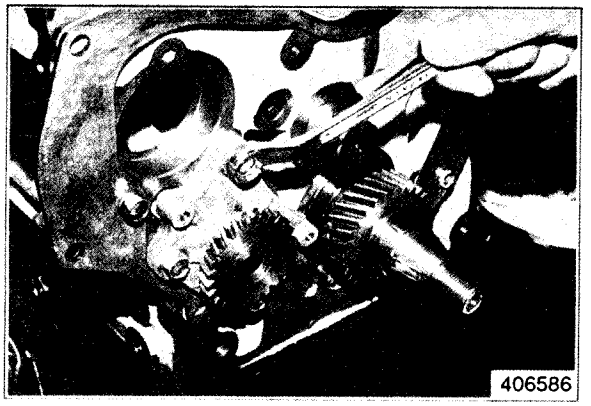
Installing front plate

2. Oil pump installation

(1) Make sure the packing has been put in position on the oil pump.

(2) Put the oil pump in position on the cylinder block. Install three bolts and tighten them evenly.

(3) Make sure the oil pump gear rotates freely.

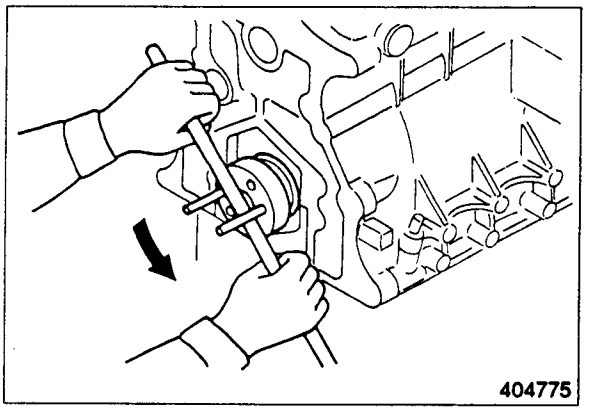


Installing oil pump

3. Engine turning

(1) Install two bolts (M12 x 1.25) in the flywheel bolt holes in the crankshaft.

(2) Put a bar between the bolts and turn the crankshaft to bring No. 1 piston to the top center as shown in the illustration.



Turning engine

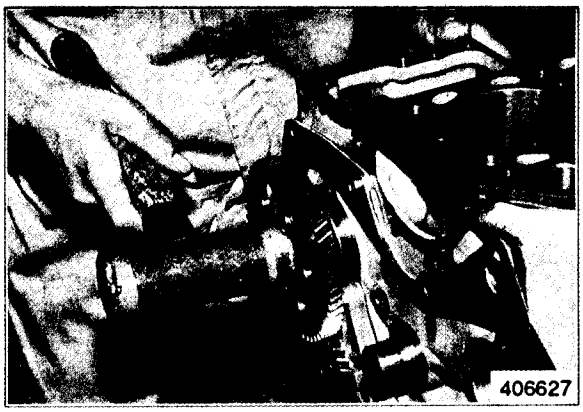
4. Fuel injection pump camshaft installation

(1) Put the camshaft (with bearing and gear) in position in the cylinder block.

(2) Hit the gear with a plastic hammer to fit the bearing in position.

(3) Make sure the camshaft rotates freely.

(4) Tighten the stopper bolt.



Installing fuel injection pump camshaft

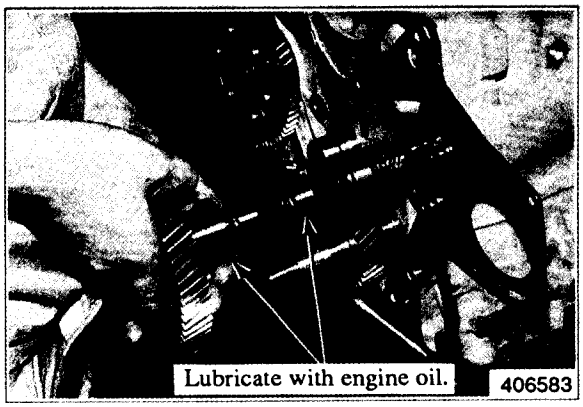
5. Camshaft installation

(1) Lubricate the lobes and journals with engine oil.

(2) Put the camshaft (with gear) in position in the cylinder block.

⚠ CAUTION

Do not cause damage to the lobes and journals when the camshaft is installed.

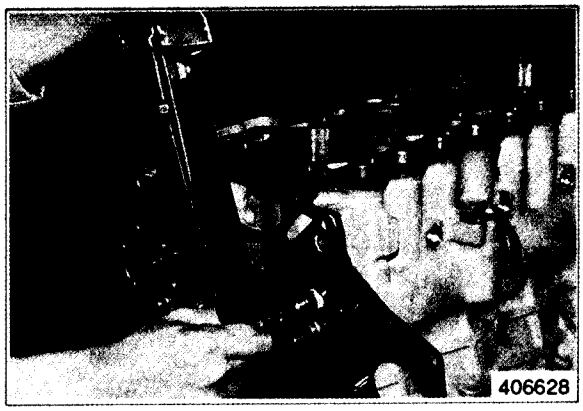


Installing camshaft

(3) Tighten the bolts that hold the thrust plate to the specified torque.

Tightening torque	1.1 ± 0.1 kgf·m (8 ± 0.7 lbf·ft) [10.8 ± 1 N·m]

(4) Make sure the camshaft rotates freely. Check the end play for the camshaft.



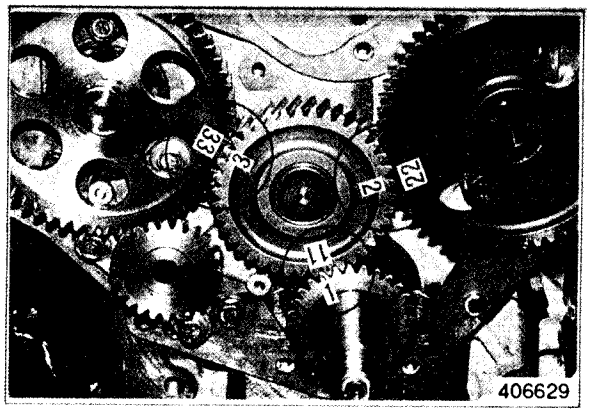
Installing thrust plate

6. Idler gear installation

(1) Lubricate the idler gear with engine oil.

(2) Install the idler gear in position with its "3," "2" and "11" marks in alignment with the "33" mark on the fuel injection pump camshaft gear, the "22" mark on the camshaft gear and the "1" mark on the crankshaft gear respectively.

(3) Check the backlash of the gears. Make reference to "Timing gear backlash measurement" (page 37).



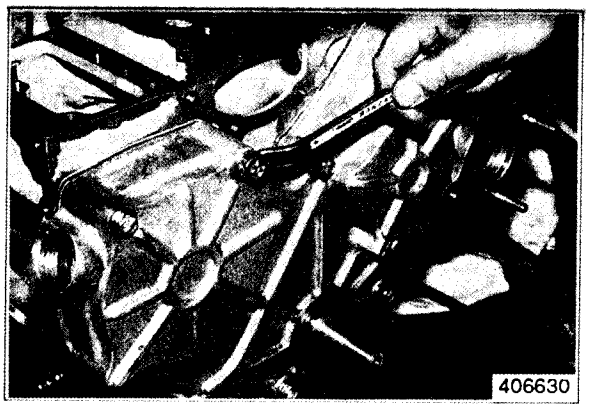
Marks on timing gears

7. Timing gear case installation

(1) Coat the gasket with adhesive and put it in position on the front plate.

(2) Lubricate the oil seal lip with engine oil.

(3) Tighten the bolts that hold the timing gear case.



Installing timing gear case

8. Crankshaft pulley nut tightening

(1) Install two bolts (M12 x 1.25) in the flywheel bolt holes in the crankshaft and hold the crankshaft.

(2) Tighten the crankshaft pulley nut to the specified torque.

Tightening torque	17.5 ± 2.5 kgf·m (127 ± 18 lbf·ft) [172 ± 25 N·m]

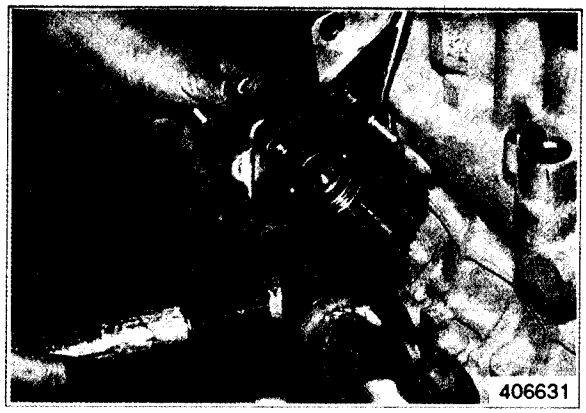
⚠ WARNING

Check the strength of the bolts and bar used for holding the crankshaft.

Tightening crankshaft pulley nut

9. P.T.O. gear installation

Install the P.T.O. gear in position in the timing gear case with the side that has no oil hole toward the rear of the engine.

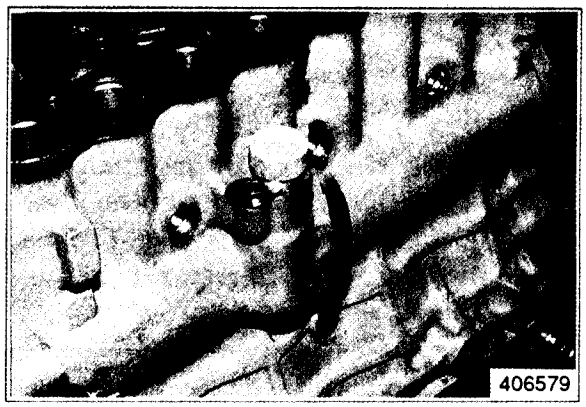


Installing P.T.O. gear

10. Speedometer driven gear installation

(1) Install the O-ring in the groove in the driven gear sleeve.

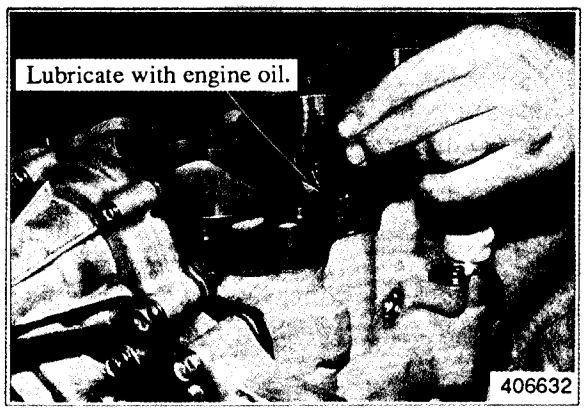
(2) Install the speedometer driven gear in position in the cylinder block while rotating it or the camshaft.



Installing speedometer driven gear

11. Tappet installation

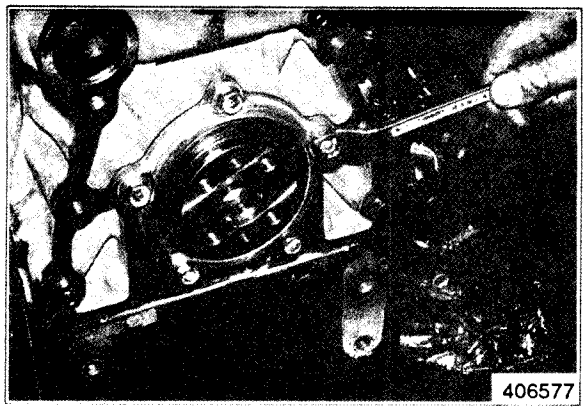
Lubricate the tappets with engine oil and put them in position in the cylinder block.



12. Oil seal case installation

(1) Put a new gasket in position on the oil seal case.

(2) Lubricate the oil seal lip with engine oil and install the oil seal in position in the cylinder block.



Installing oil seal case

13. Rear plate installation

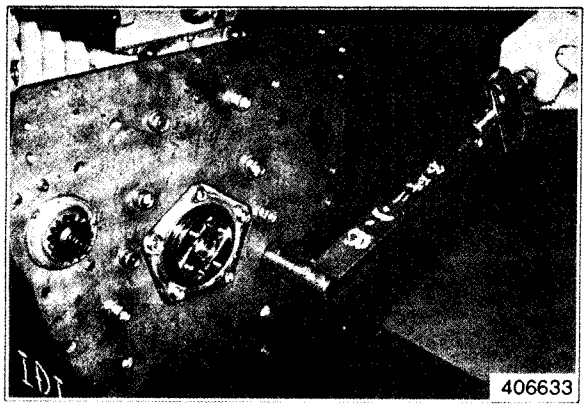
(1) Put a new gasket in position on the rear plate.

(2) Put the rear plate in position on the cylinder block with its dowel holes in alignment with the dowels. Tighten the bolts that hold the rear plate to the specified torque.

Tightening torque	6.5 ± 1 kgf·m (47 ± 7 lbf·ft) [64 ± 10 N·m]

NOTE

Install the starter to the rear plate before installing the plate to the cylinder block for convenience of rear plate installation.



Installing rear plate

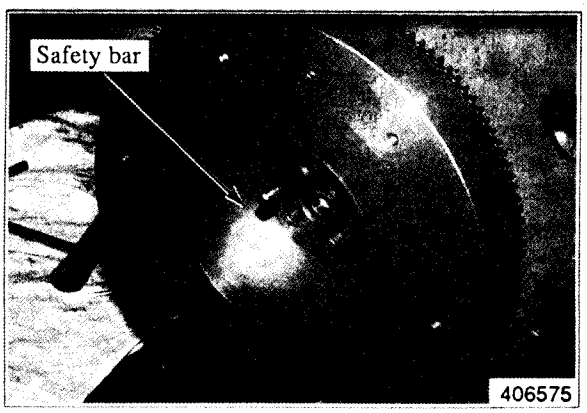
14. Flywheel installation

(1) Install a safety bar (M12 x 1.25) in the rear end of the crankshaft.

(2) Put the flywheel in position in alignment with the safety bar.

(3) Install three of four bolts in the flywheel and tighten them finger tight only.

(4) Remove the safety bar. Install the last bolt in the flywheel and tighten it finger tight only.



Safety bar

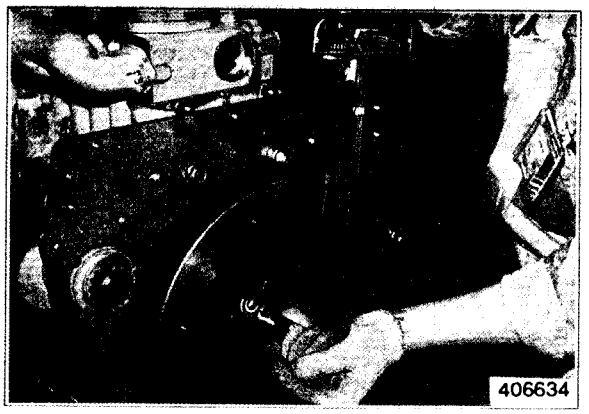
(5) Have someone hold the crankshaft pulley with a wrench to prevent the flywheel from rotating.

(6) Tighten the four bolts that hold the flywheel to the specified torque.

Tightening torque	13.5 ± 0.5 kgf·m (98 ± 4 lbf·ft) [132 ± 5 N·m]

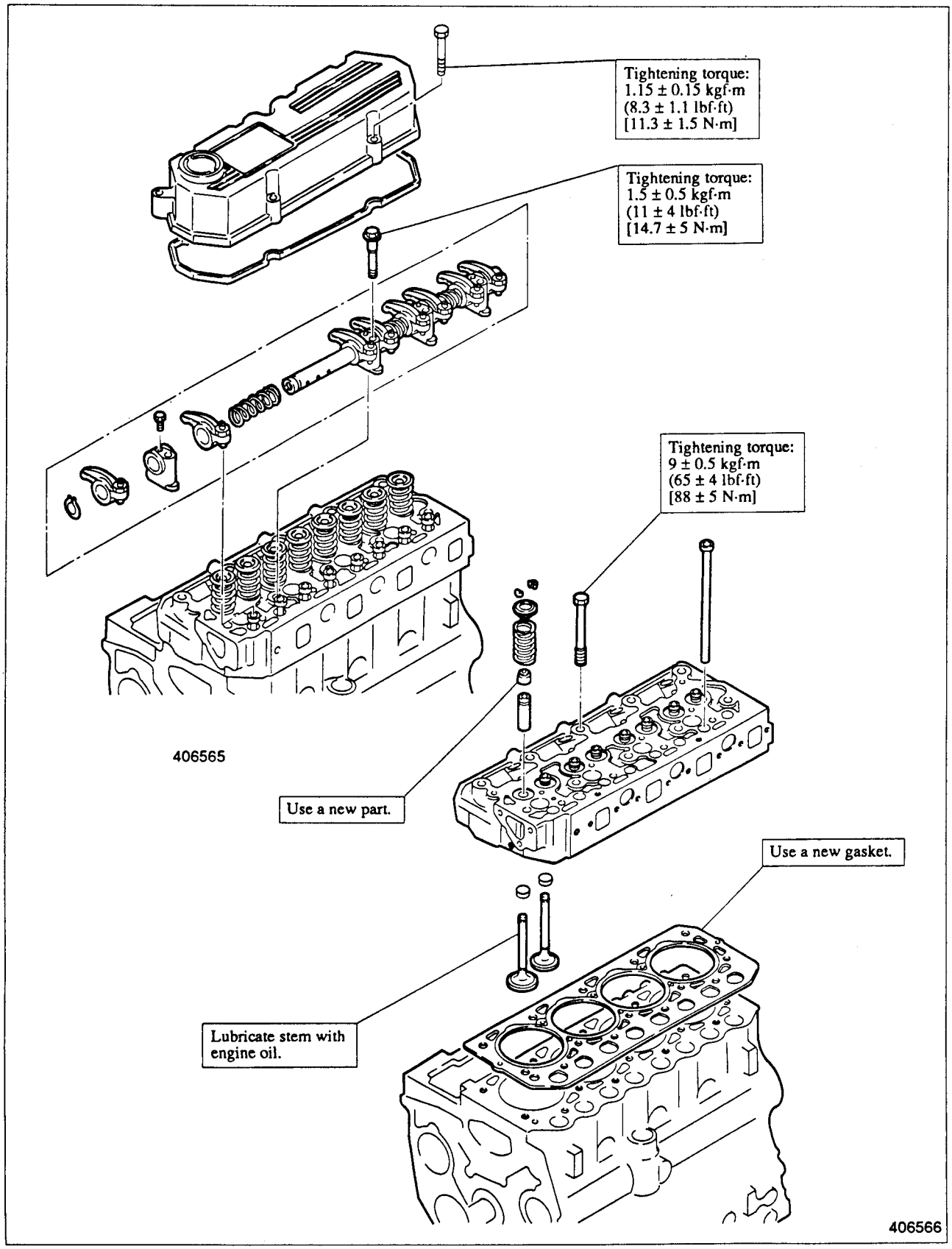
⚠ WARNING

Always signal each other to prevent possible personal injury.



Tightening flywheel bolts

CYLINDER HEAD AND VALVE MECHANISM



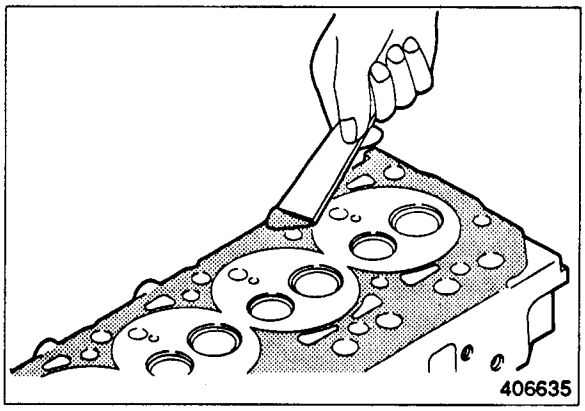
Inspection points

1. Cylinder head bottom face cleaning

Scrape the gasket from the bottom face of the cylinder head.

NOTE

After scraping the gasket, rub off gasket remnants from the face with an oilstone smeared with engine oil and thoroughly clean the face.



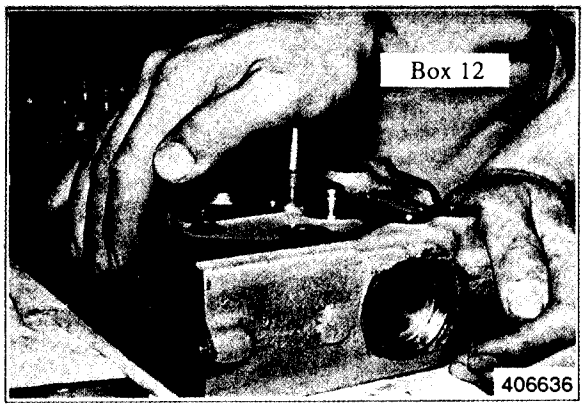
Removing cylinder head gasket

2. Valve stem seal installation

Using Box 12, install the valve stem seal in position in the valve guide. After installation, make sure the seal is in its correct position.

NOTE

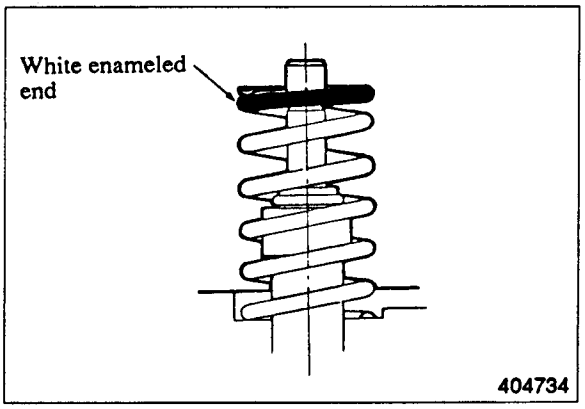
Improper stem seal installation can cause a failure to seal against downward flow of oil along the stem.



Installing valve stem seal

3. Valve spring installation

Install the valve spring with the white enameled end up.



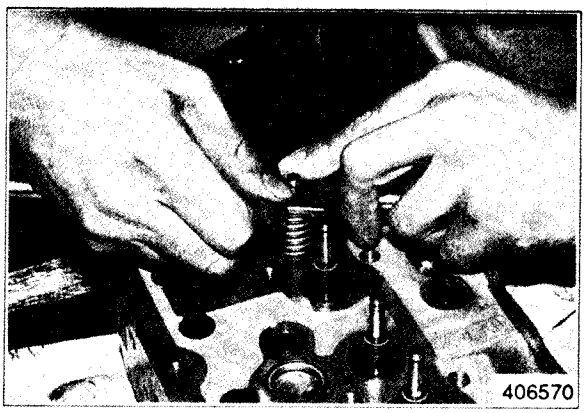
Installing valve spring

4. Valve block installation

Put compression on the valve spring with a valve lifter and install the block in position on the valve top.

⚠CAUTION

Do not put excessive compression on the valve spring. This can cause the retainer to hit and damage the stem seal.



Installing valve block

5. Cylinder head gasket installation

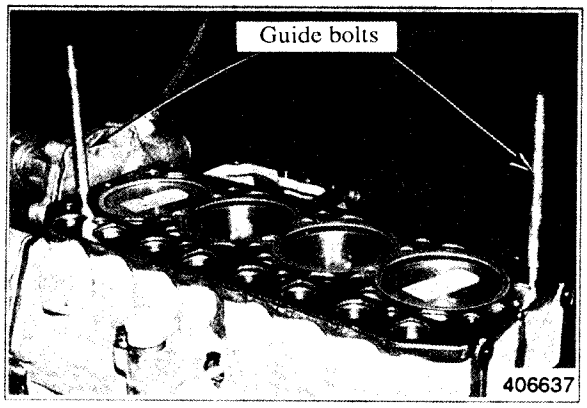
(1) Thoroughly clean the top faces of the cylinder block and pistons.

(2) Install two guide bolts (M10 x 1.25) in the bolt holes in the cylinder block.

(3) Put a new cylinder head gasket in position on the cylinder block, making sure the guide bolts are all in alignment with their respective holes in the gasket.

⚠CAUTION

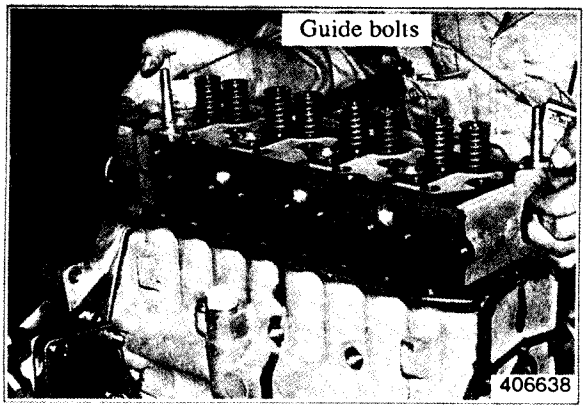
Do not use any gasket adhesive or other substances on the top face of the cylinder block.



Putting cylinder head gasket

6. Cylinder head installation

Put the cylinder head in position on the cylinder block, making sure the guide bolts are all in alignment with their respective bolt holes in the head.



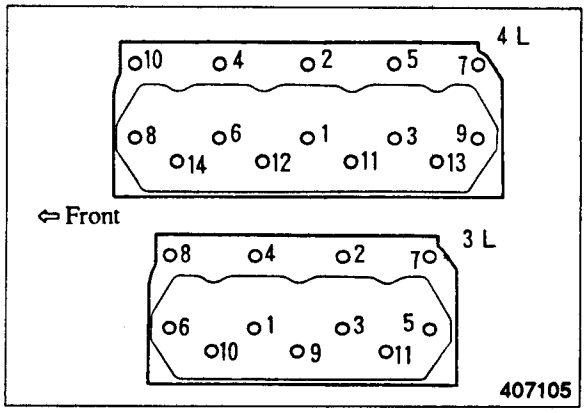
Installing cylinder head

7. Cylinder head bolt tightening

(1) Remove the guide bolts and install the bolts that hold the cylinder head to the cylinder block.

(2) Tighten the bolts in number sequence in two or three steps to the specified torque.

Tightening torque	9 ± 0.5 kgf·m (65 ± 4 lbf·ft) [88 ± 5 N·m]

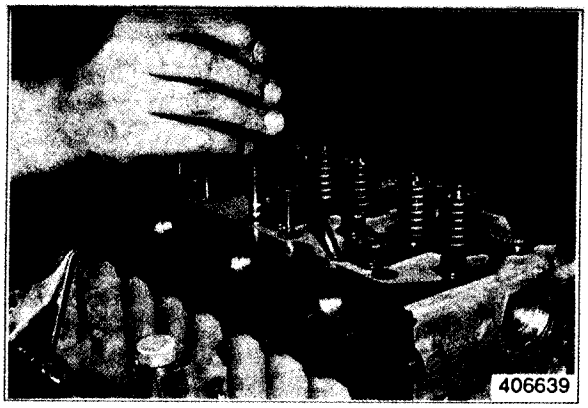


Tightening sequence

8. Valve push rod installation

(1) Put the valve push rod into position through the bore in the cylinder head.

(2) Make sure the ball end of the push rod has been put into position over the top of the tappet.



Installing valve push rods

9. Rocker shaft assembling

(1) Install the rocker arms, brackets and springs on the rocker shaft. Secure the brackets to the shaft by tightening the bolts.

(2) Make sure the rocker arms move freely.

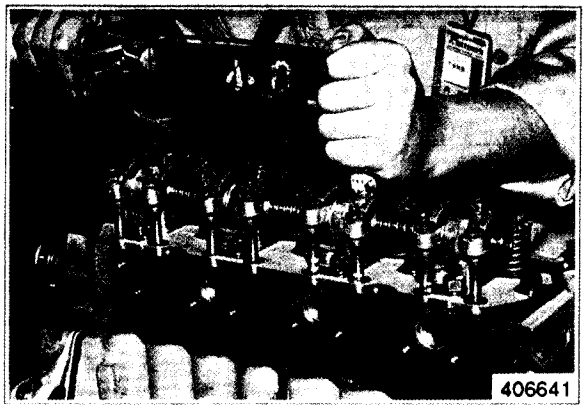
Assembling rocker arms

10. Rocker shaft assembly installation

(1) Install the valve caps in position on the top of the valves.

(2) Put the rocker shaft assembly in position on the cylinder head. Tighten the bolts that hold the rocker shaft assembly to the specified torque.

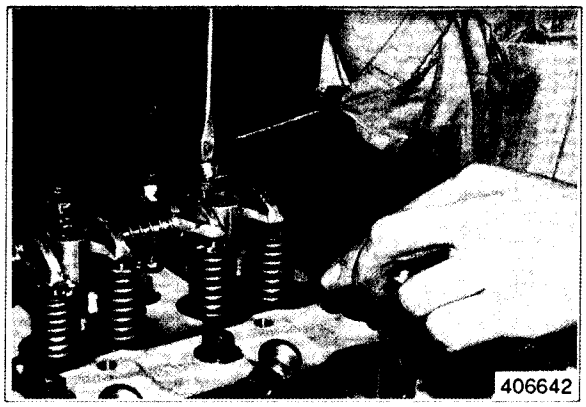
Tightening torque	1.5 ± 0.5 kgf·m (11 ± 4 lbf·ft) [14.7 ± 5 N·m]



Installing rocker shaft assembly

11. Valve clearance adjustment

Make reference to "VALVE CLEARANCE" (page 159).



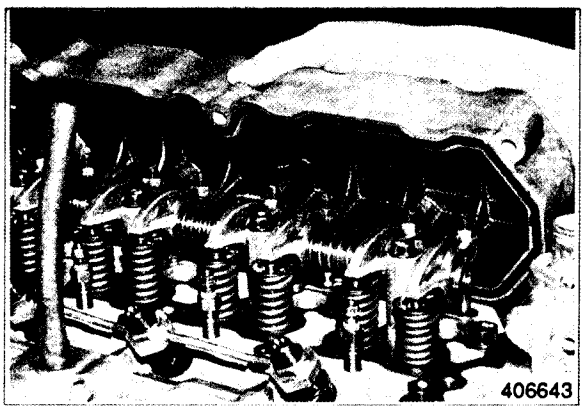
Adjusting valve clearance

12. Rocker cover installation

(1) Make sure the gasket is put on the rocker cover.

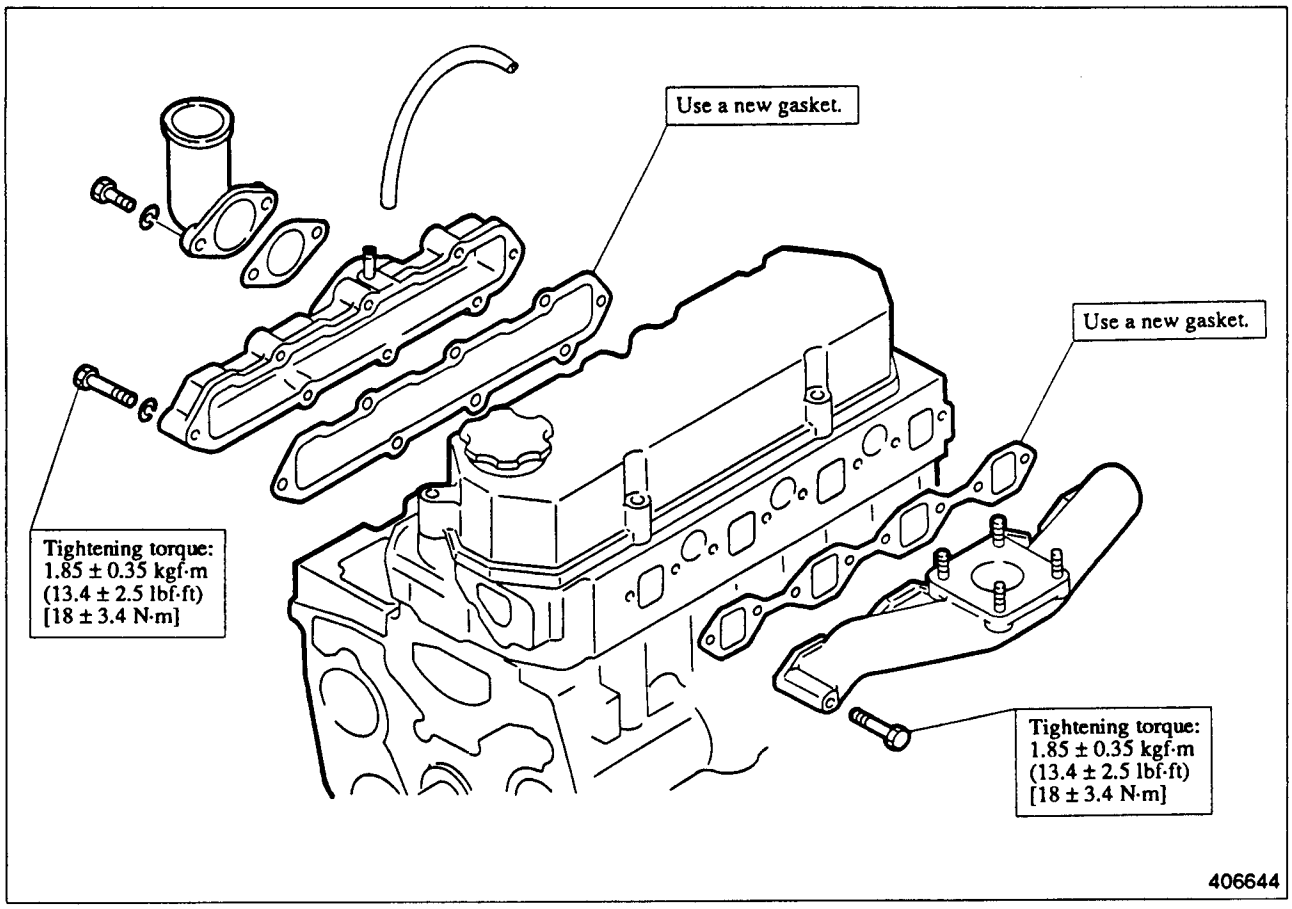
(2) Tighten the bolts that hold the rocker cover to the specified torque.

Tightening torque	1.15 ± 0.15 kgf·m (8.3 ± 1.1 lbf·ft) [11.3 ± 1.5 N·m]



Installing rocker cover

AIR INLET SYSTEM AND EXHAUST SYSTEM



1. Air inlet cover installation

Tighten the bolts that hold the air inlet cover to the specified torque.

Tightening torque	1.85 ± 0.35 kgf·m (13.4 ± 2.5 lbf·ft) [18 ± 3.4 N·m]

2. Exhaust manifold installation

Tighten the bolts that hold the exhaust manifold to the specified torque.

Tightening torque	1.85 ± 0.35 kgf·m (13.4 ± 2.5 lbf·ft) [18 ± 3.4 N·m]

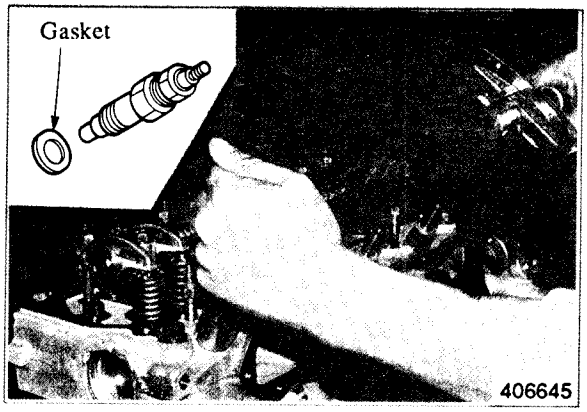
FUEL SYSTEM

1. Fuel injection nozzle installation

(1) Put the gasket on the nozzle.

(2) Put the nozzle assembly in position in the cylinder head and tighten it to the specified torque.

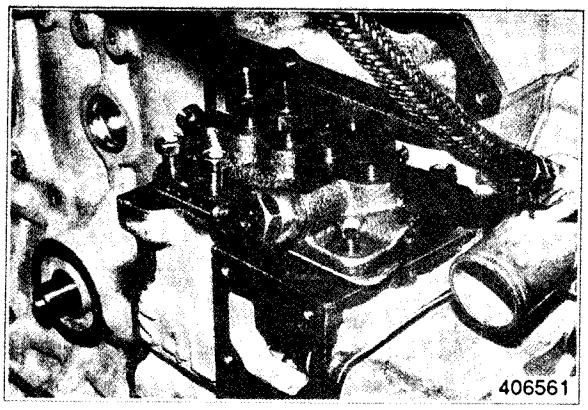
Tightening torque	5.5 ± 0.5 kgf·m (40 ± 4 lbf·ft) [54 ± 5 N·m]



Installing fuel injection nozzle

2. Fuel injection pump installation

Put the pump in position on the cylinder block and tighten the bolts that hold the pump to the specified torque.

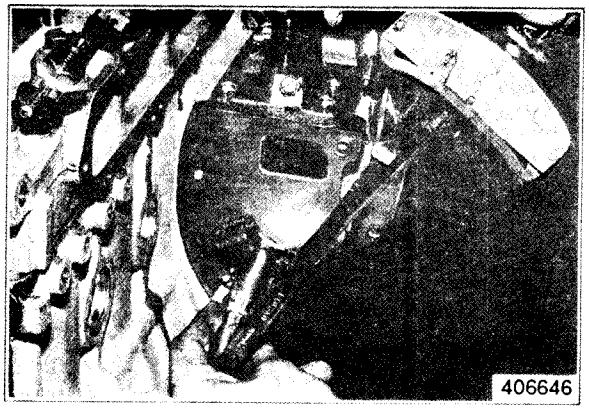


Installing fuel injection pump

3. Flyweight assembly installation

Put the flyweight assembly in position on the rear end of the fuel injection pump camshaft and tighten the sliding sleeve shaft to the specified torque.

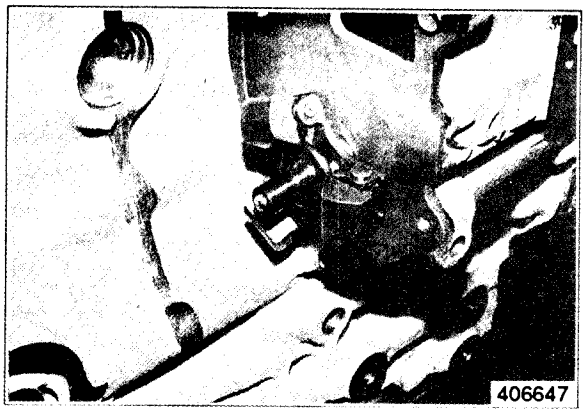
Tightening torque	3.6 ± 0.6 kgf·m (26 ± 4.3 lbf·ft) [35 ± 6 N·m]



Installing flyweight assembly

4. Sliding sleeve installation

Install the sliding sleeve on the sliding sleeve shaft and make sure the sleeve moves freely.



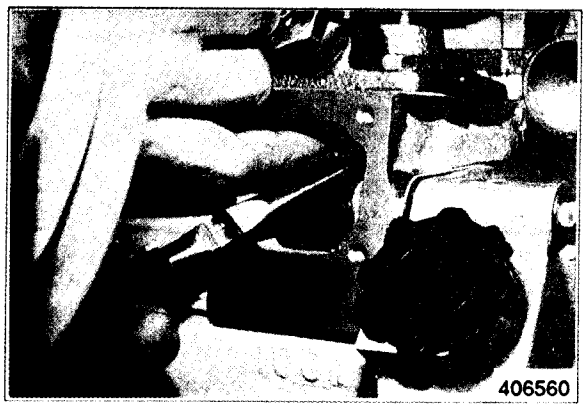
Installing sliding sleeve

5. Governor assembly installation

(1) Install the governor assembly in position while putting the tie rod and spring into position in the injection pump.

(2) Install the tie rod to the pin of the control rack and secure it with the tie rod spring.

(3) Install the tie rod cover in position.

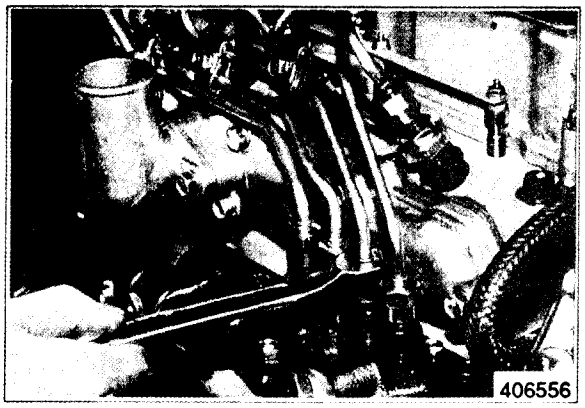


Installing governor assembly

6. Fuel injection line installation

(1) Put the fuel leak-off line in position and connect it to the fuel injection nozzles.

(2) Put the fuel injection lines in position and connect them to the fuel injection pump. Install the clamps.



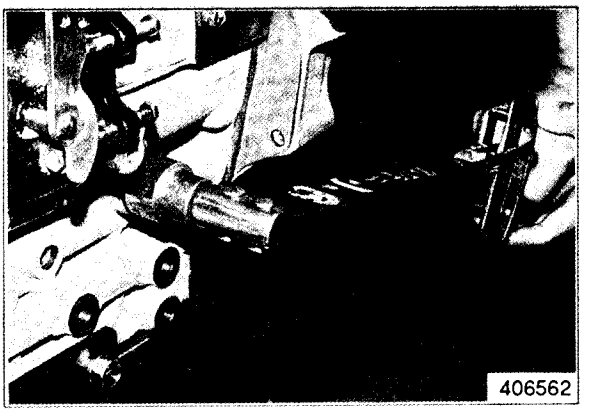
Installing fuel injection lines

LUBRICATION SYSTEM

1. Pressure relief valve installation

Put the relief valve in position on the cylinder block and tighten it to the specified torque.

Tightening torque	5 ± 0.5 kgf·m (36 ± 4 lbf·ft) [49 ± 5 N·m]

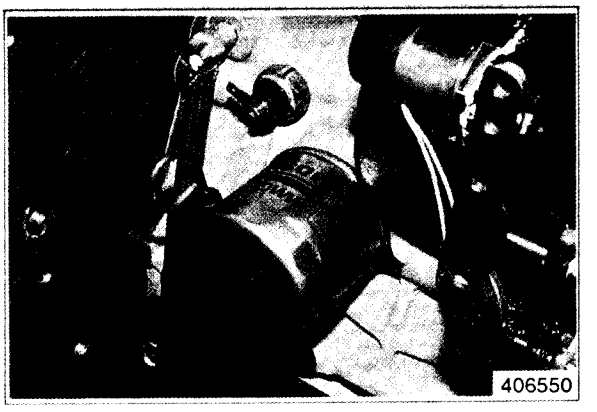


Installing pressure relief valve

2. Oil filter installation

(1) Lightly lubricate the gasket with engine oil.

(2) Install the new filter element by hand. When the gasket contacts the base, tighten one turn more.



Installing oil filter

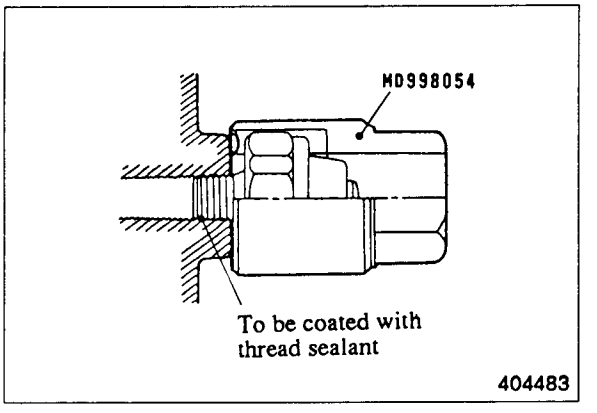
3. Oil pressure switch installation

Coat the threads of the switch with thread sealant (Three Bond 1102). Use Oil Pressure Switch Socket Wrench (MD998054) (special tool) to install the oil pressure switch.

⚠ CAUTION

a) Put the sealant on the threads only.

b) Do not over-tighten the oil pressure switch when it is installed.

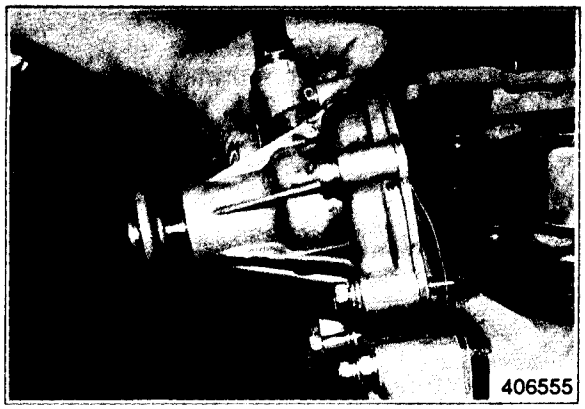


Installing oil pressure switch

COOLING SYSTEM

1. Water pump installation

Put a new gasket in position on the water pump flange. Install the water pump in position on the cylinder block.

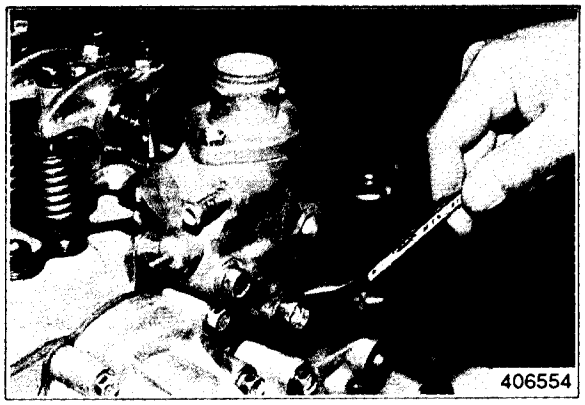


Installing water pump

2. Thermostat installation

(1) Put the thermostat in the thermostat case.

(2) Put a new gasket in position on the thermostat case. Install the thermostat assembly in position on the cylinder head.

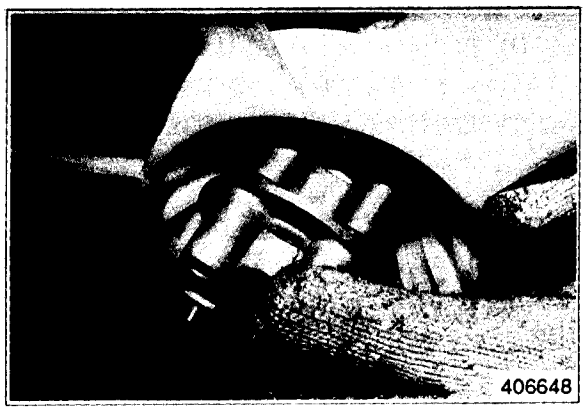


Installing thermostat

3. Cooling fan installation

(1) Install the spacers in position in the fan as shown.

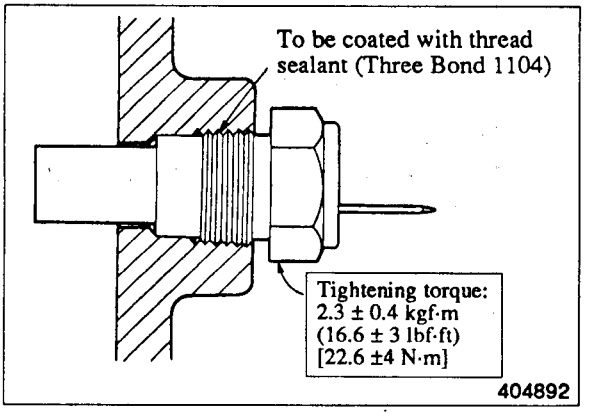
(2) Install the pulley in position on the water pump. Install the fan and spacer combination in position on the pulley.



Installing cooling fan

4. Thermoswitch and thermounit combination installation

Coat the threads of the combination with Three Bond 1104. Put the combination in position and tighten it to the specified torque.



Installing thermoswitch and thermounit combination

ELECTRICAL SYSTEM

1. Glow plug installation

Install the glow plug in position in the precombustion chamber and tighten it to the specified torque.

Tightening torque	1.75 ± 0.25 kgf·m (12.7 ± 1.8 lbf·ft) [17.2 ± 2.5 N·m]

Installing glow plugs

2. Alternator installation

(1) Put the alternator in position. Install the adjusting plate bolt in position to hold the alternator in position.

(2) Put the belt in position on the pulley. Move the alternator away from the engine to make an adjustment to the belt.

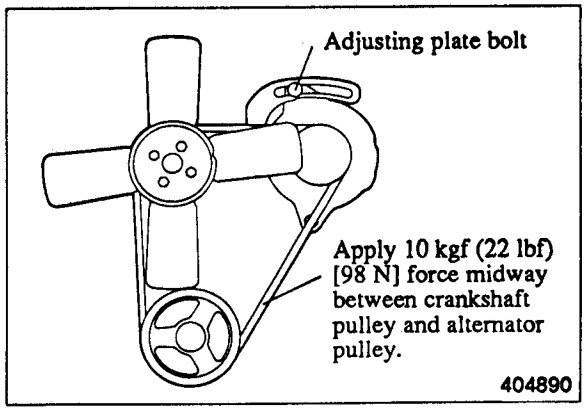
(3) Tighten the bolts.

(4) Make sure the deflection (tension) of the belt is correct.

Unit: mm (in.)

Deflection under 10 kgf (22 lbf) [98 N] force	10 to 12 (0.4 to 0.5)

Installing alternator



Adjusting alternator and fan belt

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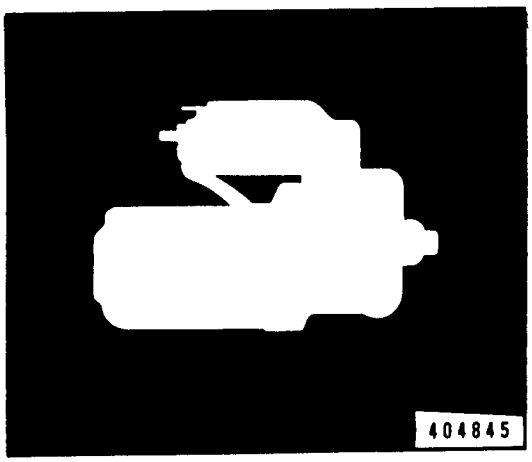
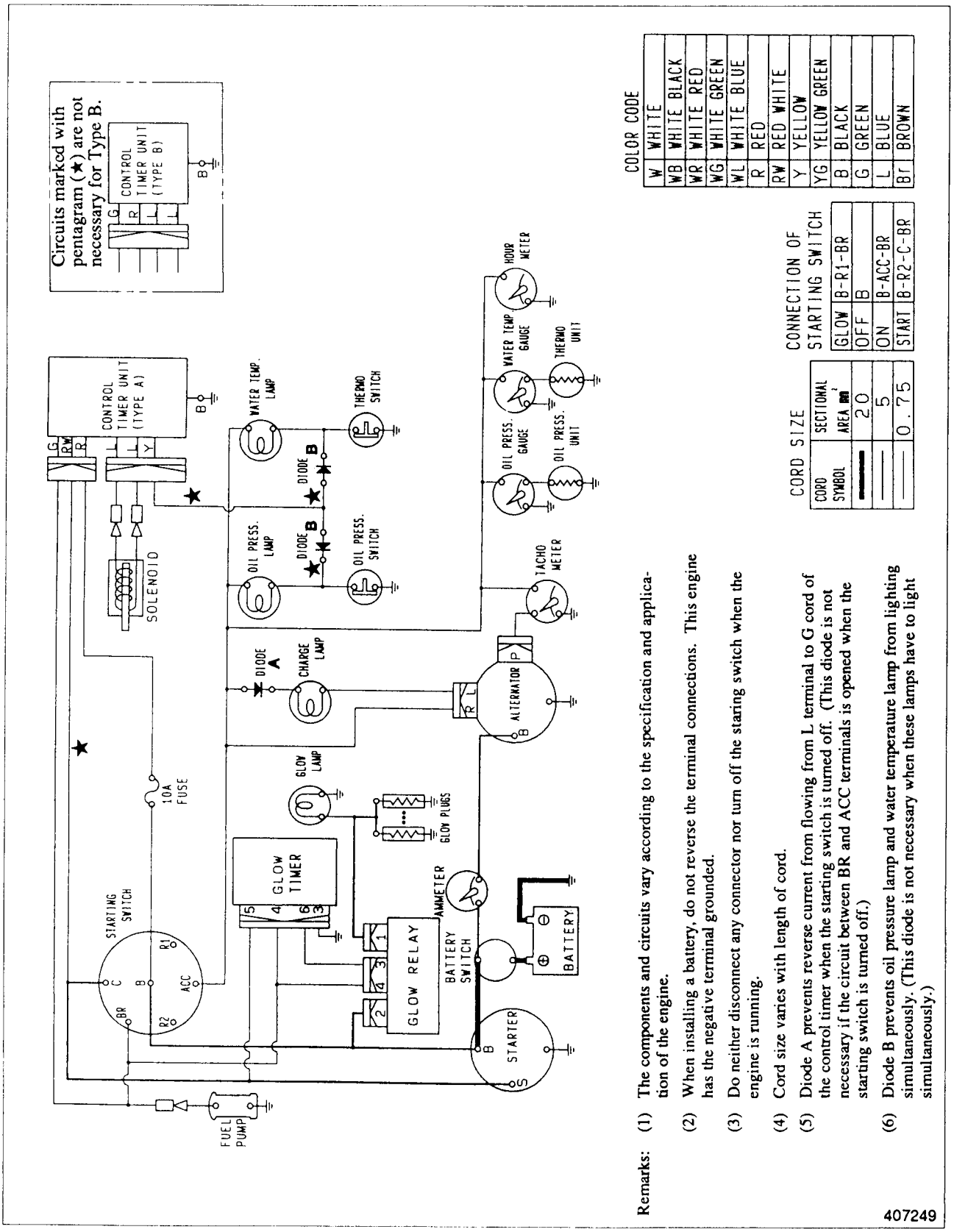
ELECTRICAL SYSTEM



GENERAL

1. Schematic



Remarks:
(1) The components and circuits vary according to the specification and application of the engine.
(2) When installing a battery, do not reverse the terminal connections. This engine has the negative terminal grounded.
(3) Do neither disconnect any connector nor turn off the staring switch when the engine is running.
(4) Cord size varies with length of cord.
(5) Diode A prevents reverse current from flowing from L terminal to G cord of the control timer when the starting switch is turned off. (This diode is not necessary if the circuit between BR and ACC terminals is opened when the starting switch is turned off.)
(6) Diode B prevents oil pressure lamp and water temperature lamp from lighting simultaneously. (This diode is not necessary when these lamps have to light simultaneously.)

Schematic

(1) Figure indicates a nominal size of automotive low-tension line (JIS C 3406).

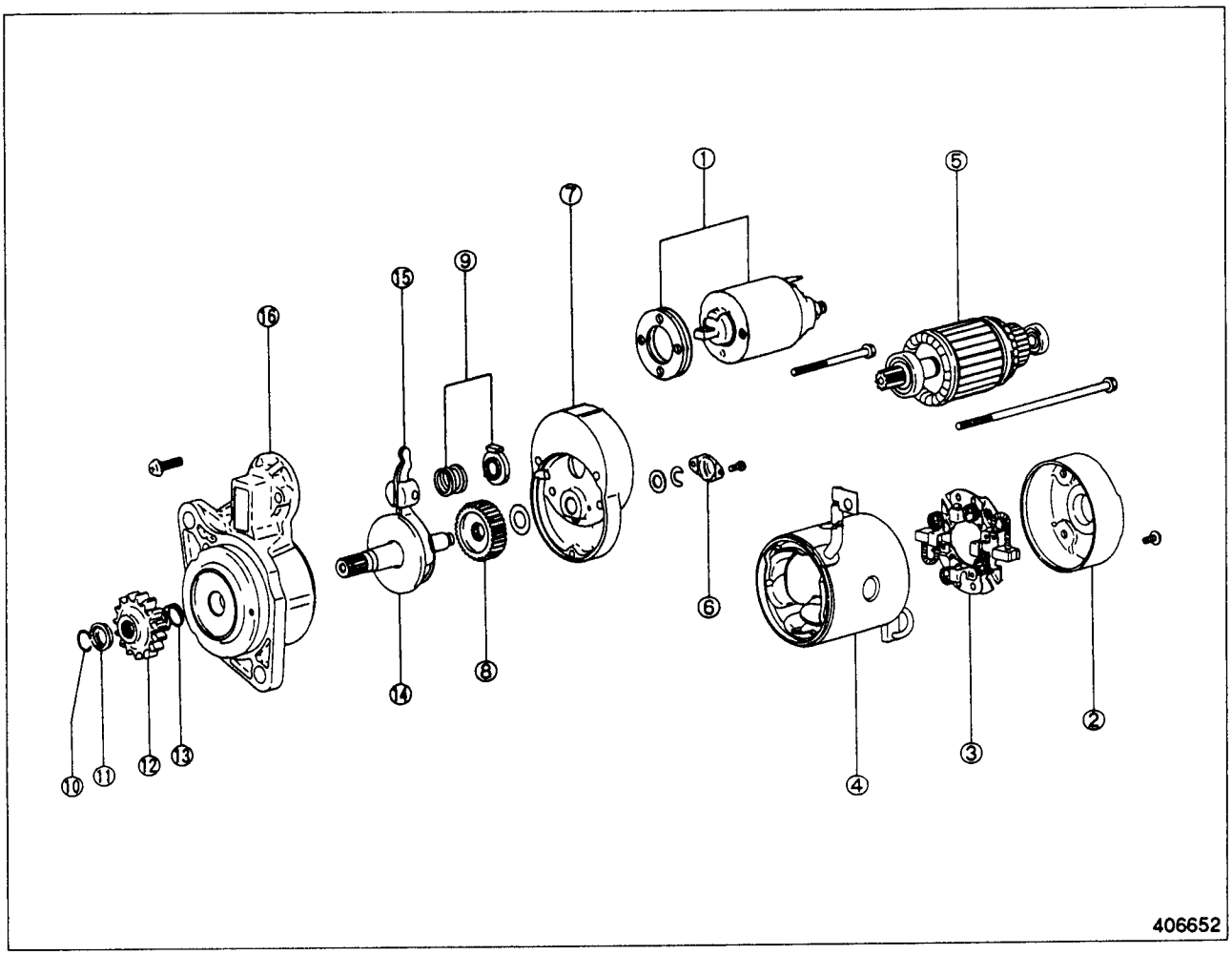
(2) This schematic shows the electrical system of the standard engine equipped with a key shut down solenoid and glow plugs.

2. Specifications (standard)

Engine model		S3L/S3L2	S4L/S4L2
Starter	Model	M2T50381	M2T56272
	Type	DC solenoid shifted (with reduction gear)	
	Nominal output, V–kW	12 –1.6	12 – 2.0
Alternator	Model	A7T02071	
	Regulator, type	IC	
	Nominal output, V–A	12 – 50	
Glow plug	Model	008816-4C	
	Type	Sheathed	
	Rated voltage, V	10.5	
	Current draw, A	9.7 ± 1.0 (30 seconds at rated voltage)	
Glow plug relay	Model	G71SP	
	Rated voltage, V	DC 12	
	Continuous rating	1 minute	
	Resistance in coil, Ω	13	
Control timer unit	Model	YM-1C	
	Input voltage range, V	DC 9 to 15	
	Load	Solenoid (resistance in coil: 1.7 Ω minimum)	
Key shut down solenoid	Model	YMS-1	
	Type	Solenoid	
	Resistance in coil, Ω	1.8 ± 10% at 20°C (68°F)	
	Stroke, mm (in.)	13.5 ± 0.5 (0.53±0.02)	
	Operating voltage, V	DC 10 to 15	
Glow controller	Model	QGS	
	Rated voltage, V	DC 12	
	Operating voltage range, V	7 to 15	
	Operating temperature range, °C (°F)	–30 to +70 (–22 to 158)	
	Storage temperature range, °C (°F)	–40 to +80 (–40 to 176)	
	Pre-glow time, second	6.2 ± 0.7	

STARTER

1. Disassembly



Disassembly sequence

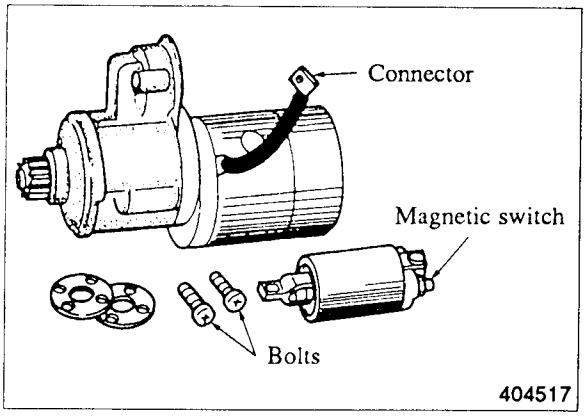
① Magnetic switch
② Rear bracket
③ Brush holder assembly
④ Yoke
⑤ Armature
⑥ Cover
⑦ Center bracket
⑧ Gear
⑨ Spring set
⑩ Stopper ring
⑪ Stopper
⑫ Pinion
⑬ Spring
⑭ Pinion shaft
⑮ Front bracket

Disassembly procedure

(1) Magnetic switch

(a) Loosen the nut that holds the connector to the M terminal of the magnetic switch and disconnect the connector from the magnetic switch.

(b) Remove the bolts (two) that hold the magnetic switch in position and remove the magnetic switch.



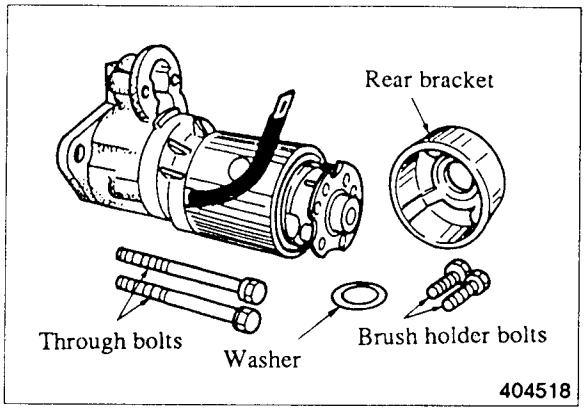
Removing magnetic switch

(2) Rear bracket removal

Remove the through bolts (two) and the bolts (two) that hold the brush holder in position. Remove the rear bracket.

NOTE

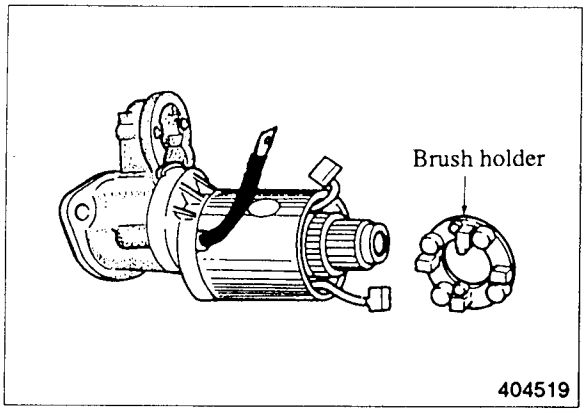
Keep the rear bracket with washer for installation.



Removing rear bracket

(3) Brush holder removal

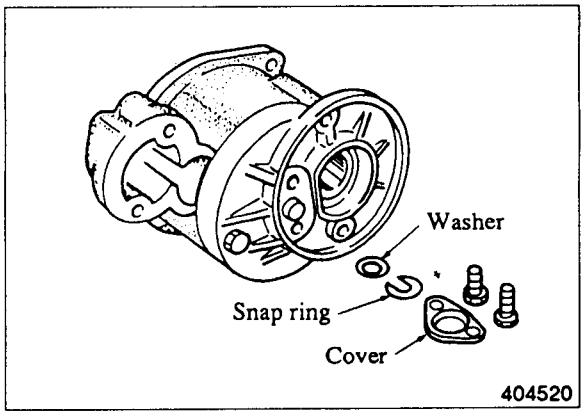
With the brushes (two) kept apart from the commutator, remove the yoke and brush holder assembly. Remove the armature.



Removing brush holder

(4) Cover removal

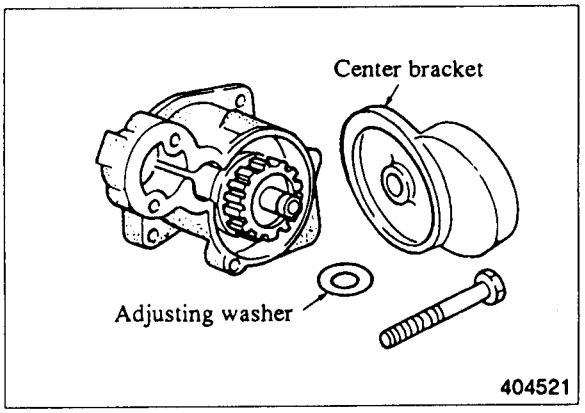
Remove the cover and remove the snap ring and washer.



Removing cover

(5) Center bracket removal

Remove the bolt and remove the center bracket. Remove the washer for adjusting the end play for the pinion shaft.



Removing center bracket

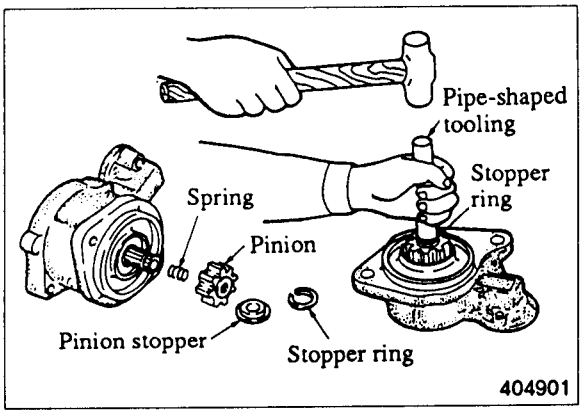
(6) Pinion removal

(a) Put a pipe-shaped tooling on the pinion stopper and hit the stopper with a hammer to expose the stopper ring.

(b) Remove the stopper ring with a pliers and remove the pinion.

NOTE

Any time the pinion is removed, a new stopper ring must be installed.



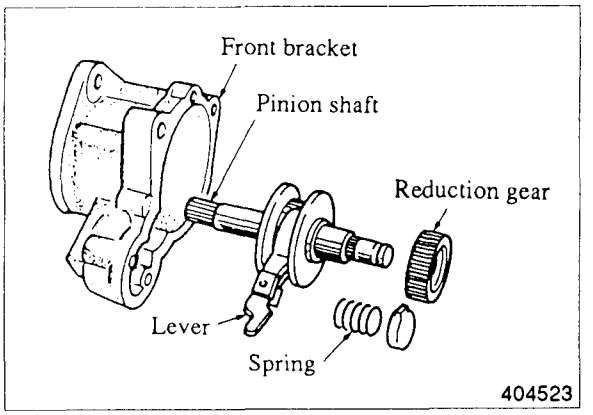
Removing pinion

(7) Pinion shaft removal

Remove the spring, lever, reduction gear and pinion shaft from the front bracket.

NOTE

Do not mix the sequence of spring, lever and reduction gear when the pinion shaft is removed.

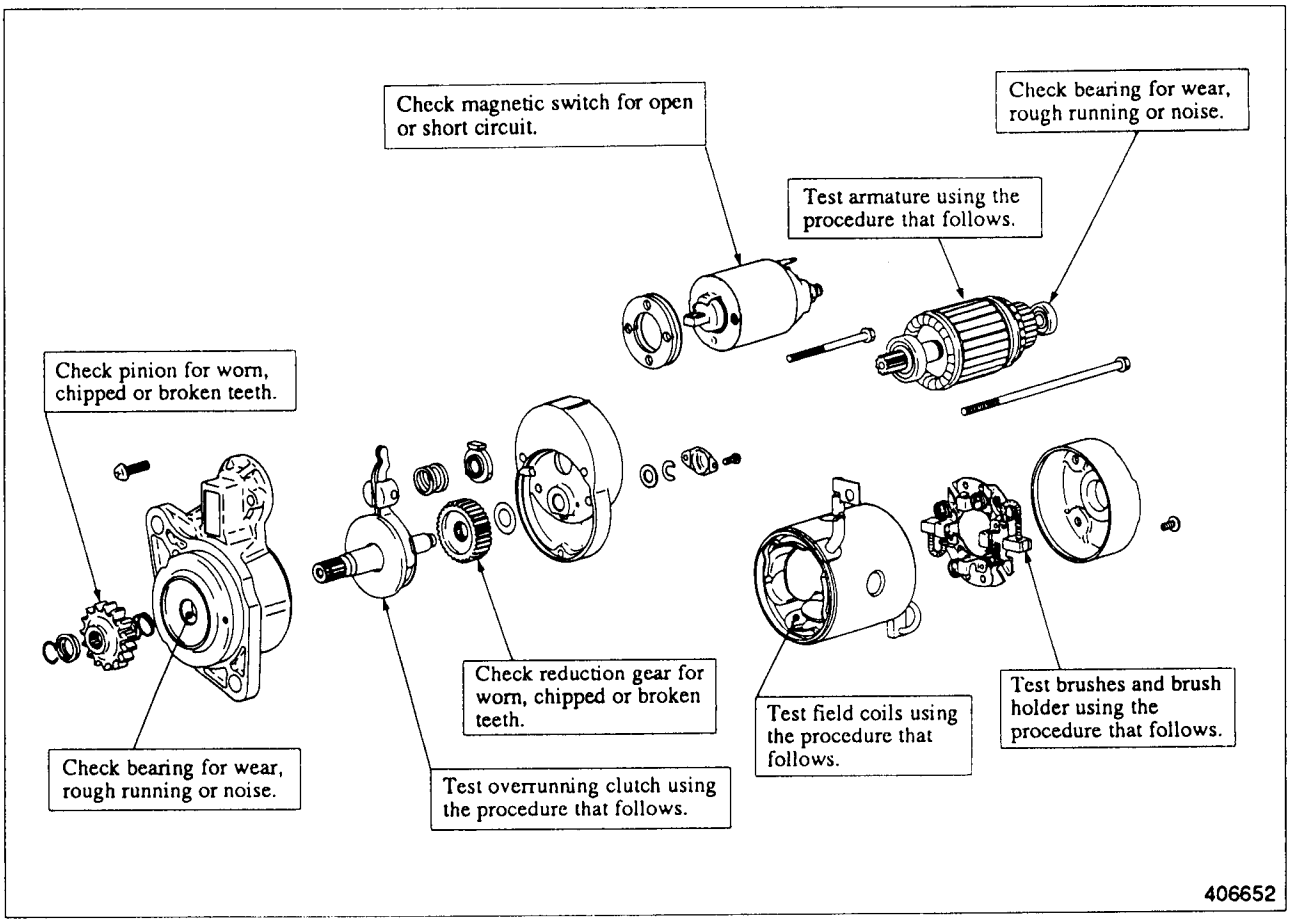


Removing pinion shaft

(8) Bearing removal

To remove the ball bearings from the ends of the armature, use a bearing puller. The bearing fitted in the front bracket is not replaceable. Replace the front bracket assembly if this bearing is defective.

2. Inspection



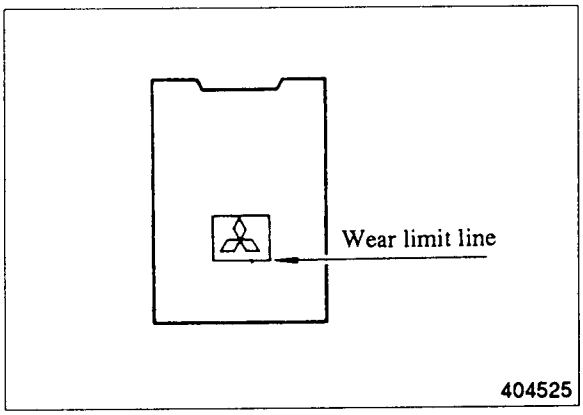
Inspection points

Inspection procedure

(1) Brushes

(a) Wear

Replace the brushes if they are worn down to the wear limit line which is the bottom of the border for Mitsubishi mark. Replace the brush holder assembly if the brushes are worn beyond the wear limit line.

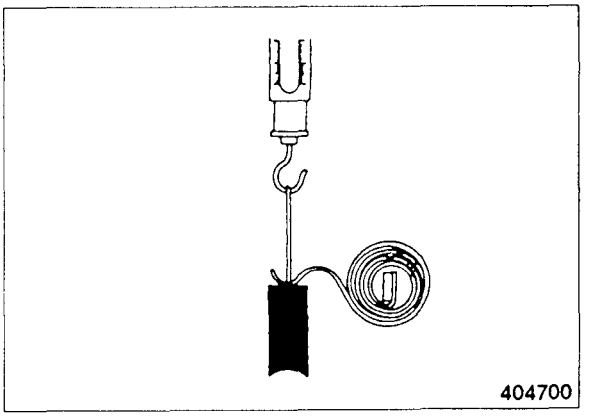


Checking brush

(b) Brush spring tension
Test the spring tension using a new brush as shown in the illustration. Read the load when the spring just moves off the brush. If the tension is below the limit, replace the spring.

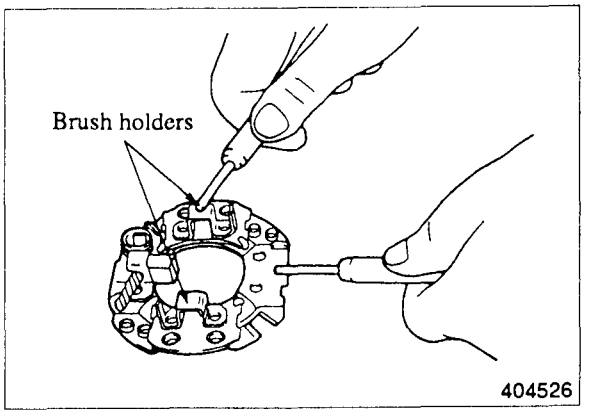
Unit: kgf (lbf) [N]

Item	Standard	Limit
Brush spring tension	3.0 (6.6) [29.4]	1.8 (4.0) [17.7]



Testing brush spring tension

(c) Brush holders
Test for no continuity between the positive brush holder and brush holder base as shown in the illustration. If there is any continuity between them, replace the brush holder. Also, check the brush holder for loose staking.



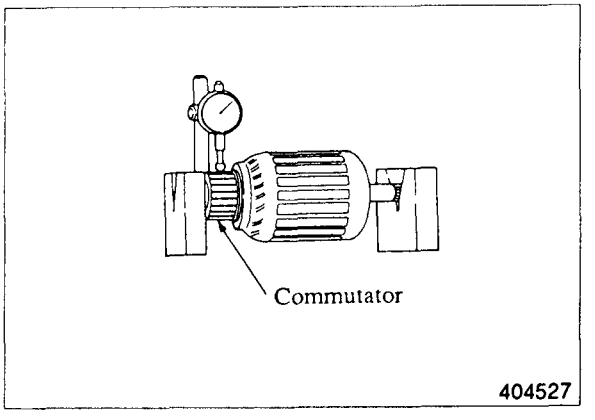
Testing brush holder for grounded circuit

(2) Armature

(a) Commutator runout
Support the armature in V-blocks and measure the commutator runout with a dial indicator. If runout exceeds the limit, turn the commutator in a lathe. The cut should be made within the limit of the commutator diameter.

Unit: mm (in.)

Item	Standard	Limit
Runout of commutator	0.03 (0.001 2)	0.10 (0.003 9)

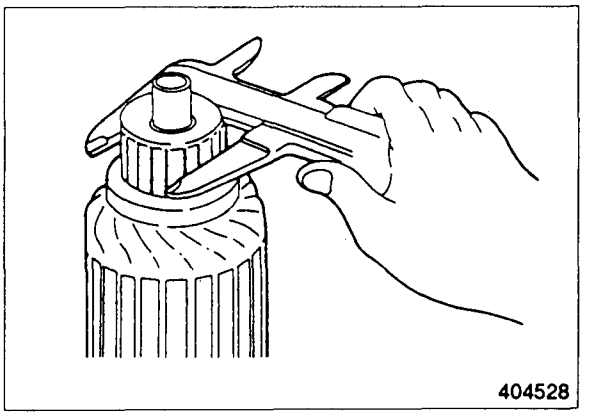


Checking commutator runout

(b) Diameter of commutator
Measure the diameter of the commutator. If it exceeds the limit, replace the armature.

Unit: mm (in.)

Item	Standard	Limit
Diameter of commutator	32 (1.26)	31 (1.22)

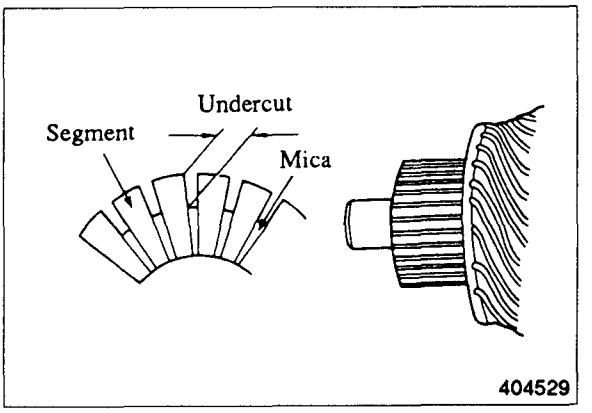


Measuring commutator diameter

(c) Mica undercut
Measure the undercut of mica insulation between the adjacent segments. If undercut exceeds the limit, recondition the mica, or replace the armature.

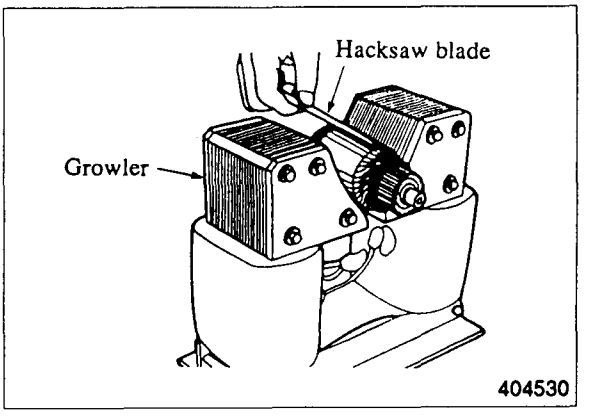
Unit: mm (in.)

Item	Standard	Limit
Undercut of mica	0.5 (0.020)	0.2 (0.008)



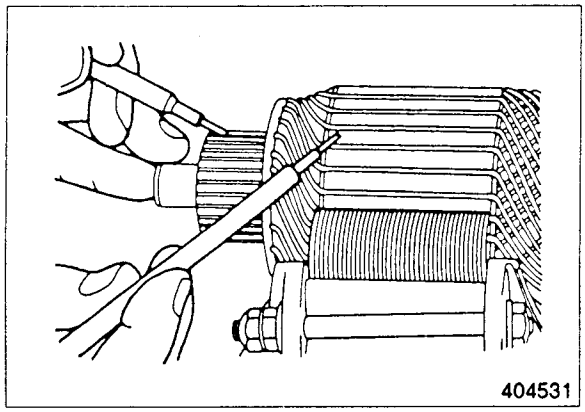
Undercut of mica

(d) Testing for short circuit
Place the armature on a growler and slowly rotate it with a hacksaw blade held above the armature core. The hacksaw blade vibrates against the core when it is above a slot containing a shorted winding. A shorted armature should be replace.



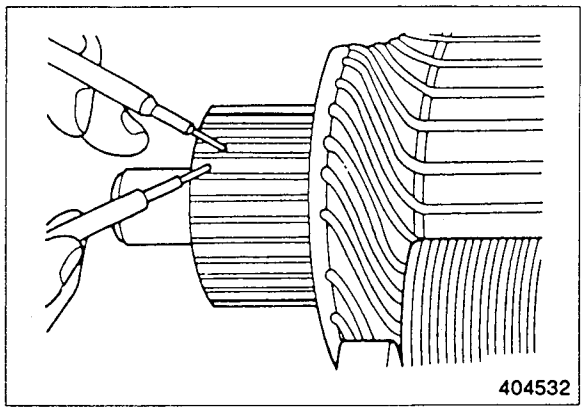
Testing armature for short circuit

(e) Testing for grounded circuit
Test the armature for grounded circuit as shown in the illustration. If there is any continuity between commutator segment and coil, the armature is grounded and should be replaced.



Testing armature for grounded circuit

(f) Testing for open circuit
Test the armature for open circuit as shown in the illustration. If there is no continuity between the segments, the armature is open circuited and should be replace.



Testing armature for open circuit

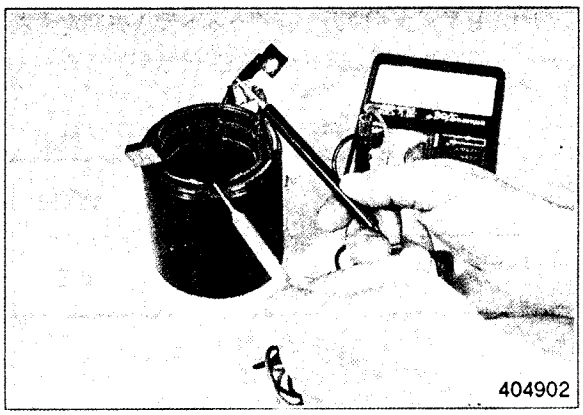
(3) Field coils

Replace the yoke assembly if —

(a) There is any continuity between the brush and yoke.

(b) There is no continuity between the brushes.

(c) The pole piece or coil is loosen.



Testing field coils

(4) Bearings

Replace the bearings if they are noisy or fail to run freely.

(5) Overrunning clutch

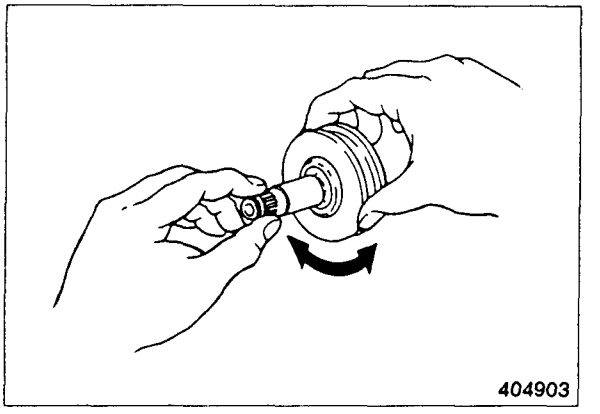
Replace the overrunning clutch assembly if —

(a) The pinion is not locked when spun counterclockwise, or if it does not rotate freely when spun in the reverse direction (clockwise).

(b) The pinion is worn or chipped.

⚠ CAUTION

Do not wash the overrunning clutch with cleaning solvent.



Testing overrunning clutch

(6) Front bracket

Replace the front bracket assembly if the ball bearing is noisy or fails to rotate freely.

(7) Reduction gears

Replace the reduction gears if they are worn or damaged.

3. Assembly

Follow the reverse of disassembly and use the procedure that follows.

Assembly procedure

(1) Lubrication

Lubricate the following starter components with grease after the starter has been assembled:

(a) Armature shaft gear and reduction gear

(b) Bearings

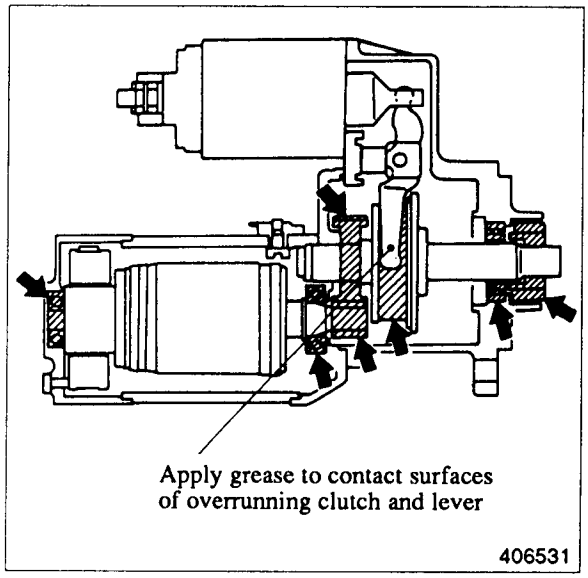
(c) Washer and stopper ring of pinion shaft

(d) Pinion

(e) Sliding surfaces of lever

⚠CAUTION

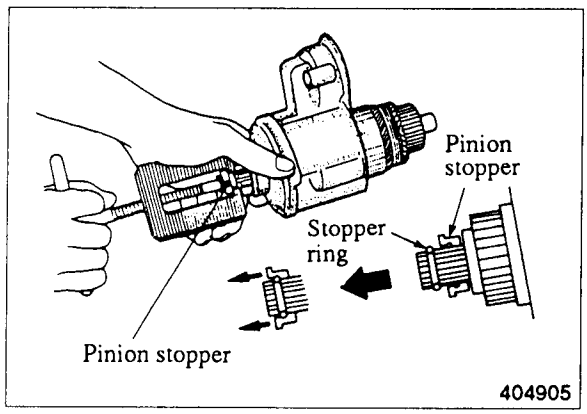
Do not put grease on the starter mounting face, brushes, commutator and other electrical parts.



Lubrication points on starter

(2) Stopper ring installation

Put the stopper ring on the pinion shaft. Using a puller, pull the pinion stopper to fit the ring in the groove.



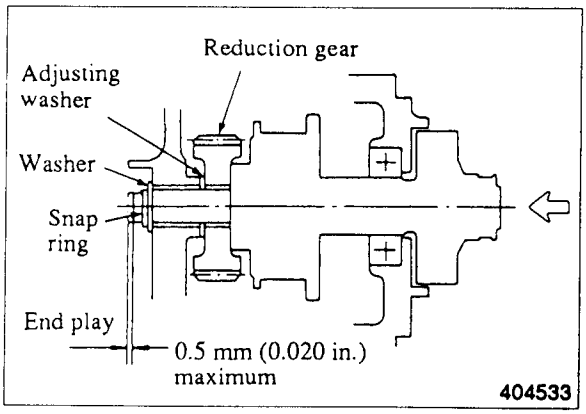
Installing stopper ring

(3) Pinion shaft end play adjustment

The maximum permissible limit of the end play (thrust gap) for the pinion shaft is 0.5 mm (0.020 in.).

(a) Put the pinion shaft, reduction gear washer and snap ring in position in the center bracket.

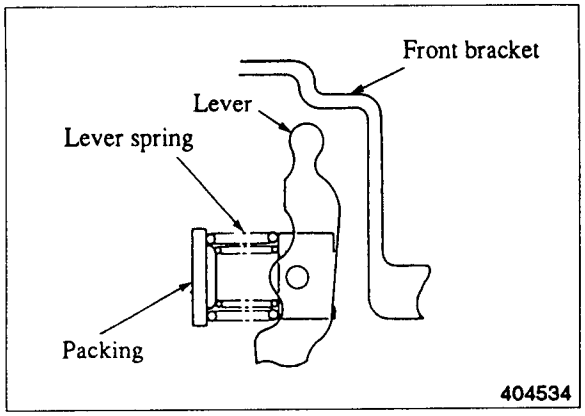
(b) Move the pinion shaft in the axial direction to measure the end play. If the end play exceeds 0.5 mm (0.020 in.), make adjustment to it by adding adjusting washer.



Adjusting pinion shaft end play

(4) Lever installation

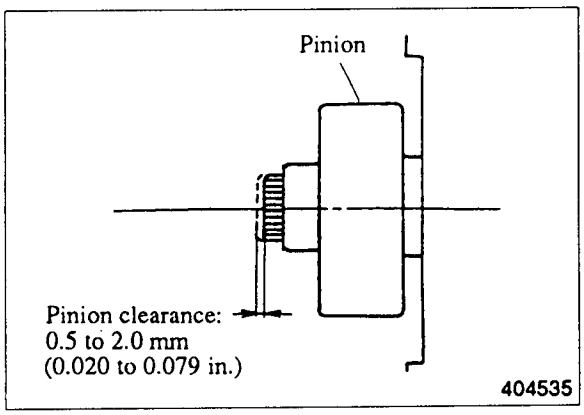
Install the lever in correct position.



Installing lever

(5) Pinion clearance adjustment

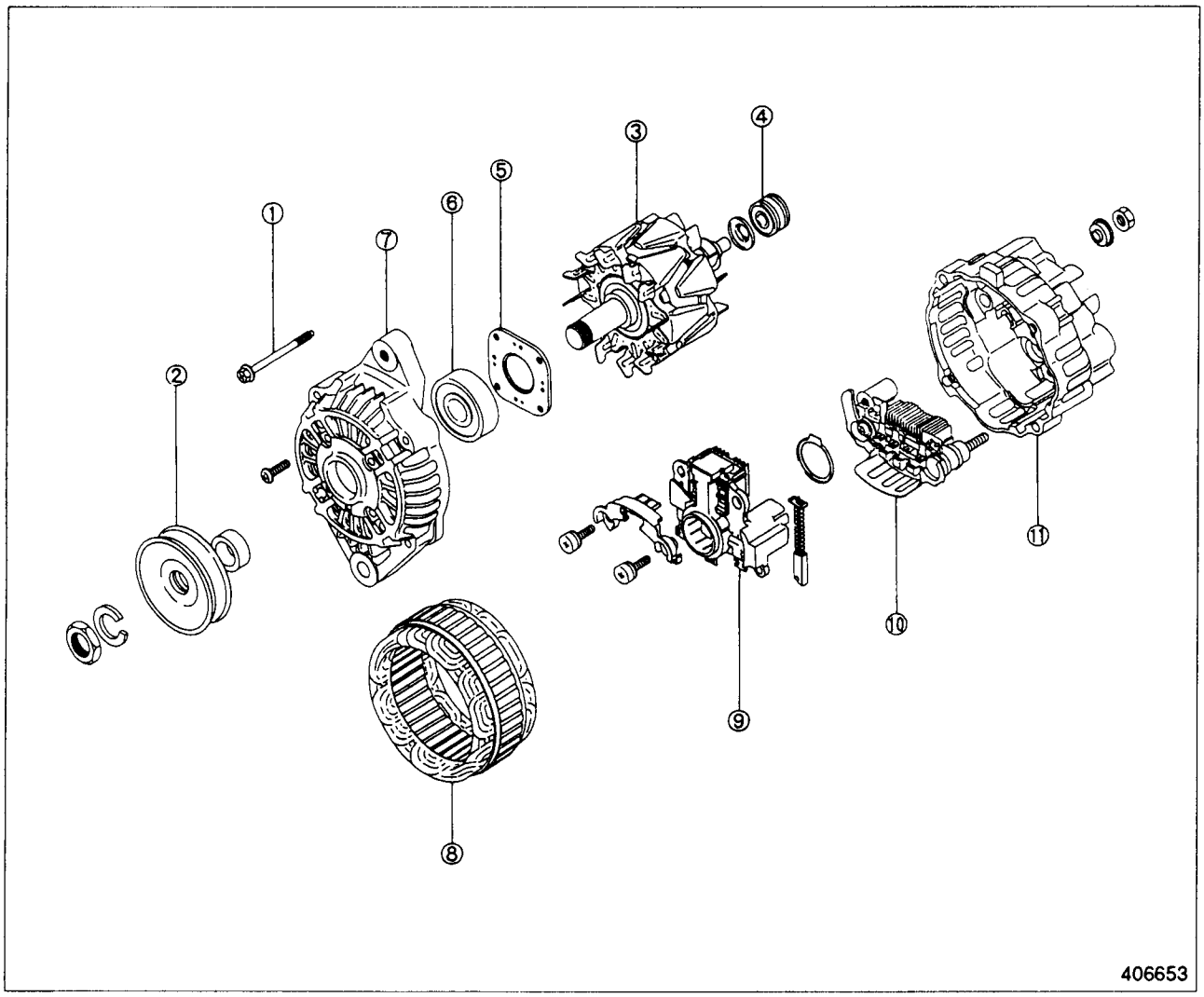
The pinion clearance must be 0.5 to 2.0 mm (0.020 to 0.079 in.). With the pinion held in cranking position, lightly push it toward commutator end to measure free movement (clearance). If the clearance is not correct, make adjustment to it. Increase the amount of packings if the clearance is too large; decrease it if the clearance is too small.



Adjusting pinion clearance

ALTERNATOR

1. Disassembly



Disassembly sequence

① Through bolt
② Pullcy
③ Rotor
④ Rear bearing
⑤ Bearing retainer
⑥ Front bearing
⑦ Front bracket
⑧ Stator core
⑨ Brush holder
⑩ Rectifier
⑪ Rear bracket

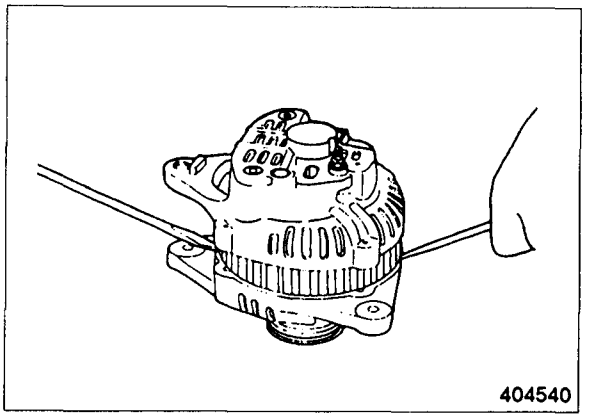
Disassembly procedure

(1) Stator core separation from front bracket

(a) Pry the stator core off the front bracket with a screwdriver as shown in the illustration.

