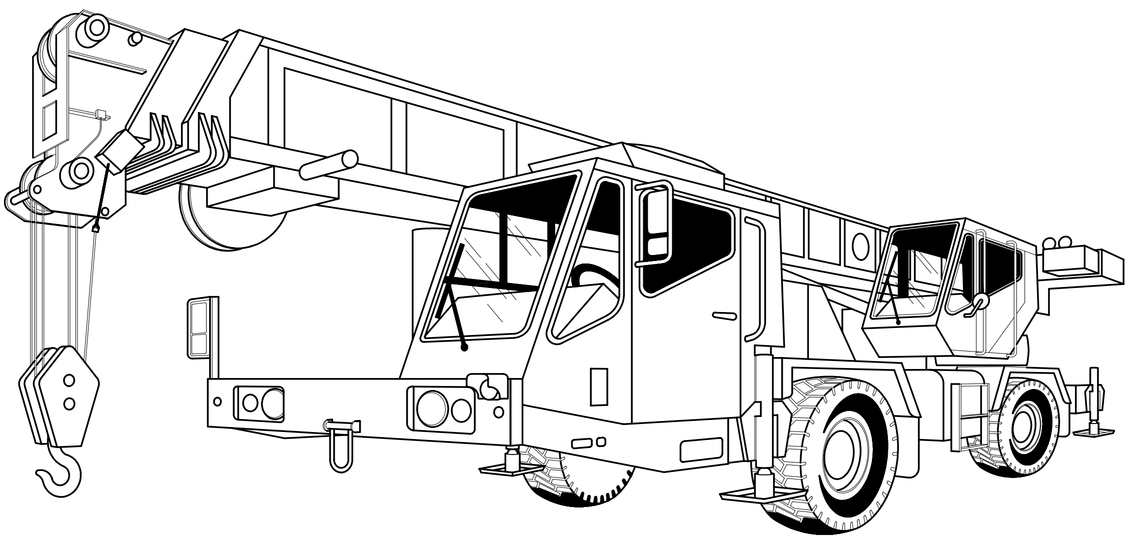
TM 5-3810-307-24-1-2

TECHNICAL MANUAL

ORGANIZATIONAL, DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL FOR ALL-TERRAIN CRANE (ATEC) AT-422T DIESEL ENGINE DRIVEN, 22 TON CAPACITY TRUCK MOUNTED WITH CAB

NSN 3810-01-448-2619



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HEADQUARTERS, DEPARTMENT OF THE ARMY

AUGUST 2000

WARNING

OPERATIONS ADJACENT TO OVERHEAD LINES ARE PROHIBITED UNLESS ONE OF THE FOLLOWING CONDITIONS ARE SATISFIED.

1	POWER HAS BEEN SHUT OFF AND POSITIVE MEANS TAKEN TO PREVENT LINES FROM BEING ENERGIZED.	
2	POSITION AND BLOCK EQUIPMENT INSURING NO PARTS, INCLUDING CABLE, CAN COME WITHIN THE FOLLOWING CLEARANCES:	VOLTAGE REQD CLEARANCE UNDER 50 KV - 10 FEET 69 KV - 12 FEET 115-161 KV - 15 FEET 230-285 KV - 20 FEET 345 KV - 25 FEET 500 KV - 35 FEET

CHECK WITH YOUR LOCAL POWER SUPPLIER FOR CORRECT LINE VOLTAGE

NOTE

READ AND UNDERSTAND ALL OF THE SAFETY WARNINGS AND CAUTIONS CONTAINED IN SECTION 2 OF THE OPERATOR'S MANUAL BEFORE OPERATING OR MAINTAINING THE CRANE, DIRECT ANY QUESTIONS THAT YOU MAY HAVE TO YOUR SUPERVISOR FOR CLARIFICATION.

TM 5-3810-307-24-1-2

CHANGE
NO. 1

HEADQUARTERS, DEPARTMENT OF THE ARMY
WASHINGTON D.C., 30 NOVEMBER 2006

TECHNICAL MANUAL

ORGANIZATIONAL, DIRECT SUPPORT AND GENERAL SUPPORT
MAINTENANCE MANUAL FOR
ALL-TERRAIN CRANE (ATEC) AT-422T
DIESEL ENGINE DRIVEN, 22 TON CAPACITY
TRUCK MOUNTED WITH CAB

NSN 3810-01-448-2619

DISTRIBUTION STATEMENT A – Approved for public release; distribution is unlimited.

TM 5-3810-307-24-1-2, 1 August 2000, is updated as follows:

1. File this sheet in front of the manual for reference.
2. This change is a result of changes documented against the configuration of the crane. Extreme weather equipment including engine coolant and hydraulic reservoir heaters have been added as an option.
3. New or updated text is indicated by a vertical bar in the outer margin of the page.
4. Added illustrations are indicated by a vertical bar adjacent to the figure number. Changed illustrations are indicated by change bars in the outside margin adjacent to the updated area and a change bar adjacent to the figure number.
5. Remove old pages and insert new pages as indicated below:

Remove Pages	Insert Pages
List of Effective Pages	List of Effective Pages
i thru iv and i thru vi	i thru x
SM02-025-0 (Page 51 and 52)	SM02-025-0 (Page 51 and 52)
SM02-025-0 (Page 67 and 68)	SM02-025-0 (Page 67 and 68)
SM02-025-0 (Page 97/(98 Blank)	SM02-025-0 (Page 97/(98 Blank)
SM02-027-0 (Page 15 and 16)	SM02-027-0 (Page 15 and 16)
Appendix B (Table of Contents)	Appendix B (B-1 thru B-4)
Appendix B (Page 7-9 thru 7-11)	Appendix B (Page 7-9 and Figure 7-9)
Appendix B (Page 8-5 and 8-6)	Appendix B (Page 8-5 and 8-6)
Appendix B (Page 9-5 and 9-6)	Appendix B (Page 9-5 and 9-6)
Appendix C (i-1 thru i-12)	Appendix C (i-1 thru i-8)
Appendix C (G-1 and G-2)	Appendix C (G-1 and G-2)
Appendix C (G-7 thru G-18)	Appendix C (G-7 thru G-14)
Appendix C (T-3 thru T-6)	Appendix C (T-3 thru T-6)
Appendix C (12-1 thru 12-170)	Appendix C (12-1 thru 12-52)
Appendix C (V-1 thru V-22)	Appendix C (V-1 thru V-16)
Appendix C (Index Page X-1 and X-2)	Appendix C (Index Page X-1/(X-2 Blank)

Remove Pages	Insert Pages
Appendix D (Page 1 thru Page 22)	Appendix D (Page D-1 thru D-14)
Appendix E (SB 1M-157 Page 1 thru Page 8)	Appendix E (SB 1M-157 Page E-1 thru E-6)
Appendix E (SB 1M-188 (Page 1, Page 2, and Page 25)	Appendix E (SB 1M-188 (Page E-7 and E-8)
Appendix G (Cover and Page 1 thru 72)	Appendix G (G-1 thru G-78)
Appendix H (Cover and Page 1 thru 79) Cover	Appendix H (H-1 thru H-48) Cover

6. Remove the following Service Maintenance (SM) Packages and Appendix (no replacements):

SM 02-026-0 (Pages 1 thru 8)
SM 07-003-0 (Pages 1 thru 6)
SM 07-010-0 (Pages 1 thru 4)
SM 07-011-0 (Pages 1 thru 6)
SM 07-013-0 (Pages 1 thru 4)
SM 07-015-0 (Pages 1 thru 8)
SM 07-016-0 (Pages 1 thru 8)
SM 07-036-0 (Pages 1 thru 14)
SM 08-016-0 (Pages 1 thru 4)
SM 08-019-0 (Pages 1 thru 4)
SM 08-021-0 (Pages 1 thru 6)
SM 08-022-0 (Pages 1 thru 4)
SM 08-023-0 (Pages 1 thru 8)
SM 08-025-0 (Pages 1 thru 4)
SM 08-028-0 (Pages 1 thru 6)
SM 08-039-0 (Pages 1 thru 4)
SM 08-040-0 (Pages 1 thru 4)
SM 08-067-0 (Pages 1 thru 6)
SM 09-001-0 (Pages 1 thru 12)
Appendix F (54 pages)

7. Add the following new pages:

Appendix I (I-1 thru I-14)
Appendix J (J-1 thru J-58)
Appendix K (K-1 thru K-90)

By Order of the Secretary of the Army:

PETER J. SCHOOMAKER
General, United States Army
Chief of Staff

Official:

JOYCE E. MORROW
Administrative Assistant to the
Secretary of the Army
0632501

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INSERT LATEST CHANGED PAGES. DESTROY SUPERCEDED DATA.

LIST OF EFFECTIVE PAGES

NOTE: The portion of text affected by the changes is indicated by a vertical line in the outer margins of the pages. Changes to illustrations are also indicated by vertical lines in the outer margins.

Dates of issue for original and changed pages are:

Original ..0..1 August 2000

Change ..1..30 November 2006

TOTAL NUMBER OF PAGES FOR THIS MANUAL IS 802
CONSISTING OF THE FOLLOWING:

Page No.	*Change No.	Page No.	*Change No.	Page No.	*Change No.
Cover	1	SM07-006-0		Appendix B	
Blank	0	1 – 4	0	B-1/(B-2	0
Warning	0	SM07-008-0		blank)	
Blank	0	1 – 6	0	B-3/(B-4	1
i and ii	1	SM07-012-0		blank)	
iii	0	1 – 4	0	7-1 – 7-8	0
iv – ix/	1	SM07-014-0		7-9	1
(x blank)		1 – 6	0	Figure 7-9	1
SM01-001-0		SM07-017-0		8-1 – 8-4	0
1 – 8	0	1 – 4	0	8-5 – 8-6	1
SM01-002-0		SM08-015-1		8-7 – 8-24	0
1 – 10	0	1 – 18	0	9-1 – 9-4	0
SM02-025-0		SM08-017-1		9-5 – 9-6	1
1 – 51	0	1 – 10	0	9-7 – 9-12	0
52	1	SM08-018-1		Appendix C	
53 – 66	0	1 – 4	0	C-1 – C-4	0
67	1	SM08-041-1		i-1	1
68 – 96	0	1 – 4	0	i-2 – i-3	0
97/(98	1	SM09-004-0		i-4 – i-8	1
blank)		1 – 8	0	E-1 – E-2	0
SM02-027-0		SM11-010-1		F-1 – F-2	0
1 – 14	0	1 – 16	0	G-1	1
15	1	SM11-011-0		G-2 – G-7	0
16 – 18	0	1 – 10	0	G-8 – G-9	1
SM03-026-0		SM13-006-0		G-10 – G-11	0
1 – 34	0	1 – 6	0	G-12 – G-14	1
SM04-019-0		SM13-007-0		T-1 – T-2	0
1 – 6	0	1 – 6	0	T-3	1
SM04-020-0		SM14-001-0		T-4	0
1 – 6	0	1 – 18	0	T-5	1
SM07-005-0				T-6 – T-10	0
1 – 4	0				

* Zero in this column indicates an original page.

LIST OF EFFECTIVE PAGES - Continued

Page No.	*Change No.	Page No.	*Change No.	Page No.	*Change No.
12-1 –12-15	1				
12-16	0				
12-17-12-18	1				
12-19	0				
12-20-12-52	1				
V-1	1				
V-2	0				
V-3 – V-16	1				
C-1 – C-4	0				
L-1 – L-6	0				
X-1/(X-2 Blank)	1				
Notes/Notes	0				
D-1 – D-14	1				
E-1/(E-2 blank)	0				
E-3 – E-8	1				
G-1 – G-78	1				
H-1 – H-48	1				
I-1 – I-14	1				
J-1 – J-58	1				
K-1 – K-90	1				

* Zero in this column indicates an original page.

HQ, DEPARTMENT OF THE ARMY, WASHINGTON D.C., 1 AUGUST 2000

TECHNICAL MANUAL

ORGANIZATIONAL, DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL FOR ALL-TERRAIN CRANE (ATEC) AT-422T DIESEL ENGINE DRIVEN, 22 TON CAPACITY TRUCK MOUNTED WITH CAB

NSN 3810-01-448-2619

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this publication. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Submit your DA Form 2028 (Recommended Changes to Equipment Technical Publications), through the Internet, on the Army Electronic Product Support (AEPS) website. The Internet address is http://aeps.ria.army.mil. The DA Form 2028 is located under the Public Applications section in the AEPS Public Home Page. Fill out the form and click on SUBMIT. Using this form on the AEPS will enable us to respond quicker to your comments and better manage the DA Form 2028 program. You may also mail, fax or E-mail your letter or DA Form 2028 direct to: AMSTA-LC-LMIT / TECH PUBS, TACOM-RI, 1 Rock Island Arsenal, Rock Island, IL 61299-7630. The email address is TACOM-TECH-PUBS@ria.army.mil. The fax number is DSN 793-0726 or Commercial (309) 782-0726.

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VOLUME 1

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CHAPTER TWO - DETAILED DESCRIPTION AND MAINTENANCE

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TABLE OF CONTENTS - Continued

APPENDICES

FOLDOUTS

TABLE OF CONTENTS - Continued

VOLUME 2

SERVICE MAINTENANCE PACKAGES

TABLE OF CONTENTS - Continued

APPENDICES

HOW TO USE THIS MANUAL

This manual contains troubleshooting and maintenance instructions for the Army's AT422T, 22-ton All-Terrain Crane (ATEC). Other manuals in the set contain operation instructions and operator maintenance and diesel engine maintenance.

Although these manuals do not conform with the format specified for other Army vehicles, the technical data presented herein is essential for properly operating and maintaining the vehicle.

These manuals were developed to help you operate and maintain the equipment. All task descriptions will take you step-by-step through the procedure. Don't take shortcuts. Before you begin any task, you should read through the complete procedure, make sure you know what needs to be done, then go back and follow the steps as written.

Pay particular attention to **WARNINGS**, **CAUTIONS**, and **NOTES**. This will prevent injury to personnel, damage to equipment, and provide clear instructions.

Use the alphabetical index at the back of the manual to find a topic not listed in the tables of contents.

The definitions of **WARNING**, **CAUTION**, and **NOTE** as used in this manual apply as follows:

WARNING

A warning or danger is used to emphasize that if an operation, procedure, or practice is not followed exactly, death or injury to personnel may result.

CAUTION

A caution is used to emphasize that if an operation, procedure, or practice is not followed exactly, equipment damage may result.

NOTE

A note is used to emphasize an important procedure or condition.

The following paragraphs provide a general description of each ATEC technical manual.

TM 5-3810-307-10 - Operator's Manual. Contains general theory of operations, operator safety, instructions for driving and operating the crane, operator troubleshooting, and operator maintenance. The manual also contains appendices for:

(1) Components of End Item and Basic Issue Items List (COEI/BII),
(2) Additional Authorization List (AAL),
(3) Expendable/Durable Supplies and Materials List (EDSML),
(4) Load Chart,
(5) Location/Description of Signs/Decals/Data Plates,
(6) Load Moment Indicator (LMI) Operator's Handbook,
(7) Instructions for Installation/Operation of Berminghammer Pile Driver System,
(8) Winterizing the ATEC (AT422T) Operation and Operator Maintenance,
(9) Instructions for Installation/Operation of Linkbelt Pile Driver System,
(10) Alphabetical Index.

TM 5-3810-307-24-1 - Maintenance Manual with Supplemental Data. This manual consists of two volumes: Volume one is the basic service manual and Volume two is the Service Maintenance (SM) packages.

Volume one, the service manual, is divided into chapters and sections. Chapter One contains 5 sections that cover: general maintenance information; preventive maintenance; lubrication; and troubleshooting. Chapter Two, divided into 16 sections, covers specific vehicle component removal/replacement procedures. At the beginning of each section is a Table of Contents listing the specific system/components contained in the section. Where vehicle components are repairable, the replacement procedure may refer to an SM package for repair. Volume One also contains the Maintenance Allocation Chart (MAC) as Appendix A.

Volume Two, the SM packages, contains repair procedures for selected components of the vehicle. Each SM package is complete with its own Table of Contents. Any requirements for tools and materials to perform each repair task are also listed. Volume Two also includes Appendices consisting of vendor repair data for components not addressed elsewhere in the manual and instructions for winterizing the ATEC (AT422T).

TM 5-3810-307-24-2 - Diesel Engine Operation and Maintenance Manual. This manual also consists of two volumes: Volume one is the Cummins operation and maintenance handbook while volume two contains engine repair information. Each manual has been edited specifically for the ATEC. Included are preventive maintenance, troubleshooting, adjustment/repair/replacement specifications/torques values, and warranty data.

TM 5-3810-307-24P – Repair Parts and Special Tools List (RPSTL). Contains a complete illustrated parts breakdown for the ATEC. Also included are:

(1) Introduction Work Package,

(2) Repair Parts List Work Package,

(3) Special Tools Work Package,

(4) Cross-Reference Index Work Packages.

WARNINGS

GENERAL

It is mandatory that all hydraulic hoses and fittings be correctly tagged and identified before they are disconnected to effect repairs or service. Failure to correctly tag and identify hoses and fittings can cause wrong reconnection, which can result in death or injury to personnel.

Review warning summaries included at the beginning of each section.

Structural repairs and/or modifications must be approved by the manufacturer. Repair requests should be submitted to Manitowoc® Crane CARE, P.O. Box 21, Shady Grove, PA 17256-0021, USA. Any unauthorized repairs and/or modification could void any remaining crane warranty.

AIR INTAKE SYSTEM

TABLE OF CONTENTS

VENDOR INFORMATION

Vendor	Source
Donaldson Company, Inc.	Service Bulletin, Service Instructions for Cyclopac Series Air Cleaners, Bulletin 1200-185 Revised 8/78

DESCRIPTION

The engine air intake system consists of an air cleaner and associated piping for channeling the air from the atmosphere to the engine intake manifold. The intake pipe also provides the necessary connections for a restriction indicator to indicate a dirty air cleaner. The air cleaner is the dry-type with a replaceable element.

MAINTENANCE

TROUBLESHOOTING.

Dust passing the air cleaner, even through small holes, can cause rapid engine wear. Ensure all connections between the air cleaner and the engine are tight and sealed. If these connections are all well sealed, and there is still evidence of dust leakage, check the following places for possible trouble.

NOTE

Dust that gets by the air cleaner system can often be detected by looking for dust streaks on the air transfer tubing or just inside the intake manifold inlet.

1. Inspect the air cleaner outlet tube for damage.

2. Ensure the element gasket washer is not damaged and the washer's rubber face seals against the element.

3. Inspect the element gasket for damage.

4. Check for structural failures. Any damaged parts must be replaced.

5. Inspect the restriction indicator tap for leaks.

Check for Filter Restriction.

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

The engine manufacturer places a recommended limit on the amount of restriction the engine will stand without loss in performance before the element must be cleaned or replaced. DDA allows 25.0 inches (63.5 cm) of water maximum at maximum governed rpm with a dirty air cleaner. Cummins allows 20 inches (50.8 cm) of water maximum with a dirty air cleaner at maximum governed rpm. CAT allows 30 inches (76.2 cm) of water maximum at maximum governed rpm with a dirty air cleaner.

Mechanical gauges, warning devices, indicators, and water manometers can be used to determine when the air cleaner restriction reaches this recommended limit. These gauges and devices are generally reliable, but the water manometer is the most accurate and dependable.

To use the manometer, hold it vertically and fill both legs approximately half full with water. One of the upper ends is connected to the restriction tap on the outlet side of the air cleaner by means of a flexible hose. The other end is left open to the atmosphere.

Maximum restriction in the air cleaner occurs at maximum air flow. On a naturally aspirated or supercharged (not turbocharged) diesel, the maximum air flow occurs at maximum (high idle) speed without regard for engine power. On a gasoline, LP, or turbo-charged diesel engine, the maximum air flow occurs only at maximum engine power.

With the manometer held vertically and the engine drawing maximum air, the difference in the height of the water columns in the two legs, measured in inches or centimeters is the air cleaner restriction. Restriction indicators are generally marked with the restriction at which the red signal flag locks up.

If the initial restriction on a new or clean filter reads above the maximum allowed for the engine, check the following items.

1. Ensure the air cleaner inlet is not plugged.

2. Inspect the air cleaner outlet to be sure it is not plugged by paper, rags, etc.

3. Ensure the correct size connections are used between the air cleaner and the engine.

4. Ensure all inlet accessories are the correct size and are not plugged by any foreign object.

FILTER ELEMENT REPLACEMENT.

CAUTION

Never service the air cleaner while the engine is running.

1. Loosen the hex head bolt on the clamp band and remove the clamp band and baffle.

2. Remove the thumbscrew and washer, then withdraw the element.

3. Clean the element as outlined in ELEMENT CLEANING. Replace the element after six cleanings or annually, whichever comes first.

4. Inspect all parts of the intake system and air cleaner.

5. Install the cleaned or new element into the air cleaner body, securing it with the washer and thumb-screw.

6. Ensure the O-ring around the air cleaner body is in place and not damaged.

7. Install the baffle on the air cleaner body with the two arrows pointing up. Secure with the clamp band and tighten the hex head bolt.

ELEMENT CLEANING.

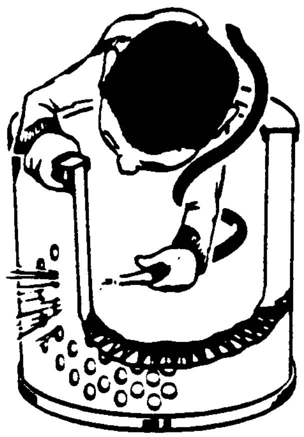
Washing in a water-detergent solution or blowing out with compressed air are two accepted methods for cleaning the element of the air cleaners. If the elements contain substantial amounts of soot or oil fumes, washing in water works better than compressed air. If the contaminant is found to be mostly loose dust, either method works equally well.

If cleaned with compressed air, elements can be put back into service immediately; however, if cleaned by washing, elements must be dried before returning them to service.

NOTE

Some elements are partially covered by a plastic sleeve with fins. The covered portion can be cleaned with water or air without removing the sleeve. Use a stiff fiber (not wire) brush to remove oil and grease deposits from the sleeve and fins. Never remove the sleeve and fins from the element.

Cleaning With Compressed Air.



0252-1

CAUTION

Pressure at the air nozzle must not exceed 100 PSI (689 kPa/6.89 Bar).

1. Direct a jet of clean, dry air from the inside of the filter element, perpendicular to the pleats.

2. Move the air jet up and down along the pleats, slowly rotating the element, until no more dust is being removed. Do not rupture the element with the nozzle or the air jet.

Cleaning With Water.

1. The elements can be cleaned by washing with water and a good non-sudsing detergent. Direct a jet of clean, dry air from the inside of the filter element. When the loose dust and soot have been removed, the element is ready to be washed.

CAUTION

NEVER USE GASOLINE OR SOLVENTS TO CLEAN THE ELEMENTS.

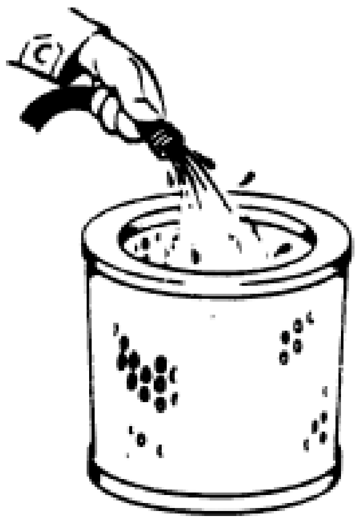
2. Dissolve the detergent in a small amount of cool water.

3. Add warm water (approximately 100 degrees F [38 degrees C]) to get the proper proportions of detergent and water (about one cup of detergent to five gallons of water).

4. Soak the element in the solution for at least 15 minutes.

0252-2

5. Agitate the element for about two minutes to loosen the dirt.



0252-3

CAUTION

Water pressure from a hose or tap should not exceed 40 PSI (276 kPa/ 2.76 Bar).

6. Rinse the element with clean water until the water coming through the element is clean. Air-dry the element thoroughly before using.

CAUTION

Heated air (maximum temperature 160 degrees [71 degrees C]) must have circulation. Do not use light bulbs for drying elements.

7. Mechanized drying methods can be used.

INSPECTION.

Element.

0212-4

CAUTION

Do not touch the inside of the filter with a bare light bulb.

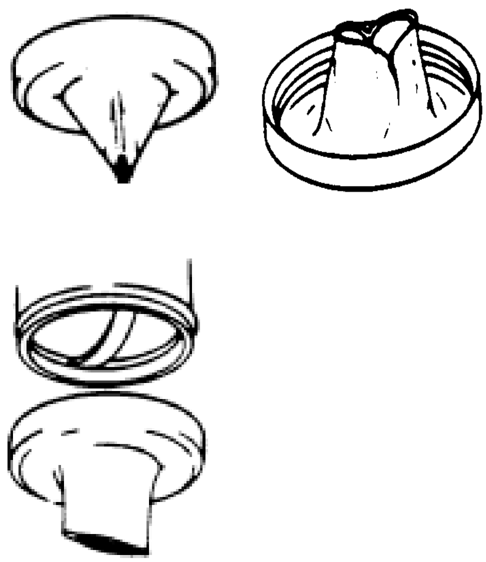
After cleaning the filter element, inspect the element for damage. Look for dust on the clean air side, the slightest rupture, or damaged gaskets. A good method to use to detect ruptures in the element is to place a light inside the element and look toward the light from the outside. Any hole in the element, even the smallest, will pass dust to the engine and cause unnecessary engine wear. Element replacement is recommended if such holes are evident.

Air Cleaner Body.

Before installing the filter element, remove any foreign material (leaves, lint or other foreign matter) that may have collected inside the air cleaner body. Inspect the inside of the body for dents or other damage that would interfere with air flow or with the fins on the element or inside the body. Repair any body dents, being careful not to damage the sealing surfaces.

Vacuator Valve.

Vacuator valves are designed to expel loose dust and dirt accumulations from the air cleaner body automatically, thus lengthening the element service life. The valve lips must point straight down to operate effectively, and must be kept free from debris. Mud and chaff can lodge in these lips periodically and hold them open during engine operation.



0252-5

Check the condition of the valve and lips frequently and keep them clean. The valve lips should be open only when the engine is shut down, or running at low idle speed. If the valve is turned inside out, check for a clogged air cleaner inlet. Malfunction of this valve does not reduce the air cleaner effectiveness, but does allow the element to get dirty faster and reduces serviceable life. If a valve is lost or damaged, replace it with a new valve of the same part number.

Duct Work.

1. Check the intake pipe cap and screen for accumulation of leaves, trash, and other debris that could restrict air flow. Repair the screen or replace the cap if any large holes are found in the screen.

2. Check all mounting hardware for security to eliminate possible vibration of intake piping. Such vibration leads to early failure of hoses, clamps, and mounting parts, and can cause hoses to slip off the connecting pipes, allowing unfiltered air into the engine air intake.

3. Check hoses for cracks, chafing, or deterioration, and replace at the first sign of probable failure.

WATER COOLING SYSTEM

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WARNING SAFETY SUMMARY

WARNING SAFETY SUMMARY (continued)

Page

WARNING

8

When removing the radiator cap, remove it slowly and pause a moment. This will avoid possible burning by hot water or steam. Continue to turn the cap to the left until it can be removed.

DESCRIPTION

The cooling system consists of the radiator, engine cooling circuit, and the connecting hoses. Its capacity varies according to the engine being used. The temperature is controlled by a 180 degree F (82 degrees C) thermostat located between the top of the engine and the top of the radiator. The radiator, in addition to cooling the engine, also contains a cooler which cools the automatic transmission oil. At all times, the coolant should be properly inhibited against corrosion. If antifreeze is used, follow the antifreeze manufacturers requirements for proper protection in regards to cooling system capacity, and only ethylene glycol base permanent antifreeze should be used. Engines equipped with cooling system filters should not use antifreeze with anti-leak additives because the additives will clog the filter.

MAINTENANCE

TROUBLESHOOTING.

SYMPTOM	PROBABLE CAUSE	SOLUTION
1. Engine overheating.	**Coolant Loss.**	
	a. Leaks at any of the following: gaskets, hose connections, water pump, radiator, heater, core plugs, drain cock or plugs, cracked head or block.	a. Check, locate, and repair leaks. Replace hoses, clamps, and other parts as required.
	NOTE Internal leakage is indicated by the presence of coolant in the engine crankcase, or oil in the radiator. Check for cracked cylinder head or block, or a blown head gasket.	
	Boiling.	
	a. Radiator or other parts of cooling system clogged with rust or scale.	a. Drain and flush cooling system.
	b. Grille or bug screen clogged.	b. Clear obstructions.
	c. Radiator core fins damaged.	c. Straighten fins.
	d. Thermostat damaged - stuck closed.	d. Replace thermostat.
	e. Water pump leaking air into system.	e. Repair or replace water pump.
	f. Radiator hose collapsed or rotting inwardly.	f. Replace radiator hoses.

SYMPTOM	PROBABLE CAUSE	SOLUTION
1. Engine overheating (continued)	g. Radiator pressure cap damaged.	g. Replace cap.
	h. Cylinder head loose, causing exhaust gas leakage into cooling system.	h. Check and tighten.
	i. Water pump impeller corroded or loose on shaft.	i. Repair or replace water pump.
	j. Antifreeze protection inadequate, causing partial freeze-up.	j. Check and add antifreeze as required.
	After Boil	
	a. Improper installation of thermostat.	a. Check and correct.
	b. Damaged thermostat.	b. Replace thermostat.
	c. High temperature thermostat used with alcohol-type antifreeze.	c. Use thermostat of proper operating range; use ethylene-glycol type antifreeze.
	d. Excessive sediment in cooling system.	d. Drain and flush cooling system.
	Foaming.	
	a. Excessive sediment in cooling system.	a. Drain and flush cooling system.
	b. Air or exhaust leak into cooling system.	b. Check, locate, and repair.
	Radiator Air Flow Obstructed.	
	a. Leaves, dirt and foreign material.	a. Clean away obstruction.
	b. Bent fan blades.	b. Straighten blades or replace fan.
	c. Improper valve timing or sticking valves.	c. Check and repair or retime engine.
	d. Clogged muffler or pipe.	d. Check and correct.
	e. Dragging brakes.	e. Check brakes and repair as required.
	f. Low engine oil level.	f. Check and add oil as required.

SYMPTOM	PROBABLE CAUSE	SOLUTION
1. Engine overheating (continued).	g. Engine overloaded.	g. Operate engine in proper load range.
	h. Stiff rebuilt engine.	h. Break-in engine properly
2. Overcooling	a. Thermostat not installed.	a. Install thermostat.
	b. Damaged thermostat stuck open.	b. Replace thermostat.
	c. Short runs and intermittent driving.	c. Warm up engine properly.

GENERAL

The cooling system includes the radiator, thermostat, the fan, and water pump drive belts. Radiator hoses are also included in this group.

Because the effects or damage that result from an improperly maintained cooling system usually occur gradually, this system is often times neglected. However, the cooling system must be treated with the same attention to maintenance as is given such other systems as fuel, air, and brakes. A review of the cooling system's function will show this more clearly.

In general, the circulation of water through the cooling system relies entirely upon the water pump. The water pump draws water from the radiator and forces it through the water jackets and cylinder head. There it accumulates heat. Then the water flows to the upper radiator tank and down through the radiator core, being cooled by air from the fan. This process of removing heat from water as it circulates holds the engine to its efficient operating temperature.

The following paragraphs point out several facts about cooling system components, the effects of cooling system neglect, and procedures to be followed for cooling system maintenance.

EFFECTS OF COOLING SYSTEM NEGLECT.

Whenever an engine does not perform at top efficiency, neglected cooling system may be at fault even though the engine part directly responsible is not even a part of the cooling system. Most of these problems will be traced to overheating; however, an engine that is running too cold can be just as troublesome.

Overheating.

An engine that is overheating may lead to troubles such as the following.

1. Burned valves.

2. Pinging or knocking.

3. Excessive fuel consumption.

4. Poor lubrication - increased engine wear.

5. Sticking valves.

6. Short injector life.

7. Engine hot spots.

8. Need for higher grade fuel.

Overcooling.

The following engine troubles result when an engine is overcooled.

1. Excessive fuel consumption.

2. Sludge formation in crankcase.

3. Corrosive acids formed in crankcase.

4. Excessive fuel deposits in the exhaust system.

RUST PREVENTION.

To keep engines operating at newness efficiency, all forms of rust formation must be prevented. The formation of rust in the cooling system is a result of the interaction of water, iron, and oxygen, and can only be prevented by maintaining full strength corrosion protection at all times.

For rust protection during the winter months an antifreeze having a corrosion preventive should be installed in the fall. When spring arrives, drain the old antifreeze solution from the cooling system as all corrosion inhibitors are weakened and may be entirely exhausted by this time depending on how the engine has been taken care of and how many operating hours have been put on it. To rustproof the cooling system for summer driving, add a good rust inhibitor with the first fill of clean water, if water is to be used, in the spring. This solution should then be drained in the fall and a fresh filling of chemically treated anti-freeze installed. A good quick test to determine if the cooling system needs cleaning or flushing due to rust, scale, or grease is to wipe the inside of the filler neck and header tank with the finger. If any sludge or excessive rust and scale are present and evidence by this test, the system needs a thorough cleaning.

SEASONAL CARE.

The cooling system of any vehicle should be drained and flushed out at least once a year. Unless the coolant has a corrosion preventive in it, rust and scale will eventually clog up the cooling system. Any effective commercially available flushing agent should be used at least once a year, and preferably twice a year, to ensure against a buildup of rust and scale.

NOTE

Remove the radiator cap when draining the system to ensure proper draining.

CLEANING.

WARNING

The cooling system is pressurized. Personal injury may result when removing the radiator cap after the operating temperature is reached. Use proper protection when removing the radiator cap.

1. Coolant shut-off valves to heaters and other accessories should be open to allow complete circulation during cleaning, flushing, and draining. Run the engine with radiator covered if necessary until temperature is up to operating range 160 to 180 degrees F (71 to 82 degrees C). Stop the engine, remove the radiator cap, and drain the system by opening the drain cocks on the radiator and engine block.

2. Allow the engine to cool, close the drain cocks, and pour the cleaning compound into the radiator according to the directions. Fill the system with water.

3. Place a clean drain pan to catch the overflow, and use it to maintain the level in the radiator. Do not spill the solution on the vehicle paint.

4. Replace the radiator cap and run the engine at moderate speed, covering the radiator if necessary, so the system reaches a temperature of 180 degrees F (82 degrees C) or above, but does not reach the boiling point. Allow the engine to run at least two hours, or according to recommendations of the manufacturer of the cleaning compound, at 180 degrees F (82 degrees C) so the cleaning solution may take effect. Do not drive the vehicle or allow the liquid level in the radiator to drop low enough to reduce circulation.

5. Stop the engine as often as necessary to prevent boiling.

6. With the engine stopped, feel the radiator core with bare hands to check for cold spots, and then observe the temperature gauge reading. Where there is no change in temperature for some time, drain the cleaning solution.

7. If clogging of the core is relieved but not fully corrected, allow the engine to cool, pressure-flush

the system (see Pressure Flushing) and repeat the cleaning operation.

8. If clogging of the core, indicated by low temperature spots on core, is not relieved, the radiator core must be removed for mechanical cleaning. Mechanical cleaning requires removal of the upper and lower tanks, and rodding out the accumulated rust and scale from the water passages of the core.

PRESSURE FLUSHING.

1. Disconnect the upper radiator hose which connects the radiator core to the engine water outlet, and remove the thermostat from the engine water outlet.

2. Clamp a convenient length of hose to the radiator core outlet opening, and attach another suitable length of hose to the radiator inlet opening to carry away the flushing stream.

3. Connect the flushing gun to compressed air and water pressure, and clamp the gun nozzle to the hose attached to the radiator outlet opening.

4. With the radiator cap on tight, fill the core with water. Turn on air pressure in short blasts to prevent core damage.

5. Continue filling the radiator with water and applying air pressure as above until the water comes out clear.

6. Clamp the flushing gun nozzle firmly to a hose attached securely to the engine water outlet opening. Fill the engine block with water, partly covering the water inlet opening to permit complete filling.

7. Turn on compressed air to blow out water and loose sediment. Continue filling with water and blowing out with air until flushing stream comes out clear.

8. For badly clogged water jackets that do not respond to regular pressure flushing, remove the engine cylinder head and core hole plugs, and with a suitable length of small copper tubing attached to the flushing gun nozzle, flush the water jackets through the openings.

9. When the vehicle is equipped with a water heater connected to the cooling system, flush the heater, following the same procedure as for the radiator core.

10. After completing the flushing operation, clean out the radiator overflow pipe; inspect the water pump; clean the thermostat and the radiator cap control valves. Check the thermostat for proper operation before installation.

11. Blow insects and dirt from the radiator core air passages, using water, if necessary, to soften obstructions.

COMPONENT INSPECTION.

Radiator.

1. Top and Bottom Tank. Look for leaks, particularly where the tank is soldered to the core. Vibration and pulsation from pressure can fatigue soldered seams.

2. Filler Neck. The sealing seat must be smooth and clean. Cams on filler neck must not be bent or worn so as to allow a loose fitting cap. Ensure the overflow tube is not plugged.

3. Radiator Cap. This is the pressure-setting type. Its purpose is to hold the cooling system under a slight pressure, increasing the boiling point of the cooling solution and preventing loss of solution due to evaporation and overflow.

The cap has a spring-loaded valve, the seat of which is below the overflow pipe in the filler neck. This prevents the escape of air or liquid while the cap is in position. When the cooling system pressure reaches a predetermined point, the cap valve opens and will again close when the pressure falls below the predetermined point.

When removing the pressure type cap from the radiator, perform the operation in two steps. Loosening the cap to its first notch raises the valve from the gasket and releases the pressure through the overflow pipe. In the first stage position of the cap, it should be possible to depress the cap approximately 0.125-inch (3.175 mm). The prongs on the cap can be bent to adjust this condition. Care must be taken that the cap is not too loose as this would prevent proper sealing.

WARNING

Whe removing the cap, loosen it slowly and then pause a moment. This will avoid possible burning by hot water or steam. Continue to turn the cap to the left until it can be removed.

4. Tubes. Because these are very small they can become easily clogged, or partially so, by rust and scale. The general condition of the cooling system and operating temperature are indications as to whether or not tubes are clean. Another good test is to feel the core for cold spots.

5. Fins. These thin metal sheets dissipate heat picked up by the tubes. They should be kept free of bugs, leaves, straw etc., so as to allow the free passage of air. Bent fins should be straightened.

Engine Water Jacket.

The water jacket permits coolant to be circulated around the cylinder walls, combustion chamber, and valve assemblies. Some of these coolant passages are small and can easily become clogged, if the cooling system does not receive the proper maintenance.

1. Core Plugs. These are sometimes mistakenly called freeze plugs. They do not provide protection against freezing expansion, but are only present because of engine block casting methods. Remove and replace core plugs that show signs of leaking or rusting through. Use an installation tool for core plug replacement.

2. Drain Plugs. The water jacket of each engine has one or more drain plugs. These should receive seasonal care and kept free of rust and scale.

3. Gaskets. Gaskets must be in good condition to prevent both internal and external leaks. If there are external leaks around gaskets, there may also be internal leaks into the engine. Proper tightening of the head bolts with a torque wrench is essential for preventing leaks around the head gasket.

Water Pump.

The pump should be checked carefully for leaks and proper lubrication, and if leaking, cracked, or worn, it should be rebuilt or replaced promptly.

Fans and Belts.

The fan should be checked for loose or bent blades. A loose blade might work free during operation and cause damage.

A bent blade could cause an imbalance and cause the water pump to fail prematurely, and it will reduce the fan’s efficiency.

Refer to the engine manual for your particular engine for fan and other belt adjustment specifications.

When one belt of dual drives is damaged or worn, they must both be changed as a matched pair.

Thermostat.

Thermostats used in these carriers are of the non-adjustable type and are incorporated in the cooling system for the purpose of retarding or restricting the circulation of coolant during engine warm up. Engine overheating and loss of coolant is sometimes due to an inoperative thermostat. To check for this condition, remove the thermostat and test by submerging it in hot water and noting the temperature at which the thermostat opens and closes. Use an accurate high temperature thermometer for making this test.

Hose and Clamps.

Hoses and their connections must be checked regularly because they are often the source of hidden trouble. Hoses may often times appear in good condition on the outside while the inside will be partially deteriorated. If there are any doubts about a hose doing its job, replacement should be made. The clamps should be inspected to make sure they are strong enough to hold a tight connection.

TEST EQUIPMENT.

The hydrometer is a primary aid in maintaining the cooling system at top efficiency. Hydrometers, which are used to test the freezing protection of an anti-freeze solution, work on the principle of specific gravity or weight of the antifreeze solution. They are simple to use provided they are used in the proper manner. When using the temperature sensitive hydrometer, the solution must be warm (at least 110 degrees F [43 degrees C]), the temperature and level must be noted correctly, and the float must be able to move freely. Read only the hydrometer scale corresponding to the type antifreeze solution in the radiator.

Keep the hydrometer clean inside and out, and treat it with the same care as given any other precision instrument.

NOTE

Hydrometers do not correctly register the freezing protection of a mixture of methanol and glycol base antifreeze. Therefore, always flush the cooling system with the thermostat removed before adding antifreeze for the winter.

TRANSMISSION/TORQUE CONVERTER

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LIST OF FIGURES AND CHARTS

DESCRIPTION

The transmission and torque converter function together as an integral unit. The transmission is a six speed forward and three speed reverse transmission. The transmission and torque converter transfers the power generated by the engine to the axles by way of the drive shafts. The torque converter generates the hydraulics for the transmission functions. The gearing in the transmission provides the different speeds of operation.

THEORY OF OPERATION

The transmission and torque converter function together and operate through a common hydraulic system. Therefore, it is necessary to consider both units in discussing operation.

With the engine running, the converter charging pump draws oil from the transmission sump through the removable oil suction screen and directs it through the pressure regulating valve and oil filter.

The pressure regulating valve maintains pressure to the transmission control for actuating the direction and speed clutches. This requires a small portion of the total volume of oil used in the system. The remaining volume of oil is directed through the torque converter circuit to the oil cooler and returns to the transmission for positive lubrication. This regulator valve consists of a hardened valve spool operating in a closely fitted bore. The valve spool is spring loaded to hold the valve in a closed position. When a specific pressure is achieved, the valve spool works against the spring until a port is exposed along the side of the bore. This sequence of events provides the proper system pressure.

After entering the converter housing, the oil is directed through the reaction member support to the converter blade cavity and exits in the passage between the turbine shaft and reaction member support. The oil then flows out of the converter to the oil cooler. After leaving the cooler, the oil is directed to a fitting on the transmission. Then, through a series of tubes and passages, lubricates the transmission bearings and clutches. The oil then gravity drains to the transmission sump.

The torque converter consists basically of three elements and their related parts to multiply engine torque. The engine power is transmitted from the engine flywheel to the impeller element through the impeller cover. This element is the pump portion of the hydraulic torque converter and is the primary component which starts the oil flowing to the other components which results in torque multiplication. This element can be compared to a centrifugal pump in that it picks up fluid at its center and discharges at its outer diameter.

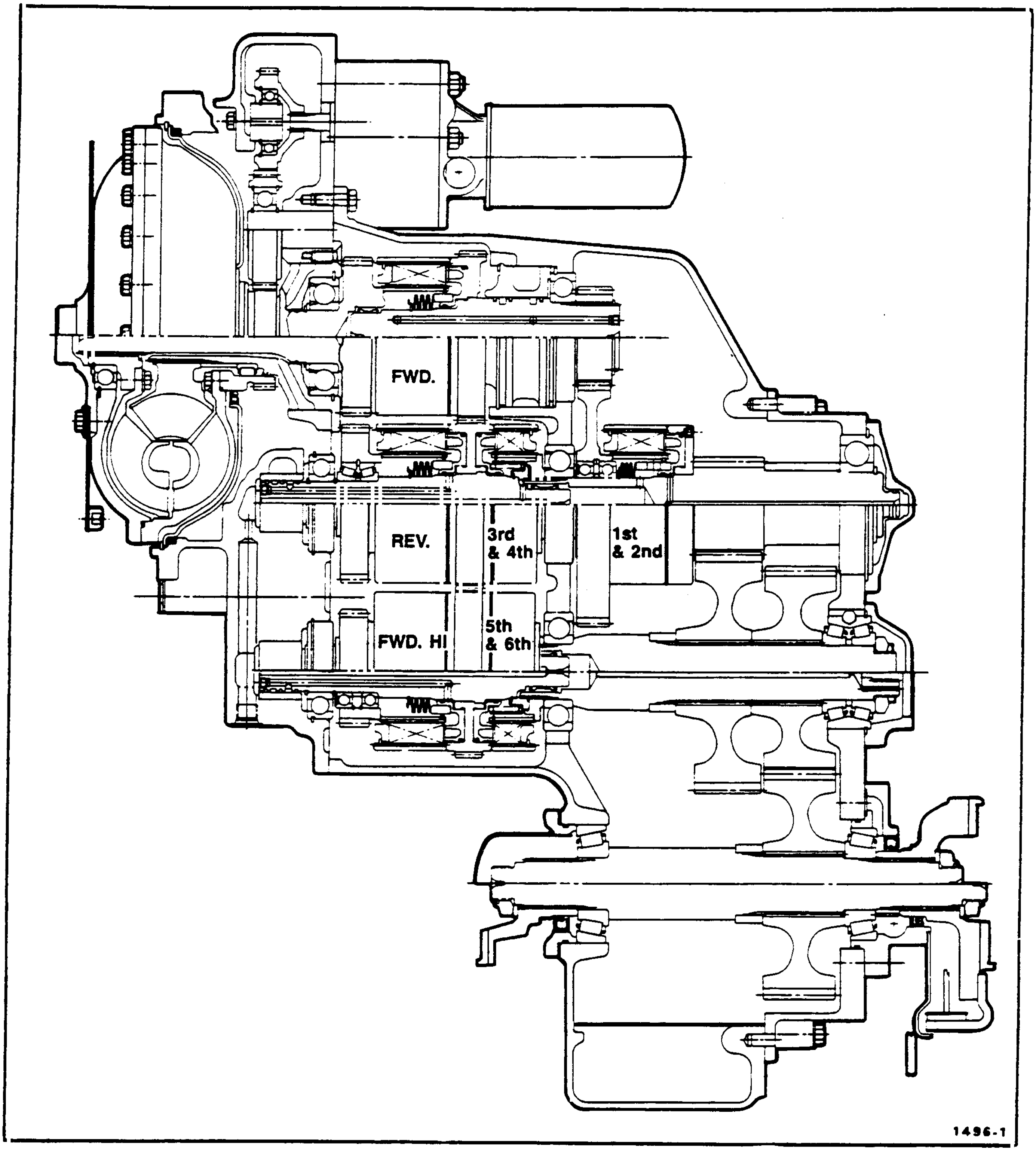
The torque converter turbine is mounted opposite the impeller and is connected to the output shaft of the torque converter. This element receives fluid at its outer diameter and discharges at its center. Fluid directed by the impeller out into the particular design of blading in the turbine and reaction member is the means by which the hydraulic torque converter multiplies torque.

The reaction member of the torque converter is located between and at the center of inner diameters of the impeller and turbine elements. Its function is to take the fluid which is exhausting from the inner portion of the turbine and change its direction to allow correct entry for recirculation into the impeller element.

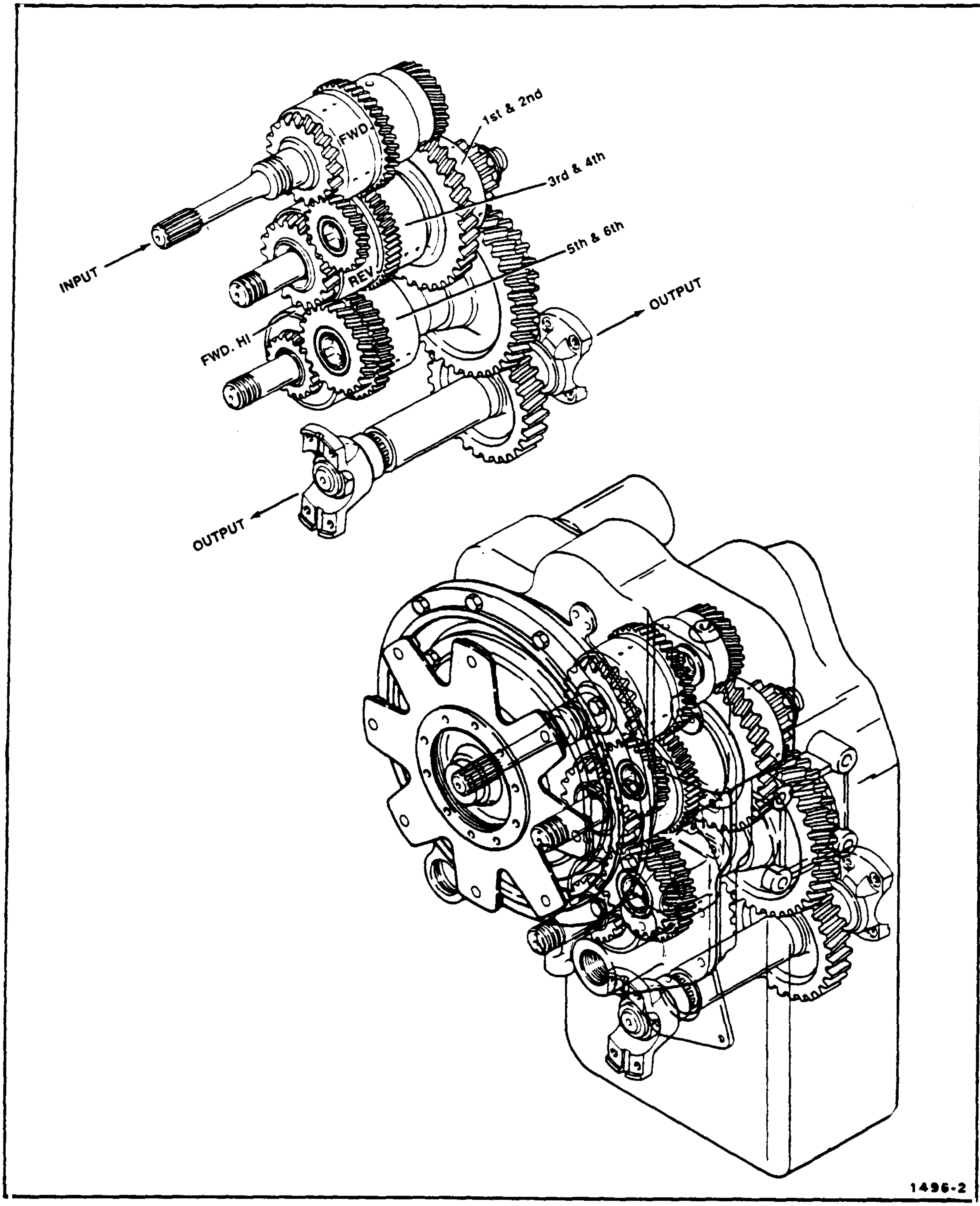
The torque converter will multiply engine torque to its designed maximum multiplication ratio when the output shaft is at zero rpm. Therefore, as the output shaft is decreasing in speed, the torque multiplication is increasing.

The shift control valve assembly consists of a valve body with selector valve spools. A detent ball and spring in the selector spool provides one position for each speed range. A detent ball and spring in the direction spool provides three positions, one each for forward, neutral, and reverse.

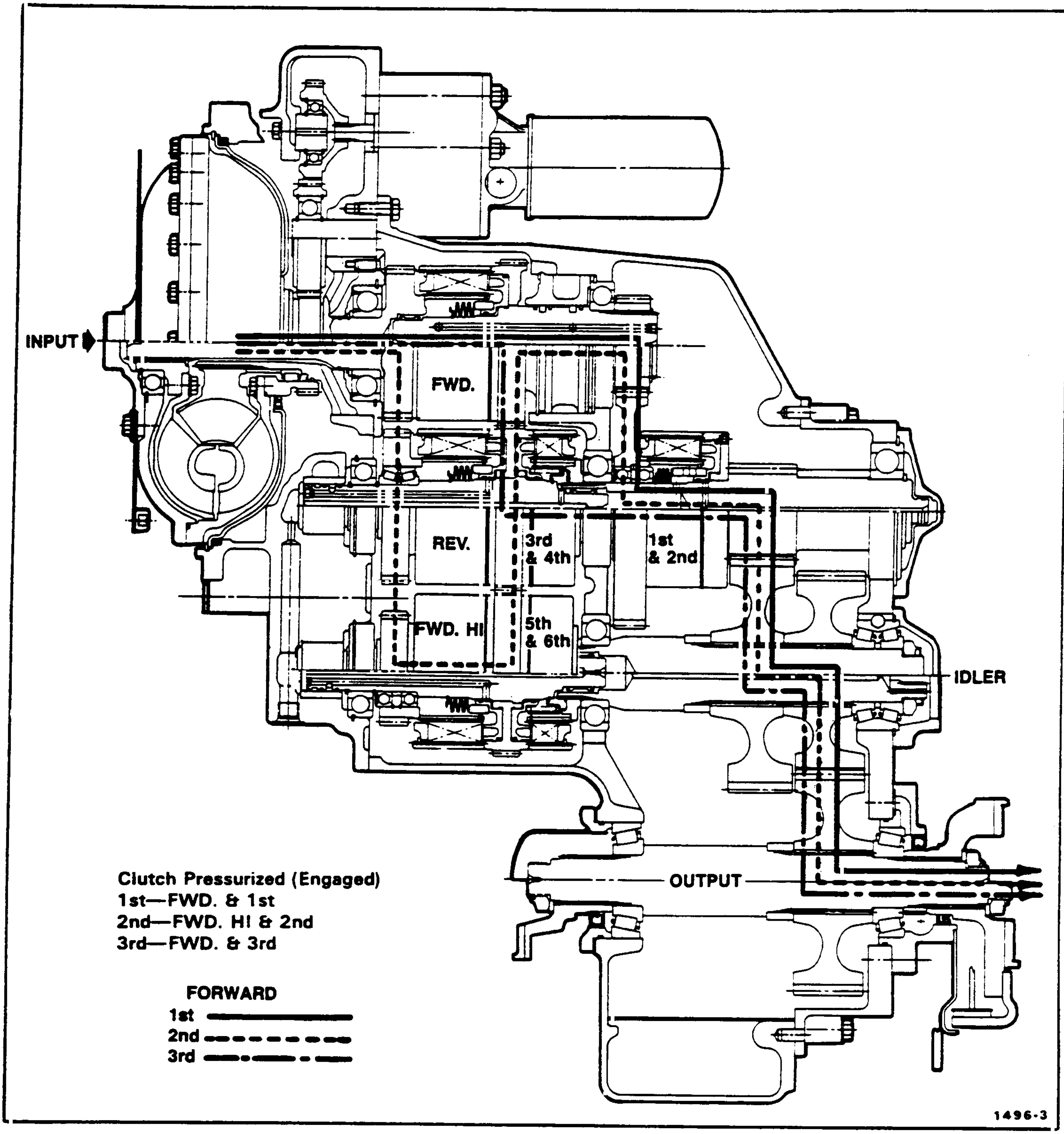
With the engine running and the directional control lever in the neutral position, oil pressure from the



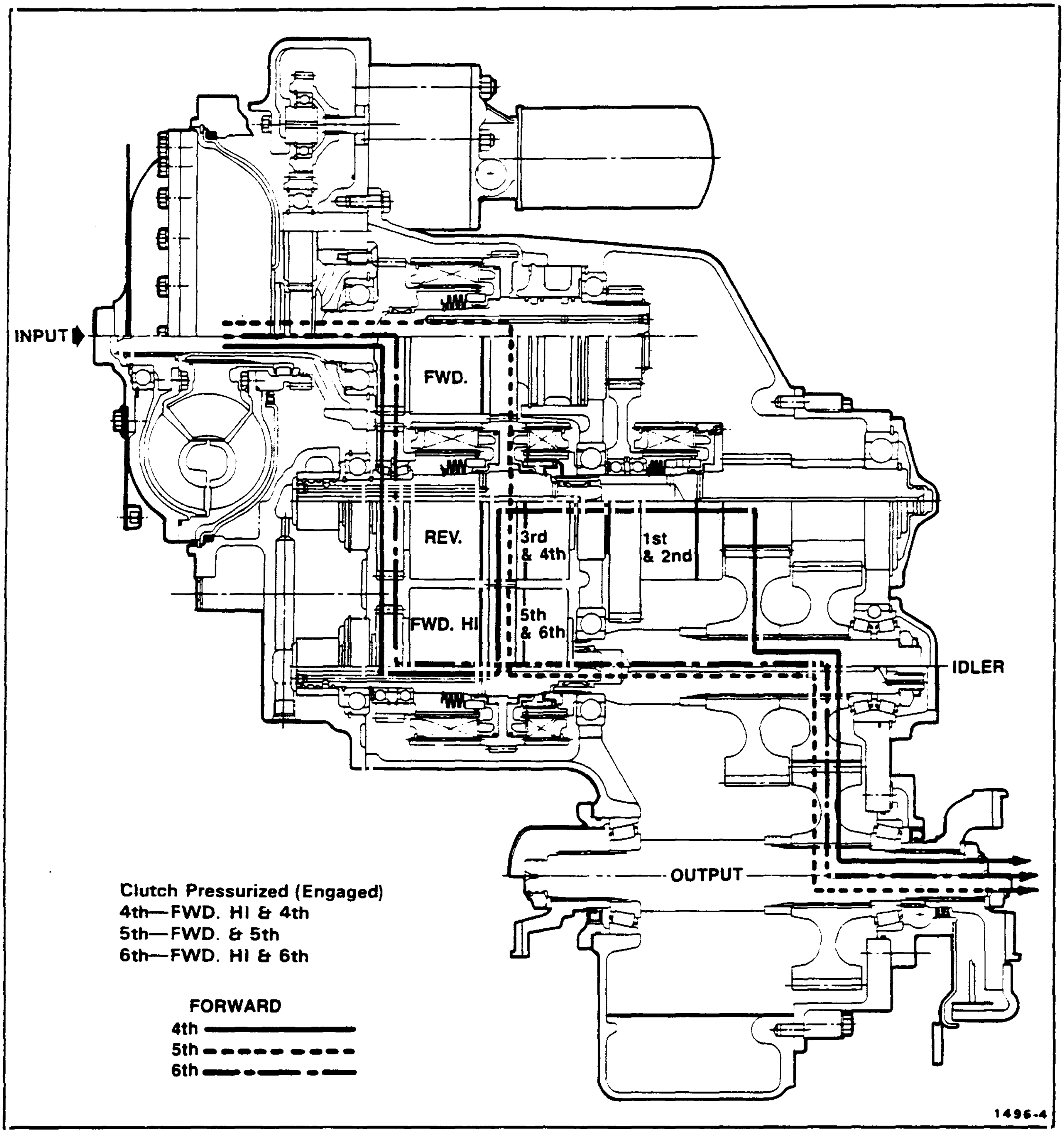
Transmission - Cross Section



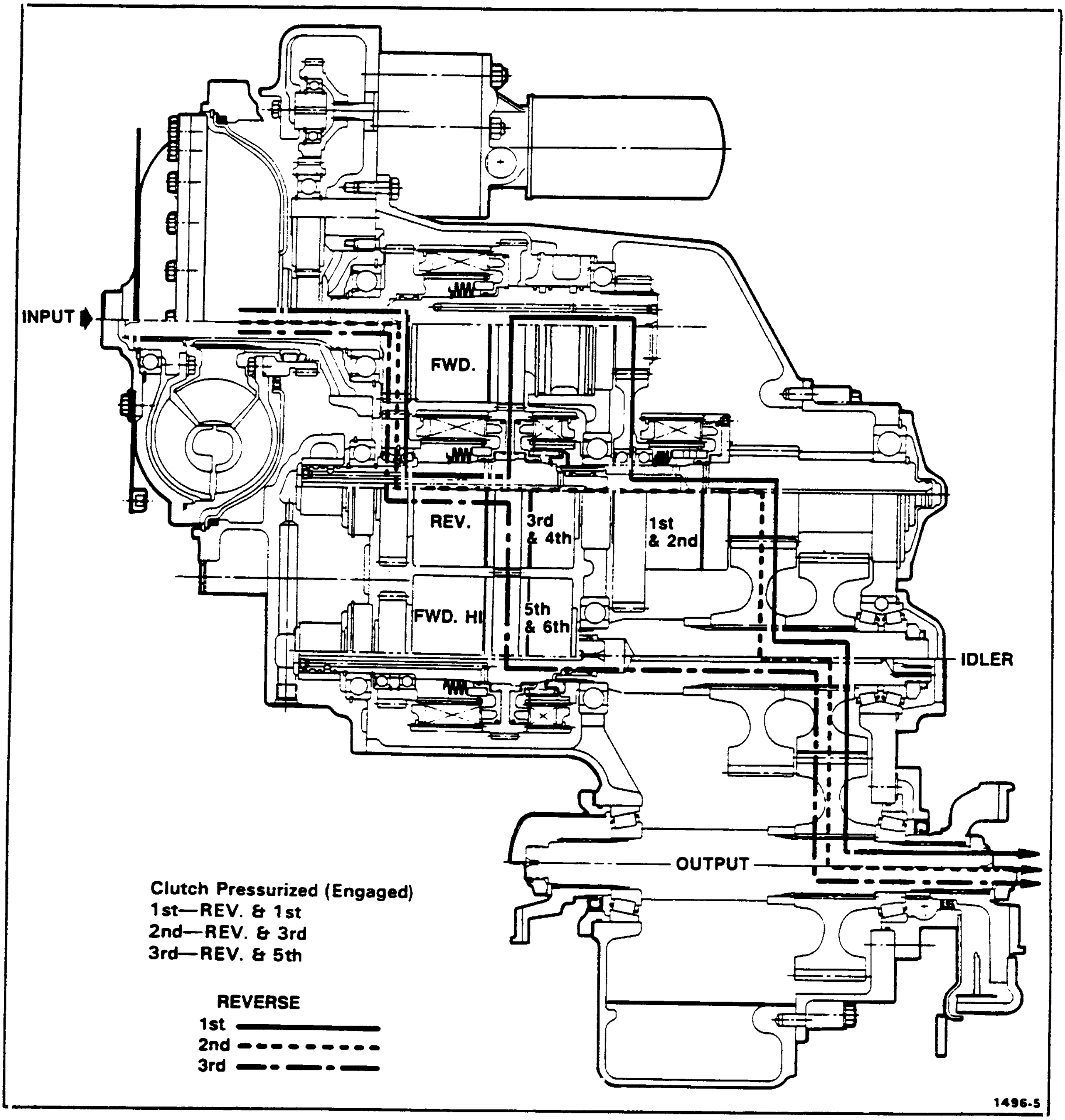
Clutch and Gear Arrangement



Power Flow in Forward 1st, 2nd, and 3rd



Power Flow in Forward 4th, 5th, and 6th



Power Flow in Reverse

regulating valve is blocked at the control valve, and the transmission is in neutral. Movement of the forward and reverse spool will direct oil, under pressure to either the forward or reverse direction clutch as desired. When either directional clutch is selected, the opposite clutch is relieved of pressure and vents back through the direction selector spool. The same procedure is used in the speed selector.

The direction or speed clutch assembly consists of a drum with internal splines and a bore to receive a hydraulically actuated piston. The piston is oil tight by the use of sealing rings. A steel disc with external splines is inserted into the drum and rests against the piston. Next a friction disc with splines at the inner. diameter is inserted. Discs are alternated until the required total is achieved. A heavy back-up plate is then inserted and secured with a snap ring. A hub with OD splines is inserted into the splines of discs with teeth on the inner diameter. The discs and hub are free to increase in speed or rotate in the opposite direction as long as no pressure is present in that specific clutch.

To engage the clutch, the control valve is placed in the desired position. This allows oil under pressure to flow from the control valve, through a tube, to a chosen clutch shaft. This shaft has a drilled passageway for oil under pressure to enter the shaft. Oil pressure sealing rings are located on the clutch shaft. These rings direct oil under pressure to the desired clutch. Pressure of the oil forces the piston and discs against the heavy back-up plate. The discs, with teeth on the outer diameter, clamping against discs with teeth on the inner diameter, enables the hub and clutch shaft to be locked together and allows them to drive as a unit.

There are bleed balls in the clutch piston which allow quick escape for oil when the pressure to the piston is released.

MAINTENANCE

GENERAL.

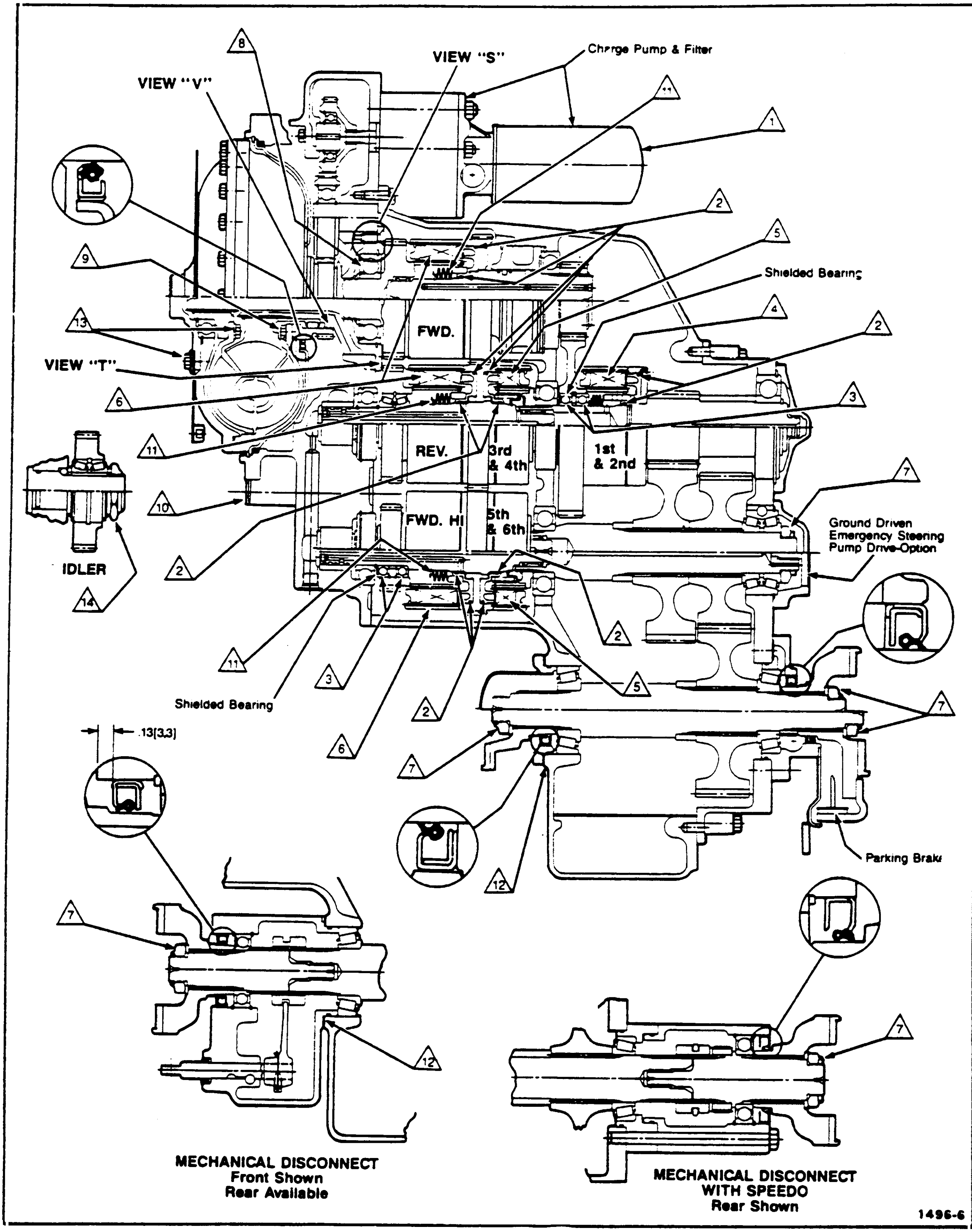
The following General Assembly Instructions, Specifications and Service Data, and Torque Chart are provided as general references to be used when servicing any part of the transmission or the transmission as a whole.

TROUBLESHOOTING.

The following data is presented as an aid to locating the source of difficulty in a malfunctioning unit. It is necessary to consider torque converter charging pump, transmission, oil cooler, and connecting lines as a complete system when checking for the source of trouble since the proper operation of any unit therein depends greatly on the condition and operations of the others. By studying the principles of operation together with data in this section, it may be possible to correct any malfunction which may occur in the system. Troubleshooting procedure basically consists of two classifications; mechanical and hydraulic.

Hydraulic Checks.

Before checking the torque-converter, transmission, and associated hydraulic system for pressures and rate of oil flow, it is essential that the following preliminary checks be made.



General Assembly Instructions (Sheet 1 of 3)

△1 Assemble oil filter and tighten 20 to 25 Lbs.Ft. [27,2-33,8 N·m]

△2 Teflon seals must be sized prior to ass'y.

△3 Must be loose internal fit bearing with a No. 3 etched on the bearing.

△4 10-outer steel plates, 10-inner paper plates. Alternately assemble, starting with outer steel plate.

△5 6-outer steel plates, 6-inner paper plates. Alternately assemble, starting with outer steel plate.

△6 12-outer steel plates, 12-inner paper plates. Alternately assemble, starting with outer steel plate.

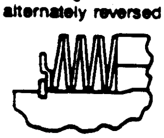
△7 Tighten 200 to 250 Lbs.Ft [271,2-338,9 N·m]

△8 Special bearing loading notches opposite snap ring.

△9 Bend lock tabs after tightening cap screws to proper torque.

△10 Tighten oil screen assy 10 to 15 Lbs.Ft. [13,6-20,3 N·m]

△11 Forward, Forward High and Reverse Clutch Springs - Concave side of first Belleville spring to be placed against clutch piston. Remaining six springs of each clutch to be stacked alternately reversed as shown.



△12 Shim output shaft bearings to produce 6 to 8 Lbs. in. [0,68-0,90 N·m] pre load.

△13 Clean mounting surfaces and tapped holes with solvent. Dry thoroughly, being certain tapped holes are dry and clean. See text for proper installation.

△14 Tighten 200-250 Lbs. Ft. [271,2-338,9 N·m] and stake nut securely into shaft notch.

△15 Stator support screw assembly: (View "S")
1. Clean stator support mounting surface and tapped holes with solvent. Dry thoroughly, being certain tapped holes are clean and dry.
2. Install 6 special stator support screws. Tighten screws 12 to 16 Lbs. Ft. [16,3-21,6 N·m] torque. See Caution.

Notes

All lead in chamfers for oil seals, piston rings, and "O" rings must be smooth and free from burrs. Inspect at assembly.

Lubricate all piston ring grooves and "O" rings with oil before assembly.

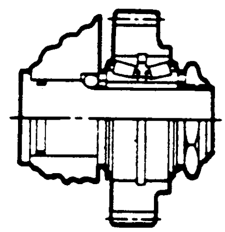
Apply a thin coating of grease between seal lips on lip type seals prior to assembly.

Apply a very light coat of Permatex No. 2 to O.D. of all oil seals and bore plugs before assy.

Apply a light coat of Loctite No. 92 to all plug threads.

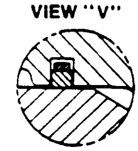
Apply a light coat of Permatex No. 2 to all thru hole stud threads.

After assembly of parts using Loctite or Permatex, there must not be any free or excess material which might enter the oil circuit.



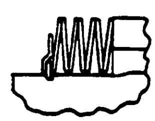
VIEW "T"
REVERSE IDLER

VIEW "V"



Enlarged view of stator support piston ring & expander

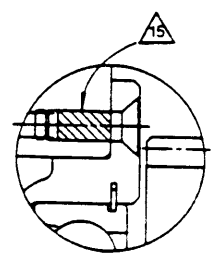
Note:
Expander gap to be approx 180° from ring hook joint to aid assembly.



1ST
(Low)

Caution:

Assembly of stator support to converter housing must be completed within a 15 minute period from start of screw installation. The special screw is to be used for one installation only. If screw is removed for any reason, it must be replaced. The Loctite left in the holes must be removed with the proper tap and cleaned with solvent. Dry hole thoroughly and use a new screw for reinstallation.



VIEW "S"

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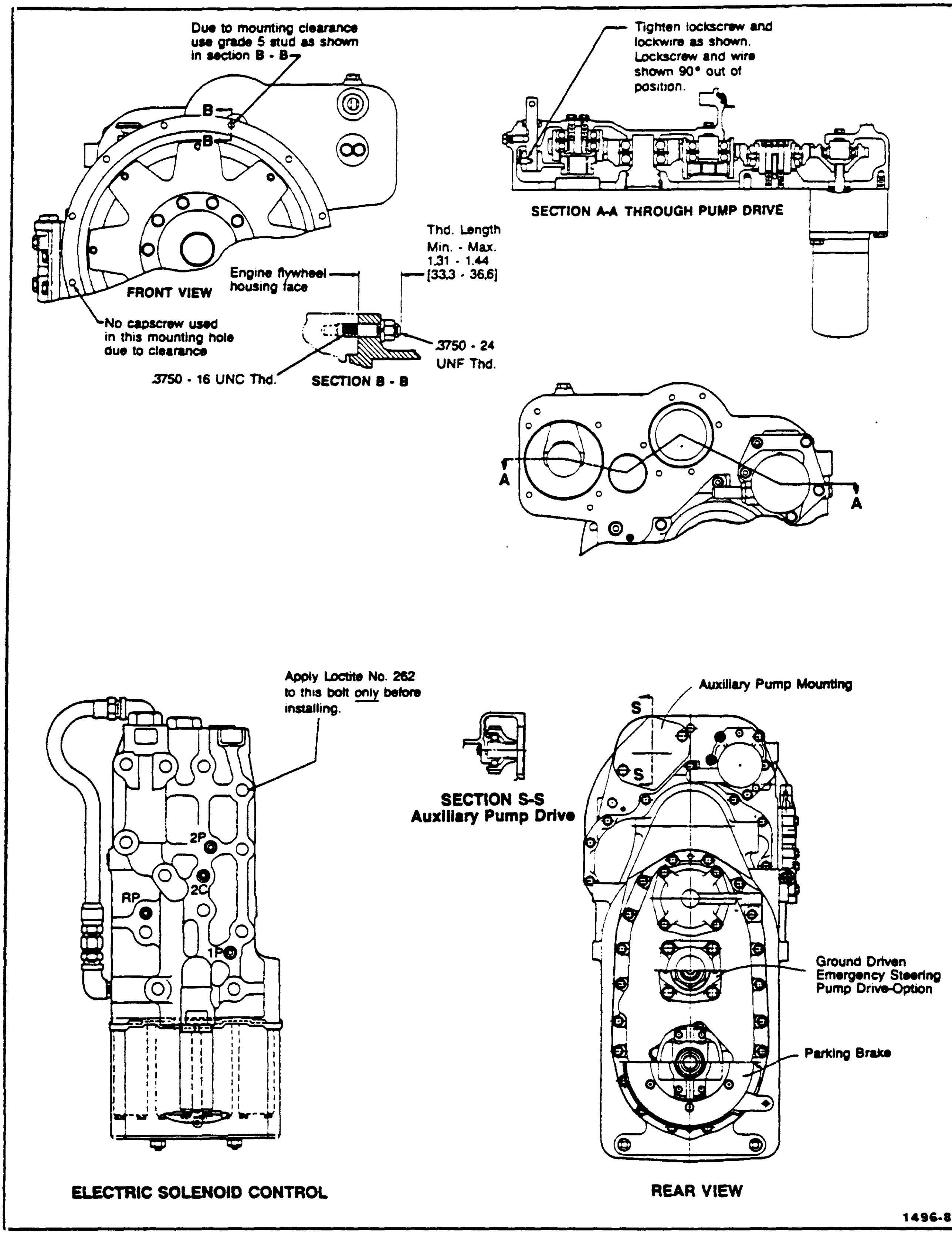
General Assembly Instructions (Sheet 2 of 3)



General Assembly Instructions (Sheet 3 of 3)

SPECIFICATIONS AND SERVICE DATA — POWER SHIFT TRANSMISSION AND TORQUE CONVERTER

CONVERTER OUT PRESSURE
55 min - 70 max p.s.i. [3.9 - 4.9 kg/cm²]
Converter outlet oil temp 180° - 200° F [82.2 - 93.3° C].
Transmission in NEUTRAL
25 P.S.I. [172.4 kPa] minimum pressure at 2000 R.P.M. engine speed AND maximum pressure with engine operating at no-load governed speed

CONTROLS
Forward and Reverse - Manual
Speed Selection - Manual

CLUTCH TYPE
Multiple discs, hydraulically actuated, spring released, automatic wear compensation and no adjustment. All clutches oil cooled and lubricated

CLUTCH INNER DISC
Friction

CLUTCH OUTER DISC
Steel

OIL FILTRATION
Full flow oil filter safety by-pass, also strainer screen in sump at bottom of transmission case

CLUTCH PRESSURE
240 - 280 psi [1654.8 - 1930.5 kPa] - With parking brake set

With parking brake set (see note), oil temperature 180 - 200° F [82.2 - 93.3° C], engine at idle (400 to 600 RPM) shift through direction and speed clutches. All clutch pressure must be equal within 5 psi [0.4 kg/cm²]. If clutch pressure varies in any one clutch more than 5 psi [0.4 kg/cm²] repair clutch

NOTE: Never use service brakes while making clutch pressure checks. Units having brake actuated declutching in forward and/or reverse will not give a true reading.

ALWAYS USE PARKING BRAKE WHEN MAKING CLUTCH PRESSURE CHECKS

LUBRICATION

TYPE OF OIL
See Lube Chart

CAPACITY
Consult Operator's Manual on applicable machine model for system capacity. Torque Converter, Transmission and allied hydraulic system must be considered as a whole to determine capacity.

CHECK PERIOD
Check oil level DAILY with engine running at 500-600 RPM and oil at 180° to 200° F [82.2 - 93.3° C]. Maintain oil level to FULL mark.

NORMAL * DRAIN PERIOD
Every 500 hours, change oil filter element
Every 1000 hours, drain and refill system as follows. Drain with oil at 150° to 200° F [65.6 - 93.3° C].

NOTE: It is recommended that filter elements be changed after 50 and 100 hours of operation on new and rebuilt or repaired units.

(a) Drain transmission and remove sump screen. Clean screen thoroughly and replace, using new gaskets.

(b) Drain oil filters, remove and discard filter elements. Clean filter shells and install new elements.

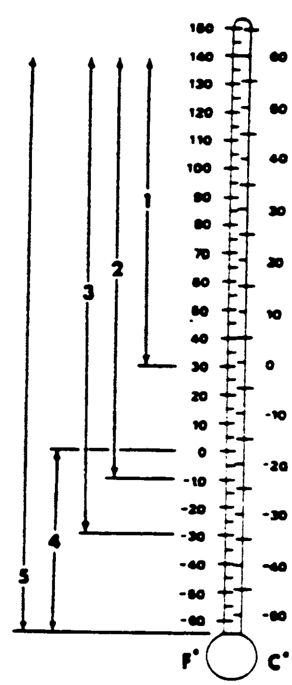
(c) Refill transmission to LOW mark.

(d) Run engine at 500-600 RPM to prime converter and lines.

(e) Recheck level with engine running at 500-600 RPM and add oil to bring level to LOW mark. When oil temperature is hot (180-200° F.) [82.2 - 93.3° C] make final oil level check. BRING OIL LEVEL TO FULL MARK.

RECOMMENDED LUBRICANTS FOR CLARK POWER SHIFTED TRANSMISSION AND TORQUE CONVERTERS

Prevailing Ambient Temperature



Temperature Range "1"
(a) C-2 Grade 30
(b) C-3 Grade 30
(c) Engine Oil - Grade 30 API-CD/SE or CD/SF
(d) MIL-L-2104C-Grade 30
(e) MIL-L-2104D-Grade 30

Temperature Range "2"
(a) MIL-L-2104C-Grade 10
(b) MIL-L-2104D-Grade 10
(c) C-2 Grade 10
(d) C-3 Grade 10
(e) Engine Oil - Grade 10 API-CD/SE or CD/SF
(f) Quintolubric 822-220 (Non Phosphate Ester Fire Resistant Fluid)

Temperature Range "3"
(a) *Dexron
(b) *Dexron II D - **See Caution Below**

Temperature Range "4"
(a) MIL-L-46167
(b) MIL-L-46167

Temperature Range "5"
(a) Conoco Polar Start DN-600 Fluid

NOTES: Temperature ranges "2" and "3" may be used to lower ambient temperatures when sump perheaters are used.

Temperature range "4" should be used only in ambient temperature range shown.

MODULATED SHIFT TRANSMISSIONS: H125, H200, H500, H600, 18000, 24000, 28000, 32000 & 34000 series transmissions with modulated shift use only C-3 or temperature range 3 items (a) & (b) *Dexron or *Dexron II D **SEE CAUTION BELOW.** 3000, 4000, 5000, 6000, 8000 & 16000 series transmissions with modulated shift use only C-3 or temperature range 3 item (a) only *Dexron. Do **NOT** use *Dexron II D **SEE CAUTION BELOW.**

CAUTION: *Dexron II D is not compatible with graphitic clutch plate friction material UNLESS IT MEETS THE APPROVED C-3 SPECIFICATIONS. *Dexron II D cannot be used, in the 3000, 4000, 5000, 6000, 8000 or 16000 series power shift transmissions, or the HR28000, HR32000 & HR34000 series having converter lock-up, or the C270 series converter having lockup UNLESS IT MEETS THE APPROVED C-3 SPECIFICATIONS.

*Dexron is a registered trademark of General Motors Corporation.

Any deviation from this lube chart must have written approval from the application department of the Clark Component Company Engineering and Marketing Department, Clark Equipment Company, Buchanan Michigan.

* Normal drain periods and filter change intervals are for average environmental and duty-cycle conditions. Severe or sustained high operating temperatures or very dusty atmospheric conditions will cause accelerated deterioration and contamination. For extreme conditions judgment must be used to determine the required change intervals.

Torque Specification for Lubricated or Plated Screw Threads

	Grade 5				Grade 8			
NOM.	FINE THREAD		COARSE THREAD		FINE THREAD		COARSE THREAD	
SIZE	LB-FT	[Nm]	LB-FT	[Nm]	LB-FT	[Nm]	LB-FT	[Nm]
.2500	9-11	[12.3-14.9]	8-10	[10.9-13.5]	11-13	[15.0-17.6]	9-11	[12.3-14.9]
.3125	16-20	[21.7-27.1]	12-16	[16.3-21.6]	28-32	[38.0-43.3]	26-30	[35.3-40.6]
.3750	26-29	[35.3-39.3]	23-25	[31.2-33.8]	37-41	[50.2-55.5]	33-36	[44.8-48.8]
.4375	41-45	[55.6-61.0]	37-41	[50.2-55.5]	58-64	[78.7-86.7]	52-57	[70.6-77.2]
.5000	64-70	[86.8-94.9]	57-63	[77.3-85.4]	90-99	[122.1-134.2]	80-88	[108.5-119.3]
.5625	91-100	[123.4-135.5]	82-90	[111.2-122.0]	128-141	[173.6-191.1]	115-127	[156.0-172.2]
.6250	128-141	[173.5-191.2]	113-124	[153.2-168.1]	180-198	[224.0-268.5]	159-175	[215.6-237.3]
.7500	223-245	[302.3-332.2]	200-220	[271.2-298.3]	315-347	[427.1-470.5]	282-310	[382.3-420.3]

Torque Chart

1. Check oil level in transmission. This should be done with oil temperature at 180 to 200 degrees F (82.2 to 93.3 degrees C). Do not attempt these checks with cold oil.

2. To bring the oil temperature to this level, it is necessary to either work the machine or stall out the converter. When it is impractical to work the machine, stall out the converter as follows:

a. Apply the parking brakes.

b. Position the shift lever to forward and high speed.

c. Accelerate engine to between half and three quarter throttle.

d. Hold converter stalled until desired temperature is reached.

CAUTION

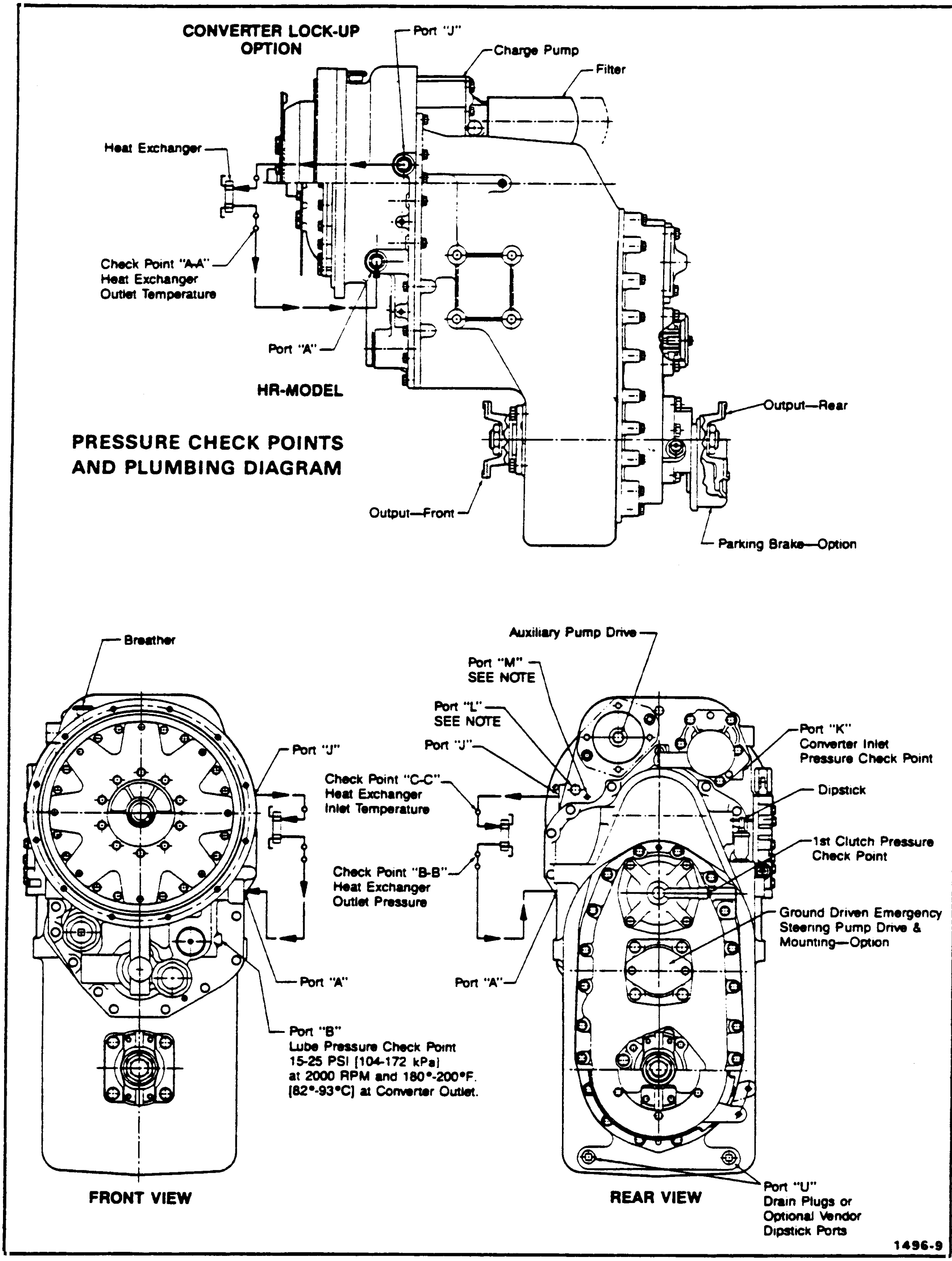
Full throttle stall speeds for an excessive length of time will overheat the torque converter.

NOTE

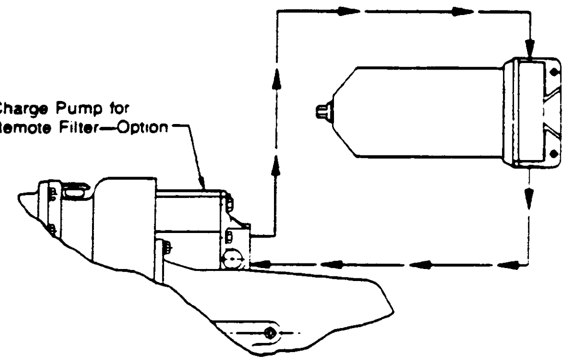
Always make all troubleshooting checks with the converter outlet temperature at least 180 to 200 degrees F (82.3 to 93.3 degrees C).

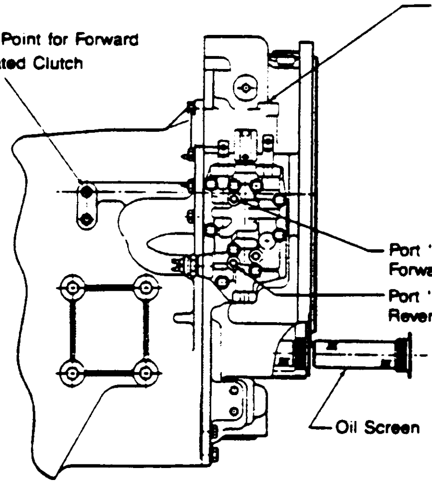
Procedure.

SYMPTOM	PROBABLE CAUSE	SOLUTION
1. Low clutch pressure	a. Low oil level.	a. Fill to proper level.
	b. Clutch pressure regulating valve spool stuck open.	b. Clean valve spool and housing.
	c. Faulty charging pump.	c. Replace pump.
	d. Broken or worn clutch shaft or piston sealing rings.	d. Replace sealing rings.
	e. Clutch piston bleed valve stuck open.	e. Clean bleed valves thoroughly
2. Low converter charging pump output.	a. Low oil level.	a. Fill to proper level.
	b. Suction screen plugged.	b. Clean suction screen.
	c. Air leaks at pump intake hose and connections or collapsed hose.	c. Tighten all connections or replace hose if necessary.
	d. Defective oil pump.	d. Replace pump.
3. Overheating.	a. Worn oil sealing rings.	a. Remove, diassemble, and rebuild converter assembly.
	b. Worn oil pump.	b. Replace.
	c. Low oil level.	c. Fill to proper level.
	d. Pump suction line taking air.	d. Check oil line connections and tighten.



External Plumbing and Pressure Check Points (Sheet 1 of 2)





Oil Temperature Gauge Specifications:
1. Normal Operating Temperature: 180-250°F. [82-121°C]
2. Red Lined Temperature: 250°F. [121°C]

Notes

Hose Line Operating Requirements:

1. Pressure Lines—Suitable for operation from ambient to 250°F. [121°C] continuous operating temperature. Must withstand 300 PSI [2068 kPa] continuous pressure, with 600 PSI [4137 kPa] intermittent surges. Ref. S.A.E. Spec. No. J517, 100R1 Hydraulic Hose Specifications.
2. See Lubrication Specifications.
3. All hose lines used must conform to S.A.E. Spec. No. J 1019 Tests and Procedures for High Temperature Transmission Oil Hose.

Port "L"—Converter Outlet Temperature
Port is to be used for Converter Outlet Temperature pick-up. Gauge is to be located in the Operator Compartment. See Oil Temperature Gauge Specifications.

Port "M"—Converter Outlet Pressure
Pressure must be measured during normal vehicle "Production Line" test. Converter outlet pressure equals the total pressure drop of the Heat Exchanger, Heat Exchanger Lines and back pressure of the transmission lubrication system.

Test Conditions:

1. Converter Outlet Oil Temperature 180-220°F. [82-104°C].
2. Transmission in Neutral.

Operating Specifications:

1. 25 PSI [173 kPa] Min. pressure at 2000 RPM engine speed and a max. of 70 PSI [483 kPa] outlet pressure at a no-load governed speed.

Ports "B", "F", "K", "L" and "M"
These ports can be used for field "Trouble Shooting" or vehicle "Production Line" tests.

Ports "F", "L" and "M"
These ports are to be used as check points for normal vehicle "Production Line" test.

Port "F"—Clutch Pressure
It is recommended that clutch pressure be monitored by a gauge having an indicator dial range of 0 to 400 PSI [0 to 2758 kPa] and located in the Operator Compartment.

Ports "G" and "H"—Back-up Warning
These ports are provided for installation of Back-up Pressure Switch for Warning Light or Horn.

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External Plumbing and Pressure Check Points (Sheet 2 of 2)

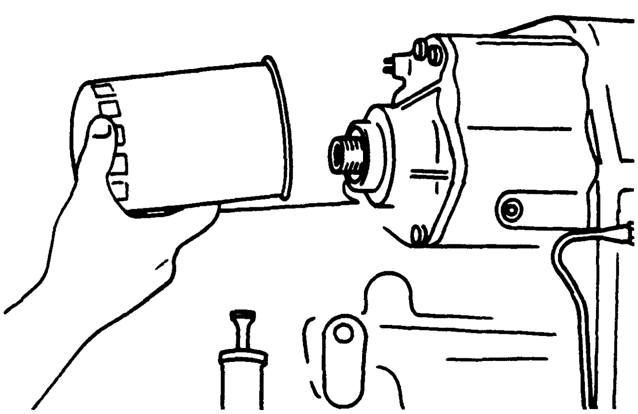
4 Noisy converter.	a. Worn oil pump. b. Worn or damaged bearings.	a. Replace pump. b. Completely disassemble to determine which bearing is faulty.
5 Lack of power	a. Low engine rpm at converter stall. b. Worn oil sealing rings c. Worn oil pump. d. Low oil level. e. Pump suction line taking air.	a. Tune engine, check governor. b. Remove, disassemble, and rebuild converter assembly. c. Replace pump. d. Fill to proper level. e. Check oil line connections and tighten.

TORQUE CONVERTER/TRANSMISSION.

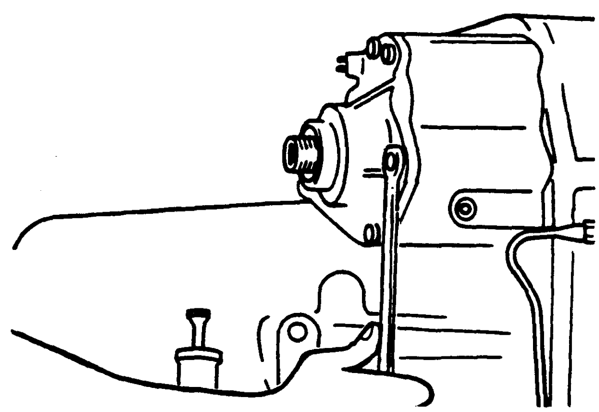
Disassembly.

CAUTION

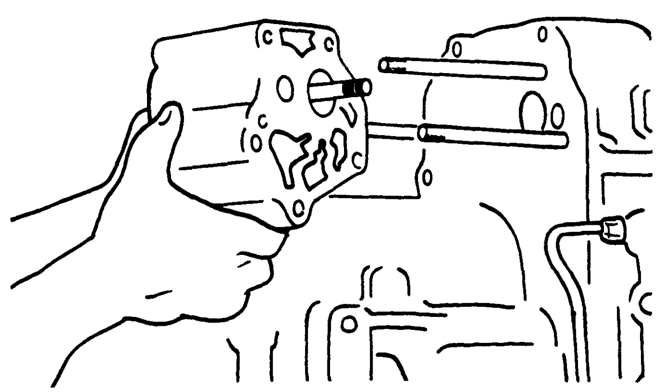
Cleanliness is of extreme importance and an abosolute must in the repair and overhaul of this unit. Before attempting any repairs, the exterior of the unit must be thoroughly cleaned to prevent the possibility of dirt and foreign matter entering the mechanism.



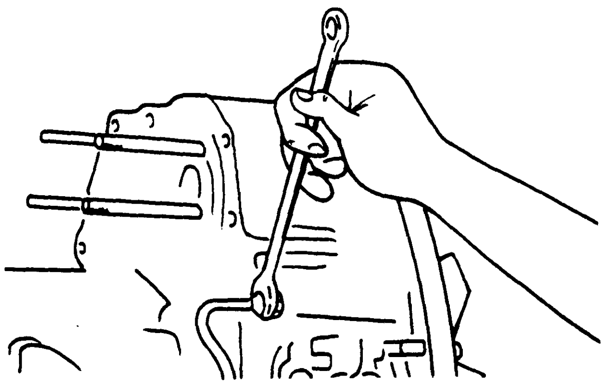
1. Loosen filter assembly and catch any oil in a drain pan. Remove the filter assembly when the oil has drained.



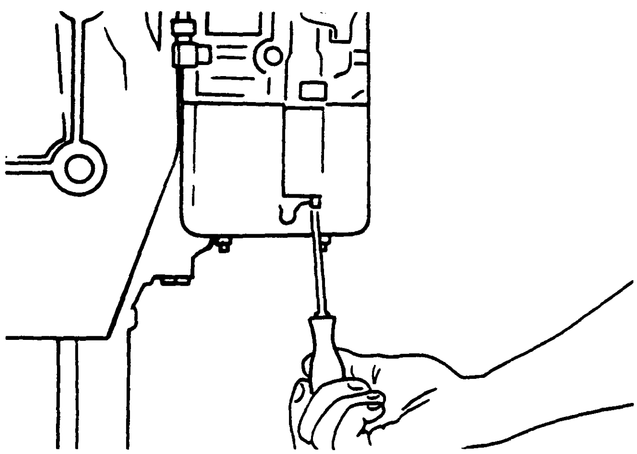
2. Remove the pressure regulating valve stud nuts, bolts and washers.



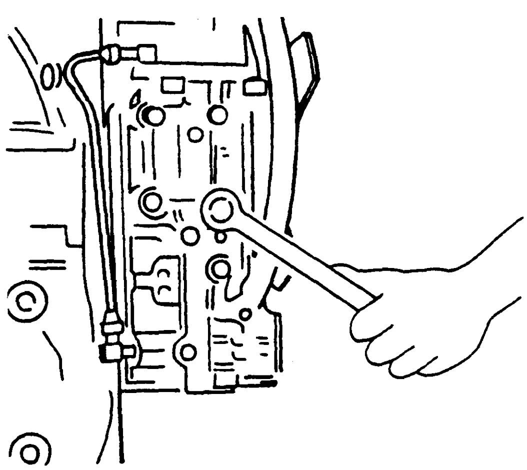
3. Remove the pressure regulating valve and charging pump assembly.



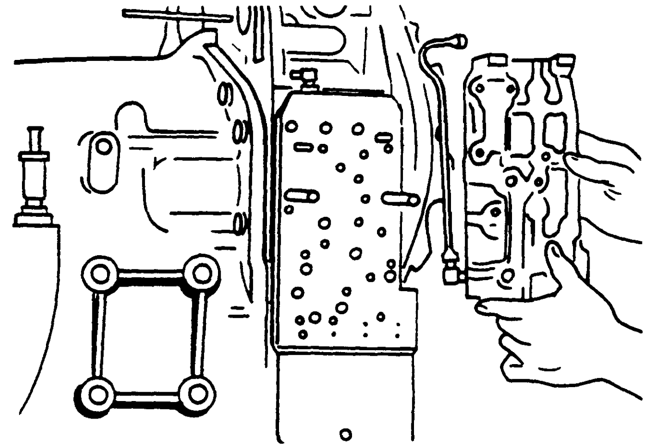
4. Disconnect the shuttle valve to control valve crossover tube.



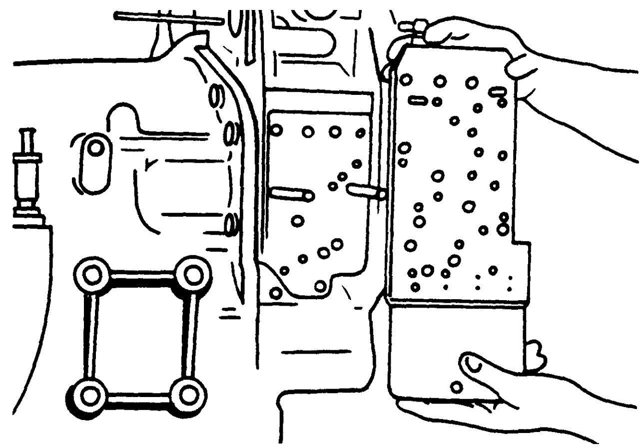
5. Disconnect the shuttle valve solenoid wires.



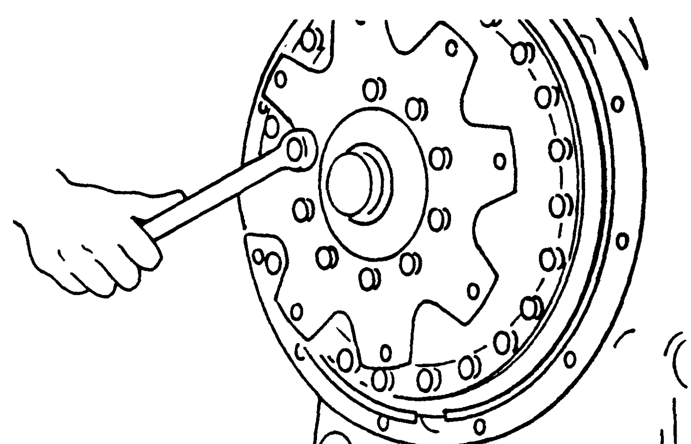
6. Remove two valve to converter housing capscrews. Install two aligning studs to facilitate valve removal. Remove the remaining capscrews.



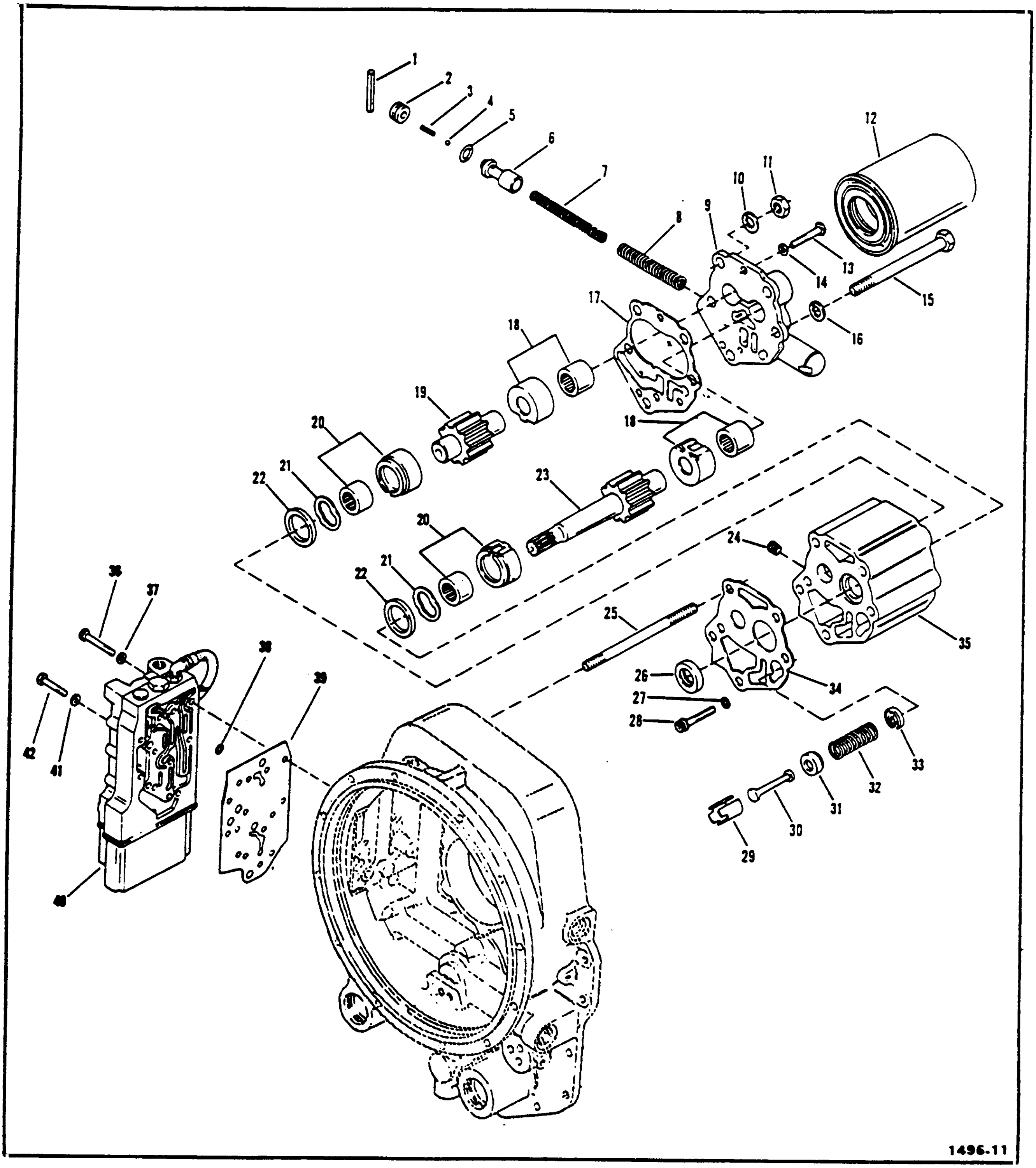
7. Remove the shuttle valve assembly from aligning studs.



8. Remove the control valve assembly.



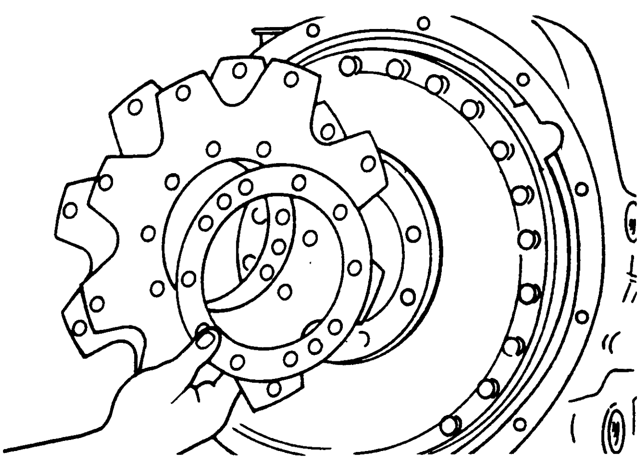
9. Remove the drive plate capscrews and washers.



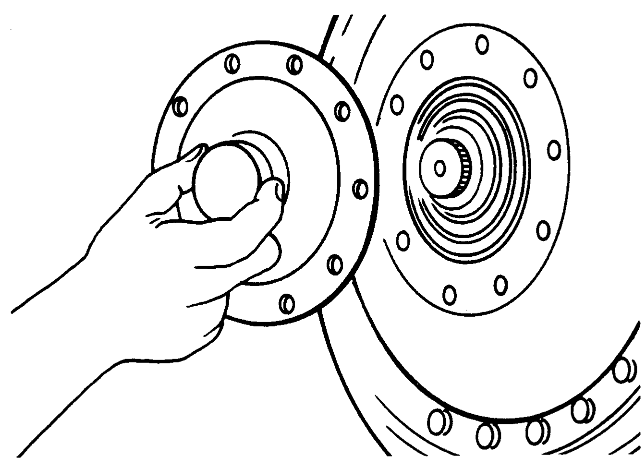
Charging Pump and Valve Assembly (Sheet 1 of 2)

1. Valve Stop Roll Pin
2. Valve Stop
3. Spring
4. Ball
5. Valve Stop O-Ring
6. Valve Piston
7. Valve Spring - Inner
8. Valve Spring - Outer
9. Regulating Valve & Filter Adaptor Assembly
10. Pump Mounting Stud Lockwasher
11. Pump Mounting Stud Nut
12. Filter Assembly
13. Valve to Pump Capscrew
14. Valve to Pump Capscrew Lockwasher
15. Valve to Pump Capscrew
16. Valve to Pump Screw Lockwasher
17. Valve to Pump Gasket
18. Thrust Plate & Bearing Assembly
19. Pump Driven Shaft Assembly
20. Thrust Plate & Bearing Assembly
21. Wave Spring
22. Thrust Plate Seal
23. Pump Drive Shaft Assembly
24. Pipe Plug
25. Pump Mounting Stud
26. Pump Drive Gear Oil Seal
27. Pump Mounting Screw Lockwasher
28. Pump Mounting Screw
29. Safety Valve Spacer
30. Safety Valve Poppet
31. Safety Valve Seat
32. Safety Valve Spring
33. Safety Valve Retainer
34. Pump Assembly to Converter Housing Gasket
35. Pump Body
36. Valve Mounting Screw
37. Valve Mounting Screw Lockwasher
38. High Clutch Pressure O-Ring
39. Valve to Converter Housing Gasket
40. Control Valve Assembly
41. Valve Mounting Screw Lockwasher
42. Valve Mounting Screw

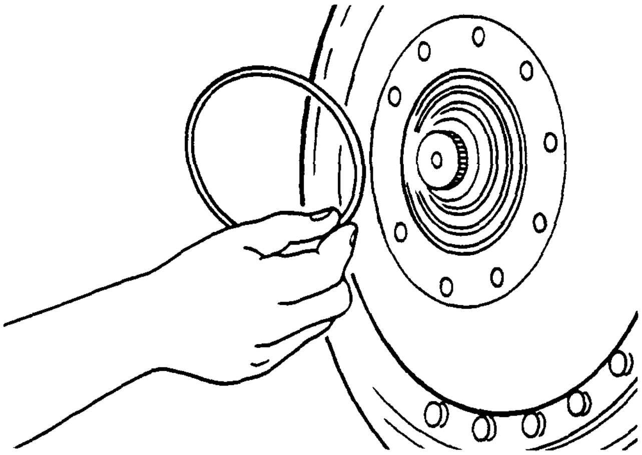
Charging Pump and Valve Assembly (Sheet 2 of 2)



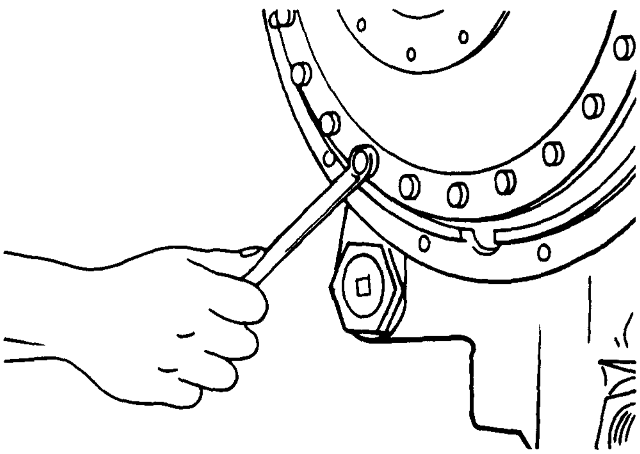
10. Remove the drive plate and backing ring.



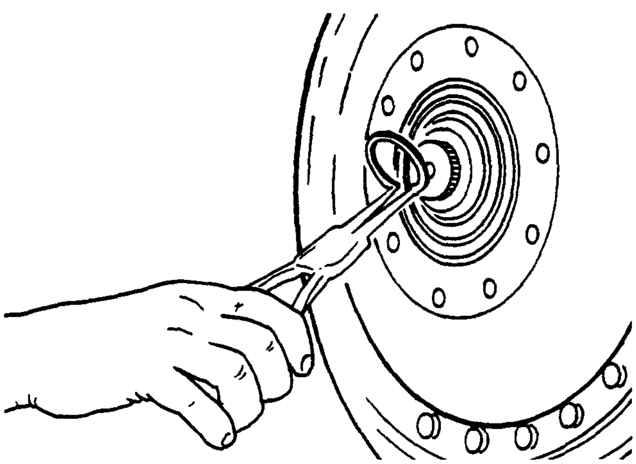
11. Remove the impeller cover bearing cap.



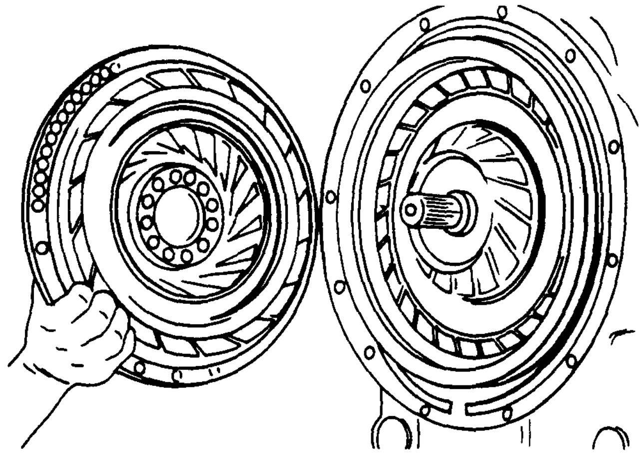
12. Remove the bearing cap o-ring.



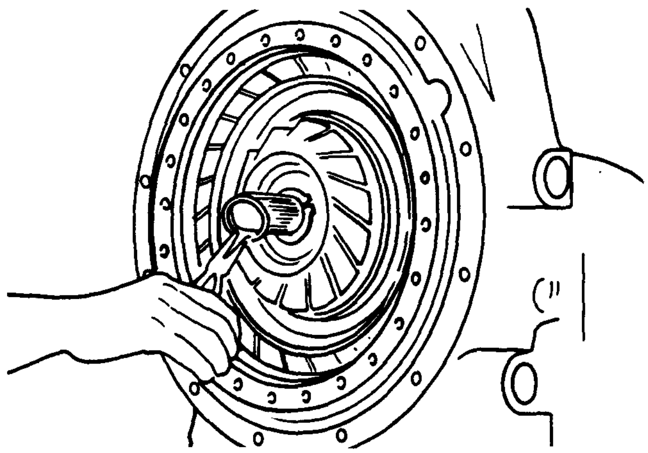
13. Remove impeller cover bolts. Catch any of the remaning oil in the wheel section in a drain pan.



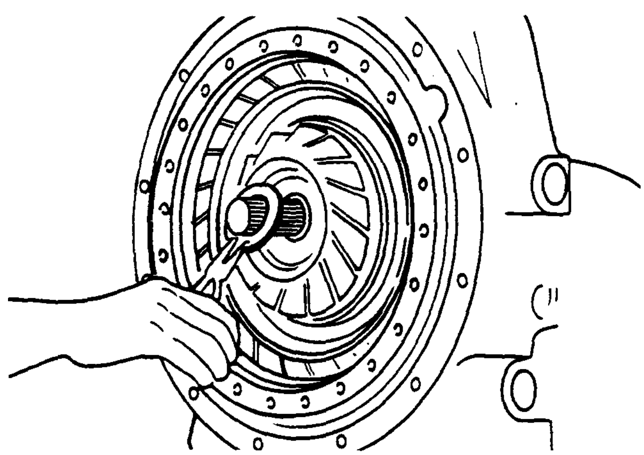
14. Remove the turbine hub to turbine shaft retaining ring.



15. Remove the impeller cover and turbine as an assembly.



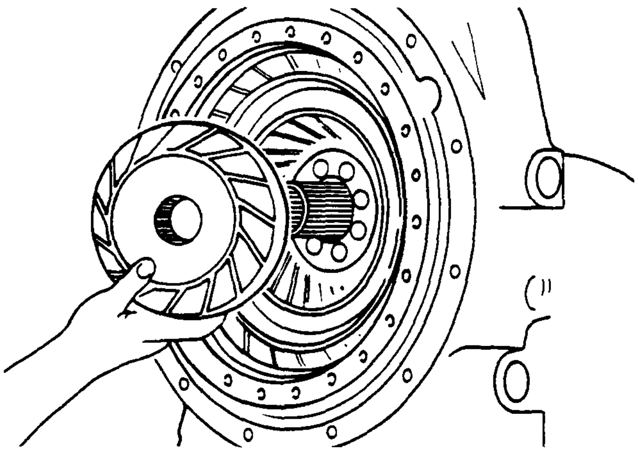
16. Remove the turbine to turbine shaft locating ring.



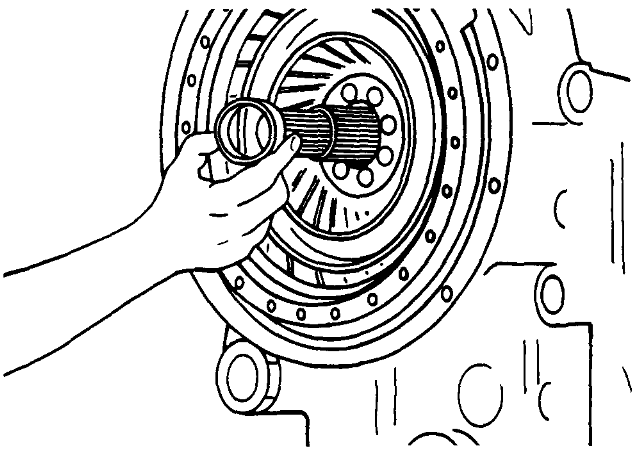
17. Remove the reaction member retaining ring.

NOTE

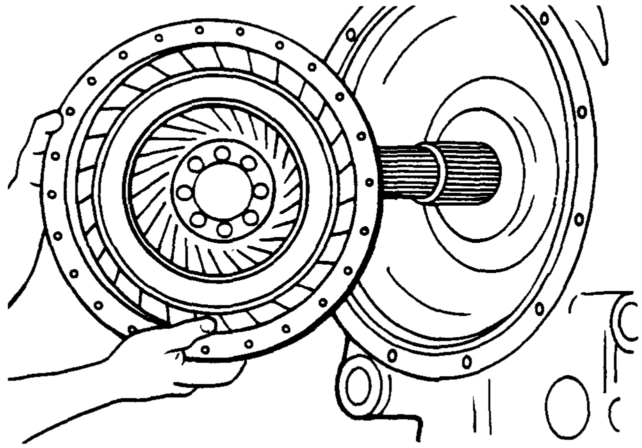
Some units will have a fixed reaction member and some units will have a freewheeling reaction member. The fixed is a one piece and the freewheeling is an assembly. Remove as an assembly.



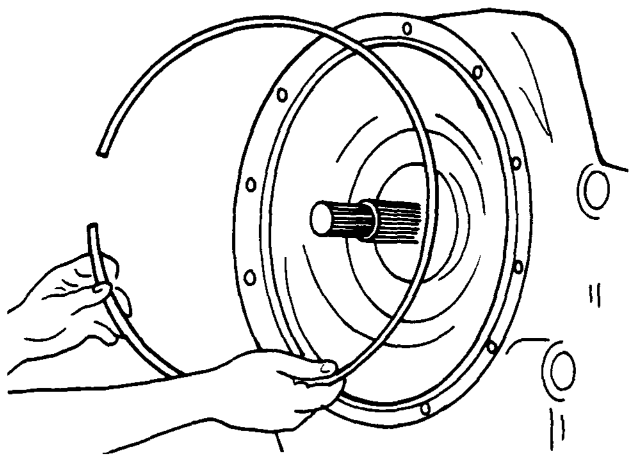
18. Remove reaction member.



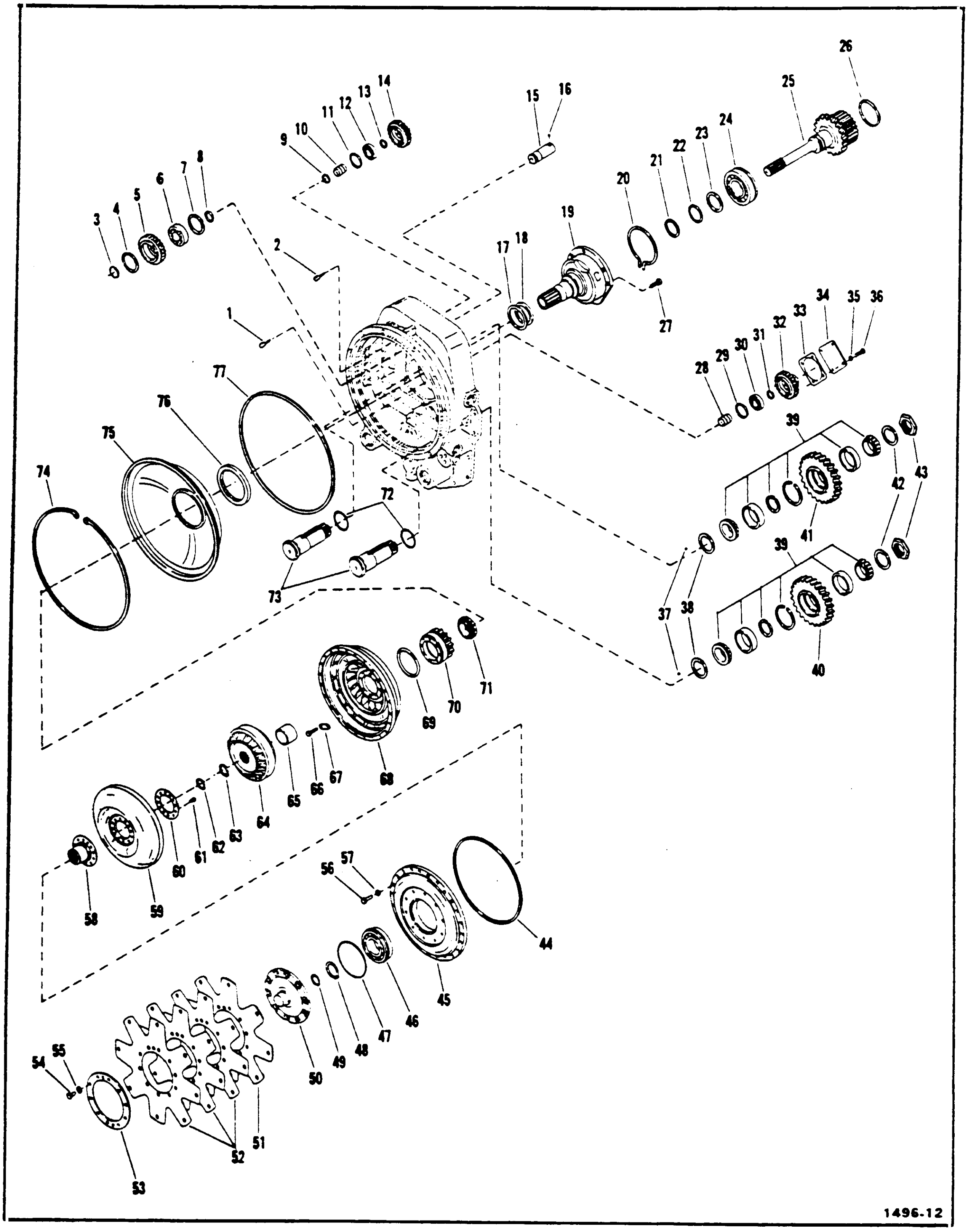
19. Remove the reaction member spacer.



20. Remove the impeller.



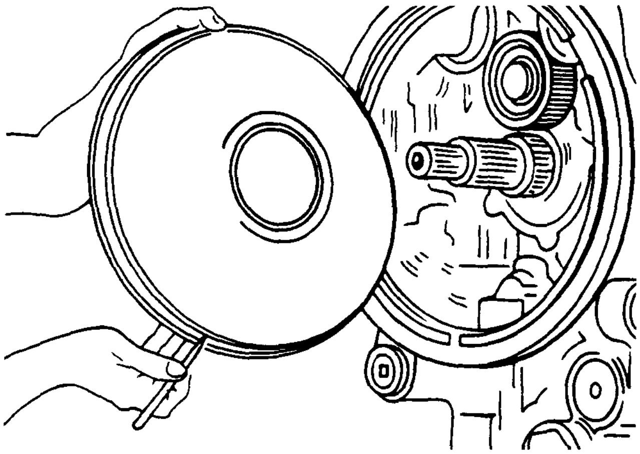
21. Remove the oil baffle retaining ring.



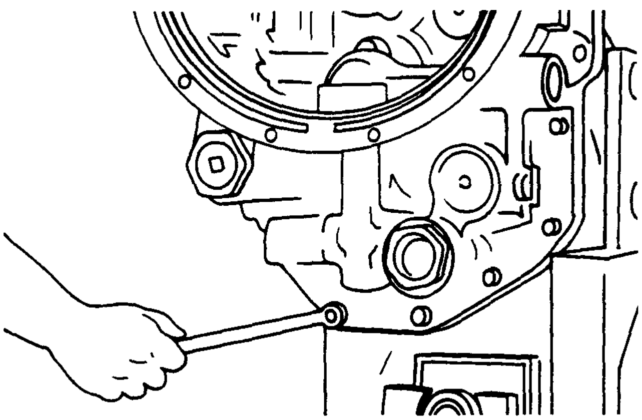
Converter and Pump Drive (Sheet 1 of 2)

1. Bearing Support Screw & Lockwasher
2. Bearing Support Screw & Lockwasher
3. Idler Gear Bearing Locating Ring
4. Idler Gear Bearing Retaining Ring
5. Pump Drive Idler Gear
6. Idler Stub Shaft Bearing
7. Bearing Retaining Ring
8. Bearing Locating Ring
9. Bearing Locating Ring
10. Pump Drive Bearing Support
11. Bearing Retaining Ring
12. Pump Drive Gear Bearing
13. Bearing Locating Ring
14. Pump Drive Gear
15. Idler Gear Stub Shaft
16. Stub Shaft Lock Ball
17. Piston Ring Expander Spring
18. Piston Ring
19. Stator Support
20. Bearing Snap Ring
21. Piston Ring
22. Bearing Retaining Ring
23. Bearing Locating Washer
24. Turbine Shaft Bearing
25. Turbine Shaft
26. Baffle Ring
27. Stator Support Screw
28. Auxiliary Pump Drive Bearing Support
29. Bearing Retaining Ring
30. Pump Drive Gear Bearing
31. Bearing Locating Ring
32. Auxiliary Pump Drive Gear
33. Pump Mounting Cover Gasket
34. Pump Mounting Cover
35. Pump Mounting Cover Capscrew Lockwasher
36. Pump Mounting Cover Capscrew
37. Idler Shaft Lockball
38. Reverse Idler Gear Bearing Thrust Plate
39. Reverse Idler Gear Bearing Assembly
40. Reverse Idler Gear - Lower Shaft
41. Reverse Idler Gear - Upper Shaft
42. Reverse Idler Gear Bearing Thrust Plate
43. Bearing Retaining Plate Nut
44. Impeller to Cover O-Ring
45. Impeller Cover
46. Turbine Hub Bearing
47. Impeller Cover to Bearing Cap O-Ring
48. Turbine Hub Bearing Retaining Ring
49. Turbine Retaining Ring
50. Impeller Cover Bearing Cap
51. Drive Plate Assembly
52. Drive Plate
53. Drive Plate Backing Ring
54. Drive Plate Mounting Screw
55. Drive Plate Mounting Screw Lockwasher
56. Impeller to Cover Screw
57. Impeller to Cover Screw Lockwasher
58. Turbine Hub
59. Turbine
60. Turbine Hub Ring
61. Turbine Hub Screw
62. Turbine Retaining Ring
63. Reaction Member Retaining Ring
64. Reaction Member
65. Impeller to Hub Bearing Spacer
66. Impeller to Hub Screw
67. Impeller to Hub Screw Lock Tab
68. Impeller
69. Impeller Hub O-Ring
70. Impeller Hub Gear
71. Impeller Hub Gear Bearing
72. Idler Shaft O-Ring
73. Reverse Idler Shaft
74. Oil Baffle Retaining Ring
75. Oil Baffle
76. Oil Seal
77. Oil Baffle Seal Ring

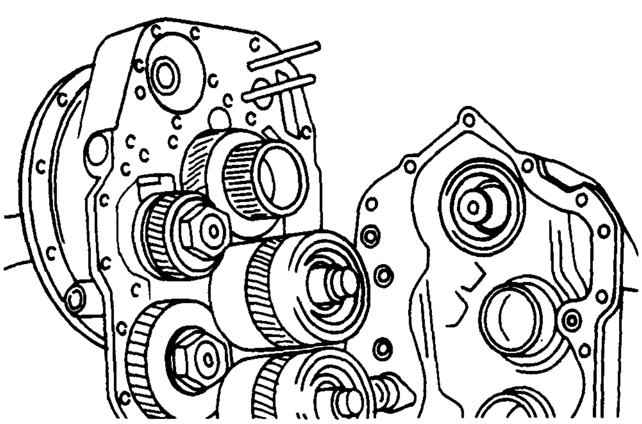
Converter and Pump Drive (Sheet 2 of 2)



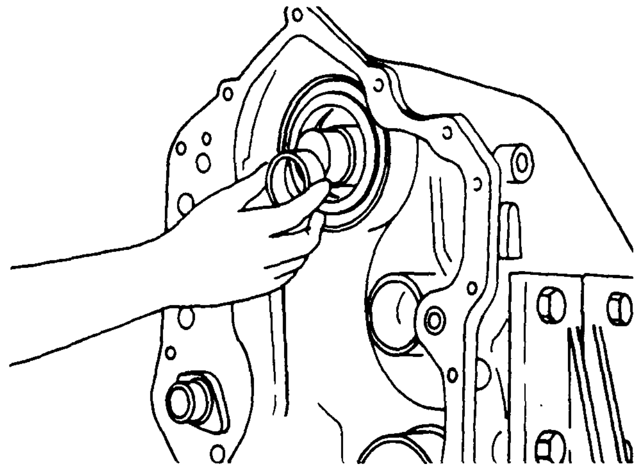
22. Pry the oil baffle from the housing. A resistance will be noted because of the heavy oil sealing ring.



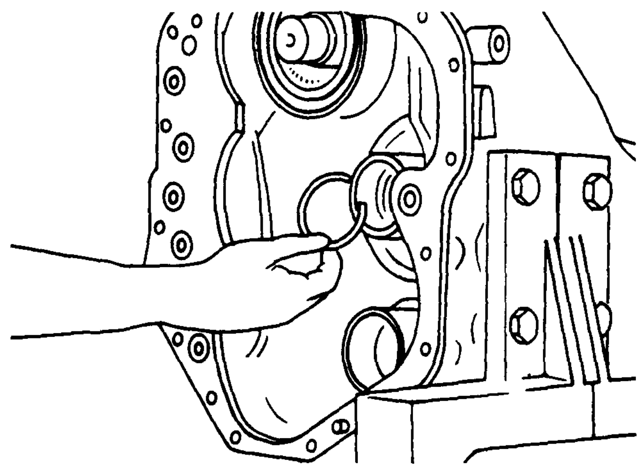
23. Support the converter housing with a chain hoist. Remove the converter housing to transmission case bolts.



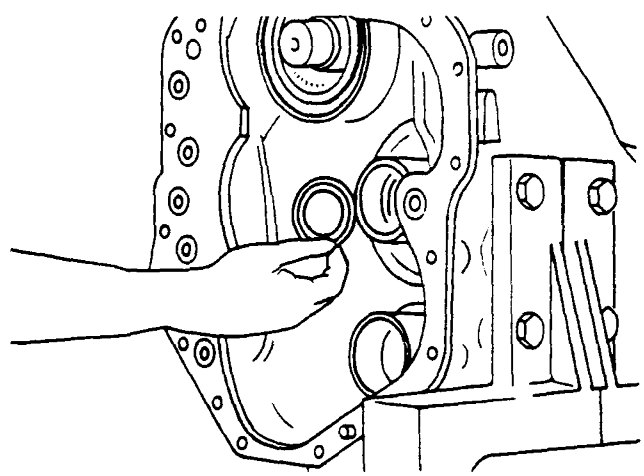
24. Separate the converter housing from the transmission case assembly. The reverse and 3rd and 4th and Forward High and 5th and 6th clutches will remain in the converter housing.



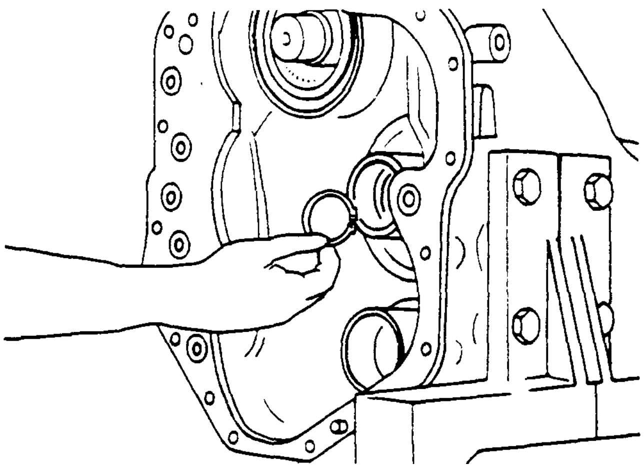
25. Remove the forward clutch front pilot bearing.



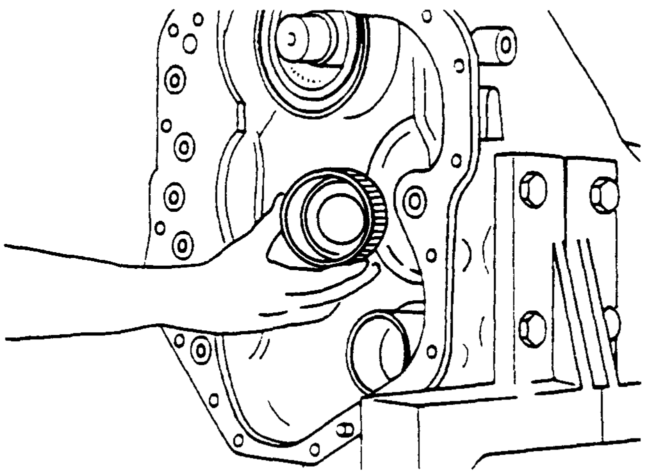
26. Remove the 3rd and 4th clutch disc hub snap ring retainer outer.



27. Remove the snap ring retainer.



28. Remove the disc hub retainer ring.

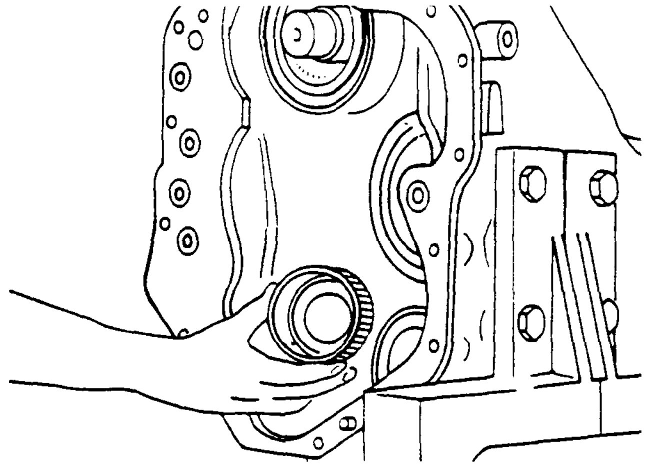


29. Remove the clutch disc hub.

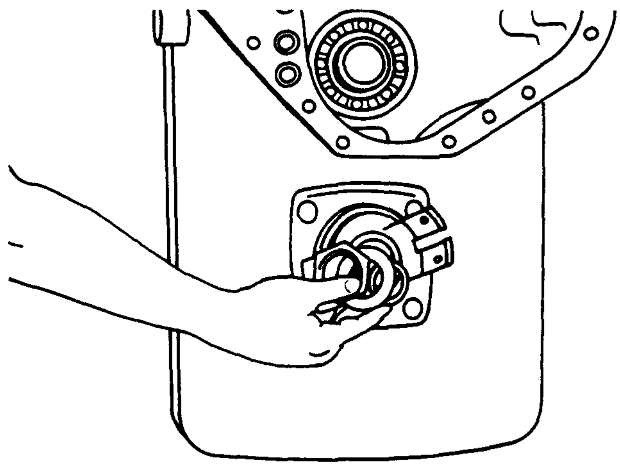
30. Remove the 5th and 6th clutch disc hub snap ring retainer outer ring.

31. Remove the snap ring retainer.

32. Remove the disc hub retainer ring.

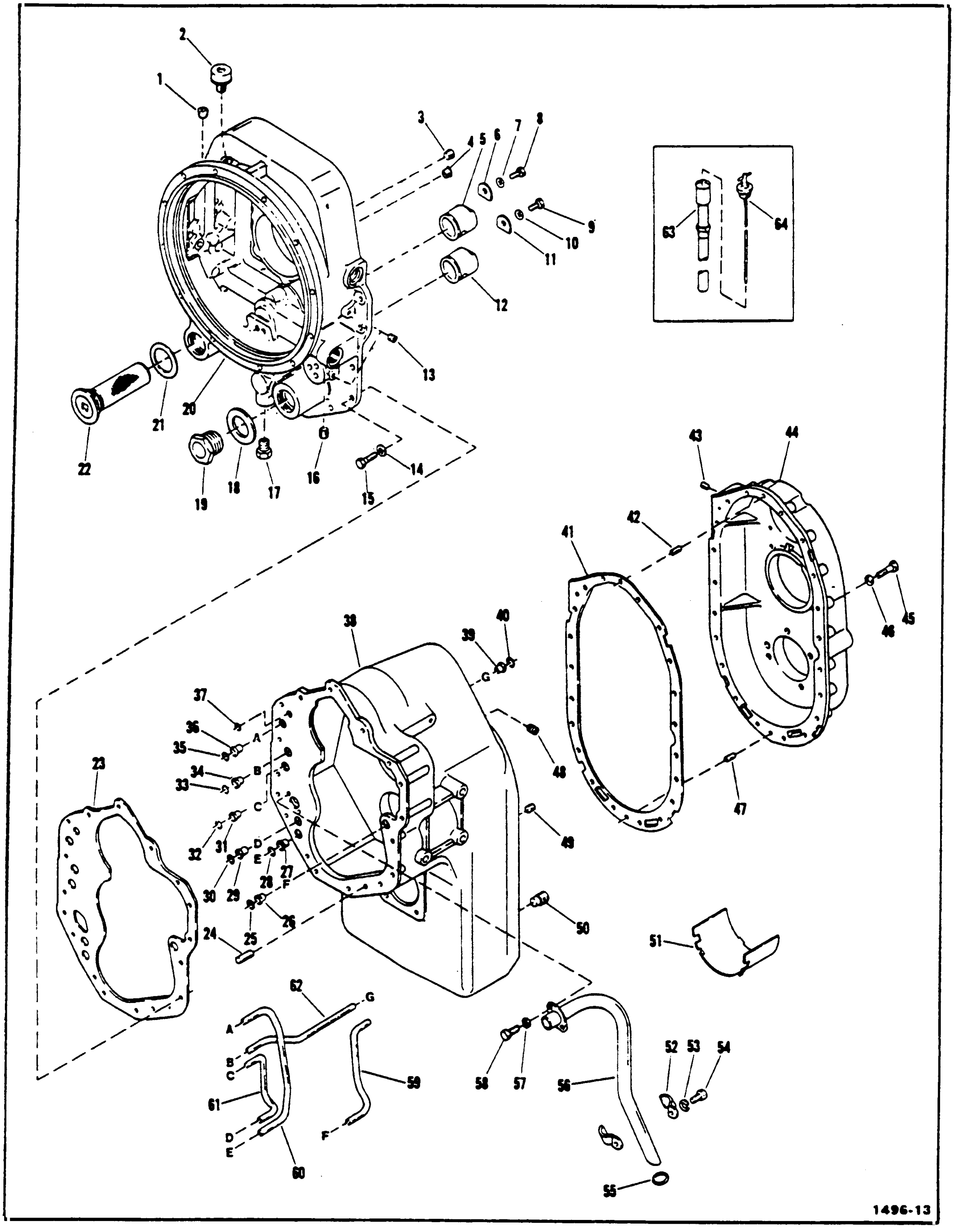


33. Remove the 5th and 6th speed clutch disc hub.



34. Using an impact wrench, loosen the output flange nut. If an impact wrench is not available, a flange retainer bar must be used to hold the companion flange from turning. Remove the nut, washer, 0-ring and flange.

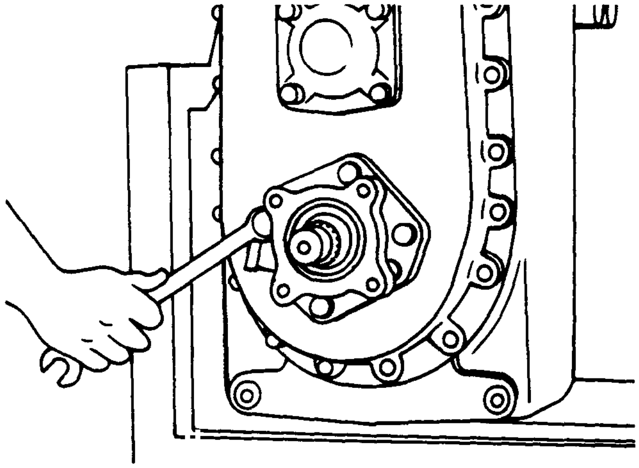
35. Remove the parking brake assembly, if so equipped.



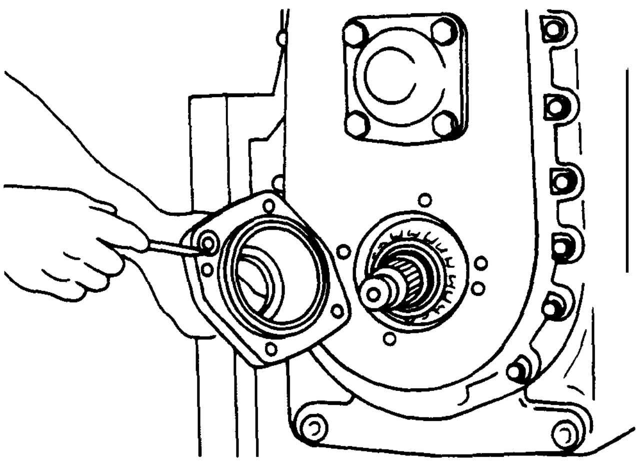
Converter and Transmission Case (Sheet 1 of 2)

1. Pipe Plug
2. Air Breather
3. Pupe Plug
4. Pipe Plug
5. Converter Housing Sleeve
6. Clip
7. Clip Screw Lockwasher
8. Clip Screw
9. Clip Screw
10. Clip Screw Lockwasher
11. Clip
12. Converter Housing Sleeve
13. Pipe Plug
14. Converter Housing to Transmission Case Screw Lockwasher
15. Converter to Transmission Case Screw
16. Pipe Plug
17. Plug
18. Hole Plug Gasket
19. Case Assembly Hole Plug
20. Converter Housing
21. Screen Assembly Gasket
22. Screen Assembly
23. Converter Housing to Transmission Case Gasket
24. Converter Housing to Case Dowel Pin
25. Clutch Pressure Tube O-Ring
26. Lube Tube Sleeve
27. Tube Sleeve
28. Clutch Pressure Tube O-Ring
29. Tube Sleeve
30. Clutch Pressure Tube O-Ring
31. Tube Sleeve
32. Clutch Pressure Tube O-Ring
33. Clutch Pressure Tube O-Ring
34. Tube Sleeve
35. Clutch Pressure Tube O-Ring
36. Tube Sleeve
37. Clutch Pressure Tube O-Ring
38. Transmission Case Assembly
39. Tube Sleeve
40. Clutch Pressure Tube O-Ring
41. Rear Cover to Transmission Case Gasket
42. Transmission Case to Rear Cover Dowel Pin
43. Rear Cover Pipe Plug
44. Rear Cover
45. Rear Cover to Case Screw
46. Rear Cover to Case Screw Lockwasher
47. Transmission Case to Rear Cover Dowel Pin
48. Pipe Plug
49. Pipe Plug
50. Magnetic Drain Plug
51. Oil Baffle
52. Tube Clip
53. Clip Screw Lockwasher
54. Clip Screw
55. Suction Line Assembly O-Ring
56. Suction Tube Assembly
57. Screw Lockwasher
58. Suction Line Screw
59. Clutch Line Tube
60. 3rd Speed Tube
61. High Speed Clutch Pressure Tube
62. Low Speed Clutch Pressure Tube
63. Dipstick Tube Assembly
64. Dipstick

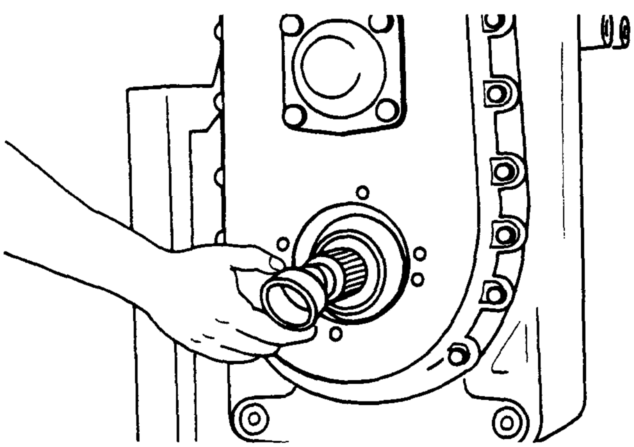
Converter and Transmission Case (Sheet 2 of 2)



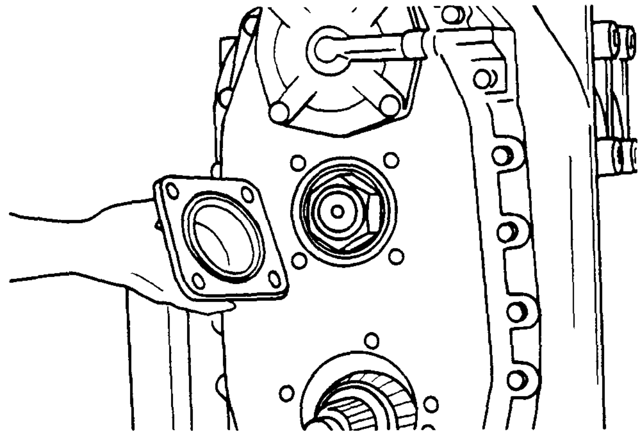
36. Remove the output shaft rear bearing cap bolts and washers.



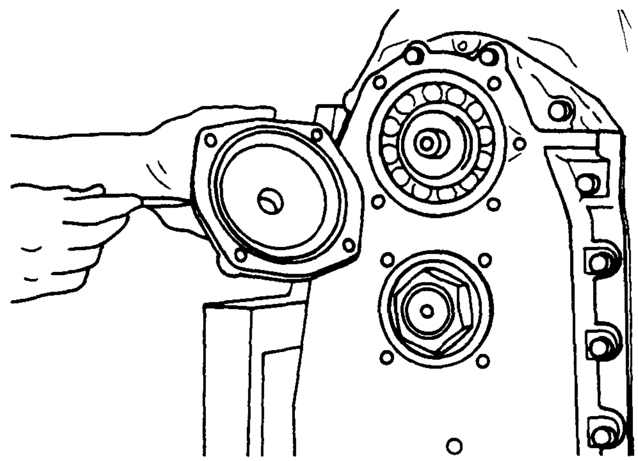
37. Remove the rear bearing cap.



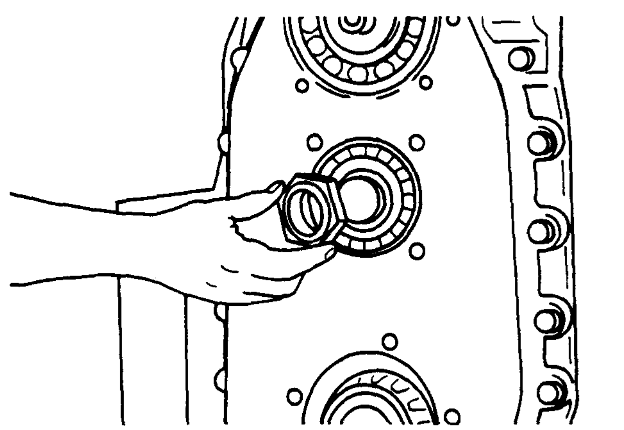
38. Remove the output flange spacer.



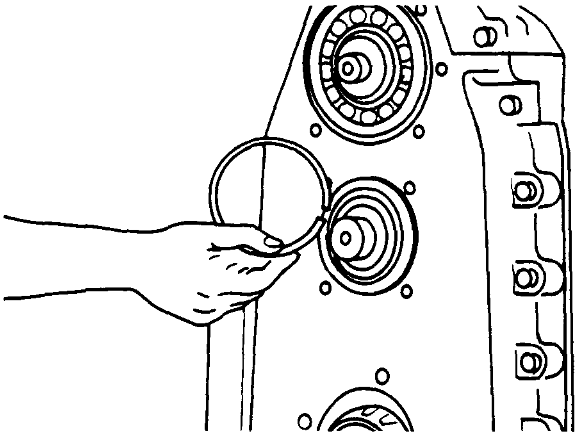
39. Remove the idler shaft bearing cap bolts and washers. Remove the bearing cap.



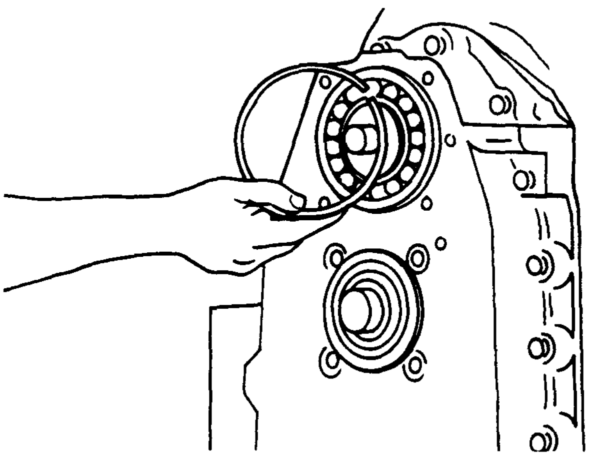
40. Remove the low clutch shaft rear bearing cap bolts and washers. Remove the bearing cap.



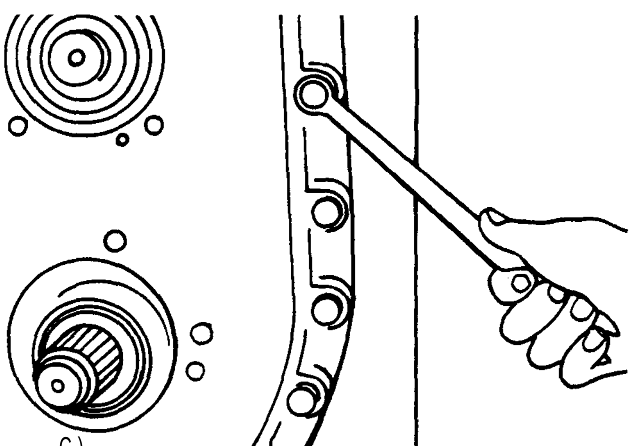
41. Remove the idler shaft rear bearing retainer nut.



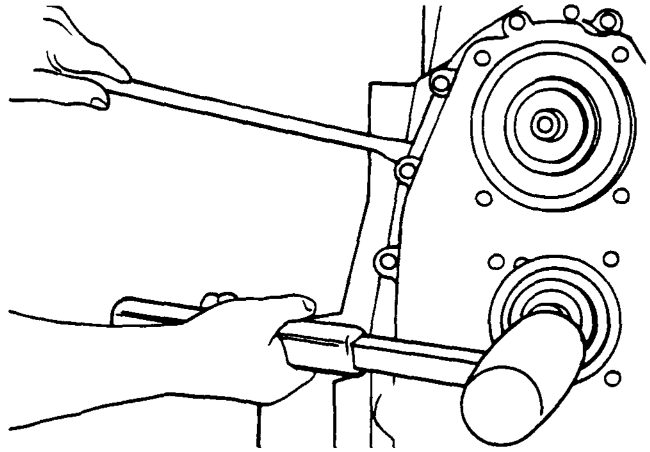
42. Remove the idler shaft rear bearing locating ring.



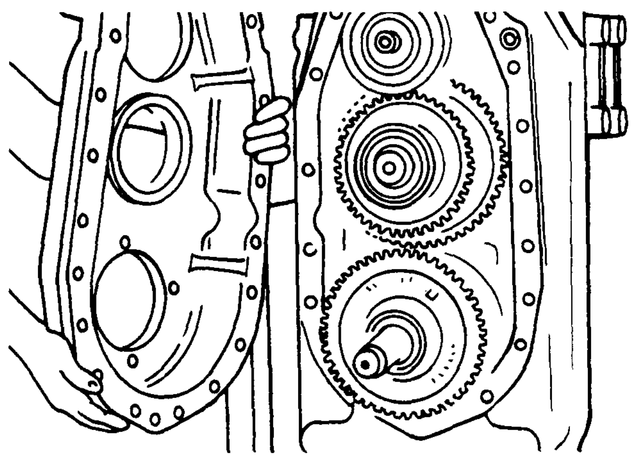
43. Remove the 1st and 2nd clutch rear bearing locating ring.



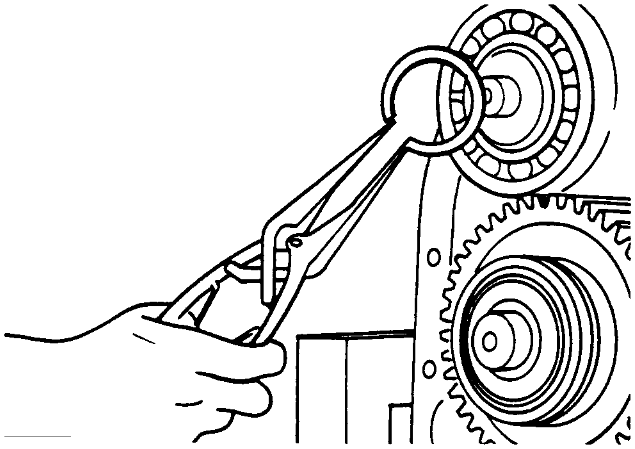
44. Remove the rear cover to case screws.



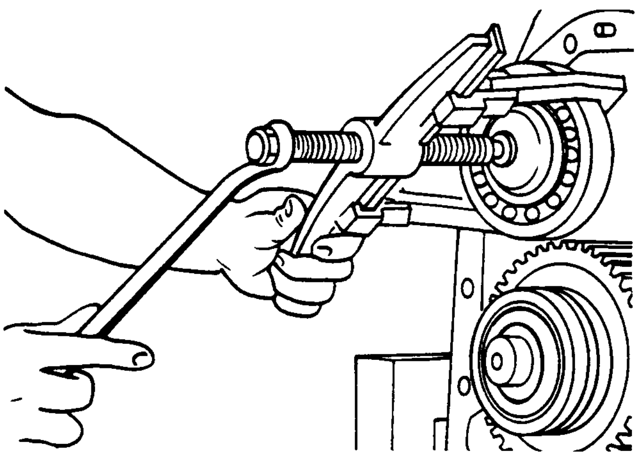
45. The use of aligning studs will facilitate the rear cover removal. Using the pry slots provided, pry the cover from transmission case using a soft hammer tap on the 1st clutch and idler shaft to prevent the cover from binding.



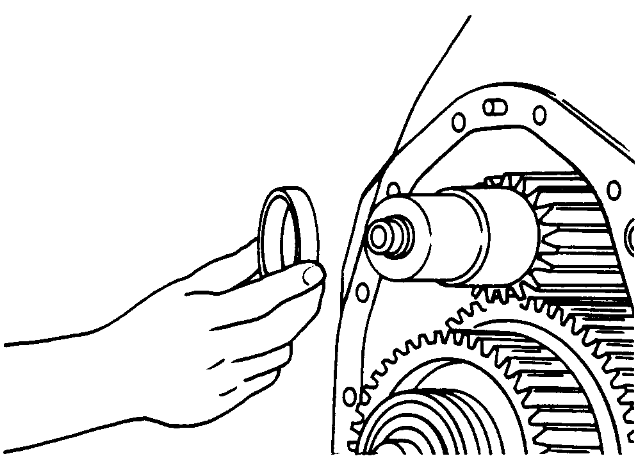
46. Remove the rear cover.



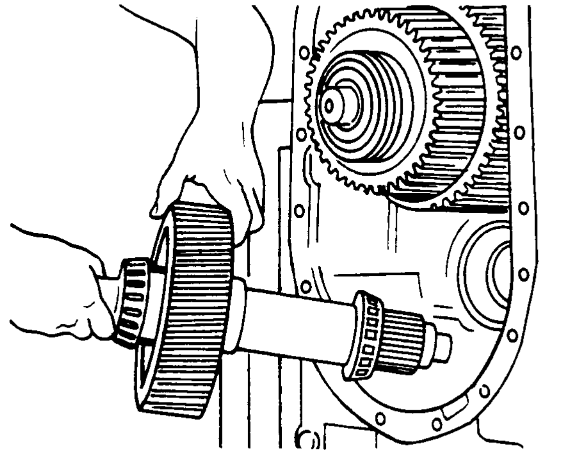
47. Remove the 1st clutch rear bearing to clutch shaft retainer ring.



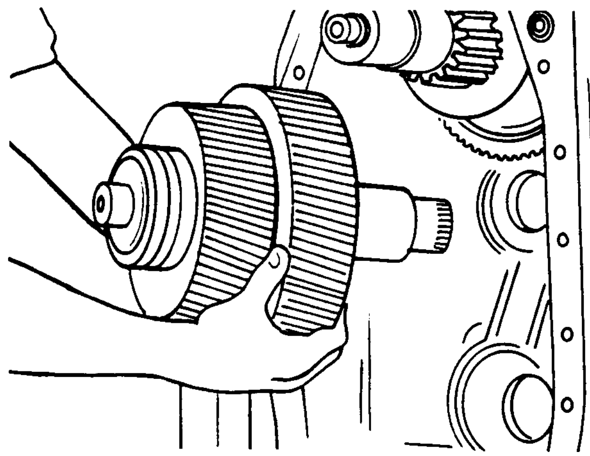
48. Remove the rear bearing.



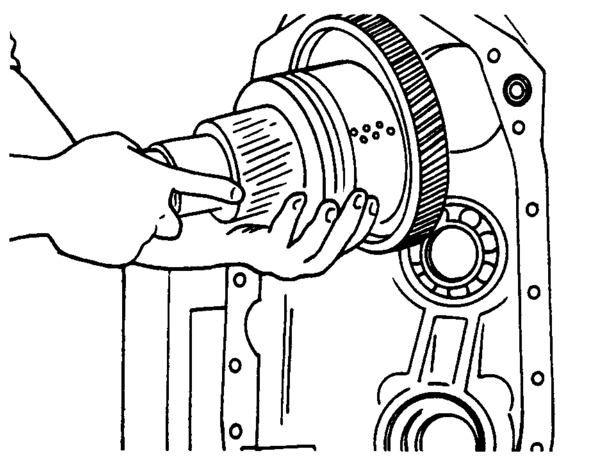
49. Remove the rear bearing spacer.



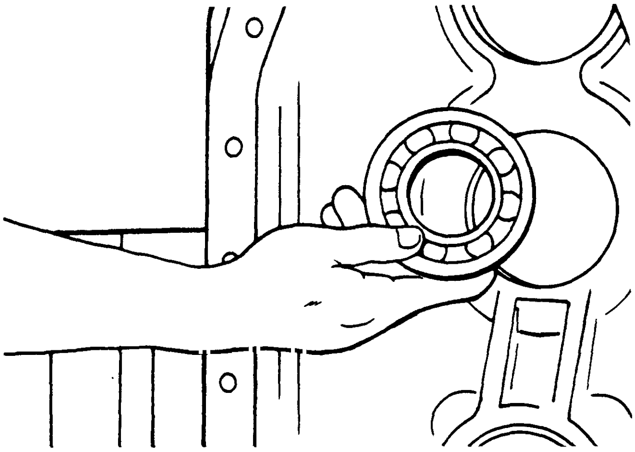
50. Remove the output shaft assembly.



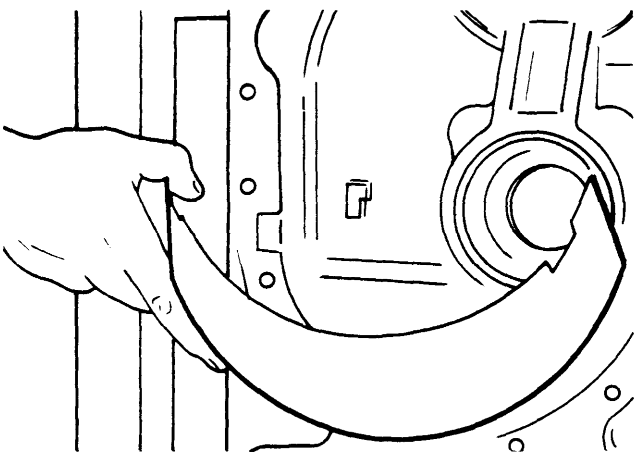
51. Remove the idler shaft assembly.



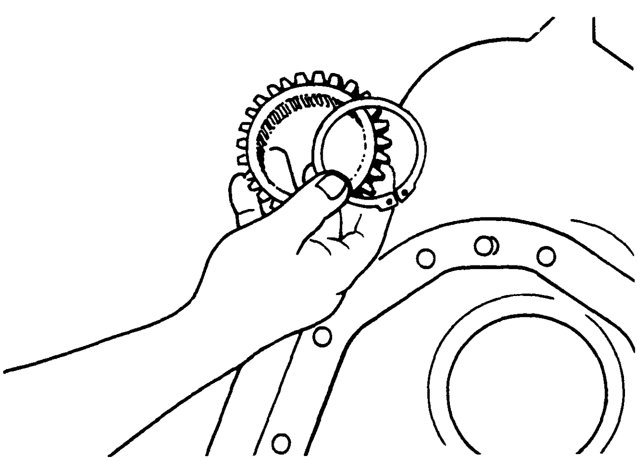
52. Remove the 1st and 2nd clutch assembly.



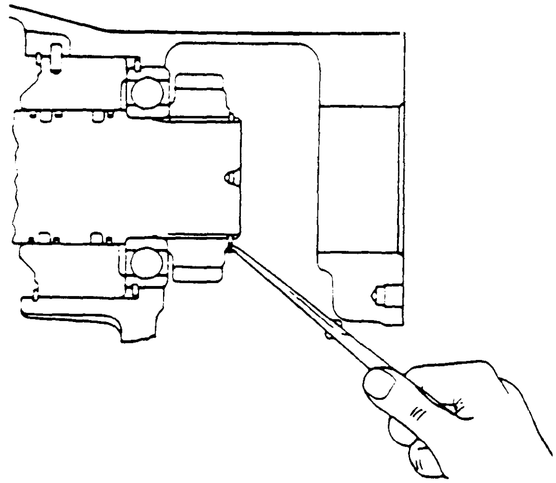
53. Remove the idler shaft front bearing.

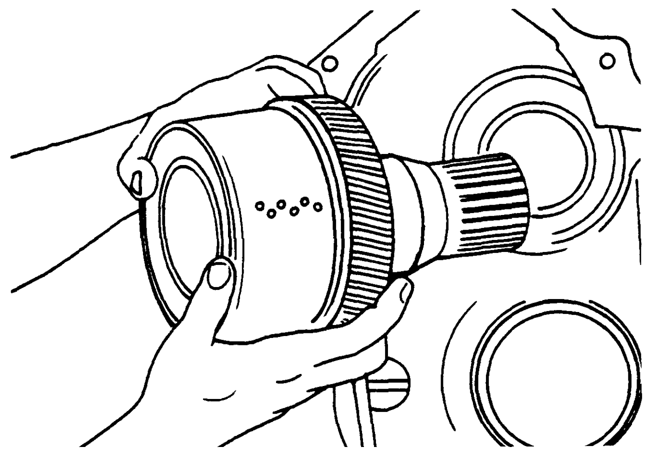


54. Remove the oil sump oil baffle.

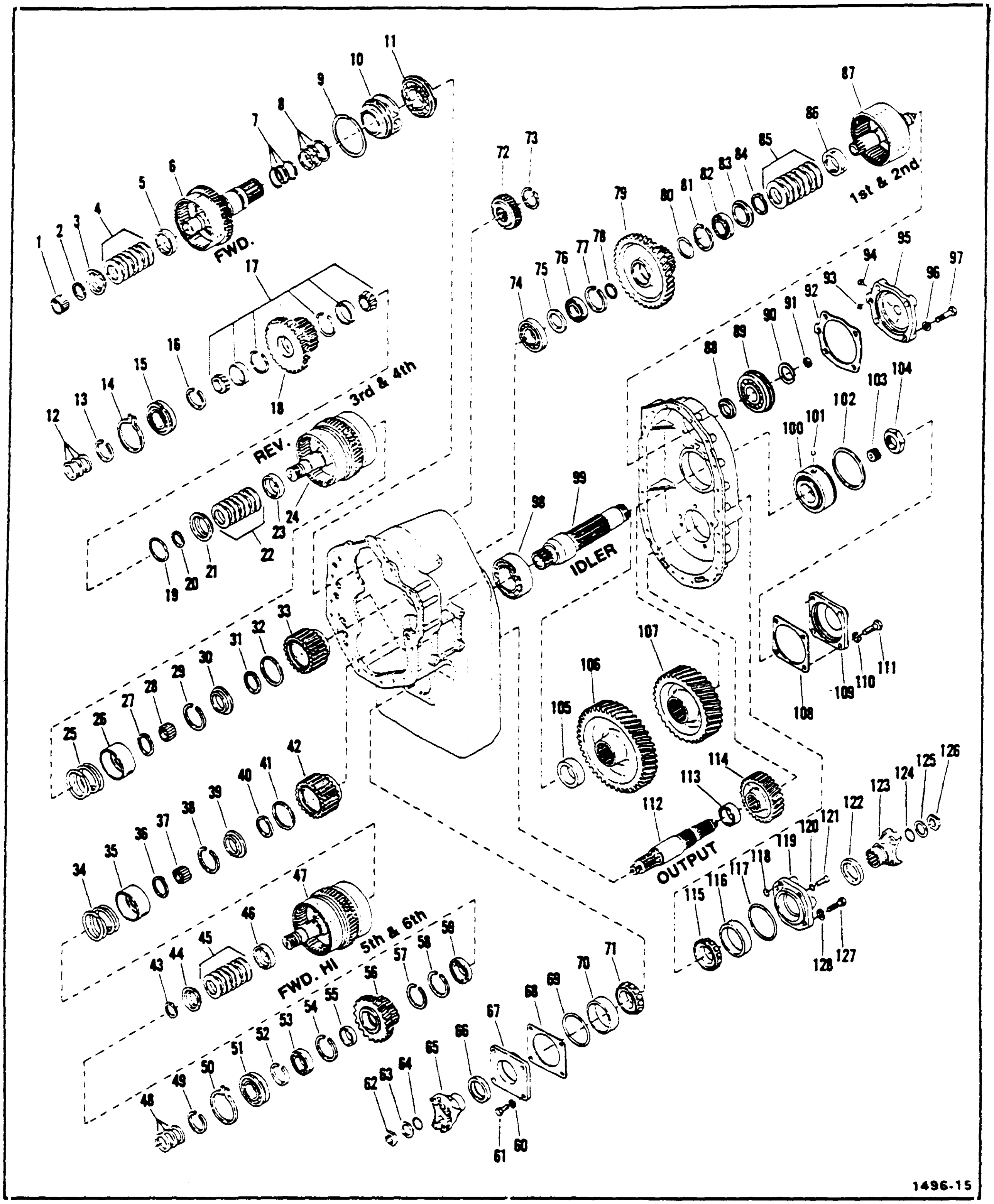


55. Remove the forward clutch shaft drive gear retainer ring and drive gear as shown below.





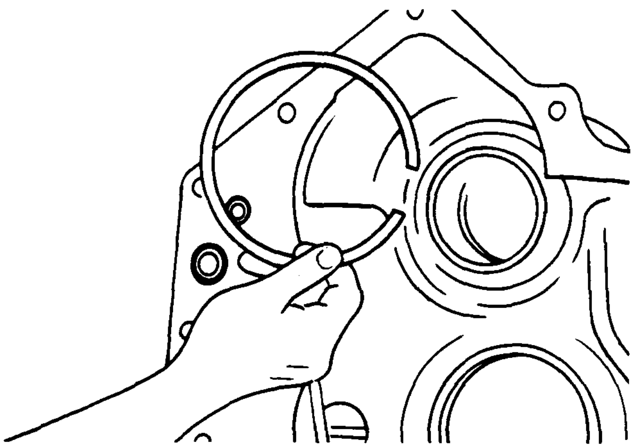
56. From the front, remove the forward clutch assembly.



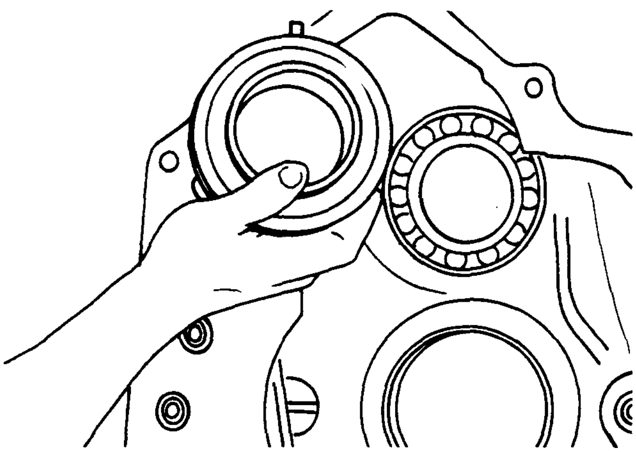
Clutch and Gear Assemblies (Sheet 1 of 2)

1. Forward Shaft Pilot Bearing
2. Spring Retainer Ring
3. Spring Retainer
4. Piston Return Spring - Belleville Washer
5. Piston Return Spring Spacer
6. Forward Shaft, Drum & Plug Assembly
7. Piston Ring Expander Spring
8. Forward Shaft Piston Ring
9. Piston Ring Sleeve Retaining Ring
10. Piston Ring Sleeve
11. Forward Shaft Rear Bearing
12. Reverse Shaft Piston Ring
13. Front Bearing Retaining Ring
14. Front Bearing Snap Ring
15. Reverse Shaft Front Bearing
16. Front Bearing Retaining Ring
17. Clutch Driven Gear Bearing Assembly
18. Reverse Clutch Gear & Hub Assembly
19. Baffle Ring
20. Spring Retaining Snap Ring
21. Spring Retainer
22. Piston Return Spring - Belleville Washer
23. Piston Return Spring Spacer
24. Reverse and 3rd & 4th Clutch Drum and Plug Assembly
25. Piston Return Spring
26. Spring Retainer
27. Spring Retainer Snap Ring
28. 3rd & 4th Clutch Shaft Pilot Bearing
29. Retainer Locating Ring
30. Retaining Ring Retainer
31. Clutch Disc Hub Retaining Ring
32. Baffle Ring
33. Clutch Disc Hub
34. Piston Return Spring
35. Spring Retainer
36. Spring Retainer Ring
37. 5th & 6th Clutch Seal Pilot Bearing
38. Retainer Snap Ring
39. Retaining Ring Retainer
40. Clutch Disc Hub Retaining Ring
41. Baffle Ring
42. lutch Disc Hub
43. Spring Retainer Ring
44. Spring Retainer
45. Piston Return Spring - Belleville Washer
46. Piston Return Spring Spacer
47. Forward High and 5th & 6th Clutch Drum & Plug Assembly
48. Forward High Shaft Piston Ring
49. Front Bearing Retaining Ring
50. Front Bearing Snap Ring
51. Forward High Shaft Front Bearing
52. Front Bearing Retaining Ring
53. Clutch Driven Gear Bearing
54. Clutch Gear Bearing Retaining Ring
55. Clutch Driven Gear Bearing Spacer
56. Forward High Clutch Gear & Hub Assembly
57. Oil Baffle Ring
58. Clutch Gear Bearing Retaining Ring
59. Clutch Driven Gear Bearing
60. Front Bearing Cap Screw Lockwasher
61. Front Bearing Cap Screw
62. Flange Nut
63. Flange Washer
64. Flange O-Ring
65. Front Output Flange
66. Front Bearing Cap Oil Seal
67. Front Bearing Cap
68. Bearing Cap Shim
69. Front Bearing Cap O-Ring
70. Front Bearing Cup
71. Front Bearing Cone
72. Forward Shaft Gear
73. Gear Retaining Ring
74. 1st & 2nd Clutch Shaft Front Bearing
75. Front Bearing Spacer
76. 1st & 2nd Clutch Gear Bearing
77. Bearing Locating Ring
78. Bearing Spacer
79. 1st & 2nd Clutch Gear
80. Baffle Ring
81. Bearing Locating Ring
82. 1st & 2nd Clutch Gear Bearing
83. Belleville Washer Retainer
84. Spring Retainer Ring
85. Belleville Washer
86. Belleville Washer Spacer
87. 1st & 2nd Clutch Drum & Bleed Valve Assembly
88. Bearing to Shaft Spacer
89. Clutch Shaft Rear Bearing
90. Bearing Retainer Ring
91. 1st & 2nd Shaft Piston Ring
92. Bearing Cap Gasket
93. Bearing Cap O-Ring
94. Bearing Cap Plug
95. Rear Bearing Cap
96. Bearing Cap Screw Lockwasher
97. Bearing Cap Screw
98. Idler Shaft Front Bearing
99. Idler Shaft
100. Idler Shaft Rear Bearing
101. Idler Shaft Rear Bearing Lock Ball
102. Rear Bearing Locating Ring
103. Pump Drive Sleeve
104. Idler Shaft Nut
105. Idler Gear Spacer
106. Idler Shaft Gear
107. Idler Shaft Gear
108. Idler Shaft Bearing Cap Gasket
109. Idler Shaft Bearing Cap
110. Idler Shaft Bearing Cap Screw Lockwasher
111. Idler Shaft Bearing Cap Screw
112. Output Shaft
113. Output Gear Spacer
114. Output Shaft Gear
115. Rear Bearing Cone
116. Rear Bearing Cup
117. Rear Bearing Cap O-Ring
118. Rear Bearing Cap O-Ring
119. Rear Bearing Cap
120. Rear Bearing Cap Screw Lockwasher
121. Rear Bearing Cap Screw
122. Rear Bearing Cap Oil Seal
123. Rear Output Flange
124. Flange O-Ring
125. Flange Washer
126. Flange Nut
127. Rear Bearing Cap Screw
128. Rear Bearing Cap Screw Lockwasher

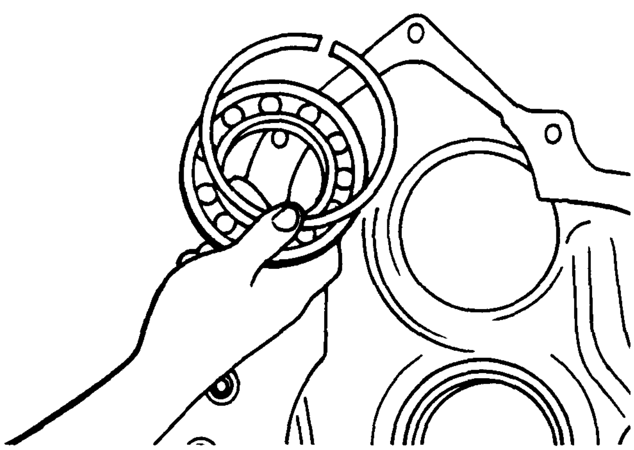
Clutch and Gear Assemblies (Sheet 2 of 2)



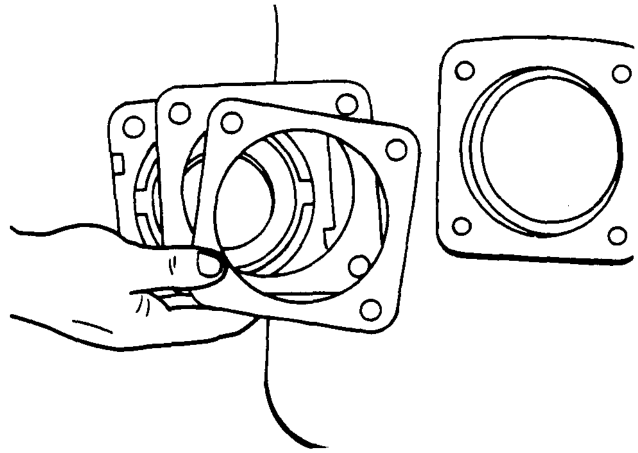
57. Remove the forward clutch oil sealing ring sleeve retainer ring.



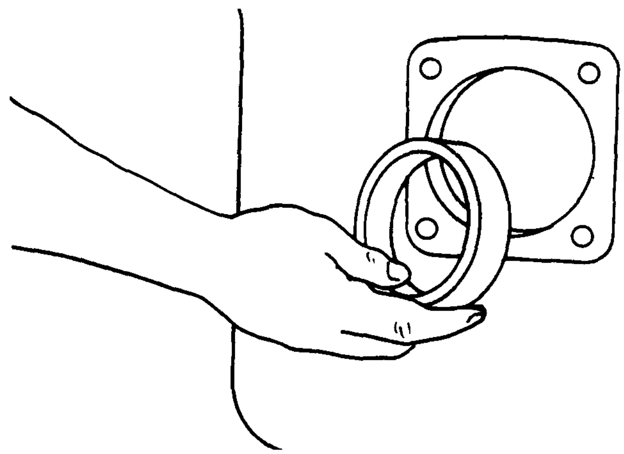
58. Remove the sealing ring sleeve.



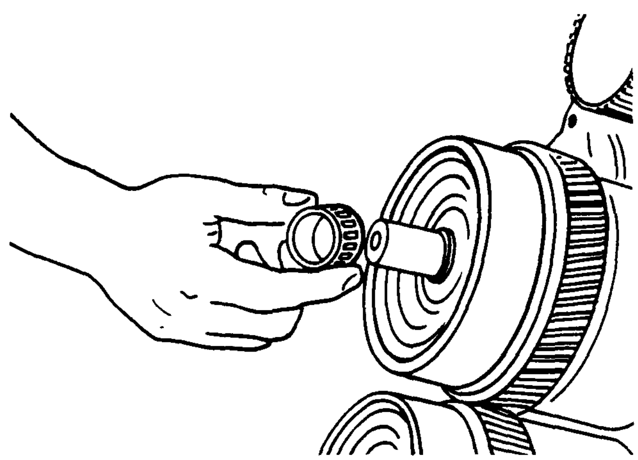
59. Remove the forward clutch shaft rear bearing retainer ring and bearing.



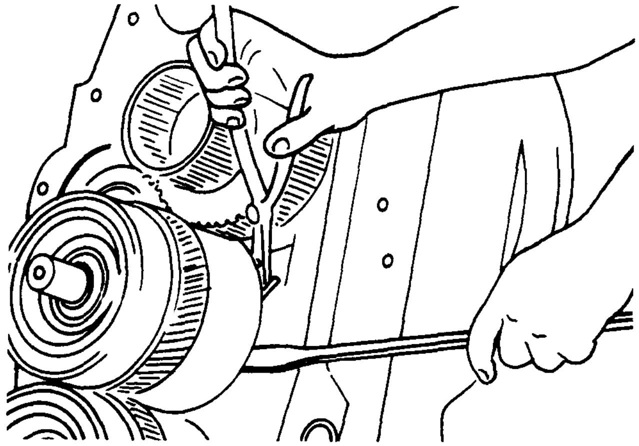
60. Remove the front output shaft bearing cap bolts and washers. Remove the bearing cap and shims.



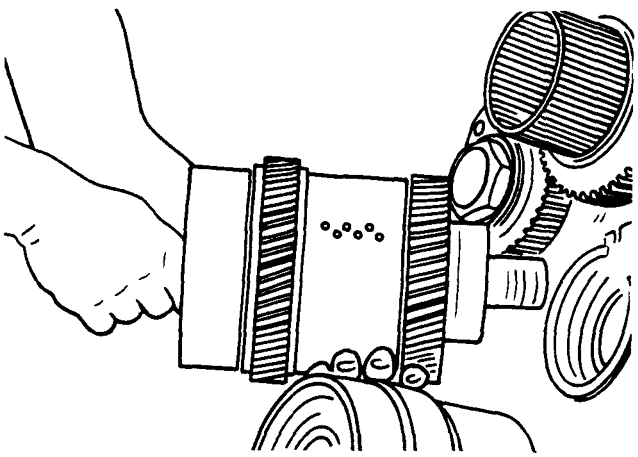
61. Remove the output shaft front taper bearing cup.



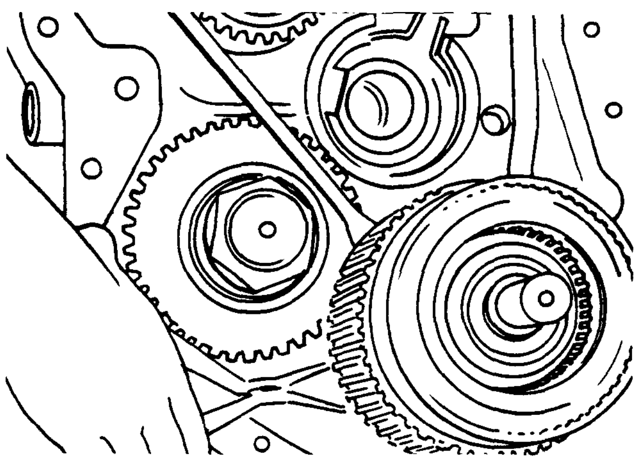
62. Remove the clutch shaft pilot bearings.



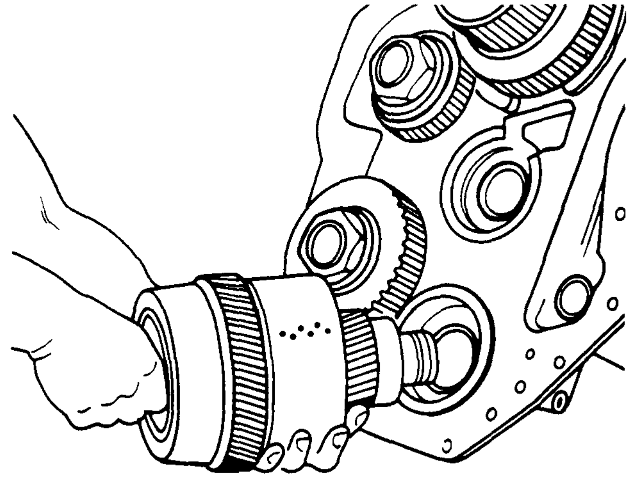
63. Spread the reverse clutch front bearing locating ring. Pry the clutch from the housing.



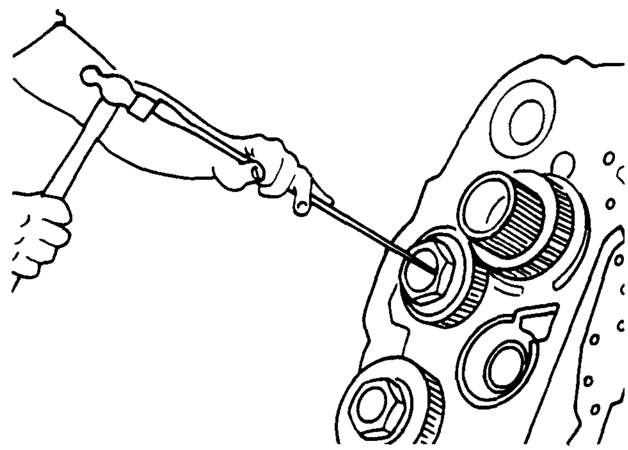
64. Remove the reverse and 3rd and 4th clutch assembly.



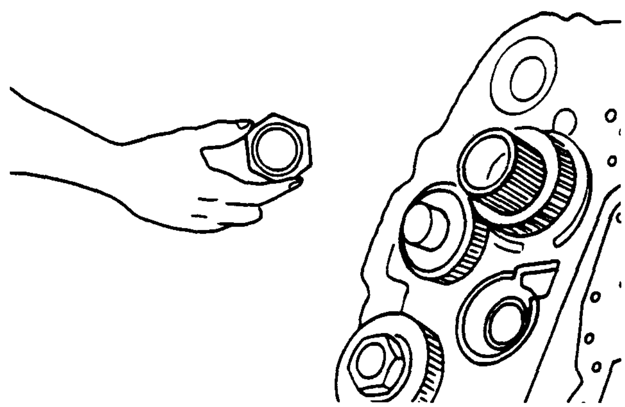
65. Spread the forward high clutch front bearing locating rlng. Pry the clutch from the housing.



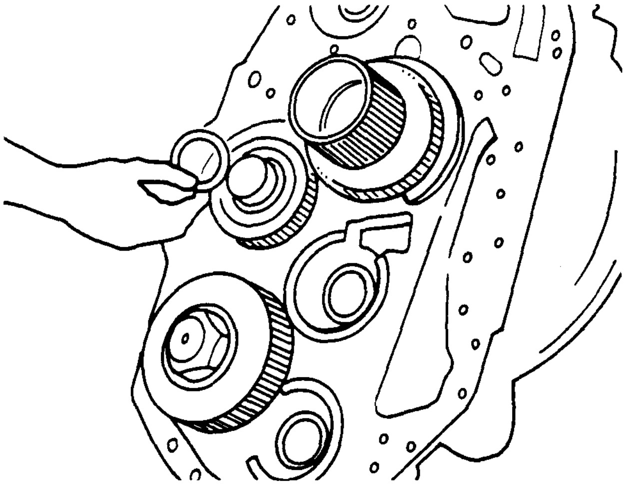
66. Remove the forward high and 5th and 6th clutch assembly.



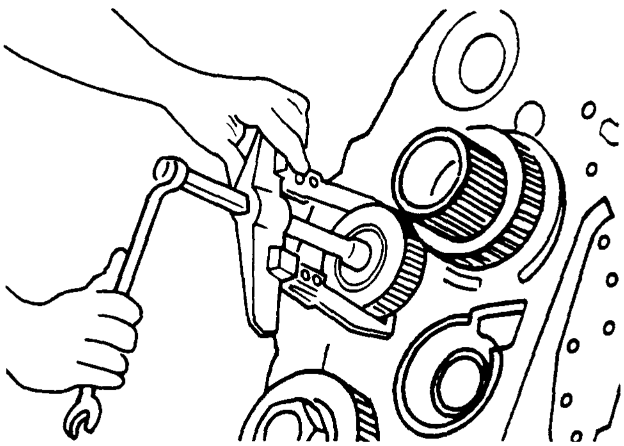
67. Unclinch the lock nut by straightening the upset metal in the notch of the idler shaft.



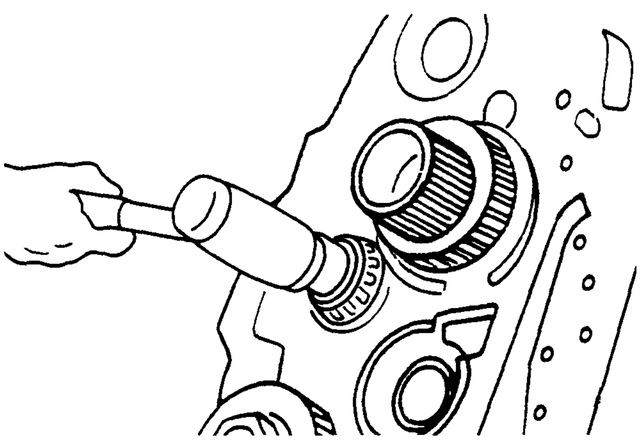
68. Remove the locknut.



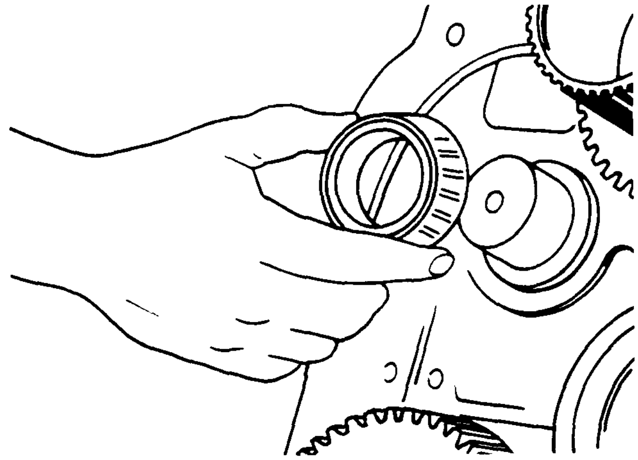
69. Remove the idler gear taper bearing outer thrust plate.



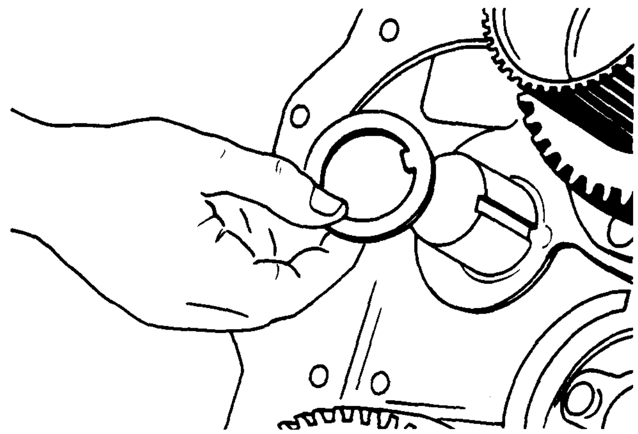
70. Remove the idler gear and outer taper bearing.



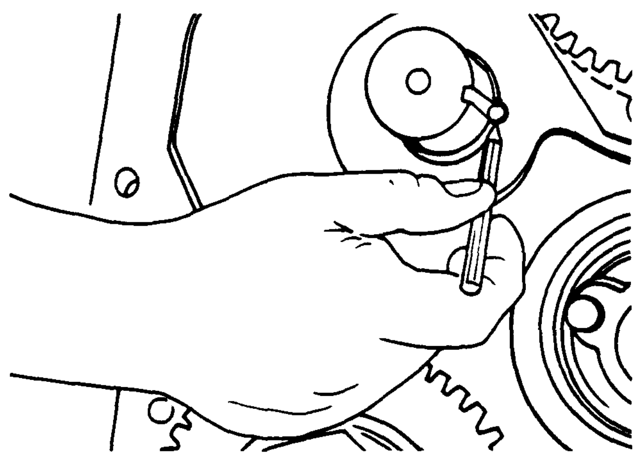
71. Using a soft hammer, tap the idler shaft from the housing to remove the inner taper bearing.



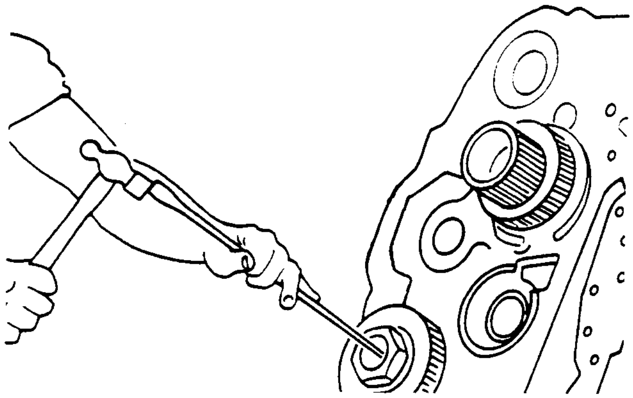
72. Remove the inner taper bearing.



73. Remove the inner bearing thrust plate.



74. Remove the idler shaft. Use caution as not to lose the shaft lockball.



75. Unclinch the lock nut on the forward high idler shaft by straightening the upset metal in the notch of the idler shaft.

76. Remove the lock nut from the forward high idler shaft.

77. Remove the idler gear taper bearing outer thrust plate.

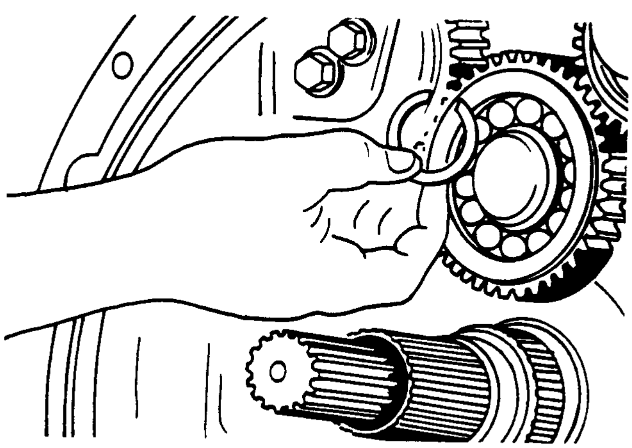
78. Remove the idler gear and outer taper bearing.

79. Using a soft hammer, tap the idler shaft from the housing to remove the inner taper bearing.

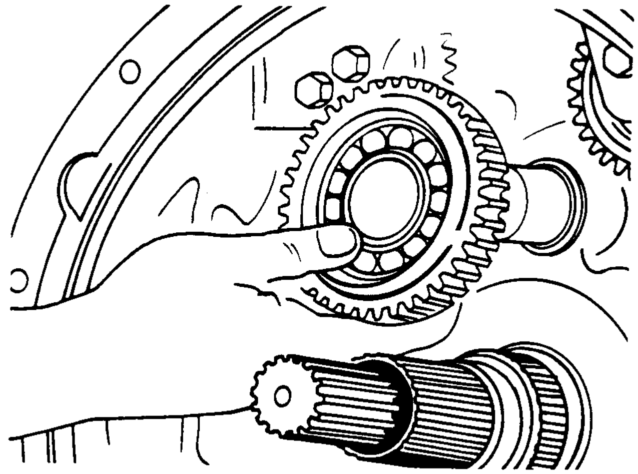
80. Remove the inner taper bearing.

81. Remove the inner bearing thrust plate.

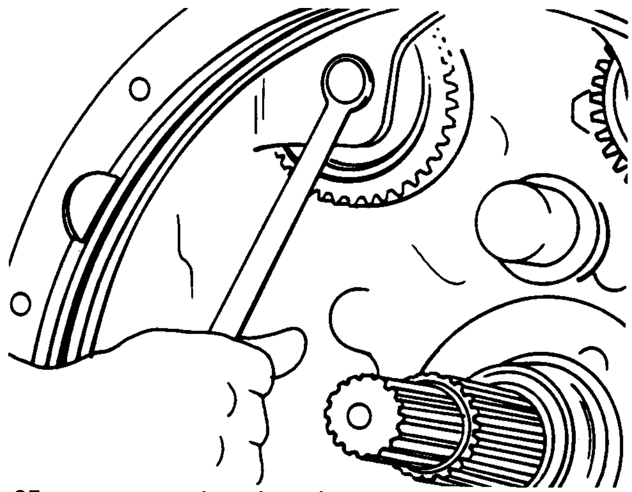
82. Remove the idler shaft. Use care as not to lose the shaft lockball.



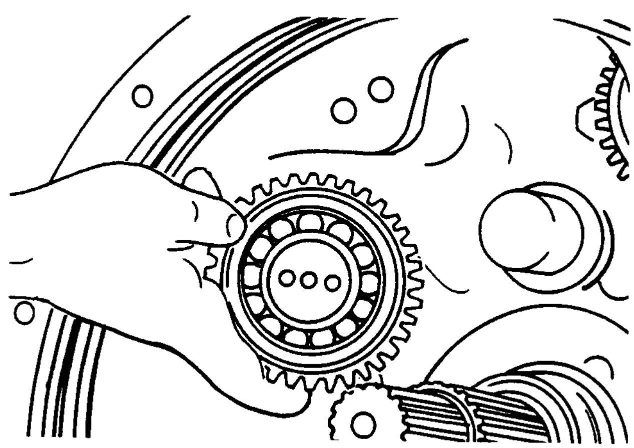
83. Remove the pump idler gear retainer ring.



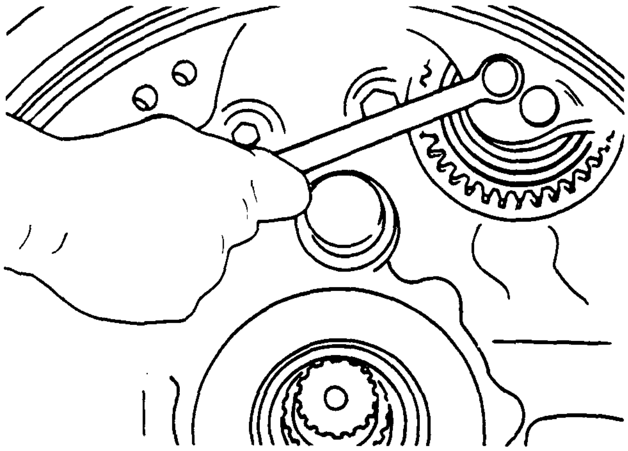
84. Remove the idler gear and bearing assembly.



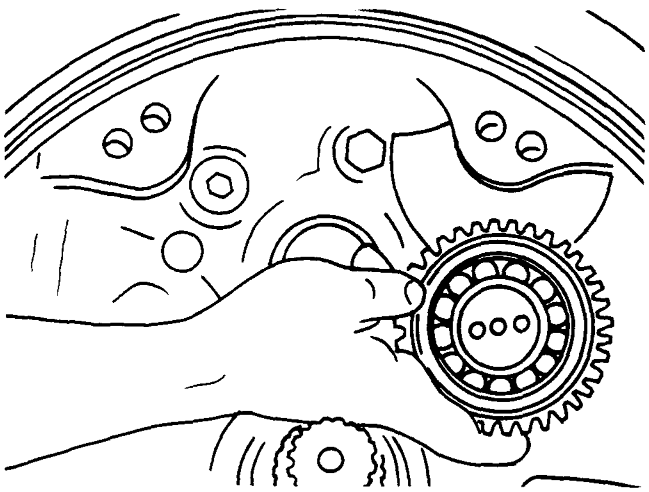
85. Remove the charging pump gear support screws and lockwashers.



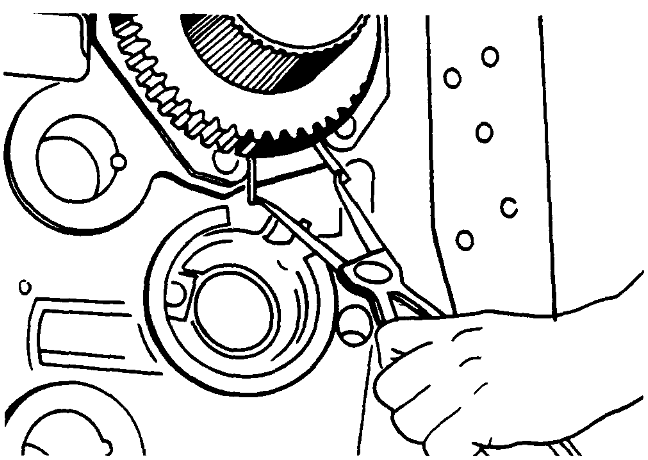
86. Remove the pump gear, bearing, and support.



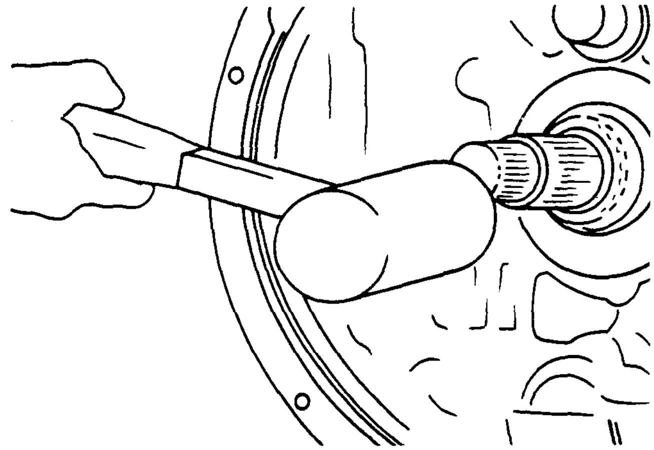
87. Remove the auxiliary pump gear support screws and lockwashers.



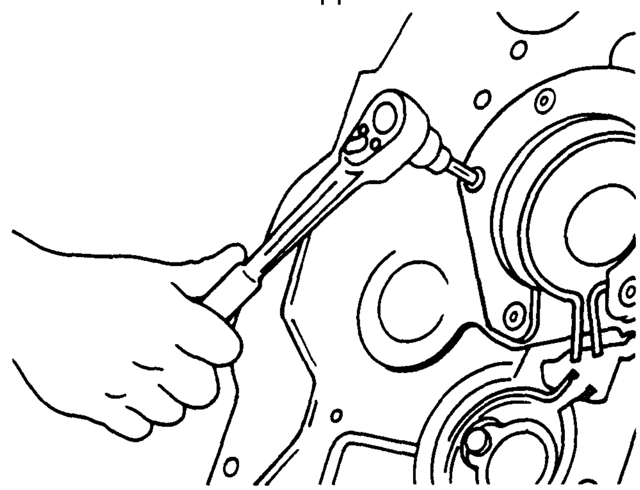
88. Remove the auxiliary pump gear, bearing, and support.



89. Spread the turbine shaft bearing locating ring.



90. Holding the ring open, tap the turbine shaft from the stator support.



91. Remove the stator support screws and support.

Cleaning.

WARNING

Exercise care to avoid skin rashes, fire hazards, and inhalation of vapors when using solvent-type cleaners.

Clean all parts thoroughly using a solvent type cleaning fluid. It is recommended that the parts be immersed in cleaning fluid and washed up and down slowly until all old lubricant and foreign material is dissolved and the parts are thoroughly cleaned.

Bearings.

Remove the bearings from the cleaning fluid and strike the larger side of the cone flat against a block of wood to dislodge solidified particles of lubricant.

Immerse again in cleaning fluid to flush out particles. Repeat the above operation until the bearings are thoroughly clean. Dry the bearings using moisture-free compressed air. Ensure the air stream is directed across the bearing to avoid spinning. Do not spin the bearings when drying. Bearing may be rotated slowly by hand to facilitate the drying process.

Housings.

WARNING

Exercise care to avoid skin rashes, fire hazards, and inhalation of vapors when using solvent-type cleaners.

Clean the interior and exterior of the housings, bearing caps, etc., thoroughly. Cast parts may be cleaned in hot solution tanks with mild alkali solutions providing these parts do not have ground or polished surfaces. Parts should remain in the solution long enough to be thoroughly cleaned and heated. This will aid the evaporation of the cleaning solution and rinse water. Parts cleaned in solution tanks must be thoroughly rinsed with clean water to remove all traces of alkali. Cast parts may be cleaned with a steam cleaner.

All parts cleaned must be thoroughly dried immediately by using moisture-free compressed air or soft, lintless absorbent wiping rags free of abrasive materials such as metal filings, contaminated oil or lapping compound.

Inspection.

The importance of careful and thorough inspection of all parts cannot be overstressed. The replacement of all parts showing indication of wear or stress will eliminate costly and avoidable failures at a later date.

Bearings.

Carefully inspect all rollers, cages, and cups for wear, chipping, or nicks to determine the fitness of bearings for further use. Do not replace a bearing cone or cup individually without replacing the mating cup or cone at the same time. After inspection, dip the bearings in hydraulic fluid and wrap in a clean lintless cloth or paper to protect them until installed.

Oil Seals, Gaskets, Etc.

Replacement of spring load oil seals, O-rings, metal sealing rings, gaskets, and snap rings is more economical when the unit is disassembled than a premature overhaul to replace these parts at a future time. Further, loss of lubricant through a worn seal may result in failure of other more expensive parts of the assembly. Sealing members should be handled carefully, particularly when being installed. Cutting, scratching, or curling under of the lip of a seal seriously impairs its efficiency, Apply a thin coat of Permatex No. 2 on the outer diameter of the oil seal to assure an oil tight fit into the retainer. When assembling new metal type sealing rings, they should be lubricated with a coat of chassis grease to stabilize the rings in their grooves for ease of assembly of the mating members. Lubricate all O-rings and seals with hydraulic fluid before assembly,

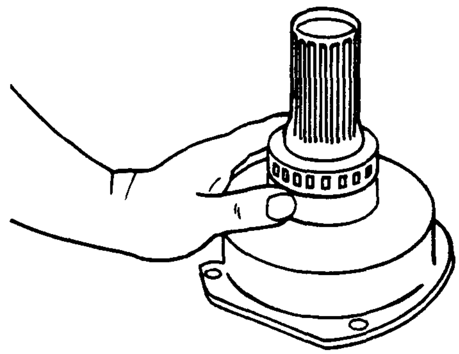
Gears and Shafts.

If a magna-flux process is available, use the process to check the parts. Examine the teeth on all gears carefully for wear, pitting, chipping, nicks, cracks, or scores, If the gear teeth show spots where the case hardening is worn through or cracked, replace it with a new gear. Small nicks may be removed with a suitable hone. Inspect the shafts and quills to ensure they are not sprung bent, or the splines twisted, and that the shafts are true.

Housings, Covers. Etc.

Inspect the housings, covers, and bearing caps ensuring they are thoroughly cleaned and the mating surfaces, bearing bores, etc. are free from nicks or burrs. Check all the parts carefully for evidence of cracks or conditions which would cause subsequent oil leaks or failures.

Assembly.

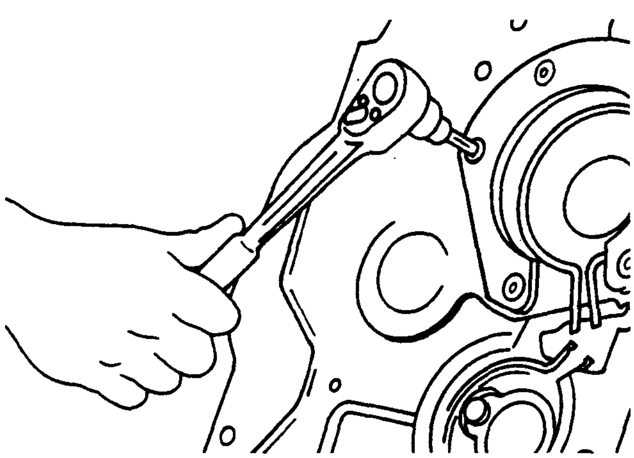


NOTE

The bearing part number must be up.

1. Install a new sealing ring expander spring and oil sealing ring on the support. The expander spring gap is to be 180 degrees from the sealing ring hook joint. Press the support bearing into position.

2. Clean the stator support mounting surface and tapped holes with solvent. Dry thoroughly ensuring the tapped holes are clean and dry.

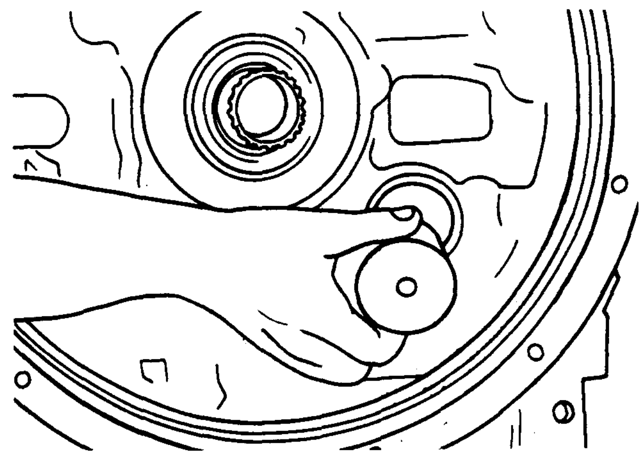


3. Position the support into the converter housing, aligning the holes in the support with the holes in the housing. Tap the support into position.

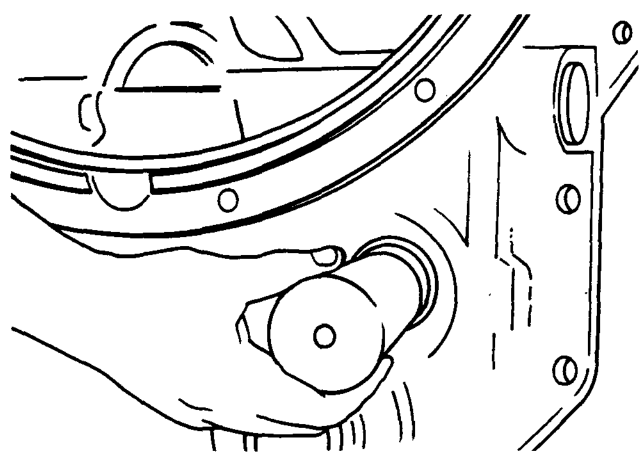
NOTE

Assembly of the stator support to converter housing must be completed within a 15 minute period from start of screw installation. The special screw is to be used for one installation only. If the screw is removed for any reason is must be replaced. The Loctite left in the holes must be removed with the proper tap and cleaned with solvent. Dry hole thoroughly and use a new screw for reinstallation.

4. Install the 6 special stator support screws. Torque the screws 12 to 16 pounds-foot (1.6 to 2.1 kgm).

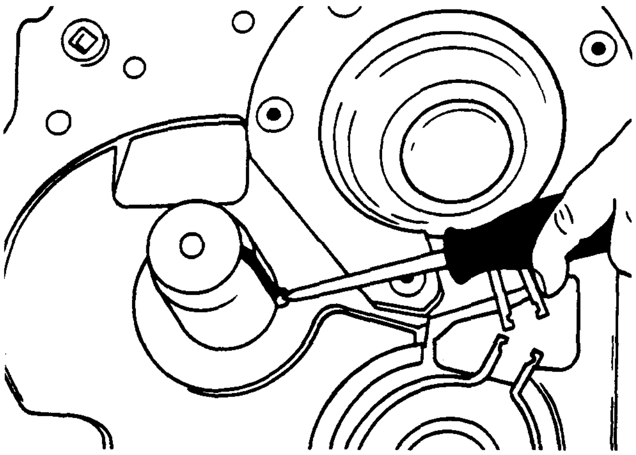


5. With a new O-ring on the shaft, position the reverse idler shaft and lock ball in the converter housing.

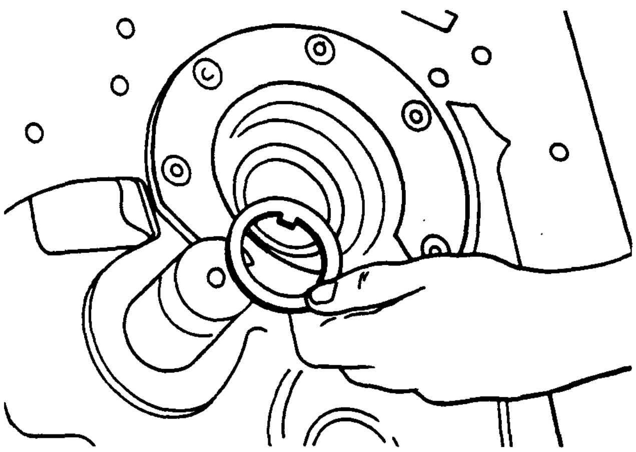


6. With a new O-ring on the shaft, position the

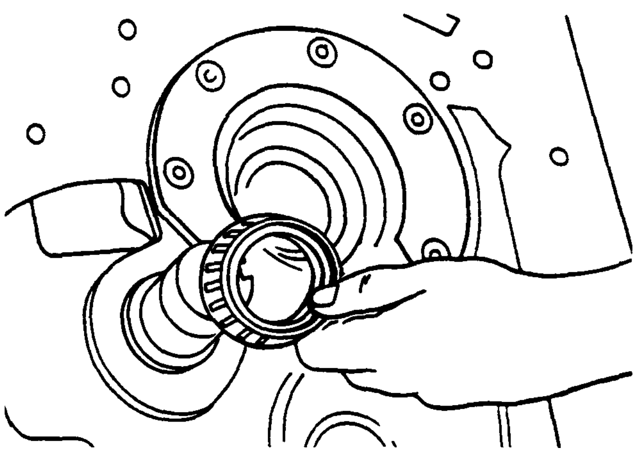
idler shaft and lock ball in the converter housing. Tap both shafts into position.



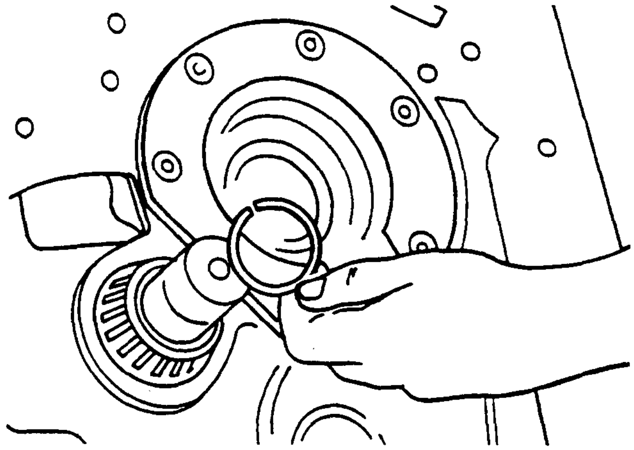
7. Note the lock ball in position in both shafts.



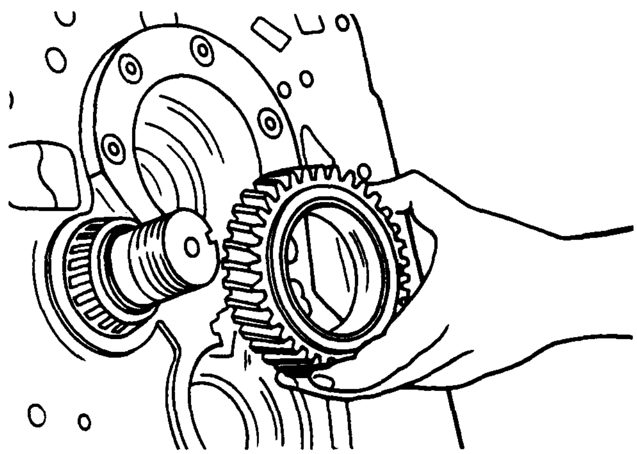
8. Install the reverse idler shaft spacer.



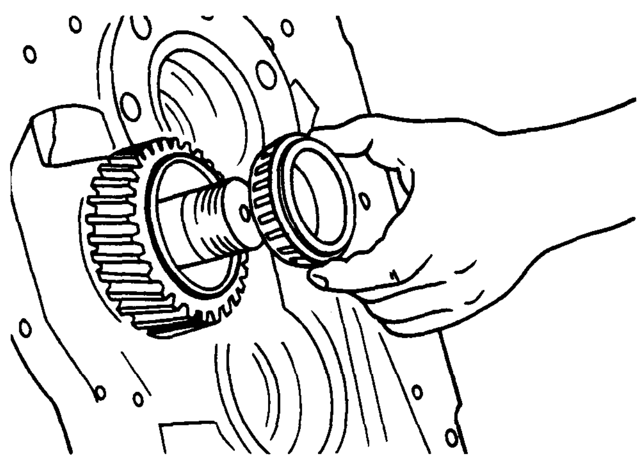
9. Install the idler gear inner taper bearing on the shaft with the large diameter of the taper down.



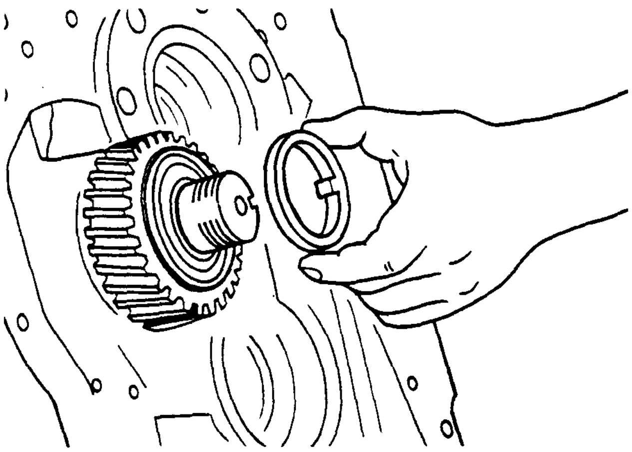
10. Position the bearing spacer on the shaft.



