PART NO. 93808SL, Rev. G

Service Manual

(Serial No. Below 240000000)

Workman® 3000/4000 Series

For Vehicles with Liquid Cooled Engines S/N 220000001 – 239999999
Use this book along with the Toro Operator's Manual and Parts Catalog for the specific model and serial number of the machine, and the Briggs–Daihatsu 3LC Gas or Diesel Engine Repair Manual: Toro Part No. 99048SL (Gas) or 01091SL (Diesel).

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 Workman 3000/4000 Series vehicles.

REFER TO THE OPERATOR'S MANUAL 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 to:

The Toro Company
8111 Lyndale Avenue South
Bloomington, MN 55420–1196

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.

Table Of Contents

Safety
Product Records and Maintenance
Liquid Cooled Gas Engine
Liquid Cooled Diesel Engine
Air Cooled Gas Engine
Drive Train
Steering, Brakes & Suspension
Electrical System
Hydraulic System

Table Of Contents

Chapter 10 – Front Wheel Drive Section (4WD)

Chapter 11 – Liquid Propane Gas Conversion Kit
(For Mitsubishi Engine only)

Chapter 1

Safety

Table of Contents

Safety Instructions

The WORKMAN 3000 Series vehicles are designed and tested to offer safe service when operated and maintained properly. 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, maintenance and storage of the machine. Improper use or maintenance of the machine can result in injury or death.

This is a specialized utility vehicle designed for off–road use. its ride and handling will have a different feel than what drivers experience with passenger cars or trucks. So take time to become familiar with your WORKMAN vehicle.

Not all of the attachments that adapt to the Workman vehicle are covered in this manual. See the specific Operator's Manual provided with attachment for additional safety instructions. READ THESE MANUALS.

CAUTION

TO REDUCE THE POTENTIAL FOR INJURY OR DEATH, COMPLY WITH THE FOLLOWING SAFETY INSTRUCTIONS.

Supervisor's Responsibilities

1. Make sure operators are thoroughly trained and familiar with the Operator's Manual and all labels on the vehicle.

2. Be sure to establish your own special procedures and work rules for unusual operating conditions (e.g. slopes too steep for vehicle operation). Use the 3rd High Lockout switch if high speed could result in a safety or vehicle abuse situation.

Before Operating

3. Operate the machine only after reading and understanding the Operator's Manual. A replacement Operator's Manual is available by sending complete model and serial number to:

The Toro Company
8111 Lyndale Avenue South
Minneapolis, Minnesota 55420.

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

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

4. Never allow children to operate the vehicle or adults to operate it without proper instructions. Only trained and authorized persons should operate this vehicle. Make sure all operators are physically and mentally capable of operating the vehicle. Anyone who operates the vehicle should have a motor vehicle license.

5. This vehicle is designed to carry Only You, the operator, and One Passenger in the seat provided by the manufacturer. Never carry any other passengers on the vehicle.

6. Never operate the vehicle when under the influence of drugs or alcohol.

7. Become familiar with the controls and know how to stop the engine quickly.

8. Keep all shields, safety devices and decals in place. If a shield, safety device or decal is malfunctioning, illegible, or damaged, repair or replace it before operating the machine.

9. Always wear substantial shoes. Do not operate machine while wearing sandals, tennis shoes or sneakers. Do not wear loose fitting clothing or jewelry which could get caught in moving parts and cause personal injury.

10. Wearing safety glasses, safety shoes, long pants and a helmet is advisable and required by some local safety and insurance regulations.

11. Keep everyone, especially children and pets away from the areas of operation.

12. Before operating the vehicle, always check all parts of the vehicle and any attachments. If something is wrong, stop using vehicle. Make sure problem is corrected before vehicle or attachment is operated again.

13. Since gasoline is highly flammable, handle it carefully.

A. Use an approved gasoline container.

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

C. Do not smoke while handling gasoline.

D. Fill fuel tank outdoors and to about one inch below top of tank, (bottom of filler neck). Do not overfill.

E. Wipe up any spilled gasoline.

14. Check the safety interlock system daily for proper operation. If a switch should malfunction, replace the switch before operating machine. (After every two years, replace the interlock switches in the safety system, whether they are working properly not.)

While Operating

CAUTION

Engine exhaust contains carbon monoxide which is an odorless, deadly poison. Carbon monoxide is also known to the State of California to cause birth defects. Do not run engine indoors or in an enclosed area.

15. Operator and passenger should remain seated whenever the vehicle is in motion. Operator should keep both hands on steering wheel, whenever possible and passenger should use hand holds provided. Keep arms and legs within the vehicle body at all times. Never carry passengers in box or on attachments. Remember your passenger may not be expecting you to brake or turn and may not be ready.

16. Never overload your vehicle. Name plate (located under dash on passenger side) shows load limits for vehicle. Never overfill attachments or exceed the vehicle maximum GVW.

17. When starting the engine:

A. Sit on operator’s seat and engage parking brake.

B. Disengage PTO (if so equipped) and return hand throttle lever to OFF position (if so equipped).

C. Move shift lever to NEUTRAL and depress clutch pedal.

D. Keep foot off accelerator pedal.

E. Turn ignition key to START.

18. Using the machine demands attention. Failure to operate vehicle safely may result in a accident, tip over of vehicle and serious injury or death. Drive carefully. To prevent tipping or loss of control:

A. Use extreme caution, reduce speed and maintain a safe distance around sand traps, ditches, creeks, ramps, any unfamiliar areas or other hazards.

B. Watch for holes or other hidden hazards.

C. Use caution when operating vehicle on a steep slope. Normally travel straight up and down slopes. Reduce speed when making sharp turns or when turning on hillsides. Avoid turning on hillsides whenever possible.

D. Use extra caution when operating vehicle on wet surfaces, at higher speeds or with a full load. Stopping time will increase with a full load. Shift into a lower gear before starting up or down a hill.

E. When loading bed, distribute load evenly. Use extra caution if the load exceeds the dimensions of the vehicle/bed. Operate vehicle with extra caution when handling off–center loads that cannot be centered. Keep loads balanced and secure to prevent them from shifting.

F. Avoid sudden stops and starts. Do not go from reverse to forward or forward to reverse without first coming to a complete stop.

G. Do not attempt sharp turns or abrupt maneuvers or other unsafe driving actions that may cause a loss of vehicle control.

H. When dumping, do not let anyone stand behind vehicle and do not dump load on any one's feet. Release tailgate latches from side of box, not from behind.

I. Before backing up, look to the rear and assure no one is behind. Back up slowly.

J. Watch out for traffic when near or crossing roads. Always yield the right of way to pedestrians and other vehicles. This vehicle is not designed for use on streets or highways. Always signal your turns or stop early enough so other persons know what you plan to do. Obey all traffic rules and regulations.

K. Never operate vehicle in or near an area where there is dust or fumes in the air which are explosive. The electrical and exhaust systems of the vehicle can produce sparks capable of igniting explosive materials.

L. Always watch out for and avoid low over hangs such as tree limbs, door jambs, over head walkways, etc. Make sure there is enough room over head to easily clear the vehicle and your head.

M. If ever unsure about safe operation, STOP WORK and ask your supervisor.

19. Do not touch engine, transaxle, radiator, muffler or muffler shield while engine is running or soon after it has stopped because these areas may be hot enough to cause burns.

20. If the machine ever vibrates abnormally, stop immediately, turn engine off, wait for all motion to stop and inspect for damage. Repair all damage before commencing operation.

21. Before getting off the seat:

A. Stop movement of the machine.

B. Lower bed.

C. Shut engine off and wait for all movement to stop.

D. Set parking brake.

E. Remove key from ignition.

F. Block wheels if machine is on an incline.

Maintenance and Service

22. Before servicing or making adjustments to the machine, stop engine, set parking brake and remove key from ignition to prevent accidental starting of the engine.

23. When changing attachments, tires or performing other service, use the correct blocks, hoists and jacks. Always chock or block the wheels and use jack stands or solid wood blocks to support the raised machine.

24. Make sure all hydraulic line connectors are tight, and 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 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 form of injury or gangrene may result.

26. Before disconnecting or performing any work on the hydraulic system, all pressure in system must be relieved by stopping engine, cycling dump valve from raise to lower and/or lowering box and attachments. Place the remote hydraulics lever in the float position. If box must be in raised position, secure with safety support.

27. To make sure entire machine is in good condition, keep all nuts, bolts and screws properly tightened.

28. To reduce potential fire hazard, keep the engine area free of excessive grease, grass, leaves and accumulation of dirt.

29. If the engine must be running to perform a maintenance adjustment, keep hands, feet, clothing, and any parts of the body away from the engine and any moving parts. Keep everyone away.

30. Do not over–speed engine by changing governor settings. Maximum engine speed is 3650 RPM. To assure safety and accuracy, have an Authorized Toro Distributor check maximum engine speed with a tachometer.

31. If major repairs are ever needed or assistance is required, contact an Authorized TORO Distributor.

32. To be sure of optimum performance and safety, always purchase genuine TORO replacement parts and accessories. Replacement parts and accessories made by other manufacturers could be dangerous. Altering this vehicle in any manner may affect the vehicle's operation, performance, durability or its use may result in injury or death. Such use could void the product warranty of The Toro Company.

33. This vehicle should not be modified without the Toro Company's authorization. Direct any inquiries to:

The Toro Company
Commercial Division
Vehicle Engineering Dept.
300 West 82nd St.
Bloomington, Minnesota 55420–1196. USA

Jacking Vehicle

CAUTION

When changing attachments, tires or performing other service, use the correct blocks, hoists and jacks. Always chock or block the wheels and use jack stands or solid wood blocks to support the machine. If the traction unit is not properly supported by blocks or jack stands, the unit may move or fall resulting in personal injury.

1. Do not start engine while vehicle is on jack, because engine vibration or wheel movement could cause vehicle to slip off jack.

2. Do not work under vehicle without jack stands supporting it. The vehicle could slip off jack, injuring any one beneath it.

3. The jacking point at the front of the vehicle is under the front center frame support and at the rear it is under the axle tube.

4. When jacking up front of vehicle, always place a 2x4 block (or similar material) between jack and vehicle frame.

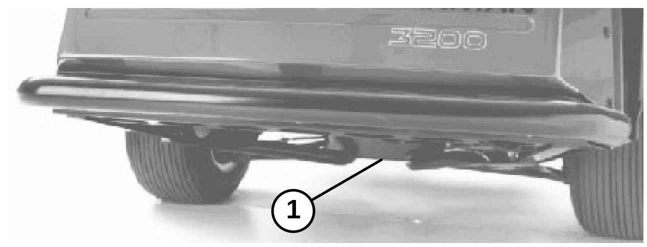


Figure 1

1. Front jacking point

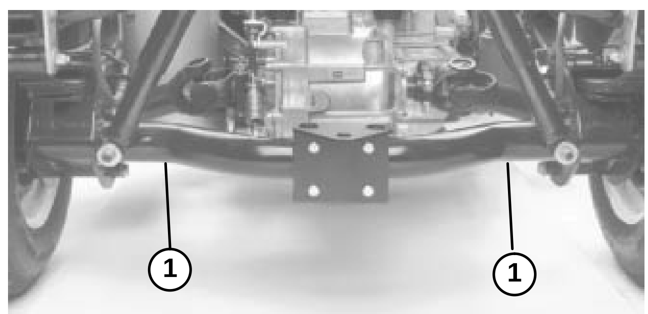


Figure 2

1. Rear jacking points

Using Bed Safety Support

Many of the procedures shown in this manual require raising and lowering the bed. The following precautions must be taken or serious injury or death could result.

WARNING

Before servicing or making adjustments to the machine, stop engine, set parking brake and remove key from ignition switch. Any load material must be removed from bed or other attachment before working under raised bed. Never work under a raised bed without positioning safety support on a fully installed cylinder rod.

After work is completed, remove safety support, slide it onto storage stud and lower bed.

1. Raise bed until lift cylinders are fully extended.

2. Remove bed support from storage stud on top of back rest support channel on Workman (Fig. 3).

3. Push bed support onto cylinder rod, making sure support end tabs rest on end of cylinder barrel and on cylinder rod end (Fig. 4).

4. To store bed support, remove bed support from cylinder and insert on stud on top of back rest support channel.

5. Always install or remove bed support from outside of bed.

6. Do not try to lower bed with bed safety support on cylinder.

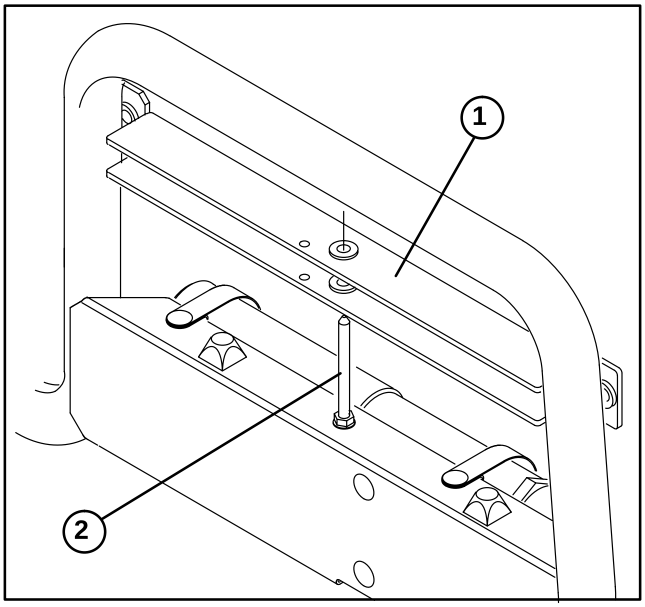


Figure 3

1. **Bed support**
2. **Storage stud**

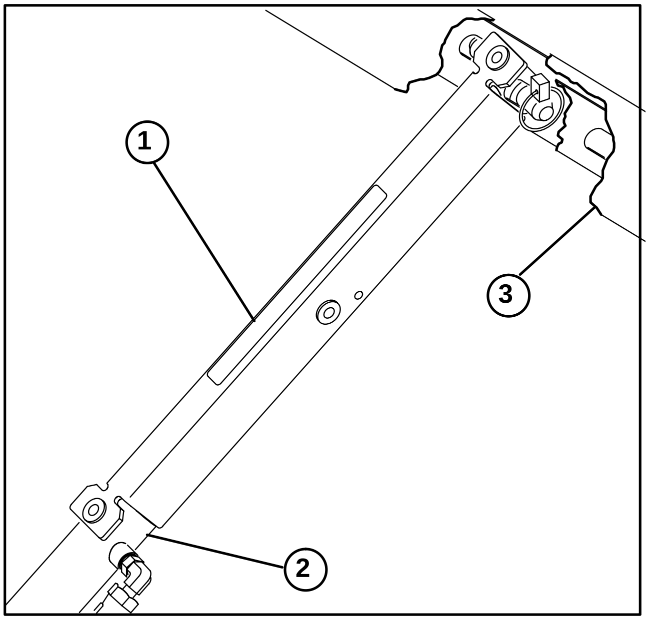


Figure 4

1. **Bed support**
2. **Cylinder barrel**
3. **Bed**

Chapter 2

Product Records and Maintenance

Table of Contents

Product Records

Record information about your Workman vehicle on the OPERATION AND SERVICE HISTORY REPORT form. Use this information when referring to your machine.

Insert Operator’s Manuals and Parts Catalogs for your Workman vehicle at the end of this section.

Equivalents and Conversions

Decimal and Millimeter Equivalents

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

U.S to Metric Conversions

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

Torque Specifications

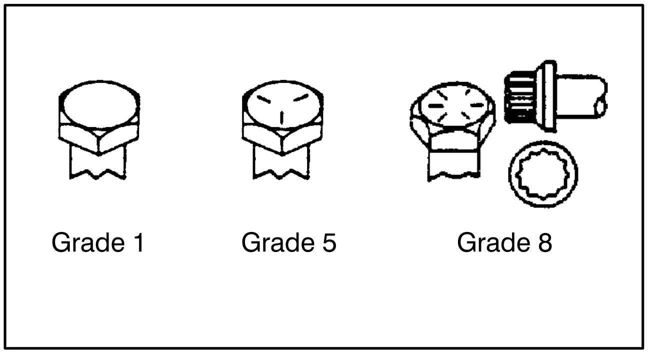
Recommended fastener torque values are listed in the following tables. For critical applications, as determined by Toro, either the recommended torque or a torque that is unique to the application is clearly identified and specified in this Service Manual.

These Torque Specifications for the installation and tightening of fasteners shall apply to all fasteners which do not have a specific requirement identified in this Service Manual. The following factors shall be considered when applying torque: cleanliness of the fastener, use of a thread sealant (Loctite), degree of lubrication on the fastener, presence of a prevailing torque feature, hardness of the surface underneath the fastener's head, or similar condition which affects the installation.

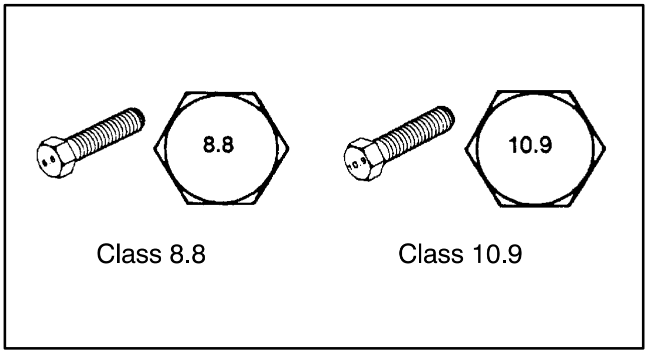
As noted in the following tables, torque values should be **reduced by 25% for lubricated fasteners** to achieve the similar stress as a dry fastener. Torque values may also have to be reduced when the fastener is threaded into aluminum or brass. The specific torque value should be determined based on the aluminum or brass material strength, fastener size, length of thread engagement, etc.

The standard method of verifying torque shall be performed by marking a line on the fastener (head or nut) and mating part, then back off fastener 1/4 of a turn. Measure the torque required to tighten the fastener until the lines match up.

Fastener Identification



Inch Series Bolts and Screws



Metric Bolts and Screws

Standard Torque for Dry, Zinc Plated, and Steel Fasteners (Inch Series)

Thread Size	Grade 1, 5, & 8 with Thin Height Nuts	SAE Grade 1 Bolts, Screws, Studs, & Sems with Regular Height Nuts (SAE J995 Grade 2 or Stronger Nuts)		SAE Grade 5 Bolts, Screws, Studs, & Sems with Regular Height Nuts (SAE J995 Grade 2 or Stronger Nuts)		SAE Grade 8 Bolts, Screws, Studs, & Sems with Regular Height Nuts (SAE J995 Grade 5 or Stronger Nuts)	
	in–lb	**in–lb**	**N–cm**	**in–lb**	**N–cm**	**in–lb**	**N–cm**
# 6 – 32 UNC	10 ± 2	13 ± 2	147 ± 23	15 ± 2	170 ± 20	23 ± 2	260 ± 20
# 6 – 40 UNF				17 ± 2	190 ± 20	25 ± 2	280 ± 20
# 8 – 32 UNC	13 ± 2	25 ± 5	282 ± 30	29 ± 3	330 ± 30	41 ± 4	460 ± 45
# 8 – 36 UNF				31 ± 3	350 ± 30	43 ± 4	485 ± 45
# 10 – 24 UNC	18 ± 2	30 ± 5	339 ± 56	42 ± 4	475 ± 45	60 ± 6	675 ± 70
# 10 – 32 UNF				48 ± 4	540 ± 45	68 ± 6	765 ± 70
1/4 – 20 UNC	48 ± 7	53 ± 7	599 ± 79	100 ± 10	1125 ± 100	140 ± 15	1580 ± 170
1/4 – 28 UNF	53 ± 7	65 ± 10	734 ± 113	115 ± 10	1300 ± 100	160 ± 15	1800 ± 170
5/16 – 18 UNC	115 ± 15	105 ± 17	1186 ± 169	200 ± 25	2250 ± 280	300 ± 30	3390 ± 340
5/16 – 24 UNF	138 ± 17	128 ± 17	1446 ± 192	225 ± 25	2540 ± 280	325 ± 30	3670 ± 340
	ft–lb	**ft–lb**	**N–m**	**ft–lb**	**N–m**	**ft–lb**	**N–m**
3/8 – 16 UNC	16 ± 2	16 ± 2	22 ± 3	30 ± 3	41 ± 4	43 ± 4	58 ± 5
3/8 – 24 UNF	17 ± 2	18 ± 2	24 ± 3	35 ± 3	47 ± 4	50 ± 4	68 ± 5
7/16 – 14 UNC	27 ± 3	27 ± 3	37 ± 4	50 ± 5	68 ± 7	70 ± 7	95 ± 9
7/16 – 20 UNF	29 ± 3	29 ± 3	39 ± 4	55 ± 5	75 ± 7	77 ± 7	104 ± 9
1/2 – 13 UNC	30 ± 3	48 ± 7	65 ± 9	75 ± 8	102 ± 11	105 ± 10	142 ± 14
1/2 – 20 UNF	32 ± 3	53 ± 7	72 ± 9	85 ± 8	115 ± 11	120 ± 10	163 ± 14
5/8 – 11 UNC	65 ± 10	88 ± 12	119 ± 16	150 ± 15	203 ± 20	210 ± 20	285 ± 27
5/8 – 18 UNF	75 ± 10	95 ± 15	129 ± 20	170 ± 15	230 ± 20	240 ± 20	325 ± 27
3/4 – 10 UNC	93 ± 12	140 ± 20	190 ± 27	265 ± 25	359 ± 34	375 ± 35	508 ± 47
3/4 – 16 UNF	115 ± 15	165 ± 25	224 ± 34	300 ± 25	407 ± 34	420 ± 35	569 ± 47
7/8 – 9 UNC	140 ± 20	225 ± 25	305 ± 34	430 ± 45	583 ± 61	600 ± 60	813 ± 81
7/8 – 14 UNF	155 ± 25	260 ± 30	353 ± 41	475 ± 45	644 ± 61	660 ± 60	895 ± 81

Note: Reduce torque values listed in the table above by 25% for lubricated fasteners. Lubricated fasteners are defined as threads coated with a lubricant such as oil, graphite, or thread sealant such as Loctite.

Note: Torque values may have to be reduced when installing fasteners into threaded aluminum or brass. The specific torque value should be determined based on the fastener size, the aluminum or base material strength, length of thread engagement, etc.

Note: The nominal torque values listed above for Grade 5 and 8 fasteners are based on 75% of the minimum proof load specified in SAE J429. The tolerance is approximately ± 10% of the nominal torque value. Thin height nuts include jam nuts.

Standard Torque for Dry, Zinc Plated, and Steel Fasteners (Metric Fasteners)

Thread Size	Class 8.8 Bolts, Screws, and Studs with Regular Height Nuts (Class 8 or Stronger Nuts)		Class 10.9 Bolts, Screws, and Studs with Regular Height Nuts (Class 10 or Stronger Nuts)	
M5 X 0.8	57 ± 5 in–lb	640 ± 60 N–cm	78 ± 7 in–lb	885 ± 80 N–cm
M6 X 1.0	96 ± 9 in–lb	1018 ± 100 N–cm	133 ± 13 in–lb	1500 ± 150 N–cm
M8 X 1.25	19 ± 2 ft–lb	26 ± 3 N–m	27 ± 2 ft–lb	36 ± 3 N–m
M10 X 1.5	38 ± 4 ft–lb	52 ± 5 N–m	53 ± 5 ft–lb	72 ± 7 N–m
M12 X 1.75	66 ± 7 ft–lb	90 ± 10 N–m	92 ± 9 ft–lb	125 ± 12 N–m
M16 X 2.0	166 ± 15 ft–lb	225 ± 20 N–m	229 ± 22 ft–lb	310 ± 30 N–m
M20 X 2.5	325 ± 33 ft–lb	440 ± 45 N–m	450 ± 37 ft–lb	610 ± 50 N–m

Note: Reduce torque values listed in the table above by 25% for lubricated fasteners. Lubricated fasteners are defined as threads coated with a lubricant such as oil, graphite, or thread sealant such as Loctite.

Note: Torque values may have to be reduced when installing fasteners into threaded aluminum or brass. The specific torque value should be determined based on the fastener size, the aluminum or base material strength, length of thread engagement, etc.

Note: The nominal torque values listed above are based on 75% of the minimum proof load specified in SAE J1199. The tolerance is approximately ± 10% of the nominal torque value.

Other Torque Specifications

SAE Grade 8 Steel Set Screws

Thread Size	Recommended Torque	
	Square Head	**Hex Socket**
1/4 – 20 UNC	140 ± 20 in–lb	73 ± 12 in–lb
5/16 – 18 UNC	215 ± 35 in–lb	145 ± 20 in–lb
3/8 – 16 UNC	35 ± 10 ft–lb	18 ± 3 ft–lb
1/2 – 13 UNC	75 ± 15 ft–lb	50 ± 10 ft–lb

Wheel Bolts and Lug Nuts

Thread Size	Recommended Torque**	
7/16 – 20 UNF Grade 5	65 ± 10 ft–lb	88 ± 14 N–m
1/2 – 20 UNF Grade 5	80 ± 10 ft–lb	108 ± 14 N–m
M12 X 1.25 Class 8.8	80 ± 10 ft–lb	108 ± 14 N–m
M12 X 1.5 Class 8.8	80 ± 10 ft–lb	108 ± 14 N–m

** For steel wheels and non–lubricated fasteners.

Thread Cutting Screws (Zinc Plated Steel)

Type 1, Type 23, or Type F	
Thread Size	**Baseline Torque***
No. 6 – 32 UNC	20 ± 5 in–lb
No. 8 – 32 UNC	30 ± 5 in–lb
No. 10 – 24 UNC	38 ± 7 in–lb
1/4 – 20 UNC	85 ± 15 in–lb
5/16 – 18 UNC	110 ± 20 in–lb
3/8 – 16 UNC	200 ± 100 in–lb

Thread Cutting Screws (Zinc Plated Steel)

Thread Size	Threads per Inch		Baseline Torque*
	Type A	**Type B**	
No. 6	18	20	20 ± 5 in–lb
No. 8	15	18	30 ± 5 in–lb
No. 10	12	16	38 ± 7 in–lb
No. 12	11	14	85 ± 15 in–lb

* Hole size, material strength, material thickness & finish must be considered when determining specific torque values. All torque values are based on non–lubricated fasteners.

Conversion Factors

in–lb X 11.2985 = N–cm
ft–lb X 1.3558 = N–m

N–cm X 0.08851 = in–lb
N–m X 0.7376 = ft–lb

Lubrication

> **WARNING**
>
> **Before servicing or making adjustments to the machine, stop engine, set parking brake, and remove key from the ignition switch. Any load material must be removed from the bed or other attachment before working under it. Always place the safety support on an extended lift cylinder to hold up the bed.**

GREASING BEARINGS AND BUSHINGS

The vehicle has grease fittings that must be lubricated regularly with No. 2 General Purpose Lithium Base Grease. If the machine is operated under normal conditions, lubricate all bearings and bushings after every 100 hours of operation. More frequent lubrication is required if the vehicle is used for heavy duty operations.

The grease fitting locations and quantities are as follows:

A. **Two** on each tie rod end and **two** on each front ball joint (Fig. 1).

B. **Nine** on each rear drive shaft (Fig. 2).

C. **One** on each control arm tower, which can be accessed from under each front fender and the skirt assembly (Fig. 3).

D. **One** on each pedal pivot and **one** on the accelerator bell crank (Fig. 4).

E. **One** on the steering shaft (Fig. 5).

F. **Three** on the front drive shaft **(4WD vehicles only)** (Fig. 6).

G. **One** on the accelerator bellcrank **(liquid cooled diesel engines only)** (Fig. 7).

H. **One** on the governor lever **(liquid cooled gasoline engines only)** (Fig. 8).

IMPORTANT: When greasing the drive shaft universal shaft bearing crosses, pump grease until it comes out of all 4 cups at each cross.

1. Wipe grease fitting clean so that foreign matter cannot be forced into the bearing or bushing.

2. Pump grease into the bearing or bushing.

3. Wipe off excess grease.

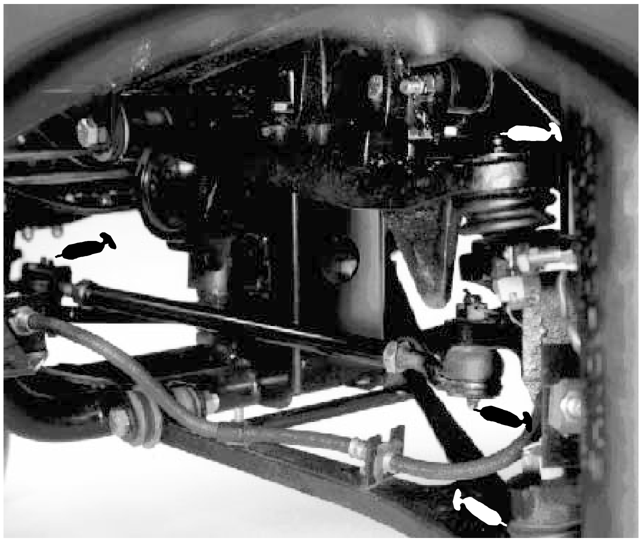


Figure 1

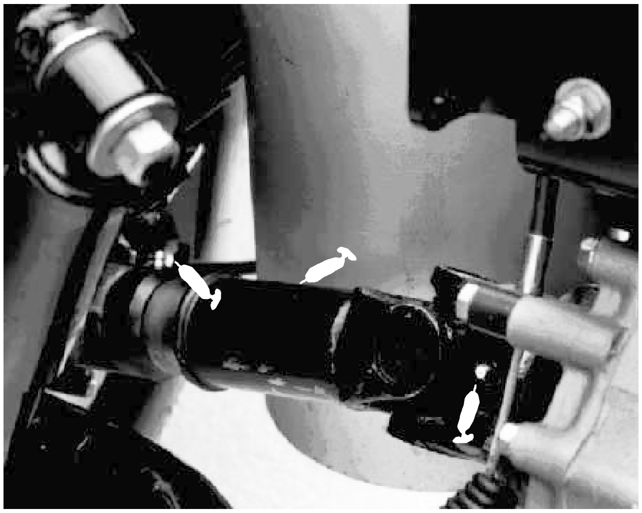


Figure 2

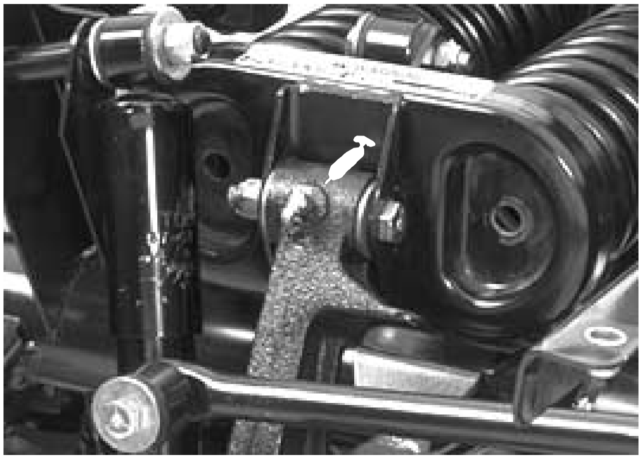


Figure 3

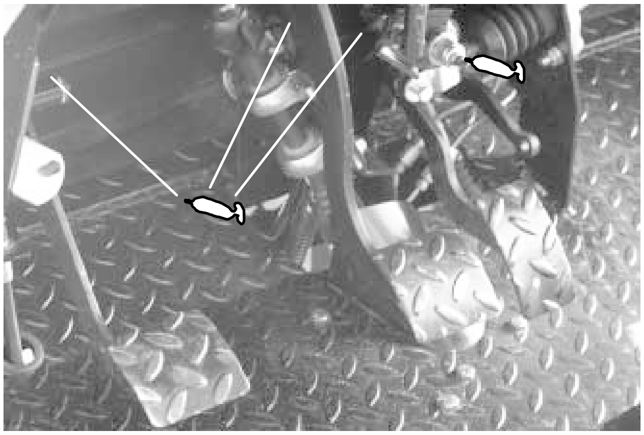


Figure 4

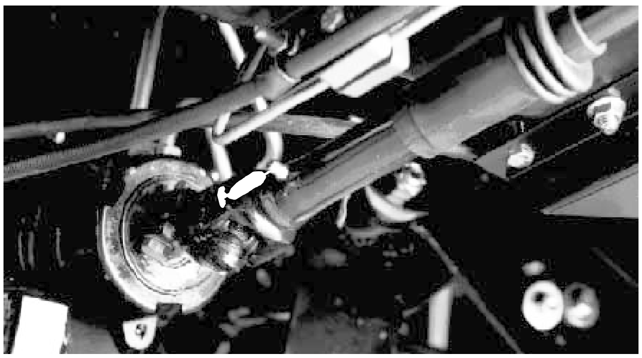


Figure 5

Figure 6

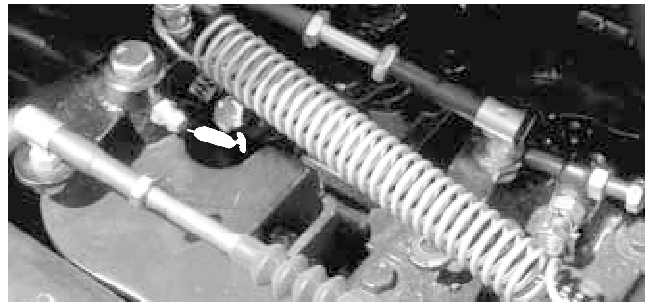


Figure 7

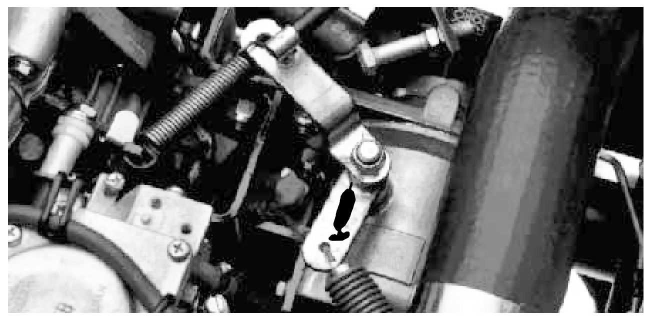


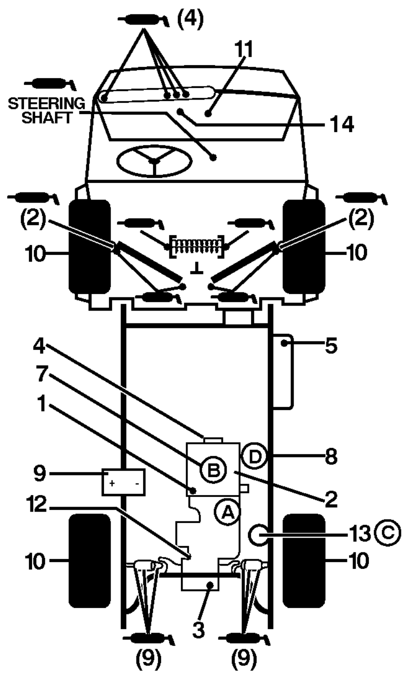
Figure 8

IMPORTANT

Heavy Duty Operation

If vehicle is subjected to conditions listed below, maintenance should be performed twice as frequently.

- **Desert operation**
- **Cold climate operation (below 32°F)**
- **Trailer or 5th wheel towing**
- **Frequent operation on dusty roads**
- **Frequent operation under maximum vehicle gross weight**
- **Construction work**
- **As soon as possible after extended operation in mud, sand, water, or similar dirty conditions: inspect and clean brakes, and grease drive axle joints. This will prevent any abrasive material from causing excessive wear.**
- **Under frequent heavy duty operating conditions, lubricate all grease fittings and inspect air cleaner daily to prevent excessive wear.**



WORKMAN 3100 QUICK REFERENCE AID

CHECK/SERVICE

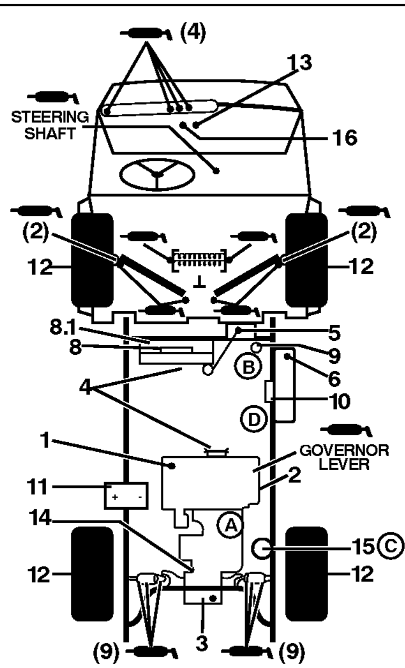
1. ENGINE OIL LEVEL
2. ENGINE OIL DRAIN
3. TRANSAXLE/HYDRAULIC OIL LEVEL (DIP STICK)
4. BELT (HYDRAULIC PUMP)
5. FUEL (UNLEADED FUEL ONLY)
6. GREASE POINTS (33) 100 HOURS
7. AIR CLEANER
8. FUEL FILTER
9. BATTERY
10. TIRE PRESSURE - MAXIMUM 20 PSI FRONT, 20 PSI REAR (23" TIRE)
11. FUSES (LIGHTS 15 AMP, IGNITION 7.5 AMP, DASH ACCESSORIES 7.5 AMP)
12. HYDRAULIC STRAINER
13. HYDRAULIC OIL FILTER
14. BRAKE FLUID

FLUID SPECIFICATIONS/CHANGE INTERVALS

SEE OPERATORS MANUAL FOR INITIAL CHANGES	FLUID TYPE	CAPACITY L	CAPACITY QT	CHANGE INTERVALS FLUID	CHANGE INTERVALS FILTER	FILTER PART NO.
ENGINE OIL 10C TO 40C. 14F TO 104F	SAE 10W–30 SG, SH or SJ	1.9	2	50 HRS	50 HRS	1205001 (A)
TRANS./HYDRAULIC OIL	DEXRON II ATF	7.1	7.5	800 HRS	800 HRS	54-0110 (C)
AIR CLEANER	CLEAN EVERY 25 HOURS				200 HRS	4708303 (B)
FUEL/FUEL FILTER	UNLEADED	26.5	7 GAL		400 HRS	18-1520 (D)
STRAINER				CLEAN 800 HOURS		87-3990

FOR HEAVY DUTY OPERATION, MAINTENANCE SHOULD BE PERFORMED TWICE AS FREQUENTLY.

93-8990



WORKMAN 3200 QUICK REFERENCE AID

CHECK/SERVICE

1. ENGINE OIL LEVEL
2. ENGINE OIL DRAIN
3. TRANSAXLE/HYDRAULIC OIL LEVEL (DIP STICK)
4. BELTS (GOVERNOR, WATER PUMP, HYDRAULIC PUMP)
5. COOLANT LEVEL FILL
6. FUEL (UNLEADED FUEL ONLY)
7. GREASE POINTS (34) 100 HRS.
8. RADIATOR SCREEN

8.1. RADIATOR SCREEN CLEANOUT DOOR

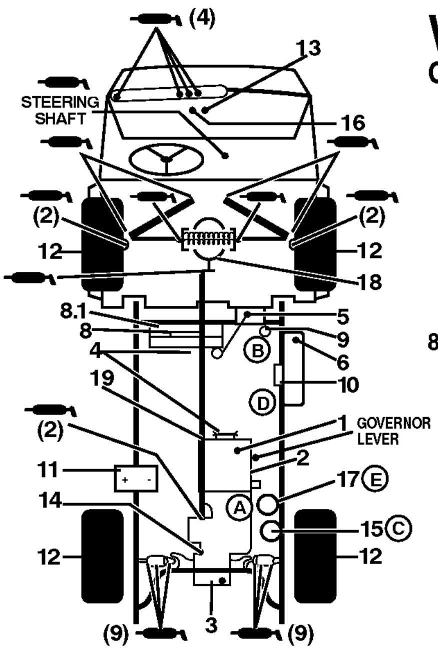
9. AIR CLEANER
10. FUEL FILTER
11. BATTERY
12. TIRE PRESSURE - MAXIMUM 20 PSI FRONT, 18 PSI REAR (24" TIRE)
13. FUSES (LIGHTS 15 AMP, IGNITION 7.5 AMP, DASH ACCESSORIES 7.5 AMP)
14. HYDRAULIC STRAINER
15. HYDRAULIC OIL FILTER
16. BRAKE FLUID

FLUID SPECIFICATIONS/CHANGE INTERVALS

SEE OPERATOR'S MANUAL FOR INITIAL CHANGES	FLUID TYPE	CAPACITY L	CAPACITY QT	CHANGE INTERVALS FLUID	CHANGE INTERVALS FILTER	FILTER PART NO.
ENGINE OIL 10°C TO 40°C/ 14°F TO 104°F	SAE 10W–30 SG, SH or SJ	3.2	3.4	100 HRS.	100 HRS.	67-4330 (A)
TRANS./HYDRAULIC OIL	DEXRON III ATF	7.1	7.5	800 HRS.	800 HRS.	54-0110 (C)
AIR CLEANER	CLEAN EVERY 50 HOURS				200 HRS.	93–2195 (B)
FUEL/FUEL FILTER	UNLEADED	26.5	7 GAL	—	400 HRS.	18-1520 (D)
COOLANT 50/50 ETHYLENE GLYCOL WATER		3.3	3.5	1200 HRS.	—	—
STRAINER				CLEAN 800 HRS.		87-3990

FOR HEAVY DUTY OPERATION, MAINTENANCE SHOULD BE PERFORMED TWICE AS FREQUENTLY.

NOTE: Two wheel drive chart shown.



WORKMAN 4300-D QUICK REFERENCE AID

CHECK/SERVICE

1. ENGINE OIL LEVEL
2. ENGINE OIL DRAIN
3. TRANSAXLE/HYDRAULIC OIL LEVEL (DIP STICK)
4. BELTS (GOVERNOR, WATER PUMP, HYDRAULIC PUMP)
5. COOLANT LEVEL FILL
6. FUEL (DIESEL FUEL ONLY)
7. GREASE POINTS (37) 100 HRS.
8. RADIATOR SCREEN

8.1. RADIATOR CLEANOUT DOOR

9. AIR CLEANER
10. FUEL PUMP
11. BATTERY
12. TIRE PRESSURE - MAXIMUM 20 PSI FRONT, 18 PSI REAR (24" TIRE)
13. FUSES (LIGHTS 15AMP, IGNITION 7.5 AMP, DASH ACCESSORIES 7.5 AMP)
14. HYDRAULIC STRAINER
15. HYDRAULIC OIL FILTER
16. BRAKE FLUID
17. WATER SEPARATOR
18. DIFFERENTIAL FILL/CHECK
19. 4WD SHAFT

FLUID SPECIFICATIONS/CHANGE INTERVALS

SEE OPERATOR'S MANUAL FOR INITIAL CHANGES	FLUID TYPE	CAPACITY		CHANGE INTERVALS		FILTER PART NO.
		L	QT	FLUID	FILTER	
ENGINE OIL	See Note Below	3.7	3.9	100 HRS.	100 HRS.	67-4330 (A)
TRANS/HYDRAULIC OIL	DEXRON III ATF	7.1	7.5	800 HRS.	800 HRS.	54-0110 (C)
AIR CLEANER	CLEAN EVERY 50 HRS.				200 HRS.	33-1300 (B)
FUEL > 32° F	NO. 2-D	26.5	7 GAL	—	400 HRS.	63-8300 WATER SEPARATOR (E)
FUEL PUMP	—	—	—	—	400 HRS.	43-2550 (D)
COOLANT 50/50 ETHYLENE GLYCOL WATER	—	4.3	4.5	1200 HRS.	—	—
STRAINER	—	—		CLEAN 800 HRS.		87-3990
DIFFERENTIAL OIL	SAE 10W-30 CD	.95	1	800 HRS.	—	—

FOR HEAVY DUTY OPERATION, MAINTENANCE SHOULD BE PERFORMED TWICE AS FREQUENTLY.

87-9110

NOTE: Four wheel drive chart shown. Use SAE 10W–30 CD, CE, CF, or CF–4 engine oil.

EQUIPMENT OPERATION AND SERVICE HISTORY REPORT
FOR
WORKMAN® 3100 AND 3120 VEHICLES

TORO Model and Serial Number: ______________–____________

Engine Numbers: ____________________________

Transaxle Numbers: ____________________________

Date Purchased: ____________________________ Warranty Expires____________

Purchased From: ____________________________

____

____

Contacts:	Parts	____________________________	Phone____________________
	Service	____________________________	Phone____________________
	Sales	____________________________	Phone____________________

See your TORO Distributor for other Publications, Manuals, and Videos from the TORO company.

WORKMAN® 3100 and 3120 Maintenance Schedule

Minimum Recommended Maintenance Intervals:

Maintenance Procedure	Maintenance Interval & Service
Check Battery Fluid Level	Every 50hrs — A Level Service
Check Battery Cable Connections	Every 50hrs — A Level Service
Lubricate Engine Prefilter	Every 50hrs — A Level Service
† Change Engine Oil and Filter	Every 50hrs — A Level Service
Lubricate All Grease Fittings	Every 100hrs — B Level Service
Remove Engine Shrouds and Clean Fins	Every 100hrs — B Level Service
Inspect Condition and Wear of Tires	Every 100hrs — B Level Service
‡ Check Cable Adjustments	Every 200hrs — C Level Service
‡ Check Pump Drive Belt Tension	Every 200hrs — C Level Service
Replace Air Filter	Every 200hrs — C Level Service
Check Engine RPM (Idle and Full Throttle)	Every 200hrs — C Level Service
‡ Torque Wheel Lug Nuts	Every 200hrs — C Level Service
Check Front Wheel Alignment	Every 400hrs — D Level Service
Inspect Service and Parking Brakes	Every 400hrs — D Level Service
Inspect Fuel Lines	Every 400hrs — D Level Service
Replace Fuel Filter	Every 400hrs — D Level Service
‡ Replace Transaxle Filter	Every 800hrs — E Level Service
Change Transaxle Oil	Every 800hrs — E Level Service
Clean Transaxle Strainer	Every 800hrs — E Level Service
Pack Front Wheel Bearings	Every 800hrs — E Level Service
Replace Spark Plugs	Every 800hrs — E Level Service

† Initial break in at 5 hours

‡ Initial break in at 10 hours

Replace all Interlock Switches	**Annual Recommendations:** *Items listed are recommended every 1200 hours or 2 years, whichever occurs first.*
Drain/Flush Fuel Tank	
Change Brake Fluid	

(See Operator’s and Service Manual for specifications an procedures)

WORKMAN® 3100 and 3120 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							
✓ Service & Park Brake Operation							
✓ Clutch & Shifter Operation							
✓ Fuel Level							
✓ Engine Oil Level							
✓ Transaxle Oil Level							
✓ Brake Fluid Level							
✓ Air Filter Prefilter							
Inspect Engine Cooling Fins							
✓ Unusual Engine Noises							
✓ Unusual Operating Noises							
✓ Tire Pressure							
✓ Hydraulic Hoses for Damage							
✓ Fluid Leaks							
✓ Instrument Operation							
✓ Accelerator Operation							
Lubricate All Grease Fittings[1]							
Touch–up Damaged Paint							

[1]= 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		
8		

(See Operator’s and Service Manual for specifications an procedures)

WORKMAN® 3100 and 3120 Supervisor Maintenance Order

Date: ______________

(Duplicate this page for routine use.)

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

Remarks:

A– Service (every 50 hours)

- ☐ Check Battery Fluid Levels
- ☐ Check Battery Cable Connections
- ☐ Lubricate Engine Prefilter
- ☐ Change Engine Oil and Filter
- ☐ ______________
- ☐ ______________
- ☐ ______________
- ☐ ______________
- ☐ ______________

B – Service (every 100 hours)

- ☐ Lubricate All Grease Fittings
- ☐ Remove Engine Shrouds & Clean Fins
- ☐ Inspect Condition and Wear of Tires
- ☐ **A – Service required**
- ☐ ______________
- ☐ ______________
- ☐ ______________
- ☐ ______________
- ☐ ______________

C – Service (every 200 hours)

- ☐ Check Cable Adjustments
- ☐ Check Pump Drive Belt Tension
- ☐ Replace Air Filter
- ☐ Check Engine RPM (Idle & Full Throttle)
- ☐ Torque Wheel Lug Nuts
- ☐ **A and B – Sevice required**
- ☐ ______________
- ☐ ______________
- ☐ ______________

D – Service (every 400 hours)

- ☐ Check Front Wheel Alignment
- ☐ Inspect Service and Parking Brakes
- ☐ Inspect Fuel Lines
- ☐ Replace Fuel Filter
- ☐ **A, B, and C – Sevice required**
- ☐ ______________
- ☐ ______________
- ☐ ______________
- ☐ ______________

E – Service (every 800 hours)

- ☐ Replace Transaxle Filter
- ☐ Change Transaxle Oil
- ☐ Clean Transaxle Strainer
- ☐ Pack Front Wheel Bearings
- ☐ Replace Spark Plugs
- ☐ **A, B, C, and D – Service Required**
- ☐ ______________
- ☐ ______________
- ☐ ______________

Other – Annual Service and Specials

- ☐ Replace All Interlock Switches
- ☐ Drain/Flush Fuel Tank
- ☐ Change Brake Fluid
- ☐ ______________
- ☐ ______________
- ☐ ______________
- ☐ ______________
- ☐ ______________
- ☐ ______________

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

Form No. 95–852–SL

EQUIPMENT OPERATION AND SERVICE HISTORY REPORT
FOR
WORKMAN® 3200, 3210, 3220, AND 4200 VEHICLES

TORO Model and Serial Number: ______________–____________

Engine Numbers: ____________________________

Transaxle/Differential Numbers: ____________________________

Date Purchased: ____________________________ Warranty Expires____________

Purchased From: ____________________________

____

____

Contacts: Parts ____________________________ Phone_____________________

Service ____________________________ Phone_____________________

Sales ____________________________ Phone_____________________

See your TORO Distributor for other Publications, Manuals, and Videos from the TORO company.

Minimum Recommended Maintenance Intervals

Maintenance Procedure	Maintenance Interval & Service
Check Battery Fluid Level	Every 50hrs — A Level Service
Check Battery Cable Connections	Every 50hrs — A Level Service
Check Dust Cup and Baffle	Every 50hrs — A Level Service
Lubricate All Grease Fittings	Every 100hrs — B Level Service
Inspect Condition and Wear of Tires	Every 100hrs — B Level Service
Check Front Differential Oil Level (4WD)	Every 100hrs — B Level Service
‡ Change Engine Oil and Filter	Every 100hrs — B Level Service
Inspect Cooling System Hoses	Every 100hrs — B Level Service
Check Governor Oil Level	Every 100hrs — B Level Service
† Check Cable Adjustments	Every 200hrs — C Level Service
Check Alternator, Governor and Fan Belts	Every 200hrs — C Level Service
Change Air Cleaner Filter	Every 200hrs — C Level Service
Check Front Axle CV Boot Joint (4WD)	Every 200hrs — C Level Service
Check Engine RPM (Idle and Full Throttle)	Every 200hrs — C Level Service
† Torque Wheel Lug Nuts	Every 200hrs — C Level Service
Check Front Wheel Alignment	Every 400hrs — D Level Service
Inspect Service and Parking Brakes	Every 400hrs — D Level Service
Inspect Fuel Lines	Every 400hrs — D Level Service
Replace Fuel Filter	Every 400hrs — D Level Service
Adjust Valves	Every 400hrs — D Level Service
Replace Spark Plugs and Check Timing	Every 400hrs — D Level Service
† Replace Transaxle Filter	Every 800hrs — E Level Service
Change Transaxle Oil	Every 800hrs — E Level Service
Clean Transaxle Strainer	Every 800hrs — E Level Service
Pack Front Wheel Bearings (2WD)	Every 800hrs — E Level Service
Change Front Differential Oil (4WD)	Every 800hrs — E Level Service

† Initial break in at 10 hours

‡ Initial break in at 50 hours

- Replace all Interlock Switches
- Flush/Replace Coolant System Fluid
- Change Brake Fluid
- Replace Engine Timing Belt

Annual Recommendations:

Replace switches, Coolant and Brake Fluid every 1200 hours or 2 years, whichever occurs first. Replace Engine Timing Belt every 2000 hours or 2 years, whichever occurs first.

(See Operator’s and Service Manual for specifications an procedures)

WORKMAN® 3200, 3210, 3220, and 4200 Daily Maintenance Checklist

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							
✓ Service & Park Brake Operation							
✓ Fuel Level							
✓ Accelerator Operation							
✓ Clutch & Shifter Operation							
✓ Engine Oil Level							
✓ Transaxle Oil Level							
✓ Cooling System Fluid Level[1]							
✓ Brake Fluid Level							
✓ Air Cleaner[2]							
✓ Unusual Engine Noises							
✓ Unusual Operating Noises							
✓ Tire Pressure							
✓ Radiator Screen/Clean out Door[2]							
✓ Hydraulic Hoses for Damage							
✓ Fluid Leaks							
✓ Instrument Operation							
Lubricate All Grease Fittings[3]							
Touch–up Damaged Paint							

[1]= Inspect at Overflow Tank
[2]= More often when conditions are dirty
[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		
8		

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

WORKMAN® 3200, 3210, 3220, and 4200 Supervisor Work Order

Date: ______________

(Duplicate this page for routine use.)

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

Remarks:

A– Service (every 50 hours)

- ☐ Check Battery Fluid Level
- ☐ Check Battery Cable Connections
- ☐ Check Dust Cup and Baffle
- ☐ ______
- ☐ ______
- ☐ ______
- ☐ ______
- ☐ ______
- ☐ ______

B – Service (every 100 hours)

- ☐ Lubricate All Grease Fittings
- ☐ Inspect Condition and Wear of Tires
- ☐ Check Front Differential Oil Level (4WD)
- ☐ Change Engine Oil and Filter
- ☐ Inspect Cooling System Hoses
- ☐ Check Governor Oil Level
- ☐ **A – Service required**
- ☐ ______
- ☐ ______

C – Service (every 200 hours)

- ☐ Check Cable Adjustments
- ☐ Check Alternator, Governor and Fan Belts
- ☐ Change Air Cleaner Filter
- ☐ Check Front Axle CV Joint Boot (4WD)
- ☐ Check Engine RPM (Idle & Full Throttle)
- ☐ Torque Wheel Lug Nuts
- ☐ **A and B – Sevice required**
- ☐ ______
- ☐ ______

D – Service (every 400 hours)

- ☐ Check Front Wheel Alignment
- ☐ Inspect Service and Parking Brakes
- ☐ Inspect Fuel Lines
- ☐ Replace Fuel Filter
- ☐ Adjust Valves
- ☐ Replace Spark Plugs and Check Timing
- ☐ **A, B, and C – Sevice required**
- ☐ ______
- ☐ ______

E – Service (every 800 hours)

- ☐ Replace Transaxle Filter
- ☐ Change Transaxle Oil
- ☐ Clean Transaxle Strainer
- ☐ Pack Front Wheel Bearings (2WD)
- ☐ Change Front Differential Oil (4WD)
- ☐ **A, B, C, and D – Service Required**
- ☐ ______
- ☐ ______
- ☐ ______

Other – Annual Service and Specials

- ☐ Replace All Interlock Switches
- ☐ Flush/Replace Coolant System Fluid
- ☐ Change Brake Fluid
- ☐ Replace Engine Timing Belt
- ☐ ______
- ☐ ______
- ☐ ______
- ☐ ______
- ☐ ______

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

Form No. 95–853–SL

TORO®

EQUIPMENT OPERATION AND SERVICE HISTORY REPORT
FOR
WORKMAN® 3300–D, 3310–D, 3320–D, AND 4300–D VEHICLES

TORO Model and Serial Number: ______________–____________

Engine Numbers: ___________________________

Transaxle/Differential Numbers: ___________________________

Date Purchased: ___________________________ Warranty Expires____________

Purchased From: ___________________________

____

____

Contacts: Parts ___________________________ Phone____________________

Service ___________________________ Phone____________________

Sales ___________________________ Phone____________________

See your TORO Distributor for other Publications, Manuals, and Videos from the TORO company.

Minimum Recommended Maintenance Intervals

Maintenance Procedure	Maintenance Interval & Service
Check Battery Fluid Level	Every 50hrs – *A Level Service*
Check Battery Cable Connections	Every 50hrs – *A Level Service*
Check Dust Cup and Baffle	Every 50hrs – *A Level Service*
Lubricate All Grease Fittings	Every 100hrs – *B Level Service*
Inspect Condition and Wear of Tires	Every 100hrs – *B Level Service*
Check Front Differential Oil Level (4WD)	Every 100hrs – *B Level Service*
‡ Change Engine Oil and Filter	Every 100hrs – *B Level Service*
Inspect Cooling System Hoses	Every 100hrs – *B Level Service*
† Check Cable Adjustments	Every 200hrs – *C Level Service*
† Check Alternator and Fan Belts	Every 200hrs – *C Level Service*
Service Air Filter	Every 200hrs – *C Level Service*
Check Front Axle CV Boot Joint (4WD)	Every 200hrs – *C Level Service*
Check Engine RPM (Idle and Full Throttle)	Every 200hrs – *C Level Service*
† Torque Wheel Lug Nuts	Every 200hrs – *C Level Service*
Check Front Wheel Alignment	Every 400hrs – *D Level Service*
Inspect Service and Parking Brakes	Every 400hrs – *D Level Service*
Inspect Fuel Lines	Every 400hrs – *D Level Service*
Replace Electric Fuel Pump Filter	Every 400hrs – *D Level Service*
Replace Fuel/Water Separator Filter	Every 400hrs – *D Level Service*
‡ Torque Cylinder Head and Adjust Valves	Every 400hrs – *D Level Service*
† Replace Transaxle Filter	Every 800hrs – *E Level Service*
Change Transaxle Oil	Every 800hrs – *E Level Service*
Clean Transaxle Strainer	Every 800hrs – *E Level Service*
Pack Front Wheel Bearings	Every 800hrs – *E Level Service*
Change Front Differential Oil (4WD)	Every 800hrs – *E Level Service*

† Initial break in at 10 hours

‡ Initial break in at 50 hours

Procedure	Annual Recommendations
Replace all Interlock Switches	**Annual Recommendations:** *Replace switches, Coolant and Brake Fluid every 1200 hours or 2 years, whichever occurs first.*
Flush/Replace Coolant System Fluid	
Change Brake Fluid	
Drain/Flush Fuel Tank	

(See Operator’s and Service Manual for specifications an procedures)

WORKMAN® 3300–D, 3310–D, 3320–D, and 4300–D Daily Maintenance Checklist

Unit Designation:_____________
TORO ID#________–_________

Daily Maintenance: (duplicate this page for routine use)

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							
✓ Service & Park Brake Operation							
✓ Fuel Level							
✓ Accelerator Operation							
✓ Clutch & Shifter Operation							
✓ Engine Oil Level							
✓ Transaxle Oil Level							
✓ Cooling System Fluid Level[1]							
✓ Brake Fluid Level							
✓ Air Cleaner[2]							
✓ Unusual Engine Noises							
✓ Unusual Operating Noises							
✓ Tire Pressure							
✓ Radiator Screen/Clean out Door[2]							
✓ Hydraulic Hoses for Damage							
✓ Fluid Leaks							
✓ Instrument Operation							
Lubricate All Grease Fittings[3]							
Touch–up Damaged Paint							

[1]= Inspect at Overflow Tank
[2]= More often when conditions are dirty
[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		
8		

(See Operator’s and Service Manual for specifications an procedures)

WORKMAN® 3300–D, 3310–D, 3320–D, and 4300–D Supervisor Maintenance Order

Date: ____________

(Duplicate this page for routine use.)

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

A– Service (every 50 hours)

- ☐ Check Battery Fluid Level
- ☐ Check Battery Cable Connections
- ☐ Check Dust Cup and Baffle
- ☐ ____________
- ☐ ____________
- ☐ ____________
- ☐ ____________
- ☐ ____________
- ☐ ____________

B – Service (every 100 hours)

- ☐ Lubricate All Grease Fittings
- ☐ Inspect Condition and Wear of Tires
- ☐ Check Front Differential Oil Level (4WD)
- ☐ Change Engine Oil and Filter
- ☐ Inspect Cooling System Hoses
- ☐ **A – Service required**
- ☐ ____________
- ☐ ____________
- ☐ ____________

C – Service (every 200 hours)

- ☐ Check Cable Adjustments
- ☐ Check Alternator, Governor and Fan Belts
- ☐ Service Air Filter
- ☐ Check Front Axle CV Joint Boot (4WD)
- ☐ Check Engine RPM (Idle & Full Throttle)
- ☐ Torque Wheel Lug Nuts
- ☐ **A and B – Sevice required**
- ☐ ____________
- ☐ ____________

D – Service (every 400 hours)

- ☐ Check Front Wheel Alignment
- ☐ Inspect Service and Parking Brakes
- ☐ Inspect Fuel Lines
- ☐ Replace Electric Fuel Pump Filter
- ☐ Replace Fuel/Water Separator Filter
- ☐ Torque Cylinder Head and Adjust Valves
- ☐ **A, B, and C – Sevice required**
- ☐ ____________
- ☐ ____________

E – Service (every 800 hours)

- ☐ Replace Transaxle Filter
- ☐ Change Transaxle Oil
- ☐ Clean Transaxle Strainer
- ☐ Pack Front Wheel Bearings (2WD)
- ☐ Change Front Differential Oil (4WD)
- ☐ **A, B, C, and D – Service Required**
- ☐ ____________
- ☐ ____________
- ☐ ____________

Other – Annual Service and Specials

- ☐ Replace All Interlock Switches
- ☐ Flush/Replace Coolant System Fluid
- ☐ Change Brake Fluid
- ☐ Drain/Flush Fuel Tank
- ☐ ____________
- ☐ ____________
- ☐ ____________
- ☐ ____________
- ☐ ____________

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

Form No. 95–854–SL

EQUIPMENT OPERATION AND SERVICE HISTORY REPORT
for
WORKMAN® 3420–LP VEHICLE

TORO Model and Serial Number: ______________–____________

Engine Numbers: ___________________________

Transaxle/Differential Numbers: ___________________________

Date Purchased: ___________________________ Warranty Expires____________

Purchased From: ___________________________

____

____

Contacts:	Parts	___________________________	Phone____________________
	Service	___________________________	Phone____________________
	Sales	___________________________	Phone____________________

See your TORO Distributor for other Publications, Manuals, and Videos from the TORO company.

Minimum Recommended Maintenance Intervals

	Maintenance Procedure	Maintenance Interval & Service
	Check Battery Fluid Level	Every 50hrs *A Level Service*
	Check Battery Cable Connections	
	Check Dust Cup and Baffle	
	Lubricate All Grease Fittings	Every 100hrs *B Level Service*
	Inspect Condition and Wear of Tires	
‡	Change Engine Oil and Filter	
	Inspect Cooling System Hoses	
	Check Governor Oil Level	
†	Check Cable Adjustments	Every 200hrs *C Level Service*
†	Check Alternator, Governor and Fan Belts	
	Change Air Cleaner Filter	
	Check Engine RPM (Idle and Full Throttle)	
†	Torque Wheel Lug Nuts	
	Check Front Wheel Alignment	Every 400hrs *D Level Service*
	Inspect Service and Parking Brakes	
	Inspect Fuel Lines	
	Replace Fuelock Filter	
	Adjust Valves	
	Replace Spark Plugs and Check Timing	
†	Replace Transaxle Filter	Every 800hrs *E Level Service*
	Change Transaxle Oil	
	Clean Transaxle Strainer	
	Pack Front Wheel Bearings	

† Initial break in at 10 hours
‡ Initial break in at 50 hours

Replace all Interlock Switches	**Annual Recommendations:**
Flush/Replace Coolant System Fluid	*Replace switches, Coolant and Brake Fluid every 1200 hours or 2 years, whichever occurs first.*
Change Brake Fluid	*Replace Engine Timing Belt every 2000 hours or 2 years, whichever occurs first.*
Replace Engine Timing Belt	

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

WORKMAN® 3420–LP Daily Maintenance Checklist

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							
✓ Service & Park Brake Operation							
✓ Fuel Level							
✓ Accelerator Operation							
✓ Clutch & Shifter Operation							
✓ Engine Oil Level							
✓ Transaxle Oil Level							
✓ Cooling System Fluid Level[1]							
✓ Brake Fluid Level							
✓ Air Cleaner[2]							
✓ Unusual Engine Noises							
✓ Unusual Operating Noises							
✓ Tire Pressure							
✓ Radiator Screen/Clean out Door[2]							
✓ Hydraulic Hoses for Damage							
✓ Fluid Leaks							
✓ Instrument Operation							
Lubricate All Grease Fittings[3]							
Touch–up Damaged Paint							

[1]= Inspect at Overflow Tank
[2]= More often when conditions are dirty
[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		
8		

(See Operator’s and Service Manual for specifications an procedures)

WORKMAN® 3420–LP Supervisor Maintenance Work Order

Date: ________________

(Duplicate this page for routine use.)

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

Remarks:

A– Service (every 50 hours)

- ☐ Check Battery Fluid Level
- ☐ Check Battery Cable Connections
- ☐ Check Dust Cup and Baffle
- ☐ ________________
- ☐ ________________
- ☐ ________________
- ☐ ________________
- ☐ ________________
- ☐ ________________

B – Service (every 100 hours)

- ☐ Lubricate All Grease Fittings
- ☐ Inspect Condition and Wear of Tires
- ☐ Change Engine Oil and Filter
- ☐ Inspect Cooling System Hoses
- ☐ Check Governor Oil Level
- ☐ **A – Service required**
- ☐ ________________
- ☐ ________________
- ☐ ________________

C – Service (every 200 hours)

- ☐ Check Cable Adjustments
- ☐ Check Alternator, Governor and Fan Belts
- ☐ Change Air Cleaner Filter
- ☐ Check Engine RPM (Idle & Full Throttle)
- ☐ Torque Wheel Lug Nuts
- ☐ **A and B – Sevice required**
- ☐ ________________
- ☐ ________________
- ☐ ________________

D – Service (every 400 hours)

- ☐ Check Front Wheel Alignment
- ☐ Inspect Service and Parking Brakes
- ☐ Inspect Fuel Lines
- ☐ Replace Fuelock Filter
- ☐ Adjust Valves
- ☐ Replace Spark Plugs and Check Timing
- ☐ **A, B, and C – Sevice required**
- ☐ ________________
- ☐ ________________

E – Service (every 800 hours)

- ☐ Replace Transaxle Filter
- ☐ Change Transaxle Oil
- ☐ Clean Transaxle Strainer
- ☐ Pack Front Wheel Bearings
- ☐ **A, B, C, and D – Service Required**
- ☐ ________________
- ☐ ________________
- ☐ ________________
- ☐ ________________

Other – Annual Service and Specials

- ☐ Replace All Interlock Switches
- ☐ Flush/Replace Coolant System Fluid
- ☐ Change Brake Fluid
- ☐ Replace Engine Timing Belt
- ☐ ________________
- ☐ ________________
- ☐ ________________
- ☐ ________________
- ☐ ________________

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

Form No. 95–853–SL

Chapter 3

Mitsubishi Engine (Workman S/N Below 220000001)

Liquid Cooled Gas Engine

Table of Contents

Liquid Cooled Gas Engine

General Information

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 engine repair facility. If no parts list is available be sure to provide your Distributor with the TORO Model Number and Serial Number.

The engine used in the Workman 3200 is manufactured by Mitsubishi Motors. Service and repair parts for Mitsubishi engines are supplied through TORO Distributors. Repair parts may be ordered by TORO Part Number

The engine model and serial number is stamped on the left side of the cylinder block.

3G83	Engine Model Number
AA0201	Engine Serial Number

Serial Number System:

AA0201 → AA9999
AB0001 → AY9999
BA0001 → YY9999

Specifications

General

Item	Specification
Make/Designation	Mitsubishi 3G83–051TV, In–line slant (60°), over head camshaft
Number of Cylinders	3
Cylinder Bore	65 mm (2.559 in.)
Piston Stroke	66 mm (2.598 in.)
Total Displacement	657 cc (40.09 cu. in.)
Compression Ratio	9.8:1
Firing Order	1 – 3 – 2
Fuel	Unleaded gasoline Minimum Octane rating 87
Valve Timing Intake Valve Exhaust Valve	 Opens (BTDC) 15° Closes (ABDC) 45° Opens (BBTC) 45° Closes (ATDC) 15°
Coolant	50/50 Ethylene Glycol / Water
Cooling System Capacity	3.3 liter (3.5 qt.)
Engine Oil 10° C to 40° C (14° F to 104° F)	API SG or SG/CD SAE 10W–30
Crankcase Oil Capacity	2.8 liter (3 qt.) with filter
Starter	Solenoid shift type 1.6 kW (12 volt)
Alternator	AC type 12 volt 40A
Spark Plug	Champion RN 16Y or NGK BPR 4ES 1.0 mm (.040 in.) air gap
High Idle (no load)	3600 RPM ± 50 rpm
Idle Speed (no load)	1200 RPM ± 100 rpm

Engine

Item	Standard Specification	Limit
Compression kPa (psi)		Minimum 960 (137)
Compression pressure difference between cylinders kPa (psi)		Maximum 100 (14)
Cylinder Head		
Overall height mm (in.)	108.9 – 109.1 (4.287 – 4.295)	0.2 (.008) see NOTE *
Flatness of gasket surface mm (in.)	Less than 0.05 (.0019)	0.2 (.008)
Oversize rework of valve seat hole mm (in.)		
Intake		
0.3 (.012) oversize	31.300 – 31.325 (1.2323 – 1.2333)	
0.6 (.024) oversize	31.600 – 31.625 (1.2441 – 1.2451)	
Exhaust		
0.3 (.012) oversize	29.300 – 29.321 (1.1535 – 1.1544)	
0.6 (.024) oversize	29.600 – 29.621 (1.1653 – 1.1662)	
Oversize rework of valve guide hole (both intake and exhaust) mm (in.)		
0.05 (.002) oversize	12.050 – 12.068 (.4744 – .4751)	
0.25 (.010) oversize	12.250 – 12.268 (.4823 – .4830)	
0.50 (.020) oversize	12.500 – 12.518 (.4921 – .4928)	
Camshaft		
Cam height mm (in.)		
Intake		
No. 1	35.09 (1.3815)	34.59 (1.3618)
No. 2	35.07 (1.3807)	34.57 (1.3610)
No. 3	35.06 (1.3303)	34.56 (1.3606)
Exhaust		
No. 1	35.15 (1.3839)	34.65 (1.3642)
No. 2	35.13 (1.3831)	34.63 (1.3634)
No. 3	35.19 (1.3854)	34.69 (1.3657)
Journal O.D. mm (in.)	40.940 – 40.955 (1.6118 – 1.6124)	
Bearing oil clearance mm (in.)	0.045 – 0.085 (.0018 – .0033)	
End play mm (in.)	0.06 – 0.14 (.0024 – .0055)	
Rocker Arm		
Clearance (rocker arm to shaft) mm (in.)	0.012 – 0.043 (.0005 – .0017)	0.1 (.004)
Rocker Shaft		
O.D. mm (in.)	16.985 – 16.998 (.6687 – .6692)	
Length mm (in.)	232.0 (9.134)	

* NOTE: Limit must be combined with amount of grinding of cylinder block gasket surface.

NOTE: O.D. = Outside Diameter

Engine (cont.)

Item	Standard Specification	Limit
Valves		
Valve length mm (in.)		
Intake	100.6 (3.960)	
Exhaust	100.8 (3.968)	
Stem O.D. mm (in.)		
Intake	6.565 – 6.580 (.2585 – .2591)	
Exhaust	6.530 – 6.550 (.2571 – .2579)	
Face angle	45° – 45.5°	
Thickness of valve head (margin) mm (in.)		
Intake	1.0 (.039)	0.5 (.020)
Exhaust	1.3 (.051)	0.8 (.031)
Valve Stem to Guide Clearance mm (in.)		
Intake	0.02 – 0.05 (.0008 – .0020)	0.10 (.0039)
Exhaust	0.050 – 0.085 (.0020 – .0033)	0.15 (.0059)
Valve Guides		
Length mm (in.)		
Intake	44 (1.73)	
Exhaust	49.5 (1.949)	
Service size mm (in.)	0.25 (.010) 0.50 (.020) oversize	
Valve Seat		
Width of seat contact mm (in.)	0.9 – 1.3 (.035 – .051)	
Seat angle	30° / 44° / 65°	
Sink mm (in.)		0.2 (.008)
Valve Spring		
Free length mm (in.)	46.3 (1.823)	45.3 (1.783)
Load / installed height N/mm (lb./in.)	210 / 37.7 (46 / 1.48)	
Out of squareness	Less than 2°	4°
Cylinder Block		
Cylinder bore mm (in.)	65.00 – 65.03 (2.5591 – 2.5602)	
Out of roundness and taper of cylinder bore mm (in.)	Less than 0.01 (.0004)	
Flatness of gasket surface mm (in.)	Less than 0.05 (.0020)	.01 (.0039)
Counterbalance Shaft		
Front journal diameter mm (in.)	19.987 – 20.000 (.7869 – .7874)	
Rear journal diameter mm (in.)	43.984 – 44.000 (1.7317 – 1.7322)	
Oil clearance mm (in.)		
Front journal	0.035 – 0.068 (.0014 – .0027)	
Rear journal	0.035 – 0.071 (.0014 – .0028)	

NOTE:
O.D. = Outside Diameter

Engine (cont.)

Item	Standard Specification	Limit
Piston		
O.D. mm (in.)	64.97 – 65.00 (2.5579 – 2.5591)	
Clearance (piston to cylinder) mm (in.)	0.02 – 0.04 (.0008 – .0016)	
Ring groove width mm (in.)		
No. 1	1.22 – 1.24 (.0480 – .0488)	
No. 2	1.21 – 1.23 (.0476 – .0484)	
Oil	2.815 – 2.835 (.1108 – .1116)	
Service size mm (in.)	0.25 (.010), 0.50 (.020), 0.75 (.030), 1.00 (.039) oversize	
Piston Ring		
End gap mm (in.)		
No. 1	0.15 – 0.30 (.0059 – .0118)	0.8 (.0315)
No. 2	0.35 – 0.50 (.0138 – .0197)	0.8 (.0315)
Oil	0.2 – 0.7 (.008 – .028)	1.0 (.0394)
Side clearance mm (in.)		
No. 1	0.03 – 0.07 (.0012 – .0028)	0.12 (.0047)
No. 2	0.02 – 0.006 (.0008 – .0024)	0.10 (.0039)
Piston Pin		
O.D. mm (in.)	16.001 – 16.007 (.6300 – .6302)	
Piston pin press–in load N (lbs.)	5.00 – 15.000 (1.102 – 3.307)	
Piston pin press–in temperature	Ordinary room temperature	
Connecting Rod		
Center length mm (in.)	101.95 – 102.05 (4.0138 – 4.0178)	
Parallelism between big end and small end mm (in.)	0.05 (.0020)	
Twist mm (in.)	0.1 (.004)	
Connecting rod big end to crankshaft side clearance mm (in.)	0.10 – 0.25 (.0039 – .0098)	0.4 (.016)

NOTE:
O.D. = Outside Diameter
O.S. = Oversize Diameter
U.S. = Undersize Diameter

Engine (cont.)

Item	Standard Specification	Limit
Crankshaft		
End play mm (in.)	0.05 – 0.25 (.0020 – .0098)	
Journal O.D. mm (in.)	39.98 – 40.00 (1.5740 – 1.5748)	
Pin. O.D. mm (in.)	35.98 – 36.00 (1.4165 – 1.4173)	
Cylindricity of journal and pin mm (in.)	Less than 0.005 (.0002)	
Concentricity of journal and pin mm (in.)	Less than 0.015 (.0006)	
Oil clearance of journal mm (in.)	0.021 – 0.045 (.0008 – .0018)	.01 (.0039)
Oil clearance of pin	0.022 – 0.052 (.0009 – .0020)	
Undersize rework dimension of journal mm (in.)		
0.25 U.S.	39.735 – 39.750 (1.5644 – 1.5650)	
0.50 U.S.	39.485 – 39.500 (1.5545 – 1.5551)	
0.75 U.S.	39.235 – 39.250 (1.5447 – 1.5453)	
Undersize rework dimension of pin mm (in.)		
0.25 U.S.	35.735 – 35.750 (1.4059 – 1.4075)	
0.50 U.S.	35.485 – 35.500 (1.3970 – 1.3976)	
0.75 U.S.	35.235 – 35.250 (1.3872 – 1.3878)	
Flywheel		
Runout mm (in.)		Less than 0.13 (.0051)
Oil Pump		
Side clearance mm (in.)		
Drive gear	0.07 – 0.13 (.0028 – .0051)	
Driven gear	0.06 – 0.12 (.0024 – .0047)	

NOTE:
O.D. = Outside Diameter
O.S. = Oversize Diameter
U.S. = Undersize Diameter

Lubrication System

Item	Standard Specification	Limit
Engine oil		
Capacity	3.2 liter (3.4 U.S. qt.) including oil filter	
API Service Class	SJ or SJ/CF	
Viscosity		
10° C to 40° C (14° F to 104° F)	SAE 10W–30	
Above 68° F (20° C)	SAE 30 or 10W–30	
Oil Pump		
Type	Gear	
Drive gear side clearance mm (in.)	0.07 – 0.13 (.0028 – .0051)	
Driven gear side clearance mm (in.)	0.06 – 0.12 (.0024 – .0047)	

Fuel System

Item	Standard Specification	Limit
Carburetor		
Type	Side draft, 1 barrel type (variable venturi)	
Identification mark	*TMB or **TEB	
Maker model no.	3 4 SHVT	
Throttle bore mm (in.)	34 (1.34)	
Primary venturi diameter mm (in.)	20 (.78) equivalent	
Wide open venturi diameter mm (in.)	21 (.82) equivalent	
Acceleration pump type	Diaphragm type	
Choke type	Automatic (wax type)	
Fuel cut–off solenoid valve	Equipped	
Choke breaker opening mm (in.) *TMB	1.8 (0.071)	
Choke breaker opening mm (in.) **TEB	2.3 (0.091)	
Unloader opening mm (in.)	4.0 (0.16)	
FCSV coil resistance Ohms	48 – 60	
Fast idle opening mm (in.)	0.30 (.012) at 23° C (73° F)	

Cooling System

Item	Standard Specification	Limit
Coolant capacity		
Engine only liter (U.S. qt.)	1.8 (1.9)	
Total system (approximate) liter (U.S. qt.)	3.3 (3.5)	
Thermostat		
Valve cracking temperature °C (° F)	82° (180°)	
Full opening temperature °C (° F)	95° (205°) or more at valve lift of 8 mm (.31 in.)	

Electrical System

Item	Standard Specification	Limit
Alternator		
Nominal Output	12V – 40A	
Slip ring O.D. mm (in.)	14.4 (.567)	14.0 (.551)
Rotor coil resistance ohms	2.8 – 3.0	
Brush length mm (in.)	10.5 (.413)	4.5 (.177)
Regulated voltage volts at 25° C (77° F)	14.2 – 14.8	
Starter		
Type	Solenoid shift type	
Nominal Output	0.7 kW / 12 Volt	
Free running characteristics		
Terminal voltage volts	11.5	
Current Amps	50 or less	
Speed RPM	6,000 or more	
Commutator runout mm (in.)	0.05 (.0020)	0.4 (.016)
Commutator diameter mm (in.)	28 (1.10)	27 (1.06)
Undercut depth mm (in.)	0.45 – 0.75 (.018 – .030)	(.008)
Brush length mm (in.)	10 (.39)	4 (.16)
Ignition system		
Basic ignition timing at curb idle speed	6° ± 2° BTDC	
Distributor		
Centrifugal timing advance		
crank angle/engine speed ° / RPM		
Initial	0° / 1,600	
Middle	10° / 3,000	
Final	22° / 6,000	
Vacuum characteristics		
Crank angle/vacuum ° / mm Hg (in. Hg)		
Initial	0° / 80 (3.15)	
Middle	14° / 150 (5.91)	
Final	21° / 250 (9.84)	
Ignition coil at 20° C (68° F)		
Primary coil resistance Ohms	1.08 – 1.32	
Secondary coil resistance k Ohms	22.1 – 29.9	
Spark plug gap mm (in.)	1.0 – 1.1 (.039 – .043)	

Tightening Torques

The Mitsubishi 3G83 engine has many bolts and capscrews of special materials and sizes. It is very important that special care be used to replace all bolts and capscrews in their proper location during assembly of the engine. The torque specifications in American Standard and Metric as listed below MUST be followed in order to have the assembled engine conform to the original specifications.

Item	Nm	(ft–lb)
Engine		
Timing belt		
Crankshaft bolt	135 – 145	(98 – 105)
Crankshaft pulley bolt	15 – 18	(11 – 13)
Timing belt cover bolt	10 – 12	(7 – 9)
Camshaft sprocket bolt	80 – 100	(58 – 72)
Oil pump sprocket nut	50 – 57	(36 – 41)
Timing belt tensioner nut	22 – 30	(16 – 22)
Timing belt rear cover bolt	10 – 12	(7 – 9)
Rocker arm, rocker shaft and camshaft		
Rocker cover bolt	5 – 7	(4 – 5)
Rocker shaft bolt	29 – 35	(21 – 25)
Camshaft thrust plate bolt	10 – 12	(7 – 9)
Rocker arm adjusting nut	8 – 10	(6 – 7)
Cylinder head and valves		
Cylinder head bolt	60 – 70	(43 – 51)
Front case, counterbalance shaft and oil pan		
Front case bolt	8 – 10	(6 – 7)
Oil pump cover bolt	8 – 10	(6 – 7)
Oil pan bolt	10 – 12	(7 – 9)
Oil drain plug	35 – 45	(25 – 33)
Oil screen bolt	15 – 22	(11 – 16)
Oil pump driven gear bolt	34 – 40	(25 – 29)
Rear cover bolt	10 – 12	(7 – 9)
Piston and connecting rod		
Connecting rod cap nut	20 – 23	(14 – 17)
Crankshaft and flywheel		
Flywheel bolt	70 – 80	(51 – 58)
Rear plate bolt	8 – 12	(6 – 9)
Bell housing cover bolt	8 – 12	(6 – 9)
Oil seal case bolt	10 – 12	(7 – 9)
Bearing cap bolt	50 – 55	(36 – 40)
Cylinder block		
Taper plug 1/16	8 – 12	(6 – 9)
Taper plug 1/8	15 – 22	(11 – 16)
Water drain plug	35 – 45	(25 – 33)
Taper plug PT–1/4	35 – 45	(25 – 33)
Fuel system		
Carburetor assembly	15 – 20	(11 – 14)
Lubrication system		
Oil screen	15 – 22	(11 – 15)
Oil filter	12 – 16	(9 – 12)
Oil filter bracket (cylinder block side)	19 – 28	(14 – 20)
Oil filter bracket (bracket A side)	9 – 14	(7 – 10)
Oil pressure switch	15 – 22	(11 – 16)
Oil pump cover	8 – 10	(6 – 7)
Oil pump driven gear bolt	34 – 40	(24 – 29)

Tightening Torques (cont.)

Item	Nm	(ft–lb)
Cooling system		
Water pump pulley bolt	8 – 12	(7 – 9)
Water outlet fitting bolt	10 – 13	(7 – 9)
Engine coolant temperature gauge sender	10 – 12	(7 – 9)
Thermo valve	20 – 30	(14 – 22)
Water inlet fitting bolt	10 – 13	(7 – 9)
Water inlet pipe bolt	12 – 15	(9 – 11)
Water pump bolt	8 – 7	(6 – 7)
Intake and exhaust		
Intake manifold bolt and nut	9 – 14	(7 – 10)
EGR valve bolt	7 – 11	(5 – 8)
PCV valve	8 – 12	(6 – 9)
Exhaust manifold nut	15 – 20	(11 – 14)
Electrical system		
Spark plug	20 – 30	(15 – 21)
Distributor	10 – 13	(7 – 9)
Alternator lock bolt	20 – 25	(14 – 18)
Alternator support bolt	50 – 70	(36 – 51)
Starter motor mounting bolt	43 – 55	(31 – 40)
Battery cable mounting nut	8 – 10	(6 – 7)

Sealants / Adhesives

Item		Specification
Oil pressure switch		3M ATD Part No. 8660 or equivalent
Engine coolant temperature gauge sender		3M ATD Part No. 8660 or equivalent

Special Tools

Order special tools from TORO SPECIAL TOOLS AND APPLICATIONS GUIDE (Commercial Products).

Some tools may be listed in the Workman 3200 Parts Catalog. Tools may also be available from a local supplier.

Filter Cleaner

Filter cleaner. Mix with water and use solution to wash the Donaldson air cleaner element.

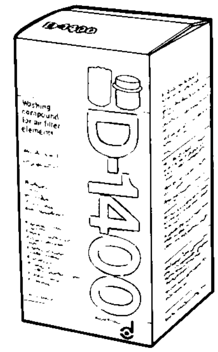


Figure 1

Pin

Used with End Yoke Holder (Fig. 3) for supporting sprocket when camshaft sprocket bolt is loosened or tightened.

Mitsubishi Motors Part No. MD998719

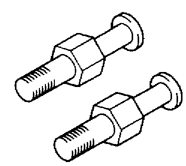


Figure 2

End Yoke Holder

Used with Pins (Fig. 2) for supporting sprocket when camshaft sprocket bolt is loosened or tightened.

Mitsubishi Motors Part No. MB990767

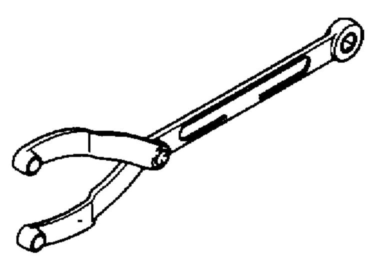


Figure 3

Flywheel Stopper

Stopper for locking crankshaft pulley, sprocket and flywheel during removal.

Mitsubishi Motors Part No. MD998608

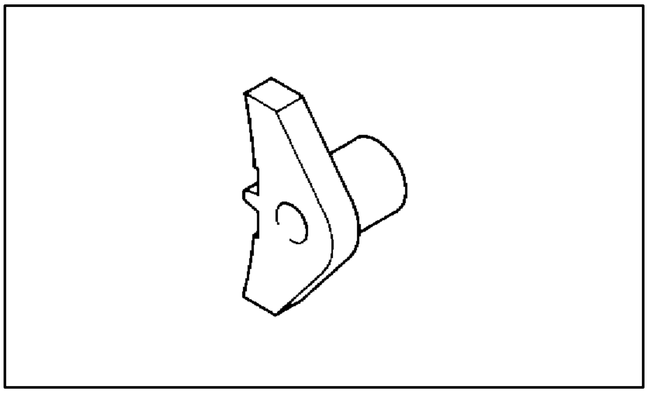


Figure 4

Valve Spring Compressor

Use for compression of valve spring during removal and installation.

Mitsubishi Motors Part No. MD999597

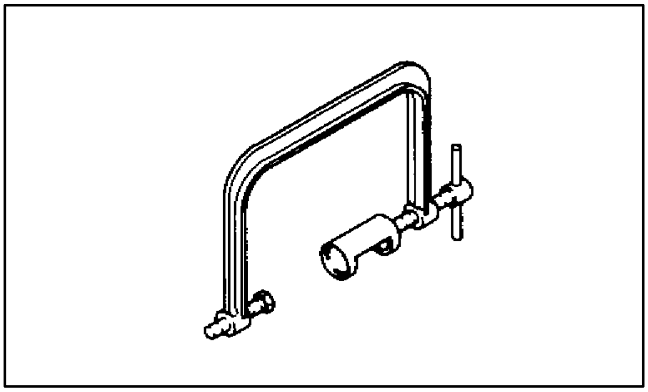


Figure 5

Valve Stem Seal Installer

Use for installation of valve stem seals.

Mitsubishi Motors Part No. MD998302

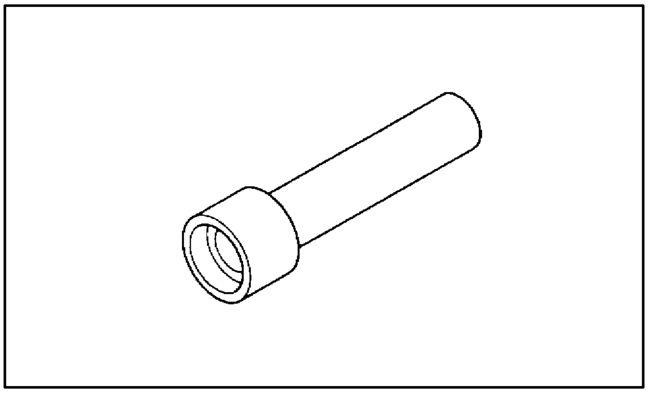


Figure 6

Oil Pan Gasket Cutter

User for Removing oil pan to break oil pan seal.

Mitsubishi Motors Part No. MD998727

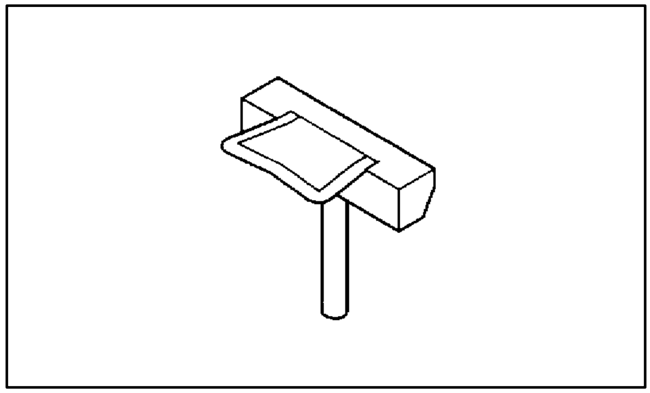


Figure 7

Balancer Shaft Bearing Remover

Use to pull out counterbalance shaft front and rear bearing.

Mitsubishi Motors Part No. MD999593

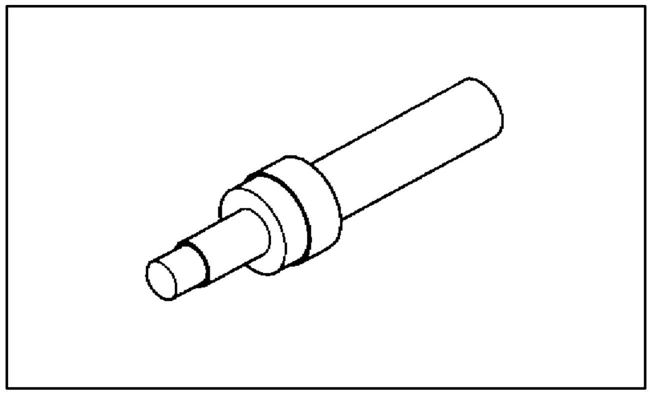


Figure 8

Balancer Shaft Front Bearing Installer

Use for press fitting counterbalance shaft front bearing.

Mitsubishi Motors Part No. MD999591

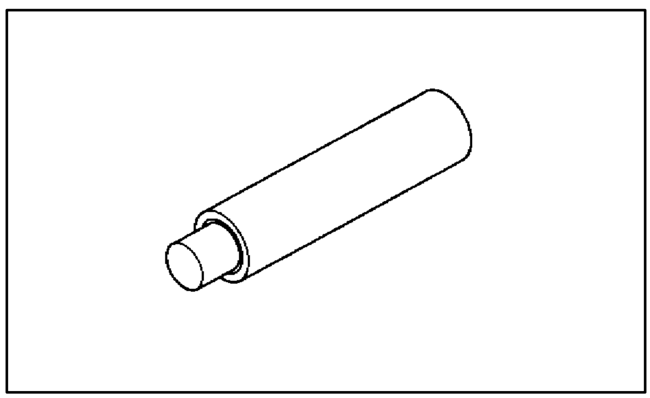


Figure 9

Balancer Shaft Rear Bearing Installer

Use for press fitting counterbalance shaft rear bearing.

Mitsubishi Motors Part No. MD999592

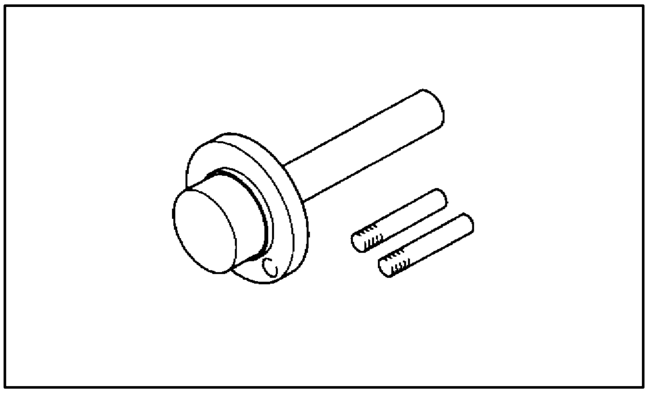


Figure 10

Crankshaft Front Oil Seal Installer

Use for installing crankshaft front oil seal.

Mitsubishi Motors Part No. MD999570

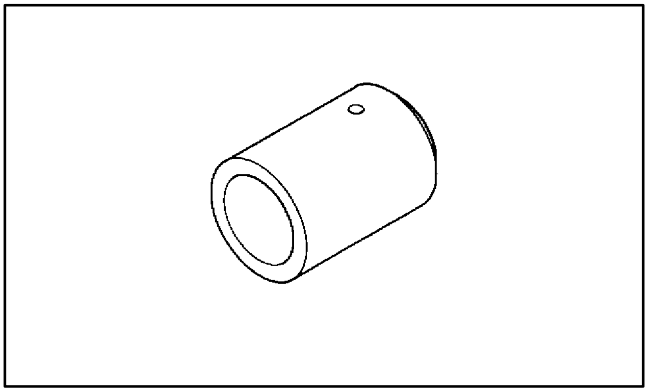


Figure 11

Camshaft Oil Seal Installer

Use for installation of camshaft oil seal.

Mitsubishi Motors Part No. MD999569

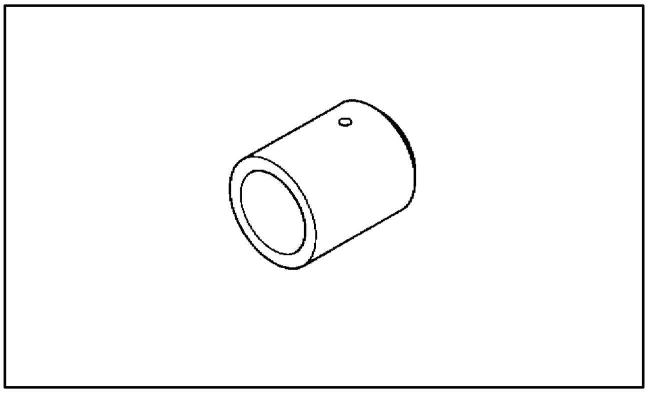


Figure 12

Crankshaft Rear Oil Seal Installer

Use for installation of crankshaft rear oil seal.

Mitsubishi Motors Part No. MD998376

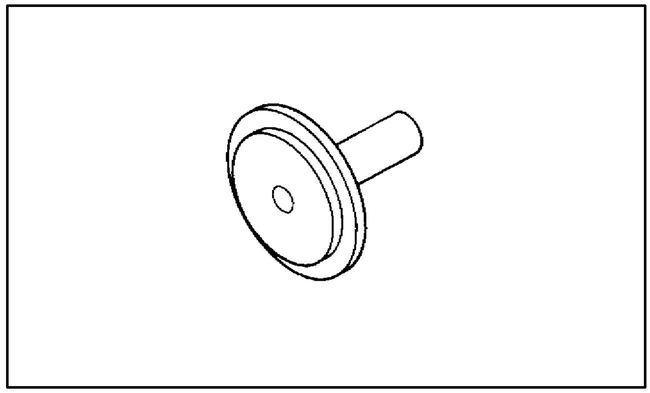


Figure 13

Piston Pin Setting Base

Use with Push Rod and Guide Pin Set (Fig. 14) to pull out and press in piston pin.

Mitsubishi Motors Part No. MD999583

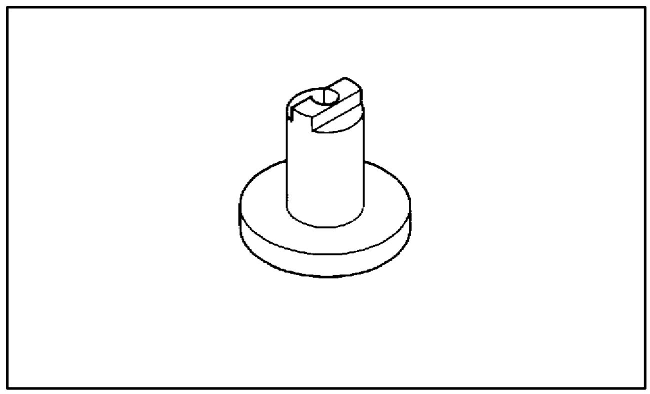


Figure 14

Push Rod and Guide Pin Set

Use with Piston Pin Setting Base (Fig. 13) to pull out and press in piston pin.

Mitsubishi Motors Part No. MD999584

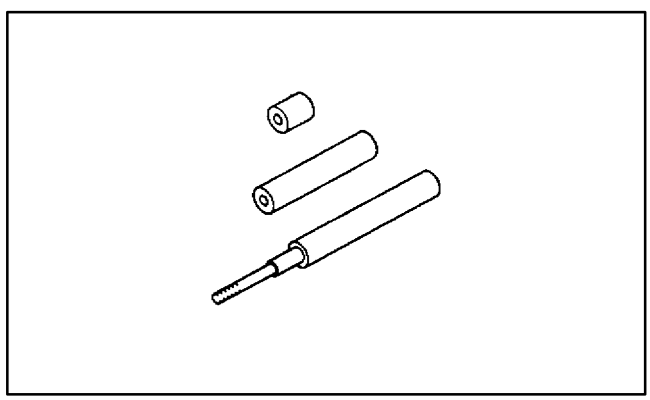


Figure 15

Inspection and Adjustments

Valve Clearance

IMPORTANT: After adjusting timing belt tension, adjust valve clearance.

1. Warm up the engine until coolant is at 80° to 95° C (176° to 203° F).

2. Remove rocker cover.

3. Remove timing belt cover.

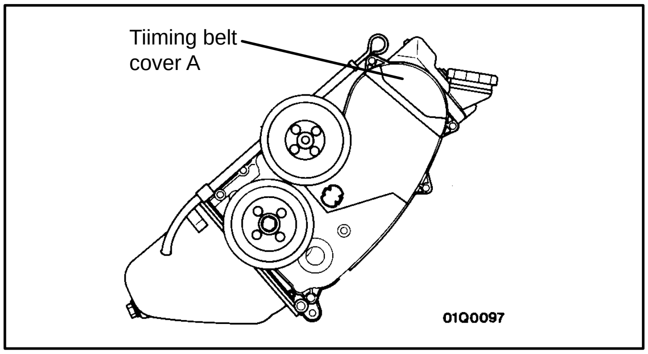


Figure 16

4. Turn crankshaft clockwise to align triangular mark on camshaft sprocket with timing mark on timing belt rear cover to set No. 1 cylinder on compression top dead center.

IMPORTANT: Turn crankshaft only in clockwise direction.

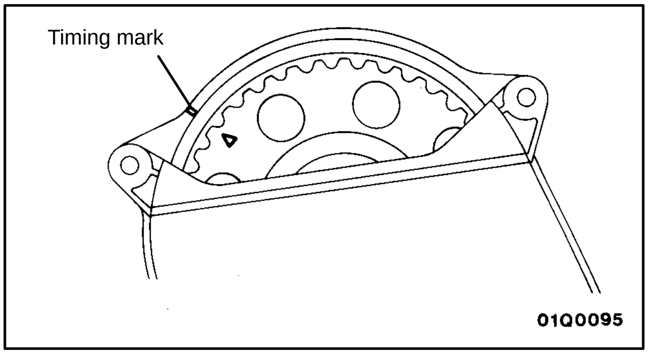


Figure 17

5. Measure valve clearances at locations shown in illustration.

Standard Values		mm (in.)
Item	**When warmed up**	**When cold** (Reference)
Intake valve	0.20 (.008)	0.14 (.006)
Exhaust valve	0.30 (.012)	0.24 (.009)

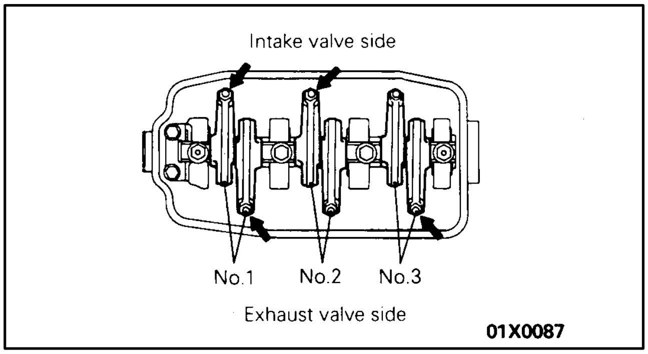


Figure 18

6. If valve clearance is not at standard value, loosen rocker arm locknut and use a feeler gauge to adjust clearance while turning adjusting screw.

7. Hold screwdriver so adjusting screw will not turn and tighten locknut to specified torque.

Adjusting screw torque	8 – 10 Nm (5.8 – 7.2 ft–lb)

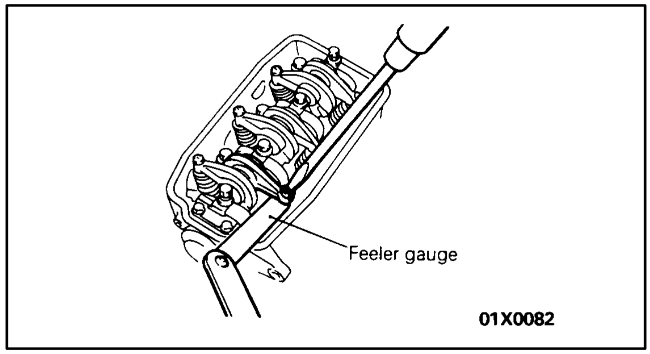


Figure 19

8. Turn crankshaft a further 240° in clockwise direction and align round mark on camshaft sprocket with timing mark on timing belt rear cover to set No. 3 cylinder on compression top dead center.

IMPORTANT: Turn crankshaft only in clockwise direction.

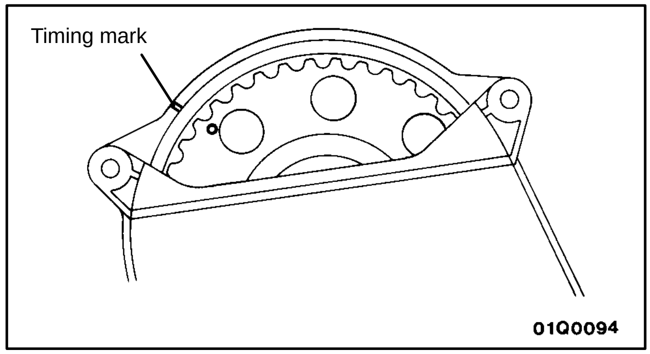


Figure 20

9. Measure valve clearance at locations shown in illustration.

Standard Values		mm (in.)
Item	**When warmed up**	**When cold** (Reference)
Intake valve	0.20 (.008)	0.14 (.006)
Exhaust valve	0.30 (.012)	0.24 (.009)

10. If valve clearance is not at standard value, adjust as instructed in steps 6 and 7.

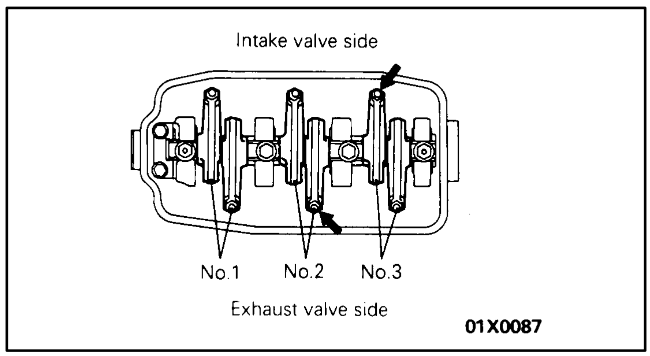


Figure 21

Timing Belt Tension

1. Remove alternator drive belt.

2. Remove timing belt cover.

3. Remove access cover.

4. Turn crankshaft clockwise (right turn) to check that timing belt is okay over it's entire length.

IMPORTANT: Turn crankshaft only in clockwise direction.

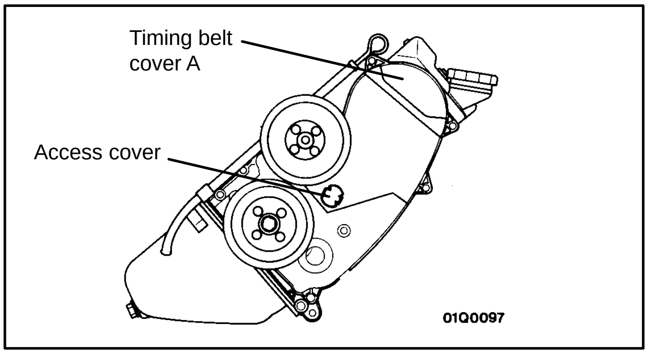


Figure 22

5. Turn crankshaft clockwise to align timing mark on camshaft sprocket and timing belt rear cover.

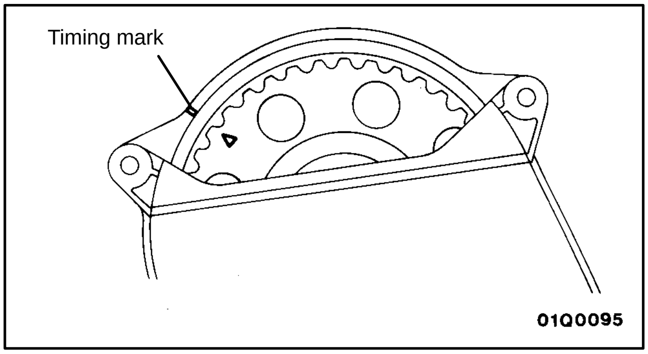


Figure 23

6. Loosen tensioner nut by one (1) or two (2) turns and allow spring force to tension belt.

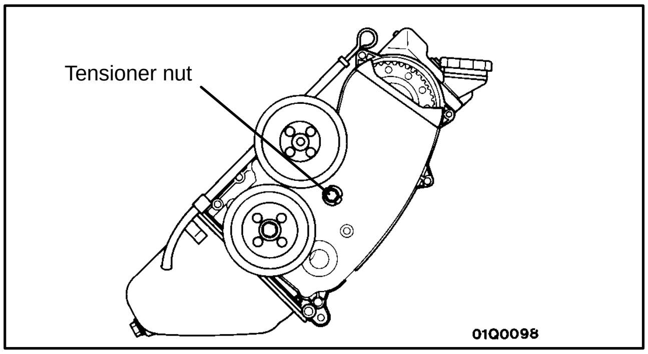


Figure 24

7. Turn crankshaft clockwise by nine (9) camshaft sprocket teeth (81°) to align timing mark on camshaft sprocket with tensioner set mark on timing belt rear cover.

8. Tighten tensioner nut.

9. Install access cover.

10. Install timing belt cover.

11. Install alternator drive belt.

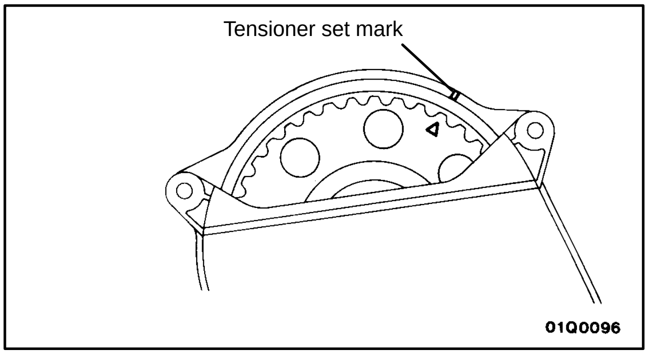


Figure 25

Liquid Cooled Gas Engine

Idle Speed

1. Make sure engine is warm (coolant temperature 80 – 95°C (176 – 203°F), all lights and accessories are OFF and transmission is in NEUTRAL.

2. If vehicle is not equipped with a tachometer, connect an electronic tachometer:

A. Insert a paper clip into ignition coil primary 3–pin connector (terminal 1) from harness side.

B. Connect tachometer to paper clip.

3. Check idle speed.

Idle speed	1200 ± 100 RPM

4. If idle speed is not at the standard value, use the speed adjusting screw (SAS) to adjust idle speed to the standard value.

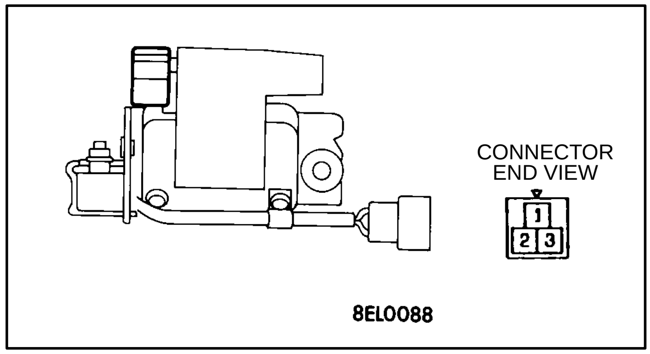


Figure 26

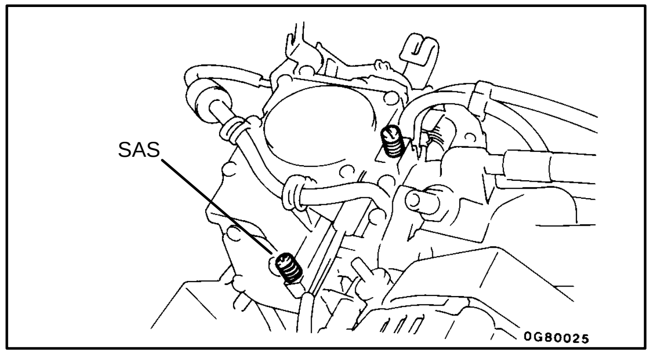


Figure 27

Ignition Timing

1. Make sure engine is warm (coolant temperature 80 – 95°C (176 – 203°F), all lights and accessories are OFF and transmission is in NEUTRAL.

2. Install a timing light.

3. Check idle speed to make sure it is at standard value (see Idle Speed in this section).

Idle speed	1200 ± 100 RPM

4. Check ignition timing.

Ignition timing	6° BTDC ± 2°

5. If timing is not within standard value, loosen distributor mounting nut and adjust by rotating distributor body.

NOTE: Turning distributor body left retards timing and turning it right advances timing.

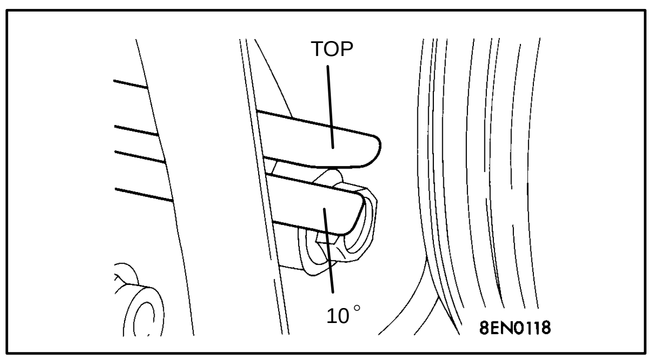


Figure 28

6. Tighten distributor mounting nut to 10 – 13 Nm (7 – 9 ft–lb).

Simplified Inspection

NOTE: Simple inspection of ignition timing can be done by using the TOP and 10° marks on the front case.

CO Concentration (Mixture Adjustment)

1. Make sure engine is warm (coolant temperature 80 – 95°C (176 – 203°F), all lights and accessories are OFF and transmission is in NEUTRAL.

2. Check to make sure that idle speed and ignition timing are the standard values(see Idle Speed and Ignition Timing in this section).

Standard values	
Idle speed	1200 ± 100 RPM
Ignition timing	6° BTDC ± 2°

3. Check CO and HC concentration for standard values.

Standard values	
CO concentration	1.0 ± 0.8%
HC concentration	800 ppm or less

Note: There are two types of carburetors which can be installed on the liquid cooled gas engine. One is marked **TMB**, which can be adjusted by the customer. The other is marked **TEB**, which is **U.S. Environmental Protection Agency (EPA)** and **California Air Resources Board (CARB)** certified and must be adjusted by the manufacturer or your Mitsubishi/Toro Distributor.

4. **On carburetors with identification mark TMB:**

A. If concentrations are outside the standard value, use the mixture adjusting screw (MAS) to adjust the CO concentration.

B. After running the engine at 2000 to 3000 RPM for 15 seconds, check CO concentration again. Use MAS screw to adjust if necessary.

C. **If test equipment is not available,** turn MAS clockwise until engine begins to idle roughly, then turn counterclockwise 1 turn.

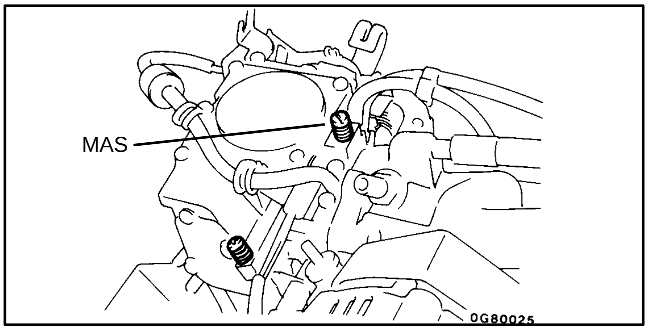


Figure 29

IMPORTANT: All carburetors with a TEB identification mark have a tamper–resistant idle Mixture Adjusting Screw (MAS). The CO setting has been done at the factory. Do not attempt to adjust the MAS, this will be in violation of U.S. Environmental Protection Agency (EPA) and California Air Resources Board (CARB) regulations.

5. **On carburetors with identification mark TEB:** If concentrations are outside the standard value, replace the carburetor.

Governor / Accelerator Pedal

1. Put vehicle on a level surface, stop engine and engage the parking brake.

2. Rotate governor input lever clockwise to put a light tension load on the governor spring. Hold carburetor throttle against wide open throttle stop and adjust ball joint on throttle rod to allow ball joint socket to travel past carburetor throttle stud by 0.200±0.031 in. (5±0.8 mm). Tighten locknuts on throttle rod. Ball joints must move freely through full travel.

3. While rotating governor input lever counterclockwise and holding carburetor throttle against low idle stop, adjust surge screw to allow governor output arm stud to travel past ball joint socket by 0.200±0.031 in. (5±0.8 mm).

CAUTION

The engine must be running to make final adjustment of governor. To guard against possible personal injury, engage parking brake and keep hands, feet, face and other parts of the body away from fan or other moving parts.

4. Start engine and allow it to warm up to normal operating temperature. With throttle plate held fully closed, adjust low idle stop on carburetor to get 1200±100 RPM.

5. Advance governor input lever to increase engine speed to 3600±50 rpm. Adjust high idle screw to contact governor input lever.

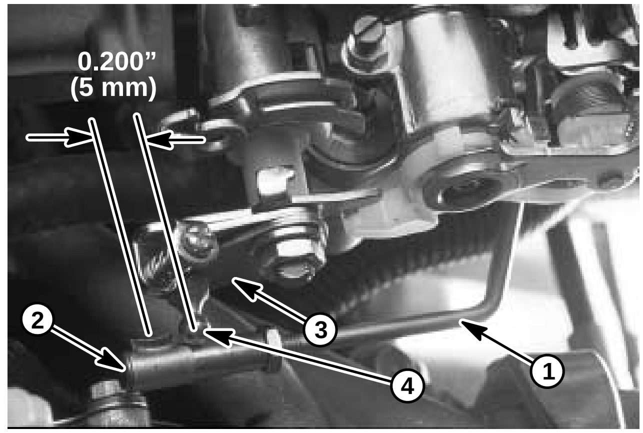


Figure 30

1. Throttle rod
2. Ball joint
3. Carburetor throttle
4. Carburetor throttle stud

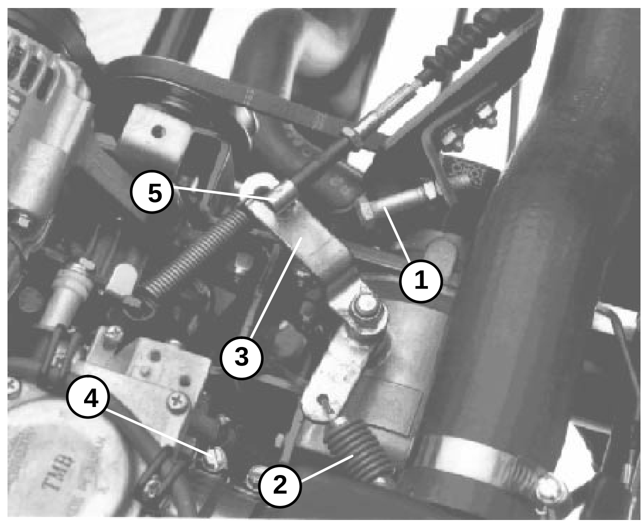


Figure 31

1. High idle screw
2. Governor spring
3. Governor input lever
4. Low idle screw
5. Ball joint

6. Release and advance accelerator to find if high idle speed is erratic (surges). If engine surges more than twice, turn surge screw clockwise until high idle speed increases 10 to 50 RPM. Release and advance accelerator to find if engine is still surging. If engine is still surging, turn screw clockwise to increase high idle an additional 10 to 50 RPM. High idle should not exceed 3650 RPM and surge screw must not increase high idle more than 100 RPM. Tighten surge screw locknut.

7. Check low idle setting. If low idle is more than setting in step 4, the surge screw was turned too far clockwise. Turn surge screw counterclockwise until the low idle setting returns to the setting in step 4. Check high idle setting as instructed in step 6.

8. Stop the engine.

NOTE: Engine must NOT be running and return spring must be attached for the next step (Step 9).

9. Adjust ball joint on accelerator cable to allow 0.200 – 0.350″ (5 – 9 mm) of clearance between accelerator pedal and top of diamond tread floor plate, when a 20 lb. (9 Kg) force is applied to center of pedal. Tighten locknut.

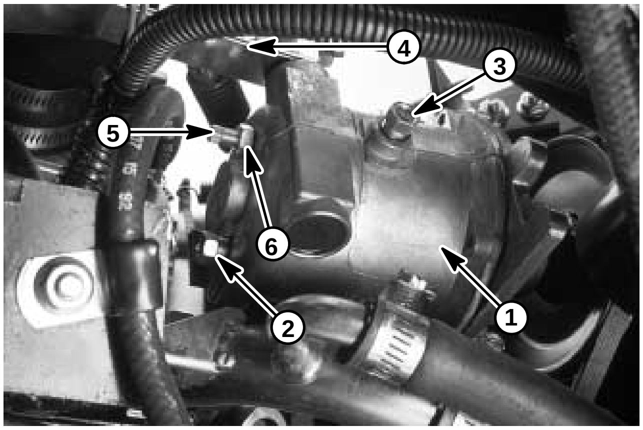


Figure 32

1. Governor
2. Oil Check plug
3. Oil fill plug (on top)
4. Governor output lever
5. Surge screw
6. Locknut

Carburetor Acceleration Pump

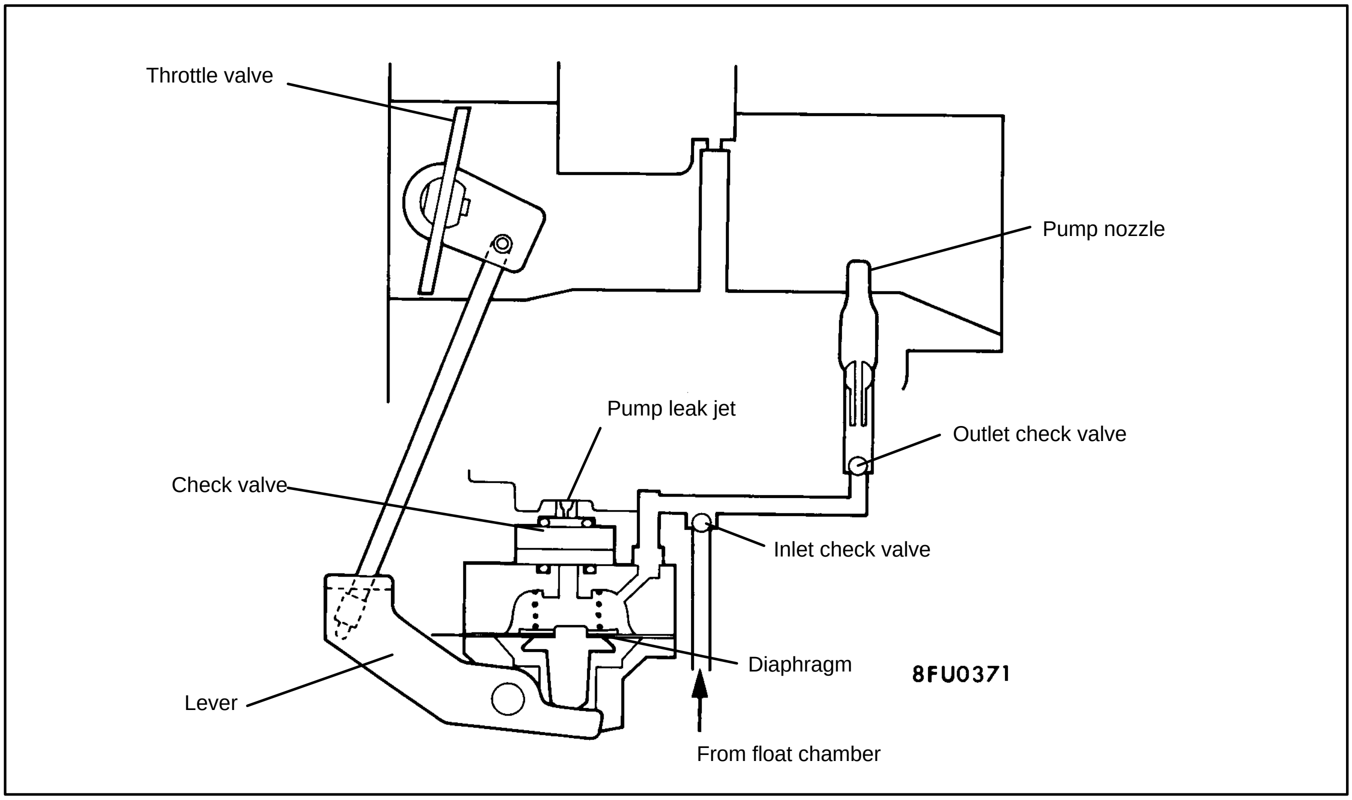


Figure 33

1. Remove air intake hose.

2. Check to see that fuel is injected from pump nozzle when throttle valve is opened while keeping the choke valve open.

3. Clean the fuel path if fuel is not injected.

Choke Valve

1. Remove air intake hose.

2. Move choke valve with a finger and check for smooth movement without backlash.

3. If there is excessive backlash replace mixing body or entire carburetor. If choke valve is sticking, clean parts around choke valve and apply oil to choke shaft.

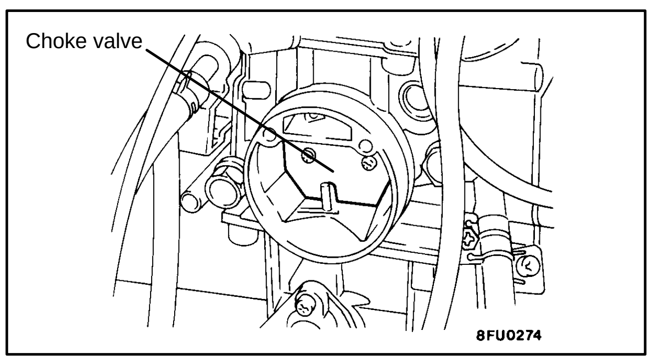


Figure 34

Full – Auto – Choke

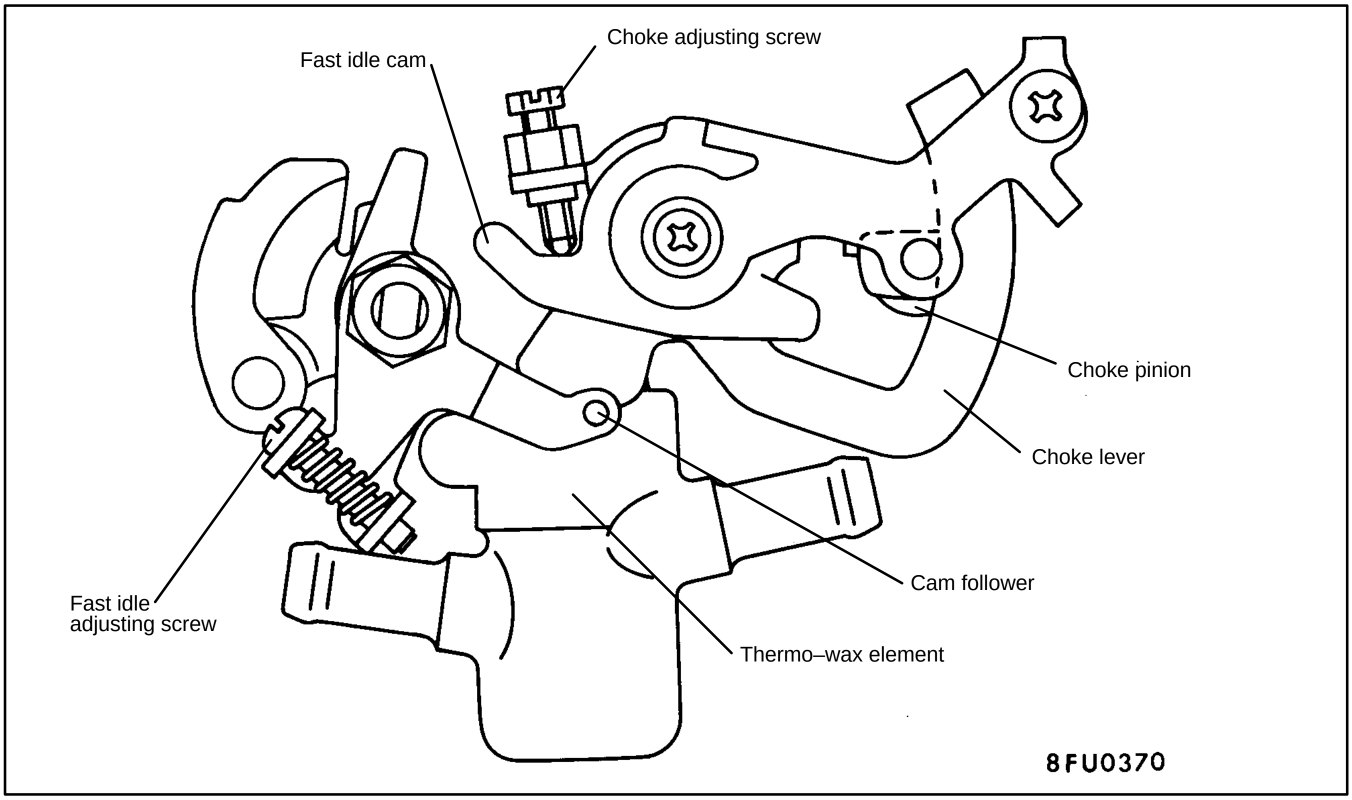


Figure 35

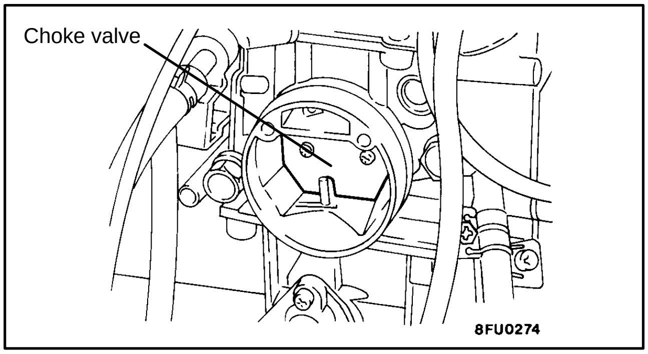


Figure 36

1. Remove air intake hose.

2. Make sure engine coolant temperature is below 10°C (50°F).

3. Check operation of choke valve under various engine conditions.

Engine condition	Choke valve operation
Before starting	Closed
Just after starting (Carburetor ID Mark TMB)	Slightly opens approx. 1.8 mm (.071 in.) clearance
Just after starting (Carburetor ID Mark TEB)	Slightly opens approx. 2.3 mm (.091 in.) clearance
During warm–up	Opens wider as engine coolant temperature increases
After warming up (running at idle)	Fully open

4. If choke valve does not operate properly, inspect and adjust or replace the choke body assembly.

Choke Breaker Opening

1. Inspect after doing Full–Auto–Choke inspection.

2. Run engine at idle. Move choke valve in closing direction with light finger force until valve resists being moved. Measure clearance between choke valve and choke bore at this point.

Choke valve to choke bore clearance (Carburetor ID Mark TMB)	1.8 mm (0.071 mm)
Choke valve to choke bore clearance (Carburetor ID Mark TEB)	2.3 mm (0.091 mm)

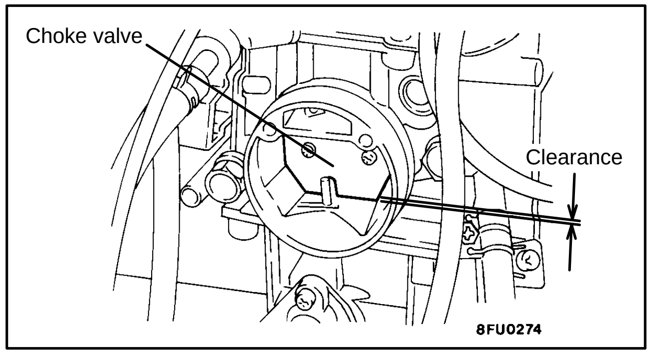


Figure 37

3. If clearance is out of specification, adjust by opening or closing part shown in illustration.

Rod end	Valve clearance	Remarks
Opened	Larger	Engine becomes more difficult to start and tends to stall
Closed	Smaller	Carbon tends to accumulate on spark plugs

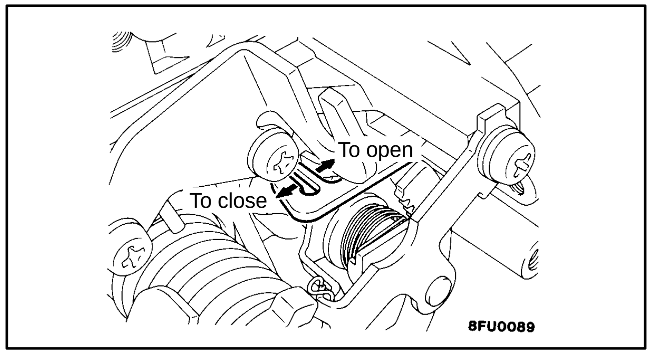


Figure 38

Fast Idle

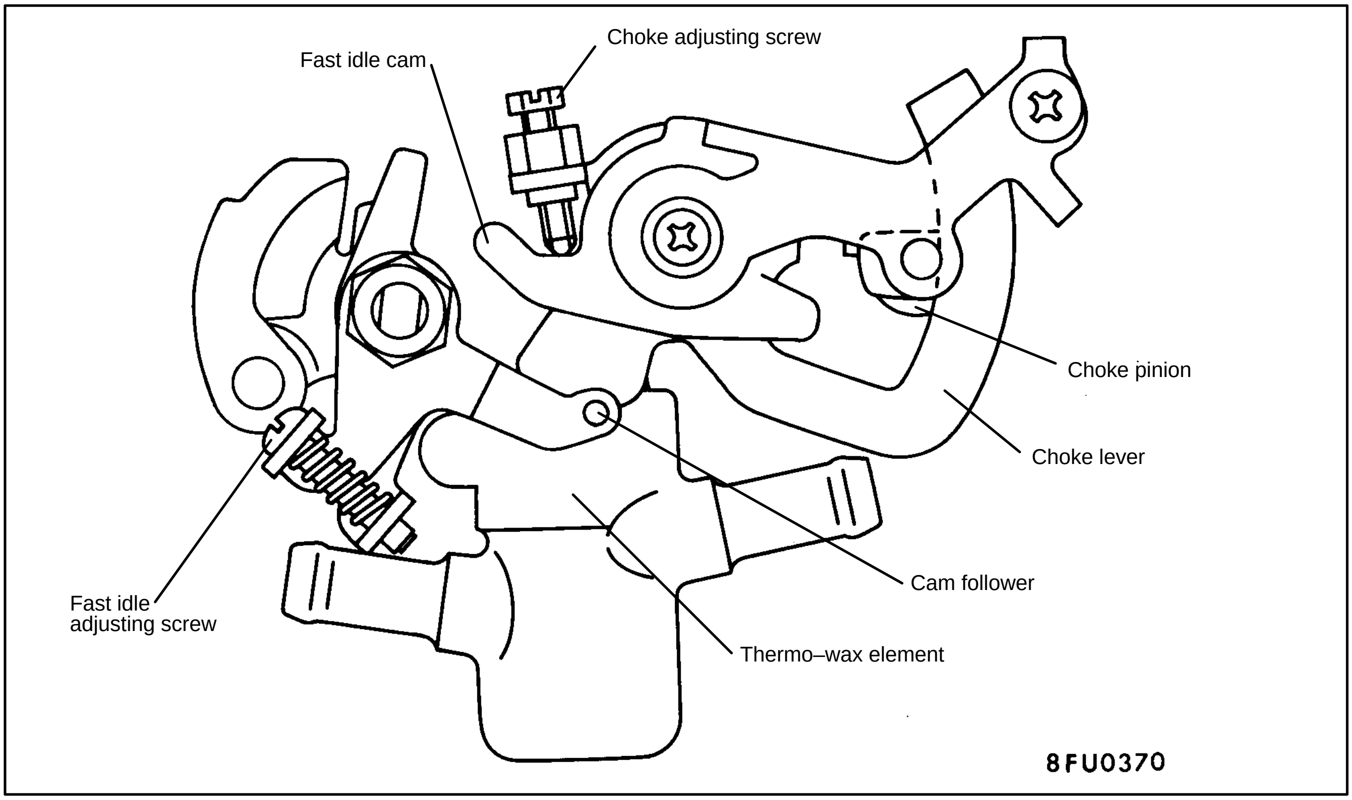


Figure 39

1. Make sure engine coolant temperature is below 10°C (50°F).

2. Start the engine. Make sure idle speed during the warm up period changes smoothly as coolant temperature increases and becomes stable at the standard speed.

Idle speed	1200 ± 100 RPM

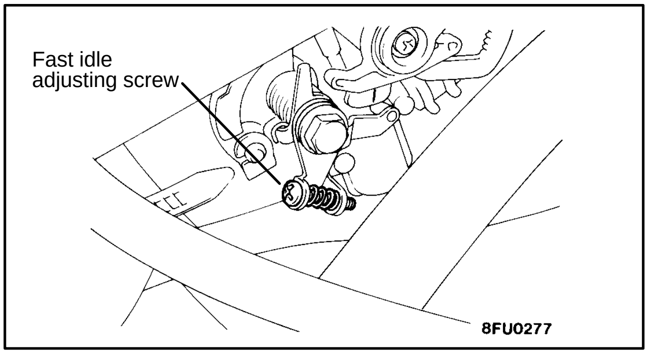


Figure 40

3. If anything abnormal occurs during step 2, adjust fast idle speed. Turn adjusting screw clockwise to increase fast idle speed and counterclockwise to decrease.

NOTE: If fast idle speed (during warm up) is normal, cam lever mating mark (scribed line) and cam follower mating mark (punch mark) should align at the thermo wax element temperature of 23°C (73°F).

IMPORTANT: Alignment of these marks are precisely adjusted at the factory. When doing ordinary adjustments, do not change the setting by turning the adjusting screw.

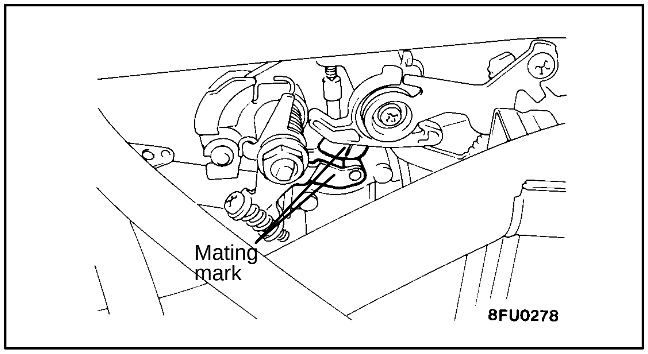


Figure 41

Troubleshooting

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

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

Symptom	Possible Causes
Engine overheats.	Cooling system faulty. – Radiator screen plugged. – Fan belt slipping. – Low coolant level. Incorrect ignition timing. Coolant leaks: – Loose cylinder head bolts. – Damaged cylinder head gasket. – Cracked cylinder block. – Cracked cylinder head. Loose intake manifold bolts or leaking from gasket. Cracked intake manifold.
Rough idle or engine stalls.	Ignition system problems. Compression too low. Idle speed set too low. Idle mixture too lean or too rich. Carburetor problems. Stale fuel in carburetor. Vacuum leaks: – Purge control valve hose. – Vacuum hoses. – Intake manifold. – Carburetor.

Symptom	Possible Causes
Engine will not start or starts too hard (cranks OK).	Ignition system problems. Compression too low. No fuel supply to carburetor. Carburetor problems. Vacuum leaks: – Purge control valve hose. – Vacuum hoses. – Intake manifold. – Carburetor.
Engine will not crank.	Starting system faulty (see Chapter 8 – Electrical System).
Engine dieseling.	Incorrect ignition timing. Carburetor problems.
Excessive oil consumption.	Valve stem seal worn or damaged. Valve step worn. Piston ring worn or damaged. Oil leak. Positive crankcase ventilation line clogged.
Poor fuel efficiency.	Clutch slips. Ignition problems. Compression too low. Carburetor problems. Fuel leak. Air filter clogged.

Testing

Temperature Gauge Sender

1. Lower the coolant level in the engine and remove the temperature gauge sender (see Water Pump, Water Hose, Pipe and Thermostat Removal and Installation).

2. Put the switch in a container of oil with a thermometer and heat the oil.

3. With an Ohm meter connected as shown, the following resistance readings should be indicated.

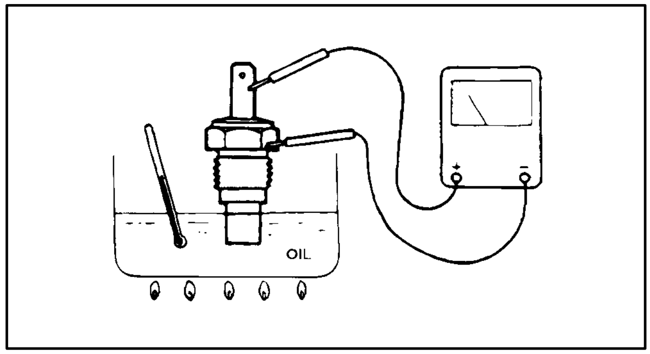


Figure 42

Temperature gauge sender resistance readings	90.5 – 117.5 ohm at 70°C (160°F)
	21.3 – 26.3 ohm at 115°C (207°F)

CAUTION

Handle hot oil with special care to prevent personal injury or fire.

Engine Oil Pressure Switch

The switch is normally closed (NC) and opens with pressure. The switch opens at approximately 8 psi (55 kPa). (See Oil Screen, Dipstick and Oil Filter Removal and Installation for location).

1. Turn ignition key switch ON. Oil pressure lamp should be on.

If oil pressure light is OFF:

1. Disconnect wire from switch and touch wire to a good ground.

2. If lamp comes on, replace switch.

3. If lamp does not come on, check lamp and/or wiring between lamp and switch for continuity.

If oil pressure light is ON with engine running:

1. Shut off engine immediately.

2. Check switch by disconnecting wire. Light should go out.

3. If light is still on, check for short circuit in wiring.

4. Install test gauge in engine oil pressure switch port. Start engine and check for 30 psi (207 kPa) minimum at 1500 rpm. If engine pressure is good, replace switch. If engine pressure is low, DO NOT operate the engine.

Thermostat Test

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

1. Remove the thermostat (see Water Pump, Hose, Pipe and Thermostat Removal and Installation).

2. Put the thermostat in a container of water with a thermometer and heat the water.

Valve cracking temperature	80°C (180°F)
Full open temperature	95°C (205°F) or more valve lift of 8 mm (.31 in.)

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

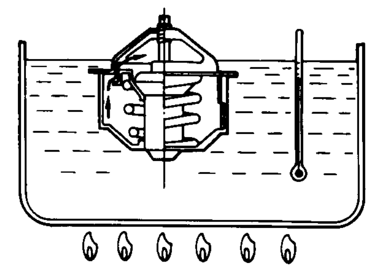


Figure 43

Fuel Cut–Off (ETR) Solenoid

NOTE: The fuel cut–off solenoid is an energize–to–run (ETR) solenoid.

1. Check that valve makes an operating sound when ignition switch is turned ON.

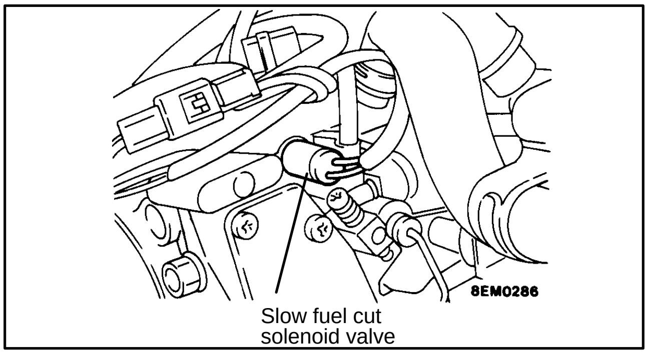


Figure 44

2. Start the engine. Let engine run at idle. Make sure engine stalls when slow fuel cut–off solenoid valve electrical connector is disconnected.

3. Stop the engine. Measure coil resistance of fuel cut–off solenoid.

Coil resistance	48 – 60 ohm at 20°C (68°F)

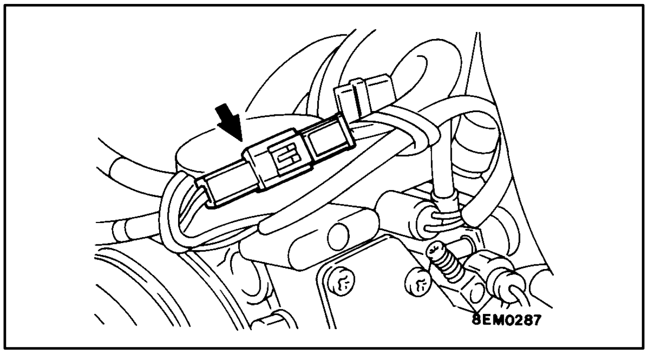


Figure 45

Compression Pressure

1. Make sure engine is warm (coolant temperature 80 – 95°C (176 – 203°F), all lights and accessories are OFF and transmission is in NEUTRAL.

2. Remove spark plug caps (3).

3. Remove spark plugs (3).

4. Install a compression gauge in a spark plug hole.

5. With throttle held open, crank engine and measure compression pressure.

Compression pressure	1,250 Kpa (178 psi) at 400 RPM
Limit	960 kPa (137 psi) at 400 RPM

6. Measure compression pressure for all cylinders. Make sure pressure differential for each cylinder is within specified limit.

Pressure differential limit	100 kPa (14 psi)

7. If a cylinder's compression or pressure differential exceeds the limit, add a small amount of engine oil through spark plug hole and repeat steps 4 – 6.

If addition of engine oil causes and increase in compression pressure, the piston ring and/or cylinder wall may be worn or damaged.

If addition of engine oil does not cause any increase in compression pressure, the cause may be valve seizure, poor valve contact or pressure leaks through head gasket.

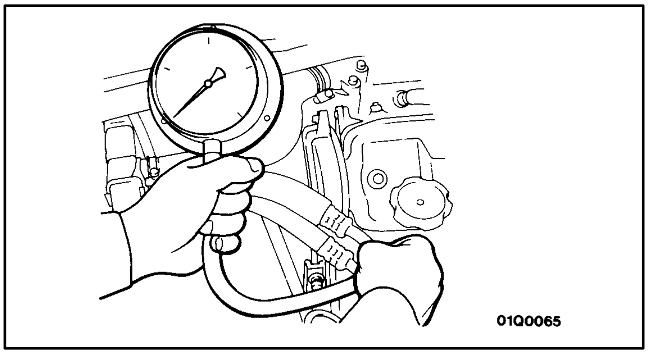


Figure 46

Intake Manifold Vacuum

1. Make sure engine is warm (coolant temperature 80 – 95°C (176 – 203°F), all lights and accessories are OFF and transmission is in NEUTRAL.