⚠ CAUTION

Be careful not to insert the screwdriver too deep. Damage to the stator core can be the result.

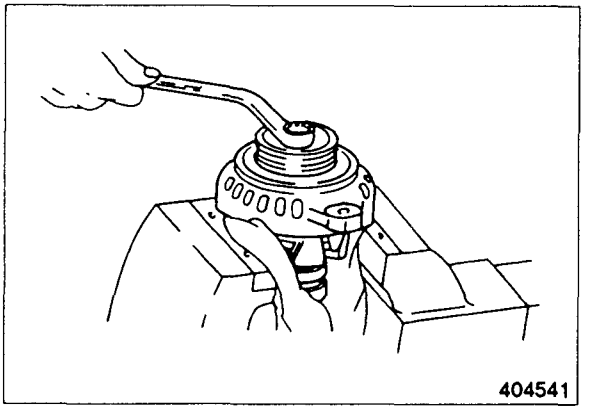


Disassembling alternator

(2) Pulley removal

(a) Hold the rotor assembly in a vise by using thick cloth as shown in the illustration. Remove the nut that holds the pulley in position, and remove the pulley and spacer.

(b) Remove the rotor assembly from the front bracket.



Removing pulley

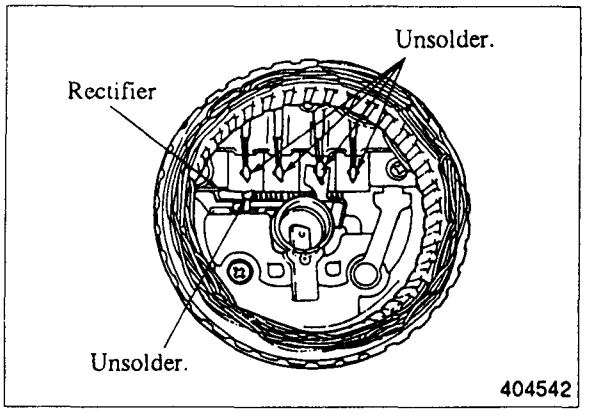
(3) Stator core and rectifier removal

(a) Unsolder the leads from the rectifier and remove the stator core from the rectifier.

⚠ CAUTION

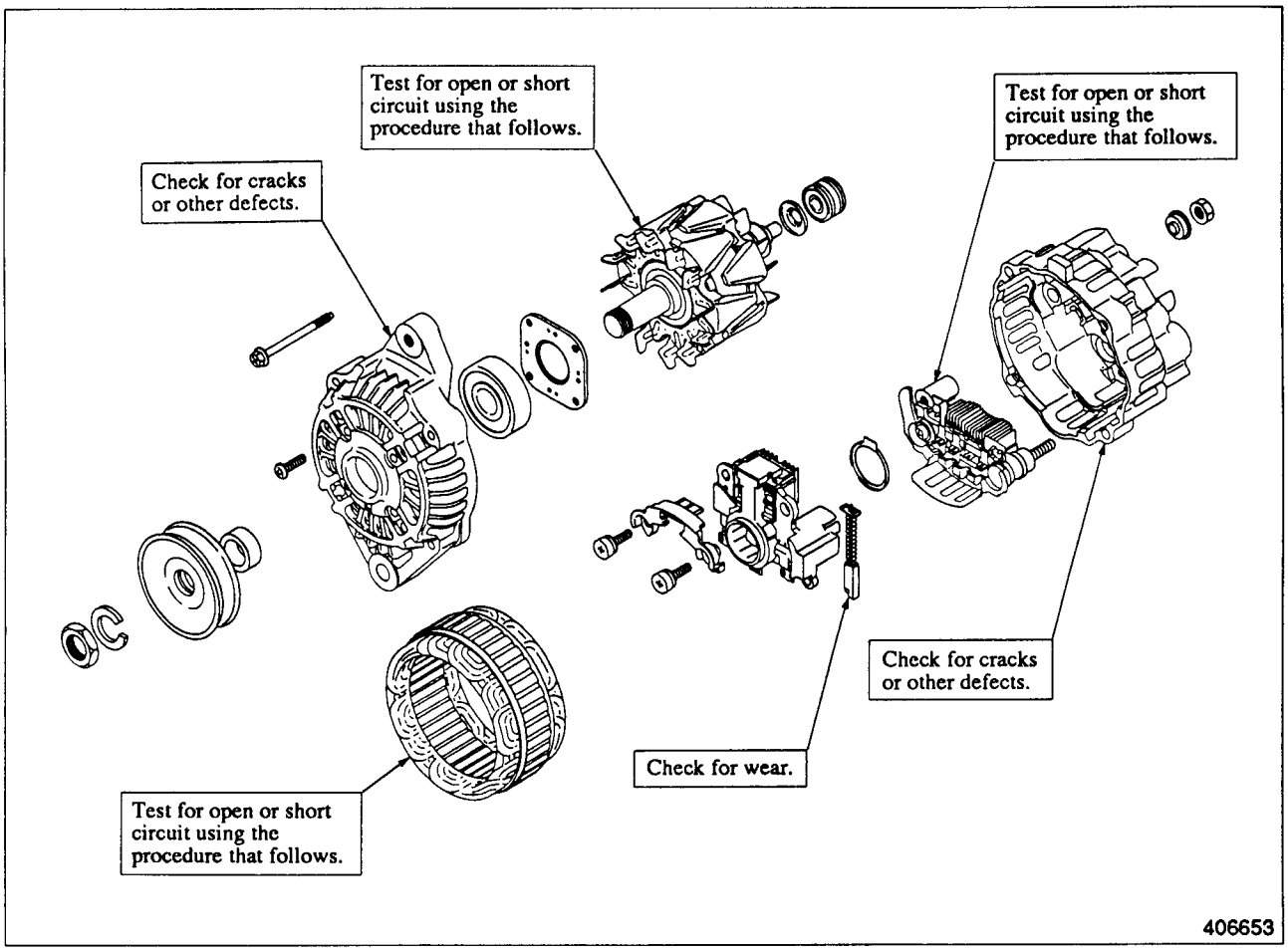
Unsolder the leads as quickly as possible to prevent damage to the diodes in the rectifier.

(b) Remove the screws that hold the rectifier in position and remove the rectifier.



Removing stator core

2. Inspection

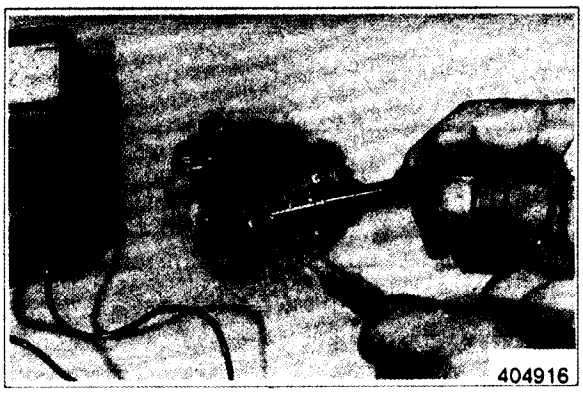


Inspection points

Inspection procedure

(1) Diodes

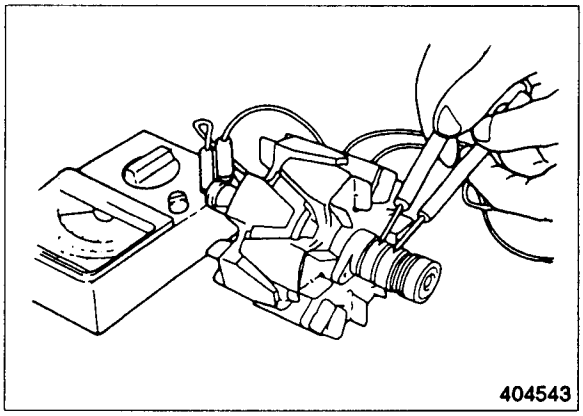
(a) Test the resistance between the diode and heat sink. First touch the positive (+) prod of an ohmmeter to the diode, then the negative (–) prod. If the resistance is infinite in both cases, the diode is open. If it is nearly zero in both cases, the diode is shorted. Do the same step for the remainder of the diodes. If any diode is open or shorted, replace the rectifier.



Testing diode

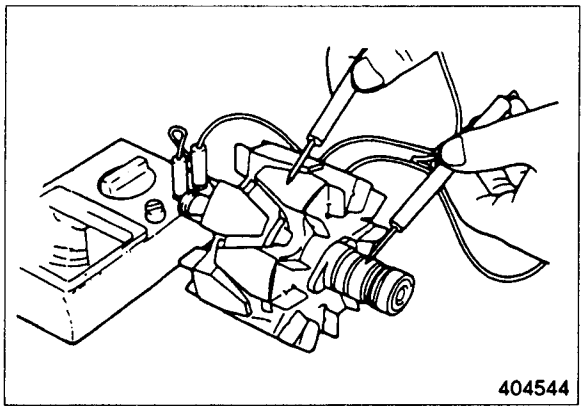
(2) Field coil

(a) Test for continuity between the slip rings as shown in the illustration. No continuity shows there is an open circuit in the field coil. Replace the field coil.



Testing field coil for open circuit

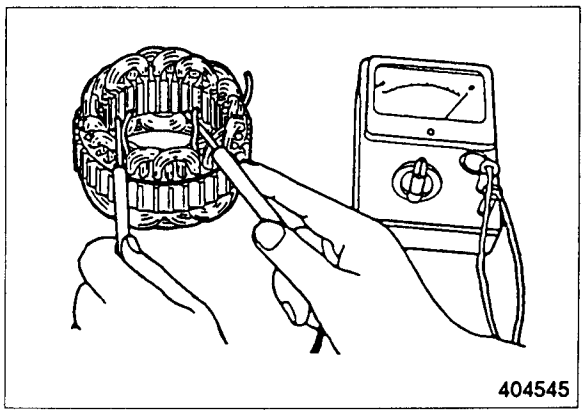
(b) Test for no continuity between the slip ring and shaft (or core) as shown in the illustration. Any continuity shows there is a grounded circuit in the field coil. Replace the field coil.



Testing field coil for grounded circuit

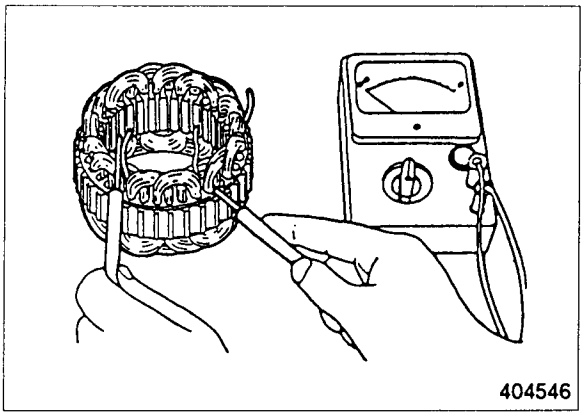
(3) Stator core

(a) Test for continuity between the leads as shown in the illustration. No continuity shows there is an open circuit in the stator core. Replace the stator core.



Testing stator core for open circuit

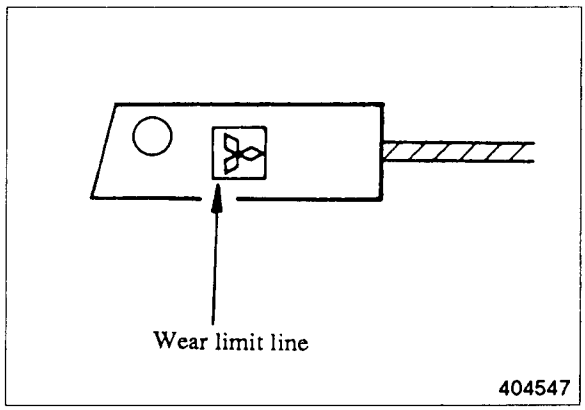
(b) Test for no continuity between each lead and stator core as shown in the illustration. Any continuity shows there is a grounded circuit in the stator core. Replace the stator core.



Testing stator core for grounded circuit

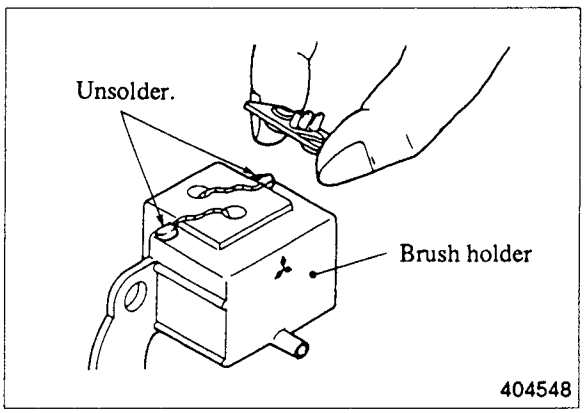
(4) Brushes

(a) Make replacement of brushes that have been worn down to, or beyond, the wear limit line.



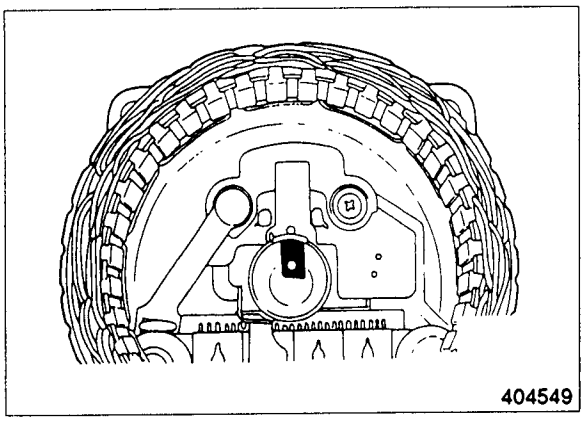
Checking brush for wear

(b) To remove the brushes from the brush holder for replacement, unsolder the leads from the brushes. This will permit removal of the brushes and springs.



Removing brushes for replacement

(c) To install the new brushes, put them in position in the brush holder and solder the leads to the brushes.



Installing new brushes

3. Assembly

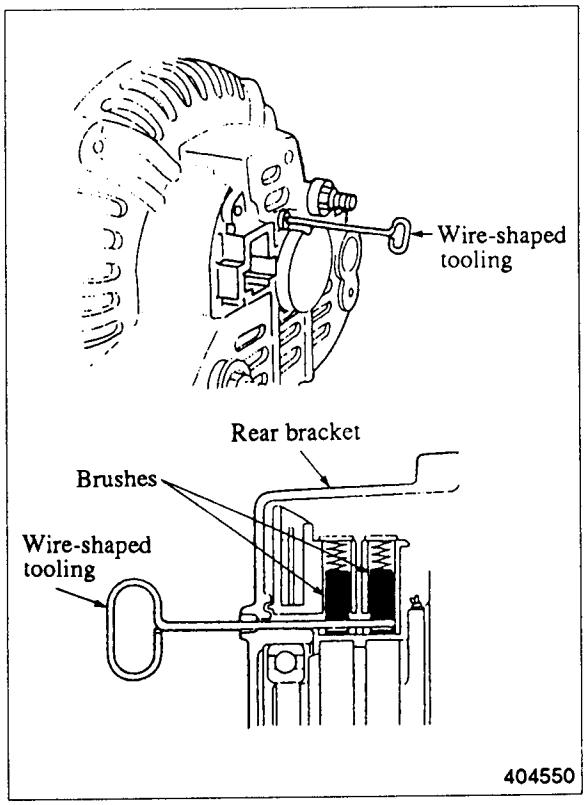
Follow the reverse of disassembly and use the procedure that follows.

(a) The rear bearing has a groove for the snap ring. Install the snap ring in this groove, making sure its tab is in the deep portion of the groove.

(b) When installing the new rear bearing, put it in position with the side that has a groove toward the slip rings of the rotor.

(c) To install the rear bearing in the rear bracket, heat the rear bracket.

(d) Before installing the rotor in the rear bracket, insert a wire-shaped tooling into the hole in the rear bracket to lift the brushes off the slip rings. Remove the tooling after the rotor has been installed in position.

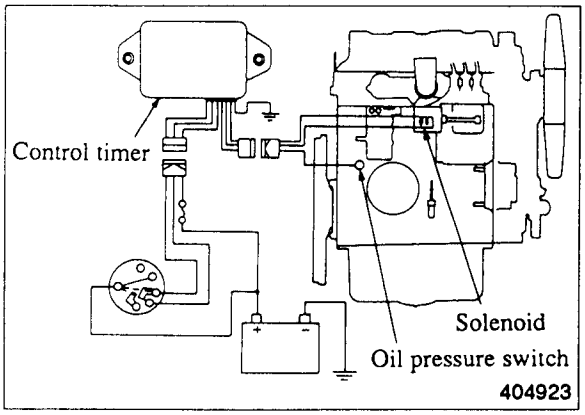


Assembling alternator

KEY SHUTOFF SYSTEM

1. General

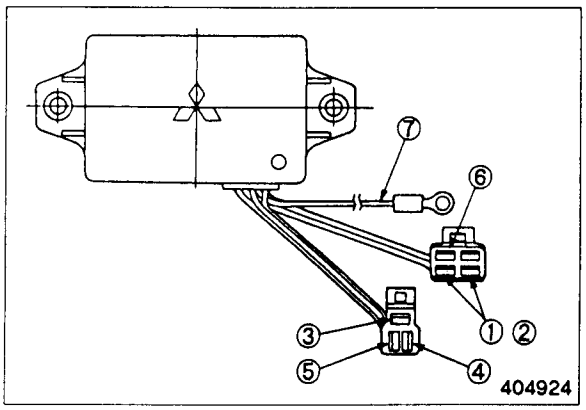
This system, consisting of a switch, a control timer and a solenoid, permits the operator to shut off the engine by turning the starter switch key to OFF position. Another function of this system is to shut off the engine automatically when the oil pressure is too low, or when coolant temperature is too high.



Key shutoff system

2. Cord color (standard)

No.	Cord color	Connected to
1	Blue	Solenoid
2	Blue	Solenoid
3	Red	Battery (starter switch B terminal)
4	Green	Starter switch ON terminal
5	Red/white	Starter (starter switch and starter)
6	Yellow	Oil pressure switch
7	Black	Ground



Control timer connection

3. Shutoff solenoid installation

(a) Remove the tie rod cover.

(b) Coat the threads of the stop solenoid with thread sealant (Three Bond 1212).

NOTE

Coat the length of the threads to be turned in the governor case.

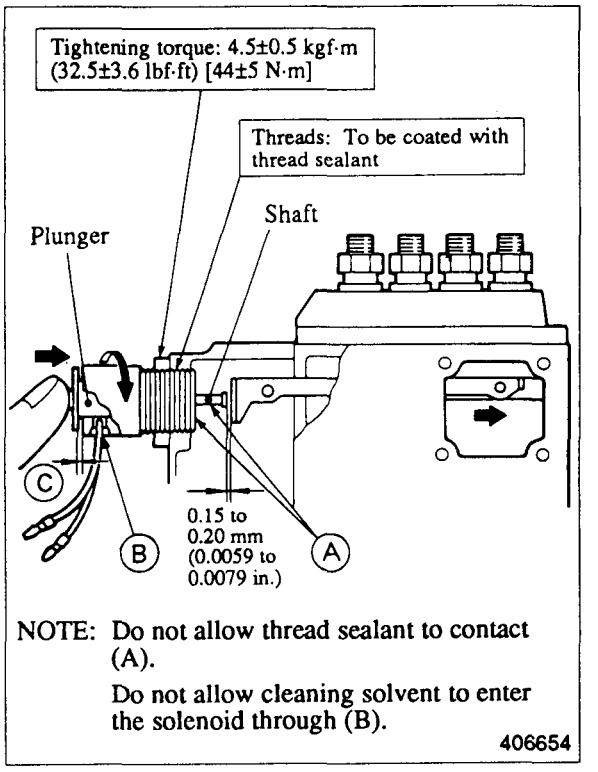
(c) Temporarily install the shutoff solenoid and nut in the governor case.

(d) Move the injection pump control rack all the way to the non-injection (shutoff) position.

(e) Turn the shutoff solenoid in the governor case while pushing the plunger toward the control rack until the shaft is in touch with the tie rod. At this time, clearance C must be 0 mm. (Under this condition, the plunger will be rotated by the shutoff solenoid being turned in.)

(f) Back off the shutoff solenoid 30° to 45° turn (the clearance between the control rack and plunger will be 0.15 to 0.20 mm (0.0059 to 0.0079 in.)) and tighten the nut to the specified torque.

(g) Start the engine and make sure the engine stops when the plunger is pushed all the way.

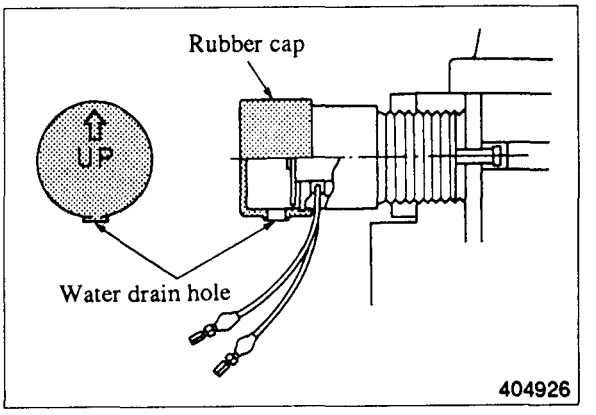


Installing shutoff solenoid

(h) Install the rubber cap in position with the arrow head toward up (with the side that has a water drain hole down) as shown in the illustration.

⚠ CAUTION

Do not allow cleaning solvent to contact any solenoid parts.



Installing rubber cap

4. Inspection after assembly

(a) For the schematic of the key shutoff system, see page 98.

(b) Start the engine and make sure the engine stops when the starter switch key is turned to OFF position.

(c) Start the engine and make sure the engine stops when the oil pressure switch terminal is shorted to the switch body.

NOTE

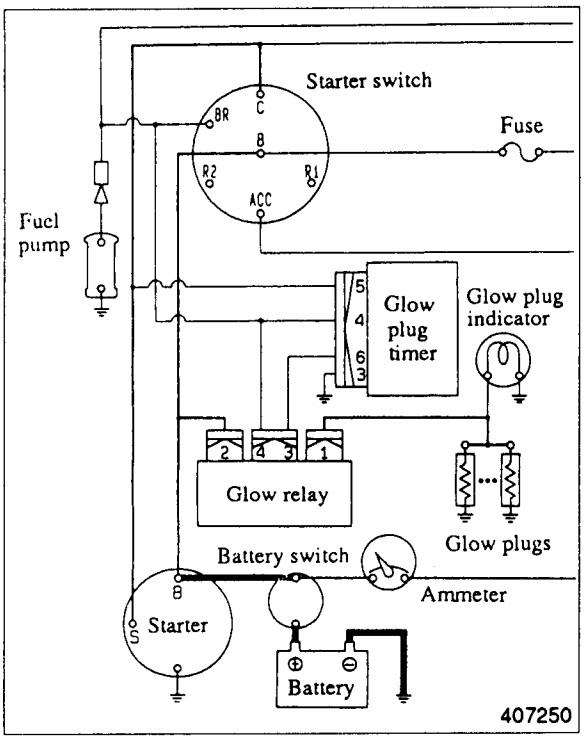
It will take about 5 minutes to restart an engine which was shut down by the key shutoff device.

AUTOMATIC GLOW PLUG SYSTEM

1. General

Turning the starter switch to ON position activates the glow plugs to heat the engine and causes the glow plug indicator to come on.

Heating time	6.2 ± 0.7 seconds



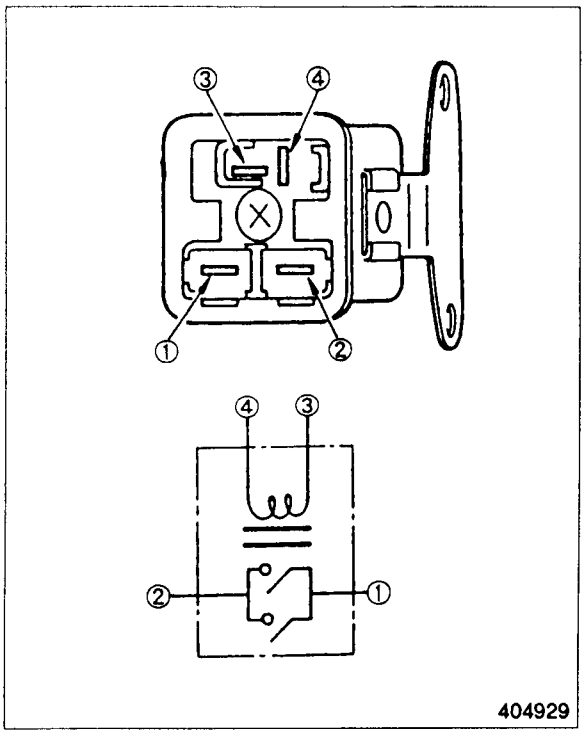
Automatic glow plug system

2. Glow plug timer specifications (standard)

Model	QGS
Type	Quick heating
Rated voltage	DC 12 V
Operating voltage range	7 to 15 V
Operating temperature range	–30°C to +70°C (–22°F to +158°F)
Storage temperature range	–40°C to +80°C (–40°F to +176°F)
Glow plug activating time	6.2 ± 0.7 seconds

3. Glow plug relay specifications (standard)

Model	G71SP
Rated voltage	DC 12 V
Continuous rating	1 minute
Coil resistance	13Ω
Inductance	24 mH (at 1 kHz)
Operating temperature range	–40°C to +100°C (–40°F to +212°F)

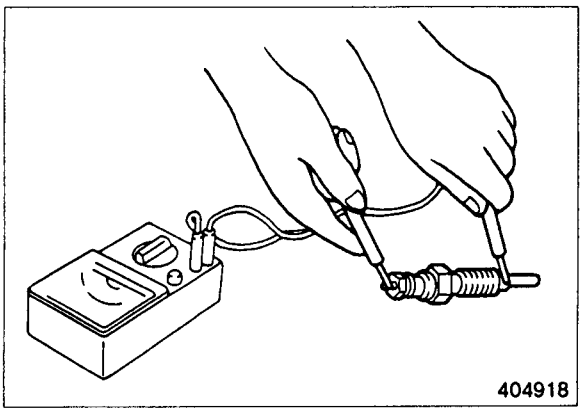


Glow plug relay

3. Glow plug inspection

Test for continuity between the terminal and body as shown in the illustration. No continu-

Item	Standard
Resistance	0.55Ω



Testing glow plug

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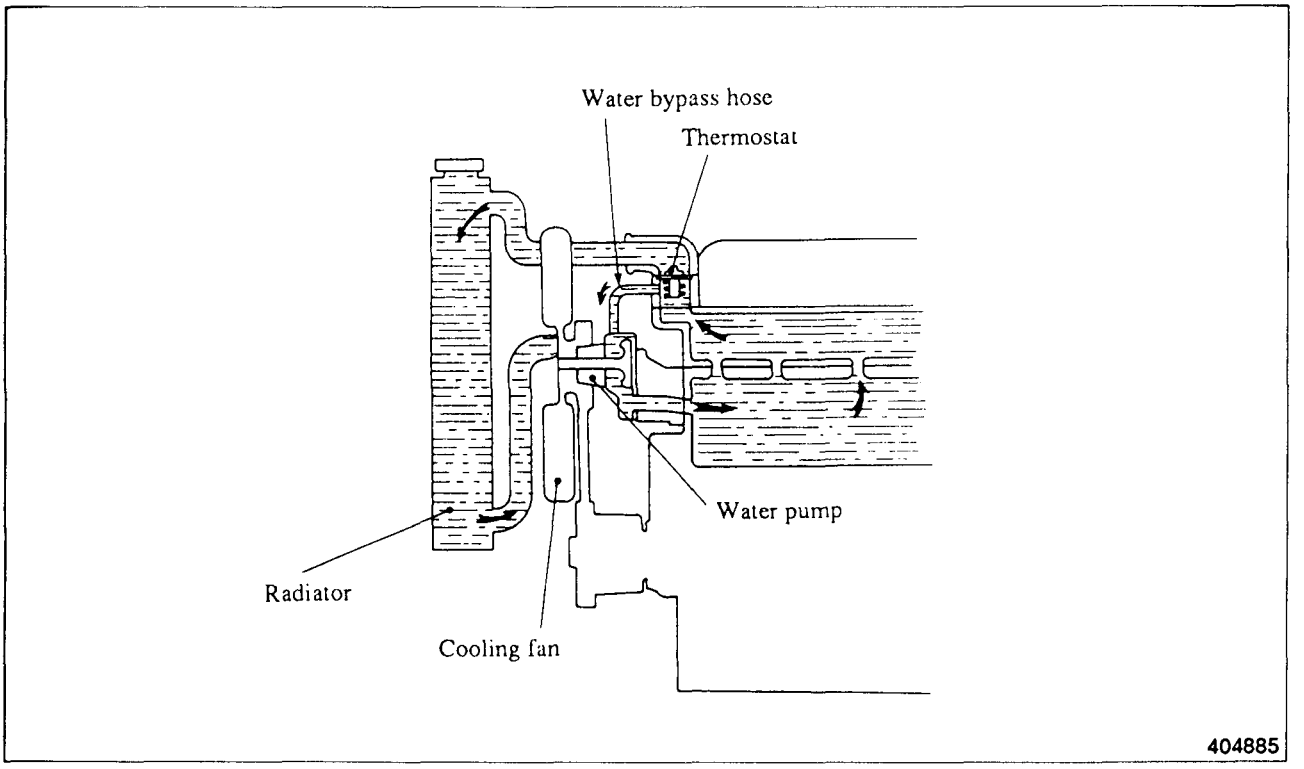
COOLING SYSTEM

GENERAL

1. Schematic

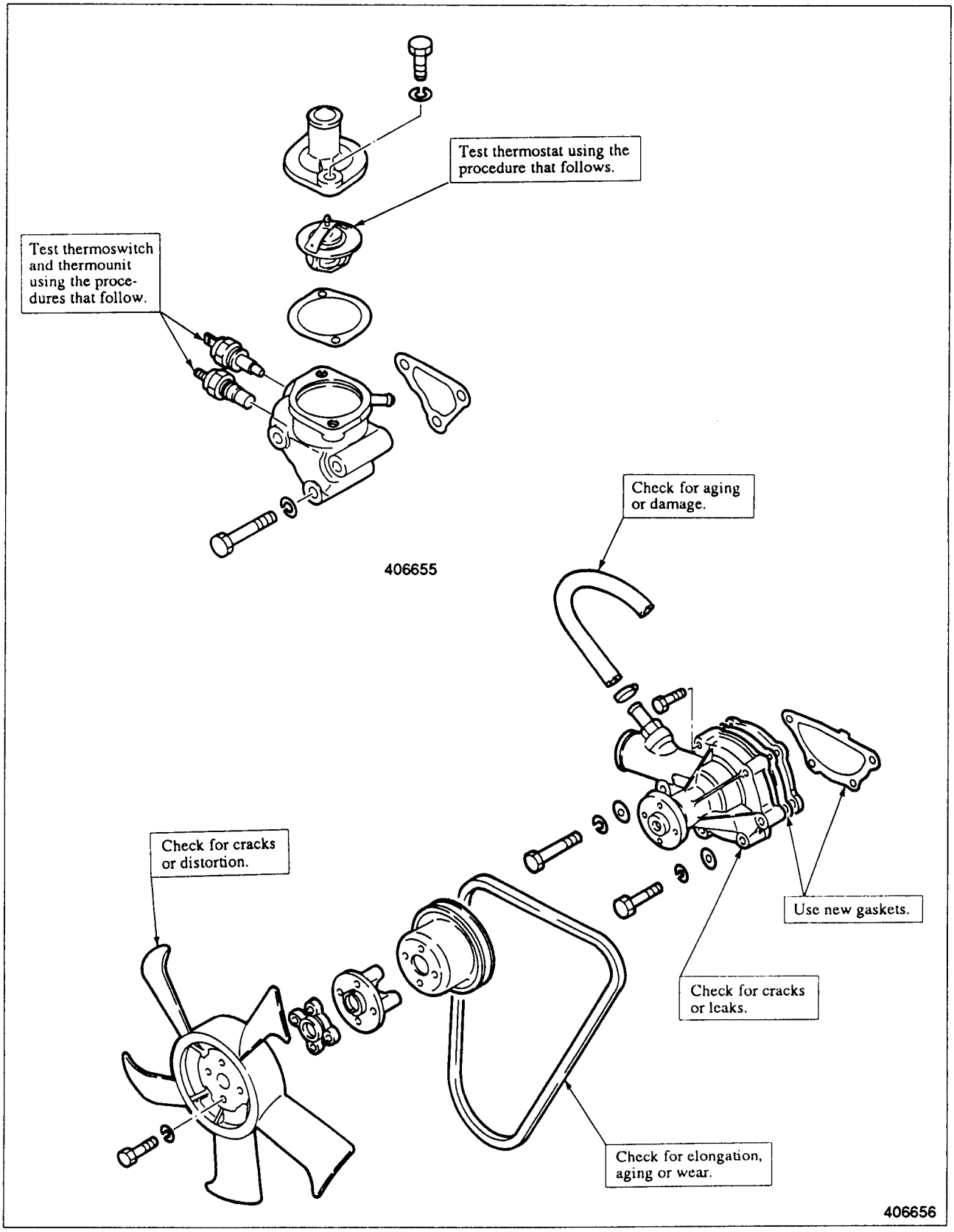


Schematic

2. Specifications (standard)

Engine model		S3L/S3L2	S4L/S4L2
Fan belt (for farm or industrial engine)		LL or HM type (width = 10.7 mm (0.42 in.), V angle = 38°, outer circumference = 980 mm (38.6 in.)	
Cooling fan	Suction type	No. of blades = 5, diameter = 320 mm (12.6 in.)	No. of blades = 5, diameter = 360 mm (14.2 in.)
Water pump		Centrifugal type	
Thermostat	Temperature at which valve starts opening	82 ± 1.5°C (180 ± 2.7°F)	
	Temperature at which valve lift is 8 mm (0.3 in.)	95°C (203°F)	
Thermoswitch	Type	Bimetal	
	Temperature at which switch is turned ON	111 ± 3.5°C (232 ± 6.3°F)	
	Temperature difference for ON-OFF control	8 ± 3.5°C (46.4 ± 6.3°F)	
Resistance in thermounit		50°C (122°F): 80 ± 10 Ω 80°C (176°F): 29.5 ± 2.5 Ω 120°C (248°F): 10 ± 0.3 Ω	

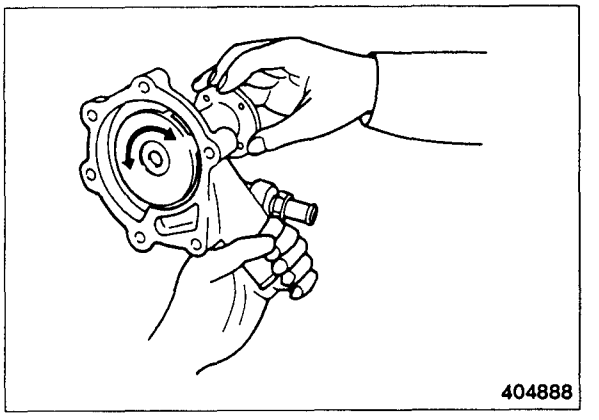
INSPECTION



Inspection points

1. Water pump

Check the impeller and shaft for rotation. If they do not rotate freely or have noise, replace the water pump assembly.

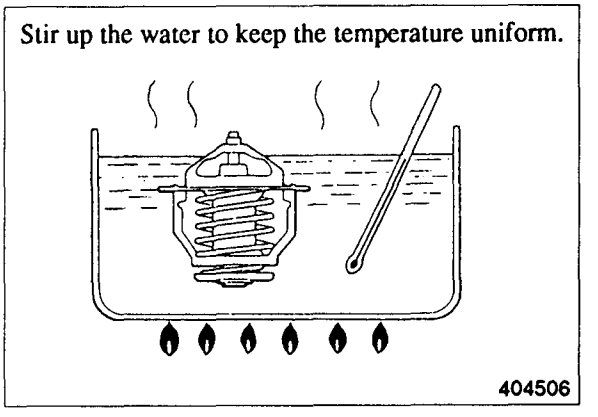


Checking water pump

2. Thermostat (standard)

Hang the thermostat in the pan of water as shown in the illustration. The thermostat must be below the surface of the water and its must be away from the sides of the pan. Heat the water uniformly in the pan and measure a temperature at which the valve starts opening and a temperature at which the valve lift (distance) is 8 mm (0.3 in.). Replace the thermostat if defective.

Temperature at which valve starts opening	85 ± 1.5°C (180 ± 2.7°F)
Temperature at which valve lift is 8 mm (0.3 in.)	95°C (203°F)



Testing thermostat

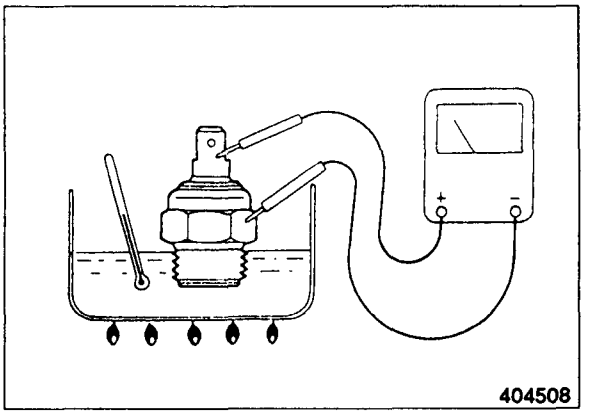
⚠ WARNING

Water in the pan is hot. Any contact can cause severe burns.

3. Thermoswitch (standard)

Hang the thermoswitch in the pan of oil with its temperature sensing end below the surface of oil and measure the resistance while heating the oil as shown in the illustration. If the resistance is incorrect, replace the thermoswitch.

Resistance at 120°C (248°F)	30 mΩ
Temperature at which switch is turned ON	111 ± 3.5°C (232 ± 6.3°F)



Testing thermoswitch

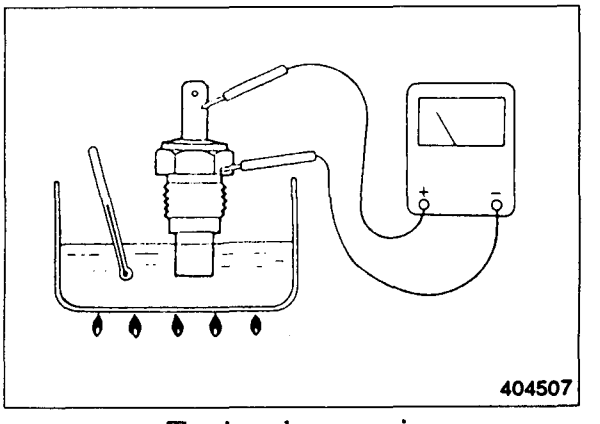
⚠ WARNING

Oil in the pan is hot. Any contact can cause severe burns.

3. Thermounit (standard)

Hang the thermounit in the pan of antifreeze with its temperature sensing end below the surface of antifreeze and measure the resistance while heating the antifreeze as shown in the illustration. If the resistance is incorrect, replace the thermounit.

Standard	50°C (122°F): 80 ± 10 Ω 80°C (176°F): 29.5 ± 2.5 Ω 120°C (248°F): 10 ± 0.3 Ω



Testing thermounit

⚠ WARNING

Antifreeze in the pan is hot. Any contact can cause severe burns.

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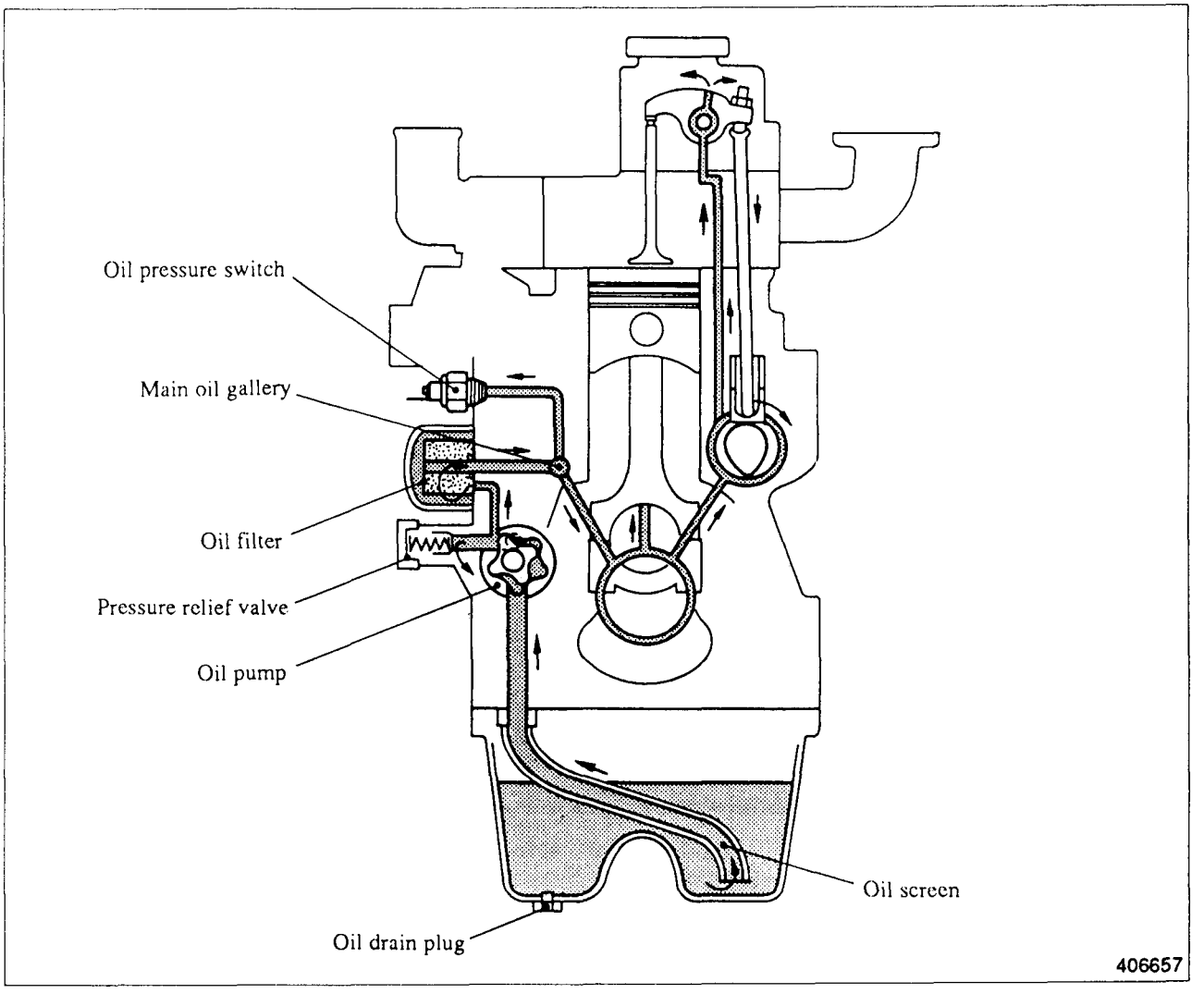
LUBRICATION SYSTEM

GENERAL

INSPECTION

GENERAL

1. Schematic



Schematic

2. Specifications

Engine model		S3L/S3L2	S4L/S4L2
Type		Force feed	
Oil		API Service Classification CC or better	
Capacity (high level excl. 0.5 liter (0.13 U.S. gal) of oil in oil filter), liter (U.S. gal)		5.7 (1.5) (with deep oil pan) 3.7 (1.0 (with standard oil pan)	7.7 (2.0) (with deep oil pan) 5.4 (1.4) (with standard oil pan)
Oil pump	Type	Trochoid	
	Driven by	Camshaft gear	
Relief valve opening pressure		3.5 ± 0.5 kgf/cm² (50 ± 7 psi) [343 ± 49 kPa]	
Pressure difference at which oil pressure switch is closed (indicator light comes on)		0.5 ± 0.1 kgf/cm² (7 ± 1.4 psi) [49 ± 10 kPa]	
Oil filter		Paper-element cartridge (full flow) type	

INSPECTION

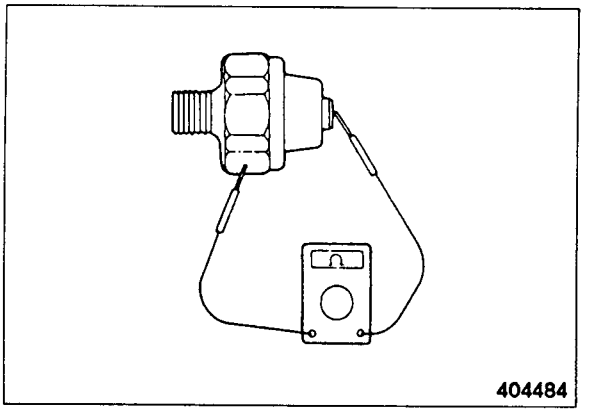
1. Oil pump

Visually check the pump for rough rotation or other defects. Replace the pump assembly if defective.

Checking oil pump

2. Oil pressure switch

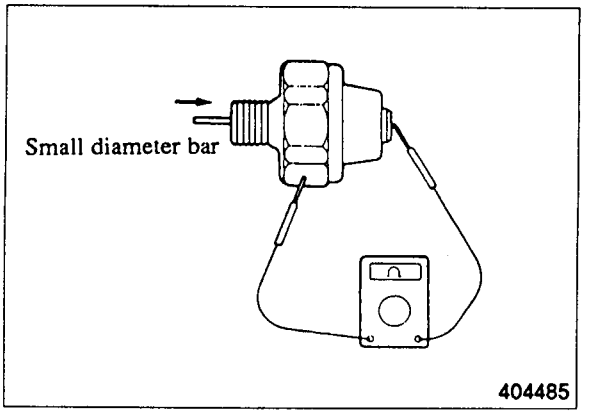
(1) Test for continuity between the terminal and body with an ohmmeter as shown in the illustration. No continuity is the cause for replacing the switch.



Testing oil pressure switch (1)

(2) Insert a small diameter bar into the oil hole in the switch and lightly push it in to test for no continuity as shown in the illustration. Any continuity is the cause for replacing the switch.

(3) Apply a pressure air of 0.5 kgf/cm^2 (7 psi) [49 kPa] to the switch through the oil hole to test for no continuity. Any continuity is the cause for replacing the switch. Also, check for air leaks. Any air leak is an indication of a ruptured diaphragm. In such a case, replace the switch.



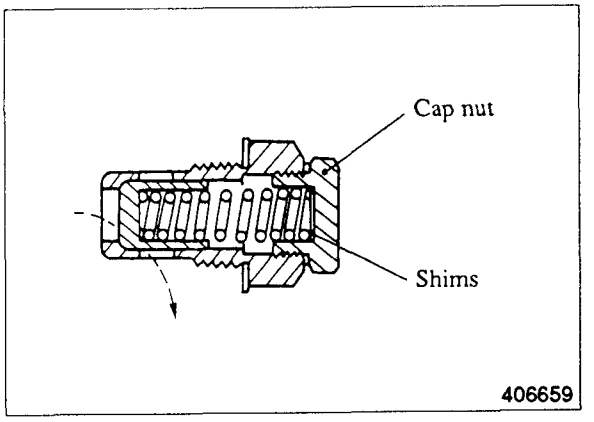
Testing oil pressure switch (2)

3. Pressure relief valve

(1) Check the valve seat for contact. Check the spring for damage.

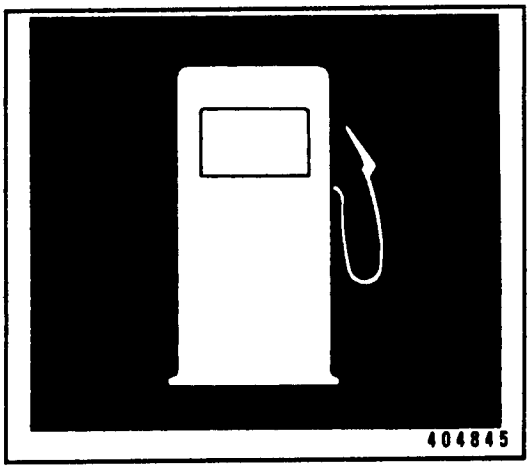
(2) Measure the oil pressure at which the relief valve opens (the oil pressure with the engine running at the rated rpm). If the pressure is not correct, remove the cap nut and increase or decrease the amount of shims. The engine oil pressure tap is located on the right side of the engine.

Relief valve opening pressure	3.5 ± 0.5 kgf/cm² (50 ± 7 psi) [343 ± 49 kPa]



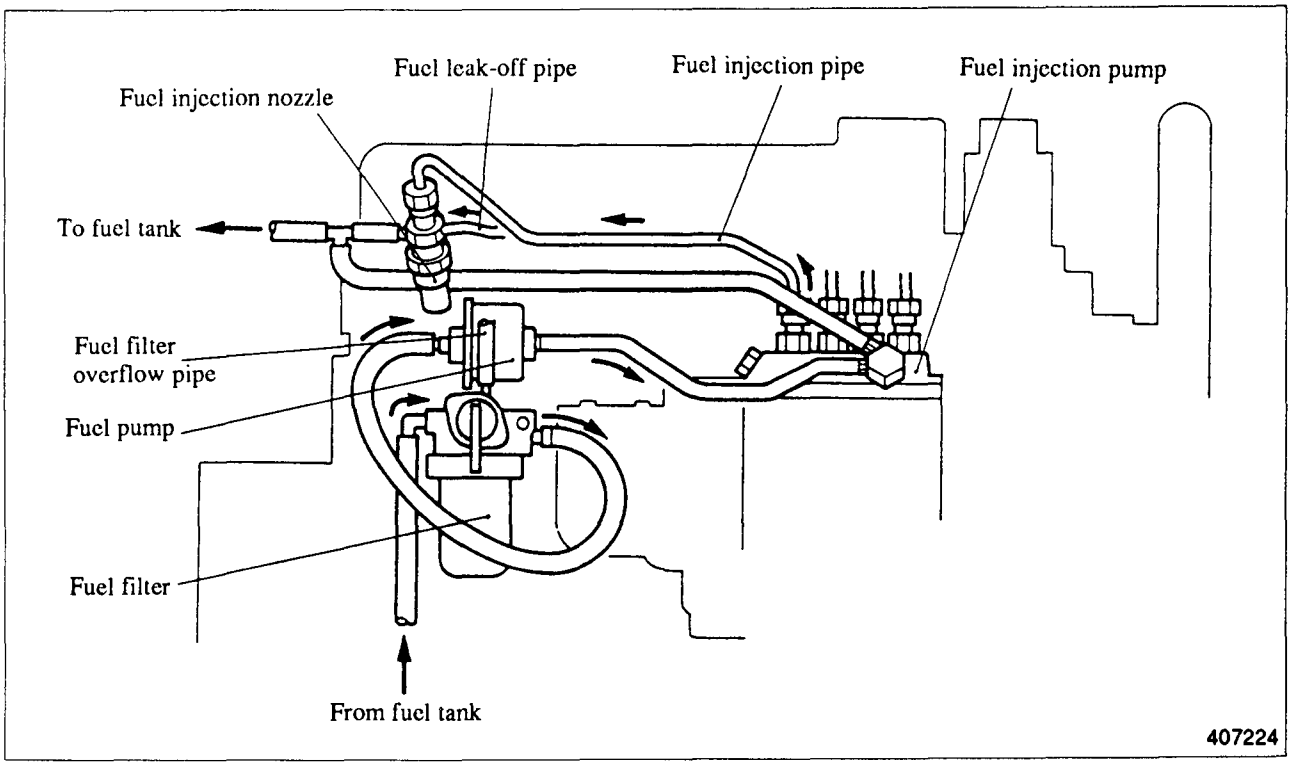
Checking pressure relief valve

FUEL SYSTEM



GENERAL

1. Schematic



2. Specifications (standard)

Engine model		S3L/S3L2	S4L/S4L2
Fuel injection pump	Type	Bosch M	
	Model	ND-PFR3M	ND-PFR4M
	Plunger diameter	5.5 mm (0.217 in.)	
	MS retard (crank angle), deg	8	
	Delivery valve, type	Silto or Bosch	
	Air vent screw	Yes	
Fuel injection nozzle	Type	Throttle	
	Model	DN15PD6	
	Injection pressure (valve opening pressure)	140^{+5}_{0} kgf/cm^2 (1991^{+71}_{0} psi) [$13\,729^{+490}_{0}$ kPa]	
Fuel filter (remote)	Type	Paper element	
Fuel pump (remote)	Type	Electric (diaphragm)	
	Capacity (at terminal voltage of DC 12 V and 20°C (68°F))	300 cc (18.3 cu in.)/min minimum or 400 cc (24.4 cu in.)/min minimum	

FUEL INJECTION NOZZLE

1. Inspection

(1) Injection pressure (valve opening pressure) test

(a) Install the injection nozzle on the tester. Slowly operate the tester handle to bleed (remove) air from the tester.

(b) Operate the tester handle at a speed of one stroke per second to make a slow increase in pressure until the valve in the injection nozzle starts to open. Read the maximum gauge pressure at the instant fluid flows from the tip.

(c) If the injection pressure is incorrect, disassemble the nozzle and change the thickness of the washer.

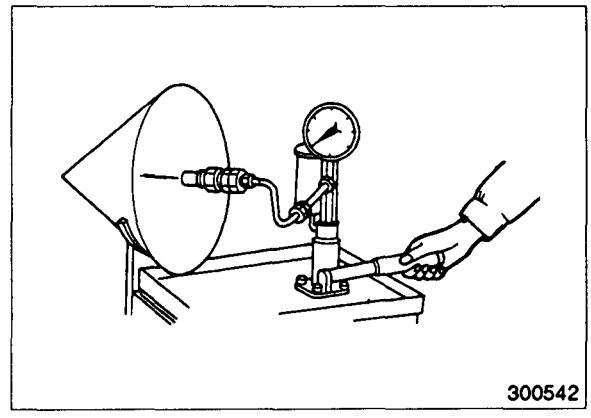
Injection pressure (valve opening pressure) Standard	140^{+5}_{0} kgf/cm^2 ($1\,991^{+71}_{0}$ psi) [$13\,729^{+490}_{0}$ kPa]

NOTE

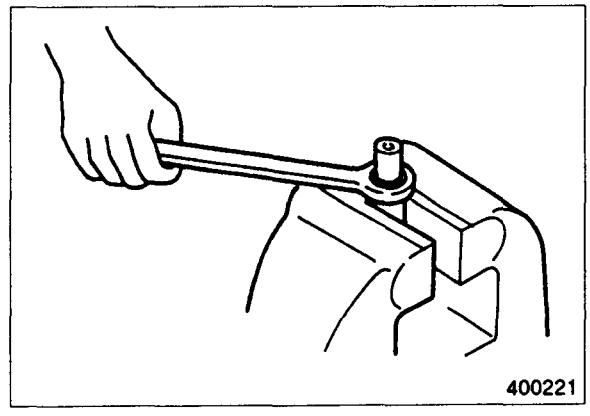
An increase or decrease of washer thickness by 0.1 mm (0.004 in.) will vary the injection pressure by 10 kgf/cm^2 (142 psi) [981 kPa]. 10 kinds of washer are available in thicknesses from 1.25 mm (0.049 2 in.) to 1.70 mm (0.066 9 in.) in increments of 0.05 mm (0.002 0 in.).

⚠ WARNING

When the injection nozzles are tested, be sure to wear eye protection. Fuel comes from the orifices in the nozzle tip with high pressure. The fuel can pierce (go through) the skin and cause serious injury to the operator. Keep the tip of the nozzle pointed away from the operator and into the fuel collector.



Fuel injection nozzle ready for test

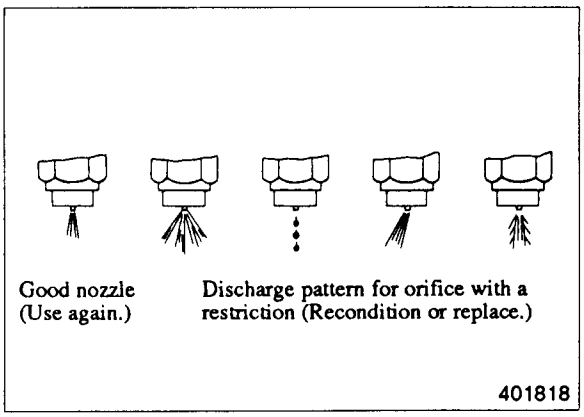


Removing tip from injection nozzle

(2) Orifice restriction test

(a) Look at the orifice discharge pattern (shape of discharge) when fluid begins to flow through the injection nozzle. The discharge must be straight. Any change is an indication of a bad nozzle.

(b) Operate the tester handle at a speed of one stroke per second to make sure the discharge is straight.



Orifice restriction test

(3) Nozzle tip washing and replacement

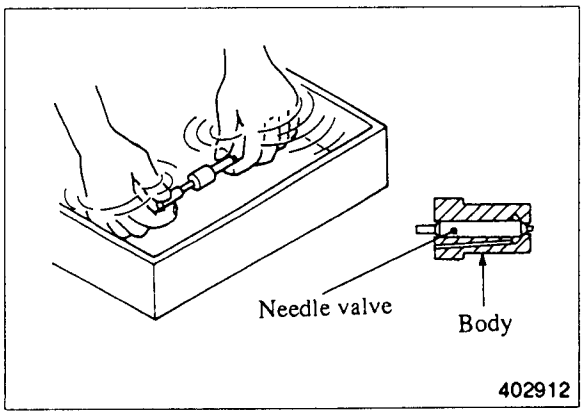
(a) Loosen the retaining nut and remove the tip from the injection nozzle. Wash the needle valve and body in clean diesel fuel. After washing, put the needle valve in the body in clean diesel fuel.

⚠ CAUTION

Do not hit the tip when removing it from the injection nozzle.

NOTE

Keep the need valves with their respective bodies. Do not use needle valves or bodies with other bodies or needle valves.



Washing nozzle tip

(b) After cleaning the tip, install it in the nozzle and tighten the retaining nut to the specified torque.

Tightening torque	3.75 ± 0.25 kgf·m (27 ± 1.8 lbf·ft) [36.8 ± 2.5 N·m]

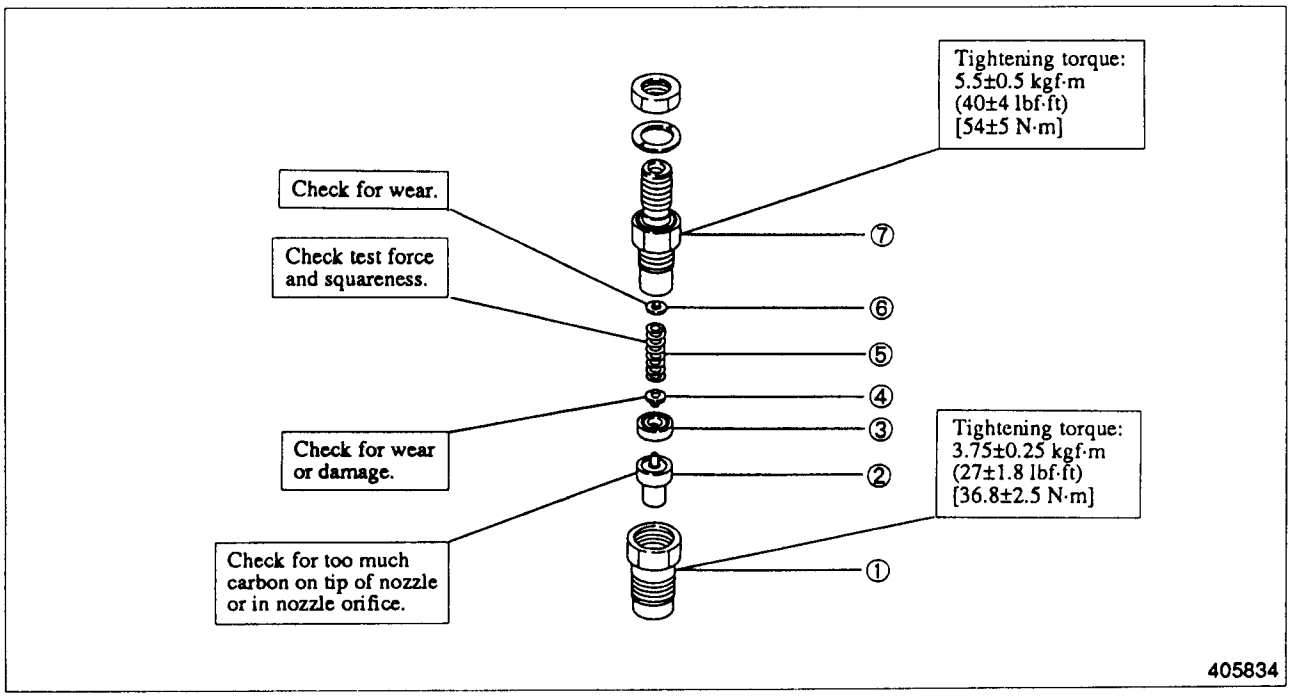
(c) If the injection nozzle is still bad after the tip has been washed, replace the tip.

NOTE

a) Do not touch the sliding surface of the needle valve.

b) When installing the new nozzle tip, remove synthetic resin film from the tip and slide the needle valve in the body in clean diesel fuel to wash off inhibitor completely.

2. Disassembly and assembly



Disassembly sequence and inspection points

① Retaining nut
② Nozzle tip assembly
③ Piece
④ Pin
⑤ Spring
⑥ Washer
⑦ Body

FUEL INJECTION PUMP

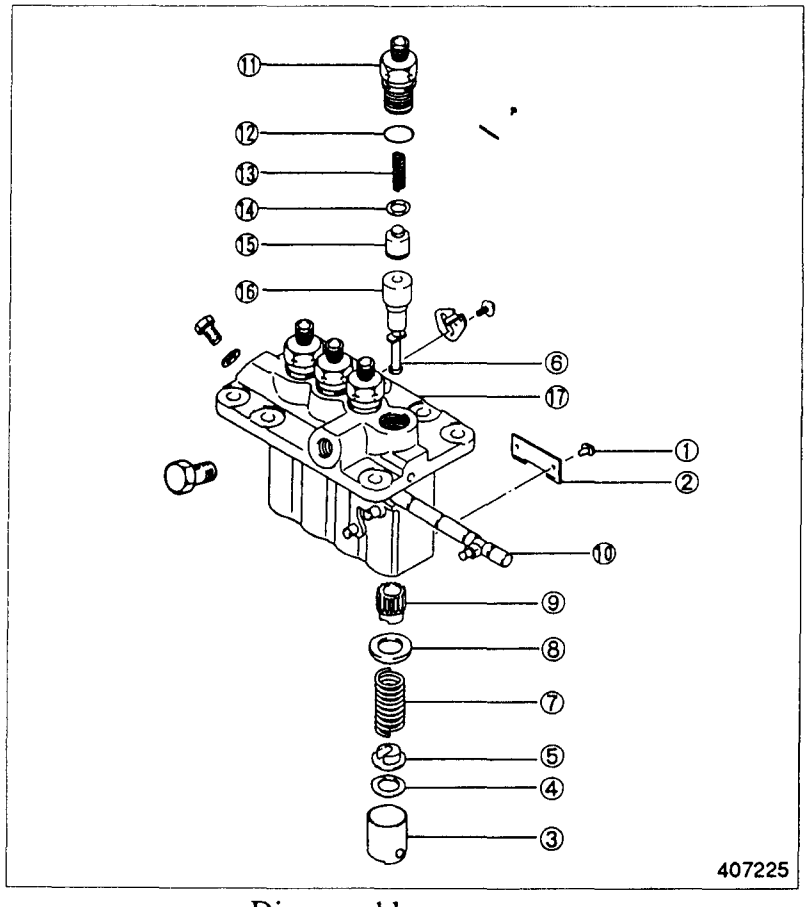
1. Test on engine

Check the injection pump for items listed in the chart below and replace it if defective. Do not attempt to make repairs by disassembling.

Test item	Test method	Criteria
Low idle speed	Use a tachometer.	Standard farm engine: 980^{+30}_{0} rpm
Exhaust smoke	1) Check by quickly increasing engine speed under no-load condition. 2) Check by starting load.	No too much black or gray smoke
Orifice discharge patter	Remove injection nozzle and reinstall it with orifice toward outside of engine. Look at discharge pattern by cranking the engine with starter.	Good discharge pattern

2. Disassembly

① Tappet guide pin
② Lock plate
③ Tappet
④ Tappet adjusting shim
⑤ Lower spring seat
⑥ Plunger
⑦ Plunger spring
⑧ Upper spring seat
⑨ Control sleeve
⑩ Control rack
⑪ Delivery valve holder
⑫ O-ring
⑬ Delivery valve spring
⑭ Delivery valve gasket
⑮ Delivery valve
⑯ Plunger barrel
⑰ Pump housing



Disassembly sequence

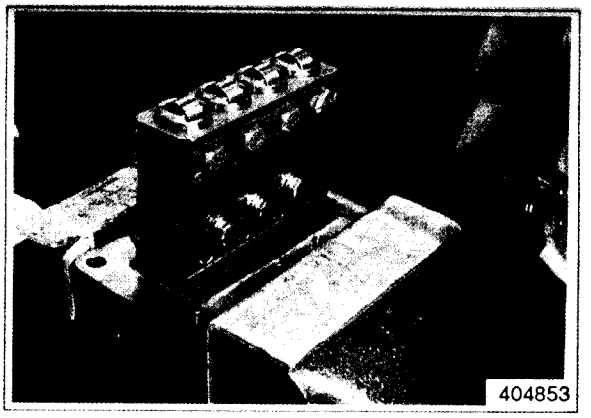
Disassembly procedure

(1) Tappet removal

(a) Hold the injection pump in a vise with the side that has tappets up.

(b) Straighten the lock plate away from the tappet guide pin with a screwdriver.

(c) Rotate the tappet guide pin 180° to unlock it from the housing.



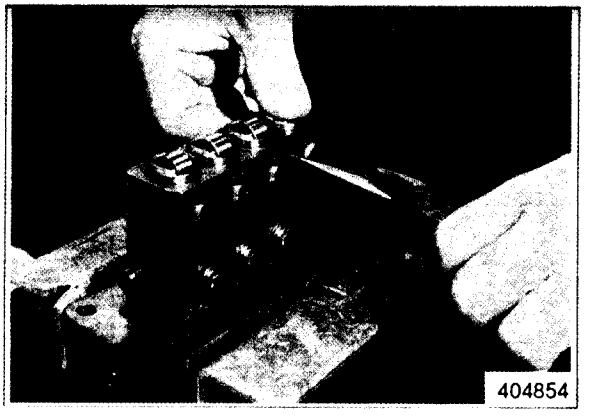
Removing tappet guide pins

(d) Remove the tappet guide pin with a needle-nose pliers while pushing down on the tappet. Remove the tappet.

(e) Do Steps (b) through (d) again for remainder of the tappets.

⚠ CAUTION

The tappet can be thrown from the housing when the tappet guide pin is removed. Hold the tappet to prevent it from falling.



Removing tappets

(2) Plunger removal

(a) Remove the tappet adjusting shim.

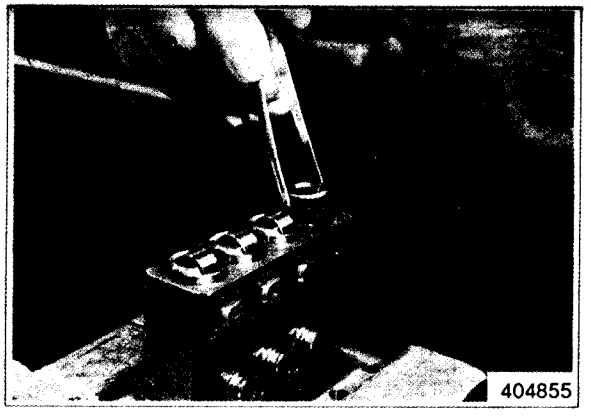
(b) Remove the lower spring seat and plunger with a tweezers.

(c) Remove the plunger spring.

(d) Remove the upper spring seat and control sleeve.

(e) Do Steps (a) through (d) again for remainder of the plungers.

(f) Remove the control rack.



Removing plungers

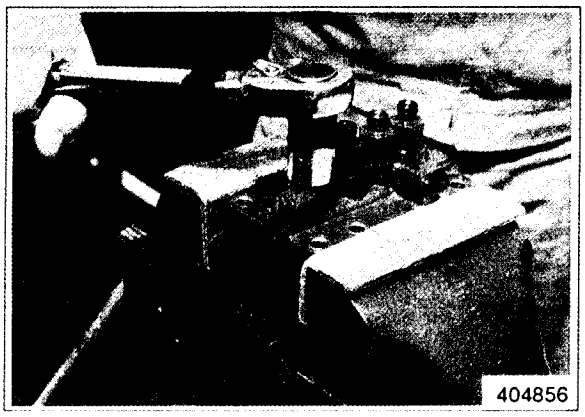
(3) Delivery valve removal

(a) Turn the injection pump upside down and hold it in a vise.

(b) Remove the delivery valve holder.

(c) Remove the delivery valve spring.

(d) Remove the delivery valve gasket.



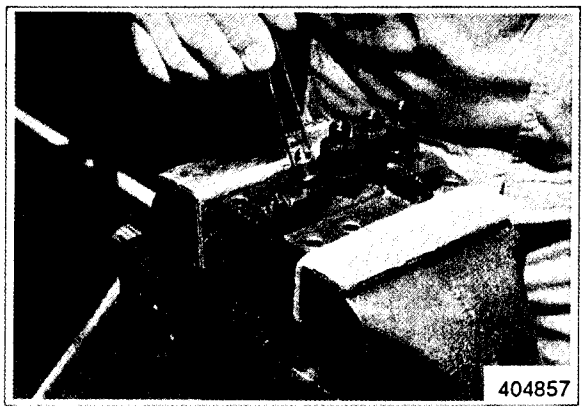
Removing delivery valve holders

(e) Remove the delivery valve with a tweezers.

(f) Do Steps (b) through (e) again for remainder of delivery valves.

⚠CAUTION

The delivery valves are finely finished parts. Keep them as clean as possible.



Removing delivery valves

(4) Barrel removal

(a) Remove the barrels from the housing.

⚠CAUTION

a) The plungers and barrels are finely finished parts. Keep them as clean as possible.

b) Keep the plungers with their respective barrels for installation. Do not use plungers or barrels with other barrels or plungers.

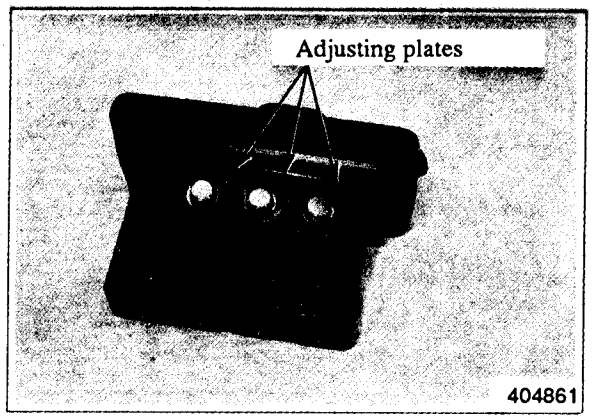
Removing barrels

NOTE

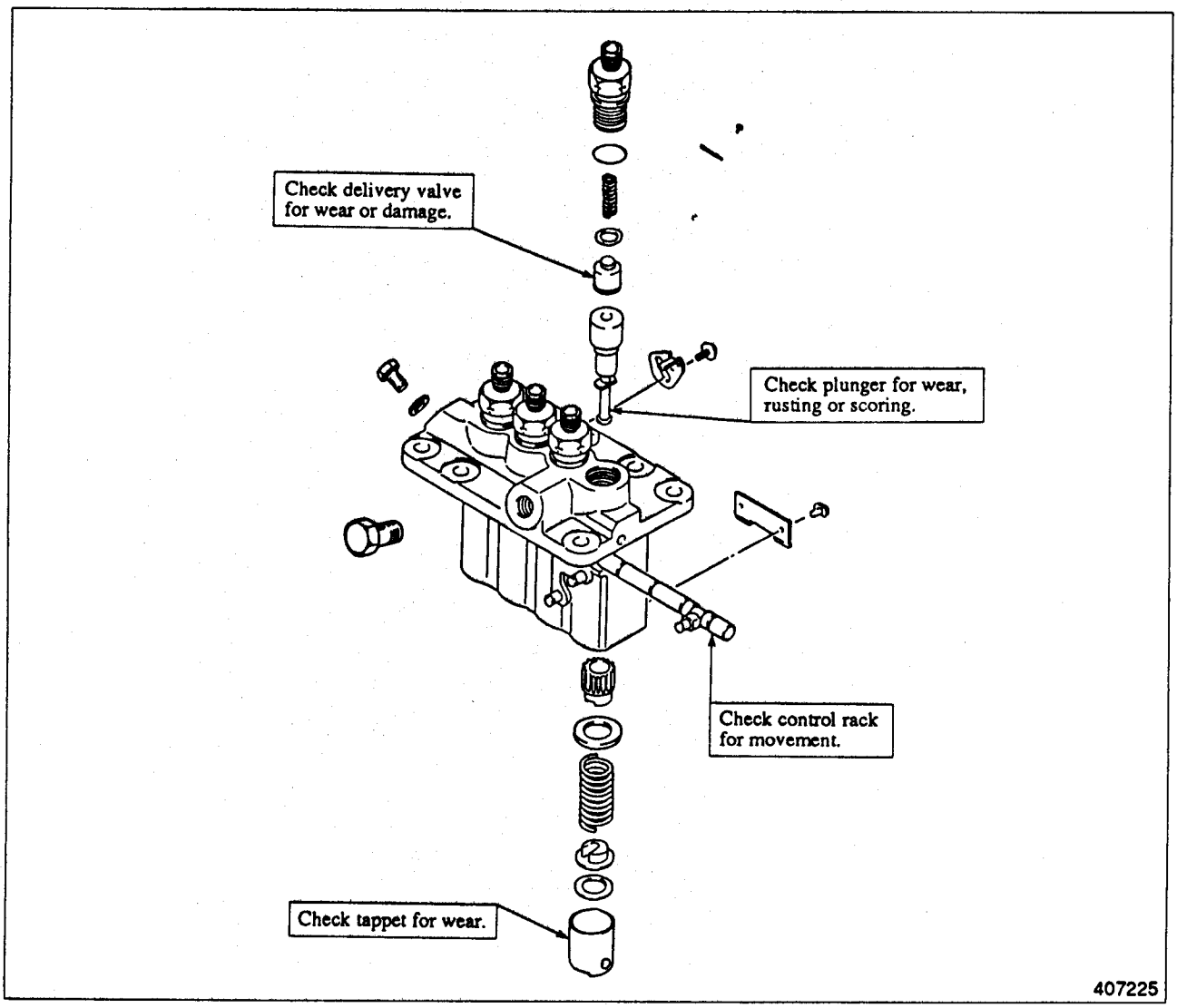
a) When replacing the plungers and barrels or delivery valves, do not loosen the adjusting plates between the pumping elements.

b) After these parts have been replaced, the injection quantity must be measured. Pump Tester Cam Box is needed for measurement of injection quantity.

c) Keep the disassembled injection pump parts in clean diesel fuel.

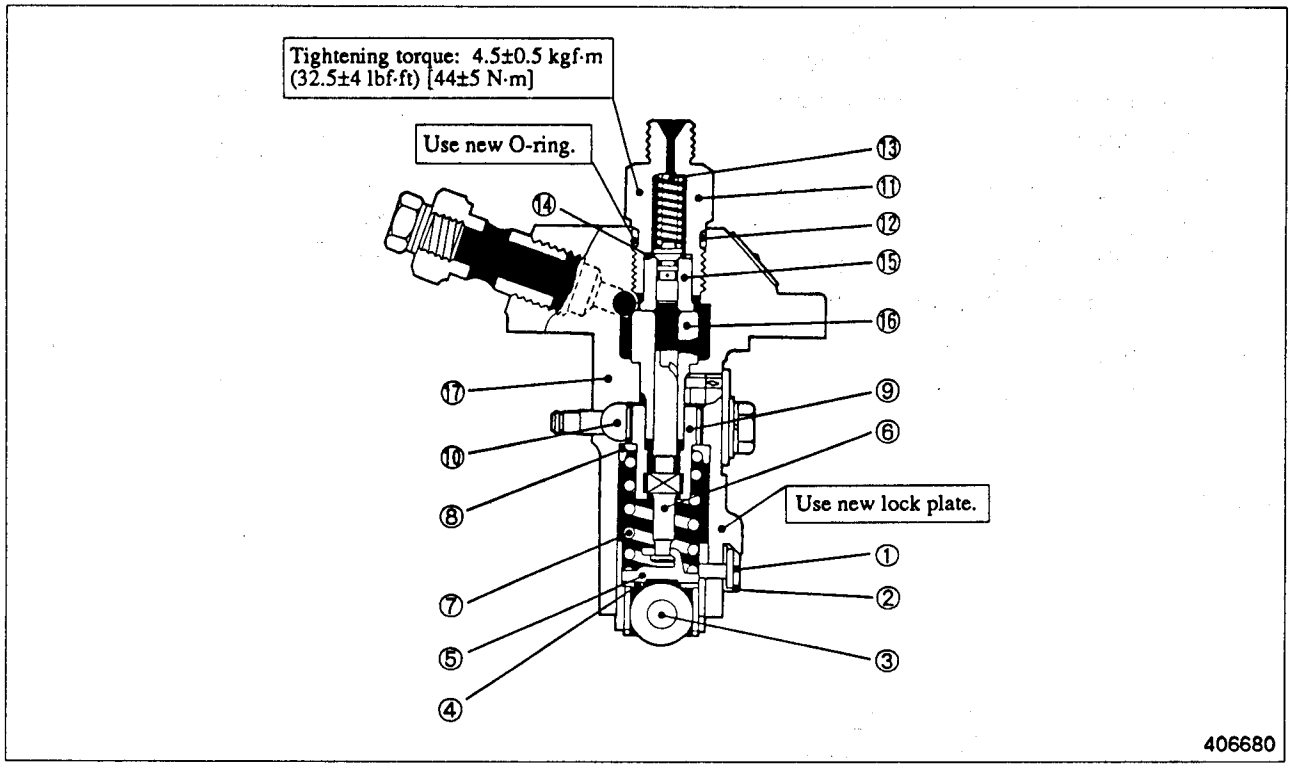


3. Inspection



Inspection points

4. Assembly



Assembly sequence

Follow the reverse of disassembly and use the procedure that follows.

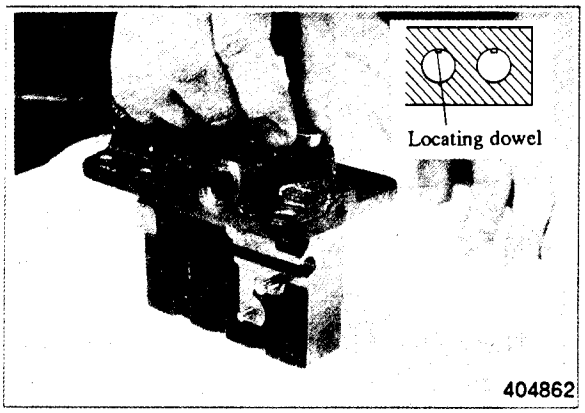
Assembly procedure

(1) Barrel installation

Put each barrel in position in the housing with its slot in alignment with the dowel of the housing and put it straight down into the bore.

NOTE

If the slot in the barrel is not aligned with the dowel of the housing, the O-ring will not seat correctly (still visible) after the delivery valve holder has been installed.



Installing barrels

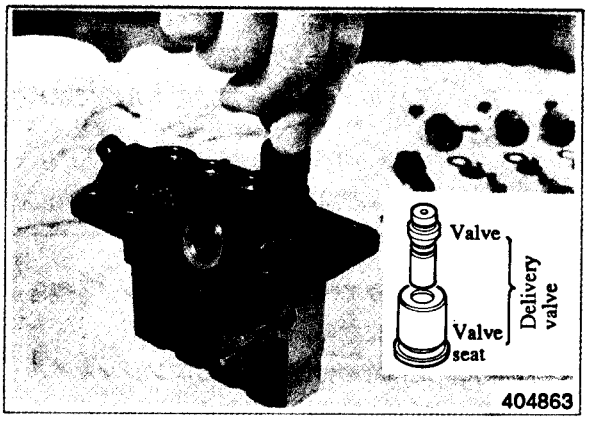
(2) Delivery valve installation

Install the delivery valve, gasket, spring and O-ring on the barrel and tighten the delivery valve holder finger tight. Do this step for remainder of the delivery valves.

⚠ CAUTION

a) Any time the injection pump is disassembled, a new O-ring must be installed.

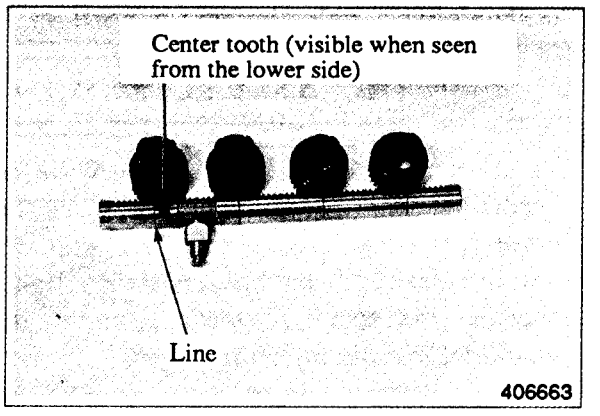
b) Make sure the threads of the delivery valve holder do not cause damage to the O-rings.



Installing delivery valves

(3) Control sleeve installation

(a) Install each control sleeve with the center tooth in alignment with the line mark of the control rack.

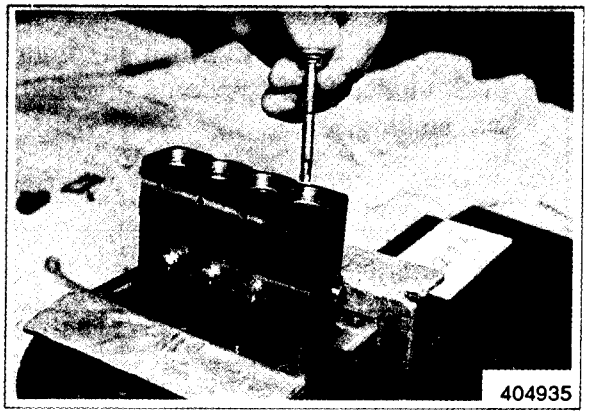


Installing control sleeves

(b) Put the plungers in position in the barrels.

⚠ CAUTION

Make sure the notch in the plunger is toward the adjusting plate.



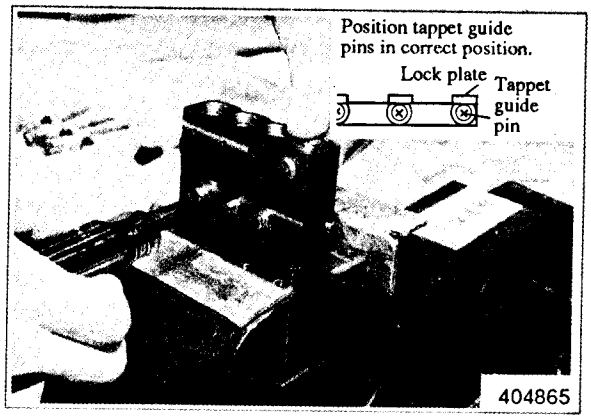
Installing plungers

(4) Tappet installation

Move the control rack back and forth while pushing down on each tappet to align the slot in the tappet with the hole in the housing for the tappet guide pin. Install the lock plates and tappet guide pins in position.

⚠CAUTION

Any time the injection pump is disassembled, new lock plates must be used.



Installing tappets

(5) Delivery valve holder installation

Put the delivery valve holders in position and tighten them to the specified torque.

⚠CAUTION

Do not over tighten the delivery valve holders. This can put end force on the barrels, resulting in a failure of the plungers to move freely. If the holders are not tightened to the specified torque, engine oil would leak in the injection pump.

Tightening delivery valve holders

(6) Inspection after assembly

(a) After the injection pump has been assembled, check to see if the control rack moves freely without any binding or catching.

(b) If the control rack fails to move freely, the possible causes are:

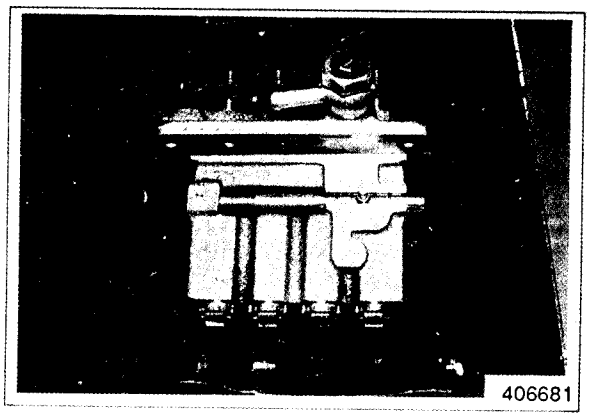
1) Pumping element(s) sticking

2) Foreign particles lodged between control rack and sleeves

3) Over-tightening of delivery valve holder(s)

Disassemble and check the injection pump to locate the cause of the trouble.

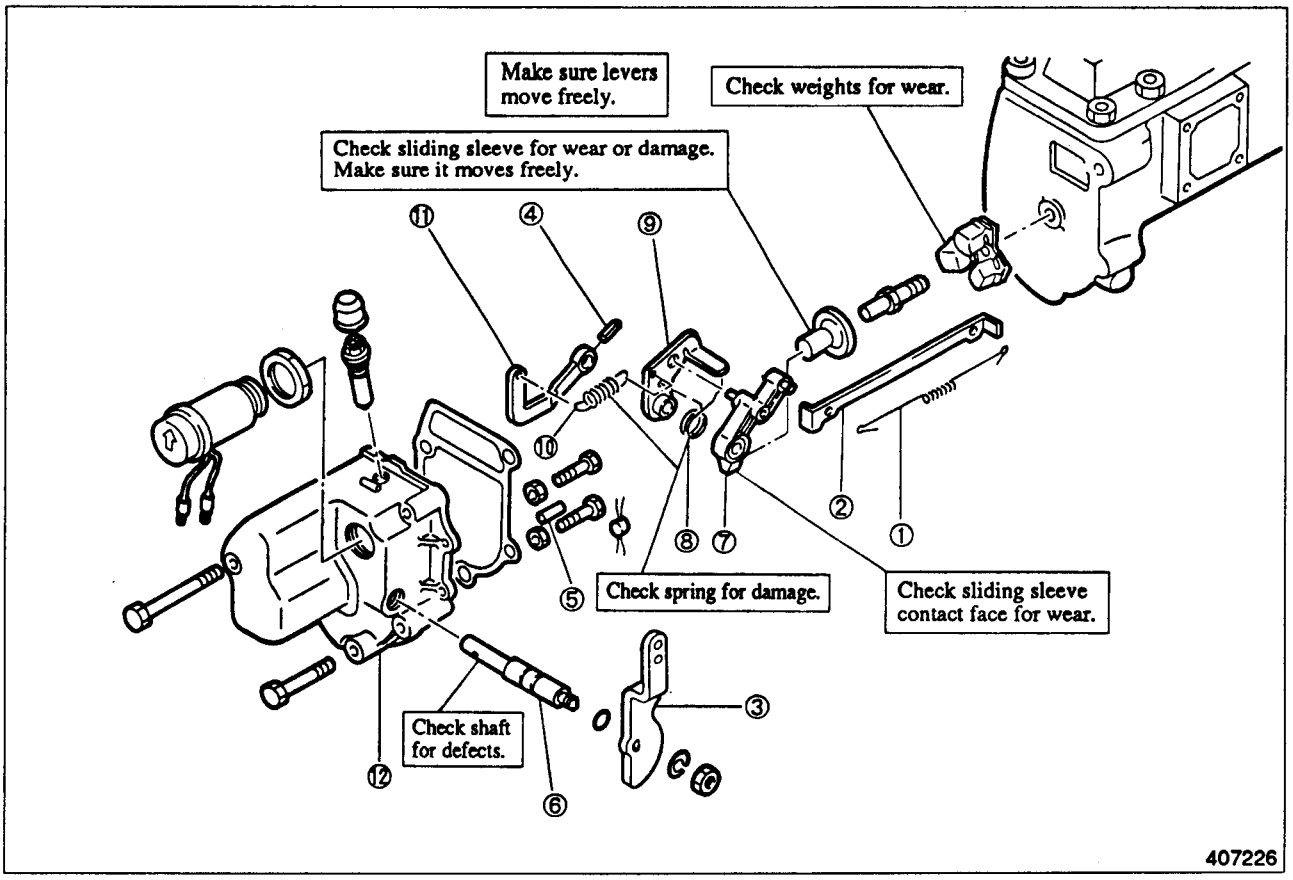
(c) After the injection pump has been finally assembled, check the injection timing.



Checking control rack movement

GOVERNOR

1. Disassembly and inspection

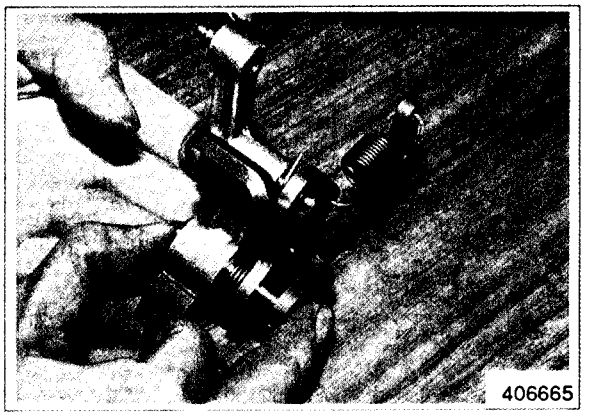


Disassembly sequence and inspection points

① Tie rod spring
② Tie rod
③ Speed control lever
④ Spring pin
⑤ Grooved pin
⑥ Governor shaft
(Remove ⑦ thru ⑪ as an assembly.)
⑦ Governor lever
⑧ Start spring
⑨ Tension lever
⑩ Governor spring
⑪ Governor spring lever
⑫ Governor case

2. Assembly

(1) Install the levers in position.



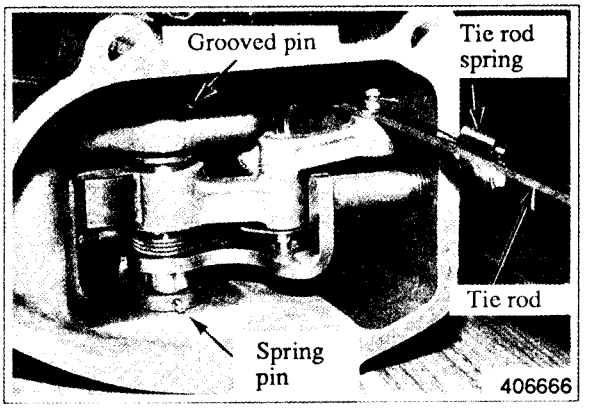
Installing governor levers

(2) Put O-ring on the governor shaft.

(3) Put the governor shaft in position in the governor case and put the levers on the governor shaft.

(4) Install the grooved pin and spring pin in position with a hammer.

(5) Install the tie rod and tie rod spring in position.



Assembling governor

3. Torque spring set installation

The torque spring set is to be installed and adjusted after an adjustment is made to the low idle speed and high idle speed, with the engine at a standstill.

(1) Remove the tie rod cover.

(2) Move the speed control lever to the high idle position and hold it there.

(3) Pull the tie rod in the direction of arrow head to the point where a slight resistance is encountered.