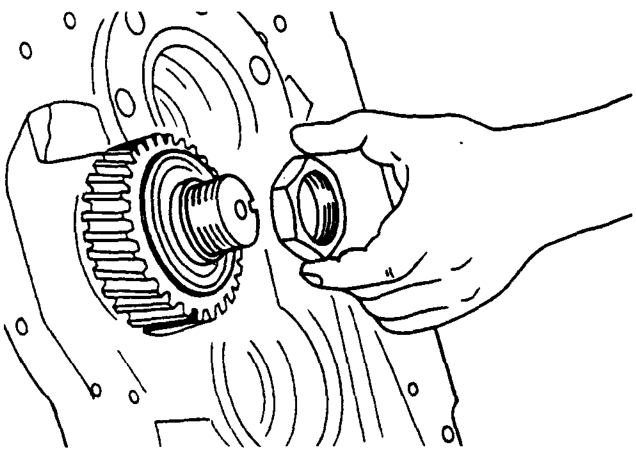
11. Position the idler gear on the bearing with the hub of the gear up.



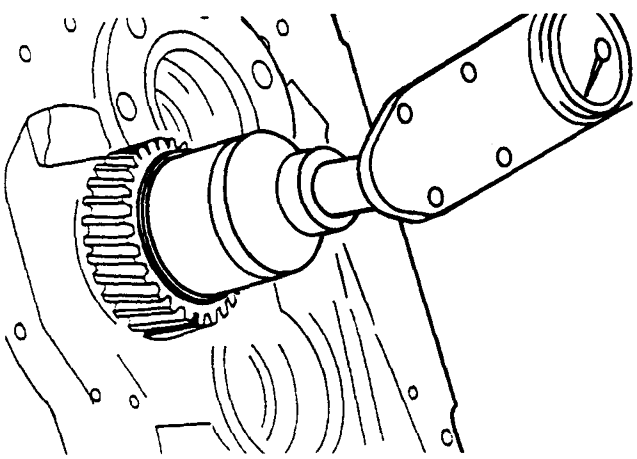
12. Install the idler gear inner taper bearing on the shaft with the large diameter of the taper up.



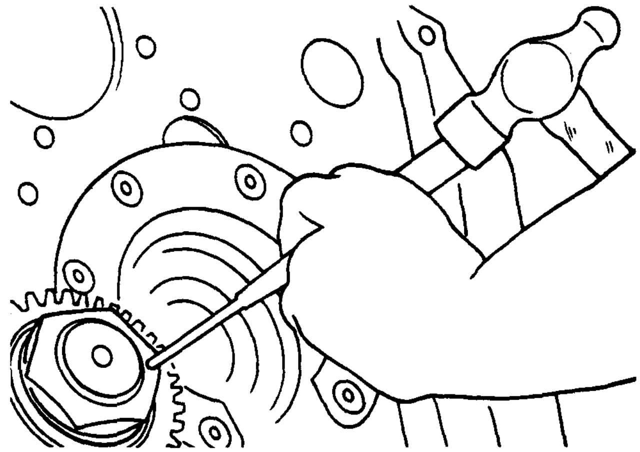
13. Position the outer spacer on the shaft.



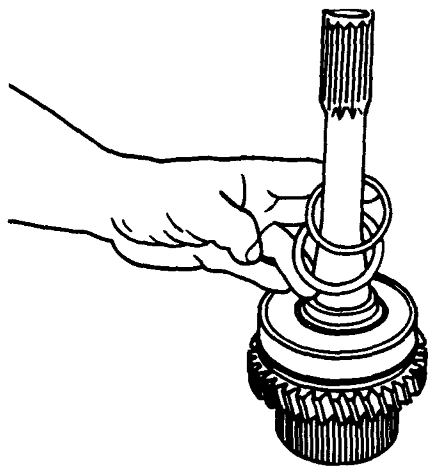
14. Install the retainer nut on the shaft.



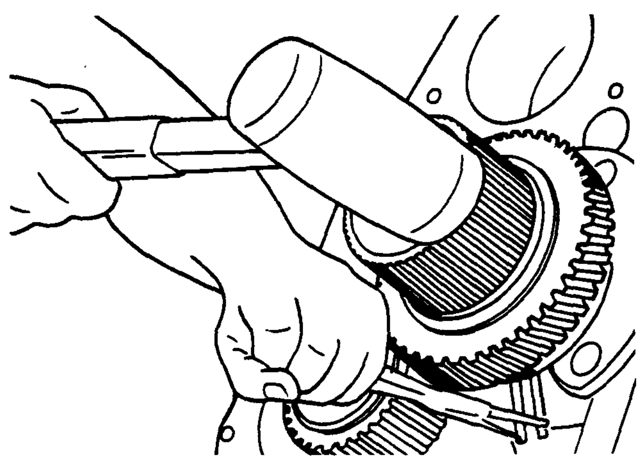
15. Torque the nut 200 to 250 pounds-foot (27.1 to 33.8 kgm).



16. Stake the nut securely into the shaft notch.

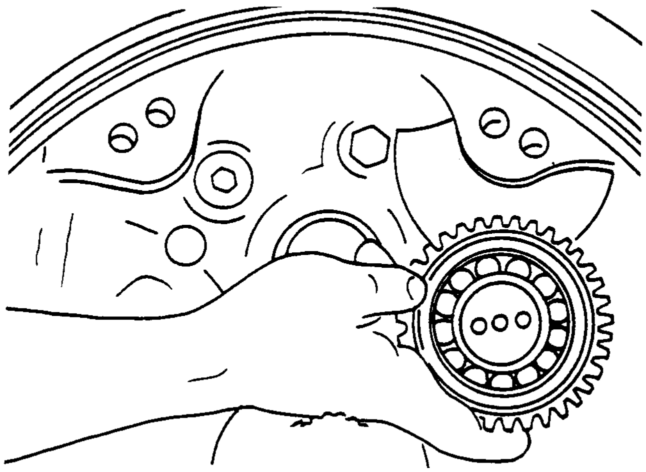


17. If the bearing was removed, press the turbine shaft bearing into position. Install the bearing washer and retainer ring. Install a new turbine shaft oil sealing ring.

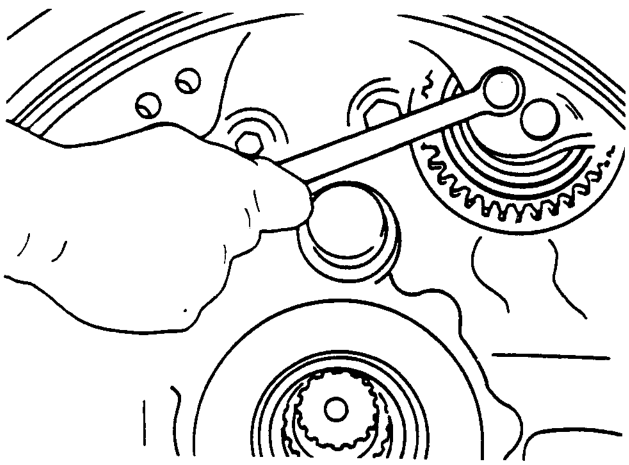


18. Spread the ears on the turbine shaft bearing

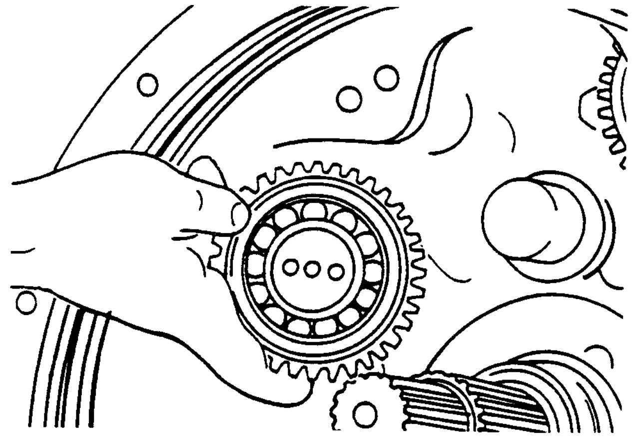
retainer ring located in the reaction member support. Tap the turbine shaft and bearing into position being certain the bearing snap ring is in full position in the snap ring groove.



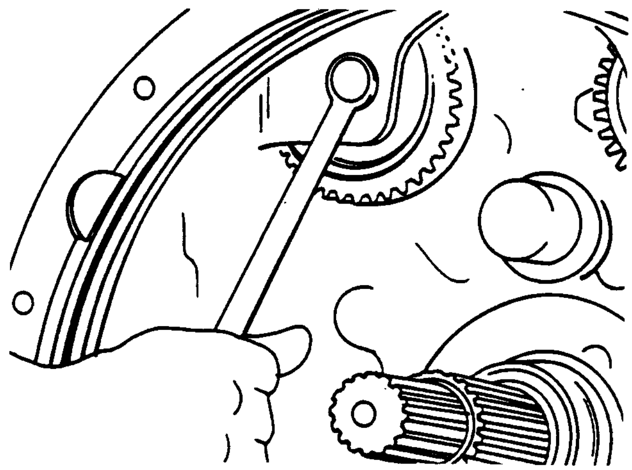
19. Position the auxiliary pump drive gear, bearing and support in the housing.



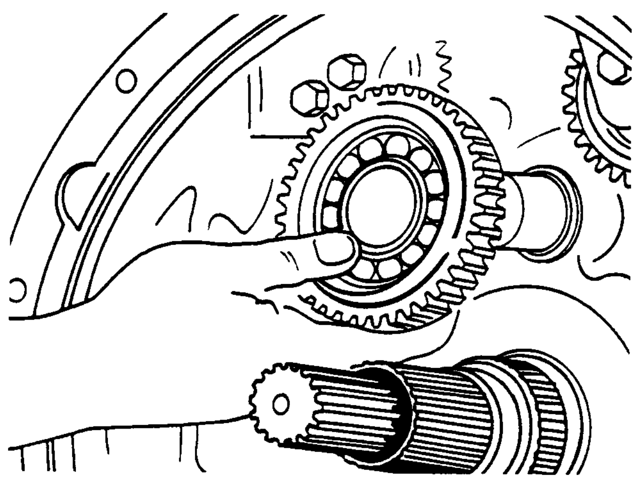
20. Align the holes in the bearing support with the holes in the housing. Install the support screws and lockwashers. Torque the screws 23 to 25 pounds-foot (3.1 to 3.3 kgm).



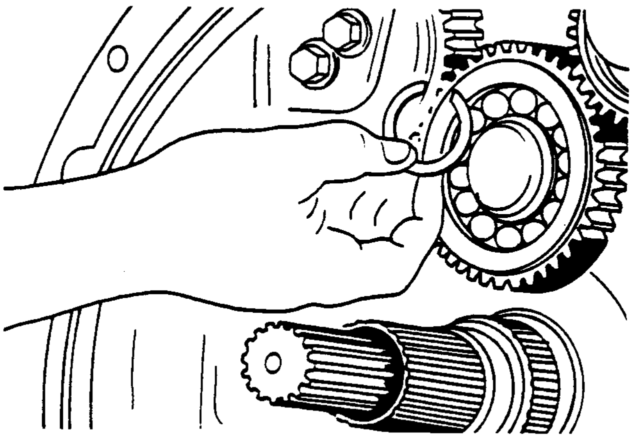
21. Position the charging pump drive gear, bearing, and support in the housing.



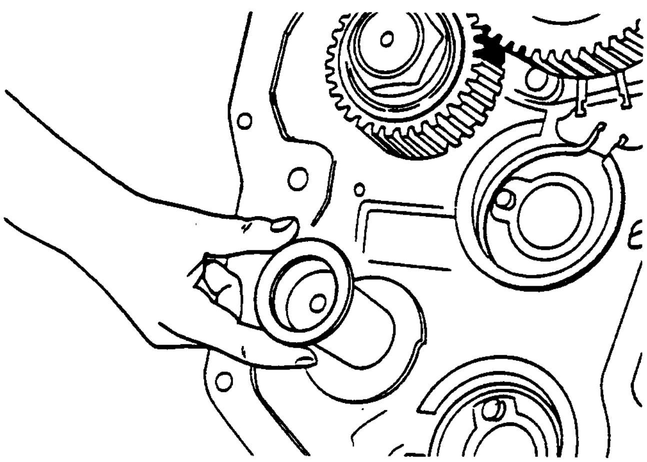
22. Install the support screws and torque 23 to 25 pounds-foot (3.1 to 3.3 kgm).



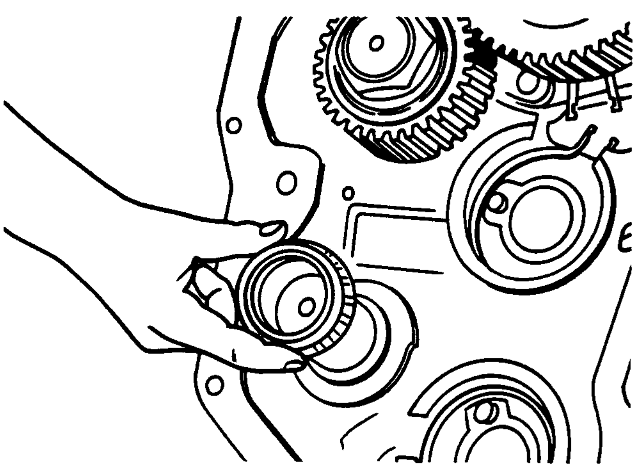
23. Position the pump drive idler gear and bearing on the idler gear stub shaft.



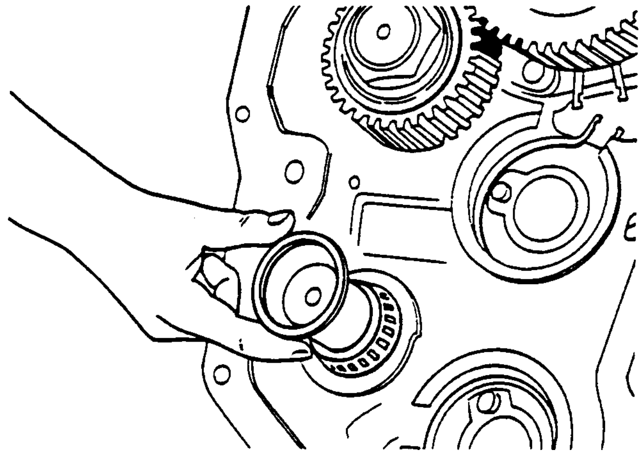
24. Install the idler gear to the stub shaft retainer ring.



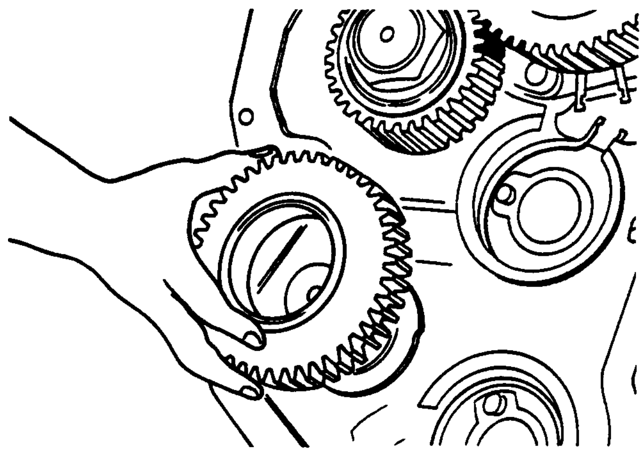
25. Install the idler shaft spacer.



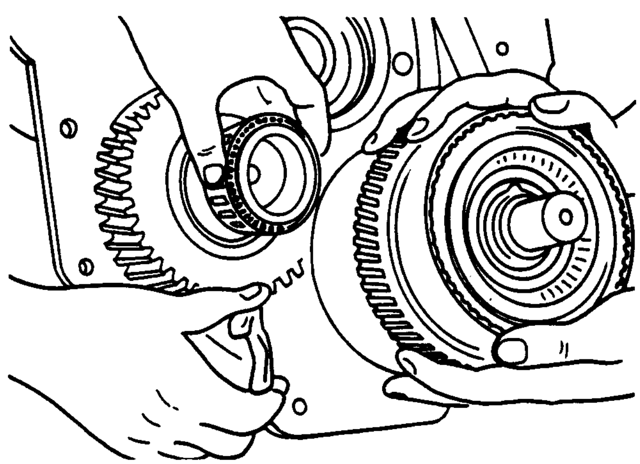
26. Install the idler gear inner taper bearing on the shaft with the large diameter of taper down.



27. Position the bearing spacer on the shaft.



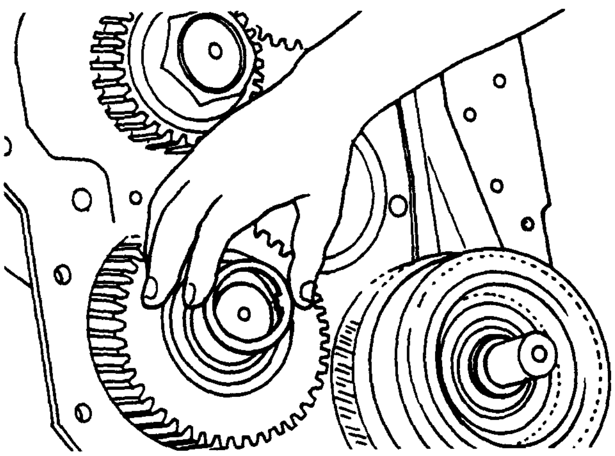
28. Position the idler gear on the bearing with the hub of the gear up.



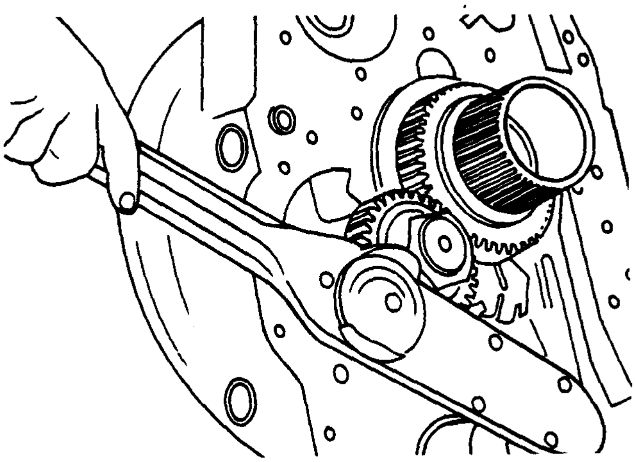
NOTE

The idler gear and taper bearing cup assembly and the forward high clutch assembly must be installed in the converter housing at the same time as the idler gear must be positioned between the forward clutch front bearing and the clutch drum. Install the idler outer taper bearing with small diameter of taper down. Make sure locating ring is in full position in ring groove.

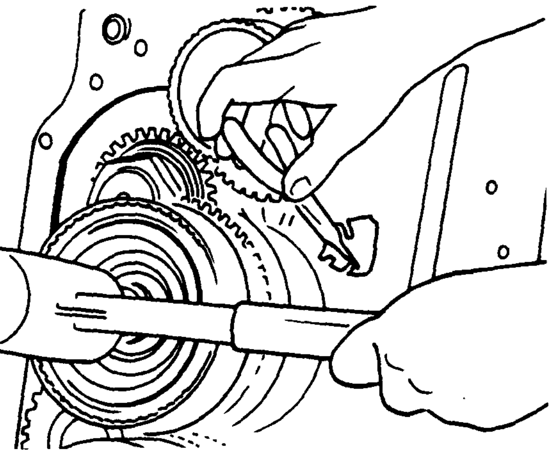
29. Spread the ears on the forward high clutch front bearing locating ring.



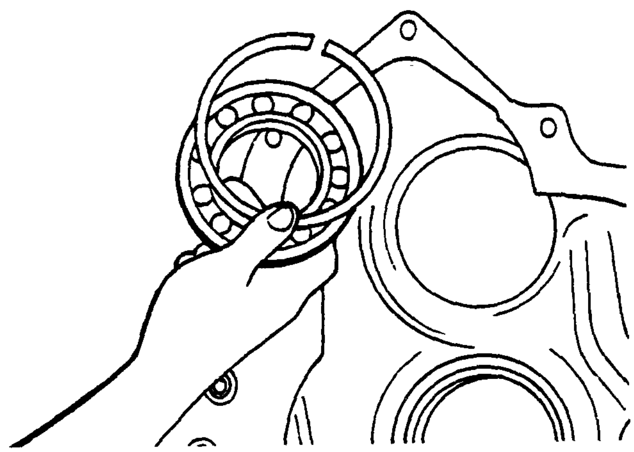
30. Position the outer spacer on the shaft.



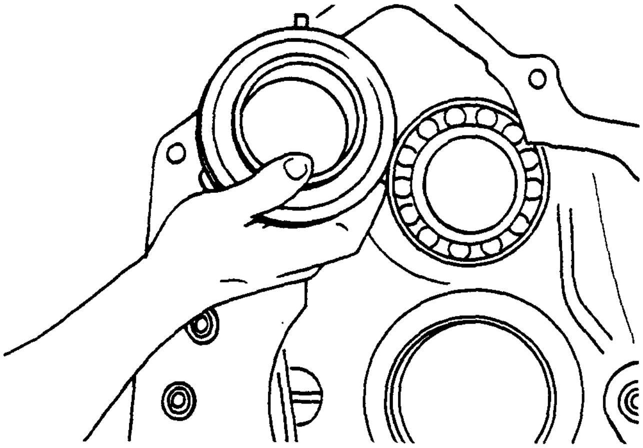
31. Install the retainer nut on the shaft and torque 200 to 250 pounds-foot (27.1 to 33.8 kgm). Stake the nut securely into the shaft notch.



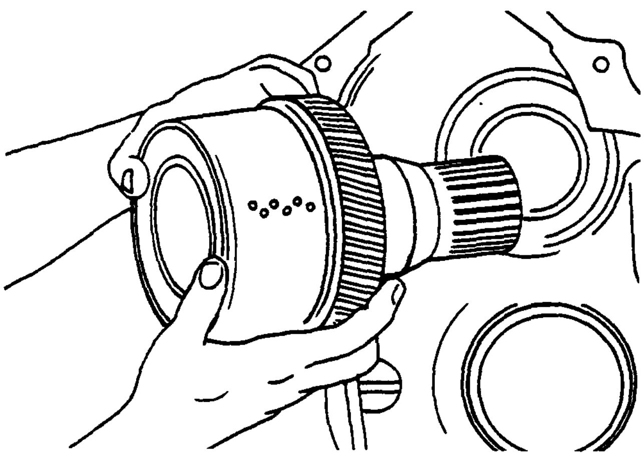
32. Spread the ears on the reverse clutch front bearing locating ring. Tap the reverse and 3rd and 4th clutch assembly into the converter housing. Align the snap ring groove in the bearing with the snap ring in the housing, being certain the bearing snap ring is in full position in the snap ring groove.



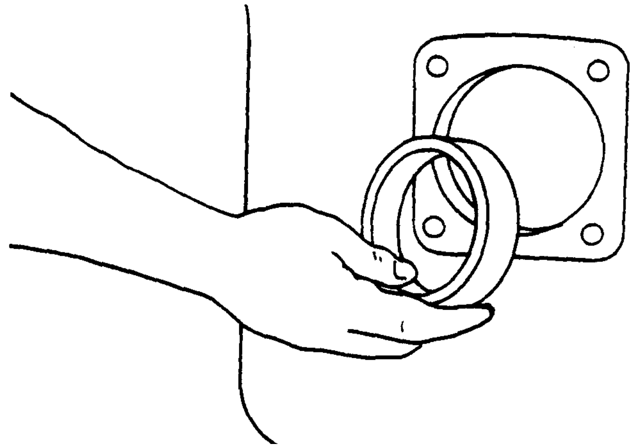
33. Install the forward clutch shaft rear bearing into the bearing bore with the bearing snap ring toward the front of the housing.



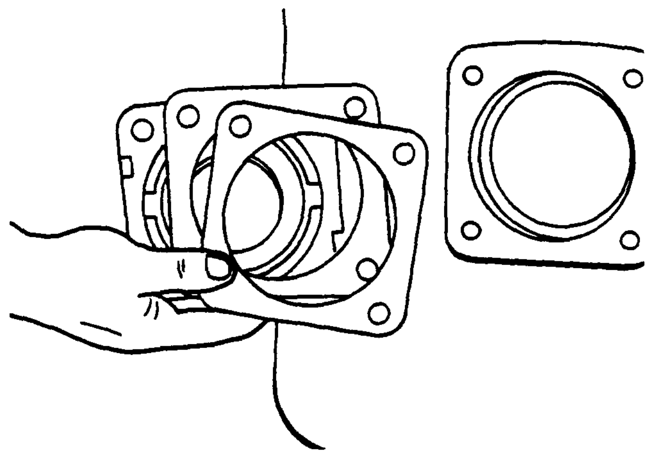
34. Align the forward clutch shaft piston ring sleeve with the groove in the housing. Tap the sleeve into position and secure with the sleeve retainer ring.



35. Position the forward clutch assembly into the transmission housing. Use caution as not to damage the forward shaft piston rings. Tap the clutch into position.

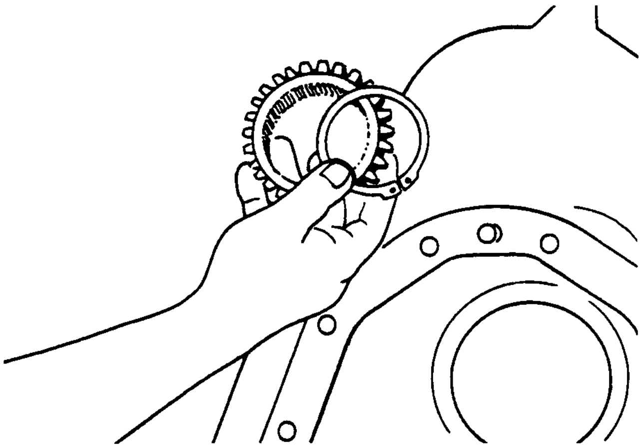


36. Install the output shaft front taper bearing cup.

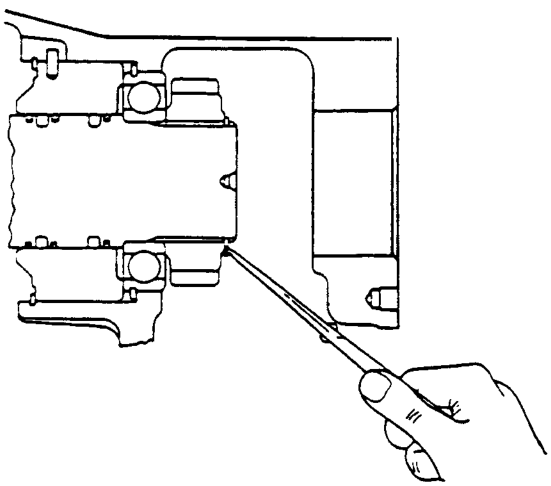


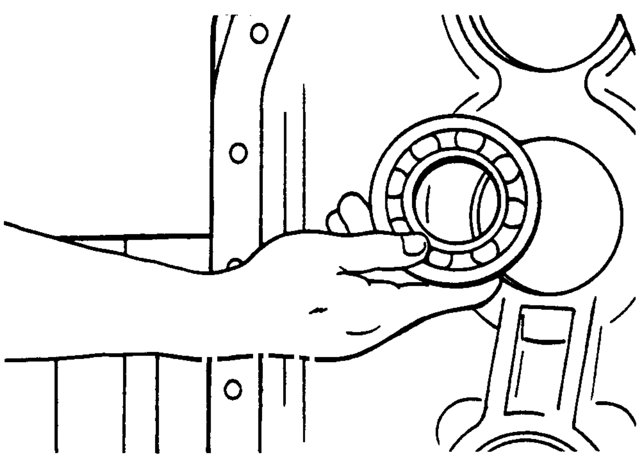
37. Coat the outer diameter of the oil seal with Permatex #2 and press the seal in the bearing cap with the lip of the seal in. Remove any excess sealant. Install a new O-ring on the bearing cap. Install the front bearing cap and shims.

38. Install the bearing capscrews and washers and tighten to the torque specified in the Torque Chart.

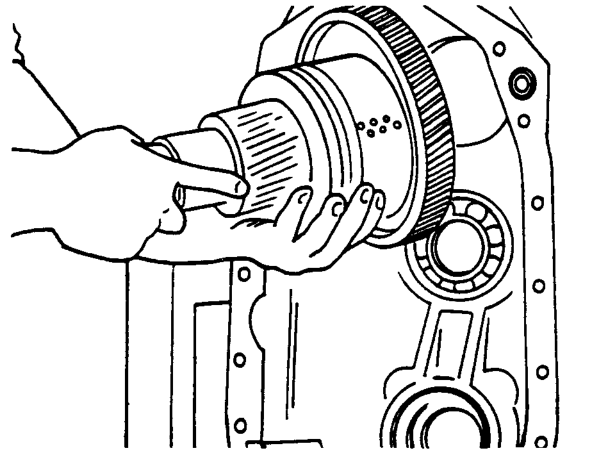


39. Position the forward gear on the forward clutch shaft with the long hub of the gear toward the bearing. Install the gear retainer ring.

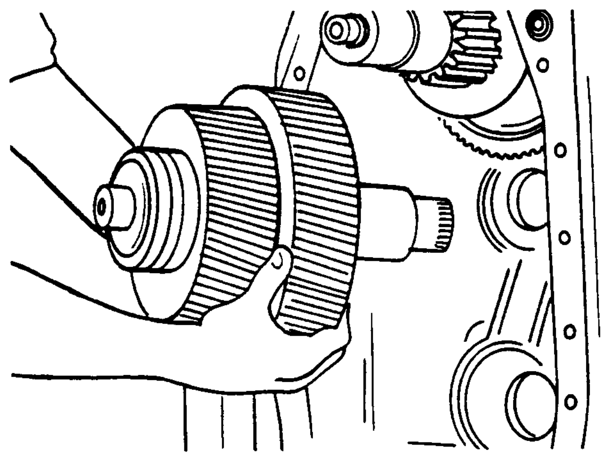




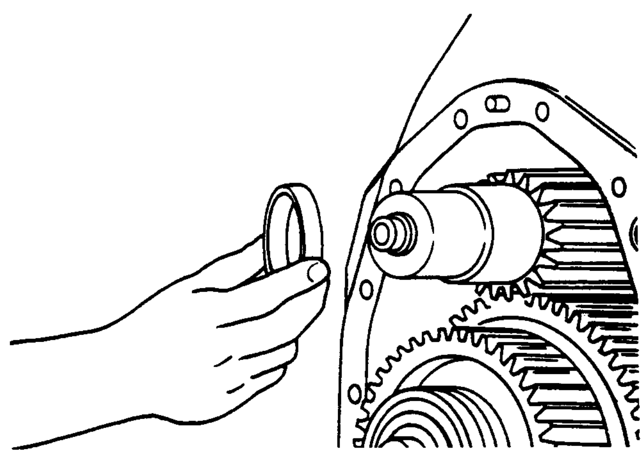
40. Install the idler shaft front bearing.



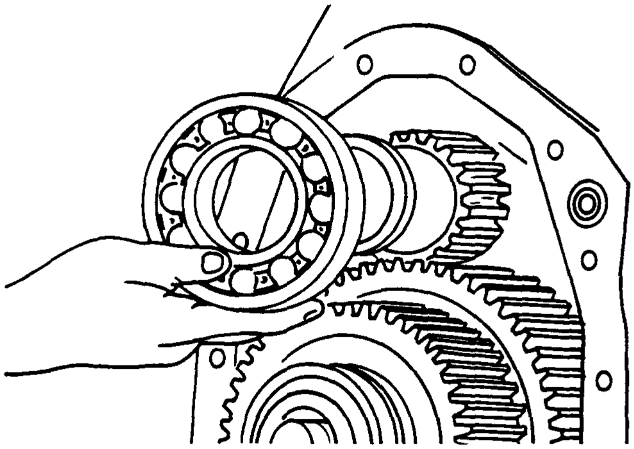
41. Position the 1st and 2nd speed clutch in the front bearing bore and tap into place.



42. Install the idler shaft assembly into the front bearing.



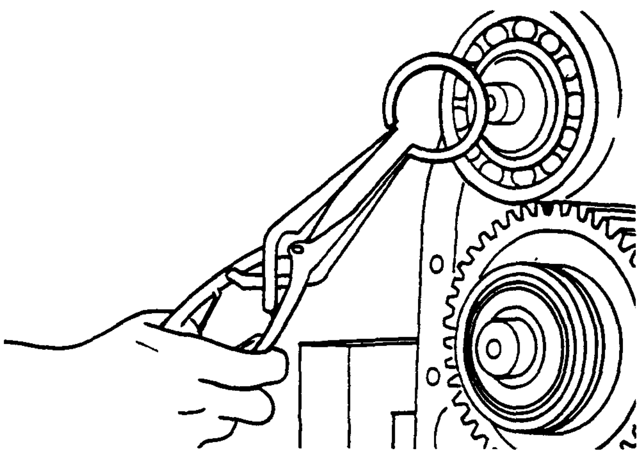
43. Position the rear bearing spacer on the clutch shaft.



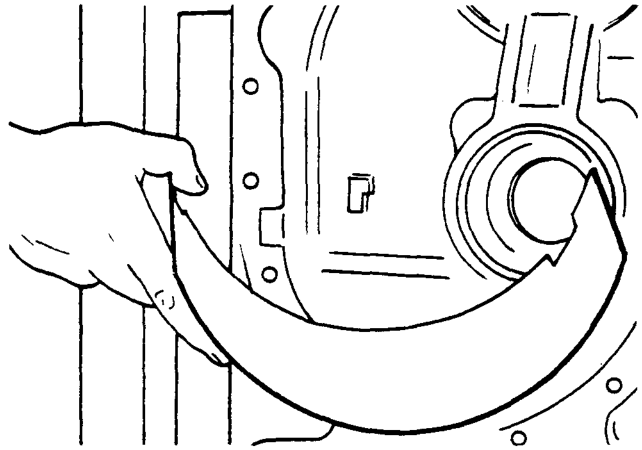
NOTE

The bearing locating ring groove must be out.

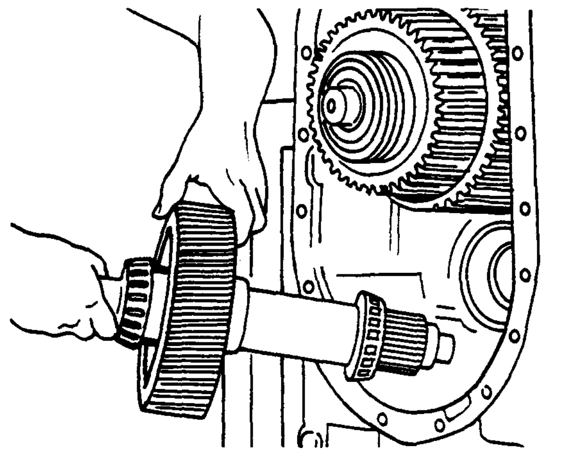
44. Install the 1st and 2nd clutch rear bearing on the clutch shaft.



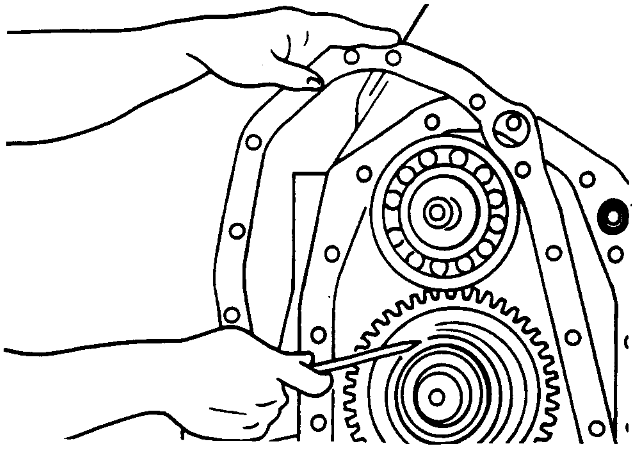
45. Install the bearing retainer ring.



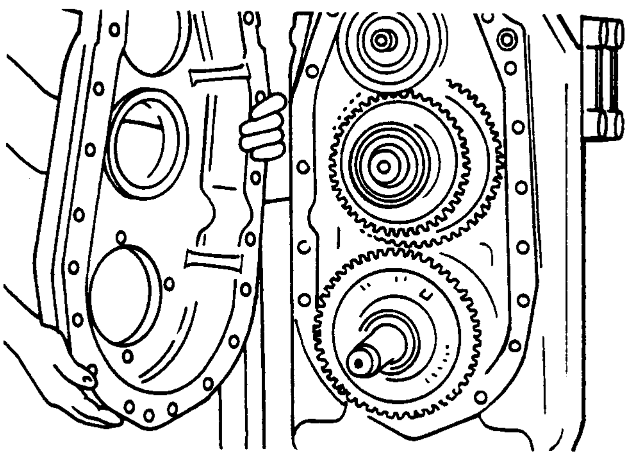
46. Position the oil baffle in the transmission sump.



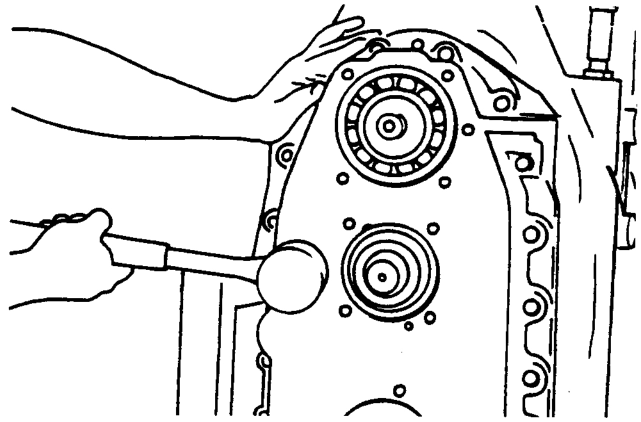
47. Position the output shaft assembly in the front bearing bore, using caution as not to damage the front oil seal.



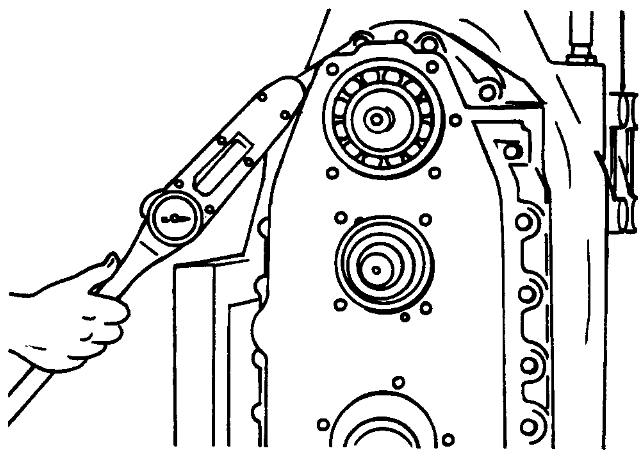
48. Position a new gasket and O-ring on the rear of the housing. A light coat of chassis grease will hold the gasket in place. Install two aligning studs in the housing, to facilitate alignment of the rear cover to the housing. Position the lock ball in the idler rear bearing.



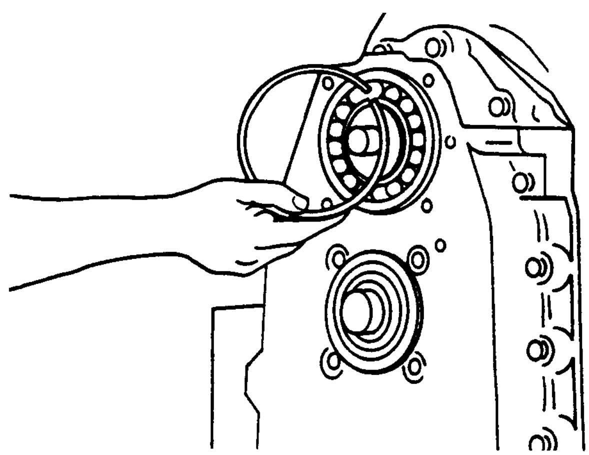
49. Align the lock ball in the idler shaft rear bearing with the notch in the rear of the transmission cover.



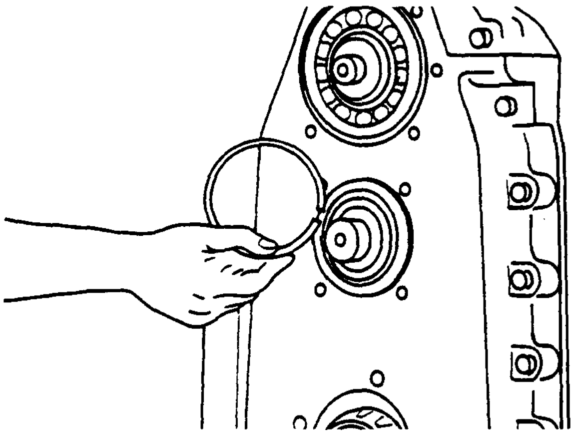
50. Tap the cover in place and secure with bolts and lockwashers. Remove the aligning studs.



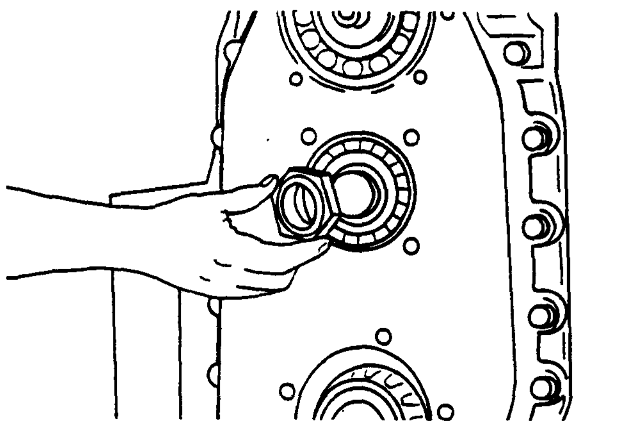
51. Tighten the cover bolts to the torque specified in the torque chart.



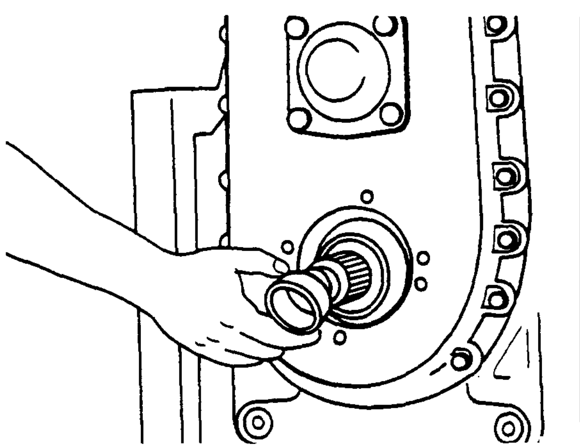
52. From the front, tap the 1st and 2nd clutch to the rear until the rear bearing locating ring groove is exposed. Install the locating ring.



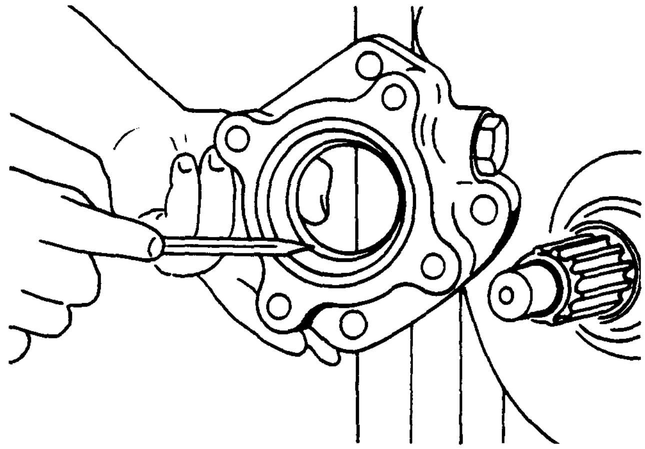
53. Repeat procedure in step 52 for the idler shaft.



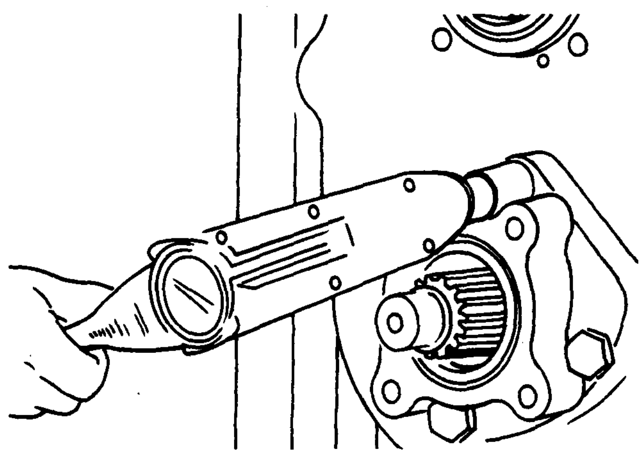
54. Install the idler shaft rear bearing retainer nut. Torque the nut 200 to 250 pounds-foot (27.1 to 33.8 kgm).



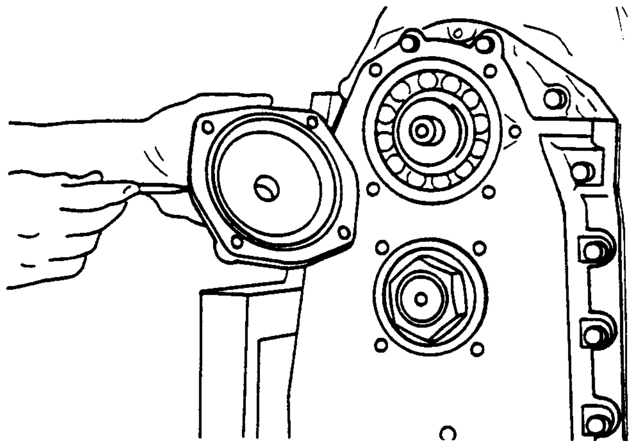
55. Position the speedometer gear on the output shaft if so equipped.



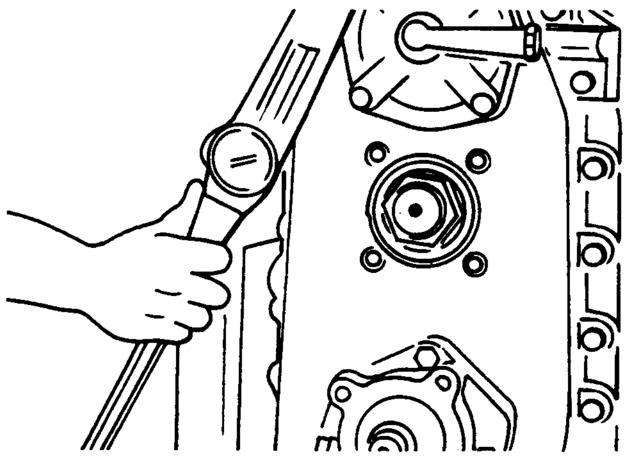
56. With the rear taper bearing cup in the rear bearing cap, apply a very light coat of Permatex #2 to the outer diameter of the rear output oil seal. Press the seal in the bearing cap with the lip or the seal in. With a new O-ring in position, install the bearing cap.



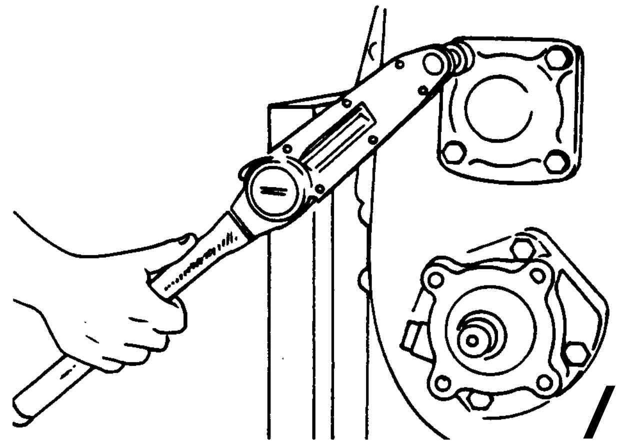
57. Install the bolts and lockwashers and tighten to the torque specified in the Torque Chart on page 14.



58. Position a new O-ring and gasket on the 1st and 2nd clutch rear bearing cap.



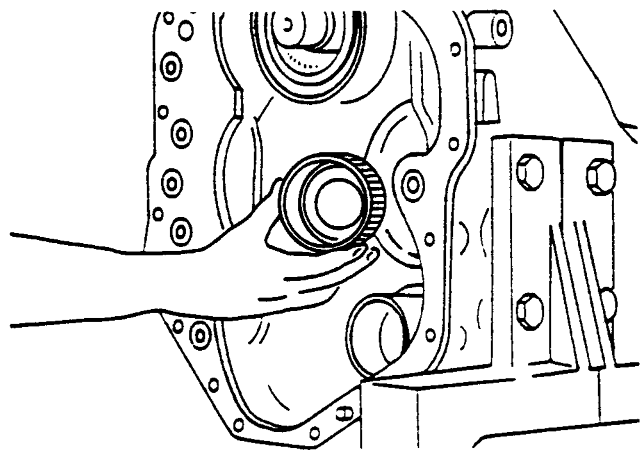
59. Position the bearing cap on the clutch shaft. Install the bolts and lockwashers, tighten to the torque specified on the Torque Chart.



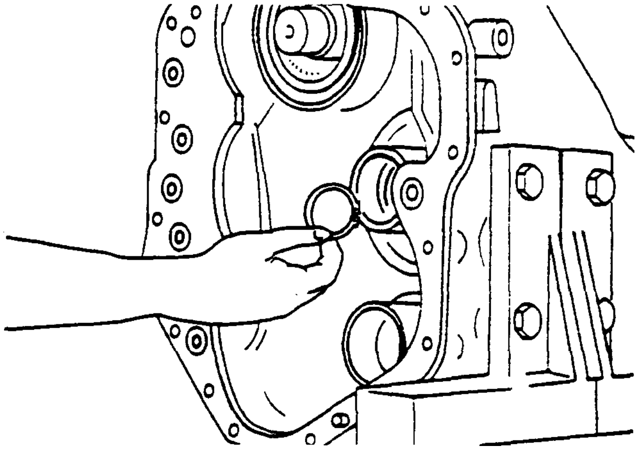
60. Position a new gasket on the idler shaft bearing cap. Install the bearing cap, bolts and lockwashers. tighten to the torque specified in the Torque Chart.

61. Set the output shaft rolling torque. Refer to Output Shaft Rolling Torque Procedure.

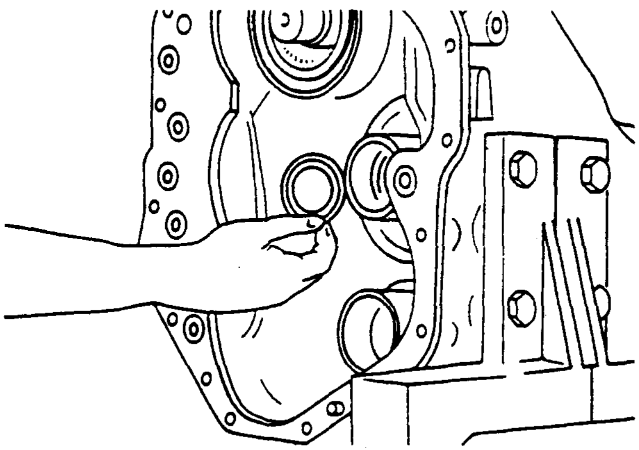
62. Install the parking brake assembly.



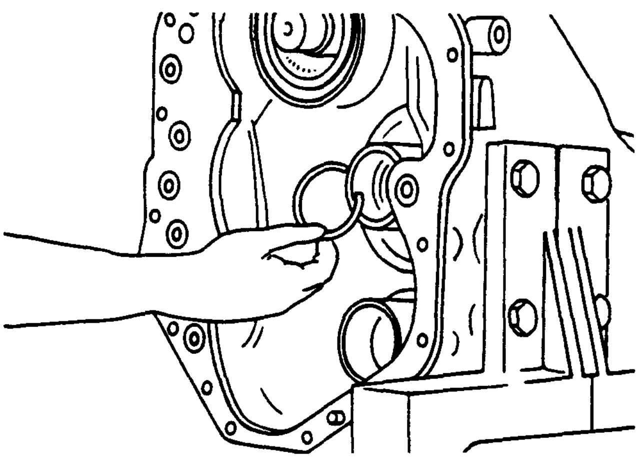
63. Position the 3rd and 4th speed clutch disc hub on the 1st and 2nd clutch shaft.



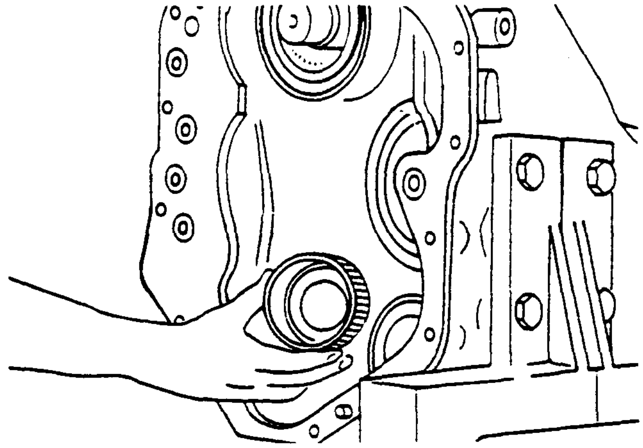
64. Install the disc hub retainer ring.



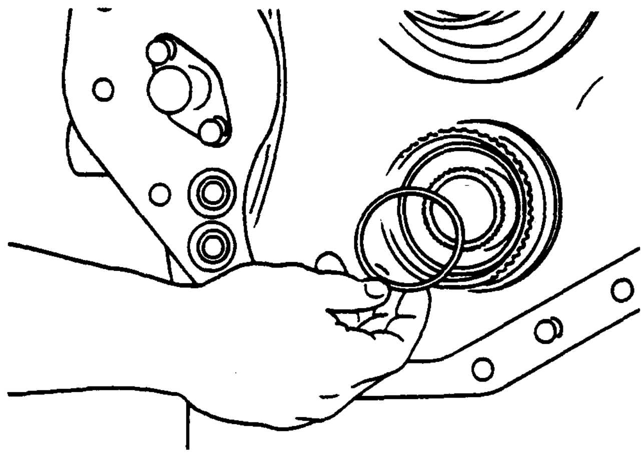
65. Install the disc hub retainer ring retainer.



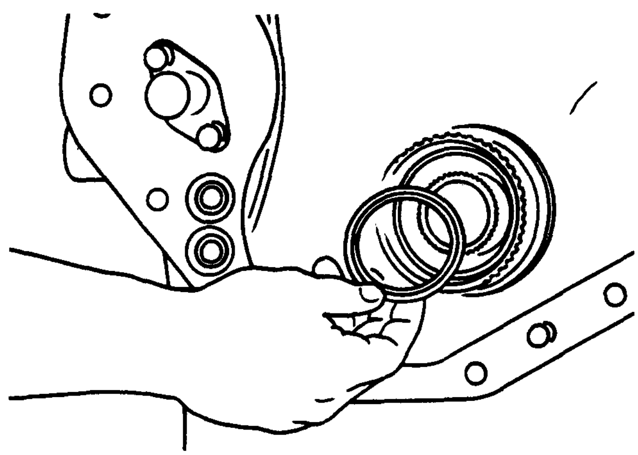
66. Install the rtng retainer retainer ring.



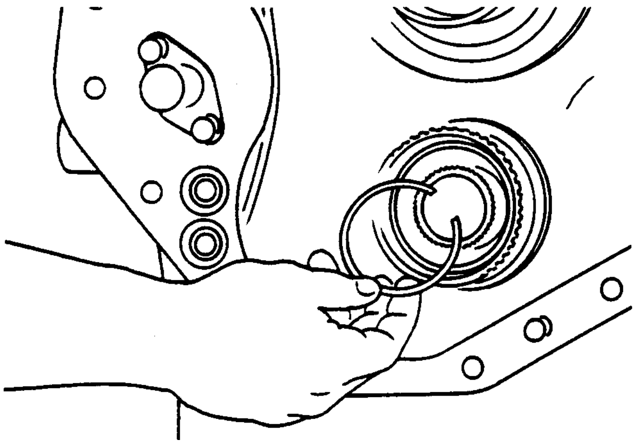
67. Position the 5th and 6th speed clutch disc hub on the idler shaft.



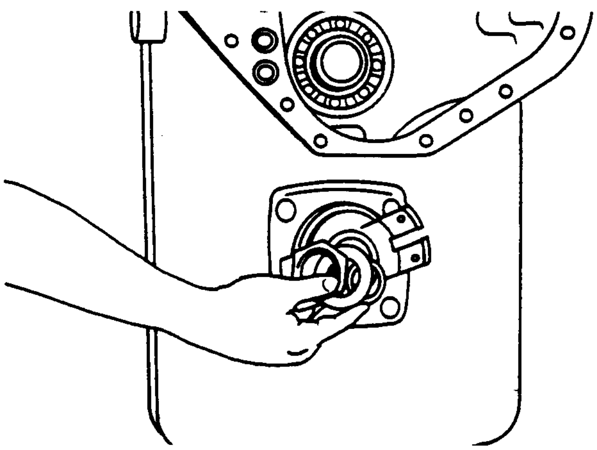
68. Install the disc hub retainer ring.



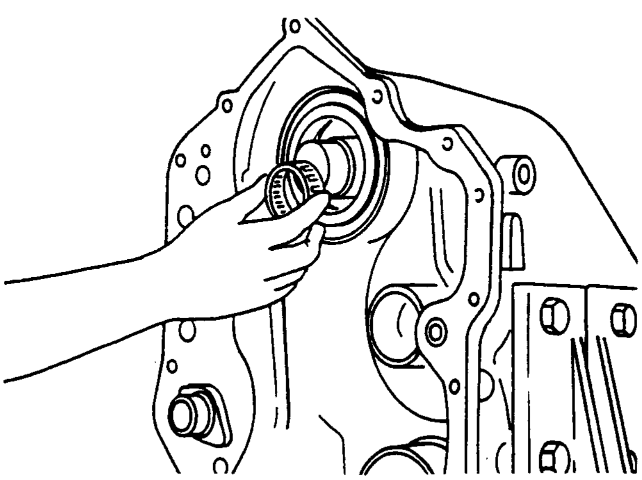
69. Install the disc hub retainer ring retainer.



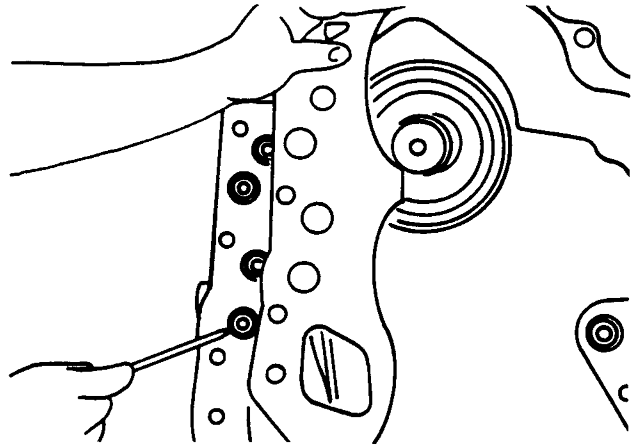
70. Install the ring retainer retainer ring.



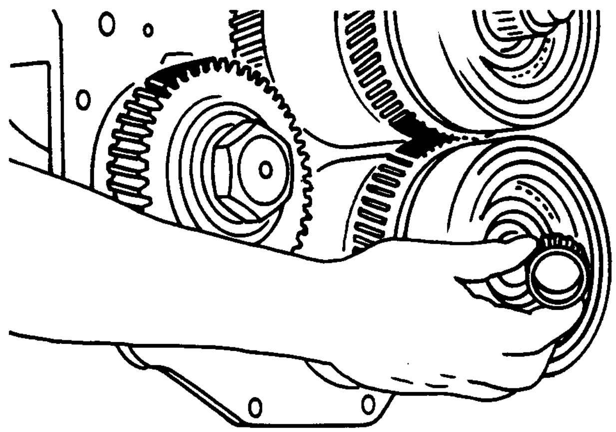
71. Install the front output flange O-ring. washer, and nut. Torque the flange nut 200 to 250 pounds-foot (27.1 to 33.8 kgm).



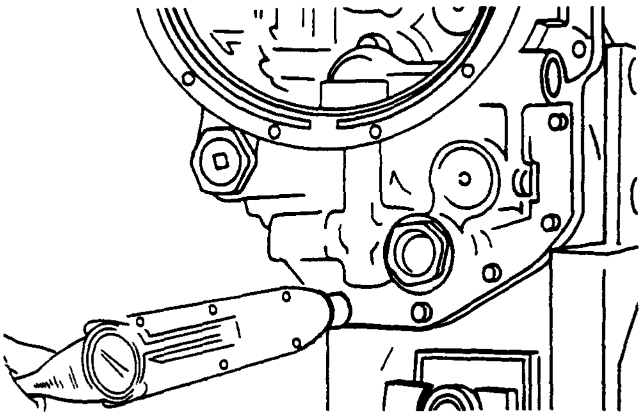
72. Install the forward clutch pilot bearing.



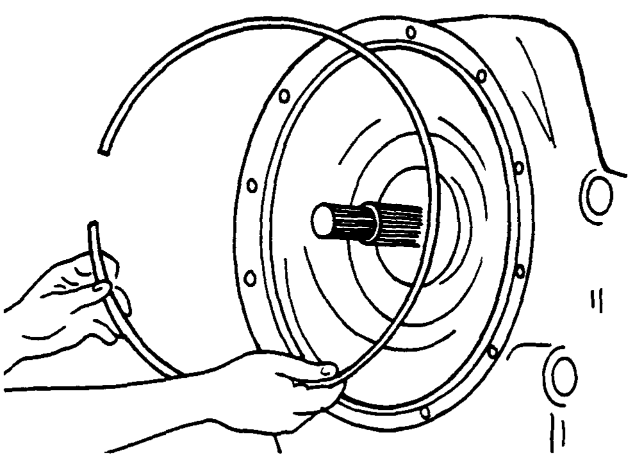
73. Position new O-rings and gasket on the front of the transmission housing. A light coat of chassis grease will hold the O-rings and gasket in place.



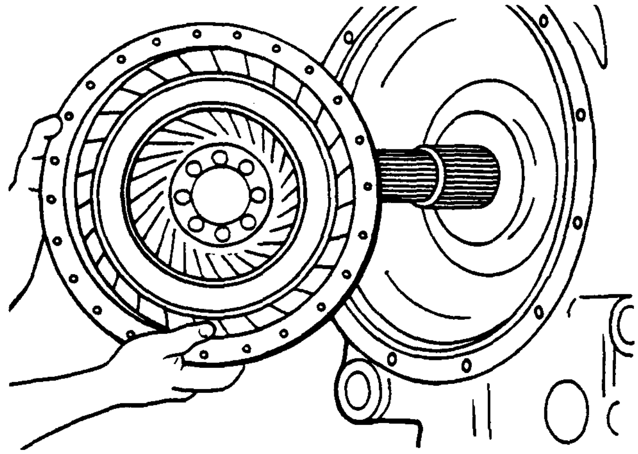
74. Position the pilot bearings on the 3rd, 4th, 5th and 6th clutch shafts, a light coat of grease will hold the pilot bearings in place.



75. The use of two aligning studs will facilitate aligning the converter housing to the transmission housing. Install the converter housing assembly to the transmission assembly using extreme caution as to align the clutch pilots into the clutch disc hubs. As the clutch pilots enter the disc hubs turn the turbine shaft and output shaft back and forth. This will help align all of the clutch inner discs with the disc hubs. DO NOT FORCE THIS OPERATION. When all the clutches are properly aligned, the converter housing will be tight against the transmission housing. Install two housing to housing capscrews and lockwashers. Remove the aligning studs. Install the remaining capscrews and lockwashers. Torque the capscrews to the torque specified in the Torque Chart.



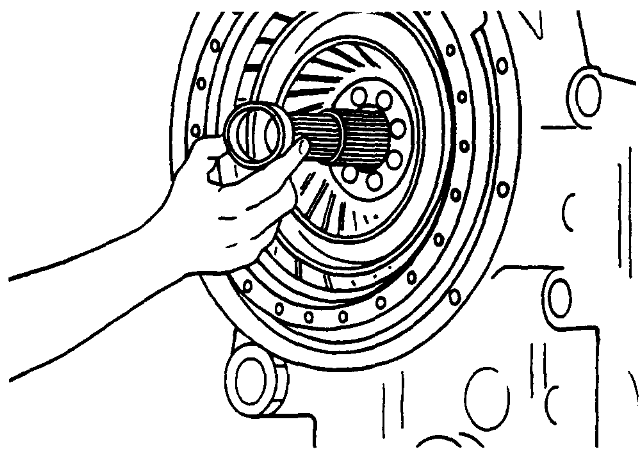
76. Apply a light coat of Permatex #2 to the outer diameter of the oil baffle oil seal. Press the seal in the baffle with the lip of the seal toward the impeller hub bearing. Position a new oil baffle sealing ring on the oil baffle. Position the oil baffle in the housing and install the retaining ring. Be sure the ring is in full position in the ring groove.



NOTE

Use extreme caution as not to cut, break or unhook the oil sealing ring on the support.

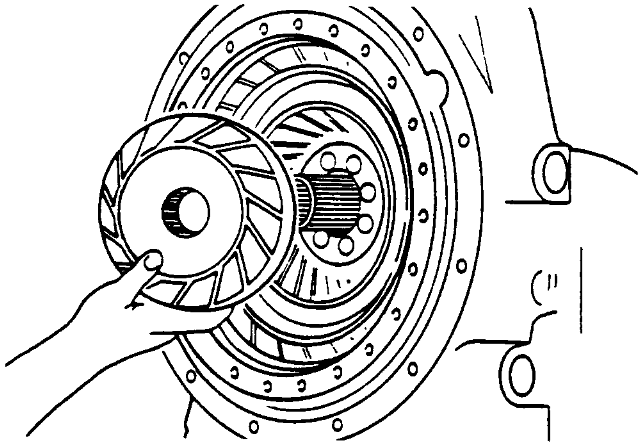
77. Install the impeller and hub assembly using caution as not to damage the oil baffle oil seal.



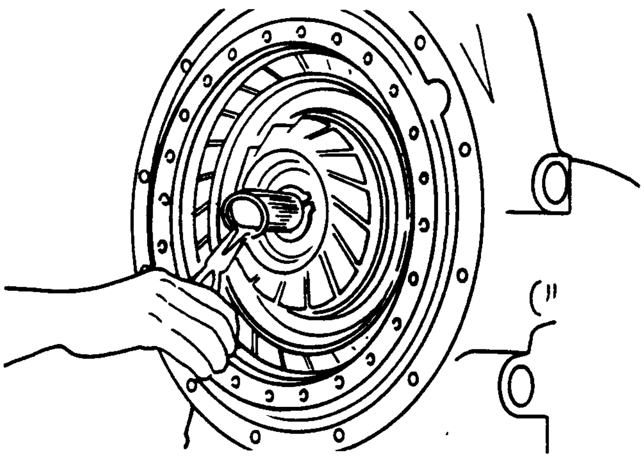
78. Position impeller hub bearing spacer on stator support.

NOTE

If equipped with a fixed reaction member, follow steps 79 and 80. If equipped with a freewheeling reaction member, follow steps 81 thru 83.



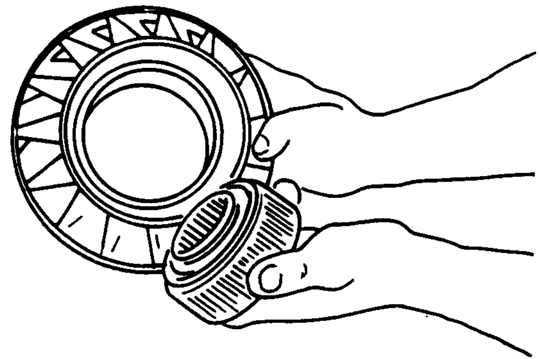
79. Install the reaction member with the thick side of the blades out.



80. Install the reaction member retainer ring.

NOTE

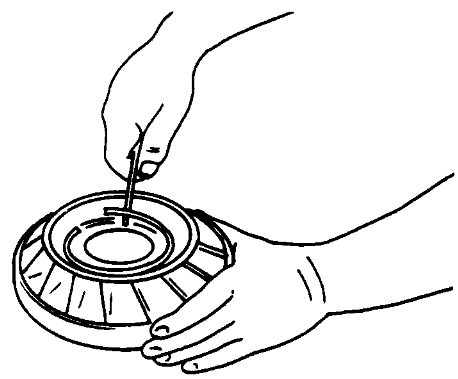
The freewheel assembly cannot be serviced. If the freewheel is damaged it must be replaced as an assembly.



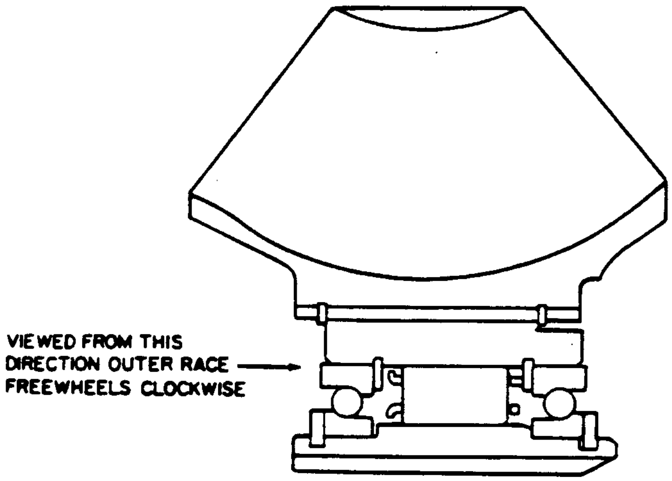
NOTE

Undercut shoulder of race must go toward the rear of the reaction member.

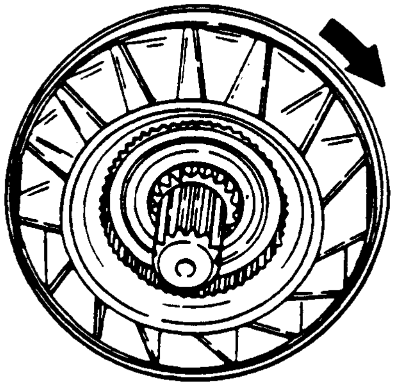
81. Install the outer race and sprag assembly in the reaction member.



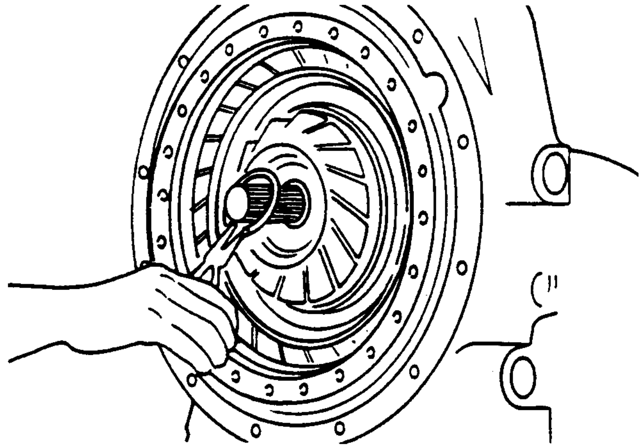
82. Install the outer race to reaction member retainer ring.



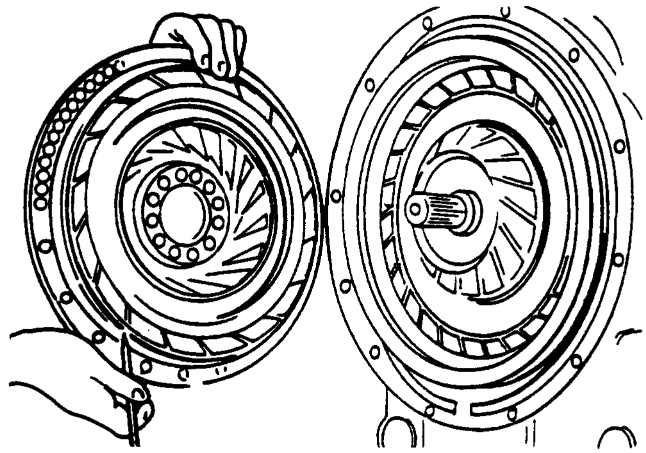
MUST FREE WHEEL IN
CLOCKWISE ENGINE ROTATION



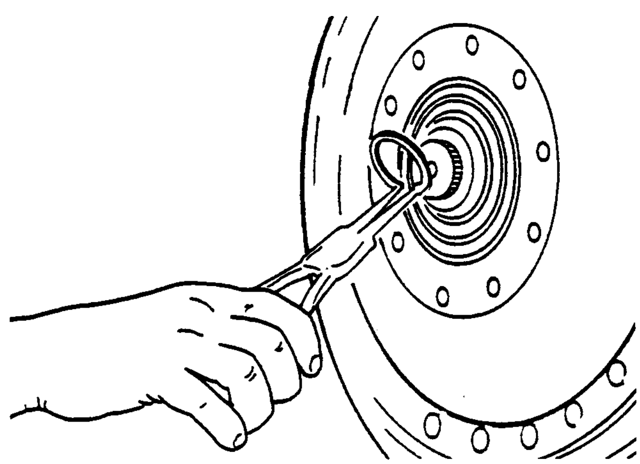
83. Position the reaction member to impeller hub gear spacer on the reaction member support. Install the reaction member on the support. Check the rotation of the freewheeling reaction member to be sure of proper freewheel assembly. Install the reaction member retaining ring.



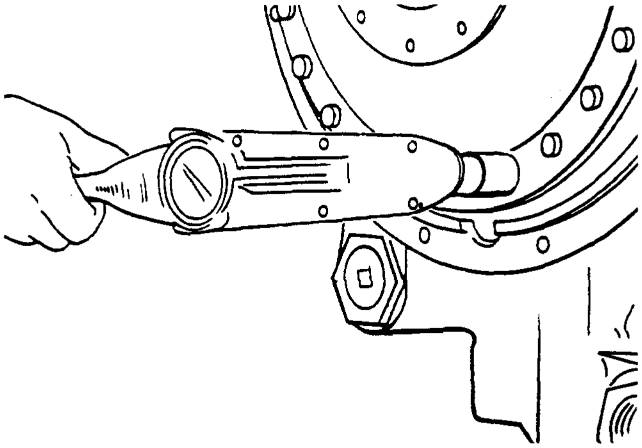
84. Install the turbine locating ring.



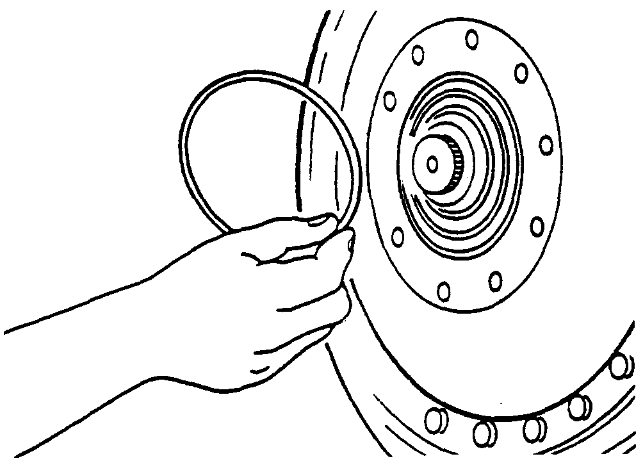
85. With a new impeller cover to impeller O-ring in place, install the turbine and impeller over assembly on the turbine shaft.



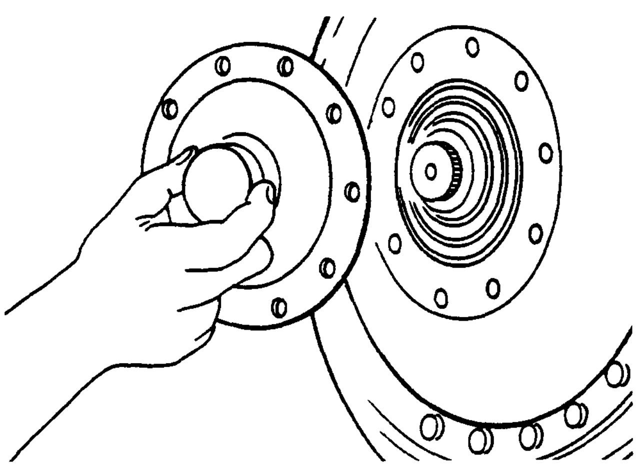
86. Install the turbine hub to turbine shaft retainer ring.



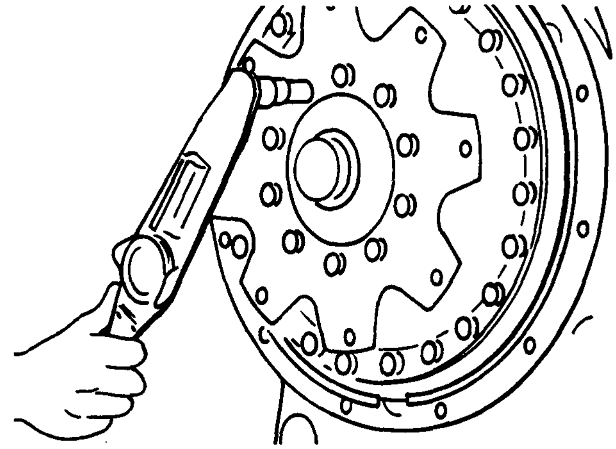
87. Install the impeller cover to impeller screws and lockwashers. Torque to the value specified in the Torque Chart.



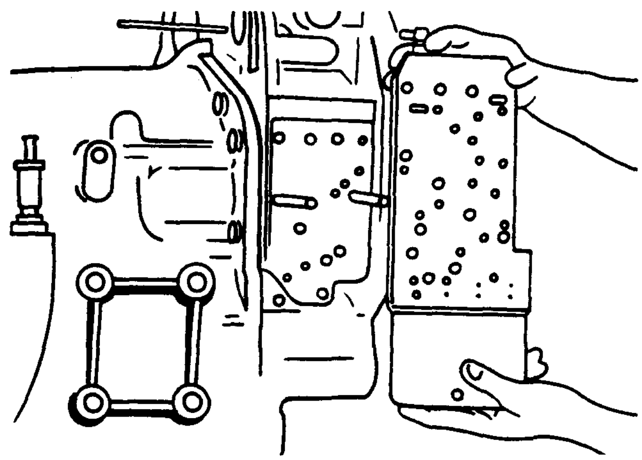
88. Position a new O-ring over the impeller cover bearing.



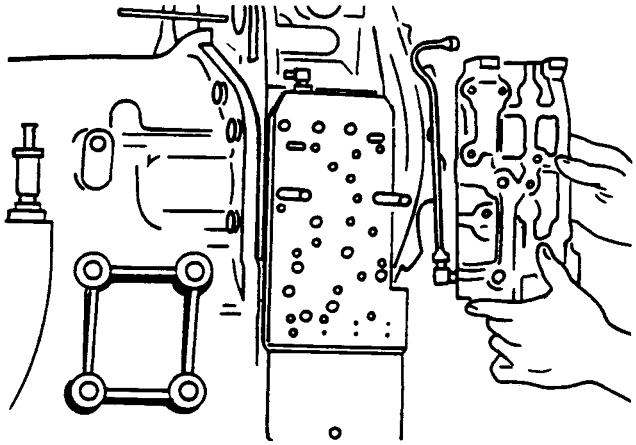
89. Position the impeller cover bearing cap on the bearing.



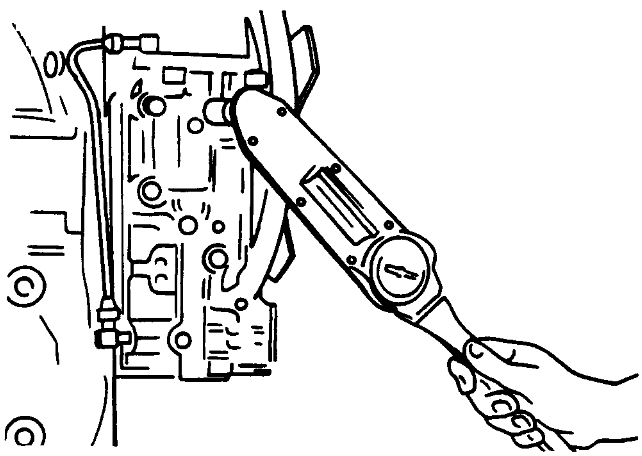
90. See special section on page 61 for drive plate installation. Install the drive plate. Refer to Drive Plate Installation.



91. To install the control valve assembly it is re commended two aligning studs be used. Position a new control valve to housing gasket on the housing. Install the control valve assembly.



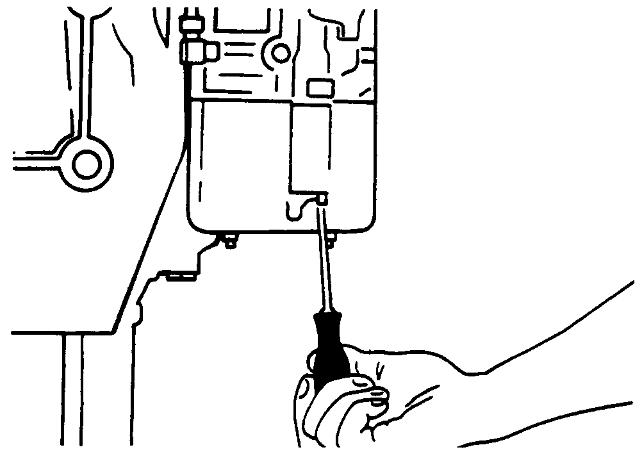
92. Position a new shuttle valve gasket on the control valve. Install the shuttle valve assembly on the control valve.



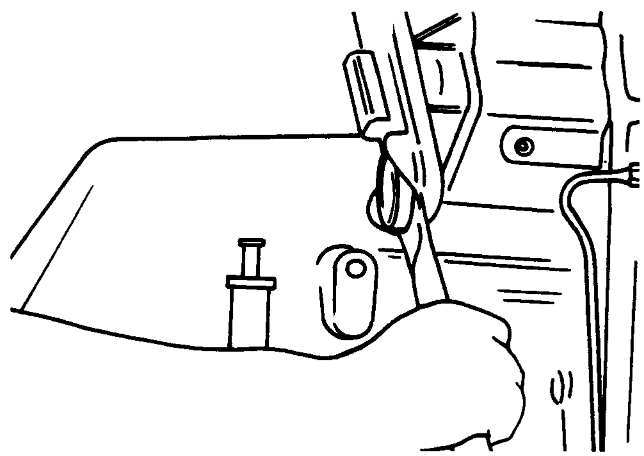
NOTE

Use Loctite #262 on upper right hand screw. Torque the screws to the value specified in the Torque Chart.

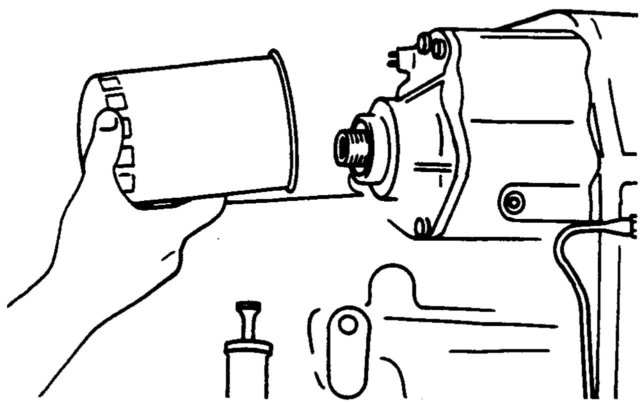
93. Install the control valve to housing screws and lockwashers.



94. Connect the pressure line from the shuttle valve to the control valve. Connect the wires from the control valve to the shuttle valve solenoid.



95. Using a new gasket, position the charging pump assembly on mounting studs. Install the washers, nuts and capscrews. Torque the nuts and capscrews to the value specified in the Torque Chart.



NOTE

It is recommended that the filter cartridge be changed after 50 and 100 hours of operation on new and rebuilt or repaired units.

96. Install a new oil filter cartridge.

Output Shaft Rolling Torque.

1. Tap the output shaft front and rear to seat the taper bearings.

2. Loosen the front bearing cap bolts.

3. Using an inch pound torque wrench, determine the rolling torque of the output shaft and record this measurement.

4. Tighten the front bearing cap bolts to the torque specified in the torque chart and check the rolling torque again. The rolling torque must be 6 to 8 pounds-inch (0.068 to 0.090 kgm) more than when the bearing cap bolts were loose.

5. Add or omit shims on the front bearing cap to achieve the proper preload.

Drive Plate Installation.

NOTE

To facilitate assembly, align the small holes in the drive plate.

1. Clean the mounting surfaces and tapped holes with solvent and the proper tap. Dry thoroughly ensuring the tapped holes are dry and clean.

2. Position the drive plate and weld nut assembly on the impeller cover with the weld nuts toward the cover.

NOTE

Two dimples 180 degrees apart in the backing ring must be out (toward the engine fly wheel).

3. Align the intermediate drive plate and backing ring with the holes in the impeller cover.

4. Install the special self-locking screws to approximately 0.06 inch (1.5 mm) of the seated position.

NOTE

Assembly of drive plates must be completed within a fifteen minute period from start of screw installation. The screws are prepared with an epoxy coating which begins to harden after installation. If not tightened to proper torque within a fifteen minute period, insufficient screw clamping tension will result. This special screw is to be used for one installation only. If the screw is removed for any reason it must be replaced. The epoxy left in the hub holes must be removed with the proper tap and cleaned with solvent. Dry the hole thoroughly and use a new screw for reinstallation.

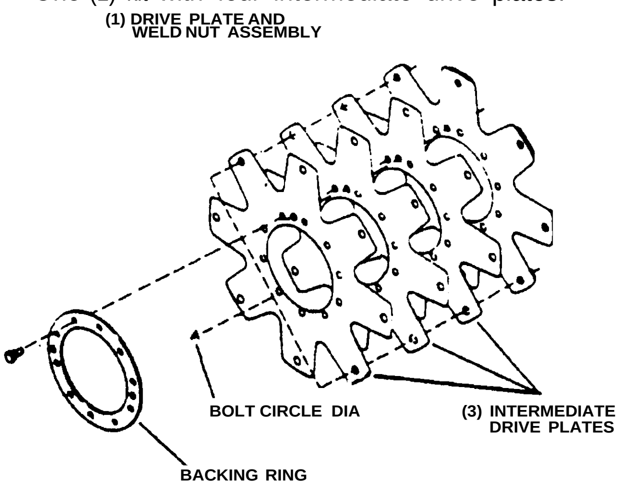
5. With a calibrated torque wrench, torque the screws 23 to 25 pounds-foot (3.1 to 3.4 kgm).

DRIVE PLATE INSTALLATION PROCEDURE

Measure the "A" dimension (Bolt Circle diameter) and order Drive Plate Kit listed below.

Note three (3) kits have three (3) intermediate drive plates and one (1) drive plate and weld nut assembly.

One (1) kit with four intermediate drive plates.



"A" Dimension (Bolt Circle Diameter)

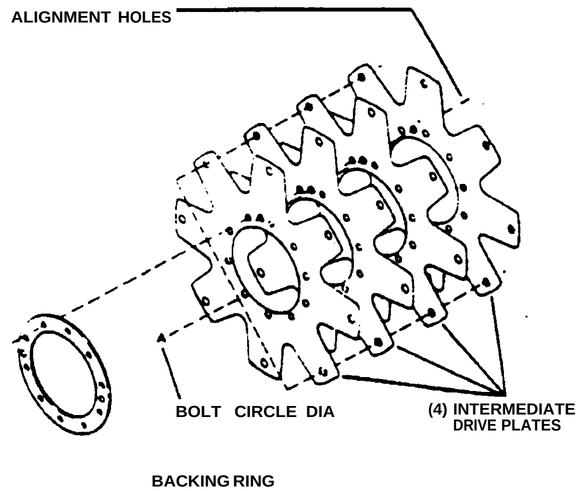
11.38" [288,9mm] Diameter
Kit No. 802215

13.125" [333,375mm] Diameter
Kit No. 802216

13.50" [342.900 mm] Diameter
Kit No. 802214

Each Kit will include the following parts:

3 Intermediate Drive Plates
1 Drive Plate and Weld Nut Assembly
1 Backing Ring
10 Capscrews
10 Lockwashers
1 Instruction Sheet



"A" Dimension (Bolt Circle Diameter)

13.50" [342,900 mm] Diameter
Kit No. 802217

Kit will include the following parts:

4 Intermediate Drive Plates
1 Backing Ring
10 Capscrews
10 Lockwashers
1 Instruction Sheet

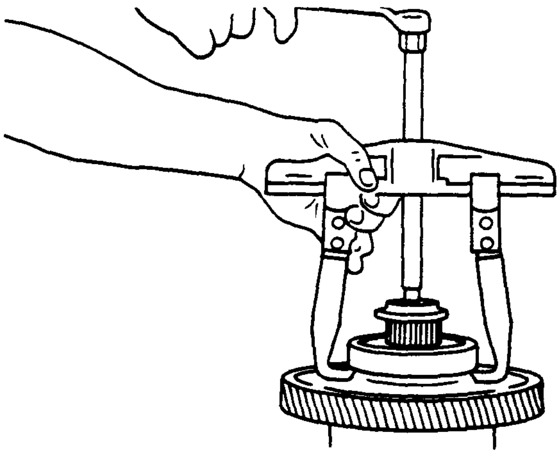
1496-19

Drive Plate Installation

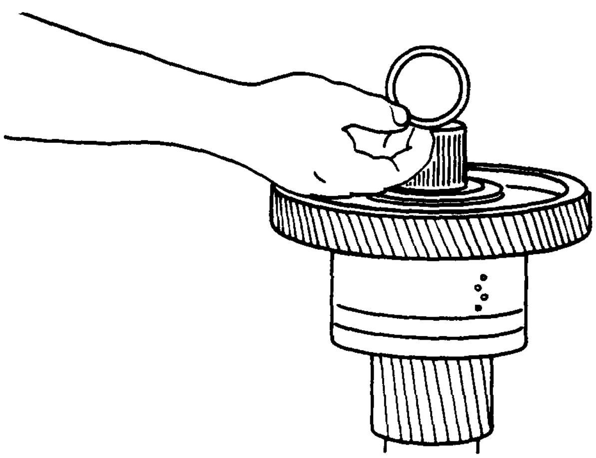
Major Transmission Components

1st and 2nd Clutch.

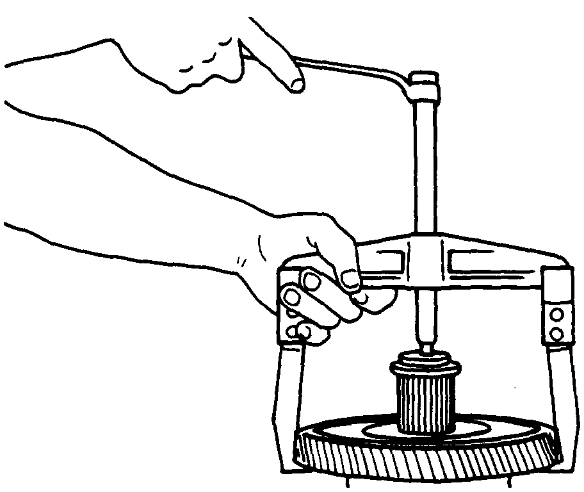
Disassembly.



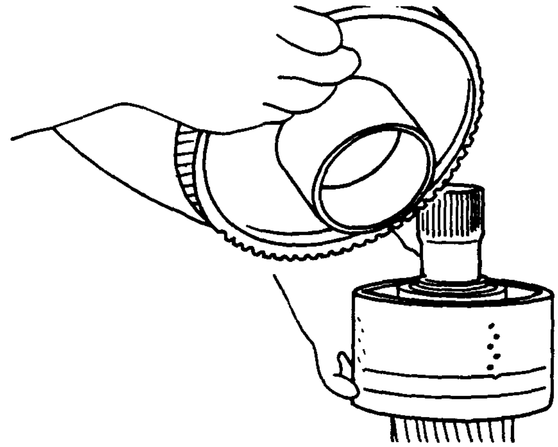
1. Remove the front bearing.



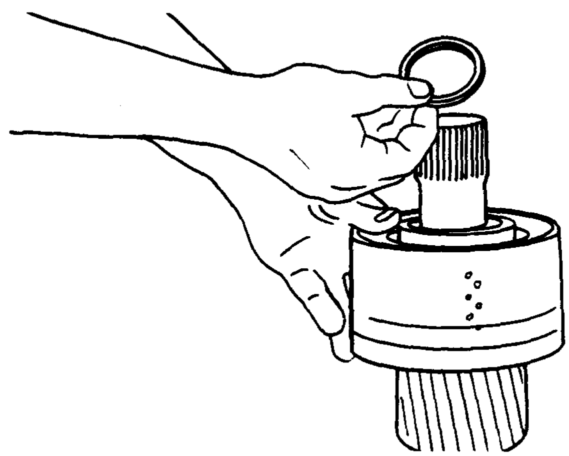
2. Remove the front bearing spacer.



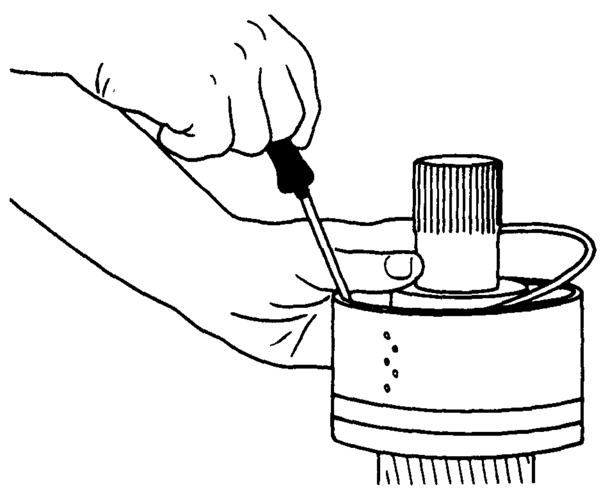
3. Remove the low gear.



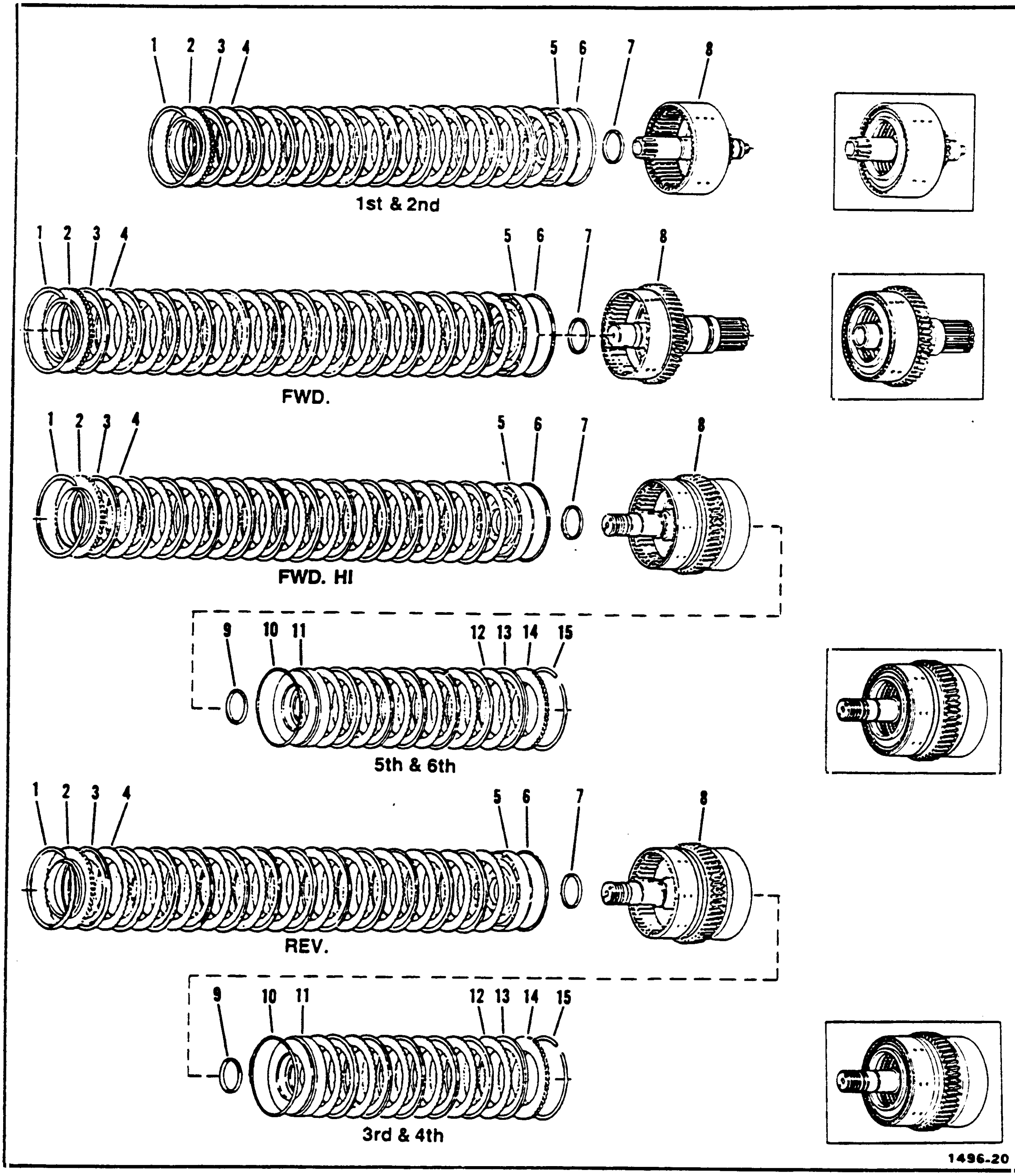
4. Low gear removed.



5. Remove the inner and outer bearing spacer.



6. Remove the end plate retainer ring.



Clutch Assemblies (Sheet 1 of 2)

CLUTCH ASSEMBLY - 1st & 2nd

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
1	Backing Plate Retaining Ring	1	5	Clutch Piston	1
2	Clutch Disc Backing Plate	1	6	Clutch Piston Seal - Outer	1
3	Clutch Inner Disc	10	7	Clutch Piston Seal - Inner	1
4	Clutch Outer Disc	10	8	1st & 2nd Clutch Drum Assembly	1

CLUTCH ASSEMBLY - FORWARD

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
1	Backing Plate Retaining Ring	1	5	Clutch Piston	1
2	Clutch Disc Backing Plate	1	6	Clutch Piston Seal - Outer	1
3	Clutch Inner Disc	12	7	Clutch Piston Seal - Inner	1
4	Clutch Outer Disc	12	8	Forward Clutch Drum Assembly	1

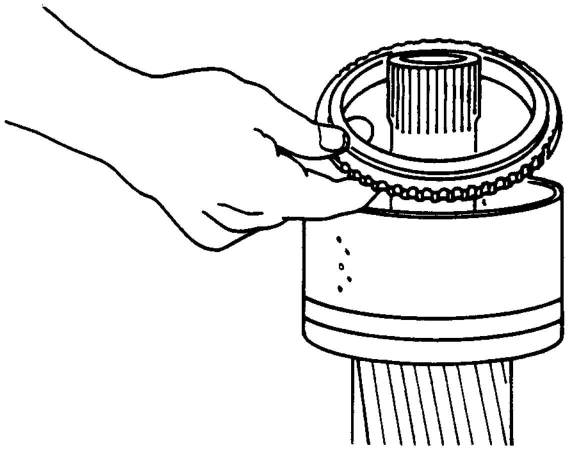
CLUTCH ASSEMBLY
FORWARD HIGH & 5th - 6th

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
1	Backing Plate Retaining Ring	1	9	Clutch Piston Seal - Inner	1
2	Clutch Disc Backing Plate	1	10	Clutch Piston Seal - Outer	1
3	Clutch Inner Disc	12	11	Clutch Piston - 5th & 6th	1
4	Clutch Outer Disc	12	12	Clutch Outer Disc	6
5	Clutch Piston - High	1	13	Clutch Inner Disc	6
6	Clutch Piston Seal - Outer	1	14	Clutch Disc Backing Plate	1
7	Clutch Piston Seal - Inner	1	15	Backing Plate Retaining Ring	1
8	Forward High & 5th - 6th Clutch Drum Assembly	1			

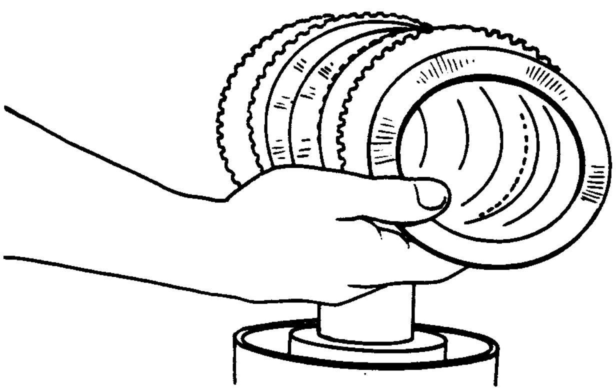
CLUTCH ASSEMBLY
REVERSE 3rd & 4th

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
1	Backing Plate Retaining Ring	1	9	Clutch Piston Seal - Inner	1
2	Clutch Disc Backing Plate	1	10	Clutch Piston Seal - Outer	1
3	Clutch Inner Disc	12	11	Clutch Piston - 3rd & 4th	1
4	Clutch Outer Disc	12	12	Clutch Outer Disc	6
5	Clutch Piston - Reverse	1	13	Clutch Inner Disc	6
6	Clutch Piston Seal - Outer	1	14	Clutch Disc Backing Plate	1
7	Clutch Piston Seal - Inner	1	15	Backing Plate Retaining Ring	1
8	Reverse & 3rd - 4th Clutch Drum Assembly	1			

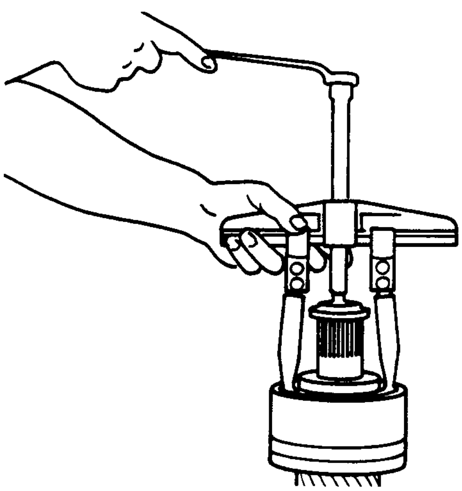
Clutch Assemblies (Sheet 2 of 2)



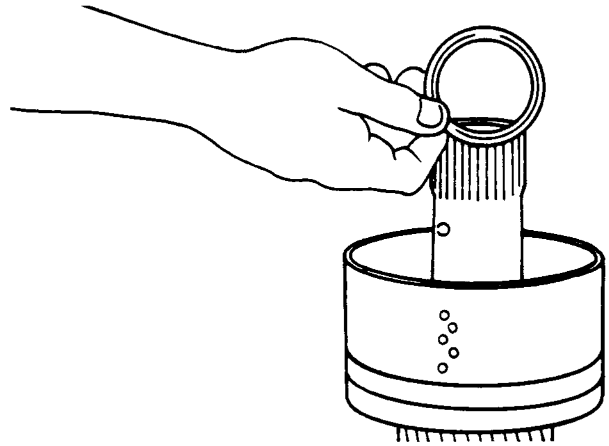
7. Remove the end plate.



8. Remove the inner and outer clutch discs.

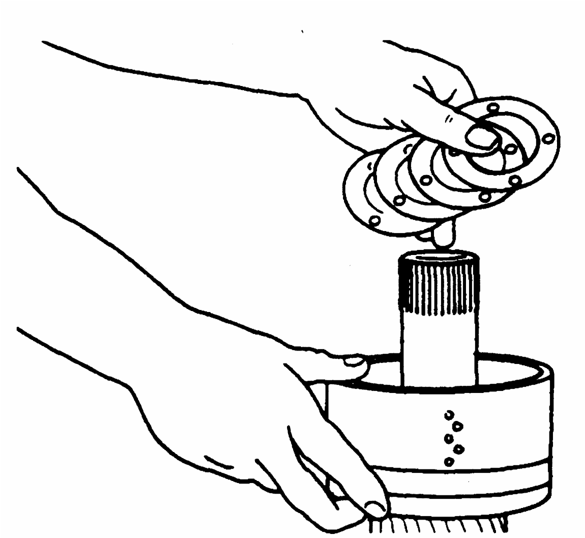


9. Remove the clutch inner bearing.



10. Remove the piston return spring (Belleville washer) retainer ring retainer.

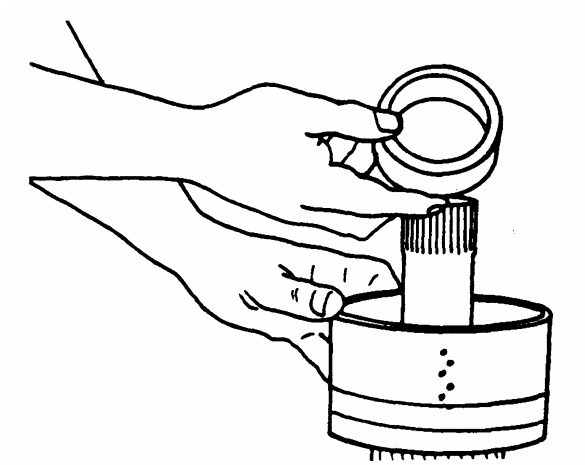
11. Remove the return spring retainer ring.



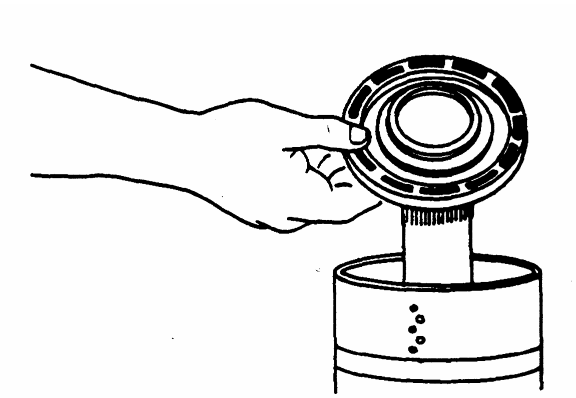
NOTE

Belleville washers in the 1st and 2nd clutch are different than washers in the forward and reverse clutch, 1st and 2nd clutch washers have (4) four holes in them (for identification only). Do not mix 1st and 2nd clutch washers with forward and reverse washers.

12. Remove the return springs (Bellevile washers).

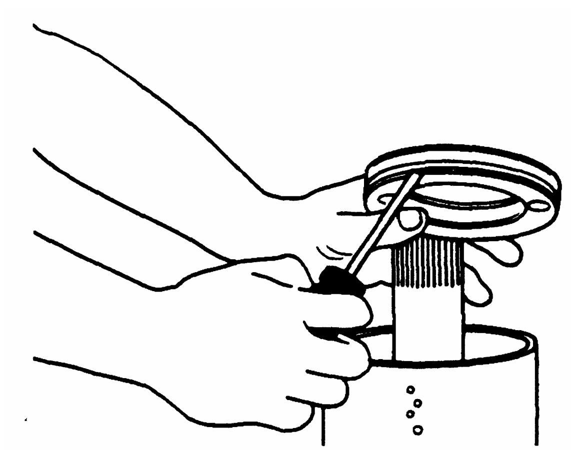


13. Remove the piston spacer.



14. Turn the clutch over and tap the clutch shaft on a block of wood to remove the clutch piston.

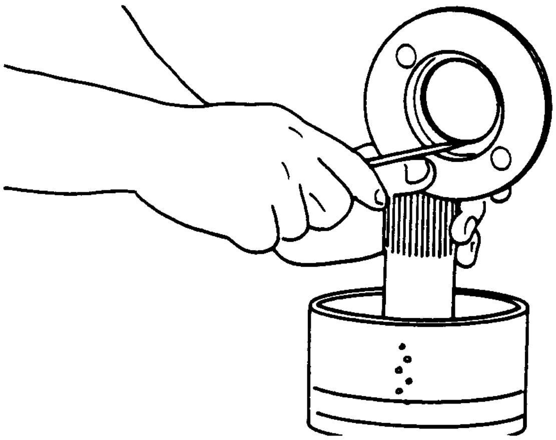
Assembly.



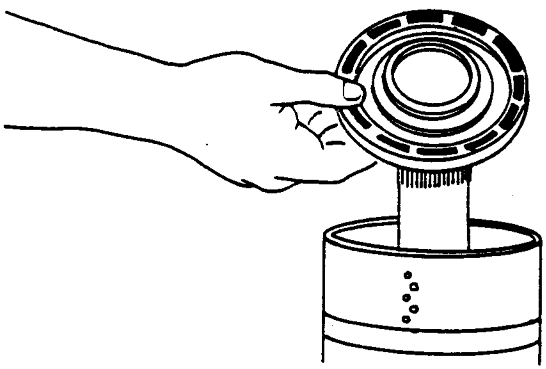
NOTE

The ring must be sized before installing in clutch drum. Sizing is best accomplished by rotating the piston while holding a round object against the new seal ring as shown. Rotate the piston until the seal ring is flush with the outer diameter of piston.

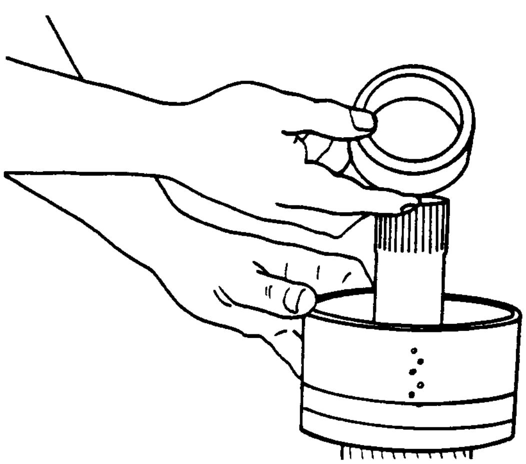
1. Install the clutch piston outer seal ring.



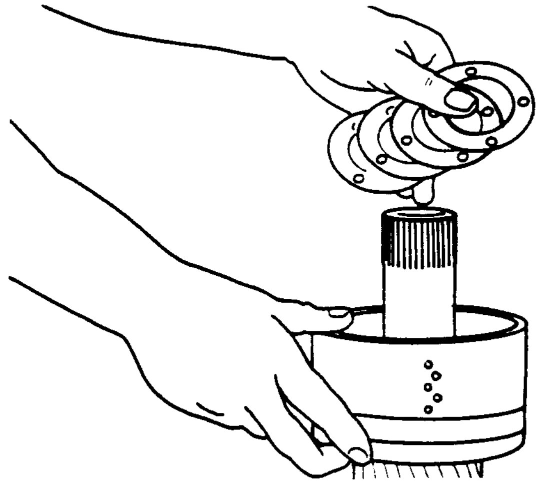
2. Install clutch piston inner seal and size as explained in step 1.



3. Position the piston in the low clutch drum as shown. Use caution as not to damage the inner and outer piston sealing rings.



4. Position the piston return spring spacer over the clutch shaft.



NOTE

Belleville washers in the 1st and 2nd clutch are different than washers in the forward and reverse clutch. 1st and 2nd clutch washers have (4) four holes in them (for identification only). Do not mix 1st and 2nd clutch washers with forward and reverse washers,

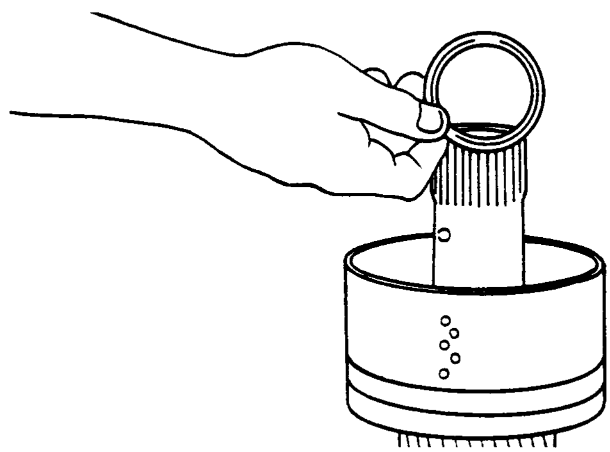
5. Install the Belleville washers. First the washer with large diameter goes toward the spacer. Alternate seven (7) washers.

6. Install the piston return spring retainer ring on the clutch shaft.

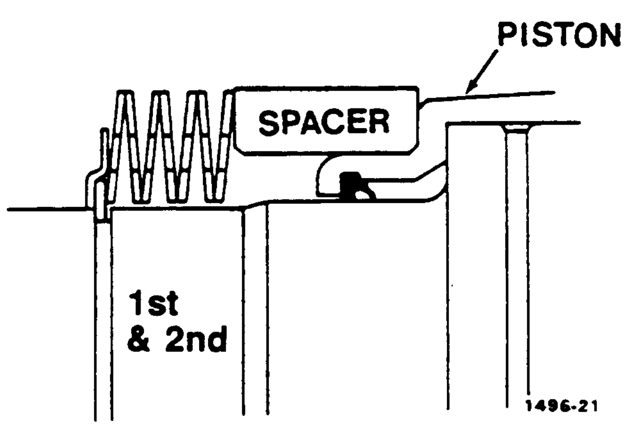
NOTE

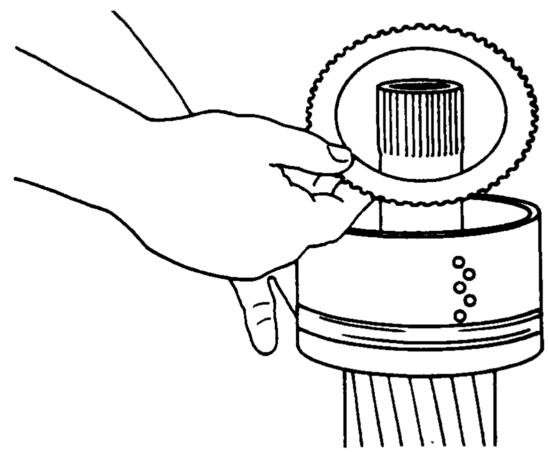
Be certain the retainer ring is in full position in the ring groove.

7. Using a sleeve with the proper inner diameter, drive the Belleville washer ring into position.

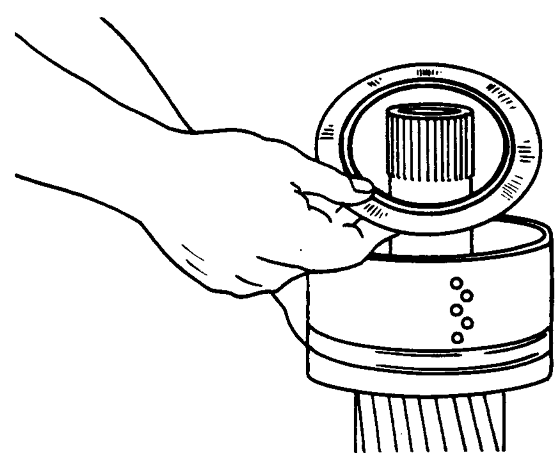


8. Position the ring retainer washer over the retainer ring.





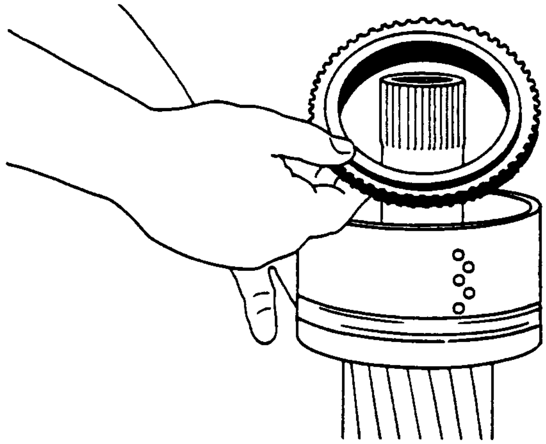
9. Install one steel disc.



NOTE

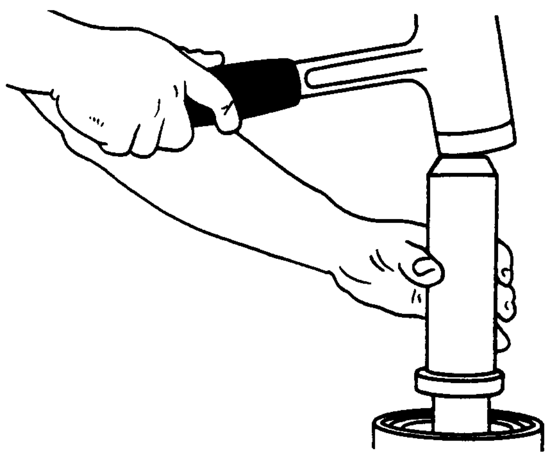
The friction discs in the low clutch have a higher co-efficient rating than the friction discs in the other clutches therefore the discs must not be mixed. The low clutch friction disc has a yellow mark of nonsoluble paint on the outer diameter for permanent identification. Alternate steel and friction discs until the proper amount of discs are installed. First disc next to the piston is steel, last disc installed is friction.

10. Install one friction disc.



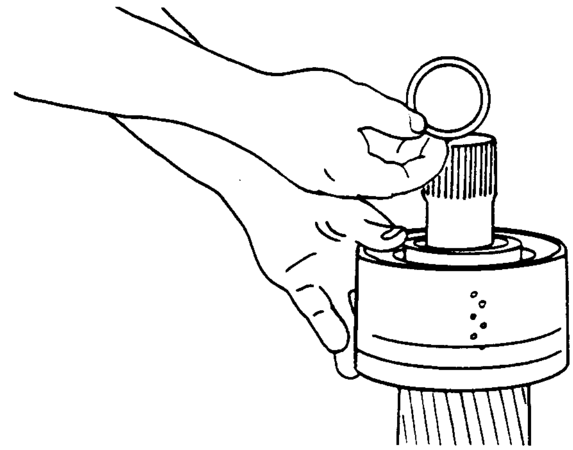
11. Install the clutch end plate.

12. Install the end plate retainer ring.

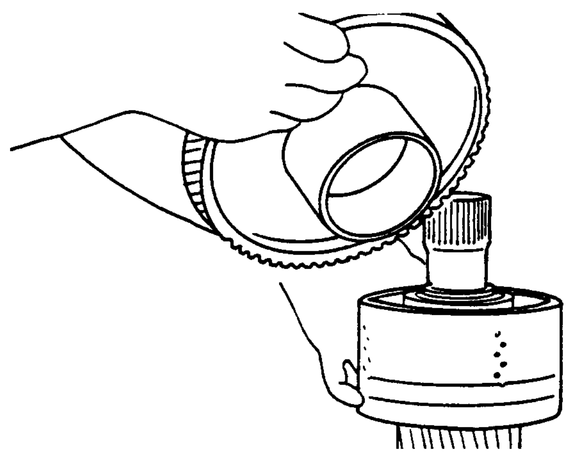


NOTE

This bearing does not have a shield in it.

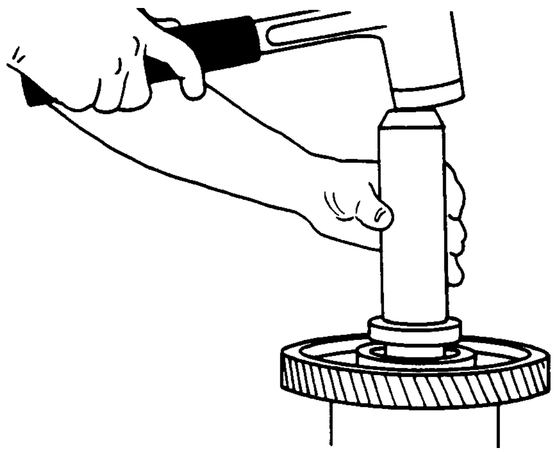


13. Install the clutch gear inner bearing.



14. Position the bearing spacer on the clutch shaft.

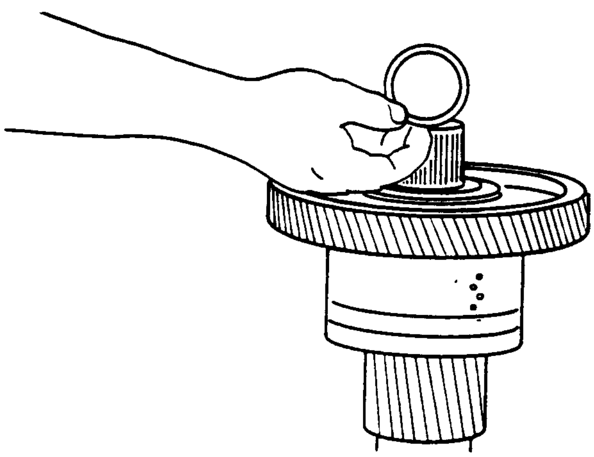
15. Install the low clutch driven gear and the hub into the clutch drum. Align the splines on the clutch hub with the internal teeth of all the friction discs.



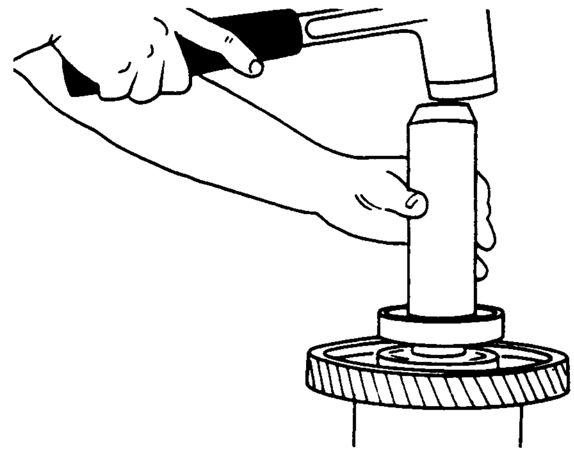
NOTE

The outer bearing has a shield in it, this shield must be up.

16. Install the clutch gear outer bearing.



17. Position the front bearing spacer on the clutch shaft.

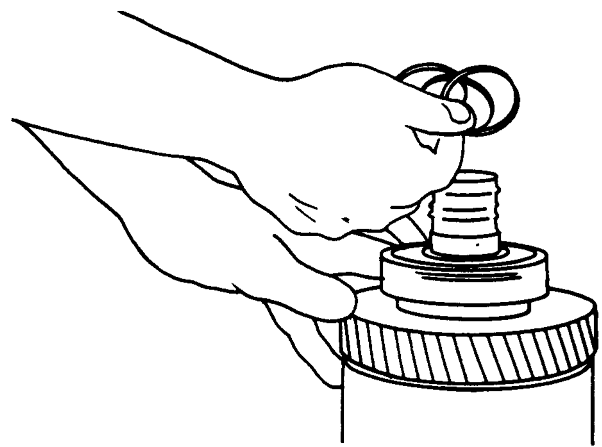


18. Install the front bearing.

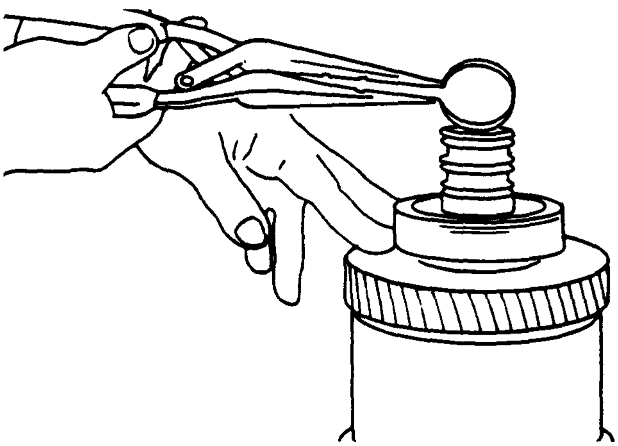
REVERSE, 3rd AND 4th CLUTCH.

Disassembly.

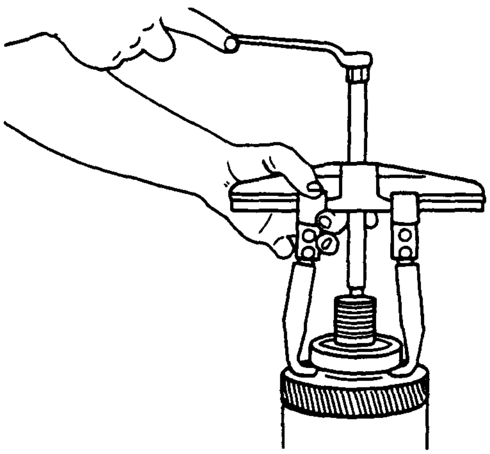
REVERSE.



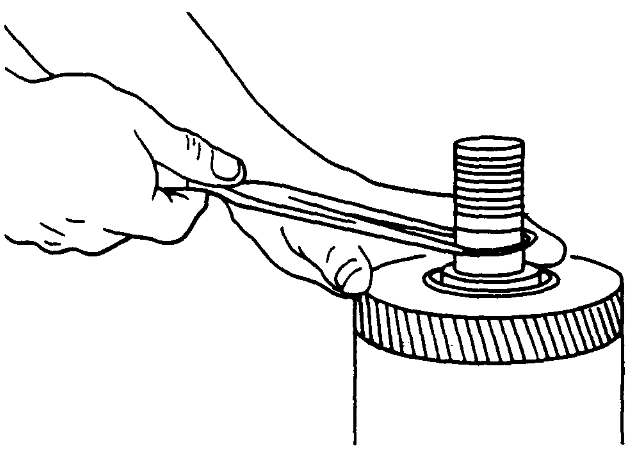
1. Remove the clutch shaft oil sealing rings.



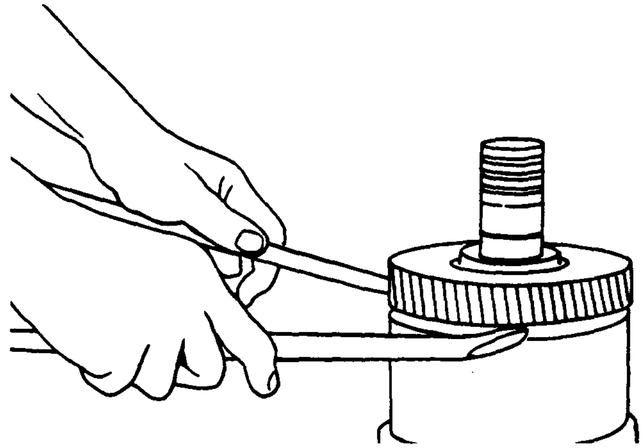
2. Remove the front bearing retainer ring.



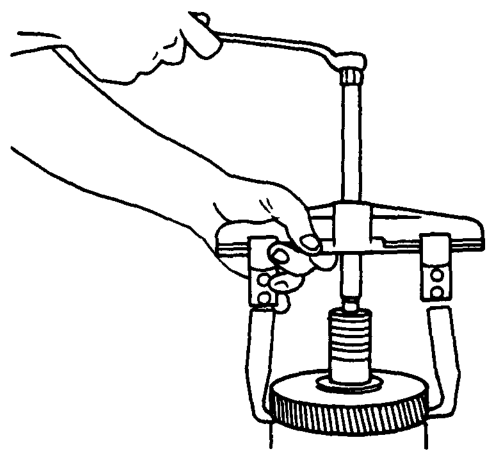
3. Remove the front bearing.



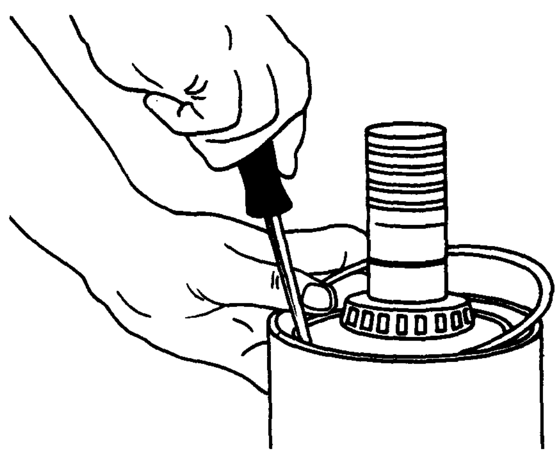
4. Remove the clutch gear bearing retainer ring.



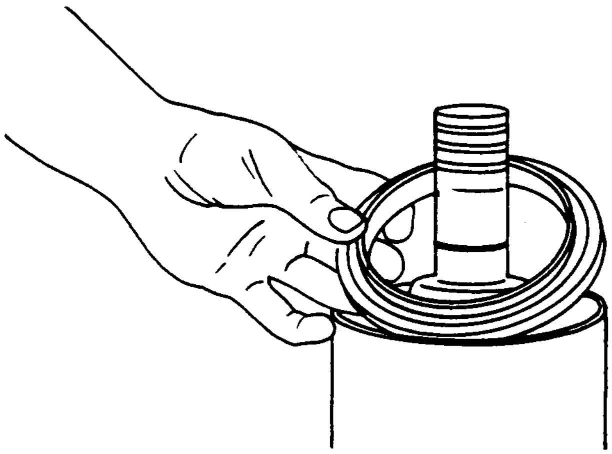
5. Pry the reverse gear from the clutch assembly far enough to use a gear puller.



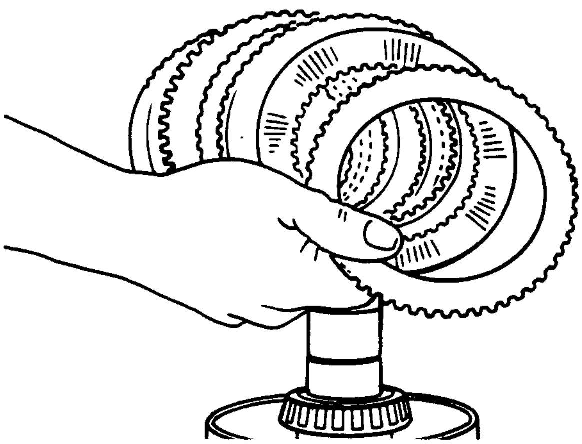
6. Remove the reverse gear.



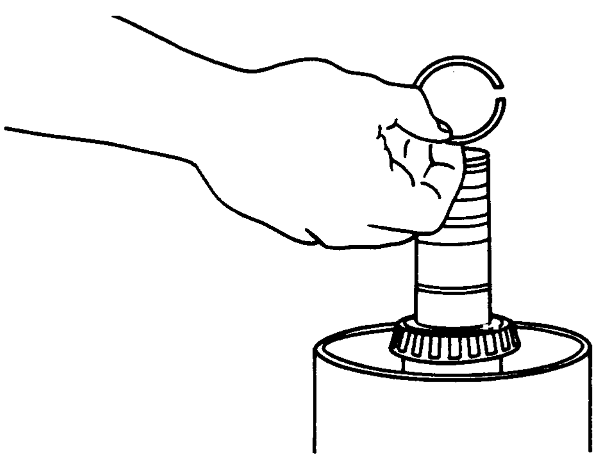
7. Remove the end plate retainer ring.



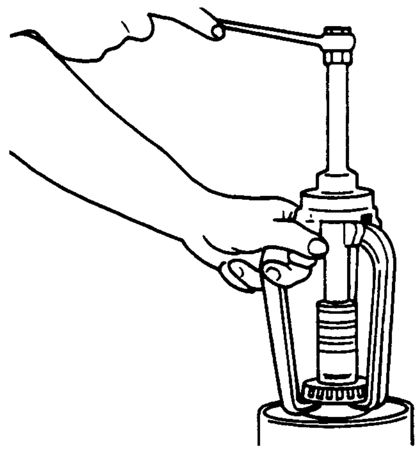
8. Remove the end plate.



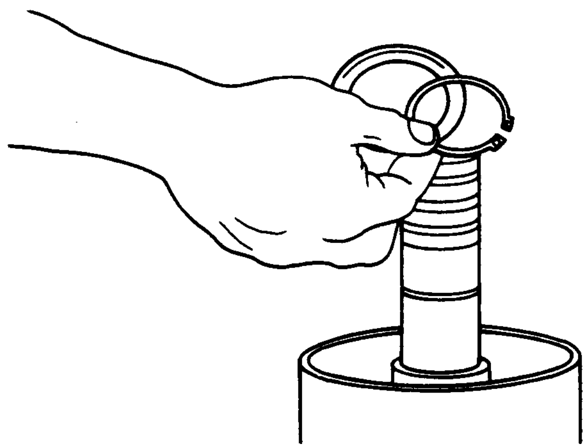
9. Remove the inner and outer clutch discs.



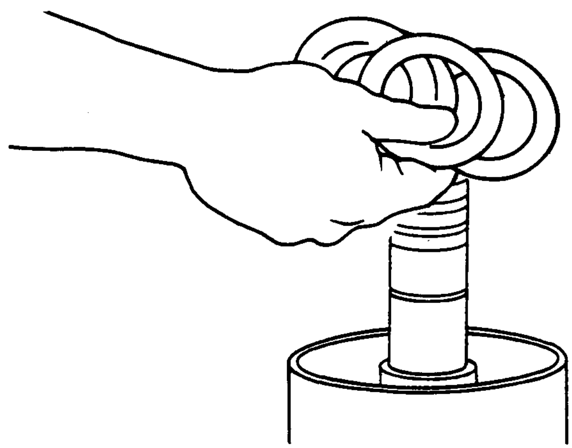
10. Remove the taper bearing spacer.



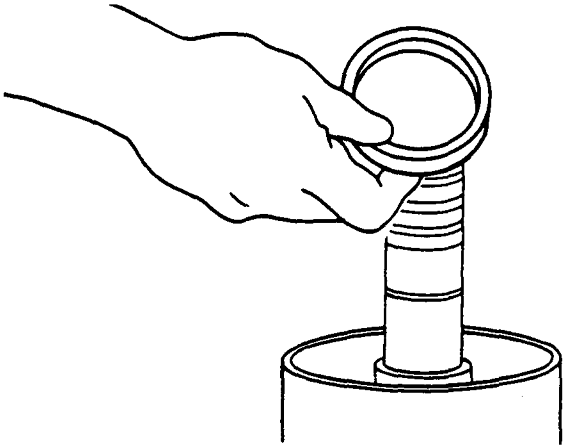
11. Remove the inner taper bearing.



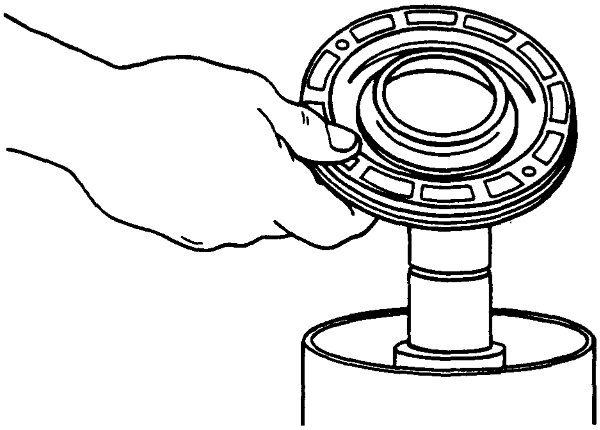
12. Compress the piston return springs (Belleville washers). Remove the return spring retainer ring and ring retainer.



13. Remove the piston return springs (Belleville washers).

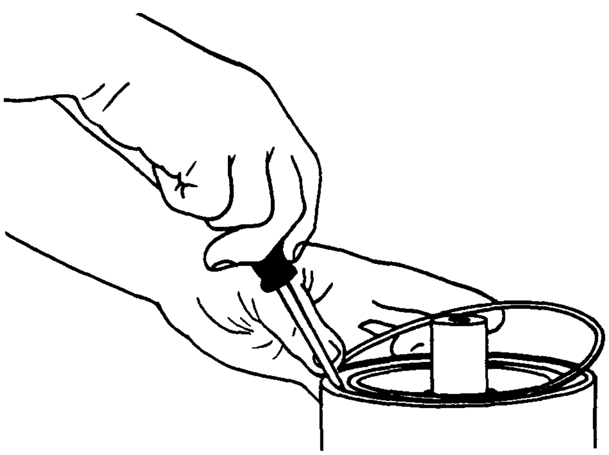


14. Remove the piston spacer.

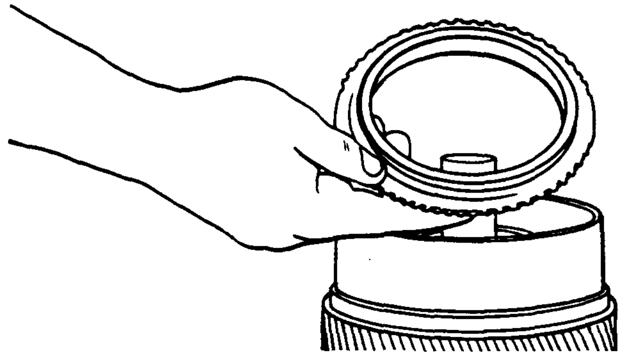


15. Remove the clutch piston.

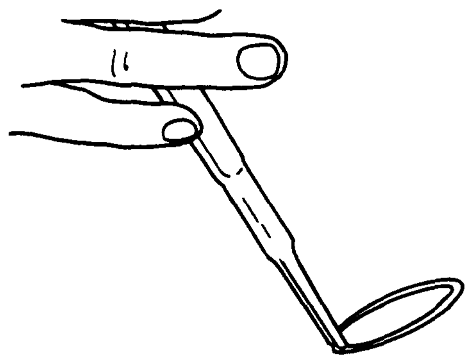
3rd AND 4th CLUTCH.



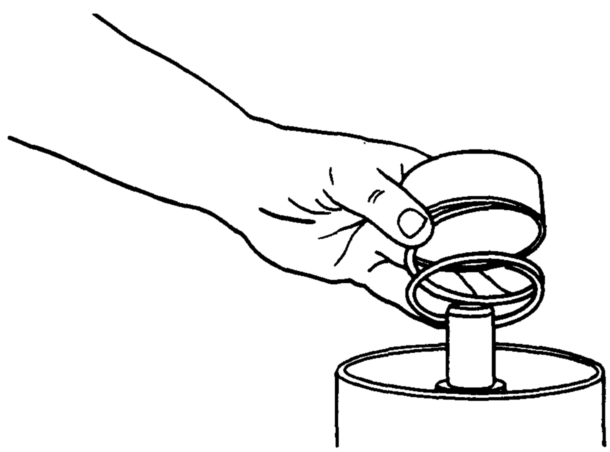
1. Remove the end plate retainer ring.



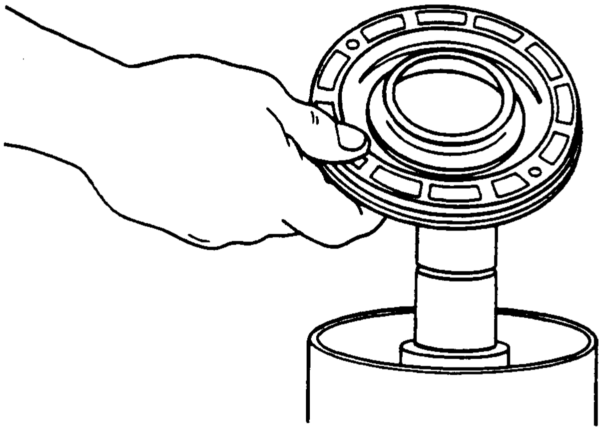
2. Remove the end plate.



3. Remove the inner and outer clutch discs. Compress the return spring retainer and remove the retainer ring.



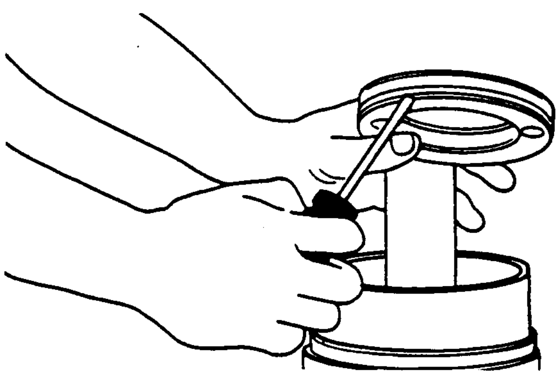
4. Remove the spring retainer and return spring.



5. Remove the clutch piston.

Assembly.

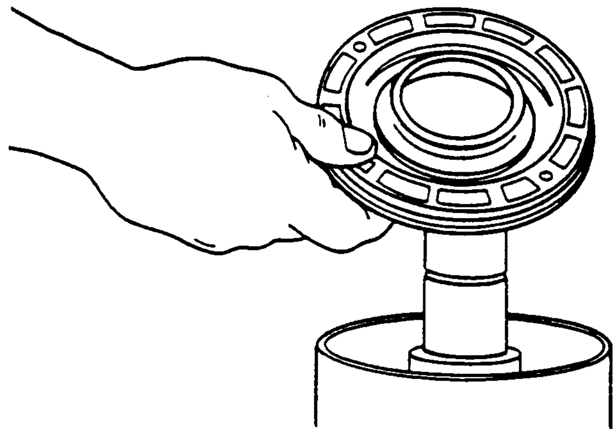
3rd AND 4th CLUTCH.



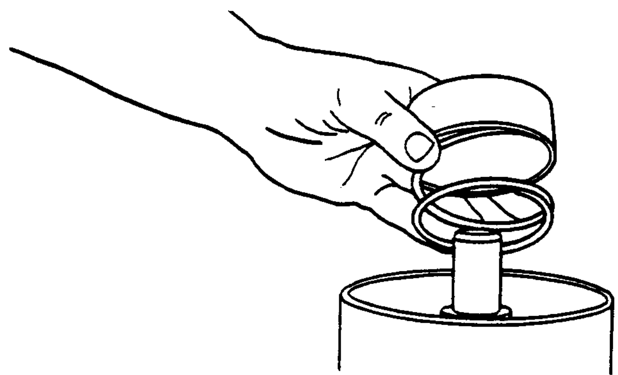
NOTE

Ring must be sized before installing in clutch drum. Sizing is best accomplished by rotating piston while holding a round object against the new seal ring as shown. Rotate piston until seal ring is flush with outer diameter of piston.

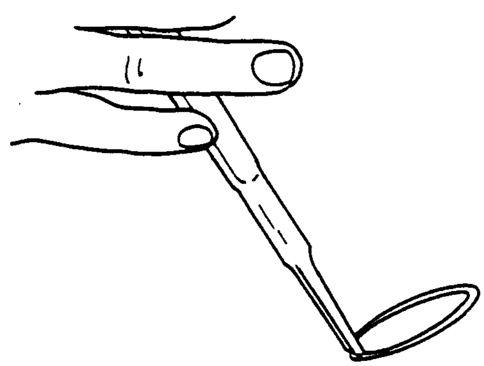
1. Install the clutch piston outer and inner seal rings.



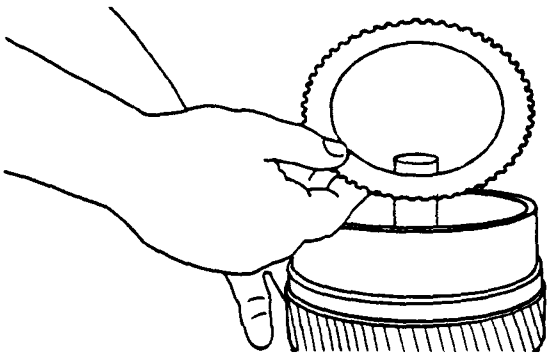
2. Install the clutch piston in the clutch drum. Use caution as not to damage the seal rings.



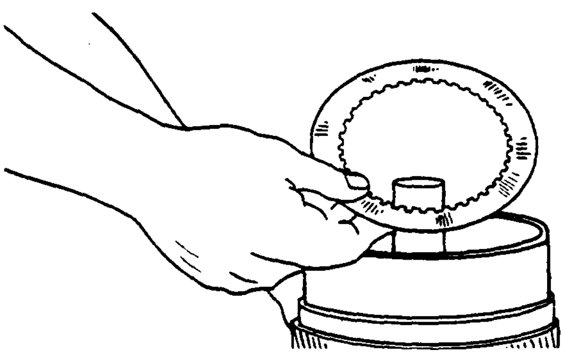
3. Position the piston return spring and spring retainer on the clutch shaft.



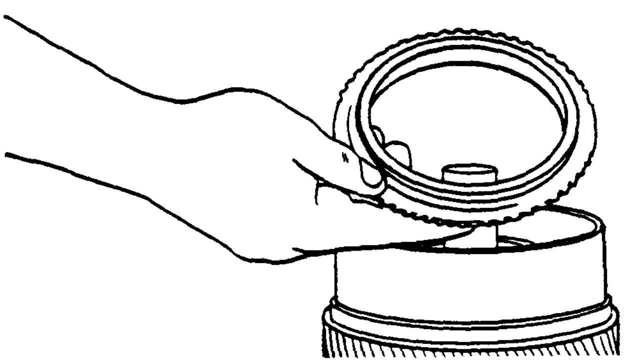
4. Compress the return spring and install the retainer ring.



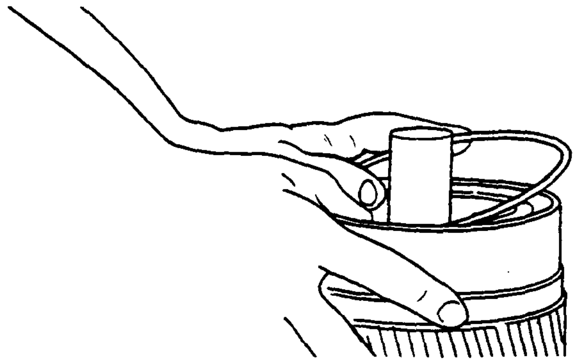
5. Install one steel disc.



6. Install one friction disc. Alternate steel and friction discs until the proper amount of discs are installed. First disc next to the piston is steel, last disc installed is friction.

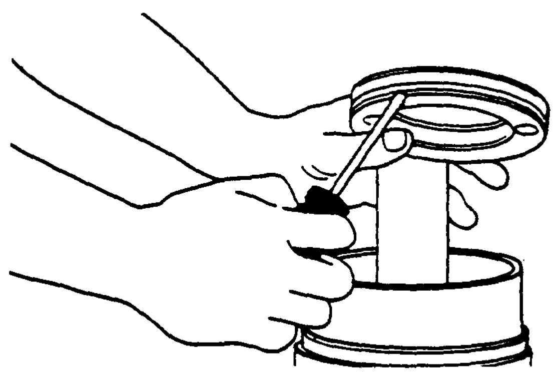


7. Install the clutch disc end plate.



8. Install the end plate retainer ring.

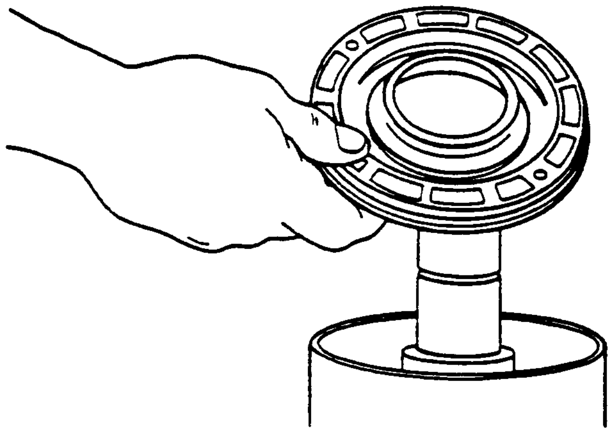
REVERSE.



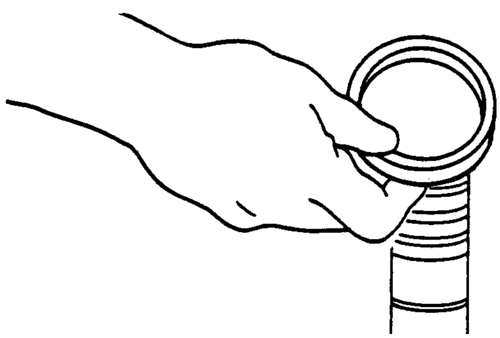
NOTE

Ring must be sized before installing in clutch drum. Sizing is best accomplished by rotating piston while holding a round object against the new seal ring as shown. Rotate piston until seal ring is flush with outer diameter of piston.

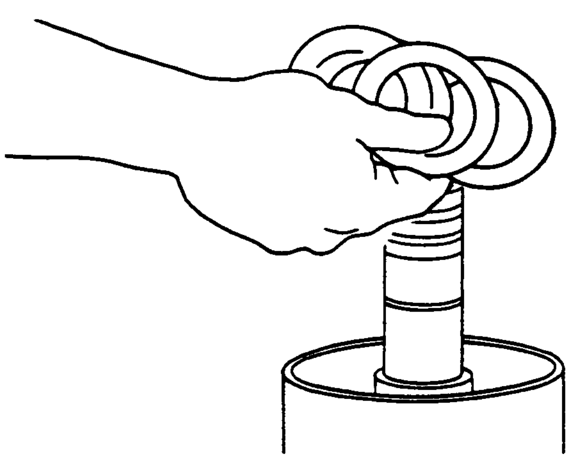
1. Install clutch piston outer and inner seal rings.



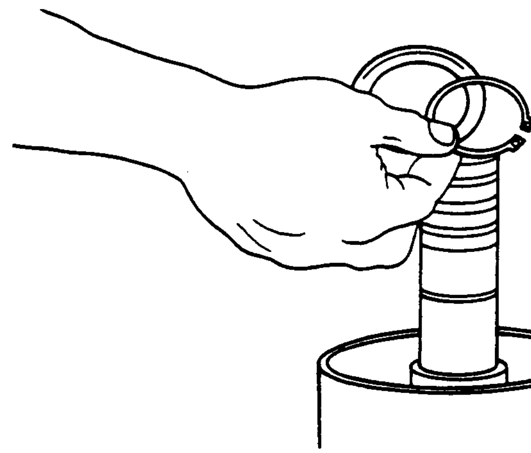
2. Install clutch piston in clutch drum. Use caution as not to damage seal rings.



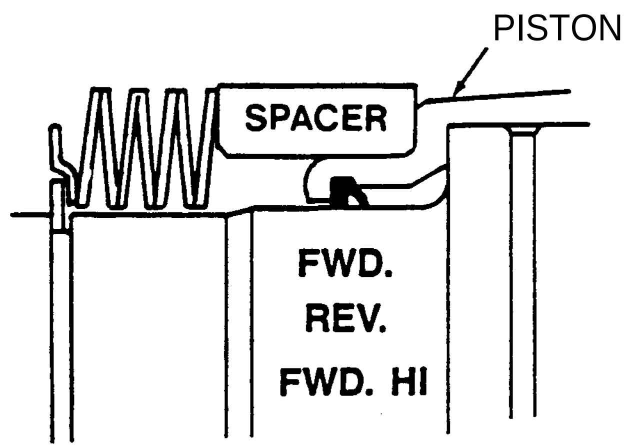
3. Position the piston return spring spacer over the clutch shaft.

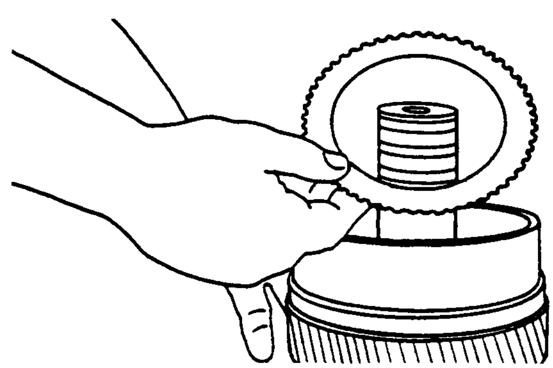


4. Install the Belleville washers, first washer with large diameter toward spacer. Alternate seven (7) washers.

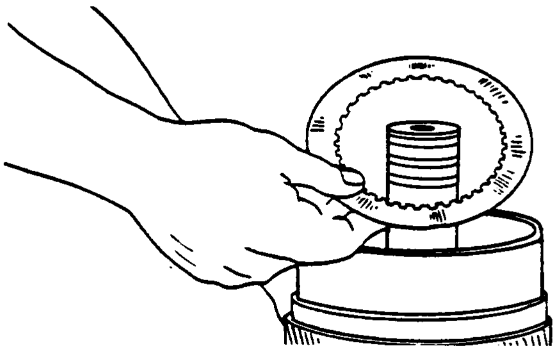


5. Install the piston return spring retainer ring retainer and retainer ring on the clutch shaft. Compress the return springs and install the retainer ring. Be sure the ring is in full position in the retainer.

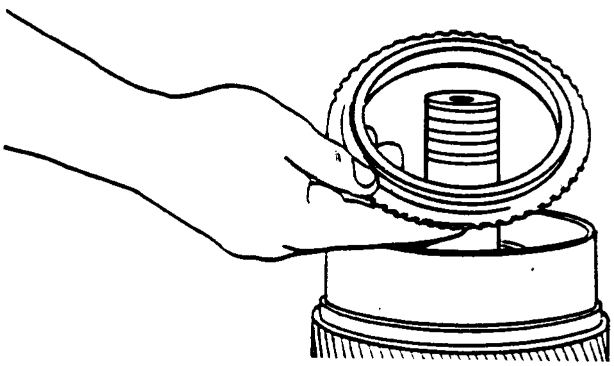




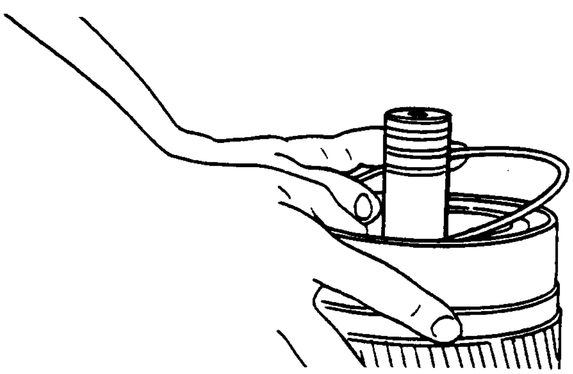
6. Install one steel disc.



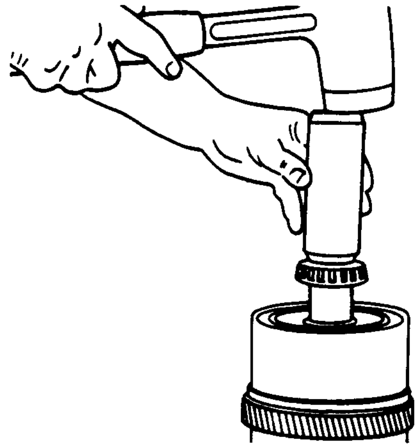
7. Install one friction disc. Alternate steel and friction discs until the proper amount of discs are installed. First disc next to the piston is steel, last disc installed is friction.



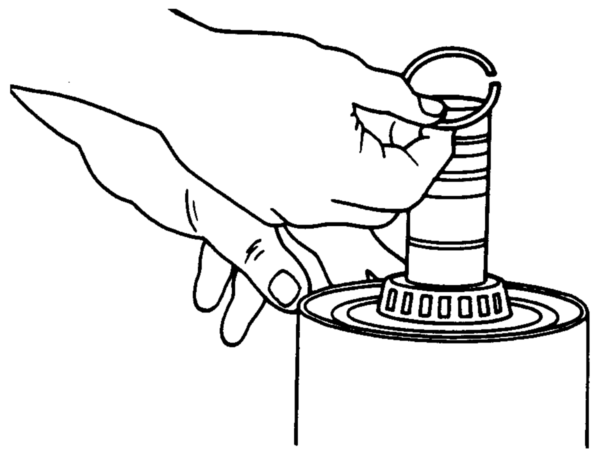
8. Install the clutch disc end plate.



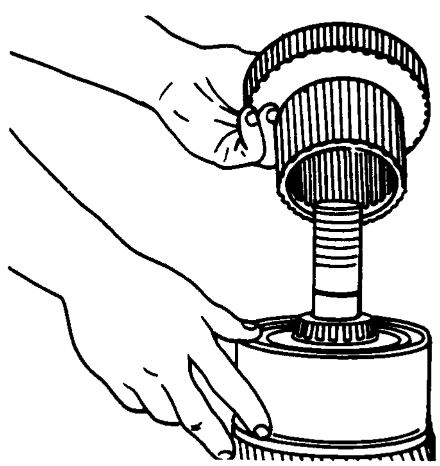
9. Install the end plate retainer ring.



10. Install the clutch gear inner taper bearing, small diameter of the taper up.

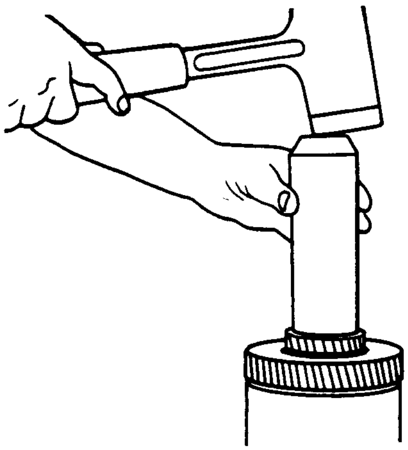


11. Position the taper bearing spacer on shaft.

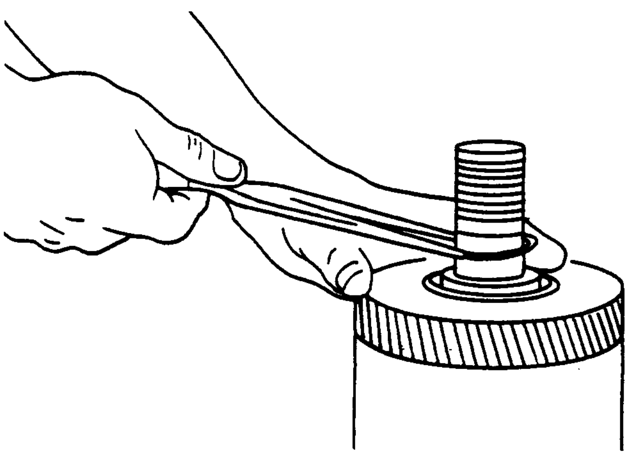


12. Install the reverse gear into the clutch drum. Align the splines on the reverse gear with the

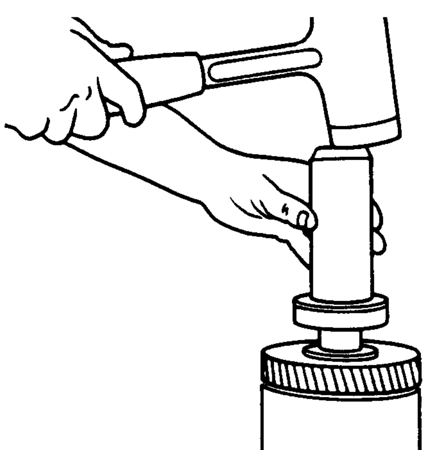
internal teeth of the friction discs. Do not force this operation. The gear splines must be in full position with the internal teeth of all friction discs.



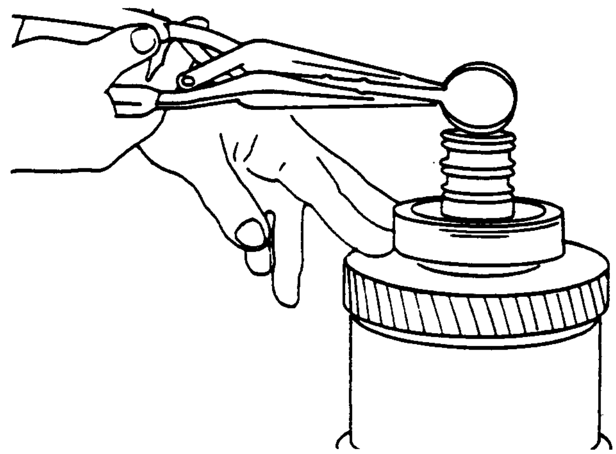
13. Install the outer taper bearing, large diameter of taper up.



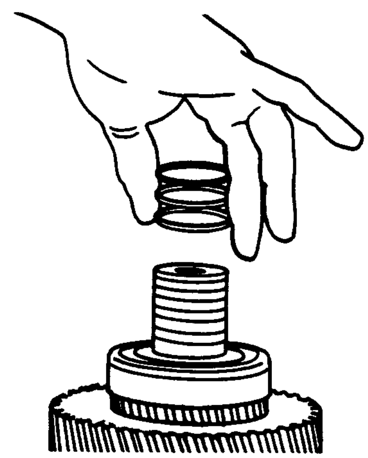
14. Install the bearing retainer ring.



15. Install the clutch shaft front bearing with the bearing locating ring groove up.



16. Install the bearing retainer ring.

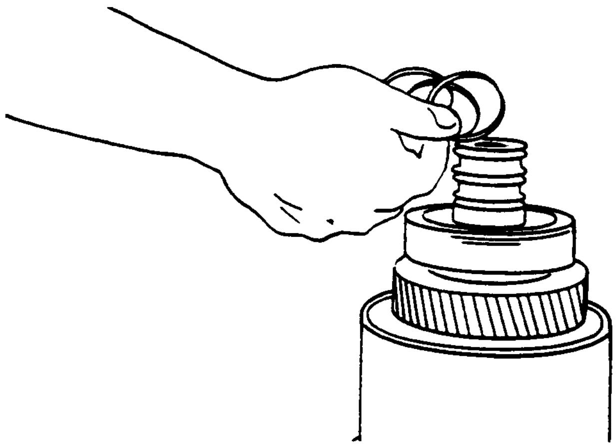


17. Install the clutch shaft oil sealing rings. Grease the rings to facilitate reassembly into the front housing.

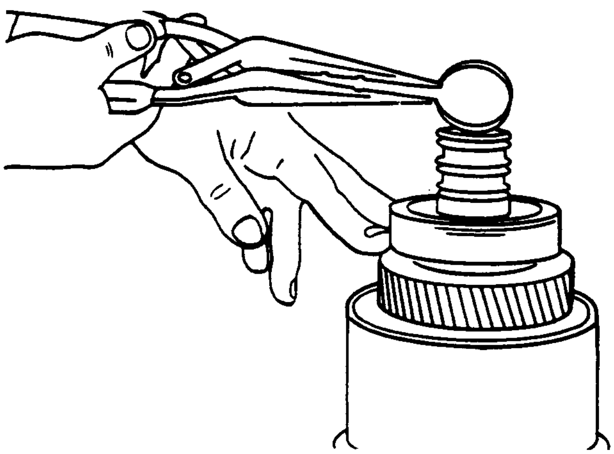
FORWARD HIGH AND 5th AND 6th CLUTCH.

Disassembly.

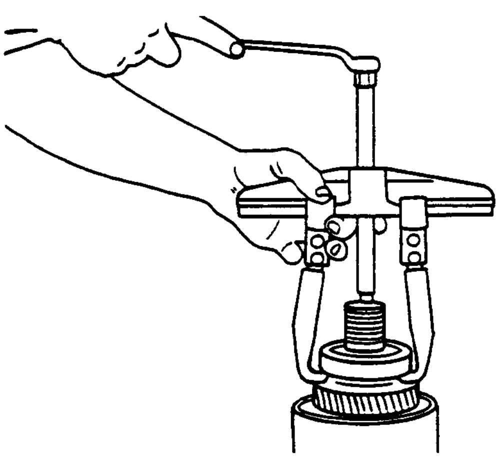
FORWARD HIGH.



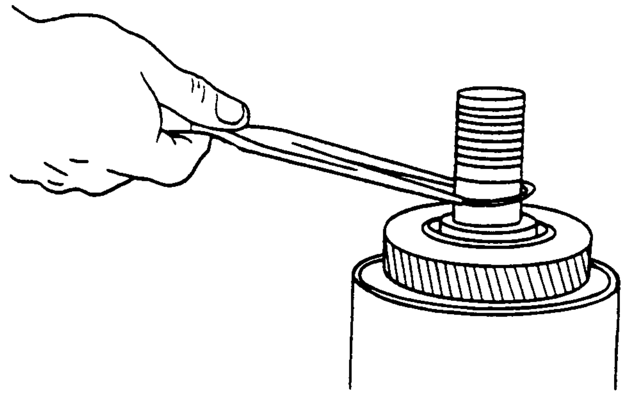
1. Remove the clutch shaft oil sealing rings.



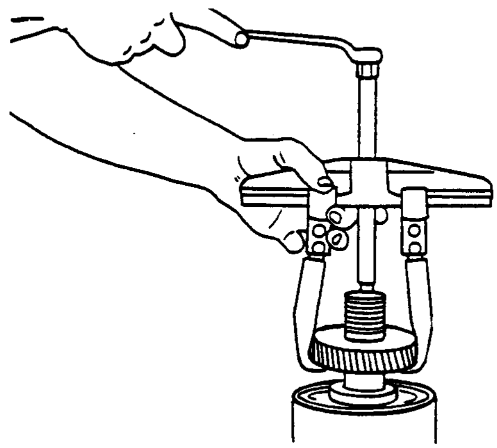
2. Remove the front bearing retainer ring.



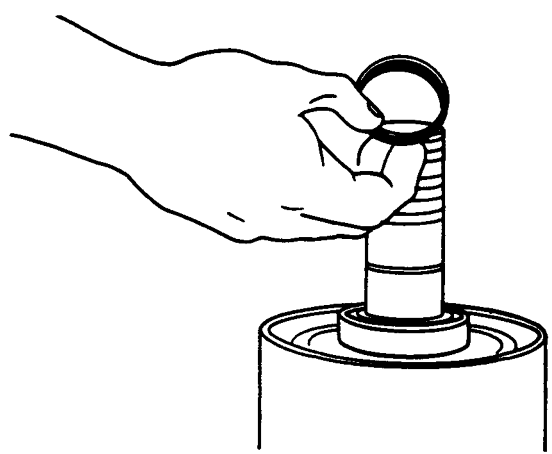
3. Remove the front bearing.



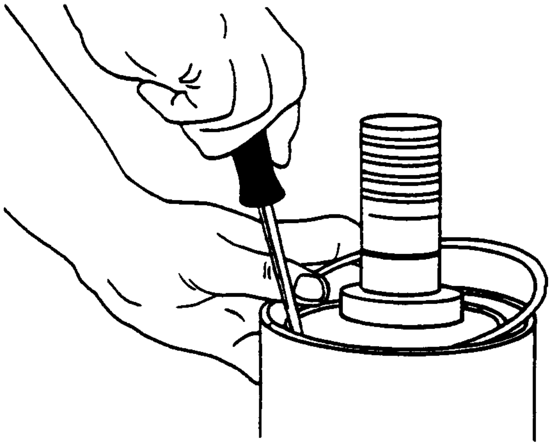
4. Remove the clutch gear bearing retainer ring.



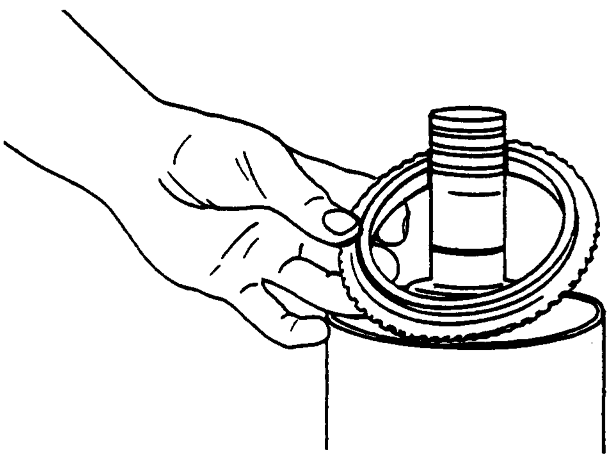
5. Remove the clutch gear and outer bearing.



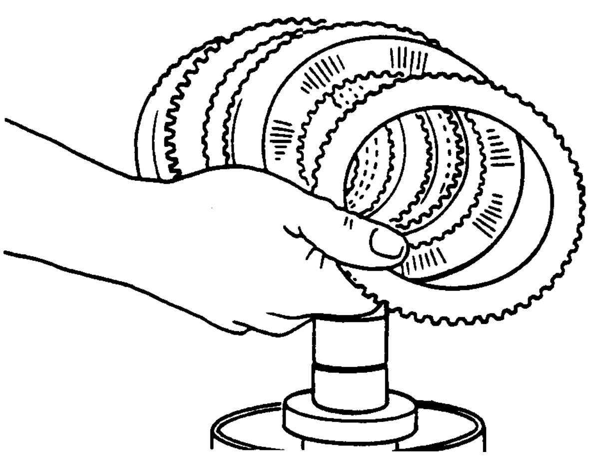
6. Remove the bearing spacer.



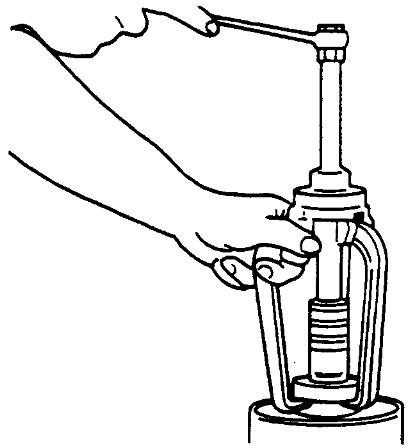
7. Remove the end plate retainer ring.



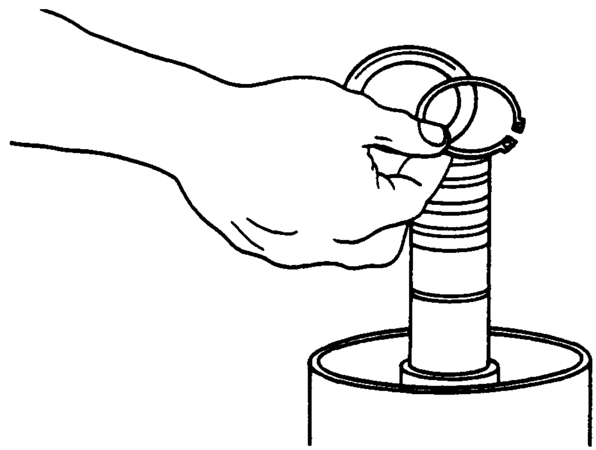
8. Remove the end plate.



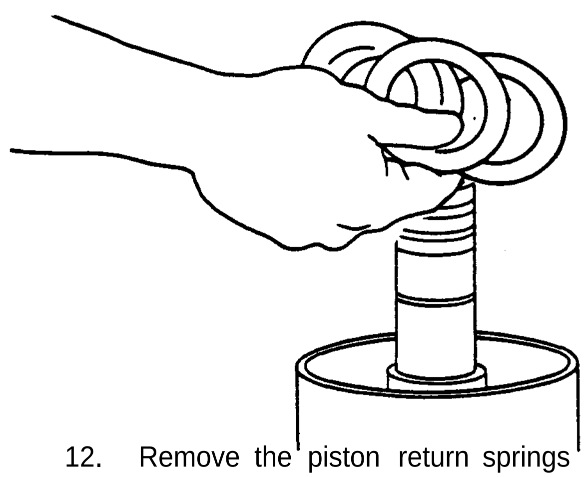
9. Remove the inner and outer clutch disc.



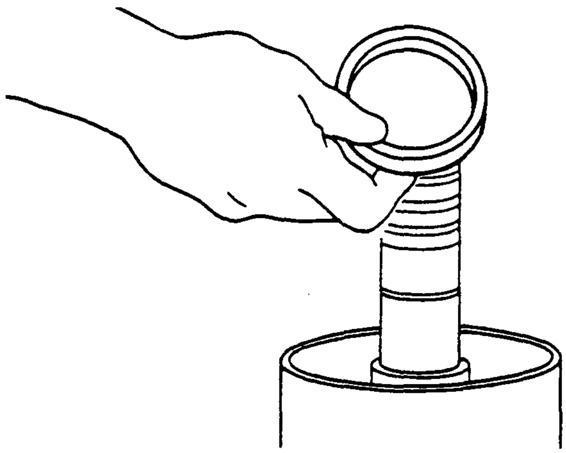
10. Remove the clutch gear inner bearing.



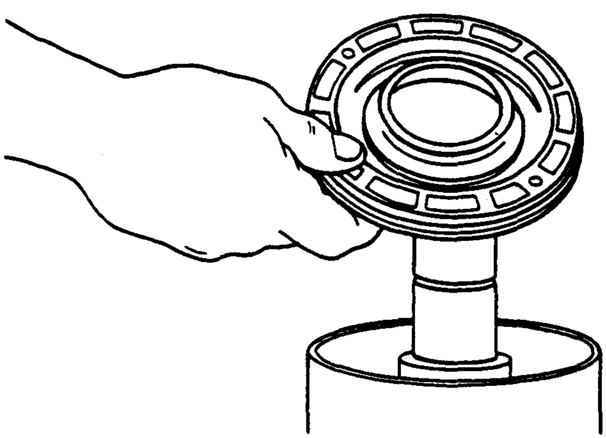
11. Compress the piston return springs (Belleville washers). Remove the spring retainer ring and ring retainer.



12. Remove the piston return springs (Belleville washers).

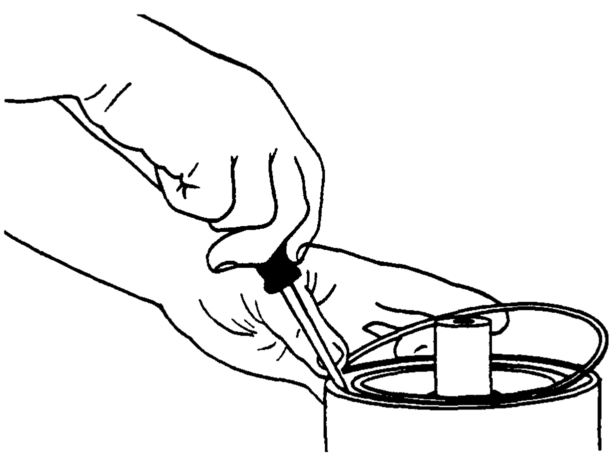


13. Remove the piston spacer.

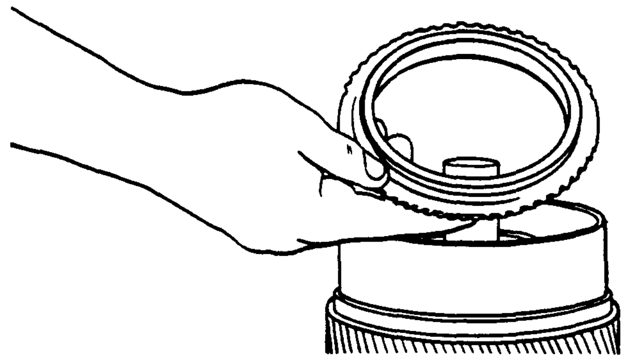


14. Remove the piston.

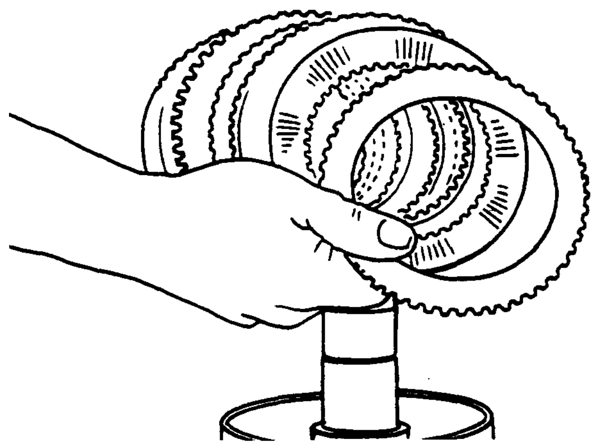
5th AND 6th CLUTCH.



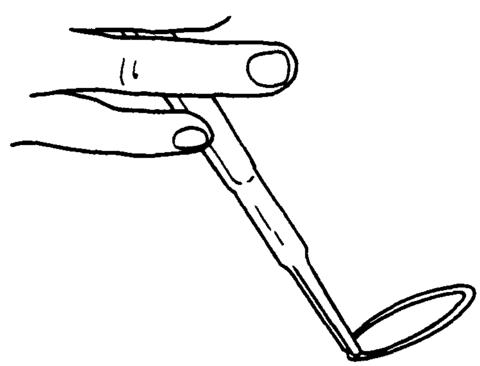
1. Remove end plate retainer ring.



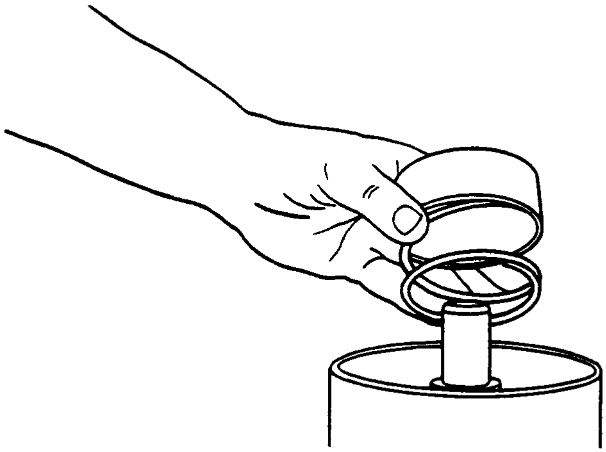
2. Remove the end plate.



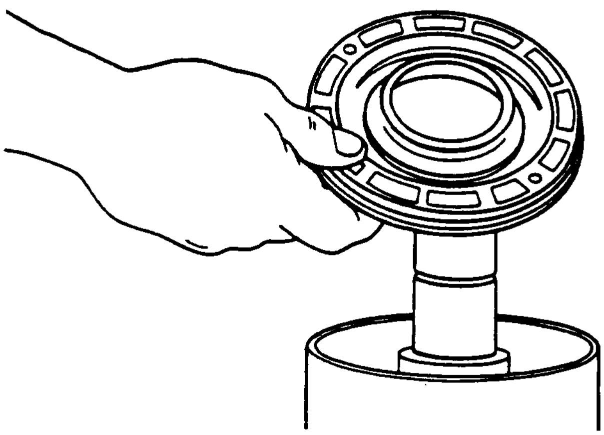
3. Remove the inner and outer clutch discs.



4. Compress the piston return spring retainer. Remove the retainer ring.



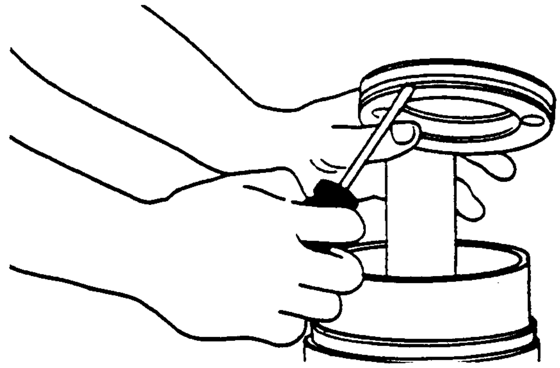
5. Remove the spring retainer and return spring.



6. Remove the clutch piston.

Assembly.

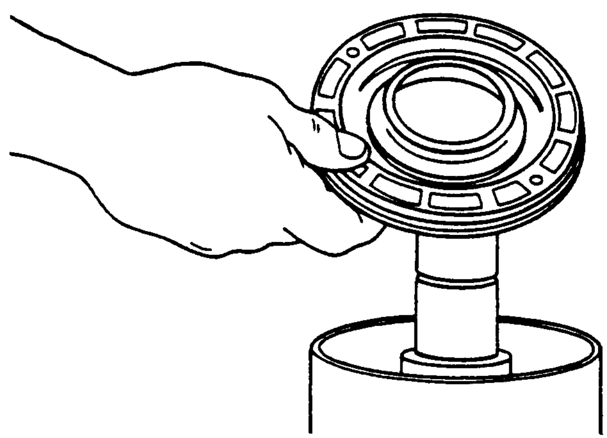
5th AND 6th CLUTCH.



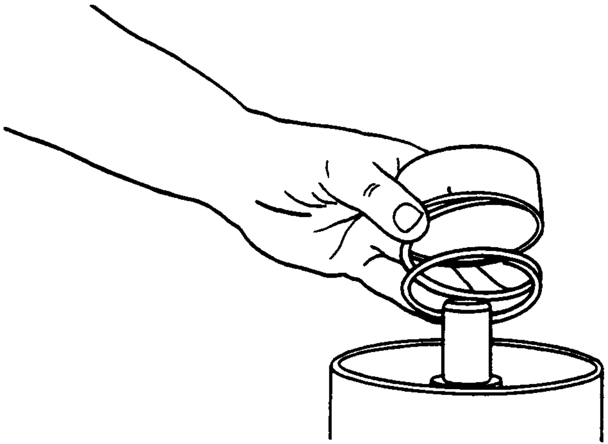
NOTE

Ring must be sized before installing in clutch drum. Sizing is best accomplished by rotating piston while holding a round object against the new seal ring as shown. Rotate piston until seal ring is flush with outer diameter of piston.

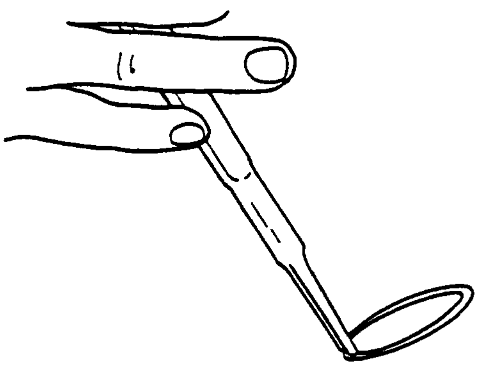
1. Install the clutch piston inner and outer seal rings.



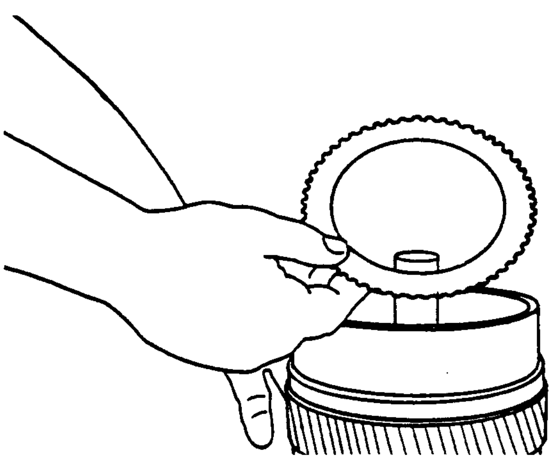
2. Install the clutch piston in the clutch drum. Use caution as not to damage the seal rings.



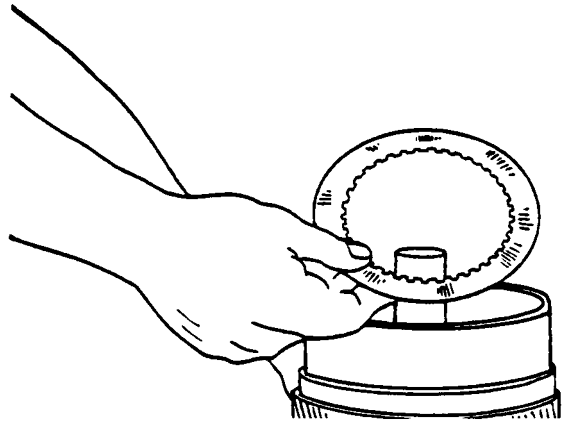
3. Position the piston return spring and spring retainer on the clutch shaft.



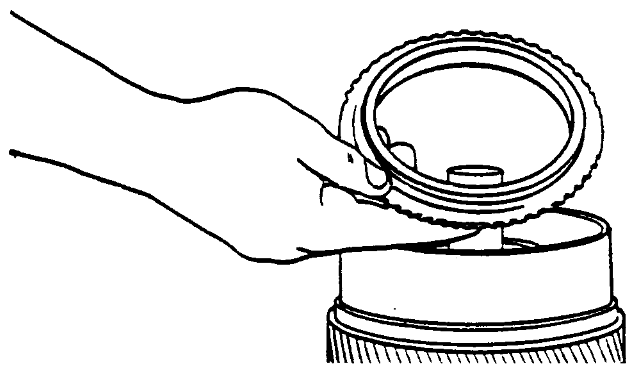
4. Compress the return spring and install the spring retainer ring



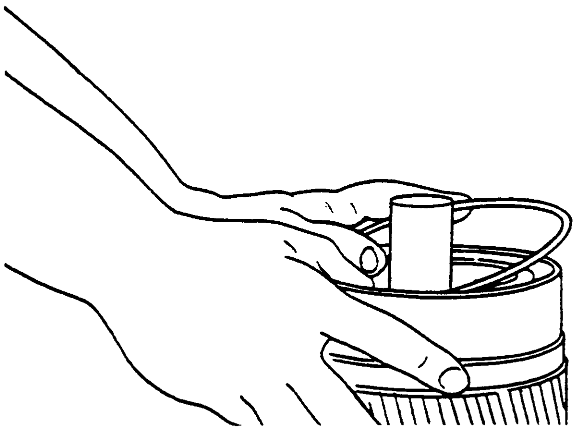
5. Install one steel disc.



6. Install one friction disc. Alternate steel and friction discs until the proper amount of discs are installed. First disc next to the piston is steel, last disc installed is friction. Install the end plate and snap ring.

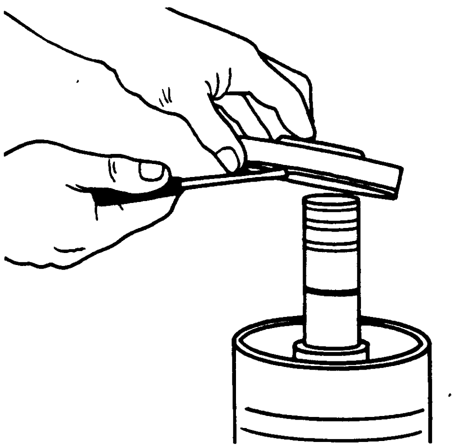


7. Install the clutch disc end plate.



8. Install the end plate retainer ring.

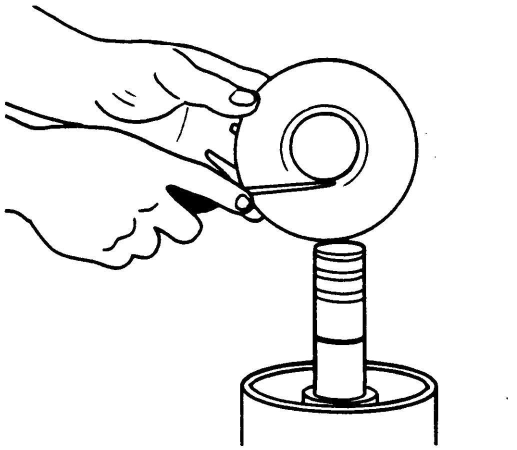
FORWARD HIGH.



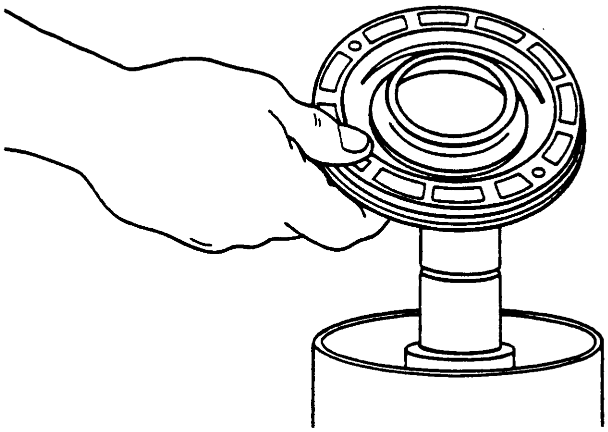
NOTE

Ring must be sized before installing in clutch drum. Sizing is best accomplished by rotating piston while holding a round object against the new seal ring as shown. Rotate piston until seal ring is flush with outer diameter of piston.

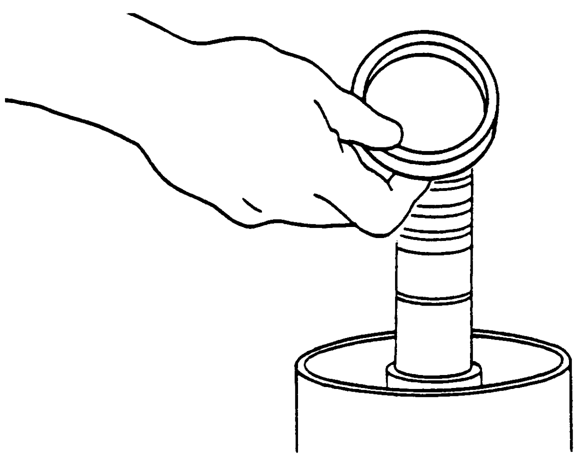
1. Install the clutch piston outer seal rings.



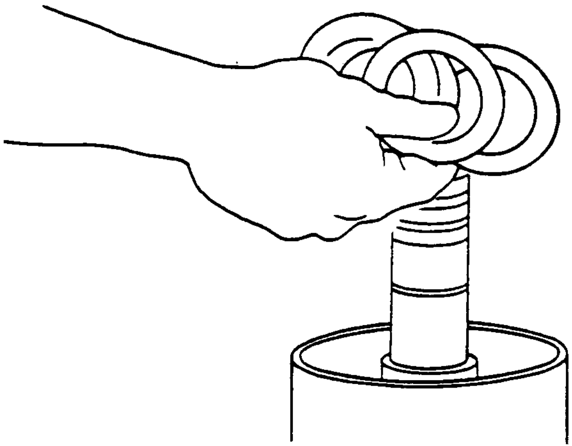
2. Install the clutch piston inner seal rings.



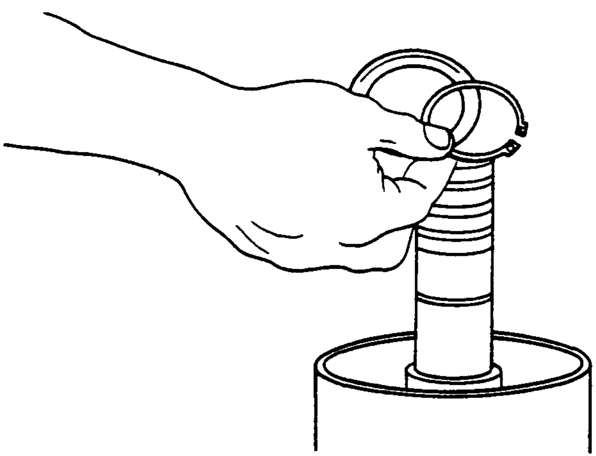
3. Install the clutch piston in the clutch drum. Use caution as not to damage seal rings.



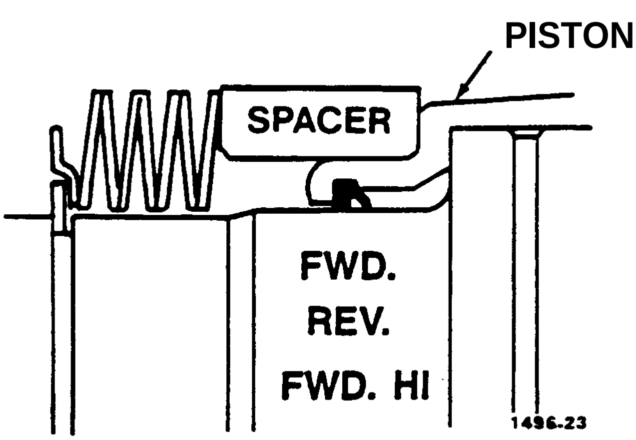
4. Position the piston return spring spacer over the clutch shaft.

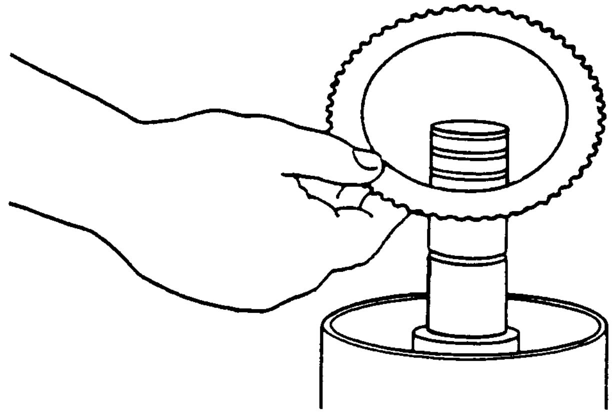


5. Install the Belleville washers. First washer with large diameter toward spacer. Alternate seven (7) washers.

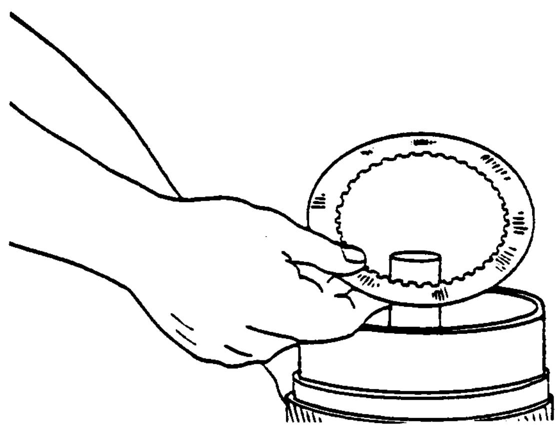


6. Install the piston return spring retainer ring retainer and the retainer ring on the clutch shaft. Compress the return springs and install the retainer ring. Be sure the ring is in full position in the retainer.

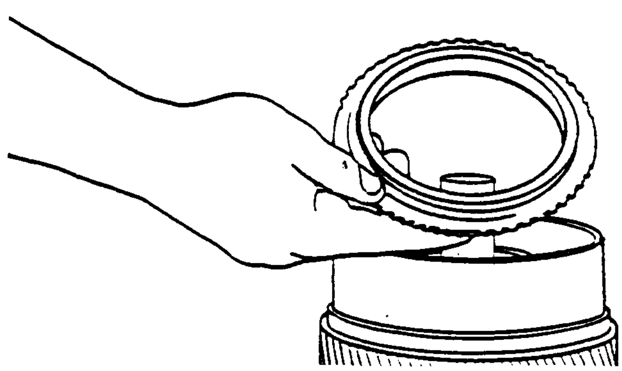




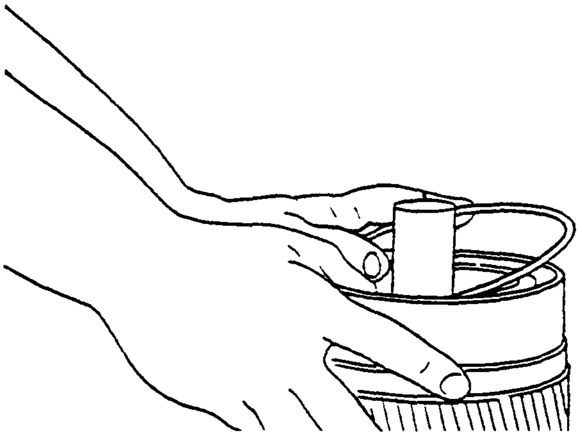
7. Install one steel disc.



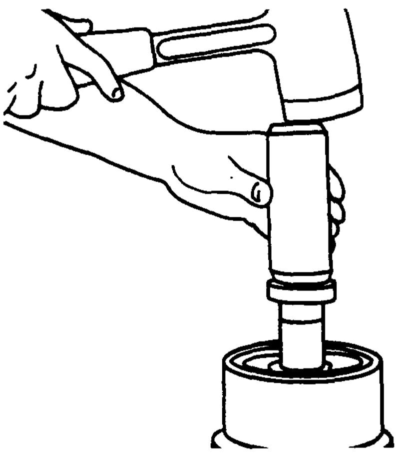
8. Install one friction disc. Alternate steel and friction discs until the proper amount of discs are installed. First disc next to the piston is steel, last disc installed is friction. Install the end plate and snap ring.



9. Install the clutch disc end plate.



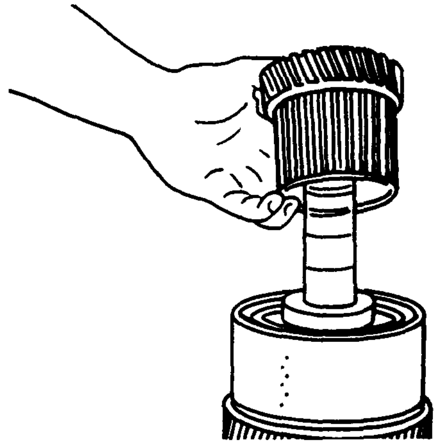
10. Install the end plate retainer ring.



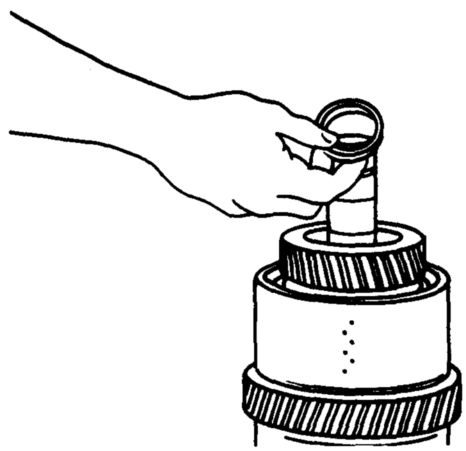
NOTE

This bearing does not have a shield in it.

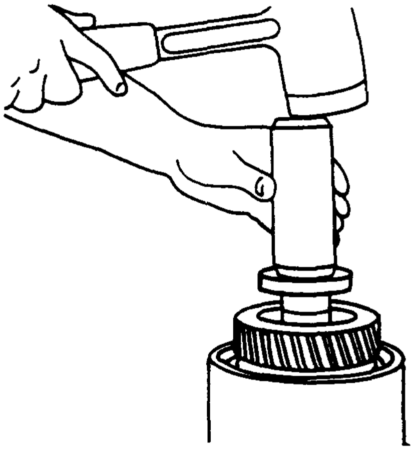
11. Install the clutch gear inner bearing.



12. Install the clutch driven gear and hub into the clutch drum. Align the splines on the clutch hub with the internal teeth of the friction discs. Tap the gear into position. Do not force this operation. Gear splines must be in full position with the internal teeth of all friction discs.



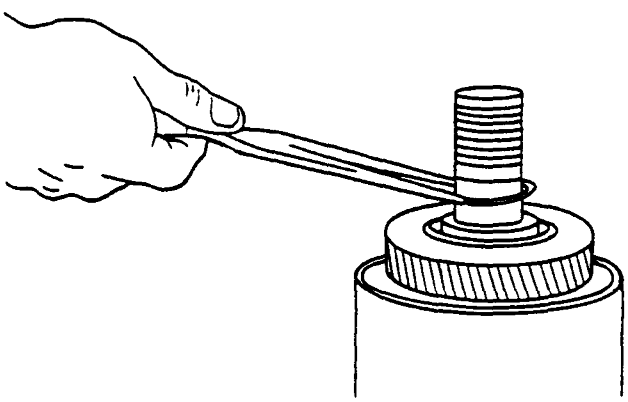
13. Install the clutch gear bearing spacer.



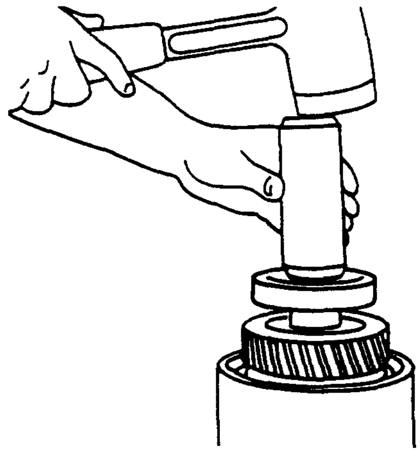
NOTE

The outer bearing has a shield in it. This shield must be up.

14. Install the clutch gear outer bearing.



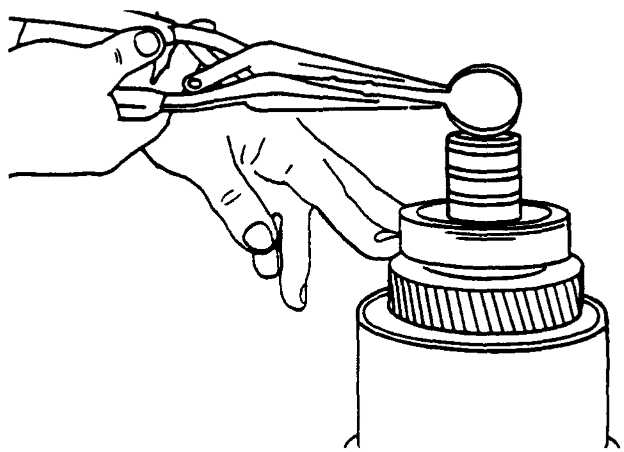
15. Install the bearing retainer ring.



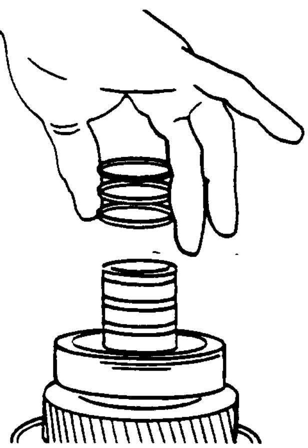
NOTE

The bearing outer diameter locating ring groove must be up.

16. Install the clutch shaft front bearing.



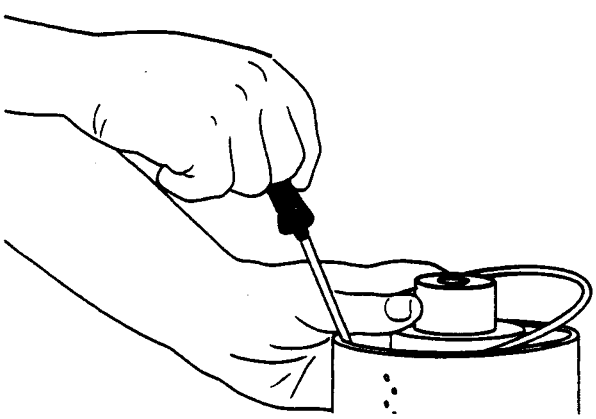
17. Install the bearing retainer ring.



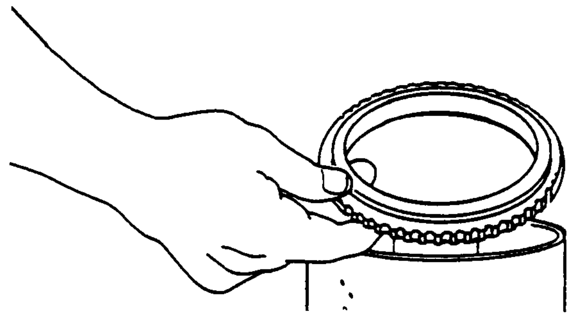
18. Install the clutch shaft oil sealing rings. Grease the rings to facilitate reassembly into front housing.

FORWARD CLTUCH.

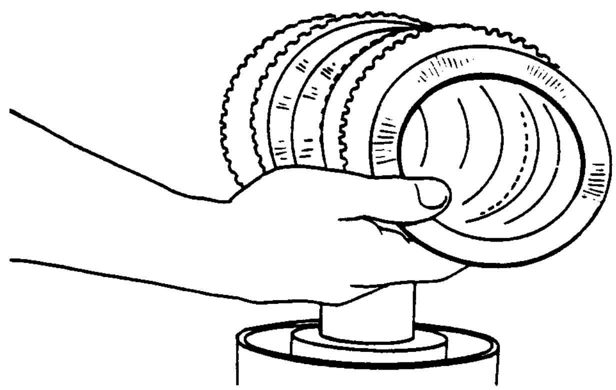
Disassembly.



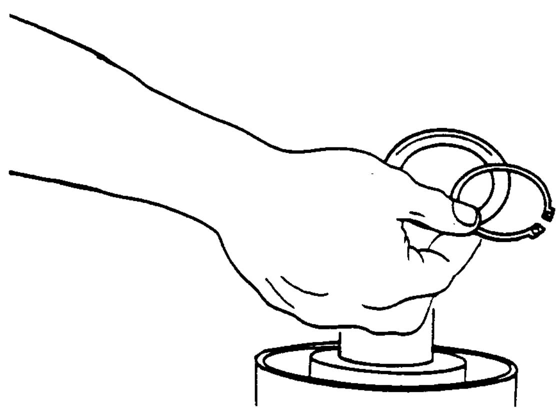
19. Remove the clutch disc end plate retainer ring.



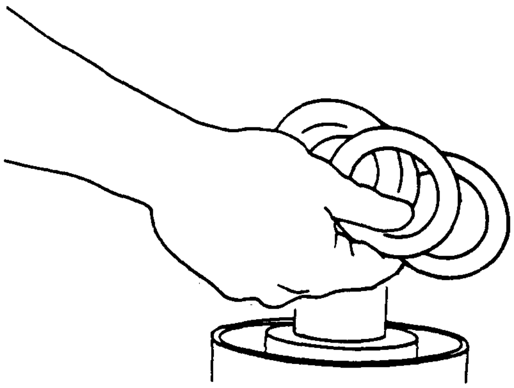
2. Remove the end plate.



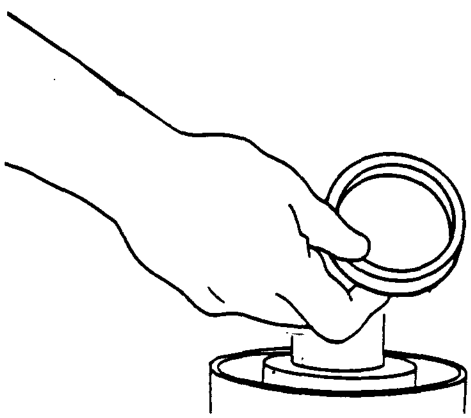
3. Remove the inner and outer clutch discs.



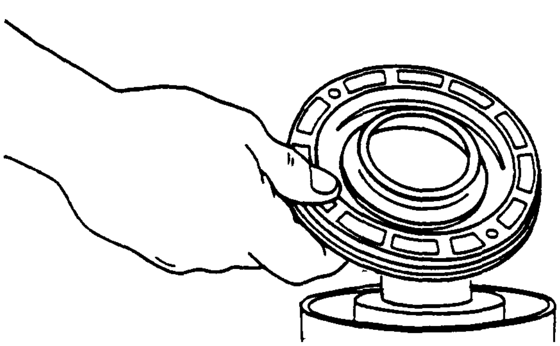
4. Compress the piston return spring (Belleville washers). Remove the return spring retainer ring and ring retainer.



5. Remove piston return springs. (Belleville washers)

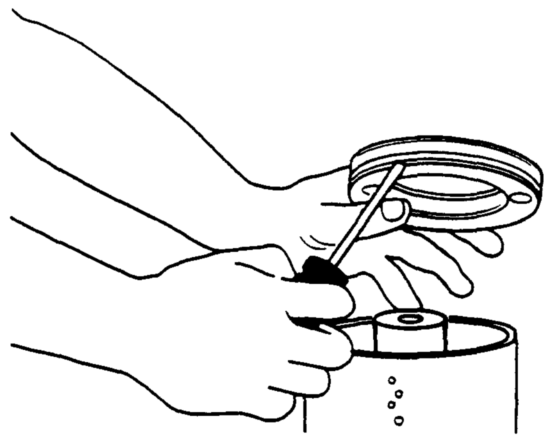


6. Remove the piston spacer.



7. Remove the clutch piston.

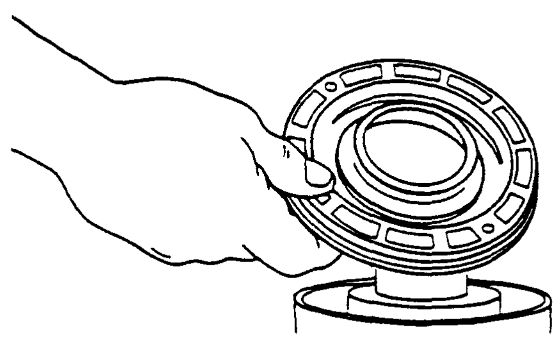
Assembly.



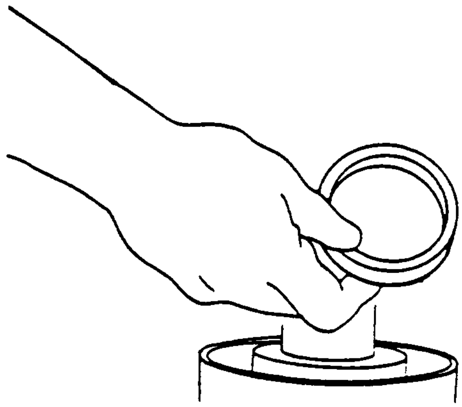
NOTE

Ring must be sized before installing in clutch drum. Sizing is best accomplished by rotating piston while holding a round object against the new seal ring as shown. Rotate piston until seal ring is flush with outer diameter of piston.

1. Install clutch piston outer and inner seal rings.

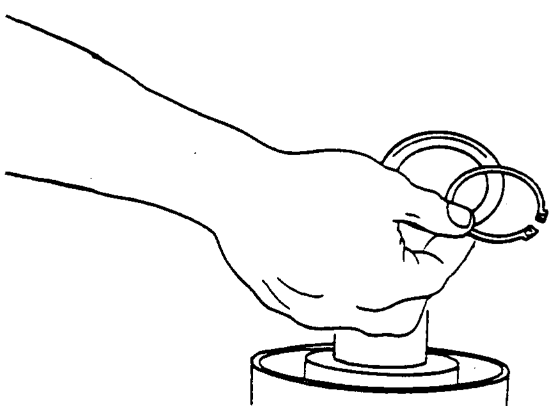


2. Install the clutch piston in the clutch drum. Use caution as not to damage the seal rings.

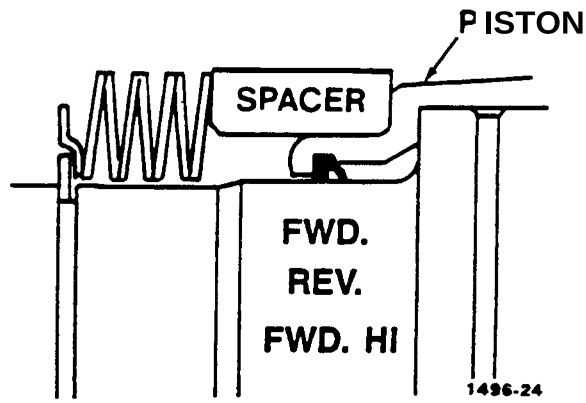


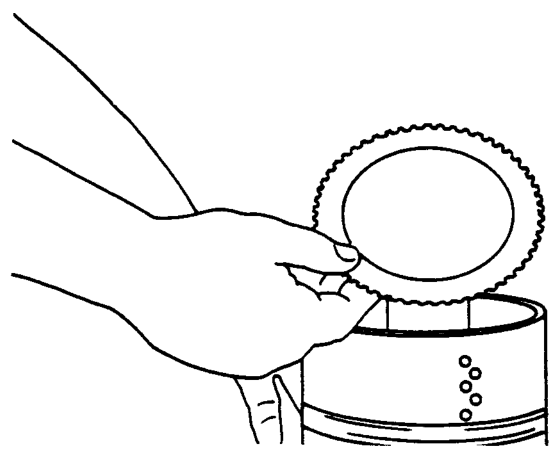
3. Position the piston return spring spacer over the clutch shaft.

4. Install the Belleville washers. First washer with large diameter toward spacer. Alternate seven (7) washers.

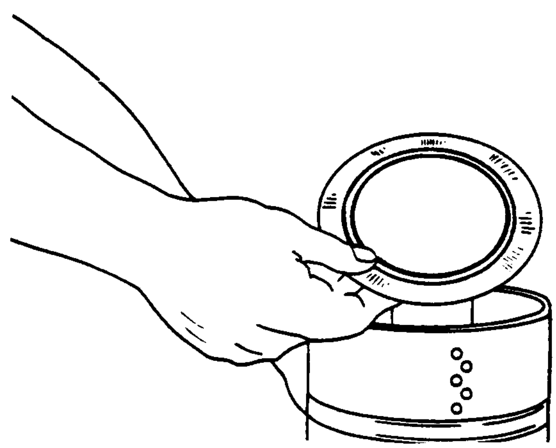


5. Install the piston return spring retainer ring retainer and retainer ring on the clutch shaft. Compress the return springs and install the retainer ring. Be sure the ring is in full position in the retainer.

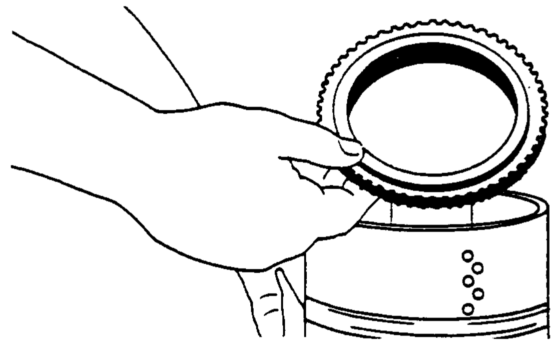




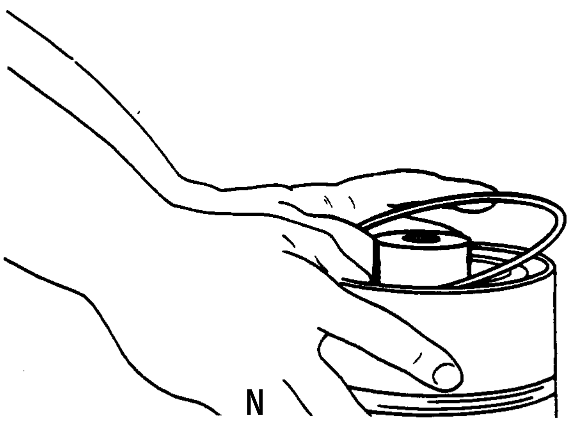
6. Install one steel disc.



7. Install one friction disc. Alternate steel and friction discs until the proper amount of discs are installed. First disc next to the piston is steel, last disc installed is friction.



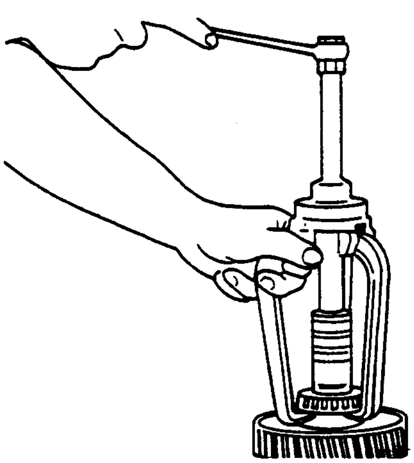
8. Install clutch disc end plate.



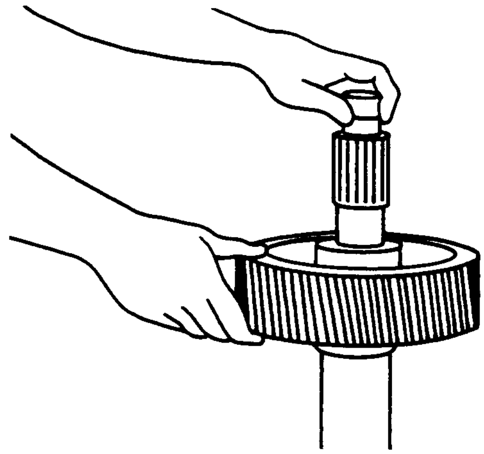
9. Install end plate retainer ring.

OUTPUT SHAFT.

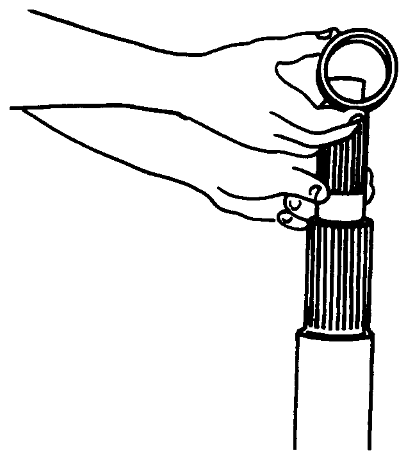
Disassembly.