2. Install a vacuum gauge.

3. Check to make sure intake manifold vacuum is at the standard value when the engine is at standard idle speed.

Intake manifold vacuum	60 Kpa (450 mm Hg, 18 in. Hg)

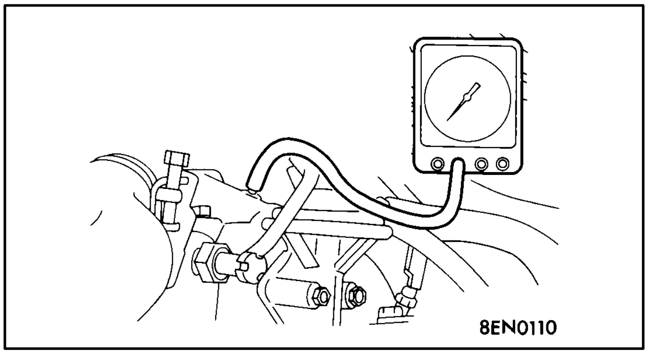


Figure 47

Centrifugal Timing Control Device

1. Start engine and run at idle.

2. Remove vacuum hose from vacuum controller. Plug disconnected vacuum hose. Plug disconnected vacuum hose.

3. Increase engine speed gradually and check advance. It is normal if advancing smoothly according to increasing speed.

Symptom	Possible cause
Excessive advance	Worn or damaged governor spring
Start up advance too sudden	Damaged spring
Inadequate advance or slow change in advance.	Malfunction of governor weight or cam

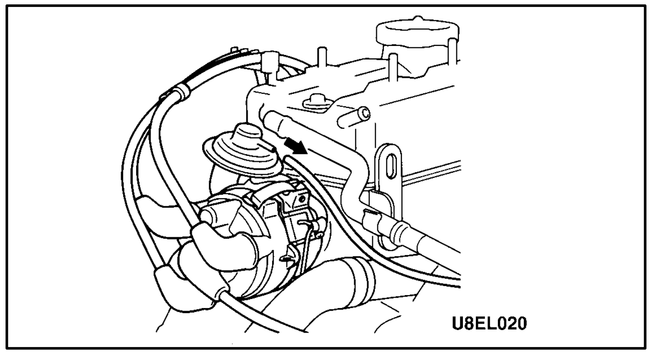


Figure 48

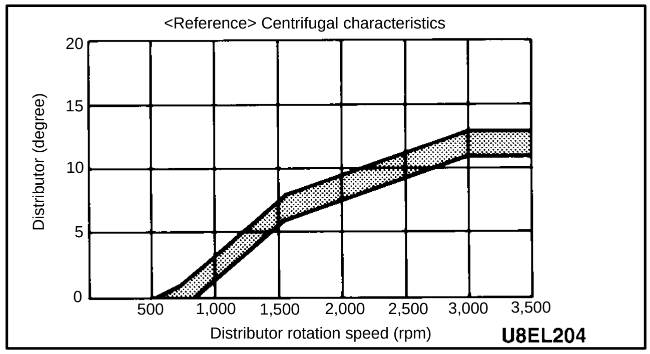


Figure 49

Vacuum Timing Control Device

1. Start engine and run at idle.

2. Remove vacuum hose from vacuum controller. Plug disconnected vacuum hose. Connect vacuum pump to nipple.

3. Add vacuum on vacuum pump gradually and check advance. Timing should advance smoothly with increased vacuum.

Symptom	Possible Cause
Excessive advance	Worn or damaged vacuum controller spring
Start–up advance too sudden	Damaged spring
Inadequate advance or slow change in advance	Breaker base malfunction
No advance	Damaged diaphragm

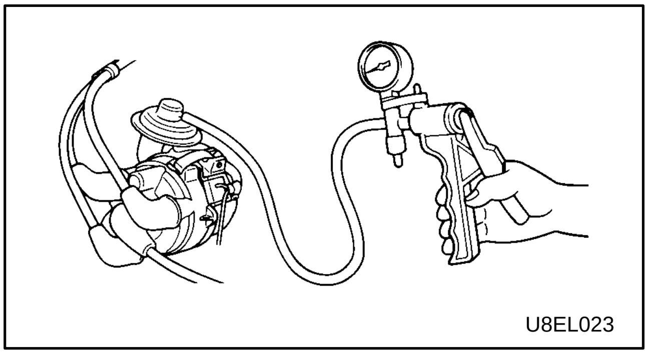


Figure 50

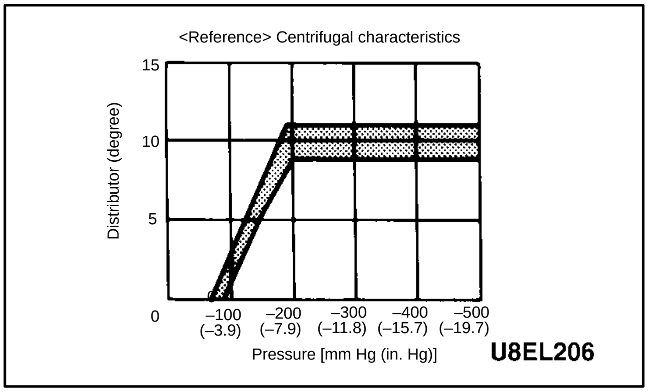


Figure 51

Liquid Cooled Gas Engine

Crankcase Emission Control System

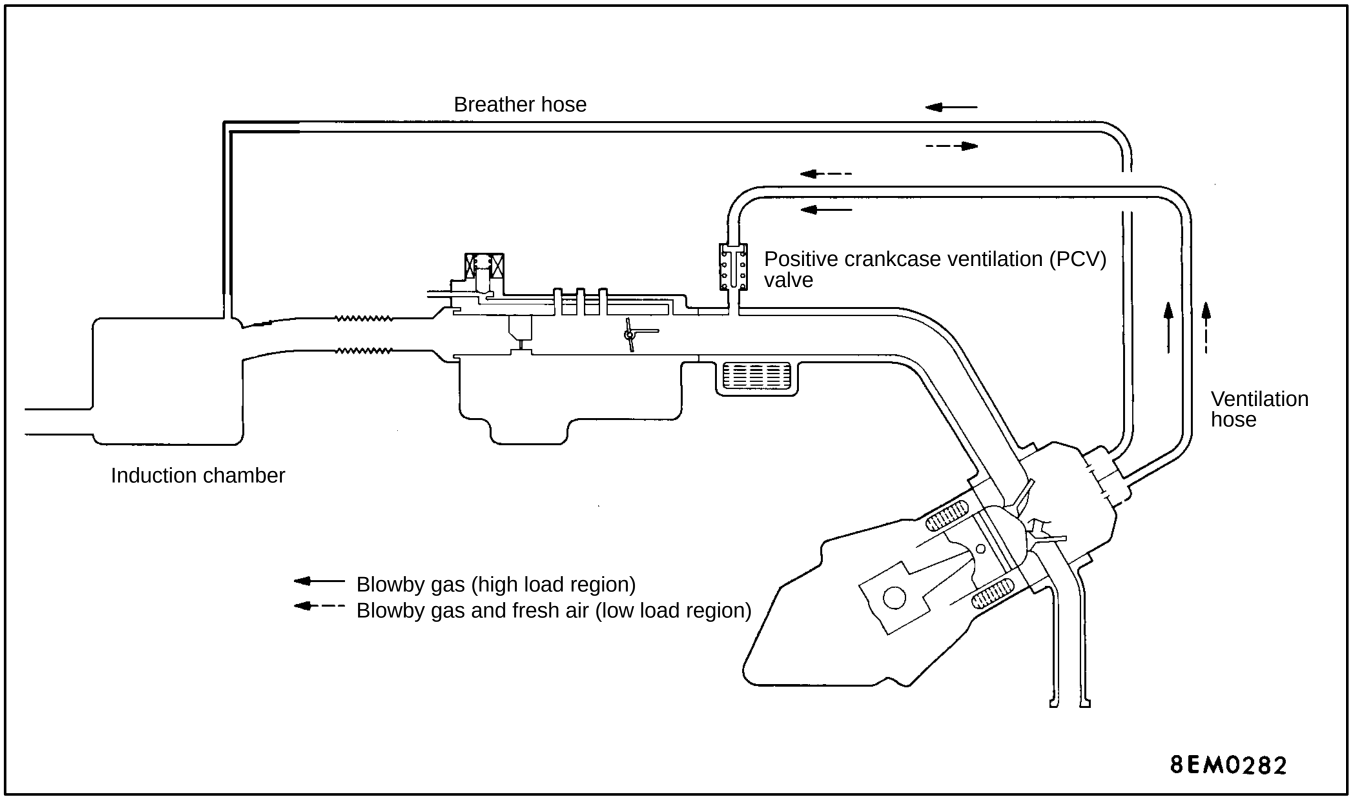


Figure 52

System Inspection

1. Remove ventilation hose from rocker cover where positive crankcase ventilation (PCV) valve is attached.

2. Run engine at idle and put a finger on open end of ventilation hose to check for intake manifold vacuum.

3. If vacuum is not felt on finger, clean or replace PCV valve.

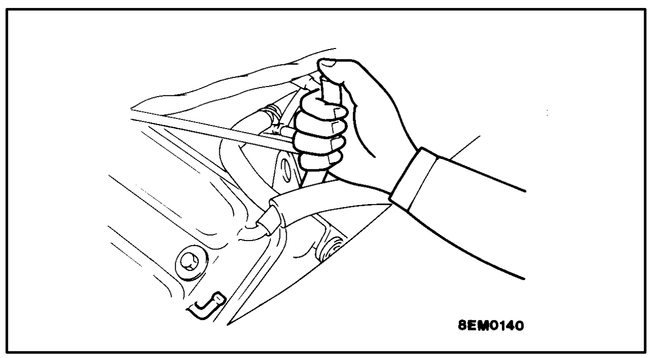


Figure 53

Inspection of PCV Valve

1. Remove PCV valve.

2. Insert a thin object into PCV valve from the black nipple side to check that the plunger moves.

3. If plunger does not move, the PCV valve is plugged. Clean or replace PCV valve.

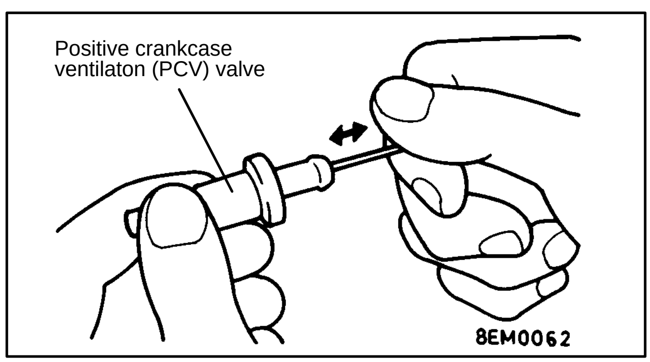


Figure 54

Exhaust Emission Control System

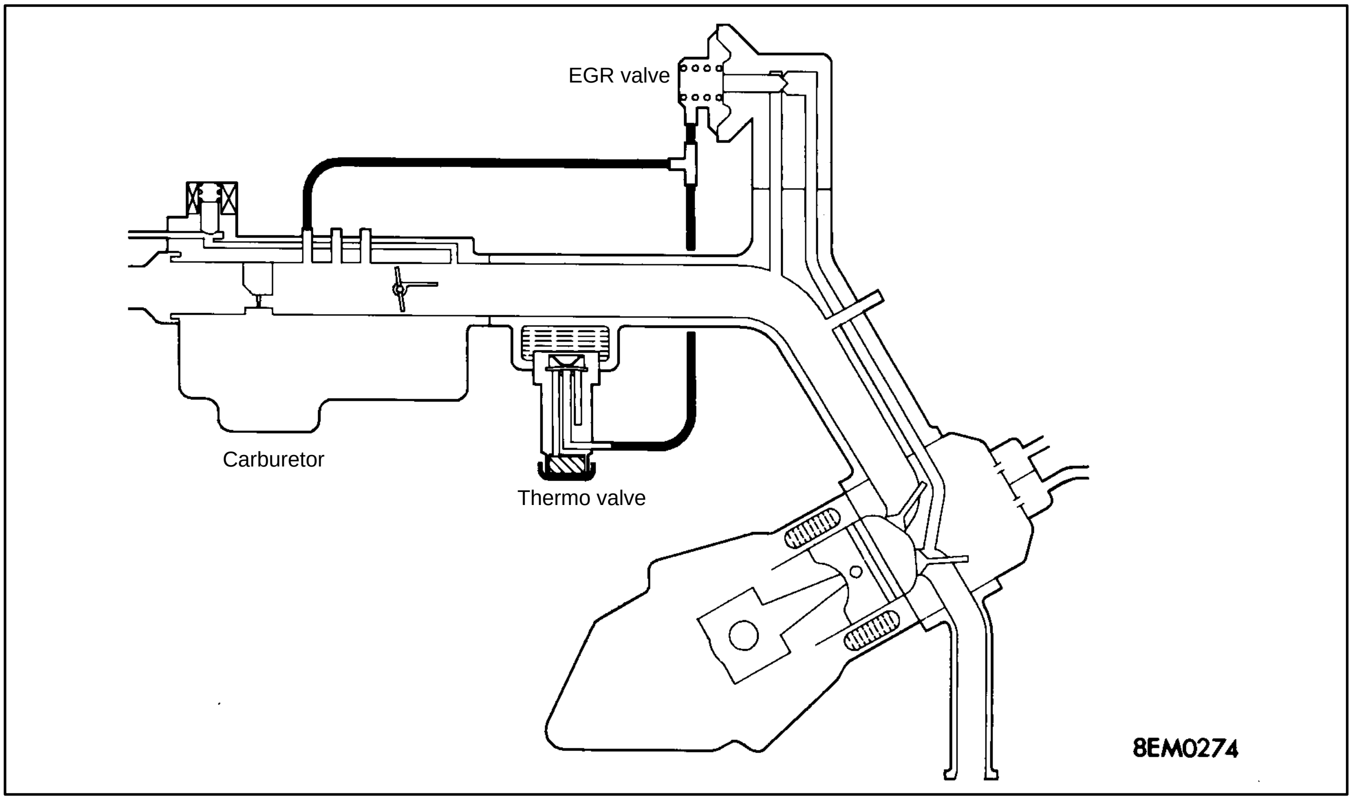


Figure 55

1. Remove vacuum hose (green stripe) from carburetor and connect a hand pump to the vacuum hose.

2. Plug nipple that vacuum hose was removed from.

3. Perform this test with the engine cold, then again when hot. Apply vacuum to vacuum hose with the engine idling.

When engine is cold
Coolant temperature 60°C (140°F) or less:

Hand vacuum pump	Normal condition	
	Engine	Vacuum
Vacuum applied	No change	Vacuum leak

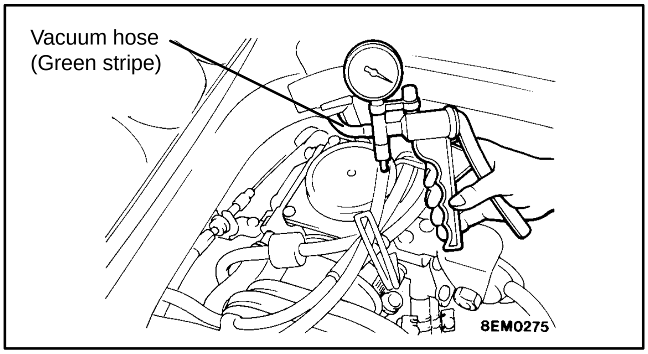


Figure 56

When engine is hot
Coolant temperature 80°C (176°F) or higher:

Hand vacuum pump	Normal condition	
	Engine	**Vacuum**
4 kPa (30 mm Hg, 1.2 in. Hg) of vacuum applied	No change	Vacuum is maintained
20 kPa (150 mm Hg, 6 in. Hg) of vacuum applied	Idling becomes slightly unstable	

EGR Valve Inspection

1. Remove EGR valve and inspect for sticking, carbon deposits, etc. Clean with a suitable solvent if necessary so valve seats correctly.

2. Connect a hand vacuum pump to EGR valve.

3. Apply 67 kPa (500 mm Hg, 20 in. Hg) of vacuum and check to make sure vacuum is maintained.

4. Apply a vacuum and check passage of air by blowing through one side of EGR passage.

Vacuum	**Passage of air**
4 kPa (30 mm Hg, 1.2 in. Hg) or less	Air is not blown out
2.0 kPa (150 mm Hg, 6 in. Hg) or more	Air is blown out

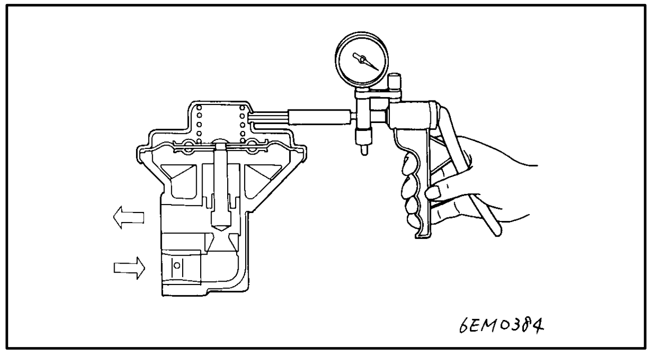


Figure 57

Installation

1. Use a new gasket and tighten to a torque of 9 Nm (0.9 kgm, 0.6 ft–lb).

Thermo Valve

1. Disconnect vacuum hose from thermo valve and connect a hand vacuum pump to thermo valve.

2. Apply a vacuum and check for passage of air through thermo valve.

Engine coolant temperature	Normal condition
40°C (104°F) or less	Vacuum leaks
80°C (176°F) or more	Vacuum is maintained

IMPORTANT: Do use a wrench on plastic part when removing or installing thermo valve. When installing, apply a dry sealant (Hermseal H1–M) to threads.

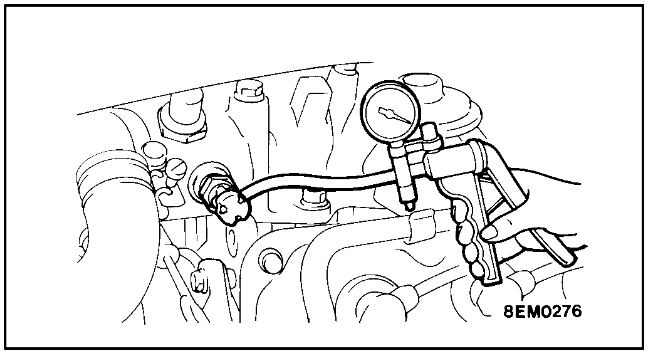


Figure 58

Liquid Cooled Gas Engine

Ignition Coil

Primary Coil

Measure resistance of (+) and (–) terminal of ignition coil.

Primary coil resistance	1.08 – 1.32 Ohm

Secondary Coil

Measure resistance between (+) terminal and high voltage terminal of ignition coil.

Secondary coil resistance	22.1 – 29.9 kohms

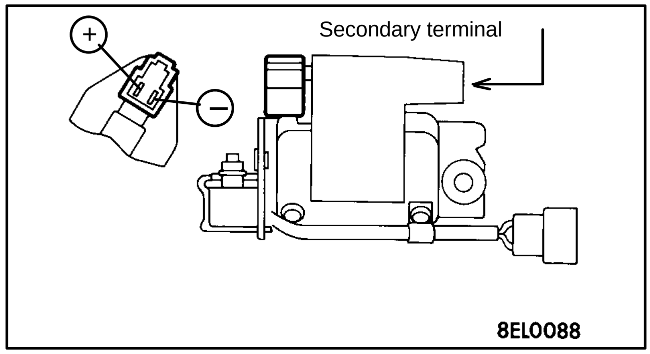


Figure 59

Starter Pinion Gap

1. Disconnect lead wire from terminal ”M” of magnetic switch.

2. Connect 12 volt battery between terminal ”50” and starter body (connect positive terminal of battery to terminal ”50”.

IMPORTANT: To prevent switch coil from overheating, never apply battery voltage for longer than 10 seconds.

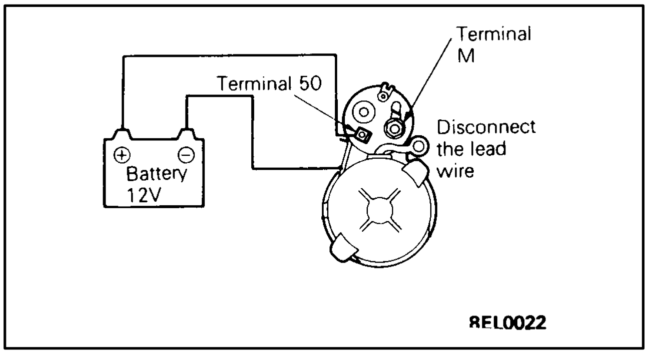


Figure 60

3. Pinion should move out and stop. Measure clearance (pinion gap) between pinion and pinion stop nut. If there is axial play, push back pinion and measure again.

Pinion gap	2.2 mm (.087 in.) or less

4. Pinion gap is not adjustable.

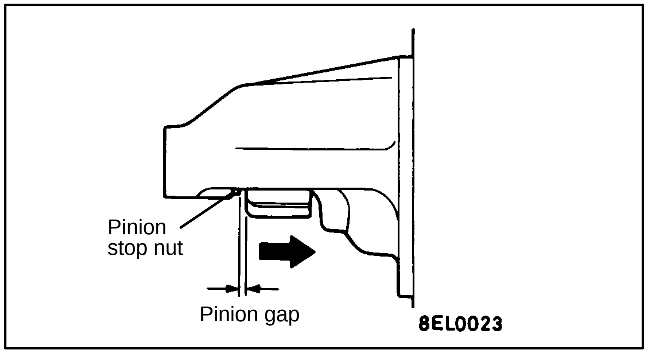


Figure 61

Liquid Cooled Gas Engine

Starter No–Load Test

1. Connect a 12 volt battery, ammeter and voltmeter to the starter as shown.

2. Starter motor should turn smooth and steady when battery is connected with a maximum resistance value. Adjust variable resistance so voltmeter indicates standard value. If current and RPM are out of specification after this adjustment, troubleshoot according to test results below.

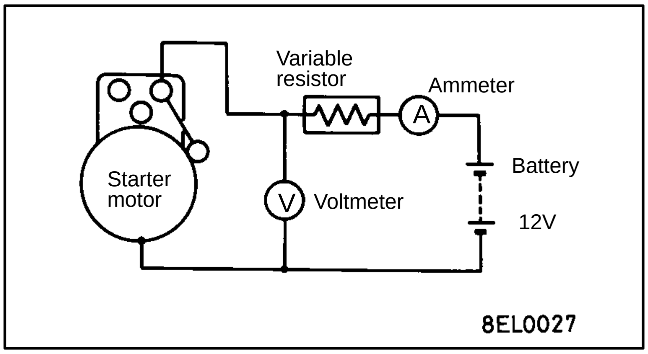


Figure 62

Standard value	
Terminal voltage	11.5 V
Current	50 A or less
Speed	6000 RPM or more

No–Load Test Results

Symptom	Possible cause
Large current with low RPM (torque also low).	Contaminated bearing. Armature coil rubbing pole piece. Armature and field coil grounding. Armature coil shorting.
Large current with no rotation.	Solenoid switch grounding. Armature and field coil grounding. Seized bearing.
No current flowing with no rotation.	Broken armature and field coils. Broken brush and pigtail. Improper contact between brush and commutator.
Small current with low RPM (torque also low).	Improper field coil connection (NOTE: Open or improperly connected shunt coil only will result in high RPM.)
Large current with high RPM (torque low).	Shorted field coil.

Magnetic Switch Pull–In Test

1. Disconnect the wire from terminal ”M”.

2. Connect a 12 volt battery to the magnetic switch terminals ”50” and ”M”. The pinion must protrude.

IMPORTANT: Lead wire must be disconnected from terminal ”M” for this test.

To prevent switch coil from overheating, never apply battery voltage for longer than 10 seconds.

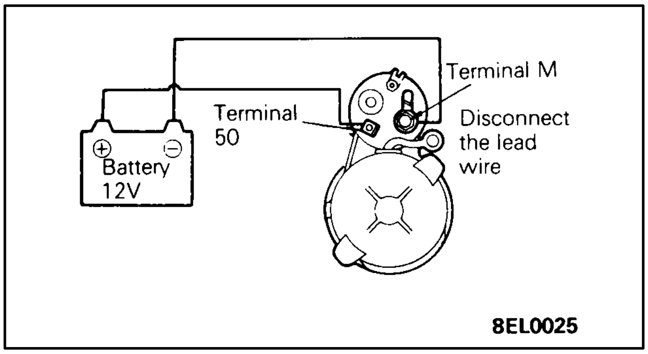


Figure 63

Magnetic Switch Hold–In Test

1. Disconnect the wire from terminal ”M”.

2. Connect a 12 volt battery to the magnetic switch terminal ”50” and the body of the magnetic switch. Pull out the pinion fully. The pinion must remain at that position even when released.

IMPORTANT: To prevent switch coil from overheating, never apply battery voltage for longer than 10 seconds.

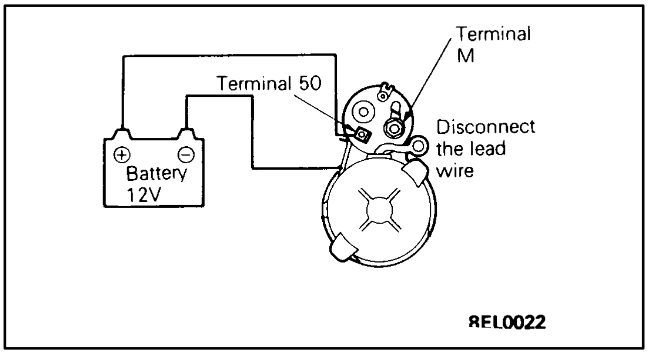


Figure 64

Magnetic Switch Return Test

1. Disconnect the wire from terminal ”M”.

2. Connect a 12 volt battery to the magnetic switch terminal ”M” and the body of the magnetic switch. Pull out the pinion fully. The pinion must return to its original position when released.

IMPORTANT: To prevent switch coil from overheating, never apply battery voltage for longer than 10 seconds.

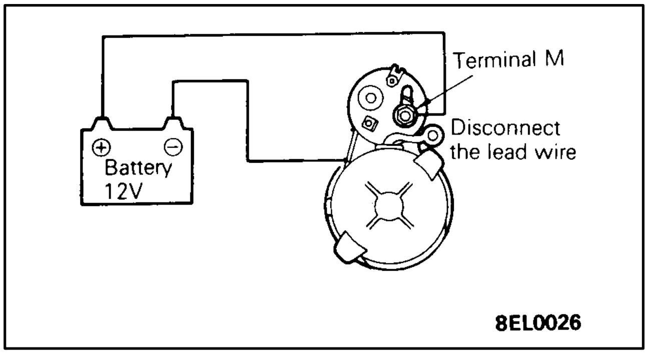


Figure 65

Liquid Cooled Gas Engine

Alternator Regulated Voltage

1. Disconnect battery ground (–) cable.

2. Install an ammeter between the positive (+) terminal of the battery and terminal ”B” of the alternator.

3. Connect a voltmeter between alternator ”L” and ground.

4. Connect the battery ground (–) cable.

5. Note that the voltmeter shows 0 volts when the ignition key switch is in the OFF position. The voltmeter will show voltage lower than battery voltage when the ignition key switch is in the ON position (engine not running).

6. Start the engine. Keep lights and other electrical loads OFF.

7. Run engine at 2500 rpm. Read voltmeter when alternator output current drops to 10 A or less. Regulated voltage will decrease slightly as alternator temperature increases.

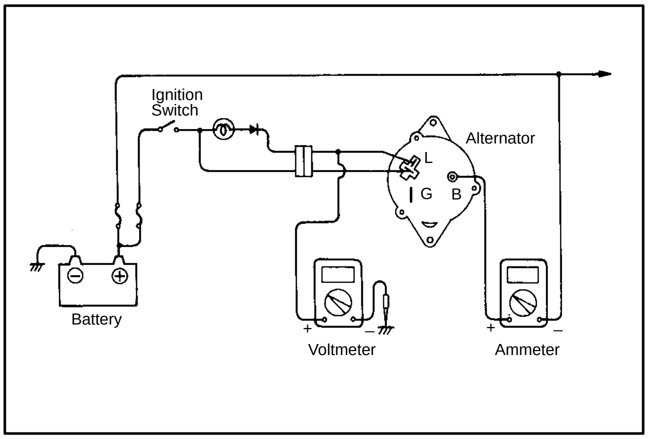


Figure 66

Voltage regulator ambient temperature °C (°F)	Regulating voltage V
–20 (–4)	14.2 – 15.2
20 (68)	14.2 – 14.8
60 (140)	13.9 – 14.8
80 (176)	13.7 – 14.8

Alternator Current Output

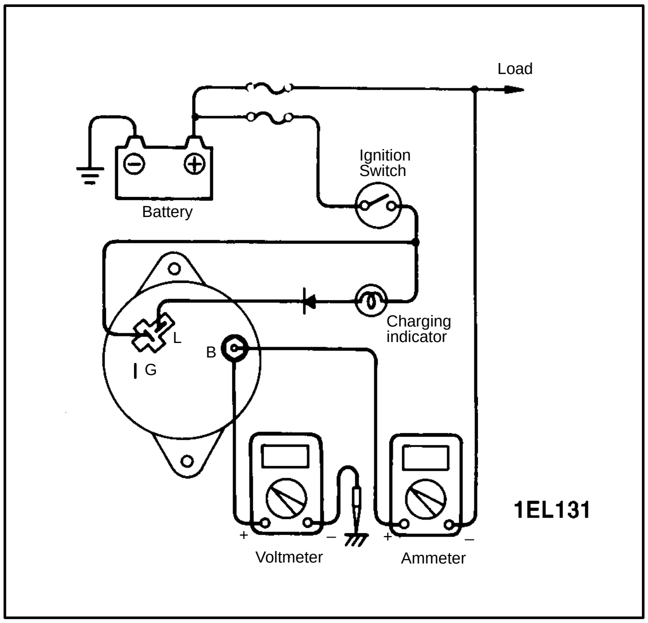


Figure 67

1. Disconnect the battery ground (–) cable.

2. Install an ammeter between the positive (+) terminal of the battery and terminal ”B” of the alternator.

3. Ground alternator terminal ”B” through a voltmeter.

4. Connect the battery ground (–) cable.

5. Check to make sure voltmeter reads battery voltage. If voltmeter reads 0 V, check for open circuit between alternator ”B” terminal and battery (–) terminal, a blow fusible link or poor grounding.

NOTE: After starting the engine, charging current drops quickly. The following step must be done quickly to read maximum current value correctly.

6. Turn on all electrical loads, start the engine, quickly run up to 2500 rpm and read maximum indication on ammeter. Reading should be higher than limit value.

Limit	28 A

NOTE: Nominal output is shown on name plate affixed to alternator body. Output current changes with electrical load and temperature of alternator. Nominal output current may not be obtained if electrical load at time of test is small. Before testing, turn on headlights while vehicle is not running to partially discharge battery.

Preparation for Engine Repair

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

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

IMPORTANT: To prevent possible damage to engine, do not spray water on a hot engine.

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

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

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

6. Be very careful when working on fuel system components. Cover the work area with clean paper.

Engine Compression

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

Cylinder and Cylinder Block Overhaul

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

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

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

2. Increased fuel consumption.

3. Increased lubricating oil consumption.

4. Poor engine starting.

5. Loud noises in the engine.

It is important to find the cause of the engine failure before beginning repair. Poor starting may be a result of electrical problems. Noises may be associated with a mechanical part outside the engine. Excess fuel or oil consumption may be the result of leaks. (See the Troubleshooting section of this chapter.)

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

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

External Engine Component Repair

Belt Replacement and Adjustment

Governor and Alternator Belt Replacement

1. Loosen idler pulley mounting nut and move pulley to remove governor belt tension.

2. If removing alternator belt, loosen the two (2) alternator mounting bolts and pivot alternator to remove belt tension.

3. Remove two (2) capscrews securing drive shaft coupler to engine crankshaft pulley, then move drive shaft out of the way so belt(s) can be removed.

4. Install new belt(s).

5. Install capscrews and washers to secure drive shaft coupler to engine crankshaft pulley.

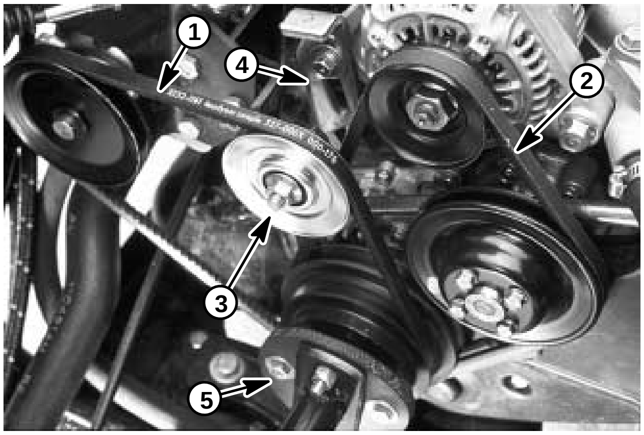


Figure 68

1. Governor belt
2. Alternator belt
3. Idler pulley
4. Alternator brace
5. Drive shaft coupler

Governor Belt Adjustment

Loosen idler pulley mounting nut, move pulley to increase tension and tighten nut. Check tension by depressing belt at mid span of governor and crankshaft pulleys with 22 lbs. (10 kg) of force. A new belt should deflect .52 – .62 in. (13 – 16 mm) A used belt should deflect .62 – .72 in. (16 – 18 mm).

Alternator Belt Adjustment

Using a pry bar, rotate alternator until proper belt tension is attained, then tighten mounting bolts. Check tension by depressing belt at mid span of crankshaft and alternator pulleys with 22 lbs. (10 kg) of force. A new belt should deflect .3 – .5 in. (8 – 13 mm) A used belt should deflect .4 – .55 in. (10 – 14 mm).

Fan Belt Replacement

1. Loosen idler pulley nut and move pulley to release belt tension.

2. Remove belt by carefully moving it around the fan blades.

3. Install a new belt.

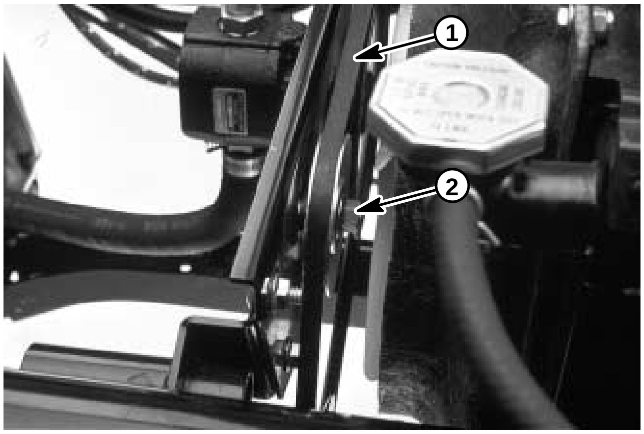


Figure 69

1. Fan belt
2. Idler pulley

Fan Belt Adjustment

Loosen idler pulley mounting nut, move pulley to increase tension and tighten nut. Check tension by depressing belt at mid span of fan and drive shaft pulleys with 22 lbs. (10 kg) of force. A new belt should deflect .48 – .58 in. (12 – 15 mm). A used belt should deflect .55 – .65 in. (14 – 17 mm).

Liquid Cooled Gas Engine

Timing Belt Replacement

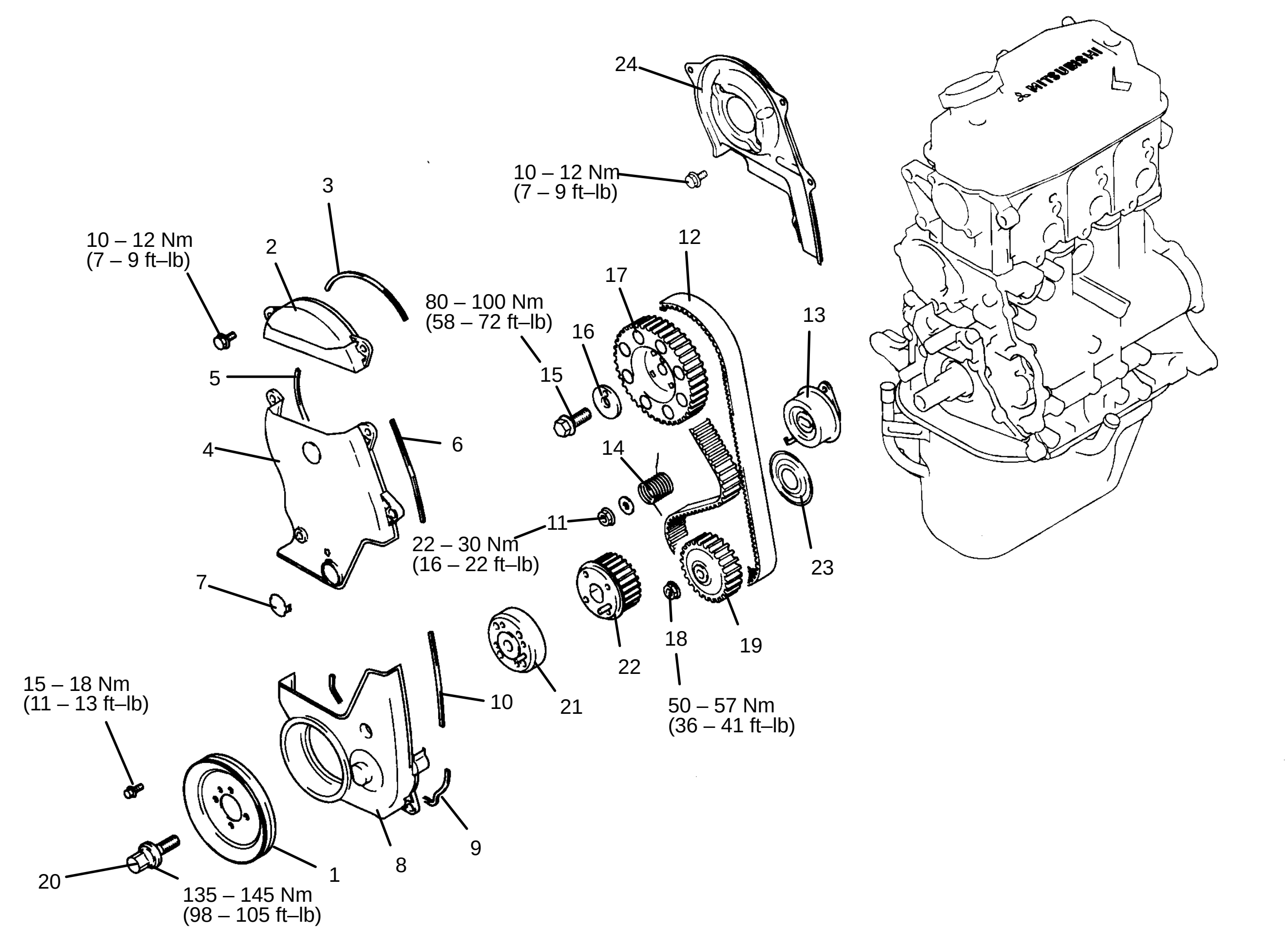


Figure 70

1. Crankshaft pulley
2. Timing belt cover A
3. Gasket
4. Timing belt cover B
5. Gasket
6. Gasket
7. Access cover
8. Timing belt cover C
9. Gasket
10. Gasket
11. Tensioner nut
12. Timing belt
13. Timing belt tensioner
14. Tensioner spring
15. Camshaft sprocket bolt
16. Camshaft sprocket washer
17. Camshaft sprocket
18. Oil pump sprocket flange nut
19. Oil pump sprocket
20. Crankshaft bolt
21. Crankshaft sprocket spacer
22. Crankshaft sprocket
23. Flange
24. Timing belt rear cover

Before removing timing belt, remove alternator/water pump belt and water pump pulley.

IMPORTANT: To prevent severely reduced belt life, be careful not to get any grease, oil or dirt on new or removed timing belt, sprocket or tensioner. Do not clean these parts. Any parts that are extremely dirty or covered with oil or grease should be replaced. If there is oil on any parts, check oil seals on front case, oil pump and camshaft.

Timing Belt Removal

1. Turn crankshaft clockwise to align timing mark on camshaft sprocket and timing belt rear cover.

IMPORTANT: Always turn crankshaft clockwise (right turn).

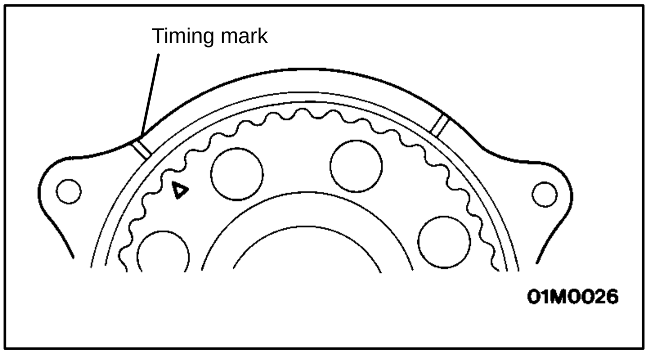


Figure 71

2. Remove plug on left side of cylinder block and insert a 8 mm (.31 in.) diameter rod to lock counterbalance shaft.

IMPORTANT: Be sure to use an inserting rod with a diameter of 8 mm (.31 in.)

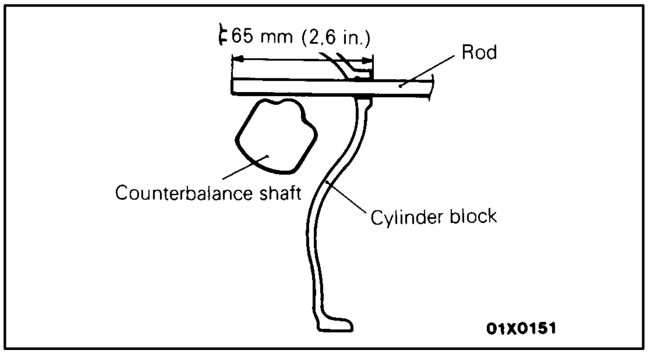


Figure 72

3. Loosen timing belt tensioner nut.

4. Move timing belt tensioner toward water pump and temporarily tighten nut to hold tensioner in position.

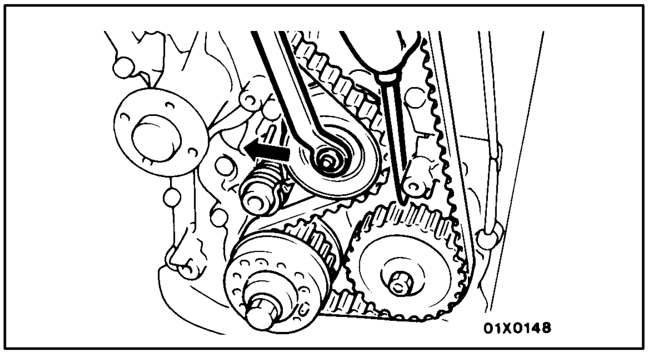


Figure 73

5. Remove timing belt.

IMPORTANT: If timing belt is to be reused, put an arrow mark on belt back to indicate direction of rotation (clockwise).

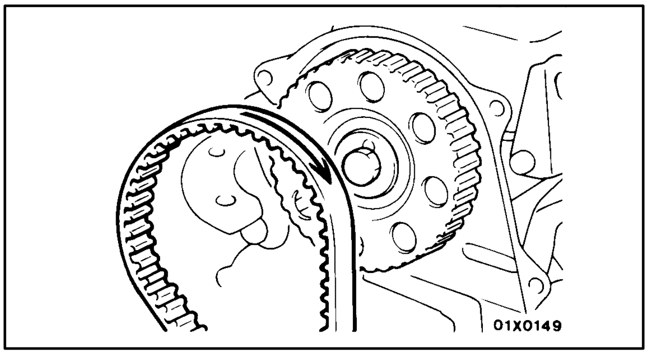


Figure 74

Liquid Cooled Gas Engine

Camshaft Sprocket Removal

1. Prevent camshaft from turning and remove camshaft sprocket bolt.

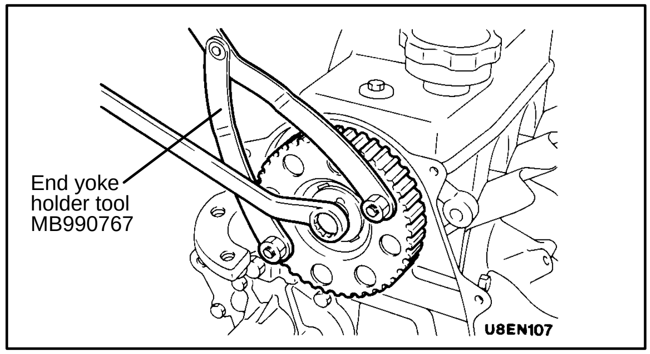


Figure 75

Oil Pump Sprocket Removal

1. Remove plug on left side of cylinder block and insert a 8 mm (.31 in.) diameter rod to lock counterbalance shaft.

2. Remove oil pump sprocket flange nut.

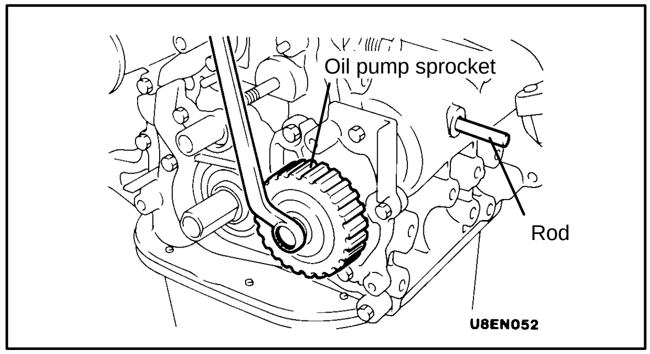


Figure 76

Crankshaft Bolt Removal

1. Use special tool to prevent flywheel from turning and remove crankshaft bolt.

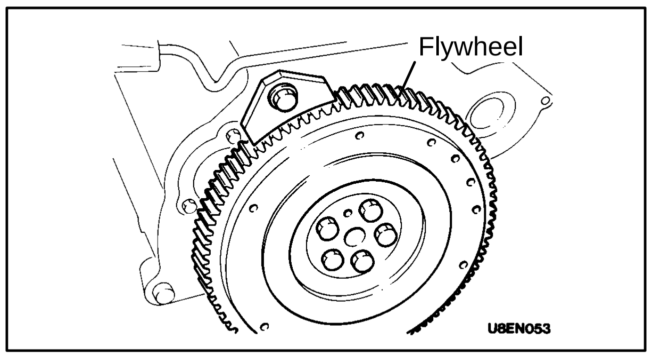


Figure 77

Timing Belt Inspection

Inspect all sections of timing belt closely. Replace the belt if any of the following conditions are found:

1. Hardening of rubber on rear surface (rear surface is glossy, no mark is left when scratched and has no elasticity).

2. Cracks in rubber on rear surface.

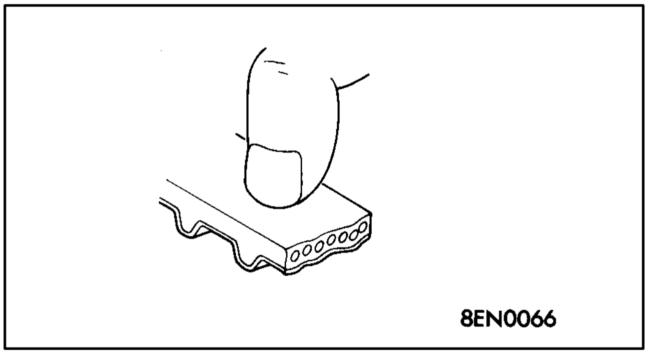


Figure 78

3. Cracked and peeling canvas.

4. Cracks at base of teeth.

5. Cracks in rear surface of belt.

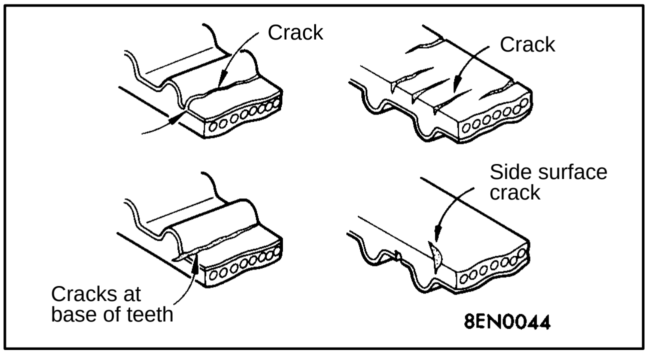


Figure 79

6. Abnormal wear on side surface of belt (NOTE: If there are any clean cuts that look like they were made with a sharp knife, these are normal).

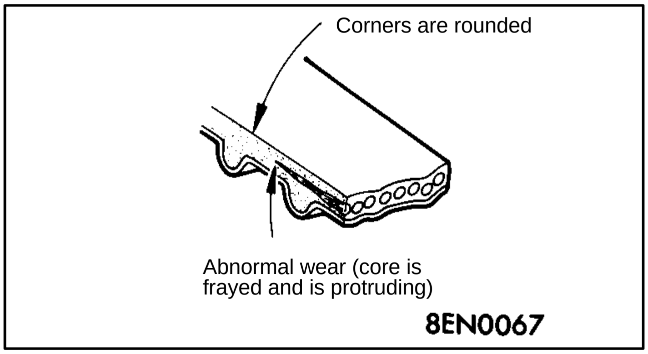


Figure 80

7. Abnormal tooth wear.

   Initial period: Worn canvas (fraying, rubber missing, whitish discoloration, indistinct canvas texture).

   Later period: Canvas worn away and rubber exposed (teeth become thin).

8. Missing teeth.

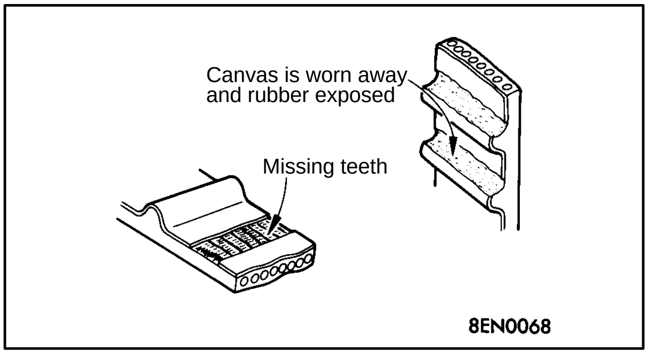


Figure 81

Belt Tensioner Inspection

Make sure pulley turns freely and does not make abnormal noises.

Flange Installation

1. Install flange as shown in the illustration before installing crankshaft sprocket.

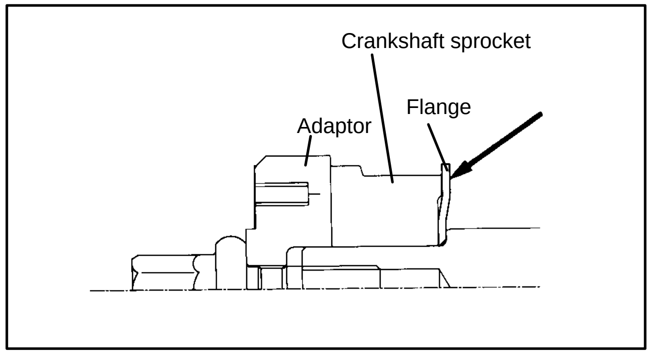


Figure 82

Crankshaft Sprocket Installation

1. Install crankshaft sprocket.

2. Install special tool to prevent flywheel from turning. Tighten the crankshaft bolt to a torque of 135 – 145 Nm (98 – 105 ft–lb).

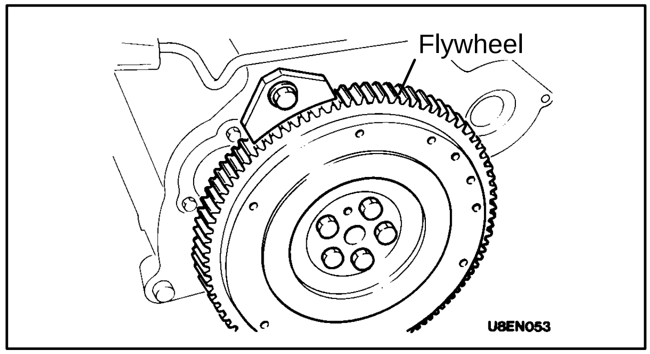


Figure 83

Oil Pump Sprocket Installation

1. Insert a 8 mm (.31 in.) diameter rod into plug hole on left side of cylinder block to prevent counterbalance shaft from turning.

2. Install oil pump sprocket.

3. Tighten nut securing oil pump sprocket to a torque of 50 – 57 Nm (36 – 41 ft–lb).

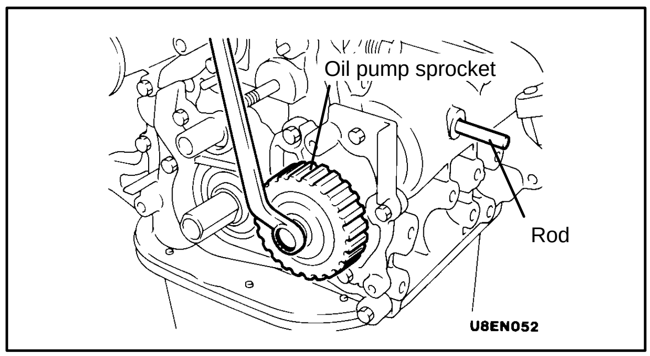


Figure 84

Camshaft Sprocket Installation

1. Install camshaft sprocket, washer and bolt.

2. Prevent camshaft from turning and tighten camshaft sprocket bolt to a torque of 80 – 100 Nm (58 – 72 ft–lb).

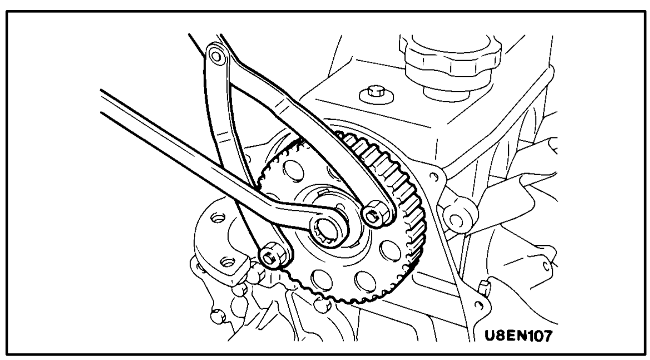


Figure 85

Timing Belt Tensioner Installation

1. Install tensioner spring and timing belt tensioner.

2. Hook tensioner spring onto bent section of timing belt tensioner bracket and onto cylinder block stopper pin.

3. Put timing belt tensioner as close as possible to water pump and tighten tensioner nut to temporarily secure in position.

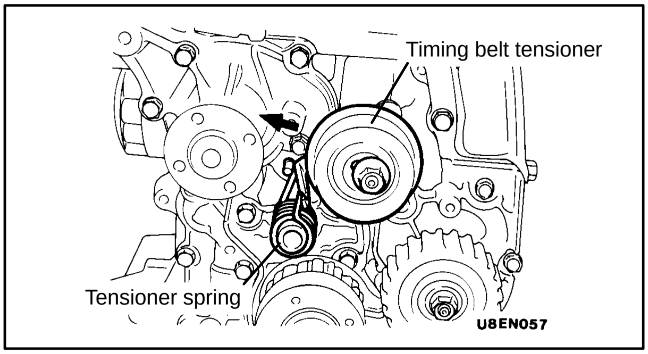


Figure 86

Timing Belt Installation

1. Align triangle mark on camshaft sprocket with mark on timing belt rear cover.

2. Align notch on crankshaft sprocket flange with mark on front case.

3. Align triangle mark on oil pump sprocket with mark on front case. Insert a 8 mm (.31 in.) diameter rod into plug hole on left side of cylinder block to a length of 65 mm (2.56 in.) or more. Check to make sure range of movement of oil pump sprocket is within specification.

Direction of rotation	Oil pump sprocket range of movement
Clockwise	4 – 5 teeth
Counterclockwise	1 – 2 teeth

4. If range of movement of oil pump sprocket is outside range of standard value:

   A. Remove rod from plug hole on left side of cylinder block.

   B. Turn oil pump sprocket one revolution to a position where rod can be re–inserted.

   C. Repeat step 3.

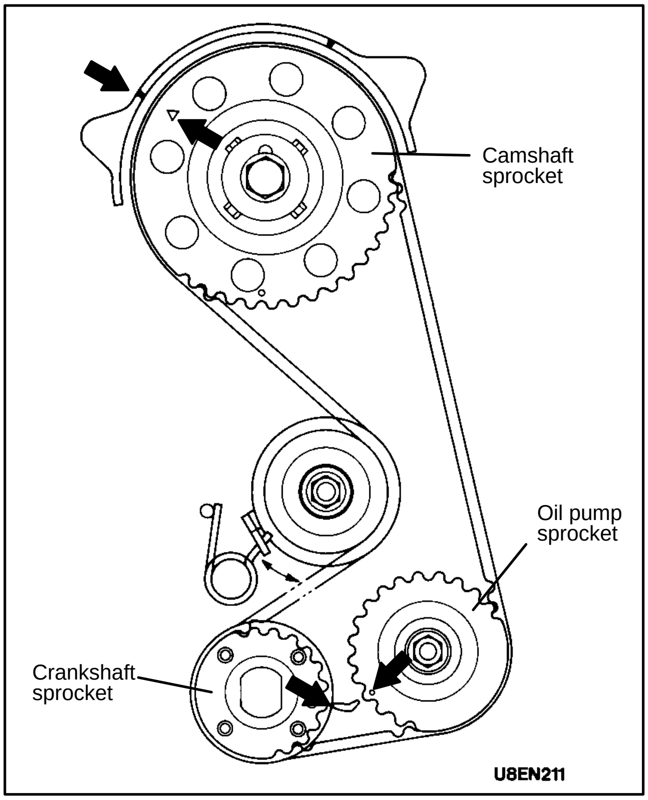


Figure 87

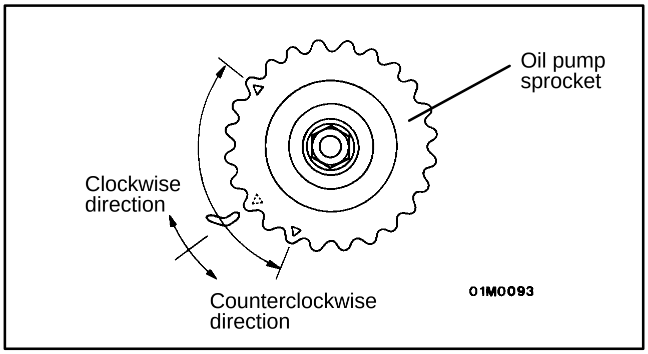


Figure 88

5. Install timing belt first onto crankshaft sprocket, then oil pump sprocket and camshaft sprocket in that order.

IMPORTANT: Install belt so there is no looseness on tension side of timing belt. The rod should not be removed until timing belt is completely installed.

6. Apply counterclockwise force to camshaft sprocket to apply tension to tension side of belt.

7. Make sure all timing marks are lined up, then loosen tensioner nut 1 to 2 turns and allow spring force to tension belt.

8. Pull rod from plug hole on left side of cylinder block. Apply 3M ATD 8660 or equivalent sealant, then install plug and tighten to a torque of 15 – 22 Nm (11 – 16 ft–lb).

IMPORTANT: The following steps give proper tension to timing belt. DO NOT turn crankshaft counterclockwise and push belt to check tension.

9. Turn crankshaft clockwise by nine (9) camshaft sprocket teeth (81°) to align timing mark on camshaft sprocket with tension set mark on timing belt rear cover.

10. Make sure timing belt teeth are engaged with camshaft sprocket teeth, then tighten tensioner nut.

11. Pull center of tension side of belt between thumb and finger as shown in illustration. Make sure clearance between belt back and inner surface of seal line is 12 mm (.47 in.).

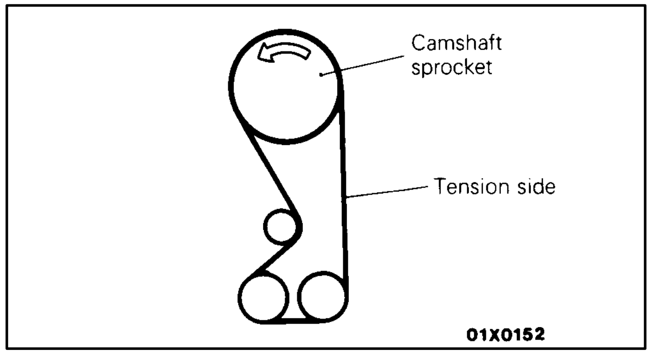


Figure 89

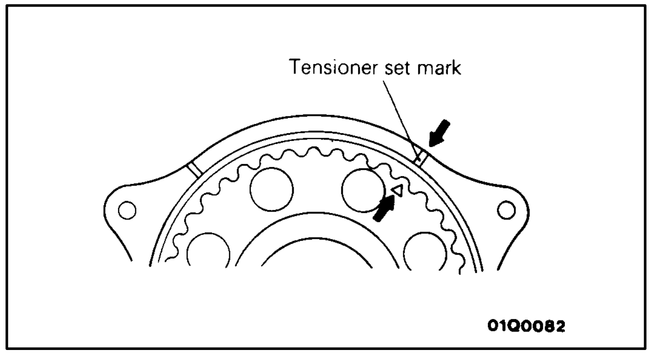


Figure 90

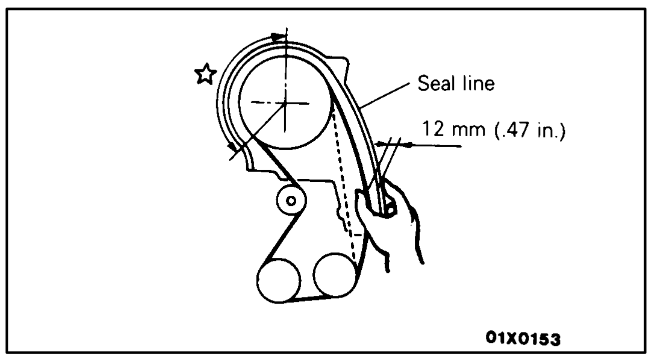
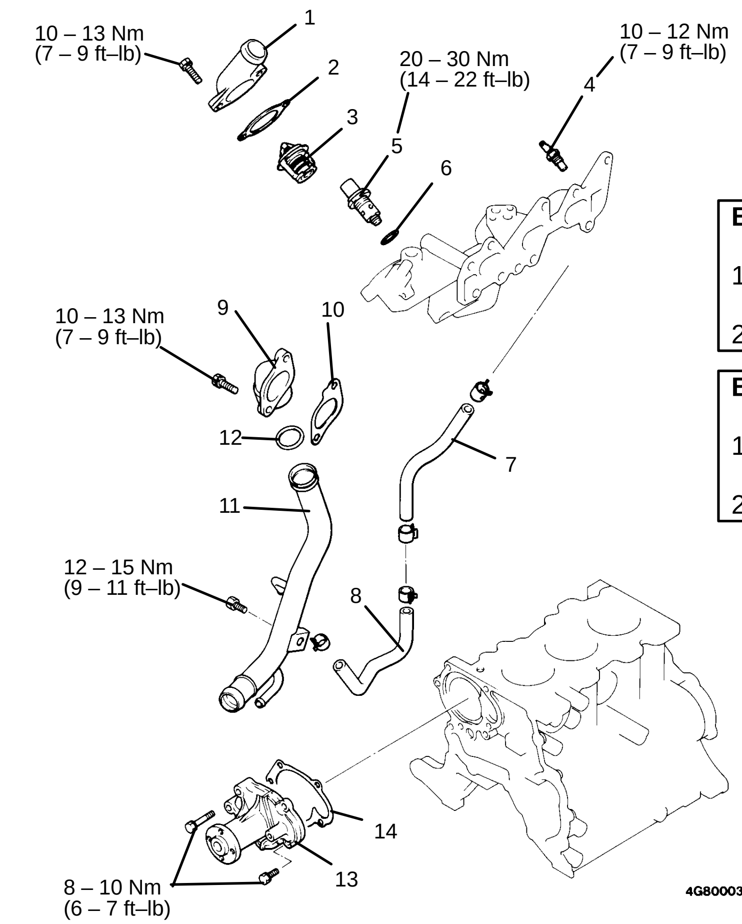


Figure 91

Water Pump, Hose, Pipe and Thermostat Removal and Installation



Before disassembling:

1. Remove timing belt.

2. Remove alternator.

Before assembling:

1. Install alternator.

2. Install timing belt.

Figure 92

1. Water outlet fitting
2. Water outlet fitting gasket
3. Thermostat
4. Coolant temp. gauge sender
5. Thermo valve
6. O–ring
7. Water hose
8. Water hose
9. Water inlet fitting
10. Water inlet fitting gasket
11. Water inlet pipe
12. O–ring
13. Water pump
14. Water pump gasket

Disassemble and assemble parts as shown in illustration above. Also use the following instructions for specific points of disassembly, inspection and reassembly.

Water Pump Inspection

1. Check parts for cracks, damage or wear and replace water pump assembly if necessary.

2. Check bearing for damage, noisy operation or sluggish rotation and replace water pump assembly if necessary.

3. Check seal for leaks and replace water pump if necessary.

4. Check for water leakage. If water leaks from hole, seal unit is faulty. Replace pump as an assembly.

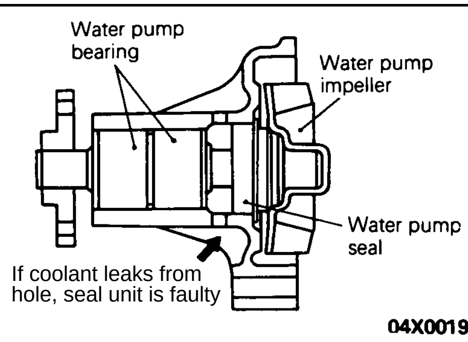


Figure 93

Water Pump Installation

Bolts used to secure water pump are different sizes. Make sure different size bolts are installed in the correct locations. Tighten bolts evenly to a torque of 8 – 10 Nm (6 – 7 ft–lb).

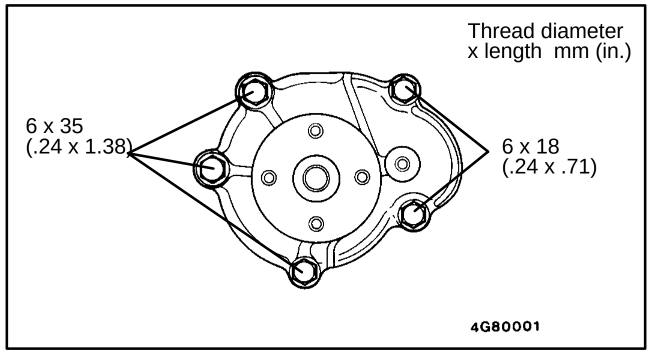


Figure 94

Water Pipe Installation

Fit water pipe O–ring in groove provided at water pipe end as shown in illustration. Wet outer diameter of O–ring with anti–freeze before inserting water pipe.

IMPORTANT: DO NOT apply oil or grease to water pipe O–ring. Keep water pipe connections free of sand, dust, dirt, etc. Insert water pipe until end bottoms.

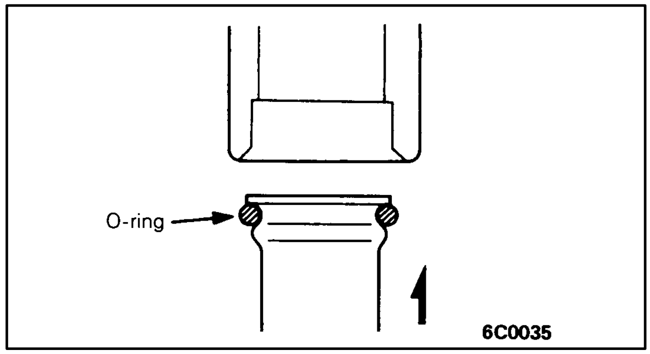


Figure 95

Governor Removal and Installation

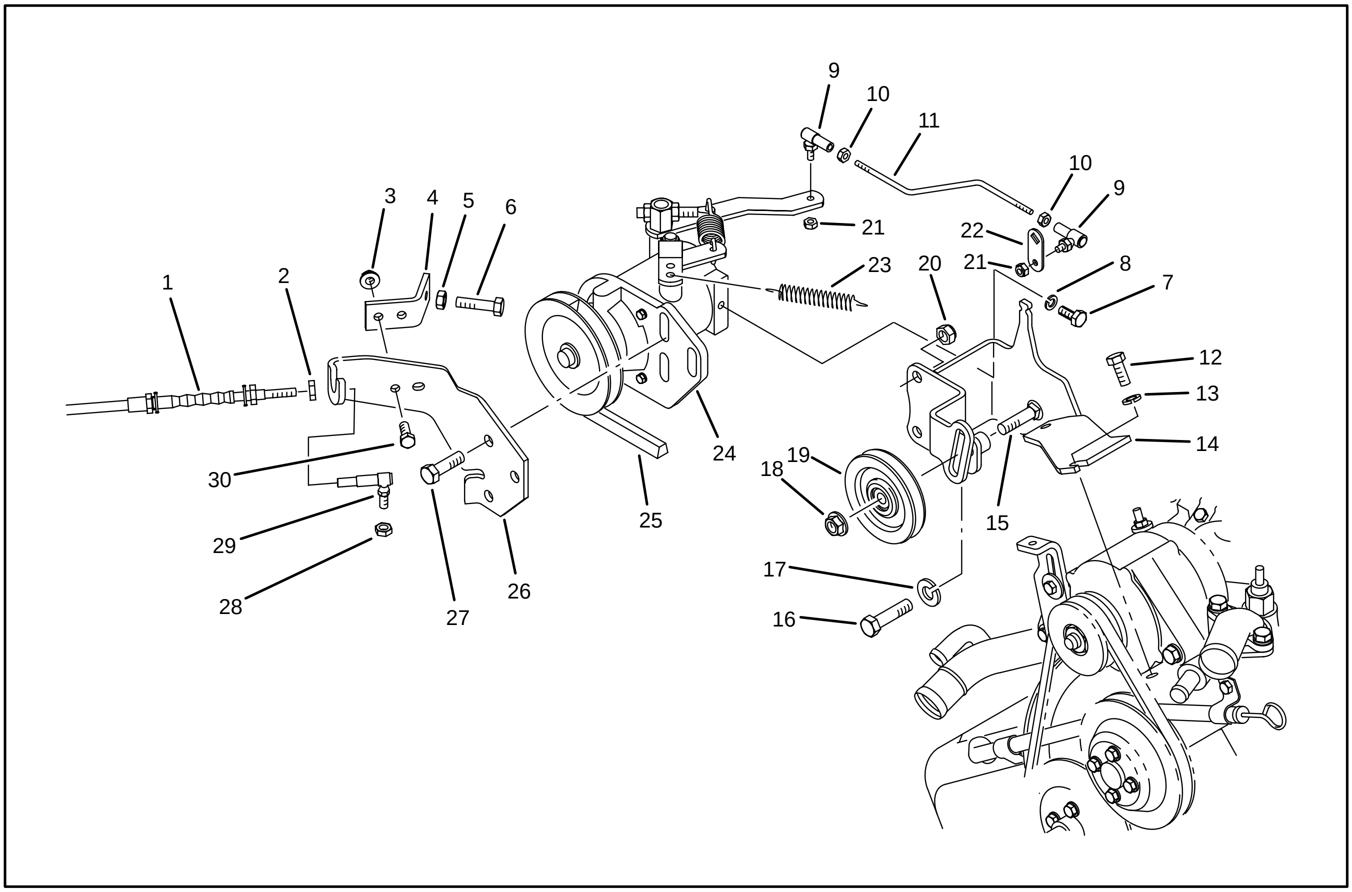


Figure 96

1. Accelerator cable	**11. Linkage rod**	**21. Locknut**
2. Jam nut	**12. Capscrew**	**22. Throttle lever**
3. Flange nut	**13. Lockwasher**	**23. Extension spring**
4. High idle stop bracket	**14. Governor bracket**	**24. Governor assembly**
5. Jam nut	**15. Carriage bolt**	**25. Belt**
6. Capscrew	**16. Capscrew**	**26. Cable bracket**
7. Capscrew	**17. Lockwasher**	**27. Capscrew**
8. Lockwasher	**18. Flange nut**	**28. Locknut**
9. Ball joint	**19. Pulley**	**29. Ball joint**
10. Jam nut	**20. Locknut**	**30. Capscrew**

Disassemble and assemble governor as shown in illustration.

After Installing Governor

1. Adjust belt tension.

2. Do governor / accelerator pedal adjustment before starting engine.

Electrical System Repairs

Spark Plug Replacement

Spark plug type	Champion RN 16Y NGK BPR 4ES

Spark plug air gap	1 mm (.040 in.)

1. Clean area around spark plugs to prevent foreign material from falling into cylinder when spark plug is removed.

2. Pull spark plug wires off spark plugs and remove plugs from cylinder head.

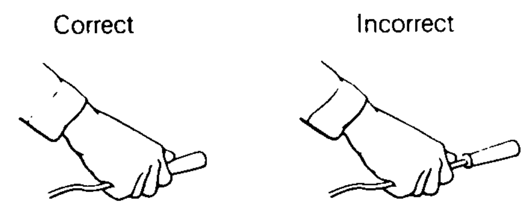
NOTE: When disconnecting spark plug wires, be sure to hold cable cap and not wire. Disconnecting spark plug wires by holding wire alone can cause damage to wire and malfunction of ignition system.

3. Check condition of side electrode, center electrode, and center electrode insulator to assure there is no damage.

IMPORTANT: A cracked, fouled, dirty or otherwise malfunctioning spark plug must be replaced. Do not sand blast, scrape, or clean electrodes by using a wire brush because grit may eventually release from the plug and fall into the cylinder. The result is usually a damaged engine.

4. Set air gap between center and side of electrodes at .040 in. (1 mm). Install correctly gapped spark plug and tighten plug to 15 – 20 ft–lb (20 – 30 Nm). If torque wrench is not used, tighten plug firmly.

5. Install spark plug wires.



Spark plug wire removal

Figure 97

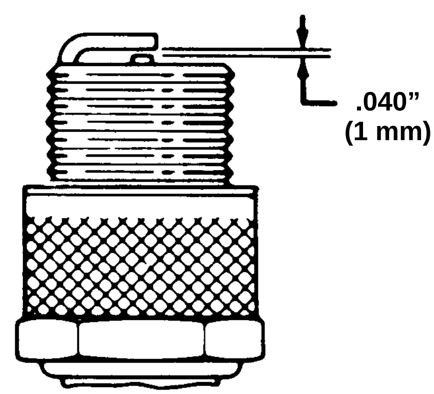


Figure 98

Alternator Removal and Installation

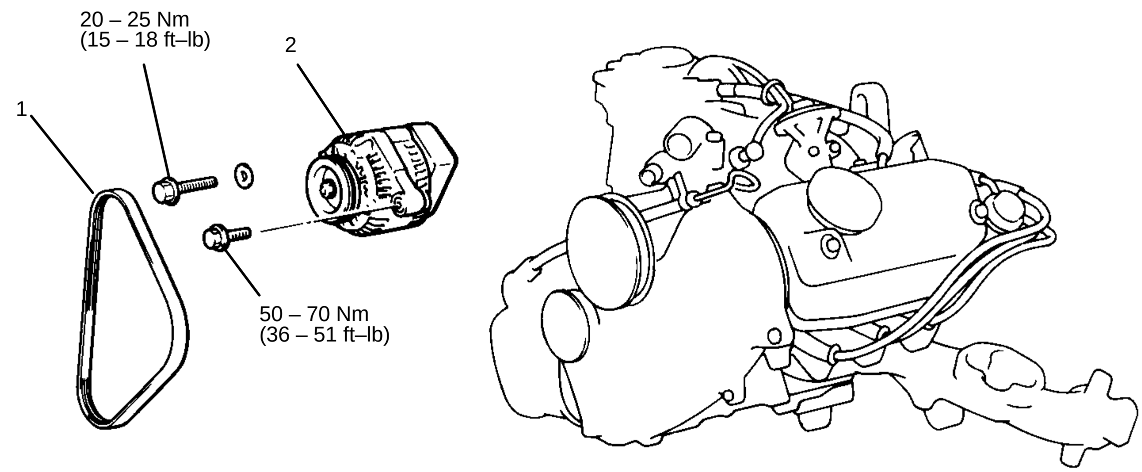


Figure 99

1. Drive belt **2. Alternator**

Remove and install alternator as shown in illustration.

Alternator Service

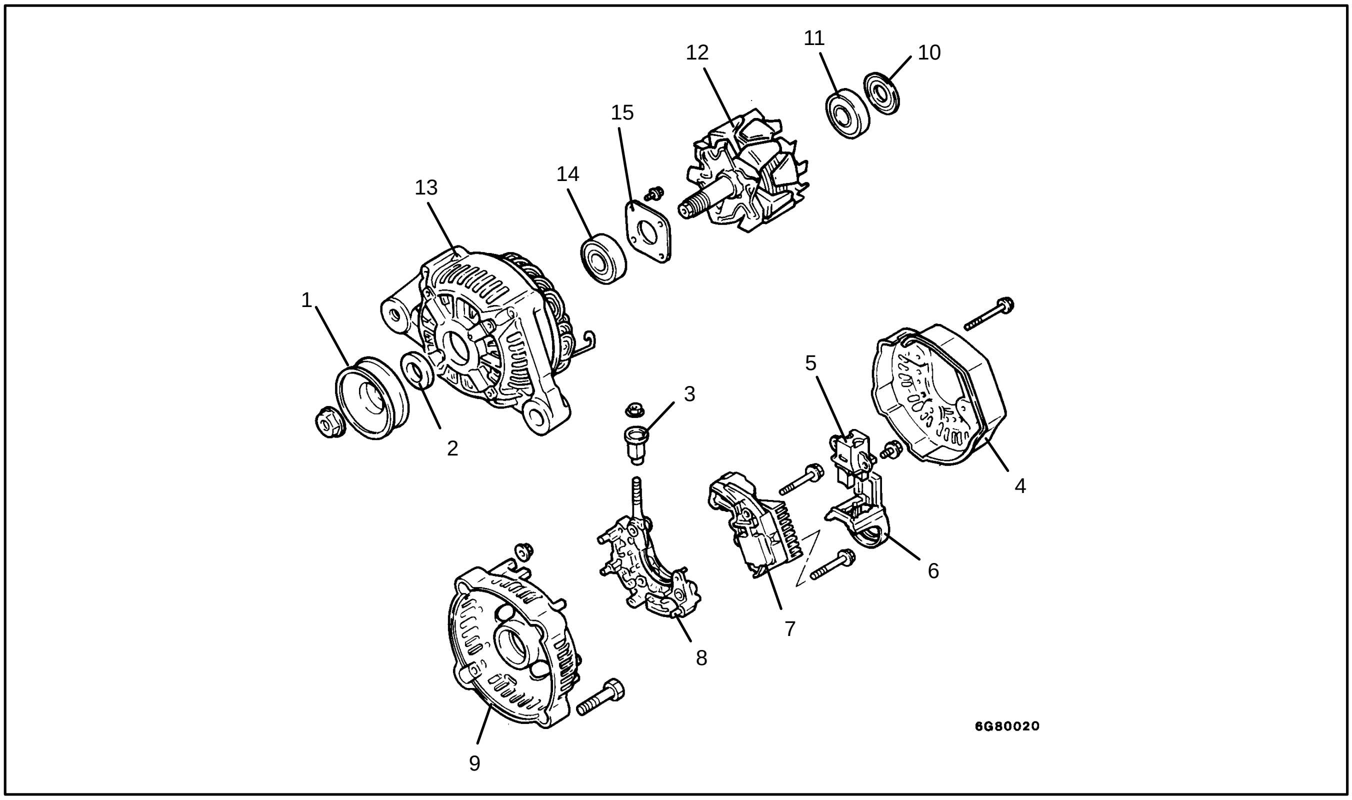


Figure 100

1. Alternator pulley	**6. Seal ring**	**11. Rear bearing**
2. Space collar	**7. IC regulator**	**12. Rotor assembly**
3. ”B” terminal	**8. Rectifier**	**13. Drive end frame and stator assembly**
4. Rear end cover	**9. Rear end frame**	**14. Front bearing**
5. Brush holder assembly	**10. Bearing cover**	**15. Retainer plate**

Disassemble and assemble parts as shown in illustration above. Also use the following instructions for specific points of disassembly, inspection and reassembly.

Alternator Disassembly

1. Extend the four (4) terminals of stator coil as shown.

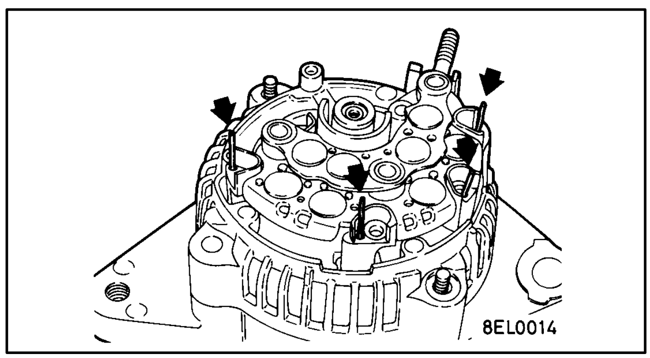


Figure 101

2. Use a puller to remove rear end frame as shown.

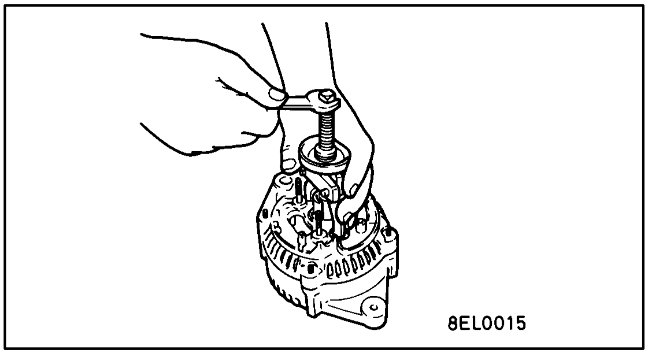


Figure 102

3. Use a puller to remove the bearing.

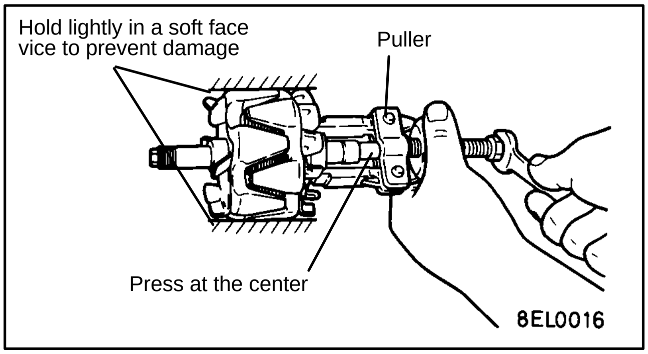


Figure 103

4. Put drive end frame on a pair of blocks as shown and use a press to remove rotor assembly.

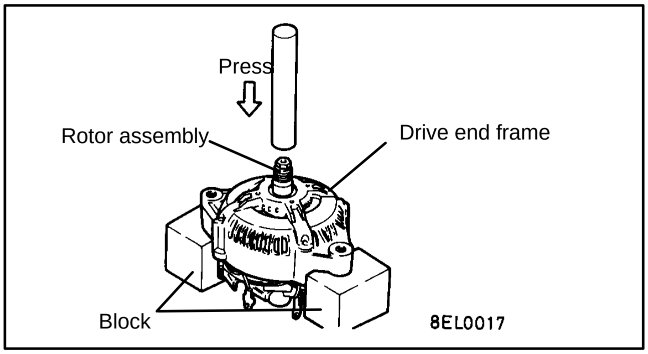


Figure 104

Liquid Cooled Gas Engine

Alternator Inspection

1. Check for continuity of rotor coil. Check for continuity between slip rings. Measure resistance of rotor. If resistance is low, it indicates a short circuit. If there is no continuity or a short circuit, replace the rotor assembly.

Resistance standard value	2.8 – 3.0 Ohms

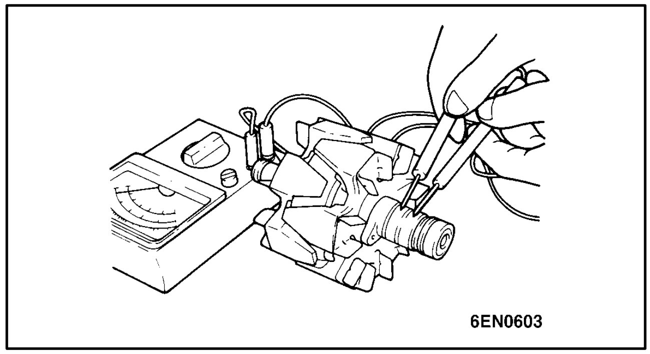


Figure 105

2. Check rotor coil for ground. Make sure there is no continuity between slip ring and core. If there is continuity, replace the rotor assembly.

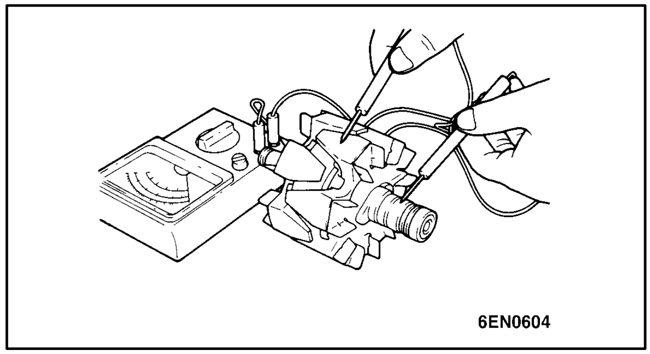


Figure 106

3. Check stator for continuity. Make sure there is continuity between coil leads. If there is no continuity, replace the stator assembly.

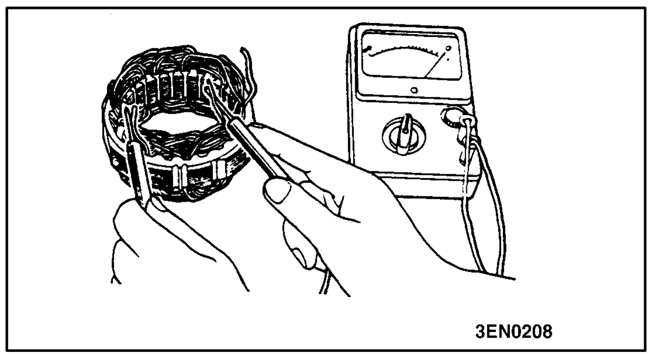


Figure 107

4. Check coil for ground. Make sure there is no continuity between the coil and core. If there is continuity, replace the stator assembly.

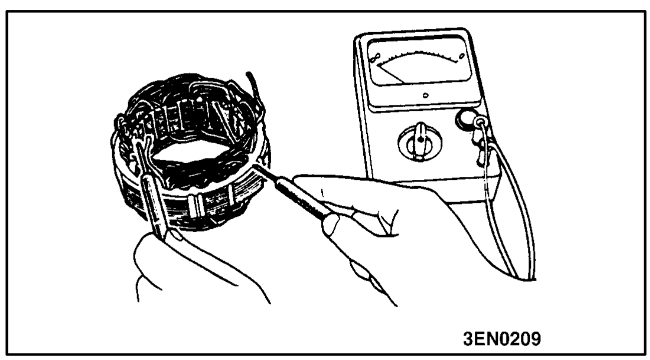


Figure 108

5. Check the rectifier for continuity. If there is continuity in only one direction of the diode, it is good.

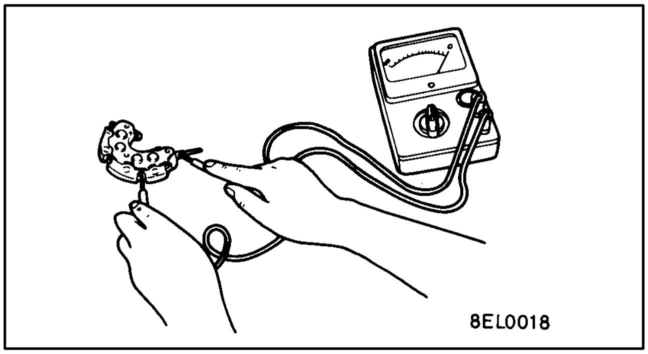


Figure 109

6. Measure the brush length from end of brush holder. If it is more than the limit value, replace the brush holder.

	Standard value	Limit
Brush length	10.5 mm (.413 in.)	4.5 mm (.177 in.)

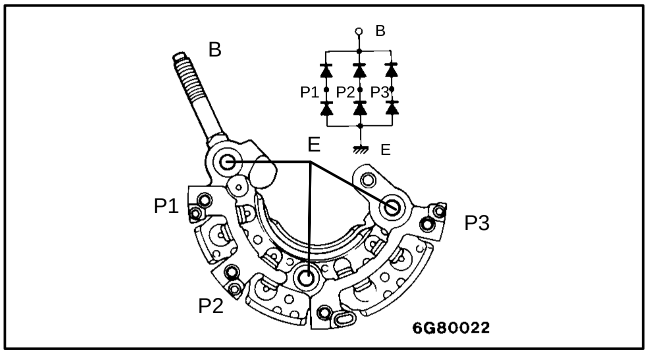


Figure 110

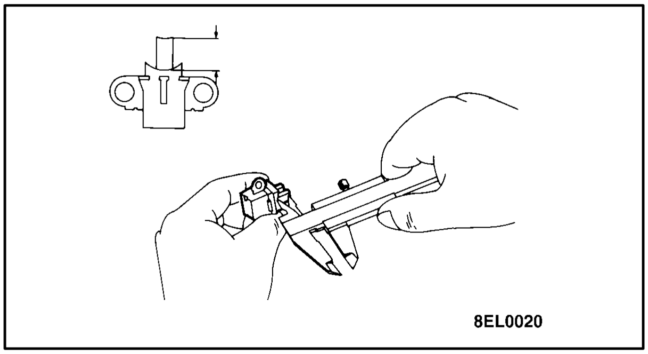


Figure 111

Reassembly of Alternator

Assembly alternator in reverse order of disassembly. To install rectifier, insert the four (4) stator coil terminals into holes of rectifier as shown, then bend terminals to fit into O.D. of bolts.

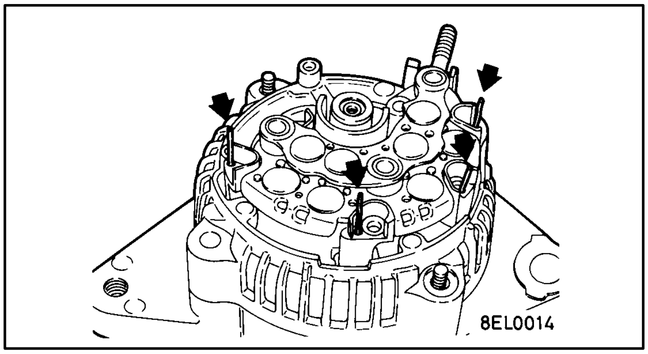


Figure 112

Liquid Cooled Gas Engine

Starter Removal and Installation

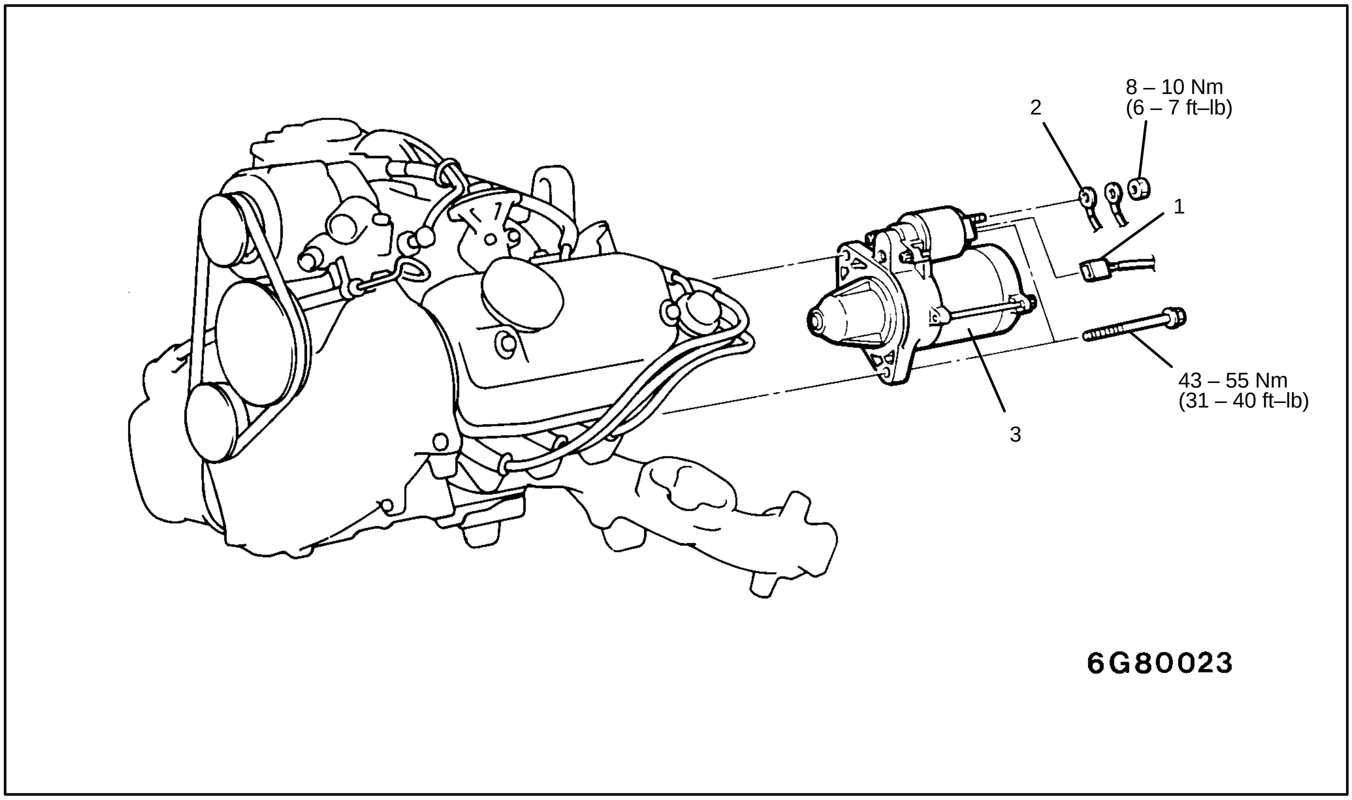


Figure 113

1. Connector **2. Battery (+) cable connection** **3. Starter motor**

Remove and install starter as shown in illustration.

Starter Service

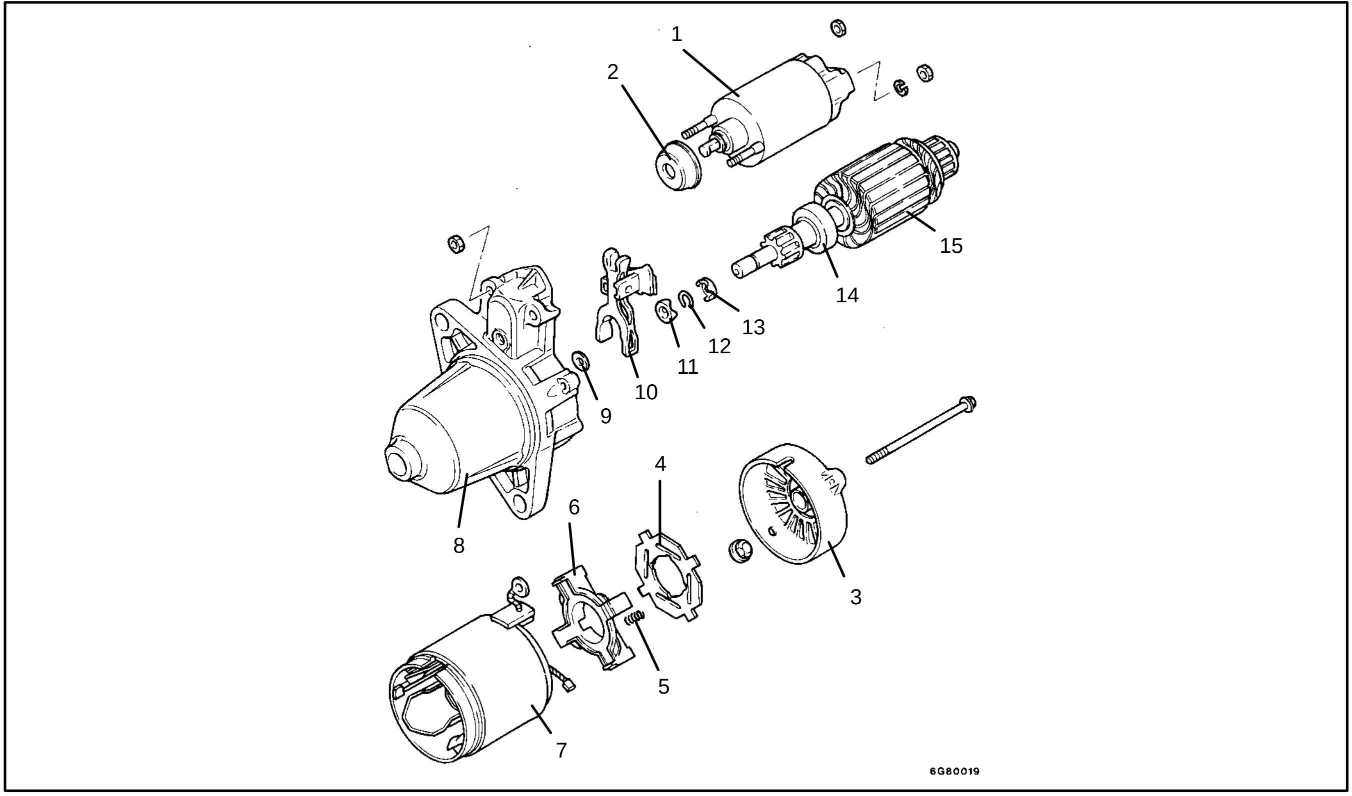


Figure 114

1. Magnetic switch	**6. Brush holder**	**11. Pinion stop nut**
2. Boot	**7. Yoke assembly**	**12. Snap ring**
3. Rear bracket assembly	**8. Front bracket assembly**	**13. Pinion stop nut**
4. Insulator	**9. Plate washer**	**14. Overrunning clutch**
5. Brush spring	**10. Drive lever**	**15. Armature**

Disassemble and assemble parts as shown in illustration above. Also use the following instructions for specific points of disassembly, inspection and reassembly.

Starter Disassembly

1. Disconnect lead wire from M terminal of magnetic switch before removing magnetic switch.

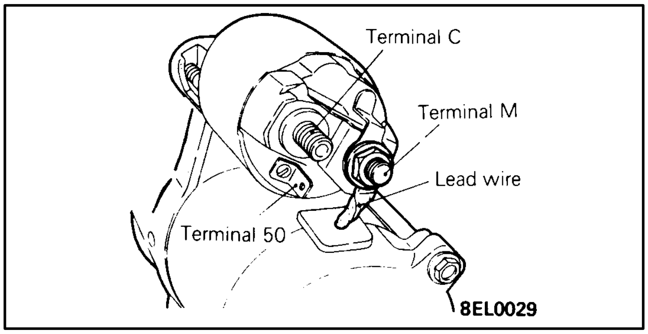


Figure 115

2. When removing brush holder, remove brush, brush spring and brush holder, in that order. NOTE: Be sure not to disconnect yoke from front bracket or the brush spring will jump out.

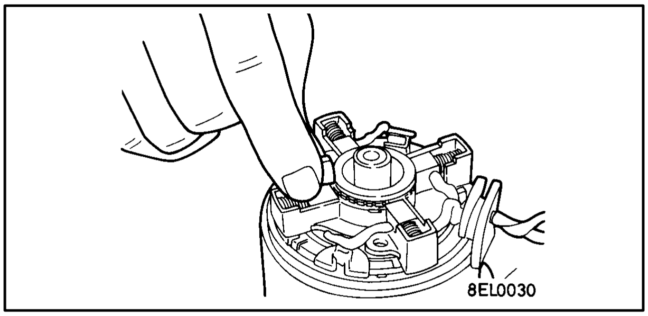


Figure 116

3. To remove overrunning clutch, expand pinion stop nut as shown and remove front side. Remove snap ring, then remove rear side of pinion stop nut and overrunning clutch.

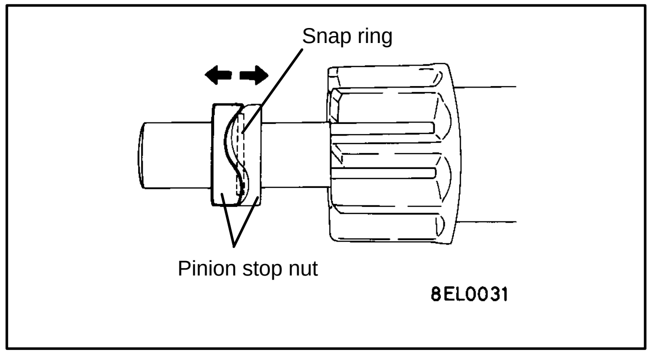


Figure 117

Starter Motor Parts Cleaning

1. Do not immerse parts in solvent for cleaning. Immersion of yoke, field coil assembly or armature in solvent causes damage to the insulation. Wipe these parts with a cloth to clean if necessary.

2. Do not immerse drive unit in cleaning solvent. The overrunning clutch has been lubricated at the factory and cleaning by a solvent removes the lubricant. Clean the drive unit using a brush wetted with a cleaning solvent, then wipe dry with a cloth.

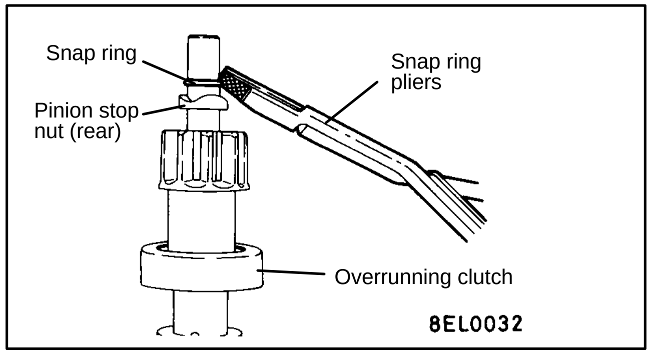


Figure 118

Starter Inspection

1. Put armature on a pair of V–blocks and check runout using a dial indicator.

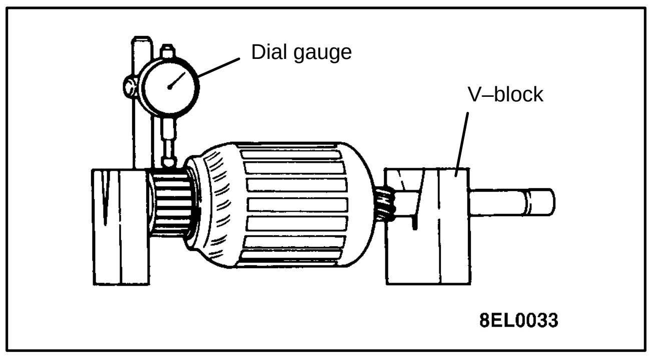


Figure 119

2. Check O.D. of commutator.

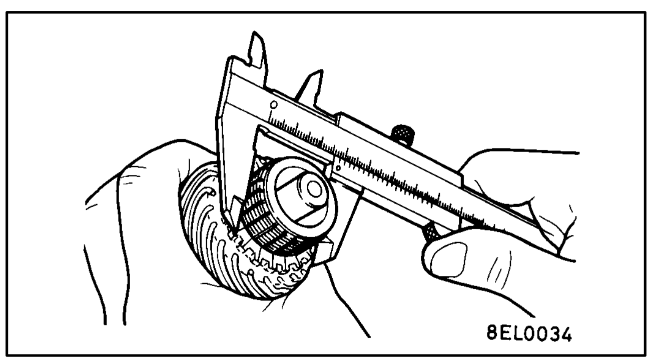


Figure 120

3. Check depth of undercuts between segments.

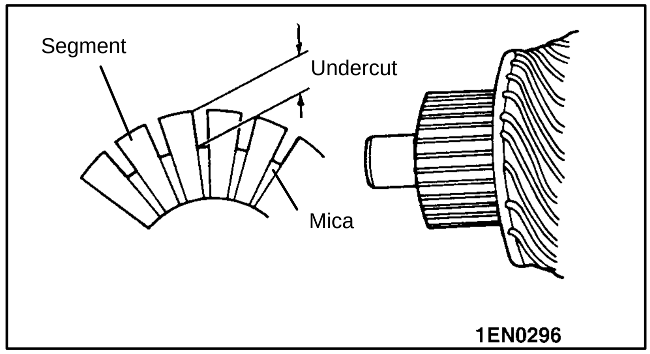


Figure 121

4. Check for continuity between brush and yoke as shown. Replace the field coil if there is no continuity.

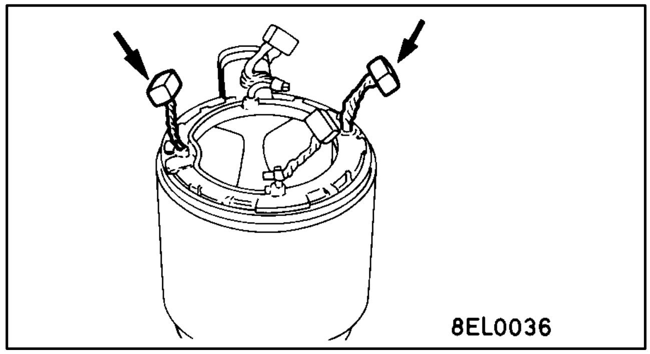


Figure 122

5. Make sure pinion on overrunning clutch locks when it is turned counterclockwise and moves smoothly when it is turned clockwise. Check pinion for wear and damage.

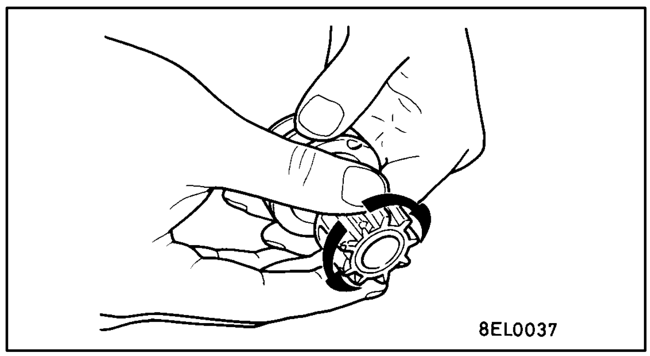


Figure 123

6. Check surface of brushes where they contact commutator. If surface is too rough, replace brush. If brush length is less than 1/3 of standard value, replace the brush.

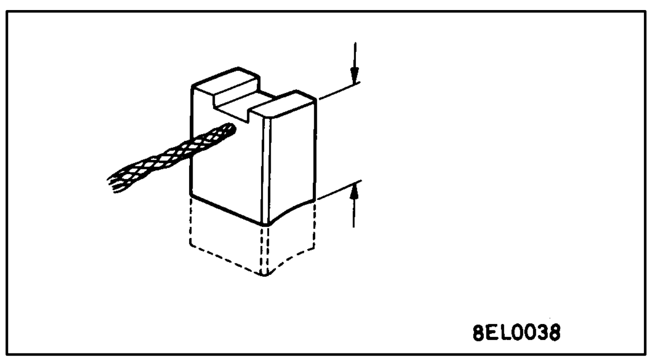


Figure 124

Liquid Cooled Gas Engine

7. Put the armature on a growler. While applying a thin iron piece in parallel with armature, turn armature slowly. Armature is okay if iron piece is not attracted or does not vibrate. NOTE: Clean armature surface thoroughly before doing growler test.

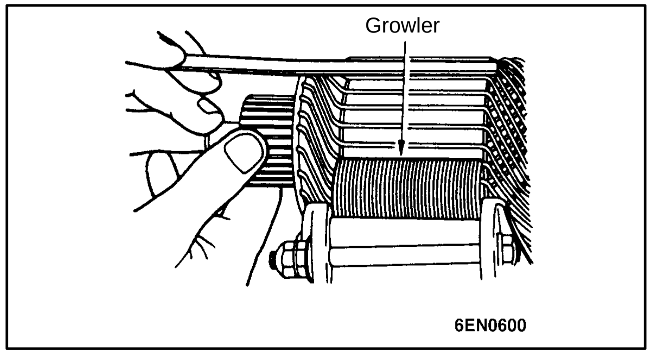


Figure 125

8. Check insulation between commutator segments and armature coil core. There should be no continuity.

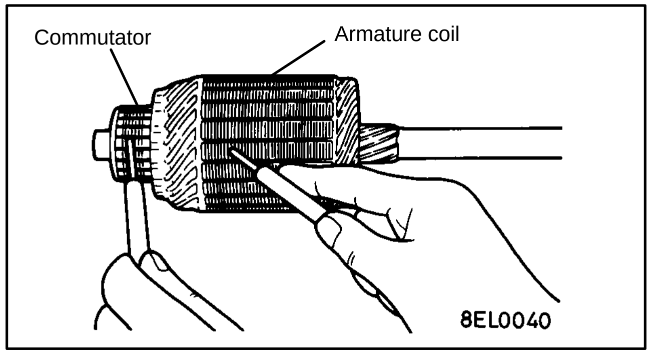


Figure 126

9. Check for continuity between commutator segments. There should be no continuity.

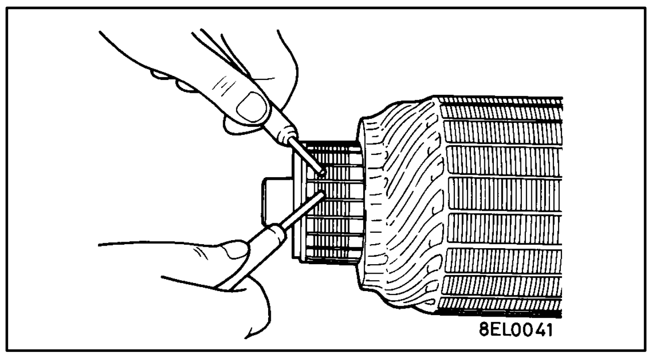


Figure 127

Starter Reassembly

Assemble starter in reverse order of disassembly. To install pinion stop nut, insert rear pinion stop nut onto shaft, then install snap ring. Install front pinion stop nut onto shaft and press manually in the direction shown to install. Make sure pinion stop nuts (front and rear) are fitted to snap ring.

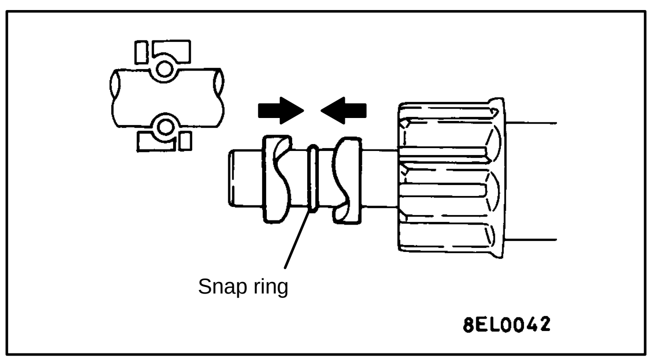


Figure 128

Distributor Removal and Installation

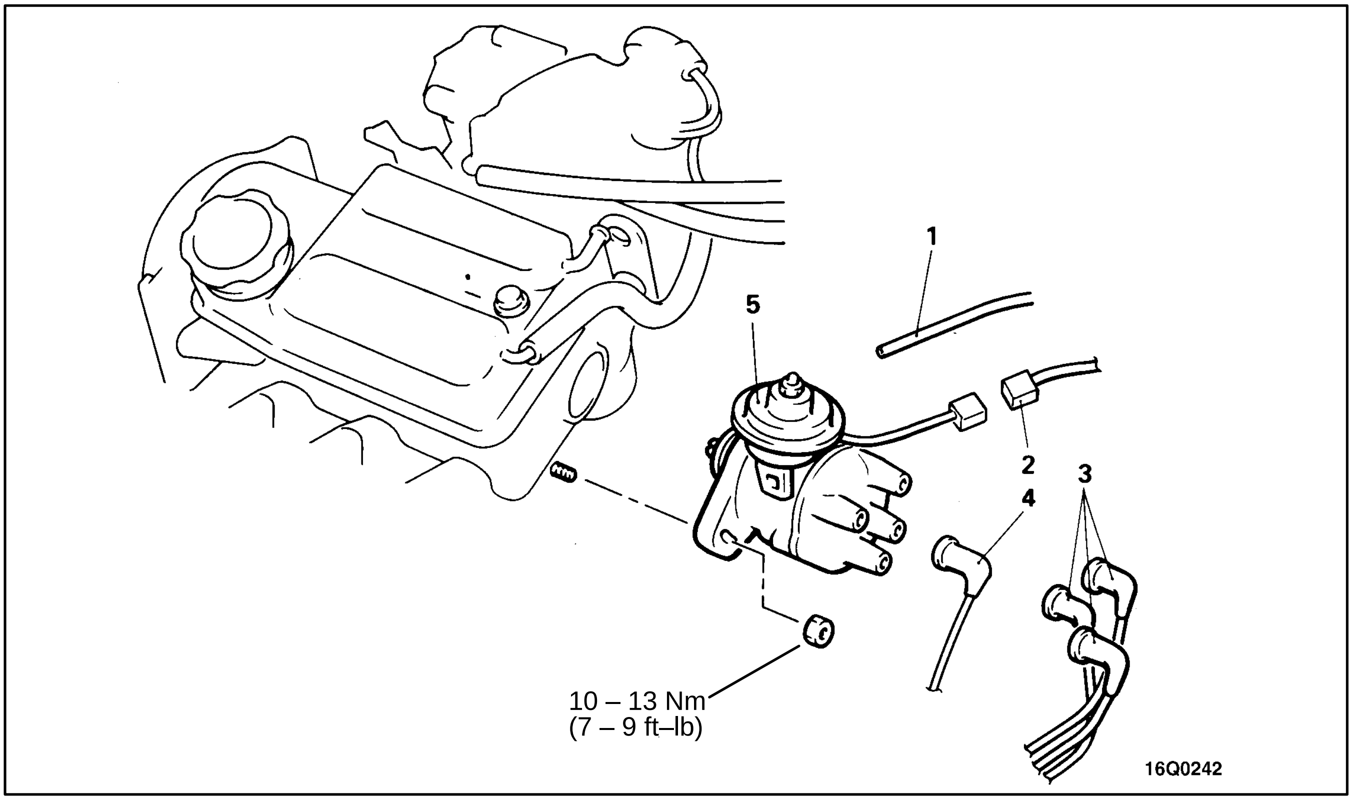


Figure 129

1. Vacuum hose connection
2. Harness connector
3. Spark plug cable connection
4. High tension cable connection
5. Distributor

Remove and install distributor as shown in illustration.

Distributor Service

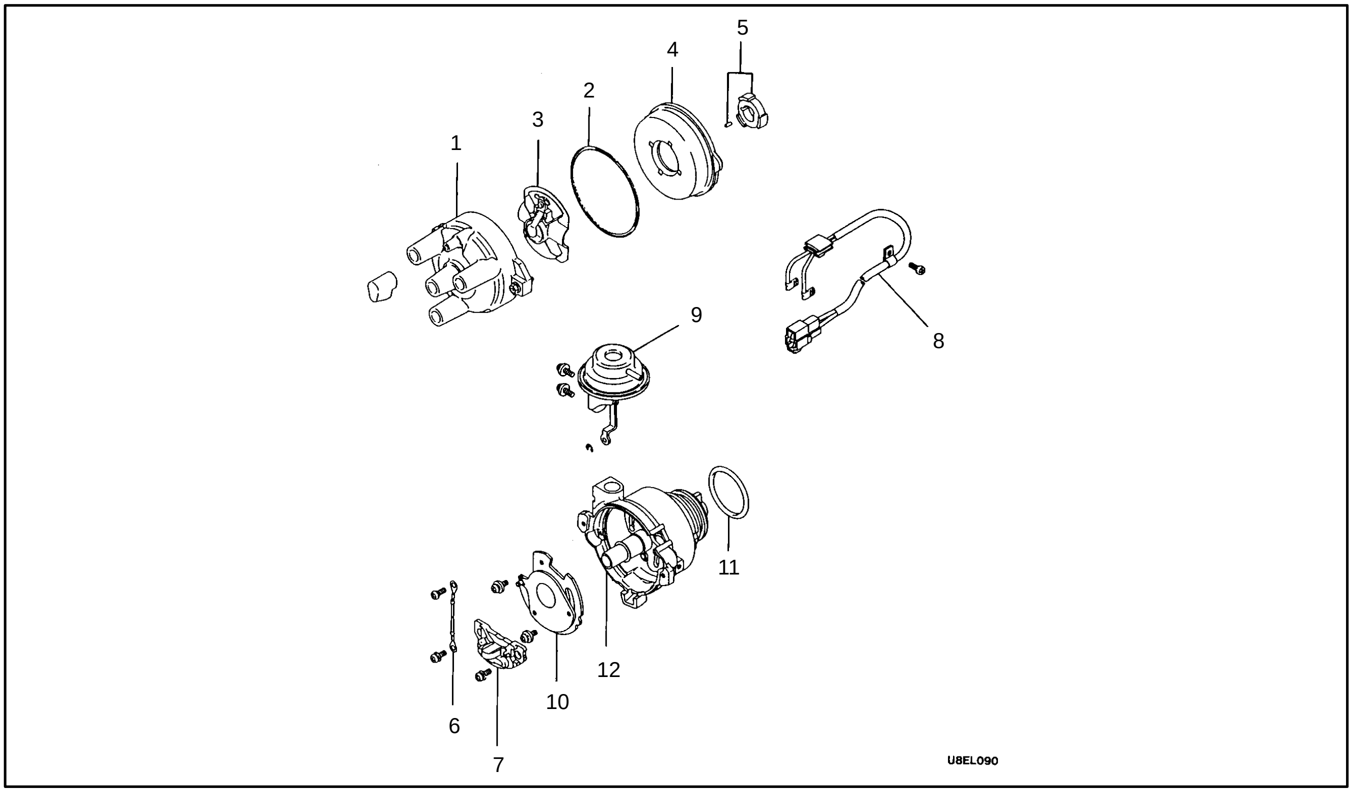


Figure 130

1. Distributor cap	**5. Signal rotor**	**9. Vacuum control**
2. Packing	**6. Lead cable**	**10. Breaker plate**
3. Rotor	**7. Pick–up assembly**	**11. O–ring**
4. Cover	**8. Lead cable**	**12. Housing assembly**

Disassemble and assemble parts as shown in illustration above. Also use the following instructions for specific points of disassembly, inspection and reassembly.

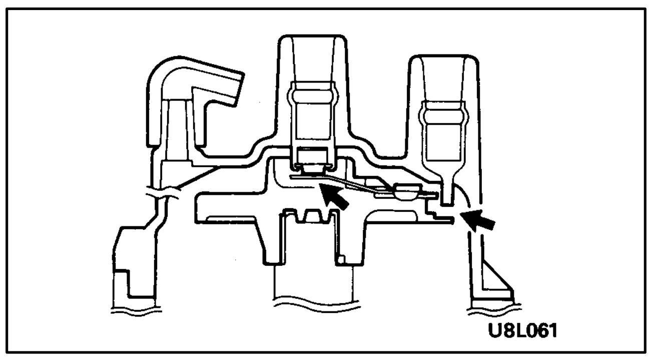


Figure 131

Distributor Inspection

1. Check cap for cracks or other damage.

2. Check rotor for cracks or other damage.

3. Check cap electrode and rotor electrode for damage.

Lubrication

Apply a small amount of engine oil to pin of vacuum control rod. NOTE: Excess oil can get on housing inside during operation and cause problems.

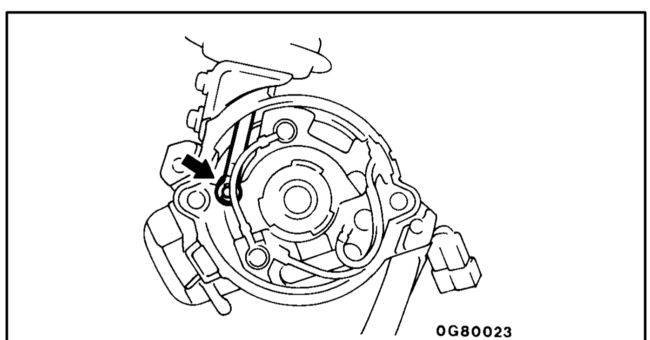


Figure 132

Distributor Installation

1. Remove timing belt cover A.

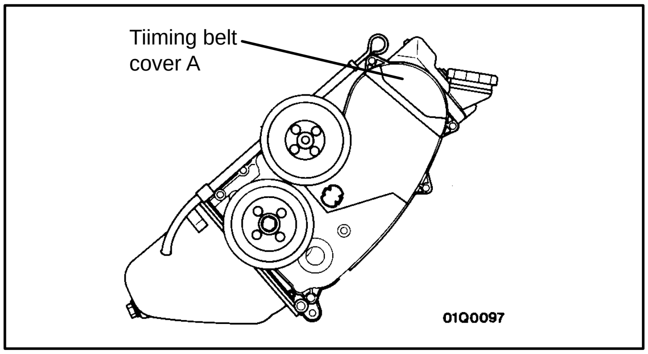


Figure 133

2. Turn crankshaft clockwise and align mating marks on camshaft sprocket and rear timing belt cover to bring No. 1 cylinder to top dead center on compression stroke.

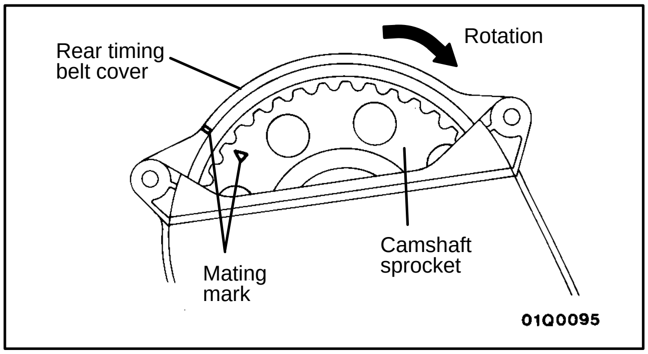


Figure 134

3. Align mating marks on distributor housing and coupling.

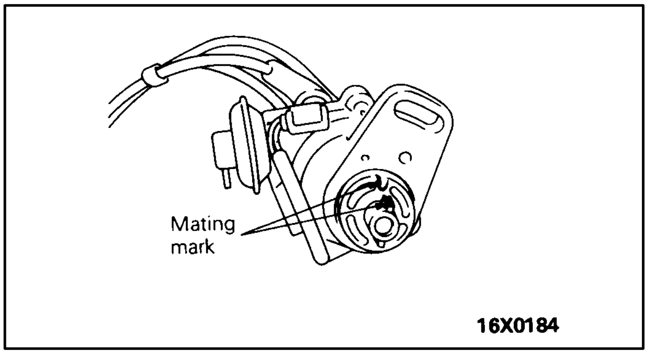


Figure 135

4. Install distributor to engine while aligning stud with elongated hole on distributor flange.

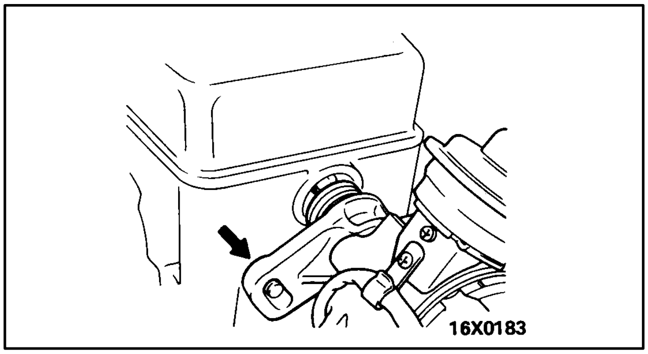


Figure 136

Liquid Cooled Gas Engine

Fuel System Repairs

Carburetor Removal and Installation

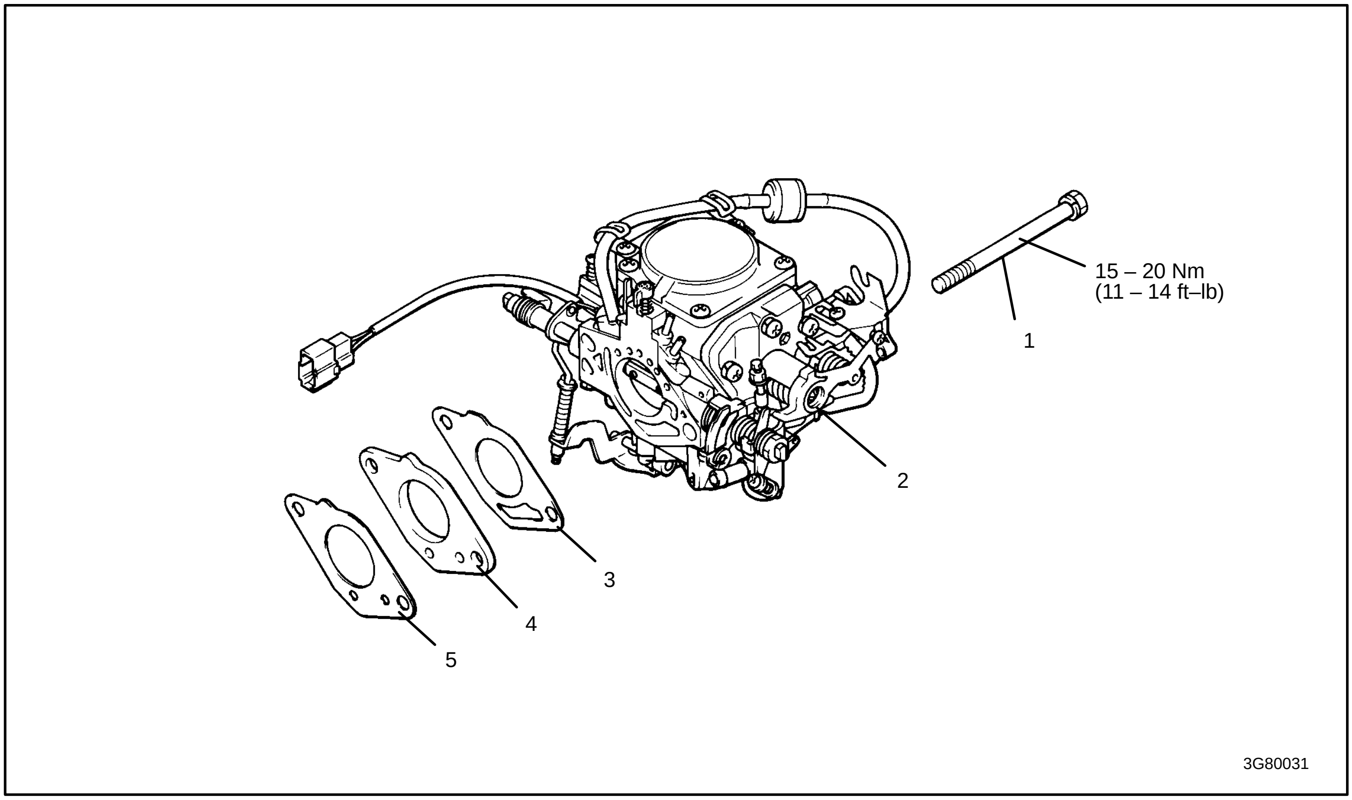


Figure 137

1. Bolt
2. Carburetor assembly
3. Gasket
4. Insulator
5. Gasket

Remove and install carburetor as shown in illustration.

Carburetor Service

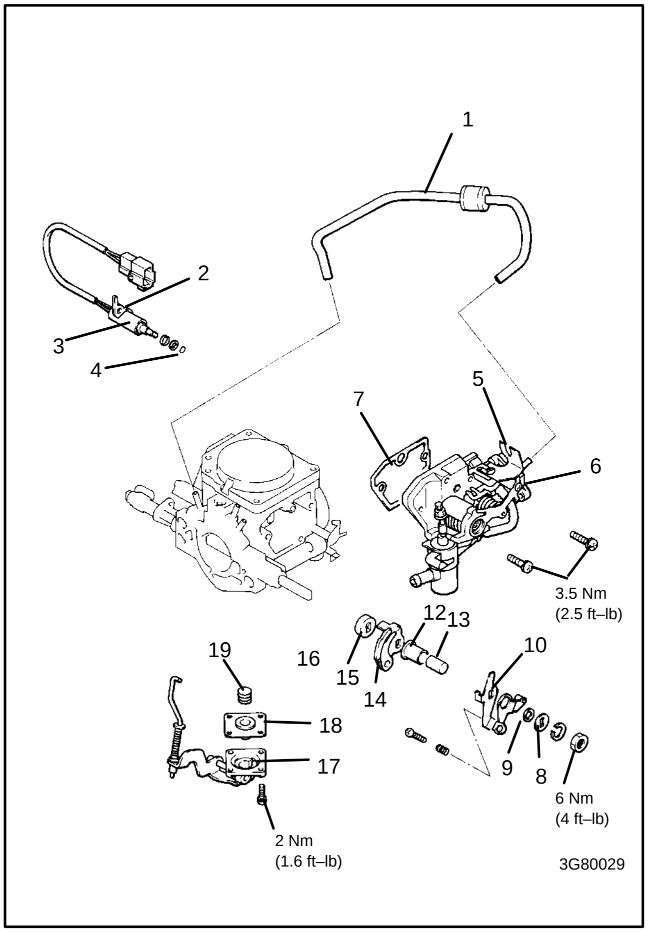


Figure 138

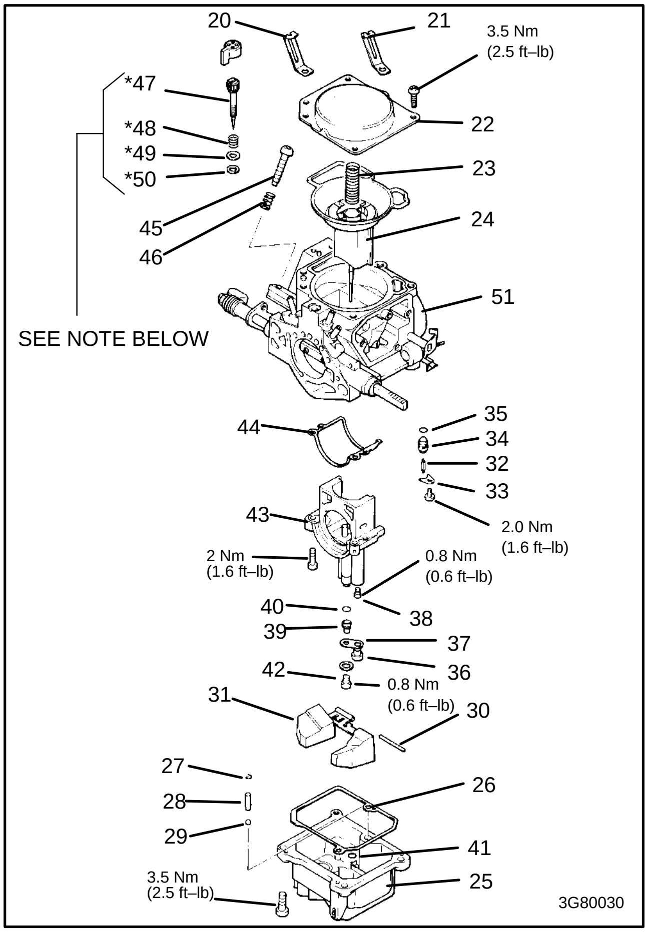


Figure 139

1. Vacuum hose kit
2. Retainer
3. Fuel cut solenoid valve (FCSV)
4. O–ring
5. Throttle wire bracket
6. Auto–choke body assembly
7. Gasket
8. Ring
9. Ring
10. Lever (cam follower)
12. Guide ring
13. Ring
14. Throttle lever
15. Guide ring
17. Pump cover
18. Diaphragm
19. Spring
20. Clip
21. Clip
22. Piston cover
23. Spring
24. Piston valve assembly
25. Float chamber body
26. O–ring
27. Retainer
28. Weight
29. Ball
30. Pin
31. Float
32. Needle valve
33. Retainer
34. Needle valve seat
35. O–ring
36. Plug
37. Plate
38. Pilot jet
39. Main jet
40. O–ring
41. O–ring
42. Power jet
43. Jet block
44. O–ring
45. Idle speed adjusting screw (SAS)
46. Spring
***47. Mixture adjusting screw (MAS) (see Note)**
***48. Spring (see Note)**
***49. Washer (see Note)**
***50. Gasket (see Note)**
51. Mixing body

Disassemble and assemble parts as shown in illustration above. Also use the following instructions for specific points of disassembly, inspection and reassembly.

Note: All carburetors with a TEB identification mark have a tamper–resistant idle Mixture Adjusting Screw (MAS). These parts **cannot** be replaced: this would be in violation of U.S. Environmental Protection Agency (EPA) and California Air Resources Board (CARB) regulations. If these parts need replacement, the entire carburetor must be replaced.

Carburetor Disassembly

IMPORTANT: Do not disassemble the following items:

– Auto–choke body assembly (Item 6).
– Throttle valve and throttle shaft.
– Piston valve assembly (Item 24).
– Vapor separator tank plate.

1. After removing retainer (Item 2), remove FCSV from mixing body by pulling out with a pliers as shown. DO NOT pull on lead wire of FCSV. Be careful not to loose the O–ring (Item 4).

2. After removing float chamber body, remove retainer (Item 27), weight (Item 28) and ball (Item 29). These parts are very small. Be careful not to lose them.

3. Use a pliers to remove needle valve seat (Item 34) as shown.

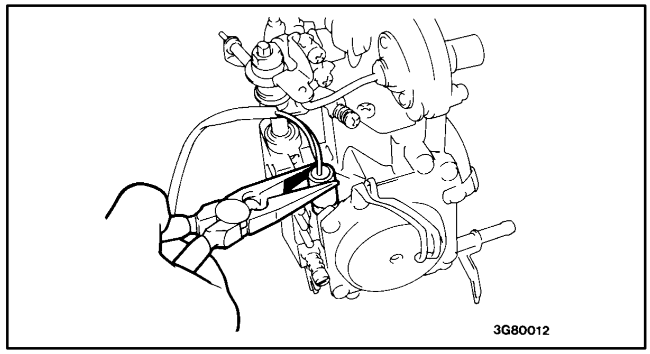


Figure 140

4. To remove pilot jet (Item 38), use a screwdriver that has an exact fit to groove in pilot jet. Be careful not to scratch the pilot jet.

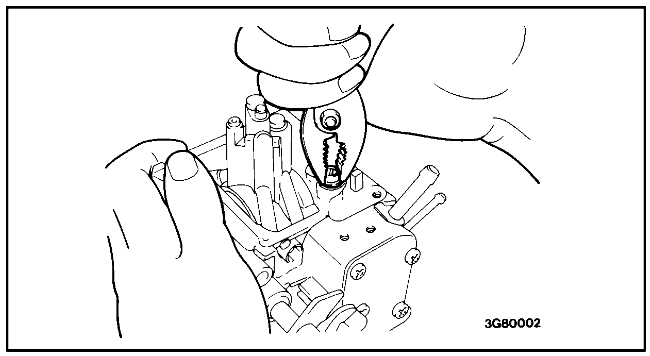


Figure 141

Carburetor Inspection

Check the following items and repair or replace parts as necessary.

1. Check fuel passages (jets) and air passages (jets or orifices) for clogging. If clogged, wash thoroughly with cleaning solvent or detergent and remove dirt with compressed air. Do not use wire or anything else that will scratch these parts.

2. Check diaphragms for damage and cracks.

3. Make sure needle valve operates with light force. Repair or replace valve if is is hard to operate or is binding. If there is fuel overflow, poor valve to seat contact should be suspected.

4. Check fuel inlet filter (located above needle valve) for clogging or damage.

5. Check float operation. Check float and lever for deformation and damage.

6. Check operation of throttle valve, choke valve and linkage. If they do not operate with light force, wash well and apply engine oil sparingly to the shaft(s).

7. Check float chamber body and mixing body for damage and cracks.

8. Check fuel cut solenoid valve (FCSV). The FCSV should operate with a click when battery voltage is applied.

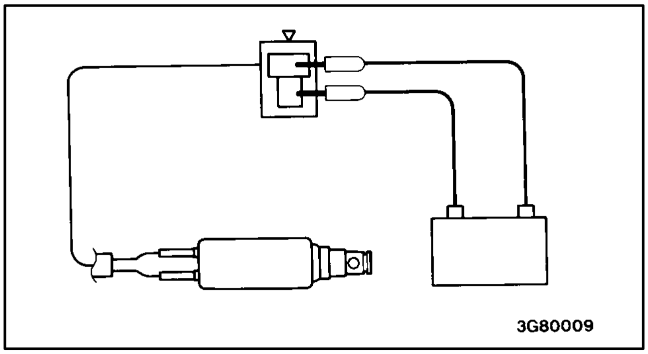


Figure 142

9. Use an ohmmeter to make sure there is no continuity between FCSV body and terminal.

10. Measure resistance between terminals.

Resistance standard value	48 – 60 Ohms at 20°C (68°F)

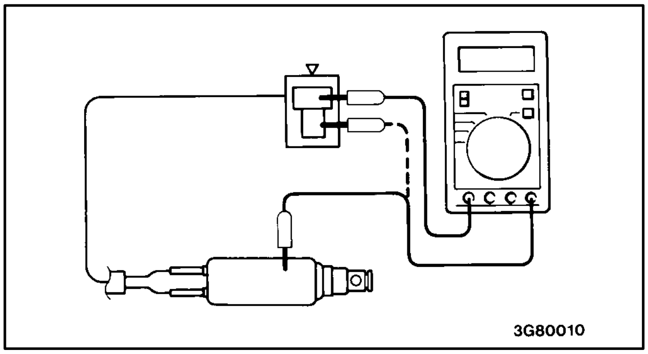


Figure 143

11. On carburetors with an identification mark of **TMB** only, check tapered end of mixture adjusting screw (MAS) for damage from overtightening or other causes.

Carburetor Reassembly

1. Make sure correct jets are installed at correct locations. Note size symbol stamped on each jet for identification and identification Mark on the carburetor.

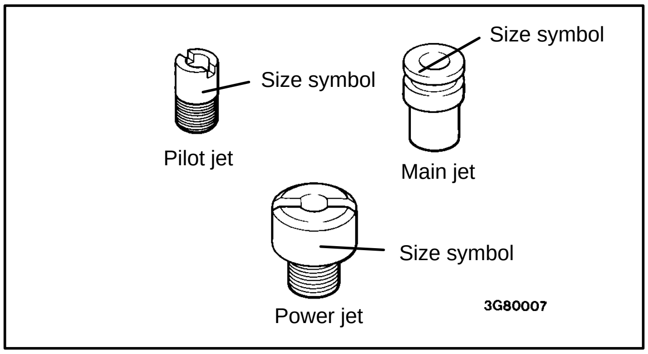


Figure 144

Carburetors with Identification Mark TMB

Power jet	120
Main jet	90
Pilot jet	50

Carburetors with Identification Mark TEB

Power jet	132.5
Main jet	101.3
Pilot jet	50

2. Adjust float level.

A. Lightly push up float until it stops, then measure clearance between needle valve and float lever.

Needle valve to float lever clearance	1.45 mm (.057 in.)

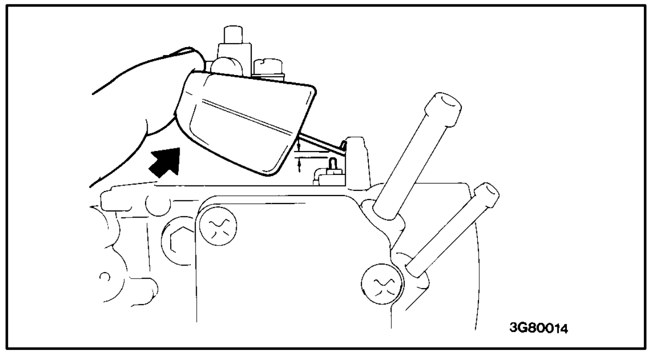


Figure 145

B. If clearance is out of specification, adjust by bending float lever as shown.

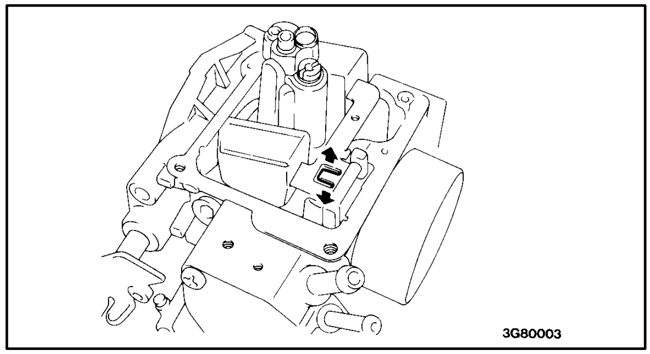


Figure 146

3. Install ball, weight and retainer in correct sequence and location as shown.

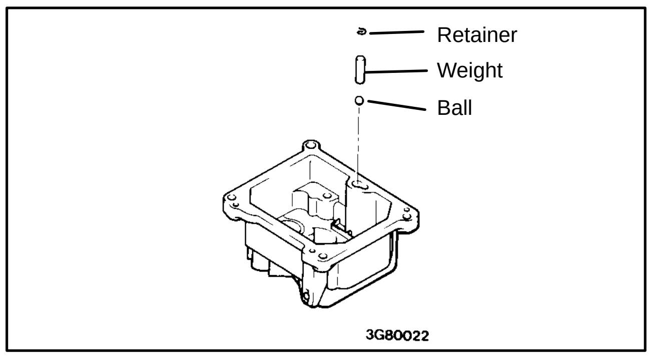


Figure 147

4. Insert power needle (attached to piston valve assembly) into power nozzle and install piston valve assembly so diaphragm outer surface does not slip out from groove.

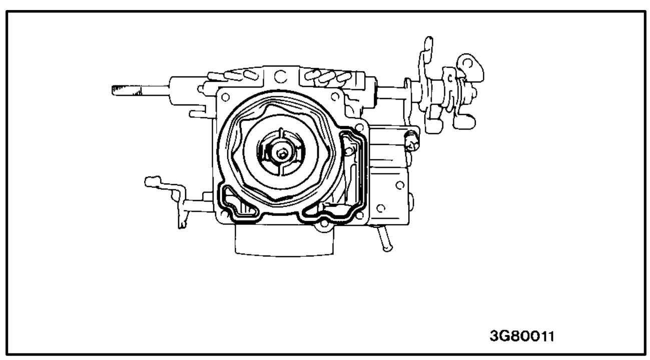


Figure 148

Carburetor Inspection and Adjustment After Reassembly

1. After installing mixture adjusting screw (MAS) set initially by turning clockwise until seated – DO NOT overtighten – then back out 2 full turns counterclockwise.

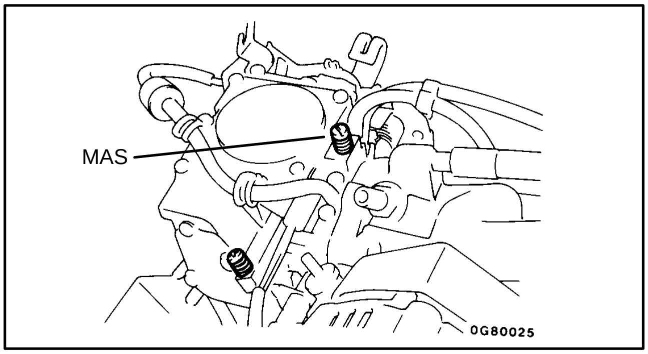


Figure 149

2. Make sure alignment mark (engraved) on cam lever is lined up with center of cam follower.

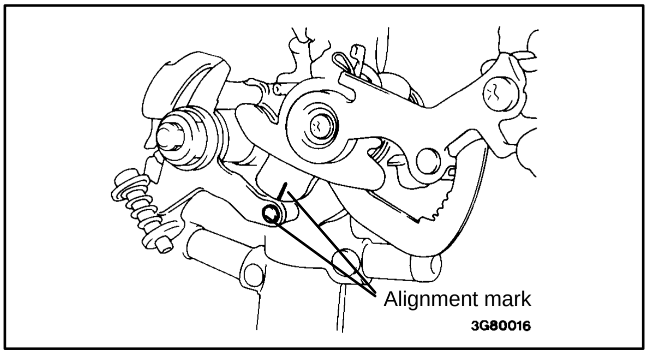


Figure 150

3. Measure throttle valve to throttle bore clearance.

Throttle valve to throttle bore clearance	0.3 mm (.012 in.)

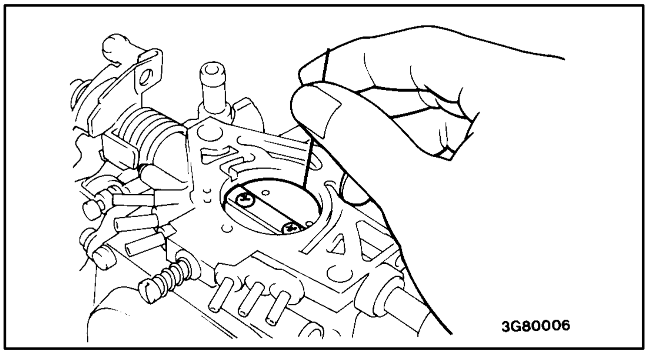


Figure 151

4. If clearance is out of specification, adjust to standard value with fast idle adjusting screw.

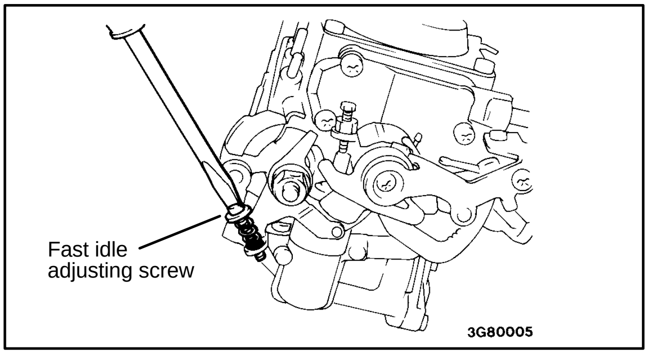


Figure 152

5. Use light pressure with a finger to fully close choke valve. Measure clearance between choke valve and choke bore when throttle valve is fully opened.

Choke valve to choke bore clearance	1.45 mm (0.57 mm)

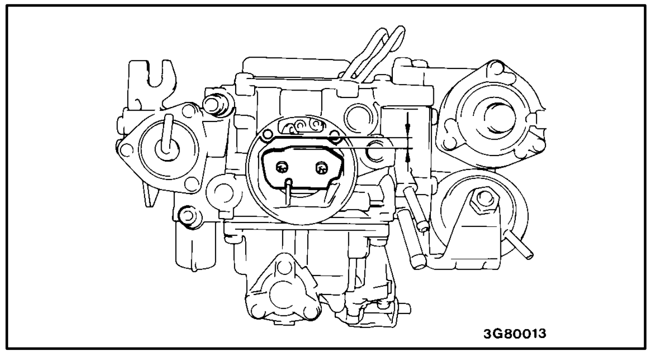


Figure 153

If clearance is out of specification, adjust by moving choke shaft end.

Choke shaft end	Valve clearance	Remarks
Lower	Larger	Engine becomes more difficult to start and tends to stall
Raise	Smaller	Carbon tends to accumulate on spark plugs

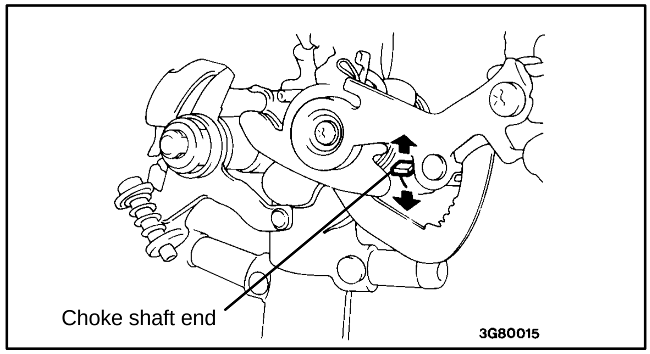


Figure 154

6. Use a hand vacuum pump to check that there are no clogs in port lines. If a port line is clogged, disassemble, clean and reassemble.

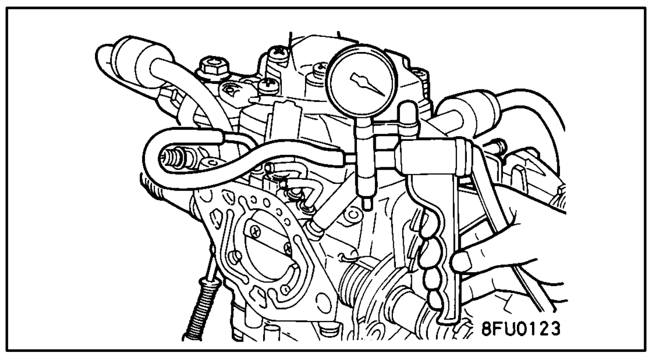


Figure 155

Removing and Installing the Engine

Removing the Engine

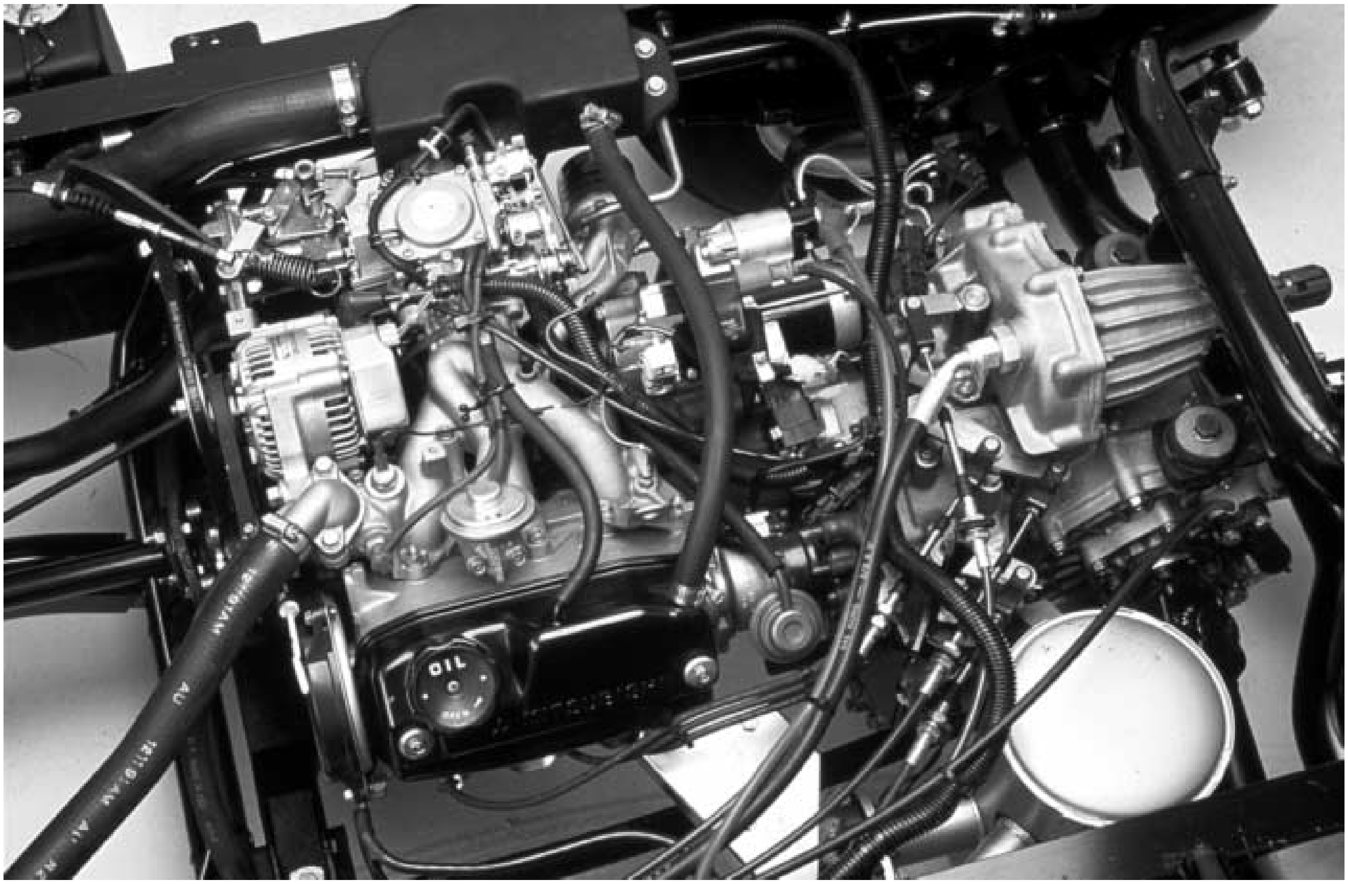


Figure 156

1. Put machine on a level surface and engage parking brake. Stop the engine and remove key from ignition switch. Remove the bed or other attachment(s). Allow engine and radiator to cool.

2. Disconnect positive (+) and negative (–) battery cables from battery.

3. Remove the starter assembly, leaving wires connected, then move starter off to the side.

4. Remove induction chamber mounting bolts. Disconnect intake hose from carburetor. Disconnect breather hose from induction chamber, then move induction chamber out of the way.

5. Open radiator cap. Put a drain pan under 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. Disconnect coolant and radiator hoses from engine.

7. Remove the muffler.

8. Disconnect fuel lines from carburetor. Plug end of fuel lines to prevent contamination.

9. Disconnect and label electrical leads that attach to engine and engine accessories.

10. Remove hydraulic pump drive shaft (connected to engine crankshaft pulley).

11. Disconnect throttle cable from governor lever on engine. Remove throttle cable from bracket.

12. Remove clamps and wire ties where wiring harness, hydraulic hoses or cables are attached to the engine.

13. Put blocking under transaxle for support.

14. Attach hoist or block and tackle to engine for support.

15. Remove one (1) capscrew securing sheet metal cover to bell housing near starter. Remove five (5) capscrews securing lower sheet metal clutch cover to engine and bell housing.

16. Remove two (2) capscrews and locknuts securing engine mount to frame.

17. Remove capscrews securing clutch bell housing to engine.

18. Use a hoist or block and tackle to remove engine from chassis. One person should operate hoist or block and tackle and the other person should help guide engine out of chassis. Move engine forward before lifting to disengage transaxle input shaft from clutch.

19. Remove, brackets and accessories from engine as necessary.

Installing the Engine

1. To install the engine, perform steps 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 accelerator pedal cable (see Governor / Accelerator Pedal Adjustment).

Cylinder Head Overhaul

Intake and Exhaust Manifold

Before Removing

1. Remove oil level dipstick and guide tube.

2. Remove alternator.

Removal and Installation

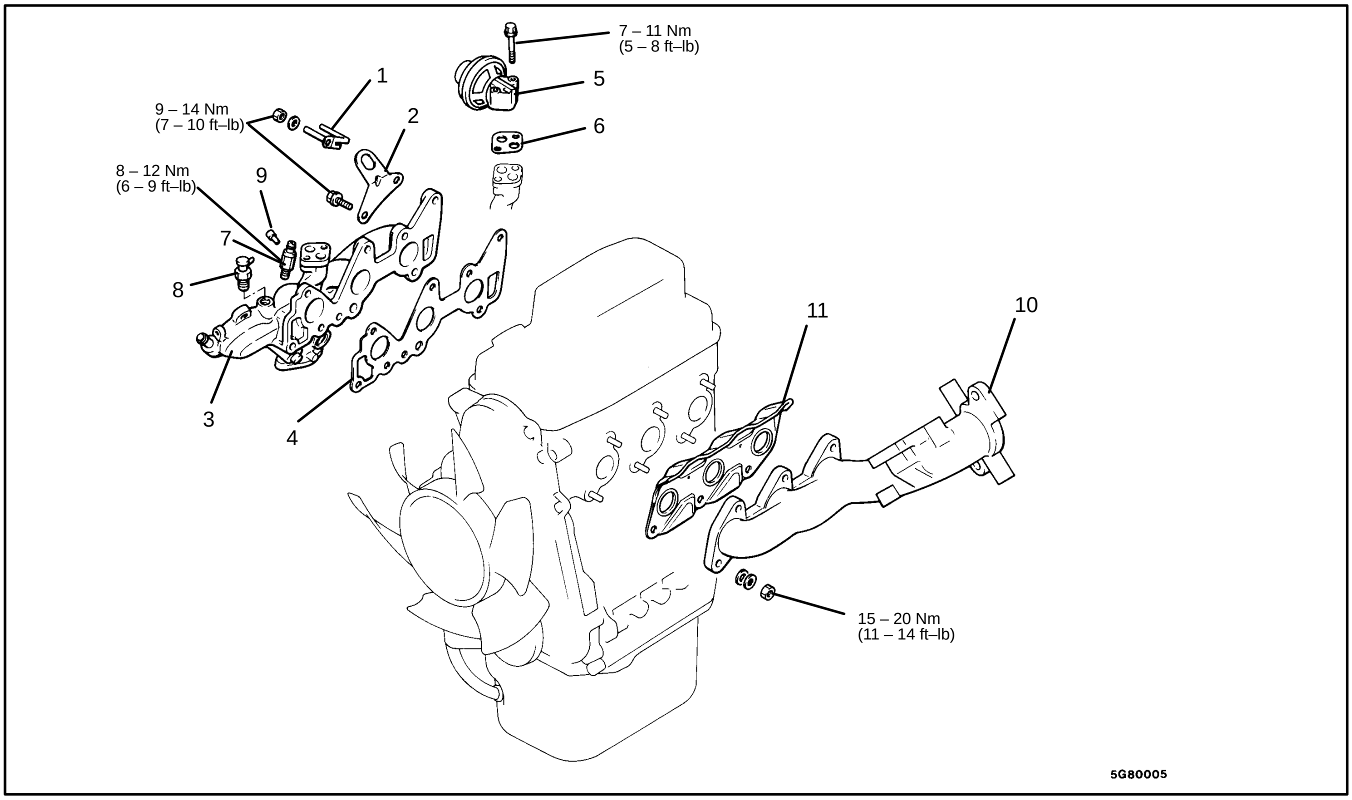


Figure 157

1. Clip
2. Engine hanger
3. Intake manifold
4. Intake manifold gasket
5. EGR valve
6. EGR valve gasket
7. PCV valve
8. Thermo valve
9. Rubber cap
10. Exhaust manifold
11. Exhaust manifold gasket

Rocker Arm, Rocker Shaft and Camshaft

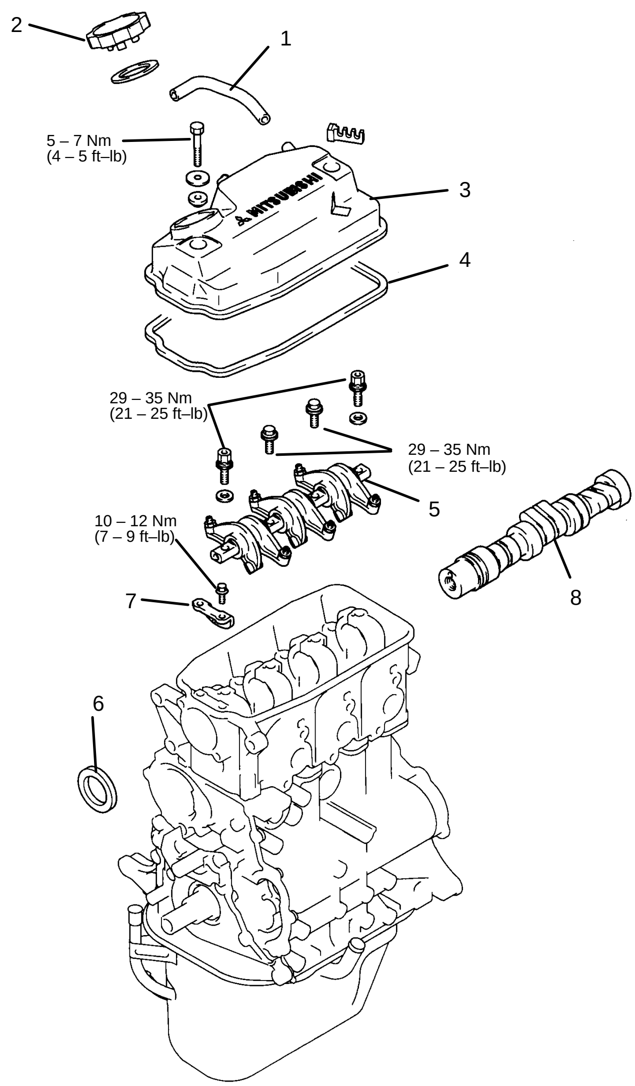


Figure 158

1. PCV hose	**4. Rocker cover gasket**	**7. Camshaft thrust plate**
2. Oil filter cap	**5. Rocker arm, rocker shaft assembly**	**8. Camshaft**
3. Rocker cover	**6. Camshaft oil seal**	

Disassemble and assemble parts as shown in illustration above. Also use the following instructions for specific points of disassembly, inspection and reassembly.