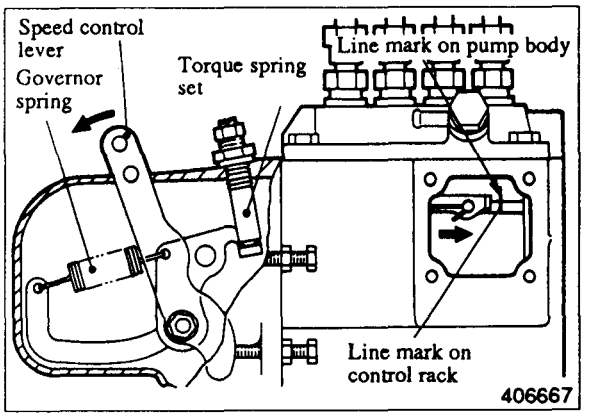
NOTE

In this position, the tie rod does not pull on the governor spring.

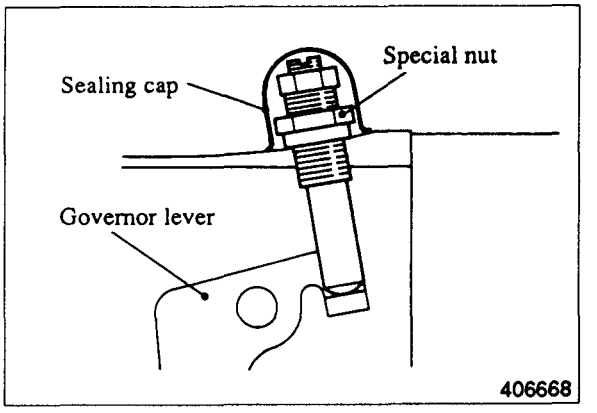
(4) Turn in the torque spring set while lightly pulling the tie rod until the line mark on the control rack is aligned with the line mark on the pump body.

(5) With these line marks aligned, lock the torque spring set in position by tightening the special nut.

(6) Install the sealing cap over the torque spring set and stake the cap in position.



Installing torque spring set

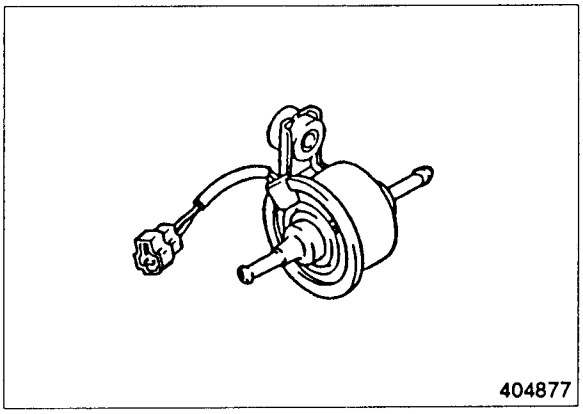


Sealing cap for torque spring set

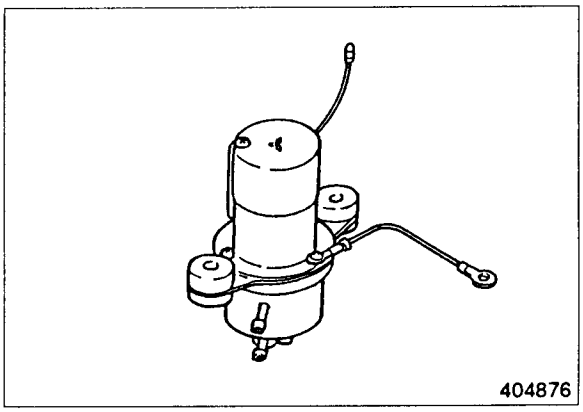
FUEL PUMP

Inspection

Look outside the pump for defects and test its performance. Do not attempt to disassemble the pump.



Fuel pump (plunger type)

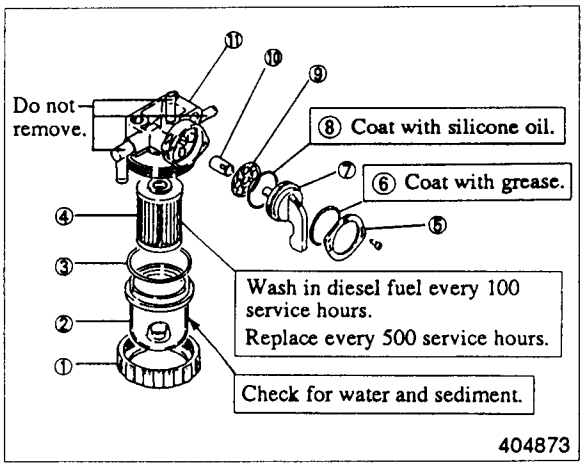


Fuel pump (diaphragm type)

FUEL FILTER

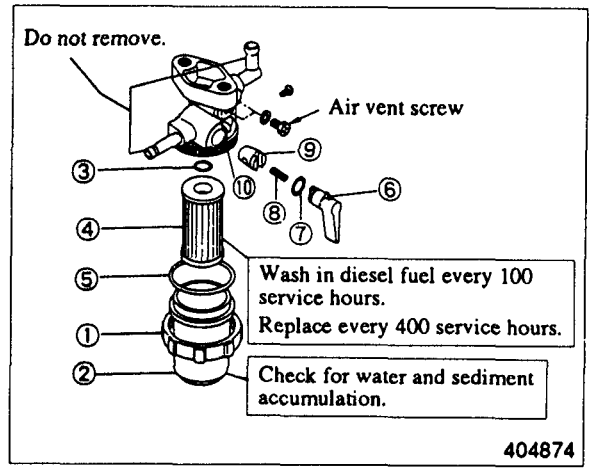
(1) Normally, the fuel filter is not to be disassembled. Only element removal for cleaning or replacement is recommended.

(2) When installing the valve lever after washing, coat the O-ring for the lever with silicone oil and the washer with grease.



Fuel filter

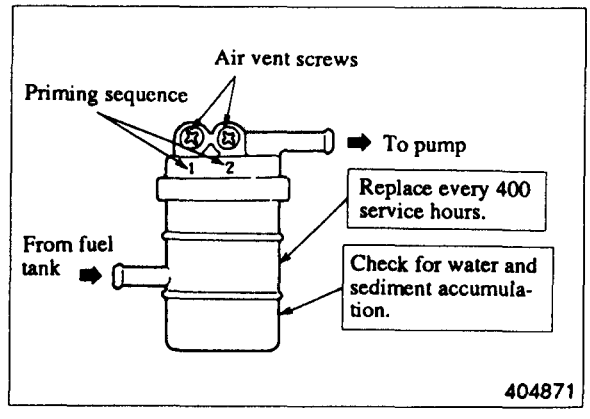
① Ring nut
② Cup
③ O-ring
④ Element
⑤ Lever plate
⑥ Washer
⑦ Valve lever
⑧ O-ring
⑨ Packing
⑩ Valve seat
⑪ Filter body



Fuel filter

① Ring nut
② Cup
③ O-ring
④ Element
⑤ O-ring
⑥ Valve lever
⑦ O-ring
⑧ Spring
⑨ Valve
⑩ Filter body

Do not attempt to disassemble the cartridge type fuel filter. Check the filter for contamination or damage and replace it as an assembly if necessary.



Fuel filter (cartridge type)

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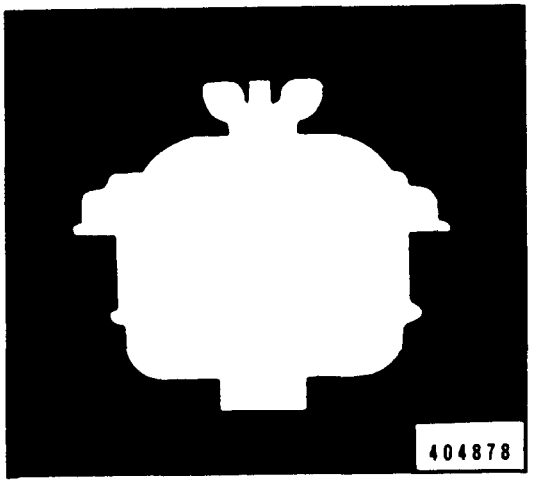
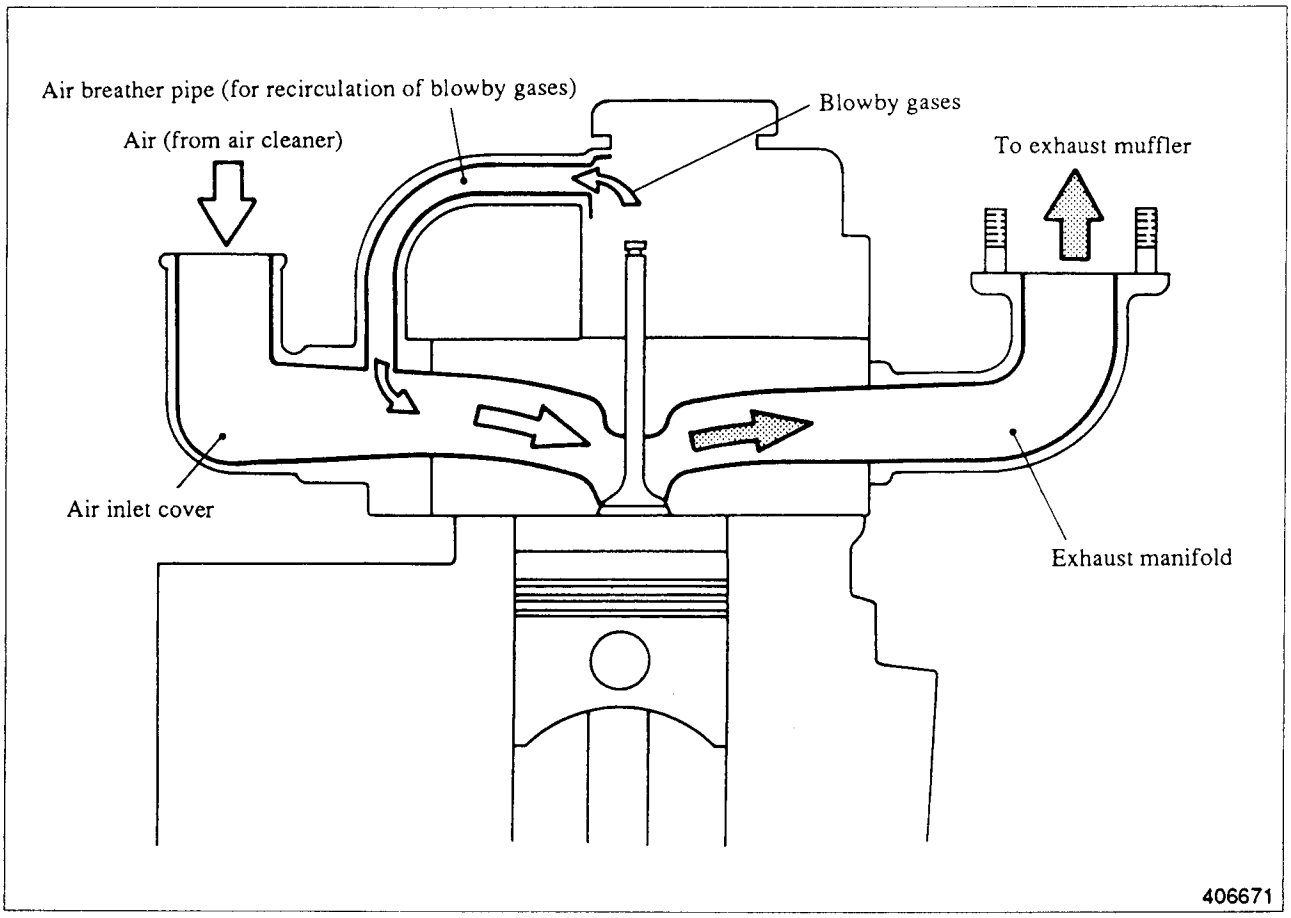
AIR INLET SYSTEM AND EXHAUST SYSTEM

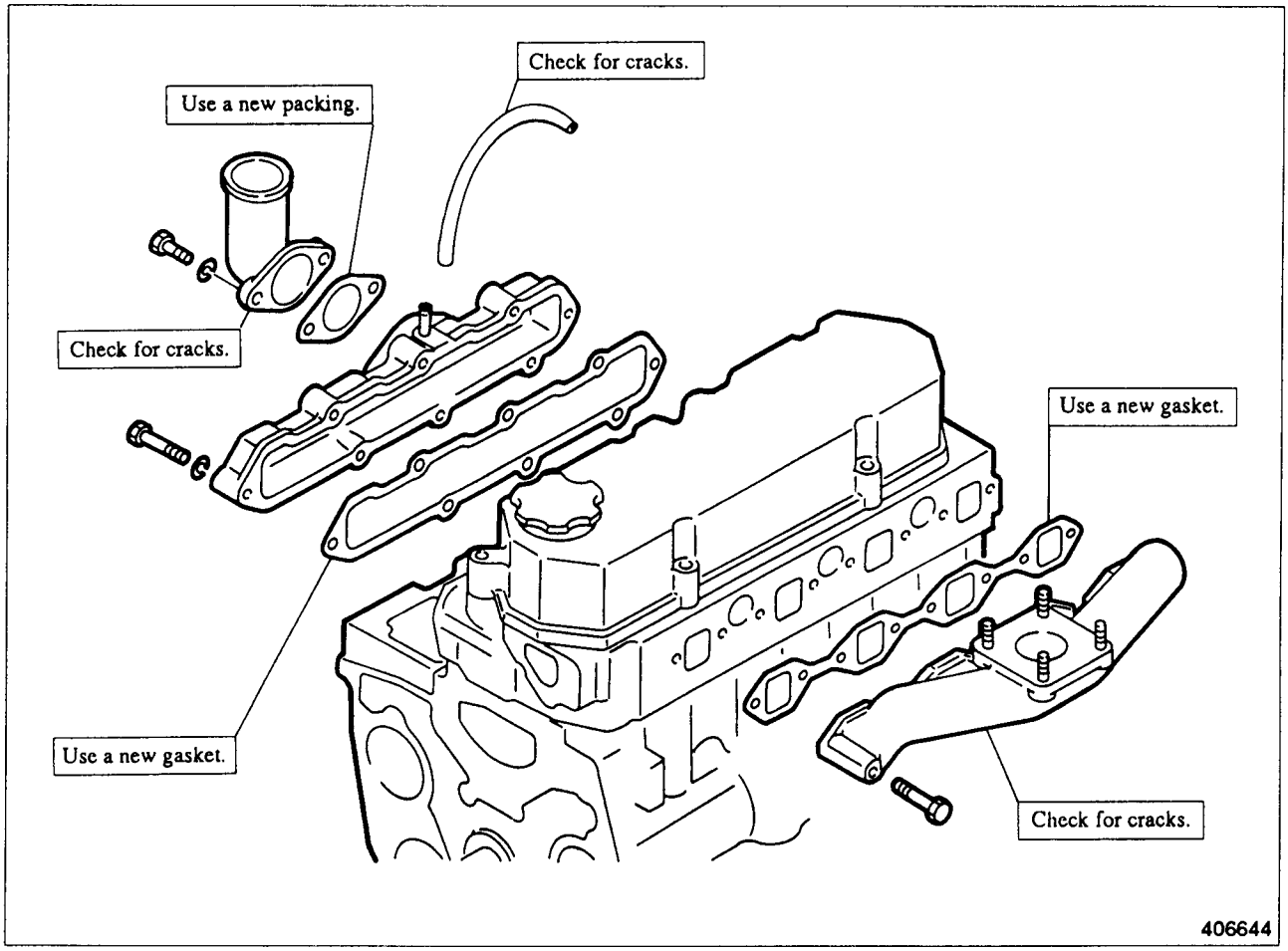


GENERAL

Schematic



INSPECTION



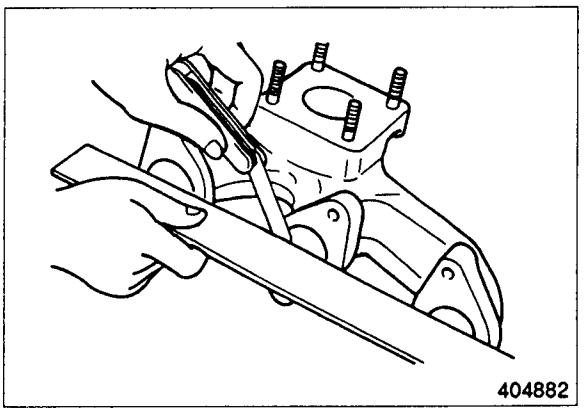
Inspection points

Inspection procedure

Using a straight edge and a feeler gauge, check the flange faces of the manifold for warpage. If warpage exceeds the limit, recondition or replace the manifold.

Unit: mm (in.)

Item	Standard
Warpage of manifold	0.15 (0.005 9)



Checking manifold for warpage

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MAINTENANCE

LUBRICATION AND MAINTENANCE CHART

(1) Recommended service should be performed at the specified intervals. Under extremely severe, dusty or wet operating conditions, more frequent lubrication than is specified in this chart may be necessary.

(2) Perform service on items at multiples of the original requirement. For example, at Every 500 Service Hours, also service those items listed under Every 100 Service Hours, Every 50 Service Hours and Every 10 Service Hours.

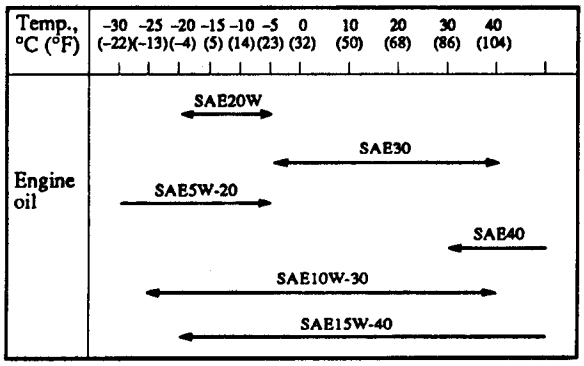
Service intervals	Item	Remarks (service data)
Every 10 service hours	Walk-around inspection Check engine oil level. Check the amount of fuel. Check coolant level.	
Every 50 service hours	Check battery electrolyte level and specific gravity. Drain water and sediment from fuel tank.	
First 50 service hours of a new or reconditioned engine	Change engine oil. Change oil filter. Retighten bolts and nuts.	Capacity: See SPECIFICATIONS.
Every 100 service hours	Change engine oil. Change oil filter. Wash fuel filter. Clean radiator fins	Capacity: See SPECIFICATIONS. After fuel filter has been washed, prime fuel system (page 165)
Every 500 service hours	Check and adjust valve clearance. Change fuel filter element. Check and adjust fuel injection nozzles. Check fan belt. Check glow plugs.	0.25 mm (0.009 8 in.) for inlet and exhaust valves Injection pressure: 140 kgf/cm² (1 991 psi) [13 729 kPa] Tension (deflection): 10 to 15 mm (0.4 to 0.6 in.)
Every 1 000 service hours	Retighten bolts and nuts. Check starter. Check alternator.	
Every 2 years	Change coolant.	Capacity: See SPECIFICATIONS.
When required	Prime fuel system. Clean air cleaner element.	

ENGINE OIL AND OIL FILTER

1. Engine oil specifications

Use oils that meet the Engine Service Classification CC.

Recommended engine oil viscosities



2. Oil level check

(1) Check the crankcase oil level with a dipstick with the engine kept level.

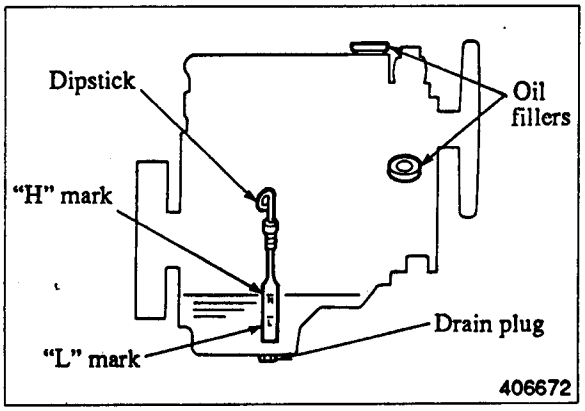
(2) If the oil level is at or below "L" (low level) mark on the dipstick, add oil to "H" (high level) mark on the dipstick.

NOTE

a) After adding oil, leave the engine standing for one minute and check the oil level.

b) Avoid mixing different brands of oils. In some cases, they are not compatible with each other and deteriorate when mixed. Use the same brand at successive intervals.

c) If the engine has been left standing for a long period of time, check the oil for level and contamination before starting the engine. Start and run the engine for a few minutes. Then stop the engine and check the oil level again.



Checking oil level

3. Oil change

(1) Change the oil after the first 50 service hours of operation of a new or reconditioned engine and every 100 service hours thereafter.

(2) Warm up the engine. Remove the drain plug and allow the oil to drain in a container. Install the drain plug, tightening it to the specified torque, and refill the engine with the new oil.

(3) Refill to the "H" mark on the dipstick. Approximately 0.5 liter (0.5 qt) of oil is required for the oil filter and oil lines.

Tightening torque	4 ± 0.5 kgf·m (29 ± 4 lbf·ft) [39 ± 5 N·m]

4. Oil filter change

(1) Change the oil filter every 100 service hours.

(2) Remove the used filter with a filter wrench. Discard the filter.

(3) Remove all of the old filter gasket from the filter base and apply a thin coat of engine oil to the gasket on the new filter. Install the filter by hand until its gasket contacts the base. Tighten 3/4 turn more.

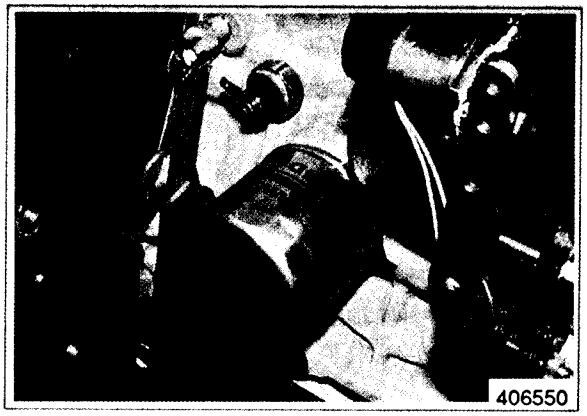
⚠CAUTION

Do not cause damage to the O-ring when installing the filter.

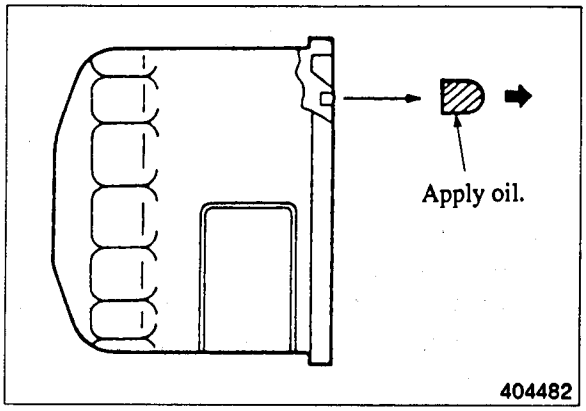
(4) Add 0.5 liter (0.5 qt) of oil.

(5) Start the engine and check for leaks around the filter.

(6) Stop the engine. Check the oil level and add oil if necessary.



Removing used oil filter



Installing new oil filter

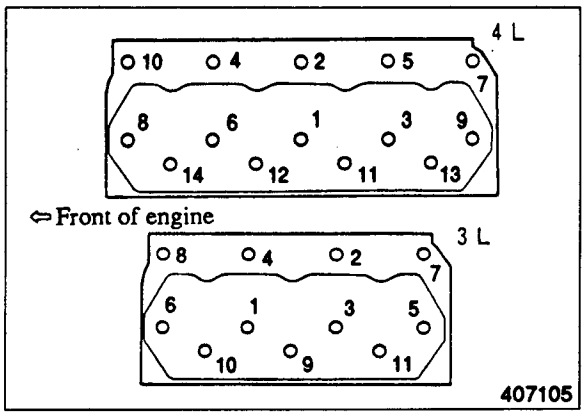
VALVE CLEARANCE

NOTE

Make an adjustment to the valve clearance when the engine is cold.

(1) Slightly loosen the cylinder head bolts and retighten them to the specified torque in number sequence.

Tightening torque	9 ± 0.5 kgf·m (65 ± 4 lbf·ft) [88 ± 5 N·m]



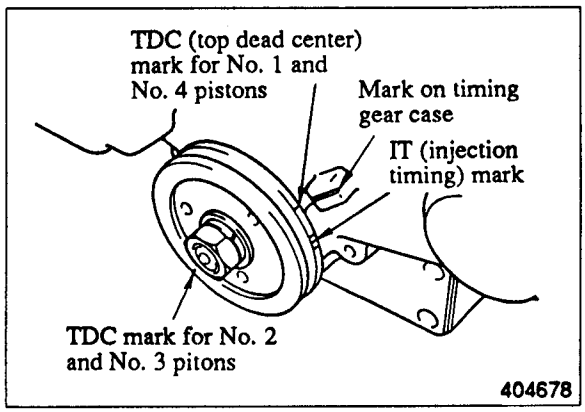
Cylinder head bolt tightening sequence

(2) Find top dead center compression position for No. 1 piston by using the procedure that follows:

(a) Turn the crankshaft until TDC mark on the crankshaft pulley is aligned with the mark on the timing gear case.

(b) With No. 1 piston at top dead center on the compression stroke, the rocker arms will not be moved when the crankshaft is turned approximately 20° in both directions.

(c) If the rocker arms move, No. 1 piston is at top dead center on the intake or exhaust stroke. In such a case, turn the crankshaft 360° in the direction of engine rotation again. No. 1 piston is now at top dead center on the compression stroke.



Timing mark

(3) Loosen the lock nut for the adjusting screw. With a feeler gauge inserted between the rocker arm and valve cap, adjust the valve clearance by turning the adjusting screw.

Unit: mm (in.)

Item	Standard
Valve clearance (both inlet and exhaust valves)	0.25 (0.0098)

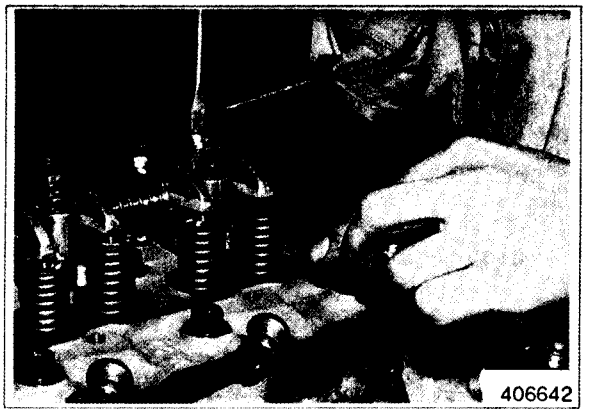
(4) Hold the adjusting screw and tighten the lock nut.

(5) After the valve clearance on the valves for No. 1 cylinder has been adjusted, turn the crankshaft 180° in the direction of engine rotation and adjust the valve clearance on the valves for the remainder of the cylinders in firing order (injection sequence)

Firing order (injection sequence)		Crankshaft rotation angle
S3L	1 – 3 – 2	240°
S4L	1 – 3 – 4 – 2	180°

⚠ CAUTION

After the valve clearance on the valves for all cylinders has been adjusted, turn the crankshaft two or three times and make sure the valve clearance is correct.



Adjusting valve clearance

FUEL INJECTION TIMING

1. Preparation

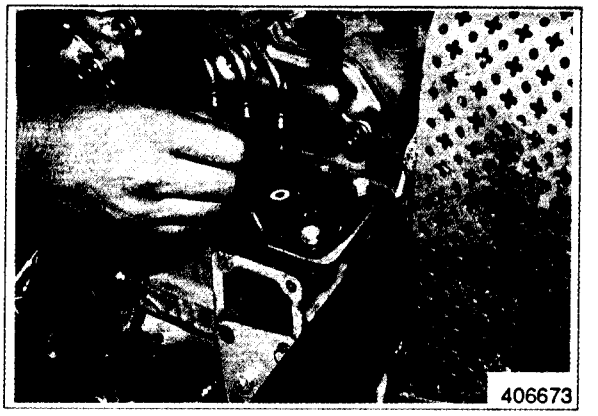
(1) Close the fuel filter valve.

(2) Disconnect the No. 1 fuel injection pipe from the cylinder head and injection pump.

(3) Remove No. 1 delivery valve holder from the injection pump. Remove the delivery valve and spring from the holder. Restore the delivery valve holder only to the injection pump.

(4) Connect the fuel injection pipe to the injection pump.

(5) Hold the speed control lever in the low speed position.



Removing delivery valve and spring

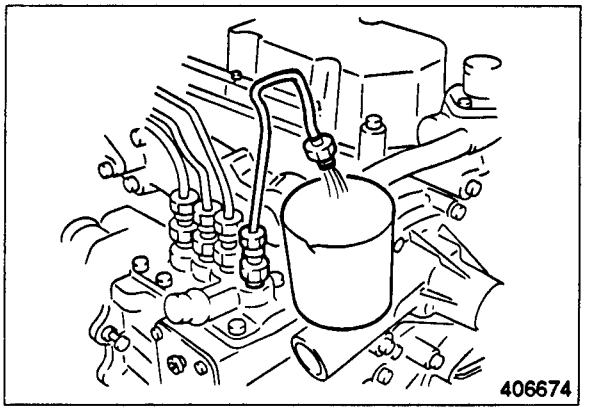
2. Inspection

2.2 Fuel flow method

(1) Open the fuel filter valve. Turn the starter switch key to ON position.

NOTE

Fuel will come from the injection pipe with high pressure when the starter switch key is turned to ON position if the engine is equipped with an electric fuel pump. Direct fuel flow into the container.

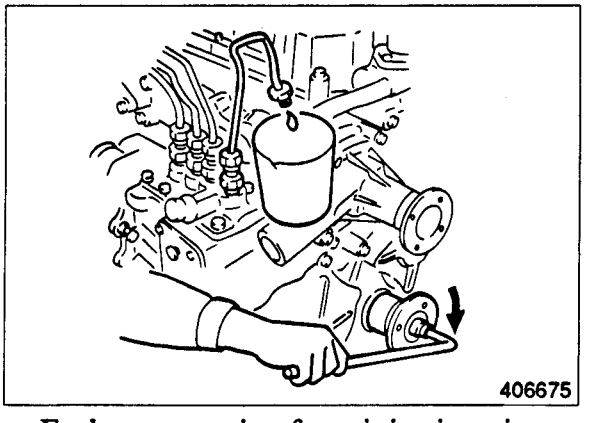


Fuel coming from injection pipe

(2) Slowly turn the crankshaft clockwise, looking at the free end of the injection pipe. The instant fuel stops coming out is the fuel injection timing.

NOTE

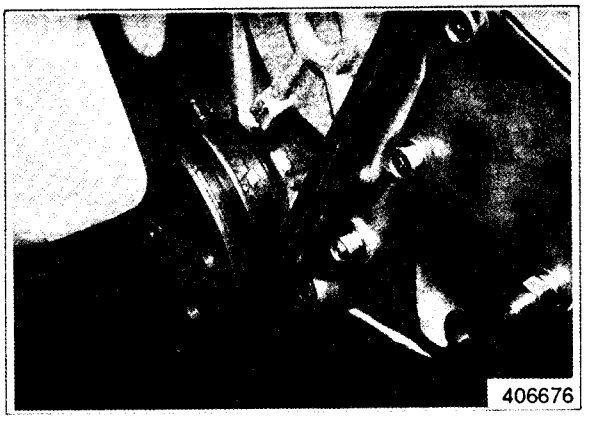
Turn the crankshaft in reverse direction just a little and do Step (2) again to verify the injection timing.



Fuel stops coming from injection pipe

(3) The fuel injection timing is correct if IT mark on the crankshaft pulley is aligned with the mark on the timing gear case when fuel stops from the injection pipe.

Fuel injection timing (BTDC)	17° (standard)



Timing mark

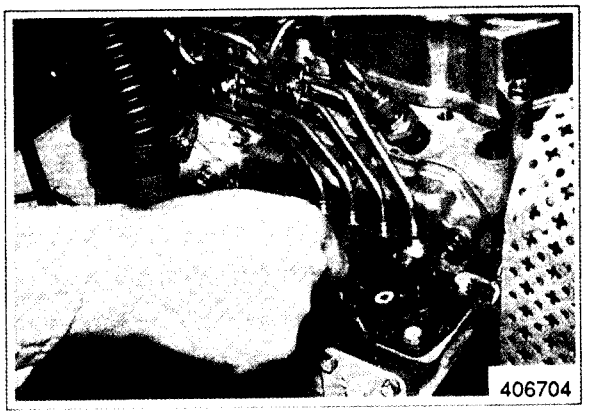
2.2 Alternate method

In the fuel flow method, the delivery valve has to be removed. As a result, there is a good chance for dirt particles to get inside the fuel injection pump. In this alternate method, however, it is not necessary to remove the delivery valve.

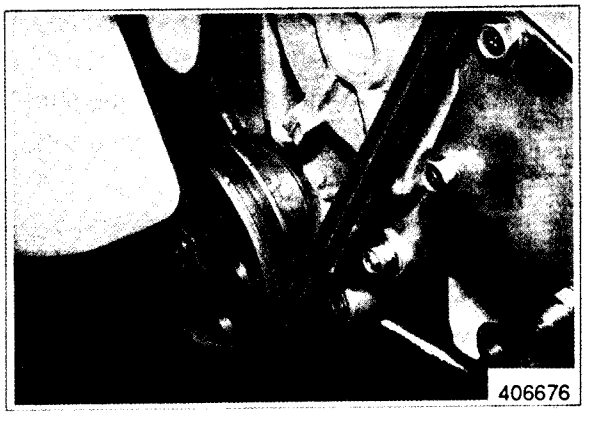
(1) Disconnect No. 1 fuel injection pipe at the fuel injection nozzle (cylinder head).

(2) Prime the fuel system.

(3) Slowly turn the crankshaft clockwise until fuel just swells at the free end of the injection pipe and, at that instant, check the position of the IT mark with respect to the mark on the gear case. This timing is approximately 1° retarded. Take this 1° retardation into account when making a shim adjustment.



Disconnecting No. 1 fuel injection pipe



Timing mark

3. Adjustment

(1) If the fuel injection timing is incorrect, change the thickness of shims under the fuel injection pump. An increase or decrease of the shims by 0.1 mm (0.004 in.) will vary the timing by 1°.

(2) Increase the thickness of the shims to retard the timing or decrease it to advance the timing.

Adjustment range	Standard ±1.5°

Four kinds of shims are available in thicknesses 0.2 mm (0.007 9 in.), 0.3 mm (0.011 8 in.), 0.4 mm (0.015 7 in.) and 0.8 mm (0.031 5 in.). These shims have no identification; measure the thickness of each shim with a calipers before using it.

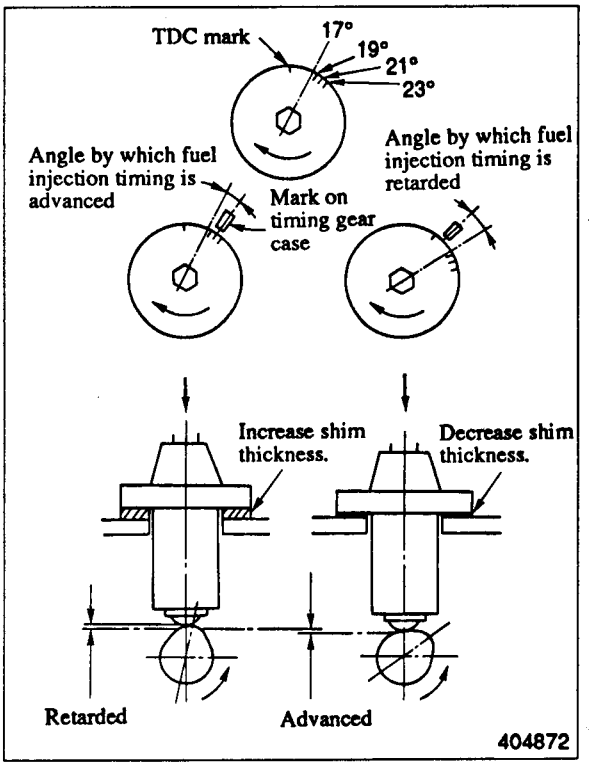
⚠ CAUTION

Apply sealant to both faces of each shim to prevent oil leaks.

(3) After the timing has been adjusted, make sure it is correct.

(4) Close the fuel filter valve and restore the delivery valve and injection pipe to the original state.

Adjusting fuel injection timing

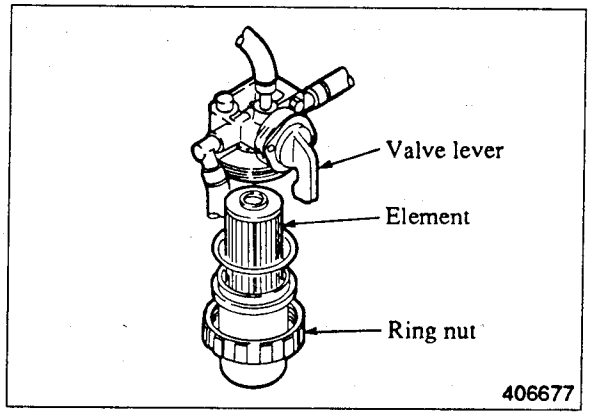


Adjusting fuel injection timing

FUEL FILTER

Fuel filter with [AIR] valve

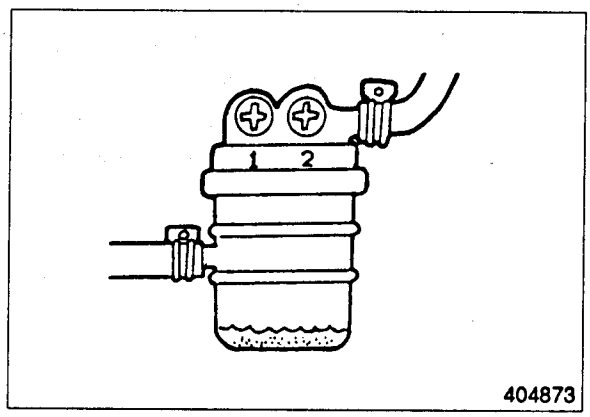
Close the fuel filter valve. Loosen the ring nut and take out the element for cleaning or replacement.



Fuel filter with [AIR] valve

Cartridge (air vent screw) type fuel filter

Replace the filter as an assembly if water and sediment have been accumulated in it.



Cartridge type fuel filter

FUEL SYSTEM PRIMING

Engine with fuel filter with [AIR] valve

(1) Move the fuel filter valve lever to AIR position.

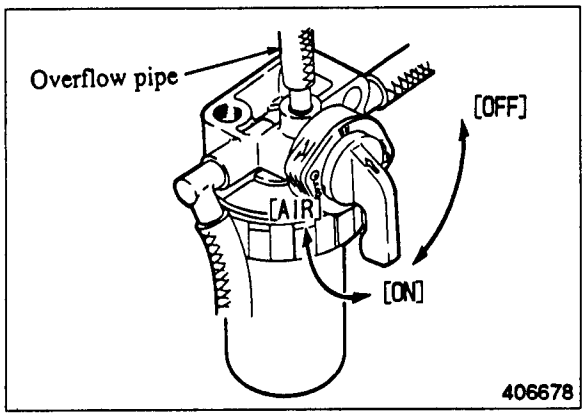
(2) Move the lever to ON position when the fuel flows free of bubbles from the overflow pipe.

(3) To prime the fuel pipe and fuel injection pump, loosen the air vent screw of the injection pump.

(4) The injection pipes and nozzles can be primed by cranking the engine.

NOTE

The fuel system of the engine with an electric fuel pump can be primed by turning the starter switch key to ON position.



Priming fuel filter with [AIR] valve

Engine with cartridge (air vent screw) type fuel filter

(1) Loosen air vent screw (1). Tighten screw (1) when the fuel flows free of bubbles from this vent.

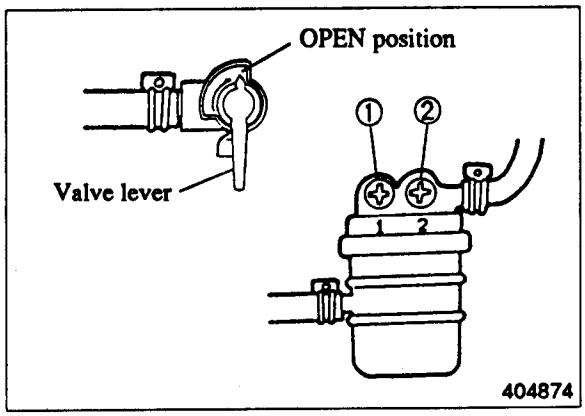
(2) Loosen air vent screw (2). Tighten screw (2) when the fuel flows free of bubbles from this vent.

(3) The injection pipes and nozzles can be primed by cranking engine engine.

NOTE

Turn the valve lever to OPEN position (if equipped) before loosening any air vent screw.

The fuel system of the engine with an electric fuel pump can be primed by turning the starter switch key to ON position.



Priming cartridge (air vent screw) type fuel filter

IDLE RPM SETTING

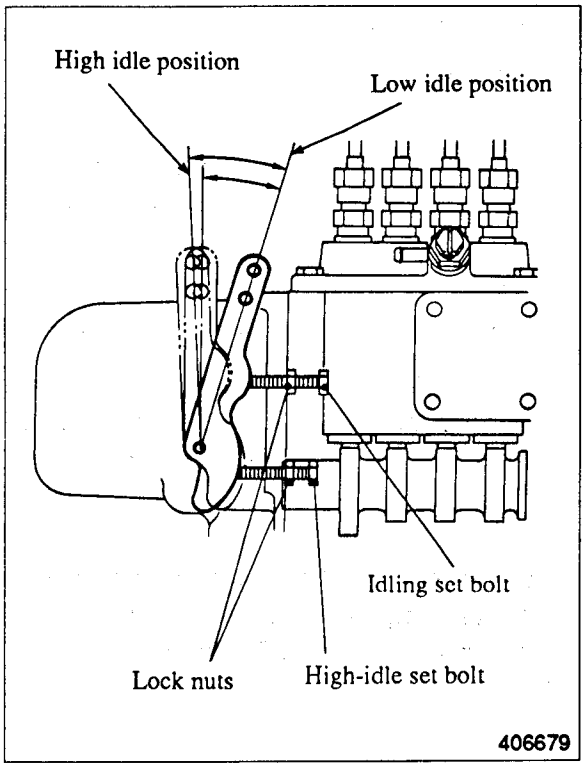
NOTE

Make sure that the valve clearance and injection timing are correct and that the fuel injection nozzles have no defect.

(1) Start and run the engine at low idle until the coolant temperature is above 60°C (140°F).

(2) To set the low idle rpm, loosen the lock nut for the idling set bolt and turn the set bolt to make the engine run at the specified rpm. Tighten the lock nut.

(3) To set the high idle rpm, loosen the lock nut for the high-idle set bolt and turn the set bolt to make the engine run at the specified rpm. Tighten the lock nut.



Idle rpm setting

FUEL INJECTION NOZZLES

1. Injection pressure (valve opening pressure) test

Make reference to FUEL INJECTION NOZZLE (page 135).

2. Orifice restriction test

Make reference to FUEL INJECTION NOZZLE (page 136).

3. Nozzle tip washing and replacement

Make reference to FUEL INJECTION NOZZLE (page 136).

4. Installation

(1) Put the gasket on the injection nozzle.

(2) Put the nozzle in position in the cylinder head and tighten it to the specified torque.

Tightening torque	5.5 ± 0.5 kgf·m (40 ± 4 lbf·ft) [54 ± 5 N·m]

Installing fuel injection nozzles

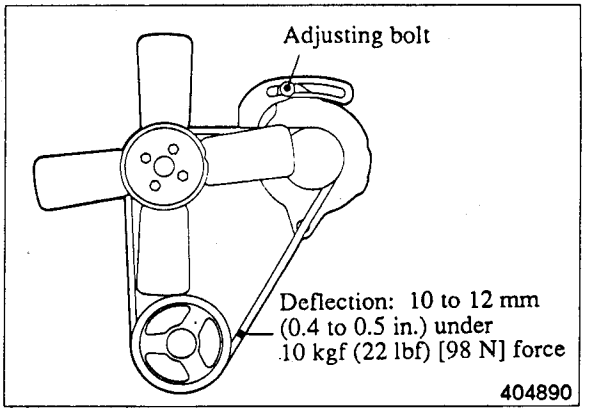
FAN BELT

(1) Measure the deflection of the belt. Apply 10 kgf (22 lbf) [98 N] force midway between the alternator pulley and the crankshaft pulley.

(2) Adjust the belt if the deflection is not correct. Loosen the adjusting bolt and move the alternator to obtain the required belt deflection.

Unit: mm (in.)

Item	Standard
Deflection	10 to 12 (0.4 to 0.5)

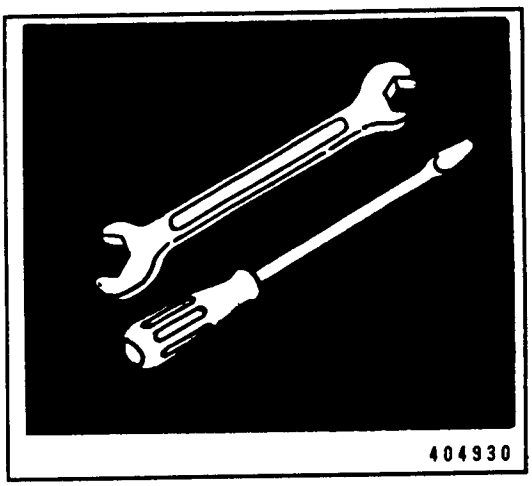


Adjusting fan belt

SERVICE DATA

SPECIFICATIONS

TIGHTENING TORQUES



SPECIFICATIONS

1. Basic engine components

Unit: mm (in.)

Item		Standard		Limit	Correction·Remarks
Compression pressure		30 kgf/cm² (427 psi) [2 942 kPa]		27 kgf/cm² (384 psi) [2 648 kPa]	Repair or replace.
Maximum permissible difference between average compression pressure of all cylinders in one engine		3 kgf/cm² (42.7 psi) [294 kPa]		—	Repair or replace.
Fuel injection timing (BTDC)		17°			
Clearance between rocker arm and shaft (oil clearance)		0.012 to 0.050 (0.000 47 to 0.001 97)		0.200 (0.007 87)	Replace rocker arm.
Valve clearance		0.25 (0.009 8)			Adjust.
Clearance between valve stem and valve guide	Inlet valve	0.02 to 0.05 (0.000 8 to 0.002 0)		0.10 (0.003 9)	Replace valve and valve guide.
	Exhaust valve	0.05 to 0.085 (0.002 0 to 0.003 35)		0.15 (0.005 9)	
Valve margin (valve lip thickness)		1.0 (0.039)		0.5 (0.020)	Replace valve.
Valve sinkage		0.5 ± 0.25 (0.020 ± 0.009 8)		1.5 (0.059)	Recondition valve seat or replace cylinder head.
Valve seat	Angle	45°		—	Recondition.
	Width	1.3 to 1.8 (0.051 to 0.071)		2.5 (0.098)	
Valve spring	Free length	47 (1.85)		46 (1.81)	Replace.
	Length under test force	39.1 (1.54)	30.5 (1.20)	—	
	Test force, kgf (lbf) [N]	13.9 ± 0.7 (30.6 ± 1.5) [136 ± 7]	29 ± 2 (64 ± 4.4) [284 ± 20]	−15%	
Warpage of cylinder head bottom face		0.05 (0.0020) maximum		0.10 (0.003 9)	Repair.
Bend (dial indicator reading) of valve push rod		—		0.3 (0.012)	Replace.
Timing gear backlash	Crankshaft gear and idler gear	0.04 to 0.12 (0.001 6 to 0.004 7)		0.30 (0.011 8)	Replace.
	Idler gear and camshaft gear				
	Idler gear and fuel injection pump camshaft gear				
	Camshaft gear and P.T.O. gear	0.08 to 0.19 (0.003 1 to 0.007 5)			
	Fuel injection pump camshaft gear and oil pump gear	0.07 to 0.20 (0.002 8 to 0.007 9)			
Lobe height of camshaft		35.72 (1.406 3)		34.72 (1.366 9)	Replace.
Lobe height of fuel injection pump camshaft		44 (1.73)		43 (1.69)	Replace.
Flatness of flywheel		0.15 (0.005 9) maximum		0.50 (0.019 7)	Recondition.

Unit: mm (in.)

Item			Standard	Limit	Correction·Remarks
Clearance between tappet and cylinder block			—	0.15 (0.005 9)	Replace tappet.
Clearance between camshaft journal and bushing			—	0.15 (0.005 9)	Replace bushing.
Clearance between idler gear and shaft			0.03 to 0.07 (0.001 2 to 0.002 8)	0.20 (0.007 9)	Replace idler gear or shaft.
Warpage of cylinder block top face			0.05 (0.002 0) maximum	0.10 (0.003 9)	Repair.
Bore in cylinder block			$78.0^{+0.03}_{0}$ ($3.07^{+0.0012}_{0}$)	78.2 (3.079)	Hone out bore for oversize piston or replace cylinder block.
Taper and out-of-round of cylinder			0.01 (0.000 4) maximum	—	
Diameter of piston		Standard	77.93 to 77.95 (3.068 1 to 3.068 9)	77.80 (3.063 0)	
		0.25 (0.0098) oversize	78.18 to 78.20 (3.077 9 to 3.078 7)	78.05 (3.072 8)	
		0.50 (0.0197) oversize	78.43 to 78.45 (3.087 8 to 3.088 6)	78.30 (3.0827)	
Clearance between piston pin and piston			0.006 to 0.018 (0.000 24 to 0.000 71)	0.050 (0.001 97)	
Clearance between piston ring and groove		No. 1 compression ring	0.06 to 0.10 (0.002 4 to 0.003 9)	0.30 (0.011 8)	Replace piston ring.
		No. 2 compression ring	0.05 to 0.09 (0.002 0 to 0.003 5)	0.20 (0.007 9)	
		Oil ring	0.03 to 0.07 (0.001 2 to 0.002 8)	0.20 (0.007 9)	
Clearance between ends of piston ring		No. 1 compression ring	0.15 to 0.30 (0.005 9 to 0.011 8)	1.50 (0.059)	Replace piston ring.
		No. 2 compression ring	0.15 to 0.35 (0.005 9 to 0.013 8)		
		Oil ring	0.20 to 0.40 (0.007 9 to 0.015 7)		
Clearance between piston and cylinder			0.035 to 0.086 (0.001 38 to 0.003 39)	0.300 (0.011 81)	Hone out bore for oversize piston or replace cylinder block.
Clearance between crankpin and connecting rod bearing			0.025 to 0.072 (0.000 98 to 0.002 83)	0.150 (0.005 91)	Replace connecting rod bearing.
Thrust clearance for connecting rod big end			0.10 to 0.35 (0.003 9 to 0.013 8)	0.50 (0.019 7)	Replace connecting rod.
Crankshaft	Diameter of journal		51.985 to 52.000 (2.046 65 to 2.047 24)	—	
	Diameter of crankpin		47.950 to 47.965 (1.887 79 to 1.888 38)	—	
	Runout		0.025 (0.000 98)	0.05 (0.002 0)	Repair or replace.
	Clearance between journal and main bearing		0.030 to 0.077 (0.001 18 to 0.003 03)	0.100 (0.003 94)	Replace main bearing.
	Clearance between crankpin and connecting rod bearing		0.025 to 0.072 (0.000 98 to 0.002 83)	0.150 (0.005 91)	Replace connecting rod bearing.
	End play		0.050 to 0.175 (0.001 97 to 0.006 89)	0.500 (0.019 69)	Replace No. 3 flanged bearing.

2. Lubrication system

Unit: mm (in.)

Item	Standard	Limit	Correction·Remarks
Pressure relief valve setting	3.5 ± 0.5 kgf/cm² (50 ± 7 psi) [343 ± 49 kPa]	—	Replace.
Pressure difference at which oil pressure switch is closed (indicator light comes on)	0.5 ± 0.1 kgf/cm² (7 ± 1.4 psi) [49 ± 10 kPa]	—	Replace.

3. Fuel system

Unit: mm (in.)

Item	Standard	Limit	Correction·Remarks
Injection pressure (valve opening pressure)	140^{+5}_{0} kgf/cm² ($1\,991^{+71}_{0}$ psi) [$13\,729^{+490}_{0}$ kPa]	—	Adjust with washer.

4. Air inlet system and exhaust system

Unit: mm (in.)

Item	Standard	Limit	Correction·Remarks
Paper-element type air cleaner element	Clean every 100 service hours.	Change every 500 service hours.	
Warpage of mounting faces of manifolds	—	0.15 (0.005 9)	Repair or replace.

5. Cooling system (standard)

Unit: mm (in.)

Item		Standard	Limit	Correction·Remarks
Thermostat	Temperature at which valve starts opening	82 ± 1.5°C (180 ± 2.7°F)	—	Replace.
	Temperature at which valve lift is more than 8 mm (0.3 in.)	95°C (203°F)	—	
Thermoswitch	Temperature at which switch is turned ON	111 ± 3.5°C (232 ± 6.3°F)	—	Replace.
	Resistance at oil temperature of 120°C (284°F)	30 mΩ maximum	—	
Resistance in thermounit	At 50°C (122°F)	80 ± 10 Ω	—	Replace.
	At 80°C (176°F)	29.5 ± 2.5 Ω	—	
	At 120°C (248°F)	10 ± 0.3 Ω	—	
Deflection of fan belt under 10 kgf (22 lbf) [98 N] force applied midway between alternator pulley and crankshaft pulley		10 to 12 (0.4 to 0.5)	—	Replace.

6. Electrical system

Unit: mm (in.)

Item				Standard		Limit	Correction·Remarks
Starter	Pinion clearance			0.5 to 2.0 (0.020 to 0.079)		—	Adjust with packing.
	No-load characteristics			S3L/S3L2	S4L/S4L2		Test.
		Terminal voltage		11.5 V	11 V	—	
		Current draw		100 A maximum	130 A maximum	—	
		Rpm		3 000 minimum	3 850 minimum	—	
	Brush length			—		Wear limit line	Replace.
	Brush spring tension			3.0 kgf (6.6 lbf) [29.4 N]		1.8 kgf (4.0 lbf) [17.7 N]	Replace.
	Runout of commutator			0.03 (0.001 2)		0.10 (0.003 9)	Repair or replace.
	Diameter of commutator			32 (1.26)		31 (1.22)	Replace.
	Undercut of mica			0.5 (0.020)		0.2 (0.008)	Repair.
Alternator	Regulated voltage at 20°C (68°F)			14.7 ± 0.3 V		—	
	Output characteristics (at operating temperature)	Below 2500 rpm	Terminal voltage	13.5 V		—	Test.
			Current	33 A		—	
		Below 5000 rpm	Terminal voltage	13.5 V		—	
			Current	47 A		—	
	Brush length			—		Wear limit line	Replace.
Resistance in glow plug				0.55 Ω		—	Replace.

TIGHTENING TORQUES

1. Major bolts and nuts

Bolt or nut	Thread, mm				Torque, kgf·m (lbf·ft) [N·m]
	Diameter	Pitch	Width across flats	Clamp length	
Cylinder head bolt	M10	1.25	14	87	9 ± 0.5 (65 ± 4) [88 ± 5]
Rocker cover bolt	M8	1.25	12	40	1.15 ± 0.15 (8.3 ± 1.1) [11.3 ± 1.5]
Rocker shaft bracket bolt	M8	1.25	12	58	1.5 ± 0.5 (11 ± 4) [14.7 ± 5]
Thermoswitch	M16	1.5	17	31.5	2.3 ± 0.4 (16.6 ± 3) [22.6 ± 4]
Crankshaft pulley nut	M18	1.5	27	—	17.5 ± 2.5 (127 ± 18) [172 ± 25]
Main bearing cap bolt	M10	1.25	17	81	5.25 ± 0.25 (38 ± 2) [51.5 ± 2.5]
Connecting rod cap nut	M9	1.0	14	—	3.55 ± 0.25 (25.7 ± 2) [34.8 ± 2.5]
Rear plate bolt (for tractor engine)	M12	1.25	17	28	9.5 ± 1 (69 ± 7) [93 ± 10]
Rear plate bolt (standard)	M12	1.25	17	28	6.5 ± 1 (47 ± 7) [64 ± 10]
Rear plate bolt (stamping)	M8	1.25	12	16	1.15 ± 0.15 (8.3 ± 1.1) [11.3 ± 1.5]
Flywheel bolt	M12	1.25	19	29	13.5 ± 0.5 (98 ± 4) [132 ± 5]
Oil pan bolt (for tractor engine)	M8	1.25	12	25	2.8 ± 0.3 (20.3 ± 2.2) [27.5 ± 3]
Oil pan drain plug	M14	1.5	22	10	4 ± 0.5 (29 ± 4) [39 ± 5]
Pressure relief valve	M22	1.5	22	33	5 ± 0.5 (36 ± 4) [49 ± 5]
Oil filter	M20	1.5	—	—	1.2 ± 0.1 (8.7 ± 0.7) [12 ± 1]
Oil pressure switch	PT1/8	—	26	11	1 ± 0.2 (7.2 ± 1.4) [10 ± 2]
Fuel injection pipe nut	M12	1.5	—	—	3 ± 0.5 (22 ± 4) [29 ± 5]
Fuel leak-off pipe nut	M12	1.5	18	—	2.75 ± 0.25 (20 ± 2) [27 ± 2.5]
Delivery valve holder	—	—	19	—	4.5 ± 0.5 (32.5 ± 4) [44 ± 5]
Fuel injection nozzle holder	M20	1.5	21	—	5.5 ± 0.5 (40 ± 4) [54 ± 5]
Retaining nut for delivery valve holder body	M16	0.75	19	—	3.75 ± 0.25 (27 ± 2) [37 ± 2.5]
Sliding sleeve shaft	M10	1.25	14	29.5	3.6 ± 0.6 (26 ± 4) [35 ± 6]
Special nut for torque spring set	M12	1.0	17	—	2 ± 0.5 (14 ± 4) [20 ± 5]
Glow plug	M10	1.25	12	60	1.75 ± 0.25 (12.7 ± 2) [17.2 ± 2.5]
Glow plug connection plate	M4	0.7	8	—	0.125 ± 0.025 (0.9 ± 0.2) [1.2 ± 0.2]
Stop solenoid nut	M30	1.5	36	—	4.5 ± 0.5 (32.5 ± 4) [44 ± 5]
Starter B terminal	M8	1.25	12	—	1.1 ± 0.1 (8 ± 0.7) [10.8 ± 1]

2. Torques for bolts and nuts with standard threads

Unit: kgf·m (lbf·ft) [N·m]

Thread diameter	Identification on head		
	4	7	
M6	0.4 ± 0.1 (3 ± 0.7) [3.9 ± 1]	0.9 ± 0.1 (6.5 ± 0.7) [8.8 ± 1]	
M8	1.1 ± 0.1 (8 ± 0.7) [10.8 ± 1]	1.85 ± 0.35 (13.4 ± 2.5) [18 ± 3]	
M10	2.15 ± 0.35 (15.6 ± 2.5) [21 ± 3]	3.6 ± 0.6 (26 ± 4.3) [35.3 ± 6]	
M12	3.6 ± 0.6 (26 ± 4.3) [35.3 ± 6]	6.5 ± 1 (47 ± 7) [63.7 ± 10]	
M14	6 ± 1 (43 ± 7) [59 ± 10]	9.5 ± 1.5 (69 ± 11) [93.2 ± 15]	

3. Torques for plugs with taperlock threads

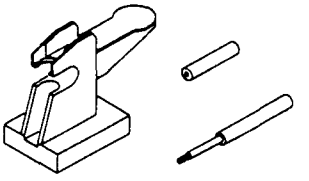
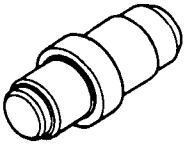
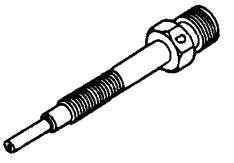
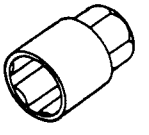
Unit: kgf·m (lbf·ft) [N·m]

Size	For aluminum materials	For ferrous materials
NPTF1/16	0.65 ± 0.15 (4.7 ± 1) [6.4 ± 1]	1 ± 0.2 (7.2 ± 1) [10 ± 2]
PT1/8	1 ± 0.2 (7.2 ± 1) [10 ± 2]	1.85 ± 0.35 (13.4 ± 2.5) [18 ± 3]
PT1/8, NPTF1/4	2.5 ± 0.5 (18 ± 4) [25 ± 5]	4 ± 0.5 (29 ± 4) [39 ± 5]
PT3/8	—	6.5 ± 1 (47 ± 7) [64 ± 10]

SEALANTS

	Component	Sealant	Mating part	Remarks
Thread parts	Stop solenoid	Three Bond 1212	Governor case	Apply to effective thread part.
	Water drain joint	Three Bond 1102	Cylinder block	
	Oil pressure switch			
	Torque spring set	Three Bond 1212	Governor case	
Force-fit parts	Sealing cap	Three Bond 1102	Cylinder block	Apply to holes in cylinder head and cylinder block.
			Cylinder head	
			Cylinder head and cylinder block	
	Expansion plug		Cylinder block	
	Dipstick guide			
Other parts	Side seal	Three Bond 1212	Cylinder block and main bearing caps	Apply to external surface.
	Main bearing caps (front and rear)		Cylinder block	Apply to surfaces that come into contact with cylinder block.
	Oil pan	Three Bond 1207C		Apply to sealing surface.

SPECIAL TOOLS

Tool No.	Tool Name	Style	Usage
31A91-00100	Piston Pin Setting Tool	 406808	Piston pin removal and installation
ST332340	Camshaft Bushing Installer	 404704	Camshaft front bushing removal and installation
ST332270	Compression Gauge Adaptor	 404931	Compression pressure measurement
MD998054	Oil Pressure Switch Socket Wrench (26)	 404840	Oil pressure switch removal and installation

Note: In addition these special tools, commercially available tools such as bearing puller, valve seat cutting tool, valve guide installing tool, valve spring compressing tool, oil filter wrench, etc. are necessary.

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Chapter 4

Hydraulic System

Table of Contents

Specifications

Item	Description
Transmission System relief pressure 2WD units 4WD units Charge relief pressure Cooler By-pass pressure Filter By-pass pressure Oil filter	Sauer-Sundstrand M25, U-type 3600 ± 150 psi at 3250 RPM 3600 ± 150 psi at 3250 RPM 150 ± 30 psi at 3250 RPM 70 ± 10 psi 70 ± 10 psi Screw-on type
Auxiliary Pump Steering relief pressure	3 section, external gear type 1250 psi (cracking)
Reel Motor (5)	External gear type
Valve Block Front reel circuit relief pressure Rear reel circuit relief pressure	Toro, cartridge logic, elec./hyd. solenoid actuated 3000 psi 2000 psi
Hydraulic Oil – Reel Drive & Steering (Fig. 2) Group 1 (for ambient temp. consistently below 100° F) Group 2 (for ambient temp. consistently above 70° F)	 ISO type 46/68 anti-wear hydraulic fluid (Mobil 424 or equiv.) ISO type 68 anti-wear hydraulic fluid (Mobil DTE 26 or equiv.)
Hydraulic Reservoir – Reel Drive & Steering (Fig. 2)	8 U.S. gal. approx. capacity (9.5 U.S. gal. approx. system capacity)
Oil filter – Reel Drive & Steering	Screw-on cartridge type, 50 psi bypass
Transmission Oil (Fig. 1)	ISO type 46/68 anti-wear hydraulic fluid (Mobil 424 or equiv.)
Transmission Resevoir	5 U.S. qt. approx. system capacity

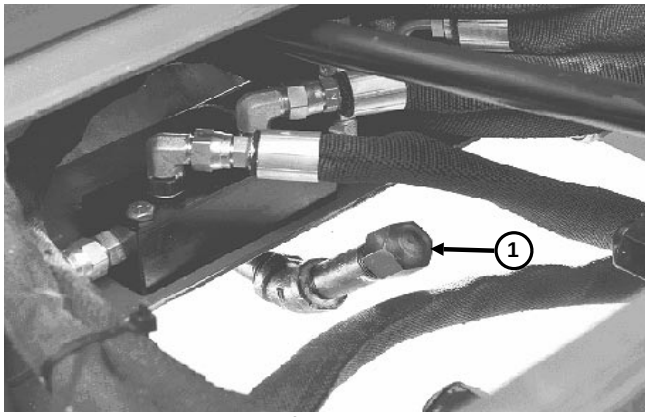


Figure 1

1. Transmission dipstick cap

Hydraulic Oil

The hydraulic system was initially filled at the factory with Mobil 424 oil.

Two groups of hydrauic oil are specified to allow optimal operation of the machine in a wide range of temperatures encountered.

The group 1 oil are a multi-viscosity hydraulic oil which allows operation at lower temperatures without the increased viscosity, which is associated with straight viscosity oils.

The group 2 type oils are straight viscosity oils which remain slightly more viscous at higher temperatures than the multi-viscosity oils.

Using group 1 oils in higher ambient temperatures may result in decreased efficiency in some of the hydraulic components compared to using group 2 oils.

Using group 2 oils in lower ambient temperatures may result in harder starting, increased engine laboring while cold, sluggish or non-operating valve spools while cold and increased filter back pressure due to the higher oil viscosity.

It is recommended that you select which conditions (either ambient temperatures above 70°F or below 100°F) and use that type of oil throughout the year, rather than changing oil types several times per year.

NOTE: When changing from one type of hydraulic oil to the other, be certain to remove all the old oil from the system, because some brands of one type are not completely compatible with some brands of the other type of hydraulic oil. If you always use Mobil products, the two types of oil are compatible and interchangeable.

IMPORTANT: Use only types of hydraulic oils specified. Other fluids could cause system damage.

NOTE: A red dye additive for the hydraulic system oil is available in 2/3 oz. bottles. One bottle is sufficient for 4 to 6 gallons of hydraulic oil. Order Part No. 44-2500 from your Authorized Toro Distributor.

Group 1 Hydraulic Oil (Recommended for ambient temperatures **consistently below 100° F**):

ISO type 46/68 anti-wear hydraulic fluid

Mobil	Mobil Fluid 424
Amoco	Amoco 1000
International Harvester	Hy-Tran
Texaco	TDH
Shell	Donax TD
Union Oil	Hydraulic/Tractor Fluid
Chevron	Tractor Hydraulic Fluid
BP Oil	BP HYD TF
Boron Oil	Eldoran UTH
Exxon	Torque Fluid
Conoco	Power-Tran 3
Kendall	Hyken 052
Phillips	HG Fluid

NOTE: The oils within this group are interchangeable.

Group 2 Hydraulic Oil (Recommended for ambient temperatures **consistently above 70° F**):

ISO type 68 anti-wear hydraulic fluid

Mobil	DTE 26 or DTE 16
Shell	Tellus 68
Amoco	Rykon Oil 68
Arco	Duro AW S-315
Boron	Industron 53
BP Oil	Energol HLP68
Castrol	Hyspin AWS68
Chevron	Chevron EP68
Citgo	Citgo A/W68
Conoco	Super Hydraulic Oil 31
Exxon	Nuto H68
Gulf	68AW
Pennzoil	AW Hyd Oil 68
Phillips	Magnus A315
Standard	Industron 53
Texaco	Rando HD68
Union	Unax AW 315

NOTE: The oils within this group are interchangeable.

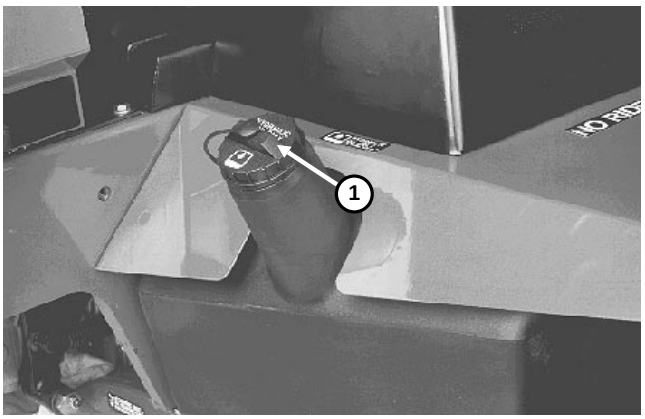


Figure 2

1. Hydraulic reservoir cap

General Information

Hydraulic Hoses

Hydraulic hoses are subject to extreme conditions such as, pressure differentials during operation and exposure to weather, sun, chemicals, very warm storage conditions or mishandling during operation or maintenance. These conditions can cause damage or premature deterioration. Some hoses, such as reel motor hoses, are more susceptible to these conditions than others. Inspect the hoses frequently for signs of deterioration or 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 lowering the cutting units to the ground and stopping the engine.

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 the 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.

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. 3).

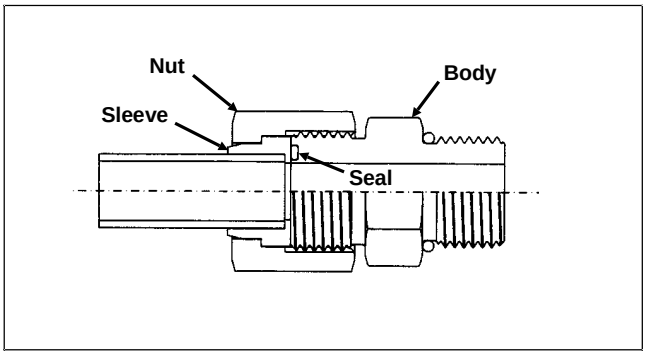
2. Make sure the O-ring is installed and properly seated in the groove. It is recommended that the O-ring be replaced any time the connection is opened.

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. 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. nominal hose or tubing)	.75 ± .25
6 (3/8 in.)	.75 ± .25
8 (1/2 in.)	.75 ± .25
10 (5/8 in.)	1.00 ± .25
12 (3/4 in.)	.75 ± .25
16 (1 in.)	.75 ± .25



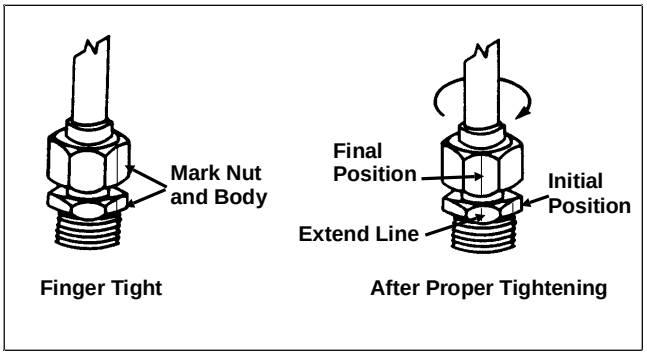


Figure 3

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. 4).

5. Tighten the fitting to the correct flats from finger tight (F.F.F.T.).

Size	F.F.F.T.
4 (1/4 in. nominal hose or tubing)	1.00 ± .25
6 (3/8 in.)	1.50 ± .25
8 (1/2 in.)	1.50 ± .25
10 (5/8 in.)	1.50 ± .25
12 (3/4 in.)	1.50 ± .25
16 (1 in.)	1.50 ± .25

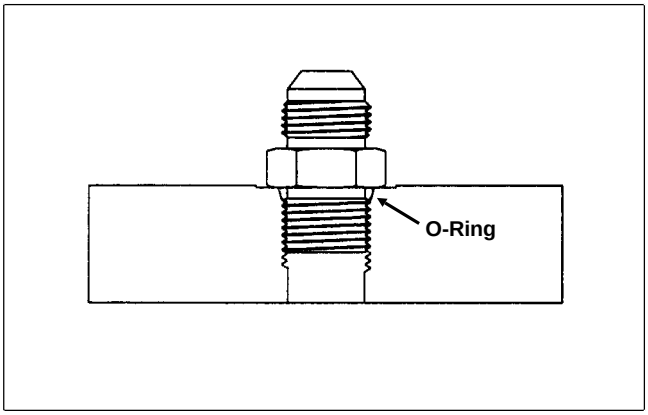


Figure 4

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. 5).

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.

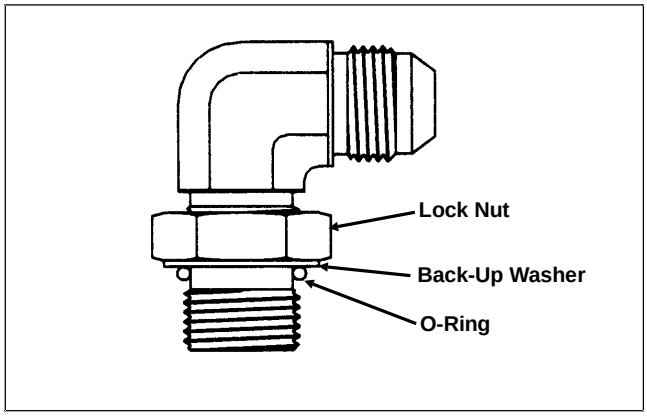
4. Turn back the jam nut as far as possible. Make sure the back up washer is not loose and is pushed up as far as possible (Step 1).

5. Install the fitting into the port and tighten finger tight until the washer contacts the face of the port (Step 2).

6. To put the fitting in the desired position, unscrew it by the required amount, but no more than one full turn (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.) (Step 4)

Size	F.F.F.T.
4 (1/4 in. nominal hose or tubing)	1.00 ± .25
6 (3/8 in.)	1.50 ± .25
8 (1/2 in.)	1.50 ± .25
10 (5/8 in.)	1.50 ± .25
12 (3/4 in.)	1.50 ± .25
16 (1 in.)	1.50 ± .25



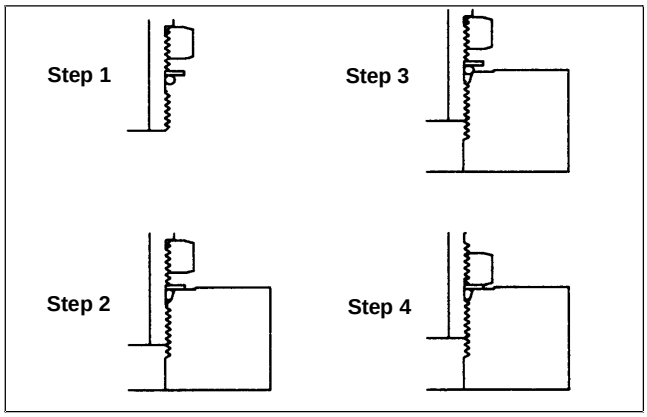


Figure 5

Pushing or Towing

If it becomes necessary to tow the machine, tow it forward only and at a speed no greater than 10 mph.

IMPORTANT: If these towing limits are exceeded, severe damage to the hydrostatic transmission may occur.

To tow a disabled machine:

1. Loosen and remove capscrews securing drive shaft to engine drive coupler. Loosen capscrews clamping drive shaft to transmission (Fig. 6). Remove drive shaft.

IMPORTANT: If drive shaft is not removed before towing, the transmission input shaft will not be able to rotate, thus not allowing transmission to maintain its internal lubrication. Severe damage to the hydrostatic transmission may occur.

2. Attach a suitable chain, strap or cable to the center of the front frame member (Fig. 7).

3. Attach the other end of the towing device to a vehicle that is capable of towing the machine safely and at speeds below 10 mph.

4. AN OPERATOR MUST BE ON THE MACHINE to steer it and keep the traction pedal fully depressed in the forward position while towing.

5. When towing is completed, install drive shaft as shown in Figure 6. The splines are designed to allow assembly only when the two halves of the shaft are properly oriented.

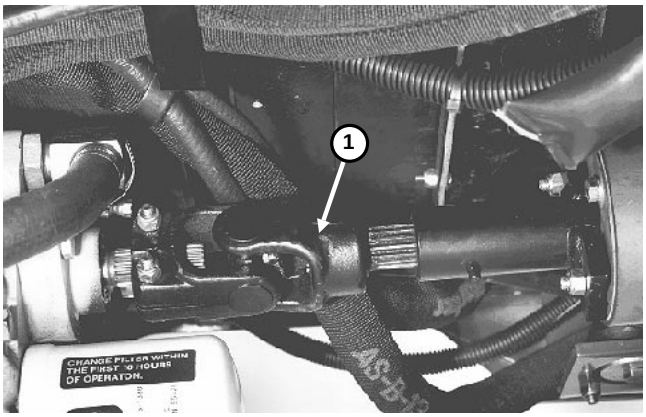


Figure 6

1. Drive shaft

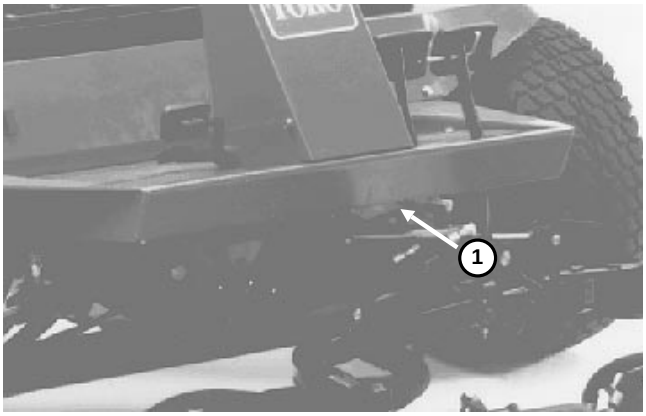


Figure 7

1. Center of front frame member

Hydraulic Schematic

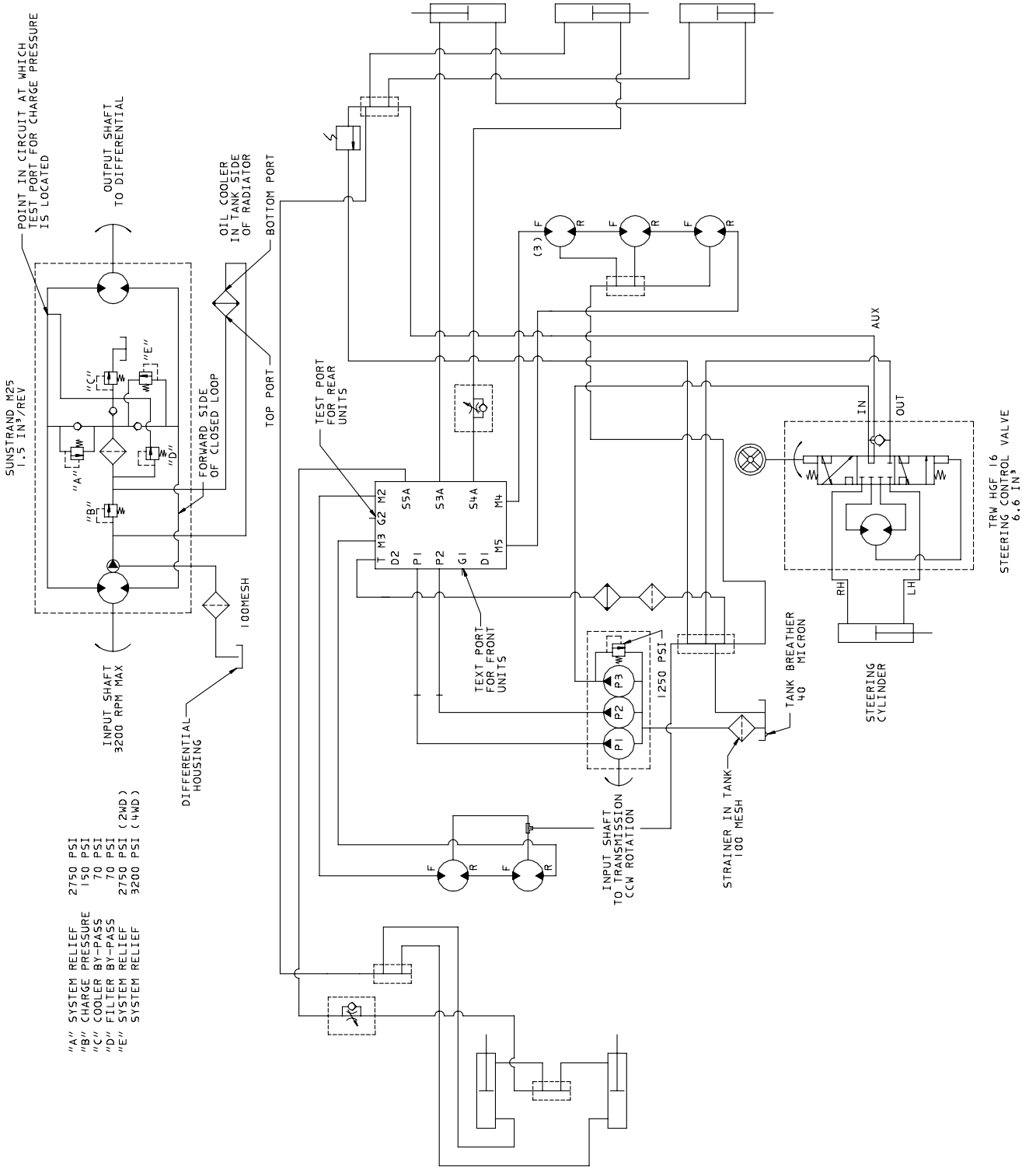


Figure 8

Hydraulic Flow Diagrams

Traction Forward

The hydrostatic transmission is driven by a drive shaft off the front of the engine crankshaft. Pushing the top of the traction pedal, rotates the variable displacement pump swash plate to create a flow of oil. This oil is directed to the fixed displacement motor which turns the differential input shaft to drive the front wheels. Operating pressure on the high pressure side of the closed loop is determined by the amount of load developed at the fixed displacement motor. As the load increases, pressure can increase to a maximum of 2750 PSI (3200 PSI if equipped with 4WD). Main system pressure is limited by a high pressure relief valve on each side of the closed loop circuit. System pressure can be measured at test ports on the transmission. If pressure exceeds the relief setting, oil flows through the relief valve to the low pressure side of the closed loop circuit.

An integral charge pump provides a constant supply of charge oil to the variable displacement pump and closed loop circuit for lubrication and to make up for oil that is lost due to internal leakage in the pump and motor. Charge pump flow is directed through the oil cooler, then through the filter to the low pressure side of the closed loop circuit. A cooler bypass valve and filter bypass valve allow charge oil flow to the closed loop if the cooler or filter becomes plugged. Charge pressure is limited to 150 PSI by a relief valve. Charge pressure can be monitored at the charge pump test port.

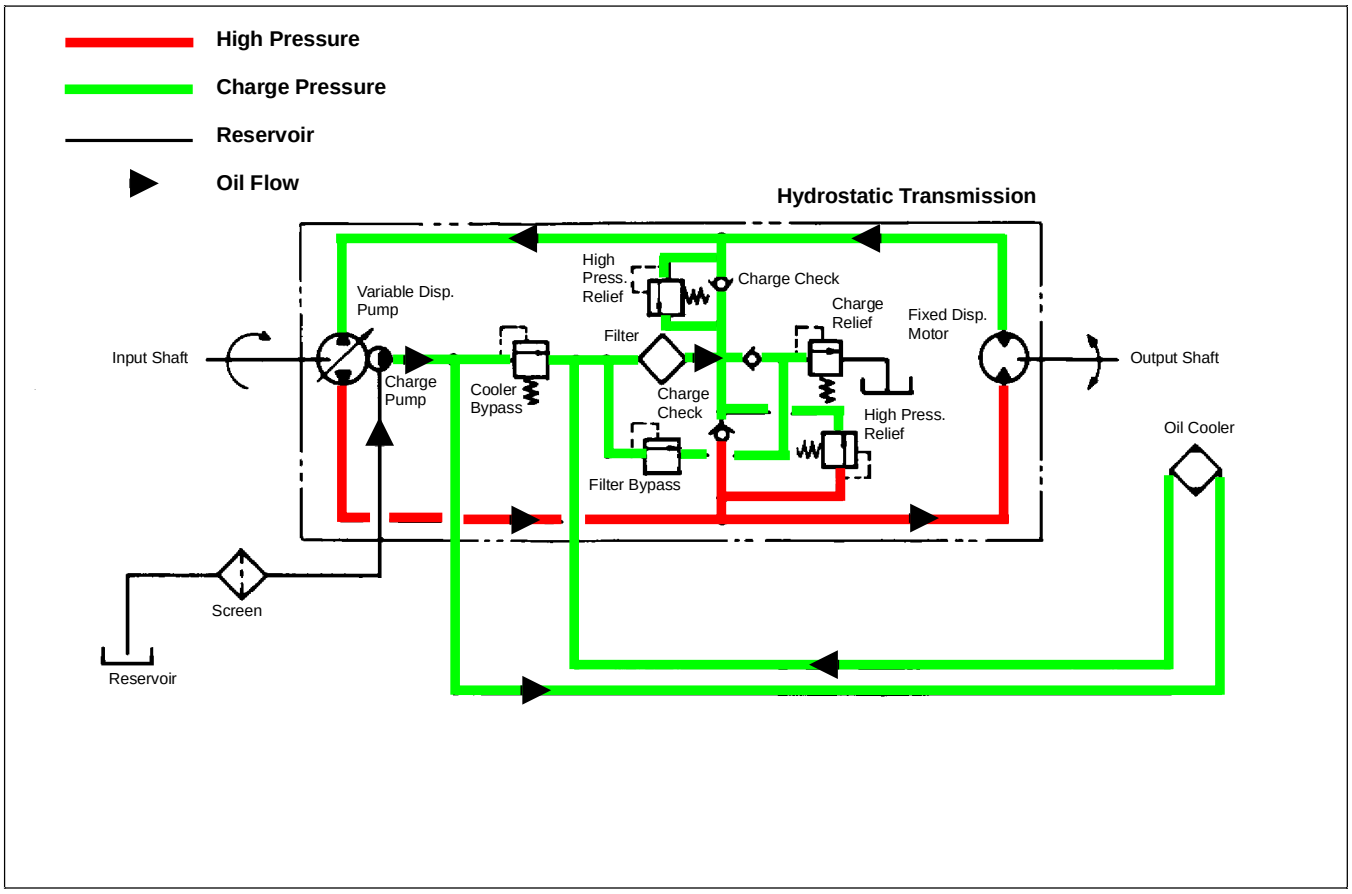


Figure 9

Lower Cutting Units / Mow

The hydraulic pump that provides oil flow to the reel drive circuit is driven off the PTO output shaft of the hydrostatic transmission. This oil flow enters a control valve block which directs the oil flow to perform the functions of reel drive and cutting unit lift and lower.

The valve block consists of two individual control circuits. Each circuit is supplied by its own pump section – "P1" and "P2". The only common connection from one circuit to the other is the case drains from the motors and the tank ports from all valves.

To lower the cutting units, solenoid valves "S3", "S4", and "S5" must be energized along with "S6". Valve "S6" is a load holding poppet-type valve. If "S6" is not energized, no cutting units will lower. Valve "S7" must be in its normal de-energized position to allow the return oil from the cylinder circuit to be directed to tank.

On the "P1" pump circuit, maximum system pressure is limited by relief valve "R1" which is set at 3000 PSI. System pressure on the "P1" side can be measured at Port "G1". Total pump flow must go through solenoid valve "S7". In its normal de-energized position, valve "S7" directs pump flow to the front reel circuit. Solenoid valve "S1" must be energized to allow pressure to build in the front reel circuit. When solenoid valve "S1" is energized, variable solenoid valve "VS1" will direct part of the pump flow to tank, while directing the remaining flow to solenoid valve "S8" and out to the front reel motors. Valve "VS1" is adjusted by the electronic control unit (ECU) with a variable duty cycle pulse-width-modulated (PWM) voltage. As the PWM duty cycle is increased, less oil is by-passed to tank, causing more oil to go to the reel motors. When "VS1" is fully energized, no flow by-passes to tank and all flow is routed to the reel motors. In its normal de-energized position, solenoid valve "S8" directs flow from "VS1" to the front reel motors to turn them in a forward or "mow" direction. Return oil from the motors is directed to tank through valve "S8".

On the "P2" pump circuit, maximum system pressure is limited by relief valve "R2", which is set at 2000 PSI. This pressure can be monitored at port "G2". Solenoid valve "S2" must be energized to allow pressure to build in the rear reel circuit. The variable solenoid valve "VS2" controls reel speed and functions the same as "VS1". In its normal de-energized position, solenoid valve "S9" directs flow from "VS2" to the front reel motors to turn them in a forward or "mow" direction. Return oil from the motors is directed to tank through valve "S9".

NOTE: The variable solenoid valves, "VS1" and "VS2", are energized with a pulse-width-modulated (PWM) voltage during most mowing or backlapping operations. Only when the reel speed control is set to full speed (position A), are the valves energized with a full 12 volts.

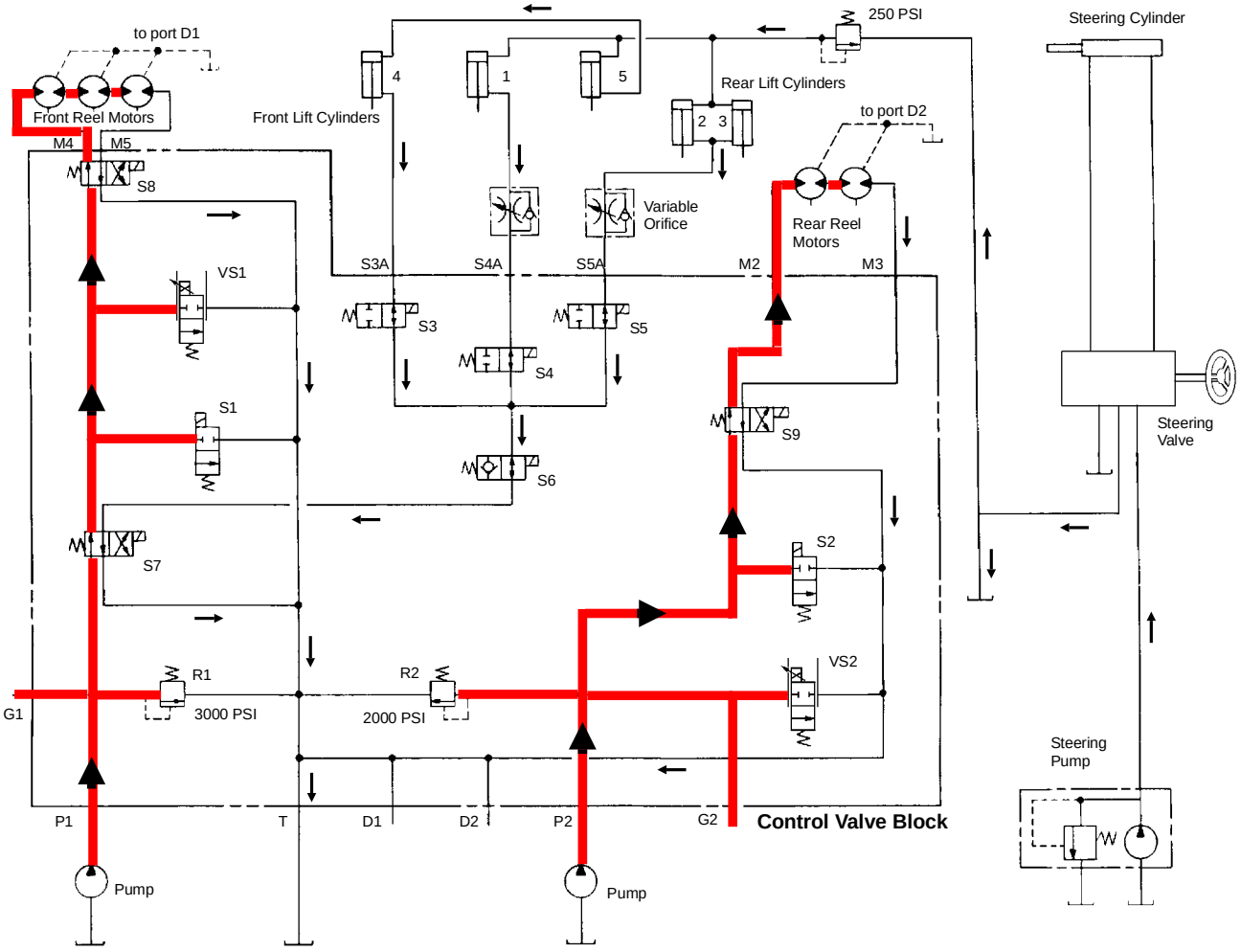

System Pressure
Low Pressure, Return or Case Drain
Oil Flow
Solenoids Energized
Mow Front and Rear: S1, VS1, S2, VS2
Lower All Cutting Units: S6, S3, S4, S5
NOTE: Shown with VS1 and VS2 fully energized (maximum reel speed).
to port D1
Front Reel Motors
M4
M5
S8
Front Lift Cylinders
4
1
5
250 PSI
Rear Lift Cylinders
2
3
to port D2
Variable Orifice
Rear Reel Motors
S3A
S4A
S5A
M2
M3
VS1
S3
S5
S4
S1
S6
S9
S7
S2
VS2
R1
3000 PSI
R2
2000 PSI
G1
P1
T
D1
D2
P2
G2
Control Valve Block
Pump
Pump
Steering Cylinder
Steering Valve
Steering Pump

Figure 10

Backlap (Front Shown)

During “backlap”, the circuits operate the same as in the “mow” mode except for the operation of solenoid valves “S8” and “S9”.