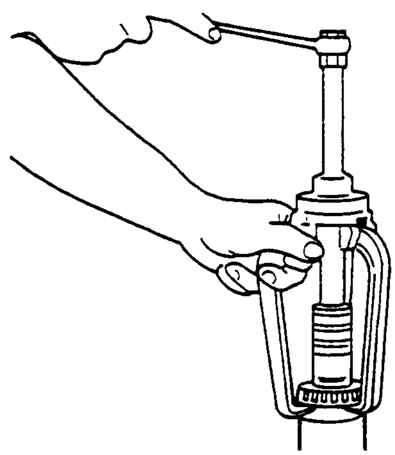
1. Remove the rear bearing.



2. Remove the output gear.

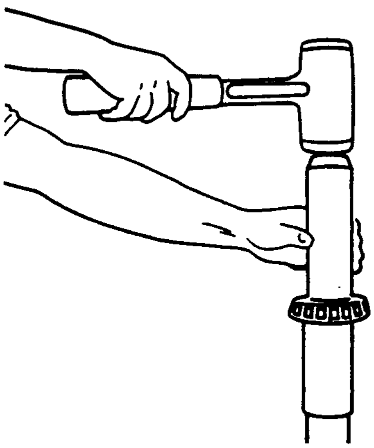


3. Remove the gear spacer.

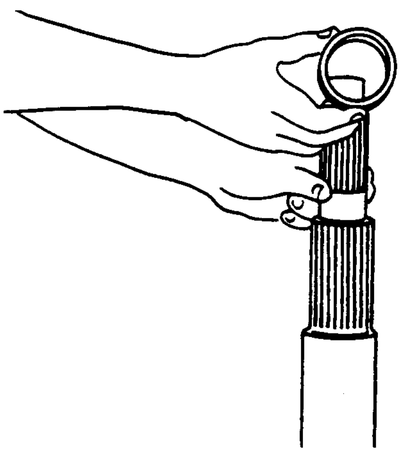


4. Remove the front bearing.

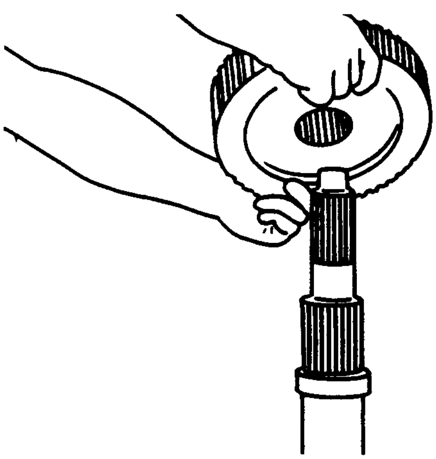
Assembly.



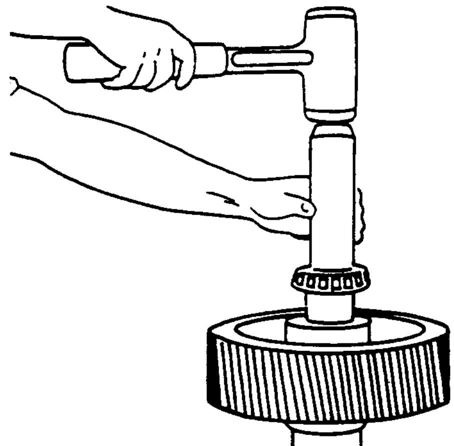
1. Install the output shaft front taper bearing, large diameter of the taper down.



2. Position the gear spacer on the output shaft.



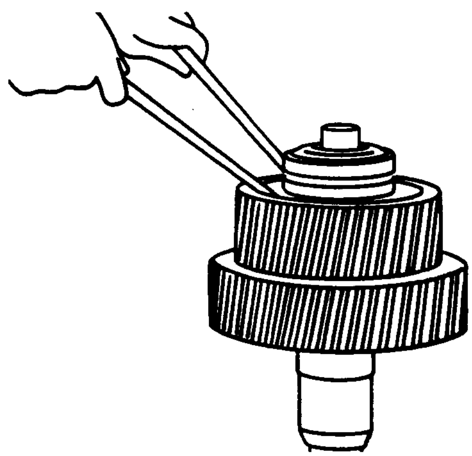
3. Position the output gear on the shaft with the long hub of the gear up.



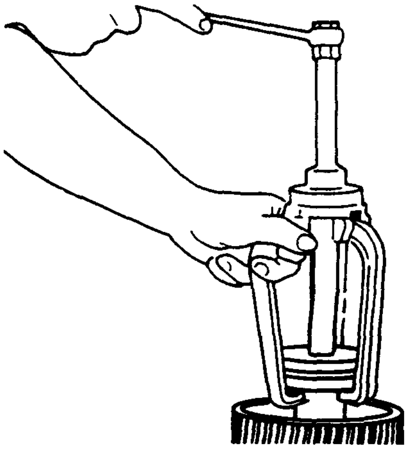
4. Install the output shaft rear taper bearing, large diameter of the taper down.

IDLER SHAFT.

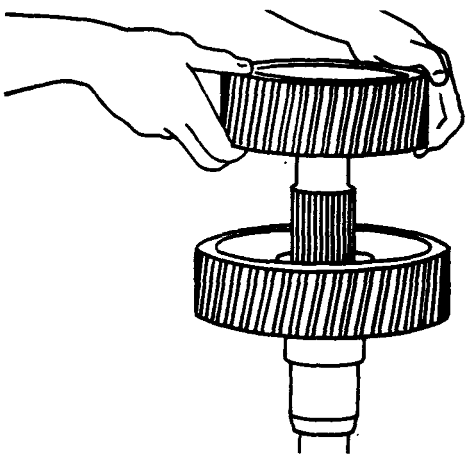
Disassembly



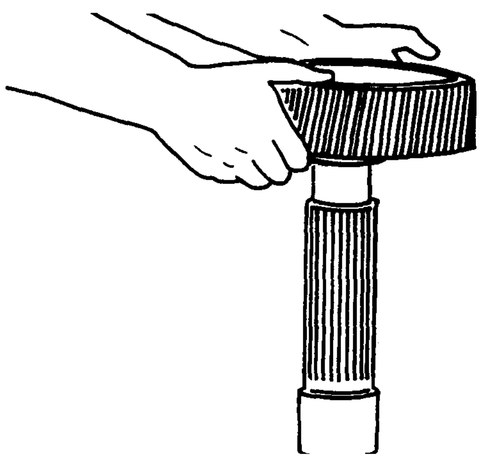
1. Pry the idler shaft rear bearing up far enough to use a bearing puller.



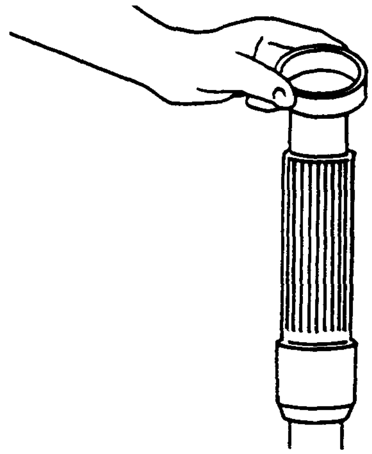
2. Remove the rear bearing.



3. Remove the small idler gear.

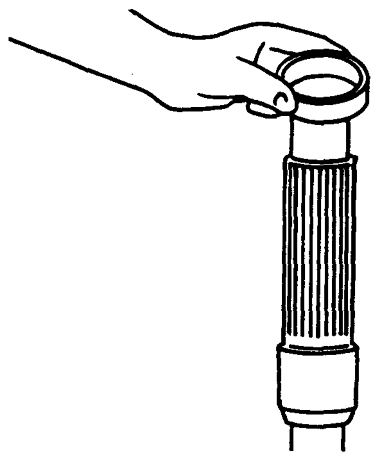


4. Remove the large idler gear.

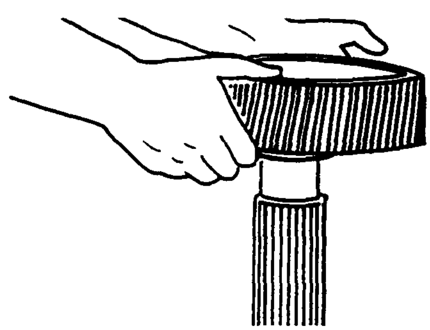


5. Remove the gear spacer.

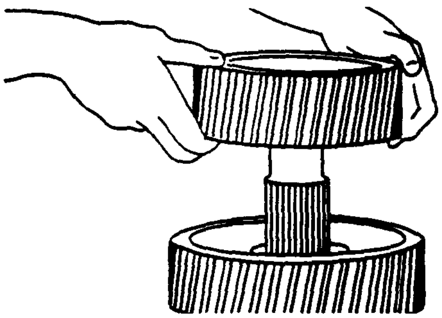
Assembly.



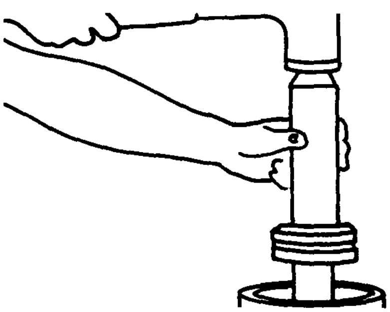
1. Position the gear spacer on the idler shaft.



2. Position the large idler gear on the shaft with the long hub on the gear down.



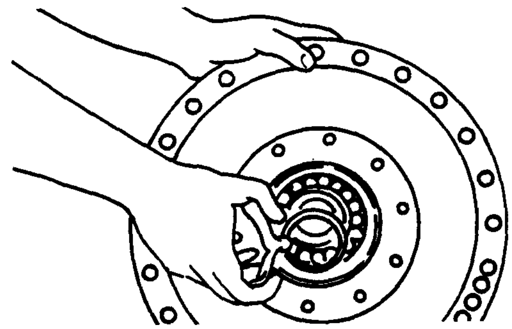
3. Position the small idler gear on the shaft with the long hub of the gear down.



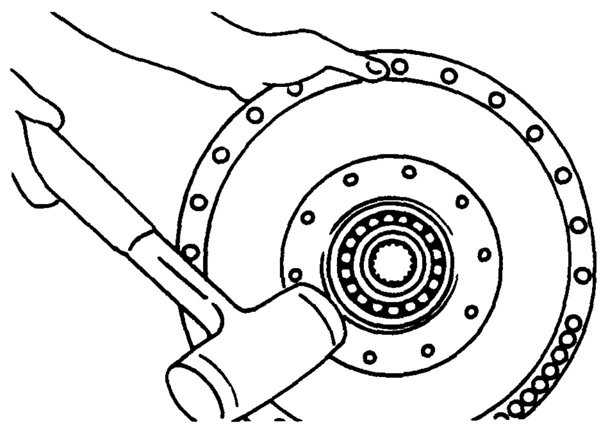
4. Install idler shaft rear bearing with bearing outer locating ring groove up.

IMPELLER COVER.

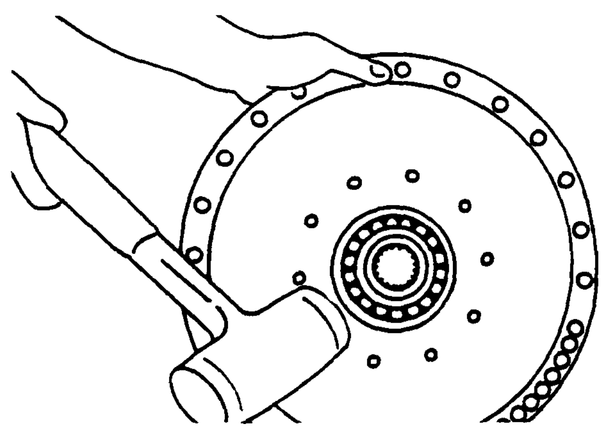
Disassembly.



1. Remove the turbine hub to impeller cover bearing retainer ring.

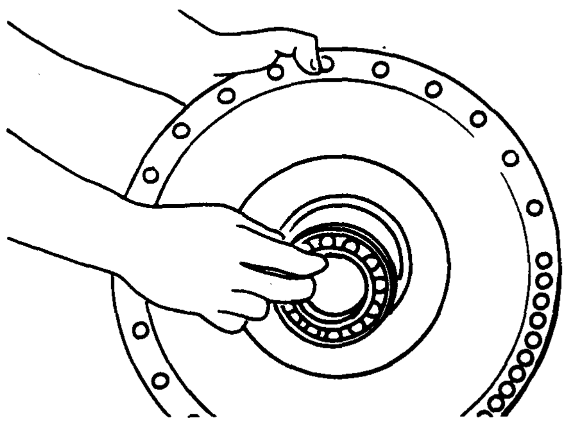


2. Tap the turbine and hub from the bearing.



3. Tap the impeller cover bearing from cover.

Assembly.



1. Install the impeller cover bearing in the cover with the bearing locating ring up.

NOTE

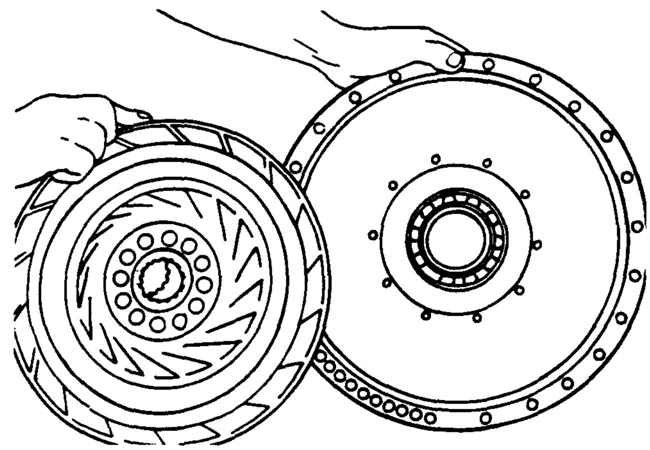
If the turbine or turbine hub was replaced or disassembled, the following steps must be used for reassembly.

2. Clean the hub mounting surface and tapped holes with solvent. Dry thoroughly being certain the tapped holes are dry and clean.

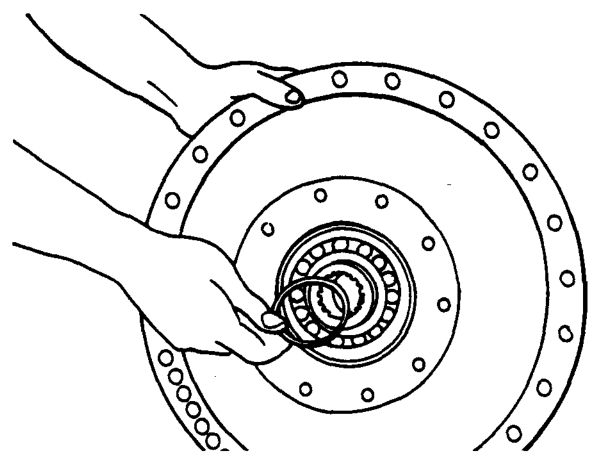
3. Install the backing ring and special screws to approximately .06 inch (1.5 mm) of seated position. With a calibrated torque wrench, tighten screws 37 to 41 lbs. ft. torque (5.0 to 5.5 kgm).

NOTE

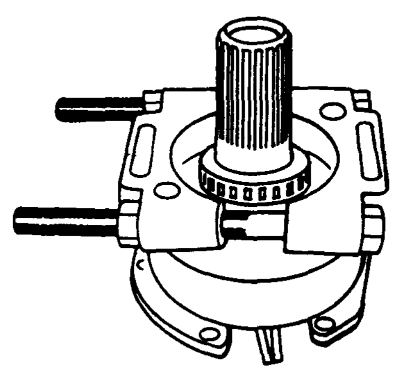
Assembly of the turbine hub must be completed within a fifteen minute period from start of screw installation. The screws are prepared with a coating which begins to harden after installation in the hub holes. If not tightened to proper torque within the fifteen minute period, insufficient screw clamping tension will result. The special screw is to be used for one installation only. If the screw is removed for any reason it must be replaced. The compound left in the hub holes must be removed with the proper tap and cleaned with solvent. Dry hole thoroughly and use a new screw for reinstallation.



4. Position the turbine assembly in the impeller cover.



5. Install the turbine hub to the impeller cover bearing retainer ring.



6. Remove the impeller hub bearing from the stator support as shown. Remove the support oil sealing ring and sealing ring expander spring.

SERVICING THE MACHINE AFTER TRANSMISSION OVERHAUL.

The transmission, torque converter, and its allied hydraulic system are important links in the drive line between the engine and the wheels. The proper operation of either unit depends greatly on the condition and operation of the other. Therefore. whenever repair or overhaul of one unit is performed, the balance of the system must be considered before the job can be considered completed.

After the overhauled or repaired transmission has been installed in the machine, the oil cooler, and connecting hydraulic system must be thoroughly cleaned. This can be accomplished in several manners and a degree of judgment must be exercised as to the method employed.

The following are considered the minimum steps to be taken.

1. Drain the transmission/torque converter system thoroughly.

2. Disconnect and clean all the hydraulic lines. Where it is feasible, hydraulic lines should be removed from the machine for cleaning.

3. Replace the converter oil filter elements, cleaning out the filter cases thoroughly.

4. The oil cooler must be thoroughly cleaned. The cooler should be back flushed with oil and compressed air until all foreign material has been removed. Flushing in the direction of normal oil flow will not adequately clean the cooler. If necessary, the cooler assembly should be removed from the machine for cleaning, using oil, compressed air, and a steam cleaner for that purpose.

5. On the remote mounted torque converter, remove the drain plug from the torque converter and inspect the interior of the converter housing, gears, etc. If the presence of considerable foreign material is noted, it will be necessary to remove, disassemble, and clean the converter thoroughly. It is realized this entails extra labor, however, such labor is a minor cost compared to the cost of difficulties which can result from the presence of foreign material in the system.

NOTE

If the dipstick is not accessible, oil level check plugs are provided.

6. Assemble all the components and use only the type oil recommended in the lubrication section. Fill the transmission through the filler opening until the fluid comes up to the LOW mark-on transmission dipstick.

Remove the LOWER check plug, and fill until oil runs from the LOWER oil hole. Replace the filler and level plug.

Run the engine two minutes at 500 to 600 rpm to prime the torque converter and hydraulic lines. Recheck the level of fluid in the transmission with the engine running at idle (500 to 600 rpm).

Add the quantity necessary to bring the fluid level to the LOW mark on the dipstick or runs freely from the LOWER oil level check plug hole. Install the oil level plug or the dipstick. Recheck with hot oil, 180 to 200 degrees F (82.2 to 93.3 degrees C).

Bring the oil level to the FULL mark on the dipstick or runs freely from the UPPER oil level plug.

7. Recheck all drain plugs, lines, connections. etc., for leaks and tighten where necessary.

TOWING OR PUSH STARTING.

CAUTION

Before towing the vehicle, disconnect both front and rear drive lines to avoid damage to crane.

NOTE

Because of the design of the hydraulic system the engine cannot be started by pushing or by towing. Refer to TM 5-3810-307-10.

TORQUE CONVERTER WITH LOCK-UP

TABLE OF CONTENTS

Page

LIST OF FIGURES

Title **Page**

DESCRIPTION

NOTE

This package must be used in conjunction with SM02-025-0, TRANSMISSION/ TORQUE CONVERTER.

NOTE

Descriptive information and a theory of operation can be found in SM02-025-0, TRANSMISSION/TORQUE CONVERTER.

MAINTENANCE

NOTE

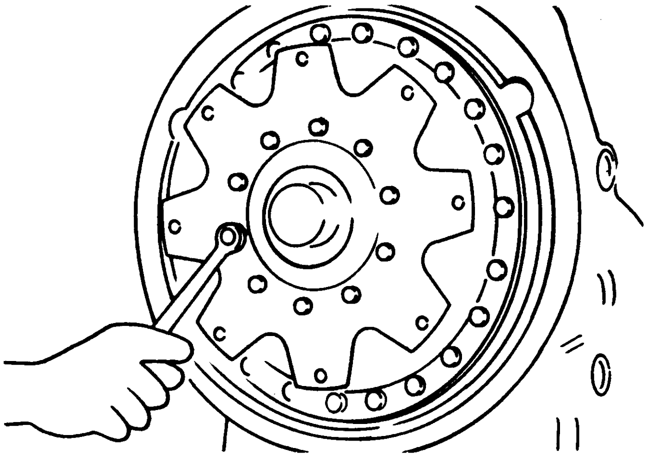
Troubleshooting procedures can be found in SM02-025-0, TRANSMISSION/TORQUE CONVERTER.

CAUTION

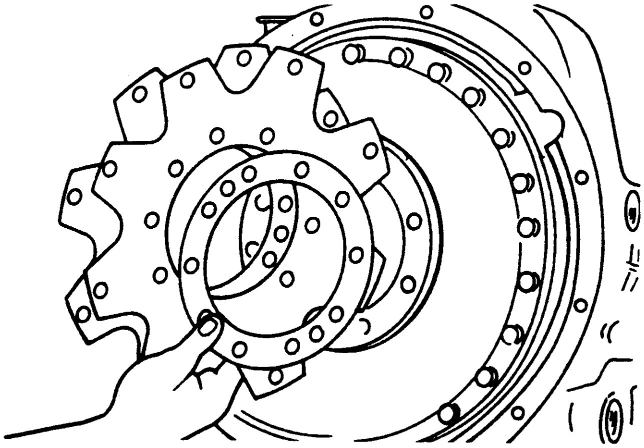
Cleanliness is of extreme importance and an abosolute must in the repair and overhaul of this unit. Before attempting any repairs, the exterior of the unit must be thoroughly cleaned to prevent the possibility of dirt and foreign matter entering the mechanism.

DISASSEMBLY.

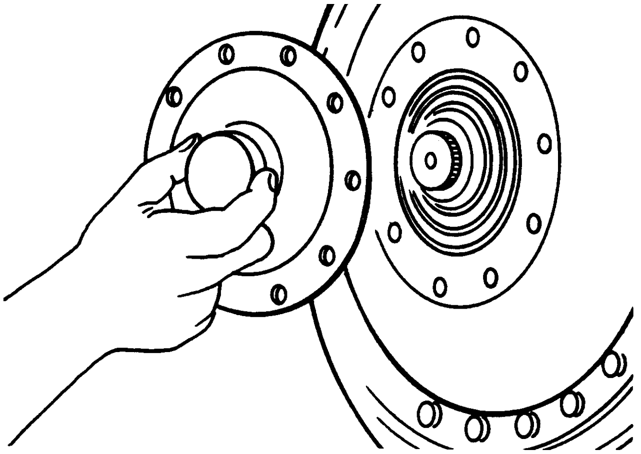
Torque Converter Assembly.



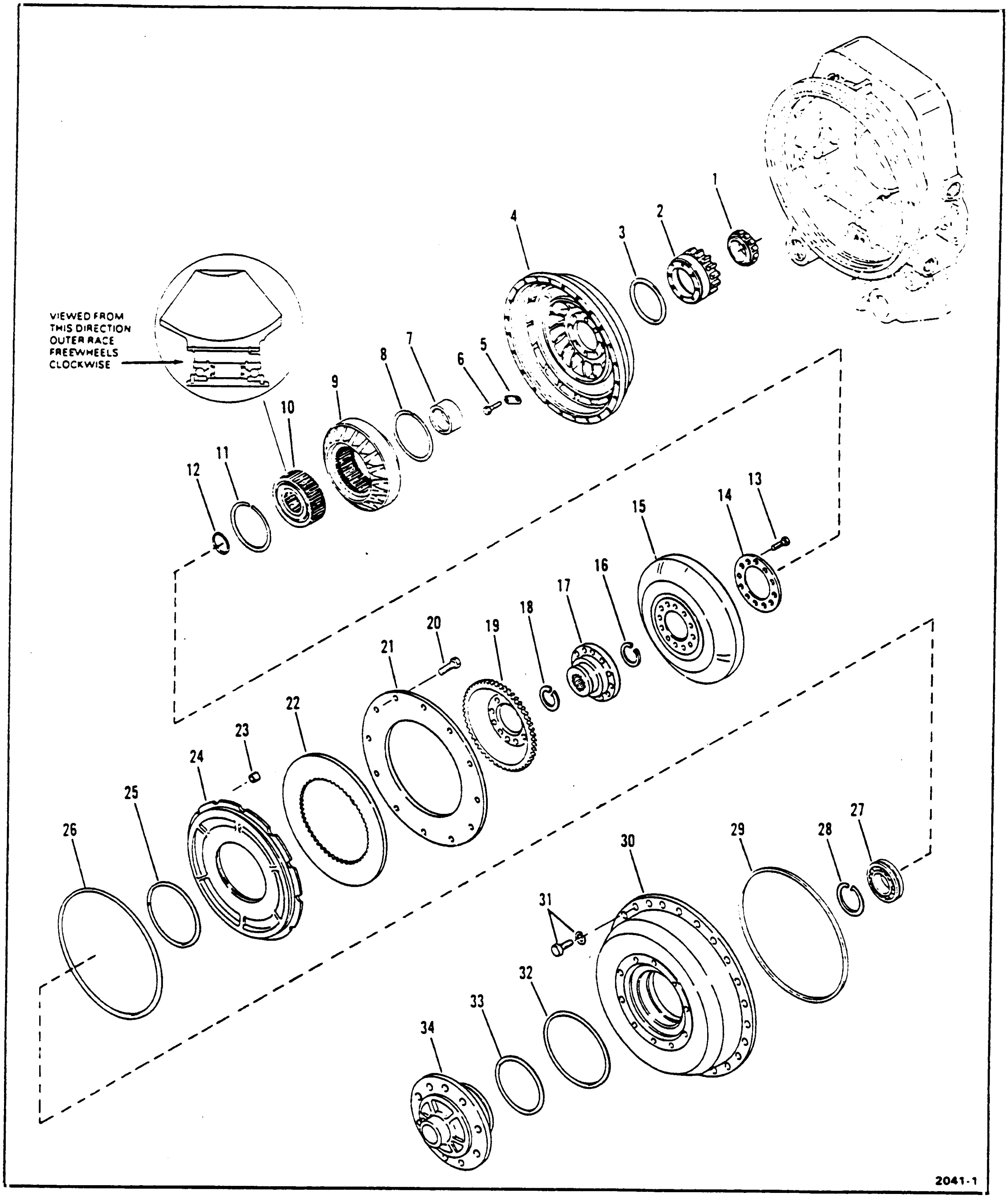
1. Remove the drive plate screws and washers.



2. Remove the drive plates and backup ring.



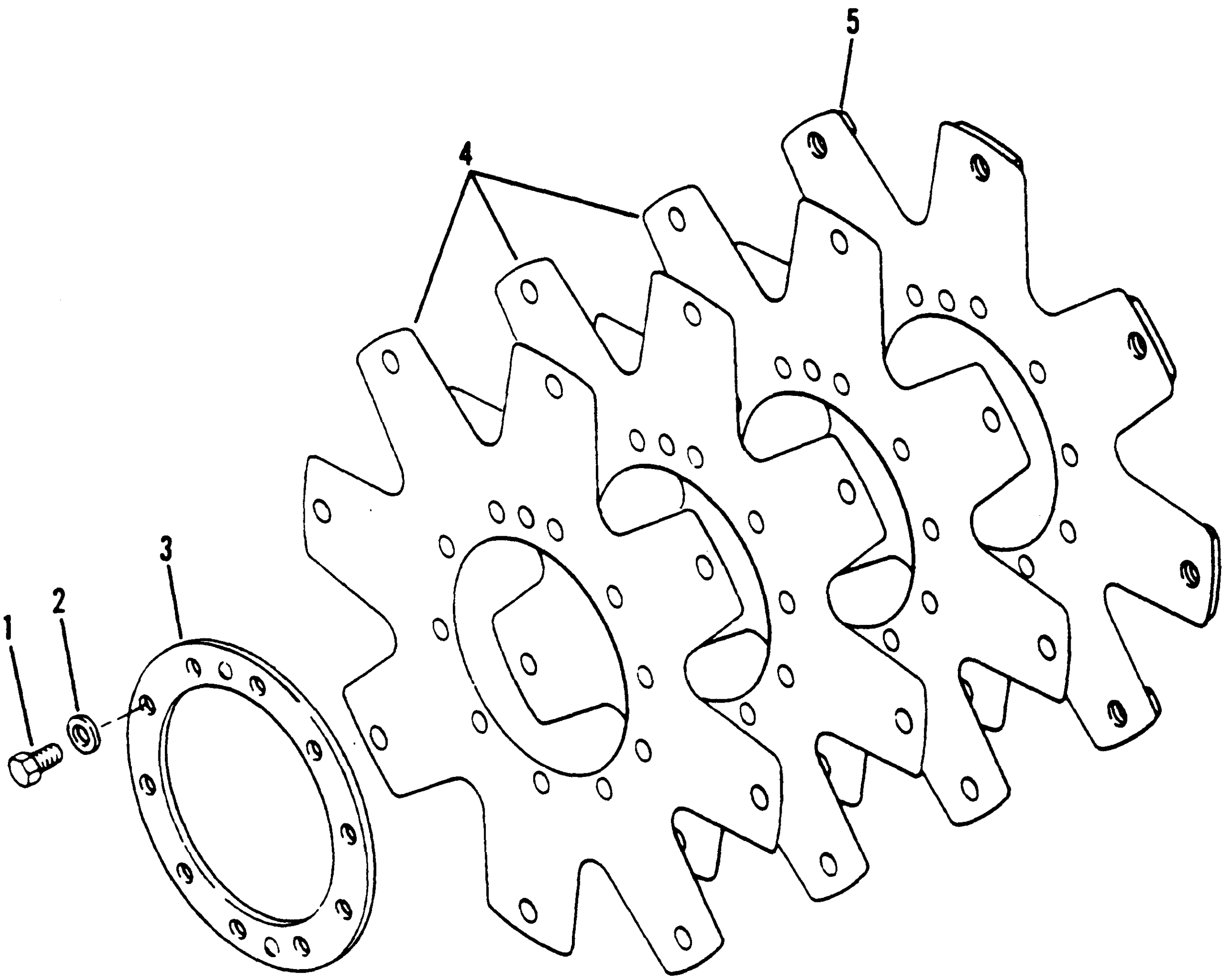
3. Remove the impeller cover bearing cap.



Torque Converter Assembly (Sheet 1 of 2)

1. Impeller Hub Gear Bearing
2. Impeller Hub Gear
3. Impeller Hub O-ring
4. Impeller
5. Lock Tab
6. Screw
7. Bearing Spacer
8. Freewheel Outer Race Snap Ring
9. Reaction Member
10. Freewheel Assembly
11. Freewheel Outer Race Snap Ring
12. Freewheel Assembly Retaining Ring
13. Self Locking Screw
14. Screw Backing Ring
15. Turbine
16. Turbine Locating Ring
17. Turbine Hub
18. Turbine Retaining Ring
19. Drive Gear
20. End Plate Capscrew
21. End Plate
22. Drive Clutch Plate
23. Drive Sleeve
24. Piston
25. Inner Seal O-ring
26. Outer Seal O-ring
27. Turbine Hub Bearing
28. Turbine Hub Bearing Retaining Ring
29. O-ring
30. Impeller Cover
31. Screw & Lockwasher
32. O-ring
33. O-ring
34. Impeller Cover Bearing Cap

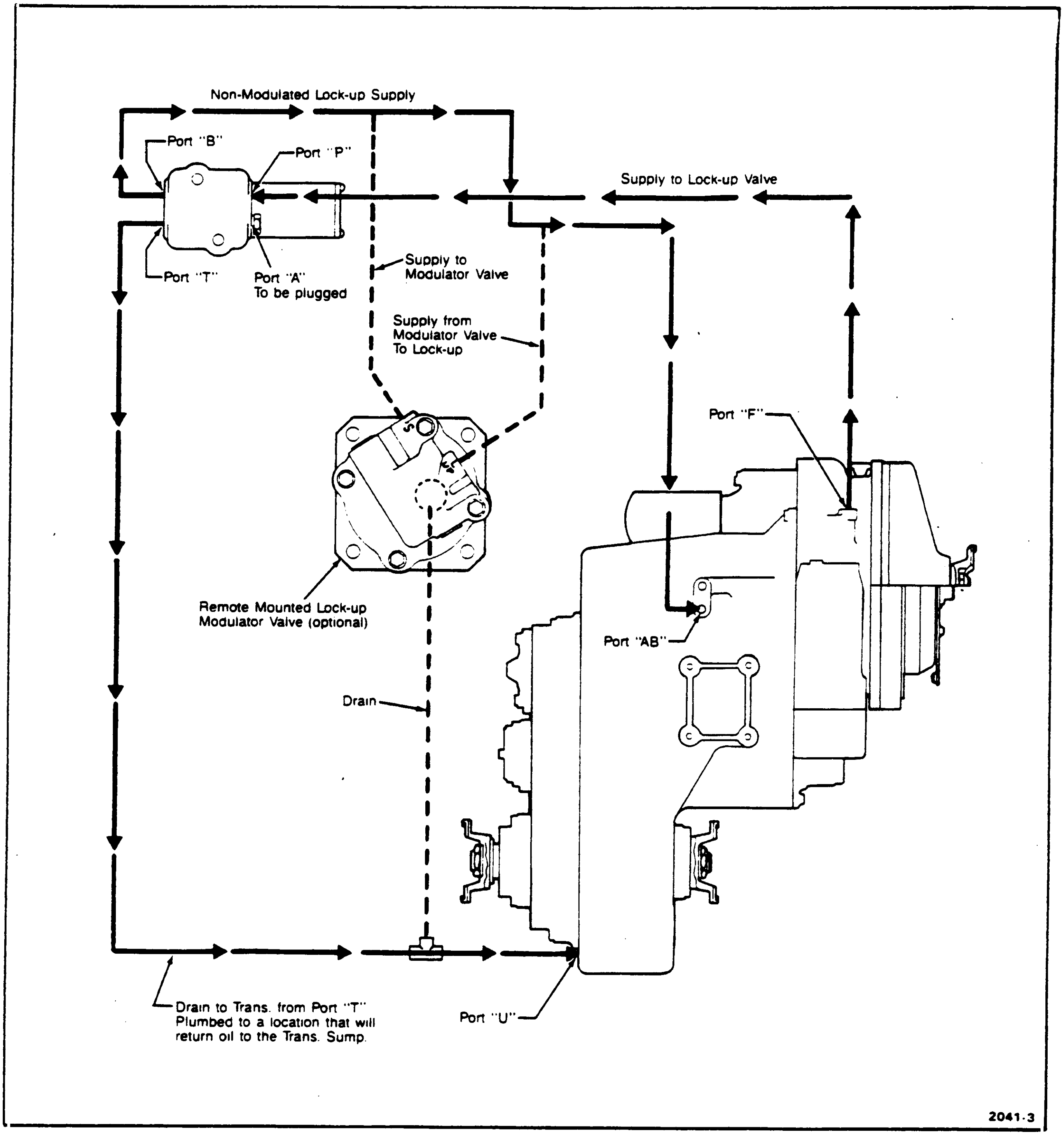
Torque Converter Assembly (Sheet 2 of 2)



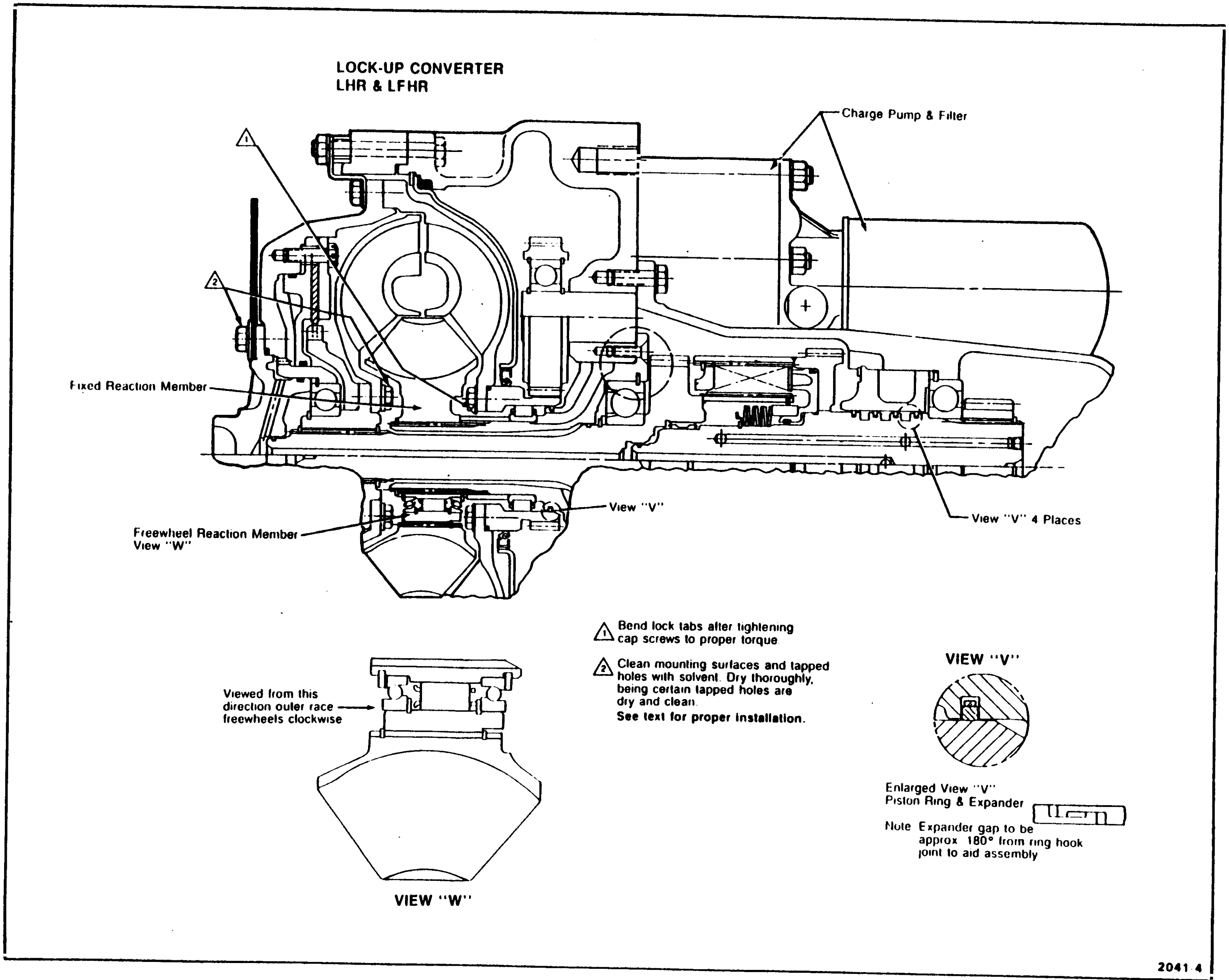
1. Mounting Screw
2. Lockwasher
3. Drive Plate Backing Ring
4. Drive Plate
5. Drive Plate and Weld Nut Assembly

2041-2

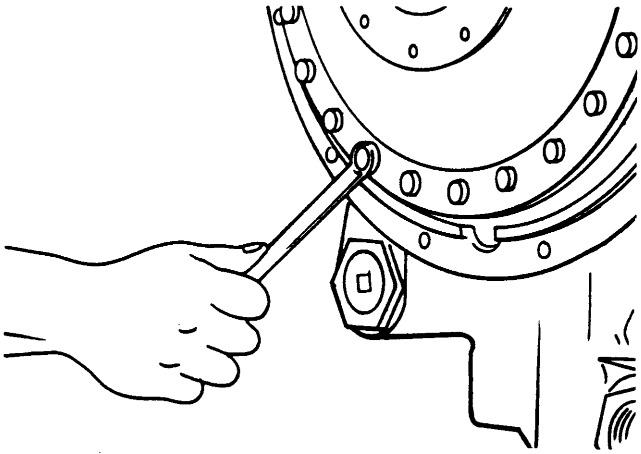
Drive Plate Group



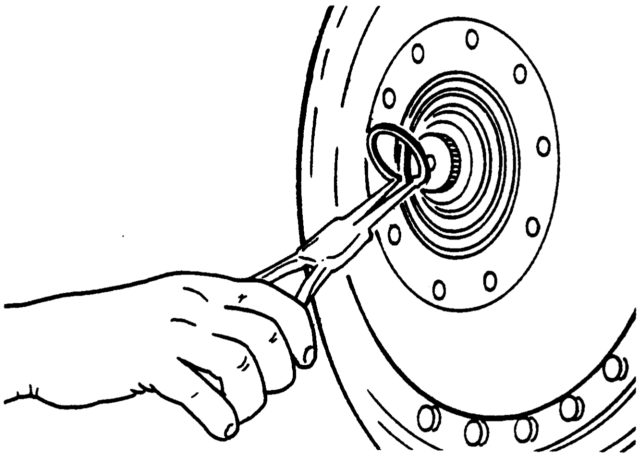
Torque Converter Hydraulic Flow Path



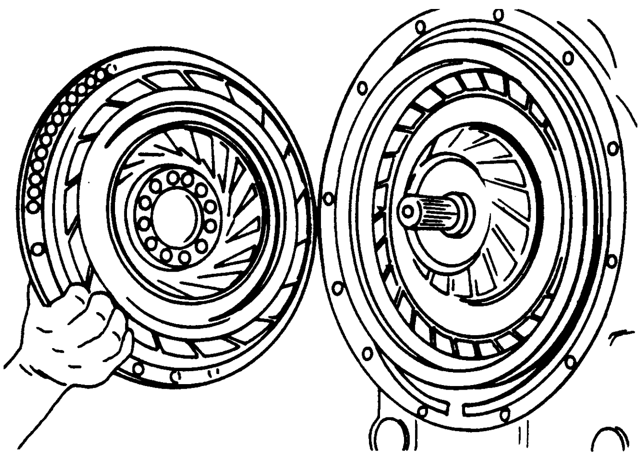
General Assembly Information



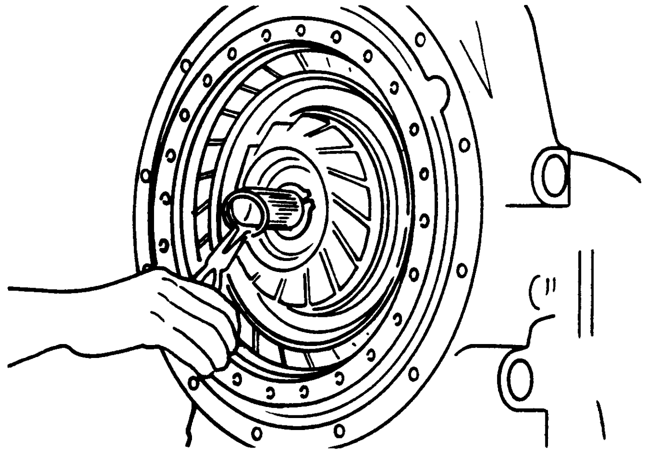
4. Remove the impeller cover bolts. Have a container ready to catch remaining oil in the wheel section.



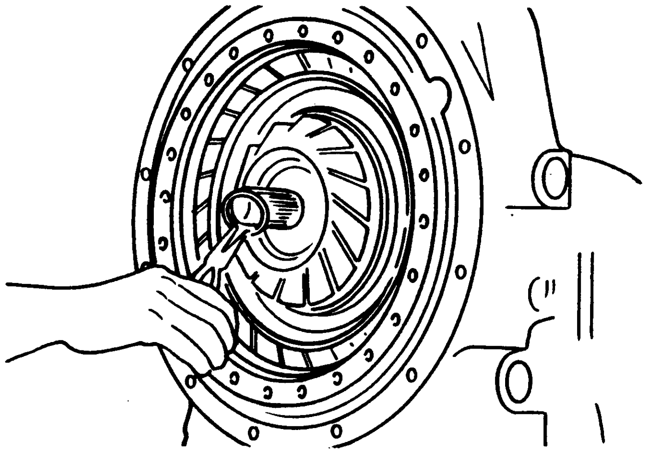
5. Remove the turbine to turbine shaft retaining ring.



6. Remove the impeller cover and turbine as an assembly.



7. Remove the turbine to turbine shaft locating ring.



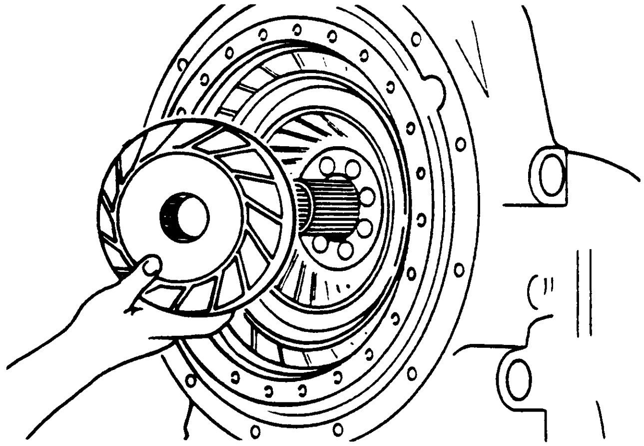
8. Remove the reaction member retainer ring.

NOTE

Some units will have a fixed reaction member and some units will have a freewheeling reaction member. The fixed is a one piece and the freewheeling is an assembly.

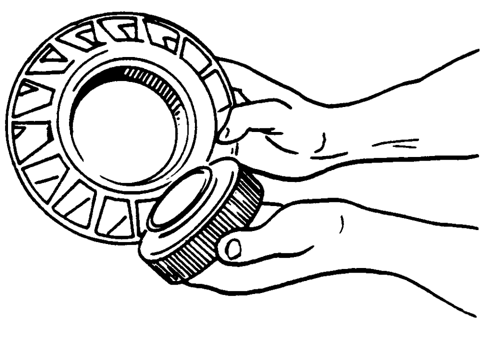
NOTE

The freewheel assembly cannot be serviced. If the freewheel is damaged it must be replaced as an assembly.

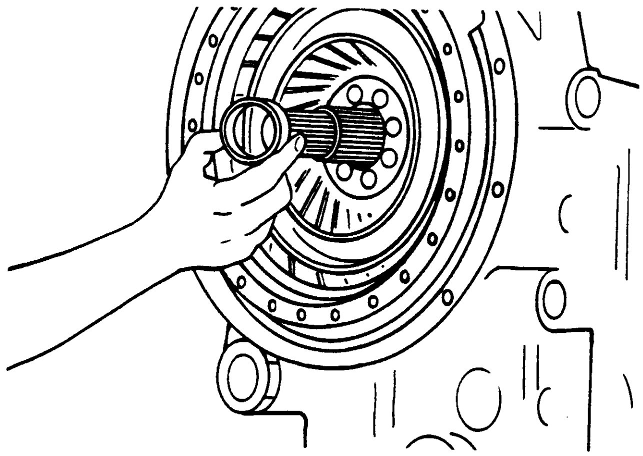


9. Remove the reaction member and freewheel ing assembly.

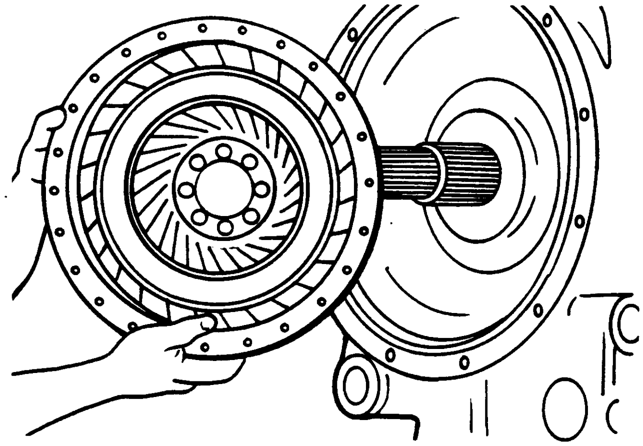
10. Remove the freewheel outer race to reaction member retainer ring.



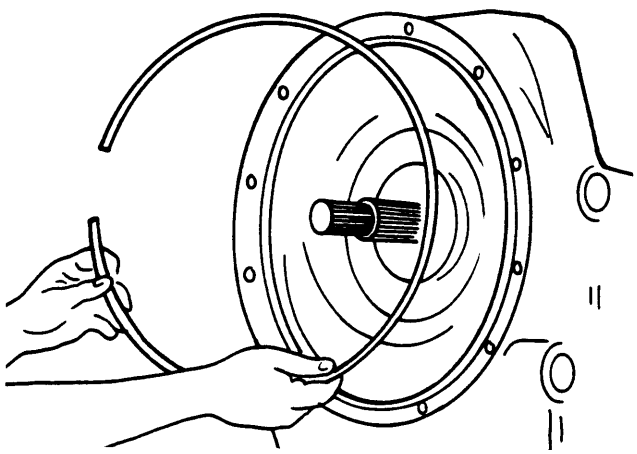
11. Remove the outer race and sprag assembly from the reaction member.



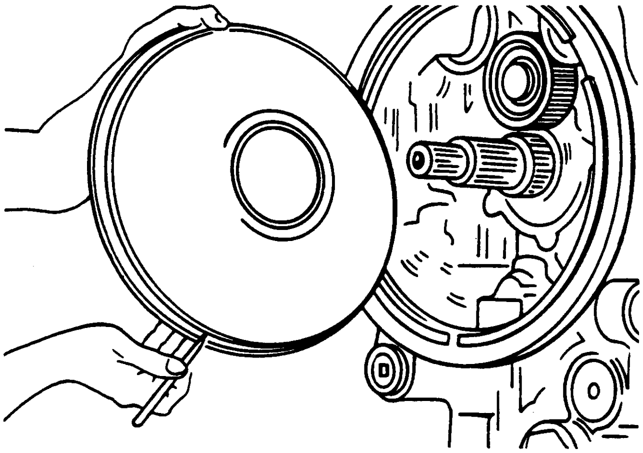
12. Remove the reaction member spacer.



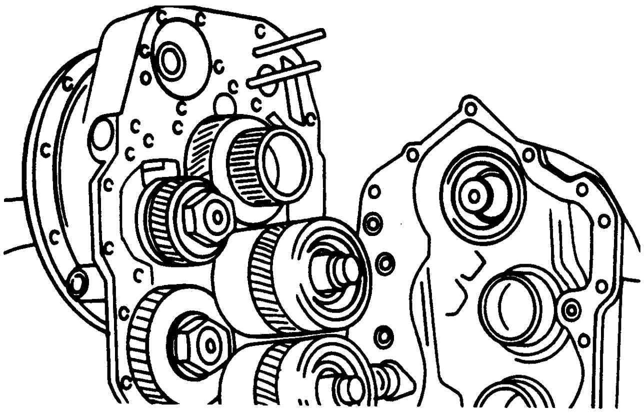
13. Remove the impeller and hub assembly.



14. Remove the oil baffle retaining ring.



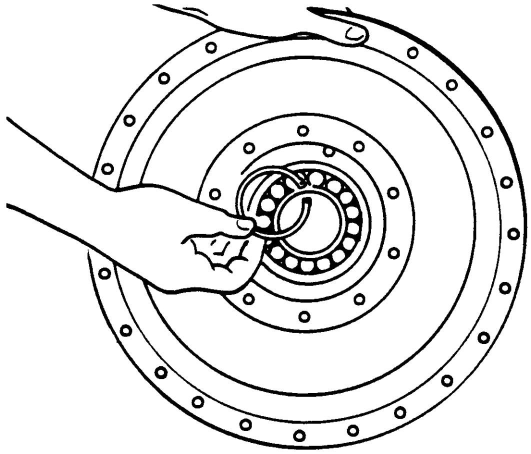
15. Pry the oil baffle from the housing. A resistance will be noted because of the heavy oil sealing ring.



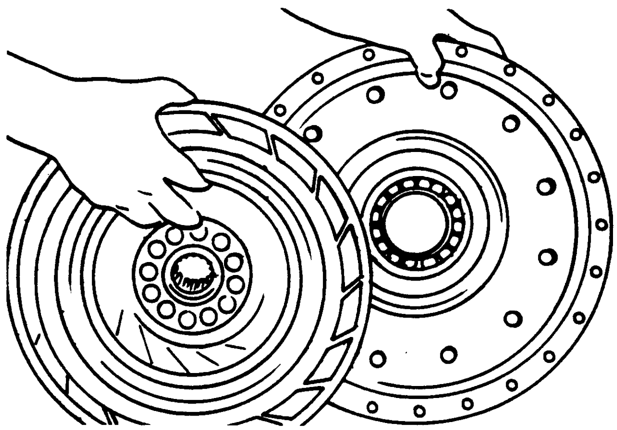
16. Support the converter housing with a chain hoist. Remove the converter housing to transmission case bolts. Separate the converter housing from the transmission case.

17. Remove the oil sealing ring from the forward clutch shaft.

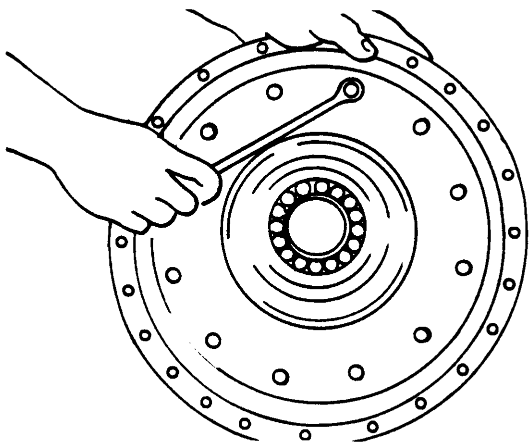
Lock-up Impeller Cover Assembly.



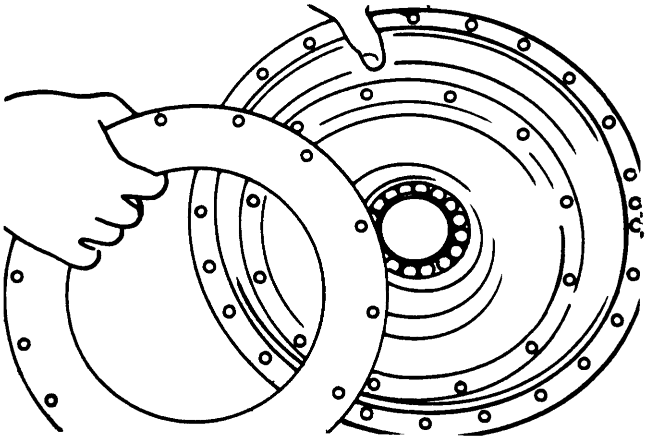
1. Remove the turbine hub to impeller cover bearing retainer ring.



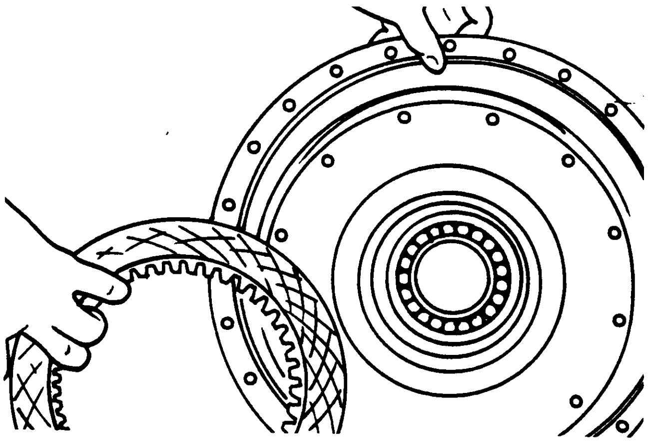
2. Tap the turbine and hub from the impeller cover.



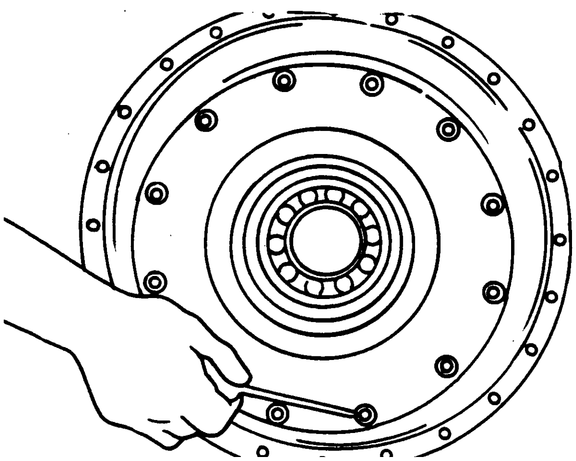
3. Remove the lock-up end plate screws.



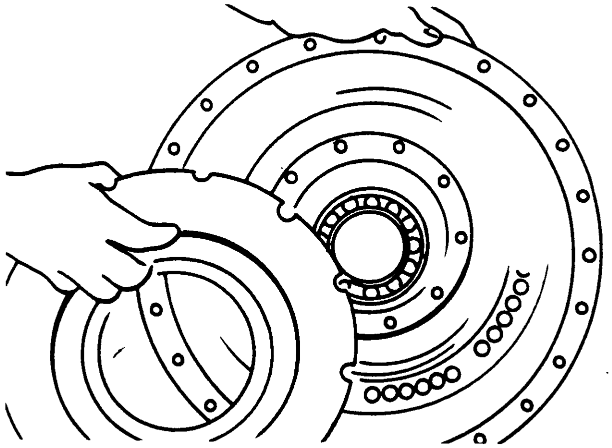
4. Remove the end plate.



5. Remove lock-up friction plate.



6. Remove the end plate spacer sleeves.



7. Remove the lock-up piston.

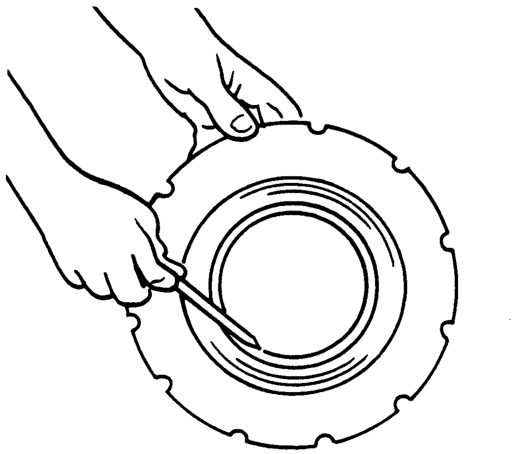
CLEANING AND INSPECTION.

NOTE

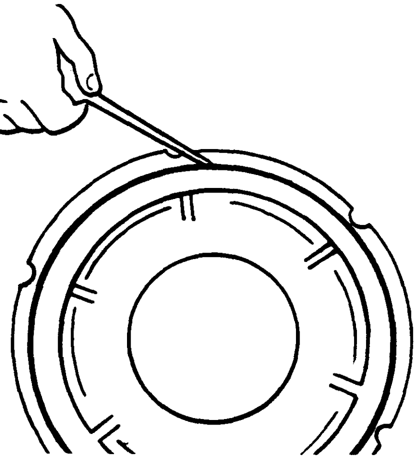
Refer to SM02-025-0, TRANSMISSION/TORQUE CONVERTER for cleaning and inspection procedures. Lubricate all parts before reassembly.

ASSEMBLY.

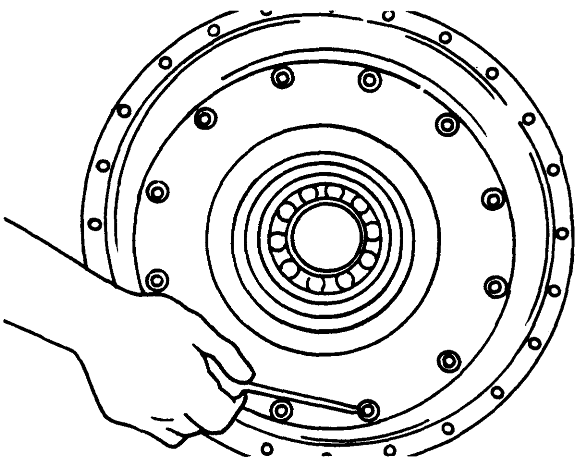
Lock-up Impeller Cover Assembly.



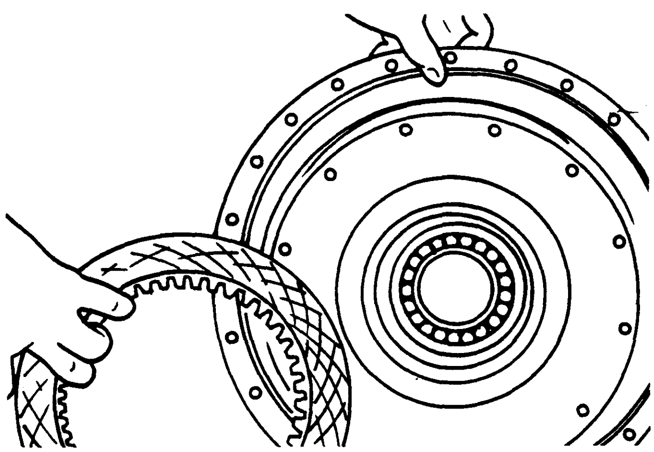
1. Install the lock-up piston inner O-ring.



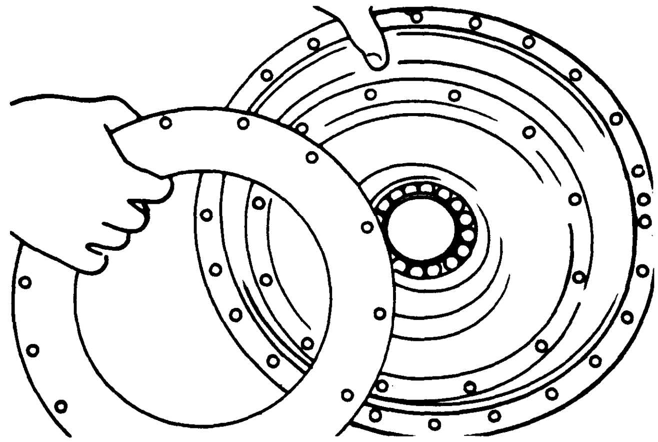
2. Install the lock-up piston outer O-ring.



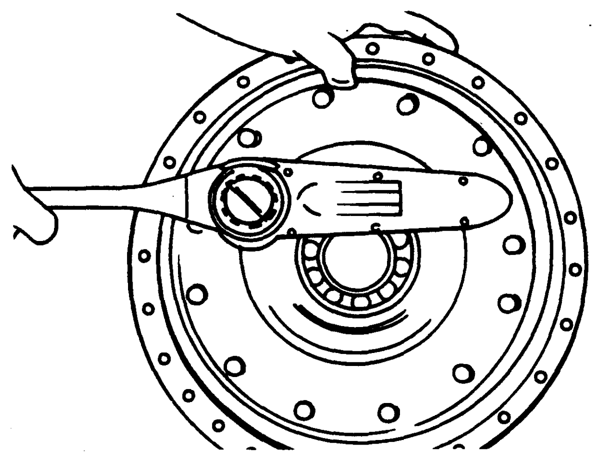
3. Position the lock-up piston in the impeller cover. Locate the spacer sleeves in notches in the piston and align with the threaded holes in the impeller cover.



4. Position the lock-up friction disc on the piston.



5. Position the disc end plate over the friction disc, aligning the holes in the end plate with the holes in the impeller cover.



6. Install the self locking capscrews and torque 23 to 25 pounds-foot (3.1 to 3.3 kgm).

NOTE

If the turbine to turbine hub was replaced or disassembled, the following procedure must be used for reassembly.

Turbine Hub Assembly with Backing Ring and Special Self Locking Screws.

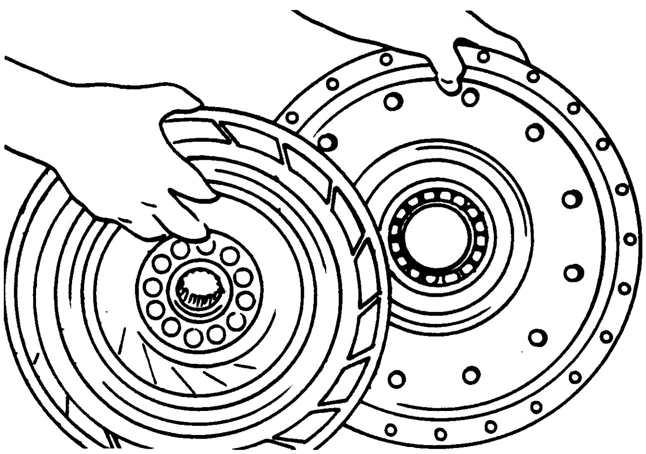
1. Clean the hub mounting surface and tapped holes with solvent. Dry thoroughly being certain tapped holes are dry and clean.

NOTE

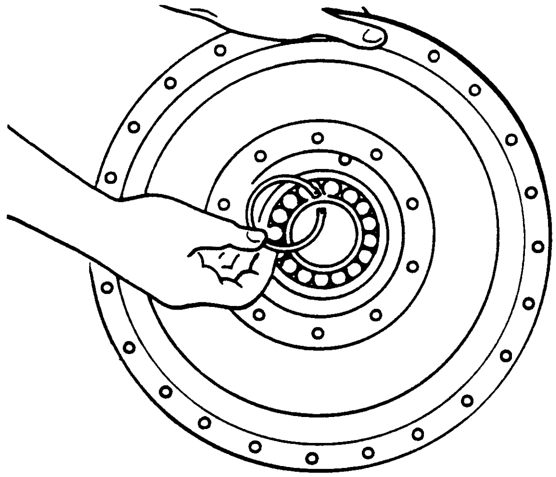
Assembly of the turbine hub must be completed within a fifteen minute period from start of screw installation. The screws are prepared with a coating which begins to harden after installation in the hub holes. If not tightened to proper torque within the fifteen minute period, insufficient screw clamping tension will result. The special screw is to be used for one installation only. If the screw is removed for any reason it must be replaced. The compound left in the hub holes must be removed with the proper tap and cleaned with solvent. Dry hole thorouhly and use a new screw for reinstallation.

2. Install the backing ring and special screws to approximately 0.06 inches (1.5 mm) of the seated position. With a calibrated torque wrench, torque the screws 37 to 41 pounds-foot (5.0 to 5.5 kgm).

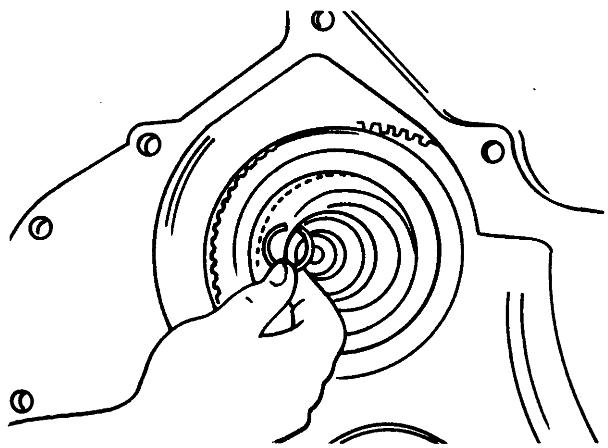
Torque Converter Assembly.



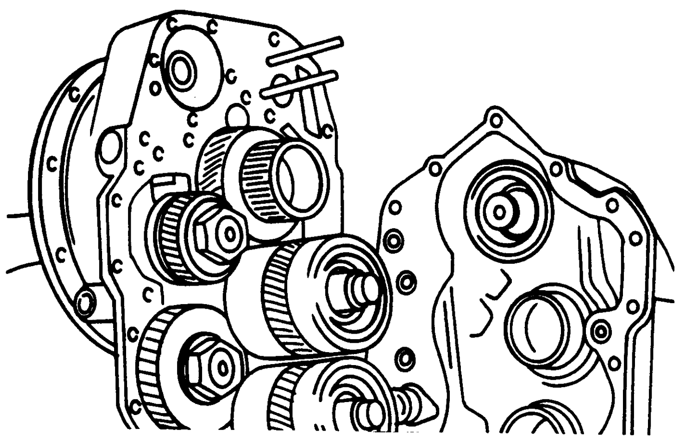
1. Position the turbine and hub assembly in the impeller and lock-up assembly, aligning the teeth on the turbine drive gear with the inner teeth in the friction disc. Do not force this operation. Tap the turbine hub into the impeller cover bearing.



2. Install the turbine hub to impeller cover bearing retainer ring.



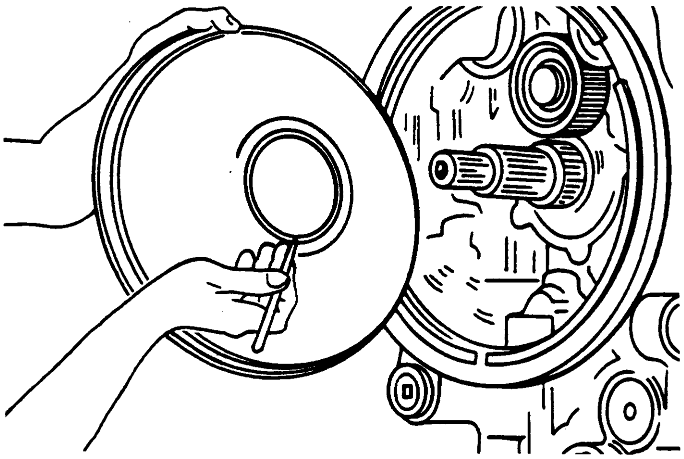
3. Install the forward clutch shaft oil sealing ring.



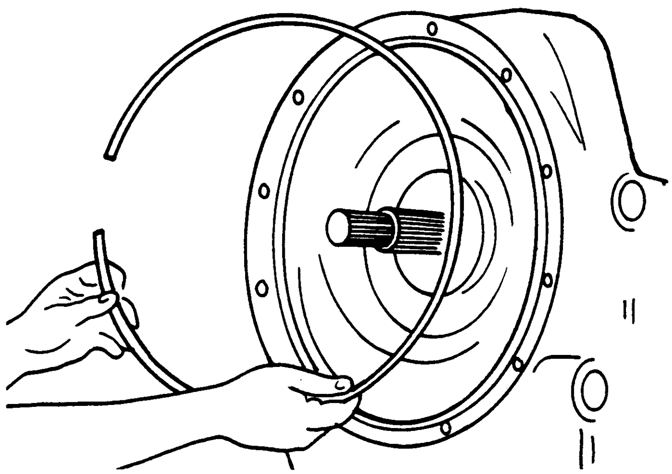
4. Position the pilot bearings on the clutch shafts. A light coat of grease will hold the pilot bearings in place.

5. The use of two aligning studs will facilitate aligning the converter housing to the transmission housing. Install the converter housing to the transmission using extreme caution to align the clutch pilots into the clutch disc hubs. As the clutch pilots enter the disc hubs, turn the turbine shaft and output shaft back and forth. This will help align all the the clutch inner discs with the disc hubs. DO NOT FORCE THIS OPERATION.

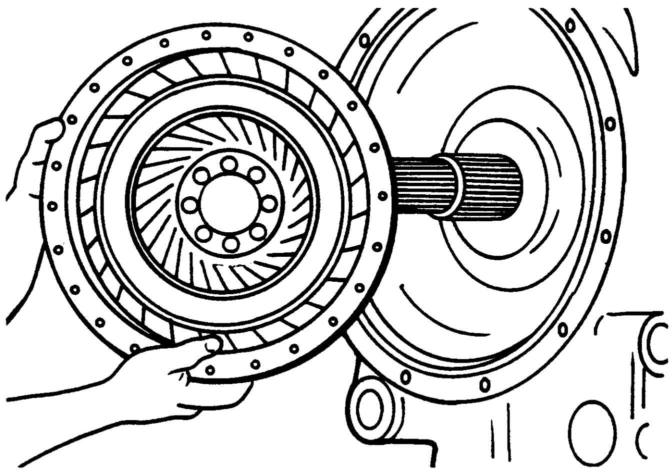
6. When all the clutches are properly aligned, the converter housing will be tight against the transmission housing. Install two housing to housing capscrews and lockwashers. Tighten the capscrews to the proper torque specified. Refer to SM02-025-0, TRANSMISSION/TORQUE CONVERTER for the applicable torque chart.



7. Apply a light coat of Permatex #2 to the outer diameter of the oil baffle seal. Press the seal into the baffle with the lip of the seal toward the impeller hub bearing. Position a new oil baffle sealing ring onto the oil baffle.



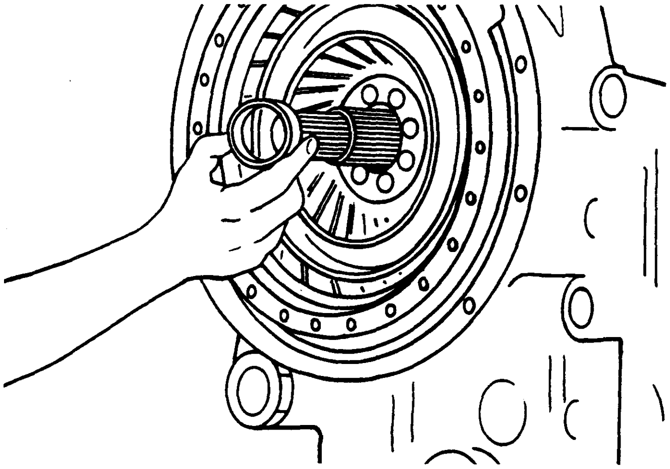
8. Position the oil baffle in the housing and install the retaining ring. Ensure the ring is in full position in the ring groove.



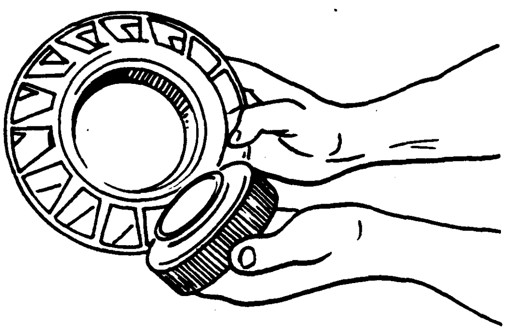
CAUTION

Use extreme caution as not to cut, break, or unhook the oil sealing ring on the support.

9. Install the impeller and hub assembly using caution as not to damage the oil baffle seal.



10. Position the impeller hub bearing spacer on the stator support.

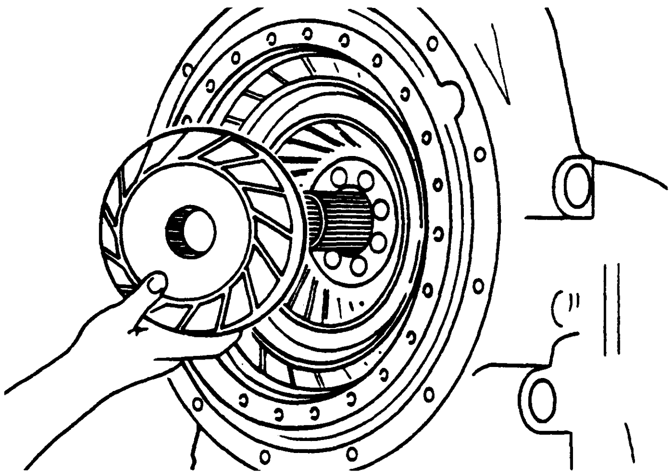


NOTE

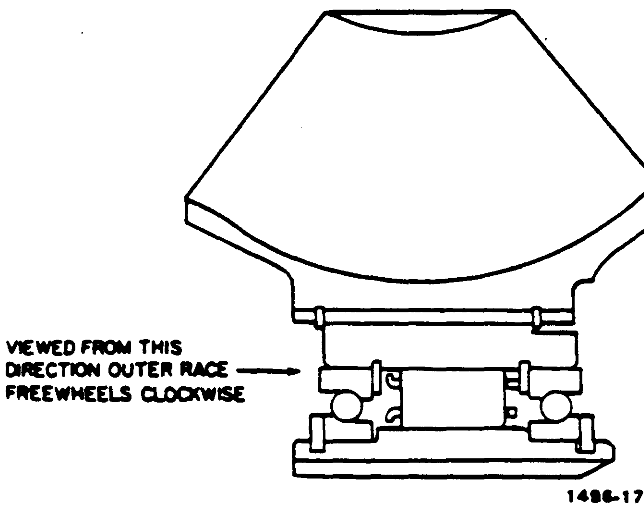
The freewheel assembly cannot be serviced. If the freewheel is damaged it must be replaced as an assembly.

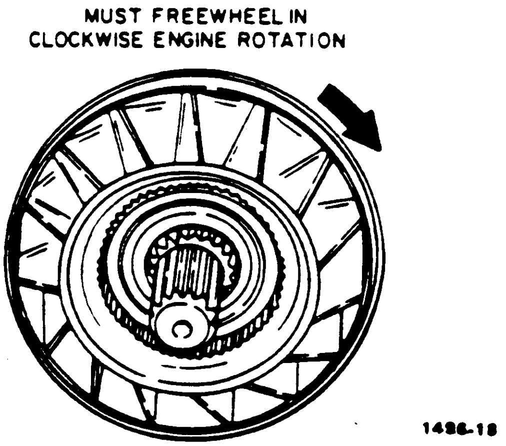
11. Install the outer race and sprag assembly into the reaction member. The undercut shoulder of the race must go toward the rear of the reaction member.

12. Install the outer race to reaction member retainer ring.

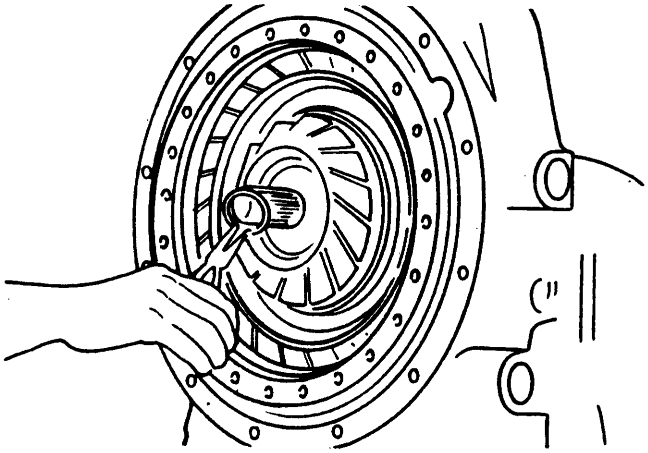


13. For a fixed reaction member, install the reaction member with the thick side of the blades out. For a freewheeling reaction member, install the reaction member with the thick side of the blades out.

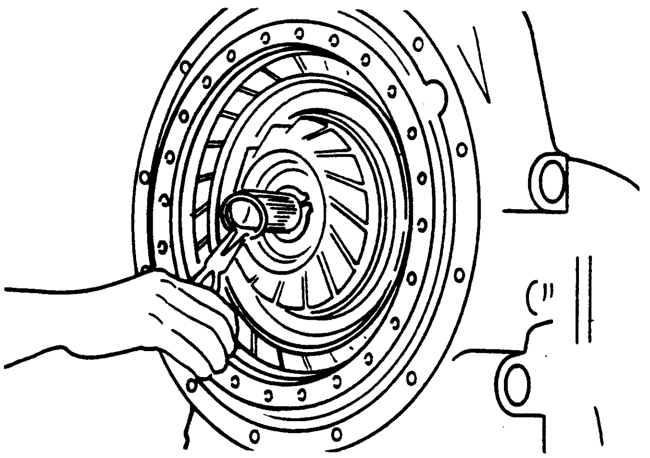




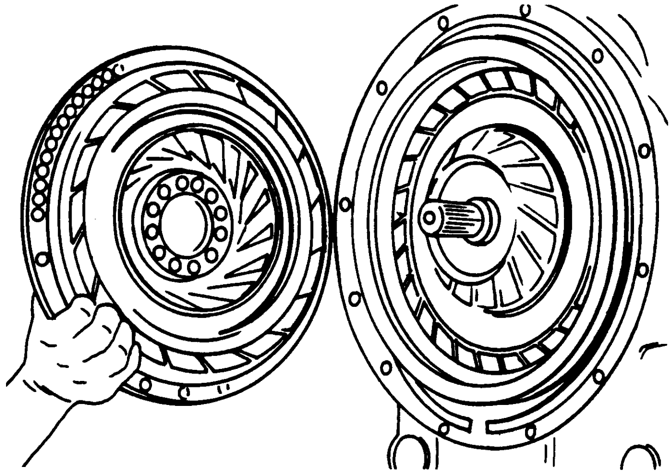
14. Check rotation of the freewheeling reaction member to ensure of proper freewheel assembly.



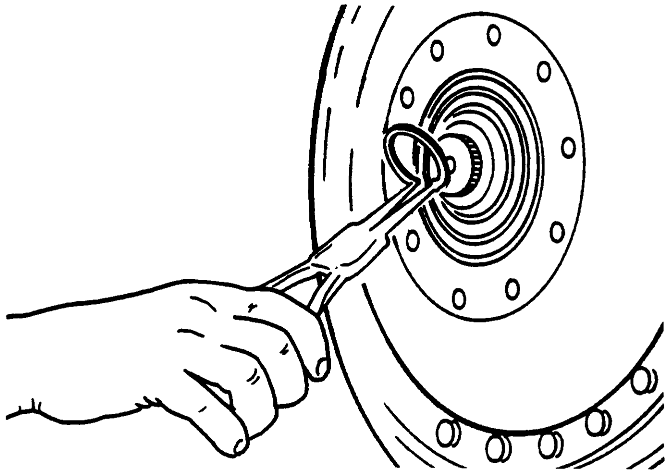
15. Install the reaction member retainer ring.



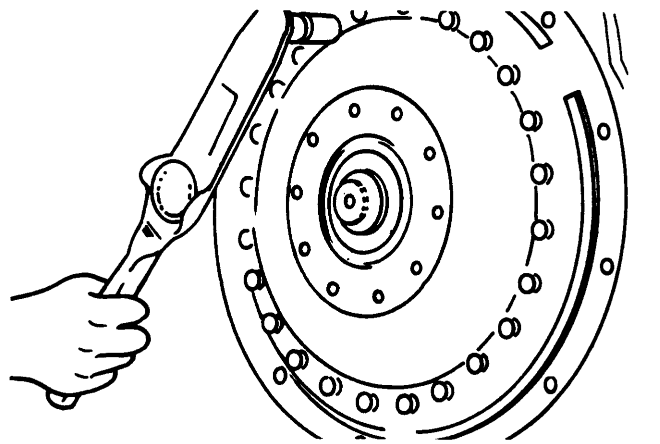
16. Install the turbine hub locating ring.



17. Position the impeller cover, lock-up, and turbine assembly onto the turbine shaft.

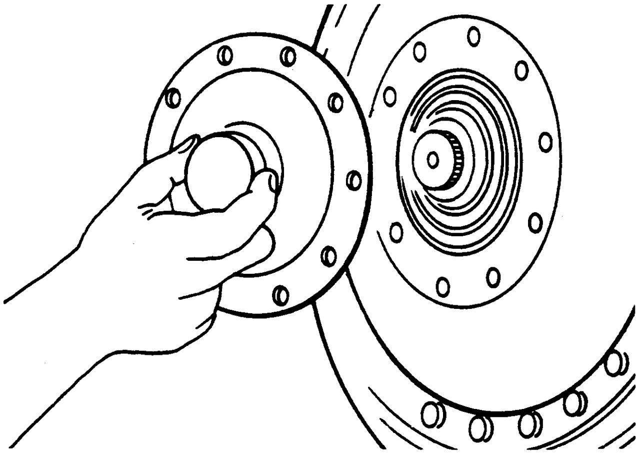


18. Install the turbine hub to turbine shaft retainer ring.

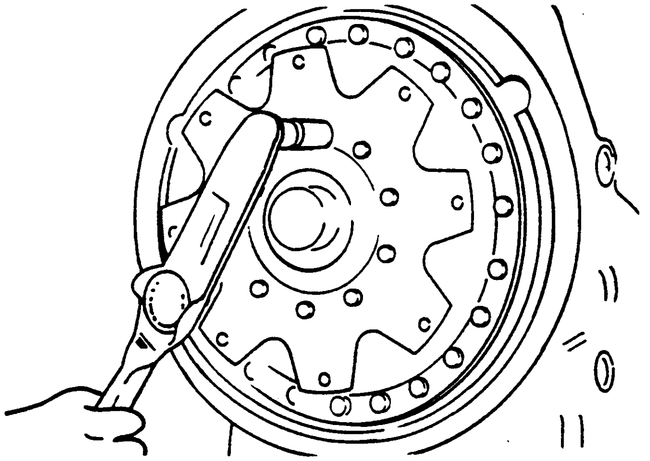


19. Install the impeller cover to impeller capscrews and washers. Tighten to the specified torque.

Refer to SM02-025-0, TRANSMISSION/TORQUE CONVERTER for the applicable torque chart.



20. Install a new oil sealing ring on the end of the turbine shaft. Install new inner bore and outer face O-rings in the impeller cover bearing cap. Position the bearing cap on the impeller cover.



21. Install the drive plates. Refer to the special section on drive plate installation in SM02-025-0, TRANSMISSION/TORQUE CONVERTER.

KESSLER AXLE

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LIST OF TABLES AND CHARTS

DESCRIPTION

The axle will be completely disassembled, cleaned, and assembled in this package. Some of the major components include; the wheel ends, the axle shafts, the steering knuckles, and the differential assembly.

The axles incorporate planetary gearing in the wheel end and a differential housing with a single reduction bevel drive gear assembly. The spiral bevel pinion and ring gear transmit power through the center differential pinions and side gears to the axle shaft. A constant velocity joint is used to transfer power from the differential gearing to the wheel end.

The axles are supported on tapered roller bearings. Steel upper and lower steering knuckles provide for movement of the wheel end for steering purposes.

MAINTENANCE

GENERAL INSTRUCTIONS.

1. All maintenance procedures are to be accomplished only by skilled maintenance personnel.

2. Drain oil before removing, check for presence of metal particles.

3. Never use a hard object to separate tightly fitted assemblies. Proper pullers must be used to remove bearings, drive flanges, and similar parts.

4. It is important that the special tools mentioned in this package be used.

5. Do not place parts on a dirty surface.

6. Replace seals, O-rings, and used bearing during disassembly.

7. Clean all parts before assembly.

8. Replace or clean corroded parts.

9. The cages of bearings rotating in oil are to be coated with oil before assembly.

10. Oil seal rings and particularly the lip seals must be filled with grease.

11. The universal joint shafts and the axle shafts must not be force-mounted, they must slide.

12. The bolted or keyed assemblies safeties are to be checked according to instructions.

13. Refill the axle assembly with oil after assembly.

SPECIAL TOOLS.

Refer to the figures titled special tools for a list of the special tools needed to perform specialized maintenance on the axle.

LOCTITE USE.

To assure the security of heavily loaded assemblies in the axle assembly, use LOCTITE as follows:

1. Lightly locked bolts (i.e. wheel safety nut) - Use LOCTITE 242 (blue).

2. Safety of bolts in general - Use LOCTITE 262 (red).

3. Increased adherence (i.e. steering lever and track rod lever, differential ring gear, etc.) - Use LOCTITE 270 (green).

WARNING

Most cleaning solvents are flammable and must be kept away form heat and open flame. Avoid inhalation of fumes and extended contact with solvent. Failure to comply can result in injury to personnel.

WARNING

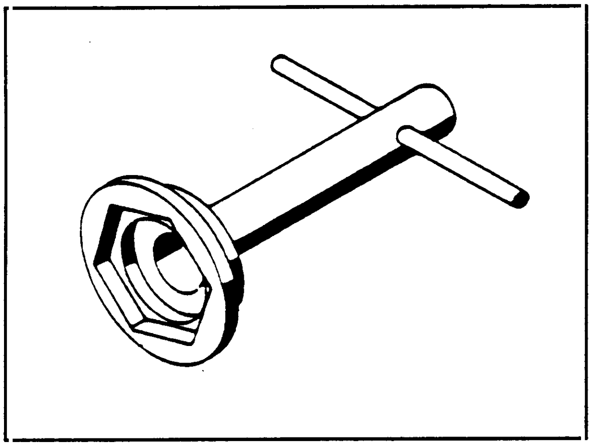
Compressed air used for cleaning can create airborne particles that can enter the eyes. Pressure will not exceed 30 PSI (206.8 kPa). Eye protection required.

CAUTION

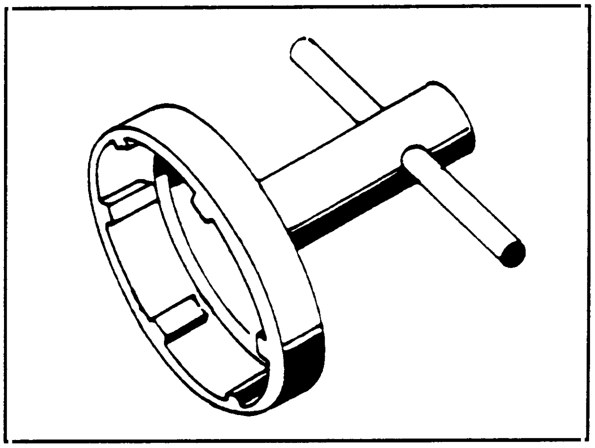
Do not spin dry bearings. Failure to follow this caution could result in damage to the bearings.

NOTE

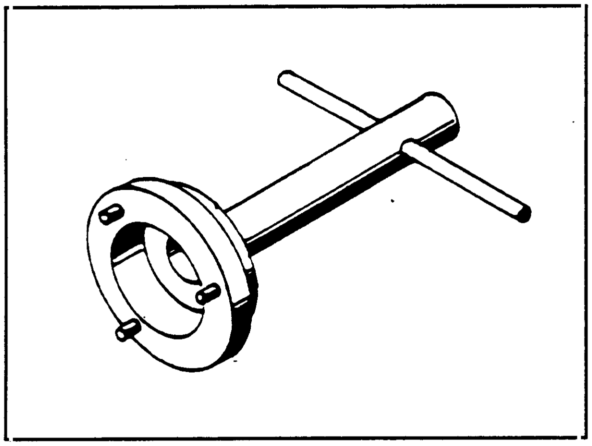
Parts fitting closely together must be free of grease. Dry cold cleaning products leaving grease traces or detergents drastically reduce the adherence of glued surfaces. Preferably, use Trichlorethylene or similar dry cleaning products such as HACU VK 1025.



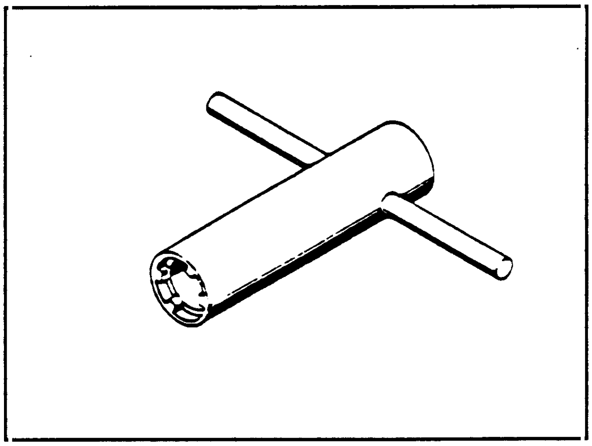
Spanner for Shaft Nut



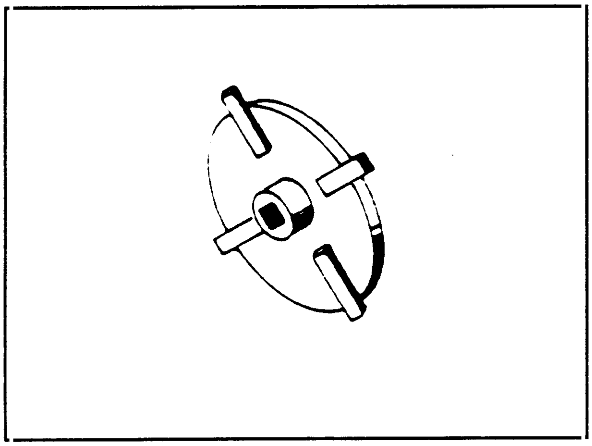
Spanner for Splined Nut



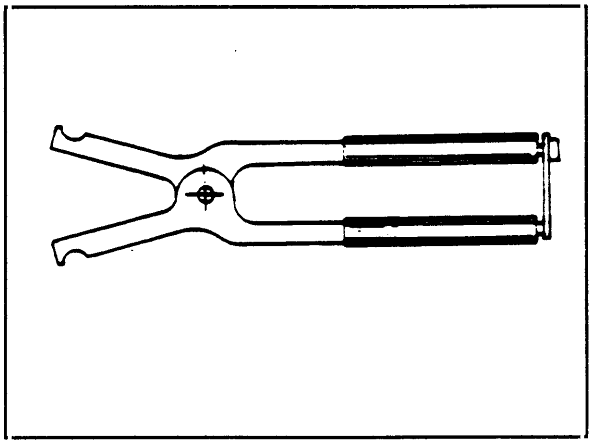
Spanner for Apertured Nut



Spanner for Locking Nut

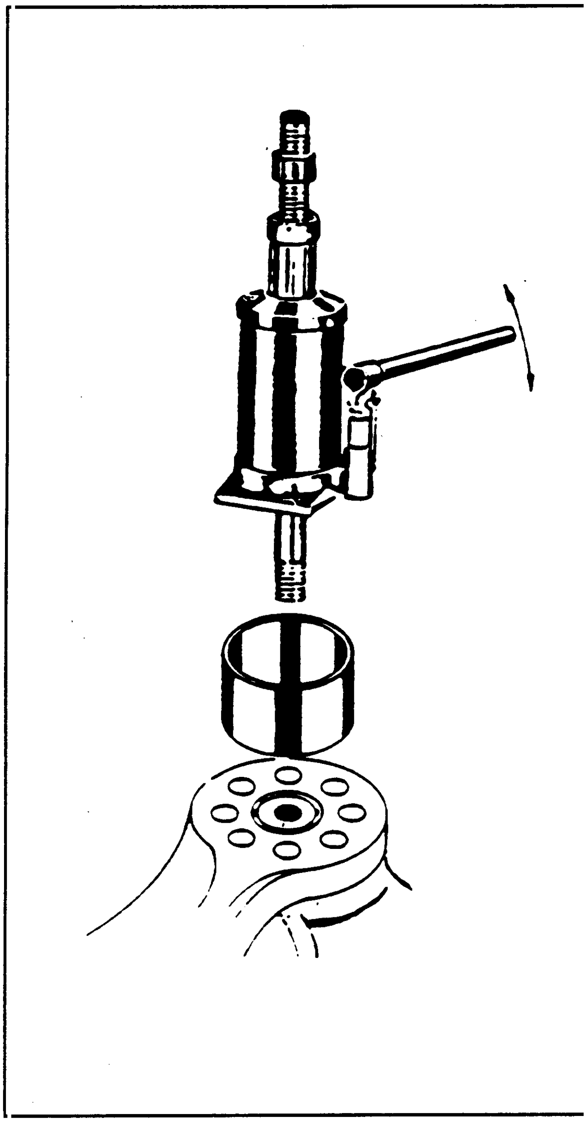


Spanner for Adjusting Nut

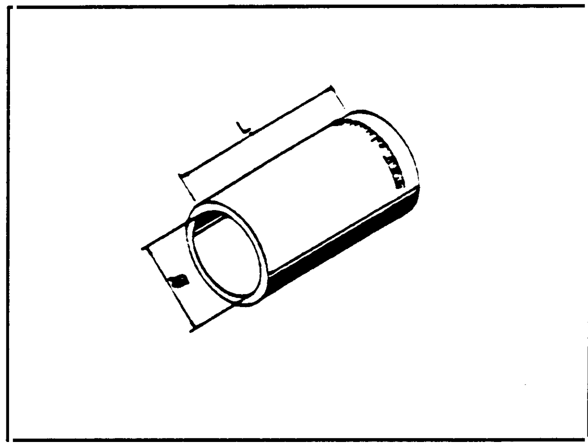


Nippers for Tension Spring

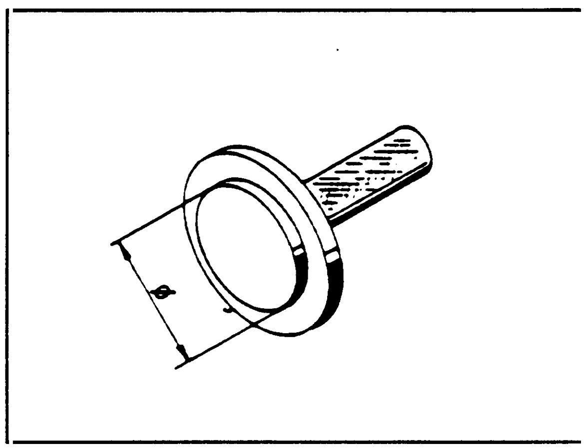
Special Tools (Sheet 1 of 3)



Hydraulic Puller for Steering Swivel Pins

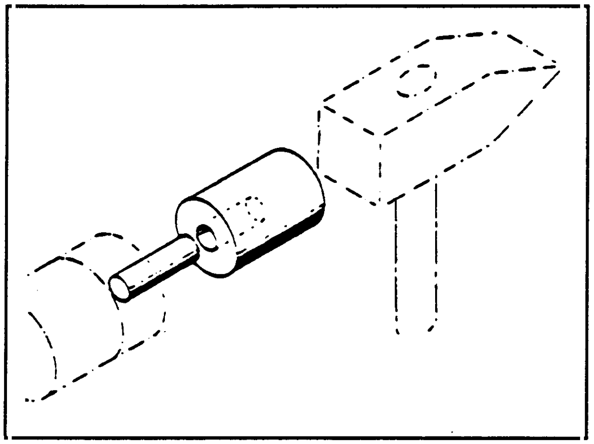


Assembling Sleeve

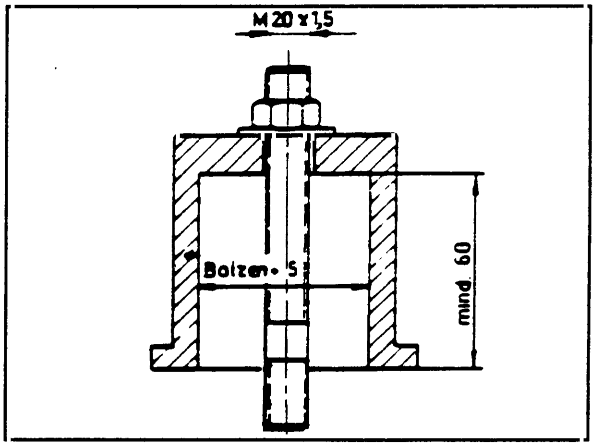


Sleeve Driver

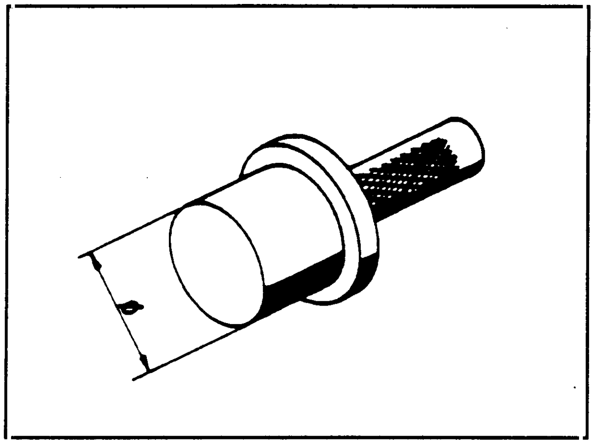
Special Tools (Sheet 2 of 3)



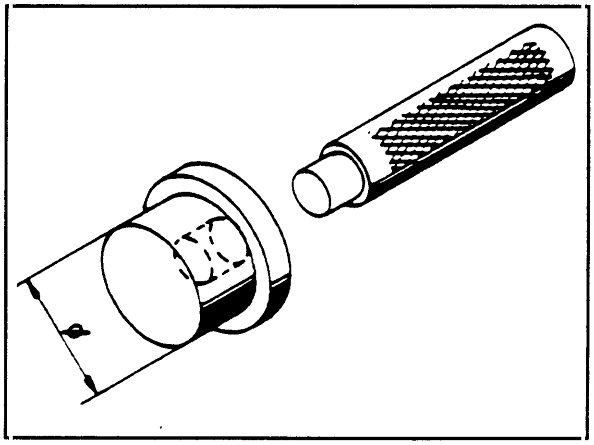
Tool to Press in Steering Swivel Pins



Mechanical Puller for Steering Swivel Pins



Sleeve Driver for Needle Bearings



Sleeve Driver for Bushings

Special Tools (Sheet 3 of 3)

LOCTITE USAGE CHART

Differential and Carrier Assembly			
SAFETY BLOCKED PARTS	**ASSEMBLED**	**LOCTITE NO.**	**REMARKS**
differential case	by bolts	262	-
differential ring gear	by bolts	262	-
differential ring gear	mating surface with carrier	270	-
differential ring gear	grommet	270	-
holding bracket	by bolts	262	-
adjusting nut	-	270	on 2 piece bearing cover
adjusting nut	-	-	on 1 piece bearing cover
safety bracket/adjusting ring	by bolts	262	-
interaxle differential	by bolts	262	-
through drive shaft flange	by bolts	262	-
pinion bearing cage	-	262	-
differential carrier	by bolts	262	-

Wheel Assembly			
SAFETY BLOCKED PARTS	**ASSEMBLED**	**LOCTITE NO.**	**REMARKS**
Steering lever and track rod lever	By bolts	262	-
Steering lever and track rod lever	Mating surface	270	-
Brakes	By bolts	262	-
Brakes	Mating surface with brake spider	270	-
Brake drum and brake disc	By bolts	262	-
Inner notched wheel safety	By bolts	270	-
Grommet	In the casing of planetary gear train	270	-
Adjusting screw and nut	Steering lever and track rod lever	270	-
Thrust ring	Spindle	270	-
Spindle	Mating surface	270	-
Spindle	By bolts	262	-
Wheel safety nut	-	242	-

NOTE

The various assemblies in the axle are locked according to the nature of the loadings on it, the type of construction of the axles and the utilization, with a liquid glue. In the case of repairs, it is recommended to insure the locking using LOCTITE as recommended on the LOCTITE Usage Chart.

GENERAL LUBRICATION INSTRUCTIONS.

Fill Levels.

Fill levels are checked at the level control plug. Refer to the Lubrication Chart for proper lubricant levels

Oil Change

Place the crane in a horizontal position. Draining of the oil is to be accomplished only after operating for a period of time long enough to ensure the oil is sufficiently warmed up. Thoroughly clean the area around all lubrication points before opening them. Open the drain holes on the carrier assembly and on the wheel end assemblies. On the wheel end assemblies, the drain plugs should be turned downward.

CAUTION

On axles with self-locking differentials, a noise is produced if normal oils are used. In case of abnormal noises and in cases of operation under bumpy conditions, use gear oil EP with additives of the limited slip-type conforming to specification M2C-104A.

CAUTION

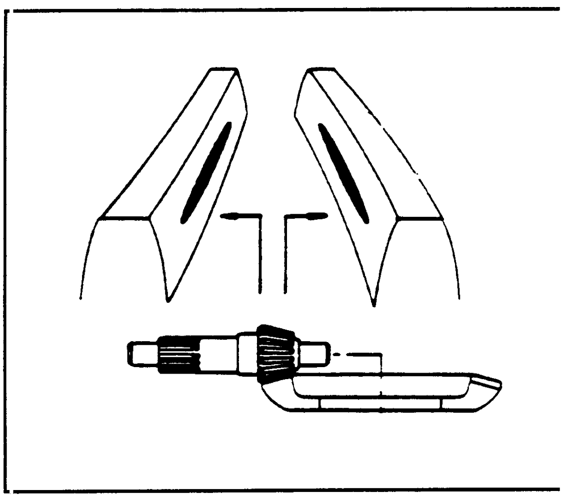
In the event of prolonged non-operation of the crane, it is recommended to start up and operate all of the parts of the geartrain every 6 months. For this purpose, maintain the proper oil level which also protects the axle against water intrusion.

ADJUSTMENT VALUES.

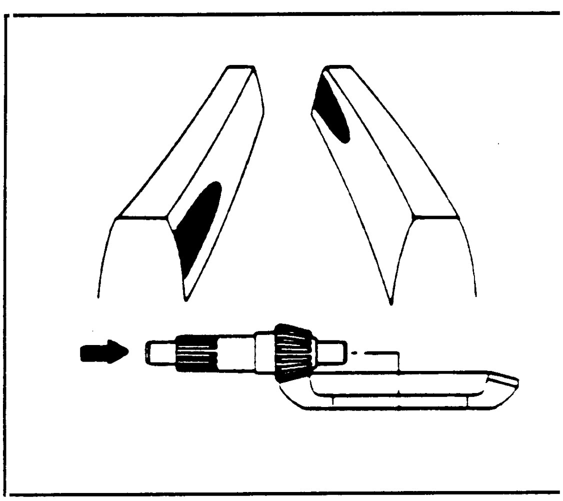
Adjustment of Ring Gear and Drive Pinion

The following figures show various improper gear meshing marks. The accompanying paragraphs give the proper procedure to obtain correct gear meshing. The black arrows on the figures indicate the direction towards which the corresponding wheel must first be moved and the white arrows indicate the direction of any secondary adjustments.

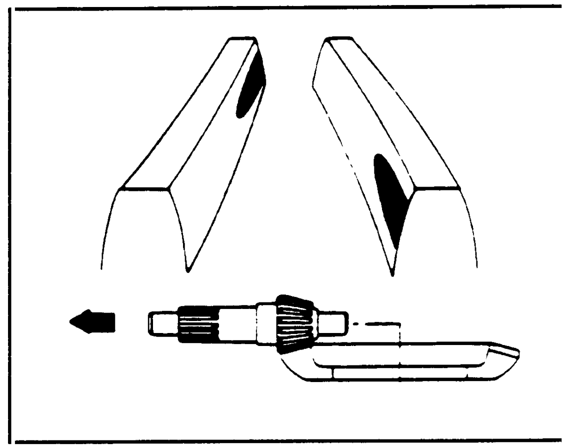
1. The following figure is an example of proper gear marking.



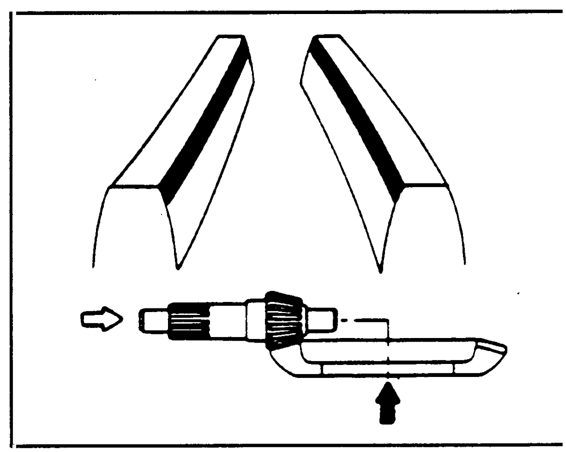
2. Move the drive pinion toward the ring gear and then adjust the gear teeth edge clearances.



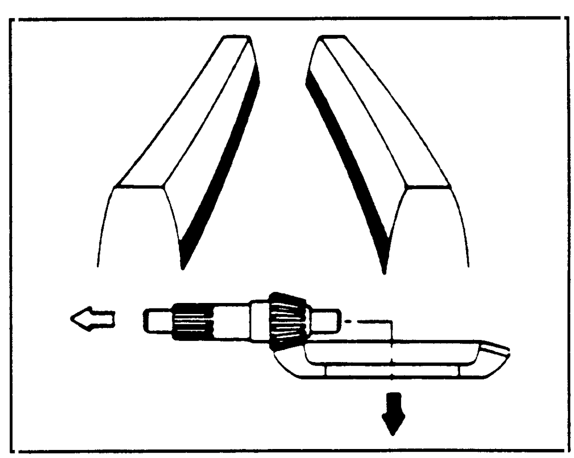
3. Back off the drive pinion from the ring gear and then adjust the gear teeth edge clearances.



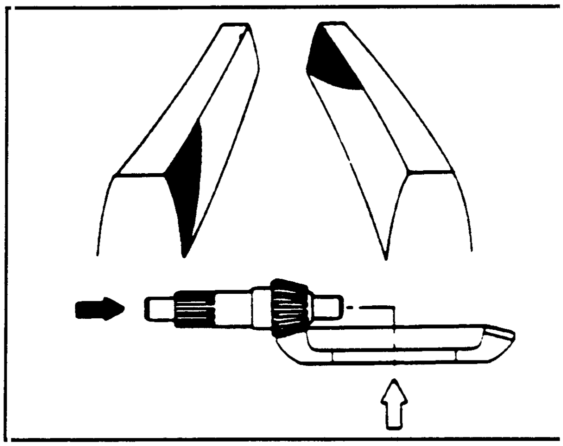
4. Reduce the gear teeth edge clearances. If the correction is insufficient, move in the drive pinion.



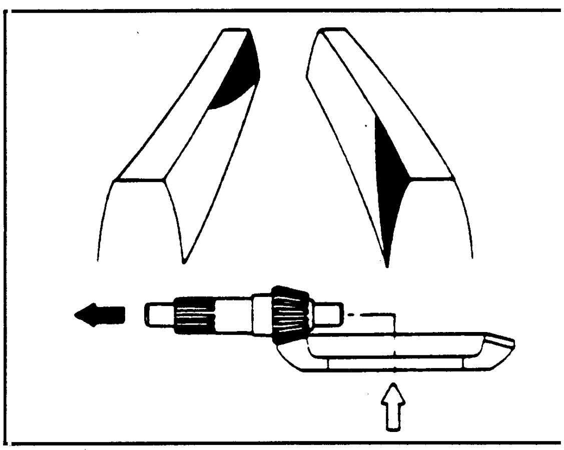
5. Increase the gear teeth edge clearances. If this change is insufficient, back off the drive pinion from the ring gear.



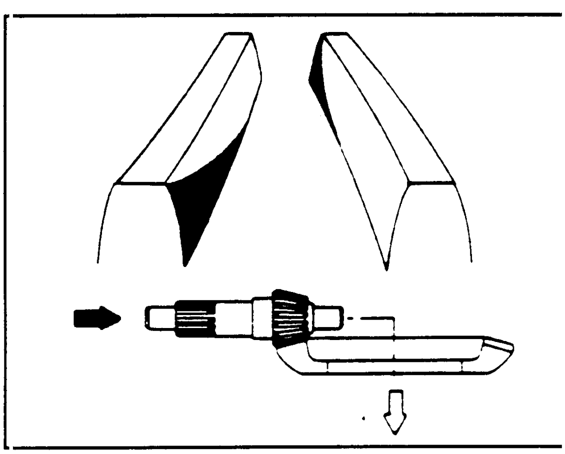
6. Move in the drive pinion towards the ring gear and then increase the gear teeth edge clearances.



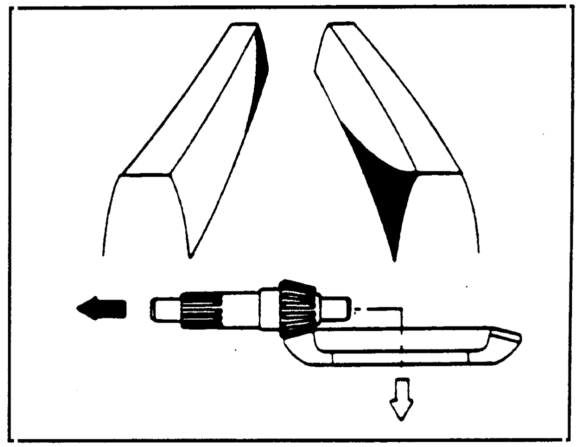
7. Back off the drive pinion from the ring gear and then reduce the gear teeth edge clearances.



8. Move in the drive pinion toward the ring gear and then increase the gear teeth edge clearances.



9. Back off the drive pinion from the ring gear and then reduce the gear teeth edge clearances.



Adjustment Values for the Differential and Carrier Assembly.

ROLLING RESISTANCE OF DRIVE PINION BEARING.

The rolling resistance of the drive pinion bearing without the seal on the shaft is approximately 0.6 to 0.9 lbs-ft (0.8 to 1.2 Nm) as measured by a torque wrench.

TIGHTENING TORQUE OF THE ADJUSTING NUT ON THE DRIVE FLANGE.

For the proper torque on the castle nut or adjusting nut on the drive flange, refer to the values on the following table.

THREAD	TIGHTENING TORQUE	
	lbs-ft	Nm
M24x1.5	109.0	147.8
M30x1.5	260.0	352.5
M36x1.5	318.0	431.1
M42x1.5	579.0	785.0
M45x1.5	615.0	833.8
M48x1.5	651.0	882.6

Adjusting Nut Torque Table

DRIVE GEAR TEETH EDGE CLEARANCES.

The bevel gear drive gear teeth edge clearances should be approximately 0.011 to 0.015 in. (0.3 to 0.4 mm) (approximate minimum value 1/1,000th of the diameter of the ring gear).

ROLLING RESISTANCE OF DIFFERENTIAL BEARINGS.

The rolling resistance of the differential bearings should be 2.0 to 2.9 lbs-ft (2.7 to 3.9 Nm).

Adjusting Values-Wheels.

1. Rolling resistance of wheel bearings should be 4.4 to 8.1 lbs-ft (6 to 11 Nm).

2. a. Tighten the wheel safety nut until there is heavy resistance (approximately 331.9 lb-ft [450 Nm]) to a point where the nut can be turned by hand only with great difficulty.

b. Move the nut according to the Wheel Safety Nut Chart and secure it.

c. The axial clearance between the universal joint shaft with respect to the axle shaft and the disk or the adjusting screw in the planetary carrier should be 0.011 to 0.015 in. (0.3 to 0.4 mm).

Designation	Execution	Back Off Rotation	Security
Slotted nut with counter nut	Fig. A	About 30 degrees	Counter nut +LOCTITE 243
Shaft nut with socket head screw and bushing	Fig. B	About 30 degrees	Cylindrical bolt +LOCTITE 242
Shaft nut with setscrew	Fig. C	About 10 degrees	Setscrew +LOCTITE 262
Shaft nut with socket head screw	Fig. D	About 10 degrees	Cylindrical screw +LOCTITE 270

WHEEL SAFETY NUT CHART (Sheet 1 of 2)

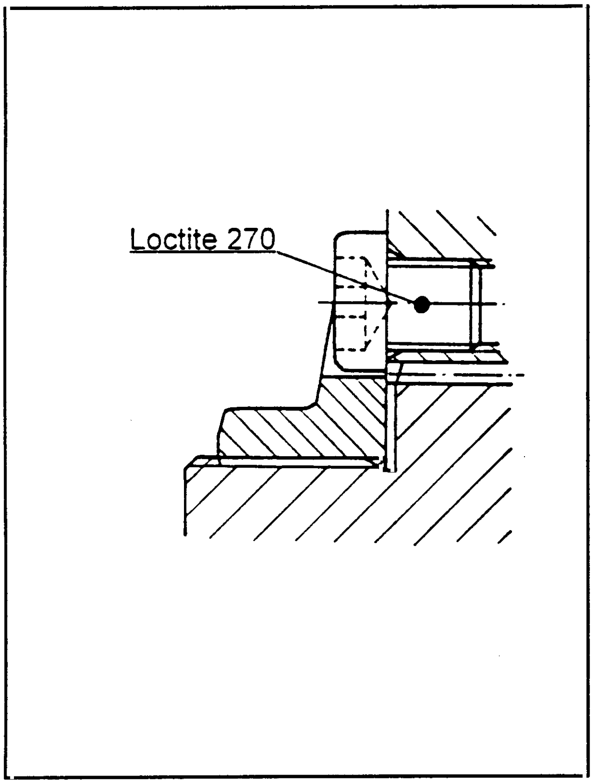


Figure A

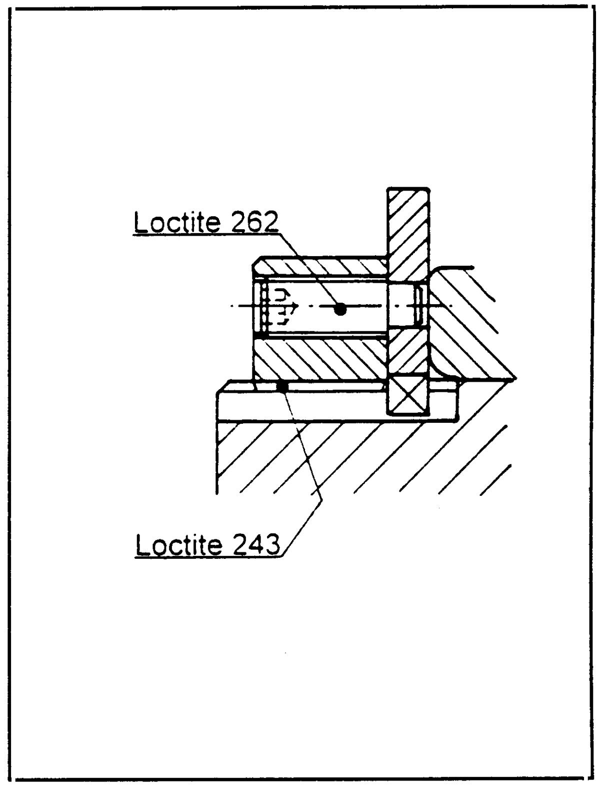


Figure C

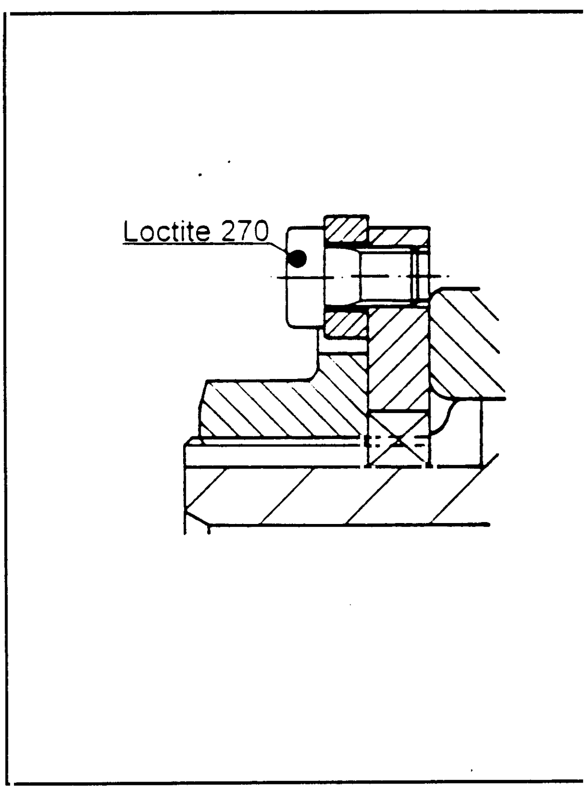


Figure B

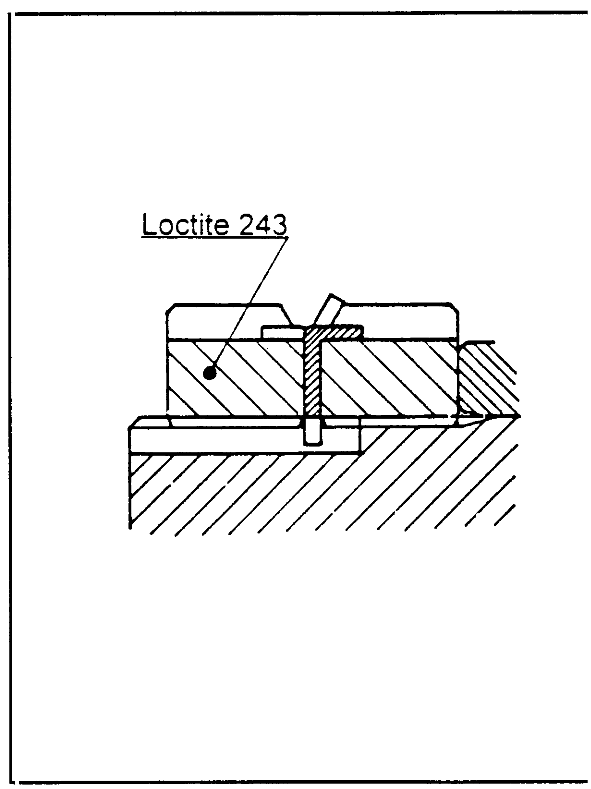


Figure D

Wheel Safety Nut Chart (Sheet 2 of 2)

Metric Threads (lbs-ft/Nm)				
Dimensions	**6.9**	**8.8**	**10.9**	**12.9**
M4	1.7/2.3	2.2/2.9	3.2/4.3	3.7/5.0
M5	3.7/5.0	4.3/5.8	6.4/8.6	7.4/10.0
M6	6.3/8.5	7.4/10.0	11.0/14.9	13.2/17.8
M8	15.4/20.8	18.4/24.9	26.5/35.9	31.7/42.9
M10	30.2/40.9	36.1/48.9	53.1/71.9	61.9/83.9
M12	53.1/71.9	62.6/84.8	92.1/124.8	106.9/144.9
M14	84.8/114.9	99.5/134.9	147.5/199.9	173.3/234.9
M16	132.7/179.9	154.9/210.0	228.6/309.9	269.2/364.9
M18	180.7/244.9	221.2/229.9	317.1/429.9	368.7/499.8
M20	254.4/344.9	313.4/425.5	449.9/609.9	523.6/709.8
M22	342.9/464.9	427.7/579.8	604.8/819.9	708.0/959.9
M24	442.5/599.9	538.4/729.9	774.4/1049.9	899.8/1219.9
M27	656.4/889.9	811.3/1099.9	1143.3/1550.0	1327.6/1799.9
M30	885.0/1199.8	1069.4/1449.8	1548.9/2099.9	1807.0/2449.9
Fine Metric Threads				
M8x1	16.9/22.9	19.9/26.9	28.7/38.9	33.9/45.9
M10x1	31.7/42.9	38.3/51.9	56.0/75.9	66.3/89.8
M12x1.5	56.0/75.9	65.6/89.0	95.8/129.8	114.3/154.9
M14x1.5	92.1/124.8	106.9/144.9	158.2/214.4	188.0/254.8
M16x1.5	140.1/189.9	165.9/224.9	243.3/329.8	287.6/389.9
M18x1.5	202.8/274.9	250.7/339.8	357.7/484.9	420.4/569.9
M20x1.5	283.9/384.9	350.3/474.9	501.5/679.9	582.6/789.8
M22x1.5	383.5/519.9	464.6/629.9	663.8/899.9	774.4/1049.9

Bolt Tightening Torques Chart

Dimensions	Wheel Nut with Spring Lockwasher			
	Phosphorous Darkened		Galvanized	
	lbs-ft	Nm	lbs-ft	Nm
M12x1.5	70.0	94.9	70.0	94.9
M14x1.5	103.2	139.9	103.2	139.9
M18x1.5	199.1	269.9	184.3	249.8
M20x1.5	258.1	349.9	221.2	299.6
M22x1.5	331.9	449.9	258.1	349.9
		Wheel Nut with Thrust Collar		
M22x1.5	479.4	649.9	-	-

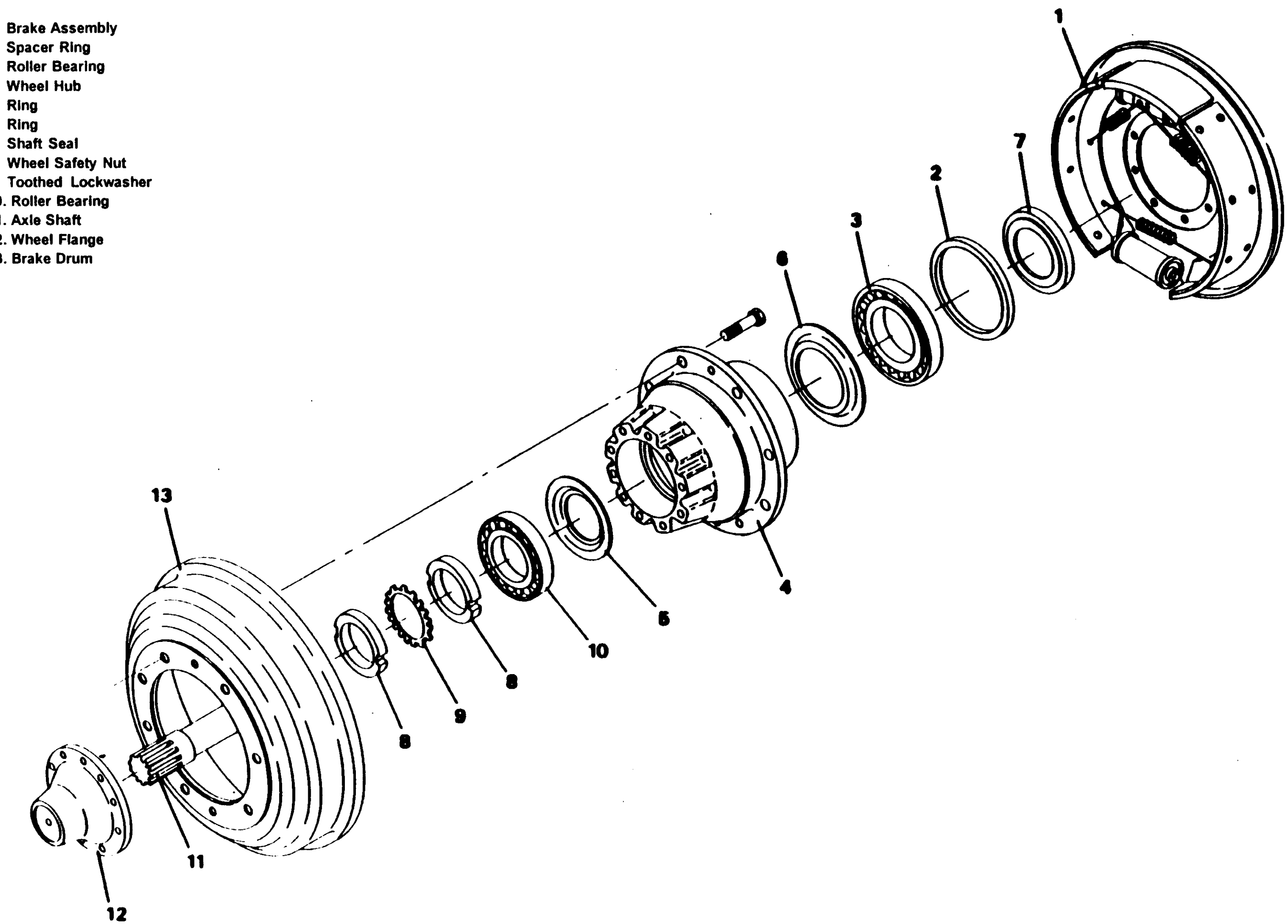
Wheel Nut Tightening Torques Chart

Maximum Cone Size d1		Thread Diameter D2 mm	Tightening Tprque of Castle Nuts	
inches	mm		Lbs-ft	Nm
0.47-0.55	12-14	M10x1	29.5-33.2	39.9-45.0
0.62	16	M12x1.5	36.8-40.5	49.8-54.9
0.70	18	M14x1.5	73.7-81.1	99.9-109.9
0.78	20	M16x1.5	110.6-118.0	149.9-159.9
0.86	22	M18x1.5	125.3-132.7	169.8-179.9
1.02	26	M20x1.5	147.5-162.6	199.9-220.4
1.18	30	M24x1.5	206.5-221.2	279.9-299.9
1.49	38	M30x1.5	250.7-265.5	339.8-359.9
1.77	45	M39x1.5	302.4-317.1	409.9-429.9
-	-	M48x1.5	368.7-390.9	499.8-529.9
-	-	M60x1.5	479.4-516.3	649.9-699.9

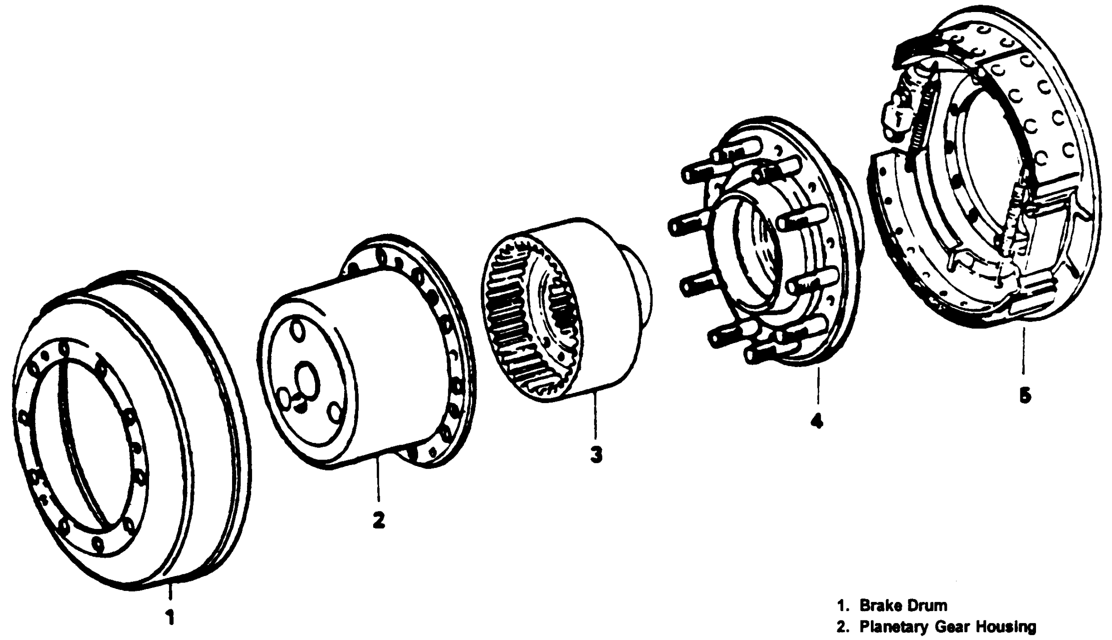
Tightening Torques for Castle Nuts on Ball Joints

The tightening torques of the different thread dimensions of the joints are applicable for nuts of quality S6.

1. Brake Assembly
2. Spacer Ring
3. Roller Bearing
4. Wheel Hub
5. Ring
6. Ring
7. Shaft Seal
8. Wheel Safety Nut
9. Toothed Lockwasher
10. Roller Bearing
11. Axle Shaft
12. Wheel Flange
13. Brake Drum



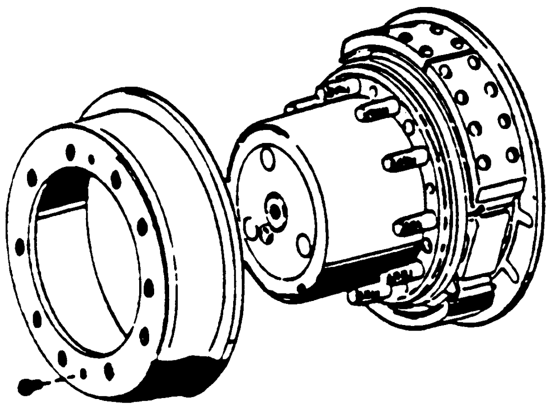
Wheel End Assembly



Wheel End Assembly (Planetary Gear Axle)

WHEEL END (PLANETARY GEAR AXLE).

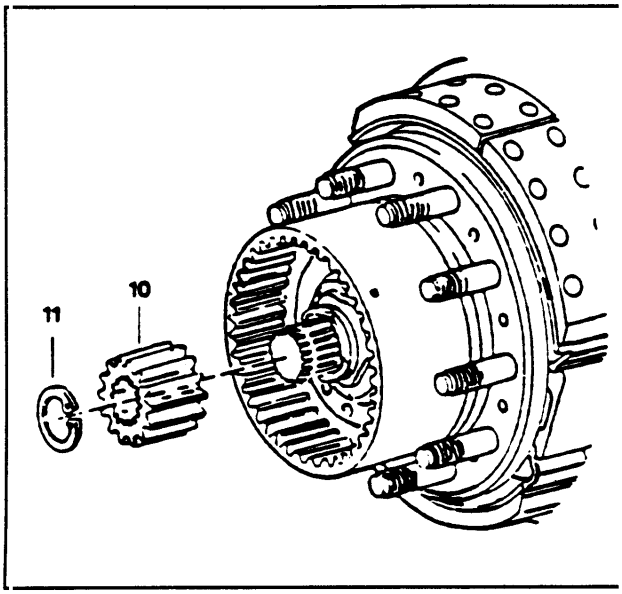
Disassembly.



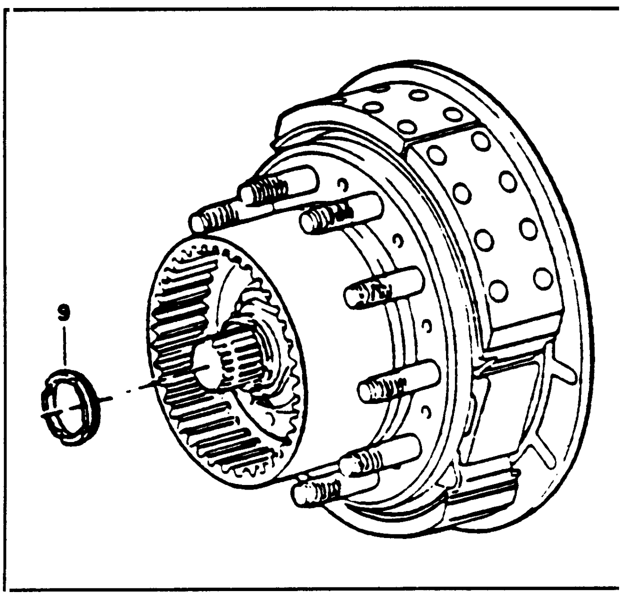
NOTE

On certain types of axles, the brake drum will not be secured with mounting screws because of the danger of gripping caused by rust.

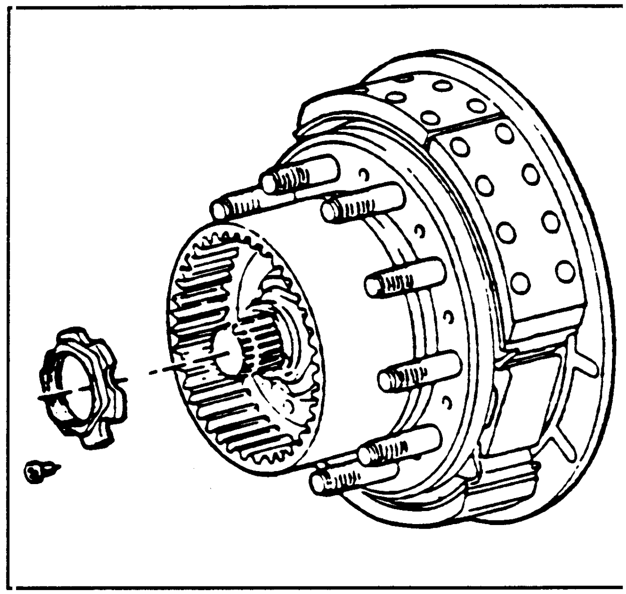
1. Remove the mounting screws securing the brake drum and remove the brake drum.



2. Remove the retaining clip (11) securing the sun gear (10) in place and remove the sun gear (10).

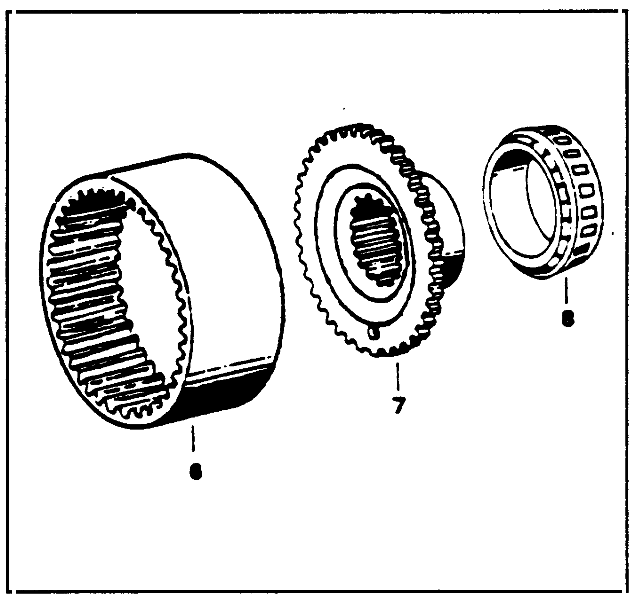


3. Remove the thrust ring (9) from the axle spindle.



4. Remove the wheel safety nut.

5. Remove the carrier (7) and ring gear (6) as an assembly from the axle spindle.



6. Remove the ring gear (6) from the carrier (7)

7. Remove the roller bearing and its inner ring (8) from the ring gear carrier.

8. Remove the wheel hub from the axle spindle.

9. Remove the shaft seal ring.

10. Remove the roller bearings and the seal rings from the wheel hub.

11. If necessary, remove the wheel studs.

12. Remove the spacer ring from the shoulder of the axle spindle.

13. Remove the brake assembly from the axle. On wheel hubs equipped with disc brakes, remove the brake supports.

Assembly.

NOTE

Take care to ensure the brake control is in the proper position.

1. Install the brake assembly (5) onto the axle. Tighten the mounting bolts to the proper torque. Refer to the proper torque chart. Use LOCTITE as outlined under LOCTITE USE in this section. On wheel hubs equipped with disc brakes, install brake supports.

CAUTION

The axle spindle mut be free of corrosion before installing the spacer ring.

2. Heat the spacer ring to about 212 deg. F (100 C) and gently tap the ring onto the shoulder of the axle spindle.

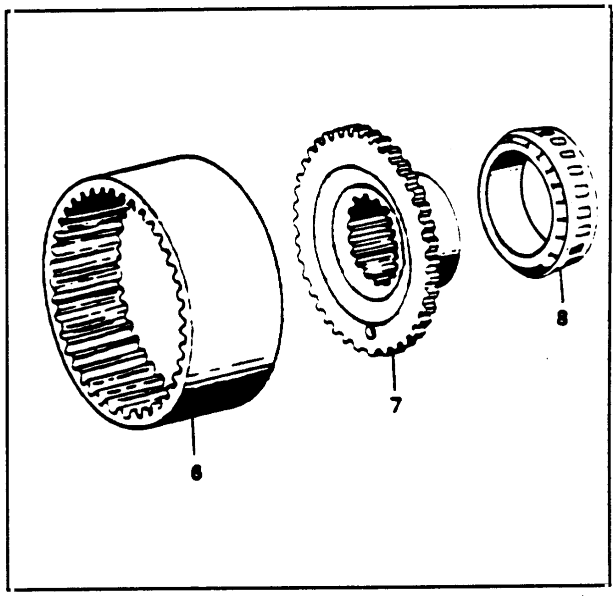
3. Install the wheel studs.

4. Install the roller bearings and the seal rings into the wheel hub. Fill the inner bearing with grease.

5. Install the shaft seal ring with the anti-dust lip facing out. Fill the seal between the lip seal and the anti-dust lip with grease.

6. Install the wheel hub onto the axle spindle.

7. Install the roller bearing and its inner ring (8) up against the ring gear carrier.

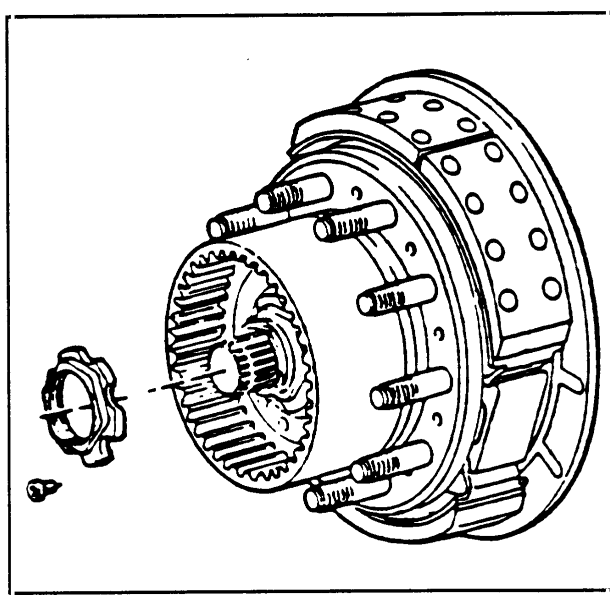


8. Place the ring gear (6) on the carrier (7) and, according to the type of construction, block it either with screws and LOCTITE 270 or with a lock ring.

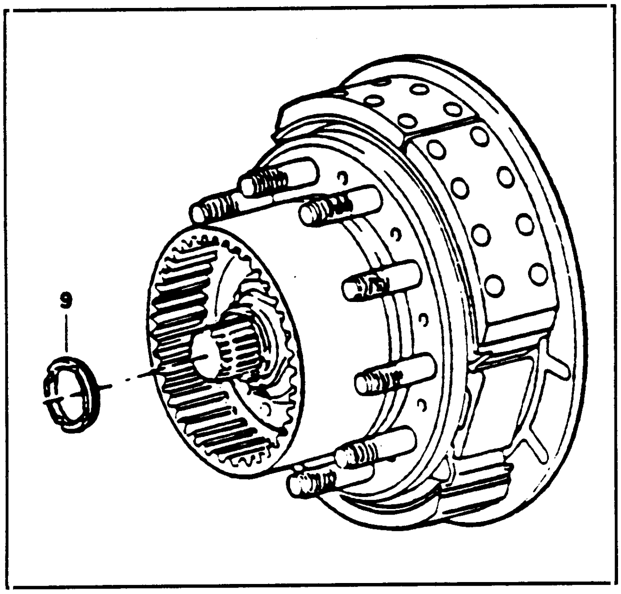
NOTE

The oil compensating hole drilled in the ring gear carrier (7) must be on the bottom.

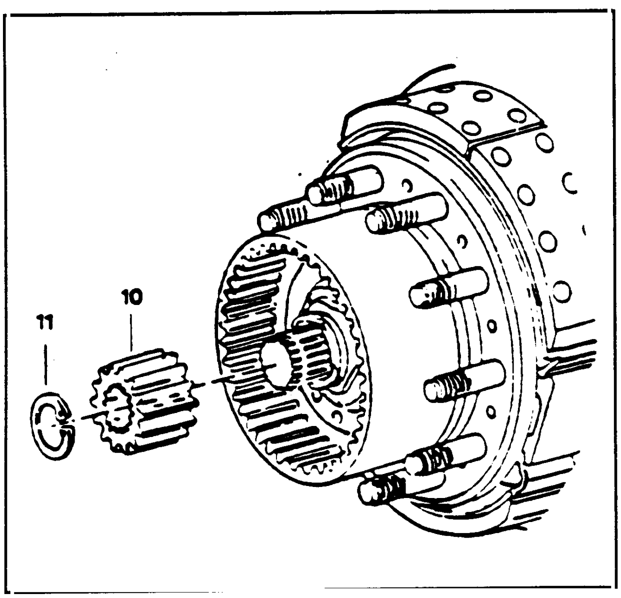
9. Install the ring gear carrier and the ring gear in the wheel hub. Install the assembly onto the axle spindle. The oil compensating hole drilled in the ring gear carrier (7) must be on the bottom.



10. Install the wheel safety nut. Refer to the Wheel Bearing Rolling Resistance and Wheel Safety Nut charts for proper installation and adjustment procedures.

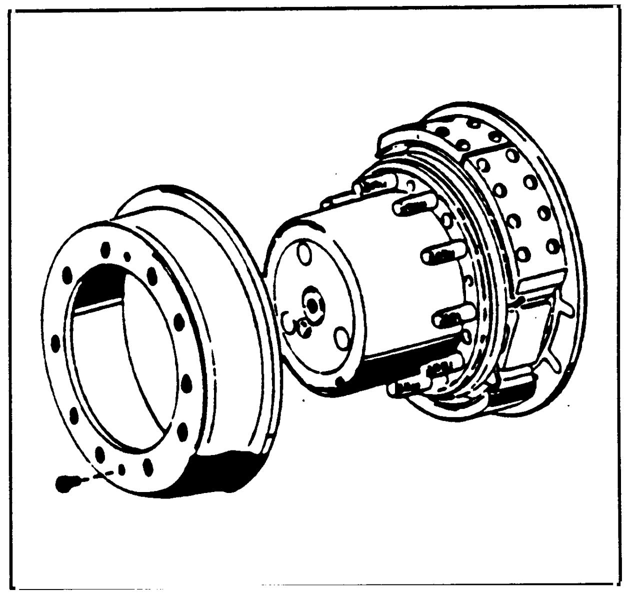


11. Slip the thrust ring (9) onto the axle spindle and secure in place. Secure with LOCTITE 270.



12. Slip the sun gear (10) onto the axle shaft and install the retaining clip (11). Move the axle shaft towards the inside until the retaining clip contacts the sun gear and the sun gear contacts the thrust ring.

13. The axial clearance between the axle shaft and the thrust ring with respect to the adjusting screw on the planetary gear housing should be 0.118 to 0.276 in. (0.3 to 0.7 mm). Refer to Axial Clearance Adjustment and set the proper clearance.

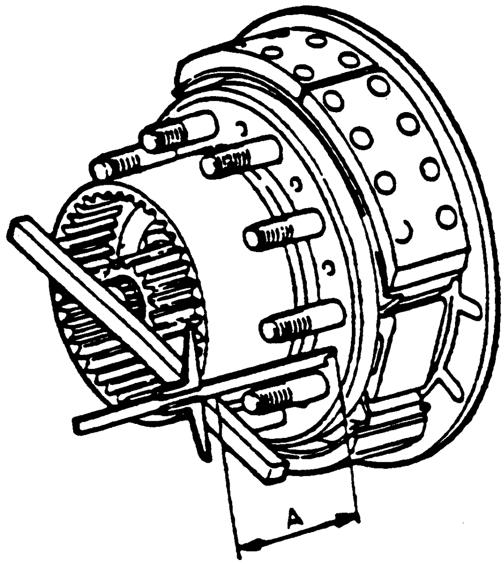


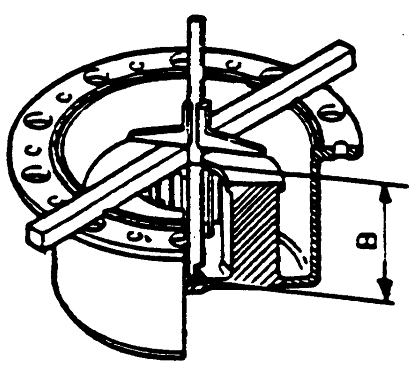
NOTE

On certain types of axles, the brake drum will not be secured with mounting screws because of the danger of gripping caused by rust.

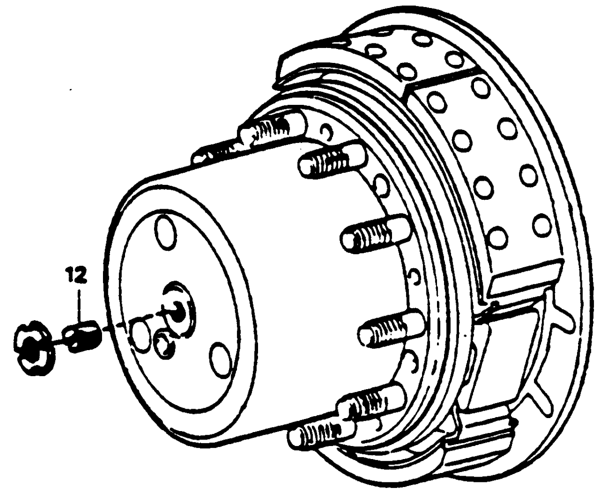
14. Install the brake drum and bolt it in place with the mounting screws. On certain types of axles, the brake drum will not be secured with mounting screws because of the danger of gripping caused by rust.

AXIAL CLEARANCE ADJUSTMENT.





1. The adjustment is made after mounting the planetary gear housing onto the wheel hub by screwing in the adjusting screw (12) until it touches the surface of the axle shaft. Back off the adjusting screw 72 to 170^{0} from the tightened position. This is approximately 0.118 to 0.276 in. (0.3 to 0.7 mm).



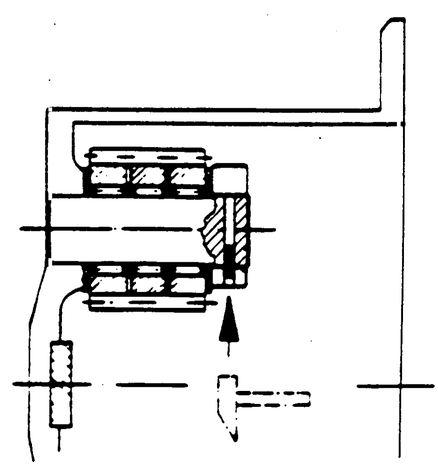
CAUTION

When tightening the counter nut, the , adjusting screw must be held in position to prevent it from being screwed in further.

2. Block the adjusting screw and the counter nut with LOCTITE 270.

PLANETARY GEARS.

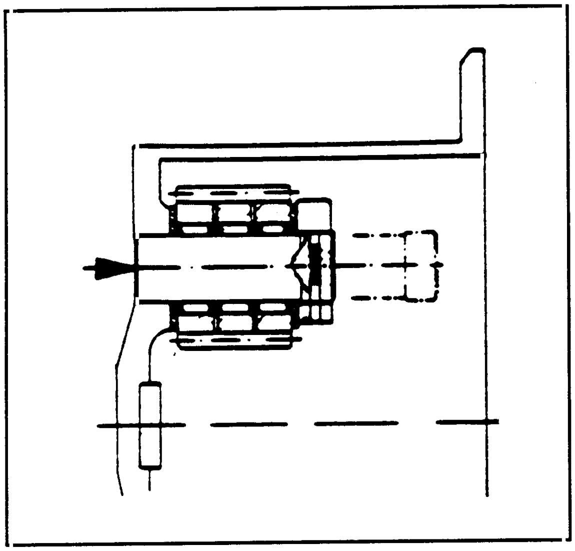
Disassembly.



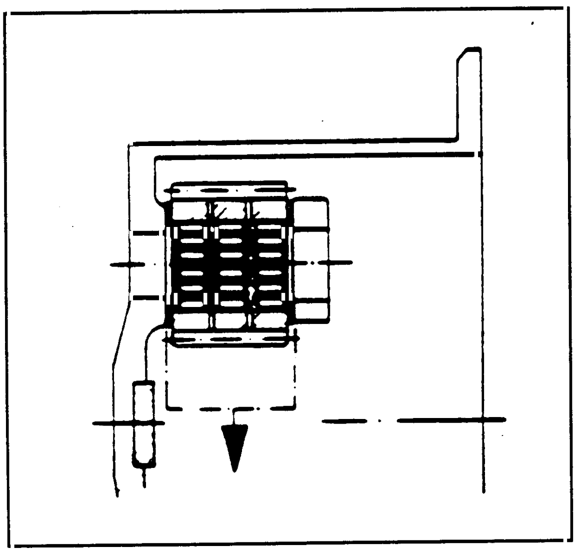
1. Press the lock pins into the planetary pins completely (dowel pin installed through the planetary pin towards the inside).

CAUTION

Because of a 0.003 IN. (0.10 MM) difference in diameter, the planetary pin must not be driven towards the outside to avoid damaging the bore.



2. Drive the planetary pin towards the inside.

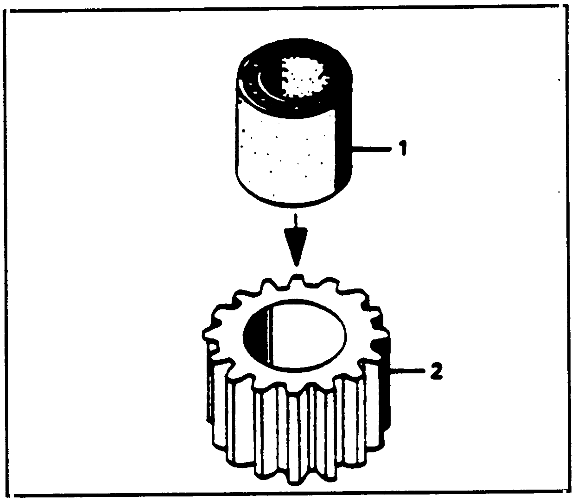


3. Remove the planetary pinions including the thrust rings and the needle bearings.

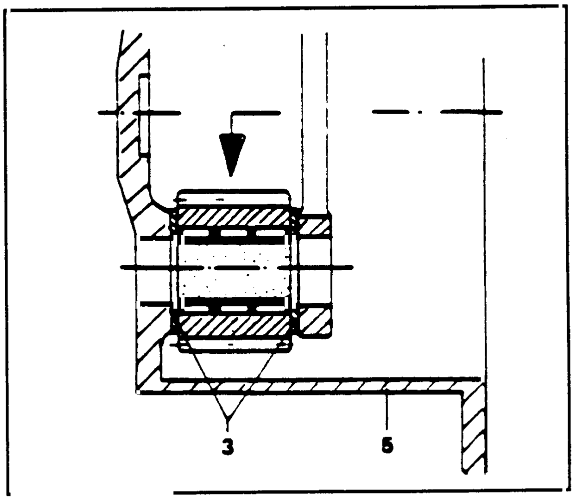
Assembly.

NOTE

Depending upon the construction of the axles, caged or free needle bearings are used. For free needle bearings, paper shells are used for assembly.



1. Install the bearing (1) in the planetary gear (2). Upon insertion, the outer paper shell is removed.



2. Planetary gears with bearings, inner paper shell and thrust ring (3) are installed into the planetary carrier (5) (the planetary carrier must be in the horizontal position).

CAUTION

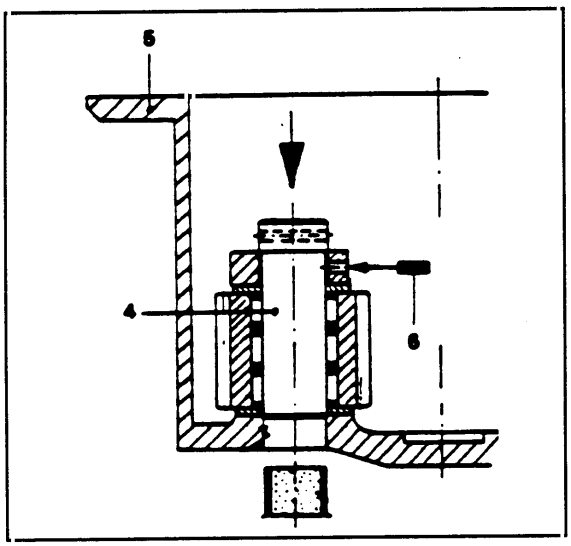
Always install the planetary pin (4) from the inside toward the outside due to the difference in the diameter. Take care to line up the key holes in the planetary pins and the carrier.

NOTE

When installing the planetary pin, the inner paper shell is removed .

NOTE

When installing the planetary pin, the outer bore of the planetary carrier (5) is to be coated with a sealant.



3. Install the planetary pin (4).

NOTE

Planetary carriers incorporating a slot for an O-ring are to have an O-ring installed.

4. After installation of the planetary pin (4), install the lock pin (6).

STEERING KNUCKLE BEARING AND DOUBLE UNIVERSAL JOINT SHAFT BEARING.

Removal.

1. Securely place the axle housing in a horizontal position.

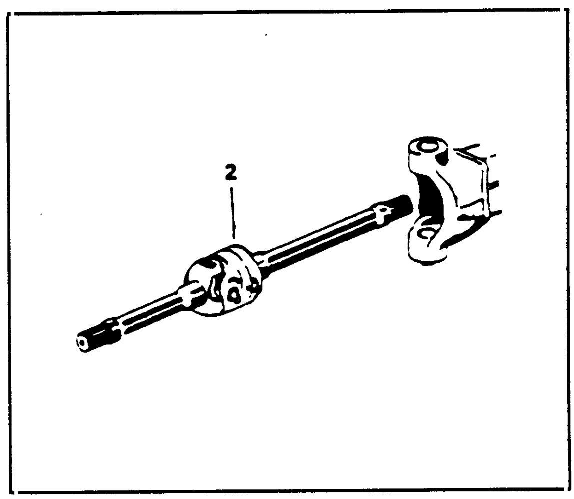
2. Remove the screws securing the differential assembly to the axle housing.

NOTE

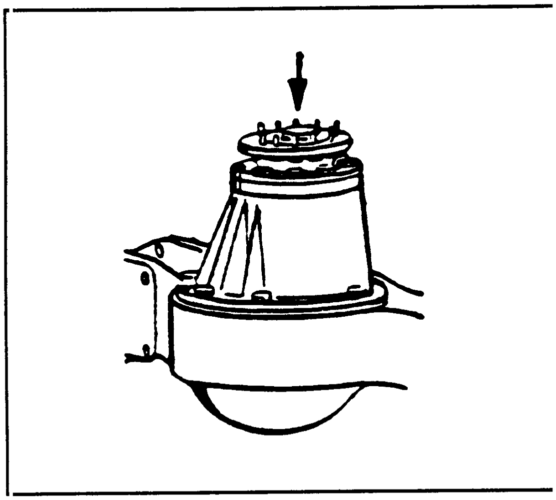
The differential lock should always be switched to the ON position when installing or removing the universal joint or axle shaft. If necessary, loosen the control cylinder from the control lever and hold the lock down by hand or fasten it down in place.

NOTE

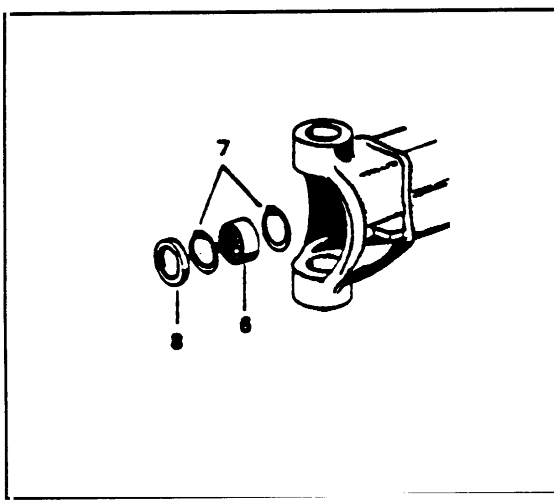
It is necessary to switch on the differential lock to prevent the sliding sleeve from dropping out of the shift fork and into the axle housing when pulling out or sliding in the uaniversal joint or axle shaft. This would mean disaassembly of the axle.



3. Remove the axle shaft from the differential.

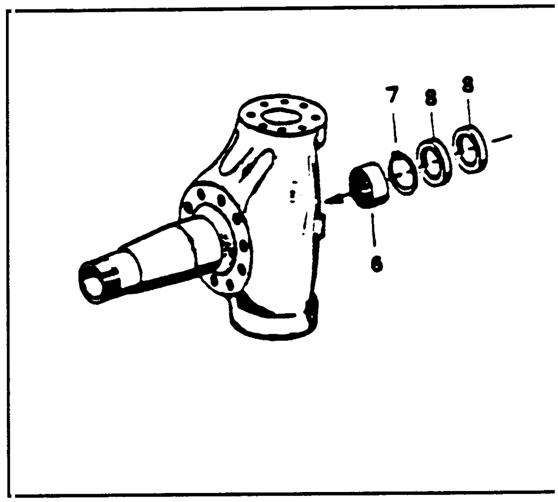


4. Ensure the axle housing is in a horizontal position. Remove the complete differential assembly including the differential lock system from the axle housing.



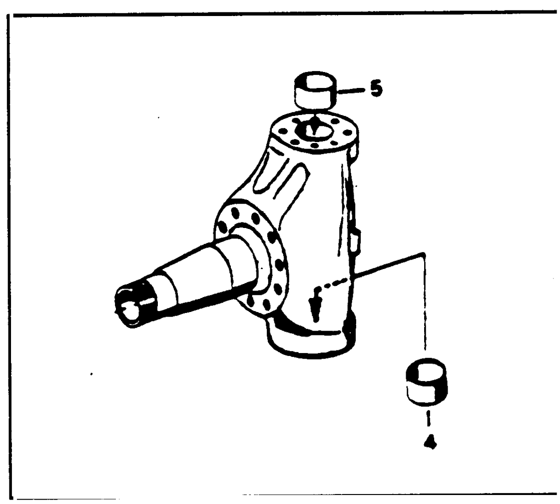
5. Remove the lock rings, seals, and needle bearings.

6. Remove the main lip seals and the anti-dust lip seal.

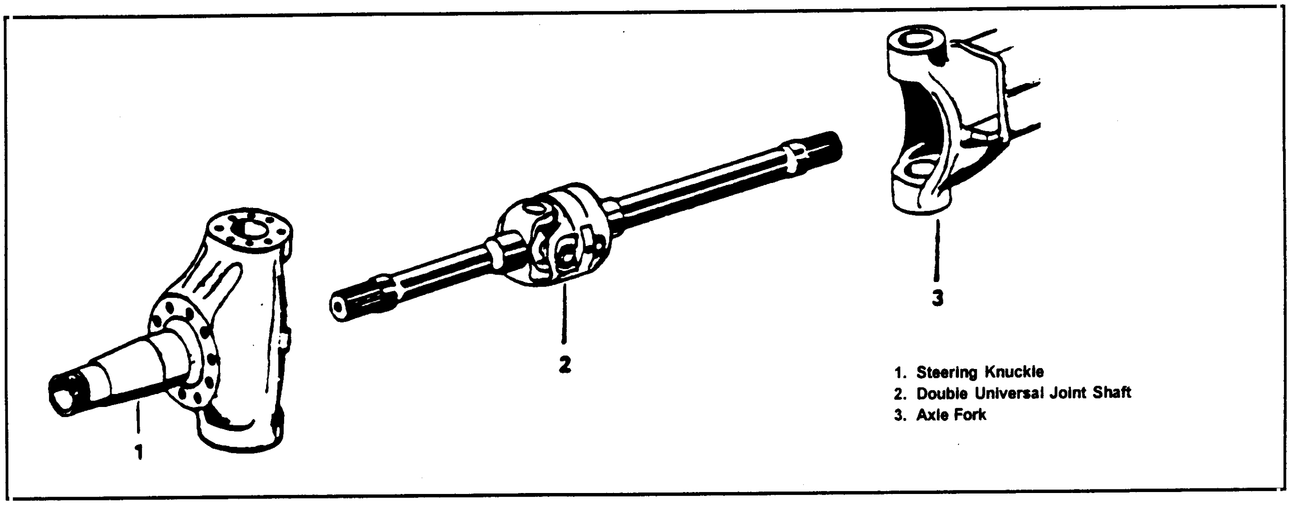


7. Remove the shaft radial seals (8) and support disk if present.

8. Remove the retaining ring (7) securing the needle bearings into the knuckle and remove the outer ring and needle bearings (6).



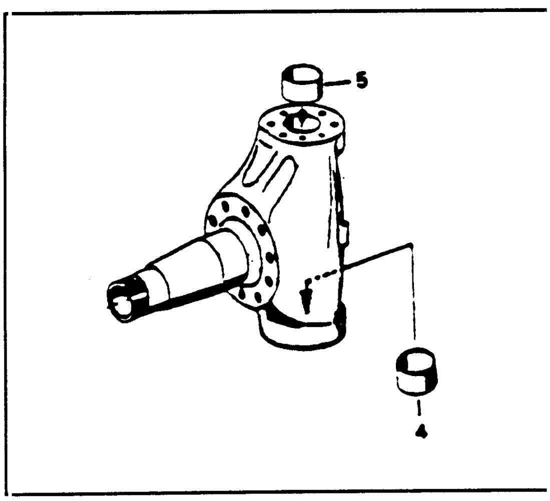
9. If necessary, remove the upper bearing socket (5) from the steering knuckle bore.



10. If necessary, remove the bushing (4) from the lower bore of the steering knuckle.

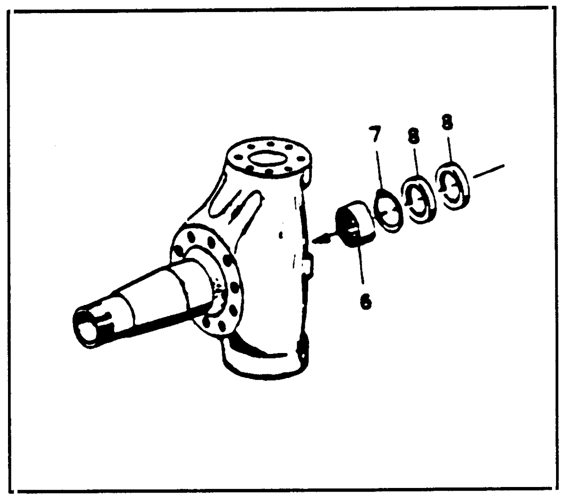
Installation.

1. Install the bushing (4) into the lower bore of the steering knuckle and press in using a sleeve (access through the steering knuckle upper bore).



2. Using a sleeve, install the upper bearing socket (5) into the steering knuckle bore.

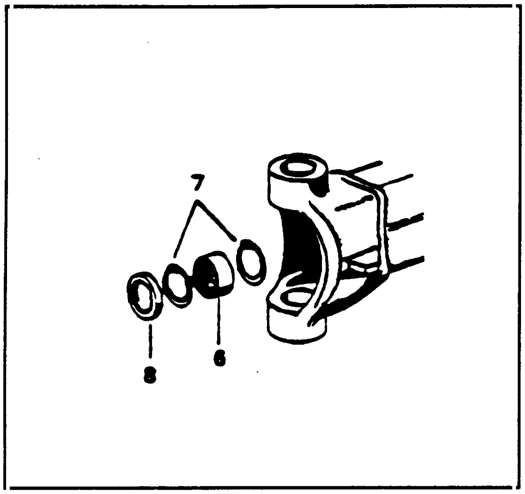
3. Insert the needle bearings with the outer ring (6) into the knuckle and lock securely in place with a retaining ring (7).



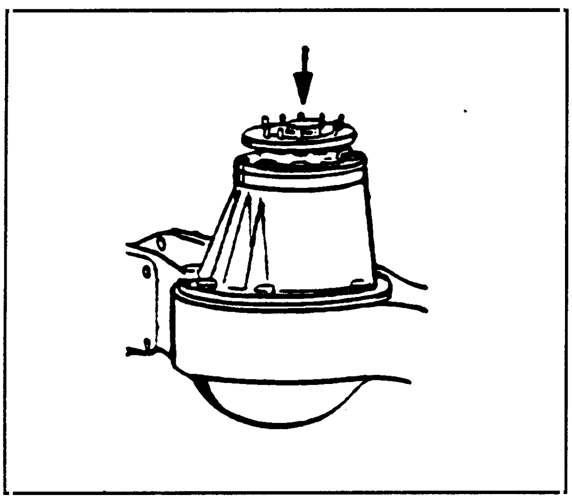
4. Install the shaft radial seals (8) after having coated the outer surfaces with LOCTITE 272. Insert support disk between seals, if present.

5. The main lip seals are to be directed towards the drive mechanism (needle bearing) and the anti-dust lip toward the double universal joint.

6. Fill the space between the lip seals with grease.



7. Install the needle bearing, the seals, and the lock rings, in the same manner as the steering knuckle.



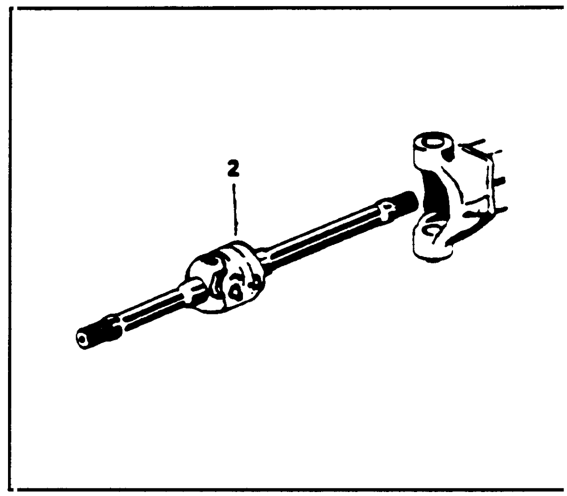
8. Install the complete differential assembly with the differential lock system. The axle housing must be in a horizontal position.

NOTE

The differential lock should always be switched to the ON position when installing or removing the universal joint or axle shaft. If necessary, loosen the control cylinder from the a control lever and hold the lock down by hand or fasten it down in place.

NOTE

It is necessary to switch on the differential lock to prevent the sliding sleeve from dropping out of the shift fork and into the axle housing when pulling out or sliding in the universal joint or axle shaft. This would mean disassembly of the axle.



9. Carefully install the long axis of the axle shaft into the differential.

NOTE

Steps 10 and 11 are for alignment of the differential assembly.

10. Turn the axle housing in both directions, with the axle shafts installed, until a large resistance is felt. Note this position and move the axle housing to an average position.

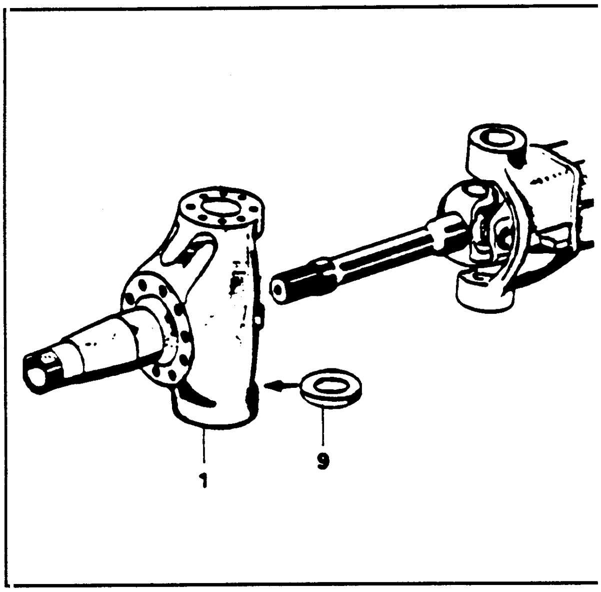
11. Using screws coated with LOCTITE 262, secure the differential assembly to the axle housing in this position.

INSTALLATION OF THE STEERING KNUCKLE TO THE AXLE HOUSING.

NOTE

Coat all installation bolts with LOCTITE 262.

1. Very carefully engage the steering knuckle (1) from the short axis of the universal joint to the axle fork.



2. Install the thrust rings (9).

3. Before inserting the king pins, the bores of the axle fork and the king pins are to be coated with MOLYKOTE powder or paste.

4. Install the king pins.

CAUTION

Clean contact surfaces between steering lever and steering knucklebefore applying LOCTITE.

5. Coat contact surfaces between steering lever and steering knuckle with LOCTITE 270. Then install lever and secure with screws coated with LOCTITE 262.

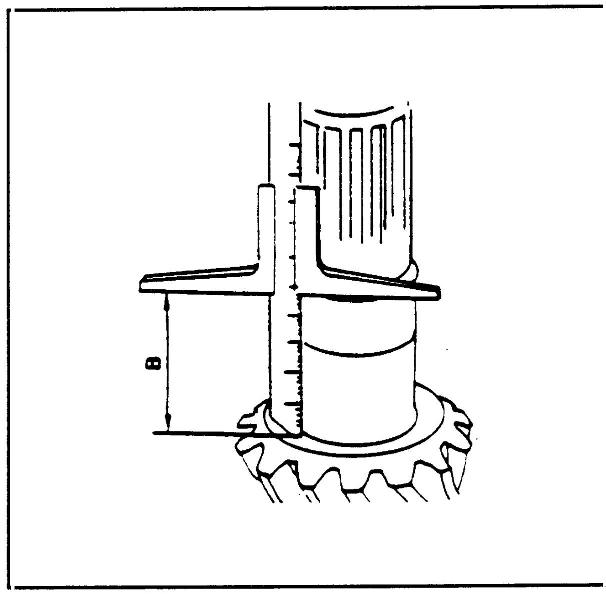
6. Apply Epple 33 to contact surface between steering knuckle and top cover. Install cover and secure with screws coated with LOCTITE 262.

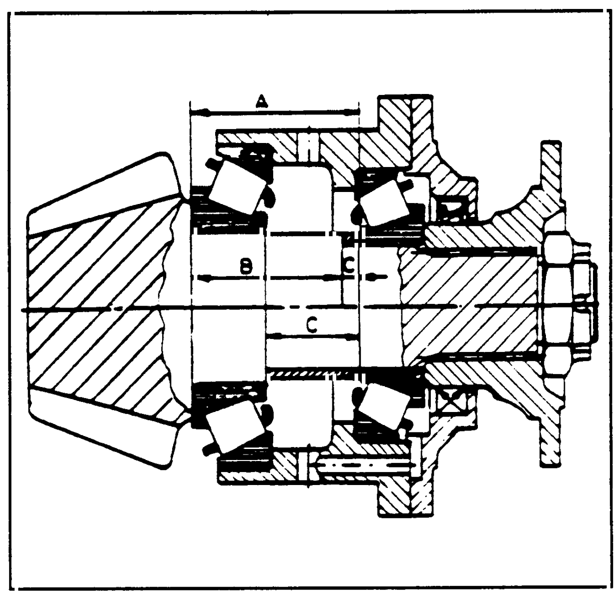
7. Install new grease fittings, if necessary.

8. Grease steering knuckle bearing. See Lubrication Chart.

INSTALLATION OF THE DRIVE PINION BEARING.

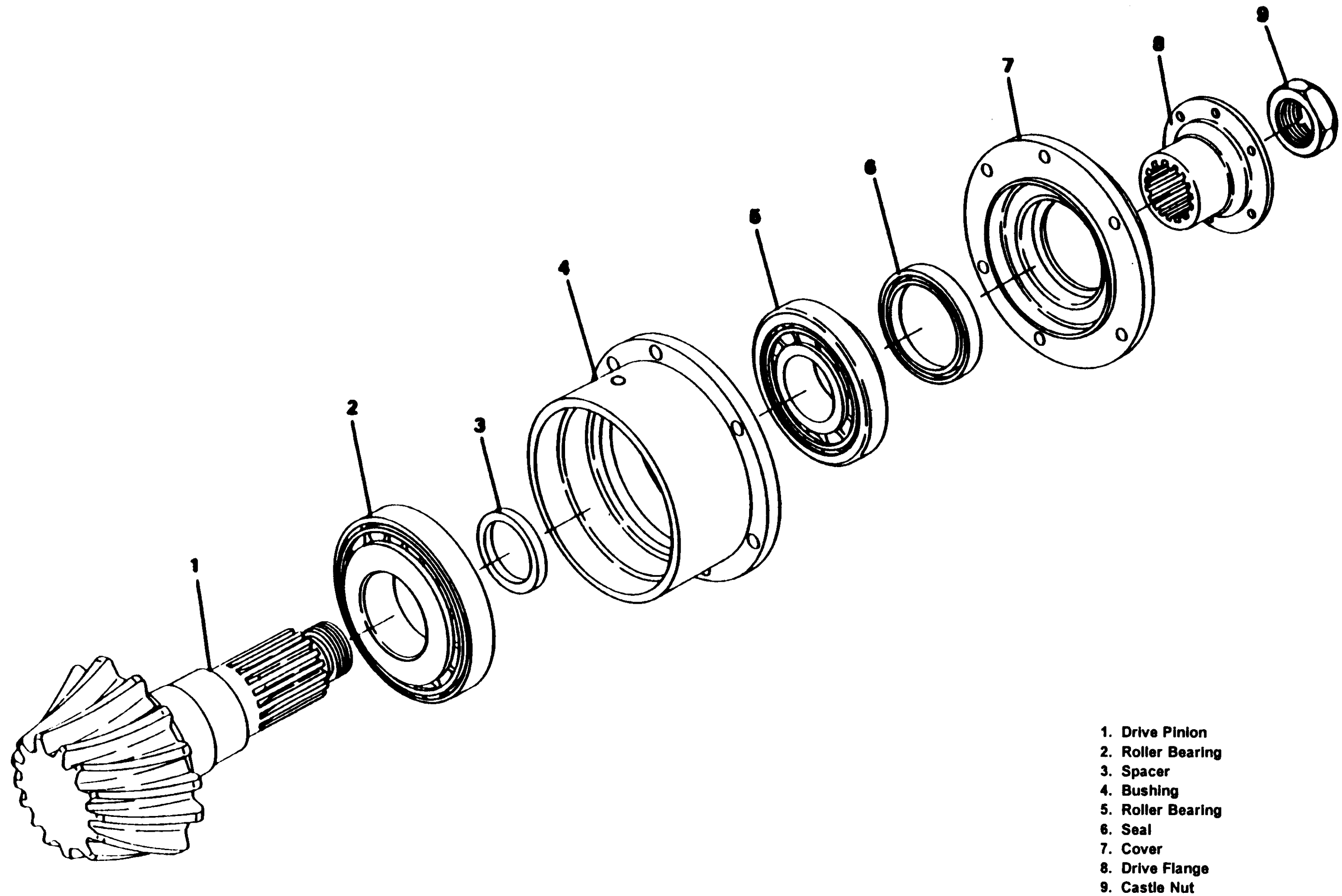
1. Install the two outer rings of the bearing into the housing.





2. Calculate the thickness of the spacer (3) using the following procedure:

a. Place the two inner rings of the roller bearings in their outer rings. Measure dimension A.



Drive Pinion Bearing

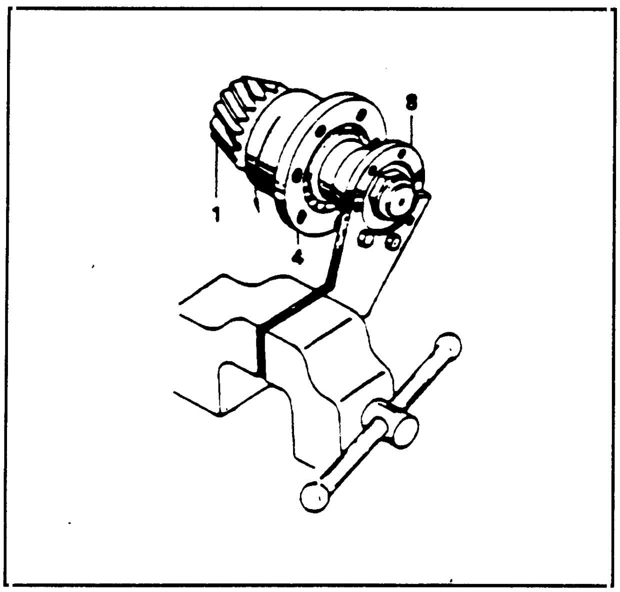
b. Measure dimension B.

c. The thickness of the spacer ring (dimension C) is calculated by subtracting dimension B from dimension A.

3. Heat the drive pinion to 212 deg. F (100 C) and install in on the gear shaft. Drive the pinion on completely after it cools.

4. Install the spacer ring on the pinion shaft.

5. Install the bushing onto the drive pinion shaft. Heat the bearing inner ring to 212 deg. F (100 C) and install it with a tube onto the drive pinion shaft.



6. Install the drive flange onto the drive pinion shaft. Torque the safety nut by turning the housing. Refer to the Adjusting Nut Torque Table. For torquing, place the drive pinion in a vice using soft jaws or clamp the drive flange with the fork support in the vice.

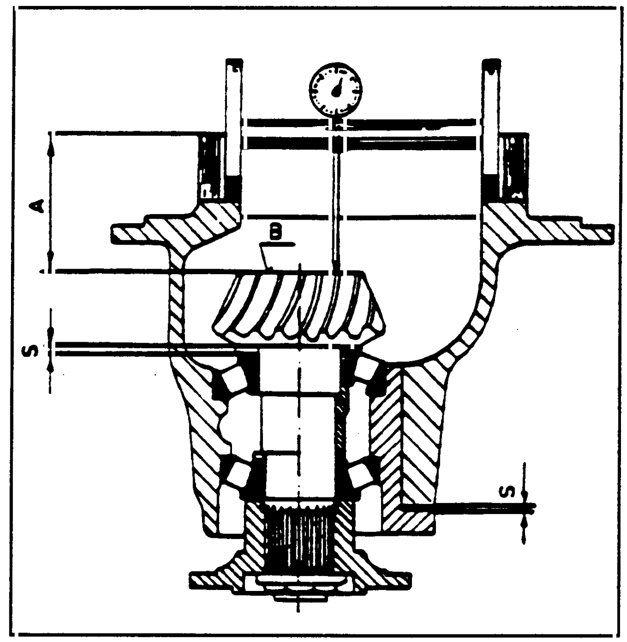
7. Measure the resistance of the housing using a torque wrench. If the measured value is not 0.8 to 1.7 lbs-ft (1.1 to 2.3 Nm), correct the resistance by adjusting the thickness of the spacing washer. After the bearing is properly adjusted, back off the shaft lock nut on the drive pinion.

8. Install the cover (7) with its shaft radial sealing rings (6). Verify the position of the oil circulation and return holes. Fill the space between the seals with bearing grease.

9. Slip on the drive flange and tighten the drive flange and tighten the lock nut as outlined in the Adjusting Nut Torque Table.

DIFFERENTIAL AND CARRIER ASSEMBLY INSTALLATION.

1. Mount and bolt in place the complete pinion gear into the pinion gear casing.



2. Determine the thickness (dimension 5) required of the adjusting screw. To obtain the proper contact on the sides as outlined under Adjustment of Ring Gear and Drive Pinion, correct the axial position using shims. This can be accomplished through trial and error or by measurement using a dial indicator.

Dimension A is the distance measured from the center of the differential to the front face of the pinion.

Dimension B is the adjusting distance for a correct installation of the pinion. To accomplish this, the setting required (variable according to the version utilized) must be corrected with respect to the setting marked on the front face of the gear.

The thickness of the washer used (dimension C) during the first installation must be modified to conform to the difference between dimensions A and B.

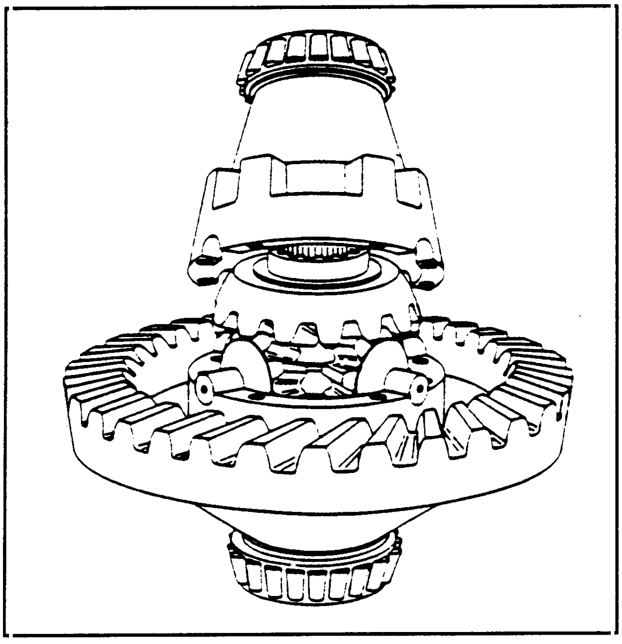
DIFFERENTIAL.

Removal and Disassembly.

I. Remove the roller bearings.

2. Remove the ring wheel from the differential case.

3. Scribe marks onto the differential case. These marks will aid in assembly.

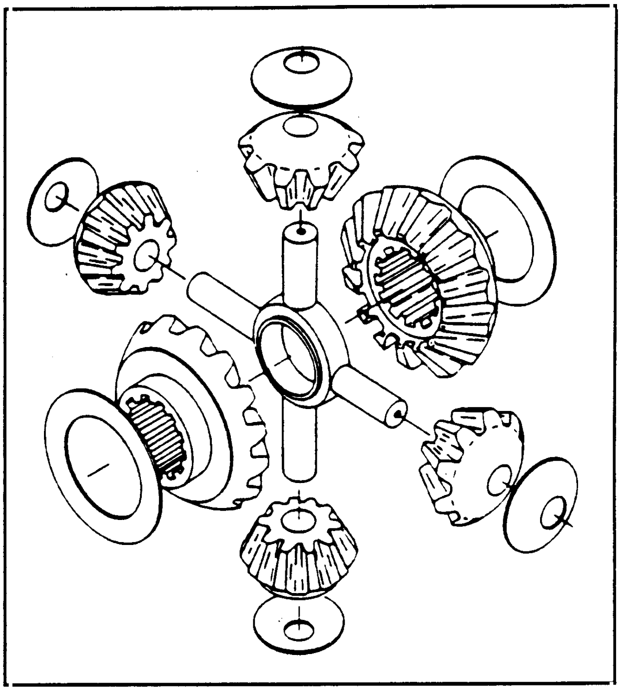


4. Remove the differential case bolts and separate the differential case halves.

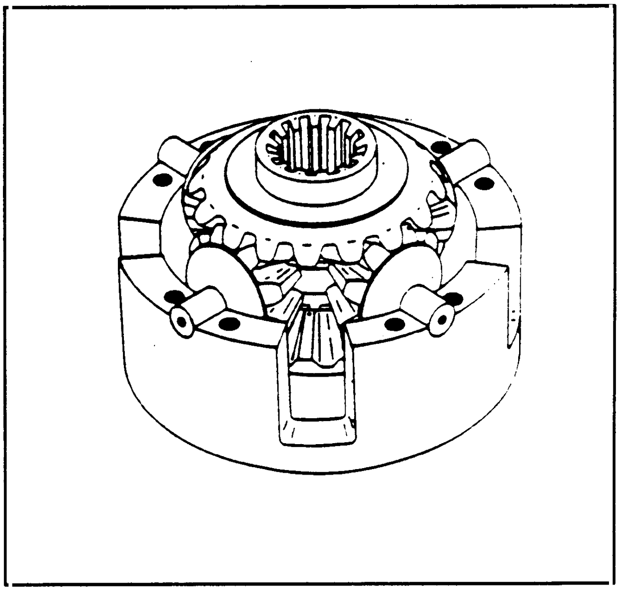
5. Remove the differential side gear and side gear thrust washer.

6. Remove the spider with differential gears and differential pinion thrust washers from the differential case.

7. Remove the remaining differential side gear with the side gear thrust washer in the differential case.



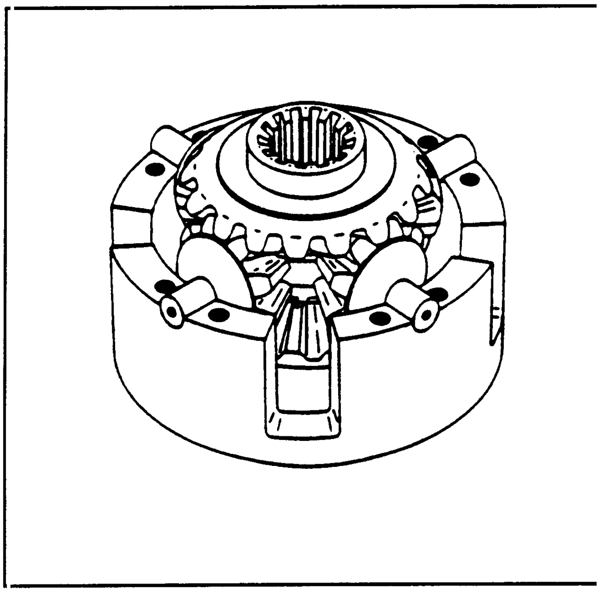
Assembly and Installation.



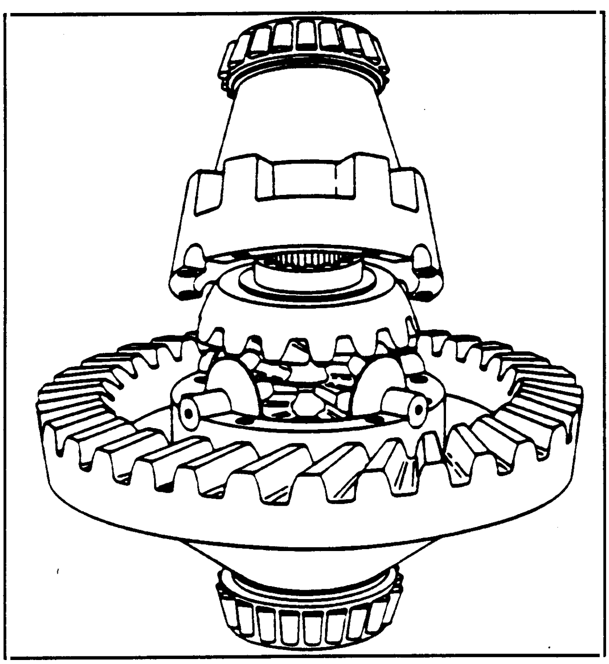
Before assembly, all of the bevel gears and the thrust rings should be well oiled. For the planetary pinions of the differential which are not equipped with bearings, coat each shaft with MOLYKOTE paste.

1. Place one differential side gear with the side gear thrust washer in the differential case.

2. Install the spider with differential gears and differential pinion thrust washers in the differential case.



3. Install the other differential side gear and the side gear thrust washer.



4. Install the other half of the differential case over the assembly in accordance with the alignment marks. Torque the differential case bolts, coated with LOCTITE 262, as outlined in the Bolt Tightening Torques Chart.

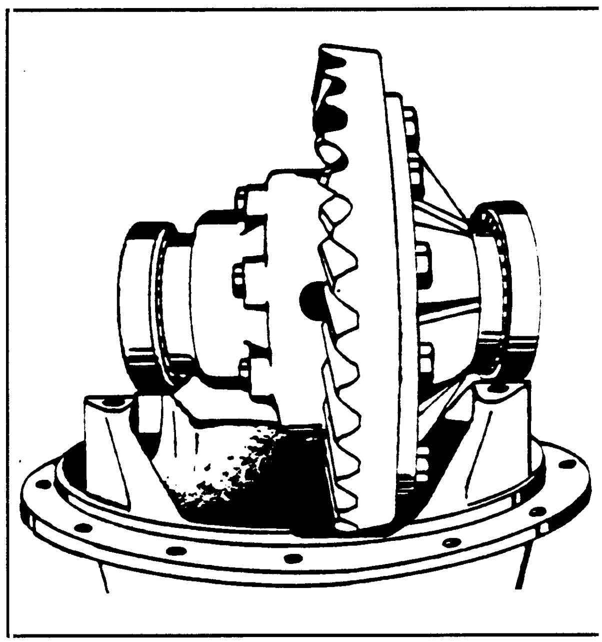
5. Check to ensure all differential pinions can rotate easily.

6. Coat the contact surface of ring gear with LOCTITE 270.

7. Install the ring gear on the differential case by tapping lightly on the circumference. Apply LOCTITE 262 to ring gear bolts. Torque the ring gear bolts as outlined in the Bolt Tightening Torques Chart.

8. Heat the two roller bearings to 212 deg. F (100 C) and install using a sleeve.

SINGLE STAGE CARRIER INSTALLATION.



1. Place the differential with the outer rings of the bearings on the differential carrier which is in a vertical position, the latter being already with the drive pinion firmly installed.

2. Mount the bearing caps and align them with the adjusting rings.

CAUTION

Do not interchange the bearing caps.

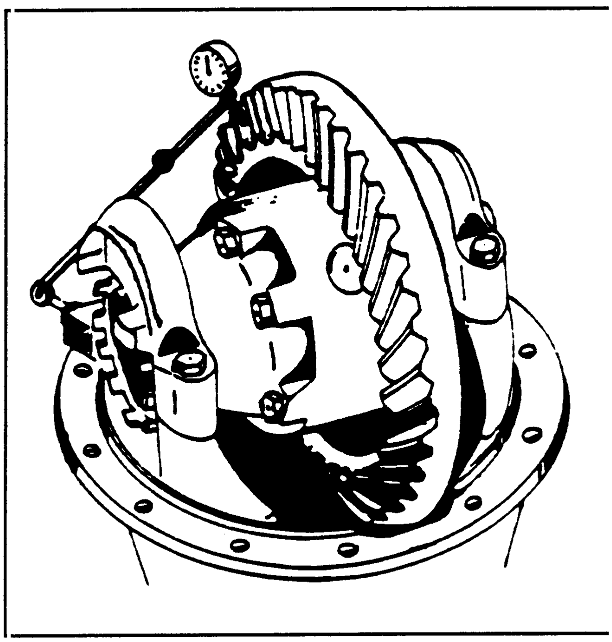
CAUTION

Be careful of the reference marks on the bearing caps with respect to the differential carrier.

3. Hand tighten the bearing cap bolts. By a counter rotation of the adjusting rings, move the differential until the teeth side play is approximately 0.011 to 0.015 in. (0.3 to 0.4 mm). The value at the narrowest place is marked on the ring gear.

4. Loosen the adjusting rings one by one without moving the differential.

5. Coat the threads of the adjusting rings and the differential carrier with LOCTITE 262.



6. Hold the drive pinion at the drive flange. Using a dial indicator, check the backlash play by rotating the ring gear. Securely tighten the gear cap bolts. Gear meshing and tooth side play is to be checked according to Adjustment of Ring Gear and Drive Pinion.

7. Individually loosen the gear cap bolts. Coat them with LOCTITE 270 and then torque them as outlined on the Bolt Tightening Torques Chart.

8. Install lock plates with screws. Bend down lock plates.

INSTALLATION OF AXLE UNIT WITH DIFFERENTIAL LOCK.

Installation of the Actuation Unit.

CAUTION

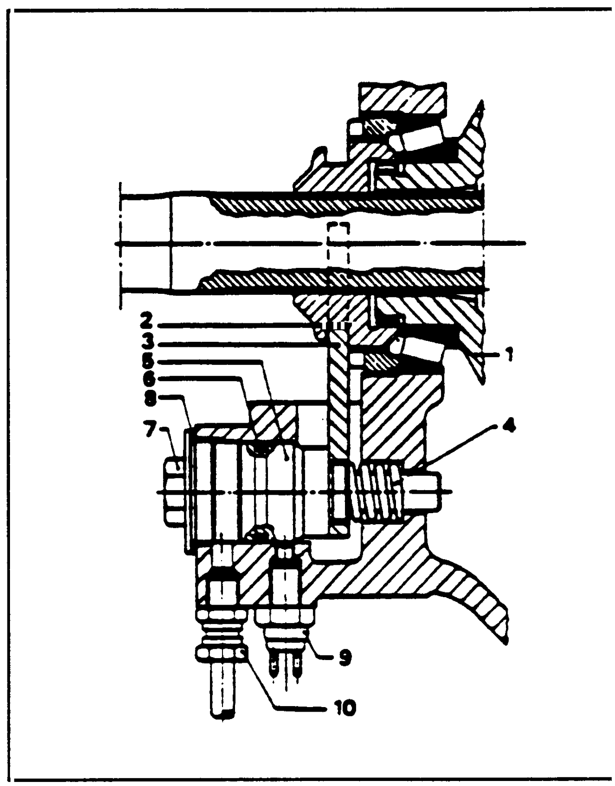
The sliding ring should not under any circumstances be subjected to pressure in the switched on condition.

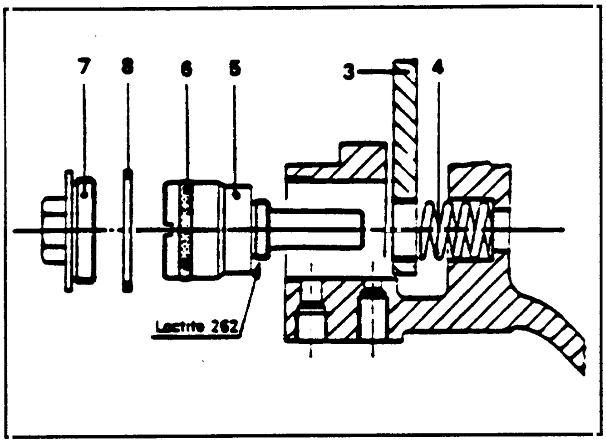
NOTE

The position of the control lever depends on the fitting position of the actuating cylinder.

1. Slide the control shaft with sliding ring fitting into the axle housing. Mount the sliding ring in the groove of the sliding sleeve. Screw the gear casing in with the sealing ring. Slip on the lever and pin it down.

INTEGRATED DIFFERENTIAL LOCK.





Assembly.

1. Install the pressure spring (4).

2. Install O-ring (6) on piston (5).

3. Apply LOCTITE 572 to threads of the shift fork (3) and maintain the shift fork (3) between the pressure spring (4) and the housing.

4. Insert the piston (5) into the housing hole (lead the pivot through the shift fork (3) and pressure spring (4) into the dead eye) and screw up with the shift fork (3). The piston is equipped with a slot for a screwdriver. Take care not to damage the O-ring.

5. Screw in the switch (9)

6. Install the sliding sleeve (2) on the shift fork.

7. Check the switching function. The indicator lamp lights when the sliding sleeve (2) meshes with the differential case (1).

8. Install the cap (7) and packing washer (8).

Disassembly.

1. Remove the packing washer (8) and cap (7).

2. Remove the sliding sleeve (2) from the shift fork.

3. Unscrew the switch (9).

4. Remove the piston (5) from the housing.

5. Remove the shift fork (3).

6. Remove the O-ring (6) from the piston (5).

7. Remove the pressure spring (4).

STEERING PUMP

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DESCRIPTION

The steering pump is a direct drive, gear type pump. The pump provides a priority flow at a fixed rate.

MAINTENANCE

TROUBLESHOOTING.

SYMPTOM	PROBABLE CAUSE	SOLUTION
1. Noisy pump.	a. Low oil supply.	a. Fill reservoir.
	b. Oil too heavy.	b. Change to proper viscosity.
	c. Air leak in inlet line.	c. Check plumbing.
	d. Partly blocked inlet line.	d. Check for foreign object and/or clean lines.
2. Foaming oil.	a. Pump cavitation.	a. Refer to Symptom 1.
	b. Water in the oil.	b. Check reservoir.
3. Pump or oil overheating.	a. Oil supply too thin.	a. Drain, and fill with proper viscosity oil.
	b. Oil supply contaminated.	b. Drain, clean filter, and fill with clean oil.
	c. Pump cavitating.	c. Refer to Symptom 1.
	d. Pump drive shaft excessively misaligned with pump driven shaft.	d. Check alignment.
	e. Pump drive shaft axially loaded by driving shaft.	e. Check for clearance at ends of shafts, for shaft misalignment or worn driving splines.
	f. System relief valve bypassing.	f. Check relief valve setting. Refer to Solution 4c.
4. Low flow.	a. Pump cavitating.	a. Refer to Symptom 1.
	b. Foaming oil.	b. Refer to Symptom 2.

DISASSEMBLY.

NOTE

Discard all O-rings and seals upon removal.

1. Clean the unit thoroughly with solvent, kerosene, or other non-corrosive cleaning fluid.

2. Scribe a line across the pump sections to act as a guide during assembly.

3. Remove the four capscrews securing the cover plate, gear plate, and flange together.

4. Separate the sections by lightly tapping them with a soft metal hammer.

5. Remove the O-rings and backup ring from the cover plate and the flange.

6. Remove the O-rings and pressure plate from the cover plate and the flange.

7. Remove the dowels from the gear plate and the cover plate.

8. Remove the seals and backup ring from the flange.

9. If necessary, remove the parts that make up the flow control valve assembly from the cover plate.

10. If necessary, remove the parts that make up the pressure relief valve assembly from the cover plate.

INSPECTION.

1. Inspect the shafts for roughness in the bearing and sealing areas.

2. Inspect the splines for damage or excessive wear.

3. Inspect the gear end faces, outside diameter, and teeth for roughness and score marks.

4. Check all internal threads for damage.

5. Inspect the wall of the gear bore diameters for excessive wear or score marks.

ASSEMBLY.

NOTE

Use only new seals and O-rings during assembly. Thoroughly coat all seals and O-rings with clean hydraulic oil prior to installation.

1. If removed, install the parts that make up the pressure relief valve assembly into the cover plate.

2. If removed, install the parts that make up the flow control valve assembly into the cover plate.

3. Install the seals and backup ring into the flange.

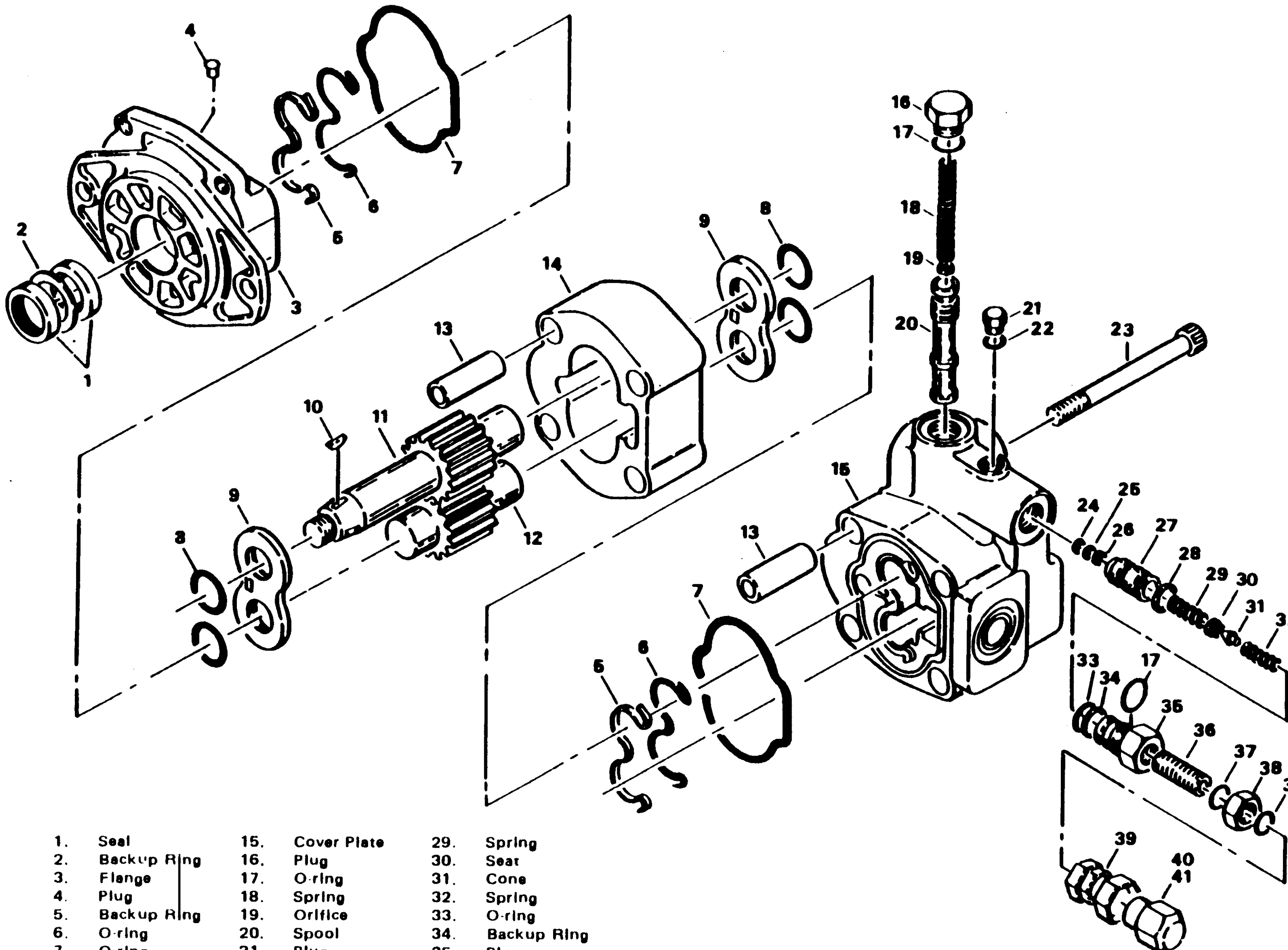
4. Install the dowels into the gear plate and the cover plate.

5. Install the O-rings and pressure plate into the cover plate and the flange.

6. Install the O-rings and backup ring into the cover plate and the flange.

7. Assemble the cover plate, gear plate, and flange together using the scribe marks made during DISASSEMBLY and install the four capscrews securing the cover plate, gear plate, and flange together.

8. Add a generous amount of clean hydraulic oil into both ports to ensure the pump is adequately lubricated. Rotate the drive shaft to distribute the oil and check for freedom of shaft rotation.



1.	Seal	15.	Cover Plate	29.	Spring
2.	Backup Ring	16.	Plug	30.	Seat
3.	Flange	17.	O-ring	31.	Cone
4.	Plug	18.	Spring	32.	Spring
5.	Backup Ring	19.	Orifice	33.	O-ring
6.	O-ring	20.	Spool	34.	Backup Ring
7.	O-ring	21.	Plug	35.	Plug
8.	O-ring	22.	O-ring	36.	Setscrew
9.	Pressure Plate	23.	Capscrew	37.	O-ring
10.	Key	24.	Snap Ring	38.	Lock Nut
11.	Drive Gear	25.	Washer	39.	Sleeve
12.	Idler Gear	26.	Screen	40.	Nut
13.	Dowels	27.	Spool	41.	Relief Valve
14.	Gear Plate	28.	Backup Ring		

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Steering Pump

MITER GEAR

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DESCRIPTION

The purpose of the miter gear is to connect the steering column to the steering gearbox when the positioning of the steering gearbox makes a direct link impossible.

MAINTENANCE

INSPECTION.

Check all screw joints and radial shaft seals for leakage. Check the screw joints of the miter gear for a firm seat and tighten, if necessary.

DISASSEMBLY.

1. Remove the protecting cap (26) from the end of the miter gear.

2. Loosen the groove nut (25) and remove the adjusting screw (24) and O-ring (22) from the housing (14). Remove the shaft seal (23) from the adjusting screw.

3. Remove the screws (5) and remove the flange assembly (6) complete with the bevel gear (13) from the housing (14).

4. Using a plastic hammer, knock the bevel gear (19) out of the housing (14).

5. Force the ball bearing (21) off of the bevel gear (19) and remove the retainer clip (20).

6. Remove the retaining ring (16) and the shim washer (17) securing the thrust bearing (18) to the bevel gear (19) and remove the thrust bearing (18).

7. Remove the needle bushing (15) from the housing (14) using an extractor.

8. Remove the protecting cap (1) from the end of the flange (6).

9. Using a plastic hammer, knock the bevel gear (13) out of the flange (6).

10. Remove the shaft seal (2) and the needle bearing (3) from the flange (6). If necessary, remove the oil plug (4).

11. Remove the retainer clip (8) and then remove the supporting ring (9), ball bearing (10), supporting ring (11), and retainer clip (12) from the bevel gear (13).

ASSEMBLY.

1. Press the needle bearing (3) into the flange (6). It should be forced in approximately 1/2-inch (12.5 mm), measured from the outer contour of the flange housing.

2. Install a new shaft seal (2) into the flange.

3. If removed, install the oil plug.

4. Install the retainer clip (12) onto the bevel gear (13) and then install the supporting ring (11), ball bearing (10), the supporting ring (9), and the retainer clip (8).

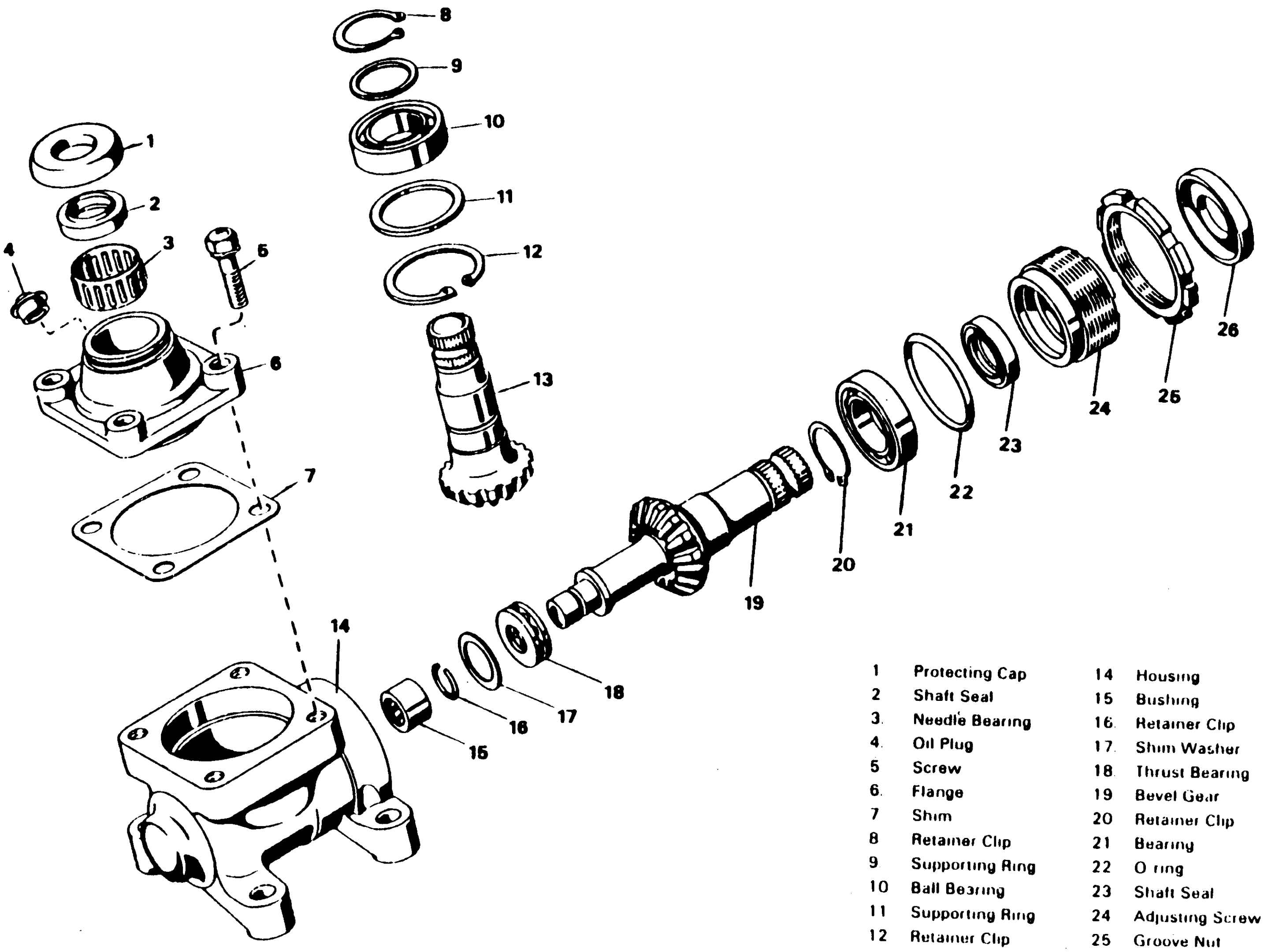
5. Install the bevel gear assembly (13) into the flange (6). Mark two adjacent teeth of the bevel gear (13) with chalk.

6. Ensure the housing bore and needle bushing (15) are free of any oil and grease. Apply Activator T and then Loctite 59 to the needle bushing (15) and the housing bore. Press the needle bushing (15) into the housing bore up to the stop.

7. Press the thrust bearing (18) on to the bevel gear (19). Slip on the ball cage and second bearing race. Place a 0.3 mm shim washer (17) on the thrust bearing (18). Install the retainer clip (16).

8. Install the retainer clip (20) onto the bevel gear (19) and install the bearing (21) onto the bevel gear (19) up to the stop.

9. Push the bevel gear assembly (19) into the housing (14). Mark a tooth of the bevel gear (19) with chalk.



1	Protecting Cap	14	Housing
2	Shaft Seal	15	Bushing
3.	Needle Bearing	16.	Retainer Clip
4.	Oil Plug	17.	Shim Washer
5	Screw	18.	Thrust Bearing
6.	Flange	19	Bevel Gear
7	Shim	20	Retainer Clip
8	Retainer Clip	21	Bearing
9	Supporting Ring	22	O ring
10	Ball Bearing	23	Shaft Seal
11	Supporting Ring	24	Adjusting Screw
12	Retainer Clip	25	Groove Nut
13	Bevel Gear	26	Protecting Cap

Miter Gear

10. Install the adjusting screw (24) into the housing (14) and tighten slightly. When turning the bevel gear (19), the turning torque should be approximately 2 pounds-inch (2 kgcm).

11. Install a 0.6 mm shim (7) onto the flange (6) and place the flange assembly with bevel gear (13) on the housing (14) so that the marked tooth of the bevel gear (19) gets situated between the two marked teeth of the other bevel gear (13). Uniformly install the screws (5) until the bevel gears mesh without any play. If this happens before the flange of the bevel gear has got contact, fill the remaining gap with shims (4). The shims (4) are available 0.1, 0.12, 0.15, 0.2, 0.3, 0.4, 0.6, and 1.0mm thick. If absence of play is not achieved, use a thinner shim.

12. After the correct shim thickness has been determined, precisely adjust the miter gear using the shim washers (17). The washers are available 0.05, 0.1, 0.12, 0.15, 0.2, 0.3, 0.4, 0.6, and 1.0mm thick. The bevel gears are adjusted right when they run without jamming or sticking almost free from play. The maximum backlash allowable is 0.04 mm. There must be no play at all in the straight ahead position of the steering gearbox. If it is not possible to achieve absence of play in the straight ahead position of the steering gearbox, the mesh has to be shifted by one or more teeth until this requirement is met. Then check mesh pattern of the bevel gears with blue paint and correct, if necessary.

13. After the required shims have been found, the flange (6) must be removed from the housing (14) in order to install the seals.

14. Screw the adjusting screw (24) out of the housing (14).

15. Install the O-ring (22).

16. Press the radial shaft seal (23) with the sealing lip facing in. Fill the space between the sealing lip and dust lip with hot bearing grease such as Aral HTR.

17. Install the adjusting screw only to such a degree that the friction torque when turning the bevel gear is 3.5 to 6.0 pounds-inch (4.0 to 7.0 kgcm).

18. Install the groove nut (25) and tighten to 37 pounds-foot (5.0 kgm). Check the torque of the bevel gear again.

19. Torque the screws (6) to 35 pounds-foot (4.8 kgm).

20. Fill the space between the shaft seal (23) and the protecting cap (26) with grease such as Aral HTR. Slip the protecting cap (26) over the bevel gear (19).

21. Fill the miter gear with ATF oil or EP transmission oil until it flows over at the oil plug (4).

RESERVOIRS

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DESCRIPTION

The reservoirs are storage tanks that function to provide a volume of compressed air for braking which must be adequate in relation to the volume used by the brakes and auxiliary devices. In addition, the first system reservoir provides a location in the system where the air heated by compression may be cooled and any additional water vapor not removed by the air dryer may condense.

The reservoirs are built in accordance with SAE Standard Air Brake Reservoir Test Code and Inspection Procedure SAE J-10-a. They are made from sheet steel, with stamped heads and rolled shells. The seams are electrically welded and each reservoir is internally coated for corrosion resistance. Each reservoir is tested at 300 psi (2068.5 kPa/20.68 bar) hydrostatic pressure.

MAINTENANCE

REPAIRS.

Minor.

Minor repairs to the reservoir consist of examining the reservoir mounting and the inspection of the outside for corrosion or damage. The outside should be kept painted to prevent the possibility of corrosion causing a failure.

Major.

Except in unusual cases, major repairs on reservoirs are not economical or practical. If a reservoir has been damaged so as to be unfit for use, it is most economical to replace it with a new one.

In exceptional cases where the outside of a reservoir has become excessively coated with sludge which cannot be drained off, it is sometimes advisable to remove it and clean with a solvent, steam or water. If a solvent is used to clean the reservoir, the reservoir should be thoroughly aerated before reinstalling.

LOW PRESSURE INDICATING SWITCH

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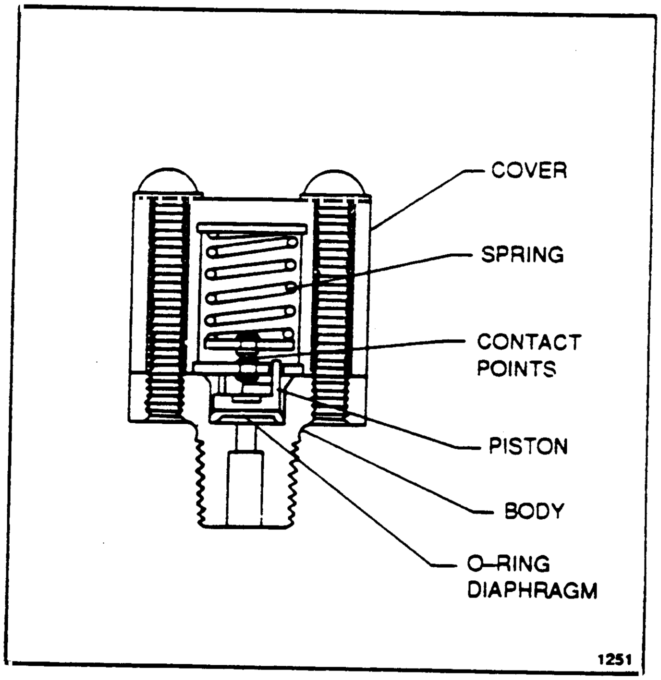
DESCRIPTION

The low pressure indicating switch is designed to provide a warning to the operator that one or both air systems are at a low pressure. The switch is electrically connected to a buzzer and a red indicator warning light. The switch has a die cast body with a nylon cover, and employs a spring loaded O-ring diaphragm and piston. A gasket is used between the cover and body. The switch is provided with electrical contacts and a single terminal from connection to the electrical system. The contacts remain closed by spring force until the air pressure below the diaphragm is great enough to overcome the spring force. This pressure setting is approximately 75 psi (517 kPa/ 5.17 bar) and should be marked on a label affixed to the valve body.