Camshaft Inspection

1. Check camshaft journal surfaces for damage or seizure. If journal is seized, check cylinder head for possible damage. Also check for clogged oil holes in cylinder head.

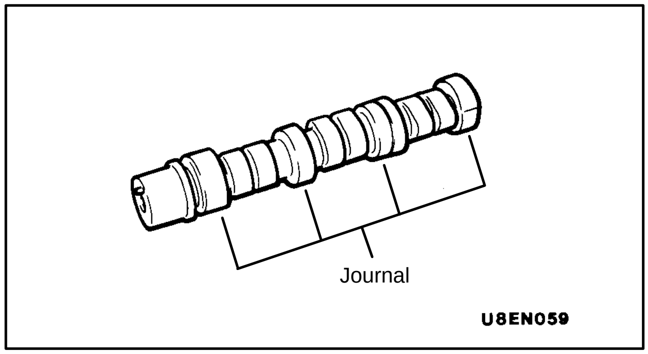


Figure 159

2. Check camshaft surface for irregular wear or damage. Measure cam height (diameter of cam length). If cam height is at the limit, replace the camshaft.

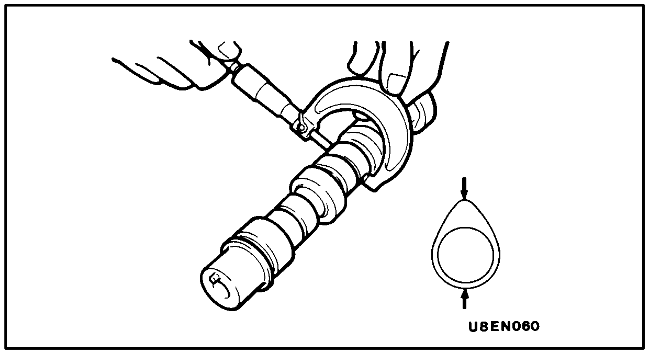


Figure 160

Cam		Standard Value mm (in.)	Limit mm (in.)
Intake	No.1	35.09 (1.3815)	34.59 (1.3618)
	No. 2	35.07 (1.3807)	34.57 (1.3610)
	No. 3	35.06 (1.3803)	34.56 (1.3606)
Exhaust	No.1	35.15 (1.3839)	34.65 (1.3642)
	No. 2	35.13 (1.3831)	34.63 (1.3634)
	No. 3	35.19 (1.3854)	34.69 (1.3657)

Camshaft Installation

1. Insert camshaft from rear of cylinder head after applying a coat of engine oil to journals of camshaft. Install camshaft thrust plate as shown. Tighten bolt to specified torque.

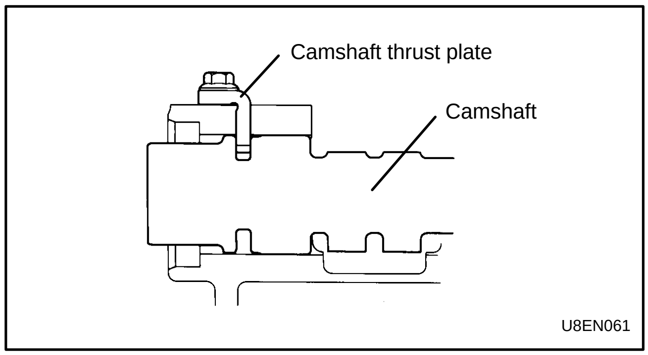


Figure 161

2. Measure end play of camshaft. If it exceeds the limit, replace camshaft thrust plate, camshaft, or both. Measure camshaft end play by inserting a feeler gauge between rear of camshaft thrust plate and No. 1 journal.

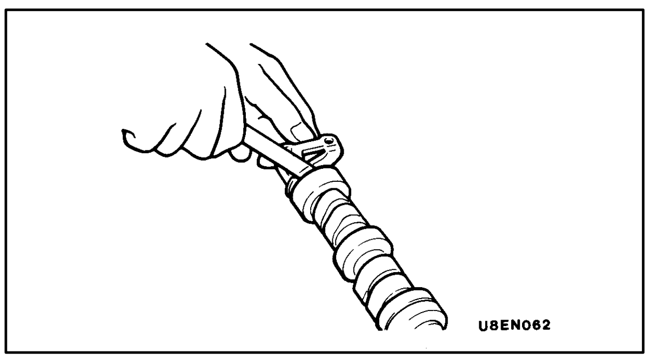


Figure 162

Standard value	0.06 – 0.14 mm (.0236 – .0551 in.)
Limit mm	0.3 mm (.118 in.)

3. Apply engine oil to lip of camshaft oil seal. Use seal installer tool to drive seal into cylinder head.

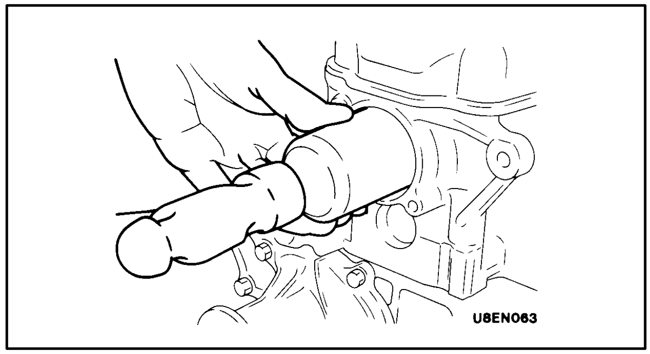


Figure 163

4. Install rocker shaft so illustrated portion is located toward the front (there is a chamfer and the oil hole is closer to the shaft end than the bolt hole).

5. Tighten rocker arm shaft attaching bolts (4 bolts) a little at a time and evenly. Tighten bolts to the specified torque.

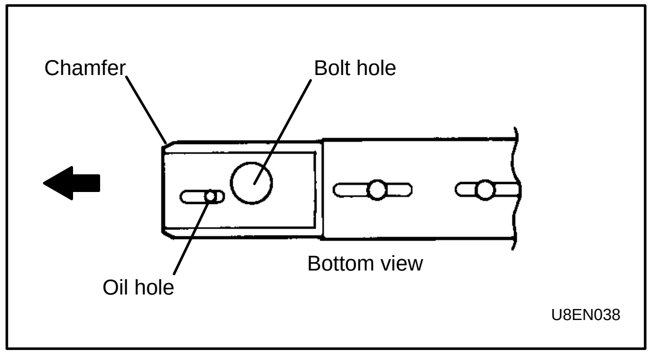


Figure 164

Rocker Arms and Rocker Shaft

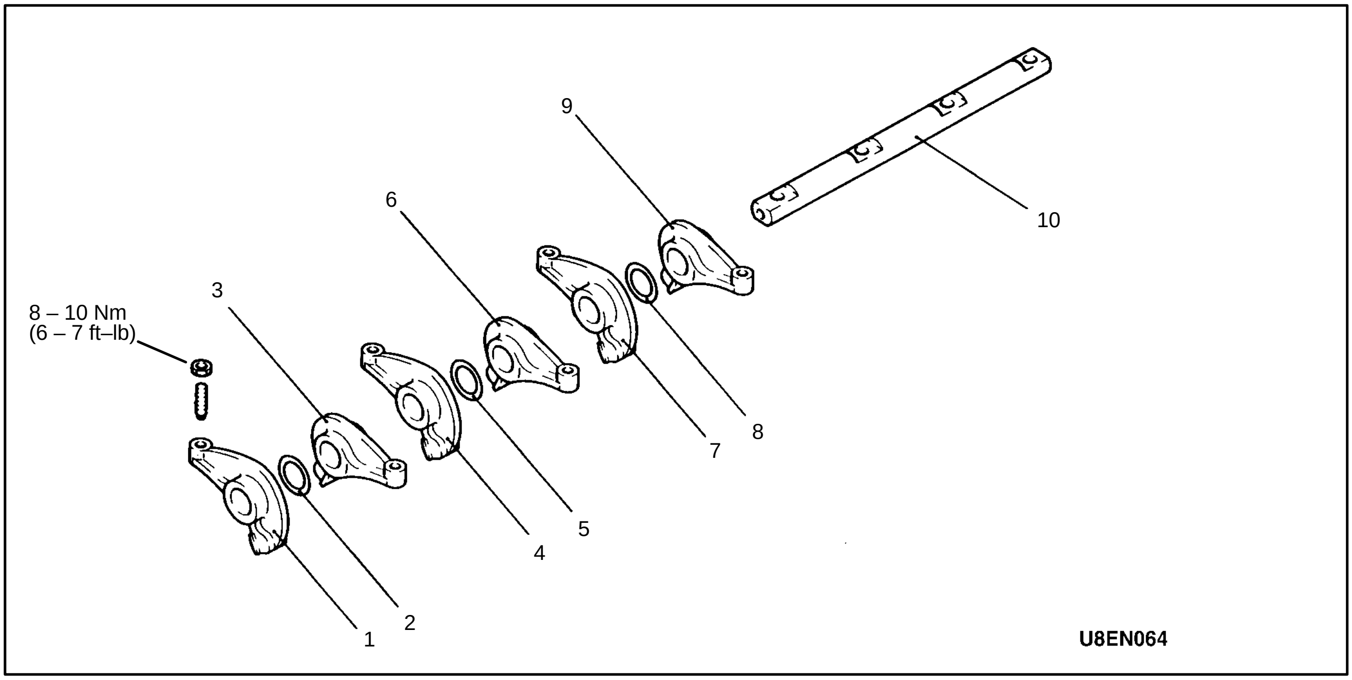


Figure 165

1. Rocker arm (intake)
2. Wave washer
3. Rocker arm (exhaust)
4. Rocker arm (intake)
5. Wave washer
6. Rocker arm (exhaust)
7. Rocker arm (intake)
8. Wave washer
9. Rocker arm (exhaust)
10. Rocker shaft

Disassemble and assemble parts as shown in illustration above. Also use the following instructions for specific points of disassembly, inspection and reassembly.

Rocker Arm and Rocker Shaft Inspection

1. Check rocker arm for wear or damage. Replace if badly worn or damaged.

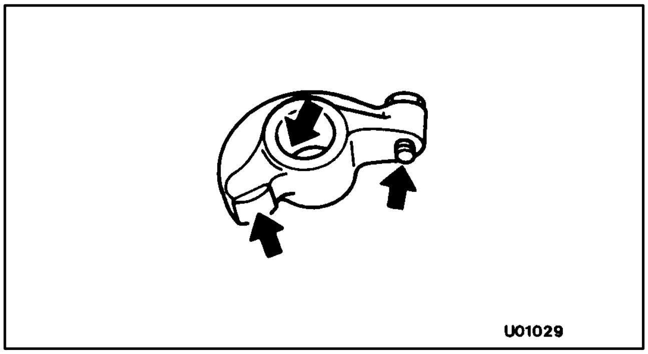


Figure 166

2. Check rocker arm mounting areas for wear or damage. Use a thin wire to make sure oil holes are clear.

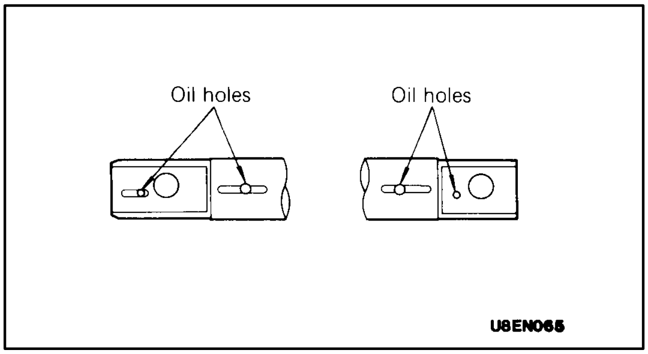


Figure 167

Cylinder Head and Valves

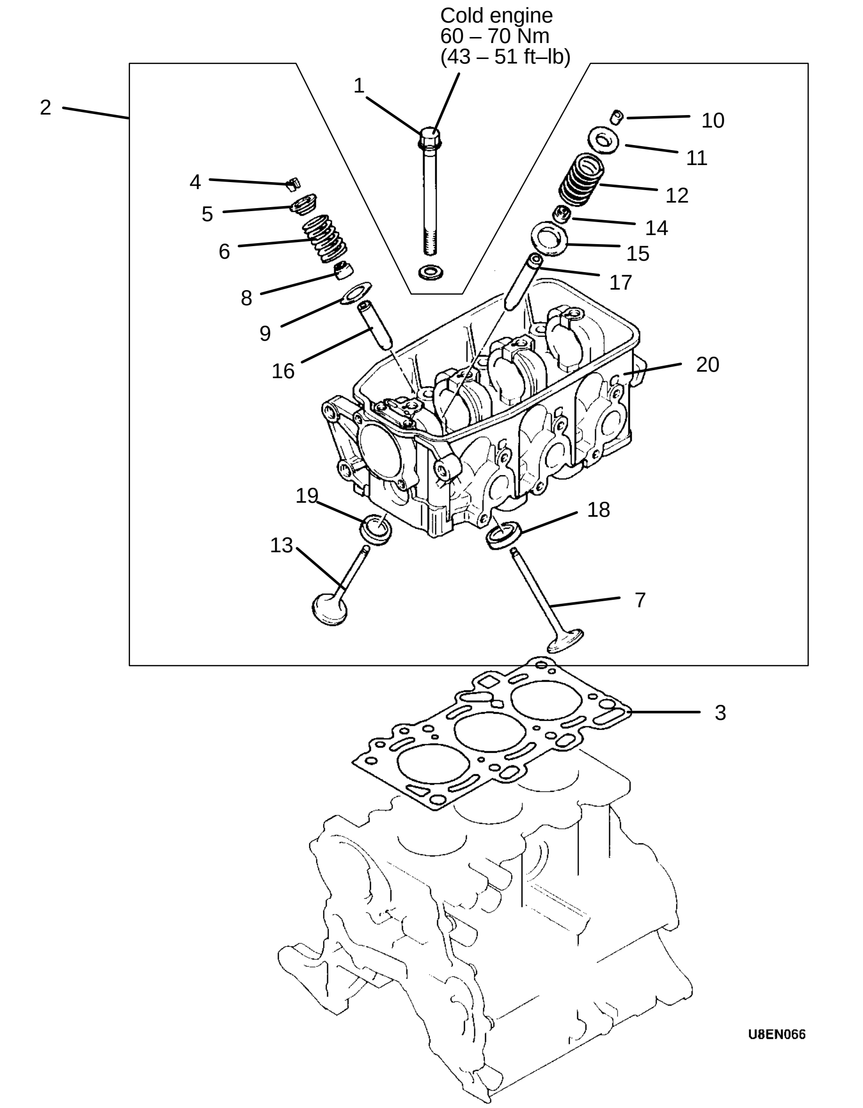


Figure 168

1. Cylinder head bolt
2. Cylinder head assembly
3. Cylinder head gasket
4. Valve spring retainer lock
5. Valve spring retainer
6. Valve spring
7. Intake valve
8. Valve stem seal
9. Valve spring seat
10. Valve spring retainer lock
11. Valve spring retainer
12. Valve spring
13. Exhaust valve
14. Valve stem seal
15. Valve spring seat
16. Intake valve guide
17. Exhaust valve guide
18. Intake valve seat
19. Exhaust valve seat
20. Cylinder head

Disassemble and assemble parts as shown in illustration above. Also use the following instructions for specific points of disassembly, inspection and reassembly.

Cylinder Head Removal and Disassembly

1. Loosen bolts in order as shown and remove cylinder head assembly.

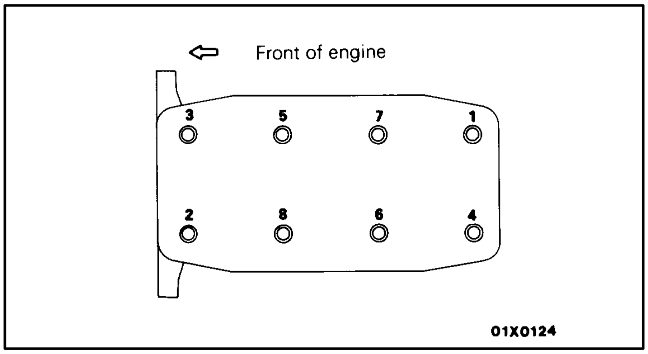


Figure 169

2. Use a valve spring compressor tool to compress valve spring. Remove retainer lock. Remove valve spring retainer, valve spring, valve spring seat and valve.

NOTE: Keep removed parts in order according to cylinder number and intake/exhaust.

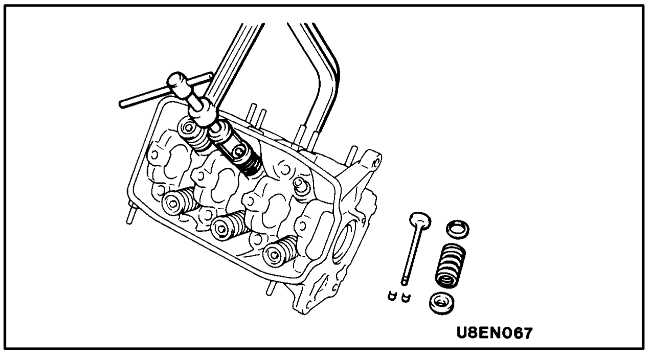


Figure 170

3. Use a pliers to remove valve stem seal. DO NOT reuse stem seals.

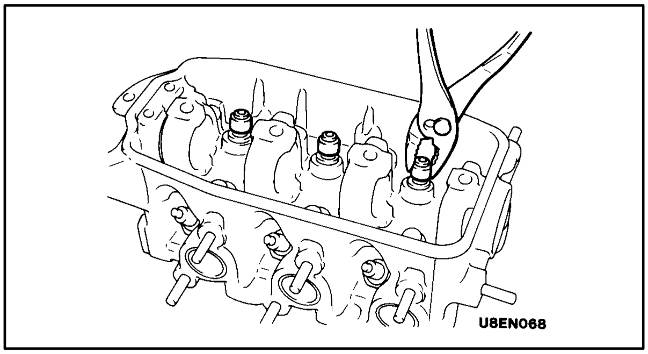


Figure 171

Cylinder Head Inspection

1. Before cleaning cylinder head, check for coolant leakage, exhaust leakage, damage and cracks. Clean cylinder head, removing all oil, sealant and carbon deposits. After cleaning oil passage, blow out with compressed air and check for blockage.

2. Use a straight edge and feeler gauge to measure flatness. If amount of warpage exceeds limit, correct by grinding.

Warpage standard value	0.05 mm (.0020 in.)
Warpage limit	0.2 mm (.0079 in.)
Grinding limit	0.2 mm (.0079 in.)
Height of cylinder head (standard value of new part)	108.9 – 109.1 mm (4.287 – 4.295 in.)

NOTE: Together with cylinder block to be assembled, grinding to within 0.2 mm (.0079 in.) is possible.

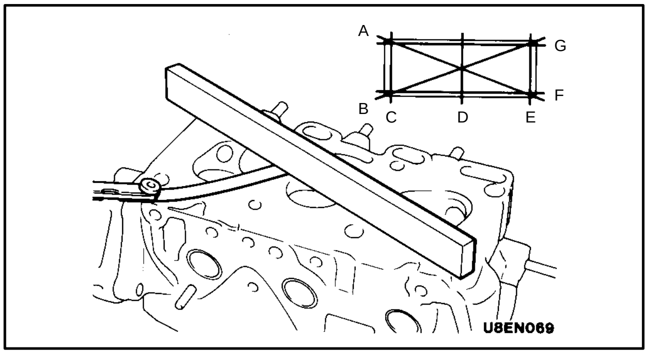


Figure 172

Liquid Cooled Gas Engine

3. Check valve seat for proper contact with valve. If it is not concentric, recondition valve seat. Check valve margin. Replace if margin is at limit.

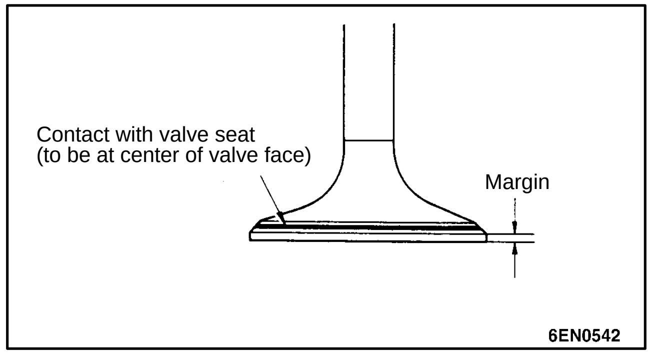


Figure 173

4. Measure free height of spring and replace if it is not within limit specification.

5. Check valve spring for squareness and replace if limit is exceeded.

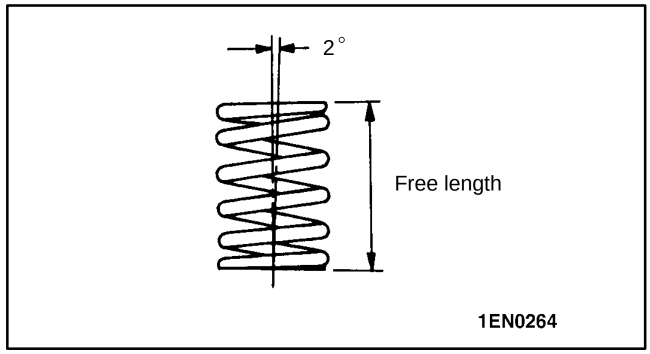


Figure 174

6. Measure clearance between valve guide and valve stem. If clearance exceeds limit, replace valve guide, valve or both.

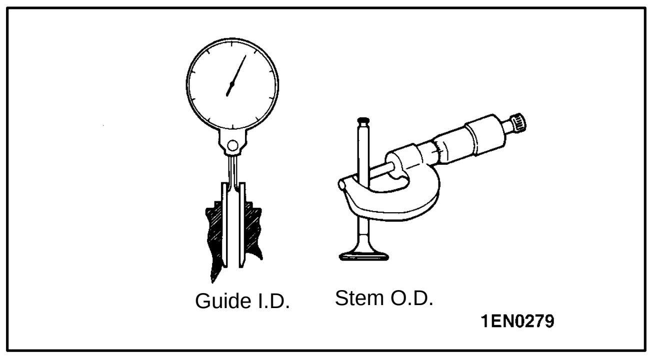


Figure 175

Valve Seat Reconditioning

1. Use a valve seat cutter and pilot or seat grinder to correct seat width and seat angle.

2. After correction, use lapping compound and lap valve and valve seat.

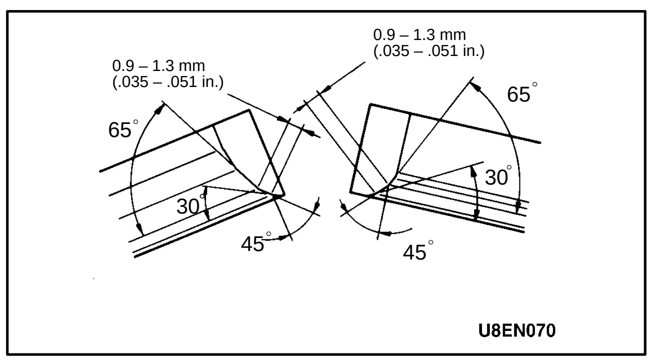


Figure 176

Cylinder Head Reassembly and Installation

1. Install valve spring seat. Use stem seal installer tool to install new stem seal to valve guide. DO NOT reuse valve stem seals.

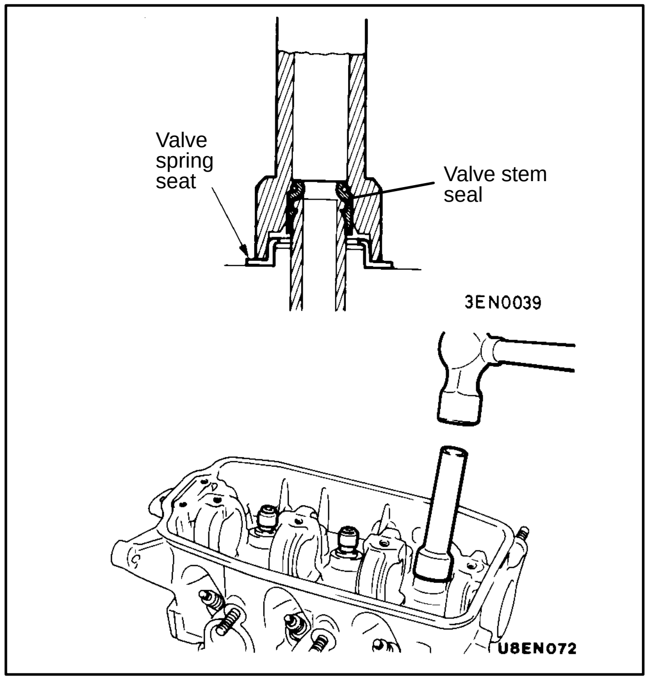


Figure 177

2. Install valve spring with enamel coated side toward rocker arm side.

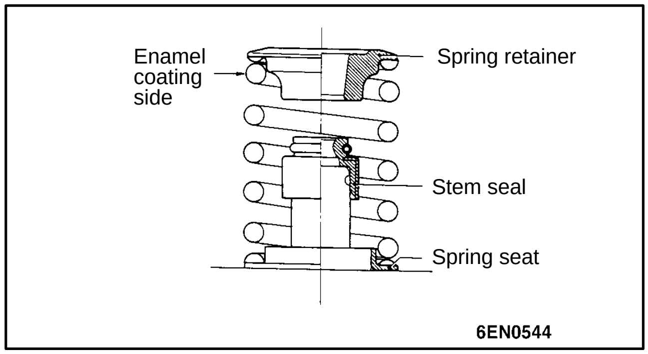


Figure 178

3. Put valve spring retainer on top of spring and use valve spring compressor tool to compress valve spring. Install retainer lock.

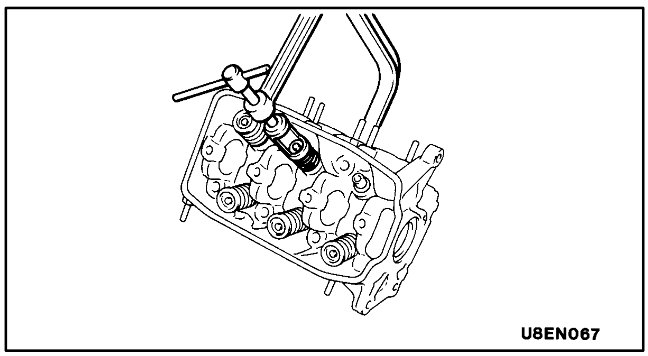


Figure 179

4. Make sure cylinder head and cylinder block gasket surface is clean. Put new cylinder head gasket on top of cylinder block with identification mark ”66N” facing up.

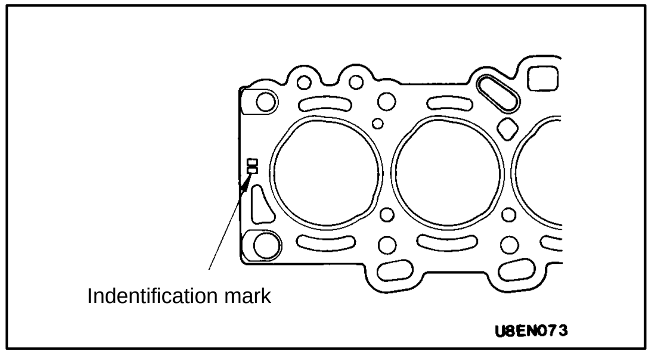


Figure 180

5. Tighten cylinder head bolts firmly in three steps. Tighten bolts in order as shown.

A. Tighten each bolt to 20 – 30 Nm (14 – 22 ft–lb) in order shown.

B. Tighten each bolt to 40 – 50 Nm (29 – 36 ft–lb) in order shown.

C. Fully tighten (cold) to 60 – 70 Nm (43 – 51 ft–lb) in order shown.

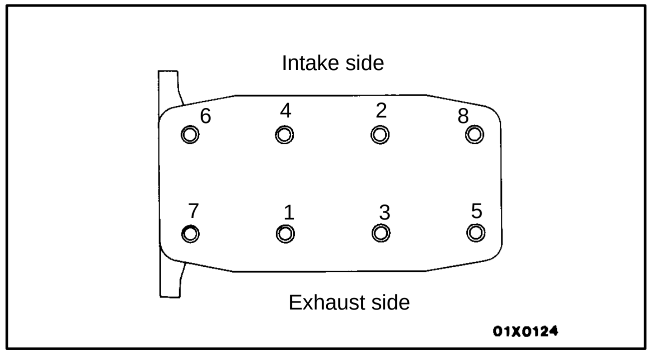


Figure 181

Cylinder Block Overhaul

Front Case, Counterbalance Shaft and Oil Pan

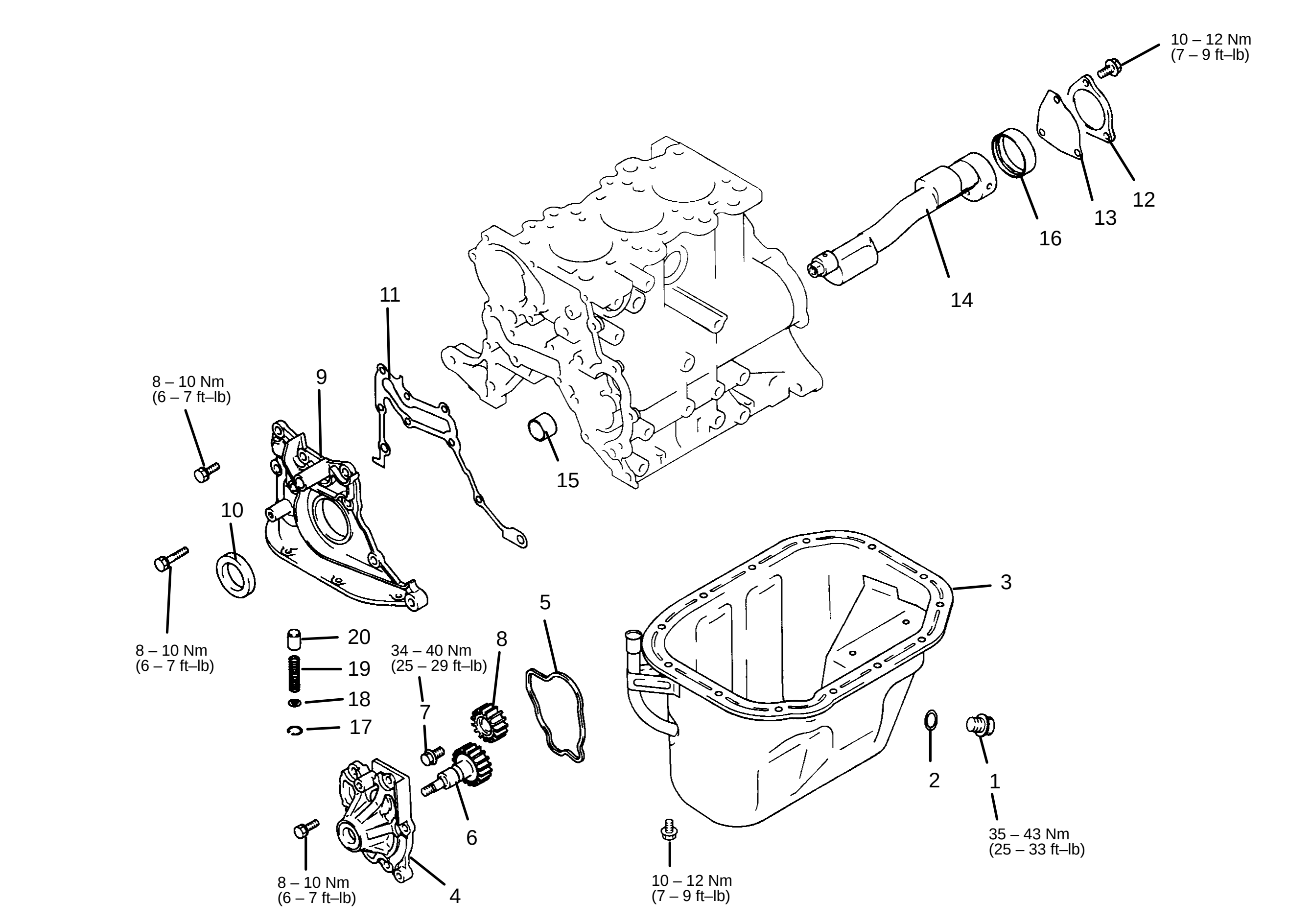


Figure 182

1. Drain plug
2. Drain plug gasket
3. Oil pan
4. Oil pump cover
5. Oil pump cover gasket
6. Oil pump drive gear
7. Flange bolt
8. Oil pump driven gear
9. Front case assembly
10. Crankshaft front oil seal
11. Front case gasket
12. Rear cover
13. Rear cover gasket
14. Counterbalance shaft
15. Counterbalance shaft front bearing
16. Counterbalance shaft rear bearing
17. Snap ring
18. Spring retainer
19. Relief spring
20. Relief plunger

Disassemble and assemble parts as shown in illustration above. Also use the following instructions for specific points of disassembly, inspection and reassembly.

Front Case, Counterbalance Shaft and Oil Pan Disassembly

1. To remove oil pan, remove bolts, then remove oil pan with special tool.

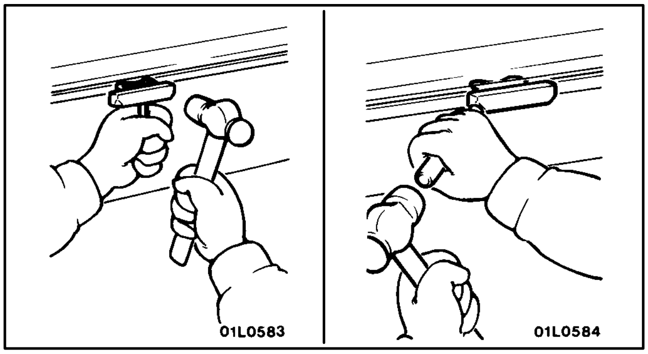


Figure 183

2. Remove plug on left side of cylinder block and insert a 8 mm (.32 in.) rod to lock counterbalance shaft. Remove flange bolt securing oil pump drive gear. Remove oil pump drive gear.

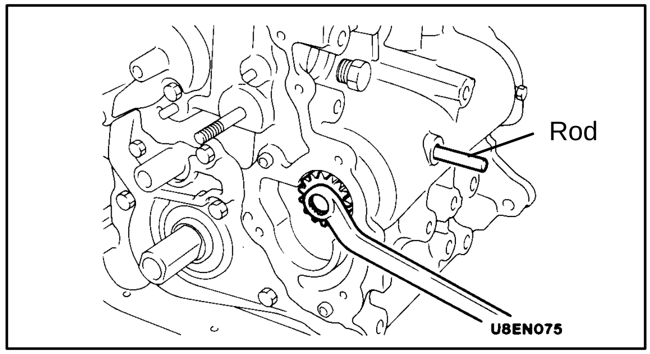


Figure 184

3. Remove rear cover. Use special tool to drive out counterbalance shaft front bearing from cylinder block.

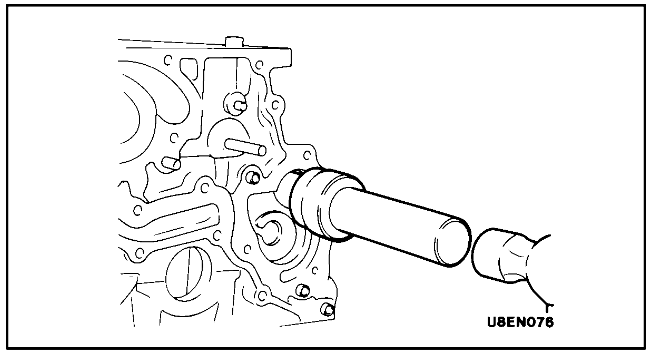


Figure 185

4. Use special tool to drive out counterbalance shaft rear bearing from cylinder block.

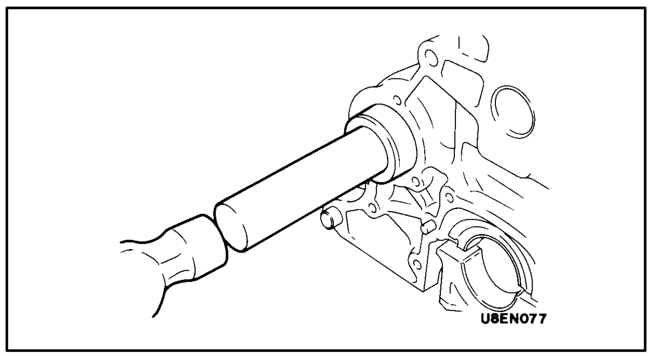


Figure 186

Front Case, Counterbalance Shaft and Oil Pan Inspection

1. Inspect counterbalance shaft oil holes for clogging and clean if necessary. Check journal for seizure, damage and contact with bearing. Replace bearings and/or counterbalance shaft if damaged.

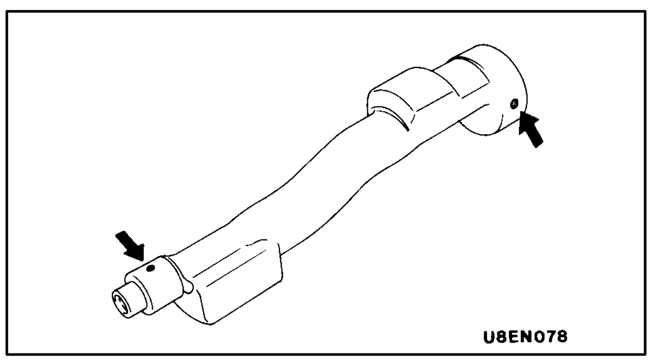


Figure 187

2. Check counterbalance shaft to bearing oil clearance. Replace bearing and/or counterbalance shaft if worn or damaged.

Front	0.035 – 0.068 mm (.0014 – .0026 in.)
Rear	0.035 – 0.071 mm (.0014 – .0028 in.)

3. Check front case oil holes for clogging and clean if necessary. Check front case and replace if cracked or damaged.

4. Check front oil seal for wear, damage or hardening. Replace front oil seal if necessary. It is recommended that you install a new front oil seal when rebuilding the engine.

Front Case, Counterbalance Shaft and Oil Pan Reassembly

1. Install counterbalance shaft rear bearing:

A. Install guide pins of special tool (bearing installer) in tapped hole of cylinder block.

B. Mate ratchet ball of bearing installer and oil hole of rear bearing, then install bearing in bearing installer.

C. Apply engine oil to bearing outer circumference and bearing hole in cylinder block.

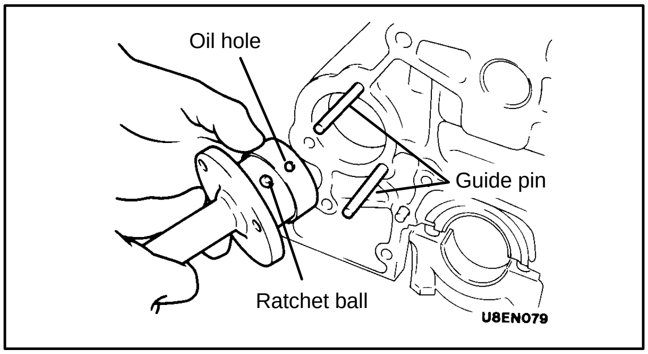


Figure 188

D. Insert installer by mating it with guide pin, then press in the rear bearing.

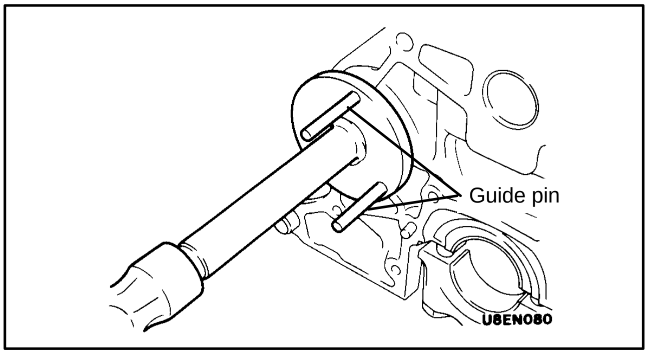


Figure 189

2. Install counterbalance shaft rear bearing:

A. Apply engine oil to bearing outer circumference and bearing hole in cylinder block.

B. Use special tool to press in the front bearing.

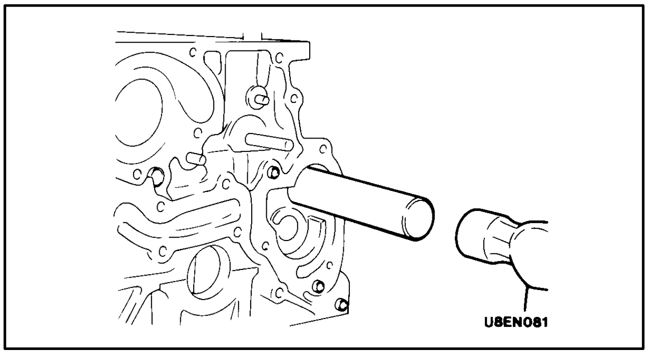


Figure 190

3. Install crankshaft front oil seal:

A. Apply engine oil to crankshaft front oil seal lip inner circumference.

B. Use special tool to install oil seal into front case.

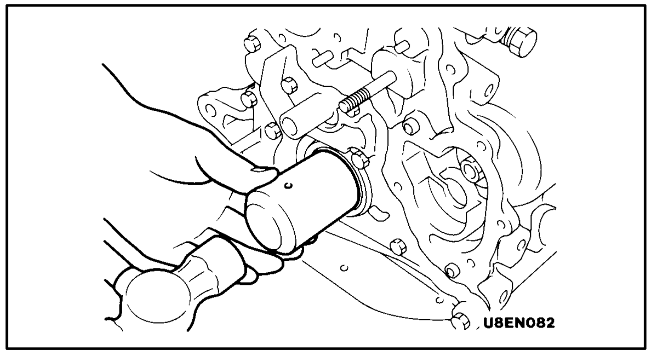


Figure 191

4. Install front case assembly with a new gasket. Make sure bolts of different lengths are installed in the correct location. Tighten bolts evenly to specified torque.

IMPORTANT: Apply engine oil to inner circumference of oil seal lip before installing front case assembly. Be careful not to damage oil seal lip when installing front case assembly.

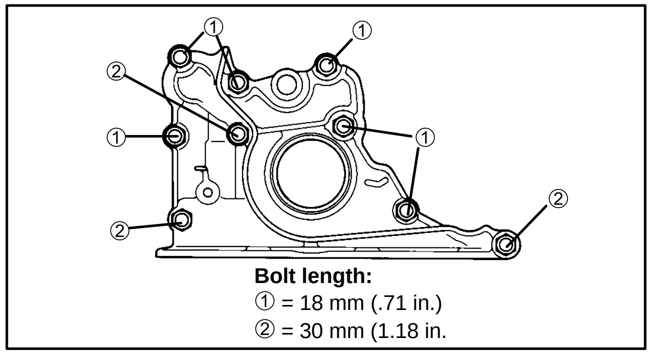


Figure 192

5. Apply engine oil to oil pump driven gear, then insert gear so timing mark is located as shown in illustration.

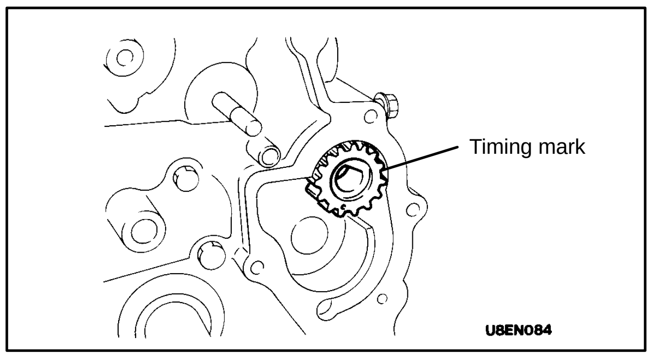


Figure 193

6. Remove plug on left side of cylinder block and insert a 8 mm (.32 in.) diameter rod to lock counterbalance shaft. Tighten flange bolt to specified torque.

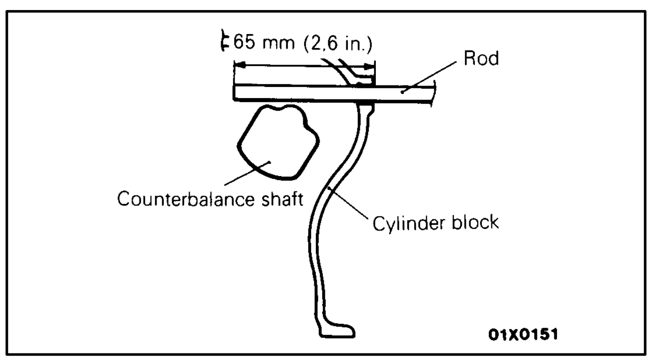


Figure 194

7. Align timing marks on oil pump drive gears, then install drive gears in cylinder block.

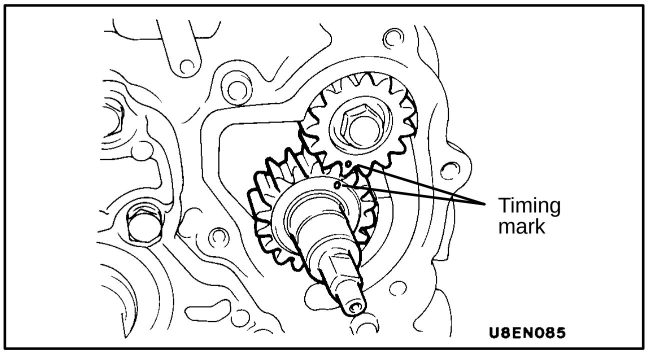


Figure 195

8. Insert a new oil pump cover gasket into groove of oil pump cover. Gasket should be inserted so flat side is toward oil pump cover.

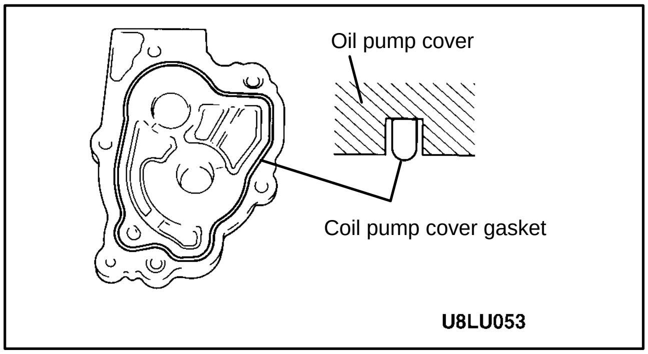


Figure 196

9. Install oil pan:

A. Use a scraper and/or wire brush to remove all sealant from oil pan and cylinder block mating surface.

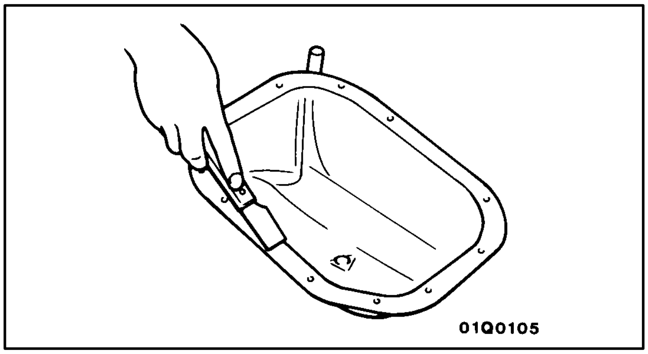


Figure 197

B. Apply a 4 mm (.16 in.) wide bead of sealant to entire circumference of oil pan flange. Apply sealant in a continuous bead as shown in illustration. Overlap end of bead with starting point.

C. Install oil pan and tighten bolts to specified torque within 5 minutes of applying sealant.

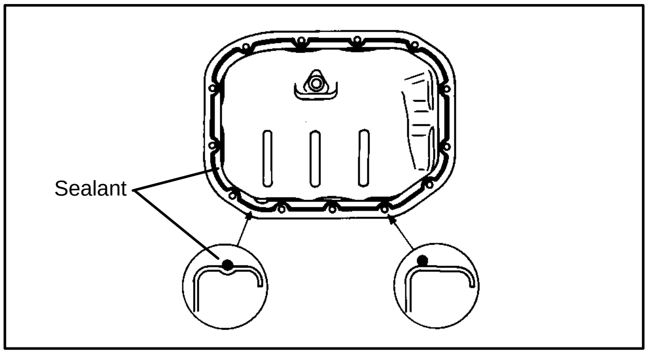


Figure 198

Liquid Cooled Gas Engine

Piston and Connecting Rod

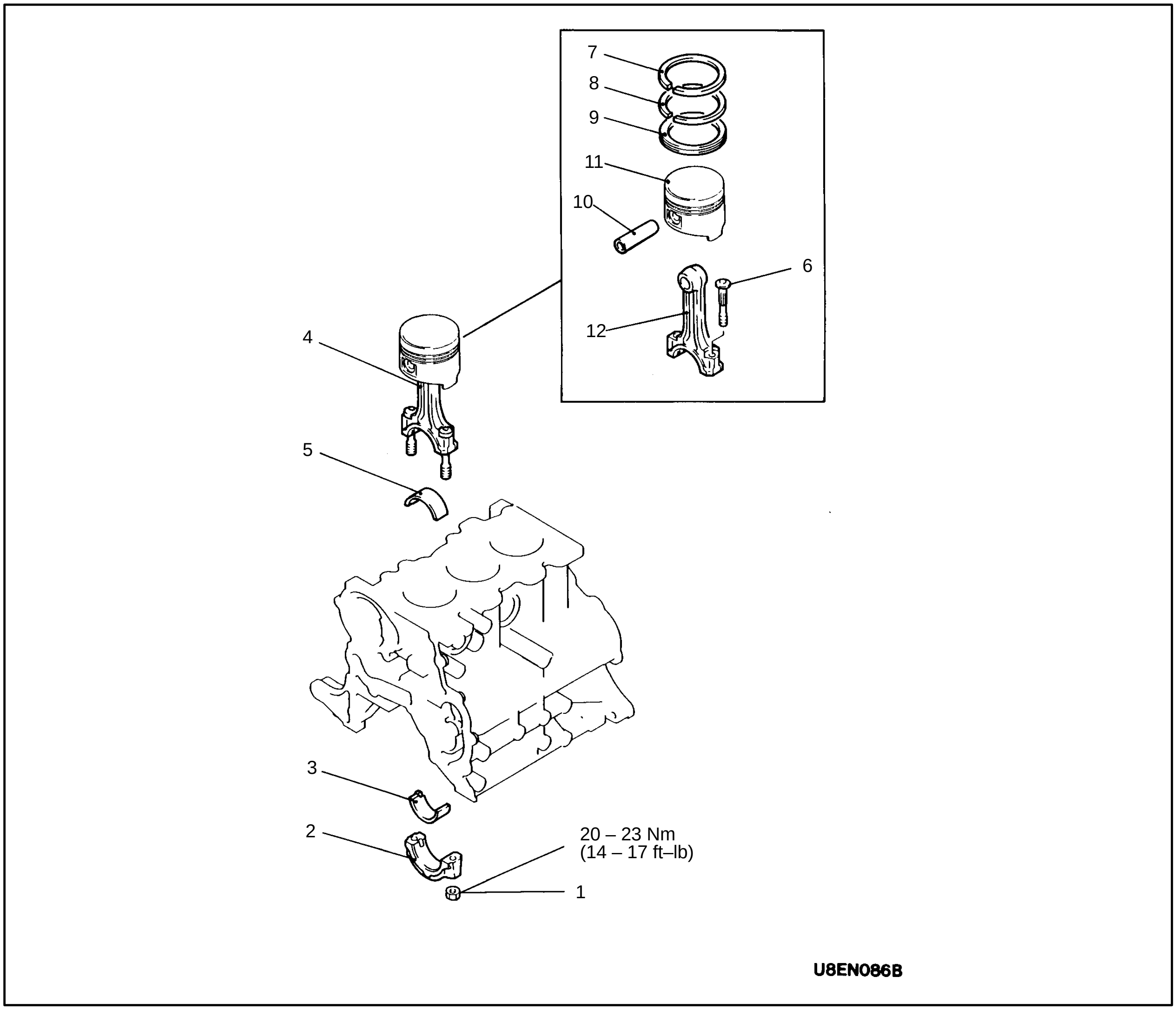


Figure 199

1. Nut	**5. Connecting rod bearing**	**9. Oil ring**
2. Connecting rod cap	**6. Bolt**	**10. Piston pin**
3. Connecting rod assembly	**7. No. 1 piston ring**	**11. Piston**
4. Piston and connecting rod	**8. No. 2 piston ring**	**12. Connecting rod**

Disassemble and assemble parts as shown in illustration above. Also use the following instructions for specific points of disassembly, inspection and reassembly.

Disassembly of Piston and Connecting Rod

1. Mark big end of connecting rod with cylinder number for proper reassembly.

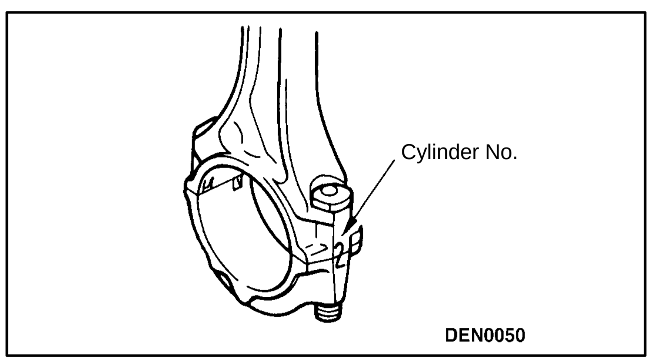


Figure 200

2. Disassemble piston pin, piston and connecting rod:

A. Insert special tool. Push rod and Guide B, into piston pin. Set piston and connecting rod assembly on base. Make sure front mark (arrow) stamped on piston top surface faces up.

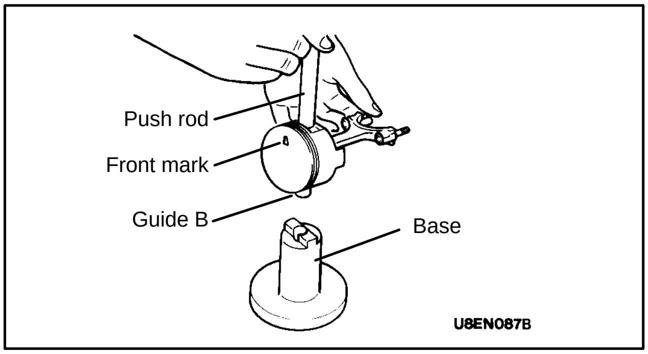


Figure 201

B. Use a press to drive out piston pin. Keep disassembled piston, pin and connecting rod together according to cylinder number.

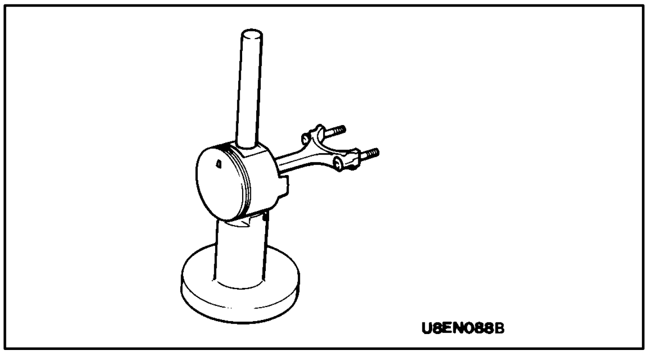


Figure 202

Piston and Connecting Rod Inspection

NOTE: Piston and piston pin must be replaced as an assembly.

1. Check piston for scuffing, seizure, cracks or other damage and replace if necessary.

2. Check oil return hole in oil ring groove and oil hole in piston boss.

3. Check piston pin hole and replace piston if signs of seizure or damage are evident.

4. Insert piston pin into piston pin hole with your thumb. You should feel a slight resistance. Replace piston and pin if pin can be easily inserted or there is free play.

5. Check piston ring for damage, wear or bending and replace if necessary. Also make sure you install new rings if a new piston is installed.

6. Check clearance between piston ring and groove. When clearance exceeds the limit, replace the rings and/or piston.

7. Insert piston ring into cylinder bore, putting it against top of piston head then pushing it in. With piston ring at a right angle to cylinder, measure ring gap with a feeler gauge. Replace piston ring if gap exceeds the limit.

Standard value	
No. 1 ring	0.15 – 0.30 mm (.0059 – .0118 in.)
No. 2 ring	0.35 – 0.50 mm (.0138 – .0197 in.)
Oil ring	0.2 – 0.7 mm (.008 – .028 in.)
Limit	
No. 1 ring	.08 mm (.031 in.)
No. 2 ring	.08 mm (.031 in.)
Oil ring	1.0 mm (.039 in.)

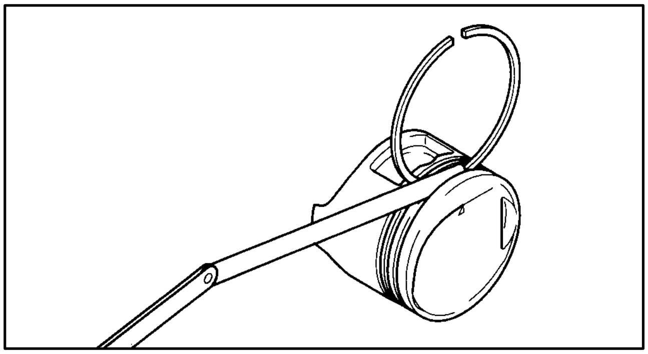


Figure 203

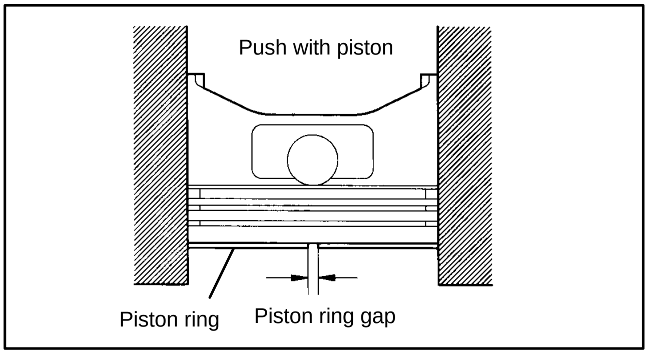


Figure 204

Liquid Cooled Gas Engine

8. Visually check surface of connecting rod bearing. Replace bearing if uneven, streaked, damaged or seized. When streaks or seizure are excessive, check the crankshaft. If crankshaft is damaged, replace crankshaft or machine to next undersize.

9. Measure inner diameter of connecting rod bearing and outer diameter of crankshaft pin. If the gap (oil clearance) exceeds the limit, replace the bearing and/or crankshaft or machine crankshaft to next undersize. Use bearings to match undersize crankshaft.

Standard value	0.022 – 0.052 mm (.0009 – .0020 in.)
Limit	.01 mm (.004 in.)

NOTE: (see Crankshaft and Flywheel for measuring oil clearance with plastic gauge method).

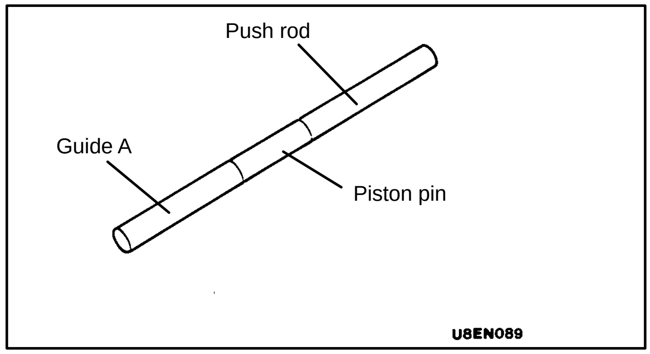


Figure 205

Piston and Connecting Rod Reassembly

1. Install connecting rod to piston with ”front” identification marks both facing the same direction (arrow mark on piston and die mark on ”convex portion” of connecting rod). Apply engine oil to piston pin and use piston pin setting tool to install piston pin from ”front” side of piston.

Piston pin setting force	5,000 – 15,000 N (1,102 – 3,307 lbs.)

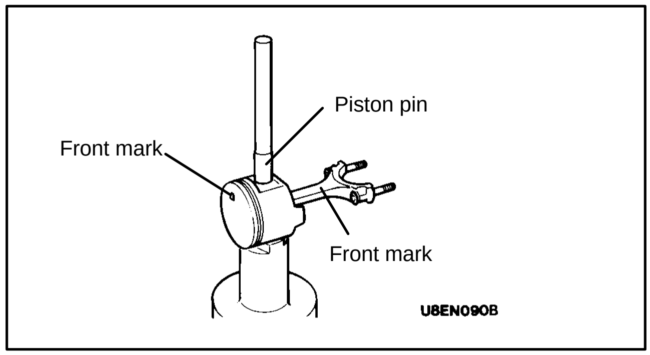


Figure 206

2. Assemble oil ring spacer into piston ring groove. Install upper side rail first, then lower side rail. NOTE: There is no difference between upper and lower side rails or spacers. The following identification colors are painted on new spacers and side rails according to size.

Size	Identification color
Standard	None
0.25 mm (.0098 in.) O.S.	Two blue lines
.050 mm (.1097 in.) O.S.	One red line
.075 mm (.0295 in.) O.S.	Two red lines
1.00 mm (.0393 in.) O.S.	One yellow line

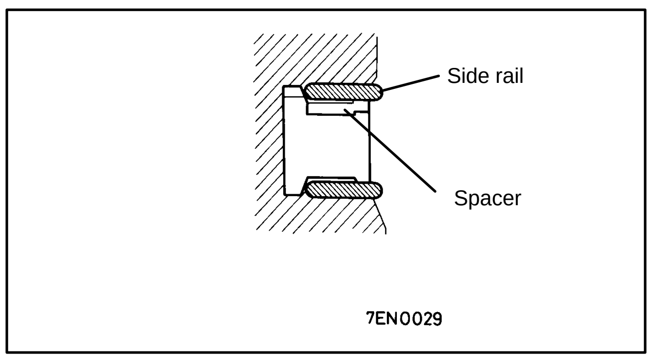


Figure 207

IMPORTANT: To install, push side rail in with your finger as shown after fitting one end over the piston groove. DO NOT use a ring expander. Use of a ring expander can break the side rail. Make sure side rails move smoothly in either direction.

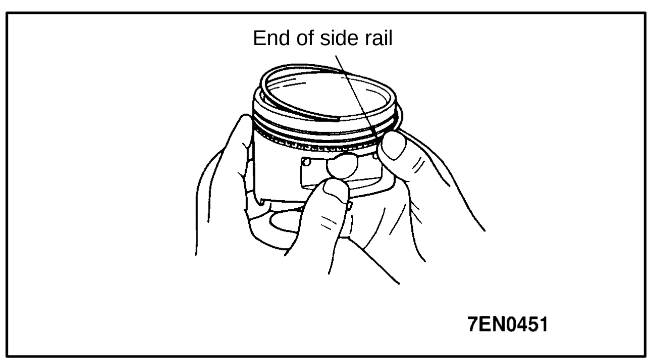


Figure 208

3. Use a ring expander to Install No. 2 and No. 1 piston rings. Pay attention to difference in shape between No. 1 and No. 2 rings. Install rings with marks facing up (towards top of piston).

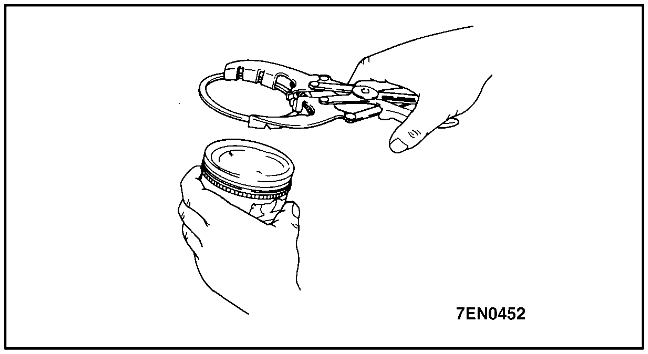


Figure 209

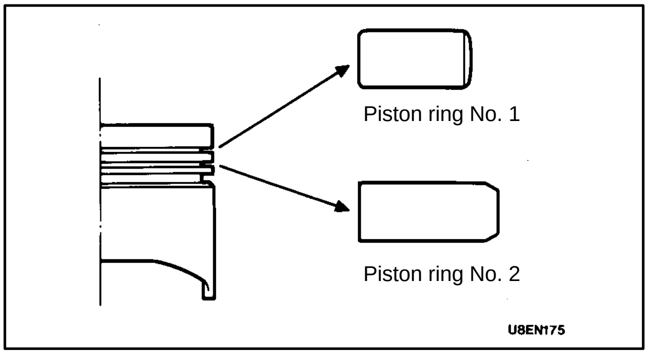


Figure 210

4. Apply an ample amount of engine oil to piston outside surfaces, piston rings and oil ring. Position piston rings and oil ring (side rails and spacer) end gaps as shown.

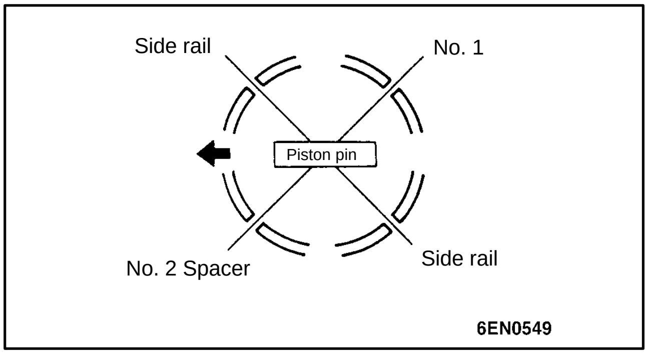


Figure 211

5. Insert piston and connecting rod assembly into cylinder, working from cylinder top surface. Make sure front mark (arrow) stamped on piston top surface faces the camshaft sprocket side.

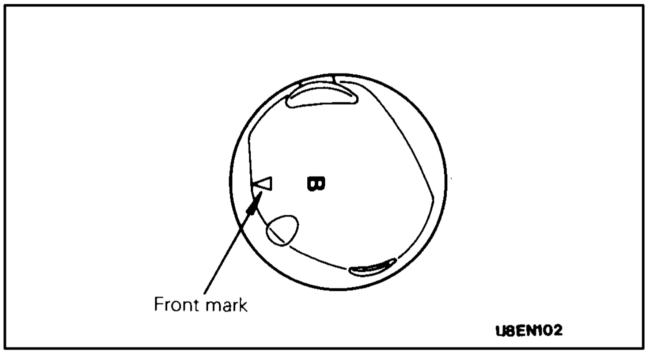


Figure 212

6. Use a ring compressor tool to compress the piston rings and carefully insert piston and connecting rod assembly into cylinder.

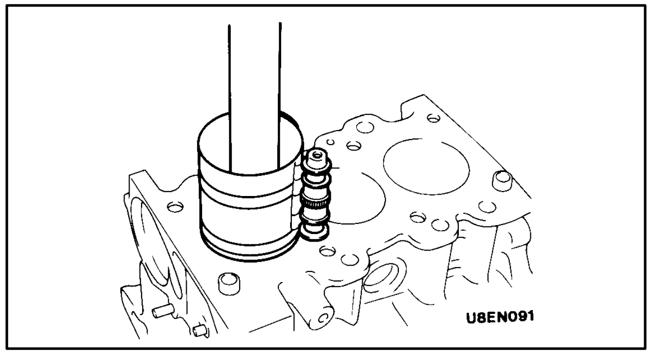


Figure 213

7. Install connecting rod bearing cap, aligning it with mark made during disassembly. If connecting rod is new and has no alignment mark, install it so notches for locking bearing are on the same side as shown.

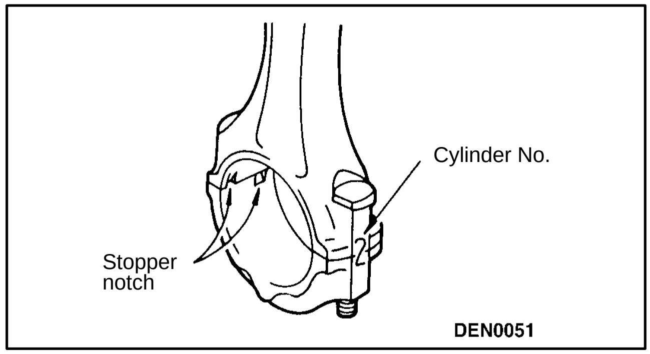


Figure 214

8. Check connecting rod thrust clearance. Replace connecting rod if thrust clearance exceeds the limit.

Standard value	0.10 – 0.25 mm (.0039 – .0098 in.)
Limit	.04 mm (.016 in.)

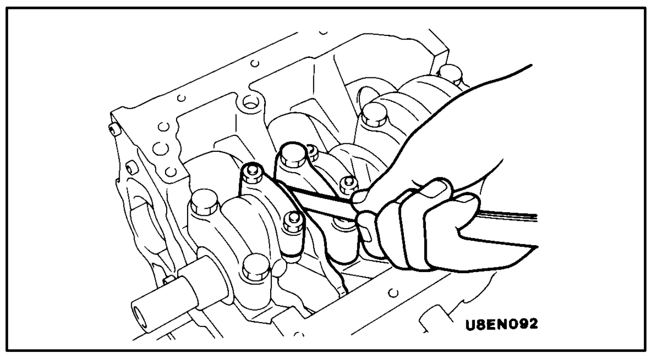


Figure 215

Oil Pump

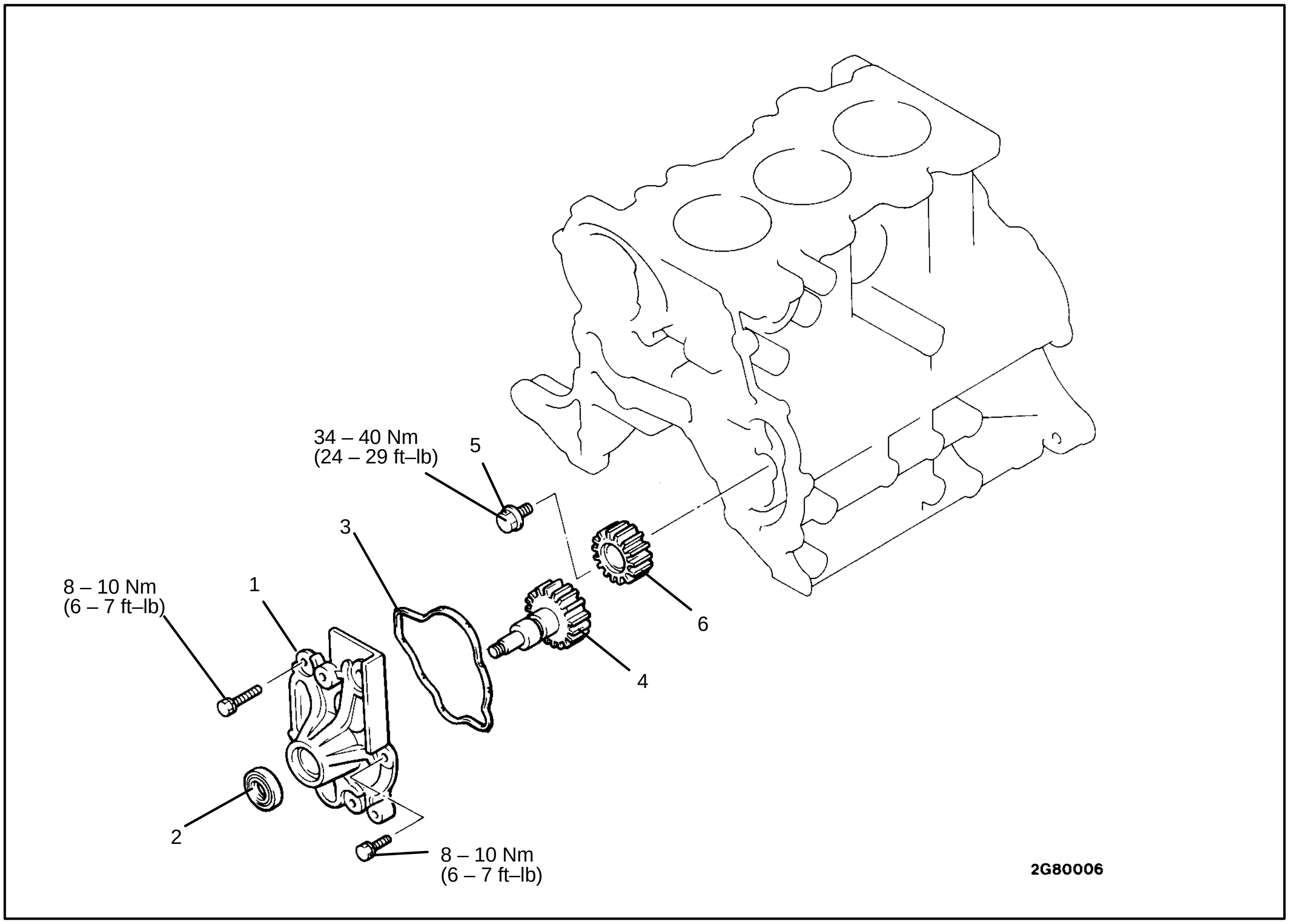


Figure 216

1. Oil pump cover	**3. Oil pump cover gasket**	**5. Flange bolt**
2. Oil pump oil seal	**4. Oil pump drive gear**	**6. Oil pump driven gear**

Disassemble and assemble parts as shown in illustration above. Also use the following instructions for specific points of disassembly, inspection and reassembly.

Removing Oil Pump

1. Remove plug on left side of cylinder block. Insert a 8 mm (.31 in.) diameter rod into hole to act as a stopper for the counterbalance shaft. Remove the flange bolt.

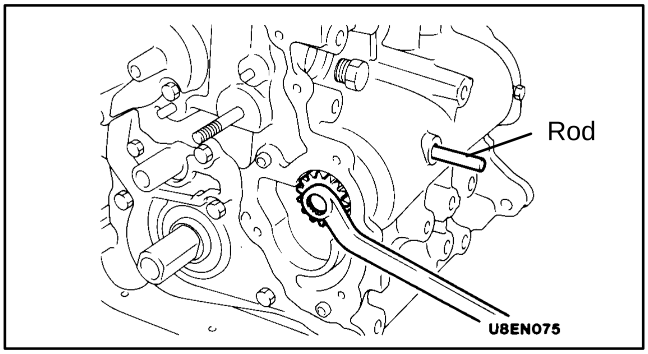


Figure 217

Oil Pump Inspection

1. Fit oil pump gear into cylinder block, then use a feeler gauge to check clearance with body at points shown.

Driven gear	A	0.410 – 0.675 mm (.0161 – .0266 in.)
	B	0.130 – 0.175 mm (.0051 – .0069 in.)
Drive gear	C	0.440 – 0.175 mm (.0173 – .0276 in.)
	D	0.150 – 0.195 mm (.0059 – .0077 in.)

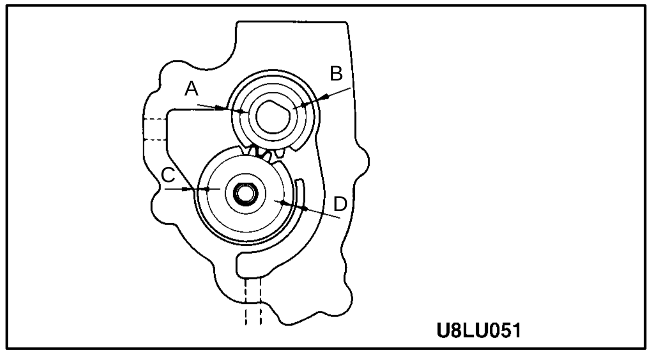


Figure 218

2. Use a straight edge and feeler gauge to check side clearance at points shown.

Driven gear	0.06 – 0.12 mm (.0024 – .0047 in.)
Drive gear	0.07 – 0.14 mm (.0027 – .0055 in.)

3. There should be no uneven wear on contact surfaces of cylinder block or pump gear side of oil pump cover.

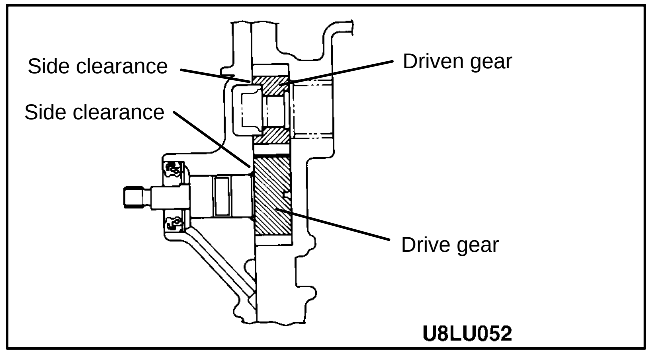


Figure 219

Oil Pump Installation

1. Apply engine oil to oil pump driven gear and install it on counterbalance shaft so timing mark is in position shown.

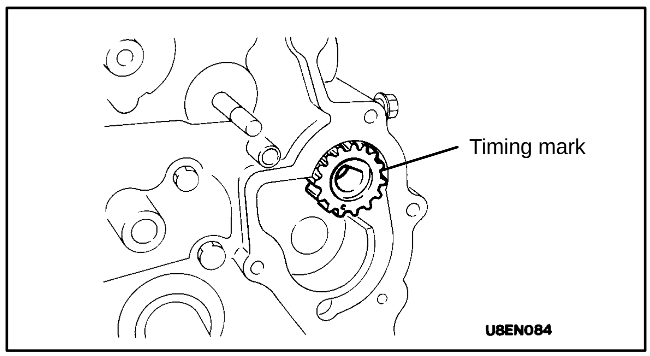


Figure 220

2. Remove plug on left side of cylinder block and insert a 8 mm (.31 in.) diameter rod into hole to act as a stopper for counterbalance shaft. Tighten flange bolt to specified torque.

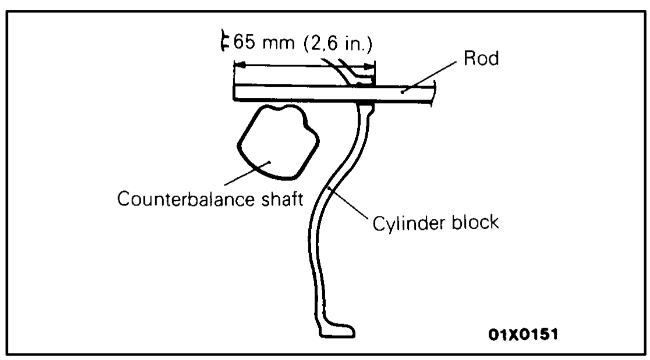


Figure 221

3. Align timing marks, then install oil pump drive gear.

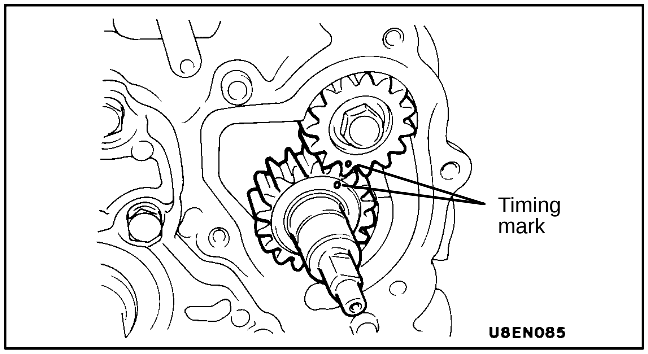


Figure 222

4. Install a new oil pump cover gasket into groove of oil pump cover. Install gasket with flat side toward oil pump cover.

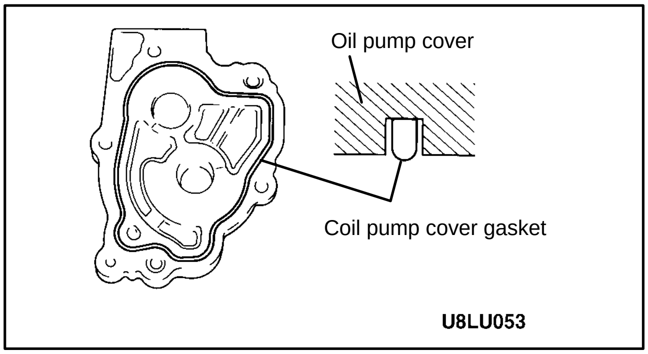


Figure 223

5. Press oil seal into oil pump cover so it is flush with the surface.

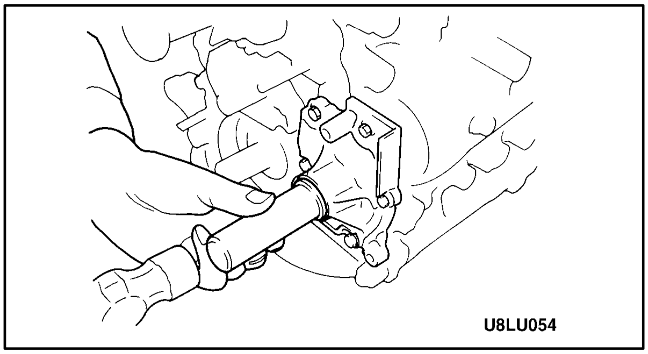


Figure 224

Crankshaft and Flywheel

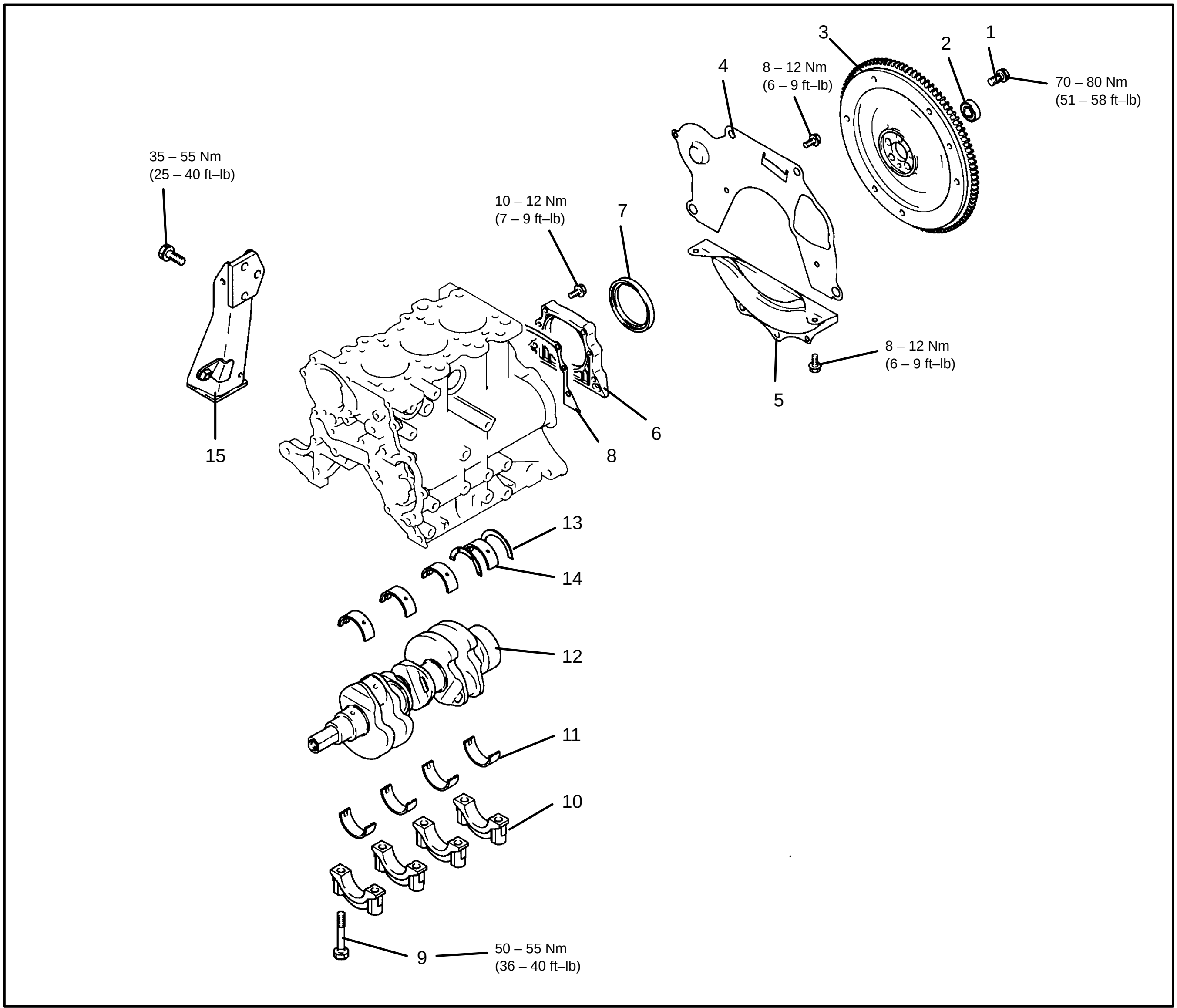


Figure 225

1. Flywheel bolt	**6. Oil seal case**	**11. Crankshaft bearing (lower)**
2. Ball bearing	**7. Oil seal**	**12. Crankshaft**
3. Flywheel assembly	**8. Oil seal gasket**	**13. Thrust bearing**
4. Rear plate	**9. Bearing cap bolt**	**14. Crankshaft bearing (upper)**
5. Bell housing cover	**10. Bearing cap**	**15. Engine support bracket**

Disassemble and assemble parts as shown in illustration above. Also use the following instructions for specific points of disassembly, inspection and reassembly.

1. Use a locking tool to prevent the flywheel from turning, then remove the flywheel.

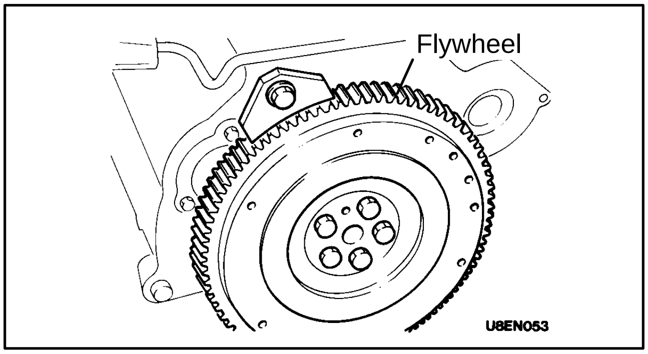


Figure 226

Crankshaft Inspection

1. Inspect crankshaft journal and pin areas for streaking or seizure. Measure outside diameter of journal and inside diameter of main bearing. If clearance exceeds the limit replace main bearing. If installing new bearing does not reduce clearance to within service limit, crankshaft must be reground and undersize bearings installed.

Standard value	0.021 – 0.045 mm (.0008 – .0018 in.)
Limit	0.1 mm (.004 in.)

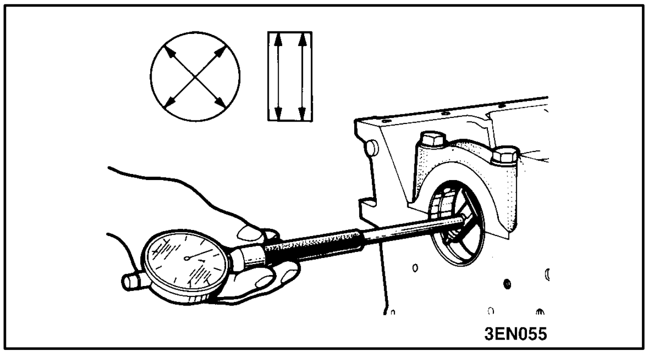


Figure 227

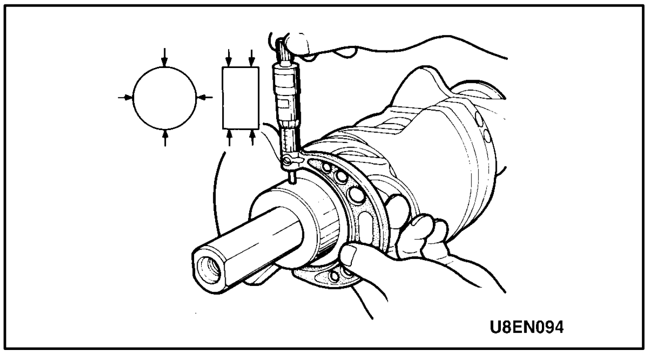


Figure 228

When grinding crankshaft to undersize, note ”R” dimensions of fillets on journal and pin areas.

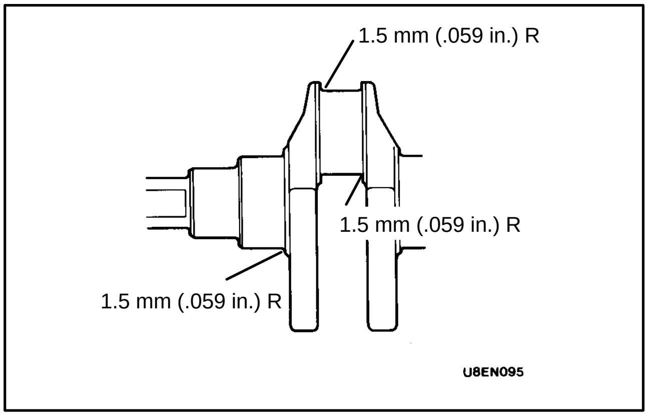


Figure 229

Liquid Cooled Gas Engine

NOTE: Crankshaft oil clearance can be measured by using a plastic gauge as follows:

A. Remove oil, grease and any other foreign material from crankshaft journal and bearing inner surface.

B. Install the crankshaft.

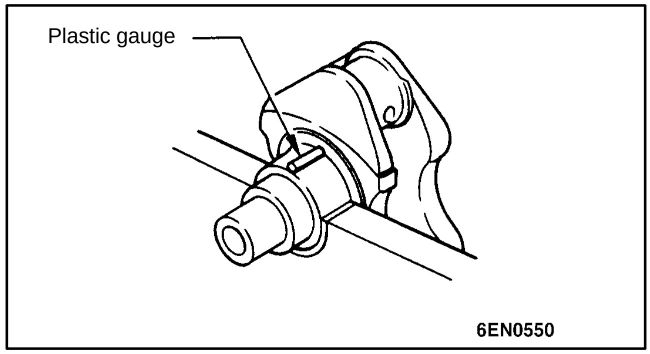


Figure 230

C. Cut plastic gauge to same length as width of bearing and put it on journal in parallel with its axis.

D. Gently put main bearing cap over plastic gauge and tighten bolts to the specified torque. DO NOT rotate connecting rod or crankshaft when plastic gauge is installed.

E. Remove bolts and gently remove main bearing cap.

F. Measure width of smashed plastic gauge (at its widest section).

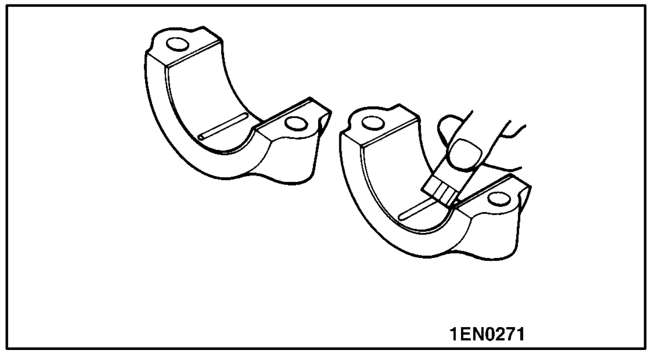


Figure 231

Rear Oil Seal Inspection

1. Check rear oil seal for wear, damage or hardening. Replace rear oil seal if necessary. It is recommended that you install a new rear oil seal when rebuilding the engine.

Flywheel and Ring Gear Inspection

1. Check ring gear teeth for wear or damage and replace ring gear if necessary. If ring gear teeth are damaged or broken, check starter motor pinion. To replace ring gear, strike ring gear at several points on out circumference. Install ring gear, then heat ring gear to 260 – 280°C (500 – 536°F) for shrink fit.

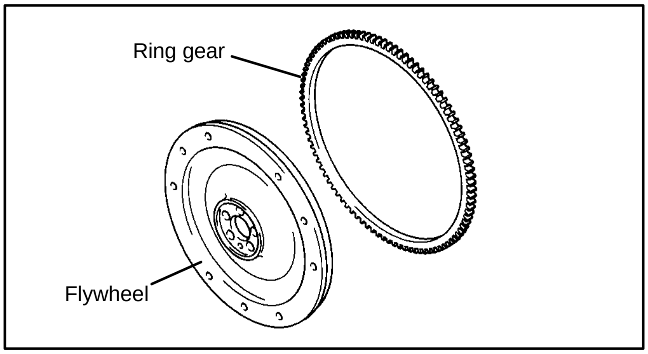


Figure 232

2. Inspect flywheel clutch disk surface for stepped wear, streaking or seizure and replace if necessary. Check flywheel runout and replace if runout exceeds the limit.

Flywheel runout limit	0.13 mm (.005 in.)

3. Check ball bearing for smooth rolling and noise. Check (sealed) bearing for grease leakage. Replace bearing if necessary.

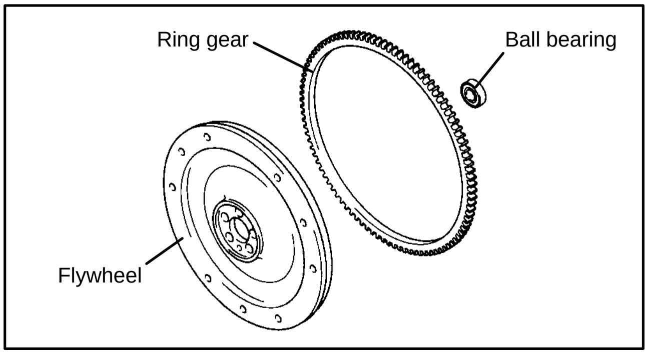


Figure 233

Crankshaft Reassembly

1. When installing crankshaft bearings note that there is an oil groove in the upper bearing and no oil groove in the lower bearing.

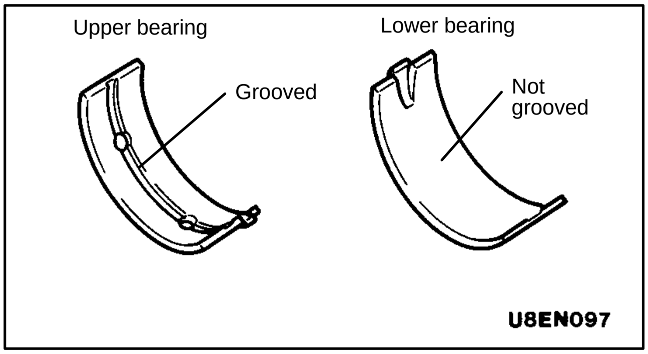


Figure 234

2. Install thrust bearing so oil groove faces out.

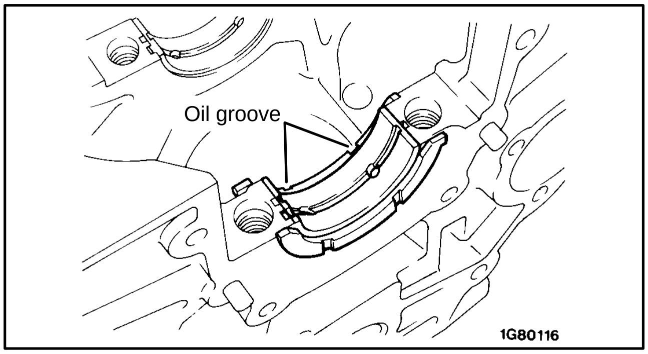


Figure 235

3. When installing bearing cap, note cap No. and arrow mark. Tighten capscrews to the specified torque. Make sure crankshaft turns freely.

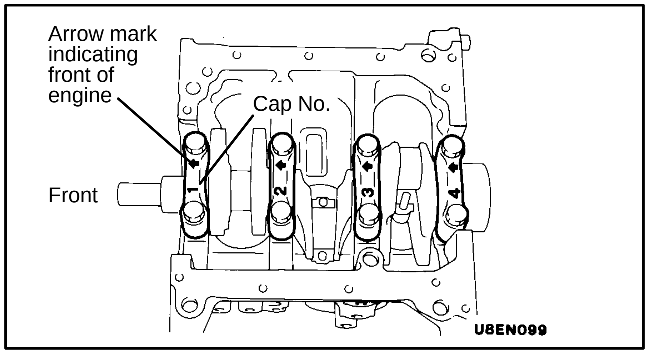


Figure 236

4. Push crankshaft rearward, then insert a feeler gauge in gap between crankshaft journal side surface and thrust bearing end surface to measure end play.

Standard value	0.05 – 0.25 mm (.0020 – .0098 in.)
Limit	0.3 mm (.012 in.)

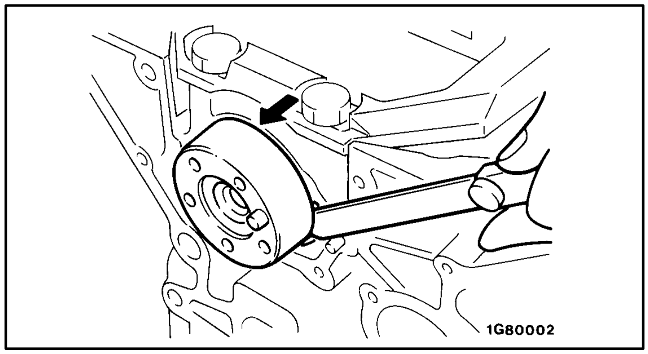


Figure 237

5. Use special tool to press oil seal into oil seal case.

6. Apply engine oil to oil seal lip and install oil seal case into cylinder block through the gasket.

IMPORTANT: Be careful when installing oil seal case to prevent damage to seal. Make sure oil seal lip is not turned up.

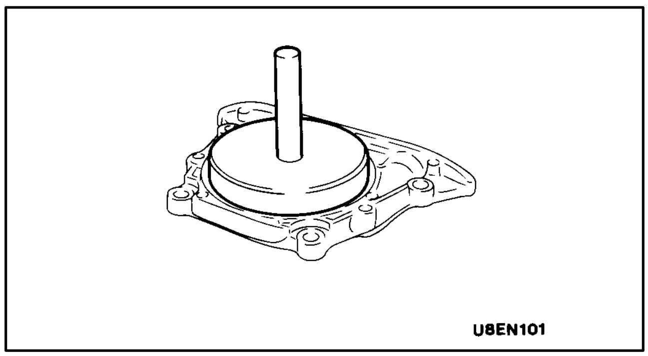


Figure 238

7. Lock flywheel and tighten bolts to the specified torque.

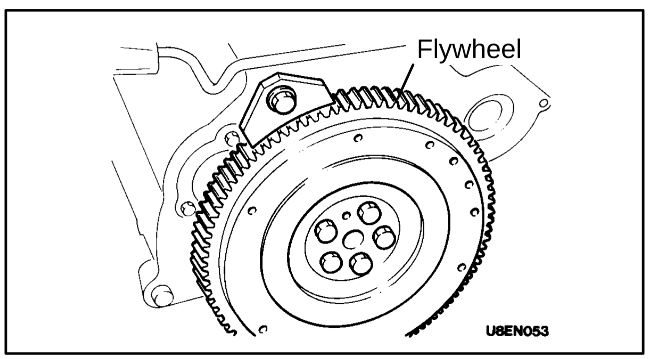


Figure 239

Cylinder Block

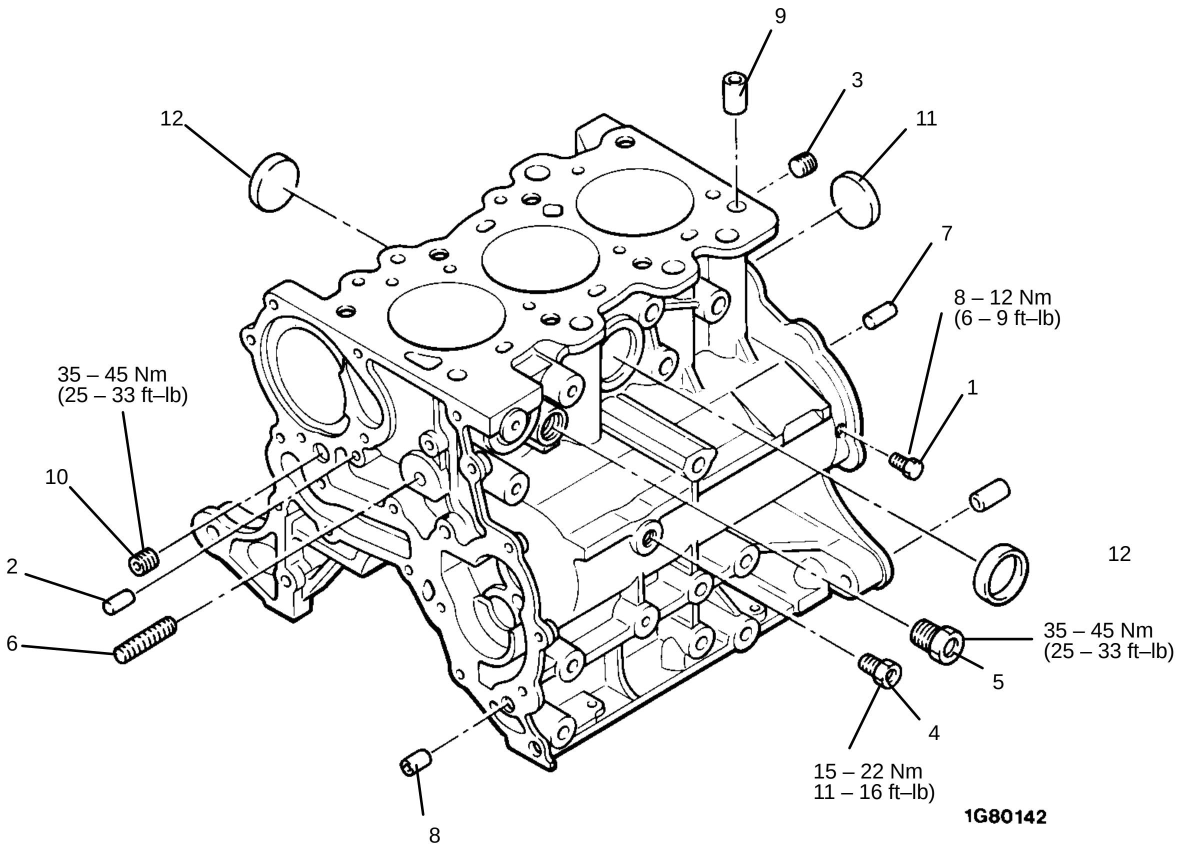


Figure 240

1. Taper plug	**6. Stud**	**11. Sealing cap**
2. Dowel pin	**7. Dowel pin**	**12. Sealing cap**
3. Plug	**8. Knock bushing**	**13. Cylinder block**
4. Taper plug	**9. Knock bushing**	
5. Water drain plug	**10. Taper plug**	

Disassemble and assemble parts as shown in illustration above. Also use the following instructions for specific points of disassembly, inspection and reassembly.

1. Before cleaning, check cylinder block for evidence of coolant leaks, oil leaks or damage. Clean all parts to remove dirt, oil, carbon deposits and water scale. Make sure no coolant or oil holes are blocked.

2. Use a straight edge and feeler gauge to measure flatness of cylinder head mating surface. If measurement exceeds the limit correct by grinding or replace.

3. Use a cylinder gauge to measure inside diameter of cylinder in six (6) locations as shown. Calculate difference between maximum and minimum values (cylindricity). If there is excessive wear or damage, rebore or replace cylinder block.

Standard value	
Cylindricity	0.01 mm (.0004 in.) or less
Cylinder diameter	65.00 – 65.03 mm (2.5591 – 2.5602 in.)
Limit	
Cylindricity	.02 mm (.0008 in.)

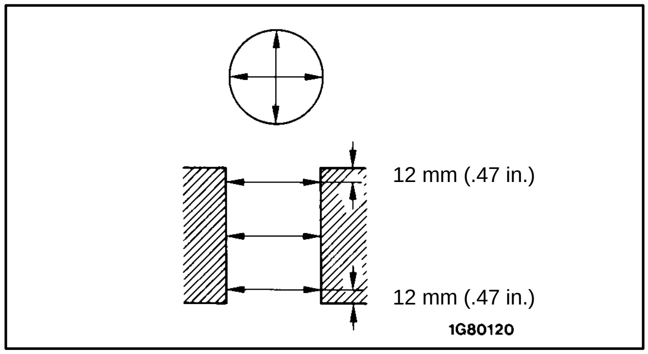


Figure 241

4. Calculate difference between minimum inside diameter in the thrust direction and outside diameter of piston at place shown in illustration. If difference is outside the standard value re–bore the cylinders and use oversize pistons and rings.

Standard value	0.02 – 0.04 mm (.0008 – .0016 in.)

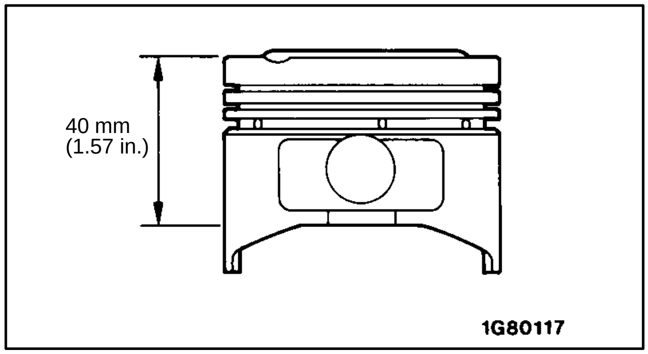


Figure 242

Cylinder Re–boring

1. Use cylinder with maximum inside diameter and most extensive damage as a base and select an over–size (O.S.) piston.

2. Calculate cylinder boring dimension from outside diameter (at correct measuring location) of O.S. piston selected.

Boring dimension = (piston outside diameter) + (piston clearance) – (honing value: 0.02 mm [.0008 in.])

O.S. piston outside diameters and cylinder inside diameters (reference) mm (in.)			
Size	Mark	Outside diameter of piston	Inside diameter of cylinder
0.25 O.S.	25	65.22 – 65.25 (2.5677 – 2.5689)	65.26 – 65.27 (2.5693 – 2.5697)
0.50 O.S.	50	65.47 – 65.50 (2.5776 – 2.5787)	65.51 – 65.52 (2.5791 – 2.5795)
0.75 O.S.	75	65.72 – 65.75 (2.5874 – 2.5886)	65.76 – 65.77 (2.5890 – 2.5894)
1.00 O.S.	100	65.97 – 66.00 (2.5972 – 2.5984)	66.01 – 66.02 (2.5988 – 2.5992)

3. Bore cylinder until diameter is at value calculated.

4. Hone cylinder to cylinder boring dimension.

5. Check cylindricity and piston clearance again.

Lubrication System Repair

Oil Screen, Dipstick and Oil Filter

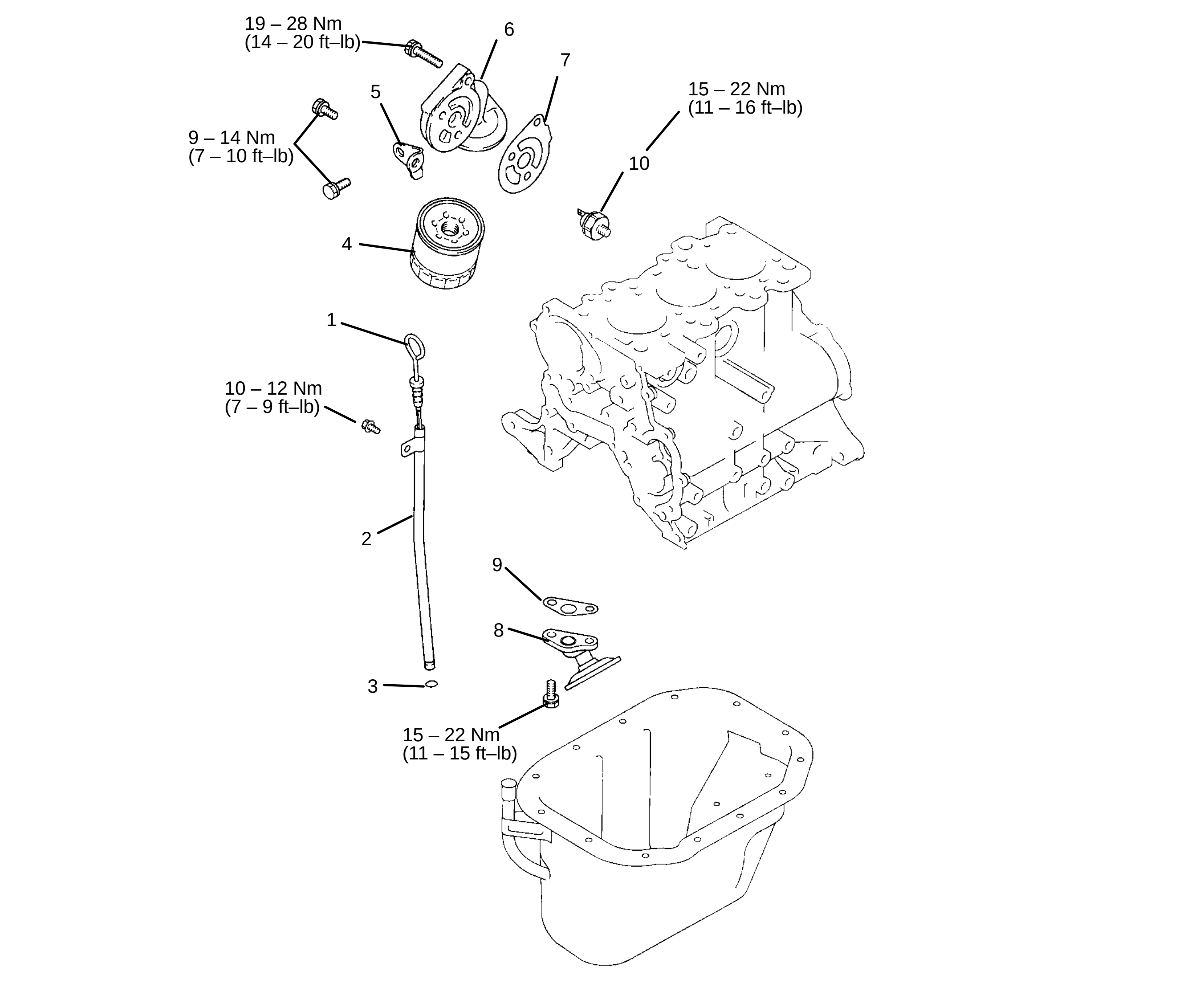


Figure 243

1. Oil level gauge
2. Oil level gauge guide
3. O–ring
4. Oil filter
5. Oil filter bracket stay
6. Oil filter bracket
7. Oil filter bracket gasket
8. Oil screen
9. Oil screen gasket
10. Oil pressure switch

Disassemble and assemble parts as shown in illustration above. Also use the following instructions for specific points of disassembly, inspection and reassembly.

Chapter 4

Mitsubishi Engine (Workman S/N Below 220000001)

Liquid Cooled Diesel Engine

Table of Contents

Liquid Cooled Diesel Engine

General Information

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 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.

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

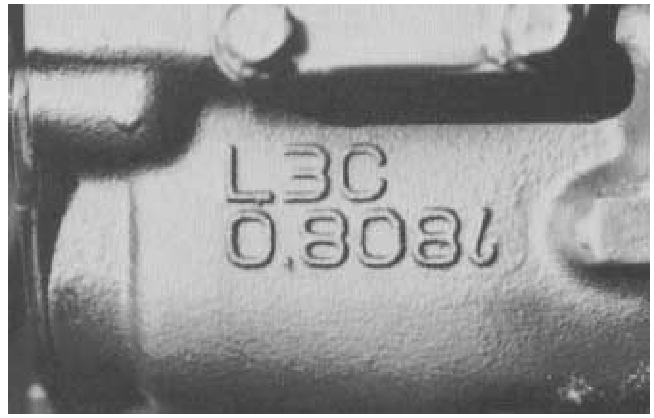


Figure 1a

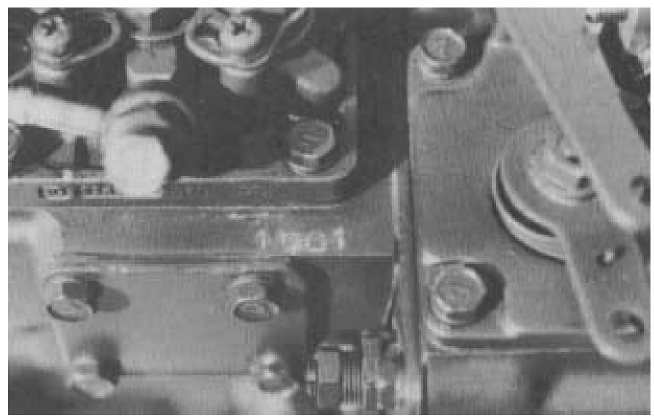


Figure 1b

Specifications

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

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

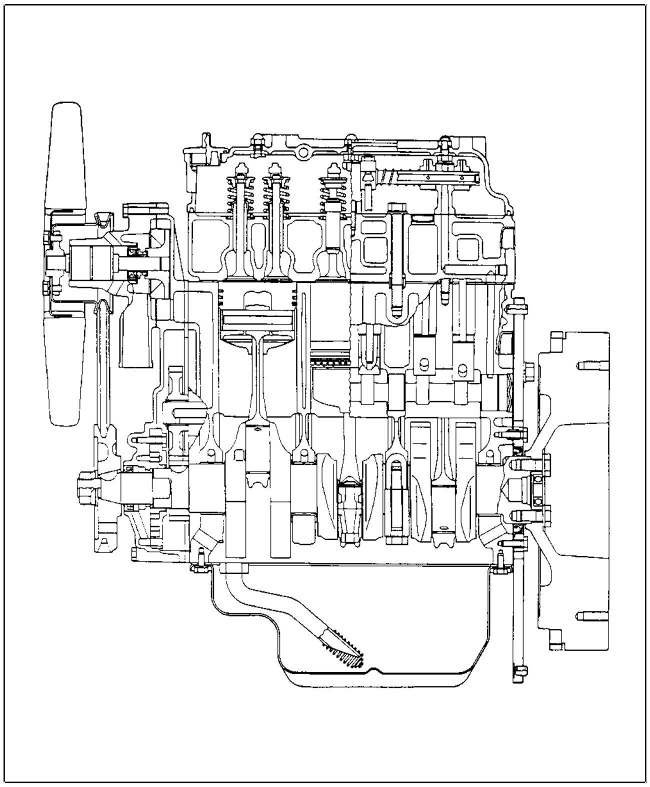


Figure 2a

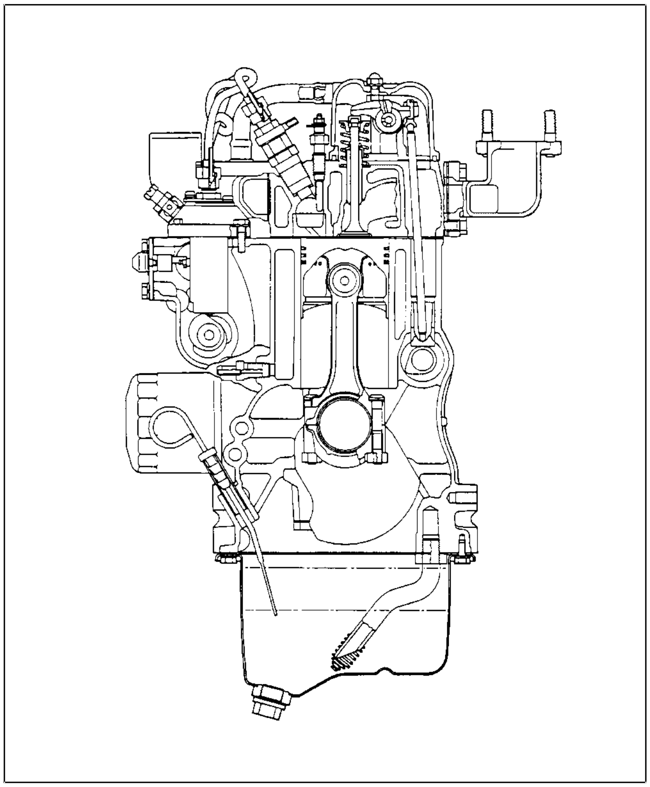


Figure 2b

General

Item	Specification
Make/Designation	Mitsubishi L3Ca-62TG or L3Ea-62TG, overhead valve, vertical in-line, 4 cycle diesel
Combustion Chamber	Swirl chamber type
Number of Cylinders	3
Bore x Stroke L3Ca-62TG L3Ea-62TG	 70 x 70 mm (2.76 x 2.76 in.) 76 x 70 mm (2.99 x 2.76 in.)
Total Displacement L3Ca-62TG L3Ea-62TG	 808 cc (49.3 $in.^3$) 952 cc (5.1 $in.^3$)
Compression Ratio	23:1
Firing Order	1 - 3 - 2
Dry Weight (approximate)	75 kg (165 lb.)
Fuel	Diesel
Fuel Injection Pump	Bosch type NC
Governor	Centrifugal weight type
Fuel Injector Nozzle	Throttle type
Fuel Injection Pressure	(140 kg/cm^2) 1990 psi
Lubrication System	Forced lubrication
Oil Pump	Gear type
Oil Filter	Paper element filter (full flow type)
Crankcase Oil Capacity: including filter of 0.5 liter (0.6 qt.) capacity - FULL / LOW	 3.6 / 1.8 liter (3.8 / 1.9 qt.)
Cooling System	Forced circulation, water cooling
Water Pump	Centrifugal type
Cooling System Capacity Engine Only Total System (approximate)	 1.8 liter (1.9 qt.) 4.3 liter (4.5 qt.)
Starter	Solenoid shift type 1.6 kW (12 volt)
Alternator	AC type 12 volt 40A
Glow Plug	Sheathed type

Engine

Item	Standard Specification	Repair Limit	Service Limit
Governor	Mechanical/Centrifugal		
High Idle (no load)	3600 rpm		± 50 rpm
Idle Speed (no load)			
L3Ca-62TG	1500 rpm		± 50 rpm
L3Ea-62TG	1600 rpm		± 50 rpm
Compression	28 kg/cm^2 (398 psi) at 280 rpm	25 kg/cm^2 (356 psi)	22 kg/cm^2 (313 psi)
Pressure Difference Between Cylinders	2.5 kg/cm^2 (36 psi) max.		
Cylinder Injection Order	1 - 3 - 2		
Injection Timing	19^o B.T.D.C. (at smoke set position) ± 1.5^o	19^o ± 2^o	
Cylinder Head			
Bottom Surface Flatness (distortion)	Within 0.05 mm (0.002 in.)	0.1 mm (0.004 in.)	
Valve Guide I.D.	6.6 mm (0.26 in.)		
Valve Seat Angle	45^o		
Valve Seat Width	1.3 - 1.8 mm (0.051 - 0.071 in.)	2.5 mm (0.1 .in.)	
Valve Seat Sinkage			–1 mm (– 0.039 in.)
Valve Clearance (cold) (both intake and exhaust)	0.25 mm (0.01 in.)		
Valves			
Valve Head Dia. (IN)	26.7 mm (1.051 in.)		
Valve Head Dia. (EX)	24.7 mm (0.972 in.)		
Overall Length	94 mm (3.701 in.)		
Valve Stem O.D.	6.6 mm (0.260 in.)		
Stem to Guide Clearance (IN)			0.10 mm (0.004 in.)
Stem to Guide Clearance (EX)			0.15 mm (0.006 in.)
Valve Seat Face Angle	45^o		
Valve Head Thickness (margin width)	1 mm (0.039 in.)		0.5 mm (0.020 in.)
Valve Head Sinkage (from cyl. head bottom face)	0.5 mm (0.020 in.)		1.5 mm (0.06 in.)
Valve Spring			
Free Length	40.5 mm (1.595 in.)	39.3 mm (1.547 in.)	
Installed Load/Height (IN)	5.94 kg/35.5 mm (13.1 lb./1.4 in.)		–15%
Installed Load/Height (EX)	14.84 kg/28 mm (32.7 lb./1.1 in.)		–15%
Squareness	3^o		3^o
Rocker Arm I.D.	12 mm (0.472 in.)		
Rocker Arm to Shaft Clearance			0.2 mm (0.008 in.)
Cylinder Block			
Cylinder Bore			
L3Ca-62TG	70 mm (2.7559 in.)	+0.2 mm (0.0079 in.)	+0.45 mm (0.0177 in.)
L3Ea-62TG	76 mm (2.9921 in.)	+0.2 mm (0.0079 in.)	+0.45 mm (0.0177 in.)
Tolerance on Oversize Cylinder Bore	Each Oversize 0 to 0.03 mm (0.001 in.)		
Taper	Within 0.01 mm (0.0004 in.)		
Gasket Fitting Surface Distortion	Within 0.05 mm (0.002 in.)	0.1mm (0.004 in.)	
Camshaft Hole Diameter			
Front	42 mm (1.654 in.) (ball bearing hole)		
No. 2	33 mm (1.299 in.)		
No. 3	33 mm (1.299 in.)		
Rear	33 mm (1.299 in.)		

Engine (cont.)

Item	Standard Specification	Repair Limit	Service Limit
Piston			
Type	Solid		
Material	Aluminum alloy		
Piston Outside Diameter (skirt end)			
L3Ca-62TG	70 mm (2.756 in.)		
L3Ea-62TG	76 mm (2.992 in.)		
Piston to Cylinder Wall Clearance			0.2 mm (0.008 in.)
Oversize	0.25, 0.50 mm (0.01, 0.02 in.)		
Protrusion from cylinder block top surface	0.9 mm (0.035 in.)		
Piston Pin			
Type	Semi-floating		
Outside Diameter	18 mm (0.709 in.)		
Pin to Piston Clearance			0.08 mm (0.003 in.)
Pin to Connecting Rod Clearance	Press-fit load: 1000 ± 500 kg (2200 ± 1100 lb.)		
Piston Rings			
Number of Rings			
2 Compression	No. 1: Chrome plated, semi-keystone type No. 2: Tapered		
1 Oil	Chrome plated ring with coil expander		
Compression Ring Width	2 mm (0.079 in.)		
Oil Ring Width	3 mm (0.118 in.)		
Compression Ring Side Clearance (No. 2)	0.05 - 0.09 mm (0.002 - 0.004 in.)		0.2 mm (0.008 in.)
Oil Ring Side Clearance	0.03 - 0.07 mm (0.001 - 0.003 in.)		0.2 mm (0.008 in.)
Ring Gap	0.15 - 0.40 mm (0.006 - 0.016 in.)		1.5 mm (.060 in.)
Connecting Rod			
Type	Forged I-beam		
Bend and Twist	Within 0.05 mm (0.002 in.)		0.15 mm (0.006 in.) max.
Big End Thrust Clearance	0.1 - 0.35 mm (0.004 - 0.014 in.)		0.5 mm (0.02 in.)
Connecting Rod Bearings			
Oil Clearance			0.15 mm (0.006 in.)
Undersize	0.25, 0.50 mm (0.01, 0.02 in.)		
Crankshaft			
Type	Fully counterbalanced		
Bend	Within 0.03 mm (0.001 in.)		0.05 mm (0.002 in.)
End Play	0.05 - 0.175 mm (0.002 - 0.007 in.)		
Journal O.D.	43 mm (1.693 in.)	– 0.15 mm (– 0.006 in.)	– 0.70 mm (– 0.028 .in)
Pin O.D.	40 mm (1.575 in.)	– 0.15 mm (– 0.006 in.)	– 0.70 mm (– 0.028 .in)
Finish Undersize			
Journal U.S. 0.25 mm (0.01 in.)	42.715 - 42.730 mm (1.6817 - 1.6823 in.)		
Journal U.S. 0.50 mm (0.02 in.)	42.465 - 42.480 mm (1.6719 - 1.6724 in.)		
Pin U.S. 0.25 mm (0.01 in.)	39.715 - 39.730 mm (1.5636 - 1.5642 in.)		
Pin U.S. 0.50 mm (0.02 in.)	39.465 - 39.480 mm (1.5537 - 1.5543 in.)		
Main Bearings			
Oil Clearance			0.10 mm (0.004 in.)
Undersize	0.25, 0.50 mm (0.01, 0.02 in.)		

Engine (cont.)

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

Lubrication System

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

Fuel System

Item	Standard Specification	Repair Limit	Service Limit
Fuel Pump Delivery Rate	225 cc (13.73 in^3) or more (15 sec., 12V)		
Fuel Injection Pump Model Injection Timing (B.T.D.C.)	 ND-PFR-NC $19^o \pm 1.52^o$ (at SS)	 $19^o \pm 2^o$	
Nozzles Type Injection Start Pressure	 Throttle type 140 kg/cm^2 (1991 psi)	 140 $^{+10}/_{-0}$ kg/cm^2 (1991 $^{+142}/_{-0}$ psi)	

Governor System

Item	Standard Specification	Repair Limit	Service Limit
Type	Centrifugal weight type		

Cooling System

Item	Standard Specification	Repair Limit	Service Limit
Coolant Capacity Engine Only Total System (approximate)	 1.8 liter (1.9 qt.) 4.3 liter (4.5 qt.)		
Thermostat Valve Cracking Temperature	 88° C (190° F)		

Electrical System

Item	Standard Specification	Repair Limit	Service Limit
Starter			
Type	Solenoid shift type		
Nominal Output	1.6 kW - 12V		
Direction of Rotation	Clockwise as viewed from pinion side		
No-load Characteristics (Cold)			
Terminal Voltage	11.5V		
Current	100A or less		
Speed	3000 rpm or more		
Load Characteristics			
Terminal Voltage	7.7 V		11.5V
Current (torque)	300A (0.98 kg/m (6.7 ft-lb) or more)		0.7 kg/m (5 ft-lb)
Speed	980 rpm or more		
Height of Brush	17 mm (0.67 in.)		6 mm (0.24 in.)
Spring Pressure	3 kg (6.6 lb.)		
Commutator O.D.	38.7 mm (1.52 in.)		– 1.0 mm (– 0.4 in.)
Depth of Commutator Undercut	0.5 mm (0.02 in.)		0.2 mm (0.008 in.)
Pinion Gap	0.5 - 2.0 mm (0.02 - 0.08 in.)		
Thrust Gap	0.5 (0.02 in.) or less		
Alternator			
Nominal Output	12V - 40A		
Direction of Rotation	Clockwise as viewed from pulley side		
Output Characteristics - Hot			
Terminal Voltage	13.5V		
Current / Speed	21A / 2500 rpm 37A/5000 rpm		
Regulated Voltage	14.7 ± 0.3V		
Glow Plugs			
Rated Voltage	10.5V DC		
Rated Current (when rated voltage is applied for 30 seconds)	9.7A ± 1.0A		
Resistance	0.16 ohm (at room temperature)		
Glow Plug Indicator			
Rated Current	29A		
Voltage Across Terminals (at 29A)	1.7V ± 0.2V		

Tightening Torque

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

Item	Size (Width across flat of hex head)	Specification
Cylinder Head Bolt,Main (Wet) Cylinder Head Bolt, Sub. (Wet)	M10 (14) M8 (12)	7.5 - 8.5 KgM (54 - 62 ft-lb) 2.0 - 3.0 Kgm (15 - 22 ft-lb)
Connecting Rod Cap Nut	M8 (14)	3.2 - 3.5 KgM (23 - 25 ft-lb)
Flywheel Bolt	M10 (17)	8.5 - 9.5 KgM (62 - 69 ft-lb)
Crankshaft Pulley Nut	M16 (24)	10.0 - 12.0 KgM (72 - 87 ft-lb)
Main Bearing Cap Bolt	M10 (17)	5.0 - 5.5 KgM (36 - 40 ft-lb)
Rocker Stay Bolt	M8 (12)	1.5 - 2.2 KgM (11 - 16 ft-lb)
Rocker Cover Nut	M6 (10)	0.5 - 0.7 KgM (4 - 5 ft-lb)
Nozzle Holder (fitting to engine)	M20 (21)	5.0 - 6.0 KgM (36 - 43 ft-lb)
Nozzle Union Collar Fixing Nut	M12 (17)	2.5 - 3.0 KgM (18 - 22 ft-lb)
Nozzle Retaining Nut	M16 (21)	3.5 - 4.0 KgM (25 - 29 ft-lb)
Fuel Injection Pipe Nut	M12 (17)	2.5 - 3.5 KgM (18 - 25 ft-lb)
Delivery Valve Holder	M16 (17)	3.5 - 3.9 KgM (25 - 28 ft-lb)
Injection Pump Hollow Screw	M10 (14)	1.0 - 1.5 KgM (7 - 11 ft-lb)
Injection Pump Air Vent Screw	M6 (10)	0.5 - 0.7 KgM (4 - 5 ft-lb)
Solenoid Locknut	M30 (36)	4.0 - 5.0 KgM (29 - 36 ft-lb)
Water Temperature Gauge Joint	M16 (23)	2.0 - 3.0 KgM (15 - 22 ft-lb)
Thermoswitch	M16 (19)	1.9 - 2.7 KgM (14 - 20 ft-lb)
Thermo Gauge Unit	M16 (17)	1.9 - 2.7 KgM (14 - 20 ft-lb)
Oil Filter	M20	1.1 - 1.3 KgM (8 - 9 ft-lb)
Oil Relief Plug	M18 (22)	4.0 - 5.0 KgM (29 - 36 ft-lb)
Oil Drain Plug	M18 (19)	5.0 - 6.0 KgM (36 - 43 ft-lb)
Glow Plug	M10 (12)	1.5 - 2.0 KgM (11 - 14 ft-lb)
Glow Plug Lead Wire Fitting Nut	M4 (7)	10 - 15 KgCM (9 - 13 in-lb)

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. 3). Mix with water and use solution to wash the Donaldson air cleaner element.

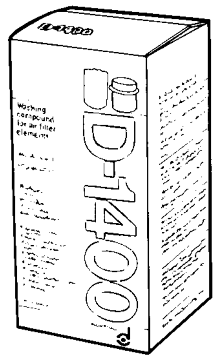


Figure 3

Diesel Engine Compression Test Kit

Diesel engine compression test kit (Fig. 5). 0-1000 PSI Gauge allows testing of diesel engines to check general operating condition of engine. Includes case, guage with hose, glow plug hole adapters and instructions.

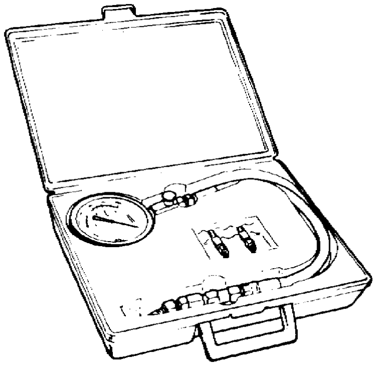


Figure 5

Piston Pin Tool

Piston pin tool (Fig. 6) is used to remove and install the wrist pin without distorting the piston. Inludes an adapter for use with Mitsubishi and most other engines.

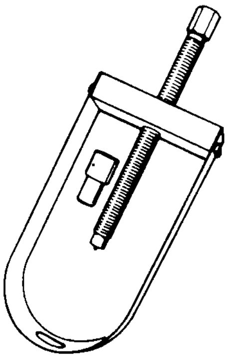


Figure 6

Nozzle Tester

Nozzle tester (Fig. 7). Tests condition and opening pressure of fuel injector nozzles.

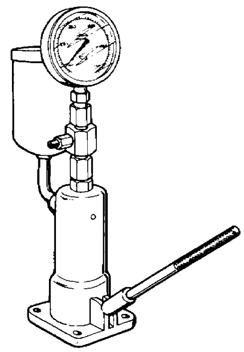


Figure 7

Nozzle Tester Adapter

Nozzle tester adapter (Fig.8) is required to test the fuel injection nozzles.

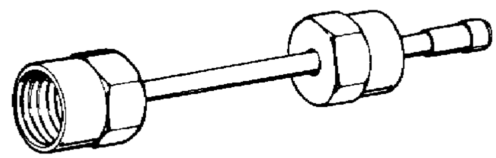


Figure 8

Valve Clearance

Check the valve clearance after the first 50 hours of operation and every 600 hours of operation after that.

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

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

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

4. Tighten the cylinder head bolts to the proper torque. The rocker assembly must be removed before tightening the cylinder head bolts. When tightening the cylinder head bolts, lower the coolant level in the engine, loosen the bolts slightly and then re-tighten in the sequence shown (Fig. 9).

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

5. Rotate the crankshaft until the TDC mark (located next to the injection timing mark(s) on the pulley lines up with the registration mark on the gear case (Fig. 10). This will be TDC on cylinder No. 1.

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

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

7. To adjust the valve clearance, loosen the adjusting lock nut and turn the rocker arm adjusting screw clockwise or counterclockwise until you get the correct clearance (Fig. 11). Tighten the locknut securely. Check to make sure that the clearance was not changed while tightening the locknut.

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

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

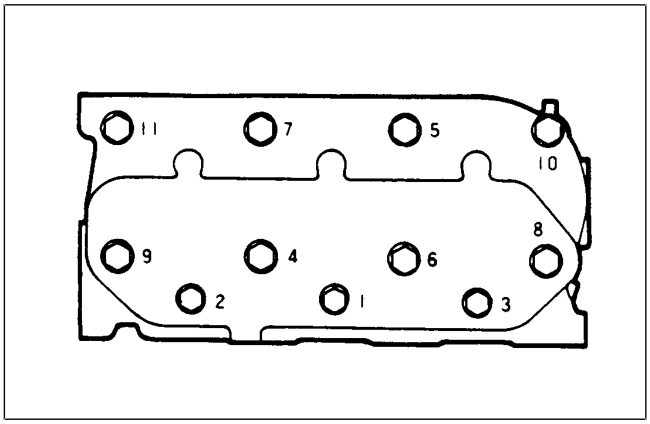


Figure 9

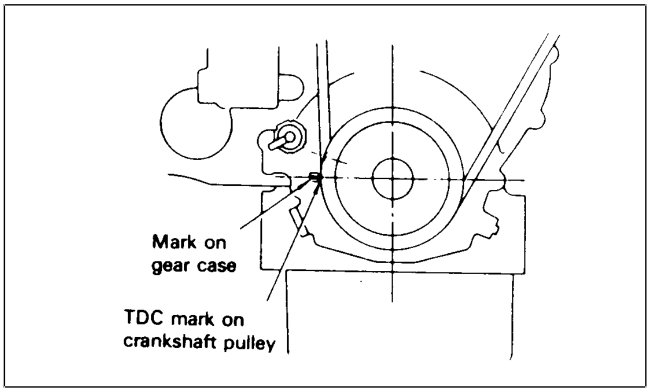


Figure 10

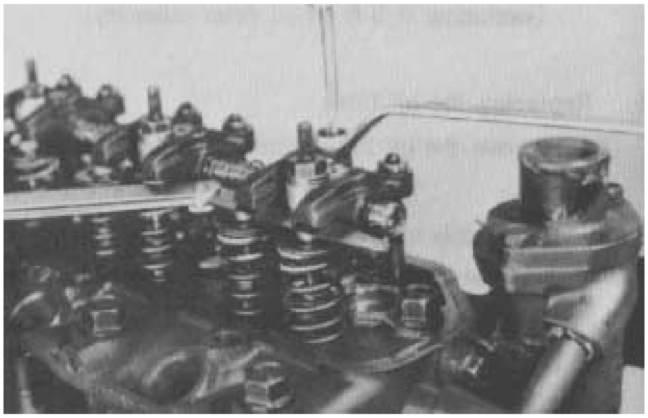


Figure 11

Liquid Cooled Diesel Engine

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.

If your machine is not equipped with the optional tachometer, use a vibration-type tachometer to set engine speed.

WARNING

Engine must be running to do these adjustments. To guard against possible personal injury, engage parking brake and keep hands, feet, face and other parts of body away from fan or other moving parts.

High Speed Adjustment

NOTE: Specified rpm is with no load on engine.

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

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

2. Loosen the lock nut on the high speed set bolt (Fig. 12).

4. Adjust maximum engine speed to 3600 ±50 rpm by rotating the high speed set bolt. Tighten the lock nut.

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

Idle Speed Adjustment

NOTE: Specified engine rpm is with no load on engine.

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

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

3. Loosen the lock nut on the low speed set bolt (Fig. 12).

4. Adjust idle speed by rotating the low speed set bolt. Tighten the lock nut.

Engine Model L3Ca-62TG: 1500 ± 50 rpm
Engine Model L3Ea-62TG: 1600 ± 50 rpm

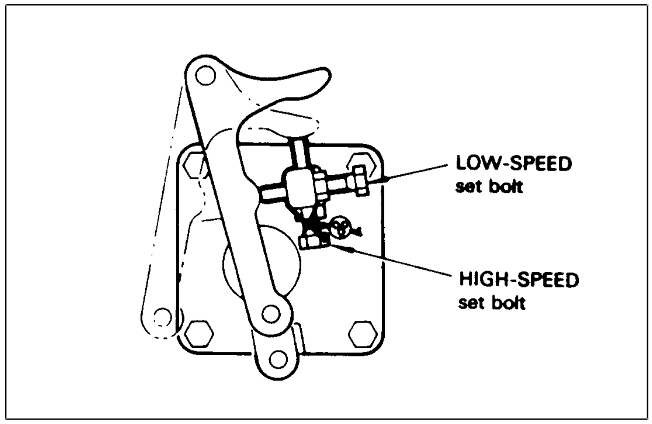


Figure 12

Accelerator Pedal Adjustment

If engine throttle lever does not contact high idle stop when accelerator pedal is fully depressed, an adjustment to the accelerator cable is required.

1. Put vehicle into position on a level surface, stop engine and engage parking brake.

NOTE: Engine must NOT be running and return spring must be attached.

2. Adjust ball joint on accelerator cable to allow 0.100 - 0.250 inch clearance between accelerator pedal and top of diamond tread floor plate, when a 25 lb. force is applied to center of pedal. Tighten locknut.

NOTE: If you cannot get proper accelerator pedal adjustment, put ball joint in another hole in engine throttle lever.

IMPORTANT: Maximum high idle speed is 3650 RPM. Do not move high idle stop bolt to get proper accelerator pedal adjustment.

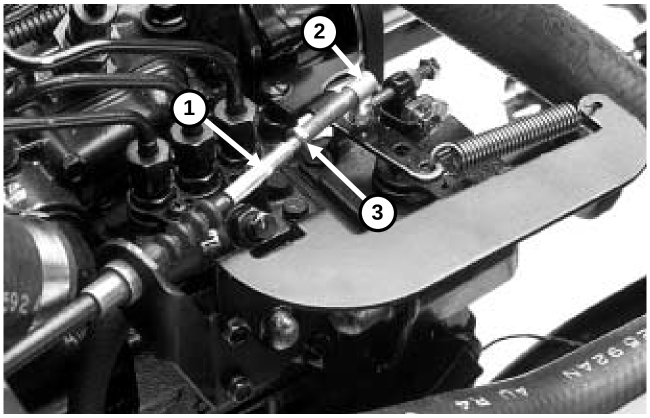


Figure 13

1. Accelerator cable
2. Ball joint
3. Locknut

Liquid Cooled Diesel Engine

Troubleshooting

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

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

(1) Engine Fails to Start

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

(1) Engine Fails to Start (continued)

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

(2) Low Power

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

(3) Excessive Oil Consumption

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

(4) Abnormal Engine Noises

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

(5) Engine Runs Rough

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

Testing

Glow Plug Test

CAUTION

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

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

2. Remove the glow plug.

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

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

4. Connect the positive (+) battery terminal to the glow plug terminal, and the negative (–) battery terminal to the plug body (Fig. 15). If the glow plug glows red-hot, the glow plug is operating correctly.

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

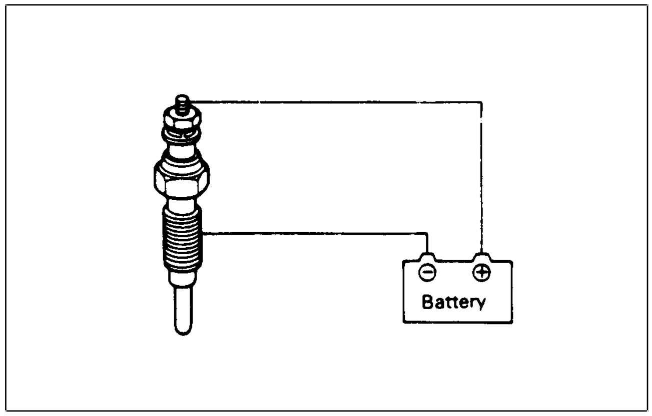


Figure 15

Compression Test

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

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

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

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

3. Connect the high pressure compression gauge to the adapter (Fig. 16).

4. Disconnect the fuel stop solenoid electrical connector to prevent fuel delivery during the compression test (Fig. 17). This will prevent wash-down of the cylinders and inaccurate readings.

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

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

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

8. Connect the fuel stop solenoid electrical connector.

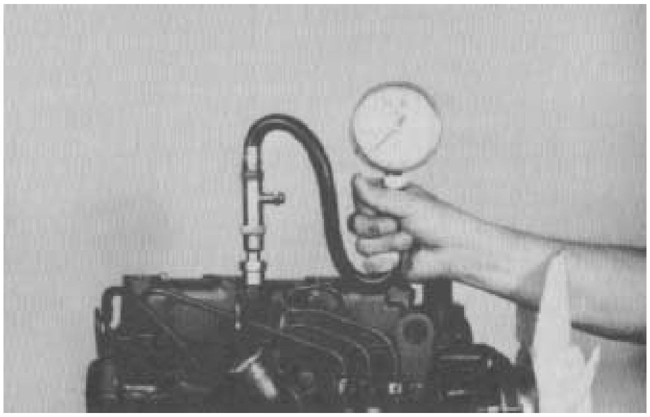


Figure 16

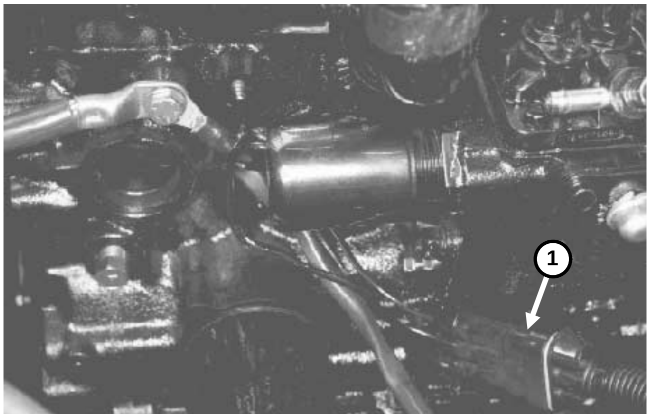


Figure 17

1. Fuel stop (ETR) solenoid electrical connector

Liquid Cooled Diesel Engine

Nozzle Tests

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

DANGER

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

CAUTION

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

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

1. Bolt the tester securely to the test bench.

2. Use a drain pan to catch fuel.

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

Injection Pressure Test

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

1. Securely fasten the nozzle to the adapter.

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

3. Allow pressure to dissipate before performing the test.

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

5. Verify that starting pressure is within the following limits: Minimum starting pressure is 140 kg/cm^2 (1991 psi); Maximum starting pressure is 150 kg/cm^2 (2134 psi).

6. Starting pressure can be adjusted by adding or removing shims from the nozzle. (See Nozzle Service in the Fuel System Repairs section of this chapter.) A 0.1 mm shim will cause a 10 kg/cm^2 (142 psi) starting pressure difference. Shims are available from 1.25 mm to 1.7 mm thick in 0.5 mm increments.

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

Chattering Test

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

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

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

Nozzle Leakage Test

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

1. Securely fasten the nozzle to the adapter.

2. Wipe all fuel from the nozzle.

3. Operate the pump until the pressure is approximately 108 kg/cm^2 (1536 psi). Maintain this pressure to the nozzle.

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

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

6. While pressure is being applied, watch for an accumulation of fuel at the tip of the nozzle (Fig. 18). A small

amount of fuel may be present due to a previous chattering test - this would be normal. If the fuel accumulates and drips down during the test (about ten seconds) the nozzle assembly is defective and must be replaced.

Spray Test

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

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

2. Observe the injector nozzle spray. The spray pattern should be finely atomized in a broad, straight stream (Fig. 19).

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

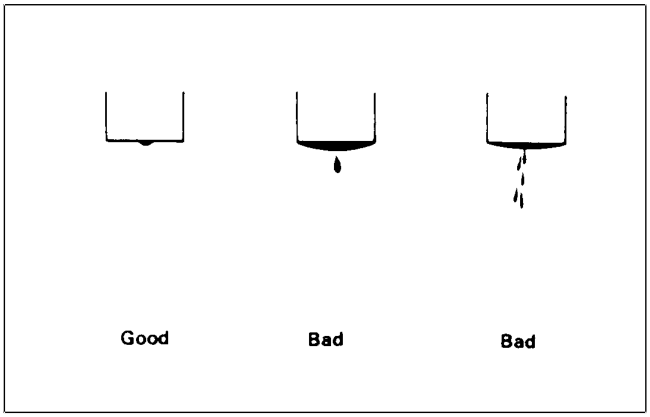


Figure 18

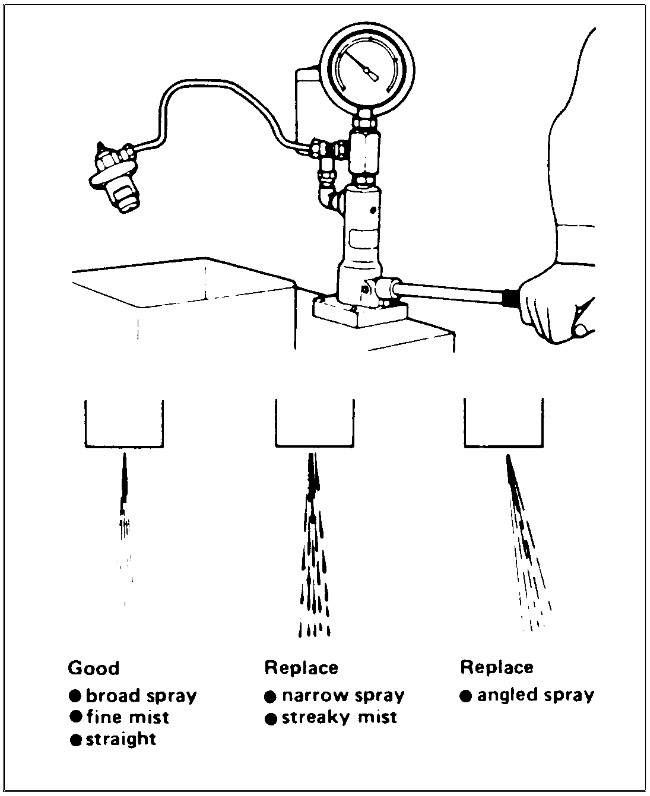


Figure 19

Injection Pump Test

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

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

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

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

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

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

B. Remove the nozzle from the cylinder head.

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

D. Push accelerator pedlal to the floor. Turn the ignition key to the START position to crank the engine. Observe the nozzle.

DANGER

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

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

5. Repeat the test for the other cylinders.

Injection Timing Test

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

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

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

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

2. Set up the injection pump for the test:

   A. Remove the delivery valve holder (Fig. 20). Remove the delivery valve and spring. The valve seat must remain in place.

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

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

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

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

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

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

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

7. Standard injection timing can be confirmed by the IT marks on the crankshaft pulley and the stationary pointer on the crankcase (Fig. 21).

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

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

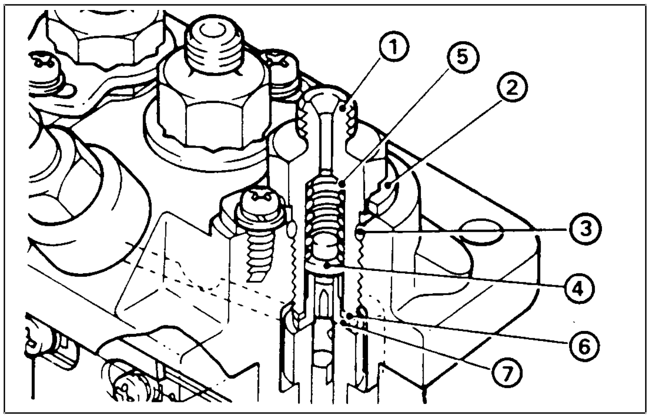


Figure 20

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

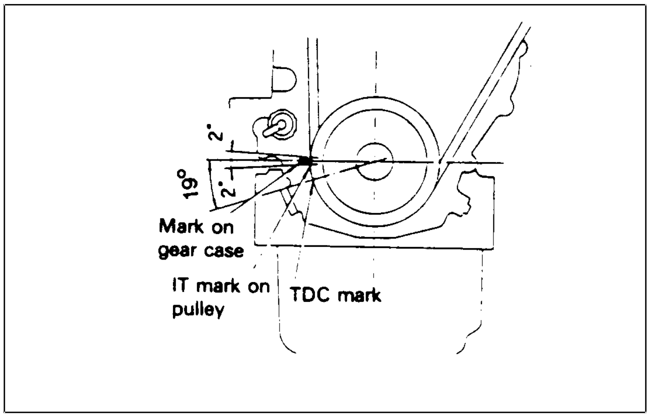


Figure 21

Fuel Pump Test

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

2. If no pumping action occurs when the ignition switch is turned on, connect a 12 volt DC battery directly to the pump (Fig. 22). If the pump now operates, check for an electrical failure of the pump circuit, eg. fuses, connections, wires, etc.

3. The delivery of the fuel pump may be checked by disconnecting the fuel lines from the water separator and fuel filter and routing them to a can of filtered diesel fuel and a drain pan (Fig. 22). Activate the pump and measure the amount of fuel pumped in during a 15 second time interval. The standard pump rate is approximately 8 ounces (225 cc) in 15 seconds.

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

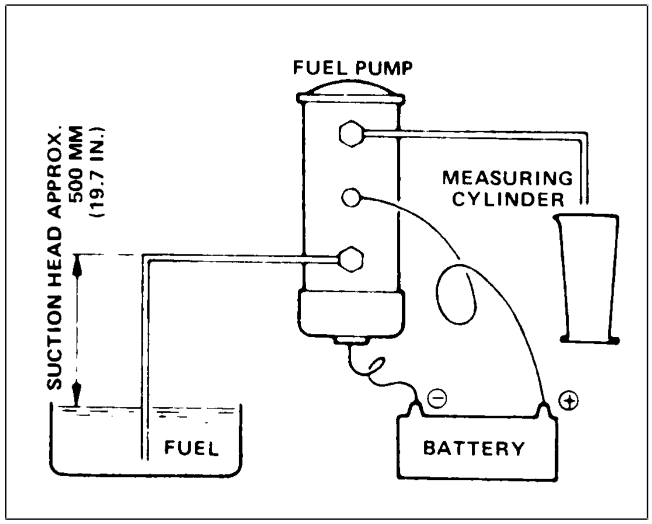


Figure 22

Thermostat Test

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

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

2. Put the thermostat in a container of water with a thermometer and heat the water (Fig. 23).

Valve cracking temperature: 88^{o} C (190^{o} F).