To backlap, solenoid valves “S8” and “S9” are energized to direct flow to the reel motors so they will run in a backwards or “backlap” direction. The electrical system is designed so that only one circuit (front cutting units or rear cutting units) can be operated when in the backlap mode. To backlap the front cuttting units, solenoid valve “S1” is energized allowing pressure to build in the front reel circuit. When solenoid valve “S1” is energized, variable solenoid valve “VS1” will direct part of the pump flow to tank, while directing the remaining flow to solenoid valve “S8” and out to the front reel motors. Return oil from the motors is directed to tank through valve “S8”.

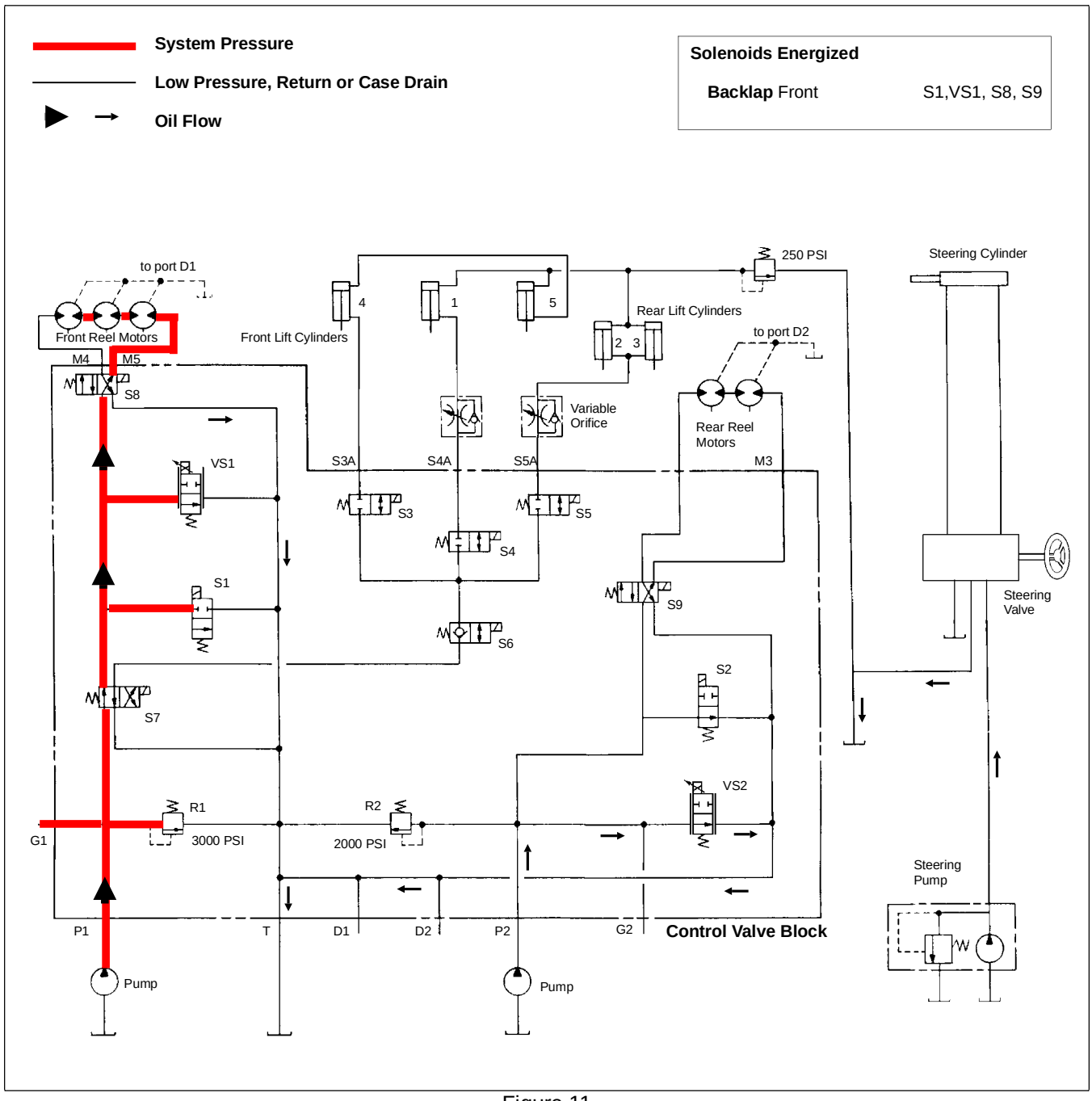


Figure 11

Raise Cutting Units

The “P1” pump circuit controls the raise and lower function of all five cutting units. On the “P1” pump circuit, maximum system pressure is limited by relief valve “R1” which is set at 3000 PSI. System pressure on the “P1” side can be measured at Port “G1”.

To raise the cutting units, solenoid valve “S7” is energized to direct pump flow through valve “S6”, a normally closed poppet-type valve, and on to valves “S3”, “S4”, and “S5”. These three normally closed valves control which cutting units raise or lower. To raise a cutting unit, valve “S7”, and “S3”, “S4” or “S5” must be energized.

The return oil from the cylinders is directed back to tank externally from the valve block.

To hold the cutting units up in any position, all of the solenoid valves are de-energized. Valve “S6” is the load holding valve and this is the reason it is a poppet-type valve.

The lift speed of No. 1 (front center), and No. 2 and 3 (rear) cutting units is regulated by one-way variable orifices which are located in the hydraulic lines between the valve block and lift cylinders.

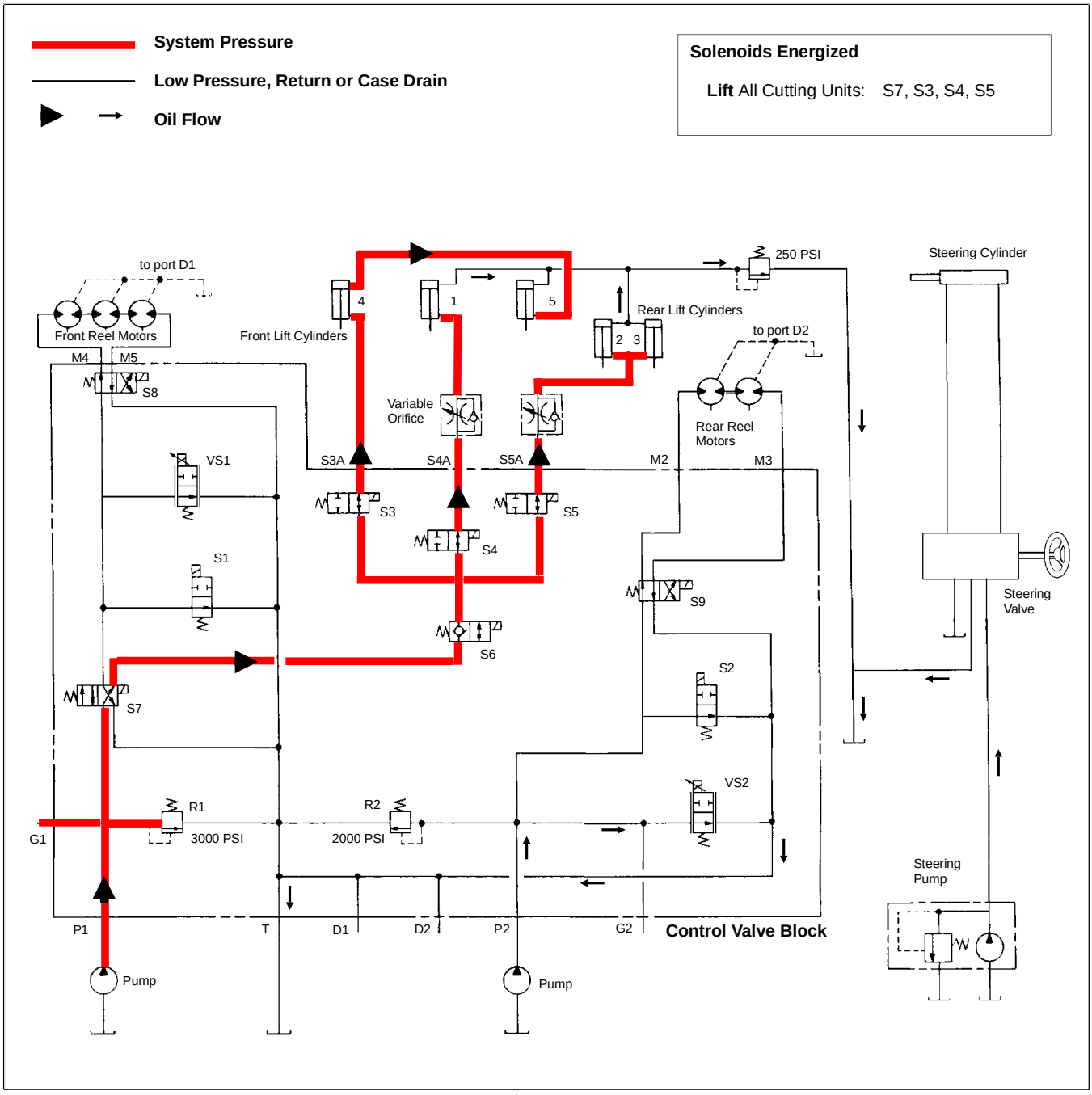


Figure 12

Special Tools

NOTE: Order special tools from the *TORO SPECIAL TOOLS AND APPLICATIONS GUIDE (COMMERCIAL PRODUCTS)*. Some tools may be listed in the Reelmaster 5300-D Parts Catalog. Some tools may also be available from a local supplier.

Seal Protector

Slide protector over reel motor shaft before installing shaft seal to protect seal from damage. Apply a light coating of clean oil to seal protector to ease movement of seal over tool. Use with seal installer tool.

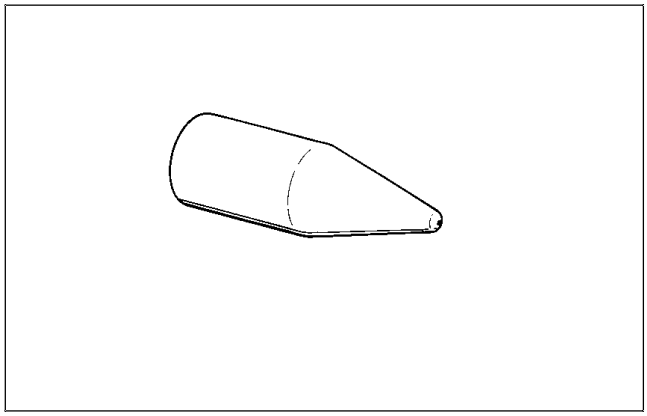


Figure 13

Seal Installer

Use installer and a small hammer to drive reel motor shaft seal into position in bore of reel motor body. Use with seal protector tool.

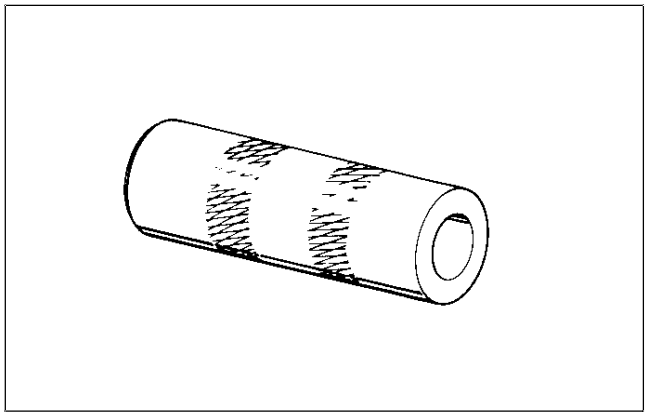


Figure 14

Hydraulic Pressure Test Kit

Used to take various hydraulic pressure readings for diagnostic tests. Quick disconnect fittings provided attach directly to mating fittings on machine test ports without tools. A high pressure hose is provided for remote readings. Contains one each, 1,000, 5,000 and 10,000 PSI gauges. Use gauges as recommended in Testing section of this chapter.

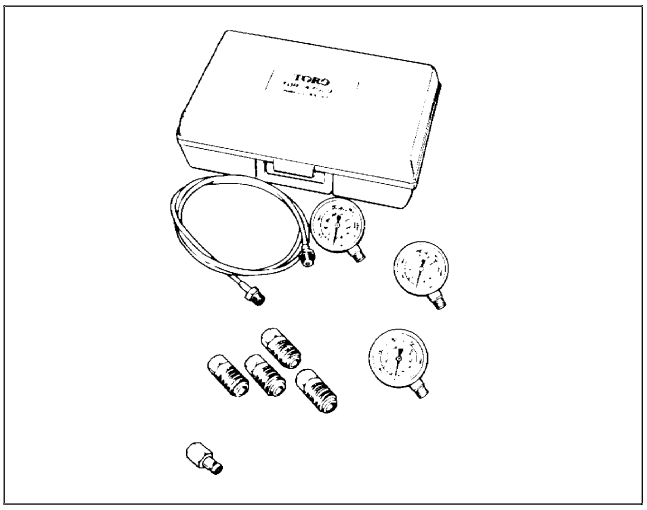


Figure 15

Hydraulic Tester (With Pressure and Flow Capabilities)

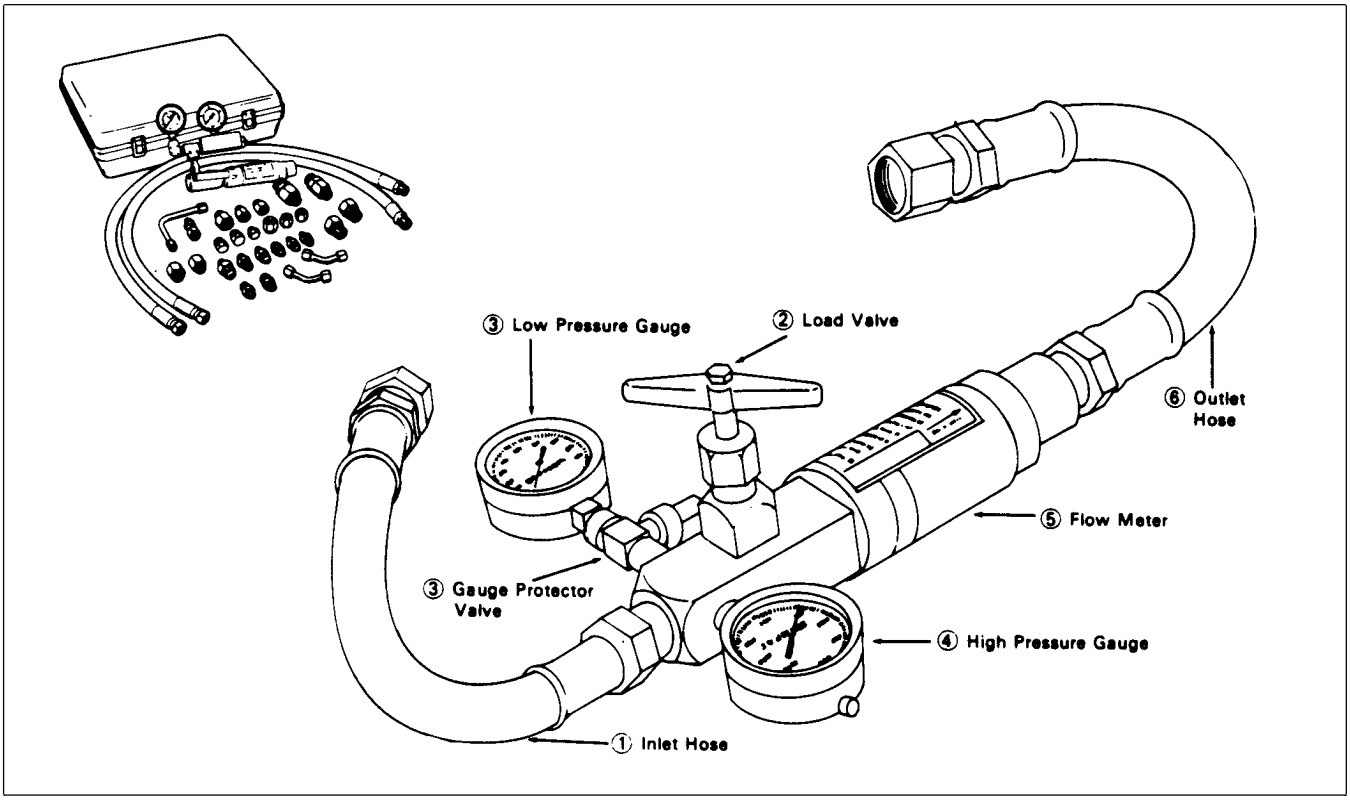


Figure 16

You must have o-ring face seal (ORFS) adapter fittings for this tester to use it on the Reelmaster 5300-D.

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

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

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

   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.

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

5. FLOW METER: This meter measures actual oil flow in the operation circuit, with a gauge rated at 15 GPM.

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

Troubleshooting

The cause of an improperly functioning hydraulic system is best diagnosed with the use of proper testing equipment and a thorough understanding of the complete hydraulic system.

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.

Refer to the Testing section of this Chapter for precautions and specific test procedures.

NOTE: In this troubleshooting guide, cartridge valves or ports in the control valve block are referred to by the labels used on the valve block and shown on the schematics, i.e. **R1**, **S1**, **VS1** (Fig. 10, 11, 12).

Transmission Operates in One Direction Only

Cause	Correction
Faulty traction control linkage.	Repair linkage
Transmission charge check/system relief valve defective.	Inspect and clean or replace charge check/system relief valve.

Traction Pedal Does Not Return to Neutral Properly

Cause	Correction
Incorrect charge check/system relief valve installed in reverse port of transmission.	Relief cartridge in reverse (bottom) port of transmission should have machined groove on sealing face.
Faulty traction control linkage.	Adjust or repair linkage.
Traction stud (eccentric) is positioned in wrong quadrant of linkage pivot (traction plate).	Traction stud (eccentric) must be in the rear quadrant to provide maximum spring tension.

Transmission Jerky When Starting

Cause	Correction
Faulty traction control linkage.	Repair linkage.
Faulty charge check/system relief valve.	Inspect and clean or replace charge check/system relief valve.

Machine Travels Too Far Before Stopping When Traction Pedal is Released

Cause	Correction
Traction linkage out of adjustment.	Adjust traction linkage.

Transmission Operating Hot

Cause	Correction
Engine RPM too low.	Adjust, use tachometer.
Transmission reservoir oil level too low.	Fill to proper level.
Cooling system not operating properly.	Clean screen, oil cooler and radiator. Repair fan or belt. Check coolant level and add coolant as necessary. Check for restricted oil cooler and repair or replace as necessary.
Faulty oil cooler bypass relief valve.	Inspect and clean or replace oil cooler bypass relief valve.
Charge pressure too low.	Inspect for plugged transmission filter and replace if necessary. Inspect charge relief valve and clean or replace if faulty. Inspect charge pump and repair or replace if faulty.
Traction pressure too high.	Reduce transmission load.
Traction pressure too low.	If pressure is low in only one direction (forward or reverse) check affected system relief valve and repair or replace if faulty. Repair or replace transmission (pump & motor).

Loss of Traction Power or Unit Will Not Operate In Either Direction

Cause	Correction
Engine RPM too low.	Adjust, use tachometer.
Drive shaft disconnected or damaged.	Repair or replace drive shaft.
Traction control linkage damaged or disconnected.	Repair linkage.
Transmission reservoir oil level too low.	Fill to proper level.
Charge pressure too low.	Inspect for plugged transmission filter and replace if necessary. Inspect charge relief valve and clean or replace if faulty. Inspect charge pump and repair or replace if faulty.
Traction pressure too low.	If pressure is low in only one direction (forward or reverse) check affected system relief valve and repair or replace if faulty. Repair or replace transmission (pump & motor).

No Cutting Units Operate

Cause	Correction
Improper operation of lower-mow/raise control lever.	Hold lever in forward (lower-mow) position until front cutting units begin operating. Do not allow lever to “slap” back to neutral.
Electrical problem.	See Chapter 5 - Electrical System.
Damaged pump or pump coupler.	Repair coupler and pump if necessary. NOTE: Steering and cutting unit lift will also be affected.

Front Reels Will Not Turn in Either Direction

Cause	Correction
S1 not shifting.	Do electrical diagnostics to make sure that voltage is being applied to S1 and that there is no electrical fault. See Chapter 5 - Electrical System. Do cartridge valve service procedure for valve S1. Interchange S1 with S2 and check operation. Replace S1 with a new valve if faulty.
R1 bypassing.	Check pressure at port G1 of valve block and adjust valve if necessary. Do cartridge valve service procedure for valve R1. Replace R1 with a new valve.
S7 partially shifted.	Try operating lift circuit up and down a number of times. Do cartridge valve service procedure for valve S7.
S7 energized (should only be energized during lift function).	Check for electrical or controller problem. See Chapter 5 - Electrical System.
VS1 not shifting.	Do electrical diagnostics to make sure that voltage is being applied to VS1 and that there is no electrical fault. See Chapter 5 - Electrical System. Do cartridge service procedure for VS1. Interchange VS1 with VS2 and check operation. Replace VS1 if faulty.

Front Reel(s) Turn Too Slow

Cause	Correction
R1 bypassing.	Check relief pressure at port G1 of valve block and adjust valve if necessary. Do cartridge valve service procedure for valve R1. Replace R1 with a new valve.
S7 partially shifted.	Try operating lift circuit up and down a number of times. Do cartridge valve service procedure for valve S7.
S8 partially shifted.	Do cartridge valve service procedure for valve S8. Interchange S8 with S9 and check operation. Replace S8 if faulty.
Internal leakage (by-passing oil) in reel motor.	Excessive case drain flow may identify faulty motor. Use hydraulic tester to perform reel motor efficiency test. Repair or replace reel motor if faulty.
P1 pump section inefficient.	Repair or replace pump.
VS1 not operating properly.	Do electrical diagnostics to make sure that voltage is being applied to VS1 and that there is no electrical fault. See Chapter 5 - Electrical System. Do cartridge service procedure for VS1. Interchange VS1 with VS2 and check operation. Replace VS1 if faulty.

Front Reels Turn Too Fast

Cause	Correction
VS1 not operating properly.	Do electrical diagnostics to make sure that voltage is being applied to VS1 and that there is no electrical fault. See Chapter 5 - Electrical System. Do cartridge service procedure for VS1. Interchange VS1 with VS2 and check operation. Replace VS1 if faulty.

Front Reels Turn in Only One Direction

Cause	Correction
S8 not shifting.	Do electrical diagnostics to make sure that voltage is being applied to S8 and that there is no electrical fault. See Chapter 5 - Electrical System. Do cartridge valve service procedure for valve S8. Interchange S8 with S9 and check operation. Replace S8 if faulty.

Front Reels Stop or Won't Start – During Backlap Only

Cause	Correction
Motors bypassing.	Increase flow to motors by adjusting HOC selector knob.
Load too high for motor.	Decrease load

Front Reels Stop Under Load

Cause	Correction
R1 bypassing.	Check relief pressure at port G1 of valve block and adjust valve if necessary. Do cartridge valve service procedure for valve R1. Replace R1 with a new valve.
Internal leakage (by-passing oil) in reel motor.	Excessive case drain flow may identify faulty motor. Use hydraulic tester to perform reel motor efficiency test. Repair or replace reel motor if faulty.
P1 pump section inefficient.	Repair or replace pump.

Front Reel Speed Erratic

Cause	Correction
Reel bearing or bedknife to reel adjustment too tight.	See Chapter 8 - Cutting Units.
Electrical problem.	See Chapter 5 - Electrical System.

REAR Cutting Unit Problems

Cause	Correction
For problems with rear cutting unit reel operation, refer to the Correction recommended for the front cutting units. NOTE: Rear cutting unit **lift functions** are controlled by P1 (front cutting unit) circuits of control valve.	Substitute R1 with R2 S1 with S2 S8 with S9 VS1 with VS2

Cutting Unit(s) Will Not Raise

Cause	Correction
One-way variable orifice closed - center and rear cutting units only - see Hydraulic Schematics.	Open speed control valve.
Engine RPM too low.	Increase engine RPM to operating speed.
S7 not shifting.	Do electrical diagnostics to make sure that voltage is being applied to S7 and that there is no electrical fault. See Chapter 5 - Electrical System. Test solenoid coil. Replace if faulty. See Chapter 5 - Electrical System. Oil viscosity too high - run machine to warm up oil to operating temperature. Do cartridge valve service procedure for valve S7.
S3, S4, or S5 not shifting (See Hydraulic Schematics to see which valve controls what lift cylinders.)	Do electrical diagnostics to make sure that voltage is being applied to solenoid for affected circuit and that there is no electrical fault. See Chapter 5 - Electrical System. Test solenoid coil for valve of affected circuit. Replace if faulty. See Chapter 5 - Electrical System. Do cartridge valve service procedure for valve in affected circuit. Interchange solenoid from affected circuit with another similar valve (S3, S4, or S5) and check operation. Replace or repair affected valve if faulty.
R1 bypassing.	Check relief pressure at port G1 of valve block and adjust valve if necessary. Do cartridge valve service procedure for valve R1. Replace R1 with a new valve.
Internal leakage in lift cylinder(s).	Check lift cylinder(s) and repair or replace if faulty.
Lift arm pivots binding.	Lubricate bushings. Inspect for damage. Repair or replace damaged parts.
P1 pump section inefficient.	Repair or replace pump.

Cutting Units Raise, But Will Not Stay Up

Cause	Correction
S6 energized (should only be energized during lower function).	Do electrical diagnostics. See Chapter 5 - Electrical System.
S6 leaking down (not seating properly).	Do cartridge valve service procedure for valve S6. Replace S6 with a new valve if faulty.

Cutting Units Raise Too Fast or Too Slow

Cause	Correction
One-way variable orifice not properly adjusted (center and rear cutting units only) - see Hydraulic Schematics.	Adjust variable orifice for affected circuit.

Cutting Units Will Not Lower

Cause	Correction
S3, S4, or S5 not shifting (See Hydraulic Schematics to see which valve controls what lift cylinders.)	Do electrical diagnostics to make sure that voltage is being applied to solenoid for affected circuit and that there is no electrical fault. See Chapter 5 - Electrical System. Do cartridge valve service procedure for valve in affected circuit. Interchange solenoid from affected circuit with another similar valve (S3, S4, or S5) and check operation. Replace affected valve with a new valve if faulty.
S6 not shifting.	Do electrical diagnostics to make sure that voltage is being applied to S6 and that there is no electrical fault. See Chapter 5 - Electrical System. Do cartridge valve service procedure for valve S6. Replace S6 with a new valve if faulty.
S7 shifted (should only be shifted during lift function).	Do electrical diagnostics to make sure that voltage is being applied to S7 and that there is no electrical fault. See Chapter 5 - Electrical System. Do cartridge valve service procedure for valve S7.

Testing

The most effective method for isolating problems 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.)

CAUTION

Failure to use gauges with the recommended pressure (psi) rating as listed in the test procedures could result in damage to the gauge and possible personal injury from leaking hot oil.

Before Performing Hydraulic Tests

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.

Do electrical diagnostics before performaing hydraulic tests to make sure the electrical system is operating properly. If the electrical system is not operating properly the hydraulic system may appear to malfunction.

WARNING

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

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.

1. Thoroughly 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. Use a tachometer when making a hydraulic test. Engine speed can affect the accuracy of the tester readings.

4. To prevent damage to 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 components, completely open the load valve by turning it counterclockwise (tester with pressure and flow capabilities).

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.

9. Check the control linkage for improper adjustment, binding or broken parts.

10. All hydraulic tests should be made with the hydraulic oil at normal operating temperature.

TEST NO. 1: Traction Circuit Charge Pressure

1. Make sure hydraulic oil is at normal operating temperature by operating the machine for approximately 10 minutes.

2. Park the machine on a level surface, engage the parking brake and stop the engine.

CAUTION

To prevent possible personal injury from rotating drive shaft, engine must be OFF before attempting to connect gauge. If gauge has a hose attached, be careful to route hose so it will not contact the drive shaft.

3. Connect a 1000 PSI gauge onto charge pressure test port (Fig. 17).

4. Start the engine and put throttle at full engine RPM (approx. 3200 RPM) with no load on the system.

GAUGE READING TO BE 150 ± 30 PSI.

5. If there is no pressure, or pressure is low, check for restriction in pump intake line. Inspect charge relief valve and valve seat. Charge pressure can be adjusted by changing shim thickness behind the spring. Check for sheared charge pump key. Disassemble charge pump and check for internal damage or worn parts.

6. Also take a gauge reading while operating the machine in forward and reverse. Start the engine and put throttle at full engine RPM (approx. 3200 RPM). Apply the brakes and push the traction pedal forward, then reverse.

GAUGE READING TO BE 150 ± 30 PSI.

7. If pressure is good under no load, but drops below specification when under traction load, the piston pump and motor should be suspected of wear and inefficiency. When the pump and/or motor is worn or damaged the charge pump is not able to keep up with the internal leakage.

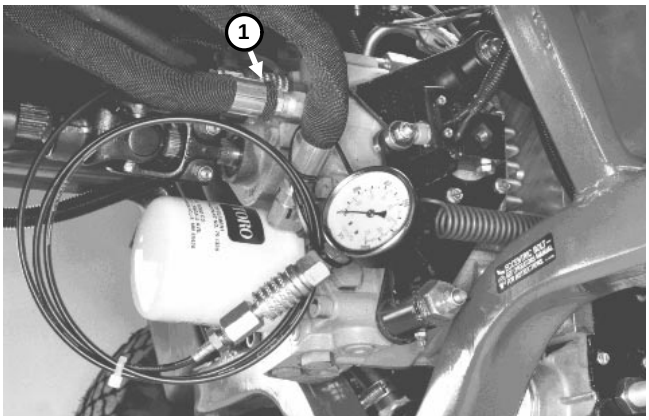


Figure 17

1. Charge pressure test port

TEST NO. 2: Traction Circuit System Pressure

1. Make sure hydraulic oil is at normal operating temperature by operating the machine for approximately 10 minutes.

2. Before doing traction pressure test:

   A. Drive machine to an open area, lower cutting units, turn the engine off and engage the parking brake.

   B. If testing forward function, connect a chain to the rear frame tie-down brackets. Connect the other end of the chain to an immovable object and remove all slack from the chain. If testing reverse function, attach chain to the center of the front frame member (Fig. 7).

CAUTION

To prevent possible personal injury from rotating drive shaft, engine must be OFF before attempting to connect gauge. If gauge has a hose attached, be careful to route hose so it will not contact the drive shaft.

3. Connect a 5,000 psi gauge to traction circuit test port for function to be checked (Fig. 18).

   NOTE: Test ports are 7/16-20 SAE O-ring ports.

4. Start the engine and move throttle to full speed (approx. 3200 RPM).

5. Sit on seat, and with brakes locked, slowly depress the top of traction pedal. While pushing top of traction pedal down, look at pressure reading on gauge.

   GAUGE READING:
   Forward: 3600 ± 150 PSI
   Reverse: 2750 ± 150 PSI

6. If traction pressure is too low, inspect check/high pressure relief valves. If problem occurs in one direction only, interchange the check/relief valves to see if the problem changes to the other direction (see NOTE below). Clean or replace valves as necessary. These cartridge type valves are factory set, and are not adjustable. If check/relief valves are in good condition, replace or overhaul transmission.

NOTE: The forward and reverse check/high pressure relief valves are different. One valve cartridge has a machined groove on seating surface and must be installed in the “reverse” port (see Check and High Pressure Relief Valves in Transmission Repairs section).

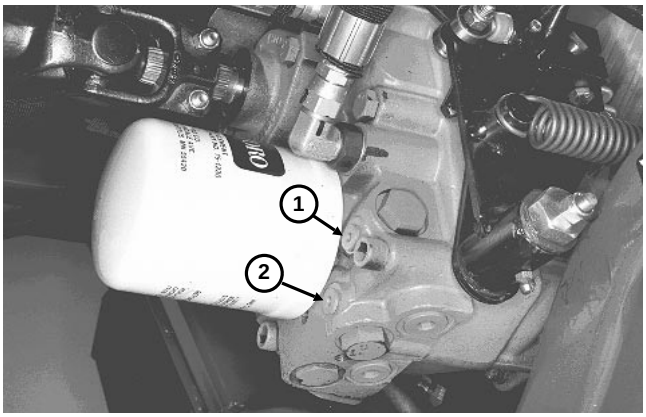


Figure 18

1. FORWARD test port **2. REVERSE test port**

TEST NO. 3: Front Mow / Lift Circuit Pressure

1. Make sure hydraulic oil is at normal operating temperature by operating the machine for approximately 10 minutes.

2. Lower cutting units, engage parking brake and stop the engine.

3. Raise seat to get access to hydraulic test fittings. Remove access cover from in front of hydraulic valve block. Install a 5000 PSI gauge with extension hose onto quick disconnect fitting in port G1 (Fig. 19). Put gauge and hose through opening in front of hydraulic valve block as shown, then lower the seat (Fig. 19A).

NOTE: It may be necessary to rotate 90° fitting in port G1 so seat can be lowered after pressure gauge with extension hose is connected. Loosen nut and rotate 90° fitting in port G1 1/4 turn so test fitting points to the right. Tighten nut to seat o-ring and secure fitting.

4. Sit on the seat and start the engine. Move throttle to full speed (approx. 3200 RPM).

5. While sitting on the seat, pull “Lower-Mow/Raise” control lever back to the RAISE position to lift the cutting units. Hold the lever in the RAISE position while looking at the gauge.

GAUGE READING TO BE 3000 ± 50 PSI.

NOTE: Normal operating pressure when mowing is approximately 500 to 600 PSI per cutting unit. Normal operating pressure of front circuit (three cutting units) when mowing is approximately 1500 to 1800 PSI.

6. Stop the engine. If pressure is too high, remove cap on relief valve R1 and adjust screw to get correct pressure (Fig. 20c). If pressure is too low, check for restriction in pump intake line. Remove cap from relief valve R1 and adjust screw to get correct pressure. If pressure is still too low, pump or lift cylinder(s) should be suspected of wear, damage or inefficiency.

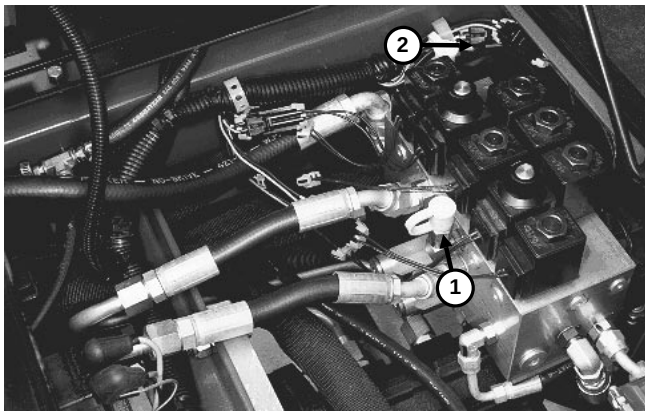


Figure 19

1. Test port G1 **2. Test port G2**

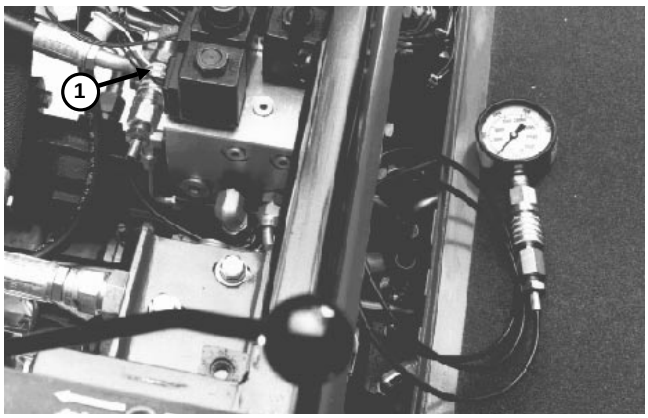


Figure 19A

1. Test port G1

TEST NO. 4: Rear Mow Circuit Pressure

1. Make sure hydraulic oil is at normal operating temperature by operating the machine for approximately 10 minutes.

2. Lower cutting units, engage parking brake and stop the engine. Set HOC Selector Knob, located under the instrument panel, to position A (full speed). Make sure Backlap switch is OFF.

3. Raise seat to get access to hydraulic test fittings. Remove access cover from in front of hydraulic valve block. Install a 5000 PSI gauge with extension hose onto quick disconnect fitting in port G2. Put gauge and hose through opening in front of hydraulic valve block as shown, then lower the seat (Fig. 20a).

NOTE: It may be necessary to rotate 90° fitting in port G2 so seat can be lowered after pressure gauge with extension hose is connected. Loosen nut and rotate 90° fitting in port G2 1/4 turn so test fitting points forward. Tighten nut to seat o-ring and secure fitting.

4. With cutting units in lowered position and engine OFF, insert a block of wood, as shown in Figure 20b, between cutting unit reel blades and front cross tube of **left-rear (No. 2)** cutting unit to prevent reel from turning.

5. Sit on the seat and start the engine. Move throttle to full speed (approx. 3200 RPM).

WARNING

Keep away from reels during test to prevent personal injury from rotating reel blades.

6. While sitting on seat, move “Enable/Disable” switch to ENABLE. Move “Lower-Mow/Raise” lever forward to engage cutting units, then look at the gauge.

GAUGE READING TO BE 2000 ± 50 PSI.

NOTE: Normal operating pressure when mowing is approximately 500 to 600 PSI per cutting unit. Normal operating pressure of rear circuit (two cutting units) when mowing is approximately 1000 to 1200 PSI.

7. Stop the engine. If pressure is too high, remove cap on relief valve R2 and adjust screw to get correct pressure (Fig. 20c). If pressure is too low, check for restriction in pump intake line. Remove cap from relief valve R2 and adjust screw to get correct pressure. If pressure is still too low, pump or motor should be suspected of wear, damage or inefficiency.

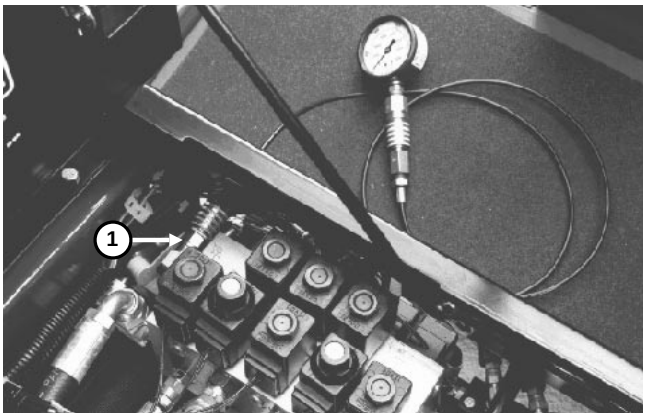


Figure 20a

1. Test port G2

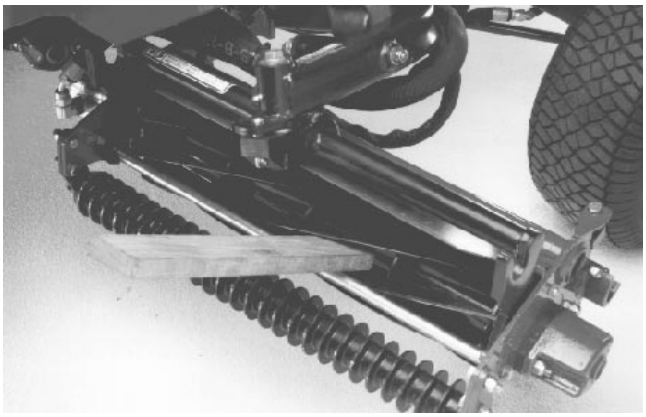


Figure 20b

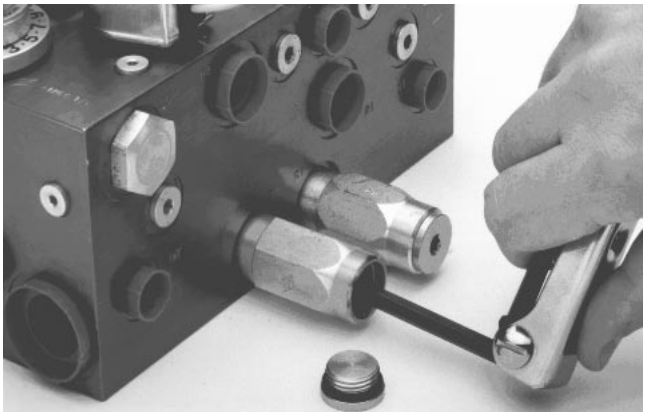


Figure 20c
(Adjusting R2 shown)

TEST NO. 5: Reel Drive Pump Efficiency

(Using Tester With Pressure and Flow Capabilities)

1. Make sure hydraulic oil is at normal operating temperature by operating the machine for approximately 10 minutes.

2. Lower cutting units, engage parking brake and stop the engine.

3. With the engine off and cutting units lowered, install tester in series between pressure hose and valve block fitting for suspected bad pump section (Fig. 21). Make sure the tester flow control valve is OPEN.

Front circuit – port P1
Rear circuit – port P2

IMPORTANT: Make sure that the oil flow indicator arrow on the flow gauge is showing that the oil will flow from the pump, through the tester and into the valve block.

IMPORTANT: The pump is a positive displacement type. If pump flow is completely restricted or stopped, damage to the pump, tester or other components could occur.

4. Make sure the parking brake is engaged. Start the engine and move throttle to full speed (approx. 3200 RPM). DO NOT engage the cutting units.

5. While watching pressure gauges, slowly close flow control valve until 2000 PSI is obtained on gauge.

TESTER READING: Flow not less than 5 GPM at 2000 PSI.

6. Stop the engine. If flow was lower than 5 GPM or a pressure of 2000 PSI cannot be obtained, check for restriction in pump intake line. If not restricted, remove pump and repair or replace as necessary.

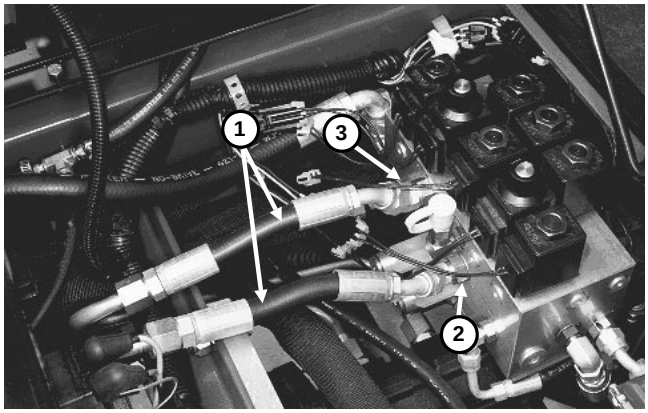


Figure 21

1. Pressure hose
2. Port P1
3. Port P2

TEST NO. 6: Reel Drive Circuit Flow

(Using Tester With Pressure and Flow Capabilities)

1. Make sure hydraulic oil is at normal operating temperature by operating the machine for approximately 10 minutes.

2. Lower cutting units, engage parking brake and stop the engine.

3. Set HOC Selector Knob, located under the instrument panel, to position A (full speed). Make sure backlap switch is OFF.

4. Install tester in series between pressure hose and motor fitting on suspected bad circuit (Fig. 22). Make sure the tester flow control valve is OPEN.

Tester Location:
Front circuit – left-front (No. 4) cutting unit.
Rear circuit – left rear (No. 2) cutting unit

IMPORTANT: Make sure that the oil flow indicator arrow on the flow gauge is showing that the oil will flow from the valve block, through the tester and into the motor.

5. One person should sit on the seat and operate the machine while another person watches the gauges.

6. Make sure the parking brake is engaged. Start the engine and move throttle to full speed (approx. 3200 RPM).

CAUTION

Cutting unit reels will rotate when lowered with Enable/Disable switch in ENABLE position. Keep away from reels during test to prevent personal injury from rotating reel blades. Do not stand in front of the machine.

7. Move “Enable/Disable” switch to ENABLE. Move “Lower-Mow/Raise” lever forward to engage the cutting units. While watching pressure gauges, slowly close flow control valve until pressure specified below is obtained.

TESTER READINGS:
Front – flow not less than 5 GPM at 2300 PSI.
Rear – flow not less than 5 GPM at 1500 PSI.

8. Stop the engine. If pressure or flow is too low, inspect relief valve (R1 or R2) for contamination or wear. Inspect flow control valve (VS1 or VS2) for restriction. Check spool travel of S7. Check spool travel of S8 or S9.

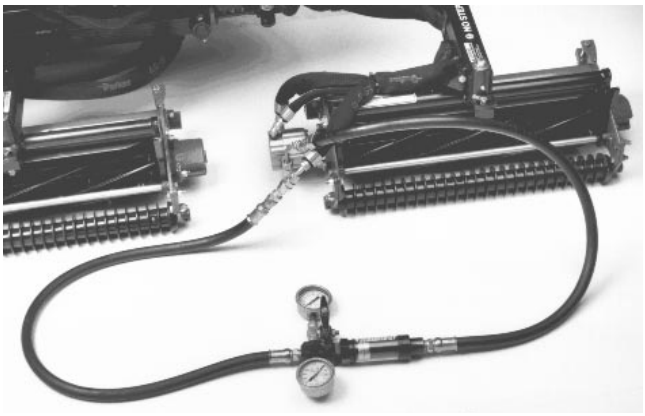


Figure 22

TEST NO. 7: Reel Drive Motor Efficiency

Reel drive motor efficiency can be tested by blocking outlet flow from the motor, then measuring flow from the motor case drain line. Use a graduated container, such as special tool TOR4077 to measure flow from the motor case drain line over a 15 second time period (Fig. 23b). Use the chart to determine the flow (Fig. 23c).

1. Make sure hydraulic oil is at normal operating temperature by operating the machine for approximately 10 minutes.

2. Lower cutting units, engage parking brake and stop the engine.

3. Disconnect the motor case drain hose (small diameter hose) where it connects to traction unit (not at the motor). Put a steel cap on the fitting at the traction unit. leave the case drain hose open (Fig. 23a)

4. Disconnect hose from outlet of motor to be tested. Put a steel cap on the motor fitting. Put a steel plug in the disconnected hose (Fig. 23a).

5. Set HOC Selector Knob, located under the instrument panel, to position A (full speed). Make sure Backlap switch is OFF.

CAUTION

Cutting unit reels will rotate when lowered with Enable/Disable switch in ENABLE position. Keep away from cutting units during test to prevent personal injury from rotating reel blades. Do not stand in front of the machine.

6. Sit on the seat and start the engine. Move throttle to full speed (approx. 3200 RPM). Move “Enable/Disable” switch to ENABLE. Move “Lower-Mow/Raise” lever forward to engage cutting units. Have another person measure flow from the case drain line for 15 seconds, then move the switch to DISABLE and stop the engine.

TEST RESULTS: Flow not more than 0.5 GPM.

7. If flow is more than 0.5 GPM motor is worn or damaged and should be repaired or replaced.

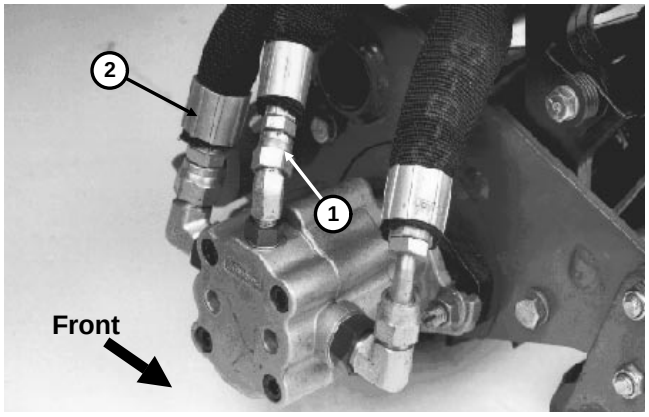


Figure 23a

1. Case drain hose **2. Outlet hose**

Figure 23b
This illustration shows flow being blocked by closing flow restrictor valve on a flow meter

GPM	Milliliters in 15 sec.	Ounces in 15 sec.
.1	95	3.2
.2	189	6.4
.3	284	9.6
.4	378	12.8
.5	473	16.0
.6	568	19.2
.7	662	22.4
.8	756	25.6
.9	852	28.8
1.0	946	32.0

Figure 23c

Traction Control Neutral Adjustment

The machine must not “creep” when traction pedal is released. If it does creep, an adjustment is required.

1. Park machine on a level surface, lower cutting units and shut engine off. Depress only the right brake pedal and engage the parking brake.

2. Jack up left side of machine until front tire is off the shop floor. Support machine with jack stands to prevent it from falling accidentally.

3. Under right side of transmission, loosen locknut on traction adjustment cam (Fig. 24).

CAUTION

Engine must be running so final adjustment of the traction adjustment cam can be performed. To guard against possible personal injury, keep hands, feet, face and other parts of the body away from the muffler, other hot parts of the engine, and rotating parts.

4. Start the engine and run at low idle. Rotate cam hex in either direction (keeping large offset portion of cam hex in rear 180° position) until wheel is not rotating.

5. Tighten locknut to secure adjustment.

6. Stop the engine and release the right brake. Remove jack stands and lower the machine to the shop floor. Test drive the machine to make sure it does not creep.

Neutral Return Spring Adjustment

1. On a large, flat, open area drive the machine at full throttle and full traction speed.

2. Remove foot from traction pedal and measure distance required for machine to come to a stop.

3. If distance required to stop is greater than 18 feet (5.5 meters) an adjustment is required.

4.To adjust, park machine on a level surface, lower cutting units to floor and shut engine off.

5. Connect brake pedals together with locking pin, push both pedals down and pull parking brake latch out.

6. Loosen outer hex nut securing eye bolt to spring anchor plate.

7. Turn inner locknut clockwise until distance between inside of eye bolt loop and inside of spring anchor plate is shortened 1/8 inch, as shown in Figure 24A. Tighten outer hex nut.

8. Operate machine and check stopping distance. Repeat procedure if necessary.

NOTE: Shortening distance between inside of eyebolt loop and inside of spring anchor plate increases pedal force on traction pedal. Do not over adjust.

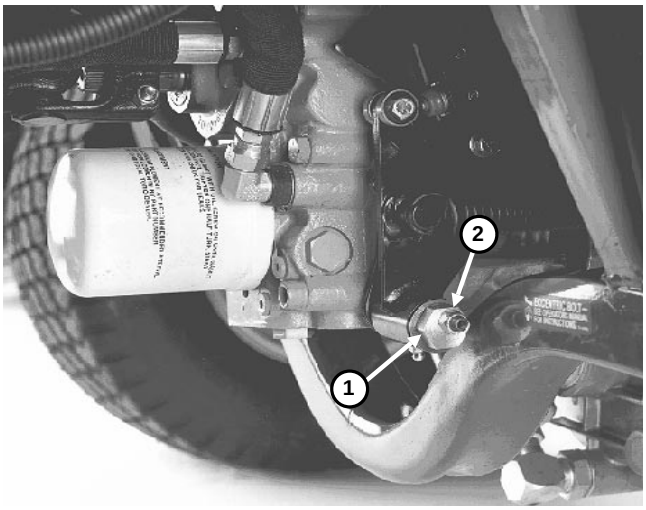


Figure 24

1. Traction adjustment cam
2. Locknut

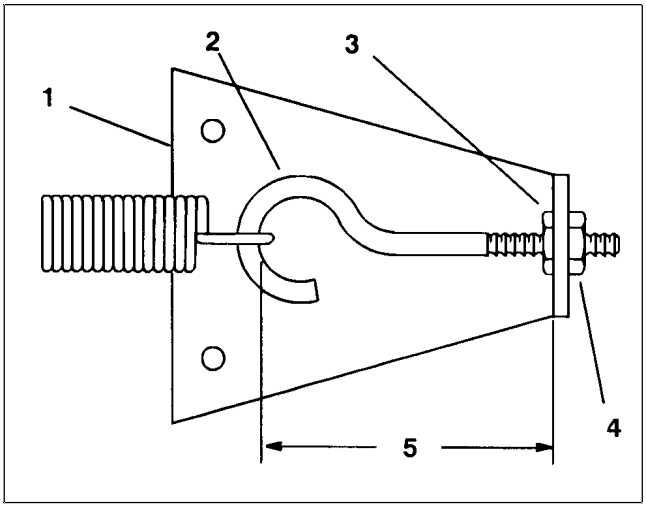


Figure 24A

1. Spring anchor plate
2. Eye bolt
3. Inner locknut
4. Outer hex nut
5. Shorten distance to decrease stop time

Lift Circuit Variable Orifice Adjustment

Adjustable orifices are adjusted at the factory and should not require adjustment unless tampered with or in special situations.

Opening valve increases lift speed. Closing valve slows lift speed.

NOTE: Adjustment for special operating conditions should not require more than 1/2 turn of valve in either direction from initial adjustment.

Front Valve Initial Adjustment (Fig. 25)

This adjustment affects the front center (No. 1) cutting unit only. Loosen set screw. Turn valve clockwise to fully closed position. Turn valve counterclockwise (open) 2-1/2 turns. Secure adjustment by tightening set screw.

Rear Valve Initial Adjustment (Fig. 26)

Loosen set screw. Turn valve clockwise to fully closed position. Turn valve counterclockwise (open) 2-1/4 turns. Secure adjustment by tightening set screw.

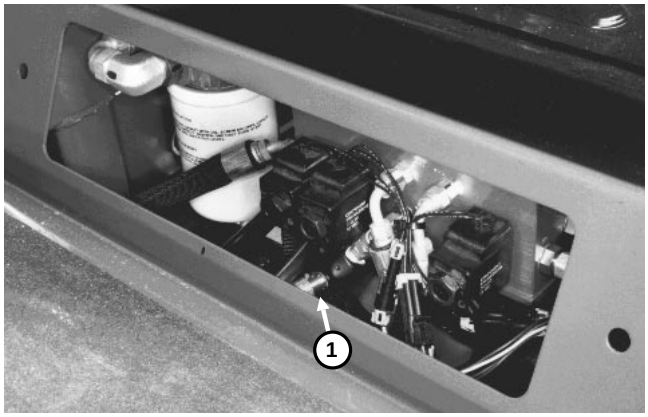


Figure 25

1. Front circuit adjustable orifice

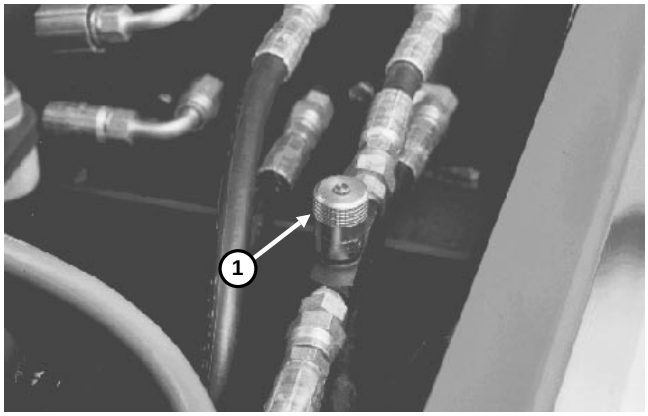


Figure 26

1. Rear circuit adjustable orifice

Shaft Seal Replacement

1. Park the machine on a level surface, lower cutting units, engage parking brake and stop the engine.

2. Disconnect the drive shaft from the transmission (Fig 27).

3. Remove retaining ring, then carefully remove seal from bore in charge pump cover (Fig. 28). The face of the seal my be punctured with a sharp instrument (such as a screwdriver) to aid in prying the seal out, or a slide hammer type puller may be used to remove the seal. Be careful to not damage the charge pump cover or shaft. Once removed the seal is not reusable.

4. Inspect the charge pump cover, new seal, and shaft for damage. Inspect sealing area on shaft for rust, wear or contamination. Polish seal area on shaft if necessary.

5. Use a seal installer tool or wrap spline end of shaft with thin plastic to prevent damage to seal lip during installation. Lubricate inside diameter of new seal with petroleum jelly.

6. Press new seal into charge pump cover, being certain the seal is perpendicular to the shaft. Be careful not to damage the seal. The outer face of the seal should be located between 0.056 to 0.096 in. below the outer surface of the charge pump cover. Install the retaining ring.

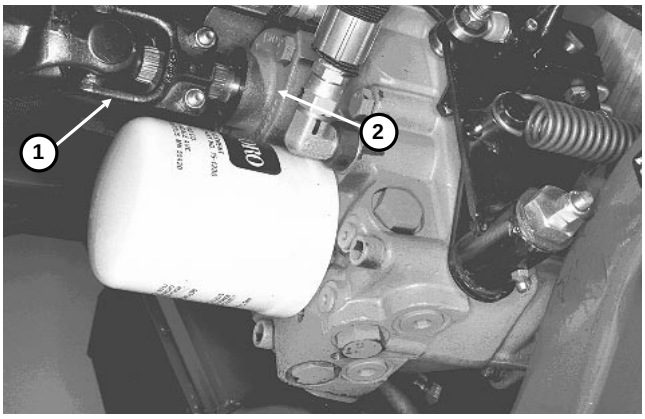


Figure 27

1. Drive shaft **2. Charge pump**

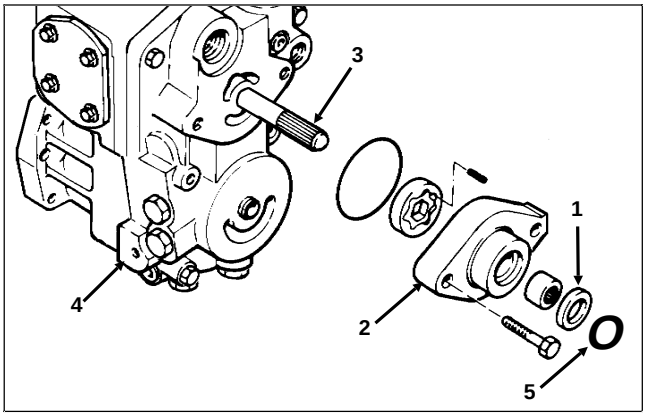


Figure 28

1. Seal
2. Charge pump cover
3. Shaft
4. Transmission
5. Retaining ring

Transmission Control Linkage Removal

1. Park the machine on a level surface, lower cutting units, engage parking brake and stop the engine.

2. Disconnect wiring harness from traction neutral switch (Fig. 29, 30).

3. Remove eybolt and extension spring.

4. Remove cotter pin and washer to disconnect traction control rod from pump control.

5. Loosen cap screw and lock nut securing pump control to swashplate control shaft. It is not necessary to disassemble transmission control assembly.

6. Remove four (4) capscrews securing traction plate to transmission housing. Remove transmission control assembly from transmission.

7. Reverse steps 2 - 6 to install transmission control linkage.

8. Do traction control neutral adjustment (see Adjustments section of this chapter).

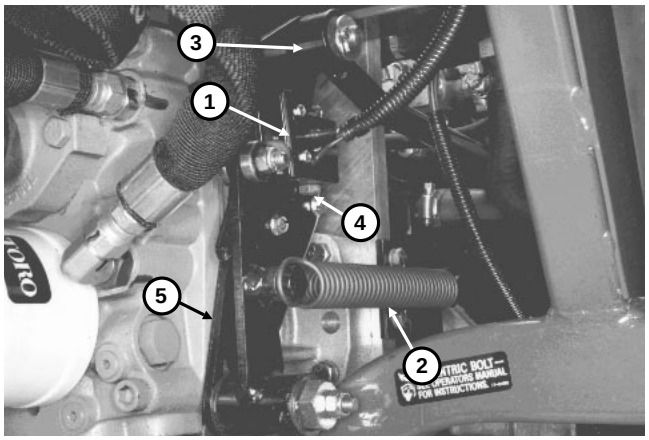


Figure 29

1. Traction neutral switch
2. Extension spring
3. Traction control rod
4. Capscrew & locknut
5. Traction plate

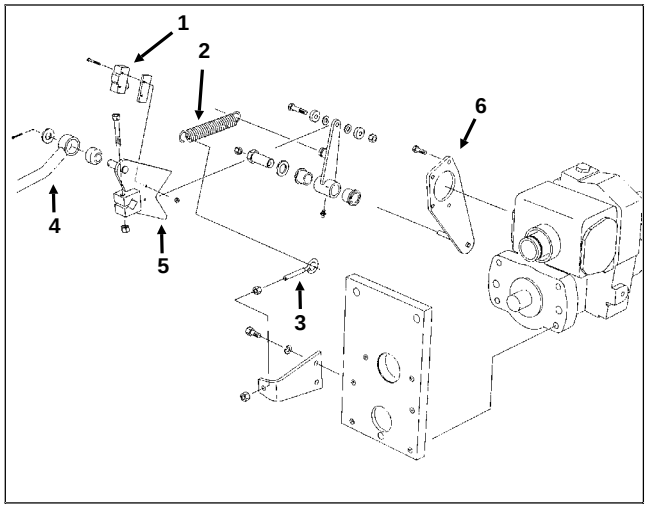


Figure 30

1. Traction neutral switch
2. Extension spring
3. Eyebolt
4. Traction control rod
5. Pump control
6. Traction plate

Trunnion Seal Replacement

1. Park the machine on a level surface, lower cutting units, engage parking brake and stop the engine.

2. Remove control linkage from swashplate control shaft on transmission (see Transmission Control Removal).

3. Remove hex tapping screws retaining trunnion seal cover to transmission housing (Fig. 31).

4. Remove trunnion seal cover with lip seal and o-ring.

5. Put seal cover in an arbor press and press out old seal. Once removed, the seal is not reusable.

6. Inspect seal cover for damage. Inspect sealing area on shaft for rust, wear, or contamination. Polish sealing area on shaft if necessary.

7. Using an arbor press, press seal into position from inside of seal cover until it bottoms out in its bore. Be careful not to damage the seal.

8. Install o-ring onto seal cover and retain with petroleum jelly.

9. Use a seal installer tool or wrap end of swashplate control shaft with thin plastic to prevent damage to seal during installation.

10. Slide seal cover assembly over swashplate control shaft onto housing. Install hex tapping screws and tighten to a torque of 6 to 9 ft-lbs.

11. Install control linkage onto transmission. Check machine for “creeping” when engine is running with foot pedal in neutral position. Do Traction Control Neutral Adjustment if necessary.

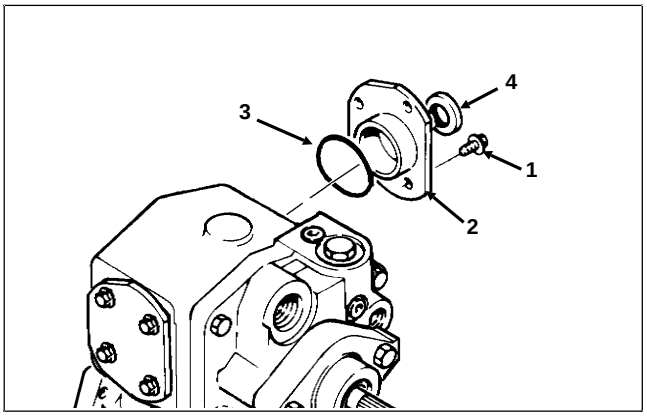


Figure 31

1. Hex tapping screw (4)
2. Trunnion seal cover
3. O-ring
4. Lip seal

Check and High Pressure Relief Valves

1. Park the machine on a level surface, lower cutting units, engage parking brake and stop the engine.

2. Remove the check/high pressure relief valve hex plug (Fig 32).

3. Remove the valve cartridge assembly. Inspect the valve and mating seat in the housing for damage or foreign material. It will be necessary to replace the center section if the seat is damaged.

IMPORTANT: The relief valves are factory set and should not be tampered with, except to replace the entire valve cartridge.

4. The valve cartridge is retained in the special plug by a circlip. The check valve spring may be removed from the special plug by pulling out at a slight angle. When reassembling, install the check valve spring into the special plug with its larger diameter toward the plug, and snap the valve cartridge into position in the plug.

NOTE: The forward and reverse valves are different. The seating surface of the “reverse” check/high pressure relief valve has a machined groove in it (Fig. 32). Installing the “reverse” check/high pressure relief valve in the wrong port may cause performance problems.

5. Reinstall the valve cartridges with o-rings into the housing and tighten the plugs to a torque of 30 to 50 ft-lb.

6. Before starting the engine check the oil level in the differential housing and add the correct oil as necessary. Start the engine and let it run for one to two minutes, then turn the engine off and check the oil level again. Check the transmission for leaks.

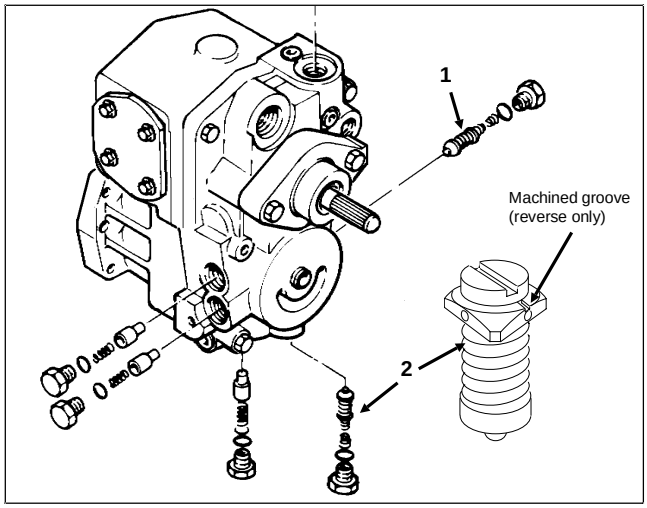


Figure 32

1. Forward check/high pressure relief valve
2. Reverse check/high pressure relief valve

Charge Pressure Relief Valve

1. Park the machine on a level surface, lower cutting units, engage parking brake and stop the engine.

2. Remove the charge relief valve hex plug (Fig. 33).

3. Remove the spring and poppet from the housing.

4. Do not interchange parts with another valve.

NOTE: The shim(s) which may be installed between the spring and plug may remain inside the plug, being held by an oil film. Make sure the same number and thickness of shims is installed when reassembling the parts unless shims need to be added or removed to adjust the pressure setting.

5. Inspect the poppet and mating seat in the end cap for damage or foreign material.

6. Reinstall the poppet, spring and plug (with shims and o-ring) into the housing. Tighten the plug to a torque of 30 to 70 ft-lb.

7. Before starting the engine check the oil level in the differential housing and add the correct oil as necessary. Start the engine and let it run for one to two minutes, then turn the engine off and check the oil level again. Check the transmission for leaks.

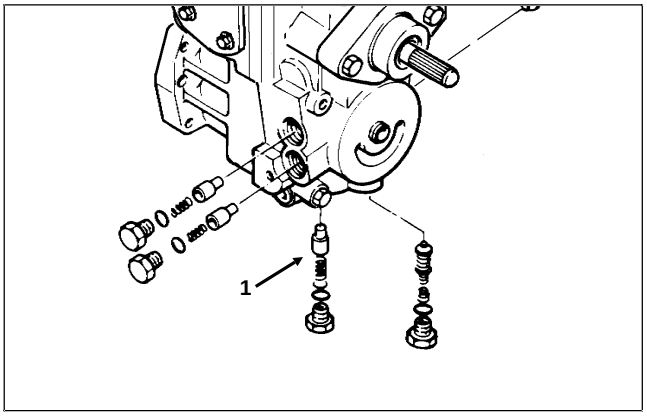


Figure 33

1. Charge pressure relief valve

Heat Exchanger Bypass Valve

1. Park the machine on a level surface, lower cutting units, engage parking brake and stop the engine.

2. Remove the heat exchanger bypass valve hex plug (Fig. 34).

3. Remove the spring and poppet from the housing.

4. Do not interchange parts with another valve. The spring used in the heat exchanger bypass valve is identified by a yellow dye mark, and requires a force of approximately 5.5 lb. to compress it to a length of 1.28 in.

5. Inspect the poppet and mating seat in the end cap for damage or foreign material.

6. Reinstall the poppet, spring and plug (with shims and o-ring) into the housing. Tighten the plug to a torque of 30 to 70 ft-lb.

7. Before starting the engine check the oil level in the differential housing and add the correct oil as necessary. Start the engine and let it run for one to two minutes, then turn the engine off and check the oil level again. Check the transmission for leaks.

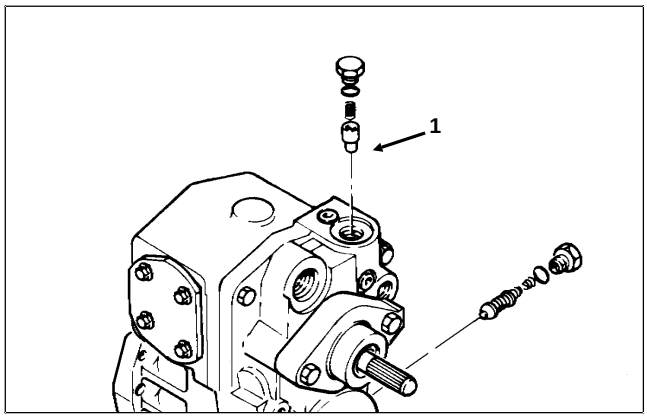


Figure 34

1. Heat exchanger bypass valve

Filter Bypass Valve

1. Park the machine on a level surface, lower cutting units, engage parking brake and stop the engine.

2. Remove the heat exchanger bypass valve hex plug (Fig. 35).

3. Remove the spring and poppet from the housing.

4. Do not interchange parts with another valve. The spring used in the heat exchanger bypass valve is identified by a red dye mark, and requires a force of approximately 2.2 lb. to compress it to a length of 1.28 in.

5. Inspect the poppet and mating seat in the end cap for damage or foreign material.

6. Reinstall the poppet, spring and plug (with shims and o-ring) into the housing. Tighten the plug to a torque of 30 to 70 ft-lb.

7. Before starting the engine check the oil level in the differential housing and add the correct oil as necessary. Start the engine and let it run for one to two minutes, then turn the engine off and check the oil level again. Check the transmission for leaks.

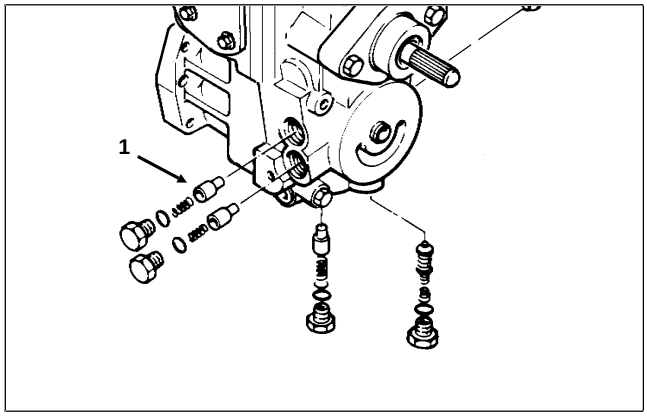


Figure 35

1. Filter bypass valve

Filter Bypass Reverse Flow Check Valve

1. Park the machine on a level surface, lower cutting units, engage parking brake and stop the engine.

2. Remove the heat exchanger bypass valve hex plug (Fig. 36).

3. Remove the spring and poppet from the housing.

4. Do not interchange parts with another valve. The spring used in the heat exchanger bypass valve is identified by a blue dye mark, and requires a force of approximately 0.3 lb. to compress it to a length of 1.28 in.

5. Inspect the poppet and mating seat in the end cap for damage or foreign material.

6. Reinstall the poppet, spring and plug (with shims and o-ring) into the housing. Tighten the plug to a torque of 30 to 70 ft-lb.

7. Before starting the engine check the oil level in the differential housing and add the correct oil as necessary. Start the engine and let it run for one to two minutes, then turn the engine off and check the oil level again. Check the transmission for leaks.

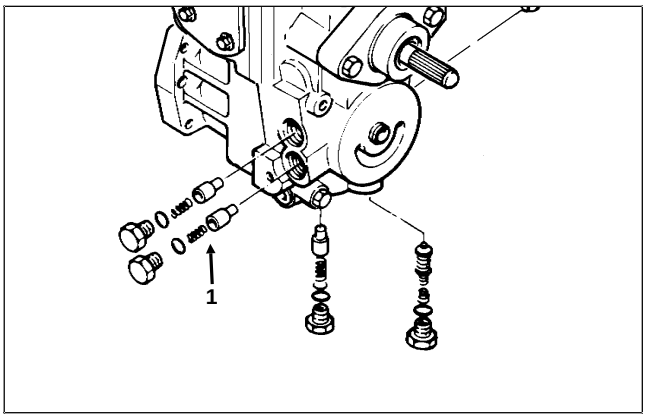


Figure 36

1. Filter bypass reverse flow check valve

Charge Pump

1. Park the machine on a level surface, lower cutting units, engage parking brake and stop the engine.

2. Remove the two (2) cap screws retaining the charge pump cover. Remove the charge pump (Fig. 37, 38).

3. Remove geroter drive pin from the groove in the shaft.

4. Remove the geroter assembly from the charge pump cover. Remove the shaft seal from the cover.

5. Each part should be inspected separately if they are to be reused. If either of the geroter assembly parts needs to be replaced, they should both be replaced. Always replace the o-ring.

6. Inspect the shaft bearing in the charge pump cover for wear or damage. If replacement is necessary, remove the needle bearing from the cover using a suitable puller. Press a new needle bearing into the cover using a suitable press pin. When installed correctly, the bearing cage will be flush to 0.02 in. below the surface of the seal counterbore in the front of the cover.

IMPORTANT: When installing the needle bearing, the printed (numbered) end of the bearing cage must face the press pin.

7. Install the geroter drive pin in the groove in the drive shaft, and retain with petroleum jelly.

8. Before assembly, lubricate the geroter assembly with clean hydraulic oil. Install the geroter assembly into the charge pump cover. Install the o-ring and retain with petroleum jelly.

IMPORTANT: Correct charge pump installation to match engine rotation is determined by the position of the charge pump cover on the transmission housing. To prevent damage to transmission from lack of replenishing oil from charge pump, the flat on the charge pump cover must be on the right (toward the heat exchanger ports).

9. With the flat on the charge pump cover to the right, install the charge pump assembly over the drive shaft and onto the transmission housing. Make sure the geroter engages the drive pin in the shaft.

10. Tighten the charge pump cover cap screws to a torque of 27 to 37 ft-lb.

11. Install a new shaft seal (see Shaft Seal Replacement).

12. Before starting the engine, check the oil level in differential housing and add the correct oil as necessary. Start the engine and let it run for one to two minutes, then turn the engine off and check the oil level again. Check the transmission for leaks.

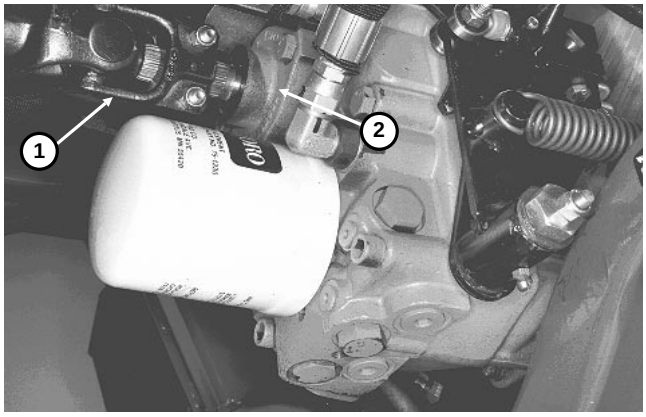


Figure 37

1. Drive shaft **2. Charge pump**

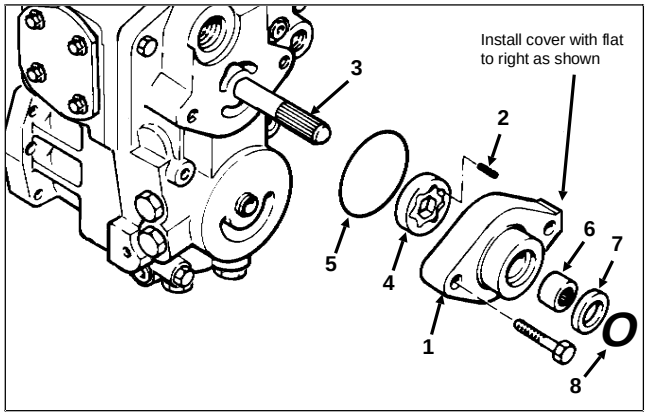


Figure 38

1. Charge pump cover
2. Drive pin
3. Pump shaft
4. Geroter assembly
5. O-ring
6. Needle bearing
7. Shaft seal
8. Retaining ring

Transmission Removal and Installation

1. Park machine on a level surface, lower cutting units, engage parking brake and stop the engine.

2. Remove the two (2) rear cutting units (see Chapter 8 - Cutting Units).

3. To prevent contamination of hydraulic system during removal, thoroughly clean exterior of transmission and differential.

4. Put a drain pan below the transmission. Remove suction line from bottom of transmission to let oil drain out of differential (Fig. 39).

5. Remove control linkage from swashplate control shaft on transmission (see Transmission Control Removal).

6. Remove hydraulic hoses and fittings connected to transmission. Put plugs or caps on disconnected hydraulic hoses to prevent contamination of the system. Put plugs in open ports of transmission.

7. Disconnect drive shaft from transmission (Fig. 39).

8. Support the transmission to prevent it from falling while carefully removing four (4) capscrews and locknuts retaining transmission to support plate. Carefully pull transmission off of support plate and lower it out of the machine (Fig. 40).

NOTE: If the machine is going to be stored until transmission is repaired or replaced, cover hole in support plate with weatherproof tape to prevent contamination of the reservoir.

9. Leave support plate installed and auxiliary pump installed on support plate.

10. Remove retaining ring and remove pinion gear from transmission output shaft.

11. Remove filter from transmission.

12. Before installing transmission, install new o-ring seal where transmission mates with support plate. Reverse steps 2 - 10 to install transmission.

13. Install a new filter and fill differential with correct oil.

14. Disconnect fuel stop solenoid electrical connector on engine to prevent engine from starting. Prime transmission by turning ignition key switch to crank engine for 10 seconds. Repeat cranking procedure again.

15. Start the engine and let it idle for approximately two minutes. Operate machine slowly in forward and reverse. Stop engine and check differential oil level. Check transmission for leaks.

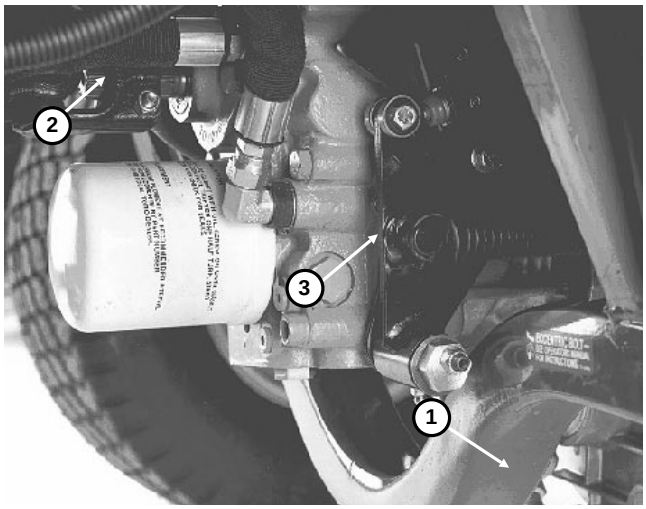


Figure 39

1. Suction line
2. Drive shaft
3. Control linkage assembly

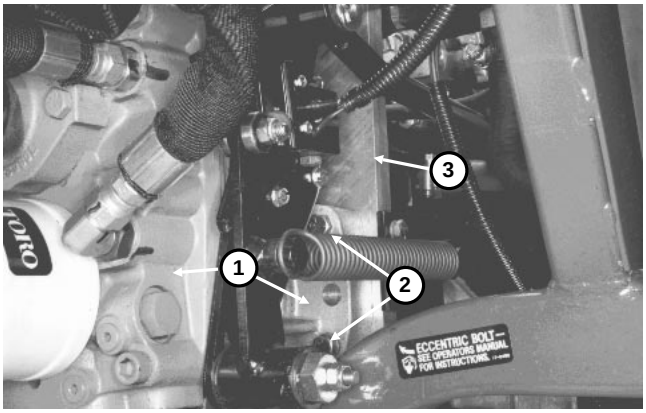


Figure 40

1. Transmission
2. Cap screws and locknuts (4)
3. Support plate

Disassembly of Transmission

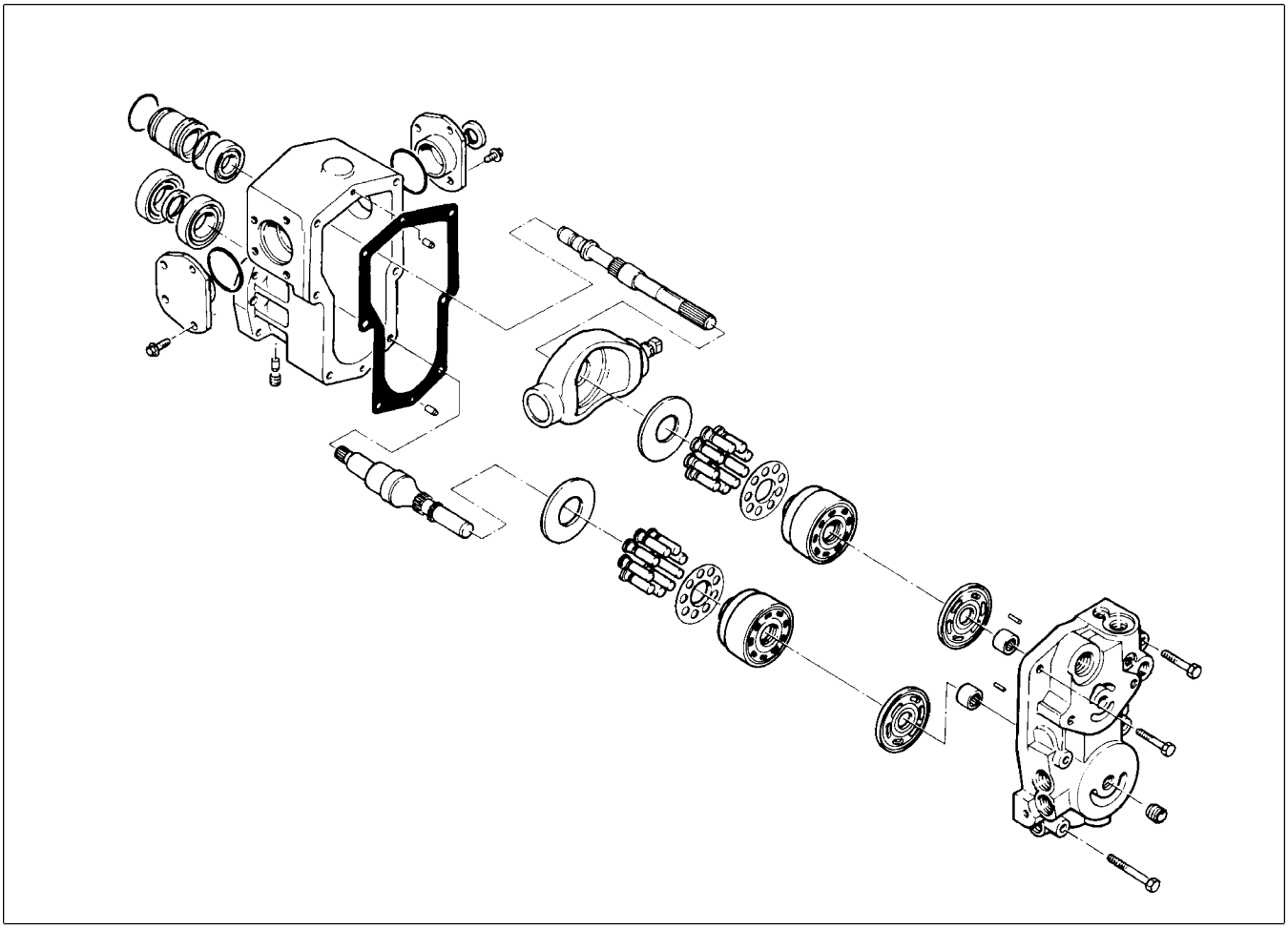


Figure 41

The procedures on the following pages are for the complete disassembly and reassembly of the transmission.

Cleanliness is a primary means of assuring satisfactory transmission life, on either new or repair units. Cleaning parts by using a clean solvent wash and air drying is usually adequate. As with any precision equipment, all parts must be kept free of foreign materials and chemicals. Protect all sealing surfaces and open cavities from damage and foreign material.

During assembly of the transmission, all surfaces which have relative motion between two parts should be coated with a film of clean hydraulic oil. This will assure that these surfaces will be lubricated during start-up.

It is recommended that all gaskets, o-rings and seals be replaced. Lightly lubricate all o-rings with clean petroleum jelly before assembly. All gasket sealing surfaces must be cleaned before installing new gaskets.

1. Before performing major repairs on the transmission, remove external components as described in previous procedures. These include the following:

Charge Check / High Pressure Relief Valves
Charge Relief Valve
Heat Exchanger Bypass Valve
Filter Bypass Valve
Filter Bypass Reverse Flow Check Valve
Charge Pump

2. Remove six (6) screws which retain center section to housing (Fig. 42). Note position of longer and shorter screws. The cylinder block springs will cause the center section to separate from the housing.

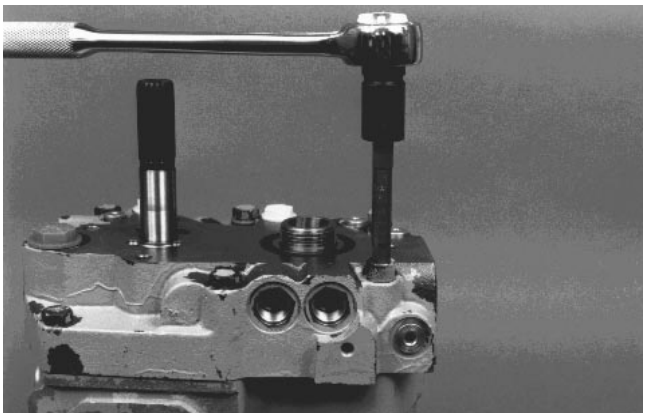


Figure 42

3. Remove center section from housing (Fig. 43).

IMPORTANT: The pump and motor cylinder blocks may stick to the valve plates and center section. Be careful to prevent damage to the sealing surfaces.

4. Remove gasket and two (2) alignment pins from housing.

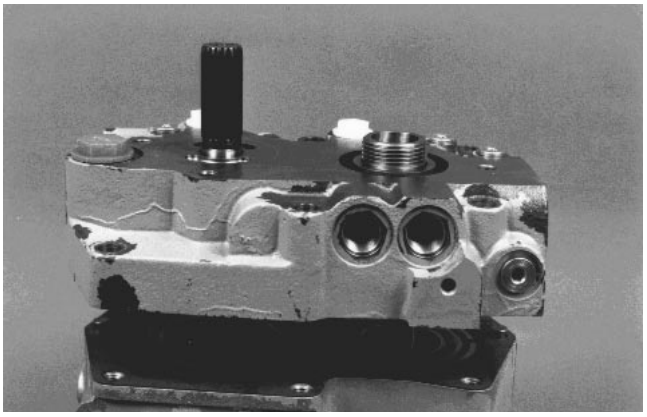


Figure 43

5. Carefully remove valve plates from center section (Fig. 44). It may be necessary to pry valve plates off with a small screwdriver.

IMPORTANT: Be careful not to damage valve plate and center section surfaces.

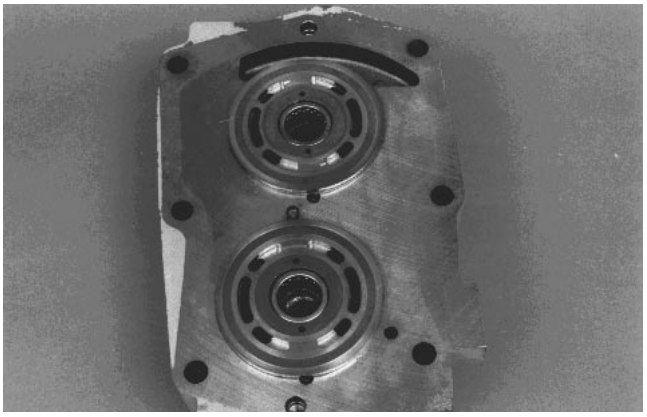


Figure 44

6. Remove valve plate pins from center section (Fig. 45).

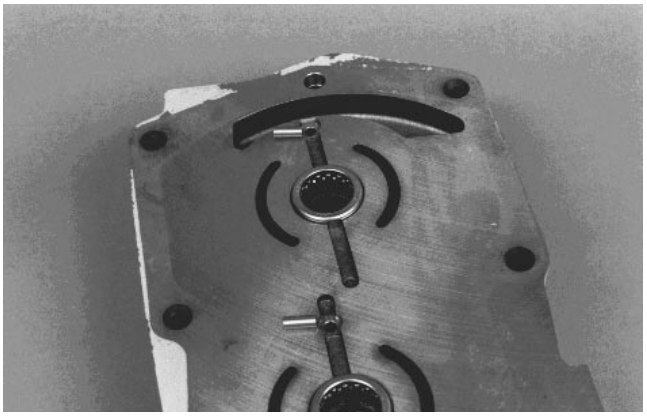


Figure 45

7. Lay transmission on its side and remove motor cylinder block assembly from the housing. Remove pump cylinder block assembly from pump shaft (Fig. 46).

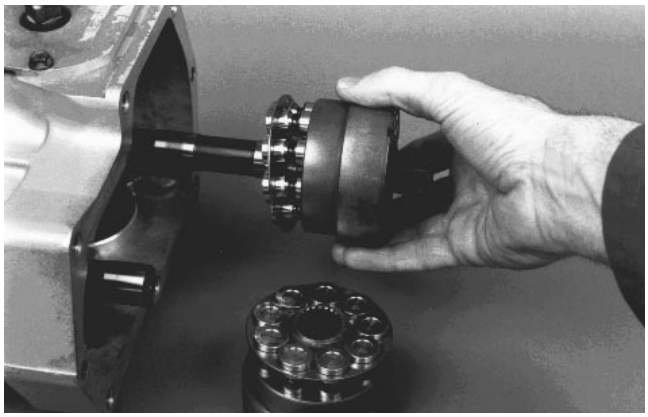


Figure 46

8. Remove the slipper guide and piston assemblies from cylinder blocks (Fig. 47).

NOTE: Pump and motor cylinder block assemblies are identical. To avoid mixing wear patterns, do not mix parts between pump and motor cylinder block assemblies.