Low Pressure Indicating Switch - Cutaway

THEORY OF OPERATION

When air pressure at the supply port and under the diaphragm is above 75 psi (517 kPa/5.17 bar), the electrical contacts remain open because the force exerted by air pressure underneath the diaphragm overcomes the force exerted by the spring above the diaphragm.

When air pressure below the diaphragm drops below 75 psi (517 kPa/5.17 bar), the spring exerts a force which is greater than the force exerted by the air pressure below the diaphragm. This causes the diaphragm and piston to move and allow the electrical contacts to close. This completes or closes the electrical circuit to the warning buzzer and the indicator light.

THROTTLE CONTROL CYLINDER

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LIST OF FIGURES

DESCRIPTION

The throttle control cylinder is bracket mounted on the engine throttle linkage. It regulates the throttle lever position in response to the amount of air pressure exerted by the foot throttle valve in the cab.

THEORY OF OPERATION

When the foot throttle valve is depressed, air pressure extends the control cylinder piston. The piston changes position in relation to the amount of air pressure received from the foot throttle valve. As the piston modulates, the throttle lever also moves. When the foot throttle valve is released, an internal spring causes the piston to return to the idle position.

MAINTENANCE

DISASSEMBLY.

NOTE

> The lever assembly (2) does not have to be removed to disassemble the cylinder. as the bearing is pre-packed. DO NOT submerge the lever assembly in solvent.

1. Remove the dust boot (3).

2. Remove the screws(S) and the cover (1).

3. Remove the 0-ring seal (14) from the body cavity.

4. Remove the piston assembly from the body (15).

5. Remove the piston sleeve (4) and the springs (17 and 21).

6. Remove the capscrew (11) from the piston (16).

7. Remove the piston (16) from the cylinder shell (18).

8. Remove the U-cup Seal (13) and the wear ring (12) from the piston (16).

CLEANING AND INSPECTION.

1. Clean all parts in a petroleum base solvent. mineral spirits (stoddard solvent) or kerosene and dry thoroughly.

2. Ensure all parts are clean and free of residue.

3. Inspect parts for wear, corrosion, or damage. Replace as necessary.

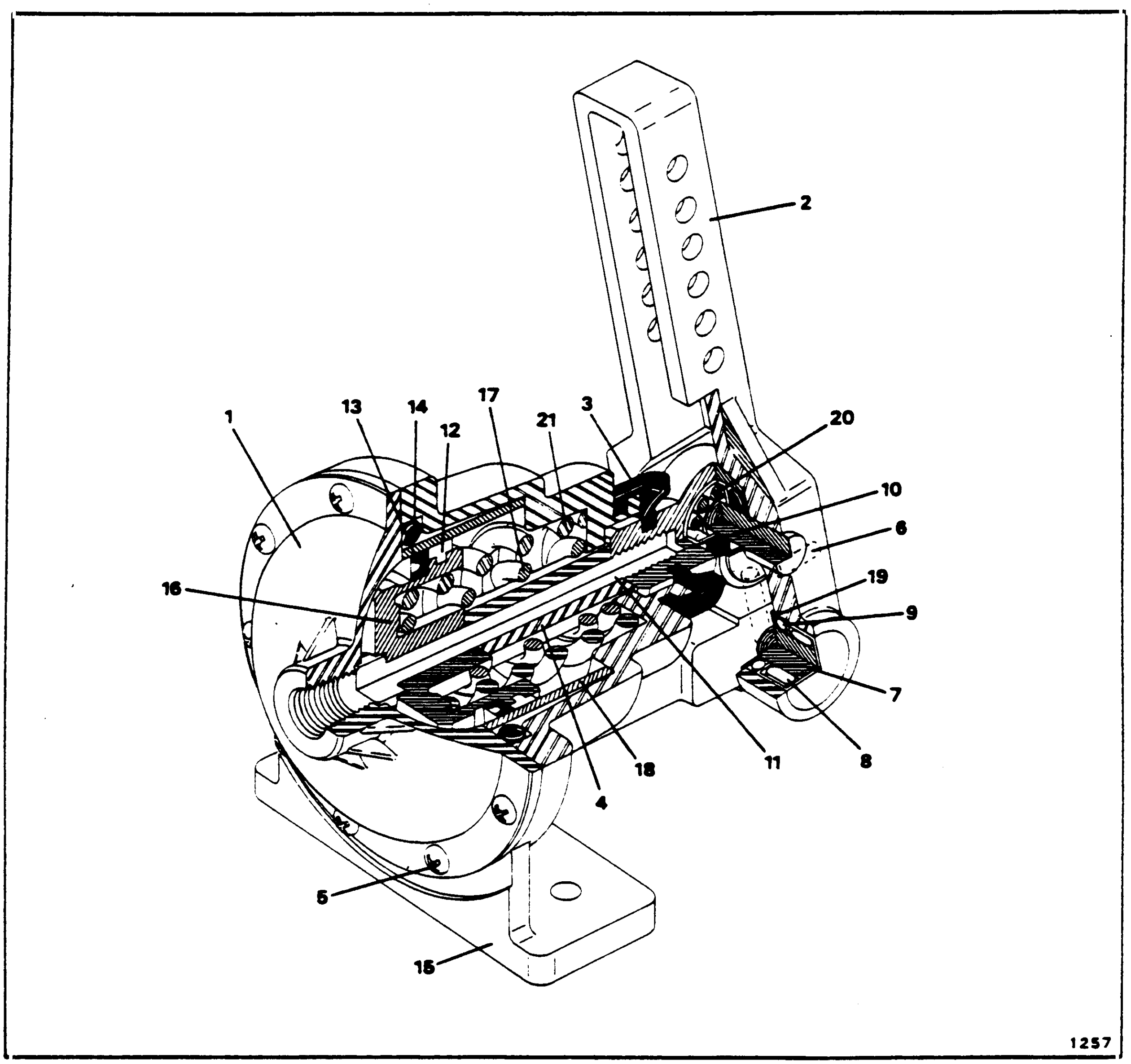
4. Check the dust boot on the control cylinder piston rod to ensure it has no tears or worn areas.

5. Check the lever pivot points for excessive wear and corrosion.

6. Check the area around the control cylinder to ensure that nothing will interfere with its operation.

ASSEMBLY.

1. Coat the O-ring seal (14), the U-cup seal (13), and the inside surface of the cylinder shell (18) with a lubricant such as Dow-Corning No. 33 medium or equivalent.



1.	Cover	11.	Piston End
2.	Lever	12.	Wear Ring
3.	Dust Boot	13.	U-cup Seal
4.	Piston Sleeve	14.	O-ring
5.	Screw	15.	Body
6.	Dowel Pin	16.	Piston
7.	Dowel Pin	17.	Spring
B.	Needle Bearing	18.	Cylinder Shell
9.	O-ring	19.	Washer
10.	Rod End	20.	Needle Bearing
		21.	Spring

Throttle Control Cylinder - Cutaway

2. Install the U-cup seal (13) and the wear ring (12) on the piston (16).

3. Slide the piston (16) in to the cylinder shell (18).

4. Install the capscrew (11) through the piston (16) and install the piston sleeve (4) and the springs (17 and 21).

5. Insert the piston assembly into the body (15).

6. Install the O-ring seal (14) into the body cavity.

7. Install the cover (1) and the screws (5) torquing them 28 to 34 pounds-inch (32.2 to 39.1 kgcm).

8. Install the dust boot (3).

PRESSURE PROTECTION VALVE

TABLE OF CONTENTS

LIST OF FIGURES

VENDOR INFORMATION

Title	Source
Bendix – Service Data Maintenance Manual	SD-03-55

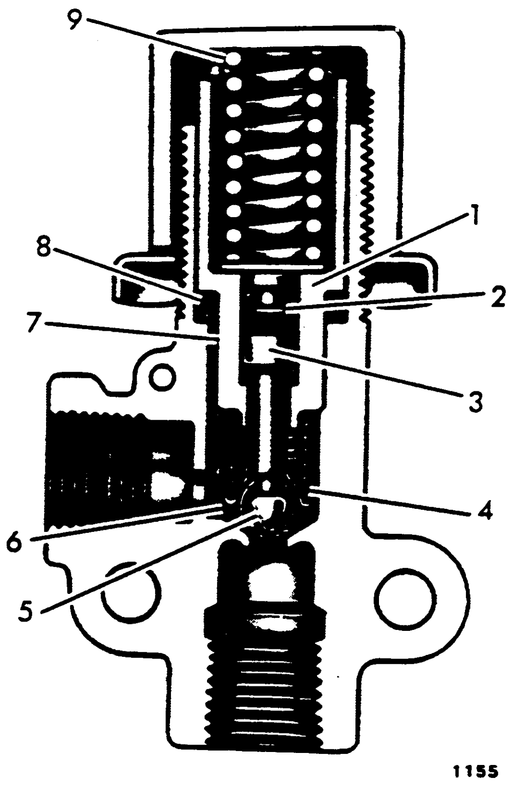
DESCRIPTION

The pressure protection valve is a normally closed pressure sensitive control valve which can be referred to as a non-exhausting sequence valve. The valve functions to protect or isolate one reservoir supply from another, by closing automatically at a preset pressure. The valve contains two ports which are identified on the valve as supply port and delivery port. Two holes through the body provide for mounting the valve. The closing pressure of the valve is adjustable, however, the valve comes preset and is installed in the system at this pressure setting. The preset pressure setting of the valve installed between the primary and secondary reservoirs is 85 psi (586 kPa/5.86 bar) and the pressure setting of the valve installed between the secondary reservoir and the transmission range and axle disconnect circuits is 75 psi (517 kPa/5.1 7 bar).

THEORY OF OPERATION

Air entering the supply port is initially prevented from flowing out the delivery port by the inlet valve which is held closed by the pressure regulating spring above the piston. When sufficient air pressure builds beneath the piston to overcome the setting of the regulating spring, the piston will move, causing the inlet valve to unseat (open), and allow air to flow out the delivery port. As long as air pressure at the supply port and beneath the piston remains above the specified closing pressure, the inlet valve will remain open. Closing pressure is noted on the label affixed to the valve. Opening pressure of the valve is 15 to 20 psi (103.4 to 138 kPa/1 .03 to 1.38 bar) higher than closing pressure.

If for any reason system air pressure is decreased below the specified closing pressure, the regulating spring will move the piston closing the inlet valve The remaining air pressure at either the supply or delivery side, (depending upon where the pressure drop has occurred) will be retained.



1. Piston Plug
2. Piston Plug O-Ring
3. Valve Stem
4. Inlet Valve Spring
5. Inlet Valve
6. Spring Retainer
7. Piston
8. Piston O-Ring
9. Pressure Regulating Spring

Pressure Protection Valve-Cutaway

R-12 RELAY VALVE

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LIST OF FIGURES

VENDOR INFORMATION

Title	Source
Bendix – Service Data Maintenance Manual	SD-03-31

DESCRIPTION

The relay valve functions as a relay station to speed up the application, modulation, and release of the service brakes. It can be considered to be a remote mounted, air controlled brake valve that releases or delivers air to the brake actuators in response to the signals received from the parking brake control valve or the dual brake control valve.

THEORY OF OPERATION

The rapid reaction of the relay valve to changes in control pressures is in part due to the relatively small volume of air required between the valve cover and the relay piston. The area of the relay piston and the pressure of the quick release also contribute greatly to the fast application and release of the air actuators.

APPLYING - RELAY VALVE DELIVERING AIR PRESSURE.

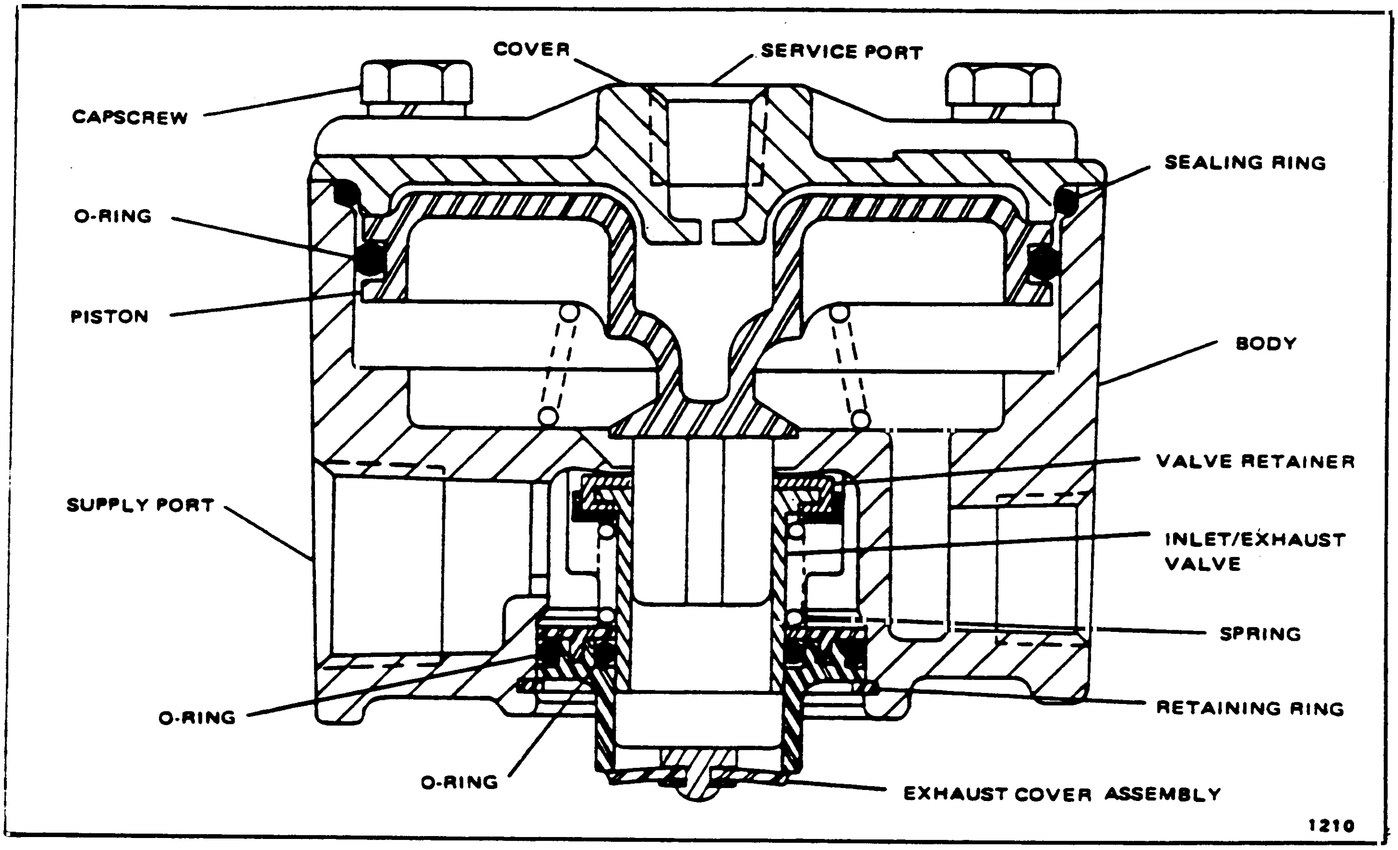
When the dual brake valve is actuated, air pressure is delivered to the service port of the relay valve. Air pressure delivered to the service port enters the small cavity above the piston and moves the piston down. The exhaust seat moves down with the piston and seats on the inner or exhaust portion of the inlet and exhaust valve, sealing off the exhaust passage. At the same time, the outer or inlet portion of the inlet and exhaust valve moves off its seat, permitting supply air to flow from the reservoir, past the open inlet valve and into the air actuator.

BALANCED - RELAY VALVE NOT DELIVERING AND NOT EXHAUSTING AIR.

The air pressure being delivered by the open inlet valve also is effective on the bottom area of the relay piston. When this air pressure beneath the piston reaches that being delivered above, the piston moves up slightly and the inlet spring returns the inlet valve to its seat. The exhaust remains closed as the service line pressure balances the relay valve delivery pressure.

RELEASING - RELAY VALVE EXHAUSTING DELIVERY PRESSURE.

When air pressure is released from the servce port and air pressure in the cavity above the relay piston is exhausted, air pressure beneath the piston lifts the relay piston and the exhaust seat moves away from the exhaust valve, opening the exhaust passage. With the exhaust passage open, the air pressure in the air actuators exhausts out the exhaust port to the atmosphere.



R-12 Relay Valve-Cutaway

MAINTENANCE

DISASSEMBLY.

1. Prior to disassembly of the relay valve, mark the relationship of the cover and body for proper assembly.

2. Remove the four hex head capscrews and lockwashers that secure the cover to the body.

3. Remove the cover, sealing ring, and mounting bracket.

4. Remove the piston and O-ring from the body.

5. While depressing the exhaust cover, remove the retaining ring and slowly relax the spring beneath the exhaust cover.

6. Remove the exhaust cover assembly and O-rings.

7. Remove the inlet/exhaust valve return spring from the body.

8. Remove the inlet/exhaust valve from the body.

9. Remove the valve retainer from the inlet/exhaust valve.

CLEANING AND INSPECTION.

1. Wash all metal parts in a good commercial cleaning solvent and dry them thoroughly.

NOTE

When rebuilding the relay valve, all springs and all rubber parts should be replaced.

2. Inspect all metal parts for deterioration and wear, as evidenced by scratches, scoring, and corrosion.

3. Inspect the exhaust valve seat on the relay piston for nicks and scratches which could cause excessive leakage.

4. Inspect the inlet valve seat in the body for scratches and nicks, which could cause excessive leakage.

5. Inspect the exhaust seat of the quick release diaphragm in the cover and make sure all internal air passages in this area are open and clean, and free of nicks and scratches.

ASSEMBLY.

General.

Prior to assembling the relay valve, lubricate all O-rings, O-ring grooves, piston bores, and metal to metal moving surfaces with a barium base lubricant.

All torques specified in this package are assembly torques and can be expected to fall off, after assembly is accomplished. Do not retorque after initial assembly torques fall.

During assembly it is recommended that hand wrenches rather than impact wrenches be used.

1. Install the large piston O-ring on the piston.

2. Install the inner and outer O-rings in the exhaust cover assembly.

3. Install the sealing ring on the cover.

CAUTION

Do not damge the piston O-ring.

4. Install the piston in the body.

5. Noting the reference marks made during disassembly, install the cover on the valve body and the mounting bracket on the cover.

6. Secure the mounting bracket and cover to the body using the four capscrews and lockwashers. Torque 80 to 120 pounds-inch (92.16 to 138.24 kgcm).

7. Install the valve retainer on the inlet/exhaust valve and install in the body.

8. Install the inlet/exhaust valve return spring in the body.

9. Install the exhaust cover assembly in the body.

10. While depressing the exhaust cover, install the retaining ring. Ensure the retainer is completely seated in its groove in the body.

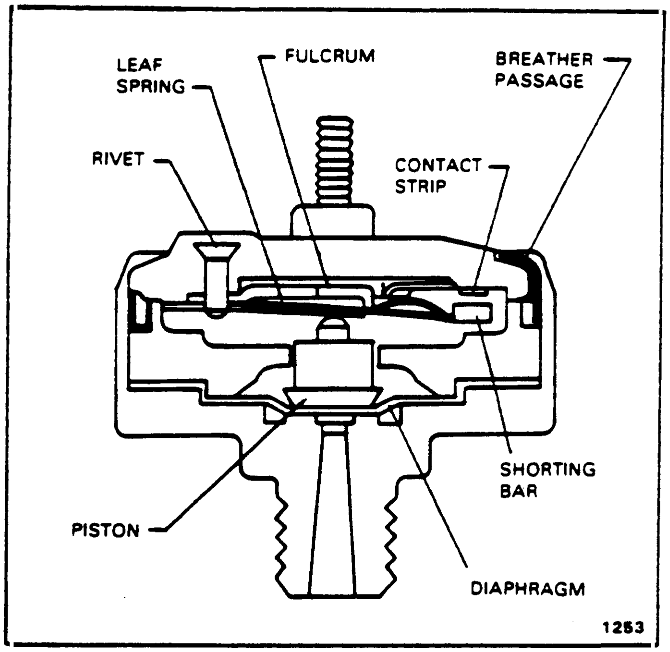
STOP LIGHT SWITCH

TABLE OF CONTENTS

LIST OF FIGURES

DESCRIPTION

A stop light switch is installed in the No. 1 circuit of the dual brake valve. The switch senses the pressure in the brake air lines. Electrically, the switch is connected to illuminate the stop lights on the rear of the machine when the brake pedal is depressed. The switch is an electro-pneumatic switch and is not a serviceable item. It must be replaced as a complete assembly.



Stop Light Switch - Cutaway

THEORY OF OPERATION

When a brake application is made, air pressure from the brake valve enters the cavity below the diaphragm. The air pressure below the diaphragm moves the piston until it contacts the leaf spring. The leaf spring travels past a fulcrum at which point the leaf spring snaps a shorting bar which mates with the contact strips. The stop light electrical circuit is completed, lighting the stop lights before the brake application pressure reaches 6 psi (41 kPa/0.41 bar).

HYDRAULIC PUMP

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Page

LIST OF FIGURES

Title **Page**

VENDOR INFORMATION

Title **Source**

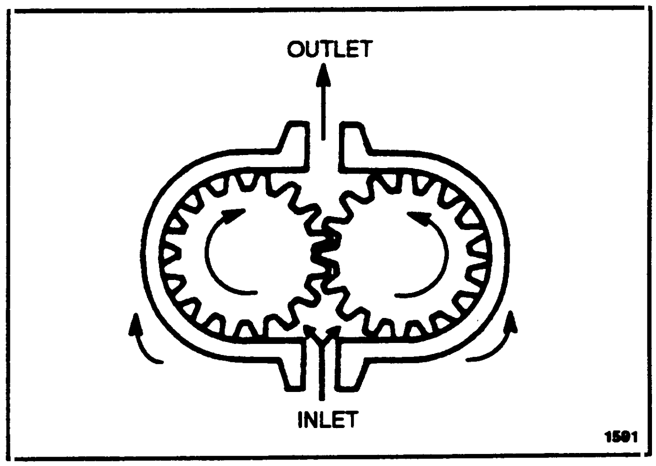
Commercial Intertech . . . . . P315/330/350/365 Service Manual

DESCRIPTION

The pump is a gear type pump and can consist of one or more sections. It is used to supply hydraulic oil to the various hydraulically operated functions on the machine.

THEORY OF OPERATION

The hydraulic gear pump consists of two meshed gears in a closely fitted housing with inlet and outlet ports opposite each other. One gear is driven by the power source and in turn drives the other gear. As the gear teeth rotate and separate past the inlet port, a partial vacuum is formed. Oil is forced into the inlet by atmospheric pressure and is carried to the outlet port in pumping chambers formed between the gear teeth and housing. As the gear teeth mesh at the outlet port, oil is forced out of the pumping chambers into the outlet port.



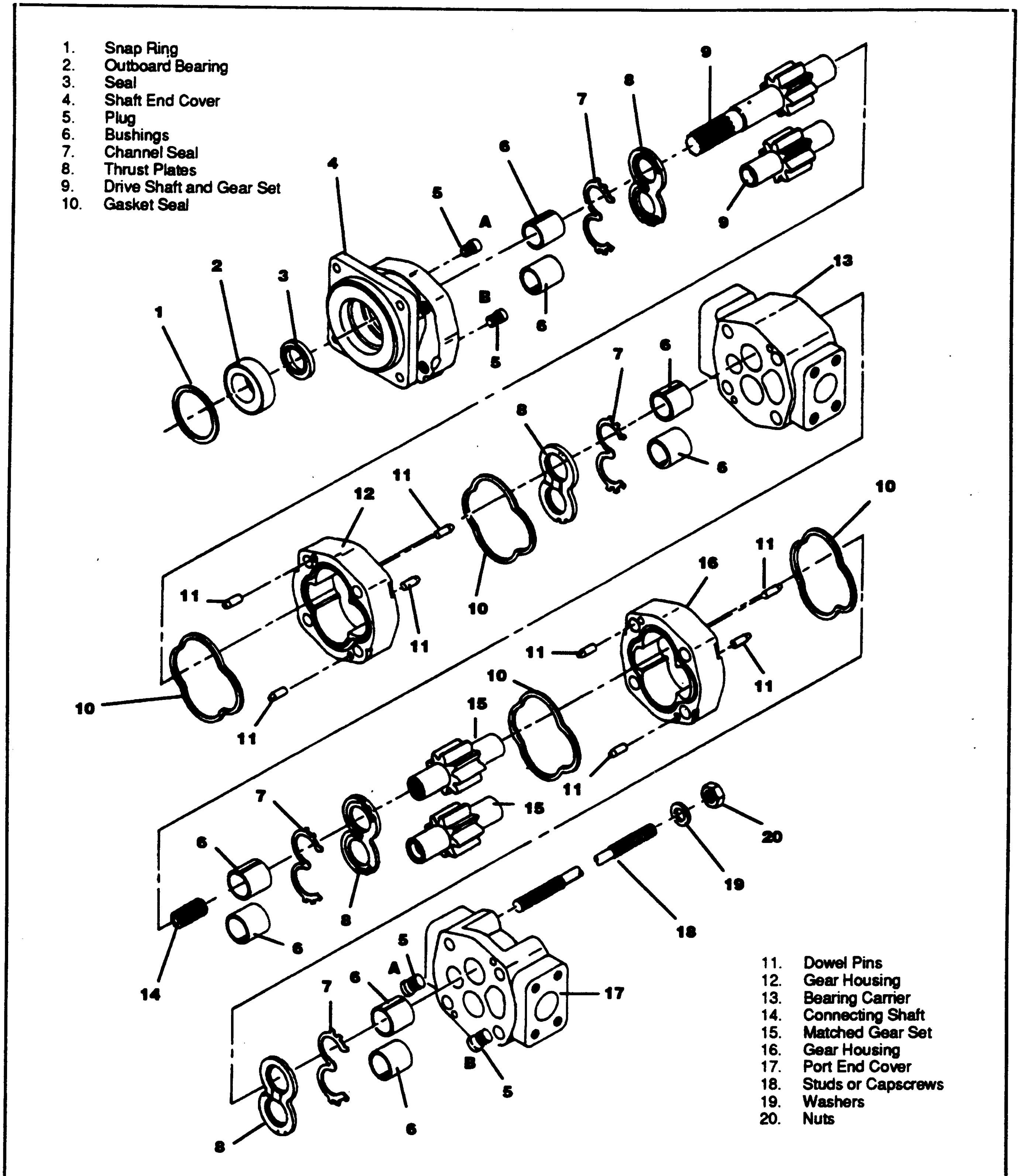
Gear Pump Operation

MAINTENANCE

REQUIRED TOOLS.

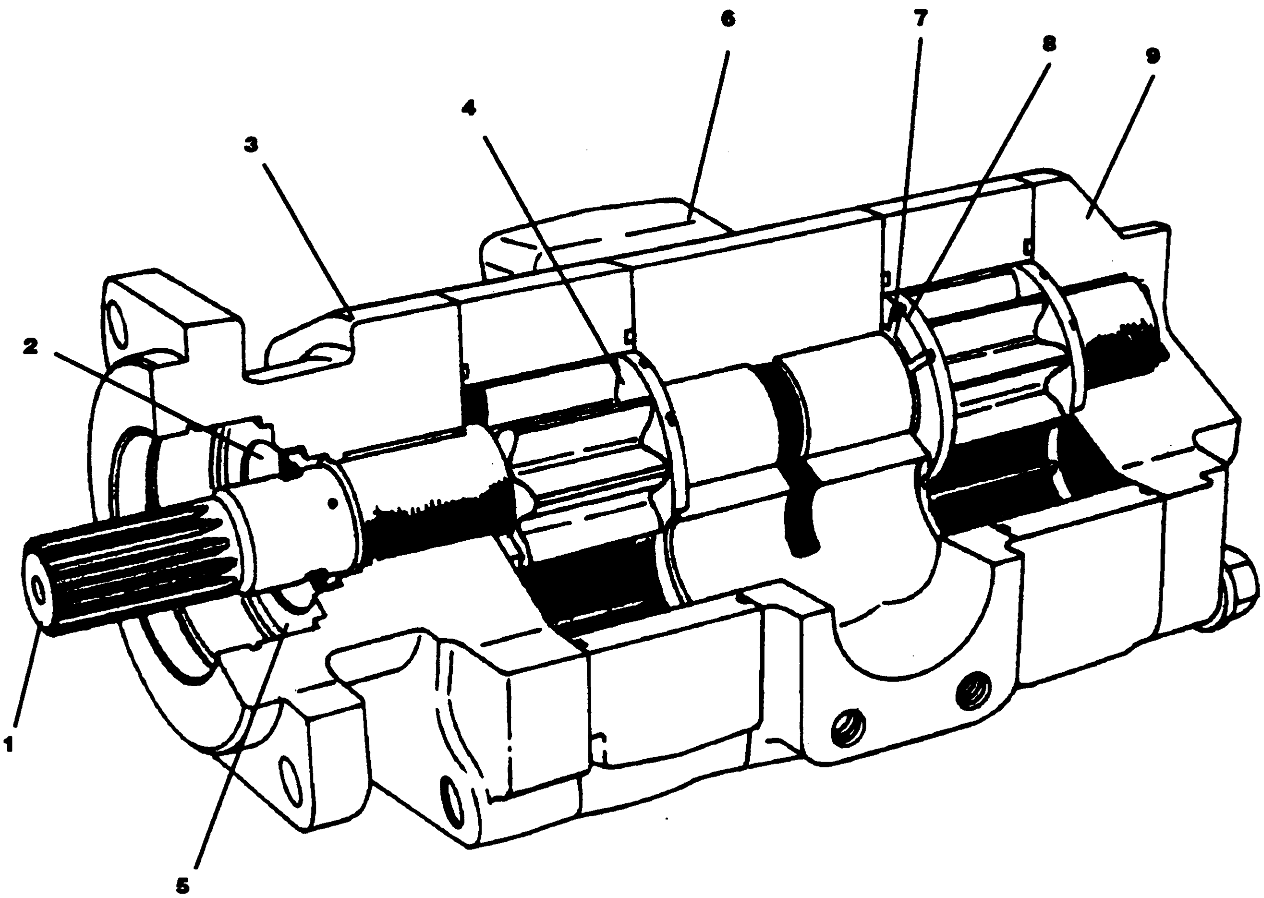
The following lists the tools necessary for proper pump maintenance.

- Arbor press
- Awl
- 1-1/2" Dia. Steel Ball
- Bearing puller (Owatonna Tool Co. MD-956 or equivalent
- Bushing Remover Tool (See Bushing Puller below)
- Clean lintless cloths
- Debumng Tool (an old file with the cutting teeth ground off
- Machinist's Hammer
- Soft Hammer
- Permatex Aviation Form-A-Gasket No. 3 or equivalent
- Medium Grit Carborundum stone
- Seal Removal Tool (See Seal Removal Tool below)
- Oil and Grease
- Snap Ring Pliers
- Prick Punch
- Bushing Installation Tool (See Bushing Installation Tool below)
- Scale (1/32" or 1/64" graduations)
- Small Screwdriver
- Torque Wrench
- Vise with 6" minimum opening
- Bar for lip seal installation (For 315 use 1-5/8" x 2" bar, for 330 use 1-3/4" x 2" bar, for 350 use 2-1/2" x 2' bar, for 365 use 2-1/2" x 2" bar)
- Special Steel Sleeve (See Special Steel Sleeve below)



NOTE: For P315 and P330 only; Plug (5) is required in position A and position B. For P350 and P365 only; Plug (5) in position B gives clockwise rotation. Plug (5) in position A gives counterclockwise rotation.

Hydraulic Pump – Exploded View

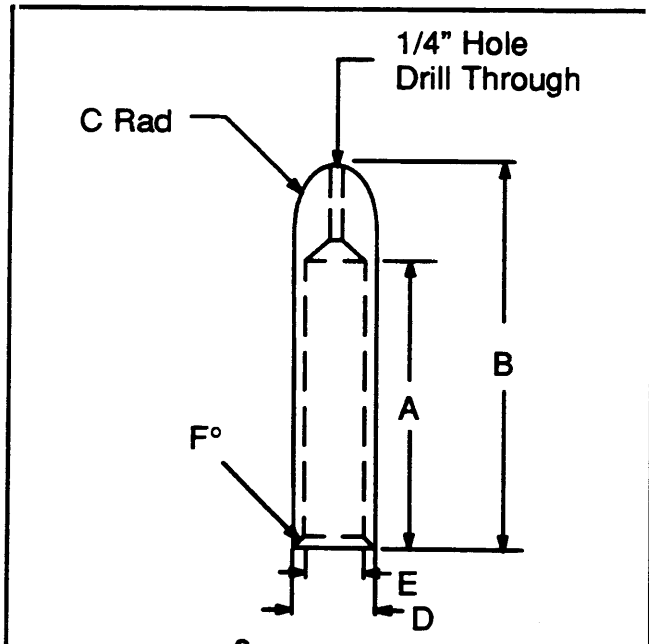


1. Drive Shaft
2. Outboard Bearing
3. Shaft End Cover
4. Thrust Plate
5. Snap Ring
6. Bearing Carrier
7. Channel Seal
8. Thrust Plate
9. Port End Cover

2831

Hydraulic Pump – Cutaway

Special Steel Sleeve.



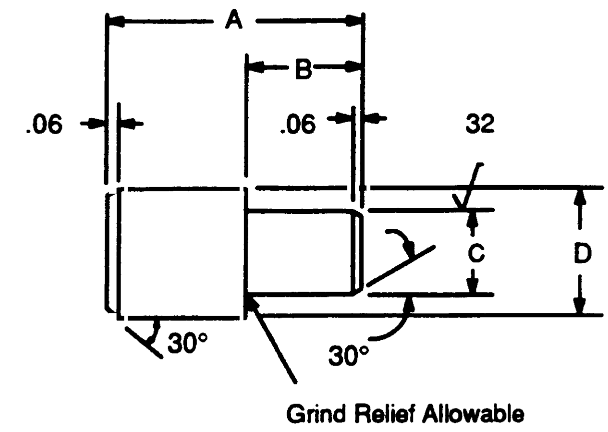
	A	B	C Rad	D Dia.	E. Dia.	F° chamfer
P315	1-7/8"	3"	9/16"	$.944^{+.000}_{-.002}$	$.885^{+.002}_{-.000}$	.050" x 60°
P330	3-3/8"	4-1/2"	9/16"	$1.065^{+.000}_{-.002}$	$1.002^{+.002}_{-.000}$	.015" x 45°
P350	3-3/8"	4-1/2"	9/16"	$1.290^{+.000}_{-.002}$	$1.250^{+.002}_{-.000}$	.015" x 60°
P365	3-3/8"	4-1/2"	9/16"	$1.377^{+.000}_{-.002}$	$1.250^{+.002}_{-.000}$	.015" x 60°

All external surfaces must be free of scratches and burrs.

Special Steel Sleeve

The special steel sleeve is used to insert the drive shaft through the lip seal without damage and can be made from bar stock. For the P315 use a 1" dia. x 3-1/8" bar; for the P330 use a 1-1/8" or 1-1/4" dia. x 4-5/8" bar; for the P350 use a 1-3/8" dia. x 4-5/8" bar ; for the P365 use a 1-3/8" dia. x 4-5/8" bar. Refer to the drawing titled Special Steel Sleeve and the accompanying chart for the dimensions needed to manufacture the tool.

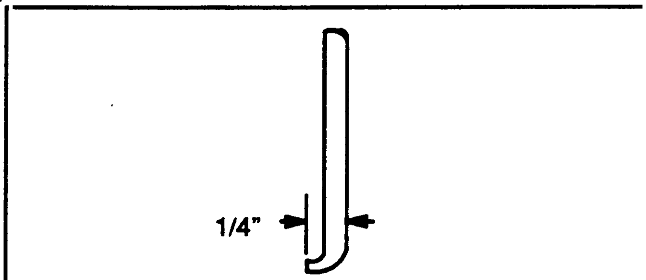
Bushing Installation Tool.



	A	B	C Dia.	D. Dia.
P315	2.312	1.15	$.937^{+.000}_{-.002}$	1.250
P330	3.00	1.47	$1.054^{+.000}_{-.002}$	1.250
P350	3.00	1.47	$1.282^{+.000}_{-.002}$	1.625
P365	3.00	1.73	$1.492^{+.000}_{-.002}$	1.750

Bushing Installation Tool

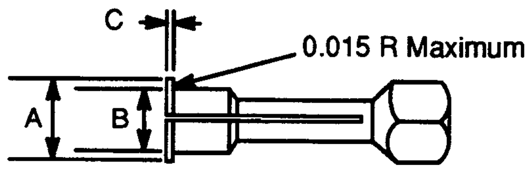
Seal Removal Tool.



Seal Removal Tool

The seal removal tool can easily be made from an old screwdriver. Heat the tip and bend as shown in the figure titled Seal Removal Tool. Grind the tip to fit the notch behind the shaft seal.

Bushing Puller.



Pump/Motor	A	B	C	Make From OTC Collet No.
315	.900 / .890	.800 / .790	.100 / .090	33863
330	.980 / .970	.875 / Ref.	.100 / .090	33863
350	1.122 / 1.122	1.000 / 0.990	.072 / .052	33864
365	1.382 / 1.372	1.260 / 1.250	.100 / .120	33865

Bushing Puller

The bushings in P315, P330, P350, and P365 pumps may be removed from their bores using blind hole collet-type bushing pullers similar to those manufactured by Owatonna Tool Co. The table illustrates the modifications necessary to adapt the OTC collets to this task. Equivalent pullers from other suppliers may be modified in similar fashions.

GENERAL PRECAUTIONS.

If prying off sections becomes necessary, take extreme care not to mar or damage machined surfaces. Excessive force while prying can result in misalignment and seriously damage parts.

If parts are difficult to fit during assembly, tap gently with a soft hammer. Never use an iron hammer.

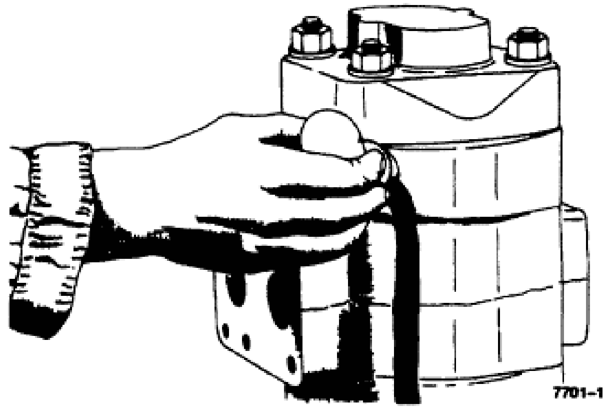
The gears are closely matched. They must be kept together as sets when removed from a unit. Handle with care to avoid damage to the joumals or teeth. Avoid touching gear journals.

Never hammer bushings into bores. Use an arbor press.

DISASSEMBLY.

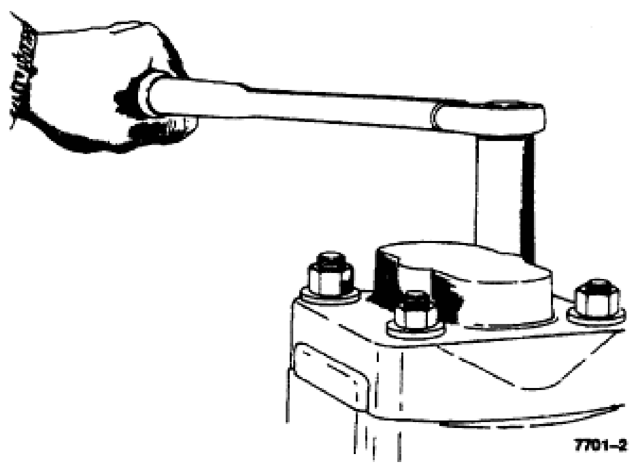
CAUTION

Do not grip on or near any machined surfaces during disassembly of assembly.



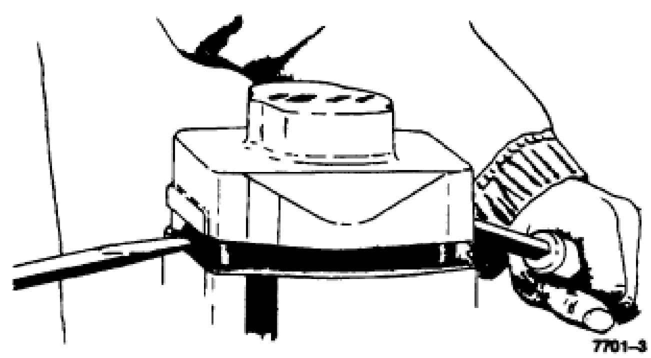
7701-1

1. Place the pump in a vise with the drive shaft pointing down. Match mark all sections. Ensure these marks are aligned during assembly.



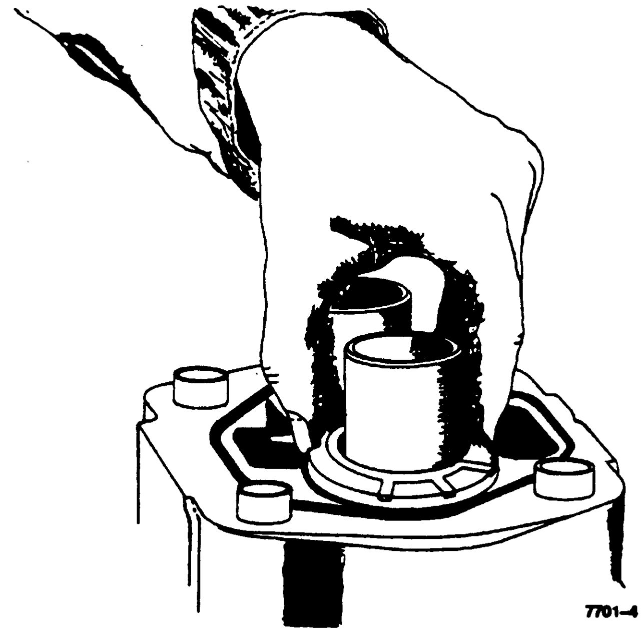
7701-2

2. Use a socket wrench to remove the capscrews (used on single section units) or the hex nuts, studs, and washers (used on multiple section units).



7701-3

3. Lift off the port end cover. If prying is necessary, be careful not to damage the machined surfaces. Dowel pins will remain in either the port end cover or the gear housing. <u>Do not remove the dowel pins</u>.

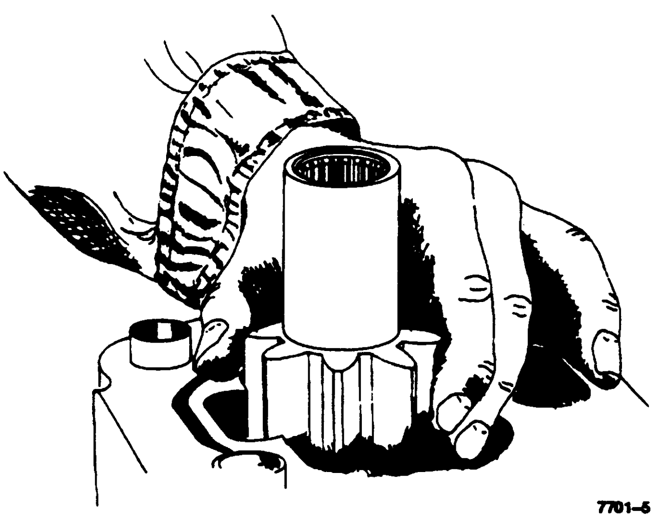


7701-4

4. Remove the thrust plate. Examine and replace if necessary. Refer to WEAR LIMITS.

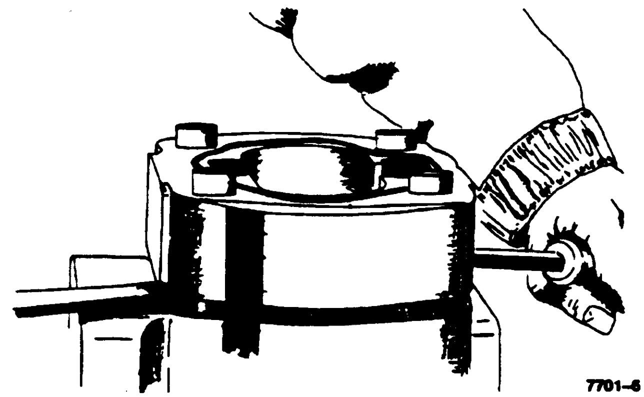
NOTE

Steps 5,6, and 7 are only necessary for multiple section pumps.



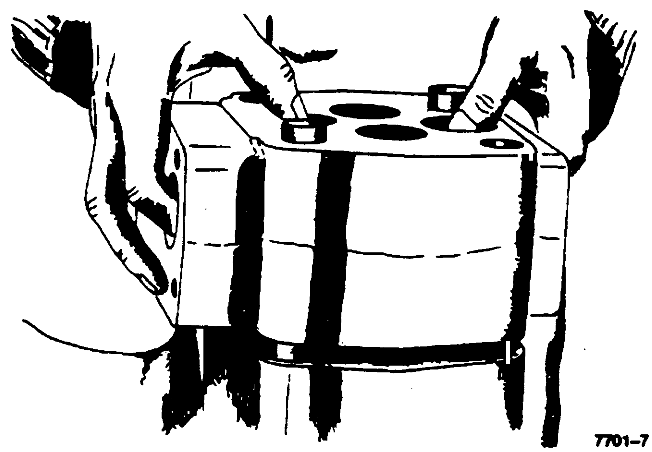
7701-5

5. Carefully remove the drive and driven gears. Avoid tapping the gear teeth together or against other hardened surfaces. Keep these gears together because they are a matched set. Examine and replace if necessary. Refer to WEAR LIMITS. Remove the thrust plate from the bearing carrier. Examine and replace if necessary. Refer to WEAR LIMITS.



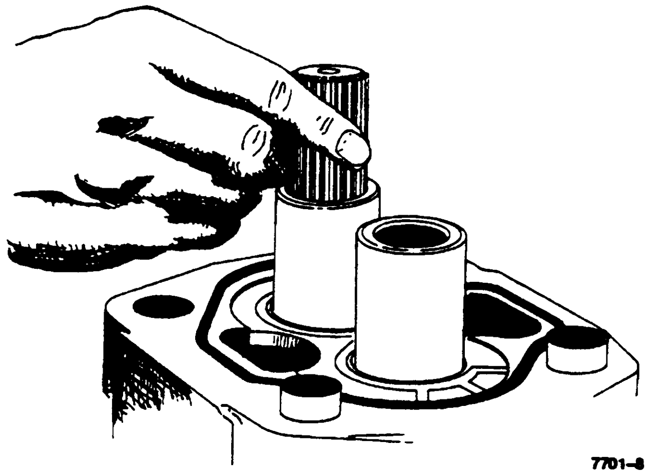
7701-6

6. Lift the gear housing from the bearing carrier. If prying is necessary, take care not to damage the machined surfaces. Examine and replace if necessary. Refer to WEAR LIMITS.



7701-7

7. Carefully lift off the bearing carrier to prevent damage to contact face and edges. Dowel pins will remain either the bearing carrier or the gear housing. Do not remove the dowel pins



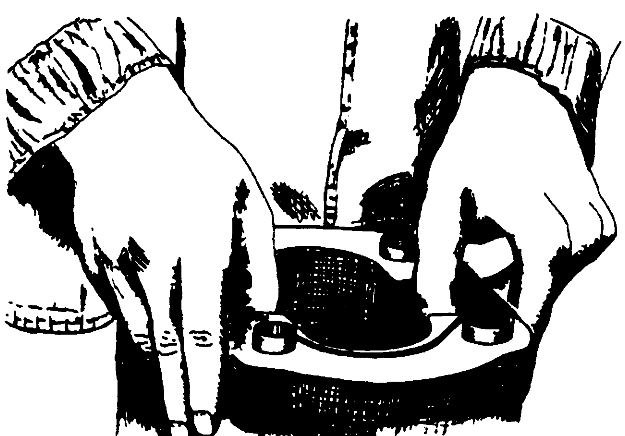
7701-8

8. Remove the connecting shaft. Remove the thrust plate. Examine and replace if necessary. Refer to

gear and the drive shaft. Keep these together as they are a matched set. Examine and replace if necessary. Refer to WEAR LIMITS. Be careful not to damage the machined surfaces of the gears.

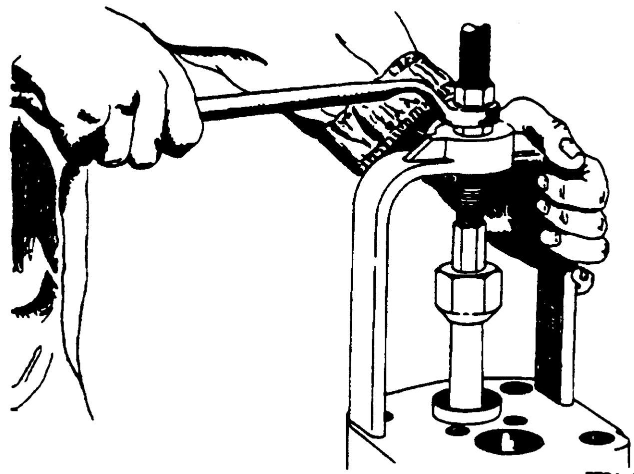
CAUTION

Be careful not to damage the machined surfaces.



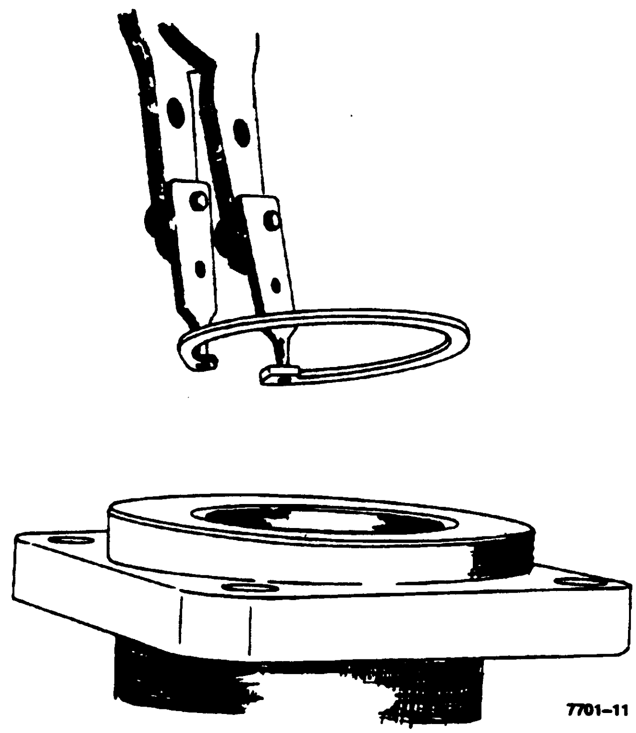
7701-9

9. Lift or pry off the first section gear housing. Examine and replace if necessary. Refer to WEAR LIMITS.



7701-10

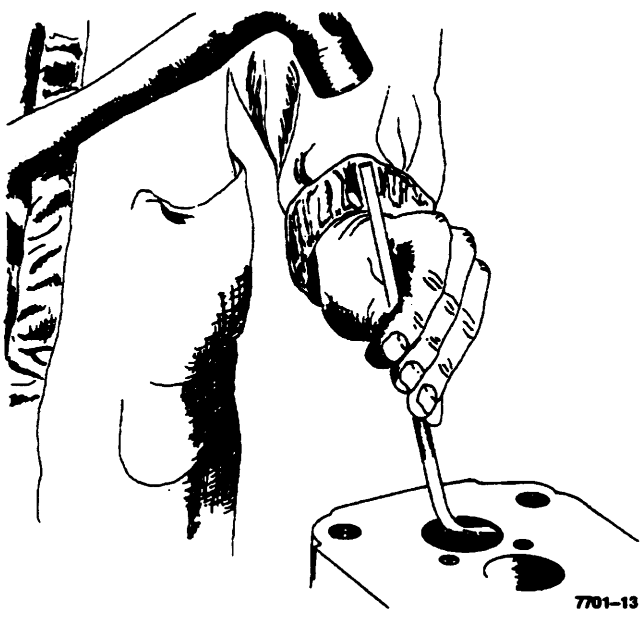
10. Inspect all bushings for scoring or discoloration and replace if necessary. Refer to WEAR LIMITS. Use a bushing puller as outlined under REQUIRED TOOLS.



7701-11

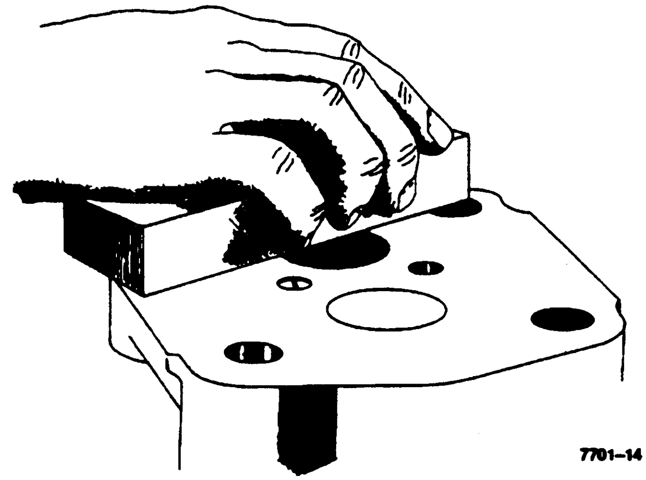
11. If the pump is equipped with an outboard bearing, place the shaft end cover in the vise with the mounting face up. Remove the snap ring with snap ring pliers. If the unit is equipped with a spiral lock retaining ring, remove with a small screwdriver or awl.

12. Use a bearing puller to remove the outboard bearing.

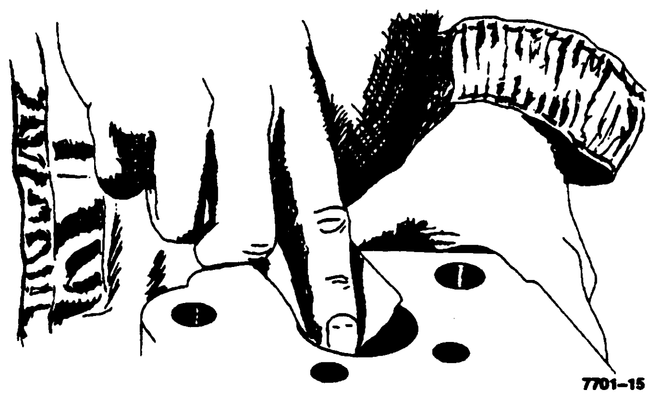


13. Grip the shaft end cover in a vise with the mounting face down. Remove the double lip seal by inserting the special seal removal tool into the notch between the double lip seal and the shaft end cover. Tap the seal out and discard. Remove and discard all rubber and polymer seals.

ASSEMBLY.



1. Stone all machined surfaces with a medium grit carborundum stone.



2. If the bushings have been removed, deburr the bushing bores with emery cloth. Rinse the parts in solvent. Air blast all parts and wipe clean with a clean lintless cloth before starting assembly.

7701-16

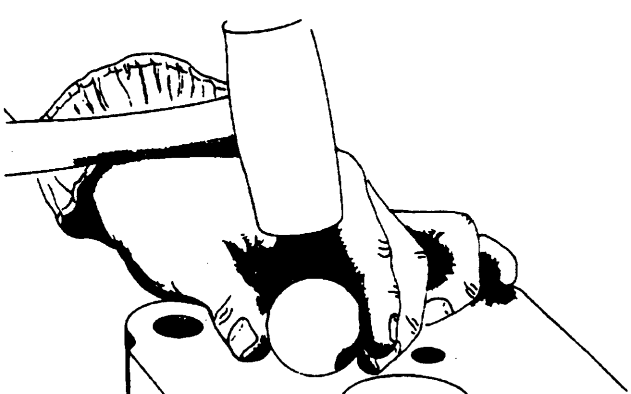
NOTE

P315 and P330 pumps have two plugs In both the shaft end and port end covers. P350 and P365 pumps have one plug on the outlet side of their shaft end and port end covers.

3. Grip the shaft end cover in a vise with the mounting face down. Examine the plug or plugs to ensure they are tightly in place. Replacement is necessary only if the parts are damaged. If necessary, remove with a screwdriver.

NOTE

If a new plug or plugs are being installed coat the threads with Loctite thread sealant.

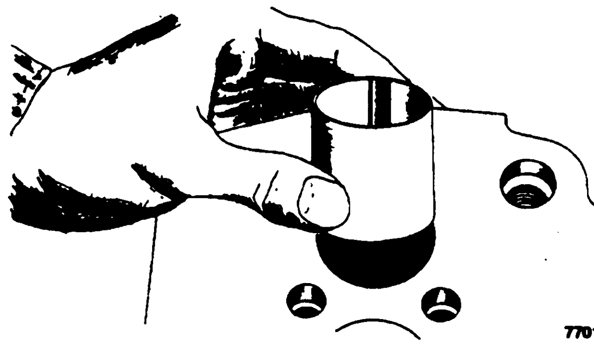


7701-17

4. New plugs should be screwed in tightly. Stake the plug with a prick punch at both ends of the screwdriver slot and around the edges. Peen the edge of the hole 1/32" to 1/16" with 1—1/2" diameter steel ball.

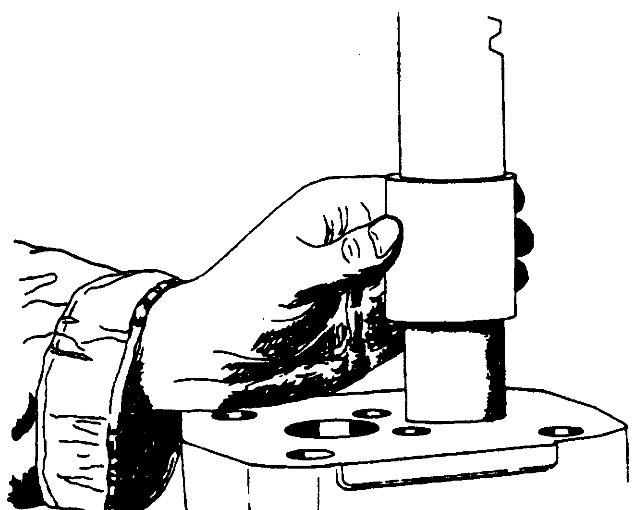
NOTE

Steps 5, 6, 7, and 8 apply to the shaft end cover, bearing carriers, and the port end cover.



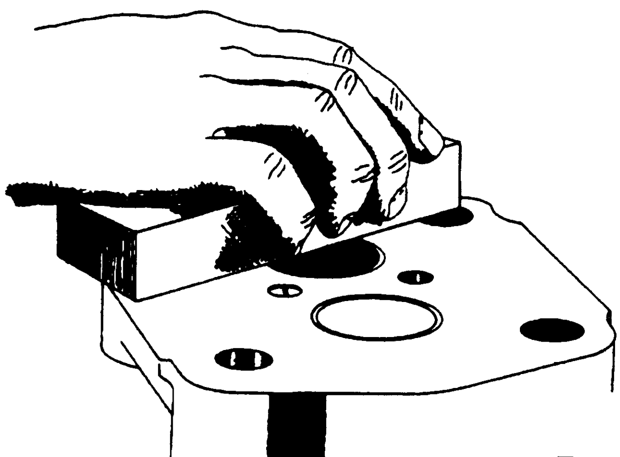
7701-18

5. Any bushings removed from the shaft end cover, port end cover, or bearing carrier cover should be assembled in drive bores with the groove to the top of the unit (12 o'clock). Assemble the bushings in driven bores with the groove to the bottom of the unit (6 o'clock). The P315 does not have grooved bushings, therefore the bushing seams should be placed at the 12 and 6 o'clock positions.

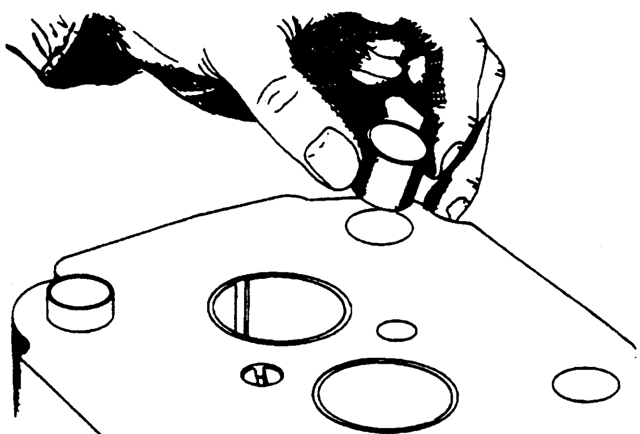


7701-19

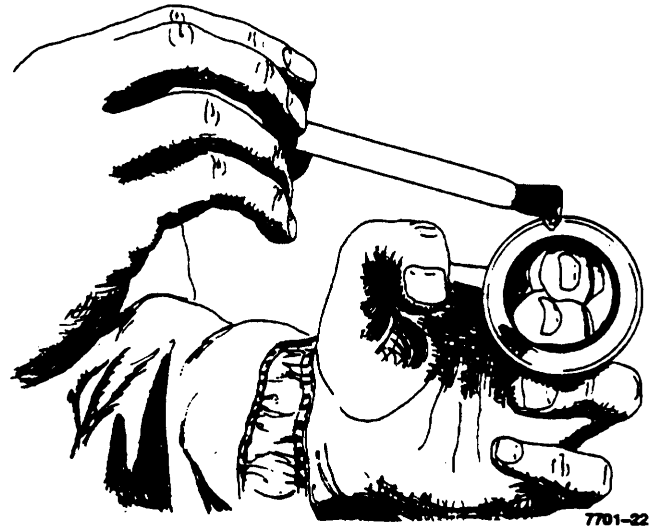
6. Bushings should be pressed into the bores, one at a time using the special installation tool and an arbor press. Ensure the grooves (or seams) are positioned as stated in step 5. The bushings must be pressed into the bores flush with the casting face. Ensure to support the castings so they are square and level.


7701-20

7. Repeat steps 11 and 2, stone and rinse all parts.


7701-21

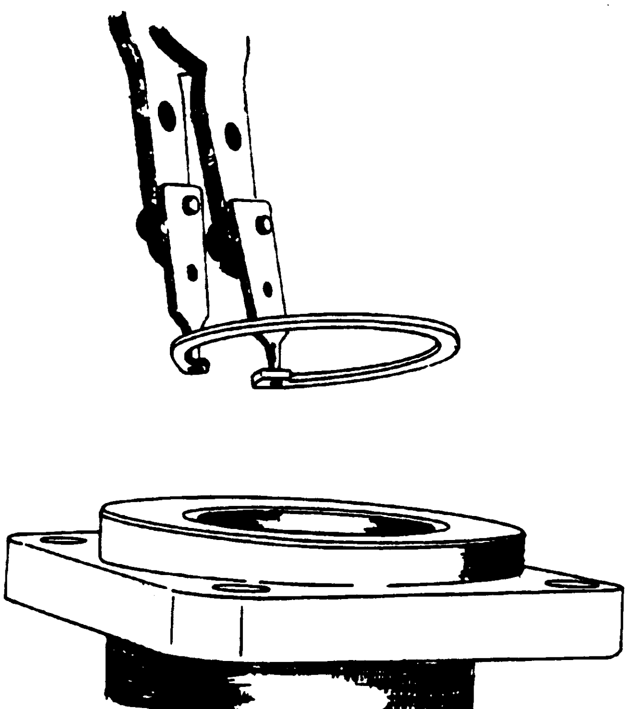
8. Ensure all dowel pins are in place in any new castings. Examine all dowels. Refer to WEAR LIMITS. Before inserting, ensure the hole is clean and free from burrs. Gently start the pin straight into the hole and tap lightly with a soft hammer.


7701-22

9. Before inserting a new lip seal in the shaft end cover, coat the outer edge of the lip seal and it's recess with Permatex Aviation Form-A-Gasket No. 3 non-hardening sealant or equivalent. With the metal side of the lip seal up, press it into the mounting flange side of the shaft end cover with an arbor press and bar. Be careful not to damage the lip of the seal. Press it in until it is flush with the recess and wipe off any sealant.

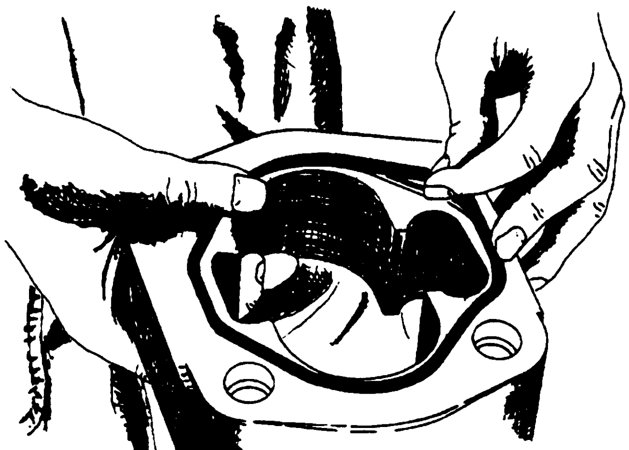

7701-23

10. If the unit is equipped with an outboard bearing, guide the bearing into it's recess in the shaft end cover. This is a light press fit. It may be necessary to lightly tap the bearing into the bore.



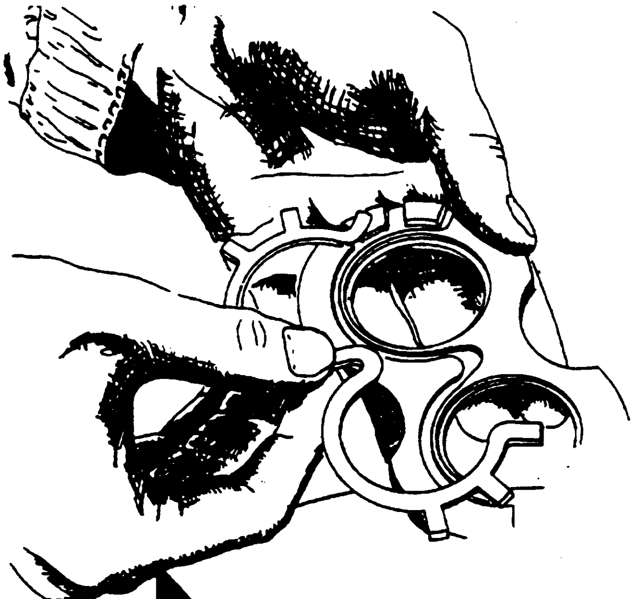
7701-11

11. If the pump is equipped with an outboard bearing, place the shaft end cover in the vise with the mounting face up. Install the snap ring in the groove to retain the outboard bearing.

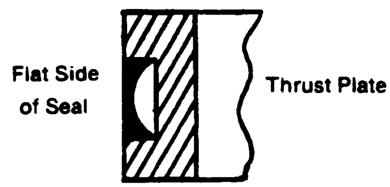


7701-24

12. Grease the new gasket seals and insert them into the grooves in both sides of all gear housings. Position the first gear housing over the shaft end cover and dowels. Tap it with a soft hammer until it rests tightly against the shaft end cover. Be careful not to pinch the gasket seal. Ensure the large rounded core is on the inlet side.



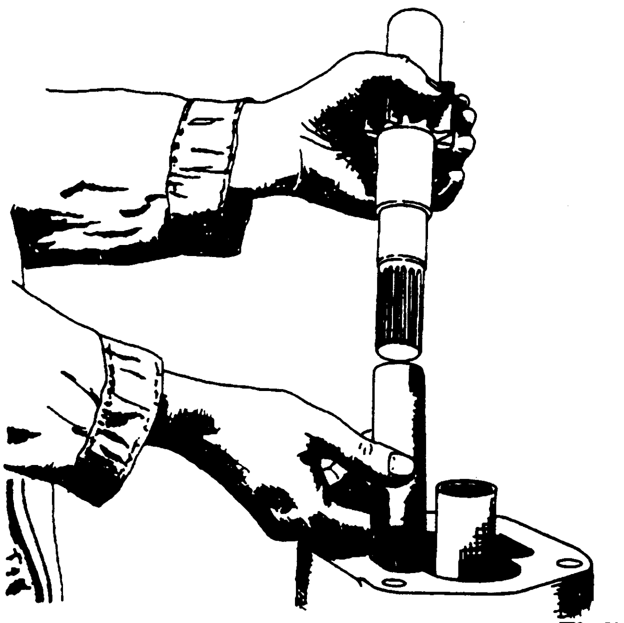
7701-25



13. Assemble the channel seals into the grooves in the thrust plates with the flat side of the seal facing away from the thrust plate as shown.

7701-27

14. Gently slip the thrust plate through the gear housing and into place on the shaft end cover. The channel seal mentioned in step 13 should face the shaft end cover. The relief groove in the plate should face the outlet side of the pump.



7701-28

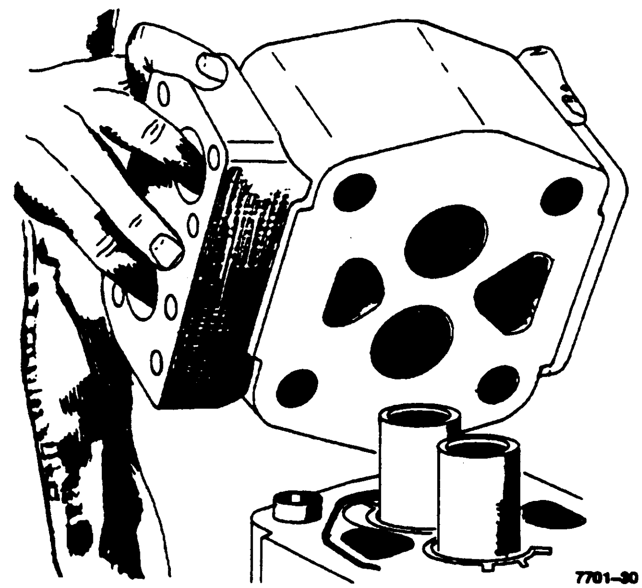
15. Slide the driven gear through the housing and into the bushing in the shaft end cover. Coat the steel sleeve tool with grease. Place the lightly greased drive shaft inside the sleeve and slide both through the shaft end cover with a twisting motion until the integral gear rests against the thrust plate. Avoid damaging the double lip seal. Remove the steel sleeve. Squirt clean oil over the gears.

7701-29

16. Slip the thrust plate with the seal over the gear journals and into the housing bore. The flat side of the seal should face up with the relief groove facing the outlet side.

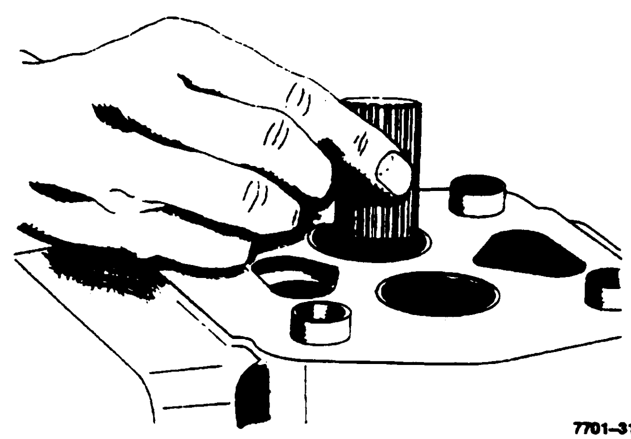
NOTE

Steps 17 thru 20 apply to multiple section pumps only.



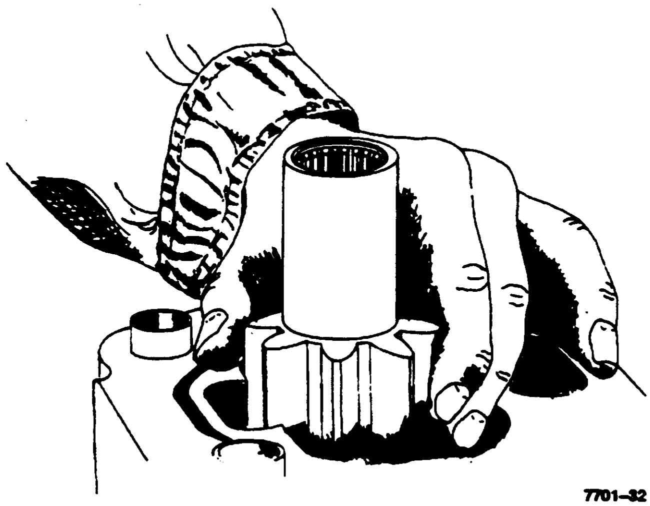
7701-30

17. Position the bearing carrier over the gear housing so that the bushings receive the joumals of the drive and driven gears. Ensure the dowel holes are lined up over the dowel pins. When the parts are parallel, squeeze them together or alternately tap over each dowel until the parts are together.

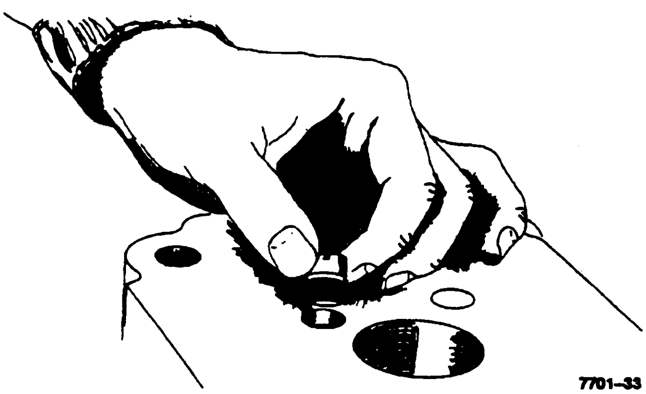


7701-31

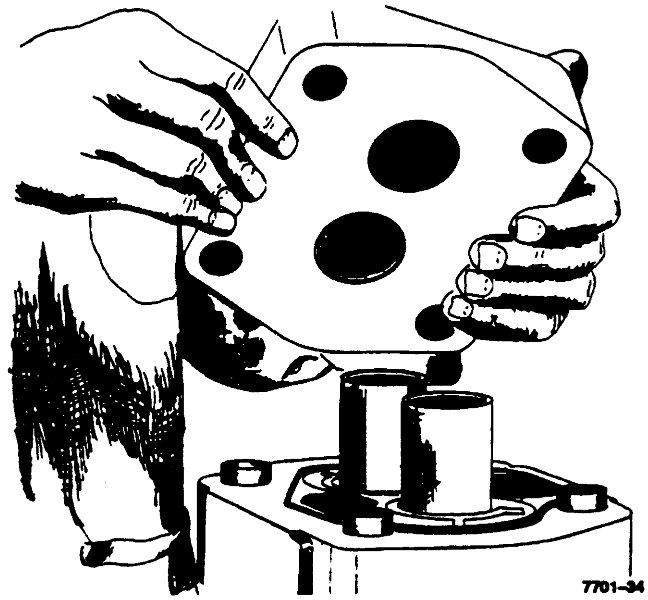
18. Insert the connecting shaft in the spline of the drive gear. Position and place the second gear housing on the bearing carrier as outlined in step 12.



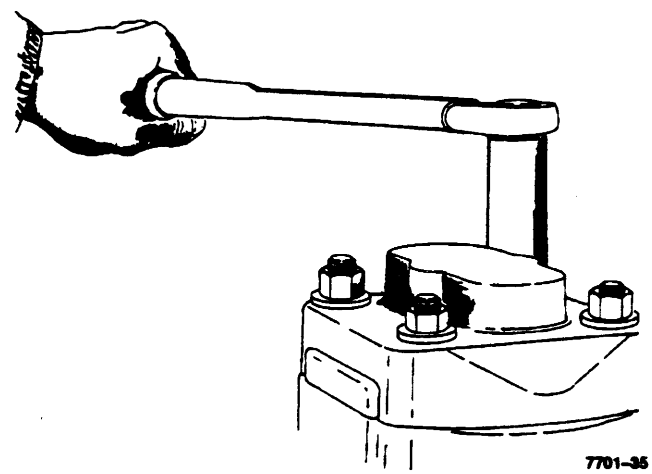
19. Place the thrust plate in the gear housing as outlined in step 14. Insert the drive and driven gears of the second section in their respective bearings. Ensure the gears are in contact with the thrust plate face. Place the port end cover plate in the housing as outlined in step 16.



20. Check the plug or plugs in the port end cover to ensure they are tight. Follow the procedure outlined in step 4 for new plugs.



21. Place the port end cover over the gear journals. Align the dowels with the holes in the mating casting. Being careful not to pinch the gasket seal, tap the port end cover lightly in the center between bearing bores to engage the dowels and to move parts together in the final seating.



22. Thread the fasteners (capscrews and washers or studs, washers, and nuts) into the shaft end cover and tighten alternately or cross-corner. Rotate the drive shaft with a 6—inch wrench to ensure there is no binding in the pump. After the fasteners are tight and you are sure there is no internal binding, torque the diagonally opposite fasteners to 200 pounds—foot (2400 pounds-inch) or 140 pounds-foot (1680 pounds-inch) for P315 models.

WEAR LIMITS

GEAR HOUSINGS,

Wear in excess of 0.007 inch cut-out necessitates replacement of the gear housing. Place a straight-edge across the bore. If it is possible to slip a 0.007 inch (0.018 mm) feeler gauge under the straight edge in the cut-out area, replace the gear housing.

Pressure pushes the gears against the housing on the low pressure side. As the hubs and bushings wear, the cut-out becomes more pronounced. Excessive cut-out in a short period of time indicates excessive pressure or oil contamination. If the relief valve settings are within prescribed limits, check for shock pressures or tampering. Withdraw an oil sample and check it, and the reservoir for dirt. Where the cut-out is moderate, (0.007 inch or less) the gear housing is in good condition and may be used.

GEARS.

Any scoring on the gear hubs necessitates replacement. Scoring, grooving, or burring of outside diameter of teeth requires replacement. Nicking, grooving, or fretting of teeth surfaces also necessitates replacement.

DRIVE SHAFTS.

Replace the drive shaft if there is any wear detectable by touch in the seat area or at the drive coupling. The maximum allowable wear is 0.002 inch (0.05 mm).

Wear in the shaft seal area indicates oil contamination. Wear or damage to splines, keys, or keyways necessitates replacement.

THRUST PLATES.

The thrust plates seal the gear section at the sides of the gears. Wear here will allow internal slippage, which means that oil will bypass within the pump.

A maximum of 0.002 inch (0.05 mm) of wear is allowable. Replace the thrust plates if they are scored, eroded, or pitted.

Check the center of the thrust plates where the gears mesh. Erosion here indicates oil contamination.

Pitted thrust plates indicate cavitation or oil aeration.

Discolored thrust plates indicate overheating, probably due to insufficient oil.

DOWEL PINS.

If either the dowel or dowel hole is damaged, the dowel or machined casting, or both, must be replaced.

If more than reasonable force is required to seat the dowels, the cause may be poorly deburred or dirty parts, cocking of the dowel in the hole, or improper pin-to-hole fit.

BUSHINGS.

If the gears are replaced, the bushings must be replaced. The bushings should fit into the bore with a heavy press fit.

SEALS AND GASKETS.

Replace all rubber and polymer seals, including all 0-rings, thrust plate channel seals, shaft seal, and gasket seals.

PLUGS.

Examine the plugs in the shaft end and port end cover to ensure they are in the proper position and tight. The P315 and P330 should have two plugs in both the shaft end and port end in tandem units only. The P350 and P365 have one plug in their shaft and port ends high pressure side only.

LUBRICATION AND OIL RECOMMENDATIONS

All parts, with the exception of the outboard bearing, are lubricated by the hydraulic oil in the circuit. Particular attention must be paid to keep the oil in the circuit system clean. Whenever there is a pump or motor failure, and there is reason to feel that metal particles may be in the system, the oil must be drained, the entire system flushed clean, and any filter screens thoroughly cleaned or replaced. New oil should be supplied for the entire system. Refer to the Lubrication Section in the Service Manual for the recommended oil.

RECOMMENDED START-UP PROCEDURE FOR NEW OR REBUILT PUMP

Before installing a new or rebuilt pump, back off the main relief valve until the spring tension on the adjusting screw is relieved. This will avoid the possbility of immediate damage to the replacement unit in the event the relief setting had been increased beyond the recommended operating pressure prior to removing the old unit.

Before connecting any lines to the pump, fill all ports with clean oil to provide initial lubrication. This is particularly important if the unit is located above the oil reservoir.

After connecting the lines and mounting the replacement unit, operate the pump at least two minutes at no load and at low rpm (400 minimum). During this break-in period, the unit should run free and not develop an excessive amount of heat. If the unit operates properly, speed and pressure can then be increased to normal operating settings.

CAUTION

Always use an accurate gauge when adjusting the relief valve pressure setting.

Reset the main relief valve to the proper setting while the pump is running at maximum operating speed for the machine.

RECOMMENDED TEST PROCEDURE

Ensure there is an adequate supply of oil for the pump, at least one gallon of oil for each gpm of pump capacity.

If one section of a tandem pump is being tested, ensure all other sections not being tested are adequately supplied with oil. If any of the other sections run dry, or if plugs are left in ports, serious and permanent damage will result.

Feeding hot oil into a cold pump may cause the pump to seize. Jog the pump by momentarily starting the driving engine or motor to gradually equalize the pump and oil temperatures.

Run the pump at least two minutes at no load and moderate speed (not over 1500 rpm). If the pump becomes excessively hot, shut down immediately and locate the problem source.

Gradually increase pressure on the pump in 500 psi increments until the desired test pressure has been reached. This should take about 5 minutes.

Delivery should run close to rated performance figures which are averaged from testing several pumps. A 5% lower reading may be used as a rated minimum if new or relatively new parts have been used. When rebuilding the pump with parts from the original pump, which, while worn, appear satisfactory for use, a 10% or 15% lower reading may be permitted, depending upon the performance expected from the equipment.

INTEGRATED OUTRIGGER VALVE

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LIST OF FIGURES

DESCR IPTION

The integrated outrigger valve consists of five subassemblies; two solenoid valves, an inlet section, an outlet section, and one or more working sections.

The solenoid valves are normally closed and may be either 12 or 24 volts. They are used to control a pilot pressure that positions the spool within the working section(s). When the solenoid valves are deenergized, the springs maintain the spool in a centered position permitting oil to flow to the pressure beyond circuit.

The inlet section contains two inlet ports and a pressure gauge port. It also contains an adjustable main relief valve. This relief valve is an adjustable pilot operated type and relieves back to the reservoir through the exhaust (EX) port. Refer to the hydraulic schematic in the Service Manual for the proper relief valve pressure settings.

The working section is the open center type and contains a spring centered spool which allows oil to flow through the center to the pressure beyond circuit when the spool is centered. Work port A is cylinder spooled, or the oil is trapped in the function while the spool is in neutral. Work port B is open to the reservoir (when the spool is in neutral) due to the fact that there are two flats ground into the end land of the spool. These flats act as an orifice preventing the complete blockage of oil in this circuit. This prevents an unwanted pressure buildup in this circuit when the spool is in neutral. The flats are so small that when the circuit is being energized, the oil passing by these flats is negligable compared to the total volume of oil. The working section also contains two nonadjustable relief valves and a check valve. Refer to the hydraulic schematic in the Service Manual for the proper relief valve pressure settings. The check valve in the bottom of the working section, prevents a reverse flow of oil if the oil pressure in the working circuit is greater than the supply pressure.

The outlet section has two ports. One port,offset to the side is the return from the circuit supplied by ports A and B. The other port is for the power beyond circuit as long as the working section spool is in neutral.

MAINTENANCE

DISASSEMBLY.

Solenoid Valve.

1. Remove the machine screws securing the solenoid valve bodies to the working section.

2. Remove the retainer and washer securing the plunger assembly in place.

3. Remove the plunger assembly. Remove the stem from the plunger assembly.

4. Remove the valve body from the valve housing.

5. Remove the spool from the valve body.

Inlet Section.

1. Remove the main relief valve assembly from the inlet section.

2. Remove the locknut and washer and unscrew the needle valve seat body from the main relief valve assembly.

3. Remove the adjusting screw, spring and needle valve from the seat body.

4. Remove the plunger and spring from the valve body.

5. If necessary, remove the plugs from the inlet section.

Working Section.

1. Remove the relief valve body from the port A side of the working section.

2. Remove the plug, spring, and needle valve from the relief valve body.

3. Remove the relief valve assembly from the port B side of the working section.

4. Remove the snap ring, washer, screen, and orifice plate.

5. Remove the spring and poppet valve.

6. If necessary, remove the poppet body cap, needle valve, and spring.

7. Remove the check valve cap, spring, and check valve.

8. Remove the spool.

CLEANING AND INSPECTION,

1. Clean all parts in a non residue type solvent.

2. Inspect the screw for any damage.

3. Check all needle valves for wear or other damage.

4. Check the orifice in the orifice plate.

ASSEMBLY.

General.

Install new 0-rings on all components.

CAUTION

Do not damage the O-rings during installion of the valve. If the valve turns freely then gets hard to turn, then easy to turn; remove the valve and check the O-rings. They have probably been damaged by a sharp edge of a port or thread.

NOTE

The valve should turn by hand until compression of the 0-rings begins.

Working Section.

1. Install the spool into the working section so the end with the ground flats is on the port B end.

2. Lubricate the 0-ring and install the check valve, spring, and cap into the bottom of the working section.

3. If removed, install the needle valve, spring, and poppet body cap into the poppet body.

4. Install the spring and poppet valve assembly.

5. Install the orifice plate, screw, washer, and snap ring into the relief valve assembly.

6. Lubricate the valve assembly and 0-rings and install the valve into the port B side of the working section.

7. Install plug, spring, and needle valve into the relief valve body.

8. Lubricate the valve assembly and 0-rings, and install the valve into the port A side of the working section.

Inlet Section.

1. If removed, lubricate and install the plugs into the inlet section.

2. Install the spring and plunger into the valve body.

3. Install the adjusting screw, spring, and needle valve into the seat body.

4. Lubricate the seat body and screw it into the main relief valve assembly. Install the locknut and washer.

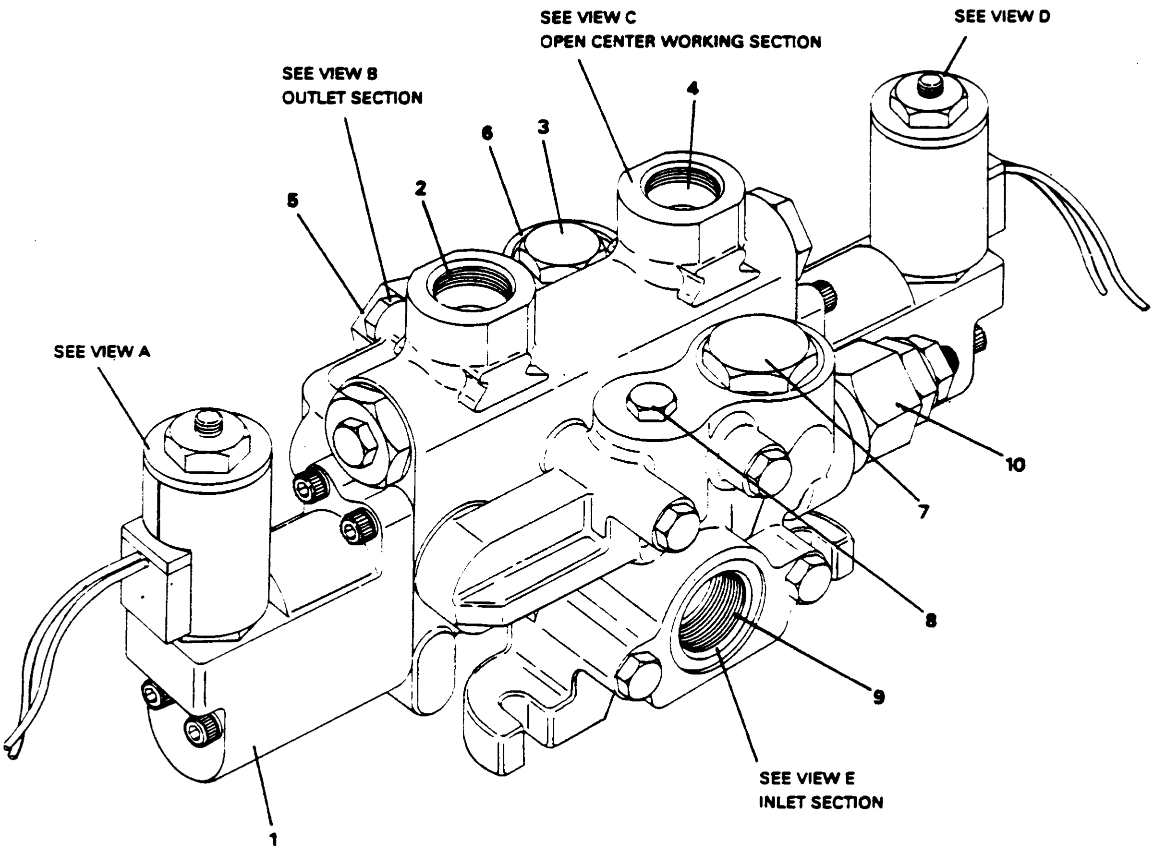
5. Lubricate the valve assembly and 0-rings and install it into the inlet section.

Solenoid Valve.

1. Install the spool into the valve body.

NOTE

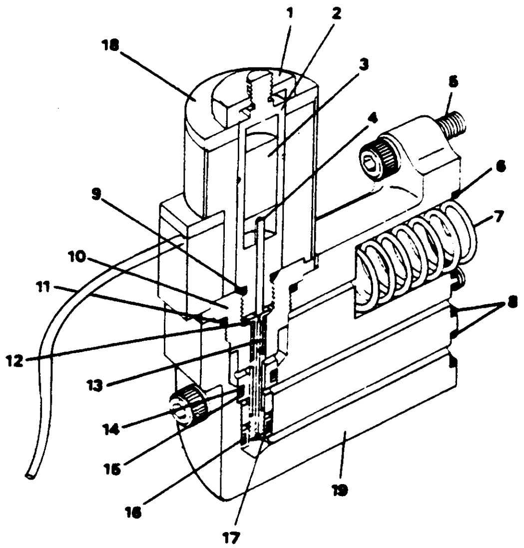
Although the figure shows a valve with just one working section, the accompanying views are also applicable to valves which utilize more than one working section.



1. Solenoid Section
2. Cylinder Port A (A)
3. Alternate Exhaust Port (EX)
4. Cylinder Port B (B)
5. Power Beyond Port (PB)
6. Exhaust Port (EX)
7. Alternate Pressure Port (IN)
8. Gauge Port (G)
9. Pressure Port (IN)
10. Relief Valve

0445-1

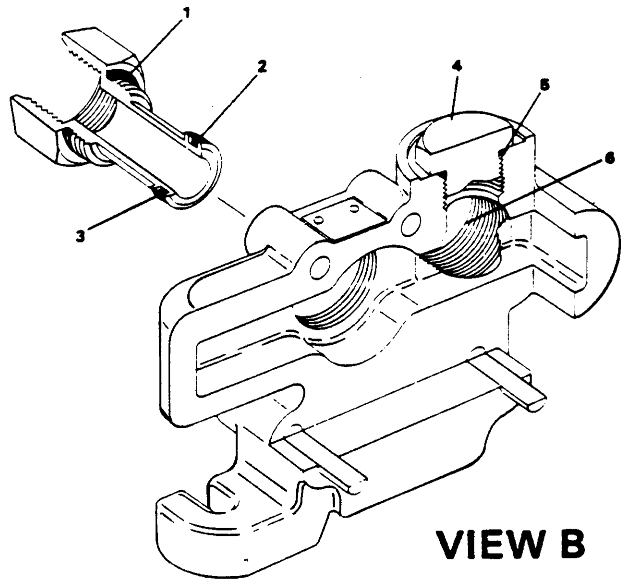
Integrated Outrigger Valve (Sheet 1 of 4)



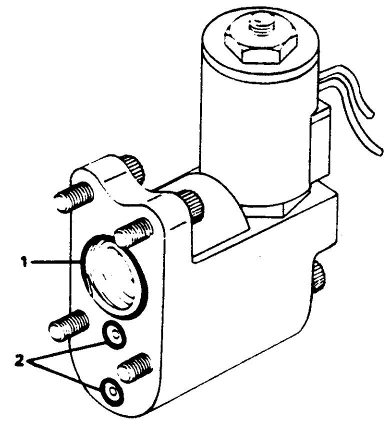
VIEW A

VIEW A

1. Retainer
2. Solenoid Plunger Assembly
3. Plunger
4. Stem
5. Machine Screw
6. O-ring
7. Spring
8. O-ring
9. O-ring
10. Valve Body
11. O-ring
12. Spool
13. Spring
14. O-ring
15. Backup Ring
16. O-ring
17. Backup Ring
18. Washer
19. Solenoid Valve Housing



VIEW B



VIEW D

VIEW B

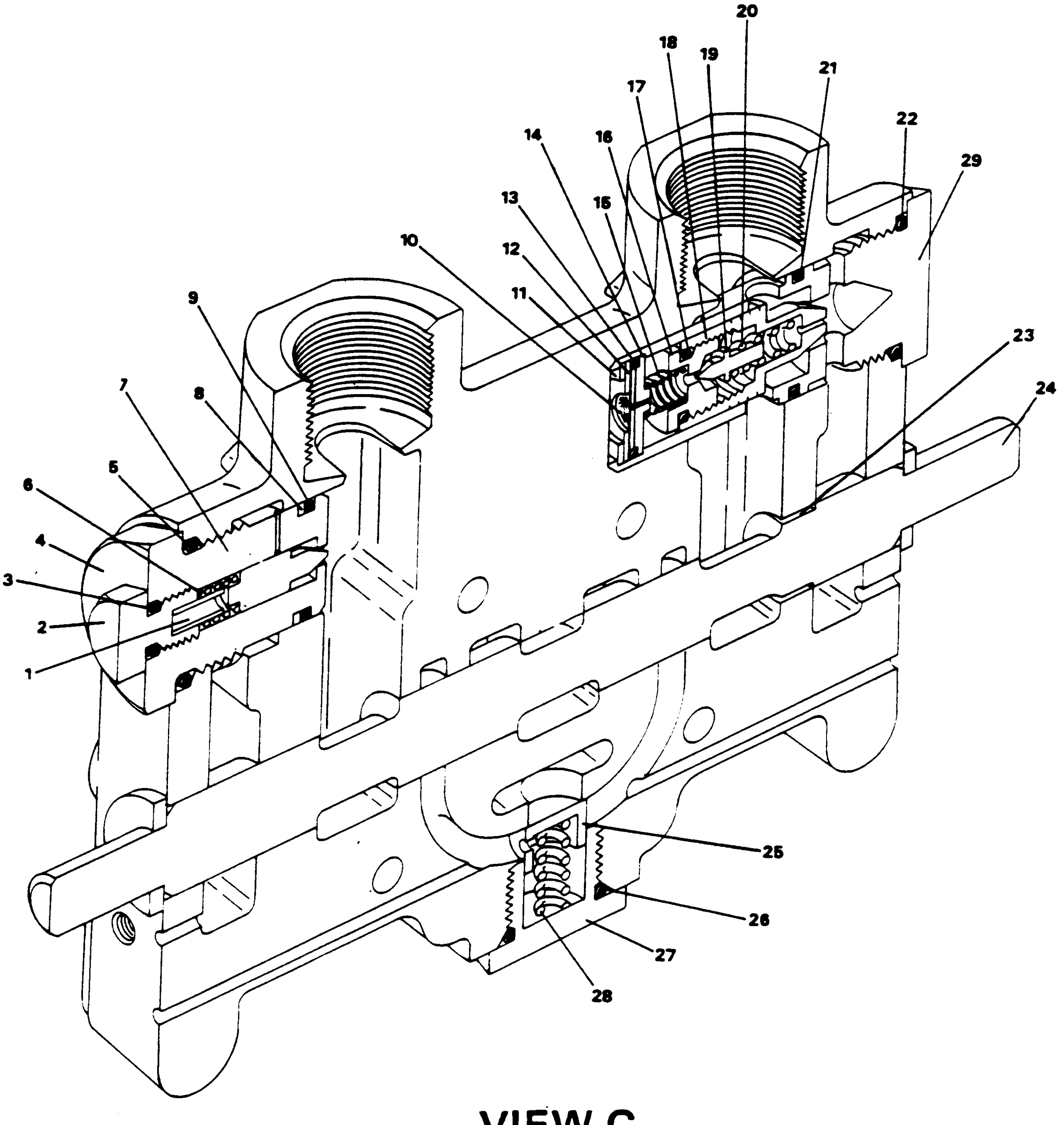
1. O-ring
2. Backup Ring
3. O-ring
4. Plug
5. O-ring
6. Port

VIEW D

1. O-ring
2. O-ring

0445-1

Integrated Outrigger Valve (Sheet 2 of 4)



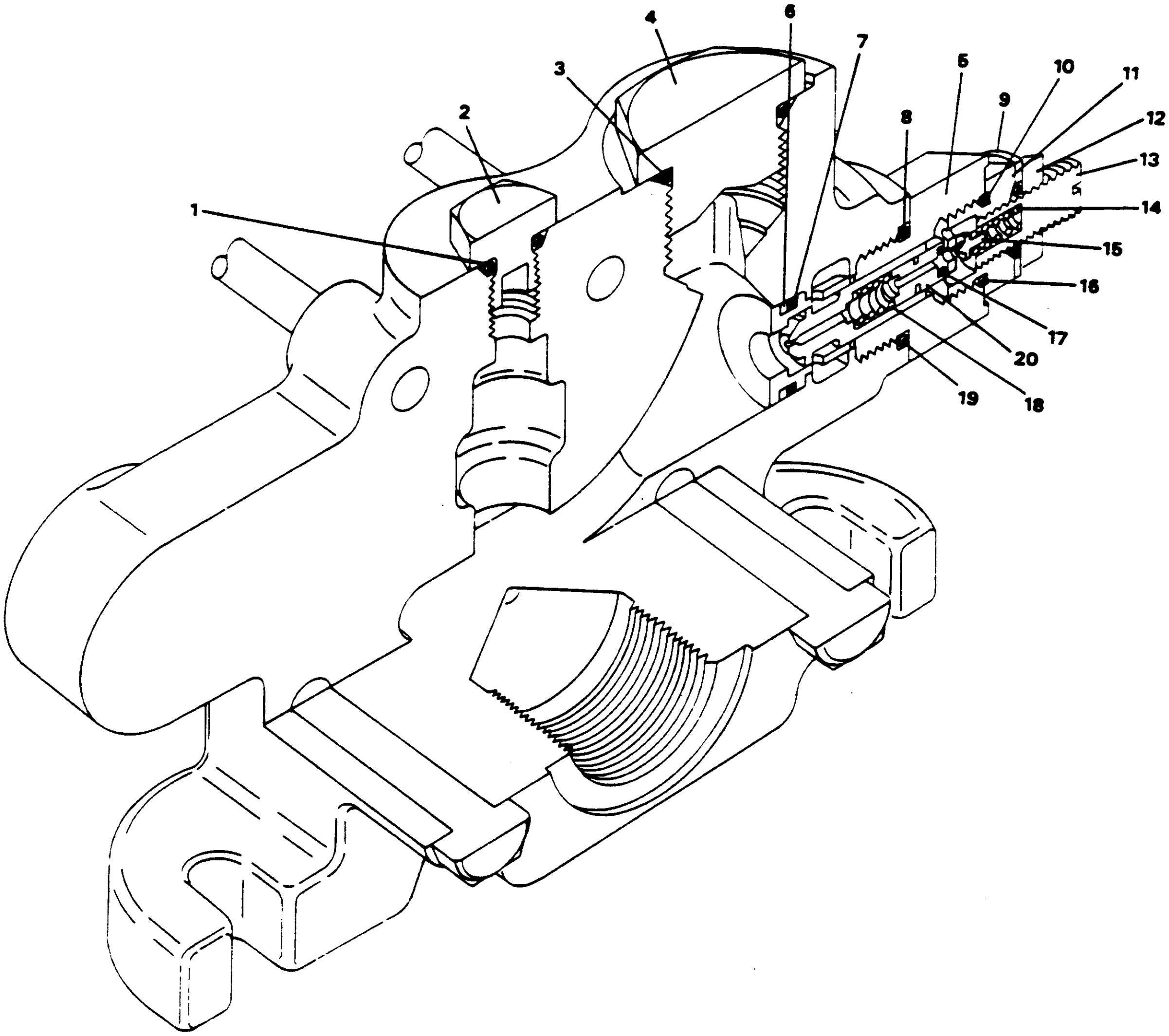
VIEW C

VIEW C

1. Spring Guide
2. Plug
3. O-ring
4. Relief Valve Body
5. O-ring
6. Spring
7. Needle Valve
8. Backup Ring
9. O-ring
10. Spring
11. Snap Ring
12. Washer
13. O-ring
14. Orifice Plate
15. Spring
16. Poppet Body Cap
17. O-ring
18. Poppet Assembly
19. Needle Valve
20. Spring
21. O-ring
22. O-ring
23. Flat on Spool
24. Spool
25. Check Valve
26. O-ring
27. Cap
28. Spring
29. Relief Valve Assembly

0445-2

Integrated Outrigger Valve (Sheet 3 of 4)



VIEW E

VIEW E

1. O-ring
2. Plug
3. O-ring
4. Plug
5. Main Relief Valve Assembly
6. Backup Ring
7. O-ring
8. O-ring
9. Washer
10. O-ring
11. Needle Valve Seat Assembly
12. Locknut
13. Adjusting Screw
14. Spring
15. Needle Valve
16. O-ring
17. O-ring
18. Spring
19. O-ring
20. Plunger

0445-2

Integrated Outrigger Valve (Sheet 4 of 4)

2. Lubricate and install the valve body into the valve housing.

3. Install the stem into the plunger assembly and screw it into the valve body.

4. Position the solenoid valve and install the washer and retainer.

5. Secure the solenoid valves to the working section with the machine screws.

PRESSURE ADJUSTMENT.

After maintenance involving the disassembly of the main relief valve, the pressure setting must be checked and if necessary adjusted to the proper pressure setting. This must be done on a test bench where the pressure can be checked. Turn the adjusting stem in to increase pressure and outward to decrease pressure.

OUTRIGGER SOLENOID VALVE STACK

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LIST OF FIGURES

Title **Page**

DESCRIPTION

The solenoid valve stack assembly consists of four valve sections, four solenoid assemblies, and an assembly kit. By using the four valves asembled together, four separate components can be controlled by a single hydraulic source.

THEORY OF OPERATION

NOTE

The theory of operation covers the operation of one solenoid valve, however, all four solenoid valves operate the same.

The valve as held in its normally closed position by a spring. When the solenoid is energized. the plunger assembly forces the spool to shift which opens the valve. Deenergizing the solenoid causes spring pressure to shift the spool to its normally closed position.

MAINTENANCE

VALVE STACK ASSEMBLY.

Disassembly.

1. Remove the two nuts on each end of the stack assembly.

2. Remove the two mounting brackets.

3. Pull the valve assemblies apart and remove the seal plates and 0-rings between the valves and the tie bolts.

Assembly.

1. Place the seal plates and 0-rings between the valves and install the tie bolts.

2. Install the mounting brackets and secure in place with the attaching nuts.

SOLENOID VALVES,

Disassembly.

1. Remove the fittings from the valve.

2. Remove the four screws from the solenoid assembly and remove the solenoid from the valve assembly.

3. Remove the base of the solenoid valve by either removing the plug or plate located on the bottom of the valve.

4. Remove the spring and washer from each end of the spool. Remove the spool and place the spool in a clean, lintless cloth.

5. Remove the plunger assembly from the solenoid coil. Remove the 0-rings from the plunger assembly.

6. Remove the sleeves and spring from the plunger assembly.

Cleaning and Inspection.

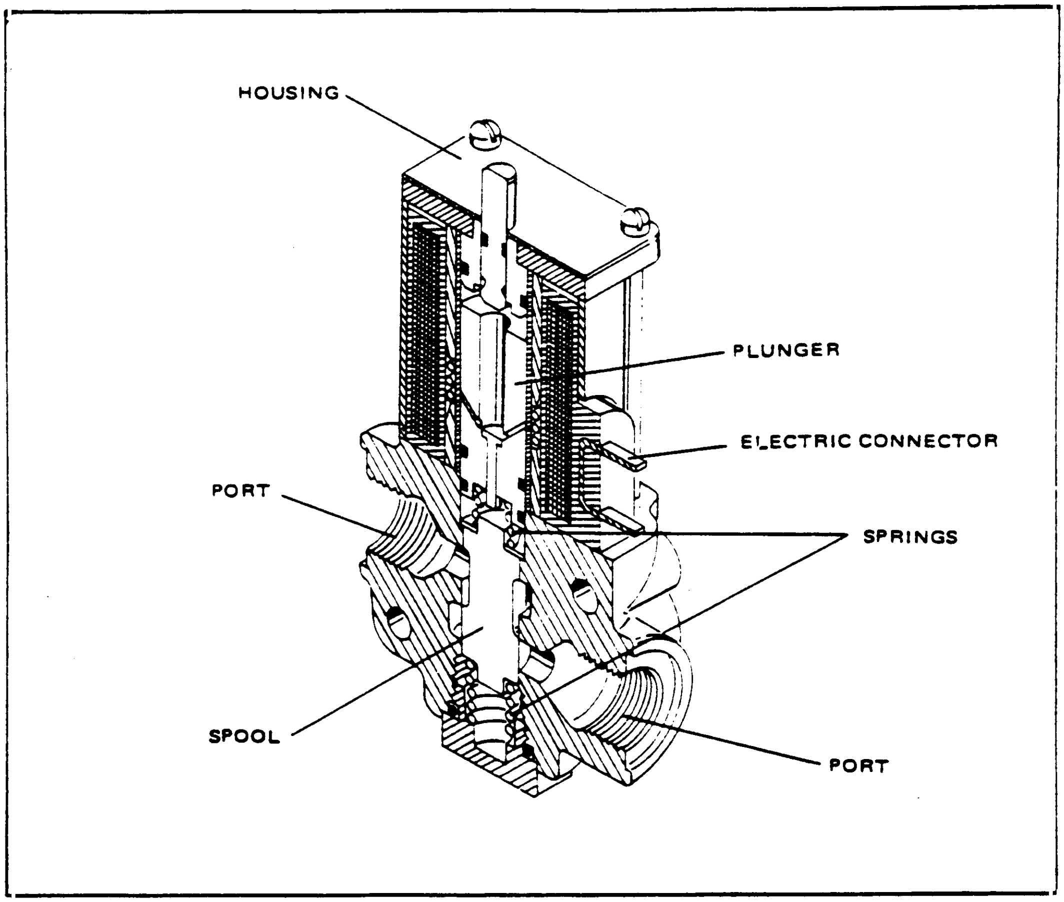
1. Clean all part in a suitable solvent, with the exception of electrical parts, and dry with air.

2. Check the spool for nicks and scratches, minor nicks and scratches may be removed with crocus cloth.

Assembly.

NOTE

It is recommended all 0-rings be replaced with new 0-rings at assembly.



Solenoid Valve

1. Coat the spool with clean hydraulic oil and install the spool into the valve body.

2. Install the washers and springs onto each end of the spool.

3. Install the O-ring on the plug or plate and install onto the base of the valve. If a base plate is used, secure the plate using the four screws.

NOTE

The longer sleeve on the solenoid assembly is always positioned on the top side of the plunger.

4. Install the O-ring onto the plunger.

5. Install the sleeves and spring onto the plunger and install the plunger assembly into the coil.

6. Install the solenoid assembly onto the valve body and secure it in place using the four screws.

7. Install the fittings into the solenoid valve.

HOLDING VALVE

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LIST OF FIGURES

DESCRIPTION

The holding valve is ported to allow hydraulic flow in two directions. To raise a load, the oil must unseat the free flow poppet valve. In this case, oil pressure must overcome the main poppet spring. To do this, the oil flows through the oil ports of the pilot release poppet valve which applies pressure to the inside face of the free flow poppet. When the main poppet unseats, the oil flows past the main poppet seat to the component to be worked.

When a load is to be lowered, as in retracting the boom, better control is necessary because of the weight of the load. For this reason a pilot pressure is used for positioning the main poppet valve which is being held against its seat by heavy springs. The pilot pressure is sensed from the lowering side of the hydraulic circuit. As the directional control valve is opened to the lower position, pressure is applied to the pilot piston. The pilot piston moves against the pilot release poppet until it unseats the pilot release poppet valve which port oil to the return side of the directional control valve.

The free flow check valve is provided for venting the pressure side of the pilot piston.

A vent is provided for venting the area between the pilot piston O-rings should weepage occur. A second vent is provided at the adjustment end of the pilot release poppet valve should weepage occur past the O-ring seal into the spring area.

MAINTENANCE

DISASSEMBLY.

NOTE

Do not remove the adjustment screw or locknut during disassembly.

1. Remove plug, with adjustment screw, from valve body by turning large nut of plug counter-clockwise. Do not remove adjustment screw or locknut from plug.

2. Remove O-ring from plug.

3. Remove spring and seats from valve body.

4. Remove poppet from valve body.

5. Remove plug, spring, and ball from poppet.

6. Remove O-rings and backup rings from valve body.

ASSEMBLY.

NOTE

It is recommended that all O-rings and backup rings be replaced with new parts at assembly.

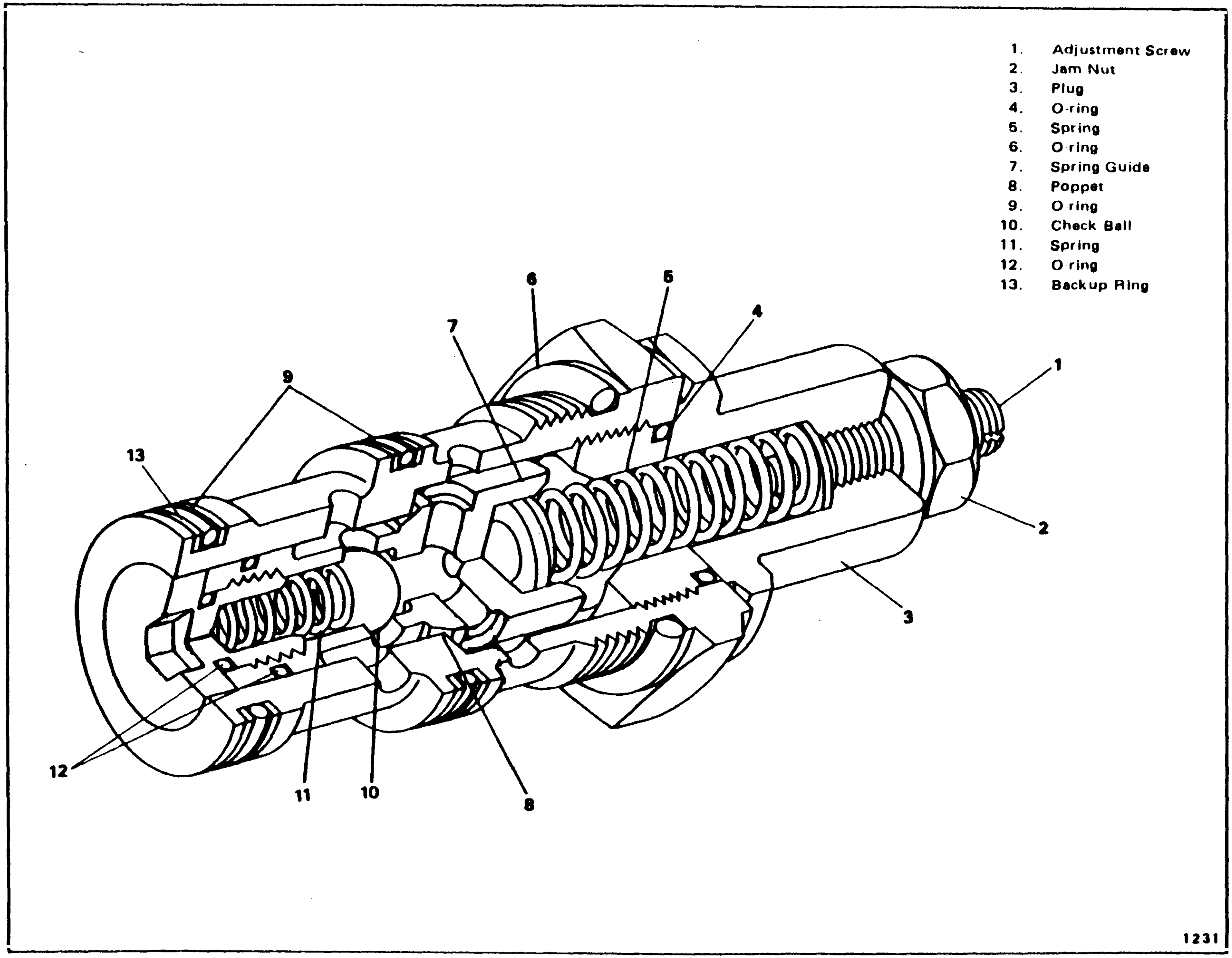
1. Install all backup rings and O-rings onto valve body.

2. Install ball and spring in poppet and secure with plug.

3. Coat poppet with clean hydraulic oil and install poppet into valve body.

4. Install seats and spring into valve body.

5. Install O-ring onto plug and install plug, with adjustment screw, into valve body.



Holding Valve

SWING GEARBOX AND BRAKE

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DESCRIPTION

SWING BRAKE.

The multi-disc swing brake assembly is mounted between the swing motor and the swing gearbox. The brake mechanism is a disc pack that is hydraulically released and spring applied. The brake has one hydraulic port.

SWING GEARBOX.

The swing gearbox is bolted to a mounting plate on the superstructure base plate, and its pinion gear (bull gear) meshes with the ring gear of the turntable bearing to rotate the turntable. The swing brake is installed on top of the gearbox and the swing motor is mounted on the brake. The swing motor drives the gearbox through the brake assembly. The swing gearbox utilizes double reduction planetary gearing which results in a component circular unit of high strength and efficiency. The round gear case with horizontal rotating gears ensures lubricant circulation.

THEORY OF OPERATION

SWING BRAKE.

When hydraulic pressure is applied to the brake release port, pressure is applied to the piston which extends and compresses the springs. This allows the stators to expand and relieve the friction between the brake discs and the stators, releasing the braking action and allowing the turntable to be rotated.

When no hydraulic pressure is applied to the brake release port, spring pressure forces the brake discs against the stators. The brake discs are splined to the splined shaft and are compressed between the stators. The friction between the brake discs and the stators stops rotation.

MAINTENANCE

SWING BRAKE.

Disassembly.

1. Remove the four bolts and washers from the cylinder housing. Remove the bolts together in stages, two turns each, so as to provide uniform release of the spring pressure.

2. Remove the cylinder head and the brake piston. Discard the O-rings and the backup rings.

3. Remove the springs from the counterbores.

4. Remove the brake discs and the stators.

5. Tap the shaft down through the bottom of the brake housing.

6. Remove the oil seal.

Assembly.

NOTE

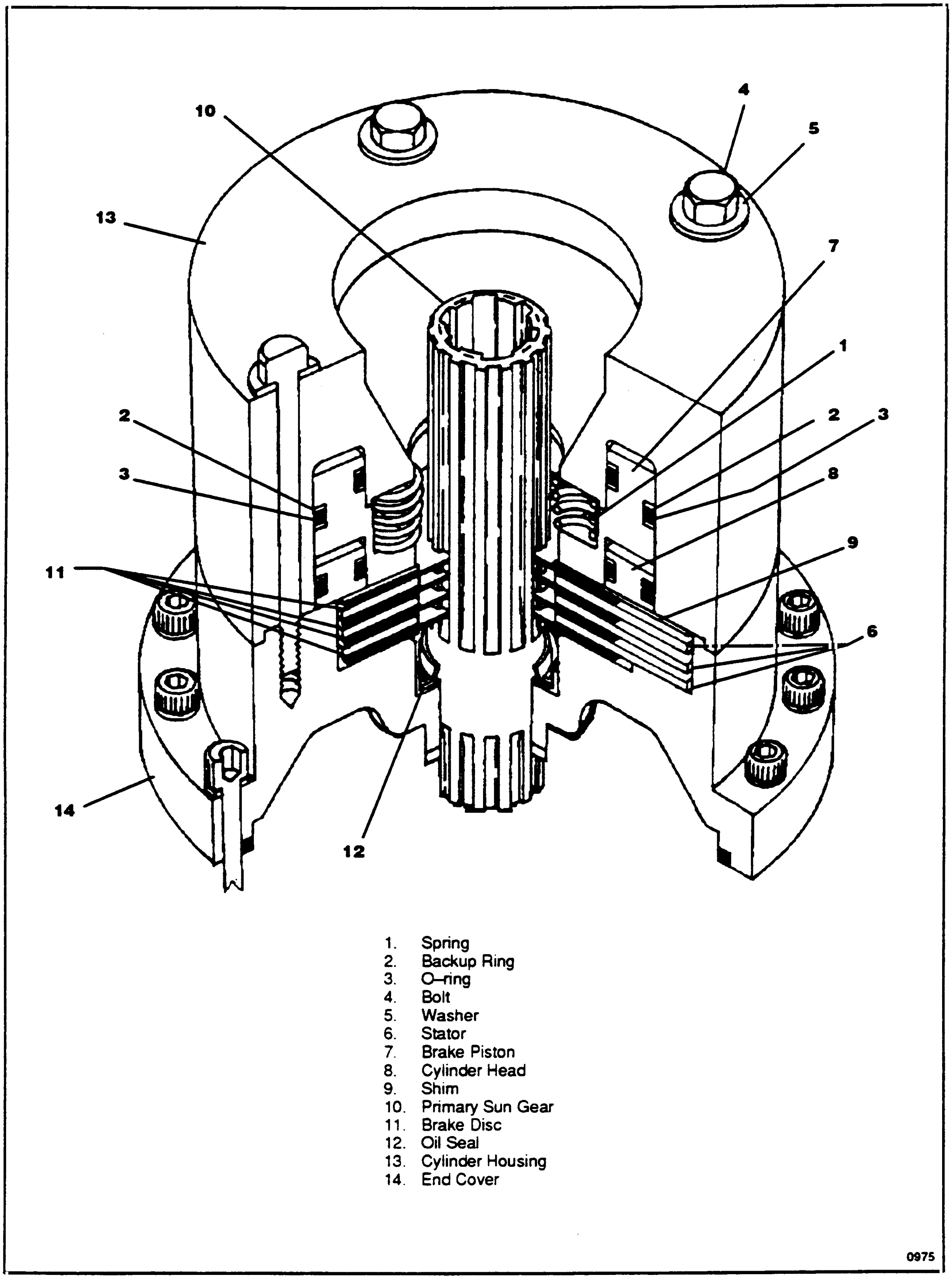
Any maintenance involving disassembly of the swing brake should include the replacement of all seals and O-rings.

NOTE

The piston and O-rings must be clean and lubricated with clean hydraulic fluid prior to assembly.

NOTE

Brake discs must be clean and dry. There should be no presence of oil on any lining material or mating surfaces of the stators.



Swing Gearbox

1. Press the oil seal into the end cover.

2. Place the shaft in the brake housing.

3. Place the stators and brake discs over the splined shaft into the brake housing. Ensure the proper order is maintained (brake disc, stator, brake disc, stator).

4. Lubricate and install new O-rings and backup rings on the piston and the cylinder head.

5. Install the cylinder head and the piston into the brake housing.

6. Insert the compression springs into the counter-bores on the piston.

7. Apply a thin, even film of RTV Sealant to the brake housing according to the following procedure:

WARNING

Minor concentrations of acetic acid vapor may be produced during application. Adequate ventilation should be provided when silicone RTV is applied in confined areas.

Eye contact with these silicone RTV materials may cause irritation. If eye contact occurs, flush eyes with water for 15 minutes and have the eyes examined by a doctor.

a. Remove dirt, grease, or moisture from the mating surfaces.

b. Dry the surfaces.

c. Apply a thin bead, maximum 0.125 inch (3.175 mm) diameter, completely around one mating surface and all fastener holes to ensure complete sealing and to prevent leakage.

8. Set the cylinder housing on the brake housing immediately to permit an even spread of RTV.

9. Install the four bolts and washers. Alternately tighten the bolts, and torque them to 35 pounds-foot (4.8 kgm).

SWING GEARBOX.

Disassembly.

NOTE

Any maintenance involving disassembly of the swing gearbox should include the replacement of all seals and O-rings.

NOTE

For ease of alignment, scribe or mark a line through the end cover, internal gear, and hub.

1. Remove the plugs and drain the housing completely.

NOTE

Steps 2 and 3 are only necessary if the swing brake and motor have not been removed.

2. Position the swing box on a clean work surface, with the swing motor up, and remove the capscrews and washers securing the motor to the gear housing cover. Remove the motor.

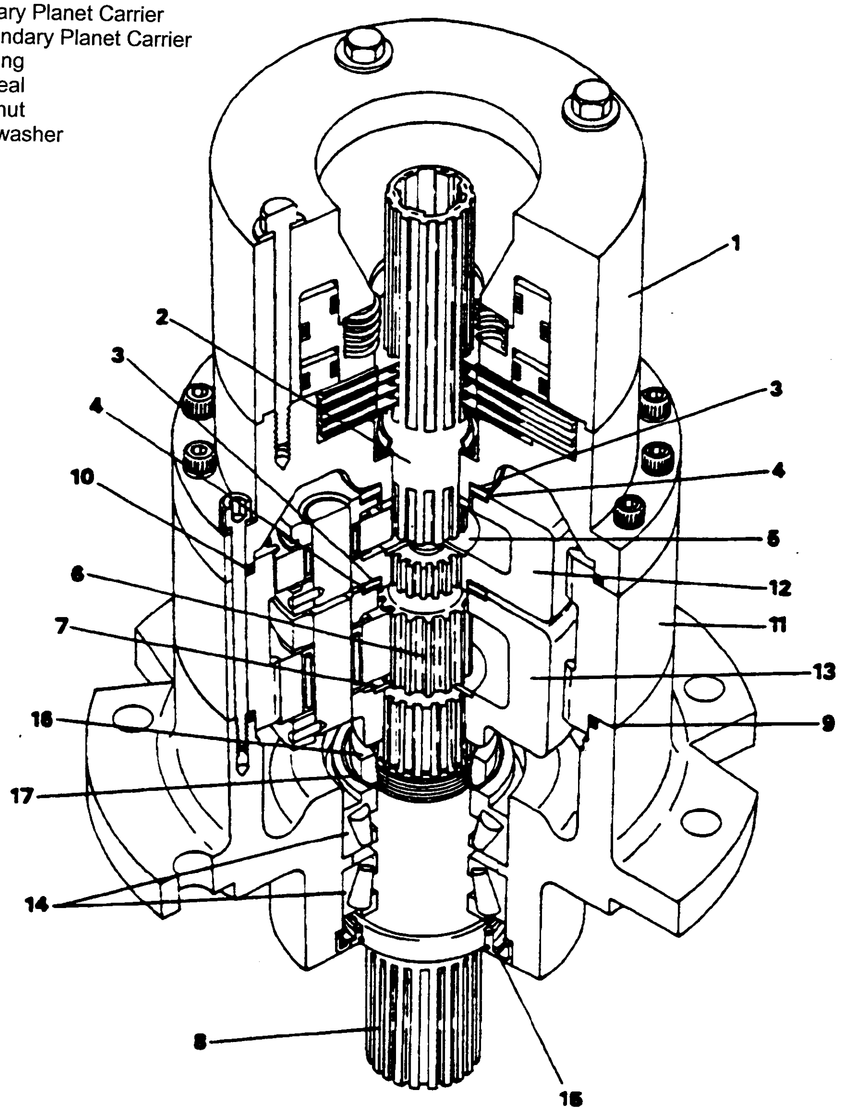
3. Remove the hex head bolts and lockwashers from the brake assembly. Remove the brake assembly.

4. Remove the thrust races and thrust bearing from the first stage planet carrier. Remove the spacer.

5. Remove the first stage planet carrier assembly.

6. Remove the thrust races and thrust bearing from the second stage planet carrier.

1. Brake Assembly
2. Primary Sun Gear
3. Thrust Race
4. Thrust Bearing
5. Spacer
6. Secondary Sun Gear
7. Spacer
8. Output Shaft
9. Shim
10. O-ring
11. Internal Gear
12. Primary Planet Carrier
13. Secondary Planet Carrier
14. Bearing
15. Oil Seal
16. Locknut
17. Lockwasher



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Swing Gearbox

7. Remove the second stage planet carrier assembly.

8. Remove the secondary sun gear from the second stage planet carrier.

9. Remove the internal gear, shims, and 0-ring from the hub.

10. Remove the lock nut and lockwasher and pull the output shaft from the hub.

11. If necessary, remove the oil seal and roller bearings from the hub.

Cleaning.

1. Clean all metal parts as required with cleaning solvent.

2. Dry with compressed air or lint free clean cloth.

Inspection.

1. Inspect all bearings for damage to the rolls, cages, or quills.

2. Inspect all gear teeth for cracks, pitting, or wear.

3. Inspect all bearing surfaces for scoring, scratches, or other damage.

Repair.

1. File off any burrs or nicks on any gears with a fine mill file or India stone.

2. Other repairs are limited to replacement of damaged components as well as all O-rings and seals.

Planet Carrier Assemblies.

The following maintenance procedures are common to both the first and second stage planet carrier assemblies.

DISASSEMBLY.

1. Drive the roll pin into the planet shaft and remove the shaft, planet gear, and thrust races. Remove the roll pin from the planet shaft.

2. If necessary, remove the needle bearing from the planet gear.

3. Repeat steps 1 and 2 for the remaining planet gears.

4. Remove the spacer from the planet carrier.

CLEANING.

1. Clean all metal parts as required with cleaning solvent.

2. Dry with compressed air or lint free clean cloth.

INSPECTION.

1. Inspect all bearings for damage to the rolls, cages, or quills.

2. Inspect all gear teeth for cracks, pitting or wear.

3. Inspect all bearing surfaces for scoring, scratches, or other damage.

REPAIR.

1. File off any burrs or nicks on any gears with a fine mill file or India stone.

2. Other repairs are limited to replacement of damaged components as well as all O-rings and seals.

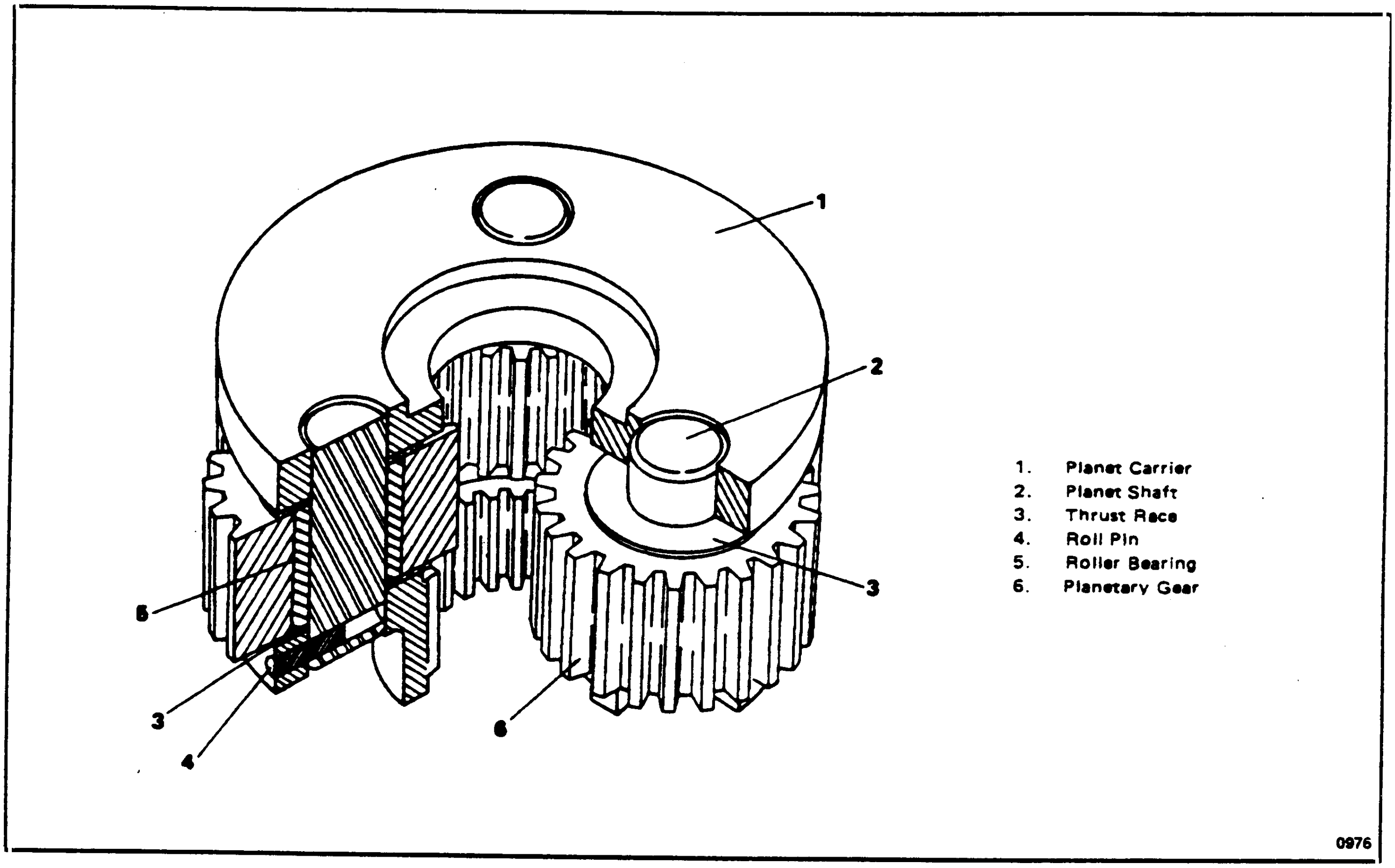
ASSEMBLY.

1. Place the spacer into the planet carrier.

2. If removed, install the needle bearing into the planet gear.

3. Place the thrust races and planet gear into the planet carrier and install the planet shaft. Secure the planet shaft in place by driving in the roll pin.

4. Repeat steps 2 and 3 for the remaining planet gears.



Planet Carrier Assembly

Assembly.

NOTE

Prior to assembly, lubricate all 0-rings and seals with gear oil. Pack all bearings with grease before installation.

1. If removed, install the roller bearings and oil seal into the hub.

CAUTION

Take care not to damage the oil seal when installing the output shaft.

2. Position the output shaft into the hub and secure in place with the lockwasher and locknut.

3. Install the O-ring, shims, and internal gear onto the hub.

4. Place the secondary sun gear into the second stage planet carrier.

5. Install the second stage planet carrier assembly into the internal gear.

6. Install the thrust races and thrust bearing onto the second stage planet carrier.

7. Install the first stage planet carrier assembly.

8. Install the thrust races and thrust bearing onto the first stage planet carrier.

9. Place the O-ring and brake assembly onto the gearbox and secure in place with the bolts. Torque the bolts to 35 pounds-foot (4.8 kgm).

10. Install the swing motor. Torque the retaining bolts to 121 pounds-foot (16.7 kgm).

GROVE MODEL HO-15 HOIST

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LIST OF FIGURES

DANGER NOTE SUMMARY

Page

WARNING **12**

Cleaning solvents can be toxic, flammable, an irritant to the skin, or give off harmful fumes. Avoid avoid prolonged skin contact, inhalation of vapors, or smoking, Failure to compy can result in injury or death to personnel.

WARNING **12**

Compressed air shall not be used for drying purposes except where reduced to less than 30 PSI (206.7 kPa), then only with effective chip guarding and personal protective equipment.

DANGER NOTE SUMMARY (continued)

	Page
WARNING Ensure the brake cylinder is installed so the vent hole will be at the top when installed on the hoist.	14

DESCRIPTION

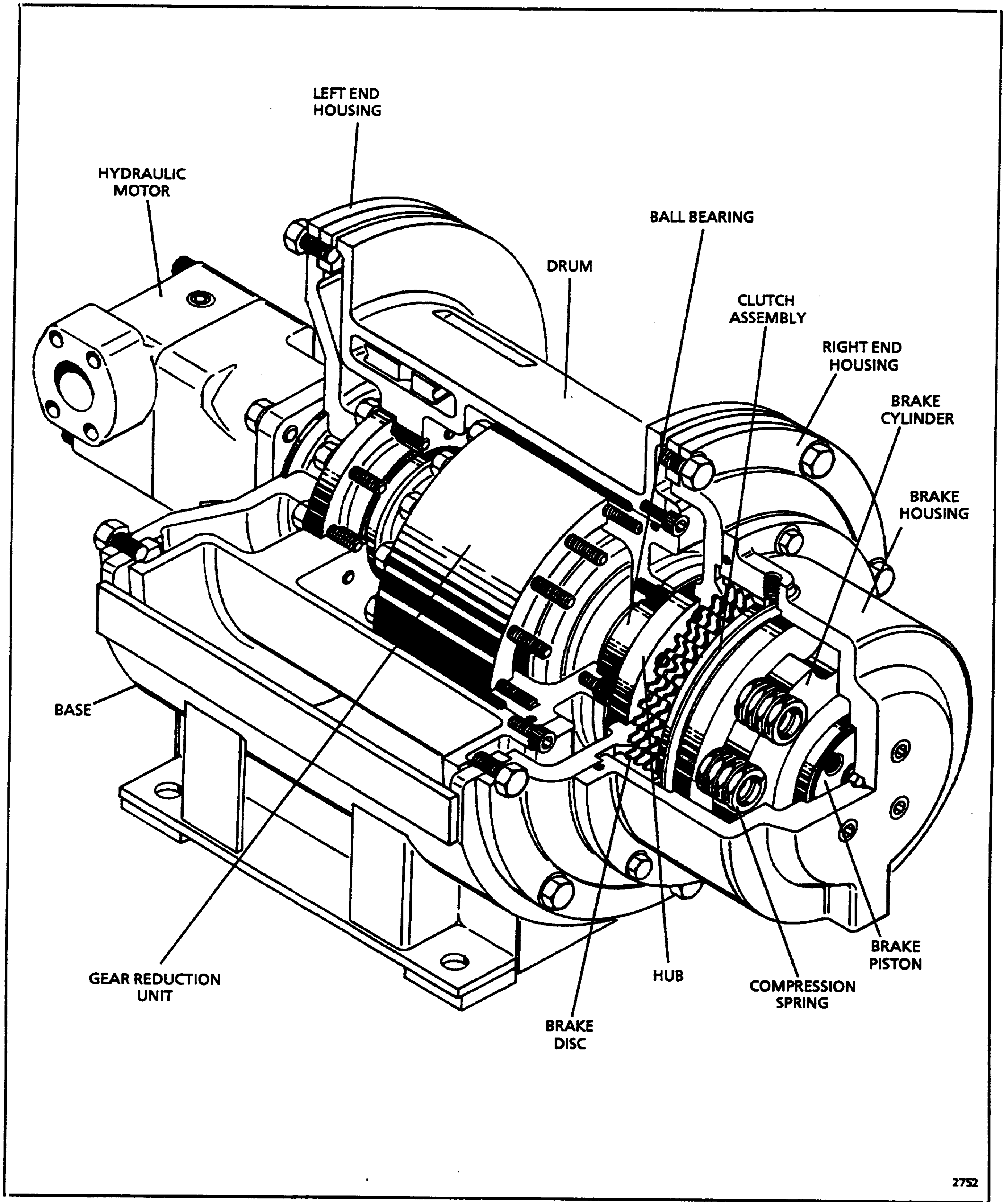
The Grove Model HO-15 hoist is a single speed hoist consisting of a hoist control valve, a vane type motor, the brake, the side and base plates, and the cable drum assembly. The cable drum assembly includes the drum and a gear reduction unit.

THEORY OF OPERATION

The hoist drum rotates on anti-friction bearings located in the drum ends. A shaft splined to the drive motor transmits the drive motor rotation to the primary carrier assembly in the gear reduction unit. A second shaft transmits this rotation from the secondary carrier assembly in the gear reduction unit to the overrunning clutch. The overrunning clutch will restrict or stop drum rotation as determined by the action of the hydraulic operated brake.

Oil from the hoist directional control valve flows to the hoist control valve mounted on the hoist drive motor. When hoisting up, oil enters the IN port of the hoist control valve and unseats the free flow poppet. Oil then flows from the OUT port of the valve to the up port of the motor, which drives the hoist to wind cable onto the drum.

When hoisting down, oil flows to the down port of the hoist motor, the hoist brake, and the pilot line of the hoist control valve. The pilot operated poppet of the hoist control valve and the hoist brake are controlled by the pressure in the down line. Because the poppet in the hoist control valve is closed and oil cannot flow from the raise port of the motor, pressure rises in the down line. As the pressure rises, the hoist brake will release and as pressure continues to rise, the pilot pressure in the hoist control valve will open the poppet allowing the hoist to run in a down direction and oil to flow to the reservoir. If the load-drop speed increases, the pressure in the down line will decrease. This decrease in pressure will cause the poppet in the hoist control valve to close and causes the spring actuated brake to slow or stop the hoist. The hoist control valve prevents the load from driving the hoist motor during hoist down operation.



Model HO - 15 Hoist - Cutaway

MAINTENANCE

Troubleshooting

SYMPTOM	PROBABLE CAUSE	SOLUTION
1. Hoist will not raise the load.	a. Too much cable on drum.	a. Each layer of cable on the drum reduces the line pull. By reducing the amount of cable on the drum, the pull will increase.
	b. Improper reeving.	b. Multiply the line pull times the number of lines used, adjusting for the amount of cable on the drum; compare with load. Add parts of line if load exceeds results.
	c. Load capacity exceeded.	c. Reduce load. (Refer to applicable Load Chart).
	d. Hydraulic oil low.	d. Replenish system.
	e. Broken hydraulic lines or fittings.	e. Replace lines or fittings.
	f. Damaged relief valve.	f. Repair or replace valve.
	g. Damaged hoist control valve.	g. Repair or replace valve.
	h. Damaged primary drive assembly.	h. Repair or replace primary drive assembly.
	i. Damaged overrunning clutch.	i. Remove brake housing and associated lines from the primary housing. The clutch assembly is keyed and bolted to the center drive shaft of the drum. The clutch assembly should turn freely in the counterclockwise direction. Repair or replace if damaged.
	j. Sheared shaft on pump or damaged pump.	j. Install a 0 to 5000 psi (0 to 34.475 kPa/344.8 bar) gauge in the inlet line of the hoist valve bank. Activate the system. No pressure or excessively low pressure indicates a damaged pump or drive shaft. Repair or replace.
	k. Motor control valve out of adjustment.	k. Refer to Adjustment of the Motor Control Valve in the Service Manual and adjust the valve.

SYMPTOM	PROBABLE CAUSE	SOLUTION
2. Hoist will not lower.	a. Broken lines or fittings.	a. Replace lines or fittings.
	b. Damaged relief valve.	b. Repair or replace valve.
	c. Damaged hoist control valve.	c. Repair or replace valve.
	d. Damaged primary drive assembly.	d. Repair or replace primary drive assembly.
	e. Motor control valve out of adjustment.	e. Refer to Adjustment of the Motor Control Valve in the Service Manual and adjust the valve.
3. Slow operation down.	a. Low engine rpm.	a. Increase speed.
	b. Damaged circuit relief valve.	b. Repair or replace valve.
	c. Damaged hydraulic pump.	c. Repair or replace valve. Damaged pumps normally build heat. By hand, carefully check the temperature of the pump in relation to the other hydraulic pumps.
4. Slow operation up.	a. Low engine rpm.	a. Increase engine rpm to recommended setting.
	b. Damaged main relief valve.	b. Repair or replace valve.
	c. Damaged hydraulic pump disconnect.	c. Check speed of other hydraulic functions under load. If all operations are slow, repair or adjust pump disconnect.
	d. Damaged hydraulic pump.	d. Repair or replace valve. Damaged pumps normally build heat. By hand, carefully check the temperature of the pump in relation to the other hydraulic pumps.
	e. Damaged O-rings in brake piston.	e. Install a pressure gauge 0 to 5000 psi [0 to 34,475 kPa/344.8 bar]) in the pipe plug hole in the line going into the center of the brake housing. The inability to build or hold pressure at 500 psi (3447.5 kPa/34.48 bar) in this line indicates defective O-rings - replace if damaged.
	f. Warped brake piston.	f. Replace piston.
	g. Motor control valve out of adjustment.	g. Refer to Adjustment of the Motor Control Valve in the Service Manual and adjust the valve.

SYMPTOM	PROBABLE CAUSE	SOLUTION
5. Erratic operation up.	a. Low engine rpm.	a. Increase speed.
	b. Damaged motor.	b. Install pressure gauge (0 to 5000 psi [0 to 34,475 kPa/344.8 bar]) in the inlet and exhaust line of the motor. Hoist upwards in low speed. Observe meter readings. If the motor has excessively more or less pressure than normal, it is damaged - repair or replace damaged motor.
6. Erratic operation down.	a. Air in brake release line.	a. Bleed pilot pressure line going into brake housing.
	b. Low engine rpm.	b. Increase speed.
	c. Damaged circuit relief valve.	c. Repair or replace valve.
	d. Motor control valve out of adjustment.	d. Refer to Adjustment of the Motor Control Valve in the Service Manual and adjust the valve.
7. Sticking spool in the control valve.	a. Excessively high oil temperature.	a. Eliminate any restriction in pipe line or filtering system.
	b. Dirt in oil.	b. Change oil and flush system.
	c. Valve warped from mounting.	c. Loosen valve and check.
	d. Excessively high presure in valve. (Relief valves not working properly).	d. Check pressure at inlet and at working ports.
	e. Handle or linkage binding.	e. Free linkage.
	f. Spacer bent.	f. Replace valve.
	g. Return spring damaged.	g. Replace faulty parts.
	h. Spring or valve cap binding.	h. Loosen cap, recenter and re-tighten.
	i. Oil not thoroughly warmed up.	i. Allow time for system warm up.
8. Leaking seals.	a. Paint on or under seal.	a. Remove and clean, as necessary.
	b. Dirt under seal.	b. Remove and clean, as necessary.
	c. Scored spool.	c. Replace valve.
	d. Loose seal plates.	d. Clean and tighten plates.

SYMPTOM	PROBABLE CAUSE	SOLUTION
9. Unable to move spool in or out.	a. Dirt in valve.	a. Clean and flush out valve assembly.
	b. Spool cap full of oil.	b. Replace seals.
	c. Bind in linkage.	c. Free linkage.
10. Load drops when spool moved from neutral.	a. Dirt in check valve.	a. Disassemble and clean check valve.
	b. Scored check valve poppet or seat.	b. Replace poppet or lap poppet to seat.
	c. Motor control valve out of adjustment.	c. Refer to Adjustment of the Motor Control Valve in the Service Manual and adjust the valve.
11. Poor hydraulic system performance or failure.	a. Damaged pump.	a. Check pressure and repair or replace pump.
	b. Dirt in relief valve.	b. Disassemble and clean relief valve.
	c. Relief valve damaged.	c. Replace relief valve.
	d. Worn hoist motor.	d. Repair or replace damaged components.

DISASSEMBLY.

NOTE

Any maintenance involving disassembly of the hoist should include replacement of all gaskets and 0-rings.

Brake Assembly.

1. Disconnect the hydraulic lines to the brake housing; cap or plug all lines and openings.

2. Remove the bolts and washers securing the brake assembly to the right end cover.

3. Using a soft faced hammer, tap the assembly until loose and remove it from the hoist

4. Remove the O-ring from the groove in the housing.

5. Place the brake assembly in a suitable press; using a sleeve larger than the overrunning clutch, compress the springs.

NOTE

Two large C-clamps can be used to compress the springs for removal of the snap ring.

6. Remove the snap ring; relieve the pressure from the springs and remove the assembly from the press.

7. Remove the pressure plate, brake discs, brake stators, and backing plate from the housing.

8. Set the housing on a flat surface with the mounting face down.

9. Remove the capscrews securing the brake piston to the housing.

10. Lift the housing free of the cylinder and piston assembly.

11. Remove the nine springs from the cylinder.

12. Using a soft faced hammer, remove the brake piston from the cylinder.

13. Remove the O-ring from the cylinder.

14. Remove the O-rings from the piston.

Hydraulic Motor.

1. Drain the oil from the drum by removing the plugs.

2. Tag and disconnect the hydraulic lines from the motor and the hoist motor control valve. Cap or plug all lines and openings.

3. Remove the hex head bolts and washers securing the motor to the left end cover; remove the motor; discard the motor gasket. For maintenance of the vane type motor, refer to the VANE MOTOR SM package.

Hoist.

1. Remove the bolts and washers securing the left side cover to the center housing; remove the end cover.

NOTE

In the older Model 15 Hoist, there is a drum support bearing cage which houses the roller bearing and seal. In the newer Model 15 Hoist, the drum support bearing cage is not used. For the older Model 15 Hoist continue with step 2. For the newer Model 15 Hoist skip to step 5 and continue.

2. Remove the bolts and washers securing the drum support bearing cage to the drum; remove the drum support bearing cage.

3. Remove the bearing with the seal from the drum support bearing cage.

4. Remove the O-ring from the drum support bearing cage.

NOTE

For older Model 15 Hoist skip to step 6.

5. Remove the bearing with the seal from inside the left side of the hoist drum.

6. Remove the shaft, coupling, and internal snap ring.

7. Remove the snap ring, clutch, and key from the main shaft (right side).

8. Remove the spacer from the main shaft.

9. Remove the capscrews securing the hub to the right end cover.

10. Remove the bolts and washers securing the right end cover to the center housing; remove the right end cover.

11. Remove the O-ring from the right end cover.

12. Remove the capscrews securing the gear reduction unit, drum end, O-ring, and spacer to the drum; remove these parts as an assembly from the drum.

Gear Reduction Unit.

1. Remove the capscrews securing the cover and thrust washer to the unit end cover; remove the cover and the thrust washer.

2. Remove the bolts and washers securing the unit end cover to the ring gear; remove the unit end cover.

3. Remove the spacer.

4. Remove the sun gear.

5. Remove the primary reduction assembly.

6. Remove the ring gear.

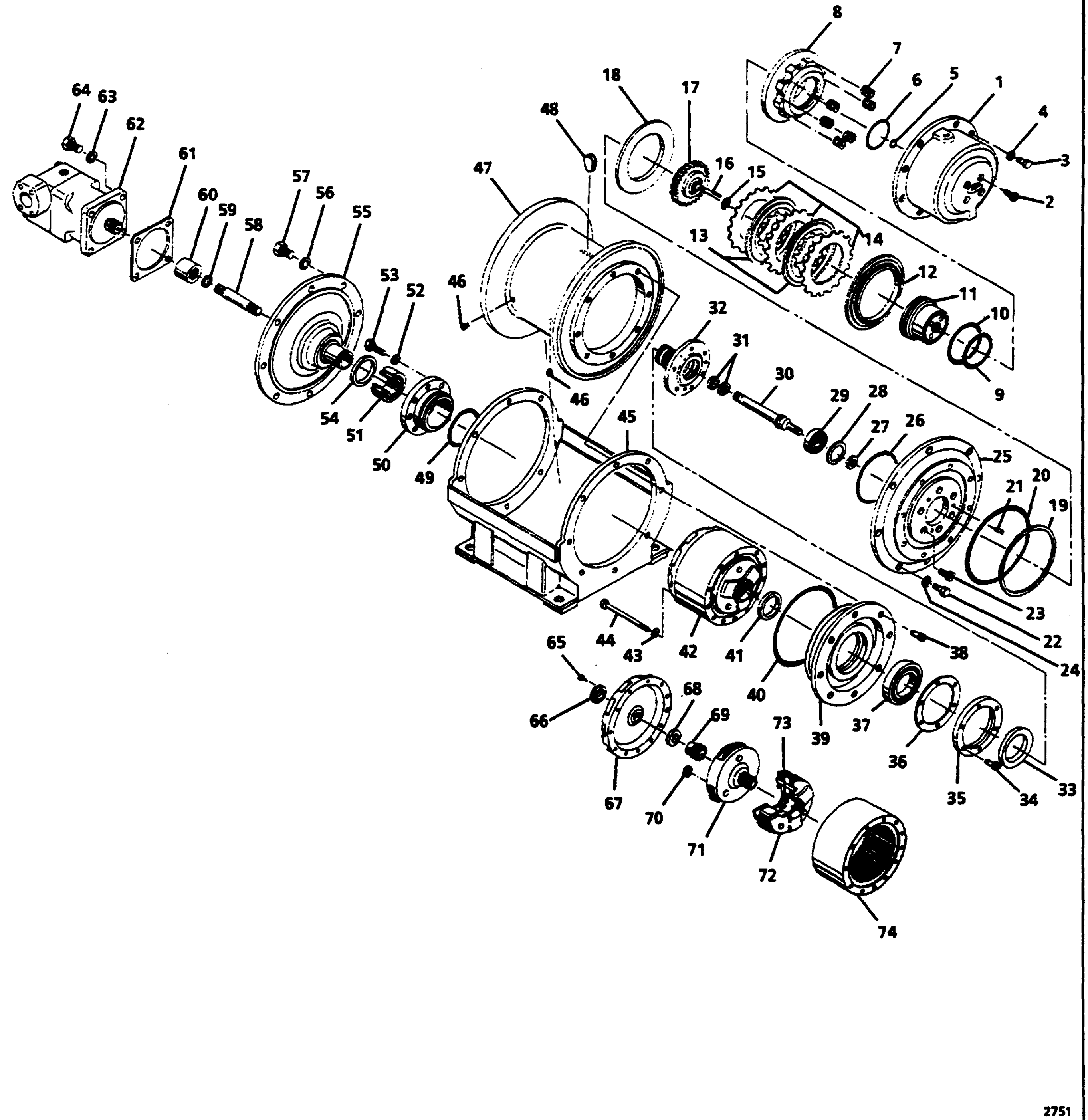
7. Remove the snap ring securing the bearing to the hub; remove the bearing and main shaft.

8. Remove the shaft seals.

9. Remove the snap ring, which retains the hub, from inside of the secondary reduction assembly.

10. Remove the secondary reduction assembly.

11. Remove the hub from the right drum end.



Model HO - 15 Hoist - Exploded View (Sheet 1 of 2)

1. Brake Housing
2. Socket Head Capscrew
3. Hex Head Bolt
4. Lockwasher
5. O-Ring
6. O-Ring
7. Compression spring
8. Cylinder
9. O-Ring
10. O-Ring
11. Piston
12. Backing Plate
13. Brake Stator
14. Brake Disc
15. External Snap Ring
16. Key
17. Overrunning Clutch
18. Pressure Plate
19. Snap Ring
20. 0-Ring
21. Dowel Pin
22. Hex Head Bolt
23. Socket Head Capscrew
24. Lockwasher
25. Right End Cover
26. 0-Ring
27. Spacer
28. Internal Snap Ring
29. Ball Bearing
30. Main Shaft
31. Oil Seals
32. Hub
33. Oil Seal
34. Socket Head Capscrew
35. Bearing Retainer
36. Gasket
37. Ball Bearing
38. Socket Head Capscrew
39. Drum End (Left)
40. O-Ring
41. Spacer
42. Gear Reduction Unit
43. Lockwasher
44. Hex Head Bolt
45. Center Housing
46. Pipe Plug
47. Drum
48. Wedge
49. O-Ring
50. Drum Support Bearing Cage
51. Roller Bearing
52. Lockwasher
53. Hex Head Bolt
54. Seal
55. Left End Cover
56. Lockwasher
57. Hex Head Bolt
58. Input Shaft
59. Internal Snap Ring
60. Coupling
61. Gasket
62. Hydraulic Motor
63. Lockwasher
64. Hex Head Bolt
65. Capscrew
66. Thrust Cover
67. End Cover
68. Spacer
69. Sun Gear
70. Snap Ring
71. Primary Reduction Assembly
72. Secondary Reduction Assembly
73. Snap Ring
74. Ring Gear

Model HO-15 Hoist Exploded View (Sheet 2 of 2)

12. Remove the dowel pins from the hub by using a punch in the pilot hole on the reverse side of the hub.

NOTE

The bearing should not be removed from the right drum end unless replacement is required. Steps 13 and 14 are not required unless removing the bearing.

13. Remove the seal from the bearing retainer.

14. Remove the capscrews securing the bearing retainer. Remove the bearing retainer and gasket.

15. Remove the bearing.

Primary or Secondary Carrier Assembly.

1. Remove the snap ring which secures the pin.

2. Use a brass drift to drive the pin out of the carrier and planet gear.

3. Remove the planet gear and thrust washer. Be careful not to lose any of the needle bearings.

4. Repeat steps 1, 2, and 3 for the other two planet gears.

CLEANING AND INSPECTION.

WARNING

Cleaning solvents can be toxic, flammable, an irritant to the skin, or give off harmful fume. Avoid prolonged skin contact, inhaling of vapors, or smoking. Failure to comply can result in injury of death to personnel.

WARNING

Compressed air shall not be used for drying purposes except where reduced to less than 30 PSI (206.7 kPa), then only with effective chip guarding and personal protective equipment.

1. Clean all metal parts as required with cleaning solvent and dry with compressed air or a lint free, clean cloth.

2. Take special care to remove all solvent from oil passages, grooves, and bearings.

3. Inspect gears for unusual wear patterns, chipped, cracked, or broken teeth.

4. Inspect bearings for chips, cracks, galling, or missing bearings. Check for signs of overheating.

5. Inspect output shaft for cracks. Check sealing surfaces for nicks, scratches, or burrs that can cause leaks.

6. Inspect the springs for distortion, cracks or other damage. Check springs against dimensions listed in the brake assembly section of this SM Package. Springs that exceed these dimensions should be replaced.

7. Inspect threaded parts for stripped, damaged threads, or burrs.

8. Prelubricate all seals, O-rings and bearings with 90 weight EPGL gear lubricant unless otherwise specified.

ASSEMBLY.

NOTE

Any maintenance involving disassembly of the hoist should include replacement of all gaskets and O-rings.

Primary or Secondary Carrier Assembly.

1. Place a small amount of EP-MPG grease around the inner diameter of the planet gear. Position one of the thrust washers on a flat surface and place the planet gear in position on top of it. Install the roller bearings in place using the grease to hold them upright. A socket just smaller than the diameter of the pin can be used to stabilize the rollers until they are all in place. Position the other thrust washer in place.

2. Carefully install the planet gear in the carrier and insert the pin. Ensure all the rollers are in position.

3. Secure the pin with the snap ring.

4. Repeat steps 1, 2, and 3 for the other planet gears.

Gear Reduction Unit.

1. Apply Loctite to the outer bearing race. Press the bearing (if the bearing was removed during disassembly), into the right drum end.

2. Install the gasket and the bearing retainer. Apply Loctite to the capscrew threads and install the capscrews. Torque 44 to 48 foot-pounds (6.1 to 6.7 kgm).

3. Install the seal in the bearing retainer.

4. Install the hub through the seal and bearing in the right drum end.

5. Install the seals in the hub.

6. Install the main shaft and bearing into the hub; secure with the snap ring.

7. Invert the hub and drum end and press the spacer into position on the hub.

8. Position the hub snap ring in place in the secondary reduction assembly.

9. Assemble the secondary reduction assembly over the hub splines, expand the snap ring and seat the snap ring in the hub groove after the reduction assembly is in position on the hub splines.

10. Position the ring gear over the secondary reduction assembly and against the drum end face.

11. Position the primary reduction assembly into the ring gear and secondary carrier.

12. Position the sun gear into the primary reduction assembly, engaging the main shaft splines.

13. Position the spacer in place over the sun gear.

14. Secure the unit end cover to the ring gear and right drum end using the capscrews and washers. Apply Loctite to the capscrew threads and torque the capscrews 27 to 29 foot-pounds (3.8 to 4.0 kgm).

15. Install the thrust cover. Install the capscrews and tighten securely.

16. Turn the main shaft by hand to check for free rotation with no tendency to lock-up or bind.

Hoist.

1. Set the drum into position in the center housing.

2. Position the gear reduction unit into the center housing. Install the O-ring and the drum end. Apply Loctite to the capscrew threads. Install the capscrews and torque 27 to 29 foot-pounds (3.8 to 4.0 kgm).

3. Install the spacer on the main shaft.

4. Install the O-ring in the right end cover.

5. Position the right end cover in place on the center housing. Apply Loctite on the capscrew threads. Install the washers and capscrews and torque the capscrews 81 to 88 foot-pounds (11.2 to 12.2 kgm).

6. Apply loctite to the capscrews; install the capscrews securing the hub to the right end cover. Torque 110 to 120 foot-pounds (15.2 to 16.6 kgm).

7. Install the dowel pins through the right end cover and hub. Install the dowel pins flush with the right end cover.

8. Install the input shaft, O-ring, and coupling.

NOTE

In the older Model 15 Hoist, there is a drum support bearing cage which houses the roller bearing and seal. In the newer Model 15 Hoist, the drum support bearing cage is not used. For the older Model 15 Hoist continue with step 9. For the newer Model 15 Hoist skip to step 12 and continue.

9. Press the bearing into the drum support bearing cage. Apply Loctite on the seal and install it in the drum support bearing cage.

10. Install the O-ring on the drum support bearing cage.

11. Position the drum support bearing cage in place on the drum. Apply Loctite on the bolt threads. Install the bolts and washers and torque 9 to 11 foot-pounds (1.3 to 1.5 kgm).

NOTE

For older Model 15 Hoist skip to step 13.

12. Press the bearing into the left side of the hoist drum. Install the seal into the left side of the hoist drum.

13. Apply Loctite to the bolt threads. Install the left side end housing to the center housing using the bolts and washers. Torque the bolts 81 to 88 foot-pounds (11.2 to 12.2 kgm).

Hydraulic Motor.

1. Using the hex head bolts and washers, secure the motor gasket and motor to the left end cover. Torque the bolts 81 to 88 foot-pounds (11.2 to 12.2 kgm).

2. Connect the hydraulic lines to the motor and the hoist motor control valve.

3. Fill the oil into the drum and replace the oil fill plug.

Brake Assembly.

1. Lubricate the O-rings with clean hydraulic oil.

2. Install the O-ring in the groove on the outer diameter of the piston. Install the O-ring in the groove on the brake cylinder.

3. Lubricate the piston and cylinder mating surfaces with a light coating of hydraulic oil.

NOTE

There is a small vent hole in the brake cylinder. This vent hole must be facing up when installed on the hoist.

4. Using a soft faced hammer, install the piston into the cylinder. Ensure the bolt holes in the end of the brake piston are aligned so the vent hole will face up when installed in the housing and mounted on the hoist. Install the O-rings on the face of the piston.

CAUTION

If any one spring is damaged, all springs should be replaced as a complete set.

NOTE

The compression springs should measure 2.5 inches (63.5 mm) in length. If any spring measures less than 2.375 inches (60.325 mm) all six springs should be replaced.

5. Set the nine springs into position on the cast sprocket of the cylinder. To facilitate assembly, rotate the springs so they lean toward the center of the cylinder.

6. Set the piston/cylinder assembly on a wood block about 5.0 inches (127 mm) high and with a circumference less than that of the housing.

WARNING

Ensure the brake cylinder is installed so the vent hole will be at the top when installed on the hoist.

7. Position the brake housing over the assembly, aligning the vent hole with the top of the brake housing.

8. Apply Loctite on the capscrew threads. Start the capscrews into the piston; draw the screws into the piston alternately until the piston face is snug against the brake housing.

9. Tighten the capscrews using a diametrically opposed sequence. Torque, in sequence, 72 to 78 foot-pounds (10.0 to 10.8 kgm).

NOTE

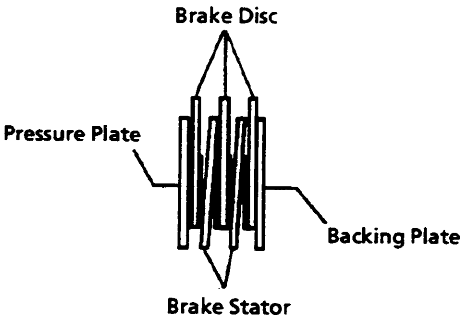
The overrunning clutch and spacer are used to align the brake disc teeth. This will simplify installation.

10. With the mounting face up, center the overrunning clutch, using a spacer under the clutch to raise the clutch flush with the housing.

NOTE

The backing plate and pressure plate are identical.

11. Install the backing plate into the housing.



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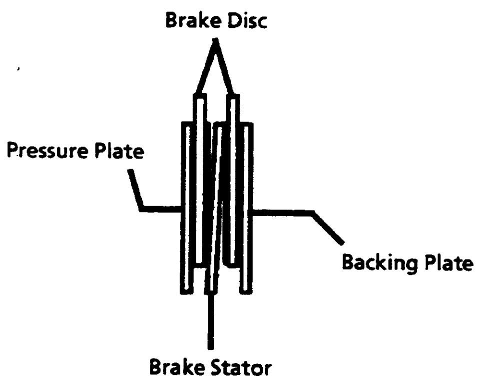

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NOTE

The number of toothed brake discs and brake stators may vary between hoist models in the HO-15 series.

12. Install the brake discs and brake stators into the housing in the order which they were removed.

13. Install the pressure plate.

14. Place the assembly in a suitable press; using a sleeve larger than the overrunning clutch, compress the springs.

15. Install the snap ring; remove the unit from the press.

NOTE

The direction of free rotation of the overrunning clutch should be counter-clockwise.

16. Remove the overrunning clutch and spacer from the brake assembly. Install the key and over-running clutch on the main shaft and secure it with the snap ring.

NOTE

Remove any excess grease when mating two machined surfaces.

17. Using EP-MPG grease as a temporary adhesive, lubricate the O-ring groove in the housing; install the O-ring.

18. Position the brake assembly in place on the right end cover, apply Loctite to the bolt threads, and install the bolts, and washers. Torque the bolts 9 to 11 foot-pounds (1.3 to 1.5 kgm).

19. Remove the plugs from the hydraulic lines and ports and connect the hydraulic lines to the brake housing.

VANE TYPE MOTOR (HO-15C HOIST)

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The vanes are held against the cam ring by tension from the springs in the rotor. If the rotor is pulled from the cam ring with no protection, tension from the springs will throw vanes out in all directions. The following procedure must be followed when disassembling the the rotor and vanes from the cam ring.

WARNING 9

Ensure the rotor and the vane assembly is inserted far enough in the cam ring to prevent the vanes from flying out of position when the ring compressor is removed.

DESCRIPTION

The vane type motor is a fixed displacement, rotary balanced motor that converts hydraulic oil flow into rotary mechanical motion. The motor consists of four basic sub-assemblies; a body or housing and shaft with a permanently lubricated bearing, a front port plate assembly consisting of the port plate with a built-in check valve, a cam ring assembly containing the rotor, vanes, vane springs and cam ring, and the end cap assembly consisting of the end cap and needle bearing.

THEORY OF OPERATION

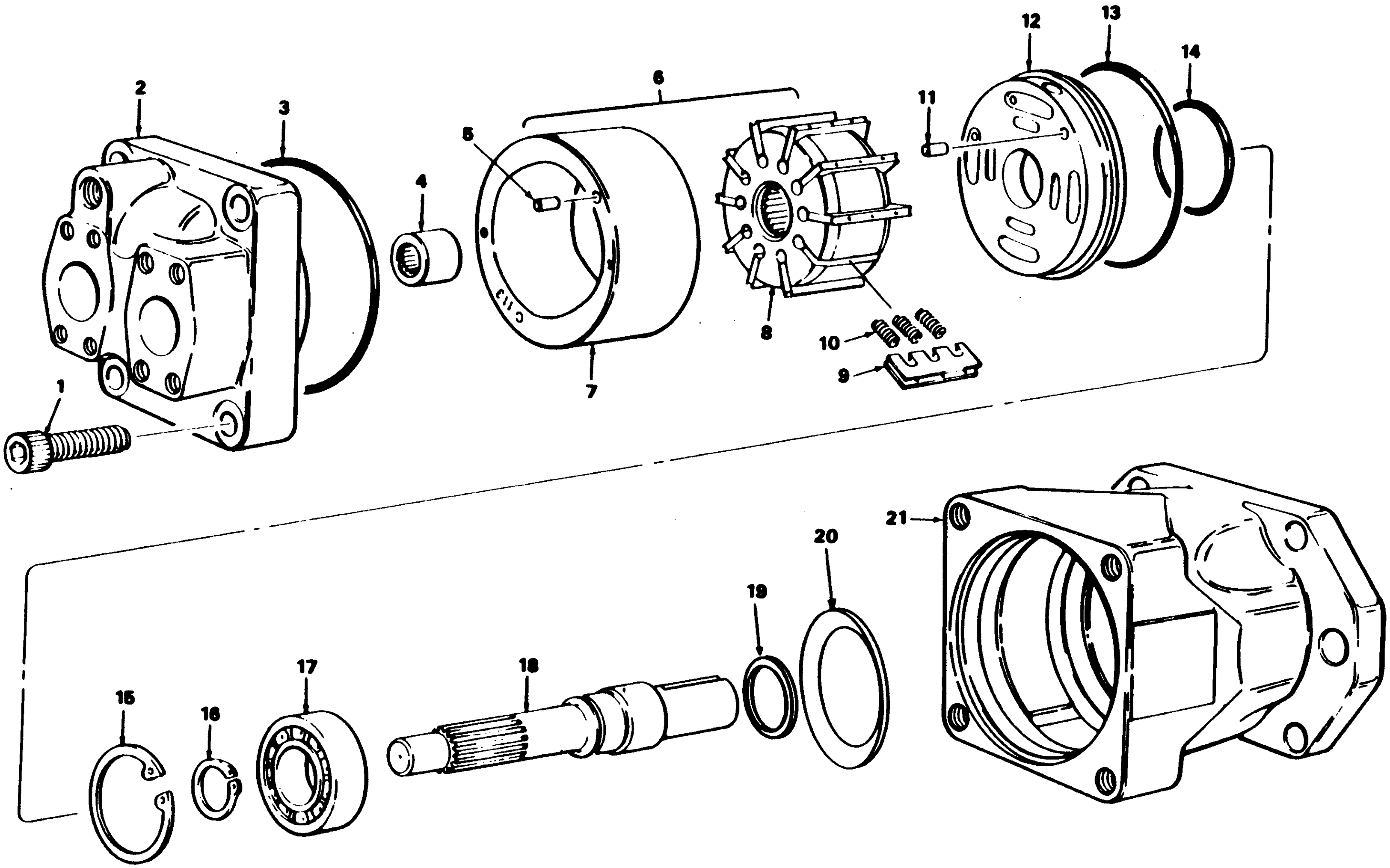
During operation, hydraulic oil flows through either one of the two ports in the end cap and is directed to both sides of the cam ring assembly through the cast ports in the end cap and port plate assembly. The pressure applied against the vanes forces the rotor to turn and at the same time rotates the motor shaft. As the rotor turns, the oil moves to the discharge ports in the port plate and end cap.

MAINTENANCE

TROUBLESHOOTING.

SYMPTOM	PROBABLE CAUSE	SOLUTION
1 External leakage.	a. Seal failure.	a. Replace seal.
	b. Defective casting.	b. Replace casting.
2. Leakage at fittings,	a. Cracked casting.	a. Replace.
	b. Defective threads.	b. Replace.
	c. Damaged O-ring.	c. Replace.
	d. Burr.	d. Stone or file flat.
3. Loss in speed under load,	a. Low inlet pressure.	a. Check pressure.
	b. Excessive back-pressure at outlet.	b. Check pressure-increase line size.
	c. Scored port plate or end cap.	c. Relap flat to clean up.
	d. High oil temperature.	d. Use heavier oil; use oil cooler; adjust relief valve setting.

SYMPTOM	PROBABLE CAUSE	SOLUTION
4. Poor speed control.	a. Insufficient fluid supply.	a. Use more efficient pump. Check oil level in reservoir and add oil as necessary.
	b. Worn rotating group.	b. Replace.
5. Motor fails to start turning.	a. Insufficient torque.	a. Increase relief valve pressure setting.
	b. Excessive motor leakage.	b. Check flow from motor outlet if excessive, check shuttle valve in front port plate. Pressure not loading plate causing plate to move away from cam ring.
	c. Worn port plates.	c. Replace.
	d. Worn rotating group.	d. Replace.
	e. Defective 0-ring on OD of front port plate.	e. Replace 0-ring if damaged.
	f. Insufficient pump delivery.	f. Pump worn or too small.
	g. Motor too small.	g. Use larger size cam ring.
6. Shaft play.	a. Worn bearings,	a. Replace.
	b. Hammering coupling on shaft.	b. Coupling bore should be slip fit on shaft.
7. Bursting of fluid supply inlet or outlet lines.	a. Excessive pressure.	a. If high inertia load overruns motor, relief valve protection is required in one or possibly both lines between directional valve and motor. Use closed center valve with caution. Relief valve protection probably required as described above.
8. Excessive noise.	a. Worn or damaged internal parts.	a. Disassemble to remove rotor vane, cam ring assembly. Inspect for excessive wear. Check condition of faces of port plate and end cap. Rework (lap) or replace if scuffed.
	b. Air in system.	b. Bleed air off - check fittings for tightness.



1.	Capscrew	7.	Cam Ring	13.	O-ring	19.	Shaft Seal
2.	End Cap	8.	Rotor	14.	Section Seal	20.	Wiper Seal
3.	Section Seal	9.	Vane	15.	Internal Snap Ring	21.	Body
4.	Needle Bearing	10.	Vane Springs	16.	External Snap Ring		
5.	Dowel Pin	11.	Dowel Pin	17.	Shaft Ball Bearing		
6.	Cam Ring Assembly	12.	Front Port Plate Assembly	18.	Shaft		

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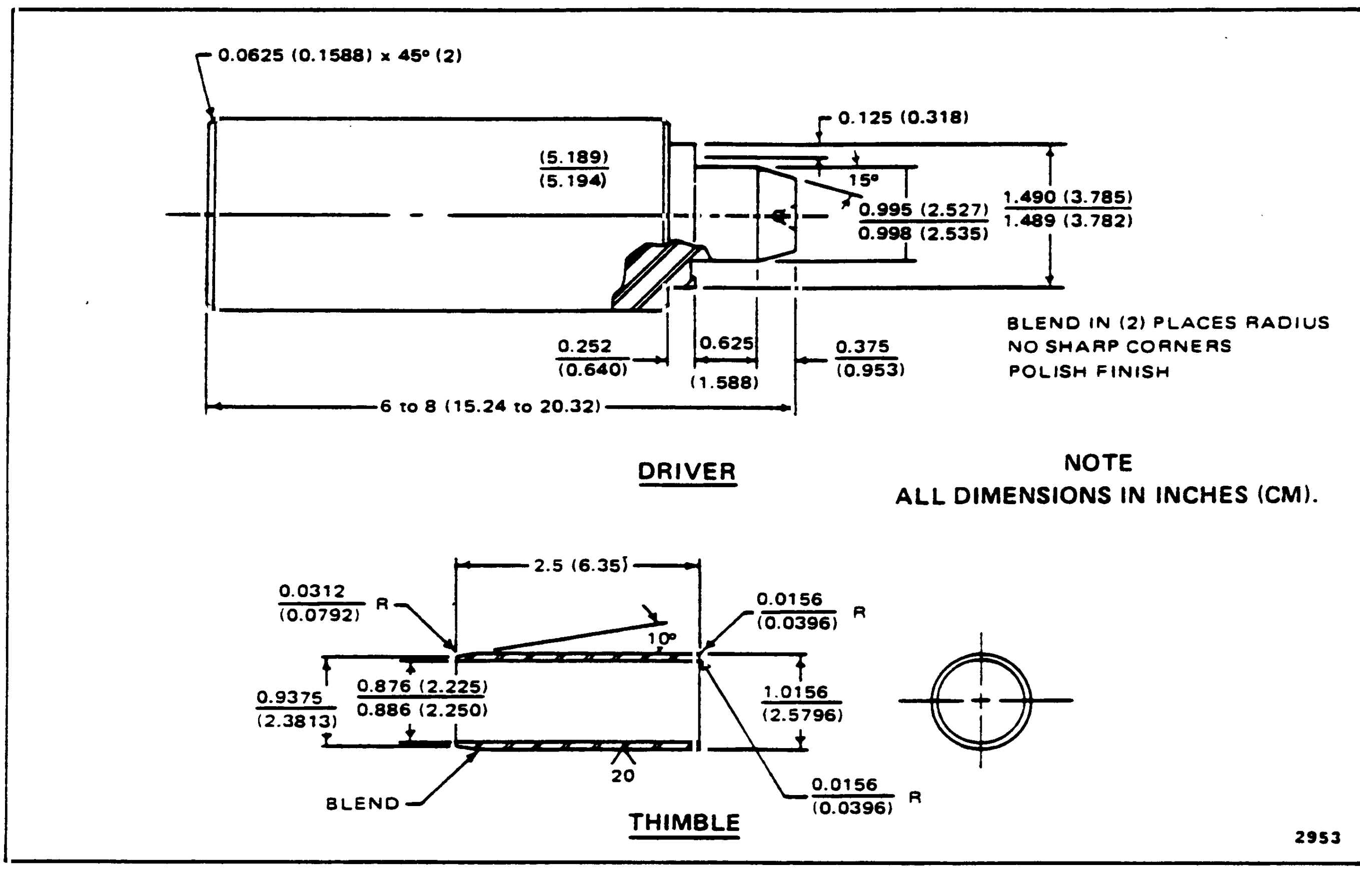
Vane Motor - Exploded View



Vane Motor Special Tools

DISASSEMBLY.

Drain all fluid from the motor and thoroughly clean all exterior surfaces. Prepare a clean, lint-free surface on which to lay the internal parts of the motor.

1. Secure the motor in a vise or other suitable holding fixture with the shaft (18) extended down.

2. Remove the screws (1) and remove the end cap (2) from the body.

3. Remove the rubber seal ring (3) from the end cap (2).

4. Check the needle bearing (4) in the end cap. If it is worn or damaged, replace it.

5. Remove the dowel pin (5) from the cam ring assembly (6).

6. Thread two No. 10-24 screws in the two tapped holes provided as puller holes in the cam ring (7) and remove the cam ring assembly (6) as a unit (7, 8, 9, and 10).

NOTE

> If resistance is encountered when lifting the cam ring assembly, lightly tap the outside of the body while lifting the assembly. This will help in removing die cam ring, rotor, vanes, and springs as a unit.

WARNING

> The vanes are held against the cam ring by tension from the springs in the rotor. If the rotor is pulled from the cam ring with no protection, tension from the springs will throw the vanes out in all directions. The following procedure must be followed when disassembling the rotor and vanes from the cam ring.

7. Place the cam ring assembly on a clean, flat surface. Push the rotor and vanes from the cam ring far enough to secure a piston ring compressor over the vanes (9) and around the rotor (8).

8. After the compressor is in place, push the rotor and vanes the remainder of the way out of the cam ring.

9. Release the tension on the compressor and remove the vanes (9) and vane springs (10) from the rotor (8).

10. Remove the dowel pin (11) from the port plate assembly (12).

11. Thread two No. 10-24 screws into the puller holes in the port plate assembly (12) and remove it from the body (21).

12. Remove the special setscrews in the side. Remove the shuttle spool from the drilled passage. The drilled holes in the port plate must be clean and free from burrs.

13. Remove the rubber seals (13 and 14).

14. Remove the snap ring (15) from the body (21).

15. Press on the external end of the shaft (18) and remove the shaft and bearing (17) from the body.

16. Remove the felt wiper (20) and shaft seal (19) from the body.

CLEANING AND INSPECTION.

CAUTION

> Dirt is the major cause of wear and motor failure. Cover all parts after cleaning to prevent dust and dirt from settling on them. All surfaces should b coated with a film of hydraulic lubricating oil, after they have been cleaned.

1. Wash all metal parts in cleaning solvent (Stoddard Solvent or equal) and dry thoroughly.

2. Inspect the seals for wear, breaks, cuts, and brittleness. Discard and replace all defective seals.

3. Inspect all springs for wear on the OD, for cracks or permanent set. Replace all defective springs.

4. Inspect the bearings for wear or flat spots. If the bearings are rough or loose they must be replaced.

5. Inspect the cam ring for excessive wear (ripples or washboard marks on the contour). Replace a badly worn or defective cam ring.

6. Inspect the rotor for scored, marred, or scratched (faces and vane slots) surfaces. Replace a defective rotor.

7. Inspect the vanes for excessive wear marks (burrs, nicks, and scoring). Replace any defective vanes.

8. Inspect the wear surfaces of the port plate and end cap for deep scratches. Replace if defective.

9. Inspect the body and end cap for cracks or other casting damage. Replace all damaged castings.

10. Inspect the shaft for excessive wear (internal, spline, bearing surface, and drive end). Replace if defective.

ASSEMBLY.

Immerse the seals and bearings in clean hydraulic fluid to make the assembly easier and to provide initial lubrication.

1. Press the bearing (17) on the shaft (18) to the shoulder and install the external snap ring (16). Ensure the ring is seated in the snap ring groove.

2. Place the body on a clean flat surface with the large open end facing up.

NOTE

Steps 3 and 4 require the use of the special assembly tool.

3. Install the felt wiper (20) into the body (21). Place the shaft seal (19) onto the shaft seal driver with the open face of the seal against the driver. Apply lubricating fluid to the O.D. of the seal and install the seal in the 1.5-inch bore of the body (21).

4. Place the special tool (thimble) over the coupling end of the shaft assembly and press the assembly into the body (21). Press on the outer race of the bearing bore. Remove the thimble from the shaft.

5. Install the snap ring (15) into the body (21). Ensure the snap ring is fully seated in the groove.

NOTE

The special screws and the port plate including the internal threads must be degreased. Apply a very small amount of Loctite No. 242 to the special screws only. An excessive amount of Loctite on the screws would be forced into the shuttle spool bore when the screws are installed. Allow the Loctite to cure for one hour after installing the screws.

6. Install one of the special screws in the shuttle spool bore of the port plate. Torque the screw 3 to 5 pounds-foot (0.41 to 0.69 kgm) maximum. Insert the shuttle spool in the shuttle bore and install the other special screw and torque. Tilt the port plate sub-assembly back and forth to be certain that the spool travels the full length of the bore.

7. Lubricate the seals (13 and 14) and then install on the back of the port plate.

8. Place some heavy grease on the section seal (14) on the back of the port plate (12).

9. Insert the dowel pin (11) in the hole in the face of the port plate assembly.

10. Thread two No. 10-24 screws in the tapped holes in the face of the port plate assembly (12) and install in the body. See the exploded drawing for the correct position.

CAUTION

Ensure the springs are started in the holes in each rotor slot.

11. Place the cam ring (7), rotor (8), vanes (9), and vane springs (10) on a clean flat surface. Arrange the vanes side by side with the three spring holes up. Insert the vane springs in the vanes. Install the vanes with the springs in the slots in the rotor.

WARNING

Ensure the rotor and vane assembly is inserted far enough to prevent the vanes flying out of position when the ring compressor is removed.

12. Place a ring compressor around the vanes and tighten the compressor gradually until the springs and vanes are in the position they will occupy while in the cam ring. Place a backup plate, slightly smaller than the outside diameter of the rotor in the ring compressor and push the rotor, springs, and vanes into the cam ring. The backup plate will prevent the vanes from sliding end wise in the rotor slots and damaging the slots and springs.

13. Thread two No. 10-24 screws into the cam ring assembly on the same side of the ring that indicates the cam size. Insert the dowel pin (5) in the cam ring and position the complete assembly in the body over the other dowel pin (11).

14. Lubricate the rubber seal (3) and install it on the cap (2).

15. Press the needle bearing (4) into the end cap (2) with the markings on the bearing 0.0625-inch (1.58 mm) below the face of the cap.

16. Position the end cap (2) over the dowel pin (5). Hold the end cap firmly against the cam ring assembly and rotate to line up the bolt holes.

17. Insert the capscrews (1) and tighten evenly to 130 pounds-foot (17.97 kgm).

SWIVEL ASSEMBLY

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DESCRIPTION

The swivel is used to provide hydraulic oil and on some models air pressure from the carrier to the superstructure or from the superstructure to the carrier. The swivel is located at the centerline of rotation of the superstructure. The swivel consists of a case, a spool, and seals.

THEORY OF OPERATION

All oil or air is routed into the spool portion of the swivel where, through a series of internally drilled passages, the oil or air is transferred to a circumferential channel on the spool exterior. This channel corresponds with a mating port on the barrel of the swivel. Each channel is separated by a series of teflon and O-ring seals that prevents transfer of oil and pressure. Return flow from the crane functions is accomplished in the same manner through another set of ports.

MAINTENANCE

DISASSEMBLY.

NOTE

Any maintenance requiring disassembly of the swivel should include replacement of all seals and rings.

1. Remove the bolts securing the center post plate and the retainer and remove the plate, retainer, and lower thrust washer.

2. Withdraw the spool from the barrel.

3. Place the spool on a clean work surface in a dust-free area and block the spool to prevent movement during disassembly.

CAUTION

When removing the seals and rings, avoid scratching the grooved and gland surfaces.

4. Remove the seals and rings from the spool.

NOTE

Aligning the discarded seals and rings in the order of disassembly will assist with installation of new seals and rings.

CLEANING AND INSPECTION.

1. Clean the spool and barrel with a suitable solvent and dry with compressed air.

2. Check the spool and the inside of the barrel for scratches, grooves, scoring, etc. If any grooves have developed with a depth exceeding 0.005-inch (0.1270 mm), the unit should be replaced.

ASSEMBLY.

1. Lubricate the spool, seals, and rings with hydraulic oil or STP.

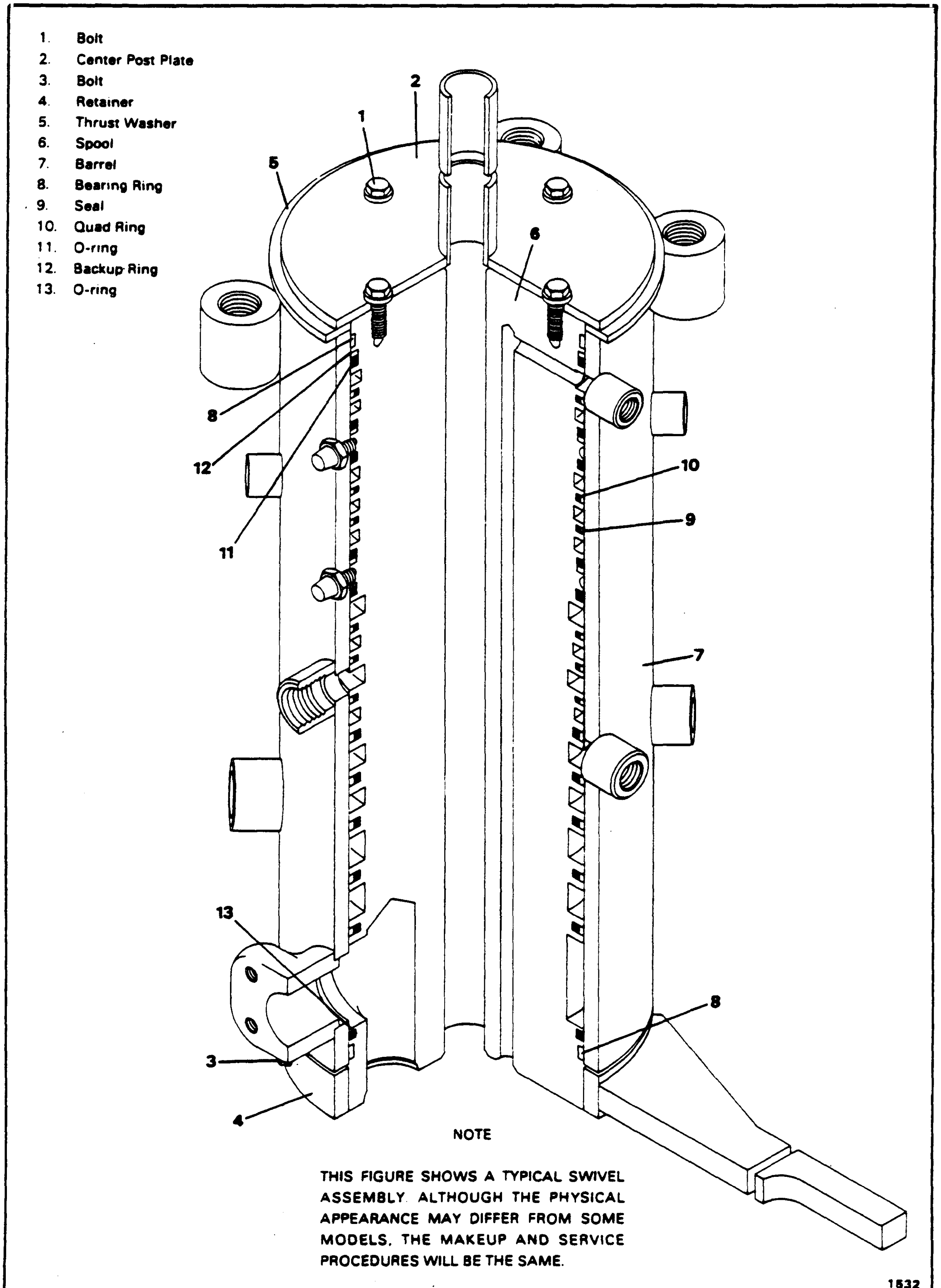
CAUTION

When install new seals and rings, avoid stretching the seals or scratching the grooved and gland surfaces.

2. Install new seals and rings on the spool using a walking method.

CAUTION

Proper alingnment when inserting the spool is required. Do not force the spool into the barrel.



Typical Swivel Assembly

3. Insert the spool into the barrel. Install the lower thrust washer, center post plate, and retainer and secure in place with the mounting bolts.

TEST.

NOTE

For individual port test pressures refer to the Service Manual.

NOTE

Use only 10W hydraulic oil during pressure testing.

1. Install a pressure gauge into a port on the swivel case.

2. Install a pressure line in the corresponding port in the swivel spool.

3. Allow the ports, on each side of the port to be tested, to vent in order to detect leakage.

4. Pressurize the port to be tested while rotating either the spool or case 360 degrees. Refer to the Service Manual for the proper pressure.

5. If leakage is detected disassemble the swivel and determine the cause.

6. Pressure check each port individually until all ports have been tested.

ELECTRICAL SWIVEL

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DESCRIPTION

The electrical swivel consists of brushes, collector rings, and a cover assembly. It is normally mounted on top of the swivel assembly. The electrical swivel is used to conduct power between the carrier and the superstructure. The swivel may also incorporate microswitches and camplates or segments to actuate the microswitches. These are normally used for area definition purposes.

THEORY OF OPERATION

The electrical swivel transfers electricity between the carrier and superstructure. Wiring harnesses transmit the electricity from the carrier components to the collector ring assembly on the swivel. The brush assembly then picks up the electricity and through wiring harnesses transmits the electricity to the superstructure components.

MAINTENANCE

NOTE

Although the amount of slip rings will vary, disassembly and assembly procdures are the same.

DISASSEMBLY.

NOTE

Do not disconnect the collector core wires at the top of the swivel assembly.

1. Move the swivel to a clean work area and block it from moving. (Block against the center post.)

2. Perform Prior to Disassembly located in the CLEANING AND INSPECTION part of this Package.

3. Tag and disconnect the knife disconnects on the brush and arm assemblies.

4. Remove the nuts and washers on the brush holding studs.

5. Remove the nylon outboard bearing.

6. If there are any spacers (on the brush holding studs) located under the nylon outboard bearing, remove and save them.

CAUTION

Ensure the brush and arm assemblies are properly tagged with the corresponding circuit numbers.

NOTE

When removing the brush and arm assemblies, it will help if they are kept in order.

7. Remove the brush and arm assemblies.

8. Loosen the setscrews securing the collector core to the mounting bracket and remove the collector core.

9. Remove the nylon bearing from the mounting bracket.

10. Perform After Disassembly located in the CLEANING AND INSPECTION part of this Package.

CLEANING AND INSPECTION.

Prior to Disassembly.

1. Check all brushes for proper contact with the collector ring conductors. Note any brush sets which

are oil-soaked or worn to one-half of their original length. These must be replaced.

2. Check the spring tension of each brush. Any that are damaged or weak must be replaced. Spring tension should be sufficient to firmly hold the brushes against the collector ring.

3. Inspect the collector ring conductors for arcing, pitting, and corrosion. Under some conditions, the ring will have a tendency to collect fine silt and in a salt atmosphere, corrosion will occur. If this happens, rotate the collector core several times. This should clean the ring. If it does not, it might be necessary to clean the core after disassembly.

4. Check the continuity between each of the collector core rings' surfaces and the electrical leads. If any conductors are defective they must be replaced.

After Disassembly.

1. If the collector rings are corroded, it may be necessary to use a standard non-residue solvent to clean them. Then lightly sand the brushes with double-ought (2/0) nonabrasive material. Blow out any dust with compressed air.

2. Any brush sets that are oil soaked cannot be cleaned. They must be replaced.

3. If the nylon bearing is worn, replace it.

ASSEMBLY.

1. Install the nylon bearing in the mounting bracket.

2. Install the collector core in the mounting bracket and tighten one setscrew to secure the core to the center post. (This setscrew will be loosened later).

CAUTION

Ensure the brush and arm assemblies are installed in the proper order.

CAUTION

Ensure that any brush and arm assemblies that have been replaced are of the proper electrical capacity.

NOTE

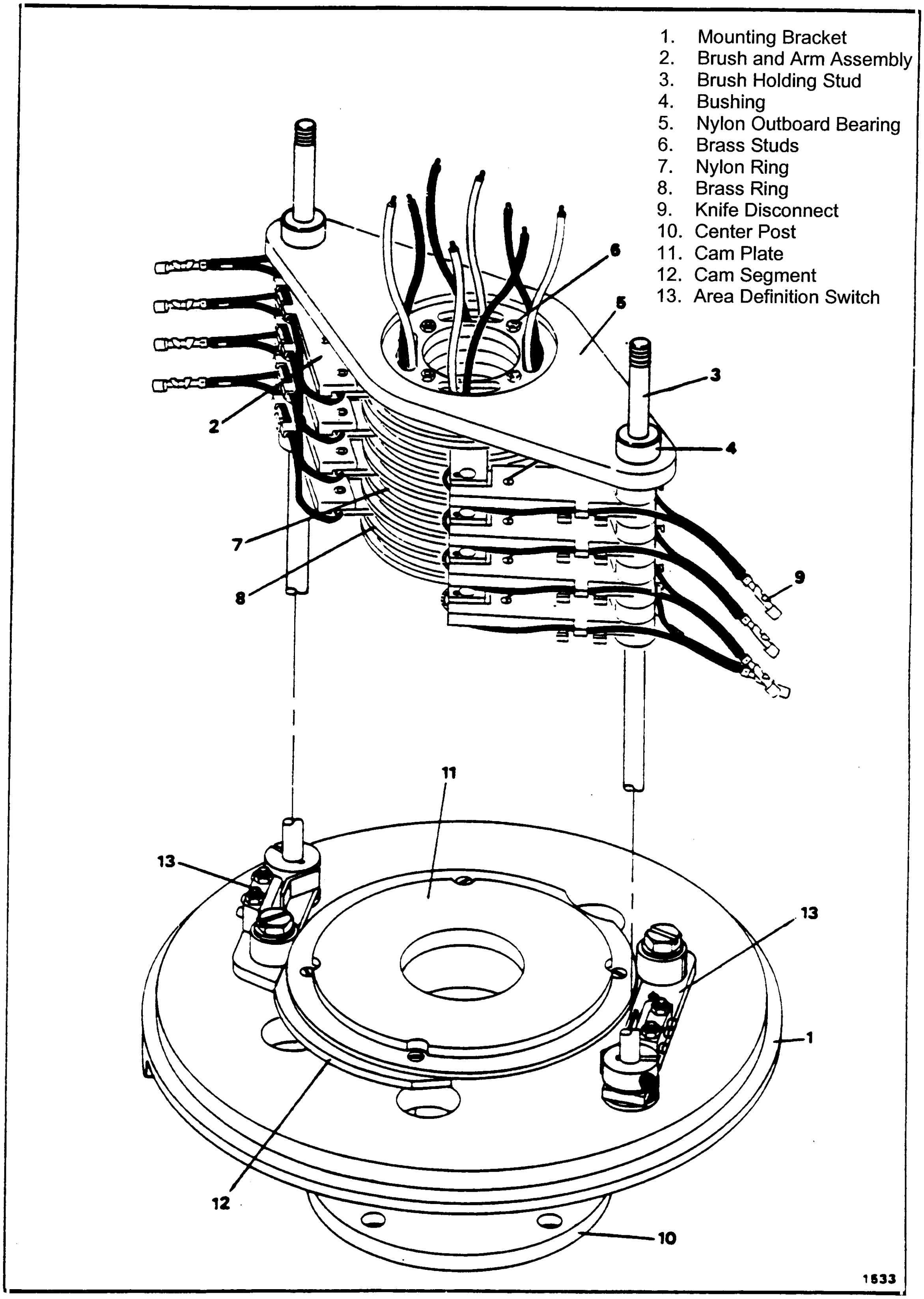
When installing the brush and arm assemblies, do not unhook the springs. Use your fingers to spread the brush arms while sliding the brush and arm assemblies onto the holding studs.

3. Install the brush and arm assemblies.

4. Install any spacers that were taken off.

5. Install the nylon outboard bearing and the nuts and washers.

6. Connect the knife disconnects on the brush and arm assemblies. Slide the plastic sleeves over the knife disconnects.



Typical Electrical Swivel

DIESEL HEATER

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WARNING 5

Do not operate the heater at less than 21 volts.

WARNING 6

The fuel needle is factory set for best heater performance, using sophisticated exhaust gas analyzing equipment. Do not drastically change the the factory setting in an attempt to speed starting. A lean fuel mixture extends heater life and reduces maintenance.

WARNING 7

The sectional view of the carburetor and burner head illustration is provided only to aid understanding of heater operation. Do not attempt to ignite the burner after it has been removed from the heat exchanger.

WARNING 7

Before performing maintenance or inspection (except operating tests), disconnect power at the battery disconnect switch.

WARNING 7

Do not oprerate the heater with the covers off.

WARNING 10

The heat exchanger must be inspected annually, or more frequently if heater usage is heavy. A damaged heat exchanger can allow poisonous gases to seep into the heated enclosure causing illness or DEATH.

WARNING SAFETY SUMMARY (continued)

Page

WARNING 10

Before doing any work on the electrical system, disconnect the batteries at the Battery Disconnect.

WARNING 10

The fuel needle is factory adjusted for the best heater performance, using sophisticated exhaust gas analyzing equipment. Do not drastically change the factory setting in an attempt to speed starting. A lean fuel mixture extends heater life and reduces maintenance.

WARNING 11

Use insulated tools and take care to prevent contact with high tension lead. High voltage is present which could lead to injury.

DESCRIPTION

The heater is a thermostatically controlled, internal combustion heater with diesel fuel oil used as the fuel.

Air for heat circulation and for combustion is provided by a 24-volt motor-blower assembly. Spark for combustion is supplied by a 24-volt ignition system which consists of a solid state ignition pack and an igniter.

Combustion air is supplied by a two-stage combustion air blower, and fuel flow to the burner head is controlled by a carburetor. Fuel flow to the carburetor bowl is controlled by a float-actuated needle-and-seat valve. A fuel needle (factory adjusted to burn DF-2 efficiently) regulates the amount of fuel siphoned by the air/fuel mixing nozzle. DF-1, DF-2. and DFA will burn in the heater, as required by ambient temperature.

The carburetor body is also provided with a fuel heater which is energized through the carburetor thermostat. The fuel heater facilitates fuel flow while starting at low ambient temperatures. A glow plug controlled by the flame switch and a relay is used to preheat the burner head to aid ignition. This is accomplished with a spark-plug-like igniter.

TABLE OF SPECIFICATIONS

Heater case dimensions	16 in. long x 11 in. wide x 6 3/4-in. high
Weight	28 lbs.
Shipping weight	30 lbs.
Rating	20,000 BTU
Heater air outlet diameter	5 in.
Exhaust outlet	1 in. dia. standard steel pipe
Combustion air inlet	1 in. OD tube
Fuel connection	1/8-in. NPT female fitting
Electrical requirements	24 volts
Current draw	
Starting	25 amps
Run	7 amps (average)
Blower only	3 to 4 amps
Fuel requirement	No. 1 or No. 2 diesel fuel or arctic diesel fuel
Fuel supply pressure	4 to 5 psi
Fuel consumption	6 1/4 hours/gallon on high thermostat setting
Burner	Low pressure atomizing type
Ignition	Solid state ignition pack (8000 volts)

Heater is factory-adjusted to burn No. 2 diesel fuel. If No. 1 fuel or arctic diesel is used, readjust carburetor as directed under CARBURETOR ASSEMBLY. Proper fuel adjustment is the key to dependable operation with minimal service requirements.

THEORY OF OPERATION

GENERAL.

WARNING

Do not operate the heater with the covers off.

WARNING

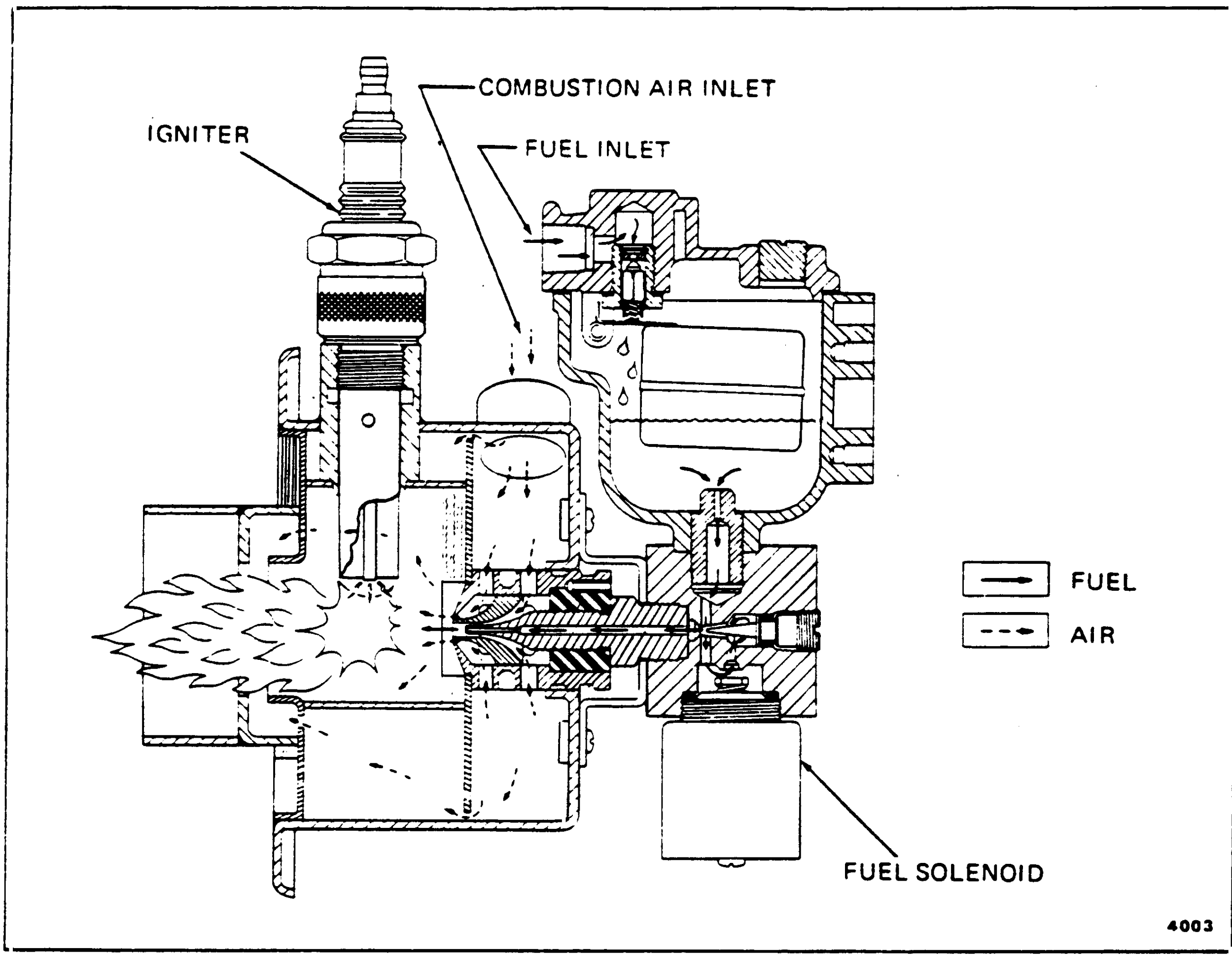
Do not operate the heater at less than 21 volts.

WARNING

The fuel needle is factory set for best performance using sophisticated exhaust gas analyzing equipment. Do not drastically change the factory setting in an attempt to speed starting. A lean fuel mixture extends heater life and reduces maintenance.

CAUTION

The tilt switch is a safety device that stops heater operation in case the vehicle overturns. Do not remove this switch or defeat its purpose.



Sectional View of Carburetor and Burner Head

WARNING

The sectional view of the carburetor and burner head illustraion is provided only to aid in understanding of heater operation. Do not attempt to ignite the burner after it has been removed from the heat exchanger.

Heater operation is controlled through the control panel and a HI-LO control knob. The control panel contains a two position START-OFF switch, a green PWR. ON indicator light, a red FAULT indicator light, a PUSH to RESET button, and a 30 ampere fuse. The HI-LO control knob positions the temperature control on the heater to control the temperature of the air.

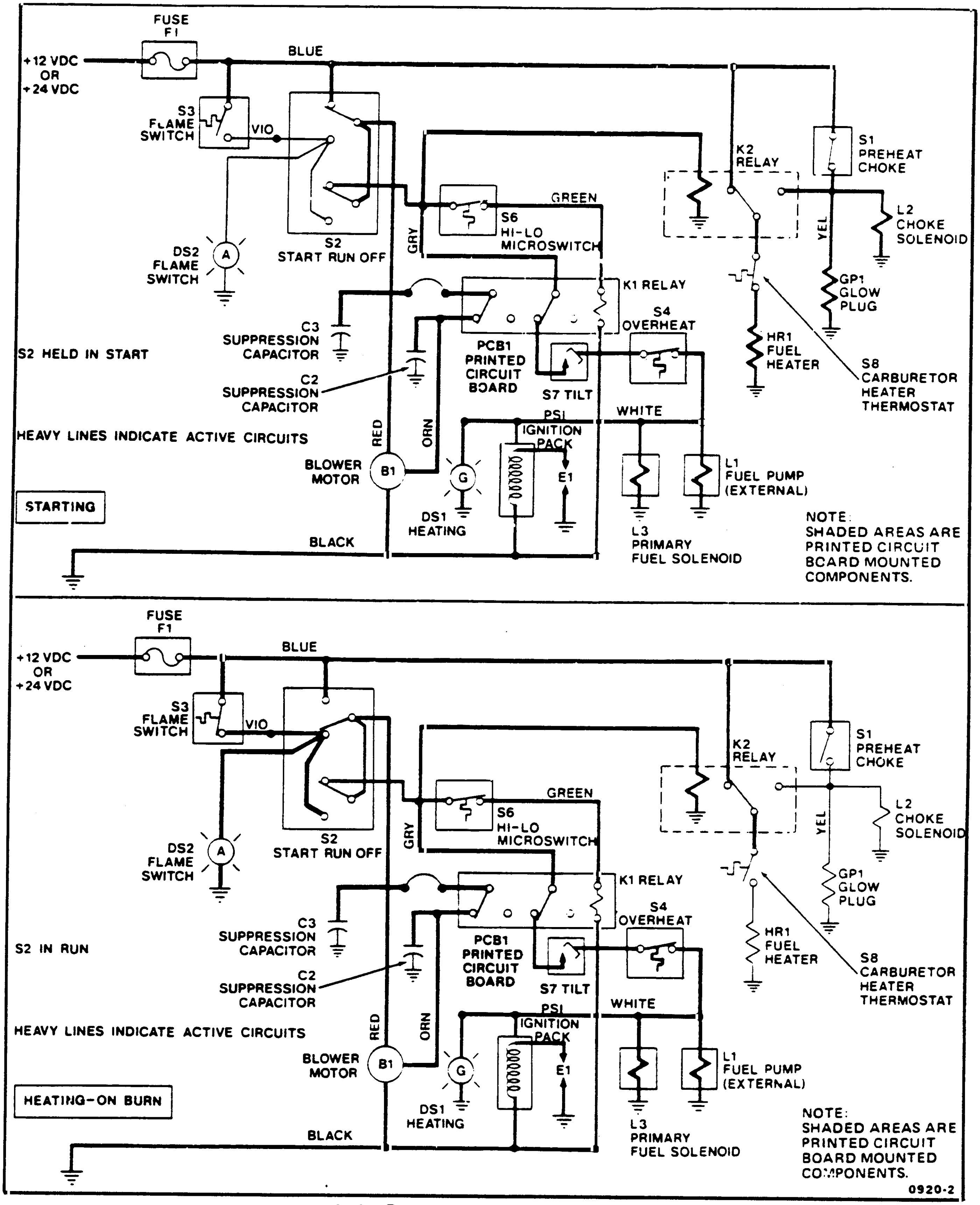
MAI NTENANCE

WARNING

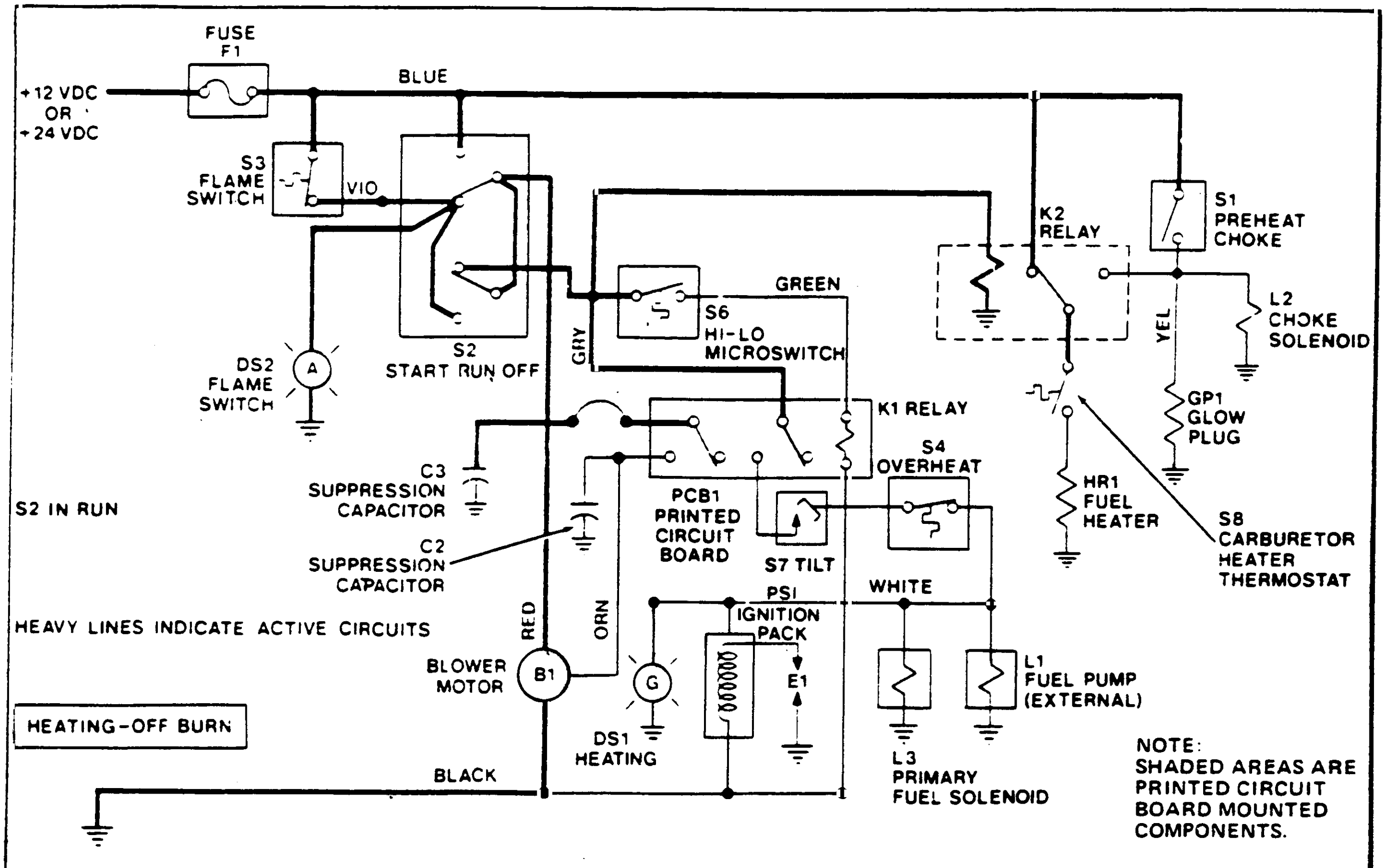
Before performing any maintenance or inspection (except operating tests), disconnect the power source.

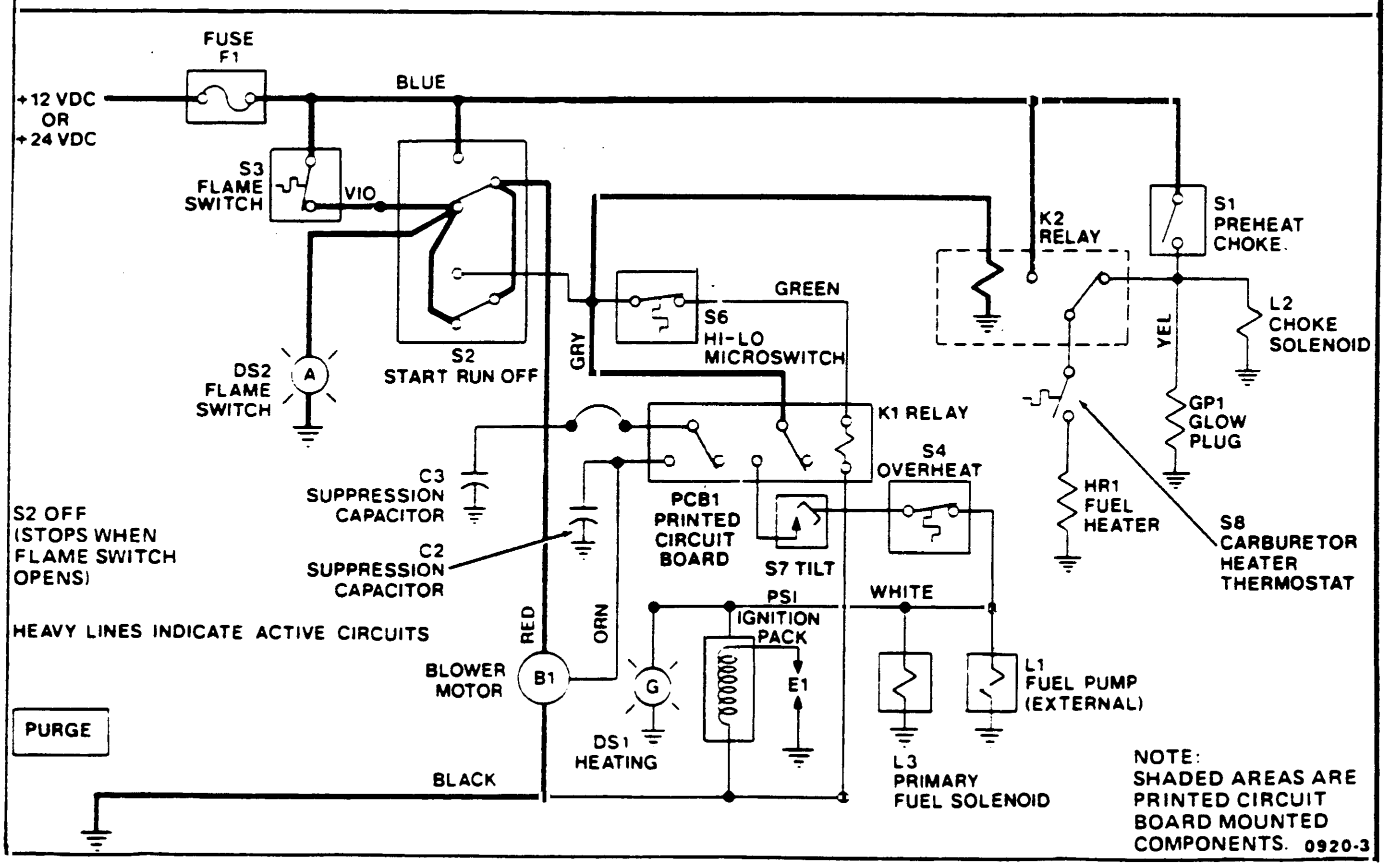
WARNING

Do not operate the heater with the covers off.



Active Electrical Circuits (Sheet 1 of 2)





Active Electrical Circuits (Sheet 2 of 2)

WARNING

The heat exchanger must be inspected annually, or more frequently if heater usage is heavy. A damaged heat exchanger can alllow poisonous gases to seep into the heated enclosure causing illness or DEATH.

WARNING

Before doing any work on the electrical system, disconnect the batteries at the Disconnect Switch.

WARNING

The fuel needle is factory set for best heater performance using sophisticated exhaust gas analyzing equipment. Do not drastically change the factory setting in an attempt to speed starting. A lean fuel mixture extends heater life and reduces maintenance.

TROUBLESHOOTING.

SYMPTOM	PROBABLE CAUSE	SOLUTION
1. Heater fails to start - motor does not run.	a. Blown fuse.	a. Check the fuse. Replace if necessary.
	b. Loose or broken electrical connections.	b. Check all electrical connections, including ground. Repair or replace if necessary.
	c. Insufficient power.	c. Check power at the heater; at least 11 VDC is required.
	d. Motor failure.	d. Check the motor. Replace if nescessary.
2. Heater fails to start - motor runs.	a. Excessive voltage drop during preheat.	a. If wire size is too small or ground connection is poor, low voltage at the heater may result.
	b. Incorrect starting procedure.	b. Check the starting procedure in this manual.

SYMPTOM	PROBABLE CAUSE	SOLUTION
2. Heater fails to start - motor runs. (continued)		**WARNING** **USE INSULATED TOOLS AND TAKE CARE TO PREVENT CONTACT WITH THE HIGH TENSION LEAD. HIGH VOLTAGE IS PRESENT WHICH COULD CAUSE INJURY.** **CAUTION** **IF THE HIGH TENSION LEAD IS DISCONNECTED FROM THE IGNITER FOR ANY REASON, DO NOT ENERGIZE THE UNIT WITHOUT FIRST PROVIDING A DISCHARGE GAP OF 0.125 INCH (3.18 MM) OR LESS FROM THE HIGH TENSION LEAD TO THE GROUNDED IGNITER. WITH A LARGER GAP, ELECTRICAL POTENTIAL CAN CAUSE AN INSULATION BREAKDOWN IN THE IGNITION PACK OR IN THE HIGH TENSION LEAD. THE SAME ALSO APPLIES IF THE HIGH TENSION LEAD IS ATTACHED TO THE IGNITOR WITH THE IGNITER REMOVED FROM THE UNIT. ALWAYS BE SURE THE IGNITER BODY IS GROUNDED.**
	c. No spark.	c. Check for spark by holding an insulated-handle screwdriver with the shaft grounded and the tip approximately 0.125-inch (3.18 mm) away from the high tension lug of the ignition pack. There should be a continuous strong spark. If no spark is produced, check that there is voltage applied to the ignition power supply. If input voltage is present and no spark or a weak spark is produced, replace the ignition pack.