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

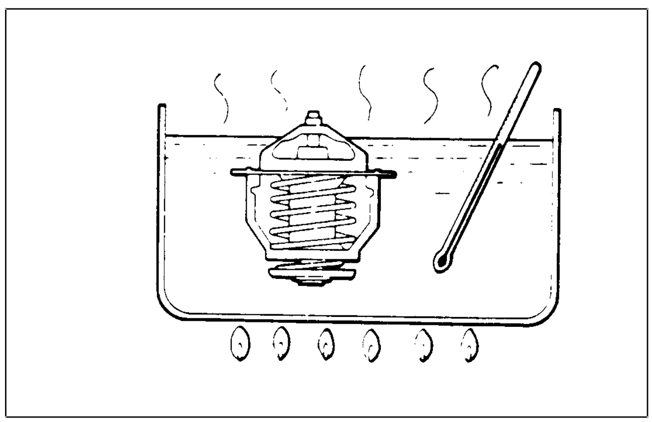


Figure 23

Fuel Stop (ETR) Solenoid

The Workman 3300-D/4300-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.

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).

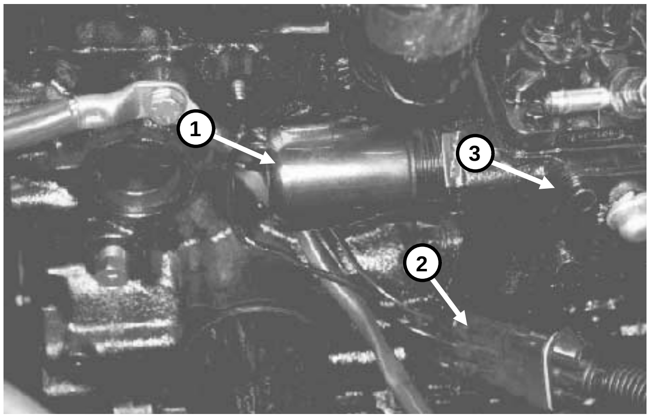


Figure 24

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

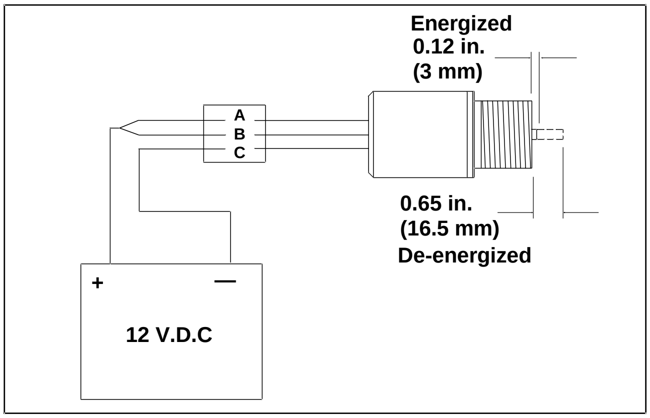


Figure 25

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.)

Engine Oil Pressure Switch

The switch is normally closed (NC) and opens with pressure.

The switch opens at approximately 8 psi.

1. Turn ignition key switch ON. Oil pressure lamp should be on.

If bulb is not on:

1. Disconnect wire from switch and touch wire to a good ground.

2. If lamp comes on, replace switch.

3. If lamp does not come on check lamp and/or wiring between lamp and switch for continuity.

If lamp is on with engine running:

1. Shut off engine immediately.

2. Check switch by disconnecting wire. Light should go out.

3. If light is still on, check for short circuit in wiring.

4. Install test gauge in engine oil pressure switch port. Start engine and check for 30 psi minimum at 1500 rpm. If engine pressure is good, replace switch. If engine pressure is low, DO NOT operate the engine.

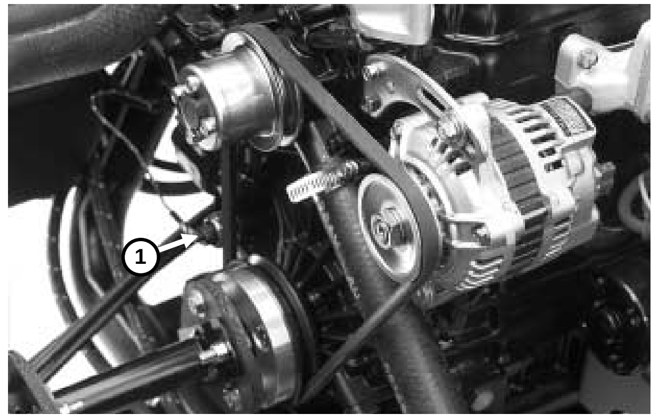


Figure 26

1. Engine oil pressure switch

Temperature Gauge Sender

1. Lower the coolant level in the engine and remove the temperature gauge sender.

2. Put the switch in a container of oil with a thermometer and heat the oil.

3. With an Ohm meter connected as shown, the following resistance readings should be indicated.

90.5 - 117.5 ohm at 160° F (70° C)
21.3 - 26.3 ohm at 207° F (115° C)

CAUTION

Handle hot oil with special care to prevent personal injury or fire.

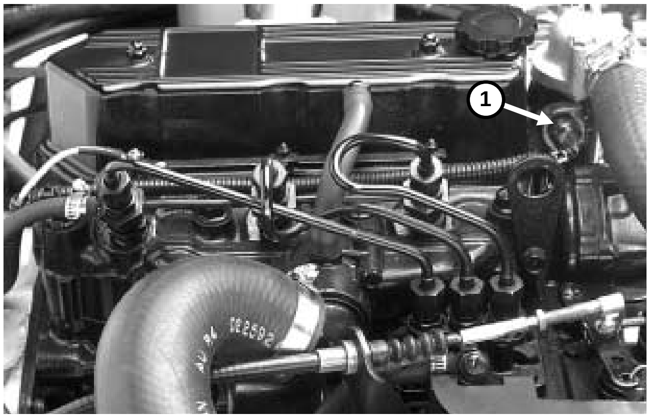


Figure 27

1. Temperature gauge sender

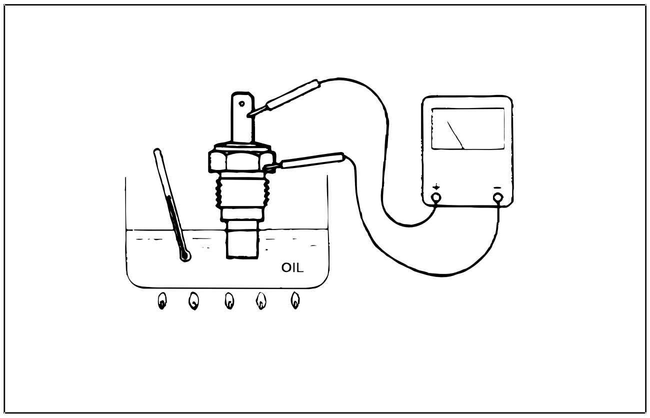


Figure 28

Checking Starter Pinion Gap

1. Install 12 volt battery between the “S” terminal and the starter body. The pinion should protrude and stop.

IMPORTANT: Never apply battery voltage to the starter for longer than 10 seconds.

2. Lightly push the pinion back and measure the return stroke (called pinion gap).

3. If the pinion gap is not within standard range of 0.5 - 2.0 mm (0.02 - 0.08 in.), adjust it by increasing or decreasing the number of packings on the magnetic switch. The gap is decreased as the number of packings increases.

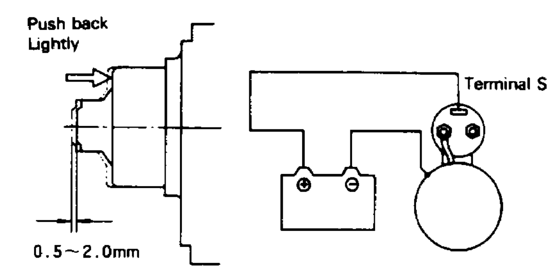


Figure 29

Starter No-Load Test

1. Connect a 12 volt battery, ammeter and voltmeter to the starter as shown.

2. When terminals “S” and “B” are connected the pinion should protrude and the starter should run smoothly.

Terminal voltage: 11.5V
Current: 100 A
Speed: 3000 rpm

No-Load Test Results

Low speed and high current draw:

- High friction (faulty bearings, bent armature shaft).
- Shorted armature.
- Grounded armature or fields.

Failure to operate with high current draw:

- Direct ground in terminals or fields.
- “Frozen” bearings.

Failure to operate with no current draw:

- Open field circuit.

Low speed and low current draw:

- Open armature coils - check commutator for badly burned bars after disassembly.

High speed and high current draw:

- Poor contact between brushes and commutator (broken brush springs, worn brushes, high insulation between commutator bars).
- High internal resistance (poor connections, damaged leads, dirty commutator or open field circuit).
- Shorted fields.

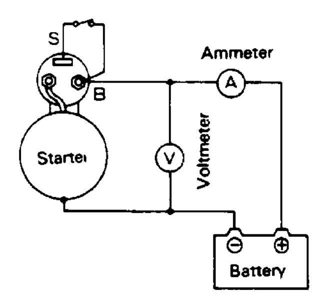


Figure 30

Magnetic Switch (Solenoid) Attraction Test

1. Disconnect the wire from terminal “M” (Fig. 31).

2. Connect a 12 volt battery to the magnetic switch terminals “S” and “M”. The pinion must protrude.

IMPORTANT: Never apply battery voltage to the starter for longer than 10 seconds.

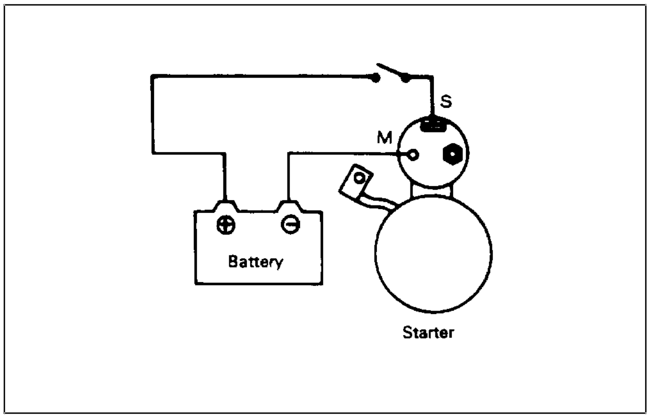


Figure 31

Magnetic Switch (Solenoid) Holding Test

1. Disconnect the wire from terminal “M”.

2. Connect a 12 volt battery to the magnetic switch terminal “S” and the starter body. Pull out the pinion fully. The pinion must remain at that position even when released.

IMPORTANT: Never apply battery voltage to the starter for longer than 10 seconds.

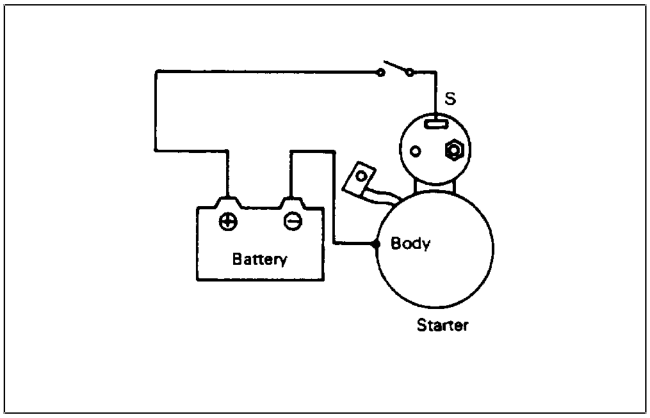


Figure 32

Magnetic Switch (Solenoid) Return Test

1. Disconnect the wire from terminal “M”.

2. Connect a 12 volt battery to the magnetic switch terminal “M” and the starter body. Pull out the pinion fully. The pinion must return to its original position when released.

IMPORTANT: Never apply battery voltage to the starter for longer than 10 seconds.

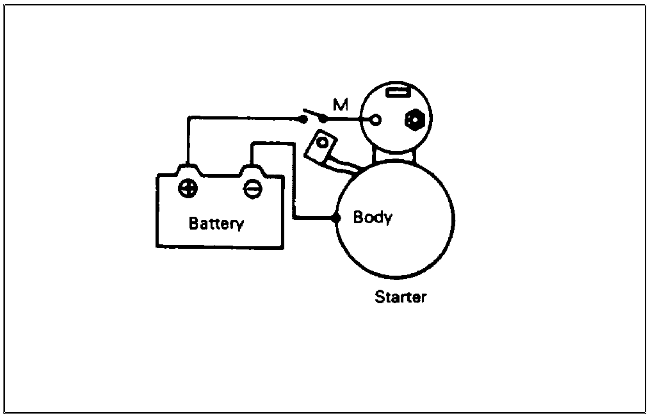


Figure 33

Alternator Regulated Voltage Test

1. Install an ammeter between the positive (+) terminal of the battery and terminal "B" of the alternator.

2. Ground alternator terminal "L" through a voltmeter.

3. Note that the voltmeter shows 0 volts when the ignition key switch is in the OFF position. The voltmeter will show voltage lower than battery voltage when the ignition key switch is in the ON position (engine not running).

4. Start the engine.

5. Run the engine with the alternator at 1300 and 2500 rpm and observe the voltmeter with all accessories OFF, Ammeter below 5 A. Regulated voltage will decrease slightly as alternator temperature increases.

Regulated voltage: 13.5 V

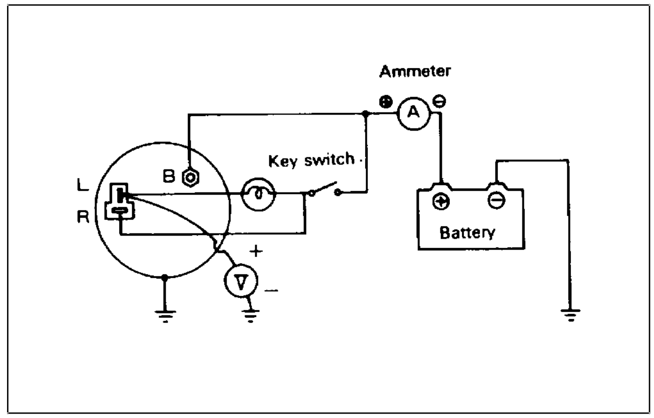


Figure 34

Alternator Output Test

1. Disconnect the battery ground (–) cable.

2. Install an ammeter between the positive (+) terminal of the battery and terminal "B" of the alternator.

3. Ground alternator terminal "B" through a voltmeter.

4. Connect the battery ground (–) cable.

5. Start the engine.

6. Run the engine with the alternator at 2500 and 5000 rpm and observe the voltmeter with all electrical load applied. Read the maximum indication on the ammeter with the voltmeter showing 13.5 V.

Output Characteristics (Hot):

21 A at 2500 rpm
37 A at 5000 rpm

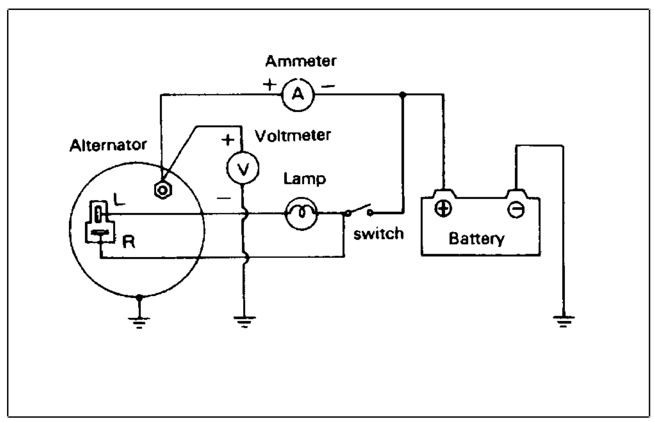


Figure 35

Preparation for Engine Repair

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

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

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

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

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

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

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

Engine Compression

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

Cylinder and Cylinder Block Overhaul

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

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

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

2. Increased fuel consumption.

3. Increased lubricating oil consumption.

4. Poor engine starting.

5. Loud noises in the engine.

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

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

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

External Engine Component Repair

Belt Replacement and Adjustment

Alternator Belt

1. Loosen bolt securing alternator brace to engine and bolt securing alternator to brace (Fig. 36).

2. Remove two capscrews securing drive shaft coupler to engine crankshaft pulley.

3. Move drive shaft out of the way so belt can be removed and new one installed.

4. Install new belt.

5. Connect drive shaft coupler to engine crankshaft pulley with two capscrews and washers.

6. To adjust belt tension, insert pry bar between alternator and engine and carefully pry alternator out until proper tension is achieved. To check tension, depress belt midway between crankshaft and alternator pulleys with 22 lbs. of force. A new belt should deflect 0.3 to 0.5 inch and a used belt 0.4 to 0.55 inch. Tighten alternator and brace bolts to secure adjustment.

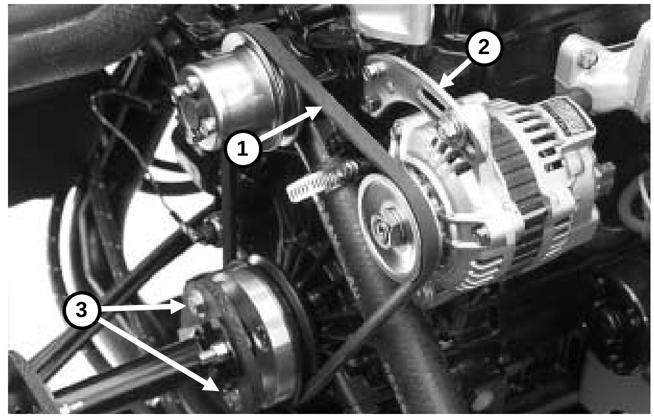


Figure 36

1. Alternator belt
2. Alternator brace
3. Capscrews and washers

Fan Belt

1. Loosen locknut on idler pulley (Fig. 37).

2. Remove belt by carefully moving around fan blades.

3. Install new belt.

4. To adjust belt tension, loosen idler pulley mounting nut and move pulley to increase tension. To check tension depress belt midway between fan and drive shaft pulleys with 22 lbs. of force. A new belt should deflect 0.48 to 0.58 inch and a used belt 0.55 to 0.65 inch. Tighten nut to secure adjustment.

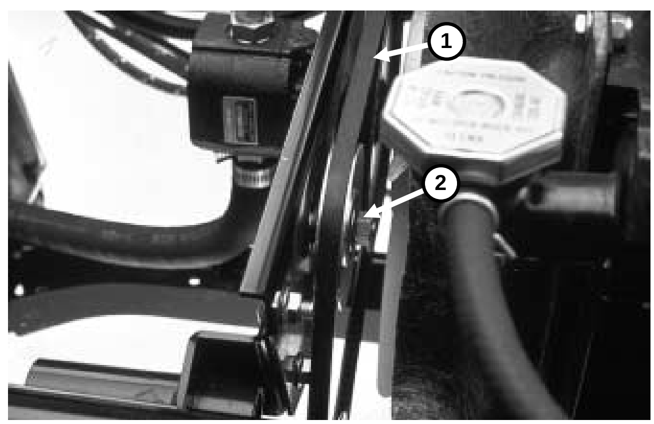


Figure 37

1. Fan belt
2. Idler pulley

Thermostat Removal and Installation

1. Lower the coolant level to below the thermostat.

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

3. Remove the water outlet fitting and gasket (Fig. 38).

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

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

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

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

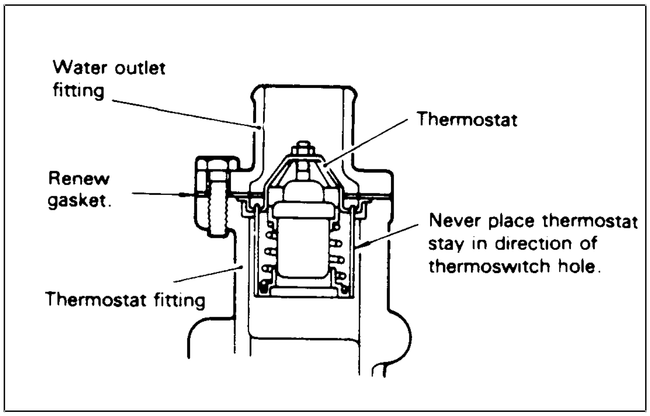


Figure 38

Water Pump Service

1. Drain the cooling system.

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

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

4. Remove the water pump (Fig. 39).

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

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

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

8. Install the alternator / water pump drive belt and adjust belt tension (see Belt Tension Adjustment).

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

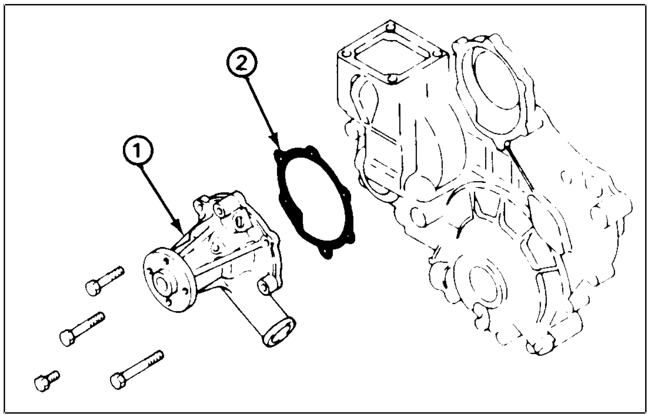


Figure 39

1. Water pump
2. Gasket

Liquid Cooled Diesel Engine

Electrical System Repairs

Alternator Removal and Installation

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

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

3. Disconnect the alternator wiring harness connector.

4. Loosen alternator brace bolt and alternator support bolt (Fig. 40). Push the alternator toward the engine and remove the belt.

5. Remove the alternator.

6. Reverse steps 1 - 5 to install the alternator. Make sure the spacer and shim is installed on the alternator support bolt between the alternator lower rear bracket and gear case bracket (Fig. 41).

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

8. Hold the alternator in position after you get proper belt tension and tighten the alternator brace bolt. Tighten the alternator support bolt. To check tension, depress belt midway between crankshaft and alternator pulleys with 22 lbs. of force. A new belt should deflect 0.3 to 0.5 inch and a used belt 0.4 to 0.55 inch.

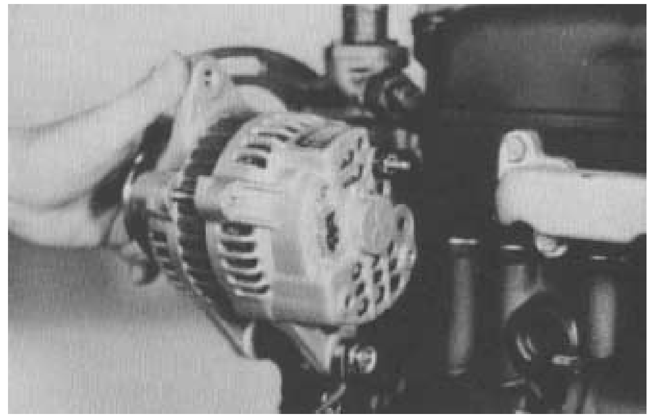


Figure 40

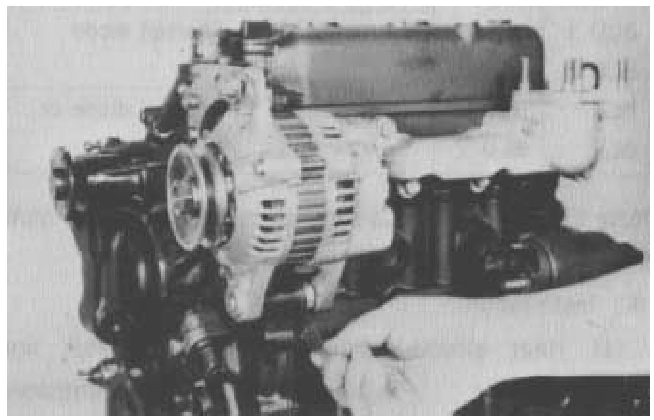


Figure 41

Starter Removal and Installation

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

2. Disconnect the wires from the starter solenoid (Fig. 42).

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

4. Remove the starter.

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

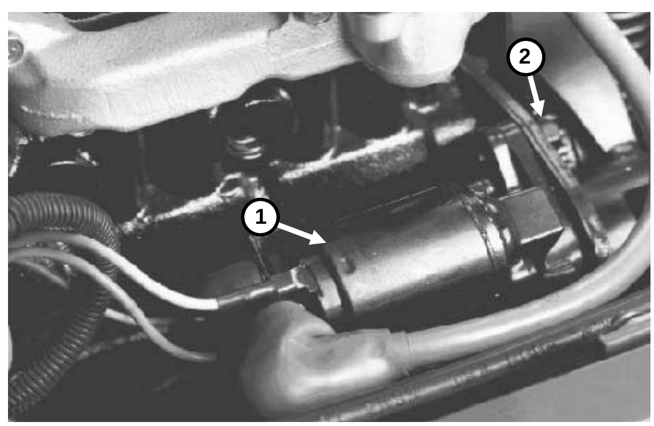


Figure 42

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

Replacing and/or Adjusting 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 (located next to the injection pump on the engine) 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. 43).

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. 44). 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. Remove the cover cap screw from the engine to get access to the solenoid nut (Fig. 43).

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

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

9. Connect the solenoid electrical connector.

10. Install the governor tie rod cover.

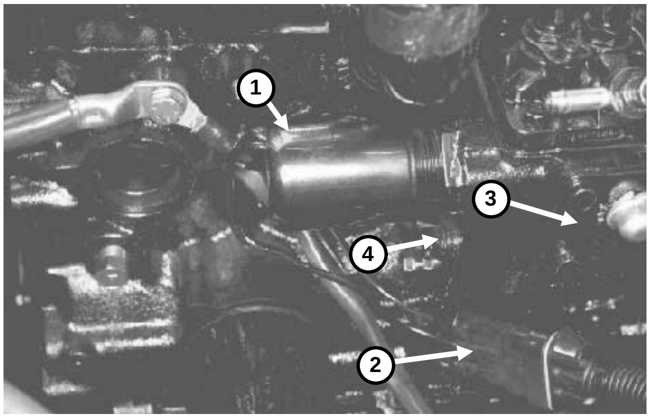


Figure 43

1. Fuel stop (ETR) solenoid
2. Solenoid electrical connector
3. Governor tie rod cover
4. Cover cap screw

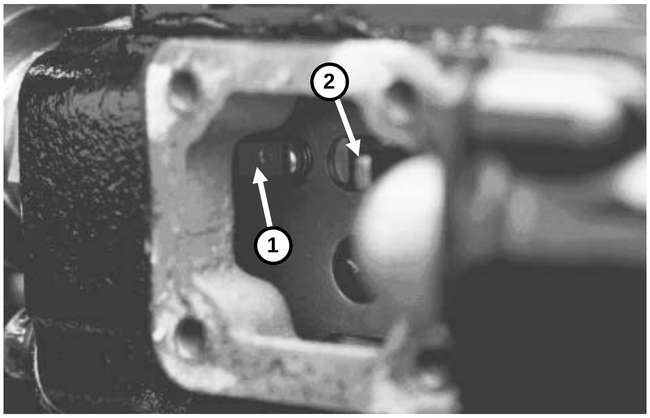


Figure 44

1. Solenoid plunger
2. Tie rod

Glow Plug Replacement

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

1. Remove the nut and lead wire.

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

3. Remove the glow plug.

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

5. Install the lead wire and nuts.

Oil Pressure Switch Replacement

The engine is equipped with an oil pressure switch (Fig. 45). This switch activates a lamp on the control panel and a buzzer if the oil pressure drops below safe levels during operation.

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

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

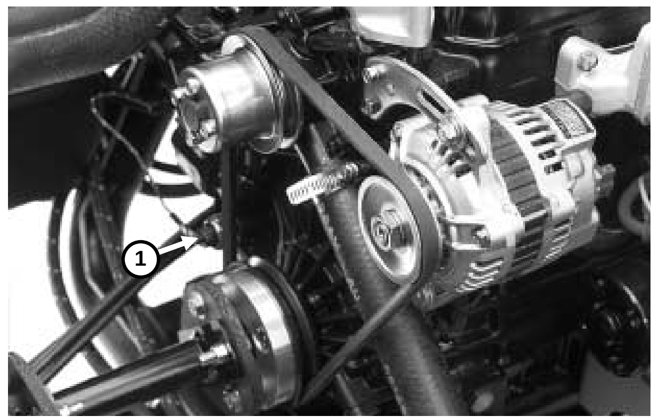


Figure 45

1. Oil pressure switch

Starter Service

Disassembly and Inspection

1. Remove the starter from the engine (see Starter Removal and Installation).

2. Disconnect wire from magnetic switch terminal “M”.

3. Loosen two screws securing the magnetic switch. Remove the magnetic switch.

4. Remove two through bolts and screws securing the brush holder. Remove the rear bracket.

5. With the two brushes in the floating state, remove the yoke and brush holder assembly. Pull the armature out.

6. Remove the cover, pry the snap ring out and remove the washer.

7. Unscrew the bolts and remove the center bracket. As the bracket is removed, washers for pinion shaft end play adjustment will come off.

8. Pull out the reduction gear lever and lever spring from the front bracket.

9. Pry the snap ring out on the pinion side and pull out the pinion and pinion shaft.

10. Remove the ball bearings from each end of the armature with a bearing puller. The bearing that is press-fitted in the front bracket cannot be removed. Replace the bracket assembly if the bearing is worn or damaged.

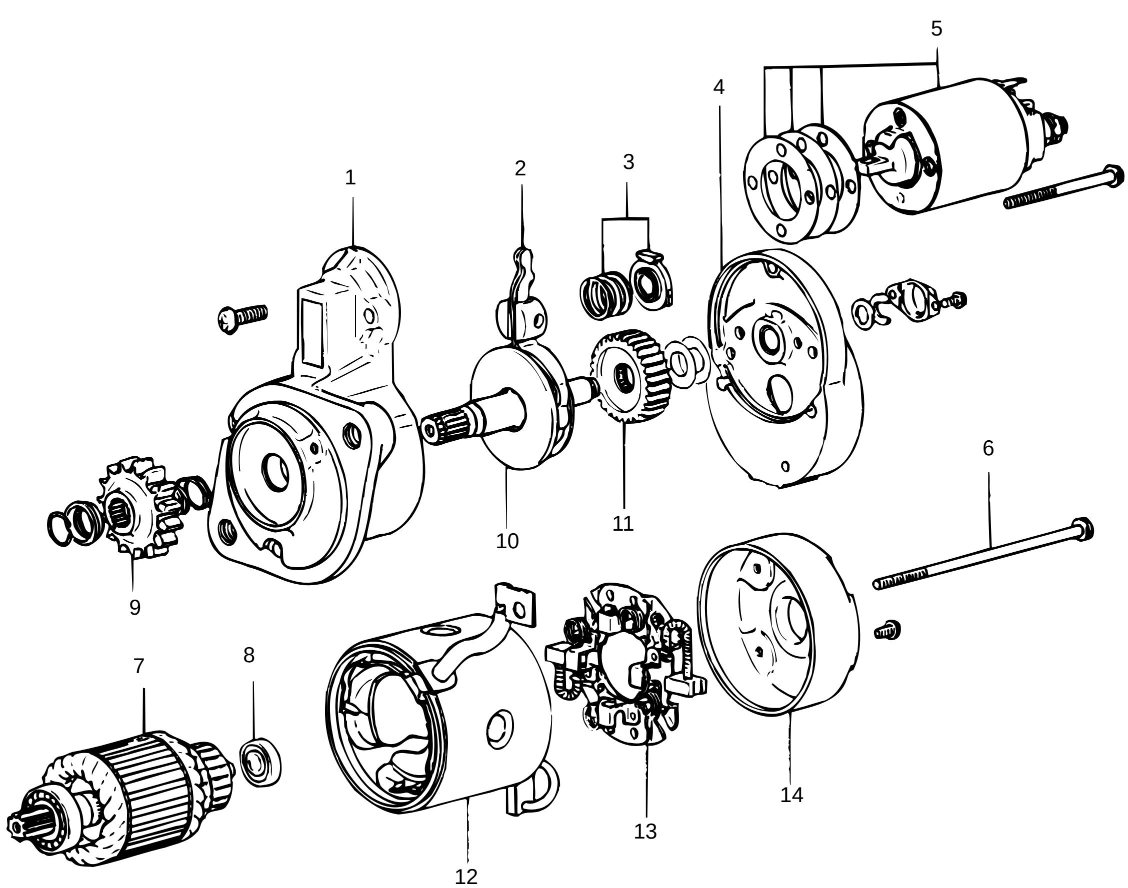


Figure 46

1. Front bracket assembly
2. Lever assembly
3. Spring set
4. Center bracket assembly
5. Switch assembly
6. Through bolt
7. Armature
8. Rear bearing
9. Pinion
10. Pinion shaft assembly
11. Gear
12. Yoke assembly
13. Brush holder assembly
14. Rear bracket

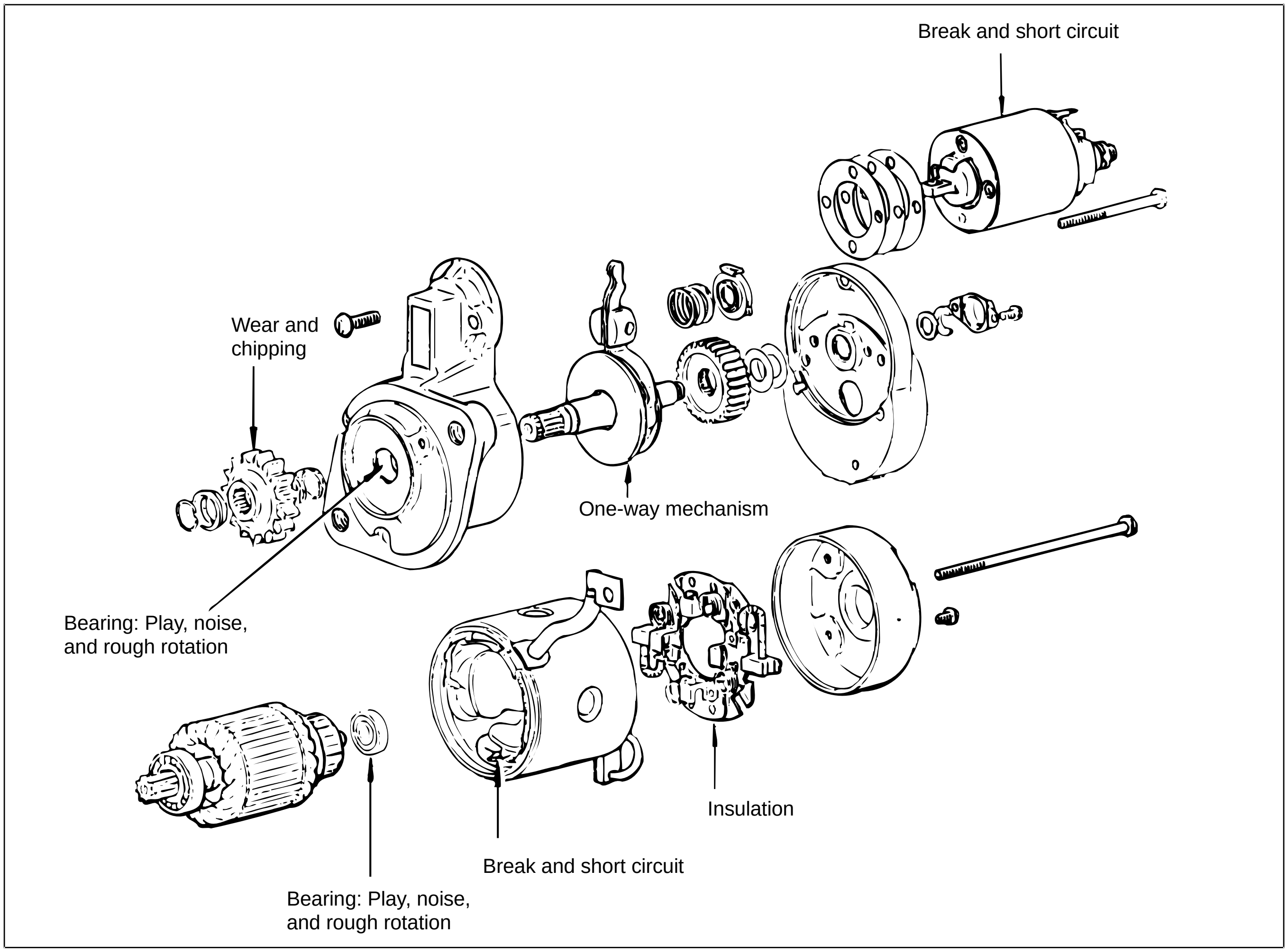


Figure 47

10. Check the magnetic switch for continuity between terminals “S” and “M” and between terminals “S” and body. If there is continuity (or zero ohm is indicated), replace the magnetic switch.

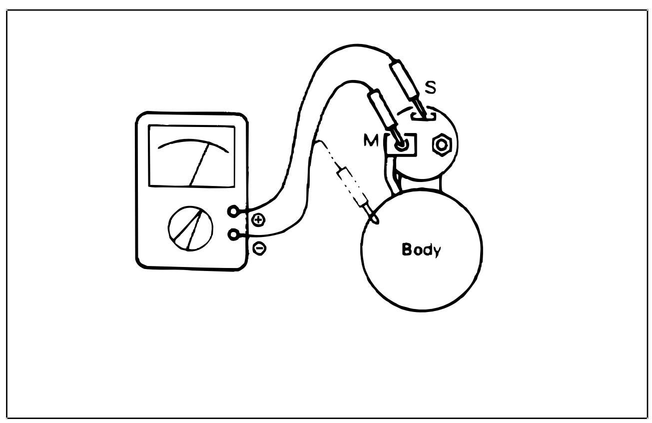


Figure 48

11. Put the armature on a growler tester to check for a shorted armature. A burned commutator bar is an indication of a shorted armature. With the growler turned on, put a thin strip of steel or a hacksaw blade on the armature as it is slowly rotated. If the metal strip vibrates over a winding, that winding is short circuited. Short circuited windings are sometimes caused by metal in the commutator bridging the gap from on commutator bar to the next. By removing the bridged metal, this condition can be corrected. If this does not correct the short replace the armature.

12. Measure the commutator O.D. and depth of undercut. Repair or replace if the service limit is exceeded. Check the commutator outside surface for dirt and roughness. If rough, polish the commutator with fine (00 or 000) sandpaper. DO NOT use emery cloth.

Item	Standard	Service Limit
Commutator O.D.	38.7 mm (1.52 in.)	– 1.0 mm (– 0.4 in.)
Depth of Undercut	0.5 mm (0.02 in.)	0.2 mm (0.008 in.)

13. Check the brushes. Replace if worn beyond the service limit. Check the brush spring tension. Replace the springs if tension is less than the service limit. Check for insulation between the positive brush holder and holder base. If poorly insulated, replace the holder assembly. Check the brush holders for proper staking.

Item	Standard	Service Limit
Height of Brush	17 mm (0.67 in.)	6 mm (0.24 in.)
Spring Pressure	3 kg (6.6 lb.)	

14. Check for continuity between one end of field coil (brush) and yoke. There should be no continuity. Check for continuity between both ends of coil (brushes). There should be continuity if the field coil is good. Check the poles and coil for tightness.

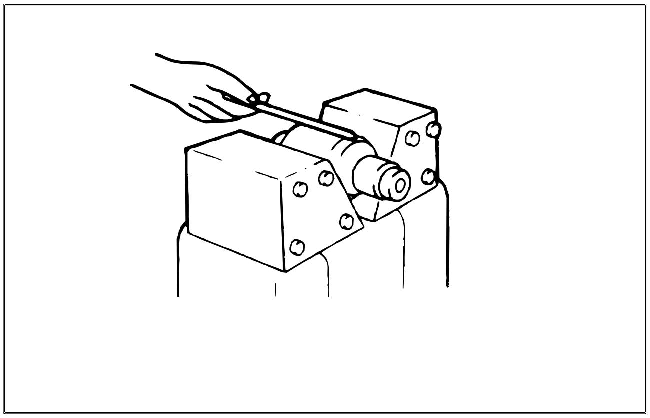


Figure 49

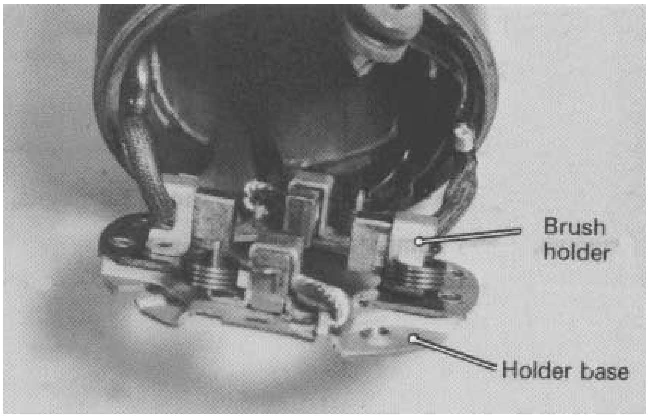


Figure 50

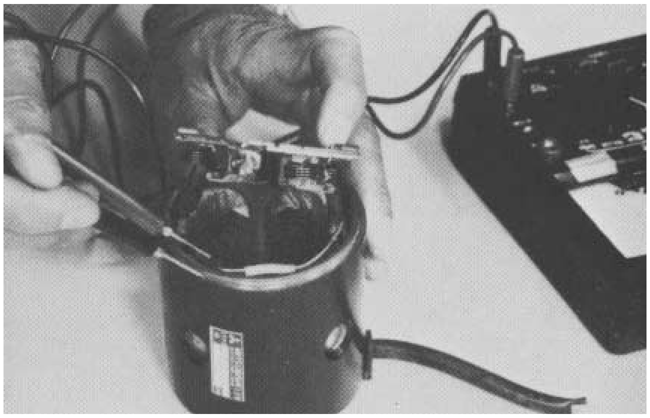


Figure 51

Liquid Cooled Diesel Engine

Assembly and Adjustment of Starter

1. Reverse steps 1 - 10 under Disassembly and Inspection and also following the following instructions:

2. Set the pinion shaft end play (thrust gap) to 0.5 mm (0.02 in.) or less by inserting an adjusting washer between the center bracket and reduction gear.

A. Fit the pinion shaft, reduction gear washer and snap ring to the center bracket.

B. Measure end play by moving the pinion shaft in and out. If end play exceeds 0.5 mm (0.02 in.), increase the number of adjusting washers.

3. Put grease on the following parts whenever the starter has been overhauled:

Armature shaft gear and reduction gear
All bearings
Bearing shaft washers and snap rings
Bearing sleeves
Pinion
Sliding part of lever

IMPORTANT: Never put grease on terminals, brushes, commutator or surface that mounts to the engine.

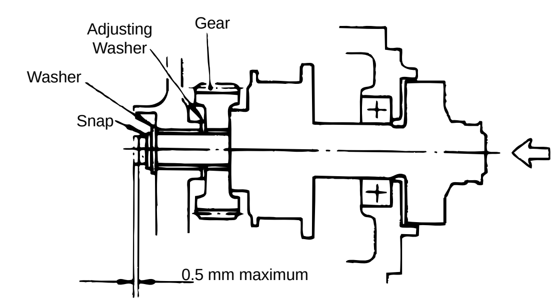


Figure 52

Alternator Service

Disassembly and Inspection

1. Remove the alternator from the engine (see Alternator Removal and Installation).

2. Remove the three through bolts.

3. Use a solder iron to heat the rear bracket around the rear bearing to 120 - 140^{o} F (50 - 60^{o} C). Separate the front and rear brackets by prying with a screwdriver blade inserted between the brackets.

IMPORTANT: Be careful not to insert the blade too far causing damage to the windings.

4. Put the rotor in a vise. Remove pulley nut and pull off the pulley and spacer.

5. Pull the rotor assembly from the front bracket.

6. Unsolder the stator core lead wires. Remove the stator assembly.

IMPORTANT: To prevent damage to the diodes, heat the stator core lead wires only long enough to remove.

7. Disconnect the capacitor from terminal “B”.

8. Loosen the screws securing the rectifier and remove the rectifier.

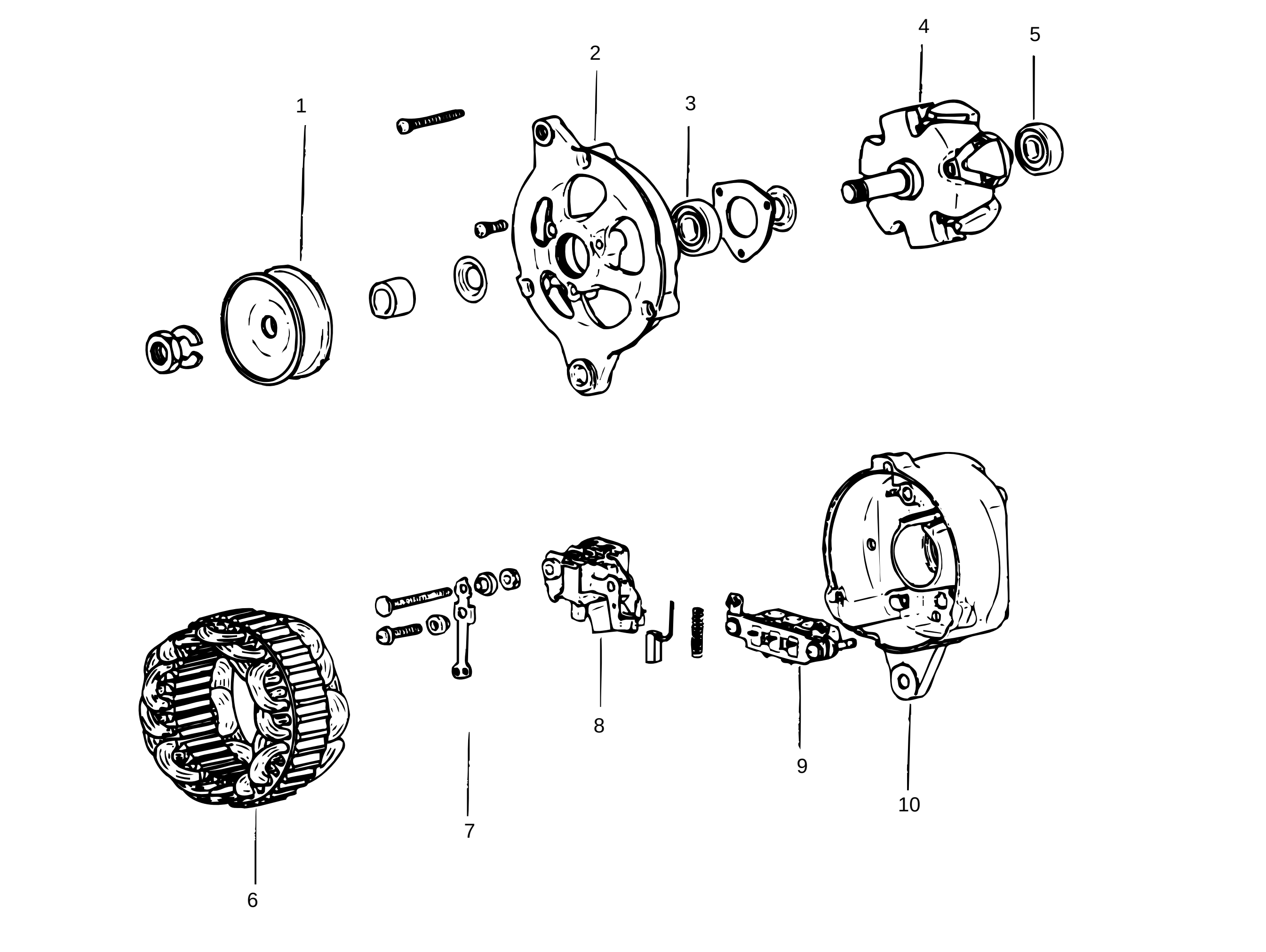


Figure 53

1. Pulley
2. Front bracket assembly
3. Front bearing
4. Rotor assembly
5. Rear bearing
6. Stator
7. Terminal set assembly
8. Regulator assembly
9. Rectifier assembly
10. Rear bracket assembly

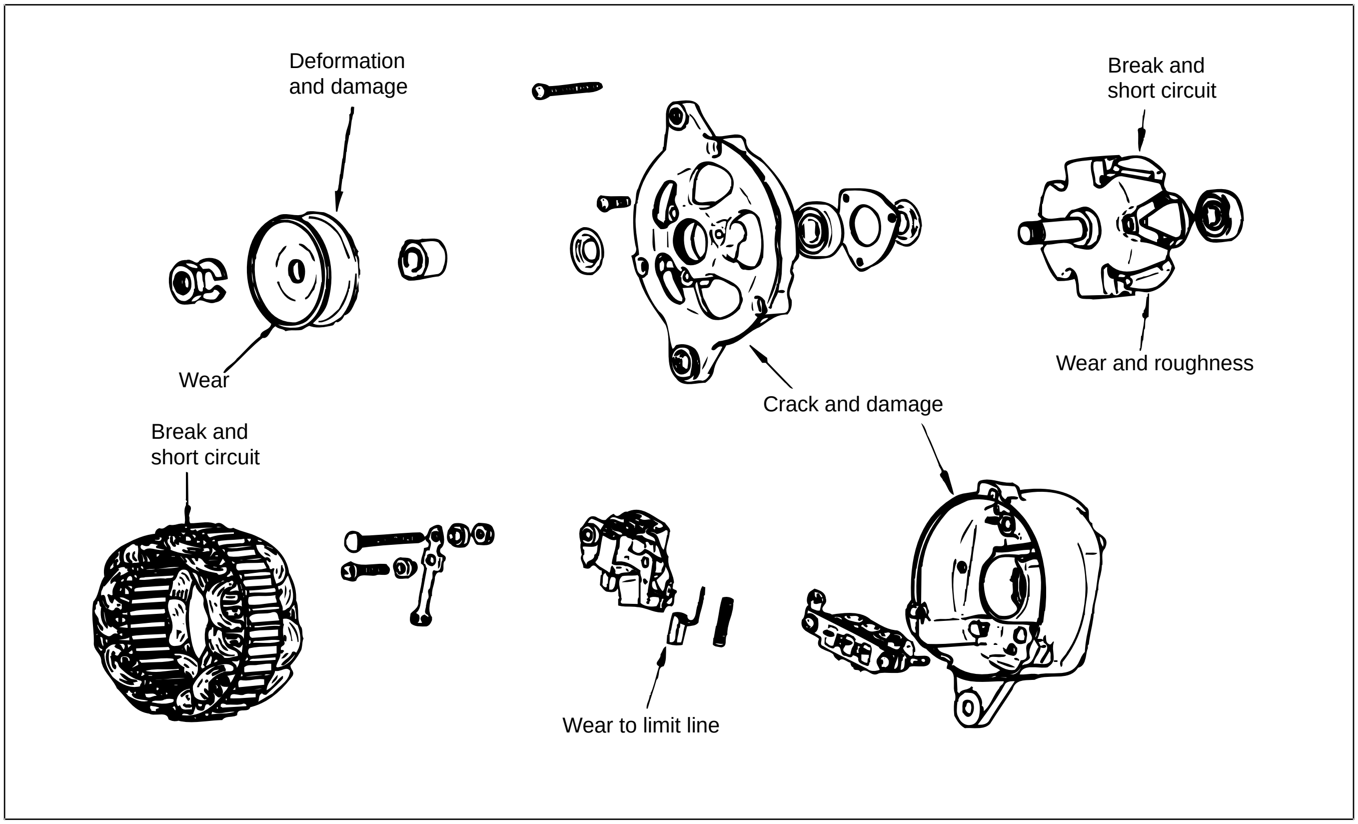


Figure 54

9. Check each diode in the rectifier for conduction. Connect an ohm meter across the lead wire and diode case. The diode is normal if its resistance is large in one direction and small in the reverse direction. If there is equal resistance in both directions the diode is damaged. Replace the rectifier assembly if a diode is damaged.

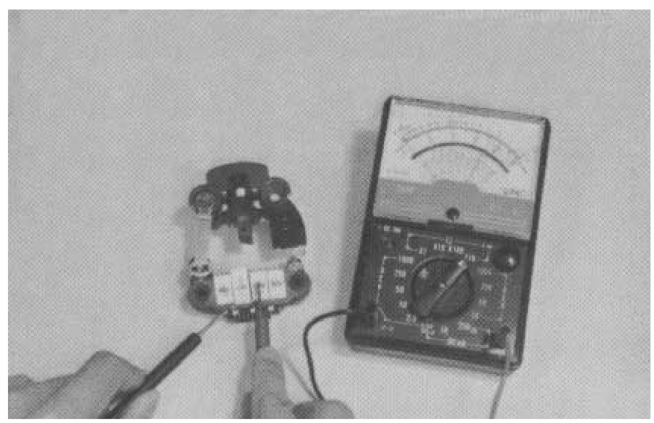


Figure 55

10. Check the field coil for continuity between the slip rings. If there is no continuity, replace the field coil.

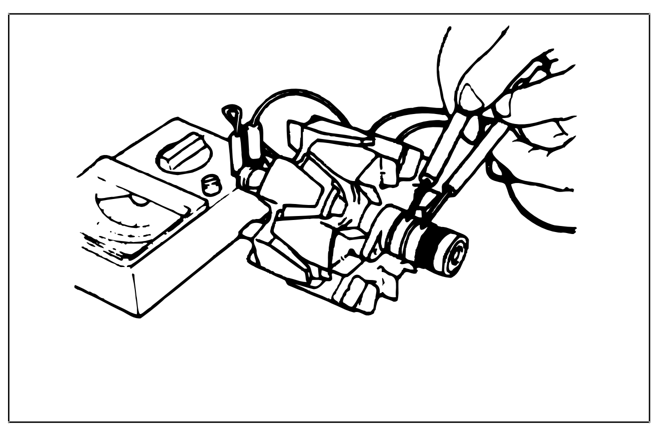


Figure 56

11. Check for continuity between a slip ring and shaft (core). Replace the field coil if there is continuity.

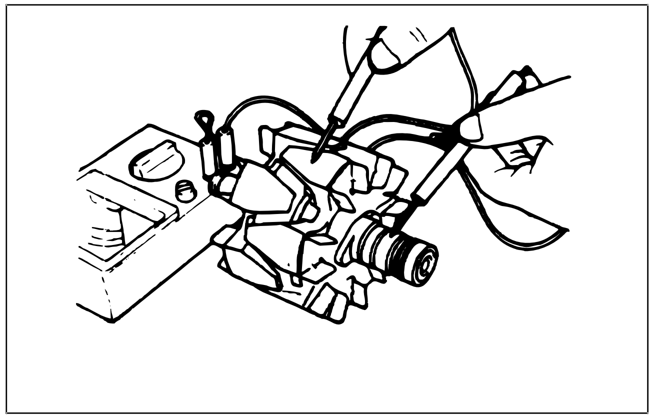


Figure 57

12. Check for continuity between lead wires of the stator coil. Replace the stator coil if there is no continuity.

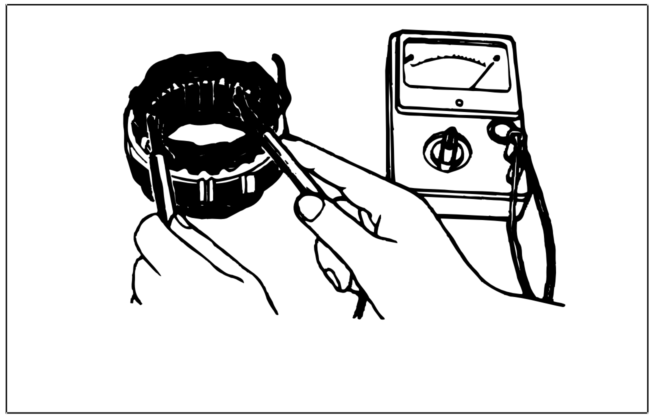


Figure 58

13. Check for continuity between each lead wire and stator core. Replace the stator coil if there is continuity.

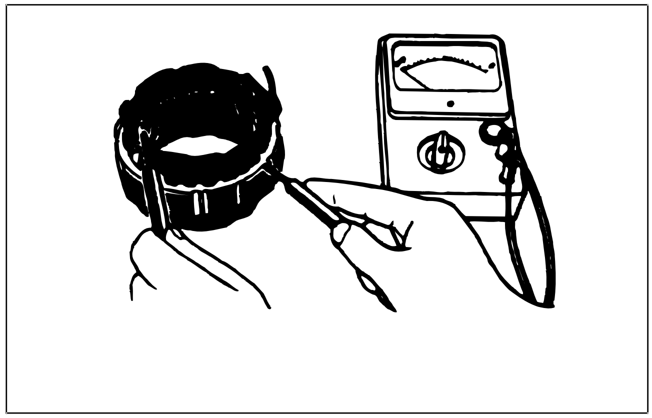


Figure 59

Assembly of Alternator

1. Reverse steps 1 - 8 under Disassembly and Inspection and also following the following instructions:

2. The rear bearing has an eccentric groove. Install the snap ring so its projection fits in the deepest part of the groove.

3. When installing a new rear bearing, press fit the bearing with its groove facing the slip ring side.

4. Heat the rear bracket when press fitting the rear bearing into the bracket.

IMPORTANT: Put a wire through the small hole in the rear bracket to lift the brushes before installing the rotor to the rear bracket. Remove the wire after the rotor is installed.

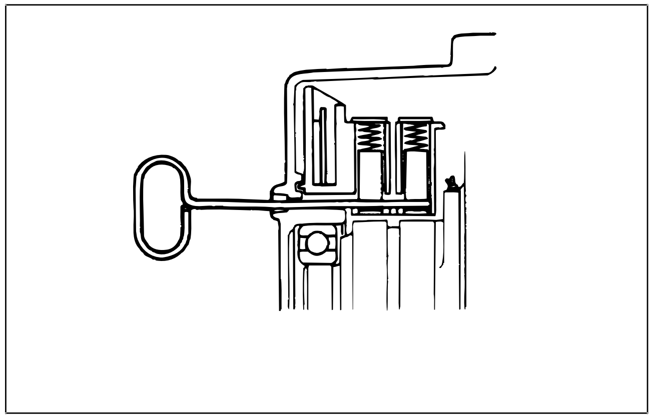


Figure 60

Governor System Repairs

Governor Operation

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

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

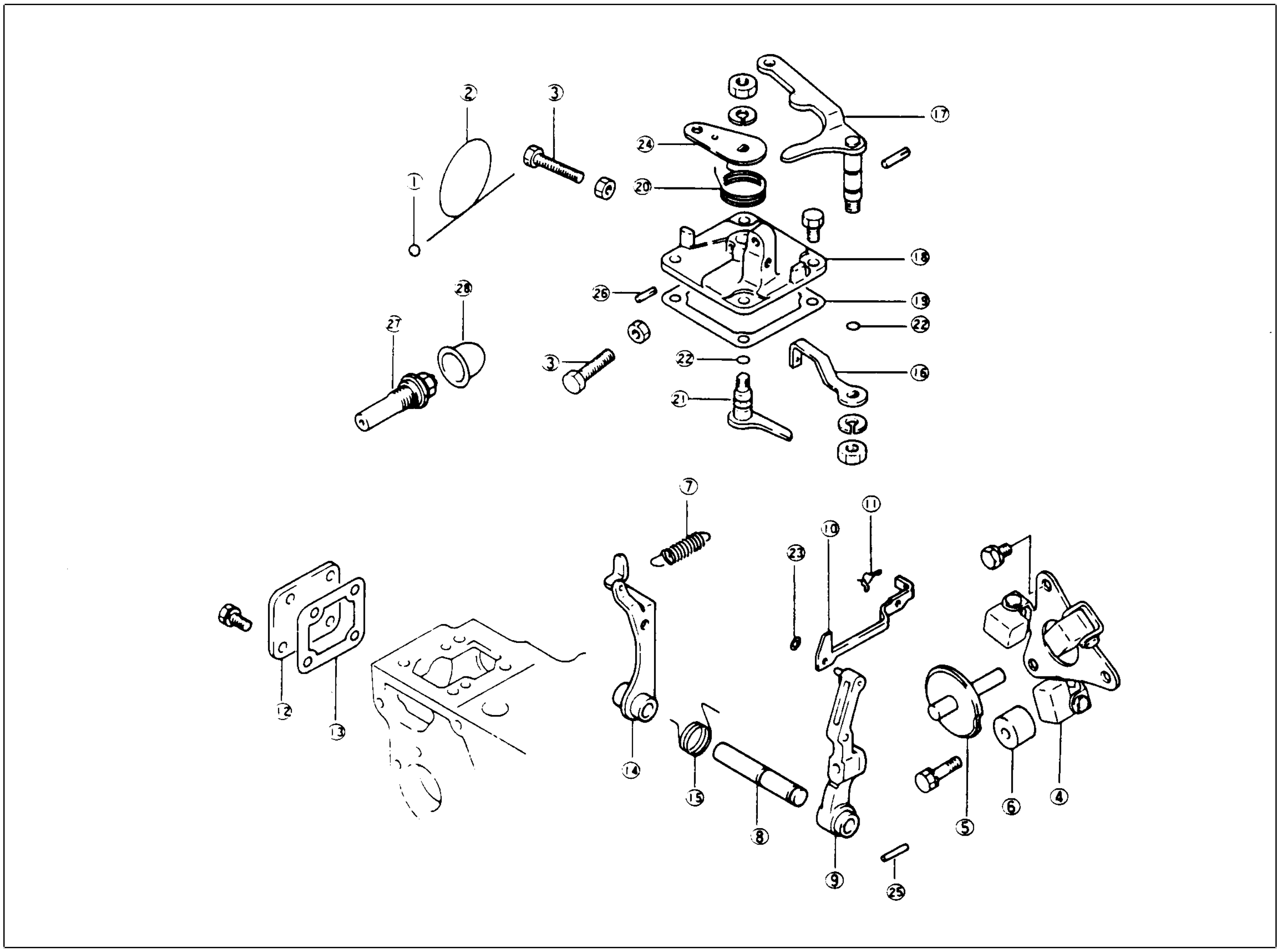


Figure 61

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

Governor Inspection

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

1. Remove the governor tie rod cover (Fig. 41).

2. While holding the stop lever (Fig. 14) in the stop position (towards the rear of the machine) turn the ignition key switch quickly to the START position and release it to the ON positon. This will retract the stop solenoid plunger, allowing movement of the injection pump control rack.

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

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

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

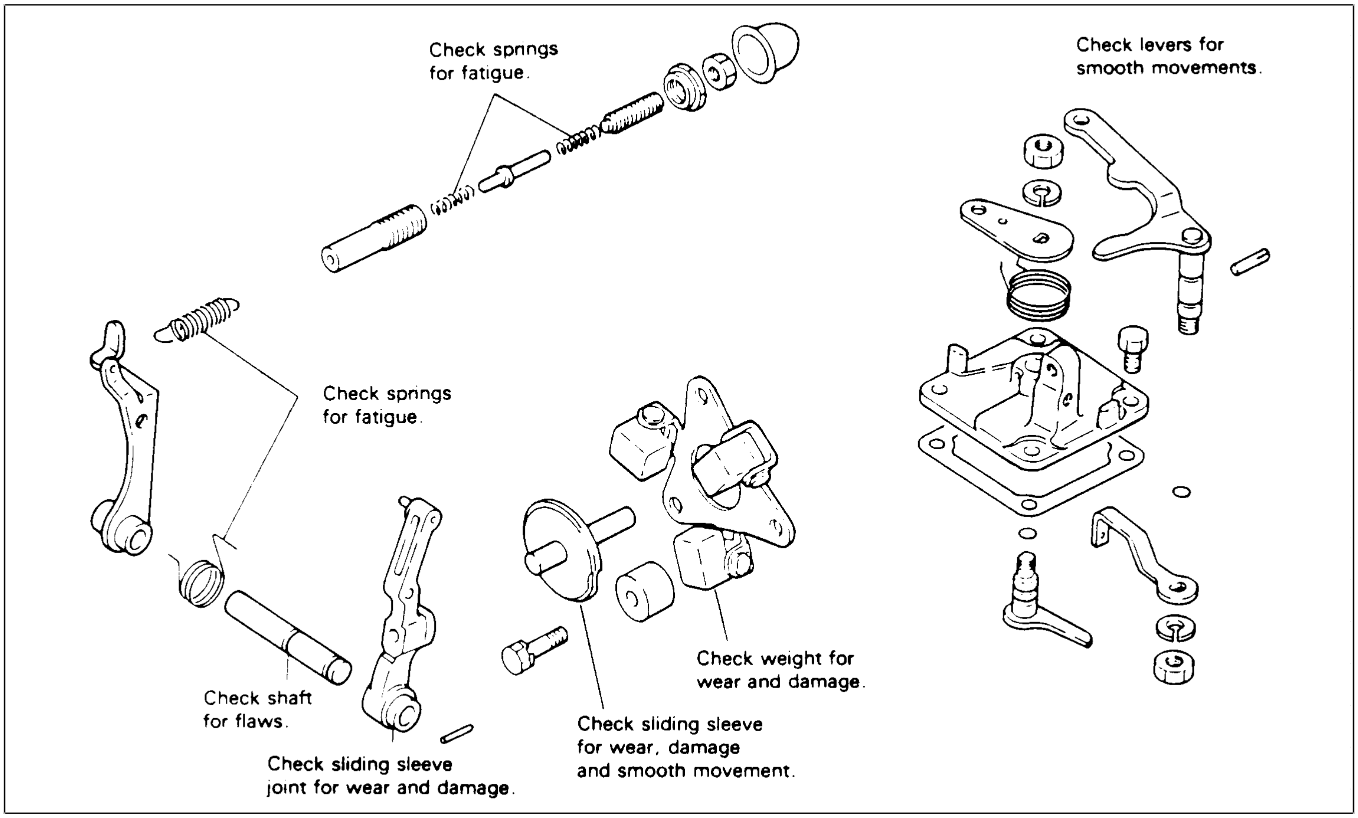


Figure 62

Governor Service

1. Remove the tie rod cover (Fig. 33).

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

3. Disconnect the governor spring from the tension lever.

4. Remove the cover assembly.

5. Removing the levers:

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

B. Loosen the bolts securing the levers and shafts.

6. Installing the levers:

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

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

C. Install the governor spring lever and speed control lever so there is a minimum play of angle between levers (Fig. 35) .

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

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

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

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

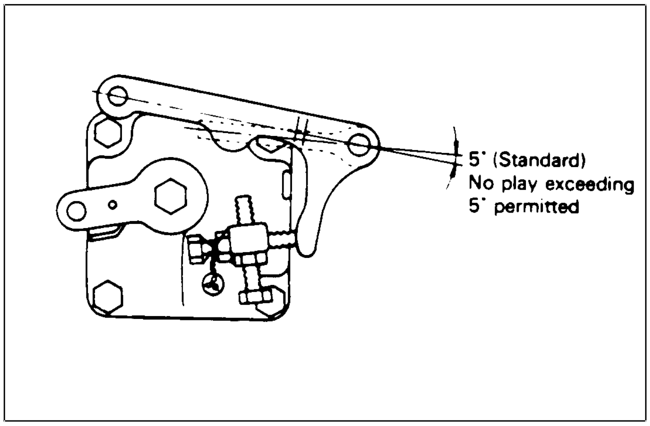


Figure 35

Liquid Cooled Diesel Engine

Installation of Torque Spring Set

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

1. Engage the parking brake. Make sure the high speed set bolt is adjusted to the correct engine speed of 3600 ±50rpm (See Adjusting Engine Speed).

NOTE: Specified rpm is with no load on engine.

2. Operate the engine at high idle speed.

3. Turn the torque spring set (Fig. 36) clockwise until engine speed drops approximately 50 rpm from high idle speed.

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

Engine Model L3Ca-62TG: N = 2.5
Engine Model L3Ea-62TG: N = 2.6

5. Install the sealing cap.

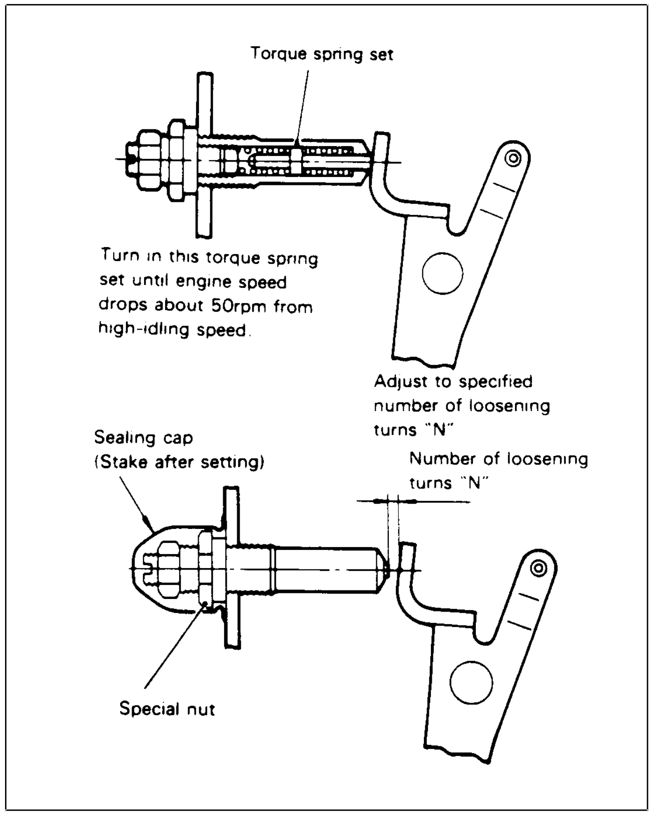


Figure 36

Assembly of Torque Spring Set

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

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

1. Assemble the torque spring set as shown in Figure 37.

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

3. Set dial on spring scale to zero (0). Tighten spring case until a value of 1270^{+10}_{-0} grams is obtained. Lock the spring case in that position with special nut.

4. Temporarily loosen adjustment screw until to get a value of 1070 grams then retighten the screw until a value of 1270^{+0}_{-10} grams is attained. Lock the adjustment screw in position with locknut.

5. To inspect torque spring set for proper adjustment, use a test set up as shown (Fig. 38). Gradually push scale against torque spring set until stopper is moved (or pointer of dial indicator moves). Check that load applied to torque spring at that moment is 1250^{+20}_{-30} grams.

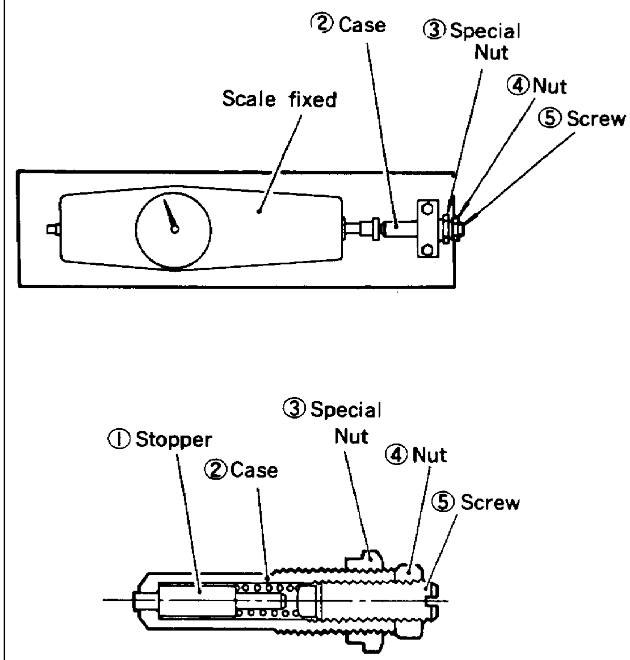


Figure 37

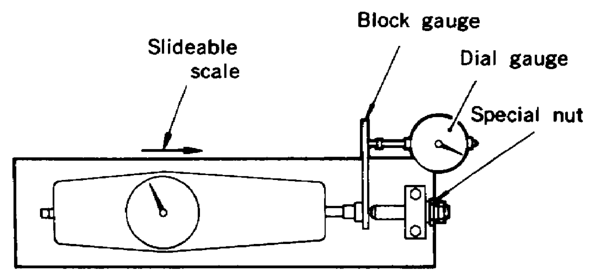


Figure 38

Liquid Cooled Diesel Engine

Fuel System Repairs

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

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

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

Bleeding the Fuel System

1. With the engine OFF, loosen the air bleed screw on the fuel filter / water separator (Fig. 39).

2. Turn the ignition key switch to ON position. The electric fuel pump will begin to operate and force fuel out around the air bleed screw. 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.

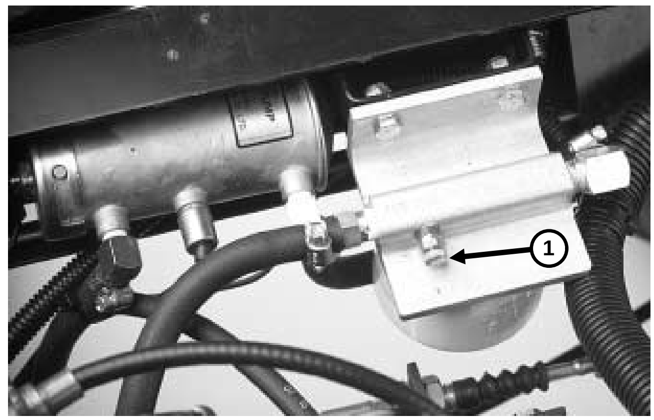


Figure 39

1. Bleed screw

3. Open the air vent screw on the fuel injection pump (Fig. 40).

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

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

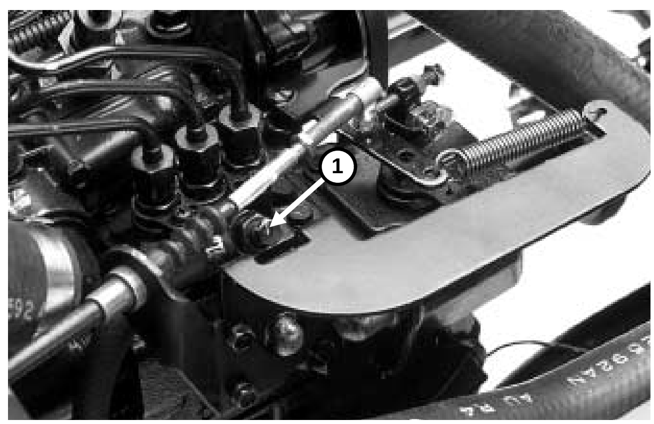


Figure 40

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. 41).

2. Push accelerator pedal to the floor.

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.

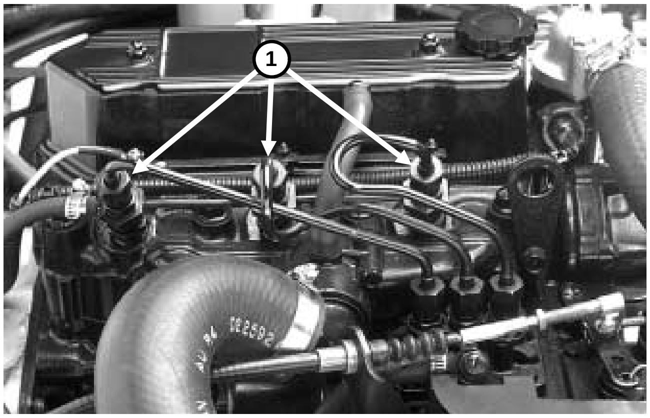


Figure 41

1. Fuel injector nozzle and holder (3)

Fuel Pump Service

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

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

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

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

4. Use a 17 mm wrench to remove the cover from the fuel pump (Fig. 42). Remove the gasket, magnet and filter element.

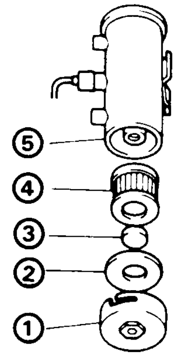


Figure 42

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

5. Carefully remove the spring retainer from the end of the plunger tube (Fig. 43). Remove the washer, o-ring, valve, plunger spring and plunger.

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

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

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

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

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

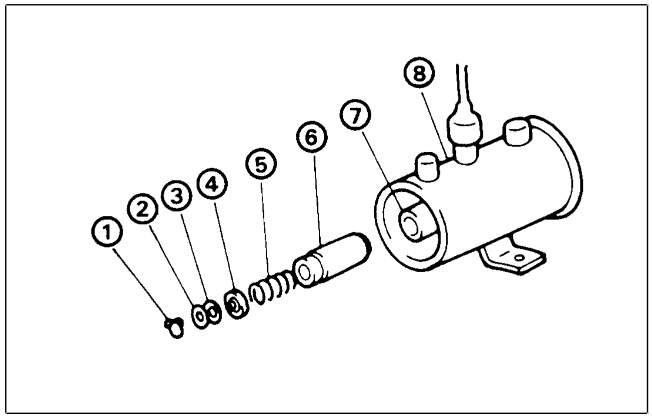


Figure 43

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

Injection Pump Service

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

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

Removing and Installing the Injection Pump

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

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

3. Remove the tie rod cover. Remove the tie rod clip and disconnect the tie rod from the injection pump control rack (Fig. 45).

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

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

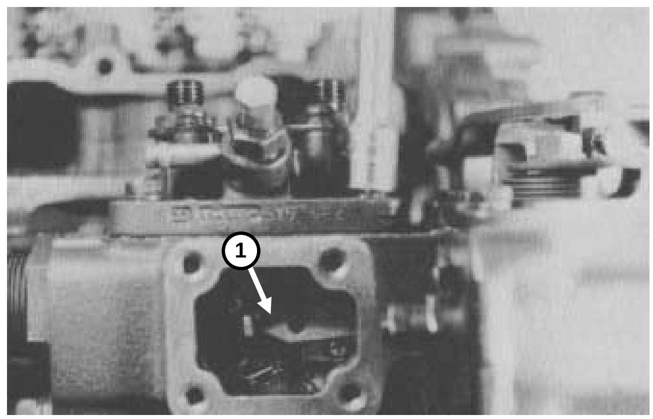


Figure 45

1. Tie rod (disconnected)

Injection Pump Disassembly

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

1. Remove the stopper holder. Remove the delivery valve holder (Fig. 46).

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

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

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

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

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

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

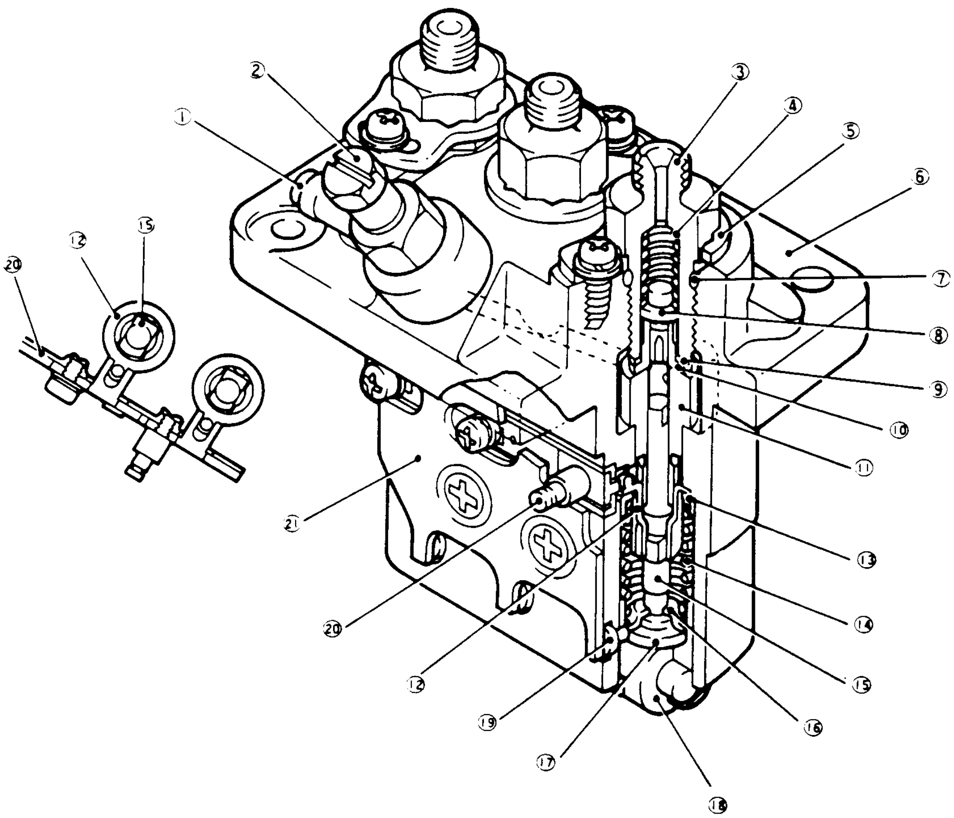


Figure 46

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

Injection Pump Inspection

Inspect the injection pump parts for proper operation, wear, corrosion, seizure, etc. (Fig. 47). Replace worn or damaged parts.

Injection Pump Assembly

1. Insert the plunger barrel into the housing.

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

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

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

5. Fit the lower seat to the plunger. Insert the plunger into the barrel (Fig. 48).

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

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

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

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

11. Install the fuel line and delivery pipes.

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

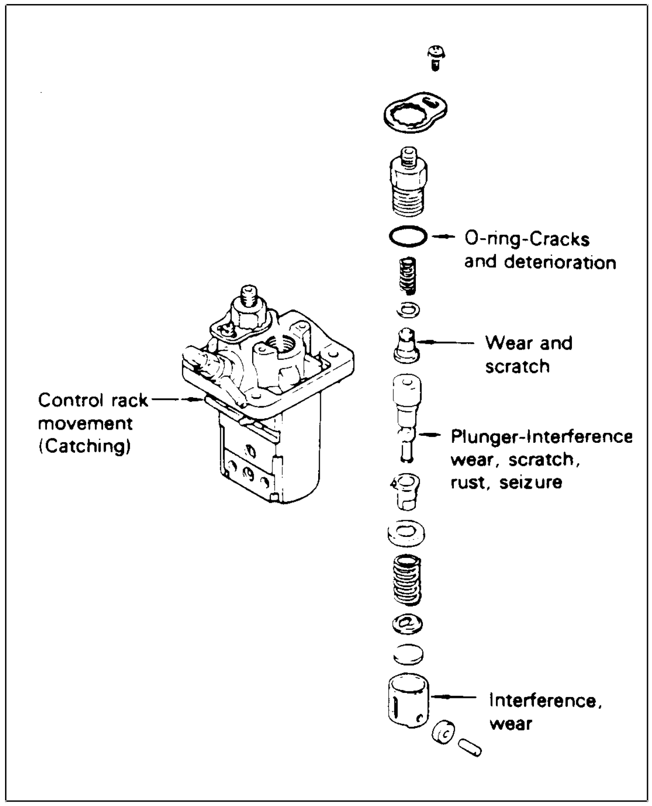


Figure 47

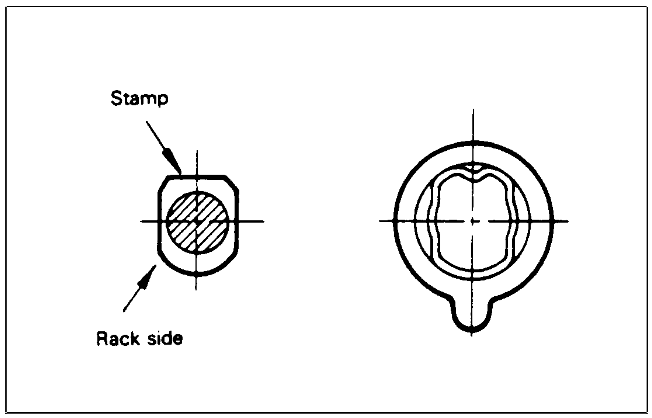


Figure 48

Nozzle Service

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

Nozzle Removal and Disassembly

1. Disconnect the injection pipes and fuel return pipe.

2. Remove the injector nozzle from the cylinder head.

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

3. Secure the nozzle holder in a vise that has aluminum or brass jaw plates. To prevent deformation do not clamp the vise onto the retaining nut (Fig. 49).

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

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

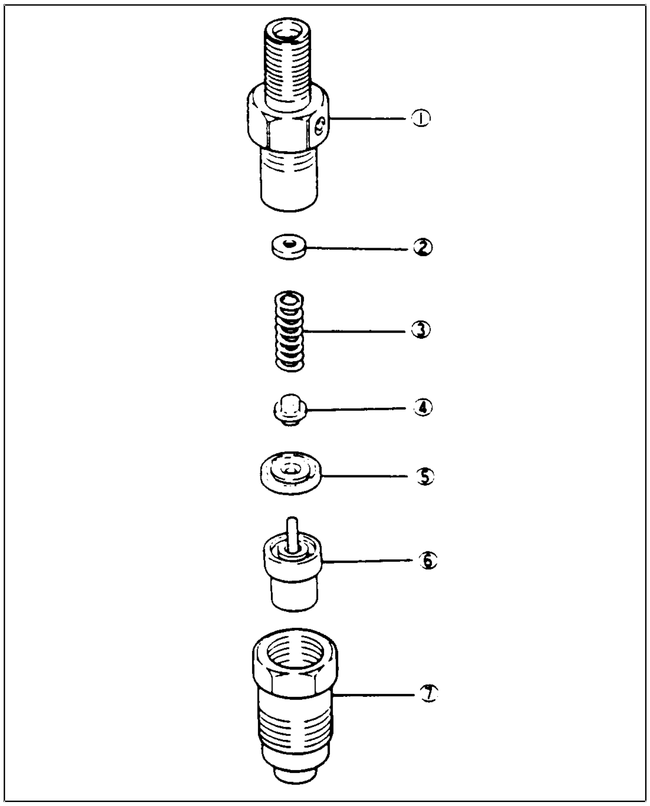


Figure 49

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

Nozzle Inspection and Cleaning

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

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

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

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

4. Inspect the removed parts (Fig. 50). Replace any worn or damaged parts.

Nozzle Assembly and Testing

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

2. Install the shim and pressure spring the body. Assemble the body to the retaining nut. Put the nozzle holder in a vise. Tighten the body and nut to a torque of 3.5 - 4.0 KgM (25 - 29 ft-lb) (Fig. 51).

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

Nozzle Installation

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

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

3. Install the fuel return pipe. Tighten the retaining nut to a torque of 2.5 - 3.0 KgM (18 - 22 ft-lb) (Fig. 49).

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

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

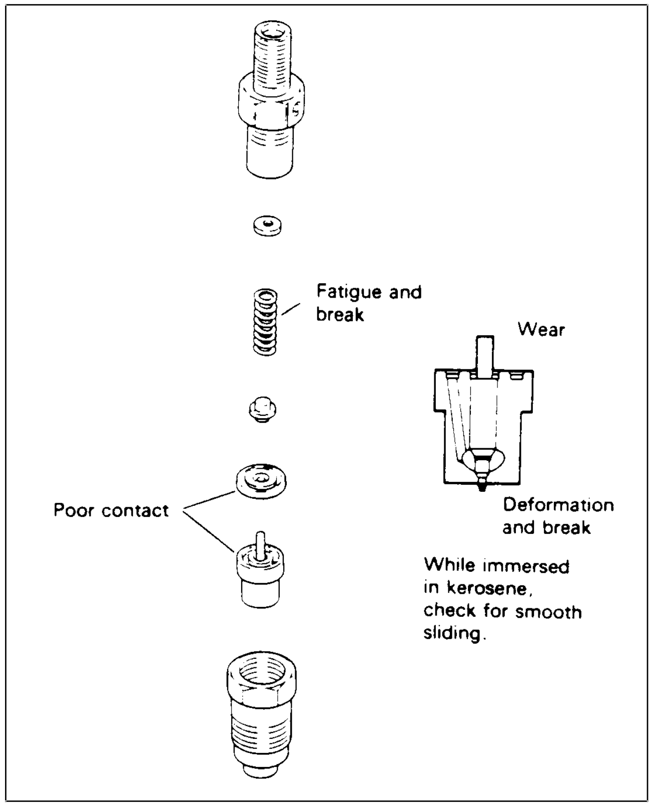


Figure 50

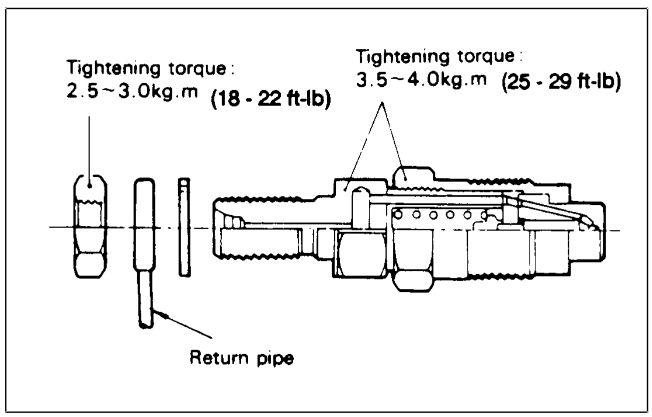


Figure 51

Removing and Installing the Engine

Removing the Engine

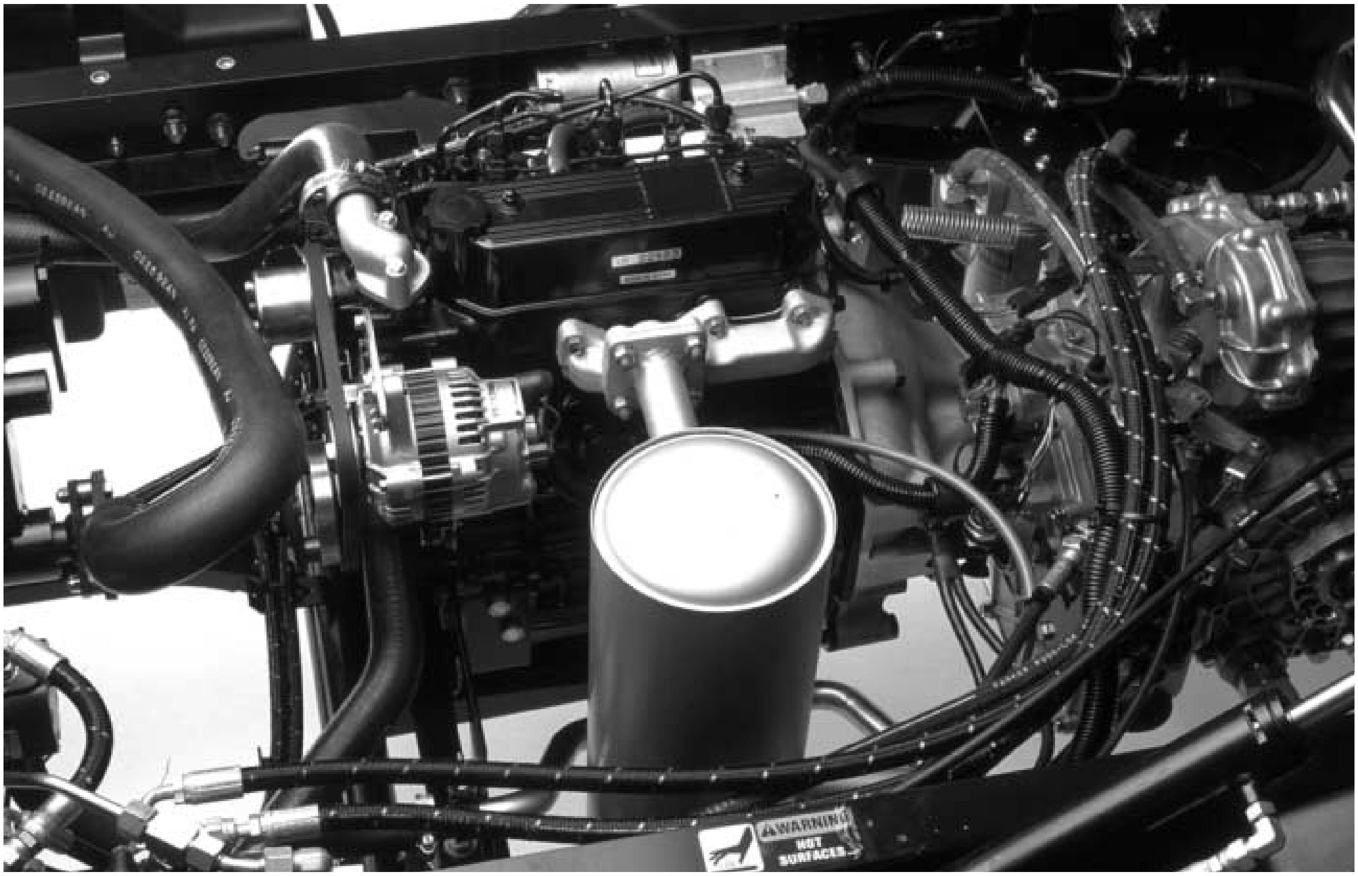


Figure 52

1. Put machine on a level surface and engage parking brake. Stop the engine and remove key from ignition switch. Remove the bed or other attachment(s). Allow engine and radiator to cool.

2. Disconnect positive (+) and negative (–) battery cables from battery.

3. Open radiator cap. Put a drain pan under 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.

4. Disconnect coolant and radiator hoses from engine.

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

6. Disconnect air intake hose from engine.

7. Remove the muffler.

8. Disconnect fuel hose from injector pump. Plug end of fuel line to prevent contamination. Disconnect fuel return hose from rear fuel injector on engine.

9. Disconnect and label electrical leads that attach to engine and transaxle.

10. Remove hydraulic pump drive shaft (connected to engine crankshaft pulley).

11. Disconnect throttle cable from governor lever on engine. Remove retaining ring securing throttle cable to bracket and pull throttle cable out of bracket.

12. Remove clamps and wire ties where wiring harness, hydraulic hoses or cables are attached to the engine.

13. Put blocking under transaxle for support.

14. Attach a hoist or block and tackle to engine for support.

15. Remove two (2) capscrews and locknuts securing front engine mounts to frame.

16. Remove capscrews securing clutch bell housing to engine.

17. Use a hoist or block and tackle to remove engine from chassis. One person should operate hoist or block and tackle and the other person should help guide engine out of chassis. Move engine forward before lifting to disengage transaxle input shaft from clutch.

18. Remove brackets and accessories from engine as necessary.

Installing the Engine

1. To install the engine, perform steps 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 accelerator pedal cable (See Accelerator Pedal Adjustment).

Cylinder Head Overhaul

Cylinder Head Removal

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

2. Remove plug from left side of cylinder block to drain the coolant from head and cylinder block.

3. Remove the muffler.

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

5. Remove the glow plug lead wires.

6. Remove the fuel injection pipes and return pipe.

7. Remove the rocker cover and gasket.

8. Loosen the rocker stay attaching bolts. Remove the rocker assembly (Fig. 59).

9. Loosen the cylinder head bolts. Use the sequence shown in Figure 60. Remove the cylinder head assembly including the intake and exhaust manifolds.

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

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

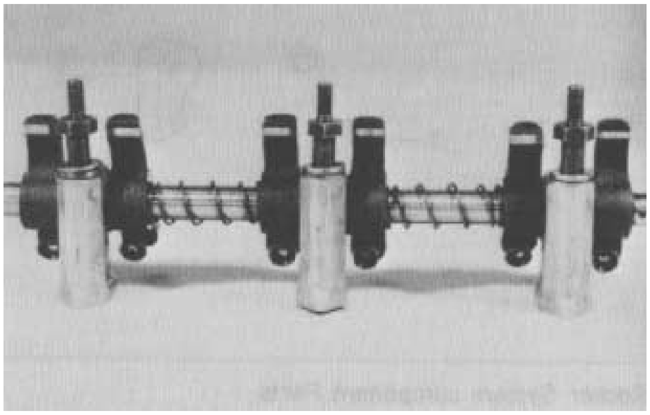


Figure 59

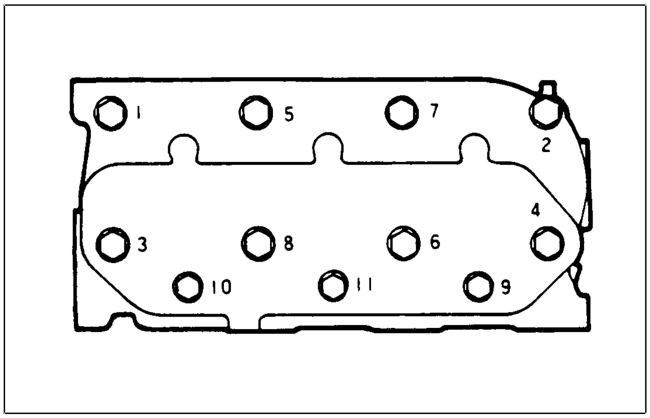


Figure 60

Liquid Cooled Diesel Engine

Cylinder Head Service

1. Use a valve lifter tool to compress the valve spring (Fig. 61). To remove each valve retainer, depress the retainer against the valve spring and remove the retainer lock (Fig. 62). Remove the valve retainer, spring and valve. Keep each valve and other parts for each cylinder separate so they can be reinstalled in the same cylinder.

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

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

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

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

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

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

CAUTION

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

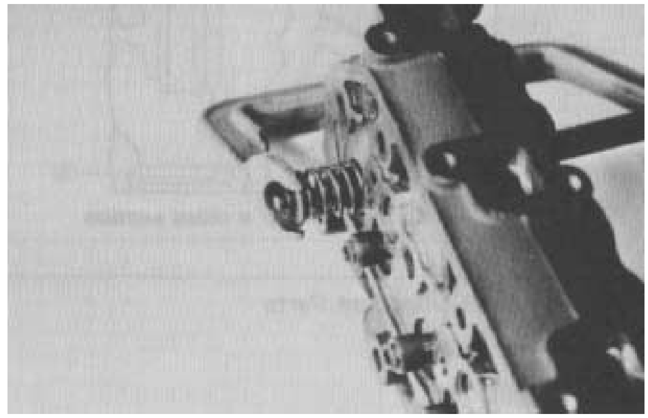


Figure 61

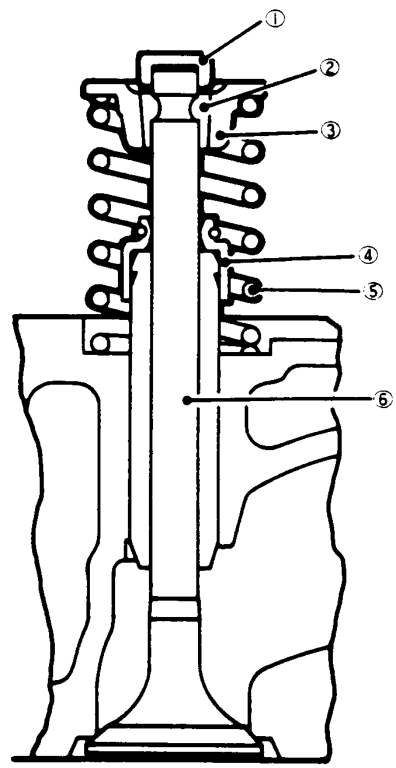


Figure 62

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

8. Use a straight edge and feeler gauge to check the flatness of the cylinder head lower surface (Fig. 63). Be sure to check the surface variation crosswise, lengthwise, and diagonally. If the variation in surface flatness exceeds (0.05 mm) 0.002 in. , the cylinder head or cylinder block must be replaced or resurfaced.

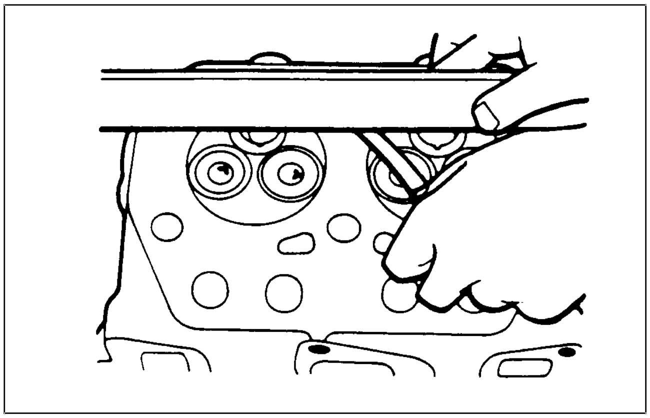


Figure 63

Valve Guides

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

Valve guide to valve stem clearance

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

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

3. To install the new valve guide press it in from the top of the cylinder head, using the valve guide mandrel. Install the valve guide so the installed height is 13.5 - 14.5 mm (0.531 - 0.571 in.) above the cylinder head (Fig. 64).

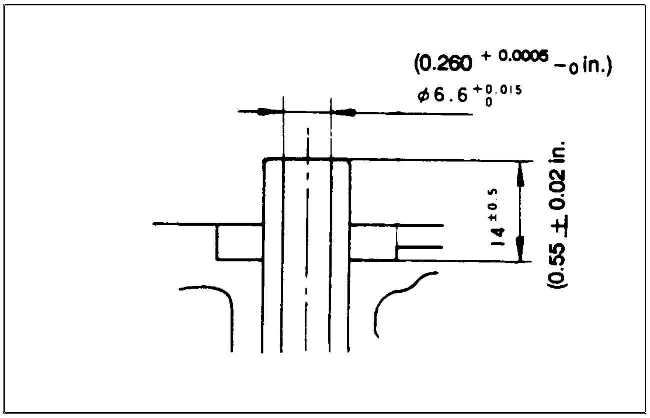


Figure 64

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

Valves

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

2. Check the valve face and valve stem for excessive wear, damage, cracks or deformation. If any of these conditions exist, the valve must be replaced. It is possible to reface the valve if the valve head thickness (margin width) is not less than the service limit (Fig.65). If the margin of the resurfaced valve is less than the service limit, replace the valve.

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

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

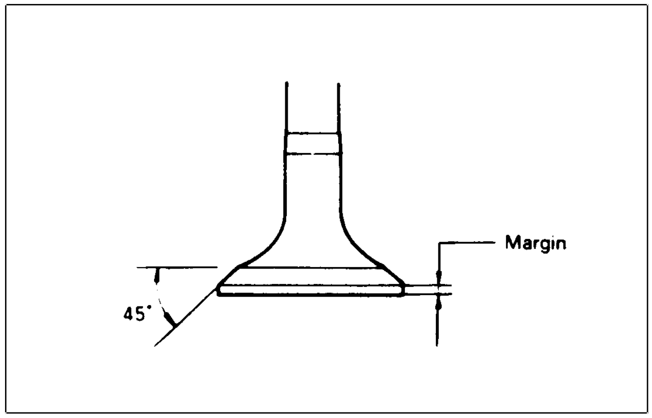


Figure 65

Valve Seats

1. Check the valve seats for damage and indications of incorrect contact (Fig. 66).

Maximum valve sinkage: 1.5 mm (0.06 in.)

2. The valve seat can be resurfaced (Fig. 67). Resurface the valve seat so it contacts the mid-portion of the valve face.

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

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

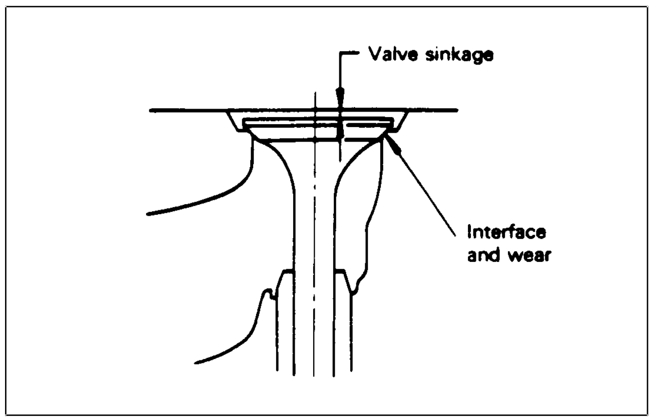


Figure 66

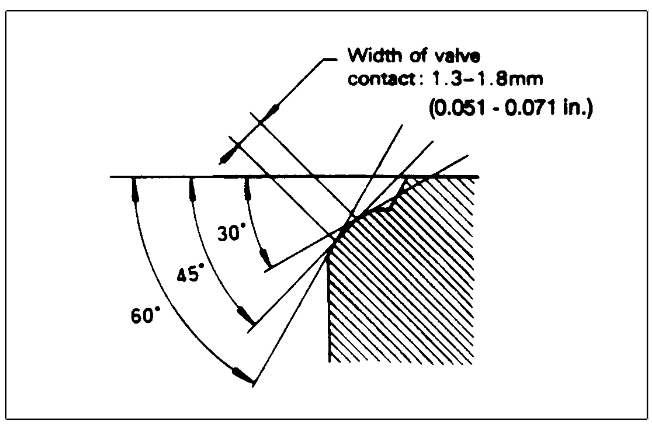


Figure 67

Valve Springs

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

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

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

4. Over a period of time, valve springs can lose some of their tension. The spring must be replaced if the tension is less than the service limit. (Fig. 68)

Minimum Installed Load/Height

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

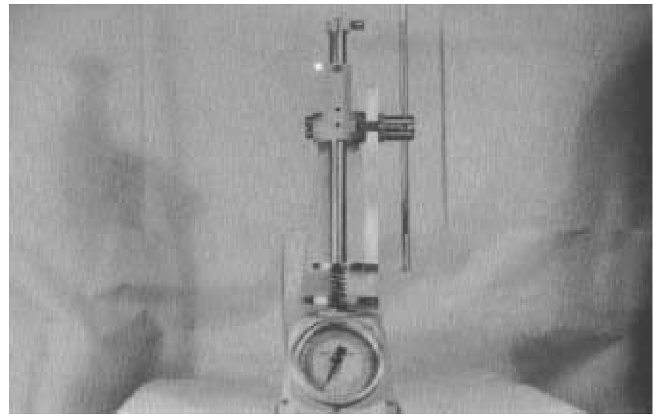


Figure 68

Rocker Arm and Rocker Shaft

1. Remove the snap ring on each end of the rocker shaft. Remove the rocker arm stay bolts. Remove rocker arm stays, spring and rocker arms from the shaft (Fig. 69).

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

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

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

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

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

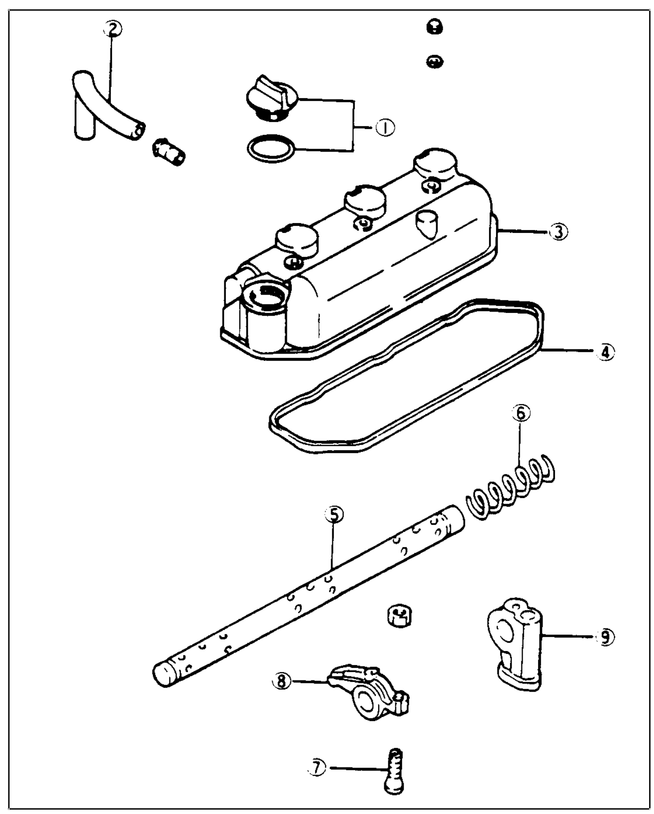


Figure 69

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

Cylinder Head Assembly and Installation

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

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

3. Make sure the valve guides are properly installed (Fig. 64).

4. Install new valve stem seals onto the valve guides (Fig. 70). DO NOT install used seals.

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

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

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

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

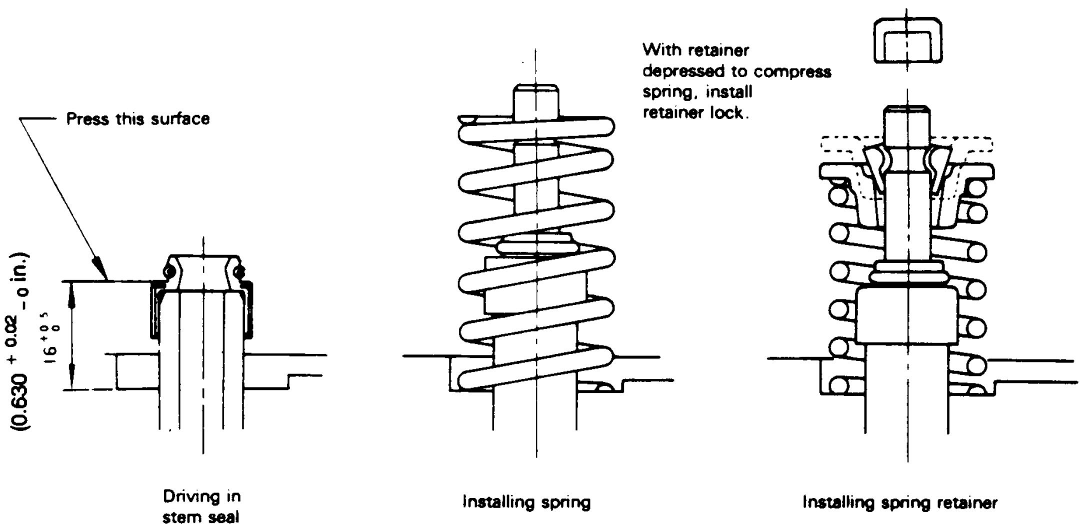


Figure 70

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

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

9. Tighten the cylinder head bolts in the order shown in Figure 71. Tighten the bolts to approximately one-third the specified torque, then two-thirds and finally to the final specified torque.

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

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

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

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

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

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

15. Install the glow plug lead wires.

16. Install the alternator.

17. Install the muffler.

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

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

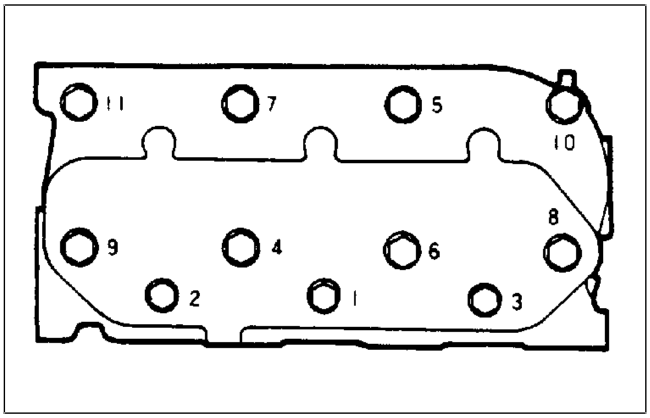


Figure 71

Cylinder Block Overhaul

NOTE: The engine must be removed from the vehicle chassis and put in an engine stand. (See Removing and Installing The Engine.)

Gear Case and Oil Pump

1. Remove the crankshaft pulley.

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

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

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

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

6. Remove the gear case assembly (Fig. 72).

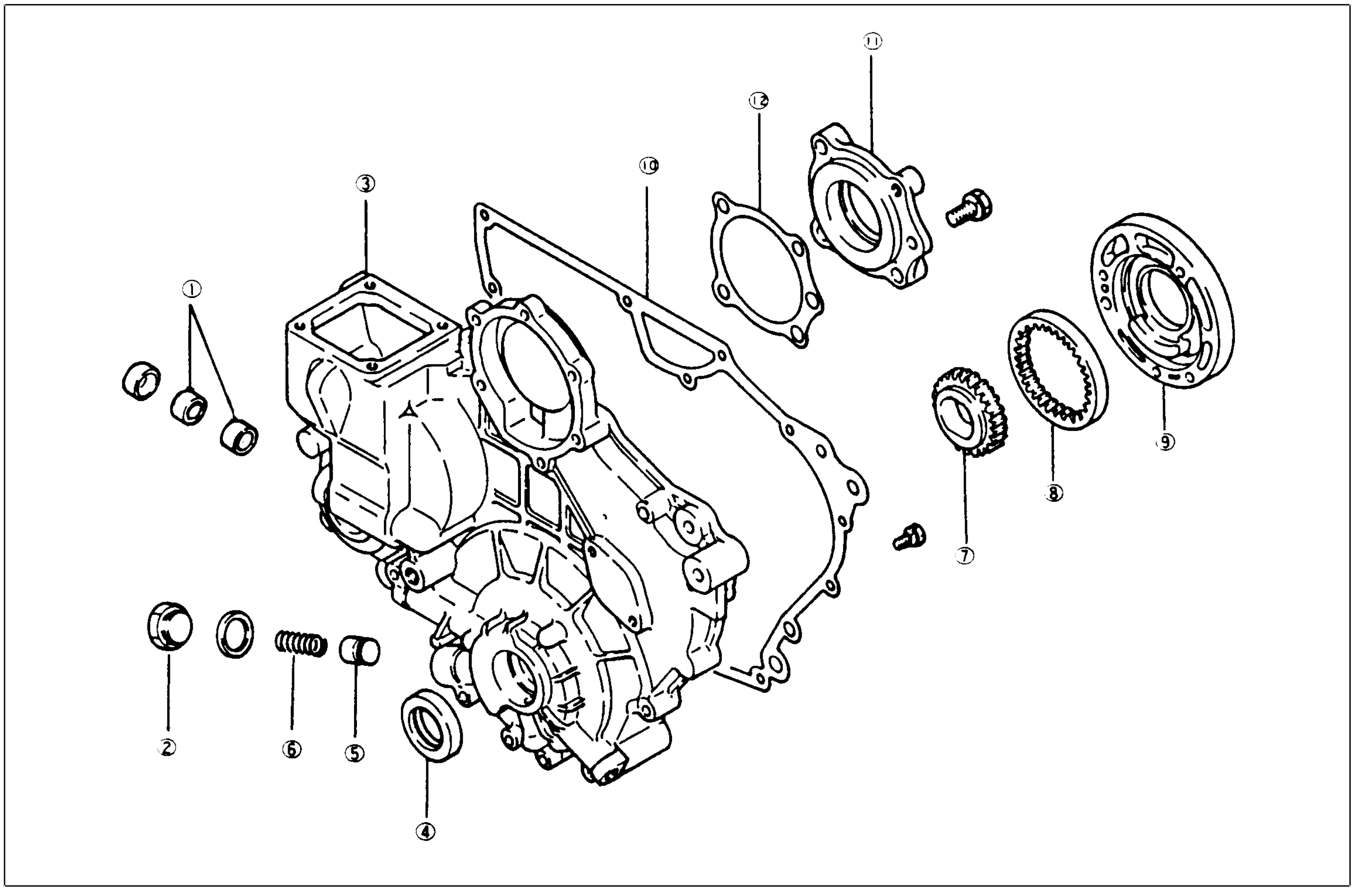


Figure 72

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

7. Check removed parts for wear or damage (Fig. 73). Replace parts as necessary.

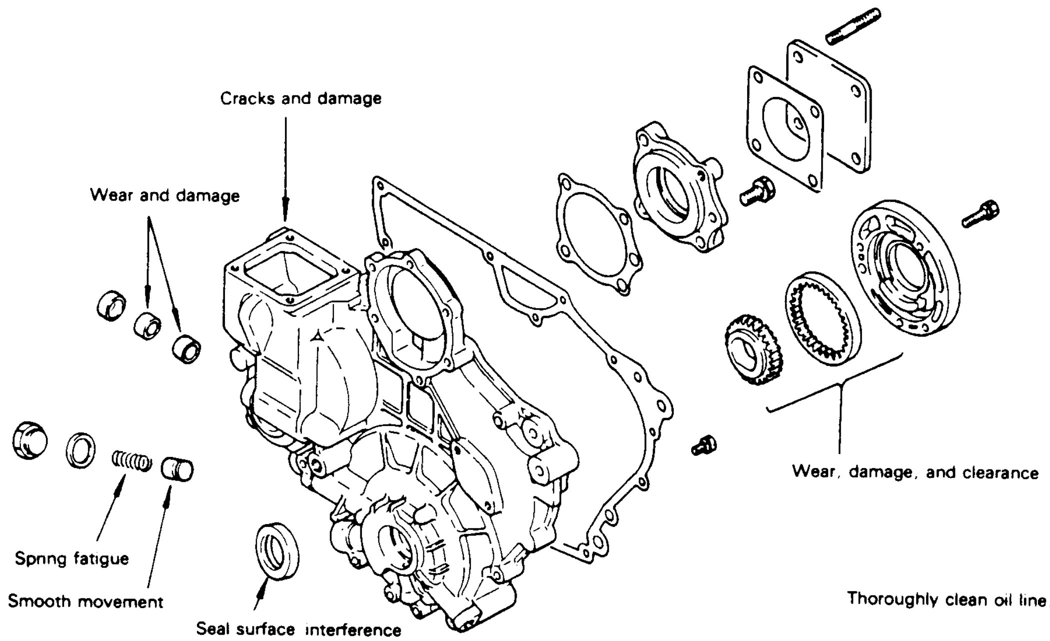


Figure 73

Liquid Cooled Diesel Engine

8. Check the governor parts for wear or damage (Fig 74). Replace parts as necessary.

A. Remove the expansion plug (Fig 75). Be careful to not scratch the gear case.

B. Pull out the grooved pin.

C. Remove the shaft, spring and levers.

D. If necessary replace the governor bushings (Fig. 76).

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

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

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

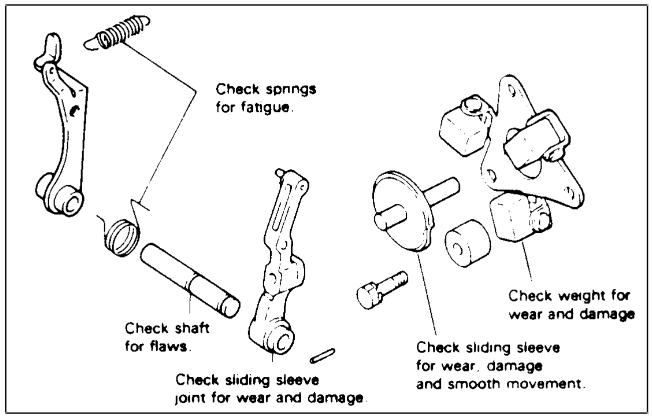


Figure 74

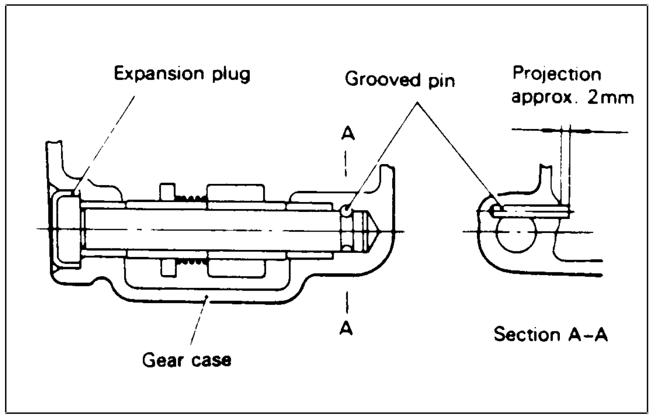


Figure 75

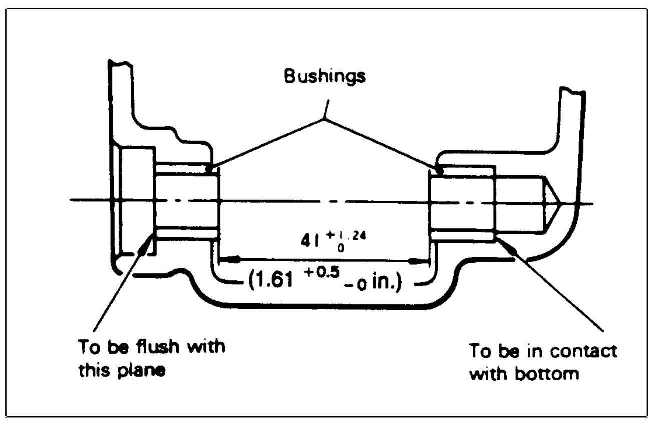


Figure 76

Timing Gears and Camshafts

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

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

3. Remove the snap ring and remove the idle gear (Fig. 77).

4. To remove the injection pump camshaft:

   A. Remove the governor weight assembly (Fig. 33).

   B. Remove camshaft rear cover.

   C. Remove the stopper bolt (Fig. 78).

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

5. To remove the valve camshaft:

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

   B. Remove the camshaft stopper bolt.

   C. Pull the camshaft out of the cylinder block (Fig 79).

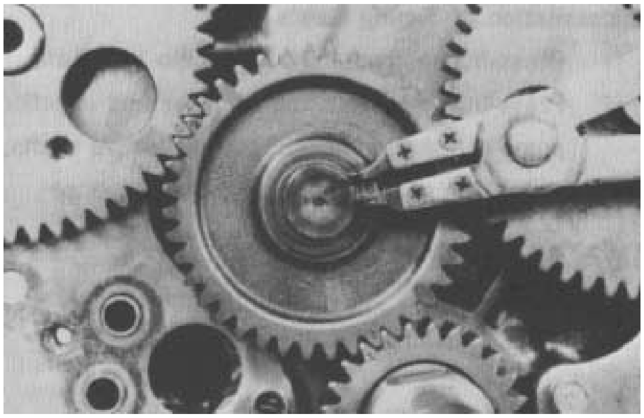


Figure 77

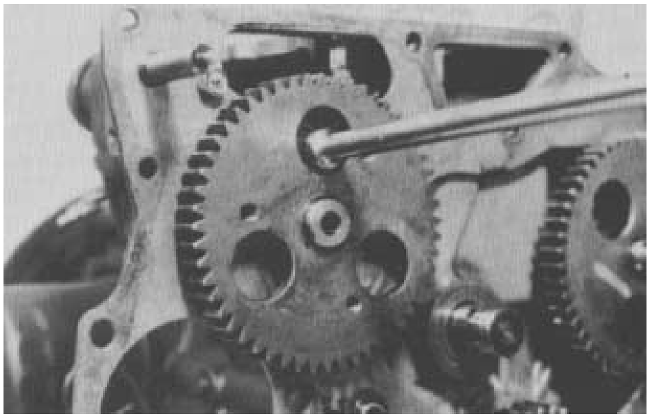


Figure 78

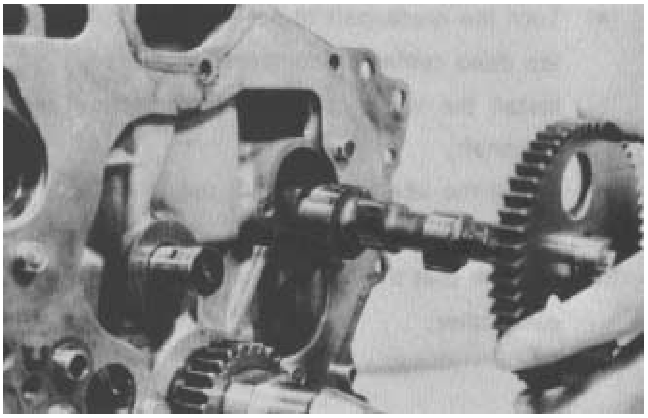


Figure 79

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

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

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

7. Inspect the camshaft parts (Fig. 80). Replace any parts that are worn or damaged.

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

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

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

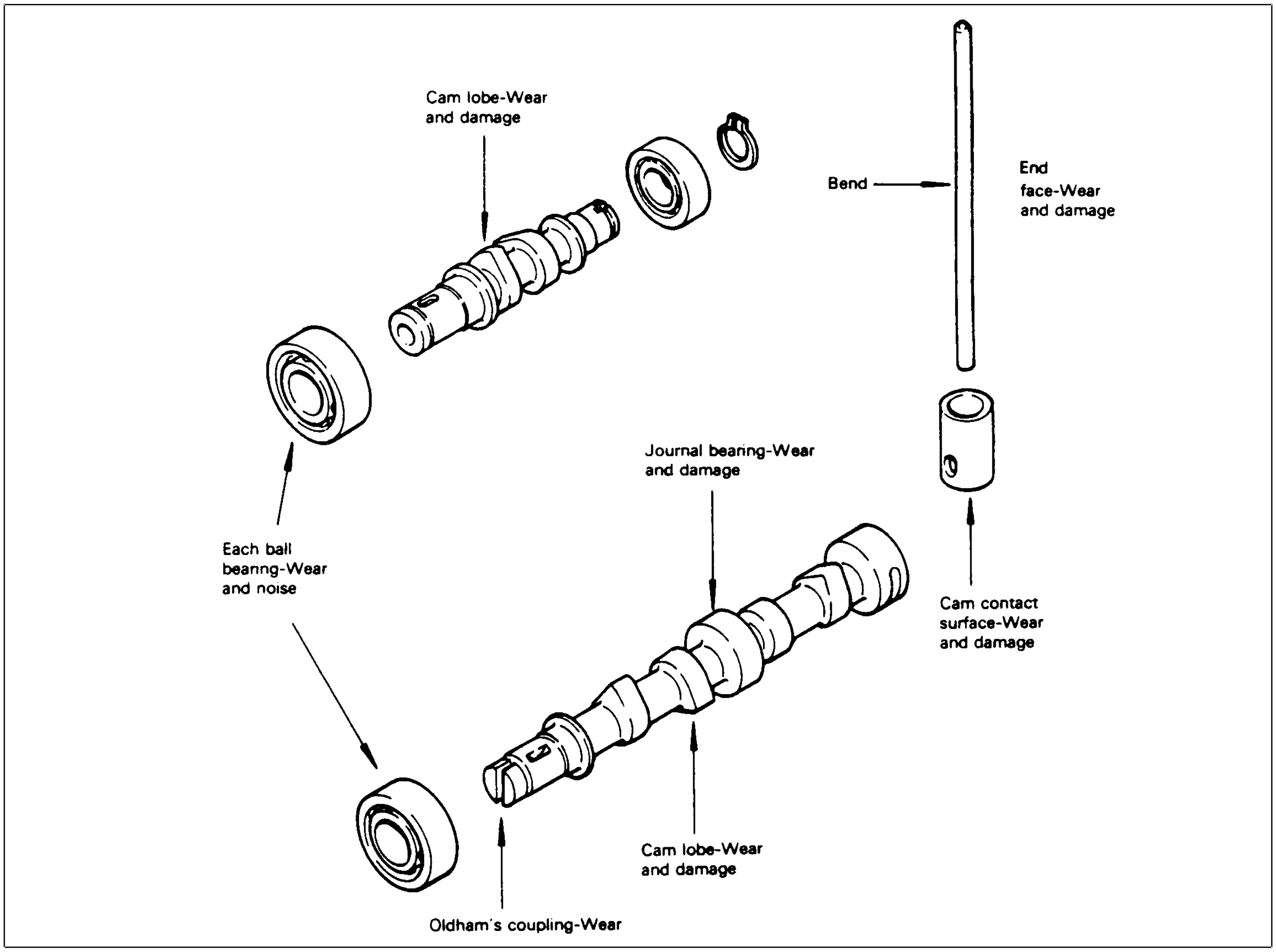


Figure 80

8. Before installing the camshafts and timing gears, turn the crankshaft to set the No. 1 cylinder to top dead center (TDC) of the compression stroke. Reverse steps 1 - 5 to install the camshafts and timing gears (Fig. 81).

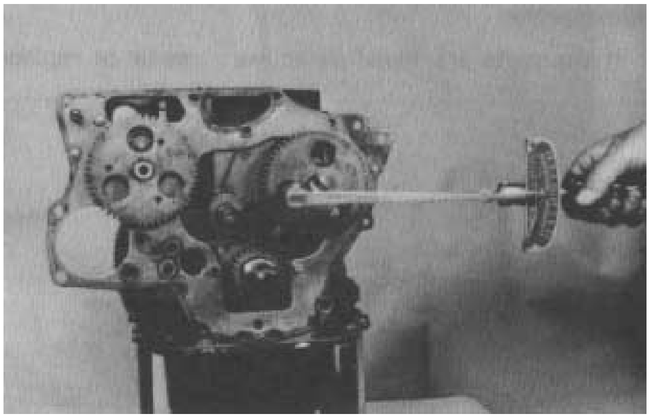


Figure 81

9. With the crankshaft set to No. 1 cylinder TDC, install the idle gear so the timing marks on all the gears are in alignment (Fig. 82).

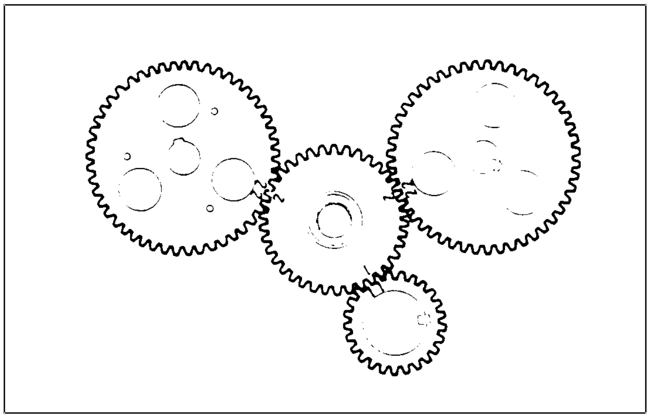


Figure 82

Piston and Connecting Rod

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

2. Remove the oil pan and gasket.

3. Remove the oil screen

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

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

5. Remove the connecting rod end caps and bearings (Fig 83). Keep these parts in cylinder number order so they can be reinstalled in the same cylinder. Use a wood block to push the pistons and connecting rods up out from the bottom of the block. Take care not to scratch the crankshaft pin and cylinder.

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

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

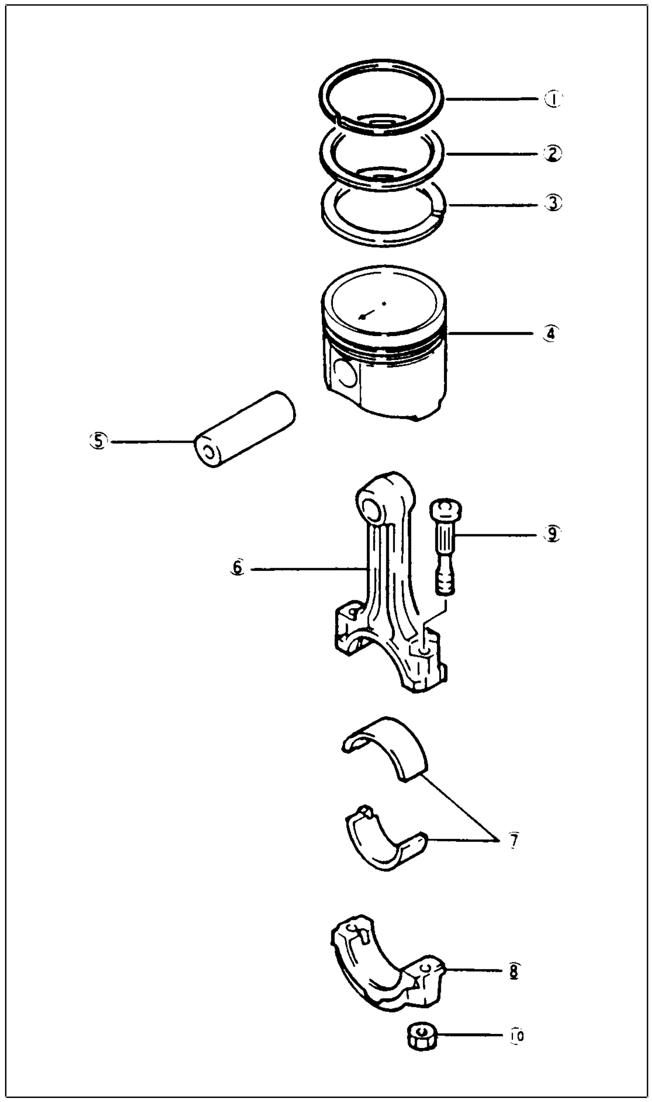


Figure 83

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

8. Measure the piston outside diameter (Fig. 84). (See Cylinder Block in this section).

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

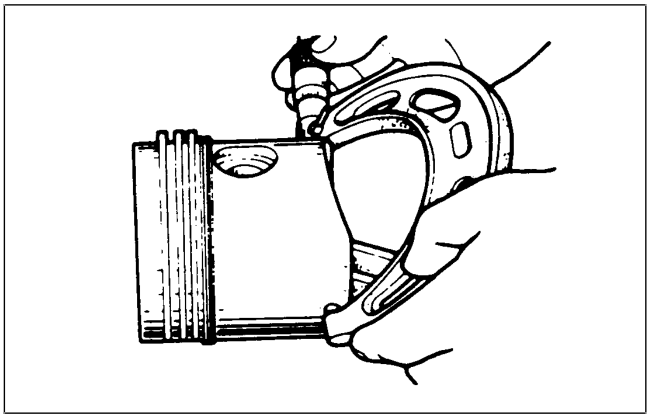


Figure 84

9. Use a thickness gauge to check the piston ring side clearance (Fig. 85).

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

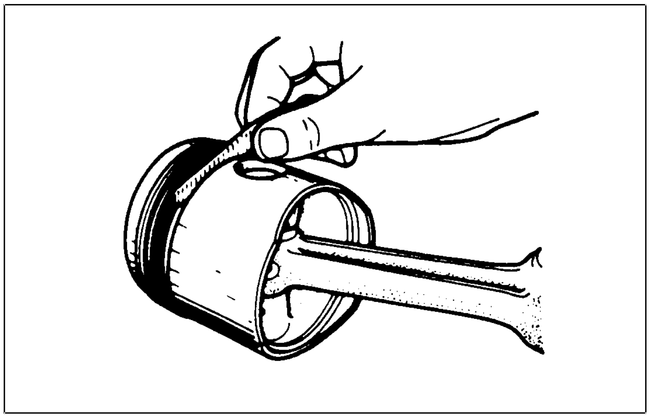


Figure 85

10. Measure the piston ring end gap. Insert the ring into the least worn area of the cylinder by pushing it into place with the piston (Fig. 86). If the gap exceeds 1.5 mm (0.060 in.) the ring must be replaced.

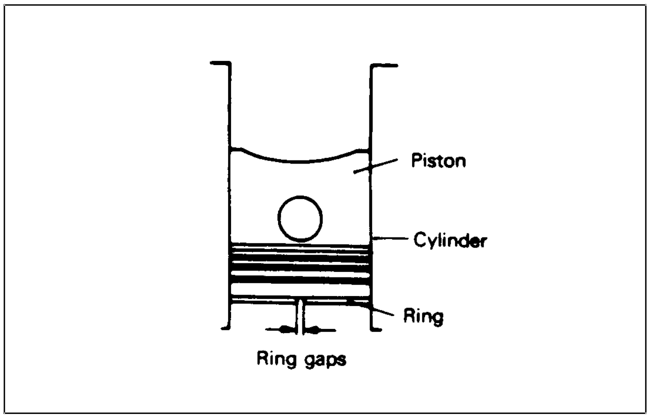


Figure 86

11. To remove the piston from the connecting rod press the piston pin from each piston. Use the piston setting tool (Fig. 87).

IMPORTANT: Do not attempt to remove the piston pins by driving then out with a hammer. A stuck piston pin, requiring excessive pressure to remove, should be replaced.

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

13. To assemble the piston to the connecting rod, press the piston pin into the set position. Use the piston pin setting tool (Fig. 88). Make sure the identification mark of the rod and the arrow mark on the piston head are directed up.

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

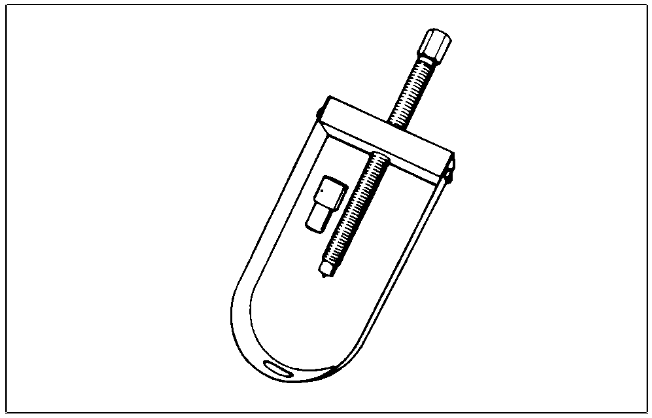


Figure 87

14. Assemble each connecting rod and bearing to the crankshaft in proper order. Use a feeler gauge to measure the side clearance between the connecting rod end and crankshaft (Fig. 89). Replace the connecting rod assembly if the side clearance is more than the specified amount.

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

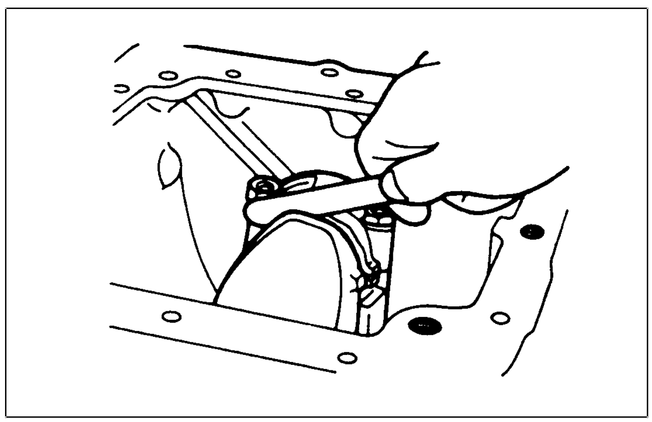


Figure 89

15.Install the piston rings. Each piston ring has different shape. Make sure they are installed in the proper position and with the ring gaps in the directions as illustrated (Fig. 90).

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

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

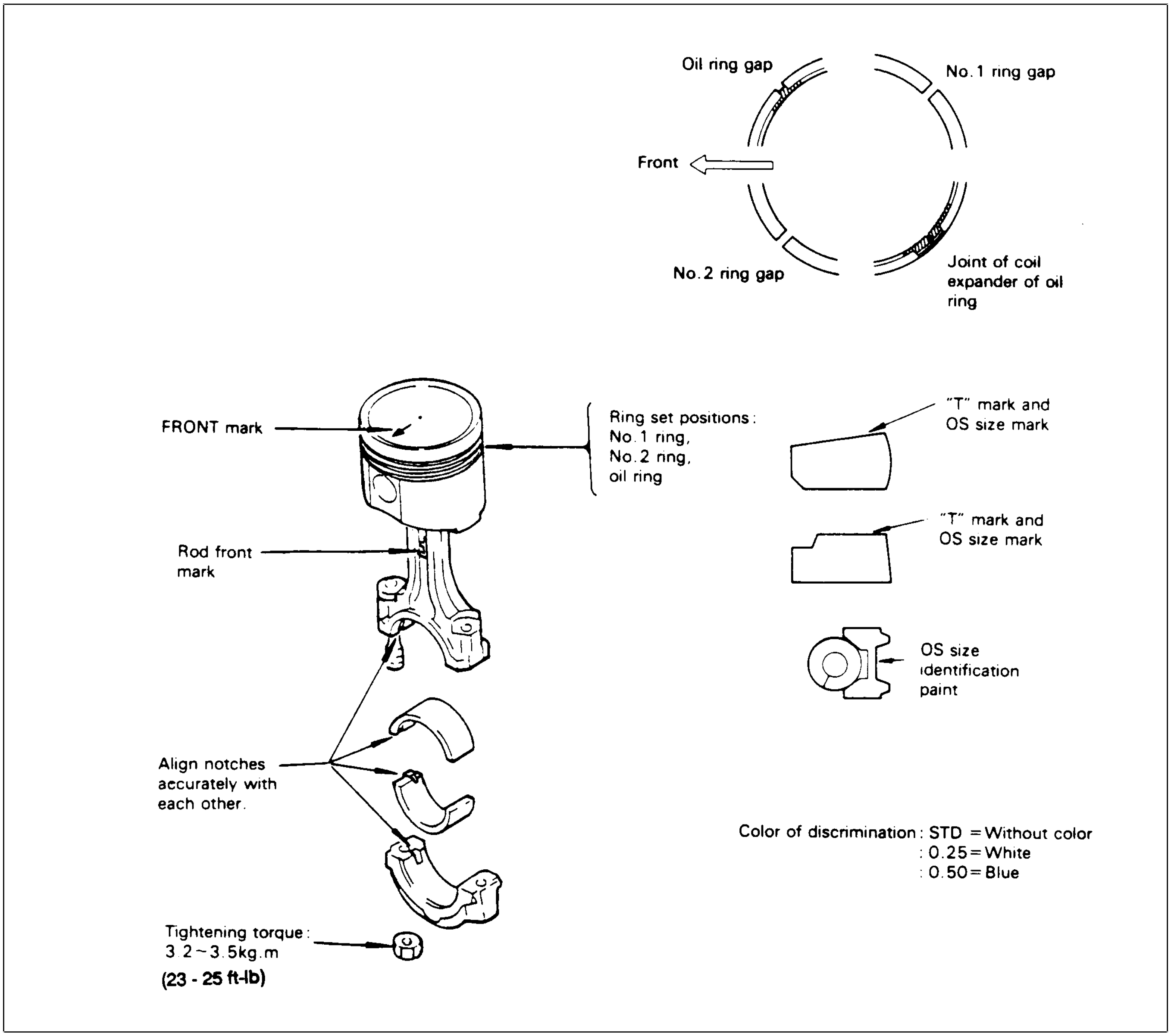


Figure 90

Crankshaft

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

2. Remove the flywheel.

3. Remove the rear oil seal case.

4. Remove the main bearing caps (Fig. 91). Keep each set of bearings together with its bearing cap.

5. Remove the crankshaft.

6. Inspect the removed parts. Repair or replace any worn or damaged parts (Fig. 92).

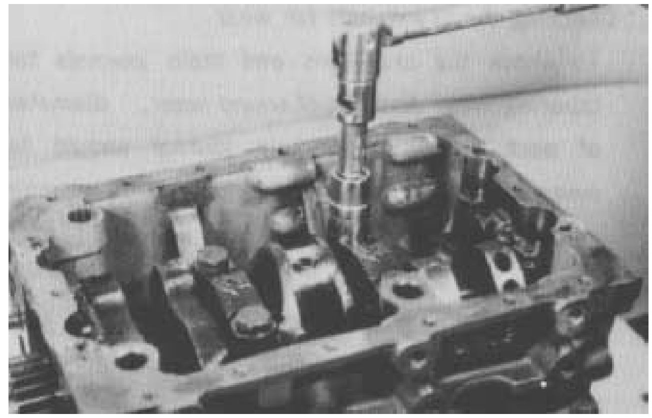


Figure 91

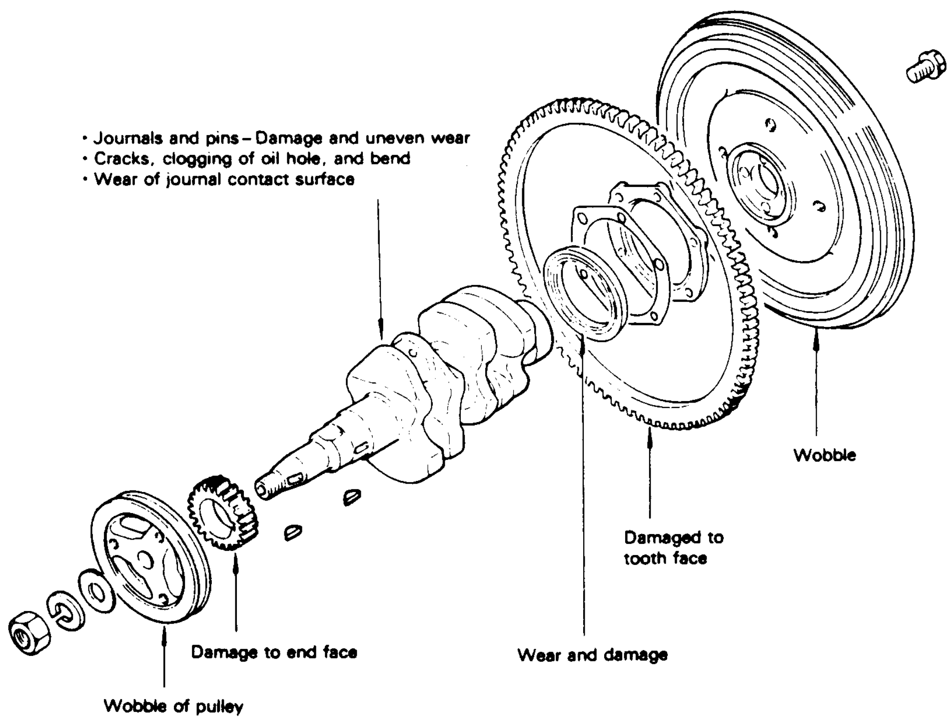


Figure 92

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

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

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

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

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

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

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

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

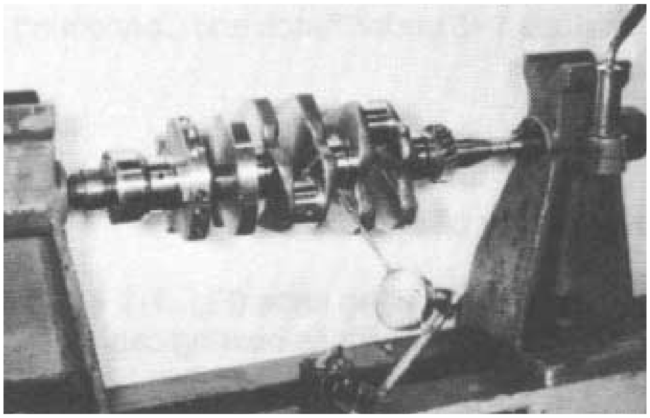


Figure 93

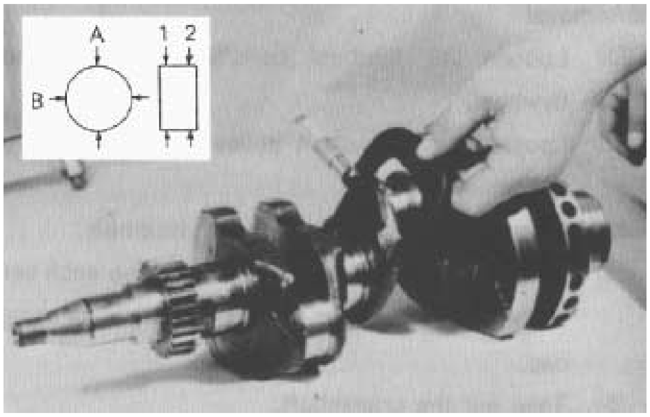


Figure 94

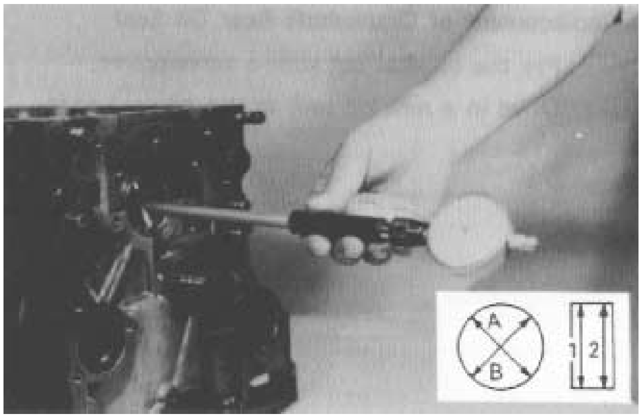


Figure 95

10. Reverse steps 1 - 5 to install the crankshaft (Fig. 97). When installing the No. 1 and No. 4 bearing caps, apply sealant (Permatex No. 2 or equivalent) to the upper surface that meets with the cylinder block.

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

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

12. Apply sealant (Permatex No. 2 or equivalent) to the outside surface of the side seals. Install the side seals with the radius towards the outside of the engine (Fig. 96).

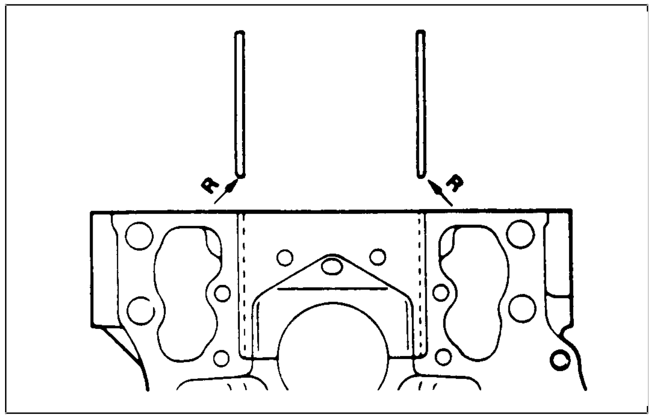


Figure 96

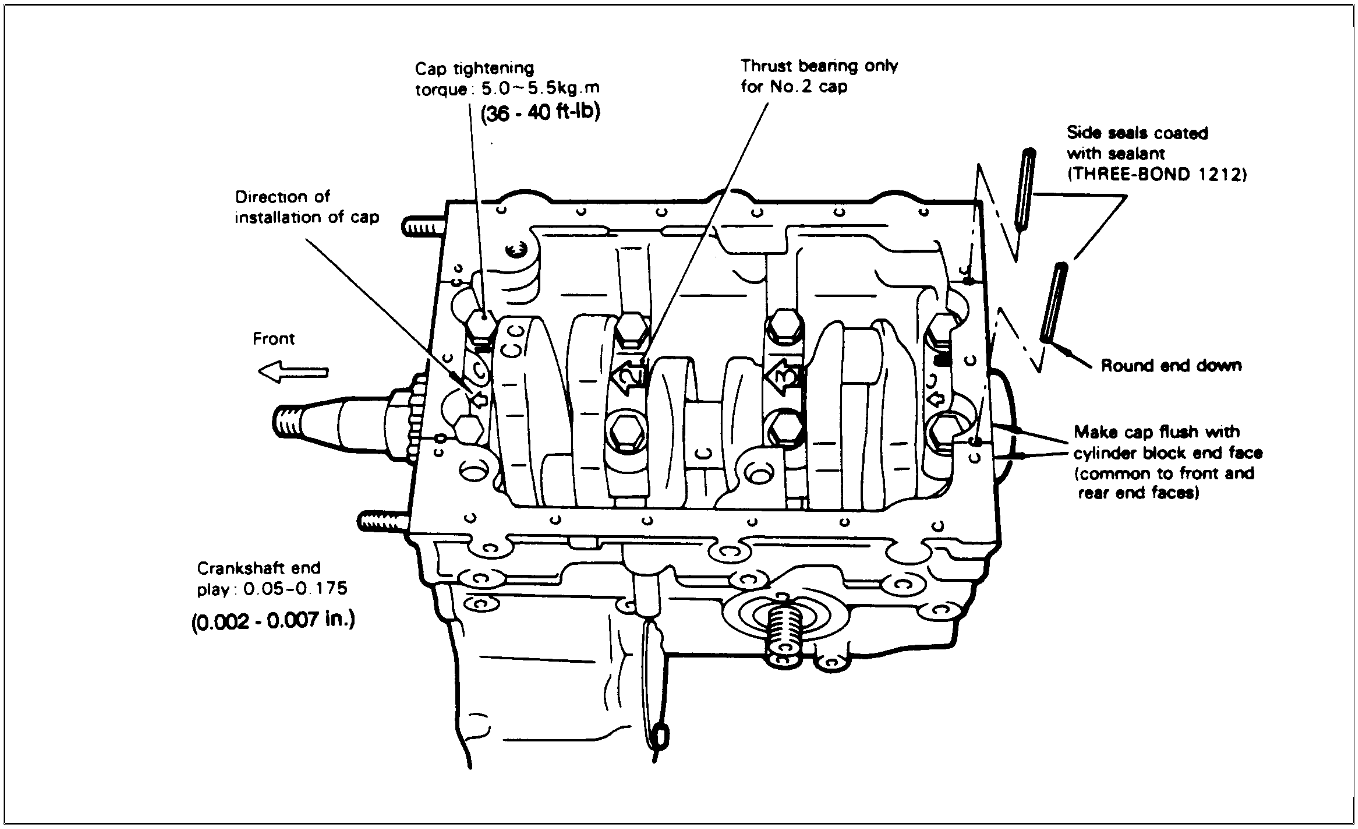


Figure 97

Cylinder Block

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

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

Measure each cylinder bore size in six locations (Fig. 98). The cylinder must be rebored and over-sized piston and rings installed if the diameter exceeds the standard by 0.2 mm (0.0079 in.). Examine the cylinder bore diameter readings to determine the amount of taper in the cylinder. If the taper exceeds 0.01 mm (0.0004 in.), the cylinder must be rebored and oversized piston and rings installed.

Engine Model L3Ca-62TG Standard Bore: 70 mm (2.7559 in.)
Engine Model L3Ca-62TG Standard Bore: 76 mm (2.9921 in.)