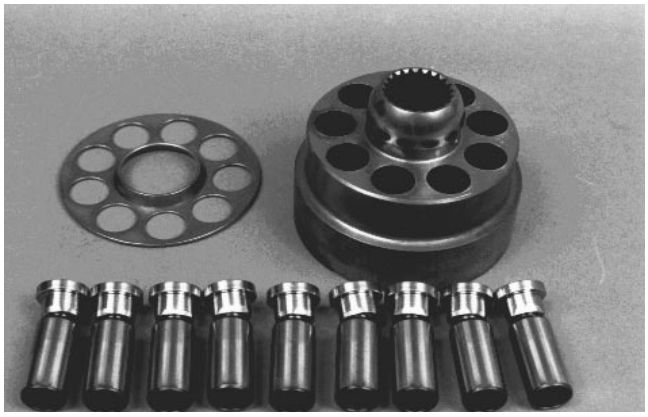


Figure 47

9. Use an o-ring pick or wire to remove thrust plates from swashplate and housing (Fig. 48).

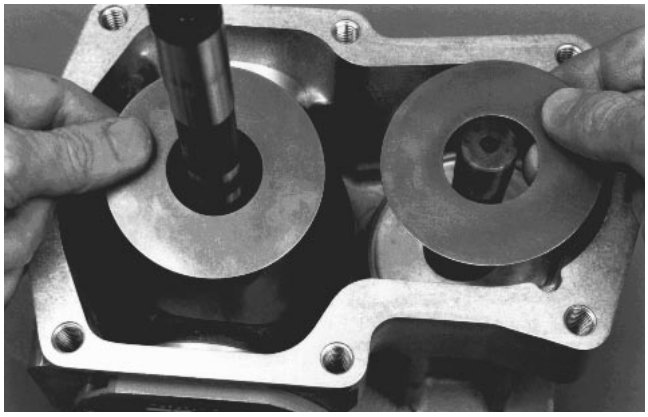


Figure 48

10. Use an internal hex wrench to remove pipe plug over motor shaft bearing retaining pin (Fig. 49).

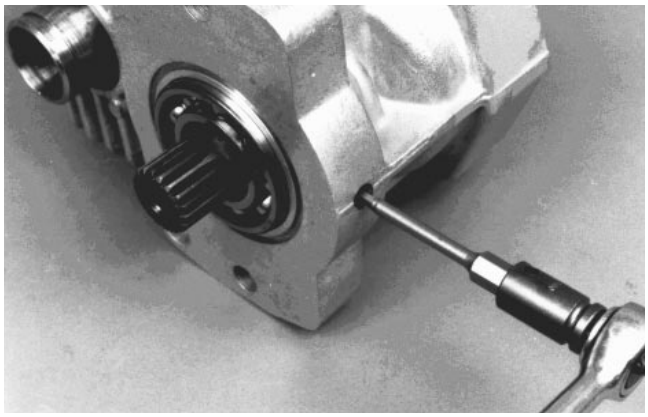


Figure 49

11. Use an 8-32 machine screw to remove motor shaft bearing retaining pin from housing (Fig. 50).

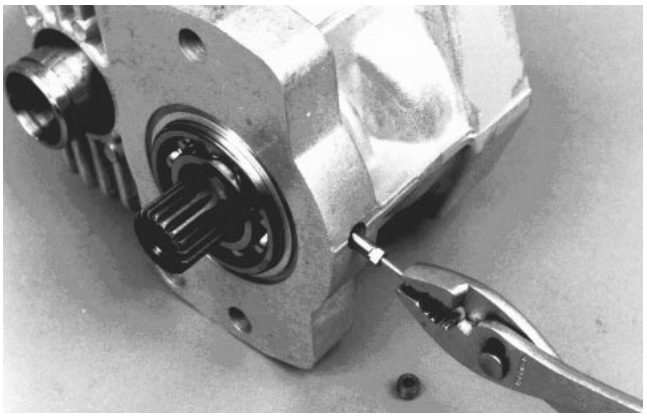


Figure 50

12. Remove motor shaft from housing (Fig. 51).

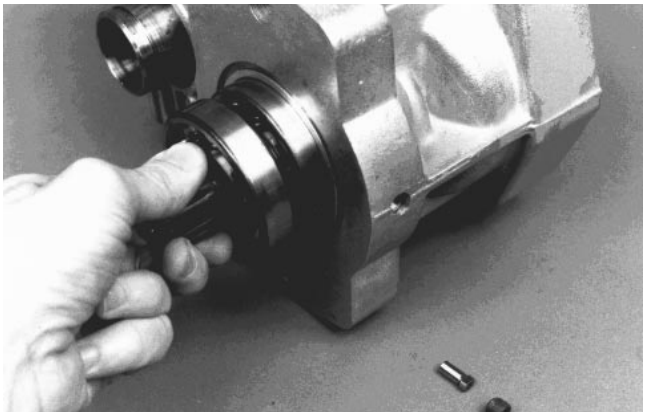


Figure 51

13. Press motor shaft out of bearings and spacer (Fig. 52).

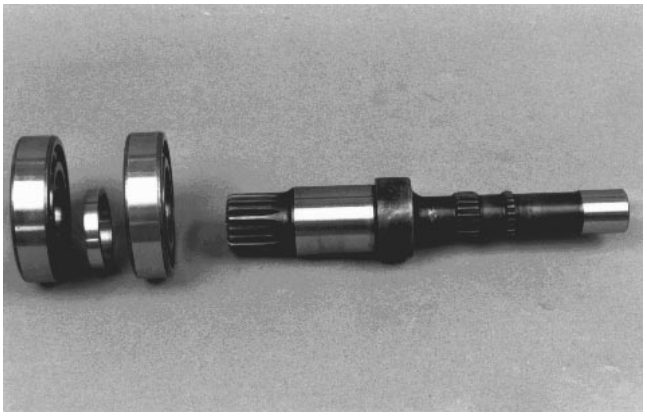


Figure 52

14. Remove spiral retaining ring and remove PTO seal guide (with o-ring) from the housing (Fig. 53).

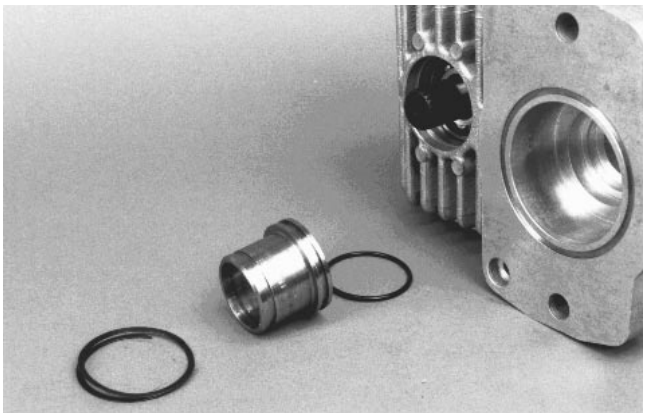


Figure 53

15. Slide pump shaft and bearing assembly from housing. Press shaft out of bearing (Fig. 54).

16. Remove hex tapping screws retaining trunnion seal cover and trunnion cover to housing (Fig. 55). Mark position of covers for reassembly. The trunnion seal cover assembly includes an o-ring, lip seal and trunnion bearing on the control side. The trunnion cover assembly includes an o-ring and trunnion bearing on the side opposite the control. Remove these parts from the housing.

17. Tilt and lift swashplate from housing (Fig. 56).

Inspection and Replacement of Parts

After disassembly, thoroughly clean all parts in a suitable solvent. Replace all o-rings, gaskets and seals.

Inspect all parts for damage, nicks or unusual wear patterns. Replace all parts having unusual or excessive wear or discoloration.

If scratches, which can be felt with a pencil lead, can be found on bronze surface of valve plates or running surface of cylinder blocks, polish or replace the parts.

Inspect needle bearings in center section. If replacement is necessary, remove shaft needle bearings using a suitable puller. Do not damage valve plate surface of center section.

Press new needle bearings into center section using a suitable press pin. When installed correctly, bearing cage will protrude from 0.09 to 0.11 in. from surface of center section to serve as pilots for valve plates (Fig. 57).

IMPORTANT: When installing the needle bearing, the printed (numbered) end of the bearing cage must face the press pin.

Install a new cylinder block kit if brass slippers on pistons are scored or excessively rounded at edges.

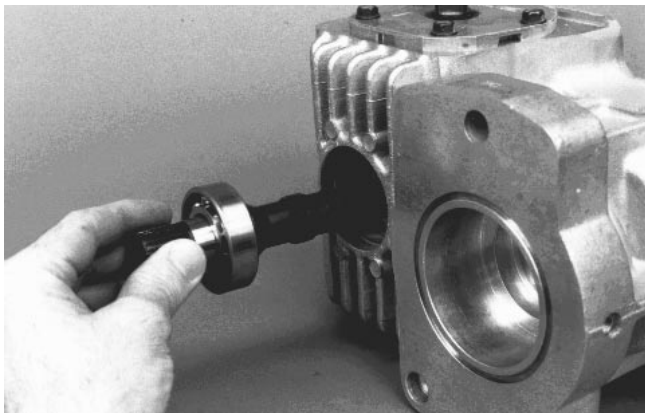


Figure 54

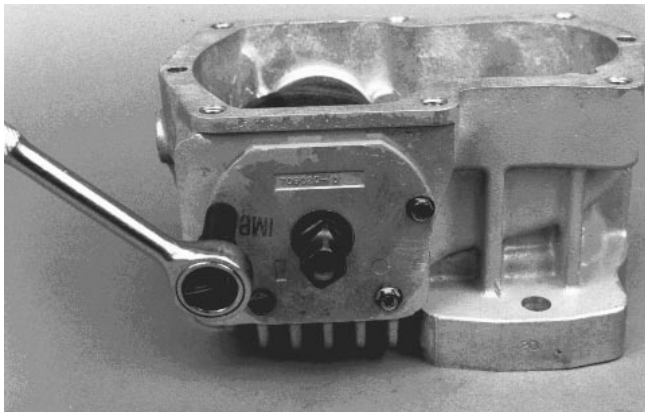


Figure 55

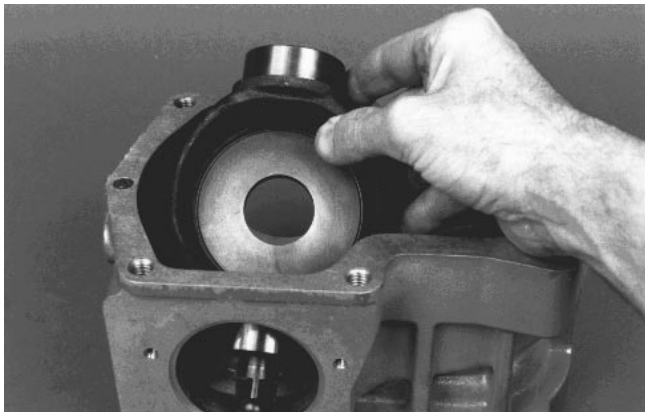


Figure 56

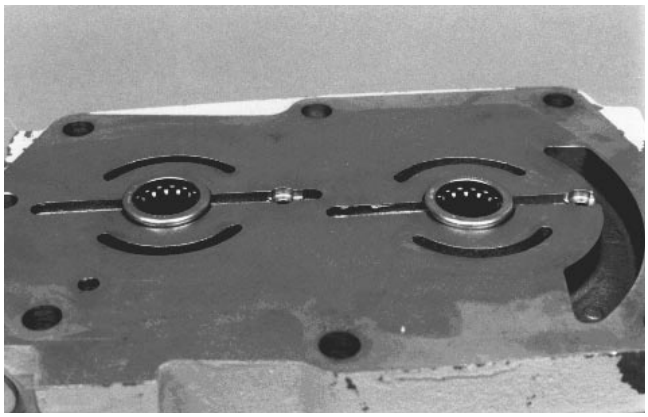


Figure 57

Assembly of Transmission

1. Clean and lightly oil parts before assembly. Tighten all threaded parts to recommended torque value.

IMPORTANT: Most parts have critical, high tolerance surfaces. Use caution to prevent damage to these surfaces during assembly. Protect exposed surfaces, openings and ports from damage and foreign material.

2. Install swashplate into housing (Fig. 58). Make sure swashplate control shaft is located on correct side of housing (note marks made during disassembly).

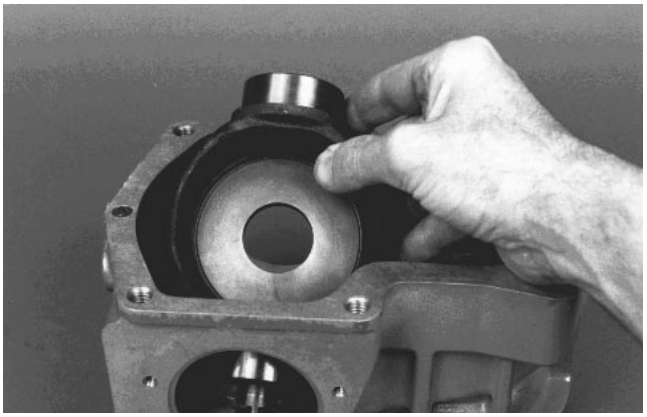


Figure 58

3. Install trunnion cover (with o-ring and trunnion bearing) into housing and over swashplate trunnion (Fig. 59).

NOTE: The trunnion bearings are pressed into the cover assemblies so the split in each bearing will be located closest to the center section.

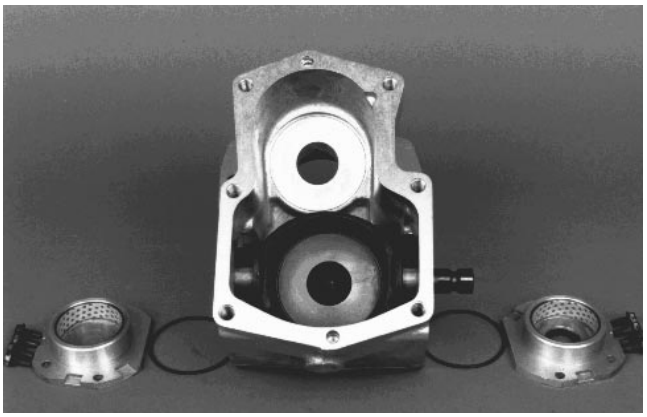


Figure 59

4. Use an arbor press to press a new seal into trunnion seal cover. Outer face of seal should be pressed flush with outer surface of seal cover. Be careful not to damage the seal.

5. Install trunnion seal cover with o-ring, seal and trunnion bearing into housing and over swashplate trunnion (see Trunnion Seal Replacement). Wrap end of swashplate control shaft with thin plastic to prevent damage to seal lip during installation (Fig. 60).

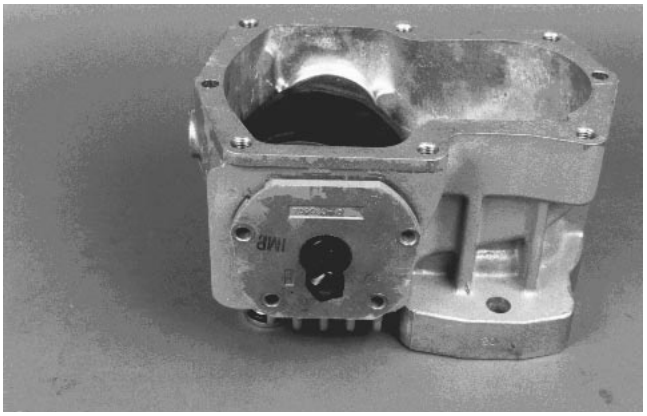


Figure 60

6. Install hex tapping screws and tighten to a torque of 6 to 9 ft-lb (Fig. 61).

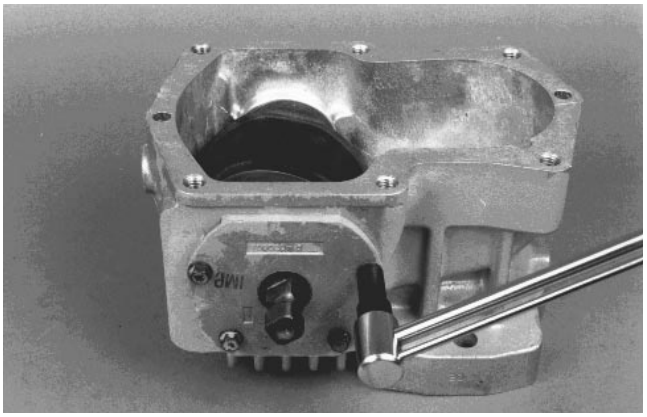


Figure 61

7. Press ball bearing onto pump shaft. Install pump shaft and bearing assembly into housing (Fig. 62).

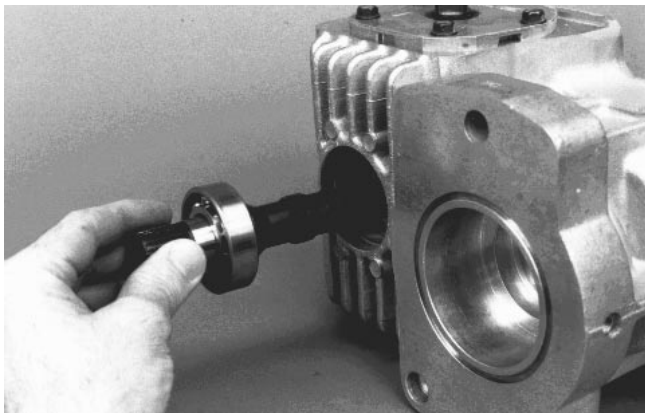


Figure 62

8. Install PTO seal guide and o-ring into housing. Install spiral retaining ring (Fig. 63).

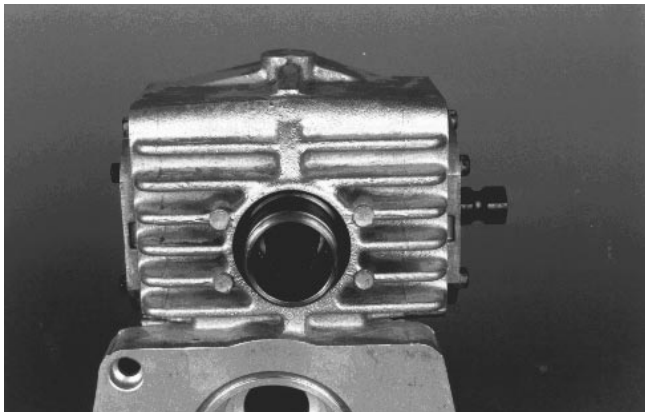


Figure 63

9. Press inner bearing, spacer and outer bearing onto motor shaft (Fig. 64).

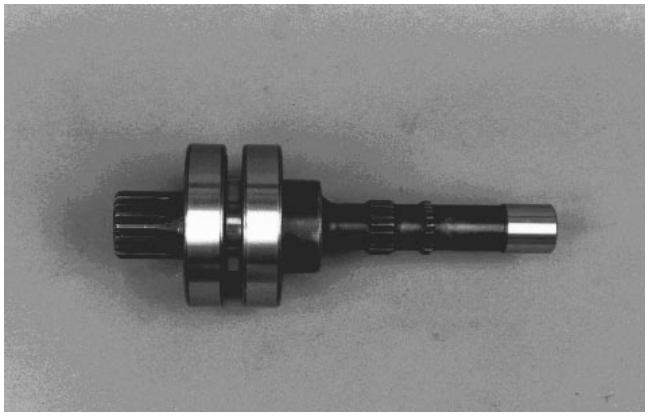


Figure 64

10. Install motor shaft assembly into housing (Fig. 65).

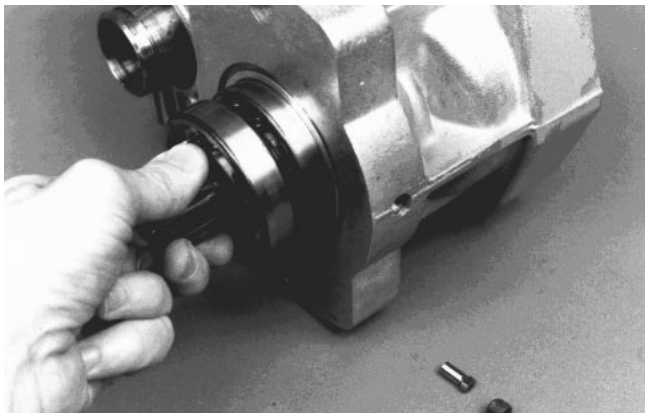


Figure 65

11. Install motor shaft bearing retaining pin into housing (Fig. 66).

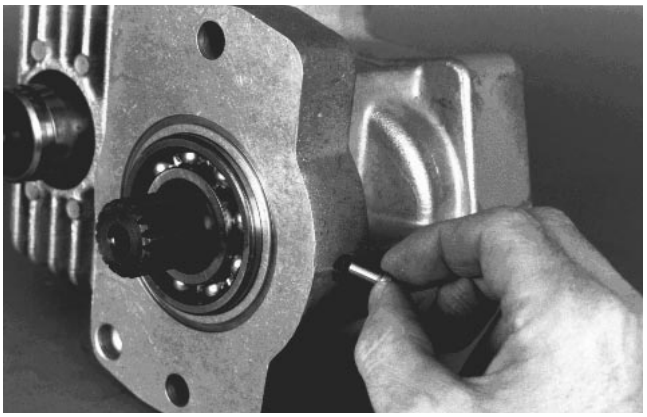


Figure 66

12. Install pipe plug over motor shaft bearing retaining pin and tighten to a torque of 6 to 9 ft-lb (Fig. 67).

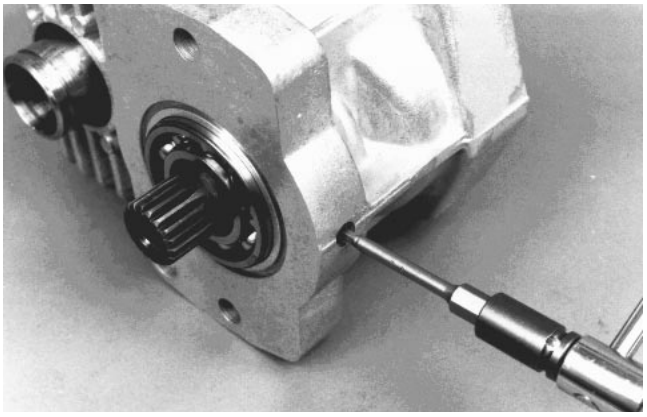


Figure 67

13. Coat thrust plates with petroleum jelly and install into housing and swashplate (Fig. 68). The thrust plates are reversible.

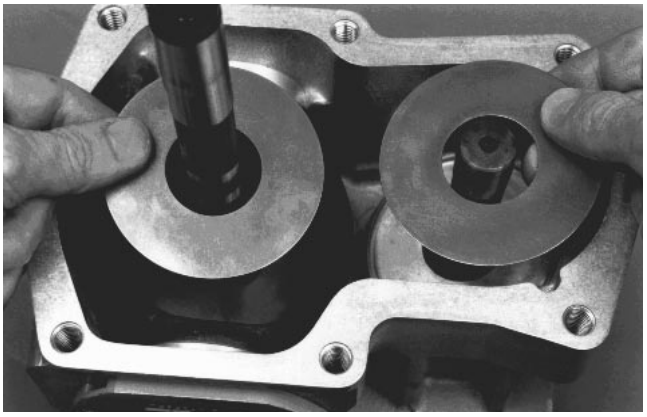


Figure 68

14. Assemble each cylinder block kit by installing piston assemblies into the slipper guide. Lubricate pistons and cylinder block bores. Install assembled guide and pistons into cylinder block by inserting pistons into cylinder block bores (Fig. 69). The pistons and bores are not selectively fitted, so no specific piston and bore orientation is required.

Figure 69

15. Lay the transmission on its side and install cylinder block kits into the housing (Fig. 70).

16. Put the transmission housing on a work surface with the center section opening facing up.

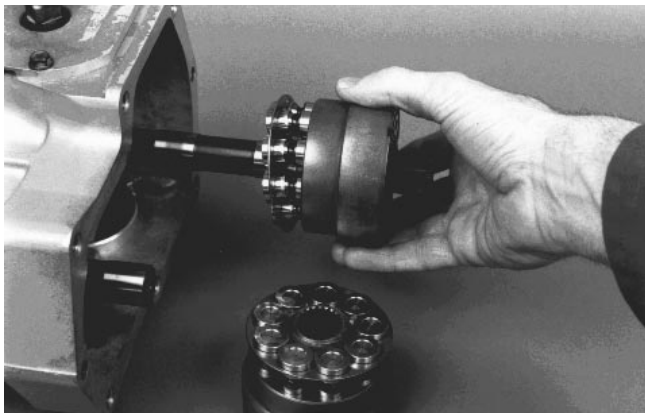


Figure 70

17. Install valve plate locating pins into center section (Fig. 71).

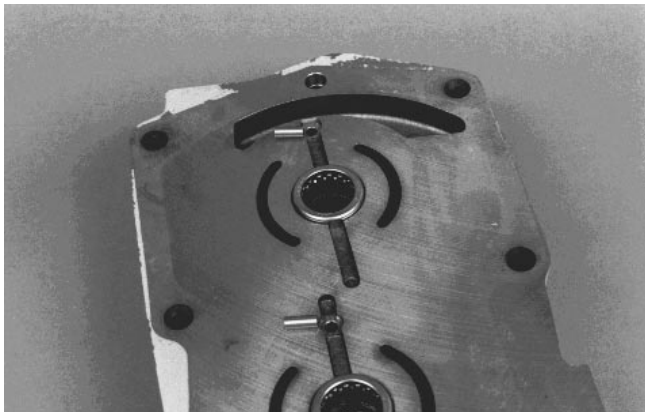


Figure 71

18. Coat back (steel side) of valve plates with petroleum jelly to hold them in position and install valve plates onto center section, with their bronze faces visible (Fig. 72). The notch on each valve plate must engage its locating pin.

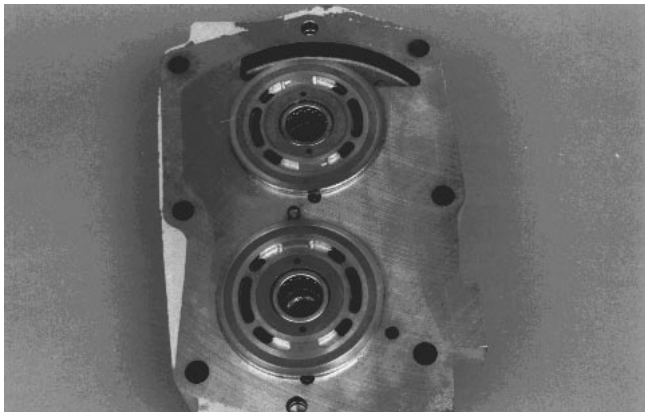


Figure 72

NOTE: Do not interchange pump and motor valve plates when assembling transmission. The pump plate can be identified by the grooves on one side of the ports (Fig. 73). The motor valve plate has no grooves.

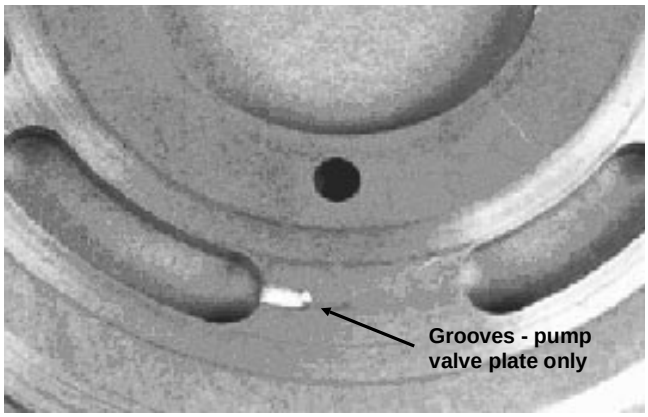


Figure 73

19. Install the two (2) alignment pins and install a new center section gasket onto the housing (Fig. 74).

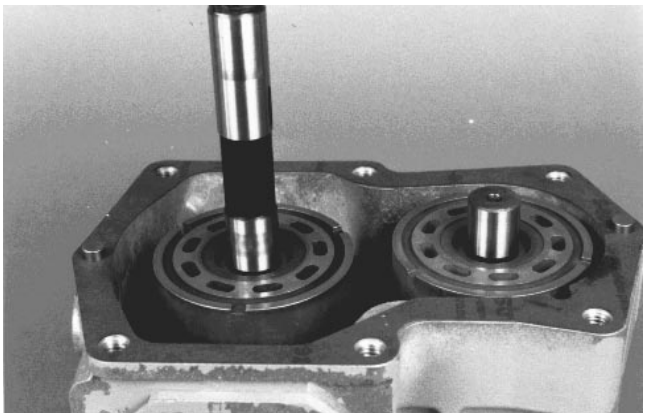


Figure 74

20. Install center section with valve plates onto transmission housing (Fig. 75).

IMPORTANT: Make sure all parts are properly aligned. Do not force center section into position on the housing.

NOTE: When the center section is properly installed, the cylinder block springs will hold the end center section away from the housing approximately 1/8 in.

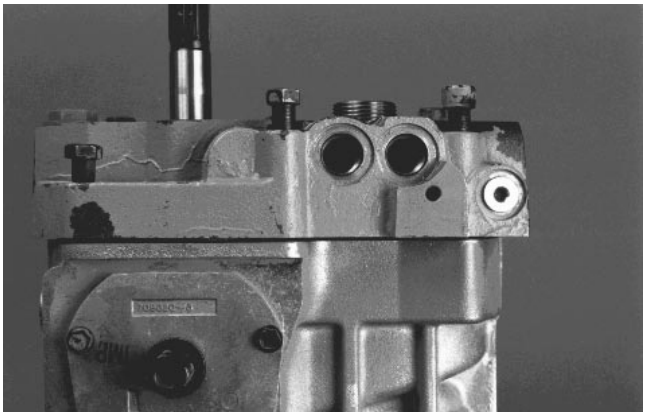


Figure 75

21. Install the six (6) screws that retain the center section to the housing and torque evenly to 33 to 41 ft-lb (Fig. 76).

22. Rotate the pump and motor shafts to make sure transmission is assembled correctly. When properly assembled, a maximum torque of 3.5 ft-lb should be required to turn either shaft.

23. Assemble the following components as described in previous procedures:

Charge Check / High Pressure Relief Valves
Charge Relief Valve
Heat Exchanger Bypass Valve
Filter Bypass Valve
Filter Bypass Reverse Flow Check Valve
Charge Pump

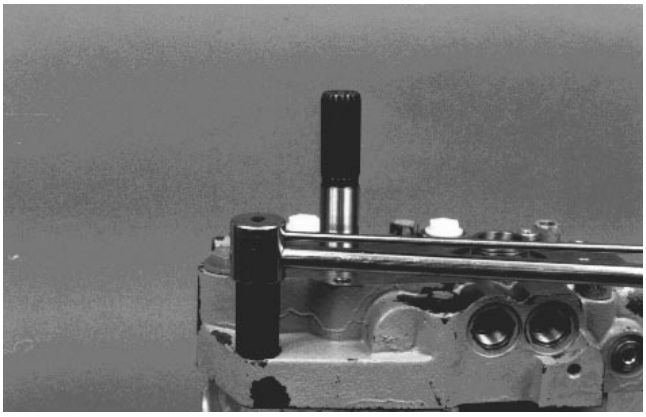


Figure 76

Mowing Circuit Repairs

Valve Block Service

1. Before removing any parts from the valve block, park the machine on a level surface, engage the parking brake, lower the cutting units and stop the engine. Remove key from ignition switch.

2. Raise seat and secure with prop rod to get access to valve block.

NOTE: Ports on valve block are marked for easy identification of components. Example: S1 is front mow circuit solenoid valve and R1 is front mow/lift circuit relief valve. (See Hydraulic Schematic and Hydraulic Flow Diagrams to identify function of hydraulic lines and cartridges at each port location.)

3. If necessary, valve block can be removed:

A. Disconnect solenoid electrical connecters.

B. Disconnect hydraulic lines. Put caps or plugs on disconnected hoses and fittings to prevent contamination.

C. Remove four (4) capscrews from bottom of valve block and lift valve block out of machine.

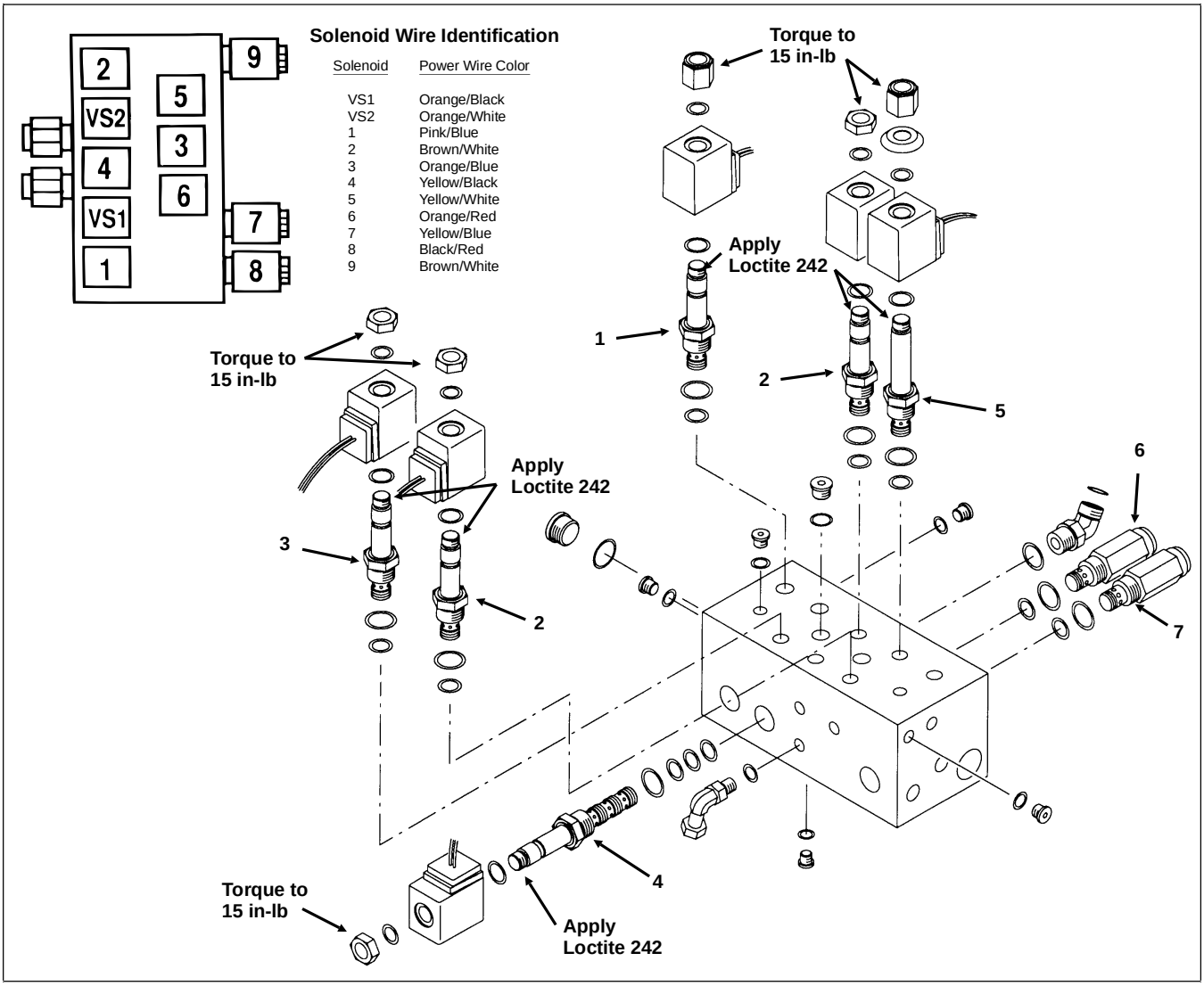


Figure 77

1. Solenoid valve **S1, S2**
2. Solenoid valve **S3, S4, S5**
3. Solenoid **S6**
4. Solenoid **S7, S8, S9**
5. Solenoid **VS1, VS2**
6. Relief Valve **R1**
7. Relief Valve **R2**

Cartridge Valve Service

1. Clean valve block to prevent contamination when valve cartridge is removed.

2. Remove the cartridge valve from its port:

A. Remove nut from solenoid.

B. Remove solenoid coil and O-ring at each end of solenoid coil.

C. Use a deep socket to remove solenoid cartridge valve. NOTE: Use care when handling valve cartridges because slight bending or distortion of stem tube can cause binding and malfunction.

3. Visually inspect port in block for damage to sealing areas, damaged threads or contamination.

4. Visually inspect cartridge for damaged seals and contamination (Fig. 78):

A. O-rings and back-up rings must be arranged properly on the valve for proper operation. Replace any damaged seals.

B. Contamination may cause valves to stick or hang-up. Contamination can become lodged in small valve orifices or seat areas on poppet type valves causing malfunction.

5. Clean and check for proper valve operation:

A. Use clean mineral spirits to clean cartridge valve. Submerge the valve in clean mineral sprits and use a probe to push the internal spool in and out 20 to 30 times to flush out contamination. Mineral spirits does not affect the O-ring material. particles as fine as talcom powder can affect the operation of high pressure hydraulic valves.

Cartridge Installation

1. Lubricate all o-rings with clean hydraulic oil.

2. Carefully thread cartridge into the port by hand. Valve cartridge should go in easily without binding.

3. Use a torque wrench and deep socket to tighten cartridge valves to a torque of 35 ft-lb. Excessive torque may cause the spool to bind and malfunction.

NOTE: Use care when handling solenoid valve cartridges because slight bending or distortion of stem tube can cause binding and malfunction.

4. Install solenoid coil. Make sure there is an O-ring at each end of the coil. Apply “Loctite 242” or equivalent to threads of stem tube before installing nut. Tighten nut securing solenoid coil nut to a torque of 15 in-lb.

5. If problem still exists, remove valve again and replace with a new valve.

Figure 78

Cartridge Valve Identification

NOTE: When troubleshooting hydraulic problems, keep in mind that is possible for some cartridge valves to be installed in the wrong ports, causing the system to malfunction.

Solenoid valves in valve block must not be interchanged between ports, **with the following exceptions**:

S1 and S2 are the same design and can be interchanged (Fig. 79).

S3, S4 and S5 are the same design and can be interchanged (Fig. 80).

S7, S8 and S9 are the same design and can be interchanged (Fig. 82).

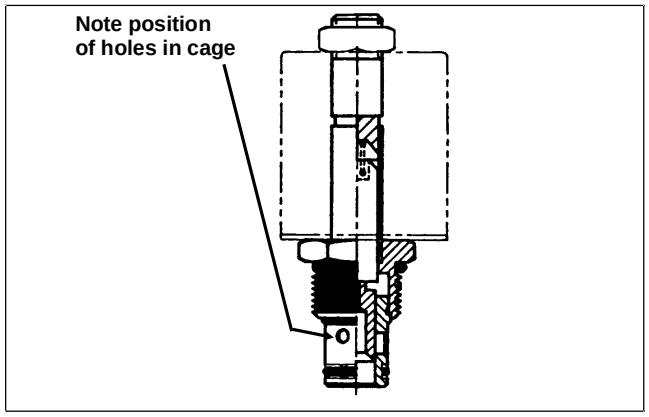


Figure 79

Solenoid valves S1 and S2
2 way spool valve – normally open

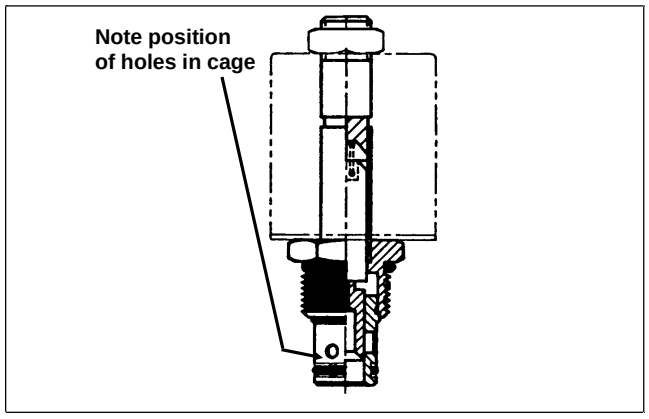


Figure 80

Solenoid valves S3, S4 and S5
2 way spool valve – normally closed

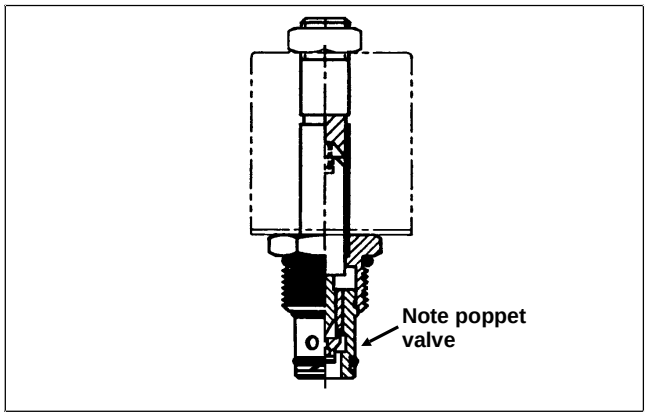


Figure 81

Solenoid valve S6
2 way pilot operated poppet valve – normally closed

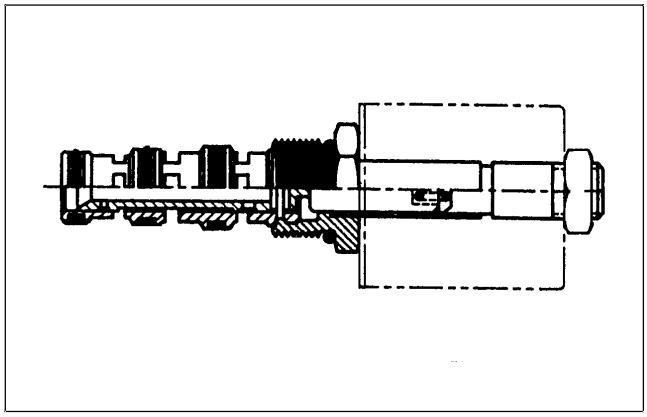


Figure 82

Solenoid valve S7, S8 and S9
4 way 2 position spool valve

Relief valves in the valve block cannot be interchanged between ports R1 and R2 because they have different internal parts and pressure settings (Fig. 84).

Figure 84

Relief valves

R1 – 3000 PSI
R2 – 2000 PSI

Flow control cartridges are the same and can be interchanged between ports VS1 and VS2 (Fig. 85).

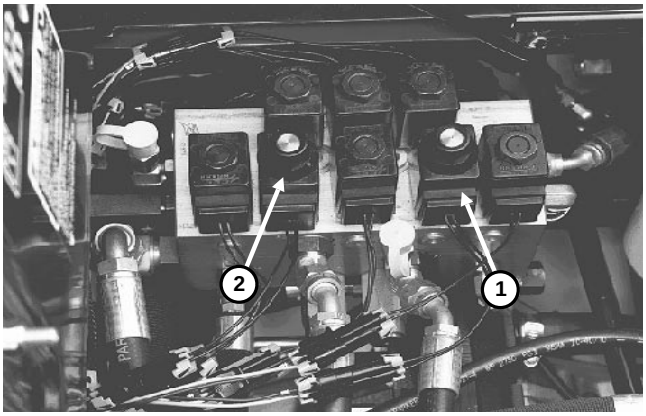


Figure 85

Flow control solenoid valves

1. **VS1**
2. **VS2**

Pump Removal and Installation

Removal

1. Park machine on a level surface, lower cutting units, engage parking brake and stop the engine. Remove key from ignition switch.

2. Raise seat and secure with prop rod to get access to pump (Fig. 91, 92).

3. Drain the hydraulic reservoir.

4. To prevent contamination of hydraulic system during removal, thoroughly clean exterior of pump and fittings.

5. Disconnect hydraulic lines from pump and put caps or plugs on open hydraulic lines and fittings. Label disconnected hydraulic lines for proper reassembly.

6. Remove two (2) capscrews and washers securing pump to support plate. Remove pump, transmission coupling, and pump sleeve.

Installation

1. Lubricate a new o-ring with clean hydraulic oil and install on pump (Fig. 92).

2. Install Pump sleeve on transmission output shaft.

3. Install transmission coupling on pump shaft and install pump on to transmission adapter. Secure pump and transmission adapter to support plate with two (2) capscrews and lock washers.

4. Replace hydraulic filter and fill hydraulic reservoir with new hydraulic oil.

5. Disconnect fuel stop solenoid electrical connector on engine to prevent engine from starting. Prime the hydraulic pump by turning the ignition key switch to crank the engine for 10 seconds. Repeat cranking procedure again.

6. Connect fuel stop solenoid electrical connector, start the engine and check for proper operation.

7. Stop the engine and check for hydraulic oil leaks. Check hydraulic reservoir oil level.

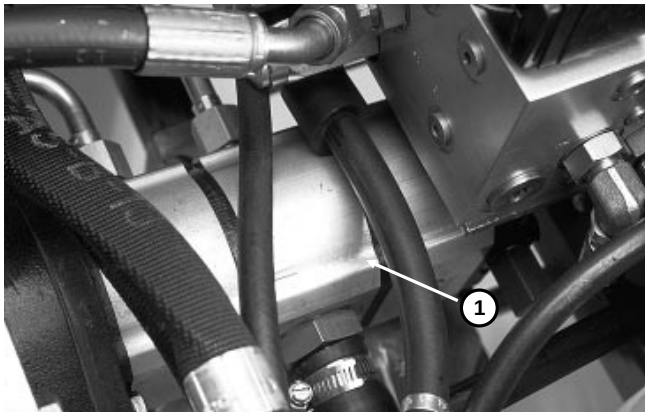


Figure 91

1. Pump

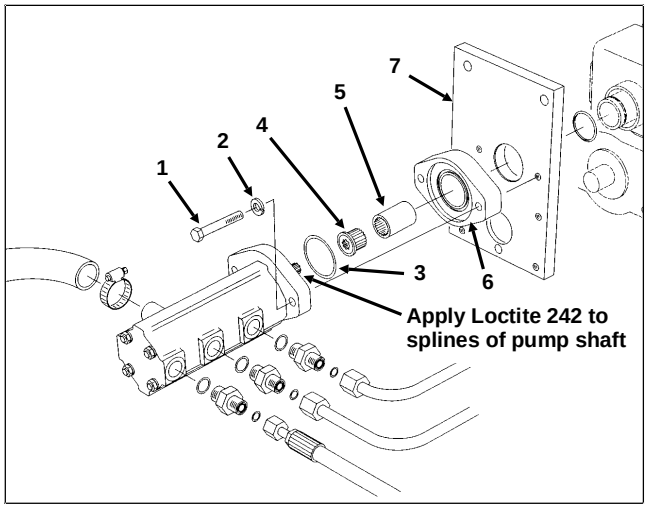


Figure 92

1. Capscrew
2. Lockwasher
3. O-ring seal
4. Transmission coupling
5. Pump sleeve
6. Transmission adapter
7. Support plate

Pump Repair

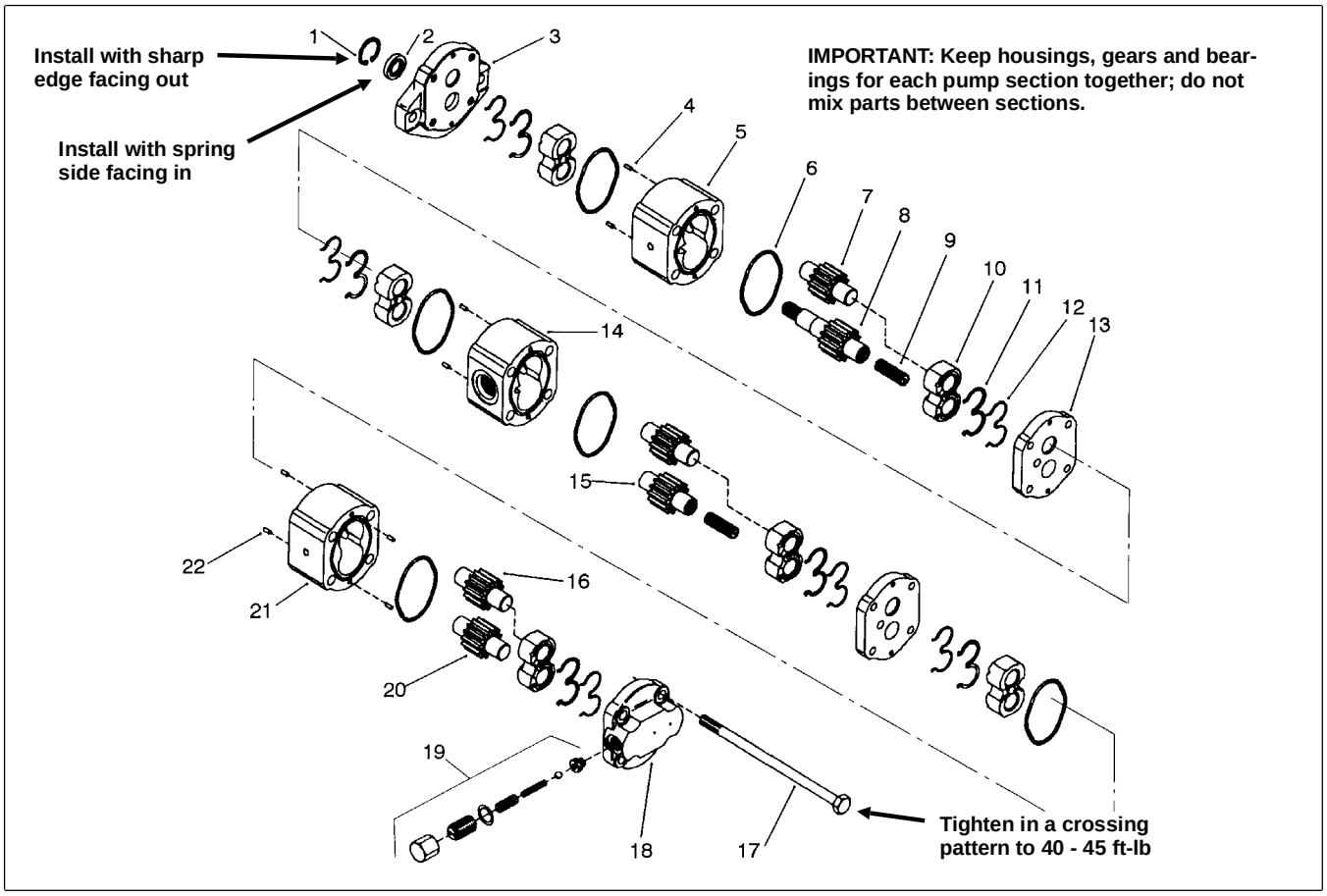


Figure 93

1. Retaining ring
2. Shaft seal
3. Flange
4. Dowel pin
5. Housing
6. O-ring
7. Idler gear
8. Drive gear
9. Coupling
10. Bearing
11. E-seal
12. Backup ring
13. Distance plate
14. Housing
15. Idler gear
16. Idler gear
17. Bolt
18. Valve block
19. Valve kit
20. Idler gear
21. Housing
22. Dowel pin

Relief Valve Service

NOTE: The relief valve (Item 19) must be replaced as a complete assembly. Disassemble parts for cleaning and inspection only.

1. Disassemble the relief valve parts. DO NOT attempt to remove the valve seat. It is installed with thread locking compound at the factory. Count the number of revolutions it takes to unscrew the relief valve adjusting screw so it can be installed at the same pressure setting.

2. Inspect ball for burrs or roughness. Inspect relief valve bore and seat in valve block.

3. Inspect spring for damage.

4. Clean and air dry all parts. Apply hydraulic oil to parts and install in the same order they were removed.

5. Before operating the machine, check steering relief pressure and adjust to 1250 psi. To adjust, remove cap, turn adjuster clockwise to increase pressure and counterclockwise to decrease pressure. (See Steering Valve and Steering Pump Test in Chapter 7 - Steering and Brakes.)

Shaft Seal Replacement

1. Remove pump (see Pump Removal and Installation).

2. Plug ports and wash exterior of pump with cleaning solvent. Make sure parts and work area are clean.

3. Remove retaining ring (Fig. 93, Item 1).

4. Remove and dispose of the seal.

NOTE: Seal can be removed by punching two holes in face of seal 180° apart, installing metal screws and pulling seal out by grasping the screws.

IMPORTANT: Do not try to pry the seal out of the pump. This usually damages the shaft seal bore and mounting hub area so oil will leak past the seal.

5. Clean seal bore and shaft on pump so it is free of any foreign material.

6. Put a seal protector tool on pump shaft or apply thin plastic or tape on the shaft to protect the seal from damage.

7. Apply grease or petroleum jelly to inside diameter of new shaft seal.

8. Use a seal installation tool to install new shaft seal. Install seal with spring side facing in. Make sure seal is installed square with the seal bore.

9. Install retaining ring with sharp edge facing OUT.

Pump Service

NOTE: Parts within each pump section must be replaced as a kit. Gears, housings and bearings cannot be serviced separately.

IMPORTANT: The pump is "run-in" at the factory to obtain precise parts tolerances. Keep housing, gears and bearings for each section together. DO NOT mix parts between different sections.

1. Plug ports and wash exterior of pump with cleaning solvent.

2. Draw a line across seam areas on pump case with a scribe or marker to ensure proper reassembly.

IMPORTANT: Use caution when clamping in a vise to avoid distorting any parts.

3. Secure the flange end of the pump (Fig. 93, Item 3) in a vise with the drive shaft pointing down.

4. Remove the four (4) bolts.

5. Put your hand on the pump case and gently tap the pump case with a soft face hammer to loosen the pump sections. Be careful not to drop parts or disengage gear mesh.

6. Remove the bearings and seals from each pump section. Before removing each gear set, apply marking dye to mating teeth to retain "timing". Pump efficiency may be affected if the teeth are not installed in the same position during reassembly. Keep the parts for each pump section together; do not mix parts between sections.

7. Remove the retaining ring (Item 1) and shaft seal (Item 2).

8. Clean all parts. Check all parts for burrs, scoring, nicks and other damage.

9. Replace pump section if parts are excessively worn or scored.

10. Apply clean hydraulic oil to all parts before assembling.

11. Assemble pump sections starting at flange end. Apply grease or petroleum jelly to new O-rings (Item 6) to hold them in position during assembly of pump.

12. After pump has been assembled, tighten capscrews by hand. Rotate the drive shaft to check for binding. Protect the shaft if using a pliers.

13. Tighten the capscrews evenly in a crossing pattern to a torque of 40 - 45 ft-lb.

14. Install shaft seal (see Shaft Seal Replacement).

Reel Motor Removal and Installation

1. Disconnect hydraulic lines. Put caps or plugs on fittings and hoses to prevent contamination. Tag hydraulic lines for proper reassembly.

2. Loosen motor mount nuts (Fig. 94).

3. Rotate motor clockwise so motor flanges clear studs and pull motor out.

4. Reverse steps 1 - 3 to reinstall motor.

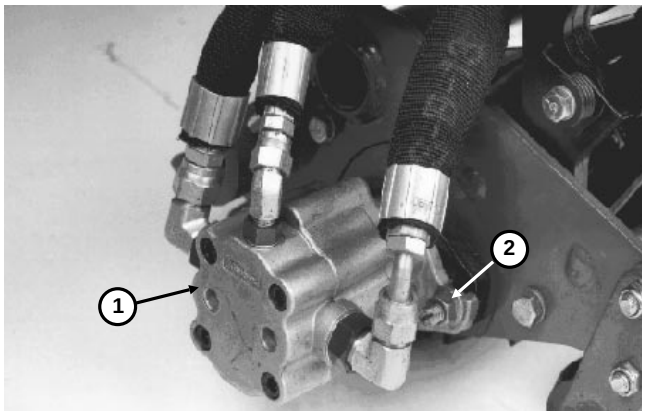


Figure 94

1. Motor **2. Motor mount nuts**

Reel Motor Shaft Seal Replacement

1. Remove reel motor (see Reel Motor Removal and Installation).

2. Plug ports and wash exterior of motor with cleaning solvent. Make sure parts and work area are clean.

3. Remove snap ring from motor (Fig. 95).

4. Install threaded metal o-ring seal plugs in the two (2) pressure ports on the motor or put metal threaded caps on the fittings in these ports.

5. With motor shaft pointed away from you into a clean five (5) gallon container, attach a hydraulic load (hand pump) or compressed air to the case drain port.

6. With the motor shaft pointed away from you into a clean five (5) gallon container, gradually apply pressure to the case drain port. The seal should come out of the motor seal cavity.

NOTE: Seal may also be removed by punching two holes in face of seal 180^{o} apart, installing metal screws and pulling seal out by grasping the screws.

IMPORTANT: Do not try to pry the seal out of the motor. This usually damages the shaft seal bore and mounting hub area so oil will leak past the seal.

7. Remove and discard shaft seal and spacer.

8. Clean seal bore and shaft on motor so it is free of any foreign material.

9. Install a new spacer on motor shaft.

10. Put seal protector tool on motor shaft (Fig. 90) or apply thin plastic or tape on the shaft to protect the seal from damage.

11. Apply “Permatex No. 2” or equivalent to outside diameter of new seal.

12. Apply grease or petroleum jelly to inside diameter of new shaft seal.

13. Use seal installation tool to install new shaft seal. Make sure seal is installed square with the seal bore.

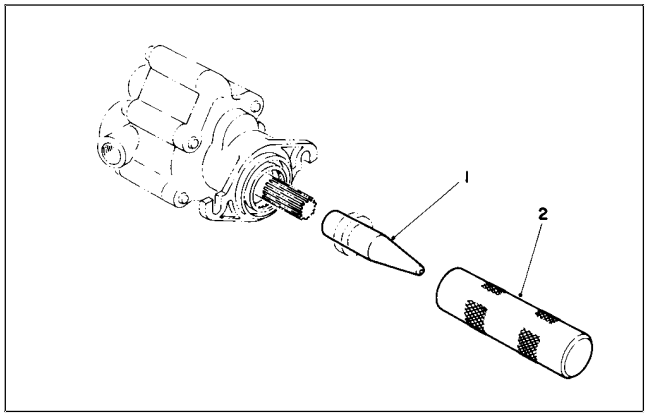


Figure 95

1. Seal protector
2. Seal installation tool

Reel Motor Repair

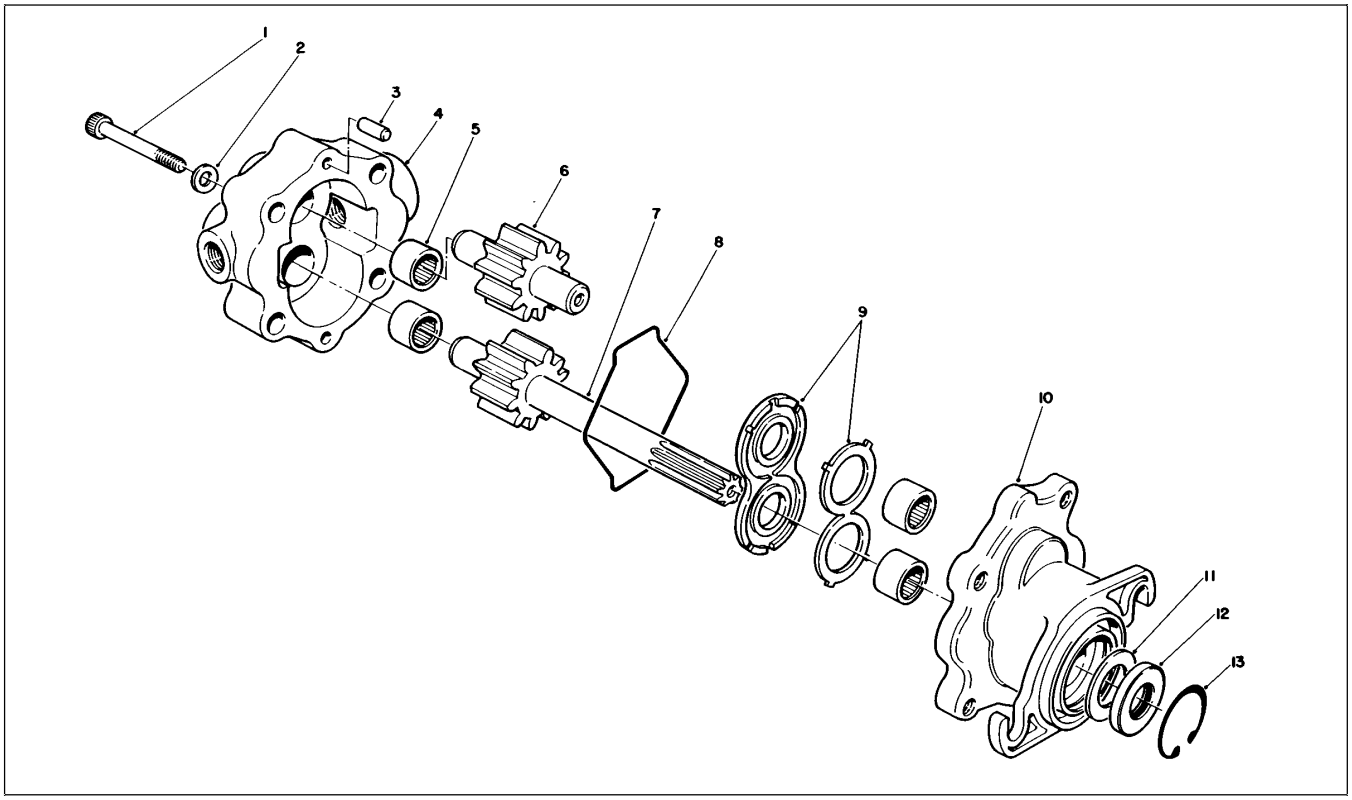


Figure 96

1. Socket head screw (2)
2. Washer (2)
3. Dowel pin (2)
4. Cover
5. Needle bearing
6. Idler gear assembly
7. Drive shaft assembly
8. Ring seal
9. Load plate assembly
10. Body
11. Spacer
12. Shaft seal
13. Retaining ring

1. Plug ports and wash exterior of motor with cleaning solvent. Make sure parts and work area are clean.

IMPORTANT: Extreme caution must be used when using a vise to avoid distorting any parts.

2. Draw a line across the seam areas on the motor case with a scribe or marker to ensure proper reassembly.

3. Remove four socket head capscrews (Fig. 96).

4. Put your hand on the cover assembly and gently tap the drive shaft with a soft face hammer to separate the body from the cover. Be careful not to drop parts or disengage gear mesh.

5. Before removing gear set, apply marking dye to mating teeth to retain “timing”. Pump efficiency may be affected if the teeth are not installed in the same position during reassembly.

IMPORTANT: To prevent damage to load plates during motor operation, do not mark gears with a punch or scribe.

6. Be careful when disassembling. The needle bearings may be of the loose grease retained type. Pack these with general purpose grease to retain them for reassembly. It is recommended NOT to remove the bearing races from the cover and body.

7. Remove and discard the ring seal, snap ring, shaft seal, and spacer (Items 8, 11, 12 and 13). These items are available in a repair kit.

8. Clean and air dry all parts. Check for burrs, scoring, nicks, etc.

9. Replace gears as a set if excessively scored or worn. Replace load plate if worn or scored.

10. Apply grease or petroleum jelly to load plate assembly and install in body. Insert gear set into body, maintaining the original timing and locations.

11. Apply grease or petroleum jelly to ring seal and install on body.

12. Apply hydraulic oil to inside of cover and assemble the cover to the body, making sure none of the parts

become displaced. Insert the capscrews and washers and hand tighten.

13. Before tightening the capscrews, rotate the drive shaft in the direction of normal rotation (counterclockwise) to check for binding. You may not be able to rotate the drive shaft by hand. Protect the shaft if using a pliers.

14. Tighten the capscrews evenly in a crossing pattern to a torque of 17 ft-lb.

15. Carefully install a new spacer, shaft seal and snap ring. (Perform steps 8 - 13 under Reel Motor Shaft Seal Replacement in this section of the book).

Lift Cylinder Removal and Installation

1. Put machine on a level surface, lower the cutting units, stop the engine, engage the parking brakes and remove key from ignition switch.

2. To prevent contamination of hydraulic system during removal, thoroughly clean exterior of cylinder and fittings.

3. Disconnect hydraulic lines from cylinder and put caps or plugs on open hydraulic lines and fittings. Label disconnected hydraulic lines for proper reassembly.

4. Remove retaining ring and thrust washer from one side of cylinder pin on each end of cylinder.

5. Remove cylinder pin from each end of cylinder and remove cylinder.

6. Reverse steps 3 - 5 to install cylinder.

Lift Cylinder Repair

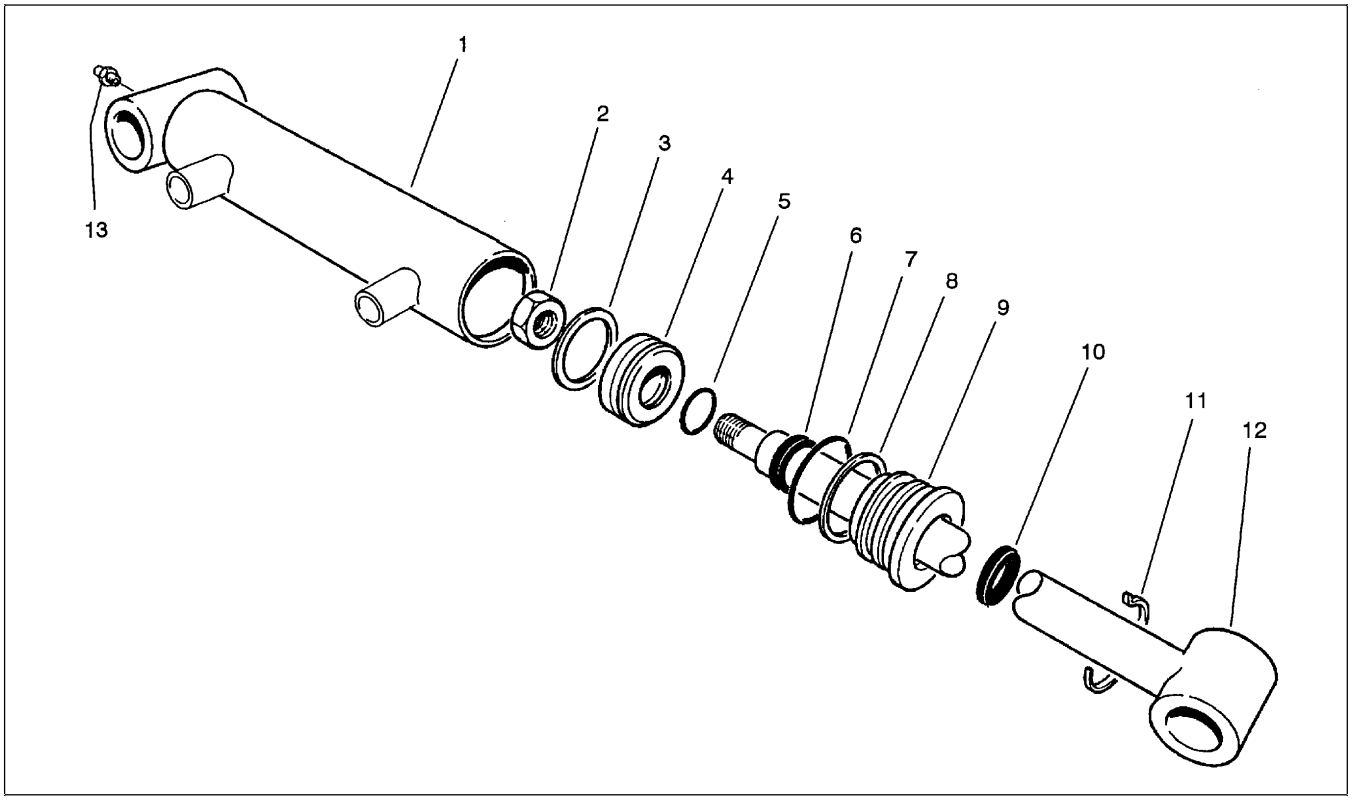


Figure 98

1. Barrel
2. Nut
3. Uni-ring seal
4. Piston
5. O-ring seal
6. Rod seal
7. O-ring seal
8. Back-up ring
9. Head
10. Dust seal
11. Retaining ring
12. Rod

IMPORTANT: To prevent damage when clamping the cylinder barrel in a vise, clamp only on the pivot end. Do not clamp the vise jaws against the smooth shaft surface. Protect the shaft surface before mounting in the vise.

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 wash the outside of the cylinder with cleaning solvent.

3. Mount the cylinder in a vise so the shaft end of the cylinder is tilted up slightly. Do not close the vise so firmly that the barrel could become distorted.

4. Use a spanner wrench to rotate the head and remove the retaining ring (Fig. 99).

Figure 99

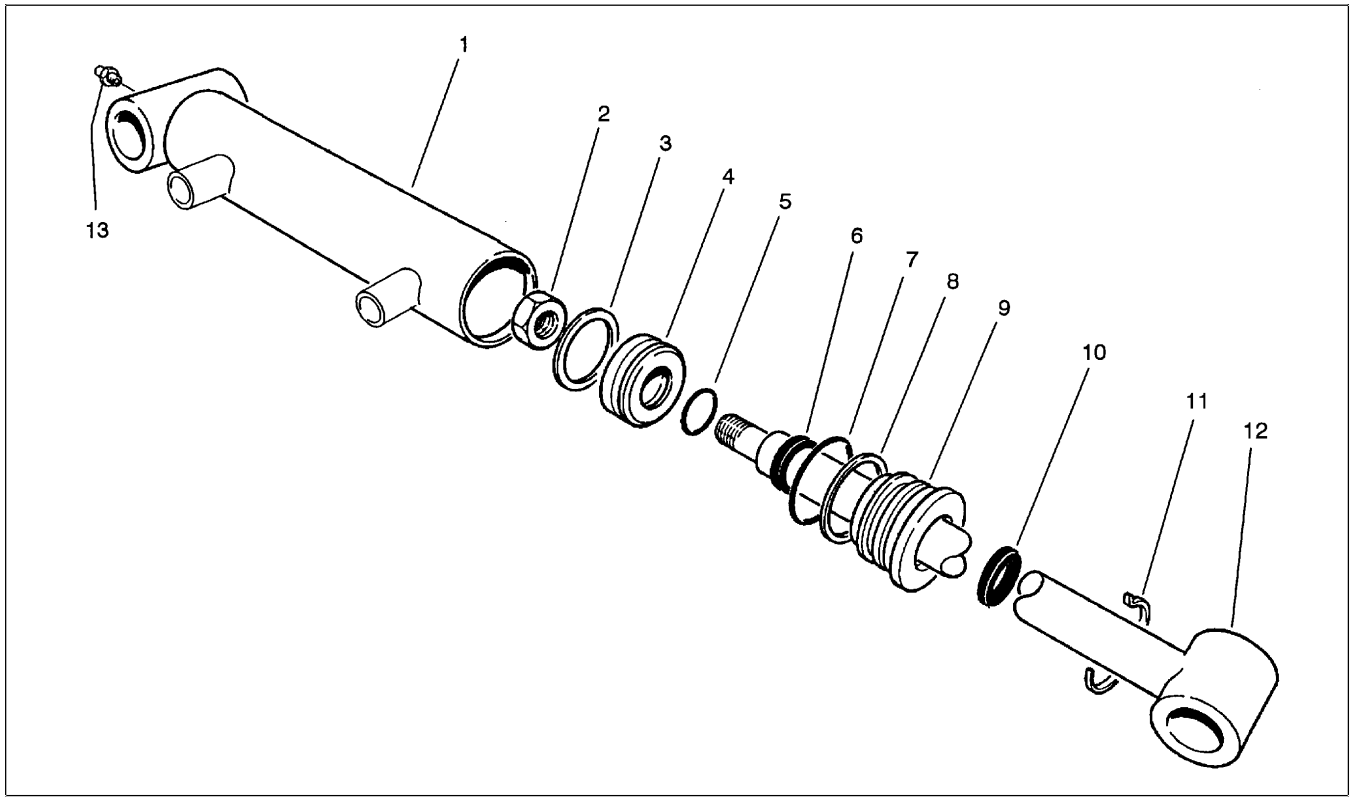


Figure 100

1. Barrel	**5. O-ring seal**	**9. Head**
2. Nut	**6. Rod seal**	**10. Dust seal**
3. Uni-ring seal	**7. O-ring seal**	**11. Retaining ring**
4. Piston	**8. Back-up ring**	**12. Rod**

5. Grasp the clevis end of the shaft and use a twisting and pulling motion to carefully extract the piston, shaft, and head from the barrel.

6. Securely mount the clevis end of the shaft in a vise and remove the lock nut from the piston end of the shaft. Remove the piston. Slide the head off of the shaft.

7. Remove and discard all seals and back-up rings.

8. 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.

9. Inspect the internal surface of the barrel for damage (deep scratches, out-of-round, etc.). Inspect the head, shaft and piston for evidence of excessive scoring, pitting, or wear. Replace any defective parts.

10. To install the two piece Uni-ring piston seal:

A.Soak the seal rings in hot water. The hot water will soften the rings allowing then to stretch over the piston.

B. Apply clean hydraulic oil to the black inner ring and Install the ring into the seal groove on the piston.

C. Apply clean hydraulic oil to the purple outer ring and install the ring into the same groove over the black ring.

11. Put a light coating of hydraulic oil on all other new seals and back-up washers. Install the new seals and back-up washers. Install the head onto the piston rod. Install the piston onto the shaft and tighten the lock nut.

12. Put a heavy coating of hydraulic oil on all cylinder parts to ease assembly. Slide the shaft assembly and head into the barrel. Install the retaining ring to secure the assembly in the barrel. Make sure “sharp edge” of retaining ring faces OUT. Make sure snap ring is fully installed into mating groove.

Flushing The Hydraulic System

IMPORTANT: Drain and refill reservoir, change oil filter and flush hydraulic system if component failure was severe or system is contaminated (oil appears milky or black or contains metal particles.

1. Lower cutting units, stop engine, engage parking brake and remove key from ignition switch.

2. Put drain pan under reservoir (Fig. 101). Remove drain plug from bottom of reservoir and let oil drain into pan. Install drain plug.

3. Inspect and clean reservoir (see Inspecting Reservoir Parts).

4. Clean area around filter mounting area. Remove and discard filter (Fig. 102). Make sure filter mounting surface is clean. Apply hydraulic oil to gasket on new filter. Fill filter with hydraulic oil. Screw filter on until gasket contacts mounting plate, then tighten filter one-half turn.

5. Fill hydraulic reservoir with approximately 8.5 gallons of hydraulic oil and install reservoir cap.

Use only hydraulic oils specified (see Specifications section of this chapter). Other fluids could cause system damage.

6. Disconnect fuel stop solenoid electrical connector to prevent engine from starting.

7. Turn ignition key switch to engage starter for ten (10) seconds to prime pump. Repeat this procedure again.

8. Connect fuel stop solenoid electrical connector.

9. Start engine and let idle at low speed for minimum of two (2) minutes.

10. Increase engine speed to high idle for minimum of one (1) minute under no load.

11. Turn steering wheel fully left and right several times.

12. Raise and lower cutting units several times.

13. Engage cutting units and run under no load for five (5) minutes.

IMPORTANT: Stop engine and remove bedknife to reel contact before operating cutting units under no load. Operating cutting units with bedknife to reel contact will cause reel and bedknife cutting edges to "rifle" and/or become dull.

14. Shut off engine and check for hydraulic oil leaks. Check oil level in hydraulic reservoir and add correct oil if necessary.

15. Replace hydraulic filter again after first 10 to 15 hours of operation, or sooner if filter bypass indicator enters the RED zone when the engine is running.

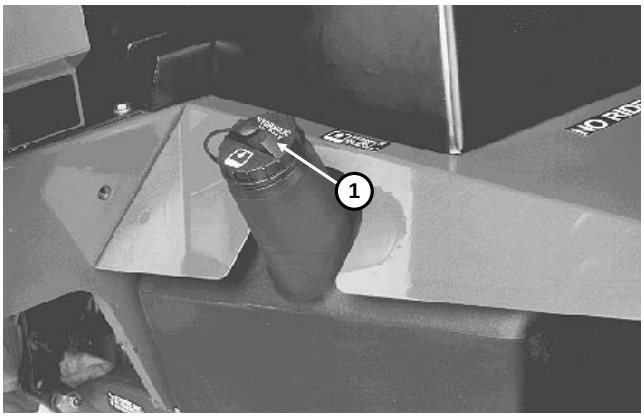


Figure 101

1. Hydraulic reservoir

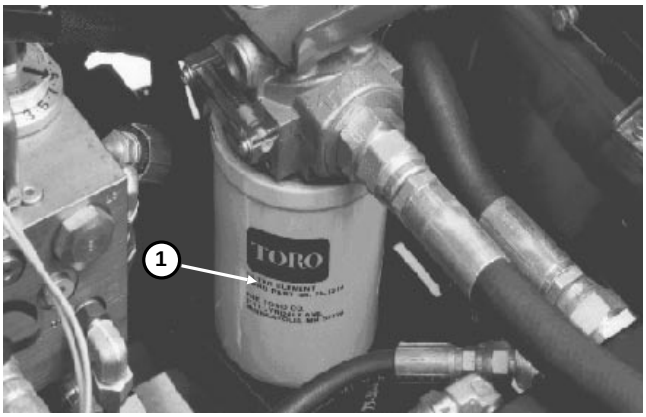


Figure 102

1. Hydraulic filter

Inspecting Reservoir Parts

1. Clean filler screen, suction screen and reservoir with clean solvent (Fig. 103).

2. Inspect reservoir for leaks, cracks or other damage.

3. Replace hoses or fittings if worn or leaking.

4. Replace breather with new part.

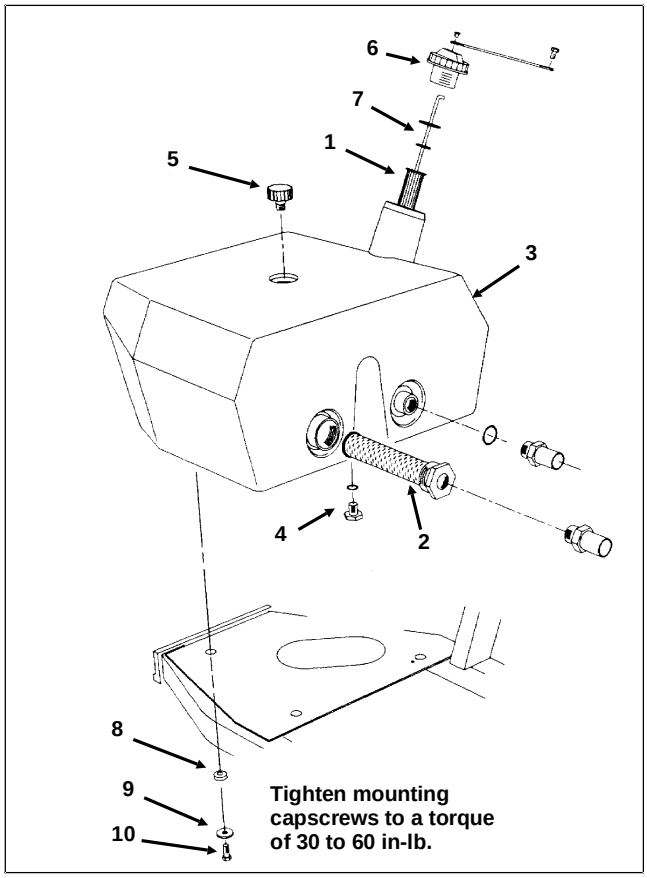


Figure 103

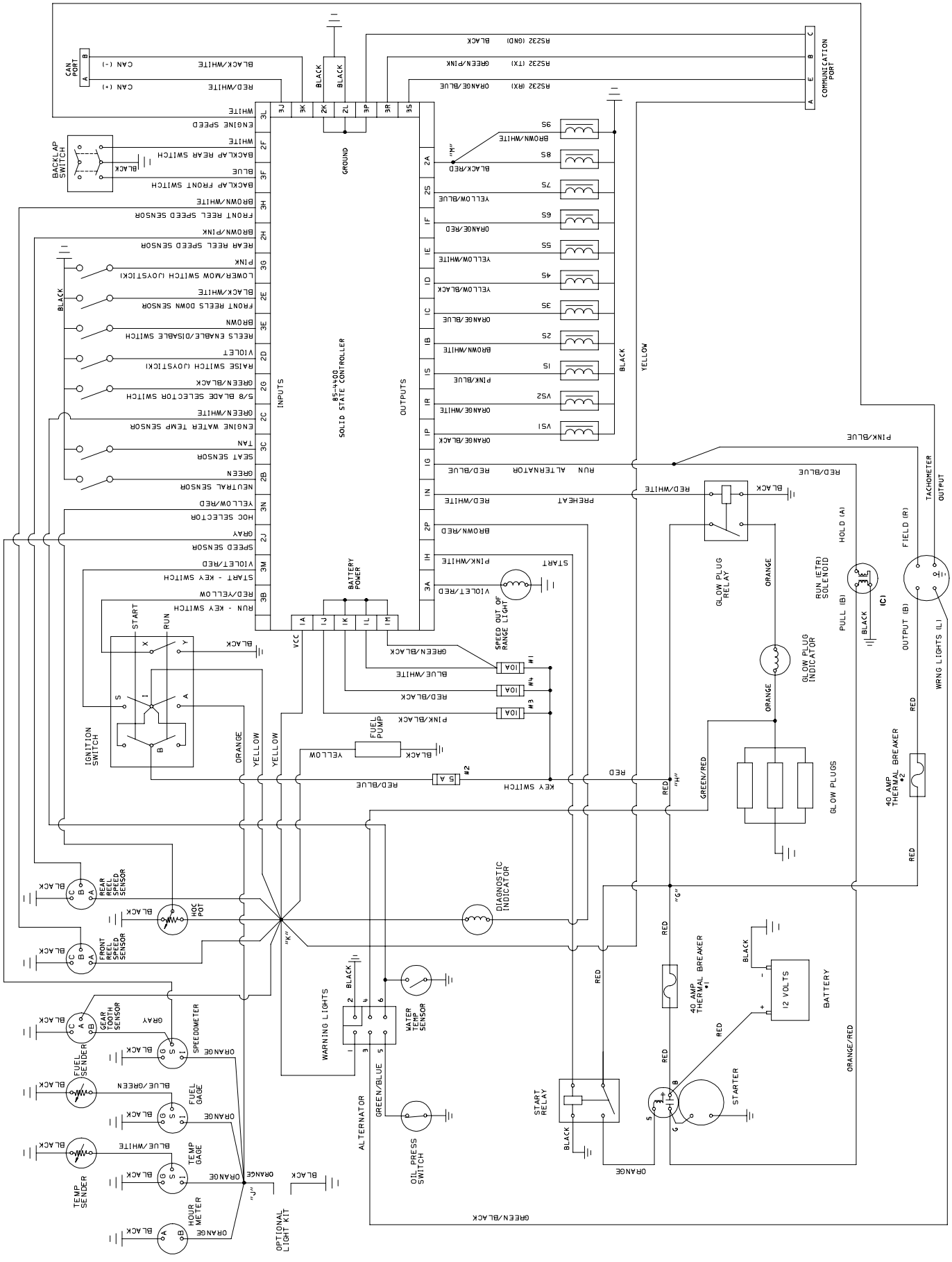
1. Filler screen
2. Suction strainer
3. Reservoir
4. Drain plug
5. Breather
6. Cap
7. Dipstick
8. Grommet (3)
9. Washer (3)
10. Capscrew (3)

Chapter 5

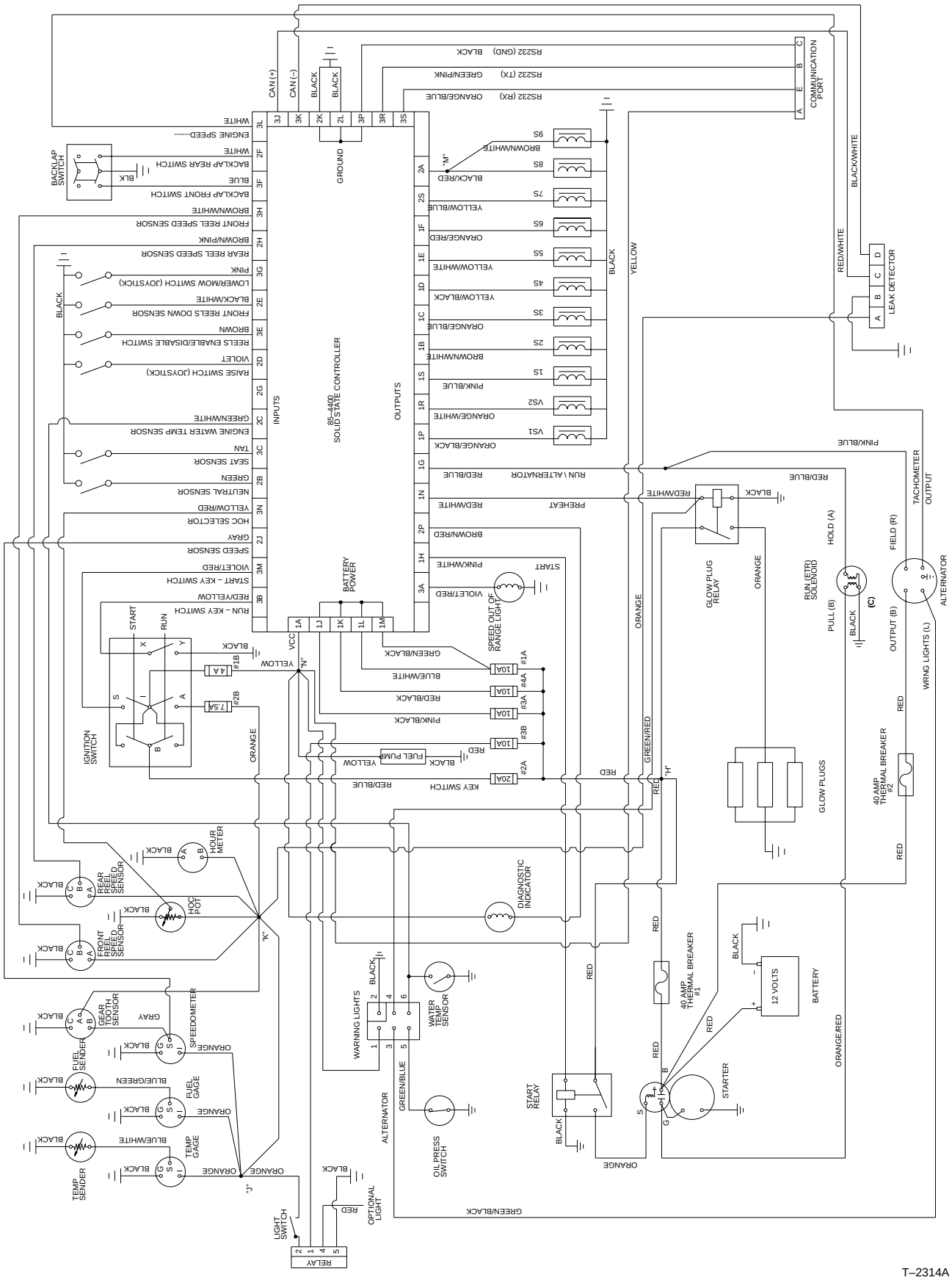
Electrical System

Table of Contents

Wiring Schematic (Model 03530, S/N Below 51001 / Model 03531, S/N Below 50301)



Wiring Schematic (Model 03530, S/N 51001 & Up / Model 03531, S/N 50301 & Up)



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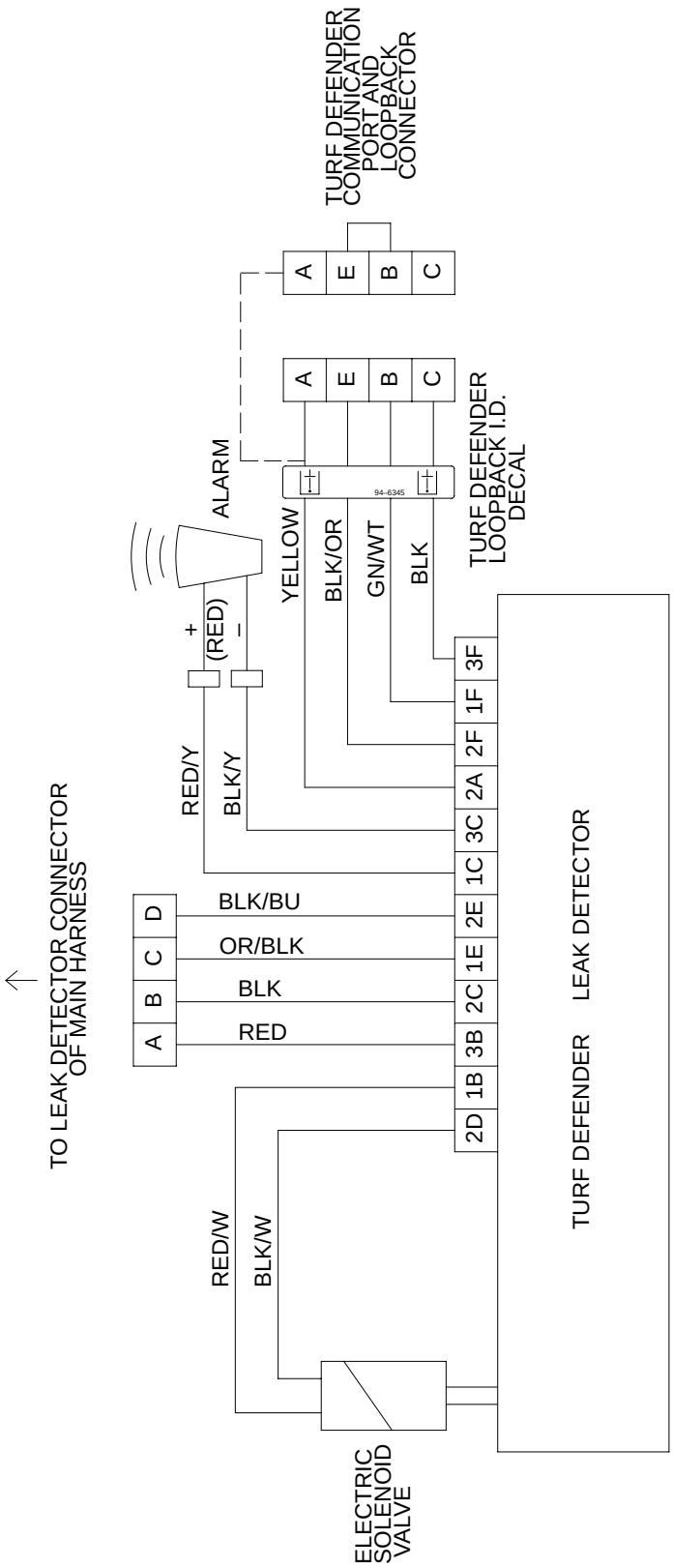
Electrical Schematic – Leak Detector



LOGIC GRID

KEY: X=CLOSED, O=OPEN, P=OUTPUT ON,
M=MOMENTARILY CLOSED,
A=OUTPUT ON IF REELS WERE PREVIOUSLY RUNNING

TIMERS
T1= .5 sec
T2= 5.0 sec
T3= .9 sec
T4= .1 sec
T5= .9 sec
T6= 15 sec

ACTIONS	0	1	2 Key Run	3 Traction Neutral	4 Seat Switch	5 High Coolant Temp	6	7 Raise	8 Enable Reels	9 Front Units Down	10 Backlap Front	11 Backlap Rear	12 Lower / Mow	13	14	15	16	17	AØ Start Key	A1	T Timer Involved	0 Diagnostic Light	1 S8,S9	2 S2	3 S3	4 S4	5 S5	6 S6	7 ETR Hold / Alt	8 VS1	9 VS2	10 S1	11 S7	12 Start	13 Preheat
0) Controller OK			X																			P												
1) Preheat			X																		T6	P												P
2) Start				X					O	O			O						X			P											P	P
3) Run (No operator)			X	X		O																P							P					
Run (with operator)			X	O	X	O																P							P					
4) Lower (To turn around)			X						O	O	O	O	O	X								P			P									
Lower (All units when disabled)			X						O	O	X	O	O	X								P			P	P	P	P						
Lower (All units when enabled)			X		X				O	X	O	O	O	X								P			P	P		P						
Lower / Mow–Front			X		X				O	X	X	O	O	M							T1	P			P	P		P	P		P			
Lower / Mow–Front & Rear			X		X				O	X	X	O	O	X							T2	P		P	P	P	P	P	P	P	P			
5) Mow			X		X				O	X	X	O	O	M								P		P					P	P	P			
6) Raise (transport)			X						X	O		O	O	O								P			P	P	P					T		
Raise (To turn around front)			X		X				M	X	X	O	O	O							T3	P		A	P	P				A		T		
Raise (To turn around front & rear)			X		X				X	X	X	O	O	O								P			P	P	P						T	
Raise (To turn around front & rear)			X		X				X	X	O	O	O	O							T5	P				P	P						T	
7) Backlap Front			X	X					O	X	X	X	O	M							T2	P	P		P	P	P	P		P		P		
			X	X					O	X	X	X	O									P	P							P		P		
8) Backlap Rear			X	X					O	X	X	O	X	M							T2	P	P	P	P	P	P	P			P			
			X	X					O	X	X	O	X									P	P	P							P			

Special Tools

NOTE: Special tools may be ordered from:
Owatonna Tool Co.
2013 4th Street, NW
Owatonna, MN 55060

Some tools may bebe listed in the Reelmaster 5300-D Parts Catalog or sold under Toro Model Numbers. Some tools may also be available from a local supplier.

Digital Multimeter

The meter can test electrical components and circuits for current, resistance, or voltage drop.

NOTE: Toro recommends the use of a DIGITAL mutlimeter when testing electrical circuits. The high impedance (internal resistance) of a digital meter will ensure that excess current is not allowed through the meter. Excess current can cause damage to a circuit that is not designed to carry it.