SYMPTOM	PROBABLE CAUSE	SOLUTION
2. Heater fails to start - motor runs. (continued)	d. Malfunctioning igniter.	d. Check the igniter. To check, remove and examine. The electrode should be centered, and not clogged or shorted with carbon. Visually check operation with the igniter removed from the burner head, but connected to the high tension lead with the body grounded. Shut off the fuel and ground the igniter on the heater case to check for spark. Replace if defective.
	e. Inadequate fuel supply or incorrect grade of fuel.	e. Check for adequate fuel supply and correct grade of fuel.
3. Motor runs - but there is no combustion.	a. Inadequate fuel at the carburetor.	a. Check for fuel at the float bowl. Remove the pipe plug at the side of the float bowl and gently depress the float. If fuel is present, it will show on the object used to depress the float and buoyancy can be felt.
	b. Malfunctioning HI-LO control and microswitch.	b. Check HI-LO control and microswitch adjustment. Refer to Adjustment and Repair, HI-LO Control and Microswitch.
	c. No spark.	c. Check for spark as described under Symptom 2.
	d. Malfunctioning igniter.	d. Check for spark as described under Symptom 2.
	e. Malfunctioning tilt switch.	e. Check the tilt switch. The switch must be secure in its bracket and be in the vertical position with the electrical leads pointing down. Check the leads on both sides of the switch for power. Replace if defective.
	f. Excessive fuel flow.	f. Check float level, fuel pressure, and carburetor fuel needle setting. Excessive fuel flow will cause rapid buildup of carbon in the heat exchanger. Correct fuel feed is 8 cc per minute (3.5 minutes per ounce).

SYMPTOM	PROBABLE CAUSE	SOLUTION
3. Motor runs - but there is no combustion. (continued)	g. Restricted circulating air flow.	g. Check for restrictions in the air circulating system, which could cause overheating.
	h. Malfunction in the fuel heater and glow plug circuits.	h. Check the fuel heater and glow plug circuits with the START-OFF switch to START. If there is power but no heat from these parts, replace the faulty component. If there is no power to the fuel heater during preheating. check all connections, wires, and the thermostat which opens at 85 degrees F (29 degrees C) and closes at 70 degrees F (21 degrees C).
4. Inadequate heat output.	a. Low voltage.	a. Check for low voltage. The heater must have 21 volts minimum so that the motor turns fast enough to ensure adequate combustion air flow.
	b. Carbon buildup.	b. The heat exchanger may have a heavy coating of carbon internally. Check fuel flow as described under, Motor runs - but there is no combustion.
	c. Incorrect adjustment of HI-LO microswitch and bi-metal blade.	c. Check Hi-LO control and microswitch adjustment. Refer to adjustment and repair. HI-LO control and microswitch.
5. Fan fails to go to high speed during burning cycle.	a. Malfunctioning relay.	a. Check the relay. Replace if defective.
	b. Malfunctioning motor.	b. Check motor and connections. With the power on, touch the orange motor lead to the red motor lead; speed must increase. Replace the motor if defective.
	c. Loose or broken electrical connections.	c. Check electrical connections. Repair or replace if necessary.
	d. Malfunctioning HI-LO control and microswitch.	d. Check HI-LO control and microswitch adjustment. Refer to Adjustment and Repair. HI-LO Control and Microswitch.

SYMPTOM	PROBABLE CAUSE	SOLUTION
6. Heater remains on burner cycle after heat demands are met.	a. HI-LO control or microswitch out of adjustment.	a. Check HI-LO control and microswitch adjustment. Refer to Adjustment and Repair, HI-LO Control and Microswitch.
	b. Bi-metal blade broken or linkage out of adjustment.	b. Replace the bi-metal blade and/or adjust linkage as required.
	c. Dirt on the fuel solenoid valve lip.	c. Clean the fuel solenoid valve lip. Refer to Adjustment and Repair, Carburetor Solenoid Valves.
7. Excessive smoke in exhaust.	a. Low voltage.	a. Check for low voltage causing slow motor speed and inadequate combustion air flow. Combustion air pressure should be at least 4 to 4.5 inches of water.
	b. Excessive fuel flow.	b. Excessive fuel flow with the fuel needle open too far. Adjust the fuel needle as described under Adjustment and Repair, Carburetor Assembly.
	c. Mechanical binding in the combustion air blower motor.	c. Check for mechanical binding in the combustion air blower motor. Refer to Adjustment and Repair, Motor and Blower Assembly.
	d. Incorrect spark.	d. Check for spark as described under Symptom 2.
	e. Malfunctioning igniter.	e. Check tne igniter as described under Symptom 2.

PREVENTIVE MAINTENANCE.

The following service procedures, if performed each year, will help ensure proper operation and will extend the life of the heater.

Tools Required.

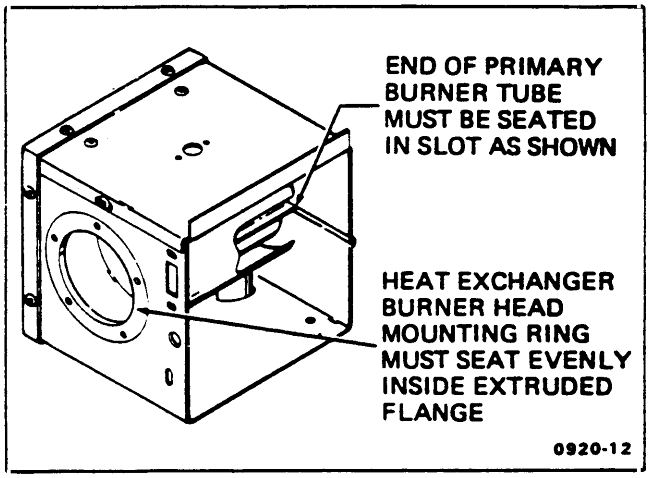
Allen wrenches
Screwdrivers, flat blade and phillips
8-inch adjustable wrench
DC voltmeter
Pliers
Rubber hose, 0.25-inch (6.35 mm) ID. 18 inches (457.2 mm) long
Inflation needle (such as used for inflating a football)

Preseason Cleaning.

1. Drain the old fuel from the fuel lines and fuel system.

2. Remove the igniter; clean and inspect. Remove the carbon from between the electrode and the shroud. Ensure the electrode is centered in the body.

3. Remove the burner head and remove any excess carbon deposits.



Heat Exchanger Installation

NOTE

Use a new gasket when refitting the burner head.

4 Clean the blower and motor by using compressed air on the combustion air inlet Apply 2 drops of light oil on the motor shaft next to the front end bearing.

5 Turn the heater at east once every week during the warm seasons of the year This will help prevent varnish buildup caused by evaporating fuel. and will help keep the motor bearings turning freely.

6. Perform the check and adjustment described below.

Operating Check and Adjustment.

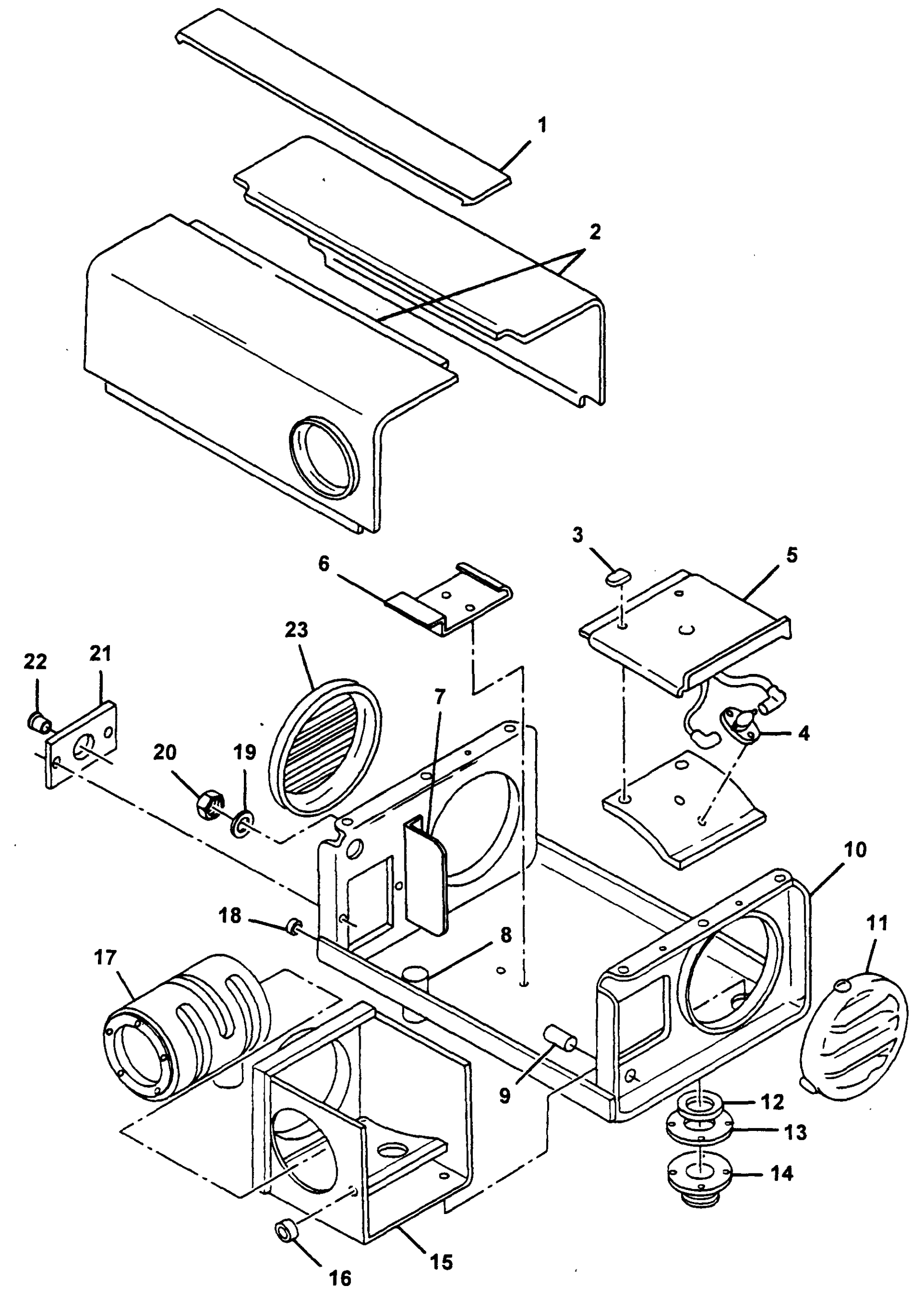
An annual service checkout should be done before the heating season starts, to ensure that the heater will be ready when required

A proper air fuel ratio, combined with a hot spark from the Hunter solid state ignition pack, will ensure that your Falconaire Heater provides trouble-free service. A well-tuned burner system will maintain a clean, carbon-free heat exchanger. An incorrect air fuel ratio wastes fuel and produces excessive smoke from the exhaust, which will soon lead to a heavy buildup of carbon in the heat exchanger

Proper combustion air pressure in the burner head and fuel mixer siphons the exact amount of fuel from the carburetor float bowl when the fuel needle is correctly adjusted.

Opening the fuel needle too far in an attempt to speed starting or increase heat output always results in heater shutdown because of carbon buildup.

Blower motor speed determines the amount of combustion air delivered to the burner head Motor speed varies directly with voltage Factory setting of the carburetor fuel needle is made with 21 volts applied at the control panel fuse. Higher voltage up to 27 volts maximum produces higher heat output while maintaining the correct air fuel ratio. Lower voltages. however, produce insufficient combustion air flow, causing smoky exhaust and subsequent carbon formation in the heat exchanger and burner head.



1. Cross Bar
2. Cover
3. Clamp
4. Thermostat
5. Top Cover
6. Ingniter Pack Mounting Bracket
7. PC Board Mounting Bracket
8. Air Tube
9. Spacer
10. Case Assembly
11. Air Deflector
12. Washer
13. Exhaust Gasket
14. Exhaust Connector
15. Bracket
16. Grommet
17. Heat Exchanger
18. Grommet
19. Lockwasher
20. Nut
21. Cover Plate
22. Terminal Connector
23. Air Deflector

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Case and Heat Exchanger

Check as follows:

1. Use a DC voltmeter to measure the voltage at the heater fuse. There must be 21 volts minimum measured to ground. If the voltage is low check for:

a. Vehicle electrical system problems

b. Loose or corroded connections

c. Poor ground

2. If the supply voltage is within limits, check combustion air pressure as follows:

a. You will need as 18-inch (457.2 mm) length of 0.25-inch (6.35 mm) ID rubber hose, a football inflation needle, and a tall jar or glass containing at least 6 inches (152.4 mm) of water. Insert the inflating needle into one end of the rubber hose, and push the inflation needle into the combustion air hose between the blower and the burner head.

b. Hold the START RUN OFF switch in the START position to obtain high blower speed, and immerse the end of the hose in the jar of water. Push the hose deeper under the surface until the bubbling just stops. Measure the length of hose that is submerged; this length must be at least 4 inches. The submerged depth represents the water column pressure produced by-the blower.

c. If the air pressure is less than 4.0 inches (101 .6 mm) of water, the air/fuel ratio will be incorrect. Check the voltage at the motor orange lead; there must be 21 volts minimum. If the voltage is high enough but air pressure is low, check the following.

Motor is defective.

Motor bearings need oil.

Combustion air inlet is plugged or restricted.

Blower wheels are loose on motor shaft.

Carburetor or fuel mixer is not seated in burner head.

3. If the air pressure is correct, check the fuel needle adjustment.

a. Mark the position of the fuel needle slot in the carburetor body. Turn the fuel needle fully clockwise until it bottoms, and count the number of turns it takes. If full shutoff requires more than 1 3/4 to 2 turns, flow rate is probably excessive.

b. Back out the fuel needle one full turn. Start the heater.

c. Allow the heater to run for a few minutes and observe the heat exchanger. When the fuel needle adjustment is correct, the first pass, or segment, of the heat exchanger will glow red, but no color will be visible on the next pass. There will be no smoke from the heater exhaust.

d. If the heater does not burn in this manner, adjust the fuel needle in 1/4 turn increments, allowing the heater to run for 5 minutes after each increment, until the heater burns as described in step c.

APPENDIX B

RED DOT HEAVY DUTY AIR CONDITIONING AND HEATING SERVICE TRAINING MANUAL

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TABLE OF CONTENTS

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Chapter 7 1

Inspection and Maintenance-*without gauges*

- Discussion of Inspection & Maintenance Survey Results
- Visual Inspection - System Off
- Electrical System Inspection
- Performance Inspection - Engine Running
- Heater System Inspection
- Preventive Maintenance Worksheet
- Chapter Review

Discussion of Inspection & Maintenance Survey Results

There are three reasons for regular inspection and maintenance procedures:

1. They save money in the long run by reducing down time and often prevent more costly repairs.
2. They help to insure driver comfort and safety
3. They add to your store of knowledge about these systems and maintain your level of efficiency.

About half of all heavy duty vehicles have air conditioners. Surveys of AC system owners find that over 30% of the systems are serviced every six months or less, and another 62% are serviced at least once a year.

The survey also covered how often the different components required maintenance. Figure 7.1 below shows survey finding percentages. Failure of any of the AC components listed in the survey could cause a system to malfunction or stop cooling.

Figure 7-1

This chart shows maintenance frequency, lists key parts and how often they require maintenance.

INSPECTION & MAINTENANCE SURVEY

How often are your air conditioners serviced?

	1 to 6 months	7 to 12 months	More than 12 months	Never
Average	30%	62%	6%	2%

Which AC components require frequent maintenance?

Belts	Compressor Clutch	Condenser	Add Refrigerant	Refrigerant Lines	Valves
32%	26%	12%	12%	11%	7%

Note: The above survey results may not apply to your situation. Actual operating conditions for the vehicles you service will determine or influence maintenance frequency and requirements.

The following inspection procedures should take about 15 to 20 minutes, longer if corrective steps, part replacement or adding refrigerant is necessary. There is a "Preventive Maintenance Worksheet" you may use at the end of this chapter, Figure 7-9.

Visual Inspection - System Off

Your observations and the corrective measures you take may be different depending on circumstances. The following inspection procedures are explained in more detail below:

1. Observe the System
2. Inspect Parts
3. Check Hoses and Fillings
4. Check for Refrigerant Leaks

Use the following procedures as a general rule in performing a visual inspection with the AC system off:

1. Observe the System

Your first inspection step is to answer the following question if you can:

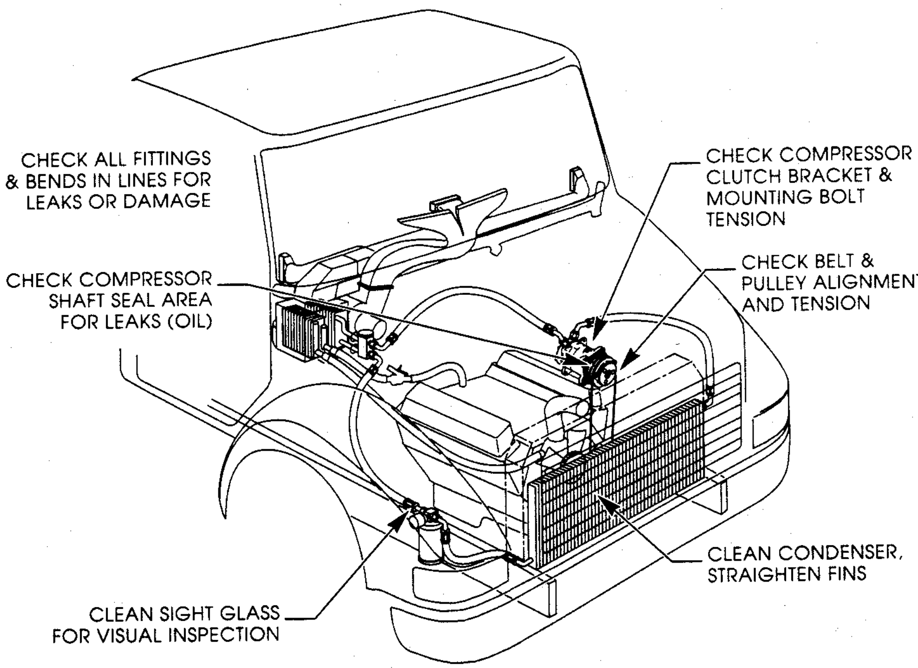
- Has the vehicle just come in off the road and has the HVAC system been in use?
- Did the operator or work order explain or describe any problems about the system?
- Did someone else work on the system yesterday, 700 miles down the road? Your first inspection step is to answer these questions if you can.

CAUTION Even when someone has told you what is wrong with an HVAC system, you should perform a visual inspection. Always make a visual inspection before you hook up the manifold gauge set. Never add refrigerant to a system until you have made a complete visual and performance inspection.

2. Inspect Parts

Look at the system for what might come loose, leak, wear out or become dirty and not function the way it should. The main points for visual inspection of the system are emphasized in Figure 7-2.

Figure 7-2
This system illustration notes the main points for visual inspection.



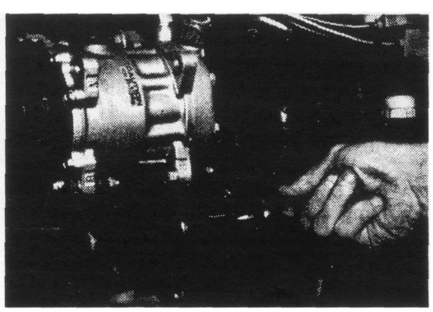
A. Condenser - Is it free of leaves, bugs, bird feathers or mud? The condenser must be relatively clean to work well as a heat exchanger. How you clean the condenser depends on where it is mounted. The condenser fin comb, air hose and nozzle, or soap and water may be used. Where possible, check condenser mounting bolts or screws and tighten them if necessary.

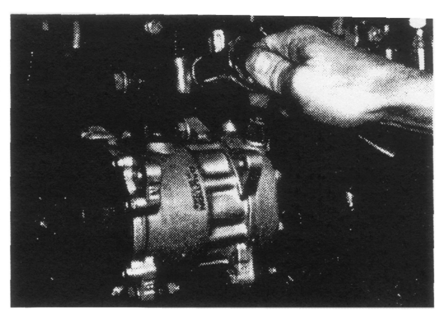
Condenser failure often results from loose hoses. Hose movement will cause fatigue failure of condenser tubing adjacent to the fittings. Make sure the hoses are securely clamped.

While inspecting the condenser check the receiver-drier sight glass and connections. Look to see if the sight glass has a moisture indicator that is showing moisture in the system.

B. Components Under the Hood - Tip the cab or raise the hood. Look at the compressor mounting bracket, compressor clutch assembly, drive belt and pulley alignment. The mounting bracket, compressor, clutch and drive pulley should be fastened securely, and a clutch groove (there may be two grooves) should be in line with the drive pulley. Tighten all bolts shown in Figure 7-3, as you inspect.

Figure 7-3
Engine and compressor vibration can work mounting bolts loose. Tighten all mounting bolts as you in spect the system. Slots in the mounting bracket are used to move the compressor clutch assembly in order to adjust belt tension or align ment.





C. Drive Belt – The drive belt should be tight and in good condition. Use a belt tension gauge to check tension (120 pounds maximum). With experience, you can feel belt tension by twisting the belt. Try feeling belt tension after using the gauge, when you know the tension is correct. Replace belts if they are frayed or look worn.

If the clutch pulley/belt alignment is obviously off, you need to loosen the compressor or mounting bracket, or both - and use the alignment bar to line up the clutch pulley with the drive pulley. Tighten compressor mounting bolts first, then the bolts holding the bracket. The mounting bracket should have slots or other means of adjustment to allow you to adjust the tension of the drive belt. When you use a pry bar to apply tension, be sure you do not pry against the compressor. Pry against the mounting bracket.

3. Check Hoses and Fittings

Check all hoses and fittings. Look for places where hoses flex when the cab is tilted. Any places the hoses or fittings are fastened, clamped, connected, bent or secured are potential wear points. This also applies to places where hoses are not clamped or supported but should be (often near the condenser). All of these spots are potential leak or damage points. Tighten, re-fasten, add, or replace as indicated by your inspection.

4. Check for Refrigerant Leaks

System refrigerant leaks can be anywhere but there are obvious places. You can spot some by looking for signs of refrigerant oil forced out with refrigerant leakage. One location leaks frequently occur is the compressor shaft seal. The shaft and seal are hidden behind the clutch assembly, but centrifugal force will throw the oil off the shaft and against the engine, bracket or whatever is close. Check these points when you examine the compressor clutch and mounting bracket. A solution of soap and water applied around potential leak points works well for detecting leaks. A leak in the evaporator may be indicated if you feel around the condensate drain hole and find oil present.

Note: You can add inexpensive dry nitrogen gas to the system instead of R-134a if system pressures are low. Dispense the gas at no more than 200-250 PSI as this is sufficient pressure to cause or indicate a leak point in the AC system. AC service procedures for complete system recovering of refrigerant, evacuating, and recharging are covered and illustrated in *Chapter 9.*

Note: A leaking heater core could also result in coolant at the condensate drain.

You can feel for oil at the bottom of all connections (see Figure 7-4) if the system is not too hot. Of course, a few minutes with an electronic leak detector is the best way to check for leaks. Keep in mind that pressure is different in a system at rest, so small leaks may be hard to find. Pressure in a system at rest, will equalize at from 60 to 95 PSI, depending on outside air temperature. This means there is more pressure in the low side of the system at rest than during normal system operation. Just the opposite is true of the high side; at rest, high side pressure is lower. You may want to use the detector to check for leaks in the high side when the air conditioner is operating, if you suspect a leak and can't find it when the system is at rest.

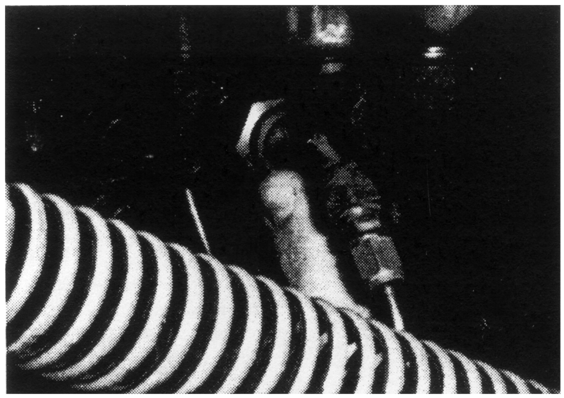


Figure 7-4
This illustration shows a potential refrigerant leak point at the condenser fitting.

Electrical System Inspection

The two stages of an electrical inspection are explained in more detail below:

1. Inspect Electrical Connections

2. Check Electrical Current Flow and Device Functions

Use the following procedures to perform an electrical system inspection:

1. Inspect Electrical Connections

First, while you are making your visual inspection under the hood (cab) and/or at the roof top condenser, take a moment and check all electrical connections visually and by feel. Look for any corrosion on leads or connectors and clean them. Make sure all leads and wires are properly supported and securely connected.

2. Check Electrical Current Flow and Device Functions

Perform the following steps to check current flow and electrical device functions:

A. Turn the Ignition On — To check current flow the ignition must be on.

B. Turn the AC System On – This will power the thermostat and clutch. If it does not come on, use the AC mode switch to check the leads to the switch. You should be able to hear a "click" from the thermostat and hear the clutch drive plate "snap" against the clutch pulley. You can not check thermostat cycling on and off until you do the performance inspection. Figure 7-5 illustrates a typical AC electrical system and the places you should inspect.

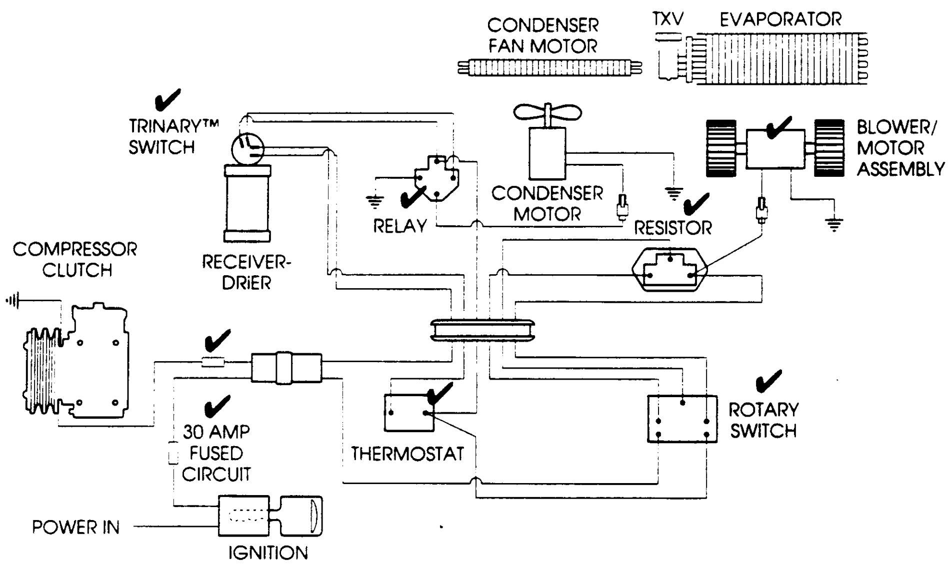


Figure 7-5
The electrical system inspection points are noted with check marks (V) on this wiring diagram (electrical schematic).

C. Check Fuses – If there is a failure and you have made sure all connections are clean and tight, you need to check fuses—in-cab as well as in-line.

D. Check Clutch Engagement – Since you can't see and may not hear the clutch engage, get out and look at the clutch. If it's engaged, you will see that the drive plate is against the pulley and not slightly spaced from it. If you are not sure the clutch is engaged, look for the lead wire connector near the clutch. Break and close that connection. The clutch will disengage and engage again.

E. Test Blower Speed Operation – Some systems have a common switch that turns on the air conditioner and powers the blower motor. Test blower speed operation by adjusting this or the separate blower control switch. Feeling the air flow from the ducts or note blower sound (speed) changes.

F. Inspect Roof Mounted Condensers – Don't forget to inspect roof mounted condensers and AC systems for dirt and debris. Be sure the condenser fan(s) are working properly and all parts and electrical connections are securely fastened. The roof mounted condenser fans may come on when the system is turned on. Like the thermostat and most clutches, the normal on-off cycling action can not be observed until the engine is running with the AC system on.

Performance Inspection - Engine Running

The purpose of visual and electrical inspection is to detect obvious problems and assure AC system function for an accurate performance inspection. If you do the performance inspection first, you could be mislead. Problem areas discovered during the performance inspection can give you false clues or symptoms, and result in repair errors and come-backs. The following performance inspection procedures are explained in more detail below:

1. Inspect System Component Cycling and Cab Temperature Levels
2. Check Clutch Cycling Under Load
3. Check Sight Glass

The performance inspection does not cover pressure and temperature sensitive safety devices (cutout switches, fan control, Trinary etc.). Testing these devices requires the use of the manifold gauge set for observation of internal system pressures during tests. These are explained in *Chapter 8.*

Use the following procedures as a general rule in a performance inspection:

1. Inspect System Component Cycling and Cab Temperature Levels

A. Turn On the Engine and Air Conditioner – Inspect for system component cycling and cab temperature levels.

Note: **System performance testing will be much faster if all doors and windows in the cab are closed.** The cab air must cool down to thermostat control setting levels before system components will cycle on and off, indicating correct function. This is called 'stabilizing the system' and takes about five minutes of operation. In very hot weather the system may not cycle.

B. Check Thermometer Readings – In the cab you can use your thermometer to measure air temperature at the vents. When the evaporator is easy to reach with a thermometer probe without removing some of the dash or duct work, use the probe to measure evaporator temperature. When the AC unit is on and working correctly, you can see the thermometer dial needle move down to about 32 degrees, then rise six to ten degrees and move back down again. The movement up and down indicates that the cycling clutch and thermostat, or orifice tube and accumulator pressure switch (to the clutch) are functioning correctly. In systems with a non-cycling clutch, this movement indicates correct function of the refrigerant metering device.

The needle movement is called "temperature swing." When you can adjust the thermostat setting, the range of swing should change. For example, from full cooling (cold) to moderate (between cold and warm), the swing may change from 32-38 to 32-42 degrees.

These readings at the vents will be higher and temperature swing slower and not as obvious. Also blower speed will cause the temperature, levels to read higher (high air speed) or lower (low air speed) at the same thermostat setting. When you measure air temperature, an electronic thermometer/pyrometer is a great tool to have. You can easily measure cab air temperature at several locations quickly

Swing temperatures vary depending on where you measure temperature, and on outside temperature, humidity and altitude. The chart in Figure 7-6, shows some examples of typical temperature variables. Don't forget that cab and sleeper area temperatures can vary within the same vehicle. Also, electronic controls used in newer HVAC systems often keep the temperature spread within a narrower range.

AIR TEMP. DEGREES F.	70°		80°		90°		100°	
AIR QUALITY	HUMID	DRY	HUMID	DRY	HUMID	DRY	HUMID	DRY
CENTER OUTLET AIR TEMP. DEGREES F.	43° to 47°	40° to 44°	44° to 48°	40° to 44°	47° to 51°	40° to 44°	52° to 56°	41° to 45°
	LEFT & RIGHT AIR OUTLET TEMPERATURE WILL VARY							
	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
OUTLET AIR TEMP. RANGE DEGREES F.	40° to 41°	41° to 44°	41° to 45°	43° to 47°	46° to 52°	47° to 54°	48° to 55°	50° to 56°

Figure 7-6
The chart of AC system and cab temperature range shows you typical variables.

2. Check Clutch Cycling Under Load

The following operating inspections, visual and by feel, are done outside the cab while you wait for the system to stabilize.

A. Lift hood – With the hood up (or cab tilted) observe the clutch cycling under load.

Note: If the condenser is hood mounted you may not have adequate air flow through it.

B. Touch suction and discharge lines – Soon after system start up you can safely feel the suction and discharge lines and note their change in temperature. The discharge line will get hot (after a while it may be to hot to touch) and the suction line will get cooler.

3. Check Sight Glass

The sight glass is the only point where you can actually see inside the air conditioner during operation. Check the sight glass through the window on the top of the receiver-drier (or the separate in-line sight glass). If the system is functioning properly and cooling the cab adequately, the sight glass should be clear (you will not see anything in it). If it is not clear when the system is first turned on, wait a few minutes for the system to stabilize, then look again. Figure 7-7 illustrates and explains what you may observe in the sight glass. Roof mounted condenser fans may run continuously or cycle on and off. If you can't tell by sound you may have to climb a ladder and observe the fan blades.

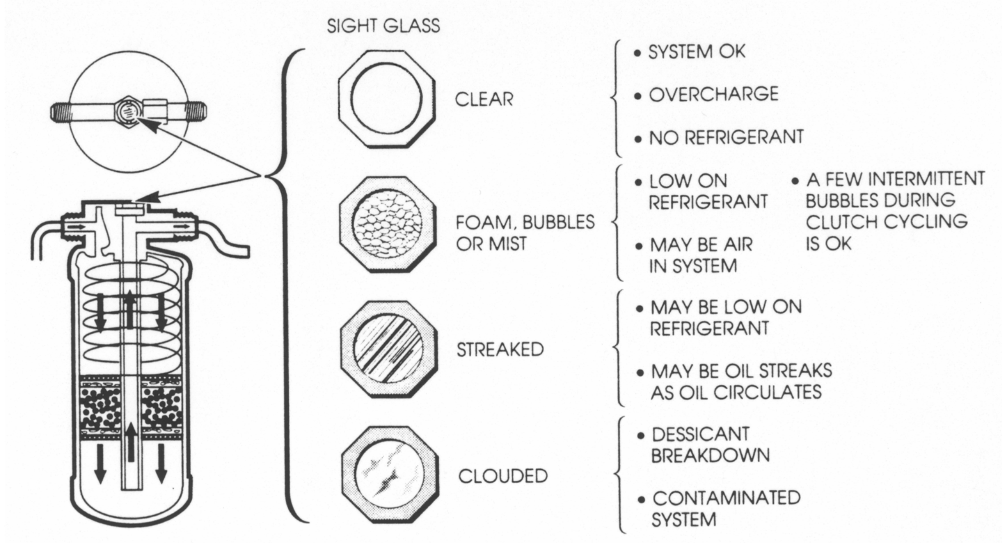


Figure 7-7
These drawings illustrate conditions you may observe in the sight glass window.

NOTE
A roof mounted condenser or AC unit assembly often includes a roof mounted receiver-drier (and sight glass) close to the condenser.

Preventive Maintenance Worksheet

Please feel free to modify or copy the worksheet in Figure 7-9. Actual vehicle use, mileage, operating conditions, and maintenance budget may influence service frequency.

Chapter Review

The purpose of these brief inspection procedures is for vehicle system maintenance and to determine if further, more detailed service is required. The uses of a manifold gauge set, system troubleshooting, recovery, flushing, evacuating, and charging are explained in the next chapter.

High usage and operating condition variations are tough on air conditioning and heater components. You should establish and follow regular inspection and maintenance procedures to improve overall system function and component service life.

The typical inspection should not take more than 15 to 20 minutes unless component replacement and/or complete system evacuation and recharging is warranted. The survey results shown in Figure 7-1, indicate belts, compressor clutch assembly, condenser, and refrigerant lines are the most frequent problem areas. However, your own experience with service and maintenance may vary from survey results.

Inspection should first be visual and by feel. Some of your electrical system inspection will be done as you inspect other components (checking leads, connections, and for loose wires). When you check the electrical circuit, begin with the engine off but ignition on. A system performance inspection with the engine running and system on really combines electrical and AC or heater system function.

Figure 7-9 Preventive Maintenance Schedule

PREVENTIVE MAINTENANCE SCHEDULE FOR AIR CONDITIONING SYSTEMS

NOTE: Typical Maintenance Schedule: 3 months or 15,000 miles, 6 months or 30,000 miles, 12 Months or 60,000 miles

Installation Date: ____ Mileage: ____________

Last Maintenance Check: ________________________________ Mileage: ____________

Checked by ____ Mileage: ____________

COMPONENT	MAINTENANCE INTERVAL (months)			DONE
	3*	6*	12*	
1. COMPRESSOR				
Check noise level	●			❑
Check clutch pulley	●			❑
Check oil level	●			❑
Run system 5 minutes	●			❑
Check belts for tension (120 lb max.)	●			❑
Inspect shaft seal (leakage)		●		❑
Check mounting bracket (tighten bolts)		●		❑
Check alignment to clutch w/ crankshaft pulley		●		❑
Perform manifold gauge check			●	❑
Verify clutch is engaging			●	❑
2. CONDENSER				
Clean dirt/bugs/leaves from coils (w/ compressed air)	●			❑
Check inlet/outlet for obstructions/damage	●			❑
3. RECEIVER/DRIER				
Check inlet line from condenser (hot to touch)	●			❑
Check sight glass (streaks or cloudiness)	●			❑
Replace if system is opened			●	❑

COMPONENT	MAINTENANCE INTERVAL (months)			DONE
	3*	6*	12*	
4. EXPANSION VALVE				
Inspect capillary tube (leakage/damage/looseness)			●	❑
5. EVAPORATOR				
Clean dirt/bugs/leaves from fins/tubes (w/ compressed air)			●	❑
Check solder joints on inlet/outlet tubes (leakage)			●	❑
Inspect condensate drain (R-12 or oil leak)			●	❑
6. OTHER COMPONENTS				
Check discharge lines (hot to touch)	●			❑
Check suction lines (cold to touch)	●			❑
Inspect fittings/clamps/hoses		●		❑
Check thermostatic switch (proper operation)			●	❑
Outlets in cab (temperature check; 40 to 50º F)		●		❑
Check fan clutch (proper operation)		●		❑
Insect all wiring connections		●		❑
Operate manual controls through full functions	●			❑

The following require monthly maintenance:

*Compressor – run system at least 5 minutes (40 degrees Fahrenheit minimum outside temp.) in order to circulate oil and lubricate components.

Maintenance notes: ____

____

____

Chapter 8

Troubleshooting & Service Procedures

- Troubleshooting Overview
- Understanding System Function
- A Troubleshooting Example
- Manifold Gauge Set Installation
- Troubleshooting by Manifold Gauge Set Readings
- Review of Frequent Problem Areas
- Conclusion

Can you fix an air conditioner or heater system without finding and correcting the cause of the problem? You bet you can! It happens every day and it's not good for business. Here is an example. A truck pulls in off the road and the operator asks to have his rig serviced in a hurry. He tells you the air conditioner isn't cooling like it should and dashes into the restaurant for lunch.

You tip the hood, and check the sight glass on top of the receiver-drier. You see bubbles, not a lot but a fairly constant stream of them. It is obvious the system is low on refrigerant so you hook up the manifold gauge set, purge the gauge set hoses of air, and add refrigerant until the sight glass clears. Then you check evaporator temperature and it's OK. **The air conditioner is repaired right?** Wrong! What you did is add refrigerant and the problem went away. You did not find and fix the cause of the problem.

Component failure in an air conditioning system may be the result of a problem elsewhere in the system. For example, a belt or clutch failure might be caused by a dirty condenser restricting air flow and increasing head pressures. High head pressures commonly create problems with other system components. **Take time to look beyond the obvious for a potential hidden problem.**

Troubleshooting Overview

Troubleshooting includes collecting enough information to locate the cause of the problem, then correcting the problem and its cause by replacement, adjustment, and/or repairing. You begin by gathering information from the most to the least important sources.

Starting with the most important:

1. Your personal knowledge and experience with AC systems.
2. The vehicle operator's knowledge and experience—question him or her.
3. The work order.
4. Good test equipment and the HVAC system

The routine you follow when troubleshooting should proceed from the most to least productive way of locating the problem and fixing the cause.

Experienced troubleshooters talk to the operator if they can, then personally verify the symptoms of the problem whenever possible. They attempt quick fixes on the basis of their knowledge of common system problems and causes when appropriate. They know where components are located, and make repairs when they have a good idea of what the problem is. They fix the cause or causes as well as the problem. They are confident of their knowledge and ability.

Note: **The best troubleshooters all know who to call when they get stuck.** They know someone who knows more than they do and are not too proud to ask for help or suggestions when needed. The key—understanding system function

The Key-Understanding System Function

Your complete understanding of AC and heater systems and how they work, plus what can go wrong, is the key to troubleshooting and repair. We have talked about components and system function before. Now let's take a little different approach in describing what happens when the air conditioner is turned on. In Figure 8-1 we have used numbers on the illustration to track normal air conditioner function.

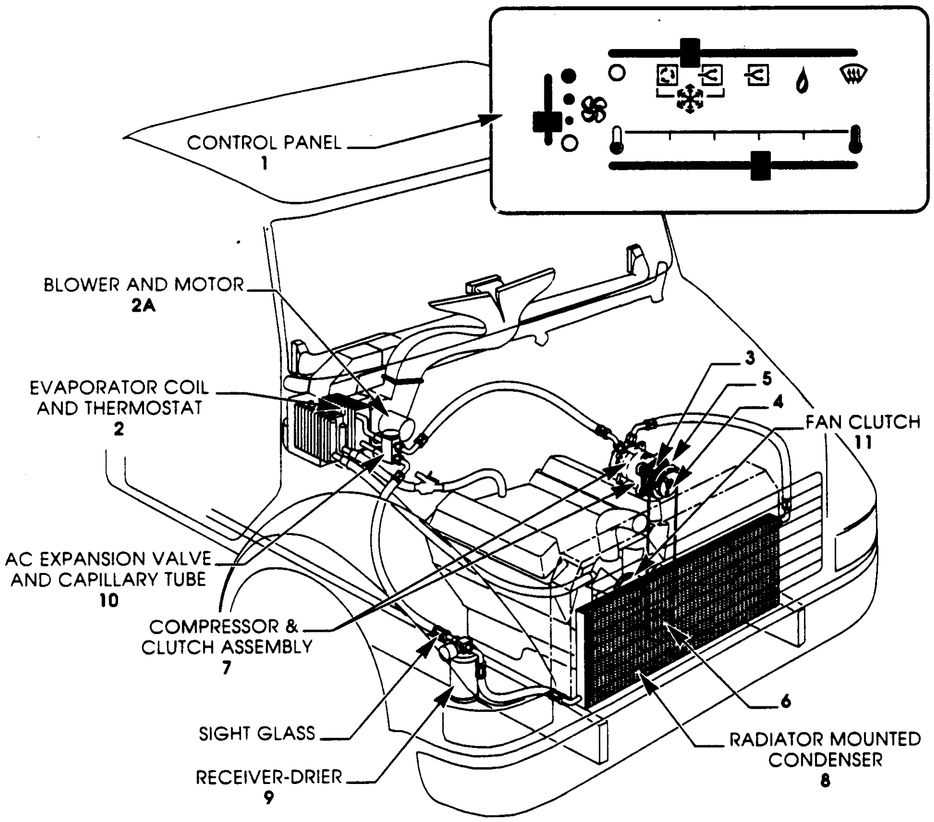


Figure 8-1
An illustration of the typical HVAC system. The numbers follow the action when the AC part of the system is working properly (moving heat out of the cab and into the outside air).

When you turn on the air conditioner at the control panel (1), the thermostat (2), is supposed to sense a warm temperature at the evaporator. A circuit in the thermostat should close, allowing current to flow through the thermostat to the compressor clutch field coil (3). When this happens, the clutch field coil becomes an electromagnet and pulls the clutch drive plate (4) tight against the clutch pulley (5).

Note: The same AC switch (1) may also turn on the fan or blower motor (2a) to circulate air in the cab. The air feels warm at first but will cool quickly.

A belt connects the clutch pulley to a drive pulley (6) on the engine. The engine provides the power to turn the clutch pulley and drive the compressor (7) when the clutch is engaged. When operating, the compressor compresses and pushes refrigerant gas to the condenser (8), through the receiver-drier (9), and to the expansion valve (10) orifice. When it does, it puts a lot of pressure on the gas. The compressor raises the temperature and pressure of the refrigerant inside the high side of the system.

At the same time, the compressor is also sucking in low pressure refrigerant gas from the expansion valve orifice, evaporator and through the low side of the system. The movement of the refrigerant inside the system transfers heat energy from the cab to the outside air for occupant comfort.

The automatic functions of the thermostat (or the pressure valve on some accumulators), and the expansion valve, help maintain pressures and temperatures inside the system at safe and efficient operating levels. Pressure and temperature are constantly changing due to compressor and expansion valve action, the amount of heat energy being moved and the environment or weather conditions.

The engine cooling system fan and clutch (11), and the evaporator blower motor (2a), move a sufficient amount of air through the condenser and evaporator. On the road, vehicle speed provides most of the (ram) air required for the condenser to work right. In a parked or slow moving vehicle the engine fan (or roof or remote mounted condenser and fans) moves sufficient air through the condenser fins.

Note: Clean refrigerant and refrigeration oil should be inside the system in the amount specified by the manufacturer. Moisture, sludge (moisture combined with refrigerant oil or desiccant), or desiccant particles will prevent the correct performance of the system and may cause component damage.

A Troubleshooting Example

Remember the story at the beginning of this chapter? The vehicle operator pulled in off the road and asked you to repair the rig. He was in such a hurry he didn't tell you anything except that the air conditioner wasn't cooling. Here is the best way to handle that kind of situation.

Use your knowledge and experience. Ask yourself what could have caused a lack of cooling in that rig! Did the compressor drive belt break? Did a pressure switch or relief valve cutout the compressor because of high or low system pressure? Does the switch or valve in this type of system reset itself? Could there be a superheat switch and thermal limiter with a melted fuse. Did someone else service the system recently and put in too much refrigerant?

Could there be contaminants in the system blocking the expansion valve (expansion tube)? If there is a leak, why and how did refrigerant get out of the system? You know if refrigerant can get out, air and moisture may get inside as well, especially if the leak is on the suction side of the system. Could there be a restriction to refrigerant flow in one of the high pressure lines because of a kink? From your knowledge and experience, you already know about these possibilities and others when you talk to the operator (before he has the chance to leave).

The right kind of questions can speed up troubleshooting and your service work by pinpointing the problem(s) that needs fixing. Your conversation with the operator might be as follows:

- *How long ago did the AC system stop cooling?*
  Answer: About an hour ago.

- *What steps did you take when you noticed the lack of cooling?*
  Answer: I put it on maximum cool.

- *Then what did you do?*
  Answer: When it wouldn't cool, I opened the window and turned the air conditioner off.

- *Is this problem new or has it happened before, and when?*
  Answer: In the last few days I've had problems with cooling off and on—this is the first time it's happened when I was close to a place that did AC service.

- *Do you get any cooling at all?*
  Answer: Yes but it seems to quit after a while.

- *Do you still get air flow at the vents from the blower~*
  Answer: Yes.

- *When was your air conditioner checked thoroughly?*
  Answer: Before I bought the rig last May (a year ago).

- *Has the heater been used recently and did it work OK?*
  Answer: Yes.

- *Have you had other service problems in the last few months?*
  Answer: No.

- *(If the answer was yes, you should ask – When? Where? What was fixed or replaced?).*

- *Finally, ask the operator if he or she has a wiring diagram for the system.*

Now let's look at the information you have gathered from the operator and what you know from experience. He believes the problem is that the AC system quits cooling after it has been on for a while! You know that the AC system has not been maintained since the rig was purchased a year ago. Because of that, there could be several causes for the problem (lack of cooling) and there may be other potential problems about to develop.

It is possible that some refrigerant has leaked. Moisture and other contamination may be inside the system. You have been told there are no heater problems, but that doesn't mean there are none that might affect AC system operation. The AC system has quit cooling several times in the last few days. The problem may have become more severe than when it quit cooling the first time.

If enough refrigerant or oil has leaked out, a low pressure cutout switch may have cut the circuit to the clutch, protecting the compressor. Because the system has not been maintained in a year, there may be other components that should be serviced. You could fix the probable causes, and the system might work and then break down again as the rig drives out of your place. From your knowledge and what the operator has just told you, you know this may not be a quick fix problem.

It's up to you to describe the service situation to the operator. Tell him you need to do a complete system maintenance inspection to find and correct the problem or other potential problems. He can give you the go ahead for full service and repair now, wait till you have inspected the system to determine cause and cost, or delay repair until he has some down time available.

Normally when the operator can tell you what the problem is, you would first operate the system to verify the problem. In this situation your troubleshooting (your own knowledge added to what the operator told you), indicates the next step. You need to do a complete maintenance inspection instead! Proceed as described in *Chapter 7*. Correct any obvious problems and check carefully for leaks. Leak testing should be visual, by feel and with a leak detector. Next, do your performance test with the engine running and the AC system on.

If your AC and heater visual, electrical and leak inspections don't turn up any problems, save time by hooking up the manifold gauge set before you make the performance test. If you find a leak and can correct it easily by tightening a connection, do so. But if too much refrigerant leaked out, you may have to add some refrigerant to the system for an effective performance test. We will get into detail on troubleshooting with gauges after we explain manifold gauge set installation and adding refrigerant.

Manifold Gauge Set Installation

CAUTION

Never hook up the gauge set when the engine and air conditioner are running. Be sure all the valves on the manifold are closed all the way (turn them clockwise). Check the hose connections on the manifold for tightness.

Locate the low and high side system service fittings and remove their protective caps. Position or hang the manifold gauge set in a convenient location. Figure 8-2 illustrates a good example of manifold gauge set hookup in one service situation.

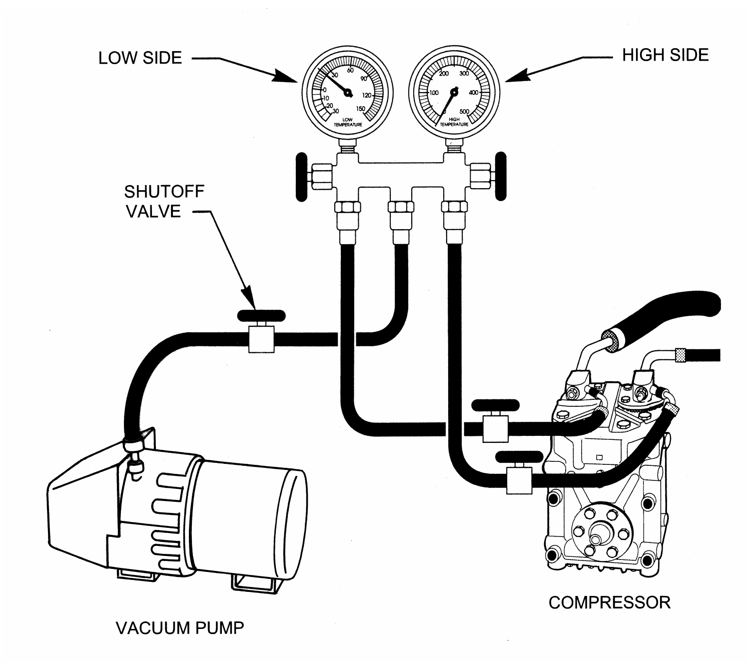


Figure 8-2
A typical manifold gauge set hookup is shown in this illustration. The center hose on the gauge set is connected to the vacuum pump.

The manifold gauge set is a necessary tool in troubleshooting AC system problems. The following steps are performed during and after installing the manifold gauge set:

1. Purging Air from the Gauge Set Hoses

2. Adding Refrigerant to the System

3. Stabilizing the AC System.

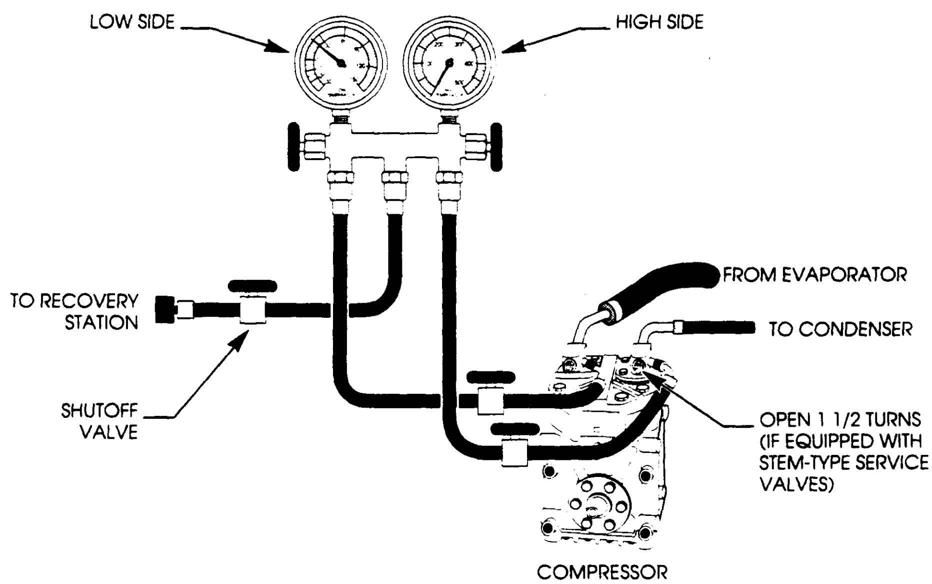
1. Purging Air From Gauge Set Hoses

Environmental regulations require that all service hoses have a shutoff valve within 12 inches of the service end. These valves are required to ensure only a minimal amount of refrigerant is lost to the atmosphere. R-12 gauge set hoses have a valve near the end of all three hoses. R-134a gauge sets have a combination quick disconnect and shutoff valve on the high and low sides. The utility (center) hose also requires a valve.

The initial purging is best accomplished when connected to recovery or recycle equipment. Figure 8-3 illustrates the gauge set connections for purging and refrigeration recovery.

Figure 8-3

The purging setup for manifold gauge set and compressor service valves are shown here.



Note: The manifold gauges read system pressure when the hand valves are closed if the hose end valves, and the stem type service valves (if included) are open.

2. Adding Refrigerant to the System

Now that the gauges are connected, you may need to add some refrigerant to the AC system before you can do an effective performance inspection. However, if leaks are obvious they should be repaired prior to adding refrigerant.

Note: Loss of some refrigerant is not unusual over an extended period of time. Adding refrigerant is a typical procedure when the AC system is maintained on a regular basis.

When adding refrigerant to the system, connect the center hose from the manifold gauge set to the refrigerant dispensing valve on the container. Figure 8-4 illustrates this connection.

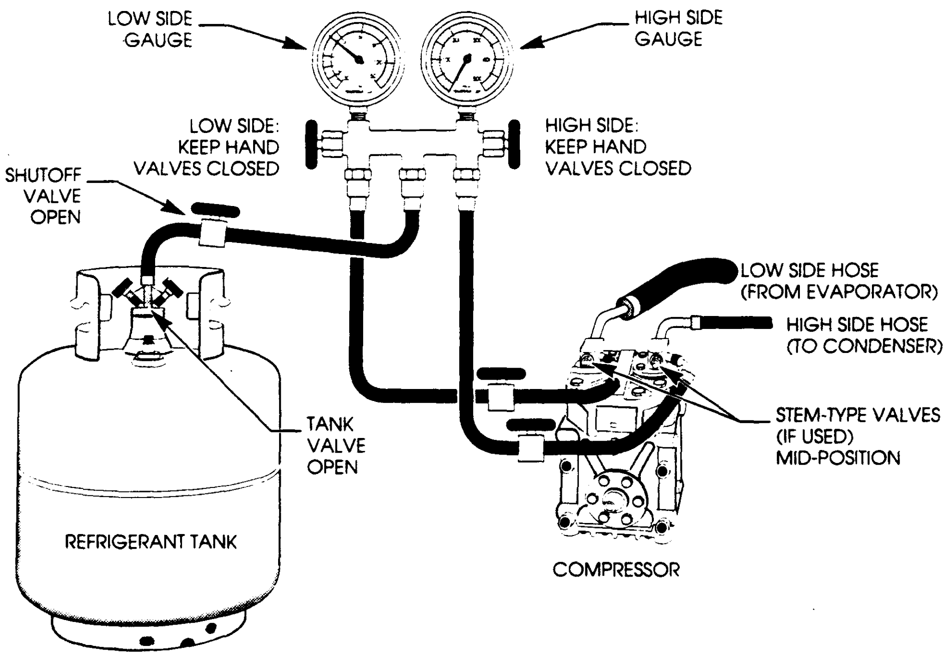


Figure 8-4

In this illustration we have noted how refrigerant is added to the air conditioner.

Before adding refrigerant to the system you should study the sight glass while the engine is running and the air conditioner is on. Even if you found a leak during the system inspection and corrected it, you have no way of knowing how much refrigerant has leaked. You will not be able to tell how much refrigerant is in there, but you can see if bubbles are present.

Then check the gauges for unusually high or low readings, or a lack of pressure. Following this procedure, and using your knowledge and experience, decide if it is safe and makes sense to add refrigerant in order to make your full performance inspection.

You are now ready to add refrigerant to the system. For your safety and to prevent system damage use the following procedure.

1. Turn on the engine and set the idle at 1200 to 1500 RPM and then turn on the air conditioner.

CAUTION Do not open the high pressure hand valve on the manifold gauge set. The compressor could pump refrigerant into the container and cause it to BURST. Be sure to keep the refrigerant container upright to prevent liquid refrigerant from entering the compressor.

2. Open the refrigerant dispensing valve on the container and then the low pressure hand valve on the manifold. This allows refrigerant to enter the system as a gas on the low pressure or suction side of the compressor. The compressor will pull refrigerant into the system.

3. Add refrigerant until the gauges read in the normal range and the sight glass appears clear. The sight glass may not be clear for a moment just before or after the clutch cycles on and off but should generally be clear. Gauge readings will fluctuate as the compressor cycles on and off.

Note: Pressures within the air conditioning system vary with ambient temperature. A normal pressure range is defined as follows:

Low side	15—30 PSIG
High side	150—280 PSIG

If R-134a is used in place of R-12 the high side readings will be about 20 PSI higher. For this reason many OEMs are recommending an increase in condenser capacity when retrofitting to the new refrigerant, R-134a.

CAUTION If the gauges show any abnormally high or low pressures as you are adding refrigerant, stop and investigate for probable cause. Never add more than one pound of refrigerant. If the system is low enough on refrigerant to require more than that amount you should stop and check again for leaks. Then recover all of the refrigerant, repair, evacuate and recharge the air conditioner. (See *Chapter 9). You* may want to add dry nitrogen gas to the AC system instead of R-12 if pressures are below normal and a leak is suspected. Nitrogen gas is sold in cylinders under high pressure, 1800 to 2000 PSI. Be sure the cylinder has a pressure regulating valve to control the pressure when dispensing nitrogen gas. Dispose the gas at no more than 200-250 psi, as this is sufficient pressure to cause or indicate a leak point. See note under *Troubleshooting by Manifold Gauge Set Readings* in this chapter.

4. When the gauges show normal, close the hand valve on the manifold, the hose end shutoff valve, and the valve on the refrigerant container. You can now proceed with the performance inspection.

3. Stabilizing The AC System

For reliable gauge readings as an aid in troubleshooting, the AC system must be stabilized.

CAUTION Be sure your tools and test equipment are clear of all moving parts of the engine and air conditioner.

Start the engine and set to a fast idle of 1200 to 1500 RPM. Turn on the air conditioner. After a quick in-cab performance test of control function, blower speeds and air flow, set the AC system controls to maximum cooling and blower speed on high. All windows must be closed. If cab temperature is hot (rig has been sitting in the sun with the windows closed), open the windows for a minute or so to let the hot air out. Run the engine and air conditioner about five minutes for the system to stabilize. In hot humid weather or where the AC condenser can't receive adequate air flow from the engine fan you may have to use a floor mounted fan to force sufficient air flow through condenser fins. This helps to stabilize the system by simulating ram air flow found under normal operating conditions.

When a vehicle has a tilt cab or hood and the condenser is part of the grill, you must use the floor fan to get air to the condenser. You could tilt the cab or hood back to normal position, carefully routing the manifold gauge set and hoses away from moving parts. Then place the gauges so you can read system pressure.

Troubleshooting by Manifold Gauge Set Readings

The series of figures that follow (Figures 8-6 through 8-15) show gauges with typical readings indicating AC system problems. Each figure is followed by troubleshooting tips, probable causes for the gauge readings shown, and appropriate service and repair procedures.

Low Refrigerant Charge in the System

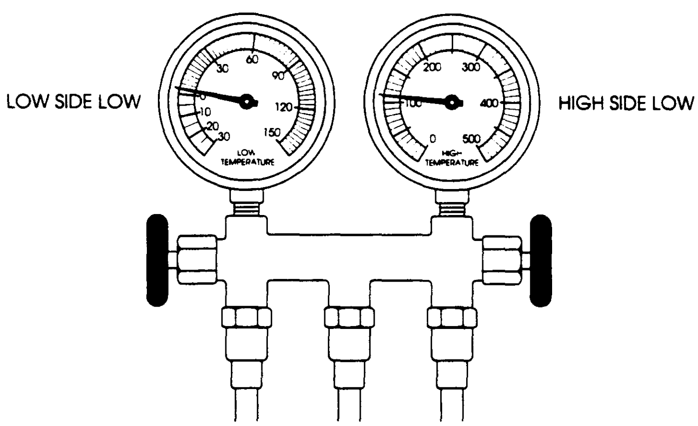


Figure 8-5
Gauge reading, low refrigerant charge in the system.

Tip: You see bubbles in the sight glass. The air from vents in the cab is only slightly cool.

Cause: Insufficient refrigerant (charge) in the system.

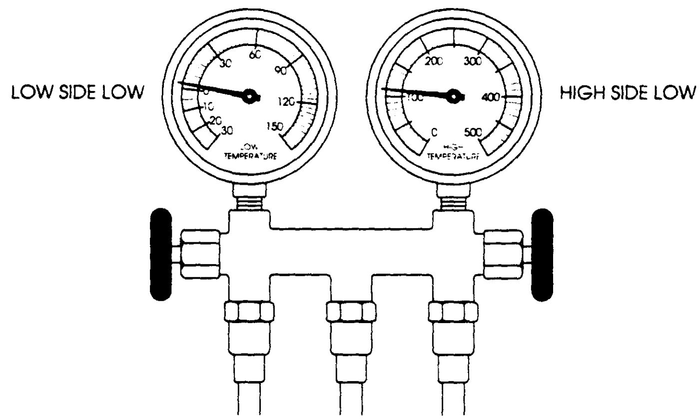
Repair Procedure:

Check for leaks with your leak detector. If you find a leak at a connection, tighten it then add refrigerant as necessary. If a component or line is leaking (defective), recover all refrigerant from the system. Replace the defective part and then check the compressor oil level and replace missing oil. Evacuate and recharge with refrigerant, then check AC operation and performance.

Figure 8-6

Gauge reading, extremely low refrigerant charge in system.

Extremely Low Refrigerant Charge in the System



Tip: The sight glass is clear or shows oil streaks. The air from vents in the cab seems warm. If there is a low pressure or Trinary™ switch in the system it may have shut off the compressor (clutch).

Cause: Extremely low or no refrigerant in the system. There is a leak in the system.

Repair Procedure:

Add refrigerant to the system, at least half of the normal full charge amount. Then perform your leak test. As an alternative to a refrigerant, add dry nitrogen gas to the system and then test for leaks.

Note: It may be necessary to use a jumper wire to bypass some types of low pressure cutout switches to operate the compressor (clutch) when you add refrigerant to the system.

After finding a leak, recover all refrigerant from the system and repair the leak. Check the compressor and replace any refrigeration oil lost due to leakage. Evacuate and recharge the system with refrigerant, then check AC operation and performance.

Air and/or Moisture in the System

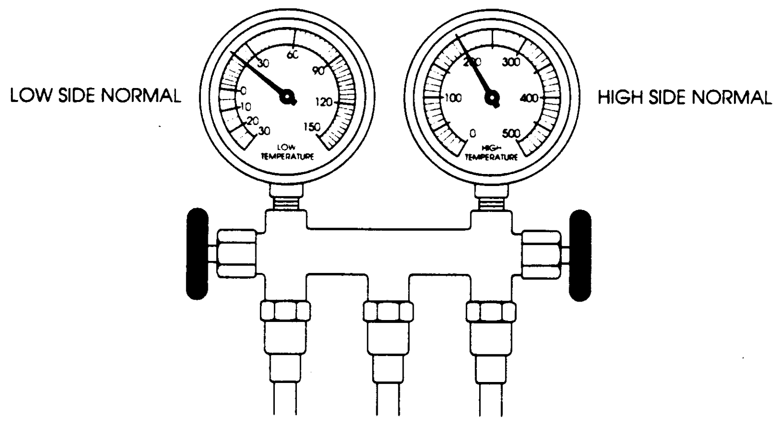


Figure 8-7
Gauge reading, air andlor moisture in the system.

Tip: The sight glass maybe clear or show some bubbles. The air from vents in the cab is only slightly cool. In a cycling clutch type system with a thermostatic switch, the switch may not cycle the clutch on and off, so the low pressure gauge will not fluctuate.

Cause: Air and/or moisture in the system.

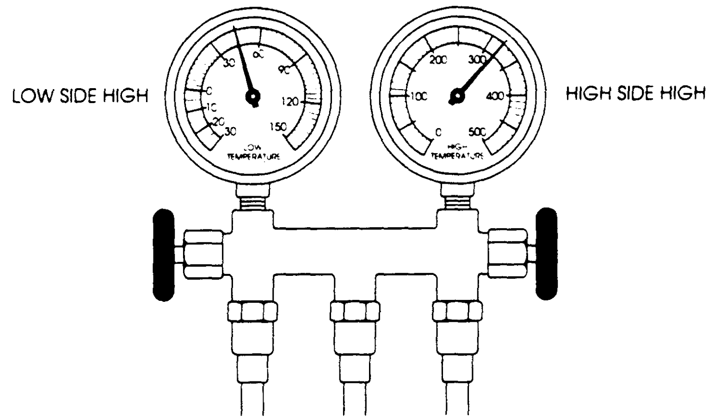
Repair Procedure:

Test for leaks, especially around the compressor shaft seal area. When the leak is found, recover refrigerant from the system and repair the leak. Replace the receiver-drier or accumulator because the desiccant may be saturated with moisture (there is no way to tell). Check the compressor and replace any refrigeration oil lost due to leakage. Evacuate and recharge the system with refrigerant, then check AC operation and performance.

Figure 8-8

Gauge reading, *excessive* air and/or moisture in the system.

Excessive Air and/or Moisture in the System



Tip: There may be occasional bubbles in the sight glass. Air from vents in the cab is only slightly cool.

Cause: System contains excessive air and/or moisture.

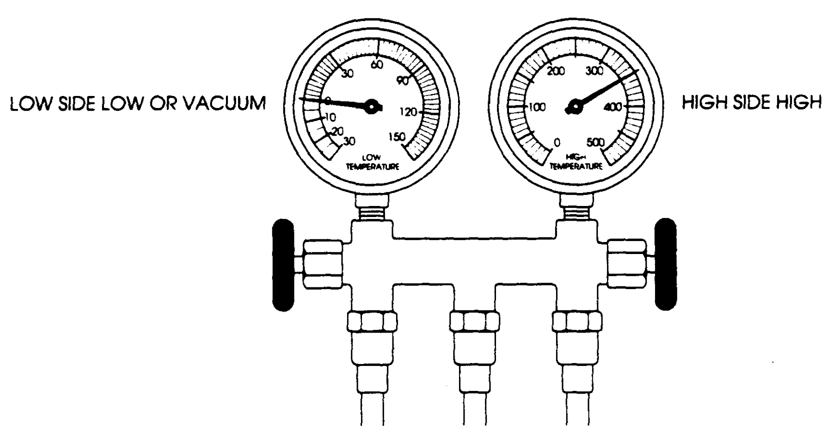
Repair Procedure:

Test for leaks, recover refrigerant from the system and repair the leak. Depending on the type of system, replace the receiver-drier or accumulator. The desiccant is saturated with moisture. Check and replace any compressor oil lost due to leakage. Evacuate and recharge the system, then check AC operation and performance.

Figure 8-9

Gauge reading, expansion valve (TXV) stuck closed.

Expansion Valve (TXV) Stuck Closed or Plugged



Tip: Air from vents in the cab is only slightly cool. The expansion valve body is frosted or sweating.

Cause: An expansion valve malfunction could mean the valve is stuck in the closed position, the filter screen is clogged (block type expansion valves do not have filter screens), moisture in the system has frozen at the expansion valve orifice, or the sensing bulb is not operating. In vehicles where the TXV and sensing bulb are accessible, perform the following test. If not accessible, then proceed to *Repair Procedure.*

Test:

1. Warm diaphragm and valve body in your hand or carefully with a heat gun. Activate system and watch to see if the low pressure gauge rises.

2. Next, carefully spray a little nitrogen, or any substance below 32 degrees Fahrenheit, on the capillary coil (bulb) or valve diaphragm. The low side gauge needle should drop and read at a lower (suction) pressure on the gauge. This indicates the valve was part way open and that your action closed it. Repeat the test, but first warm the valve diaphragm or capillary with your hand. If the low side gauge drops again, the valve is not stuck.

3. Clean the surfaces of the evaporator outlet and the capillary coil or bulb. Make sure the coil or bulb is securely clamped to the evaporator outlet tube and the insulation is in place. Next proceed with recovering refrigerant from the system.

Repair Procedure:

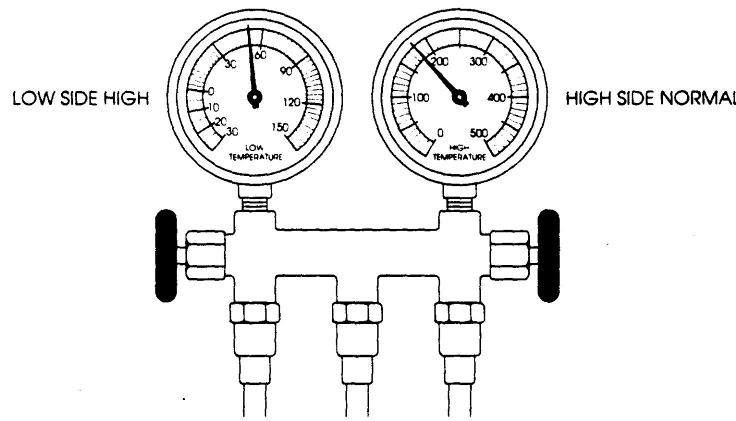
Inspect the expansion valve screen (except block type valves). To do this you must recover all refrigerant from the system. Disconnect the inlet hose fitting from the expansion valve. Remove, clean and replace the screen, then reconnect the hose. Any signs of contamination will **require** flushing the system. Next, replace the receiver-drier. Then evacuate and recharge the system with refrigerant, and check AC operation and performance.

Note: If the expansion valve tests did not cause the low pressure gauge needle to rise and drop, and if the other procedures described did not correct the problem, the expansion valve is defective. You must recover all refrigerant from the system again, and replace the expansion valve and receiver-drier. Evacuate and recharge the system with refrigerant, then check AC operation and performance.

Figure 8-10

Gauge reading, expansion valve (TXV) stuck open.

Expansion Valve (TXV) Stuck Open



Tip: Air from vents in the cab is warm or only slightly cool.

Cause: The expansion valve is stuck open and/or the capillary tube (bulb) is not making proper contact with the evaporator outlet tube. Liquid refrigerant may be flooding the evaporator making it impossible for the refrigerant to vaporize and absorb heat normally. In vehicles where the TXV and sensing bulb are accessible, check the capillary tube for proper mounting and contact with the evaporator outlet tube. Then perform the following test. If the TXV is not accessible, then proceed to *Repair Procedure.*

Test:

1. Operate the AC system on it's coldest setting for a few minutes. Carefully spray a little nitrogen or other cold substance, on to the capillary tube coil (bulb) or head of the valve.

2. The low pressure (suction) side gauge needle should now drop on the gauge. This indicates the valve has closed and is not stuck open. Repeat the test, but first warm the valve diaphragm with your hand.

3. If the low side gauge shows a drop again, the valve is not stuck. Clean the surfaces of the evaporator outlet and the capillary coil or bulb. Make sure the coil or bulb is securely fastened to the evaporator outlet and covered with insulation material. Operate the system and check performance.

Repair Procedure:

If the test did not result in proper operation of the expansion valve, the valve is defective and must be replaced. Recover all refrigerant from the system and replace the expansion valve and the receiver-drier. Evacuate and recharge the system with refrigerant, then check AC operation and performance.

System High Pressure Side Restriction

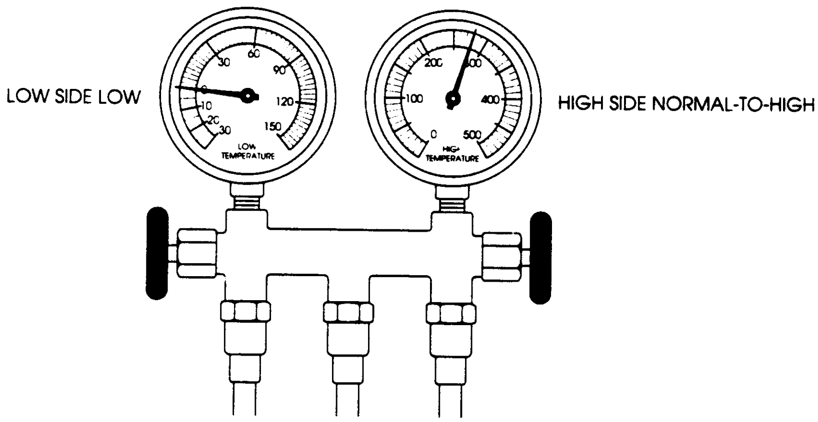


Figure 8-11
Gauge reading, system high pressure side restriction.

Tip: Air from vents in the cab is only slightly cool. Look for sweat or frost on high side hoses and tubing, and frost appearing right after the point of restriction. The hose or line may be cool to the touch near the restriction.

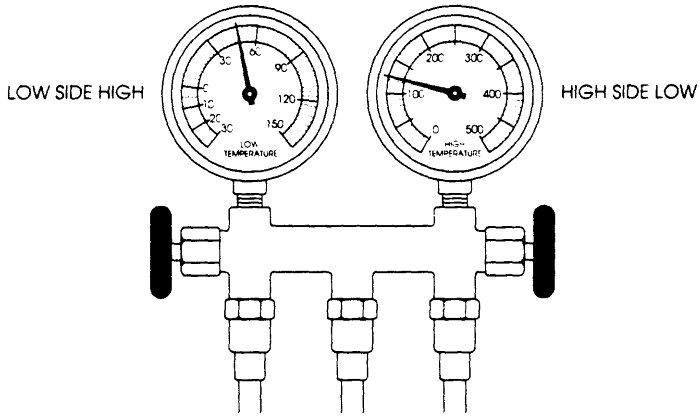
Cause: There could be a kink in a line, or other restriction in the high side of the system.

Repair Procedure:

After you locate the defective component containing the restriction, recover all of the refrigerant. Replace the defective component and the receiver-drier. Evacuate and recharge the system with refrigerant, then check AC operation and performance.

Figure 8-12
Gauge reading, compressor malfunction.

Compressor Malfunction



Tip: The compressor may be noisy when it operates.

Cause: Defective reed valves or other compressor components. If the compressor is not noisy, there may be a worn or loose compressor clutch drive belt.

Repair Procedure:

If you find the belt worn or loose, replace or tighten it and recheck system performance and gauge readings. To inspect and service the compressor, you must isolate (front seat the stem type compressor service valves) and recover refrigerant, or fully recover R-12 from systems containing Schrader valves. Remove the compressor cylinder head and check the appearance of the reed valve plate assembly. If defective, replace the valve plate and install with new gaskets, or replace the compressor assembly.

If you find particles of desiccant in the compressor, remove and replace it and the receiver-drier. Before doing so, back flush other system components (except the expansion valve) using a flushing kit. If there are stem type valves and you isolate the compressor, the rest of the system must be purged of refrigerant before you can disconnect and flush system components *(Chapter 9)* describes the flushing procedure). After flushing, reassemble the components. Always check the oil level in the compressor, even if you install a new or rebuilt unit. Tighten all connections and evacuate the system. Recharge the air conditioner with refrigerant and check system operation and performance.

Note: Rotary compressors have a limited oil reservoir. Extra oil must be added for all truck installations

Condenser Malfunction or System Overcharge

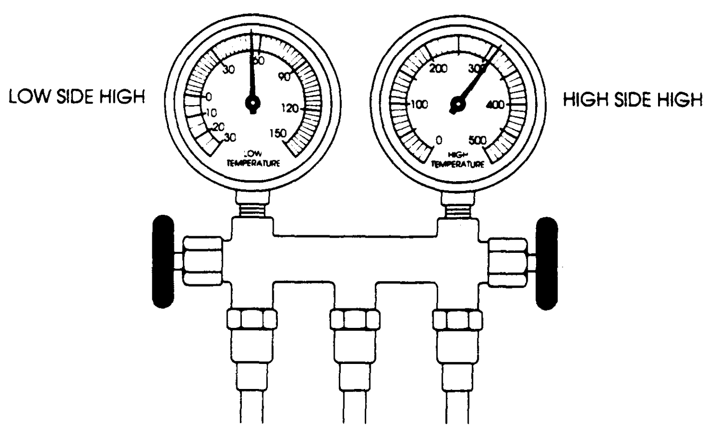


Figure 8-13
Gauge reading, condenser malfunction or system overcharge.

Tip: The air from vents in the cab may be warm. In R-12 systems there can be bubbles in the sight glass. The high pressure hoses and lines will be very hot. Don't forget to check the engine cooling system components—fan and drive belt, fan clutch operation, and the radiator shutter.

Cause: The condenser is not functioning correctly or there may be an overcharge of refrigerant inside the system. Another possibility is lack of (ram) air flow through the condenser fins during testing. Engine cooling system component malfunction can cause high pressure by blocking air flow (radiator shutter) or not providing air flow (fan clutch) in sufficient quantity.

Repair Procedure:

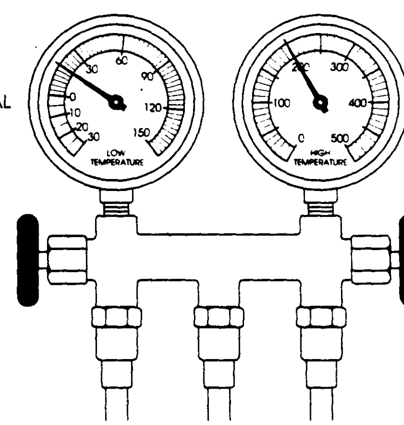
Inspect the condenser for dirt, bugs or other debris and clean if necessary. Be sure the condenser is securely mounted and there is adequate clearance (about 1-1/2 inches) between it and the radiator. Check the radiator pressure cap and cooling system, including the fan, fan clutch, drive belts and radiator shutter assembly. Replace any defective parts and then recheck AC system operation, gauge readings and performance.

If the problem continues, the system may be overcharged (have too much refrigerant inside). Recover the system slowly until low and high pressure gauges read below normal, and bubbles appear in the sight glass. Then add refrigerant (charge the system) until pressures are normal and the bubbles disappear. Add another quarter to half pound of refrigerant and recheck AC system operation, gauge readings and performance.

If the high gauge readings do not change, you should recover all of the refrigerant and flush (it may be partially plugged) or replace the condenser. Also replace the receiver-drier or accumulator. Then connect the components and evacuate the system. Recharge the air conditioner with refrigerant and check system operation and performance.

Figure 8-14
Gauge reading, thermostatic switch malfunction.

Thermostatic Switch Malfunction



Tip: The low side gauge needle may fluctuate in a very narrow range compared to a normal range. The compressor clutch may be cycling on and off more frequently than it should.

The low side gauge needle may fluctuate in an above normal range as the clutch cycles. This may be an indication that the thermostat is set too high (someone may have attempted to adjust the factory setting). A new thermostat may have been installed incorrectly (capillary tube not inserted between the evaporator fins in the proper position).

Cause: The thermostatic switch is not functioning properly or at all.

Repair Procedure:

Replace the thermostatic switch. When you remove the old thermostat, replace it with one of the same type. (They operate in a factory preset temperature range.) Take care in removing and handling the thermostat and thin capillary tube attached to it. Don't kink or break the tube.

Position the new thermostat capillary tube at or close to the same location and seating depth between the evaporator coil fins as the old one. Connect the electrical leads.

Note: See the *Thermostat* section in *Chapter 10.* Fan clutch, radiator shutter, condenser, compressor, and the newer air and water valve control systems are covered in *Chapter 10.*

Review of Frequent Problem Areas

In HVAC systems a limited number of things can go wrong. Moving parts of the compressor, clutch, and expansion valve or refrigerant metering device can malfunction or break down from metal fatigue, contamination, abnormal pressure or lack of lubrication. Electrical connections may corrode, become disconnected or break. Fuses blow from shorts or overload. Belts slip or break.

Vibration from the engine or road surface can work bolts and air or vacuum lines loose, or rub and break or wear parts out. Motors may burn out. The inside of the system can become contaminated from moisture, air or desiccant material breakdown. Refrigerant may leak out of the system quickly or very slowly. Moisture in the system can combine with refrigerant to form acid and attack (corrode) metal parts from the inside. Moisture and refrigeration oil can combine to form sludge that may block refrigerant flow.

The following problems are discussed in more detail in this section:

1. Belts and Compressor Clutch
2. Condenser

3. Refrigerant Lines, Hoses, and Fiftings
4. Refrigerant Metering Valves
5. Other Problems

1. Belts and Compressor Clutch

Let's review problem areas listed at the beginning of *Chapter* 7. The most frequent repairs are replacing belts and servicing or replacing the compressor or clutch. Heavy duty vehicle operation puts a lot of stress on these parts. There are several main reasons.

There is often continuous operation for long periods of time. There may be frequent sudden RPM variations when shifting gears up or down. For this reason the AC clutches used in heavy duty systems usually have double row ball bearings. Vibration and road shock contribute to loose or broken mounting brackets, electrical connections and fittings. Belts, bearings and compressor reed valves wear out.

Various compressor clutch cutout switches are used because the AC designers know about compressor operating conditions. System leaks, high operating pressures, malfunctioning engine cooling system components—all cause compressor problems and failures. When refrigerant and refrigeration oil leaks out of a system or there is contamination blocking oil flow, the compressor will be starved for oil and seize.

2. Condenser

Condensers get dirty and the dirt reduces heat movement by insulating the condenser. The fittings come loose or break from stress if the condenser or connecting hoses are not secured properly to keep the effects of vibration at a minimum.

Heat transfer efficiency and pressure in the condenser are affected by the amount of outside air flowing through condenser fins. A lack of air flow can mean the refrigerant doesn't give up enough heat energy to the outside air (it doesn't change state). The refrigerant arrives at the evaporator as a gas and can't pick up any heat energy from cab air. In the cab, air from the vents is only slightly cool or warm.

One possible cause of condenser malfunction could be the engine cooling system. This is why fan clutches and radiator shutters are often controlled or overridden by AC switch function. In fact, we can add fan clutch, radiator shutters and also fan motors to condenser problems. If they don't function to allow sufficient air through the condenser, pressure inside the system may become dangerously high. A lack of air through the condenser fins can raise high side pressure and blow out the weakest point in a system, or damage the compressor.

3. Refrigerant Lines, Hoses and Fittings

Problems with these parts may be caused by normal deterioration, vibration damage, lack of maintenance or human error (improper installation or replacement). All rubber parts are attacked by ozone (oxygen) in the air. Rubber parts break down slowly and become more vulnerable to the effects of vibration with the passage of time.

Heavy duty vehicle vibration causes stress on all lines, fittings and connections. Regular maintenance includes checking and tightening any suspect line, or hose retainers, or grommet position where the grommet is protecting a line or hose from abrasion. Any insulating material wrapped around hoses must be in place and securely fastened.

4. Refrigerant Metering Valves

When you consider valve problems there are obvious differences in valve construction and what can go wrong. If a valve is clogged with sludge or other obstruction, the result is a valve problem but the cause is contamination in the system. Valves get stuck open or closed, although most often closed when the gas charge is lost from the diaphragm housing in a traditional TXV. The capillary tube can vibrate loose from the evaporator outlet tube. The capillary can break and the small quantity of temperature sensitive gas can escape. The diagnosis of a valve as defective calls for replacement.

5. Other Problems—Leaks, Moisture, and Adding Refrigerant

Before any refrigerant was put inside the AC system, someone used a vacuum pump to evacuate any air and moisture. Vacuum is really a force pulling against all hoses, fittings and components from the inside. When the system is charged with refrigerant, the pressure goes from minus (a vacuum) to plus pressure inside the hoses and all components. The refrigerant and refrigeration oil are trying to escape from the system at all times.

Technicians frequently add refrigerant to a system, replacing refrigerant seepage through system connections or fittings. If the system has been maintained regularly (every three to six months), adding a small amount of refrigerant may result in normal system function. However, the best procedure is to check all connections and look for, find and repair any leaks before adding refrigerant.

When your leak detector indicates the presence of a leak, you can't tell how long the system has been leaking. Finding one leak doesn't mean there are not others. Until you have some AC system work experience, it will be hard to guess how much refrigerant may have leaked. If you have to top a system off with a half pound of refrigerant or more, adding refrigerant is not the answer.

Find the leak. Recover all of the refrigerant and repair the system. The moisture absorbing capacity of any desiccant material is limited and cannot be measured. For that reason, replace the receiver-drier or accumulator. Then evacuate the system for an hour and recharge with refrigerant.

When a compressor shaft seal has leaked oil and the refrigerant charge is a little low, the shaft seal may have leaked because the air conditioner was not used. The seal can get a little out of round from the weight of the crankshaft and leak above the shaft. Running the compressor may cause the seal to swell and close up the leak. The shaft rotation exerts force all around the seal and puts life back into it. To prevent this from happening, manufacturers recommend regular AC system operation a minimum of every couple of weeks even in cool weather.

Keep in mind that the compressor can cause a vacuum inside the system if there is a restriction in the system. That means it can suck air and moisture inside under some conditions. It will pull these contaminants in through the same space where refrigerant and refrigerant oil has leaked out.

Conclusion

What could the air conditioning problem and it's cause have been at the beginning of this chapter? The operator was in a hurry, but you were able to start your troubleshooting with the answers he gave you. Problems your inspection may have turned up are a very low refrigerant charge, a contaminated system or defective compressor. Those are not quick fix jobs.

On the other hand, you might have found enough debris on the condenser fin surface to boost high side pressures to an abnormal level during the hottest part of the day. So the Trinary™ or high pressure switch would cut out from high pressure—but reset itself. You cleaned the condenser, added a half pound of refrigerant and AC system pressures and function returned to normal. Service and repair took a half hour. But there was no way to tell without using your knowledge and experience. By now you are pretty familiar with AC system problems, the reasons for some of them, troubleshooting and repair. In *Chapter* 9 we will describe complete system purging, evacuation, flushing and recharging.

Chapter 9 Refrigerants

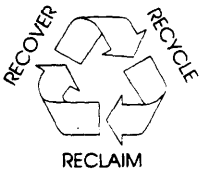
- Description and Properties of Refrigerants
- Changes in Service Procedures
- Recovering and Recycling the Refrigerant
- Flushing the AC System
- Evacuating and Charging the AC System
- Reclaiming a Refrigerant
- Chapter Review

Description and Properties of Refrigerants

Refrigerants are contained in the closed system of an air conditioner and circulate under pressure, moving heat energy from the cab to the outside air. Different refrigerants require different operating pressures, causing the refrigerant to undergo a "change of state" .

Changes in Service Procedures

Since the beginning of 1992, the EPA has required that any refrigerant removed from an AC system be recovered and recycled before reuse. Unlike the purging process which releases ozone depleting refrigerant into the atmosphere, the recovery processes allow us to use the same refrigerant over and over.



A major difference between purge and recovery/recycle procedures is the refrigerant is contained in an externally sealed container when undergoing recovery/ recycle procedures in order to ensure environmentally safe processing.

In order to reuse a refrigerant in an AC system, the following steps are required:

1. Prepare the station for the recovery process
2. Recover refrigerant from the AC system
3. Recycle the recovered refrigerant
4. Perform the maintenance or repair the system
5. Flush the AC system when necessary
6. Evacuate the AC system
7. Charge the AC system with recycled refrigerant

Recycling the refrigerant involves the following processes:

- **Recovery** — You recover a refrigerant when you remove it from an AC system (in order to repair or replace a component) and then store, transport, recycle, or reclaim it. This is a closed loop process. The recovered refrigerant may vary in quality. Refer to the *Recovering and Recycling the Refrigerant* section for a complete description of the recovery process.
- **Recycle** — You recycle a refrigerant when you remove contaminants such as moisture, acidity, and particulate matter. Many refrigerants are reusable at this stage. Refer to the *Recovering and Recycling the Refrigerant* section for a complete description of the recycle process.
- **Reclaim** — You reclaim a refrigerant when you send it to an outside facility which can restore it to a new product specification. This reprocessing usually includes both a chemical analysis and distillation of the recycled refrigerant. Refer to the *Reclaiming the Refrigerant* section for a complete description of the recycle process.

Recharging an AC system requires the following procedures:

- **Flush** — You flush certain AC system components and hoses to remove contaminants within them. Flushing prepares the AG system for the new refrigerant. Refer to *Flushing the AC System* section below.
- **Evacuate** —You evacuate the AC system to remove moisture and air. Refer to the *Evacuating and Charging the AC System* section below.
- **Charge** — You charge the AC system by adding new refrigerant to the system.

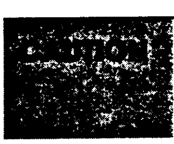
Recovering and Recycling the Refrigerant

Recovery/Recycle Station

When troubleshooting indicates that a component in a closed AC system be replaced or removed for service, refrigerant must be removed from the system. A handy, dual purpose station performs both recovery and recycle procedures allowing us to follow the new guidelines for handling used refrigerant. The recovered refrigerant can then be recycled to reduce contaminants, and reused.

Equipment is also available to just remove or extract the refrigerant. Extraction equipment does not clean the refrigerant. It is used to recover the refrigerant from an AC system prior to servicing.

To accomplish this, the recovery/recycle station separates the oil from the refrigerant and filters the refrigerant multiple times to reduce moisture, acidity, and particulate matter found in a used refrigerant.



Mixing refrigerant types damages equipment. Dedicate one recovery/recycle station to each type of refrigerant processing to avoid equipment damage.

Figure 9-1 shows a recovery/recycle machine. Recycle equipment must meet certain standards as published by the Society of Automotive Engineers and carry a UL approved label. The basic principles of operation remain the same for all machines, even if the details of operation differ somewhat.

Figure 9-1
Recycle station.

A full system recovery is not necessary when you service or replace a compressor with stem type service valves. These valves may be front seated to isolate the rest of the AC system from the compressor. The refrigerant stays in the system and only the refrigerant in the compressor is recovered, recycled and replaced.

Note: Keep the collection cylinder in an upright position for the duration of the recovery/recycle cycle to ensure no liquid is drawn back into the system.

Draining the Oil from the Previous Recovery Cycle

In preparation for recovery, do the following:

1. Place the power switch and the controller on the recovery unit in the OFF position.
2. Plug in the recovery station to the correct power source.
3. Drain the recovered oil through valve marked OIL DRAIN on the front of the machine.
4. Place the controller knob in the ON position. The low pressure gauge will show a rise.
5. Immediately switch to the OFF position and allow the pressure to stabilize. If the pressure does not rise to between 5 psig and 10 psig, switch the controller ON and OFF again. With practice, this procedure should become easier.

6. When the pressure reaches 5 to 10 psig, open the OIL DRAIN valve, collect oil in an appropriate container, and dispose of container as indicated by local, state, or Federal Regulation. THE OIL IS NOT REUSABLE, DUE TO CONTAMINANTS ABSORBED DURING ITS PREVIOUS USE.

Performing the Recovery Cycle

You are now ready to recover. Follow these steps:

1. Be sure the equipment you are using is designated for the refrigerant you intend to recover.
2. Record the sight glass oil level. Having drained it, it should be zero.
3. Check the cylinder refrigerant level before beginning recovery to make sure you have enough capacity.
4. Confirm that all shut-off valves are closed before connecting to the AC system.
5. Attach the appropriate hoses to the system being recovered.
6. Start the recovery process by operating the equipment as per the manufacturer's instructions.
7. Continue extraction until a vacuum exists in the AC system.
8. If an abnormal amount of time elapses after the system reaches 0 psig and does not drop steadily into the vacuum range, close the manifold valves and check the system pressure. If it rises to 0 psig and stops, there is a major leak. Refer to *Chapter 8* for troubleshooting leak procedures.
9. Check the system pressure after the recovery equipment stops. After five minutes, system pressure should not rise above "0" gauge pressure. If the pressure continues to rise, restart and begin the recovery sequence again. This cycle should continue until the system is void of refrigerant.
10. Check the sight glass oil level to determine the amount of oil that needs to be replaced.
11. Mark the cylinder with a RECOVERED (red) magnetic label to reduce the chance of charging a system with contaminated refrigerant. Keep a record of the amount of refrigerant recovered, if you have the capability.

WARNING

Check the sight glass oil level to determine the amount lost during recovery. You must add this amount of oil back into the system.

Performing the Recycling Procedure

The recovered refrigerant contained in the cylinder must undergo the recycle procedure before it can be reused. The recycle or clean mode is a continuous loop design and cleans the refrigerant rapidly. Follow equipment manufacturer's instructions for this procedure.

Purging Non-Condensable Gases (Air)

During purging and refrigerant recovery air can be entrapped in the refrigerant container. Air must not be put into an AC system. The result is higher operating pressures and possible system damage.

A simple check can be performed as follows:

1. Store the recovered refrigerant at constant temperatures above 650 deg. F (18.7C). The container should include a pressure gauge reading to 1 psi increments. The container should not be in direct sunlight or near a heat source.
2. Use a calibrated thermometer to establish temperature within 4 inches of the container.
3. Compare the pressures for like temperatures in Figure 9-2. If the container pressure is equal to or less than the pressure shown in the table, excess air is not present.
4. If container pressure is greater than shown in the table, connect the container to recovery or recycle equipment with the pressure gauge in place.
5. Bleed a small amount of vapor from the container until the pressure is below that shown on the table, then close the valve.
6. Tank temperature may change during the bleed off process. Mild shaking will assist in temperature stabilizing, but it is a good idea to let it set for several hours before again checking pressure against the table.
7. If the pressure remains above that shown on the table, excess air or another contaminant (i.e., another refrigerant) is still present. This material must be recycled or reclaimed.
8. If the pressure is equal or below that shown on the table identify the cylinder as “recycled.”

R-134a Allowable Container Pressure

° F	Psig	° F	Psig	° F	Psig	° F	Psig	° F	Psig
65	69	76	85	87	103	98	125	109	149
66	70	77	86	88	105	99	127	110	151
67	71	78	88	89	107	100	129	111	153
68	73	79	90	90	109	101	131	112	156
69	74	80	91	91	111	102	133	113	158
70	76	81	93	92	113	103	135	114	160
71	77	82	95	93	115	104	137	115	163
72	79	83	96	94	117	105	139	116	165
73	80	84	98	95	118	106	142	117	168
								118	171
74	82	85	100	96	120	107	144	119	173
75	83	86	102	97	122	108	146	120	176
° C	**kPa**	**° C**	**kPa**	**° C**	**kPa**	**° C**	**kPa**	**° C**	**kPa**
18	476	25	593	32	752	39	917	46	1124
19	483	26	621	33	765	40	945	47	1158
20	503	27	642	34	793	41	979	48	1179
21	524	28	655	35	814	42	1007	49	1214
22	545	29	676	36	841	43	1027		
23	552	30	703	37	876	44	1055		
24	572	31	724	38	889	45	1089		

Figure 9-2
The pressures in these English and metric charts refer to recycled and R-134a refrigerant.

Flushing the AC System

Flushing has long been recommended as a means of removing contaminants or other debris from certain system components. The normal flushing materials, such as R-11, are now prohibited.

Using compressed air is not a good method of flushing. Air should never be used in an R-134a system. Closed loop flushing kits are now available, although they may not remove all foreign material.

The primary use of a flushing kit is to remove contaminants from the AC system hoses, evaporator, and condenser. Any other component of an AC system should be bench checked or replaced, since flushing may be ineffective or may damage a component. Flushing is usually performed after the recovery process. We recommend it before you replace the compressor, or when you find contamination in other components (receiver-drier, expansion valve, or connections). Some recover/recycle machines have optional "flush kits." The only proper way to flush system components is to use refrigerant in a closed-loop system.

Evacuating and Charging the AC System

Evacuate the system once the air conditioner components are repaired or replacement parts are secured, and the AC system is reassembled. Evacuation removes air and moisture from the system. Then, the AC system is ready for the charging process, which adds new refrigerant to the system.

Evacuating the System

Follow this procedure:

1. Tighten all connections and attach a vacuum pump to the center hose of the gauge set.

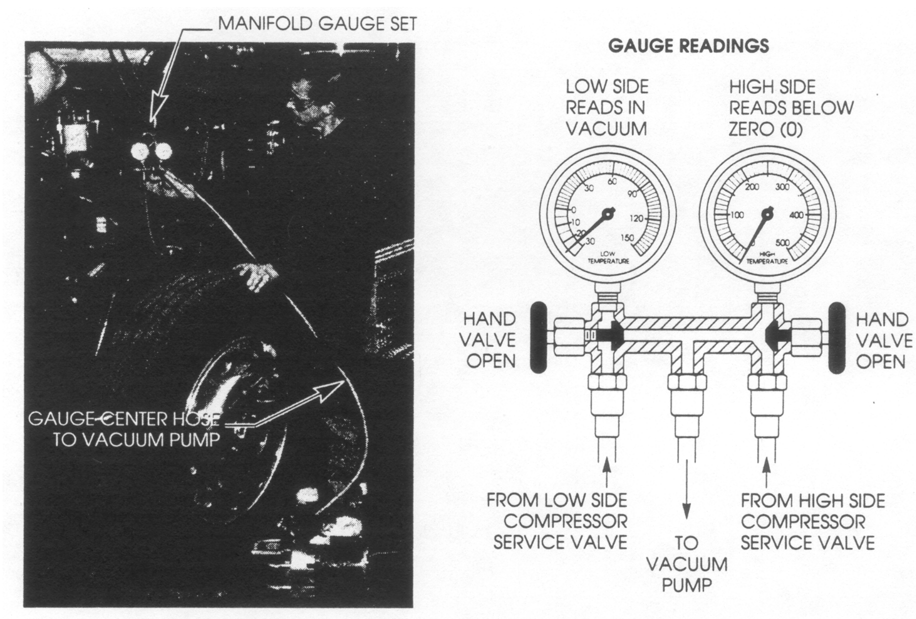


Figure 9-3
This illustration shows evacuation of an AC system before recharging. It is very important to run the vacuum pump long enough to insure the removal of any moisture that may be in the system.

2. Start the vacuum pump and open both the hand valves on the manifold all the way. Run the pump for five minutes, then close the hand valves and shut off the pump.
3. Check the gauge readings for five minutes. If the gauge needles move up, the system is not sealed. There is a leak. Air and moisture are being sucked into the system by the vacuum.
4. Tighten any loose connections. Re-start the pump, and open the hand valves on the gauges again. Repeat the vacuum test.

5. Run the vacuum pump for at least an hour to remove the moisture from the system.

The moisture must turn to gas before the pump can pull it out. The moisture takes time to boil away, so that it can be drawn out of the system.

Your vacuum pump can draw most of the air out pretty quickly. But a deep vacuum requires more time; the deeper the vacuum the longer it takes to get there. To ensure the least possible amount of air and moisture in the system, buy a good quality vacuum pump, take care of it, and use it *for at least an hour.*

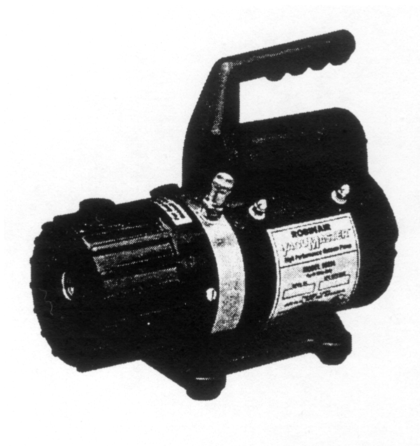


Figure 9-4
Vacuum Pump.

WARNING Lubricants removed during the recovery process must be replaced with new lubricants.

Charging the AC system

*Use a charging station whenever possible.

When adding a full charge of refrigerant, you can put it in as a gas or as a liquid. Adding refrigerant as a liquid is faster but can damage the compressor if not done correctly. The procedure you use, and where you add the refrigerant in the AC system makes a difference. When using refrigerant as a liquid, never add more than two thirds of system requirements as a liquid. Finish charging the system using gas. Always keep the refrigerant containers in an upright position so that no liquid is drawn into the system.

Refer to the *Charging with Refrigerant Gas* section below for the procedure for gas charging. Refer to the *Charging the System with Liquid Refrigerant* section for the procedure for liquid charging.

Charging with Refrigerant Gas (on the Low Side)

Perform this procedure to charge with refrigerant gas:

1. Use a charging meter or station to select the exact amount of refrigerant required. Never add more than the amount of refrigerant recommended by the manufacturer (in pounds and ounces). To measure, use a container and scale, or charging station.

2. Connect the center service hose from the gauge set to the refrigerant container dispensing valve. Purge the hose of any air using refrigerant gas pressure from the container.
3. Run the engine at 1200 to 1500 RPM, with the AC unit on maximum cool.
4. Open the dispensing valve, then the low side hand valve on the manifold. Figure 9-5 illustrates system charging with refrigerant gas entering the compressor on the suction (low pressure) side of the system.

Note: If there are no manufacturer's charging specifications, you can watch the sight glass first for bubbles, then clearing.

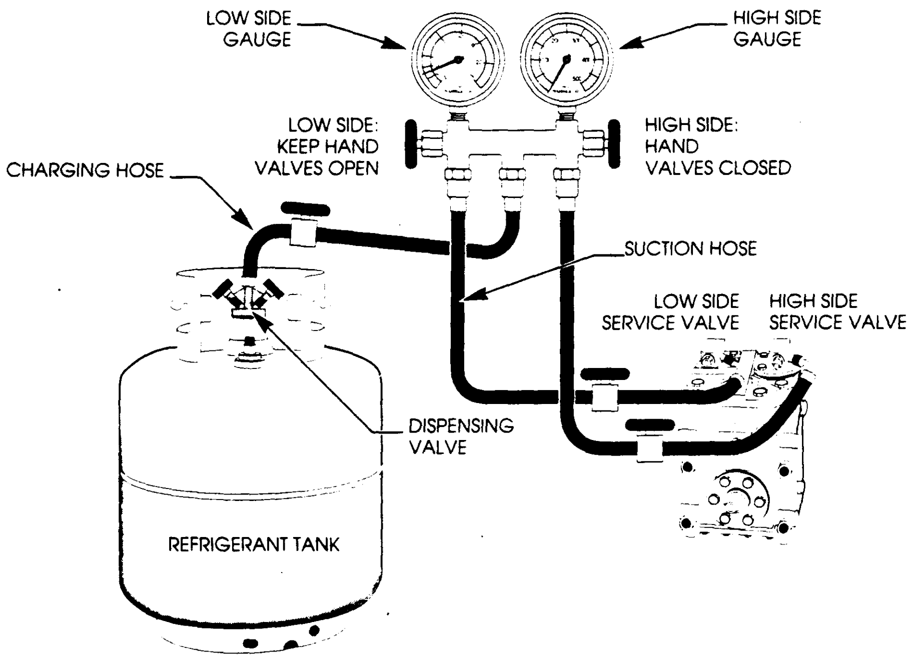


Figure 9-5
In this illustration, refrigerant is added on the low side of the system as a gas. The engine must be running at 1200 to 1500 RPM to draw the gas in.

5. Check the sight glass when you have added nearly the specified amount of refrigerant. Keep adding refrigerant until the sight glass clears or you have added the specified refrigerant charge. Use an oil injector to replace oil drained from the system. Remember, a large leak may have resulted in nearly all the lubricant being lost.
6. Close the valve on the refrigerant container. Close the hand valve on the gauge set and check the gauge readings. The gauges should read in the normal range.
7. Turn off the engine and AC system. Check for leaks. If the system checks out OK, back seat the service valves. Remove the manifold gauge set hose fittings from the compressor. If Schrader valves are in use, be sure to remove the manifold hose fittings quickly and carefully, using a glove or shop towel to protect your hand. Replace the protective caps on the compressor service valves.

Charging the System with Liquid Refrigerant

This process is used as a time-saver, but requires much more care to avoid compressor damage.

1. Check the amount of refrigerant recovered, and add approximately two thirds of that amount, and no more than recommended by the manufacturer (in pounds and ounces).
2. Connect the center service hose from the gauge set to the refrigerant container dispensing valve.
3. Add refrigerant liquid through the compressor discharge service valve (high side of system). If an accumulator is used, add the liquid refrigerant (and gas during final charging) via a Schrader valve.
4. Open the refrigerant dispensing valves and hand valves on the hose and gauge set. Liquid refrigerant flows into the system.

Figure 9-6 illustrates how to connect the manifold gauge set when adding liquid at the compressor (or accumulator).

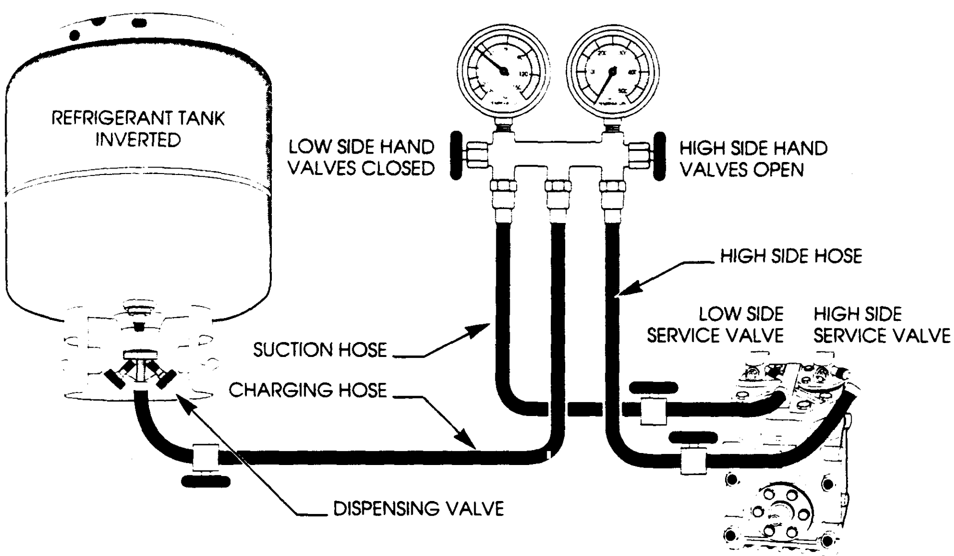


Figure 9-6

Adding refrigerant liquid to partially charge the AC system is illustrated and described.

5. When you have added two thirds of the recorded, actual recovered amount of refrigerant, shut off the refrigerant supply. If you added liquid refrigerant at the compressor high side service fitting, there may be liquid in the compressor. Attach a wrench to the nut holding the clutch the compressor shaft. Turn the compressor shaft a few times in the direction of normal rotation to clear any liquid from the compressor.
6. Finish charging the system with refrigerant gas by starting the engine and AC system. Follow the procedure for charging with gas as shown in Figure 9-5.

Reclaiming Refrigerant

Reclaiming refrigerant reprocesses the material to virgin purity. For sources of reclaimed refrigerant or to send refrigerant for reclamation, contact the EPA, the independent industry organizations, or your state's Department of Ecology.

Chapter Review

- Common refrigerants have varying properties and operating pressures.
- New laws require that we standardize our refrigerant processing methods throughout the industry. This includes the processes that handle refrigerant, including **recovering** and **recycling,** which are the most economic and environmentally friendly ways of handling the refrigerant.
- **Recovery/recycle** processes deal directly with the refrigerant. During **recovery** the refrigerant is removed from the AC system. During **recycling** it is restored to reusable condition by removing moisture, acidity, and particulate matter.
- The **flushing** procedure removes contaminants from the AC system hoses, evaporator, and condenser. The **evacuation** process removes air and moisture from the AC system. This is necessary before adding new or recycled refrigerant. The process of adding refrigerant is called **charging.**
- **Reclaiming** a refrigerant means processing the refrigerant so that it meets standards for new refrigerant.

APPENDIX C

MASTER REPAIR MANUAL
AIR COMPRESSORS

Foreword

This repair manual provides complete service information for the air compressors. This publication includes installation guidelines, troubleshooting and rebuild procedures, and specifications.

The repair procedures used in this manual are recommended by engine manufacturer. Some procedures require the use of special service tools. Use the correct tools as described.

The latest technology and the highest quality components are used to manufacture the compressor. When replacement parts are needed, use only genuine exchange parts from the manufacturer.

Table of Contents

NOTES

Section i - Introduction

Section Contents

About the Manual

This manual provides complete service information for troubleshooting, and rebuilding the air compressors. The procedures were developed to provide optimum performance and to minimize maintenance.

How to Use the Manual

This repair manual is divided into sections for installation guidelines, troubleshooting, and repair and rebuild. Refer to TM 5 3810-307-24-2-2 for procedures to remove the air compressor from the engine.

The troubleshooting section provides the troubleshooting symptom charts necessary for accurate diagnosis of air compressor complaints. A list of troubleshooting symptoms on Page T-1 outlines the most common complaints. Complete the following steps to locate and correct an air compressor complaint:

1. Locate the symptom on the list on Page T-1. Refer to the appropriate symptom tree on the page listed.

2. Follow the left column in the order provided to locate the cause of the symptom. The boxes are arranged to guide the technician through the most common causes and easiest repairs first.

3. Refer to the right column for procedures to verify and correct the possible causes. These boxes refer to procedures in Section 12 - Compressed Air System.

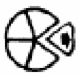
The repair and rebuild procedures are outlined in Section 12 - Compressed Air System. When necessary, the procedures will show different steps for different air compressor models. The rebuild procedures are at the end of this section and include the disassemble and assemble steps.

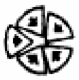
Symbols

The following group of symbols have been used in this manual to help communicate the intent of the instructions. When one of the symbols appears, it conveys the meaning defined below:


WARNING - Serious personal injury or extensive property damage can result if the warning instructions are not followed.


CAUTION - Minor personal injury can result or a part, an assembly, or the engine can be damaged if the caution instructions are not followed.

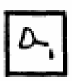

Indicates a **REMOVAL** or **DISASSEMBLY** step.

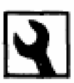

Indicates an **INSTALLATION** or **ASSEMBLY** step.


INSPECTION is required.


CLEAN the part or assembly.


PERFORM a mechanical or time **MEASUREMENT**.


LUBRICATE the part or assembly.

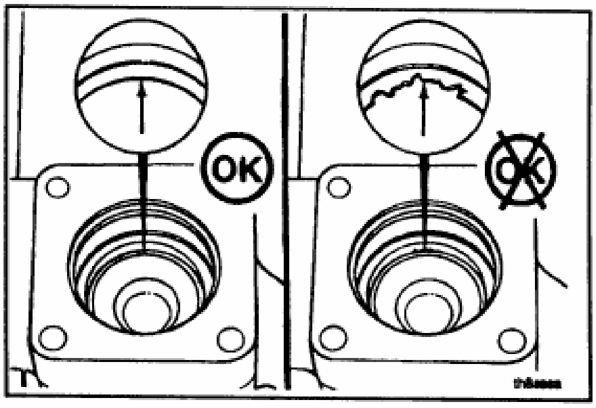

Indicates that a **WRENCH** or **TOOL SIZE** will be given.

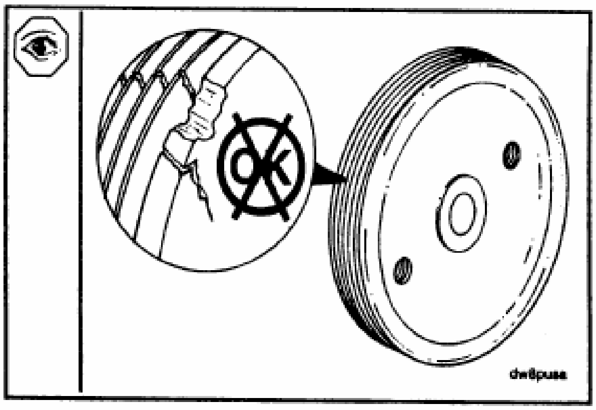

TIGHTEN to a specific torque.


PERFORM an electrical **MEASUREMENT**.


Refer to another location in this manual or another publication for additional information.


The component weighs 23 kg [50 lb] or more. To avoid personal injury, use a hoist or get assistance to lift the component.





Illustrations

The illustrations used in this manual are intended to give an example of how to perform the action or the repair being described. Many of the illustrations are common and will not look exactly like the parts used in your air compressor. Most of the illustrations contain symbols to indicate an action required or to indicate an **acceptable (OK)** or **unacceptable (Not OK)** condition.

General Safety Instructions

Important Safety Notice

WARNING

Improper practices or carelessness can cause burns, cuts, mutilation, asphyxiation or other bodily injury or death.

Read and understand all of the safety precautions and warnings before performing any repair. This list contains the general safety precautions that must be followed to provide personal safety. Special safety precautions are included in the procedures when they apply.

- Make sure the work area surrounding the product is dry, well lit, ventilated; free from clutter, loose tools, parts, ignition sources and hazardous substances. Be aware of hazardous conditions that can exist.
- **Always** wear protective glasses and protective shoes when working.
- Rotating parts can cause cuts, mutilation or strangulation.
- Do **not** wear loose-fitting or torn clothing. Remove all jewelry when working.
- Disconnect the battery (negative [-I cable first) and discharge any capacitors before beginning any repair work. Disconnect the air starting motor if equipped to prevent accidental engine starting. Put a "Do **Not** Operate" tag in the operator's compartment or on the controls.
- Use ONLY the proper engine barring techniques for manually rotating the engine. Do **not** attempt to rotate the crankshaft by pulling or prying on the fan. This practice can cause serious personal injury, property damage, or damage to the fan blade(s) causing premature fan failure.
- If an engine has been operating and the coolant is hot, allow the engine to cool before you slowly loosen the filler cap and relieve the pressure from the cooling system.
- Do **not** work on anything that is supported ONLY by lifting jacks or a hoist. **Always** use blocks or proper stands to support the product before performing any service work.
- Relieve all pressure in the air, oil, and the cooling systems before any lines, fittings, or related items are removed or disconnected. Be alert for possible pressure when disconnecting any device from a system that utilizes pressure. Do **not** check for pressure leaks with your hand. High pressure oil or fuel can cause personal injury.
- To prevent suffocation and frostbite, wear protective clothing and ONLY disconnect liquid refrigerant (freon) lines in a well ventilated area. To protect the environment, liquid refrigerant systems **must** be properly emptied and filled using equipment that prevents the release of refrigerant gas (fluorocarbons) into the atmosphere. Federal law requires capture and recycling refrigerant.
- To avoid personal injury, use a hoist or get assistance when lifting components that weigh 23 kg [50 Ib] or more. Make sure all lifting devices such as chains, hooks, or slings are in good condition and are of the correct capacity. Make sure hooks are positioned correctly. **Always** use a spreader bar when necessary. The lifting hooks **must not** be side-loaded.
- Corrosion inhibitor contains alkali. Do not get the substance in your eyes. Avoid prolonged or repeated contact with skin. Do **not** swallow internally. In case of contact, immediately wash skin with soap and water. In case of contact, immediately flood eyes with large amounts of water for a minimum of 15 minutes. IMMEDIATELY CALL A PHYSICIAN. KEEP OUT OF REACH OF CHILDREN.
- Naptha and Methyl Ethyl Ketone (MEK) are flammable materials and **must** be used with caution. Follow the manufacturer's instructions to provide complete safety when using these materials. KEEP OUT OF REACH OF CHILDREN.
- To avoid burns, be alert for hot parts on products that have just been turned OFF, and hot fluids in lines, tubes, and compartments.
- **Always** use tools that are in good condition. Make sure you understand how to use them before performing any service work. Use ONLY genuine Cummins or Cummins Recon® replacement parts.
- **Always** use the same fastener part number (or equivalent) when replacing fasteners. Do not use a fastener of lessor quality if replacements are necessary.
- Do not perform any repair when fatigued or after consuming alcohol or drugs that can impair your functioning.
- Some state and federal agencies in the United States of America have determined that used engine oil can be carcinogenic and can cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil.

General Repair Instructions

This engine incorporates the latest diesel technology; yet, it is designed to be repaired using normal repair practices performed to quality standards.

WARNING

The manufacturer does not recommend or authorize any modifications or repairs to engines or components except for those detailed in the service literature. In particular, unauthorized repair to safety-related components can cause personal injury. Below is a partial listing of components classified as safety-related.

Air Compressor
Air Controls
Air Shutoff Assemblies
Balance Weights
Cooling Fan
Fan Hub Assembly
Fan Mounting Bracket(s)
Fan Mounting Capscrews
Fan Hub Spindle
Flywheel
Flywheel Crankshaft Adapter
Flywheel Mounting Capscrews
Fuel Shutoff Assemblies
Fuel Supply Tubes
Lifting Brackets
Throttle Controls
Turbocharger Compressor Casing
Turbocharger Oil Drain Line(s)
Turbocharger Oil Supply Line(s)
Turbocharger Turbine Casing
Vibration Damper Mounting Capscrews

- **Follow All Safety Instructions Noted in the Procedures.**
  - Follow the manufacturer's recommendations for cleaning solvents and other substances used during the repair of the engine. Always use good safety practices with tools and equipment.
- **Provide A Clean Environment and Follow the Cleaning Instructions Specified in the Procedures**
  - The engine and its components **must** be kept clean during any repair. Contamination of the engine and components will cause premature wear.
- **Perform the Inspections Specified in the Procedures.**
- **Replace all Components or Assemblies Which are Damaged or Worn Beyond the Specifications**
- **Use Genuine Service Parts and Assemblies**
  - The assembly instructions have been written to use again as many components and assemblies as possible. When it is necessary to replace a component or assembly, the procedure is based on the use of new components.
- **Follow The Specified Disassembly and Assembly Procedures to Avoid Damage to the Components.**

General Cleaning Instructions

Solvent and Acid Cleaning

Several solvent and acid-type cleaners can be used to clean the engine parts. Cummins Engine Company, Inc. does not recommend any specific cleaners. Always follow the cleaner manufacturer's instructions.

Experience has shown that the best results can be obtained using a cleaner that can be heated to 90 to 95 degrees Celsius [180 to 200 degrees Fahrenheit. A cleaning tank that provides a constant mixing and filtering of the cleaning solution will give the best results.

Remove all the gasket material, 0-rings, and the deposits of sludge, carbon, etc., with a wire brush or scraper before putting the parts in a cleaning tank. Be careful not to damage any gasket surfaces. When possible, steam clean the parts before putting them in the cleaning tank.

WARNING

The use of acid can be extremely dangerous to personnel, and can damage the machinery. Always provide a tank of strong soda water as a neutralizing agent**.**

Rinse all of the parts in hot water after cleaning. Dry completely with compressed air. Blow the rinse water from all of the capscrew holes and the oil drillings. If the parts are not to be used immediately after cleaning, dip them in a suitable rustproofing compound. The rustproofing compound must be removed from the parts before installation on the engine.

Steam Cleaning

Steam cleaning can be used to remove all types of dirt that can contaminate the cleaning tank. It is a good way to clean the oil drillings.

WARNING

Wear protective clothing to prevent personal injury from the high pressure and extreme heat.

Do not steam clean the following parts:

1. Electrical Components and electrical wiring
2. Injectors and fuel pump
3. Belts and Hoses
4. Bearings

Glass or Plastic Bead Cleaning

Glass or plastic bead cleaning can be used on many engine components to remove carbon deposits. The cleaning process is controlled by the size of the glass or plastic beads, the operating pressure, and the cleaning time.

CAUTION

Do not use glass or plastic bead cleaning on aluminum piston skirts. Do not use glass bead cleaning on aluminum ring grooves. Small particles of glass or plastic will embed in the aluminum and result in premature wear. Valves, turbocharger shafts, etc., can also be damaged. Follow the cleaning directions listed in the procedures.

NOTE

Plastic bead blasting media, Part No. 3822735, can be used to clean aluminum ring grooves. Do **not** use any bead blasting media on pin bores or aluminum skirts.

The following guidelines can be used to adapt to manufacturer's instructions:

1. Bead size: - Use U.S. size No. 16-20 for piston cleaning with plastic bead media, Part No. 3822735.
   - Use U.S. size No. 70 for piston domes with glass media.
   - Use U.S. size No. 60 for general purpose cleaning with glass media.
2. Operating Pressure: - Glass: Use 620 kPa [90 psi] for general purpose cleaning.
   Plastic: Use 270 kPa [40 psi] for piston cleaning.
3. Steam clean or wash the parts with solvent to remove all of the foreign material and glass or plastic beads after cleaning. Rinse with hot water. Dry with compressed air.
4. Do **not** contaminate the wash tanks with glass or plastic beads.

Definition of Terms

BDC: Bottom Dead Center; refers to the position of the piston or the crank shaft rod journal. The piston is at its lowest position in the cylinder.
Inside Diameter

End Clearance: The clearance in an assembly determined by pushing the shaft in an axial direction one direction, and then pushing the shaft the opposite direction.

MAX: Maximum allowed.

MIN: Minimum allowed.

No.: Number

O.D.: Outside Diameter

T.I.R.: Total Indicator Reading; referred to when measuring the concentricity or the run out. The TIR refers to the total movement of the needle on a dial indicator, from the most negative reading to the most positive reading.

Section E - Component Identification

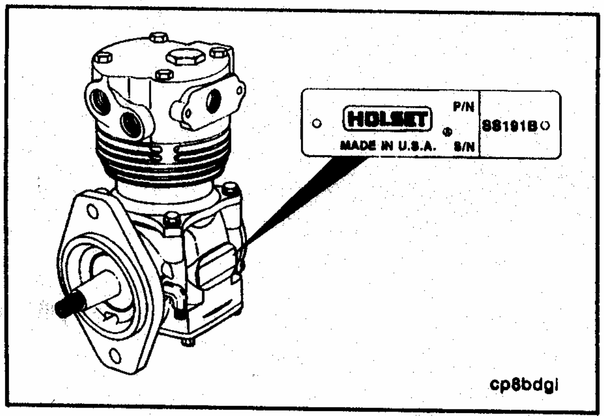
Section Contents

Component Identification

Identification

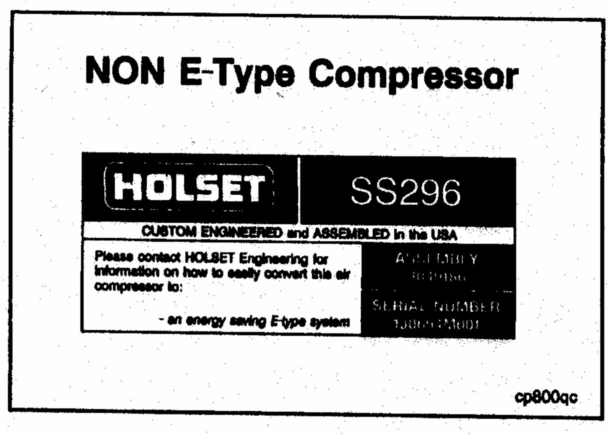
NOTE

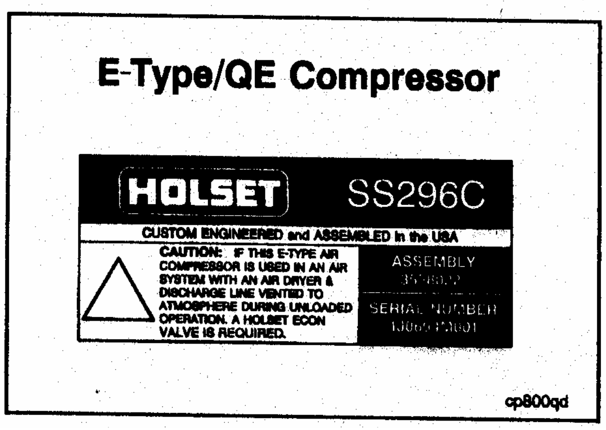
The dataplate is located on the side of the crankcase. Always write the assembly number of the air compressor and the air compressor model number on all orders for parts.



NOTE

The air compressor dataplate must not be changed.





Air compressor date code (S/N):

<u>1</u>	<u>D</u>	<u>16</u>	<u>91</u>	<u>M</u>	<u>001</u>
Shift:	**Month:**	**Day of the Month**	**Year (Last 2 Digits)**	**Plant: M-Madison B-Brazil**	**Serialization (Optional)**
1	A Jan				
2	B Feb				
	C Mar				
	D Apr				
	E May				
	F Jun				
	G Jul				
	H Aug				
	J Sep				
	K Oct				
	L Nov				
	M Dec				

Section F - Familiarization

Section Contents

General Information

The air compressor is an engine-driven, piston-type compressor which supplies compressed air to operate air powered devices. The compressor runs continuously but has loaded and unloaded operating modes. The operating mode is controlled by a pressure activated governor and the compressor unloading assembly. When the air system reaches cut-out pressure, the governor applies an air signal to the air compressor unloader assembly causing the unloader cap valve to activate and stops compressed air from flowing into the air system. As the air in the air system is used, the pressure drops. At cut-in pressure, the governor exhausts the air signal to the compressor unloader assembly, allowing the compressor to again pump compressed air into the air system.

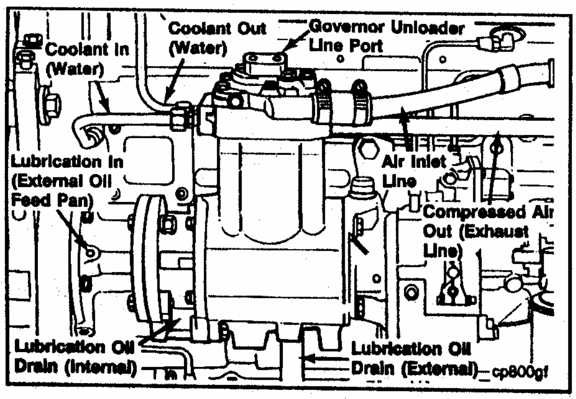
- The E-Type (E for economy) unloader differs in that the intake is closed by the unloader cap during the unloaded mode. Back pressure on the exhaust valve at the same time traps air in the cylinder causing the piston to move against an air spring, thereby reducing parasitic horsepower draw in the unloaded mode. Additional benefits include reduced oil passage, cooler exhaust air temperature and unlimited turbocharger boosting capability. For more information on E-type systems, refer to Service Bulletin No. 3666104, Air Compressor Familiarization – Holset E-Type.

NOTE

The E-Type System can require modification to the vehicle air system plumbing if an air dryer vented to the atmosphere during the unloaded mode is used on the vehicle. All QE Model Air Compressors utilize the E-Type unloader.

Section G - Installation Guidelines

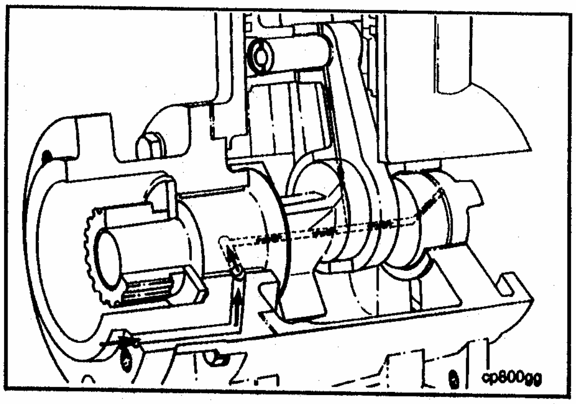
Section Contents



Recommended Installation Guidelines

Following the installation guidelines can greatly affect and enhance functional performance, operating efficiency, and useful product life of an engine accessory or brake system component.

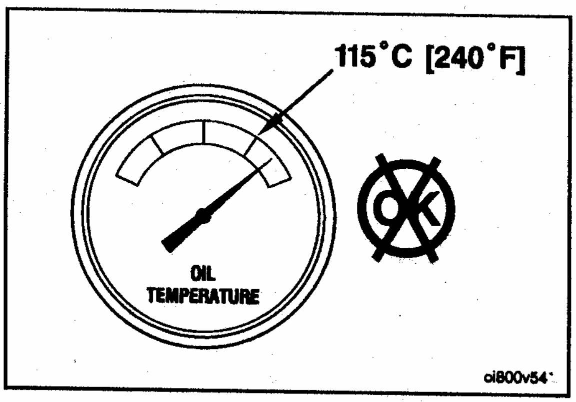
Following these recommended installation guidelines for air compressors will help provide reliable, service free operation well beyond the product warranty period.



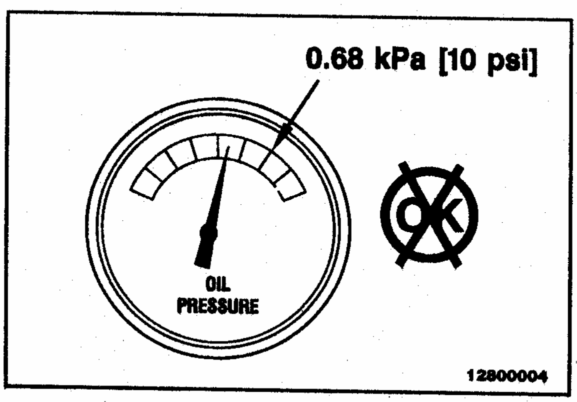
Lubrication System

Air compressors are lubricated with pressurized engine oil. The oil provides both a lubrication and cooling medium for bearings, piston rings and cylinder walls.

For optimum air compressor performance, the following lubrication system guidelines are provided:

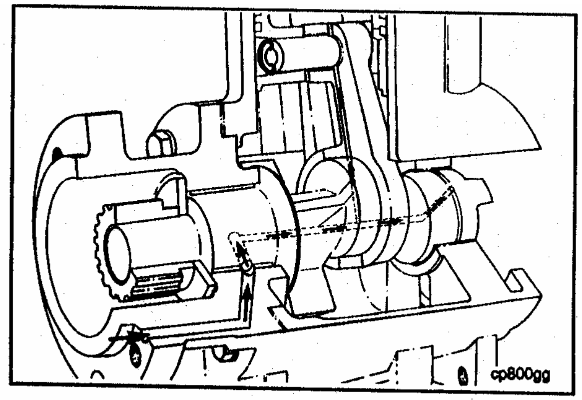


Oil Temperature: Must not exceed 115°C [240°F] to provide proper lubrication capability. Higher operating temperatures will reduce cooling effects on the compressor and cause oil breakdown, and result in shortened compressor life.



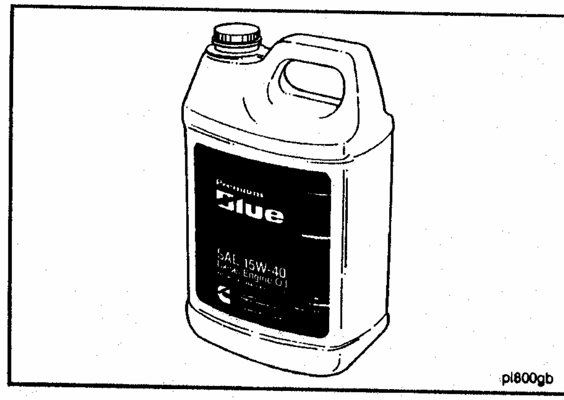
Oil Pressure: Maintain a minimum oil pressure of 0.68 kPa [10 psi]. Lower pressure can result in a lack of lubrication on critical bearing surfaces, and shorten compressor life.

Oil Supply: Engine oil supply is provided either internally or externally to the compressor. Flange mount models can have internal or external oil supply sources, while base mount models are provided with external oil supply only. When an external supply is used, a minimum of 3.18 mm [0.125 in] inside diameter (ID) line size must be used to provide adequate oil flow.



The supply line **must** be free of sharp bends or kinks which can cause flow restrictions. The oil supply source must be taken immediately after oil filtration from the engine for best results.

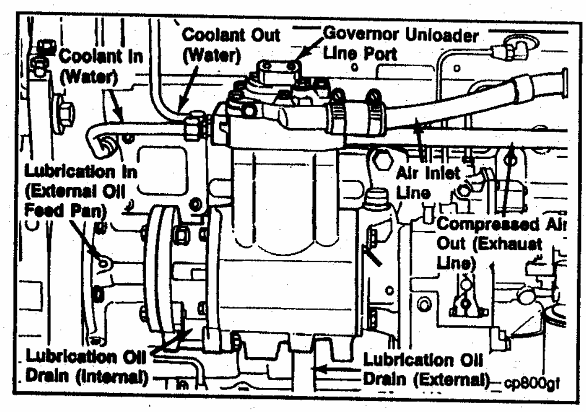
Oil Change Interval: Use the oil drain interval specified for a particular engine model. The use of a high quality SAE 15W40 heavy duty engine oil which meets the American Petroleum Institute (API) performance classifications CE or CF-4 is recommended.



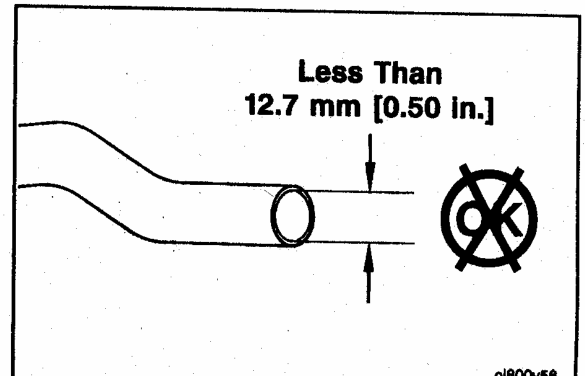
NOTE

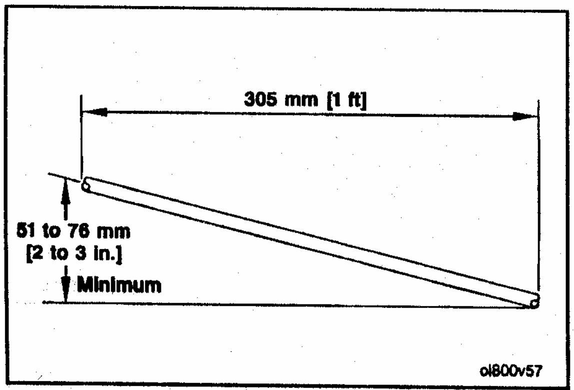
When operating in extreme environments where very high or very low temperatures or airborne dirt or dust is present, consider much shorter oil change intervals consistent with engine manufacturer recommendations.

Oil Drain: Compressor oil drainage is critical to prevention of oil consumption. Flange mount compressor models provide either internal or external oil drainage. Base mount model provides external oil drainage only.



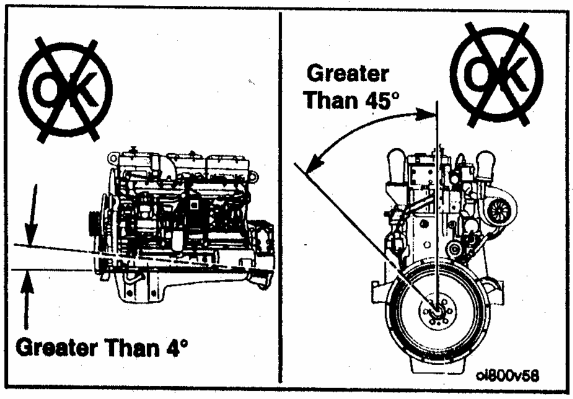
A 12.7 mm [0.50-inch] ID size is required when using an external oil drain. Using a smaller line size, or less than 12.7 mm [0.50-inch] fittings, can cause excessive oil build-up in the compressor crankcase. The potentially damaging results include crankcase pressurization and oil passage into the vehicle's air system.



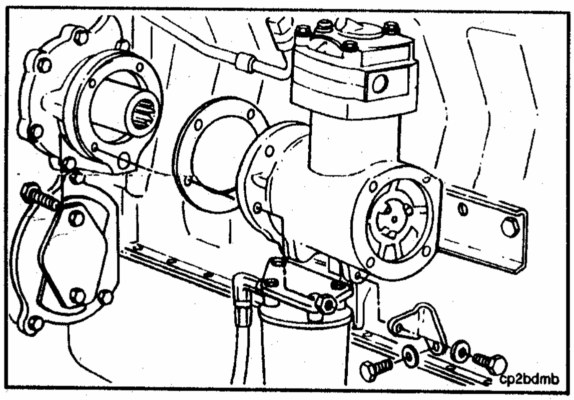


The oil drain system is gravity based, and therefore, requires installation of the drain line to be free of low spots or traps with a downward flow of 51 to 76 mm [2 to 3 inches] per 305 mm [1 foot] minimum fall.

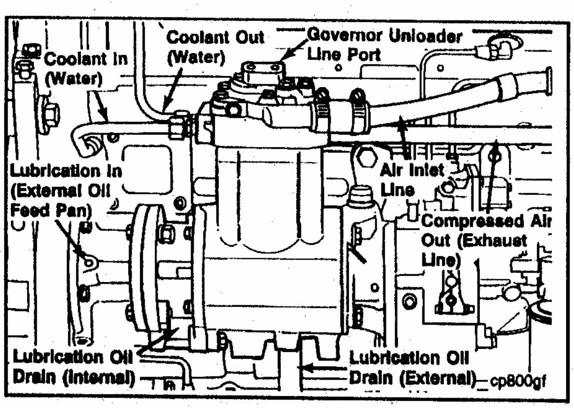
The drain line **must** enter the engine at the point above the engine oil level to prevent a back flow restriction.



Where flange mount compressor drainage is internal to the compressor with engine oil drain or return through engine block holes, vehicle installation tilt angles greater than 4 degrees from the horizontal or roll angles exceeding 45 degrees from the vertical position, can cause less than optimum drain back conditions.



When mounting air compressors to the engine always use new Original Equipment Manufacturer (OEM) supplied gaskets to provide a leak free connection. Do not use form-in place or similar sealant materials as oil drain holes can become blocked.

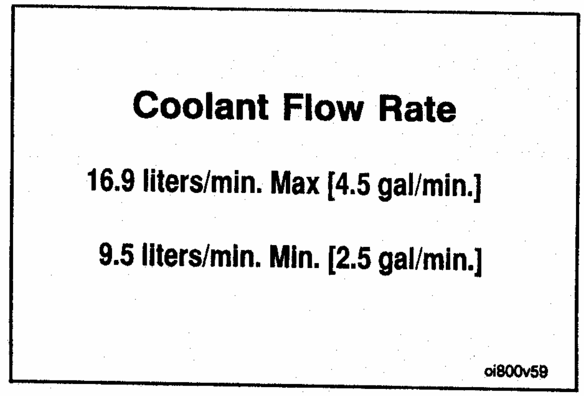


Cooling System

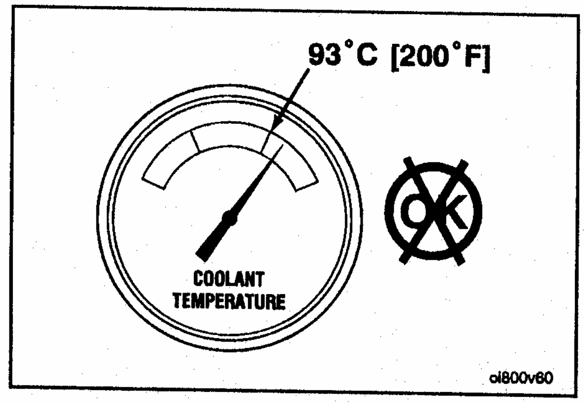
The engine cooling system provides the cooling water for air compressors. The air compressor function produces high temperature exhaust air, which if not con-trolled, causes excessive carbon formation in the com-pressor head and discharge or exhaust line. It can shorten compressor life.

The following cooling system installation guidelines will provide optimum compressor performance.

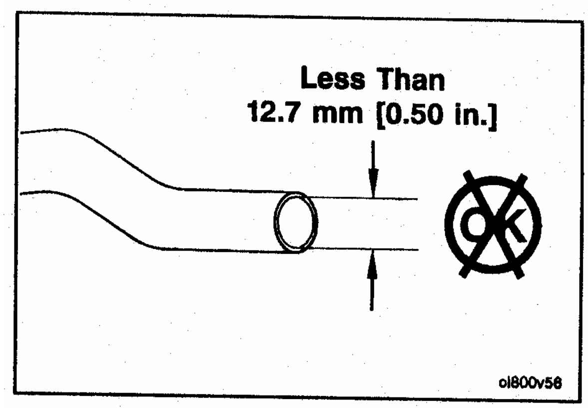
Water Flow Rate: To provide adequate head cooling, a water flow rate of 16.9 liters [4.5 gallons] plus or minus 3.785 liters [1.0 gallon] per minute is required at rated engine speeds. Recommended minimum water flow rate through the head is 9.4625 liters [2.5 gallons] per minute at rated engine speed with a 1:1 compressor drive ratio. Compressor to engine drive ratios higher than 1:1 can require higher coolant flow rates to provide optimum operating life.



Water Temperature: The engine's cooling water must be sourced immediately after the water pump to provide the lowest temperature water available. Water temperature to the compressor must never exceed 93°C [200°F].



Water Lines: inlet and outlet water line size must be 12.7 mm [0.50-inch] outside diameter (OD) minimum of optimum flow rate. Either water port can be used for inlet or outlet water plumbing.



Normal air compressor life cycle is a function of application operating parameters and system installation configuration, both of which, along with maintenance practices, will influence compressor duty cycle.

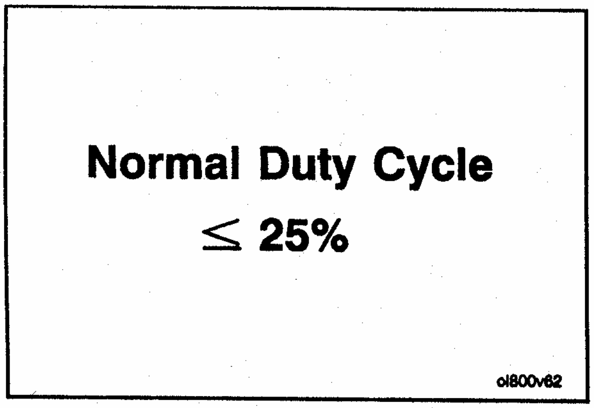
Duty Cycle

Duty cycle is defined as the period of time the compressor is pumping (compressing air) as a percentage of total operating time. The air compressor duty cycle defines the life cycle, generally, lower duty cycles result in the longest life cycles.

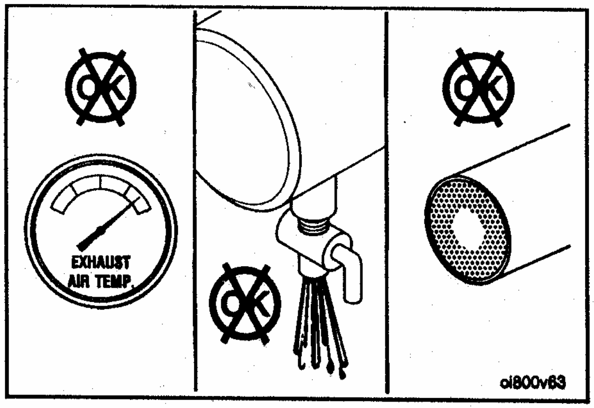
$$\text{Duty Cycle} = \frac{\text{Compressor Pumping Time}}{\text{Total Operating Time}} \times 100$$

oi800v61

Duty cycle observations range from 5 to 10 percent on new vehicles used in line haul tractor applications to as high as 50 to 60 percent, or higher, for off-highway, garbage pick-up, or transit bus applications. Duty cycle can be measured on vehicles with either data recorders or by monitoring or timing the pumping cycle of the compressor (audible measurement) during vehicle operation.



The air compressors are designed, for any given application, to have normal duty cycles of up to 25 percent, and our life expectancy is defined with this duty cycle as the operating standard. The life of the air compressor will be progressively shortened as duty cycles continue to increase above 25 percent. If the duty cycle for a specific application exceeds 25 percent, then additional compressor or system maintenance will be required or a larger size compressor must be specified to reduce the duty cycle.



High compressor exhaust air temperatures, excessive oil consumption, and carbon formation are typical characteristics of air compressors operating in excess of 25 percent duty cycle. If these symptoms are observed, corrective action must be taken immediately to reduce the duty cycle to a maximum of 25 percent. Failure to correct the cause of the high duty cycle (greater than 25 percent) can result in premature air compressor failure.

The following life cycle information is provided for all current models produced by the manufacturer.

Duty Cycle	Expected Life
0 to 25 Percent	Equal to or above 3 years/300,000 miles/10,800 hours
26 to 40 Percent	2 years or less
41 to 50 Percent	1 year or less
Greater Than 50 Percent	Less than 1 year

The following application restrictions also apply:

- Maximum allowable system pressure set at 135 kPa [135 psi].
- Maximum turbocharged pumping cycle length = 1 minute (at maximum engine boost or rated engine speed).
- This information does not alter or affect the written warranty for a specific unit, which is the only warranty that applies to a specific unit. See written warranty for details.

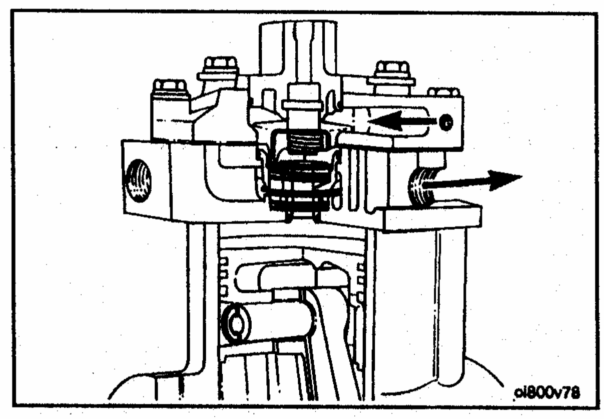
Application Recommendations

The following application information is generic and must be used only as a guide to the air compressor size required for a specific application. If vehicles are equipped with multiple air accessories, the next larger air compressor size is required.

Application	Alr Compressor Model Recommended
Line Haul Tractor or Trailer	SS296 or QE296
Line Haul Doubles or Triples	SS338E or QE296
City Pick-Up or Delivery	SS338E or QE296
Off-Highway or Construction	SS338E or QE338
Off-Highway or Mixer	QE338
School Buses or Rural	SS296 or QE296
School Buses or City	QE296 or QE338
Travel Coaches	SS338 or QE338
City Transit Buses	ST676
Residential Garbage Trucks	QE338 or ST676
Fire Trucks	QE338 or ST676
Bulk Haulers	QE338 or ST676
RV	QE230 or QE296

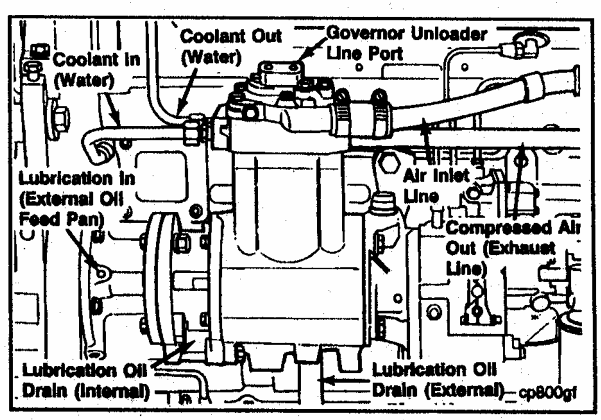
Air Intake System

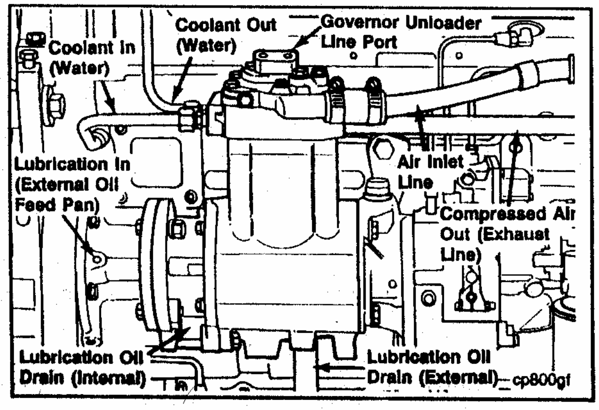
For optimum compressor performance and system life, intake air must be clean and free flowing.

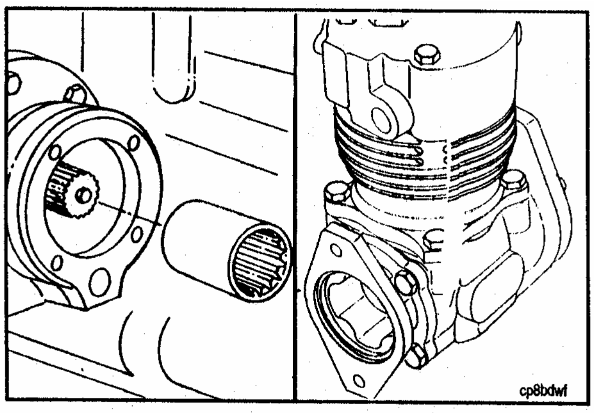


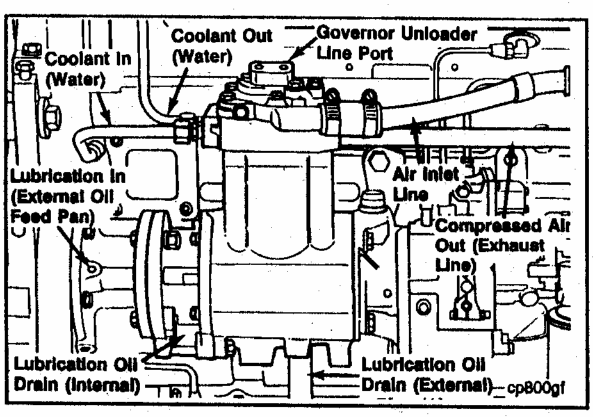
Two sources of intake air are available:

- Engine intake manifold (turbocharged engine applications).
- Air cleaner to the engine intake plumbing (naturally aspirated inlet air).









Turbocharged Inlet Air: Optimum air pressure build-up time (shortest period) will result when using the engine intake manifold as an air supply source. Utilizing this source of air, the compressor intake will be pressurized by the engine turbocharger system.

The manufacturer recommends turbocharged inlet air, sourced from the engine manifold, for all air compressors operating under normal duty cycle applications.

NOTE

The air compressors are designed for the full engine operating range of turbocharged (pressurized) inlet air without use of pressure reducing or restrictive devices.

Drive Options

The air compressor can be driven by either of two options:

- Gear driven via axial load, splined coupling combination, or
- side load direct drive, meshed gears.

All flanged mounted compressors are gear driven.

NOTE

Compressor through-drive options are available for power steering and fuel pumps on some engine applications.

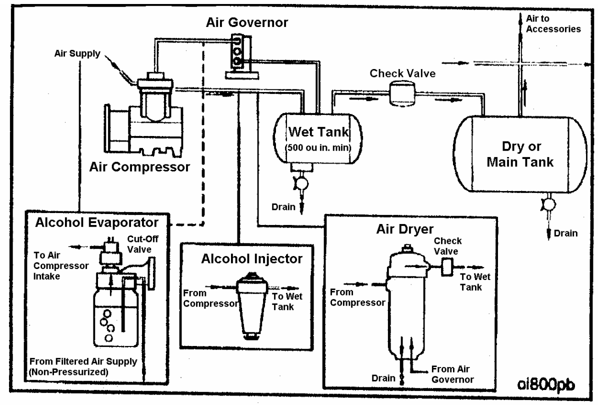
Air System Accessories

Air governors, air dryers, and air tanks are key functional components in the air system. The following recommendations will minimize air system problems and maximize the life of the air compressor and the air system.

Air Governor: The air governor provides the signal to actuate and terminate compressor pumping cycles.

The governor mounts on the compressor governor mounting pad. If not, and remote mounting is required, locate the governor as close as possible to the compressor. Using a signal line between the governor and the compressor exceeding 1.06 m [3.5 feet] is not recommended and can result in unloader actuation problems.

Avoid mounting the governor in high heat areas of the engine. Rubber seals in the governor can deteriorate and cause failures under high temperature exposure. Environmental temperatures exceeding 93°C [200°F] **must** be avoided.



Air Dryers: Air dryers are recommended for all vehicle air brake systems. The primary function of the air dryer is moisture removal to prevent downstream freeze-ups and corrosion of air lines, air tanks, and valving components.

The air dryer also functions as oil and air contamination removal system, which helps provide improved system performance and longer service life.

Consult the manufacturer for optimum air dryer installation requirements.

Alcohol Additive Devices: The manufacturer does not recommend alcohol injectors and evaporators. Typically, these devices use a wide variety of alcohol mixtures which can cause negative reactions with downstream components, and shorten system life.

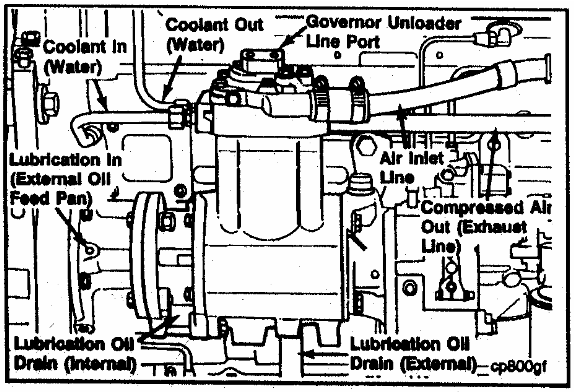
Use of an evaporator system with turbocharged compressor inlet air can require an additional valve to prevent siphoning the alcohol into the compressor air intake and subsequently into the engine.

Use of an injector system adds inherent restrictions in the compressor discharge line, potentially increasing build-up times and carbon formation problems.

Air Tanks: Air tanks provide the vehicle with an air storage reservoir area for braking needs. As a minimum, a service and emergency air reservoir tank are required. A third tank is also provided and acts as a reservoir wet tank where moisture and other system contaminates condense during the air cooling process downstream of the compressor.

NOTE

To obtain optimum air system performance, all air reservoir tanks must be purged daily to prevent excess accumulation of contaminate material and reduced air storage volume.



Discharge Air System

The air discharge line provides the route for compressed high pressure air from the air compressor to the air storage or reservoir tank system.

As a result of compressor discharge air containing a small amount of oil mist at high temperatures, carbon formation in the discharge line becomes a common air system problem.

Discharge Line Requirements

- Copper, Steel or Wire Braided Teflon
- Withstand 1034 kPa [150 psi] Peak, 931 kPa [135 psi] Normal
- 3.1 m [10 ft] Length Minimum of Teflon/Stainless Steel

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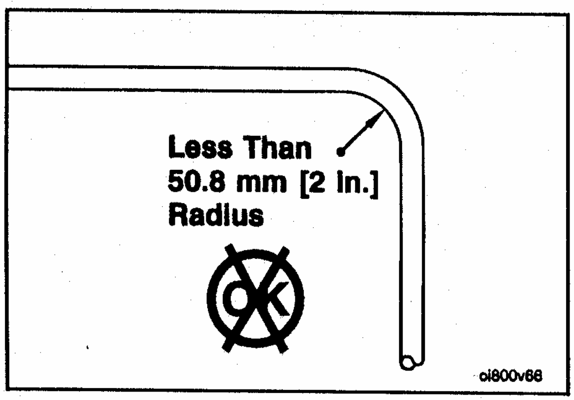
In severe instances, the problem can lead to discharge line restrictions and shorten compressor life. To prevent this problem, the following installation guidelines must be followed:

- ***Discharge Air Cooling:*** To provide air cooling of discharge air, the plumbing line connected to the exhaust port must be made of copper, steel, or wire braided Teflon® tubing capable of withstanding 1034 kPa [150 psi] pressure peaks and normal continuous line pressures of 931 kPa [135 psi] at temperatures of 232°C [450°F]. Ideally, 1.8 m [6 ft] minimum length of copper tubing, or 3.1 m [10 ft] minimum of Teflon®/stainless steel tubing provides adequate air cooling.

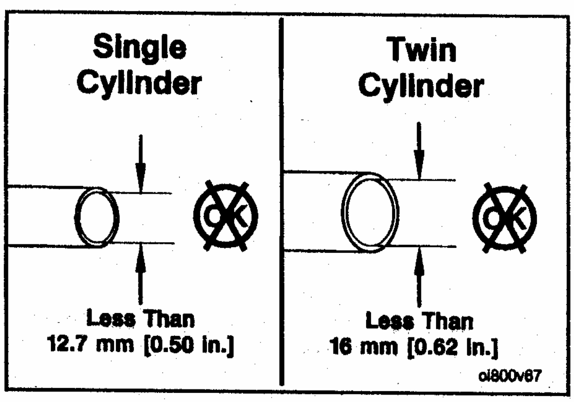
NOTE

If an air dryer is used, see manufacturer's guidelines.



- ***Air Flow Restrictions:*** To minimize air flow restriction caused by carbon formation, avoid discharge line bends with a radius of less than 50.8 mm [2 inches].

General air flow direction must be downward from the discharge port without traps where oil and moisture can collect. Discharge line low spots or traps can result in carbon formation or water freeze points which restrict air flow.

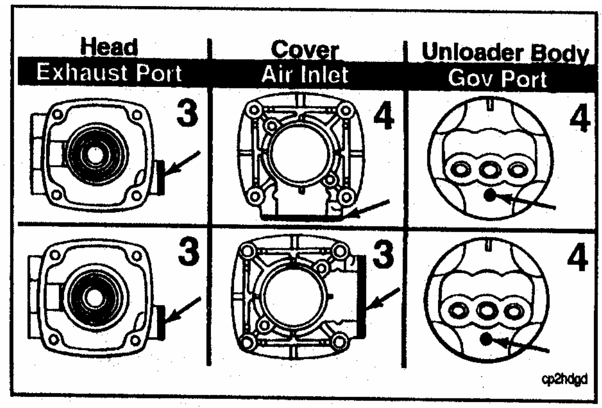


- ***Discharge Line Size:*** Discharge line sizes for the single cylinder compressors must be 16 mm [5/8- inch] ID or a No. 12 hose, with a minimum of 12.7 mm [1/2-inch] ID or a No. 10 hose for optimum performance.

The twin cylinder compressor optimum line size is 19 mm [1 inch] ID or No. 16 hose, with a minimum of 16 mm [5/8-inch] ID or No. 12 hose.

Smaller than optimum line sizes will reduce compressor life under high duty cycle conditions.

Porting Option Flexibility



The single cylinder compressor's unique design allows multiple independent porting options for plumbing flexibility in the field. Both the top cover (containing the inlet air port) and the head (containing the water and air discharge ports) can be independently rotated 360 degrees, in 90 degree increments.

Additionally, the unloader body mounted on top of the compressor can be rotated 360 degrees in 90 degree increments, independent of the top cover and head, to allow governor mounting orientations four times.

NOTE

When orientation is changed in the field, new gaskets must be used when the air compressor is assembled.

Recommended Installation Guidelines - E-Type Systems

The air compressor is an engine driven, piston type compressor which supplies compressed air to operate air activated devices. The compressor operates continuously but has a loaded and unloaded operating mode. The operating mode is controlled by a pressure activated governor and the compressor unloading assembly. Intake air can come from the intake manifold or near the engine air cleaner.

For an E-Type unloader system used with an air dryer, an Econ valve, and check valve with makeup line must be installed in the air system, or an approved dryer incorporating all valves must be used. The Econ valve must be mounted in a position and altitude to avoid collecting condensation which can freeze during cold weather. The Econ valve must be installed with its inlet port above the outlet port to avoid condensation traps in the discharge line or fittings, per normal recommended installation practice for air compressor discharge lines.

The air inlet temperature for the Econ valve must not exceed the inlet air maximum temperature recommendation of the air dryer manufacturer. When possible, the Econ valve must be 2 to 7 feet from the air compressor or the air dryer must be 8 to 10 feet from the air compressor. The air discharge line must be downward sloping from the air compressor outlet air port to the air dryer inlet air port.

The differential check valve must be installed either on the upper part of the wet tank, or on the side of the dryer outlet fitting to avoid condensed moisture (see option diagrams below).

CAUTION

It is critical to have the poppet end of the differential check valve installed toward the wet tank or toward the air dryer outlet.

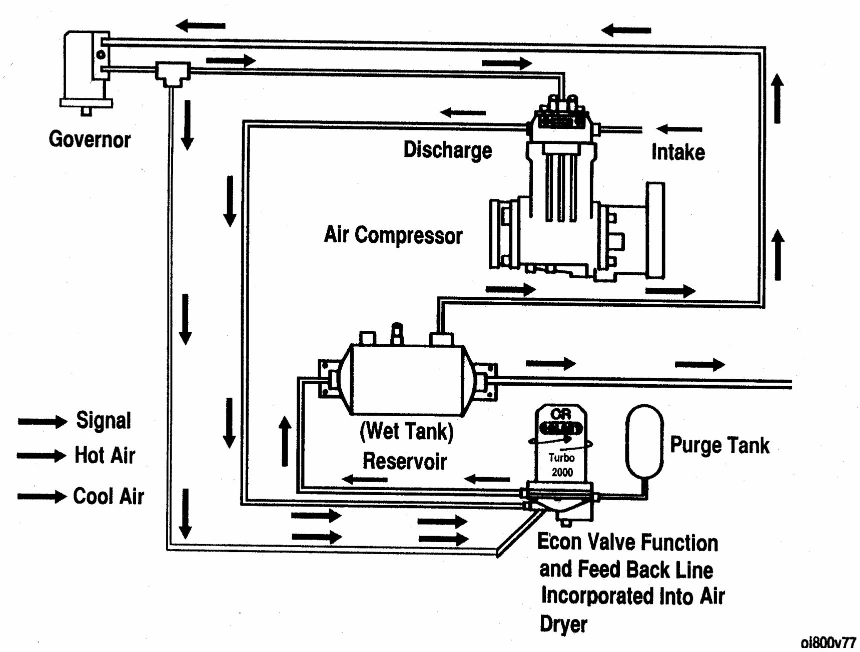
NOTE

Use of a differential check valve other than the identified part, can result in system malfunction. Contact the dryer manufacturer for recommendation.

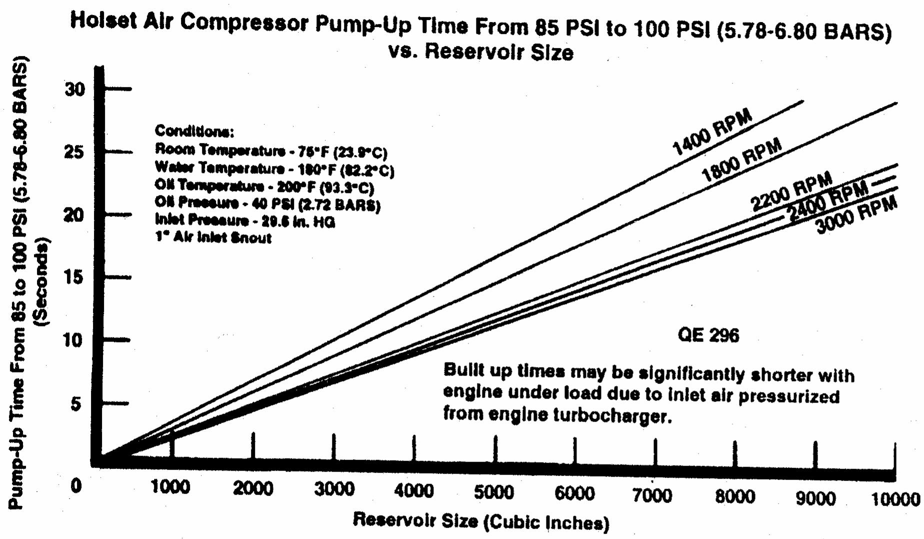
NOTE

To prevent overnight or shutdown freeze-ups of the Econ valve **not** confirming to the 2 to 7 foot Econ valve location, make sure that the vehicle wet tank is drained to below governor cut-in pressure (via wet tank drain valve) following vehicle shutdown. This action will open the Econ valve and allow compressor air flow at vehicle start-up.

Air Compressors Installation Diagram with Turbocharger Air Dryer and E-Type System



Performance Curves and Specifications
QE296



Specifications

Rated Displacement	13.2 CFM (296 cc.)
Bore	3.625" (92.1)
Stroke	1.75" (44.5)
Cylinders	1
Valving	Disc
Operating rpm	3000 (max.)
Cooling	water
Lubrication	Pressurized engine oil
Turbocharged	
inlet pressure	30 PSIG (max.)
(max. acceptable)	(2.04 BARS)
Line Sizes	
water in	1/2" OD (12.7)
water out	1/2" OD (12.7)
air in*	7/8" ID min (22.2)
air out**	5/8" ID min (15.9)

* 1" inlet air lines are recommended for all applications.

** 5/8" air out (exhaust) line is recommended for single cylinder models and a 1" exhaust line is recommended for twin cylinder models.

Package envelope	
Height*	8.83" (212.9)
Width**	6.54" (166.1)
Length	10.7 (271.8)
Weight	37 lbs. (16.8 kg)
Max. Pressure	135 PSIG (9.18 BARS) Max. System Pressure

(mm)

* Measured from centerline of crankshaft drive location

** Tilted width, 3.1" (78.74 mm) inside crankshaft centerline and 7.8" (198.12 mm) outside centerline.

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NOTES

Section T - Troubleshooting

Section Contents

Procedures and Techniques

A thorough analysis of the customer's complaint is the key to successful troubleshooting. The more information known about a complaint, the faster and easier the problem can be solved.

The Troubleshooting Symptoms Charts are organized so that a problem can be located and corrected by doing the easiest and most logical things first. Complete all steps in the sequence shown from top to bottom.

It is not possible to include all the solutions to problems that can occur; however, these charts should stimulate a thought process that will lead to the cause and correction of the problem.

Follow these basic troubleshooting steps:

- Get all the facts concerning the complaint.
- Analyze the problem thoroughly.
- Relate the symptoms to the basic engine systems and components.
- Consider any recent maintenance or repair action that may relate to the problem.
- Double-check before beginning any disassembly.
- Solve the problem by using the logic charts and doing the easiest things first.
- Determine the cause of the problem and make a thorough repair.
- After repairs have been made, operate the engine to make sure the cause of the problem has been corrected.

Troubleshooting Symptoms Charts

Use the charts on the following pages of this section to aid in diagnosing specific engine problems. Read each row of blocks from top to bottom. Follow the arrows through the chart to identify the corrective action.

Air Compressor Air Pressure Rises Slowly

Cause	Corrections
Intake Air Restriction to Air Compressor Excessive (Naturally Aspirated Air Compressors Only)	Replace air compressor air cleaner (if installed). Check engine intake air restriction if air compressor inlet is installed in intake piping between air cleaner and turbocharger. Refer to the engine base Troubleshooting and Repair Manual.
OK ↓	
Air System Leaks	Block vehicle wheels and check for system air leaks with spring brakes applied and released. Check for air compressor gasket, hoses, fittings, etc., leaks. Refer to Procedure 012-019.
OK ↓	
Air Governor Malfunctioning or Set Incorrectly	Check air governor operation. Refer to Procedure 012-017.
OK ↓	
Carbon Buildup Excessive in the Air Discharge Line or Cylinder Head	To check for carbon buildup, refer to Procedure 012-003. To check the turbocharger for oil leaks, and to check the intake tube for oil, refer to the appropriate base engine Troubleshooting and Repair Manual.
OK ↓	
Air System Component is Malfunctioning	Check operation of check valves, alcohol evaporators, air dryers, etc. Refer to the manufacturer's instructions.
OK ↓	
Unloader Valve Malfunctioning. Air Compressor Intake or Exhaust Valve Leaks Air	Check unloader valve operation. Refer to Procedure 012-013. Inspect intake and exhaust valve assemblies and unloader to body seal. Refer to Procedure 012-104.

Air Compressor Noise Excessive

Cause	Corrections
Carbon Debris Buildup Excessive in the Air Discharge Line or Cylinder Head	Check for ice in low spots, blocked Econ valve or dryer inlet, and blocked elbow fittings near compresor. To check for carbon buildup , refer to Procedure 012-003. To Check the turbocharger for oil leakage, refer to the base engine Troubleshooting and Repair Manual.
OK ↓	
Single Cylinder Air Pulse into Air Tanks	Install a ping tank between the air dryer and wet tank. Refer to the manufacturer's recommendations.
OK ↓	
Accessory Drive is Worn (Axial End Play Out of Specification)	Check accessory drive for wear. Refer to the appropriate base engine Shop Manual.
OK ↓	
Splined Drive Coupling or Gear Excessively Worn	Check coupling for wear. Refer to Procedures 12-105.
OK ↓	
Air Compressor Excessively Worn or Damaged Internally	Check for pin bore wear. Refer to Procedure 012-010. Replace or rebuild the air compressor. Refer to Procedures 012-105. Replace the desiccant element on the Air Dryer (if equipped). Refer to Manufacturers Instructions.
OK ↓	
Air Compressor Timed Incorrectly	Check the air compressor timing marks to the accessory drive shaft. Refer to Procedure the appropriate base engine Troubleshooting and Repair Manual.
OK ↓	
Air Compressor Drive Gear or Engine Gear Train Worn or Damaged	Inspect condition of the gears and repair as needed. Refer to the appropriate base engine Troubleshooting and Repair Manual.

Air Compressor Pumping Excess Lubricating Oil into Air System

Cause	Corrections
Engine Oil Drain Intervals Excessive	Refer to Engine Operation and Maintenance Manual for correct drain intervals.
OK ↓	
Contaminants Not Being Regularly Drained From the System Reservoirs	Drain the reservoirs daily. Refer to the base engine Operation and Maintenance Manual.
OK ↓	
E-Type System Improperly Plumbed	Install Econ valve, check valve, and proper hoses. Refer to Section G – Installation Guidelines.
OK ↓	
Air Compressor Pumping Time Excessive	Replace desiccant cartridge on Air Dryer (if installed). Refer to the OEM Service Manual. Check air compressor duty cycle. Upsize the air compressor if the duty cycle is incorrect. Refer to Section G – Installation Guidelines.
OK ↓	
Carbon Buildup Excessive in the Air Discharge Line or Cylinder Head	To check for carbon buildup, refer to Procedure 012-003. To check the turbo-charger for oil leakage, and to check the air compressor intake tube, refer to the base engine Troubleshooting and Repair Manual.
OK ↓	
Engine Power Angle or Angularity During Operation Exceeds Specifications	Refer to engine specification data sheet. Install external drain from air compressor sump to oil pan.
OK ↓	
Engine Crankcase Pressure Excessive	Check crankcase pressure and replace or repair vent line. Refer to the base engine Troubleshooting and Repair Manual.
OK ↓	

(Continued)

Air Compressor Pumping Excess Lubricating Oil into Air System (Continued)

Cause	Corrections
Excessive Engine Oil Pressure	Check oil pressure. Refer to the base engine Troubleshooting and Repair Manual.
OK	
Air Compressor Runs Hot	Check coolant circuit. Refer to the base engine Troubleshooting and Repair Manual.
OK	
Oil Drain Restricted	External oil drain blocked. Refer to the base engine Troubleshooting and Repair Manual.
OK	
Air Compressor Excessively Worn or Damaged Internally	Replace or rebuild the air compressor. Refer to Procedures 012-105. Replace the desiccant element on the Air Dryer (if equipped). Refer to Manufacturer's OEM Service Manual.

Air Compressor Will Not Stop Pumping

Cause	Corrections
Air System Leaks	Block vehicle wheels and check for system air leaks with spring brakes applied and released. Check for air compressor gasket, hoses, fittings, etc., leaks. Refer to Procedure 012-019.
OK ↓	
Air Governor Malfunctioning or Set Incorrectly.	Check air governor operation. Refer to Procedure 012-018.
OK ↓	
Air Governor Signal or Actuating Line Plugged	Inspect signal and actuating line. Refer to the Manufacturer's Instructions.
OK ↓	
Air System Component Malfunctioning	Check operation of check valves, alcohol evaporators, air dryers, etc. Refer to manufacturer's instructions.
OK ↓	
Unloader Valve Malfunctioning. Air Compressor Intake or Exhaust Valve Leaks Air	Check unloader valve operation. Refer to Procedure 012-013. Inspect intake and exhaust valve assemblies and unloader to body seal. Refer to Procedures 012-104. Check for cracked manifold or leaking mounting gasket.

Air Compressor Cycles Frequently

Cause	Corrections
Air System Leaks	Block vehicle wheels and check for system air leaks with spring brakes applied and released. Refer to Procedure 012-019. Check for air compressor gasket, hoses, fittings, etc., leaks. Refer to the OEM Service Manual.
OK ↓	
Air Governor Malfunctioning or Set Incorrectly	Check air governor operation. Refer to Procedure 012-018.
OK ↓	
Air System Component Malfunctioning	Check operation of check valves, alcohol evaporators, air dryers, etc. Refer to manufacturer's instructions.
OK ↓	
Econ Valve Incorrectly Plumbed (E-Type Systems With Air Dryers Only)	Verify correct plumbing arrangement. Refer to Section G-Installation Guidelines.
OK ↓	
Carbon Buildup Excessive in the Air Discharge Line or Cylinder Head	To check for carbon buildup, refer to Procedure 012-003. To check the trubocharger for oil leakage, and to check the air compressor intake tube, refer to the base engine Trouble-shooting and Repair Manual.
OK ↓	
Air Compressor Pumping Time Excessive	Replace desiccant cartridge on Air Dryer (if installed). Refer to the OEM Service Manual. Check air compressor duty cycle. Upsize the air compressor if the duty cycle is incorrect. Refer to Section G - Installation Guidelines.
OK ↓	
Air Dryler Outlet Check Valve Sticks	Lubricate or replace dryer outlet check valve assembly. Refer to manufacturer's recommendations.

Air Compressor Will Not Maintain Adequate Air Pressure

Cause	Corrections
Air System Leaks	Block vehicle wheels and check for system air leaks with spring brakes applied and released. Refer to Procedure 012-019. Check for air compressor gasket, hoses, fittings, etc., leaks. Refer to OEM Service Manuals.
OK ↓	
Air Governor Malfunctioning or Set Incorrectly	Check air governor operation. Refer to Procedure 012-017.
OK ↓	
Air Compressor Intake or Exhaust Valve Leaks Air	Inspect intake and exhaust valve assemblies. Refer to Procedures 012-104.
OK ↓	
Cover Gasket Leaking Internally	SS unloader screws overtorqued. Refer to Procedure and 12-103.

Air Compressor Will Not Pump Air

Cause	Corrections
Air Governor Malfunctioning or Set Incorrectly	Check air governor operation. Refer to Procedure 012-017.
OK ↓	
Unloader Valve Malfunctioning. Air Compressor Intake or Exhaust Valve Leaks Air	Check unloader valve operation. Refer to Procedure 012-013. Inspect intake and exhaust valve assemblies and unloader to body seal. Refer to Procedures 012-104.
OK ↓	
Splined Drive Coupling or Gear Excessively Worn	Check coupling for wear. Refer to Procedures 12-105.
OK ↓	
Air Compressor Excessively Worn or Damaged Internally	Replace or rebuild the air compressor. Refer to Procedures 012-105. Replace the desiccant element on the Air Dryer (if equipped). Refer to Manuafacturer's OEM Service Manuals.
OK ↓	
SS Cover Gasket Ruptured	Check for discharge line blockage. Refer to Procedure 012-003. Check that cover is flat. Replace cover gasket. Refer to Procedure 01[illegible] and 12-103.

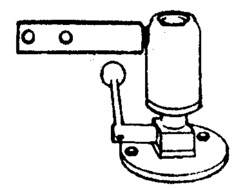
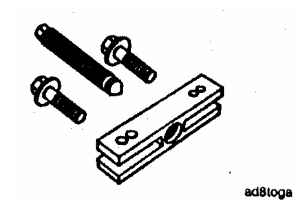
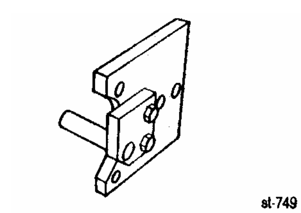
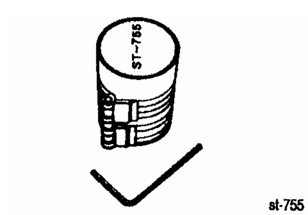
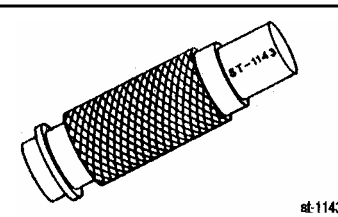
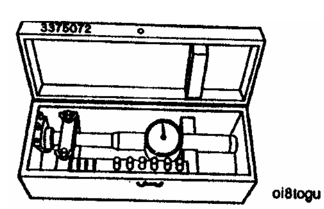
Section 12 - Compressed Air System

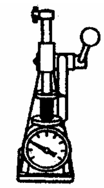
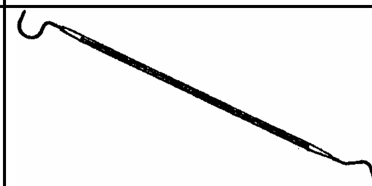
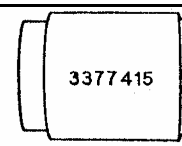
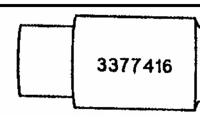
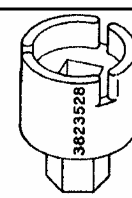
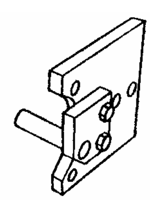
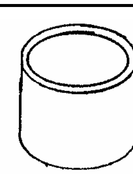
Section Contents

Service Tools

Compressed Air System

The following special tools are recommended to perform procedures in this manual. The use of these tools is shown in the appropriate procedure. These tools can be purchased from your local Cummins Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
ST-302	**Ball Joint Vise** Use to hold the air compressor for disassembly or assembly.	
ST-647	**Standard Puller** Use to pull the drive gear. Use with puller capscrews that have M8 x 1.25-6H thread.	
ST-749	**Mounting Plate** Use to mount the air compressor to the vise.	
ST-755	**Piston Ring Compressor** Use to compress all piston rings to permit easy installation of piston/rod assemblies.	
ST-1143	**Air Compressor Bushing Mandrel** Use to remove and install the crankshaft bushing in the crank-case and the support.	
3375072	**Dial Bore Gauge** Use to measure the cylinder bores.	

Tool No.	Tool Description	Tool Illustration
3375182	**Valve Spring Tester** Use to check the exhaust valve, intake valve and unloader valve cap springs.	 kn8togs
3376399	**O-Ring Pick** Use to remove and install o-rings.	 76399
3376663	**Coupling Puller** Use to remove the splined coupling hub.	 bp8togg
3377415	**Air Compressor Seat Installation Tool** Use to install the exhaust valve seats.	 3377415
3377416	**Air Compressor Seat Removal Tool** Use to remove the exhaust valve seats.	 3377416
3823528	**Air Compressor Seat Socket** Use to remove the exhaust valve seat and the inlet valve cage.	 3823528
3823597	**Mounting Plate** Use to mount the air compressor to the vise.	
3823923	**Spacer** Use with coupling puller, Part No. 3376663, to remove the-hydraulic pump drive coupling.	 3823923

Compressed Air System Specifications
13.2 CFM Single Cylinder Air Compressor (SS 296/55 296E/QE 296)

Cylinders 1
Compressor Swept Volume @ 1250 RPM.......... 6.2 L per sec. [13.20 CFM]
Piston Displacement .... 296 cc [18.06 C.I.D.]
Bore.......... 92.08 mm [3.625 in.]
Stroke.......... 44.45 mm [1.750 in.]
Speed.......... Engine Speed
Cooling .... Engine Coolant
Lubrication.......... Engine Lubricating Oil
Plumbing Line Sizes
  Coolant Inlet and Outlet (Pipe Fitting) .... 9.53 mm NPTF [0.375 in. NPTF]
  Air inlet (Inside Diameter).......... 22.22 mm [0.875 in.]
  Air Outlet (Minimum Inside Diameter) .... 12.7 mm [0.50 in.]
Height, Overall (Approximate).......... 31.1 cm [12.25 in.]
Width, Overall (Approximate).......... 14.6 cm [5.75 in.]
Length, Overall (Approximate) .... 22.9 cm [9.00 in.]
Weight (Approximate) .... 18 kg [40.0 lbs]

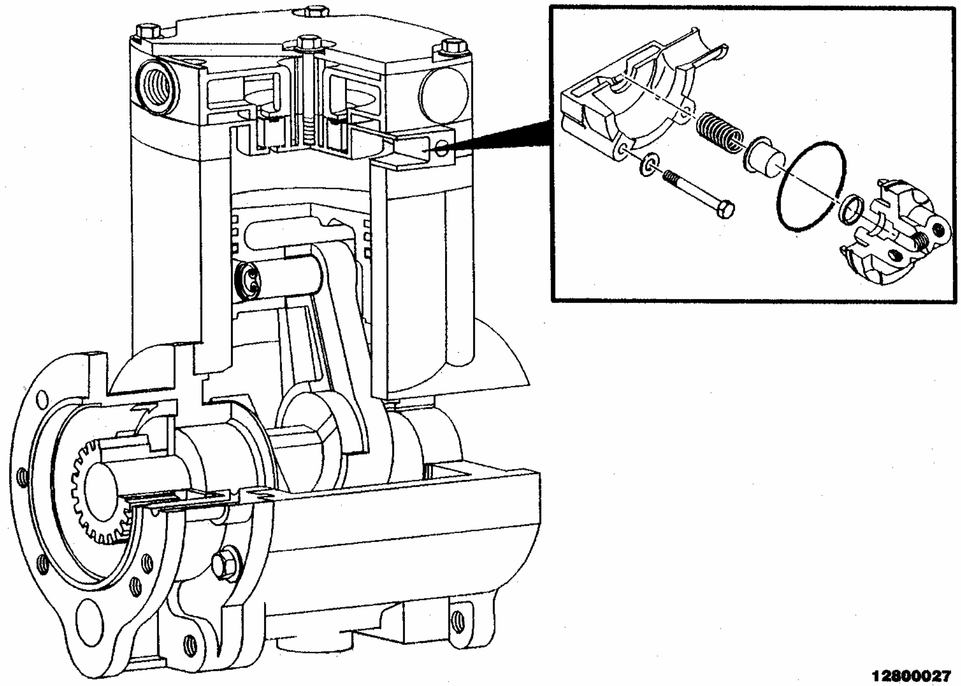
NOTE

In applications where duty cycles average 10 percent or more, or air pressures are above 862 kPa [125 psi]; use a discharge line with a minimum inside diameter of 19 mm [0.75 inch] to prevent carbon buildup. Examples of these applications are as follows: refuse trucks, pickup and delivery trucks, transit buses and equipment with high accessory air usage.

Air Compressor General Information

Cutaway View - QE230, QE296, and QE338

Gear Driven Compressor



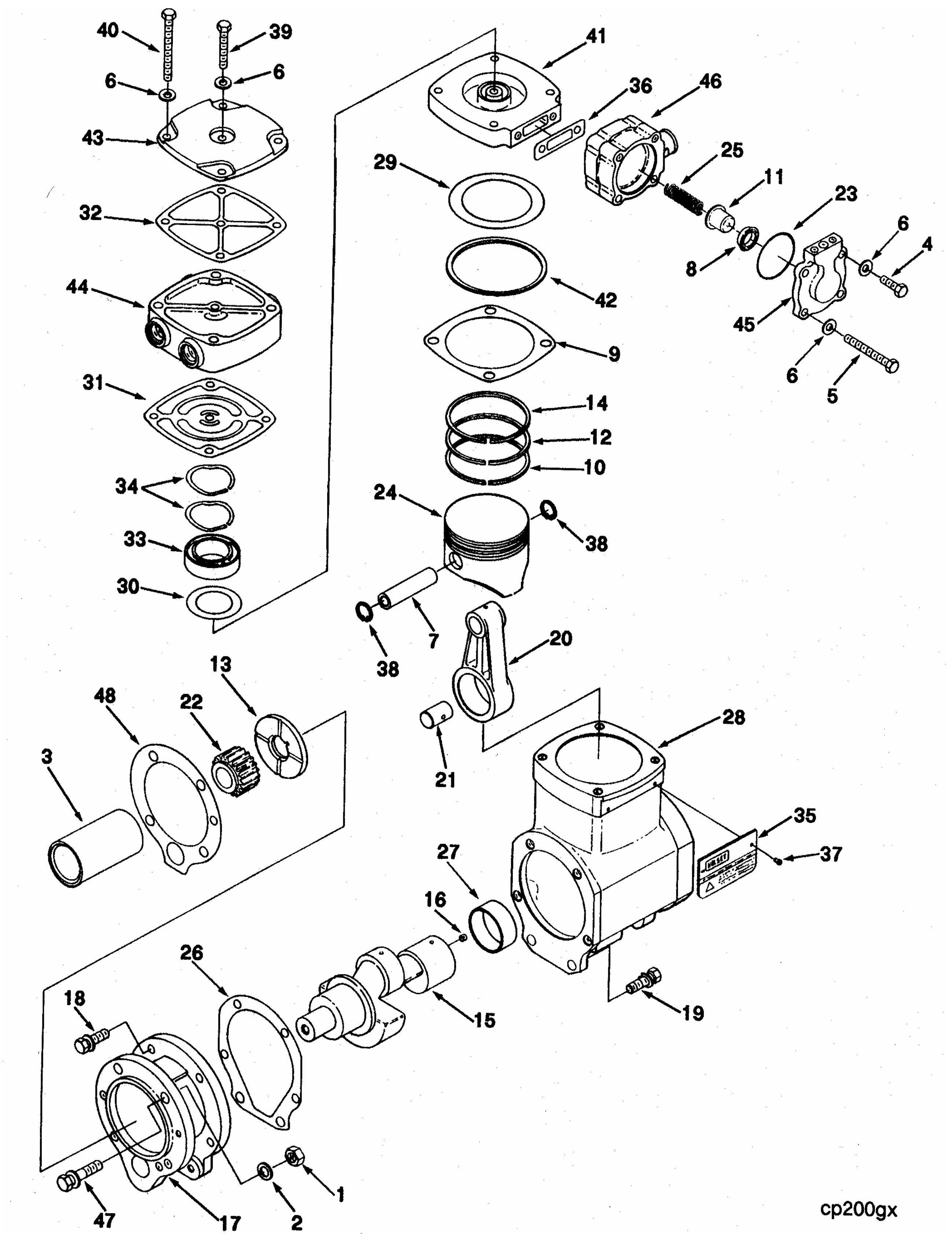
12800027

Ref. No.	Part Name	Qty.
1	Nut, Heavy Hexagon	2
2	Washer, Plain	2
3	Sleeve, Spline Coupling Compressor, Air	1
4	Screw, Hexagon Head Cap	2
5	Screw, Hexagon Head Cap	2
6	Washer, Plain	9
7	Pin, Piston	1
8	Seal, Rectangular Ring	1
9	Gasket, Air Compressor	1
10	Ring, Oil Piston	1
11	Cap, Unloader Valve	1
12	Ring, Compression Piston	1
13	Bearing, Thrust	1
14	Ring, Compression Piston	1
	Crankshaft, Compressor	1
15	Crankshaft, Compression	1
16	Plug, Pipe	1
17	Support, Air Compressor	1
18	Screw, Captive Washer Cap	4
19	Screw, Captive Washer Cap	2
	Rod, Compressor Connecting	1
20	Rod, Compressor Connecting	1
21	Bushing	1
22	Hub, Spline Coupling	1
23	Seal, O-Ring	1
24	Piston, Compressor	1
25	Spring, Compression	1

Ref. No.	Part Name	Qty.
26	Gasket, Support	1
27	Crankcase, Compressor	1
	Bushing	1
28	Crankcase, Compressor	1
29	Valve, Compressor Intake	1
30	Valve, Compressor Exhaust	1
31	Gasket, Air Compressor	1
32	Gasket, Air Compressor	1
33	Retainer, Valve Disc	1
34	Washer, Spring	2
35	Nameplate	1
36	Gasket, Connection	1
37	Screw, Drive	2
38	Ring, Retaining	2
39	Screw, Hexagon Head Cap	1
40	Screw, Hexagon, Head Cap	4
41	Body, Compressor Valve	1
42	Retainer, Cpr. Intake Valve	1
43	Plate, Cover	1
44	Head, Compressor	1
45	Body, Unloading Valve	1
46	Connection, Air Cpr. Inlet	1
47	Screw, Captive Washer Cap	4
48	Gasket, Air Compressor	4

Exploded View - QE230, QE296, and QE338

Gear Driven Compressor



Air Compressor Carbon Buildup (012-003)

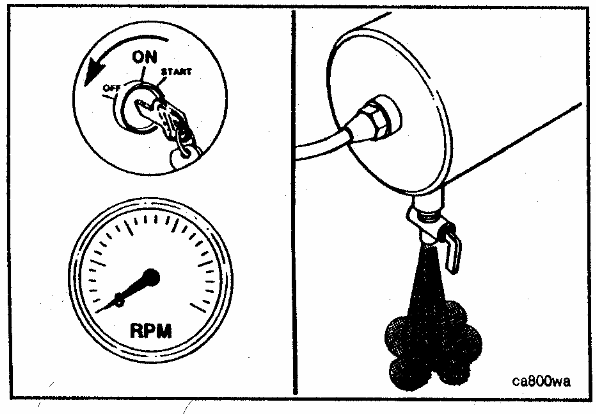
Initial Check (012-003-001)

WARNING

Compressed air can drive debris into eyes and ears. Keep head well away and wear protective eye wear.

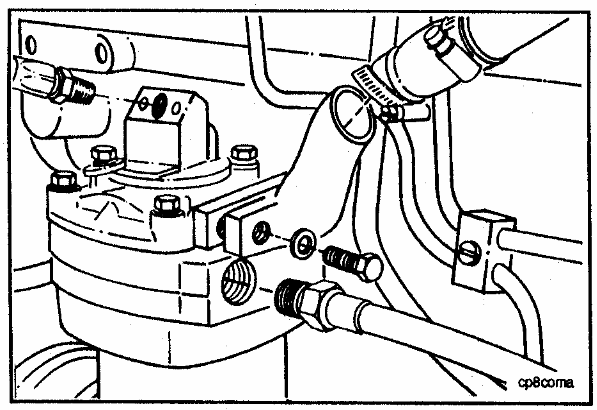
NOTE

The illustrations shown will be of the SS model single cylinder air compressor. Differences in procedures for SS, QE and ST model Holset air compressors will be shown where necessary.



Shut off the engine. Open the drain cock on the wet tank to release compressed air from the system.

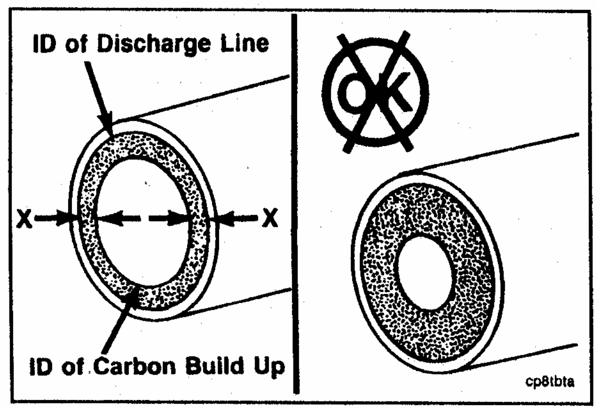
Remove the air inlet and outlet connections from the air compressor.

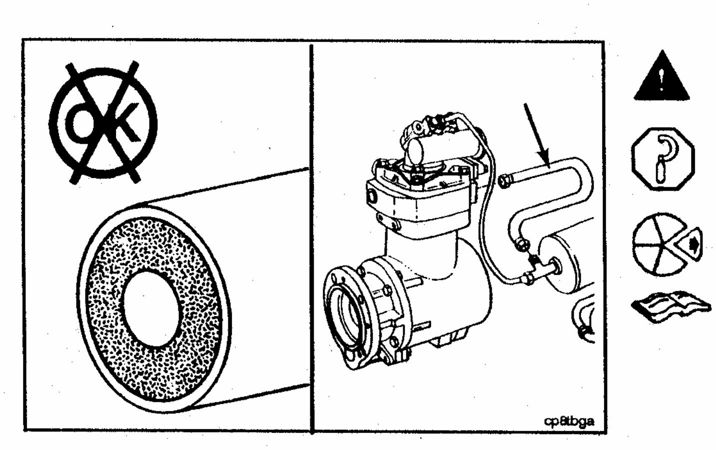


Measure the total carbon deposit thickness inside the air discharge line as shown.

NOTE

The carbon deposit thickness must not exceed 1.6 mm [0.06 (1/16)-inch].



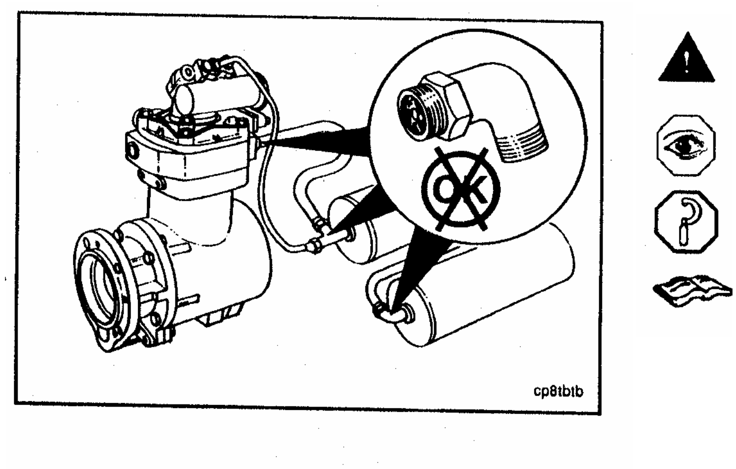


WARNING

The air discharge line must be capable of with-standing extreme heat and pressure to prevent personal injury and property damage. Refer to the manufacturer's specifications.

NOTE

If the total carbon deposit thickness exceeds specification, remove and clean, or replace the air discharge line. Refer to the manufacturer's material specifications.



WARNING

The air discharge line must be capable of with-standing extreme heat and pressure to prevent personal injury and property damage. Refer to the manufacturer's specifications.

Continue to check for carbon buildup in the air discharge line connections up to the first connection, or wet tank.

Clean or replace any lines and fittings with carbon deposits greater than 1.6 mm [0.06 (1/16)-inch]. Refer to the manufacturer's specifications for cleaning or replacement instructions.

CAUTION

Do not use a sharp object to remove carbon. The sealing surfaces can be damaged.

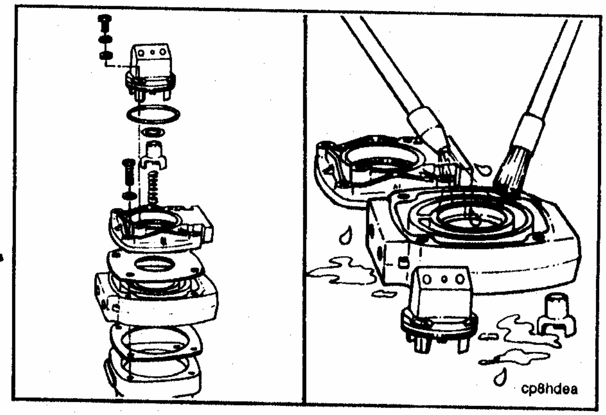
Remove the air compressor head and valve assembly. Refer to Air Compressor Cylinder Head, Procedure 012-103.

CAUTION

Do not use caustic cleaners on aluminum parts.

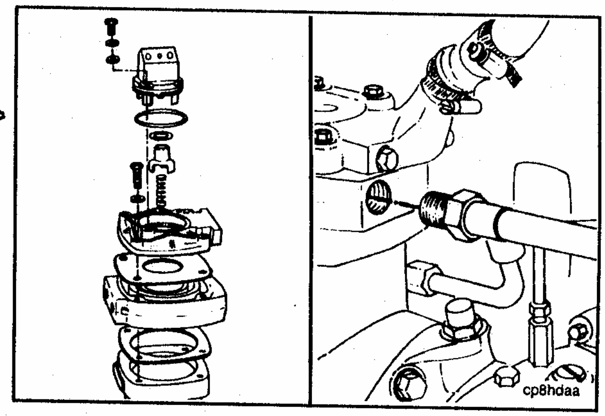
Clean the compressor head and valve assembly components with solvent and a nonmetallic brush to remove carbon.

Inspect the valve assembly components for reuse. Refer to Air Compressor Cylinder Head, Procedure 012-104.



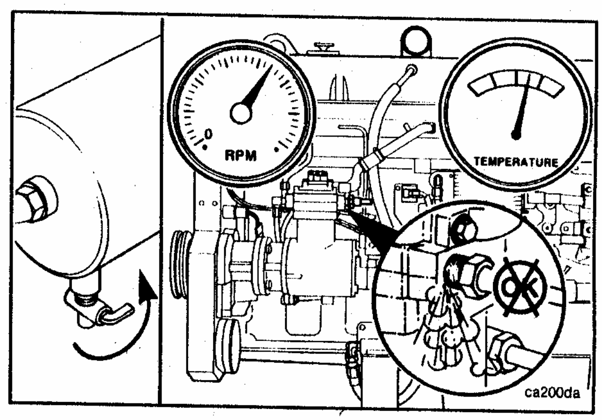
Assemble the air compressor using new gaskets and 0-rings. Refer to Air Compressor Cylinder Head, Procedure 01 2-104

Install and tighten the air inlet and outlet connections.



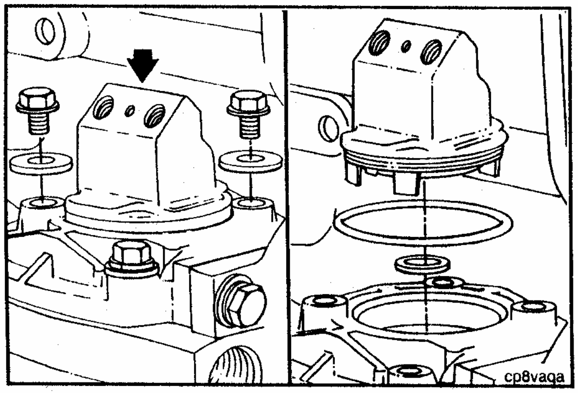
Close the wet tank drain cock.

Operate the engine and check for air leaks.



Air Compressor Pin Bore Wear (SS, E-Type, and ST Models) (012-010)

Initial Check (012-010-001)



WARNING

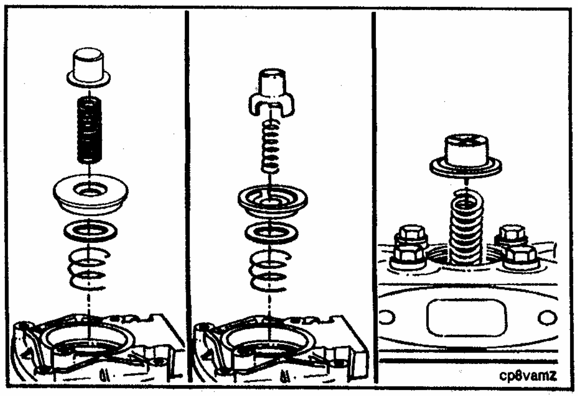
The unloader valve body is installed with spring tension. Use care when removing to prevent personal injury. Always wear protective eye wear.

Hold the unloader valve body down and remove the two captive washer capscrews and the two plain washers.

Remove the unloader valve body.

Remove the 0-ring seal.

Remove the rectangular ring seal.



Remove the unloader valve cap and the unloader valve spring.

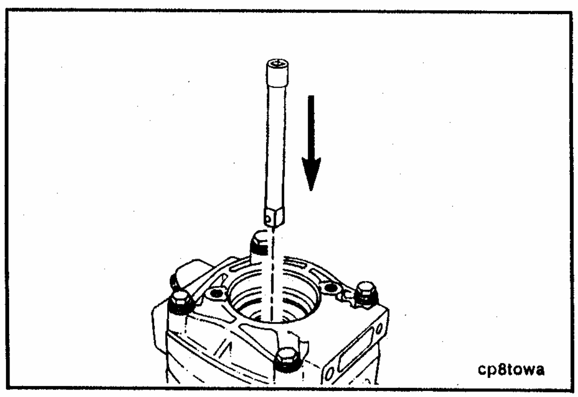
NOTE

Disassembly of the center unloader valve on Holset two cylinder air compressors is similar to the single cylinder unloader valve.

Remove the intake valve seat and valve.

Remove the intake valve spring.

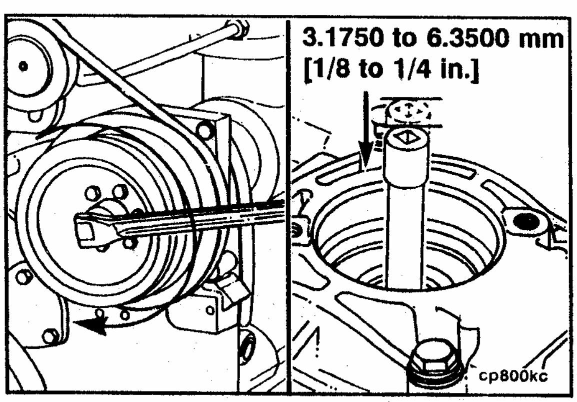
To avoid damage to the air compressor, do **not** allow any debris to fall into the air compressor cylinder.



NOTE

Do not use a screwdriver. A screwdriver can gouge the top of the piston.

Insert the small end of a 3/8 inch drive socket extension (6 to 10 inches long) through the exhaust valve seat onto the top of the piston.

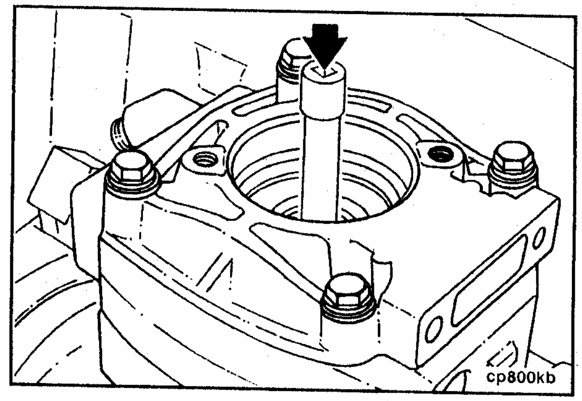


Bar the crankshaft over until the compressor piston reaches top dead center (TDC), and the extension starts to move downward approximately 3 to 6 mm [1/8 to 1/4 inch].

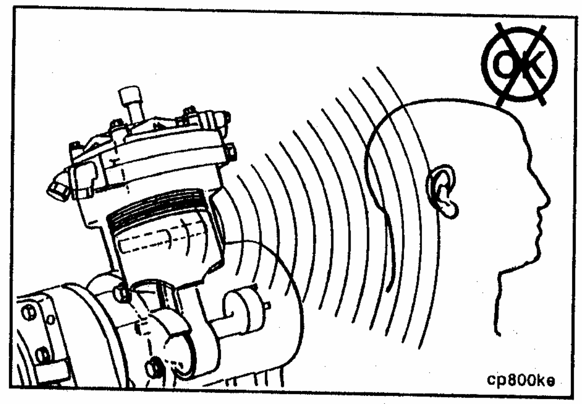
NOTE

To prevent damage to the top of the piston, do not use a hammer.

Give a quick hard push downward on the extension and listen for a metallic click as wear clearance is taken up.



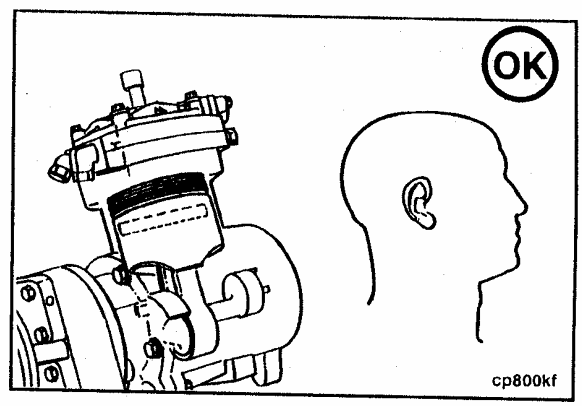
If significant piston motion is felt or a metallic click is heard, the pin bores can be worn, and the compressor must be examined further.



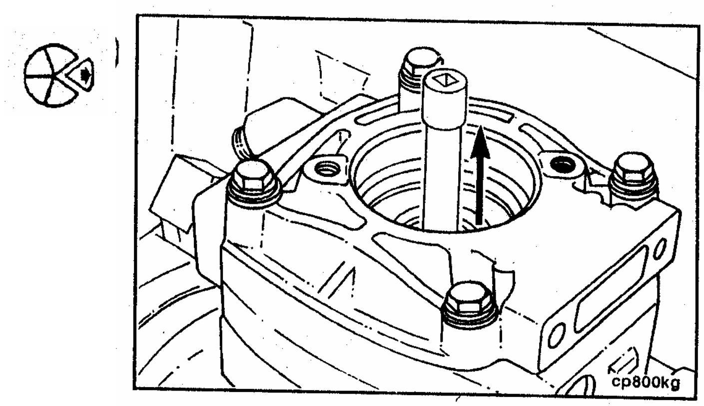
If no motion or sound is heard, the compressor is in satisfactory condition and does not need to be replaced.

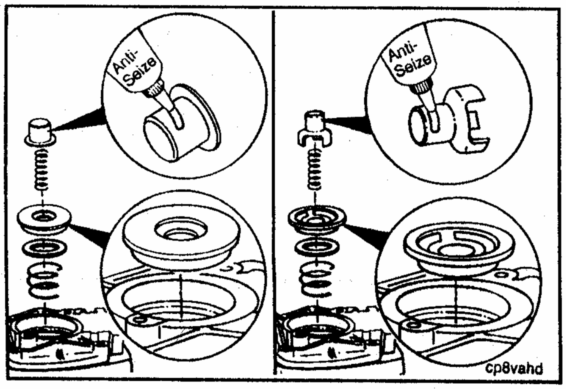
NOTE

Not all air compressors will exhibit pin bore wear.



Remove the extension.





Install the intake valve spring with the tang down.

Install the intake valve.

Install the intake valve seat with the flange side up.

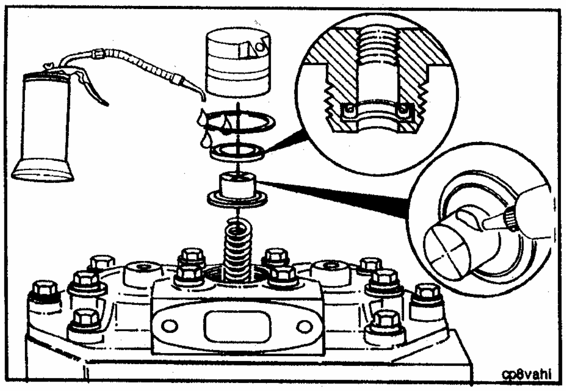
Install the unloader valve cap spring.

Install the unloader valve cap.

Use high temperature grease (Accrolube Lubrication Teflon® Grease or equivalent) to lubricate the outside diameter of the cap.

NOTE

The rectangular ring seal must be installed with the grooved side up.



Install the rectangular ring seal.

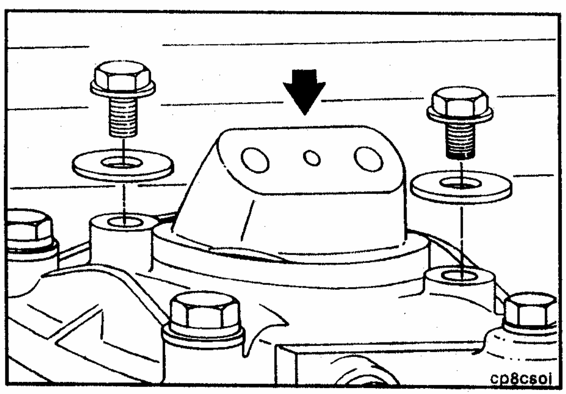
Install the 0-ring seal.

Use clean engine oil to lubricate the 0-ring seal.

Install the unloader valve body.

NOTE

Press the unloader valve body down to be sure the tangs of the unloader valve cap are in the three slots of the intake valve seat.



CAUTION

Do not over torque. Compressor damage will result.

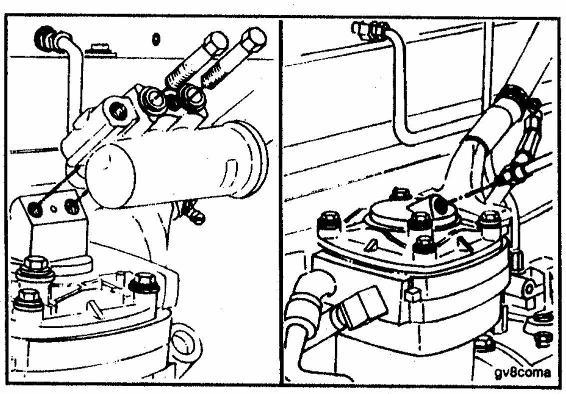
Hold the unloader body down and install the two plain washers and captive washer capscrews.

Tighten the capscrews.

Torque Value: 14 N•m [10 ft-lb]

Air Compressor Unloader Valve (012-013)

Initial Check (012-013-001)



WARNING

Air pressure must be released from system before removing the air governor.

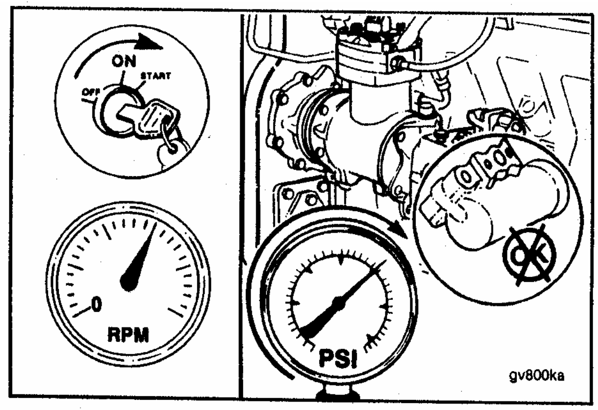
NOTE

The illustrations shown will be of the SS model single cylinder air compressor. Differences in procedures for SS, QE and ST model Holset air compressors will be shown where necessary.

Remove the air governor or air governor hose from the air compressor unloader body.

Operate the engine to activate the air compressor.

If the air compressor is not pumping, the unloader valve is malfunctioning, and must be repaired or replaced.



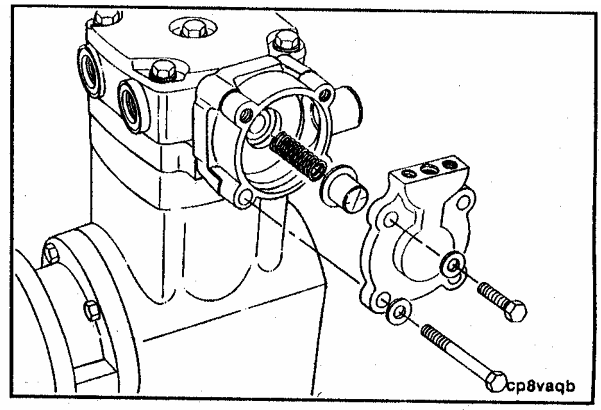
Remove (012-013-002)

Holset QE Models

WARNING

The unloader body is installed with spring tension. Use care when removing to prevent personal injury. Always wear protective eye wear.

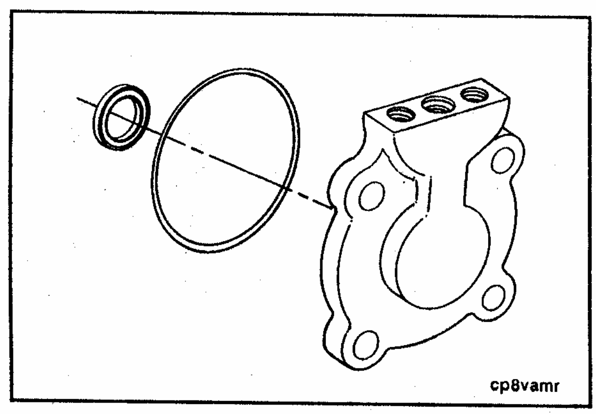
Hold the unloader valve body down and remove the four capscrews.



Remove the unloader valve spring.

Remove the unloader valve cap.

Remove the unloader body gasket and unloader valve cap rectangular ring seal.

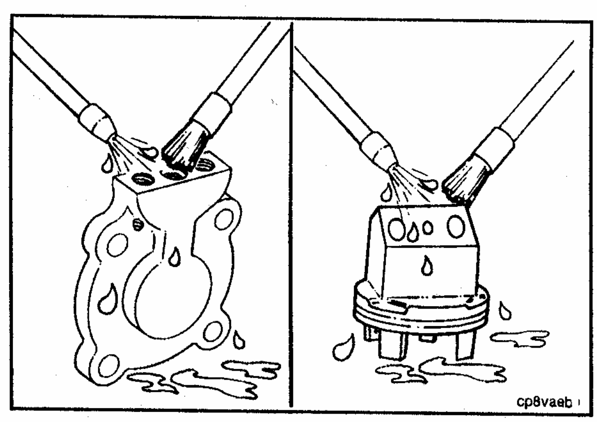


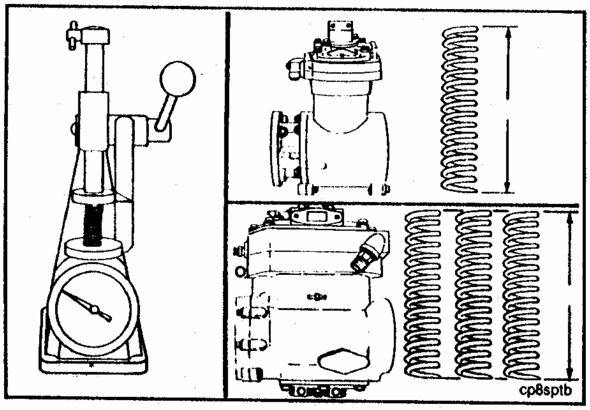
Clean (012-013-006)

CAUTION

Do not use caustic cleaners.

Remove all carbon and varnish from the unloader valve cap body.





Inspect for Reuse (012-013-007)

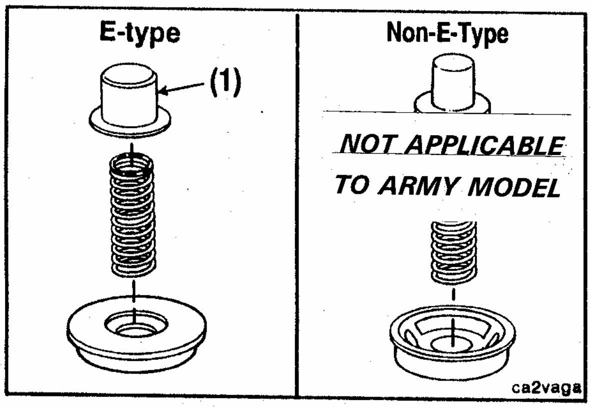
Use a valve spring tester to check the unloader spring.

Refer to the Compressor Spring Force Specifications chart shown in Section V.

Replace the unloader spring if it does not meet the specifications shown, or the wrong spring has been used.