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

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

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

Reboring Cylinder

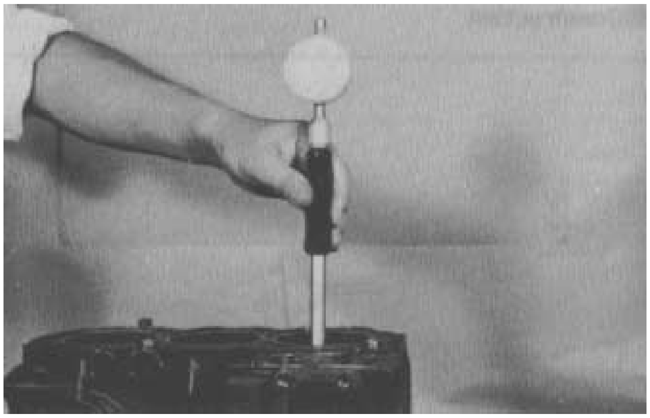
1. Select a piston:

0.25, 0.50 mm (0.01, 0.02 in.) oversize

2. Measure the piston diameter (Fig. 84).

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

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



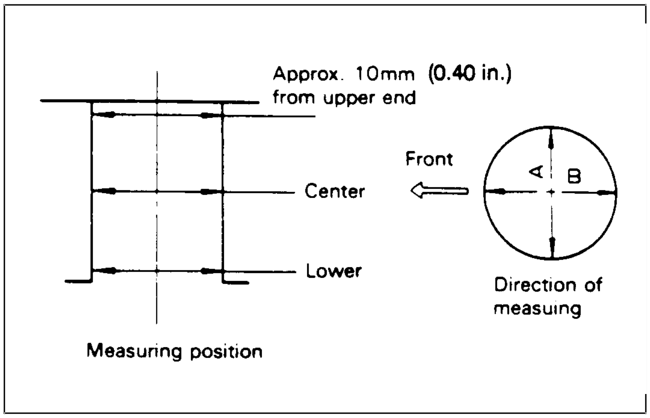


Figure 98

Liquid Cooled Diesel Engine

Chapter 5

Air Cooled Gas Engine

Table of Contents

Air Cooled Gas Engine

Specifications

Item	Specification
Make / Designation Serial Number Below 220000000 Serial Number Above 220000000	Kohler Air Cooled, Gasoline Engine CH 22S Spec. No. 66513 CH 23S Spec. No. 76548
Bore/Stroke Serial Number Below 220000000 Serial Number Above 220000000	 3.03 in. / 2.64 in. (77 mm / 67 mm) 3.15 in. / 2.64 in. (80 mm / 67 mm)
Displacement Serial Number Below 220000000 Serial Number Above 220000000	 38.1 cu. in. (624 cc) 41.1 cu. in. (674 cc)
Crankcase oil capacity	2 U.S. qt. (1.9 L) with filter
Oil	API Service Classification SF or SG Above 0°F (–20°C) SAE 10W–30 or 10W–40 Below 32°F (0°C) SAE 5W–20 or 5W–30
Fuel	Unleaded Regular Gasoline Minimum Octane 87
High idle speed (no load)	3600 $\pm$ 50 RPM
Low idle speed (no load)	1200 $\pm$ 100 RPM

General Information

Removing Debris From Engine

To ensure proper cooling, make sure the grass screen, cooling fins and other external surfaces of the engine are kept clean at all times.

To clean, remove the blower housing and other cooling shrouds and clean the cooling fins and external surfaces as necessary. Make sure cooling shrouds are reinstalled after cleaning.

IMPORTANT: Operating the engine with a blocked grass screen, dirty or plugged cooling fins or cooling shrouds removed will cause engine damage due to overheating.

Spark Plug Replacement

Spark plug type	Champion RC 12YC or equivalent

Spark plug air gap	1 mm (.040 in.)

1. Clean area around spark plugs to prevent foreign material from falling into cylinder when spark plug is removed.

2. Pull spark plug wires off spark plugs and remove plugs from cylinder head.

NOTE: When disconnecting spark plug wires, be sure to hold cable cap and not wire. Disconnecting spark plug wires by holding wire alone can cause damage to wire and malfunction of ignition system.

3. Check condition of side electrode, center electrode, and center electrode insulator to assure there is no damage.

IMPORTANT: A cracked, fouled, dirty or otherwise malfunctioning spark plug must be replaced. Do not sand blast, scrape, or clean electrodes by using a wire brush because grit may eventually release from the plug and fall into the cylinder. The result is usually a damaged engine.

4. Set air gap between center and side of electrodes at .040 in. (1 mm). Install correctly gapped spark plug and tighten plug to 18 – 22 ft–lb (24 – 30 Nm). If torque wrench is not used, tighten plug firmly.

5. Install spark plug wires.

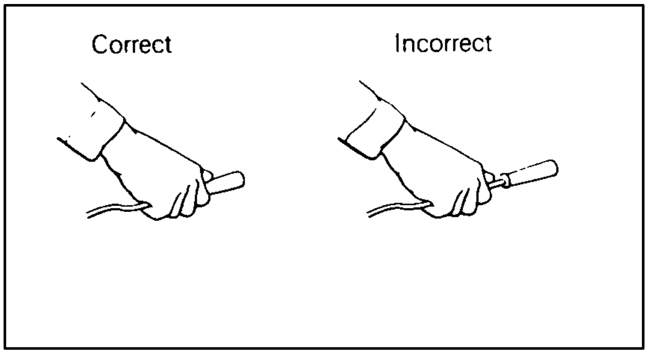


Figure 1

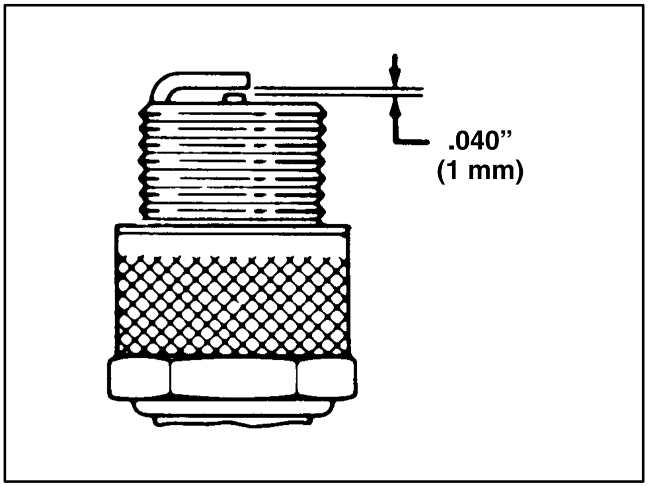


Figure 2

Adjustments

Belt Adjustment

1. Park machine on a level surface, stop engine and engage parking brake.

2. Check tension by depressing belt at mid span of crankshaft and pump pulleys with 22 lbs. (10 Kg) of force. A new belt should deflect .48 – .58 in. (12 – 15 mm). A used belt should deflect .55 –.65 in. (14 – 17 mm) If deflection is out of specification, go to next step. If deflection is within specification, no adjustment is necessary.

3. To adjust belt tension:

   A. Loosen nuts securing hydraulic pump to engine frames.

   B. Rotate pump to obtain correct belt tension, then tighten nuts.

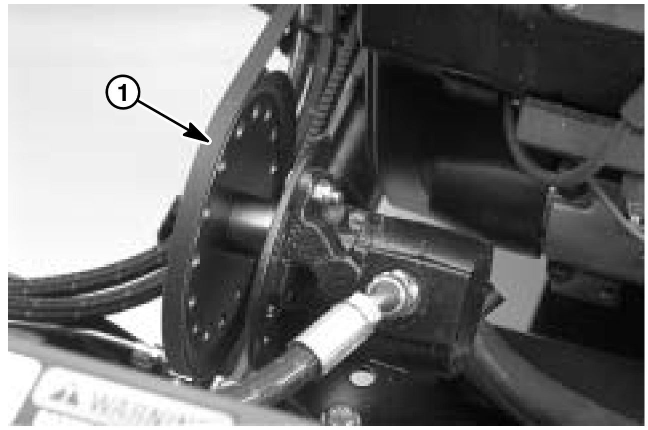


Figure 3

1. Pump belt

Carburetor Adjustment

IMPORTANT: Before doing carburetor adjustment, make sure:
– Engine has warmed up.
– Choke is operating correctly.
– Fuel tank is full.
– Fuel tank cap vent is not blocked.
– Fuel filter is clean.
– Air cleaner element is clean.
– All components are fastened securely.

1. Park machine on a level surface, stop engine and engage parking brake.

2. Low Idle Adjusting Needle – Close adjusting needle by gently rotating in clockwise.

3. Rotate (open) adjusting needle 1–$^5/_8$ turns counterclockwise.

WARNING

Engine must be running so final adjustment of carburetor can be performed. To guard against possible personal injury, keep hands, feet, face and other parts of the body away from muffler, engine and other moving or rotating parts.

4. Start engine and let it run for 5 to 10 minutes. Engine must be warm before making final adjustments. Check to make sure throttle and choke plates open fully.

5. With engine idling, turn low idle speed adjusting screw in or out to obtain a low idle speed of 1200 $\pm$ 100 RPM. Check speed with a tachometer.

6. Turn low idle adjusting needle in SLOWLY until engine speed decreases and then back it out approximately $^3/_4$ to 1 turn to get the best low speed performance.

7. Check idle speed again using a tachometer and re–adjust if necessary.

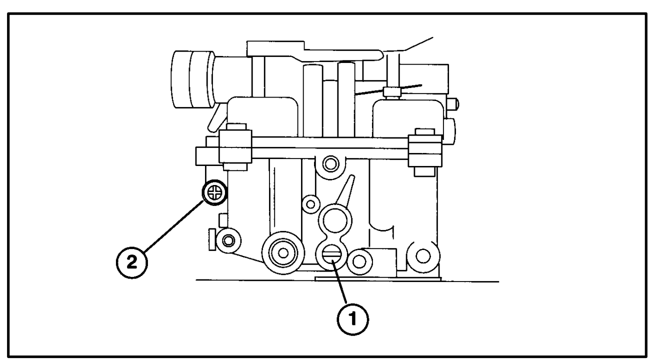


Figure 4

1. Low idle adjusting needle
2. Low idle speed adjusting screw

Choke Adjustment

1. Park machine on a level surface, stop engine and engage parking brake.

2. Loosen cable clamp screw securing choke cable to engine.

3. Push choke control knob down to OFF position.

4. Push choke cable firmly toward operator's side of vehicle and tighten cable clamp screw.

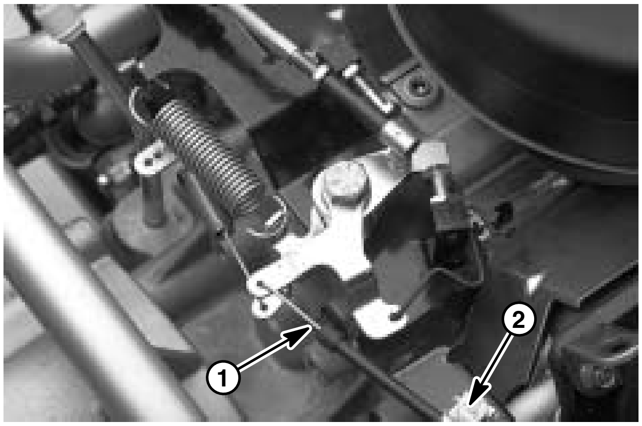


Figure 5

1. Choke cable **2. Cable clamp**

Accelerator Adjustment

1. Park machine on a level surface, stop engine and engage parking brake.

2. With return spring installed, hold engine governor arm toward operator's side of vehicle and adjust low idle stop to get a 0.01 – 0.05 in. (0.25 – 1.3 mm) gap between O.D. of hole in throttle lever and inside of governor spring hook.

> **WARNING**
>
> **Engine must be running so final adjustment of accelerator can be performed. To guard against possible personal injury, keep hands, feet, face and other parts of the body away from muffler, engine and other moving or rotating parts.**

3. Start engine and allow it to warm up to normal operating temperature. Verify low idle setting of 1200 ± 100 RPM.

4. Adjust high idle stop to get 3600 ± 50 RPM when throttle lever contacts stop.

5. Stop engine.

6. Make sure engine is stopped and return spring is attached. With throttle lever against high idle stop, adjust ball joint on accelerator cable and/or cable jam nuts to allow .100 – .250 in. (2.5 – 6 mm) of clearance between accelerator pedal arm and top of diamond tread floor plate when a 25 lb. (11 Kg) force is applied to center of pedal. Tighten locknut.

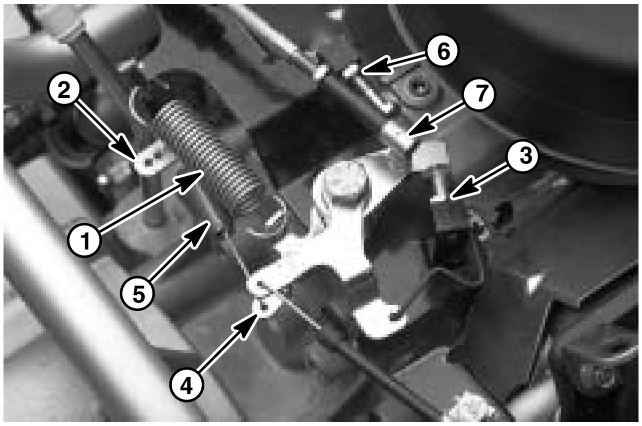


Figure 6

1. Return spring
2. Engine governor arm
3. Low idle stop
4. Throttle lever
5. Governor spring
6. High idle stop
7. Ball joint

Air Cooled Gas Engine

Engine Removal and Installation

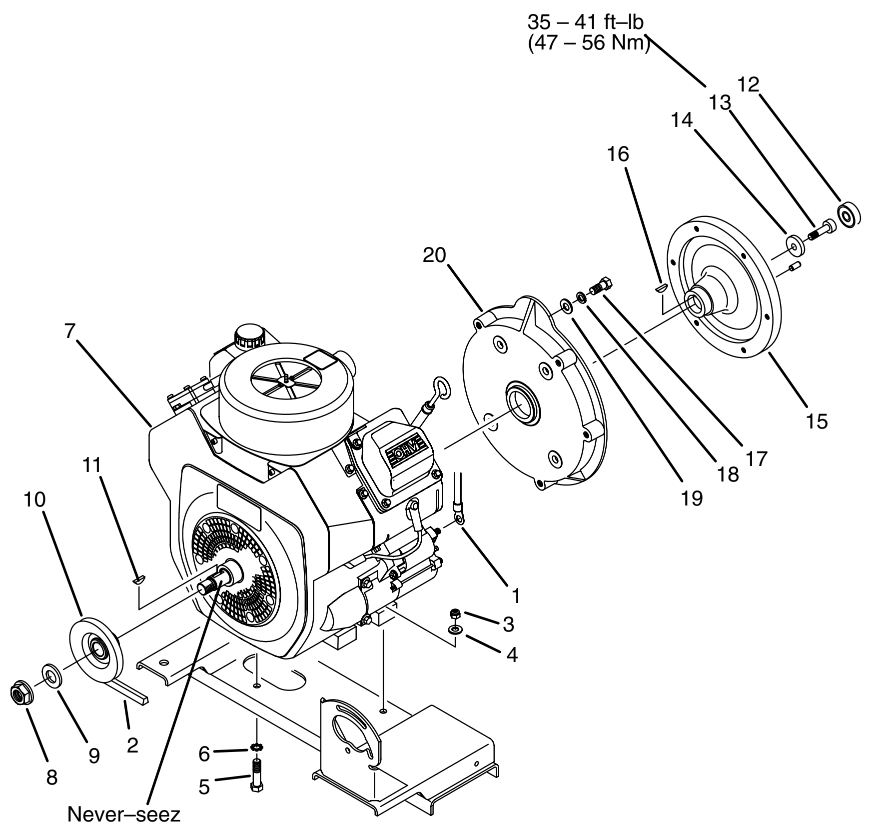


Figure 7

1. Battery Positive (+) cable	**8. Locknut**	**15. Flywheel**
2. Hydraulic pump drive belt	**9. Flat washer**	**16. Woodruff key**
3. Locknut	**10. Pulley**	**17. Capscrew**
4. Flat washer	**11. Woodruff key**	**18. Lockwasher**
5. Capscrew	**12. Pilot bearing**	**19. Flat washer**
6. Lockwasher	**13. Socket head screw**	**20. Clutch adapter**
7. Engine	**14. Washer**	

Removing the Engine

1. Put machine on a level surface and engage parking brake. Stop the engine and remove key from ignition switch. Remove the bed or other attachment(s). Allow engine to cool.

2. Disconnect positive (+) and negative (–) battery cables from battery. Disconnect battery cable (Item 2) from starter.

3. Remove the muffler and exhaust manifold.

4. Disconnect fuel line from carburetor. Plug end of fuel line to prevent contamination and fuel spillage.

5. Disconnect and label electrical leads that attach to engine and engine accessories.

6. Remove hydraulic pump drive belt (Item 2).

7. Disconnect accelerator cable from throttle lever on engine. Remove throttle cable from bracket.

8. Disconnect choke cable from choke lever on engine. Remove choke cable from bracket.

9. Remove any clamps and wire ties where wiring harness, hoses or cables are attached to the engine.

10. Put blocking under transaxle for support.

11. Attach hoist or block and tackle to engine for support.

12. Remove four (4) locknuts (Item 3), flat washers (Item 4), capscrews (Item 5) and lockwashers (Item 6) securing engine to frame.

13. Remove capscrews securing clutch bell housing to engine.

14. Use a hoist or block and tackle to remove engine from chassis. One person should operate hoist or block and tackle and the other person should help guide engine out of chassis. Move engine forward before lifting to disengage transaxle input shaft from clutch.

15. If necessary, remove hydraulic pump drive pulley from stub shaft on flywheel side of engine. Locate and retrieve woodruff key.

16. If pressure plate and clutch disc removal is necessary, see Clutch Disassembly and Inspection in Chapter 6 – Drive Train.

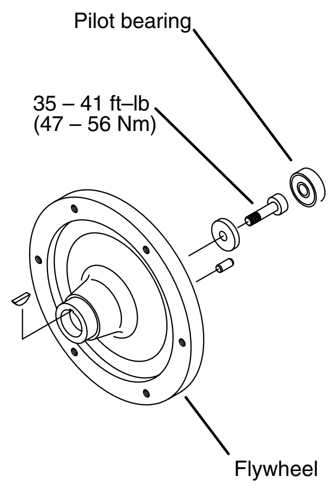


Figure 8

Flywheel and Pilot Bearing Inspection

1. Inspect flywheel clutch disk surface for stepped wear, streaking or seizure and replace if necessary. Check flywheel runout and replace if runout exceeds the limit.

Flywheel runout limit	0.13 mm (.005 in.)

2. Check pilot bearing for smooth rolling and noise. Check (sealed) bearing for grease leakage. Replace bearing if necessary. Remove pilot bearing by backing out socket head capscrew that attaches flywheel to crankshaft (Fig. 8). Do not reuse bearing if removed.

Installing the Engine

1. To install the engine, perform steps Removing the Engine in reverse order. Scrape RTV sealant off engine / bell housing surface. Apply new sealant in same area.

2. If pressure plate and clutch disc were removed, see Installing Clutch Disc and Cover in the Repairs section of Chapter 6 Drive Train.

3. If hydraulic pump drive pulley was removed, apply antiseize lubricant on shaft surface before installing pulley.

4. Install a new engine oil filter. Fill engine with the correct oil.

5. Adjust accelerator and choke.

Chapter 6

Drive Train

Table of Contents

General Information

Workman 3000/4000 Series vehicles are equipped with a Toro designed transaxle with 3 forward speeds, 1 reverse and a differential lock. Hi–Lo range gives an effective 6 forward and 2 reverse speeds.

The transaxle is a constant mesh, collar shift transmission with synchronizers for gears 1, 2 and 3. Reverse and High–Low range must be shifted with the vehicle stationary.

An optional top mounted PTO operates at 540 RPM.

The transaxle with automotive type clutch is bolted to the engine with the engine/transaxle assembly isolation mounted to the vehicle frame.

Two heavy duty universal drive shafts transfer power from the transaxle to the rear wheels. A fully independent rear suspension and Dedion type rear axle isolate the mid–mounted engine/transaxle assembly from the terrain.

The transaxle housing also functions as the hydraulic system reservoir.

On units equipped with four wheel drive (4WD), the front drive shaft transfers power from the transaxle to the front wheels.

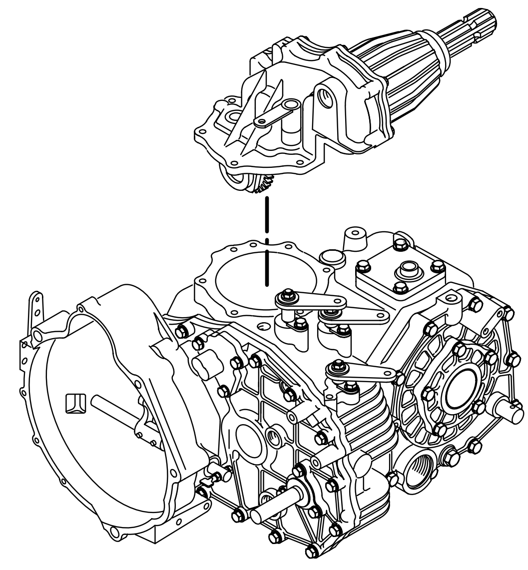


Figure 1

Specifications

General Specifications

Item	Specification
Clutch pedal free play	19 mm (.75 in.) min.
Transaxle countershaft end play	0.00 – 0.10 mm (.000 – .0039 in.)
Transaxle ring gear backlash	0.08 – 0.18 mm (.0031 – .0071 in.) with max. variation of 0.05 mm (.0019 in.) at three different points checked
Liquid gasket (transaxle case gasket)	Three–Bond 1216 or Loctite 599
Transaxle oil	Dexron III ATF
Oil capacity (Fig. 2)	7.5 qt. U.S. (7.1 liter) system capacity

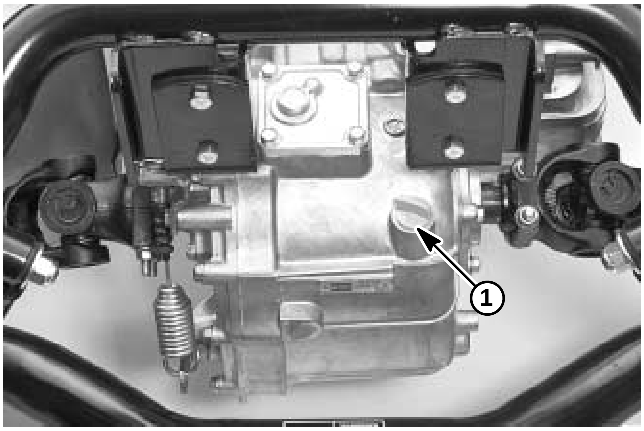


Figure 2

1. Dipstick

Torque Specifications

Item	Specification
Clutch cover bolt	7.0 – 9.0 Nm (5 – 7 ft–lb)
Drive shaft yoke to stub axle flange nut	300 – 340 Nm (220 – 250 ft–lb)
Drive shaft clamp bolt	47 – 57 Nm (35 – 42 ft–lb)
Transaxle differential case to ring gear capscrews	24.5 – 29.5 Nm (18.5 – 22 ft–lb)
Transaxle shift arm locknuts	24.5 – 29.5 Nm (18.5 – 22 ft–lb)
Transaxle case capscrews	24.5 – 29.5 Nm (18.5 – 22 ft–lb)
Transaxle PTO cover capscrews	15 – 17 Nm (11 – 13 ft–lb)

Special Tools

Drive Shaft Yoke Flange Nut Wrench

A modified 1–1/8″ box end wrench is required to remove and install flange nut securing drive shaft yoke to stub axle on early production machines. **NOTE:** If your machine has a half yoke on the stub axle, this modified tool is not necessary.

Recommended Tool: Snap–On Part No. GOEX36B

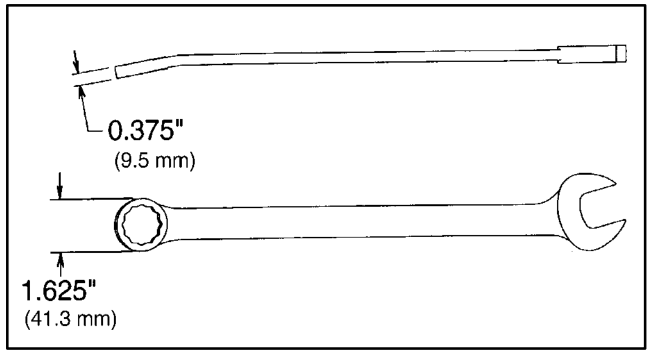


Figure 3

Stub Axle Removal Tool

Use this tool with modified box end wrench shown above to remove flange nut securing drive shaft yoke to stub axle. Fabricate this tool according the dimensions shown. Remove a rear wheel and brake drum, then attach this tool to the wheel studs on the stub axle. Secure tool with wheel nuts.

NOTE: Stub Axle shown on next page can also be used as a removal tool if the nut is welded to the shaft.

Figure 4

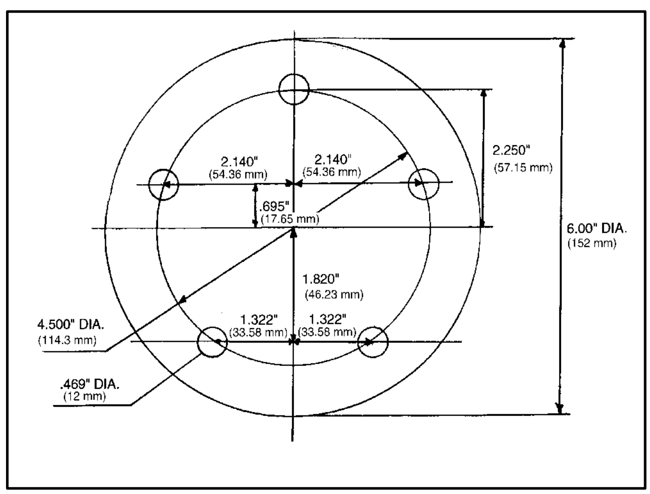


Figure 5

Stub Axle

Use an extra stub axle (Toro P/N 87–8740) with washer (Toro P/N 87–3060) and flange lock nut (Toro P/N 32128–53) as a tool to install stub axle. Attach this tool to the wheel studs on the stub axle. Secure tool with wheel nuts. Use a 1–1/8″ six point socket, torque wrench, and modified 1–1/8″ combination wrench to tighten stub axle flange nut to a torque of 300 – 340 Nm (220 – 250 ft–lb).

Figure 6

Clutch Alignment Tool

Use this tool to align clutch friction disk to engine flywheel before tightening clutch cover capscrews.

Mitsubishi Motors Part No.	MD999572

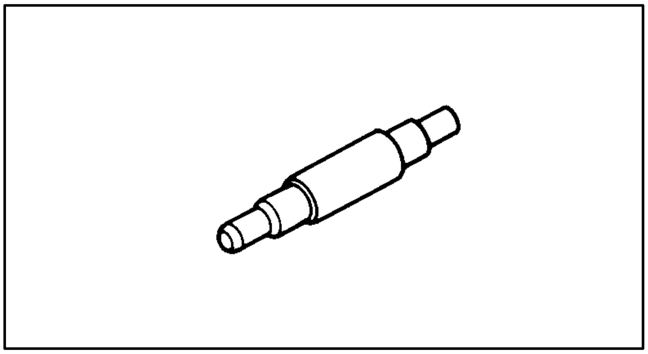


Figure 7

NOTE: Main shaft (Toro P/N 92–0663) from transaxle can also be used as an alignment tool.

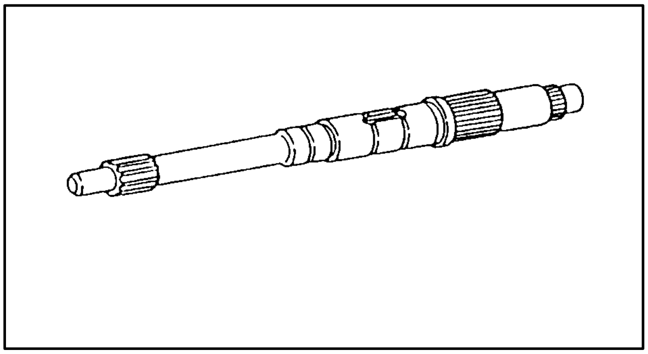


Figure 8

Drive Train

Clutch Pedal Adjustment

1. Loosen jam nuts securing clutch cable to bracket on bell housing.

NOTE: Ball joint may be removed and rotated, if additional adjustment is required.

2. Disconnect return spring from clutch lever.

3. Adjust jam nuts/or ball joint until bottom rear edge of clutch pedal is “A” from top of floor plate diamond pattern, when an 4 lb. force is applied to pedal.

Vehicle	Dimension “**A**”
Workman 3200 / 3100	95 ± 3 mm (3.75″ ± .12″)
Workman 3300–D	108 ± 3 mm (4.25″ ± .12″)

NOTE: Force is applied so release bearing lightly contacts pressure plate fingers.

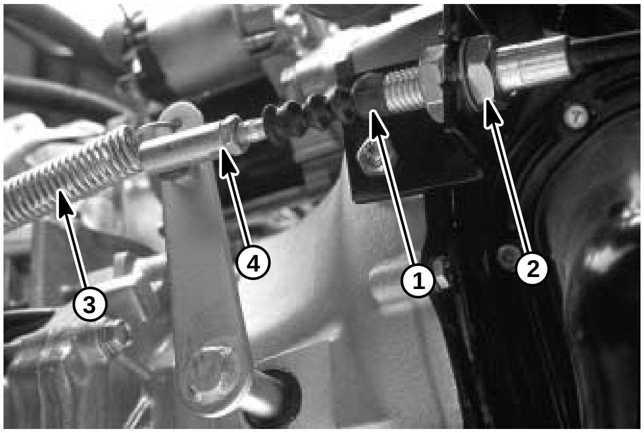


Figure 9

1. Clutch cable
2. Jam nuts
3. Return spring
4. Ball joint

4. Verify that rear edge of clutch pedal is 140 ± 3 mm (5.5″ ± .12″) from top of floor plate diamond pattern. If dimension is not attained, adjust clutch pedal up stop.

NOTE: The clutch free play should never be less than 19 mm (.75″).

5. Tighten jam nuts after adjustment has been attained.

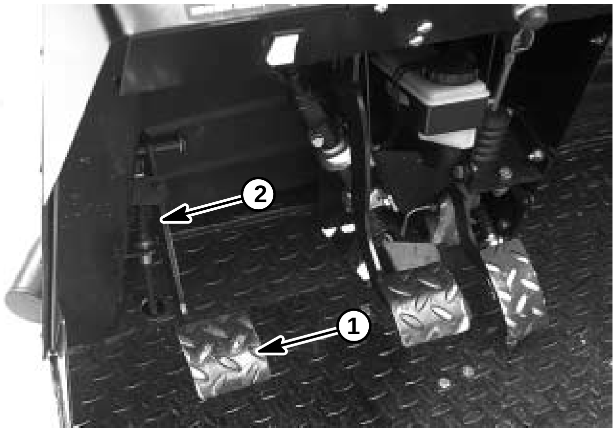


Figure 10

1. Clutch pedal
2. Clutch pedal up–stop

6. Recheck clutch safety switch adjustment. Engine must not crank unless clutch pedal is 32 ± 3 mm (1.25″ ± .12″) from floor. If an adjustment is required, loosen switch jam nuts and adjust up or down.

Figure 11

1. Clutch switch

Shift Cable Adjustment

1st–Rev. / 2nd–3rd Cable Adjustments

1. Move shift lever to neutral.

2. Remove clevis pins securing shift cables 1st–Rev. and 2nd–3rd cables to transaxle shift arms.

3. Loosen clevis jam nuts and adjust each clevis so cable free play is equal forward and backward relative to hole in transaxle shift arm (with transaxle lever free play taken up in same direction).

4. Reinstall clevis pins and tighten jam nuts after adjustments have been made.

5. Make sure force limiter spring has a length of 20 mm (.8″). Adjust length by tightening or loosening lock nut.

6. Adjust shift stops after doing shift cable adjustments:

   A. Shift lever forward to 2nd gear position.

   B. Hold lever in position.

   C. Back out shift stop screw until screw makes contact with shift lever.

   D. Hold stop screw and tighten jam nut.

   E. Repeat steps A – D with shift lever moved forward to Rev. gear position.

High–Low Cable Adjustment

1. Remove clevis pin securing High–Low cable to transaxle (Fig. 12).

2. Loosen clevis jam nut and adjust clevis so clevis hole aligns with hole in High–Low shift arm.

3. Reinstall clevis pin and tighten jam nut after doing adjustment.

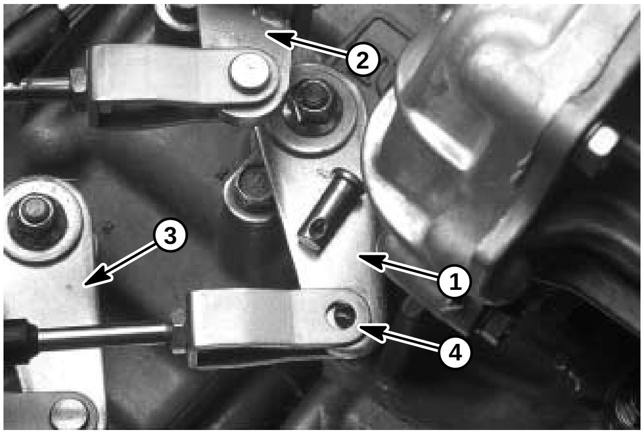


Figure 12

1. Shift arm (1st – Rev.)
2. Shift arm (2nd – 3rd)
3. Shift arm (High – low)
4. Transaxle shift arm hole

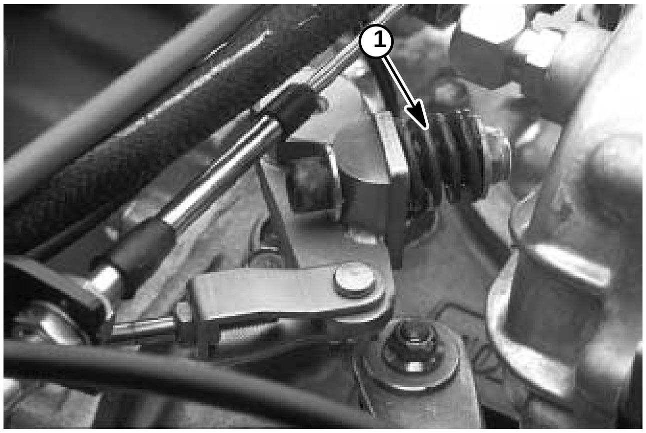


Figure 13

1. Force limiter spring

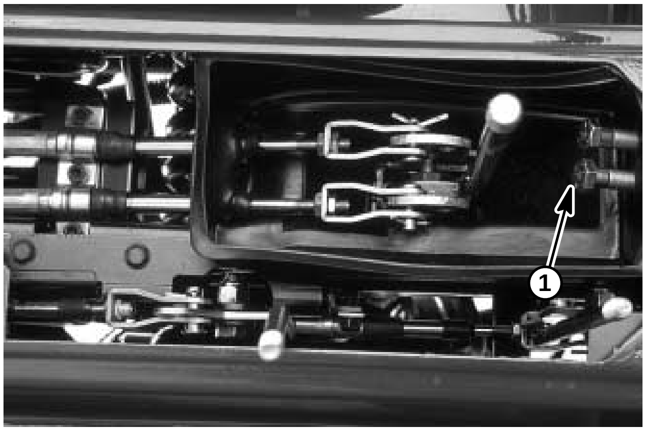


Figure 14

1. Shift stop bolt

Drive Train

Differential Lock Cable Adjustment

Note: On units without a Differential Lock lever, do not perform this adjustment.

1. Move differential lock lever to OFF position.

2. Loosen jam nuts securing differential lock cable to bracket on transaxle.

3. Adjust jam nuts to obtain 0.9 ± 0.6 mm (.035″ ± .025″) gap between spring hook and O.D. of hole in transaxle lever.

4. Tighten jam nuts after adjustment has been made.

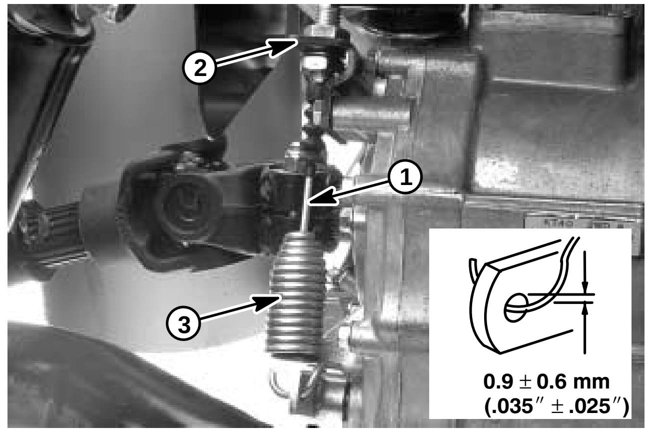


Figure 15

1. Differential lock cable
2. Transaxle bracket
3. Spring

PTO Cable Adjustment

1. Remove clevis pin securing PTO cable to PTO arm.

2. Loosen clevis jam nut and adjust clevis so clevis hole aligns with hole in PTO arm.

3. Reinstall clevis pin and tighten jam nut after doing adjustment.

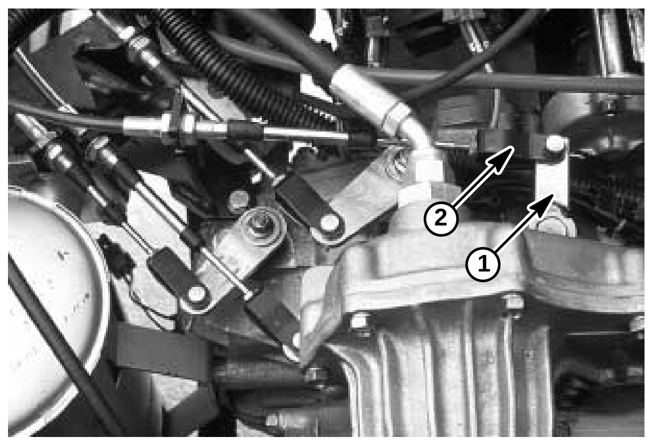


Figure 16

1. PTO lever arm
2. Cable clevis

Troubleshooting

Clutch

Symptom	Possible Causes
Clutch slips.	Excessive wear of clutch disc facing. Clutch pedal out of adjustment. Hardening of clutch disc facing, or adhesion of oil. Weak or broken clutch diaphragm spring. Damaged pressure plate or flywheel.
Clutch operation erratic or rough.	Improper installation of clutch cover assembly. Damaged clutch disc. Excessive wear of clutch disc facing. Weak or broken clutch torsion spring. Damaged or broken clutch pressure plate. Bent or broken clutch diaphragm spring tip. Dirty or improperly lubricated clutch disk spline. Damaged or distorted flywheel. Damaged release bearing.
Clutch noisy.	Improper installation of clutch cover assembly. Excessive wear of clutch disc facing. Worn clutch disc spline. Weak or broken clutch torsion spring. Damaged pilot bushing. Damaged release bearing.
Clutch drags or does not release.	Control cable loose or out of adjustment. Bent or broken clutch diaphragm spring tip. Damaged or distorted clutch disc. Worn or rusted clutch disc spline. Damaged pressure plate or flywheel. Damaged release bearing.

Clutch (continued)

Symptom	Possible Causes
Clutch chatters.	Worn or damaged clutch disc facing. Oil adhered to clutch disc facing. Uneven height of diaphragm spring. Weak or damaged clutch torsion spring. Damaged pressure plate or flywheel. Damaged release bearing.

Transaxle

Symptom	Possible Causes
Noisy operation.	Low oil level in transaxle. Damaged or worn bearings. Gears worn, scuffed or broken. Excessive end play in countershaft. Gears loose on shaft. Excessive wear of differential side gear liners and pinion liners. Excessive wear of splined slider on axle drive joints.
Difficult shifting.	Clutch not releasing. Shift cable out of adjustment. Shift cable damaged. Shifter capscrew loose (at operator station). Loose shift lever on transaxle. Cable clamp securing cables near shifter is loose. Sliding gear tight on shaft or splines. Synchronizing unit damaged. Sliding gear teeth damaged. Synchronizer keys damaged.

Transaxle (continued)

Symptom	Possible Causes
Gears make clashing noise when shifting.	Shifting too fast. Excessive wear of synchro rings. Excessive wear of differential side gear liners and pinion liners. Damaged synchro springs and/or keys. Main gear needle bearings worn or damaged. Excessive wear of drive shaft(s).
Transaxle sticks in gear.	Clutch not releasing. Shift fork detent ball stuck. Shift linkage damaged, loose or out of adjustment. Sliding gears tight on shaft splines. Synchronizer shift keys damaged.
Transaxle slips out of gear.	Shift linkage out of adjustment. Gear loose on shaft. Gear teeth worn. Excessive end play in gears. Lack of spring pressure on shift fork detent ball. Badly worn bearings.
Overheating of transaxle.	Oil level too high. Excessive hydraulic load. See in Chapter 8 – Hydraulic System.

Shifter Cable Replacement

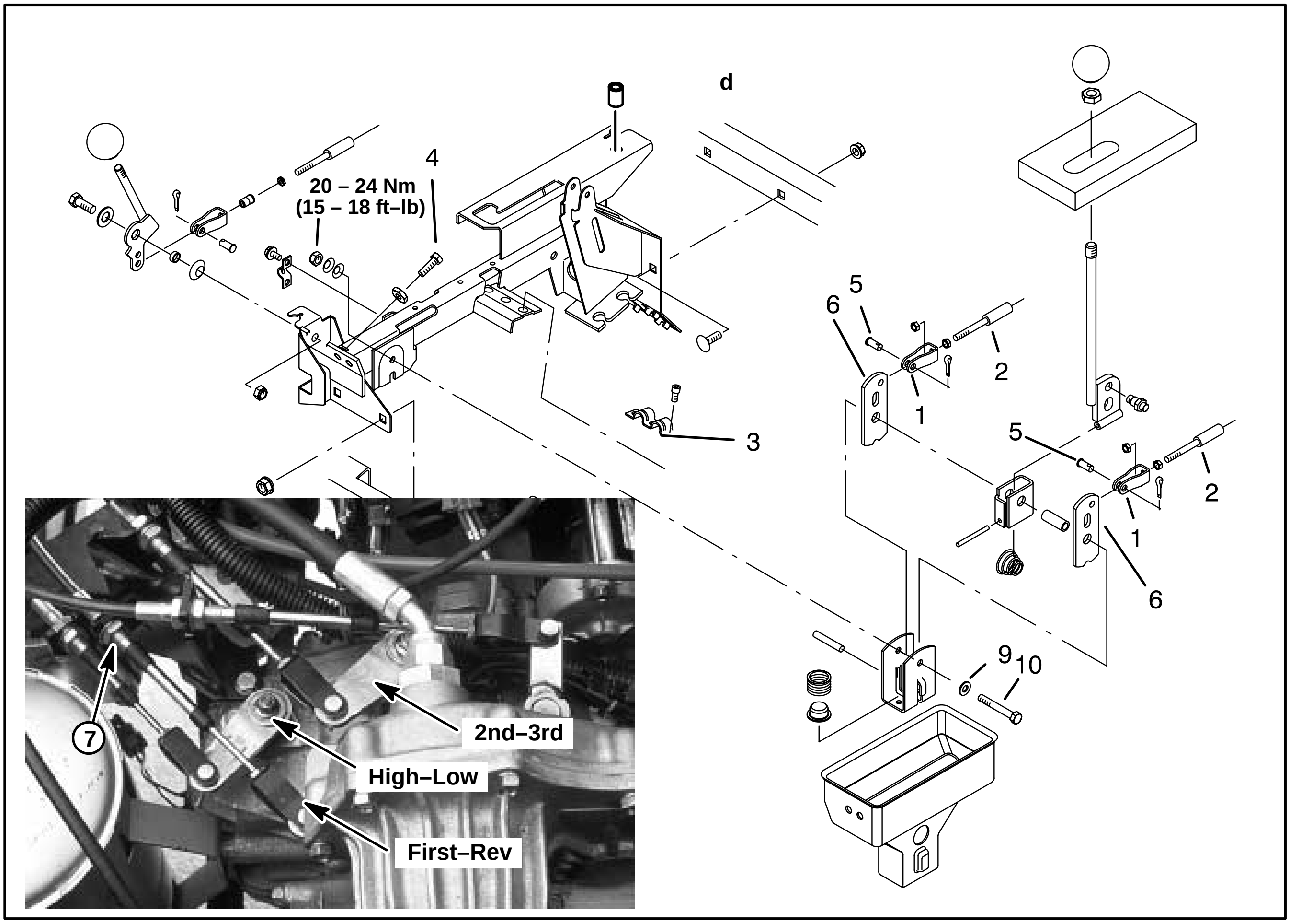


Figure 17

NOTE: Before removing cable(s), note routing and location of cable ties.

1. Before installing cables adjust clevis (Item 1) on 1st–Rev and 2nd–3rd cables as shown Figure 18.

2. Connect shift cables to shift links (Item 6) on shifter in operator platform by inserting both clevis pins (Item 5) from the passenger side, then install cotter pins.

3. Securely fasten cables to shifter bracket with clamp (Item 3).

4. Spread jam nuts (Item 7) on bulkhead fittings of cable. With cable properly routed to transaxle, install cable bulkhead fitting to cable bracket on transaxle and tighten jam nuts.

5. Install cable ties in the original locations.

6. Do cable adjustments.

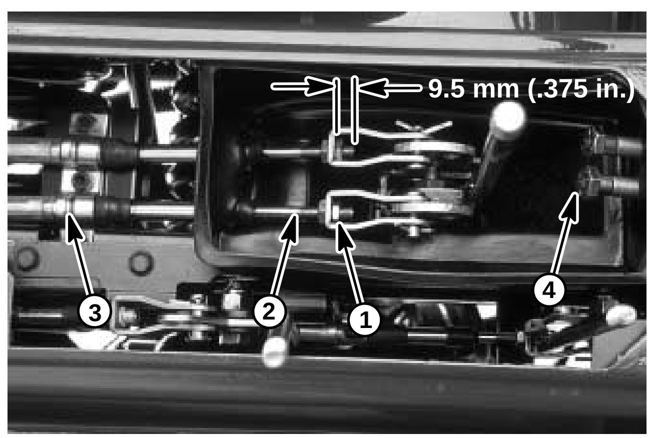


Figure 18

1. Clevis	**3. Clamp**
2. Shift cable	**4. Shift stop bolt**

Stub Axle and Drive Shaft Service

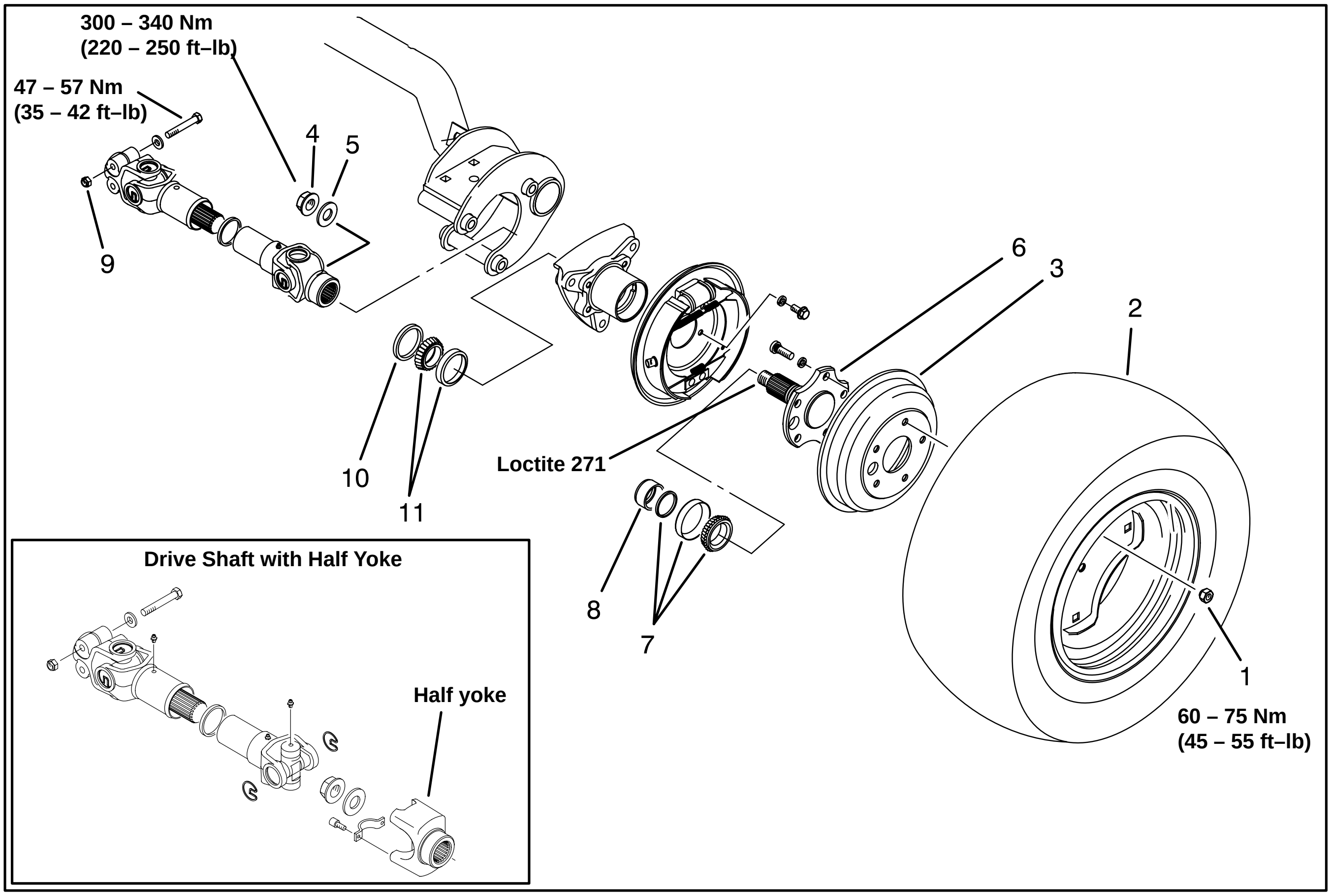


Figure 19

1. Wheel nut	**5. Washer**	**9. Locknut**
2. Wheel and tire	**6. Stub axle**	**10. Seal**
3. Brake drum	**7. Bearing with thin spacer**	**11. Bearing**
4. Flange nut	**8. Spacer**	

NOTE: Later production machines have a half yoke on the stub axle. See inset in Figure 19.

Stub Axle and Driveshaft Removal

1. Loosen wheel nuts (Item 1).

2. Jack up rear of machine and support with jack stands.

3. Remove wheel (Item 2).

4. Remove brake drum (Item 3).

5. On early production machines, not equipped with a half–yoke, insert modified 1–1/8″ box end wrench on stub axle flange nut (Item 4). NOTE: On machines equipped with a half yoke type driveshaft, remove the straps securing the bearing cross to the half yoke, then disconnect the drive shaft. You can then use a standard 1–1/8″ box end wrench.

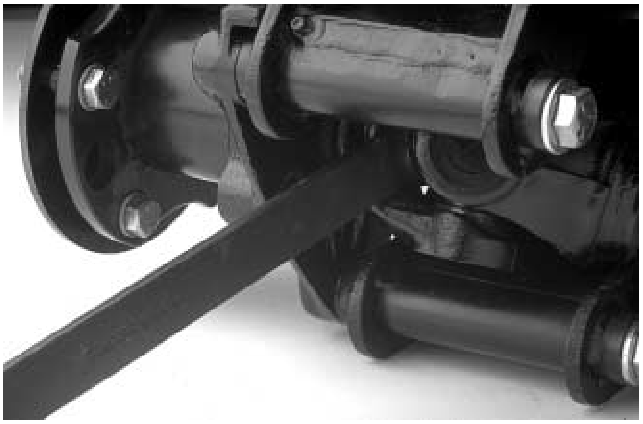


Figure 20

Drive Train

6. Install stub axle removal tool onto wheel studs.

7. Loosen flange lock (Item 4) nut by turning counter-clockwise.

8. Remove stub axle (Item 6).

9. To remove driveshaft, loosen locknuts (Item 9) , then remove bolts securing driveshaft at splined axle shaft of transaxle. Slide driveshaft outward and remove from transaxle.

Installation

1. If driveshaft was removed, install drive shaft clamp end onto splined axle shaft. Tighten clamp bolts to a torque of 47 – 57 Nm (35 – 42 ft–lb).

2. Inspect bearings and replace if necessary. If outer bearing is removed from stub axle, bearing set must be replaced. Bearings, with bearing cups and thin spacer, are a MATCHED SET. Use one set per housing. Parts are NOT INTERCHANGEABLE.

3. Press bearing cups into housing.

4. Use a bearing packer tool to pack bearings with axle bearing grease.

5. Press larger bearing (Item 7), wide end first, onto stub axle, then slide thin spacer onto stub axle.

6. Insert stub axle (Item 6) with bearing and thin spacer into housing.

7. Insert large spacer (Item 8), tapered end outward – toward threaded end of stub axle, onto shaft inside housing.

8. Insert smaller bearing (Item 11), small end first, onto shaft inside housing.

9. Install new seal (Item 10) over shaft and into housing. Be careful not to damage the seal.

10. Install drive shaft yoke onto stub axle shaft.

11. Apply Loctite 271 or equivalent to threads of stub axle, then install washer (Item 5) and flange nut (Item 4).

12. Insert modified 1–1/8″ box end wrench on stub axle flange nut (Item 4).

13. Use an additional stub axle as a tool. Install second stub axle to wheel studs as shown. Install an extra flange nut on second stub axle threads. Use a 1–1/8″ six point socket and torque wrench to tighten stub axle flange nut to a torque of 300 – 340 Nm (220 – 250 ft–lb).

14. Install brake drum (Item 3) and wheel. Tighten wheel nuts to a torque of 60 – 75 Nm (45 – 55 ft–lb).

Figure 21

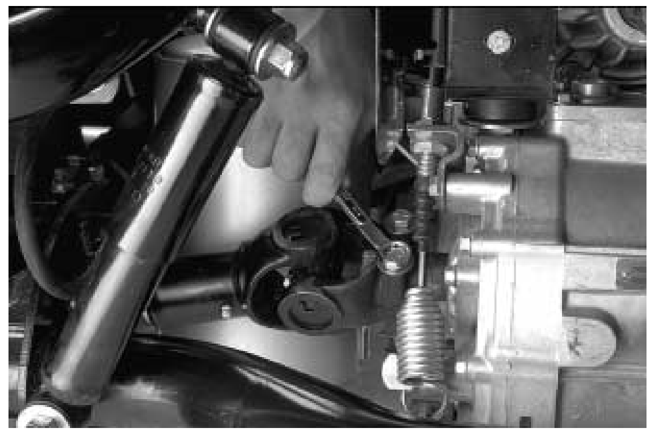


Figure 22

Figure 23

Drive Shaft Universal Joint Service

1. Remove drive shaft from machine (see Stub Axle and Drive Shaft Service).

2. Remove snap rings (Item 1).

IMPORTANT: Yokes must be supported when removing and installing bearings to prevent bending.

3. Use a press to remove cross and bearings (Item 2).

4. To install new cross and bearings:

A. Apply a coating of grease to bearing bores.

B. Press one bearing partially into yoke (Item 3).

C. Insert cross into yoke and bearing.

D. Hold cross in alignment and press bearing in until it hits the yoke.

E. Install snap ring into groove by first bearing cap installed.

F. Place second bearing into yoke bore and onto cross shaft. Press second bearing into yoke.

G. Tap axle yoke outward with hammer and alignment punch to allow 2nd snap ring to fit. Install snap ring.

H. Repeat procedure for other yoke.

I. Grease cross until grease comes out of all four (4) cups.

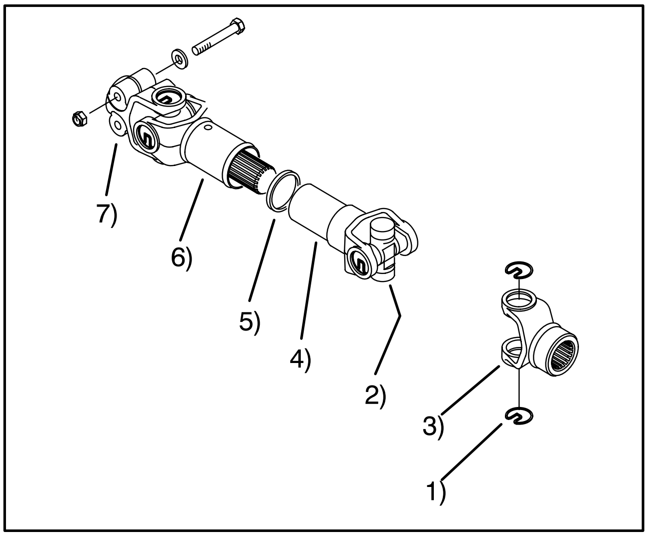


Figure 24

Drive Train

P.T.O. Removal and Installation

PTO Removal

1. Remove clevis pin to disconnect PTO control cable clevis from shift arm on PTO. Do not loosen jam nuts to remove cable from support bracket.

2. Disconnect and label electrical lead that attaches to PTO switch.

3. Disconnect hydraulic hose from fitting on PTO. Put labels on hydraulic hoses for proper reassembly. Put caps or plugs on all open hoses or fittings to prevent contamination. Label hoses and fittings for proper reinstallation.

4. Loosen capscrews and remove nut with washer. Separate P.T.O. and O–ring from transaxle case.

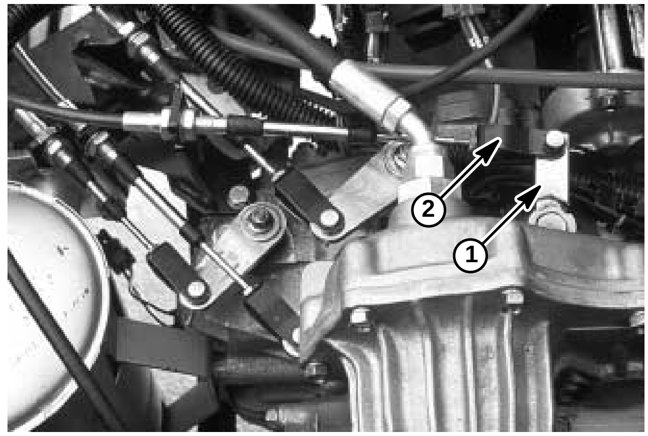


Figure 25

1. PTO lever arm
2. Cable clevis
3. Hydraulic hose
4. PTO switch electrical lead

PTO Installation

1. Apply multi–purpose grease to O–ring and insert O–ring into groove of transaxle case. Insert 2 dowel pins in transaxle case.

IMPORTANT: When installing PTO assembly, make sure O–ring is properly positioned in groove.

2. Install PTO. Tighten capscrews and nut with lockwasher to a torque of 15 – 17 Nm (11 – 13 ft–lb).

3. Install hydraulic hose to fitting on PTO.

4. Connect PTO switch electrical lead.

5. Loosen clevis jam nut and adjust clevis so clevis hole aligns with hole in PTO arm.

6. Reinstall clevis pin and tighten jam nut after doing adjustment.

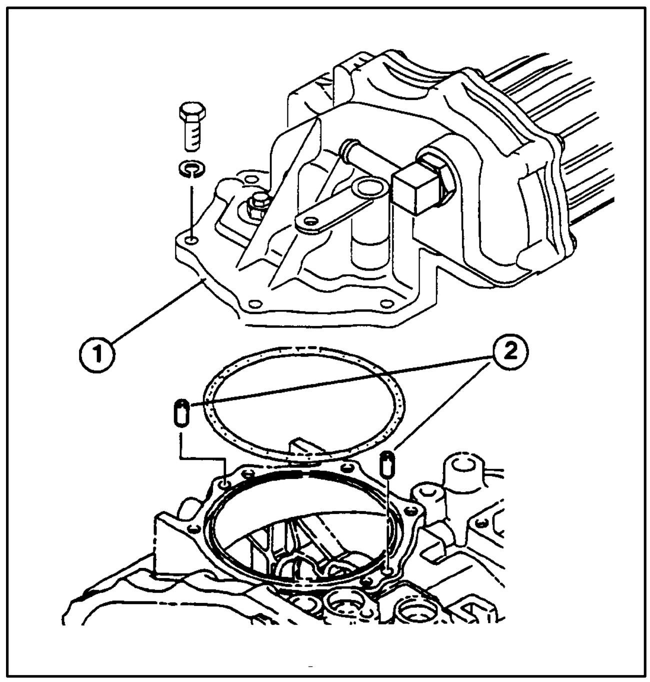


Figure 26

1. PTO assembly **2. Alignment pins**

Transaxle Removal and Installation

Transaxle Removal

1. Put machine on a level surface. Stop the engine and remove key from ignition switch. Remove the bed or other attachment(s). Allow engine and radiator to cool.

2. Disconnect positive (+) and negative (–) battery cables from battery.

3. Remove drain plug from bottom of transaxle and allow oil to drain into a drain pan. Install drain plug.

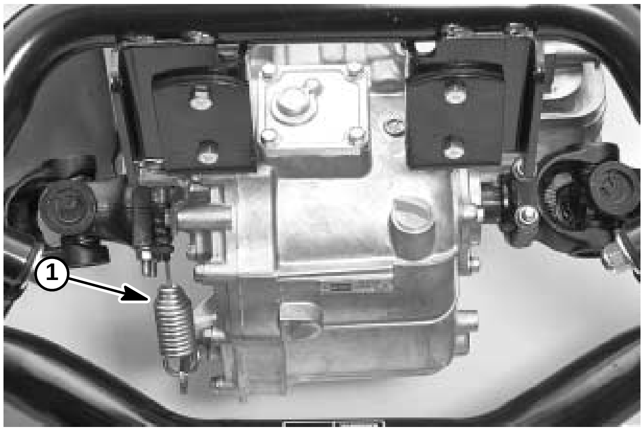


Figure 27

1. Drain plug

4. Note orientation of hydraulic hose and 90° fitting connected to strainer on side of reservoir. Remove hydraulic hose and 90° fitting. (NOTE: Workman 3300–D has a steel tube line instead of a hose.)

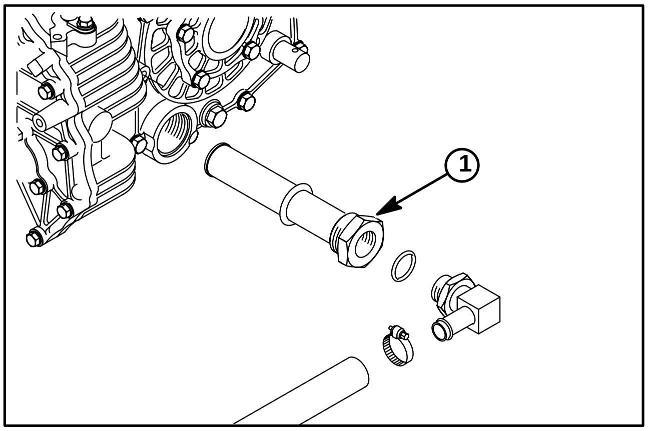


Figure 28

1. Strainer

Drive Train

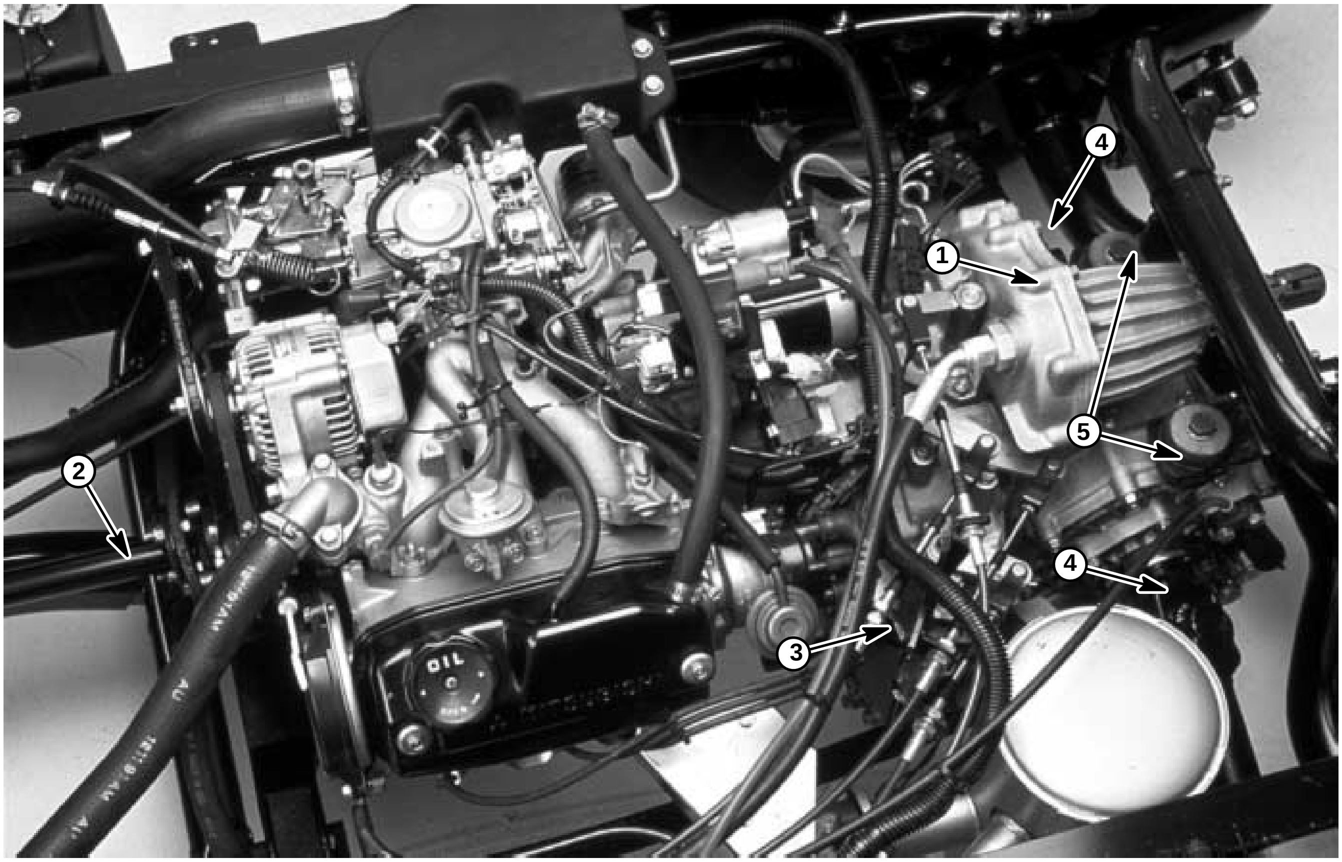


Figure 29
(Workman 3200 shown)

1. PTO
2. Drive shaft coupler
3. Control cable support bracket
4. Drive shaft assembly
5. Mount bracket

5. Remove muffler.

6. Remove hydraulic filter assembly and bracket.

7. Remove starter assembly from bell housing (Workman 3200 only).

8. Disconnect and label electrical leads that attach to transaxle and PTO.

9. Disconnect clutch cable from clutch release lever, then loosen jam nut to remove cable from support bracket (see Clutch Pedal Adjustment).

10. On units with the differential lock lever installed, loosen jam nut to remove cable from support bracket, then disconnect differential lock cable from lever at left rear of transaxle (see Differential Lock Cable Adjustment).

11. Disconnect shifter control cables from levers on transaxle and PTO (see Shift Cable Adjustment). Do not loosen jam nuts to remove cables from support bracket.

12. Remove control cable support bracket, keeping shifter control cables attached to bracket.

13. Remove differential drive shaft, bidirectional clutch, and adapter plate from the transaxle (see Bidirectional Clutch Removal in Chapter 10 – Front Wheel Drive Section (4WD)).

14. Disconnect hydraulic hoses from transaxle and PTO. Put labels on hydraulic hoses for proper reassembly. Put caps or plugs on all open hoses or fittings to prevent contamination. Label hoses and fittings for proper reinstallation.

15. Remove PTO, if equipped, from top of transaxle (see PTO Removal and Installation).

16. Block front wheels. Jack–up rear of machine under rear axle and install jack stands so transaxle can be removed by sliding out under rear axle.

17. Put blocking under engine for support. Support transaxle with a floor jack or suspend transaxle from vehicle frame rails. NOTE: PTO hole cover has a threaded boss where you can attach a bracket or ring for supporting the transaxle.

18. Remove transaxle isolation mounts and mount brackets.

19. Remove drive shaft clamp bolts, then slide transaxle side–to–side to disconnect each drive shaft from axle shafts on transaxle.

20. Remove capscrews securing clutch bell housing to engine. Remove capscrews securing clutch cover to bell housing (Workman 3200).

21. Carefully pull transaxle back to disengage transaxle input shaft from clutch. Use floor jack to lower transaxle and slide out rear of machine under the frame.

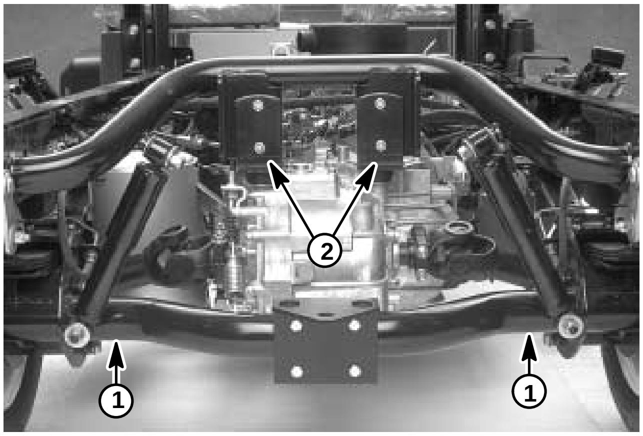


Figure 30

1. Jacking points **2. Mount brackets**

Transaxle Installation

1. To install the transaxle, perform Transaxle Removal procedure in reverse order.

IMPORTANT: Workman 3100 (air cooled gas) machines require application of silicone sealant to gap between bell housing and engine on right side of bell housing. This will prevent dirt and debris from getting into bell housing and damaging clutch or release bearing.

2. Install a new hydraulic oil filter and fill transaxle with the correct oil (see Chapter 9 – Hydraulic System). Check for oil leaks and repair as necessary.

3. Adjust clutch pedal, shift cables, high–low cable, differential lock cable and PTO cable.

Clutch Service

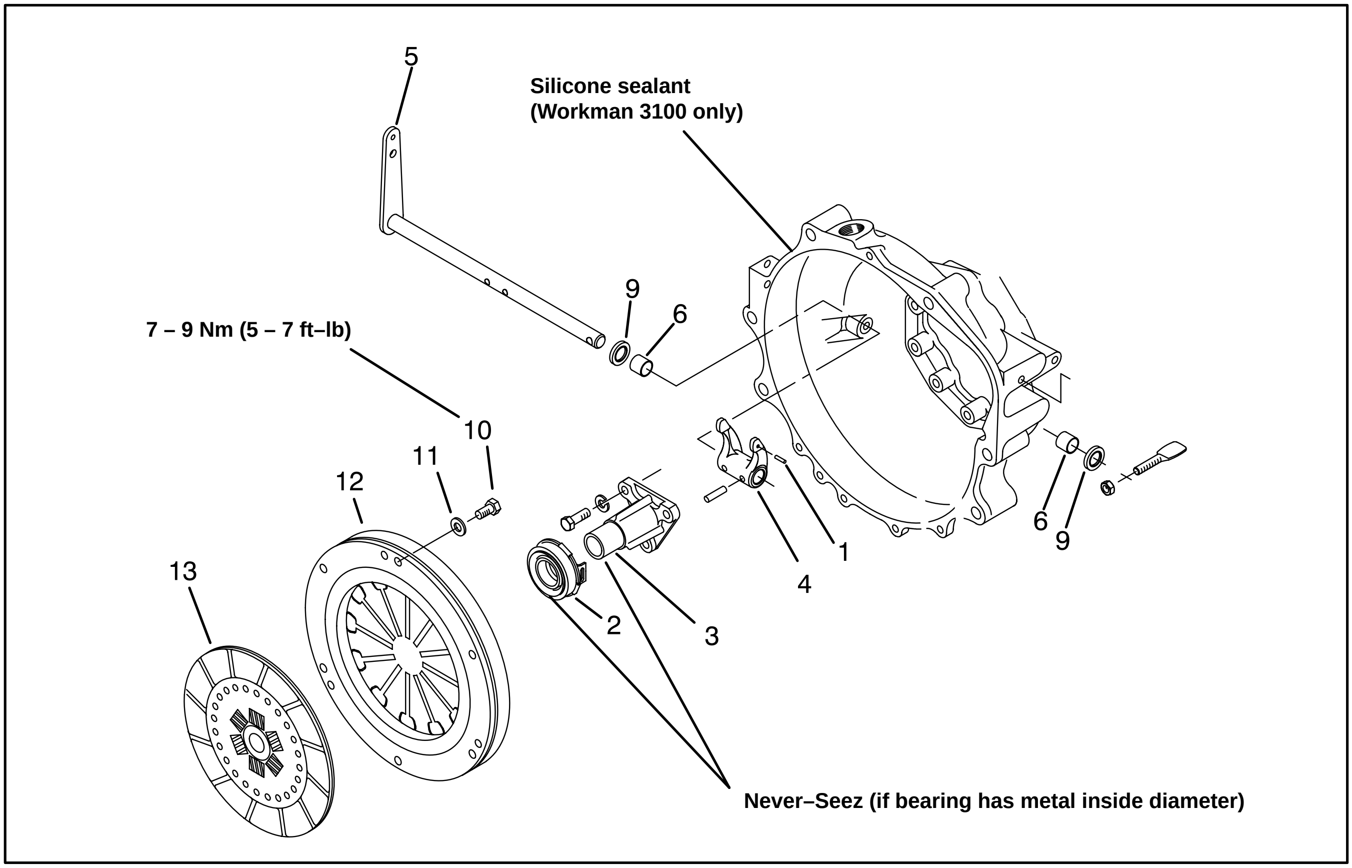


Figure 31

Clutch Release Mechanism

1. Remove transaxle.

2. Inspect main shaft of transaxle for wear or damaged splines.

3. Remove roll pin (Item 1), then remove release bearing (Item 2). Inspect release bearing and replace if it is loose on the sleeve, if it appears burned or is worn. Make sure release bearing slides freely on release guide. (Item 3).

4. Inspect clutch fork (Item 4), release shaft (Item 5), and bushings (Item 6) for wear or damage. Inspect extension spring (Item 8). Replace worn or damaged parts. Replace seals (Item 9).

5. If release bearing has metal inside diameter, apply ”Never–Seez” or equivalent to the following:
– Fill annular groove of release bearing.
– Coat remainder of bearing bore.
– Apply thin coat to release guide bore.
– Apply thin coat to fingers of clutch fork.
– Remove any excess Never–Seez.
(Bearing with plastic inside diameter does not require lubrication).

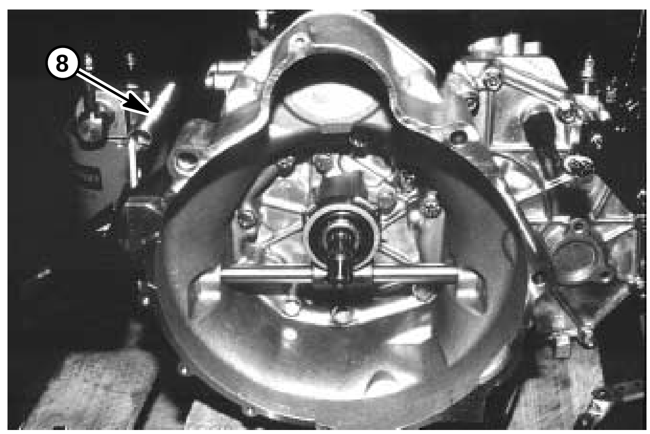


Figure 32

Clutch Disassembly and Inspection

1. Insert special tool (or transaxle main shaft) in flywheel pilot bearing hole to keep disk from falling off.

2. Loosen clutch cover capscrews (Item 10) in a diagonal sequence.

3. Remove capscrews, washers (Item 11) and clutch cover (Item 12), then pull out the special tool and remove clutch disk (Item 13).

4. Inspect diaphragm spring end of cover for wear and uneven height. Replace if wear is evident or height difference exceeds the limit.

Height difference	0.5 mm (.020 in.) maximum

5. Check pressure plate surface for wear, cracks and color change.

6. Check strap plate rivets for looseness and replace clutch cover assembly if loose.

7. Check clutch disk facing for loose rivets, uneven contact, deterioration due to seizure, adhesion of oil or grease. Replace clutch disk if damaged.

8. Measure rivet sink and replace clutch disk if out of specification.

Clutch disk thickness standard value	7.8 – 8.6 mm (.307 – .339 in.)
Clutch disk rivet sink	0.3 mm (.012) minimum

9. Check for torsion spring play or damage and replace clutch disk if necessary.

10. Install clutch disk on transaxle main shaft. Make sure clutch slides freely on splines of shaft. Check for excessive play in rotating direction.

11. Inspect flywheel pilot bearing (Item 14) for wear or damage and replace if necessary. Inspect flywheel surface for scratches and cracks. Clean any oil or rust off surface with a light abrasive.

Installing Clutch Disk and Cover

1. Apply a coating of grease to clutch disk spline, then use a brush to rub it in. Wipe off any excess grease.

2. Use special tool (or transaxle main shaft) to place clutch disk on flywheel.

3. Install clutch cover assembly. Tighten capscrews a little at a time, working in a diagonal sequence.

Clutch cover capscrew torque	7.0 – 9.0 Nm (5 – 7 ft–lb)

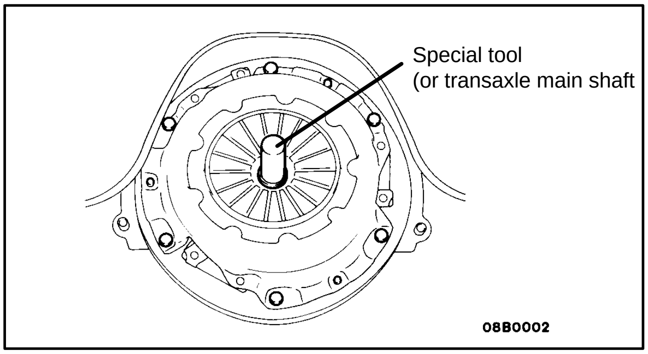


Figure 33

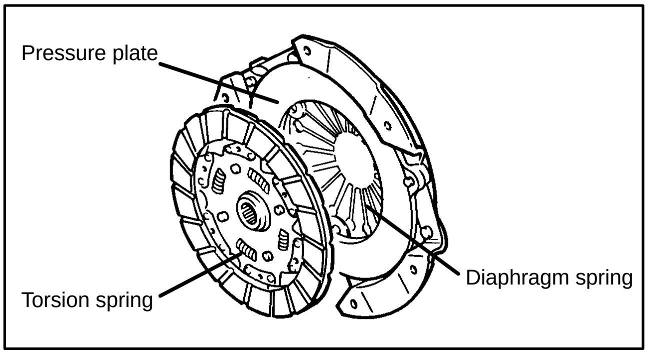


Figure 34

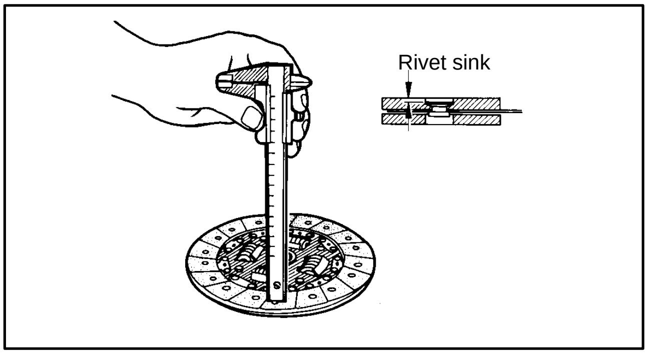


Figure 35

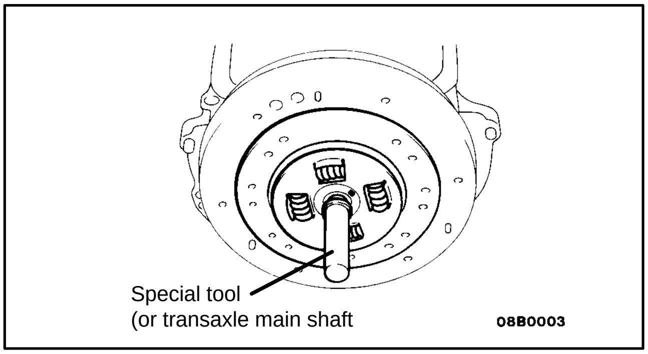


Figure 36

Drive Train

Transaxle Service

Transaxle Disassembly

NOTE: Item numbers in figures are shown in order of disassembly; for example, remove Item 1 first, then Item 2, etc. Reassemble in reverse order; for example, install Item 1 last.

1. Remove extension spring (Item 1).

2. Loosen capscrews (Item 2) and remove bell housing assembly from transaxle.

3. Thoroughly clean outside surface of transaxle.

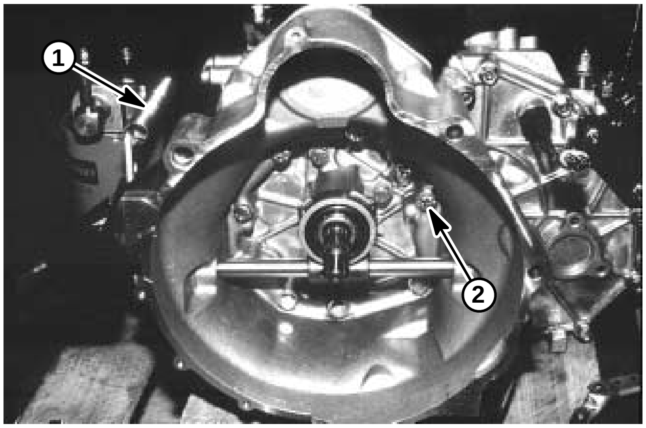


Figure 37

4. Loosen capscrews (Item 1) and remove fork shaft case (Item 2) from center plate. Note location of longer capscrew. Be careful when removing cover as steel balls inside are spring loaded.

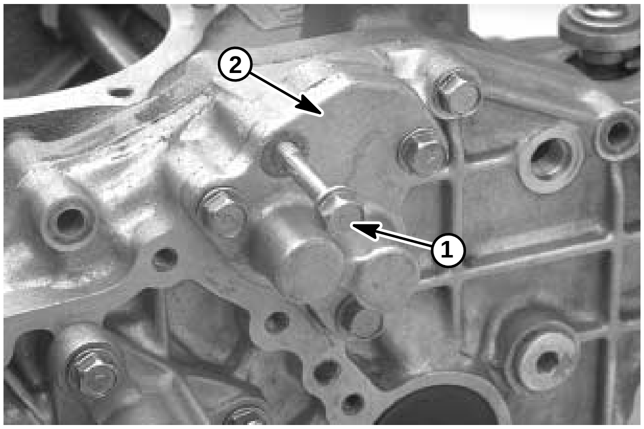


Figure 38

5. Hold your hand over the area and shift R–1 and 2–3 levers to move rails outward so balls (Item 3), springs (Item 2) and spindle (Item 1) can be removed.

6. Inspect fork shaft case for cracks or damage and replace if necessary.

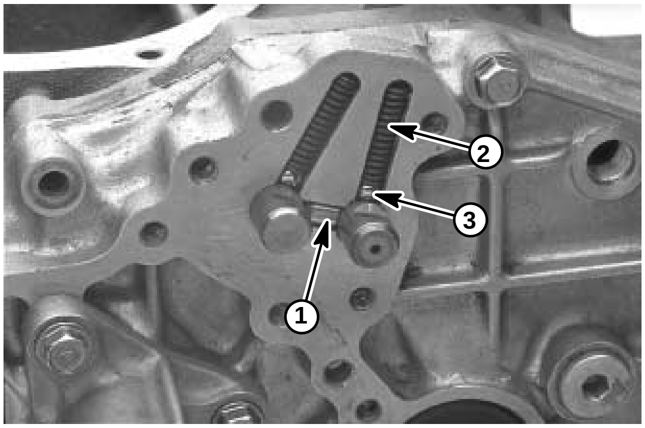


Figure 39

IMPORTANT: Make sure to note the type of shim set removed from the center plate. Early versions of the centerplate have either four shims (Item 2) without tabs <u>or</u> one thick shim (Item 4) with a tab (Fig. 40). Newer versions of the center plate have one tabbed shim (Item 4) <u>with</u> three tabless shims (Item 2) (Fig. 41).

7. Loosen capscrews and separate center plate from transaxle case. Note dowel pins in transaxle case. Remove seal cap (Item 1), shims (Item 2 and/or 4) and snap ring (Item 3) from center plate (Fig. 40 and 41).

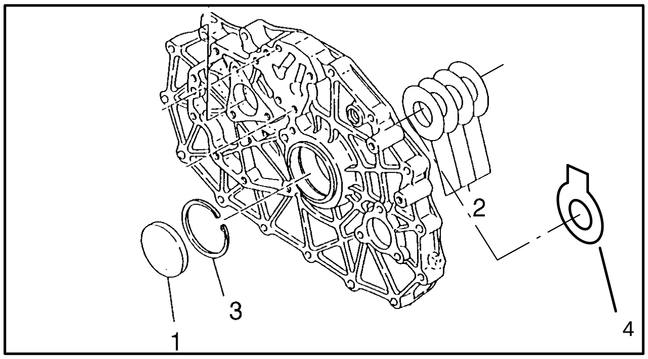


Figure 40

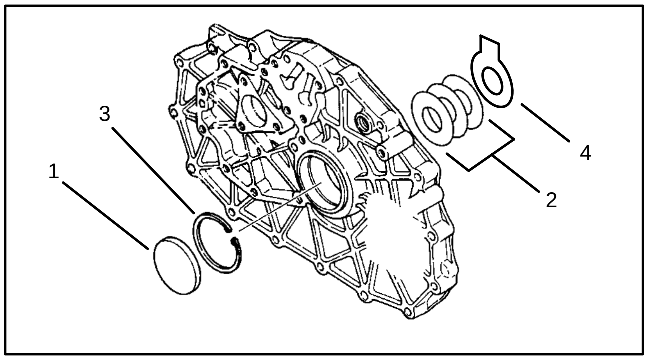


Figure 41

8. **On 4WD units**, remove front drive shaft and 41T gear from the gear case (see Item 2 of Fig. 42). Remove bearing from gear case and center plate.

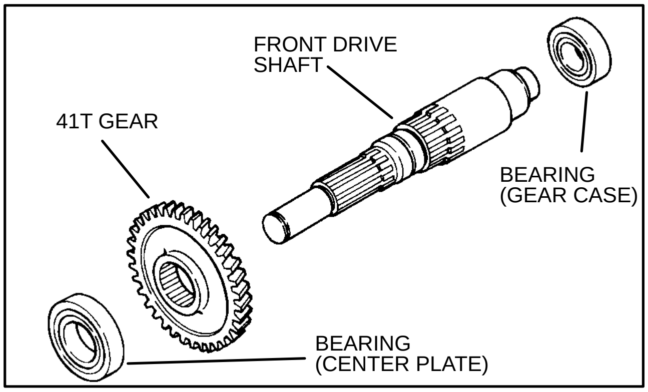


Figure 42

9. Remove reverse shaft (Item 1) from transaxle case.

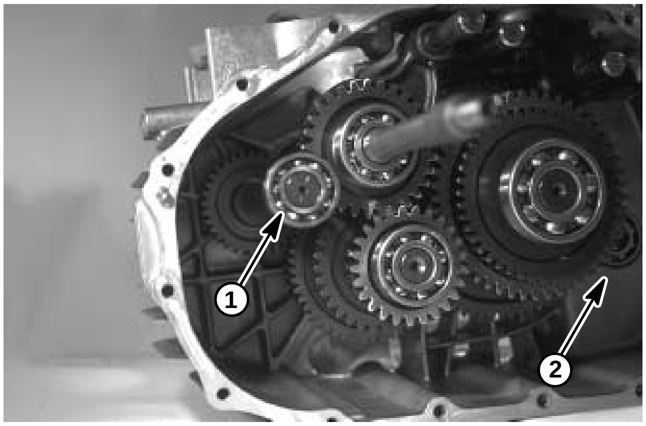


Figure 43

Drive Train

10. Remove main shaft assembly (Item 1) together with fork shaft assembly (Item 2) from transaxle case.

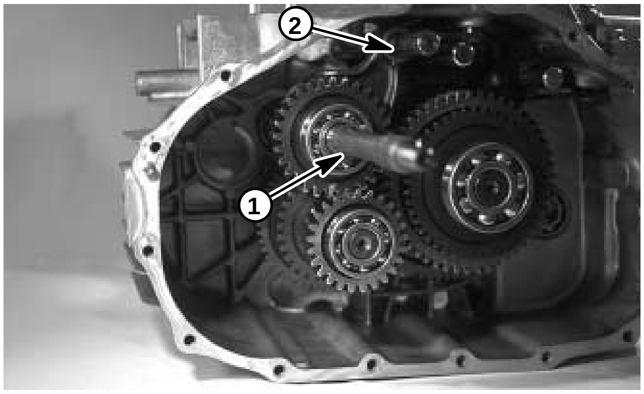


Figure 44

11. Remove, all at the same time, reduction shaft assembly (Item 1), 2nd–3rd shift assembly (Item 2), countershaft assembly (Item 3) and High–Low shift assembly (Item 4).

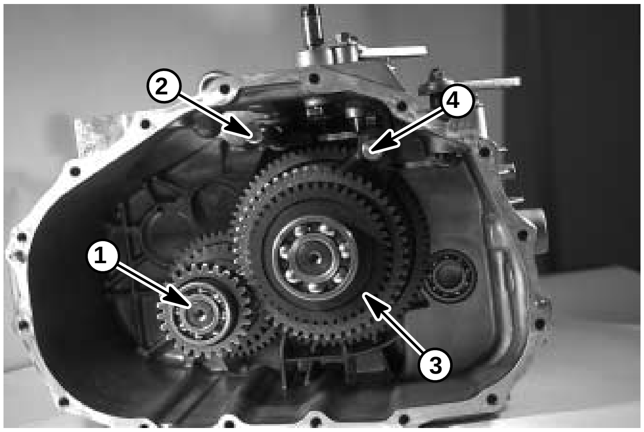


Figure 45

12. Loosen capscrews (Item 1) and remove L.H. axle shaft assembly (Item 2) and shims (Item 3) from side cover.

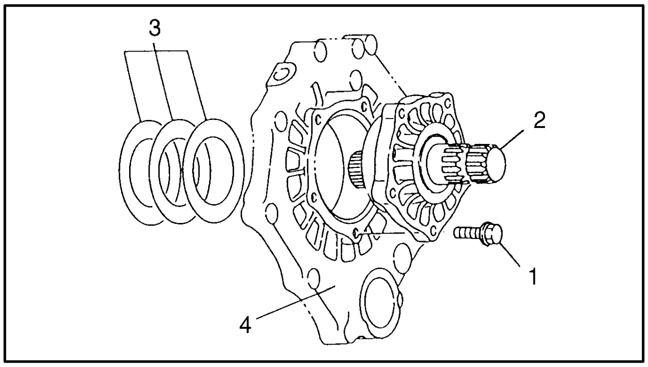


Figure 46

13. Remove roll pin from arm. Remove arm (Item 1) from fork shaft. Loosen capscrews (Item 2) and remove side cover (Item 3) from transaxle case.

14. Inspect side cover for cracks or damage and replace if necessary.

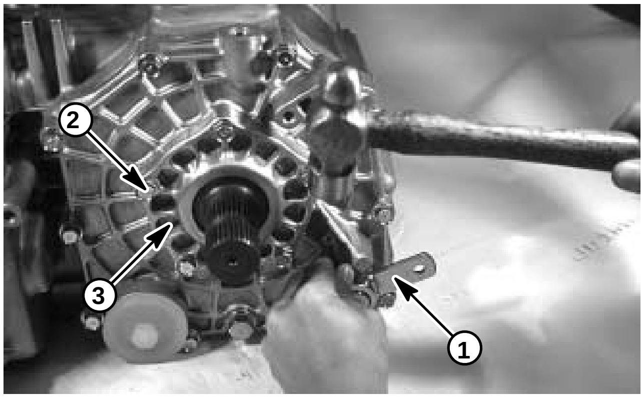


Figure 47

15. Loosen capscrews and remove R.H. axle shaft assembly from transaxle case.

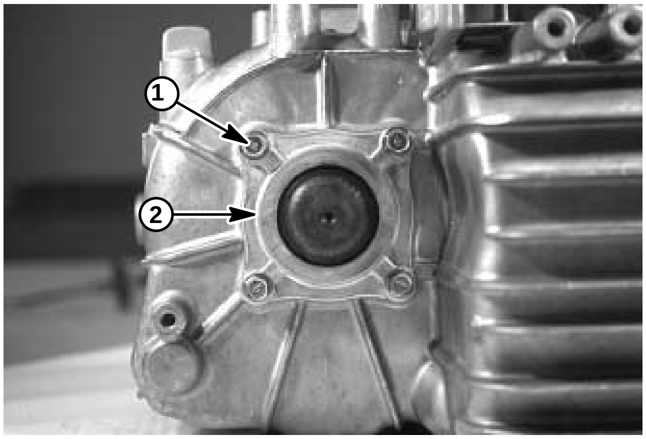


Figure 48

16. Remove differential gear assembly (Item 1) together with fork shaft assembly (Item 2).

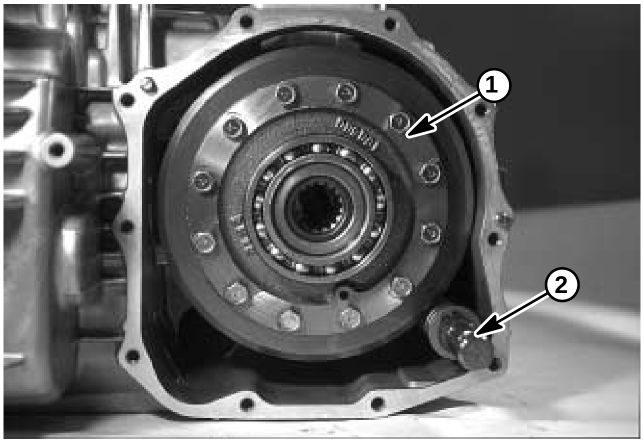


Figure 49

17. Remove washer (Item 1) from inside of transaxle case. NOTE: Washer may stick to fork shaft when removed in step 15.

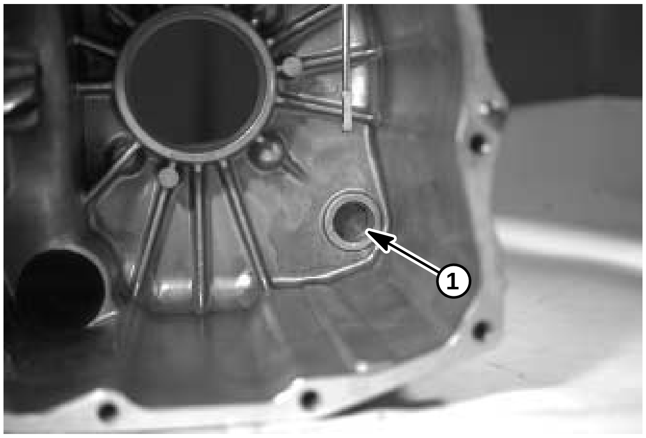


Figure 50

18. To remove shift arms (Transaxle Model KT40):

A. Loosen shift arm clamp bolt (Item 1) with a 3/16″ Allen wrench.

B. Loosen nut (Item 2), then remove 2nd–3rd shift arm (Item 3) together with shift arm plate (Item 4), spring (Item 5), locknut (Item 6), washer (Item 7) and capscrew (Item 8).

C. Loosen locknut (Item 9) and remove washer (Item 10). Remove 1st–Rev. shift arm (Item 11) and High–Low shift arm (not shown).

D. Loosen capscrews(Item 12) and remove keeper plates (Item 13).

E. Remove oil seals (Item 14).

F. Inspect shift arms and keeper plates for bending or damage and replace if necessary.

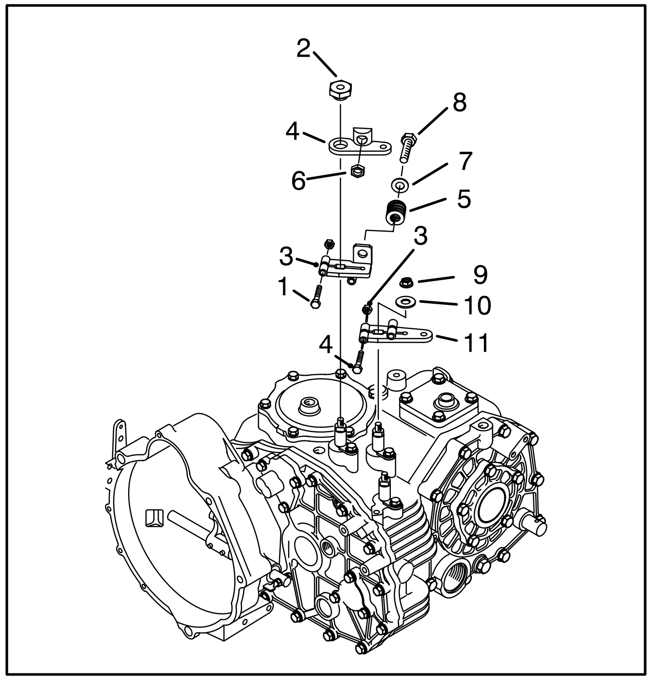


Figure 51

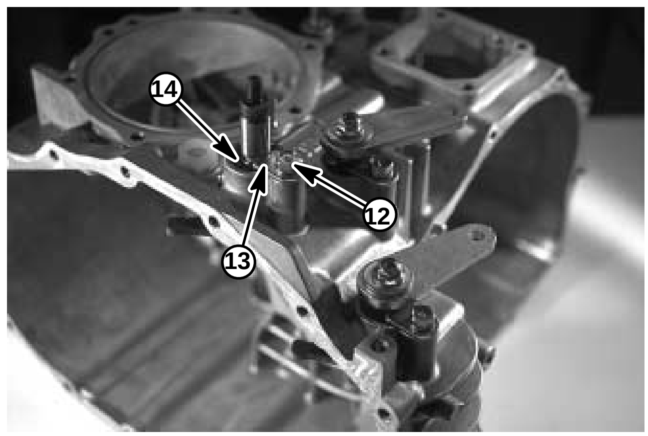


Figure 52

19. To remove shift arms (Transaxle Model KT40A):

A. Loosen nut (Item 1) and washer (Item 2), then remove 2nd–3rd shift arm (Item 3) together with shift arm plate (Item 4), spring (Item 5), locknut (Item 6), washer (Item 7) and capscrew (Item 8).

B. Loosen locknut (Item 9) and remove washer (Item 10). Remove 1st–Rev. shift arm (Item 11) and High–Low shift arm (not shown).

C. Loosen capscrews (Fig. 50, Item 12) and remove keeper plates (Item 13).

D. Remove oil seals (Item 14).

E. Inspect shift arms and keeper plates for bending or damage and replace if necessary.

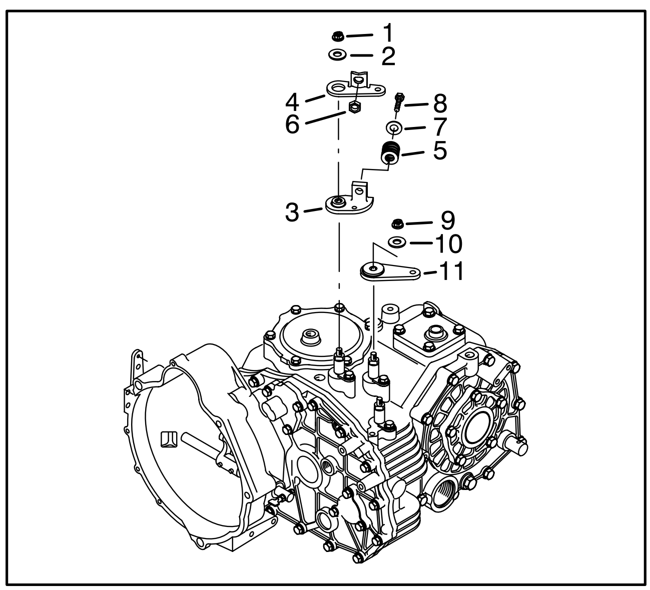


Figure 53

20. Loosen capscrews (Item 1) and remove nut (Item 2) with washer. Separate P.T.O. cover (Item 3) or P.T.O. and O–ring from transaxle case. Inspect P.T.O. cover for cracks or damage and replace if necessary.

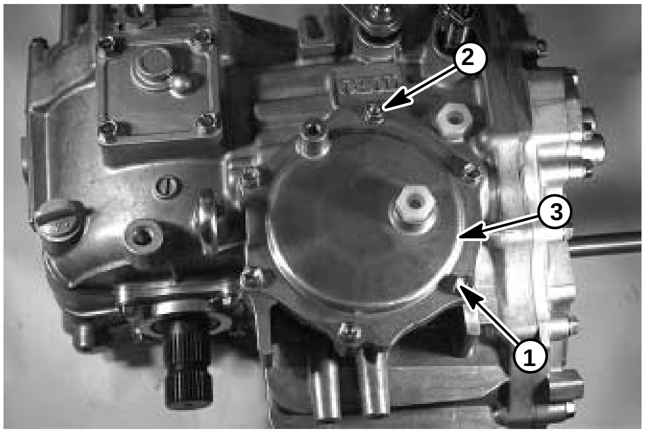


Figure 54

21. Remove oil cap (Item 1) and O–ring from transaxle case if necessary.

22. Remove air breather (Item 2) if necessary.

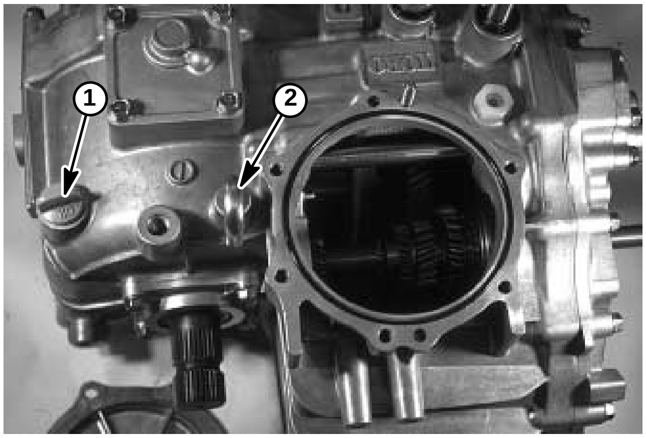


Figure 55

23. Loosen capscrews (Item 1) and remove upper cover (Item 2) from transaxle case.

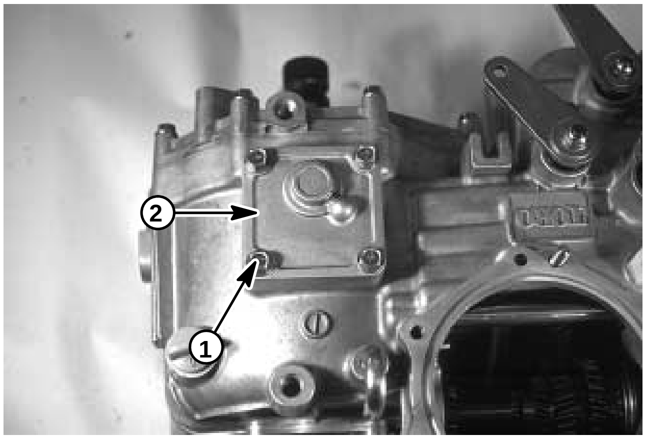


Figure 56

24. Disassemble main shaft assembly:

A. Use a bearing puller to remove bearing (Item 1) from main shaft.

B. Remove snap ring (Item 2) and washer (Item 3). Measure thickness of washer. Replace washer if it is less than 1.8 mm (.0709 in.) thick.

C. Remove 2 needle bearings (Item 5) and gear (Item 4). Inspect needle bearings and replace if necessary.

D. Remove synchro ring (Item 6).

E. Remove snap ring (Item 7).

F. Remove shifter (Item 8) together with spring, hub and 3 keys.

G. Remove key (Item 9).

H. Remove snap ring (Item 10).

I. Remove synchro ring (Item 6), gear (Item 11), 2 needle bearings (Item 12) and washer (Item 13). Inspect needle bearings and replace if necessary.

J. Use a bearing puller to remove bearing (Item 14).

K. Remove gear (Item 15), snap ring (Item 16), gear (Item 17) and gear (Item 18).

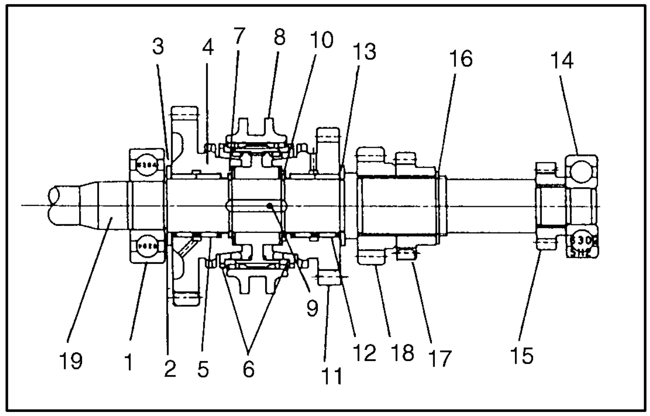


Figure 57

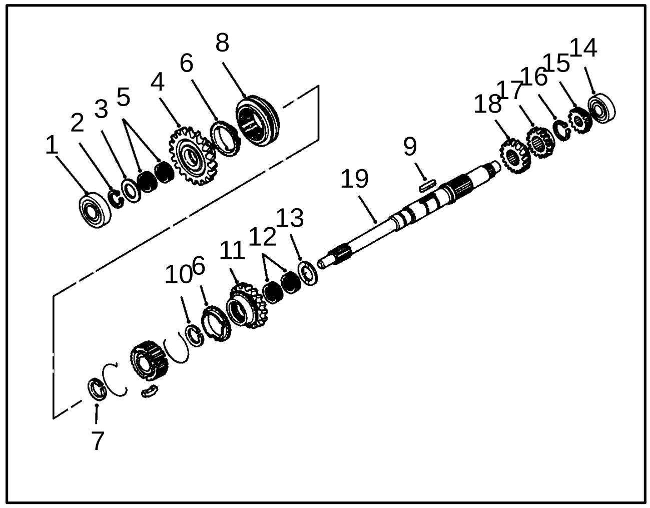


Figure 58

25. Disassemble reduction shaft assembly:

A. Use a bearing puller to remove bearing (Item 1) from reduction shaft.

B. Remove gear (Item 2), helical gear (Item 3), collar (Item 4) and gear (Item 5).

C. Use a bearing puller to remove bearing (Item 6).

D. Remove washer (Item 7), needle bearing (Item 9) and gear (Item 8).

E. Remove spacer (Item 10).

F. Remove snap ring (Item 11).

G. Remove shifter (Item 12) together with spring, hub and 3 keys.

H. Remove key (Item 13)

I. Remove synchro ring (Item 14) from gear (Item 15).

J. Remove gear (Item 15), needle bearing (Item 16) and thrust washer (Item 17). Inspect needle bearing and replace if necessary. Measure thickness of thrust washer. Replace thrust washer if thickness is less than 1.8 mm (.0709 in.)

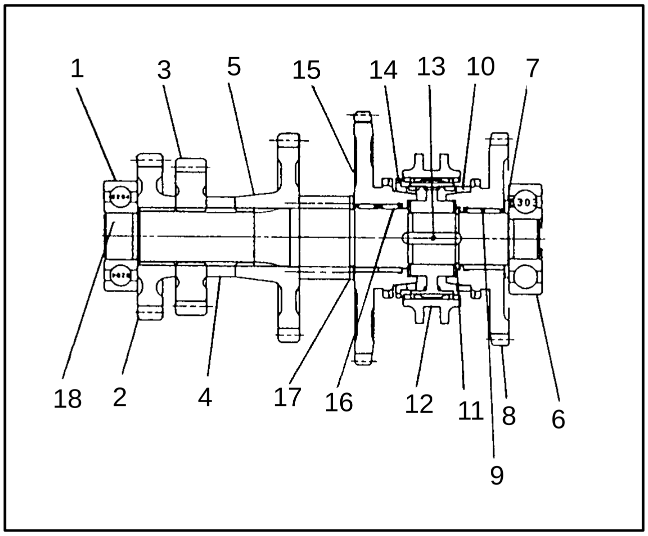


Figure 59

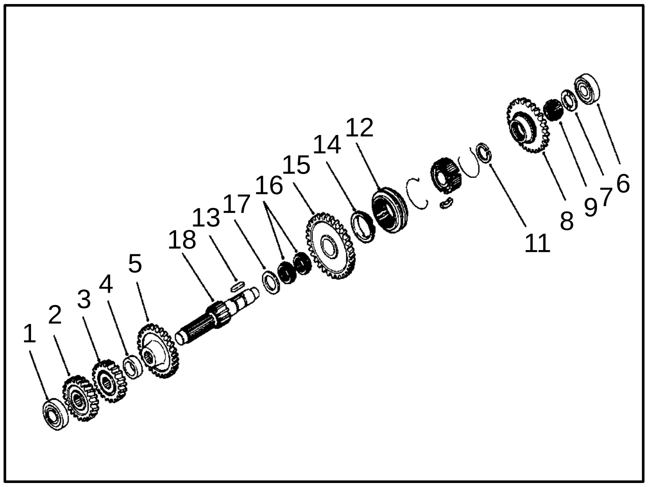


Figure 60

Drive Train

26. Disassemble reverse shaft assembly:

A. Use a bearing puller to remove bearing (Item 1) from reverse shaft.

B. Remove gear (Item 2).

C. Use a bearing puller to remove bearing (Item 3) from reverse shaft.

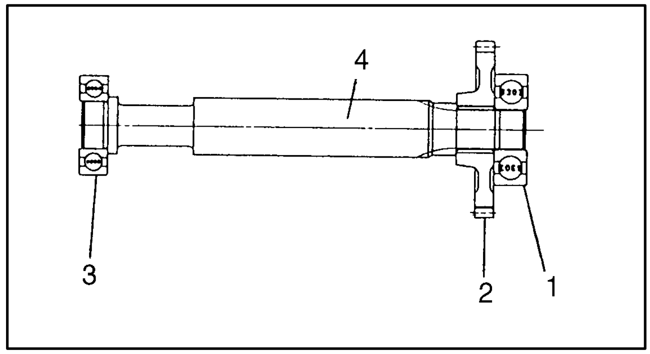


Figure 61

27. Disassemble countershaft assembly:

A. Use a bearing puller to remove bearing (Item 1) from countershaft.

B. Remove thrust washer (Item 2) and snap ring (Item 3).

C. Remove thrust washer (Item 4) and gear (Item 5).

D. Remove inner (Item 6) and thrust washer (Item 7). Inspect inner for wear and damage. Replace inner if O.D. is less than 31.95 mm (1.258 in.). Measure thickness of thrust washer. Replace thrust washer if thickness is less than 1.8 mm (.079 in.)

E. Remove 2 snap rings (Item 8).

F. Remove Hi–Lo shifter (Item 9) and collar spline (Item 10).

G. Remove gear (Item 11). Inspect bushing for wear and damage. Replace gear if I.D. exceeds 30.08 mm (1.184 in.).

H. Remove washer (Item 12), snap ring (Item 13) and collar (Item 14). Measure thickness of washer. Replace washer if thickness is less than 2.8 mm (.110 in.)

I. Use a bearing puller to remove 2 bearings (Item 15).

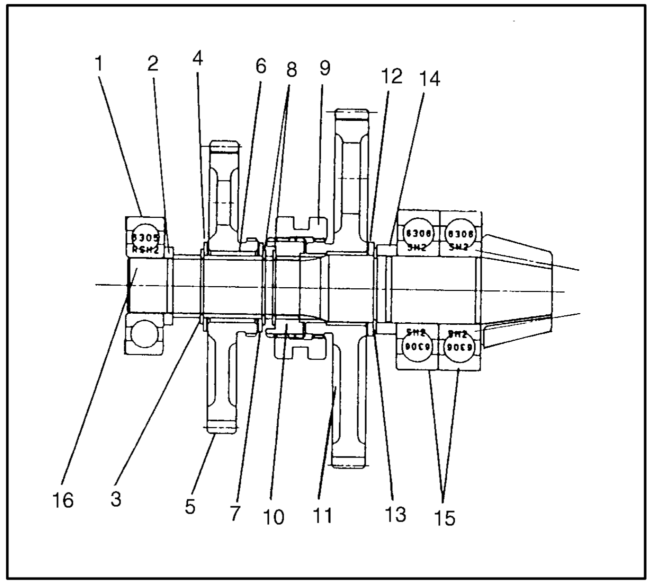


Figure 62

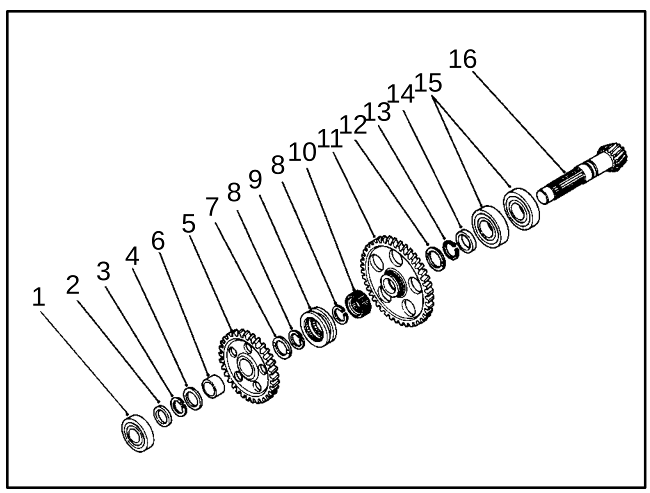


Figure 63

28. Disassemble fork shaft assemblies:

A. Remove lock pin (Item 1) from 2nd–3rd fork shaft assembly.

B. Remove shift fork (Item 2) from fork shaft.

C. Remove lock pin (Item 1) from 1st–R fork shaft assembly.

D. Remove fork (Item 2) from fork shaft.

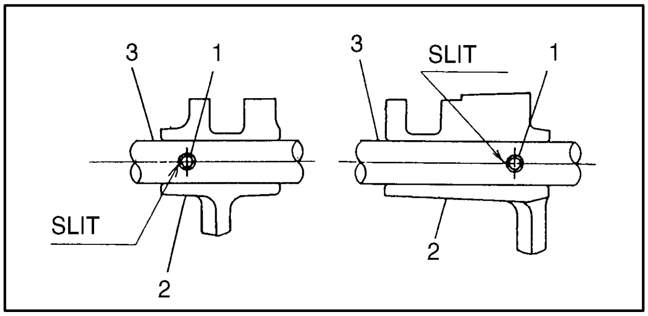


Figure 64

29. Disassemble Hi–Lo fork shaft assembly:

A. Remove shift fork (Item 1), steel ball (Item 2) ad spring (Item 3) from Hi–Lo shift fork assembly.

B. Remove E–ring (Item 4).

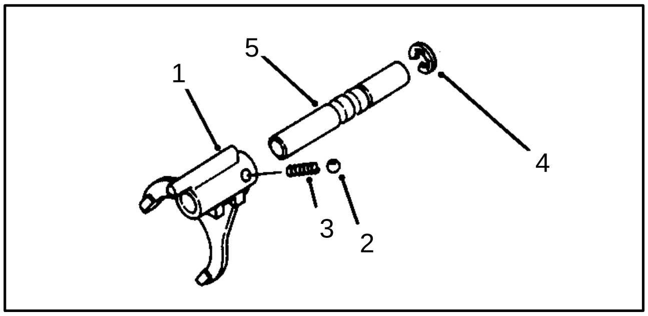


Figure 65

30. Disassemble differential gear assembly:

A. Use a bearing puller to remove bearing (Item 1) from differential case.

B. Remove snap ring (Item 2).

C. Use a bearing puller to remove bearing (Item 3) and slider (Item 4).

D. Loosen screws (Item 5) from ring gear.

E. Remove ring gear (Item 6) from differential case and remove 2 dowel pins (Item 7).

F. Drive lock pin (Item 8) out of pinion shaft (Item 9).

G. Remove pinion shaft (Item 9) from differential case.

H. Remove 2 differential pinions (Item 10) and 2 liners (Item 11).

I. Remove L.H. side gear (Item 12), R.H. side gear (Item 13) and 2 liners (Item 14).

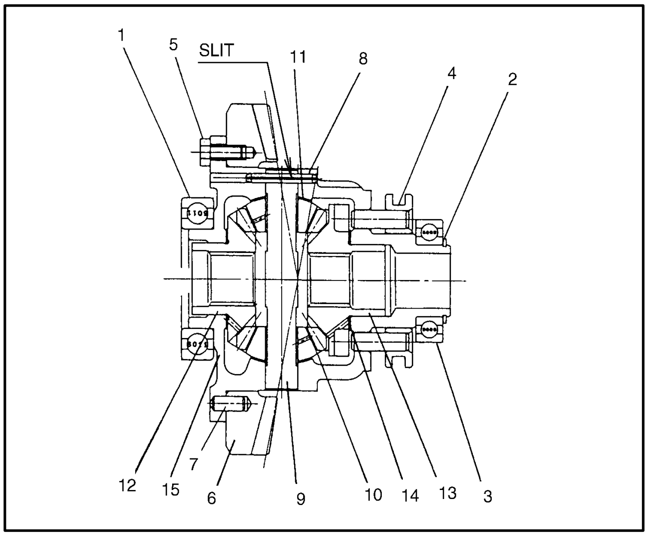


Figure 66

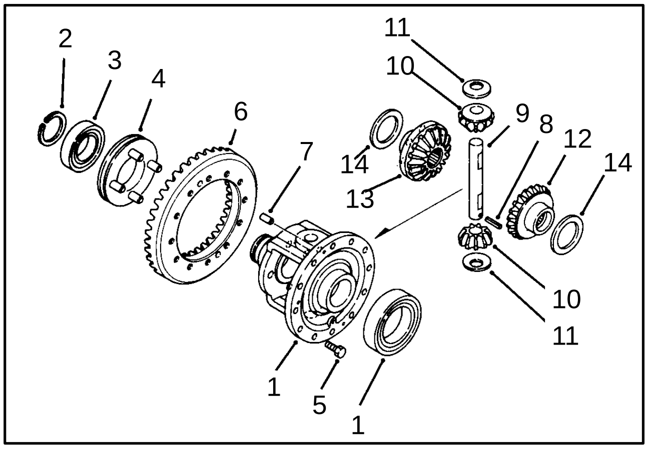


Figure 67

Drive Train

31. Disassemble differential fork shaft assembly:

   A. Remove O–ring (Item 1) from fork shaft.

   B. Remove snap ring (Item 2), washer (Item 3) and spring (Item 4).

   C. Remove fork (Item 5).

   D. Remove lock pin (Item 6) if necessary.

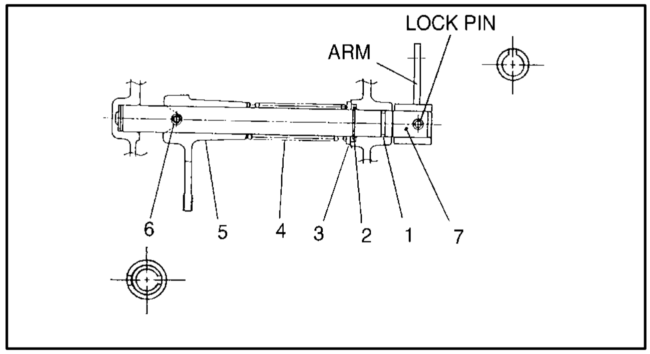


Figure 68

32. Disassemble axle shaft assemblies:

   A. Remove O–ring (Item 1) from differential carrier.

   B. Remove snap ring (Item 2).

   C. Remove L.H. axle shaft assembly (Item 3).

   D. Remove snap ring (Item 4) and washer (Item 5).

   E. Use a bearing puller to remove bearing (Item 6) from axle shaft.

   F. Remove oil seal (Item 7) from differential carrier (Item 8).

   G. Remove R.H. axle shaft assembly (Item 1) from seal cover.

   H. Remove snap ring (Item 2) and washer (Item 3) from axle shaft.

   I. Use a bearing puller to remove bearing (Item 4).

   J. Remove oil seal (Item 5) from seal cover.

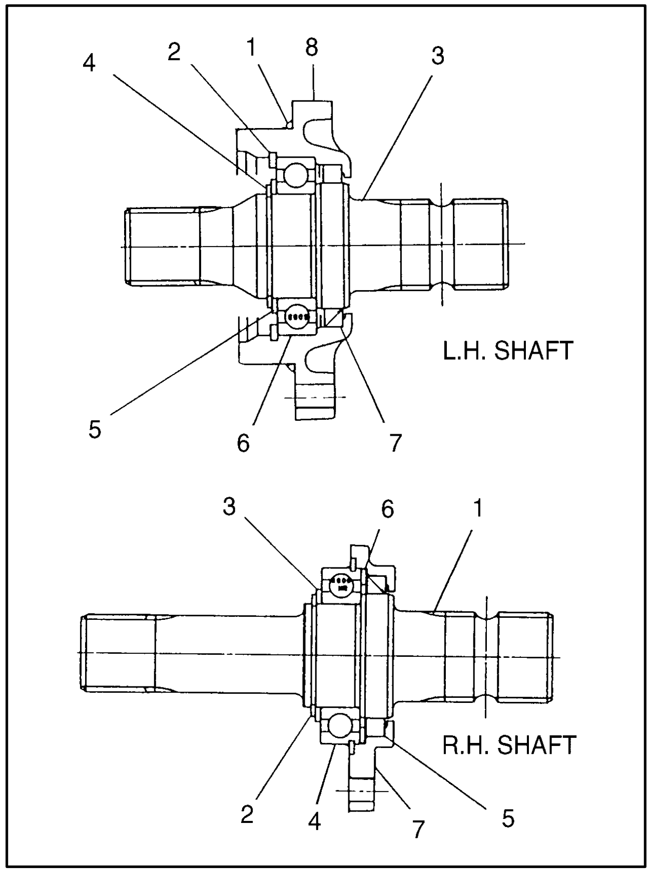


Figure 69

Transaxle Inspection

1. Thoroughly clean and dry all parts.

2. Use emery cloth to remove nicks and burrs from all parts.

3. Inspect synchronizer ring:

A. Inspect the chamfer for excessive wear or damage.

B. Inspect inner tapered area for excessive wear or damage.

C. Measure the clearance between synchronizer ring and synchro gear in three equally spaced points. If clearance is less than 0.5 mm (.0195 in.) replace the synchronizer ring.

4. Inspect synchro gears:

A. Inspect the cone surface for roughness, material transfer (brass color material) or damage.

B. Inspect the spline chamfer for excessive chipping or damage.

C. Inspect I.D. of synchro gear for excessive wear or scoring. If synchro gears have the following I.D., replace the synchro gear.

22T, 25T, 40T	I.D. exceeds 26.08 mm (1.027 in.)
49T	I.D. exceeds 29.08 mm (1.145 in.)

5. **On 4WD unit**s, inspect 41T gear and front drive shaft (Fig. 70):

A. Inspect gear teeth for roughness, material transfer (brass color material) or damage.

B. Inspect spline chamfer for excessive chipping or damage.

C. Inspect I.D. of gear for excessive wear or scoring. Gear should fit snuggly on shaft.

Figure 70

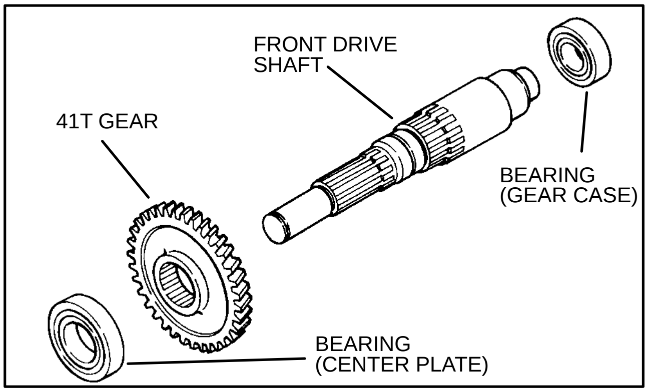


Figure 71

Drive Train

6. Inspect hub, shifter, synchro key and synchro spring:

A. Inspect hub for worn or damaged spline.

B. Inspect shifter for chipping or damaged chamfer.

C. Inspect synchro keys for wear or damage.

D. Inspect synchro springs for wear or damage.

E. The shifter should move freely on the hub.

F. Measure the clearance between shifter groove and fork. Replace shift fork, if the clearance exceeds 1.0 mm (.039 in.)

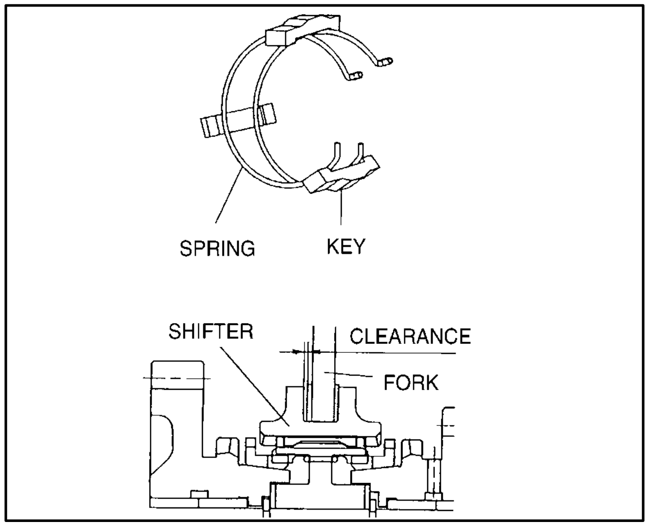


Figure 72

7. Inspect main shaft:

A. Inspect main shaft for worn or damaged surface. If O.D. of needle bearing surface is less than 21.95 mm (.864 in.), replace the main shaft.

B. Inspect lip portion of oil seal for wear or damage.

C. Insert spline in clutch disk and check for excessive looseness and free sliding of clutch disk hub.

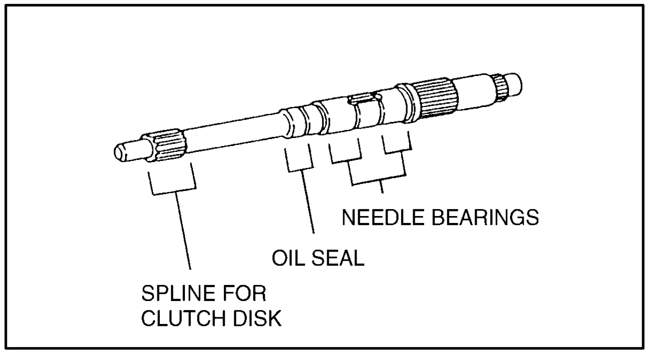


Figure 73

IMPORTANT: Early versions of the centerplate have either four shims (Item 2) without tabs <u>or</u> one thick shim (Item 4) with a tab (Fig. 74).

8. Inspect both snap ring (item 3) and shim(s) (items 2 or 4) for damage. Replace all parts if any part is cracked or broken. Shims (Item 2) must be replaced with tabbed shim (Item 4) (Fig. 74).

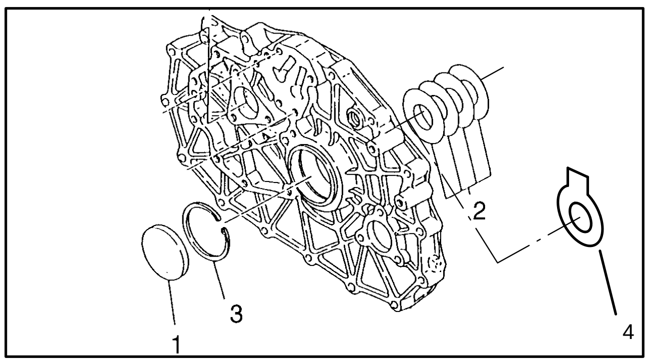


Figure 74

IMPORTANT: Newer versions of the center plate have one tabbed shim (Item 4) <u>with</u> three tabless shims (Item 2) (Fig. 75).

9. Inspect both snap ring (item 3) and shim(s) (items 2 and 4) for damage. Replace all parts if any part is cracked or broken (Fig. 75).

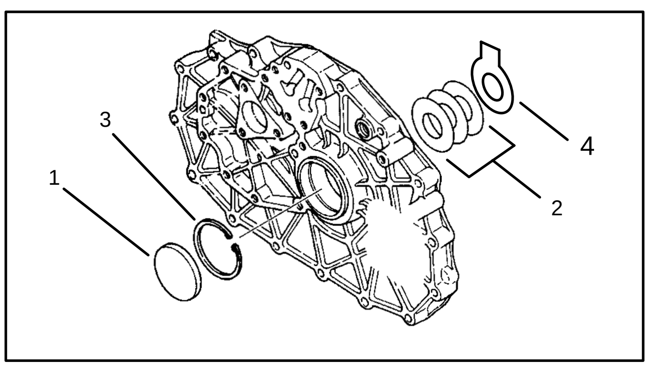


Figure 75

10. Inspect center plate for cracks and damage. Replace center plate if the snap ring groove has more than 15% of its edges damaged due to nicks, rounding, cracks, or dents (Fig. 76 and 77).

Figure 76

Figure 77

Drive Train

11. Inspect reduction shaft:

A. Inspect reduction shaft for wear or damage. If O.D. of needle bearing area is less than 21.95 mm (.864 in.) or 24.95 mm (.982 in.), replace the reduction shaft.

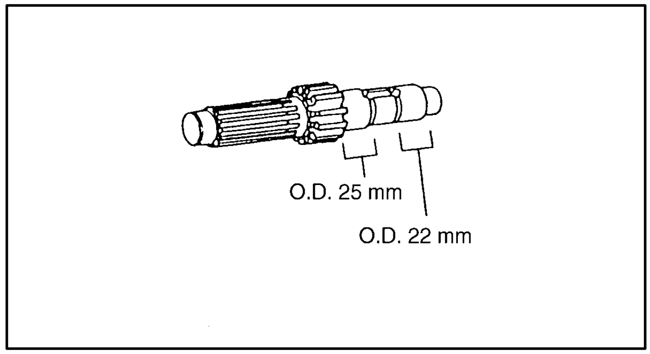


Figure 78

12. Inspect countershaft:

A. Inspect countershaft for wear or damage. If O.D. of inner portion is less than 27.95 mm (1.100 in.) or 71T gear portion is less than 29.95 mm (1.179 in.), replace the countershaft

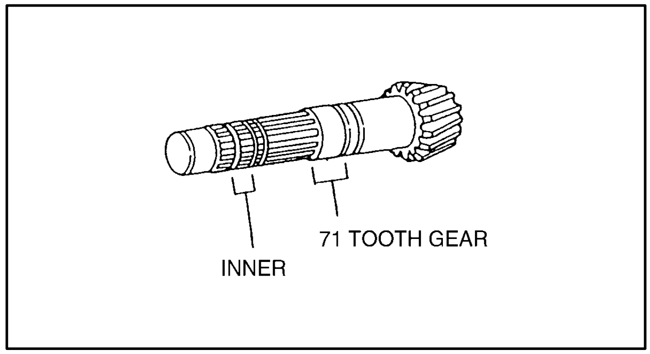


Figure 79

13. Inspect differential:

A. Inspect pinion shaft for excessive wear or damage. If O.D. is less than 17.95 mm (.707 in.), replace the pinion shaft.

B. Measure thickness of pinion liners. If thickness is less than 0.9 mm (.035 in.), replace the pinion liners.

C. Measure thickness of side gear liners. If thickness is less than 1.1 mm (.043 in.), replace the side gear liners.

D. Inspect the gear contact condition between spiral bevel pinion and ring gear.

E. Inspect differential case for wear in side gears and pinion shaft mating area. Replace the case if machined surfaces are scored or if the pinion shaft fits loosely in the bore.

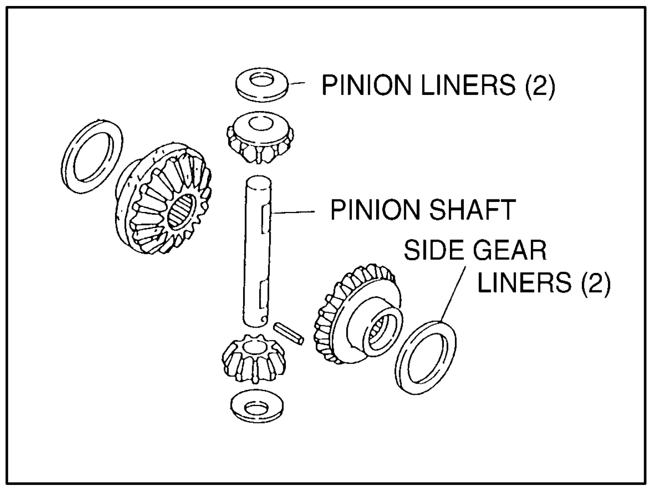


Figure 80

Transaxle Reassembly

NOTE: Item numbers in figures are shown in reverse order of assembly; for example, when reassembling, install Item 1 last.

1. Clean gasket material from all mating surfaces before reassembling. Make sure all parts are clean and free of dirt and dust.

IMPORTANT: Be careful not to damage mating surfaces when removing gasket material.

2. Assemble L.H. axle shaft:

   A. Install new oil seal (Item 7) into differential carrier.

   B. Use a press to install bearing (Item 6) onto L.H. axle shaft.

   C. Install washer (Item 5) and snap ring (Item 4).

   D. Install L.H. axle shaft assembly into differential carrier.

   E. Install snap ring (Item 2).

   F. Install new O–ring (Item 1). Apply multi–purpose grease on O–ring before installing.

3. Assemble R.H. axle shaft:

   A. Install new oil seal (Item 5) into seal cover. Apply multi–purpose grease on O–ring before installing.

   B. Insert washer (Item 6).

   C. Use a press to install bearing (Item 4) onto R.H. axle shaft.

   D. Install washer (Item 3) and snap ring (Item 2).

   E. Install R.H. axle shaft assembly into seal cover (Item 7).

4. Assemble differential fork shaft:

   A. Drive 2 lock pins (Item 6) into fork shaft (Item 7). Make sure lock pins are installed with slit facing the correct direction.

   B. Install fork (Item 5), spring (Item4), washer (Item 3) and snap ring (Item 2) onto fork shaft using a press. Apply moly disulfide grease onto fork portion of fork shaft before installing.

   C. Install new O–ring (Item 1). Apply multi–purpose grease on O–ring before installing.

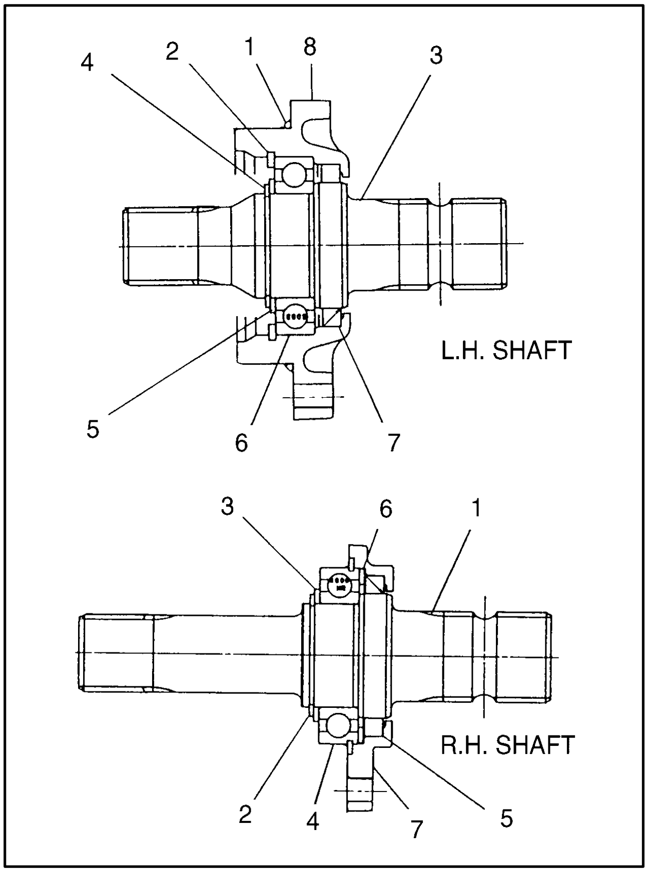


Figure 81

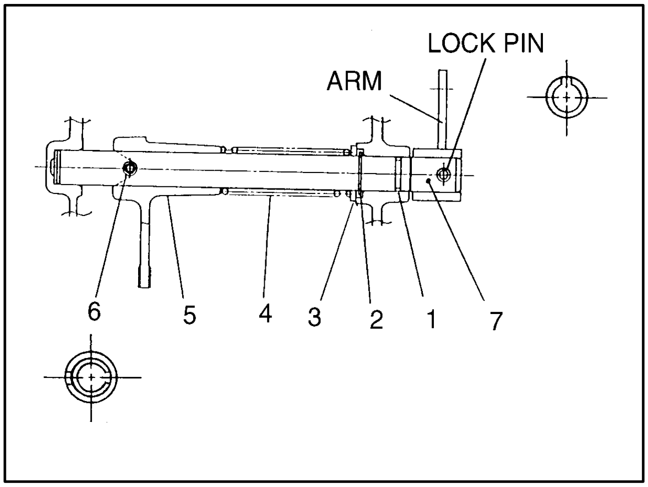


Figure 82

5. Assemble differential gears:

A. Apply moly disulfide grease on pinion liners (Item 11), holes of pinion gears (Item 10), side gear liners (Item 14) and hubs of side gears (Item 13, 12).

B. Install side gear liners (Item 14), side gears (Item 13, 12), pinion liners (Item 11) and pinion gears (Item 10).

C. Rotate side gears until holes of pinion gears and liners line up with holes of differential case (Item 1).

D. Insert pinion shaft (Item 9). Grease the shaft to aid assembly.

E. Assemble lock pin (Item 8). Drive the pin to the approximate center location of the pinion mate shaft. Pay attention to direction of slit in lock pin.

F. Check for smooth revolution of pinion gears and side gears.

G. Completely clean oil from threads in ring gear (Item 6).

NOTE: Ring gear and countershaft are supplied in matched sets only.

H. Insert 2 dowel pins (Item 7) onto ring gear (Item 6).

I. Completely clean oil from threads of capscrews (Item 5).

NOTE: It is recommended that whenever the ring gear screws are removed that they be replaced with new screws.

J. Apply Loctite to threads of capscrews.

K. Clean oil from contact surface of differential case and ring gear.

L. Drive ring gear onto differential case.

M. Tighten capscrews to a torque of 24.5 – 29.5 Nm (18.5 – 22 ft–lb).

N. Use a press to install bearing (Item 1) onto differential case.

O. Install slider (Item 4). Put moly disulfide grease onto sliding area of differential case before installing.

P. Use a press to install bearing (Item 3).

Q. Install snap ring (Item 2).

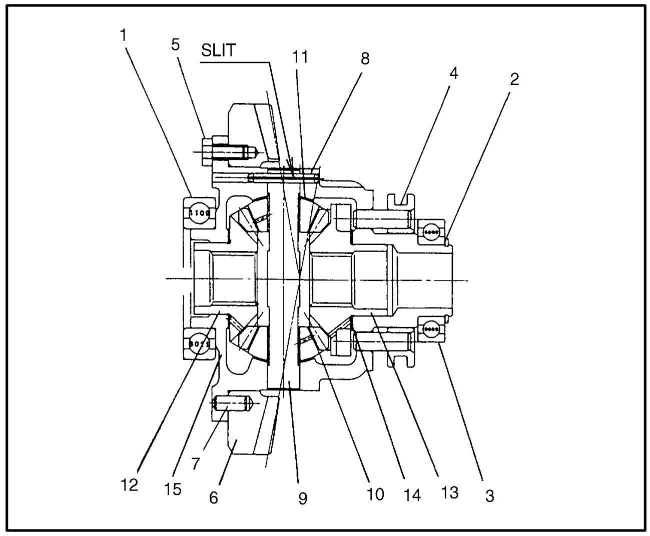


Figure 83

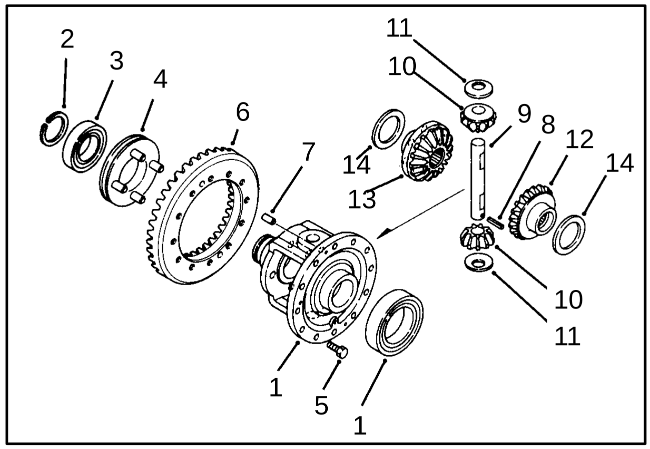


Figure 84

Figure 85

Figure 86

6. Assemble Hi–Lo fork shaft:

A. Install E–ring (Item 4) onto fork shaft (Item 5).

B. Insert spring (Item 3) and steel ball (Item 2) into fork (Item 1).

C. Insert fork shaft into fork. Put moly disulfide grease onto the shaft before installing.

7. Assemble R–1 and 2–3 fork shaft:

A. Insert R–1 fork shaft (Item 2) into R–1 fork (Item 3).

B. Drive lock pin (Item 1) into fork and fork shaft. Pay attention to direction of slit in lock pin.

C. Insert 2–3 fork shaft (Item 2) into 2–3 fork (Item 3).

D. Drive lock pin (Item 1) into fork and fork shaft. Pay attention to direction of slit in lock pin.

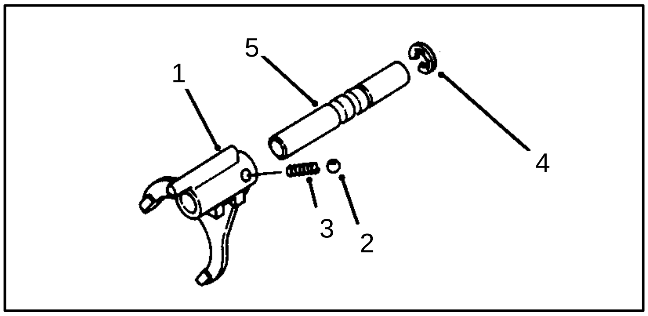


Figure 87

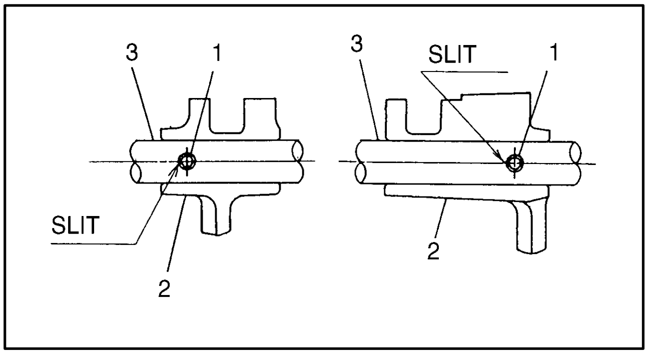


Figure 88

Drive Train

8. Assemble countershaft:

A. Use a press to install 2 new bearings (Item 15) onto countershaft.

B. Install collar (Item 14) and snap ring (Item 13).

C. Install washer (Item 12) and gear (Item 11). Apply moly disulfide grease into bushing of countershaft gear before installing. Oil groove on washer must face the gear.

D. Install collar–spline (Item 10) and snap ring (Item 8).

E. Install shifter (Item 9) onto collar–spline.

F. Install snap ring (Item 8), washer (Item 7) and inner (Item 6). Oil groove on washer must face the gear.

G. Install gear (Item 5).

H. Install washer (Item 4) and snap ring (Item 3). Oil groove on washer must face the gear.

I. Install washer (Item 2) and a new bearing (Item 1) using a press.

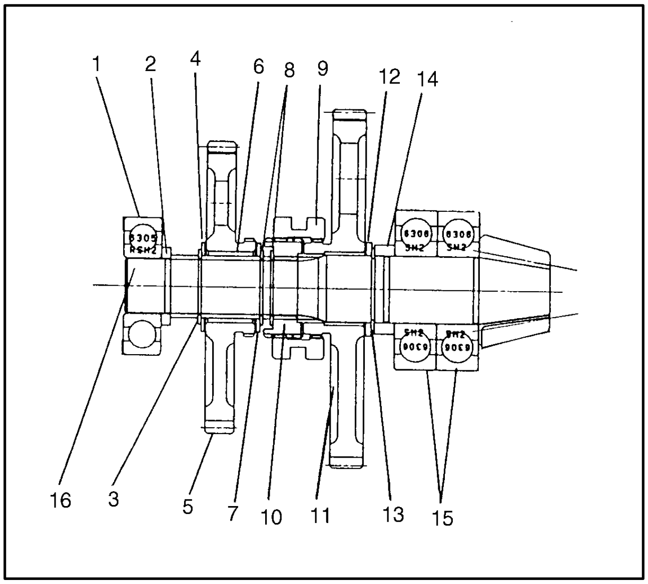


Figure 89

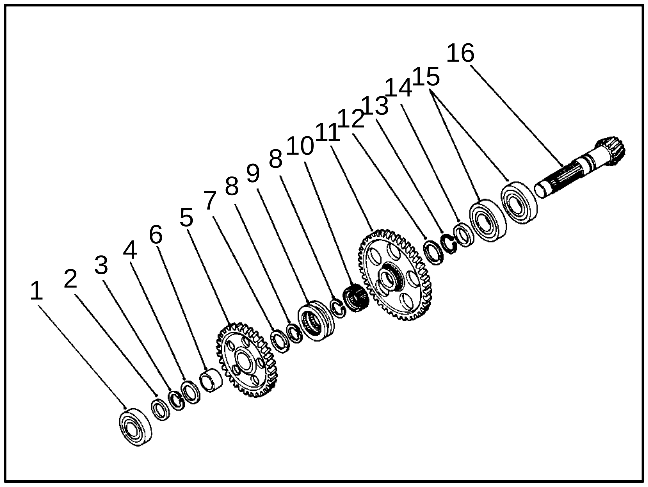


Figure 90

9. Assemble synchro hub:

A. Install 3 keys (Item 1) into grooves of hub (Item 2).

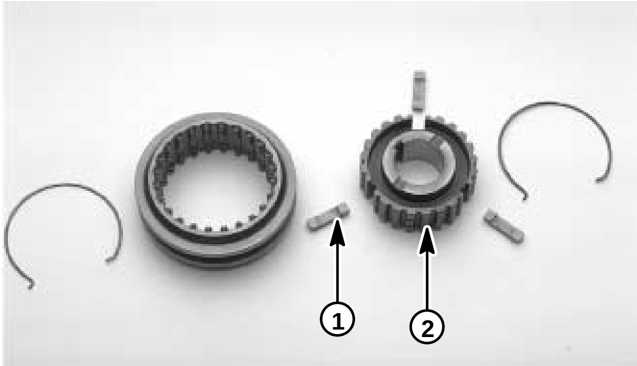


Figure 91

B. Install shifter (Item 1) onto hub (Item 2).

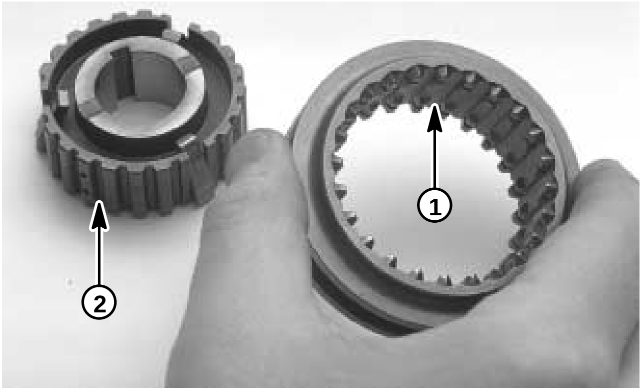


Figure 92

C. Insert 2 springs (Item 3) into hub. Pay attention to direction of spring.

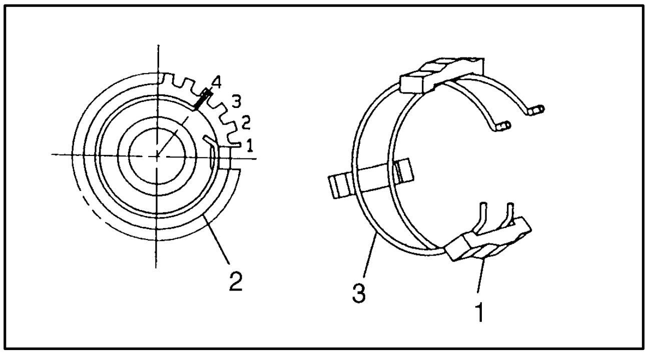


Figure 93

Figure 94

Drive Train

10. Assemble reduction shaft:

A. Install washer(s) (Item 17), 2 needle bearings (Item 16) and gear (Item 15) onto reduction shaft (Item 18). Apply moly disulfide grease to washer and needle bearings before installing. Oil groove on washer must face the gear.

B. Install synchro ring (Item 14) onto gear (Item 15). Apply Dexron II transmission oil on cone face of gear before installing synchro ring.

C. Insert key (Item 13) onto reduction shaft.

D. Install synchro hub sub–assembly (Item 12).

E. Install snap ring (Item 11).

F. Install spacer (Item 10) onto gear (Item 8).

G. Insert needle bearings (Item 9) into gear (Item 8).

H. Install washer (Item 7). Oil groove on washer must face the gear.

I. Use a press to install bearing (Item 6).

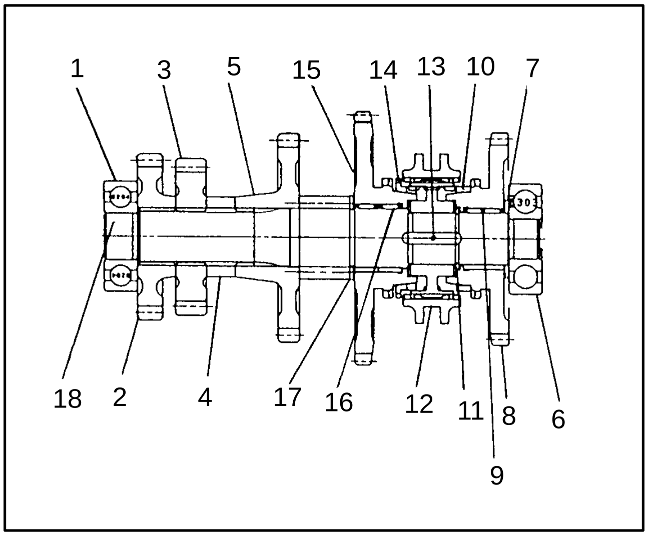


Figure 95

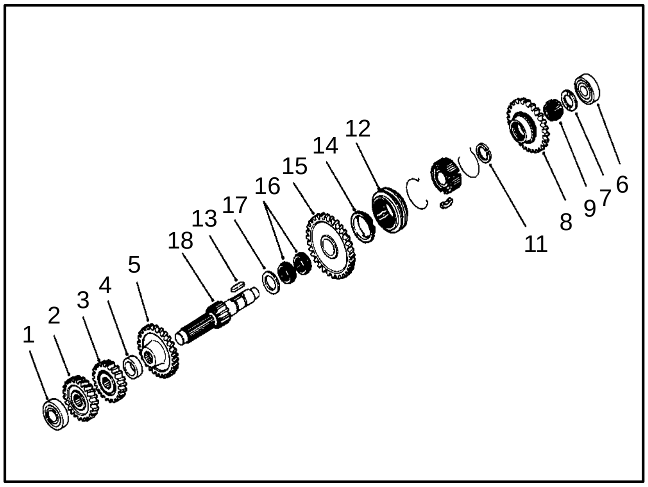


Figure 96

11. Assemble reverse shaft:

A. Install gear (Item 2) onto reverse shaft.

B. Use a press to install bearings (Item 3, 1).

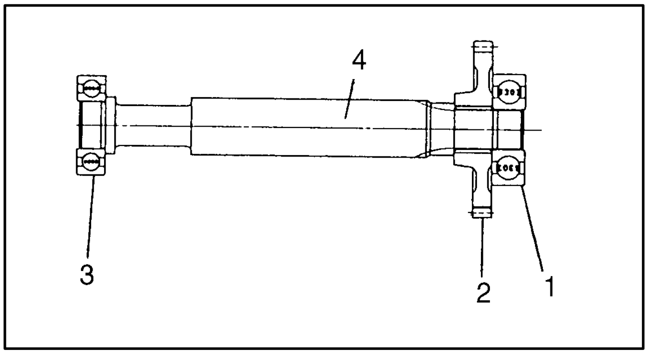


Figure 97

12. Assemble main shaft:

A. Install gear (Item 18), gear (Item 17) and snap ring (Item 16).

B. Install gear (Item 15).

C. Use a press to install bearing (Item 14).

D. Install washer (Item 13) and 2 needle bearings (Item 12) onto main shaft. Apply moly disulfide grease onto washer and needle bearings before installing. Oil groove on washer must face the gear.