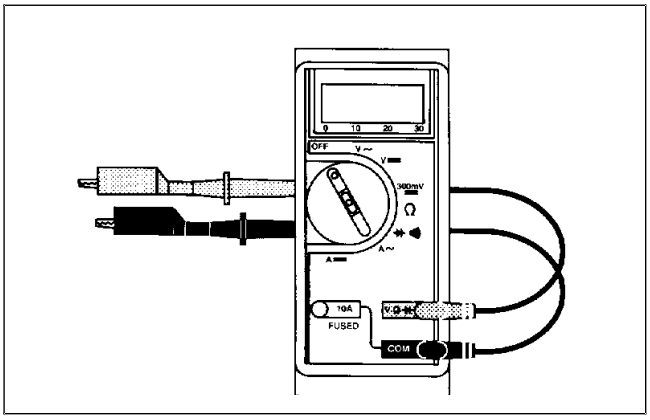


Figure 1

Inductive Ammeter (AC/DC Current Transducer – Hall Effect)

Use this tool, connected to a Digital multimeter for doing current draw tests. This tool can be useful when checking glow plug and starter circuits.

Skin-Over Grease

Special non-conductive grease which forms a light protective skin to help waterproof electrical switches and contacts (Fig. 2).

Toro P/N **505–47** 8 oz. (.24 L) can

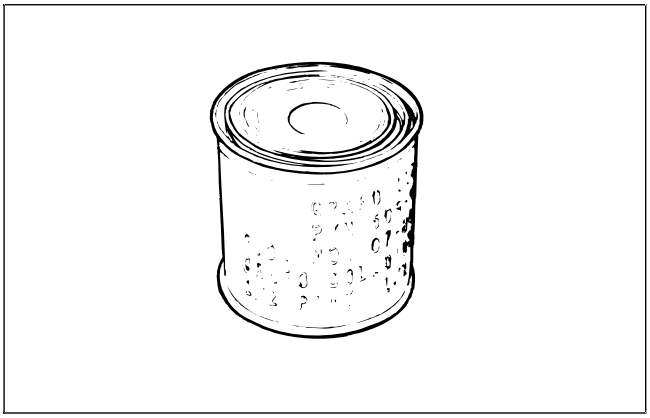


Figure 2

Diagnostic ACE Display

The diagnostic display (Fig. 4) is connected to the wiring harness connector near the electronic control unit (ECU) to help the user verfiy correct electrical functions of the machine.

When in “INPUTS DISPLAYED” mode, LED’s on the display illuminate to show input switches that are closed. When in “OUTPUTS DISPLAYED” mode, LED’s illuminate to show outputs turned on by the ECU.

Diagnostic ACE Tool, Toro P/N **85-4750**

RM5100-D/5300-D Overlay, V1.0, Toro P/N **85-4760**

TurfDefender Overlay, V1.0, Toro P/N **94-5386**

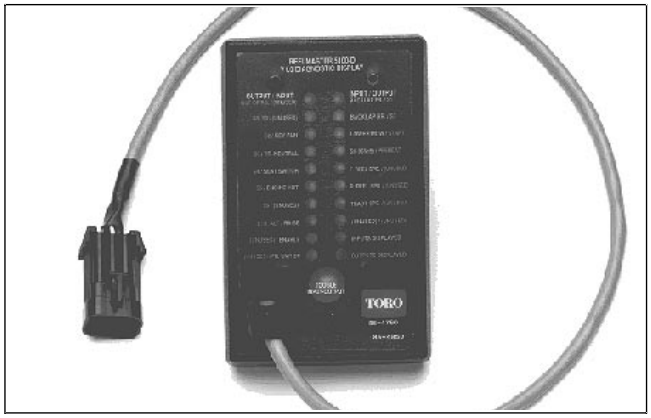


Figure 4

Troubleshooting

For all electrical problems, the use of the quick reference troubleshooting method is recommended. Using the Diagnostic ACE™ Display allows you to quickly find the source of the electrical problem.

For **intermittent electrical problems**, which are not repeatable, use of the Data Log System is recommended. The data log system records the actual state of machine inputs and outputs at the time of malfunction. Your Toro Distributor can then isolate the cause of the electrical problem.

Quick Reference Troubleshooting Guide

NOTE: See "Using the Diagnostic ACE" book, Form 92-800-SL for more information.

Controller Diagnostic Lamp

Before doing any troubleshooting, check green controller diagnostic lamp. If diagnostic lamp is *ON*, with key switch in RUN position, the electronic control unit (ECU) is functioning normally.

If diagnostic lamp is *FLASHING ON* and *OFF*:

1. ECU has detected an output with a short circuit.
2. ECU has detected an output with an open circuit.

Use diagnostic display to find which output is malfunctioning.

If the diagnostic lamp is *OFF*:

1. Loop-back connector is not attached.
2. Diagnostic light is burned out.
3. ECU is not powered on.
4. ECU is not functioning correctly.

Check electrical connections, input fuses and diagnostic light to find malfunction. Make sure loop-back connector is secured to wire harness connector.

Diagnostic ACE™ Display

Use diagnostic display tool to verify correct electrical function of the machine and to locate electrical malfunctions.

1. Park machine on a level surface, engage parking brake, lower cutting units and turn ignition key switch off.

2. Carefully disconnect loop-back connector from wire harness (Fig. 7).

3. Connect diagnostic display tool to communication connector on wiring harness (where loop-back connector was removed). Make sure correct overlay decal is installed on diagnositc display.

4. Turn ignition key switch ON, but DO NOT start the engine.

5. The "INPUTS DISPLAYED" LED, on lower right column of diagnositc display, should be on. If necessary, push input-output toggle switch on diagnostic display so "INPUTS DISPLAYED" LED is on. Do not hold the button down.

NOTE: Red text on overlay decal refers to input switches and green text to outputs.

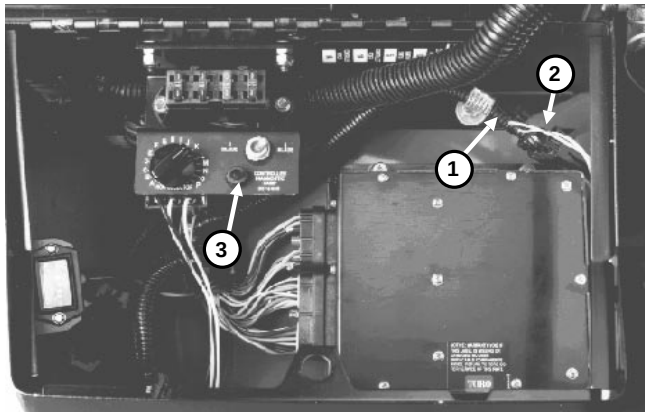


Figure 7

1. Wire harness and connector
2. Loop-back connector
3. Controller diagnostic lamp

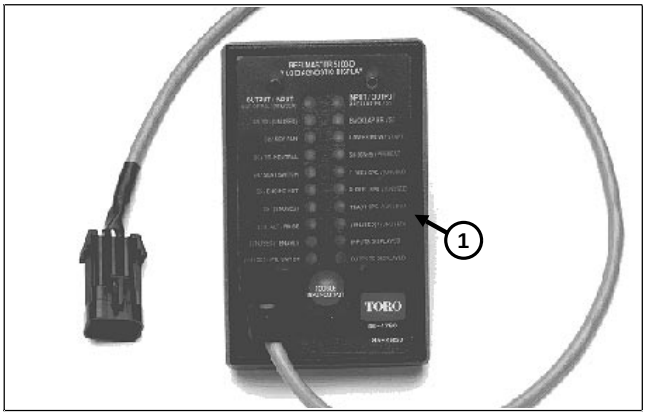


Figure 8

1. Diagnostic ACE™ Display

6. The diagnostic display will illuminate the LED associated with each of the inputs when that input switch is closed. Check each switch (input) by opening and closing switch, then verifying that corresponding LED goes on and off as switch position is changed. For example, with traction pedal in neutral, "TR. NEUTRAL" LED should be on, then go off, when traction pedal is moved out of neutral. Check function for each switch that can be changed manually.

7. If a switch is closed and corresponding LED does not go on, check all wiring and connections to switch and/or test switch with a continuity tester or ohm-meter. Replace any faulty switches and repair or replace any faulty wiring or connectors.

To verify output functions:

8. Do steps 1 - 4 in above procedure to connect diagnostic display, if not already connected.

9. If necessary, push input-output toggle switch on diagnositic display so "OUTPUTS DISPLAYED" LED is on.

NOTE: Red text on overlay decal refers to input switches and green text to outputs.

NOTE: It may be necessary to toggle between "INPUTS DISPLAYED" and "OUTPUTS DISPLAYED" several times to do this procedure. To toggle back and forth, press toggle button once. This may be done as often as necessary. DO NOT hold button.

10. Sit on the seat and attempt to operate desired function of machine – DO NOT start engine. Put input switches in required position to allow desired functions to occur as defined by Logic Chart on page 4. The appropriate output LED's should illuminate to indicate that the ECU is turning on that function.

If any output LED is *FLASHING ON* and *OFF*, this indicates and electrical problem with that OUTPUT. To reset a flashing LED, turn the key switch OFF, then back ON.

If no output LED's are flashing on and off, but the correct output LED's do not illuminate, verify that the required input switches are in the necessary positions to allow that function to occur. If input switches are correct, but output LED's are not correct, this indicates a controller malfunction.

If output LED's are correct, but machine does not function properly, this indicates a hydraulic problem.

NOTE: Due to electrical system constraints, the output LED's for "START", "PREHEAT" and "ETR/ALT" may not flash on and off, even though an electrical problem may exist for one of those functions. If the machine problem appears to be with one of these functions, see the troubleshooting charts.

IMPORTANT: The diagnostic display must not remain connected to the machine. When done using diagnostic display, carefully disconnect it. Connect loop-back connector to wire harness connector. Machine will not operate without loop-back connector installed on wire harness. Store diagnostic display in dry, secure location in shop, not on machine.

Figure 8A

1. Diagnostic ACE™ Display

Retrieving Stored Faults

NOTE: The machine may require installaton of updated software for this function to operate. This required software was installed on machines starting with S/N 70001. Older machines can have new software installed. Contact your Toro Distributor for assistance.

1. Turn ignition key switch to OFF. Unplug loopback connector and connect Diagnostic ACE to the ECU harness connector.

2. Move the Lower–Mow/Raise lever to the RAISE position and hold.

3. Turn Ignition key switch to ON while continuing to hold the lever in the RAISE position until the top left light on the Diagnostic ACE comes on (approximately 2 seconds).

4. Make sure Diagnostic ACE is set to OUTPUTS.

5. Release the RAISE lever to the center position.

   There will be 8 records displayed. The fault is displayed on the 8th record. Each record will be displayed for 10 seconds. Records will repeat until the Ignition switch is turned to OFF. The machine will not start in this mode.

6. Observe Diagnostic ACE for the playback of the retained fault in the ECU memory. The problem circuit will be flashing.

Clearing Fault Memory

Once a fault is repaired, it must be must be cleared from the ECU memory so any future fault can then be stored.

1. Turn Ignition key switch to OFF.

2. Move the Backlap switch to the FRONT or REAR position.

3. Move the Enable/Disable switch to the ENABLE position.

4. Move the Lower–Mow/Raise lever to the RAISE position and hold.

5. Turn Ignition key switch to ON while continuing to hold the lever in the RAISE position until the Reel Control Lamp on the steering column starts to flash (approximately 2 seconds).

6. Release the RAISE lever and turn Ignition switch to OFF. Move the Backlap switch to OFF and the Enable/Disable switch to DISABLE. **Fault memory is now cleared.**

IMPORTANT: The Diagnostic ACE display must not be left connected to the machine. After using the Diagnostic ACE, disconnect it from the machine and reconnect loopback connector to the harness connector. The machine will not operate without the loopback connector installed to the harness. Store Diagnostic ACE in a dry, secure location.

TurfDefender Leak Detector

The TurfDefender™ is an electronic hydraulic fluid leak detection device that fits inside the hydraulic tank of your machine. It is a pressure based system which requires a sealed hydraulic tank to function properly. Very small changes to the oil level in the sealed tank result in a large movement of the leak detector's internal float. The TurfDefender's internal microprocessor analyzes the float movement and determines if there is a leak in the system.

- Turn ignition key to "ON" position start the system. The system will reset itself whenever the ignition key is moved to "OFF" position. Wait 5 seconds, then move key to "ON" position to restart the system.
- When machine is started, the alarm will give one short beep to indicate that everything is operating properly. If the alarm makes no noise at all, it should be checked by a mechanic.
- If the alarm gives 4 short beeps it means a system problem has been detected and it should be checked by a mechanic. The 4 beep pattern will continue for approximately 1–1/2 minutes, then stop, unless the ignition key is moved to "OFF" position.

  Note: The low or high oil level 4 beep signal may occur if machine is started on a slope. Move machine to a level surface, move ignition key to "OFF" position, wait 5 seconds, then move key to "ON" position to restart the system.
- If the alarm gives a loud continuous beep while mowing and shuts off the cutting units, it means that a leak has been detected. On the traction unit, the red light on the steering console will also blink indicating the ECU has shut off the cutting units.

Checking Leak Detector Operation

The operation of the TurfDefender™ should be checked if any of the following conditions occur:

a. No beeps are heard when ignition switch is turned "ON".

b. Any time the machine gives a series of 4 short beeps.

c. False alarms are observed.

1. Park machine on a level surface, stop the engine and engage the parking brake.

2. Open control panel cover. Locate leak detector harness loopback connector with hydraulic symbol tag. Carefully unplug loopback connector from harness connector.

3. Connect the Diagnostic ACE display connector to the correct harness loopback connector. Install TurfDefender overlay decal (supplied with leak detector kit) onto Diagnostic ACE (Fig. 8b).

4. Turn the key switch to the ON position, but do not start machine.

Note: Red text on the overlay decal refers to inputs and green text refers to outputs.

5. The red "Inputs displayed" LED (Light Emitting Diode), on lower right column of the Diagnostic ACE, should be illuminated. If green "Outputs displayed" LED is illuminated, press and release the toggle button, on Diagnostic ACE, to change LED to "Inputs displayed". Do not hold button down (Fig. 8b).

If TurfDefender is functioning normally:

1. When the "Inputs displayed" LED is lit, the actual Float position (1 or 2 LED's on left row) and "Oil level OK" LED – should be displayed (Fig. 8c).

2. Press toggle button until green "Outputs displayed" LED is lit. "Valve ON", "data line" and "self diagnostic"LED's should be lit steadily. "Alarm ON" LED may be displayed temporarily (about 5 seconds) (Fig. 8d).

Note: If "data line" or "self diagnostic" LED's are blinking, there is a problem in the system.

If No beeps are heard:

1. Check alarm wires to make sure they are not disconnected, broken or "+" and "–" reversed.

2. Toggle "outputs displayed" on Diagnostic ACE display (Fig. 8d).

- Alarm open circuit (LED blinking): Check / replace TurfDefender alarm or wires.
- Alarm short circuit (LED blinking): Check / replace TurfDefender alarm or wires.

If 4 beeps are heard:

The most common cause for a 4 beep signal is from an improper oil level reading. Make sure machine is on a level surface when checking oil level. Since oil level will vary with temperature, it is best to check when cool.

1. When toggling "input", a LED should display (Fig. 8c) any of the following problems diagnosed by the TurfDefender:

- Oil level low: Position machine on a level surface and fill to proper level.
- Oil level high: Position machine on a level surface and remove excess oil until proper level is attained.
- Oil too hot: Allow machine to cool and clean any debris from oil cooler.
- Air leak in system: Assure tank cap is tight or check for leak in tank.

  Note: Only large air leaks can be detected by hand held Diagnostic ACE. A leakdown test is required to identify small air leaks. Consult your Authorized Toro Distributor for assistance.

2. When toggling “output” a LED should display (Fig. 8d) any of the following problems diagnosed by the TurfDefender:

- Valve open circuit (LED blinking): Check / replace TurfDefender electric solenoid valve or wires.
- Valve short circuit (LED blinking): Check / replace TurfDefender electric solenoid valve or wires.
- Self diagnostic LED Blinking: Internal circuit failure in TurfDefender. Consult your Authorized Toro Distributor for assistance.
- Data Line LED Blinking: Problem with communications between machine and leak detector; or problem with wires. Consult your Authorized Toro Distributor for assistance.

Note: If machine must be operable with leak detector disabled, unplug leak detector 4–pin connector from 4–pin connector of main harness. Do not unplug leak detector alarm.

If false alarms are observed:

1. Oil level may be low causing air to be drawn out of system. Check oil level.

2. Extremely hard left turns can cause oil to slosh to the right, exposing suction line and purging air out of system. Normal maneuvering should not cause this condition.

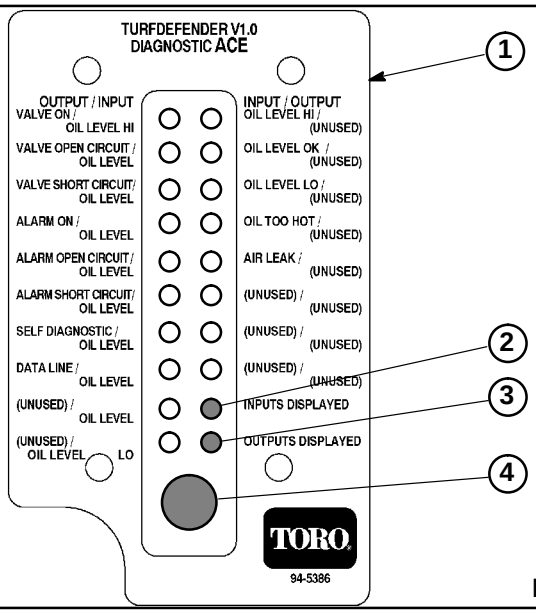
3. Air leak in system. Check to make sure cap is securely on tank. Contact your local authorized Toro Distributor for further assistance with air leak problem.

4. To check for a system problem, install hand held Diagnostic ACE, toggle input/output and check for any problems previously discussed.

Note: The system will reset itself whenever the ignition key is turned to “OFF” position. The hand held Diagnostic ACE must be connected and observed during a false alarm. Once the ignition key is turned to “OFF” position, the TurfDefender will reset itself.

5. Your Authorized Toro Distributor has equipment to analyze system problems.

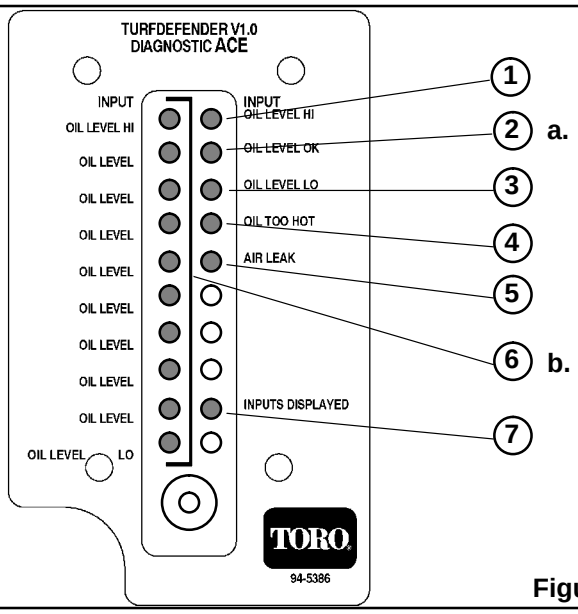
IMPORTANT: The Diagnostic ACE displays must not be left connected to the machine. It is not designed to withstand the environment of the machine’s every day use. When done using Diagnostic ACE, disconnect them from the machine and reconnect loopback connectors to harness connectors. Machine will not operate without loopback connectors installed on harnesss. Store Diagnostic ACE in dry, secure location in shop, not on machine.



Diagnostic ACE Display Functions

1. **Overlay decal (English shown)**
2. **“Inputs Displayed” LED (Red)**
3. **“Outputs Displayed” LED (Green)**
4. **Toggle button**

Figure 8b



Using “Inputs Displayed” (Red Text)

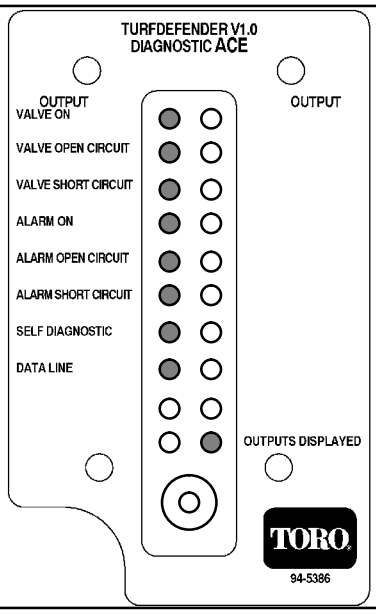
1. **LED lit if oil level is too high**
2. **LED lit if oil level is OK**
3. **LED lit if oil level is too low**
4. **LED lit if oil is too hot**
5. **LED lit if system air leak has been detected**
6. **One or two LED’s lit displaying relative position of the Turfdefender’s internal float.**
7. **“Inputs Displayed” LED “ON” (Red)**

Normal Operation:

a. “Oil Level OK” LED lit

b. 1 or 2 LED’s lit on left column

Figure 8c



Using “Outputs Displayed” (Green Text)

Normal Operation:

a. “Valve ON” LED lit steadily

b. “Self Diagnostic” LED lit steadily

c. “DATA LINE” LED lit steadily

d. “Alarm ON” LED lit temporarily

Problem Diagnosed:

The appropriate LED will blink to identify the problem

Figure 8d

Starting Problems

Condition	Possible Cause	Correction
All electrical is dead, including gauges.	Low battery charge.	Charge battery. Replace battery if it will not hold a charge.
	Thermal circuit breaker No. 1 open.	Find cause for open circuit breaker and correct. Circuit breaker will reset automatically after has cooled.
	5A key switch fuse open.	Check fuse and replace if fuse is open. If fuses burn out often, find and correct cause. NOTE: If auxillary lights are added, this fuse must be replaced with a 15A fuse.
	Faulty key switch wiring.	Repair wiring.
	Faulty key switch.	Test key switch and replace if necessary.
Starter solenoid clicks, but starter will not crank. (If solenoid clicks, problem is not in interlock system or controller.)	Low battery charge.	Charge battery. Replace battery if it will not hold a charge.
	Loose or corroded battery cables. Loose or corroded ground.	Clean and tighten or repair as necessary.
	Faulty wiring at starter.	Repair wiring.
	Loose starter mounting bolts.	Clean mounting surface and tighten bolts.
	Faulty starter.	Repair or replace starter.
	Faulty starter solenoid.	Replace starter solenoid.

Condition	Possible Cause	Correction
Nothing happens when start attempt is made (control panel lights and gauges DO operate with ignition key switch in ON position).	Faulty ignition (key) switch or wiring.	Test switch and replace if faulty. Correct wiring problem if necessary.
	Traction neutral switch circuit open.	Check traction control linkage and adjust or repair.
	Short circuit or open circuit between controller and start relay.	Check wiring and repair if necessary.
	Start relay faulty.	Test relay and replace if necessary.
	Wiring between start relay and starter faulty.	Check wiring and repair if necessary.
	Start solenoid faulty.	Test start solenoid and replace if necessary.
Engine starts, but dies when ignition key switch is released from start position.	Run solenoid out of adjustment.	Adjust run solenoid.
	Run solenoid faulty.	Replace run solenoid.
	Run solenoid wiring faulty.	Repair wiring.
	Faulty high engine water temperature shut-down switch (engine not overheated) or wiring.	Check switch and wiring and replace or repair if necessary.
Starter cranks but engine will not start.	Engine not cranking fast enough.	Check battery and cable connections. Charge battery. Replace battery if it won't accept a charge. Repair wiring if necessary.
	Run solenoid out of adjustment	Adjust run solenoid.
	Faulty run solenoid.	Replace run solenoid.
	Problem is not electrical.	See Troubleshooting section of Chapter 3 - Engine.
Starter cranks, but should not when traction pedal is depressed.	Traction neutral switch circuit closed.	Check traction neutral switch adjustment and adjust if faulty.
		Test traction neutral switch and replace if faulty.
		Check traction neutral switch wiring and repair if faulty.

General Run and Transport Problems

Condition	Possible Cause	Correction
Engine continues to run, but should not, when ignition key is turned off.	Engine fuel lever or run solenoid stuck in “on” position.	Check operation of run solenoid and adjust or replace if necessary. Make sure fuel stop lever moves without sticking and repair if necessary.
	Ignition switch faulty.	Replace ignition switch.
Engine continues to run, but should not, when traction pedal is engaged with no operator on seat.	Seat switch circuit is closed.	Check seat plate hinges and seat support pin and repair if faulty. Check for water soaked seat cushion. Test seat switch and replace if faulty. Check seat switch wiring and repair if faulty.
	Traction neutral switch circuit closed.	Check traction neutral switch adjustment and adjust if faulty. Test traction neutral switch and replace if faulty. Check traction neutral switch wiring and repair if faulty.
Engine kills during operation, but restarts.	Seat lifting off seat switch.	Instruct operator to sit back in seat during operation. Operate machine slower when operating in rough terrain.
	Seat switch circuit open.	Check seat plate hinges and seat support pin and repair if faulty. Test seat switch and replace if faulty. Check seat switch wiring and repair if faulty.
	Faulty ignition switch.	Replace switch.
	Faulty ignition switch wiring.	Repair wiring.

Condition	Possible Cause	Correction
Engine kills when traction pedal is depressed.	Seat lifting off seat switch.	Instruct operator to sit back in seat during operation. Check seat plate hinges and seat support pin and repair if faulty.
	Seat switch circuit open.	Test seat switch and replace if faulty. Check seat switch wiring and repair if faulty.
Battery does not charge.	Alternator belt slipping.	Adjust belt tension.
	Faulty wiring.	Check and repair wiring.
	Malfunctioning alternator.	Repair or replace alternator.
	Faulty battery.	Replace battery.

Cutting Unit Operation Problems

Condition	Possible Cause	Correction
Cutting units remain engaged, but should not, with no operator on seat.	Seat switch circuit closed.	Check seat plate hinges and seat support pin and repair if faulty. Check for water soaked seat cushion. Check seat switch and replace if faulty. Check seat switch circuit wiring and repair if faulty.
Cutting units run, but should not, when raised (but shut off with Enable/Disable switch).	Front reels down sensor closed.	Test front reels down sensor and replace if faulty. Check front reels down sensor wiring and repair if faulty.

Condition	Possible Cause	Correction
Cutting units run, but should not, when raised and do not shut off with Enable/Disable switch.	Both the front reels down sensor and enable switch circuits are closed.	Check front reels down sensor and enable switch and replace if necessary. Check wiring to both switches and repair if necessary.
	Hydraulic problem.	See Troubleshooting section of Chapter 4 - Hydraulic System.
Cutting units run, but should not, when lowered with Enable/ Disable switch in disable position.	Enable/Disable switch circuit closed.	Test Enable/Disable switch and replace if faulty. Check Enable/Disable switch wiring and repair if faulty.
No cutting units operate in either direction (raise and lower function OK).	Seat lifting off seat switch.	Instruct operator to sit back in seat during operation. Check seat plate hinges and seat support pin and repair if faulty.
	Seat switch circuit open.	Check seat switch and replace if faulty. Check seat switch wiring and repair if faulty.
	Enable/Disable switch circuit open.	Check Enable/Disable switch and replace if faulty. Check Enable/Disable switch wiring and repair if faulty.
	Front reels down sensor circuit open.	Check front reels down sensor and replace if faulty. Check front reels down sensor wiring and repair if faulty.
	Solenoid problem.	Test solenoid and replace if faulty. Check wiring to solenoid and repair if necessary.
	Hydraulic problem.	See Troubleshooting section of Chapter 4 - Hydraulic System.

Condition	Possible Cause	Correction
Front cutting units do not operate in either direction (raise and lower function OK).	Problem with solenoid S1.	Test solenoid S1 and replace if faulty. Check wiring to S1 solenoid and repair if faulty.
	Problem with S7 solenoid.	Check wiring to S7 solenoid and repair if faulty.
	Hydraulic problem.	See Troubleshooting section of Chapter 4 - Hydraulic System.
Rear cutting units do not operate in either direction (raise and lower function OK).	Problem with solenoid S2.	Test solenoid S2 and replace if faulty. Check wiring to S2 solenoid and repair if necessary.
	Hydraulic problem.	See Troubleshooting section of Chapter 4 - Hydraulic System.
Cutting units operate, but speed is either too slow or too fast and is not regulated by changing the HOC selector or traction speed.	Problem with solenoid VS1 or VS2 (only front or rear cutting units will be affected).	Test solenoid VS1 (front cutting units) or VS2 (rear cutting units) and replace if faulty. Check wiring to VS1 or VS2 solenoid and repair if faulty.
	Problem with reel speed sensor (only front or rear cutting units will be affected).	Check affected reel speed sensor (front or rear) and replace if faulty. Check wiring to affected reel speed sensor and repair if faulty.
	Problem with HOC selector.	Check calibration of HOC selector and replace if necessary. Check wiring to HOC selector and repair if necessary.
	Problem with traction speed sensor.	Check speedometer for proper performance. If it is not functioning, check operation of traction speed sensor and replace if faulty. Check wiring to traction speed sensor and repair if necessary.

Condition	Possible Cause	Correction
No cutting units lower.	Lower - Mow switch circuit is open.	Check for faulty Lower-Mow switch (joystick). Check Lower-Mow switch wiring and repair if faulty.
	Problem with solenoid S6.	5A SOL S3/S6 fuse open. If fuses burn out often, find and correct cause.
	Faulty S6 solenoid coil.	Check S6 solenoid wiring and repair if faulty.
	Hydraulic problem.	See Troubleshooting section of Chapter 4 - Hydraulic System.
No cutting units raise.	Raise switch circuit open .	Test for faulty Raise switch (joystick). Check Raise switch wiring and repair if faulty.
	Problem with S7 solenoid.	Test solenoid S7 and replace if faulty. Check wiring to solenoid S7 and repair if necessary.
	Hydraulic problem.	See Troubleshooting section of Chapter 4 - Hydraulic System.
Left (No. 4) and right (No. 5) front cutting units will not raise/lower, but other cutting units raise and lower OK.	Problem with solenoid S3.	Test solenoid S3 and replace if faulty. Check wiring to solenoid S3 and repair if necessary.
	Hydraulic problem.	See Troubleshooting section of Chapter 4 - Hydraulic System.
Center (No. 1) cutting unit will not raise/lower, but other cutting units raise and lower OK.	Problem with solenoid S4.	Test solenoid S4 and replace if faulty. Check wiring to solenoid S4 and repair if necessary.
	Hydraulic problem.	See Troubleshooting section of Chapter 4 - Hydraulic System.

Condition	Possible Cause	Correction
Rear (No. 2 and 3) cutting units will not raise/lower, but other cutting units raise and lower OK.	Problem with solenoid S5.	Test solenoid S5 and replace if faulty. Check wiring to solenoid S5 and repair if necessary.
	Hydraulic problem.	See Troubleshooting section of Chapter 4 - Hydraulic System.
Front cutting units do not backlap, but run forward instead.	Problem with solenoid S8.	Test solenoid S8 and replace if faulty. Check wiring to solenoid S8 and repair if necessary.
	Hydraulic problem.	See Troubleshooting section of Chapter 4 - Hydraulic System.
Front cutting units do not backlap, but ALL cutting units run forward instead.	Front backlap switch circuit open.	Test front backlap switch and replace if faulty. Check wiring to front backlap switch and repair if necessary.
Rear cutting units do not backlap, but run forward instead.	Problem with solenoid S9.	Test solenoid S9 and replace if faulty. Check wiring to solenoid S9 and repair if necessary.
	Hydraulic problem.	See Troubleshooting section of Chapter 4 - Hydraulic System.
Rear cutting units do not backlap, but ALL cutting units run forward instead.	Rear backlap switch circuit open.	Test rear backlap switch and replace if faulty. Check wiring to rear backlap switch and repair if necessary.

Verify Interlock System Operation

The purpose of the interlock system is to prevent the engine from cranking or starting unless the traction pedal is in NEUTRAL the Enable/Disable switch is in DISABLE and the Lower-Mow/Raise control is in the neutral position. Also, the engine will stop when the traction pedal is depressed with the operator off the seat.

CAUTION

The interlock switches are for the operator's protection, so do not disconnect them. Check operation of the switches daily to assure interlock system is operating. If a switch is defective, replace it before operating. Do not rely entirely on safety switches - use common sense!

To check interlock system operation:

1. In a wide open area free of debris and bystanders, lower cutting units to the ground. Stop engine.

2. Sit on the seat. Depress traction pedal in forward and reverse directions, while trying to start the engine. If engine cranks there may be a malfunction in the interlock system. Use Diagnostic Display to help isolate problem and repair immediately. If engine does not crank, proceed to step 3.

3. Sit on seat. Position ENABLE/DISABLE switch in ENABLE. Try to start the engine. If engine cranks, there may be a malfunction in the interlock system. Use Diagnostic Display to help isolate problem and repair immediately. If engine does not crank, proceed to step 4.

4. Sit on seat and start engine. Position the ENABLE/DISABLE switch in ENABLE. Move the LOWER-MOW/RAISE control forward to turn the cutting units ON. Rise off the seat slowly. The cutting units should stop. If cutting units stop, the switch is operating correctly. Proceed to step 5. If cutting units do not stop, there is a malfunction in the interlock system. Use Diagnostic Display to help isolate problem and repair immediately.

5. Position the ENABLE/DISABLE switch in DISABLE. Sit on seat and start the engine. Raise the cutting units to the transport position. Position the ENABLE/DISABLE switch in ENABLE. Move the LOWER-MOW/RAISE control forward to lower the cutting units. If any of the cutting units begin operating before the front left and right cutting units have reached the turn around position, there may be a malfunction in the interlock system. Use Diagnostic Display to help isolate problem and repair immediately. If the cutting units remain OFF until the turnaround position; proceed to step 6.

6. Sit on seat and start the engine. Lower the cutting units to the ground. Position the ENABLE/DISABLE switch in ENABLE. Raise the cutting units. If the front right or left cutting units raise past the turnaround position, there may be a malfunction in the interlock system. Use Diagnostic Display to help isolate problem and repair immediately.

Testing

Testing of the electrical system has been greatly simplified by use of the ACE™ Diagnostic Display, Data Log system and ToroPC software. Before testing or replacing any electrical components, it is recommended that you verify electrical performance of the part(s) in question by using the above mentioned tools (see Troubleshooting section of this chapter).

This section will define given components, and the tests that can be performed on those components, when those parts are disconnected from the electrical system.

For accurate resistance and/or continuity checks, electrically disconnect the component being tested from the circuit (e.g. unplug the seat switch connector before doing a continuity check).

CAUTION

When testing electrical components for continuity with a volt-ohm meter or continuity tester, make sure that power to the circuit has been disconnected.

NOTE: Electrical troubleshooting of any 12 Volt power connection can also be performed through voltage drop tests without disconnection of the component.

Ignition Key Switch

The ignition (key) switch has three positions (OFF, START and RUN). The terminals are marked as shown in Figure 9.

The circuitry of the ignition switch is shown in the chart (Fig. 10). 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.

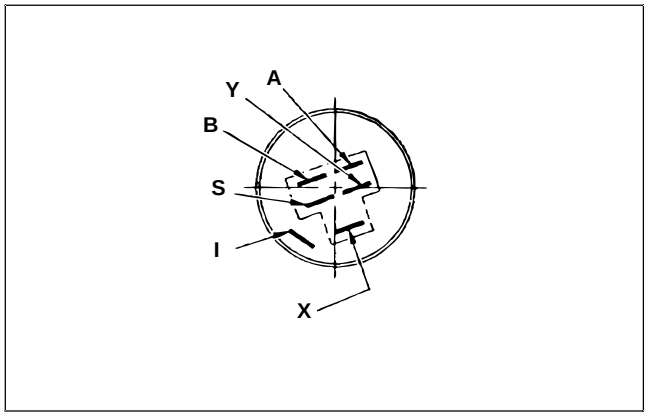


Figure 9

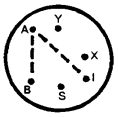
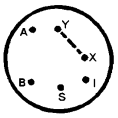
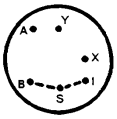
POSITION	CONTINUITY AMONG TERMINALS	OTHER CIRCUITS MADE
1. OFF	NONE	NONE
2. RUN	 B + I + A	 X + Y
3. START	 B + I + S	NONE

Figure 10

Electronic Control Unit (ECU)

The Toro electronic control unit (ECU) senses the condition of various switches, such as the seat switch, cutting unit down switches, traction neutral switch, etc., and directs power output to allow certain machine functions, such as engine run, cutting units engage, etc.

Because of the solid state circuitry built into the controller, there is no method to test it directly. The controller may be damaged if an attempt is made to test it with an electrical test device, such as a volt-ohm meter.

IMPORTANT: Before welding on the machine, disconnect both battery cables from the battery, disconnect both wire harness connectors from the electronic control unit and disconnect the terminal connector from the alternator to prevent damage to the electrical system.

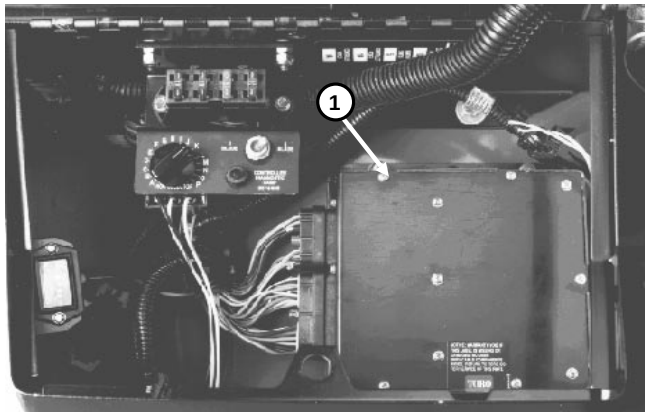


Figure 11

1. Electronic control unit (ECU)

Seat Switch

The seat switch is a proximity type, normally open (NO) reed switch that closes when the operator is on the seat. With the operator on the seat, the magnet on the bottom of the seat activates the reed switch causing it to close and complete the circuit.

1. Raise the seat to get access to the seat switch wiring connector.

2. Disconnect the seat switch wiring connector and install a continuity tester or ohm meter between the two leads of the seat switch.

3. Lower the seat. The continuity tester should show no continuity.

NOTE: Make sure the compression spring holds the seat up off the seat switch when there is no operator on the seat.

4. Have the operator sit on the seat, slowly depressing the seat switch magnet. The continuity tester should show continuity as the seat approaches the bottom of its travel.

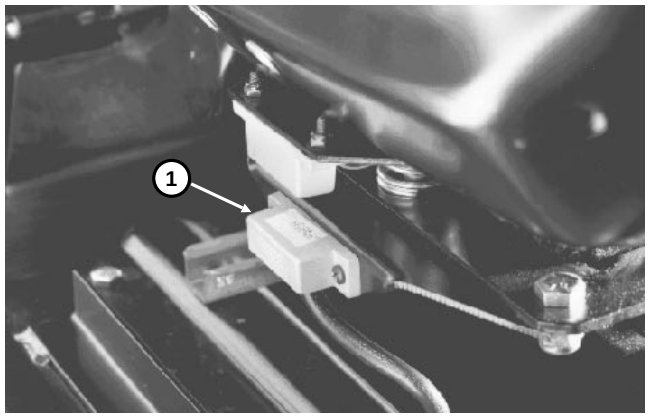


Figure 12

1. Seat switch

Traction (Neutral) Switch

The traction switch is a normally closed and opens when traction pedal is depressed in either direction. The switch is located on the right side of the hydrostatic 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 disconnecting the wires from the switch terminals and connecting a continuity tester across the two terminals that had wires connected to them. 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 opening and closing. Allow the traction pedal to return to neutral. There should be continuity across the terminals. (See Replacing the Traction Switch in the Repairs section of this chapter for replacement and adjustment procedures.)

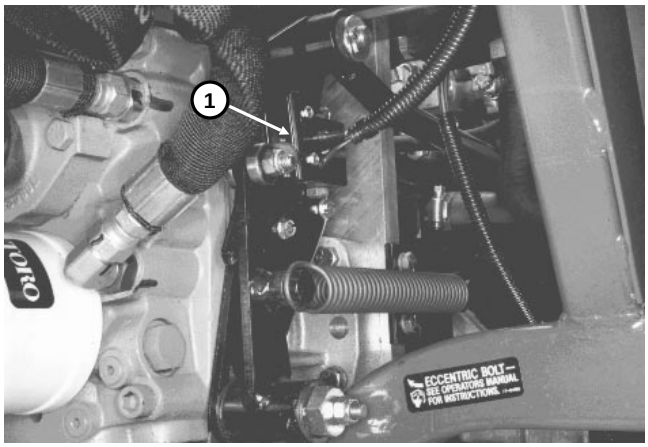


Figure 13

1. Traction (neutral) switch

Cutting Unit Down Switch

The cutting unit down switch is a normally open (NO) reed switch located on the left front lift arm that closes when the lift arm is in the lowered position. As the lift arm is lowered a magnet in the lift arm causes the reed switch to close and complete the circuit.

1. Disconnect the switch wire connector and install a continuity tester or ohm meter between the two leads of the switch.

2. With the lift arm in the lowered position the tester should show continuity. With the lift arm in the raised position, the tester should show no continuity.

NOTE: When the Enable/Disable switch is in the ENABLE position, the controller uses inputs from this switch to turn the cutting units on and off. When raising the cutting units with the Enable/Disable switch in ENABLE, the cutting units lift part way to a "turn around" position.

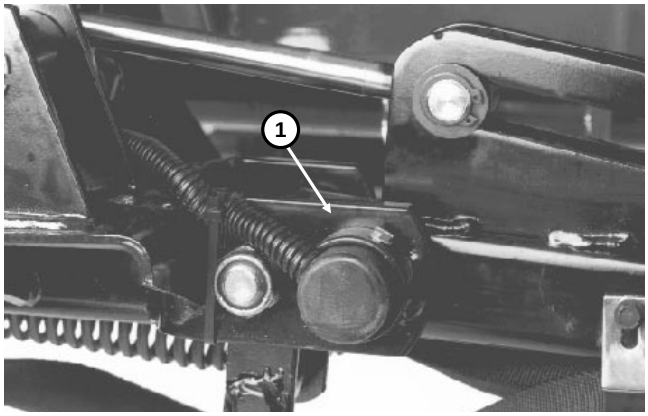


Figure 14

1. Cutting unit down switch

Lower-Mow/Raise Switches (Joystick)

The Lower-Mow/Raise Control has two (2) normally open (NO) switches, one for the Lower-Mow function and one for the Raise function. Each switch is normally open and closes when the joystick is moved (Fig. 15).

Test each switch by disconnecting the wiring connector from the switch and connecting a continuity tester across the two terminals of the switch being tested.

Lower-Mow Switch

With the engine turned off, move the joystick forward, then allow it to return to neutral while watching the continuity tester. There should be indications that the switch is opening and closing. With the joystick in the neutral position there should be no continuity across the terminals.

Lower-Mow Switch

With the engine turned off, move the joystick toward the rear, then allow it to return to neutral while watching the continuity tester. There should be indications that the switch is opening and closing. With the joystick in the neutral position there should be no continuity across the terminals.

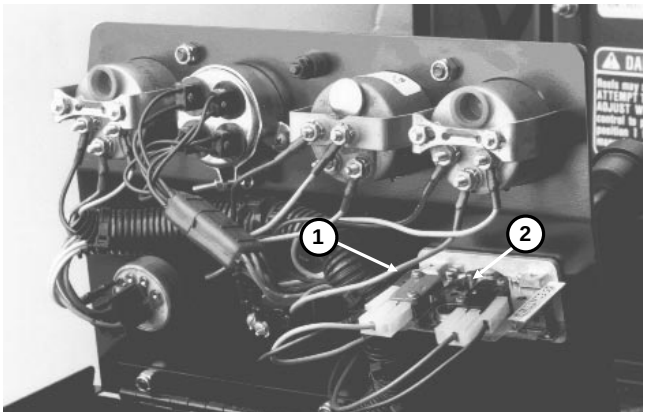


Figure 15

1. Lower-mow switch **2. Raise switch**

Enable/Disable Switch

Test the Enable/Disasble switch by disconnecting the wires from the switch and connecting a continuity tester across the terminals of the switch.

With the switch in the DISABLE position, the tester should show no continuity. With the switch in the ENABLE position, the tester should show continuity.

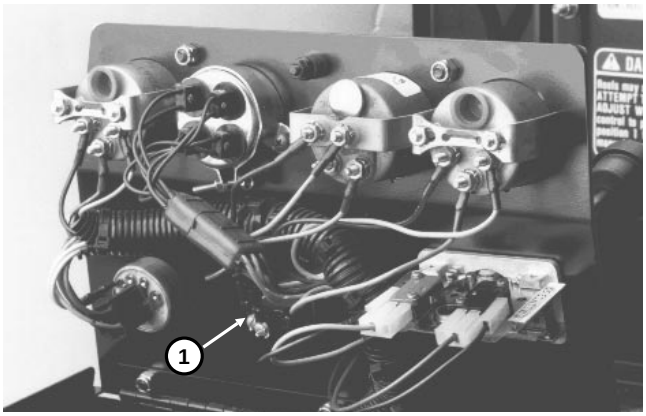


Figure 16

1. Enable/Disable switch

Backlap Switch

The Backlap switch is a three-way switch (Fig. 17). Test the switch by disconnecting the wires and connecting a continuity tester across terminals of switch.

With the switch OFF, the tester should show no continuity across terminals 4 – 5 or 5 – 6.

With the switch in the FRONT position (toward keyway), tester should show continuity across terminals 4 and 5.

With the switch in the REAR position (away from keyway), tester should show continuity across terminals 5 and 6.

Terminals on switch	Wire color
1	(Not used)
2	(Not used)
3	(Not used)
4	Blue
5	Black
6	White

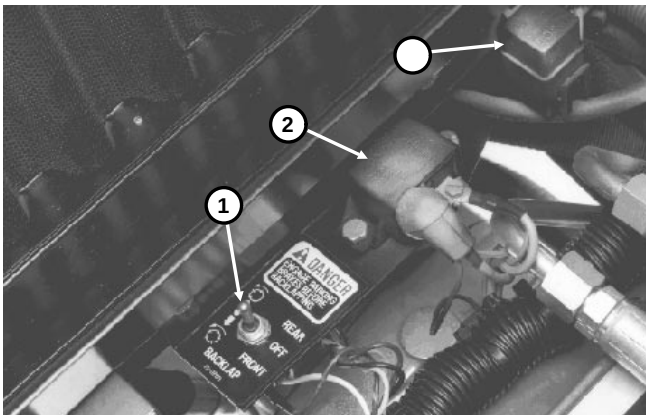


Figure 17

1. Backlap switch
2. Glow relay
3. Start relay

Start Relay

To test the start relay (Fig. 17), disconnect the relay wire connector and install a continuity tester between the relay terminals (terminals 30 and 87) (Fig. 18). The relay should make and break continuity at terminals 30 and 87 as 12 V.D.C. is connected and disconnected to terminal 85 with terminal 86 connected to ground.

Resistance specifications:

Terminals 85 and 86 = 80 to 90 Ohms

Terminals 30 and 87a (normally closed) = continuity

Terminals 30 and 87 (normally open) = continuity when 12V DC is applied to terminals 85 and 86

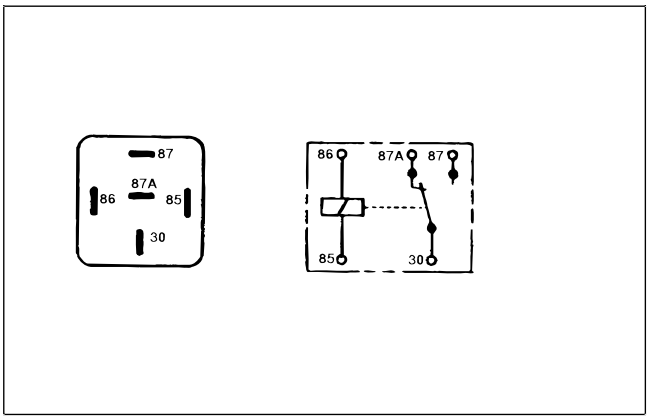


Figure 18

Glow Relay

To test the glow relay (Fig. 17), disconnect the relay wire connector and install a continuity tester between the relay terminals (terminals 30 and 87) (Fig. 19). The relay should make and break continuity at terminals 30 and 87 as 12 V.D.C. is connected and disconnected to terminal 85 with terminal 86 connected to ground.

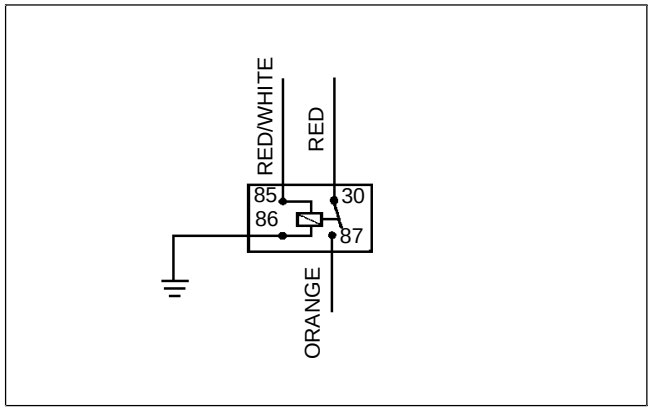


Figure 19

Battery

1. Use a volt-ohm meter to measure the voltage between the battery terminals.

2. If the voltage is less than 12.3 Volts D.C. , the battery should be charged.

NOTE: Regulated voltage will increase to 13.5 Volts when the engine is running.

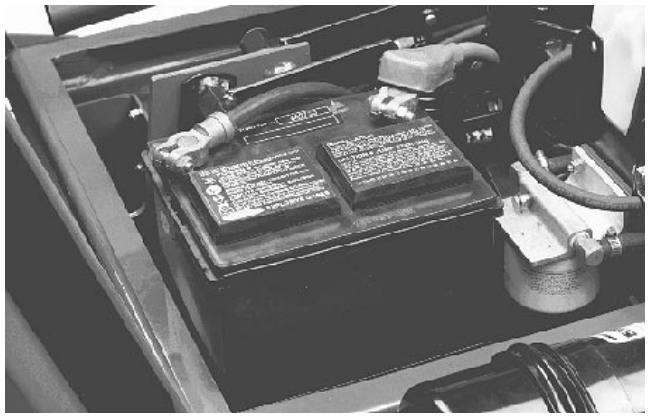


Figure 20

Fuel Stop (ETR) Solenoid

The Reelmaster® 5300-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. 21).

2. Connect a 12 volt battery so the positive (+) battery terminal is connected to terminals A (hold) and B (pull) (Fig. 22). Connect the negative (–) battery terminal to solenoid terminal C (common). The plunger should retract to the dimension shown.

IMPORTANT: Do not connect Voltage to 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 Chapter 3 - Engine.)

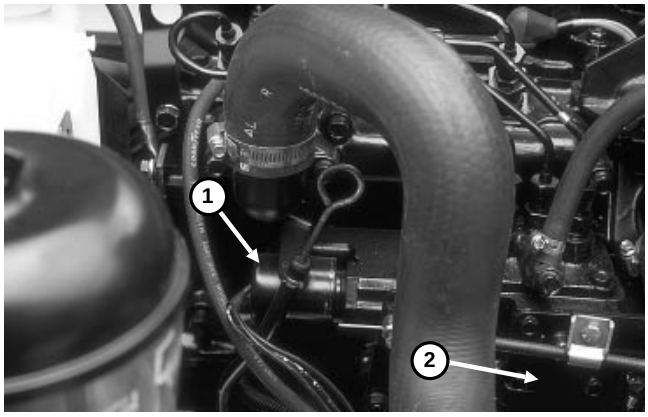


Figure 21

1. Fuel stop (ETR) solenoid
2. Governor tie rod cover

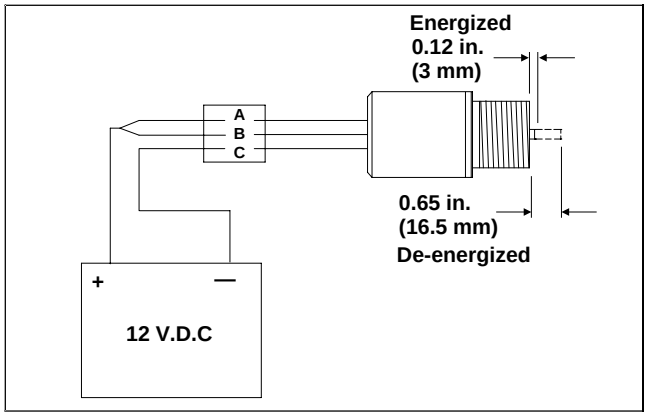


Figure 22

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.

NOTE: You can also test operation without removing the governor tie rod cover. Listen for an audible “click” as the solenoid extends and retracts while doing steps 2 and 3 of the above procedure. This will not show if the solenoid is adjusted correctly or if it is fully extending and retracting. (See Replacing and/or Adjusting the Stop Solenoid in the External Engine Component Repair section of Chapter 3 - Engine.)

Indicator Lights and Gauges

Diagnostic Lamp

The diagnostic lamp should come on when the ignition key switch is turned to the RUN position. If the lamp is ON, it indicates that the electronic control unit (ECU) is functioning normally. If this lamp is OFF, it indicates a lack of power to the ECU, or a disconnected loop-back connector. If this lamp is flashing ON and OFF, it indicates an output fault. If controller diagnostic lamp is flashing, immediately connect the diagnostic display (without turning off the key switch) and push input-output toggle switch on diagnostic display tool so "OUTPUTS DISPLAYED" LED is on. The flashing LED on the diagnostic display will indicate which output is faulted.

Test the lamp by disconnecting the wires and applying 12 V.D.C. between the lamp wiring terminals.

Reel Speed Light

The reel speed light should come ON when the cutting units are operating with the machine not moving. When the light is ON, it indicates that the machine is being operated in a way in which the automatic reel speed control cannot obtain the desired clip.

Test the lamp by disconnecting the wires and applying 12 V.D.C. between the lamp wiring terminals.

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 lamp wiring 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 lamp wiring 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 lamp wiring 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^o F (108^{o}C).

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 connecting a 12 volt battery so the positive (+) battery terminal is connected to the positive terminal on the hourmeter. Connect the negative (–) battery terminal to the negative (–) terminal on the alternator. The hourmeter should operate as 12 V.D.C. is applied between the terminals.

Temperature Gauge, Fuel Level Gauge and Speedometer

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.

Fuel Gauge Sender

1. Disconnect wire and remove the fuel gauge sender from the fuel tank.

2. Install an ohm meter between the terminal and base.

3. With arm completely down (empty position), resistance should be 240-260 ohms.

4. With arm completely up (full position), resistance should be 29-34 ohms.

NOTE: Bend float arm, if necessary, to get proper gauge reading for a 1/2 full tank.

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.

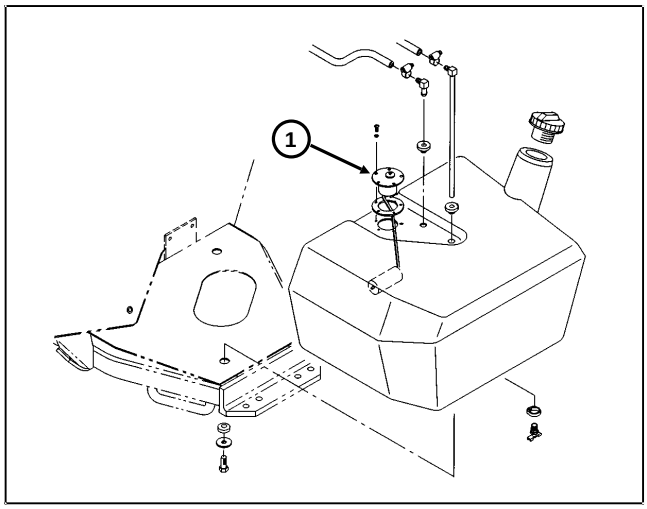


Figure 23

1. Fuel gauge sender

Hydraulic Valve Block Solenoids

1. Disconnect the wire connector.

2. Connect a 12 volt battery so the positive (+) battery terminal is connected to colored solenoid lead. Connect the negative (–) battery terminal to black lead. The valve spool should retract completely as 12 V.D.C is applied between leads.

3. If valve spool does not retract check for binding or damage in valve.

4. If valve operates smoothly, but does not retract when 12 V.D.C is applied to solenoid leads, replace solenoid coil.

5. If valve still does not retract after replacing solenoid coil, replace the valve.

NOTE: To to a quick test without removing solenoid valve, hold a screwdriver to top of affected valve. When solenoid is energized, screw driver should be attracted to valve stem, due to magnetism from energized solenoid. This test will not identify a sticking valve spool.

Resistance specifications:

20 Watt solenoid:7.2 Ohms

28 Watt solenoid: 5.1 Ohms

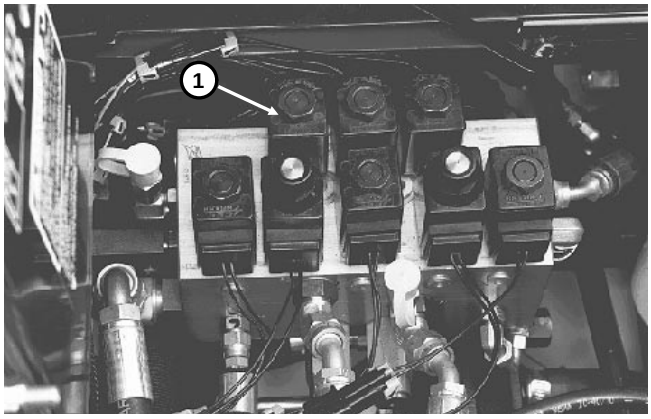
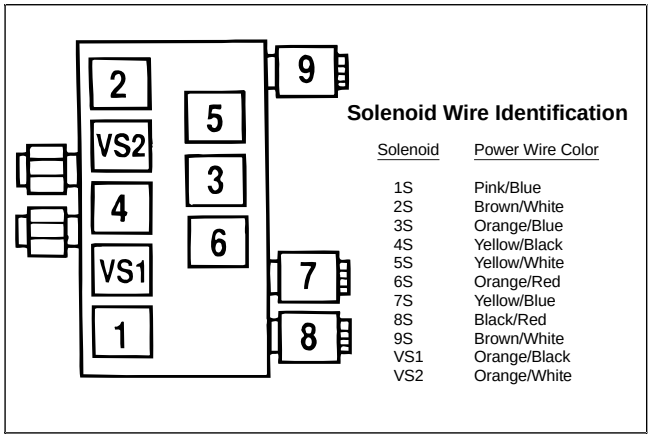


Figure 24

1. Solenoid



Solenoid Wire Identification

Solenoid	Power Wire Color
1S	Pink/Blue
2S	Brown/White
3S	Orange/Blue
4S	Yellow/Black
5S	Yellow/White
6S	Orange/Red
7S	Yellow/Blue
8S	Black/Red
9S	Brown/White
VS1	Orange/Black
VS2	Orange/White

Figure 25

Repairs

IMPORTANT: Before welding on the machine, disconnect both battery cables from the battery, disconnect both wire harness plugs from the electronic control unit and disconnect the terminal connector from the alternator to prevent damage to the electrical system.

Battery Service

IMPORTANT: To prevent damage to the electrical components, do not operate the engine with the battery cables disconnected.

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 for loose battery hold-downs. 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. 27). 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.

CAUTION

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.

Electrolyte Specific Gravity

Fully charged: 1.250 - 1.280
Discharged: less than 1.240

Battery Specifications

BCI Group 26 SMF–5 Battery:
530 Amp Cranking Performance at 0° F (–17 ° C)
85 min. Reserve Capacity at 80° F (27 ° C)

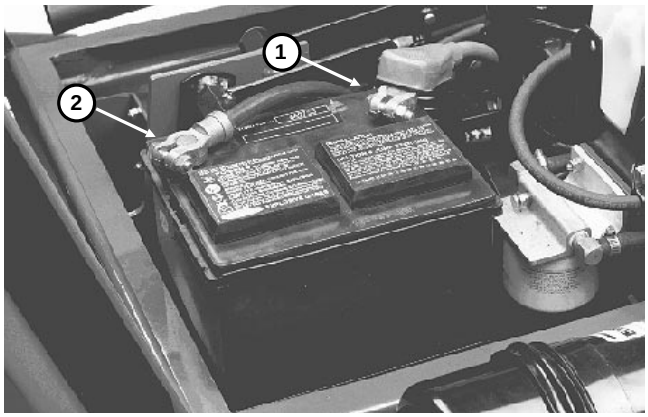


Figure 26

1. Positive (+) terminal
2. Negative (–) terminal

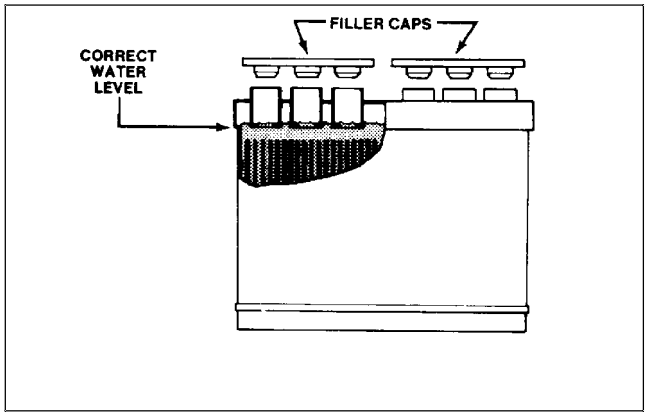


Figure 27

Fuses

The electrical system is protected by fuses located under the control panel to the operator's right (Fig. 28, 29).

NOTE: It is not always possible to see if a fuse is faulty. It is recommended that you check for faulty fuses with a continutiy tester, not visually.

The electrical system is also equipped with thermal circuit breakers. The thermal circuit breakers automatically reset when allowed to cool.

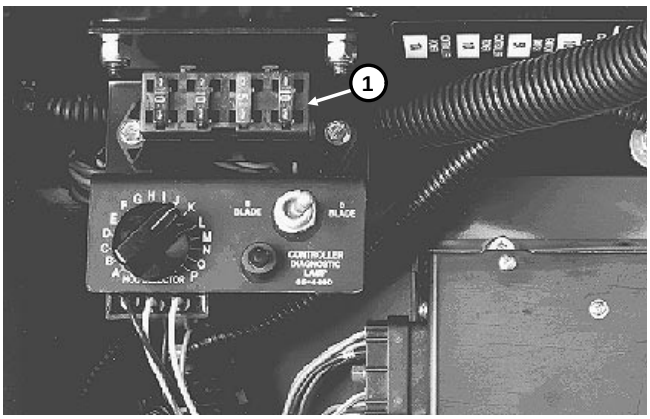


Figure 28a
(Model 03530, S/N Below 51001
Model 03531, S/N Below 50301

1. Fuses

Figure 28b
(Model 03530, S/N 51001 & Up
Model 03531, S/N 50301 & Up)

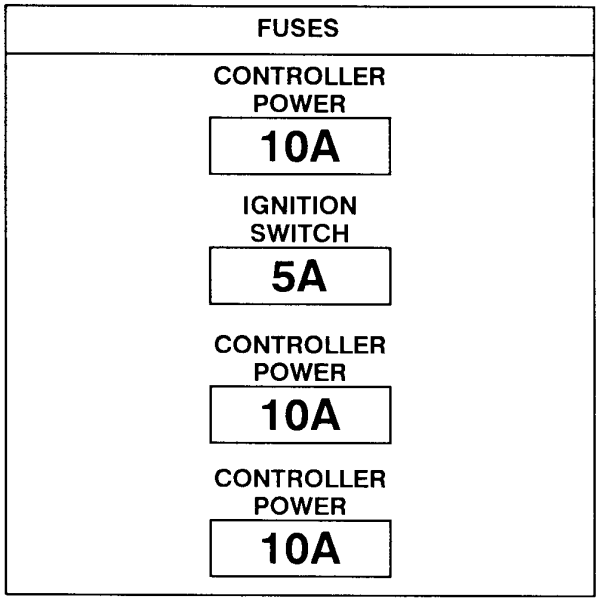


Figure 29a
(Model 03530, S/N Below 51001
Model 03531, S/N Below 50301

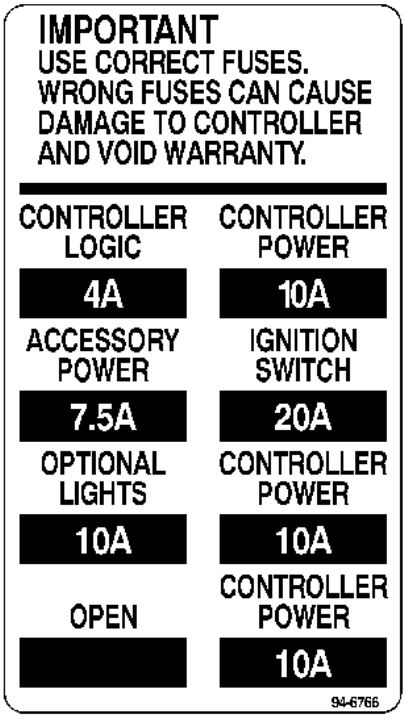


Figure 29b
(Model 03530, S/N 51001 & Up
Model 03531, S/N 50301 & Up)

Traction (Neutral) Switch Replacement

1. Remove the two wires that are connected to the traction switch (Fig. 30).

2. Have a helper push the traction pedal down into either the FORWARD or REVERSE position; this will take the switch arm tension off of the switch. Loosen two (2) screws and remove the switch.

3. Install new switch. DO NOT over-tighten screws as the switch case could break.

NOTE: Have a helper hold the traction pedal down while installing the switch.

4. 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” (NO) 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.

5. Coat the switch terminals and wires with skin-over grease.

6. Check traction control neutral adjustment. (See Traction Control Neutral Adjustment in the Adjustments section of Chapter 4 - HYDRAULIC SYSTEM.

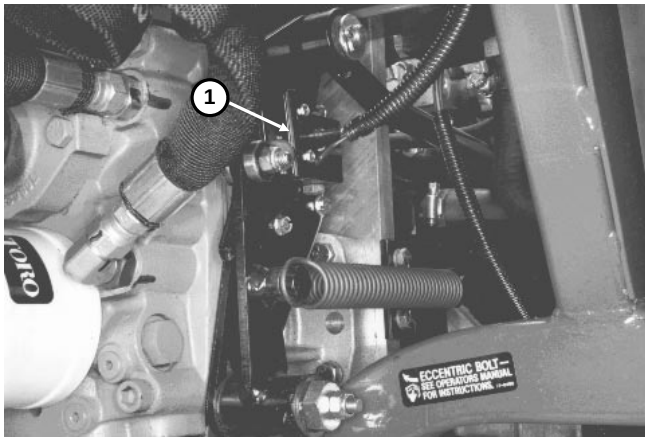


Figure 30

1. Traction (neutral) switch

Electronic Control Unit (ECU) Replacement

IMPORTANT: Before welding on the machine, disconnect both battery cables from the battery, disconnect both wire harness connectors from the ECU and disconnect the terminal connector from the alternator to prevent damage to the electrical system.

1. Stop the engine.

2. Remove nuts securing ECU to frame.

3. Loosen nuts on wiring connectors with a 1/4" nut driver, then disconnect wiring connectors from ECU (Fig. 31).

4. Remove ECU.

5. To install ECU, connect wiring connectors to ECU, then tighten nuts on wiring connectors. Secure ECU to frame with nuts removed in step 2.

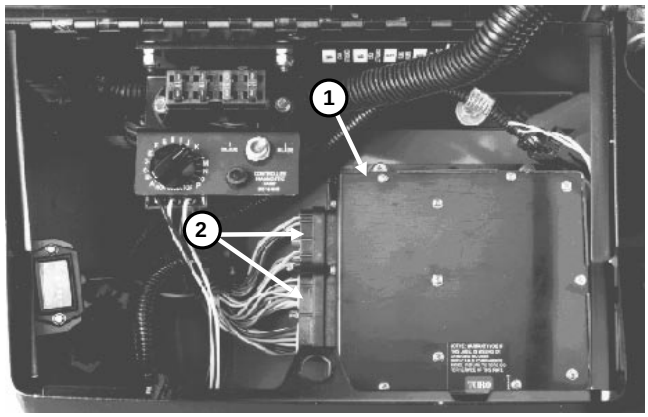


Figure 31

1. Electronic control unit (ECU)
2. Wiring connectors

Solenoid Valve Coil Replacement

1. Park machine on a level surface, engage parking brake, lower the cutting units and turn engine OFF.

2. Disconnect solenoid electrical connector.

3. Remove nut from solenoid.

4. Remove solenoid coil.

5. Install new solenoid coil, Make sure O-ring is installed at each end of coil. Apply “Locktite 242" or equivalent to threads on end of stem tube before installing nut. Tighten nut to a torque of 15 in-lb. Over-tightening may damage the solenoid or cause the solenoid valve to malfunction.

6. Connect electrical wiring connector.

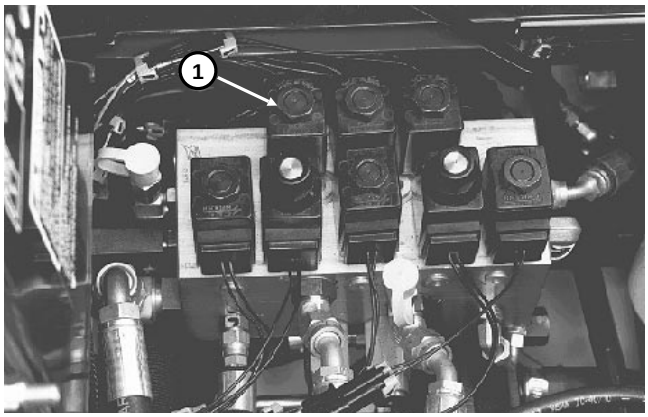
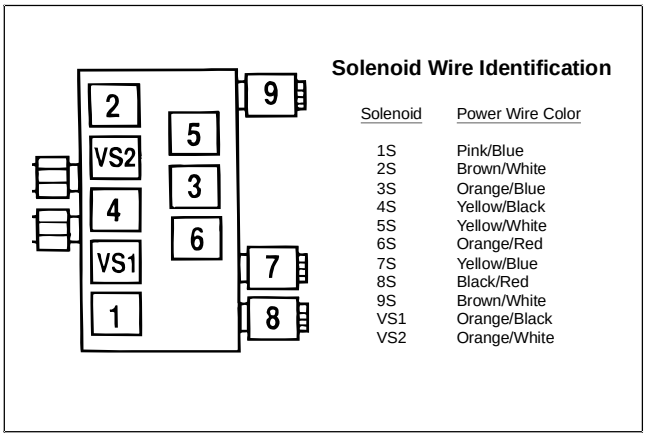


Figure 32

1. Solenoid



Solenoid Wire Identification

Solenoid	Power Wire Color
1S	Pink/Blue
2S	Brown/White
3S	Orange/Blue
4S	Yellow/Black
5S	Yellow/White
6S	Orange/Red
7S	Yellow/Blue
8S	Black/Red
9S	Brown/White
VS1	Orange/Black
VS2	Orange/White

Figure 33

Speedometer Sensor Installation

To install speedometer sensor:

1. If axle cover plate was not removed, go to step 9.

2. Lubricate and install O-ring into plate.

3. Apply silicone sealant to face of plate where it will contact cover.

4. Install plate to inside face of cover, then install capscrew and lockwasher through cover into plate.

5. Install machine screw throught plate and cover, then install locknut to machine screw.

6. Tighten capscrew and locknut to secure plate to cover.

7. Install jam nut onto long machine screw until near lock nut.

8. Install plate and cover assembly to axle assembly using silicone sealant to seal cover to axle, then install eight (8) screws to secure cover.

9. Lubricate and install O-ring if not done in step 2 above.

10. Insert sensor into hole in cover with hole in sensor going over long machine screw, and push sensor in until it contacts axle gear.

11. Thread jam nut out until is contacts sensor. Turn jam nut one more turn out from this point (this pulls sensor out slightly).

12. Install other locknut to machine screw and tighten to secure sensor in position.

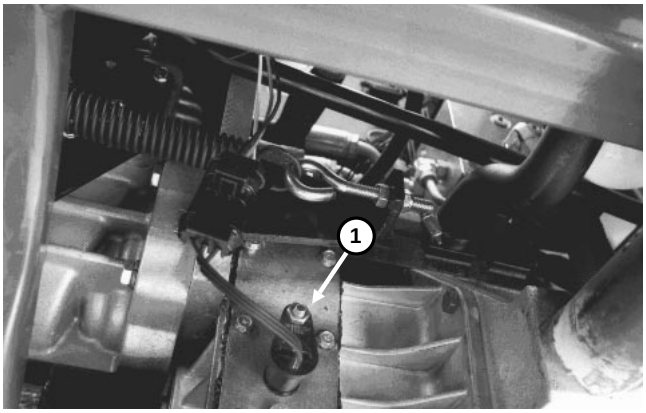


Figure 34

1. Speedmeter sensor

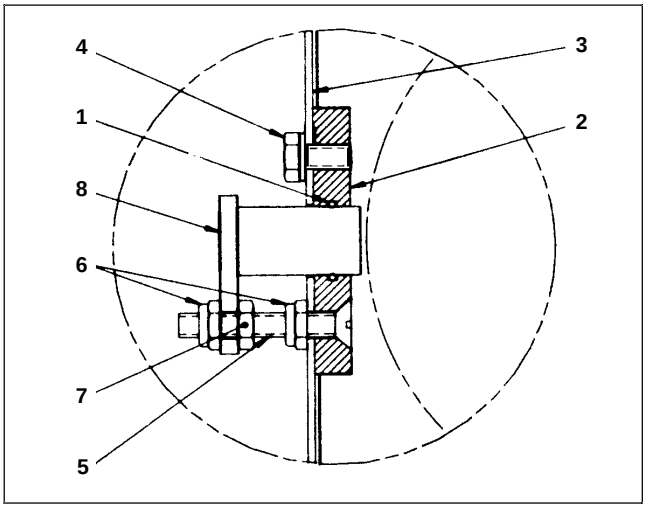


Figure 35

1. O-ring
2. Plate
3. Cover
4. Capscrew & lockwasher
5. Machine screw
6. Locknut (2)
7. Jam nut
8. Sensor

Reel Speed Sensor Installation

Reel speed sensors are located on the left front and left rear cutting units.

1. Thread reel speed sensor into sensor holder until dimension shown in Figure 36 is attained. Lock adjustment with two (2) jam nuts.

2. Align mounting holes and insert sensor and holder into hole in top of counterweight.

3. Secure sensor holder to counterweight with 1/4-20 x 3/4" capscrew.

4. Install magnet on end of reel shaft through opening in end of counterweight with a 3/8-16 x 1" capscrew. Install magnet so counterbore faces towards end of reel shaft and smooth side faces out. Tighten capscrew securing magnet to a maximum torque of 5 ft-lb.

IMPORTANT: Over tightening capscrew securing magnet will damage magnet and cause sensor to malfunction.

5. Install cap plug into end of counterweight.

6. Route front sensor wire across carrier frame cross tube, up the pull arm and connect to wiring harness above front cutting unit lift cylinders.

7. Route rear sensor wire across carrier frame cross tube, up the pull arm and connect to wiring harness connector near engine fuel stop (ETR) solenoid.

8. Use cable ties to secure sensor wires to carrier frame cross tubes and hydraulic hoses.

IMPORTANT: Make sure sensor wires do not hang where they could come in contact with hot or moving parts or interfere with operator getting on or off machine.

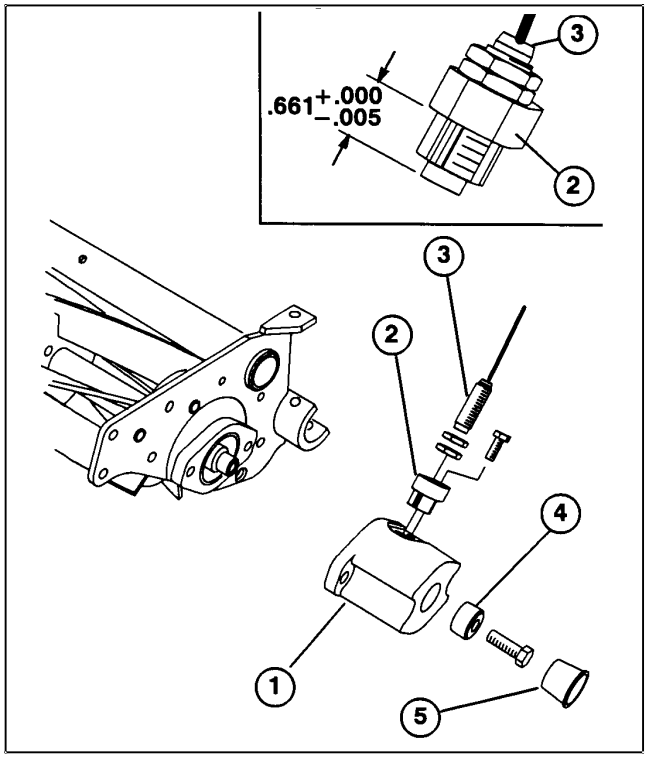


Figure 36

1. Counterweight
2. Sensor holder
3. Sensor
4. Magnet
5. Cap plug

Chapter 6

Differential Axle

Table of Contents

Introduction

The Reelmaster® 5300-D uses a Dana Hydrostatic Axle, model GT-20. The differential and axle form the final drive of the power train (Fig. 1).

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. 1A).

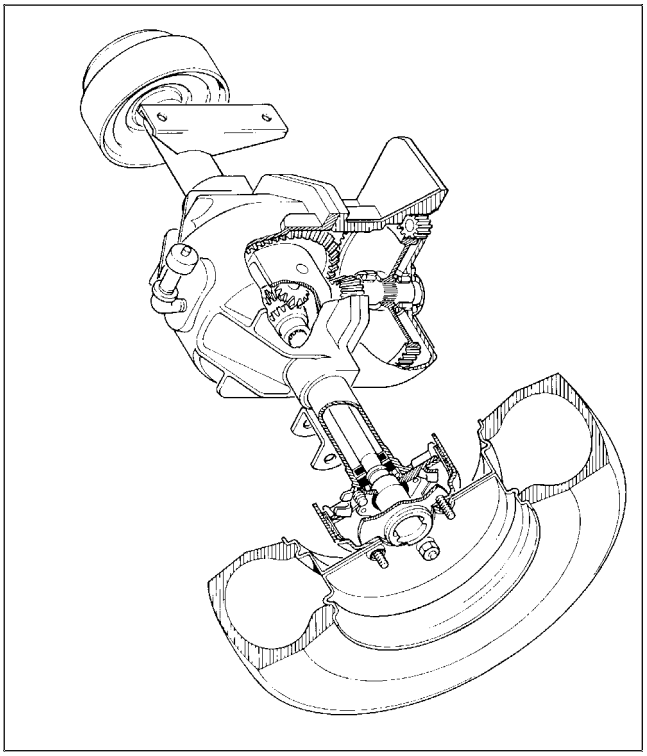


Figure 1

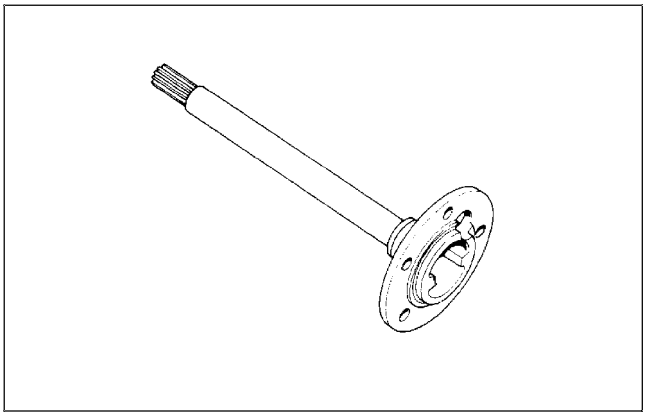


Figure 1A

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 pinion coupler for 4WD drive shaft.

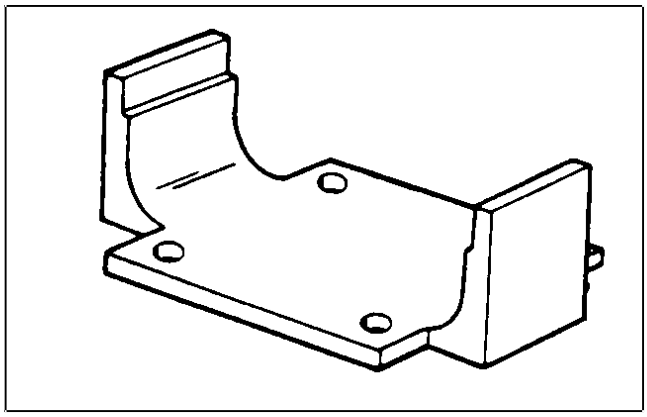


Figure 2

Axle Removal and Installation

1. Put machine on a level surface, lower cutting units, stop the engine and remove key from ignition switch. Block rear wheels to prevent machine from moving.

2. Remove the cutting units. (See the Repairs section of Chapter 8 - Cutting Units.)

3. If unit is equipped with 4WD, remove rear axle drive shaft (see Chapter 9 - 4WD Axle). Remove nut, pinion spacer and pinion coupler.

5. Remove hydrostatic transmission. (See Repairs section of Chapter 4 - Hydraulic System.) Keep transmission support attached to frame and gear pump attached to transmission support.

6. Slightly loosen all front wheel lug nuts. Jack both front wheels off the ground and install jackstands or blocks under traction unit frame (not axle tubes) to prevent machine from falling. Remove both front wheels.

7. Remove the cotter pin and clevis pin to disconnect the brake cable from brake actuating lever on each brake. Loosen jam nut to remove brake cable from each end of axle bracket. Disconnect speedometer sensor wire connector.

9. Put a jack or blocking under differential to hold it in place. Remove cap screws and lock nuts securing axle mounting pads to frame. Carefully lower differential axle and pull it out from under traction unit.

10. To install axle , reverse steps 1 - 9. Apply silicone sealant between axle housing and transmission support. Leave axle mounting pad nuts loose. Install shims (P/N 42-6080) between axle mounting pads and frame to align differential with transmission support, then tighten axle mounting nuts.

11. Before installing pinion coupler, apply Permatex No. 2 to external splines of pinion and internal splines of pinion coupler. Tighten nut securing pinion coupler. Tighten nut to 75 - 90 ft-lb (102 - 122 N-m)

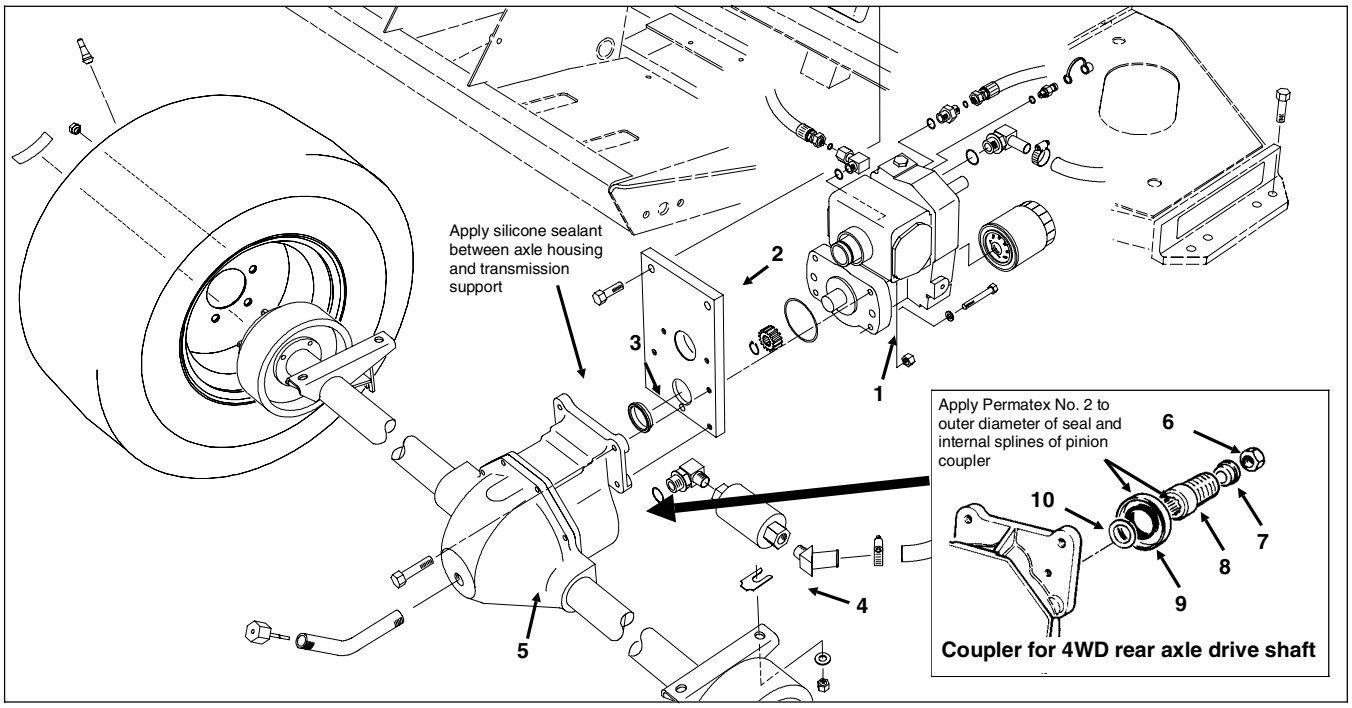


Figure 3

1. Hydrostatic transmission
2. Transmission support
3. Transmission collar
4. Axle shim
5. Differential axle
6. Nut
7. Spacer
8. Pinion coupler
9. Seal
10. Shim

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).

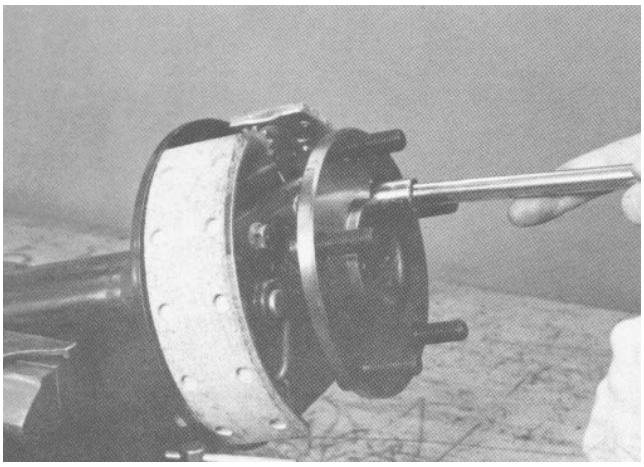


Figure 6

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.

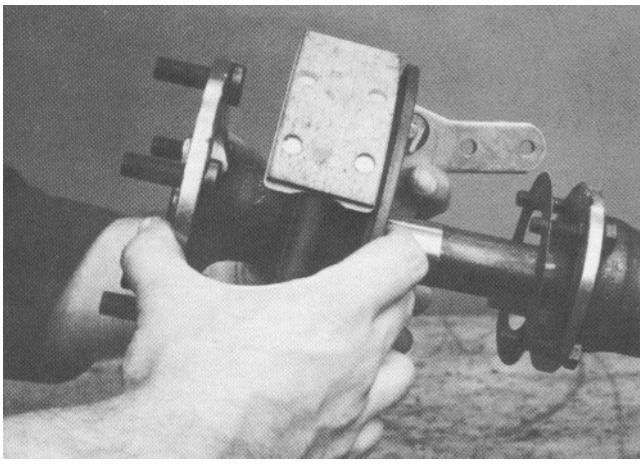


Figure 7

4. Remove the inner axle shaft seal (Fig. 8). Discard the seal and replace with a new one at the time of assembly.

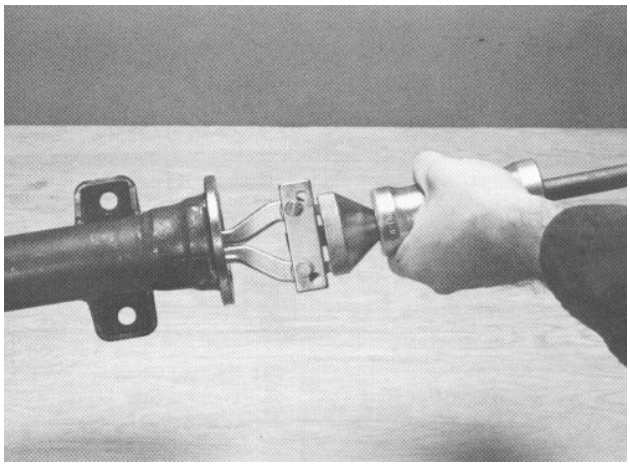


Figure 8

5. Center punch the outside of the retaining ring (Fig. 9).

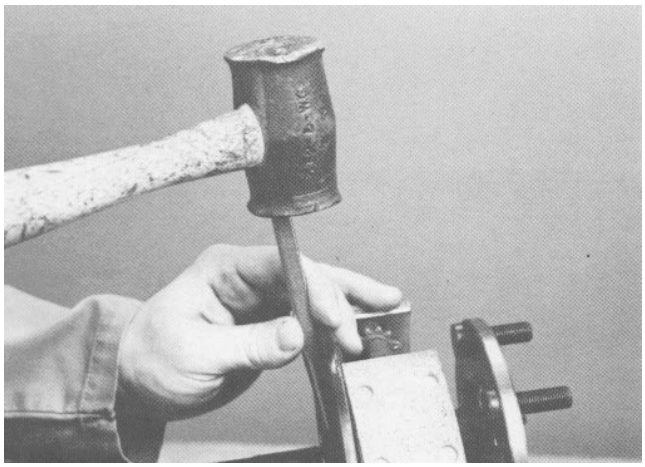


Figure 9

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.

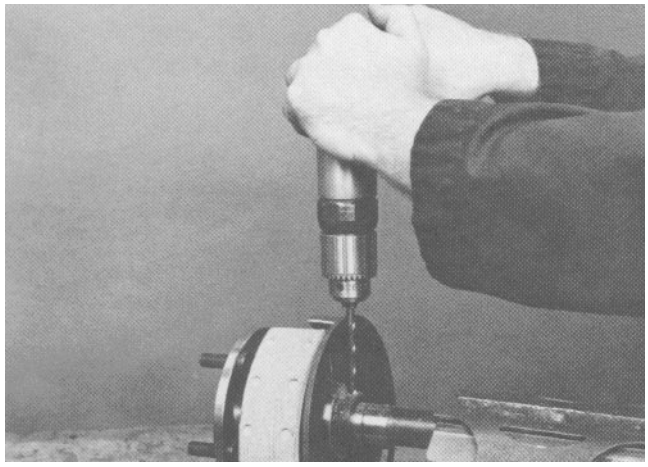


Figure 10

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.

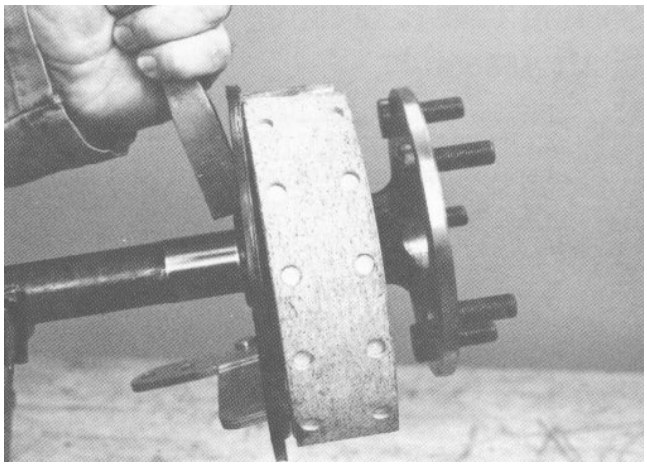


Figure 11

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.