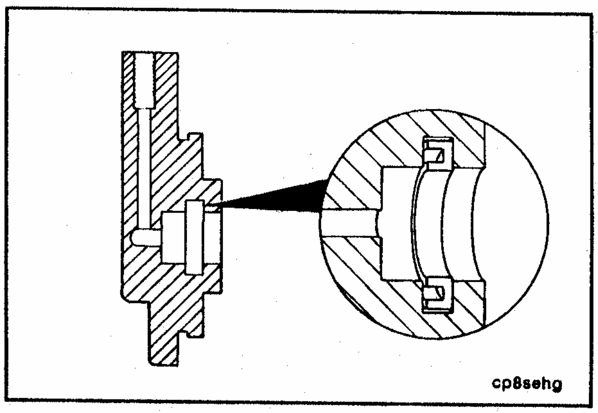
NOTE

For Holset two cylinder air compressors check both cylinder and center unloader springs. New springs shall be installed during rebuild.



NOTE

If the compressor has a flat hat type unloader cap (1), it must use an unloader spring and valve seat different than that used with the three prong unloader.



Install (012-013-026)

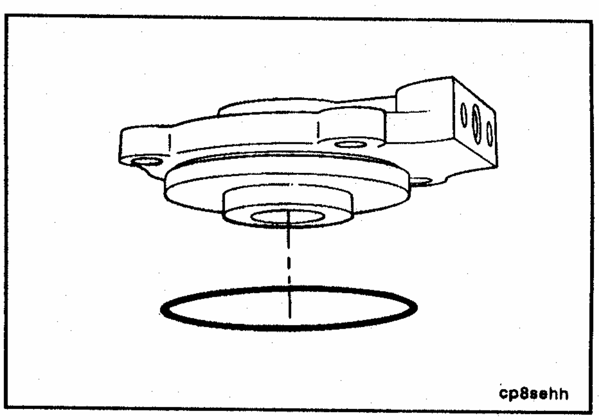
Holset QE Models

Install the new rectangular vee seal into the unloader body.

NOTE

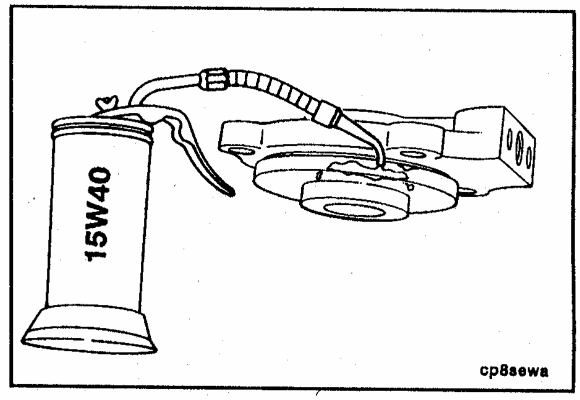
The seal must be installed with the grooved side up.

Liberally lubricate the unloader valve bore above and below the rectangular ring seal with high temperature grease. (Accrolube Lubrication Teflon® Grease or equivalent.)



Install a new o-ring seal on the unloader valve body.

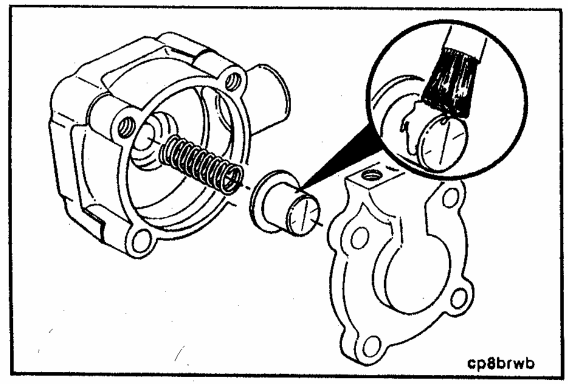
Use clean 15W40 oil or Accrolube Lubrication Teflon® Grease (or equivalent) to lubricate the seal.



Liberally lubricate the unloader valve body bore and unloader cap with high temperature grease (Accrolube Lubrication Teflon® Grease or the equivalent).

Install the unloader cap.

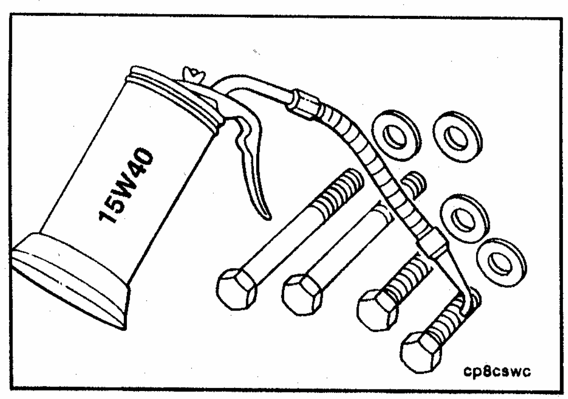
Install the unloader spring.



Lubricate the unloader screw threads and underhead with clean engine oil (SAE 15W40), before installation.

NOTE

The two unloader body screws must not be used to attach any brackets.



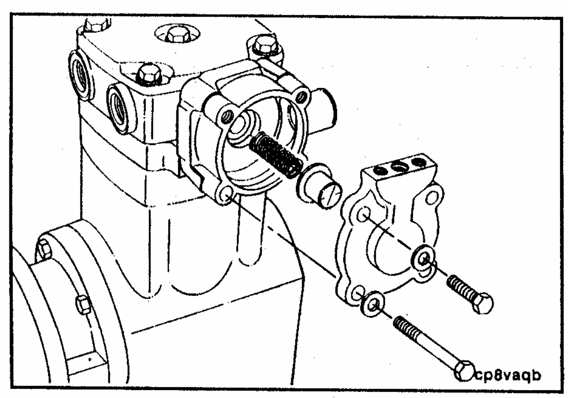
Assemble the unloader components and attach the unloader assembly to the valve plate with the four capscrews and washers.

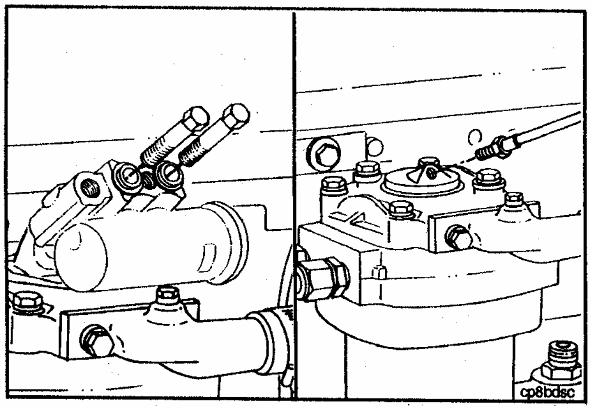
NOTE

The longer capscrews are used to mount the manifold to the air compressor.

Torque Value: 27 N•m [20 ft-lb]

Operate the engine and check the air compressor for air leaks.





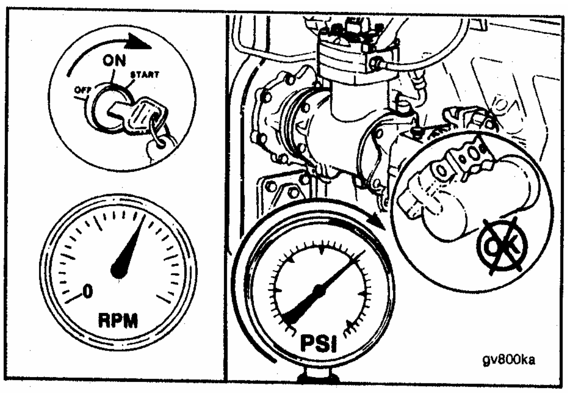
Air Governor (Air Compressor Will Not Pump) (012-017)

Initial Check (012-017-001)

NOTE

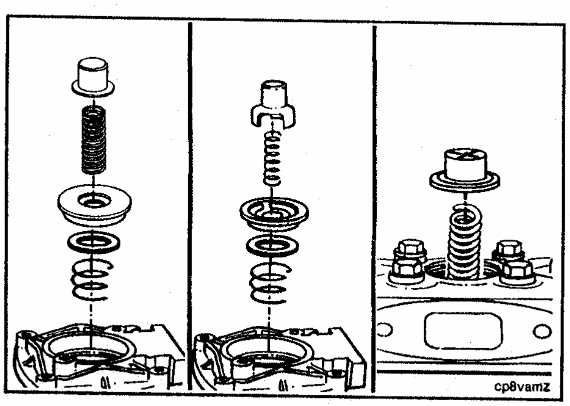
The illustrations shown will be of the SS model single cylinder air compressor. Differences in procedures for SS, QE and ST model Holset air compressors will be shown where necessary.

Remove the air governor or air governor line from the air compressor unloader body.



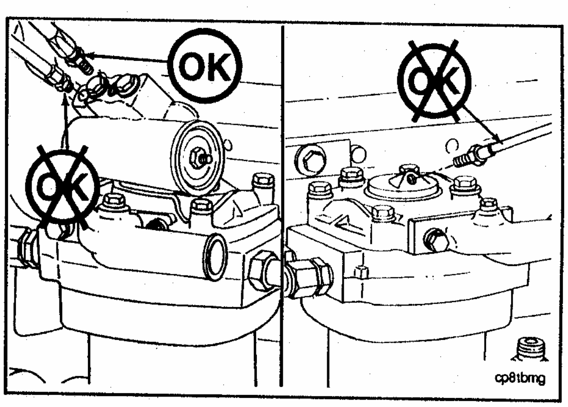
Operate the engine to activate the air compressor.

If the air compressor is pumping, the air governor is malfunctioning and must be repaired or replaced. Refer to the manufacturer's instructions.



If the air compressor does not pump, remove, clean, and inspect the air compressor unloader valve assembly. Refer to Air Compressor Unloader Valve, Procedure 012-013.

If the unloader valve assembly is okay, clean and inspect the exhaust valve assembly. Refer to Air Compressor Cylinder Head, Procedure 012-104.



Air Governor (Air Compressor Pumps Continuously) (012-018)

Initial Check (012-018-001)

NOTE

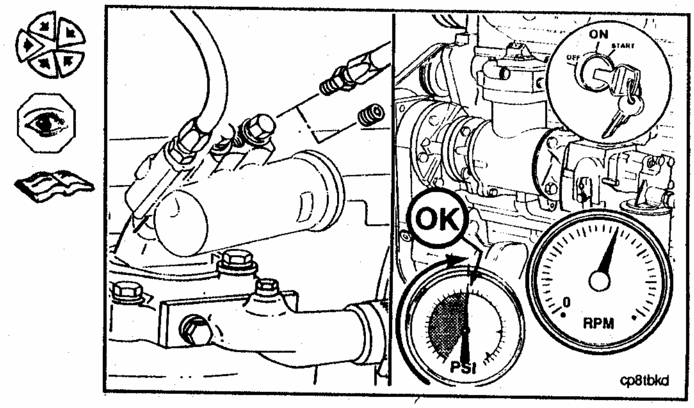
The illustrations shown will be of the SS model single cylinder air compressor. Differences in procedure for SS, QE and ST model Holset air compressors will be shown where necessary.

Remove the air accessory air lines from the air compressor governor.

Install pipe plugs in the air governor unloader ports where accessory air lines were removed.

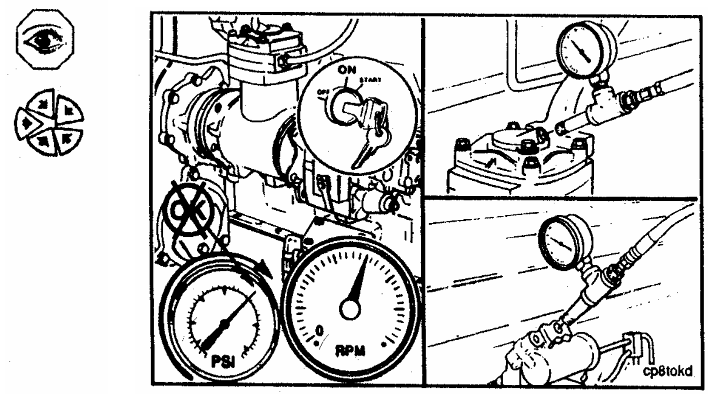
Operate the engine to activate the air compressor.

If the air compressor stops pumping (air pressure stops rising) at the governed air pressure, there is a leak in an accessory or an accessory air line. Refer to the equipment manufacturer's instructions for troubleshooting and repair.



If the air compressor does not stop pumping (air pressure continues to rise) at the governed air pressure, connect a regulated shop air pressure line to one of the following:

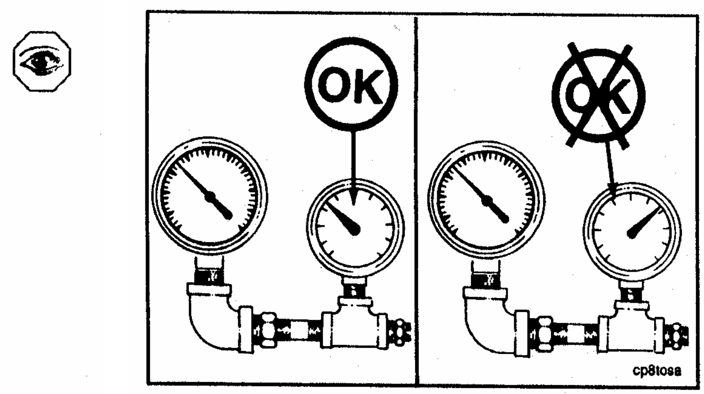
- The air compressor unloader valve port
- One of the air governor unloader valve ports.



NOTE

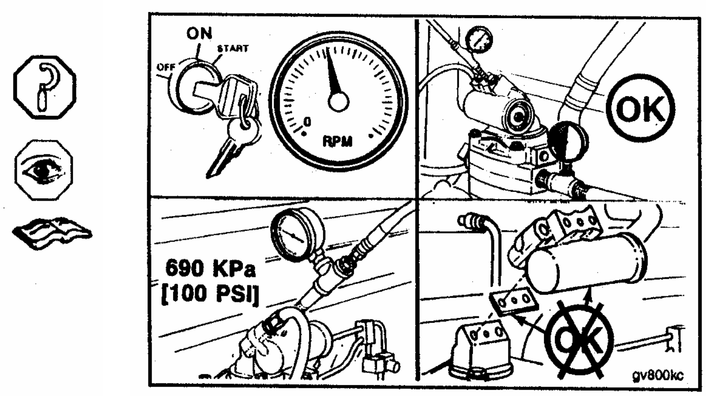
Be sure the air pressure gauge is accurate, and the supply lines and fittings are in good condition before per-forming any air pressure checks.

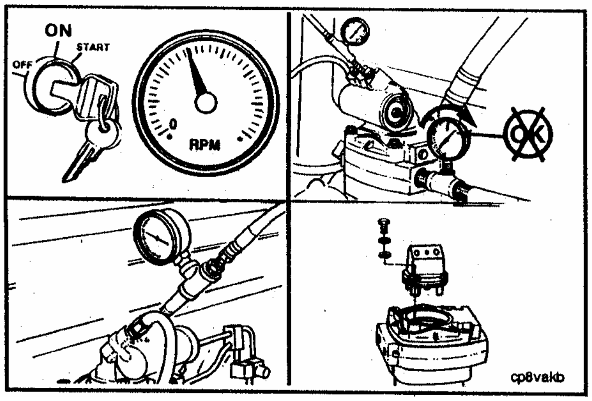
Use a master gauge of known accuracy to check the air pressure gauge.



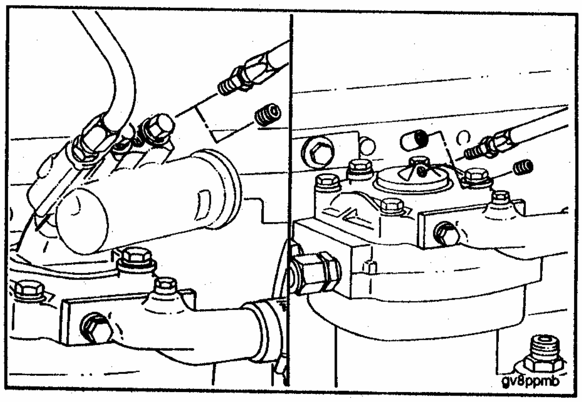
Apply 690 kPa [100 psi] air pressure to the unloader port.

If the air compressor stops pumping (air pressure stops rising), the air governor is malfunctioning and must be repaired or replaced, or the air governor mounting gasket is leaking. Refer to the manufacturer's instructions.





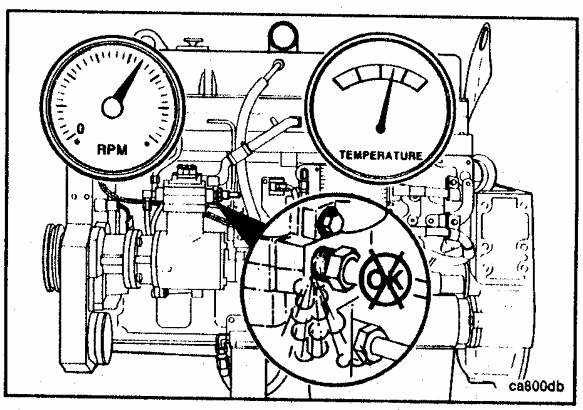
If the air compressor continues to pump (air pressure continues to rise), the unloader valve is malfunctioning, and must be repaired or replaced. Refer to Air Compressor Unloader Valve, Procedure 012-013.



Remove the pipe plugs from the unloader ports used for accessory air lines.

Install and tighten the accessory air lines.

Connect the line to the unloader valve.



Operate the engine and check for air leaks.

Air Leaks, Compressed Air System (012-019)

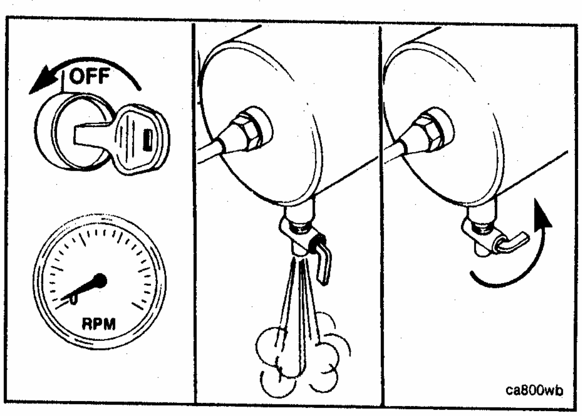
Initial Check (012-019-001)

WARNING

Compressed air can drive debris into eyes and ears. Keep head well away and wear protective eye wear.

NOTE

The illustrations shown will be of the single cylinder air compressor. Differences in procedures for SS, QE and ST model Holset air compressors will be shown where necessary.



Shut off the engine.

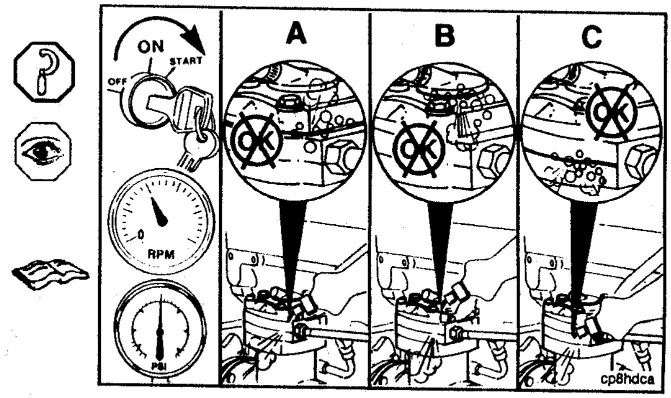
Open the drain cock on the wet tank to release air from the system. Close the drain cock after the pressure is released.

Operate the engine to activate the air compressor.

With the air compressor pumping between 550 to 690 kPa [80 to 100 psi], use a solution of soapy water to check for air leaks in the following areas:

- Air Compressor cover gasket
- Unloader body o-ring
- Air Compressor head gasket
- Air Compressor valve plate gasket (QE models only)
- Hose and fitting leaks

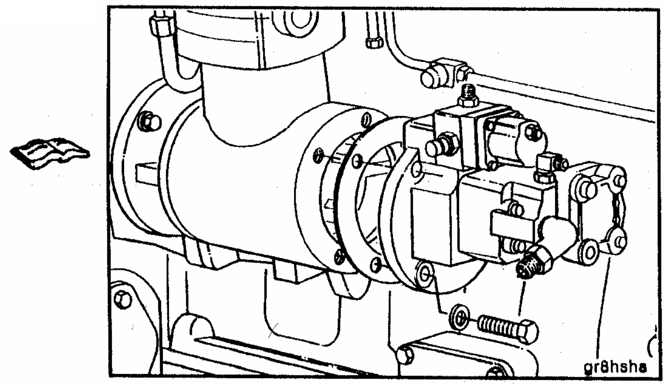
If air leaks are found, replace the leaking gasket or o-ring. Refer to Air Compressor Cylinder Head, Procedure 012-104.



Air Compressor (012-021)

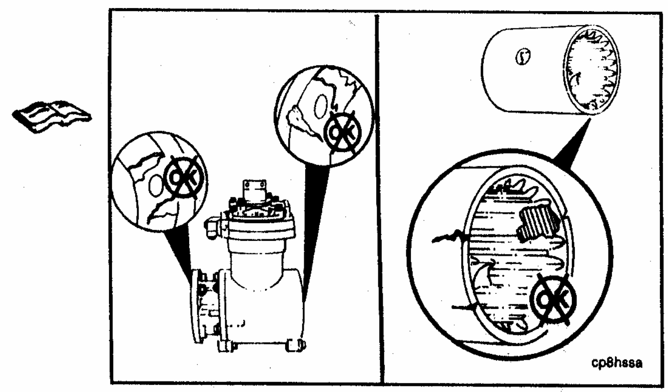
Remove (012-021-002)

Refer to the engine troubleshooting and repair manual for air compressor removal.



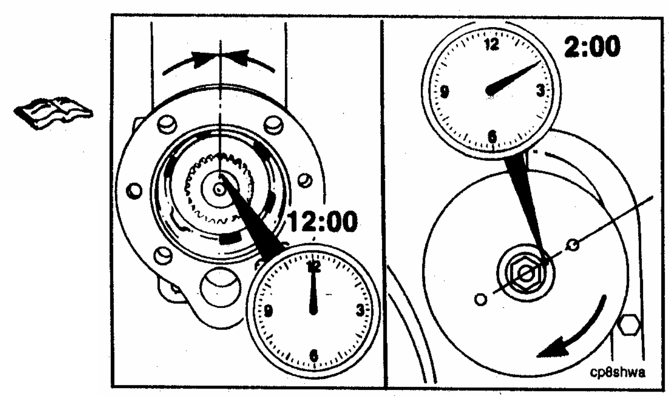
Inspect for Reuse (012-021-007)

Refer to the engine troubleshooting and repair manual for air compressor inspect for reuse.

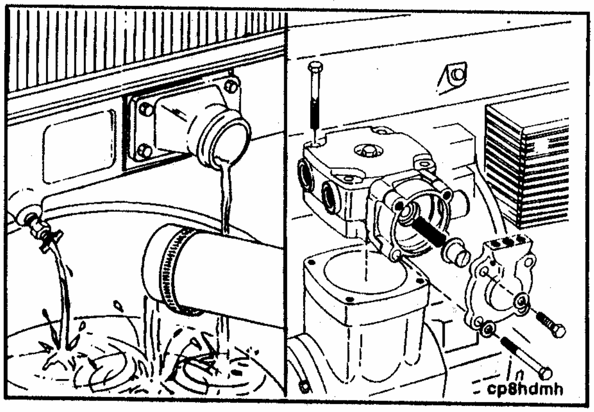


Install (012-021-026)

Refer to the engine troubleshooting and repair manual for air compressor install.



Air Compressor Cylinder Head (Holset QE Models) (012-104)
Disassemble (012-104-003)

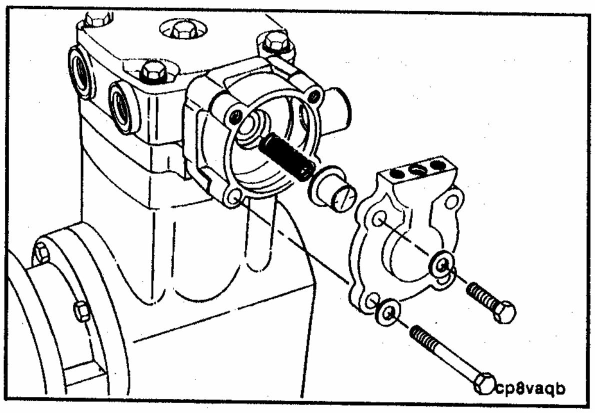


NOTE

If the cylinder head is removed while the air compressor is on the engine, drain the engine coolant. Refer to the engine manual.

NOTE

Since the valve plate, head and unloader body are indexible, marking of these parts is recommended to make sure they are reassembled in the proper orientation.



WARNING

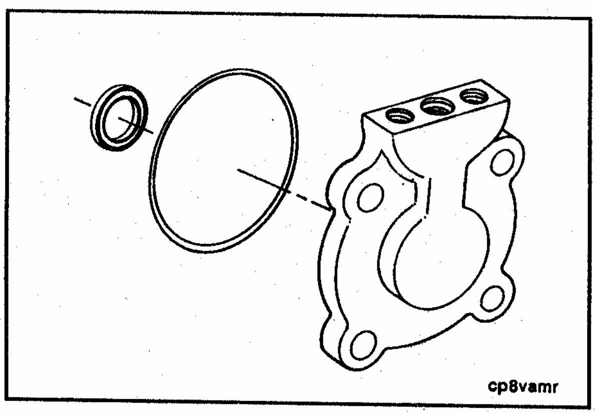
The unloader body is installed with spring tension. Use care when removing to prevent personal injury. Always wear protective eye wear.

Hold the unloader valve body down and remove the four capscrews.

Remove the unloader valve body.

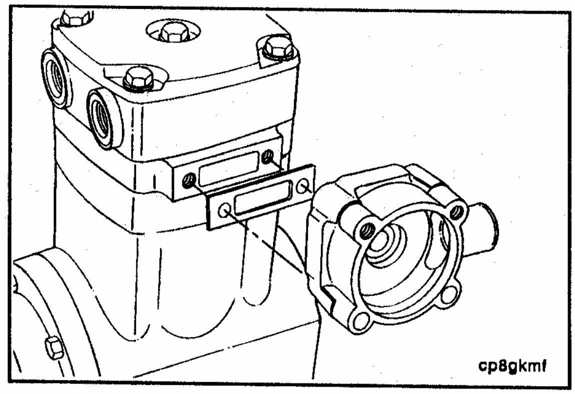
Remove the unloader valve spring.

Remove the unloader valve cap.



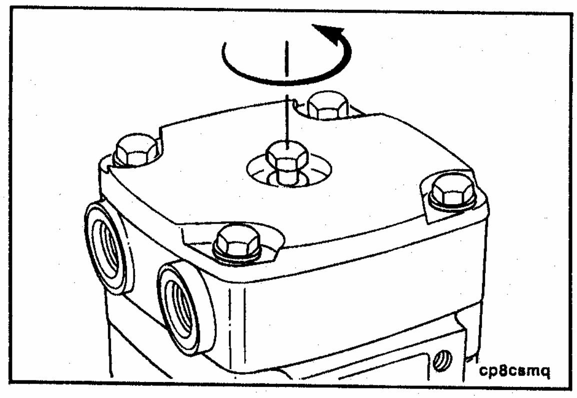
Remove the unloader body gasket and unloader valve cap rectangular ring seal.

Remove the intake manifold and gasket.



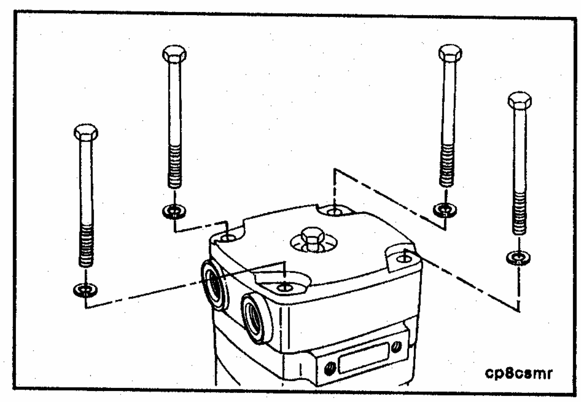
Loosen, but do not remove the center head capscrew.

Mark the head for orientation during assembly.



Loosen and remove the four corner head capscrews.

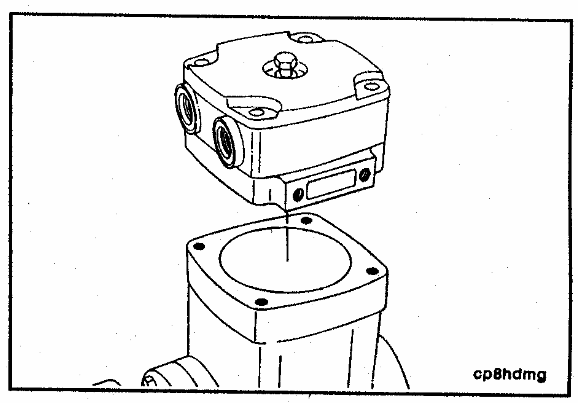
Save the capscrews for reuse.

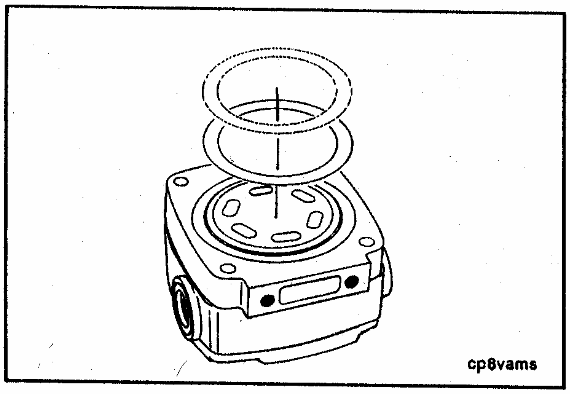


Remove the head, cover, and valve plate assembly and place it on a clean work surface with the intake valve facing upward.

NOTE

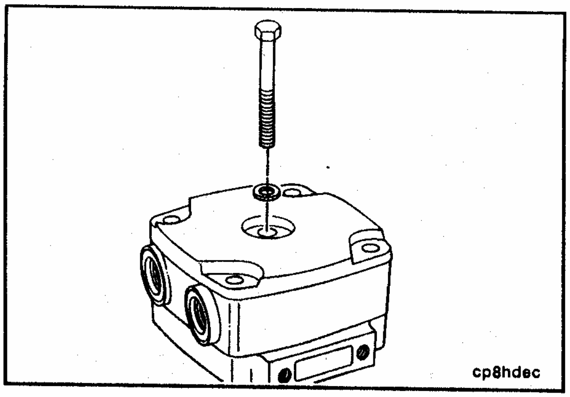
If continuing with disassembly of the head, valve plate, and cover, be sure the work surface is clean. Grit pushed into the valve sealing surfaces by setting components on a dirty surface will cause a malfunction after reassembly.



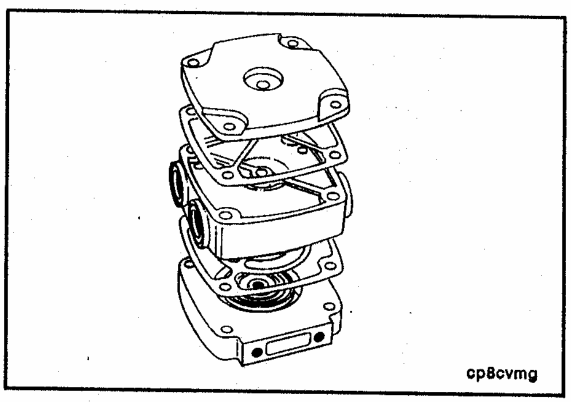


Some units have a press-fit intake valve retainer. If present, carefully remove it to prevent part damage.

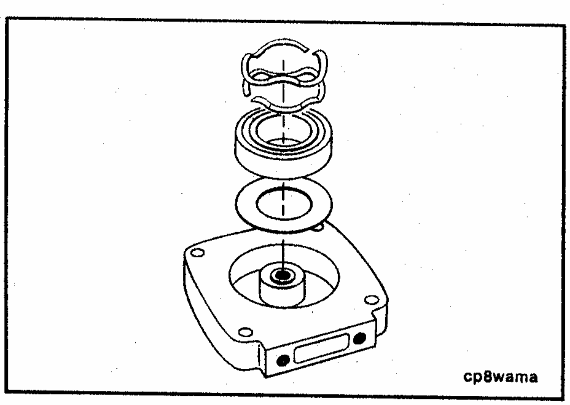
Remove the intake valve.



Turn the head assembly over and set it on a clean surface. Remove the center capscrew. This capscrew can be re-used. Note that this capscrew is shorter than the four corner capscrews.



Remove the cover, cover gasket, head and head gasket.

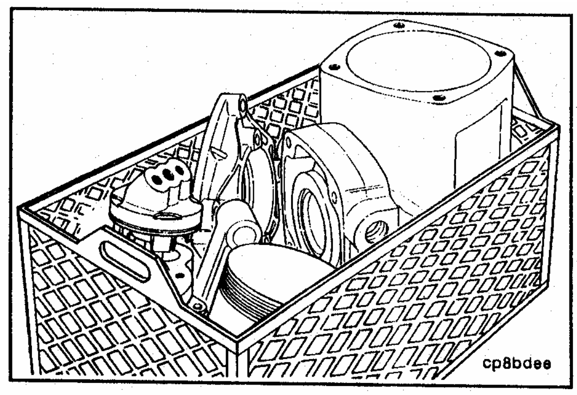


Remove the two wave washers, exhaust valve retainer and exhaust valve. These wave washers must be replaced.

Clean (012-105-006)

WARNING

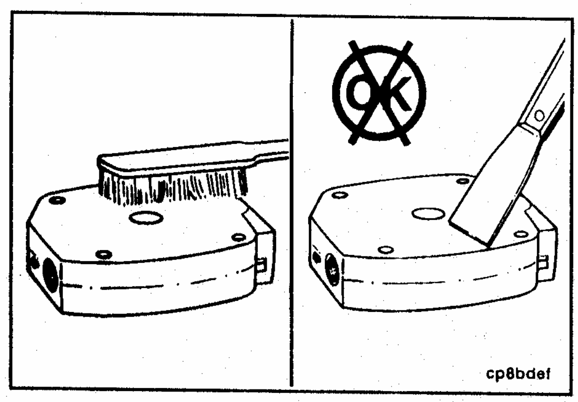
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing.



Soak the parts in a kerosene emulsion based cleaner designed to remove carbon. The cleaner must have a pH of 9.5 or less to avoid turning aluminum parts black. The cleaner manufacturer or supplier can be contacted about solution concentration, temperature and soak time.

NOTE

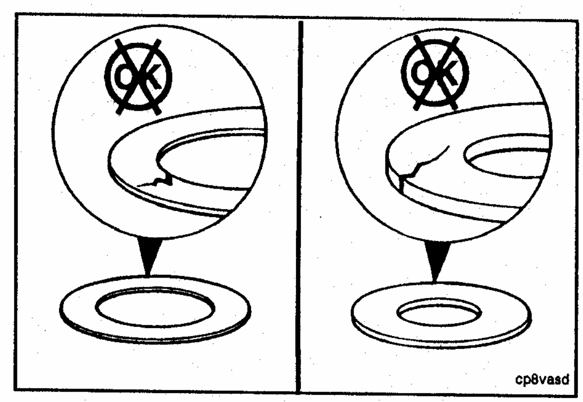
Do not use a scraper to remove carbon and scale; the sealing surfaces can be damaged.



The parts can be scrubbed with a stiff non-metallic bristle brush.

Inspect for Reuse (012-104-007)

Visually inspect the intake and exhaust valves for cracks or damage.



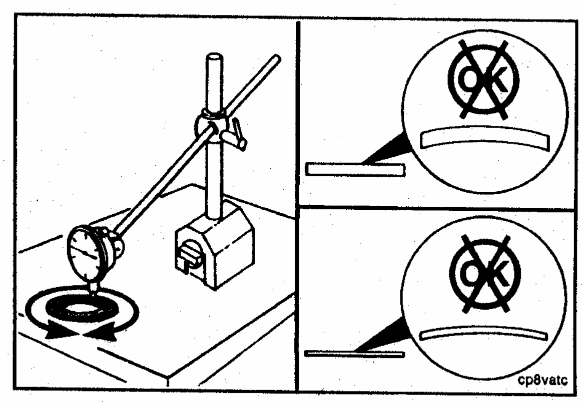
Measure the flatness of the intake and exhaust valves.

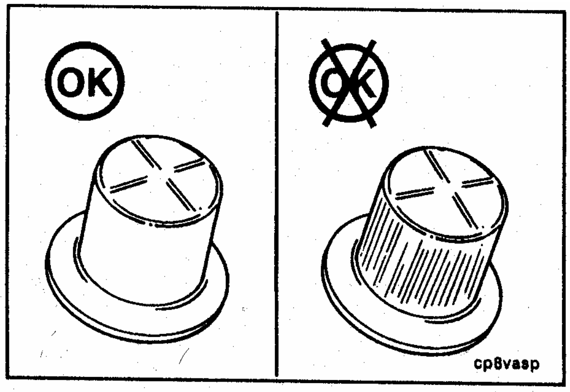
Both valves must be flat within 0.03 mm [0.001-inch].

Replace valves if cracked, damaged, or not flat.

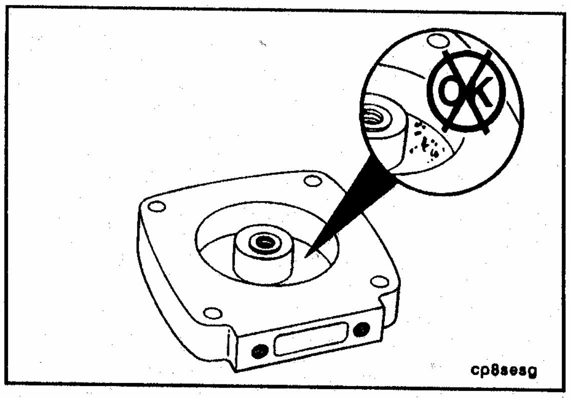
NOTE

Install new valves.





Inspect the upper part of the unloader valve cap where the rectangular vee seal operates. Check for scoring.

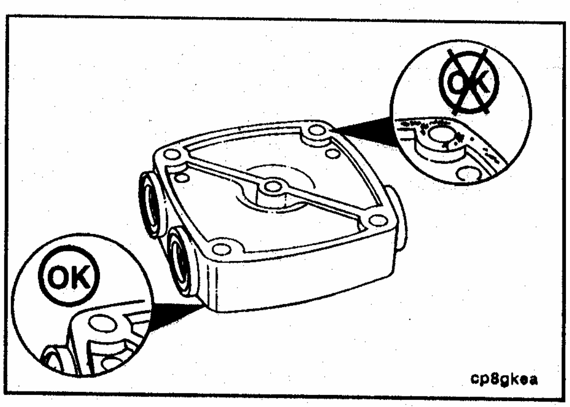


Inspect the valve seat surfaces.

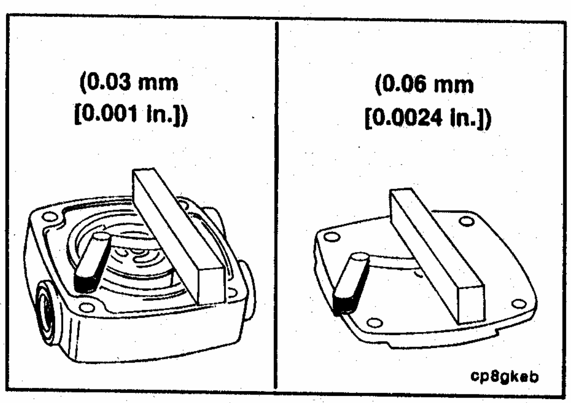
NOTE

Inspection of the valve seats in the valve plate requires specialized equipment and is beyond the scope of field service.

If the valve seat is visibly damaged, or cannot be cleaned, a new valve plate is available in a service kit. Otherwise, a QE valve plate service assembly can be used.

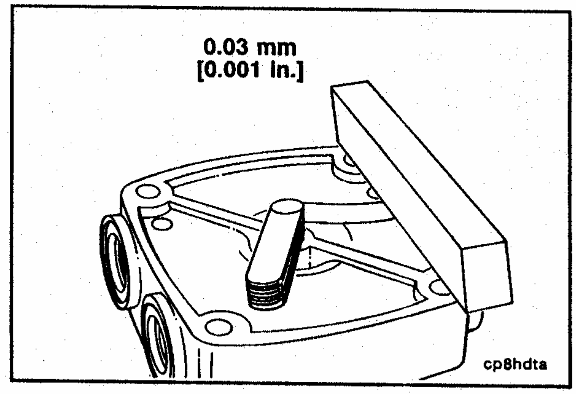


Gasket sealing surfaces must be clean and free of all old gasket material, carbon, rust, and other buildup. Surfaces must be free of scratches, gouges, burrs, and other deformities.

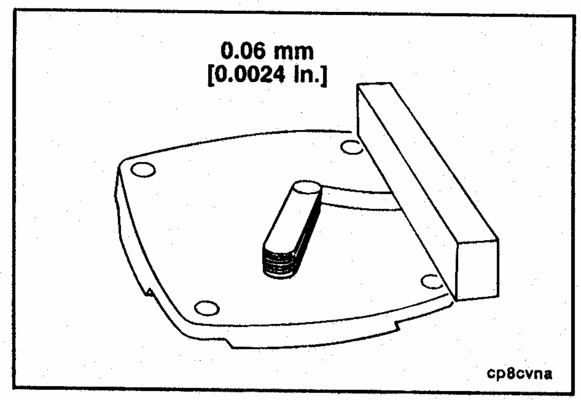


After making sure all gasket surfaces are clean and free of the above, inspect the head and cover for flatness. Use the flat plate and the feeler gauges.

Single cylinder heads must be flat within 0.03 mm [0.001 - inch] between any two adjacent capscrew holes.

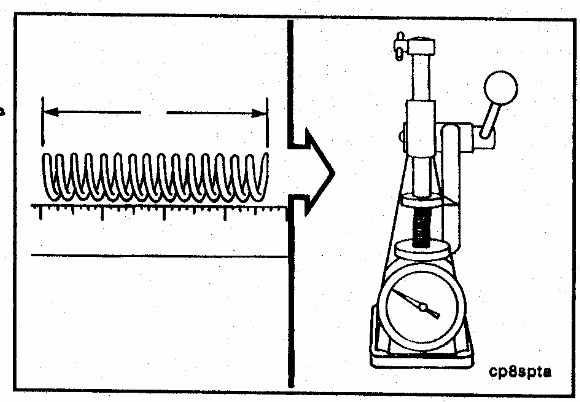


Single cylinder top cover must be flat within 0.06 mm [0.0024-inch] between any two adjacent capscrew holes and 0.10 mm [0.004-inch] total.



NOTE
Inspection of the valve seats in the valve plate requires specialized equipment and is beyond the scope of field service.

Use valve spring tester, Part No. 3375182, to check the unloader valve spring. Replace any spring that does **not** meet specifications.



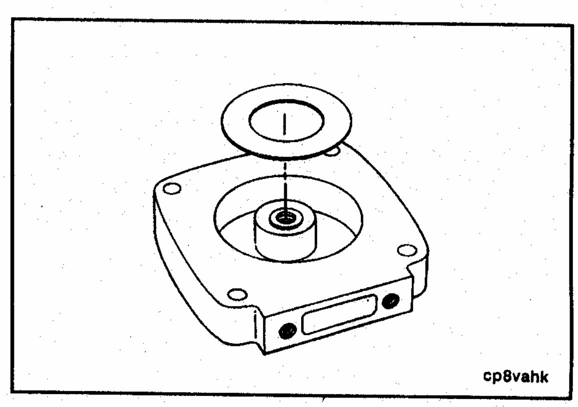
NOTE
Install new springs.

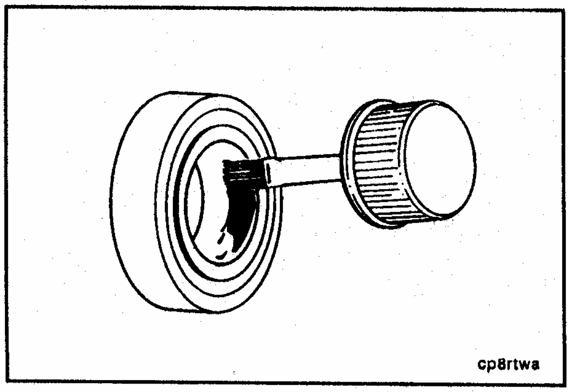
Refer to the Compressor Spring Specifications chart shown in Section V.

Assemble (012-104-025)

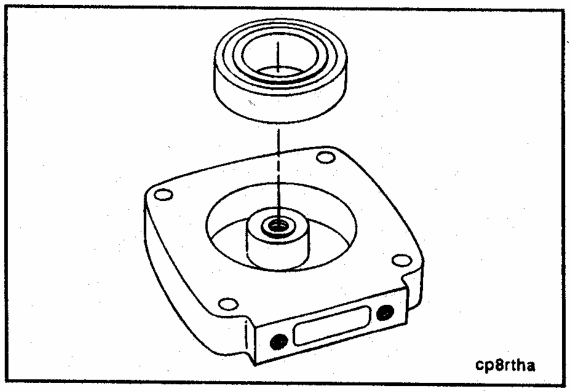
QE, Non-European

Install the exhaust valve over the post in the valve plate.

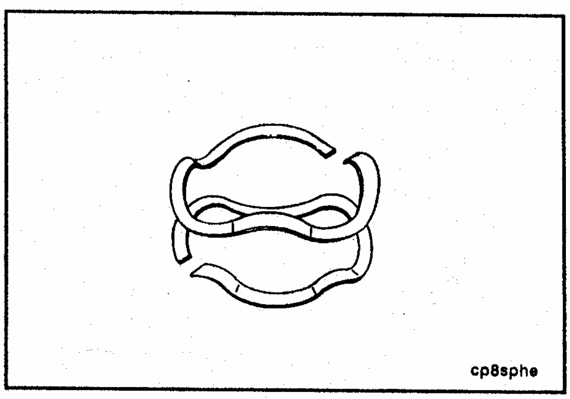




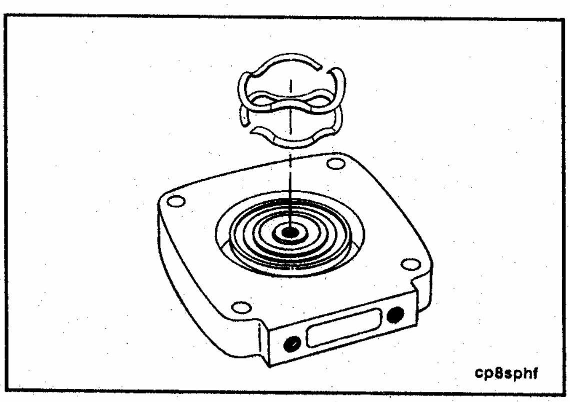
Apply a thin coating of anti-seize to the inside diameter of the exhaust valve retainer.



Slide the exhaust valve retainer over the valve plate. Make sure that the end of the retainer with the groove faces upward.



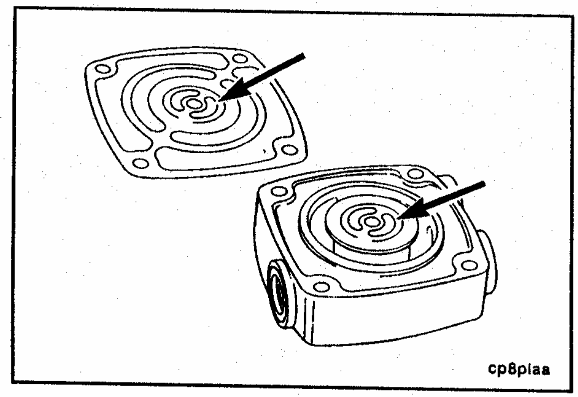
Align the wave spring gaps 180 degrees from each other so they do not overlap.



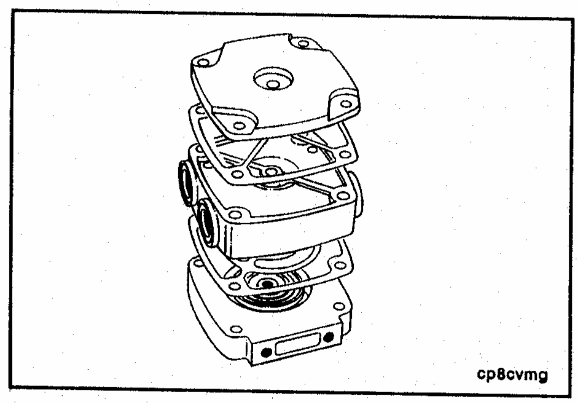
Place the wave springs in the retainer groove.

Determine the final orientation of the valve plate (air intake location) and the head (coolant ports with respect to air inlet or manifold location). Align the kidney-shaped slots in the head with the kidney shaped slots in the gasket.

If orientation marks were made before disassembly, use them.



Assemble the cover, cover gasket, head, head gasket, and valve plate.



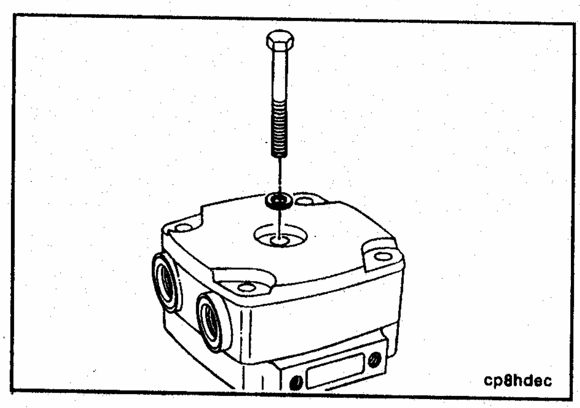
NOTE

Make sure corner capscrew holes are aligned.

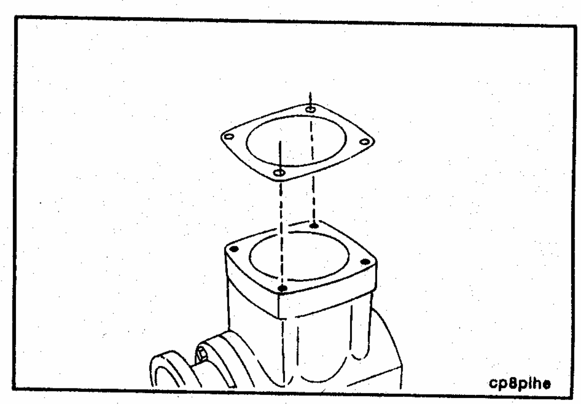
Lubricate the threads under the head.

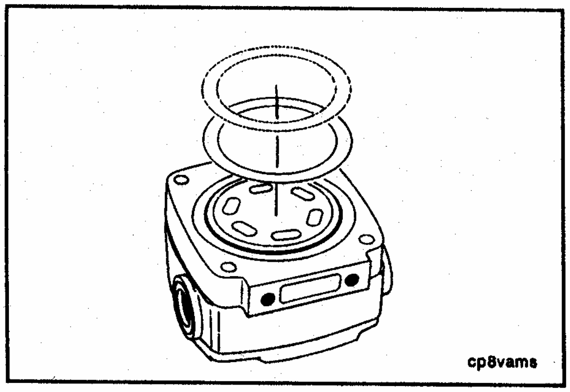
Install the shorter capscrew with washer through the center hole.

Torque Value: 14 N•m [120 in-lb]

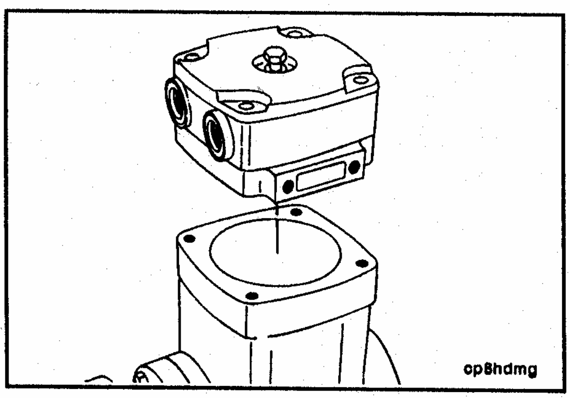


Install the valve plate gasket.

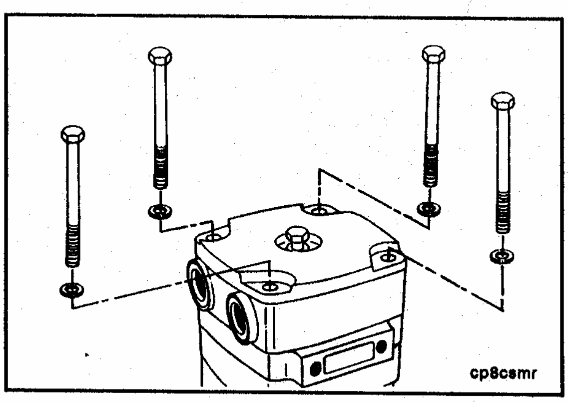




Carefully place the intake valve in the valve plate. Install the intake valve retainer.

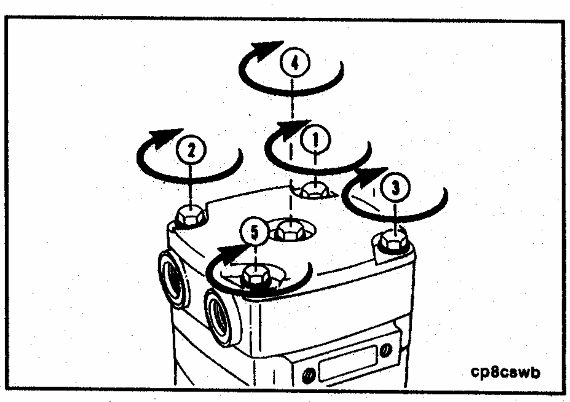


Install the valve plate assembly.



Lubricate the threads under the head and washer of the capscrews if initially installed.

Install the four head capscrews and washers.



Tighten all five capscrews.

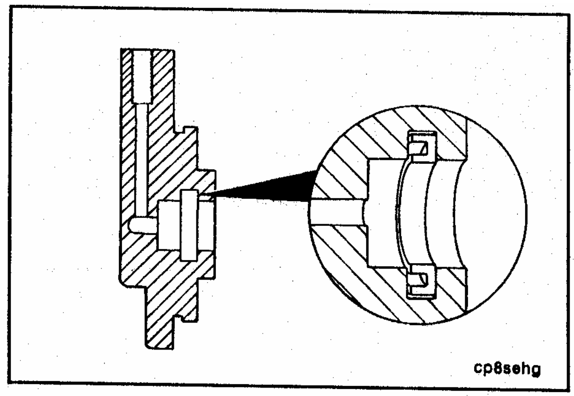
Torque Value: 28 N•m [250 in-lb]

Install the new rectangular vee seal into the unloader body.

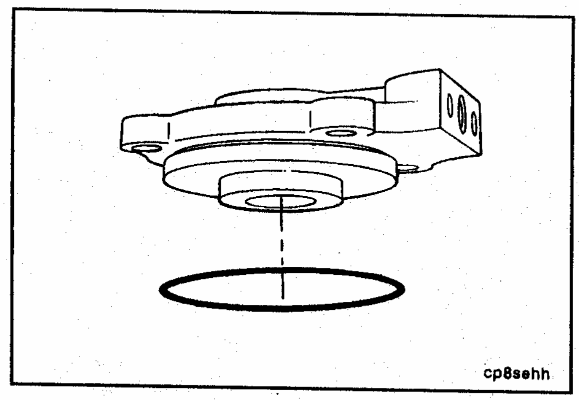
NOTE

The seal must be installed with the grooved side up.

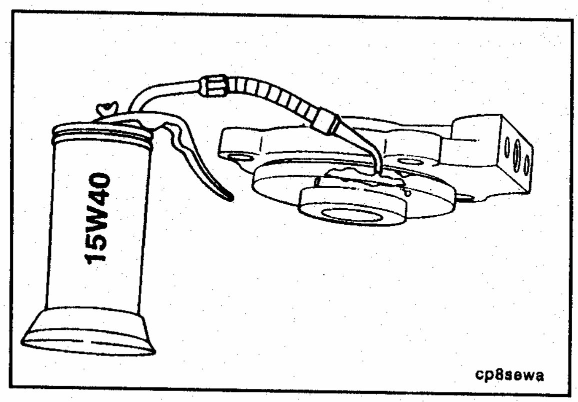
Liberally lubricate the unloader valve bore above and below the rectangular ring seal with high temperature grease (Accrolube Lubrication Teflon® Grease or equivalent).



Install a new o-ring seal on the unloader valve body.



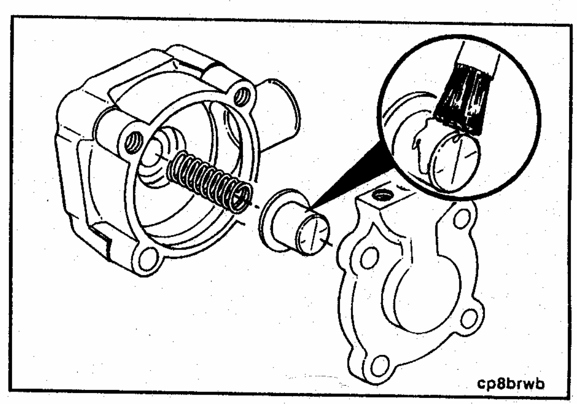
Use clean 15W40 oil or Accrolube Lubrication Teflon® Grease (or equivalent) to lubricate the seal.

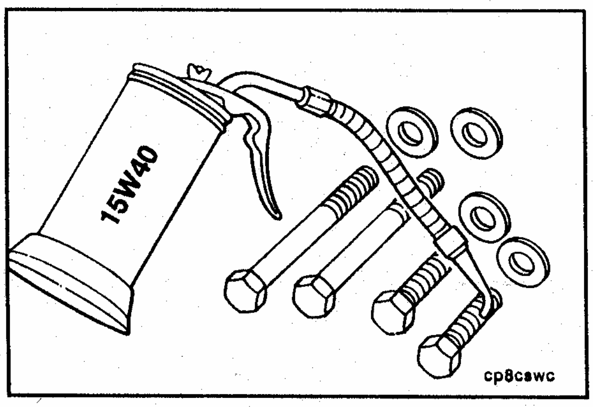


Liberally lubricate the unloader valve body bore and unloader cap with high temperature grease (Accrolube Lubrication Teflon® Grease or the equivalent).

Install the unloader cap.

Install the unloader spring.

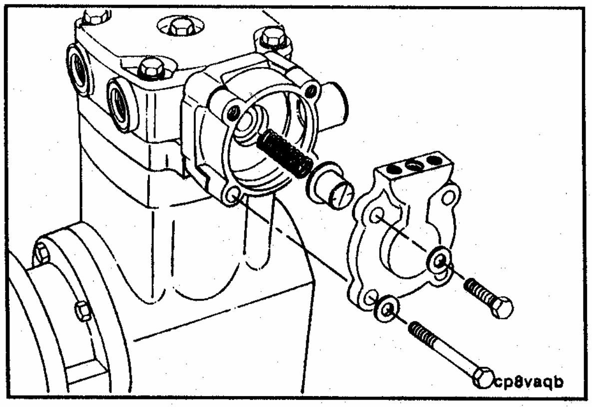




Lubricate the unloader screw threads and underhead with clean engine oil (SAE 15W40), before installation.

NOTE

The two unloader body screws must not be used to attach any brackets.

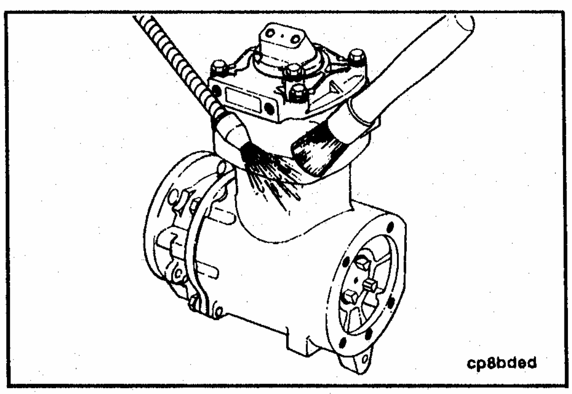


Assemble the unloader components and attach the unloader assembly to the valve plate with the four capscrews and washers.

NOTE

The longer capscrews are used to mount the manifold to the air compressor.

Torque Value: 27 N•m [20 ft-lb]



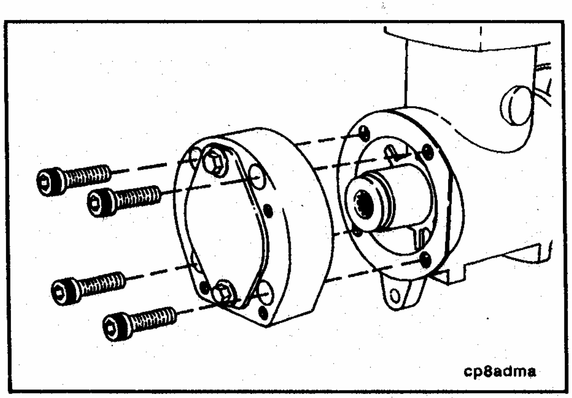
Air Compressor (Holset QE230, SS296, SS296E, QE296, SS338E and QE338 Models) (012-105)

Disassemble (012-105-003)

WARNING

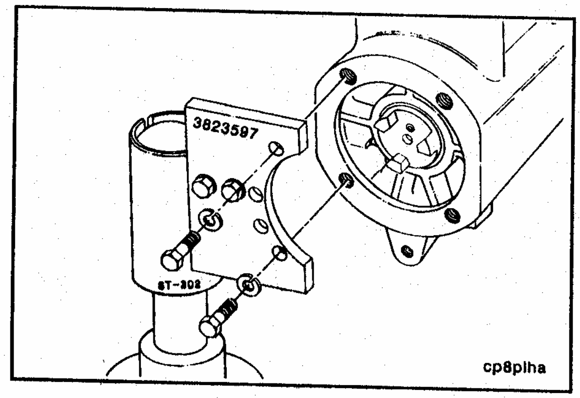
Steam and compressed air present hazards that can result in burns, eye damage or other personal injury. Always wear protective clothing and eye wear.

Use steam to clean the compressor. Use compressed air to dry.



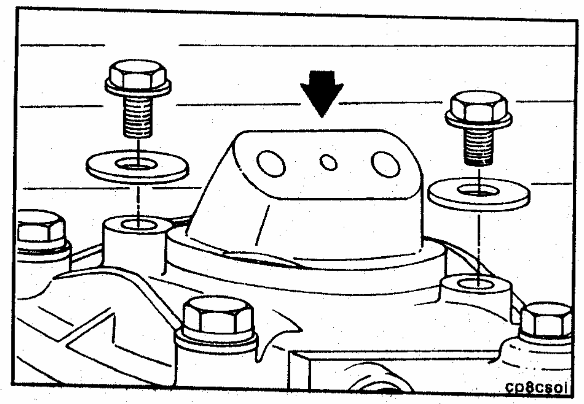
Remove the hydraulic pump adapter from the compressor crankcase.

Install the compressor to the mounting plate, Part No. 3823597, which is used with the ball joint vise, Part No. ST-302.



Disassemble the air compressor cylinder head.

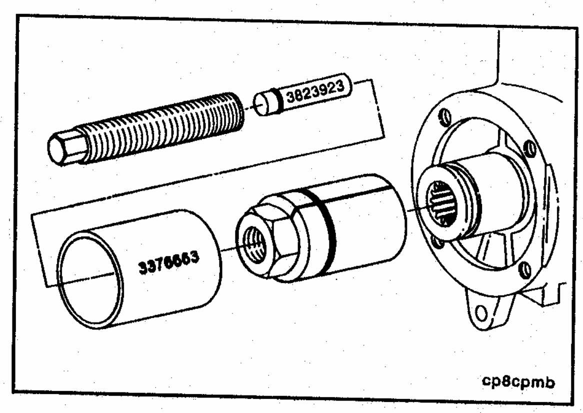
Refer to Procedure 012-104-003.



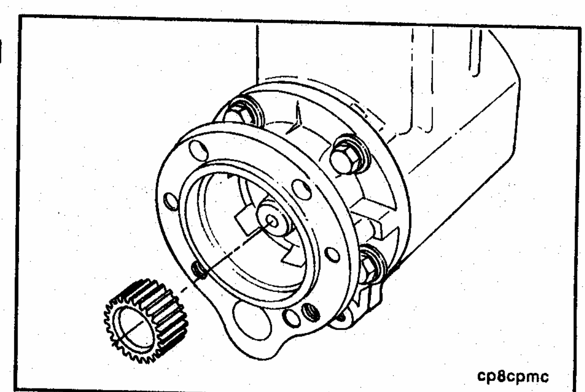
Use coupling puller, Part No. 3376663, and spacer, Part No. 3823923, to remove the hydraulic pump drive coupling from the crankshaft.

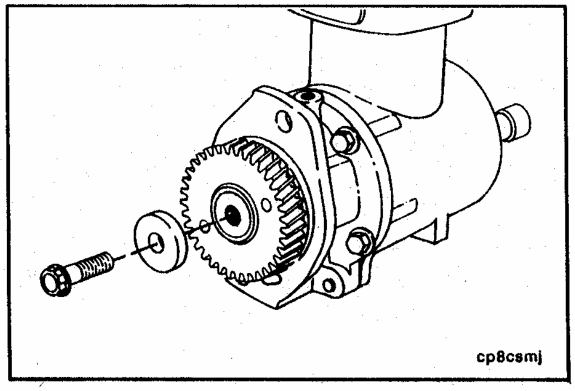
NOTE

This coupling hub only needs to be removed from the crankshaft if it is to be replaced.



Use a coupling puller, Part No. 3376663, to remove the splined coupling hub.

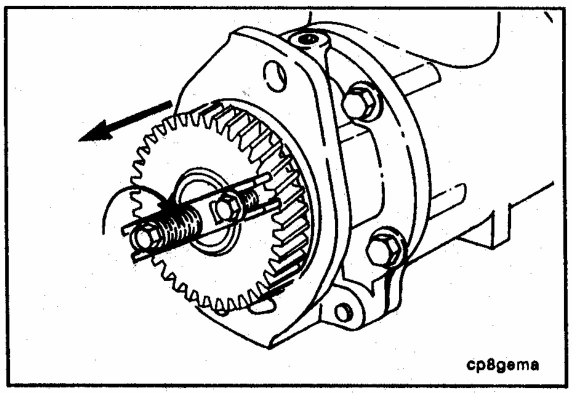




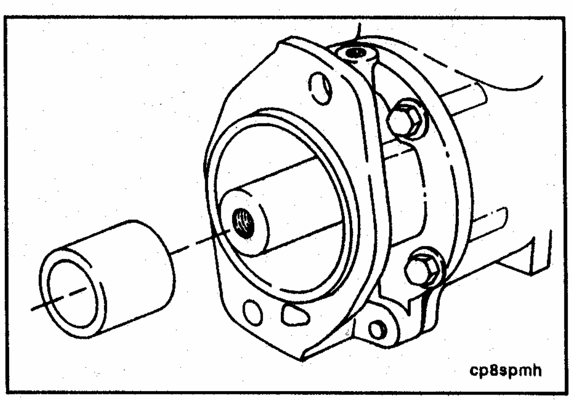
NOTE

Use a hammer handle or socket drive extension wedged between the crankshaft counterweight and crankcase to keep the crankshaft from turning.

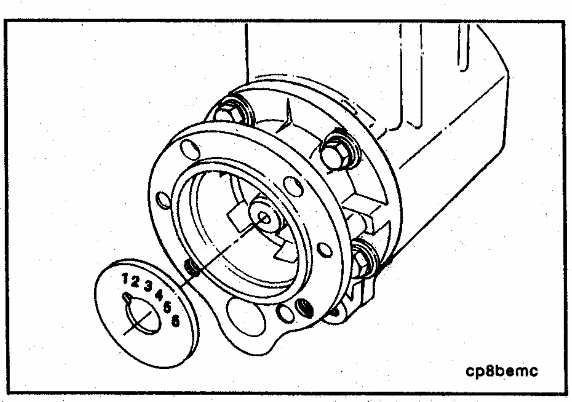
Remove the drive gear retaining capscrew and washer.



Use puller, Part No. ST-647 to remove the drive gear from the crankshaft. Puller capscrews must be M8X1.25-6H thread.

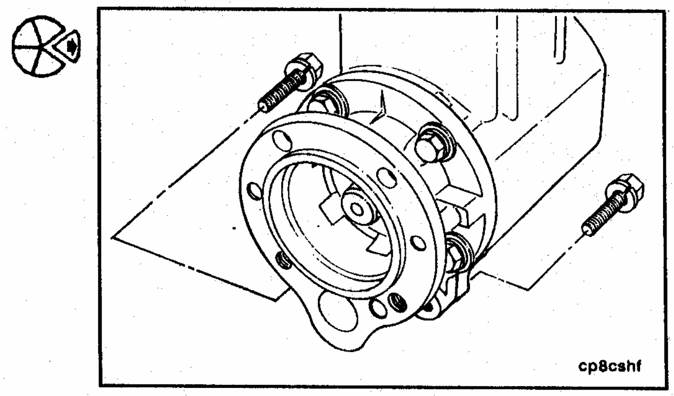


Remove the thrust spacer.

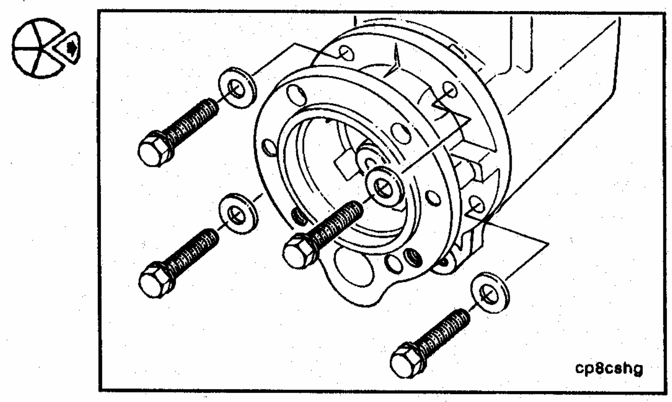


Remove the thrust bearing.

Remove the two hexagon head capscrews and lock washers.

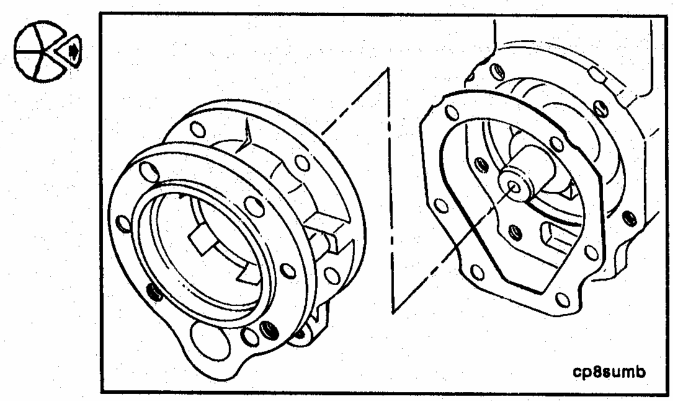


Remove the four captive washer capscrews and the four plain washers.

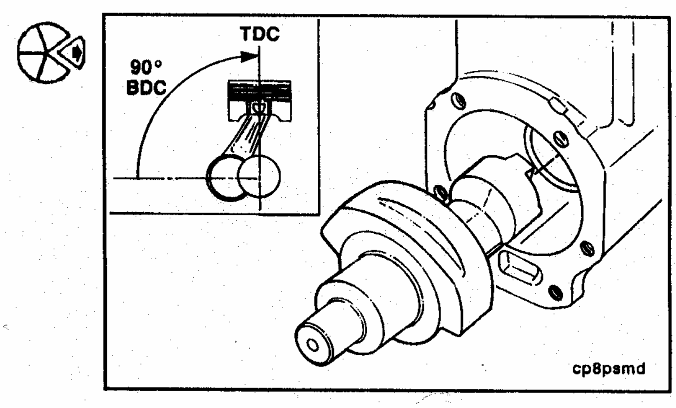


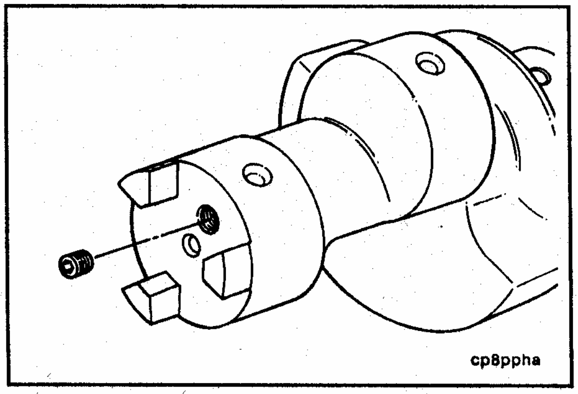
Remove the support.

Remove and discard the crankcase gasket.

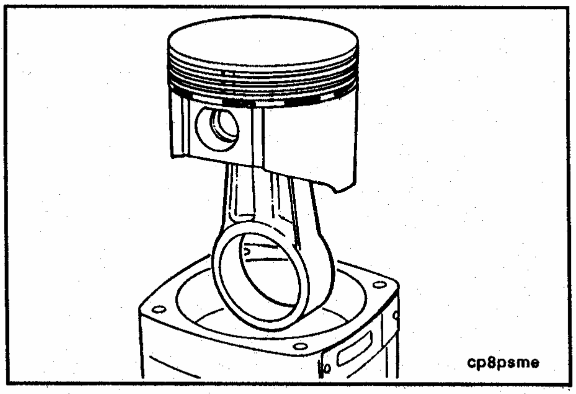


Remove the crankshaft by rotating the crankshaft so that the piston is approximately 90 degrees before or after top dead center. The piston and crankshaft must be in this position before the crankshaft can be removed.

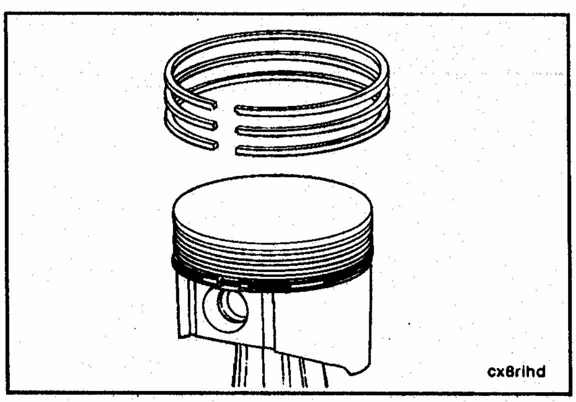




Remove the pipe plug.

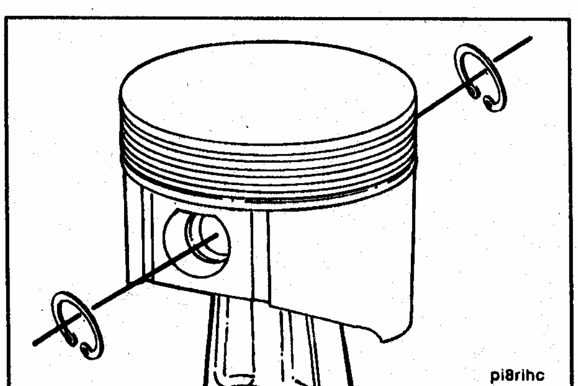


Remove the piston and connecting rod assembly.



Install the connecting rod in a soft jawed vise.

Use a piston ring expander and remove the piston rings.

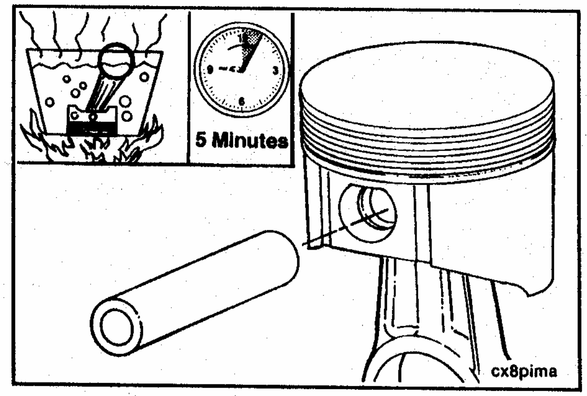


Use a snap ring pliers and remove the two retaining rings.

NOTE

Do not force the piston pin from the piston; the piston can be damaged.

If the pin cannot be removed by hand pressure, place the piston in boiling water for 5 minutes to expand the pin bore. This will allow the pin to be removed.

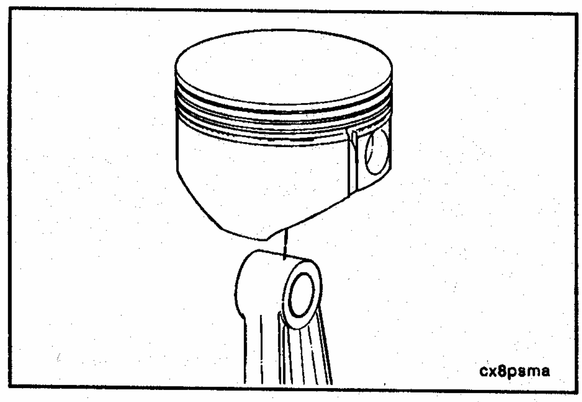


WARNING

Use insulated gloves when handling the heated piston.

Remove the piston pin.

Remove the piston.

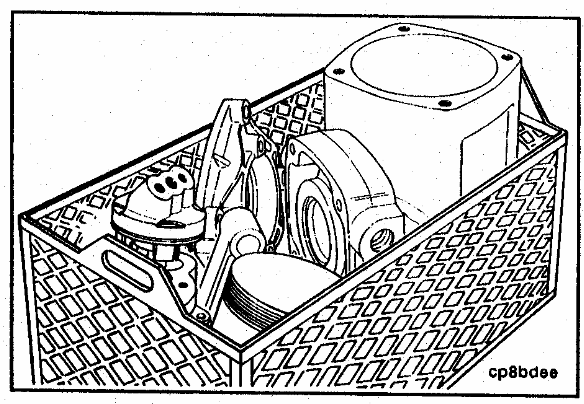


Clean (012-105-006)

WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing.

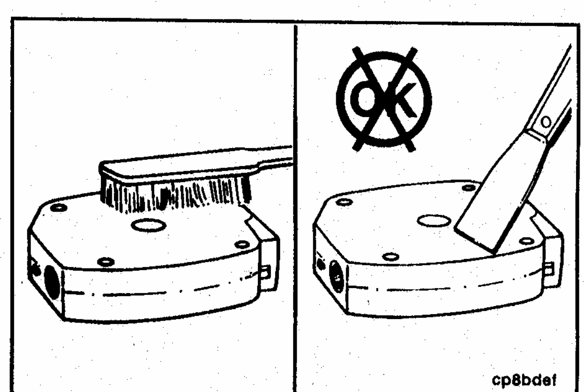
Soak the parts in a kerosene emulsion based cleaner designed to remove carbon. The cleaner must have a pH of 9.5 or less to avoid turning aluminum parts black. The cleaner manufacturer or supplier can be contacted about solution concentration, temperature and soak time.

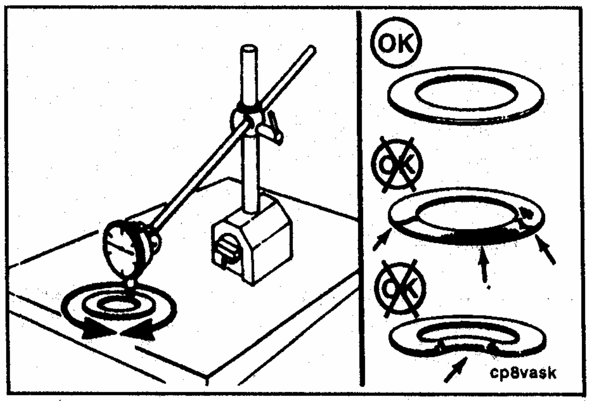


CAUTION

Do not use a scraper to remove carbon and scale; the sealing surfaces can be damaged.

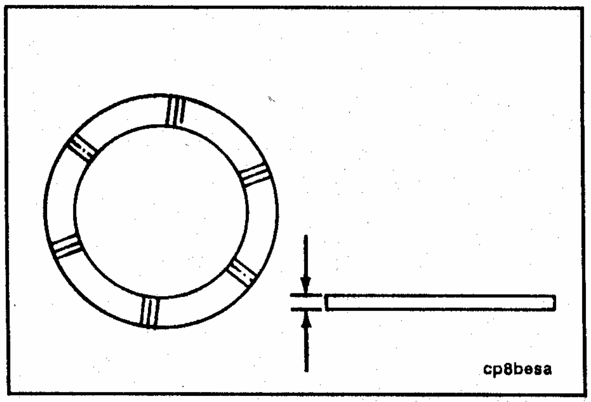
The parts can be scrubbed with a stiff non-metallic bristle brush.





Inspect for Reuse (012-105-007)

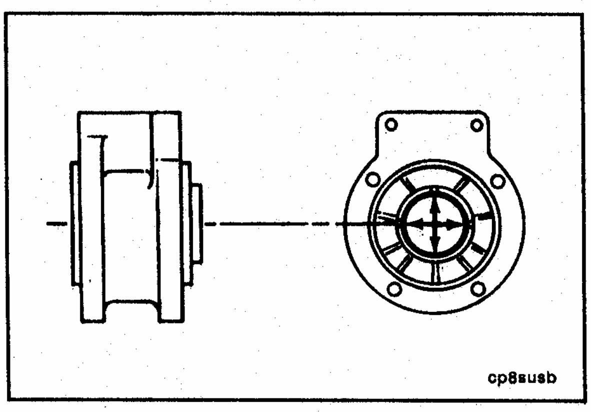
Inspect the cylinder head components. For SS and E-Type models, refer to Procedure 012-103-007. For QE models, refer to Procedure 012-104-007.



Measure the thrust bearing thickness.

Bearing Thickness

Part No.	mm		in
130080	2.24	MIN	0.088
	2.29	MAX	0.090
130081	2.29	MIN	0.090
	2.34	MAX	0.092
130082	2.54	MIN	0.100
	2.59	MAX	0.102
130083	2.34	MIN	0.092
	2.39	MAX	0.094
188040	2.29	MIN	0.090
	2.31	MAX	0.091
188042	2.31	MIN	0.091
	2.34	MAX	0.092
188044	2.34	MIN	0.092
	2.36	MAX	0.093
211662	6.10	MIN	0.240
	6.30	MAX	0.248
3050924	6.10	MIN	0.240
	6.30	MAX	0.248



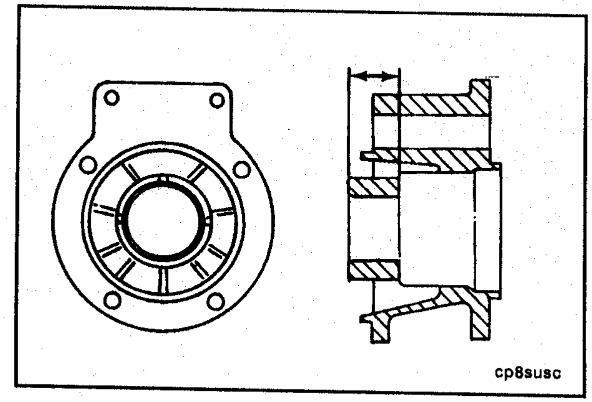
Measure the inside diameter of the support.

Support I.D.

mm		in
47.600	MIN	1.8740
47.688	MAX	1.8775

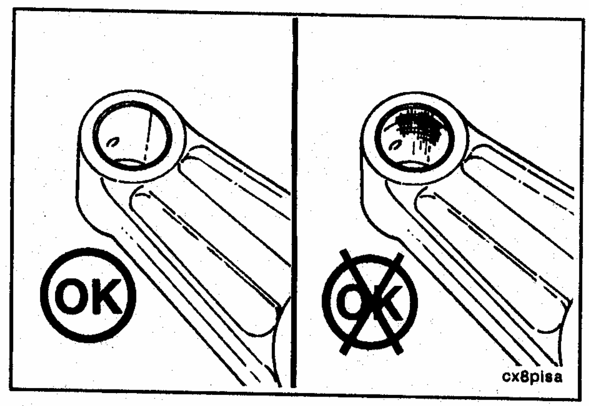
Measure the dimensions between thrust faces.

Replace if worn beyond the limits given in the Distance Between Thrust Faces Specifications Chart in Section V.



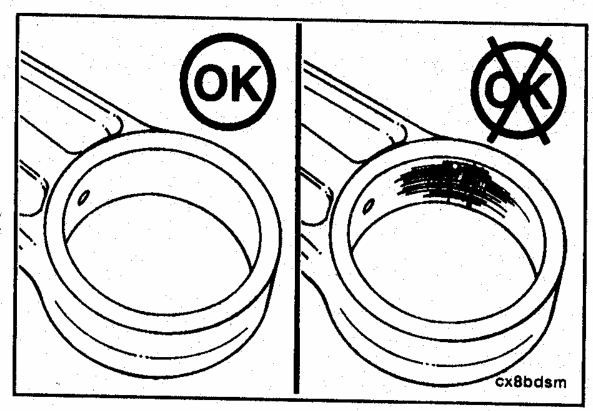
Inspect the connecting rod piston pin bore for damage.

Replace if damaged.



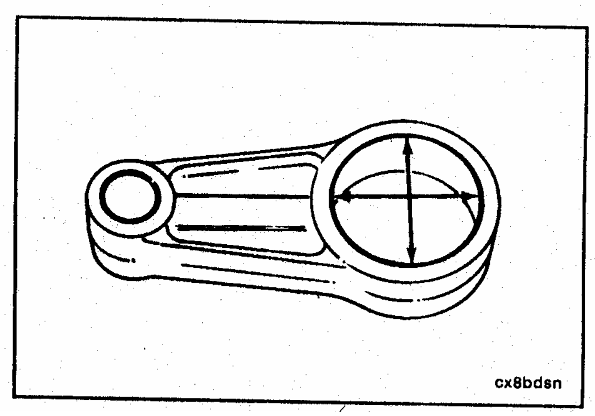
Inspect the connecting rod crankshaft bore for damage.

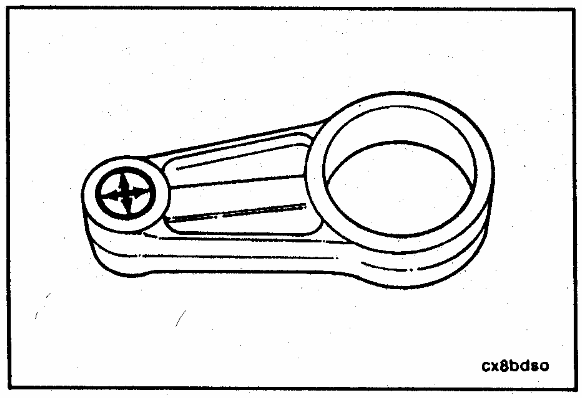
Replace if damaged.



Measure the inside diameter of the crankshaft end of the connecting rod.

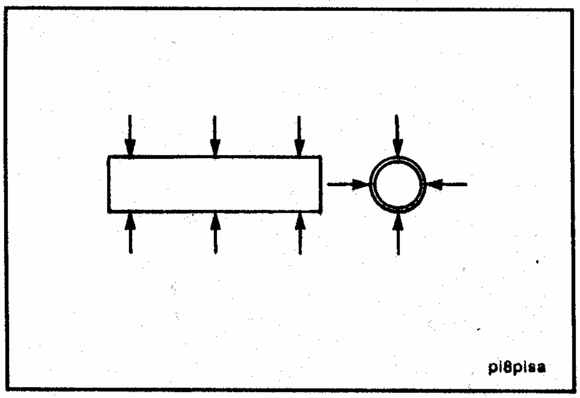
If the I.D. exceeds 49.263 mm [1.9395 inch], replace the connecting rod.





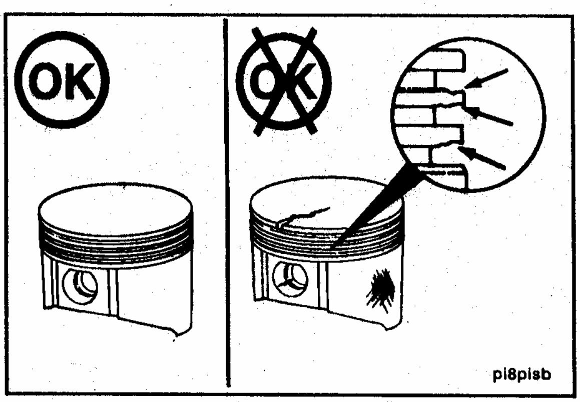
Measure the inside diameter of the piston end of the connecting rod.

If the I.D. exceeds 17.513 mm [0.6895-inch], replace the connecting rod.



Measure the outside diameter of the piston pin.

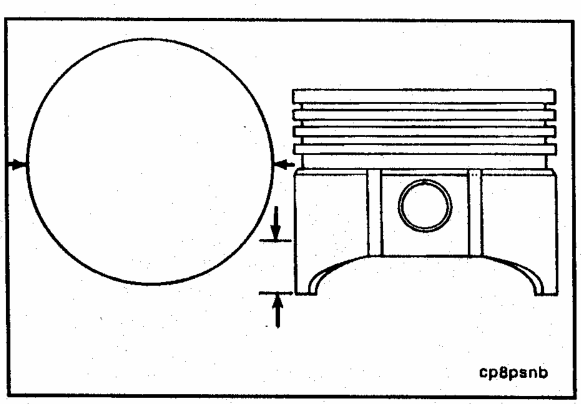
mm	Piston Pin	in
17.455	MIN	0.6872
17.465	MAX	0.6876



Inspect the piston top and pin bore for cracks.

Inspect the ring grooves and skirt for damage.

Replace if damaged.



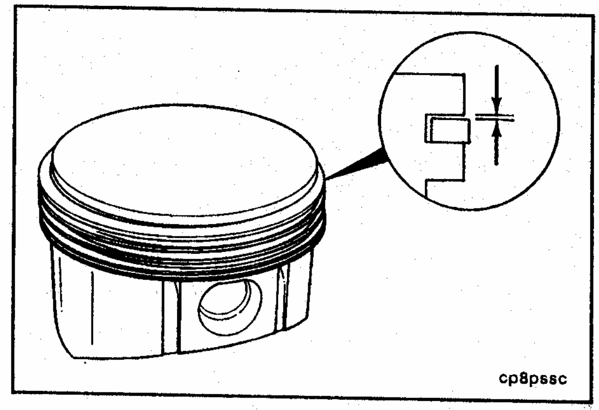
Measure the outside diameter of the piston.

Measure at 6.35 mm [0.25-inch] above the bottom of the piston skirt and at right angle to the piston pin bore.

Replace if worn smaller than 91.87 mm [3.617 in].

Use new piston rings and a feeler gauge to measure for ring groove wear.

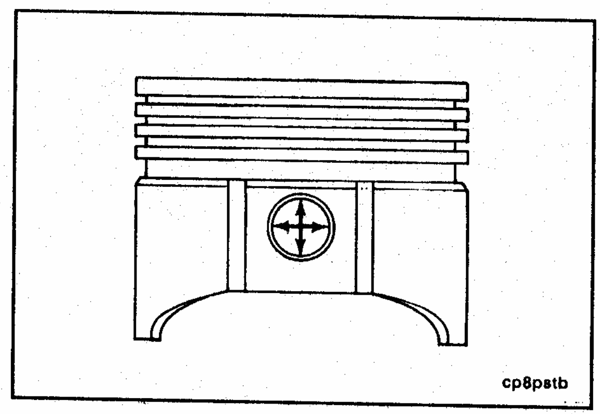
Replace the piston if the gaps are worn larger than the dimensions listed below.



Ring to Groove Clearance	mm		in
Piston Ring (Top)	0.05	MIN	[0.002]
	0.11	MAX	[0.005]
Piston Ring (2nd)	0.05	MIN	[0.002]
	0.11	MAX	[0.005]
Piston Ring (Oil)	0.05	MIN	[0.002]
	0.10	MAX	[0.004]

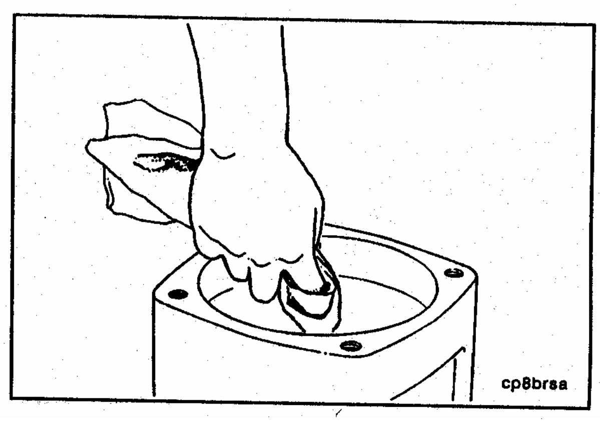
Measure the piston pin bore.

Replace the piston if the bore is worn larger than 17.49 mm [0.689-inch].



Inspect the cylinder bore of the crankcase for scoring or other damage.

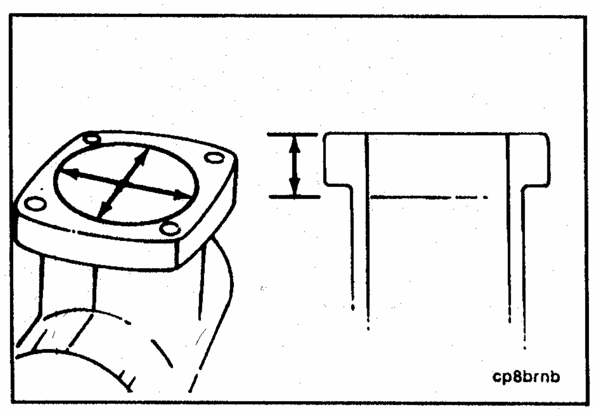
If the cylinder bore is damaged, bore or hone the cylinder for oversized piston and rings.



Use a dial bore gauge, Part No. 3375072, to measure the cylinder bore diameter.

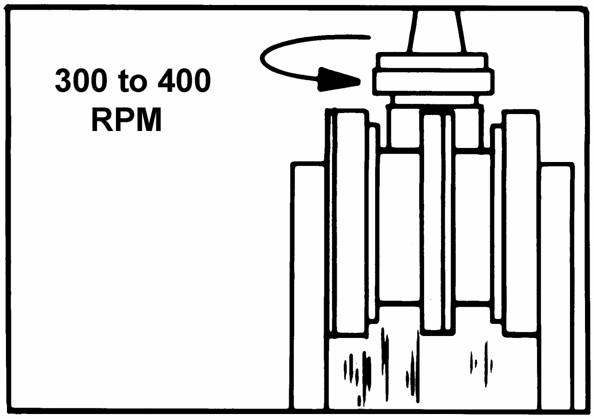
Measure at 25.0 mm [1.00 inch] below the top of the crankcase.

Maximum out-of-round is 0.038 mm [0.0015-inch].



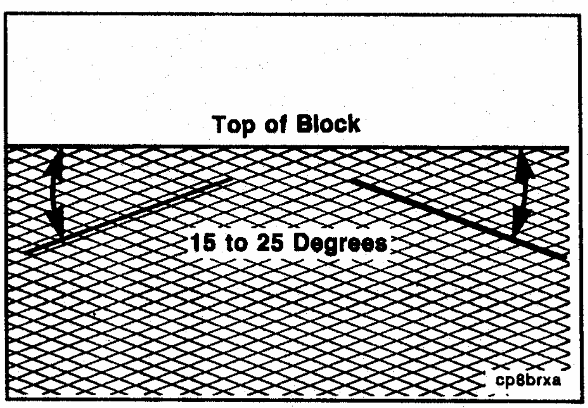
Cylinder Bore mm		in
92.08	MIN	[3.625]
92.16	MAX	[3.628]

If the crankcase bore is not within specifications, bore the cylinder to use oversize piston and rings.

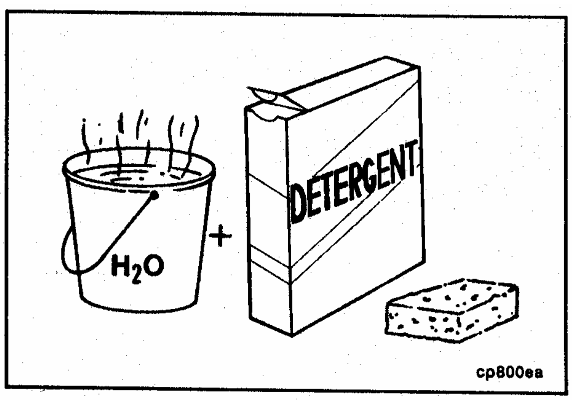


Bore or hone the cylinders (per the following instructions) to the specifications listed below:

Cylinder Bore Oversize mm [in]	Diameter mm [in] MIN	MAX
0.25 [0.010]	92.33 [3.635]	92.36 [3.6365]
0.51 [0.020]	92.58 [3.645]	92.621 [3.6465]
0.76 [0.030]	92.84 [3.655]	92.875 [3.6565]

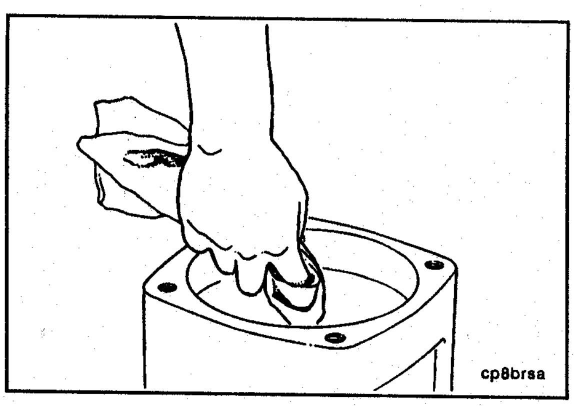


Use a 280 grit hone to produce a cross hatched surface finished with lines at a 15 to 25 degree angle with the top of the crankcase.



Use a strong solution of laundry detergent and hot water to clean the cylinder bore.

Use compressed air to dry.



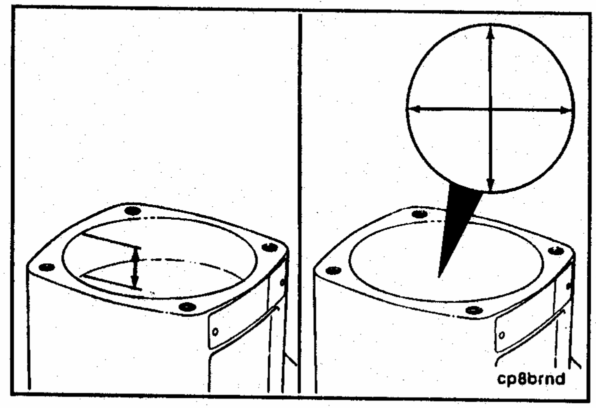
Use a white, lint-free, lightly oiled cloth to check the bore for cleanliness.

If grit is still present, clean again.

Use a dial bore gauge, Part No. 3375072, to measure the cylinder bore diameter.

Measure at 25.0 mm [1.00-inch] below the top of the crankcase.

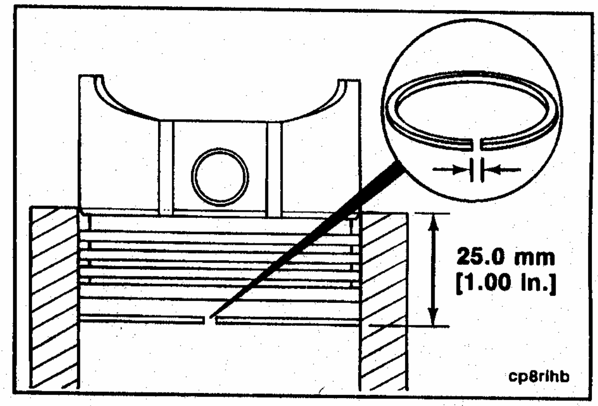
Maximum out-of-round is 0.04 mm [0.002-inch]



NOTE
Install new piston rings during rebuild.

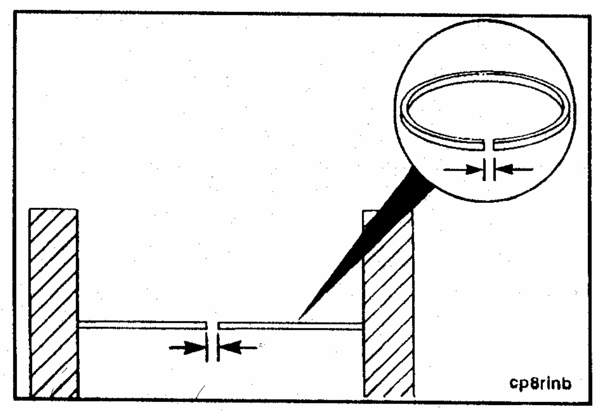
If old piston rings are used, follow the instructions listed below to measure the ring gaps.

Insert one ring at a time into the cylinder bore. Seat the ring with a piston head squarely 25.0 mm [1.00 inch] below the top of the crankcase.

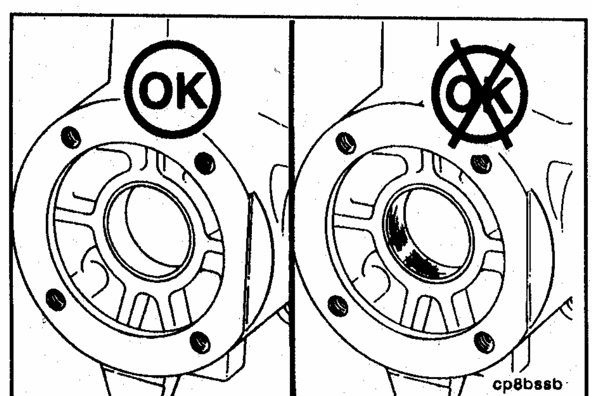


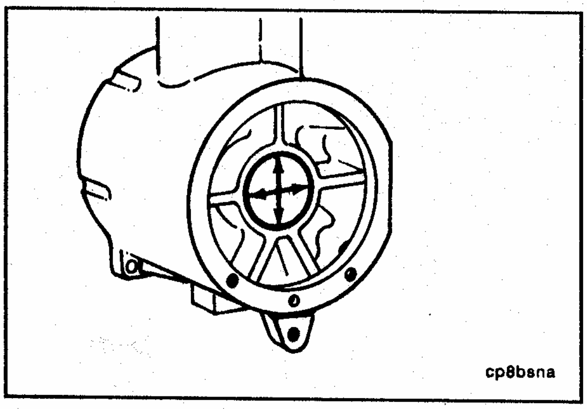
QE296 Piston Ring Gaps

	MIN		MAX	
	mm	**in**	**mm**	**in**
Piston Ring (Top)	0.25	[0.010]	0.51	[0.020]
Piston Ring (2nd)	0.25	[0.010]	0.51	[0.020]
Piston Ring (Oil)	0.38	[0.015]	1.40	[0.055]



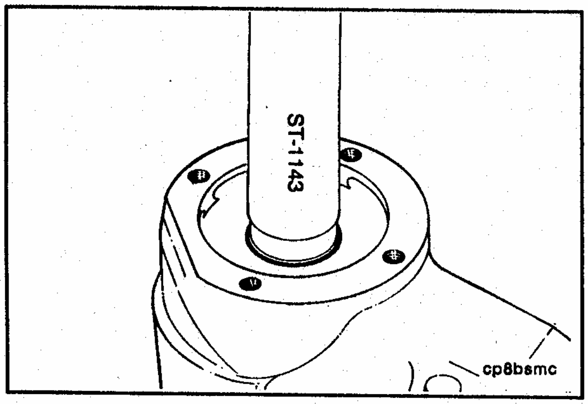
Inspect the bushing in the crankcase and replace if damaged.



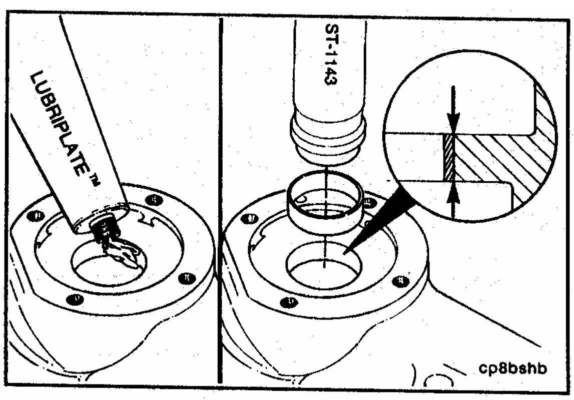


Measure the inside diameter.

Replace the bushing if worn larger than 47.70 mm [1.8780 inch].



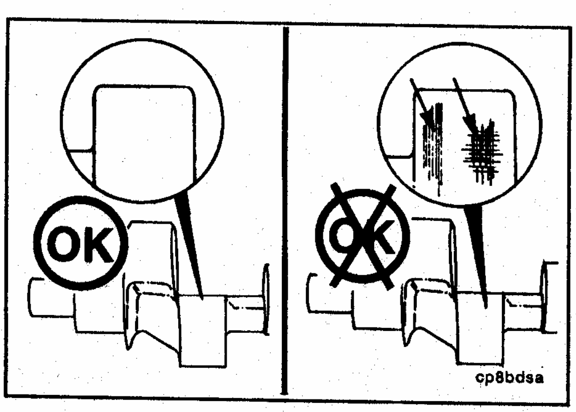
Use an air compressor bushing mandrel, Part No. ST-1143, to remove the bushing.



Use clean Lubriplate® to lubricate the bushing bore in the crankcase.

Use an air compressor bushing mandrel, Part No. ST-1143, to install the new bushing.

Push in the new bushing until it is flush with the bore surface. Oil holes in the bushing and crankcase must be aligned.

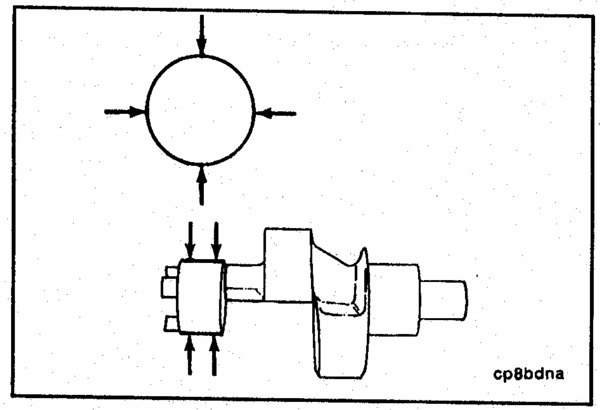


Inspect the crankshaft for scratches and scoring.

Replace if damaged.

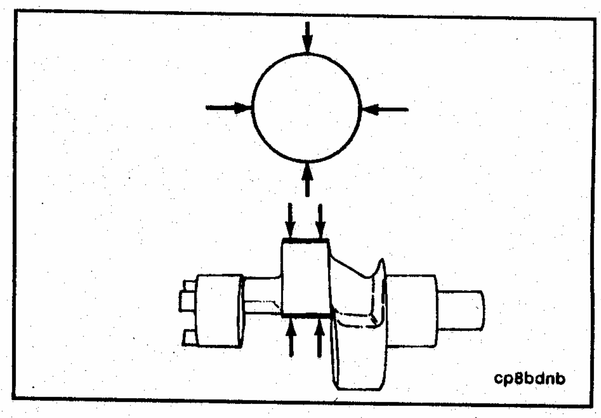
Measure the outside diameter of the journal at the crankcase (A).

Replace if worn beyond limits given in the Crankshaft Dimensions Chart in Section V.



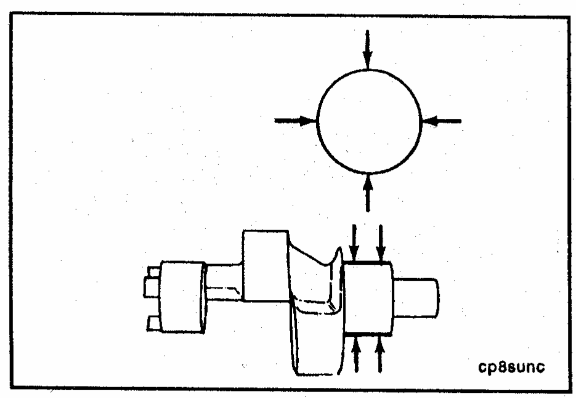
Measure the outside diameter of the journal at the connecting rod (B).

Replace if worn beyond limits given in the Crankshaft Dimensions Chart in Section V.



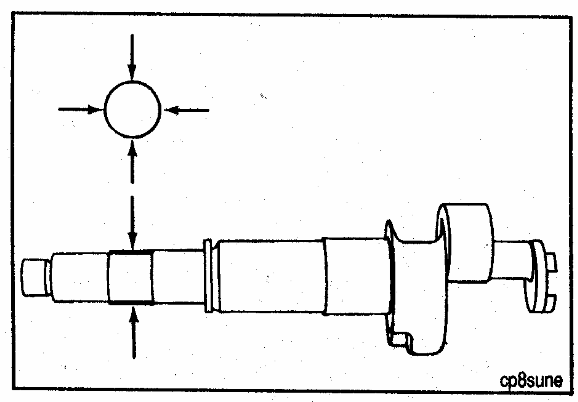
Measure the outside diameter of the journal at the support (C).

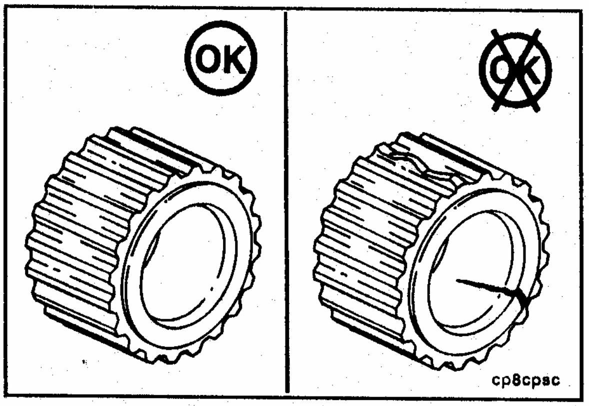
Replace if worn beyond limits given in the Crankshaft Dimensions table in Section V.



For QE296, measure the outside diameter of the journal at the engine gearcase journal (long nose crankshaft) (D).

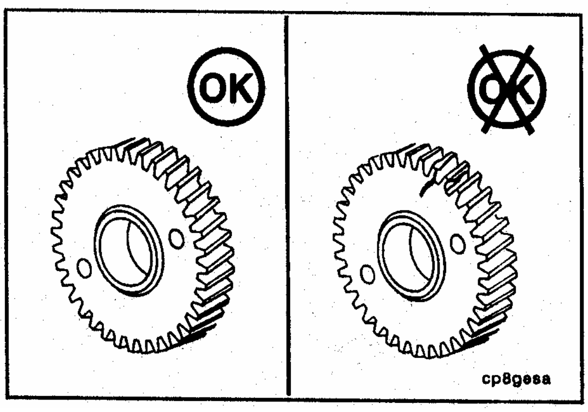
Replace if worn beyond limits given in the Crankshaft Dimensions table in Section V.





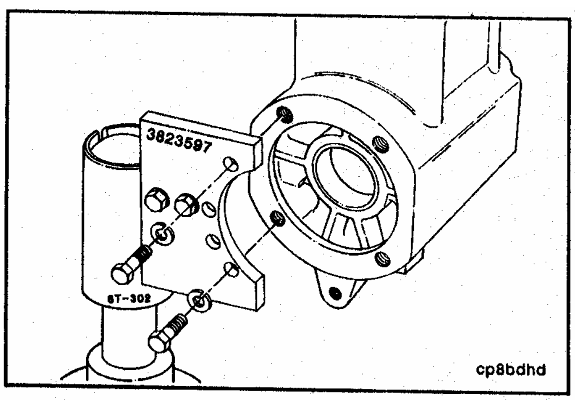
Inspect the splined coupling hub for cracks, worn or broken teeth.

Replace if damaged.

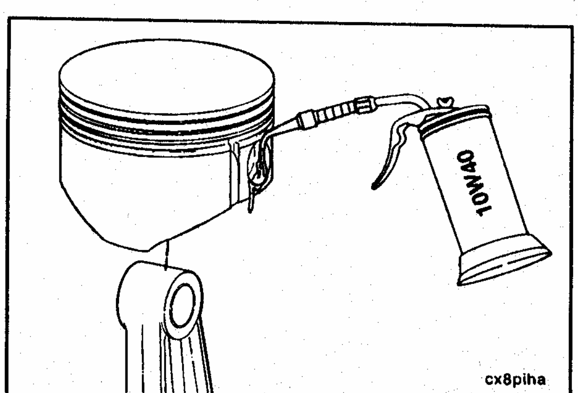


Inspect the drive gear for cracks (gear driven compressors only), worn or broken teeth. Replace if damaged.

Assemble (012-105-025)



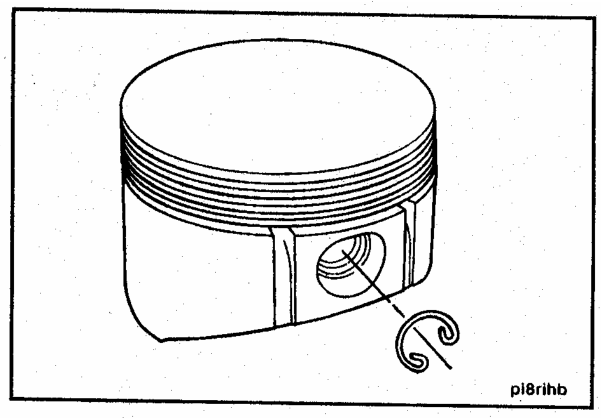
Install the crankcase to the mounting plate, Part No. 3823597, which is used with the ball joint vise, Part No. ST-302.



Install the connecting rod in a soft jawed vise.

Use clean engine oil to lubricate the piston pin bore.

Install one retaining ring.



NOTE

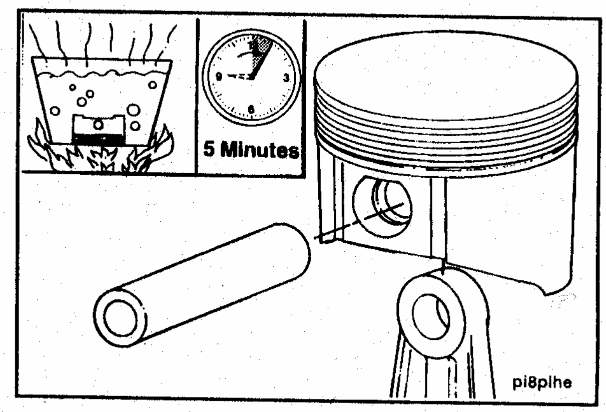
Do not force the piston pin into the pin bore; this will damage the piston.

If the piston pin cannot be installed by hand pressure, heat the piston in boiling water for 5 minutes to expand the pin bore. This will enable the piston pin to be installed.

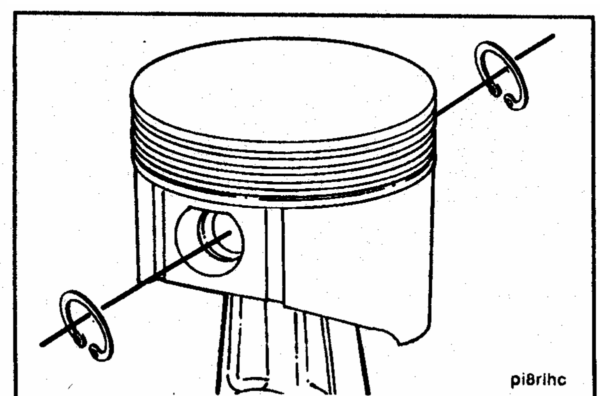
WARNING

Use insulated gloves when handling the heated piston.

Install the piston pin.



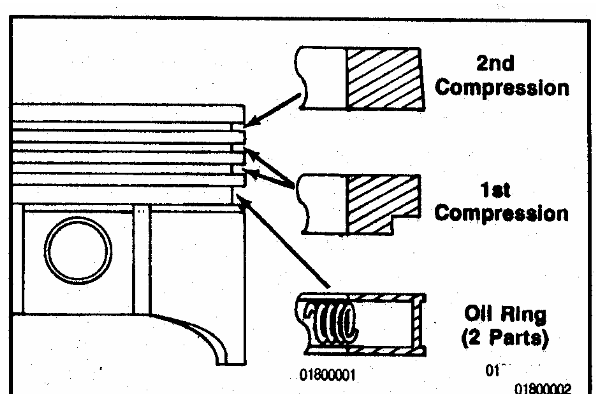
Install the second retaining ring.

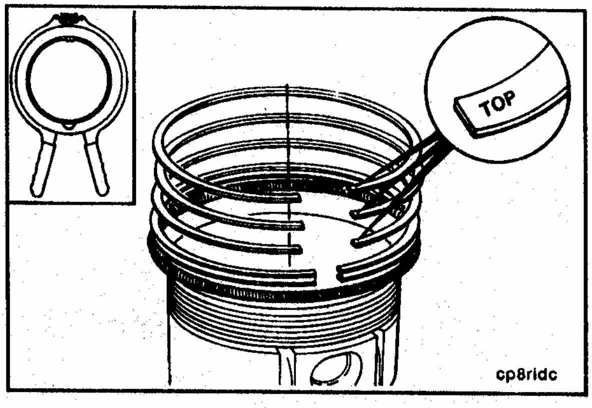


Piston ring position for QE296.

NOTE

The first compression ring is hook scraper and the second compression ring is taper face.

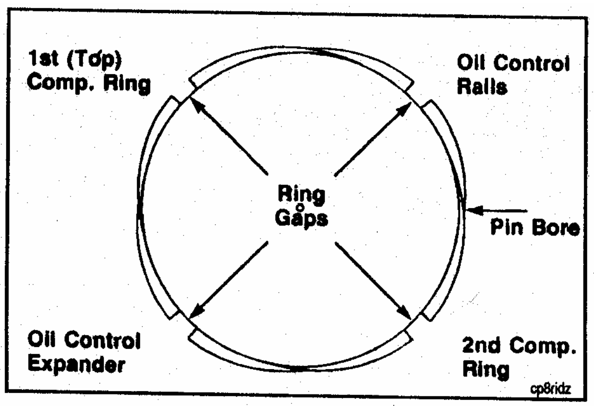




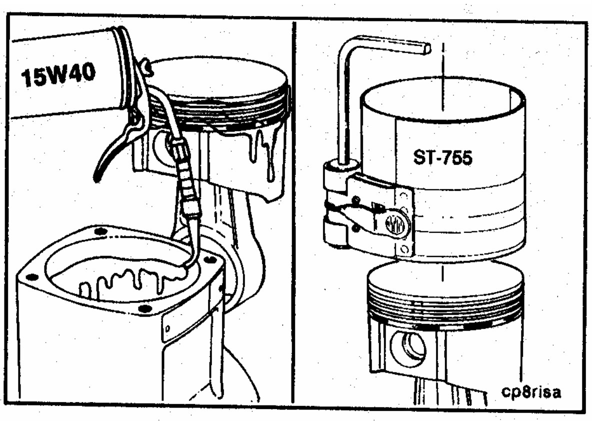
Install the piston rings with the part number or side marked TOP up.

NOTE

Install new rings during rebuild.

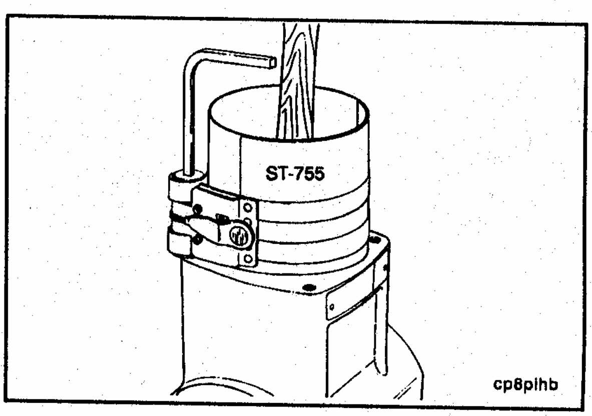


Position the QE296 piston ring gaps so they are not over the piston pin bore.



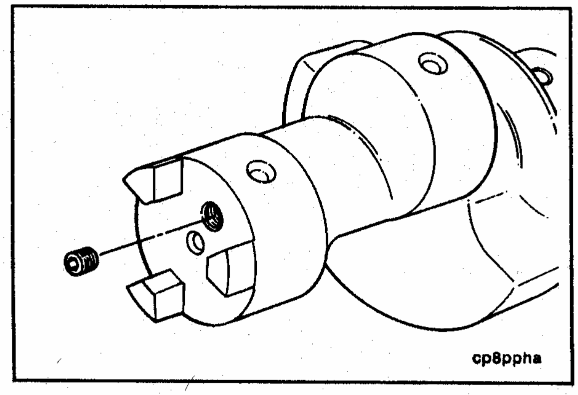
Use clean 15W-40 oil to lubricate the rings, piston and crankcase.

Use a piston ring compressor, Part No. ST-755, to compress the piston rings.



Install the piston and connecting rod assembly.

Install and tighten the pipe plug.
Torque Value: 8 N•m [6 ft-lb]

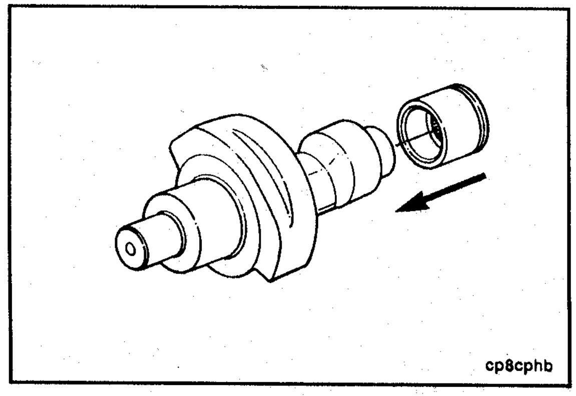


NOTE
Gear driven compressor only.

CAUTION
Do not exceed 53379 N [12,000 lbf] load. Excessive load can bend the crankshaft.

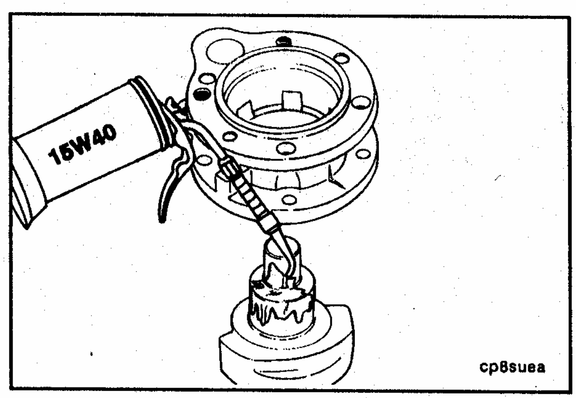
Use a press to install the hydraulic pump drive coupling onto the crankshaft until it bottoms.

NOTE
The free end of the crankshaft must be supported when installing the coupling. Couplings cannot be installed with the air compressor on the engine.



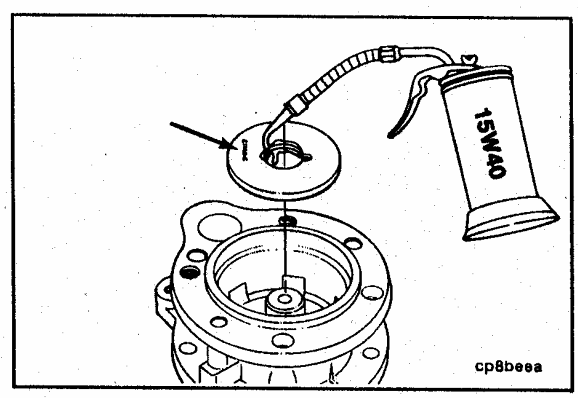
Use clean 15W-40 oil to lubricate the crankshaft and support bore.

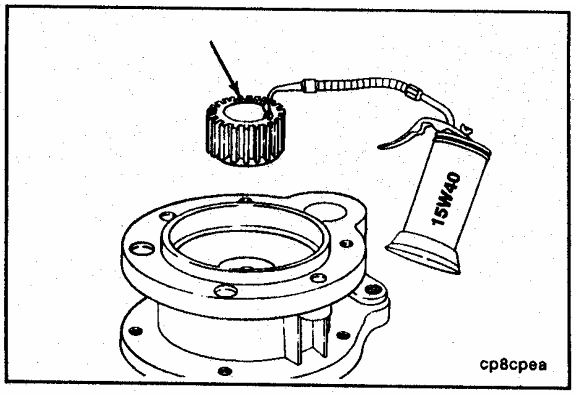
Install the support onto the crankshaft.



Use clean 15W-40 oil to lubricate the thrust bearing.

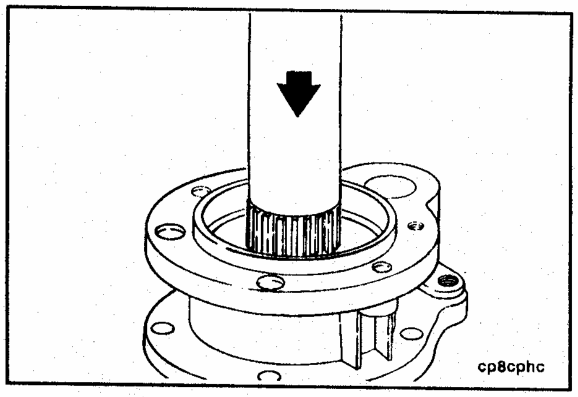
Install the thrust bearing with the part number side OUT or the grooved side IN.





Use clean 15W-40 oil to lubricate the splined coupling hub bore.

Position the splined coupling hub with the flanged side IN or the part number side OUT.



CAUTION

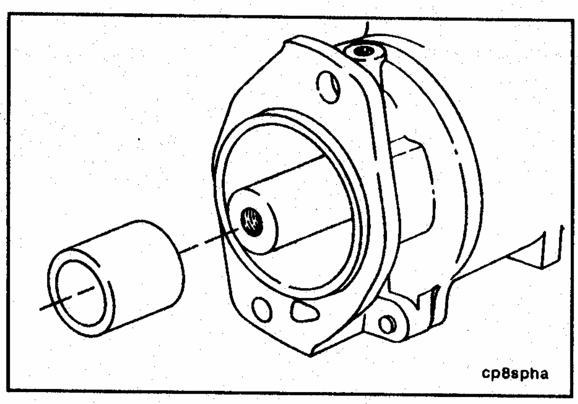
Do not exceed 53379 N [12,000 lbf] load Excessive load can bend the crankshaft.

Use a hand or hydraulic press to push the splined coupling hub into the crankshaft until it contacts the thrust bearing.

NOTE

The free end of the crankshaft must be supported when pressing on the coupling. Couplings cannot be installed with the air compressor on the engine.

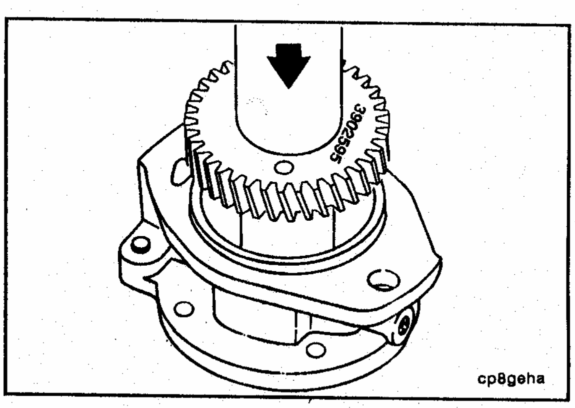
Install the thrust spacer.



CAUTION

Do not exceed 53379 N [12,000 lbf] load. Excessive load can bend the crankshaft.

Use a press to push the drive gear onto the crankshaft with the part number side out until the back side of the gear bottoms against the crankshaft shoulder.



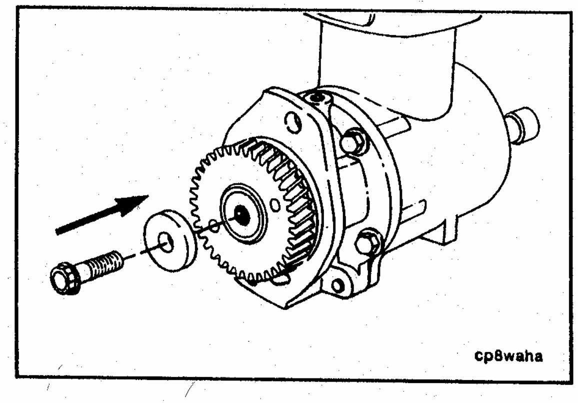
NOTE

The free end of the crankshaft must be supported when pressing on the coupling. Couplings cannot be installed with the air compressor on the engine.

NOTE
Gear driven compressor only.

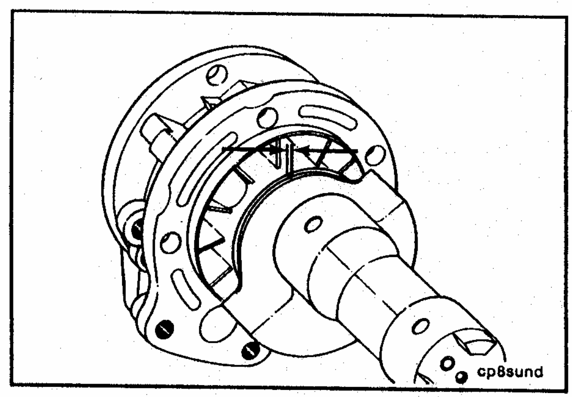
Install the washer and drive gear retaining capscrew.

Torque Value: 100 N•m [75 ft-lb]



Measure the clearance between the support and the crankshaft mating surfaces.

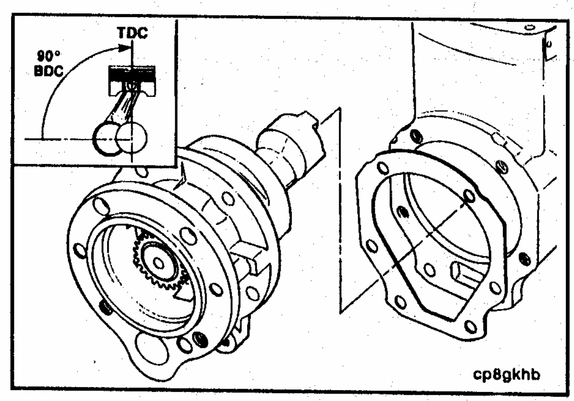
Refer to the Crankshaft End Clearance table in Section V.



Position the piston at 90 degrees after top dead center. This will allow the crankshaft to be installed through the connecting rod.

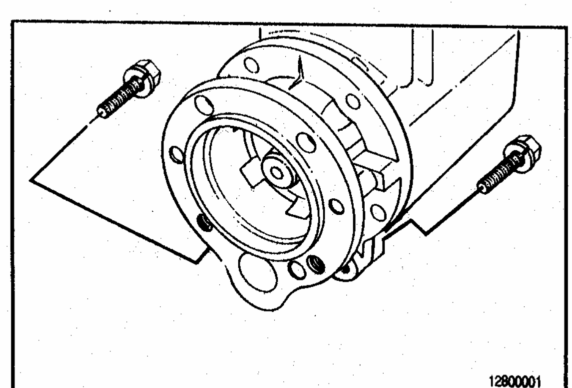
Install a new gasket on the support.

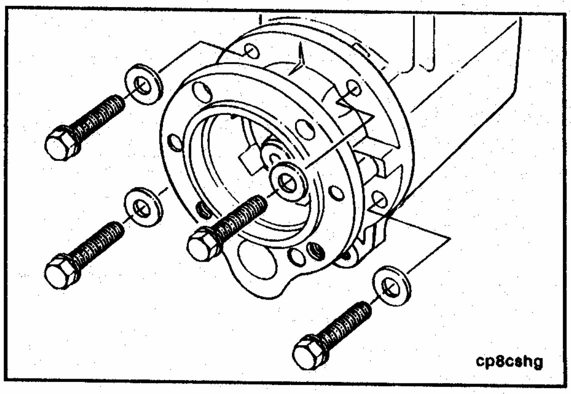
Install the crankshaft.



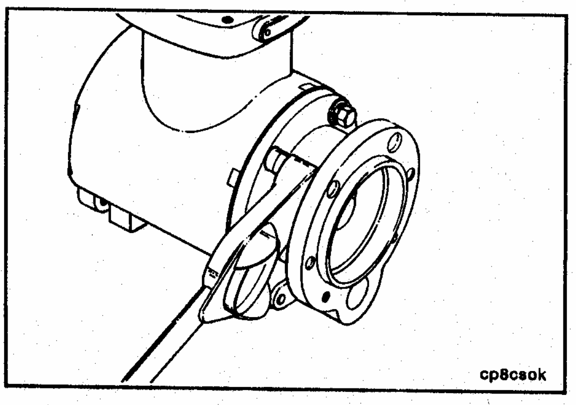
Install the two captive washer capscrews.

CAUTION
Do not use the capscrews to pull the support housing/crankshaft assembly into the crankcase. Damage to the connecting rod can result.



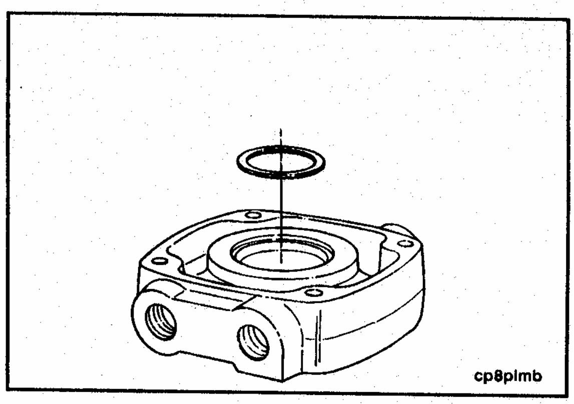


Install the four flat washers and the four captive-washer capscrews.

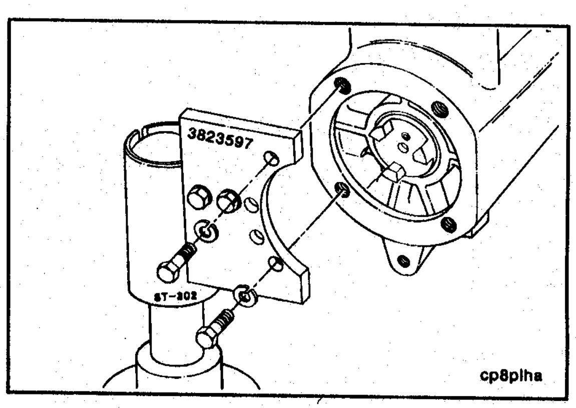


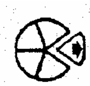
Tighten the capscrews.

Torque Value: 47 N•m [35 ft-lb]



Assemble the cylinder head. For SS and E-Type models, refer to Procedure 012-103-025. For QE models, refer to Procedure 012-104-025.



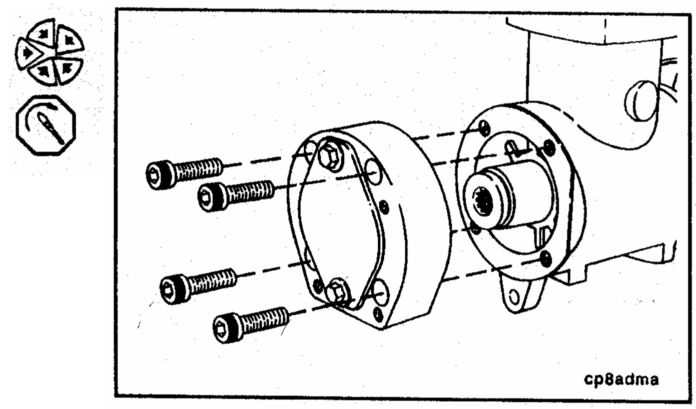


Remove the compressor from the ball joint vise and mounting plate.

NOTE

Gear driven compressor only. Install the hydraulic pump adapter and capscrews.

Torque Value: 60 N•m [45 ft-lb]



Section V - Compressed Air System Specifications and Torque Values

Section Contents

Compressor Spring Force Specifications

				Load Required to Com press Spring to Measu ment Length			
Spring P/N	Spring Use	Approx. Free Length mm [inch]	Number of Coils	Wire Diameter mm [inch]	Measure-ment Length mm [inch]	Minimum kg [lb.]	Maximum kg [lb.]
128080	Exhaust Valve	17.02 [0.670]	3.0	2.03 [0.080]	7.11 [0.280]	3.6 [8.55]	4.7 [10.35]
190334	Intake Valve	12.70 [0.500]	2.8	1.58 [0.062]	7.11 [0.280]	0.35 [0.65]	0.5 [1.10]
150631	Unloading Valve (naturally aspirated) center unloading valve__twin	41.91 [1.650]	11.5	2.03 [0.080]	24.89 [0.980]	14.5 [32.00]	17.2 [38.00]
3023101	Unloading Valve (all turbocharged engines)	41.91 [1 .650]	10.8	1.65 [0.065]	24.89 [0.980]	5.9 [13.00]	7.7 [17.00]
3049553	E.Type Unloader Valve	41.91 [1.650]	11.25	1.93 [0.076]	24.89 [0.980]	10.4 [23.00]	12.2 [27.00]
800399-XW	Unloader	17.02 [0.67]	6	1.04 [0.041]	6.60 [0.260]	N/A	2.54 [5.60]
					10.03 [3.95]	1.71 [3.78]	N/A
802000-FZ	Intake and Exhaust	10.16 [0.40]	4.25	0.79 [0.031]	4.57 [0.18]	N/A	0.36 [0.80]
					5.99 [0.275]	0.20 [0.45]	N/A
3054489	Exhaust Valve	21.49 [0.846]	4.5	2.54 [0.100]	15.21 [0.599]	3.88 [8.55]	4.74 [10.45]

QE296 Specifications

Compressor Worn Replacement Limits

Part or Location	mm		in
Crankcase piston bore (QE296)	92.08	MIN	3.625
	92.16	MAX	3.628
Crankcase bushing bore	47.70	MAX	1.8780
Piston skirt diameter (QE296)	91.87	MIN	3.617
Piston pin bore at 21ºC [70ºF)	17.49	MAX	0.689
Piston ring to groove clearance (use new rings) (QE296)			
Piston Ring (Top)	0.05	MIN	0.002
	0.11	MAX	0.005
Piston Ring (2nd)	0.05	MIN	0.002
	0.11	MAX	0.005
Piston Ring (oil)	0.04	MIN	0.002
	0.10	MAX	0.004
Ring gap clearance (QE296)			
Piston Ring (Top)	0.25	MIN	0.010
	0.51	MAX	0.020
Piston Ring (2nd)	0.25	MIN	0.010
	0.51	MAX	0.020
Piston Ring (oil)	0.38	MIN	0.015
	1.40	MAX	0.055
Piston Pin:	17.455	MIN	0.6872
	17.465	MAX	0.6876
Connecting Rod:			
Piston pin bore	17.513	MAX	0.6895
Crankshaft bore	49.263	MAX	1.9395
Exhaust valve bore	20.688	MAX	0.81 45
Exhaust valve seat height	12.32	MIN	0.485
Intake valve seat height	6.86	MIN	0.270

Part or Location		mm		in
Thrust bearing thickness	Part No. 130080	2.24	MIN	0.088
		2.29	MAX	0.090
	Part No.130081	2.29	MIN	0.090
		2.34	MAX	0.092
	Part No. 130082	2.54	MIN	0.100
		2.59	MAX	0.102
	Part No. 130083	2.34	MIN	0.092
		2.39	MAX	0.094
	Part No. 188040	2.29	MIN	0.090
		2.31	MAX	0.091
	Part No. 188042	2.31	MIN	0.091
		2.34	MAX	0.092
	Part No. 188044	2.34	MIN	0.092
		2.36	MAX	0.093
	Part No. 211662	6.10	MIN	0.240
		6.30	MAX	0.248
	Part No. 3050924	6.10	MIN	0.240
		6.30	MAX	0.248
Support I.D.		47.600	MIN	1.8740
		47.688	MAX	1.8775

Support Dimensions

Support Part No.	Distance Between Thrust Faces MIN mm	MIN in	MAX mm	MAX in
QE296				
152105	42.52	1.674	43.08	1.696
156088	60.55	2.384	61.11	2.406
156097	127.86	5.034	128.42	5.056
159208	147.22	5.796	147.78	5.818
160111	147.22	5.796	147.78	5.818
160113	120.47	4.743	121.03	4.765
163032	34.87	1.373	35.59	1.401
163503	42.52	1.674	43.08	1.696
163832	147.22	5.796	147.78	5.818
163836	127.86	5.034	128.42	5.056
163838	147.22	5.796	147.78	5.818
163840	67.95	2.675	68.50	2.697
167994	42.52	1.674	43.08	1.696
169836	42.52	1.674	43.08	1.696
176026	42.52	1.674	43.08	1.696
176029	42.52	1.674	43.08	1.696
176037	147.22	5.796	147.78	5.818
176045	120.22	4.733	120.78	4.755
176046	120.22	4.733	120.78	4.755
176048	139.57	5.495	140.14	5.517
176049	139.57	5.495	140.14	5.517
176054	58.24	2.293	58.80	2.315
176057	115.14	4.533	115.70	4.555
176058	62.61	2.465	63.18	2.487
176064	42.52	1.674	43.08	1.696
186256	42.52	1.674	43.08	1.696
188039	137.49	5.413	138.05	5.435
188956	118.05	4.648	118.62	4.670
193836	137.49	5.413	138.05	4.435
199337	30.40	1.197	30.99	1.220
202273	42.52	1.674	43.08	1.696
215761	40.13	1.580	40.69	1.602
218598	42.52	1.674	43.08	1.696
3005152	32.69	1.287	33.27	1.310
3005153	32.69	1.287	33.27	1.310
650183	42.52	1.674	43.08	1.696

Support Part No.	Crankshaft End Clearance			
	MIN		MAX	
	mm	in	mm	in
QE296				
152105	0.15	0.006	0.76	0.030
156088	0.18	0.007	0.79	0.031
156097	0.20	0.008	0.81	0.032
159208	0.25	0.010	0.86	0.034
160111	0.25	0.010	0.86	0.034
160113	0.23	0.009	0.84	0.033
163032	0.15	0.006	0.76	0.030
163503	0.15	0.006	0.76	0.030
163832	0.25	0.010	0.86	0.034
163836	0.20	0.008	0.81	0.032
163838	0.25	0.010	0.86	0.034
163840	0.18	0.007	0.84	0.033
167994	0.15	0.006	0.76	0.030
169836	0.15	0.006	0.76	0.030
176026	0.15	0.006	0.76	0.030
176029	0.15	0.006	0.76	0.030
176037	0.25	0.010	0.86	0.034
176045	0.20	0.008	0.81	0.032
176046	0.20	0.008	0.81	0.032
176048	0.25	0.010	0.86	0.034
176049	0.25	0.010	0.86	0.034
176054	0.18	0.007	0.79	0.031
176057	0.23	0.009	0.84	0.033
176058	0.18	0.007	0.84	0.033
176064	0.15	0.006	0.76	0.030
186256	0.15	0.006	0.76	0.030
188039	0.05	0.002	0.61	0.024
188956	0.05	0.002	0.61	0.024
193836	0.05	0.002	0.61	0.024
199337	0.05	0.002	0.69	0.027
202273	0.15	0.006	0.76	0.030
215761	0.15	0.006	0.76	0.030
218598	0.15	0.006	0.76	0.030
3005152	0.05	0.002	0.69	0.027
3005153	0.05	0.002	0.69	0.027
650187	0.15	0.006	0.76	0.030

Assembly Torque Specifications

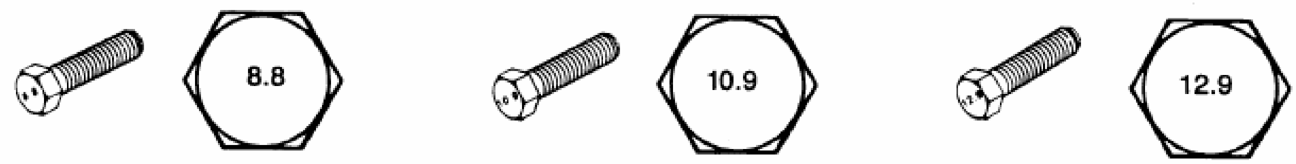
	Step	Torque Values N•m	ft-lb
Crankshaft Pipe Plug	(1)	8	6
	(2)	17	5
	(3)	20	15
Support to Crankcase Captive Washer Capscrews	(4)	47	35
Drive Gear Retaining Capscrew		100	75
Head Hexagon Head Capscrews (All QE Models)			
Center Capscrew	(1)	14	10
	(2)	28	20.8
Corner Capscrews		28	20.8
Unloading Valve Body		27	20

Capscrew Markings and Torque Values - Metric

Commercial Steel Class

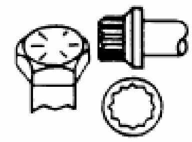
8.8 10.9 12.9

Capscrew Head Markings



Body Size	Torque (8.8)				Torque (10.9)				Torque (12.9)			
Diam.	Cast Iron		Aluminum		Cast Iron		Aluminum		Cast Iron		Aluminum	
mm	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
6	9	5	7	4	12	9	7	4	14	9	7	4
7	14	9	11	7	18	14	11	7	23	18	11	7
8	25	18	18	14	33	25	18	14	40	29	18	14
10	45	33	30	25	60	45	30	25	70	50	30	25
12	80	60	55	40	105	75	55	40	125	95	55	40
14	125	90	90	65	165	122	90	65	195	145	90	65
16	180	130	140	100	240	175	140	100	290	210	140	100
18	230	170	180	135	320	240	180	135	400	290	180	135

Capscrew Markings and Torque Values - U.S. Customary

SAE Grade Number	5	8
Capscrew Head Markings These are all SAE Grade 5 (3) line 		

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

Capscrew Markings and Torque Values

CAUTION

When replacing capscrews, always use a capscrew of the same measurement and strength as the capscrew being replaced. Using the wrong capscrews can result in engine damage.

Metric capscrews and nuts are identified by the grade number stamped on the head of the capscrew or on the surface of the nuts. U.S. Customary capscrews are identified by radial lines stamped on the head of the capscrew.

The following examples indicate how capscrews are identified:

Metric - M8-1.25 X 25		
M8	**1.25**	**25**
Major Thread Diameter in Millimeters	Distance Between Threads in Millimeters	Length in Millimeters

U.S. Customary [5/16 X 18 X 1-1/2]		
5/16	**18**	**1-1/2**
Major Thread Diameter in Inches	Number Threads per Inch	Length in Inches

NOTE

1. Always use the torque values listed in the following tables when specific torque values are not available.
2. Do not use the torque values in place of those specified in other sections of this manual.
3. The torque values in the table are based on the use of lubricated threads.
4. When the ft-lb value is less than 10, give consideration to converting the ft-lb value to in-lb to obtain a better torque with an in-lb torque wrench. Example: 6 ft-lb equals 72 in-lb.

FRACTION, DECIMAL, MILLIMETER CONVERSIONS											
8 THS.	16 THS.	32 NDS.	64 THS.	INCHES	MM	8 THS.	16 THS.	32 NDS.	64 THS.	INCHES	MM
			1	0.0156	0.397				33	0.5156	13.097
		1		0.0313	0.794			17		0.5313	13.494
			3	0.0469	1.191				35	0.5469	13.891
	1			0.0625	1.588		9			0.5625	14.288
			5	0.0781	1.984				37	0.5781	14.684
		3		0.0938	2.381			19		0.5938	15.081
			7	0.1094	2.778				39	0.6094	15.478
1				0.1250	3.175	5				0.6250	15.875
			9	0.1406	3.572			41		0.6406	16.272
		5		0.1563	3.969			21		0.6563	16.669
			11	0.1719	4.366				43	0.6719	17.066
	3			0.1875	4.763		11			0.6875	17.463
			13	0.2031	5.159				45	0.7031	17.859
		7		0.2188	5.556			23		0.7188	18.256
			15	0.2344	5.953				47	0.7344	18.653
1/4				0.2500	6.350	3/4				0.7500	19.050
			17	0.2656	6.747				49	0.7656	19.447
		9		0.2813	7.144			25		0.7813	19.844
			19	0.2969	7.541				51	0.7969	20.241
	5			0.3125	7.938		13			0.8125	20.638
			21	0.3281	8.334				53	0.8281	21.034
		11		0.3438	8.731			27		0.8438	21.431
			23	0.3594	9.128				55	0.8594	21.828
3				0.3750	9.525	7				0.8750	22.225
			25	0.3906	9.922				57	0.8906	22.622
		13		0.4063	10.319			29		0.9063	23.019
			27	0.4219	10.716				59	0.9219	23.416
	7			0.4375	11.113		15			0.9375	23.813
			29	0.4531	11.509				61	0.9531	24.209
		15		0.4688	11.906			31		0.9688	24.606
			31	0.4844	12.303				63	0.9844	25.003
1/2				0.5000	12.700	1 IN.				1.0000	25.400
CONVERSION FACTOR: 1 INCH = 25.4MM											

Newton-Meter to Foot-Pound Conversion Chart

N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
1	8.850756 in-lb	55	41	155	114
5	44 in-lb	60	44	160	118
6	53 in-lb	65	48	165	122
7	62 in-lb	70	52	170	125
8	71 in-lb	75	55	175	129
9	80 in-lb	80	59	180	133
10	89 in-lb	85	63	185	136
1	0.737562 ft-lb	90	66	190	140
12	9	95	70	195	144
14	10	100	74	200	148
15	11	105	77	205	151
16	12	110	81	210	155
18	13	115	85	215	159
20	15	120	89	220	162
25	18	125	92	225	165
30	22	130	96	230	170
35	26	135	100	235	173
40	30	140	103	240	177
45	33	145	107	245	180
50	37	150	111	250	184

NOTE

To convert from Newton-Meters to Kilogram-Meters divide Newton-Meters by 9.803.

Pipe Plug Torque Values

Size		Torque		Torque	
Thread	Actual Thread O.D.	In Aluminum Components		In Cast Iron or Steel Components	
in	in	N•m	ft-lb	N•m	ft-lb
1/16	0.32	5	45 in-lb	15	10
1/8	0.41	15	10	20	15
1/4	0.54	20	15	25	20
3/8	0.68	25	20	35	25
1/2	0.85	35	25	55	40
3/4	1.05	45	35	75	55
1	1.32	60	45	95	70
1-1/4	1.66	75	55	115	85
1-1/2	1.90	85	65	135	100

Tap-Drill Chart - U.S. Customary & Metric

NOTE ON SELECTING TAP-DRILL SIZES: The tap drill sizes shown on this card give the theoretical tap drill size for approximately 60% and 75% of full thread depth. Generally, it is recommended that drill sizes be selected in the 60% range as these sizes will provide about 90% of the potential holding power. Drill sizes in the 75% range are recommended for shallow hole tapping (less than 1 1/2 times the hole diameter) in soft metals and mild steel.

Tap Size		Drill
60 %	75 %	Size
		48
		1.95mm
		5/64
	3-48	47
		2.00mm
	M2.5x.45	2.05mm
		46
3-48	3056	45
		2.10mm
M2.5x.45	M2.6x.45	2.15mm
3-56	4-36	44
		2.20mm
M2.6x.45		2.25mm
4-36	4-40	43
		2.30mm
		2.35mm
4-40	4-48	42
		3/32
	M3x.6	2.40mm
4-48		41
		2.45mm
		40
M3x.6	M3x.5	2.50mm
		39
	5-40	38
M3x.5		2.60mm
5-40	5-44	37
		2.70mm
5-44	6-32	36
		2.75mm
		7/64
		35
		2.80mm
		34
6-32	6-40	33
	M3.5x6	2.90mm
		32
M3.5x6		3.00mm
6-40		31
		3.10mm
		1/8
		3.20mm
	M4x.75	3.25mm
		30
	M4x.7	3.30mm
M4x.75		3.40mm
M4x.7	8-32	29
		3.50mm
	8-36	28
8-32		9/64
		3.60mm
8-36		27
		3.70mm
		26
	M4.5x.75	3.75mm
	10-24	25
		3.80mm
		24
M4.5x.75		3.90mm
		23
		5/32
10-24		22
	M5x1	4.00mm
	10-32	21
		20
	M5x.9	4.10mm
M5x1	M5x.8	4.20mm
10-32		19
M5x.9		4.25mm
M5x.8		4.30mm
		18
		11/64
		17

Tap Size		Drill
60 %	75 %	Size
		4.40mm
	12-24	16
		4.50mm
		15
	M5.5x.9	4.60mm
12-24	12-28	14
		13
		4.70mm
M5.5x.9		4.75mm
12-28		3/16
		12
		4.80mm
		11
		4.90mm
		10
		9
	M6x1	5.00mm
		8
		5.10mm
	1/4-20	7
		13/64
		6
M6x1		5.20mm
		5
	M6x.75	5.25mm
		5.30mm
1/4-20		4
M6x.75		5.40mm
	1/4-28	3
		5.50mm
		7/32
		5.60mm
1/4-28		2
		5.70mm
		5.75mm
		1
		5.80mm
		5.90mm
		A
		15/64
	M7x1	6.00mm
		B
		6.10mm
		C
M7x1		6.20mm
		D
	M7x.75	6.25mm
		6.30mm
		E
		1/4
M7x.75		6.40mm
		6.50mm
	5/16-18	F
		6.60mm
		G
		6.70mm
		17/64
	M8x1.25	6.75mm
5/16-18		H
		6.80mm
		6.90mm
	5.16-24	I
M8x1.25	M8x1	7.00mm
		J
		7.10mm
5/16-24		K
		9/32
M8x1		7.20mm
		7.25mm
		7.30mm
		L
		7.40mm
		M

Tap Size		Drill
60 %	75 %	Size
		7.50mm
		19/64
		7.60mm
		N
		7.70mm
	M9x1.25	7.75mm
		7.80mm
		7.90mm
	3/8-16	5/16
M9x1.25	M9x1	8.00mm
		O
		8.10mm
M9x1		8.20mm
		P
		8.25mm
		8.30mm
3/8-16	1/8-27NPT	21/64
		8.40mm
	3/8-24	Q
	M10x1.5	8.50mm
		8.60mm
		R
3/8-24		8.70mm
1/8-27NPT		11/32
	M10x1.25	8.75mm
M10x1.5		8.80mm
		S
		8.90mm
M10x1.25	M10x1	9.00mm
		T
		9.10mm
		23/64
M10x1		9.20mm
		9.30mm
	7/16-14	U
		9.40mm
	M11x1.5	9.50mm
		3/8
		V
		9.60mm
		9.70mm
		9.75mm
M11x1.5		9.80mm
7/16-14		W
		9.90mm
	7/16-20	25/64
		10.00mm
7/16-20		X
	M12x1.75	10.20mm
		Y
		13/32
		Z
M12x1.75	M12x1.5	10.50mm
	1/2-13	27/64
M12x1.5	M12x1.25	10.75mm
M12x1.25		11.00mm
1/2-13		7/16
1/4-18NPT		
		11.25mm
		11.50mm
		29/64
		11.75mm
		11.50mm
	1/2-20	29/64
	9/16-12	15/32
	M14x2	12.00mm
		12.25mm
9/16-12		31/64
M14x2	M14x1.5	12.50mm
	9/16-18	1/2
M14x1.5	M14x1.25	12.75mm
M14x1.25		13.00mm
9/16-18		33/64

Tap Size		Drill
60 %	75 %	Size
		13.25mm
	5/8-11	17/32
	M15x1.5	13.50mm
M15x1.5		13.75mm
5/8-11		35/64
	M16x2	14.00mm
		14.25mm
	5/8-18	9/16
M16x2	M16x1.5	14.50mm
5/8-18		37/64
		14.75mm
M16x1.5		15.00mm
		19.32
		15.25mm
		39/64
	M17x1.5	15.50mm
M17x1.5	M18x2.5	15.75mm
		5/8
M18x2.5	M18x2	16.00mm
M18x2		16.25mm
	3/4-10	41/64
	M18x1.5	16.50mm
3/4-10	M19x2.5	21/32
M18x1.5		16.75mm
M19x2.5		17.00mm
		43/64
		17.25mm
3/4-16	3/4-16	11/16
	M20x2.5	17.50mm
		17.75mm
		45/64
M20x2.5	M20x2	18.00mm
M20x2		18.25mm
		23/32
	M20x1.5	18.50mm
		47/64
M20x1.5		18.75mm
		19.00mm
		3/4
		19.25mm
	7/8-9	49/64
	M22x2.5	19.50mm
7/8-9		25/32
		19.75mm
M22x2.5	M22x2	20.00mm
	7/8-14	51/64
M22x2		20.25mm
	M22x1.5	20.50mm
7/8-14		13/16
		20.75mm
M22x1.5	M24x3	21.00mm
		53/64
		21/25mm
		27/32
M24x3		21.50mm
		21.75mm
		55/64
	M24x2	22.00mm
	1”-8	7/8
M24x2		22.25mm
	M24x1.5	22.50mm
1”-8		57/64
M24x1.5		22.75mm
	M25x2	23.00mm
	1”-12	29/32
M25x2		23.25mm
1”x12	1”-14	59/64
	M25x1.5	23.50mm
M20x1.5		23.75mm
1”-14		15/16

Weight and Measures - Conversion Factors

QUANTITY	U.S. CUSTOMARY		METRIC		FROM U.S. CUSTOMARY TO METRIC MULTIPLY BY	FROM METRIC TO U.S. CUSTOMARY MULTIPLY BY
	Unit Name	**Abbr.**	**Unit Name**	**Abbr.**		
Area	sq. inch	in^2	sq. millimeters	mm^2	645.16	0.001550
			sq. centimeters	cm^2	6.452	0.155
	sq. foot	ft^2	sq. meter	m^2	0.0929	10.764
Fuel Consumption	pounds per horsepower hour	lb/hp-hr	grams per kilowatt hour	g/kw-hr	608.277	0.001 645
Fuel Performance	miles per gallon	mpg	kilometers per liter	km/l	0.4251	2.352
	gallons per mile	gpm	liters per kilometer	l/km	2.3527	0.4251
Force	pounds force	lbf	Newton	N	4.4482	0.224809
Length	inch	in	millimeters	mm	25.40	0.039370
	foot	ft	millimeters	mm	304.801	0.00328
Power	horsepower	hp	kilowatt	kw	0.746	1.341
Pressure	pounds force per sq. in	psi	kilopascal	kPa	6.8948	0.145037
	inches of mercury	in Hg	kilopascal	kPa	3.3769	0.29613
	inches of water	in H_20	kilopascal	kPa	0.2488	4.019299
	inches of mercury	in Hg	millimeters of mercury	mm Hg	25.40	0.039370
	inches of water	in H_20	millimeters of water	mm H_20	25.40	0.039370
	bars	bars	kilopascals	kPa	100.001	0.00999
	bars	bars	millimeters of mercury	mm Hg	750.06	0.001333
Temperature	Fahrenheit	°F	Centigrade	°C	(°F-32) ÷ 1.8	(1.8 x °C) +32
Torque	pound force per foot	ft lb	Newton-meter	N•m	1.35582	0.737562
	pound force per inch	in lb	Newton-meter	N•m	0.113	8.850756
Velocity	miles/hour	mph	kilometers/hour	kph	1.6093	0.6214
Volume: liquid displacement	gallon (U.S.)	gal.	liter	l	3.7853	0.264179
	gallon (Imp*)	gal.	liter	l	4.546	0.219976
	cubic inch	in^3	liter	l	0.01639	61.02545
	cubic inch	in^3	cubic centimeter	cm^3	16.387	0.06102
Weight (mass)	pounds (avoir.)	lb	kilograms	kg	0.4536	2.204623
Work	British Thermal Unit	BTU	joules	j	1054.5	0.000948
	British Thermal Unit	BTU	kilowatt-hour	kw-hr	0.000293	3414
	horsepower hours	hp-hr	kilowatt-hour	kw-hr	0.746	1.341

NOTES

Section C - Component Manufacturers

Section contents

Component Manufacturers' Addresses

NOTE: The following list contains addresses and telephone numbers of suppliers of accessories used on Cummins engines. Suppliers may be contacted directly for any specifications not covered in this manual.

Air Compressors

Bendix Heavy Vehicles Systems
Div. of Allied Automotive
901 Cleveland Street
Elyria, OH 44036
Telephone: (216) 329-9000

Holset Engineering Co., Inc.
1320 Kemper Meadow Drive
Suite 500
Cincinnati, OH 45240
Telephone: (513) 825-9600

Midland-Grau
Heavy Duty Systems
Heavy Duty Group Headquarters
10930 N. Pomona Avenue
Kansas City, MO 64153
Telephone: (816) 891-2470

Air Cylinders

Bendix Ltd.
Douglas Road
Kingswood
Bristol
England
Telephone: 0272-671 881

Catching Engineering
2101 Roberts Drive
Broadview, IL 60153
Telephone: (312) 344-2334

Air Heaters

Fleetguard, Inc.
Cookeville, TN 38502
P0. Box 6001
Telephone: (615) 526-9551

Kim Hotstart Co.
West 917 Broadway
Spokane, WA 99210
Telephone: (509) 534-6171

Air Starting Motors

Ingersoll Rand
Chorley New Road
Horwich
Bolton
Lancashire
England
BL6 6JN
Telephone: 0204-65544

Ingersoll-Rand Engine
Starting Systems
888 Industrial Drive
Elmhurst, IL 60126
Telephone: (312) 530-3800

StartMaster
Air Starting Systems
A Division of Sycon Corporation
P 0. Box 491
Marion, OH 43302
Telephone: (614) 382-5771

Alternators

Robert Bosch Ltd.
P.O. Box 98
Broadwater Park
North Orbital Road
Denham
Uxbridge
Middlesex UD9 5HG
England
Telephone: 0895-833633

Butec Electrics
Cleveland Road
Leyland
PR5 1XB
England
Telephone: 0744-21 663

C.A.V. Electrical Equipment
P.O. Box 36
Warple Way
London
W3 7SS
England
Telephone: 01-743-3111

A.C. Delco Components Group
Civic Offices
Central Milton Keynes
MK9 3EL
England
Telephone: 0908-66001

C. E. Niehoff
2021 Lee Street
Evanston, IL 60202
Telephone: (708) 866-6030

Delco-Remy
P.0. Box 2439
Anderson, IN 46018
Telephone: (317) 646-7838

Leece-Neville Corp.
1374 E. 51st St.
Cleveland, OH 44013
Telephone: (216) 431-0740

Auxiliary Brakes

The Jacobs Manufacturing Company
Vehicle Equipment Division
22 East Dudley Town Road
Bloomfield, CT 06002
Telephone: (203) 243-1441

Belts

Dayco Rubber U.K.
Sheffield Street
Stockport
Cheshire
5K4 1RV
England
Telephone: 061-432-5163

T.B.A. Ind. Products
P0. Box 77
wigan
Lancashire
WN2 4XQ
England
Telephone: 0942-59221

Dayco Corp.
Belt Technical Center
P.O. Box 3258
Springfield, MO 65804
Telephone: (417) 881-7440

Gates Rubber Company
5610 Crawfordsville Road
Suite 2002
Speedway, IN 46224
Telephone: (317) 248-0386

Goodyear Tire and
Rubber Company
49 South Franklin Road
Indianapolis, IN 46219
Telephone: (317) 898-4170

Catalytic Converters

Donaldson Company, Inc.
1400 West 94th Street
P.O. Box 1299
Minneapolis, MN 55440
Telephone: (612) 887-3131

Nelson Industries, Inc.
Exhaust and Filtration Systems
Highway 51 West, P.O. Box 428
Stoughton, WI 53589
Telephone: (608) 873-4373

Walker Manufacturing
3901 Willis Road
P.O. Box 157
Grass Lake, MI 49240
Telephone: (517) 522-5500

Clutches

Twin Disc International S.A.
Chaussee de Namur
Nivelles
Belguim
Telephone: 067-224941

Twin Disc Clutch Co.
Racine, WI 53403
Telephone: (414) 634-1981

Coolant Heaters

Fleetguard, Inc.
P.0. Box 6001
Cookeville, TN 38502
Telephone: (615) 526-9551

Drive Plates

Detroit Diesel Allison
Division of General Motors
Corporation
P0. Box 894
Indianapolis, IN 46206
Telephone: (317) 244-1511

Electric Starting Motors

Butec Electrics
Cleveland Road
Leyland
PR5 1XB
England
Telephone: 0744-21663

C.A.V. Electrical Equipment
P0. Box 36
Warple Way
London
W3 7SS
England
Telephone: 01-743-3111

A.C. Delco Components Group
Civic Offices
Central Milton Keynes
MK9 3EL
England
Telephone: 0908-66001

Delco-Remy
P0. Box 2439
Anderson, IN 46018
Telephone: (317) 646-7838

Leece-Neville Corp.
1374 E. 51st Street
Cleveland, OH 44013
Telephone: (216) 431-0740

Nippondenso Sales, Inc.
24777 Denso Drive
P0. Box 5133
Southfield, MI 48086-5133
Telephone: (313) 350-7500

Nippondenso of Los Angeles, Inc.
3900 Via Oro Avenue
Long Beach, CA 90810
Telephone: (310) 834-6352

Engine Protection Controls

Teddington Industrial
Equipment
Windmill Road
Sunburn on Thames
Middlesex
TW167HF
England
Telephone: 09327-85500

The Nason Company
10388 Enterprise Drive
Davisburg, MI 48019
Telephone: (313) 625-5381

Fan Clutches

Holset Engineering Co. Ltd.
P0. Box 9
Turnbridge
Huddersfield
England
Telephone: 0484-22244

Horton Industries, Inc.
P0. Box 9455
Minneapolis, MN 55440
Telephone: (612) 378-6410

Rockford Division
Borg-Warner Corporation
1200 Windsor Road
P0. Box 7007
Rockford, IL 61125-7007
Telephone: (815) 633-7460

Transportation Components Group
Facet Enterprises, Inc.
Elmira, NY 14903
Telephone: (607) 737-8212

Fans

Truflo Ltd.
Westwood Road
Birmingham
B6 7JF
England
Telephone: 021 -557-4101

Hayes-Albion
1999 Wildwood Avenue
Jackson, MI 49202
Telephone: (517) 782-9421

Engineering Cooling Systems
201 W. Carmel Drive
Carmel, IN 46032
Telephone: (317) 846-3438

Brookside
McCordsville, IN 46055
Telephone: (317) 335-2014

Aerovent
8777 Purdue Rd.
Indianapolis, IN 46268
Telephone: (317) 872-0030

Kysor
1100 Wright Street
Cadillac, MI 49601
Telephone: (616) 775-4681

Schwitzer
1125 Brookside Avenue
P0. Box 80-B
Indianapolis, IN 46206
Telephone: (317) 269-3100

Filters

Fleetsguard International Corp.
Cavalry Hill Industrial Park
Weedon
Northampton NN7 4TD
England
Telephone: 0327-41 313

Fleetguard, Inc.
P.0. B ox 6001
Cookeville, TN 38502
Telephone: (615) 526-9551

Flexplates

Corrugated Packing and
Sheet Metal
Hamsterley
Newcastle Upon Tyne
Telephone: 0207-560-505

Allison Transmission
Division of General Motors
Corporation
P0. Box 894
Indianapolis, IN 46206
Telephone: (317) 244-1511

Allison Transmission
Division of General Motors
36501 Van Born Road
Romulus, MI 48174
Telephone: (313) 595-5711

Midwest Mfg. Co.
30161 Southfield Road
Southfield, MI 48076
Telephone: (313) 642-5355

Wohlert Corporation
708 East Grand River Avenue
Lansing, MI 48906
Telephone: (517) 485-3750

Fuel Warmers

Fleetguard, Inc.
P0. Box 6001
Cookeville, TN 38502
Telephone: (615) 526-9551

Gauges

A.I.S.
Dyffon Industrial Estate
Ystrad Mynach
Hengoed
Mid Glamorgan
CF8 7XD
England
Telephone: 0443-812791

Grasslin U.K. Ltd.
Vale Rise
Tonbridge
Kent
TN9 1TB
England
Telephone: 0732-359888

Icknield Instruments Ltd.
Jubilee Road
Letchworth
Herts
England
Telephone: 04626-5551

Superb Tool and Gauge Co.
21 Princip Street
Birmingham
B4 61 E
England
Telephone: 021-359-4876

Kabi Electrical and Plastics
Cranborne Road
Potters Bar
Herts
EN6 3JP
England
Telephone: 0707-53444

Datcon Instrument Co.
P0. Box 128
East Petersburg, PA 17520
Telephone: (717) 569-5713

Rochester Gauge of Texas
11637 Denton Drive
Dallas, TX 75229
Telephone: (214) 241-2161

Governors

Woodward Governors Ltd.
p.o. Box 15
663/664 Ajax Avenue
Slough
Bucks
SL1 4DD
England
Telephone: 0753-26835

Woodward Governor Co.
1000 E. Drake Road
Fort Collins, CO 80522
Telephone: (303) 482-5811

Barber Colman Co.
1300 Rock Street
Rockford, IL 61101
Telephone: (815) 877-0241

UnIted TechnologIes
Diesel Systems
1000 Jorle Blvd.
Oak Brook, IL 60521
Telephone: (312) 325-2020

Heat Sleeves

Bentley Harris Manufacturing Co.
100 Bentley Harris Way
Gordonville, TN 38563
Telephone: (313) 348-5779

Hydraulic and Power Steering Pumps

Hobourn Eaton Ltd.
Priory Road
Strood
Rochester
Kent
ME2 2BD
Telephone: 0634-71773

Honeywell Control Systems Ltd.
Honeywell House
Charles Square
Bracknell
Berks RG12 1EB
Telephone: 0344-424555

Sundstrand Hydratec Ltd.
Cheney Manor Trading Estate
Swindon
Wiltshire
SN2 2PZ
England
Telephone: 0793-30101

Sperry Vickers
1401 Crooks Road
Troy, MI 48084
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Section L - Service Literature

Section Contents

Page

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NOTES

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APPENDIX D

DELCO REMY 21-SI DELCOTRON GENERATOR SERVICE MANUAL 1G-286

PRODUCT INFORMATION AND SERVICE MANUAL
DELCOTRON® GENERATOR
(21-SI SERIES)

CONTENTS

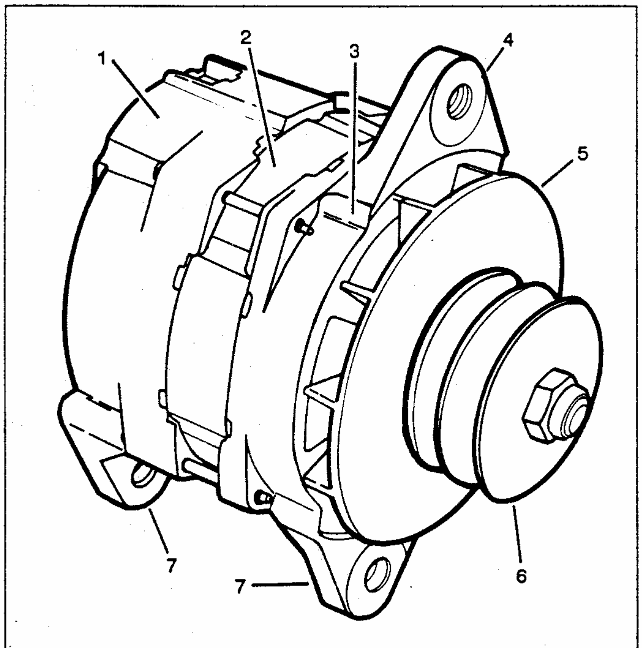


Figure 1. 21-SI Generator

INTRODUCTION

The 21-SI series Delcotron® Generator is a high-output integral charging system with built-in diode rectifier and voltage regulator, producing DC current for battery electrical systems. The 21-SI series is designed for use on large and mid-range diesel and gasoline engines in over-the-road service, as well as for off-road, agricultural, and construction equipment.

The 21-SI generator may be operated in either clockwise or counter-clockwise directions (external fan may require changing to reverse rotation) at continuous speeds of up to 10,000 generator rpm. Intermittent speeds of up to 12,000 generator rpm are also acceptable. The ambient temperature range for proper operation is -34°C to +93°C (-30°F to +200°F).

The solid state, integrated circuit voltage regulator built into the 21-SI generator limits system voltage by switching the ground circuit for the rotor field on and off. When the ground circuit is on, field current passes from a diode trio through the rotor via brushes and slip rings on the rotor shaft. Nominal regulated voltage is 27.5 volts for 24-volt systems.

Various output levels are available. For 24-volt systems, output rating 70 amperes. For output ratings of specific 21-SI models refer to the Specifications section of this manual.

FEATURES

The 21-SI Delcotron® Generator is a one-wire configuration. One-wire refers to the minimum number of lead wire connections necessary at the generator for operation. Some applications may use additional connections for accessory operation, and/or an additional ground lead connection.

The one-wire type requires only that the generator output ("BAT") terminal be connected to the battery positive terminal and that a ground path be provided between the generator housing and the battery negative terminal (refer to Figure 2). "R" and/or "I" terminal connections are optional and do not affect generator operation.

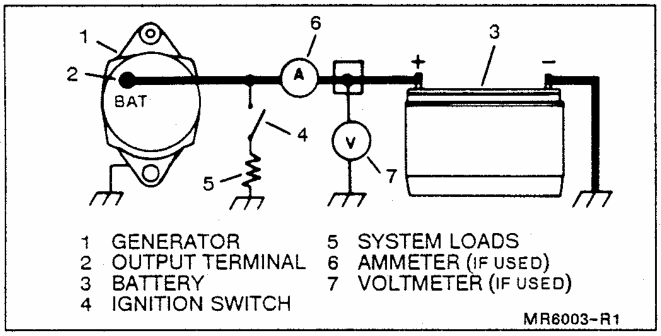


Figure 2. Basic One-Wire System

External connections to the 21-SI generator are made to terminals as shown in Figure *3.* The BAT terminal may be 1/4", 5/16", or M6 (metric) size, depending on the application requirement.

Optional connections to the 21-SI series include "R" (relay) and "I" (indicator light) terminals, and a ground lead connection to the generator housing.

A Relay terminal may be located either counter-clockwise from the BAT terminal where an R is molded into the casting, or at an opening clockwise from the BAT terminal and labeled "RELAY" by a permanent adhesive label next to the terminal. On a replacement unit, there will be a round push-on label on the terminal itself. This terminal may be used to operate a charge indicator, ADLO system, tachometer, or similar device by providing voltage pulses at about half of system voltage and at a frequency of 1/10 of the generator rpm.

When an "I" terminal is present it will be located where there is an "I" molded into the casting, clockwise from the BAT terminal. An "I" terminal is connected internally to the field circuit. If an

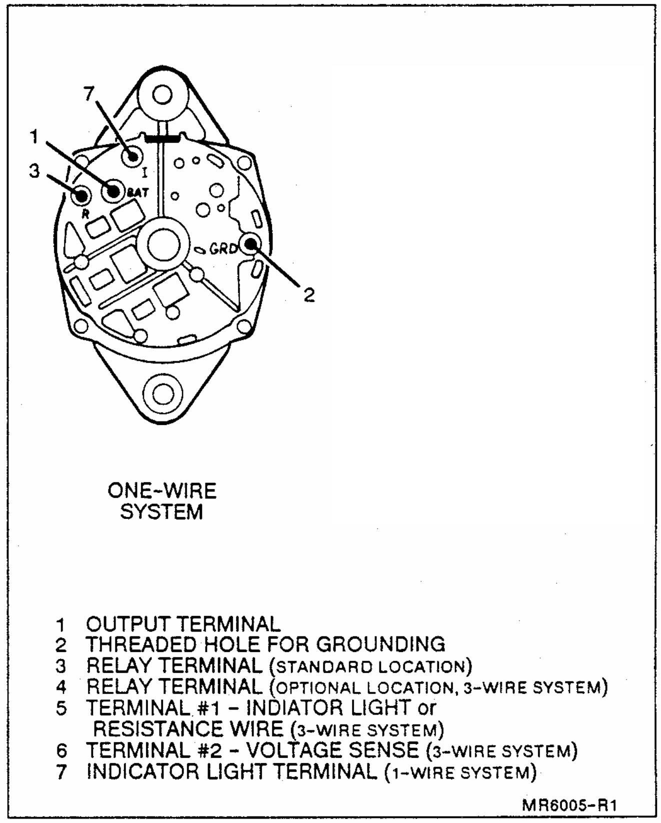


Figure 3. 21-SI Electrical Terminals

indicator light is connected in series with this terminal, the light will be on whenever there is a voltage difference between the "positive" side of the field circuit and the system voltage at other side of the indicator light. During normal generator operation, the light will be off since the diode trio output voltage equals the system voltage.

The "R" and "I" terminals are available in either threaded (10-24 or M4) or pin types.

A threaded 1/4" or 5/16" hole in the slip ring end (SRE) frame is provided to connect a ground lead if used; otherwise, the ground path is through the mounting hardware and brackets to the engine.

Some applications use a debris shield on the outside of the SRE housing of the generator. Such shields are added by the engine manufacturer to reduce the amount of airborne debris that enters the generator in severe environments. A stud mounted in the "I" terminal hole may be used to attach the debris shield to the generator. The stud is not connected electrically inside the unit.

OPERATING PRINCIPLES

A generator is a voltage-creating machine. The voltage regulator limits the maximum voltage that the generator will produce at the output (BAT) terminal by controlling the magnetic field present in the rotor. The voltage produced allows current to flow to satisfy the electrical loads placed on the system, up to a maximum current characteristic of the generator design.

Schematics of the generator circuitry are shown in Figure 4 (one-wire systems)

With the generator rotor turning, magnetic fields around the rotor induce voltages in the stator windings. The faster the rotor turns, the higher the induced voltage will be.

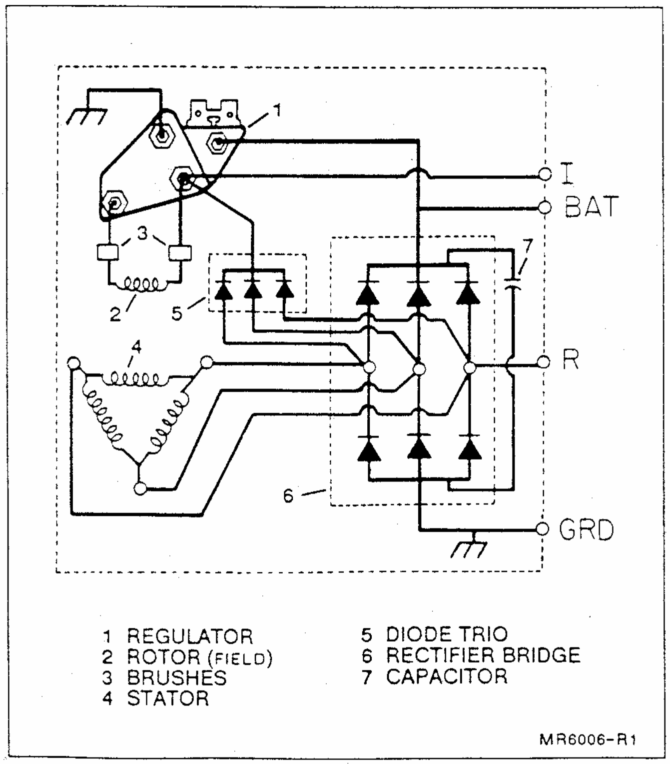


Figure 4. One-Wire Generator Schematic

As speed and output increase, voltage available at the diode trio becomes sufficient to supply field current for normal operation. When the output voltage exceeds the battery voltage, the generator begins to drive the system voltage. If the wiring system includes an indicator light, the presence of system voltage at the diode trio equalizes the voltage on both sides of the indicator light and the light goes out.

While the system voltage is below the voltage regulator setting, the regulator turns on the field current through the rotor and allows the generator to produce as much output as possible for the generator speed (rpm), temperature and system voltage. When the voltage setting is reached, the regulator turns the field current off. When the field current is turned off, the magnetic field in the rotor collapses and the generator output voltage begins to fall. The falling voltage causes the regulator to turn the field current back on and the magnetic field to rebuild. This switching action of the regulator continues rapidly, keeping the output and system voltage very close to the voltage setting. This will continue unless the electrical demands of the system cause the system voltage to fall below the voltage setting. Should this happen, the regulator will again allow full field current to flow so that the maximum output of the generator at the given speed, temperature and system voltage is realized.

One-wire systems use system voltage at the generator to control the output voltage, and extra sense wiring is not needed.

TROUBLESHOOTING

Trouble in the charging system will normally be indicated by one of the following:

- Undercharged or overcharged battery.
- Short life of light bulbs or other electric equipment caused by abnormally high system voltage.
- System voltmeter readings outside normal range.

Diagnose system as follows (refer to Fig. 5):

A. ALL CHARGING SYSTEMS

TEST EQUIPMENT NEEDED:

- Belt Tension Gage
- Battery State-of-Charge Indicator

1. Check electrical system wiring and battery terminals for poor connections or other obvious conditions that might result in shorts, opens, grounds, or high resistance. Correct as necessary.

2. Check generator drive belt for proper tension. Adjust to manufacturer's specifications.

3. Check battery for state-of-charge. If low, recharge according to manufacturer's specifications and load test to establish serviceability. Further diagnostic tests require a known good, fully-charged battery for accurate results.

B. SYSTEMS WITHOUT INDICATOR LIGHT

TEST EQUIPMENT NEEDED:

- Voltmeter

1. If battery is undercharged, or System voltmeter shows operating voltage is below acceptable range:

   With engine stopped and all electrical loads turned off, use voltmeter to check voltage across battery terminals. Record voltage.

   Start engine and run at moderate speed. Check voltage across battery terminals with engine running.

- If voltage reading at battery terminals is different from reading showing at system voltmeter (if equipped), locate and correct cause of incorrect reading.

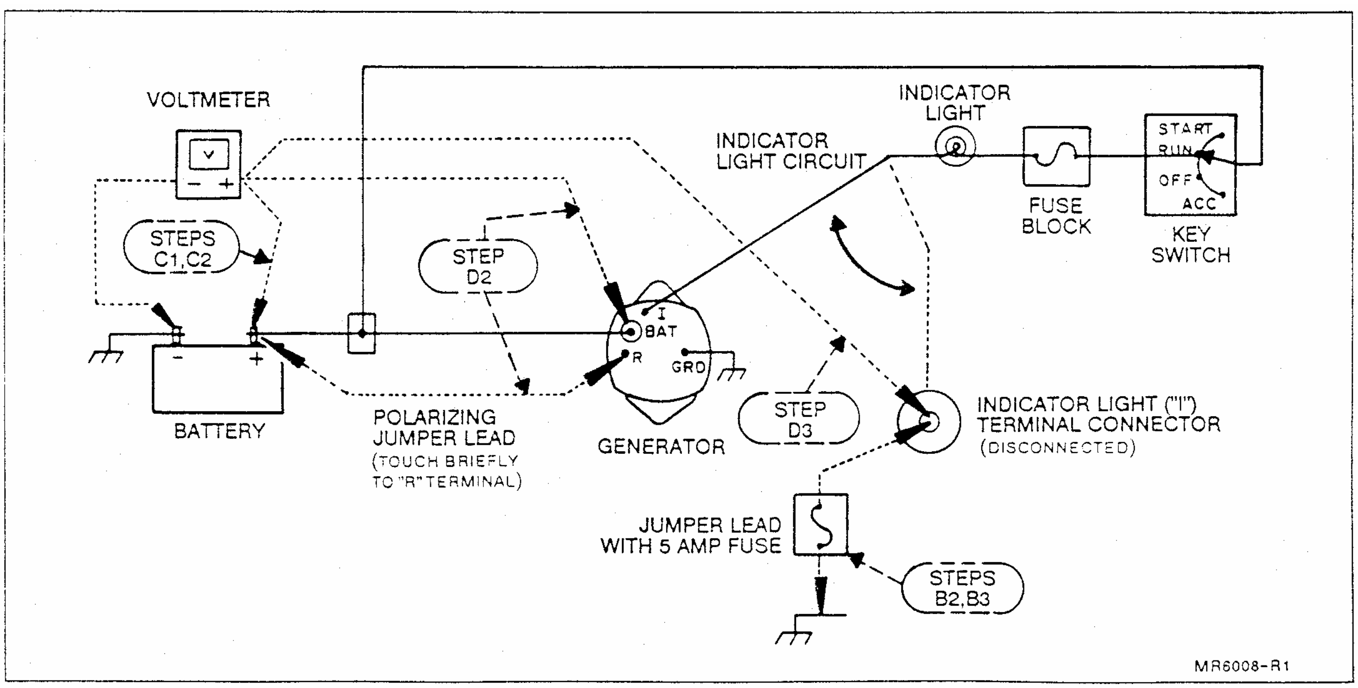


Figure 5. Troubleshooting a One-Wire System

- If voltage is lower than reading previously recorded with engine stopped, there is no generator output. Proceed to section on "No Output."

- If voltage is higher than previous reading with engine stopped, generator output is present. Proceed to section on "Rated Output Check".

2. If battery is overcharged (as evidenced by excessive water use or electrolyte spewing from battery vents), light bulbs or other electrical equipment have shortened life due to suspected high system voltage, or system voltmeter reads above normal range:

   With fully charged battery, engine running at moderate speed and all electrical loads off, use voltmeter to check voltage at battery terminals.

   For a 24-volt system, readings should be stable, around 27 - 28 volts and in no case go above 31 volts.

- One-wire system: If voltage is erratic or goes above 31 volts on 24-volt system replace regulator as described under "Unit Repair".

C. NO OUTPUT

TEST EQUIPMENT NEEDED:

- Voltmeter
- Jumper Lead (18 ga. mm; no fuse)

NOTE

21-SI generators must be connected to a battery for the voltage sensing circuit to allow initial turn on (refer to section on Features). When properly connected and system checks indicate a "no output" condition, use the following steps to determine if the generator requires repair:

1. For one-wire systems <u>without</u> an "I" terminal, battery positive voltage at the "BAT" terminal and residual magnetism in rotor are necessary for generator to turn on. Use voltmeter to verify that battery voltage is present at "BAT" terminal. If not, locate and correct cause of voltage loss.

   Residual magnetism in the rotor is sometimes lost during servicing of the generator. If the generator has no "R" or "RELAY" terminal, proceed to step 2. If the generator has an "R" terminal, the rotor can be remagnetized without removing generator from application. To remagnetize rotor, make sure the normal connections are made to the generator BAT terminal and to the ground circuit. Disconnect the wiring harness from the "R" terminal. Momentarily connect a jumper lead from battery positive to the generator "R" terminal. This will cause field current to momentarily flow through the rotor in the proper direction and restore magnetism. Reconnect wiring harness to "R" terminal, then recheck generator for output.

2. If no conditions have been found that might prevent the generator from turning on, remove and replace the generator.

D. RATED OUTPUT CHECK

TEST EQUIPMENT NEEDED:

- Voltmeter
- Ammeter (current capability at least 15 amperes higher than generator rating)
- Variable Carbon Pile Load Test

WARNING

Failure to disconnect negative battery cable at battery before removing or attaching generator "BAT" terminal lead may result in an injury. If a tool is shorted at generator "BAT" terminal, the tool can quickly heat enough to cause a skin burn.

1. Refer to Fig. 6 for test equipment hookups as described in following steps. If inductive pick-up ("clamp on") type ammeter is used, place current clamp on generator output lead and skip to step 4. If series ammeter is used, disconnect negative battery cable at battery.

2. Install ammeter in series with generator "BAT" terminal.

3. Reconnect negative battery cable at battery.

CAUTION

When a 12-volt carbon pile load test is used to diagnose a 24-volt system, attach load test only to 12-volt potential in battery pack. Attaching a 12-volt load test to a 24-volt potential will damage the load test.

4. With load turned off, attach carbon pile load test across battery.
5. Attach voltmeter negative to grounded negative battery terminal. Leave positive meter lead open for checks at various points.
6. Check and record voltage at battery positive terminal. For multi-battery systems, check positive voltage of battery set connected as if in battery charging mode.
7. With all system electrical loads off, start engine and run at moderate speed (rpm).
8. Recheck voltage at battery positive terminal. Voltage should be higher than previous reading, but below 31 volts on 24-volt system.

- If reading is lower than previous reading (step 6), refer to section on “No Output”.
- If reading is higher than 31 volts on 24-volt system, refer to section on “High Voltage Output”.

9. Turn carbon pile load on and adjust to obtain maximum generator output on ammeter without allowing voltage at battery positive terminal to drop below 25 volts on 24-volt system. Record maximum ampere output.

With generator still running at maximum output, check and record voltage drop in ground circuit between generator housing and battery negative terminal. Turn carbon pile load off.

Maximum ampere output should be within 15 amps of output rating stamped next to part number on generator drive end (DE) frame, or as listed in Specifications section of this manual. Voltage drop should be 0.5 volts or less on a 24-volt system.

- If ground circuit voltage drop is over 0.5 volts on 24-volt system, clean and tighten all ground circuit connections. If this does not correct excessive voltage drop, check ground circuit cables for improper sizing or high resistance conditions. Correct as necessary.
- If within 15 amps of rating, generator is good. Look elsewhere for cause of problem.
- If more than 15 amps below rating, repair or replace generator.

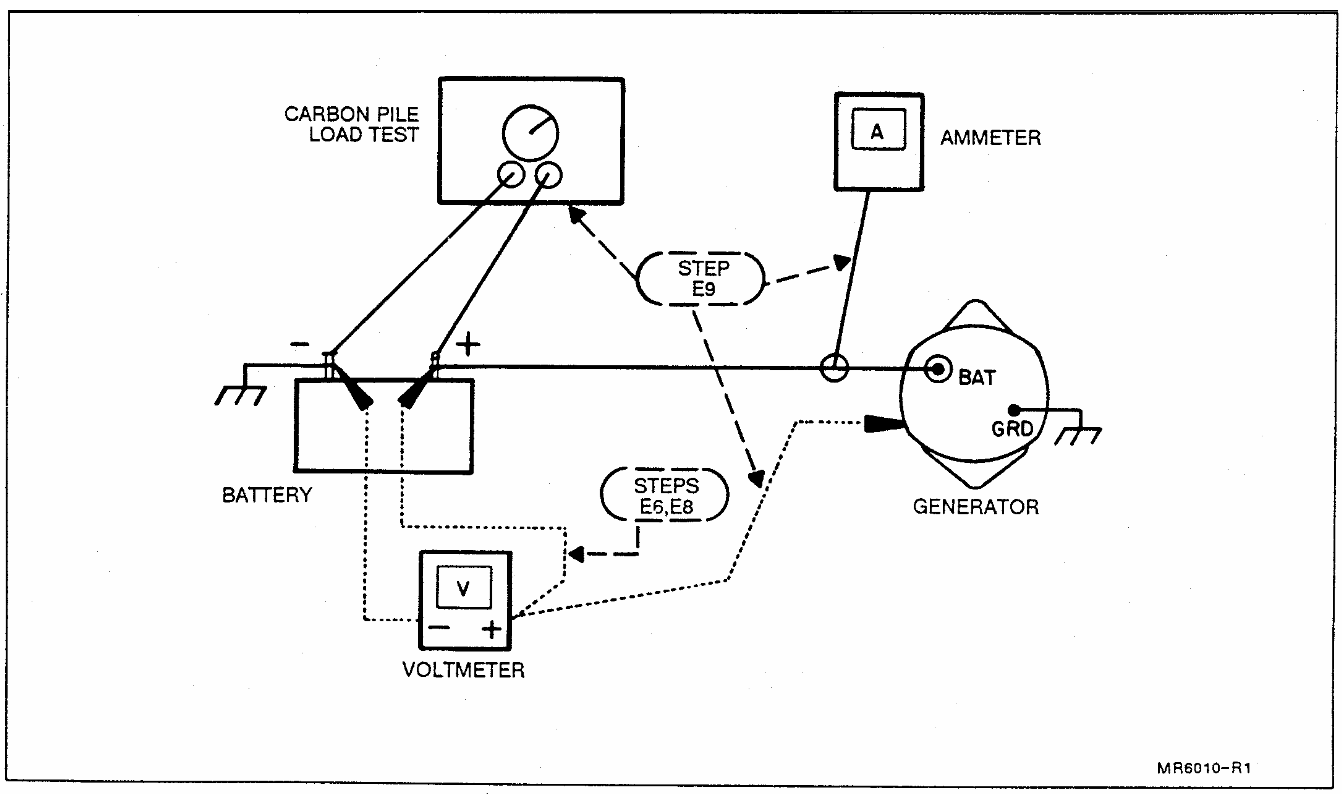


Figure 6. Rated Output Check

GENERATOR BENCH TEST

TEST EQUIPMENT NEEDED:

- Generator Test Stand (5000 rpm capability)
- Battery or Battery Set (fully charged)
- Variable Carbon Pile Load Test
- Ammeter (current capability at least 15 amps higher than generator rating)
- Voltmeter
- Ohmmeter

This bench test procedure is used to verify that the generator is functioning properly prior to installation on the vehicle. This test checks the generator output in the same manner as the Rated Output Check covered earlier in this procedure. If bench test equipment is not available, install the generator on the engine according to manufacturer's instructions and repeat the Rated Output Check to verify generator operation. If bench test equipment is available, proceed as follows:

1. Mount generator in suitable test stand, according to test stand manufacturer's instructions. Test stand must be capable of driving generator at speeds up to 5000 rpm.

NOTE

Battery or battery set must be fully charged for test results to be valid.

CAUTION

When a 12-volt carbon pile load test is used to diagnose a 24-volt system, attach load test only to 12-volt potential in battery set. Attaching a 12-volt load test to a 24-volt potential will damage the load test.

With carbon pile load turned off and with battery or battery set fully charged, make electrical connections as shown in Fig. 7.

Battery voltage and ground polarity must be same as system in which generator is used. Check and record battery voltage before proceeding with test.

2. With carbon pile load "off," start test stand and slowly increase generator speed to 5000 rpm. Observe voltmeter.

- If voltage does not increase but remains at or below previous reading (step 2), there is no generator output. Skip to step 5.
- If voltage increases above 31 volts on 24-volt system, voltage is uncontrolled. Recheck generator for proper assembly. Assure that test tab in "D" hole is not grounded. If generator has been assembled properly, replace regulator as described under "Unit Repair".
- If voltage is proper, proceed to next step.

3. With generator running at about 5000 rpm, turn on carbon pile load and adjust to obtain maximum generator output on ammeter without allowing voltage on voltmeter to fall below 25 volts on a 24-volt system

- If ammeter reading is within 15 amps of cold output shown under "Specifications", generator is good. Turn off carbon pile and stop test stand.
- If ammeter reading is more than 15 amps below specification, generator is not operating properly. Proceed to step 5.

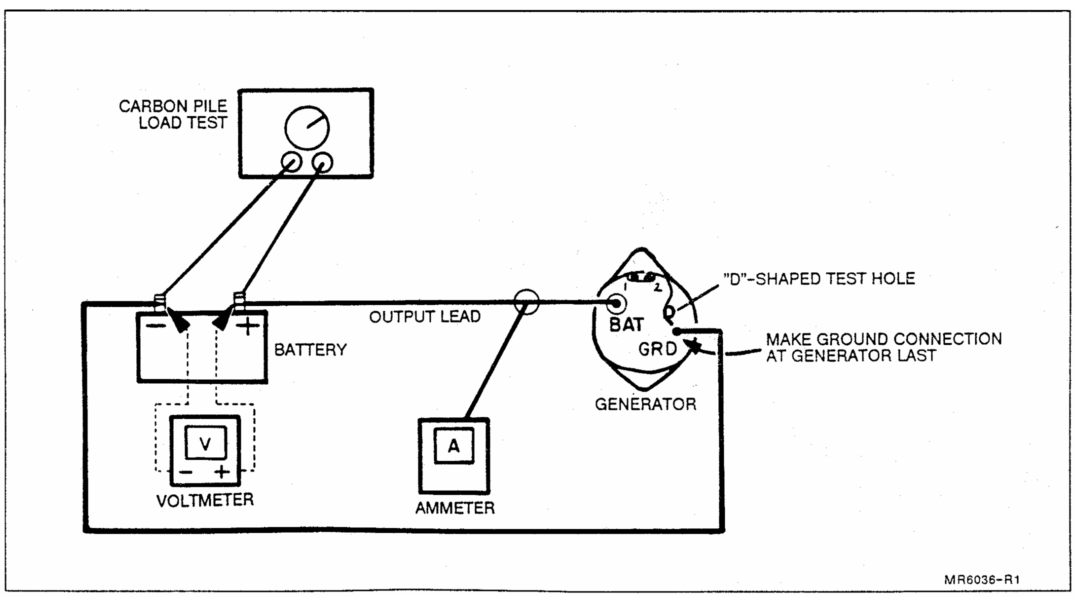


Figure 7. Generator Bench Test

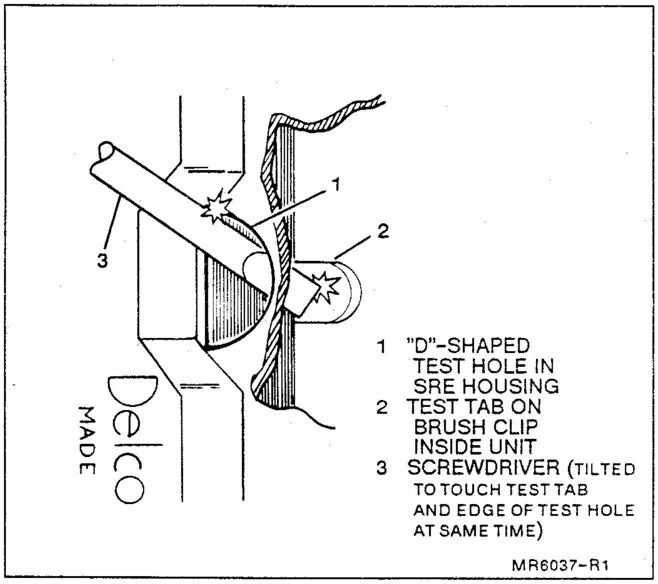


Figure 8. Using Test Hole

CAUTION

Do not insert screwdriver more than about 3/4" into test hole during this step. The grounding tab on the brush holder assembly is reached at this distance. Inserting the screwdriver deeper may result in internal damage to the generator.

4. Test hole is provided in SRE housing to allow direct grounding of rotor field circuit (Fig. 8). Grounding the brush tab inside this hole bypasses the regulator and turns the generator on in "full field" mode. If the generator output is proper with the brush tab grounded, the previous low output is due to conditions within the regulator. Because the voltage is not regulated and can exceed 16 volts in full field mode, the test hole should be used only for bench test procedures.

   Insert screwdriver straight into test hole in SRE housing to make contact with tab on grounding brush. Tilt handle slightly to ground tab to housing at edge of test hole and hold. Again adjust carbon pile to obtain maximum output on ammeter without allowing voltage on voltmeter to fall below (25 volts on 24-volt system). Record reading, then turn off carbon pile and stop test stand.

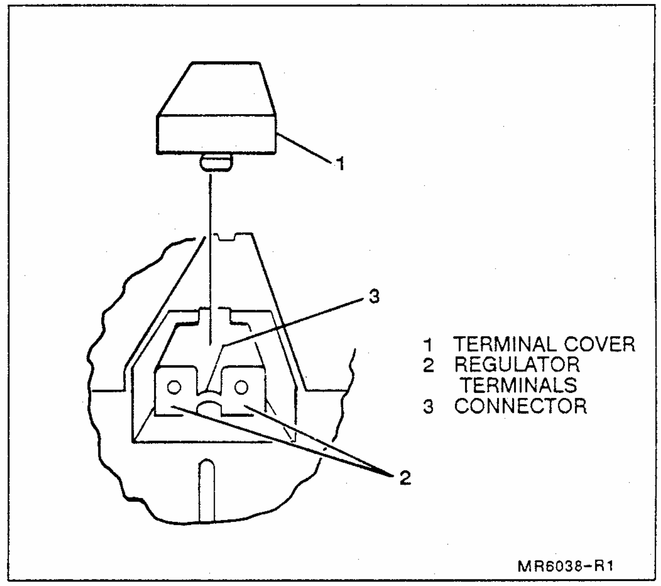


Figure 9. Checking 1-Wire Regulator Terminals

- If there is still no output, refer to "Unit Repair" and check rotor and brushes for an open circuit. Be sure that brushes are assembled properly and in contact with the slip rings. Check internal electrical connections to be sure grounding and insulated mounting screws are installed in the proper locations.

  For a one-wire system only, remove the regulator terminal cover and verify that there is a connector between the two regulator terminals (Fig. 9). If not, replace regulator as described under "Unit Repair".

- If the output is now within 15 amps of the cold output specification, but was not when checked per step 4., check the regulator mounting to assure that grounding and insulated mounting screws are installed in the proper location. If assembly is proper, replace regulator as described under "Unit Repair".

- If there is some generator output, but it is still more than 15 amps below the cold output specification, check the rotor field, brushes, stator, diode trio, and rectifier bridge as described under "Unit Repair".

GENERATOR MOUNTING

WARNING

Failure to disconnect negative cable at battery before removing or attaching generator "BAT" terminal lead may result in an injury. If a tool is shorted at generator "BAT" terminal, the tool can quickly heat enough to cause a skin burn.

NOTE

Always re-install fasteners at original location. If necessary to replace fasteners, use only correct part number or equivalent.

- If correct part number is not available, use only equal size and strength.
- Fasteners that are NOT to be reused will be noted in procedure.
- Fasteners requiring thread locking compound will be noted in procedure.
- Use specified torque values when shown.

CAUTION

Using or replacing fasteners in any other manner could result in part or system damage.

Always follow engine manufacturer's instructions for mounting generator on engine. The following procedure is typical and may not match all steps necessary for a particular application.

TEST EQUIPMENT NEEDED:

- Belt Tension Gage

Remove or Disconnect

1. Negative cable at battery.

Adjust

2. SRE hinge bushing position so that the mounting lugs will fit over the bracket spool.

Install or Connect

3. Generator double mounting lugs to mounting bracket on engine (Fig. 10). Adjust hinge bushing in mounting lug by tapping endways until it just clears the spool on the mounting bracket. Install flanged mounting bolt and flanged mounting bolt nut. If bolt and/or nut are not flanged, 1/8" thick hardened steel washers (part no. 1967343) must be substituted for flanges (Fig. 11).
4. Generator adjustment lug to adjustment bracket on engine, with 1/8" thick hardened steel washer (part no. 1967343) and flanged adjustment bolt (Fig. 39). Finger tighten.
5. Generator belt to pulley.
6. If engine uses automatic belt tensioner (idler), skip to step 7.

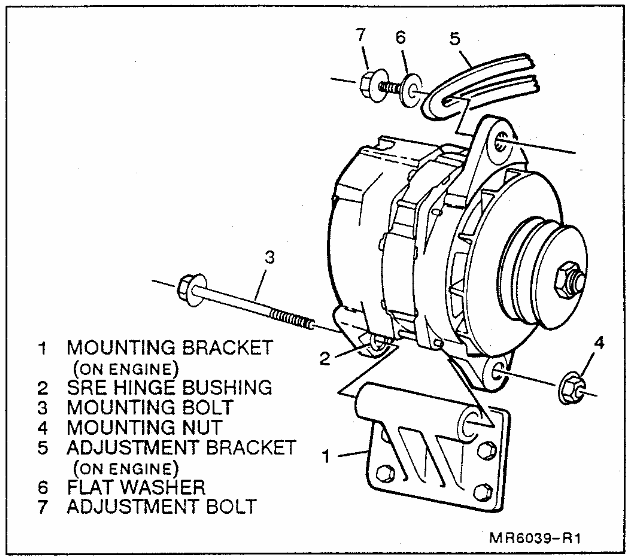


Figure 10. Installing Generator on Engine

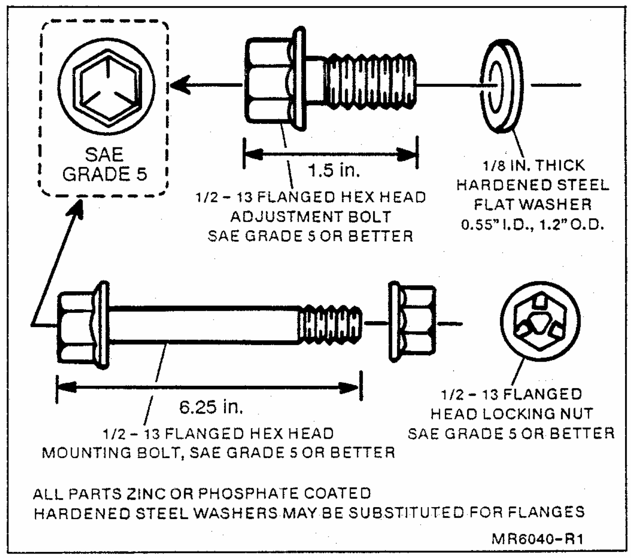


Figure 11. Generator Mounting Bolts

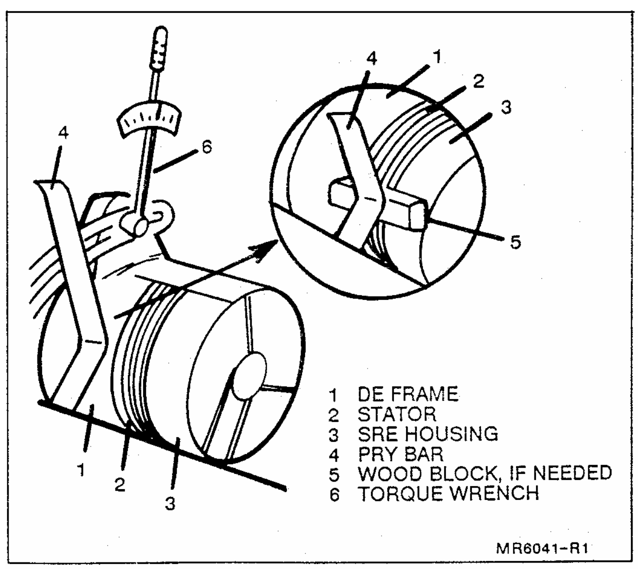


Figure 12. Adjusting Belt Tension

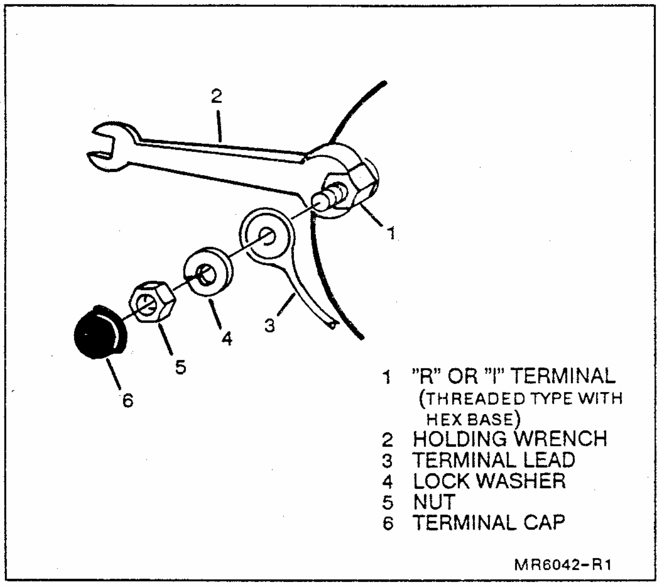


Figure 13. Threaded "I" and "R" Terminals

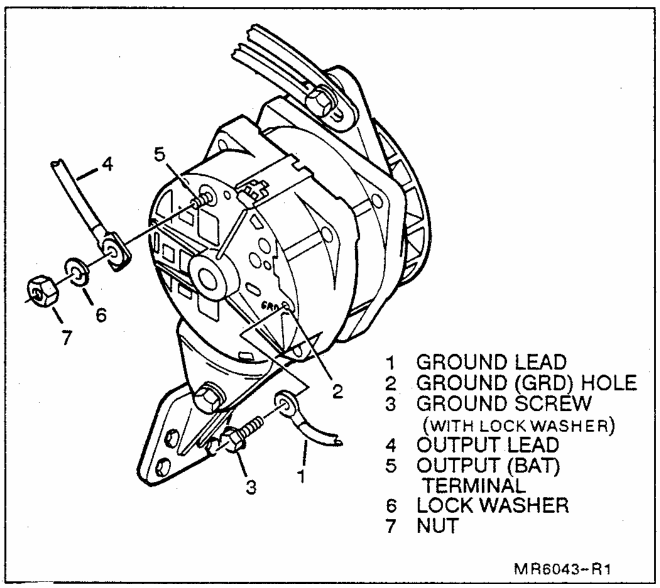


Figure 14. Installing Ground and Output Leads

CAUTION

Do not pry directly against stator or SRE housing to adjust belt tension. Force must be applied to DE frame as described. Prying only against stator or SRE housing may damage the generator.

If belt tension is adjusted by forcing generator against belt, use suitable pry bar positioned against DE frame of generator (Fig. 12). If DE frame is not accessible, place wood block along side of generator against both DE frame and SRE housing and pry against wood block.

Adjust

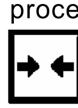
Using belt tension gage, adjust to engine manufacturer's specification and hold.

Tighten

7. Adjusting lug bolt to 88 N•m (65 lb. ft.).
8. Hex mounting bolt nut to 88 N•m *(65* lb. ft.).

Measure

9. Belt tension to be sure specification is maintained. If not, repeat tensioning procedure.



Install or Connect

10. "I" and/or "R" (or "Relay") terminal connectors, if used. For threaded terminals with a hex base, hold hex portion of terminal as anti-turn while tightening nut (Fig. 13).

Tighten

M4 "I" and "R" (or "Relay") terminal nuts to 2.0 N•m (20 lb. in.).

10—24 "I" and "R" (or "Relay") terminal nuts to 2.0 N•m (20 lb. in.).

11. Terminal caps to "I" and "R" (or "Relay") terminals as necessary.
12. Ground lead to "GRD" hole in SRE housing, with ground screw/lockwasher assy (Fig. 14).

Tighten

1\4" ground screw to 6 N•m *(55* lb. in.).

5\16" ground screw to 11 N•m (100 lb. in.).

13. Output lead to "BAT" terminal, using lock washer and output terminal nut (Fig. 14).

Tighten

M6 output terminal nut to 11 N•m (100 lb. in.).

1/4" output terminal nut to 7 N•m (65 lb. in.).

5/16" output terminal nut to 11 N•m (100 lb. in.).

14. Negative cable at battery.

21-SI GENERATOR SPECIFICATIONS

Generator Model	Rated Volts/Amps	GND	Rotation Viewed From DE	Spec.	Rotor Field Checks: Ohms @ 80°F.	Rotor Field Checks: Current Amps@Volts		Cold Output @ 80° F: Amps @ 1600 rpm	Cold Output @ 80° F: Amps @ 5000 rpm
1117900	24V/70A	N	Either	8115	9.5-10.7	2.2-2.5	24	15	70

[1]Rated 160 Amperes at 8300 rpm.

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APPENDIX E

DELCO REMY CRANKING MOTORS
SERVICE BULLETIN 1M-157
AND
DELCO REMY STARTERS
SERVICE TEST SPECIFICATIONS 1M-188

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Service Bulletin 1M-157

CRANKING MOTORS
37-MT/300

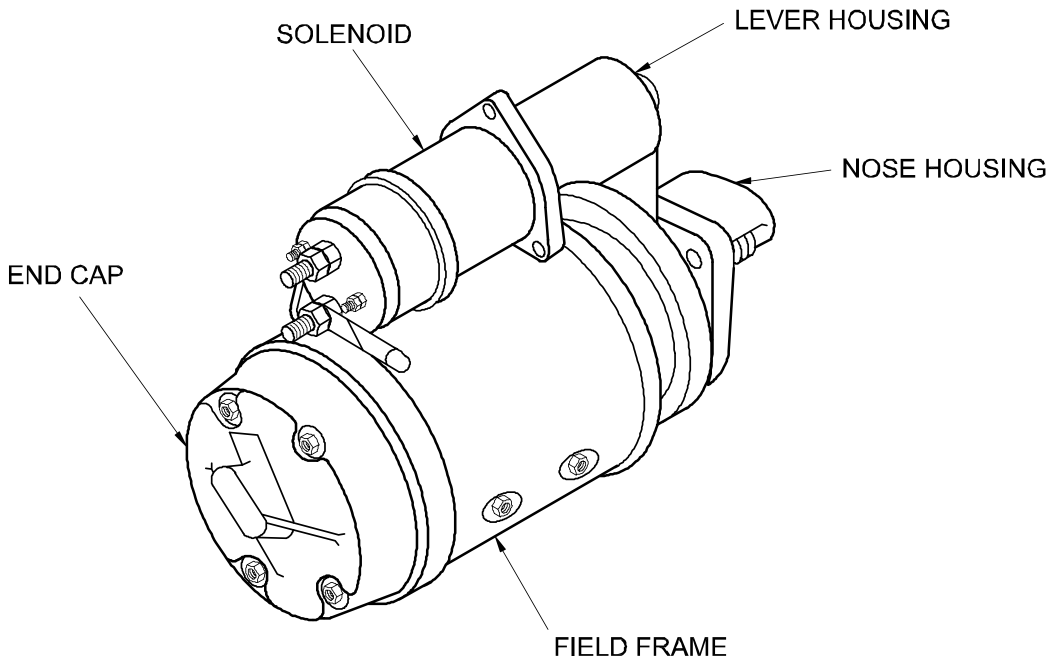

Figure 1 – Typical 37-MT motor.

Heavy duty cranking motors have a shift lever and solenoid plunger that are totally enclosed to protect them from exposure to dirt, icing conditions and splash. The nose housing can be rotated to obtain a number of different solenoid positions with respect to the mounting flange. High durability features include a newly designed drive, solenoid, and brush rigging and one-piece brushes which provide extra long brush life. Also, the commutator end cap can be removed to inspect the brushes.

Lubrication is provided in the sintered bronze bushings by an oil saturated wick. Oil can be added to each wick by removing an oil reservoir cup which is accessible on the outside of the motor.

The pinion is moved into mesh with the ring gear by the action of the solenoid. The pinion remains engaged until the solenoid circuit is interrupted.

MAINTENANCE
Under normal operating conditions, no maintenance will be required between engine overhaul periods. At time of engine overhaul, motors should be inspected, cleaned, and tested as described in succeeding paragraphs.

ADJUSTABLE NOSE HOUSING
As shown in the cross-sectional views of Figure 2, the nose housing is attached to the lever housing by means of bolts located around the outside of the housing. To relocate the housing, it is only necessary to remove the bolts, rotate the housing to the desired position, and reinstall the bolts.

The bolts should be torqued to 13-17 lb. ft. during reassembly. In this type of assembly, the lever housing and the commutator end cap are attached to the field frame independently by bolts entering threaded holes in the field frame.

OPERATION
There are many different cranking motor circuits used on various applications. The cranking circuit may contain a key start switch or push switch, or both, a relay, magnetic switches, solenoids, oil pressure switch, fuel pressure switch and other protective devices, such as an “ADLO” relay.

Reference should be made to the ATEC electrical schematics in TM 5-3810-307-24-1-1.