E. Install gear (Item 11) and snap ring (Item 10).

F. Install synchro ring (Item 6) onto gear (Item 11). Apply Dexron II transmission oil on cone face of gear before installing synchro ring.

G. Insert key (Item 9).

H. Install synchro hub sub–assembly (Item 8).

I. Install snap ring (Item 7).

J. Install synchro ring (Item 6) onto gear (Item 4). Apply Dexron II transmission oil to cone face of gear before installing synchro ring.

K. Insert 2 needle bearings (Item 5) into gear (Item 4). Apply moly disulfide grease onto needle bearings before installing.

L. Install gear (Item 4) with synchro ring onto main shaft.

M. Install washer (Item 3) and snap ring (Item 2). Apply moly disulfide grease to washer before installing. Oil groove on washer must face the gear.

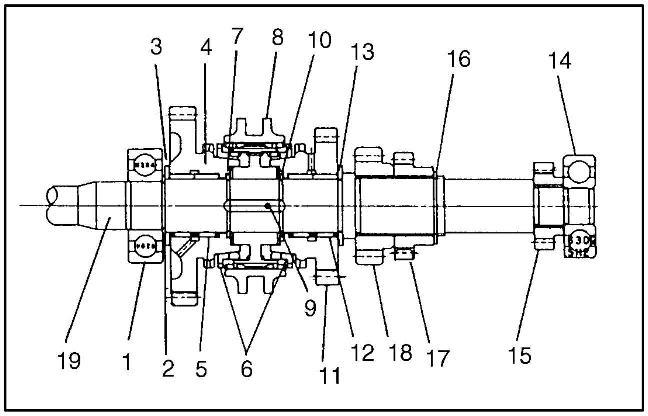


Figure 98

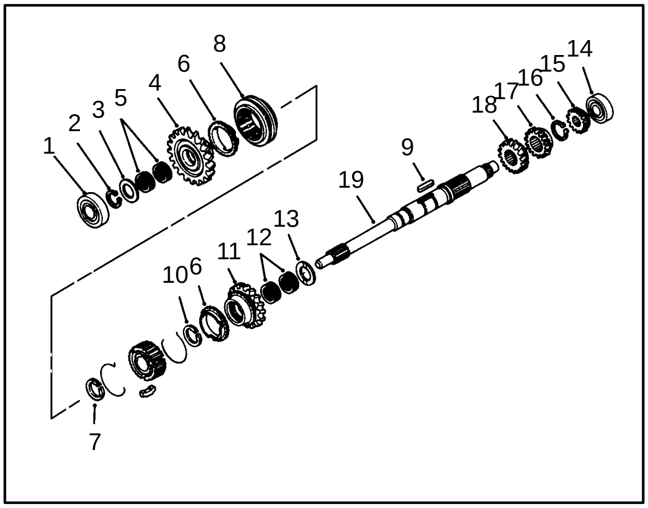


Figure 99

13. Assemble shift arms (Transaxle Model KT40):

A. Install 3 new oil seals (Item 14) onto transaxle case. Apply multi–purpose grease on lips of oil seals before installing.

B. Install 3 keeper plates (Item 13) and tighten 3 capscrews (Item 12) to a torque of 15 – 17 Nm (11 – 13 ft–lb).

IMPORTANT: This sequence for installing the shift arms must be followed in sequence. Fully tighten shift arm clamp bolts before tightening retaining nuts, or shift arm will work loose in a short period of time.

C. Install 2 shift arms (Item 11) and washers (Item 10). Install shift arm assembly (Item 8, 7, 6, 5, 4, 3).

D. Lightly tighten shift arm retaining nuts (Item 9, 2).

E. Tighten shift arm clamp bolts (Item 4, 1) with a 3/16″ Allen wrench.

F. Tighten shift arm retaining locknuts (Item 9, 2) to a torque of 24.5 – 29.5 Nm (18.5 – 22 ft–lb). Make sure you hold the shift lever in position while tightening the retaining nuts.

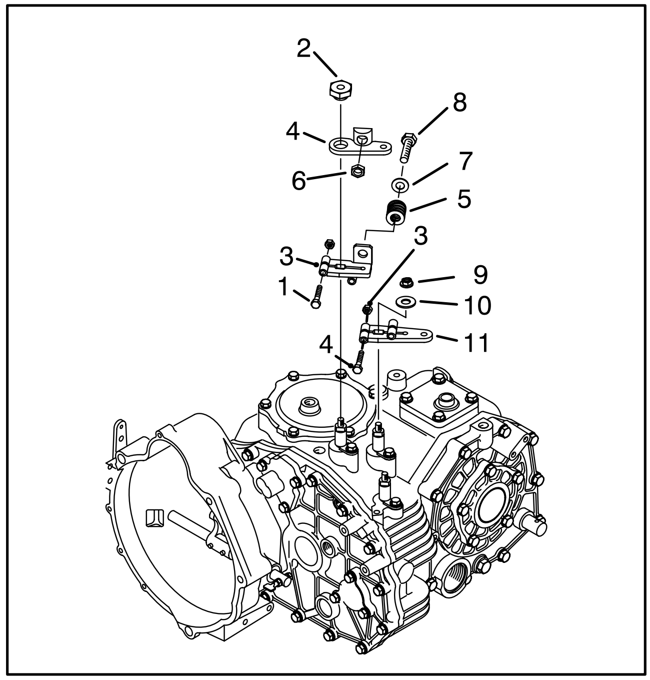


Figure 100

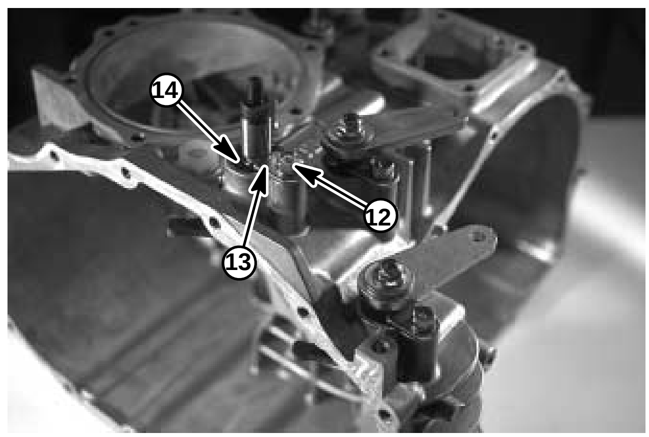


Figure 101

14. Assemble shift arms (Transaxle Model KT40A):

A. Install 3 new oil seals (Item 14) onto transaxle case. Apply multi–purpose grease on lips of oil seals before installing.

B. Install 3 keeper plates (Item 13) and tighten 3 capscrews (Item 12) to a torque of 15 – 17 Nm (11 – 13 ft–lb).

C. Apply Loctite 680 or equivalent to threads and tapers of shift fork arms.

D. Install 2 shift arms (Item 11). Install shift arm assembly (Item 8, 7, 6, 5, 4, 3).

E. Install washers (Item 10, 2) and locknuts (Item 9, 1). Tighten shift arm retaining locknuts to a torque of 24.5 – 29.5 Nm (18.5 – 22 ft–lb).

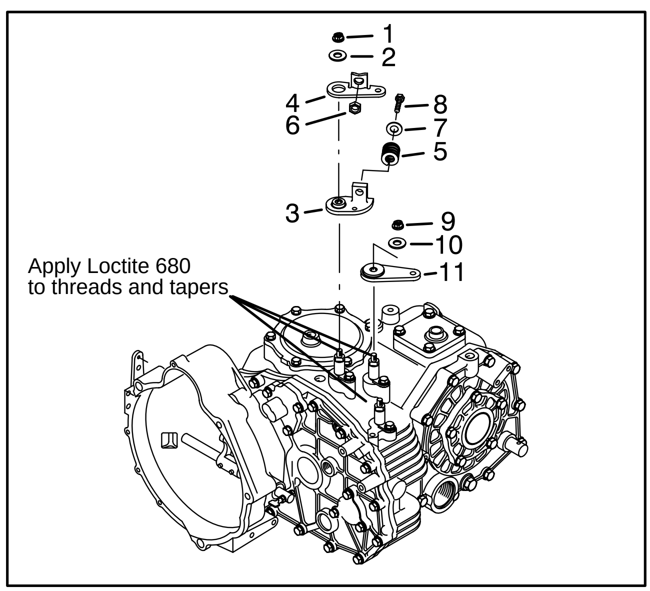


Figure 102

15. Install oil cap (Item 1) with O–ring. Apply multi–purpose grease to O–ring.

16. Install air breather (Item 2). Use sealing tape on threads of air breather.

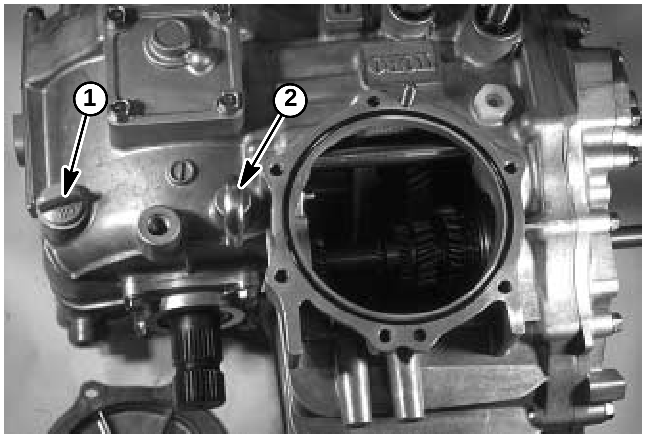


Figure 103

Drive Train

17. Install reduction shaft and countershaft together with R–1 fork shaft and Hi–Lo fork shaft. Insert heads of shift arms into grooves of forks when installing them.

Figure 104

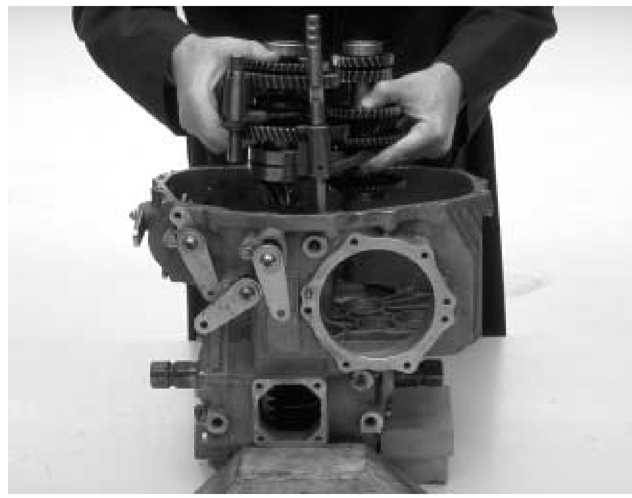


Figure 105

18. Install main shaft together with 2–3 fork shaft. Insert head of shift arm into groove of fork while installing.

Figure 106

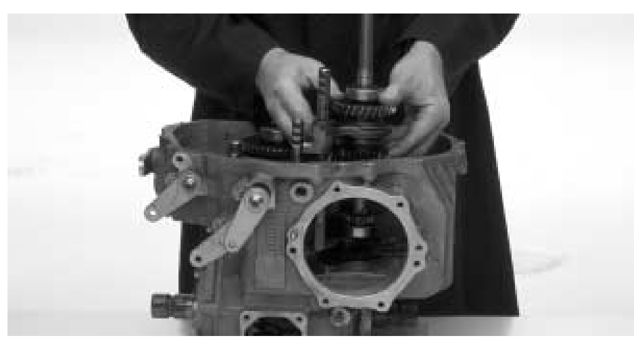


Figure 107

19. Install reverse shaft (Item 1). Rotate main shaft and reverse shaft gears to mesh gears when installing.

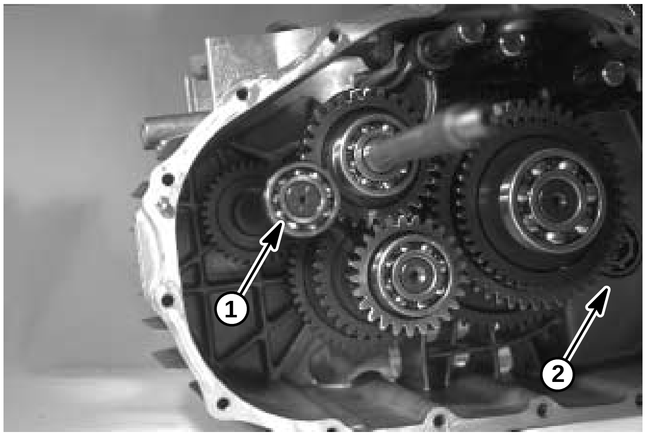


Figure 108

20. **On 4WD units**, install bearing to gear case and center plate. Install front drive shaft and 41T gear to the gear case (see Item 2 of Fig. 103).

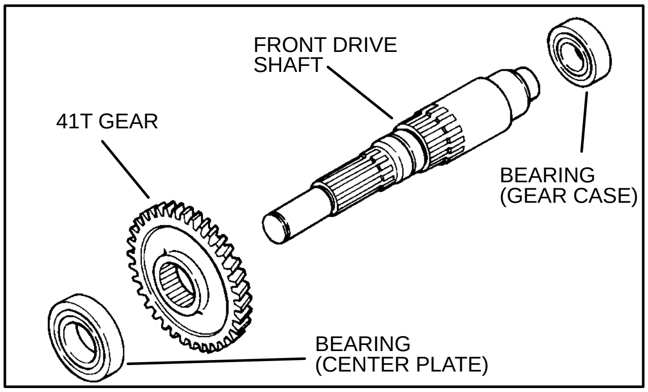


Figure 109

21. Install center plate:

A. Insert 2 dowel pins into transaxle case.

B. Apply silicone sealant onto mating surface of center plate.

C. Tighten capscrews to a torque of 24.5 – 29.5 Nm (18.5 – 22 ft–lb).

D. Apply multi–purpose grease onto lips of oil seal, then insert oil seal flush with face of housing.

E. Apply moly disulfide grease to spline of main shaft for clutch disk hub.

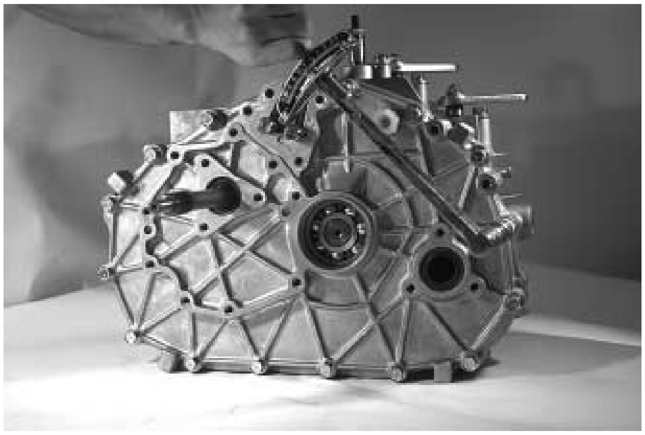


Figure 110

Drive Train

IMPORTANT: On early versions of the center plate, use one thick, tabbed shim (Item 2) (Fig. 111).

22. Insert shim (Item 2) against the bearing. Use thickest shim possible that will permit installation of the snap ring. (Fig. 111 and 113).

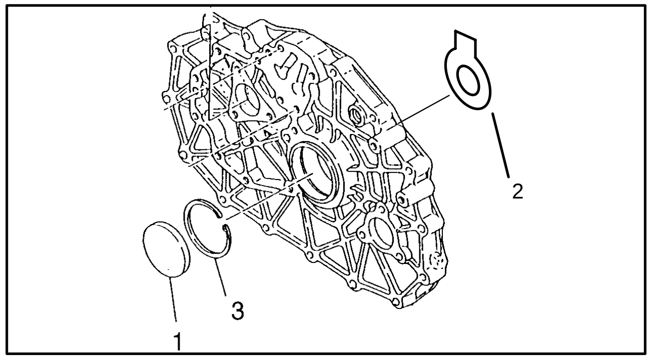


Figure 111

IMPORTANT: On newer versions of the center plate, use one tabbed shim (Item 4) with three tabless shims (Item 2) (Fig. 112).

Note: The thickest shim of the shim set (Item 2) should be positioned against the snap ring (Fig. 112).

23. Insert tabbed shim (Item 4) against the bearing. Insert shim set (Item 2) against the tabbed shim. Use thickest shims in set possible, that will permit installation of the snap ring. (Fig. 112 and 113).

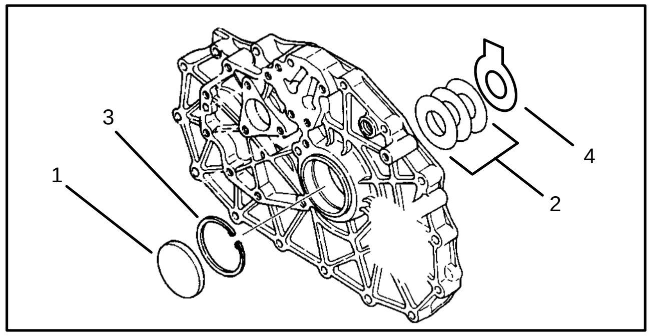


Figure 112

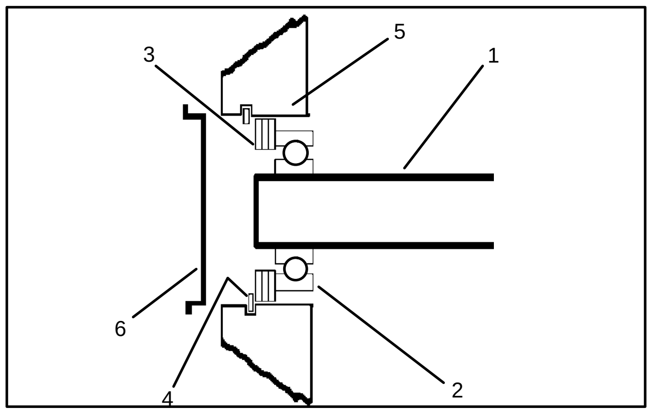


Figure 113

1. **Countershaft**
2. **Bearing**
3. **Shims**
4. **Snap ring**
5. **Center plate**
6. **Sealing cap**

24. Install snap ring into the groove of the bearing housing (Fig. 113 and 114).

Figure 114

25. Measure countershaft end play. Rotate one of the axle shafts back and forth to take up all back lash. Rotating the shaft in one direction will pull the shaft and bearing away from the snap ring. Rotate axle shaft in this direction, then measure space between the snap ring and shim (set) with a feeler gauge. Make sure shim (set) is held against the bearing during the measurement. End play should be 0.00 to 0.0039 inch (0.0 to 0.10 mm) (Fig. 115).

IMPORTANT:If end play is too large, replace shim/ shim set (item 2) in steps 22. and 23. with thicker shims to correct the problem.

Figure 115

26. Insert sealing cap (Item 1) flush with face of housing. Make sure not to insert sealing cap too far. Pay attention to direction of sealing cap.

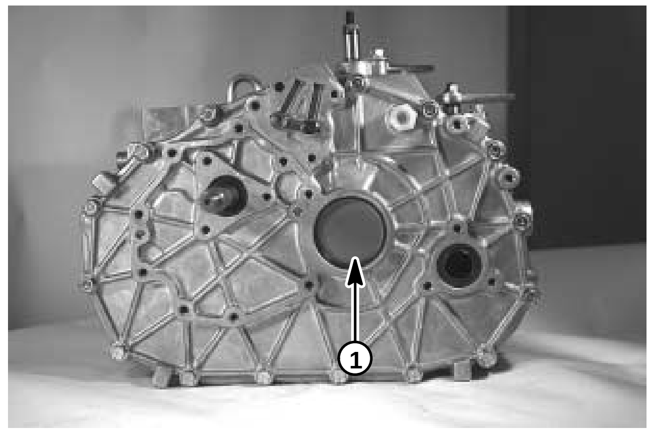


Figure 116

27. Install fork shaft case:

A. Apply silicone sealant to mating surface of fork shaft case.

B. Insert spindle (Item 1) between fork shafts.

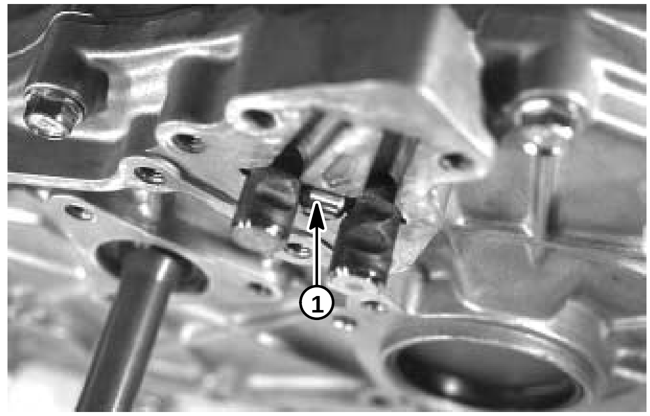


Figure 117

C. Insert 2 steel balls (Item 2) and 2 springs (Item 1) into the grooves.

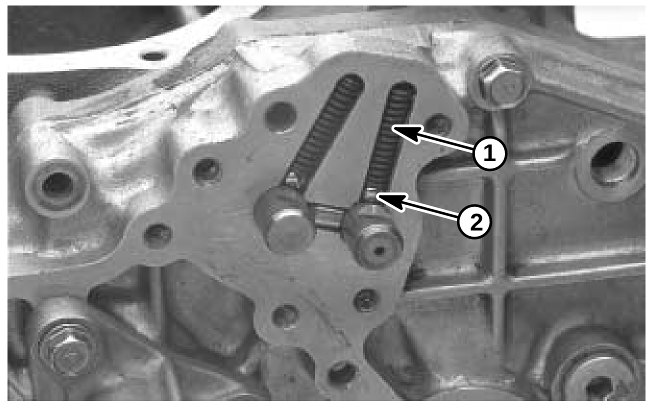


Figure 118

D. Install fork shaft case (Item 2). Tighten capscrews (Item 1) to a torque of 24.5 – 29.5 Nm (18.5 – 22 ft–lb). Check operation of shifters and detent.

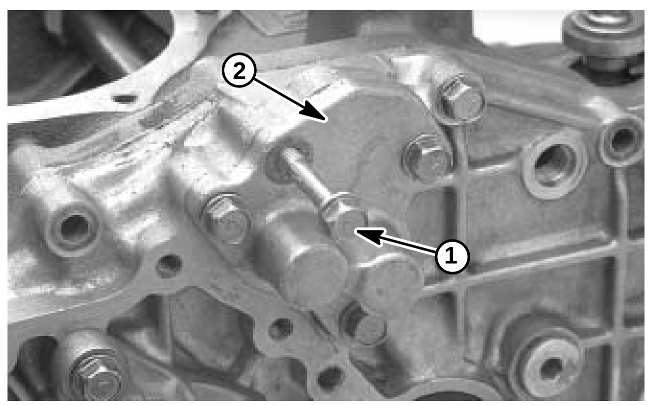


Figure 119

28. Insert a washer (Item 1) into housing of transaxle case. Apply moly disulfide grease to washer before installing.

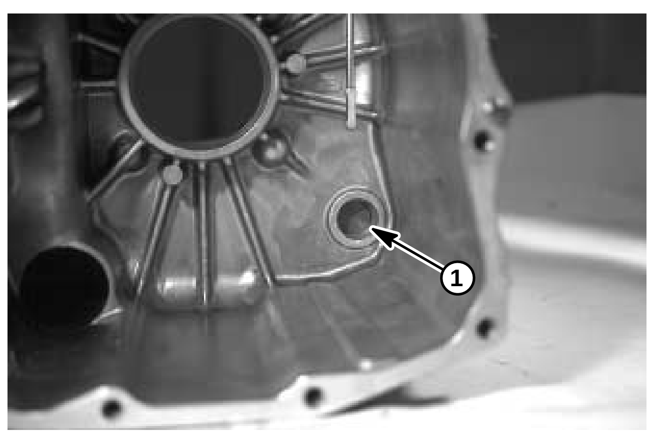


Figure 120

29. Install differential gear assembly (Item 1) together with fork shaft (Item 2) onto transaxle case.

Figure 121

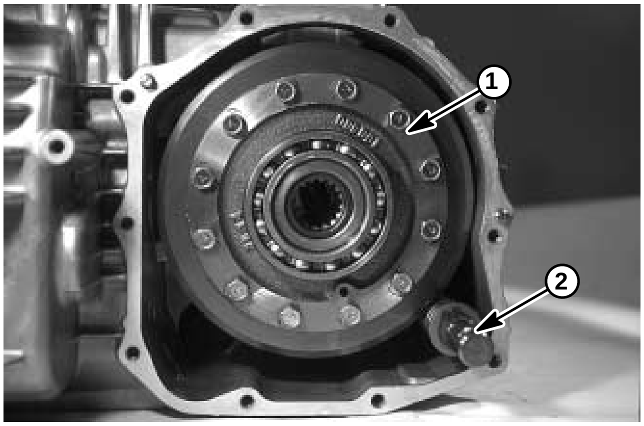


Figure 122

30. Install side cover:

A. Insert 2 dowel pins onto transaxle case.

B. Apply silicone sealant onto mating surface of side cover.

C. Install side cover. Tighten capscrews to a torque of 24.5 – 29.5 Nm (18.5 – 22 ft–lb).

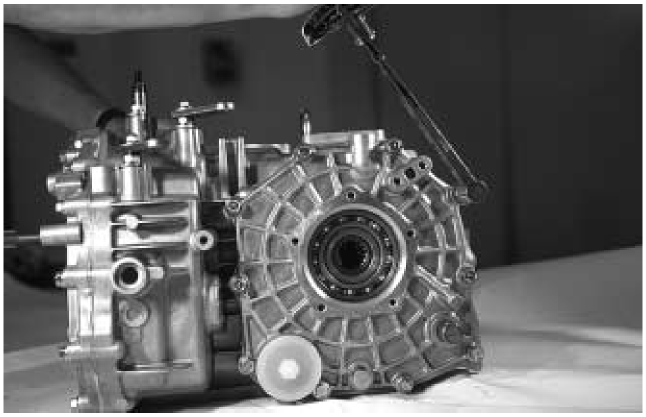


Figure 123

31. Install R.H. axle shaft assembly:

A. Apply silicone sealant onto mating surface of seal cover.

B. Install axle shaft assembly (Item 2) and tighten capscrews (Item 1) to a torque of 24.5 – 29.5 Nm (18.5 – 22 ft–lb).

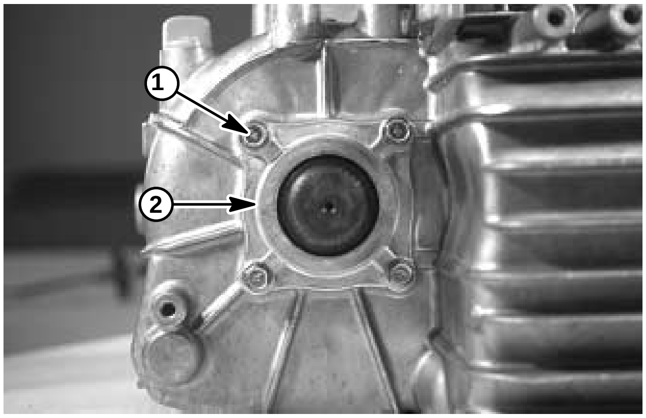


Figure 124

Drive Train

32. Install L.H. axle shaft assembly:

A. Thoroughly clean mating surface of differential carrier and side cover (Item 1).

B. Insert selected shims (Item 2) into housing of side cover. NOTE: The thickest shim should be inserted against the bearing.

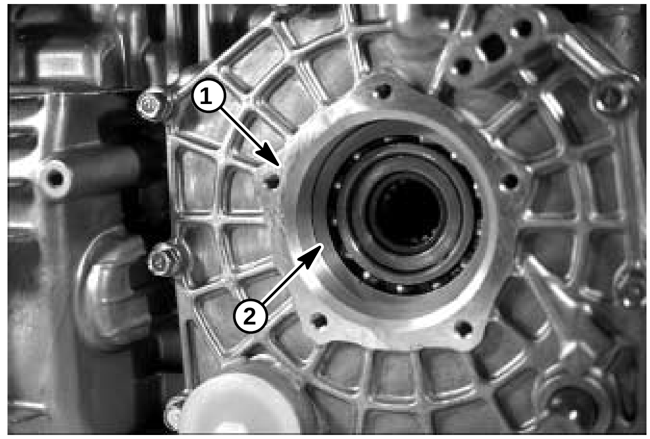


Figure 125

C. Install axle shaft assembly and tighten capscrews (Item 1) to a torque of 24.5 – 29.5 Nm (18.5 – 22 ft–lb).

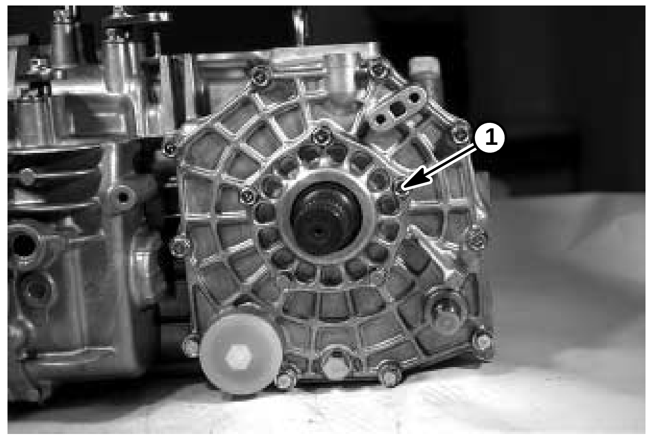


Figure 126

33. Measure backlash of ring gear through window on transaxle case. Using a dial indicator, check ring gear backlash in three equally spaced points. Backlash should be 0.08 – 0.18 mm (.0031 – .0071 in.) and must not vary more than 0.05 mm (.0019 in.) at the points checked. If backlash is not in this range, replace shim set in end of differential carrier:

A. If less than target range, decrease total thickness of shim set until correct backlash is achieved.

B. If exceeds the target range, increase total thickness of shim set until correct backlash is achieved.

NOTE: Thickest shim should be installed against the bearing.

Figure 127

34. Install differential lock arm (Item 1) onto fork shaft. Insert lock pin into fork shaft and arm. Pay attention to direction of slit in lock pin.

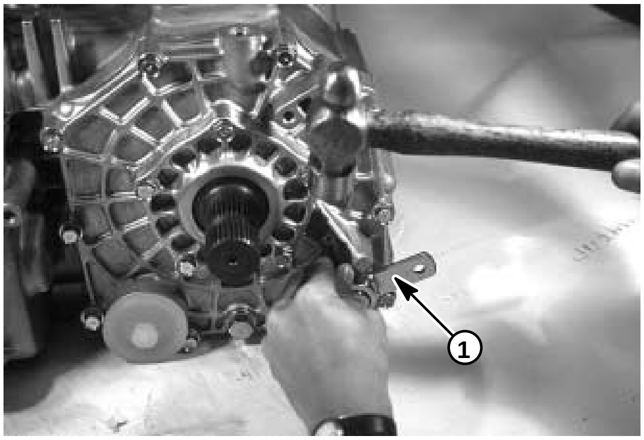


Figure 128

35. Apply silicone sealant to mating surface of upper cover (Item 2). Pay attention to direction of cover and install. Tighten capscrews (Item 1) to a torque of 24.5 – 29.5 Nm (18.5 – 22 ft–lb).

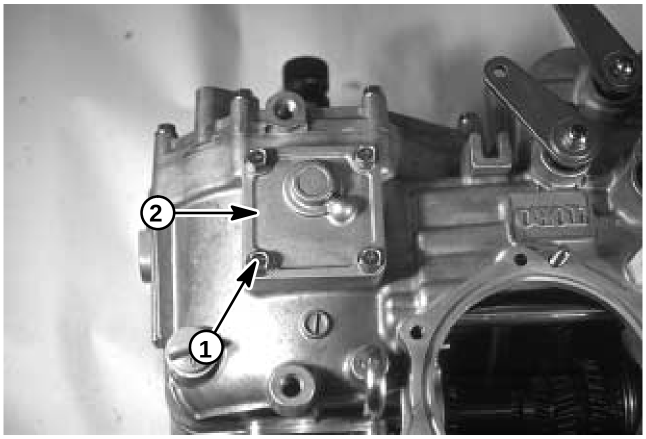


Figure 129

36. Apply multi–purpose grease to O–ring and insert O–ring into groove of transaxle case. If installing P.T.O., insert 2 dowel pins in transaxle case. Install P.T.O. or cover. Tighten capscrews and nut with lockwasher to a torque of 15 – 17 Nm (11 – 13 ft–lb).

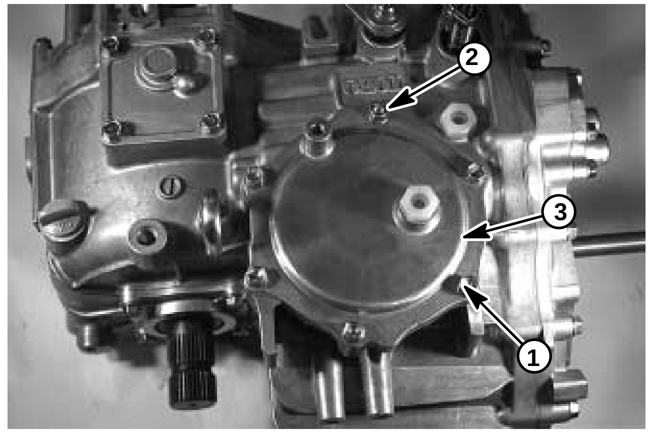


Figure 130

37. Install bell housing and secure with capscrews (Item 2). Tighten capscrews to a torque of 24.5 – 29.5 Nm (18.5 – 22 ft–lb).

38. Install extension spring (Item 1).

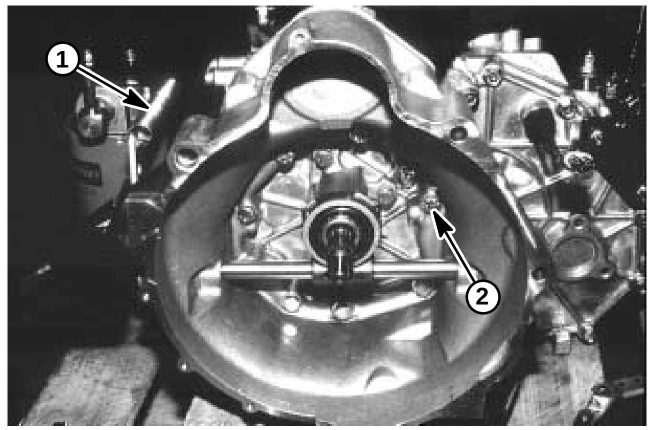


Figure 131

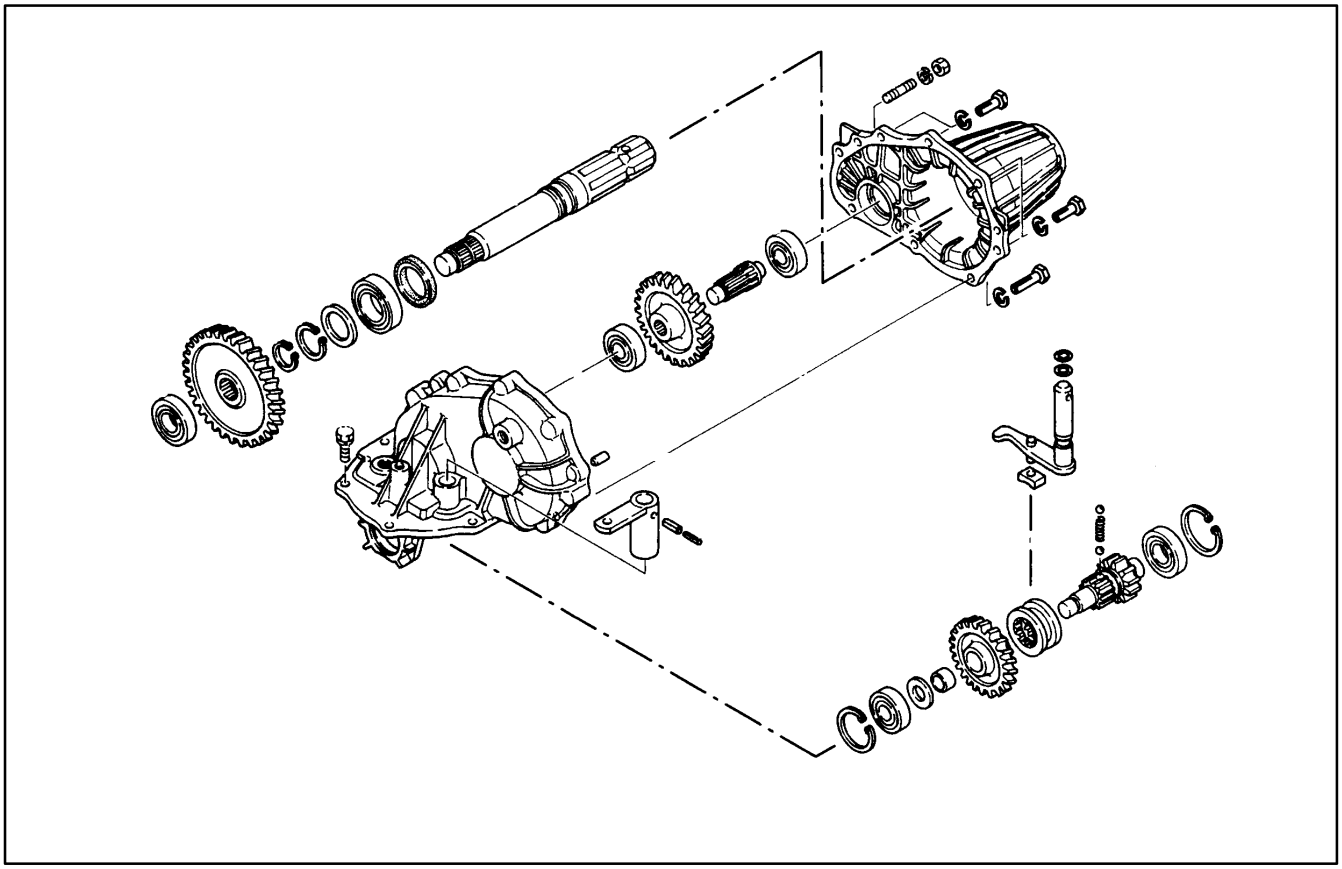


Figure 132

Power Take–Off (PTO) Disassembly

NOTE: Item numbers in figures are shown in order of disassembly; for example, remove Item 1 first, then Item 2, etc. Reassemble in reverse order; for example, install Item 1 last.

1. Thoroughly clean outside surface of PTO case.

2. Loosen capscrews and nut. Separate PTO cover from PTO case.

Figure 133

3. Remove PTO shaft assembly (Item 1) from PTO case. Remove oil seal from PTO cover.

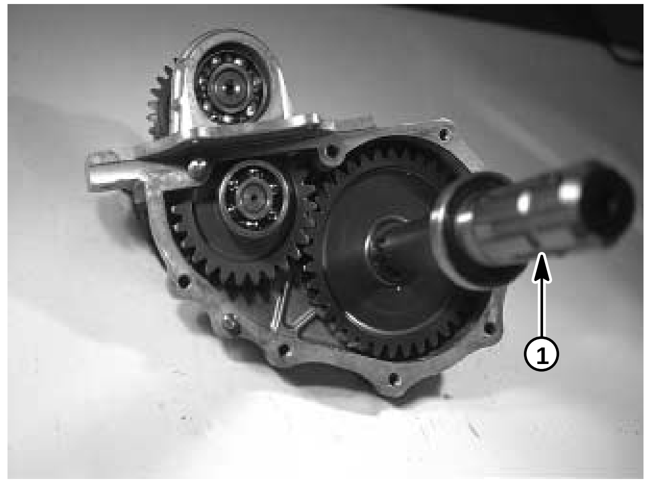


Figure 134

4. Remove idle shaft assembly (Item 1) from PTO case. Remove idle gear (Item 2). Remove bearing (Item 3) if necessary.

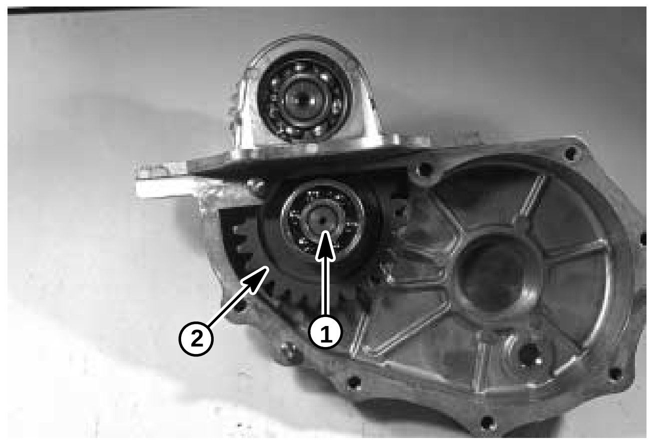


Figure 135

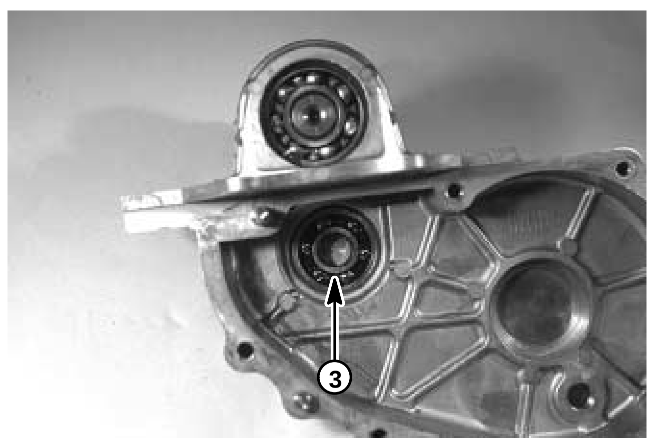


Figure 136

5. Remove PTO drive shaft:

C. Shift PTO to "ON" position.

D. Remove 2 snap rings (Item 1, 2) from PTO case.

E. Slide drive shaft assembly (Item 3) toward PTO shaft side.

F. Remove bearing (Item 4).

G. Slide drive shaft toward other side.

H. Remove bearing (Item 5).

I. Remove washer (Item 6) and gear (Item 7), sliding drive shaft toward PTO shaft side.

J. Release shift arm (Item 8) from block (Item 9).

K. Remove drive shaft assembly.

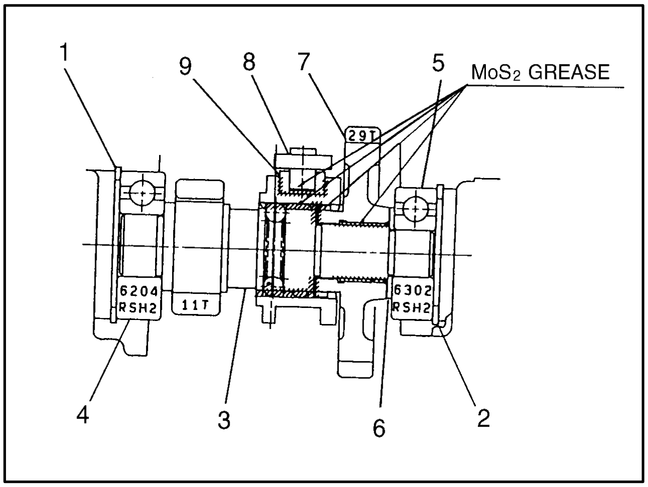


Figure 137

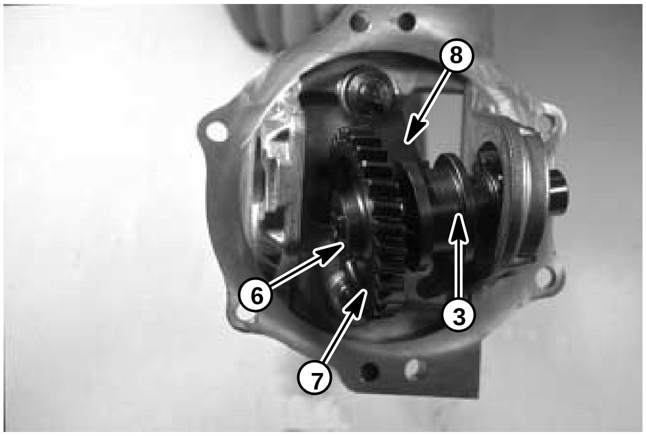


Figure 138

6. Disassemble PTO drive shaft:

A. Remove shifter (Item 1).

B. Remove 2 steel balls (Item 2) and spring (Item 3).

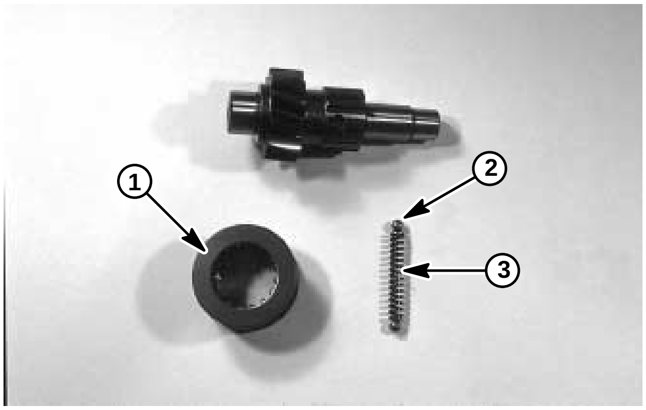


Figure 139

Drive Train

7. Disassemble PTO idle shaft:

A. Use a bearing puller to remove bearing (Item 1) if necessary.

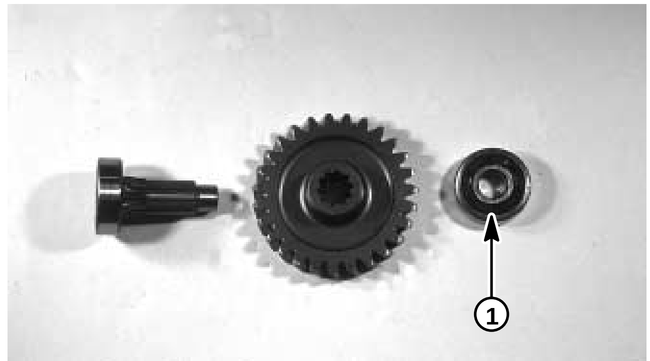


Figure 140

8. Disassemble PTO shaft:

A. Use a bearing puller to remove bearing (Item 1).

B. Remove gear (Item 2) and snap ring (Item 3).

C. Remove snap ring (Item 4) and washer Item 5).

D. Use a bearing puller to remove bearing (Item 6) if necessary.

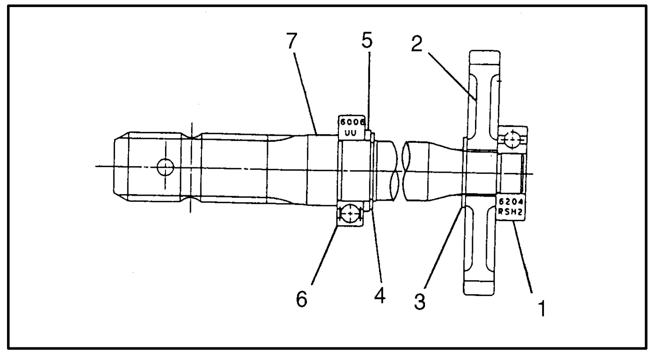


Figure 141

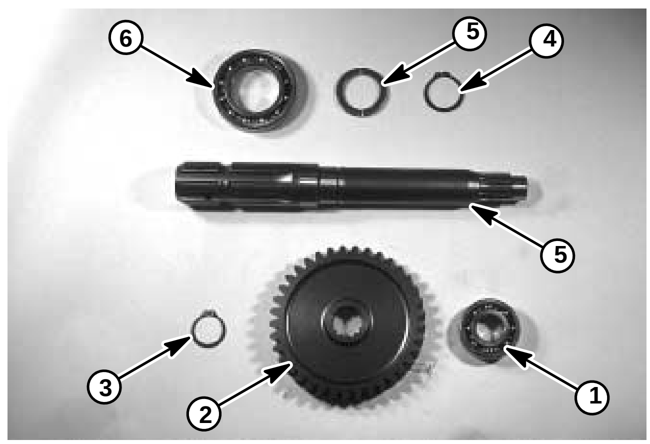


Figure 142

9. Disassemble shift arm:

A. Remove 2 lock pins from shift arm.

B. Remove 2 O–rings (Item 1).

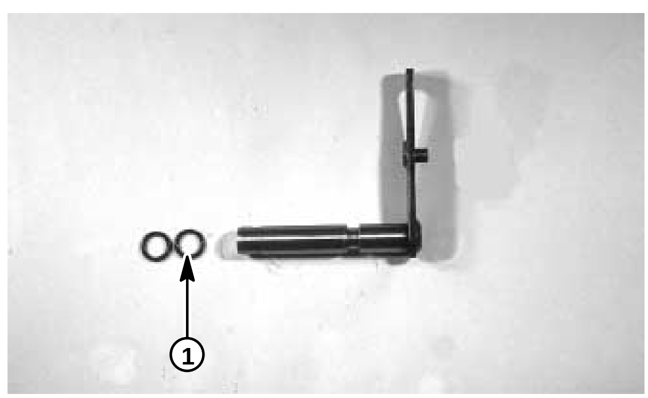


Figure 143

Power Take–Off (PTO) Inspection

1. Thoroughly clean and dry all parts.

2. Use emery cloth to remove nicks and burrs from all parts.

3. Measure clearance between shifter groove and shifter block. Replace shifter block if clearance exceeds 1.0 mm (.039 in.).

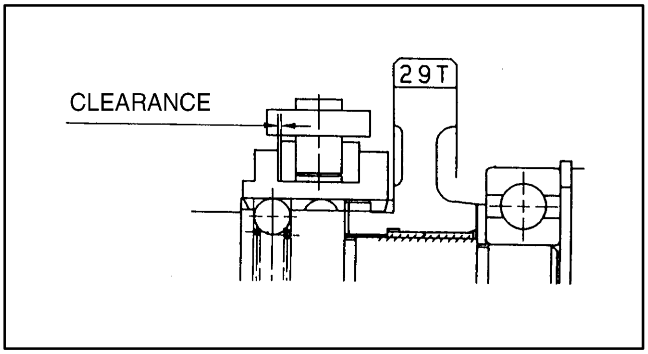


Figure 144

4. Measure I.D. of bushing (Item 1). Replace bushing if I.D. exceeds 17.10 mm (.673 in.).

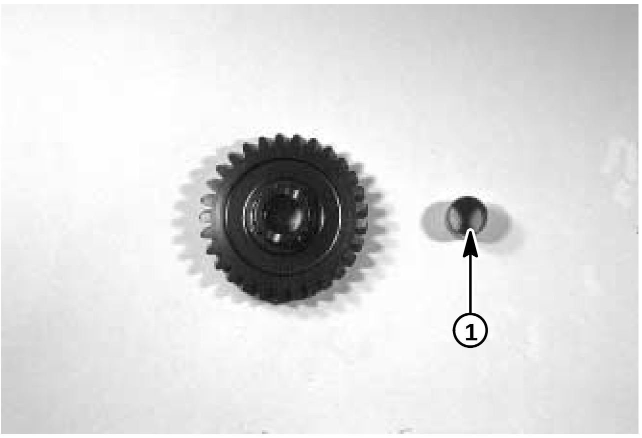


Figure 145

5. Measure O.D. of bushing area on shaft. Replace shaft if O.D. is less than 16.95 mm (.667 in.). Inspect surface of bushing area for scoring or damage.

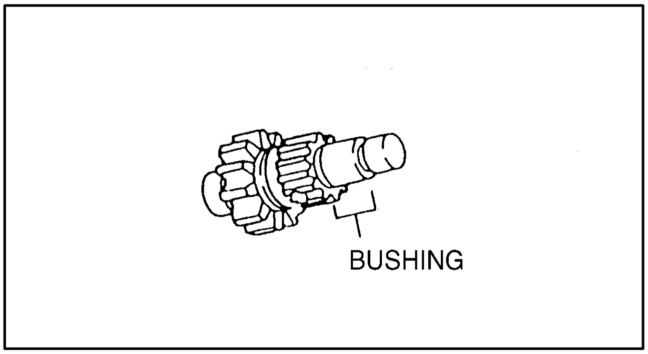


Figure 146

6. Inspect surface of oil seal area for wear or damage.

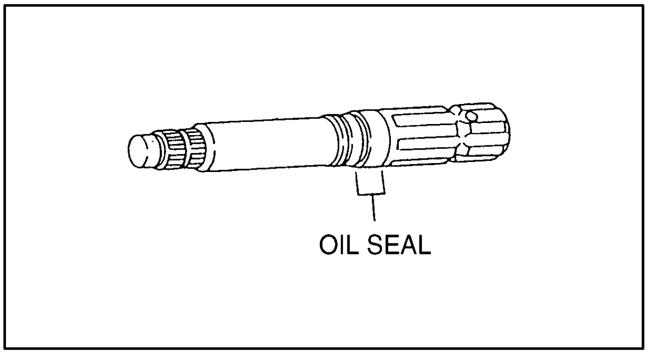


Figure 147

Drive Train

Power Take–Off (PTO) Reassembly

NOTE: Item numbers in figures are shown in reverse order of assembly; for example, when reassembling, install Item 1 last.

1. Clean gasket material from mating surfaces of case and cover.

IMPORTANT: Be careful not to damage mating surfaces when removing gasket material.

2. Make sure all parts should be free of dirt and dust.

3. Assemble shift arm:

A. Install 2 new O–rings (Item 1) onto shift arm. Apply moly disulfide grease to O–rings before installing.

B. Apply moly disulfide grease to arm pin and shaft.

C. Install shift arm into PTO case.

D. Install arm onto shift arm

E. Drive lock pins into arm and shift arm. Pay attention to direction of slit in lock pins.

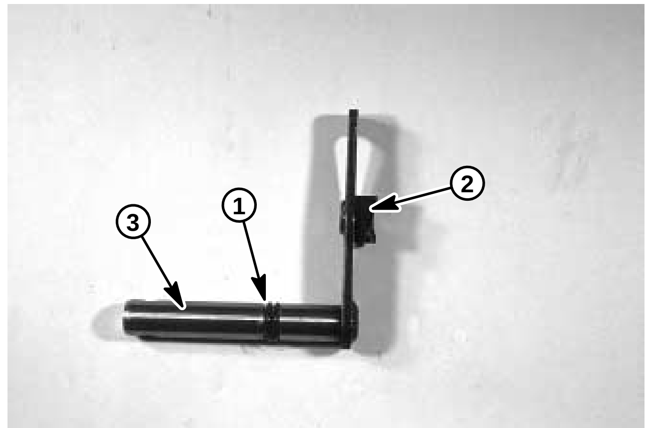


Figure 148

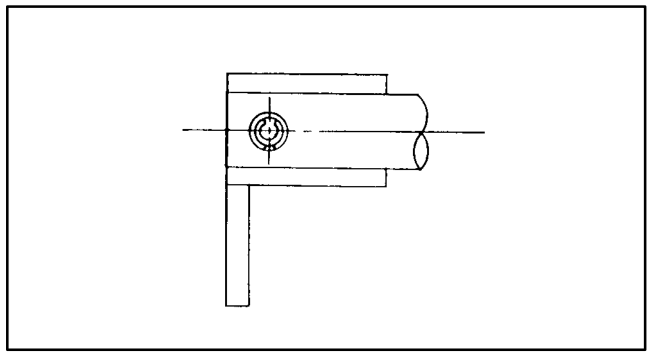


Figure 149

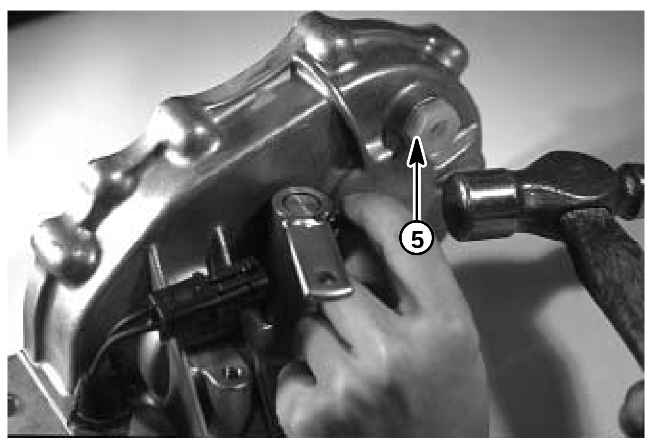


Figure 150

4. Assemble PTO shaft:

A. Use a press to install bearing (Item 6) onto PTO shaft.

B. Install washer (Item 5) and snap ring (Item 4).

C. Install snap ring (Item 3) and gear (Item 2).

D. Use a press to install bearing (Item 1).

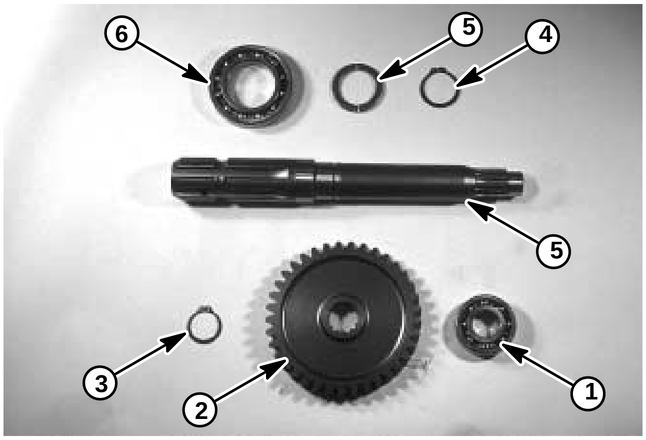


Figure 151

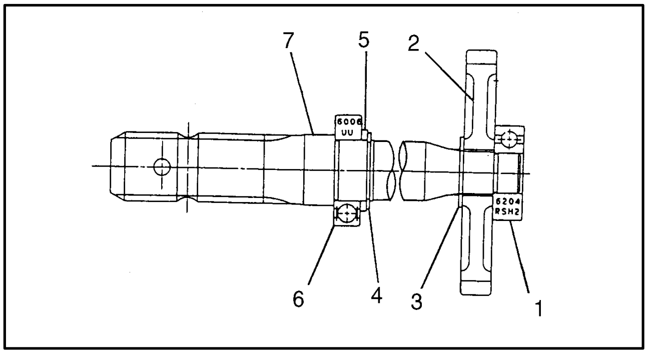


Figure 152

5. Use a press to install bearing (Item 1) onto idle shaft.

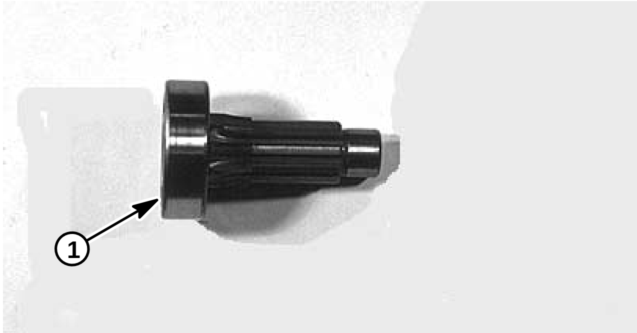


Figure 153

6. PTO drive shaft sub–assembly:

A. Insert spring (Item 3) and 2 steel balls (Item 2) into hole.

B. Insert shifter (Item 1) onto PTO drive shaft.

C. Move shifter to ”ON” position.

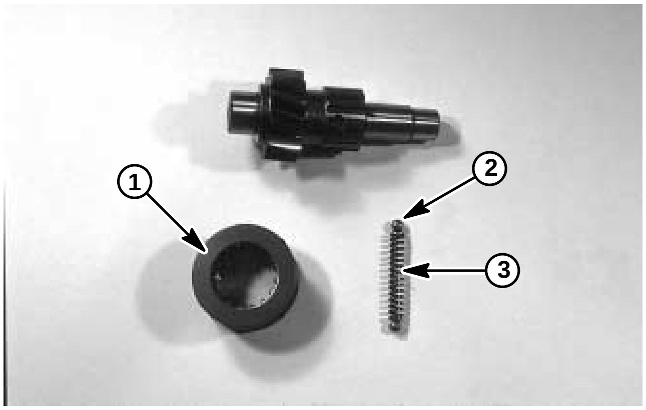


Figure 154

7. Install PTO drive shaft sub–assembly:

A. Insert block (Item 9) into pin of shift arm. Apply moly disulfide grease onto both sides of block before installing.

B. Put shifter of PTO drive shaft sub–assembly (Item 3) on the block.

C. Install gear (Item 7) with bushing and washer (Item 6) onto drive shaft after sliding the assembly toward PTO shaft side. Apply moly disulfide grease to bushing of gear and washer before installing.

D. Install 2 bearings (Item 5, 4) onto drive shaft by hand.

E. Insert 2 snap rings (Item 2, 1).

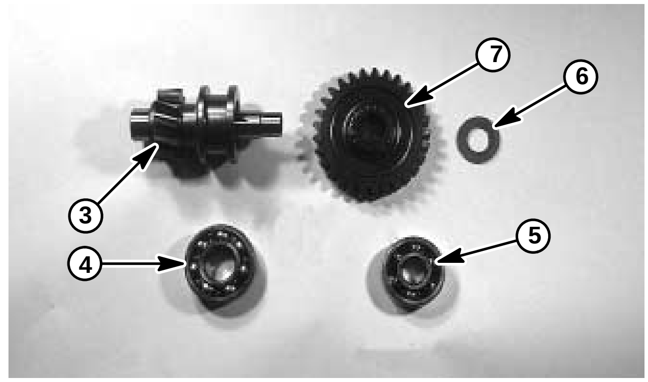


Figure 155

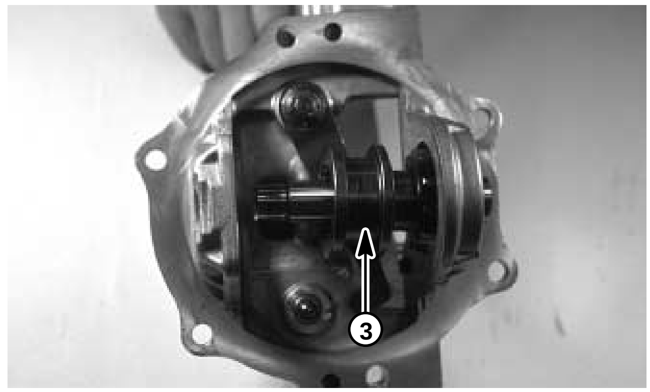


Figure 156

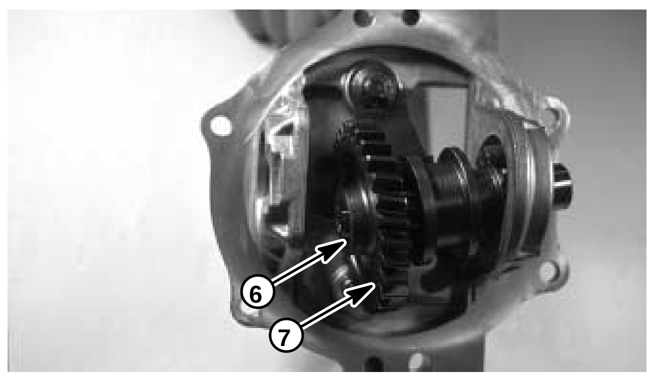


Figure 157

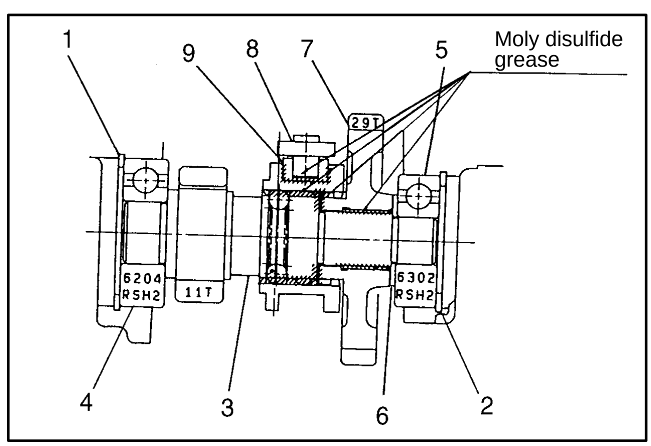


Figure 158

8. Install PTO idle shaft sub–assembly:

A. Insert bearing (Item 3) into PTO case.

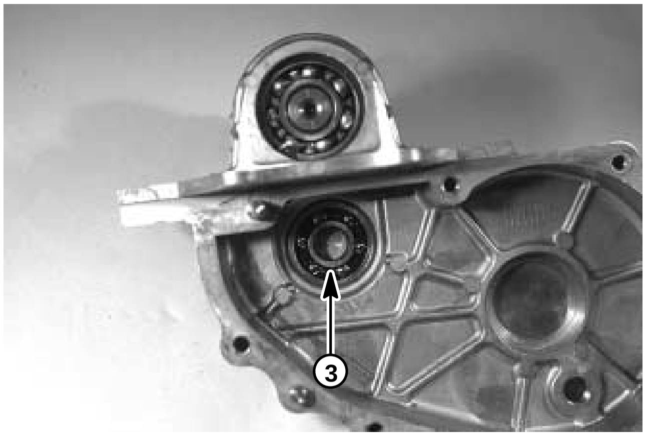


Figure 159

B. Put gear (Item 2) on mating gear.

C. Move gear until holes of gearing and bearing line up.

D. Insert idle shaft sub–assembly (Item 1). Apply grease to idle shaft to aid assembly.

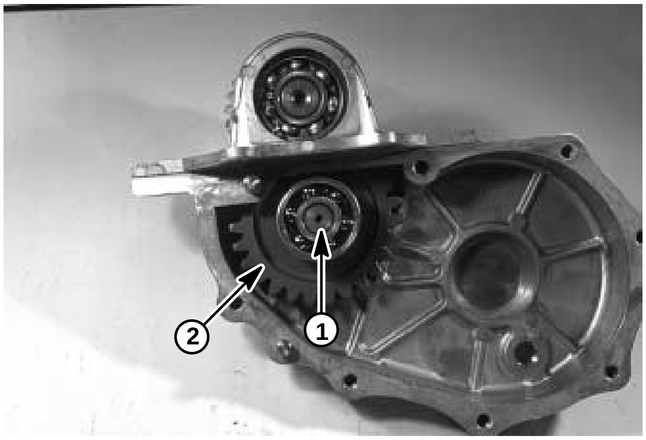


Figure 160

9. Insert PTO shaft assembly (Item 1) into bearing housing of PTO case.

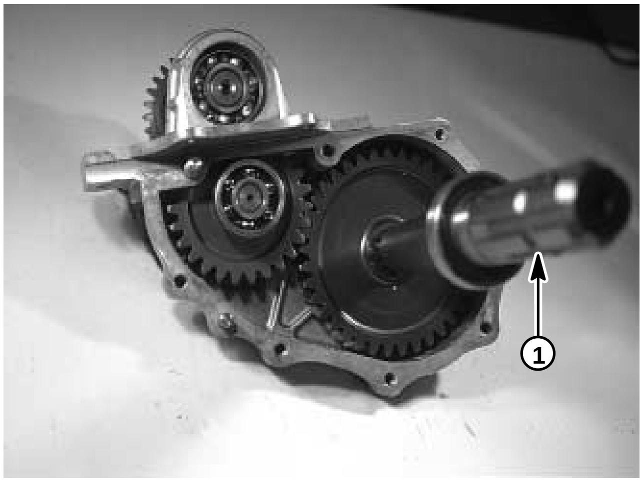


Figure 161

10. Install PTO cover:

A. Insert new oil seal into PTO cover. Apply multi–purpose grease to lip of oil seal.

B. Insert 2 dowel pins onto PTO case.

C. Apply silicone sealant onto mating surface of PTO cover.

D. Install PTO cover. Tighten capscrews and nut with lockwasher to a torque of 24.5 – 29.5 Nm (18.5 – 22 Nm).

Figure 162

Chapter 7

Steering, Brakes and Suspension

Table of Contents

Specifications

Item	Specification
Front wheel toe–in	0 to 0.125 in. (0 – 3 mm)
Front tire pressure 20″ x 10″ – 10, 4 ply (Std. on all turf models) 175/80 D13 (Std on industrial models)	 20 PSI (138 kPa) max. 35 PSI (241 kPa) max.
Rear tire pressure 23″ x 10.5″ – 12, 6 ply (Std. on Workman 3100) 24″ x 13″ – 12, 6 ply (Std. on all other turf models) 205/75 D14 (Std. on industrial models)	 32 PSI (220 kPa) max. 18 PSI (124 kPa) max. 50 PSI (345 kPa) max.
Wheel nut torque	45 to 55 ft–lb (61 – 75 Nm)
Brake fluid (Fig. 1)	DOT 3

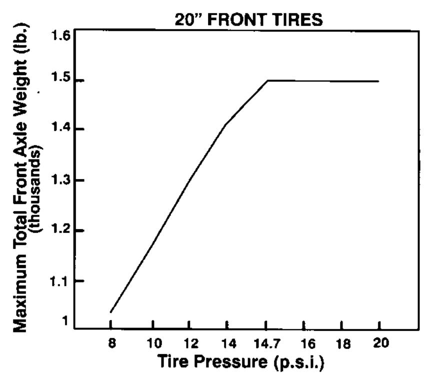
IMPORTANT:On 4WD vehicles, used only Toro approved tires (see Operator's Manual) to prevent the clutch from locking up.

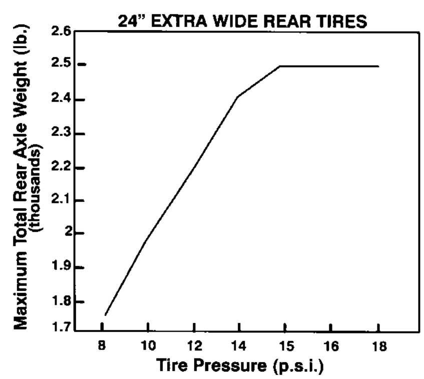
Tire Pressure

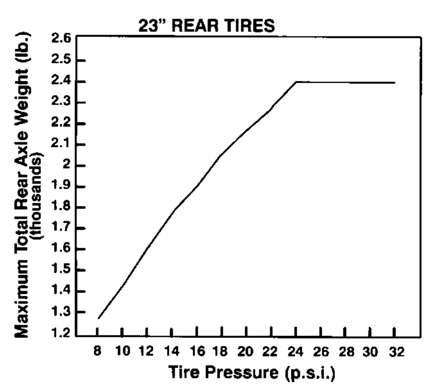
1. Air pressure needed is determined by the payload carried.

2. The lower the air pressure, the less the compaction, and tire marks are minimized. Lower pressure should not be used for heavy payloads at high speeds. Tire damage may result.

3. High pressure should be used for heavier payloads at higher speeds. Do not exceed the maximum pressure. Use the following charts to determine correct tire pressures for tire size and payload of turf vehicle **(charts do not apply to industrial models)**.







Special Tools

Compression Spring Tool

Use to remove and install the two (2) front suspension compression springs.

Qty.	Item
2	1/2″ x 20″ threaded steel rods
4	1/2″ nuts
4	1/2″ flat washers

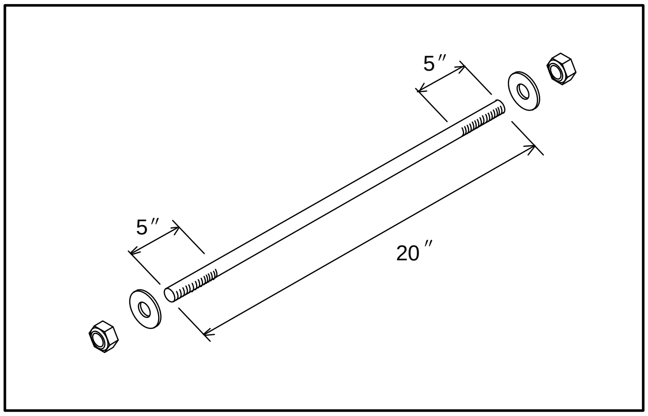


Figure 1

Adjustments

Brake Pedal Adjustment

1. Loosen jam nut on link rod ball joint.

2. Rotate rod until gap between brake pedal and up stop is 0.020 to 0.080 inch (0.5 to 2 mm).

3. Tighten jam nut after making adjustment.

CAUTION

Worn or misadjusted brakes may result in personal injury. If brake pedal travels to within $1^1/_2''$ (38 mm) of the vehicle floor board, the brakes must be adjusted or repaired.

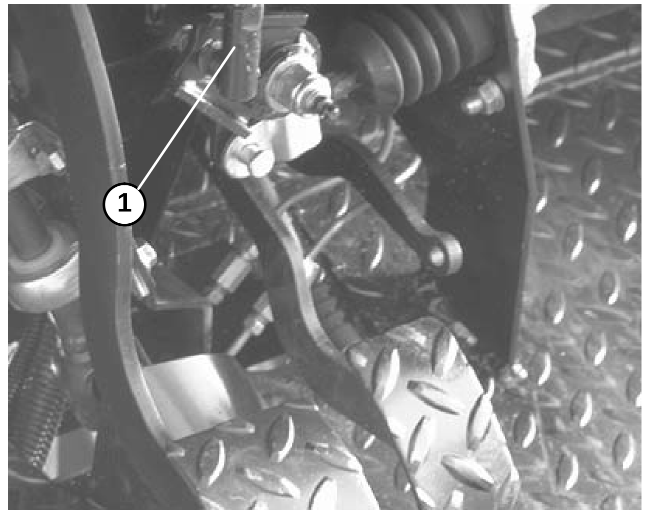


Figure 2
1. **Link rod ball joint**

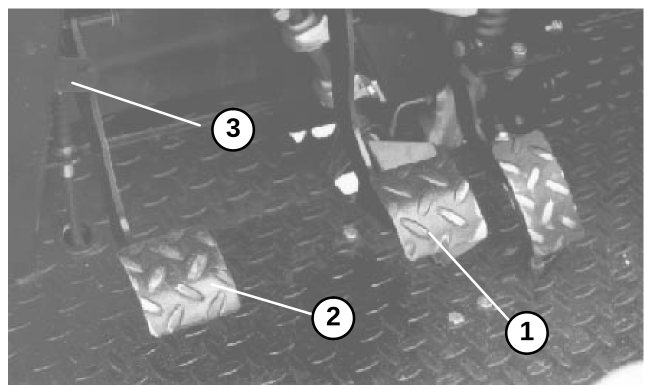


Figure 3
1. **Brake pedal**
2. **Clutch pedal**
3. **Clutch pedal up stop**

Parking Brake Adjustment

1. Loosen set screw securing knob to parking brake lever.

2. Rotate knob until a force of 55 to 65 lbs. (25 to 29 kg) is required to actuate lever.

3. Tighten set screw after making adjustment.

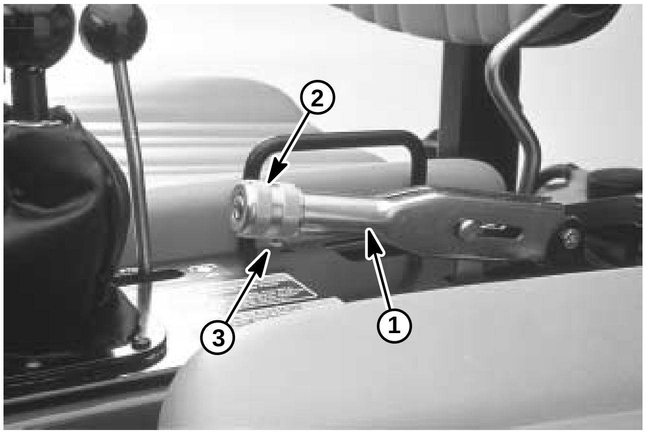


Figure 4

1. Parking brake lever
2. Knob
3. Set screw

Front Wheel Toe–In

1. Measure center to center distance (at axle height) at front and rear of steering tires. Front measurement must be equal to the rear measurement ± 1/8 in. (3 mm).

2. To adjust, loosen jam nuts at both ends of tie rod.

3. Rotate tie rod to move front of tires inward or outward.

4. Tighten tie rod jam nuts after making adjustment.

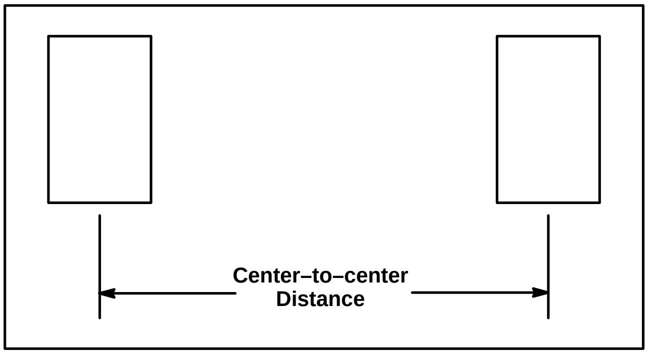


Figure 5

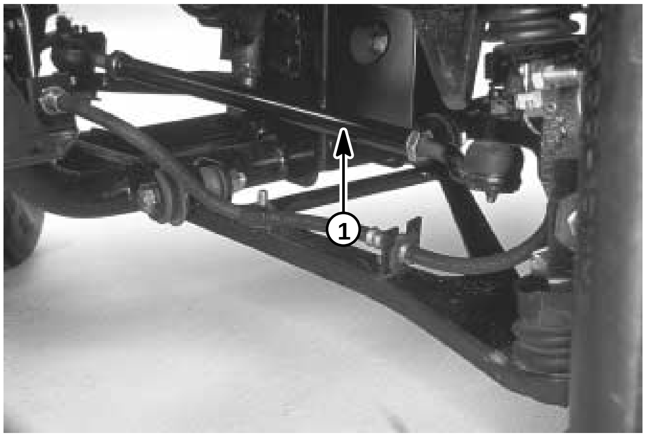


Figure 6

1. Tie rod

Steering, Brakes & Suspension

Troubleshooting

Suspension and Steering

Problem	Possible Cause
Front end noise.	Loose or worn front wheel bearings. Worn shock absorbers. Worn stabilizer link bushings. Loose steering gear. Worn control arm bushings.
Rear end noise.	Worn or brinelled rear wheel bearings. Worn shock absorbers. Worn leaf spring bushings. Clutch, drive shaft or transaxle problem (see Chapter 6 – Drive Train).
Excessive steering play.	Loose or worn front wheel bearings. Loose or worn steering linkage. Worn tie rod ends. Incorrect steering gear adjustment.
Front wheel shimmy.	Loose or worn front wheel bearings. Tires out of round or uneven tire wear. Worn tie rod ends. Incorrect front wheel alignment (toe–in). Worn shock absorbers.
Instability (wander).	Low or uneven tire pressure. Loose wheel bearings. Loose steering shaft bearings. Broken or loose rear leaf spring. Bad shock absorber. Improper steering gear adjustment. Incorrect front wheel alignment (toe–in).

Suspension and Steering (continued)

Problem	Possible Cause
Hard steering.	Loose worn or glazed hydraulic pump drive belt. Binding or damaged steering linkage. Low or uneven tire pressure. Low hydraulic pressure (see Chapter 9 – Hydraulic System). Worn or damaged steering gear. Incorrect front wheel alignment.
Vehicle pulls to one side when not braking.	Low or uneven tire pressure. Broken or weak rear leaf spring. Incorrect front wheel alignment. Damaged or bent suspension or steering component.

Brakes

Problem	Possible Cause
Pedal goes to floor.	Incorrectly adjusted brakes. Air in brake system. Leaking wheel cylinders. Loose or broken brake lines. Leaking or worn master cylinder. Excessively worn brake shoes.
Spongy brake pedal.	Air in brake system. Excessively worn or cracked brake drums. Broken or worn pedal pivot bushing.

Brakes (continued)

Problem	Possible Cause
Brakes pulling.	Incorrect tire pressure. Contaminated brake linings. Front end out of alignment. Incorrect brake adjustment. Distorted brake shoes. Restricted brake lines or hoses. Broken rear spring. Unmatched tires on same axle.
Squealing brakes.	Glazed brake lining. Saturated brake lining. Weak or broken shoe return spring. Weak or broken shoe retaining spring. Distorted brake shoes. Bent support plate. Dust in brake drums and brakes. Scored brake drums. Out of round drums.
Dragging brakes.	Improper brake or parking brake adjustment. Parking brake engaged. Weak or broken brake shoe return spring. Binding brake pedal. Sticking master cylinder. Saturated brake linings. Bent or out of round brake drums.

Brakes (continued)

Problem	Possible Cause
Hard brake pedal.	Incorrect brake lining material. Restricted brake lines or hoses. Brake pedal linkage binding.
Wheel locks.	Contaminated brake linings. Loose or damaged brake linings. Wheel cylinder sticking. Incorrect wheel bearing adjustment.
Brakes fade.	Overheated brake drums. Saturated brake linings.
Surge at slow speeds. Chatter at fast speeds.	Bent or out of round brake drums.
Shoe lock.	Machining grooves in contact face of brake drums. Weak hold down springs.
Brakes do not self adjust.	Adjuster bolt seized in thread. Adjuster lever does not engage star wheel.

Wheel Installation

1. Mount wheel and evenly tighten nuts to a torque of 45 – 55 ft–lb (61 – 75 Nm).

WARNING

Failure to maintain proper torque could result in failure of loss of wheel and may result in personal injury. Torque front and rear wheel nuts to 45 – 55 ft–lb (61 – 75 Nm) after 1 – 4 hours of operation and again after 10 hours of operation and every 200 hours thereafter.

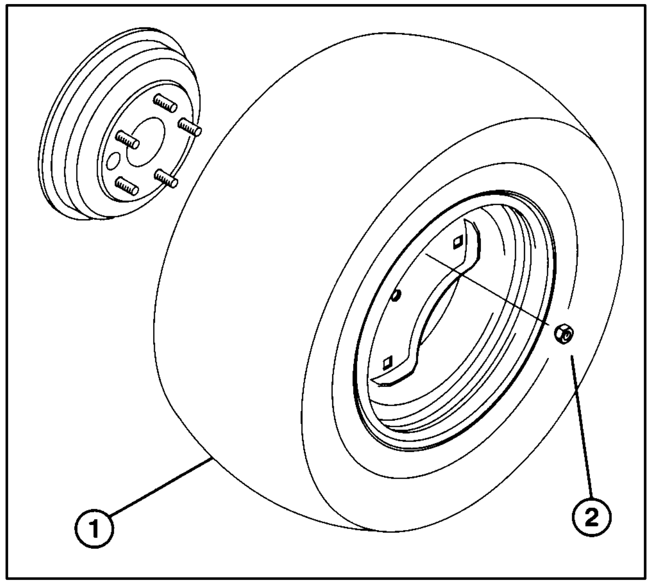


Figure 7

1. Wheel
2. Wheel nut

Front Wheel Bearing Service

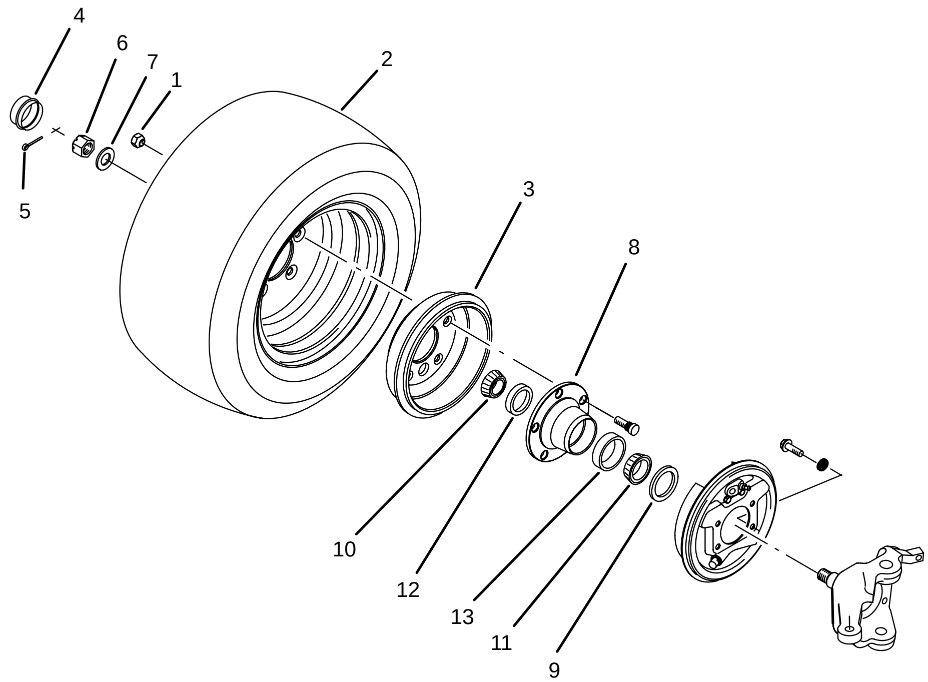


Figure 8

1. Lug nut
2. Wheel and tire
3. Brake drum
4. Dust cup
5. Cotter pin
6. Slotted nut
7. Washer
8. Wheel hub.
9. Seal
10. Bearing cone
11. Bearing cone
12. Bearing cup
13. Bearing cup

1. Partially loosen lug nuts (Item 1), then jack up and support front of vehicle. Remove lug nuts then remove wheel (Item 2) and brake drum (Item 3).

2. Remove dust cup (Item 4). Remove cotter pin (Item 5), slotted nut (Item 6) and washer (Item 7), then pull wheel hub (Item 8) off of spindle.

3. Pull seal (Item 9) out of wheel hub. Remove bearing cones (Item 10, 11) from wheel hub. Check bearing cups (Item 12, 13) for wear, pitting or other damage. Replace worn or damaged parts.

4. If bearing cups were removed, press new cups into hub until they seat against shoulder inside hub.

5. Pack inner bearing cone (Item 11) with wheel bearing grease. Install inner bearing cone into bearing cup in hub. Apply grease to new seal (Item 9) and press into wheel hub.

6. Carefully slide wheel hub (Item 8) with inner bearing and seal onto spindle. Fill cavity of wheel hub 50% full with wheel bearing grease.

7. Pack outer bearing cone (Item 10) with wheel bearing grease then insert into wheel hub over spindle. Install washer (Item 7) over bearing and secure hub to spindle with slotted nut (Item 6). DO NOT tighten nut or install cotter pin.

8. While rotating wheel hub, tighten nut to a torque of 17 – 25 ft–lb (23 – 34 Nm). Back off nut 1/2 turn and retighten nut to a torque of 10 – 15 **in–lb** (12 – 17 Kg cm). Insert cotter pin. If cotter pin does not align, continue to tighten nut until next slot on nut is aligned. Bend cotter pin completely around nut, then install dust cup (Item 4).

9. Install brake drum (Item 3), then install wheel (Item 2) and secure with lug nuts (Item 1). Tighten lug nuts in a crossing pattern to a torque of 45 – 55 ft–lb (61 – 75 Nm).

Rear Wheel Bearing Service

See Stub Axle and Drive Shaft Service in Repairs section of Chapter 6 – Drive Train.

Brake Service

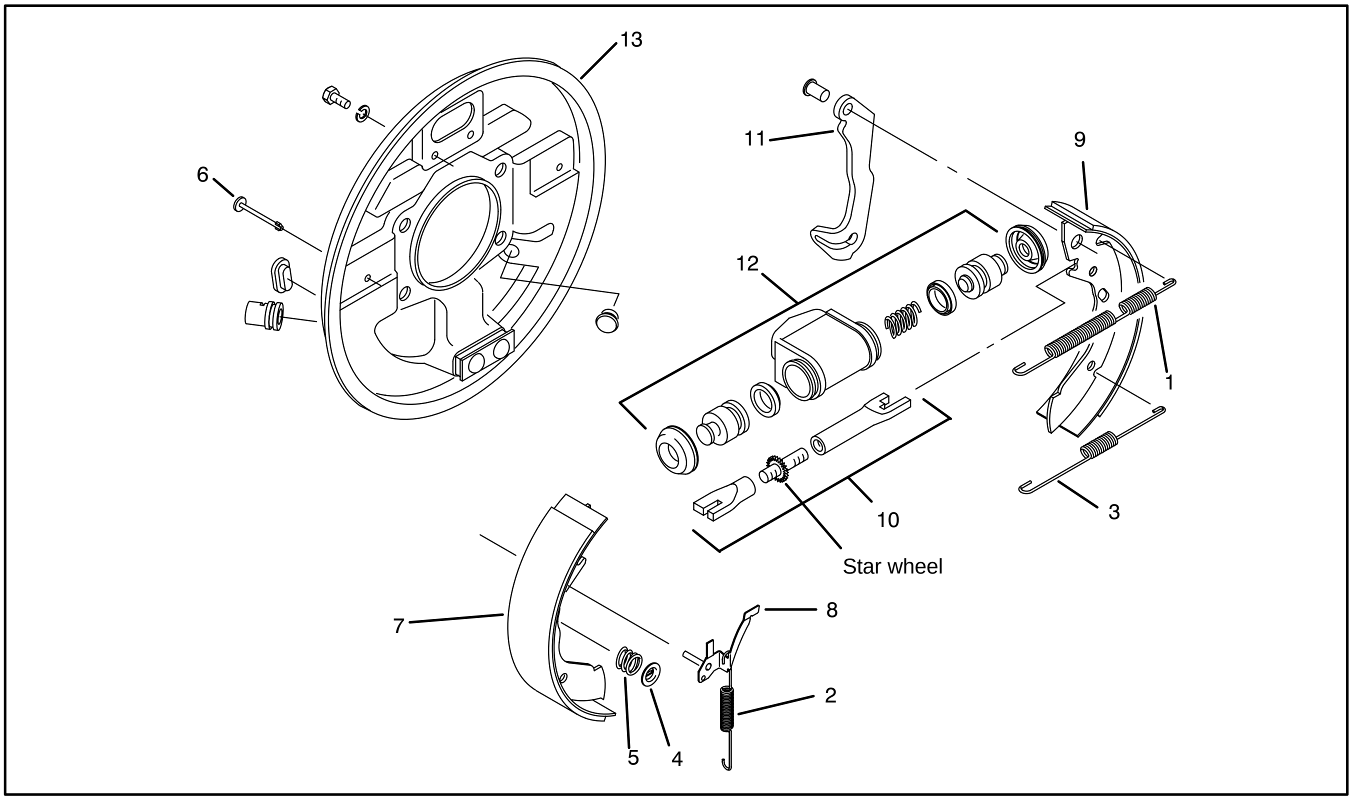


Figure 9

1. Upper spring
2. Adjuster spring
3. Lower spring
4. Hold down washer
5. Hold down spring
6. Hold down pin
7. Brake shoe and lining
8. Pawl
9. Brake shoe and lining
10. Adjuster assembly
11. Parking brake lever
12. Wheel cylinder
13. Backing plate

CAUTION

Worn or misadjusted brakes may result in personal injury. If brake pedal travels to within $1^1/_2''$ (38 mm) of the vehicle floor board, the brakes must be adjusted or repaired.

1. Partially loosen wheel lug nuts then jack up and support vehicle. Remove lug nuts then remove wheel.

NOTE: It may be necessary to back off adjuster to remove brake drum. To back off adjuster, rotate brake drum until access hole lines up with star wheel (Fig. 10). Use a hooked piece of wire to pull pawl away from star wheel, then turn star wheel.

2. Remove brake drum.

3. If servicing front brakes, remove wheel hub (see Front Wheel Bearing Service). If servicing rear brakes, remove stub axle (See Chapter 6 – Drive Train).

Brake Drum Inspection

1. Any time brake drums are removed for brake service, braking surface diameter should be checked with a suitable micrometer at several points to determine if they are within the safe oversize limit cast into the brake drum outer surface. If braking surface diameter exceeds specifications, the drum must be replaced. If braking surface diameter is within specifications, drums should be cleaned and inspected for cracks, scores, deep grooves, taper, out of round and head spotting. If drums are cracked or heat spotted, they must be replaced.

2. Remove minor scores with sandpaper. Grooves and large scores can only be removed by machining with special equipment, as long as the braking surface is within specifications, stamped on brake drum outer surface. Any brake drum sufficiently out of round to cause vehicle vibration or noise while braking, or showing taper should also be machined, removing only enough stock to true up the brake drum.

3. After a brake drum is machined, wipe braking surface diameter with a cloth soaked in denatured alcohol. If one brake drum is machined, the other should also be machine to the same diameter to maintain equal braking forces.

Brake Lining and Spring Inspection

1. Inspect brake linings for excessive wear, damage, oil, grease, or brake fluid contamination. If any of these conditions exist, brake linings should be replaced. Do not attempt to replace only one set of brake shoes; they should be replaced as an axle set only to maintain equal braking forces.

2. Examine brake shoe webbing, hold–down springs and return springs for for signs of overheating, indicated by a slight blue color. If any component exhibits signs of overheating, replace hold–down and return springs with new ones. Overheated springs lose their pull and could cause brake linings to wear out prematurely. Inspect all springs for sags, bends and external damage and replace as necessary.

3. Inspect hold down retainers and pins for bends, rust and corrosion. If any of these conditions exist, replace retainers and pins.

Backing Plate Inspection

1. Inspect backing plate shoe contact surface for grooves that may restrict shoe movement and cannot be removed by lightly sanding with emery cloth or other suitable abrasive. If backing plate exhibits above condition, it should be replaced. Also inspect for signs of cracks, warpage and excessive rust, indicating need for replacement.

Adjuster Mechanism Inspection

1. Inspect all components for rust, corrosion, bends and fatigue. Replace as necessary.

Parking Brake Cable Inspection

1. Inspect parking brake cable end for kinks, fraying, sticking and elongation and replace as necessary.

Removal

1. Remove upper spring (Item 1), then the adjuster spring (Item 2) and lower spring (Item 3). Remove hold–down washers (Item 4) and hold–down springs (Item 5), then remove brake shoe assemblies (Item 7–8, 9) and adjuster assembly (Item 10).

2. Loosen set screw on parking brake control lever knob (Fig. 14). Turn knob on parking brake lever counterclockwise all the way to loosen cable adjustment.

3. Disengage parking brake cable from parking brake lever (Fig. 10, Item 11).

Installation

1. Clean backing plate (Item 13), then lubricate backing plate shoe contact areas.

2. Apply a light coat of long life grease to threaded areas of adjuster (Item 10).

3. Position brake shoes on backing plate and secure with hold down pins (Item 6), springs (Item 5) and washers (Item 4).

4. Rear brakes only: Attach parking brake cable to parking brake lever (Item 11). After installing cable to each rear brake, check to make sure bottoms of brake shoes are seated in grooves at bottom of backing plate.

5. Install lower spring (Item 3).

6. Install adjuster assembly (Item 10) in slots on brake shoes, then the adjuster lever (Item 10) on adjuster lever pin. Install adjuster spring (Item 2).

7. Install upper spring (Item 1).

8. Install brake drum. NOTE: Make sure access hole in rear brake drums align with hole in stub axle flange.

9. Adjust brake shoes: Align access hole in brake drum with star wheel on adjuster assembly, then rotate adjusting screw to increase adjuster length until brake shoes contact brake drum, then back off star wheel until drum rotates freely.

10. Install wheel and secure with lug nuts. Tighten lug nuts in a crossing pattern to a torque of 45 – 55 ft–lb (61 – 75 Nm).

11. After servicing brakes, start the engine and depress brake pedal several times while vehicle is moving in reverse. Adjust parking brake (see Parking Brake Adjustment).

Brake Cylinder Service

Disassembly

1. Disassemble brakes as described in Brake Service.

2. Disconnect brake line from brake cylinder. Put a cap on brake line to prevent contamination of system and brake fluid leakage.

3. Remove two (2) capscrews and lockwashers securing brake cylinder to backing plate (Fig. 12). Remove brake cylinder assembly.

4. Remove dust covers (Fig. 11, Item 1), pistons (Item 2), seals (Item 3) and spring (Item 4). Discard dust covers and seals.

Inspection

1. Clean all metal parts with isopropyl alcohol, then clean out and dry grooves and passageways with compressed air. Make sure cylinder bore and component pieces are thoroughly clean.

2. Check cylinder bore and pistons and spring for damage or excessive wear. Replace brake cylinder assembly if signs of pitting, scoring or cracks are evident.

Assembly

1. Apply a film of clean brake fluid to new piston seals (Item 3), then install onto pistons (Item 2).

2. Apply a film of clean brake fluid to cylinder bore and piston assemblies. Carefully install one piston, the spring (Item 4), then the other piston.

3. Install new dust covers (Item 1).

4. Install brake cylinder assembly to backing plate with two (2) capscrews and lockwashers.

5. Connect brake line to brake cylinder.

6. Reassemble brakes as described in Brake Service.

7. Bleed brakes.

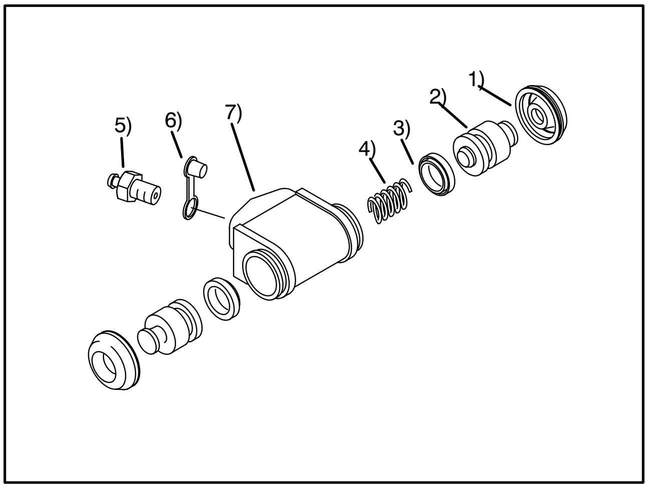


Figure 10

1. Dust cover
2. Piston
3. Seal
4. Spring
5. Bleed screw
6. Bleed screw cap
7. Body

Bleeding the Brakes

1. Connect a suitable transparent hose to bleeder valve on right rear wheel cylinder and submerge other end in a glass container partially filled with clean brake fluid.

2. Have a helper pump brake pedal several times, then hold pedal down firmly.

3. With pedal firmly depressed, open bleeder valve of right rear brake until pedal fades to floor, then close bleeder valve.

4. Repeat procedure until a continuous flow of brake fluid, with no air bubbles, is released from bleeder valve. **Make sure fluid level is maintained in brake fluid reservoir at all times**.

5. Do steps 1 – 4 for left rear, right front and left front brakes.

6. After bleeding of brakes is completed, road test vehicle to make sure brakes are operating correctly and pedal is solid.

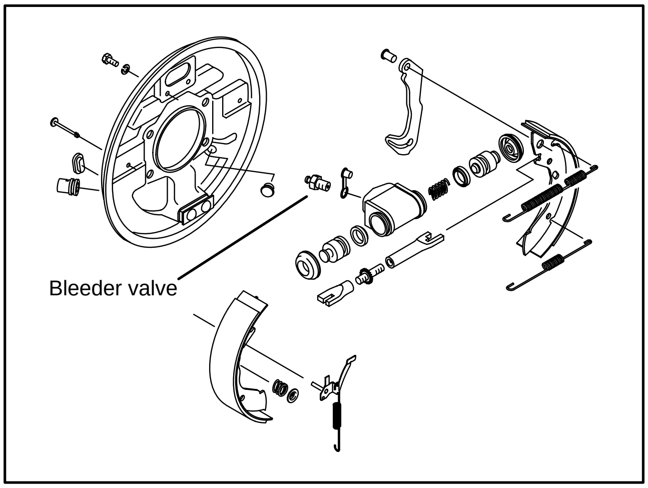


Figure 11

Master Brake Cylinder Service

Note: Unlike older versions (Fig. 12) of the master cylinder, newer versions (Fig. 13) have the reservoir attached to the cylinder.

Disassembly

1. Remove pipe adapter (Item 1), if installed, and adapter or flange seal (Item 2). Push in on the push rod so the stop pin (Item 3) can can be removed.

2. Disconnect lower end of the dust cover (Item 6) from the housing.

3. Push in on the push rod and remove circlip (Item 8), then remove push rod with dust cover and clevis.

4. Remove primary piston assembly (Item 10) and secondary piston assembly (Item 11).

Inspection

1. Clean all metal parts with isopropyl alcohol, then clean out and dry grooves and passageways with compressed air. Make sure cylinder bore and component pieces are thoroughly clean.

2. Check cylinder bore and pistons and springs for damage or excessive wear. Replace brake cylinder assembly if signs of pitting, scoring or cracks are evident.

Assembly

1. Apply a film of clean brake fluid to cylinder bore and piston assemblies.

2. Install secondary piston assembly (Item 10) and primary piston assembly (Item 11).

3. Install retainer washer (Item 9).

4. Install push rod (Item 7) and secure in place with circlip (Item 8). Install lower end of dust cover (Item 6) to housing.

5. Push in on push rod so stop pin can can be installed to retain secondary piston assembly, then install adapter or flange seal (Item 2) and pipe adapter (Item 1) if installed.

6. Adjust brake pedal and bleed brakes after installing in machine.

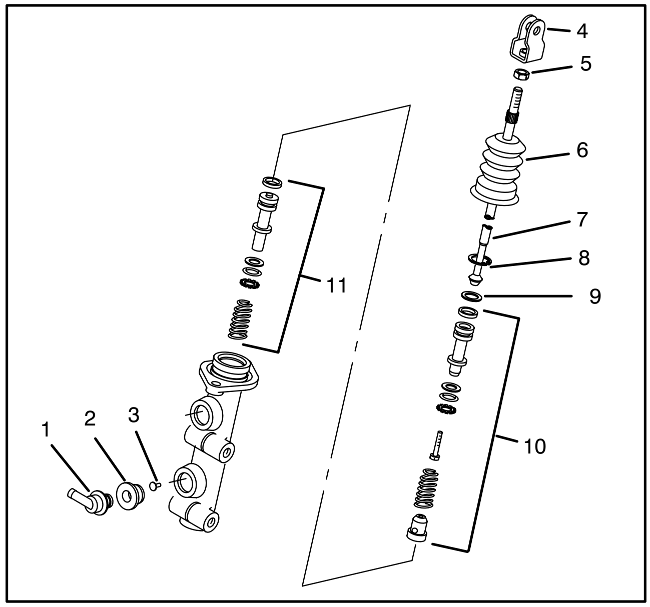


Figure 12

1. Pipe adapter
2. Adapter
3. Stop pin
4. Clevis
5. Nut
6. Dust cover
7. Push rod
8. Circlip
9. Retainer washer
10. Primary piston assembly
11. Secondary piston assembly

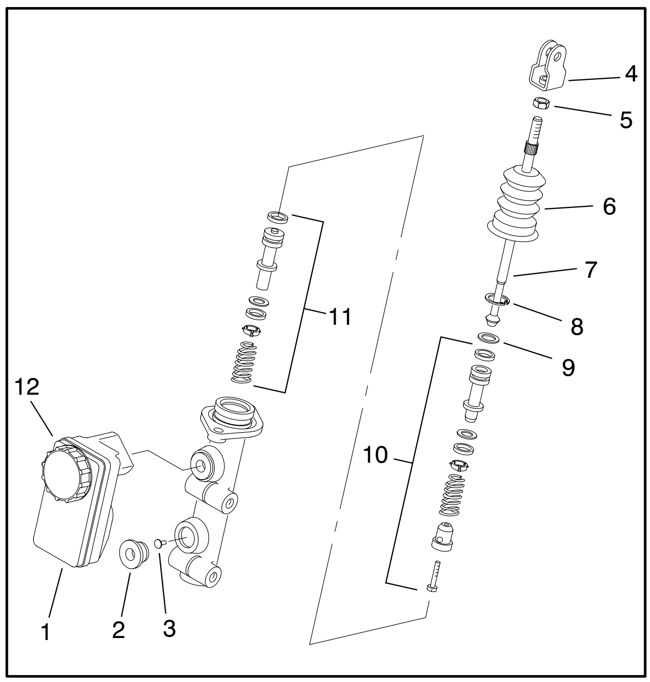


Figure 13

1. Master cylinder reservoir
2. Flange seal
3. Stop pin
4. Clevis
5. Nut
6. Dust cover
7. Push rod
8. Circlip
9. Retainer washer
10. Primary piston assy.
11. Secondary piston assy.
12. Cap assembly

Parking Brake Cable Replacement

1. Loosen set screw on parking brake control lever knob (Fig. 14). Turn knob on parking brake lever counter-clockwise all the way to loosen cable adjustment.

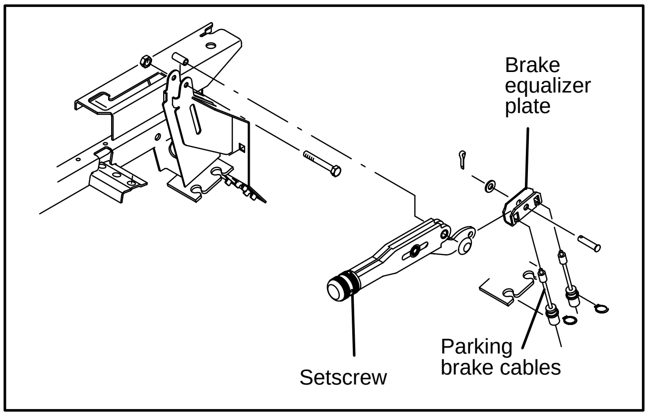


Figure 14

2. Remove knobs from transmission shifter and other control levers, then remove center console plate assembly. Remove seats and skirt assembly to get access to parking brake cables (Fig. 15):

A. Remove seats.

B. Remove lower bolts on seat frame bracket.

C. Loosen lower front bracket support bolts.

D. Disconnect radiator overflow tank hose at radiator and plug the hose.

E. Fully rotate the seat back assembly forward.

F. Remove skirt assembly.

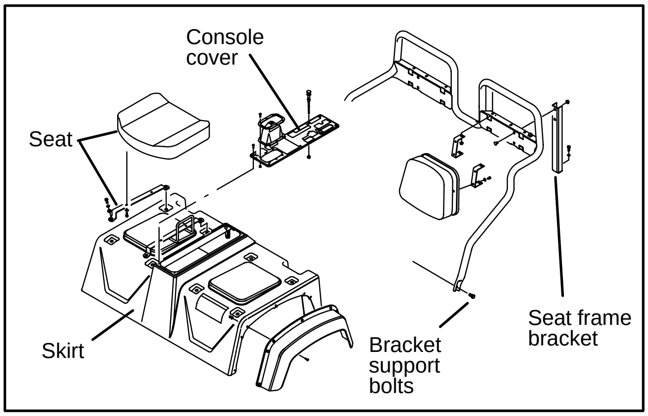


Figure 15

3. Jack up and support rear of machine, then remove both rear wheels and brake drums.

4. Remove clip that holds each brake cable into brake backing plate (Fig. 16).

5. Remove cable end from parking brake lever (Fig. 16).

6. Remove brake equalizer plate from parking brake control lever (Fig. 14).

7. Note routing of cables and cable ties before removing cables.

8. Connect each cable to brake by inserting into parking brake lever and install brake cable clip (Fig. 16).

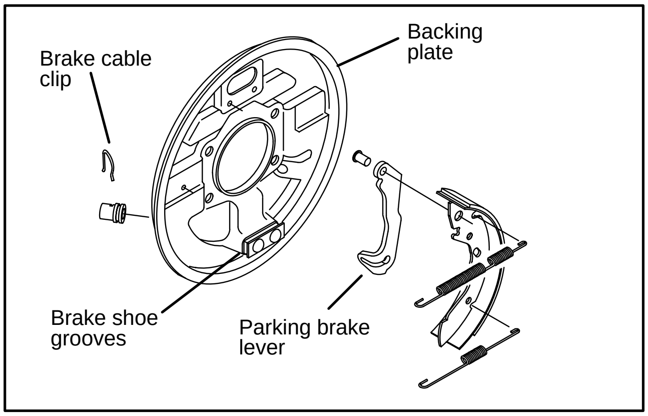


Figure 16

9. Install new cables at brake equalizer. Route cables in same location as before and secure with cable ties. Start from rear of machine and work towards front.

10. After installing cable to each rear brake, check to make sure bottoms of brake shoes are seated in grooves at bottom of backing plate.

11. Adjust parking brake control lever and check operation of brakes before using the machine.

Steering Wheel Installation

1. Slide foam seal, steering wheel and washer onto steering shaft.

2. Secure steering wheel to shaft with jam nut and tighten to a torque of 10 – 15 ft–lb (13 – 20 Nm).

3. Install cap to steering wheel.

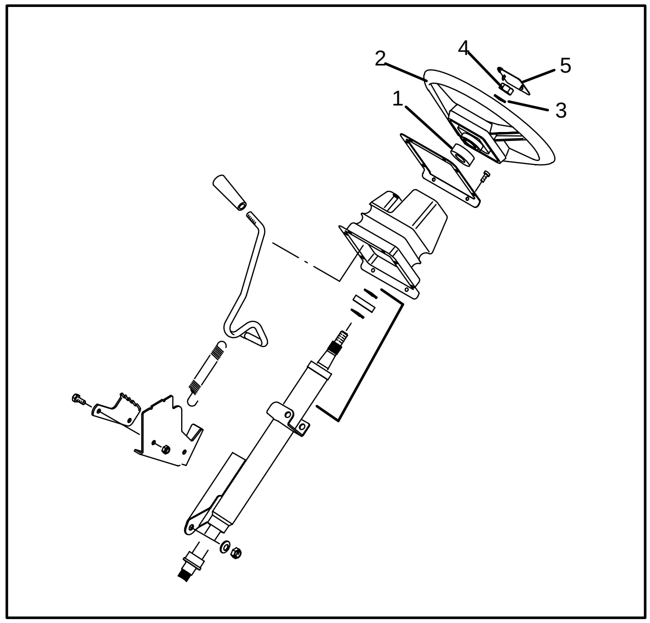


Figure 17

1. Foam seal **3. Washer** **5. Cap**
2. Steering wheel **4. Jam nut**

Steering Linkage Service

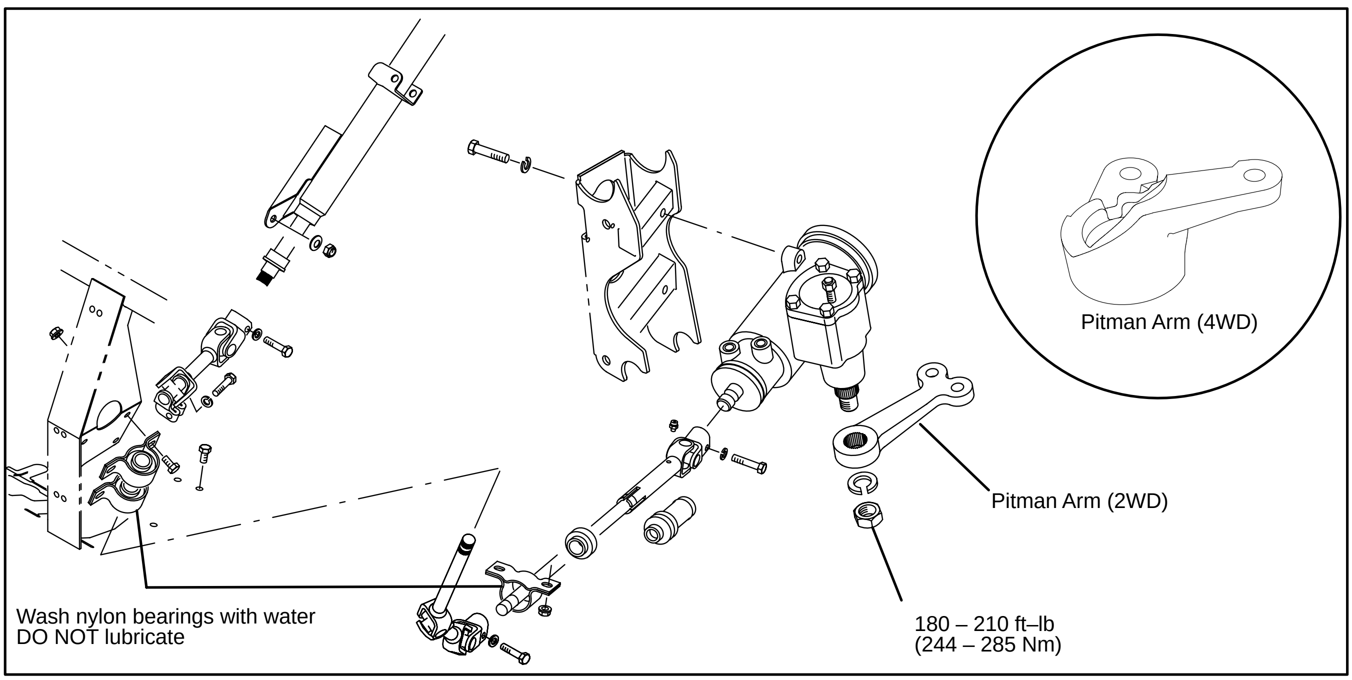


Figure 18

Note: Do not attempt to disassemble U–joints. U–joint parts are not replaceable.

Note: The pitman arm has a splined and tapered joint. Use a puller when removing.

1. Disassemble and reassemble as shown in illustration.

Front Shock Absorber Replacement

1. Remove lower and upper locknuts, then remove shock absorber and washers.

2. Insert two (2) new rubber bushings (Item 1) into each end of new shock absorber. Insert spacer (Item 2) into ram (lower) end of shock absorber.

3. Install large washer (Item 3) onto stud above control arm.

4. Install new shock absorber (Item 4) with ram end down and secure upper end with small flat washer (Item 5) and locknut (Item 6).

5. Insert capscrew (Item 7) down through angled hole in shock stand. Install washer (Item 8) onto capscrew and slide shock absorber onto capscrew. Install second washer (Item 9) onto capscrew and secure with locknut (Item 10).

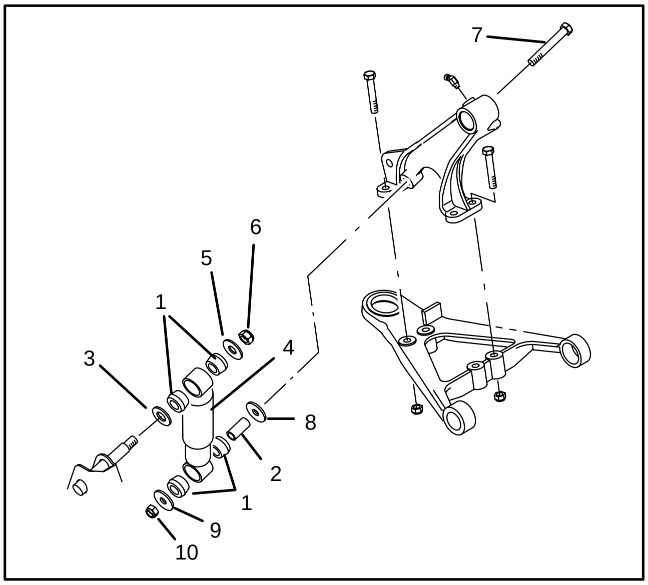


Figure 19

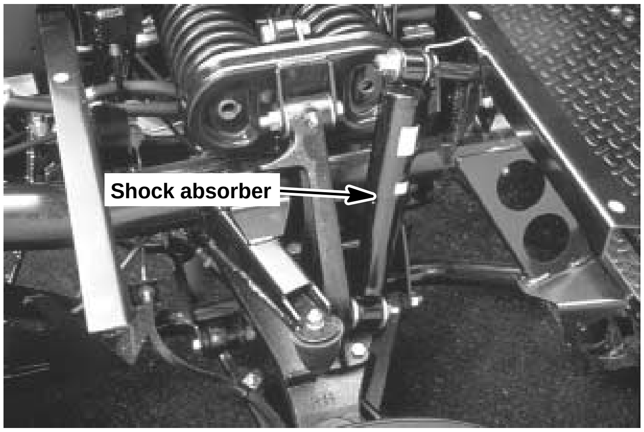


Figure 20

Steering, Brakes & Suspension

Rear Shock Absorber Replacement

1. Remove lower and upper locknuts, then remove shock absorber and washers.

2. Insert two (2) new rubber bushings (Item 1) into each end of new shock absorber.

3. Install one large washer (Item 2) onto each shock absorber mounting stud.

4. Install new shock absorber (Item 3) with ram end down and secure each end with with a large washer (Item 4) and locknut (Item 5).

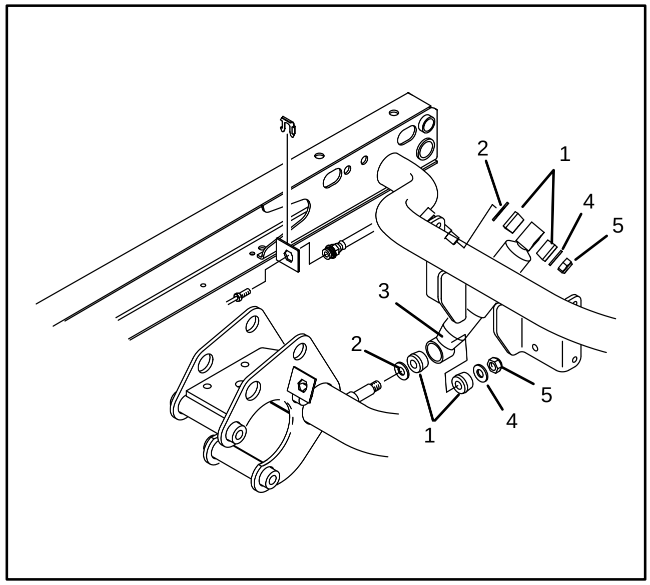


Figure 21

1. Rubber bushing
2. Large washer
3. Shock absorber
4. Large washer
5. Locknut

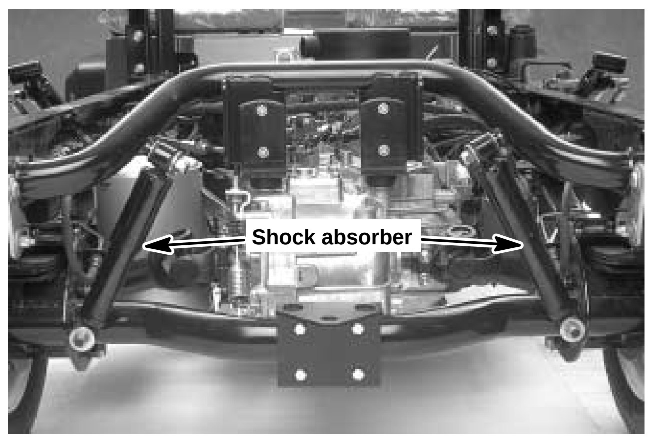


Figure 22

Ball Joint Replacement

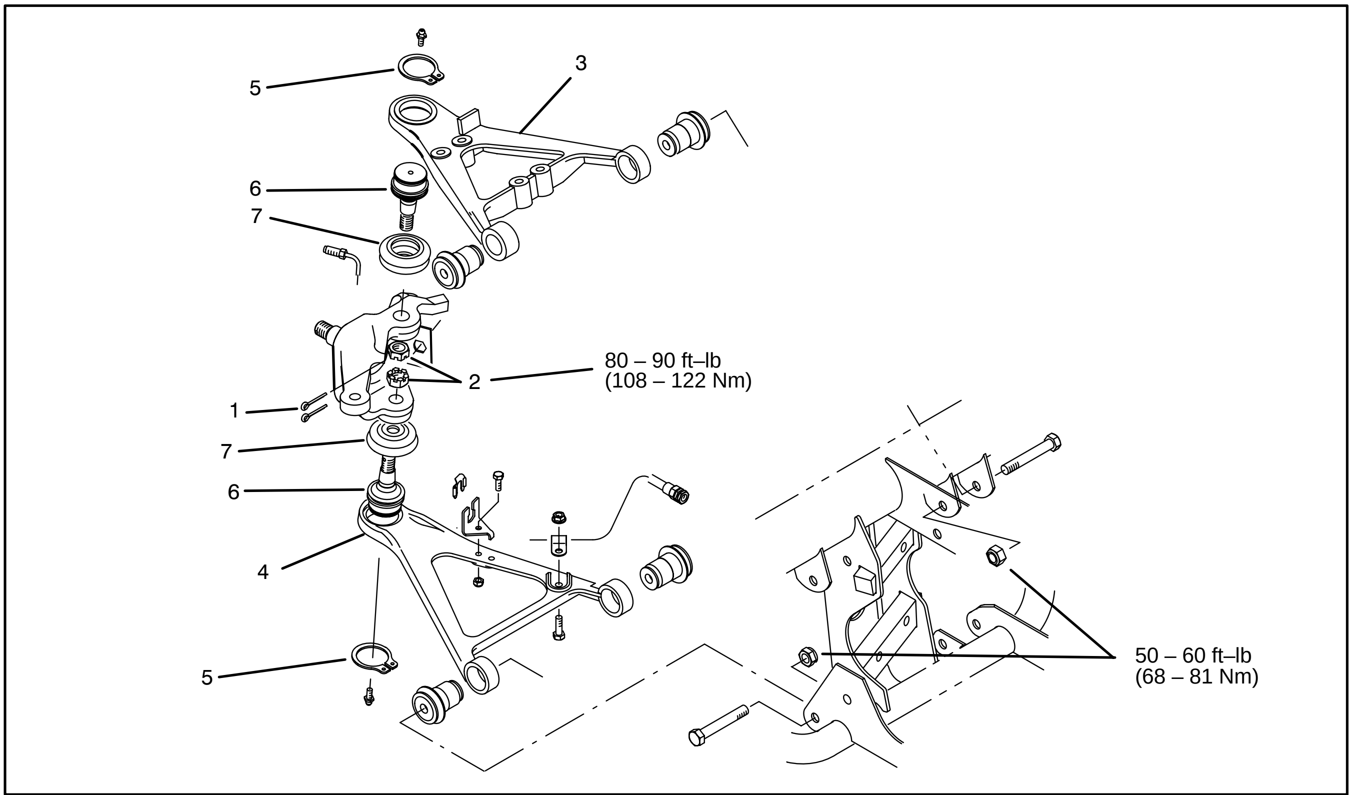


Figure 23

1. Cotter pin
2. Slotted nut
3. Upper control arm
4. Lower control arm
5. Snap ring
6. Ball joint
7. Boot

Removal

WARNING

FRONT SUSPENSION IS SPRING LOADED! To prevent possible personal injury, use special tool to remove compression springs before disassembling the front suspension.

1. If servicing upper ball joint or control arm, remove front compression springs (see Front Compression Spring Removal and Installation). NOTE: Compression springs do not need to be removed if servicing only the lower ball joint or lower control arm.

2. Remove cotter pin (Item 1) from affected ball joint, then remove slotted nut (Item 2). Press ball joint (Item 6) out of spindle.

3. Remove control arm (Item 3 or 4).

4. Remove snap ring (Item 5). Press ball joint (Item 6) out of control arm.

Installation

1. Press new ball joint (Item 6) into control arm. Install snap ring (Item 5) to secure ball joint.

2. Install grease fitting into ball joint. Install boot (Item 7) over shaft on ball joint. Edge of boot must be inserted into ball joint slot.

3. Install control arm (Item 3 or 4). Tighten control arm fasteners to 50 – 60 ft–lb (68 – 81 Nm). Make sure frame tabs collapse against rubber bushings when control arm fasteners are tightened.

4. Secure ball joint to spindle with slotted nut (Item 2). Tighten slotted nut to a torque of 80 – 90 ft–lb (108 – 122 Nm) and secure with cotter pin (Item 1).

5. Install front compression springs.

6. Grease ball joint.

Tie Rod End Replacement

Removal

1. Loosen jam nut (Item 1)

2. Remove cotter pin (Item 2) from affected rod end. Remove slotted nut (Item 3).

3. Use a suitable puller to disconnect rod end (Item 4) from spindle or steering arm.

4. When removing rod end (Item 4) from tie rod (Item 5), count the number of revolutions it takes to remove so new tie rod end can be installed without changing the toe–in adjustment.

Installation

1. Install new rod end (Item 4) to tie rod. Thread in the same number of revolutions as the old one took to remove.

2. Insert rod end shaft to spindle or steering arm and secure with slotted nut. Tighten slotted nut to a torque of 45 – 55 ft–lb (61 – 75 Nm) and secure with cotter pin.

3. Tighten jam nut (Item 1).

4. Install grease fitting into rod end.

5. Check toe–in adjustment.

6. Grease tie rod end.

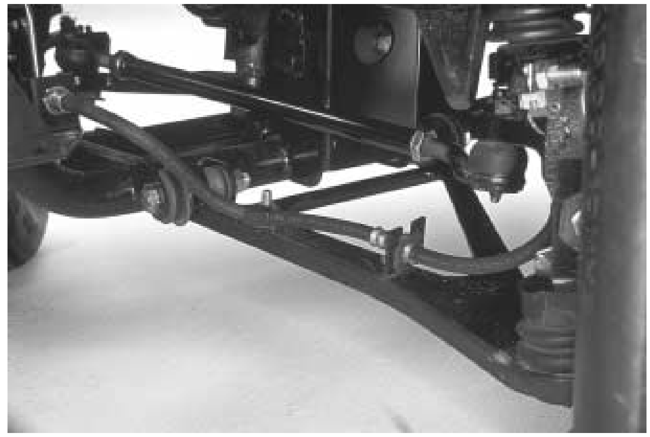


Figure 24

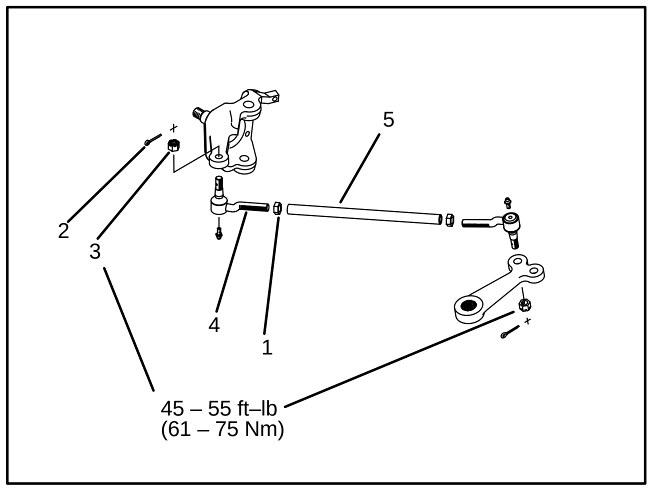


Figure 25

1. Jam nut
2. Cotter pin
3. Slotted nut
4. Rod end
5. Tie rod

Front Compression Spring Removal and Installation

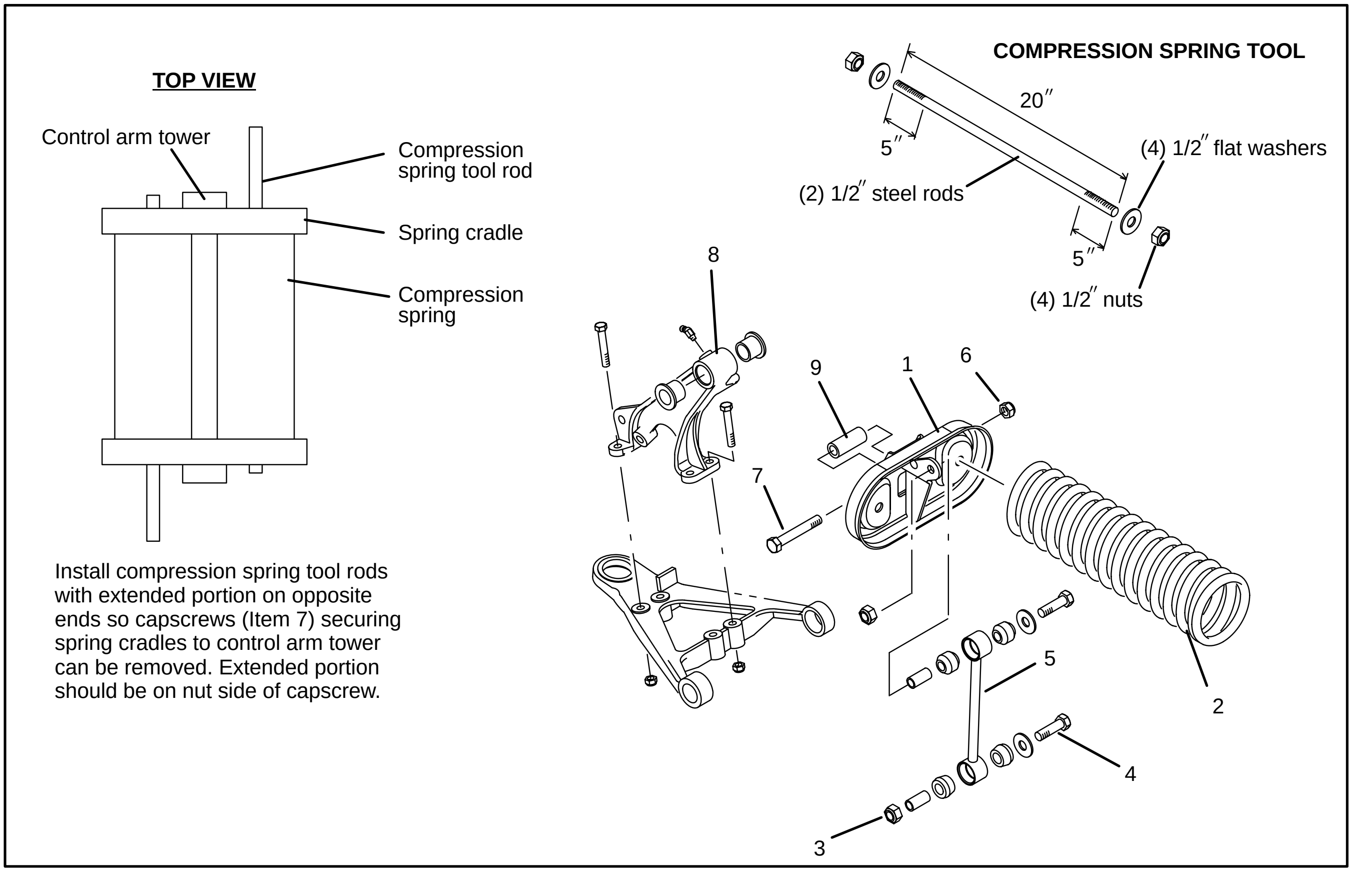


Figure 26

1. Spring cradle	**4. Capscrew**	**7. Capscrew**
2. Spring	**5. Stabilizer link**	**8. Control arm tower**
3. Locknut	**6. Locknut**	**9. Spring pivot sleeve**

1. Remove skirt assembly to get access to front suspension assembly (see step 2 under Parking Brake Cable Replacement).

2. Jack up front of machine and secure with jack stands. Remove front wheels.

3. Remove front shock absorbers.

> **WARNING**
>
> **FRONT SUSPENSION IS SPRING LOADED! To prevent possible personal injury, use special tool to remove compression springs before disassembling the front suspension.**

4. Install a compression spring tool rod through holes in each spring cradle (Fig. 30, Item 1), then install nuts and washers on both ends of each rod. Tighten one nut on each rod to secure springs (Item 2). NOTE: Extended portion of each compression spring tool must be on opposite ends so capscrews (Item 7) can be removed.

5. Remove locknut (Item 3) and capscrew (Item 4) from lower end of each stabilizer link (Item 5).

6. Remove locknut (Item 6) and capscrew (Item 7) securing each spring cradle to control arm towers (Item 8), then remove springs and cradles along with the stabilizer links.

7. Reverse this procedure to install springs.

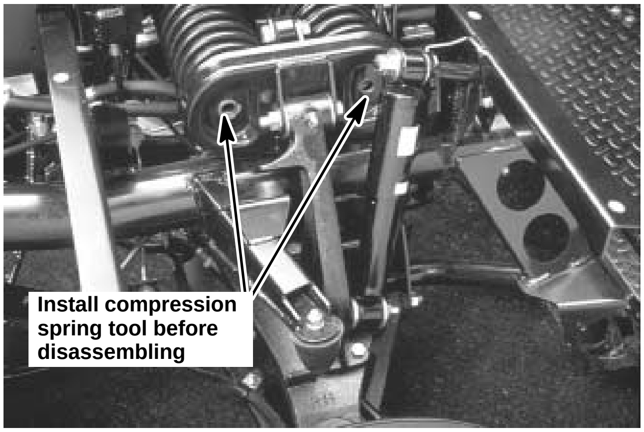


Figure 27

Rear Leaf Spring Replacement

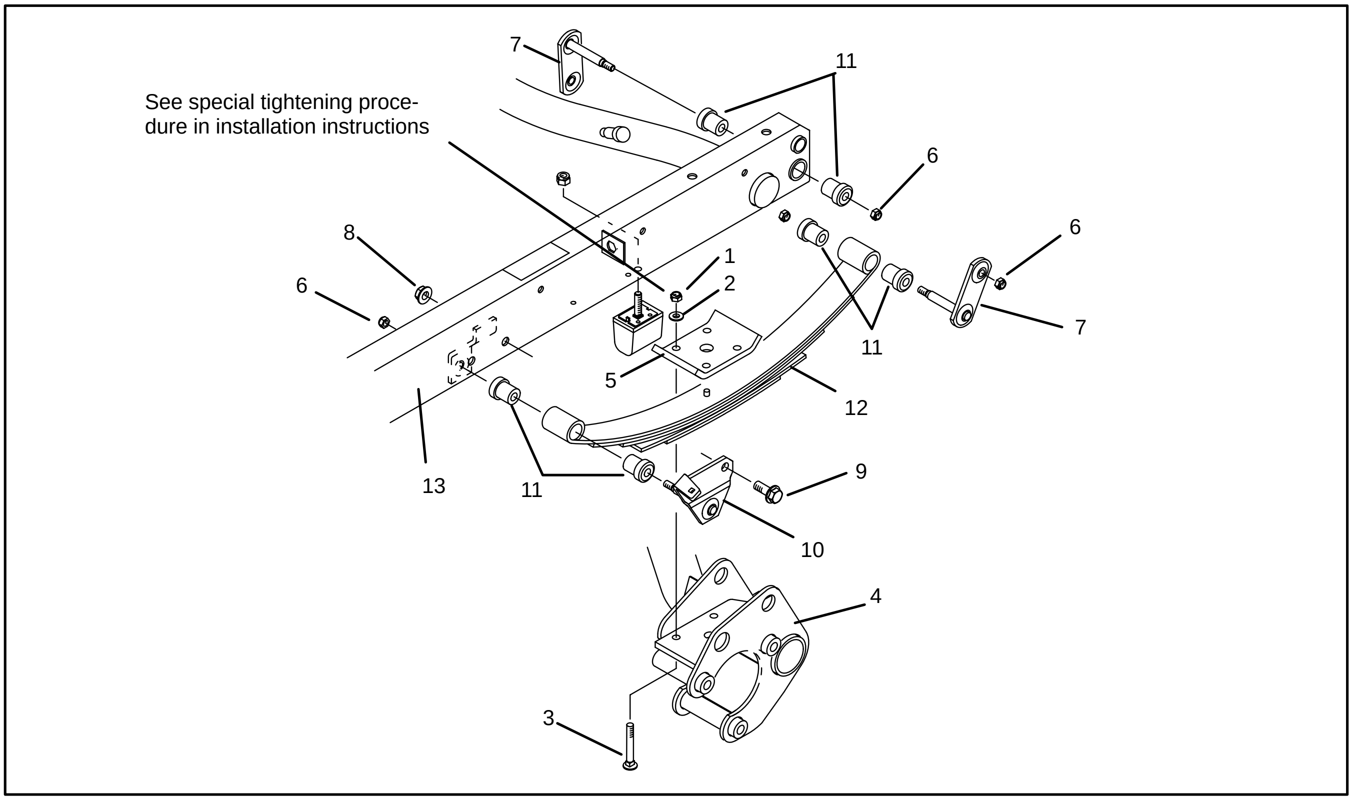


Figure 28

1. Locknut
2. Washer
3. Carriage bolt
4. Rear axle
5. Clamp plate
6. Locknut
7. Spring shackle
8. Flange head locknut
9. Flange head capscrew
10. Spring mount
11. Rubber bushing
12. Leaf spring
13. Frame rail

IMPORTANT: For proper vehicle performance, always replace the springs on both sides of the vehicle.

Removal

1. Jack up and support rear of vehicle. Remove rear wheel(s).

2. Support frame side rails (Item 13) so rear axle (Item 4) can be removed.

3. Support rear axle (Item 4), then remove four (4) locknuts (Item 1) and washers (Item 3) securing rear axle (Item 4) to leaf spring (Item 12).

4. Remove two (2) locknuts (Item 6) from spring shackles (Item 7). Remove spring shackles (Item 7). Remove two (2) flange head locknuts (Item 8) and flange head capscrews (Item 9) securing spring mount (Item 10) to frame rail, then remove leaf spring assembly.

Installation

1. Before installing new leaf spring, insert four (4) rubber bushings (Item 11) into leaf spring. Insert two (2) rubber bushings into frame side rail.

2. Insert one (1) spring shackle (Item 11), from outside/in, into rear of leaf spring. Insert spring mount (Item 10), from outside/in, to front of leaf spring and secure, finger tight, with locknut. **NOTE:** Clip is on front end of spring.

3. Install leaf spring assembly to frame. Secure front spring mount (Item 10) with flange head capscrews (Item 9 and locknuts (Item 8) and tighten finger tight. Install locknuts (Item 6) to spring shackles (Item 7) and tighten finger tight. Tighten locknuts (Item 6). Leave flange locknuts (Item 8), securing spring mount to frame rail, finger tight.

4. Install plate (Item 5) to top of spring, then secure axle to spring with carriage bolts (Item 3), washers (Item 2) and locknuts (Item 1). **NOTE:** Make sure axle (Item 4) and plate (Item 5) are centered on leaf spring knob.

5. Tighten nuts (Item 1) in a crossing pattern until clamp plate, leaf spring and axle contact. Tighten flange locknuts (Item 8) securing spring mount to frame rail. Tighten nuts (Item 1) securing axle and clamp plate to leaf spring using a crossing pattern and the following torque values:

   A. Tighten nuts to 20 – 30 ft–lb (27 – 41 Nm) in a crossing pattern.

   B. Tighten nuts to 50 – 60 ft–lb (68 – 81 Nm) in a crossing pattern.

   C. Retighten nuts to 50 – 60 ft–lb (68 – 81 Nm).

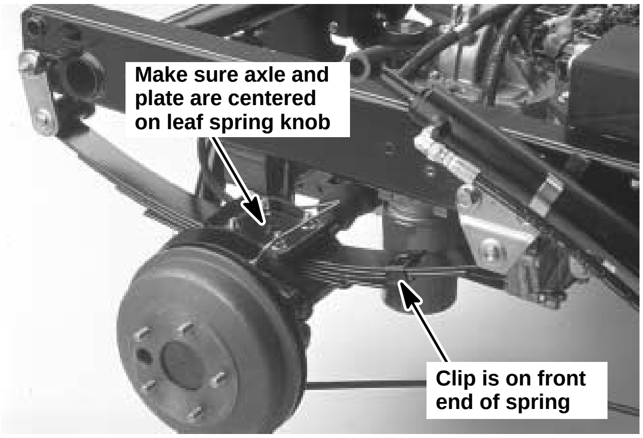


Figure 29

Steering, Brakes & Suspension

Steering Gear Service

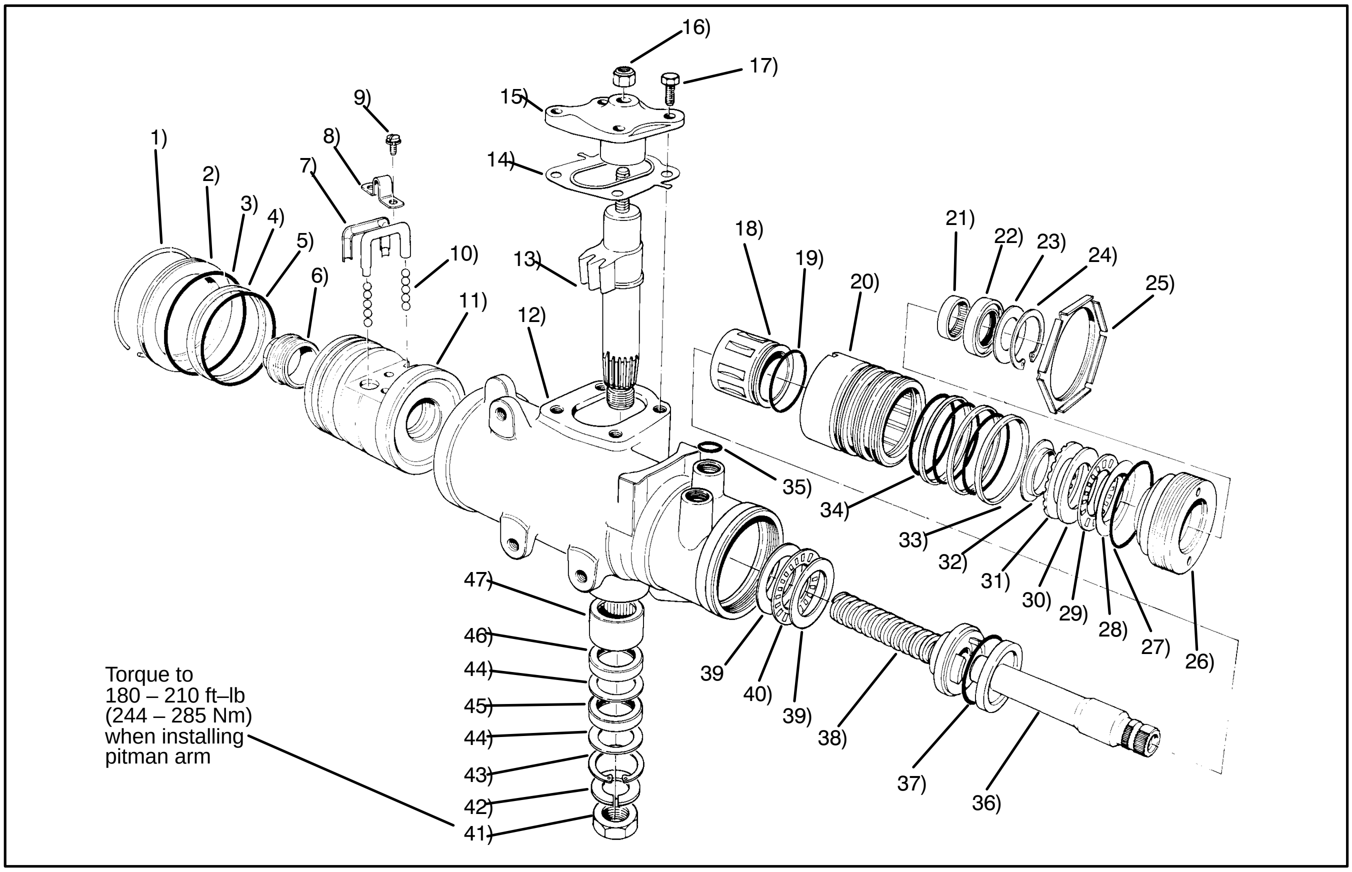


Figure 30

1. Retaining ring
2. Housing end plug
3. Housing end plug seal
4. Rack piston seal
5. Rack piston o–ring
6. Rack piston end plug
7. Guide ball return
8. Ball return guide clamp
9. Screw/lockwasher ass'y
10. Chrome alloy ball
11. Rack piston
12. Steering gear housing
13. Pitman shaft
14. Side Cover seal
15. Housing side cover
16. Lash adjuster nut
17. Flange hex bolt
18. Spool valve
19. Spool valve o–ring
20. Valve body
21. Needle bearing
22. Stub shaft seal
23. Stub shaft dust seal
24. Retaining ring
25. Adjuster plug lock nut
26. Adjuster plug
27. O–ring
28. Upper bearing race
29. Thrust roller bearing
30. Thrust bearing race
31. Thrust bearing spacer
32. Bearing retainer
33. Valve body ring
34. O–ring
35. O–ring
36. Stub shaft
37. O–ring
38. Steering worm
39. Thrust bearing race
40. Thrust roller bearing
41. Pitman arm nut
42. Lockwasher
43. Retaining ring
44. Seal backup washer
45. Pitman shaft seal
46. Pitman shaft seal

The power steering gear has a recirculating ball system which acts as a rolling thread between the worm shaft and the rack piston. The worm shaft is supported by a thrust bearing preload and two conical thrust races at the lower end, and a bearing assembly in the adjuster plug at the upper end.

The control valve in the steering gear directs the power steering fluid to either side of the rack piston. The rack piston converts the hydraulic pressure into a mechanical force. If the steering system loses hydraulic pressure, the vehicle can be controlled manually.

Turning the worm shaft moves the rack piston up or down. The rack piston teeth mesh with the pitman shaft sector. Turning the worm shaft turns the pitman shaft, which turns the wheels through the steering linkage.

Disassembly

1. Pry retaining ring (Fig. 29, Item 1) out of housing groove with a screwdriver.

2. Turn stub shaft (Item 36) to the left until plug (Item 2) on opposite end is forced out of cylinder, then remove seal (Item 3).

3. Remove plug (Item 6) from rack piston (Fig. 30).

4. Remove nut (Fig. 29, Item 16), bolts (Item 17), side cover (Item 15) and gasket (Item 14), then turn adjuster screw right until side cover (Item 15) separates from pitman shaft (Item 13).

5. Remove pitman shaft, then turn stub shaft (Item 36) left until pitman shaft teeth and rack piston (Item 11) disengage.

6. Remove retaining ring (Item 43), washers (Item 44) and seals (Item 45, 46), then remove bearing (Item 47) (Fig. 31).

7. Remove rack piston and balls as follows:

A. Insert ball retainer tool into rack piston bore with pilot seated into end of worm (Fig. 30).

B. Hold tool against worm and turn stub shaft (Fig. 29, Item 36) to left. Rack piston (Item 11) will be forced onto the tool.

C. Hold tool and pull rack piston toward handle until it is against flange. This will prevent balls (Item 10) from falling out.

8. Remove adjuster nut (Fig. 29, Item 25) (Fig. 32).

9. Remove adjuster plug (Fig. 29, Item 26) using a spanner wrench (Fig. 33).

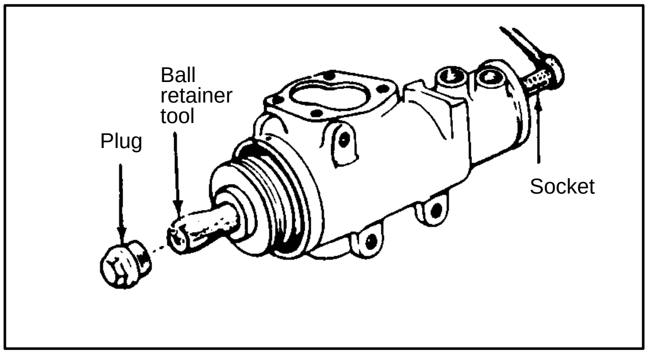


Figure 31

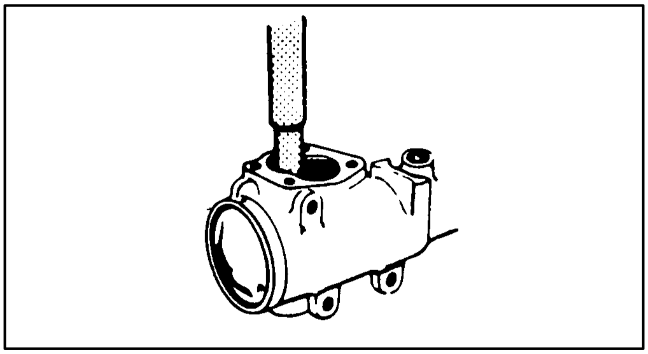


Figure 32

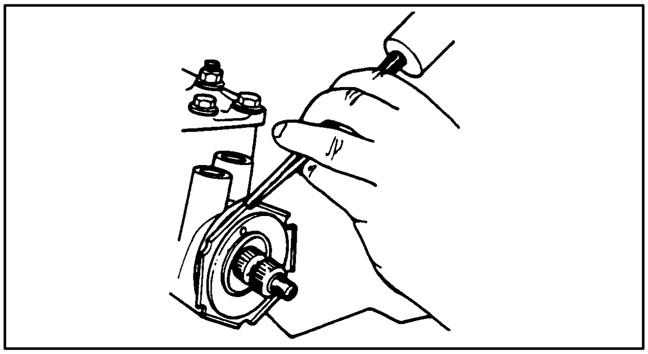


Figure 33

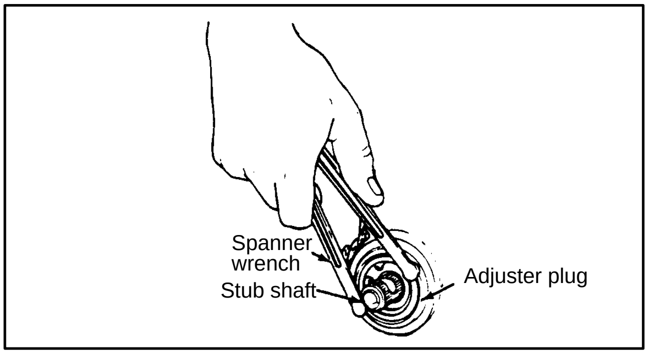


Figure 34

10. Disassemble adjuster plug as follows:

A. Remove retaining ring (Fig. 29, Item 24), washer (Item 23), seal (Item 22) and bearing (Item 21).

B. Remove bearing retainer (Item 32) by prying at raised area, then remove seal and needle bearing (Fig. 34).

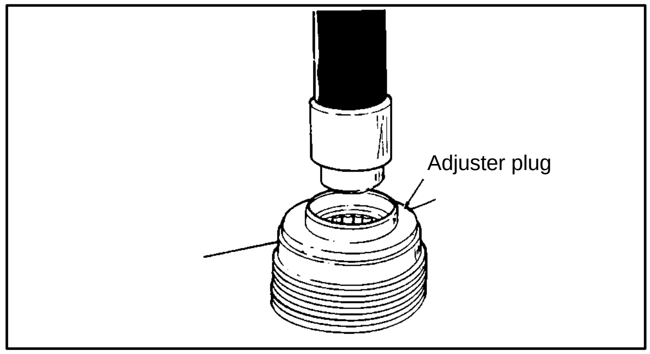


Figure 35

11. Remove valve and worm shaft as an assembly with both races and bearing. Separate as follows (Fig. 35):

A. Remove worm shaft (Fig. 29, Item 38) from valve body (Item 20).

B. Remove races (Fig. 29, Item 39) and bearing (Item 40) from worm shaft, then remove seal (Item 37).

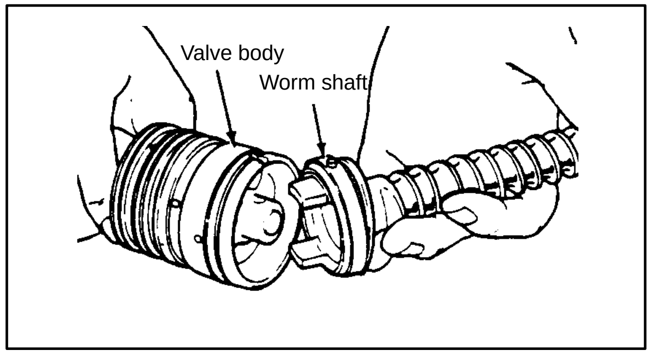


Figure 36

12. Remove stub shaft from valve body as follows:

A. Hold assembly and lightly tap stub shaft (Fig. 29, Item 36) against work bench until shaft cap is free from valve body (Fig. 36).