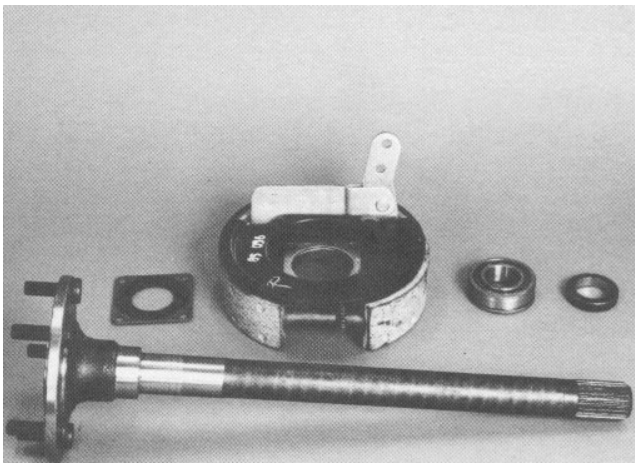


Figure 12

10. Press the assembly until the bearing is firmly seated against the axle shaft shoulder (Fig. 13).

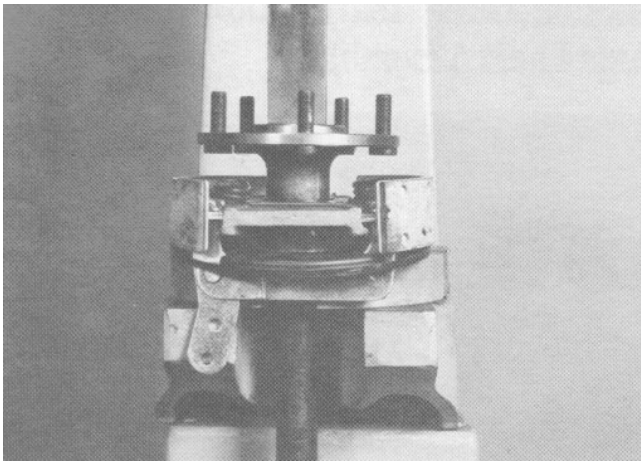


Figure 13

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.

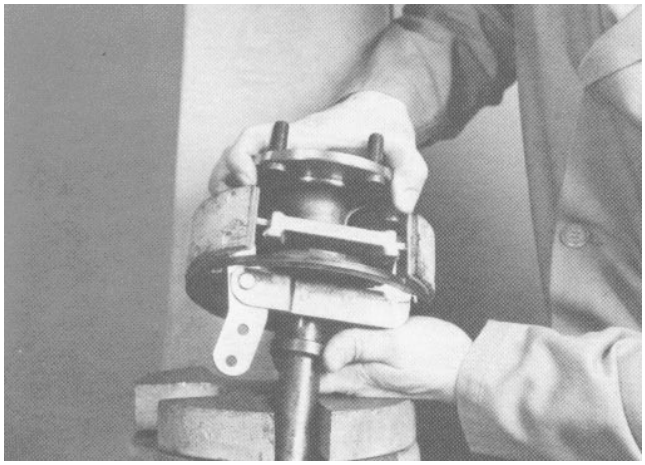


Figure 14

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.

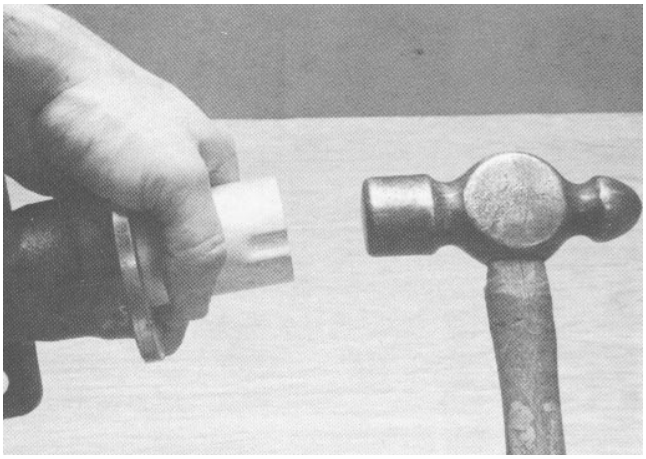


Figure 15

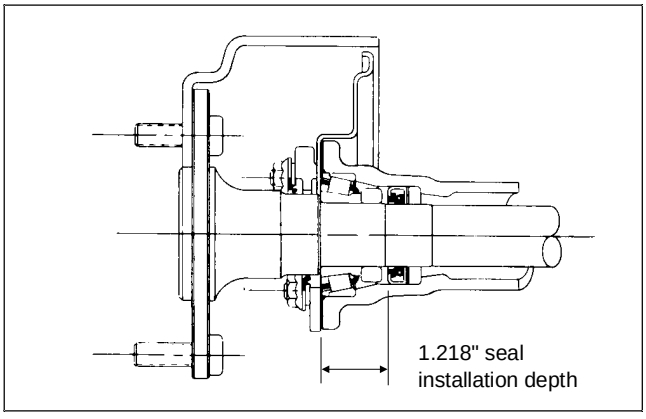
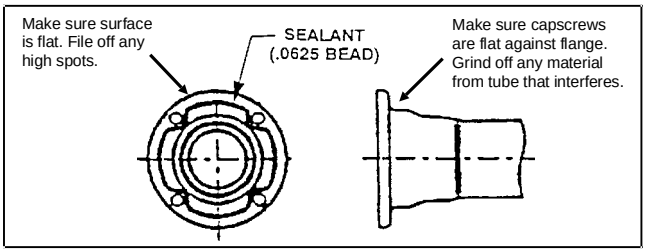


Figure 16

13. Assemble the bearing retainer bolts to the axle housing. Apply a .0625 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)



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 17

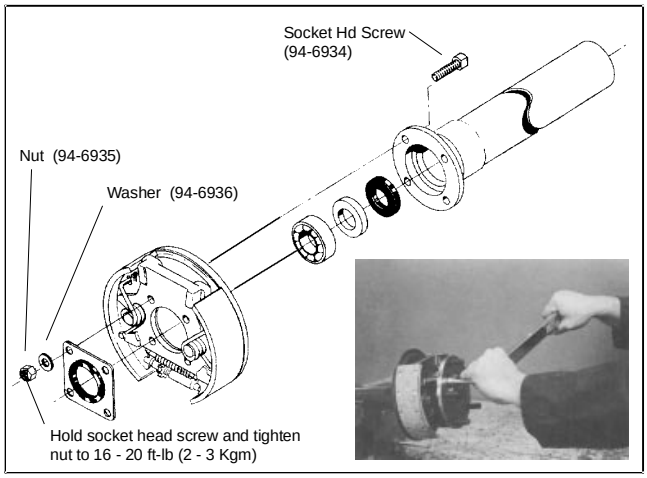


Figure 18

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 establilsh the correct contact pattern between the ring and pinion gears.

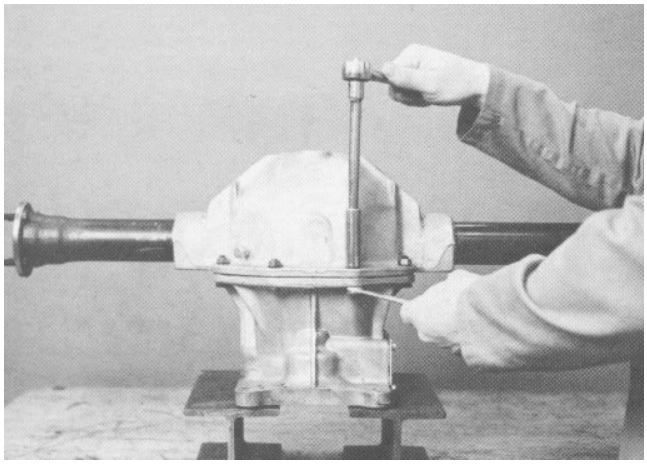


Figure 19

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.

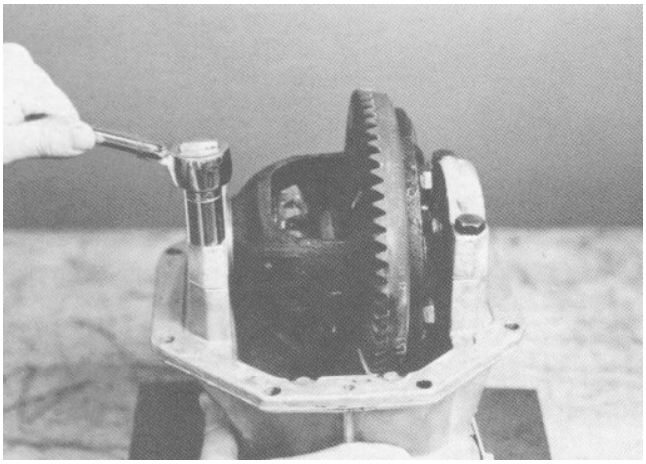


Figure 20

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).

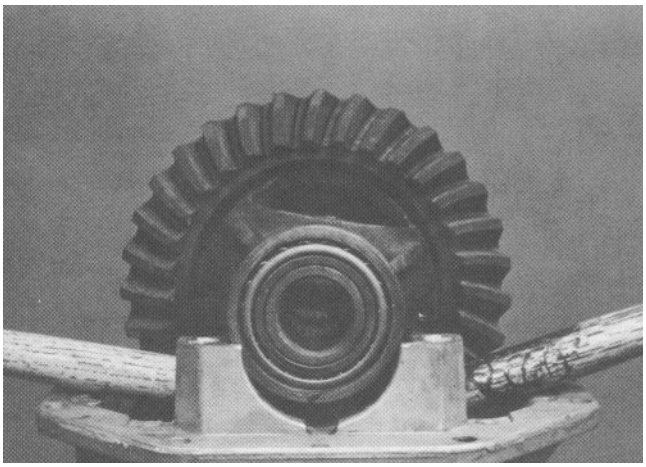


Figure 21

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.

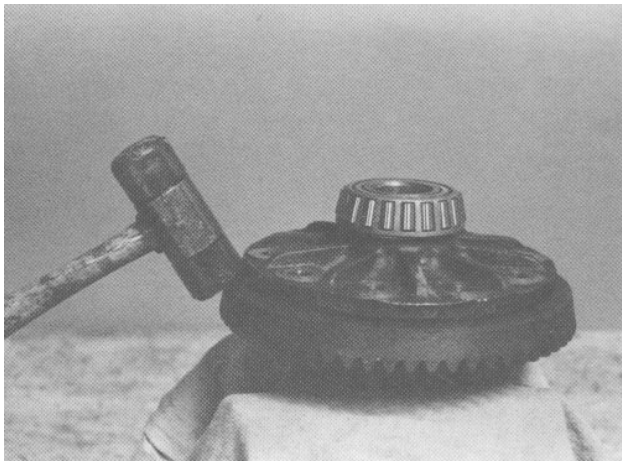


Figure 22

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).

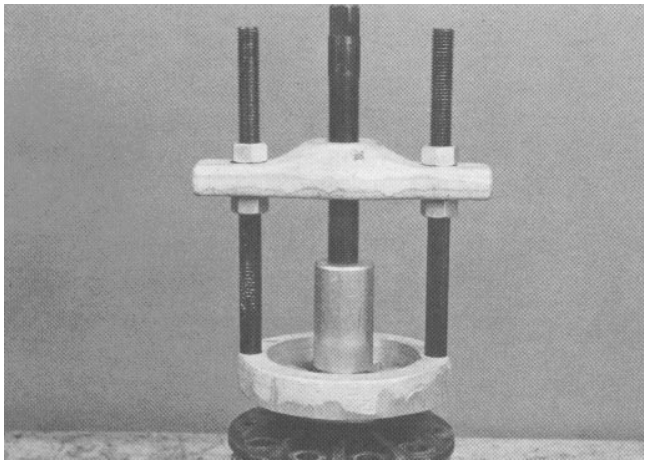


Figure 23

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.

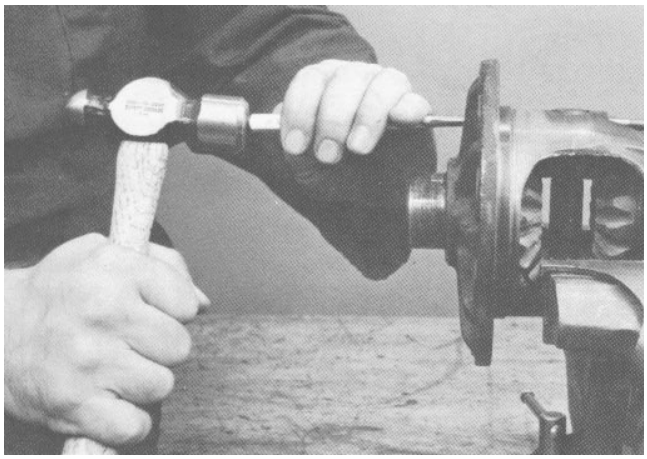


Figure 24

7. While supporting the differential in a vise, drive the pinion mate shaft from the differential with a long drift punch (Fig. 25).

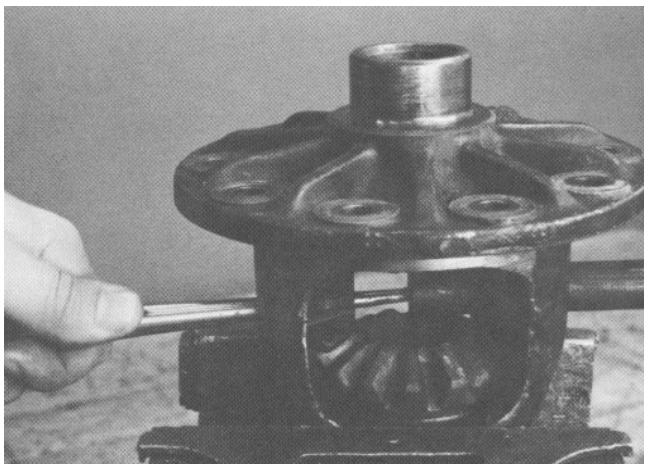


Figure 25

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.

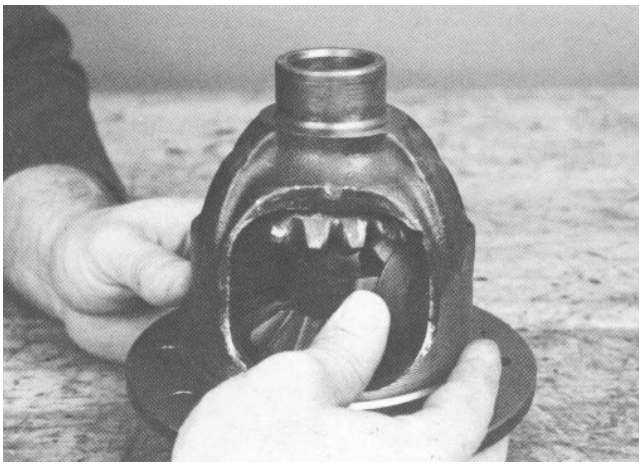


Figure 26

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.

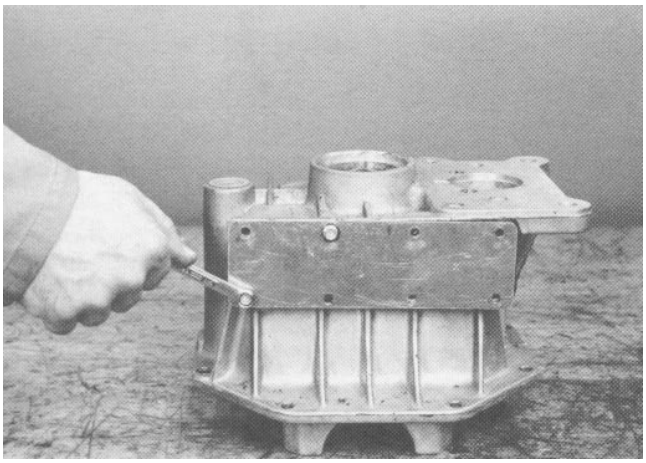


Figure 27

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).

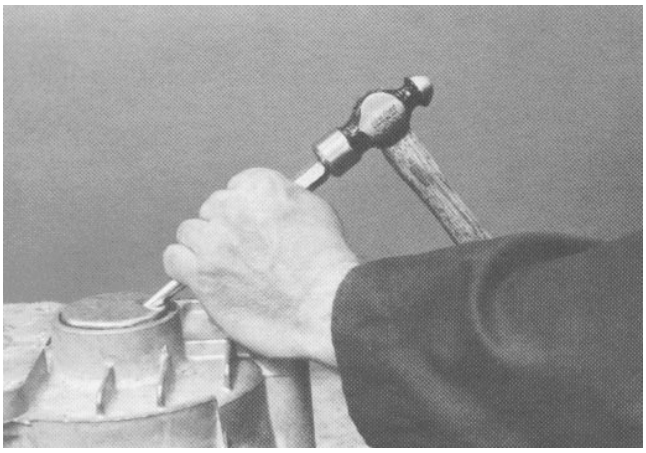


Figure 28

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 pinion coupler for 4WD (no expansion plug), nut, pinion spacer and pinion coupler (Fig. 3) must be removed before pressing pinion out of housing.

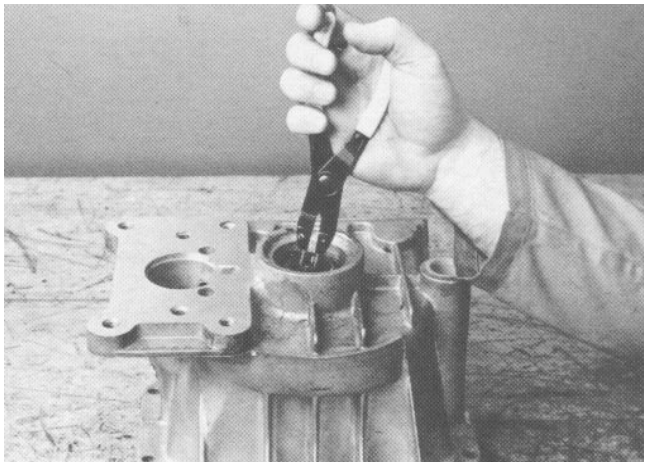


Figure 29

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.

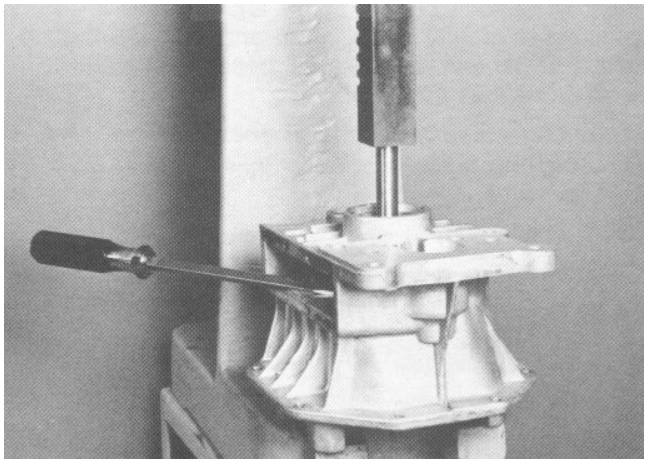


Figure 30

Removing the drive pinion releases the spur gear, spacer, and outer pinion bearing for removal (Fig. 31).

If unit was equipped with a pinion coupler for 4WD (no expansion plug), remove oil seal from housing (Fig. 3).

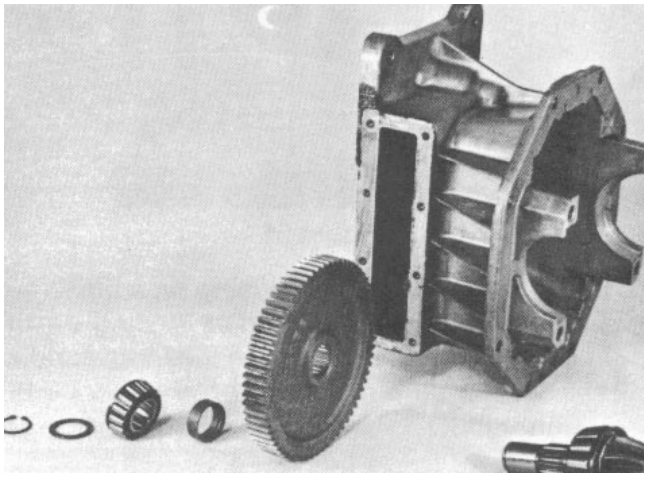


Figure 31

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.

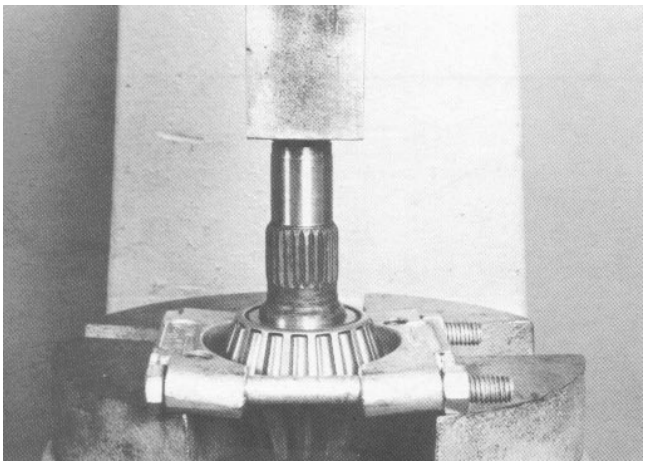


Figure 32

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).

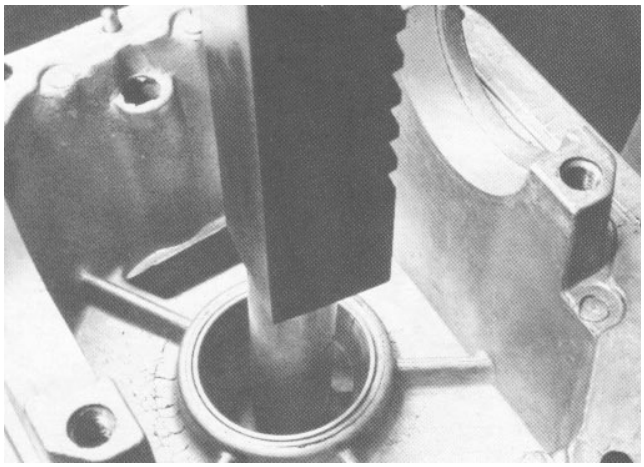


Figure 33

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.

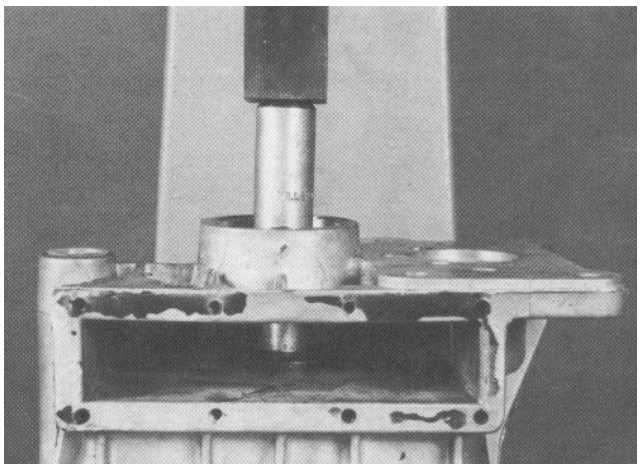


Figure 34

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).

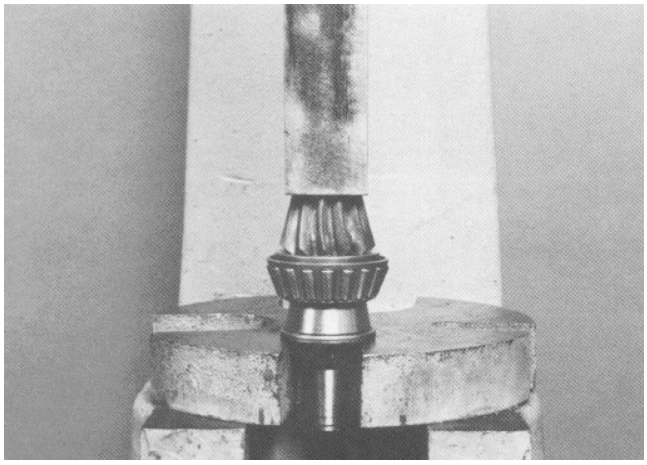


Figure 35

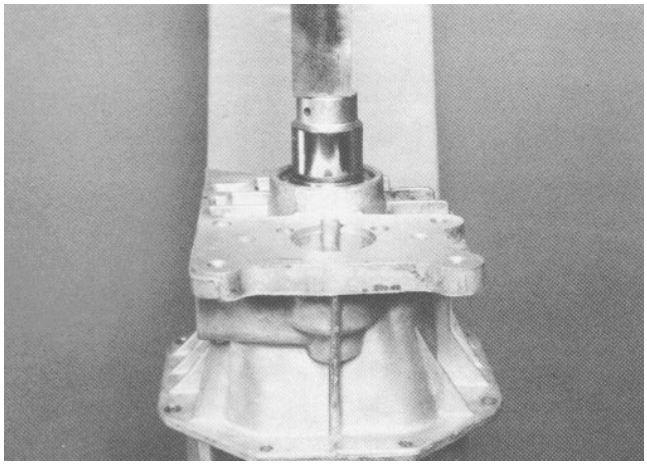


Figure 36

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.

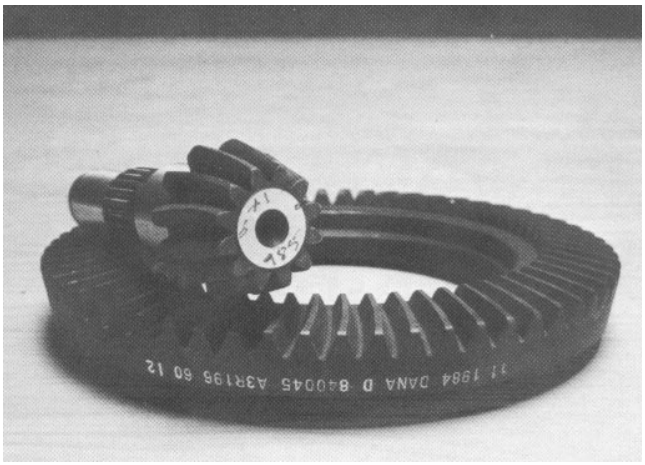


Figure 37

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).

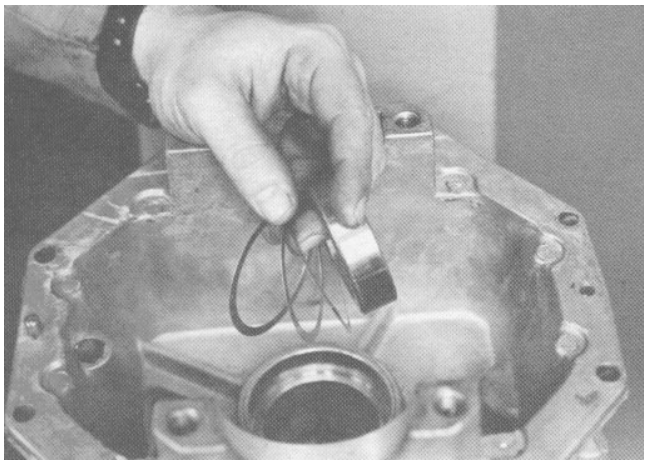


Figure 38

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.

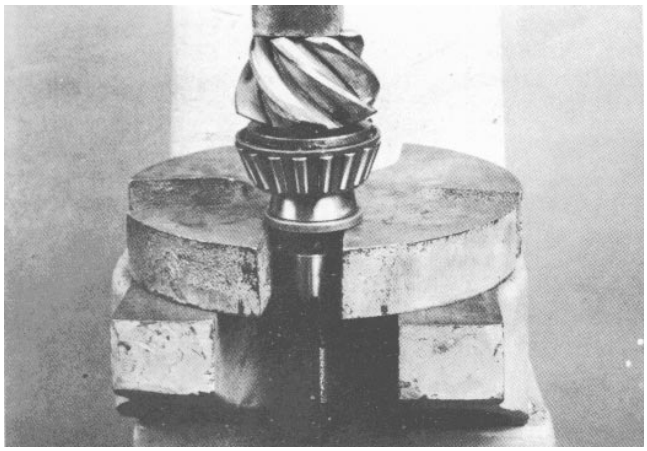


Figure 39

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).

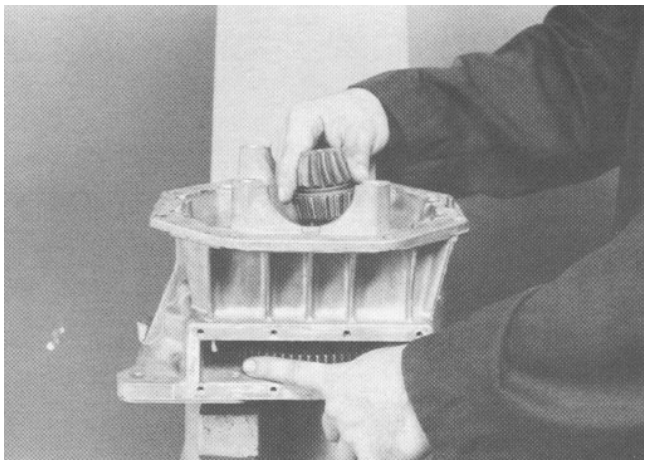


Figure 40

7. Support the drive pinion in a suitable press (Fig. 41).

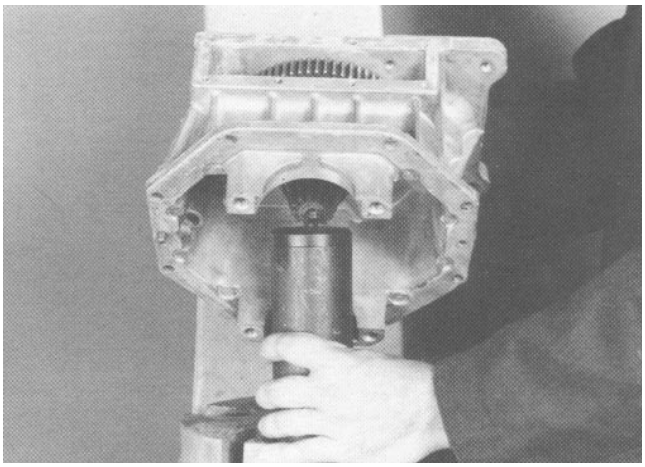


Figure 41

8. Install the outer pinion spacer with the chamfer towards the pinion splines and install the new outer pinion bearing cone (Fig. 42).

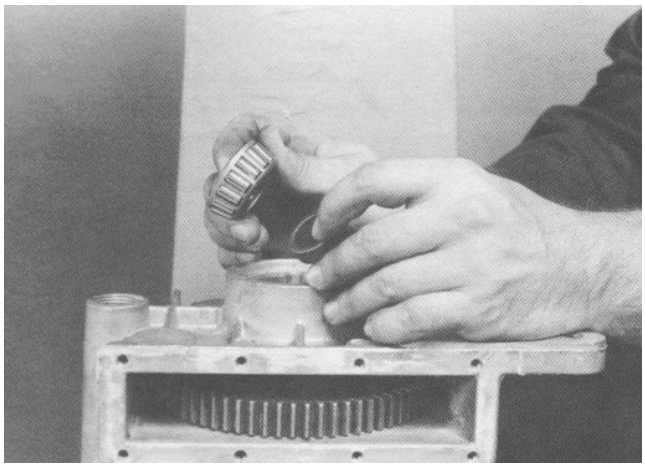


Figure 42

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.

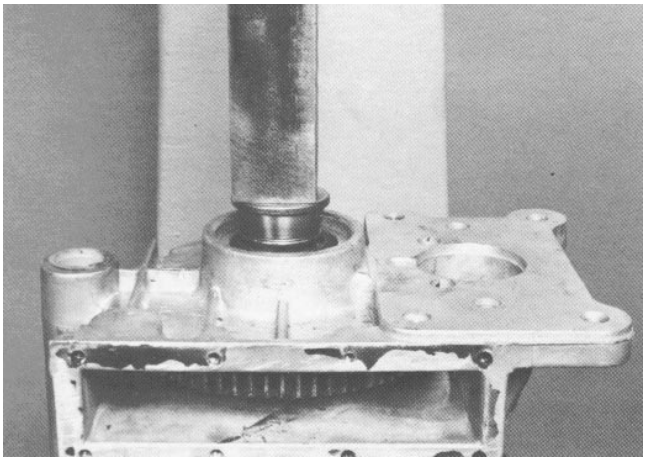


Figure 43

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).

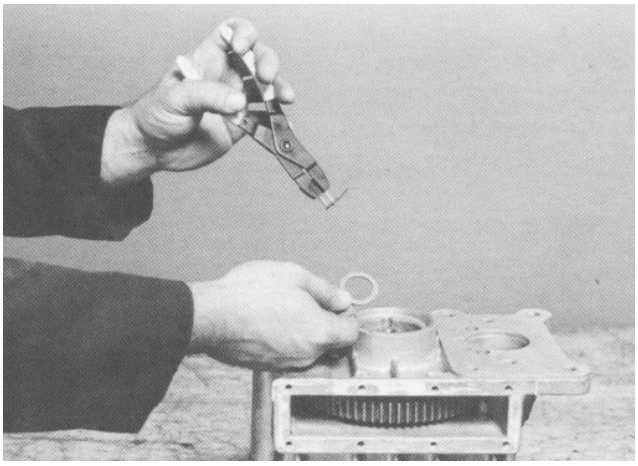


Figure 44

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 pinion coupler for 4WD) into carrier until plug or seal seats firmly in carrier bore (Fig. 45).

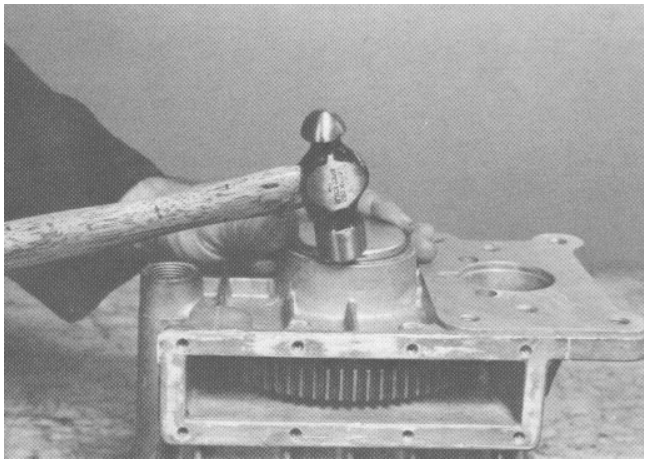


Figure 45

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).

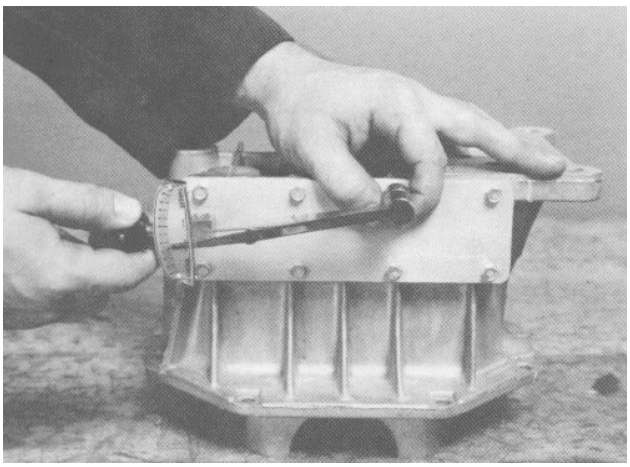


Figure 46

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.

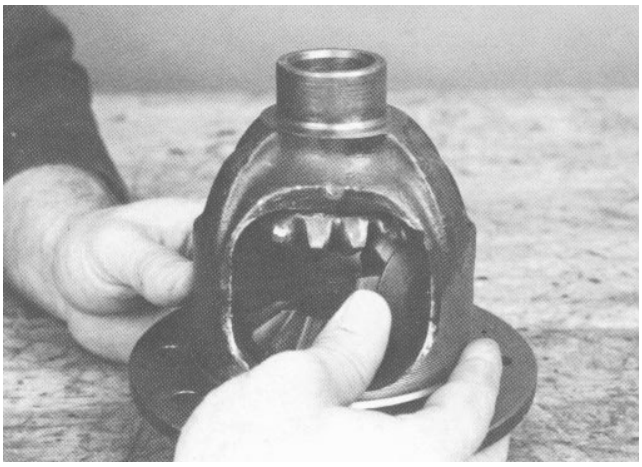


Figure 47

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).

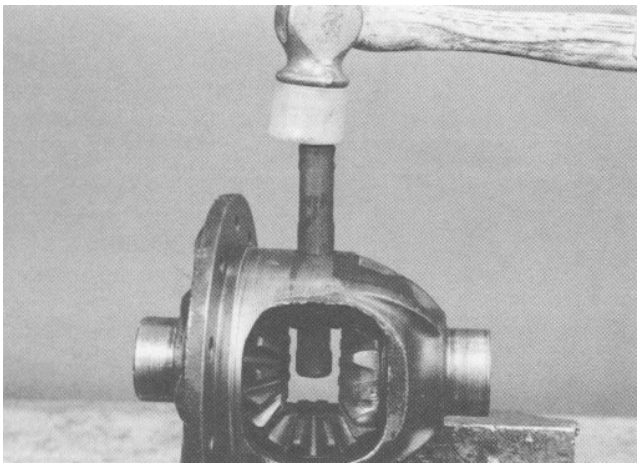


Figure 48

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).

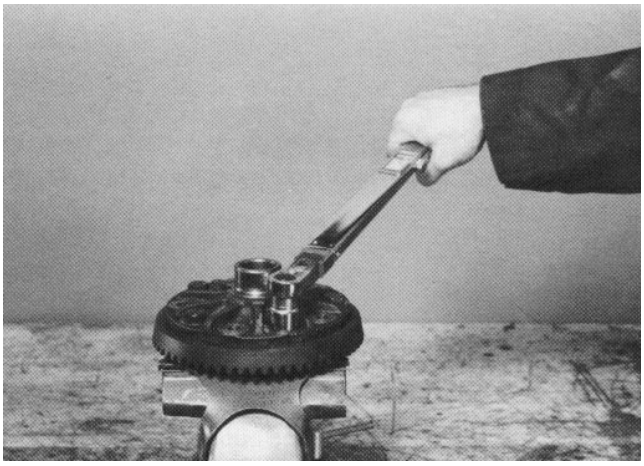


Figure 50

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).

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: The Reelmaster 223-D/5100-D/5300-D application requires that the ring gear teeth face toward the spur gear cover.

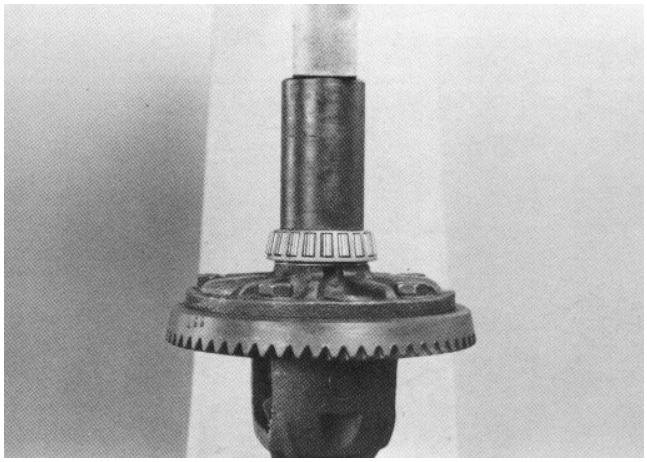


Figure 51

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.

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).

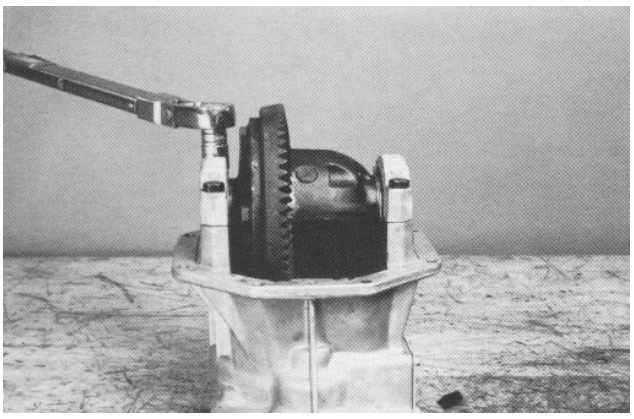


Figure 52

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.

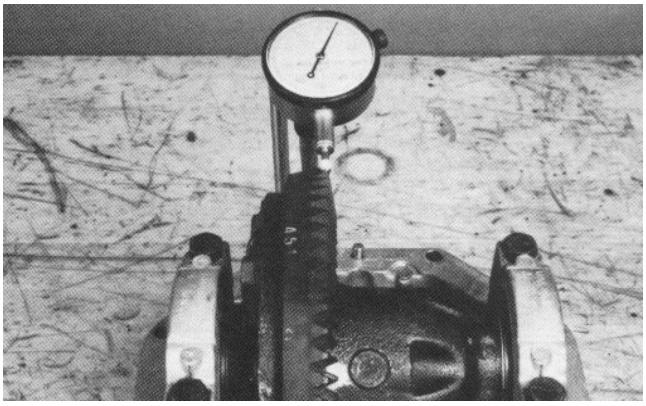


Figure 53

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.

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.

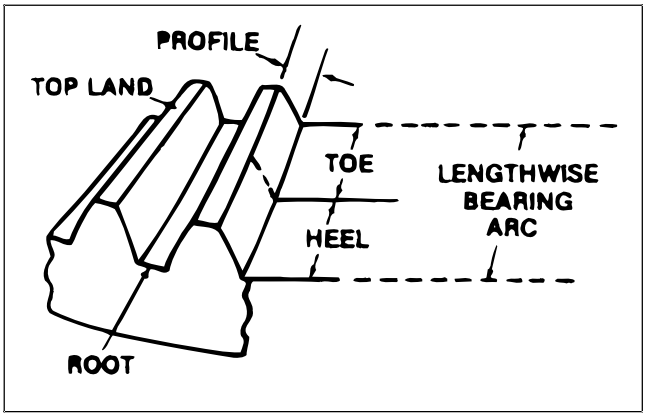


Figure 54

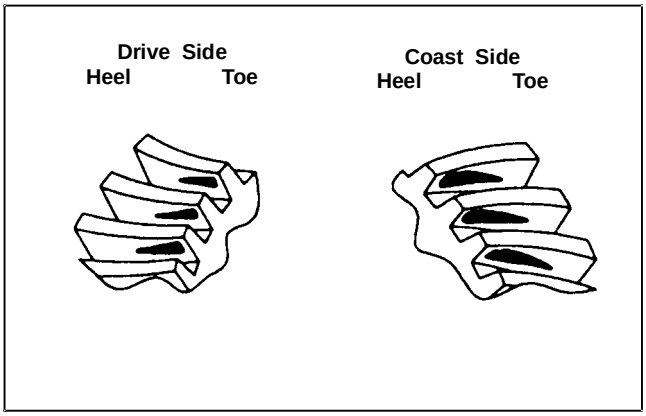


Figure 54A

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.

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.

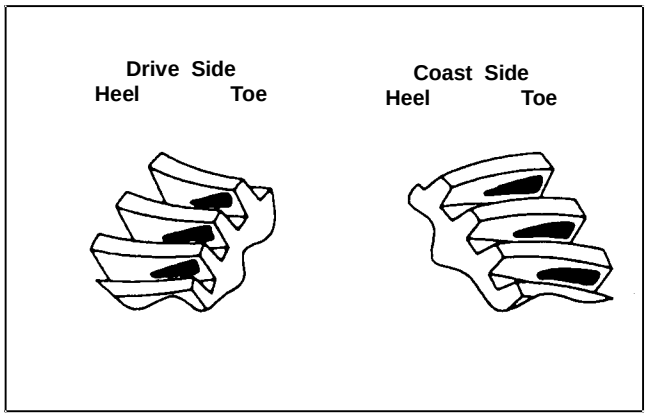


Figure 55

Backlash correct. Thinner pinion position shims required.

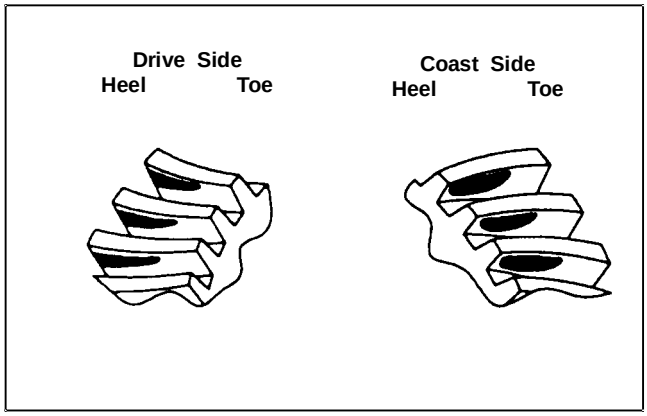


Figure 56

Backlash incorrect. Thinner pinion position shim required. Adjust backlash to match.

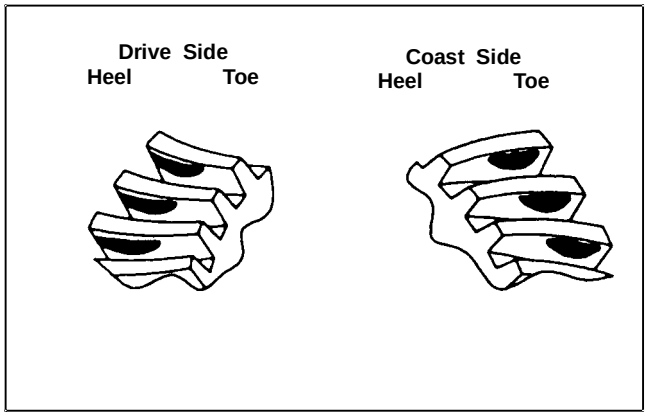


Figure 57

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).

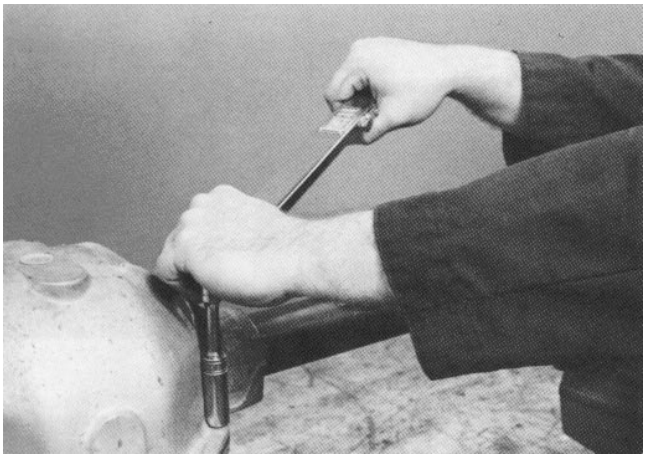


Figure 58

Chapter 7

Steering And Brakes

Table of Contents

Introduction

Power Steering

The Reelmaster® 5300-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 front section of auxiliary hydraulic pump. The steering section of the pump has a built-in relief valve.

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).

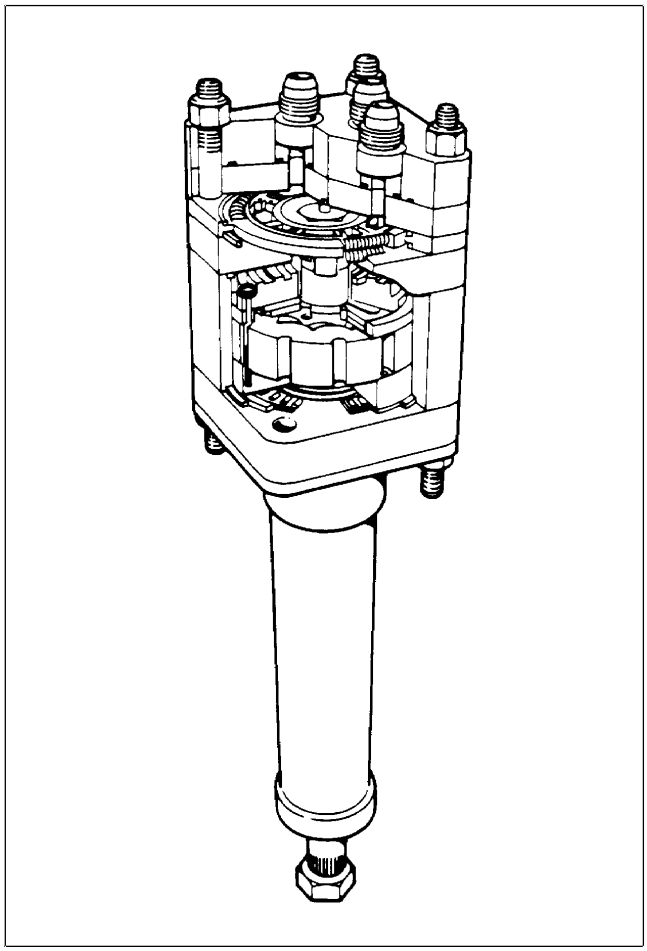


Figure 1

Brakes

The Reelmaster® 5300-D is equipped with 7 inch diameter x 1-3/4 inch wide mechanical drum brakes on the front wheels (Fig. 2).

Two pedals are used to control the brakes. When used separately, the pedals can control each wheel brake to assist steering or traction on side hills. The two pedals may be locked together with the brake lock arm. 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.

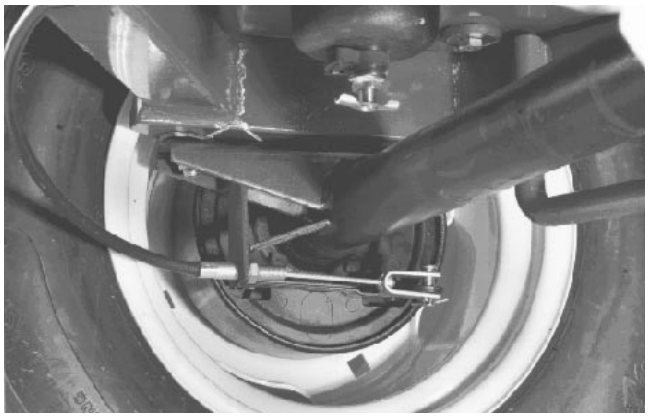


Figure 2

Power Steering Schematics

When the steering wheel is turned to the right (Fig. 3), the control valve within the steering valve shifts to close the “AUX” port. This directs oil supplied by the steering 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.

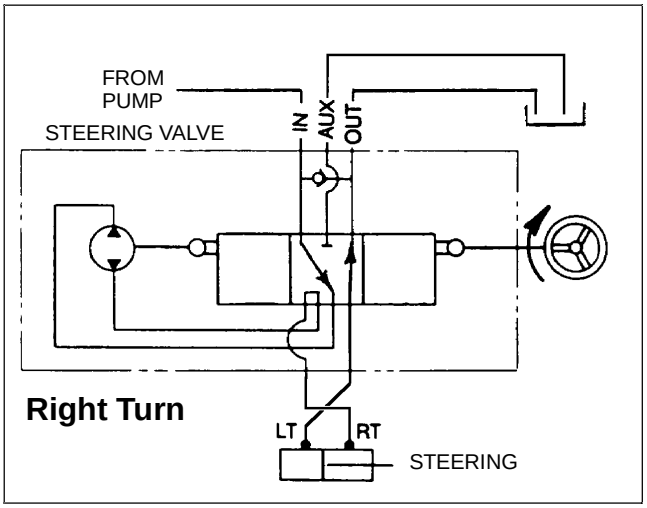


Figure 3

When the steering wheel is stationary, the control valve within the steering valve shifts back to neutral (Fig. 4), allowing system oil to flow through the steering valve and out the “AUX” port back to reservoir. Oil in the rest of the steering circuit is then trapped.

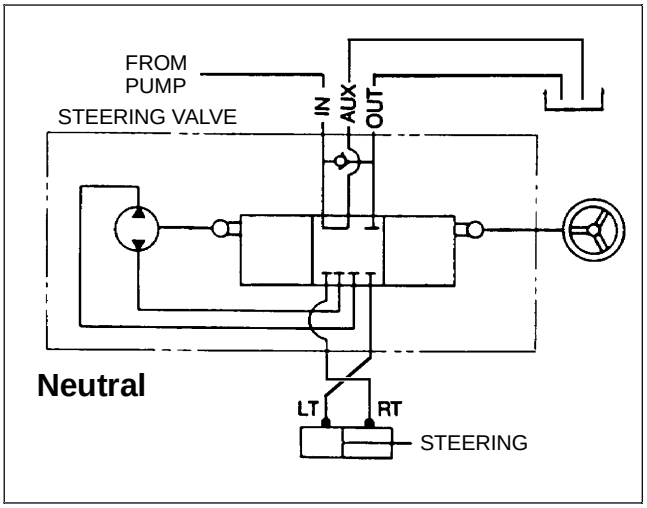


Figure 4

When the steering valve is turned to the left (Fig. 5) 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.

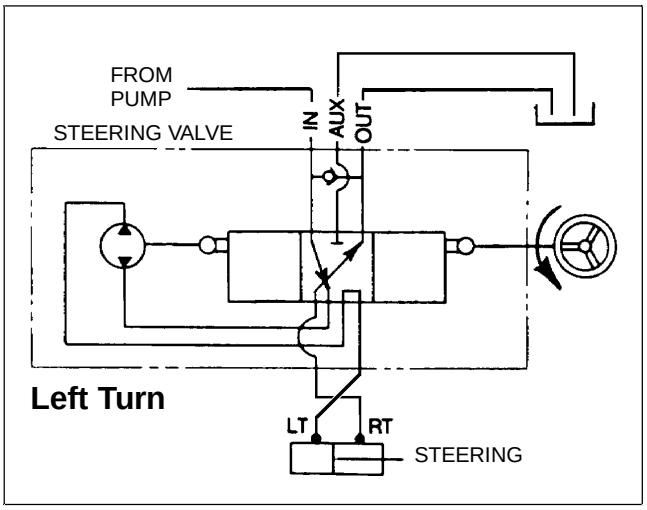


Figure 5

Specifications

Item	Specification
Front wheel lug nut torque	45 to 55 ft-lb
Rear wheel lug nut torque	30 to 35 ft-lb
Steering cylinder bolt torque	130 to 150 ft-lb
Rear wheel toe-in	0 to 1/8 in.
Tire pressure	10 to 15 psi, front and rear
Brake pedal free travel	1/2 to 1 in.

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. 6) and use it as instructed (See Steering Valve Service in the Repairs section of this chapter).

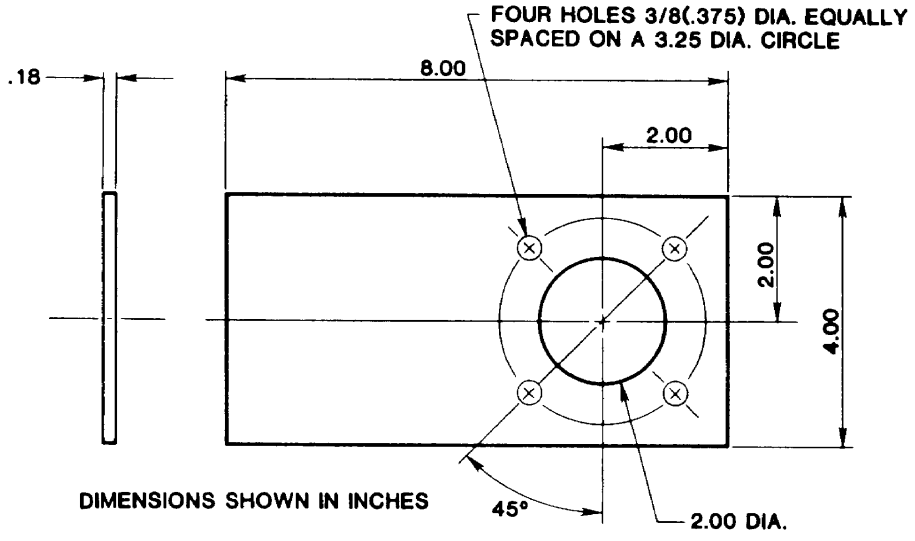


Figure 6

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 hydraulic 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.

Steering Valve and Pump Tests

1. Make sure the hydraulic oil is at normal operating temperautre by operating the machine for approximately 5 minutes.

2. Engage the parking brakes, lower the cutting units to the floor and turn the engine OFF.

3. Remove the cover from the steering tower.

4. Place a drain pan under the steering valve. Disconnect the hydraulic hose at the AUX port of the steering valve (Fig. 7a).

5. Connect the inlet hose of the tester to the AUX port on the steering valve. Connect the outlet hose of the tester to hose that was disconnected in step 4.

IMPORTANT: Make sure that the oil flow indicator arrow on the flow gauge is showing that the oil will flow from the steering valve, through the tester and into the hose that was disconnected in step 4.

6. With the tester load valve fully open (counterclockwise) run the engine at full throttle.

Steering Valve Test (Control Valve Section)

7. Turn the steering wheel all the way in one direction and hold it against the right stop.

There should be no flow as the steering wheel is held against the right stop.

8. Release the steering wheel.

Flow should be approximately 3 gpm when the steering wheel is released. 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.

9. Repeat steps 7 and 8, turning the steering wheel in the opposite direction.

Steering Pump Flow and Relief Pressure Test

10. While watching the pressure gauges, slowly close flow control valve on tester untils 1000 PSI is obtained on gauge.

TESTER READING: Flow not less than 3.5 GPM at 1000 PSI.

11. If flow is lower than 3.5 GPM or a pressure of 1000 PSI cannot be obtained, check for restriction in pump intake line. Check relief valve in pump for contamination or wear. Adjust pump relief valve to 1250 PSI cracking pressure by removing cap and turning adjustment screw (Fig. 7b). If pump intake line is not restricted and relief valve is functioning properly, remove pump and repair or replace (see Pump Removal and Installation and Pump Repair in Mowing Circuit Repairs section of Chapter4 - Hydraulic system).

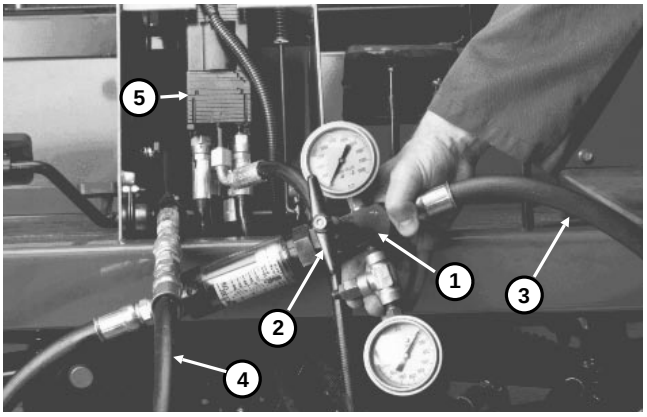


Figure 7a

1. Tester
2. Load valve
3. Inlet line to tester
4. Outlet line from tester
5. Steering valve

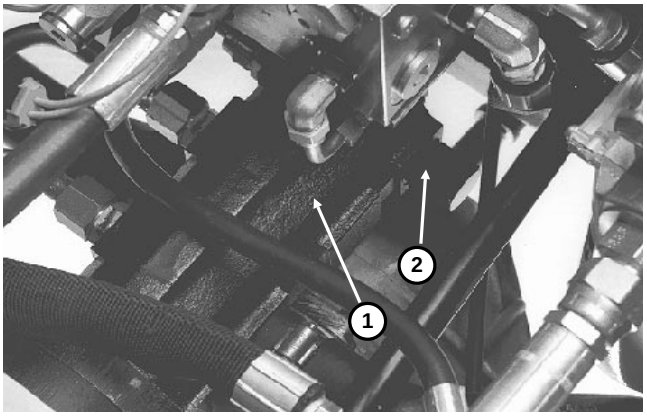


Figure 7b

1. Pump
2. Relief valve

Steering Cylinder Internal Leakage Test

1. Engage the parking brake, and lower the cutting units to the floor.

2. Turn the steering wheel all the way to the left (counterclockwise) so the steering cylinder rod is extended all the way.

3. Turn the engine OFF.

4. Disconnect the hydraulic hose from the fitting on the rod end of the cylinder (Fig. 8). 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) with the cylinder rod completely extended 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.

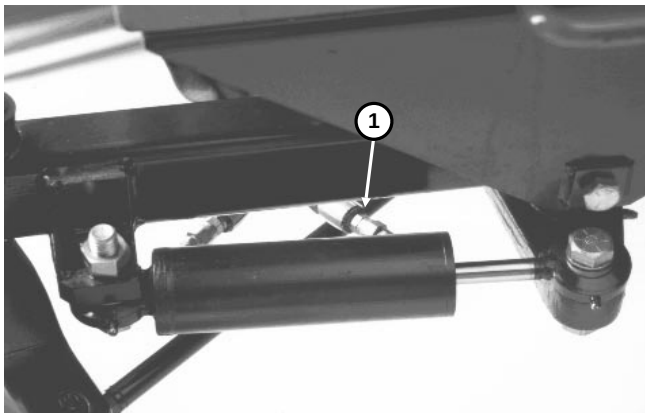


Figure 8

1. Hydraulic hose and fitting

Rear Wheel Toe-in Adjustment

The rear wheels should have 0 to 1/8 of an inch toe-in when they are pointed straight ahead. To check toe-in, measure the center-to-center distance, at axle height, in front and rear of steering 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 less than at the rear of the wheels (Fig. 9).

3. When toe-in is correct, tighten jam nuts against tie rods (Fig. 9).

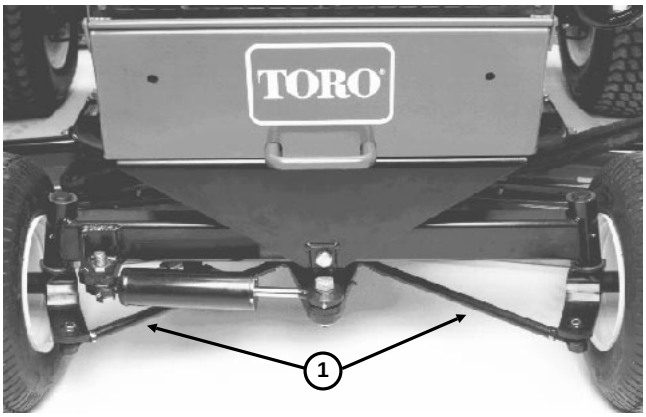


Figure 9

1. Tie rods

Brake Adjustment

Adjust the service brakes when there is more that one inch of “free travel” of the brake pedals. Free travel is the distance the brake pedal moves before braking resistance is felt (Fig. 11).

Adjust where brake cables connect to bottom of brake pedals. When cable is no longer adjustable, star nut on inside of the brake drum must be adjusted to move brake shoes outward. Brake pedals must be adjusted again after star nut is adjusted.

1. Disengage lock arm from left brake pedal so both pedals work independently of each other.

2. To reduce free travel of brake pedals:

   A. Loosen front nut on threaded end of brake cable (Fig. 12).

   B. Tighten rear nut to move cable toward the rear until brake pedals have 1/2 to 1 in. of free travel.

   C. Tighten front nut after adjusting.

3. When brake cables cannot be adjusted to get free travel within 1/2 to 1 in., star nut inside brake drum must be adjusted. Before adjusting the star nut, loosen brake cable nuts to prevent unnecessary strain on the cables.

4. Loosen (do not remove) the five (5) wheel lug nuts.

5. Jack up machine until front wheel is off the floor. Use jack stands or block machine to prevent it from falling accidentally.

6. Remove wheel nuts and slide wheel off the studs. Rotate the brake drum until adjusting slot is at the top and centered over star-nut (Fig. 13).

7. Use a brake adjusting tool or a screwdriver to rotate star nut until brake drum locks because of outward pressure of brake shoes (Fig. 14).

8. Loosen star nut approximately 12 to 15 notches or until brake drum rotates freely.

9. Install wheel onto studs with five (5) wheel nuts. Tighten the wheel lug nuts.

10. Remove jack stands or blocking and lower machine to floor. Tighten wheel lug nuts to a torque of 45 to 55 ft-lb.

11. Adjust brake cables (see step 2 of this procedure).

Figure 11

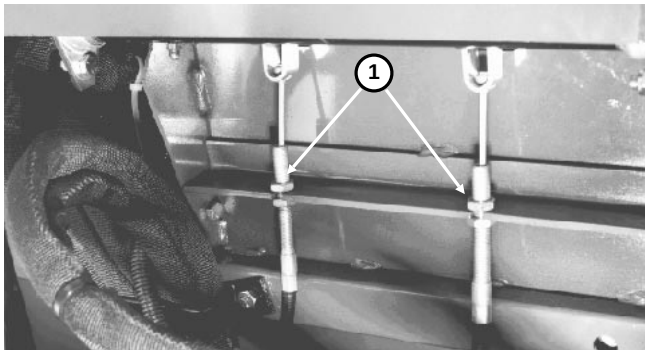


Figure 12

1. Jam nuts

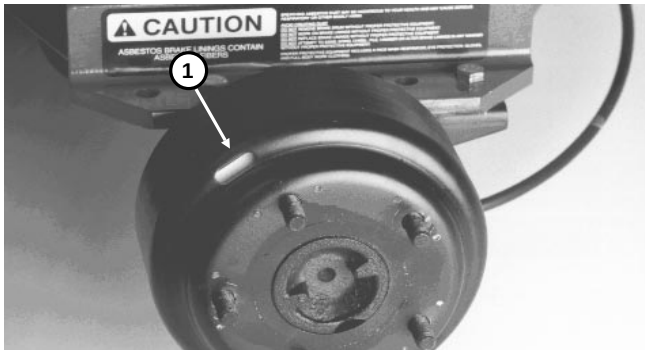


Figure 13

1. Brake adjusting slot

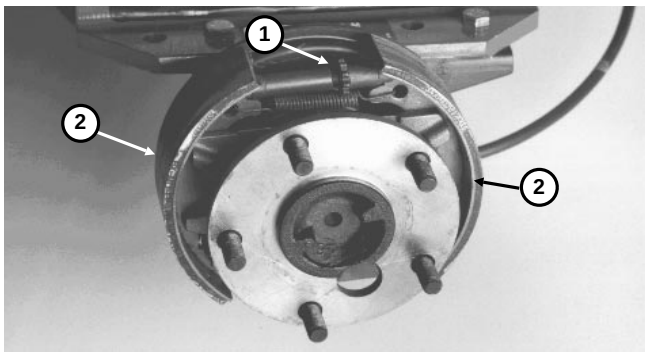


Figure 14

1. Star nut **2. Brake shoe**

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. 15). 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 jam nut (Fig. 10). Tighten the nut to 10 to 15 ft-lb.

4. Install cap to steering wheel with screw.

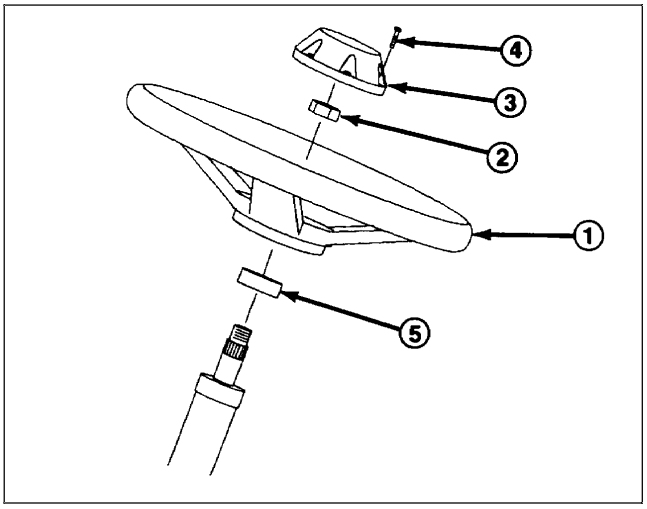


Figure 15

1. Steering wheel
2. Jam nut
3. Cap
4. Screw
5. Foam seal

Rear 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 cap screw securing the end of the axle pin to the chassis (Fig. 16).

3. 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.

4. 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.

5. 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.

6. 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.

7. Wipe the rear axle pin with a rag to remove dirt and grease. Inspect the pin for wear or damage and replace as necessary.

8. 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 3). Secure the axle pin in place with the cap screw.

9. Remove the jackstands and lower the machine to the floor.

10. Install the hydraulic hoses to the steering cylinder.

11. Lubricate the rear axle bushings through the grease fitting on the rear axle.

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. 16).

2. Remove two (2) nuts to disconnect the tie rod end from the spindle arm. Inspect all tie rod end ball joints for wear or damage and replace as necessary.

3. Remove the retaining ring and thrust washer. 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 thrust washer and retaining ring.

7. Connect the tie rod end to the spindle bracket with one (1) nut. Tighten the nut to a torque of 25 - 33 ft-lb. Install the jam nut and tighten against the other nut to secure 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 130 to 150 ft-lb.

9. Lubricate the bushings through the grease fitting on the steering pivot.

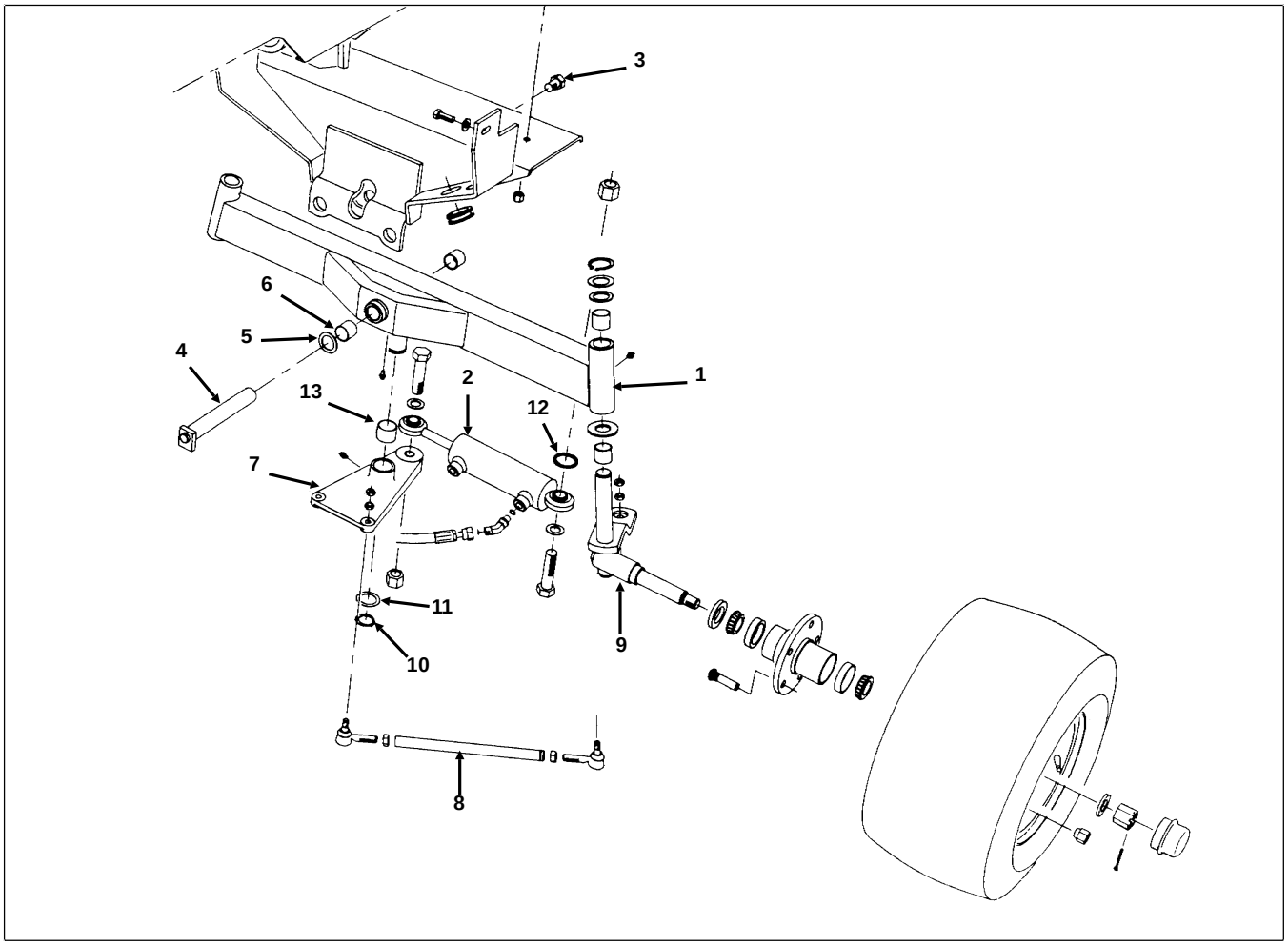


Figure 16

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. Cylinder spacer
13. 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 cap screw securing the end of the axle pin to the chassis (Fig. 17).

3. 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.

4. Carefully roll the entire rear axle and wheel assembly out from under the machine.

5. Remove two (2) nuts to disconnect the tie rod end from the spindle arm.

6. 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.

7. 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.

8. 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.

9. Wipe the spindle shaft with a rag to remove any dirt and grease. Inspect the spindles for wear and replace as necessary.

10. 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.

11. Connect the tie rod end to the spindle bracket with one (1) nut. Tighten the nut to a torque of 25 - 33 ft-lb. Install the jam nut and tighten against the other nut to secure tie rod end.

12. Mount the axle to the frame with the axle pin. The washer(s) must be positioned the between the front end of the pivot tube and the frame (see the NOTE after step 3). Secure the axle pin in place with the cap screw.

13. Remove the jackstands and lower the machine to the shop floor.

14. Install the hydraulic hoses to the steering cylinder.

15. Lubricate the steering spindle and rear axle pivot.

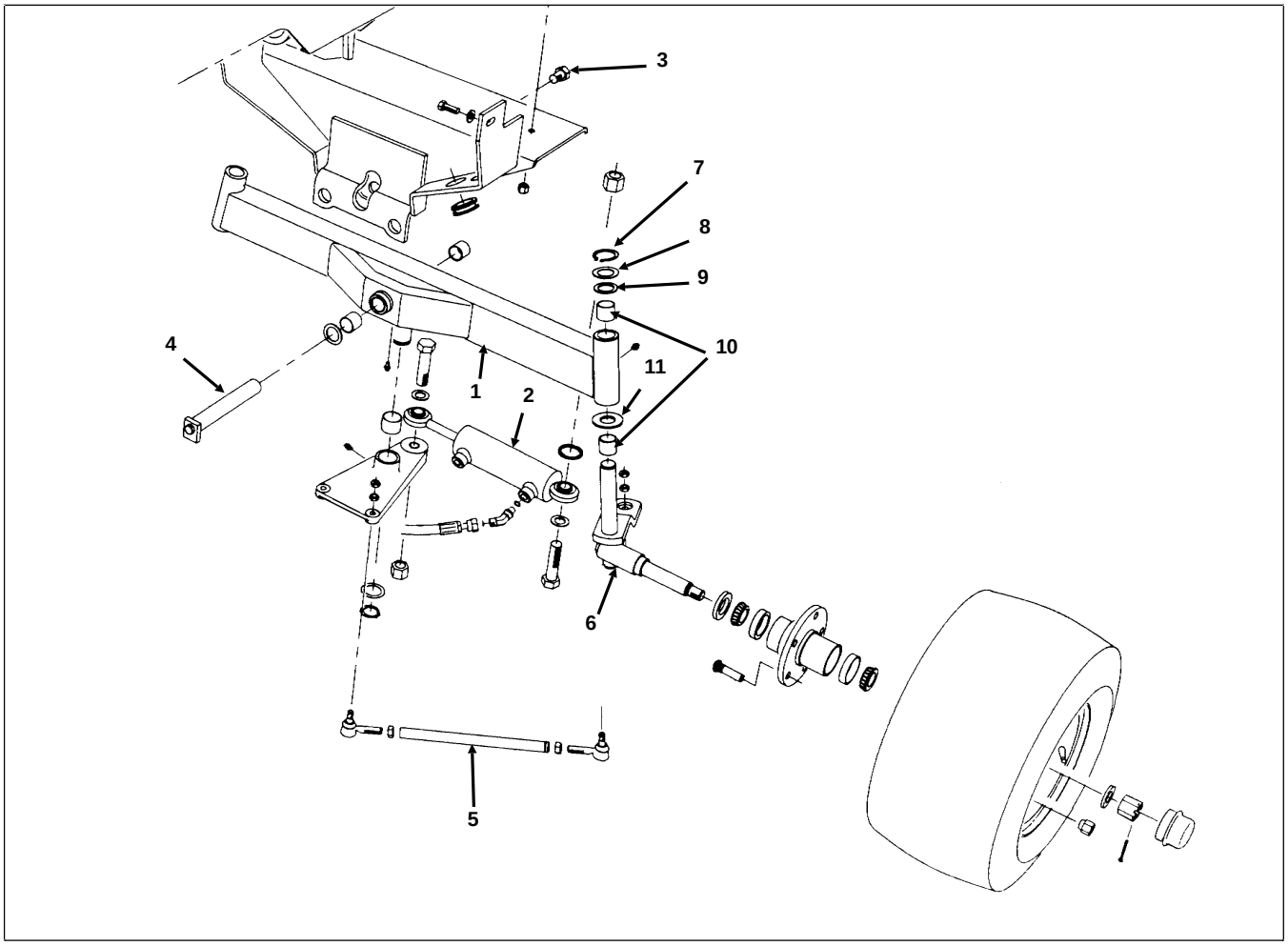


Figure 17

1. Rear axle
2. Steering cylinder
3. Capscrew
4. Rear axle pin
5. Tie rod
6. Wheel spindle
7. Snap ring
8. Shim washer
9. Thrust washer
10. Bushing
11. Thrust washer

Front Wheel Bearing Service

See Axle Shaft Disassembly and Wheel Bearing Service in the Repairs section of Chapter 6 - Differential.

Rear Wheel Bearing Service

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. 18).

3. Remove the cotter pin, slotted nut, and washer. Slide the wheel off spindle shaft.

4. Pull the seal out of the wheel hub.

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.

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.

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 flat washer and slotted nut. DO NOT tighten the nut or install the cotter pin.

10. Adjust preload on the wheel bearings.

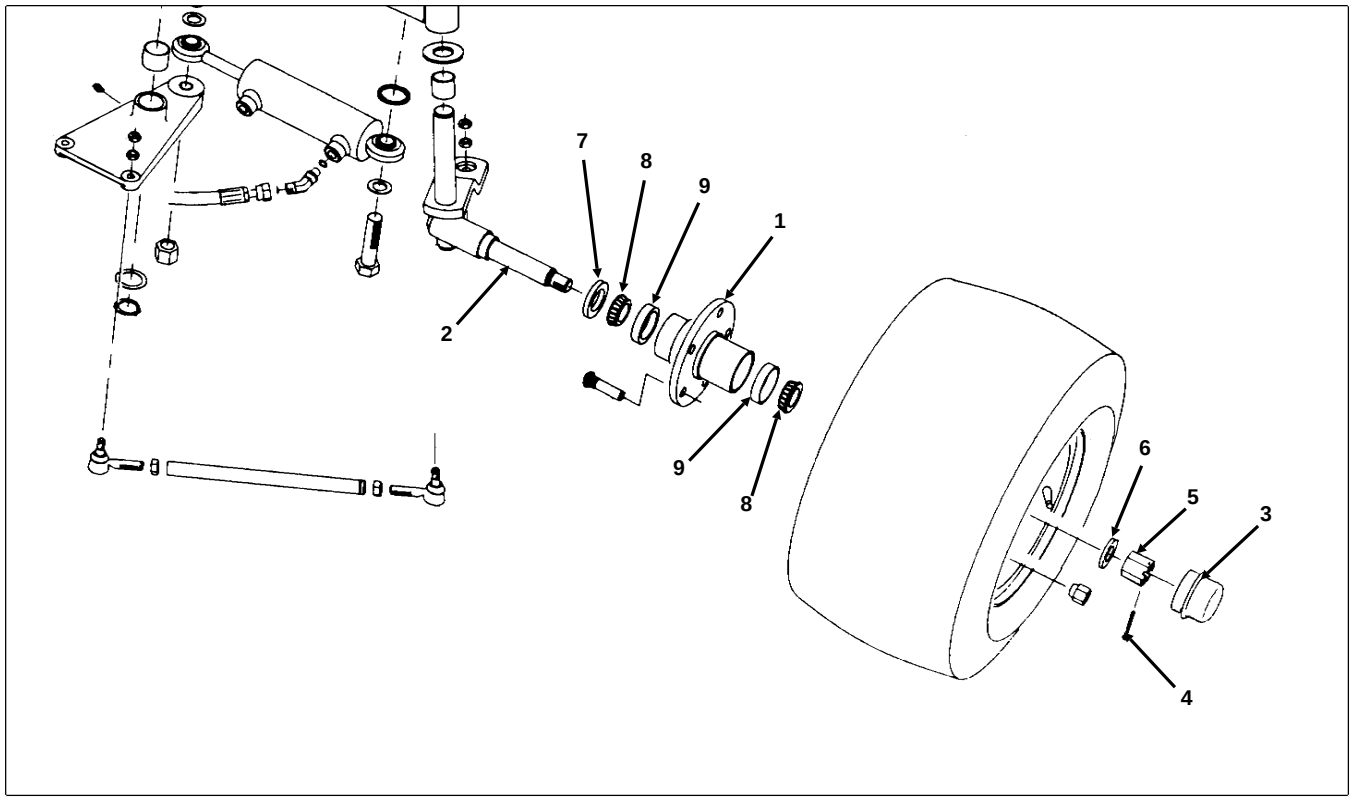


Figure 18

1. Wheel hub
2. Wheel spindle
3. Dust cap
4. Cotter pin
5. Slotted nut
6. Washer
7. Seal
8. Bearing cone
9. Bearing cup

Adjusting Rear Wheel Bearings

1. Remove dust cap from end of wheel spindle. Also remove cotter pin retaining slotted nut in place (Fig. 18).

2. Rotate the wheel by hand and tighten the slotted nut (Fig. 19) 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.

3. Remove jack stands or blocks and lower machine to floor.

4. Put a coating of grease on the inside of the dust cap. Install dust cap on the end of the wheel spindle (Fig. 18).

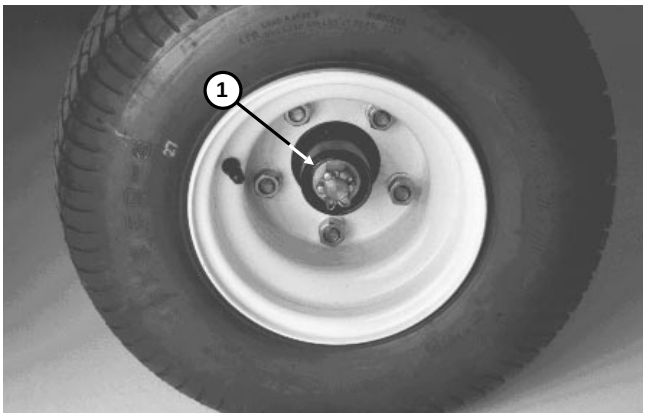


Figure 19

1. Cotter pin and slotted nut

Steering Cylinder Removal and Installation

1. Engage the parking brakes, lower the cutting units to the ground, turn the engine OFF and remove the key from the ignition switch.

2. 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.

3. Remove the lock nut and cap screw securing the rod end of the cylinder to the steering pivot (Fig. 20).

4. Remove the lock nut, cap screw and spacer securing the barrel end of the cylinder to the rear axle.

5. Remove the cylinder.

6. Reverse steps 2 - 5 to install the steering cylinder. Tighten the cap screw and nut securing the rod end of the cylinder to the steering pivot to 130 - 150 ft-lb.

7. After installing the cylinder, bleed the hydraulic system. (See Bleeding the Hydraulic System in the Repairs section of Chapter 4 - Hydraulic System.)

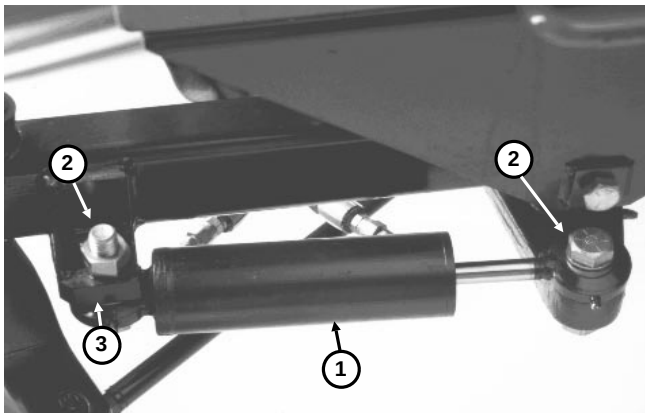


Figure 20

1. Steering cylinder
2. Lock nut and cap screw
3. Cylinder spacer

Steering Cylinder Service

IMPORTANT: To prevent damage to rod or barrel, clamp vise on pivot ends only. DO NOT clamp against smooth rod surface.

1. After removing the cylinder, pump oil out of cylinder into a drain pan by SLOWLY moving piston in and out of cylinder bore.

2. Plug the ports and clean the outside of the cylinder.

3. Mount cylinder in a vise so rod end of cylinder is tilted up slightly. Do not close the vise so firmly that the cylinder barrel could become distorted.

4. Use a spanner wrench to unscrew (counterclockwise) head from barrel (Fig. 21).

5. Grasp large end of piston rod and use a twisting and pulling motion to carefully extract piston, rod, and head from cylinder tube.

6. Securely mount piston, rod, and head into vise so large nut is easily accessible for removal. Remove nut by turning it counterclockwise.

7. Remove piston. Slide head off of piston rod.

8. Remove all seals and O-rings.

9. Wash parts in a safe solvent. Dry parts with compressed air. DO NOT wipe them dry with a cloth or paper as lint and dirt may remain.

10. Carefully inspect internal surface of barrel for damage (deep scratches, out-of-round, etc.). Replace entire cylinder if barrel is damaged. Inspect head, rod, and piston for evidence of excessive scoring, pitting, or wear. Replace any damaged parts.

11. Put a light coating of oil on all new seals, and O-rings. Install new seals and O-rings.

12. Install head onto piston rod.

13. Install piston onto rod and tighten hex nut to 30 - 34 ft-lb.

14. Put a light coating of oil on all cylinder parts.

15. Slide piston rod assembly into cylinder tube.

16. Install head into tube and tighten by hand to properly engage threads. Tighten head with a spanner wrench.

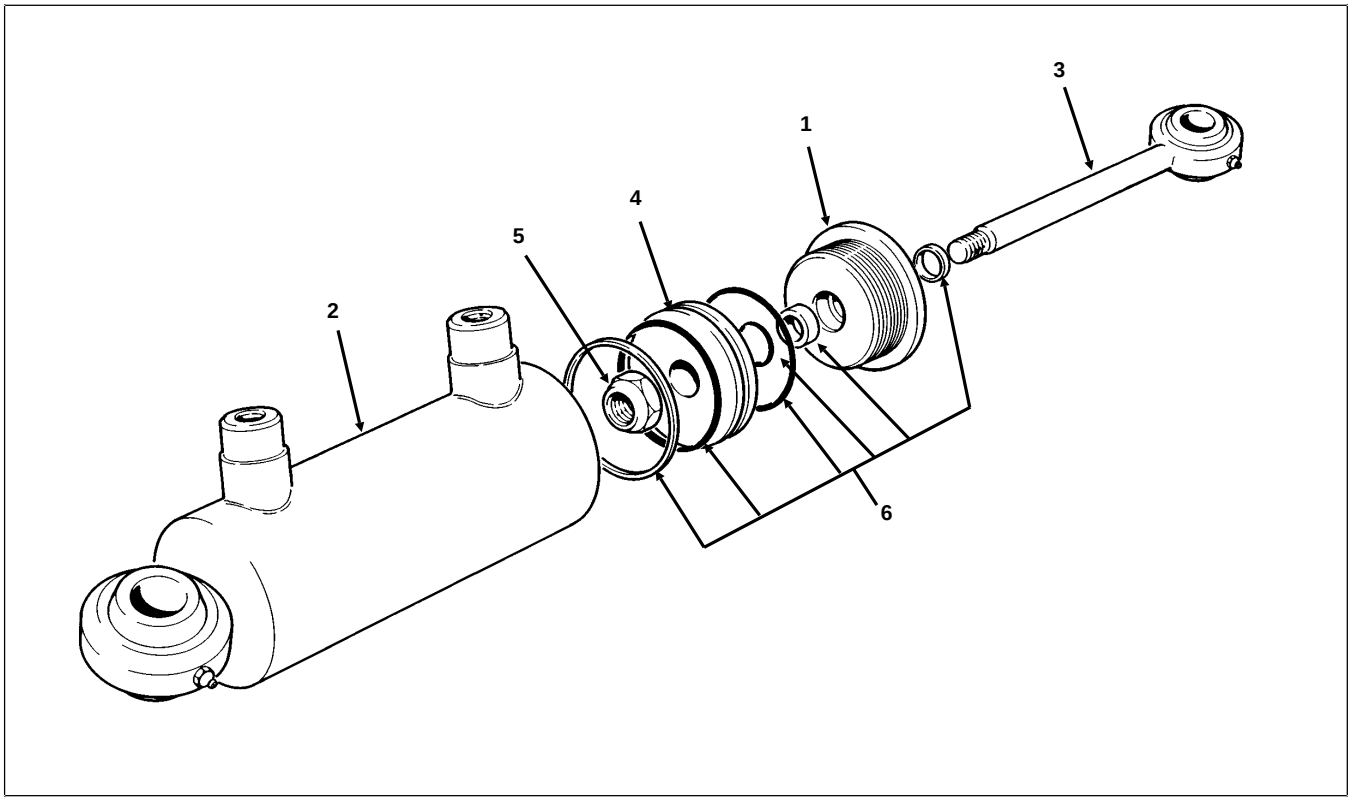


Figure 21

1. Head
2. Cylinder barrel
3. Piston rod
4. Piston
5. Lock Nut
6. Seals

Brake Shoe Replacement

1. Loosen wheel lug nuts. Jack up machine until front wheel is off of floor. Use jackstands to prevent machine from falling accidentally. Remove wheel lug nuts and slide wheel and tire assembly off of studs.

2. Remove brake drum. If drum will not come off easily, brake shoes may have to be retracted with star nut (see Brake Adjustment).

3. Remove brake shoe return spring (Fig. 22) by prying the end of the spring up and over its retaining boss. Use a brake spring pliers or flat blade screwdriver.

CAUTION

Wear a face shield when removing brake return spring (Fig. 22). The spring is under tension and could possibly slip during removal.

4. Remove brake lever retainers (cotter pins) with a slip joint pliers.

5. Pull strut and lever from brake shoes. Remove brake shoes by sliding them both on one motion straight down off cast-iron spider.

6. Remove adjusting screw spring and star wheel assembly.

7. Install new brake shoes (reverse steps 2 - 7) Install new brake drum if it is severely scored.

8. Install wheel and tire assembly on studs with five (5) wheel nuts. Tighten wheel lug nuts. Remove jack stands or blocking and lower machine to the floor. Tighten wheel lug nuts to a torque of 45 - 55 ft-lb.

9. Adjust brakes (see Brake Adjustment).

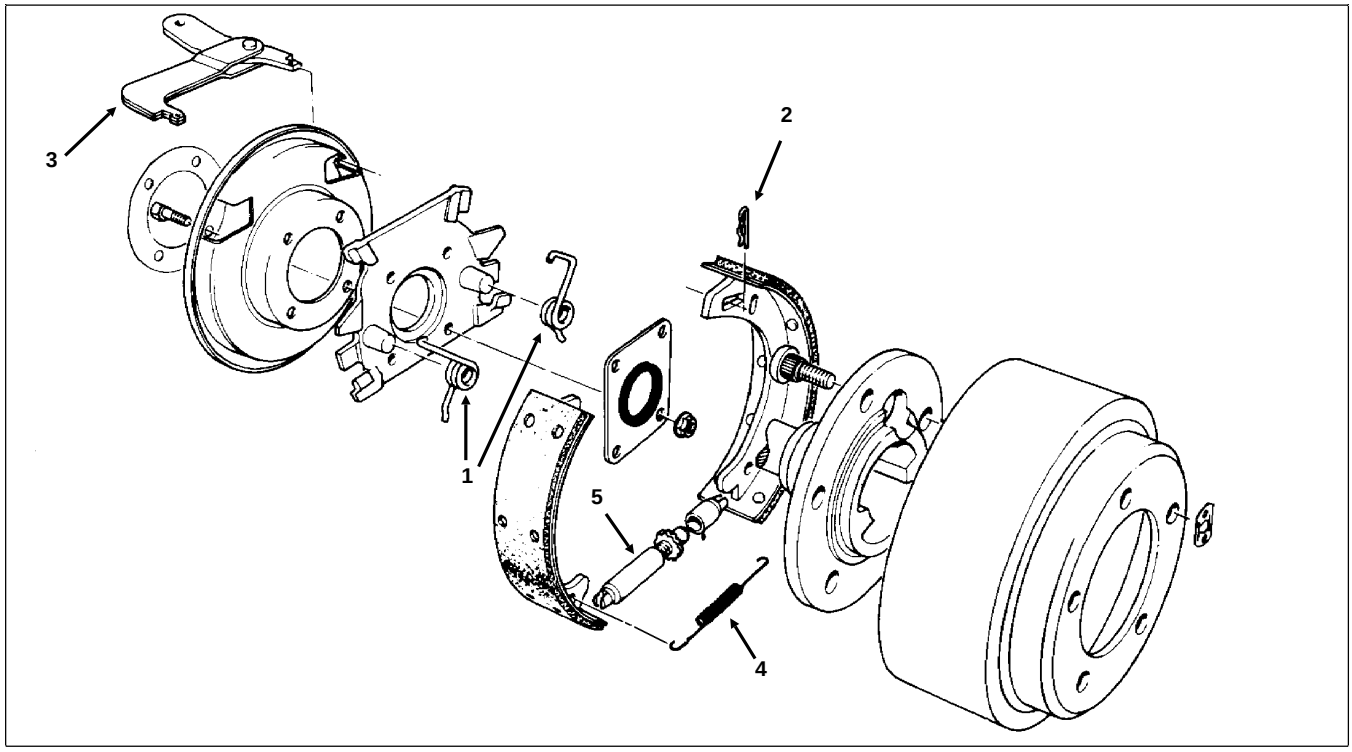


Figure 22

1. Return spring
2. Cotter pins
3. Strut and lever
4. Adjusting screw spring
5. Star wheel assembly

Steering Valve Removal and Installation

1. Engage the parking brakes, lower the cutting units to the ground, turn the engine OFF and remove the key from the ignition switch.