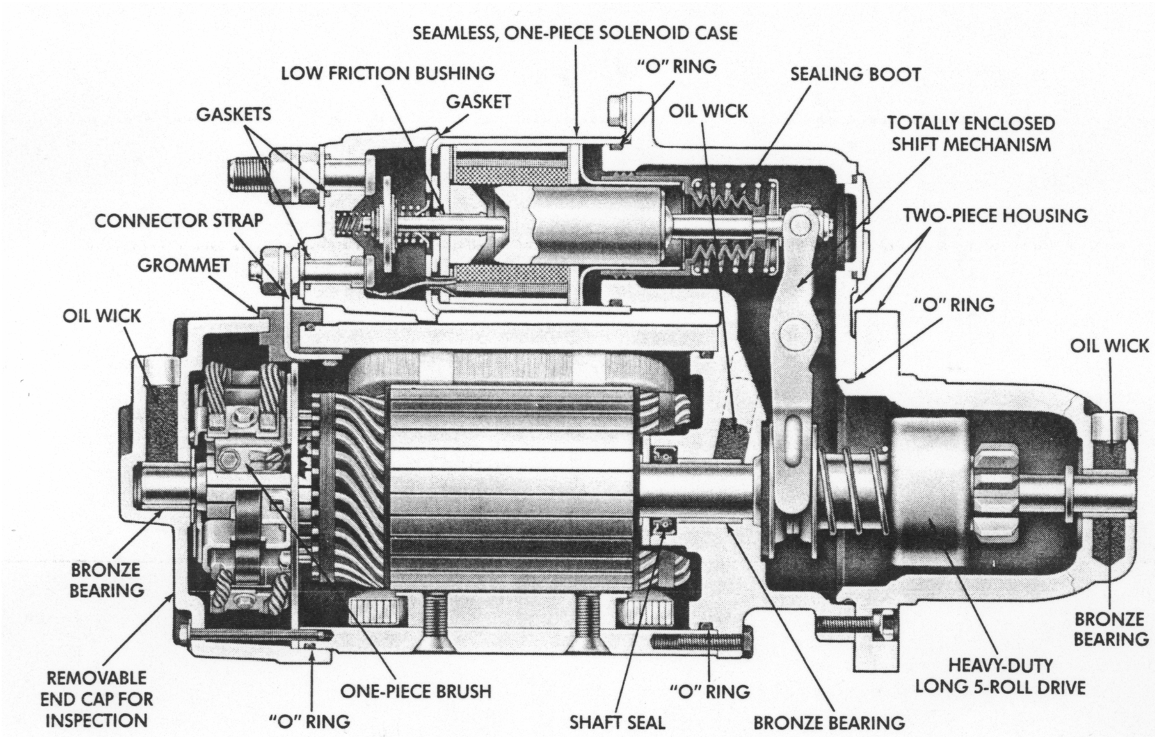

Figure 2 – Cross-sectional view, typical 37-MT motor.

A basic circuit of a 37-MT is shown in Figure 3.

For all circuits, when the start switch is closed, the magnetic switch contacts close, and the solenoid windings are connected to the battery.

The resulting plunger and shift lever movement causes the pinion to engage the engine flywheel ring gear and the solenoid main contacts to close, and cranking takes place. When the engine starts, pinion overrun protects the armature from excessive speed until the switch is opened, at which time the return spring causes the pinion to disengage. To prevent excessive overrun and damage to the drive and armature windings, the switch must be opened immediately when the engine starts. A cranking period for all types of motors should never exceed 30 seconds without stopping to allow the motor to cool for at least two minutes.

The 30-second limit also applies to motors with a thermostat. If over-cranking should occur, the thermostat will open and the cranking cycle will stop to protect the motor. After the cranking motor cools, usually 1-6 minutes, the thermostat will close and then a new starting attempt can be made.

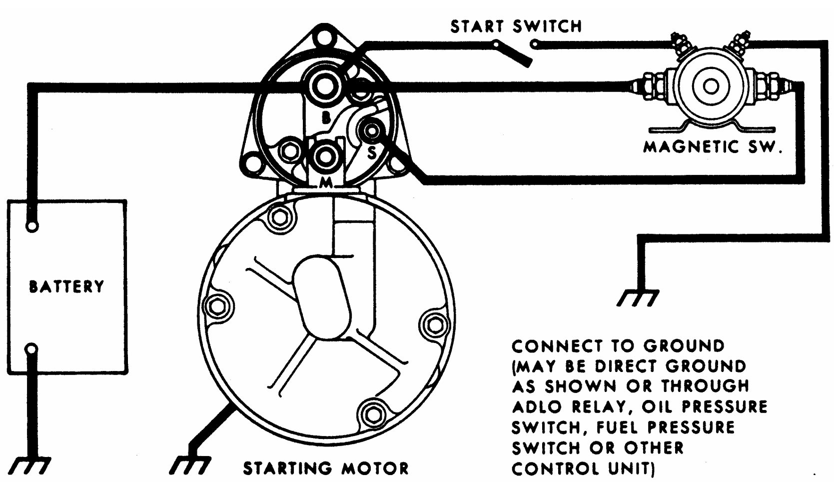

Figure 3 – Basic cranking circuit (37-MT).

TROUBLESHOOTING THE CRANKING CIRCUIT

If the cranking system is not performing properly, make the following checks to help determine which part of the circuit is at fault.

Battery: The battery is fully charged. The wiring, switches, and cranking motor cannot be checked if the battery is defective or discharged.

Wiring: Inspect the wiring for damage. Inspect all connections to the cranking motor, solenoid, magnetic switch, ignition switch or any other control switch, and battery, including all ground connections. Clean and tighten all connections as required. The cranking system cannot operate properly with excessive resistance in the circuit.

Magnetic Switch, Solenoid and Control Switches: Inspect all switches to determine their condition. From the vehicle wiring diagram, determine which circuits should be energized with the starting switches closed. Use a voltmeter to detect any open circuits.

Motor: If the battery, wiring and switches are in satisfactory condition, and the engine is known to be functioning properly, remove the motor and follow the test procedures outlined below.

A cranking motor is designed for intermittent duty only, and should never be operated for more than 30 seconds at a time. After 30 seconds, the cranking must be stopped for at least two minutes to allow the motor to cool.

With the cranking motor removed from the engine, the armature should be checked for freedom of rotation by prying the pinion with a screwdriver. Tight bearings, a bent armature shaft, or a loose pole shoe screw will cause the armature to not turn freely. If the armature does not turn freely the motor should be replaced immediately. However, if the armature does rotate freely, the motor should be given a no-load test before replacement.

The no-load test may point to specific defects. Also, the no-load test can identify open or shorted fields. The no-load test also can be used to indicate normal operation on a repaired motor before installation.

No-Load Test (Fig. 4)

Connect a voltmeter from the motor terminal to the motor frame, and use an r.p.m. indicator to measure armature speed. Connect the motor and an ammeter in series with a fully charged battery of the specified voltage, and a switch in the open position from the solenoid battery terminal to the solenoid switch terminal. Close the switch and compare the r.p.m., current, and voltage reading with the specifications in SB 1M-188 (page E-7). It is not necessary to obtain the exact voltage specified in these bulletins, as an accurate interpretation can be made by recognizing that if the voltage is slightly higher the r.p.m. will be proportionately higher, with the current remaining essentially unchanged. However, if the exact voltage is desired, a carbon pile connected across the battery can be used to reduce the voltage to the specified value. If more than one 12-volt battery is used, connect the carbon pile to only one of the 12-volt batteries. If the specified current draw does not include the solenoid, deduct from the ammeter reading the specified current draw of the solenoid hold-in winding. Make disconnections only with the switch open. Interpret the test results as follows:

1. Rated current draw and no-load speed indicates normal condition of the cranking motor.
2. Low free speed and high current draw indicate:
   a. Too much friction – tight, dirty, worn bearings, bent armature shaft or loose pole shoes allowing armature to drag.
   b. Shorted armature.
   c. Grounded armature or fields.
3. Failure to operate with high current draw indicates:
   a. A direct ground in the terminal or fields.
   b. "Frozen" bearings (this should have been determined by turning the armature by hand).
4. Failure to operate with no current draw indicates:
   a. Open field circuit.
   b. Open armature coils.
   c. Broken brush springs, worn brushes, high insulation between the commutator bars or other causes which would prevent good contact between the brushes and commutator.
5. Low no-load speed and low current draw indicate:
   a. High internal resistance due to poor connections, defective leads, dirty commutator and causes listed under Number 4.
6. High free speed and high current draw indicate shorted field.

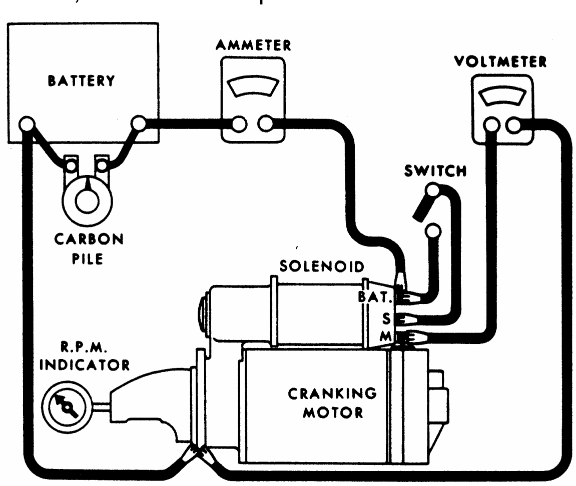

Figure 4 – No-load test circuit.

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SERVICE TEST SPECIFICATIONS

For Starters Released 1978 - 1994

STARTERS AND MISCELLANEOUS D.C. MOTORS

Specifications contained in this bulletin are for the purpose of testing the performance of starter and D.C. motors. The specifications apply only when tests are conducted as recommended in the applicable service bulletin.

To obtain performance data on a motor or to determine the cause of abnormal operation, the motor should be subjected to a “no-load” test. This test is performed as described below, with the motor removed from the engine.

No-Load Test

Be sure switch is OPEN before connections or disconnections are made.

To perform the no-load test, connect the starter motor in series with a fully charged battery of the specified voltage as illustrated in Figure 5. An rpm indicator is necessary to measure pinion speed. Obtain the specified voltage by varying the carbon pile. Read the current draw and the pinion speed and compare these readings with the values listed in the published specifications.

NOTE

Do not apply voltage above what is specified. Excessive voltage may cause the armature to throw windings.

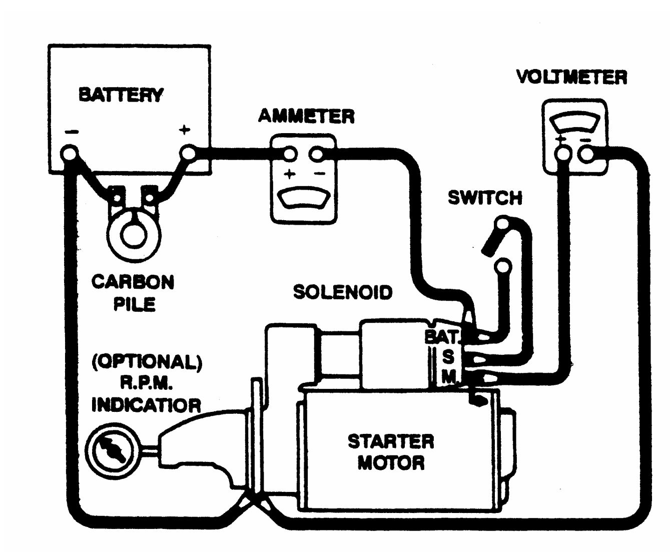

Fig. 5 – No Load Test hookup with solenoid. Current specification includes solenoid current.

SERVICE SPECIFICATIONS – STARTER MOTORS

1.	Motor Model	5.	Rotation Viewing D./E./				
2.	Series	6.	Spec. No				
	NOTE: Series codes have been standardized To present designations as follows: …was 5 MT, …now SD200 or SD250 …was 10 MT, …now SD300 …was PMGR, …now PG200	7.	No Load Test (includes solenoid current when applicable)				
3.	Type		Volts	Min. Amps	Max. Amps.	Min. RPM	Max. Rpm
			Volt	Amp Min.	Amp Max.	U/Min Min.	U/Max Max.
4.	Service Bulletin		Tension	Amps Mini	Amps Maxi	RPM Mini	RPM Maxi

1. MOTOR MODEL	2. SERIES	3. TYPE	CLEARANCE (mm)	4. SERVICE BULLETIN	5. ROTATION FROM DE	6. SPEC NO.	7. LOAD TEST				
							VOLTS	MIN AMPS	MAX AMPS	MIN RPM	MAX RPM
1993904	37MT	300	0.25-1.78	1M-157	CW	7112	20	50	75	3300	4400
(CUMMINS MODEL 10479108)											

APPENDIX G

DS350 LMI

for ATEC (AT422T)

TROUBLESHOOTING SECTION

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TABLE OF CONTENTS

TABLE OF CONTENTS - continued

GENERAL INFORMATION

MANUAL INFORMATION

This troubleshooting handbook is designed to assist a service or maintenance person in identifying the system problem areas or malfunctions. A digital voltmeter and regular maintenance and service tools, see tool list below, will be required to troubleshoot the system.

NOTE

Knowledge of how to use a digital voltmeter is assumed.

This handbook covers machines with 024-350-062-766 and 024-350-062-767 central units. The troubleshooting the system use ‘A’ drawings for the 2766 central unit and ‘B’ drawings for the 2767 central unit. The central unit 024-350-062-767 hardware changes is effective on crane serial number 86638 and beyond.

The drawings in Section 10 and the procedures in Section 11 are provided as reference material that will be used in the troubleshooting flow charts. Use the drawings and procedures in conjunction with the flow charts to help understand the operation of the LMI. To further understand the theory for LMI operations, refer to Section 12.

TOOL LIST

1 - DIGITAL MULTIMETER COMPLETE WITH 2 SETS OF LEADS
1 - SOLDERING IRON
1 - INCLINOMETER
1 - #0, #1, & #2 PHILLIPS HEAD SCREWDRIVERS
1 - #0 & #1 - PHILLIPS HEAD PRECESSION SCREWDRIVERS
1 - 3/16, 1/4, & 9/32 INCH SLOTTED HEAD SCREWDRIVERS
1 - 0.040, 0.070, & 0.100 INCH SLOTTED HEAD PRECESSION SCREWDRIVERS
1 - 5.5mm, 10mm NUT DRIVERS
1 - 8” ADJUSTABLE WRENCH
1 - 10” ADJUSTABLE WRENCH
1 - 200’ TAPE MEASURE FT/METERS
1 - WIRE CUTTERS
1 - WIRE CRIMPING PLIERS
1 - UTILITY KNIFE
1 - METRIC HEX KEYS SIZES 1.5, 2, 2.5, 3, 4, 5, 6, 8, & 10.
1 - STANDARD HEX KEYS SIZES 5/64, 3/32, 7/64, 1/8, 9/64, 5/32, 3/16, 7/32, 1/4, 5/16, 3/8 INCH
1 - VICE GRIP PLIERS
3 - ROLLS INSULATION TAPE
1 - 3/8” DRIVE 1/2”, 7/10”, 9/16”, DEEP WELL SOCKETS
1 - 3/8” DRIVE RATCHET AND 3” EXTENSION BAR
1 - 1/4” ADAPTER FOR 3/8” DRIVE RATCHET
1 - 1/4” -DRIVE 1/4, 9/32, 5/16, 11/32, 3/8, 7/16, & 1/2 INCH SOCKET SET
1 - 1/4” -DRIVE 4, 5, 5.5, 6, 7, 8, 9, 10, 11, 12, 13, & 14 mm SOCKET SET
1 - RETAINING RING PLIERS
1 - NEEDLE NOSE PLIERS
1 - CHANNEL LOCK PLIERS
1 - FLASHLIGHT
1 - EPROM PULLER

BASIC SYSTEM INFORMATION

This low temperature system uses heaters for stable system operation in a subzero climate. The main electronics are automatically warmed before the system boards and components are energized. Therefore, all system components must be installed and sealed from the environment when operating and/or troubleshooting in low temperature conditions.

For system operation refer to TM 5-3810-307-10, Appendix G

The PAT Load Moment Indicator (LMI) DS 350 has been designed to provide the crane operator with the essential information required to operate the machine within its design parameters.

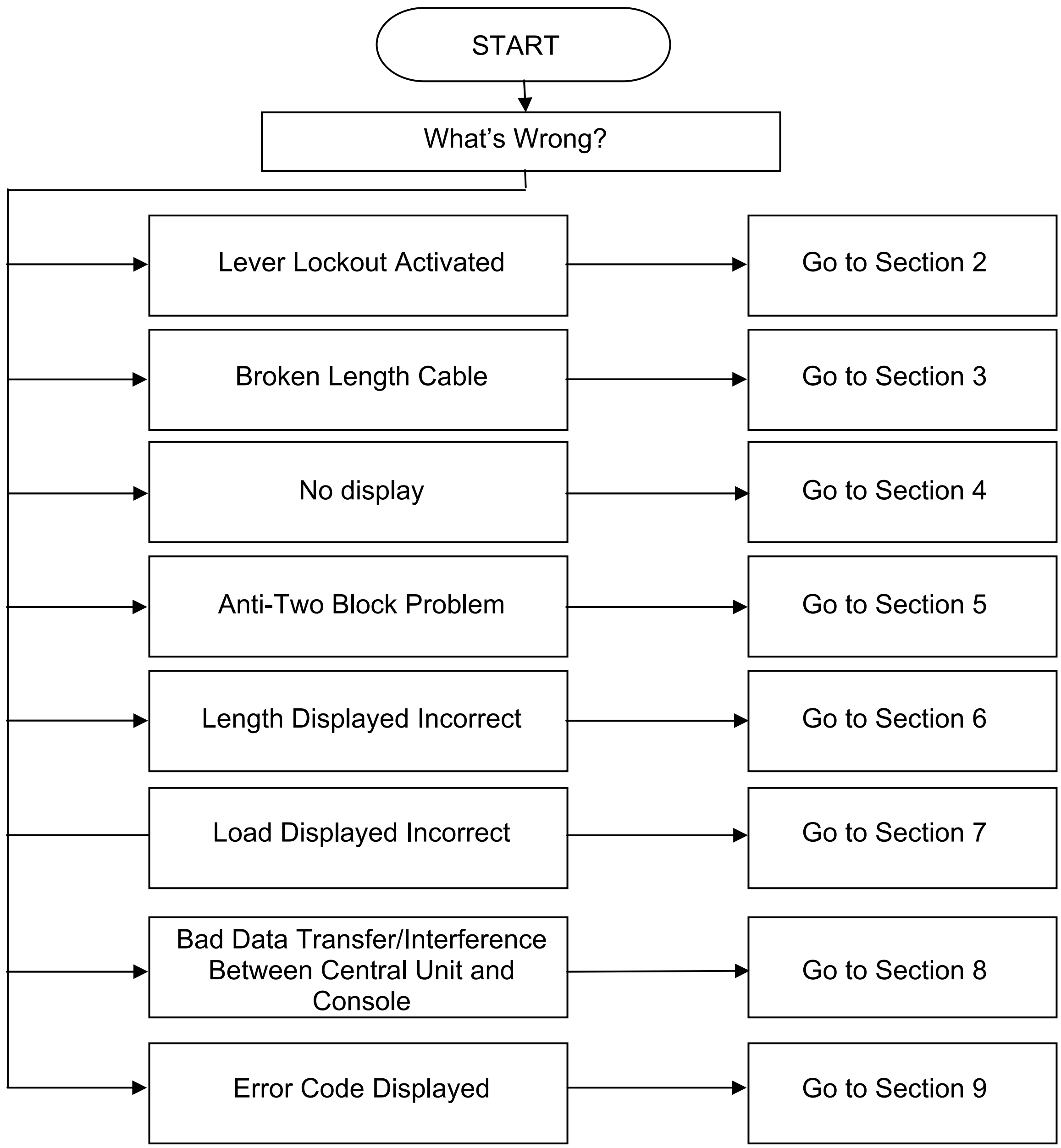
Using a variety of sensing devices, the Load Moment Indicator (LMI) System monitors various crane functions and provides the operator with a continuous reading of the crane's capacity. The readings continuously change as the crane moves through the motions necessary to make the lift.

The LMI provides the operator with information regarding the length and angle of the boom, working radius, rated load and the calculated total weight being lifted by the crane.

If prohibited conditions are approached, the DS 350 Load moment Indicator will warn the operator by sounding an audible alarm, lighting a warning light, and rendering inoperative those functions that may aggravate the crane's condition.

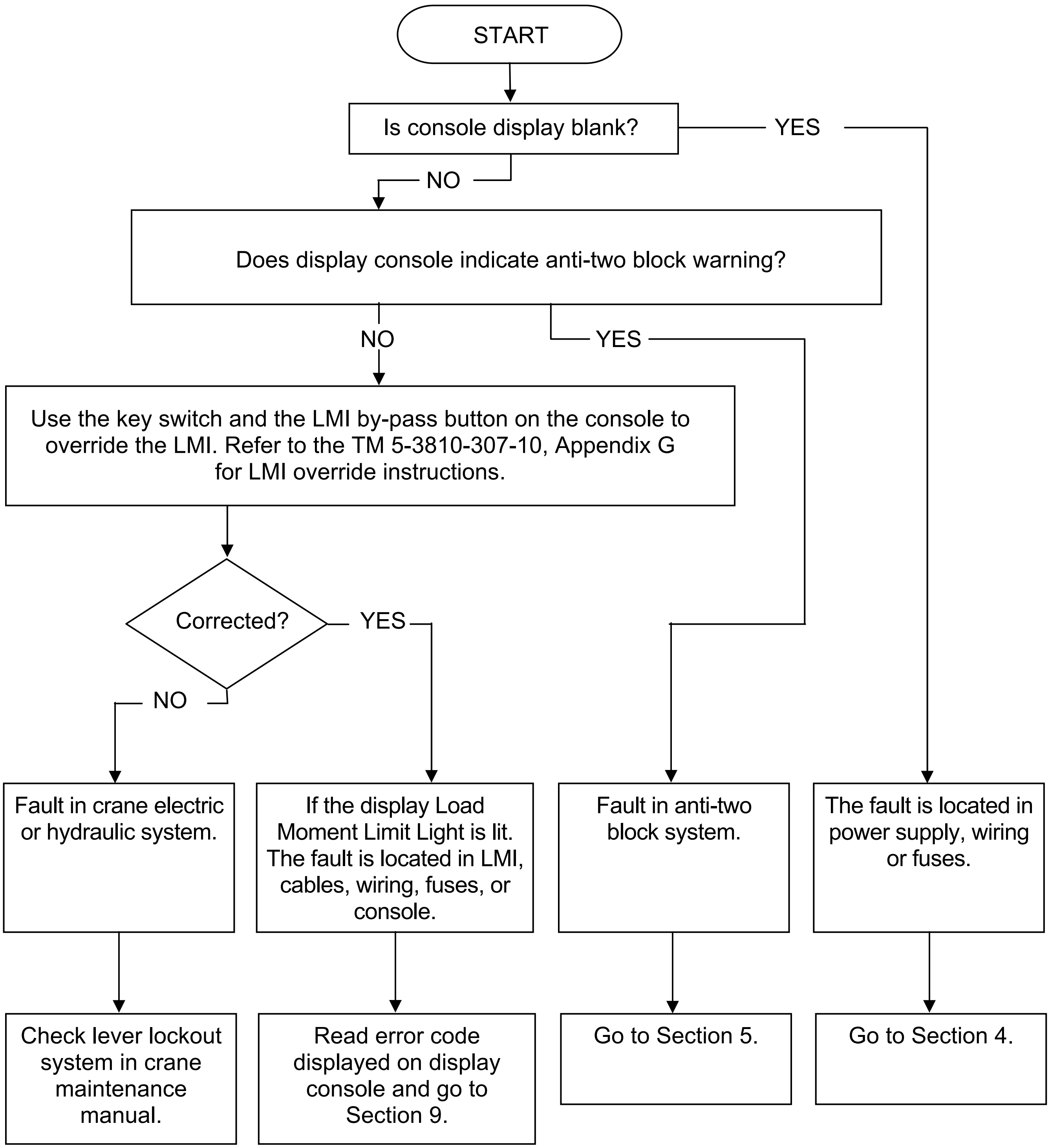
1. GENERAL FLOWCHART AND DRAWINGS

This section explains how to handle a problem that may arise with the PAT Load Moment Indicator System-PAT DS350. The procedures are given in flowchart form for the following sections. Start with the general flowchart below which will guide you to one of the detailed flowcharts shown in Sections 2 through 9. The drawings in this section will be referenced in the troubleshooting flow charts, Sections 2 through 9.



2. LEVER LOCKOUT ACTIVATED

PROBLEM: The lever lockout system of the crane is activated, crane movements “hoist up”, “telescope out”, and “boom down” are stopped. Crane is not in overload or two-block condition.



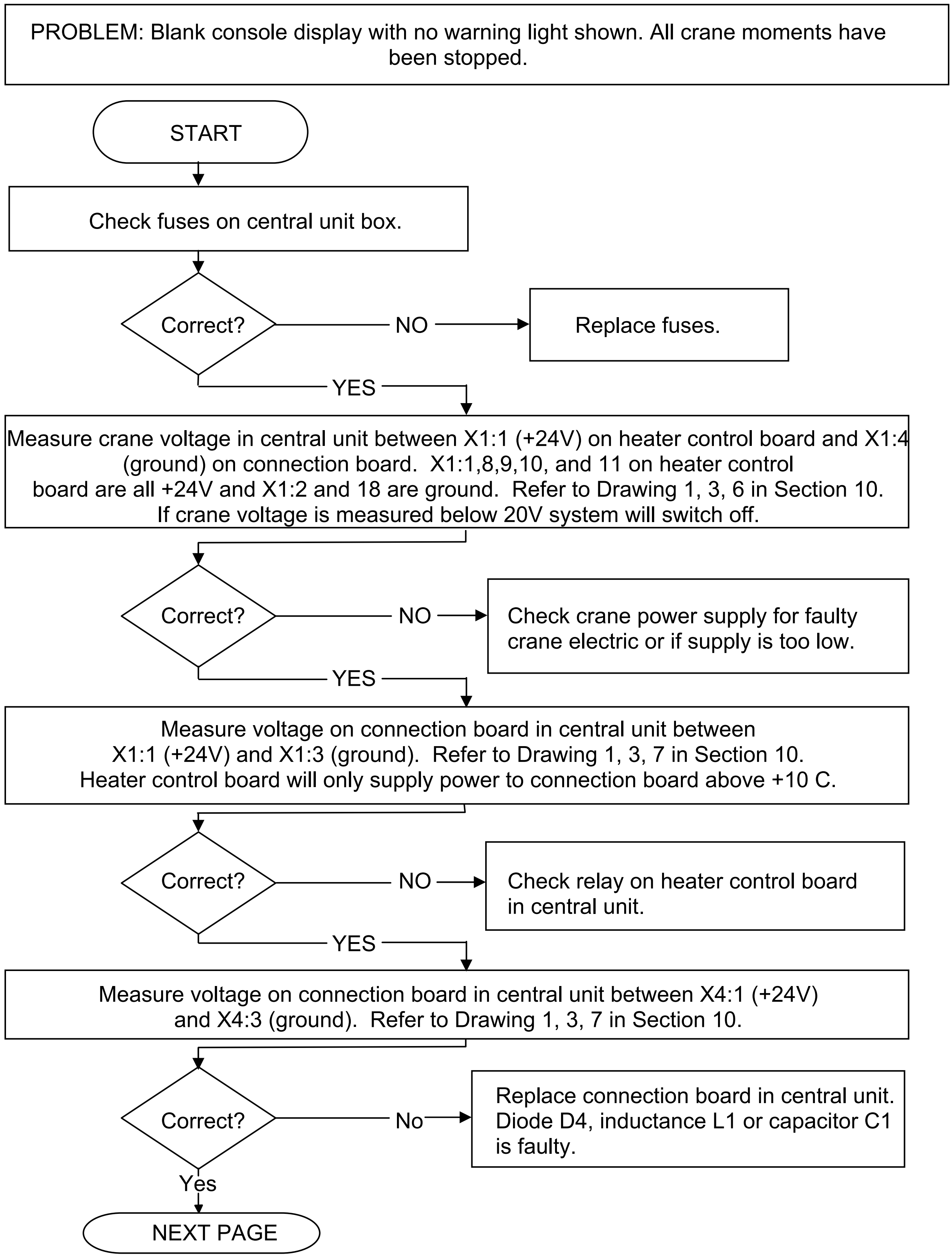
3. BROKEN LENGTH CABLE

PROBLEM: Damaged or broken length cable.

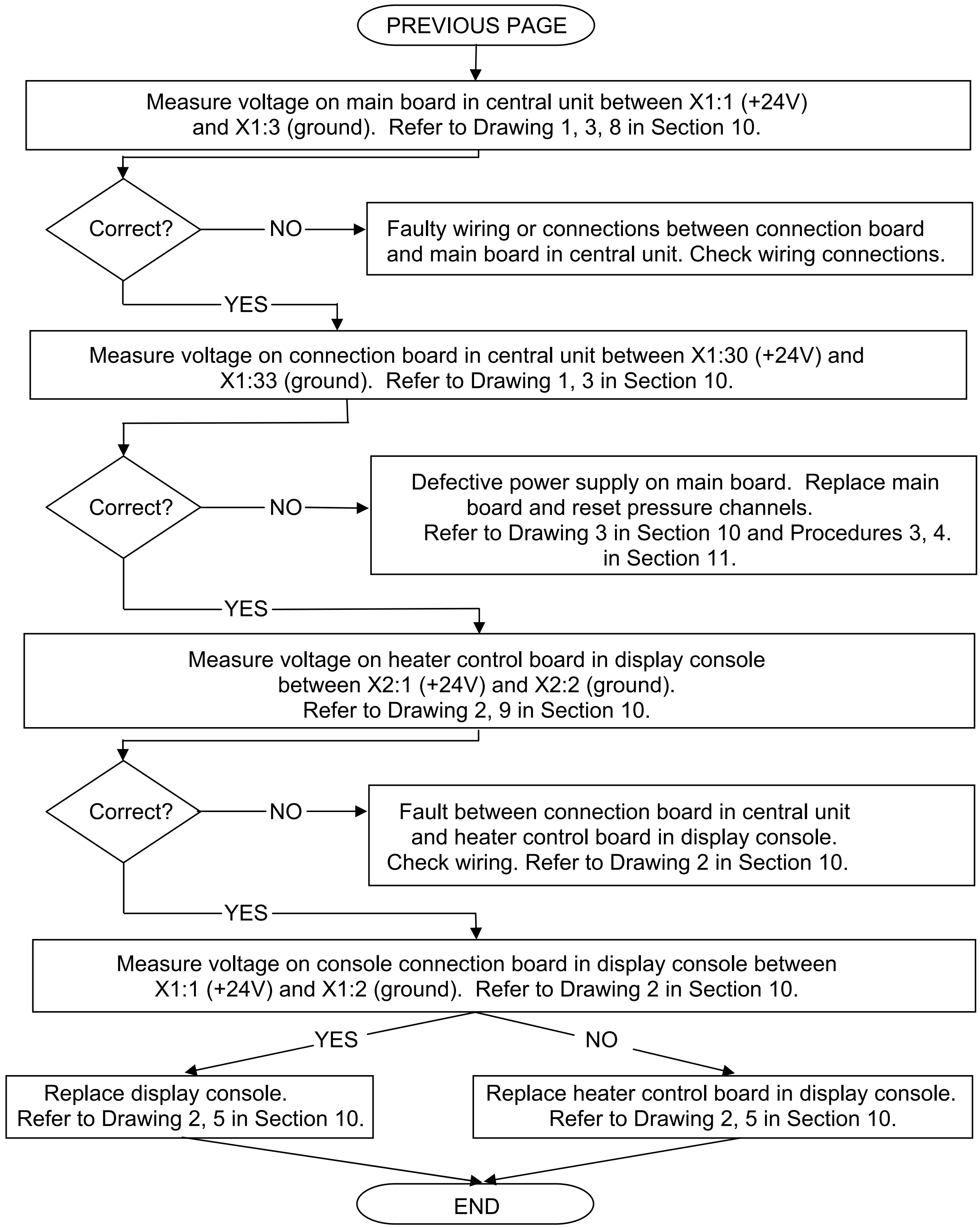
Replace length cable using the following procedure:
Refer to: Drawing 2 - Electrical Wiring Central Unit to Console/Cable Reel
Drawing 4 - Cable Reel - Parts List
Drawing 10 - Boom Nose Junction Box w/ohmmeter on 1 & 2
Drawing 11 - Slip Ring w/ohmmeter on X2:Red & X1:Brown
Procedure 5 - Length Potentiometer and Angle Sensor Adjustment

1. Cut old cable at cable drum
2. Disconnect damaged length cable from junction box at the boom nose. Refer to Drawing 2, 10.
3. Open cable reel cover and disconnect wiring from terminal block. Pull 7-conductor cable out of strain relief.
4. Remove cable reel from mounting brackets.
5. Remove damaged length cable, which is mounted to the slip rings in the cable reel, from slip ring terminal. Refer to Drawings 2, 4, 11.
6. On the back side of the cable reel, open the strain relief attached to the axle in the center of the drum. Pull existing length cable out of the cable reel.
7. Pull new length cable through the hole, pipe and strain relief and push it through the axle of the reeling drum. Tighten strain relief to ensure sealing.
8. Reconnect the length cable to the slip ring. Refer to Drawing 2, 4, 11.
9. Remount cable reel to the boom.
10. Turn reeling drum clockwise to spool the new cable neatly onto the drum.
11. Set pre-load on cable reel by turning the drum counter-clockwise 5 to 8 turns.
12. Wrap the new length cable around the boom tip anchor pin (8 - 10 wraps) and secure with tie wraps. Leave enough length cable to connect into the boom tip junction box.
13. Connect the length cable into the boom tip junction box. Refer to Drawing 2, 10.
14. Reset length potentiometer in length angle transducer (screw is located in center of white gear); with boom fully retracted, turn potentiometer carefully counter-clockwise until it reaches a soft stop. Recheck length and angle display. Refer to Procedure 5.

4. NO DISPLAY


PROBLEM: Blank console display with no warning light shown. All crane moments have been stopped.
START
Check fuses on central unit box.
Correct?
NO
Replace fuses.
YES
Measure crane voltage in central unit between X1:1 (+24V) on heater control board and X1:4 (ground) on connection board. X1:1,8,9,10, and 11 on heater control board are all +24V and X1:2 and 18 are ground. Refer to Drawing 1, 3, 6 in Section 10. If crane voltage is measured below 20V system will switch off.
Correct?
NO
Check crane power supply for faulty crane electric or if supply is too low.
YES
Measure voltage on connection board in central unit between X1:1 (+24V) and X1:3 (ground). Refer to Drawing 1, 3, 7 in Section 10. Heater control board will only supply power to connection board above +10 C.
Correct?
NO
Check relay on heater control board in central unit.
YES
Measure voltage on connection board in central unit between X4:1 (+24V) and X4:3 (ground). Refer to Drawing 1, 3, 7 in Section 10.
Correct?
No
Replace connection board in central unit. Diode D4, inductance L1 or capacitor C1 is faulty.
Yes
NEXT PAGE

4. NO DISPLAY - continued



5a. ANTI-TWO BLOCK PROBLEM (SINGLE SWITCH)

PROBLEM: Function of Anti-Two Block System is faulty.

START

Check to see whether or not crane is in two-block condition.

Correct?

NO

Lower hook down into safe position.

YES

Turn power off or disconnect blue wire from X1:35 on connection board in central unit.
Refer to Drawings 2, 3, 14 in Section 10.

Next

Remove length cable core wire from terminal 1 in Boom Nose Junction Box.
Measure the resistance at the boom nose junction box between terminals 1 and 2 with ohmmeter. This checks the function of the anti-two block switch.
Switch closed = 4700 ±500 Ohms (weight installed)
Switch open => 1 Megaohm (weight removed)
Refer to Drawing 2, 10 in Section 10.
Replace length cable core wire to terminal 1 in Boom Nose Junction Box.

Correct?

NO

Replace anti-two block switch.

YES

NEXT PAGE

5a. ANTI-TWO BLOCK PROBLEM (SINGLE SWITCH) – cont'

PREVIOUS PAGE

Remove blue wire from terminal 7 on terminal board in cable reel.
Measure the anti-two block signal in the cable reel with an ohmmeter between X1: Brown and X2: Red wires on the slip ring.
Switch closed = 4700 ±500 Ohms
Switch open => 1 Megaohm
. Refer to Drawing 2, 4, 11 in Section 10.

Correct?

NO → Fault in wiring between boom nose junction box and cable reel. Check for damaged length cable and wiring.
Refer to Drawing 2 in Section 10.
If broken length cable, Refer to Section 3.

YES ↓

Measure the anti-two block signal in the cable reel with an ohmmeter between terminals 7 and 8 on terminal board.
Switch closed = 4700 ±500 Ohms
Switch open => 1 Megaohm
Reconnect blue wire to terminal 7 on terminal board in cable reel.
Refer to Drawing 2, 4, 12 in Section 10.

Correct?

NO → Replace slip ring in cable reel.
Refer to Drawing 2, 4, 11 in Section 10.

YES ↓

Unplug cable assembly from Central Unit to Boom Base Junction Box. Measure the anti-two block signal in boom base junction box between terminal 5 and 6 with an ohmmeter.
Switch closed = 4700 ±500 Ohms
Switch open => 1 Megaohm
Reconnect cable assembly
Refer to Drawing 2, 13 in Section 10.

Correct?

NO → Fault in 7 conductor cable between cable reel and boom base junction box.
Refer to Drawing 2, 4, 13 in Section 10.

YES ↓

NEXT PAGE

5a. ANTI-TWO BLOCK PROBLEM (SINGLE SWITCH) – cont'

PREVIOUS PAGE

Turn system power off and disconnect blue wire from terminal X1:35 in central unit.
Check anti-two block signal in central unit with ohmmeter.
Measure between blue wire disconnected from X1:35 and terminal X1:34 on connection board.
Anti-two block switch closed = 4700 Ohms ±500 Ohms
Anti-two block switch open => 1 Megaohm.
Refer to Drawing 2, 3, 14 in Section 10.

Correct?

NO → Faulty wiring between boom base junction box and central unit. Check cable.
Refer to Drawing 2 in Section 10.

YES

Tag and disconnect wires from X1:34 and X1:35 on connection board in central unit.
Check main board function by installing a temporary resistor,
4700 Ohms, between X1:35 and X1:34 on connection board in central unit.
With resistor connected and power on to central unit, the anti-two block alarm should be inactive. Refer to Drawing 2, 3, 15 in Section 10.

Correct?

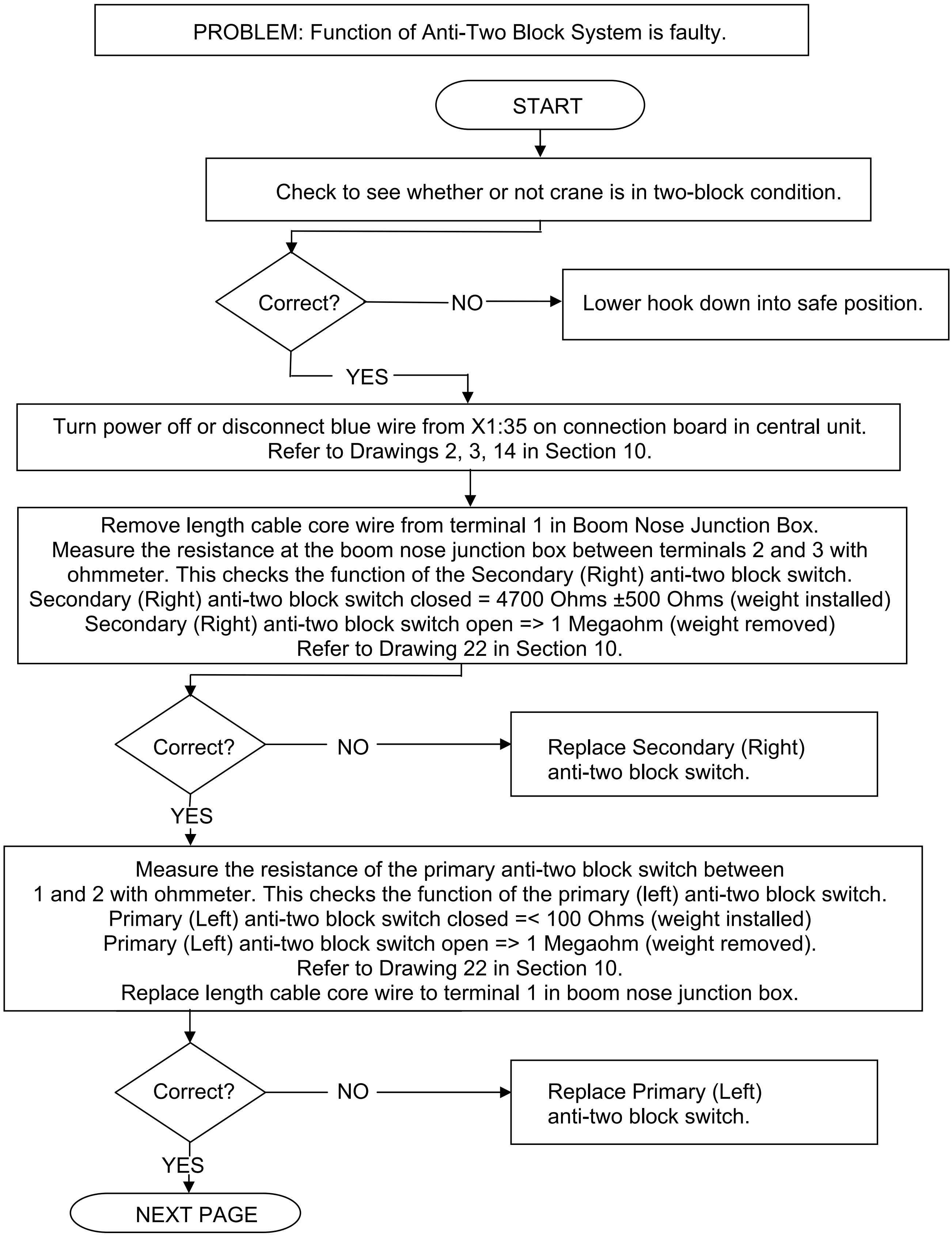
NO → Defect on main board in central unit. Replace main board and reset pressure channel. Refer to Drawings 1, 3 in Section 10 and Procedures 3 and 4 in Section 11.

YES

Reconnect Gray wire to X1:34 and Blue to X1:35 on connection board in central unit.
Refer to Drawings 2, 3 in Section 10.

END

5b. ANTI-TWO BLOCK PROBLEM (DOUBLE SWITCH)



5b. ANTI-TWO BLOCK PROBLEM (DOUBLE SWITCH) – cont'

PREVIOUS PAGE

↓

Remove blue wire from terminal 7 on terminal board in cable reel.
Measure the anti-two block signal in the cable reel between X1:Brown and X2:Red wires on the slip ring.
Anti-two block switch(es) closed = 4700 ±500 Ohms
Anti-two block switch(es) open => 1 Megaohm.
Refer to Drawing 2, 4, 11, 22 in Section 10.

↓

Correct?

NO → Fault in wiring between boom nose junction box and cable reel.
Check for damaged length cable and wiring.
Refer to Drawing 2 in Section 10.
If broken length cable, Refer to Section 3.

YES ↓

Measure the Anti-two Block signal in the cable reel with an ohmmeter between terminals 7 and 8 on terminal board.
Anti-two block switch(es) closed = 4700 ±500 Ohms
Anti-two block switch(es) open => 1 Megaohm
Reconnect blue wire to terminal 7 on terminal board in cable reel.
Refer to Drawing 2, 4, 12, 22 in Section 10.

↓

Correct?

NO → Replace slip ring in cable reel.
Refer to Drawing 2, 4, 11 in Section 10.

YES ↓

Unplug cable assembly from Central Unit to Boom Base Junction Box. Measure the anti-two block switch signal in boom base junction box between terminal 5 and 6 with an ohmmeter.
Anti-two block switch(es) closed = 4700 Ohms ±500 Ohms
Anti-two block switch(es) open => 1 Megaohm
Reconnect cable assembly.
Refer to Drawing 2, 13, 22 in Section 10.

↓

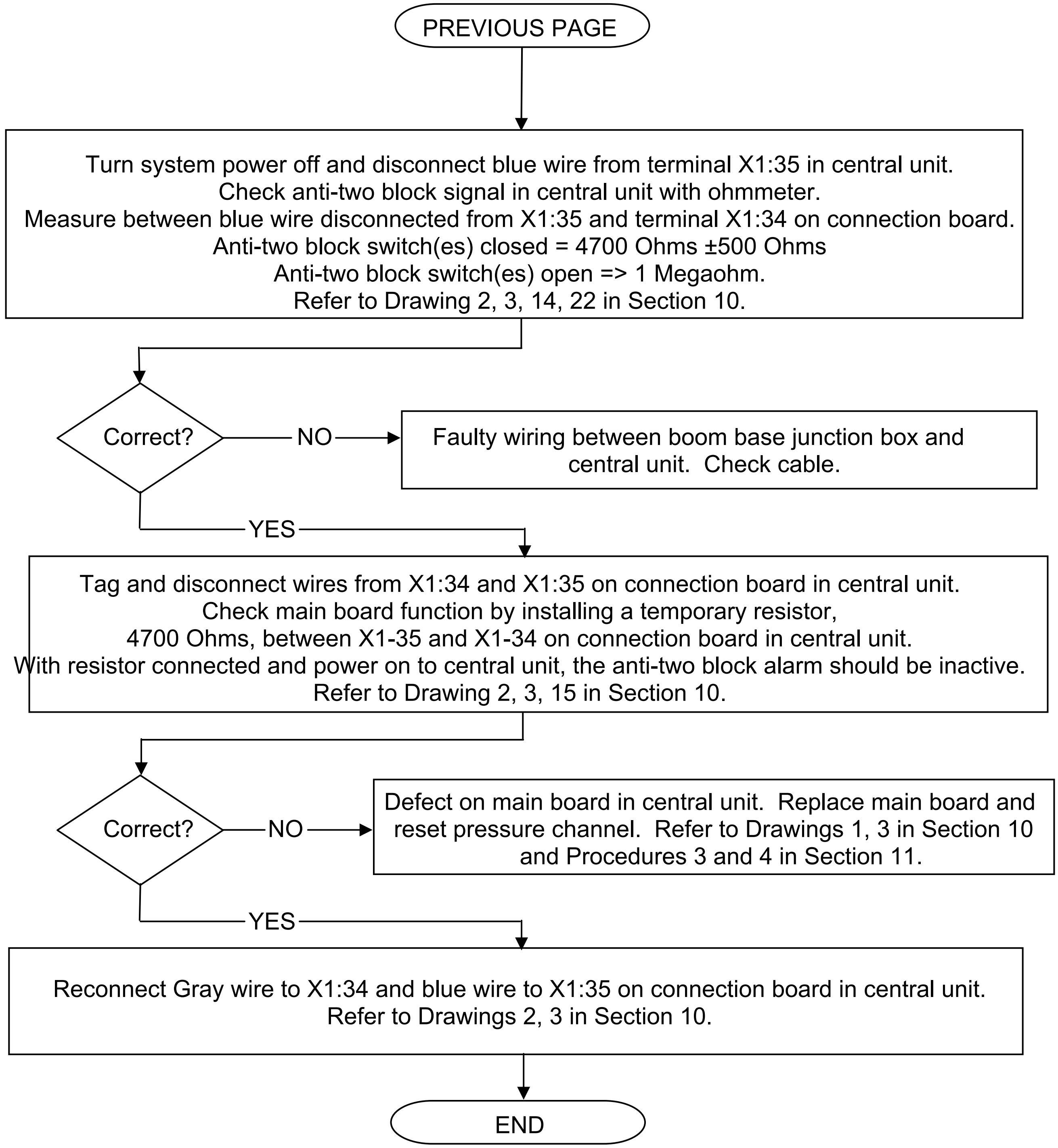
Correct?

NO → Fault in 7 conductor cable between cable reel and boom base junction box.
Refer to Drawing 2, 4, 13 in Section 10.

YES ↓

NEXT PAGE

5b. ANTI-TWO BLOCK PROBLEM (DOUBLE SWITCH) – cont’



6. LENGTH READING PROBLEM

PROBLEM: Length displayed incorrect. Crane is not in “out of load chart” condition.

START

Check mechanical adjustment of length potentiometer in cable reel. When main boom is fully retracted, adjust length potentiometer counter-clockwise until it reaches a soft stop. Refer to Procedure 5 in Section 11.

Correct?

NO → Replace length potentiometer assembly, refer to Drawings 4, 11 in Section 10. Remove slip ring body from shaft and remove gear wheel from potentiometer axle. Unscrew mounting plate and remove potentiometer assembly from mounting plate. Remove assembly wires from terminal block. Connect new assembly to terminal block. Reinstall mounting plate, gear wheel and slip rings. With boom fully retracted, reset potentiometer by turning counter-clockwise until it reaches a soft stop. Refer to Drawing 4, 11 in Section 10 and Procedure 5 in Section 11.

YES ↓

Check out clutch in big gear wheel of length potentiometer. Extend and retract boom to ensure that clutch is not slipping on potentiometer axle. Refer to Drawing 4 in Section 10 and Procedure 5 in Section 11.

Correct?

NO → Replace the gear wheel, clean length potentiometer axle. Reset length potentiometer. Refer to Drawing 4 Section 10 and Procedure 5 in Section 11.

YES ↓

Check power supply to length potentiometer on connection board In central unit, terminal X1:8 (ground) and X1:11 (-5V) Refer to Drawing 2, 3, 16 in Section 10.

Correct?

NO → Main board in central unit defective. Replace main board and reset pressure channel. Refer to Drawing 3 in Section 10 and Procedures 3 and 4 in Section 11.

YES ↓

NEXT PAGE

6. LENGTH READING PROBLEM - continued

PREVIOUS PAGE

Measure power supply to length potentiometer in cable reel between terminal 1 (ground) and 3 (-5v) on terminal board. Refer to Drawing 2, 4, 17 in Section 10.

Correct? NO → Faulty wiring between central unit and length potentiometer. Check wiring.

YES ↓

Measure signal from length potentiometer in cable reel between terminal 2 (signal) and 1 (ground) on terminal board. The measurement should be between –0.5 volts and –4.5 volts. –0.5 volts with the boom fully retracted and the length potentiometer set fully counterclockwise to a soft stop (minimum sensor output). –2.1 volts (±0.1 V) with boom fully extended (actual working range). –4.5 volts with the potentiometer turned completely clockwise 10 turns to a soft stop (maximum sensor output). Refer to Drawing 2, 4, 17 in Section 10.

Correct? NO → Replace length potentiometer assembly. Remove slip ring body from shaft and remove gear wheel from potentiometer axle. Unscrew mounting plate and remove potentiometer assembly from mounting plate. Remove assembly wires from terminal block. Connect new assembly to terminal block. Reinstall mounting plate, gear wheel and slip ring. With boom fully retracted, reset potentiometer by turning counter-clockwise until it reaches a soft stop. Refer to Drawing 2, 4 in Section 10 and Procedure 5 in Section 11.

YES ↓

Measure signal from length potentiometer in central unit connection board between X1-8 (ground) and X1-10. The measurement should be between –0.5 volts and –4.5 volts. –0.5 volts with the boom fully retracted and the length potentiometer set fully counterclockwise to a soft stop (minimum sensor output). –2.1 volts (±0.1 V) with boom fully extended (actual working range). –4.5 volts with the potentiometer turned completely clockwise 10 turns to a soft stop (maximum sensor output). Refer to Drawing 2, 3, 18 in Section 10.

Correct? NO → Faulty wiring between central unit and cable reel. Check wiring

YES ↓

NEXT PAGE

6. LENGTH READING PROBLEM - continued

PREVIOUS PAGE

Measure length signal of amplified output on main board in central unit . Measure between test point MP15 (analog ground) and test point MP6 (length signal). The measurement should be between +0.5 volts and +4.5 volts. +0.5 volts with the boom fully retracted and the length potentiometer set fully counterclockwise to a soft stop (minimum sensor output). +2.1 volts (±0.1 V) with boom fully extended (actual working range). +4.5 volts with the potentiometer turned completely clockwise 10 turns to a soft stop (maximum sensor output). Negative signal will be converted into positive signal at MP6 (i.e.: negative signal = -0.5V; output test between MP15 and MP6 = +0.5v). Refer to Theory 1 and 2 in Section 12.

Correct?

NO → Main board in central unit defective. Replace main board and reset pressure channel.
Refer to Drawing 3 in Section 10 and
Procedures 3 and 4 in Section 11.

YES →

END

7. LOAD READING PROBLEM

PROBLEM: Load reading incorrect.

START

Check selected operating mode (code on operating mode switch).

Correct? NO → Select operating mode switch to correct position (see operating mode in load chart) between test point MP15 (ground) and MP2 (-5V). Refer to Theory 1 in Section 12. If incorrect, replace main board and reset pressure channel. Refer to Drawing 3 in Section 10 and Procedures 3 and 4 in Section 11.

YES ↓

Check boom length reading on display.

Correct? NO → Reset length potentiometer. With fully retracted boom, turn potentiometer axle counter-clockwise until it reaches a soft stop. (See Section 6.) Refer to Procedure 5 in Section 11.

YES ↓

Measure radius and check with the displayed radius.

Correct? NO → Check if mechanical adjustment of angle sensor is correct. Angle sensor box should be in line with boom and adjusted to actual boom angle. Refer to Procedure 5 in Section 11.

YES ↓

Check power supply to pressure transducers (rod and piston side). Unplug each transducer cable from transducer. Measure at each pressure transducer cable connection between terminals B (ground) and C (-5V) and between terminals B (Ground) and A (+5V). Refer to Drawings 1 and 19 in Section 10.

NEXT PAGE

7. LOAD READING PROBLEM - continued

PREVIOUS PAGE

Correct?

NO → Check power supply at connection board in central unit between X1:14 (gnd) to X1:13 (-5.0v) and X1:14 (gnd) to X1-15(+5.0v) for rod side. Measure between X1-19 (gnd) to X1-18 (+5.0v) and X1-19 (gnd) to X1-20 (-5.0v) for piston side. Refer to Drawing 1, 3, 20 in Section 10.

Correct?

YES → Fault in pressure transducer cable. Refer to Drawing 1 in Section 10.

NO → Main board in central unit defective. Replace main board and reset zero point on pressure transducers. Refer to Drawing 3 in Section 10 and Procedures 3 and 4 in Section 11.

YES

Measure signal from pressure transducers in central unit connection board between X1:14 (gnd) and X1-16 (signal) for the rod side and between X1:19 (gnd) and X1-21 (signal) for the piston side. The measurements should be between 0.0 volts and –1.0 volt (±0.025 volt). –0.0 volts with no pressure (0 psi) in the hydraulic lines (minimum sensor output). –1.0 volt (±0.025 volt) with maximum pressure (4,410 psi/300 bar). Refer to Drawing 1 and 3 in Section 10 and Theory 1, 4, and 5 in Section 12.

Correct?

NO → Check continuity of signal wire and Pin D of pressure transducer(s). First, unplug transducer cable(s) from transducer(s). Second, move the respective YEL wire(s) connected to X1:16 (rod side) or X1:21 (piston side) on the connection board in the central unit to AGND terminal X1:14 (rod side) or X1:19 (piston side). Measure Voltage at the pressure transducer cable connection(s) between terminals D (ground) and A (+5v). The measurement should be +5.0 volts. Reconnect respective YEL wire(s) to X1:16 (rod side) or X1:21 (piston side) on the connection board in the central unit and reconnect transducer cable(s). Refer to Drawing 1 in Section 10.

Correct?

NO → Fault in pressure transducer cable(s). Refer to Drawing 1 in Section 10.

YES → Adjust zero point on pressure transducers. Refer to Procedure 4 in Section 11.

If pressure transducer(s) are not adjustable, replace pressure transducer(s) and adjust zero point. Refer to Drawing 1 in Section 10 and Procedure 4 in Section 11.

YES

NEXT PAGE

7. LOAD READING PROBLEM - continued

PREVIOUS PAGE

Measure pressure transducer signal of amplified output on main board in central unit. Measure between test point MP15 (analog ground) and MP4 (signal) for piston side and between test points MP15 (analog ground) and MP5 (signal) for rod side. The measurements should be between +0.5 volts and +4.5 volts. +0.5 volts with no pressure (0 psi) in the hydraulic lines (minimum sensor output). +4.5 volts with maximum pressure (4,410 psi/300 bar). Refer to Drawing 1 and 3 in Section 10 and Theory 1, 4, and 5 in Section 12.

Correct?

NO

Main board in central unit defective.
Replace main board in central unit and reset zero point on pressure transducers.
Refer to Procedures 3 and 4 in Section 11.

YES

END

8 BAD DATA TRANSFER BETWEEN DISPLAY CONSOLE & CENTRAL UNIT, INTERFERENCE PROBLEM

PROBLEM: Error Code “E93/E94” No data transfer to and from console, interference from crane electric, or console display frozen.

START

Make sure that Data EPROM is plugged into main board socket D5 and System EPROM is plugged into main board socket D4. Check that EPROMs are inserted with notch on EPROM to matching notch on socket. Refer to Procedure 2 in Section 11.

Correct? NO → Place EPROM in correct socket.

YES

Check crane supply voltage to the display console from the central unit at connection board between X1:33 (ground) and X1:30 (+24V). Refer to Drawing 2, 3, 21 in Section 10.

Correct? NO → Make sure external and internal power supply is correct. Refer to Section 4.

YES

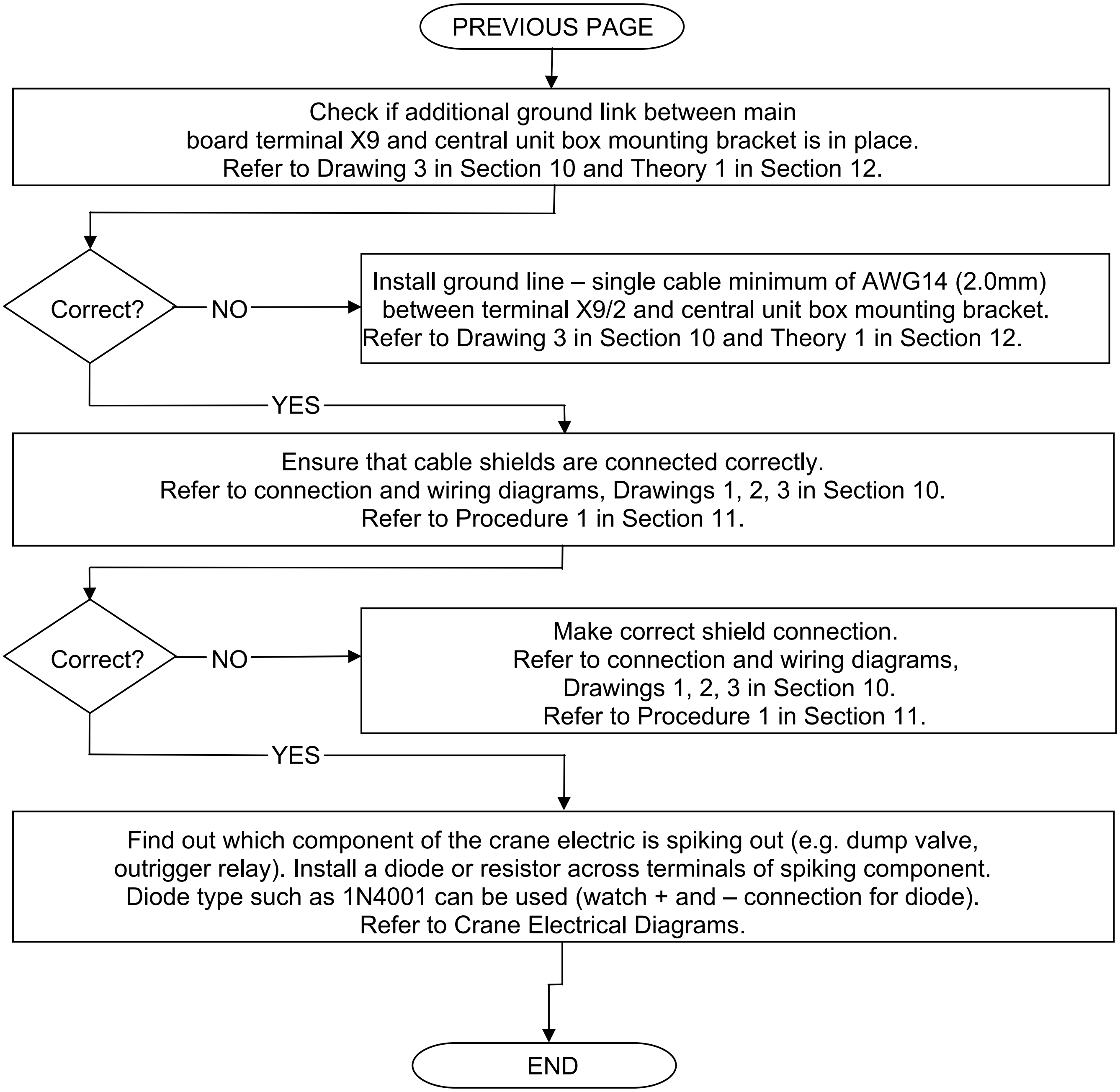
Turn off system power. Check continuity of the receive (RXD) and transmit (TXD) wires between central unit and display console. Tag and disconnect the wires from X1:31 (TXD) and X1:32 (RXD) on the connection board in the central unit and X1:3 (TXD) and X1:4 (RXD) on the NT-/AS (connection) board in the display console. Check continuity of WHT (RXD) and GRN (TXD) wires from central unit to display console. Refer to Drawing 2 in Section 10.

Correct? NO → Check connections and replace cable from central unit to display console, if necessary. Refer to Drawing 2 in Section 10 and Procedure 1 in Section 11.

YES

NEXT PAGE

8 BAD DATA TRANSFER BETWEEN DISPLAY CONSOLE & CENTRAL UNIT, INTERFERENCE PROBLEM - continued



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9. ERROR CODE DISPLAY

PROBLEM: Error code displayed. Lever lockout activated. Warning Lights on.

ERROR CODE	ERROR	CAUSE	ACTION
E01	Minimum radius or maximum angle range exceeded	Fallen below the minimum radius or above the angle given in the load chart due to raising the boom too far.	Lower boom back to a radius or angle given in the load chart.
E02	Maximum radius or minimum angle range exceeded	The maximum radius or minimum angle given in the load chart was exceeded due to lowering the boom too far.	Raise boom back to a radius or angle given in the load chart.
E04	Operating mode not available	Operating mode switch in the console set incorrectly. Operating mode is not permissible with actual crane configuration.	Set operating mode switch correctly to the code assigned to the operating mode of the crane.
E05	Length range not permitted	Boom has been extended too far or not far enough. Length sensor adjustment changed; i.e. length sensor cable slid off the cable drum.	Retract or extend boom to correct length given in the load chart. See Section 6.
E07	No acknowledgment signal from overload relay (K1)	Overload relay is stuck, defective or not being selected.	Replace relay.
E08	No acknowledgment signal from anti-two block switch relay (K2)	Anti-two block switch relay is defective or not being selected.	Replace relay.
E11	Fallen below limit for the measuring channel "length"	a.) Cable between length sensor and central unit is defective, not connected or water in the connectors. b.) Length sensor is potentiometer defective. c.) Electronic board in the measuring channel is defective.	a.) Check cable and connector as well and replace, if necessary. Section 6. b.) Replace and reset length sensor potentiometer. See Section 6 & Procedure 5. c.) Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.

ERROR CODE	ERROR	CAUSE	ACTION
E12	Fallen below lower limit value for the measuring channel “pressure transducer piston side”	a.) Cable leading from the central unit to the pressure transducer is defective, loose or water in the connector. b.) Pressure transducer on piston side is defective. c.) Electronic component in the measuring channel is defective.	a.) Check cable and connector as well and replace, if necessary. Section 7. b.) Replace pressure transducer and reset pressure channel. See Section 7 & Procedure 4. c.) Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.
E13	Fallen below lower limit value for the measuring channel “pressure transducer rod side”	a.) Cable leading from the central unit to the pressure transducer is defective, loose or water in the connector. b.) Pressure transducer on rod side is defective. c.) Electronic component in the measuring channel is defective.	a.) Check cable and connectors as well and replace, if necessary. See Section 7. b.) Replace pressure transducer and reset pressure channel. See Section 7 & Procedure 4. c.) Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.
E15	Fallen below lower limit value for the measuring channel “angle main boom”	a.) Cable from central unit to the length/angle sensor is defective or loose. b.) Angle sensor is defective. c.) Electronic component in the measuring channel is defective.	a.) Check cable. Replace if necessary. See Section 6 b.) Replace angle sensor and reset adjustment. See Procedure 5 c.) Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.
E19	Error in the reference voltage	Electronic component on the main board is defective.	Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.
E20	No analog voltages	a.) The crane supply voltage is too low. b.) The voltage converter is defective or short circuit in the wiring.	a.) Check crane voltage. b.) Check supply voltages.
E21	Upper limiting value for the measuring channel “length” exceeded	a.) Cable from central unit to the length/angle sensor is defective or loose. b.) Length potentiometer is defective. c.) Electronic component in the measuring channel is defective on main board.	a.) Check cable. Replace if necessary. See section 6. b.) Replace and reset length potentiometer. See Procedure 5. c.) Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.

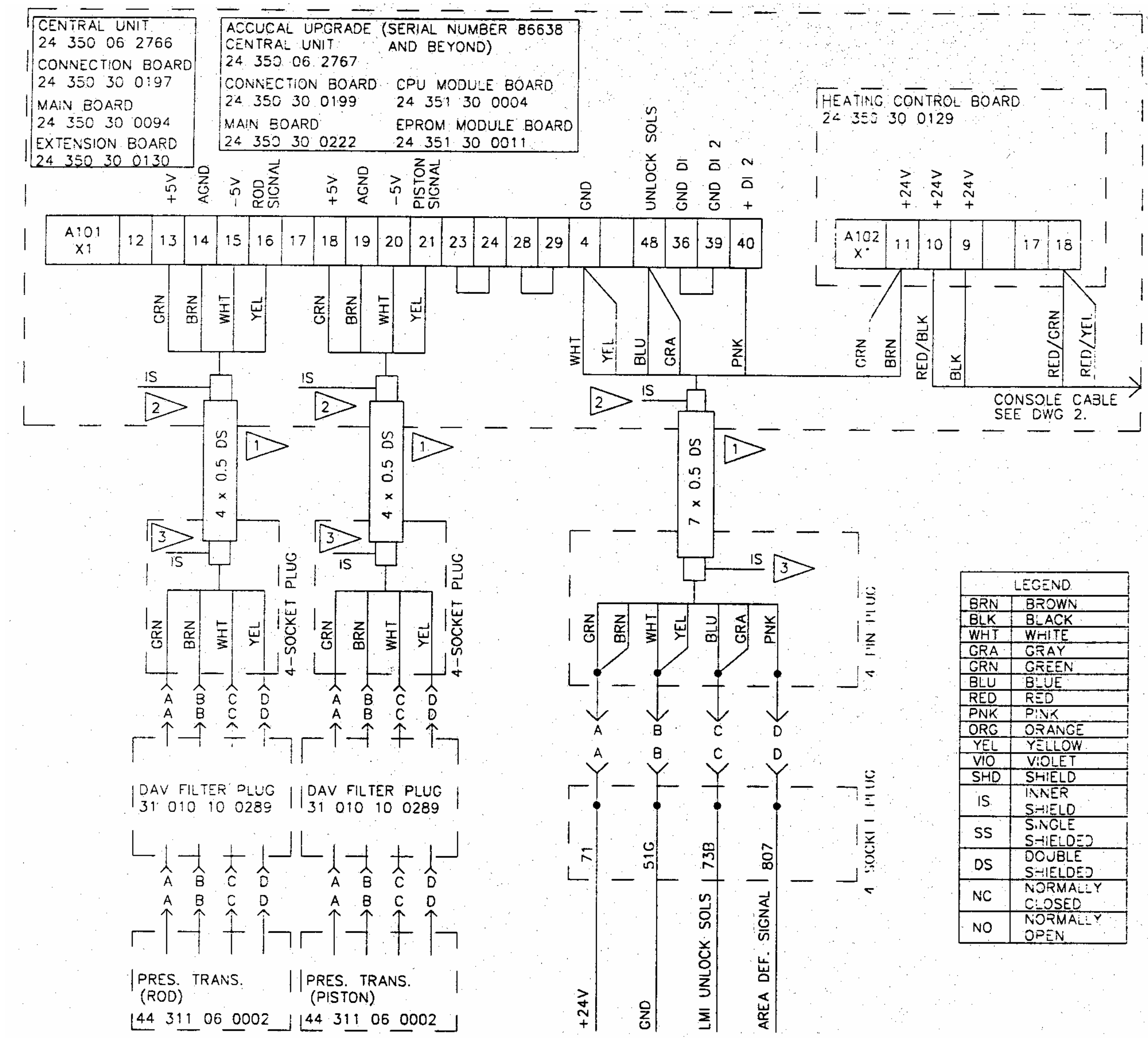
ERROR CODE	ERROR	CAUSE	ACTION
E22	Upper limiting value for the measuring channel “pressure piston side” exceeded	a.) Cable from central unit to the pressure transducer is defective, loose or water in the plug. b.) Pressure transducer on piston side is defective. c.) Electronic component in the measuring channel is defective on main board.	a.) Check cable as well as plug. Replace if necessary. See Section 7. b.) Replace pressure transducer and reset pressure channels. See Section 7. c.) Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.
E23	Upper limit value for the measuring channel “pressure transducer rod side” exceeded	a.) Cable lead in from the central unit to press trans is defective, not connected or water in the connectors. b.) Pressure transducer on road side is defective. c.) Electronic component in the measuring channel is defective.	a.) Check cable and connectors as well and replace, if necessary. See Section 7. b.) Replace pressure transducer c.) Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.
E25	Upper limit value for the measuring channel “angle main boom” exceeded	a.) Cable leading from the central unit to the length/ angle sensor is defective, loose or water in the connectors. b.) Angle sensor is defective. c.) Electronic component in the measuring channel is defective.	a.) Check cable as well as connectors and replace, if necessary. See Section 6. b.) Replace angle sensor and reset adjustment. See Section No. 6 & Procedure 5. c.) Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.
E27	Upper limit value for the measuring channel 7 exceeded	a.) Cable leading from the central unit to the sensor of channel 7 is defective, loose or water in the connectors. b.) Sensor of channel 7 is defective. c.) Electronic component in the measuring channel 7 is defective.	a.) Check cable as well as connectors and replace, if necessary. b.) Replace sensor of channel 7 and reset adjustment. c.) Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.
E29	Reference voltage defective	a.) The total of the supply and the reference voltages on MP10 is more than 3.3V. b.) A/D converter is defective.	a.) Check supply voltages. b.) Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.
E31	Error in the system program	a.) EPROM with system program is defective. b.) Electronic component on the main board is defective.	a.) Replace system program EPROM. b.) Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.

ERROR CODE	ERROR	CAUSE	ACTION
E37	Error in the program run	a.) EPROM with system program is defective. b.) Electronic component on the main board is defective.	a.) Replace system program EPROM. b.) Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.
E38	Wrong system program in the LMI	The system program in the LMI does not correspond to the programming in the data EPROM.	Replace system program EPROM
E41	Error in the external RAM	Defective electronic component.	Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.
E42	Error in the external write/read memory (RAM)	Internal defect in digital part of CPU.	Exchange write/read memory (CMOS-RAM). Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.
E45	Error in internal communications	Defective electronic component.	Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.
E48	Malfunction in the monitored write/read memory	Internal defect in digital part of CPU.	Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.
E51	Error in data memory	Data EPROM on the main board is defective.	Replace Data EPROM. Make sure BR3 on the main board is installed. See Theory 1.
E71	Incorrect acknowledgment of the “1” relay on the terminal board A101	a.) Anti two block relay is stuck or defective. b.) Anti-two block relay is not being selected due to a break on the terminal board A101, main board or ribbon cables.	a.) Replace “1” relay. b.) Check terminal board A101, main board and ribbon cables as well as replace defective part, if necessary.
E72-77	Analogous to E71 for the relays 2 thru 7	Analogous to E71 for the relays 2 thru 7.	Analogous to E71 for the relays 2 thru 7.
E89	Change of the operating code during lifting a load	The operating mode switch in the console was used during lifting a load.	Lower the load and set the operating mode switch correctly to the code assigned to the actual operating mode of the crane.

ERROR CODE	ERROR	CAUSE	ACTION
E91	No data transmission from console to central unit (See Section 8)	a.) 24V supply of console is interrupted b.) Interruption or accidental ground in the line from console electronics to central unit. c.) Transmitter/receiver module is defective.	a.) Check 24V at terminal X1 of console electronics. b.) Check the connection between console electronics and central unit. c.) If you find an accidental ground, the transmitter module in the console electronics can be damaged. You should, therefore, replace the console electronics. Replace console electronics or main board, respectively. See Procedure 3.
E92	Error in the data transmission from console to central unit (See also Section 8)	a.) Temporary interruption of the data line from console electronics to central unit. b.) Transmitter/receiver module is defective.	a.) Check the connection between console electronics and central unit. b.) Replace console electronics or main board, respectively. See Procedure 3.
E93	Error in the data transmission from central unit to console (See also Section 8)	a.) Temporary interruption of the data line from console electronics to central unit. b.) Transmitter/receiver module is defective.	a.) Check the connection between console electronics and central unit. b.) Replace console electronics or main board, respectively. See Procedure 3.
E94	No data transmission from central unit to console (See also Section 8)	a.) Interruption or accidental ground in the line from console electronics to central unit. b.) Transmitter/receiver module is defective. c.) Data-EPROM is defective. d.) CPU is defective. e.) Electromagnetic interference (when switching contractors or valves).	a.) Check the connection between console electronics and central unit. If you find an accidental ground, the transmitter module in the console electronics can be damaged. Replace the console electronics. b.) Replace console electronics or main board, respectively. c.) Check data EPROM. d.) Replace main board. e.) Eliminate interference source by inverse diodes or varistors.

ERROR CODE	ERROR	CAUSE	ACTION
E95	Error in the crane data EPROM	a.) Data EPROM is defective. b.) Position of jumper for the selection of the type of EPROM is wrong. c.) Electronics component on the main board is defective.	a.) Replace data EPROM. b.) Check the jumper position. c.) Replace main board and reset pressure channels. See Drawing 3 & Procedures 3 & 4.
E96	Error in the internal RAM of the CPU of the console	CPU or main board of the console is defective.	Replace console main board.
E97	Error in the external RAM of the CPU of the console	a.) External RAM of the console is defective. b.) Electronic component on the main board is defective.	a.) Replace console main board. b.) Replace console main board.
E98	Wrong jumper position in the console	a.) The jumper position BR 9/BR 10 in the console does not correspond to the actual type of central unit. b.) Electronic component on the main board is defective.	a.) Check the jumper position. b.) Replace console main board.

10. DRAWING 1. ELECTRICAL WIRING CENTRAL UNIT TO CRANE/PRESSURE TRANSDUCERS



LEGEND	
BRN	BROWN
BLK	BLACK
WHT	WHITE
GRA	GRAY
GRN	GREEN
BLU	BLUE
RED	RED
PNK	PINK
ORG	ORANGE
YEL	YELLOW
VIO	VIOLET
SHD	SHIELD
IS	INNER SHIELD
SS	SINGLE SHIELDED
DS	DOUBLE SHIELDED
NC	NORMALLY CLOSED
NO	NORMALLY OPEN

NOTES:

TAPE AND STOW ALL WIRES NOT CONNECTED

1 OUTER SHIELD CONNECTED TO STRAIN RELIEF INSERT.

2 INNER SHIELD INSULATED AND CONNECTED AS SHOWN.

3 INNER SHIELD CUT AND INSULATED

4 INNER SHIELD INSULATED AND CONNECTED AS SHOWN

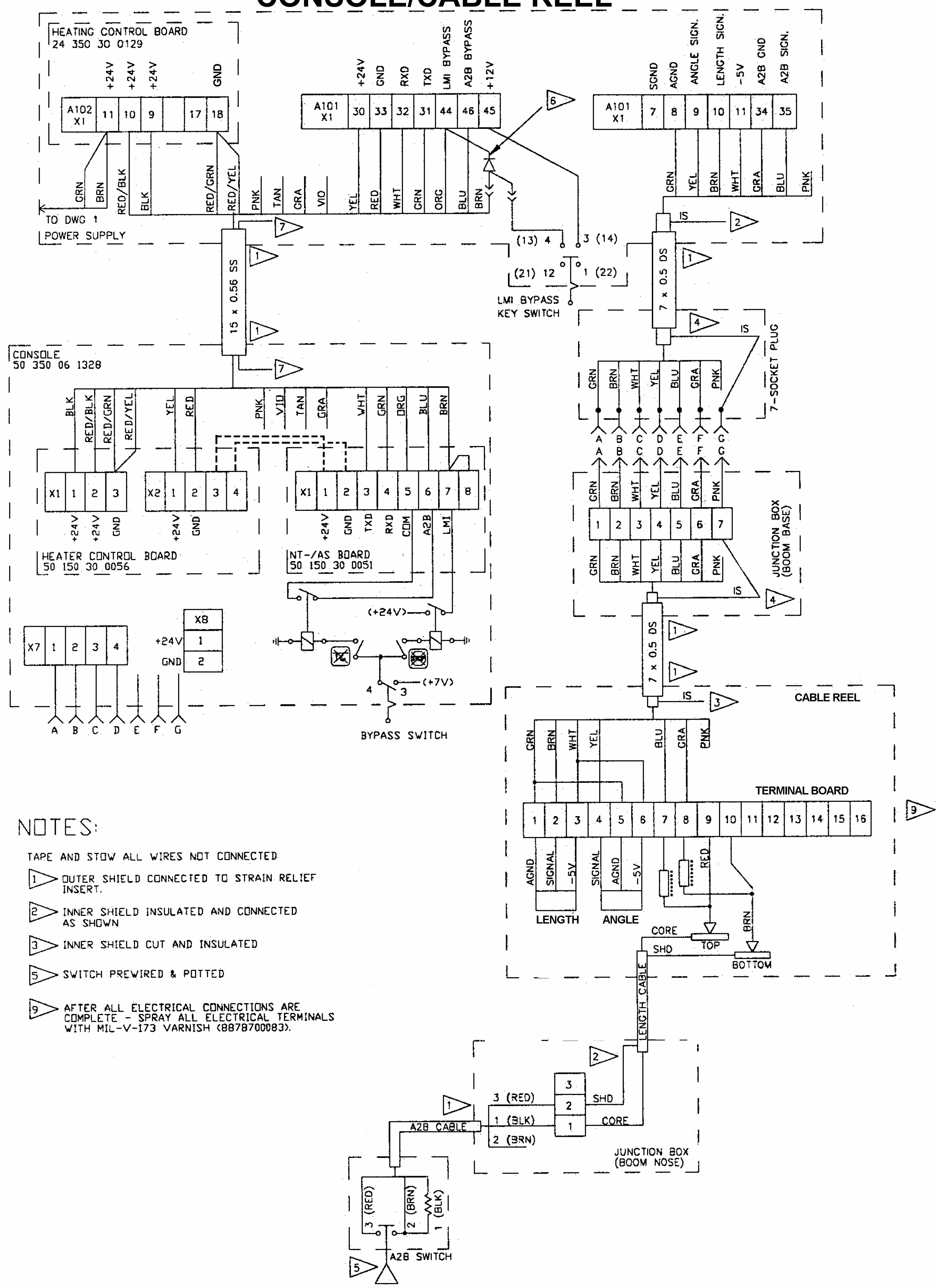
5 SWITCH PREWIRED & POTTED

6 (DIODE ASSY) IS PREWIRED.

7 CUT, TAPE AND STOW UNINSULATED DRAIN WIRE

8 SECURE RING TERMINAL TO P.C. BOARD MOUNTING PLATE USING THE EXISTING SCREW LOCATED IN THE LOWER RIGHT HAND CORNER. (WHERE EXISTING GROUND STRAP TO C.U. COVER IS SECURED)

10. DRAWING 2. ELECTRICAL WIRING CENTRAL UNIT TO DISPLAY CONSOLE/CABLE REEL

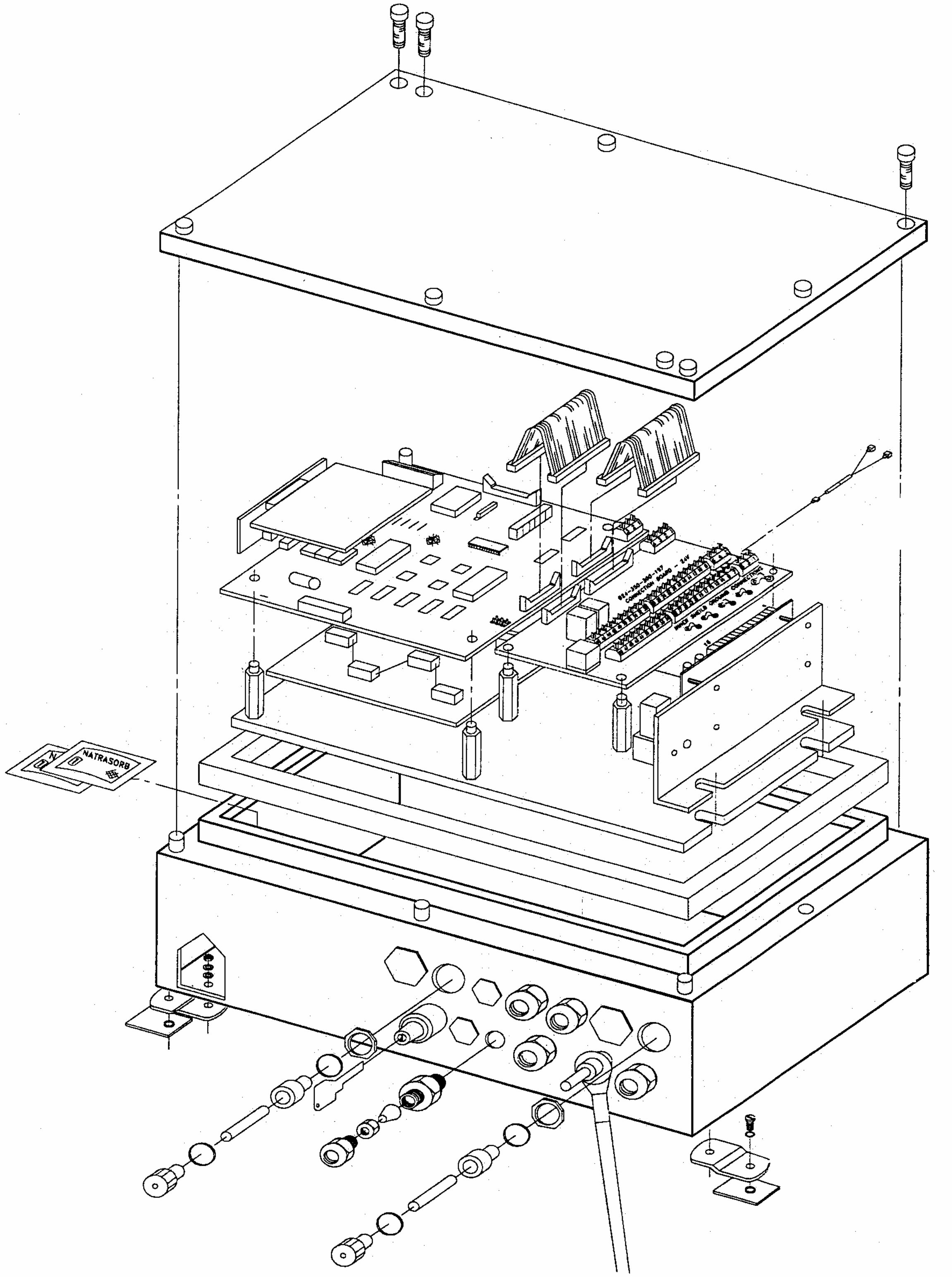


NOTES:

TAPE AND STOW ALL WIRES NOT CONNECTED

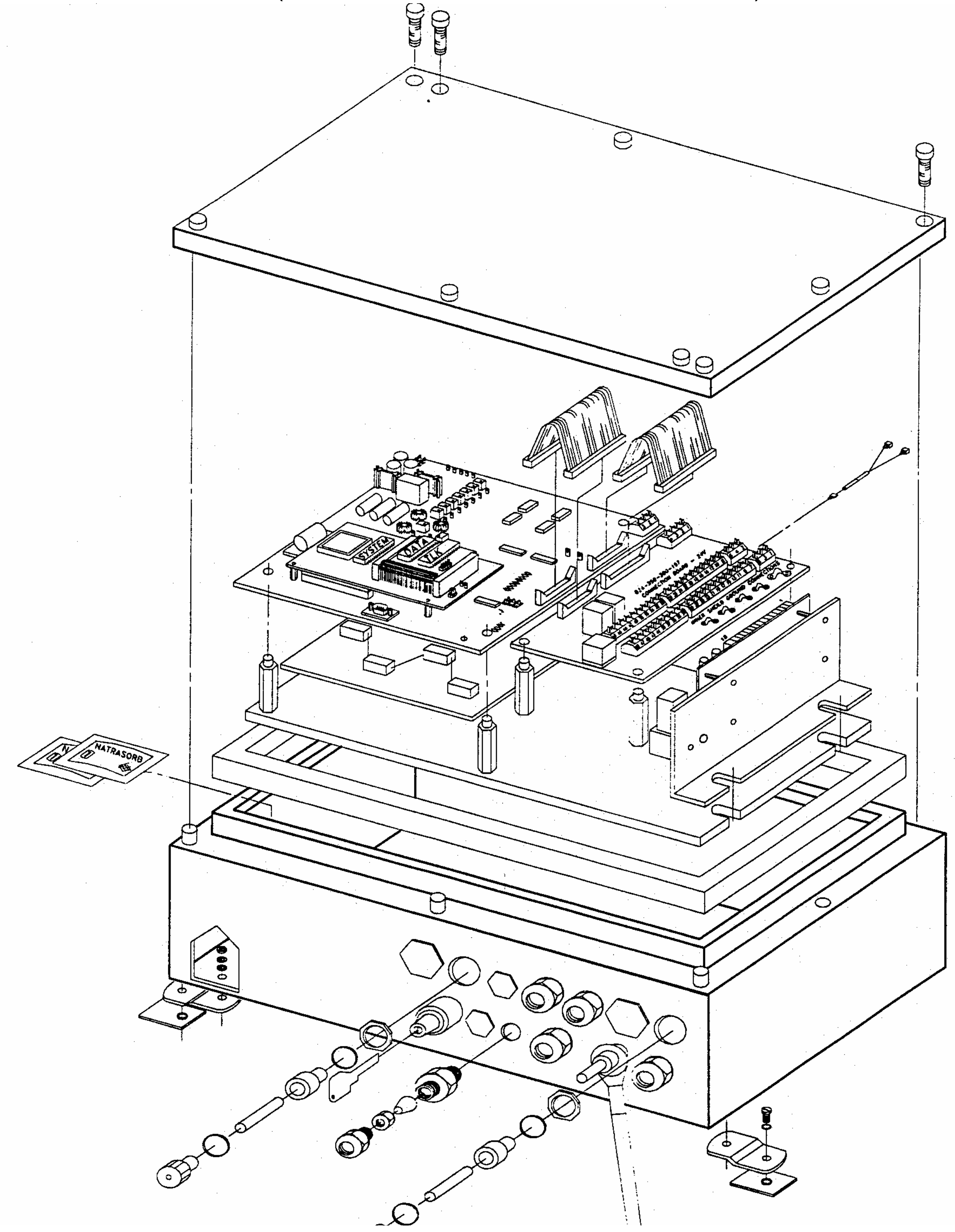
1. OUTER SHIELD CONNECTED TO STRAIN RELIEF INSERT.
2. INNER SHIELD INSULATED AND CONNECTED AS SHOWN
3. INNER SHIELD CUT AND INSULATED
5. SWITCH PREWIRED & POTTED
9. AFTER ALL ELECTRICAL CONNECTIONS ARE COMPLETE - SPRAY ALL ELECTRICAL TERMINALS WITH MIL-V-173 VARNISH (8878700083).

10. DRAWING 3A. CENTRAL UNIT DS350/2766

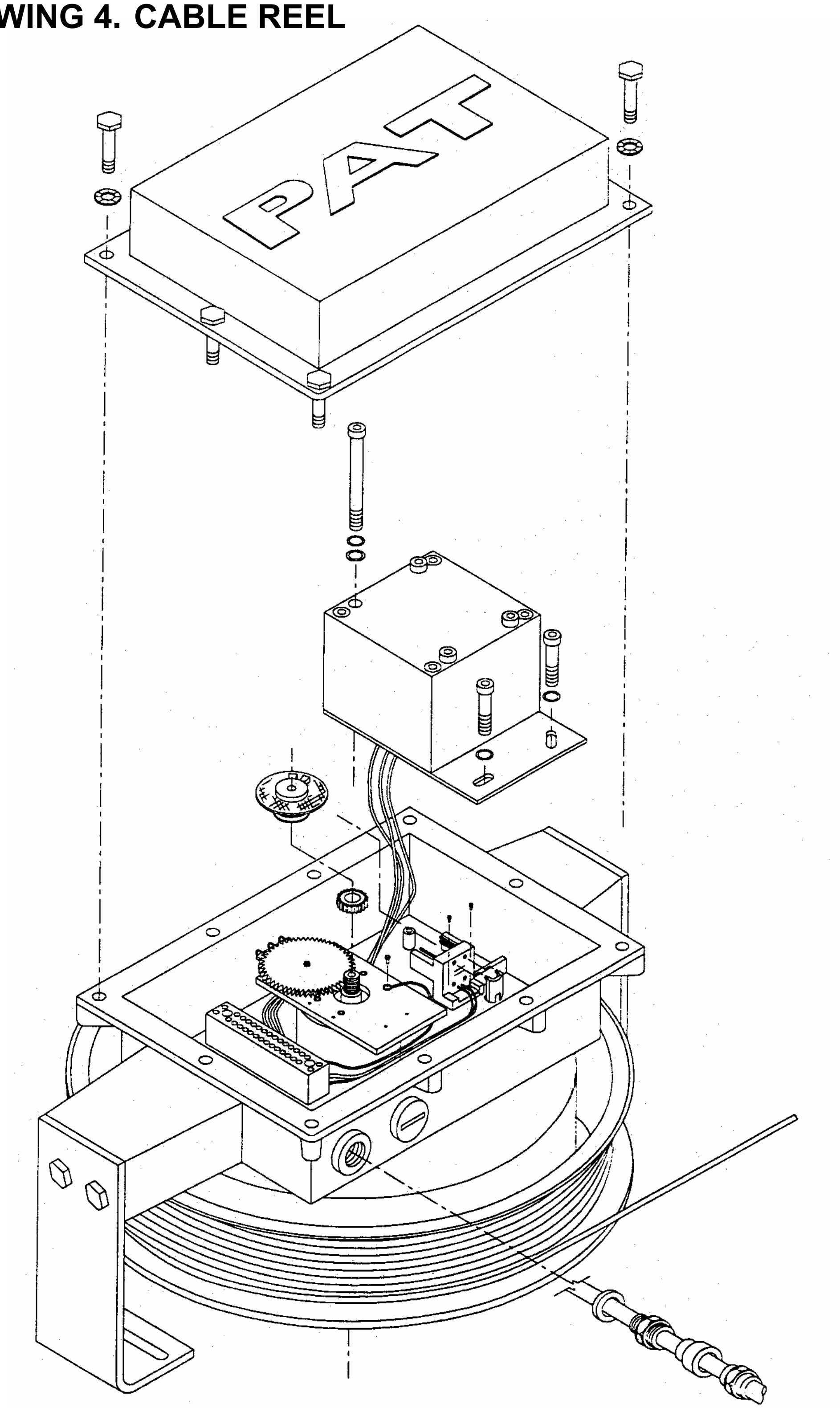


10. DRAWING 3B. CENTRAL UNIT DS350/2767

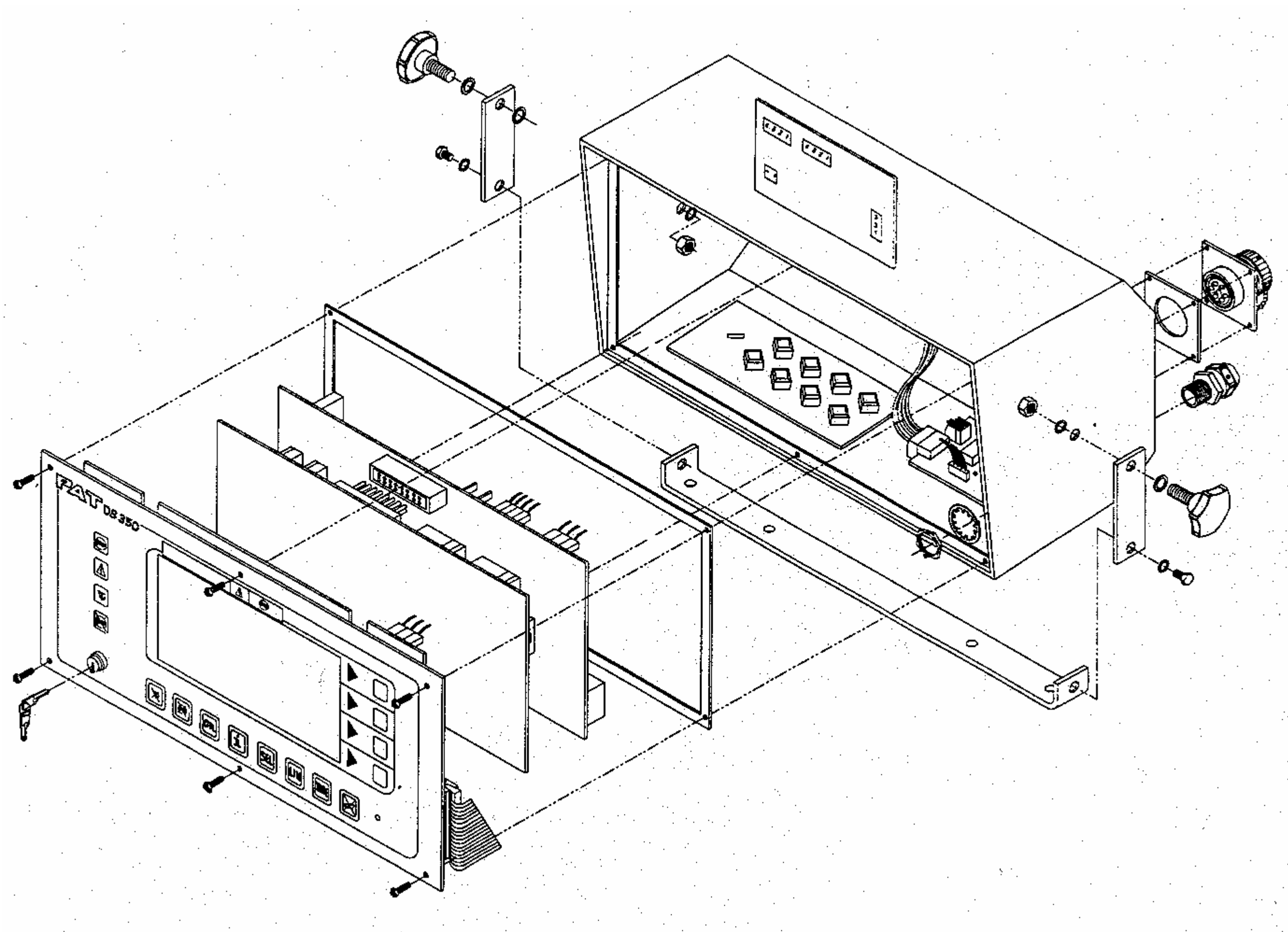
ACCUCAL UPGRADE (SERIAL NUMBER 86638 AND BEYOND)



10. DRAWING 4. CABLE REEL



10. DRAWING 5. 050-350-061-328 DISPLAY CONSOLE



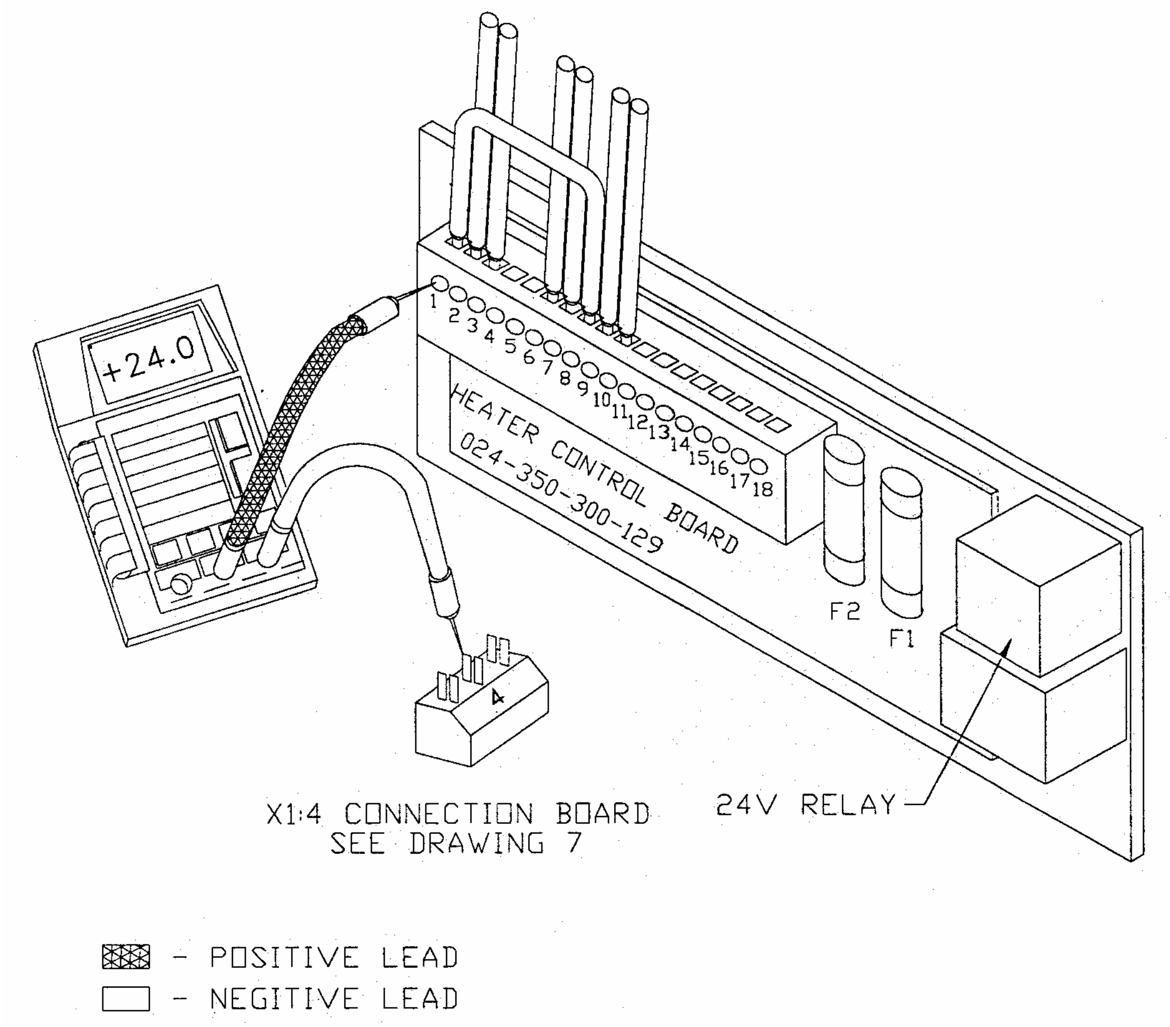
10. DRAWING 6. IN CENTRAL UNIT, HEATER CONTROL BOARD W/VOLTMETER ON X1:1 AND CONNECTION BOARD WITH VOLTMETER ON X1:4

VOLTMETER SHOULD MEASURE +24 VOLTS BETWEEN CONNECTIONS X1:1 (POSITIVE) ON HEATER CONTROL BOARD AND X1:4 (GROUND) ON CONNECTION BOARD.

NOTE

ON HEATER CONTROL BOARD, X1:1, 8, 9, 10, 11 ARE ALL +24V AND X1:2, 18 ARE GROUND.

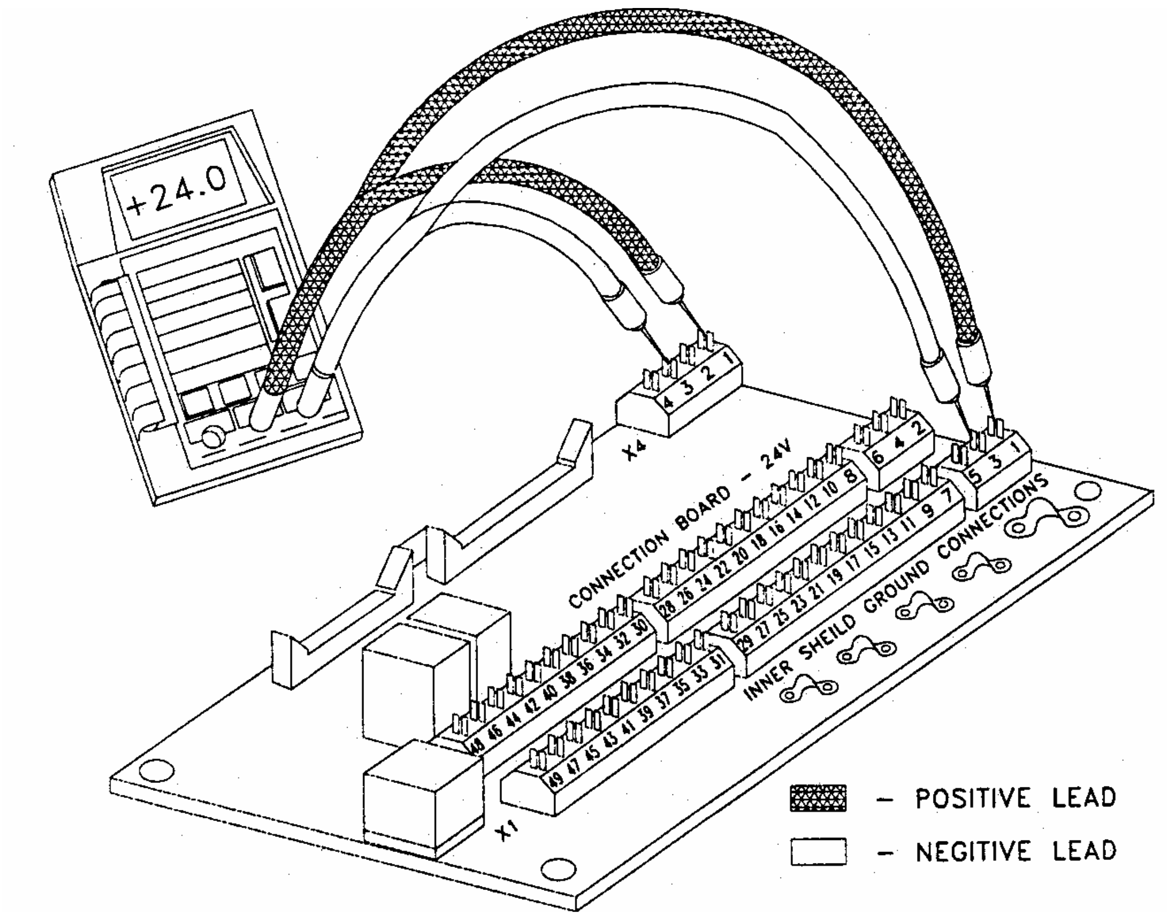
REFER TO DRAWINGS 1 AND 2 FOR WIRING DIAGRAM.
REFER TO DRAWING 3 FOR BOARD LOCATION.



10. DRAWING 7. CONNECTION BOARD IN CENTRAL UNIT W/VOLTMETER ON X1:1 & X1:3 W/VOLTMETER ON X4:1 & X4:3

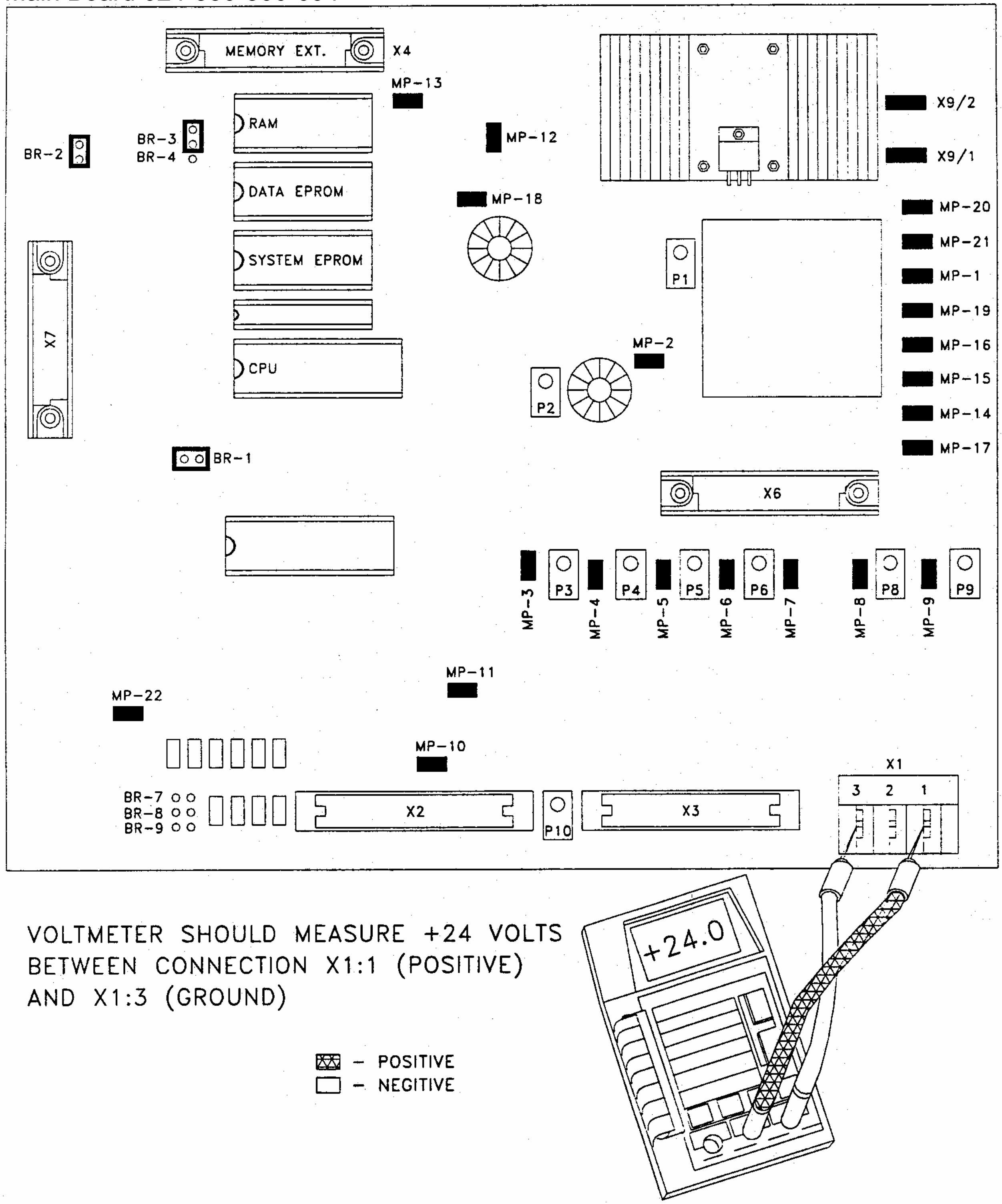
VOLTMETER SHOULD MEASURE +24 VOLTS BETWEEN CONNECTIONS:
INPUT – X1:1 (POSITIVE) & X1:3 (GROUND)
OUTPUT – X4:1 (POSITIVE) & X4:3 (GROUND)

REFER TO DRAWING 2 FOR WIRING DIAGRAM.
REFER TO DRAWING 3 FOR BOARD LOCATION.



10. DRAWING 8A. MAIN BOARD W/VOLTMETER ON X1:1 & X1:3

Main Board 024-350-300-094

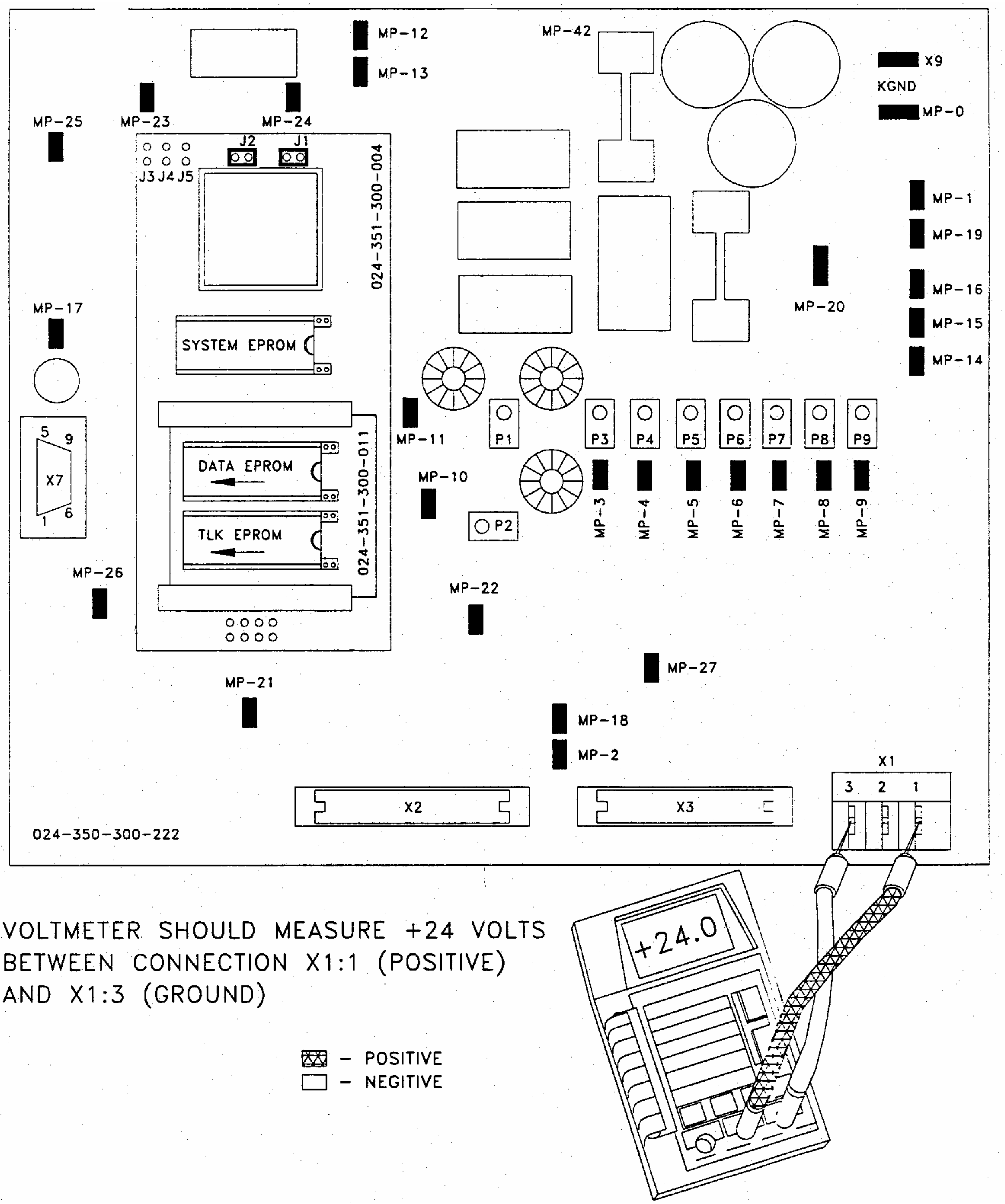


VOLTMETER SHOULD MEASURE +24 VOLTS BETWEEN CONNECTION X1:1 (POSITIVE) AND X1:3 (GROUND)

- POSITIVE
- NEGITIVE

10. DRAWING 8B. MAIN BOARD W/VOLTMETER ON X1:1 & X1:3

Main Board 024-350-300-222



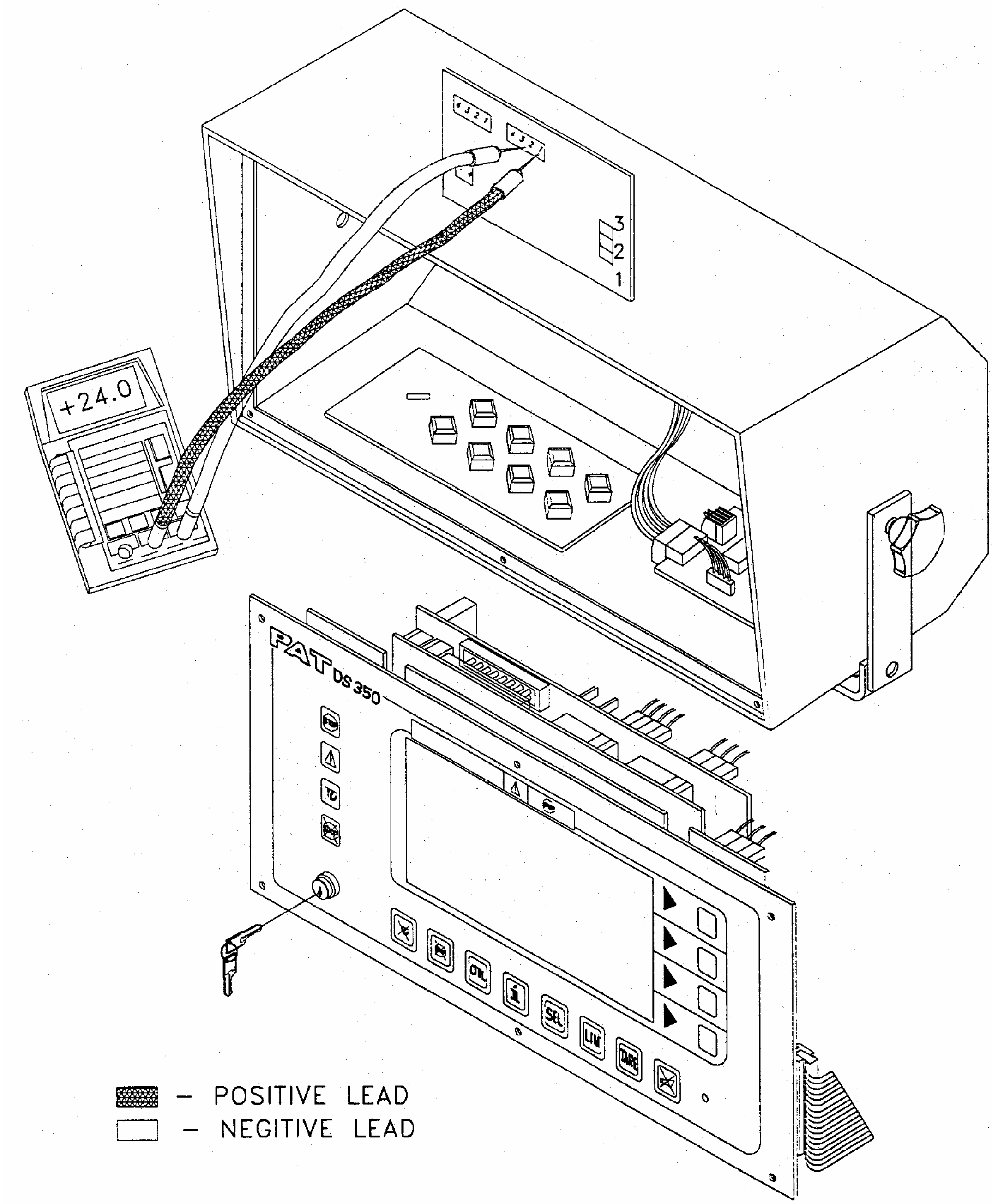
VOLTMETER SHOULD MEASURE +24 VOLTS BETWEEN CONNECTION X1:1 (POSITIVE) AND X1:3 (GROUND)

- POSITIVE
- NEGITIVE

10. DRAWING 9. IN DISPLAY CONSOLE, HEATER CONTROL BOARD W/VOLTMETER ON X2:1 & X2:2

VOLTMETER SHOULD MEASURE +24 VOLTS BETWEEN CONNECTIONS X2:1 (+24v) AND X2:2 (GROUND)

REFER TO DRAWING 2 FOR WIRING DIAGRAM.

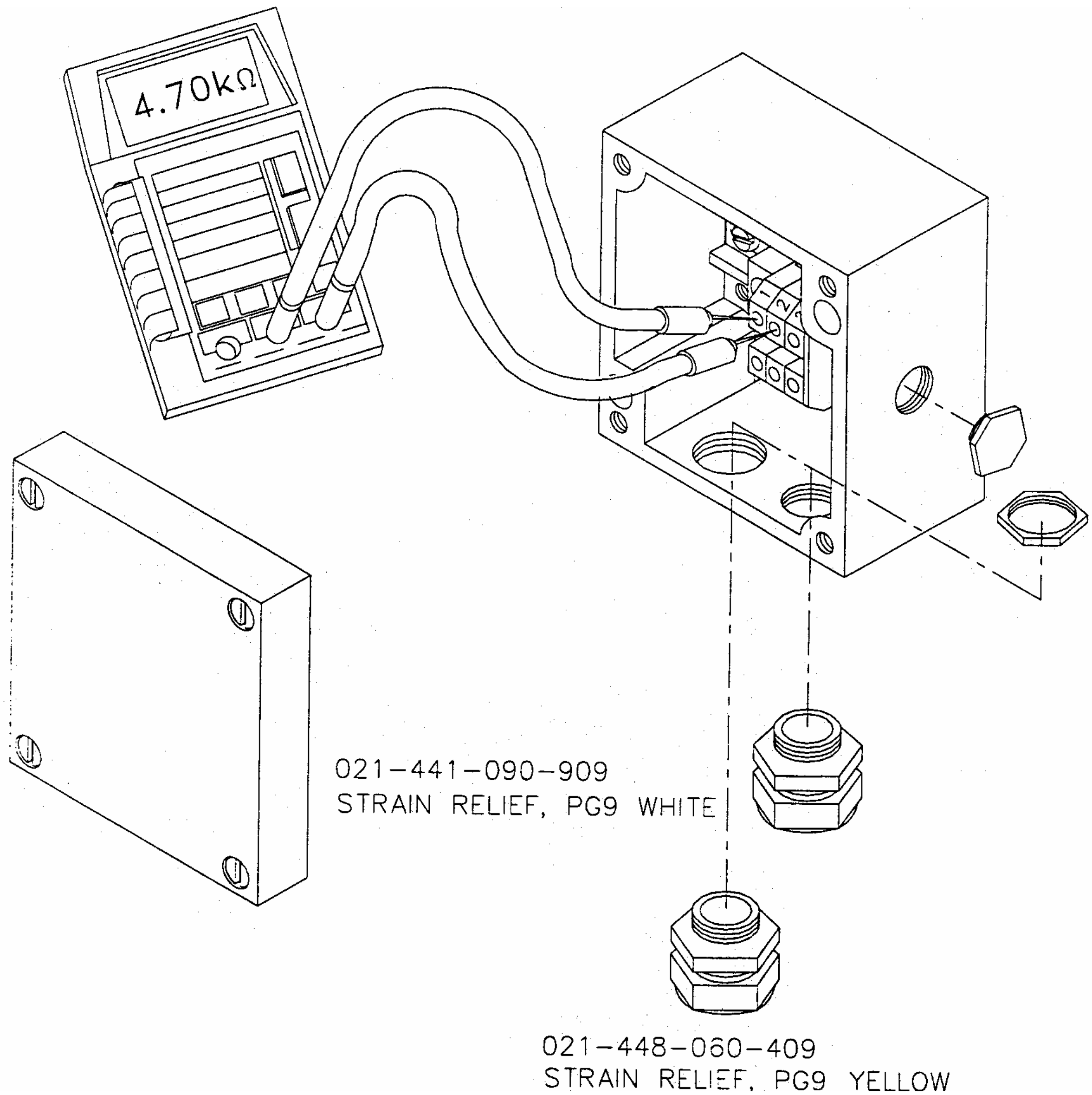


10. DRAWING 10. BOOM NOSE JUNCTION BOX W/OHMMETER ON 1 & 2

TURN POWER OFF OR DISCONNECT X1:35 ON CONNECTION BOARD IN CENTRAL UNIT. REMOVE LENGTH CABLE CORE WIRE FROM TERMINAL 1 IN BOOM NOSE JUNCTION BOX. MEASURE THE RESISTANCE BETWEEN TERMINALS 1 & 2 IN BOOM NOSE JUNCTION BOX.

- ANTI-TWO BLOCK SWITCH CLOSED = 4700 ±500 OHMS
- ANTI-TWO BLOCK SWITCH OPEN ≥ 1 MEGAOHM

REFER TO DRAWING 2 AND 22 FOR WIRING DIAGRAM.



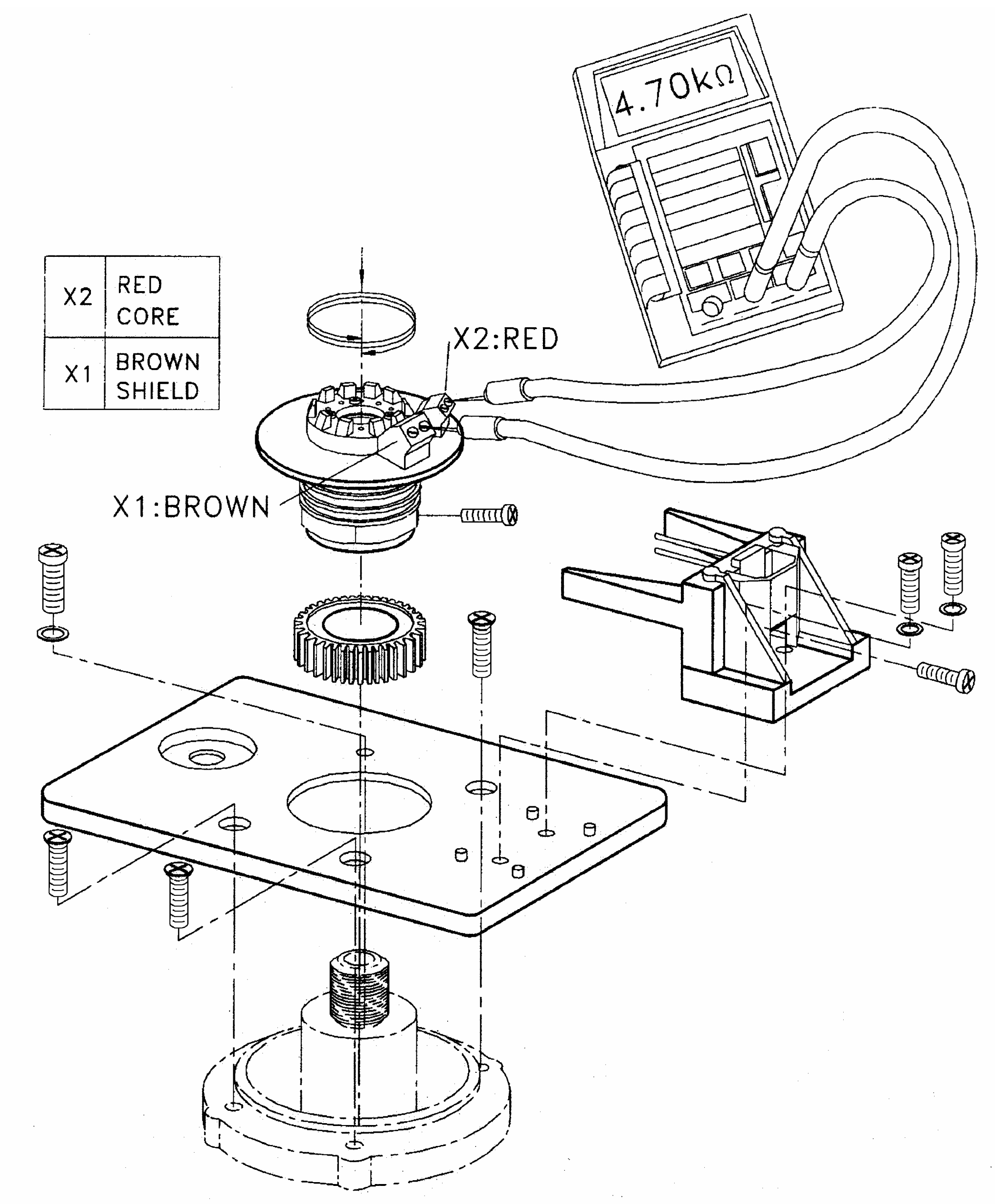
10. DRAWING 11. SLIP RING W/OHMMETER ON X2:RED & X1:BROWN

TURN POWER OFF OR DISCONNECT X1:35 ON CONNECTION BOARD IN CENTRAL UNIT. REMOVE BLUE WIRE FROM TERMINAL 7 ON TERMINAL BOARD IN CABLE REEL. MEASURE THE RESISTANCE BETWEEN X2:RED & X1:BROWN TERMINALS ON THE SLIP RING.

- ANTI-TWO BLOCK SWITCH CLOSED = 4700 ±500 OHMS
- ANTI-TWO BLOCK SWITCH OPEN ≥ 1 MEGAOHM

NOTE

REFER TO DRAWING 2 AND 22 FOR WIRING DIAGRAM.



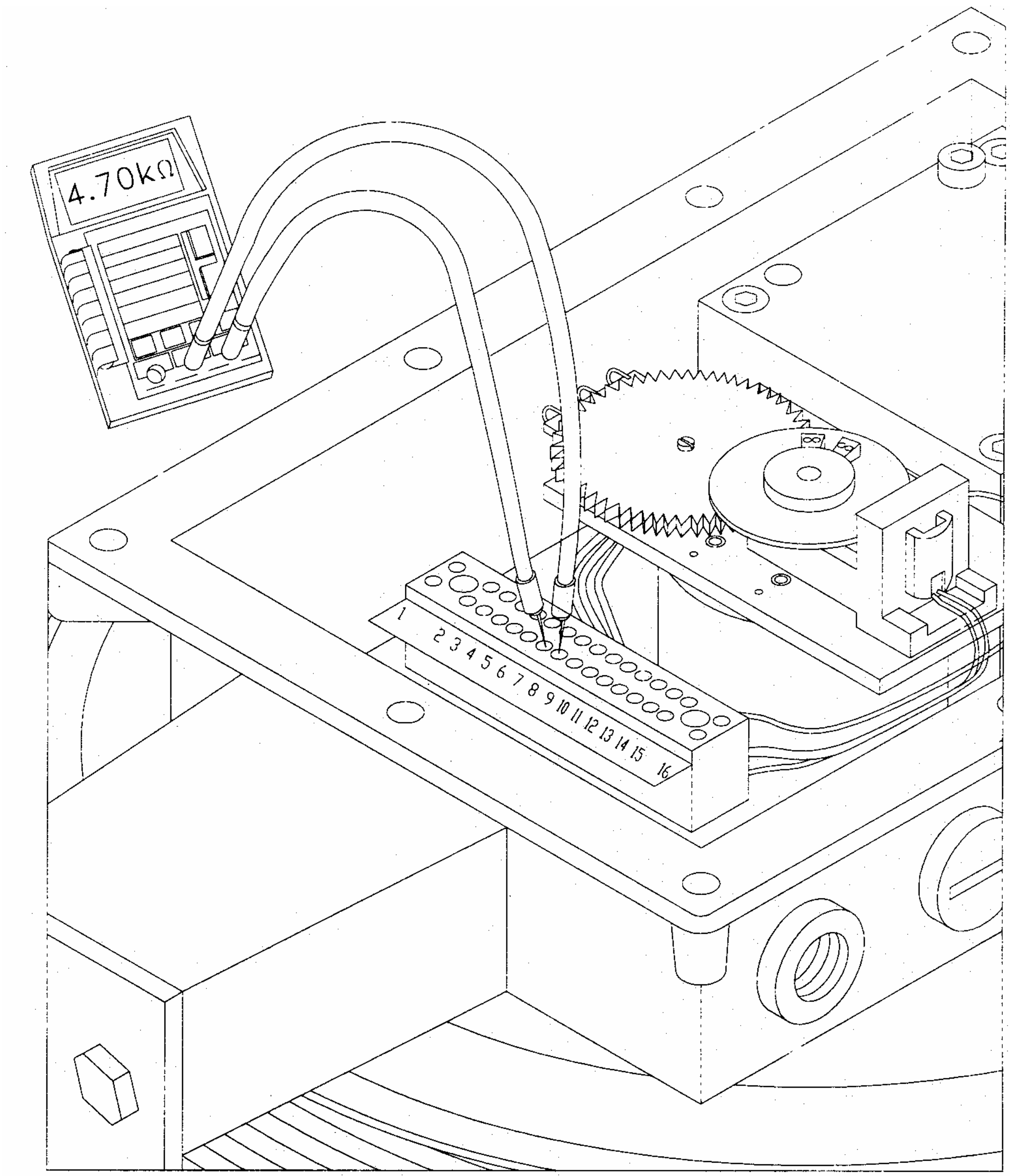
10. DRAWING 12. CABLE REEL W/OHMMETER ON TERMINALS 7 & 8 ON TERMINAL BOARD

TURN POWER OFF OR DISCONNECT X1:35 ON CONNECTION BOARD IN CENTRAL UNIT. REMOVE BLUE WIRE FROM TERMINAL 7 ON TERMINAL BOARD IN CABLE REEL. MEASURE THE RESISTANCE BETWEEN TERMINALS 7 & 8 ON TERMINAL BOARD.

- ANTI-TWO BLOCK SWITCH CLOSED = 4700 ±500 OHMS
- ANTI-TWO BLOCK SWITCH OPEN ≥ 1 MEGAOHM

NOTE

REFER TO DRAWING 2 AND 22 FOR WIRING DIAGRAM.



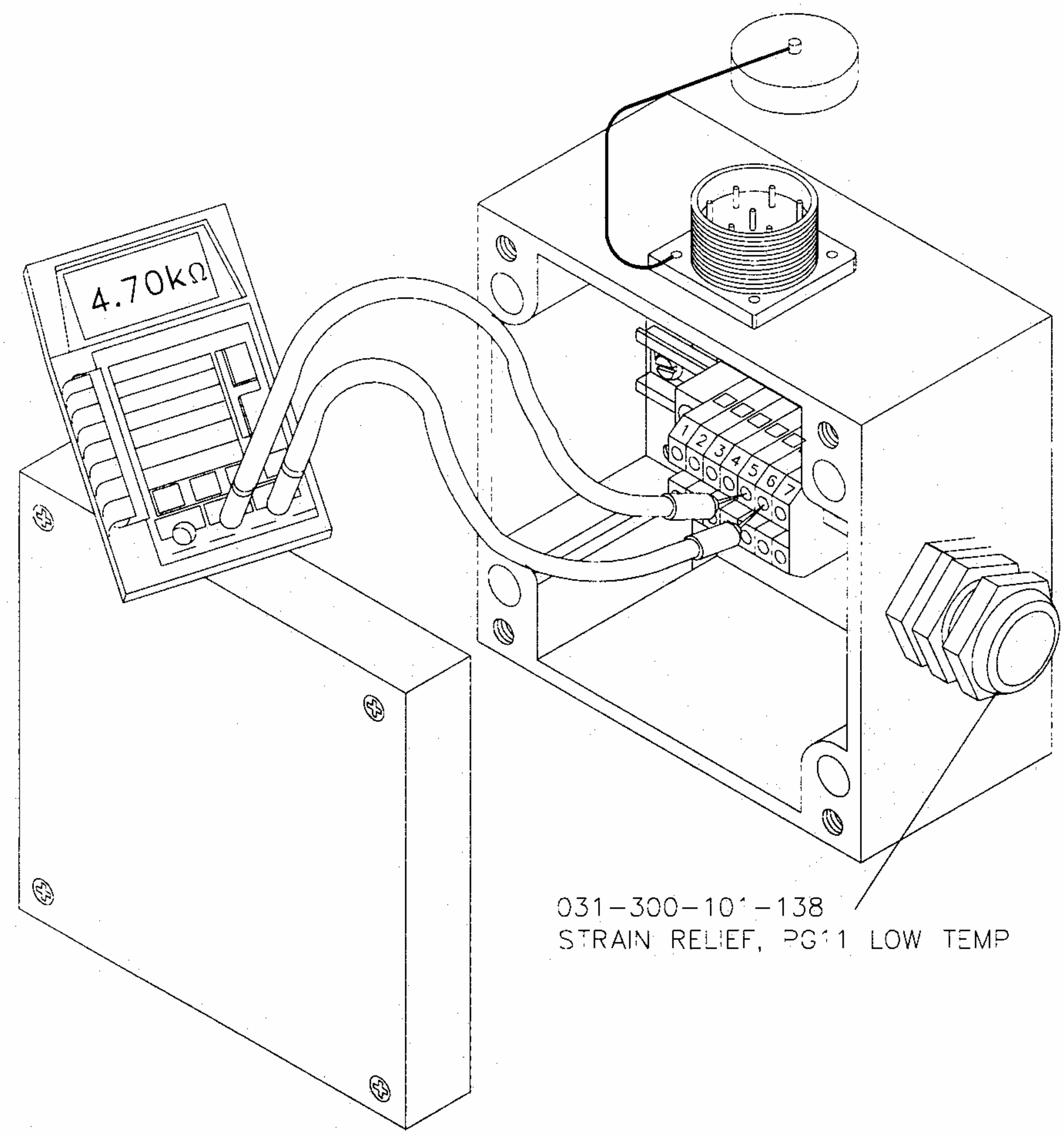
10. DRAWING 13. BOOM BASE JUNCTION BOX W/OHMMETER ON 5 & 6

TURN POWER OFF OR DISCONNECT X1:35 ON CONNECTION BOARD IN CENTRAL UNIT. UNPLUG CABLE ASSEMBLY FROM CENTRAL UNIT TO BOOM BASE JUNCTION BOX. MEASURE THE RESISTANCE BETWEEN TERMINALS 5 & 6 IN BOOM BASE JUNCTION BOX.

- ANTI-TWO BLOCK SWITCH CLOSED = 4700 ±500 OHMS
- ANTI-TWO BLOCK SWITCH OPEN ≥ 1 MEGAOHM

NOTE

REFER TO DRAWING 2 AND 22 FOR WIRING DIAGRAM.

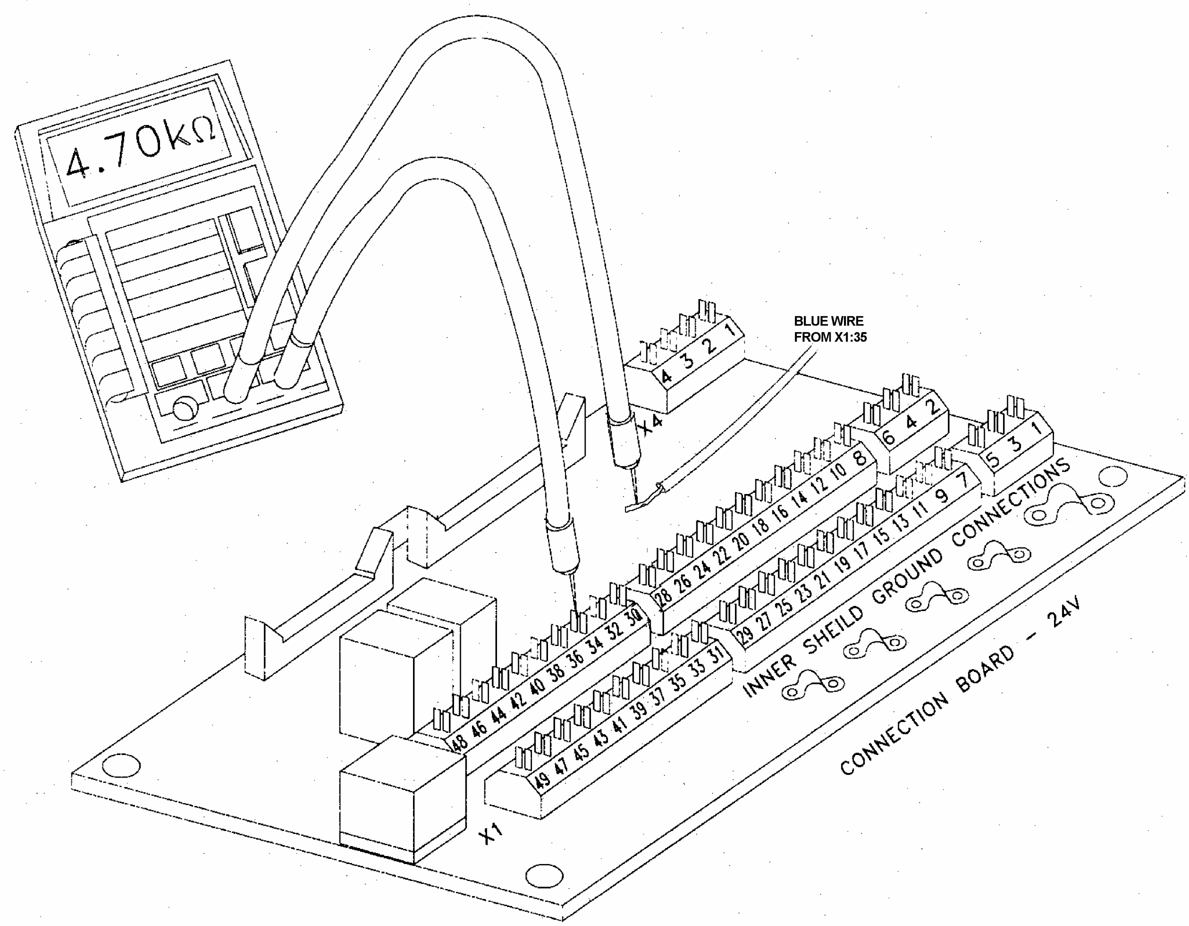


10. DRAWING 14. CONNECTION BOARD IN CENTRAL UNIT W/OHMMETER ON X1:34 & BLUE WIRE DISCONNECTED FROM X1:35

TURN POWER OFF AND DISCONNECT BLUE WIRE FROM X1:35 ON CONNECTION BOARD IN CENTRAL UNIT. MEASURE THE RESISTANCE BETWEEN X1:34 & BLUE WIRE DISCONNECTED FROM X1:35 ON CONNECTION BOARD.

- ANTI-TWO BLOCK SWITCH CLOSED = 4700 ±500 OHMS
- ANTI-TWO BLOCK SWITCH OPEN ≥ 1 MEGAOHM

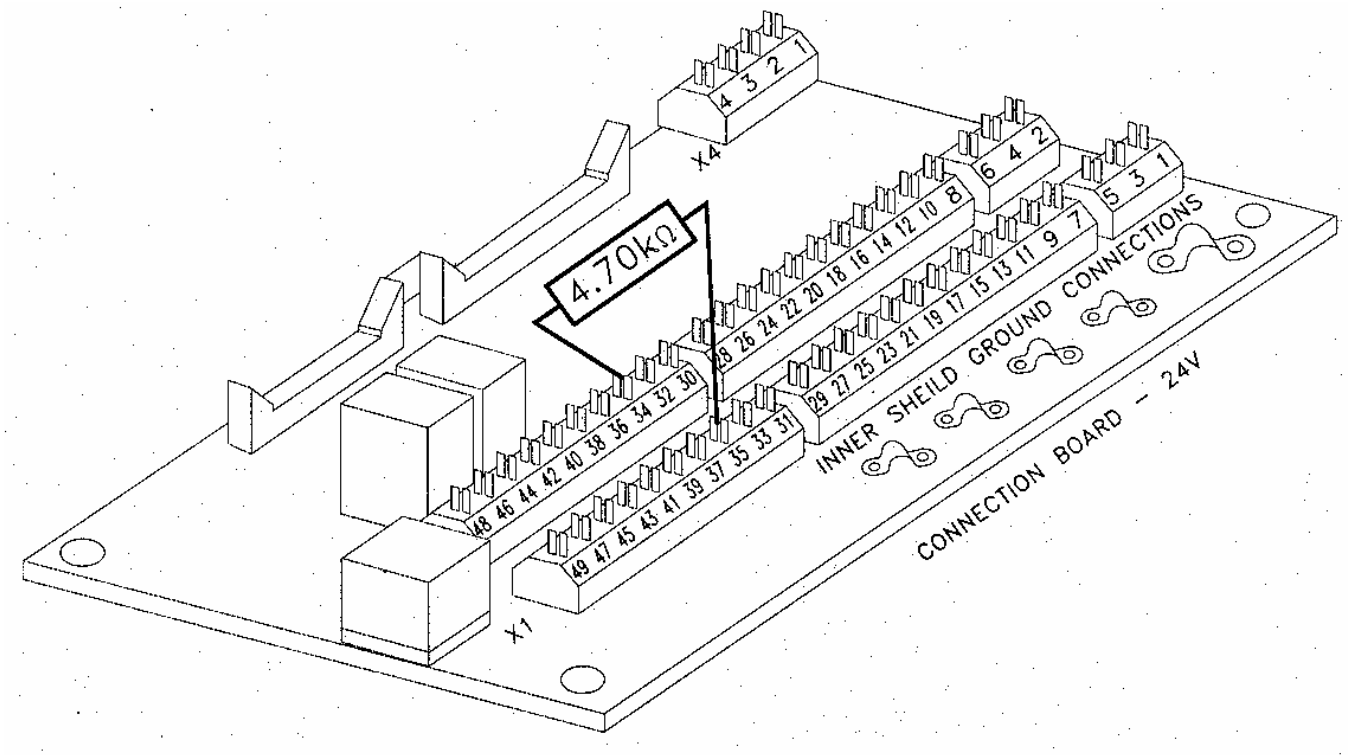
REFER TO DRAWING 2 AND 22 FOR WIRING DIAGRAM.
REFER TO DRAWING 3 FOR BOARD LOCATION.



10. DRAWING 15. CONNECTION BOARD IN CENTRAL UNIT W/TEMPORARY 4.7K OHM RESISTOR INSTALLED ON X1:34 & X1:35

TURN POWER OFF TO CENTRAL UNIT. TAG AND DISCONNECT WIRES FROM X1:34 & X1:35 ON CONNECTION BOARD IN CENTRAL UNIT. INSTALL THE 4700 OHM RESISTOR BETWEEN X1:34 & X1:35. TURN POWER ON TO CENTRAL UNIT AND THE ANTI-TWO BLOCK ALARM SHOULD BE INACTIVE.

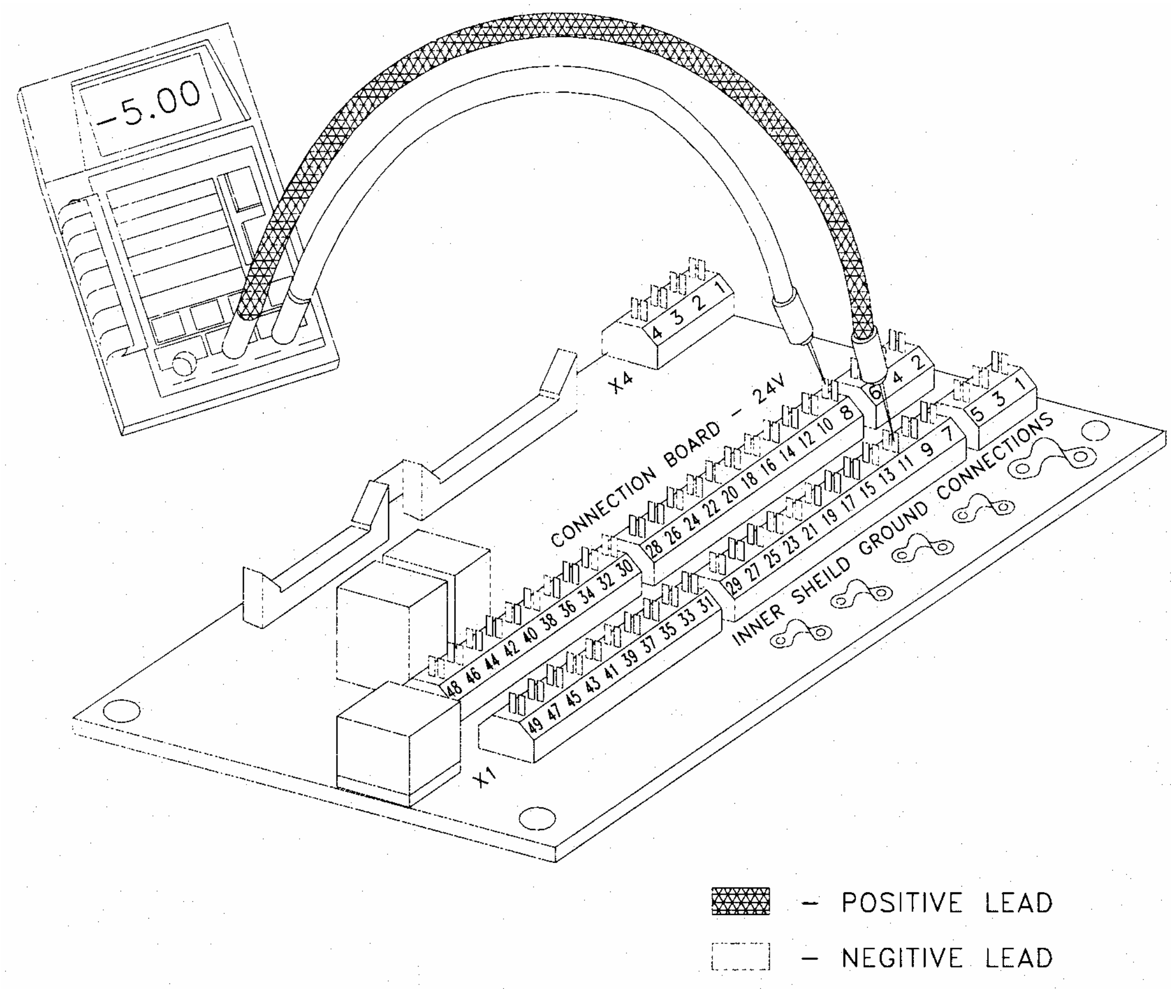
REFER TO DRAWING 2 FOR WIRING DIAGRAM.
REFER TO DRAWING 3 FOR BOARD LOCATION.



10. DRAWING 16. CONNECTION BOARD IN CENTRAL UNIT W/VOLTMETER ON X1:8 & X1:11

VOLTMETER SHOULD MEASURE –5.0 VOLTS BETWEEN TERMINALS X1:8 (GROUND) & X1:11 (-5.0V)

REFER TO DRAWING 2 FOR WIRING DIAGRAM.
REFER TO DRAWING 3 FOR BOARD LOCATION.



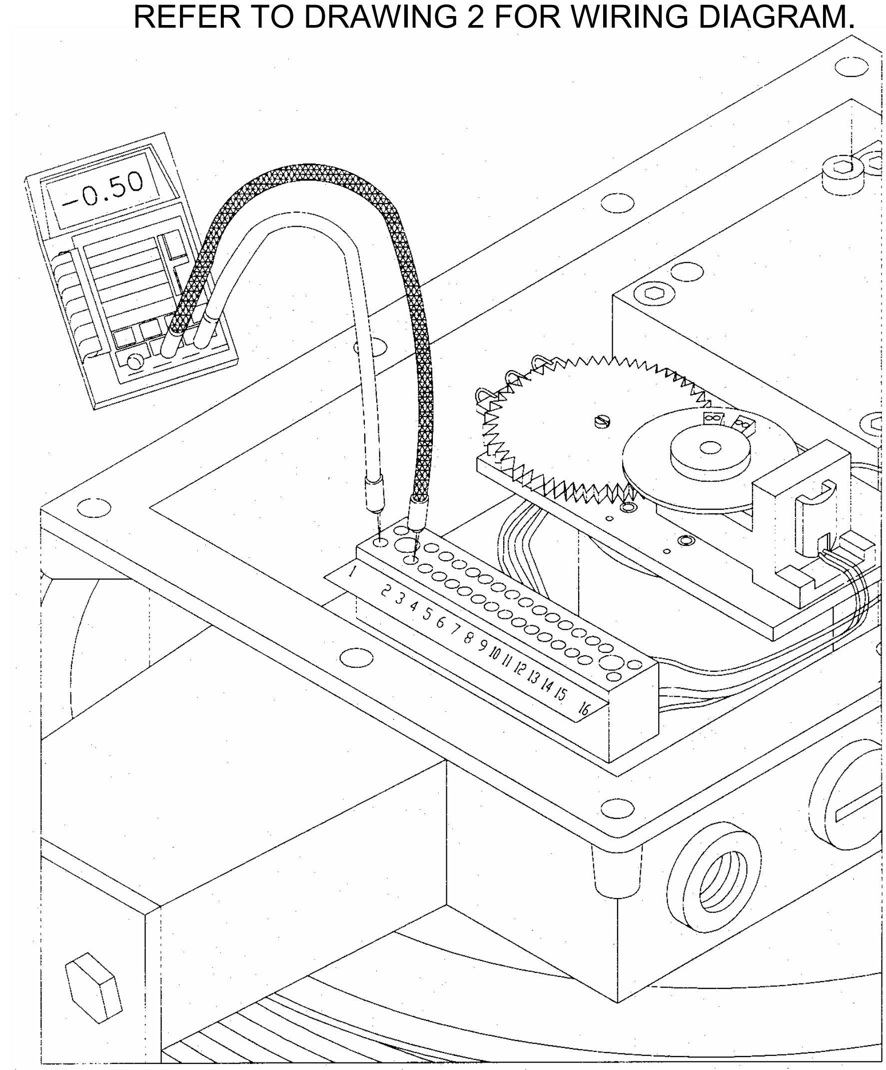
10. DRAWING 17. CABLE REEL TERMINAL BOARD W/VOLTMETER ON TERMINALS 1 & 2 AND ON TERMINALS 1 & 3

THE VOLTMETER SHOULD MEASURE –5.0 VOLTS BETWEEN TERMINALS 1 (GROUND) AND 3 (SUPPLY VOLTAGE) – VOLTMETER NOT SHOWN

THE VOLTMETER SHOULD MEASURE THE FOLLOWING BETWEEN TERMINALS 1 (GROUND) AND 2 (SIGNAL VOLTAGE):

- –0.5 VOLTS WITH THE BOOM FULLY RETRACTED AND LENGTH POTENTIOMETER SET FULLY COUNTERCLOCKWISE TO A SOFT STOP (MINIMUM SENSOR OUTPUT)
- –2.1 VOLTS (± 0.1 V) WITH THE BOOM FULLY EXTENDED (ACTUAL WORKING RANGE)
- –4.5 VOLTS WITH THE LENGTH POTENTIOMETER TURNED COMPLETELY CLOCKWISE 10 TURNS TO A SOFT STOP (MAXIMUM SENSOR OUTPUT)

NOTE
REFER TO DRAWING 2 FOR WIRING DIAGRAM.

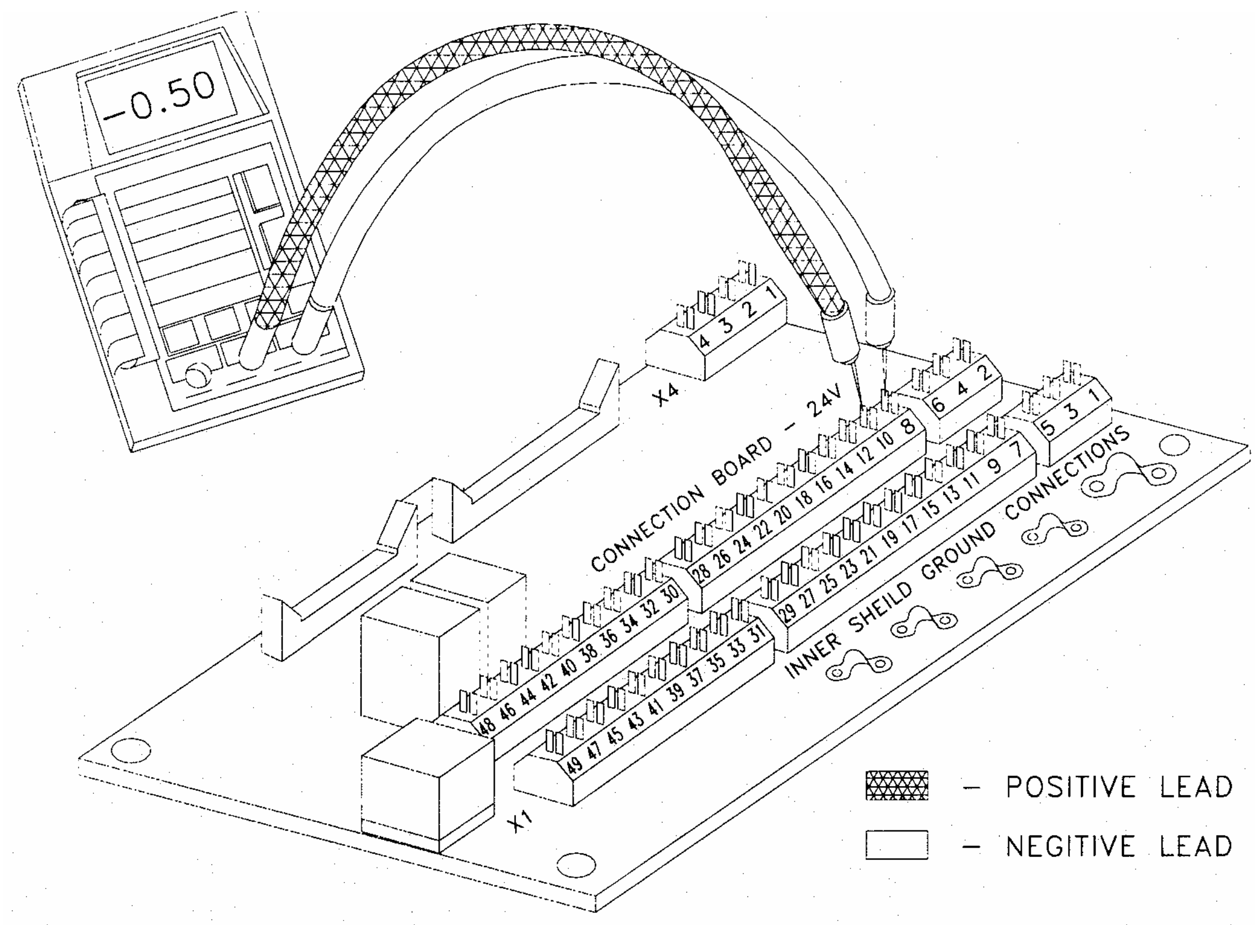


10. DRAWING 18. CONNECTION BOARD IN CENTRAL UNIT W/VOLTMETER ON X1:8 & X1:10

THE VOLTMETER SHOULD MEASURE THE FOLLOWING BETWEEN TERMINALS X1:8 (GROUND) AND X:10 (LENGTH SIGNAL):

- –0.5 VOLTS WITH THE BOOM FULLY RETRACTED AND LENGTH POTENTIOMETER SET FULLY COUNTERCLOCKWISE TO A SOFT STOP (MINIMUM SENSOR OUTPUT)
- –2.1 VOLTS (± 0.1 V) WITH THE BOOM FULLY EXTENDED (ACTUAL WORKING RANGE)
- –4.5 VOLTS WITH THE LENGTH POTENTIOMETER TURNED COMPLETELY CLOCKWISE 10 TURNS TO A SOFT STOP (MAXIMUM SENSOR OUTPUT)

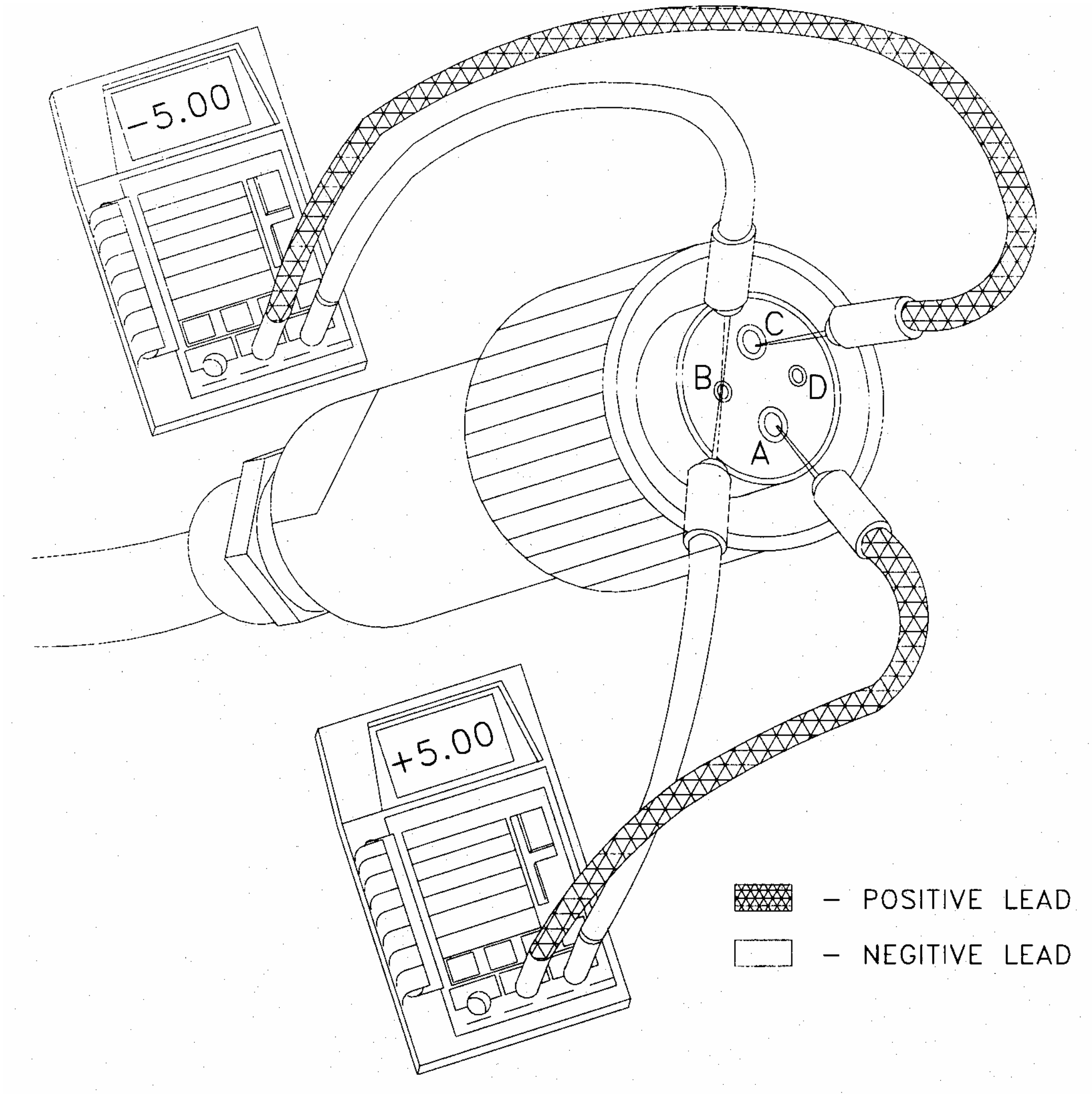
REFER TO DRAWING 2 FOR WIRING DIAGRAM.
REFER TO DRAWING 3 FOR BOARD LOCATION.



10. DRAWING 19. PRESSURE TRANSDUCER CABLE W/VOLTMETER ON TERMINALS A & B AND B & C

- VOLTMETER SHOULD MEASURE +5.0 VOLTS BETWEEN TERMINAL A (+5.0V) & B (GROUND)
- VOLTMETER SHOULD MEASURE –5.0 VOLTS BETWEEN TERMINAL C (-5.0V) & B (GROUND)

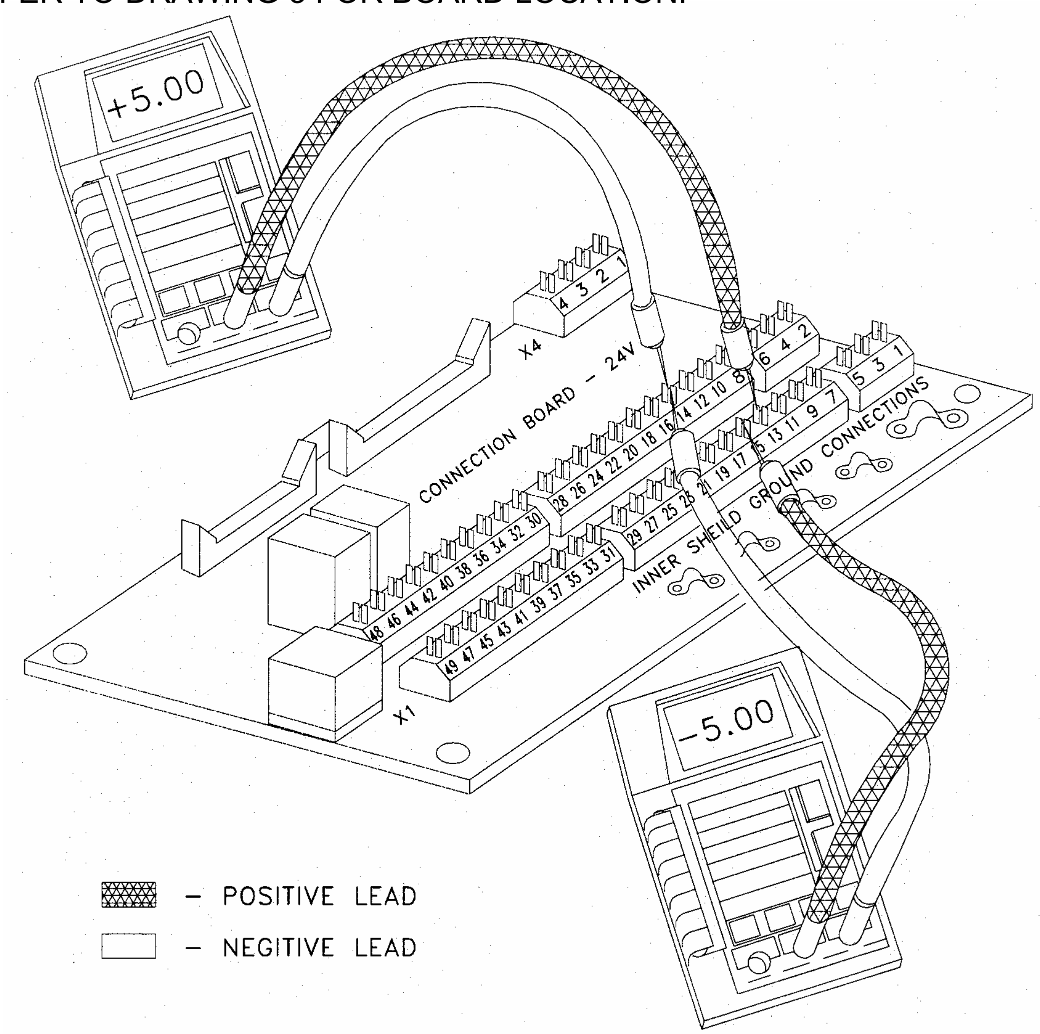
REFER TO DRAWING 1 FOR WIRING DIAGRAM.



10. DRAWING 20. CONNECTION BOARD IN CENTRAL UNIT W/VOLTMETER ON X1:13 & X1:14 W/VOLTMETER ON X1:15 & X1:14 W/VOLTMETER ON X1:18 & X1:19 W/VOLTMETER ON X1:20 & X1:19

- VOLTMETER SHOULD MEASURE +5.0 VOLTS BETWEEN TERMINALS: X1:13 (+5.0V) & X1:14 (GROUND) AND X1:18 (+5.0V) & X1:19 (GROUND) – ACTUAL MEASUREMENT NOT SHOWN
- VOLTMETER SHOULD MEASURE –5.0 VOLTS BETWEEN TERMINALS: X1:15 (-5.0V) & X1:14 (GROUND) AND X1:20 (-5.0V) & X1:19 (GROUND) – ACTUAL MEASUREMENT NOT SHOWN

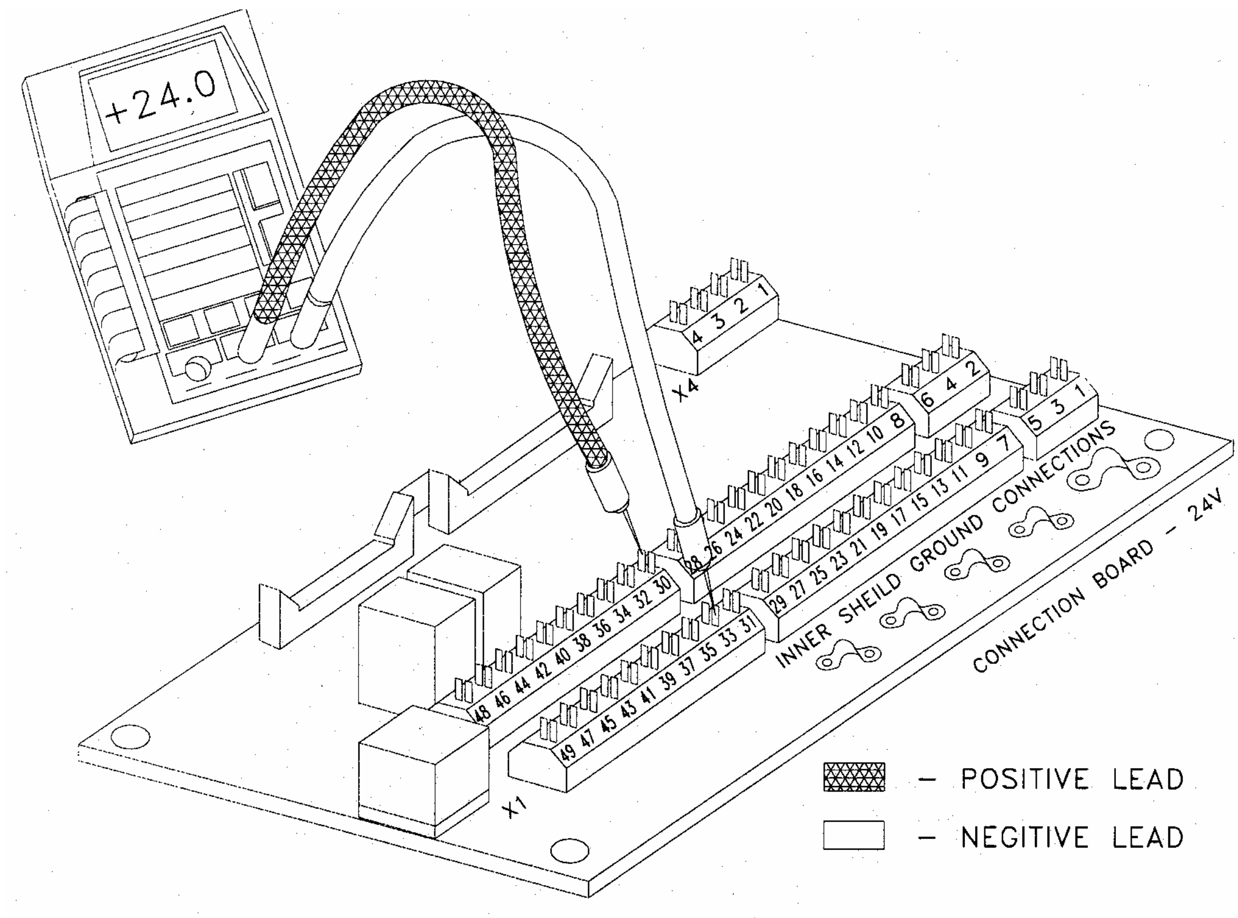
REFER TO DRAWING 1 FOR WIRING DIAGRAM.
REFER TO DRAWING 3 FOR BOARD LOCATION.



10. DRAWING 21. CONNECTION BOARD IN CENTRAL UNIT W/VOLTMETER ON X1:30 & X1:33

VOLTMETER SHOULD MEASURE +24 VOLTS BETWEEN TERMINALS:
X1:30 (POSITIVE) & X1:33 (GROUND)

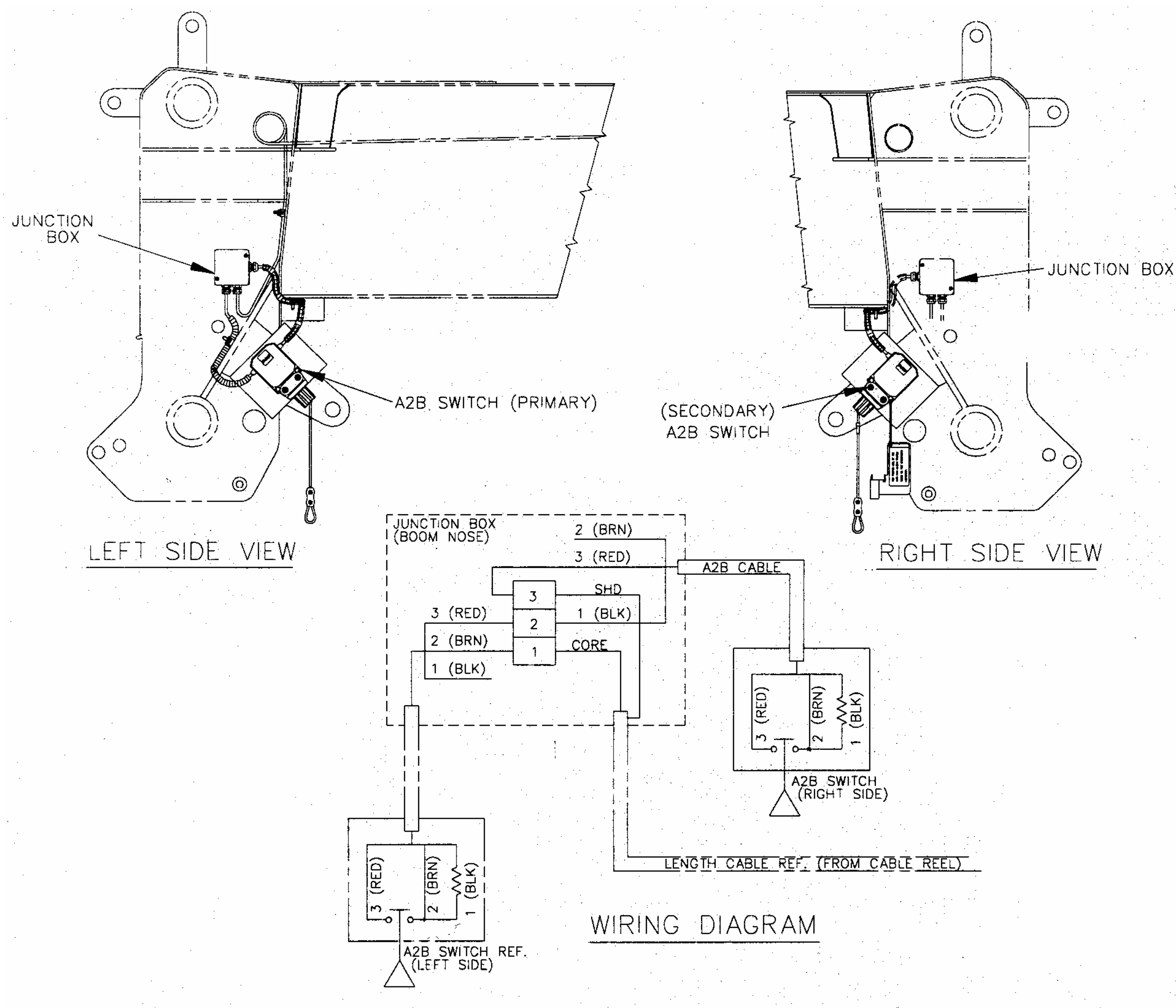
REFER TO DRAWING 2 FOR WIRING DIAGRAM.
REFER TO DRAWING 3 FOR BOARD LOCATION.



10. DRAWING 22. SECONDARY ANTI-TWO BLOCK SWITCH FOR USE WITH PILE-DRIVER OPERATION

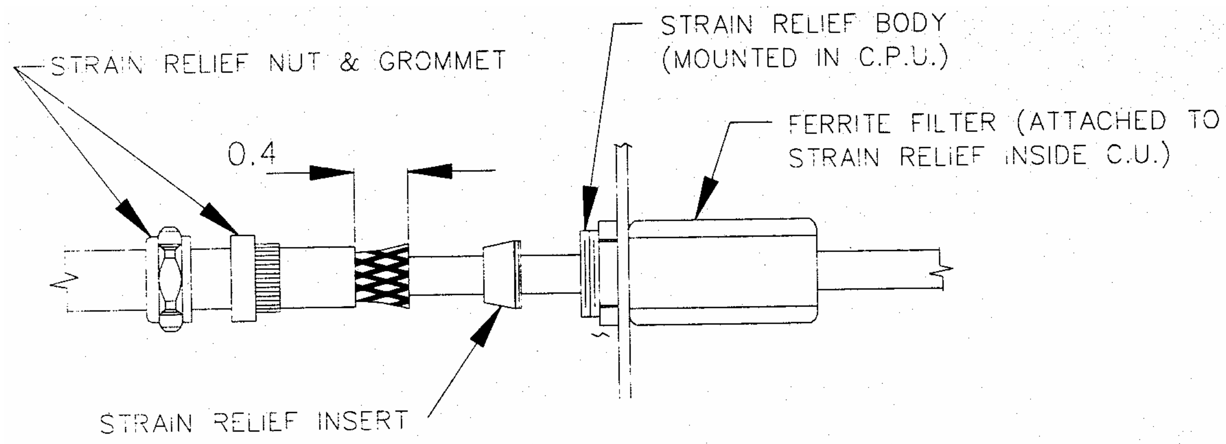
TO CHECK FUNCTION OF SECONDARY ANTI-TWO BLOCK SWITCH, MEASURE RESISTANCE AT BOOM NOSE JUNCTION BOX BETWEEN TERMINALS 2 AND 3 WITH OHMMETER.

SWITCH CLOSED = 4700 ±500 Ohms (WEIGHT INSTALLED)
SWITCH OPEN => 1 MegaOhm (WEIGHT REMOVED)

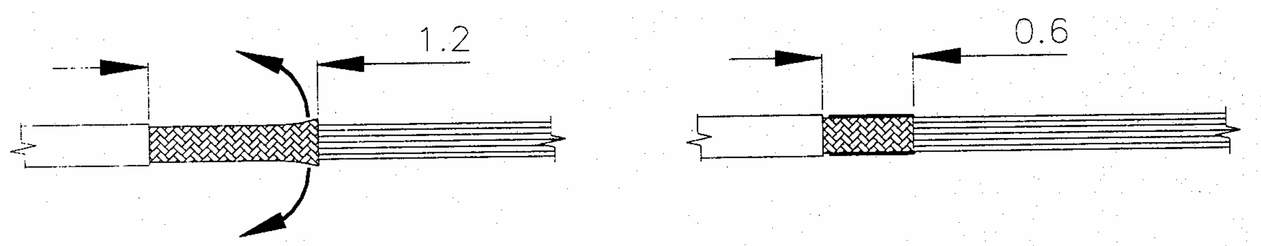


11. PROCEDURE 1. STRAIN RELIEF INSTALLATION

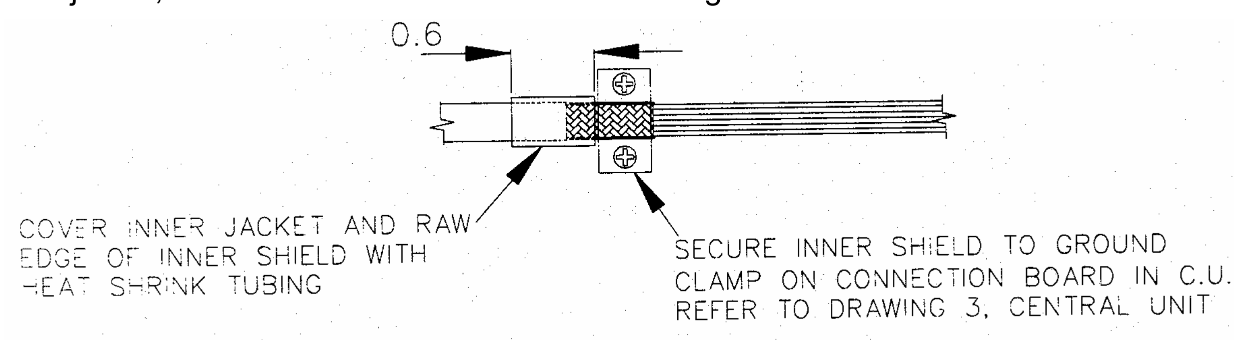
DOUBLE SHIELDED CABLE PREPARATION FOR EMC APPLICATIONS
Outer shield is grounded at strain relief with ferrite filter.



Inner shield is grounded on connection board.

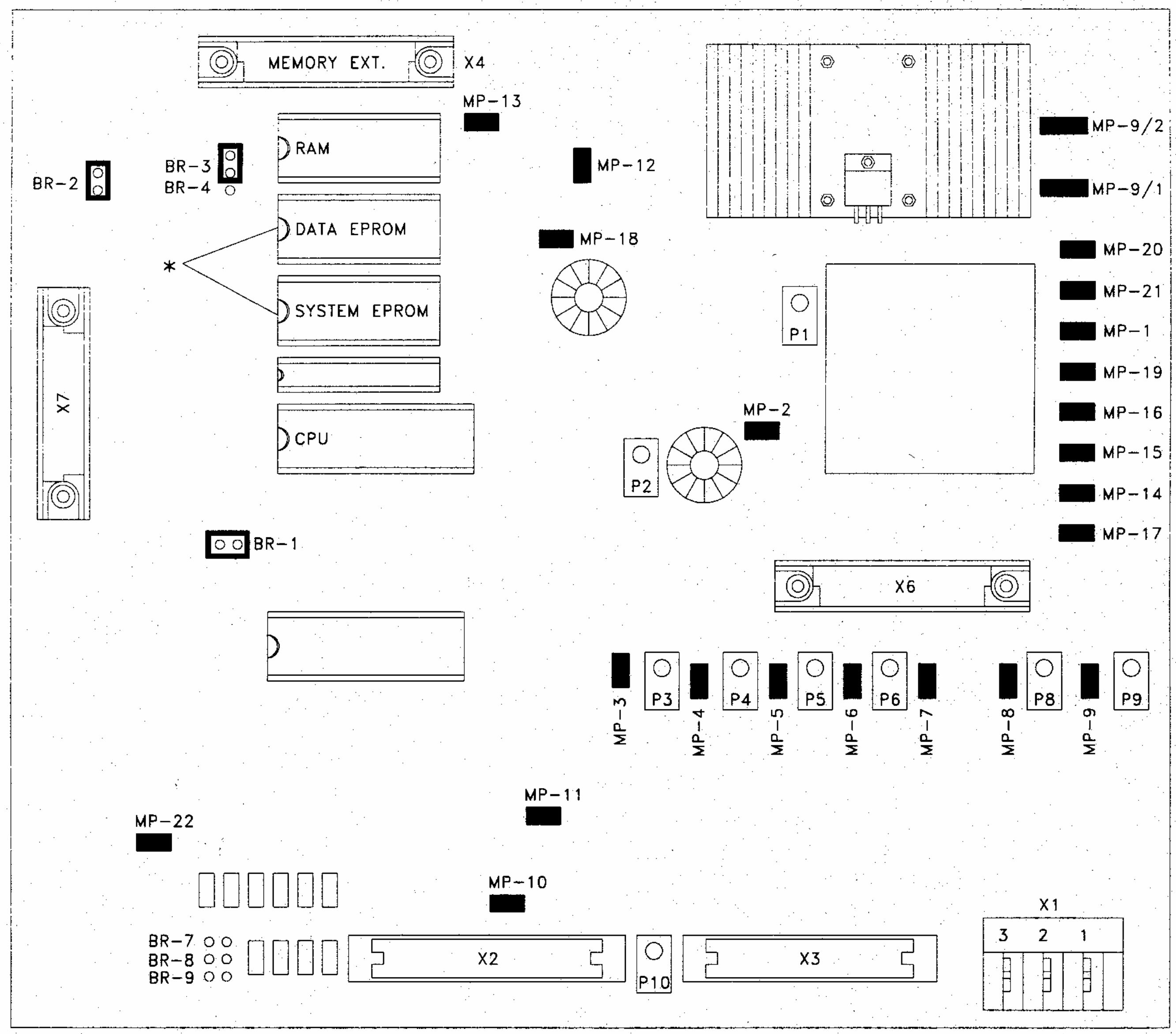


Cut inner shield back to approximately 1.2 inch. Then fold inner shield back to inner jacket, so the inner shield is 0.6 inches in length.



11. PROCEDURE 2A. EPROM LOCATION AND INSTALLATION

Main Board 024-350-300-094



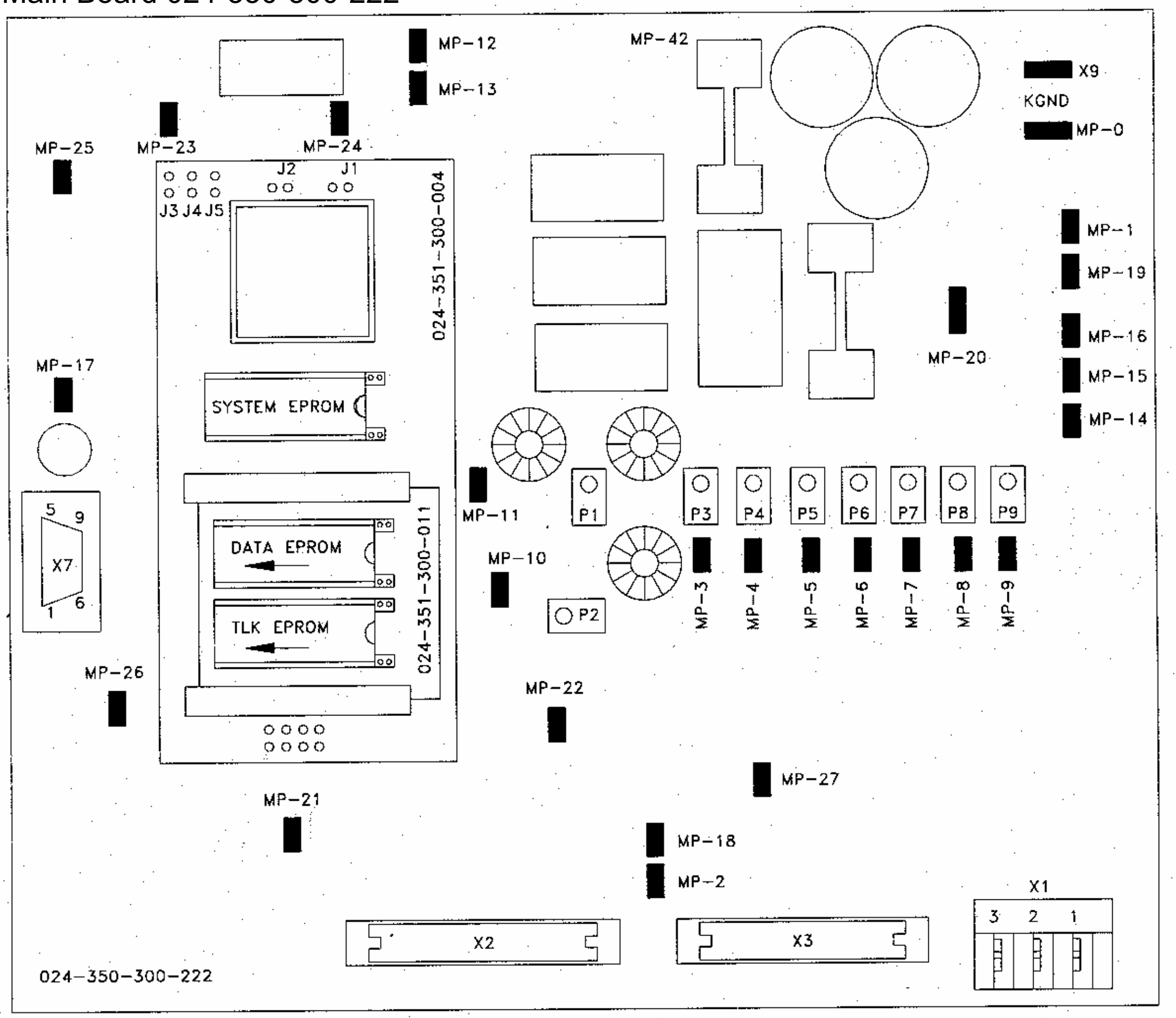
- Ensure the notch is in the correct direction.

  * Notch on EPROM must match the notch on the socket and markings on the board.

- Place EPROMs in the correct EPROM socket as shown.

11. PROCEDURE 2B.EPROM LOCATION AND INSTALLATION

Main Board 024-350-300-222



- Ensure the notch is in the correct direction. Notch on EPROM must match the notch on the socket and markings on the board.
- The DATA and TLK EPROMs fill the bottom of the socket as shown by the arrows.
- Place EPROMs in the correct EPROM socket as shown.

11. PROCEDURE 3A. MAIN BOARD 024-350-300-094 REPLACEMENT

Refer to Drawing 3A in Section 10, central unit parts list for board location.

NOTE

Mark all connections before removing, to identify location for reconnecting.

1. Turn system power off.
2. Remove the central unit lid.
3. See Procedure 2A for main board layout of data and system EPROMs. Use an EPROM puller to remove EPROM, be careful not to bend or break the legs on the EPROM. Remove data and system EPROMs from old board and place in new board.
4. Remove timer board and 90° adapter #20 and #21 from old board and place in new board, see Drawing 3A for timer board location.
5. Disconnect ribbon cable #7 and #8, see Drawing 3A.
6. Disconnect connection X1:1 and X1:3, see Drawing 3A.

CAUTION

Take care not to damage boards, when removing and inserting screws.

7. Remove the 9 main board mounting screws.
8. Take notice of the orientation of the main board in the central unit. Remove main board and place in the packing material that the replacement main board came in.
9. Carefully insert the new main board in place, see Drawing 3B.
10. Insert the main board mounting screws and washers.
11. Connect X1:1, X1:3 and ribbon cables #7 and #8, see Drawing 3A.
12. Inspect the gasket for nicks, cuts, or damages. Refer to 031-300-340-003 DS 350 Central Unit Gasket Recommendations and 031-300-340-002 Central Unit Cover Installation and Tightening Procedure.

11. PROCEDURE 3B. MAIN BOARD 024-350-300-222 REPLACEMENT

Refer to Drawing 3B in Section 10, central unit parts list for board location.

NOTE

Mark all connections before removing, to identify location for reconnecting.

1. Turn system power off.
2. Remove the central unit lid.

CAUTION

Take care not to damage the boards with the screw driver, when removing and inserting screws.

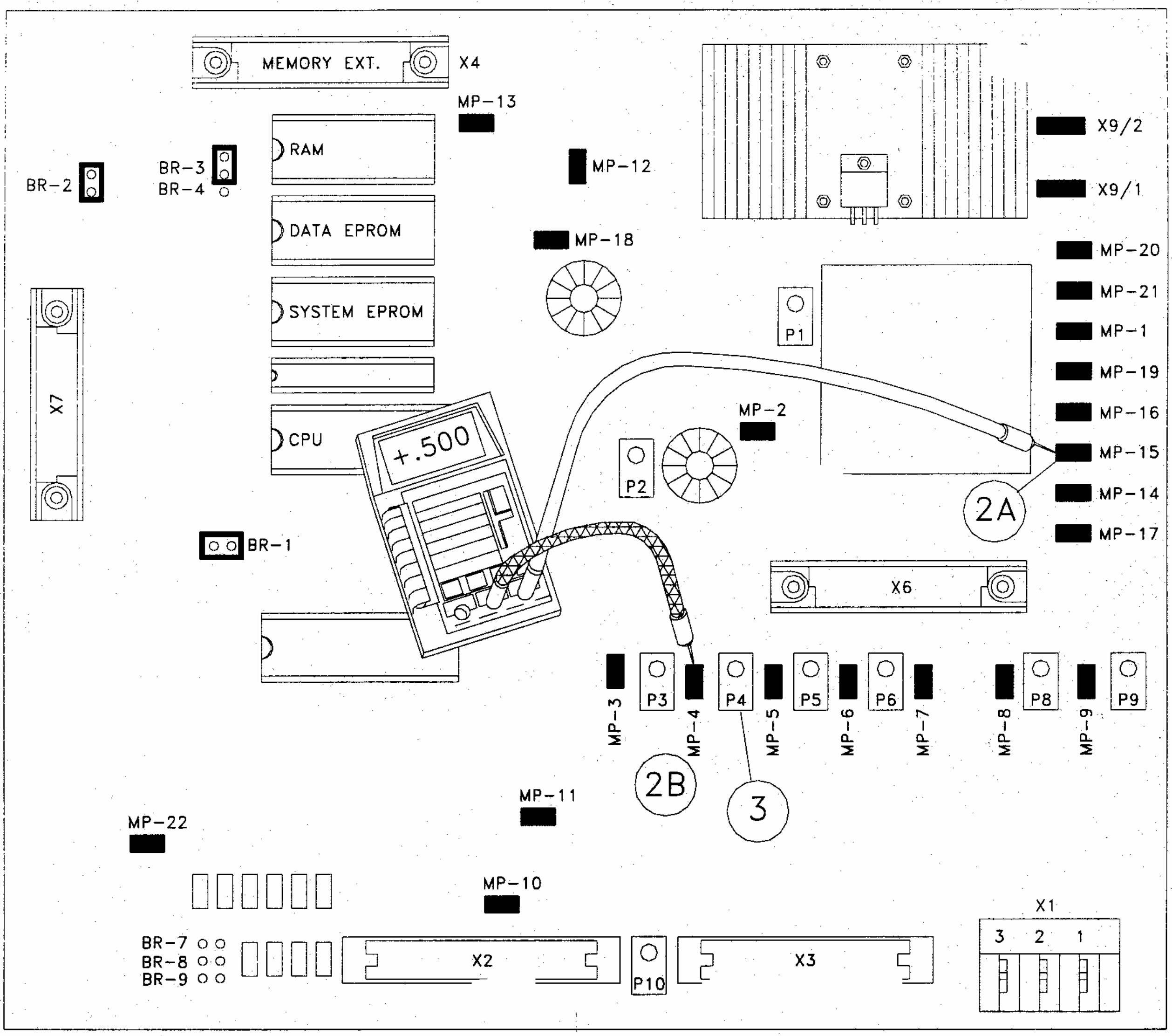
NOTE

Use care when lifting the CPU module board and analog input module from the main board, due to the fact that these boards have pins on the bottom side which insert into the main board.

3. Remove CPU module board and EPROM module Items #20 and #21, see Drawing 3B, by taking out the 4 small Philips screws holding them in place.
4. Disconnect ribbon cable #7 and #8, see Drawing 3B.
5. Disconnect connection X1:1 and X1:3, see Drawing 3B.
6. Remove the 9 main board mounting screws.
7. Take notice of the orientation of the main board in the central unit. Remove main board and place in the packing material that the replacement main board came in.
8. Carefully insert the new main board in place. see Drawing 3B.
9. Insert the main board mounting screws and washers.
10. Insert CPU module board by lining up the pins into the sockets on the main board and the 4 screws holes.
11. Insert the 4 small Philips screws and washers.
12. Connect X1:1, X1:3 and ribbon cables #7 and #8, see Drawing 3B.
13. Inspect the gasket for nicks, cuts, or damages. Refer to 031-300-340-003 DS 350 Central Unit Gasket Recommendations and 031-300-340-002 Central Unit Cover Installation and Tightening Procedure.

11. PROCEDURE 4A. PRESSURE TRANSDUCER ZERO ADJUSTMENT

Main Board 024-350-300-094



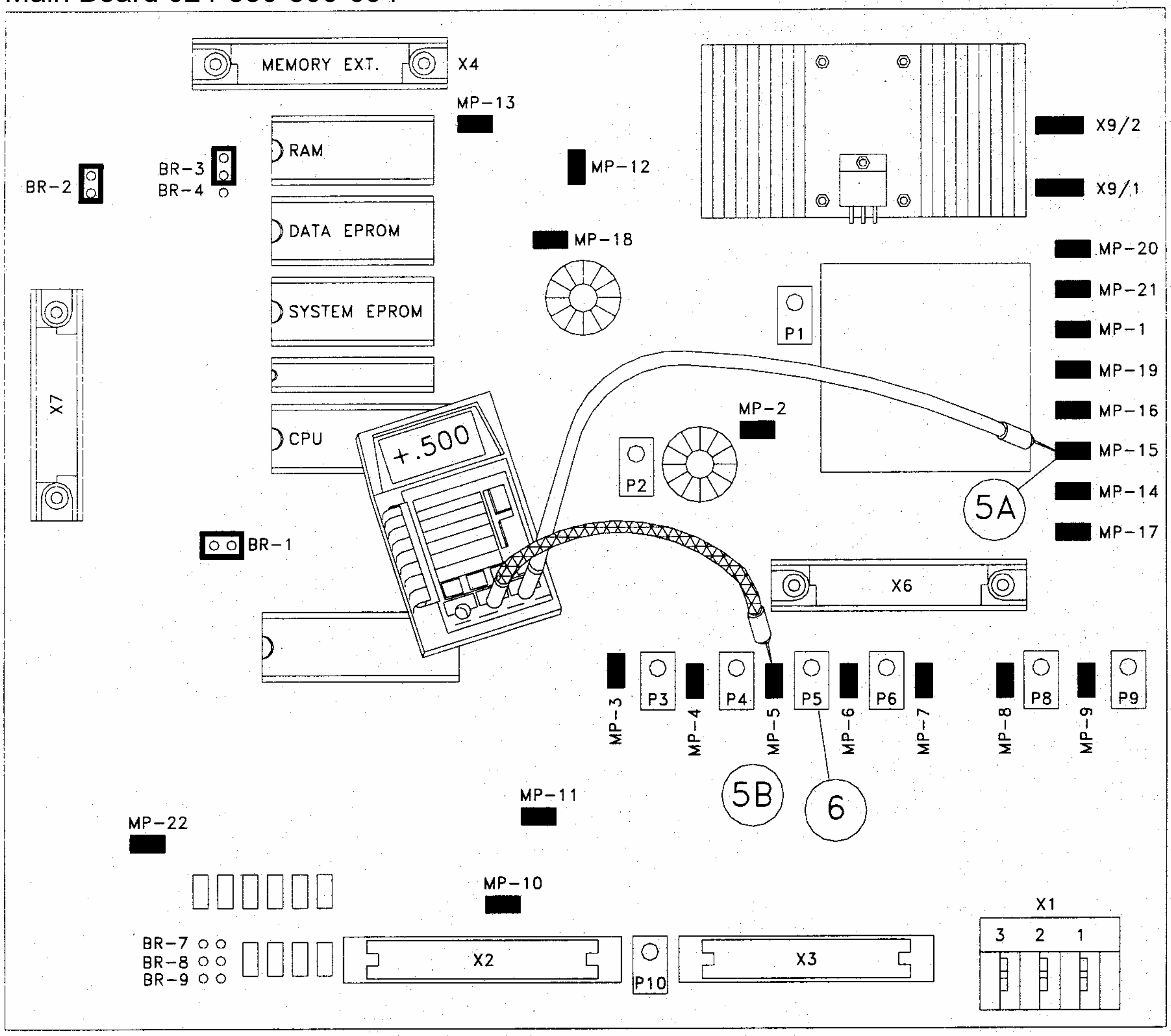
1. Lower boom all the way down (no rest pressure) then disconnect hydraulic hose from the piston side pressure transducer.
2. Connect a digital voltmeter to main P.C. board:

   A) black (-) lead to MP15

   B) red (+) lead to MP4
3. Adjust P4 to obtain a reading of 0.500 volts (500mV) on meter.

11. PROCEDURE 4A. PRESSURE TRANSDUCER ZERO ADJUSTMENT – continued

Main Board 024-350-300-094



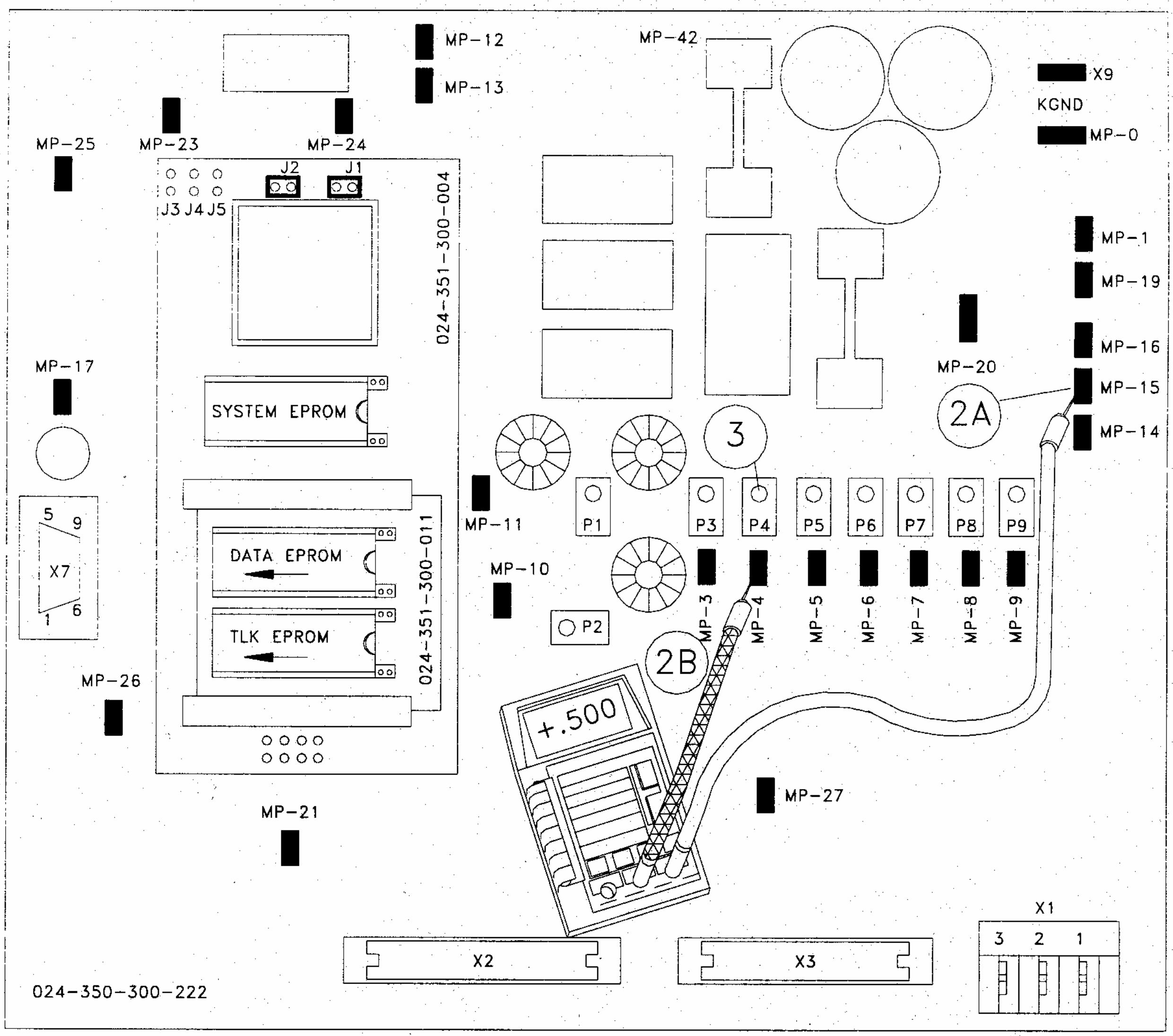
4. Disconnect hydraulic hose from the rod side pressure transducer.
5. Connect a digital voltmeter to main P.C. board:

   A) black (-) lead to MP15

   B) red (+) lead to MP5
6. Adjust P5 to obtain a reading of 0.500 volts (500mV) on meter.
7. Reconnect hydraulic hoses to pressure transducers, then bleed the air from hydraulic lines.

11. PROCEDURE 4B. PRESSURE TRANSDUCER ZERO ADJUSTMENT

Main Board 024-350-300-222



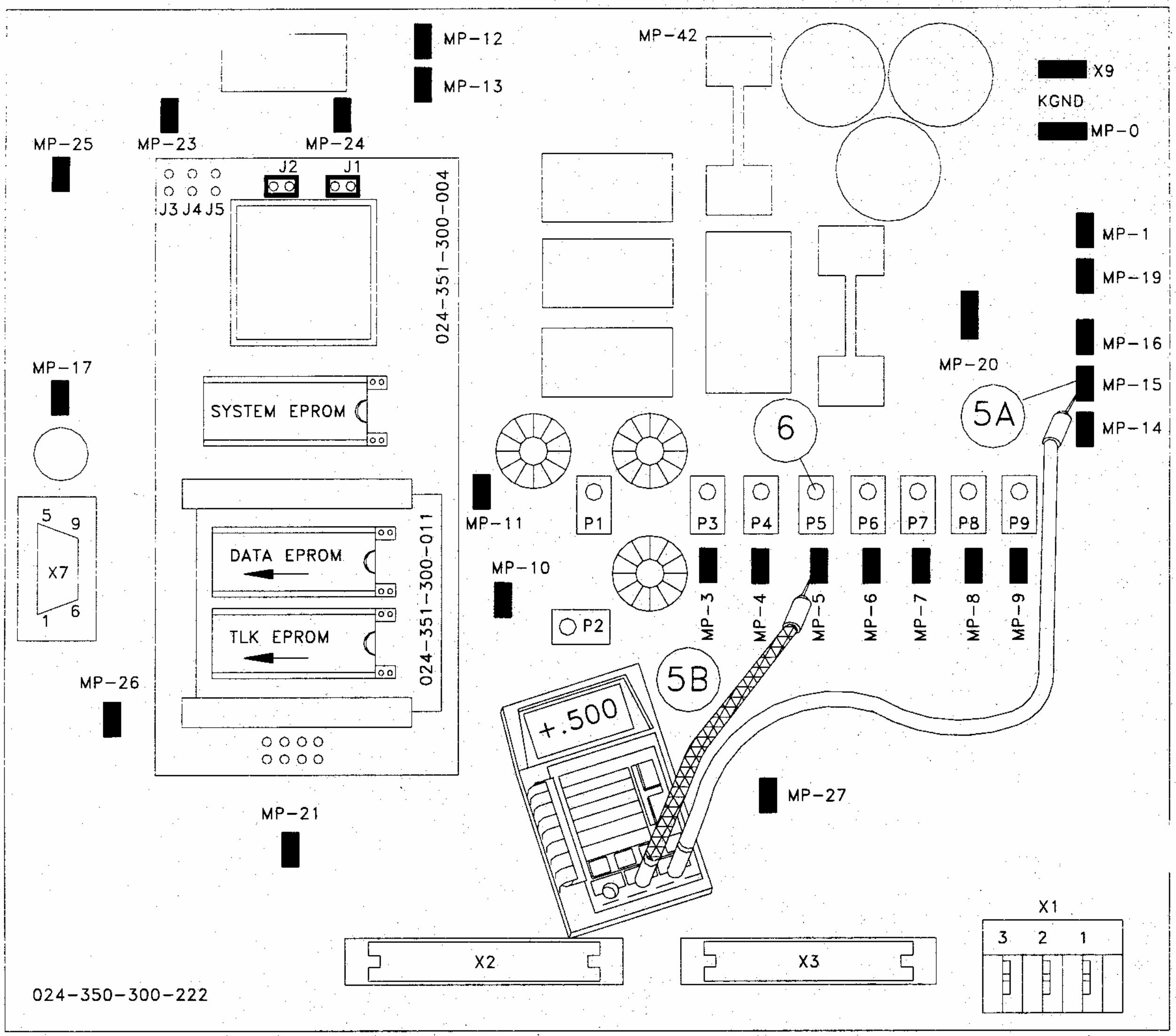
1. Lower boom all the way down (no rest pressure) then disconnect hydraulic hose from the piston side pressure transducer.
2. Connect a digital voltmeter to main P.C. board:

   A) black (-) lead to MP15

   B) red (+) lead to MP4
3. Adjust P4 to obtain a reading of 0.500 volts (500mV) on meter.

11. PROCEDURE 4B. PRESSURE TRANSDUCER ZERO ADJUSTMENT – continued

Main Board 024-350-300-222

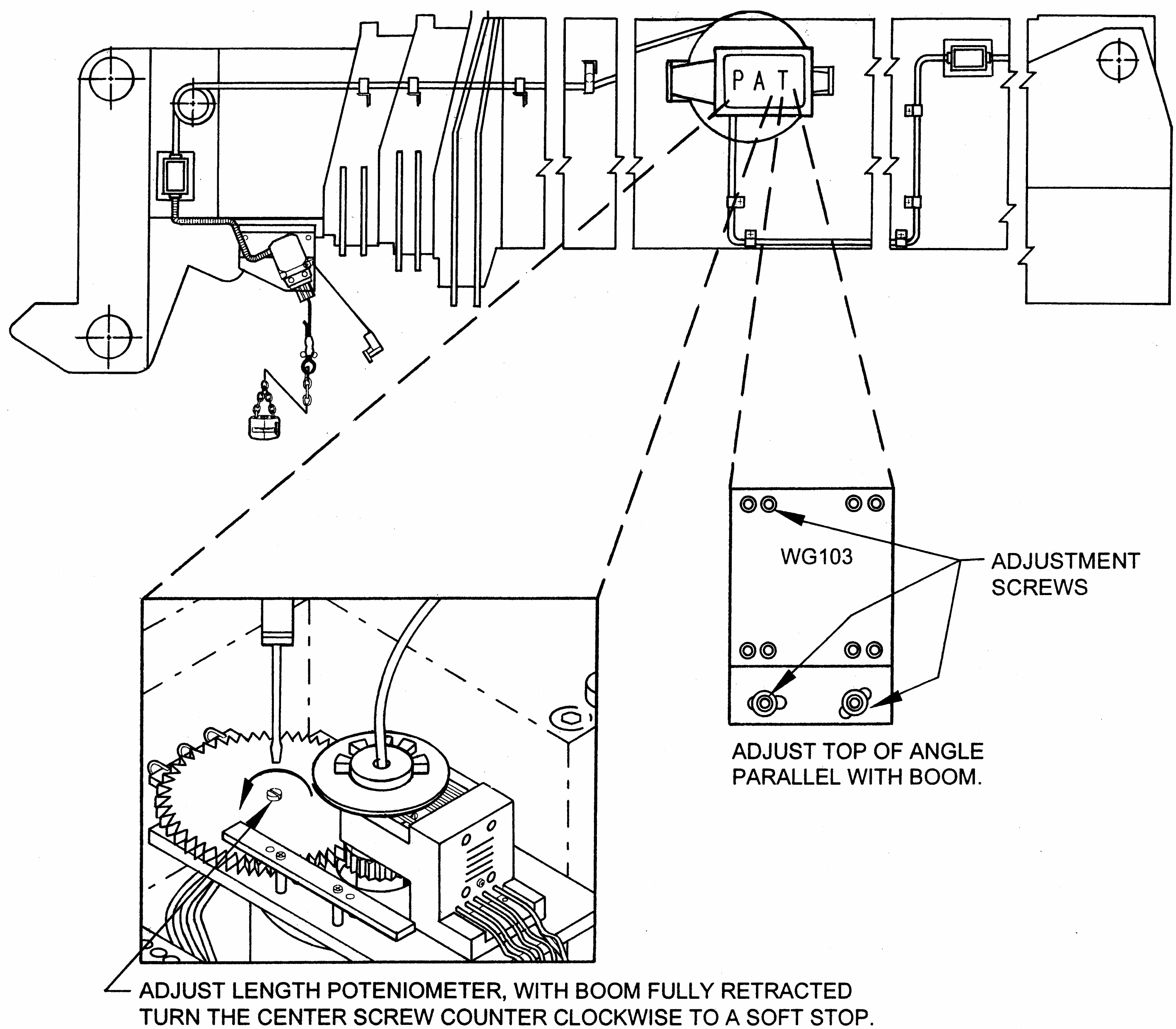


4. Disconnect hydraulic hose from the rod side pressure transducer.
5. Connect a digital voltmeter to main P.C. board:

   A) black (-) lead to MP15

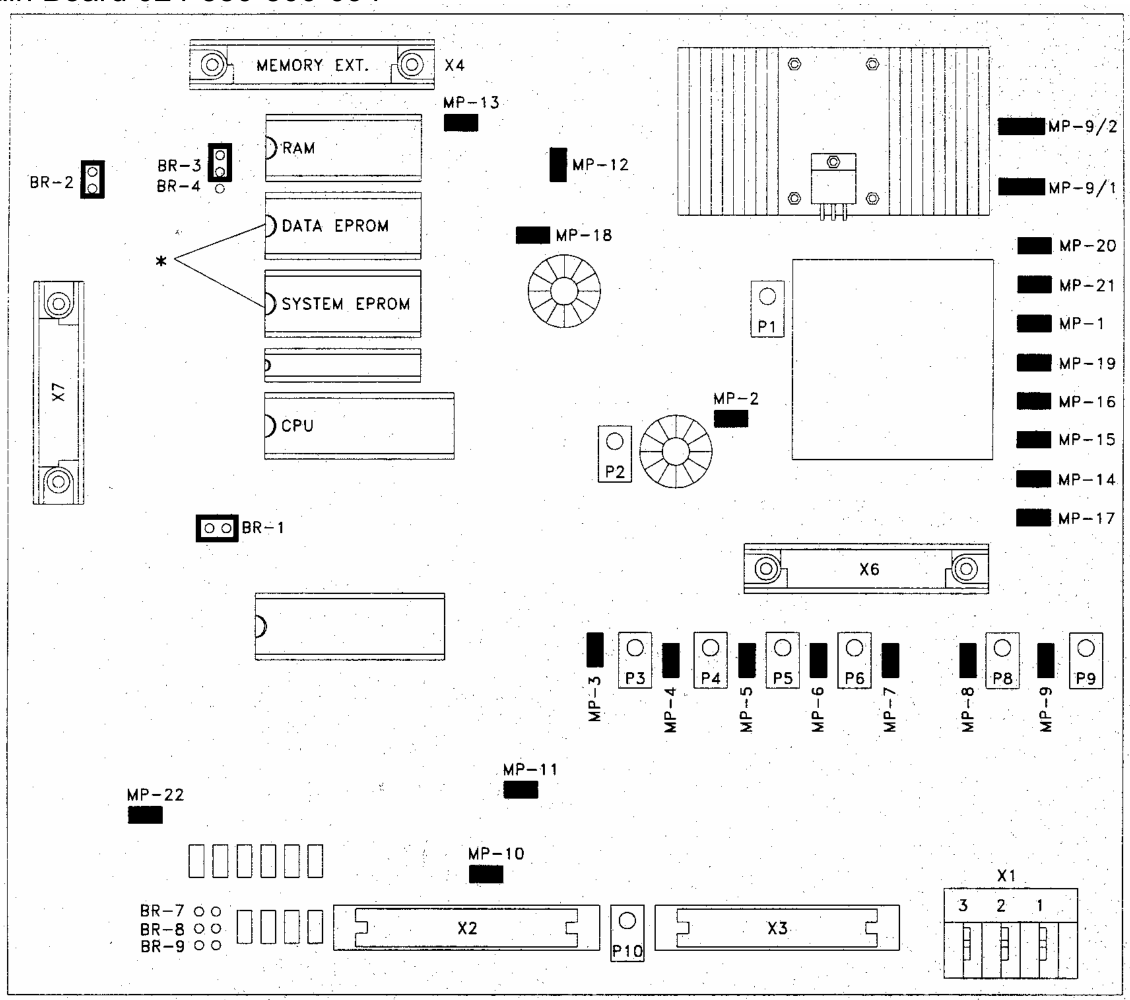
   B) red (+) lead to MP5
6. Adjust P5 to obtain a reading of 0.500 volts (500mV) on meter.
7. Reconnect hydraulic hoses to pressure transducers, then bleed the air from hydraulic lines.

11. PROCEDURE 5 LENGTH POTENTIOMTER AND ANGLE SENSOR ADJUSTMENT



12. THEORY 1A. MAIN BOARD MEASURING POINTS

Main Board 024-350-300-094



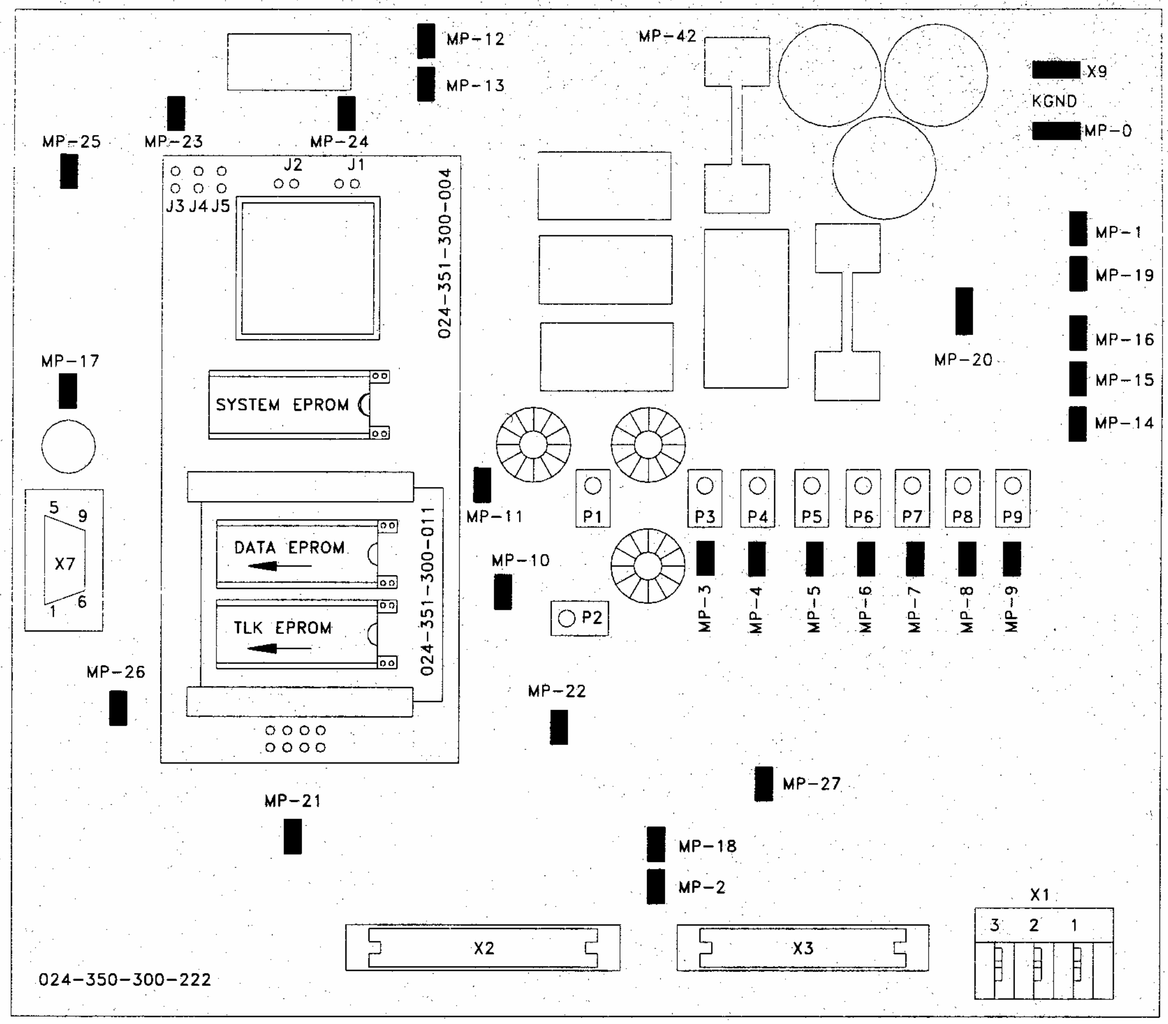
* Notch on EPROM must match the notch on the socket and markings on the board.