B. Pull shaft assembly until shaft cap clears valve body by approximately 1/4 in. (6 mm).

C. Remove valve spool (Fig. 29, Item 18) and seals (Item 19, 33, 34).

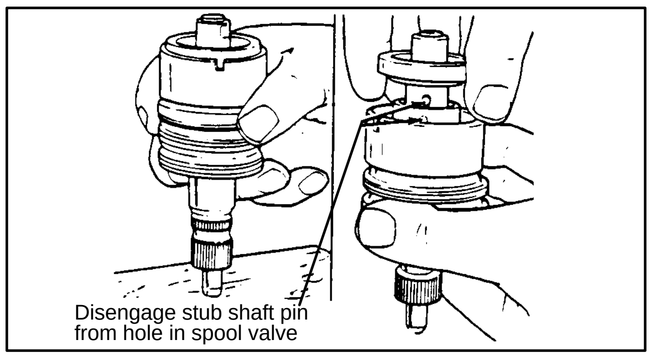


Figure 37

13. Remove screws (Fig. 29, Item 9), clamp (Item 8) and ball guide (Item 7) from rack piston, then remove balls (Item 10).

Assembly

1. Lubricate 11 balls (Fig. 37, Item 10) with hydraulic fluid, then install alternately by color into rack piston. Use ball retainer tool to hold balls inside (Fig. 30).

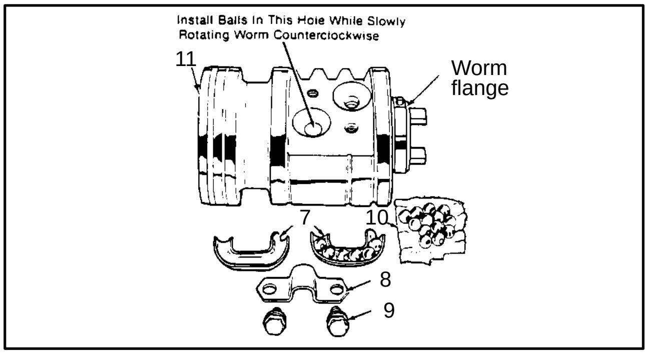


Figure 38

2. Install balls (Fig. 38, Item 7) in ball guide alternately by color. Retain balls in guide with petroleum jelly.

3. Connect ball guide (Fig. 37, Item 7), clamp (Item 8) and screws (Item 9) to rack piston (Item 11).

4. Lubricate stub shaft (Fig. 29, Item 36), valve spool (Item 18) and seals (Item 19, 34, 33) with hydraulic fluid, then install into valve body (Item 20).

5. Connect valve body (Item 20), seal, worm shaft (Item 38), races (Item 39) and roller bearing (Item 40).

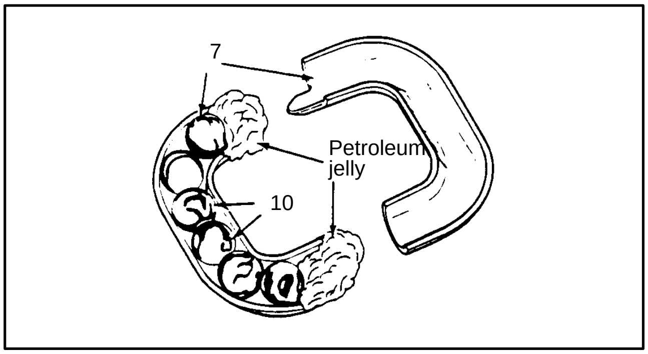


Figure 39

6. Install seal (Fig. 29, Item 27) on adjuster plug (Item 26). Install needle bearing (Item 21) in adjuster plug. (Fig. 39).

7. Install seal (Item 22), washer (Item 23) and retaining ring (Item 24) in adjuster plug. **Retainer projections must not extend beyond washer when retainer ring is seated. Washer must rotate freely.**

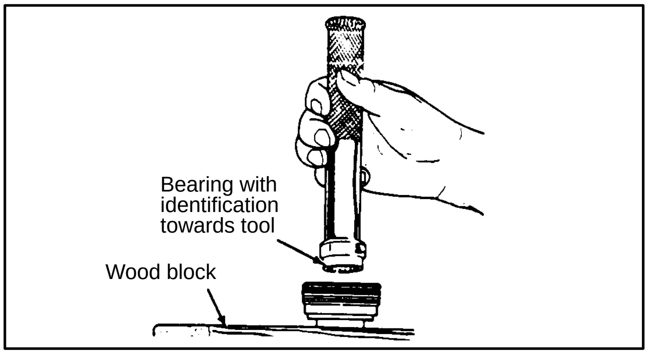


Figure 40

8. Install worm shaft and valve assembly into gear housing.

9. Install adjuster plug into gear housing using a spanner wrench (Fig. 40).

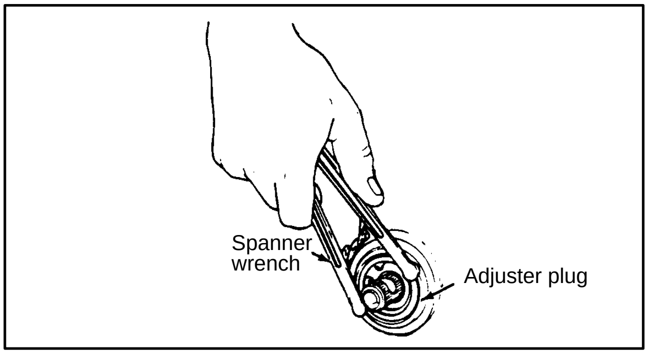


Figure 41

Worm Bearing Preload Adjustment

1. Loosen and remove adjuster plug nut (Fig. 29, Item 25) (Fig. 41).

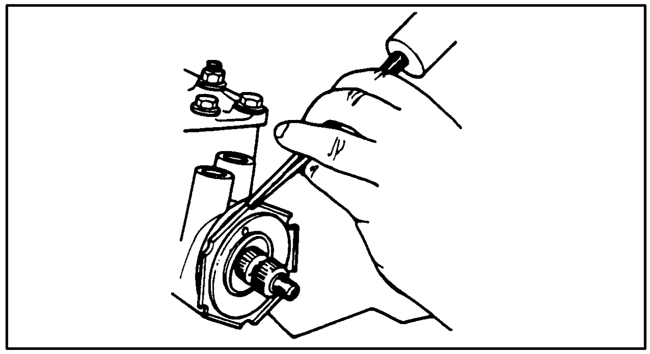


Figure 42

2. Turn adjuster plug (Fig. 29, Item 26) clockwise using a spanner wrench until plug and thrust bearing are firmly bottomed in housing (Fig. 42).

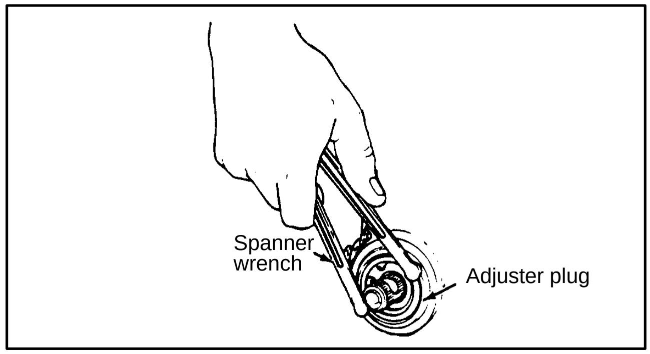


Figure 43

3. Scribe an index mark on the housing even with a hole on adjuster plug.

4. Measure back 3/16 – 1/4 in. (5 – 6 mm) from first index mark and scribe a second index mark (Fig. 43).

5. Rotate adjuster plug counterclockwise until hole is aligned with second index mark.

6. Install adjuster plug nut (Fig. 29, Item 25).

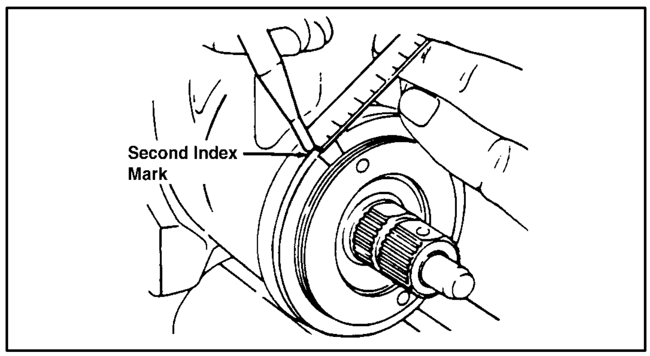


Figure 44

7. Using an inch–pound torque wrench and 12 point deep socket, measure torque required to turn stub shaft. Take reading with handle of torque wrench near vertical position (Fig. 44). Turn stub shaft to right stop, then back 1/4 turn at an even rate. Record torque reading. Torque reading should be 4 – 10 in–lb (5 – 12 kgcm^2). If not, adjuster plug may not be tightened properly or may have turned during adjuster plug nut installation. Thrust bearings and races may also be damaged.

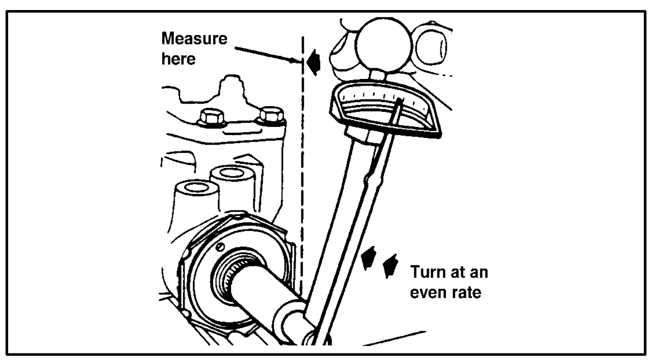


Figure 45

Over Center Preload Adjustment

1. Turn pitman shaft adjuster screw counterclockwise until fully extended, then reverse 1/2 turn clockwise.

2. Rotate stub shaft from stop to stop and count number of turns.

3. Starting at either stop, turn stub shaft halfway back. When gear is centered, flat on stub shaft will face upward and be parallel with side cover (Fig. 45).

4. Put torque wrench on stub shaft and rotate 45° each side of center. Record highest drag torque measured on or near center.

5. Adjust over–center drag torque by loosening adjuster screw jam nut and turning pitman shaft adjuster screw clockwise until correct drag torque is obtained.

6. On new steering gears, add 6 – 10 in–lb (7 – 12 $kgcm^2$) torque to previously measured worm bearing preload torque. Do not exceed a total steering gear preload of 18 in–lb (21 $kgcm^2$).

7. On used steering gears, add 4 – 5 in–lb (5 – 6 $kgcm^2$) torque to previously measured worm bearing preload torque. Do not exceed a total steering gear preload of 14 in–lb (16 $kgcm^2$).

8. Install and tighten adjuster screw jam nut.

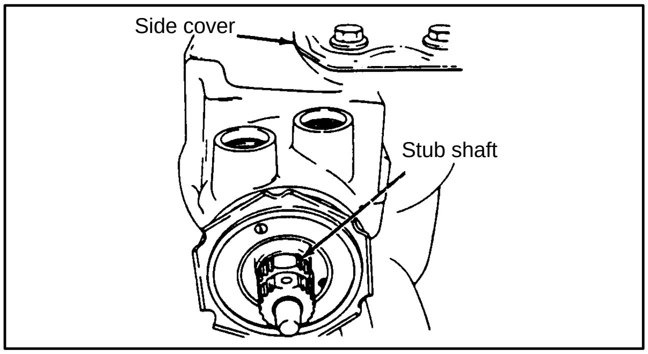


Figure 46

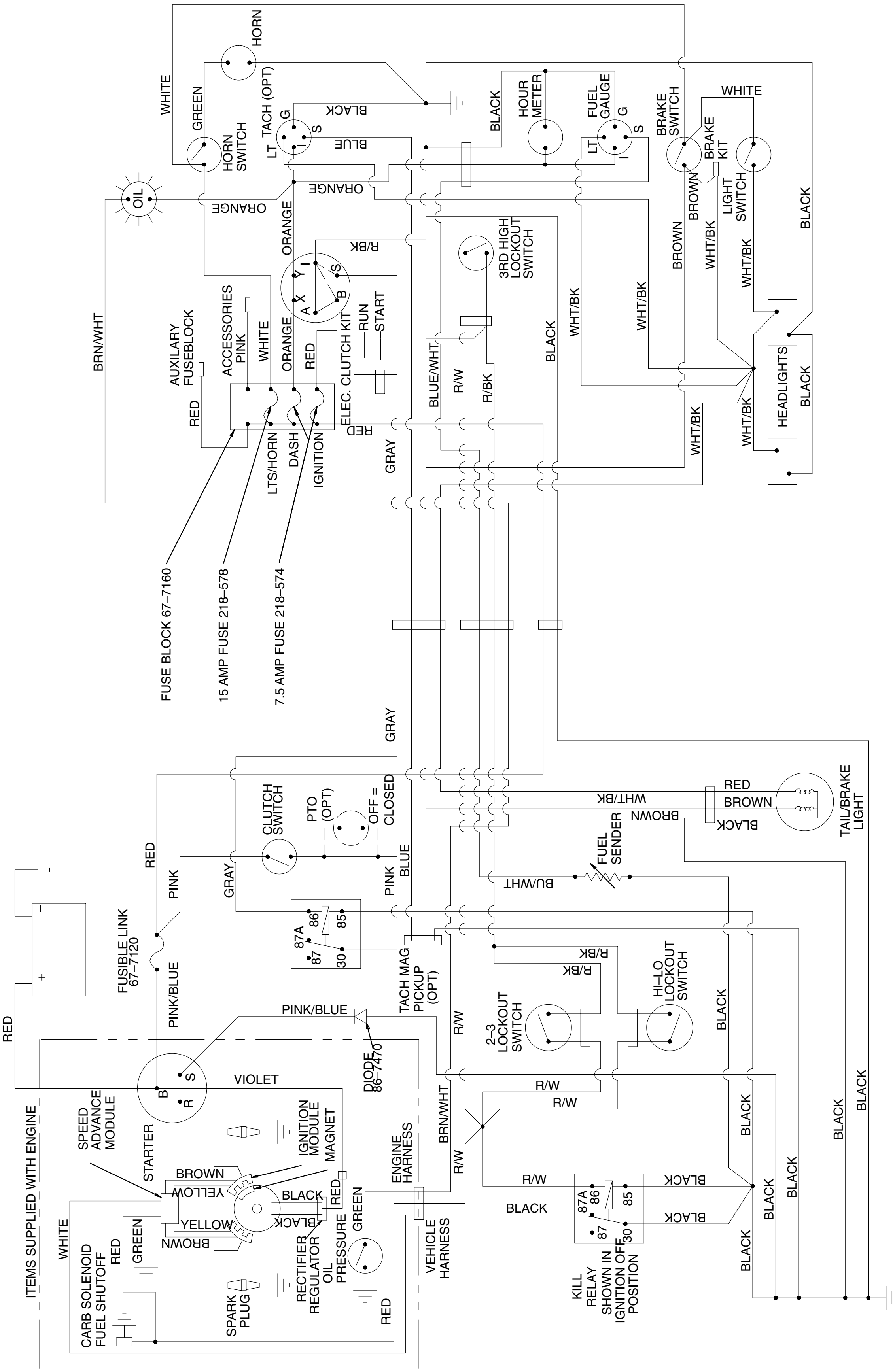
Steering, Brakes & Suspension

Chapter 8

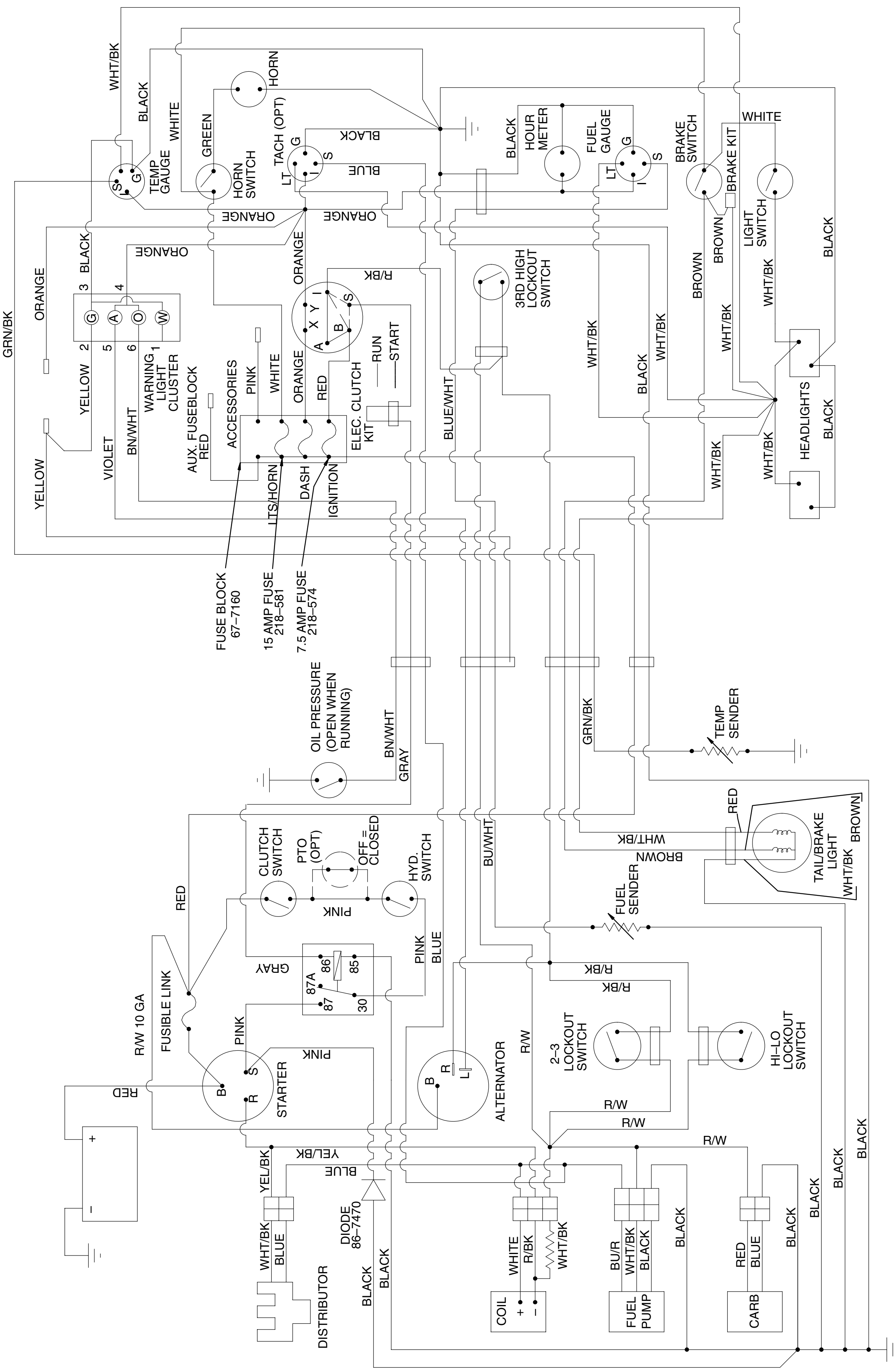
Electrical System

Table of Contents

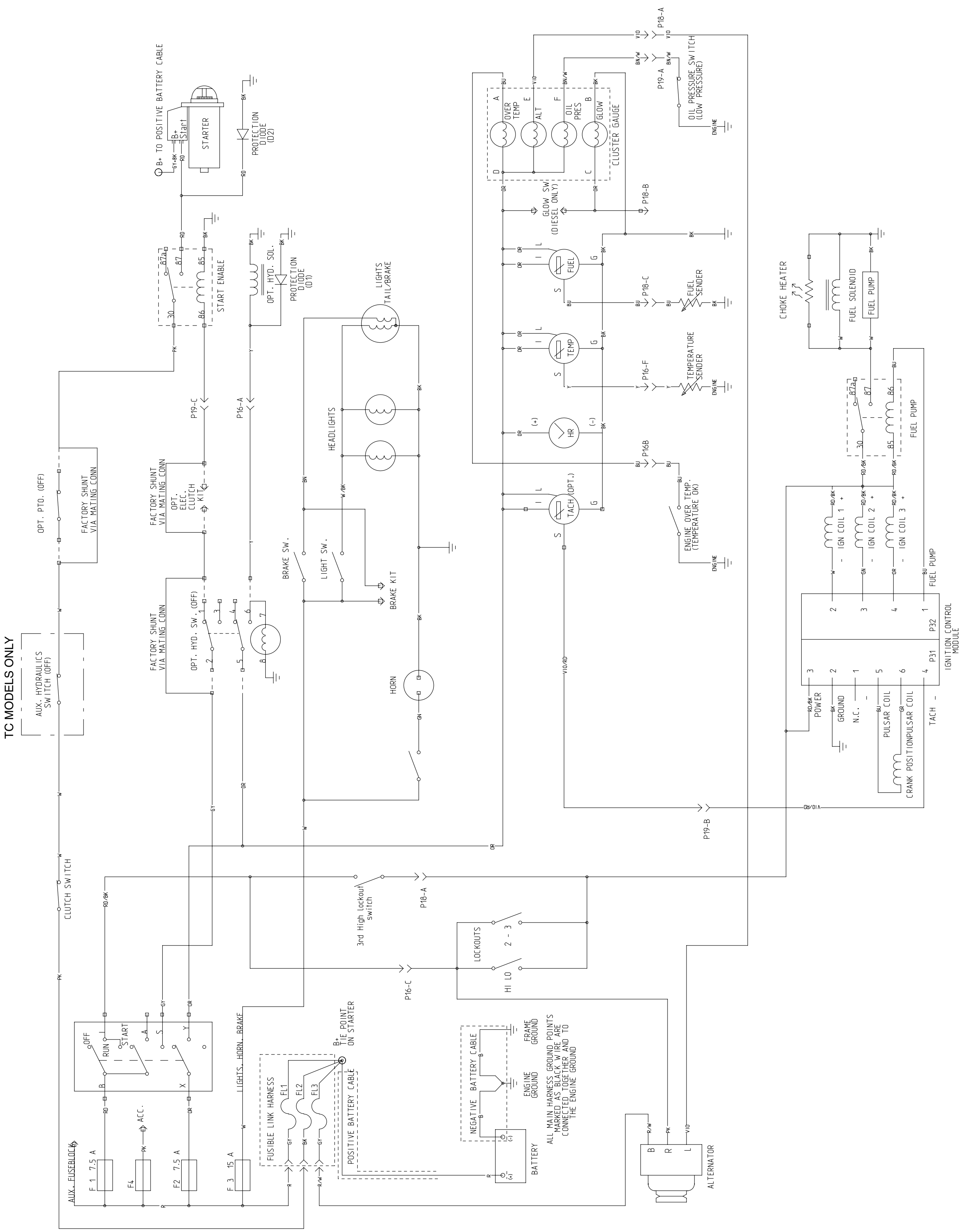
Workman 3100 (Model 07210 and 07214)



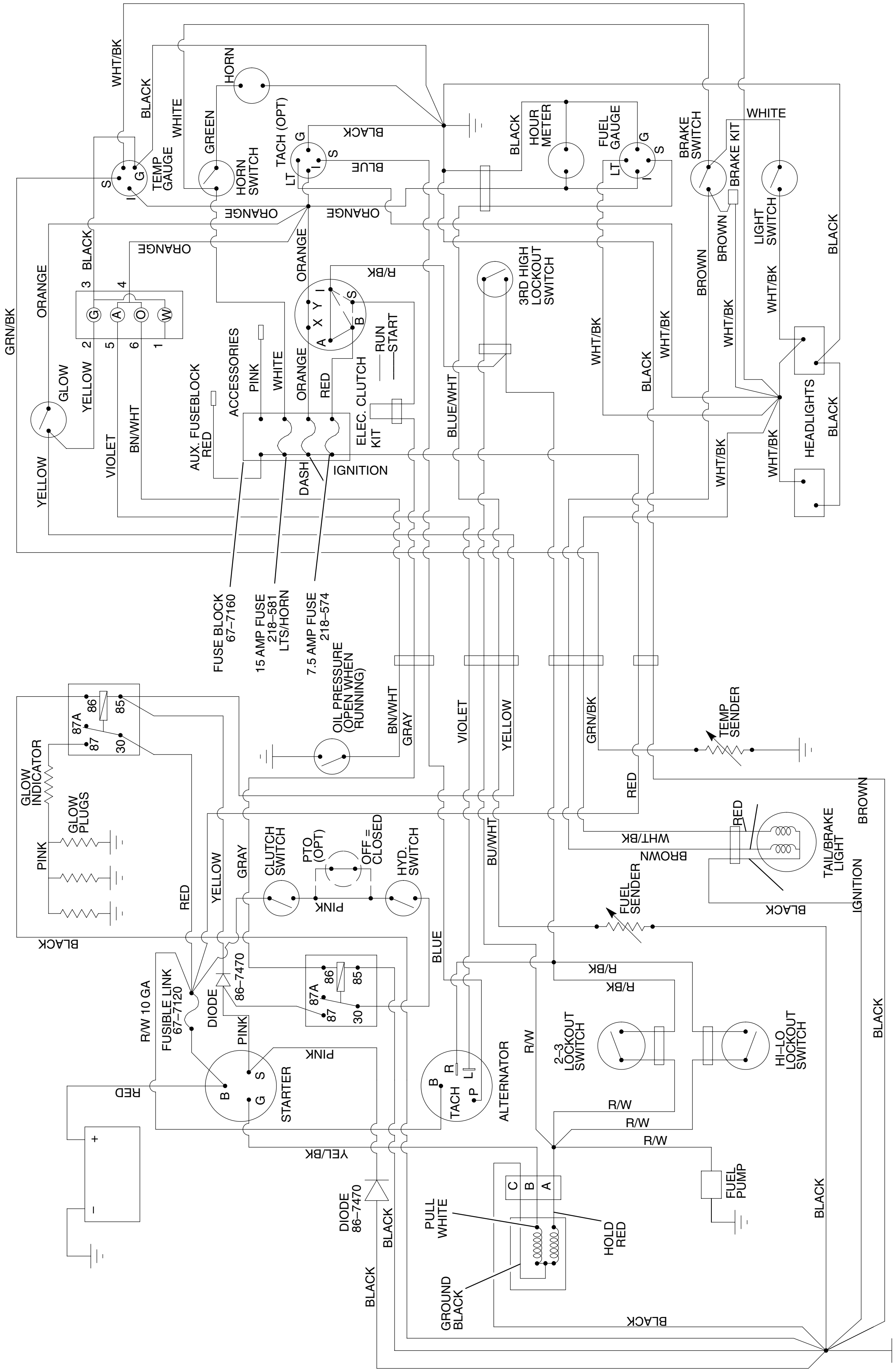
Workman 3200/4200 (Models 07200, 07202, 07216, and 07200TC)



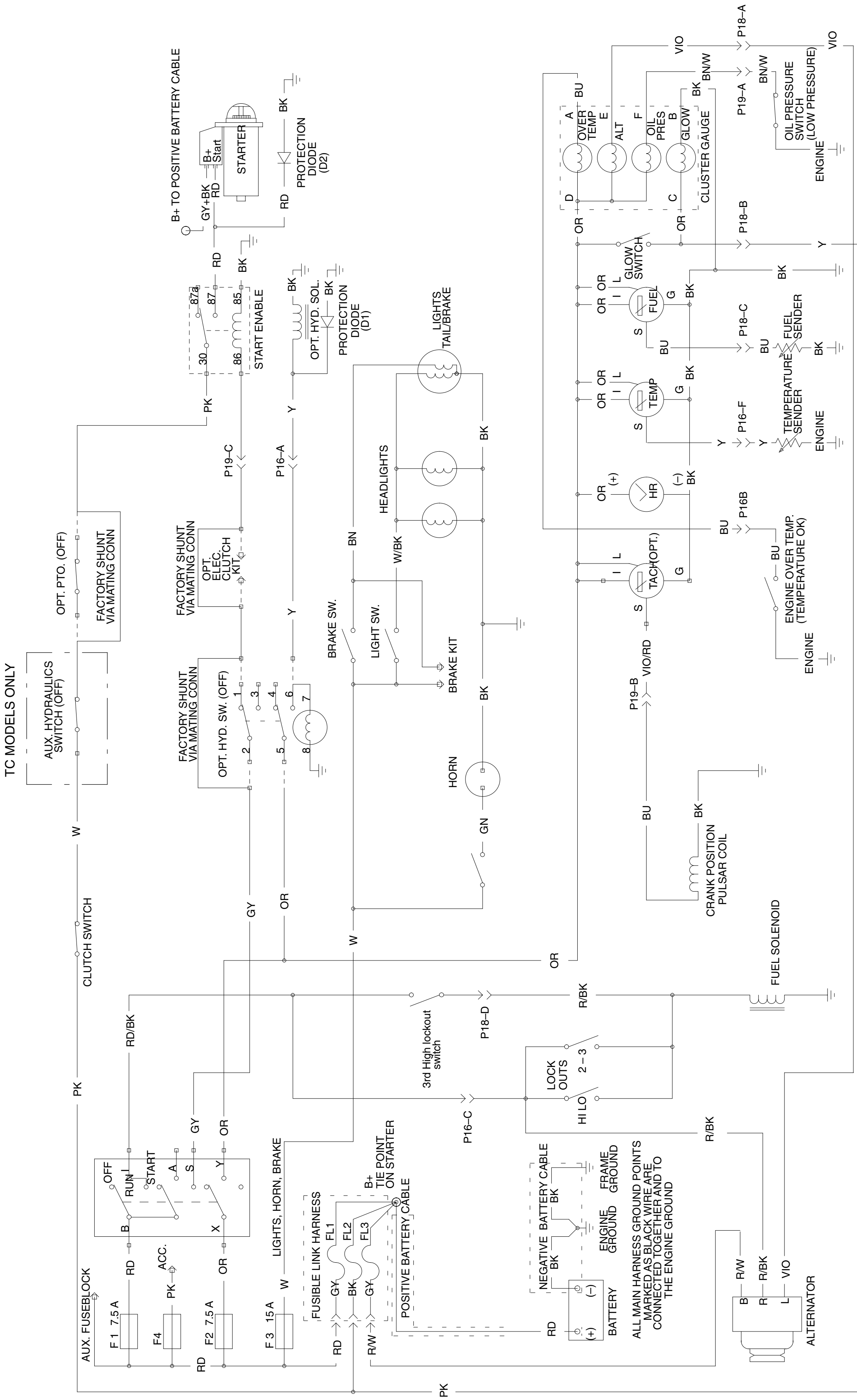
Workman 3200/4200 (Models 07211, 07212, 07218, and 07211TC)



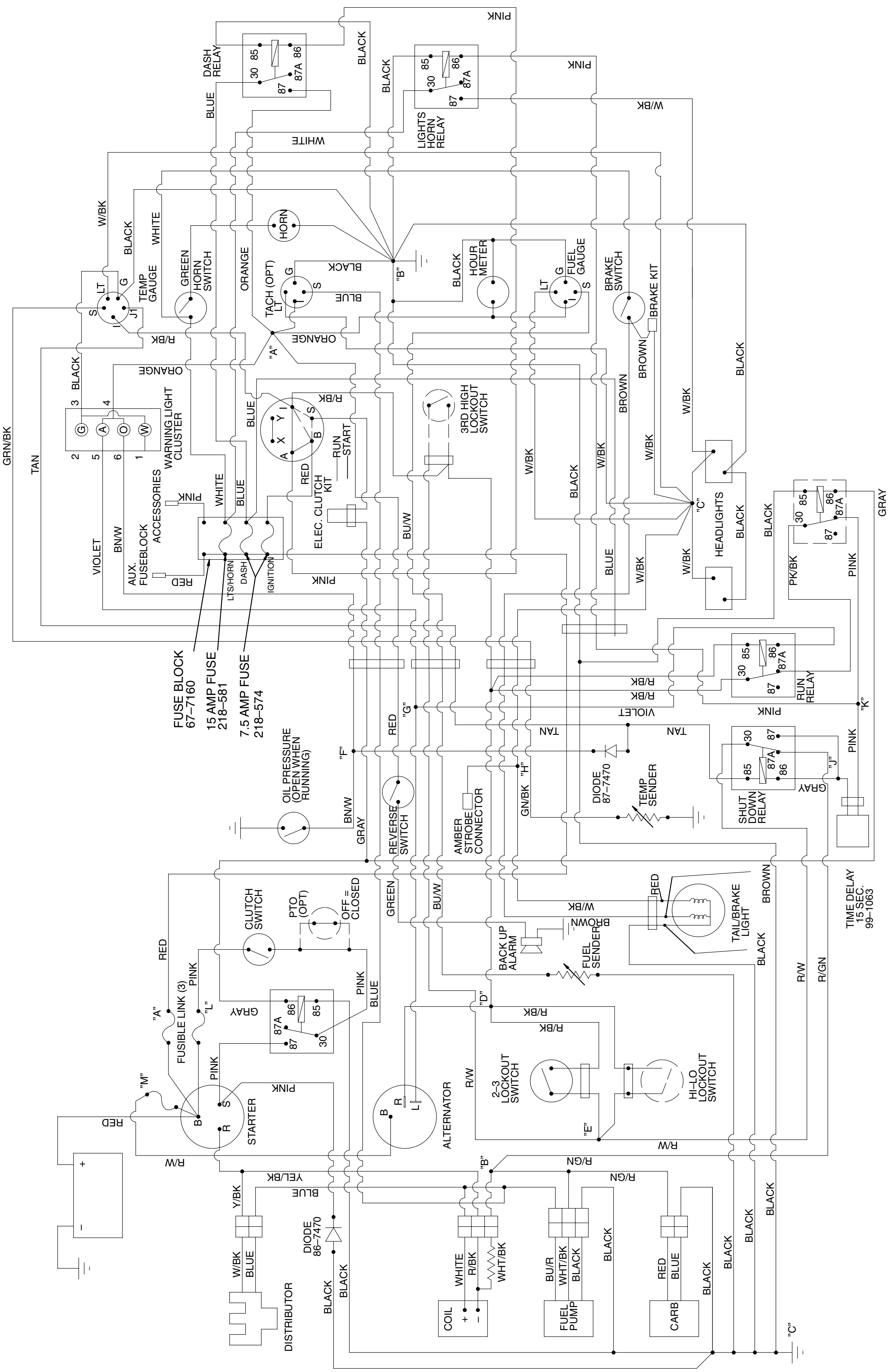
Workman 3300–D/4300–D (Models 07205, 07206, 07215, 07205TC, 07206TC, 07215TC)



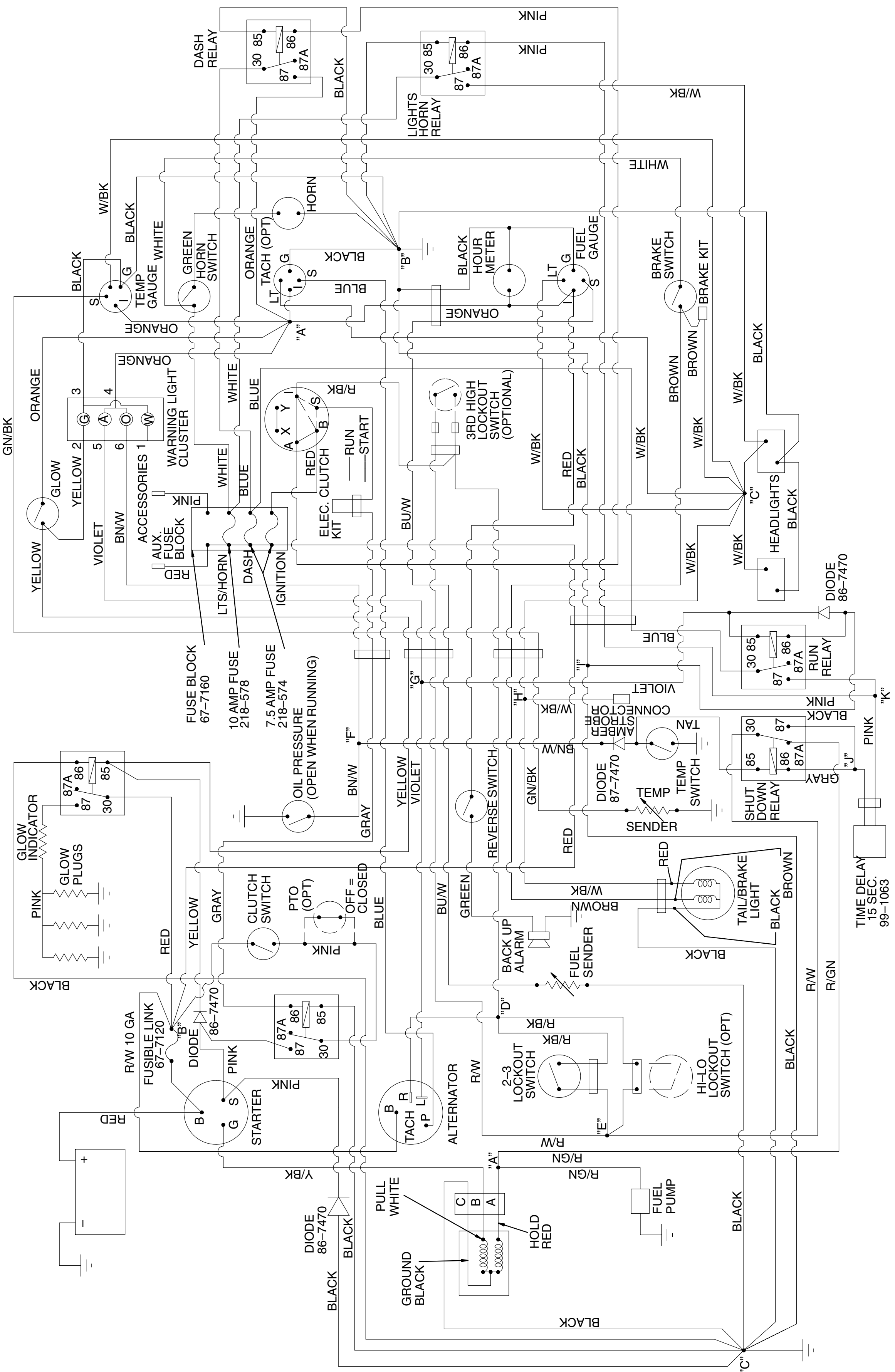
Workman 3300–D/4300–D (Models 07213, 07217, 07213TC, and 07217TC)



Workman 3210 (Heavy Industrial Model 07220)



Workman 3310–D (Heavy Industrial Model 07222)



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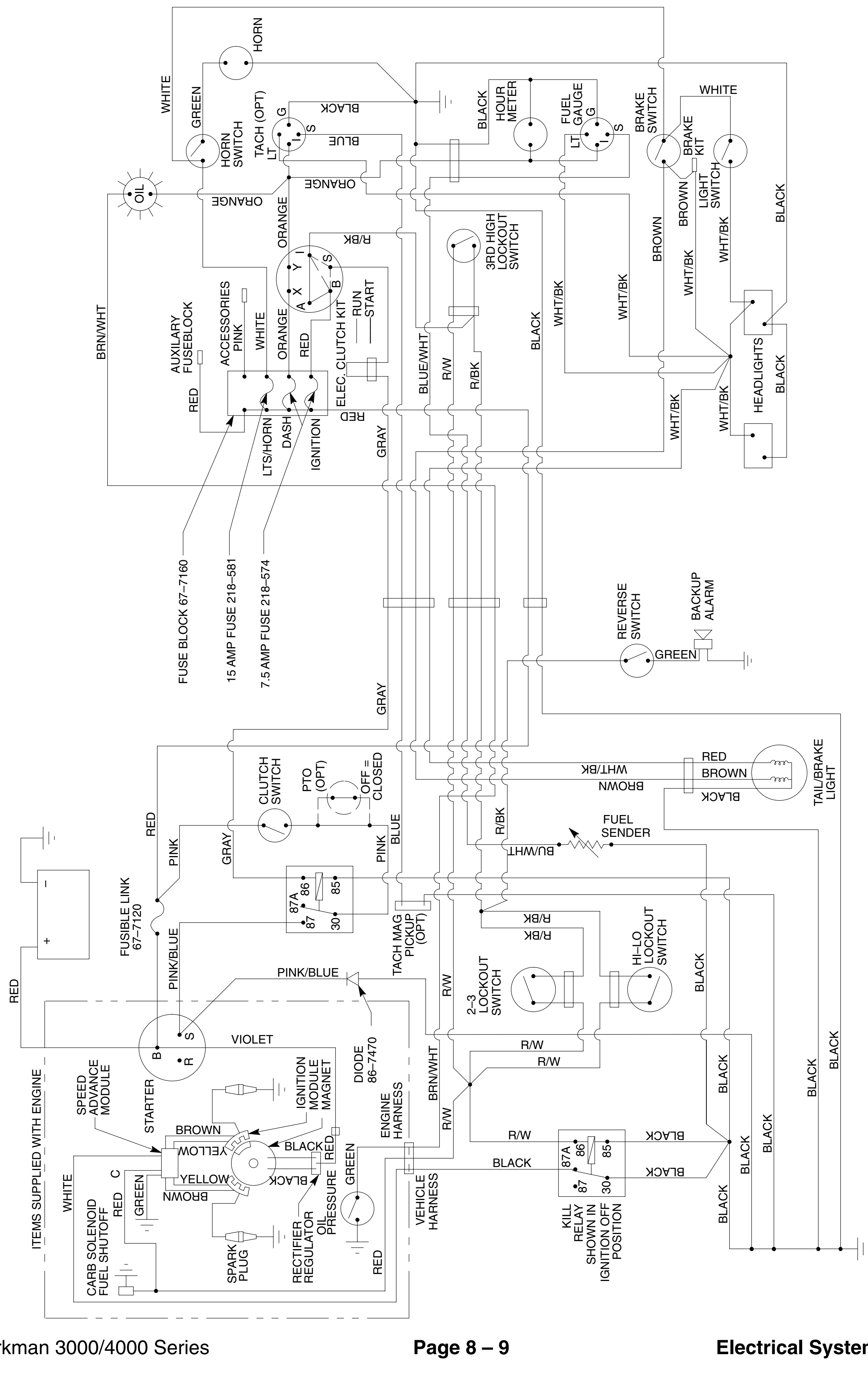
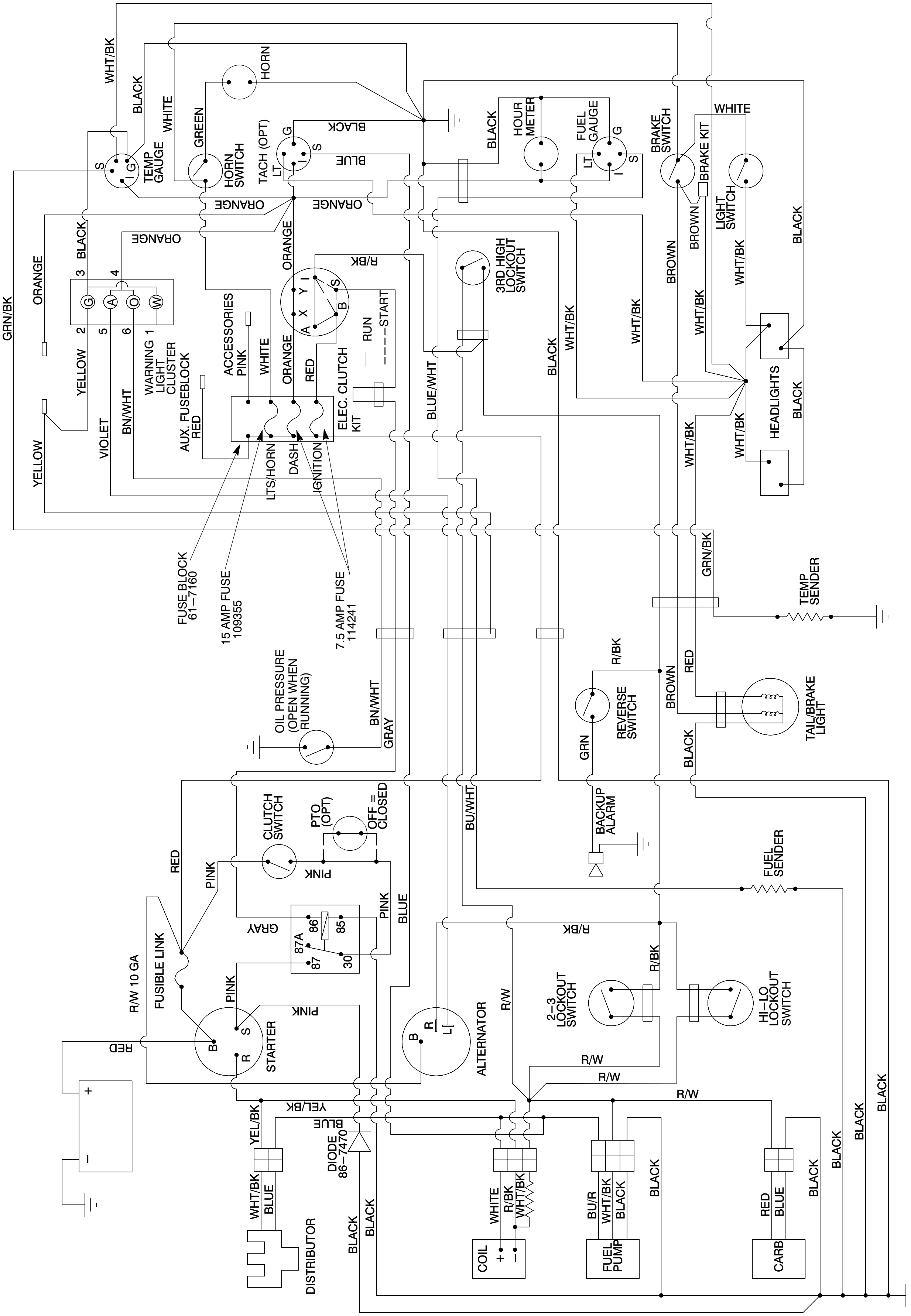
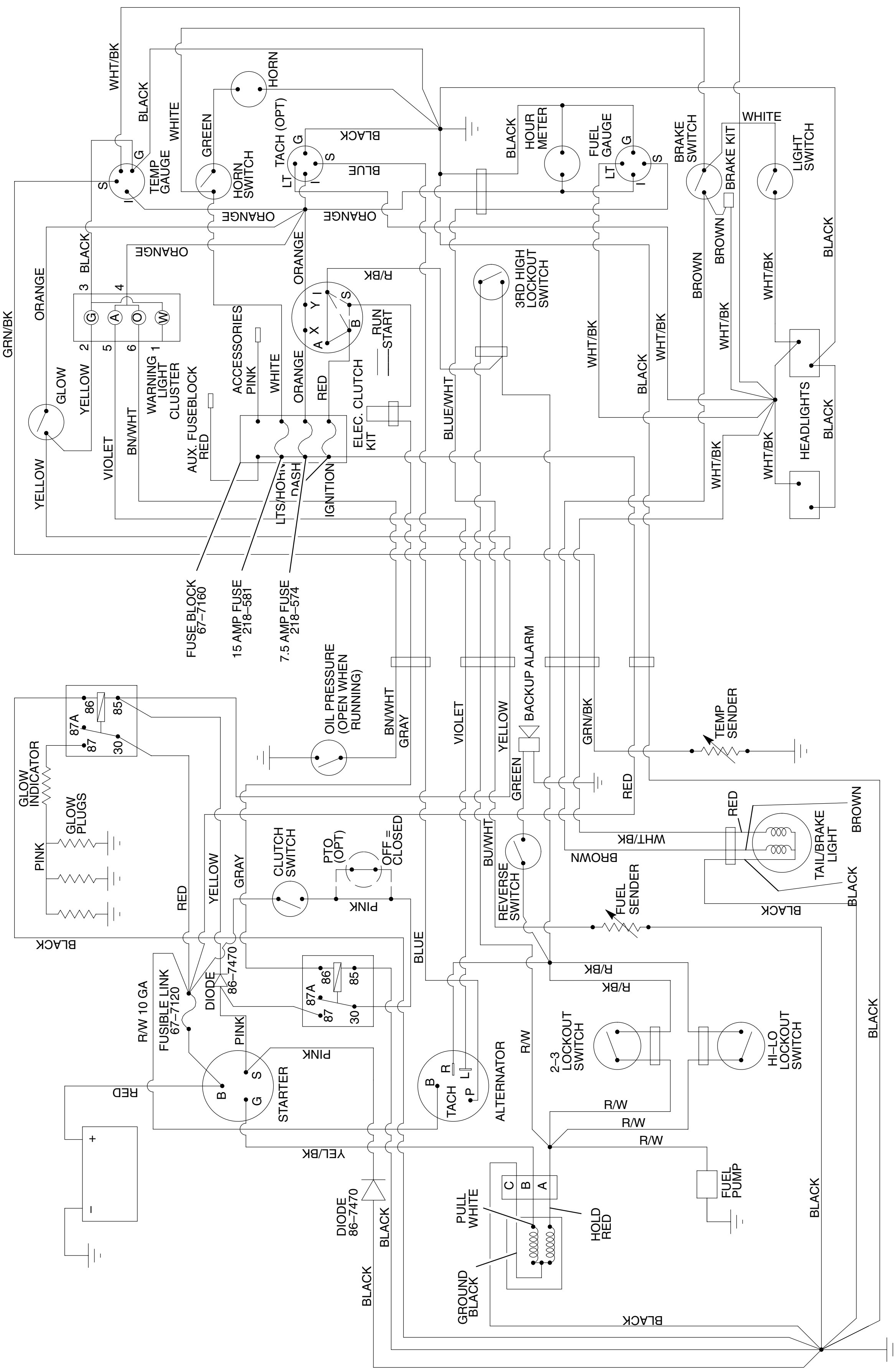


Workman 3220 (Industrial Model 07231)

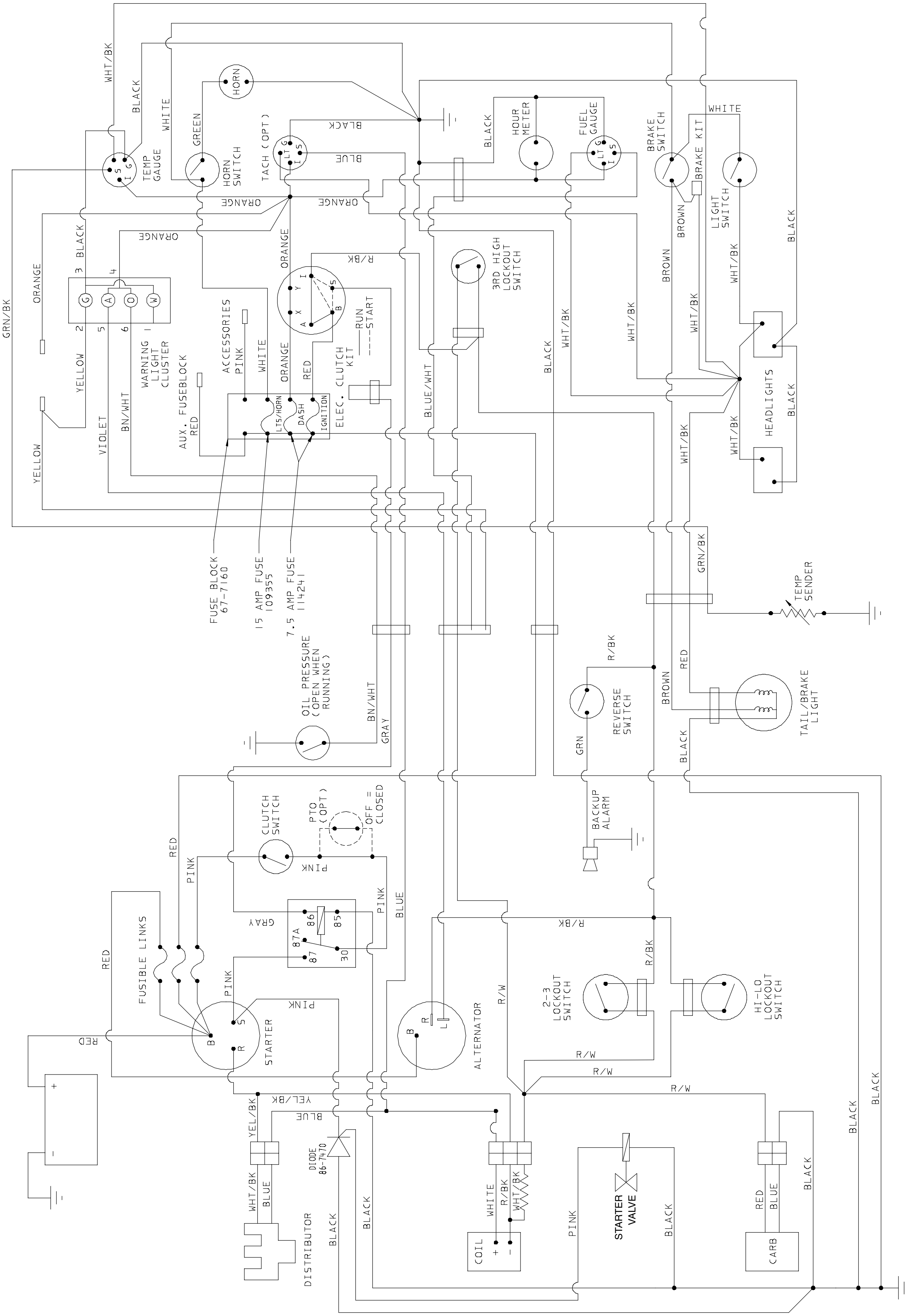


Workman 3320–D (Industrial Model 07230)



Electrical System

Workman 3420–LP (Industrial Model 07233)



Special Tools

Order special tools from the *TORO SPECIAL TOOLS AND APPLICATIONS GUIDE (COMMERCIAL PRODUCTS)*.

Some tools may also be available from a local supplier.

Continuity Tester

Battery powered test lamp which is helpful in testing for continuity of circuits and electrical components when the current is off.

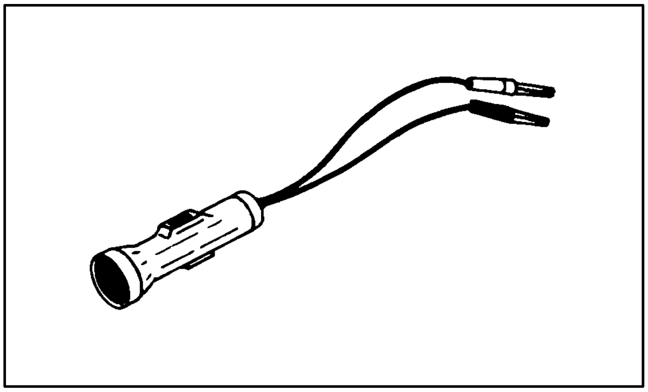


Figure 1

Multimeter

The meter can test electrical components and circuits for current, resistance, or voltage.

NOTE: Toro recommends the use of a DIGITAL Volt–Ohm–Amp multimeter when testing electrical circuits. The high impedance (internal resistance) of a digital meter in the voltage mode will make sure that excess current is not allowed through the meter. This excess current can cause damage to circuits not designed to carry it.

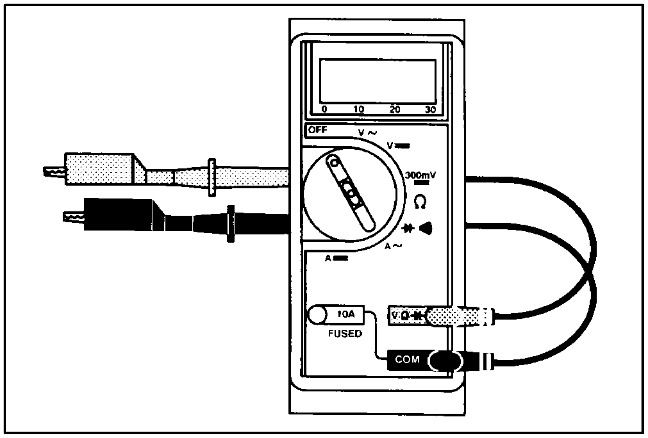


Figure 2

Skin–Over Grease

Special non–conductive grease (Toro Part No. 505–47) which forms a light protective skin which helps waterproof electrical switches and contacts.

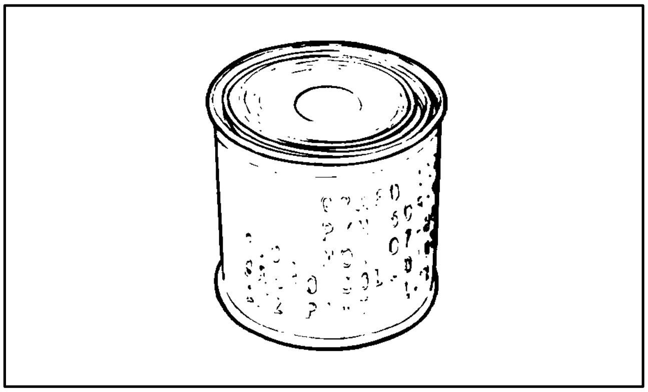


Figure 3

Troubleshooting

CAUTION

Remove all jewelry, especially rings and watches, before doing any electrical troubleshooting or testing. Disconnect the battery cables unless the test requires battery voltage.

For effective troubleshooting and repairs, you must have a good understanding of the electrical circuits and components used on this machine (see Wiring Schematics section of this chapter).

If the machine has any interlock switches by–passed, they must be reconnected for proper troubleshooting and safety.

Condition	Possible Cause
Starter cranks, but should not, with clutch pedal released.	Clutch switch out of adjustment or faulty.
Starter cranks, but should not, with PTO engaged.	PTO switch faulty.
Starter solenoid clicks, but starter will not crank. (If solenoid clicks, problem is not in interlock system.)	Low battery charge. Loose or corroded battery cables or ground. Loose, corroded or damaged wiring at starter. Loose starter mounting bolts. Faulty starter. Faulty starter solenoid.
Starter cranks but engine will not start.	3rd–High lockout key switch in Slow position with transaxle in 3rd gear and High range – instruct operator. "I" terminal wire of ignition key switch loose, corroded or damaged. Engine or fuel system problem (see appropriate Engine chapter).
Engine does not shut off immediately when ignition key switch is turned off (Workman 3100 only).	Damaged or disconnected wiring for shut–down relay. Shut–down relay faulty

Condition	Possible Cause
Nothing happens when start attempt is made.	Clutch pedal not depressed – instruct operator. PTO engaged – instruct operator. Low battery charge. Loose or corroded battery cables. Loose or corroded ground. ”RUN” fuse open. Fusible link open. Clutch cable out of adjustment. Clutch switch out of adjustment or faulty. Clutch switch wiring loose, corroded or damaged. PTO switch faulty. PTO switch wiring loose, corroded or damaged. Faulty ignition key switch. Ignition switch wiring loose, corroded or damaged. Start relay faulty. Start relay wiring loose, corroded or damaged. Starter solenoid wiring loose, corroded or damaged. Starter solenoid faulty.
Engine runs, but should not, with 3rd–High lockout switch in Slow position and transaxle in 3rd gear and High range.	3rd–High lockout key switch faulty. 2–3 lockout switch on transaxle faulty. High–Low lockout switch on transaxle faulty.
Engine kills when shifted to 3rd gear.	3rd–High lockout key switch on Slow position with transaxle in High range – instruct operator. Damaged or disconnected wiring for 3rd–High lockout key switch. Damaged or disconnected wiring for 2–3 lockout switch or High–Low switch on transaxle.
Battery does not charge.	Loose or broken wire(s). Faulty alternator. Dead battery.

Verify Interlock System Operation

The purpose of the interlock system is to prevent the engine from cranking or starting unless the clutch pedal is depressed or PTO (if so equipped) is disengaged.

CAUTION

The interlock switches are for the operator's protection, so do not bypass them. Check operation of the switches daily to assure interlock system is operating. If a switch is malfunctioning replace it before operating. Regardless whether switches are operating properly or not, replace them every two years to assure maximum safety. Do not rely entirely on safety switches – use common sense!

To verify clutch interlock switch operation:

1. Sit on operator's seat and engage parking brake. Move shift lever to NEUTRAL position. Disengage PTO (if so equipped).

2. Without depressing clutch pedal, rotate key clockwise to start position.

3. If engine cranks or starts, there is a malfunction in the interlock system that must be repaired before operating vehicle.

To verify PTO interlock switch operation:

1. Sit on operator's seat and engage parking brake. Move shift lever to NEUTRAL position.

2. Engage PTO.

3. Depress clutch pedal and rotate key clockwise to start position.

4. If engine cranks or starts, there is a malfunction in the interlock system that must be repaired before operating vehicle.

Testing

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 clutch switch connector before doing a continuity check).

Note: Electrical troubleshooting of any 12 Volt power connection can also be performed through voltage drop tests without disconnection of the component.

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.

Ignition Key Switch

The ignition (key) switch has three positions (OFF, START and RUN). The terminals are marked as shown in Figure 4.The circuitry of the ignition switch is shown in the chart (Fig. 5). 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.

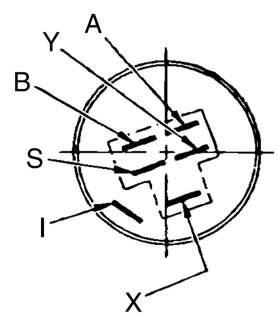


Figure 4

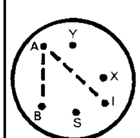
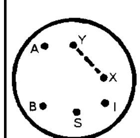
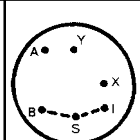
POSITION	CONTINUITY AMONG TERMINALS	OTHER CIRCUITS MADE
1. OFF	NONE	NONE
2. RUN	 B+A+I	 X+Y
3. START	 B+S+I	NONE

Figure 5

Clutch Switch

The clutch switch is normally open and closes when the clutch pedal is depressed.

Test the switch by disconnecting the wiring connector and connecting a continuity tester across the two terminals. With the engine off, depress the clutch pedal completely – there should be an indication of continuity. Release the clutch pedal – there should be no continuity (see Clutch Pedal Adjustment in Chapter 6 – Drive Train).

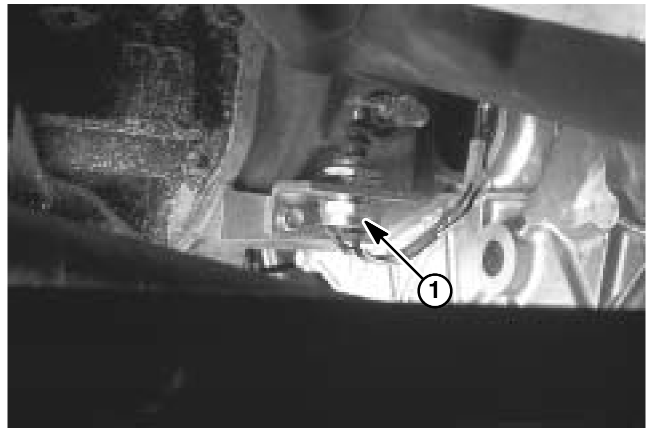


Figure 6

1. Clutch switch

Brake Switch

The brake switch is normally open and closes when the brake pedal is depressed.

Test the switch by disconnecting the wiring connector and connecting a continuity tester across the two terminals. With the engine off, depress the brake pedal – there should be an indication of continuity. Release the brake pedal – there should be no continuity.

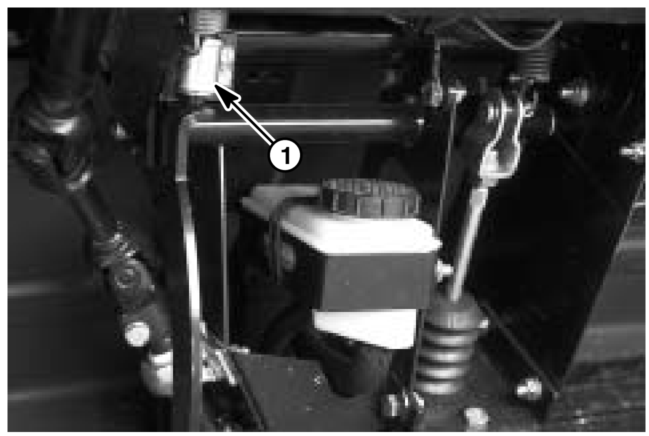


Figure 7

1. Brake switch

Rear PTO Switch

The PTO switch is normally closed and opens when the PTO is engaged.

Test the switch by disconnecting the wiring connector and connecting a continuity tester across the two terminals. With the engine off, move PTO lever to OFF position – there should be an indication of continuity. Move PTO lever to ON – there should be no continuity.

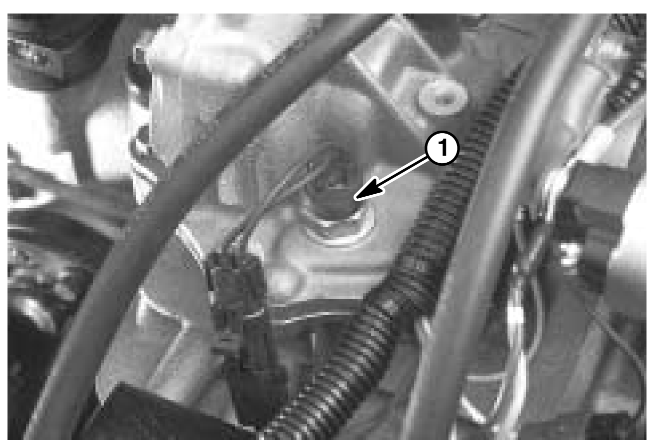


Figure 8

1. PTO switch

2–3 and High–Low Lockout Switches

2–3 Lockout Switch

The 2–3 Lockout switch is closed in 2nd gear and open in 3rd gear.

Test the switch by disconnecting the wiring connector and connecting a continuity tester across the two terminals. With the engine off, move transmission shifter to 2nd gear – there should be an indication of continuity. Move shifter to 3rd gear – there should be no continuity.

High–Low Lockout Switch

The High–Low Lockout switch is closed in Low range and open in High range.

Test the switch by disconnecting the wiring connector and connecting a continuity tester across the two terminals. With the engine off, move shifter to Low range – there should be an indication of continuity. Move shift lever to High range – there should be no continuity.

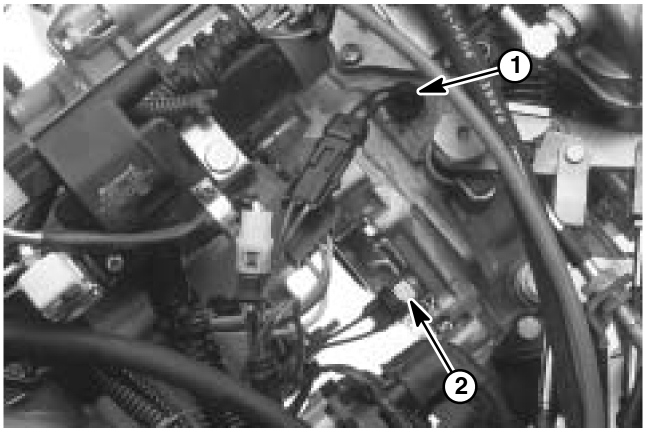


Figure 9

1. 2–3 lockout switch
2. Hi–Lo lockout switch

3rd–High Lockout Key Switch

The 2–3 Lockout switch is closed in Fast position and open in Slow position.

Test the switch by disconnecting the wiring and connecting a continuity tester across the two terminals. With the engine off, move key to Fast position – there should be an indication of continuity. Move key to Slow position – there should be no continuity.

Figure 10

Relays

To test the relay, disconnect the relay wire connector and install a continuity tester between the relay terminals (terminals 30 and 87). 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.

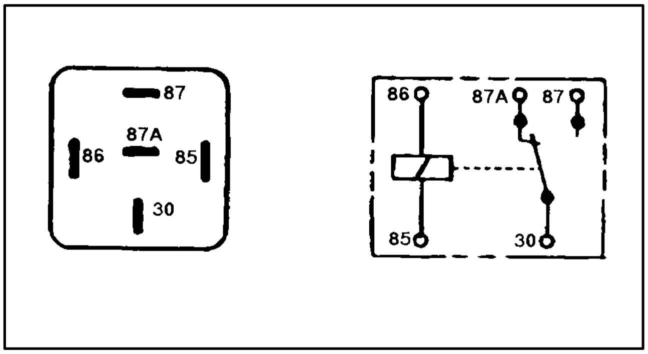


Figure 11

Battery

Use a volt–ohm meter to measure the voltage between the battery terminals.

If the voltage is less than 12.3 Volts D.C., the battery should be charged.

NOTE: Regulated voltage will increase to approximately 13.5 Volts when the engine is running.

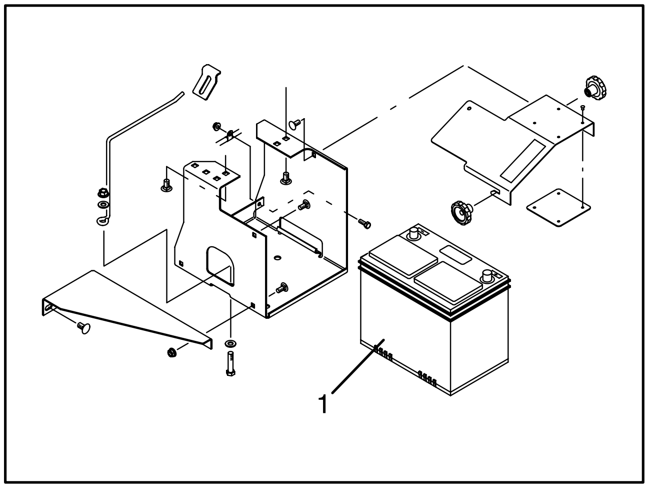


Figure 12

1. Battery

Indicator Lights and Gauges

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/cm2).Test the lamp by disconnecting the wires and applying 12 V.D.C. between the lamp wiring terminals.

Amp Light (Liquid Cooled Engines)

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 (Diesel Engine)

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.

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 hourmeter. The hourmeter should operate as 12 V.D.C. is applied between the terminals.

Temperature Gauge and Fuel Level Gauge

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

Disconnect wire and remove the fuel gauge sender from the fuel tank.

Install an ohm meter between the terminal and base.

With arm completely down (empty position), resistance should be 240–260 ohms.

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.

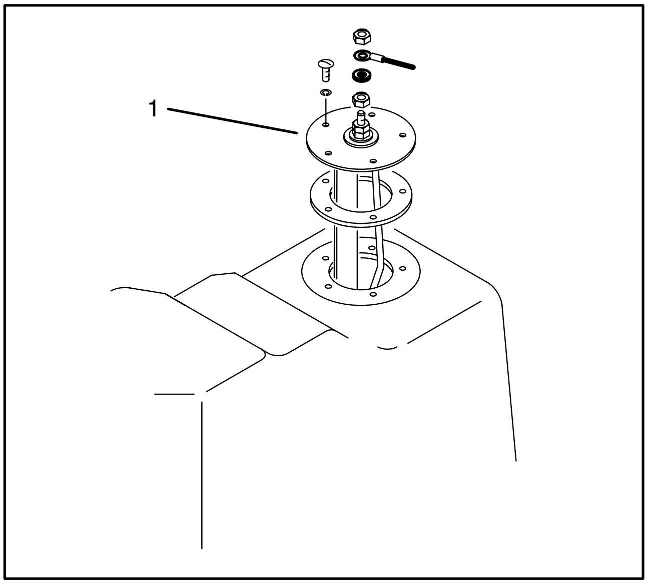


Figure 13

1. Fuel gauge sender

Electrical System)

Service and Repairs

Battery Service

The battery is the heart of the electrical system. With regular and proper service, battery life can be extend. Additionally, battery and electrical component failure can be prevented.

CAUTION

When working with batteries, use extreme caution to avoid slashing or spilling electrolyte. Electrolyte can destroy clothing and burn skin or eyes. Always wear safety goggles and a face shield when working with batteries.

Electrolyte Specific Gravity

Fully charged: 1.250 – 1.280
Discharged: less than 1.240

Battery Specifications (Gasoline Engines)

BCI Group 24 Battery:
370 Amp Cranking Performance at 0° F (17° C)
45 min. Reserve Capacity at 80° F (27°C)

Battery Specifications (Diesel Engines)

BCI Group 24 Battery:
630 Amp Cranking Performance at 0° F (17° C)
130 min. Reserve Capacity at 80° F (27°C)

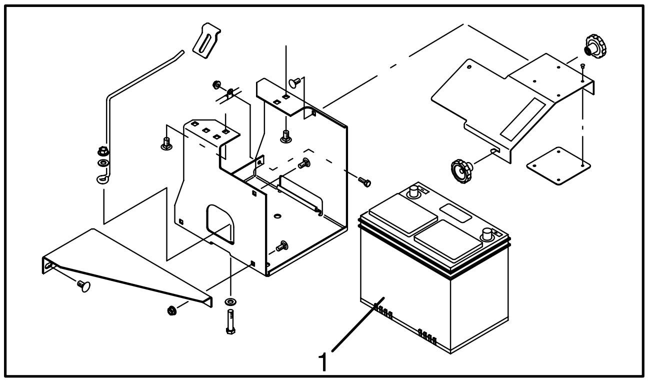


Figure 14
1. Battery

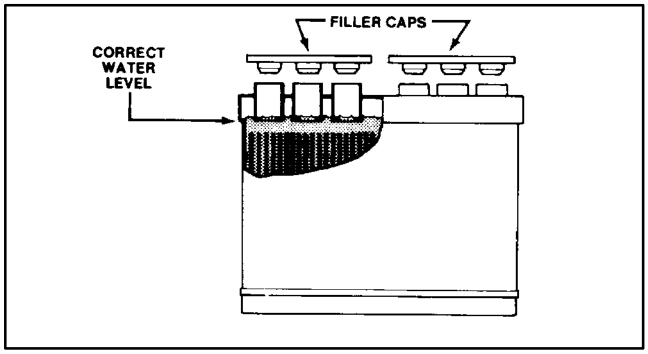


Figure 15

Removal (Fig. 14)

IMPORTANT: Be careful not to damage terminal posts or cable connectors when removing the battery cables.

1. Remove battery cover from the frame. Loosen battery retainer securing the back of the battery to the battery support.

2. Loosen nut on ground cable (–) post first and remove cable from battery. This should prevent short circuiting the battery, other components, or the operators hands.

3. Loosen nut on positive (+) cable post and remove cable from battery.

4. Make sure battery vent caps are on tightly.

5. Remove battery from the battery compartment to a service area to allow better access for service.

Inspection, Maintenance, and Testing

1. Perform following inspections and maintenance:

A. Check for cracks. Replace battery if cracked or leaking.

B. Check battery terminal posts for corrosion. Use wire brush to clean corrosion from posts.

IMPORTANT: Before cleaning the battery, tape or block vent holes to the filler caps and make sure the caps are on tightly.

C. Check for signs of wetness or leakage on the top of the battery which might indicate a loose or missing filler cap, overcharging, loose terminal post, or overfilling. Also, check battery case for dirt and oil. Clean the battery with a solution of baking soda and water, then rinse it with clean water.

D. Check that the cover seal is not broken away. Replace the battery if the seal is broken or leaking.

E. Check the electrolyte level in each cell. If the level is below the tops of the plates in any cell, fill all cells with **distilled** water between the minimum and maximum fill lines. Charge at 15 to 25 amps for 15 minutes to allow sufficient mixing of the electrolyte.

2. Conduct a hydrometer test of the battery electrolyte.

IMPORTANT: Make sure the area around the cells is clean before opening the battery caps.

A. Measure the specific gravity of each cell with a hydrometer. Draw electrolyte in and out of the hydrometer barrel prior to taking a reading to warm–up the hydrometer. At the same time take the temperature of the cell.

B. Temperature correct each cell reading. For each 10°F (5.5°C) above 80°F (26.7°C) add 0.004 to the specific gravity reading. For each 10°F (5.5°C) below 80°F (26.7°C) subtract 0.004 from the specific gravity reading.

Example: Cell Temperature	100°F
Cell Gravity	1.245
100°F minus 80°F equals 20°F	
(37.7°C minus 26.7°C equals 11.0°C)	
20°F multiply by 0.004/10°F equals 0.008	
(11°C multiply by 0.004/5.5°C equals 0.008)	
ADD (conversion above)	0.008
Correction to 80°F (26.7°C)	1.253

C. If the difference between the highest and lowest cell specific gravity is 0.050 or greater or the lowest cell specific gravity is less than 1.225, charge the battery. Charge at the recommended rate and time given in **Charging** or until all cells specific gravity is 1.225 or greater with the difference in specific gravity between the highest and lowest cell less than 0.050. If these charging conditions can not be met, replace the battery.

3. Perform a high–discharge test with an adjustable load tester.

This is one of the most reliable means of testing a battery as it simulates the cold–cranking test. A commercial battery load tester is **required** to perform this test.

CAUTION

Follow the manufacturer's instructions when using a battery tester.

A. Check the voltage across the battery terminals prior to testing the battery. If the voltage is less than 12.4 VDC, recharge the battery.

B. If the battery has been charged, apply a 150 amp load for 15 seconds to remove the surface charge. Use a battery load tester following the manufacturer's instructions.

C. Make sure battery terminals are free of corrosion.

D. Measure the temperature of the center cell.

E. Connect a battery load tester to the battery terminals **following the manufacturer's instruction**s. Connect a digital multimeter to the battery terminals.

F. Apply a test load of one half the Cranking Performance (see Battery Specifications) rating of the battery for 15 seconds.

G. Take a voltage reading at 15 seconds, then remove the load.

H. Using the table below, determine the minimum voltage for the cell temperature reading.

Minimum Voltage	Battery Electrolyte Temperature	
9.6	70°F (and up)	21.1°C (and up)
9.5	60°F	15.6°C
9.4	50°F	10.0°C
9.3	40°F	4.4°C
9.1	30°F	–1.1°C
8.9	20°F	–6.7°C
8.7	10°F	–12.2°C
8.5	0°F	–17.8°C

I. If the test voltage is below the minimum, replace the battery. If the test voltage is at or above the minimum, return the battery to service.

Installation

IMPORTANT: To prevent possible electrical problems, install only a fully charged battery.

1. Make sure ignition and all accessories are **off**.

2. Make sure battery compartment is clean and repainted if necessary.

3. Make sure all battery cables and connections are in good condition and battery retainer has been repaired or replaced.

4. Place battery in its compartment. Make sure battery is level and flat. Connect positive cable connector onto positive battery post. Tighten cap screw and lock nut with two wrenches.

5. Secure battery retainer. Do not overtighten to prevent cracking or distorting the battery case.

6. Apply a light coat of grease on all battery posts and cable connectors to reduce corrosion after connections are made.

7. Connect a digital multimeter (set to amps) between the negative battery post and the negative (ground) cable connector. The reading should be less than 0.1 amp. If the reading is 0.1 amp or more, the unit's electrical system should be tested and repaired.

8. Connect negative (ground) cable connector to the negative battery post. Tighten cap screw and lock nut with two wrenches.

Charging

To minimize possible damage to the battery and allow the battery to be fully charged, the slow charging method is presented here. This charging method can be accomplished with a constant current battery charger which is available in most shops.

CAUTION

Follow the manufacturer's instructions when using a battery charger.

NOTE: Using specific gravity of the battery cells is the most accurate method of determining battery condition.

1. Determine the battery charge level from either its open specific gravity or circuit voltage.

Battery Charge Level	Specific Gravity	Open Circuit Voltage
100%	1.265	12.68
75%	1.225	12.45
50%	1.190	12.24
25%	1.155	12.06
0%	1.120	11.89

2. Determine the charging time and rate **using the manufacturer's battery charger instructions** or the following table.

Battery Reserve Capacity (Minutes)	Battery Charge Level (Percent of Fully Charged)			
	75%	50%	25%	0%
80 or less	3.8 hrs @ 3 amps	7.5 hrs @ 3 amps	11.3 hrs @ 3 amps	15 hrs @ 3 amps
81 to 125	5.3 hrs @ 4 amps	10.5 hrs @ 4 amps	15.8 hrs @ 4 amps	21 hrs @ 4 amps
126 to 170	5.5 hrs @ 5 amps	11 hrs @ 5 amps	16.5 hrs @ 5 amps	22 hrs @ 5 amps
171 to 250	5.8 hrs @ 6 amps	11.5 hrs @ 6 amps	17.3 hrs @ 6 amps	23 hrs @ 6 amps
above 250	6 hrs @ 10 amps	12 hrs @ 10 amps	18 hrs @ 10 amps	24 hrs @ 10 amps

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 to dissipate gases produced from charging. These 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.

3. **Following the manufacturer's instructions**, connect the charger cables to the battery. Make sure a good connection is made.

4. Charge the battery **following the manufacturer's instructions**.

5. Occasionally check the temperature of the battery electrolyte. If the temperature exceeds 125°F (51.6°C) or the electrolyte is violently gassing or spewing, the charging rate must be lowered or temporarily stopped.

6. Three hours prior to the end of the charging, measure the specific gravity of a battery cell once per hour. The battery is fully charged when the cells are gassing freely at a low charging rate and there is less than a 0.003 change in specific gravity for three consecutive readings.

Fuses

The fuse block is located under the right side of the dash panel.

NOTE: It is not always possible to see if a fuse is faulty. It is recommended that you check for faulty fuses with a continuity tester, not visually.

FUSES	
OPEN	—
LIGHTS & HORN	15A
DASH	7.5A
IGNITION	7.5A

Figure 16

Figure 17

1. Fuse block

Headlamp Replacement

Assemble and disassemble headlamp as shown in illustration.

NOTE: Bulb can be replaced without removing headlamp assembly. Be careful when replacing bulb. Never touch bulb with fingers – handle by the base.

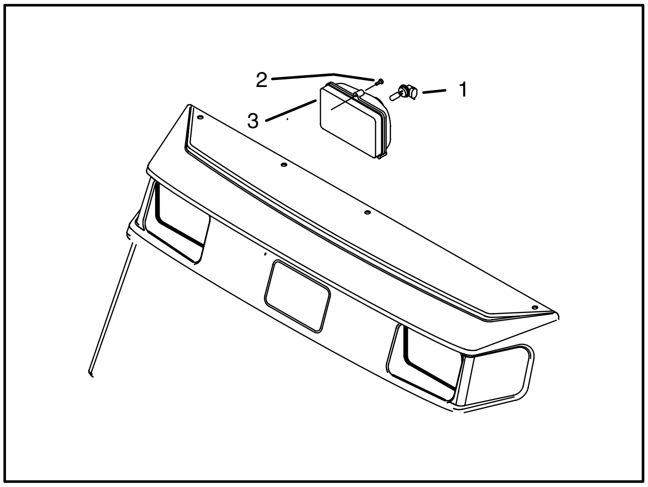


Figure 18

1. Bulb
2. Screw
3. Lens

Electrical System)

Tail Lamp Replacement

Assemble and disassemble tail lamp as shown in illustration.

The tail lamp uses a standard #1157 12volt bulb.

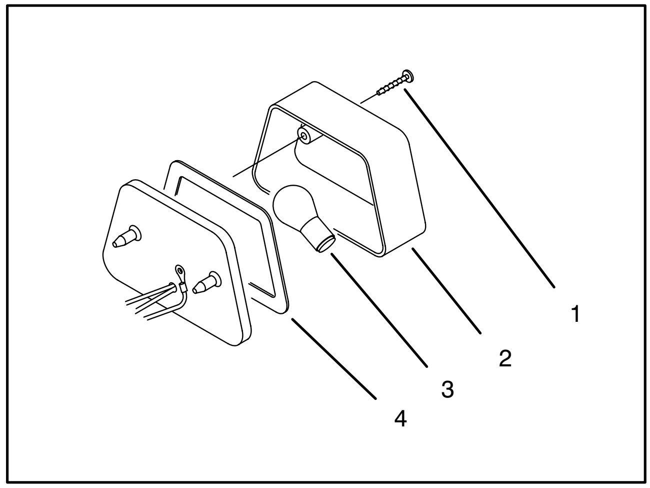


Figure 19

1. Screw
2. Lens
3. Bulb #1157
4. Gasket

Chapter 9

Hydraulic System

Table of Contents

Specifications

Item	Description
Pump Pump Capacity Pump Relief Pressure (Vehicles with Hydraulic Lift Capabilities) Pump Relief Pressure (Vehicles without Hydraulic Lift Capabilities)	 3.5 GPM (13.4 liter/min.) at 1,500 PSI (10,342 kPa) and 2,250 RPM Full bypass at 2,500 PSI (17,238 kPa) Full bypass at 1,000 PSI (6,895 kPa)
Lift Control Valve (Vehicles with Hydraulic Lift Capabilities)	Three position control valve Spring return to neutral Ball checks to maintain load
Remote Hydraulics Relief Pressure (Vehicles with Hydraulic Lift Capabilities)	1,900 PSI (13,100 kPa)
Power Steering Relief Pressure	1,000 PSI (6,895 kPa)
Hydraulic Filter	Automotive spin–on cartridge type 10 micron with 25 PSI by–pass valve 100 mesh strainer in reservoir
Hydraulic Oil	Dexron III ATF
Reservoir (Transaxle) (Fig. 1)	7.5 U.S. qt. (7.1 Liter) system capacity

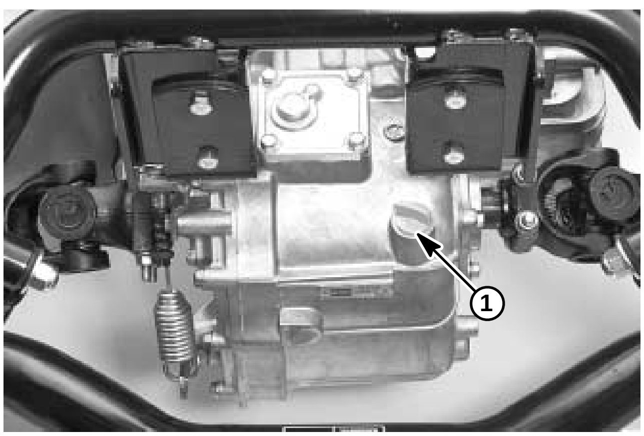


Figure 1

1. Dipstick

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 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 hydraulic system, all pressure in system must be relieved by stopping the engine and lowering or supporting the box and/or other attachment.

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 (Fig. 2, 3)

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches, or any foreign material.

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

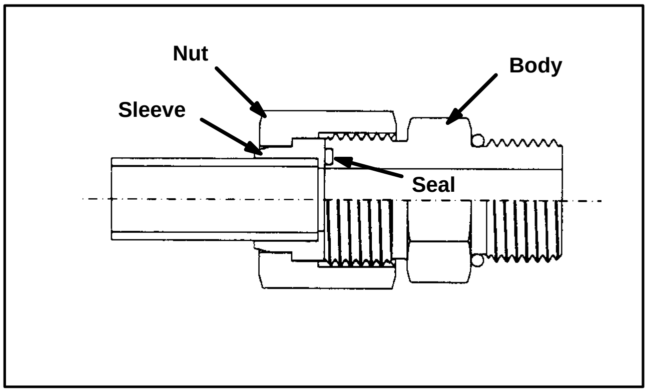


Figure 2

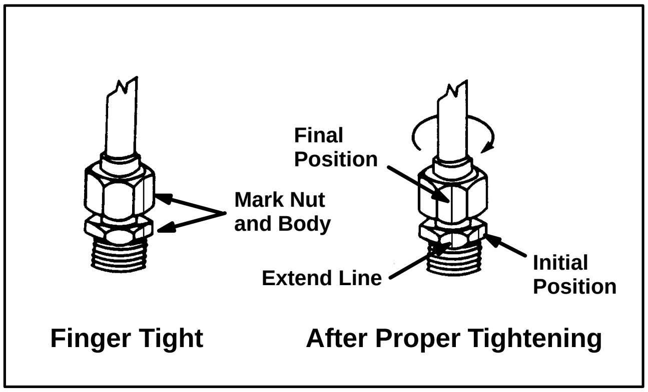


Figure 3

SAE Straight Thread O–Ring Port – Non–adjustable (Fig. 4)

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.

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

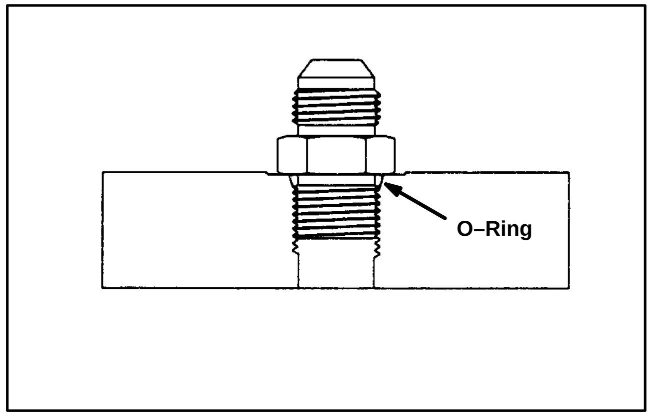


Figure 4

SAE Straight Thread O–Ring Port – Adjustable (Fig. 5, 6)

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. 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

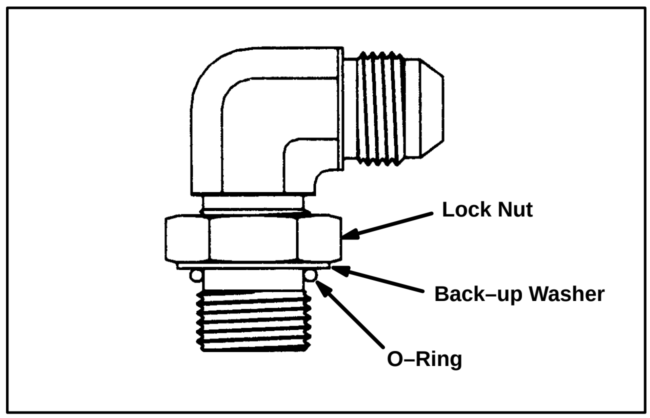


Figure 5

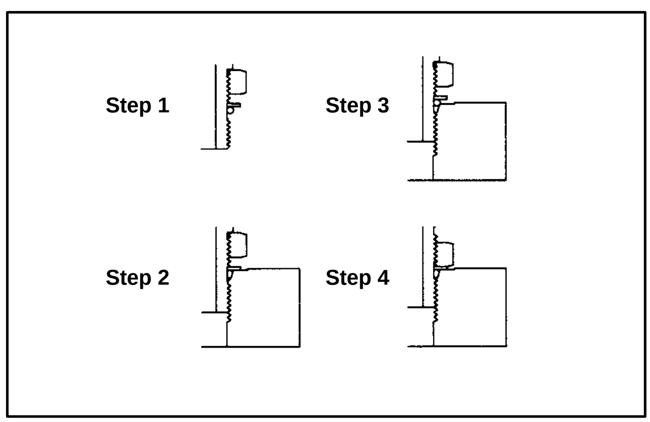
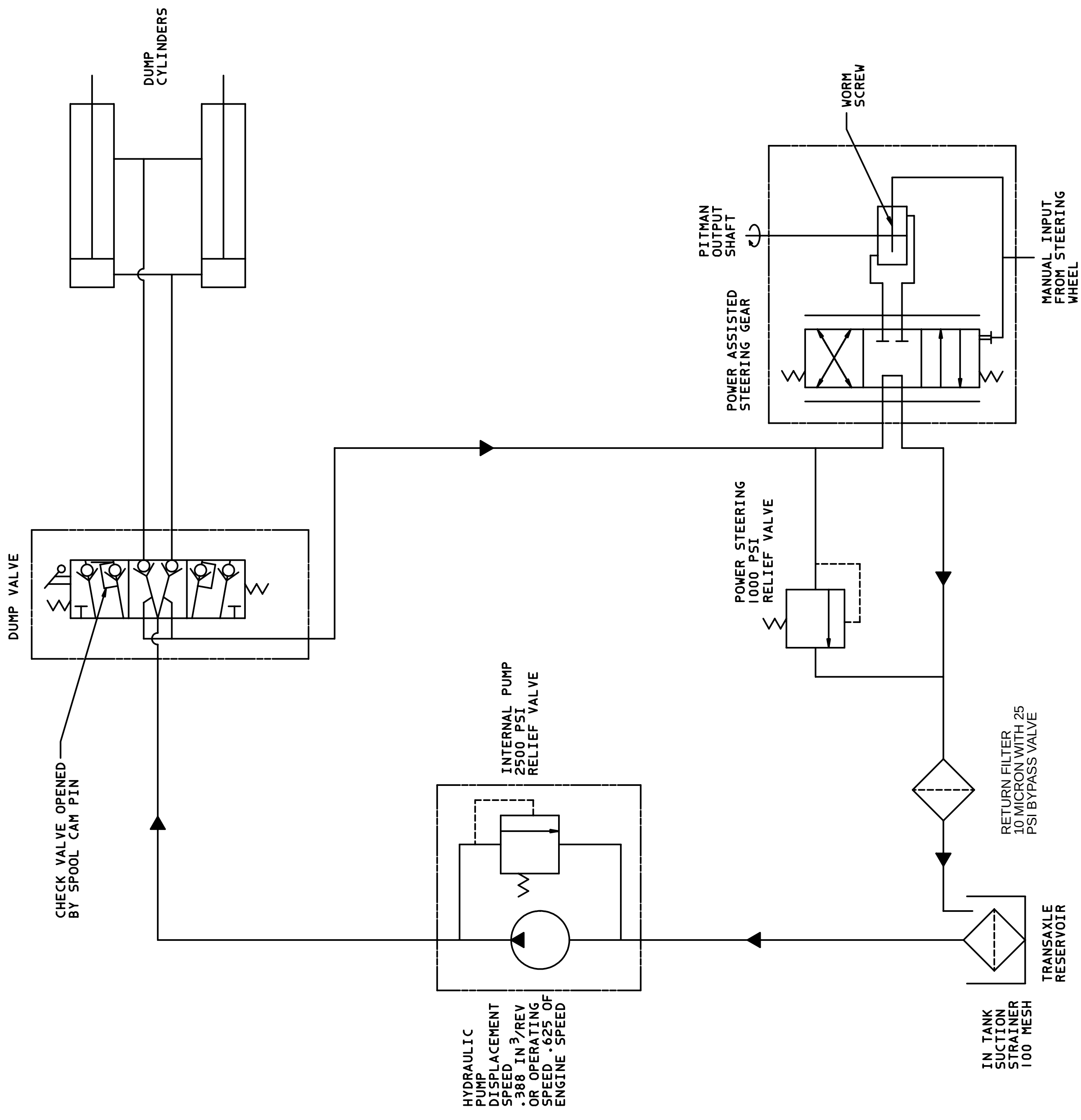


Figure 6

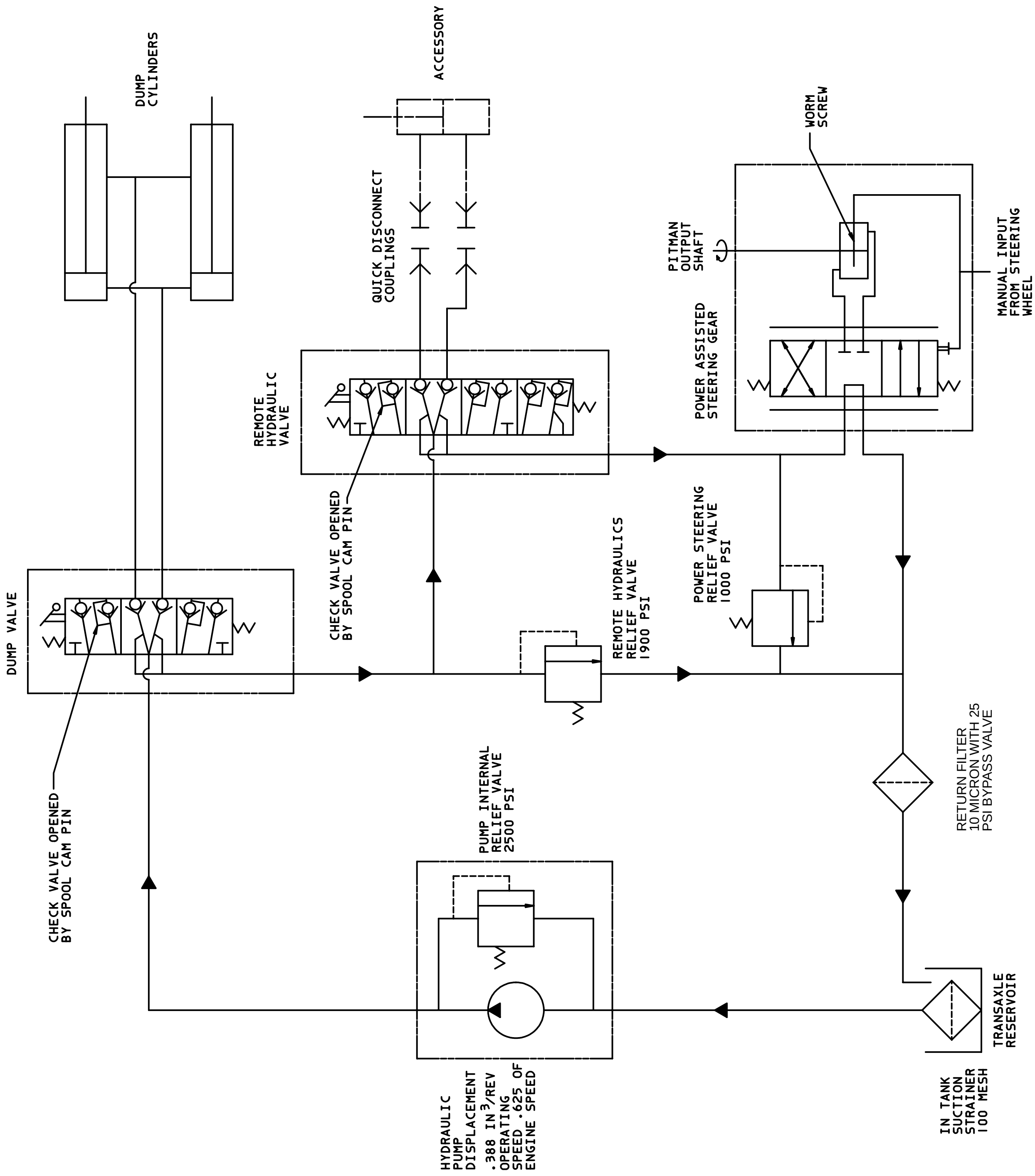
Hydraulic Schematics

Base Vehicle



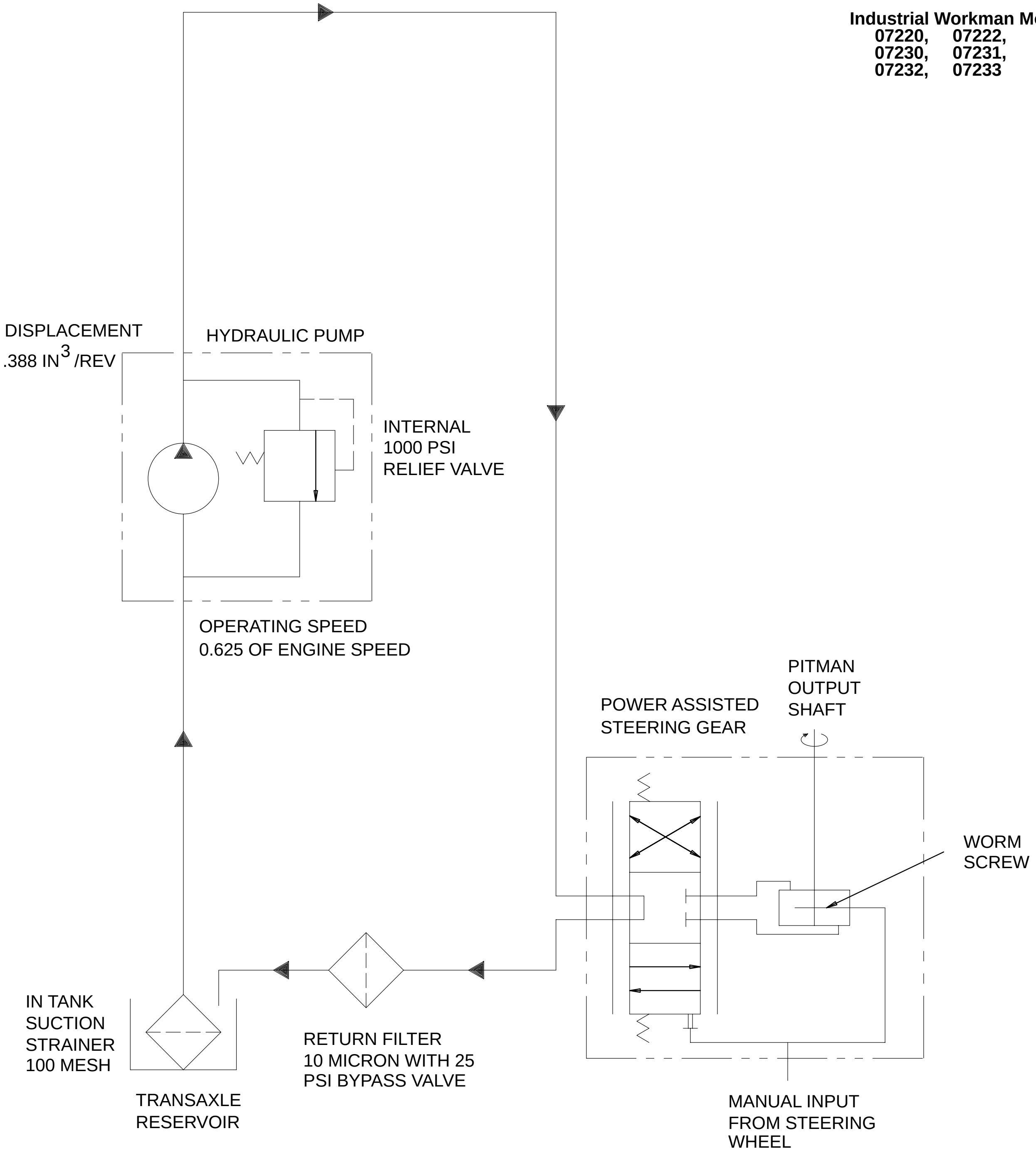
Hydraulic System)

Vehicle with Optional Remote Hydraulic Kit



Industrial Models without Hydraulic Lift Capabilities

Industrial Workman Models:
07220, 07222,
07230, 07231,
07232, 07233



Special Tools

Order these tools from the *TORO SPECIAL TOOLS AND APPLICATIONS GUIDE (COMMERCIAL PRODUCTS)*.

Hydraulic Pressure Test Kit – TOR47009

Use to take various 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: 1000 PSI (70 Bar), 5000 PSI (350 Bar) and 10000 PSI (700 Bar) gauges. Use gauges as recommended in Testing section of this chapter.

Figure 7

Hydraulic Tester (Pressure and Flow) – TOR214678

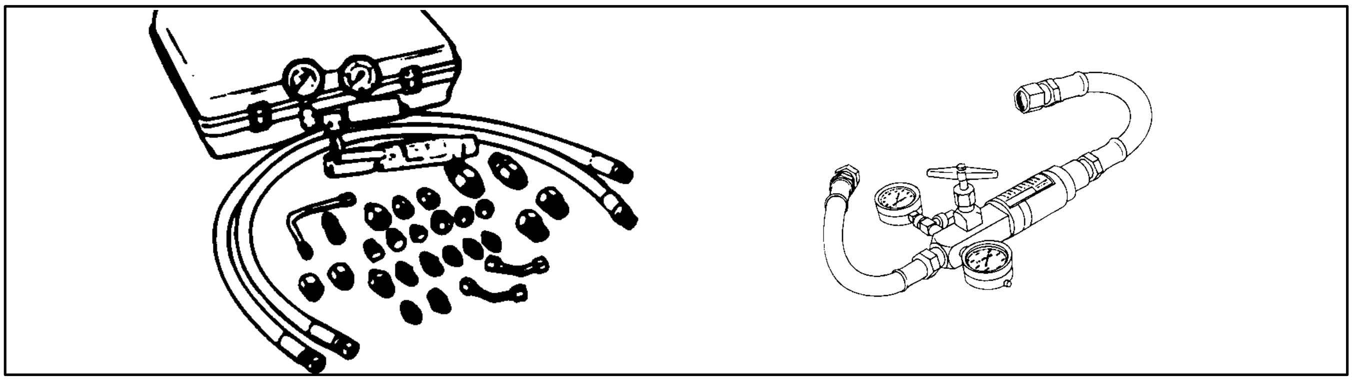


Figure 8

This tester requires O–ring face seal (ORFS) adapter fittings for use on this machine.

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

2. LOAD VALVE: A simulated working load is created in the circuit by turning the valve to restrict flow.

3. LOW PRESSURE GAUGE: Low range gauge to provide accurate reading at low pressure, 0 to 1000 PSI.

   A protector valve 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 which accommodates pressures beyond the capacity of the low pressure gauge, 0 to 5,000 PSI.

5. FLOW METER: This meter measures actual oil flow in the operating circuit with a gauge rated at 15 GPM.

6. OUTLET HOSE: A hose from the outlet side of the hydraulic tester connects to the hydraulic system circuit.

Hydraulic Test Fitting Kit – TOR4079

This kit includes a variety of O–ring Face seal fittings to enable you to connect test gauges into the system.

The kit includes: tee’s, unions, reducers, plugs, caps, and male test fittings.

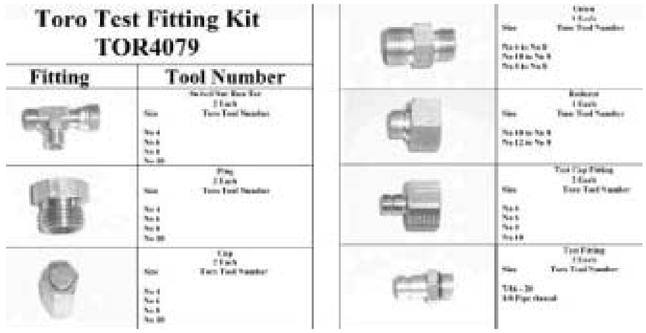


Figure 9

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 information to assist in troubleshooting. There may possibly be more than one cause for a machine malfunction.

Refer to the Testing section of this Chapter for precautions and specific test procedures.

Problem	Possible Causes
Hydraulic oil leak(s).	Fitting(s), hose or tube loose or damaged. Missing or damaged o–ring.
Squealing noise.	Remote hydraulic valve left in ON detent position (hydraulic oil flowing over relief valve).
Hydraulic oil overheating.	Hydraulic oil level low. Kinked or severely bent hose or tubing. Hydraulic oil going over relief valve excessively (too heavy a load on remote hydraulics or quick coupler disconnected with remote valve engaged). Damaged pump. Oil level in transaxle too high.
Dump box does not lift or lifts too slowly.	Excessive load in dump box. Pump drive belt loose. Sheared key on pump shaft. Hydraulic oil level too low. Low engine RPM. Lift cylinder pivots or dump box pivots binding or damaged. Lift cylinder(s) worn or damaged. Hydraulic oil overheated or too thin (improper oil). Low pump flow or pressure – TEST NO. 1.
Lift (dump) cylinders extend with valve in neutral position.	Load checks in valve leaking.

Problem	Possible Causes
Difficulty in connecting or disconnecting quick couplers.	Pressure not relieved (coupler under pressure – engine running). Remote hydraulic valve not in float position.
Attachment does not function.	Quick couplers not fully engaged. Quick couplers are interchanged. Pump drive belt loose. Sheared key on pump shaft. Hydraulic oil level low. Low engine RPM. Excessive load. Low pump flow or pressure – TEST NO. 1. Remote hydraulics relief valve stuck open damaged – TEST NO. 2. Remote hydraulic valve worn or damaged. Hydraulic component(s) on attachment malfunctioning or damaged.
Box drops from raised position with lift valve in centered position.	Improperly positioned valve. Dump valve worn or damaged. Internal leakage of lift cylinder(s). Lift cylinder hydraulic lines or fittings leaking.
Power steering hard.	Remote valve not in neutral or float position or Remote hydraulic valve linkage out of adjustment. Pump drive belt loose. NOTE: A loose pump drive belt will also cause the box not to lift or other attachment to not operate. Low engine RPM. Hydraulic oil level low. Hydraulic oil overheated. Low pump flow or pressure – TEST NO. 1. NOTE: Low pump flow or pressure will also cause the box not to lift or other attachment to not operate. Power steering gear worn or damaged.

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 recommended pressure (psi) rating as listed in test procedures could result in damage to 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.

WARNING

Before disconnecting or performing any work on the hydraulic system, all pressure in the system must be relieved by stopping the engine and lowering or supporting the dump box or other accessories.

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 load valve in hydraulic tester (when using 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: Pump Flow and Relief Pressure

1. Make sure hydraulic oil is at normal operating temperature before performing tests.

2. Raise and support dump box if installed, then engage parking brake and stop the engine.

3. Install tester in series between pump outlet (pressure hose) and dump valve or steering valve on units without dump cylinders. Make sure tester flow control valve is open.

CAUTION

The engine must be running to perform hydraulic tests. To guard against possible personal injury, engage parking brake and keep clothing, hands, feet, face and other parts of the body away from fan or other moving parts.

4. Start engine and operate at full speed (pump seed of 2,250 RPM). While watching pressure gauges, slowly close flow control valve until the following pressure is obtained:

1,500 PSI on units **with** dump cylinders
800 PSI on units **without** dump cylinders.

Read gauges and observe that flow is the following:

Nominal Pump Flow (Units with Dump Cylinders)	3.5 GPM at 1,500 PSI (13.2 Liter/min. at 10,342 kPa)
Nominal Pump Flow (Units without Dump Cylinders)	3.7 GPM at 800 PSI (14.0 Liter/min. at 5,516 kPa)

If pressure is too low or
flow is less than the following:

3.0 GPM (11.4 Liter/min.)on units **with** dump cylinders

3.1 GPM (11.7 Liter/min.) on units **without** dump cylinders.

check for:
- Slipping pump drive belt.
- Worn or stuck relief valve.
- Restriction in pump intake line.
- Worn or damaged pump.

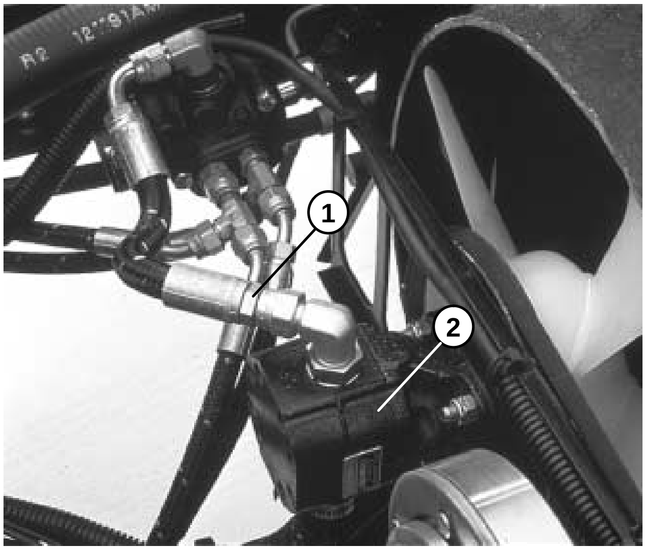


Figure 10

1. **Pump outlet**
2. **Hydraulic pump**

Relief Pressure Test

5. Start engine and operate at full speed (pump seed of 2.250 RPM). Leave tester flow control valve open. Watch pressure gauges.

On units **with** dump cylinders, actuate and hold hydraulic dump control lever so oil flow goes over relief.

On units **without** dump cylinders, close flow control valve so oil flow goes over relief.

Pump Relief Pressure (Units with Dump Cylinders)	2,500 PSI (17,238 kPa)
Pump Relief Pressure (Units without Dump Cylinders)	1,000 PSI (6,895 kPa)

If unable to get specified pressure, check for:
- Slipping pump drive belt.
- Worn or stuck relief valve.
- Internal leakage of dump cylinder(s).

TEST NO. 2: Remote Hydraulics Relief Pressure

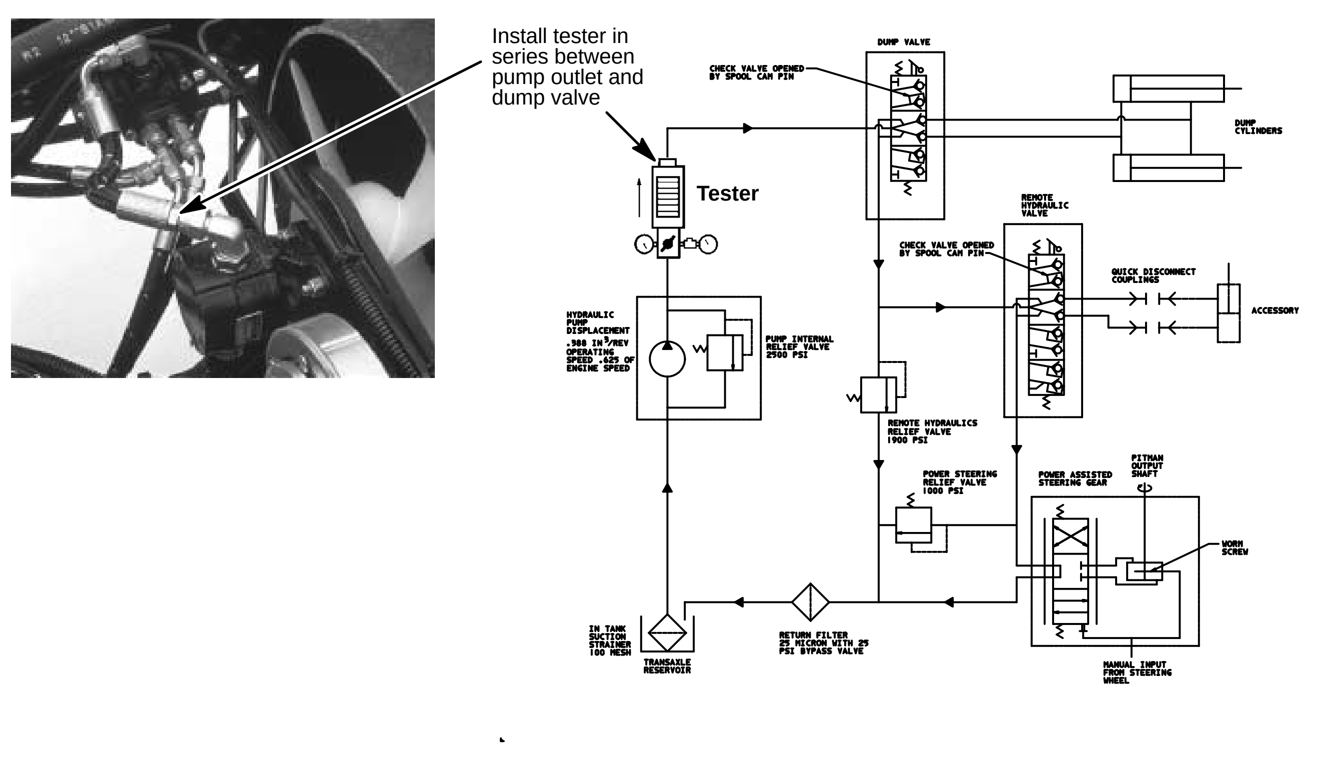


Figure 11

1. Make sure hydraulic oil is at normal operating temperature before performing tests.

2. Raise and support dump box, if equipped, then engage parking brake and stop the engine.

3. Install tester in series between pump outlet (pressure hose) and dump valve. Make sure tester flow control valve is open.

CAUTION

The engine must be running to perform hydraulic tests. To guard against possible personal injury, engage parking brake and keep clothing, hands, feet, face and other parts of the body away from fan or other moving parts.

4. Start the engine and operate at full speed (3,600 RPM). Leave tester flow control valve open. While watching pressure gauges actuate and hold remote hydraulics control lever so oil flow goes over relief.

Remote hydraulics relief pressure	1,900 ± 100 PSI (13,100 ± 690 kPa)

If unable to get specified pressure, check for:
- Worn or stuck relief valve.
- Internal leakage of remote cylinder(s).

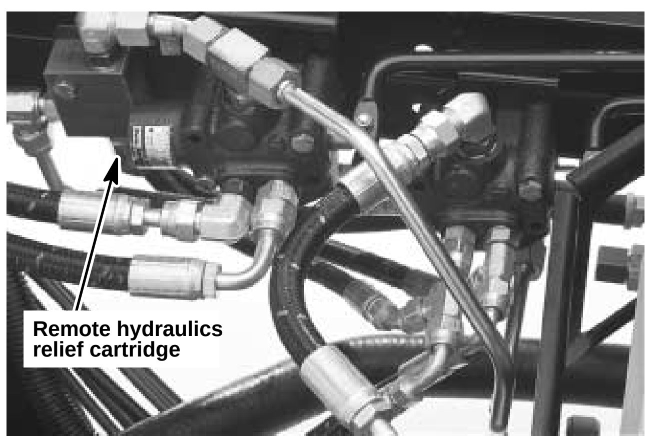


Figure 12

TEST NO. 3: Power Steering Relief Pressure(Units with Lift Capabilities Only)

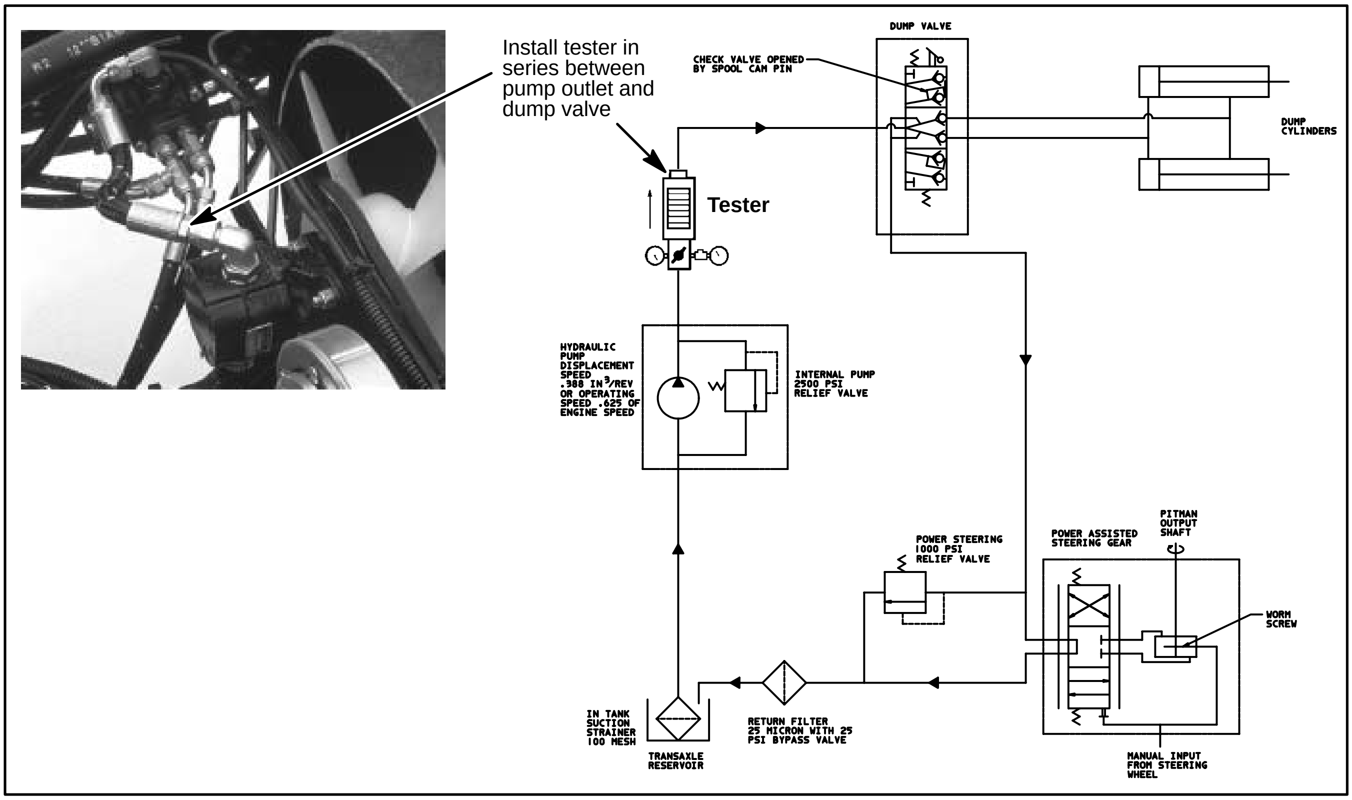


Figure 13

IMPORTANT: This test can be performed on units with dump cylinders installed. Units without dump cylinders installed do not have a separate relief valve installed for the steering valve.

1. Make sure hydraulic oil is at normal operating temperature before performing tests.

2. Raise and support dump box, if equipped, then engage parking brake and stop the engine.

3. Install tester in series between pump outlet (pressure hose) and dump valve. Make sure tester flow control valve is open.

CAUTION

The engine must be running to perform hydraulic tests. To guard against possible personal injury, engage parking brake and keep clothing, hands, feet, face and other parts of the body away from fan or other moving parts.

4. Start the engine and operate at full speed (3,600 RPM). Leave tester flow control valve open. While watching pressure gauges turn steering wheel all the way to stop and hold so oil flow goes over relief.

Steering relief pressure	1,000 ± 100 PSI (6,895 ± 690 kPa)

If unable to get specified pressure, check for worn or stuck relief valve.

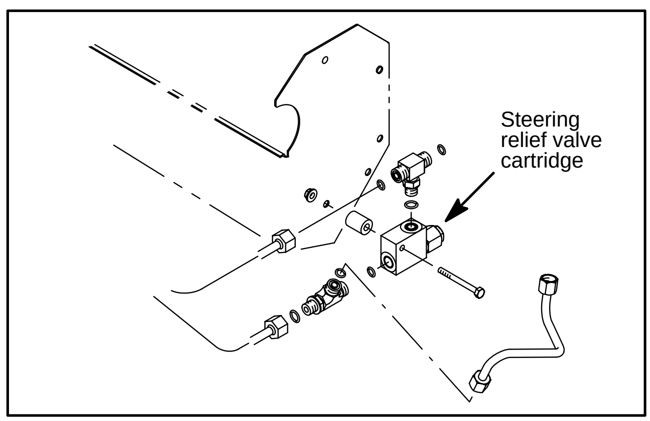


Figure 14

TEST NO. 4: Lift Cylinder Internal Leakage Test.

1. Remove all pressure from cylinder by fully retracting it (e.g. put hydraulic dump lever in LOWER position).

2. Shut of engine and engage parking brake.

3. Disconnect hose from base end of cylinder and install a steel plug with o–ring seal in the hose. Clean any remaining oil off of cylinder port.

4. Start engine and apply pressure to rod end of cylinder (e.g., put hydraulic dump lever in LOWER position).

5. If any oil comes out of open cylinder port, cylinder has an internal leak. Repair or replace cylinder.

6. Reconnect hose disconnected in step 3 after test or repairs are complete.

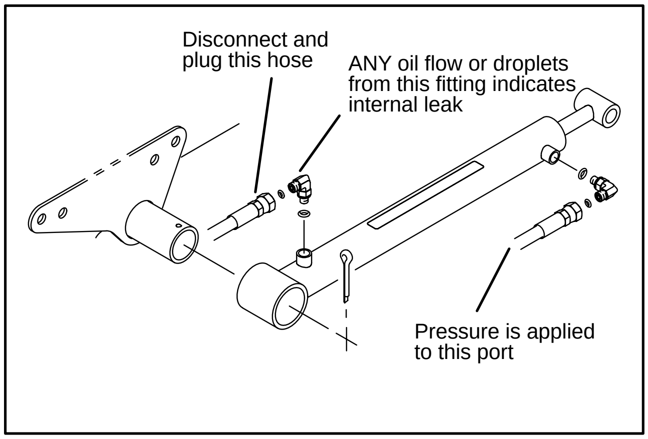


Figure 15

Service and Repairs

Removing Hydraulic System Components

1. Thoroughly clean the machine before disconnecting, removing 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 or fittings left open or exposed.

3. Put labels on disconnected hydraulic lines and hoses for proper installation after repairs are completed.

After Repair or Replacement of Components

1. Check oil level in hydraulic reservoir and add correct oil if necessary. Drain and refill hydraulic system reservoir and change oil filter if component failure was severe or system is contaminated.

2. After repairs, check control linkage for proper adjustment, binding or broken parts.

3. After disconnecting or replacing any hydraulic components, operate machine functions slowly until air is out of system.

4. Check for hydraulic oil leaks. Shut off engine and correct leaks if necessary. Check oil level in hydraulic reservoir and add correct oil if necessary.

Pump Drive Shaft Service (Workman 3200/3300–D)

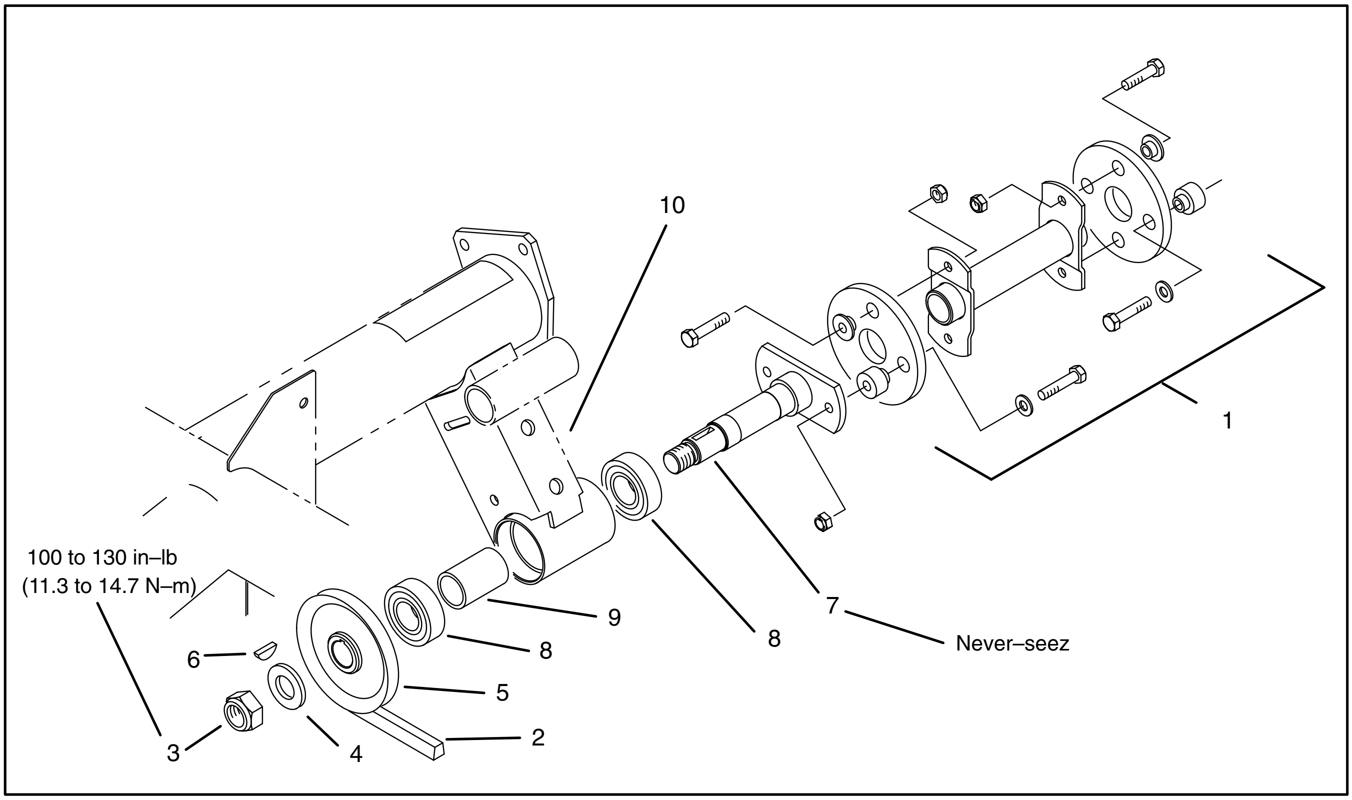


Figure 16

1. Driveshaft assembly	**5. Pulley**	**8. Bearing**
2. Belt	**6. Woodruff key**	**9. Spacer**
3. Locknut	**7. Driveshaft**	**10. Support bracket**
4. Washer		

1. Disassemble and reassemble as shown in Figure 16.

2. Do not reuse bearings (Item 8) if removed. Replace with new bearings.

3. Inspect support bracket for wear or damage.

4. Inspect spacer (Item 9) for wear or damage. Also, check that spacer length is from 1.884” to 1.894” (47.85 to 48.10 mm). Replace spacer if necessary.

5. To install bearings (Item 8) into support bracket:

   A. Install pulley side bearing into support bracket by pressing on outer race until bearing contacts shoulder in support bracket.

   B. Place the spacer (Item 9) into bracket cavity.

   C. Install second bearing into bracket by pressing on the outer race until bearing inner race contacts spacer.

6. Apply never–seez or equivalent to pulley end of driveshaft (Item 7) before installing woodruff key (Item 6) and pulley (Item 5).

7. Secure pulley to driveshaft with washer and locknut. Torque locknut from 100 to 130 in–lb (11.3 to 14.7 N–m).

Pump Removal and Installation (Excluding Models with Air Cooled Engines)

Removal

1. Loosen fan belt and remove from drive pulley.

2. Disconnect hydraulic lines from pump (Item 11). Install caps or plugs in hydraulic lines to prevent contamination and leakage of hydraulic oil. Install plugs in pump ports.

3. Remove fan mount bracket (Item 1) with pump attached.

4. Remove parts as shown in illustration.

Installation

1. Install parts as shown in illustration and using the following instructions.

2. Apply never–seez or equivalent to shaft of pump (Item 11) before installing pulley (Item 7).

3. After installing key and pulley, tighten locknut (Item 5) to a torque of 130 – 160 in–lb (150 – 184 kgcm).

4. Install pump suction line, then fill pump through pressure port, with clean hydraulic oil.

5. After installing the pump and connecting hydraulic lines, adjust belt tension (see Chapter 3 – Liquid Cooled Gas Engine or Chapter 4 – Liquid Cooled Diesel Engine). Start the engine and operate at idle speed until air is out of hydraulic system.

6. Stop the engine and check oil level in transaxle. Add oil (Dexron III) if necessary.

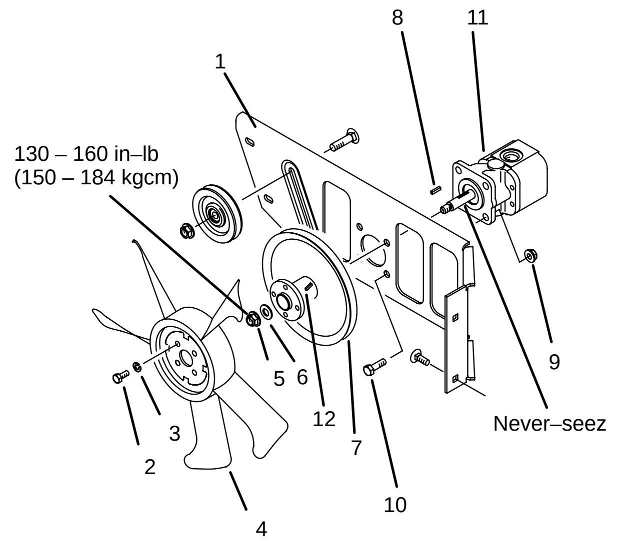


Figure 17

1. Fan mount bracket
2. Capscrew
3. Lockwasher
4. Fan
5. Flange locknut
6. Flat washer
7. Pulley
8. Square key
9. Flange locknut
10. Capscrew
11. Hydraulic pump
12. Set screw

Hydraulic System

Pump Removal and Installation (Models with Air Cooled Engines Only)

Removal

1. Disconnect hydraulic lines from pump (Item 9). Install caps or plugs in hydraulic lines to prevent contamination and leakage of hydraulic oil. Install plugs in pump ports.

2. Disassemble parts as shown in illustration.

Installation

1. Install parts as shown in illustration and using the following instructions.

2. Apply never–seez or equivalent to shaft of pump (Item 9) before installing pulley (Item 4).

3. After installing key and pulley, tighten locknut (Item 4) to a torque of 130 – 160 in–lb (150 – 184 kgcm).

4. Install pump suction line, then fill pump through pressure port, with clean hydraulic oil.

5. After installing the pump and connecting hydraulic lines, adjust belt tension (see Chapter 5 – Air Cooled Gas Engine). Start the engine and operate at idle speed until air is out of hydraulic system.

6. Stop the engine and check oil level in transaxle. Add oil (Dexron II) if necessary.

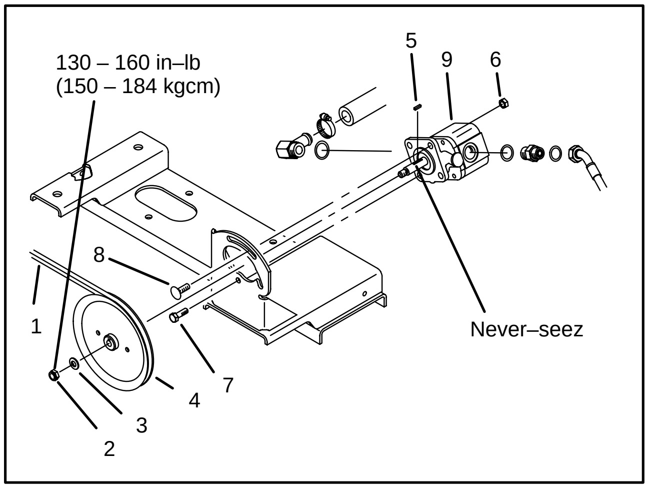


Figure 18

1. Belt
2. Locknut
3. Flat washer
4. Pulley
5. Square key
6. Locknut
7. Capscrew
8. Carriage bolt
9. Hydraulic pump

Pump Repair

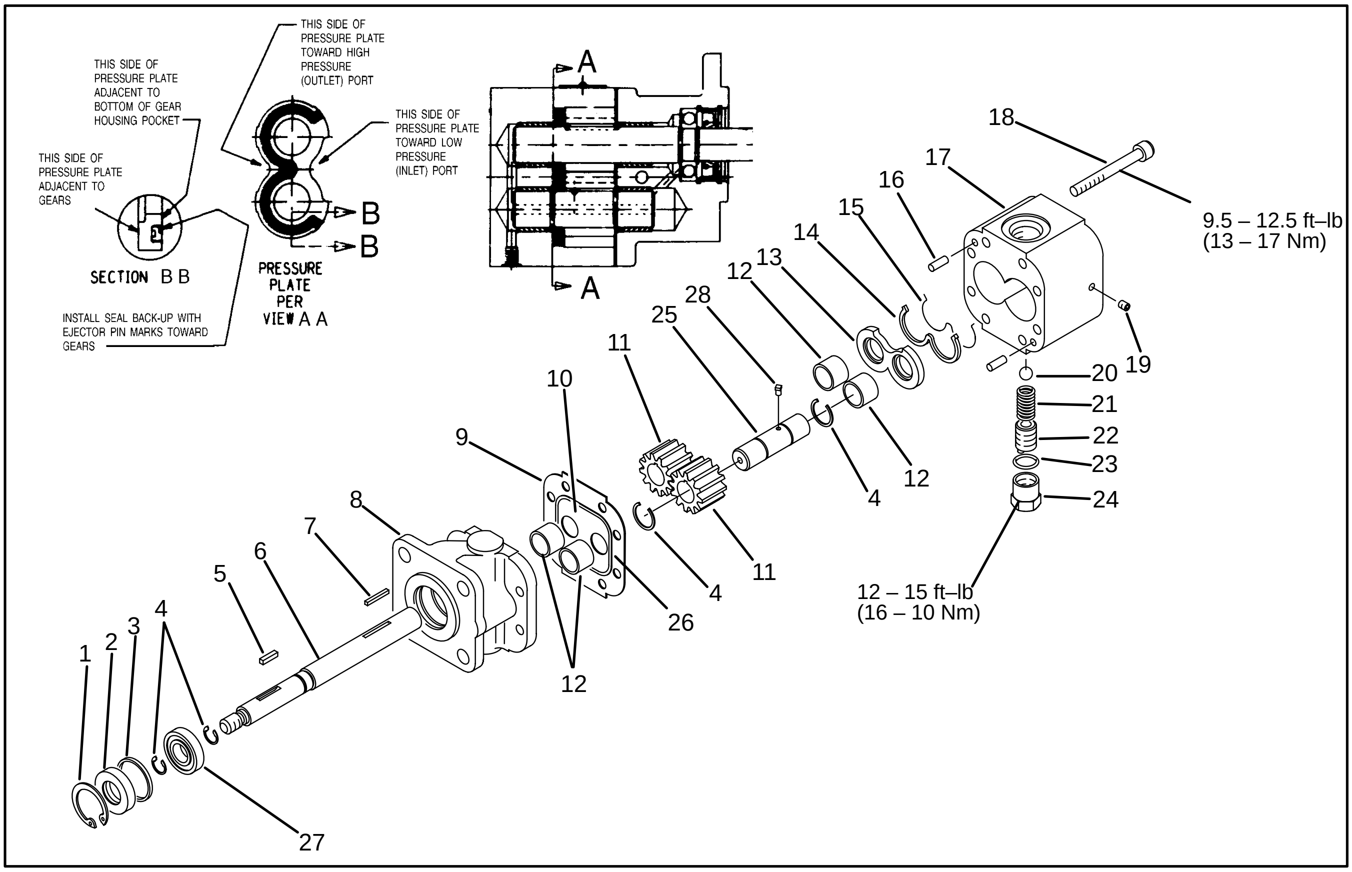


Figure 19

1. Retaining ring	**11. Gear**	**20. Ball**
2. Oil seal	**12. Bearing**	**21. Spring**
3. Spacer	**13. Pressure plate**	**22. Adjusting screw**
4. Crescent ring	**14. Back–up seal**	**23. Copper gasket**
5. Square key	**15. Pressure plate seal**	**24. Relief valve cap**
6. Driveshaft	**16. Dowel pin**	**25. Idler shaft**
7. Shear pin	**17. Gear end housing**	**26. Seal**
8. Stator	**18. Socket head capscrew**	**27. Bearing**
9. Seal plate	**19. Plug**	**28. Ball Key**
10. Wear plate		

Before disassembling pump, plug ports, wash exterior with cleaning solvent and dry thoroughly.

Shaft Seal Replacement

1. Remove retaining ring (Item 1).

2. Punch two (2) holes in face of seal, 180° apart, and install metal screws. Remove seal by grasping and pulling on screws.

IMPORTANT: Do not try to pry seal out of housing. This can damage the shaft seal bore so oil will leak past the seal.

3. Remove and discard seal (Item 2). Remove spacer (Item 3).

4. Clean seal bore and shaft on pump so it is free of any foreign material.

5. Install spacer (Item 3) on driveshaft.

6. Put a seal protector tool on driveshaft or apply thin plastic or tape on shaft to protect seal from damage.

7. Apply grease or petroleum jelly to inside diameter of new seal.

8. Use a seal installation tool to install new seal (Item 2). Make sure seal is installed square with seal bore.

9. Install retaining ring (Item 1).

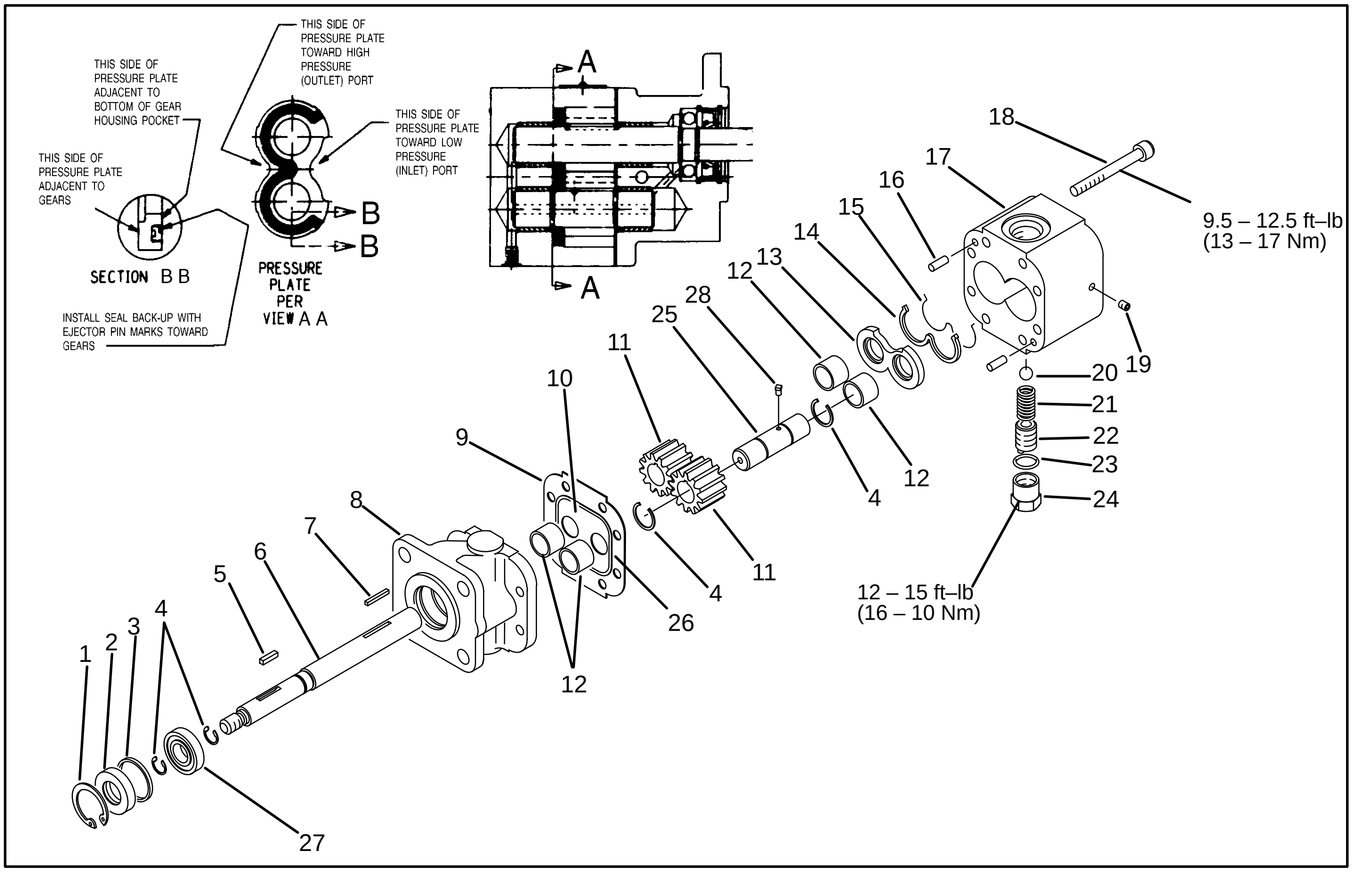


Figure 20

1. Retaining ring	**11. Gear**	**20. Ball**
2. Oil seal	**12. Bearing**	**21. Spring**
3. Spacer	**13. Pressure plate**	**22. Adjusting screw**
4. Crescent ring	**14. Back–up seal**	**23. Copper gasket**
5. Square key	**15. Pressure plate seal**	**24. Relief valve cap**
6. Driveshaft	**16. Dowel pin**	**25. Idler shaft**
7. Shear pin	**17. Gear end housing**	**26. Seal**
8. Stator	**18. Socket head capscrew**	**27. Bearing**
9. Seal plate	**19. Plug**	**28. Ball Key**
10. Wear plate		

Relief Valve Service

1. Remove cap (Item 24). Remove o–ring (Item 23) from cap.

2. Remove adjusting screw (Item 22), spring (Item 21) and ball (Item 20). NOTE: Count number of turns it takes to unthread adjusting screw so it can be reinstalled for the same approximate pressure setting.

3. Inspect ball for burrs or roughness. Inspect relief valve bore and seat inside gear end housing (Item 17). Inspect spring for damage. Replace any worn or damaged parts.

4. Clean and dry all parts. Apply clean hydraulic oil to parts.

5. Install ball (Item 20), spring (Item 21) and adjusting screw (Item 22).

6. Install new o–ring (Item 23). Apply clean hydraulic oil to o–ring and install cap (Item 24).

7. Check relief pressure and adjust if necessary after installing pump in machine (see TEST NO.1 – Pump Flow and Relief Pressure).

Disassembly

1. Remove shaft seal (see Shaft Seal Replacement).

2. Remove relief valve (see Relief Valve Service).

3. Secure flange end of pump (Item 8) in a vise with driveshaft (Item 6) facing down.

IMPORTANT: Use caution when using a vise to avoid distorting any parts.

4. Remove four (4) socket head capscrews (Item 18).

5. Put you hand on gear end housing (Item 17) and gently tap housing with a soft face hammer to loosen from stator (Item 8). Be careful not to drop any parts or disengage gear mesh.

6. Before removing gears (Item 11), apply marking dye to mating teeth to retain ”timing” and location when reassembling.

7. Remove and discard the pressure plate seal (Item 15), back–up seal (Item 14) and seal (Item 26) as the pump is disassembled.

8. Press driveshaft and bearing assembly (Item 6, 27, 4) out of stator (Item 8). Remove crescent rings (Item 4), then remove bearing from driveshaft

Inspection

1. Wash all parts in cleaning solvent.

2. Check all parts for burrs, scoring, nicks, etc.

3. Check bearings (Item 12) in stator and gear end housing for excessive wear or scoring. Replace the assemblies as necessary. Replace wear plate (Item 10) if it appears scored, then stone face of gears. Replace gears if if excessively worn or damaged.

4. Check bearing (Item 27) for smooth operation. Replace bearing if loose on shaft or noisy when rotated.

5. Inspect square key (Item 5), shear pin (Item 7), ball key (Item 28) and keyways for wear or damage and replace parts as necessary.

Reassembly

1. Install one crescent ring (Item 4) on inside portion of driveshaft (Item 6), then install bearing (Item 27) and other crescent ring. Install driveshaft and bearing assembly into stator (Item 8).

2. Apply oil to wear plate (Item 10) and install on stator.

3. Install one crescent ring (Item 4) to idler shaft, then install ball key (Item 28), gear (Item 11) and other crescent ring. Apply oil to gear and idler shaft assembly, then install into stator.

4. Install shear pin (Item 7), then apply oil to other gear and install to driveshaft (Item 6) maintaining the original timing and locations.

5. Apply oil to pressure plate seal (Item 15), back–up seal (Item 14) and pressure plate (Item 13), then install into gear end housing.

6. Install dowel pins (Item 16). Apply oil to seal plate (Item 9) and seal (Item 26), then install. Assemble gear end housing (Item 17) to stator (Item 8). In capscrews (Item 18) and tighten in a crossing pattern to 9.5 – 12.5 ft–lb (13 – 17 Nm).

7. Install relief valve (see Relief Valve Service).

8. Install shaft seal (see Shaft Seal Replacement).

Lift Valve Repair

1. After removing control valve, wash valve in solvent and dry thoroughly.

2. Carefully mount control valve in a vise so that control valve mounting pads are against jaws of vise. Control valve spool snap ring (Item 15) should be facing up.

3. Remove hex cap plug (Item 1) from side of valve body. Inside valve body, behind each hex cap plug, there is a spring (Item 3), ball (Item 4) and cam pin (Item 6); remove these parts.

4. Remove snap ring (Item 15) from spool (Item 8). Carefully push and twist spool to remove from valve body.

5. Use a hooked scribe or thin screwdriver to remove o–rings from inside bore of valve body (be careful not to scratch valve bore finish). These o–rings are the seals for the spool. Inspect all components for wear, paying special attention to the spool. Signs of wear on one side of the spool may indicate a bent spool. Inspect the spool for flatness and replace if necessary.

6. Use new o–rings when reassembling. Before reassembly, coat all o–rings with clean hydraulic oil. Install spool into valve body before inserting cam pins, balls, springs and hex plugs.

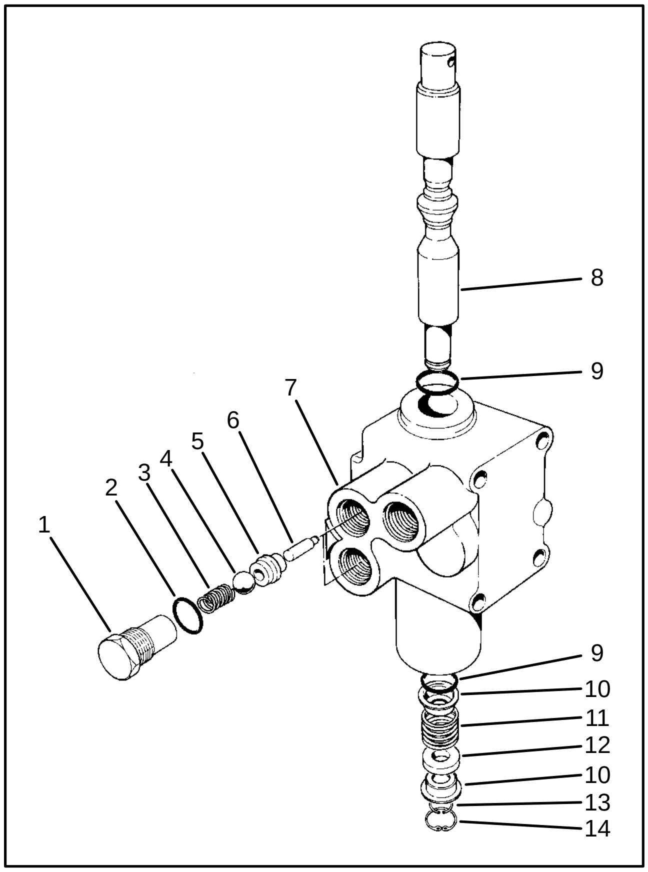


Figure 21

1. Plug
2. O–ring
3. Spring
4. Ball
5. Check valve seat
6. Cam pin
7. Body
8. Spool
9. O–ring
10. Spring retainer
11. Spring
12. Spacer
13. Spool retaining ring
14. Retaining ring

Lift Cylinder Repair

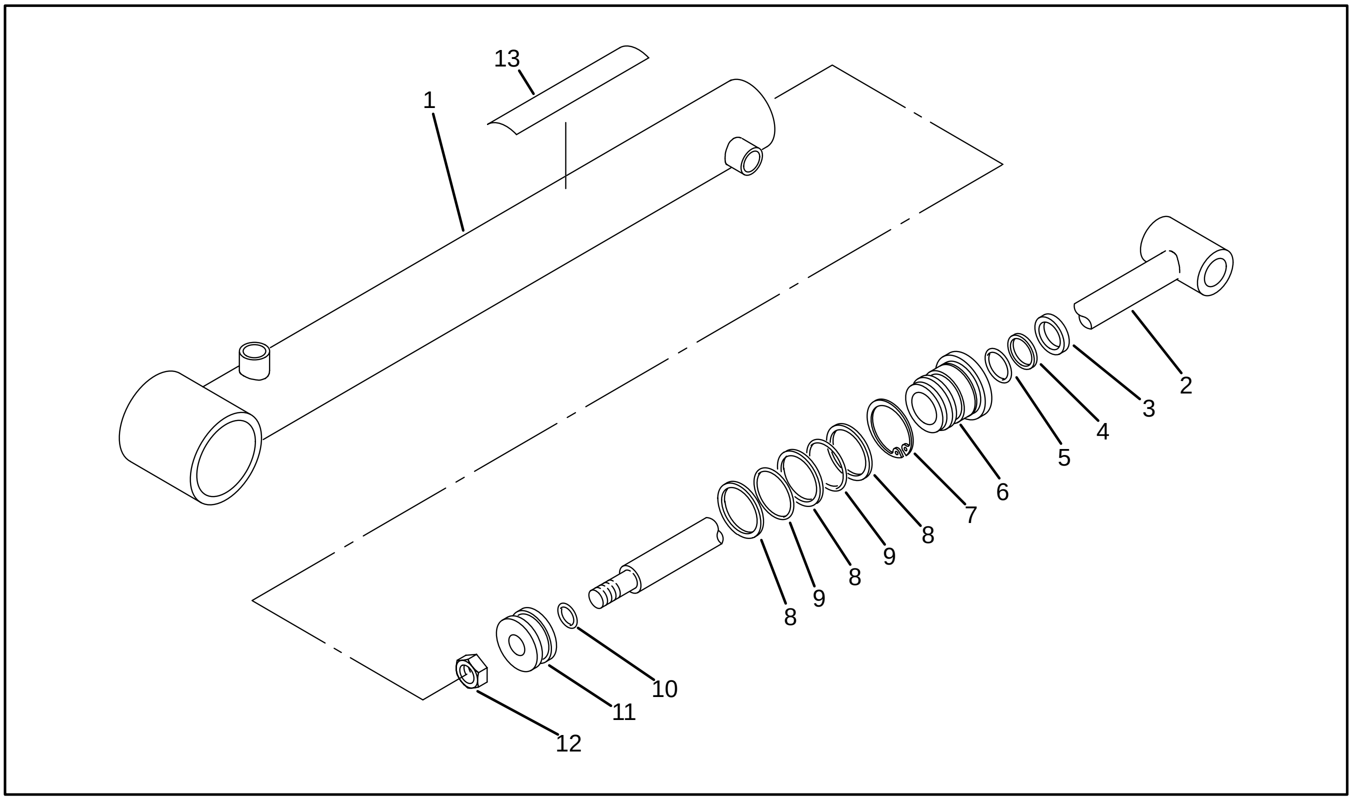


Figure 22

1. Barrel
2. Shaft
3. Dust seal
4. Backup ring
5. O–ring seal
6. Head
7. Retaining ring
8. Backup ring
9. O–ring seal
10. O–ring seal
11. Piston
12. Nut
13. Warning decal

Disassembly

1. Pump oil out of cylinder into a drain pan by slowly moving piston back and forth.

2. Before disassembling cylinder, plug ports, wash exterior with cleaning solvent and dry thoroughly.

IMPORTANT: Use caution when using a vise to avoid scratching or distorting any parts.