2. Remove the front center cutting unit (see Repairs section of Chapter 8 - Cutting Units).

3. Remove cap screws from steering tower cover and remove the cover from steering tower.

4. Clean outside of the steering valve and the area around the hydraulic fittings. Disconnect hydraulic hoses from steering valve (Fig. 23). Put caps or plugs on all fittings and hoses to prevent contamination.

NOTE: To ease reassembly, tag each hose and tube line to show their correct position on the steering valve.

5. Remove the steering wheel.

6. Remove the clamp securing the steering column to the steering tower.

7. Remove four (4) nuts and washers securing steering valve to steering tower.

8. Carefully move hydraulic lines to the side and pull steering valve and column out through bottom of steering tower.

9. Reverse steps 2 - 8 to install the steering valve.

10. After installing the steering valve, bleed the hydraulic system (see Chapter 4 - Hydraulic System).

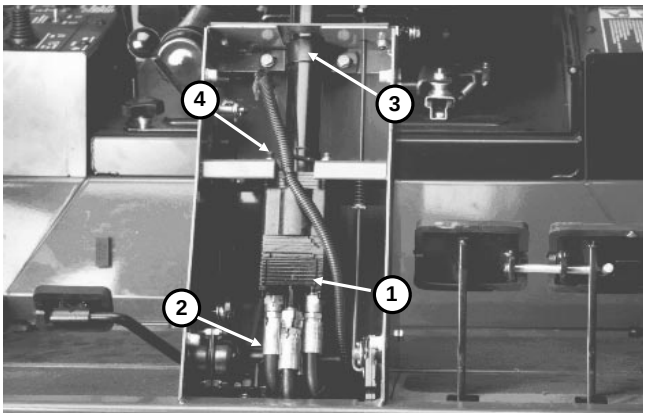


Figure 23

1. Steering valve
2. Hydraulic lines
3. Clamp
4. Nuts and washers

Steering Valve Service

Before Disassembly

When disassembling any of the parts, use a clean work bench. Wash all parts in solvent and dry them with compressed air. DO NOT wipe them dry with a cloth of paper as lint and dirt may remain. Keep each part separate to prevent nicks and burrs.

Components of the steering valve are stacked on four bolts and held in alignment with alignment pins. The alignment pins are designed to be a slip fit into the components. Use the minimum force necessary and maximum care when separating or assembling the components.

The steering valve has several components that are of brazed laminate construction. These components have plates and parts bonded together permanently to form an integral component that cannot be disassembled. Disassemble the steering valve only to the extent shown in this book.

IMPORTANT: Do not force or abuse closely fitted parts, or you may damage them.

Components of the steering valve with alignment grooves, must be assembled so that their alignment grooves are positioned as illustrated for the valve to function correctly (Fig. 24).

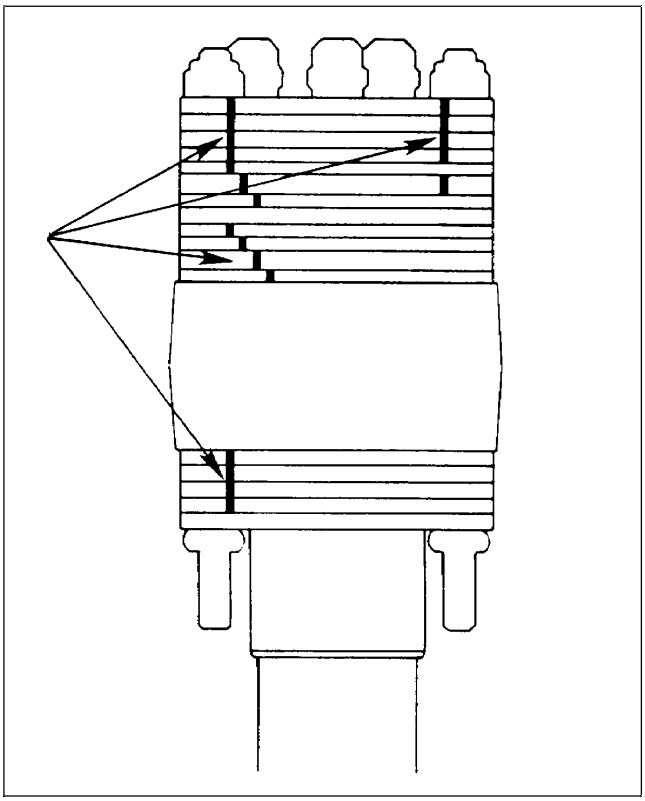


Figure 24

Chapter 8

Cutting Units

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Specifications

Height of Cut:
5 Blade: 1/2 to 3/4 in.
8 Blade: 1/4 to 5/8 in.

Roller Adjustment:
Front: Fixed
Rear: Screw adjustable with bolt clamp lock

Bedknife To Reel Adjustment: Bedknife adjusts against reel, with opposed screw adjustment on each end of bedbar.

Bedknife Screw Torque: 200 in-lb.

Reel Splined Drive Nut Torque: 40 to 60 ft-lb.

Reel Bearing Rolling Torque: 4 to 7 in-lb with no end play.

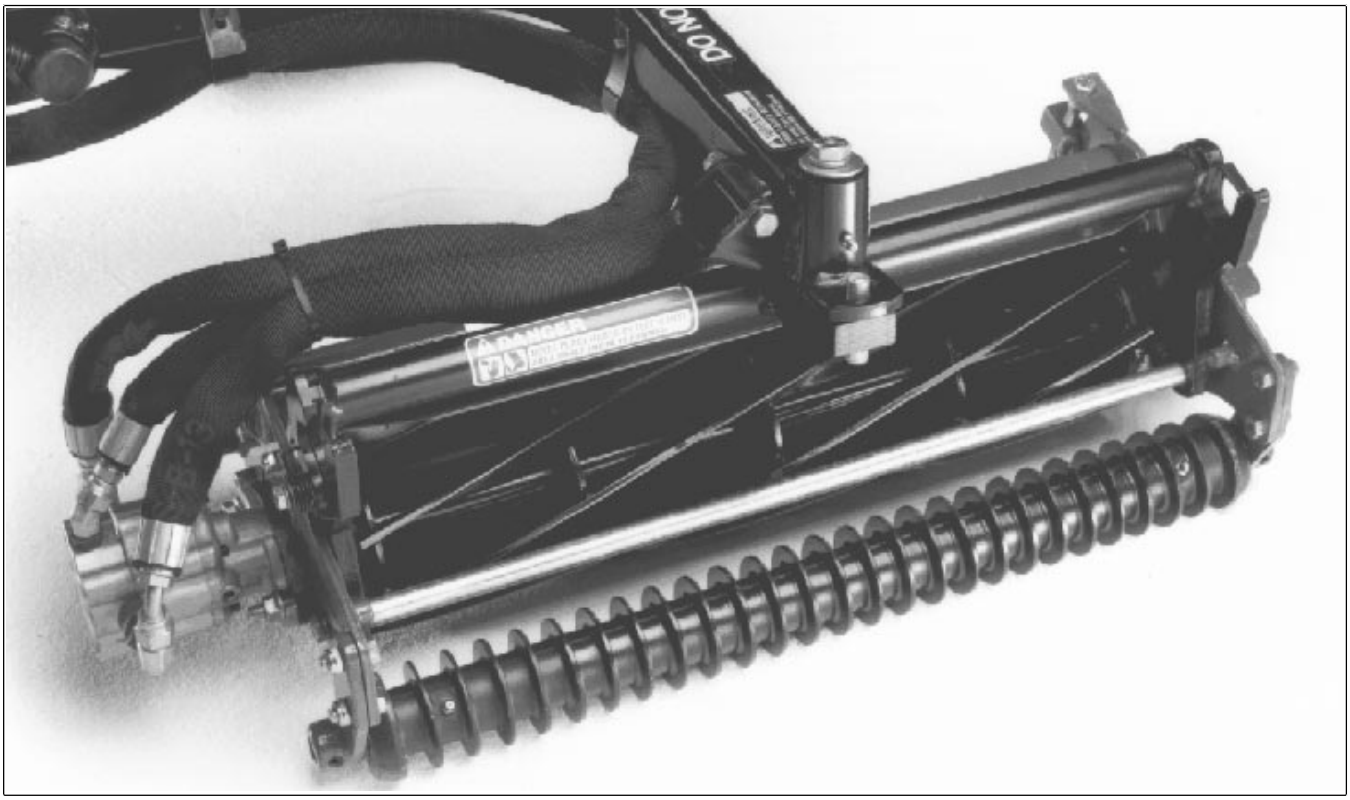


Figure 1

Special Tools

NOTE: Order special tools from the *TORO SPECIAL TOOLS AND APPLICATIONS GUIDE (COMMERCIAL PRODUCTS)*. Some tools may be listed in the Reelmaster 5300-D Parts Catalog. Some tools may also be available from a local supplier.

Plastic Plug

Insert plug in cutting unit bearing housing in place of reel motor when sharpening or grinding the reel.

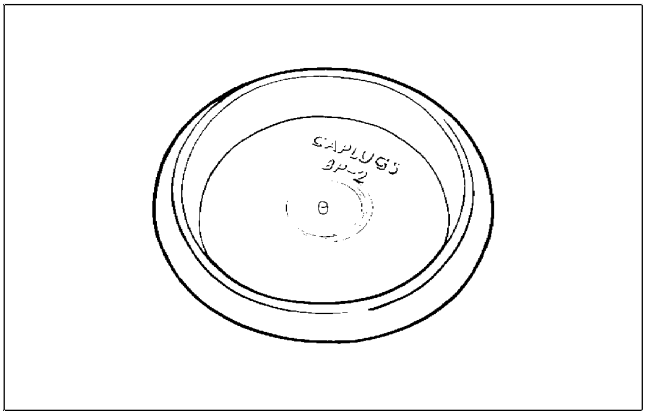


Figure 2

Handle Assembly

For applying lapping compound to cutting units while keeping hands a safe distance from the rotating reel assembly.

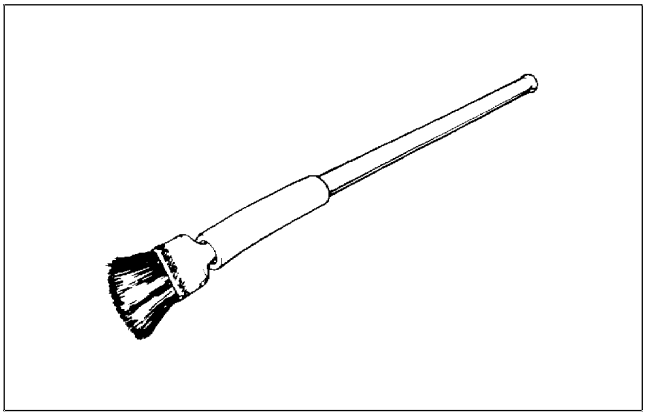


Figure 3

Bedknife Screw Tool

Fits Toro bedknife attaching screws. Use with torque wrench to secure bedknife to bedbar. With clean bedbar threads and new screws, tighten to a torque of 200 in-lb.

NOTE: Remove all rust, scale and corrosion from bedbar surface before installing bedknife.

DO NOT use an air impact wrench with this tool.

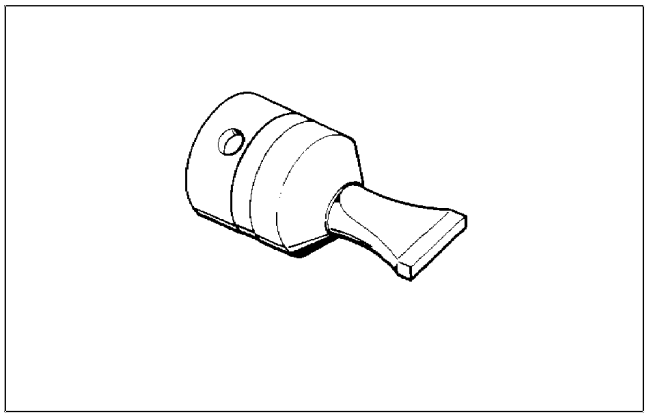


Figure 4

Troubleshooting

There are a number of factors that can contribute to unsatisfactory quality of cut, some of which may be turf conditions. Turf conditions such as excessive thatch, “sponginess” or attempting to cut off too much of the grass height may not always be overcome by adjusting the machine. It is important to remember that the lower the height of cut, the more critical these factors are. See the Adjustments and Repairs sections for detailed adjustment and repair information.

Factors That Can Affect Quality of Cut

Factor	Possible Problem/Correction
1. Engine maximum governed speed.	Check maximum governed engine speed. Adjust to specification if necessary. If engine is not running at specified maximum governed RPM, reel speed settings may not match ground speed.
2. Reel speed and ground speed.	Adjust reel speed to settings shown on REEL SPEED SETTINGS graph for number of reel blades (5 or 8) and desired ground speed (see Operator’s Manual). All reels must rotate at same speed (within 150 RPM). All cutting units must have equal bedknife to reel contact and reel bearing adjustment before checking. Do not run the reel too long or it may get hot and “rifle” when no grass is being cut. See Troubleshooting in Chapter 4 - Hydraulic System.
3. Cutting unit down pressure adjustment.	Down pressure spring on each cutting unit lift arm can be adjusted to compensate for different turf conditions. Increased down pressure will help keep the cutting units on the ground when mowing at higher speeds and helps maintain a uniform height of cut in rough conditions or in areas of thatch build up. Make sure all springs have the same down pressure adjustment. NOTE: Increased down pressure may lower the actual or “effective” height of cut.
4. Tire pressure.	Check tire pressure. Adjust to specification if necessary. Must be equal in two front tires and two rear tires.
5. Reel bearing condition/adjustment.	Check and adjust to specification. Replace bearings if worn or damaged. Bearing cones must be installed square to bearing housing - make sure there is no “flash”, paint or other foreign material in housing before installing new bearing cone.
6. Reel and bedknife sharpness.	Reel and/or bedknife that has rounded cutting edges or “rifling” cannot be corrected by tightening bedknife to reel contact. Grind reel to remove taper (cone shape) and/or rifling (grooved or ribbed appearance). Grind bedknife to sharpen and/or remove rifling. (Most common cause of rifling is bedknife to reel contact that is too tight.) NOTE: New bedknife must be ground after installing on bedbar to match bedknife to bedbar.

Factor	Possible Problem/Correction
7. Bedknife to reel contact.	Check bedknife to reel contact daily and adjust as necessary. Bedknife must have light contact all across reel. No contact will cause cutting edges to become dull. Excessive contact accelerates wear; quality of cut may be adversely affected. Slightly dull cutting edges may be corrected by back-lapping. Excessively dull cutting edges must be corrected by grinding the reel and bedknife.
8. Front roller adjustment.	Check and adjust as necessary to avoid mismatch between cutting units.
9. Height of cut.	All cutting units set at same height of cut. Set with rear roller – must be equal at both ends of roller. Bench set height of cut and actual (effective) height of cut are different. Effective height of cut depends on cutting unit down pressure adjustment and turf conditions.
10. Rear roller scraper adjustment.	Set scraper to 1/32 in. clearance from roller.
11. Stability of bedbar.	Make sure bed bar pivot bolts are securely seated (maximum 40 ft-lb.) Make sure opposing bedknife adjustment screws are tight. To prevent distortion of adjustment screw mounting plate and to prevent damage to bedbar, do not over-tighten the screws.
12. Number of reel blades.	Select cutting unit model with correct number of blades for desired height of cut and reel speed.
13. Cutting unit alignment and carrier frame ground following.	Check lift arms and carrier frames for binding, bushing wear or damage. Repair if necessary.
14. Roller condition	All rollers must rotate freely. Grease when needed or repair bearings if necessary. Make sure roller brackets are in alignment to prevent excessive bearing wear.

Set Up and Adjustments

Adjustment Summary and Check List

DETAILED ADJUSTMENT INSTRUCTIONS FOLLOW THIS SUMMARY AND CHECK LIST. Study this information and refer to it often to get maximum life and performance from the cutting units.

Daily Performance Checks

NOTE: It is not necessary to remove cutting units from traction unit to perform these daily checks. It is recommended that mowers be washed after each use. Always remove key from ignition switch when working on the machine.

1. Purge water and debris from all bearings by greasing them. Use No. 2 multi-purpose lithium base grease.

2. Visually check for sharp reel and bedknife.

- Remove burrs, nicks, and rounded edges.

3. Lower cutting units to the ground (setting on both rollers). Remove reel motor and rotate the reel backwards by hand. Light contact between the bedknife and reel should be felt and heard.

- It should be possible to pinch newspaper when inserted from the front, and cut paper when inserted at a right angle (along entire length of bedknife).
- It should be possible to cut paper with minimum bedknife to reel contact. Should excessive reel drag be evident you must backlap or grind the cutting unit.
- No contact will dull the cutting edges.
- Excessive contact accelerates wear, and quality of cut may be adversely affected.

4. Check reel speed controls. If necessary, adjust reel speed to settings shown on REEL SPEED SETTINGS graph for number of reel blades (5 or 8) and desired ground speed (see Operator's Manual and decal on machine under seat plate).

NOTE: Reel speed settings may require "fine tuning" from initial adjustment for optimum cutting performance.

Weekly Checks

1. Check reel bearing adjustment and bearing condition.

2. Make sure bed bar pivot bolts are securely seated (maximum 40 ft-lb.).

3. Using a gauge bar, verify correct height of cut setting and adjust as necessary.

4. Check lift arm down pressure springs. Make sure all springs have same down pressure setting.

Monthly Adjustments

NOTE: Remove cutting unit from traction unit before doing these checks and adjustments (See Cutting Unit Removal and Installation in the Repairs section of this chapter.)

1. Visually check for sharp reel and bedknife. Backlap or grind reel and bedknife if necessary.

2. Adjust front roller.

3. Adjust bedknife to reel contact.

4. Using a gauge bar, set the height of cut adjustment.

5. Adjust rear roller scraper (if equipped) to be 1/32 in. from roller.

6. Check grass shield adjustment.

7. Set top bar adjustment.

- 0.060 in. from reel - normal.

Special Notes

1. A "rifled" reel and/or bedknife must be corrected by grinding.

2. If reel bearings will not hold adjustment during operation, loosen adjustment nut, tap on head of bolt at end of reel shaft with a small hammer until end play of reel shaft can be felt, tighten reel shaft *spline nut* to a torque of 40 to 60 ft-lb, then adjust reel bearings.

Reel Bearing Service and Adjustment

1. Adjust the bedknife so it is not in contact with the reel.

2. Reel bearing drag should be 4 to 7 in-lb. This can be measured with a torque wrench (Fig. 5). If bearing drag does not meet above specification, adjust the reel bearings.

NOTE: If you do not have an inch-pound torque wrench, do steps 1 - 3 under Reel Bearing Adjustment below.

Reel Bearing Adjustment

1. Remove mounting nuts from counterbalance end cap and remove end cap from the mounting studs (Fig. 6).

CAUTION

Do not use your hand to prevent reel from turning while servicing; this can result in personal injury. Use a 1/2 in. thick x 3 in. wide x 8 in. long piece of hardwood inserted into front of cutting unit between reel blades.

2. Loosen large reel bearing adjustment nut (Fig. 7). Tap on the head of the hex head bolt on the end of the reel shaft with a small hammer, until end play of the reel shaft can be felt.

NOTE: If reel bearings will not hold adjustment during operation, loosen adjustment nut, tighten reel shaft spline nut on right hand end of reel shaft to a torque of 40 to 60 ft-lb, then adjust reel bearings.

3. Tighten reel bearing adjustment nut until there is no reel shaft end play, then tighten an additional 1/16 to 1/8 turn. Be certain to remove all end play, but do not over-tighten.

NOTE: Adjustment nut must have enough resistance against reel shaft threads to retain bearing adjustment. Replace adjustment nut if necessary.

4. Check rolling torque with an inch-pound torque wrench (Fig. 7). Reel bearing rolling torque should not exceed 7 in-lb. Repeat steps 2, 3 and 4 if necessary.

5. If bearings require replacement, see Reel Removal and Bearing Replacement in the Repairs section of this chapter.

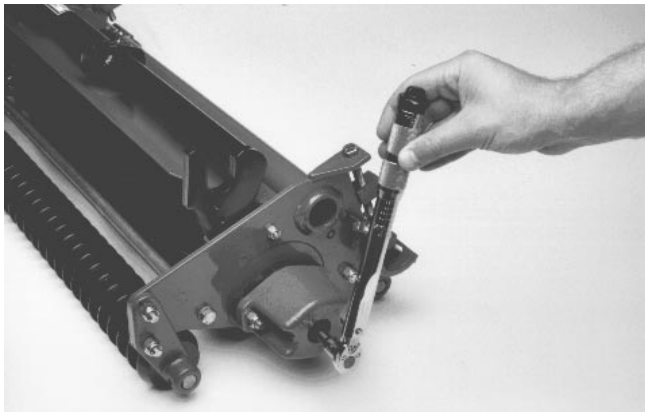


Figure 5

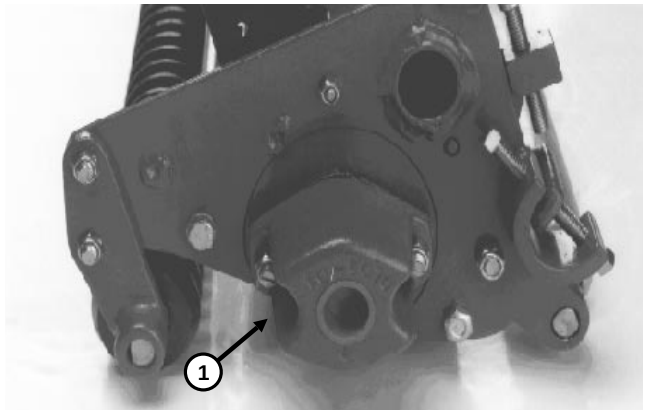


Figure 6

1. Counterbalance end cap

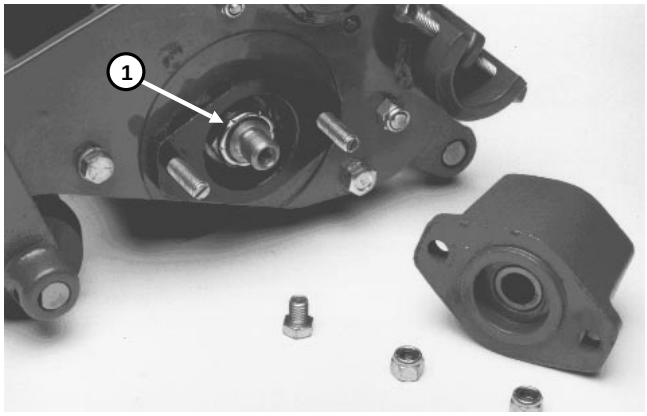


Figure 7

1. Reel bearing adjustment nut

Bedknife To Reel Adjustment

IMPORTANT: For adjusting bedknife to reel, use a 3/8 in. open end wrench that is 3 to 6 in. in length. A longer wrench will provide too much leverage and may cause distortion of the adjustment screw mounting plate or bedbar breakage.

1. To move bedbar closer to reel blades, loosen bottom screw on each side of cutting unit then tighten top adjustment screw on each side of cutting unit (Fig. 8). To move bedknife away from reel blades, loosen top screw on each side of cutting unit, then tighten bottom adjustment screw on each side of cutting unit.

2. After adjusting bedknife to reel, make sure that both the top and the bottom adjustment screws are secured at both ends of cutting unit.

3. After adjustment, check to see if reel can pinch paper when inserted from the front, and cut paper when inserted at a right angle (Fig. 9). It should be possible to cut paper with minimum contact between the bedknife and reel blades. Should excessive reel drag be necessary to cut paper (more than 7 in-lb) it **will** be necessary to either back lap or grind the cutting unit to achieve the sharp edges needed for precision cutting.

IMPORTANT: If excessive bedknife to reel contact is maintained, bedknife and reel wear will be accelerated. Uneven wear can result and quality of cut may be adversely affected.

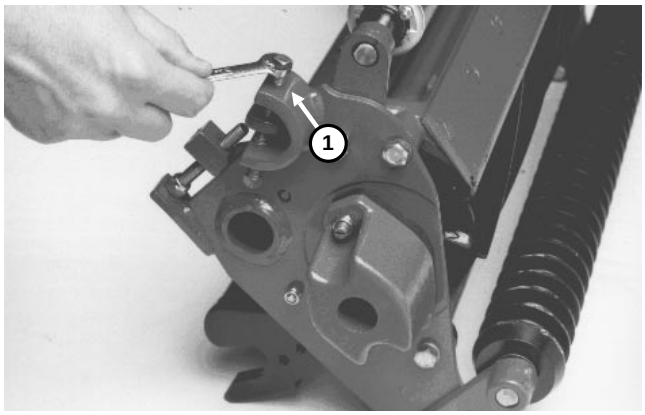


Figure 8A

1. Bottom bedknife adjustment screw

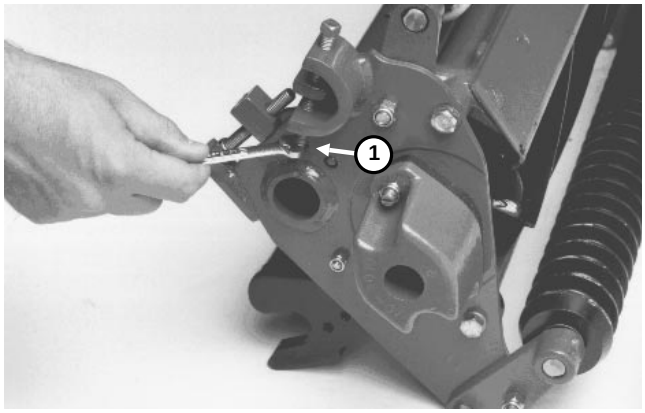


Figure 8B

1. Top bedknife adjustment screw

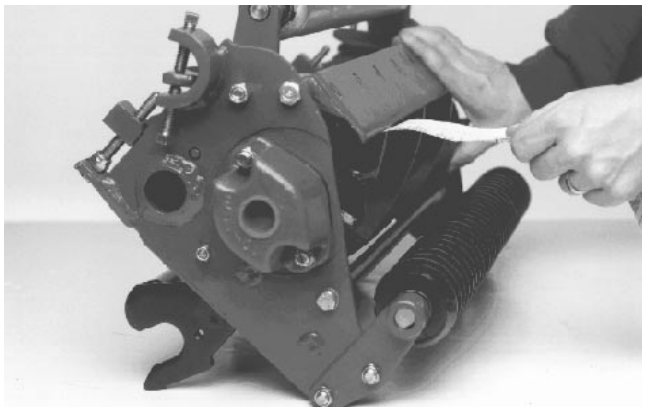


Figure 9

Front Roller Adjustment

Loosen four (4) capscrews holding front roller brackets. Push roller towards the rear, then hold in position and tighten capscrews. Make sure roller has not changed position. NOTE: When securing front roller brackets, tighten fastener on inside of cutting unit frame so position of roller bracket does not change.

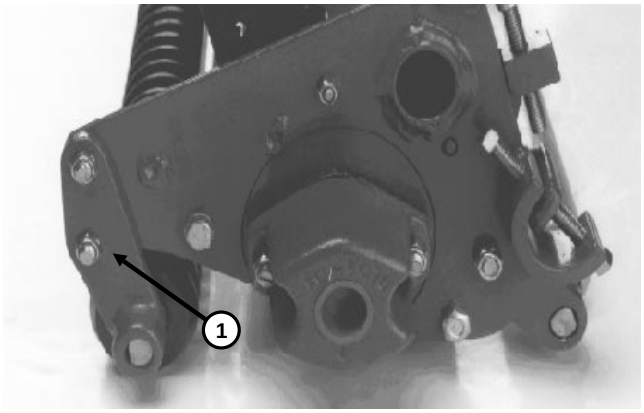


Figure 10

1. Roller bracket

Height Of Cut Adjustment

NOTE: Effective height of cut in the turf can be affected by lift arm down pressure adjustment and turf conditions, such as grass type, grass density, and amount of thatch.

1. Do bedknife to reel adjustment and front roller adjustment before adjusting height of cut.

2. To adjust height of cut, cutting unit should be turned over (Fig. 11).

3. Loosen locknut securing height of cut bracket to side plate on each end of cutting unit and loosen locknut on each height of cut adjusting bolt.

4. Set head of screw on gauge bar to desired height of cut. Height of cut measurement is from face of bar to under side of screw head.

5. Put bar across front and rear rollers. Turn height of cut adjustment bolt until underside of screw head engages bedknife cutting edge.

IMPORTANT: Do step 5 on each end of bedknife. Tighten height of cut adjustment bolt locknuts and height of cut bracket locknuts on both ends of cutting unit. Check adjustment and readjust if necessary.

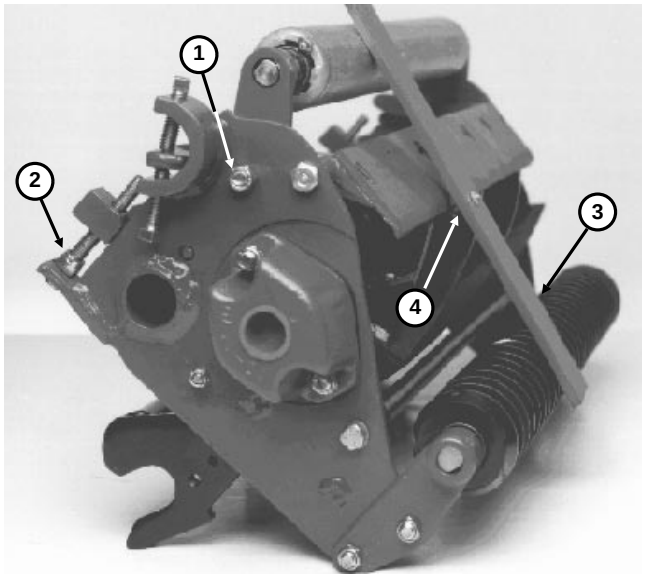


Figure 11

1. Locknut
2. Height of cut adjustment bolt
3. Gauge bar
4. Gauge bar screw head

Shield Height Adjustment

Adjust shield to get proper grass clipping discharge into basket or for desired front discharge when not using baskets.

1. Set cutting unit in normal cutting position.

2. Loosen capscrews and nuts securing shield to each side-plate, adjust shield to correct height and tighten fasteners (Fig. 13).

3. Repeat adjustment on remaining cutting units and adjust top bar. (See Top Bar Adjustment in this section of the book.)

NOTE: Shield can be lowered in dry grass conditions (clippings fly over top of baskets) or raised to allow for heavy wet grass conditions (clippings build up on rear edge of basket.

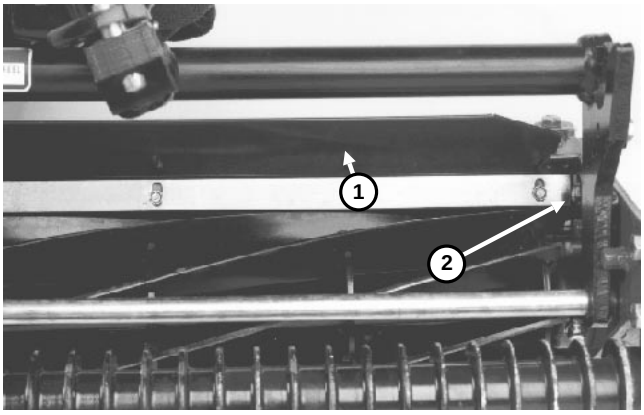


Figure 13

1. Shield **2. Shield fastener (one on each side)**

Opening Rear Shield

When mowing in conditions in which an excessive amount of clippings is being removed, rear discharge may be desirable. Opening the rear shield will allow direct discharge of clippings, to prevent cutting the clippings again.

1. Loosen locking bolt on side of cutting unit (Fig. 14).

2. Open rear shield to desired position.

3. Tighten locking bolt on each side of cutting unit.

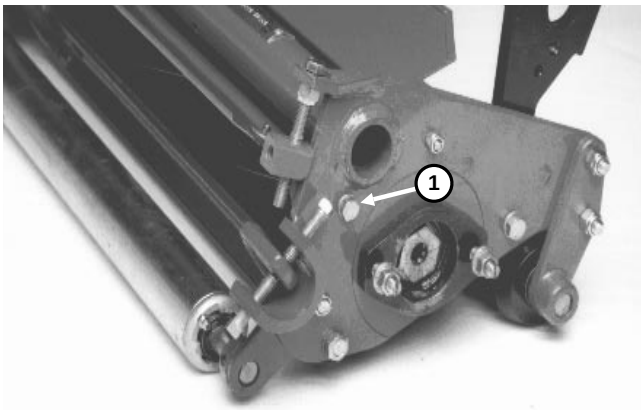


Figure 14

1. Rear shield locking bolt

Top Bar Adjustment

Adjust top bar to make sure clippings are cleanly discharged from reel area:

1. Loosen screws securing top bar (Fig. 15). Insert 0.060 inch feeler gauge between top of reel and bar and tighten screws. Make sure bar and reel are equal distance apart across complete reel.

2. Do adjustment on remaining cutting units.

NOTE: Bar should be parallel to reel for optimum performance and should be adjusted whenever shield height is adjusted or whenever reel is sharpened on a reel grinder.

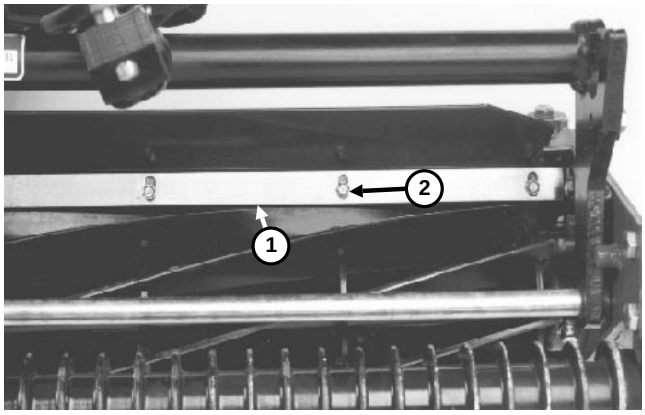


Figure 15

1. Top bar
2. Bar mounting screws

Lock-up Roller Adjustment

Adjust lock-up rollers so they contact the lock-up lever on each rear lift arm and support the cutting units when fully raised (Fig. 15a). The cutting units should have approximately 3/8 to 5/8 in. vertical travel when measured at the rear roller.

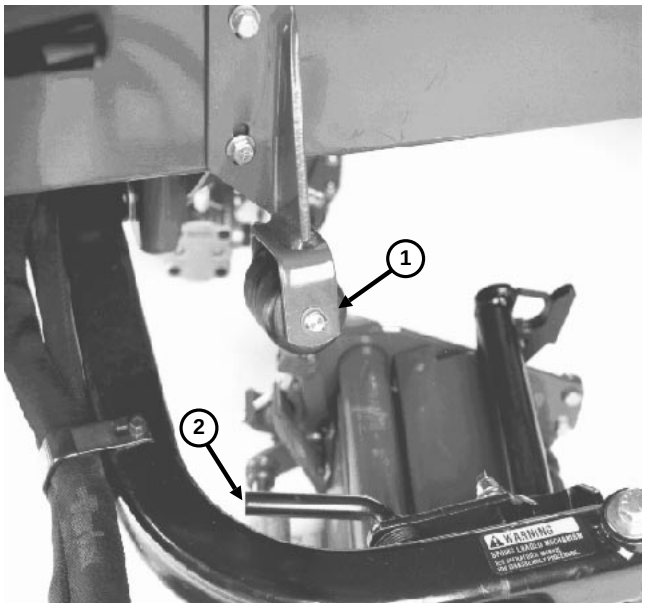


Figure 15a

1. Lock-up roller
2. Lock-up lever

Lift Arm Down Pressure Adjustment

The down pressure spring on each cutting unit lift arm can be adjusted to compensate for different turf conditions. Increased down pressure will help keep the cutting units on the ground when mowing at higher speeds and helps maintain a uniform height of cut in rough conditions or in areas of thatch build up.

Each down pressure spring may be adjusted to one of four (4) settings. Each increment increases or decreases down pressure on cutting unit by 8 lbs.

1. Put machine on a level surface, lower the cutting units, stop the engine, engage the parking brakes and remove key from ignition switch.

2. Remove floor plate in front of seat and open the hood to get access to all five (5) springs.

CAUTION

Springs are under tension. Use caution when adjusting.

3. Put an open end wrench on hex shaft of spring bracket.

NOTE: Because wrench can be moved only a limited distance, it may be necessary to use a second wrench to hold hex shaft while re-positioning other wrench for further rotation of hex shaft.

4. Remove capscrew and locknut securing retaining bracket, while rotating hex shaft to relieve spring tension.

5. Move spring bracket to desired position and install capscrew and locknut, while rotating hex shaft to relieve spring tension.

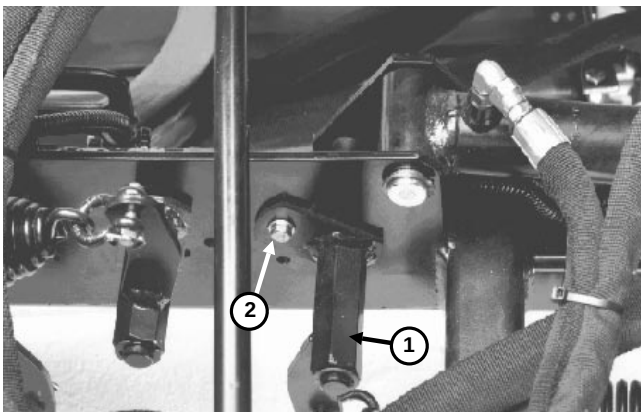


Figure 16

1. Spring bracket hex shaft
2. Retaining bracket

Cutting Unit Removal and Installation

Remove cutting unit from traction unit before doing adjustments or repairs.

1. Remove basket from cutting unit.

2. Disconnect chain from cross tube on each rear cutting unit (Fig. 17).

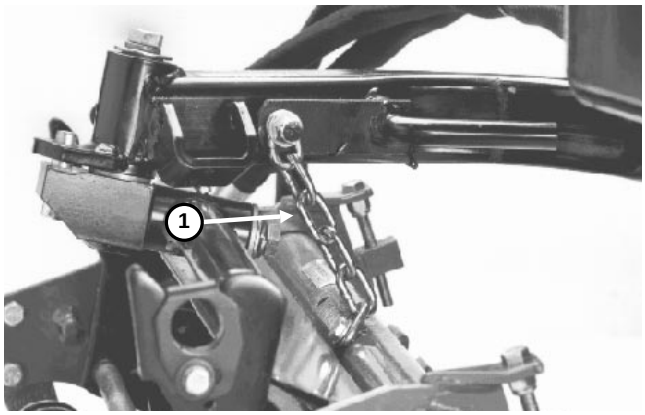


Figure 17

1. Lock up chain

3. Loosen reel motor mounting nuts (Fig. 18). Rotate the motor clockwise so motor flanges clear studs and pull motor off of cutting unit.

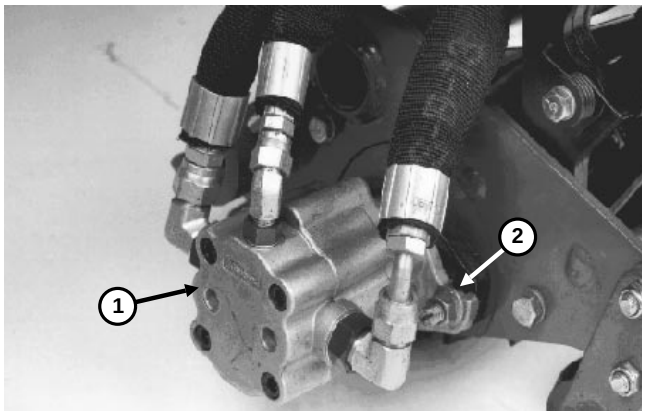


Figure 18

1. Reel drive motor **2. Mounting nuts**

4. Remove capscrew, lock washer, flat washer and thrust washer from cutting unit mounting shaft (Fig. 19).

5. Pull cutting unit off mounting shaft.

6. Reverse steps 1 - 5 to install cutting unit.

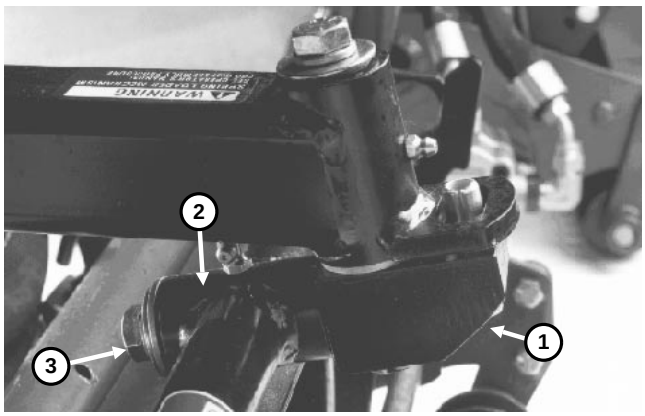


Figure 19

1. Cutting unit mounting shaft
2. Carrier tube frame pivot tube
3. Capscrew, lockwasher, flat washer and thrust washer

Reel Lapping

DANGER

Reel may stall while backlapping. Do not attempt to restart reels by hand or adjust while backlapping. Stop engine and turn H.O.C. knob one position toward "A".

1. Put the machine on a clean, level surface, lower cutting units, stop the engine, engage the parking brakes, move the enable/disable switch to DISABLE and remove key from ignition switch (Fig. 20)

2. Unlock and raise seat to expose controls.

3. Open control cover and turn the height of cut selection knob to position "P".

4. Make initial bedknife to reel adjustment for backlapping on all cutting units.

5. Start engine and run at IDLE SPEED.

DANGER

To avoid personal injury, never put hands or feet in reel area while engine is running. Changing reel speed while backlapping may cause reels to stall. Never change engine speed while backlapping. Only backlap at engine idle speed. Never attempt to turn reels by hand or with foot while engine is running.

6. Move backlap switch to either FRONT or REAR to select with reels are to be backlapped.

DANGER

To avoid personal injury, make sure you are clear of cutting units before proceeding.

7. Move enable/disable switch to ENABLE. Move lower mow/raise lever forward to start backlapping operation on selected reels (front or rear).

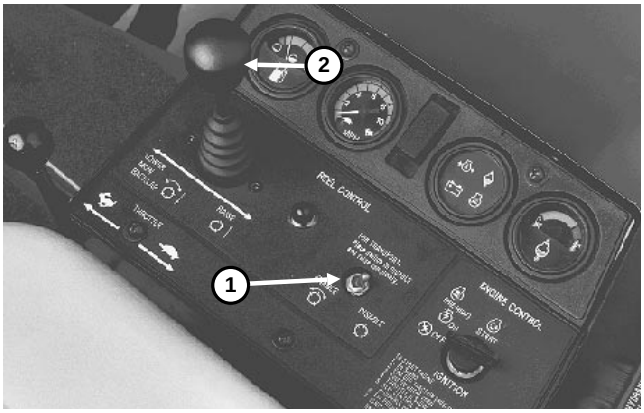


Figure 20

1. Enable / Disable switch
2. Lower Mow / Raise control lever

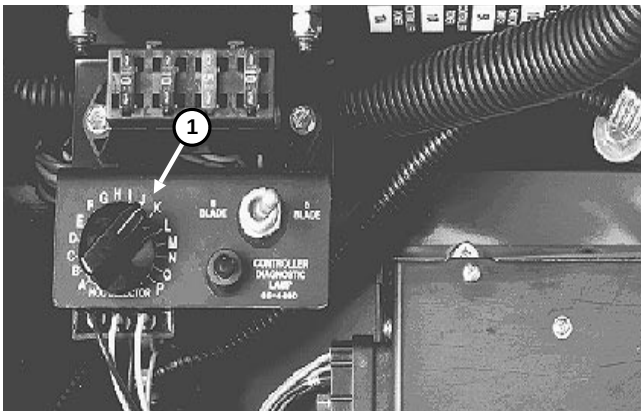


Figure 21

1. Height of cut (H.O.C.) selector knob

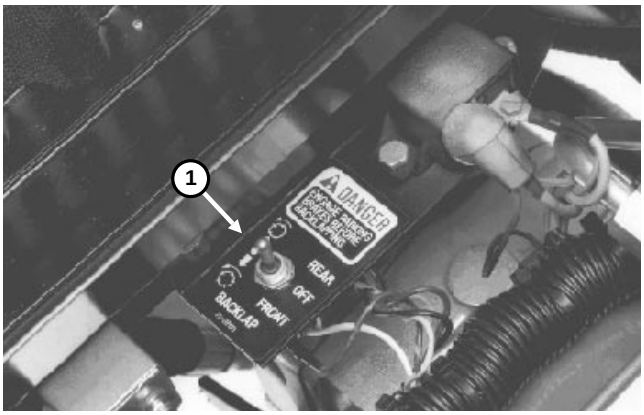


Figure 22

1. Backlap switch

8. Apply lapping compound with long-handled brush supplied with machine (Fig. 23). Never use a short handled brush.

9. If reel to be backlapped turns too slowly, or erratically, stop engine and turn H.O.C. knob one position toward “A”. Repeat steps 5 – 8. Position “P” will provide the slowest speed for backlapping. Position “A” will provide the fastest speed for backlapping. New motors will generally backlap at position “P”, but with time, the setting may need to be moved closer to “A” to compensate for motor wear.

10. To make an adjustment to the cutting units while backlapping, turn reels OFF by moving the lower mow / raise lever rearward; move the enable / disable switch to disable and turn the engine OFF. After adjustments have been completed, repeat steps 5 – 8.

11. Repeat procedure for all cutting units to be backlapped.

12. When backlapping operation has been completed, return the backlap switch to OFF, lower seat and tighten both locking bolts securely. Wash all lapping compound off cutting units. Do cutting unit reel to bedknife adjustment as necessary.

IMPORTANT: If the backlap switch is not returned to OFF position after backlapping, the cutting units will not raise or function properly.

IMPORTANT: If the cutting units are removed for backlapping (such as when bedknives are replaced) the reel speed sensors must be removed from the left front and left rear cutting units. Before backlapping, install a 3/8" capscrew in the left end of the reel shaft to drive the reel when backlapping. DO NOT attempt to use the capscrew which attaches the magnet to drive the reel for backlapping – this capscrew must be tightened to a maximum torque of 5 ft-lb to avoid damage to the magnet.

NOTE: For a better cutting edge, run a file across the front face of the bedknife when the lapping operation is completed. This will remove any burrs or rough edges that may have built up on the cutting edge.

Figure 23

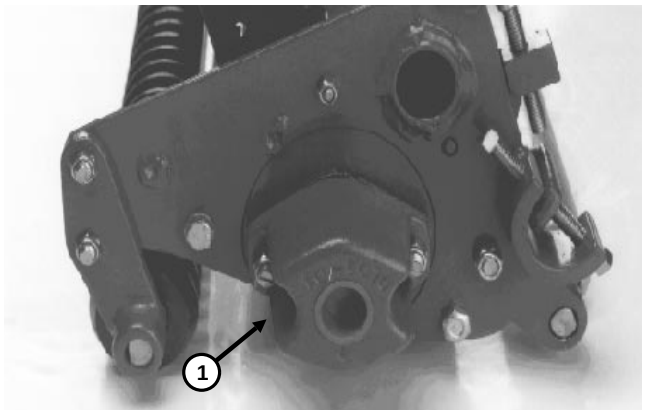


Figure 24

1. Counterbalance weight

Bedbar Removal and Installation

The rear roller assembly must be removed so the bedbar can be removed for bedknife sharpening.

1. Remove locknut securing rear roller height of cut bracket to side plate on both ends of cutting unit (Fig. 25).

2. Loosen allen head setscrews securing rear roller shaft to height of cut brackets.

3. Unthread height of cut adjustment bolts and remove them from both side plates.

4. Remove bedbar pivot bolts from each end of cutting unit. Loosen bedknife adjusting screws at each end of cutting unit. Remove the bedbar by rotating it away from the reel.

NOTE: For proper grinding of bedknife follow procedures in the Toro publication “Sharpening Reel & Rotary Mowers”, Form No. 80-300-PT.

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

IMPORTANT: When installing bedbar, be sure to assemble rear roller brackets UNDER arms of bedbar.

IMPORTANT: Securely seat the (2) bedbar pivot bolts to a maximum torque of 40 ft-lbs. Always check reel bearing adjustment after installing bedbar.

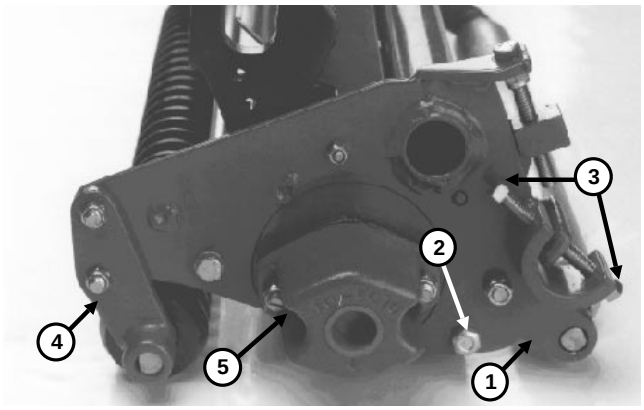


Figure 25

1. Rear roller height of cut bracket
2. Bedbar pivot bolt
3. Bedknife adjusting screws
4. Front roller brackets
5. Counterbalance end cap

Bedknife Replacement

1. Remove bedbar (see Bedbar Removal and Installation).

2. Remove bedknife screws and remove bedknife.

3. Remove all rust, scale and corrosion from bedbar surface before installing the new bedknife.

4. Install new bedknife with the proper bedknife screws (57-4910). Bedknife screws must bottom out on the bedknife, not the bedbar. Tighten the screws to a torque of 200 in-lb, working from the center toward each end of the bedbar (Fig. 26).

5. Grind the new bedknife to match it to the bedbar.

NOTE: For proper grinding of bedknife, follow procedures in the Toro publication “Sharpening Reel and Rotary Mowers”, Form No. 80-300-PT.

6. Install the bedbar.

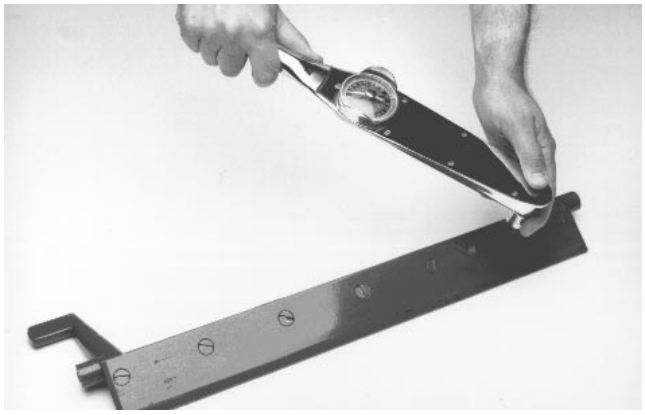


Figure 26

Preparing Reel For Grinding

IMPORTANT: Adjust reel bearings before grinding reel. (See Reel Bearing Service and Adjustment in the Adjustments section of this chapter.

1. Remove bedbar (see Bedbar Removal and Installation).

NOTE: Some reel grinders may require rear roller assembly be mounted to the cutting unit for proper support in reel grinder. Rear roller MUST be parallel to reel shaft to remove taper when grinding.

2. If necessary, remove front roller assembly.

   A. Remove locknuts securing front roller brackets to side plates at both ends of cutting unit (Fig. 27).

   B. Remove roller assembly by pulling evenly on both sides.

For proper grinding of reel, follow procedures in the Toro publication “Sharpening Reel & Rotary Mowers, Form No. 80-300-PT.

3. Install bedbar. After grinding, assemble cutting unit and do all adjustments. Back lap if necessary to get desired fit between reel and bedknife.

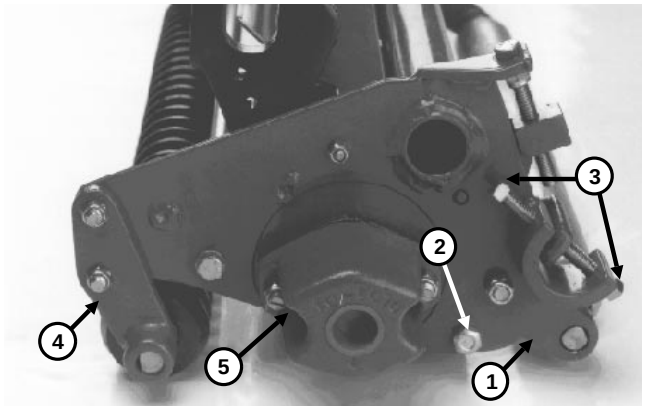


Figure 27

1. Rear roller height of cut bracket
2. Bedbar mounting bolts
3. Bedknife adjusting screws
4. Front roller brackets
5. Counterbalance end cap

Reel Removal and Bearing Replacement

1. Remove front and rear roller assemblies. Remove bedbar. Remove carrier frame.

2. Remove counterbalance end cap (Fig. 28). Remove large bearing adjustment nut from left hand end of reel shaft (Fig. 28) and special spline nut from opposite end of reel shaft.

3. Remove machine screws securing bearing housing on each end of cutting unit (Fig. 29). Machine screw heads will have to be cut off before screw can be completely removed:

A. Unscrew machine screw approximately two turns.
B. Cut head off of machine screw.
C. Use a screw driver to back out remaining part of screw from side plate (outwards, not inwards towards reel).

IMPORTANT: Remove grease fittings from bearing housing at each end of cutting unit. Note that 45° fitting is on right end and 90° fitting is at left end (when viewed in the direction of travel).

4. Use a plastic headed hammer to rotate bearing housing slightly, install bolts from outside of housing and turn bolts alternately against side plate to remove bearing housing (Fig. 30). Bearing housing will slip out of side plates and reel assembly can be removed as soon as bearing housings are disassembled from side plates.

5. Before installing reel, install new special machine screws and washers from inside of frame to secure bearing housing.

6. If necessary, install new bearings and seals:

A. Remove outer seal (in counterbalance weight), bearing cup, bearing cone and inner seal.

B. Bearing housing must be completely free of paint and foreign material before installing bearing cup. If necessary, remove any “flash” from bearing housing that may interfere with accurate seating of bearing. Install new inner seal. Install bearing cup.

C. Install bearing housing to frame. Pack bearing cone with grease and install over reel shaft into bearing cup. Install outer seal (in counterbalance weight).

8. Install bedbar. Install front and rear roller assemblies. Install carrier frame.

7. Tighten spline nut to 40 - 60 ft-lb, then adjust bearings (See Reel Bearing Service and Adjustment.)

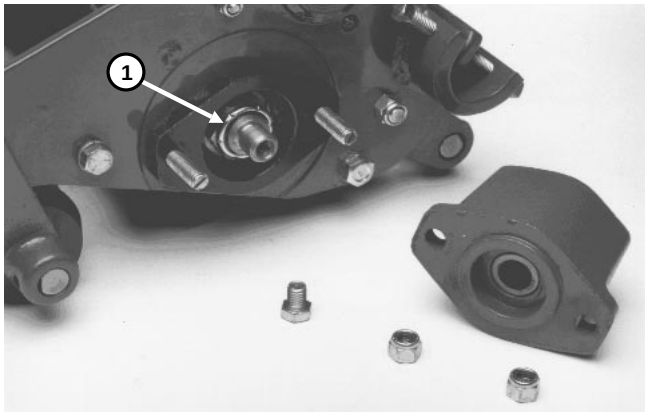


Figure 28

1. Reel bearing adjustment nut

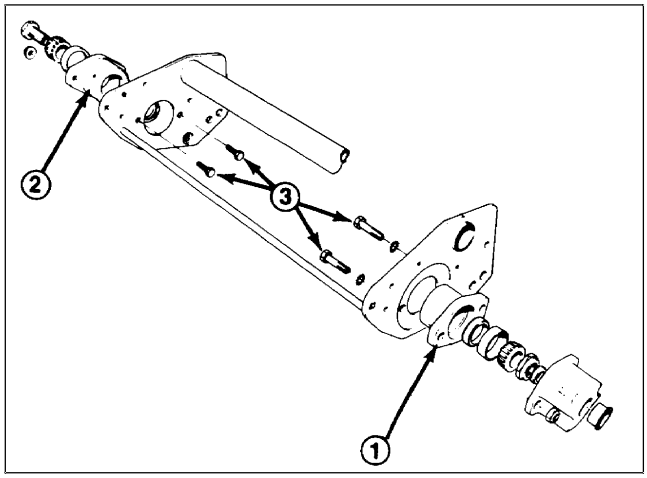


Figure 29

1. Left reel bearing housing
2. Right reel bearing housing
3. Machine screws

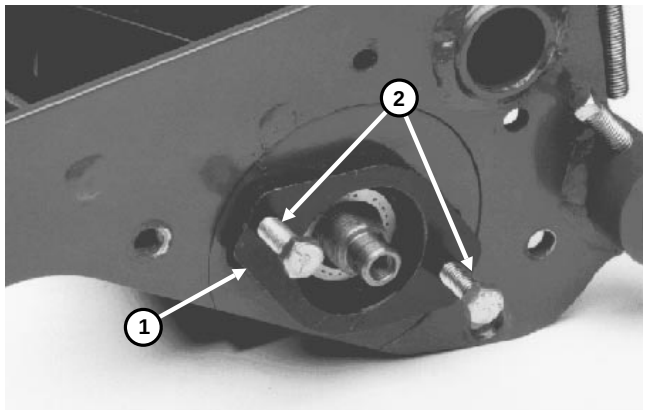


Figure 30

1. Bearing housing - rotate slightly
2. Bearing housing mount bolts - thread against side plate to remove housing

Lift Arm Spring Replacement

1. Put machine on a level surface, lower the cutting units, stop the engine, engage the parking brakes and remove key from ignition switch.

2. Remove floor plate in front of seat to get access to front springs or open hood to get access to rear springs.

CAUTION

Springs are under tension. Use caution when removing or adjusting.

3. Put an open end wrench on hex shaft of spring bracket.

NOTE: Because wrench can be moved only a limited distance, it may be necessary to use a second wrench to hold hex shaft while re-positioning other wrench for further rotation of hex shaft.

4. Remove capscrew and locknut securing retaining bracket, while rotating hex shaft to relieve spring tension, then rotate hex shaft to completely relieve spring tension.

5. Remove spring.

6. Install new spring.

7. Use an open end wrench to move spring bracket to desired position and install capscrew and locknut, while rotating hex shaft to relieve spring tension.

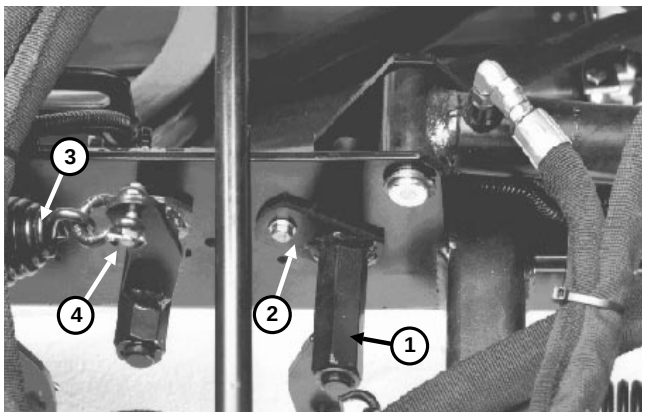


Figure 31

1. Spring bracket hex shaft
2. Retaining bracket
3. Spring
4. Clevis, clevis pin, and cotter pin

Chapter 9

4WD Rear Axle

Table of Contents

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

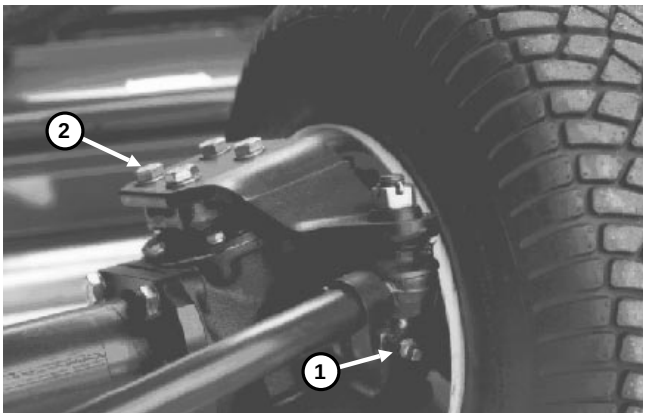


Figure 1
(Right-hand end of axle shown)

1. Check plugs (2) **2. Mounting bolts**

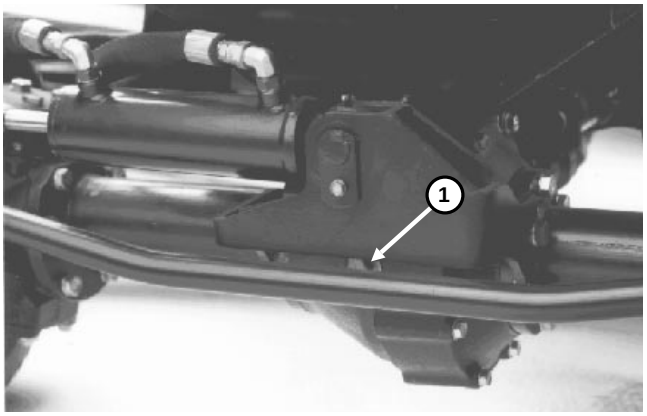


Figure 2

1. Check/fill plug

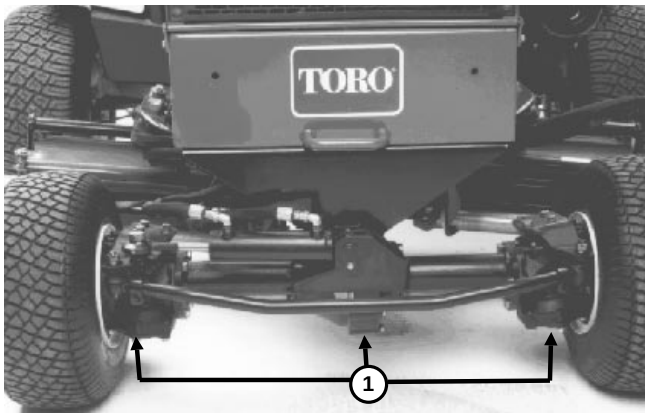


Figure 3

1. Drain plugs

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 (Fig. 4, 5).

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 (Fig. 4).

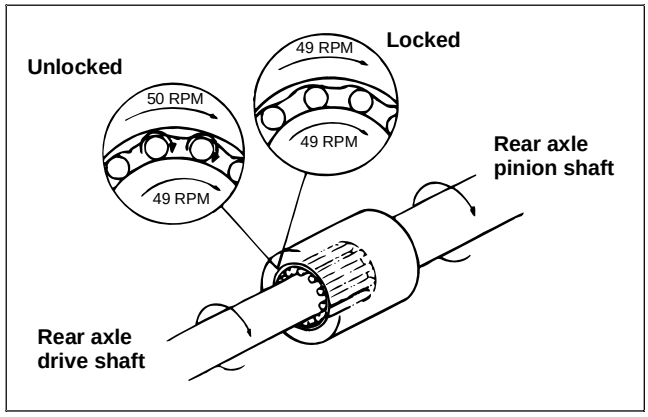


Figure 4

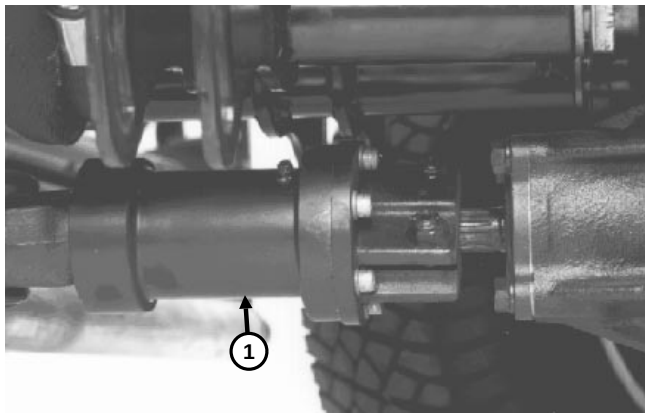


Figure 5

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 (Fig. 6).

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.

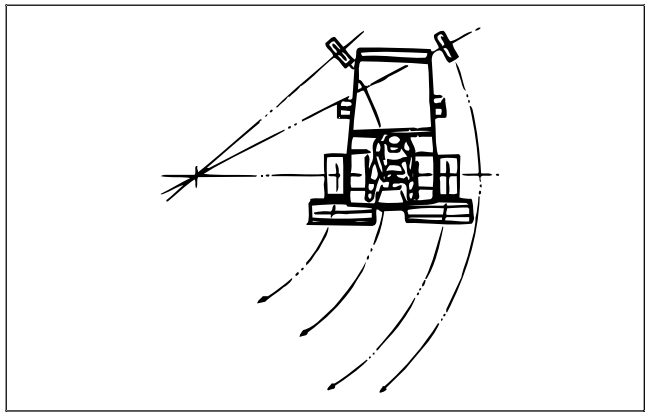


Figure 6

Rear Wheel Toe-in (Fig. 7)

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.

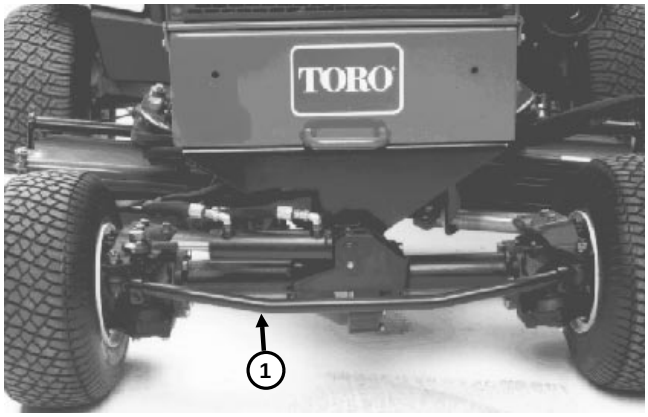


Figure 7

1. Tie rod

Drive Shaft Service

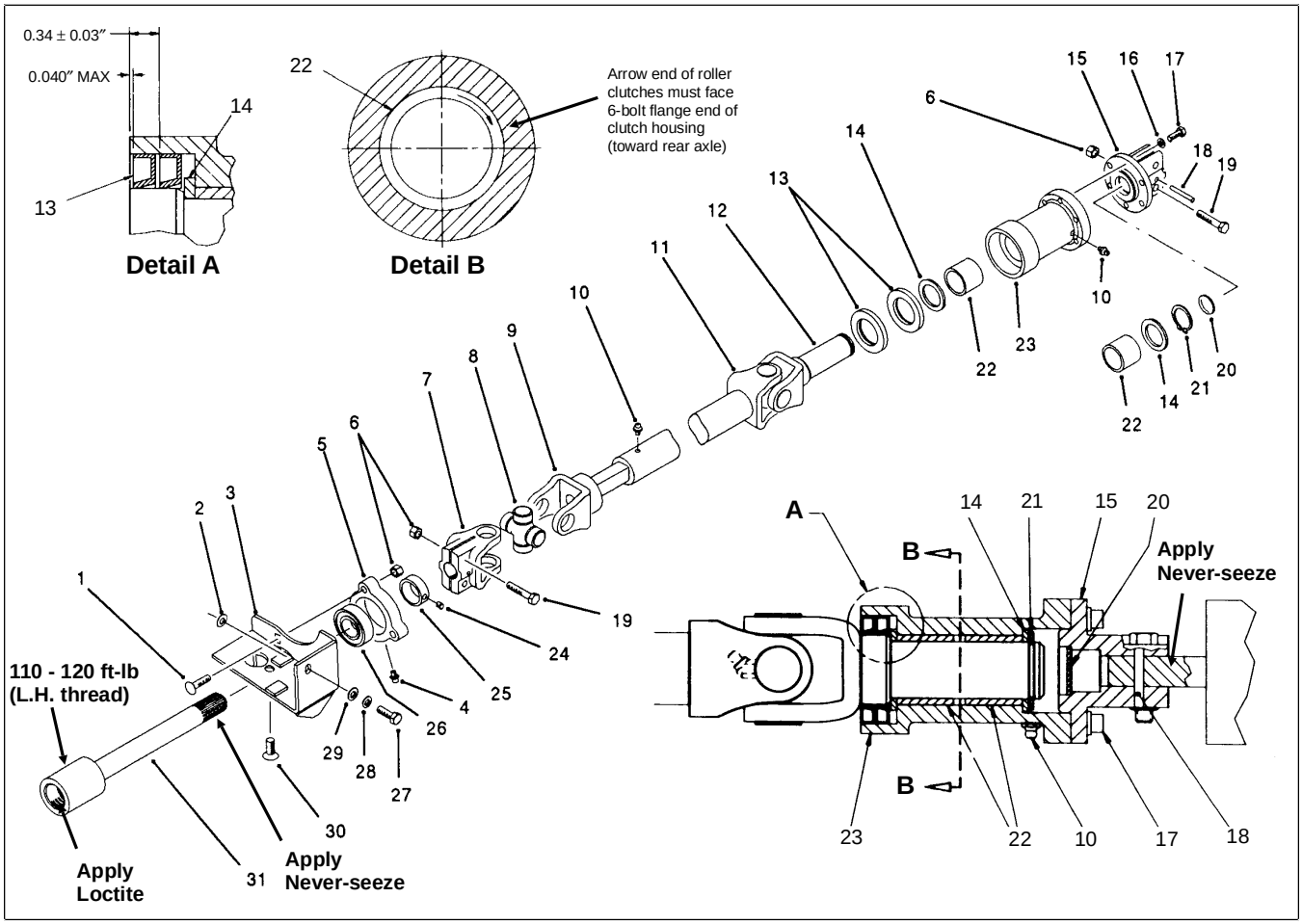


Figure 8

Removing Drive Shaft

1. Put machine on a level surface, lower cutting units, stop the engine and remove the key from the ignition switch. Block the rear wheels to prevent the machine from moving.

2. If front axle will be removed for repairs, first loosen traction shaft (Item 31) before removing drive shaft. To loosen traction shaft, use an open end wrench on square shaft of slip yoke (Item 9) and loosen by turning CLOCKWISE (left hand threads).

3. Use a hammer and punch to drive roll pin (Item 18) out of axle coupling (Item 15) and rear axle shaft. Loosen two (2) capscrews and locknuts securing coupling to axle shaft. Slide coupling off of shaft.

4. Loosen two (2) capscrews and locknuts securing end yoke (Item 7) to traction shaft spline (Item 31), then slide drive shaft yoke off of traction shaft.

Clutch Service

1. To disassemble clutch, remove six (6) capscrews (Item 17) and lockwashers (Item 16). Remove axle coupling (Item 15) from clutch housing (Item 23).

2. Remove retaining ring (Item 21). Clutch housing (Item 23), along with thrust washers (Item 14), roller clutches (Item 22) and seals (Item 13) can now be removed from yoke shaft (Item 12).

3. Inspect parts and replace as necessary.

4. Roller clutches (Item 22) must be installed into housing (Item 23) 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 14) in housing adjacent to roller clutch as shown. Press both seals (Item 13) into end of housing to dimensions shown. Seals must be installed with lip facing out.

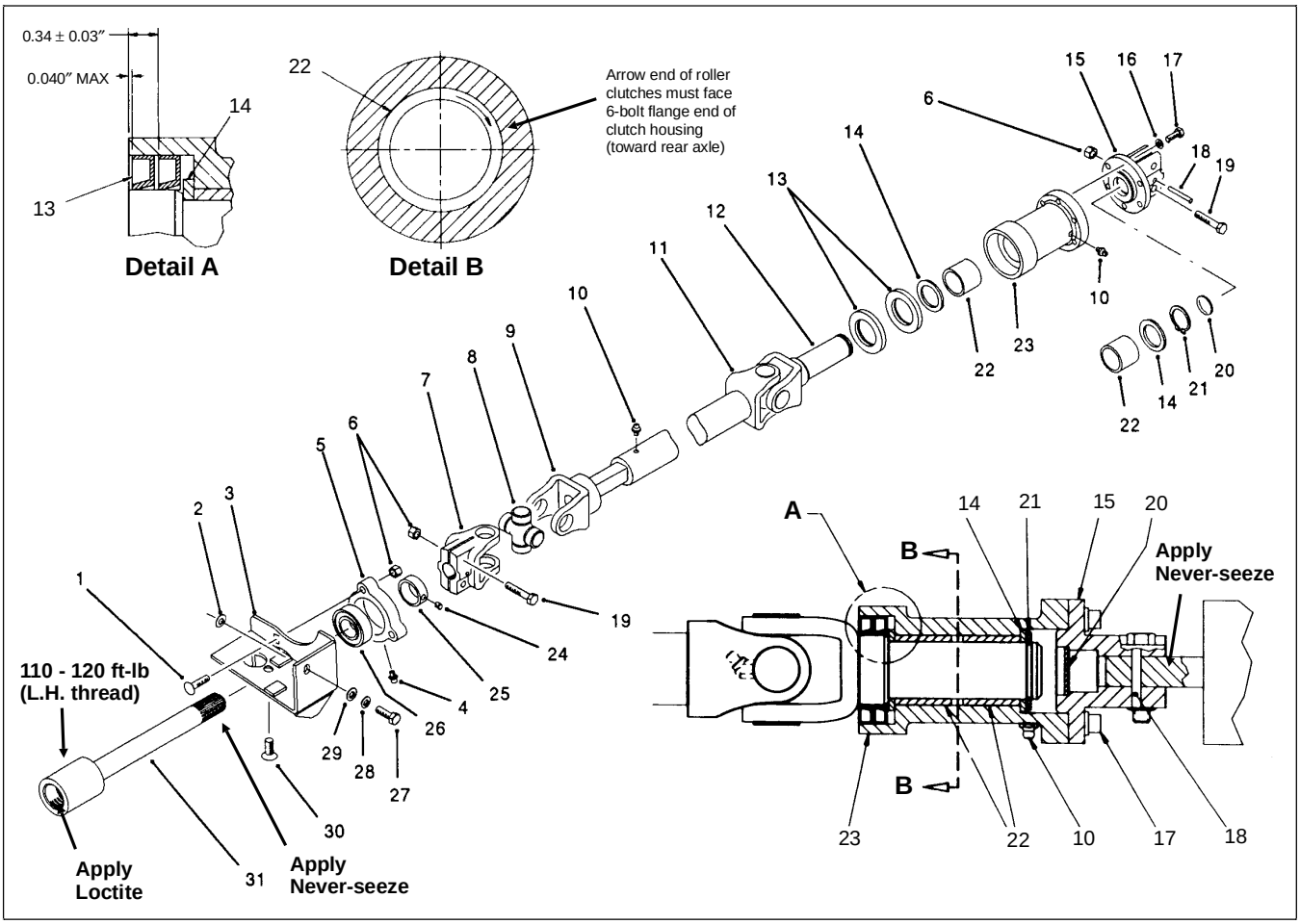


Figure 9

6. Install clutch assembly onto yoke shaft (Item 12), then install other thrust washer. Install retaining ring (Item 21) to secure clutch assembly to shaft. Install axle coupling (Item 15) 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.

Removing Traction Shaft (Item 31)

NOTE: If traction shaft threads were not loosened, (as instructed in step 2 under Removing Drive Shaft) you will have to connect drive shaft to traction shaft so it can be loosened by turning it clockwise (left hand threads).

1. Loosen setscrew (Item 24). Use a hammer and punch to loosen locking collar (Item 25) by rotating it in a counterclockwise direction as viewed from rear of machine.

2. Remove three (3) locknuts (Item 6) securing bearing (Item 5) to bracket (Item 3). Remove three (3) carriage bolts (Item 1) and bearing (Item 5).

3. Remove traction shaft from differential axle pinion coupler by rotating it clockwise.

Installing Traction Shaft (Item 31)

1. Apply medium strength Loctite or equivalent to threads of pinion coupler on rear of differential axle.

2. Thread traction shaft (Item 31) (left hand thread) onto pinion coupler. Do not tighten traction shaft at this time.

3. If bracket (Item 3) was removed:

Loosely mount bearing support (Item 5) to bracket (Item 3) with three (3) carriage bolts (Item 1) and locknuts (Item 6). Slide bearing bracket and bearing onto traction shaft, aligning the two (2) bearing bracket mounting holes with the holes in rear and bottom of hydrostatic transmission. Loosely mount bottom of bearing bracket to transmission with a 3/8-16 x 3/4 in. socket head screw (Item 30). Mount side of bracket to transmission with m8 x 1.25 x .25 capscrew (Item 27), m8 lockwasher (Item 28), m8 flat washer (Item 29) and 1 or 2 shims (Item 2). Determine whether 1 or 2 shims are required between bracket and transmission before tightening any fasteners. After shim(s) are in position on capscrew, tighten socket head screw and capscrew.

If bracket (Item 3) was not removed:

Slide bearing assembly onto traction shaft. Loosely mount bearing support (Item 5) to bracket (Item 3) with three (3) carriage bolts (Item 1) and locknuts (Item 6).

4. Slide locking collar (Item 25) onto traction shaft (Item 31). Do not tighten at this time.

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 (Item 15). Install roll pin (Item 18) through coupling and shaft.

3. Tighten two (2) capscrews (Item 19) and locknuts (Item 6) to secure coupling to shaft.

4. Slide yoke end (Item 7) of drive shaft onto traction shaft spline (Item 31).

5. Tighten two (2) capscrews (Item 19) and locknuts (Item 6) to secure yoke to shaft.

Do steps 6 - 9 only if traction shaft (Item 31) was removed:

6. Block front tires and jack up rear wheels of machine until there is approximately one inch clearance between rear tires and the ground. SECURELY BLOCK FRAME.

7. Using an open end torque wrench on square slip yoke shaft (Item 9) of drive shaft assembly, tighten traction shaft (counterclockwise) to a torque of 110 - 120 ft-lb.

8. Tighten locknuts (Item 6) securing bearing to bracket.

9. Rotate locking collar (Item 25) in a clockwise direction, as viewed from rear of machine. Tighten collar onto shaft by carefully rotating it with a hammer and punch. tighten set screw.

Rear Axle Removal and Installation

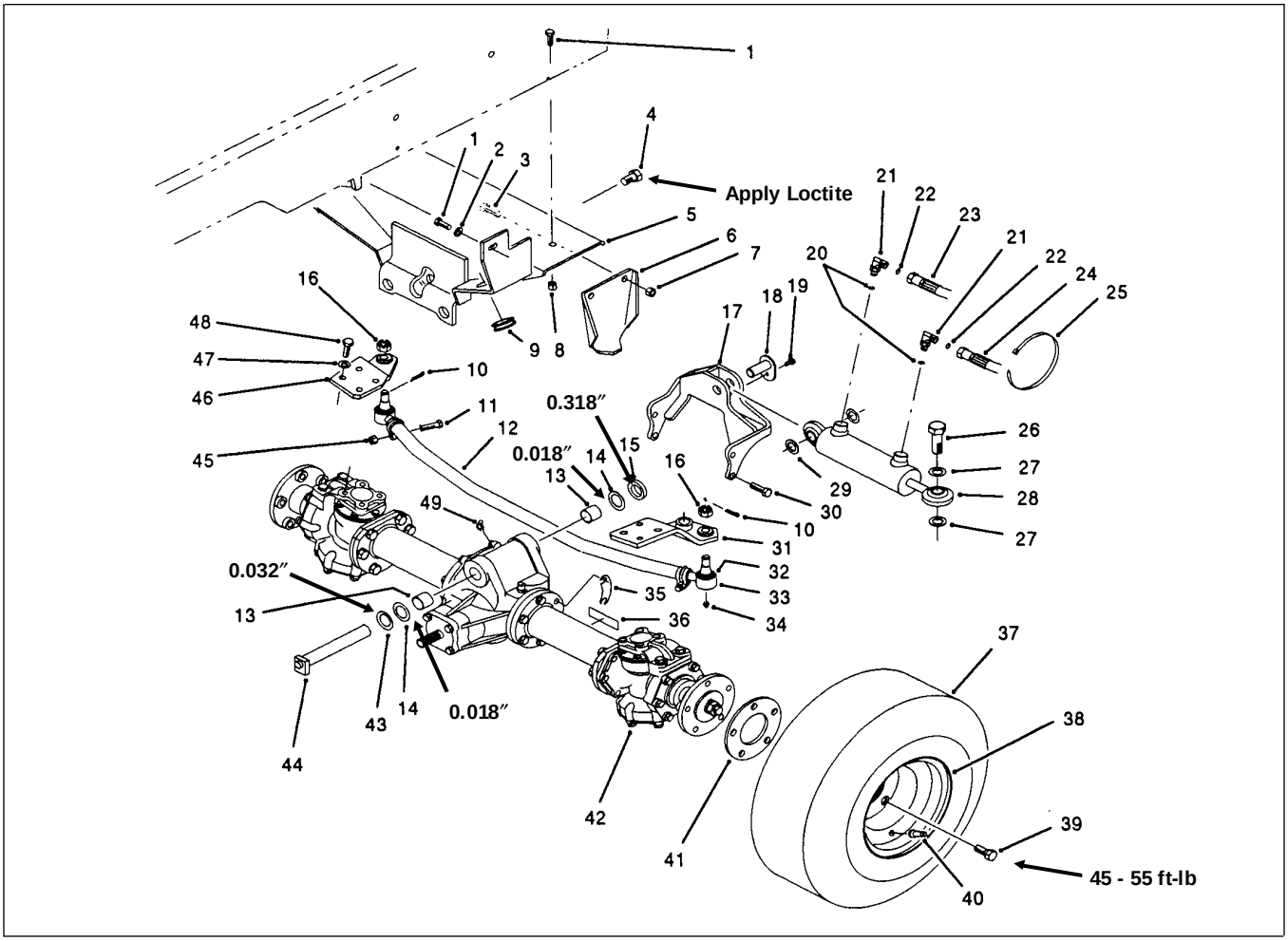


Figure 10

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 39).

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 and wheel spacers (Item 41).

6. Remove capscrew (Item 4) from pin (Item 44). Remove pin (Item 44) from axle support, allowing axle to be lowered to floor and removed.

7. Reverse steps 1 - 7 to install axle.

Install washers (Items 14, 15, 43) between axle and axle support.:

Item 14 (qty. 2) is 0.018″ thick.
Item 15 is 0.318″ thick.
Item 43 is 0.032″ thick.

Apply medium strength locktite to capscrew (Item 4) before installing to secure pin (Item 44).

NOTE: To hold wheel spacer (Item 41) on hub when installing wheel, apply a small amount of grease to hub side of spacer before putting into position on hub.

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.

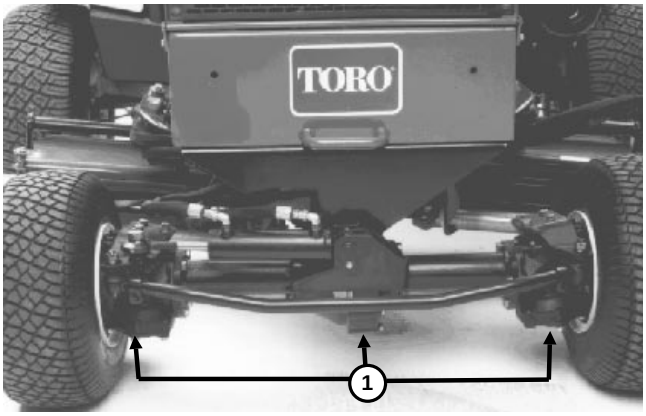


Figure 11

1. Drain plugs

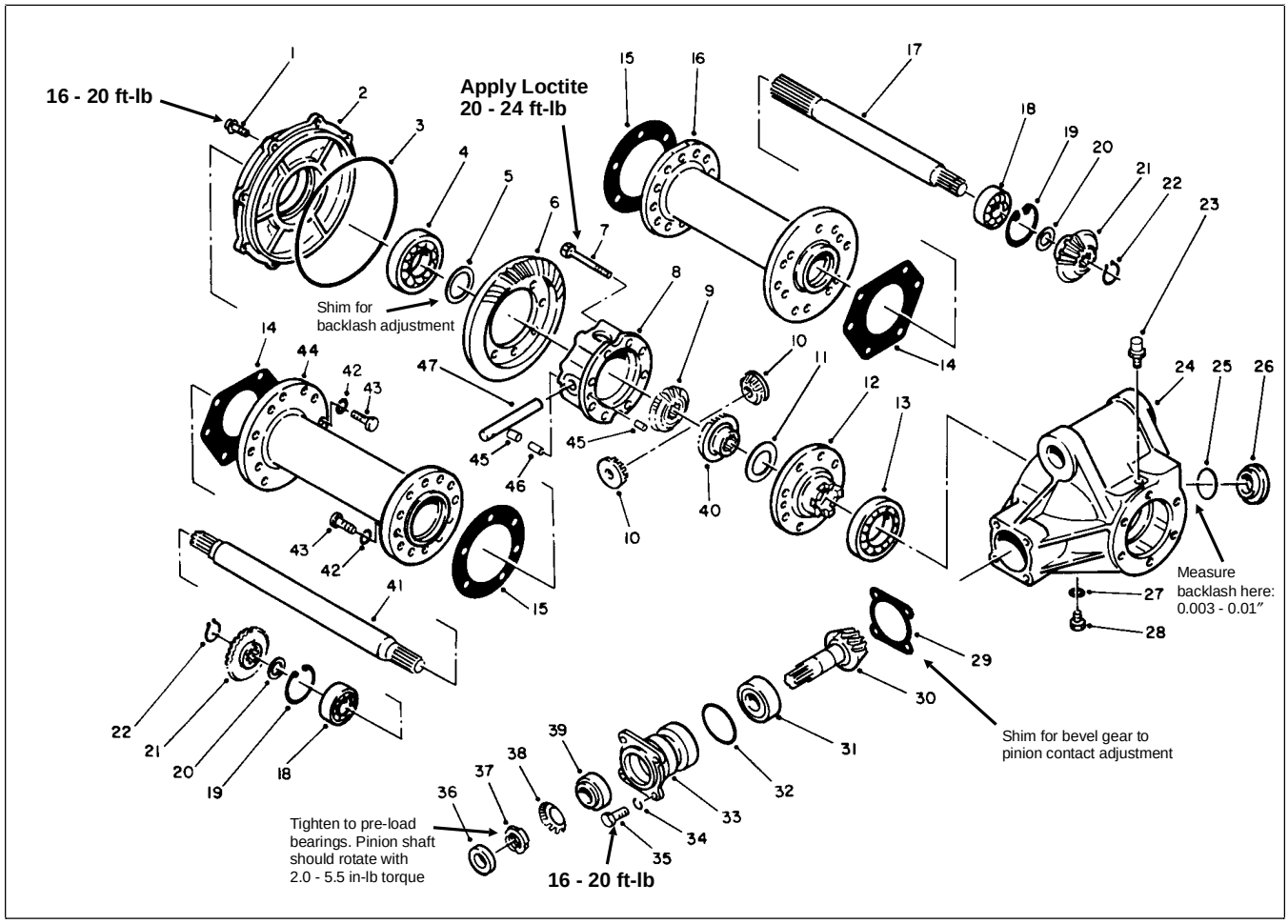


Figure 12

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.

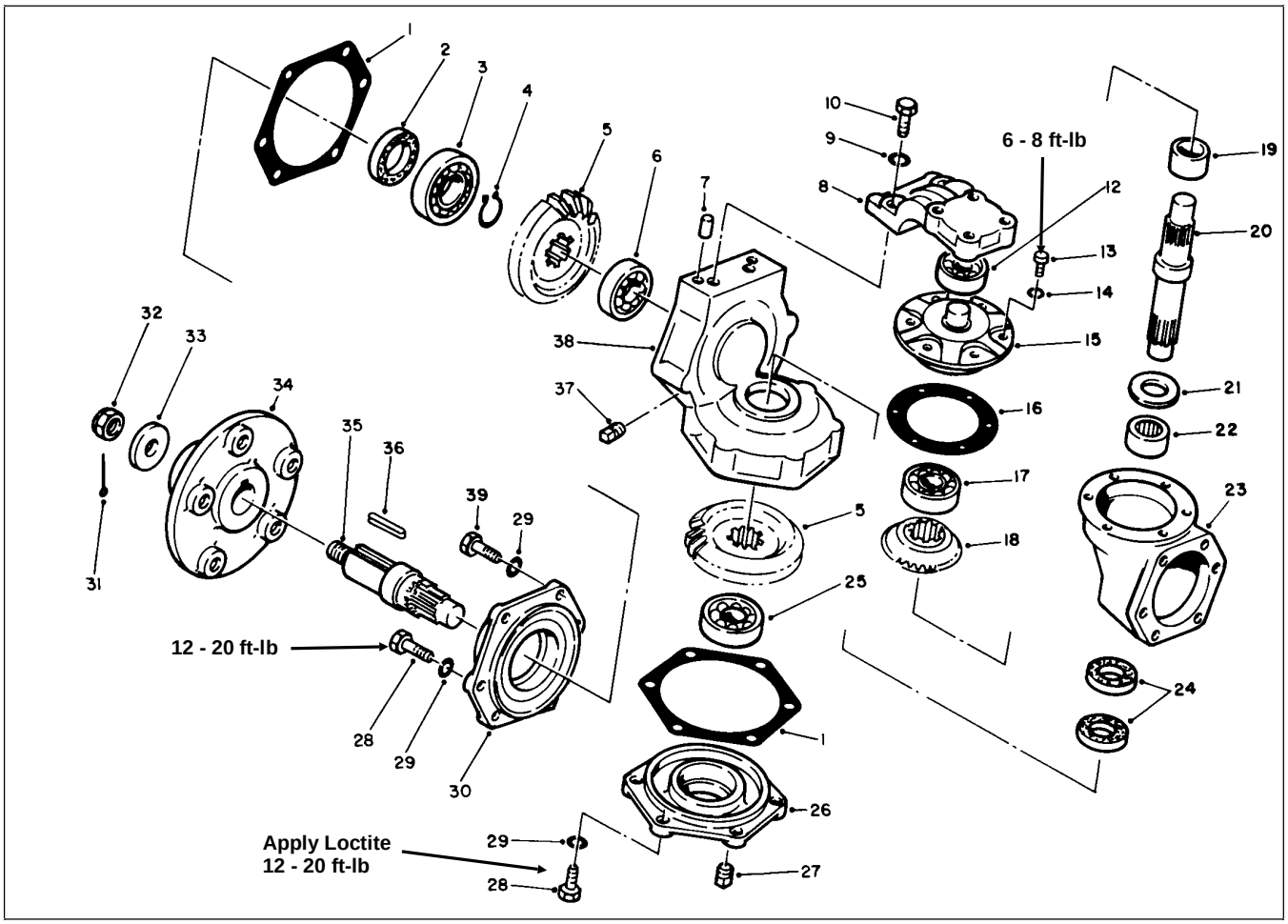


Figure 13

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).

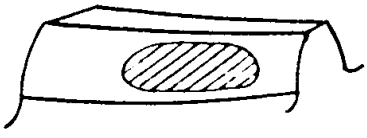
   C. Adjust tooth contact of bevel gear (Item 6) to pinion (Item 30). Use shims (Item 29) to make good contact with light load between bevel gear and pinion (Fig. 13).

   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).



Tooth contact between bevel gear and pinion with light load

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).

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