3. Put cylinder in a vise so shaft end is facing up.

4. Use a spanner wrench to rotate head (Item 11) and remove retaining ring (Item 7). Grasp end of shaft and use a twisting and pulling motion to carefully extract the piston, shaft and head assembly from the barrel.

5. Remove cylinder from vise.

6. Remove nut (Item 12) from shaft, then remove piston (Item 11), and head (Item 6). Remove and discard seals and back–up rings (Items 3 – 5 & 8 – 10).

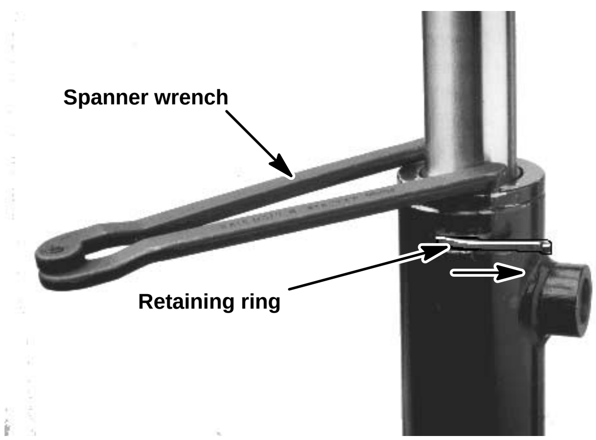


Figure 23

Removing retaining ring

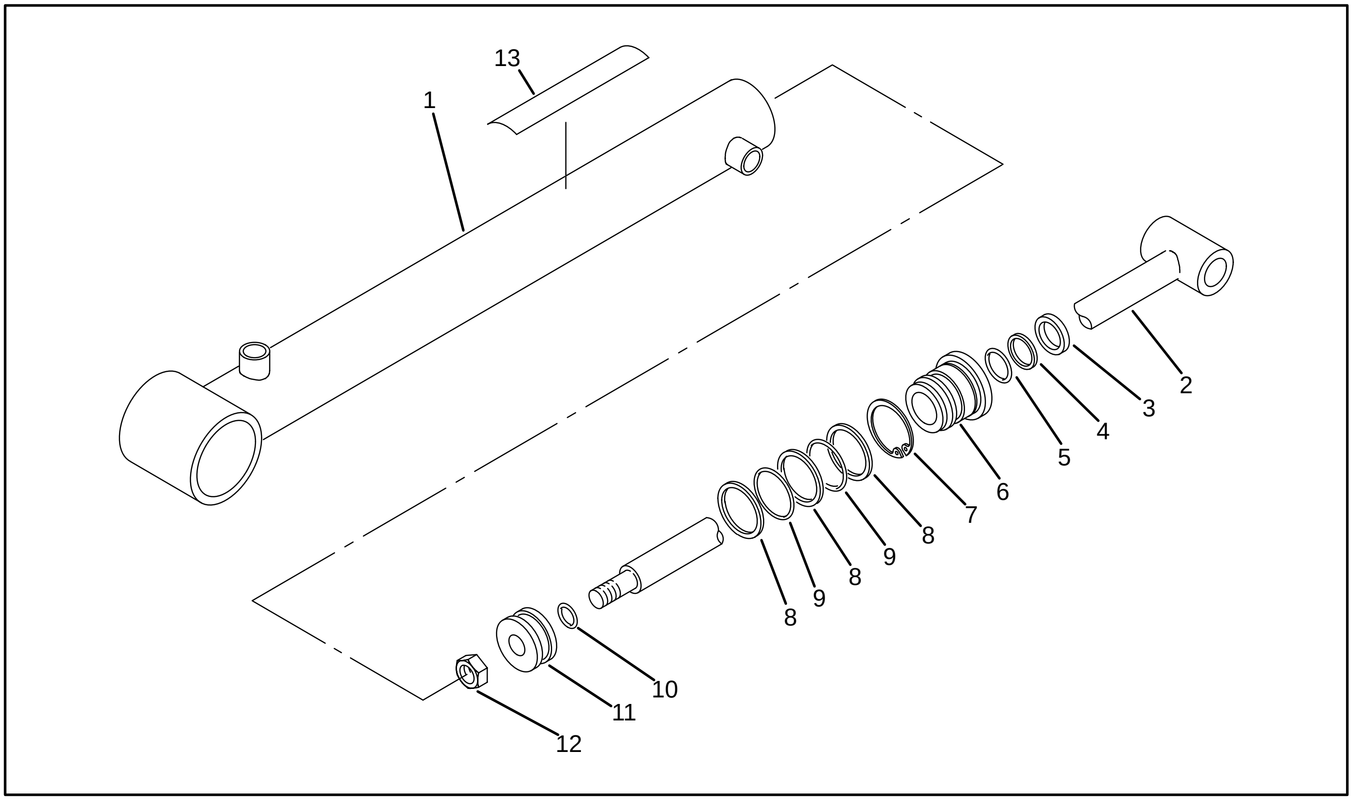


Figure 24

1. Barrel
2. Shaft
3. Dust seal
4. Backup ring
5. O–ring seal
6. Head
7. Retaining ring
8. Backup ring
9. O–ring seal
10. O–ring seal
11. Piston
12. Nut
13. Warning decal

Inspection

1. Inspect head (Item 6), piston (Item 11) and shaft (Item 1) for excessive scoring, pitting or wear. Replace any worn or damaged parts.

2. Inspect inside of barrel for scoring, pitting or out–of–round and replace if worn or damaged.

Assembly

1. Use a new repair kit (Items 3 – 5 & 8 – 10) to replace all o–rings. seals and back–up rings. Apply clean hydraulic oil to all o–rings, seals, back–up rings before installing.

2. Install head (Item 6) with new seals onto shaft (Item 2). Install piston (Item 11) with new seals and back–ups onto shaft. Install piston onto shaft and secure with nut (Item 12).

3. Coat all cylinder parts with clean hydraulic oil. Slide shaft assembly and head into barrel, being careful not to damage seals.

4. Install retaining ring (Item 7) to secure assembly in barrel. To install retaining ring, align key slot in head with access groove in barrel. Rotate head clockwise as far as the retaining ring will allow. Offset end of retaining ring will be against left side of barrel groove as shown.

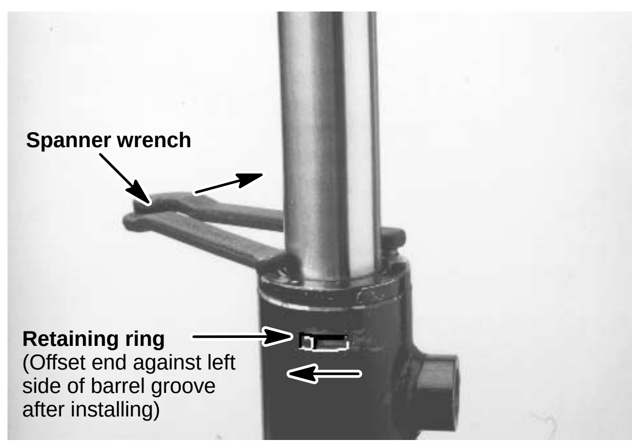


Figure 25

Installing retaining ring

Chapter 10

Front Wheel Drive – 4WD

Table of Contents

Specifications

Item	Description
Front Differential	5.0 to 1 ratio, single reduction
Front Brakes	Hydraulically operated, self adjusting, 8–inch diameter drum
Bidirectional Clutch	Overrunning type

General

The “Automatic on Demand” four wheel drive feature, on this vehicle, does not require operator activation. The front wheel drive is not engaged (no power delivered to front wheels) until the rear wheels begin to lose traction. The bidirectional clutch senses the rear wheels slipping, engages the front wheel drive, and delivers power to the front wheels. The four wheel drive system continues to deliver power to the front wheels until the rear wheels have enough traction to move the vehicle without slipping. Once this occurs, the system stops delivering power to the front wheels and the handling characteristics become similar to that of a two wheel drive vehicle. The four wheel drive system functions in both froward and reverse, however, when turning the rear wheels will slip slightly more before power is delivered to the front wheels.

Check Front Differential Oil

The differential is filled with 10W30 oil. Check level of oil every 100 hours or monthly. Capacity of system is 1 qt.

1. Position the vehicle on a level surface.

2. Clean area around fill/check plug on the side of differential.

3. Remove fill/check plug and check level of oil. Oil should be up to the hole. If oil is low, add 10W30 oil.

4. Re–install fill/check plug.

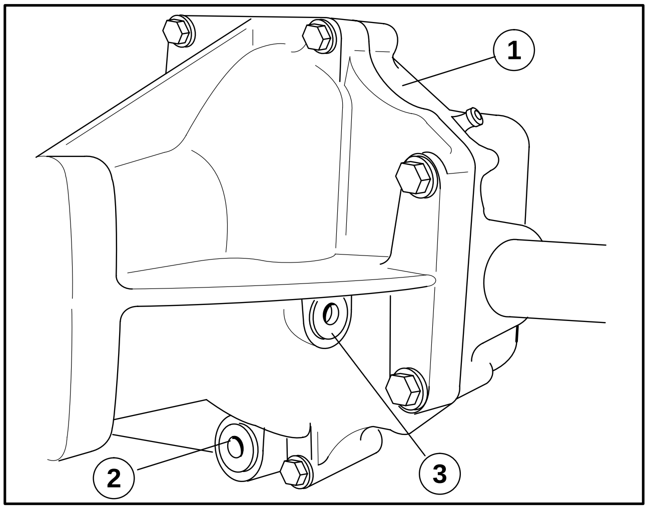


Figure 1

1. **Front differential**
2. **Drain plug**
3. **Fill/check plug**

Front Wheel Assembly

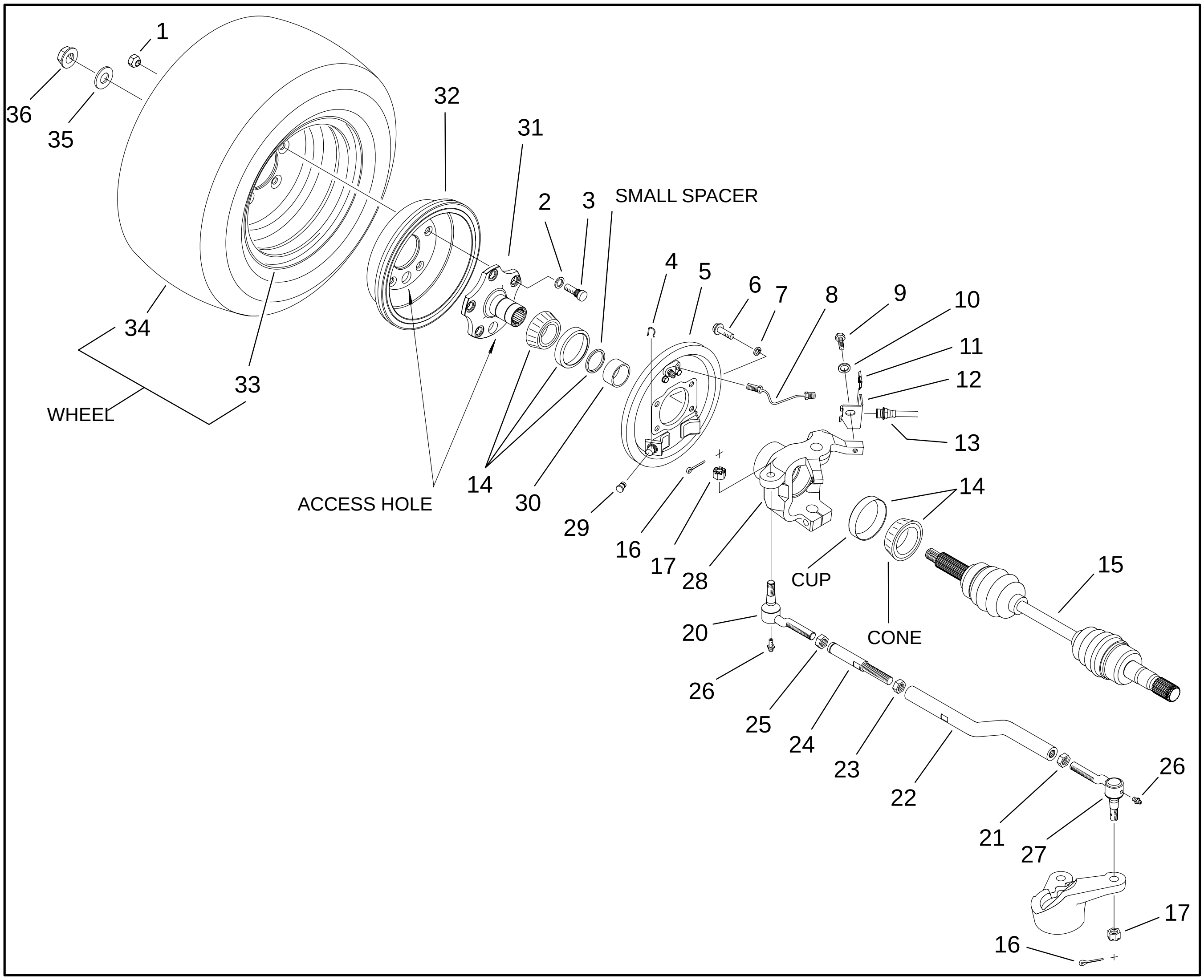


Figure 2

1. **Lug nut**
2. **Lock washer**
3. **Cap screw**
4. **Brake cable clip**
5. **Brake assembly**
6. **Cap screw**
7. **Lock washer**
8. **Brake tube**
9. **Cap screw**
10. **Flat washer**
11. **Retainer**
12. **Brake hose bracket**
13. **Front brake hose**
14. **Bearing (matched set)**
15. **Constant velocity (CV) joint**
16. **Cotter pin**
17. **Slotted hex nut**
18. **Not used**
19. **Not used**
20. **Tie rod end**
21. **Jam nut**
22. **Tie rod**
23. **Jam nut**
24. **Turnbuckle**
25. **Jam nut**
26. **Grease fitting**
27. **Tie rod end**
28. **Axle housing**
29. **Plug**
30. **Large spacer**
31. **Stub axle**
32. **Brake drum**
33. **Rim**
34. **Tire**
35. **Flat washer**
36. **Flange lock nut**

Front Wheel Bearing

Disassembly (Fig. 2)

1. Park machine on a level surface. Make sure engine is off. Set parking brake and block rear wheels.

2. Partially loosen lug nuts (1). Jack up and secure front wheel off the ground (see Jacking Vehicle in Chapter 1 – Safety). Remove lug nuts and wheel from the brake drum (32).

3. Remove brake drum (32) from the cap screws (3) and stub axle (31).

4. Remove flange lock nut (36) and flat washer (35) from the threaded shaft of the CV joint (15) and stub axle (31).

5. Pull stub axle (31) and bearing (14) cone from the axle housing (28). Remove large spacer (30) and small spacer from the axle housing. Remove remaining bearing (14) cone from the housing.

6. Remove cap screw (9) and flat washer (10) securing the brake hose bracket (12) to the axle housing (28).

7. Remove four cap screws (6) and lock washers (7) securing the brake assembly (5) to the axle housing (28). Secure assembly clear of the housing.

8. Remove cotter pin (16) and slotted hex nut (17) from the tie rod end assembly (20). Disconnect end assembly from the axle housing (28).

9. Remove axle housing (28) from the suspension as follows (Fig. 3):

   A. Remove cotter pin and slotted hex nut from the upper ball joint. Separate upper ball joint from the axle housing.

   B. Remove lock nut and cap screw from the axle housing. Separate lower ball joint from the axle housing. Separate axle housing from the CV joint.

   C. Remove remaining bearing cone from the housing.

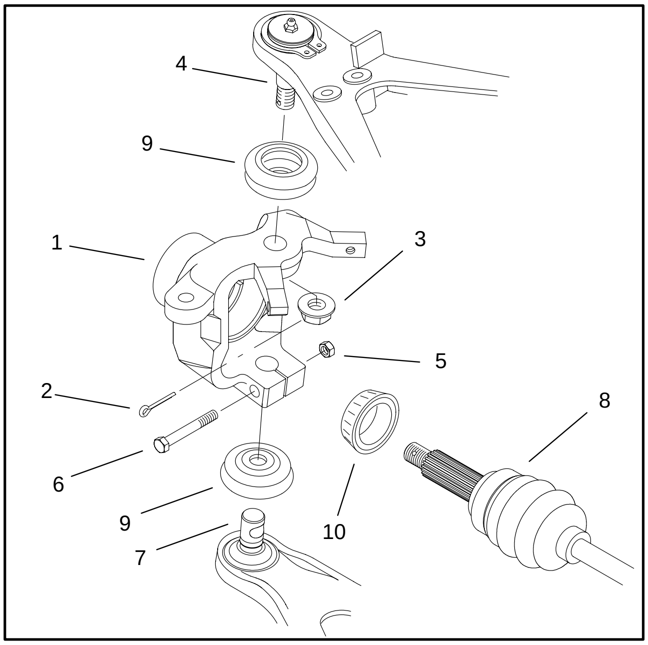


Figure 3

1. Axle housing	**6. Cap screw**
2. Cotter pin	**7. Lower ball joint**
3. Slotted hex nut	**8. CV joint**
4. Upper ball joint	**9. Ball joint seal**
5. Lock nut	**10. Bearing cone**

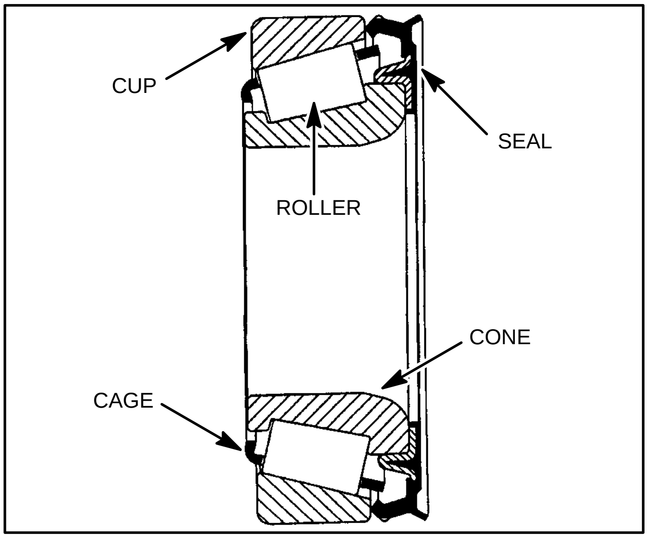


Figure 4

Inspection (Fig. 2)

IMPORTANT:If any part of a bearing (14) needs replacement, replace bearings as a matched set.

1. If foreign material is in the bearing, clean bearing and determine cause of the material. Replace bearings (14) if any of the following conditions occur (Fig. 4):

   A. Spalling or pitting on roller or cone contact surfaces. Corrosion that can not be cleaned up with light polishing.

   B. The rib face on the cone is worn back, or roller ends are worn or scored. The roller cage is cracked or broken.

   C. Peeling, gouges, or nicks inside the cup or on rollers. Scalloping, high spots, brinelling, or burrs in the cups.

   D. The seal attached to the bearing cone is cracked, torn, or damaged.

2. If ball joint seals are torn or cracked, replace seals and lubricate ball joints (Fig. 3).

3. Replace worn or cross–threaded cap screws (3) or lug nuts (1).

4. Replace large spacer (30) if worn or damaged.

Assembly (Fig. 2)

1. If cap screws (3) were removed from the stub axle (31), Install new cap screws and lock washers (2) to the stub axle. Apply Loctite 680 or equivalent to the threads near the head of the cap screws. Torque cap screws from 40 to 60 ft–lb (5.5 to 8.3 kg–m).

IMPORTANT: Bearing cones (14) and bearing cups (14) are part of a matched set; these parts are not interchangeable. Use one bearing set per axle housing (28).

2. If a bearing cup (14) was removed from the axle housing (28), press **new** bearing cups into each end of the axle housing (28).

3. Pack both bearing (14) cones with Mobile high temperature grease or equivalent. If the bearing cone was removed from the stub axle (31), slide wide end of **new** bearing cone onto the shaft of the stub axle and press cone onto the shaft (Fig. 5).

4. Insert shaft of the stub axle (31) into the axle housing (28). Slide small spacer onto the shaft, then slide large spacer (30) onto the shaft.

5. Slide bearing (14) cone, with its narrow end first, onto the shaft of the stub axle (31).

6. Apply No. 2 general purpose grease to the splines of the CV joint (15).

7. Position brake backing plate assembly (5) to the axle housing (28). Secure brake assembly to the axle housing with four cap screws (6) and lock washers (7).

8. Position stub axle (31)/axle housing (28) assembly to the CV joint (15). Insert splined end of the CV joint into the stub axle.

9. Apply Loctite 271 or equivalent to the threads of the CV joint (15). Install flat washer (35) and flange lock nut (36) to the CV joint threads.

10. Install suspension to the axle housing (28) as follows (Fig. 3):

A. Connect lower ball joint to the axle housing. Install cap screw and lock nut to the axle housing.

IMPORTANT: If the cotter pin does not align, tighten slotted hex nut until the key hole is aligned. Make sure cotter pin has a 0.002 inch (0.005 cm) clearance from the CV joint boot.

B. Connect upper ball joint to the axle housing. Install slotted hex nut and cotter pin to the ball joint.

C. Torque flange lock nut (36) from 170 to 200 ft–lb (23.5 to 27.7 kg–cm).

IMPORTANT: If the cotter pin does not align, tighten slotted hex nut until the key hole is aligned.

11. Connect tie rod assembly (20) to the axle housing (28). Secure slotted hex nut (17) and cotter pin (16) to the tie rod end assembly.

12. Secure brake hose bracket (12) to the axle housing (28) with cap screw (9) and flat washer (10).

Note: Make sure access hole on both the brake drum and stub axle align when installed.

13. Install brake drum (32) to stub axle (31) with cap screws (3).

14. Secure wheel to the brake drum (32) with five lug nuts (1). Lower front wheel to the ground. Torque lug nuts from 45 to 55 ft–lb (6.2 to 7.6 kg–m).

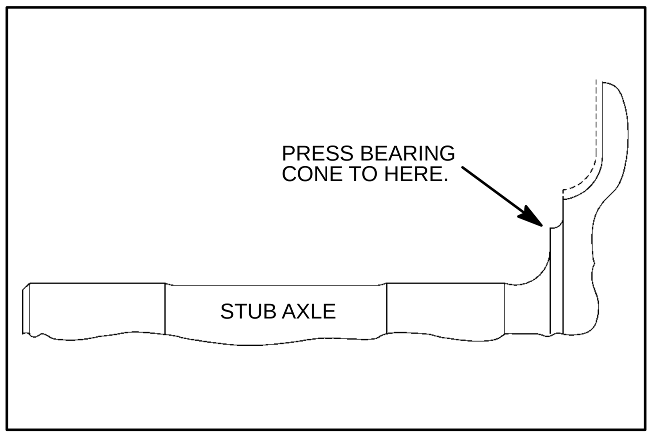


Figure 5

Front Brake

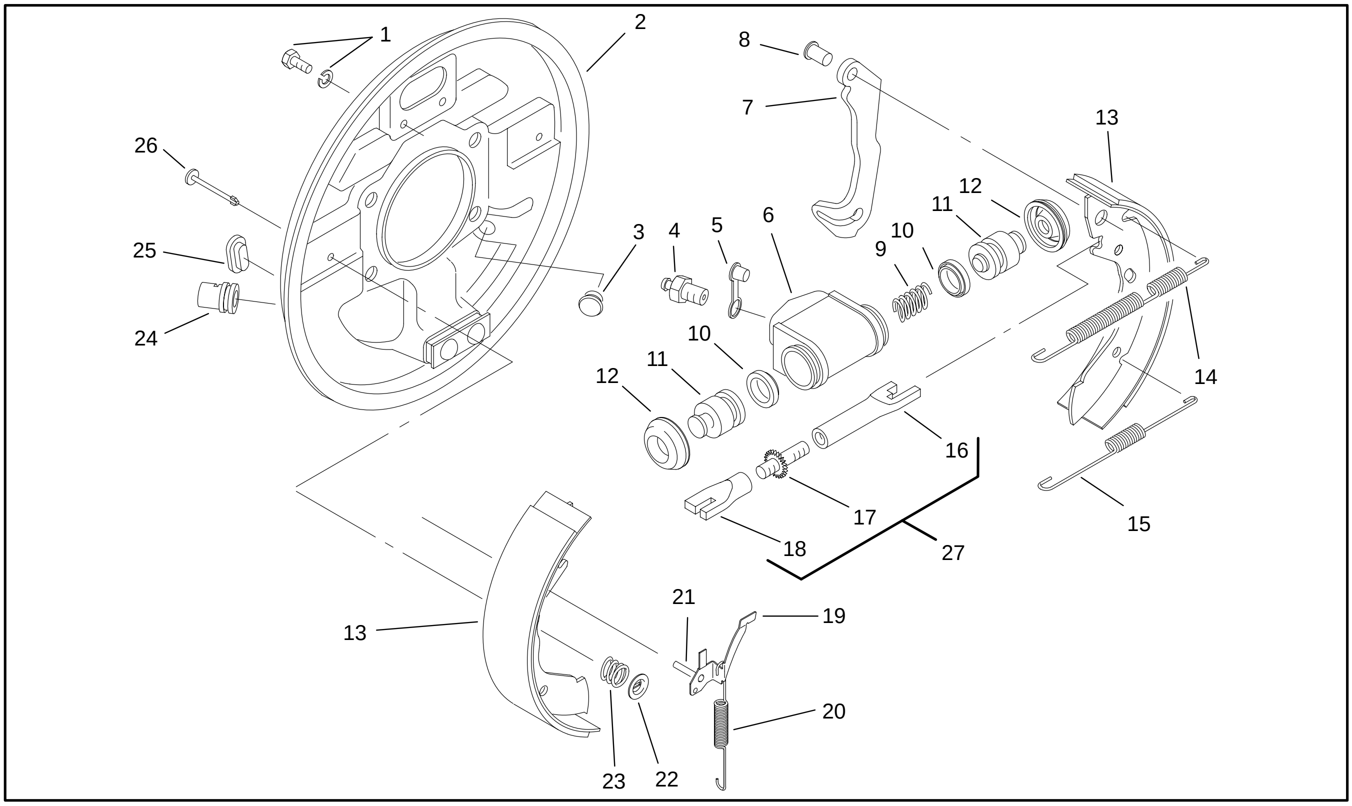


Figure 6

1. **Cap screw and lock washer**
2. **Back plate**
3. **Plug**
4. **Bleed screw**
5. **Bleed screw cap**
6. **Cylinder body**
7. **Operating lever**
8. **Pin**
9. **Spring**
10. **L–type seal**
11. **Piston**
12. **Dust cover**
13. **Brake shoe**
14. **Upper shoe spring**
15. **Lower shoe spring**
16. **Female push rod**
17. **Bolt adjuster**
18. **Adjuster sleeve**
19. **Pawl**
20. **Adjuster spring**
21. **Pawl pin**
22. **Hold down washer**
23. **Hold down spring**
24. **Pipe guide**
25. **Inspection plug**
26. **Hold down pin**
27. **Adjuster assembly**

Removal (Fig. 2)

1. Park machine on a level surface. Make sure engine is off. Set parking brake and block rear wheels.

2. Partially loosen lug nuts (1). Jack up and secure front wheel off the ground (see Jacking Vehicle in Chapter 1 – Safety). Remove lug nuts and wheel from the brake drum (32).

Note: If the brake drum sticks to the brake shoes (13) during removal, loosen brake shoes from the drum by turning bolt adjuster (17) (Fig. 6).

3. Remove brake drum (32) from the cap screws (3) and stub axle (31).

4. Remove flange lock nut (36) and flat washer (35) from the threaded shaft of the CV joint (15) and stub axle (31).

5. Pull stub axle (31) and bearing (14) cone from the axle housing (28) and the splined end of the CV joint (15). Make sure large spacer (30) and small spacer come out with the stub axle.

Note: It may be necessary to remove the brake assembly (5) from the axle housing (28) for servicing parts such as the brake cylinder assembly.

6. If necessary, remove brake assembly (5) as follows:

A. Disconnect brake tube (8) from the brake assembly (5) and brake hose (13). Plug front brake hose (13).

B. Remove brake assembly from the axle housing (28) by removing the four cap screws (6) and lock washers (7) from the housing.

Disassembly (Fig. 6 and 7)

Note: The front brake assembly may be disassembled as necessary for inspection and repairs.

1. Remove upper shoe spring (14), adjuster spring (20), and then lower shoe spring (15).

Note: The adjuster assembly (27) consists of the female push rod (16), bolt adjuster (17), and adjuster sleeve (18).

2. Remove hold down washers (22) and hold down springs (23) from the hold down pins (26). Remove brake shoes (13), pawl (19), and adjuster assembly (27).

Note: The brake cylinder assembly consists of the following: bleed screw (4), bleed screw cap (5), body (6), spring (9), L–type seals (10), pistons (11), and dust covers (12)

3. Disassemble brake cylinder assembly as follows:

A. Remove both cap screws and lock washers (1) from the back plate (2) and body (6). Remove brake cylinder assembly.

B. Remove dust covers (12) and pistons (11) from the body. make sure not to lose the spring (9).

C. Remove L–type seals (10) from the pistons. Discard seals and dust covers.

Inspection (Fig. 6)

1. Clean and inspect brake drum (2) any time they are removed for brake service (Fig. 2).

A. Check drum diameter at a minimum of three locations. Diameter should not exceed the over size limit cast into the outside of the drum. Replace drum if limit is exceeded.

B. Replace drums if they are cracked or heat spotted.

C. Scoring, grooves, taper, out of round, and glazing can be machined out as long as the oversize limit is not exceeded. Minor scoring or glazing can be removed with sand paper.

IMPORTANT: If one drum is machined, the drum on the opposite side should be machined to the same diameter to maintain equal braking forces.

D. Wipe braking surface of drum after machining with a cloth soaked in denatured alcohol.

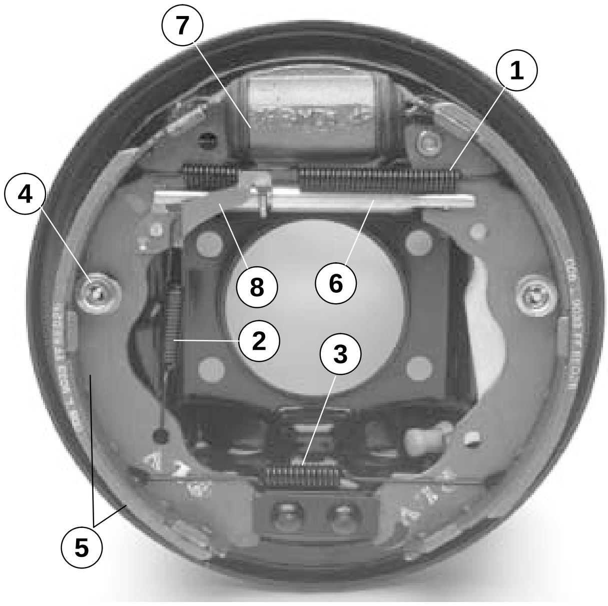


Figure 7

1. Upper shoe spring
2. Adjuster spring
3. Lower shoe spring
4. Hold down washer
5. Brake shoe
6. Adjuster assembly
7. Brake cylinder assy
8. Pawl

2. Inspect shoe and lining set (13).

IMPORTANT: Shoe and lining sets (13) should be replaced for each wheel on the axle. Equal braking forces must be maintained.

A. Replace if linings are excessively worn or damaged. Oil, grease, or brake fluid contamination is not acceptable.

B. Replace if shoe webbing show signs of overheating as indicated by a slight blue color.

3. Inspect hold down washer (22), hold down spring (23), and hold down pin (26). Replace parts if rusted, corroded, or bent. Replace washers and springs if they are unable to lock onto the pin.

4. Inspect upper shoe spring (14), lower shoe spring (15), and adjuster spring (20).

A. Replace if springs show signs of overheating as indicated by a slight blue color. Over heated springs lose their pull and could cause brake linings to wear out prematurely.

B. Replace sagging, bent, or externally damaged springs.

5. Inspect back plate (2).

A. Replace if shoe contact surfaces have grooves that may restrict shoe movement and can not be removed by sanding lightly with emery cloth.

B. Replace if cracked, warped, or excessively rusted.

6. Inspect female push rod (16), bolt adjuster (17), and adjuster sleeve (18) for rust, corrosion, bending, and fatigue. Replace parts as necessary.

Note: The brake cylinder assembly consists of the following: bleed screw (4), bleed screw cap (5), body (6), spring (9), L–type seals (10), pistons (11), and dust covers (12)

7. Inspect brake cylinder assembly.

CAUTION

Use eye protection such as goggles when using compressed air

A. Clean all metal parts with isopropyl alcohol. Clean out and dry grooves and passageways with compressed air. Make sure body (6) bore and other parts are thoroughly cleaned.

B. Replace body or piston (11) if body bore or piston is pitted, scored, excessively worn, or cracked.

C. Replace spring (9) if distorted, worn, or it does not compress.

Assembly (Fig. 6 and 7)

1. Assemble brake cylinder assembly as follows:

A. Apply a thin coat of clean brake fluid to the **new** L–type seals (10). Install seals into the groove of the pistons (11).

B. Apply a thin coat of clean brake fluid to the bore of the body (6) and pistons. Install one piston, the spring (9), and then the other piston carefully into the body.

C. Install **new** dust covers (12) onto the body.

D. Secure body to back plate (2) with both cap screws and lock washers (1). Torque cap screws from 49 to 97 in–lb (56 to 112 kg–cm).

2. Clean back plate (2). Lubricate shoe contact areas with a thin coat of grease.

3. Apply a light coat of grease to the threaded areas of the adjuster assembly (27).

4. Position shoe and lining set (13) onto the back plate (5). Secure shoes with hold down pins (26), hold down spring (23), and hold down washers (22).

5. Install lower shoe spring (15) to both brake shoes (13).

6. Install adjuster assembly (27) in the slots on the brake shoes (13). Install pawl (19) into brake shoe and onto top of bolt adjuster (17).

7. Install adjuster spring (20) to pawl (19) and brake shoe (13).

8. Install upper shoe spring (14) to both brake shoes (13).

Installation (Fig. 2)

1. If the brake assembly (5) was removed from the axle housing (28), install assembly as follows:

A. Secure brake assembly to the axle housing with four cap screws (6) and lock washers (7).

IMPORTANT: Make sure brake hose connections are clean and free of dirt.

B. Unplug front brake hose (13). Connect brake tube (8) to the brake assembly and brake hose.

2. Insert small spacer and then large spacer (30) onto the stub axle (31). Make sure bearing (14) cone is sufficiently greased.

3. Insert stub axle (31), bearing (14) cone, and spacers into the axle housing and onto the splined end of the CV joint (15).

4. Secure stub axle (31) to the threaded end of the CV joint (15) with the flat washer (35) and flange lock nut (36). Torque flange lock nut from 170 to 200 ft–lb (23.5 to 27.7 kg–cm).

Note: Make sure access hole on both the brake drum and stub axle align when installed.

5. Install brake drum (32) to stub axle (31) with cap screws (3).

6. Adjust brake shoes (13) as follows (Fig. 6).

A. Align access hole in the brake drum with the bolt adjuster (17).

B. Rotate bolt adjuster so adjuster assembly (27) length makes both brake shoes (13) contact the brake drum.

C. Back off bolt adjuster until drum rotates freely.

7. Bleed front brakes (see Bleeding the Brakes in the Repairs section of Chapter 8 – Steering, Brakes, and Suspension).

8. Secure wheel to the brake drum (32) with five lug nuts (1). Lower front wheel to the ground. Torque lug nuts from 45 to 55 ft–lb (6.2 to 7.6 kg–m).

Inspect Constant Velocity (CV) Joint Boot and Test CV Joint

Inspecting Boot

Inspect CV joint boot after every 200 hours of operation. A torn boot is the most common cause of CV joint failures.

Note: A worn and noisy CV joint with the boot in good condition and filled with grease is not uncommon. Potholes, curb contact, or collision damage can chip bearing components and initiate worn conditions.

1. Look for grease on the suspension, inner tire sidewall, or fender to indicate a possible torn boot. Inspect boot for cracks, holes, tears, or loose clamps. Dirty grease within the boot may indicate damage to the CV joint.

2. If the boot is cracked or torn, or has any holes or loose clamps, remove and inspect CV joint (see Constant Velocity Joint).

Testing for Outboard Joint Problem

1. Test drive vehicle on a smooth surface to verify problem.

2. Accelerate or back–up vehicle slowly with the wheels turned. Listen for snapping or clicking noise at the wheel, then drive straight ahead.

A. If the noise remains constant, the wheel bearing is the likely problem (see Front Wheel Bearing).

B. If the noise gets louder when turning, the outboard CV joint is worn. A badly worn joint will snap or click when driving straight ahead, however the noise will increase when accelerating or backing up into a turn. Remove and inspect CV joint (see Constant Velocity Joint).

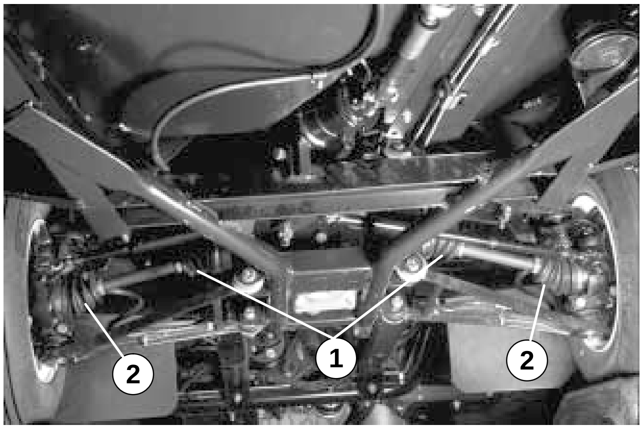


Figure 8

1. **Inboard boot**
2. **Outboard boot**

Testing for Inboard Joint Problem

1. Test drive vehicle on a smooth surface to verify problem.

2. Accelerate vehicle quickly and straight ahead. Vibration or shudder indicates a worn or sticking inboard CV joint.

3. Accelerate vehicle at an angle over a ramp or up an hill. A clunking noise indicates a worn inboard CV joint.

4. Remove and inspect CV joint (see Constant Velocity Joint).

Constant Velocity (CV) Joint

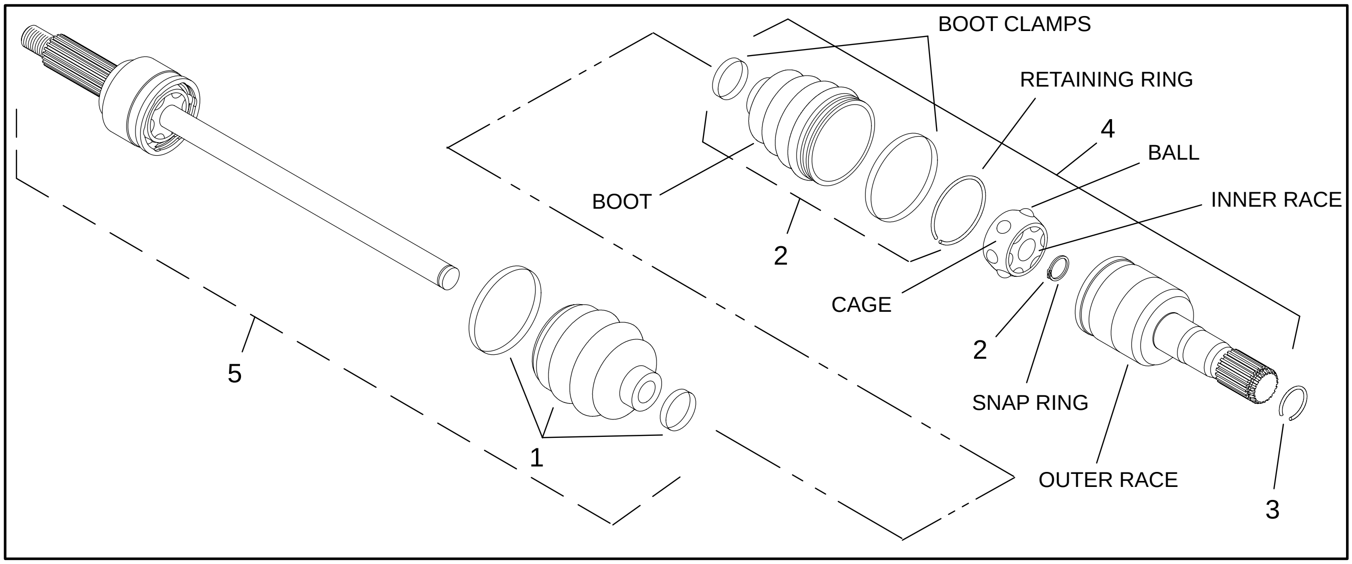


Figure 9

1. **Outboard boot kit**
2. **Inboard boot kit**
3. **Circular clip**
4. **Inboard joint assembly**
5. **Outboard joint and shaft**

Removal (Fig. 2)

1. Remove wheel, stub axle (31) and axle housing (28) from the CV joint (15) and front suspension (see Front Wheel Bearing Service Disassembly).

IMPORTANT:Make sure not to damage the oil seal on the front differential with the screw drivers when removing the CV joints.

2. Use two small pry bars (180° apart) to leverage the CV joint out of the front differential. Use even pressure on both pry bars (Fig. 10).

IMPORTANT:With damaged CV joints, there is the possibility that the wheel bearings may be damaged. It is recommended that the wheel bearings be inspected when CV joints are repaired or replaced.

3. Inspect front wheel bearings (14) (see Front Wheel Bearing Service Inspection).

Note: The inboard and outboard joint are similar in construction and part make up.

Installation (Fig. 2)

1. If necessary, install a new circular clip onto the splined (inboard) end of the CV joint. Grease with No. 2 general purpose lithium base grease (Fig. 9).

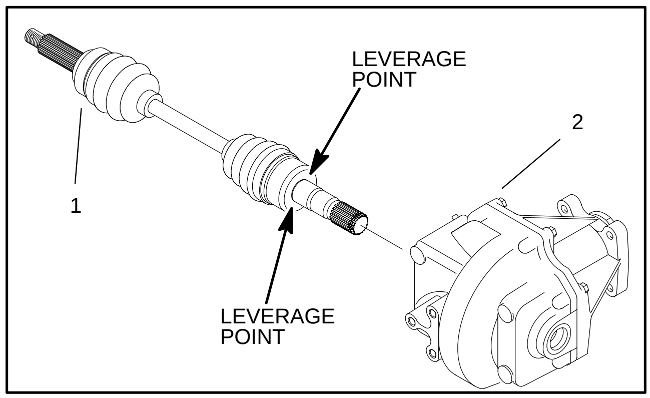


Figure 10

1. **CV joint**
2. **Front differential**

2. Insert end of CV joint into the front differential until a snap is heard. **Pull outward on CV joint as close as possible to the front differential to make sure that the CV joint is properly snapped properly into place (Fig. 10).**

3. Reassemble axle housing (28), stub axle (31), and wheel to the CV joint (15) and front suspension (see Front Wheel Bearing Service Assembly).

Disassembly (Fig. 9)

Note: The inboard and outboard joints are similar in construction. The principle difference is the inboard joint's outer race has internal ball tracks that are longer, which allow the shaft of the outboard joint to plunge into the inboard joint. Also, the inboard joint does not come with a shaft. The same Assembly and Disassembly instructions can be used for both joints.

1. Unlock boot clamps securing the boot to the outer race. Slide boot away from the outer race.

2. Remove retaining ring carefully from the groove inside the outer race (Fig. 11).

3. Pull cage, ball, and inner race assembly out of the outer race by pulling on the shaft of the outboard joint (Fig. 12).

4. Remove snap ring from the outboard shaft. Slide cage, ball, and inner race assembly off the shaft (Fig. 12 and 13).

5. Press all six balls out of the cage. Rotate inner race so its points are aligned with the center of the cage windows. Pull inner race out of the cage (Fig. 14).

Assembly (Fig. 9)

1. Set cage on a working surface with its tapered side down. Position inner race into the cage so that the grooved end faces down and its points are aligned with the center of the cage windows (Fig. 14).

2. Snap all six balls into the cage windows. **If the balls do not stay snapped in place, replace the entire joint assembly.**

3. Slide new boot and boot clamps onto the shaft of the outboard joint.

Note: The cage, ball, and inner race assembly can be secured onto the shaft in only one position, otherwise the snap ring will not fit into the groove of the shaft.

4. Grease splines of shaft for the outboard joint. Slide cage, ball, and inner race assembly onto the shaft. Secure assembly to the shaft with the snap ring (Fig. 12).

5. Grease inside of outer race. **Make sure ball tracks are greased heavily.** Insert cage, ball, and inner race assembly into outer race (Fig. 11).

6. Install retaining ring carefully into the groove inside the joint (Fig. 11).

7. Make sure joint assembly is completely packed with grease.

8. Slide boot onto the joint. Secure boot to the outer race and shaft with the boot clamps.

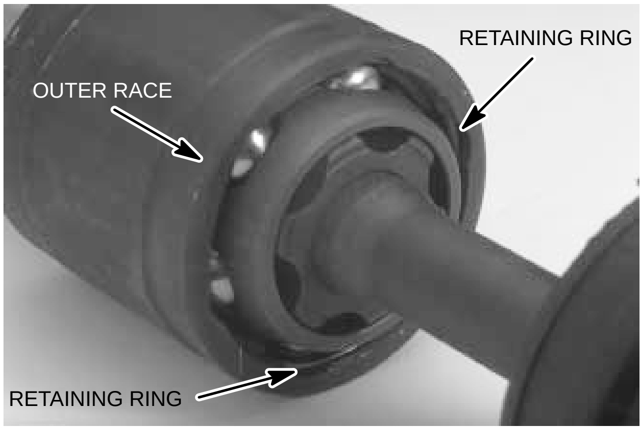


Figure 11

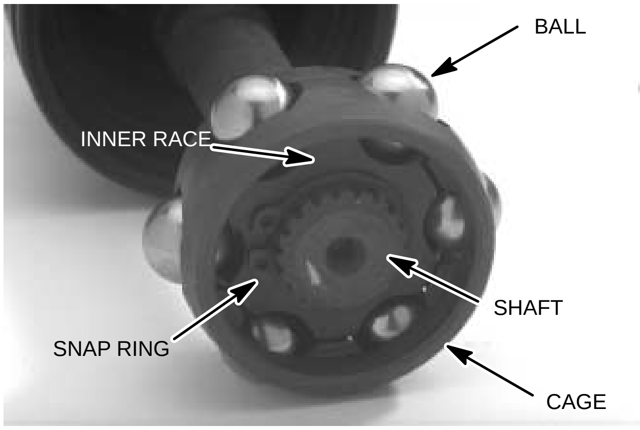


Figure 12


Figure 13

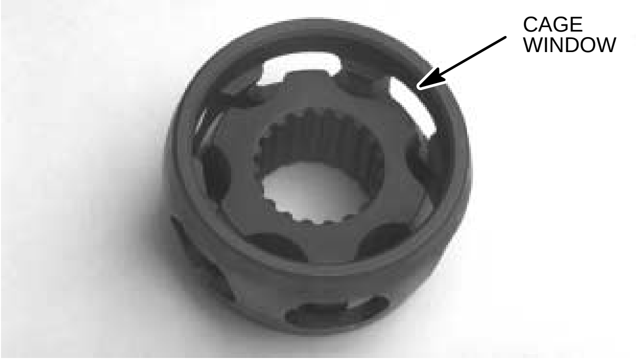


Figure 14

Inspection

1. Clean all parts thoroughly of dirt, grease, and debris.

Note: If any single part of either the outboard or inboard joint is defective, the complete inboard or outboard joint must be replaced

2. Inspect cage for worn windows; balls should be able to snap in. Replace joint if cage is cracked, distorted, or windows are worn (Fig. 15).

3. Inspect balls for damage and wear. Replace joint if balls are cracked, chipped, grooved, feel rough, have flat spots, or do not stay snapped into the cage windows (Fig. 15).

4. Inspect inner race for damage and wear. Replace joint if cracked, chipped, distorted, or worn (Fig. 16).

5. Inspect outer race for worn ball tracks. Replace joint if ball tracks in the housing are worn, chipped, or cracked (Fig. 17).

6. Inspect outboard joint shaft for bending or damage. Replace outboard joint if the shaft is visibly bent or cracked (Fig. 18).


Figure 15


Figure 16

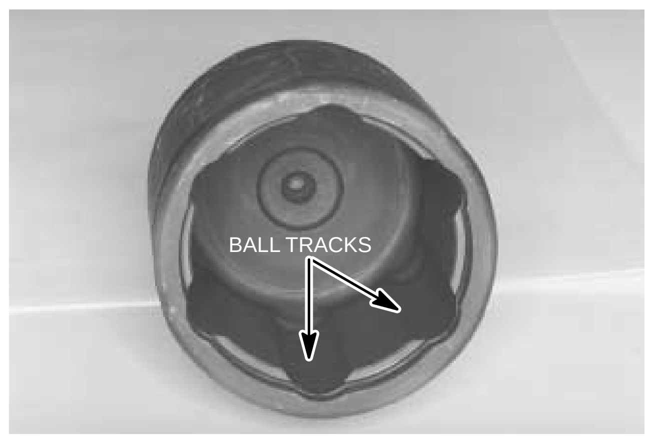


Figure 17

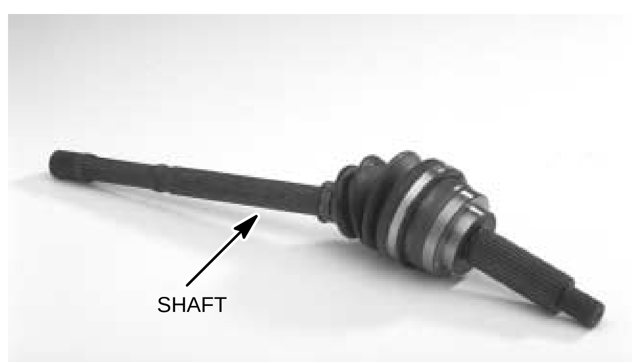


Figure 18

Change Front Differential Oil

Change front differential oil every 800 hours.

1. Position vehicle on a level surface. stop engine and engage parking brake. Remove key from ignition switch.

2. Clean area around drain plug on the side of the differential. Place drain pan under the drain plug.

3. Remove drain plug and let oil flow into the drain pan. Reinstall and tighten plug when the oil stops draining.

4. Clean area around the fill/check plug on side of differential.

5. Remove fill/check plug and add 10W30 oil until oil is up to hole.

6. Re–install fill/check plug.

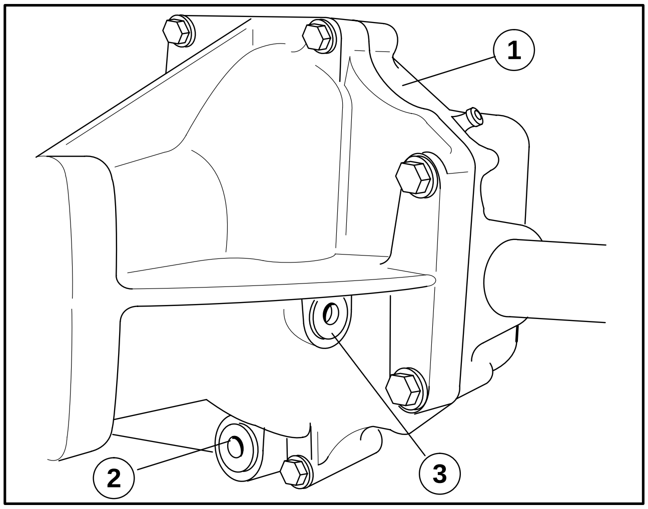


Figure 19

1. **Front differential**
2. **Drain plug**
3. **Fill/check plug**

Front Suspension Control Arm Assembly

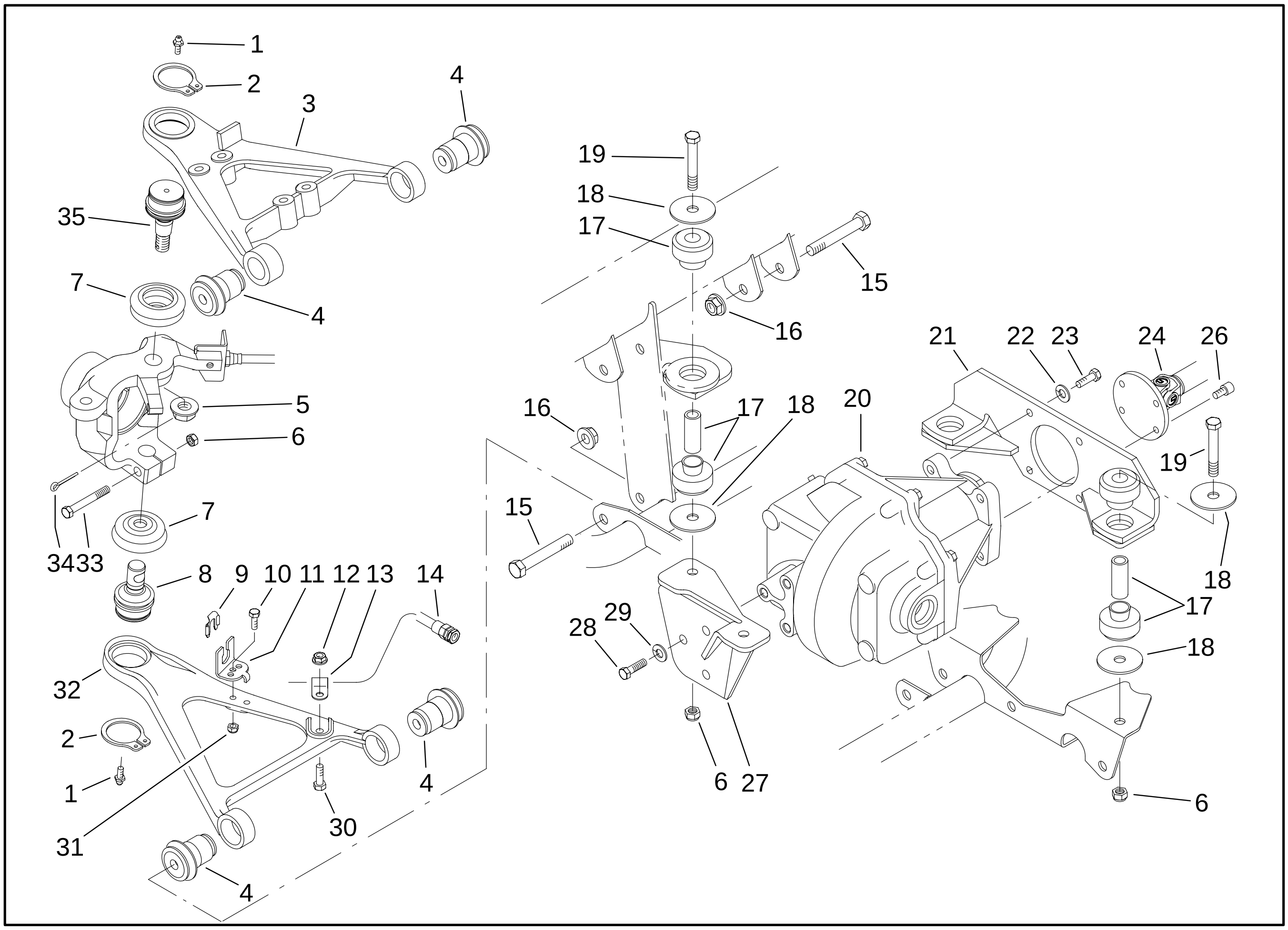


Figure 20

1. Grease fitting
2. Retaining ring
3. Upper control arm
4. Flange bushing
5. slotted hex nut
6. Lock nut
7. Ball joint seal
8. Lower ball joint
9. Retainer
10. Cap screw
11. Brake hose bracket
12. Lock nut
13. R–clamp
14. Front brake hose
15. Cap screw
16. Hex nut
17. Engine mount assembly
18. Snubbing washer
19. Cap screw
20. Front differential
21. Differential rear mount
22. Lock washer
23. Cap screw
24. Differential drive shaft
25. Not used
26. Socket hex head screw
27. Differential front bracket
28. Cap screw
29. Lock washer
30. Cap screw
31. Lock nut
32. Lower control arm
33. Cap screw
34. Cotter pin
35. Upper ball joint

Front Differential

Removal (Fig. 20)

1. Park machine on a level surface. Make sure engine is off. Set parking brake and block rear wheels.

2. Drain front differential (20) oil into a suitable container by removing the drain plug from its bottom. Install drain plug when draining is complete.

3. Remove both CV inboard joint assemblies from the front differential (20) (see CV Joint Assembly Removal).

4. Remove differential drive shaft (24) from the front differential (20) flange (see Differential Drive Shaft Removal).

5. Remove front brake lines and clamps that might interfere with the removal of the front differential (20). Tie any cables out of the way that might interfere with removal.

CAUTION

Support front differential during removal to prevent personal injury from falling and damage to the differential.

6. Remove four cap screws (23) and lock washers (22) securing the front differential (20) to the differential rear mount (21).

7. Remove differential rear mount (21) from frame by removing both lock nuts (6) and cap screws (19).

8. Remove four cap screws (28) and lock washers (29) from the differential front bracket (27) and front differential (20).

9. Pull front differential (20) from the vehicle.

Installation (Fig. 20)

CAUTION

Support front differential during installation to prevent personal injury from falling and damage to the differential.

1. Secure front differential (20) to the differential front bracket (27) with four cap screws (28) and lock washers (29).

2. Secure differential rear mount (21) to frame with cap screws (19), snubbing washers (18), engine mount assemblies (17), and lock nut (6).

3. Secure front differential (20) to differential rear mount (21) with cap screws (23) and lock washers (22).

4. Reconnect front brake lines and clamps. Reposition cables.

5. Reinstall differential drive shaft (24) to the front differential (20) flange (see Differential Drive Shaft Installation).

6. Reinstall both CV joints to the front differential (20) (see CV Joint Assembly Installation).

7. Make sure drain plug to the front differential (20) is installed properly. Fill front differential with oil (see Change Front Differential Oil).

8. Bleed front brakes (see Bleeding the Brakes in Repairs section of Chapter 7 – Steering, Brakes, and Suspension).

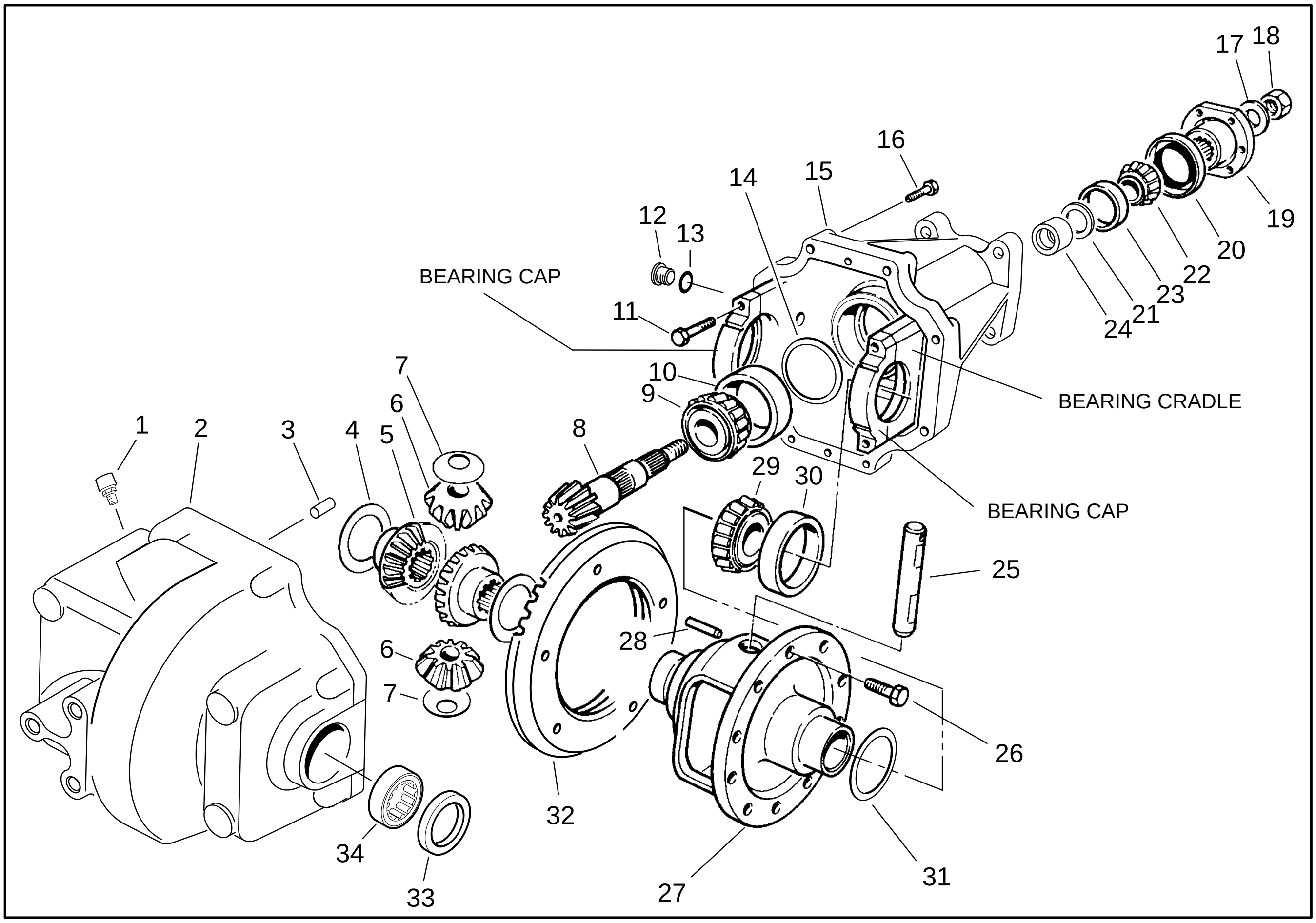


Figure 21

1. **Vent**
2. **Front housing**
3. **Alignment pin**
4. **Thrust washer**
5. **Side bevel gear**
6. **Pinion gear shaft**
7. **Thrust washer**
8. **Pinion gear**
9. **Bearing cone**
10. **Bearing cup**
11. **Cap screw**
12. **Plug**
13. **O–ring seal**
14. **Shim**
15. **Carrier assembly**
16. **Cap screw**
17. **Washer**
18. **Lock nut**
19. **Coupler flange**
20. **Oil seal**
21. **Shim**
22. **Bearing cone**
23. **Bearing cup**
24. **Bearing spacer**
25. **Pinion shaft**
26. **Cap screw**
27. **Differential case**
28. **Roll pin**
29. **Bearing cone**
30. **Bearing cup**
31. **Shim**
32. **Ring gear**
33. **Oil seal**
34. **Needle bearing**

Disassembly (Fig. 21)

1. Remove flange (19) from the pinion shaft (8) by removing lock nut (18) and washer (17) from the threaded end of the shaft. Use a bearing puller if necessary to remove the coupler flange (Fig. 22).

2. Secure carrier assembly (15) so that pinion gear shaft (8) is facing up. Remove eight cap screws (16) securing the front housing to the carrier assembly.

Figure 22

3. Separate front housing (2) from the carrier assembly (15) using a cold chisel to initially separate the two parts. Use a putty knife to further separate the housing and carrier assembly (Fig. 23).

Figure 23

IMPORTANT: The bearing caps are marked for reassembly. Place caps in a safe place to avoid damaging their machined surface. Place caps back in the same position during reassembly.

4. Remove four cap screws (11) and both bearing caps from the bearing cradles (Fig. 24).

Figure 24

IMPORTANT: Keep mating bearing bearing cups (30) with matching bearing cups (30) and bearing caps.

5. Remove differential gears from the carrier assembly by using two wooden handles under the differential case (27) to pry up the case and gears (Fig. 25).

Figure 25

IMPORTANT: When using a hammer and punch to remove the roll pin (28) and pinion shaft (25), be careful not to damage any gear teeth.

6. Drive roll pin (28) from the pinion shaft (25) using a long thin drift punch (Fig. 26).

Figure 26

7. Support differential case (27) in a vise. Drive pinion shaft (25) from the differential case using a long drift punch (Fig. 27).

Figure 27

8. Remove both sets of pinion gear shafts (5 and 6) and thrust washers (4 and 7) by rotating the gears 90° through the opening in the differential case (27) (Fig. 28).

Figure 28

IMPORTANT: Avoid damaging gear teeth when removing the gear ring (32) from the differential case (27).

9. Remove five cap screws (26) from the differential case (27) and gear ring (32). Drive ring gear off the differential case using a hard wood block and a hammer (Fig. 29).

Figure 29

Note: Remove bearing cones (29) from the differential case **only** if they need replacing (see Inspection). Retain shims (31) for reassembly of new bearing cones.

10. Remove bearing cone (29) from the differential case (27) with a puller. **Make sure puller is inserted into the indentations on the differential case (Fig. 30).**

Figure 30

IMPORTANT: Make sure shims (21) are kept after they are removed from the carrier assembly (15).

11. Pull pinion gear shaft (8) and bearing cone (9) from the carrier assembly (15). If necessary, press pinion gear shaft out of the carrier housing. Remove oil seal (20) and discard it. Remove bearing cone (22), shims (21), and spacer (24) from the carrier housing(15) (Fig. 31).

Figure 31

Note: Remove bearing cone (9) from the pinion gear shaft (8) **only** if it needs replacing (see Inspection).

12. Press pinion gear shaft (8) out of the bearing cone (9) using bearing press. **Make sure shaft does not drop to the floor (Fig. 32).**

Figure 32

Note: Remove bearing cup (23) from the carrier housing (15) **only** if it needs replacing (see Inspection).

13. Press bearing cup (23) from the carrier assembly (15) (Fig. 33).

Figure 33

IMPORTANT: Make sure shims (14) are kept after they are removed from the carrier assembly (15).

Note: Remove bearing cup (10) from the carrier housing (15) **only** if it needs replacing (see Inspection).

14. Pull bearing cup (10) and shims (14) from the carrier assembly (15) (Fig. 34).

Figure 34

Note: Remove needle bearing (34) from the front housing (2) **only** if it needs replacing (see Inspection).

15. Remove oil seal (33). Press needle bearing (34) from the front housing (2) (Fig. 35).

Figure 35

Inspection (Fig. 21)

1. Inspect front housing (2) and carrier assembly (15) for cracks and damage. Replace either part if its condition could affect the operation of the front differential assembly. Clean flange surfaces of any sealant, oil, and dirt (Fig. 36).

Figure 36

2. Inspect needle bearings (34) for wear and damage. Replace bearings if needles are bent, do not rotate freely, or do not remain in the bearing cage. Replace oil seal (33) if it is cracked, nicked, torn, or distorted such that it would not hold a proper seal (Fig. 37).

Figure 37

3. Inspect differential case (27) in the area where the bevel side gears (5) and pinion gear shafts (6) mesh. Replace case if machined areas are scored or if the pinion shaft (25) fits loosely in its bore (Fig. 38).

Figure 38

IMPORTANT: The ring gear (32) and pinion gear (8) must be replaced as a matched set.

4. Inspect bevel side gears (5), pinion gear shafts (6), pinion gear (8), and ring gear (32) for abnormal wear or damage. Replace any gear that is worn or damaged. Cracked, broken, missing, or chipped gear teeth are not acceptable (Fig. 39).

Figure 39

IMPORTANT: If any part of a bearing needs replacement, both bearing cone and cup must be replaced.

5. Replace bearing cones (9, 22, or 29) and corresponding bearing cups (10, 23, or 30) if any of the following conditions occur (Fig. 40 and 41):

A. Spalling or pitting on roller or cone contact surfaces. Corrosion that can not be cleaned up with light polishing.

B. The rib face on the cone is worn back, or rollers are worn or scored. The roller cage is cracked or broken.

C. Peeling, gouges, or nicks inside the cup or on rollers. Scalloping, high spots, brinelling, or burrs in the cups.

Figure 40

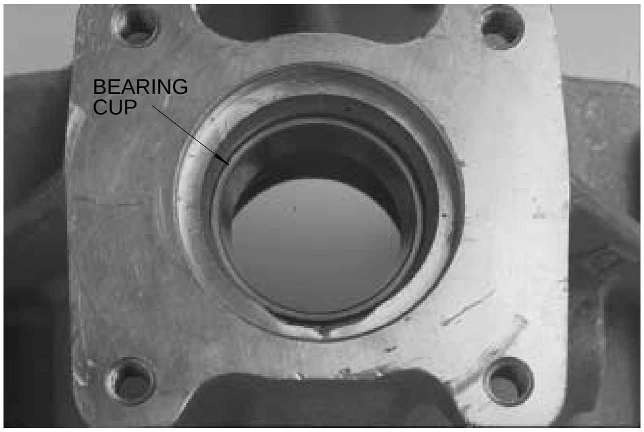


Figure 41

Assembly (Fig. 21)

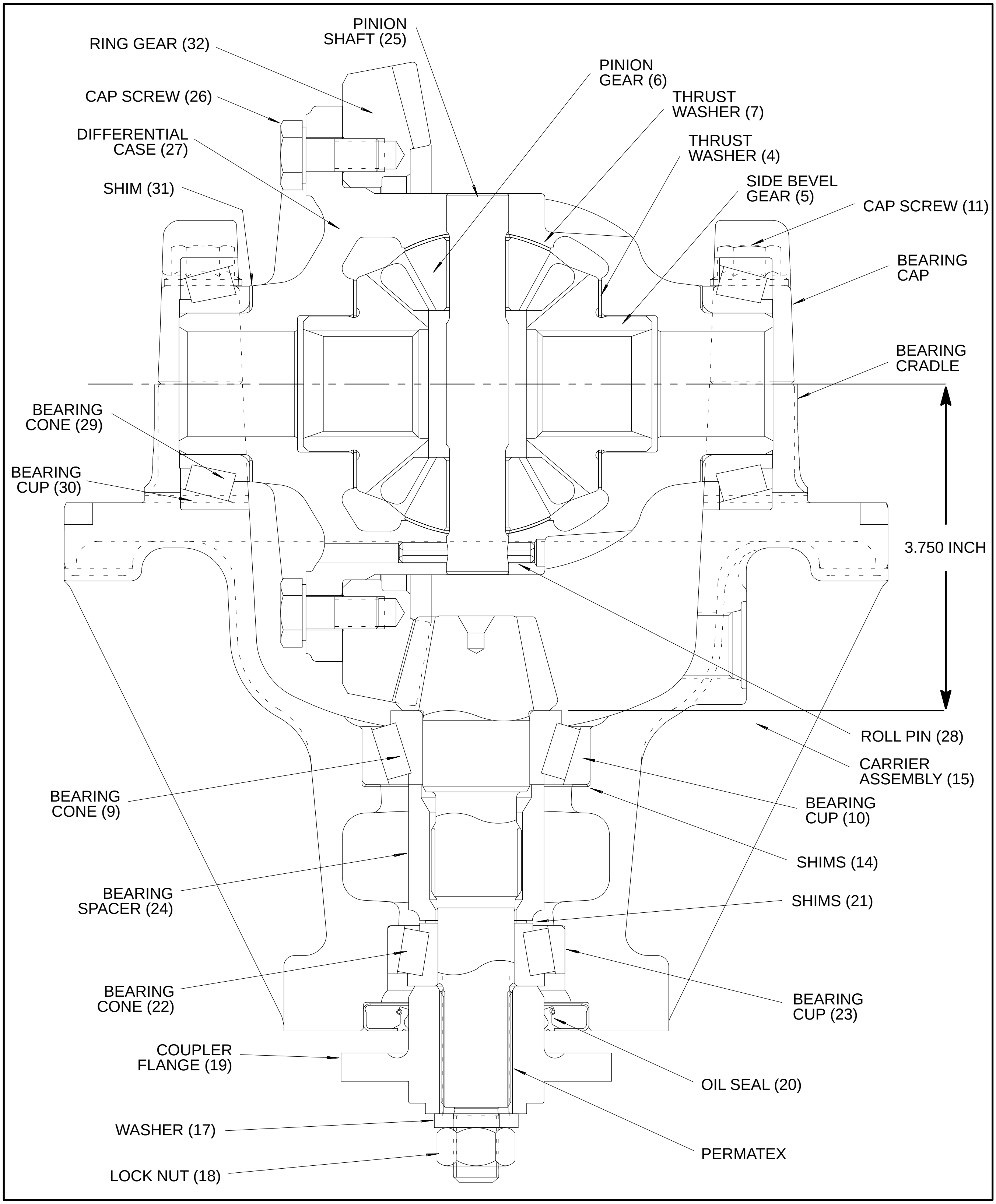


Figure 42

Note: Part numbers in parentheses ( ) correspond to the part numbers in Figure 21.

The ring gear (32) and pinon gear (8) are supplied as a matched set. Both gears are etched for verification with matching numbers. If a new gear set is being used, verify that the matching numbers are the same on both the ring and pinion gear before assembling the front differential (Fig. 43).

The distance from the center line of the ring gear to the bottom of the pinion gear teeth is 3.750 inches (5.525 cm). This distance represents the best running position for the gear set (Fig. 42).

On the end of each pinion gear, there is an etched number indicated by plus (+), minus (–), or zero (0). This number indicates a shimming dimension for the best running position of the gear set. This dimension is controlled by shimming between the the bearing cup (10) and the carrier assembly (15) (Fig. 43).

For example: If a pinion gear shaft is etched +4, this pinion would require 0.004 inch less shims than a pinion etched "0". By removing shims, the running position is increased to 3.754 inches. The +4 represents a 0.004 inch increase in the running position. On the other hand: If a pinion gear shaft is etched –4, this pinion would require 0.004 inch more shims than a pinion etched "0". By adding shims, the running position is decreased to 3.746 inches. The –4 represents a 0.004 inch decrease in the running position.

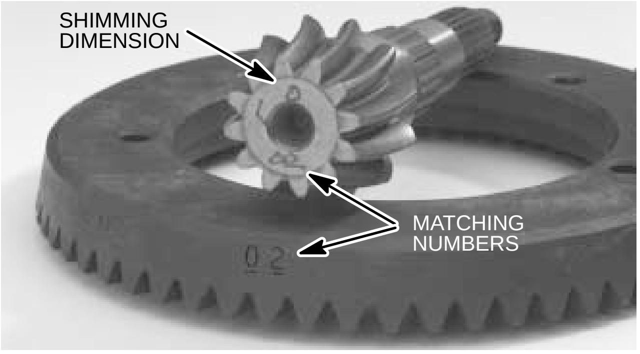


Figure 43

When reusing an old ring gear and pinion gear shaft set, measure the old shim pack thickness and build a new shim pack to the same thickness. Measure each shim separately with a micrometer. Add each shim thickness to get the total shim pack thickness.

If a new gear set is being used, note the (+) or (–) etching on both the old and new pinion gear shaft. Change the thickness of the new shim pack to compensate for the difference between these two dimensions.

For example: If the old pinion gear shaft reads + 2 and the new gear is –2, add 0.004 inch of shims to the old shim pack (see Table 1).

Note: All shims (14, 21, and 31) are available in thicknesses of 0.003, 0.005, 0.010, and 0.030 inch.

Old Pinion Marking	New Pinion Marking								
	–4	–3	–2	–1	0	+1	+2	+3	+4
+4	+0.008	+0.007	+0.006	+0.005	+0.004	+0.003	+0.002	+0.001	0
+3	+0.007	+0.006	+0.005	+0.004	+0.003	+0.002	+0.001	0	–0.001
+2	+0.006	+0.005	+0.004	+0.003	+0.002	+0.001	0	–0.001	–0.002
+1	+0.005	+0.004	+0.003	+0.002	+0.001	0	–0.001	–0.002	–0.003
0	+0.004	+0.003	+0.002	+0.001	0	–0.001	–0.002	–0.003	–0.004
–1	+0.003	+0.002	+0.001	0	–0.001	–0.002	–0.003	–0.004	–0.005
–2	+0.002	+0.001	0	–0.001	–0.002	–0.003	–0.004	–0.005	–0.006
–3	+0.001	0	–0.001	–0.002	–0.003	–0.004	–0.005	–0.006	–0.007
–4	0	–0.001	–0.002	–0.003	–0.004	–0.005	–0.006	–0.007	–0.008

Table 1

1. If the bearing cone (9) was removed, press new bearing cone onto the shaft of the pinion gear (8) (Fig. 44).

Figure 44

2. If the bearing cup (23) was removed, press new bearing cup into the carrier assembly (15) (Fig. 45).

Figure 45

3. If the bearing cup (10) was removed, place shims (14) into the carrier assembly (15). Press new bearing cup into the assembly (Fig. 46).


Figure 46

4. If a **new** carrier assembly (15) is being installed, proceed as follows:

A. Press bearing cup (10) into the assembly with out any shims (14).

B. Place pinion gear (8) with bearing cone (9) installed into the carrier assembly and bearing cup.

C. Measure and note distance from the centerline of the ring gear to the bottom of the pinion gear teeth using a depth micrometer (Fig. 42 and 47).


Figure 47

D. Note shimming dimension on the pinion gear (Fig. 43). If the dimension is (+) positive, add the dimension to 3.750 inch. If the dimension is (–) negative, subtract the dimension from 3.750 inch.

For Example: If the pinion gear shaft is etched +4. Add 0.004 to 3.750 to get 3.754 inch. If the pinion gear shaft is etched –4. Subtract 0.004 from 3.750 to get 3.746 inch.

E. Now determine the difference between the measurement taken in a step C and the value calculated in step D. This difference is the **new** shim thickness.

F. Remove bearing cup from the carrier assembly.

G. Install required shim thickness and bearing cup into the carrier assembly.

IMPORTANT: The pinion gear (8) and ring gear (32) are supplied only as a matched set. Matching numbers on both gears are etched for verification. When using a new gear set, make sure the matching numbers are verified before using (Fig. 43).

5. Install pinion gear (8) and bearing cone (9) into the carrier assembly (15). Place bearing spacer (24), shims (21), and bearing cone (22) on to the shaft of the pinion gear (Fig. 48).


Figure 48

6. Verify bearing preload and pinion gear shaft (8) rotation as follows:

A. Install coupler flange (19), washer (17), and lock nut (18) to the shaft of the pinion gear. Torque lock nut from 75 to 90 ft–lb (10.3 to 12.4 kg–m).

B. The torque required to rotate the shaft of the pinion gear should be from 7 to 12 in–lb (8 to 14 kg–cm) (Fig. 49).

C. If the torque required to rotate the shaft of the pinion gear is more than specified in step B, remove lock nut, washer, coupler flange, bearing cone (22), and shim (21) from the shaft of the pinion gear. **Increase** shim thickness to **decrease** bearing preload.

D. If the torque required to rotate the pinion gear shaft is less than specified in step B, remove lock nut, washer, coupler flange, bearing cone (22), and shim (21) from the pinion gear shaft. **Decrease** shim thickness to **increase** bearing preload.

E. Install shim, bearing cone, coupler flange, washer, and lock nut to the pinion gear shaft. Torque lock nut from 75 to 90 ft–lb (10.3 to 12.4 kg–m).

F. The torque required to rotate the pinion gear shaft should be from 7 to 12 in–lb (8 to 14 kg–cm). If the torque to rotate the pinion gear shaft does not meet specification, repeat steps C or D and E as necessary.

G. If the torque required to rotate the shaft of the pinion gear shaft is as specified in step B or F, remove lock nut, washer, coupler flange, bearing cone (22) from the shaft of the pinion gear. Press new oil seal (20) into the carrier assembly (15) (Fig. 50).

H. Apply No. 2 Permatex sealant or equivalent to the splines of the pinion gear. **Make sure not to get sealant on the oil seal (20)** (Fig. 51)**.**

I. Install flange coupler, washer, and lock nut back onto the pinion gear. Torque lock nut from 75 to 90 ft–lb (10.3 to 12.4 kg–m).

7. Install thrust washers (7) to pinion gear shafts (6), and thrust washers (4) to side bevel gears (5) (Fig. 52).

A. Place gears and washers into the differential case (27).

B. Rotate both sets of gears simultaneously until the pinion shaft (25) can be inserted through the differential case, thrust washers, and pinion gear shafts.

C. Install pinion shaft into the differential case and pinion gear shafts. Secure shaft with roll pin (28).

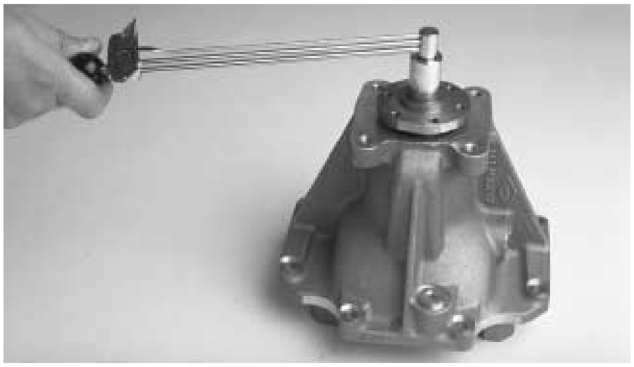


Figure 49

Figure 50

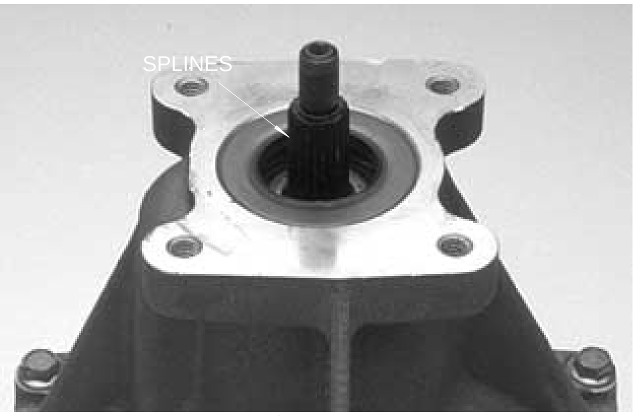


Figure 51

Figure 52

IMPORTANT:When bearing cones (29) are removed removed from the differential case (27) they should replaced with new ones. When installing new bearing cones to the differential case, use original shims (31) or new shims of the same thickness.

8. Press bearing cone (29) onto the differential case (27) (Fig. 53).

Figure 53

9. Position ring gear (32) to the differential case (27). Secure ring gear to the case with five cap screws (26) in a criss–cross pattern so the gear is pulled evenly into place. Torque cap screws from 58 to 65 ft–lb (8.1 to 9.0 kg–m) (Fig. 54).

Figure 54

Note: The bearing cradle are designed to apply a slight preload to the bearings. Therefore, it is important to push both bearing assemblies simultaneously into their cradles.

IMPORTANT:If new bearing cones (29) were installed onto the differential case (27), new bearing cups (30) must be installed to the bearing cradles.

10. Place bearing cups (30) onto bearing cones (29). Install bearing assemblies into the bearing cradles of the carrier assembly (15). Make sure bearing cups (30) are matched to the proper bearing cradle and bearing cone (29) (Fig. 55).

Figure 55

IMPORTANT:The bearing caps are marked for identification. Place caps back in the same position during reassembly (Fig. 56).

11. Secure bearing caps to their original positions on the bearing cradles with for cap screws (11). Torque cap screws from 30 to 45 ft–lb (4.1 to 6.2 kg–m) (Fig. 56).

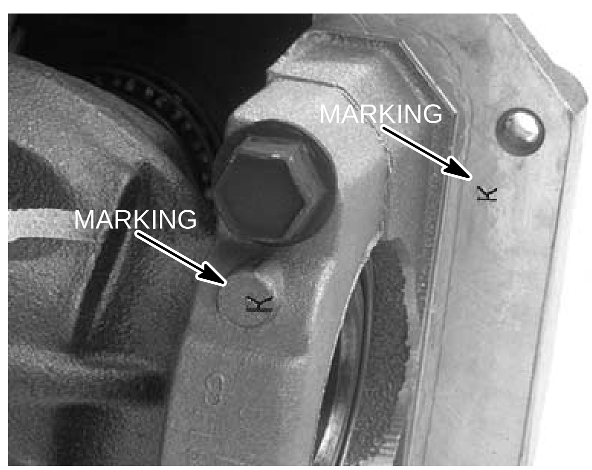


Figure 56

12. Check backlash of ring gear (32) with a dial indicator at three equally spaced positions (Fig. 57).

A. Backlash should be from 0.002 to 0.006 inch (0.051 to 0.152 mm) and should not vary more than 0.002 inch (0.051 mm).

B. If backlash does not meet specifications, move shims (31) from one side of the differential case (27) to the other until the correct backlash is attained.

13. Check ring to pinion gear engagement (see Ring and Pinion Gear Engagement in this chapter of the manual).

Figure 57

14. If the needle bearings (34) were removed, press two new bearings into the front housing (2). Press new oil seals into housing (Fig. 58).

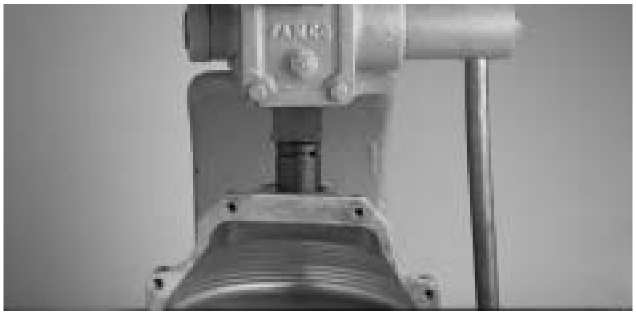


Figure 58

15. Make sure flange surface of carrier assembly (15) is clean and free of any sealant, dirt, and oil. Apply thin bead of non–acidic silicon sealer along the entire flange surface of the carrier assembly (Fig. 59).

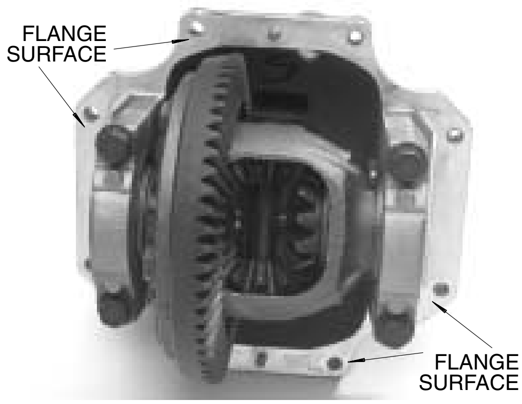


Figure 59

16. Make sure flange surface of front housing (2) is clean and free of any sealant, dirt, and oil. Attached front housing to the carrier assembly (15) using alignment pins (3) as guides. Secure housing to assembly with eight cap screws (16). Torque cap screws from 15 to 20 ft–lb (2.1 to 2.8 kg–m) using a criss–cross pattern (Fig. 60).

Figure 60

17. Make sure both plugs (12) and O–rings (13) are installed. Verify that plugs are torqued between 20 to 25 ft–lb (2.8 to 3.5 kg–m).

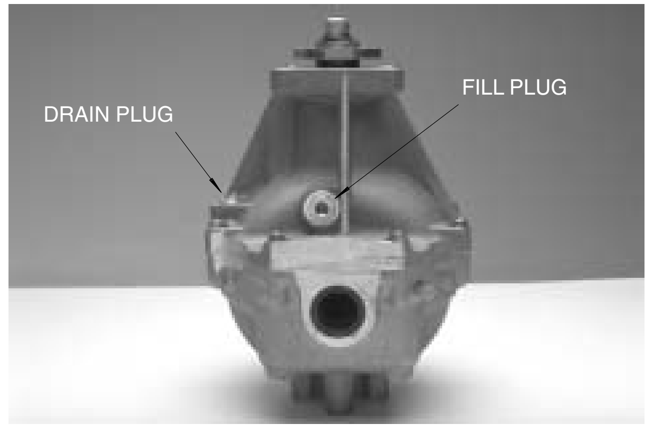


Figure 61

Ring to Pinion Gear Engagement

When replacing the ring and pinion gear set, final position of pinion is verified by using the gear contact pattern method as described in the following procedure. **Note:** engagement contact of original production ring and pinion gear may differ slightly from gear pattern shown.

GEAR TOOTH DEFINITIONS (Fig. 62):

Toe - the portion of the tooth surface at the end towards the center.

Heel - the portion of the gear tooth at the outer end.

Top Land - top surface of tooth.

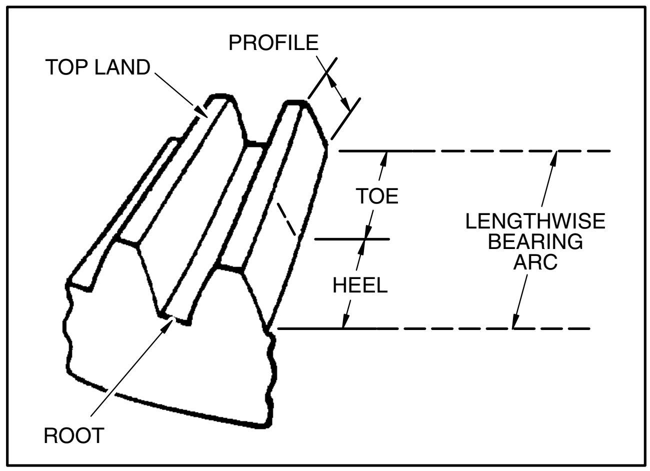


Figure 62

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. Both the drive side pattern and the coast side pattern on the ring gear should be at the toe portion of the tooth (Fig. 63).

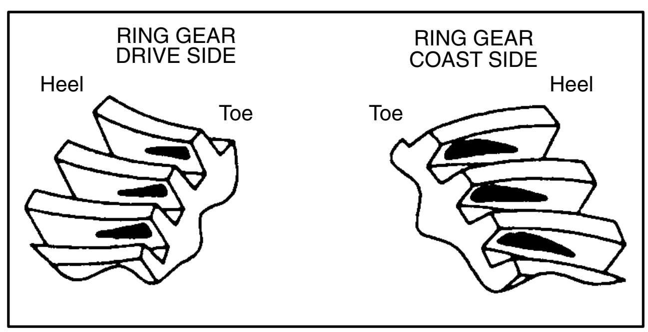


Figure 63

Study the patterns in the following illustrations and correct engagement as necessary.

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 re–checking the pattern.

Every gear has a characteristic pattern. The illustrations show typical patterns only and explain how patterns shift as gear location is changed. When making pinion position changes, shims should be changed in the range of .002” to .004” until a correct pattern has been obtained.

When a change in backlash is required, backlash shims should be changed in the range of 1-1/2 times the amount of backlash required to bring the gears into specification. For example, if the backlash needed to be changed by .004”, the shim pack should be changed by .006” 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.

Example 1: Backlash correct. Thicker pinion position shims required (Fig. 64).

Example 2: Backlash correct. Thinner pinion position shims required (Fig. 65).

Example 3: Backlash incorrect. Thinner pinion position shim required. Adjust backlash to match (Fig. 66).

GEAR PATTERN MOVEMENT SUMMARY:

A. 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.

B. Increasing backlash moves the ring gear away from the pinion.

Drive pattern (convex side of gear) moves higher and toward the heel.

Coast pattern (concave side of gear) moves slightly lower and toward the toe.

C. Thicker pinion position shim with the backlash constant moves the pinion closer to the ring gear.

Drive pattern (convex side of gear) moves deeper on the tooth (flank contact) and slightly toward the toe.

Coast pattern (concave side of gear) moves deeper on the tooth and toward the heel.

D. Thinner pinion position shim with backlash constant moves the pinion further from the ring gear.

Drive pattern (convex side of gear) moves toward the top of the tooth (face contact) and toward the heel.

Coast pattern (concave side of gear) moves toward the top of the tooth (face contact) and toward the heel.

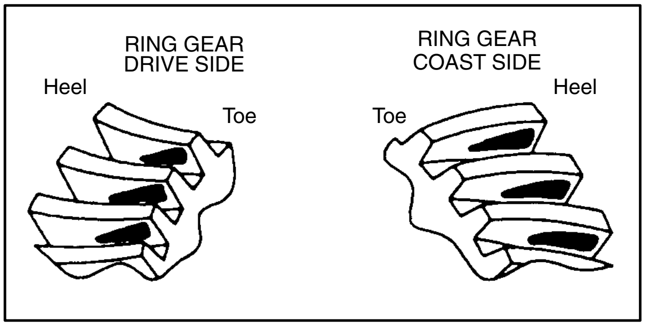


Figure 64

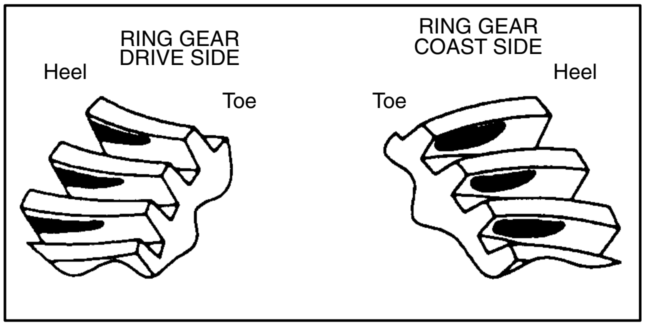


Figure 65

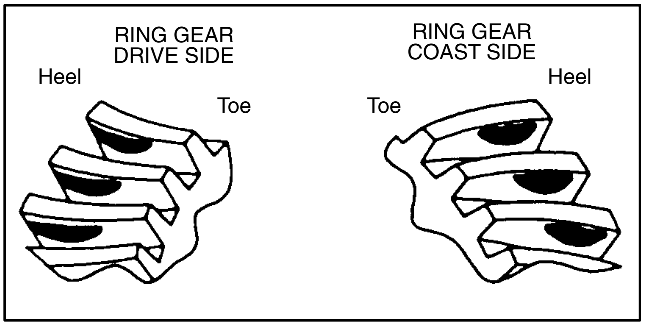


Figure 66

Differential Drive Shaft

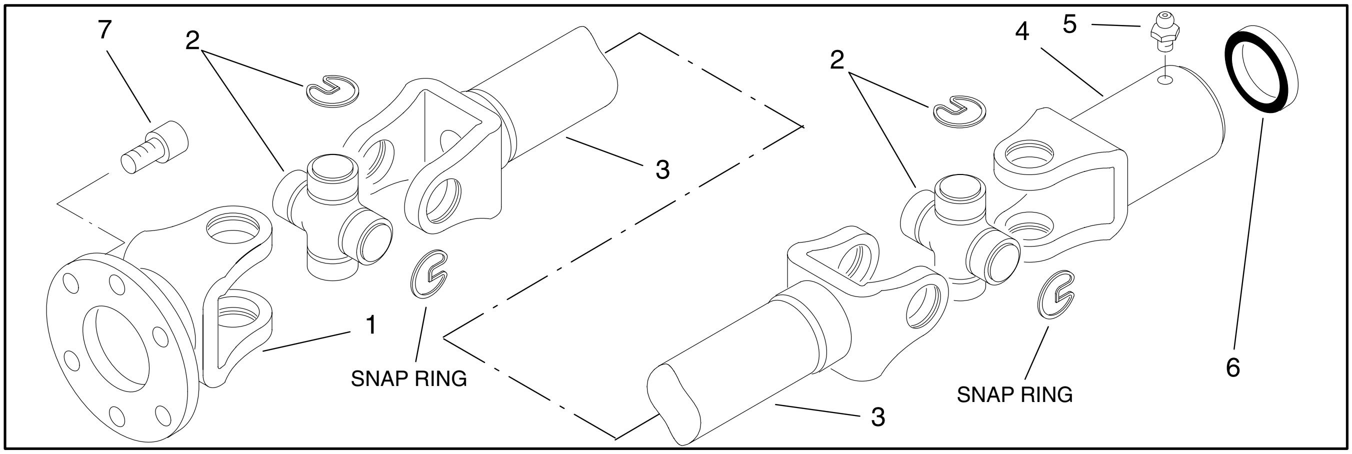


Figure 67

1. **Flange yoke**
2. **Cross and bearing kit**
3. **Tube yoke**
4. **Slip yoke**
5. **Grease fitting**
6. **Seal**
7. **Socket head screw**

Removal

1. Park machine on a level surface. Make sure engine is off. Set parking brake and block rear wheels.

2. Jack up and secure front wheels off the ground (see Jacking Vehicle in Chapter 1 – Safety).

> **WARNING**
>
> **Prevent flange yoke from dropping and causing personal injury when removing.**

3. Remove socket head screws securing the flange yoke to the coupler flange on the front differential (Fig. 68).

4. Slide slip yoke towards the bidirectional clutch. Pull slip yoke off the clutch shaft (Fig. 69).

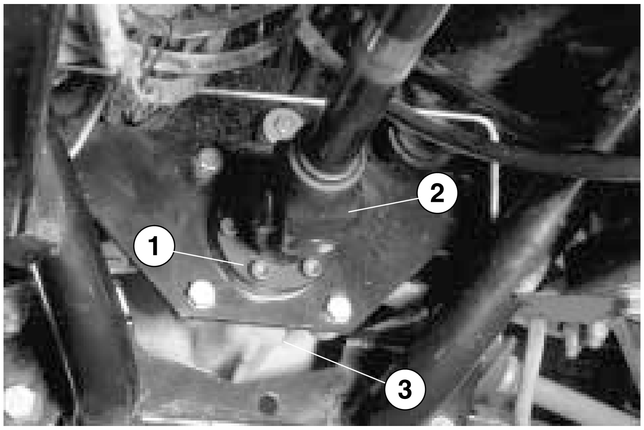


Figure 68

1. **Socket head screw**
2. **Flange yoke**
3. **Front differential**

Installation

1. Slide slip yoke onto clutch shaft(Fig. 69).

2. Position flange yoke to the coupler flange on the front differential. Secure yoke to the flange with socket head screws (Fig. 68).

3. Grease differential drive shaft assembly (see Lubrication).

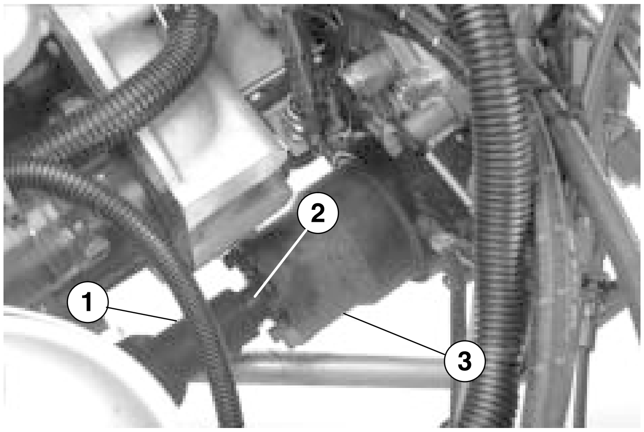


Figure 69

1. **Slip yoke**
2. **Clutch shaft**
3. **Bidirectional clutch**

Disassembly and Assembly (Fig. 67)

1. The differential drive shaft can be disassembled and assembled using Figure 67 as a guide.

2. Replace any worn or damaged parts.

Bidirectional Clutch

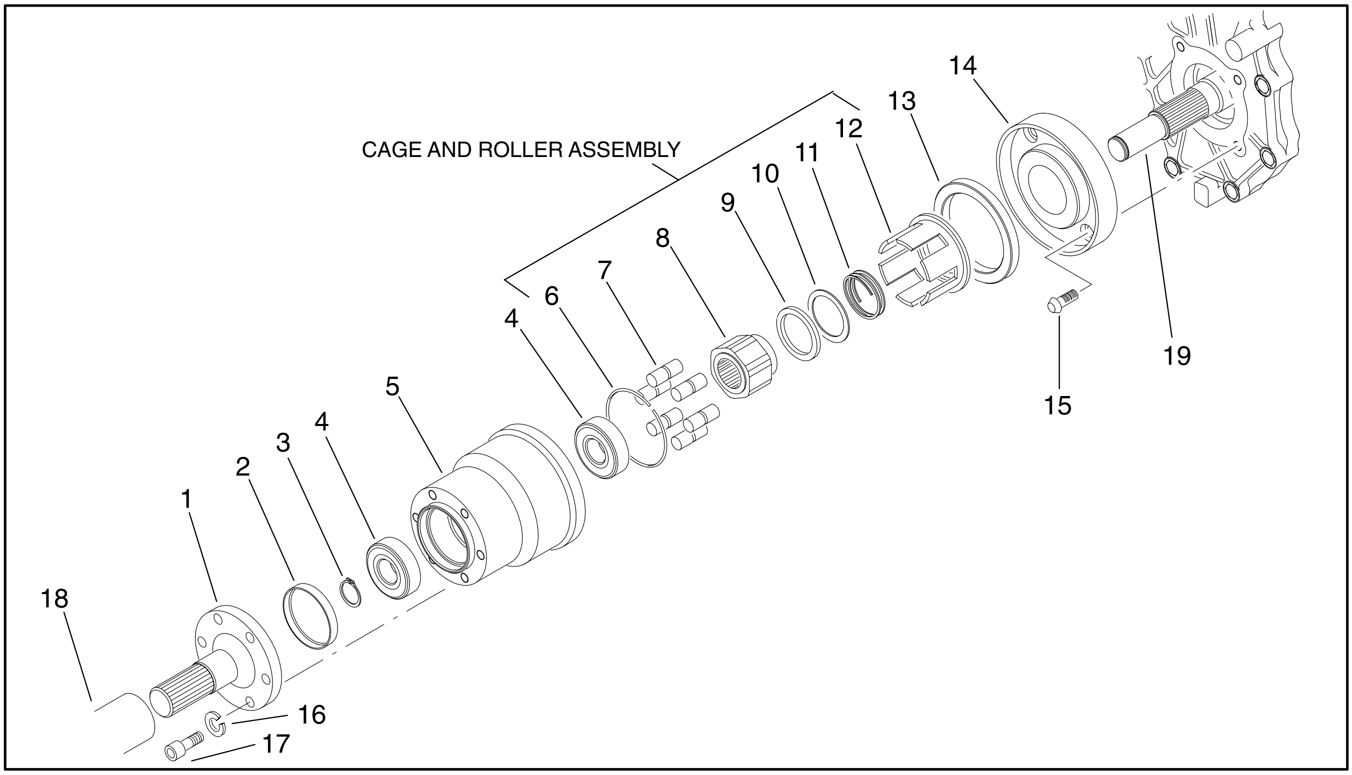


Figure 70

1. **Clutch shaft**
2. **Seal plug**
3. **Retaining ring**
4. **Ball bearing**
5. **Housing and race**
6. **Garter gear**
7. **Roller**
8. **Cam**
9. **Thrust bearing**
10. **Thrust washer**
11. **Spring**
12. **Cage**
13. **Oil seal**
14. **Adapter plate**
15. **Screw**
16. **Lock washer**
17. **Hex socket head screw**
18. **Differential drive shaft**
19. **Front drive shaft (transaxle)**

Removal (Fig. 70)

1. Park machine on a level surface. Make sure engine is off. Set parking brake and block rear wheels.

2. Remove drain plug from the transaxle. Drain all oil into a suitable container. Install drain plug.

3. Jack up and secure front wheels off the ground (see Jacking Vehicle in Chapter 1 – Safety).

4. Remove differential drive shaft (18) from clutch shaft (1) and the front differential (see Differential Drive Shaft Removal).

5. Remove hex socket head screws (17) and lock washers (16) securing the clutch shaft (1) to the housing and race (5).

6. Remove seal plug (2) from the housing and race (5). Discard seal plug.

7. Remove retaining ring (3) from the transaxle front drive shaft (19) using a snap ring pliers. Discard snap ring if it is cracked, distorted, or bent.

IMPORTANT: When removing the bidirectional clutch from the front drive shaft (19), hold the bearing end of the housing and race (5) down as it is removed to prevent dropping of parts. Be careful not to damage oil seal (13) on drive shaft splines.

8. Pull bidirectional clutch (5 through 12) from the transaxle front drive shaft (19) and adaptor plate (14).

Disassembly (Fig. 70)

Note: The cage and roller assembly consists of the garter spring (6), rollers (7), cam (8), thrust bearing (9), thrust washer (10), spring (11), and cage (12).

1. Tilt bearing end of the clutch up and slowly pull cage and roller assembly out of the housing and race (5) as a complete assembly and disassemble (see Fig. 71 and 72). **Be careful not to drop parts or damage oil seal.**

2. Pull ball bearings (4) if they require replacement (see Inspection).

3. Pull oil seal (13) if it requires replacement (see Inspection).

Inspection (Fig. 70)

1. Replace cage (12) if it is bent, cracked, or broken. Corrosion that can not be cleaned up with light polishing is not acceptable.

2. Replace spring (11) if flattened or distorted.

3. Replace thrust washer (10) if flat surfaces are pitted, gouged, or distorted.

4. Replace thrust bearing (9) if bent, distorted, or the needles do not spin freely.

5. Replace rollers (7) or cam (8) if any of the following conditions occur:

    A. Contact surfaces have excessive spalling or pitting. Peeling, gouges, or nicks are present.

    B. Corrosion that can not be cleaned up with light polishing is present.

    C. Roller ends are worn or scored. The rolling surface of the roller has any flat spots.

6. Replace garter spring (6) if it is distorted in any way that the rollers (7) are not held snuggly by the cam (8) and cage (12) when assembled (Fig. 71).

7. Replace ball bearings (4) if any of the following conditions occur:

    A. Play between bearing races and balls is excessive. The bearing cage is cracked or distorted.

    B. The inner or outer bearing races are cracked, distorted, discolored from over heating, or corroded.

    C. The balls are nicked, distorted, discolored from over heating, or corroded.

8. Replace oil seal (13) if its metal ring is distorted or bent. Distortion, cracks, or tears of the rubber seal is not acceptable.

9. Replace adapter plate (14) if the contact surface with the oil seal is nicked, cracked, or distorted (Fig. 74).

Figure 71

Figure 72

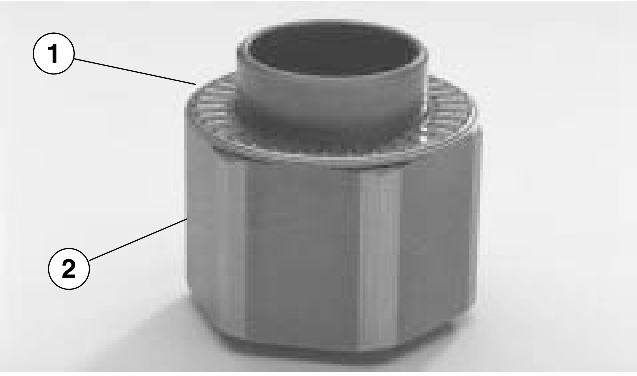


Figure 73

1. **Thrust bearing** 2. **Cam**

Figure 74

Assembly (Fig. 70)

1. Clean all parts thoroughly of all dirt and debris to prevent damage to the bidirectional clutch and transaxle.

2. Place garter spring around the cage and into the groove (Fig. 75).

3. Place thrust bearing, thrust washer, and spring onto the cam (Fig. 76).

4. Insert cam with thrust bearing, thrust washer, and spring into the cage (Fig. 77).

Note: Rollers must be replaced as a complete set.

5. Insert rollers into the slots of the cage. Make sure garter spring fits snuggly into the groove of all rollers (Fig. 77).

Note: Both bearings must be replaced as a set.

6. If the ball bearings (4) were remove, press **new** bearings into the housing and race (5).

7. If the oil seal (13) was removed, press **new** seal into the housing and race (5). Make sure the metal side of the seal faces out from the housing.

Installation (Fig. 70)

1. Clean adapter plate (14) thoroughly of all dirt and debris to prevent damage to the bidirectional clutch and transaxle.

2. If the adapter plate (14) was removed from the transaxle, install as follows:

   A. Make sure contact surfaces between the adapter plate and transaxle are free of dirt, debris, and oil.

   B. Apply Loctite 59375 black silicone sealant or equivalent to the back side of the adapter plate.

   C. Secure adapter plate to the transaxle with four screws (15). Make sure not to get sealant into the threaded holes of the transaxle.

3. Coat front drive shaft (19) and adapter plate (14) lightly with Dexron III ATF. Slide cage and roller assembly as a complete assembly (see Fig. 71) slowly onto the front drive shaft. Make sure large base end of the cage was installed first.

4. Position housing and race (5) over the cage and roller assembly. Make sure assembly parts are positioned properly by pushing the clutch towards the transaxle and feeling for spring (11) compression.

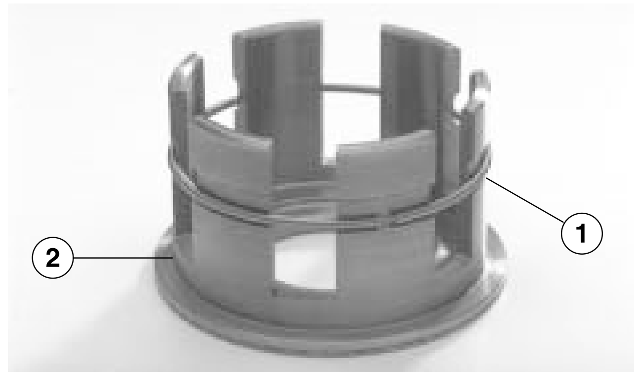


Figure 75

1. **Garter spring**
2. **Cage**

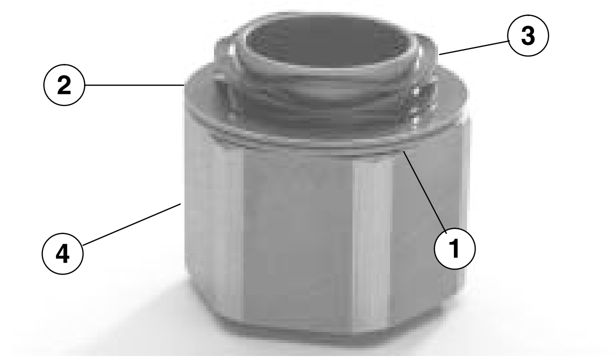


Figure 76

1. **Thrust bearing**
2. **Thrust washer**
3. **Spring**
4. **Cam**

Figure 77

1. **Cam**
2. **Cage**
3. **Roller**
4. **Garter spring**

IMPORTANT: Make sure retaining ring (3) is properly seated in the drive shaft (19) groove. Pull clutch out from the transaxle to make sure that it holds in place. Replace ring if bent or damaged.

5. Secure clutch to front drive shaft (19) with retaining ring (3).

IMPORTANT: Make sure rubber side of the seal plug (2) faces towards the clutch when installing.

6. Insert seal plug (2) into the housing and race (5) using a driver.

7. Secure clutch shaft to housing and race (5) with lock washers (16) and hex socket head screws (17).

8. Lower front wheels to ground.

9. Make sure drain plug is installed properly to the transaxle. Fill transaxle with Dexron III ATF (see Changing Transaxle/Hydraulic Fluid in the Service and Repairs section of Chapter 6 – Drive Train).

10. Install differential drive shaft (18) to clutch shaft (1) and the front differential (see Differential Drive Shaft Installation).

Lubrication

WARNING

Before servicing or making adjustments to the machine, stop engine, set parking brake and remove key from ignition switch. Any load material must be removed from bed or other attachment before working under raised bed. Always place the safety support on extended lift cylinder to hold box up.

The differential drive shaft has 3 grease fittings that must be lubricated regularly with No. 2 General Purpose Lithium Base Grease. If the machine is operated under normal conditions, lubricate the shaft after every 100 hours of operation. More frequent lubrication is required if used for heavy duty vehicle operations (Fig. 78).

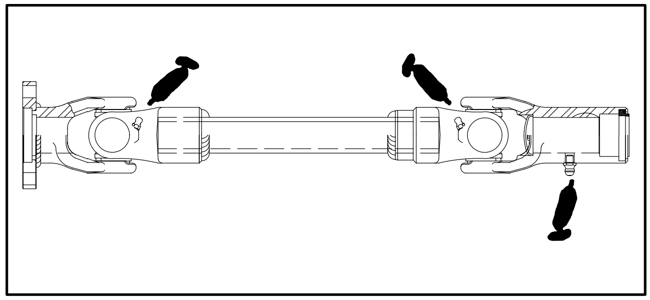


Figure 78

IMPORTANT: When greasing the universal shaft bearing crosses of the drive shaft, pump grease until it comes out of all 4 cups at each cross.

1. Wipe grease fitting clean so foreign matter cannot be forced into the bearing crosses.

2. Pump grease into the bearing crosses and slip yoke.

3. Wipe off excess grease.

Chapter 11

(For Mitsubishi Engine only)

Liquid Propane Gas Conversion Kit

Table of Contents

Specifications

Item	Description
Engine	Mitsubishi 3G83 liquid cooled gasoline (Modified)
Ignition Timing (low idle)	11° BTDC ± 2° @ 1200 ± 100 RPM
Ignition Timing (high speed)	22° BTDC ± 2° @ 3000 ± 100 RPM
Spark Plug Gap	0.030 inch (0.762 mm)
Fuel	Liquid propane gas
Fuel Tank	20 lb (9.1 kg) forklift style LP gas
Mixing adapter	In–line venturi
Vaporizer–Regulator	Engine vacuum demand, water heated
CARB Emission Levels for Recreational Vehicles under 25 HP	Tier I

General Information

Precautions for Working on Liquid Propane (LP) Gas Fuel Systems

CAUTION

Before starting work on any liquid propane system, disconnect the negative cable (black) from the battery.

CAUTION

Occupants should not remain in the vehicle while refueling. Refueling should be done by qualified personnel only.

DANGER

****Liquid propane (LP) gas is highly flammable.**

****Perform service work and refueling on an LP gas fuel system in an open or well ventilated area. NEVER FiLL FUEL TANK INDOORS! Never allow the gas to escape into a closed area. LP gas is heavier than air and may settle in low places.**

****Do not smoke. Avoid open flames and sparks that might ignite the fuel!**

****Avoid cutting and welding operations near LP gas systems.**

****Handle LP gas containers carefully. Do not drop or drag.**

****Installation and repair should be done by qualified service personnel only.**

****Never test for leaks with a flame. Use soap suds or an approved leak detector to test.**

****Do not fill tanks that are not properly labeled for LP gas use. Do not put LP gas into tanks with a service pressure capacity of less than 240 PSI. Do not tamper with valves or fittings in the LP gas system.**

WARNING

Avoid body contact with liquid fuel; its freezing capability can have the same effect as a severe burn.

CAUTION

LP gas must be treated with care. This fuel is naturally odorless and invisible. An identifying odor has been added to LP gas so the presence of the gas can be quickly detected. When escaping LP gas is detected, take the following steps:

1. Shut off tank service valves immediately.

2. Eliminate all possible sources of ignition.

3. Get qualified LP gas personnel to fix the problem.

WARNING

In case of a fire with LP gas, take the following steps:

1. Stop flow of gas immediately. Never put out flame, unless the gas can be shut off.

2. Clear immediate area of all people and notify fire department.

3. After gas flow is stopped, put out the fire. Usually the fire will stop once the gas flow is stopped. Use carbon dioxide and dry chemical fire extinguishers. DO NOT USE CARBON TETRACHLORIDE EXTINGUISHERS (PYRENE, ETC.); these will produce a poisonous gas.

4. If gas flow can not be stopped immediately, direct water on tanks to keep them cool. Do not try to put out fire with water.

CAUTION

Service on liquid propane fuel systems may require certification or special training. Check local and state regulations before performing any service or maintenance on LP gas systems.

1. Clean machine thoroughly before disconnecting or disassembling any LP gas system components. Always keep in mind the need for cleanliness when working on LP gas equipment. Contamination can cause early equipment failure.

2. Install fittings finger tight and far enough to make sure that they are not cross–threaded, then tighten fittings with a wrench.

Refueling

LPG gas is stored in a 20 lb fork lift style tank. Acceptable LP Gas mixtures should meet the specifications for Propane HD–5 of Gas Producers Association Standard 2140, or the specifications documented in California title 13 CCR 2292.6 or a mixture with a minimum of 90% propane by volume that can pass the ASTM D2713 test for moisture content.

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.

2. Read Precautions for Working on Liquid Propane Gas (LP) Fuel Systems carefully before proceeding further.

3. Remove propane tank (Fig. 1) from vehicle as follows:

A. Close valve on the propane tank. Disconnect hose quick connect fitting from the quick connect fitting on the tank.

B. Remove lynch pin securing the tank to the tank mount.

C. Lift front of the tank off the tank mount pin. Slide tank forward releasing the rear flange from the clips, and remove tank.

4. Remove protective cap from the filler valve and connect filler hose.

5. Open valve at the end of the fill hose. Next open main valve at the storage tank.

IMPORTANT: Fuel tank must be upright during refueling. This allows the bleeder valve that is set at the 80% filled position to operate properly during refueling.

6. Open bleeder valve on the fuel tank. **(Slight opening of the valve is sufficient)**.

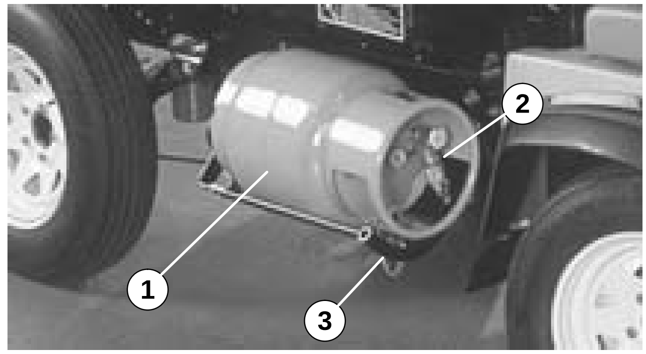


Figure 1

1. **Propane tank**
2. **Hose w/quick connect**
3. **Lynch pin w/lanyard**

WARNING

Never fill past the maximum safe level as indicated by 20% liquid level gauge. DO NOT OVER–FILL.

7. Turn propane pump on. Start fuel transfer. (Be sure all liquid valves are open before starting the pump).

8. When a white liquid stream of fuel appears from the bleeder valve, close valve on the end of fill hose immediately. Close bleeder valve on fuel tank hand tight (never use pliers).

9. Shut Propane Pump ”OFF”. Close main valve at the storage tank. Disconnect all hoses and replace caps.

10. Install propane tank onto the vehicle as follows:

A. Position tank onto the tank mount by sliding the rear flange of the tank under the clips and hole onto the pin. Secure tank to the pin with lynch pin.

B. Connect hose quick connect fitting to the quick connect fitting on the tank. Make sure fitting is tight so the check valve in the hose is released. Open valve on the fuel tank.

Starting Engine

1. Sit on operator’s seat and engage parking brake.

2. Disengage any attachments and return hand throttle lever to OFF position (if so equipped).

3. Move shift lever to NEUTRAL and depress clutch pedal.

4. Depress accelerator pedal slightly.

IMPORTANT: If the engine is cold, it may crank for 10 seconds before starting.

5. Turn ignition key to START.

6. If engine does not start after initial cranking, wait 30 to 60 seconds before cranking again.

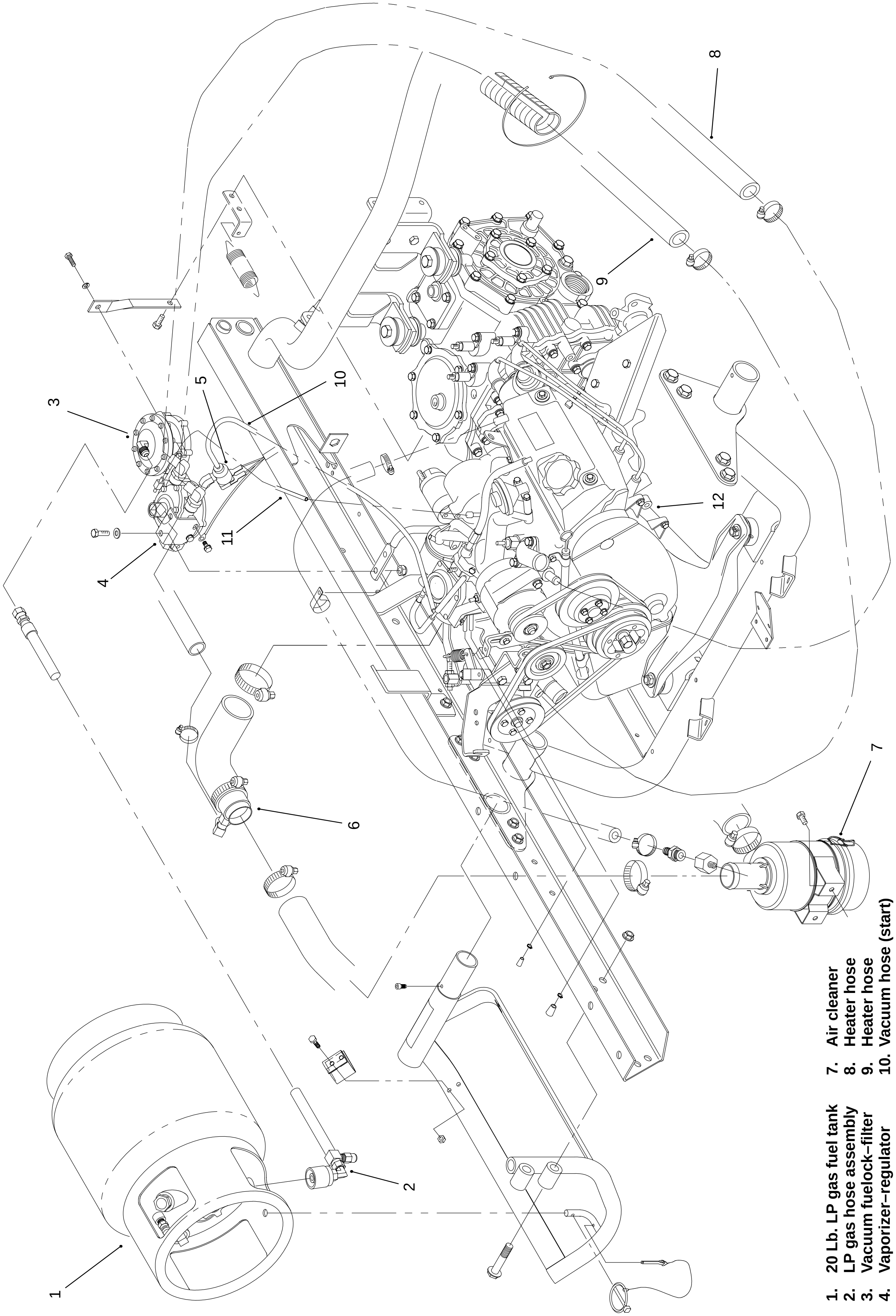
Special Tools

Pressure Test Pressure Gauge Kit

Use this kit to take various pressure readings for diagnostic tests of the liquid propane (LP) gas fuel system. The kit contains one each of the following: 0 to 160 PSI test gauge, 0 to 5 PSI test gauge, and 0 to 10 inches (H_2O) vacuum gauge, vacuum hose, and assorted fittings. Use gauges as recommended in Testing section of this chapter. These gauges and fittings can be obtained locally or through a local IMPCO Technologies distributor. When acquiring this equipment through local suppliers, make sure to check test port fitting sizes as illustrated in the Testing section of this chapter.

Figure 2

Functional Operation



1. 20 Lb. LP gas fuel tank
2. LP gas hose assembly
3. Vacuum fuelock–filter
4. Vaporizer–regulator
5. Starting valve
6. Mixing adapter
7. Air cleaner
8. Heater hose
9. Heater hose
10. Vacuum hose (start)
11. Vacuum hose (run)
12. Engine

Figure 3

Application

The Liquid Propane (LP) Gas Conversion Kit is installed to replace the gasoline fuel system on the Mitsubishi 3G83 liquid cooled engine. With the kit installed, only LP gas can be used to fuel the engine. LP gas is used for cleaner emissions over conventional gasoline. The carburetor is left intact.

Major Components (Fig. 3)

LP gas is stored in the 20–lb. fork lift style fuel tank. The tank has a fuel gauge. LP gas is delivered to the vacuum fuelock–filter through a LP gas hose assembly. The hose has a female quick fitting that attaches to the fuel tank. Both the tank and hose assembly automatically stop fuel flow should a rupture or high fuel flow rate occur in the fuel system.

The vaporizer–regulator allows LP gas to vaporize and expand. Attached to the vaporizer–regulator is the vacuum fuelock–filter. The vacuum fuelock–filter stops fuel flow when the engine is not operating.

The mixing adapter controls the air/fuel mixture when the engine is operating faster than idle speeds. It is located in–line of the air inlet hose between the air cleaner and the carburetor.

Operation (Fig. 3 and 4)

With the engine off and the cutoff valve on the fuel tank open, LP gas (150 PSI nominal to 250 PSI maximum) is supplied as a liquid to the vacuum fuelock–filter. The vacuum fuelock–filter is shut and no fuel enters into the vaporizer–regulator.

When the ignition switch is turned to the START position, the starter motor and starting valve are energized. As the engine rotates, a vacuum signal is transmitted from the air intake manifold, through a vacuum hose (run), and to the vacuum fuelock–filter and vaporizer–regulator. The signal opens the vacuum fuelock–filter to allow LP gas flow to the vaporizer–regulator and unlocks the vaporizer–regulator to allow LP gas flow into its primary chamber. Also, engine vacuum draws fuel through the vaporizer–regulator's primary and secondary chambers, through the starting valve, and then directly into the carburetor's air intake chamber while the engine is cranking.

When the ignition switch is released to the RUN position, the starter motor and starting valve are deenergized. The engine now is running on its own power and producing sufficient vacuum to keep the vacuum fuelock–filter open and the vaporizer–regulator unlocked.

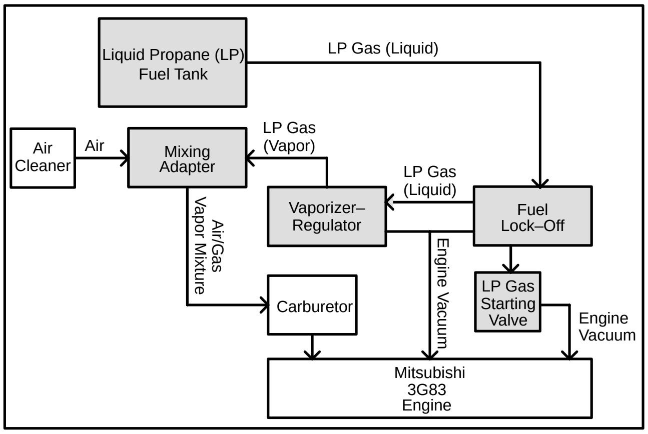


Figure 4

Fuel entering the primary chamber of the vaporizer–regulator vaporizes and expands to a pressure of 4 to 5 PSI. During the expansion and vaporization process, heat is removed from the LP gas. Engine coolant passes through the vaporizer–regulator so heat is added back to the fuel after the engine warms up. The vaporized LP gas is then released to the secondary chamber of the vaporizer–regulator.

The vacuum of the engine draws air through the air cleaner, mixing adapter, and carburetor to the engine. The inside of the mixing adapter acts as a venturi that creates a negative pressure that draws vaporized fuel from the secondary chamber of the vaporizer–regulator. The fuel flow out of the chamber varies closely with airflow. A fuel–metering device (orifice) is connected to the mixing adapter in–line with the vaporizer–regulator. The orifice regulates the fuel entering the adapter, which results in a consistent air/fuel mixture to the engine. The mixture is determined by the design of the components and is not adjustable. The fuel/air mixture obtained at idle speed and starting is controlled by a screw adjustment at the vaporizer–regulator. At idle speed, the venturi pressure signal is not sufficient to draw fuel into the adapter. To provide sufficient fuel flow at this low speed, the vaporizer–regulator has an idle screw adjustment that will make sure a minimum amount of fuel flows to the mixing adapter.

After the air/fuel mixture leaves the mixing adapter and enters the carburetor, the carburetor is used as throttling device to change the air/fuel mixture flow rate into the engine. Once in the engine, the fuel is consumed in the same manner as a gasoline engine.

When the ignition switch is taken to the OFF position, electrical power is interrupted to the spark plugs. Ignition in the engine stops and the shuts down. Once the engine slows down enough, engine vacuum will not be sufficient enough to keep the vacuum fuelock–filter open and the vaporizer–regulator unlocked. The vacuum fuelock–filter shuts and the vaporizer–regulator locks. Fuel flow is stopped to the vaporizer–regulator, mixing adapter, and the engine.

Troubleshooting

With the exception of the fuel system, a gasoline engine converted to run on LP gas operates as a gasoline one. When looking for the source of a engine malfunction, it is important to eliminate all other possible causes that are not associated with the fuel system (see Troubleshooting in Chapter 3 – Liquid Cooled Gas Engine).

If the fuel system is not operating properly, take the following steps to determine the cause:

1. Look for obvious causes of malfunction such as an empty fuel tank, a shut fuel tank cutout valve, or a disconnected or loose fuel hose.

2. Make sure there are no air leaks in the fuel system. The LP gas fuel system operates using negative pressures. Make sure all components and hoses are secured tightly. Check for fuel leaks with soapy water.

3. Make sure filter screen in the vacuum fuelock–filter is not clogged or dirty (see Replace Filter Screen in Vacuum Fuelock–Filter).

4. Use Testing LP Gas Fuel System procedures to determine the malfunctioning component

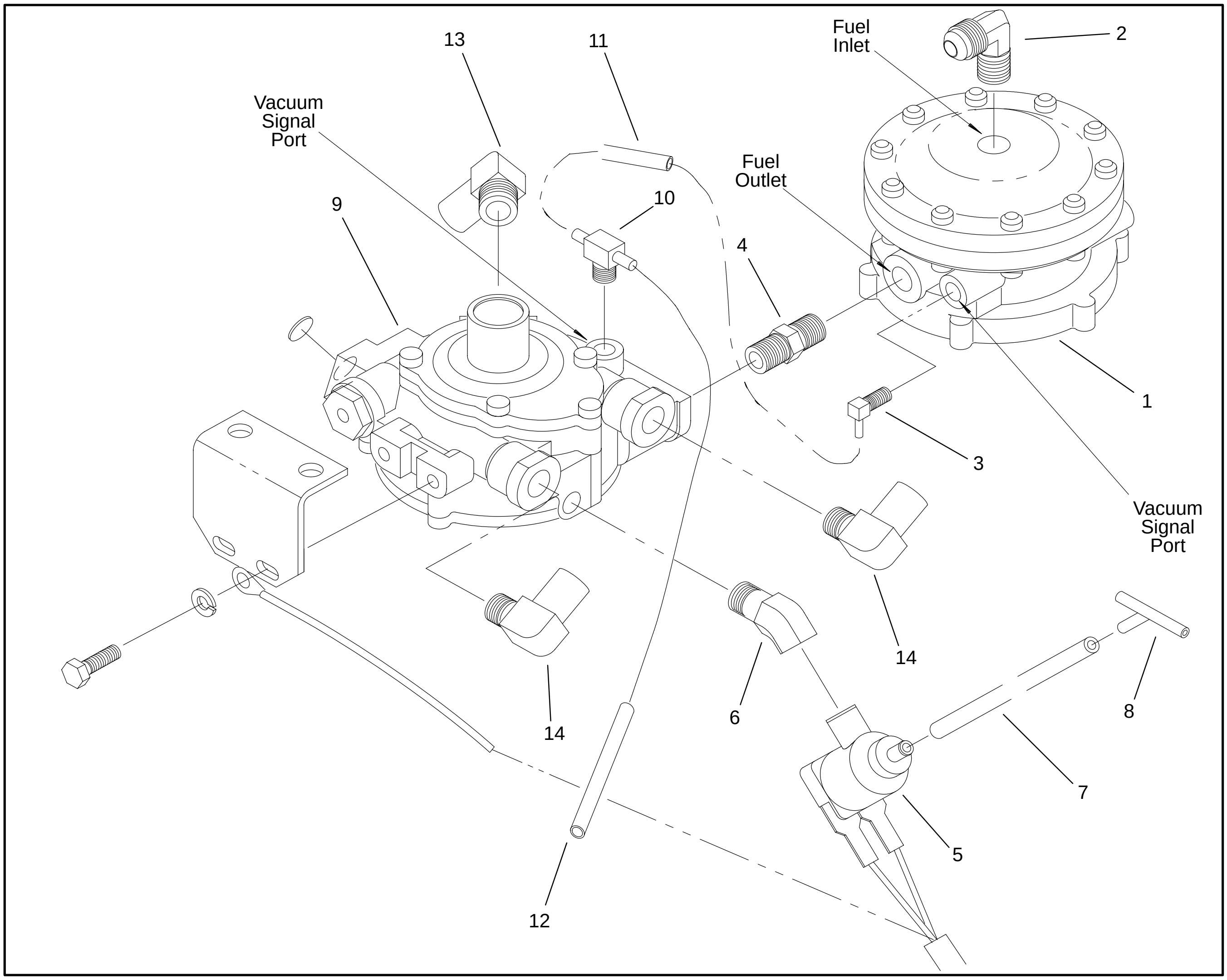


Figure 5

1. **Vacuum fuelock filter**
2. **3/8 in. flare to 1/4 in. fitting**
3. **1/8 in. NPT to 1/4 in.**
4. **1/4 in. NPT nipple fitting**
5. **Starting valve**
6. **1/8 in. NPT brass fitting (45°)**
7. **5/32 in. vacuum hose**
8. **Wye vacuum connector**
9. **Vaporizer–regulator**
10. **1/4 in. to 1/4 in. fitting**
11. **5/32 in. vacuum hose**
12. **5/32 in. vacuum hose**
13. **3/8 in. NPT to 5/8 in. elbow**
14. **1/4 inch NPT elbow**

Testing LP Gas Fuel System (Fig. 5)

Preliminary

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.

2. Read carefully Precautions for Working on Liquid Propane Gas Systems before proceeding to any of the tests.

3. Make sure there is sufficient LP gas in the tank to run the engine before each test.

Test Vacuum Fuelock Filter

1. Connect 0 to 160 PSI test gauge in–line between the fuel outlet of the vacuum fuelock filter and the vaporizer regulator.

2. Connect 0 to 10 inches (H_2O) vacuum gauge in–line between the vacuum signal port of the vacuum fuelock filter and the vacuum hose.

3. Make sure all fittings are tight and the fuel cut out valve on the fuel tank is open.

4. If the engine is operable, start the engine. If the engine is unable to start, crank the engine for sufficient time to read the gauges.

5. If the vacuum gauge is reading 2 inches or more, the pressure gauge should read about 150 PSI (nominal). This indicates the vacuum fuelock is open.

6. Stop the engine. The vacuum gauge should read less than 2 inches. The pressure gauge should read about 0 PSI (nominal). This indicates the vacuum fuelock is closed.

7. If the vacuum gauge is reading less than 2 inches with the engine cranking or running, the pressure gauge should read about 0 PSI (nominal). Check the connections to the vacuum gage to make sure there is no leakage.

8. Shut off engine, remove gauges, and reconnect hoses and fittings.

Test Vaporizer–regulator

1. Connect 0 to 5 PSI test gauge to the primary pressure test port on the vaporizer regulator (Fig. 6).

2. Connect 0 to 10 inches (H_2O) vacuum gauge in–line between the vacuum signal port of the vaporizer–regulator and the vacuum hose from the air intake manifold.

3. Make sure all fittings are tight and the fuel cut out valve on the fuel tank is open.

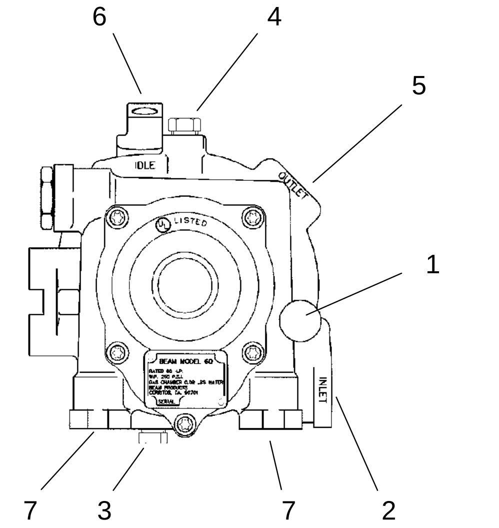


Figure 6

1. Vacuum port (1/8 inch NPT)
2. LP gas inlet (1/4 inch NPT)
3. To carburetor air intake (1/8 inch NPT)
4. Primary press. test port (1/8 inch NPT)
5. Vaporized fuel outlet (3/8 inch NPT)
6. Idle adjustment screw
7. Water connection (1/4 inch NPT)

4. If the engine is operable, start the engine. If the engine is unable to start, crank the engine for sufficient time to read the gauges.

5. If the vacuum gauge is reading 2.7 inches or more, the pressure gauge should read about 4.0 to 5.0 PSI. This indicates the vaporizer–regulator is operating properly.

6. Stop the engine. The vacuum gauge should read less than 2.7 inches, the pressure gauge should read about 0 PSI (nominal). This indicates the vaporizer–regulator is locked off.

7. If the vacuum gauge is reading less than 2.7 inches with the engine cranking or running, the pressure gauge should read about 0 PSI (nominal). Check the connections to the vacuum gage to make sure there is no leakage.

8. Shut off engine, remove gauges, and reconnect hoses and fittings.

Adjustments

Adjust LP Fuel System

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.

2. Read carefully Precautions for Working on Liquid Propane Gas (LP) Fuel Systems before proceeding further.

3. Slowly open valve on propane fuel tank and close. Use leak check or soap solution to check all fittings, valves, couplers, and lines for leaks. **No fuel leaks should be present.** Any detected fuel leaks must be repaired before engine is started.

IMPORTANT: Use exhaust gas analyzer to monitor CO readings.

4. Reopen tank valve and start engine. Allow engine to reach normal operating temperature. Using idle adjustment screw, adjust for a CO readIng of 1 to 3% at idle speed of 1200 rpm (Fig. 7).

5. Run engine at 3000 rpm and recheck idle CO adjustment. High load mixture is not adjustable but will produce a CO readIng of 3 to 7%.

6. To prevent tampering with adjustment, install welsh plug over idle mixture screw (Fig. 7).

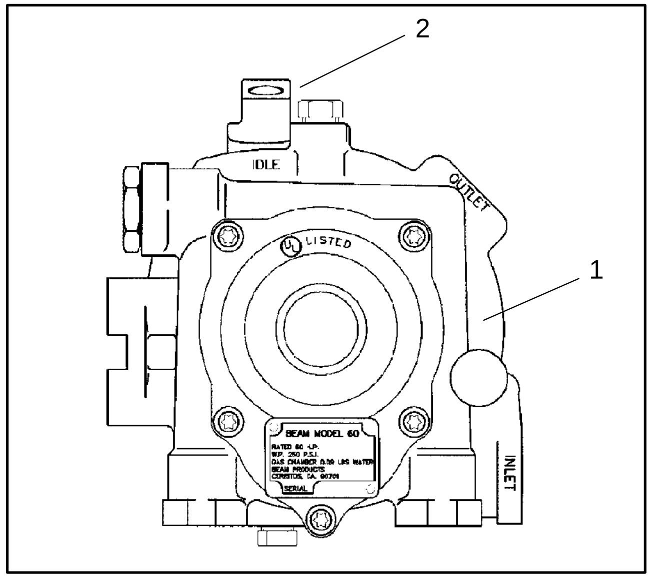


Figure 7

1. Vaporizer–regulator **2. Idle adjustment screw**

Service and Repairs

Check Spark Plug Gap

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.

2. Read carefully Precautions for Working on Liquid Propane Gas (LP) Fuel Systems before proceeding further.

3. Clean area around spark plugs so foreign matter cannot fall into cylinder when spark plug is removed.

4. Disconnect spark plug wires off spark plugs. Remove plugs from cylinder head.

IMPORTANT: A cracked, fouled, dirty or otherwise malfunctioning spark plug must be replaced. Do not sand blast, scrape, or clean electrodes by using a wire brush because grit may eventually release from the plug and fall into the cylinder usually resulting in a damaged engine.

5. Check condition of side electrode, center electrode, and center electrode insulator to assure there is no damage.

6. Set air gap between center and side of electrodes at 0.030 inch (0.762 mm). Install correctly gapped spark plug and tighten plug to 15 to 20 ft–lb (20 to 27 N–m).

7. Connect spark plug wires to spark plugs.

Replace Filter Screen in Vacuum Fuelock–Filter

1. Park machine on a level surface. Raise bed (if so equipped) and place safety support under bed to hold it up. Stop engine, engage parking brake, and remove key from the ignition switch.

2. Read carefully Precautions for Working on Liquid Propane Gas (LP) Fuel Systems before proceeding further.

3. Close valve on propane tank.

4. Run engine until all fuel has been drawn out of fuel line and engine dies.

5. Remove fasteners securing the cover of vacuum fuelock–filter to its base.

6. Remove filter screen from the base.

7. Replace filter screen and install cover.

8. Slowly open valve on propane tank. Check for leaks using soapy water solution. **No fuel leaks should be present.** Any detected fuel leaks must be repaired before engine is started.

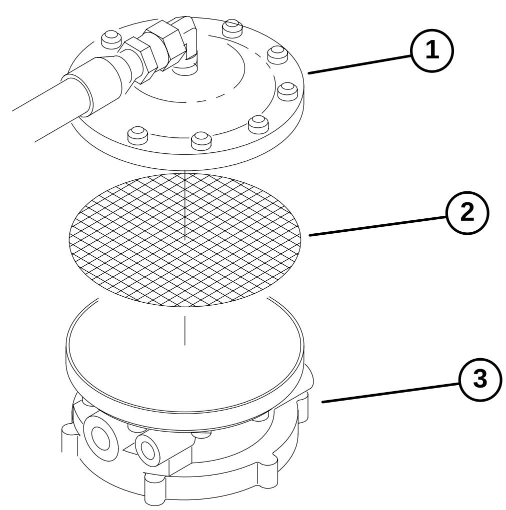


Figure 8

1. **Cover**
2. **Filter screen**
3. **Base**

Fuel Tank Assembly

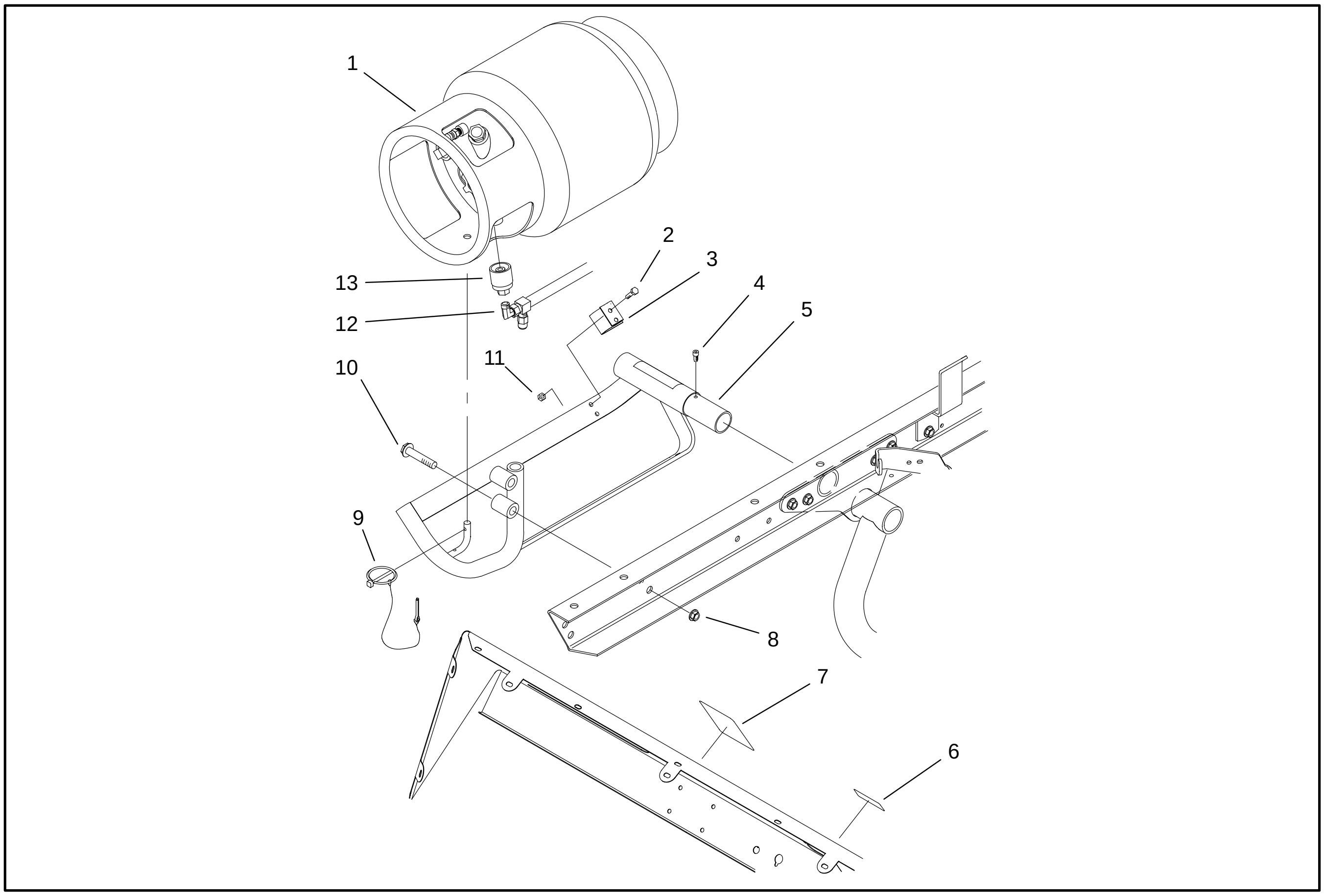


Figure 9

1. 20 lb. LP gas fuel tank
2. Flange head screw
3. Clip
4. Thread forming screw
5. Tank mount
6. LP gas fuel decal
7. LP gas dash decal
8. Flange nut
9. Lynch pin
10. Flange head screw
11. Lock nut
12. Hose assembly
13. Quick fitting (female)

Removal

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.

2. Read carefully Precautions for Working on Liquid Propane Gas Systems before proceeding further.

3. Remove component parts as necessary using Figure 9 as a guide.

Installation

1. Read carefully Precautions for Working on Liquid Propane Gas Systems before proceeding further.

2. Install component parts as necessary using Figure 9 as a guide.

Conversion Kit Assembly

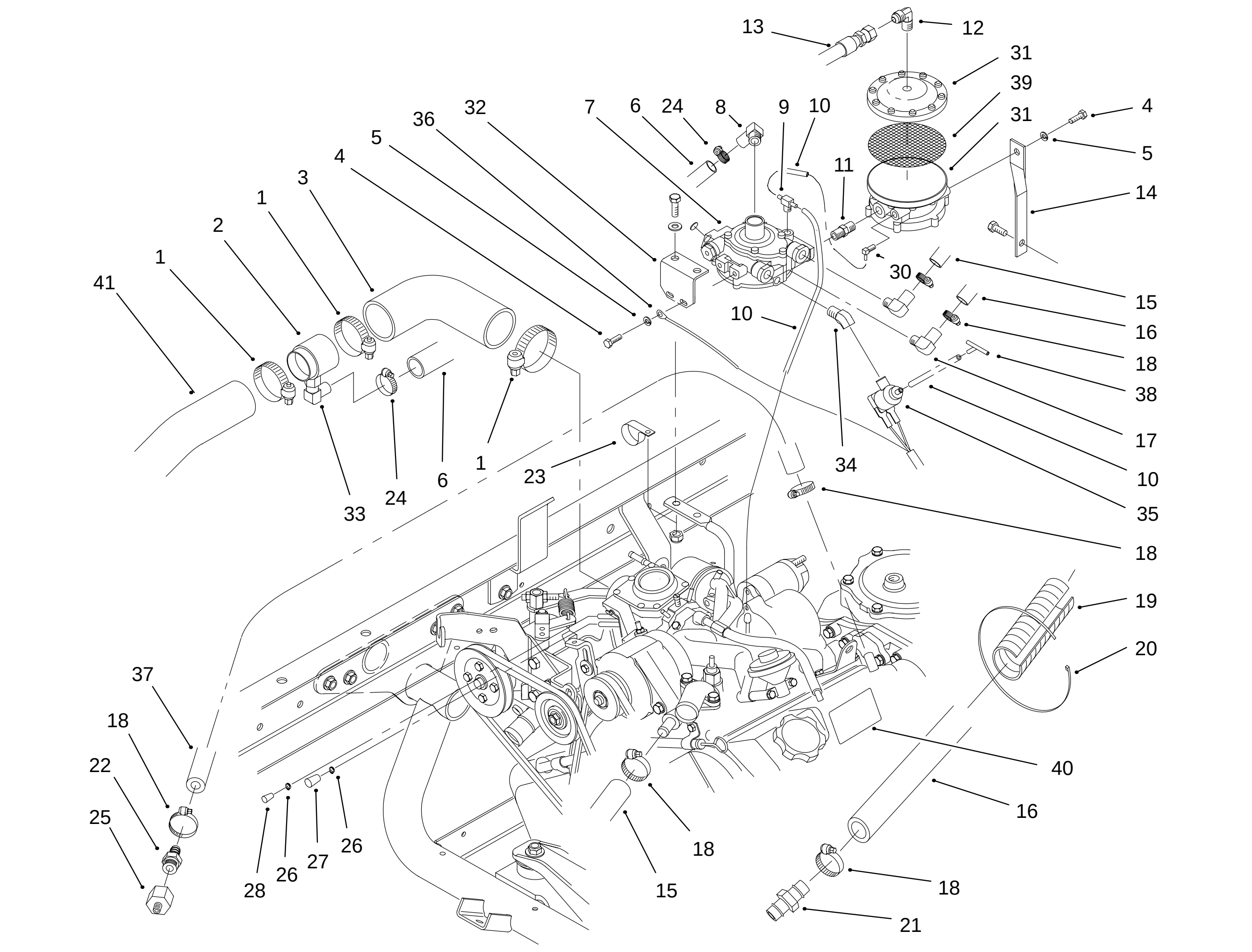


Figure 10

1. Hose clamp	**15. 1/2–inch heater hose**	**29. Not used**
2. Hose adapter	**16. 1/2–inch heater hose**	**30. 1/8–inch NPT to 1/4–inch fitting**
3. 2–inch rubber elbow	**17. 1/4–inch NPT**	**31. Vacuum fuelock–Filter**
4. Cap screws	**18. Worm clamp**	**32. Converter bracket**
5. Lock washer	**19. Convoluted split tubing**	**33. 5/8–inch by 3/8–inch NPT fitting**
6. Vapor hose	**20. Cable tie**	**34. 45° fitting**
7. Vaporizer–regulator	**21. 1/2–inch hose mender**	**35. Starting valve**
8. Elbow	**22. Hose bard fitting**	**36. Wire harness**
9. Fitting	**23. R–clamp**	**37. PVC hose**
10. Vacuum hose	**24. Hose clamp**	**38. Vacuum connector**
11. 1/4–inch NPT nipple fitting	**25. Expander adapter**	**39. Filter screen**
12. 3/8–inch flare to 1/4–inch fitting	**26. Worm clamp**	**40. Engine decal**
13. HOse assembly	**27. 1/4–inch vacuum clamp**	**41. Air intake hose**
14. Support strap	**28. 3/16–inch vacuum cap**	

Removal

1. Park machine on a level surface, stop engine, engage parking brake, and remove key from the ignition switch.

2. Read carefully Precautions for Working on Liquid Propane Gas Systems before proceeding further.

3. Remove component parts as necessary using Figure 10 as a guide.

Installation

1. Read carefully Precautions for Working on Liquid Propane Gas Systems before proceeding further.

2. Install component parts as necessary using Figure 10 as a guide.

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