MP TEST POINTS

MP- 0 / X9 = KGND
MP- 1 = +5V
MP- 2 = -5V
MP- 3 = SIGNAL FORCE TRANSDUCER (LOAD CELL)
MP- 4 = SIGNAL PRESSURE PISTON SIDE
MP- 5 = SIGNAL PRESSURE ROD SIDE
MP- 6 = 1ST LENGTH INPUT FOR MAIN BOOM
MP- 7 = 2ND LENGTH INPUT
MP- 8 = ANGLE MAIN BOOM
MP- 9 = ANGLE LUFFING FLY JIB
MP-10 = +3V REFERENCE VOLTAGE
MP-11 = GROUND MP-12 = +5V
MP-13 = DIGITAL GROUND
MP-14 = +9V
MP-15 = ANALOG GROUND
MP-16 = -9V
MP-17 = +5V
MP-18 = +5V
MP-19 = -5V
MP-20 = OPERATING VOLTAGE
MP-21 = INPUT VOLTAGE
MP-22 = +10V
CH.1 BOOM LENGTH, MP-6/P6 (DO NOT ADJUST)
CH.2 FORCE CHANNEL, MP-4/P4 (NOT USED)
CH.3 FORCE CHANNEL, MP-5/P5 (AUX. HOIST)
CH.4 FORCE CHANNEL, - MP-3/P3 (MAIN HOIST)
CH.5 ANGLE CHANNEL, - MP-8/P8 (MAIN BOOM) (DO NOT ADJUST)
CH.6 ANGLE CHANNEL, - MP-9/P9 (LUFFING) (DO NOT ADJUST)

12. THEORY 1B. MAIN BOARD MEASURING POINTS

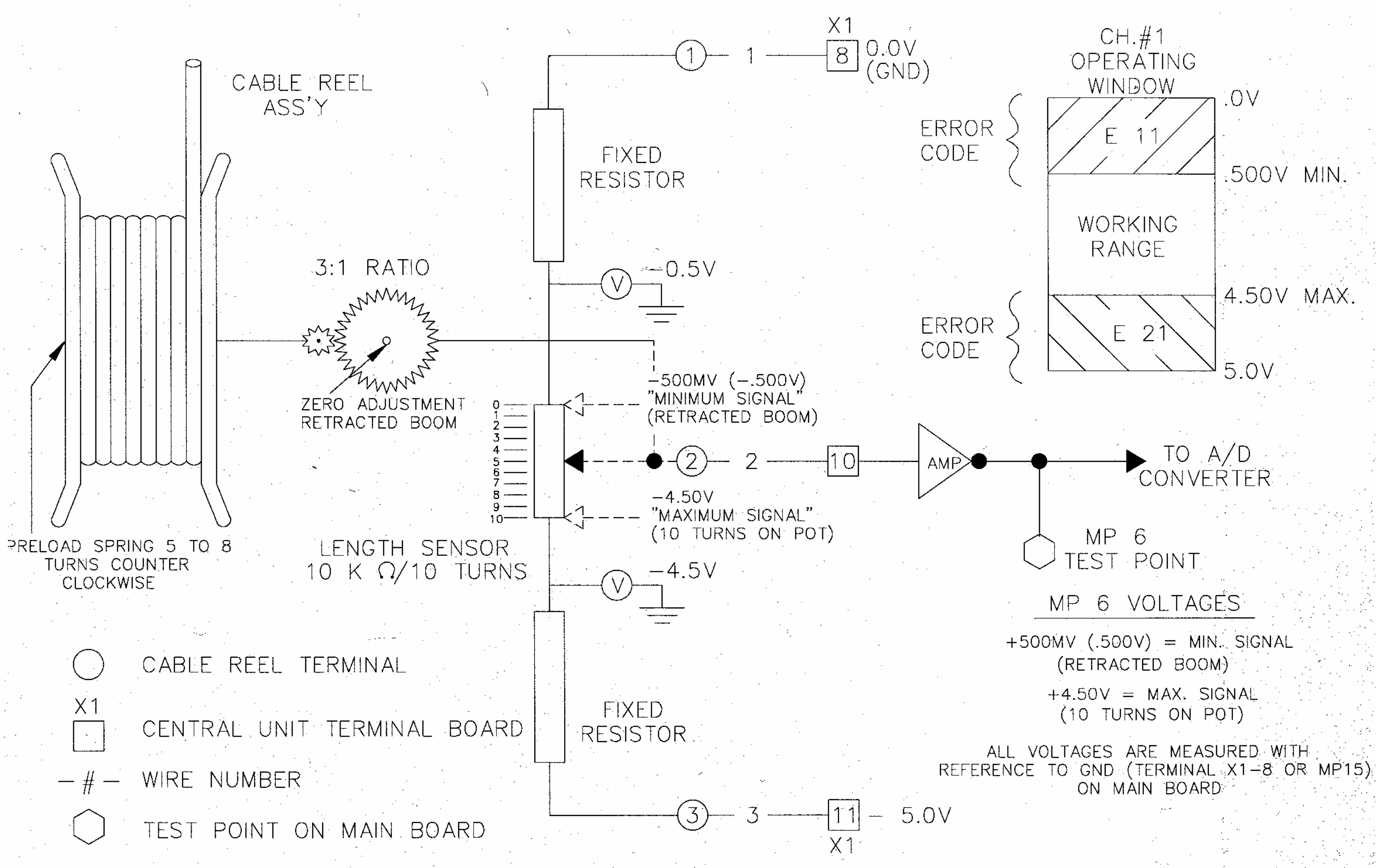
Main Board 024-350-300-222



MP TEST POINTS

MP- 0 / X9 = KGND
MP- 1 = +5V
MP- 2 = -5V
MP- 3 = SIGNAL FORCE TRANSDUCER (LOAD CELL)
MP- 4 = SIGNAL PRESSURE PISTON SIDE
MP- 5 = SIGNAL PRESSURE ROD SIDE
MP- 6 = 1ST LENGTH INPUT FOR MAIN BOOM
MP- 7 = 2ND LENGTH INPUT
MP- 8 = ANGLE MAIN BOOM
MP- 9 = ANGLE LUFFING FLY JIB
MP-10 = +3V REFERENCE VOLTAGE
MP-11 = GROUND MP-12 = +5V
MP-13 = DIGITAL GROUND
MP-14 = +9V
MP-15 = ANALOG GROUND
MP-16 = -9V
MP-17 = +5V
MP-18 = +5V
MP-19 = -5V
MP-20 = OPERATING VOLTAGE
MP-21 = INPUT VOLTAGE
MP-22 = +10V
CH.1 BOOM LENGTH, MP-6/P6 (DO NOT ADJUST)
CH.2 FORCE CHANNEL, MP-4/P4 (NOT USED)
CH.3 FORCE CHANNEL, MP-5/P5 (AUX. HOIST)
CH.4 FORCE CHANNEL, - MP-3/P3 (MAIN HOIST)
CH.5 ANGLE CHANNEL, - MP-8/P8 (MAIN BOOM) (DO NOT ADJUST)
CH.6 ANGLE CHANNEL, - MP-9/P9 (LUFFING) (DO NOT ADJUST)

12. THEORY 2. OPERATION OF LENGTH POTENTIOMETER



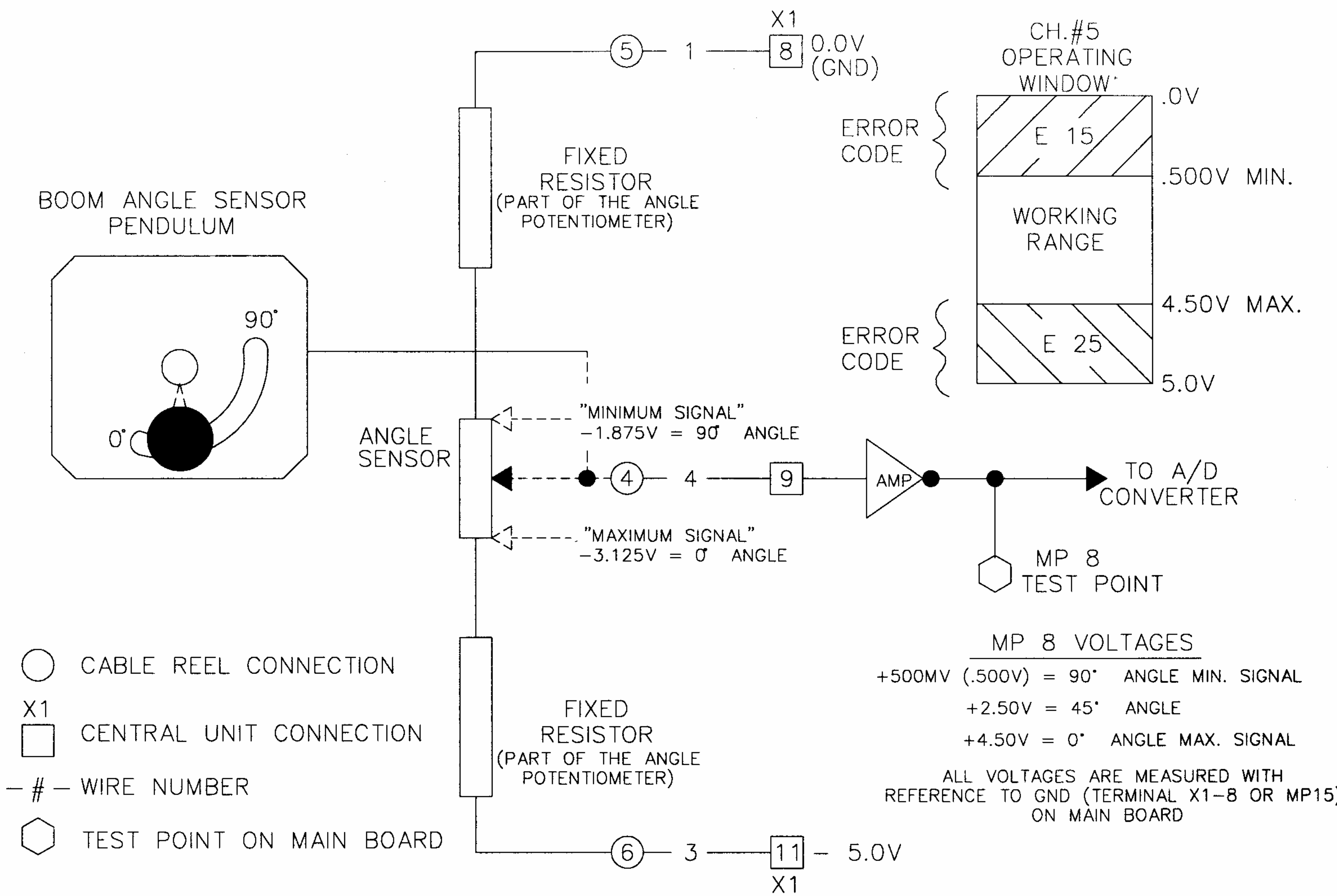
PAT DS350G/GW LMI
BOOM LENGTH MEASURING CHANNEL
CHANNEL #1

PAT DS350 MAIN BOOM LENGTH SIGNAL VOLTAGES

NO. OF TURNS ON CABLE REEL	NO. OF TURNS ON LENGTH POT.	"INPUT" SIGNAL IN VOLTS AT TERM. X1:10 IN CU (VOLTS)	"OUTPUT" SIGNAL IN VOLTS AT MP6 TEST POINT ON MAIN BOARD IN CU (VOLTS)
0	0	-0.50	0.50
3	1	-0.90	0.90
6	2	-1.30	1.30
9	3	-1.70	1.70
12	4	-2.10	2.10
15	5	-2.50	2.50
18	6	-2.90	2.90
21	7	-3.30	3.30
24	8	-3.70	3.70
27	9	-4.10	4.10
30	10	-4.50	4.50

(3 TURNS OF THE CABLE REEL = 1 TURN OF THE LENGTH POT = 0.4V)
Chart shows typical voltages. These voltages are to be used as reference only, the actual signal may vary slightly. For specific boom length voltages, check voltages at MP6 or X1:10 and compare with test data in central unit.

12. THEORY 3. OPERATION OF ANGLE SENSOR



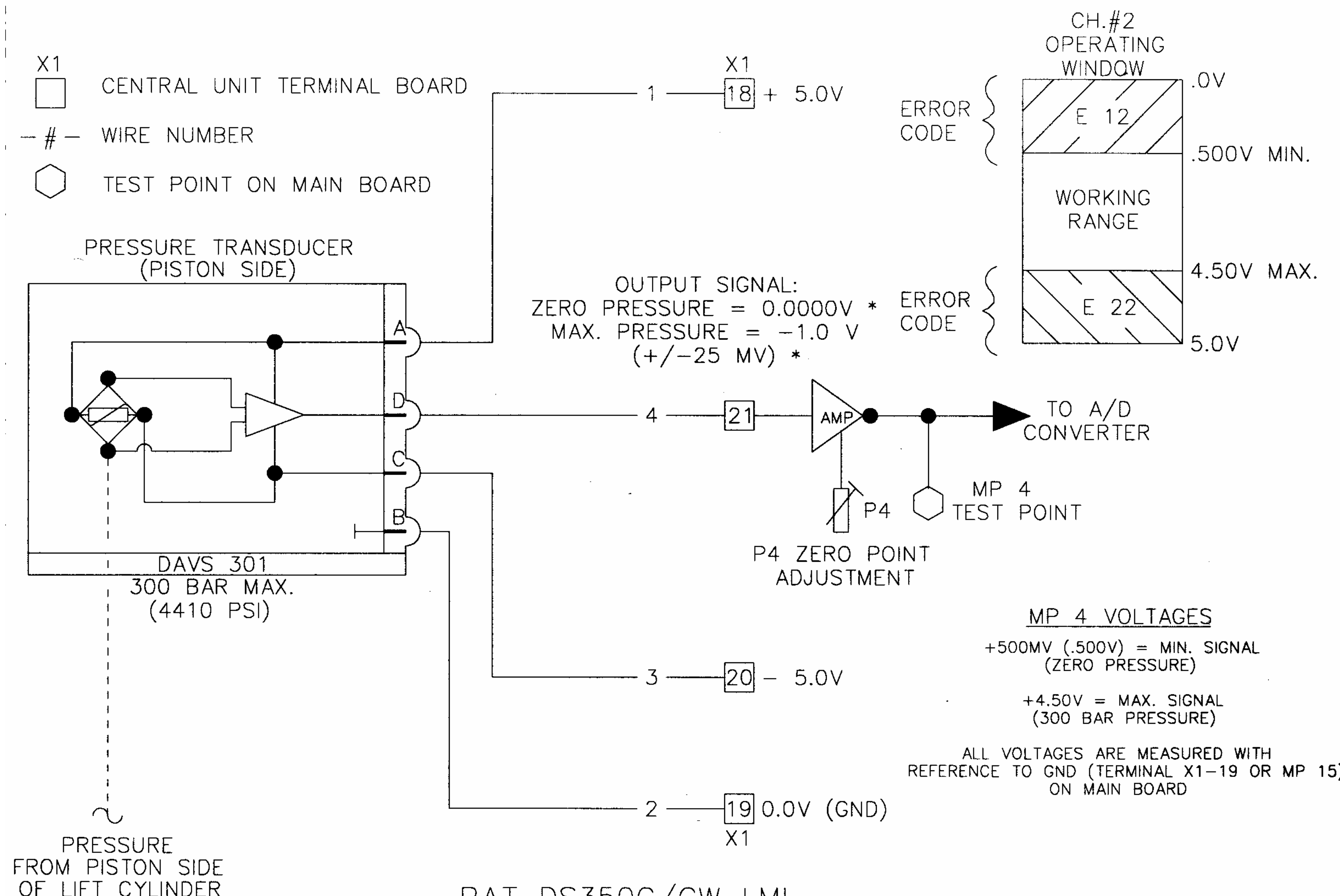
PAT DS350G/GW LMI
ANGLE MEASURING CHANNEL
CHANNEL #5

PAT DS350 MAIN BOOM ANGLE SIGNAL VOLTAGES

ACTUAL BOOM ANGLE	INPUT SIGNAL AT TERM #4 IN CABLE REEL AND TERM X1:9 IN CU (VOLTS)	OUTPUT SIGNAL AT MP8 TEST POINT ON MAIN BOARD IN CU (VOLTS)
90	-1.875	0.500
85	-1.944	0.722
80	-2.014	0.944
75	-2.083	1.167
70	-2.153	1.389
65	-2.222	1.611
60	-2.292	1.833
55	-2.361	2.056
50	-2.431	2.278
45	-2.500	2.500
40	-2.569	2.722
35	-2.639	2.944
30	-2.708	3.167
25	-2.778	3.389
20	-2.847	3.611
15	-2.917	3.833
10	-2.986	4.056
5	-3.056	4.278
0	-3.125	4.500

Chart shows typical voltages. These voltages are to be used as reference only, the actual signal may vary slightly.

12. THEORY 4. OPERATION OF PISTON SIDE PRESSURE TRANSDUCER



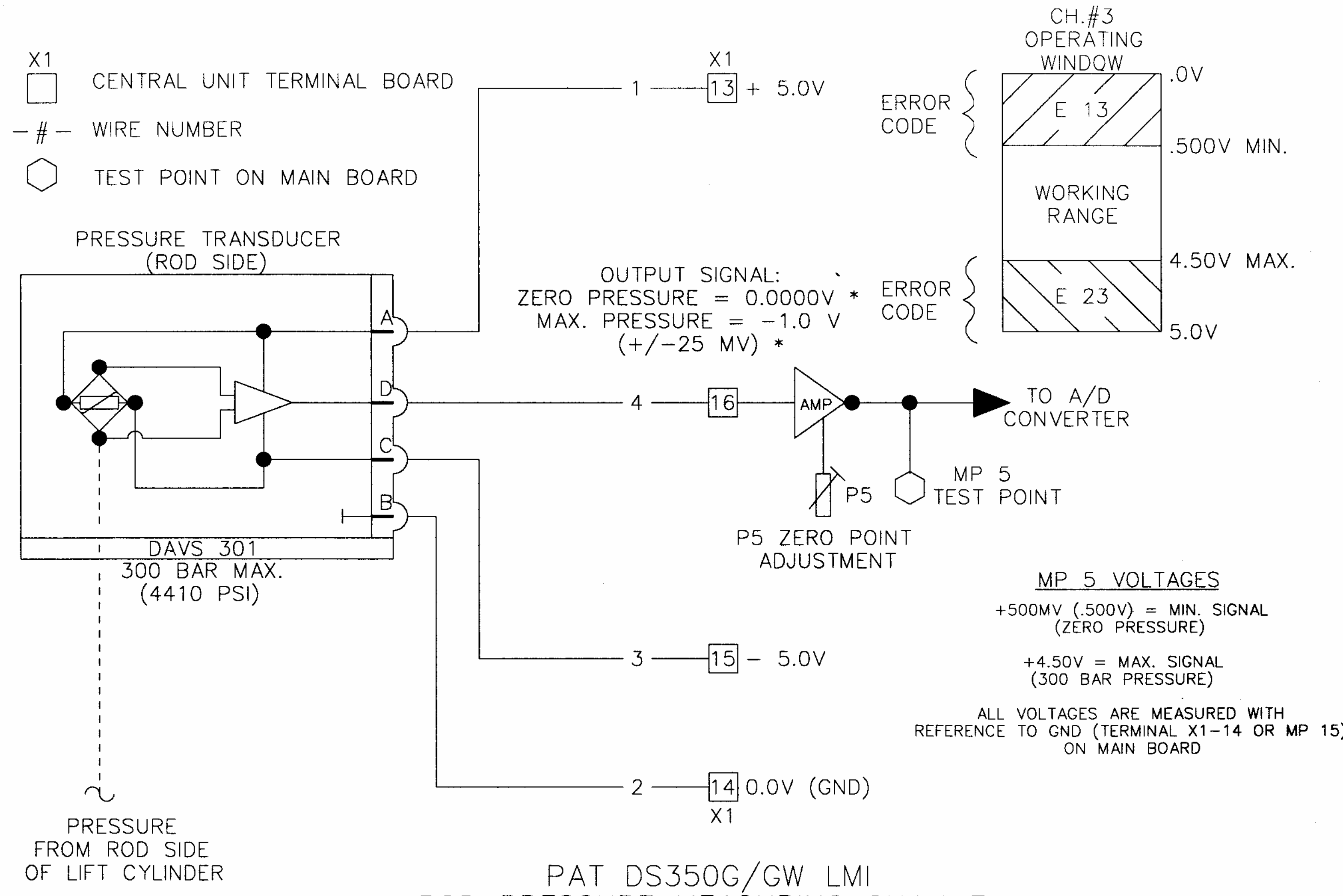
PAT DS350G/GW LMI
PISTON PRESSURE MEASURING CHANNEL
CHANNEL #2

PAT DS350 PRESSURE TRANSDUCER SIGNAL VOLTAGES

PRESSURE (PSI)	INPUT SIGNAL AT TERM X1:21 IN CU (MILLIVOLTS)	OUTPUT SIGNAL AT MP4 TEST POINT ON MAIN BOARD IN CU (VOLTS)
0	0.0	0.50
145	-33.3	0.63
290	-66.6	0.77
435	-99.9	0.89
580	-133.3	1.03
725	-166.6	1.17
870	-199.9	1.29
1015	-233.2	1.43
1160	-266.6	1.57
1305	-299.9	1.69
1450	-333.2	1.83
1595	-366.5	1.97
1740	-399.9	2.09
1885	-433.2	2.23
2030	-466.5	2.36
2175	-499.8	2.49
2320	-533.1	2.63
2465	-566.5	2.76
2610	-599.8	2.89
2755	-633.1	3.03
2900	-666.4	3.16
3045	-699.7	3.29
3190	-733.1	3.43
3335	-766.4	3.56
3480	-799.7	3.69
3625	-833.1	3.83
3770	-866.3	3.96
3915	-899.7	4.09
4060	-932.9	4.23
4205	-966.3	4.36
4350	-999.9	4.50

Chart shows typical voltages. These voltages are to be used as reference only, the actual signal may vary slightly.

12. THEORY 5. OPERATION OF ROD SIDE PRESSURE TRANSDUCER



PAT DS350G/GW LMI
ROD PRESSURE MEASURING CHANNEL
CHANNEL #3

PAT DS350 PRESSURE TRANSDUCER SIGNAL VOLTAGES

PRESSURE (PSI)	INPUT SIGNAL AT TERM X1:21 IN CU (MILLIVOLTS)	OUTPUT SIGNAL AT MP4 TEST POINT ON MAIN BOARD IN CU (VOLTS)
0	0.0	0.50
145	-33.3	0.63
290	-66.6	0.77
435	-99.9	0.89
580	-133.3	1.03
725	-166.6	1.17
870	-199.9	1.29
1015	-233.2	1.43
1160	-266.6	1.57
1305	-299.9	1.69
1450	-333.2	1.83
1595	-366.5	1.97
1740	-399.9	2.09
1885	-433.2	2.23
2030	-466.5	2.36
2175	-499.8	2.49
2320	-533.1	2.63
2465	-566.5	2.76
2610	-599.8	2.89
2755	-633.1	3.03
2900	-666.4	3.16
3045	-699.7	3.29
3190	-733.1	3.43
3335	-766.4	3.56
3480	-799.7	3.69
3625	-833.1	3.83
3770	-866.3	3.96
3915	-899.7	4.09
4060	-932.9	4.23
4205	-966.3	4.36
4350	-999.9	4.50

Chart shows typical voltages. These voltages are to be used as reference only, the actual signal may vary slightly.

APPENDIX G REVISIONS

REV	DATE	NAME	DESCRIPTION
-	10/27/97	CSH	Troubleshooting hand book created.
A	12/22/97	CSH	Add Appendix F Tool List - Pages changed #1, and Table of Contents
B	01/27/98	CSH	Chg console wiring in system diagram drawings 1 and 2 Correct drawing 3 and CU Parts List Correct drawing 4; Cable Reel Parts List Correct drawing 6; Console Parts List
C	02/10/98	CSH	Add Operator's Manual specifically created for the AT422T
D	03/06/98	CSH	Copy Error Codes to Operator's Section.
E	07/10/98	CSH	Chg CU to DS350/2767 with hardware for Accucal. AT422T Crane Serial Number 86638 and Beyond Restructure Troubleshooting Section • Drawings to Section 10 • Procedures to Section 11 • Theory to Section 12
F	02/02/99	CSH	Chg Key Switch Operation description in Operator's Hbk. Update Error Codes to match Trouble Shooting Section. Update TroubleShooting Section • Corrections to flow chart (dwg. no.'s and procedures) • Corrections to wiring diagrams • Update Central Unit Parts List • Update Console Parts List • Correction to Drawing 6 (Section 10) • Delete Section 13
G	03/30/99	CSH	Combine Trouble Shooting and Parts Manual. Handbook separate manual. • Corrections to wiring diagrams (console & J.B.) • Delete all Parts Lists from Trouble Shooting Section • Update Boom Nose Junction Box • Correction of Section 5 (Primary anti-two block problem) • Addition of Section 5a (Secondary anti-two block problem) • Addition of drawing 22 (Secondary anti-two block)
H	06/09/03	CSH	• Correct error codes in operator's and troubleshooting manual. • Correct section 4. No Display. • Correct section 10, drawing 6.

APPENDIX H

ZF SEMI-INTEGRAL POWER STEERING GEAR, TYPE 7421
INSTRUCTIONS FOR OPERATION, MAINTENANCE, AND INSPECTION

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ZF-Semi-Integral Power Steering Gear, Type 7421
(Single Circuit Steering Gear)

Instructions for
Operation, Maintenance and Inspection

Preface

These instructions are intended as an aid to ensure correct performance of the maintenance and repair jobs on ZF Power Steering Gear.

We should like to emphasize that steering systems should be repaired on principle in workshops only, which have:

1. trained personnel
2. the specified equipment e.g.,. test bench, crack-testing equipment and special tools

All the work on steering systems must be performed with maximum care and precision. This applies in particular for steering systems and transmission elements for vehicles following an accident and damaged as a result of external forces. The manufacturer of the respective part is not liable for damage and the resulting consequences due to incorrect and inexpert repairs within the scope of contractual liability.

For the compilation of these instructions the standard steering system used for this purpose may differ slightly with regard to operations and technical details on the unit to be repaired. Consequently, these instructions belong into the hands of expert foremen and mechanics whose practical and theoretical training in our Service Training Center is supplemented by this reference volume.

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1. IMPORTANT INFORMATION FOR DRIVER

ZF Power Steering Gears which are installed according to instructions, expertly maintained and operated free of accidents will attain a long life. To obtain full functional capacity, we recommend a checkup of all mechanical steering components (visual check of all and a crack test of highly stressed parts as well as an exchange of seals and gaskets within scope of 3rd inspection (refer to Section 8, Page H-24.).

The size of the steering system and the mechanical steering ratio are selected in cooperation with the manufacturer of the respective vehicle in such a manner that in the event of a failing hydraulic steering support (power steering) the max actuating forces to be applied at steering wheel will not exceed a maximum extent considered reasonable by pertinent legislation.

This force is 600 N at the circumference of the steering wheel when the car, traveling straight ahead, is turned into a circle with a 12 m radius (BO-circle - FRG- specific). At a road speed of approx. 10 km/h, the requisite lock should be applied within 6 seconds at the most, or 8 seconds in the case of vehicles having a design-related maximum speed of 25 km/h. The driver must be aware that should the hydraulic assistance suddenly fail, due to the failure of the pump drive, for example, the vehicle will still be steerable although considerably more force will be necessary to turn the steering wheel. Since situations of this nature are extremely rare and generally give no prior warning of their occurrence, the driver may mistakenly assume that the steering system is locked. However, this is not the case. The driver need only apply the requisite force to steer the vehicle.

Single-circuit steering systems which require the application of a force in excess of 600 N to steer the aforementioned BO-circle in the event of the hydraulic assistance failing are equipped with an engine-independent back-up emergency steering pump.

This important information is intended to serve general safety and should be of assistance to clarify interrelations as described above to protect the driver against erroneous assumptions in such a case.

2. CONSTRUCTION AND FUNCTION – ZF SINGLE CIRCUIT POWER STEERING GEAR, TYPE 7421

2.1 Construction:

The ZF Single Circuit Power Steering Gear comprises a completely mechanical steering gear unit, where the power is transmitted from the steering spindle to the steering nut and from there to the sector shaft. In a single circuit power steering gear there is one hydraulic control valve before steering nut, centrally in relation to steering spindle and organically attached to steering case.

The valve in front of the steering nut controls steering circuit I with either a drive dependent pump or an engine-driven pump and an additional drive-dependent pump (3-pump steering system). If one circuit fails - for example circuit II because the engine has stopped - hydraulic assistance is maintained by the additionally connected emergency steering pump which is driven by the forward movement of the vehicle. The valve housings of each steering circuit accommodate a **replenishing valve**, through which oil can be in-taken from the return line when one circuit is without hydraulic assistance, and a **pressure-relief valve** which protects the lines if an obstacle is encountered or limits operating pressure in steering systems without steering-lock limitation.

Steering systems with mechanical steering-lock limitation:

Adjustment is by means of adjuster rings on the steering spindle on the steering gear.

Outside the steering gear each circuit requires:

One or two **pressure oil pumps** per steering circuit. The flow volume must be designed in such a manner that a steering speed of approximately 1.5 steering wheel turns per second is possible. On engine-dependent pump, this steering speed should be available within entire speed range of engine as required for normal driving. In some cases, this steering speed can be reduced in lower speed range, but should not drop below one steering wheel turn per second at idle speed. For the drive-dependent pump the transmission ratio from drive to pump should be selected in such a manner that the above steering speed is attained at a vehicle speed of approx. 10 km/h.

One or more **power cylinders** attached to the steered axle or axles of the vehicle and connected to the steering system valve by high-pressure hoses or pressure pipes. A ball joint or universal joint connects the piston rod of the power cylinder to the steering arm or track arm, or in some cases to the track rod.

2.2 Function:

To obtain hydraulic support via steering, which is initiated by turning the steering wheel, the worm and the two valve sleeves (on single circuit power steering gears one valve sleeve) must be displaced from their neutral position. The worm is held in this neutral position by means of cup springs. For this reason, forces must be provided to overcome the preload of the spring. The steering nut, positively connected with sector shaft and with the steered wheels, will resist the rotary movement. When the steering system is operated, the worm is therefore axially loaded via steering nut and ball chain and the resistance of the spring is overcome. As a result of the connected movement of the valve sleeves from their neutral position the valve control grooves will be adjusted.

As a result, the pressure oil is now routed only to one side of the double side power cylinder. Under influence of the pressure difference in power cylinder an axial force will act on piston rod. The direction in which the piston rod is moving is respectively controlled in such a manner that it will follow the movement of the steering linkage which is generated by turning the steering wheel, and will thereby support the steering movement.

When the steering wheel is released, the cup springs will make sure that the valve returns back to its neutral position.

A cross-type disk provides longitudinal compensation between steering spindle and worm, preventing transmission of the worm's axial movement to the steering column.

If a force acts in the reverse direction from the wheels to the steering linkage while the driver is holding the steering wheel in its position, the worm is again axially displaced; now, however, the hydraulic support is acting in the opposite direction and absorbs the impact and will thereby relieve the driver.

But if a force is transmitted from the direction of the wheels to the steering gear and the steering wheel is released, e. g. while driving around a bend, the worm will not be displaced axially owing to the preload of the springs, but will automatically perform a rotary movement.

The force of the cup spring preload is therefore important for the return movement of the steering system.

Legend for Figure 1

A. Two-chamber Oil Reservoir
B. Pressure Oil Pump, engine-driven
C. Pressure Oil Pump, drive-dependent
D. Not used
E. Valve Unit comprising:
   a. Flow Rate Indicator
   b. Supplementary Valve
   c. Check Valve
   d. Check Valve
   e. Remote Control Valve
F. Check Valve
G. Replenishing Valve
H. Pressure Limiting Valve
I. Not used
J. Not used
K. Not used
L. Steering Limit Valve
M. Not used
N. Sector Shaft
O. Steering Nut
P. Worm
Q. Steering Spindle

NOTE

Control valve in operating position. Steering wheel turned counter-clockwise. Steering limit valves closed, only drive-dependent pump (emergency steering pump) is delivering oil.

This figure depicts a typical installation. Refer to the ATEC hydraulic schematics for specific configuration.

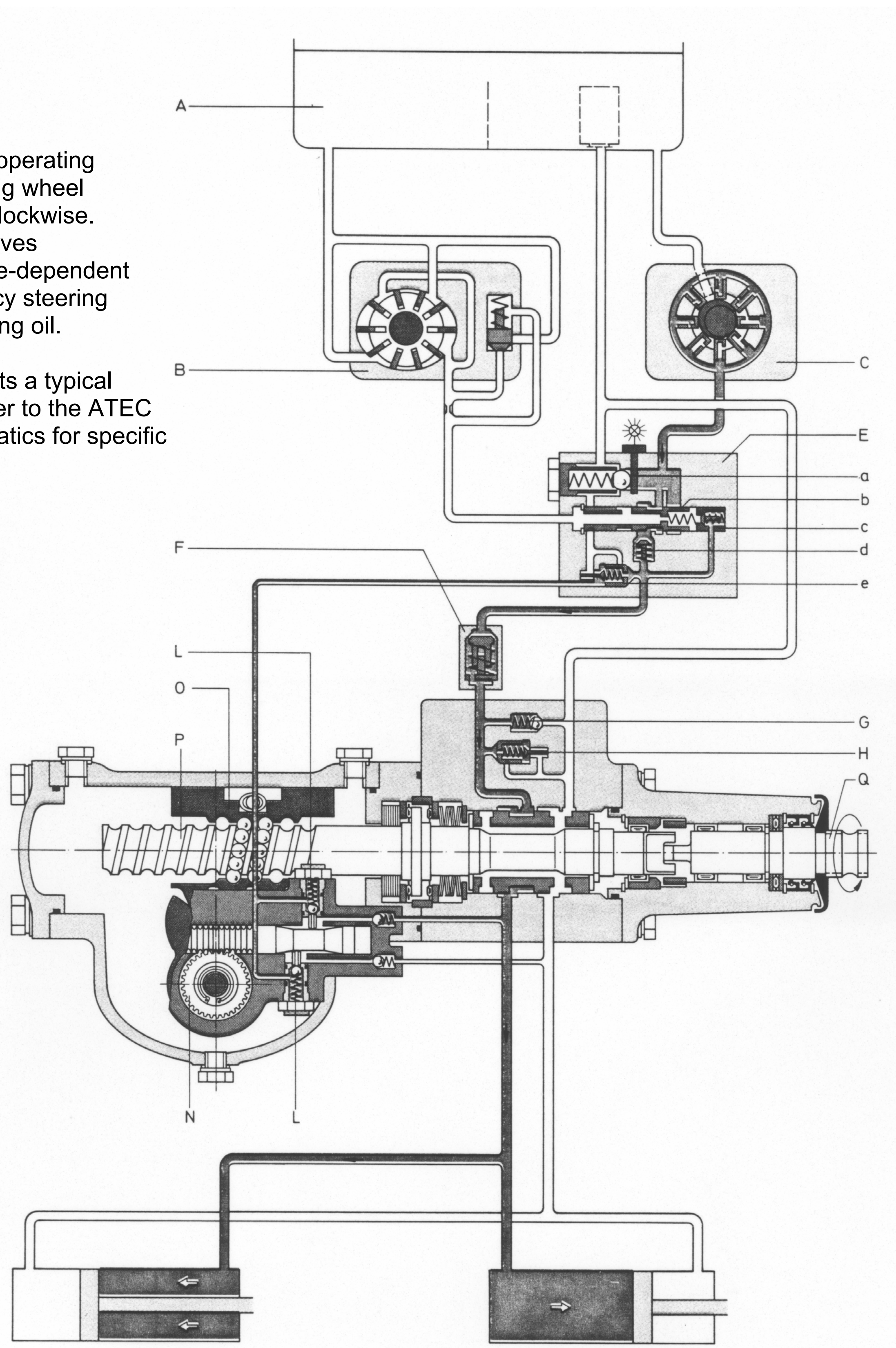


Figure. 1. Diagrammatic view of a ZF Single Circuit Power Steering Gear with an engine-driven or a drive-dependant pump (emergency steering pump)

3. FUNCTION AND ADJUSTMENT OF HYDRAULIC STEERING LIMIT (STEERING LOCK)

NOTE

Find numbers in ( ) refer to the illustrations in Section 12.

3.1 ZF Single Circuit Power Steering Gear, Type 7421

3.1.1 Function

The housing cover (21) holds the control piston (224) which is axially moved by the teeth at face end on sector shaft. On one side of the control piston are two steering limit valves (231), their balls are moved by cones on control piston via pins (229). When the sector shaft is rotated, the pistons will remain in rest position until a cone of the control piston encounters and thereby raises a pin. As a result, the hydraulic steering limit can be separately controlled for each steering circuit. The two steering limit valves are connected with remote control valve by means of a common control line. The steering limit valves are simultaneously connected with the power cylinders by way of check valves. When the control piston is moved to the right when the steering wheel is turned, steering limit valve (b2) will open after a given pitman arm deflection. The opening point of the steering limit valve can be changed by screwing in or out.

The result is that the oil pressure in the control line to remote control valve drops and the oil will flow through the opened check valves in the power cylinder sides connected to the return flow line. The connections of the power cylinders are selected in such a manner that with the steering limit valve opened no pressure rests against check valve or that the respective power cylinder side is connected with the return flow line. The remote control valve opens so that the oil flow generated by the pumps flows into the return line. The steering limit valve (a2) remains closed during this procedure.

If the control piston is moved to the left when the steering wheel is turned, the steering limit valve (a2) will open after a given pitman arm deflection, so that the pressure of the oil in the control line will drop and the remote control valve will let the oil flow from the pump into the return line.

With the steering limit valves opened the steering can be turned up to stop in steering or in power cylinder at increased manual force and considerably reduced hydraulic support (e.g. with drag link disconnected).

3.1.2 Adjustment

Screw in pressure gauge (pressure range up to 250 bar) into pressure line between pump and pressure connection 1 of steering control valve (refer to Fig. 3) and jack steering axle(s). Position vehicle jack at axle. If the vehicle has no rigid steering axle(s), the steered wheels for adjusting the hydraulic steering limit must be placed on rotary supports; the steering axle must be definitely loaded for the approximate compensation of deflection faults which may occur while measuring. On vehicles with hinged frame steering no axle need be jacked up. Turn steering with engine running without major manual force up to wheel lock. Have another mechanic hold a spacing sheet 2 - 3 mm thick between the wheel lock components so that a small reserve is still available.

The thickness of the sheet depends on the stiffness of the steering system and it is therefore possible that on some vehicles the sheet must be thicker. After lock has been attained, a short period (max 5 s) of turning the steering wheel will overcome the resetting force of the steering valves until a fix stop has been attained. This requires a circumferential force on steering wheel of approx. 100 - 200 N. In this position, the pressure gauge should indicate an oil pressure of 30 to 35 bar. The adjustment is corrected by loosening the counternuts (b1 or a1) and screwing the respective adjusting screw (b2 or a2) in or out; 20º turning travel on adjusting screw corresponds with a pitman arm deflection of 1º. While turning the adjusting screw, release steering wheel so that only a passing pressure will be established during this job. Then tighten counternut (b1 or a1) to 30 Nm. The adjustment for the second wheel lock is performed in the same manner. Adjusting screw (b2) and counternut (b1) in Fig. 2 must be adjusted, when the pitman arm is moved in direction “A” as shown in Fig. 3. The adjusting screw (a2) and the counternut (a1) are adjusted likewise, when the pitman arm is turning in direction “B”.

After adjustment has been made as described, the hydraulic support should be available until shortly before reaching wheel lock.

If the pressure drops too early or too late when turning the pitman arm in direction “A” or “B”, the adjusting screws (b2) and (a2) must be turned as described below.

If the pressure measured is higher than 35 bar, the respective steering limit valve must be screwed further into the cover (clockwise).

If the pressure measured is lower than 30 bar, the respective steering limit valve must be turned further out (counterclockwise).

In Fig. 4, the distance “f” is the clearance between the wheel-stop components which should be 1 - 3 mm when the hydraulically remote-controlled or mechanical steering-lock limitation responds.

3.1.3 Checkup:

Drive normally loaded vehicle slowly and turn steering wheel until power-assist switches off. Between the wheel lock (wheel stop) components there should now be a gap of 1 - 3 mm which corresponds with a steering wheel turn of approx. 20 degrees up to 30 degrees.

Legend for Figures 2 and 3

1.	Pressure Connection
2.	Return Connection
3.	Power Cylinder Connection
4.	Power Cylinder Connection
5.	Oil Pump
6.	Not used
7.	Oil Tank
8.	Not used
9.	Control Line – Remote Control Valve with Supporting Valve
10.	Pressure Line
11.	Suction Line
12.	Return Line
13.	Pressure Gauge
a2.	Adjusting Screw of Hydraulic Steering Limit for Pitman Arm Deflection in Direction B
b2.	Adjusting Screw of Hydraulic Steering Limit for Pitman Arm Deflection in Direction A
A/B	Control Lines – Power Cylinders

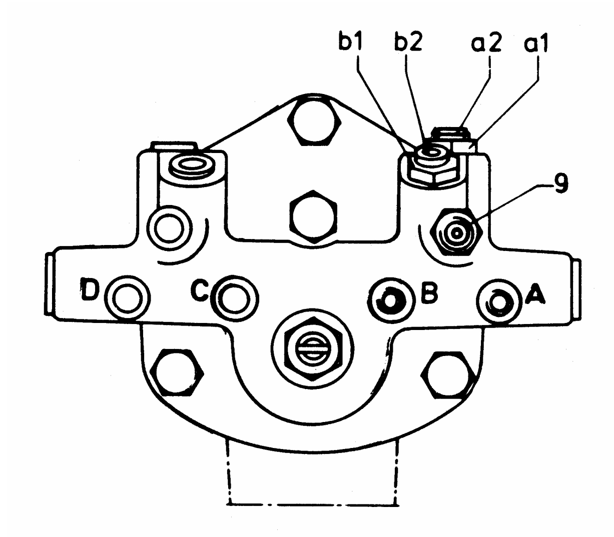


Figure 2.

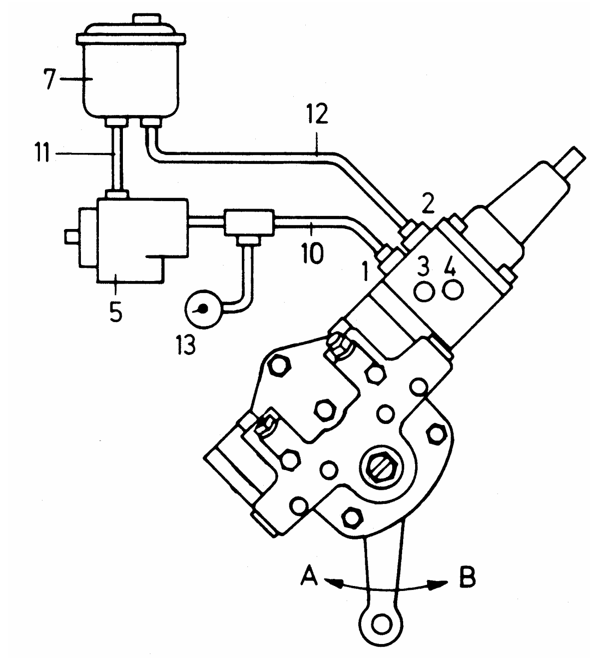


Figure 3.

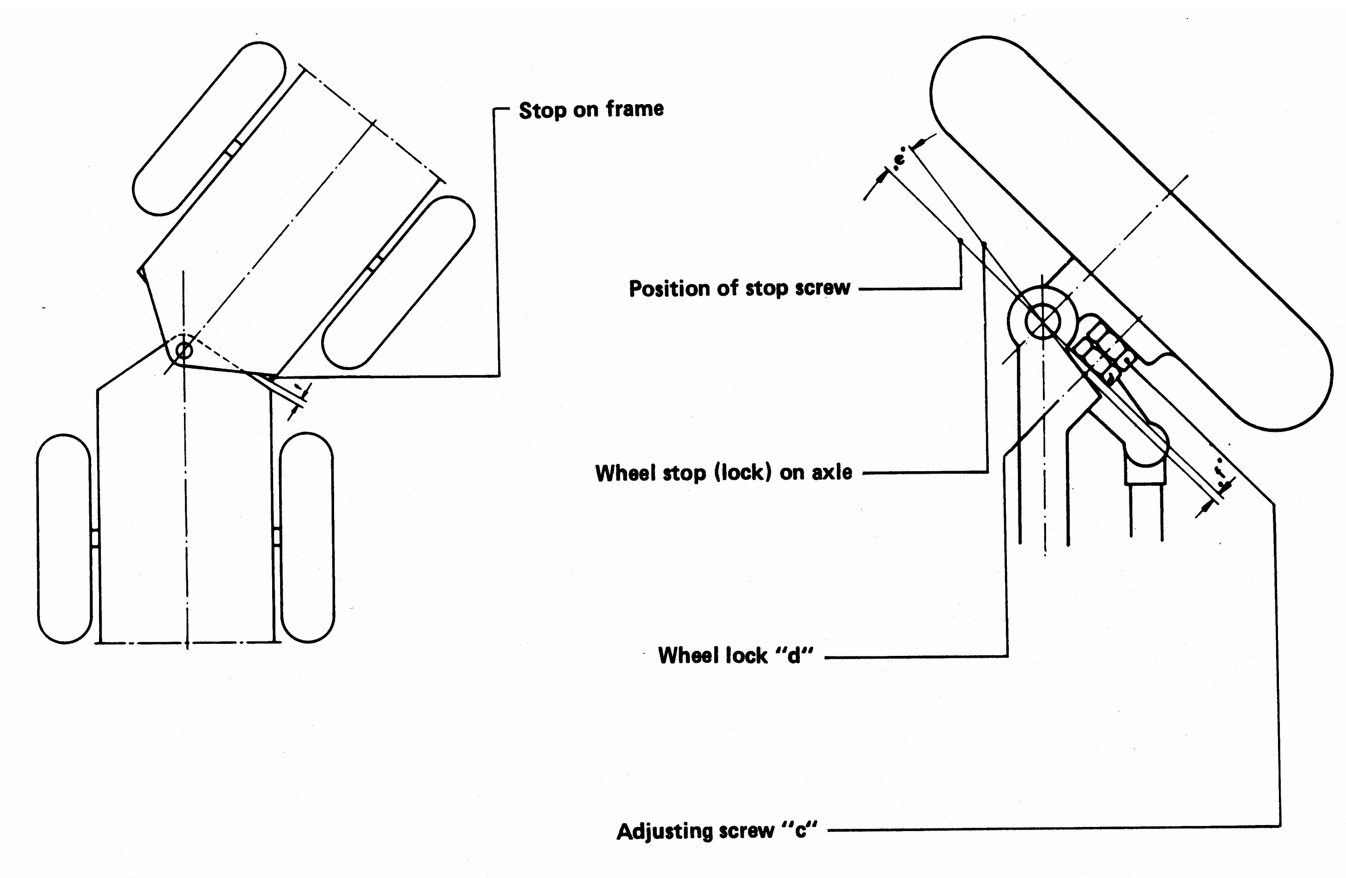


Figure 4.

3.2 Steering Systems with Mechanical Steering-Lock Limitation

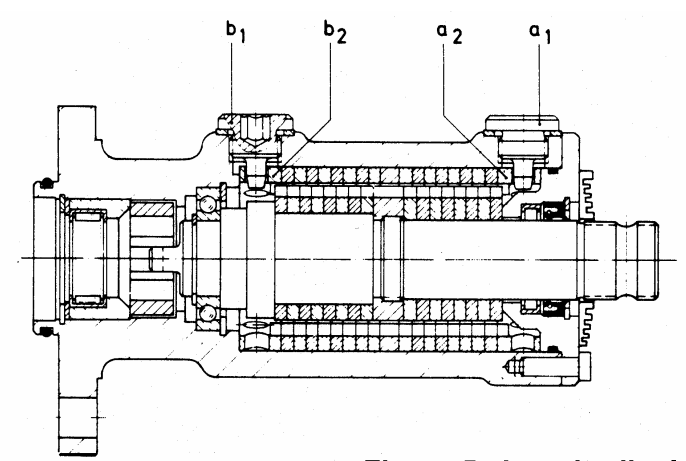
3.2.1 Function

Eight inner drivers (143) each with two external protruding stops are pushed up to their respective shoulders or circlips (154) on the steering spindle (93) or bevel gear (331) of a right-angle type gear. These drivers can turn in the opposite direction to the spindle. The last driver (148) has two external protruding stops and is splined so that it mates rigidly and turns with the steering spindle. In turn, this ring is followed by another eight rotating inner drivers (145) each with two external protruding stops.

All the rings are held together with axial play by the end flange (151) and the centering ring (346).

A special intermediate flange (95) above these inner drivers carries another sixteen outer drivers (147), arranged eight on each side of a spacer (144) and each of which has two internal protruding stops. These drivers rotate and each outermost ring contacts an adjuster ring (146). The spacer is centered above the carrier (148) and is thinner than the latter by the width of an inner or outer driver. Hence, the outer drivers which contact the spacer protrude above the carrier (148) to a distance equal to half the width of a ring, with the result that when the spindle is rotated, the protruding stops of the carrier which also turns are made to contact those of the first outer rings. Since inner and outer drivers are of the same width, these rings are also offset by a distance equal to half the width of a ring and when the angle of rotation is correct the protruding stops of each ring meet those of two opposite rings.

When steering spindle and steering wheel are turned with the carrier (148), the protruding stops of this driver soon meet these of the protruding outer drivers (147). These two outermost rings are now made to turn as well until their protruding stops meet those of the first inner driver, causing the latter to turn. Further rotation means that the latter turns the next outer ring and so on, until the last inner drivers contact the protruding stops of the adjuster rings (146). The adjuster rings are rotate-able, but are engaged by the stud bolts (152) in such a way that they can be fixed in any position in the intermediate flange, thus limiting steering lock separately for each side. The design is such that each adjuster ring can act as a stop in only one full-lock position of the steering. To permit adjustment of steering lock, the adjuster rings can be moved and repositioned from outside without difficulty.



Legend for Figure 5

a1	Upper Stud Bolt (152)
a2	Upper Adjuster Ring (146)
b1	Lower Stud Bolt (152)
b2	Lower Adjuster Ring (146)

Figure 5. Longitudinal Section through the Mechanical Steering-lock Limiter – Stud Type

3.2.2 Adjustment

NOTE

The hydraulic steering-lock limitation is pre-adjusted on the test bench before leaving the manufacturer. For practical reasons, fine adjustment takes place when the steering gear is installed with the vehicle at rest. The procedure is as follows:

Vehicle carrying normal load, steered wheels not raised clear of the ground, engine running. Turn steering wheel to right until full lock is almost applied (if necessary, use a spacer of 2 - 3 mm in thickness) (Fig. 4). Switch off engine and release steering wheel (steering will return to neutral position, the steering wheel turning through approximately 1/4 of a turn).

With the engine at a standstill (with the engine running, the oil is under line pressure), remove the lower stud bolt (b1) and by turning the adjuster ring (b2) through the threaded hole in the intermediate flange (92), bring the protruding stops of all the rings into contact with each other. In this position, turn the steering wheel back until the stud bolt can be screwed into the next radial hole in the adjuster ring. Tighten the stud bolt. Refer to Technical Data for tightening torque.

Start the engine and carry out the adjustment in the same way for the left-hand lock. In this case, it is the upper stud bolt (a1) which must be removed **with the engine switched off.**

Finish by checking the settings on both sides and correct if necessary.

Turn the lower adjuster ring anticlockwise with right-hand lock applied and turn the upper adjuster ring clockwise with left-hand lock applied. If such a procedure appears beneficial, the upper adjuster ring can be used for right-hand lock and the lower adjuster ring for left hand lock. Invariably, however, the adjuster rings have to be turned as far as they will go in the direction opposite to that in which the steering wheel is turned.

3.2.3 Check:

With the vehicle carrying its normal load, motionless with the engine running, steered wheels not raised clear of the ground, turn the steering until full lock is applied in one direction. There should now be a space of 1 - 3 mm between the full-lock stop components, corresponding to a wheel lock of approximately 20 to 30 degrees.

4. MAINTENANCE AND TYPES OF OILS

NOTE

a) Thoroughly clean the oil tank and its immediate vicinity before removing the cap, in order to prevent dirt entering the hydraulic oil.
b) When cleaning the vehicle with steam-cleaning equipment, do not direct the jet of steam directly against exposed seals of units belonging to the steering system. Water penetrating protective caps, shaft seals or the seals of universal joints may cause corrosion damage.
c) In the sections below, the intervals for inspections of ZF hydraulic steering gear are stated in kilometers driven and in service hours. The kilometers-driven data are applicable to road-going vehicles, the service-hour data apply to off-road vehicles. The quantity of fuel consumed will serve as a reference value for the intervals for vehicles equipped with neither an odometer nor a service-hour counter.

4.1 Checkup

In the course of general service jobs for the respective vehicle all the screw connections and lines of the power steering gear, pumps, engine and drive-dependent valves and power cylinders are checked for leaks. The piston rod of the power cylinder may be coated with a thin oil film, but no drops should show up.

If the steering system is subsequently installed, the installing workshop should make this checkup after driving 1,000 km or after 25 hours of operation.

4.2 Oil Quantity

The power steering gear is delivered from the factory without oil. The required oil quantity for the steering gear amounts to approx. 1.2. dm^3.

4.3 Oil Change

Oil change is recommended when the steering gear or pump or both are repaired or exchanged. In such a case, the filters in the oil reservoir (tank) should also be exchanged and the lines should be cleaned.

When pulling out the contaminated filter cartridge, the lower opening must be kept closed immediately after lifting the cartridge from filter carrier to make sure that the contaminated oil in the filter cartridge flows back into the tank and will then again enter the oil circuit.

Drain the oil as follows:

CAUTION

Do not run engine for more than ten seconds (at idle and with oil tank sucked dry), otherwise the pump will seize. Mixing of oil types should be avoided.

Jack up steering axles as well as the associated drive axle for the drive-dependent pump drive. Unscrew oil drain plug below on steering case and loosen hose connections on power cylinders. Engage a gear step and start engine for a short moment until oil has been drained out of the tank. Keep turning steering wheel from lock to lock. After stopping the engine, turn steering once again from lock to lock until no more oil is flowing out. Fasten line connections again to power cylinder. Screw in oil drain plug. For tightening torque, refer to Technical Data.

4.4 Filter Change

Together with the main inspection *) the **filter cartridges** in single or multi-chamber oil tank should also be replaced. When pulling out the used-up filter cartridges keep lower bore closed to make sure that the used oil from the filter cartridge is not running back into the tank or entering the oil circuit. Lubricate filter carrier prior to inserting cartridge.

4.5 Filling-in and Venting

4.5.1 Filling-in

NOTE

During the subsequent procedure make particularly sure that the oil tank is not sucked empty, since otherwise new air bubbles will again and again enter the steering system. Also make sure while filling-in and while venting, that the engine and drive-dependent pumps are operating at the lowest possible speed (idle speed with gear step engaged and drive axle for drive-dependent pump jacked up). If the suction current is too high, small air bubbles would again be sucked in in direction of the pumps and would be torn into tiny particles when running through the pumps, which may lead to foaming and then make the venting process disproportionately long.

Under influence of different installation conditions for our power steering gear and power cylinders there may be a case in which the steering system in a given vehicle model cannot be completely vented quickly enough and that the share of the air remaining in the power cylinders will be removed gradually only. In such a case we recommend loosening the connection between the power cylinders and the vehicle components on piston side so that the entire piston stroke from stop to stop in power cylinder can be used for venting.

This will reduce the air remaining in the cylinder to a minimum. This air has no influence on driving and is automatically absorbed by the oil while driving and discharged. The steering system and the pumps are filled through the filler neck on single or multi-chamber oil tank. For initial filling and for an oil change it will be of advantage to remove the tank cover and to fill in hydraulic oil up to edge of tank. Then, with a gear step engaged (drive axle for drive-dependent pump jacked up), crank engine several times with the starter motor to fill the entire hydraulic system with oil. Since the oil level in tank will drop quickly during this process, keep adding oil to make sure that the pumps are not sucking in air.

4.5.2 Bleeding the System

Once the steering system has been filled to the extent that the oil level no longer drops beneath the upper mark on the oil dipstick, allow the engine to run at low speed for a period (if a drive-dependent is fitted, with driven wheels raised clear of the ground and gear engaged), during which time most of the air will be expelled from the cylinder chambers. Observe the oil level during this process. If the level sinks, replenish the supply immediately. To accelerate the bleeding procedure, it is advisable to turn the steering wheel several times from stop to stop with the steered wheels raised clear of the ground. With full lock applied, do not apply more force to the steering wheel than is required to turn the steering. If necessary, add oil until the level remains constant at the upper mark on the dipstick and air bubbles cease to appear in the tank when the steering wheel is turned from lock to lock.

*) Minor deviations are permitted, if desired by vehicle manufacturer, to include the intervals into vehicle maintenance schedule.

If the vehicle is equipped with additional power cylinders, the line connections must face upward so that the air in the cylinders and lines can escape. If necessary, slacken the power cylinders or remove the cylinders.

Bleed the steering case by opening the threaded plug (7) located at the highest point (depending on attitude) by 1/2 - 1 turn to allow any residual air to escape from the case at this point. As soon as oil issues from the hole, retighten the threaded plug. Observe the oil level and top up if the level drops. Then move steering wheel energetically several times from lock to lock. Add oil, if oil level in tank drops.

Then repeat venting procedure. Open closing plug by 1/2 – 1 turn. As soon as oil flows out, close plug again immediately and tighten to specified torque (refer to Technical Data). Add oil.

If the instructions above are followed, the oil level in the tank should not rise by more than approx. 1 to 2 cm, depending on the capacity of the steering system, when the engine is switched off. When the vehicle is under way, the residual air still remaining in the steering system is negligible. This air is absorbed by the oil while the vehicle is on the move and expelled.

Stop engine and lower steering axle or drive axle.

4.6 Checking the Oil Level

Check the oil level with the oil at operating temperature. Thoroughly clean the tank and its immediate vicinity before removing the cap to prevent dirt entering the hydraulic oil.

CAUTION

Malfunctions may result if the oil level is too low.

4.6.1 Oil Level Checkup with Engine Stopped and Drive-Dependent Pump Not Driven:

To make sure that no air is sucked in when starting the engine, first check whether oil has been lost on stopped engine. For this purpose, add oil into tank until the oil level is approx. 1 - 2 cm above the upper mark of oil sight glass.

4.6.2 Checking Oil Level with Engine Running and Drive-dependent Pump Driven:

With the engine running and the drive-dependent pump driven (gear step engaged and the driving axle for the drive-dependent pump jacked up), the oil level will slightly drop, since the oil requires a pressure of 2 - 4 bar owing to the flow resistance while through steering gear.

Now add enough oil so that the oil level is constantly at upper mark. The engine can then be stopped again. The oil level may rise max 1 to 2 cm. If this is exceeded, it is an indication that there is air included in the oil.

5. ADJUSTMENTS ON STEERING GEAR INSTALLED IN VEHICLE

5.1 Elimination of Steering Play in Straight-ahead Range (Pressure Point Adjustment)

a. Pull drag link from pitman arm.

b. Turn steering to center position (found by halving total number of steering wheel turns).

c. Loosen sealing nut (24) on housing cover.

d. Turn steering into an end position and measure the required friction torque for turning steering outside straight ahead driving range (approx. 1/2 turn before final lock). For turning steering, use a torque measuring instrument which is plugged onto steering wheel nut (55).

e. Then measure friction torque of steering in pressure point range (center position). For this purpose, turn torque measuring instrument approx. 1/2 turn each to the left and to the right beyond the straight-ahead position, while tightening the adjusting screw (62) to the extent that a friction torque increase of 30 - 60 Ncm as compared with value measured under Step d. is obtained.

f. Tighten sealing nut (24) with a tightening torque of 70 Nm; sealing ring should face housing cover), while holding adjusting screw in position. Check set friction torque once again. Fasten drag link again to pitman arm. Adjustment of friction torque in straight-ahead range higher than 30 - 60 Ncm does not improve the steering characteristics and operating conditions in steering gear in any way whatsoever. It will actually cause excessive pressure at parts which are in contact with each other and will thereby result in unnecessary wear.

5.2 Adjustment of Steering Limit

For adjustment of steering limit, refer to Section 3, Function and Adjustment of Hydraulic Steering Limit (Steering Lock).

6. INSTRUCTIONS FOR REPAIRING EXTERNAL LEAKS

NOTE

The measuring and adjusting tools used for reconditioning must be regularly subjected to a precision checkup.

6.1 Replacing Shaft Sealing Rings on Lower Steering Spindle

a. Remove lower fastening screw on universal joint. Pull the universal joint from splines of the lower steering spindle (93)* Remove protective cap (102). Release locking ring (98) and pull shaft sealing rings (100 and 101) out of end flange (95).

b. Press new shaft sealing rings (100 and 101) into the end flange (tool 5) with the sealing lips facing into the housing [shaft sealing ring (100) with the dust-excluder lip facing outward]. Pack the space between the sealing lip and the dust-excluder lip with Texando FO 20 grease or an equivalent consistency-class 2 calcium-compound grease. Insert circlip (98). Install protective cap (102). Do not attempt to remove or install the steering wheel by applying axial blows to the steering spindle.

6.2 Replacing Shaft Sealing Rings on Drive Pinion on Versions with Angular Gears

a. Remove lower fastening screw on universal joint. Pull universal joint from the splines of bevel gear (306).

b. Remove protective cap (314).

c. Loosen slot nut (313) and remove adjusting screw (321) from housing (301).

d. Force shaft sealing ring (310 and 310.1) from adjusting screw. Pull o-ring (308) from housing groove.

NOTE

Do not pull bevel gear (306) out of housing, since otherwise the tooth mesh, which must be free of play in straight-ahead driving position of steering gear, is no longer correct.

e. Install 0-ring (308) in the radial groove of the case behind the threaded hole. Using tool 6, press the low shaft sealing rings (310 and 310.1) into the adjuster screw (312) with the sealing lips facing into the case (beginning with the dust-excluder-lip sealing ring). Pack the spaces between the sealing lips with Texando FO 20 grease or an equivalent, consistency-class 2 calcium complex grease.

f. Wind a strip of paper around bevel gear (6) in such a way that the splines and the radial groove are covered (to protect the sealing lips of the shaft sealing rings, or use tool 7. Insert adjuster screw (312) and tighten. Screw on slotted nut (313) and tighten to 50 Nm. Apply Texando FO 20 or an equivalent, consistency-class 2 calcium-complex grease to the shaft sealing ring. Push dust cap (102) into place.

*) Numbers in brackets refer to illustrations in Section 12.

g. Slip universal joint on splines in such a manner that the slot in the lower joint fork and the marking notch on bevel gear (306) are in alignment.

h. Insert hex bolt through bore of fork. Screw on nut and tighten. Tightening torque of nut M 8 = 24 Nm and M 10 x 1.25 = 48 Nm.

6.3 Replacing Shaft Sealing Ring on Pitman Shaft

CAUTION

Never remove pitman arm by forcing a wedge between housing neck and pitman arm or by means of hammer blows, since this will result in serious damage inside steering gear.

a. Loosen fastening of pitman shaft and pull off pitman shaft with suitable puller (tool 10.).

b. Unsnap locking ring (1) on housing neck.

c. Force shaft sealing ring (2) out of housing neck by means of a suitable screwdriver.

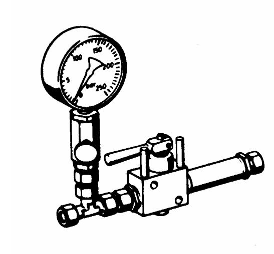
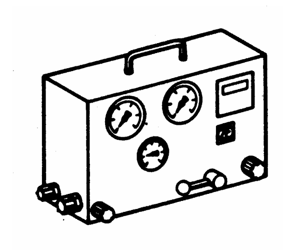
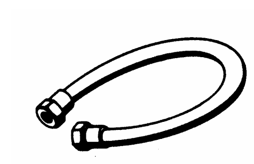
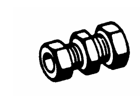
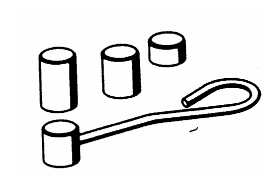
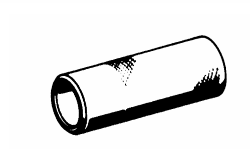
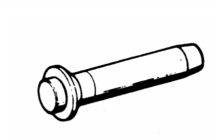
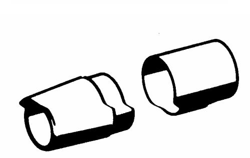
d. Plug tool 1. on steering shaft. Slip shaft sealing ring with sealing lip over sleeve and press with tool 9. into housing neck.

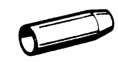
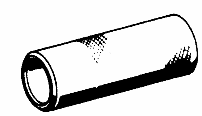
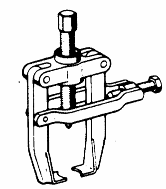
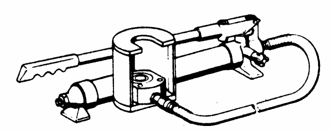
e. Reinsert locking ring (1).

f. Slip pitman arm on pitman shaft, making sure that the marking on pitman arm and pitman shaft are in alignment. Tighten hex nut to a tightening torque of 400 Nm and lock.

7. TOOLS FOR DISASSEMBLY AND ASSEMBLY

7.1 Tools for Inspection

Description	Tool Number	Figure
Tool 1. Damped pressure gauge – 0-250 bar with shutoff valve and installed safety valve (130 bar)	7418 798 515	
Tool 1. Hydro steering tester (when using hydro steering tester, tool 1.a), 4. and 5. are not required).	7418 798 550	
Tool 2. Two pressure hoses (AD 12 Ø / M 18 x 1.5)	0632 702 131	
Tool 3. Two reductions for high-pressure hoses (15 Ø / 12 Ø)	0637 880 552	
Tool 4. Thrust pieces for limiting wheel lock (1 set = 4 each)	7418 798 551	
Tool 5. Pressing-in sleeve for shaft sealing rings (100 and 101) – lower steering spindle (shaft sealing ring 30 x 42 x 7/8)	7421 798 001	
Tool 6. Mandrel for shaft sealing rings (310 and 310.1) – angular gears (shaft sealing rings (26 x 37 x 7/8)	7418 798 051	
Tool 7. Inserting sleeve for shaft sealing rings (310 and 310.1) – angular gears (shaft sealing rings 26 x 37 x 7/8)	7418 798 009	

Description	Tool Number	Figure
Tool 8. Inserting sleeve for shaft sealing ring (2) – sector shaft (shaft sealing ring 45 x 60 x 7/8)	7425 798 002	
Tool 9. Pushing-in sleeve for shaft sealing ring (2) – sector shaft (shaft sealing ring 45 x 60 x 7/8)	7425 798 003	
Tool 10. Pullers for pitman arms a. mechanical claw puller b. Hydraulic pullers for steering shafts with 45 mm diameters	7418 798 202	
	7418 798 211	

8. INSTRUCTIONS CONCERNING INSPECTION

As already stated in maintenance instructions, all the vehicles with ZF Power Steering Gear should be taken to the workshops for inspection of ZF Steering System as well as of the ZF Oil Pumps after completing the mileage shown below:

	Long-distance Driving	Mixed and Short-distance Driving	Driving on Construction Sites and Cross-country
I. Inspection	100 000 km 60 000 miles	100 000 km 60 000 miles	80 000 km 50 000 miles 2 500 operating hours
II. Inspection	200 000 km 120 000 miles	175 000 km 105 000 miles	150 000 km 90 000 miles 4 500 operating hours
III. Inspection	300 000 km 180 000 miles	250 000 km 150 000 miles	200 000 km 120 000 miles 6 000 operating hours

The following description applies only to inspections I and II. Removing the steering gear and pumps from vehicle are not required, except when the inspection shows non-permissible play or other faults.

To increase traffic safety, we recommend disassembly of steering gears and pumps during III. inspection to check the mechanical steering components (visual checkup of all and crack test of highly stressed parts), and to install new seals or gaskets.

8.1 <u>Performance of I and II Inspections</u>

NOTE

a) The description of the following inspection jobs is based on a dual circuit power steering gear, which differs from the single circuit power steering gear only by a second steering control valve, located behind steering nut. For inspecting the hydraulic operation of steering gear and pump of single circuit power steering gear the same conditions apply as described under Para. 8.1.5.

b) To evaluate the condition of vehicles and of the power steering gear prior to performing the following inspection and to compare the performance of the power steering gear before and after the inspection, a test drive is recommended. This recommendation applies above all, whenever the evaluation of the steering system by the driver is poor. Prior to test drive, check oil level and venting to steering system.

8.1.1 Checking Mechanical Function of Steering

8.1.1.1 <u>Checking Seat of Fastening Screws</u>

Retighten screws and bolts on steering system and steering attachment to specified tightening torque.

8.1.1.2 Checking Straight-ahead Position of Steering and Vehicle

Check up steering axles (if the vehicle has no rigid steering axles, place wheels on rotary supports). Move steering gear into center position by having the total steering wheel turned. Then continue turning the steering wheel until the marking notches on steering spindle and end flange, or on angular gear version and angular gear housing, are in alignment. The steered wheels should be in straight-ahead driving position (approximate check by placing a measuring bar against front and gear rears. Take toe-in into account). A correction is then made by screwing ball joint and drag link in or out.

NOTE

If a longitudinal correction must be made on steering linkage, the cause might have been a previous, accident-like event. Inspect the splining on the sector shaft (60) for distortion (pulling of pitman arm for this purpose), the steering spindle for distorted installation or other transmission components for bends or cracks.

Do not recondition distorted parts, discard and replace with new components.

8.1.1.3 Checking Play between Steering Nut (40) and Sector Shaft (60) in Center Position (Pressure Point Adjustment)

a. Turn steering to center position (refer to Para. 8.1.1.2) and pull drag link from pitman arm.

b. Measure increase of friction torque while turning over pressure point range. The increase must be 40 to 60 Ncm higher than outside the pressure point. For adjustment of pressure point, refer to Section 5.

8.1.1.4 Checking Steering Lock

Attach drag link provisionally. Turn steering to the left up to lock. Disconnect drag link and check by turning steering wheel further, whether there is a steering reserve. Repeat measuring by turning to the right. There must be a steering reserve on both sides. If not, readjust wheel stop (wheel lock) screws again. Reconnect drag link.

8.1.1.5 Reconnect Play of Steering Spindle Bearing

By turning steering wheel (shaking) back and forth, check for play. In the event of play, remove the bearing bushing.

8.1.1.6 Check for Torsional Play or Hard-to-move Universal Joint or Companion Plate between Upper Steering Spindle and Steering Gear

In the event of play (may result in audible rattling when moving back and forth) or reluctant operation, install new part.

8.1.1.7 Check Steering Spindle and Jack Tube for Max. Permissible Distortion

Jack up steering axle. Remove steering wheel and also remove ball bearing sleeve from jacket tube. Check permissible distortion of steering spindle and jacket tube according to Section 10.

8.1.2 Checking for External Leaks

a. Check whether all screw connections, locks and lines of steering system, as well as the sealing rings on steering gear and pump are free of leaks. Tighten screw connections if required and replace damaged sealing rings. When installing new sealing rings, we recommend our special tools to protect sealing rings.

b. Check all hoses and lines for any signs of chaffing. Replace damaged parts. Use only the manufacturer's approved and pressure tested spare parts to replace hoses with visible external damage such as cracks.

8.1.3 Filter Change

a. Remove cover of single or multi-chamber oil tank (oil reservoir).

b. Pull out used up filter cartridges at metal collar. When pulling out, keep bore or filter cartridges closed so that the contaminated oil is not flowing back into tank.

c. Insert new filter cartridges with metal collar in upper direction.

8.1.4 Hydraulic Steering Tester Connected into Steering Circuit

Steering systems in which the **pressure limiting valve is located in steering or separately in line between tester and steering** - The pressure limiting valve can therefore no longer reduce the oil pressure, since the pressure line is locked by the shutoff valve.

8.1.5 Testing Hydraulic Function of Steering and Engine-driven Pump

For testing of steering circuit I (engine-driven and drive-dependent pump) refer to Para. 8.1.6.

8.1.5.1 Checking V-Belt Tension

Check tension of V-belt by means of conventional thumb test. (V-belts should not slip even under maximum pressure). Replace defective V-belts.

WARNING

Pressurized tools may be ejected - avoid close contact on eye level. In any case, if the tool is held under steering lock conditions, take care that sufficient free space is provided between wheel and frame. For instance, the operator's hand may get squeezed by a jerk of the wheel while the tool is being pressed out! According to the axle type, use a thrust piece, specifically designed for this purpose by the vehicle manufacturer (e.g. inset to Figure 6).

8.1.5.2 For Steering Systems According to Para 8.1.4:

At idle speed of engine and while watching pressure gauge, slowly close installed shutoff valve until the specified maximum pressure is attained. Then be sure to keep shutoff valve still further closed to prevent unchecked increase above permissible maximum pressure. **Let maximum pressure act only for a short period, max. five seconds, since otherwise the interior parts of the pumps will be excessively heated which in turn may lead to early wear.**

8.1.5.3 Testing and Adjusting Hydraulic Steering Limit

Refer to Section 3.

8.1.5.4 Testing Steering for Pressure

Hold pressure elements, approximately 15 mm thick, (Fig. 6) between wheel stop components which are designed in such a manner that the steering lock is limited 1/2 to 3/4 steering wheel turn before attaining final lock. The limitation of the steering lock should be attained reliably at these pressure elements, but not in hydro steering by steering nut in the housing. Turn steering wheel at idle speed of engine clockwise up to stop and keep turning clockwise on steering wheel at a force of 100 - 200 N until the restoring force of the steering valve is overcome. The resulting oil pressure is read on pressure gauge. The same measurement is performed when steering to the left. If steering to the right or to the left or towards both sides, it is shown that the oil pressure at a steering force of 100 -200 N is below the previously measured maximum oil pressure of the pump, the function of the hydraulic steering is not in order. The cause of the pressure drop may be too much leak oil in steering valve of steering or in power cylinders.

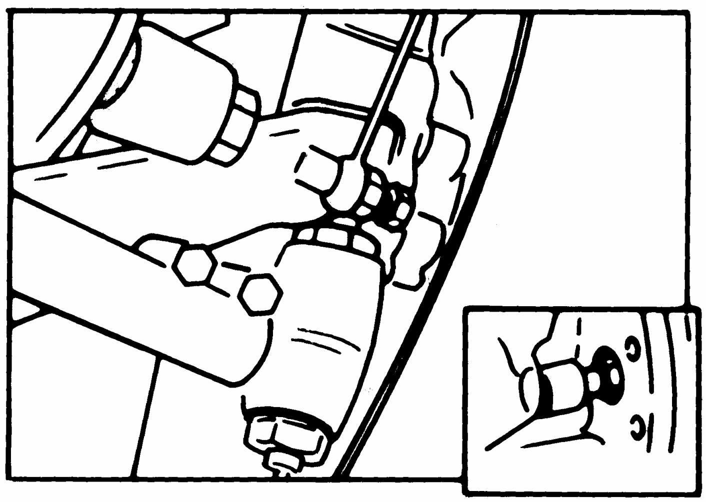


Figure 6. Pressure Elements

8.1.5.5 Testing Oil Pump with Hydro Steering Tester for Volume Flow

With the engine idling, close the shutoff valve (8) until the test pressure specified for the type of pump in question is applied. Check volume-flow reading (see description of hydraulic steering tester or the appropriate repair instructions for the volume-flow, test-pressure and test-speed specifications).

8.1.5.6 Testing Steering and Power Cylinder with Hydro Steering Tester for Leak Oil (At Idle Speed of Engine)

Steering System **With** Power Cylinder

Open the throttle valve (9). Close the shutoff valve (8) completely and the throttle valve until a back pressure builds up to 20 bar beneath the maximum pressure as stated on the rating plate. Open the shutoff valve. Place a thrust element approximately 15 mm in thickness on the full-lock bolts.

Turn steering up to lock and pull for a short moment (max. 5 s) at 200 N on steering wheel, so that the steering valve is completely closed. Repeat test in opposite turning direction.

Permissible values: for steering circuit II 2.5 dm^3/min at 100 bar
for steering circuit I 2.5 dm^3/min at 100 bar

If these values are exceeded, the cause may be an excessive oil leak in steering or in power cylinders.

Steering System **Without** Power Cylinder

Unscrew line from steering to power cylinder, which is under pressure when the steering wheel is turned clockwise and close connection to steering with a plug. Repeat leak oil test as described under Para. 8.1.5.6, Steering System **with** Power Cylinder above. If this test shows less leak oil, an inside leak in power cylinders is indicated.

8.1.6 Testing Hydraulic Function of Steering and Engine-driven Pump in Steering Circuit I

Remove pressure and return lines from valve housing of steering circuit II and connect to valve housing of steering circuit I (upper valve). Vent steering system and run oil temperature to approx. 50º C. Perform function test as described under Para. 8.1.5 for steering circuit II.

8.1.7 Testing Hydraulic Function of Steering and Drive-dependant Pump (Emergency Steering Pump) in Steering Circuit I

NOTE

The following section shows testing of steering circuit I with drive-dependent pump (emergency steering pump) on rolling vehicle with engine stopped. Testing of engine-driven pump (steering systems with 1 or 2 engine-dependent and 1 drive-dependent pumps) proceeds with engine running at vehicle stopped (refer to Paras. 8.1.5. and 8.1.6.)

a. Run vehicle at a speed of 30 km/h

b. Move gear shift lever to neutral and push engine shutoff button until indicator lamp for steering circuit I lights up.

c. Turn steering wheel repeatedly 1/4 to 1/2 turn to the right and left. The steering should move “easily”; actuating force approx. 50 N at a steering wheel diameter of 500 mm. These measurements must be performed within a speed range from 25 to 10 km/h. If the drive-dependent pump is no longer operational, the vehicle can no longer be steered (actuating force more than 250 N at a steering wheel diameter of 500 mm).

8.1.8 Test Drive

Upon completion of the inspection jobs, a test drive should be made to check the vehicle or the steering system for perfect operation and absence of external leaks.

9. REMOVAL OF STEERING SYSTEM FROM VEHICLE

a. Thoroughly clean the steering gear and the immediate vicinity, paying particular attention to the connections.

b. Drain oil by opening closing plug (7).

c. Loosen respective pressure, return flow and the two power cylinder lines on steering circuits I and II.

d. Close all oil lines to avoid risk of contamination.

CAUTION

Never attempt to remove the pitman arm by forcing a wedge between housing neck and pitman arm or by means of hammer blows, since this will lead to serious damage inside steering gear.

e. Pull off pitman arm with suitable puller (refer to tool 10.).

f. Loosen universal joint or flexible coupling between steering gear and steering column or separately installed angular gears. When disassembling steering wheel, do not direct any axial blows against steering spindle.

g. Remove fastening screws on housing and remove steering.

10. INSTALLATION OF STEERING SYSTEM INTO VEHICLE

NOTE

To guarantee reliable operation of entire steering system, maximum cleanliness is required during the installation of all the units included in the system, as well as during installation of the lines. To prevent operational trouble caused by foreign bodies or dirt in steering oil circuit, the closing plugs on line connections of steering, oil pump, power cylinder, valves, etc. should be removed only when the lines are connected. Connecting lines and screw connections must be carefully cleaned and deburred.

a. Ensure contact surfaces of fastening eyes of bearing bracket and steering free of paint and dirt.

b. Place steering gear into bearing bracket and screw down. Tighten screws at specified torque.

c. When fastening jacket tube and steering spindle, particularly with separately installed angular gear units with flanged-on jacket tube avoid any **distortions** which may be caused during the assembly of steering gear/bearing bracket by holding and mounting equipment on fire wall or on instrument panel.

Distortions may cause bending torques, particularly in steering spindle, which may lead, depending on size and frequency, among others to permanent fractures or may impair easy operation of steering gear.

A checkup with regard to correct installation of steering gear should be made as follows:

1) **Check for Easy Operation of Steering Gear**. Check for easy operation of steering gear or separately installed angular gear unit in connection with bearing bracket, pitman arm and drag link(s).

2) **Checking Permitted Deformation of Steering Spindle.**

a) Check up steering axle so that the steering can be easily turned manually.
b) Take off steering wheel and remove ball bearing cage or self-aligning bearing from jacket tube of separately installed angular gear unit.
c) By turning steering spindle for min. 360º, check steering spindle for deformation. Measurement can be performed with a dial gauge or a depth gauge. Always take measurement from the same jacket tube peripheral point. The entire radial run-out divided by 2 indicates the deformation of the steering spindle. The maximum permissible deformation depends on length of jacket tube and on the diameter of steering spindle. For this purpose refer to diagram Fig. 7, and subparagraph 4) below for determining jacket tube length.

3) **Checking for Permissible Distortion of Jacket Tube.** For this purpose, mark steering spindle at one point of circumference by a line. Then keep turning steering spindle in steps (minimum four steps) and after each step always measure distance to marked point on steering spindle from outside diameter of jacket tube by means of depth gauge. Since the same steering spindle side is facing the measuring point around jacket tube, the own run-out of the steering spindle is not included in the measurement. The difference of the distance, max. dimension to min. dimension, divided by 2, provides the deformation of the jacket tube. The max. possible deformation depends on length and diameter of jacket tube, for this purpose refer to diagram Fig. 7 as well as to explanations of jacket tube length.

NOTE

This test must also be made in front range during main inspection of steering system, as well as on vehicle with previous damage following an accident.

4) **Determination of Jacket Tube Length**. Measure jacket tube length (in mm) as shown to the point where the jacket tube flange mates to the housing (Fig. 8).

d. Turn steering to straight-ahead position (determined by halving all the steering wheel turns). The markings on steering spindle and jacket tube or valve housing should match.

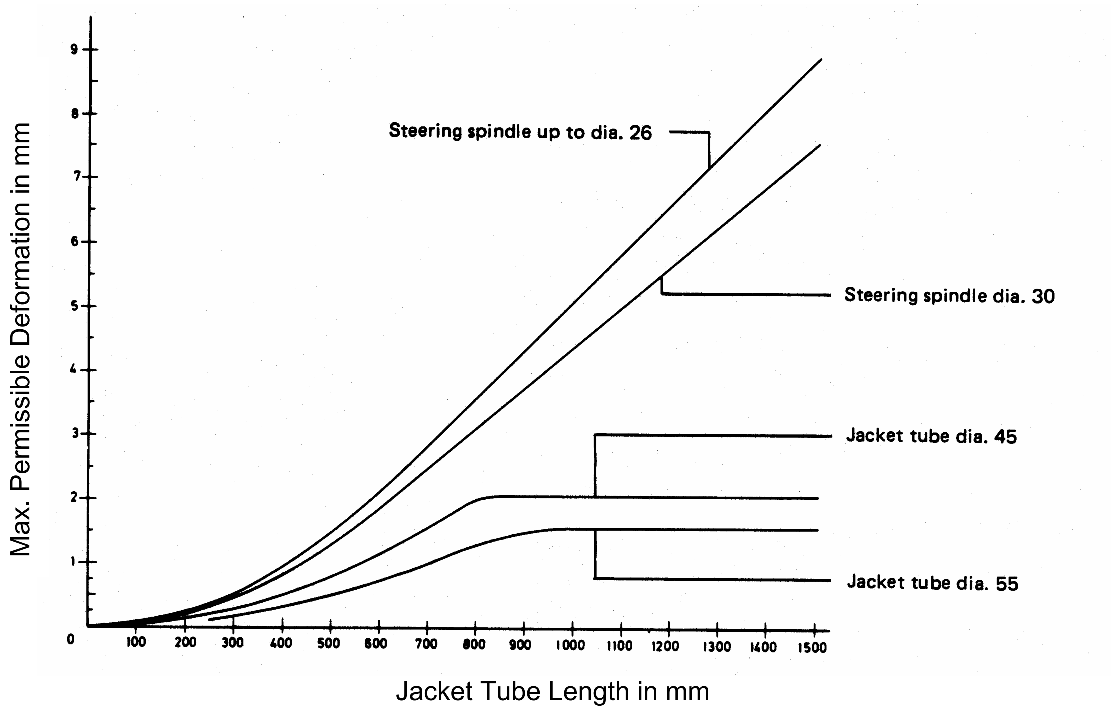


Figure 7. Steering Spindle and Jacket Tube Diameter Chart

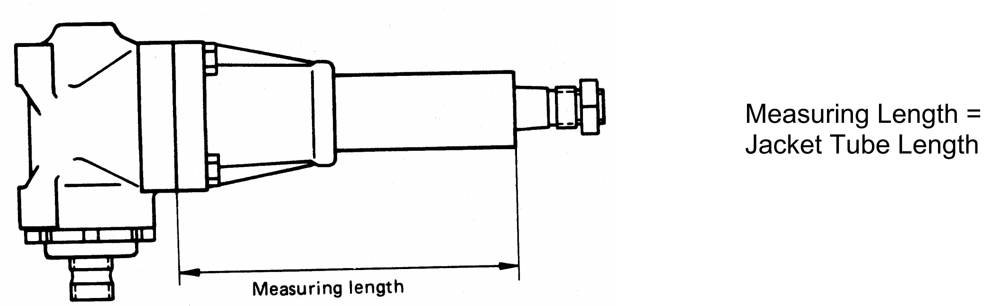


Figure 8. Jacket Tube Length

e. Valid for separately installed angular gear unit with rigid steering column: Mount steering wheel with nut (83). Screw in slip contact and tighten to 5 Nm. Tightening torques for steering wheel nuts with cylindrical splines and taper 1:16:

M 18 x 1.5 = 35-45 Nm
M 22 x 1.5 = 40-50 Nm
M 26 x 1.5 = 60-70 Nm

CAUTION

During assembly and disassembly of steering wheel do not apply axial blows against steering spindle.

Valid for steering systems with divided steering column: Install universal joint or flexible coupling between steering column and steering gear. In straight-ahead driving position the angular fork member must be at right angle to markings on steering spindle and jacket tube or valve housing. When using two joints, the bending angles should be the same and the joint forks should be located on one plane. If such an installation is not possible, synchronization can be obtained by displacing the forks on splining in relation to each other. Hammer blows against aluminum universal joints should be avoided, since this may result in destruction or sluggish operation. Connect by insertion of fitted bolts, as well as by tightening nuts to each other. Tightening torques of fitted bolts:

M 8 = 24 Nm
M 10 x 1.25 = 48 Nm

f. Move the steered wheels of the vehicle into straight-ahead driving position. This position is attainted the moment the steered wheels are in alignment with or parallel with the second pair of wheels (place measuring bar against front and rear wheel).

g. With the spaces packed with Texando FO20 grease or an equivalent consistency-class 2 calcium complex grease, press the dust seal (65) onto the shaft (60). Then position the pitman arm on the splines, taking care to align the marks on the pitman arm and the shaft. Tighten the castle nut (67) provisionally and apply full lefthand lock. Remove the pitman arm and turn the steering wheel further to ascertain whether the steering has a reserve of movement. Repeat this measurement at right-hand lock. Tighten the castle nut (67) to the torque stated below and insert a split pin. Engage the radius link and tighten.

M 35 x 1.5 = 400 Nm

h. Connect pressure and return line between pump, steering and power cylinder for each steering circuit. Install steering circuit II on steering valve, located behind steering nut; steering circuit I on steering valve, located in front of steering nut. Install separate valves combined in a valve unit or as individual valves (flow rate indicator, remote control valve with pressure limit, pressure limit valve for hose lock, replenishing valve and check valve) according to line diagram. If lines must be rebent, the lines should be cold, so that no scaling occurs.

Use only the manufacturer's approved and pressure-tested spare parts to replace hoses with visible external damage such as cracks. Note the manufacturer's spare-parts numbers.

i. Fill system with oil from oil tank and vent (refer to Section 4.).

j. Adjust hydraulic steering lock (refer to Section 3.).

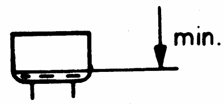
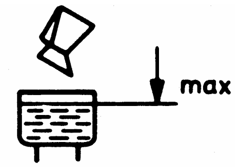
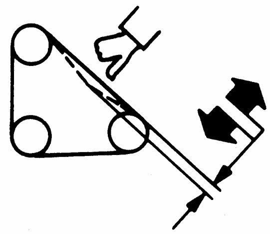
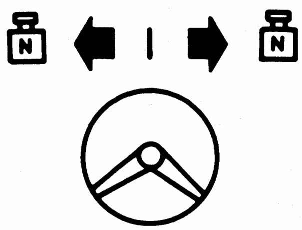
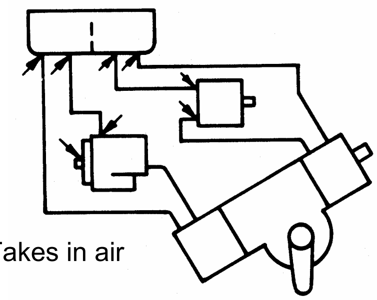
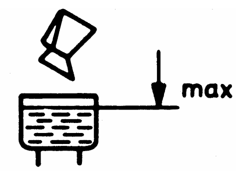
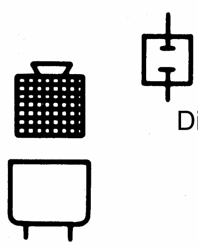
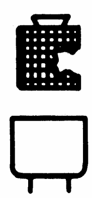
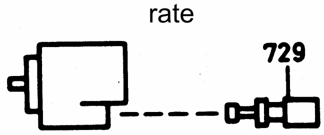
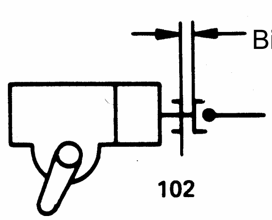
11. FAULTS AND REMEDIES

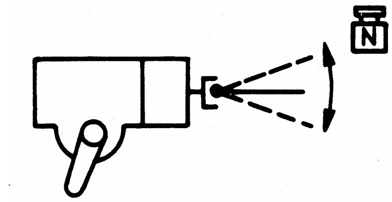
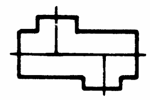
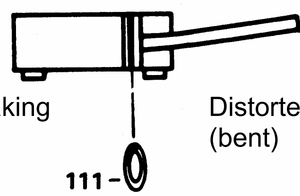
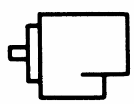
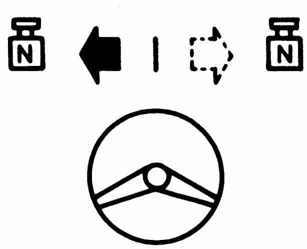
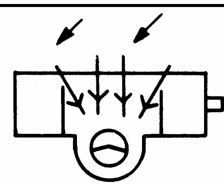
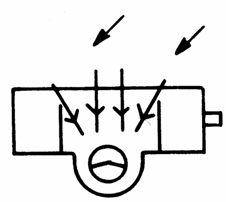
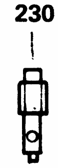
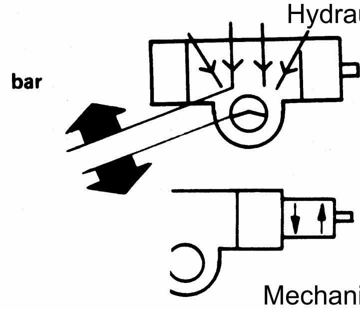
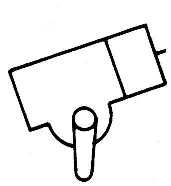
The ZF Single Circuit Power Steering Gear has been developed for high demands. The system has been designed in such a manner that no faults will occur with satisfactory maintenance during normal operation. If unexpected trouble should nevertheless show up at one time or other, the following information should be of assistance for pertinent location and removal.

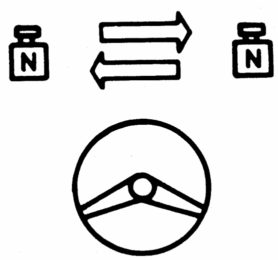
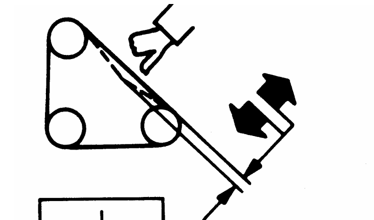
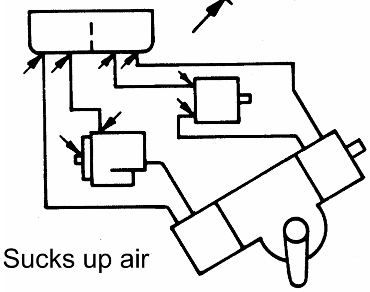
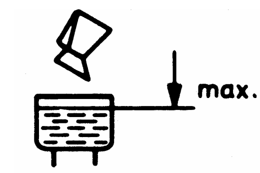
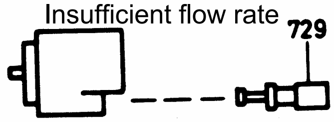
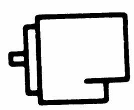
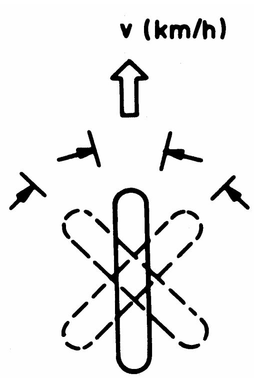
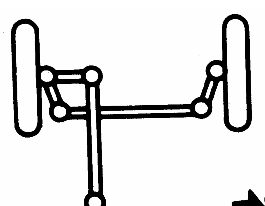
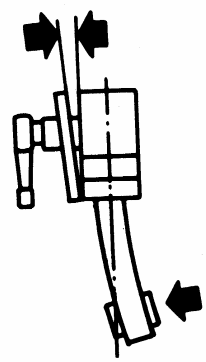
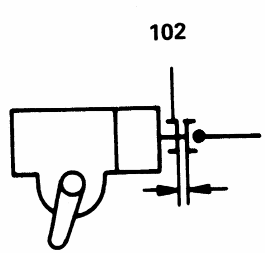
Prior to checking the steering system for individual troubles, check the oil level with the engine running, a gear step engaged and with the driving axle for the drive dependent pump jacked up. The accurate procedure of filling-in the oil is described in detail in Section 4, page H-16. Simultaneously we added that the use of heavily foaming oils may lead to trouble, since such oils will release any air, after entering the steering system, with difficulty only or not at all.

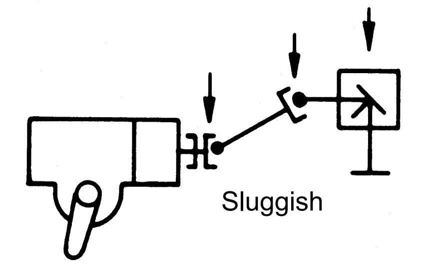
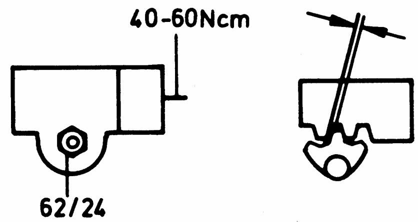
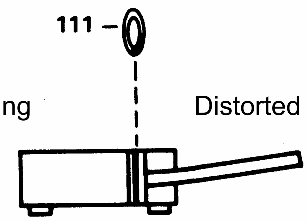
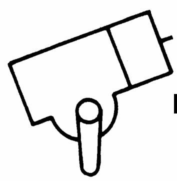
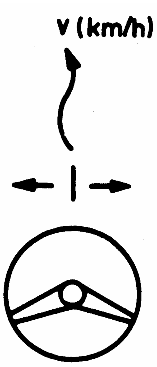
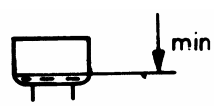
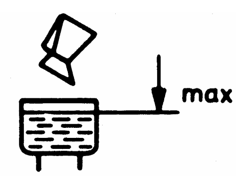
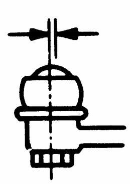
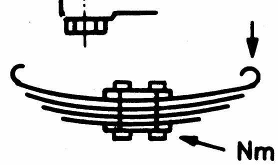
NOTE

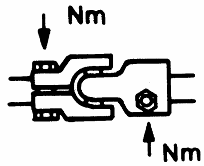
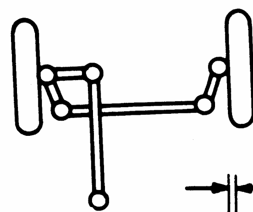
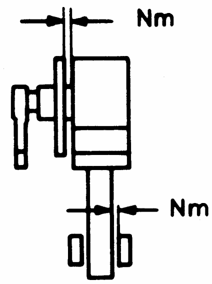
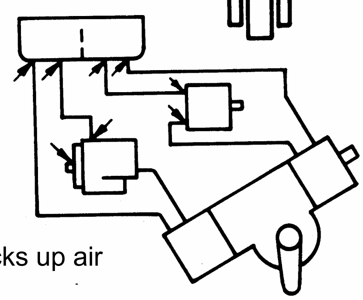
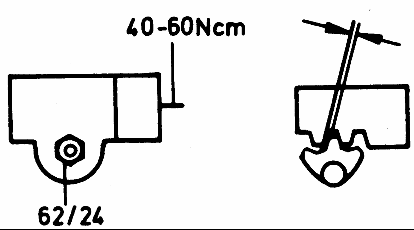
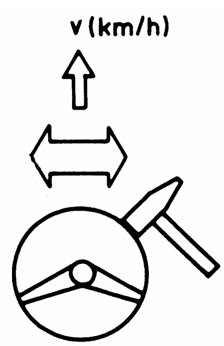
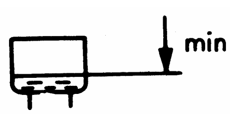
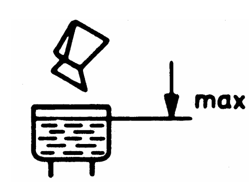
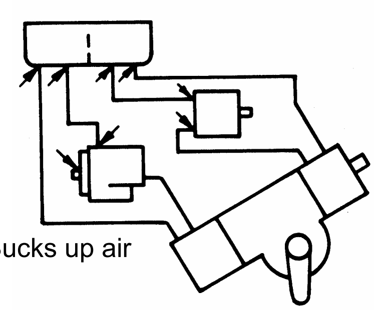
For finding the cause of a fault, each steering circuit must be tested and checked separately: On three-pump steering systems the two engine-dependent pumps in steering circuit I and II on stationary vehicle with engine running. The drive-dependent pump (emergency steering pump) in steering circuit I on rolling vehicle (drive axle for drive-dependent pump driven on roller-type dynamometer) with engine stopped.

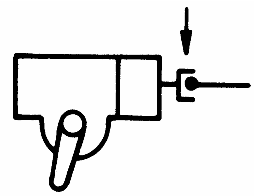
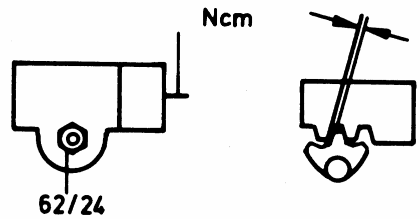
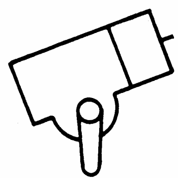
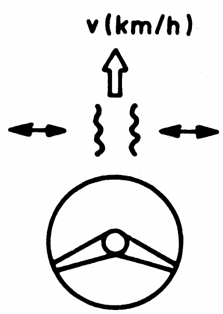
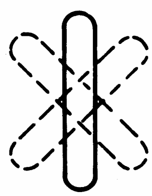
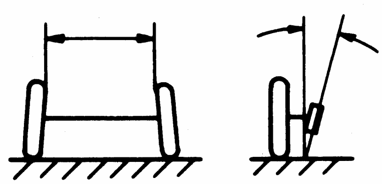
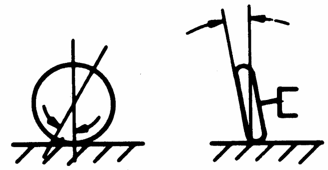
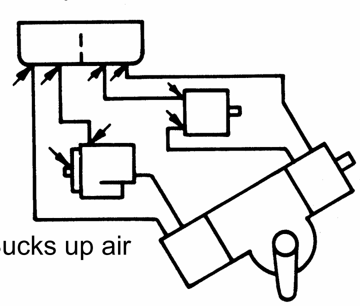
Fault	Cause	Remedy
		Eliminate leaks 
		Adjust
Sluggish on both sides 	Takes in air 	Renew sealing rings  Bleed
	 Dirtied	Renew
	 Insufficient flow rate	Renew, clean control valve and suction line
		Remove, clean, make operable
	Binding 	Grind off/renew

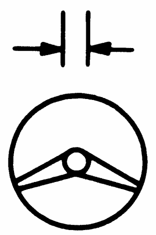
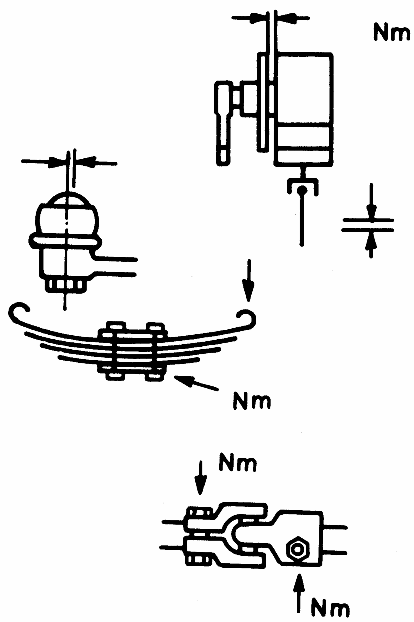
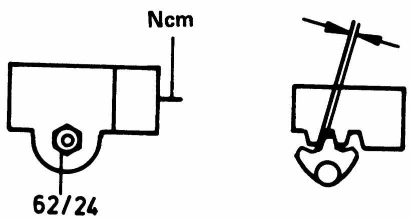
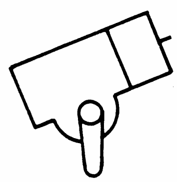
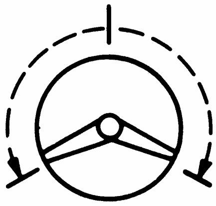
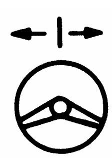
Fault	Cause	Remedy
		Make operable or exchange
	Separate valves seizing 	Clean: remote control valve, pressure limiting valve, replenishing valve, flow dividing valve
	 Leaking; Distorted (bent)	ZF Service Department
	 Insufficient flow rate	ZF Service Department
Sluggish on one side 	 Leaking	 Renew
	 Leaking	 Renew
		Adjust hydraulic or mechanical steering-lock limitation
		ZF Service Department

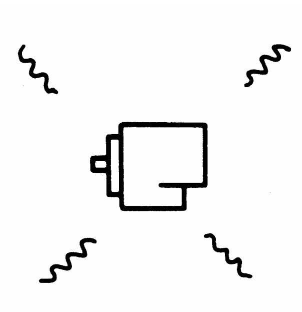
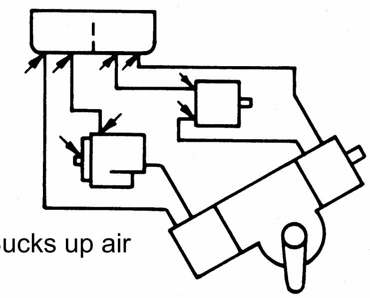
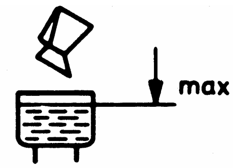
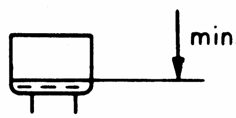
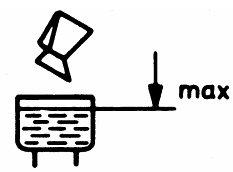
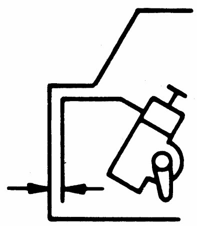
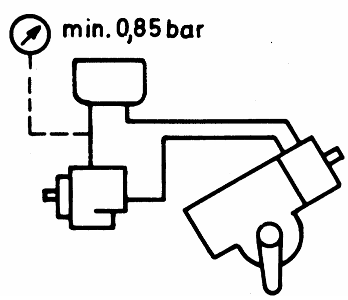
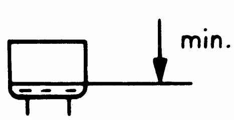
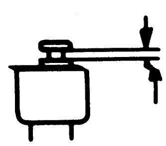
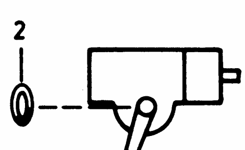
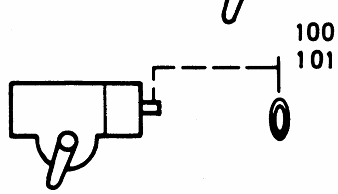
Fault	Cause	Remedy
Sluggish during faster steering 		Adjust
	 Sucks up air	Renew sealing ring  Bleed
	Insufficient flow rate 	Remove, clean, make operable
	 Insufficient flow	ZF Service Department
Retarded return flow 	 Sluggish	Lubricate
	Distorted 	Loosen distortion
	 Binding	Grind off / renew

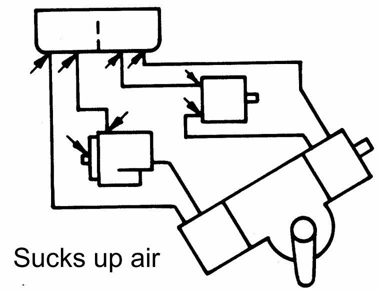
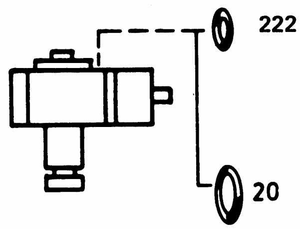
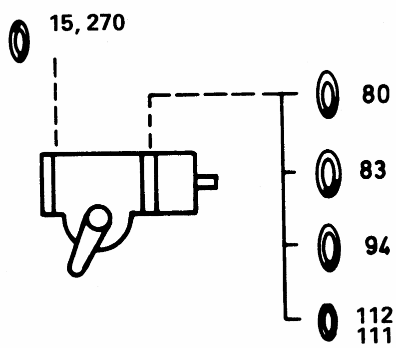
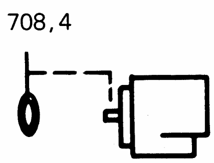
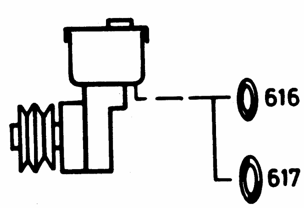
Fault	Cause	Remedy
	 Sluggish	Lubricate
		Adjust
	 Leaking Distorted (bent)	ZF Service Department
	 Insufficient flow rate	ZF Service Department
Inaccurate 		Eliminate Leaks  Bleed (vent)
	 	Tighten

Fault	Cause	Remedy
		Tighten / exchange
		Lubricate
		Tighten
	 Sucks up air	Renew sealing rings Bleed (vent)
		Adjust
Blows against steering wheel 		Eliminate leaks 
	 Sucks up air	Renew sealing rings Bleed

Fault	Cause	Remedy
	 Play	Renew
		Adjust
	 Insufficient flow rate	ZF Service Department
Oscillations 	 Unbalance	Balance
		Adjust
		Adjust
	 Sucks up air	Renew sealing rings Bleed (vent)

Fault	Cause	Remedy
Steering wheel play (flutter) 		Tighten / exchange
		Adjust
	 Insufficient flow rate	ZF Service Department
Slipping 	 Hydraulic center	ZF Service Department

Fault	Cause	Remedy
Noises 	 Sucks up air	Renew sealing rings  Bleed (vent)
		Eliminate leaks 
	 Pressure line	Rubber holder
		ZF Service Department
Oil loss 		Close
		Renew
		

Fault	Cause	Remedy
		Retighten lines
	   	ZF Service Department

12. ILLUSTRATIONS AND EXPLODED DIAGRAMS

12.1 Key to Illustrations and Exploded Diagrams

1. Locking ring
2. Shaft sealing ring
3. Bearing bushing
4. Bearing bushing
5. Housing
6. Sealing ring
7. Closing plug
8. Sealing ring
9. Closing plug
11. Round head notched nail
12. Nameplate
15. O-ring
16. End cover
17. Washer
18. Hex head bolt
20. O-ring
21. Housing cover
22. Washer
23. Hex head bolt
24. Hex nut
25. Seal
26. Closing plug
29. Pressure limiting valve
30. O-ring
31. Strain filter
40. Steering nut
41. Cup spring
41.1. Washer
42. Axial washer
43. Axial needle cage
44. Worm/steering spindle
44.1. Axial needle cage
48. Valve sleeve
49. Washer
51. Locking ring
56. Bore
57. Circulation pipe half
58. Cover
60. Shaft
61. Guide disk
62. Adjusting screw
63. Locking ring
64. Pitman arm
65. Dust seal
67. Castle nut
68. Cotter pin
80. O-ring
81. Fillister head screw
82. Intermediate cover
83. O-ring
84. Sealing ring
84.1. O-ring
85. Spacing ring
86. Valve housing, top
90. Cross-type disk
91. Locking ring
92. Axial needle cage
92.1. Thrust washer
93. Lower steering spindle
95. End flange
96. Washer
97. Hex bolt
98. Locking ring
99. Needle bearing
100. Shaft sealing ring (external)
101. Shaft sealing ring (internal)
102. Protective cap
103. Bearing ring
103.1. Washer
103.2. Locking ring
117. Sealing ring
118. Closing plug
220. Ball
221. Compression spring
222. O-ring
224. Control piston
226. Compression spring
228. Closing plug
229. Needle
230. O-ring
231. Valve
232. Hex nut
233. Spring plate
234. Locking ring
235. Supporting valve
268. Valve housing, lower
270. Sealing ring
278. Replenishing valve
301. Housing
302. Needle sleeve
304. Compensating washer
306. Bevel gear
308. O-ring
310. Shaft sealing ring, external
310.1. Shaft sealing ring, internal
312. Adjusting screw
313. Slot nut
314. Protective cap
331. Bevel gear
332. Ball bearing
333. O-ring
334. Stud
334.1. Washer
334.2. Nut
342. Locking ring
343. Ball bearing
344. Washer
345. Locking ring
350. Washer
352. Fillister head screw

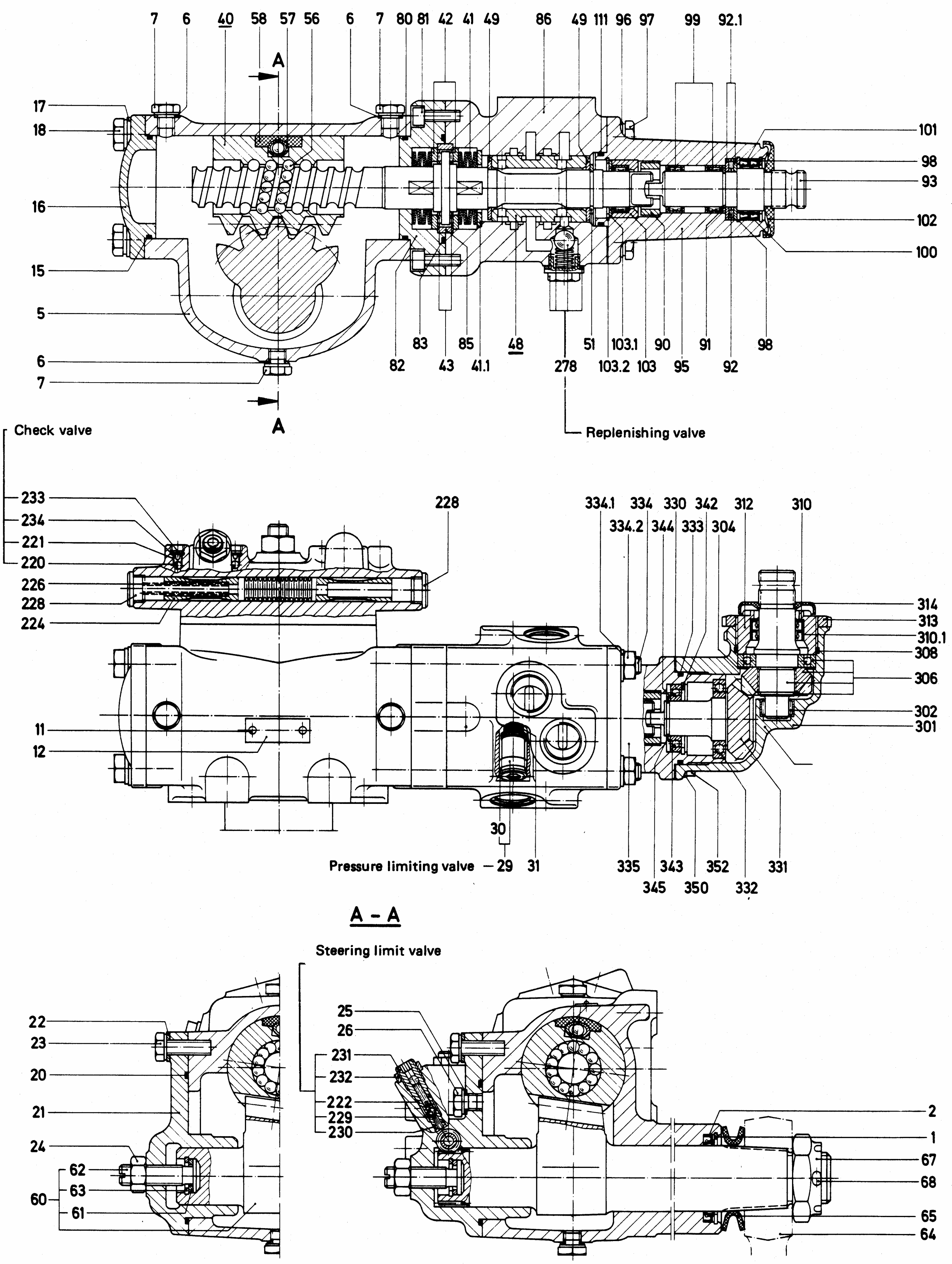


Figure 9. Single-circuit Steering Gear

Legend for Figures 10 and 11

90.	Cross-recessed disc	147.	Outer driver
91.	Circlip	148.	Carrier
92.	Ball bearing	149.	Support ring
93.	Steering spindle	151.	End flange
95.	Intermediate flange	152.	Stud bolt
98.	Circlip	153.	Washer
99.	Roller cage	154.	Circlip
100.	Shaft sealing ring	156.	Circlip
102.	Protective cap	157.	0-ring
103.	Bearing ring	330.	Shim
103.1.	Washer	331.	Bevel gear
103.2.	Circlip	332.	Ball bearing
143.	Inner driver	342.	Circlip
144.	Spacer	344.	Shim
145.	Inner driver	345.	Circlip
146.	Adjuster ring	346.	Aligning ring

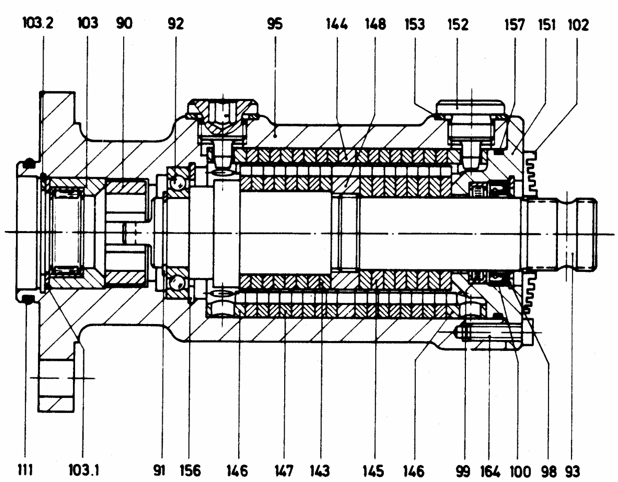


Figure 10. Longitudinal Section through the Mechanical Steering-lock Limiter – Stub Type

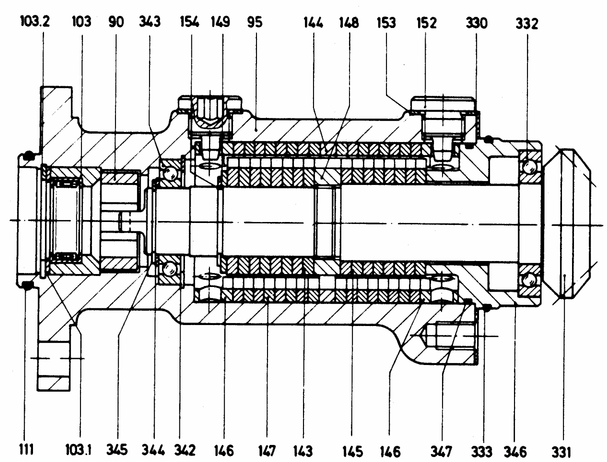
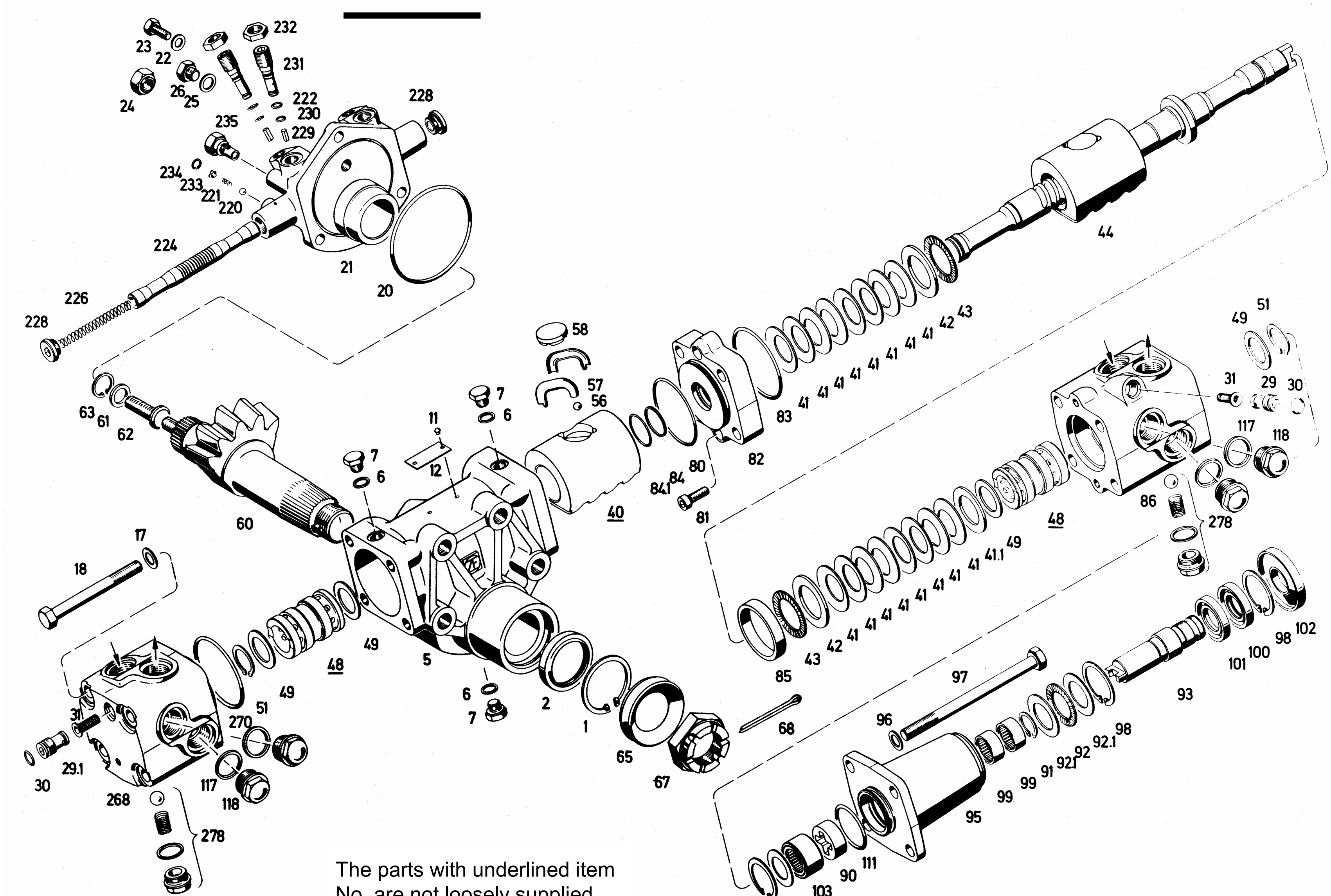
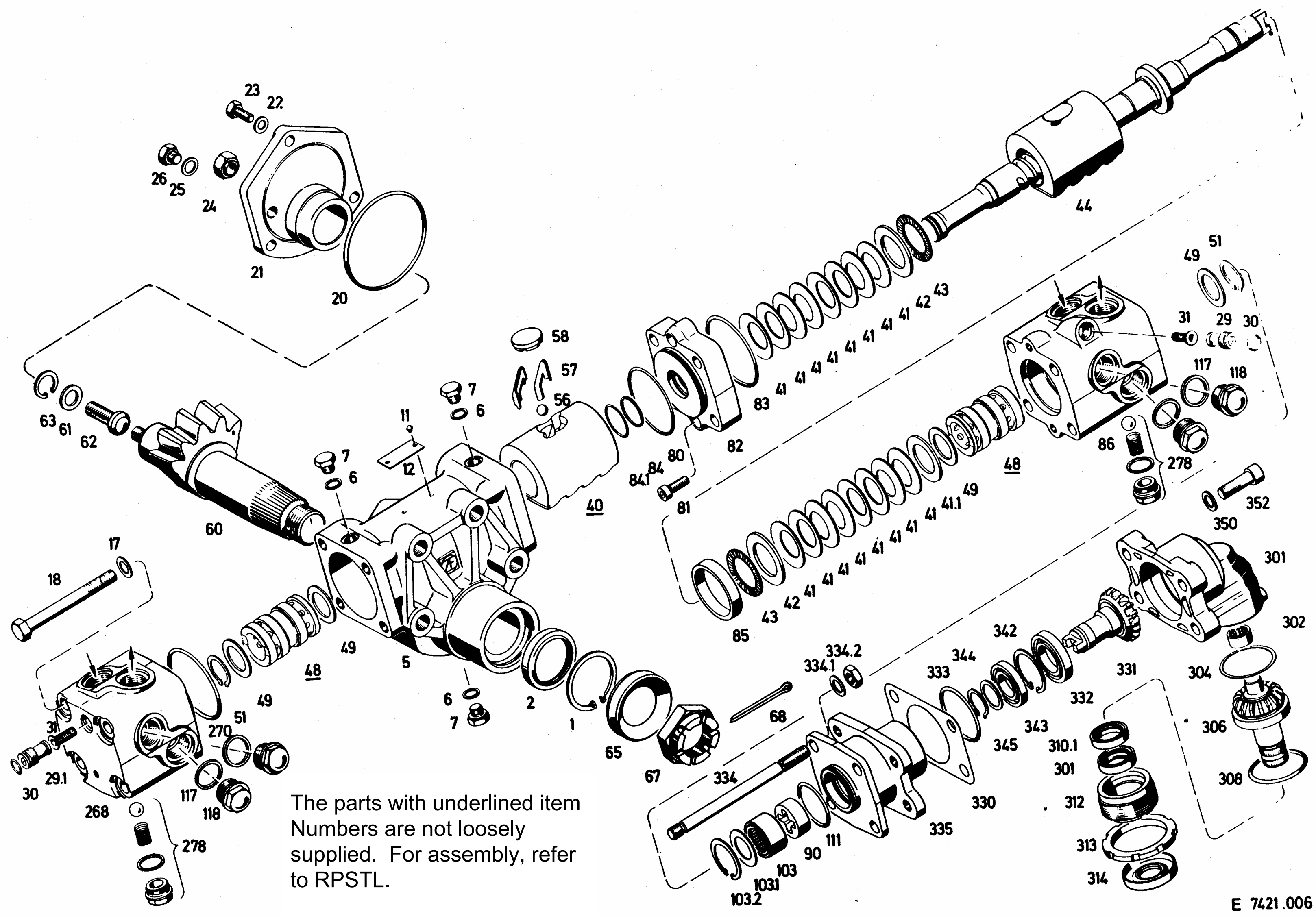


Figure 11. Longitudinal Section through the Mechanical Steering-lock Limiter – Right-angle Gear Type



The parts with underlined item No. are not loosely supplied. For assembly, refer to Spare Parts Lists.

Figure 12. ZF Semi-integral Power Steering Gear, Type 7421



The parts with underlined item Numbers are not loosely supplied. For assembly, refer to RPSTL.

Figure 13. ZF Semi-integral Power Steering Gear, Type 7421

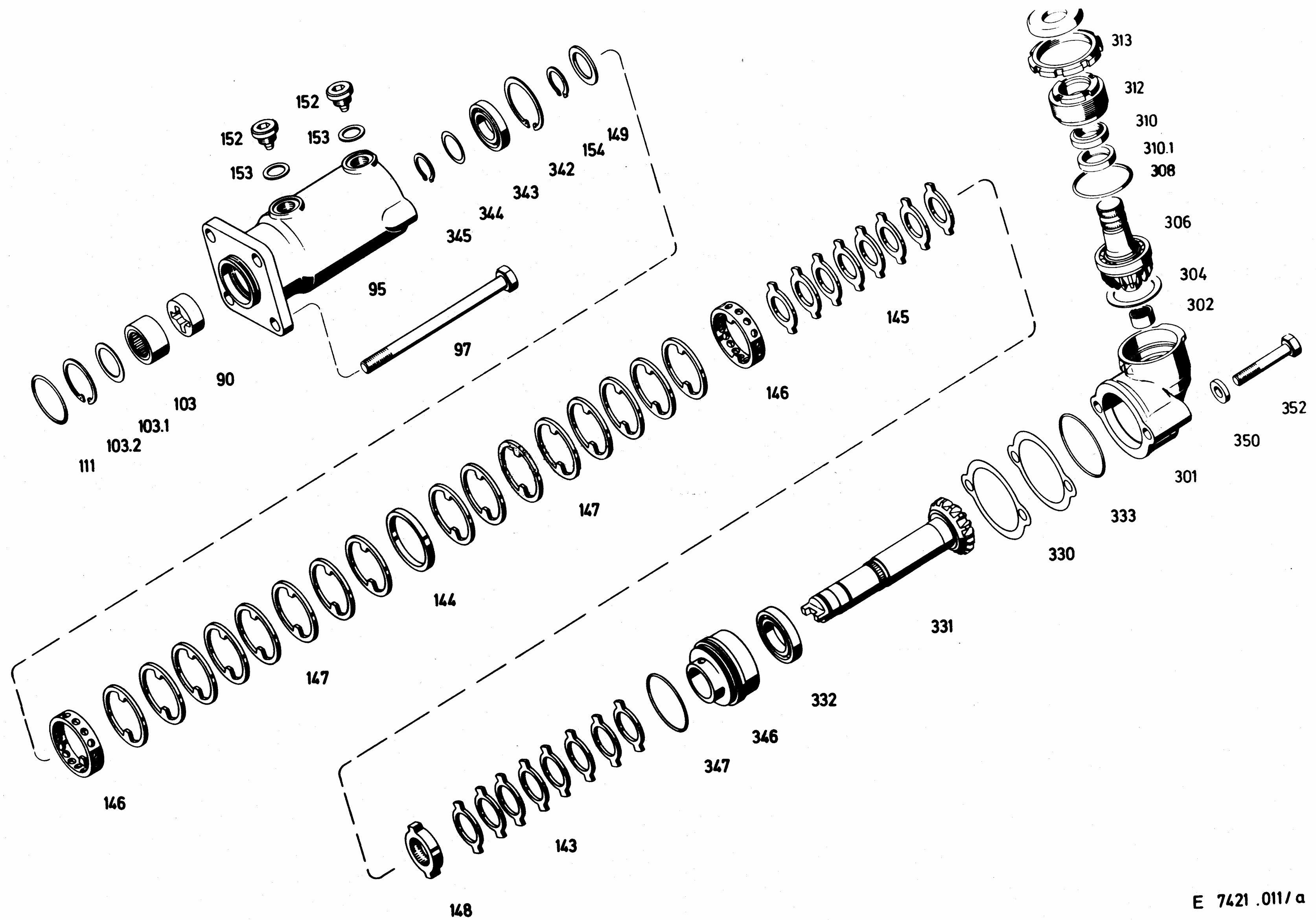


Figure 14. ZF Right-angle Gear, Type 7860 (for Flange-mounting to the Steering-lock Limiter Casing of Type 7421 ZF Power Steering Gear)

APPENDIX I

CUMMINS FIELD SERVICE PROCEDURES FOR WABCO AIR COMPRESSOR

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I-1. INTRODUCTION

The air compressor is an engine-driven, piston-type compressor which supplies compressed air to operate air-powered devices. The compressor runs continuously but has loaded and unloaded operating modes. The operating mode is controlled by a pressure-activated governor and the compressor unloading assembly. When the air system reaches cut-out pressure, the governor applies an air signal to the air compressor unloader assembly causing the unloader cap valve to activate and stop compressed air from flowing into the air system. As the air in the air system is used, the pressure drops. At cut-in pressure, the governor exhausts the air signal to the compressor unloader assembly, allowing the compressor to again pump compressed air into the air system.

I-2. TROUBLESHOOTING

NOTE

The following air compressor troubleshooting assumes that the crane's air system is otherwise operating properly e.g., the governor is operating; exhaust line is not blocked, frozen, or leaking; air dryer, reservoirs, and piping are functional.

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
1. Compressor will not pump air.	a. Unloader valve stuck open.	a. Replace head assembly.
	b. Inlet valve broken.	b. Replace head assembly.
	c. Exhaust valve broken.	c. Replace head assembly.
	d. Exhaust valve wedged open.	d. Replace head assembly.
	e. Internal relief valve broken.	e. Replace head assembly.
2. Compressor slow to build air.	a. Air intake valve leaks.	a. Replace head assembly.
	b. Exhaust valve leaks.	b. Replace head assembly.
	c. Excessive piston ring wear.	c. Replace piston assembly.
	d. Head gasket leaks.	d. Replace piston assembly.
	e. Internal relief valve leaks.	e. Replace head assembly.
3. Compressor exceeds cut-out pressure.	a. Unloader failure.	a. Replace head assembly.

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
4. Air getting into coolant system (or coolant in air system).	a. Internal gasket leakage.	a. Replace head assembly and gasket/seal kit.
	b. Internal casting porosity.	b. Replace air compressor.
5. Excessive blow-by.	a. Worn piston rings.	a. Replace piston assembly.
	b. Worn or scored cylinder head bore.	b. Replace air compressor.
	c. Debris in piston ring sealing area.	c. Disassemble and clean.
6. Excessive noise.	a. Internal relief valve cycling.	a. Correct fault in the crane's air system.
	b. Excessive piston ring wear.	b. Replace piston assembly.
	c. Carbon buildup on head and piston.	c. Disassemble and clean.
	d. Piston pin worn.	d. Replace piston assembly.
	e. Connecting rod worn.	e. Replace connecting rod assembly.
	f. Loose connecting rod cap bolts.	f. Replace connecting rod assembly.
	g. Front or rear crankshaft bearing worn.	g. Replace crankshaft bearings.
	h. Internal relief valve leakage.	h. Replace head assembly.
	i. Excessive crankshaft journal or throw pin wear.	i. Replace air compressor.
7. Excessive oil consumption.	a. Excessive duty cycle or excessively high pressure operation.	a. Correct fault in the crane's air system.
	b. Worn piston rings.	b. Replace piston assembly.
	c. Restricted air intake passage.	c. Replace head assembly.
	d. Worn or scored cylinder head bore.	d. Replace air compressor.
8. External oil leak.	a. Head gasket leakage.	a. Remove head and replace gasket/seal kit.
	b. Bottom cover leakage.	b. Replace sump plug (part of gasket/seal kit).
	c. Internal casting porosity.	c. Replace air compressor.

I-3 MAINTENANCE

I-3.1 Head Assembly Replacement. (Refer to Figures I-1 and I-2.)

NOTE

This procedure covers the replacement of the Single Cylinder Air Compressor Cylinder Head Assembly Kit, Cummins kit part number 4089208. The repair kit includes a complete head assembly (manifold, valves, cover, etc.) new head bolts, coolant seals, and gaskets.

Gasket and Seal Kit, Cummins kit part number 4089240 can be used if necessary to replace leaking cylinder head gaskets and coolant seals (assuming the cylinder head is serviceable). The repair kit includes a head gasket, two cover gaskets, intake valve, head bolts, cover assembly bolts, sump plug, and rear flange adapter with O-ring seal.

Removal.

a. Note the locations of all air and coolant fittings. Then remove and retain all air and coolant fittings installed in the air compressor head (1, Figure I-1).

b. Remove and discard four head bolts (2) – "A, B, C, & D", Figure I-2. Bolts "A", "C", and "D" are 3-1/8 in. (80 mm) long and bolt "B" is 4-1/8 in. (105 mm) long.

c. Note the orientation of the head assembly (1, Figure I-1) with respect to the air compressor crankcase.

d. Remove and discard the head assembly (1) and head gasket (3).

Cleaning.

a. Rotate air compressor crankshaft until the piston is at the top of the cylinder bore.

WARNING

Many cleaning solvents are toxic, flammable, and/or may cause skin and eye irritation. Strictly follow the manufacturer's instructions and use eye protection, gloves, and protective clothing. Use in well-ventilated areas away from heat and open flames. Use good personal hygiene prior to eating, drinking, or smoking.

CAUTION

Do not use abrasive products that will leave grit after cleaning. Do not allow debris and cleaning solvent to enter the area between the piston and cylinder bore.

b. Remove any carbon and varnish build-up by carefully scraping. If necessary, use a light application of cleaning solvent.

c. Ensure all surfaces are clean, dry, and free of debris.

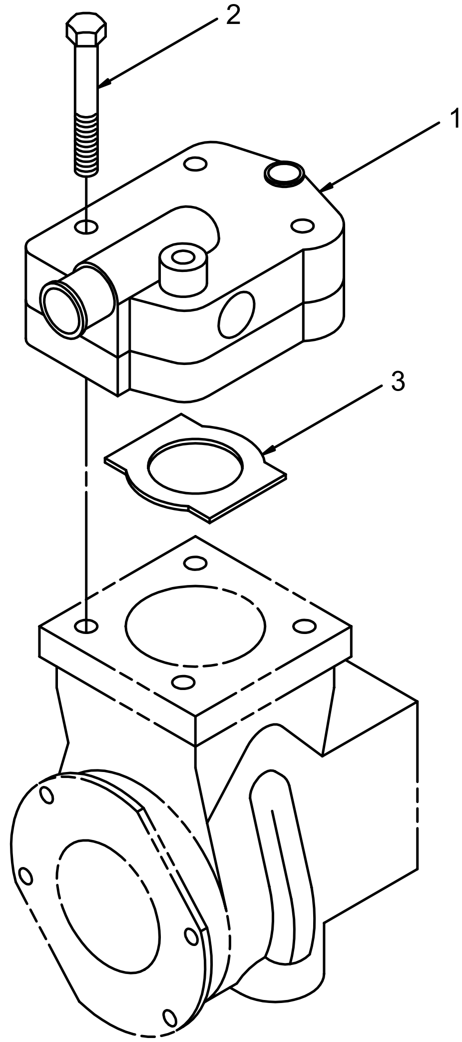

Figure I-1. Cylinder Head Installation

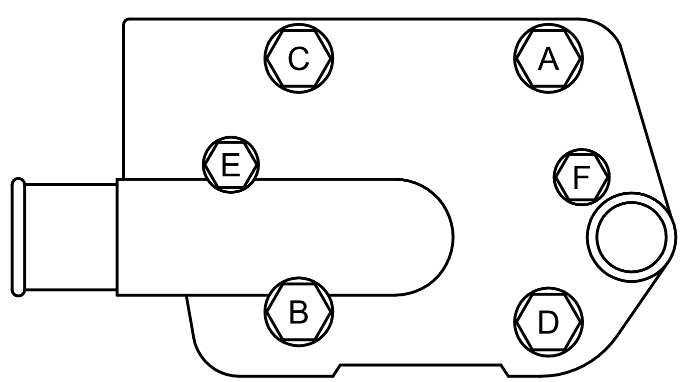

Figure I-2 Cylinder Head Bolt Tightening Sequence

Installation.

a. Ensure that sliding valve is in place and that the head assembly (1, Figure I-1) is oriented properly as noted in step c in “Disassembly”. Ensure guide pins are aligned properly.

b. Place mounting gasket (3) and head assembly (1) on the compressor crankcase.

c. Insert four new head bolts (2) and tighten finger tight. The longer head bolt (M8x105mm) should be installed in position “B”, Figure I-2. Two cover bolts “E” and “F” have been loosely installed at the factory to hold the head assembly together.

<u>CAUTION</u>

Use a torque wrench and the following torque-turn sequencing method with Figure I-2 to tighten head bolts “A” thru “D” and head assembly bolts “E” and “F”. Failure to follow the correct sequence could result in a field failure of the compressor.

d. Torque head bolts “A”, then “B”, then “C”, then “D” to between 10 and 12 ft-lbs (13.5 to 16.5 Nm).

e. Torque head bolts “A”, then “B”, then “C”, then “D” to between 17 and 20 ft-lbs (23 to 27 Nm).

f. Turn head bolt “A” an additional 180 degrees (+/- 10°). Then turn head bolt “B” an additional 270 degrees (+/- 10°). Finally, turn head bolt “C” then “D” an additional 180 degrees (+/- 10°).

g. Torque head assembly bolt “E” then bolt “F” to between 48 and 58 in.-lbs (5.4 to 6.6 Nm).

h. Turn head assembly bolt “E” then “F” an additional 90° (+15/-5°).

i. Install air and coolant fittings retained from the removal procedure.

I-3-2 Rear Seal and Adapter Replacement. (Refer to Figures I-3 and I-4.)

NOTE

This procedure covers the replacement of the Single Cylinder Air Compressor Rear Seal and Adapter Kit, Cummins kit part number 4089222. The repair kit includes an adapter, O-ring, gasket, and two flat head screws.

Removal.

a. Remove two bolts (1, Figure I-3) securing the back cover (2).

b. Remove and discard cover gasket (3).

c. Remove two flat head screws (4), if installed. Then remove and discard the metal pump adapter (5).

d. Remove and discard O-ring seal (6).

Installation.

a. Lube new O-ring seal (6, Figure I-3) with clean oil, MIL-L-2104. Then insert the seal into the fillet pocket formed by the corner of the rear bearing and the wall of the crankcase. Refer to Figure I-4.

b. Install new pump adapter (5, Figure I-3) into compressor while aligning the mounting holes for the two flat head screws (4). Install and torque the flat head screws (4) to 5 ft-lbs (6 Nm).

c. Install back cover (2) with new cover gasket (3) and secure with two bolts (1). Torque bolts (1) to 15 ft-lbs (20 Nm).

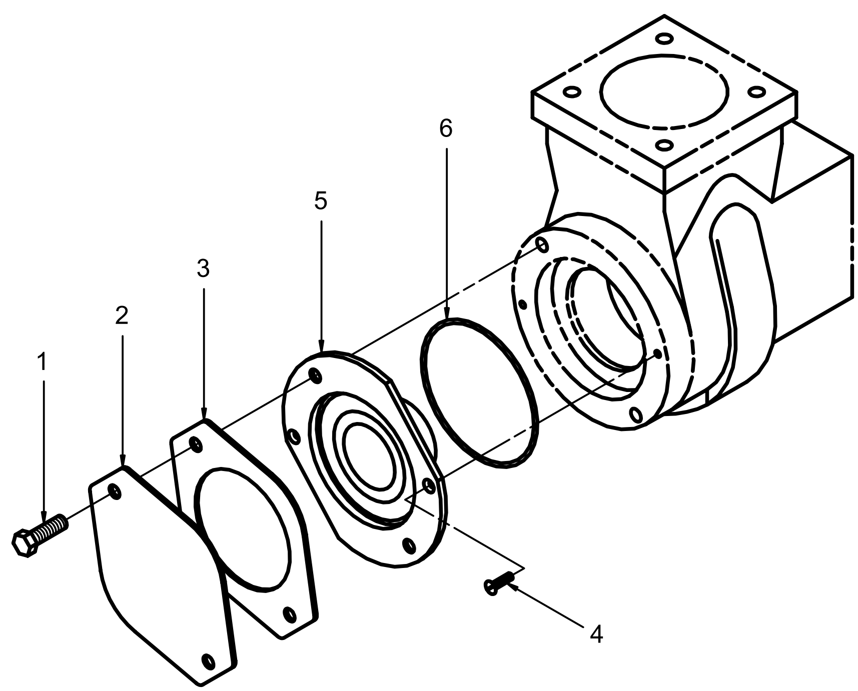

Figure I-3. Air Compressor Rear Seal and Adapter

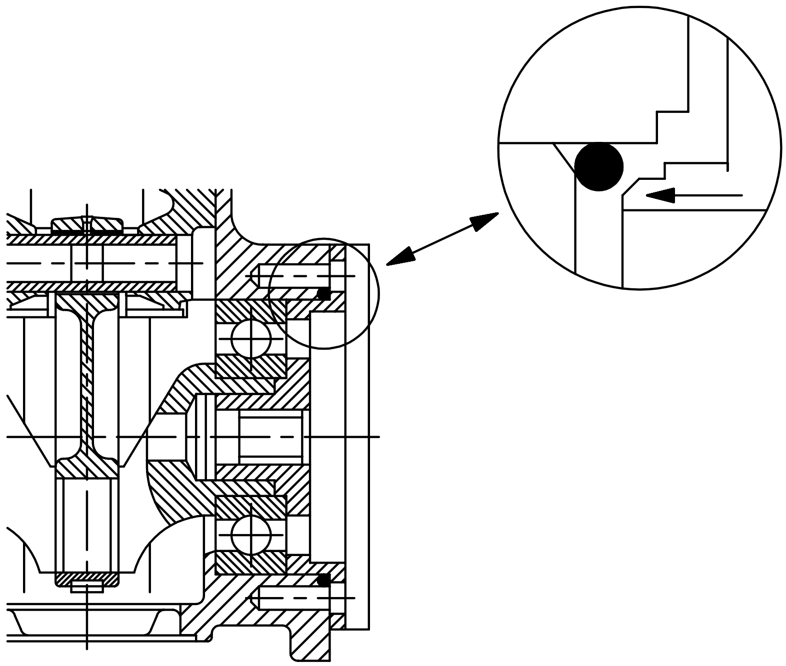

Figure I-4. Compressor Rear Bearing O-ring Seal Installation

I-3-3 Piston Assembly Replacement. (Refer to Figure I-5.)

NOTE

This procedure covers the replacement of the Single Cylinder Air Compressor Piston Assembly, Cummins kit part number 4089210. The repair kit includes a piston with rings, pin, coolant seals, sump plug, retainers, gaskets, head bolts, and head and cover gaskets.

Removal.

NOTE

There is no need to remove the air and coolant fittings from the head assembly unless replacing the head.

a. Remove the head assembly. Refer to paragraph I-3-1. Remove two head cover screws and head cover gasket. Retain the head assembly but discard the four large head bolts, two cover screws, head cover gasket, and head gasket.

b. Use a large screwdriver to remove the sump plug (1, Figure I-5). Discard the plug.

c. Rotate the crankshaft until connecting rod cap appears in the access hole.

d. Remove two Torx head bolts (2). Retain the bolts unless replacing the connecting rod with the piston.

e. Remove connecting rod cap (3). Retain the cap unless replacing the connecting rod with the piston.

f. Push the piston (4) and connecting rod out of the top of the crankcase by pushing the bottom of the connecting rod with a wooden dowel.

g. Remove one piston pin retaining clip (5). Then push out piston pin (6) to separate the piston (4) and connecting rod (7). Discard the clip, piston pin, and piston but retain the connecting rod if not replacing the rod.

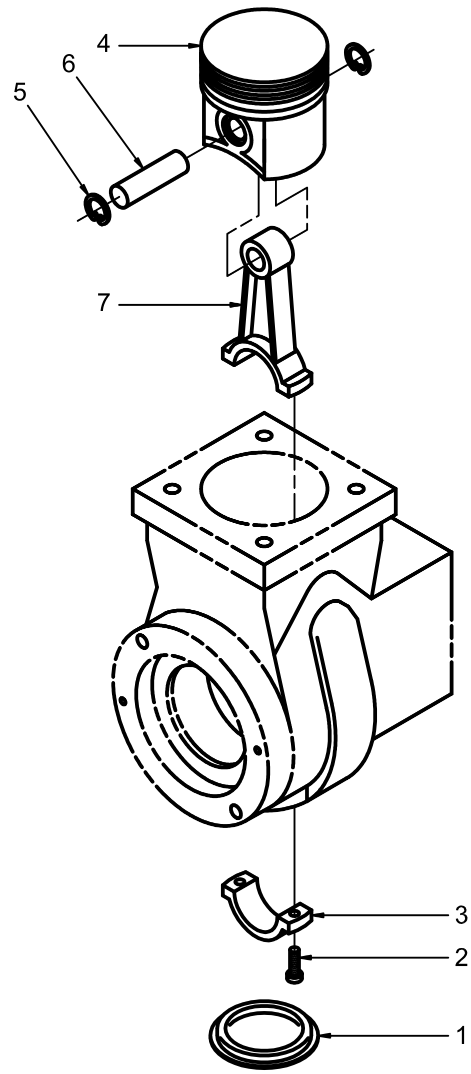

Figure I-5. Piston Assembly Replacement

Cleaning.

WARNING

Many cleaning solvents are toxic, flammable, and/or may cause skin and eye irritation. Strictly follow the manufacturer's instructions and use eye protection, gloves, and protective clothing. Use in well-ventilated areas away from heat and open flames. Use good personal hygiene prior to eating, drinking, or smoking.

CAUTION

Do not use abrasive products that will leave grit after cleaning. Do not allow debris and cleaning solvent to enter the cylinder bore.

a. Remove any carbon and varnish build-up by carefully scraping. If necessary, use a light application of cleaning solvent.

b. Ensure all surfaces are clean, dry, and free of debris.

Installation.

a. Ensure that gaps in the piston rings are staggered 90° apart on the new piston assembly. Also ensure that the "hook" in the upper piston rings is away from the top of the piston as shown in Figure I-6.

b. Coat the piston pin (6), connecting rod bore, and piston pin bore with light oil, MIL-L-2104.

CAUTION

Do not force the piston pin (6) into the piston pin bore; this will damage the piston (4)

c. Assemble the connecting rod (7) and piston (4) with piston pin (6) and piston pin retainer clips (5). Ensure clips (5) are secure in their grooves.

d. Ensure the connecting rod (7) moves freely.

e. Coat the crankcase cylinder bore with light oil, MIL-L-2104. Then using a piston ring compressor, install the piston and connecting rod into the cylinder bore while aligning the connecting rod with the crankshaft. When aligned properly, the connecting rod cap (3) should line up with the connecting rod end.

f. Apply light oil, MIL-L-2104 to the crankshaft rod journal. Then install the connecting rod cap (3). Install the two Torx head bolts (2) finger tight.

g. Use a torque wrench to tighten the Torx head bolt closest to the "W" of the cast word "WABCO" from between 48 and 58 in.-lbs (5.4 to 6.6 Nm). Then torque the other bolt from between 48 and 58 in.-lbs (5.4 to 6.6 Nm).

h. Turn the Torx head bolt closest to the "W" an additional 70° (+15/-5°). Then turn the other bolt an additional 70° (+15/-5°).

i. Ensure that the crankshaft rotates freely without binding. The maximum torque require to rotate the crankshaft is 53 in. lbs (6 Nm).

j. Apply Loctite® 648 sealant to the edge of the sump plug (1). Press the plug evenly into the crankcase until the plug flange seats.

k. Insert the new head cover gasket and assemble the head and the cover with two new head cover screws. Install the head assembly with new head gasket and head bolts supplied with the piston assembly service kit. Refer to paragraph I-3-1.

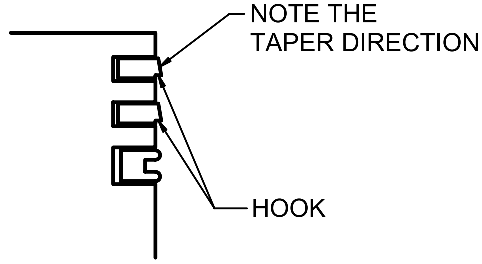

Figure I-6. Correct Piston Ring Orientation

I-3-4. Connecting Rod Assembly Replacement.

NOTE

This procedure covers the replacement of the Single Cylinder Air Compressor Connecting Rod Assembly, Cummins kit part number 4089212. The repair kit includes a connecting rod, sump access plug, seals, gaskets, head bolts, and head and cover gaskets.

Removal.

NOTE

There is no need to remove the air and coolant fittings from the head assembly unless replacing the head.

a. Remove the head assembly. Refer to paragraph I-3-1. Remove two head cover screws and head cover gasket. Retain the head assembly but discard the four large head bolts, two cover screws, head cover gasket, and head gasket.

b. Remove the piston assembly. Refer to paragraph I-3-3. Retain the piston assembly, piston pin, and piston pin retaining clips unless also replacing the piston assembly.

c. Discard the connecting rod assembly, Torx head bolts, and connecting rod cap.

Cleaning.

WARNING

Many cleaning solvents are toxic, flammable, and/or may cause skin and eye irritation. Strictly follow the manufacturer's instructions and use eye protection, gloves, and protective clothing. Use in well-ventilated areas away from heat and open flames. Use good personal hygiene prior to eating, drinking, or smoking.

CAUTION

Do not use abrasive products that will leave grit after cleaning. Do not allow debris and cleaning solvent to enter the cylinder bore.

a. Remove any carbon and varnish build-up by carefully scraping. If necessary, use a light application of cleaning solvent.

b. Ensure all surfaces are clean, dry, and free of debris.

Installation.

a. Install the piston assembly with new connecting rod. Refer to paragraph I-3-3. Use new Torx head bolts and connecting rod cap supplied with the connecting rod service kit.

b. Insert the new head cover gasket and assemble the head and the cover with two new head cover screws. Install the head assembly with new head gasket and head bolts supplied with the connecting rod service kit. Refer to paragraph I-3-1.

Crankshaft Bearing Replacement. (Refer to Figure I-7.)

NOTE

This procedure covers the replacement of the Single Cylinder Air Compressor Crankshaft Bearing, Cummins kit part number 4089213. The repair kit includes a ball and journal bearings, sump access plug, seals, and head and cover gaskets.

Removal.

NOTE

There is no need to remove the air and coolant fittings from the head assembly unless replacing the head.

a. Remove the head assembly. Refer to paragraph I-3-1. Remove two head cover screws and head cover gasket. Retain the head assembly but discard the four large head bolts, two cover screws, head cover gasket, and head gasket.

b. Remove the piston and connecting rod assemblies. Refer to paragraph I-3-3. Retain the piston assembly, piston pin, piston pin retaining clips, connecting rod, Torx head bolts, and connecting rod cap unless also replacing the piston and connecting rod assemblies.

c. Position the crankshaft (1, Figure I-7) in the Top Dead Center (TDC) position. The gear alignment pin will also be in the TDC position. Press the crankshaft (1) with ball bearing (2) out of the rear of the crankcase. This requires approximately 3,000 pounds (1,360 kg) of force.

d. Using a cylindrical piece of steel that is a loose fit to the crankcase bore, press the journal bearing (3) out of the crankcase toward the front. Discard the journal bearing.

e. Clamp the crankshaft (1) by the counterweight and remove the ball bearing retaining nut (4). Removal will require a high torque in the counter-clockwise direction.

f. Remove and discard the ball bearing (2).

Cleaning.

WARNING

Many cleaning solvents are toxic, flammable, and/or may cause skin and eye irritation. Strictly follow the manufacturer's instructions and use eye protection, gloves, and protective clothing. Use in well-ventilated areas away from heat and open flames. Use good personal hygiene prior to eating, drinking, or smoking.

CAUTION

Do not use abrasive products that will leave grit after cleaning. Do not allow debris and cleaning solvent to enter the cylinder bore.

a. Remove any carbon and varnish build-up by carefully scraping. If necessary, use a light application of cleaning solvent.

b. Ensure all surfaces are clean, dry, and free of debris.

Installation.

a. Press new ball bearing (2, Figure I-7) onto the rear crankshaft journal and install ball bearing retainer nut (4). Ensure the force is applied to the inner race of the ball bearing (2). Torque the bearing retainer nut from 424 to 460 ft lbs (575 to 625 Nm).

NOTE

Ensure the oil hole is aligned with the crankcase oil supply hole.

b. Press the journal bearing (3) into the crankcase to a depth of 0.689 to 0.708 in. (17.5 to 18 mm) below the machined mounting flange.

c. Assemble the crankshaft (1) with ball bearing (2) into the crankcase. Ensure that the rod throw is in the TDC position and will enter through the cast clearance slot.

CAUTION

Ensure that the load is applied to the outer race of the ball bearing (2) to avoid bearing damage.

d. Press the crankshaft into the crankcase until it bottoms on the shoulder.

e. Install the piston and connecting rod assemblies. Refer to paragraph I-3-3.

f. Insert the new head cover gasket and assemble the head and the cover with two new head cover screws. Install the head assembly with new head gasket and head bolts supplied with the crankshaft bearing service kit. Refer to paragraph I-3-1.

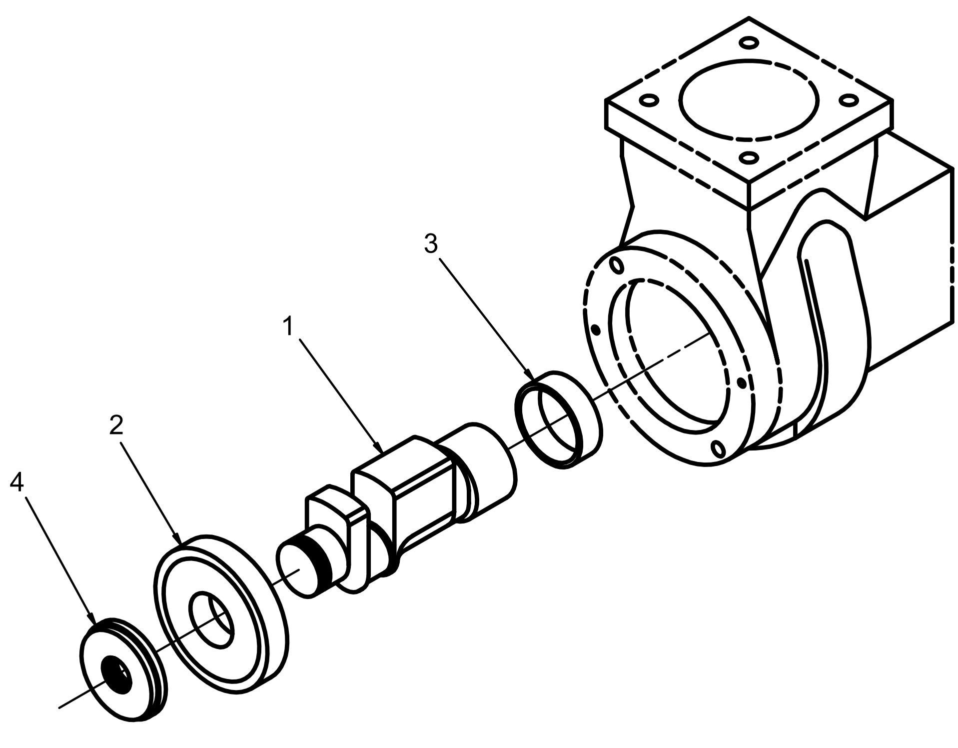

Figure I-7. Crankshaft Bearing Replacement

APPENDIX J

WINTERIZING THE ATEC CRANE AT422T

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SAFETY SUMMARY

WARNING

Correct installation of the heater is necessary to ensure safe operation. Read and understand this manual before attempting to install the heater. Failure to follow these procedures could result in serious injury or death.

WARNING

The heater MUST be turned off while re-fueling. Do not install the heater in an enclosed area where combustible fumes may be present. Failure to follow these procedures could result in serious injury or death.

WARNING

Install the exhaust system so that a minimum distance of 2 inches (50 mm) from any flammable material is maintained at all times. Ensure that the fuel system is intact and that there are no fuel leaks.

Route the heater exhaust system so that exhaust fumes cannot enter either cab compartment. If running exhaust components through an enclosed compartment, ensure that it is vented to the outside. Failure to follow these procedures could result in serious injury or death.

WARNING

The engine coolant system should contain the proper mixture of anti-freeze and water to prevent coolant from freezing or slushing. If the coolant becomes slushy or frozen, the heater's coolant pump cannot move the coolant, causing a blockage in the coolant system. Pressure could rapidly build-up in the heater and in the coolant hose causing it to burst or blow off of its connection point. Failure to ensure that the engine coolant system is properly filled could result in damage to the engine and/or serious injury. Refer to Chapter 2, Section 2 in this manual.

INTRODUCTION.

The Espar Hydronic 10 is a diesel-fired coolant heater that heats the crane's engine coolant and the oil in the hydraulic tank. The heater consists of a water pump, a heat exchanger, and an electronic control system. The unit pumps the engine coolant into the heat exchanger where the coolant is heated before being returned to the engine coolant system. The warmed coolant is used to warm the diesel engine head and cylinder block to promote cold weather starting.

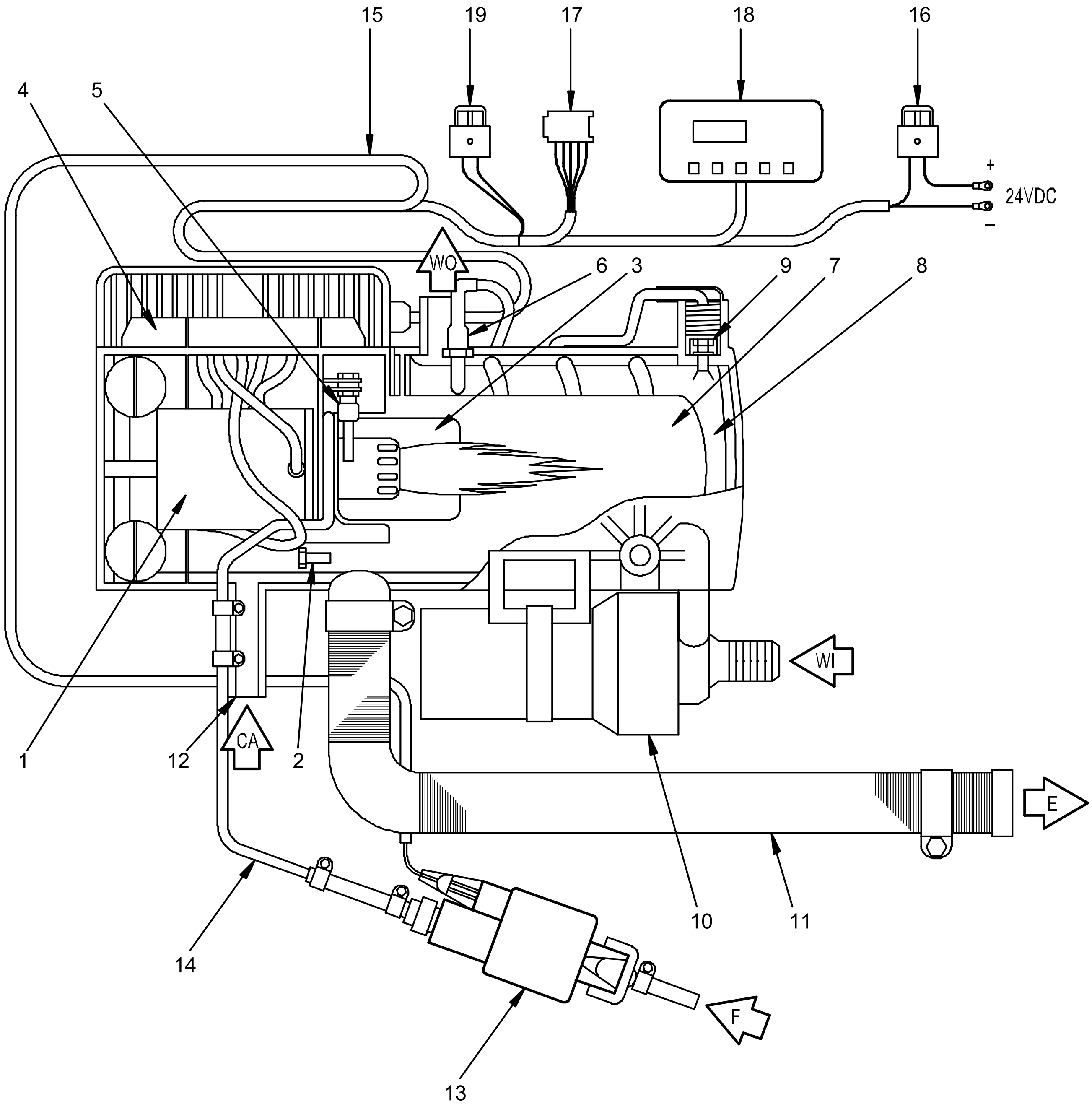
The warmed coolant also passes through two hydraliner heating elements located in the main hydraulic reservoir. These heating elements enable heat transfer from the warm coolant to the hydraulic oil in order to improve cold weather operation of the crane's hydraulic components.

The coolant heater operates independently of the crane's diesel engine. It does, however, use 24-volt DC power from the crane's electrical system as well as diesel fuel from the crane's fuel tank. The coolant heater features a temperature regulating switch that controls the coolant temperature by switching the unit on when the coolant temperature is below 154° F (68° C) and off when the temperature is above 185° F (85° C).

The coolant heater control circuit includes a seven day timer mounted in the cab, a control unit, flame sensor, temperature sensor, and an overheat sensor.

Table J-1. Leading Particulars

Heat Output		
	(Boost)	9.5 kW (32,400 BTU/hr)
	(High Heat)	7.5 kW (25,600 BTU/hr)
	(Medium)	3.2 kW (10,900 BTU/hr)
	(Low Heat)	1.5 kW (5,100 BTU/hr)
Current Draw		
	(Boost)	5.2 amps
	(High Heat)	3.2 amps
	(Medium)	1.8 amps
	(Low Heat)	1.5 amps
Diesel Fuel Consumption		
	(Boost)	0.32 gal./hr (1.2 l/hr)
	(High Heat)	0.24 gal./hr (0.9 l/hr)
	(Medium)	0.11 gal./hr (0.4 l/hr)
	(Low Heat)	0.05 gal./hr (0.2 l/hr)
Operating Voltage		20 to 30 VDC
Coolant Pump Flow		370 gal./hr (1400 l/hr)
Coolant Temperature Range		154-185° F (68-85° C)
Overheat Shutdown (Coolant Temperature)		240° F (115° C)
Weight		14.3 lbs (6.5 kg)



LEGEND

1. Blower Motor
2. Flame Sensor
3. Combustion Chamber
4. Control Unit
5. Glow Pin
6. Temperature Sensor
7. Flame Tube
8. Heat Exchanger
9. Overheat Sensor
10. Water Pump
11. Exhaust Pipe
12. Combustion Air Intake
13. Fuel Metering Pump
14. Fuel Line (Plastic)
15. Wiring Harness
16. In-line Fuse (15A)
17. Connector (Not Used)
18. Seven Day Timer
19. In-line Fuse (5A)

CA = Combustion Air Inlet
E = Exhaust Outlet
F = Fuel Supply Line
WI = Water Inlet
WO = Water Outlet

Figure J-1. Coolant Heater Operation

THEORY OF OPERATION

Start Up (Refer To Figure J-1.)

Operate the coolant heater manually by depressing the Heater "On" pushbutton on the seven day timer (18) located in the cab. The following sequence occurs:

a. Coolant heater control unit (4) performs a system readiness check lasting one to three seconds. The control unit verifies that the flame sensor (2), temperature sensor (6), and overheat sensor (9), etc., are operational.

b. Water pump (10) starts and circulates engine coolant through the water jacket surrounding the heat exchanger (8).

c. The combustion air blower motor (1) starts.

d. Glow pin (5) begins a pre-heat sequence that lasts from 20 to 50 seconds.

e. Fuel metering pump (13) delivers fuel to the combustion chamber (3) at the end of the glow pin pre-heat sequence while the combustion air blower motor (1) ramps up gradually to full air flow.

f. Fuel is ignited in the combustion chamber (3). Upon fuel ignition, the flame sensor (2) signals the control unit that ignition has occurred and the control unit shuts off the glow pin (5) (ignition time: 1-1/2 to 2 minutes).

NOTE

If the coolant heater fails to start on the first try, the control unit (4) will automatically attempt a second start which includes a second pre-heat sequence (50 seconds). If the heater does not start after the second attempt, the heater and control unit will shut down completely.

FIRST TIME STARTUP. When starting the coolant heater for the first time, the system may require several start up attempts in order to self prime the fuel system.

Coolant Heater Running (Refer To Figure J-1.)

Fuel ignition occurs and is verified. The following sequence occurs:

a. Coolant heater runs in full heat mode and the coolant temperature is monitored in the heat exchanger (8) via temperature sensor (6).

b. When the engine coolant reaches 162° F (72° C), the coolant heater control unit (4) will cycle the coolant heater up and down between high, medium, and low.

c. The coolant heater control unit (4) shuts off the coolant heater when the engine coolant temperature reaches 185° F (85° C).

d. The water pump (10) continues to circulate engine coolant while the temperature sensor (6) monitors the temperature. The coolant heater control unit (4) will automatically re-start the coolant heater if the coolant temperature drops to 154° F (68° C).

e. The coolant heater will continue to cycle on and off as described in steps b, c, and d until it is either manually (by depressing the Heater “On” pushbutton) or automatically (seven day timer times out) shuts down.

NOTE

If the coolant heater flames out while in the running mode, the control unit (4) will automatically re-start the heater. If the coolant heater does not re-start after one attempt, the control unit (4) will shutdown the heater.

The coolant heater control unit (4) continually senses the input voltage from the crane’s batteries. If the input voltage drops below 20 VDC or rises above 30 VDC, the heater control unit (4) will automatically shutdown the coolant heater.

Coolant Heater Shutdown (Refer To Figure J-1.)

The coolant heater can be shutdown manually (by depressing the Heater “On” pushbutton) or automatically (via the seven day timer). The following sequence occurs:

a. When switched off, the coolant control unit (4) initiates a heater cool down cycle.

b. The fuel metering pump (13) stops running and the flame is extinguished.

c. The combustion air blower motor (1) and water pump (10) continue operating for approximately three minutes to cool down the coolant heater combustion chamber.

d. The coolant heater shuts down after the cool down period. The combustion air blower motor (1) and the water pump (10) stop running.

Safety Equipment (Refer To Figure J-1.)

The coolant heater control unit (4) monitors the heater for malfunctions. The unit employs temperature (6), overheat (9), and flame (2) sensors to monitor coolant heater performance. The coolant heater will shut down whenever a malfunction occurs.

a. The control unit (4) performs a self-test of the electrical circuit prior to starting the coolant heater.

b. The control unit (4) will automatically repeat the startup sequence if the flame sensor (2) fails to detect a flame 90 seconds after the fuel metering pump (13) comes on. If the heater fails to ignite after the second 90-second timer times out, the control unit (4) will perform a safety shutdown.

c. The control unit (3) will attempt to re-ignite the coolant heater if it fails or flames-out during operation. If the heater fails to re-ignite after ten seconds or if the heater flames out again after only three minutes of operation, the control unit (4) will initiate a flame out shutdown. The coolant heater cannot be restarted until the problem is corrected.

d. Overheating can occur when the coolant flowing through the coolant heater is low, restricted, or poorly bled. The overheat sensor (9) will most likely detect a temperature rise in the coolant heater’s heat exchanger. When this occurs, the control unit (4) will perform an overheat shutdown of the heater. Again, the problem should be corrected before attempting to re-start the heater.

e. The coolant heater control unit (4) senses high and low input voltage. The control unit (4) will initiate a low/high voltage shutdown if the input voltage drops below 20 VDC or rises above 30 VDC. This type of shutdown typically indicates a problem with the crane's batteries and/or it's charging system.

f. The coolant heater's electrical connections are protected by a 15A in-line fuse (16), located in the crane's battery box at the battery connections, and a second 5A in-line fuse (19), located in the coolant heater boxed enclosure. The 15A in-line fuse (16) protects the main 24 VDC input.

INSTALLATION

WARNING

ASPHYXIATION HAZARD. Ensure that exhaust fumes cannot enter the cab. Failure to comply with this warning could result in personal injury or death from asphyxiation.

WARNING

The engine coolant heater exhaust is hot, ensure a minimum clearance of 2 inches (5 cm) from any heat sensitive material. Failure to follow this warning could result in personal injury and/or damage to the crane.

CAUTION

Ensure that the engine coolant heater exhaust outlet and pipe cannot be plugged by dirt, rainwater, or snow. Ensure that the exhaust outlet and pipe does not face the crane slipstream.

CAUTION

Ensure the engine coolant heater combustion air intake opening cannot be plugged by dirt, rainwater, or snow. Ensure that the combustion air intake opening does not face the crane slipstream.

CAUTION

Ensure the battery disconnect switch is in the OFF position prior to starting installation of the coolant heater.

Fuel Tank Modification. (Refer To Figures J-2 and J-3.) Modify the crane's fuel tank as follows:

a. Drain and remove the fuel tank in accordance with the technical manual, TM 5-3810-307-24-1-1.

b. Mark the centers for the two 0.25" and one 1.0" diameter hole in accordance with the dimensions shown on Figure J-2 and create an indent in the centers using a punch.

c. Drill the two 0.25" diameter holes in the fuel tank.

NOTE

Blow shavings away while drilling to reduce amount of shavings that may fall into fuel tank.

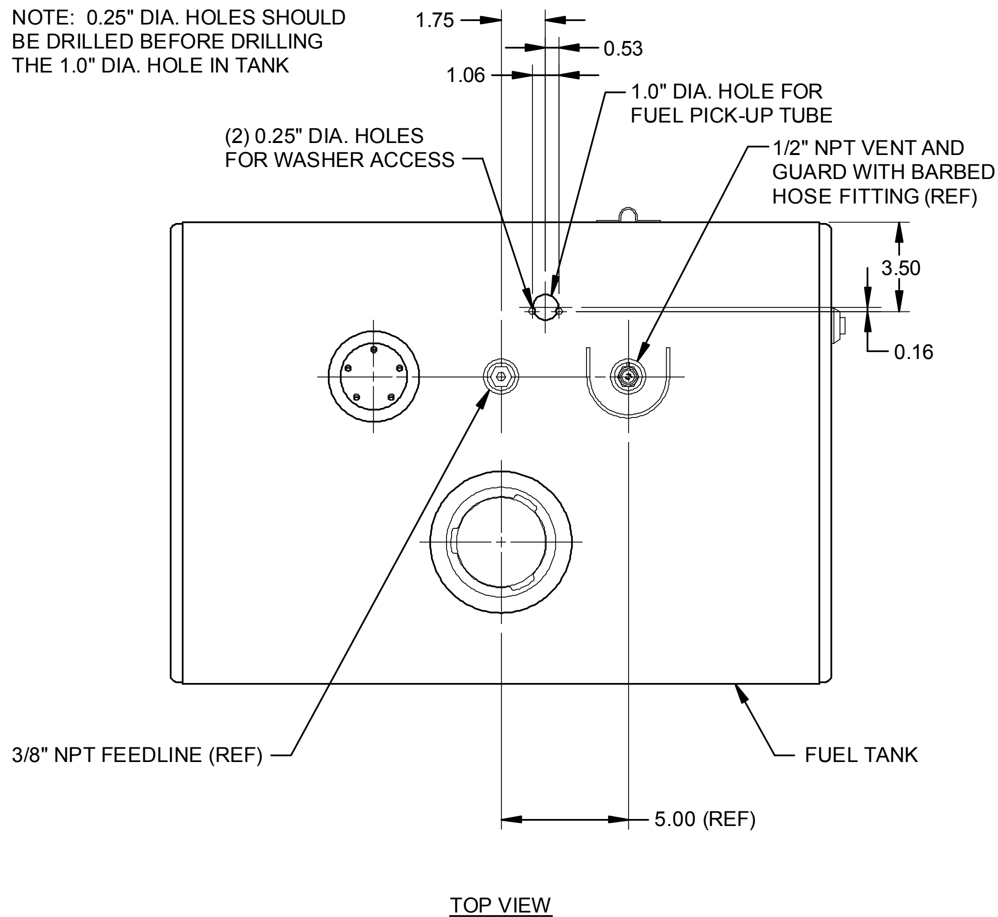


Figure J-2. Fuel Tank Modification Dimensions

d. Drill the one 1.0” diameter hole in the fuel tank.

e. Clean the edges of the 1.0” diameter hole using a round file.

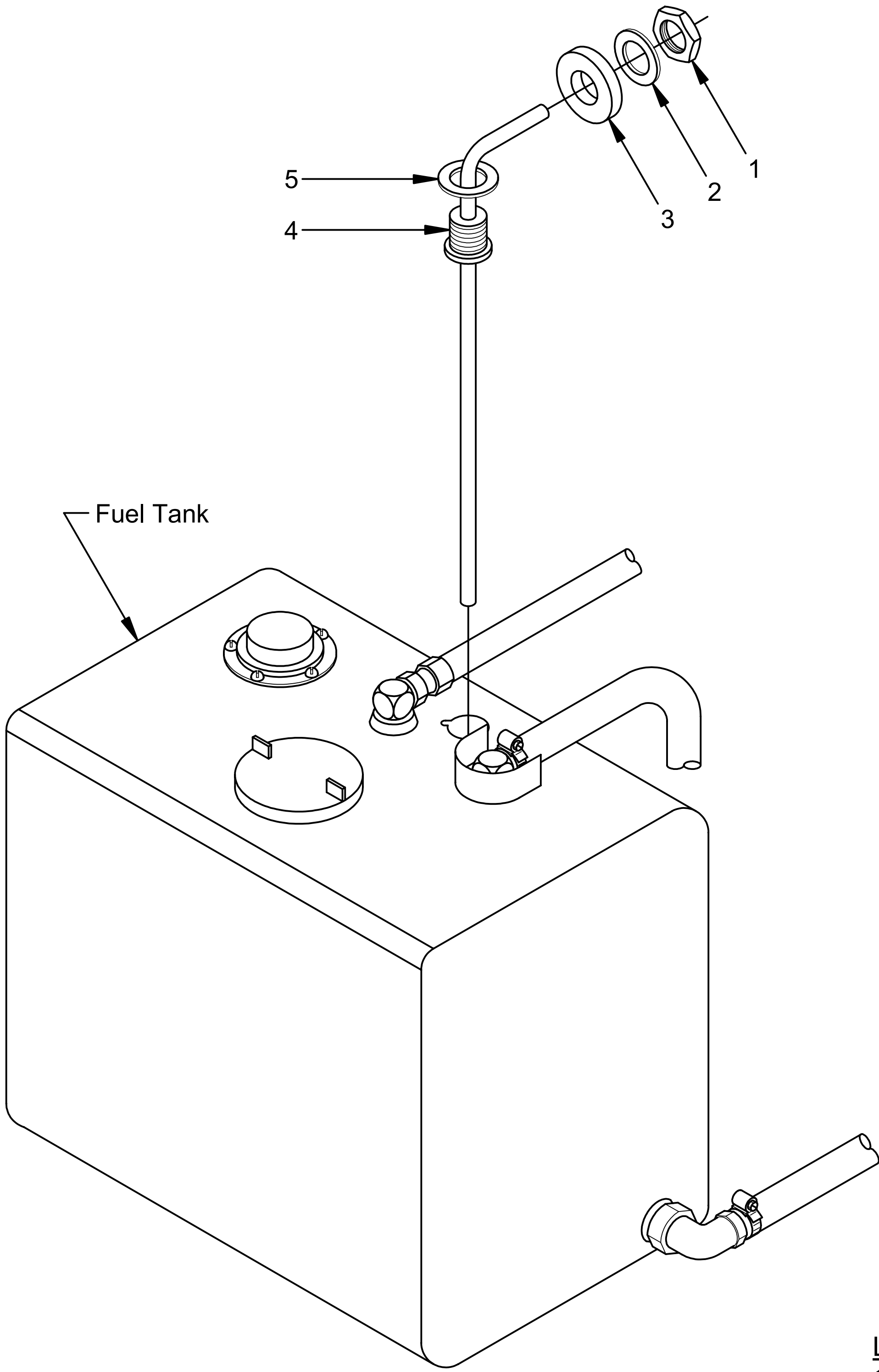
f. Remove nut (1, Figure J-3), flat washer (2), and rubber washer (3) from fuel pickup tube - P/N CA0 12 058 (4). The second flat washer (5) should remain on the fuel pickup tube (4).

g. Insert fuel pickup tube - P/N CA0 12 058 (4) and flat washer (5) into the 1.0” diameter hole in the fuel tank. The flat washer (5) should slide through the gap created by the two 0.25” holes.

h. Slide rubber washer (3), flat washer (2), and nut (1) over fuel pickup tube - P/N CA0 12 058 (4), align hose connection of fuel pickup tube to face the front left hand corner of the fuel tank (when viewed with fuel tank installed on crane), and tighten nut (1).

i. Turn the fuel tank over with filler cap down. Then clean the inside by spraying a phosphate cleaner through the filler cap opening while draining cleaner and residue from the filler cap opening. Rinse with clean water and completely dry inside of tank using compressed air.

j. Reinstall fuel tank in accordance with Technical Manual, TM 5-3810-307-24-1-1.



LEGEND
1. Nut
2. Flat Washer
3. Rubber Washer
4. Fuel Pickup Tube
5. Flat Washer

Figure J-3. Fuel Pickup Tube Installation

Hydraulic Reservoir Modification. (Refer To Figures J-4, J-5, J-6, and J-7.) Modify the crane's hydraulic reservoir as follows:

a. Drain and remove the hydraulic reservoir in accordance with the technical manual, TM 5-3810-307-24-1-1.

NOTE

Prior to removing hydraulic lines from hydraulic reservoir, loosen all tee fittings. This will allow easy adjustment to accommodate heater element coolant connections during reinstallation.

b. Remove the return filter, sample valve hose connection, breather, and anything that might be damaged during the modification of the hydraulic reservoir.

c. Locate the existing engine-driven steer pump suction tank flange on the lower part of the hydraulic reservoir. Refer to Figure J-4. Install pipe plug - P/N 6443100005 in the existing tank flange as far as it will go.

NOTE

The engine-driven steer pump suction hose that was connected to the existing tank flange will be moved to a new 1.25" NPT tank flange - P/N 7450000030 located above the two main hydraulic pump suction fittings.

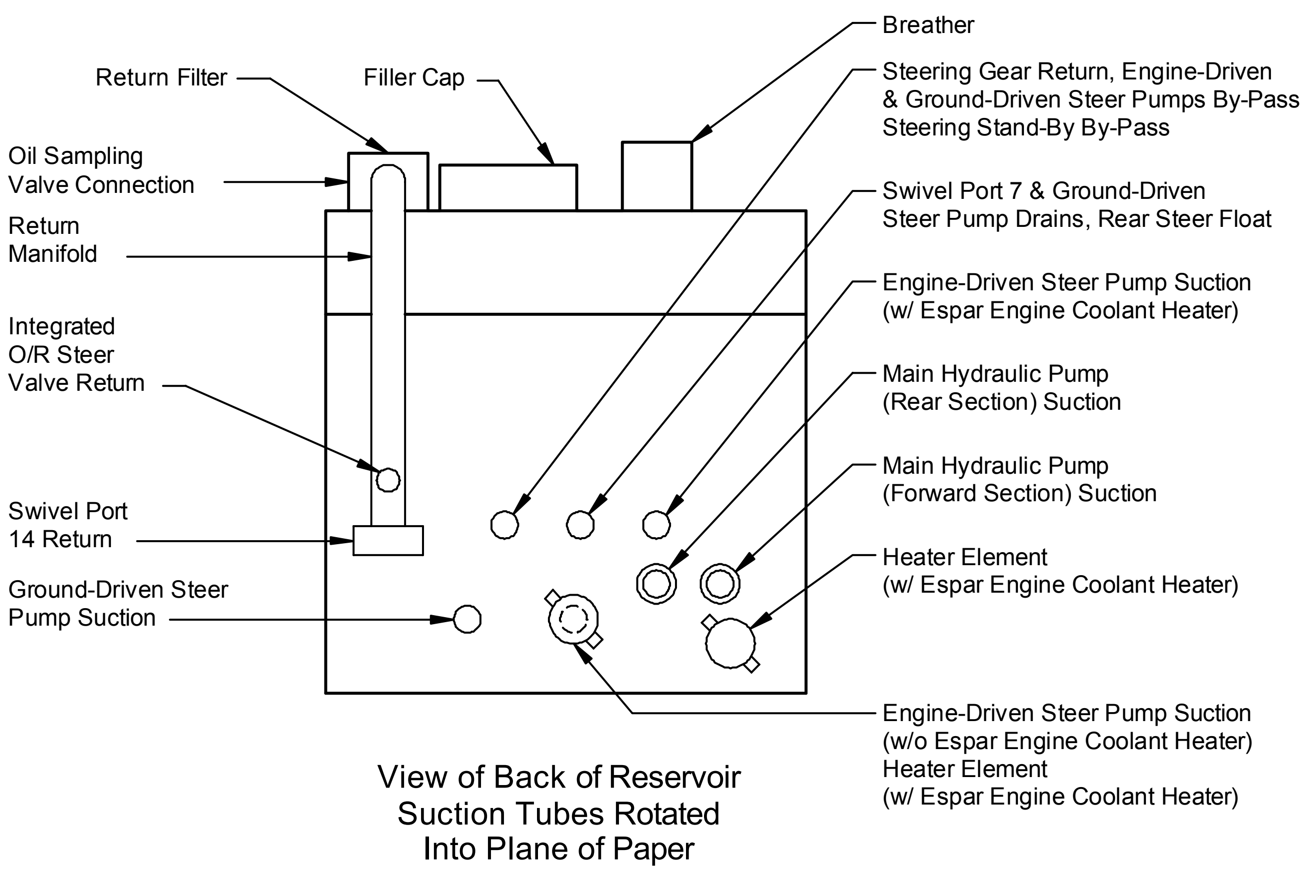


Figure J-4. Hydraulic Reservoir Connection Legend

d. Draw two diagonal lines across square part of pipe plug - P/N 6443100005 to mark center and create indent in center using a punch.

e. Pre-drill a 0.25” hole in center of pipe plug - P/N 6443100005 to be used as a guide for drilling a new 3.0” hole in hydraulic reservoir with a hole saw.

f. Drill out the existing tank flange to 3.0” diameter using 3” hole saw. This hole will be used for a new 2.0” NPT coupler - P/N A-3228HD. Discard old tank flange and pipe plug - P/N 6443100005.

g. Determine which doubler plate - P/N 6705170879 or 6705170884 to use and the proper dimensions for two new holes on hydraulic reservoir by placing each doubler plate on edge of reservoir as shown in Figures J-5 and J-6. The proper doubler plate will fit cleanly on radius of hydraulic reservoir without any gaps between the plate and the hydraulic reservoir.

CAUTION

If doubler plate - P/N 6705170879 is to be used, refer to Figure J-5 for the proper dimensions. If doubler plate - P/N 6705170884 is to be used, refer to Figure J-6.

h. Mark the centers for the 2.12” and second 3.0” diameter hole in accordance with the appropriate dimensions shown on Figure J-5 or J-6.

i. Use a punch to create an indent in the centers of the 2.12” and 3.0” diameter holes.

j. Pre-drill 0.25” holes to be used as guides for drilling the holes in hydraulic reservoir with hole saws.

k. Using a 2.12” (2-1/8”) hole saw, drill the hole for the 1.25” NPT tank flange - P/N 7450000030.

l. Using a 3” hole saw, drill the hole for the second 2.0” NPT coupler - P/N A-3228HD.

m. Clean edges and remove paint from the area around the three new holes and the area where the appropriate doubler plate - P/N 6705170879 or 6705170884 will be welded in place.

n. Insert 1.25” NPT tank flange - P/N 7450000030 in 2.12” diameter hole, align, and weld 1.25” NPT tank flange to hydraulic reservoir.

o. Mark the outside of the two 2.0” NPT couplers - P/N A-3228HD in the middle of the coupler body. This mark will line up with the hydraulic reservoir body to allow approximately 1.5” of each coupler to extend outside of the hydraulic reservoir.

p. Insert 2.0” NPT couplers - P/N A-3228HD in 3.0” diameter holes, align mark on side with hydraulic reservoir, ensure couplers are even and level with hydraulic reservoir, and weld couplers to hydraulic reservoir.

q. Clean welds at 2.0” NPT couplers - P/N A-3228HD by sanding.

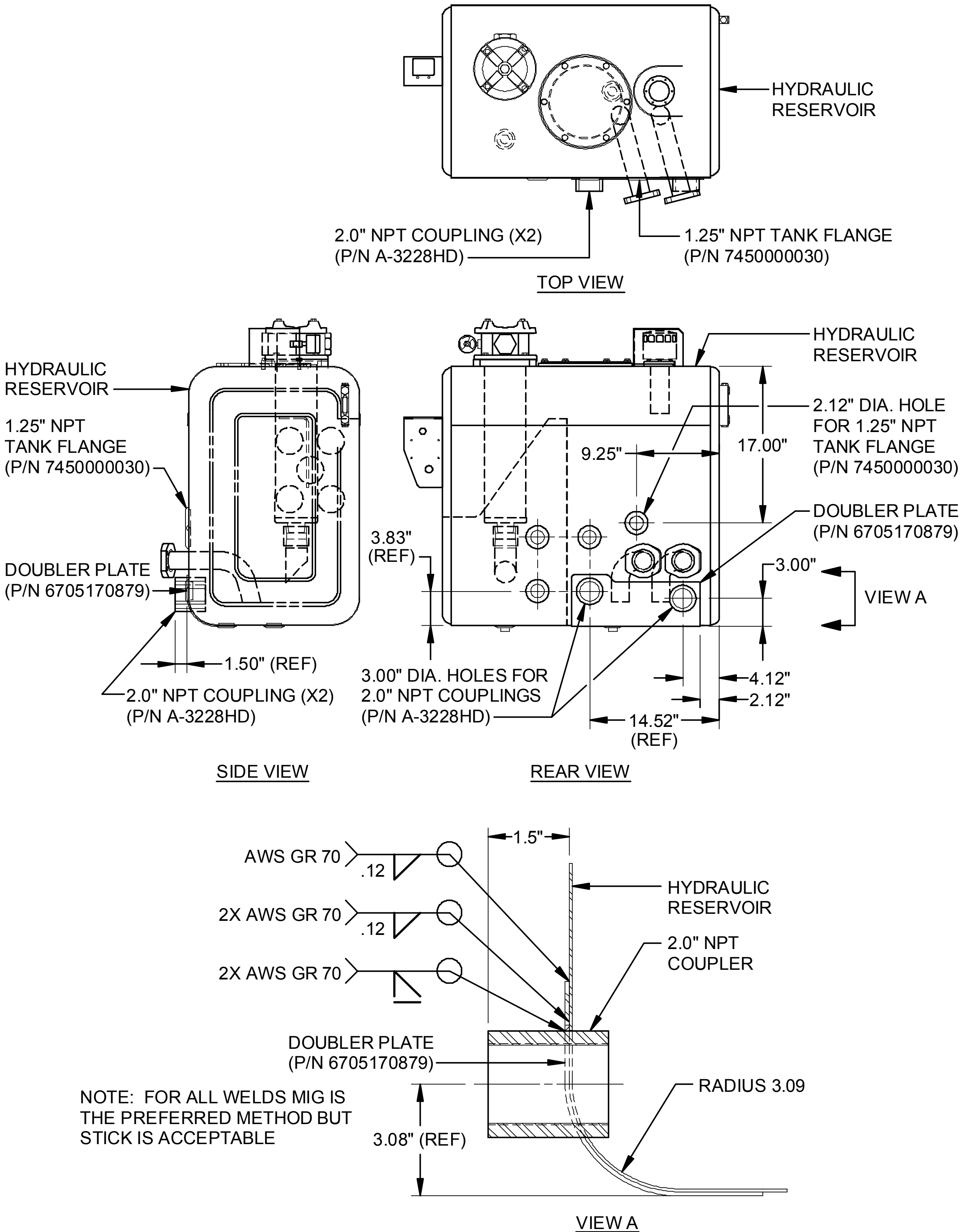


Figure J-5. Hydraulic Reservoir Modification Dimensions – Doubler Plate P/N 6705170879

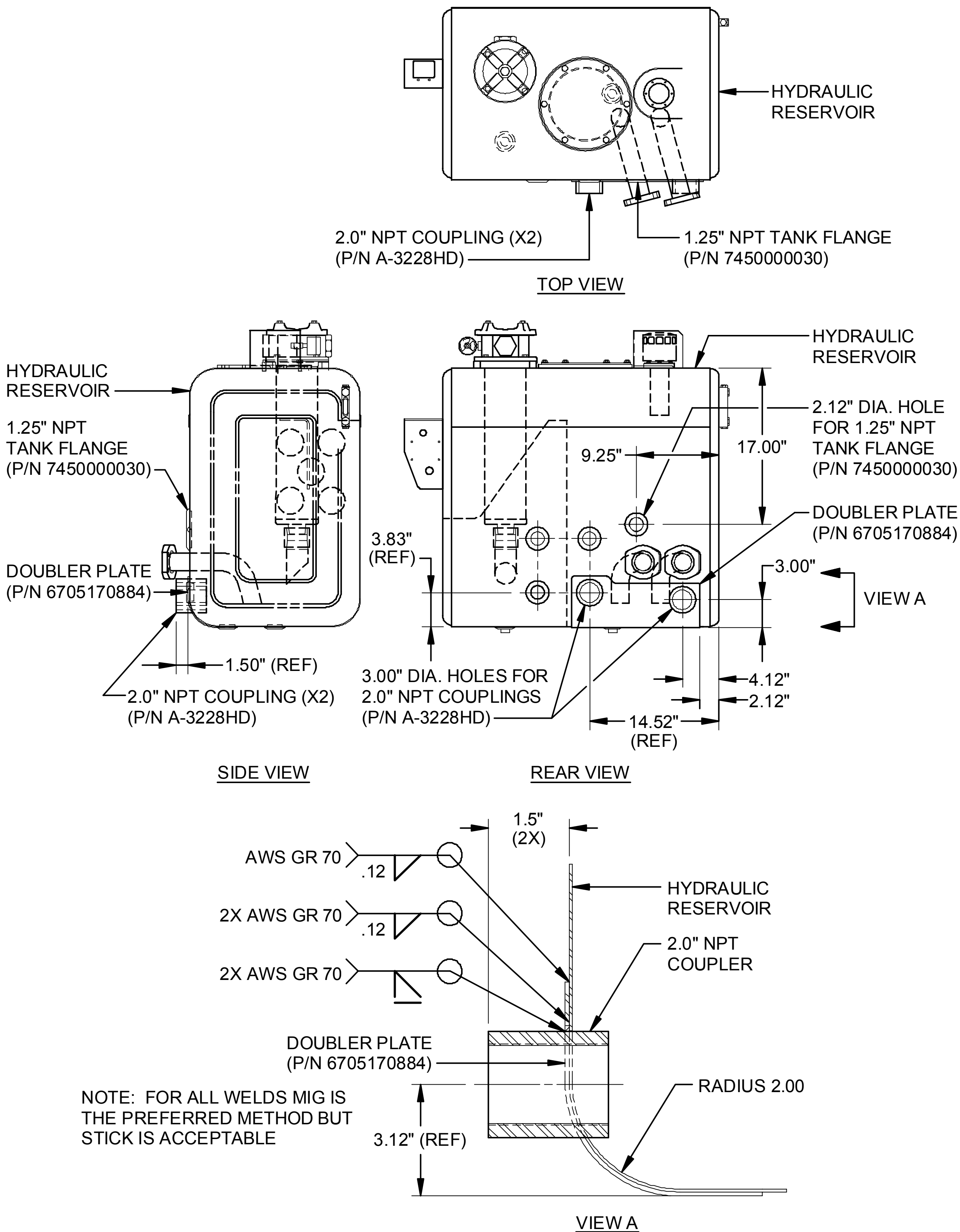


Figure J-6. Hydraulic Reservoir Modification Dimensions – Doubler Plate P/N 6705170884

r. Slide appropriate doubler plate - P/N 6705170879 or 6705170884, determined in Step g. above, over the two 2.0” NPT couplers - P/N A-3228HD and align over edge of hydraulic reservoir. Ensure there are no gaps between the doubler plate and the hydraulic reservoir.

s. Weld doubler plate to the two 2.0” NPT couplers and the hydraulic reservoir.

t. Clean inside of hydraulic reservoir by spraying a phosphate cleaner inside while draining from the filler cap opening. Rinse with clean water and completely dry inside of reservoir using compressed air.

u. Reinstall any items removed in Step b above.

Hydraulic Reservoir Modification Pressure Test. (Refer To Figure J-7.) Test the crane’s hydraulic reservoir after modification as follows:

a. If necessary, install the filler cap and return filter assembly.

b. Using duct tape, completely cover the return filter fittings, main hydraulic pump suction fittings, new 2.0” NPT couplers - P/N A-3228HD, and all openings (except the breather and new 1.25” NPT tank flange - P/N 7450000030) on the hydraulic reservoir.

c. Assemble a test fitting, as shown in Figure J-7, from a 1.25” NPT X 0.5” NPT adapter fitting (1), a 0.5” NPT X 3/8” NPT adapter fitting (2), and a 3/8” NPT quick connect fitting (3). Install the test fitting in the new 1.25” NPT tank flange - P/N 7450000030 on the hydraulic reservoir.

d. Have a second person hold a hand over the breather opening in the top of the hydraulic reservoir and pressurize the hydraulic reservoir to approximately 7 psi (48.3 kPa) via the test fitting connected to the new 1.25” NPT tank flange - P/N 7450000030.

NOTE

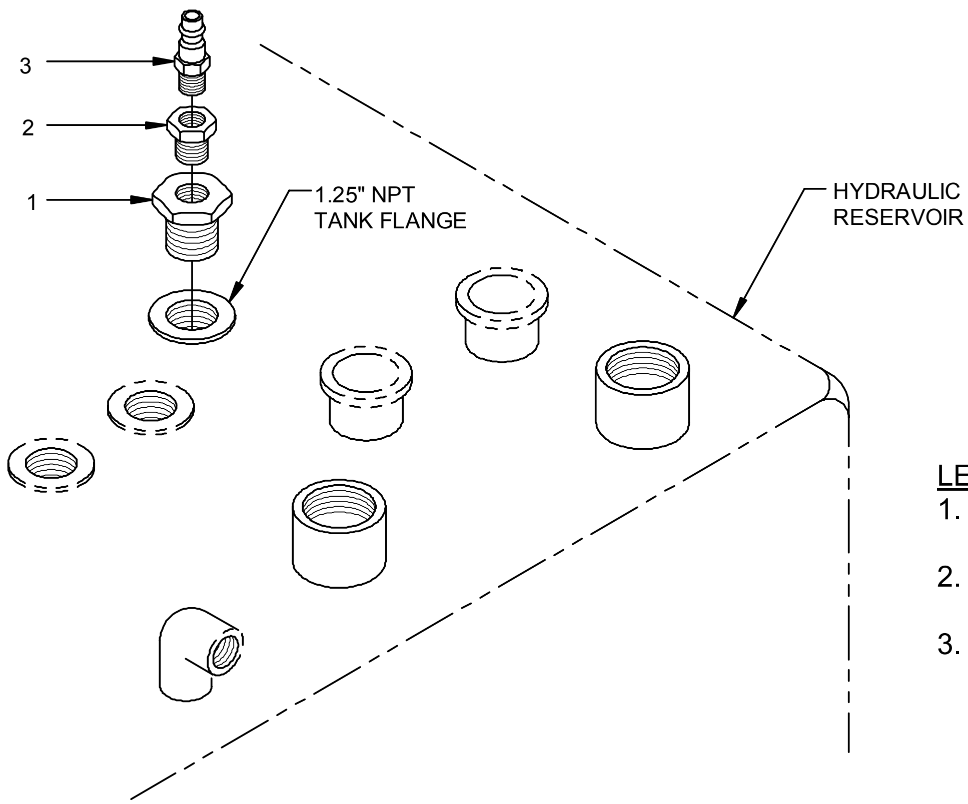
Holding a hand over the breather opening seals the hydraulic reservoir and also acts as a pressure regulator to allow the reservoir to only pressurize to a low level.

e. Using soapy water, check for air leaks around all welds.

f. Repair any welds and clean hydraulic reservoir as necessary.

g. Remove test fitting and reinstall any components removed (including the breather).

h. Repaint welded areas on hydraulic reservoir.



LEGEND
1. 1.25” NPT X 0.5” NPT adapter fitting
2. 0.5” NPT X 3/8” NPT adapter fitting
3. 3/8” NPT quick connect fitting

Figure J-7. Hydraulic Reservoir Test Fitting

Hydraulic Reservoir Heater Element Installation. (Refer To Figure J-8 and J-9.) Install the heating elements in the modified hydraulic reservoir as follows:

a. Place Loctite® 565 on threads of the two heater elements - P/N H-4000-20 (1, Figure J-8) and install in 2.0” NPT couplers - P/N A-3228HD installed on hydraulic reservoir. Tighten until COOLANT IN or OUT points toward the lower RH corner of tank. Refer to the detail on Figure J-8.

b. Place Loctite® 565 on threads of four 0.5” X 0.75” pipe bushings - P/N A-282 (2), install in COOLANT IN and OUT of each heater element (1), and tighten.

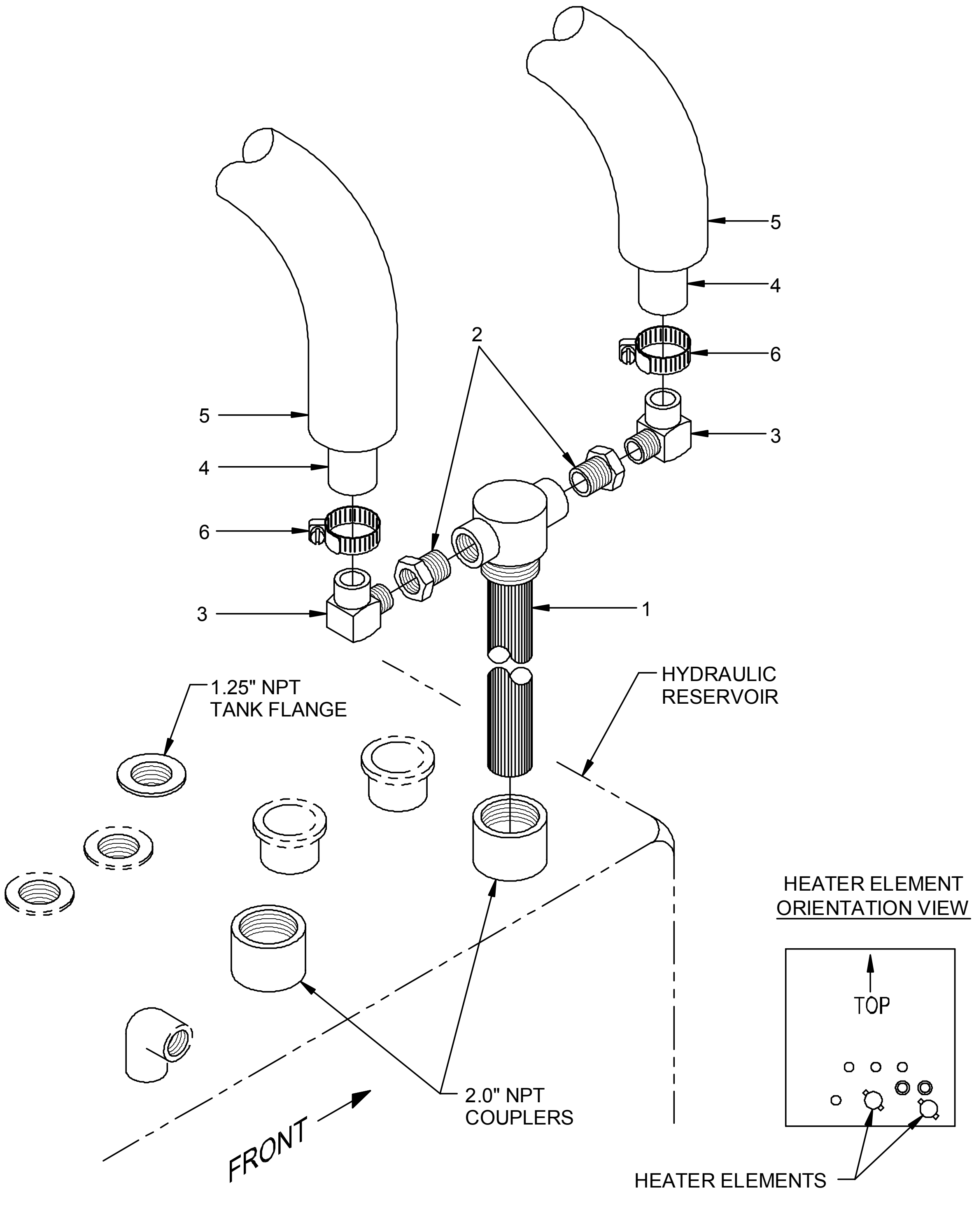
c. Place Loctite® 565 on threads of four 0.75” brass elbows - P/N A-653 (3), install in each 0.5” X 0.75” pipe bushing – P/N A-282 (2), and tighten.

d. Carefully place the hydraulic reservoir on its mounting bracket and check for interference between the heater elements/fittings and the mounting bracket. If necessary, mark the point of interference, remove the tank, and cut a half-moon notch in the front hydraulic reservoir bracket as shown in Figure J-9. Repaint the modified mounting bracket.

e. Reinstall hydraulic reservoir in accordance with the Technical Manual, TM 5-3810-307-24-1-1.

NOTE

Due to the fact that the engine-driven steer pump suction location has been moved, the existing set of fittings may have to be completely disassembled and reassembled at the new location.



LEGEND

1. Heater Element
2. 0.5” X 0.75” pipe bushings
3. 0.75” brass elbows
4. Coolant Hose
5. Insulation Tubing
6. Hose Clamp

Figure J-8. Hydraulic Reservoir Heater Element Installation

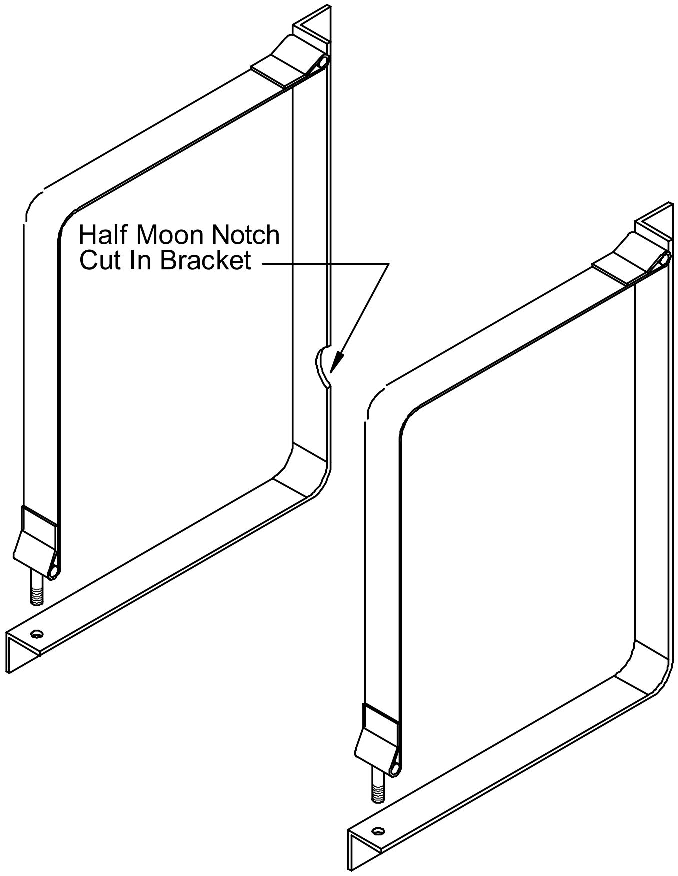


Figure J-9. Hydraulic Reservoir Bracket Modification (If Necessary)

Seven Day Timer Installation. (Refer To Figure J-10.) Install the seven day timer on the dash panel in the carrier cab as follows:

a. Place wedge bezel (1, Figure J-10) and mounting bracket (2) - P/N 22 1000 50 01 00 on top right hand corner of dash panel and align to face the operating seat at a slight angle (to avoid dash panel lights underneath). Refer to Figure J-10.

CAUTION

Ensure mounting holes will not interfere with the dash panel lights on front underside of the dash panel prior to drilling holes.

b. Mark locations for four mounting holes.

CAUTION

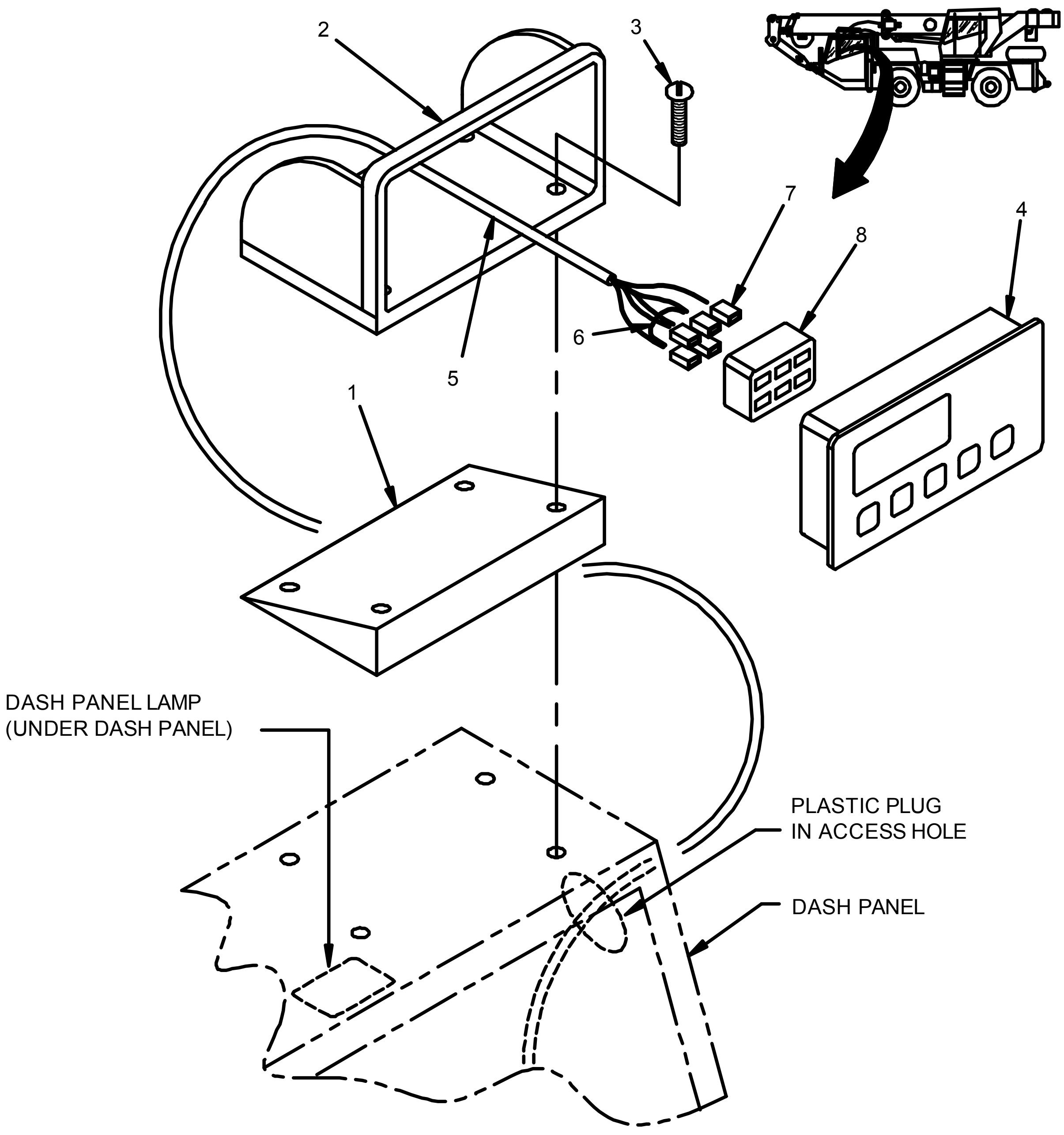
To avoid unnecessary damage, do not allow drill bit to penetrate too deep into the dash during drilling.

c. Drill four 1/8” holes in top of dash panel.

d. Position wedge bezel (1) on dash panel so that mounting bracket (2) has a slight upward angle, position the mounting bracket (2) on top, and align the holes.

e. Secure the wedge bezel (1) and mounting bracket (2) - P/N 22 1000 50 01 00 to the dash panel with four self-tapping screws (3) (not included in kit).

f. Ensure the 24V bulb (green bulb casing) is installed in the seven day timer - P/N 22 1000 30 36 00 (4) and slide the seven day timer into the mounting bracket assembly.



LEGEND

1. Wedge Bezel
2. Mounting Bracket
3. Self-tapping Screws
4. Seven Day Timer
5. Wiring Cable
6. Jumper Wire
7. Terminal
8. Connector Body

Figure J-10. Seven Day Timer Installation

Fuel Metering Pump Installation. (Refer To Figure J-11.) Install the fuel metering pump on the inside rear of the battery disconnect bracket underneath the battery box as follows:

NOTE

It may be necessary to remove the oil sampling valve that is next to the bracket underneath the battery box in order to gain better access to the bracket.

a. Align the fuel metering pump (1, Figure J-11) on the inside of the bracket as shown in Figure J-11, mark the centers for two mounting holes, and create an indent in the centers with a punch.

b. Drill two 0.25” holes in the bracket and clean out holes with round file.

c. Connect a short section of 3.5 mm fuel hose - P/N 360 75 300 (2) to outlet of fuel metering pump (1) and secure with small No. 6 clamp (3).

NOTE

The outlet of the fuel metering pump (1) is smaller and on the side with the electrical connection.

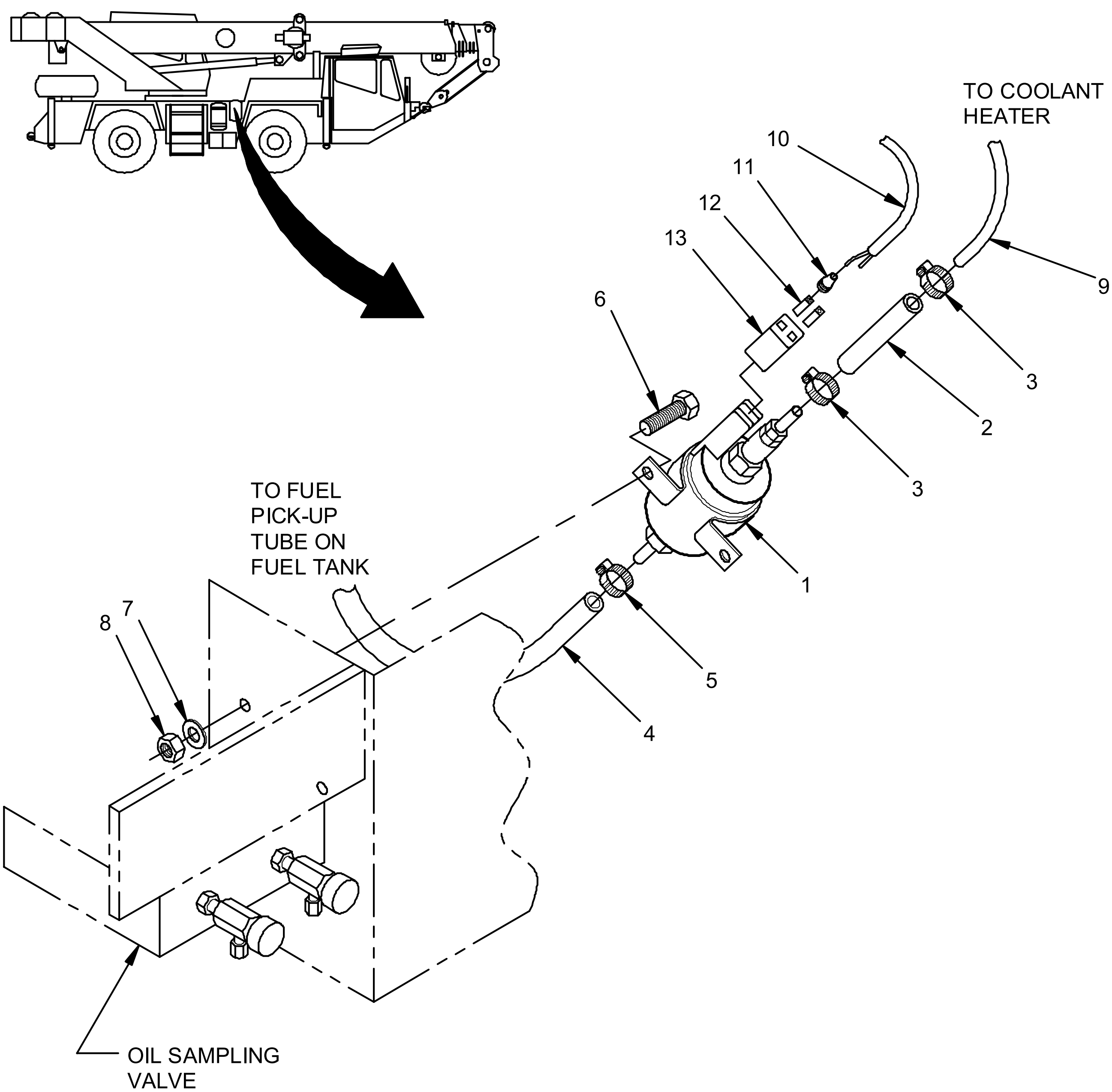
d. Install the larger fuel hose - P/N 360 75 350 (4) on the inlet of fuel metering pump (1) and secure with larger No. 11 clamp (5).

e. Install the fuel metering pump (1) on the inside of the bracket with the outlet facing upward and secure with two M6X12 hex bolts (6), flat washers (7), and hex nuts (8).

f. If necessary, reinstall oil sampling valve.

g. Route the larger fuel hose - P/N 360 75 350 (4) to the fuel pickup tube on the fuel tank. Use tie wraps to secure the fuel hose.

h. Connect the end of the larger fuel hose - P/N 360 75 350 (4) to the fuel pickup tube on the fuel tank and secure with remaining No. 11 clamp (5).



LEGEND

1. Fuel Metering Pump
2. 3.5 mm Fuel Hose
3. No. 6 Clamp
4. Fuel Hose
5. No. 11 Clamp
6. M6X12 Hex Bolts
7. Flat Washer
8. Hex Nut
9. Plastic 2mm Fuel Line
10. Wiring Cable
11. Rubber Grommet
12. Terminal
13. Connector Body

Figure J-11. Fuel Metering Pump Installation

Coolant Heater Installation. (Refer To Figures J-12 and J-13.) Install the engine coolant heater on the rear of the crane's left front fender as follows:

a. Remove the grill from the rear cowl of the diesel engine hood in accordance with the Technical Manual, TM-5-3810-307-24-1-1.

b. Mark the centers in the left front fender for the four 0.38" (3/8") diameter holes and one 1.5" diameter hole in accordance with the appropriate dimensions shown on Figure J-12.

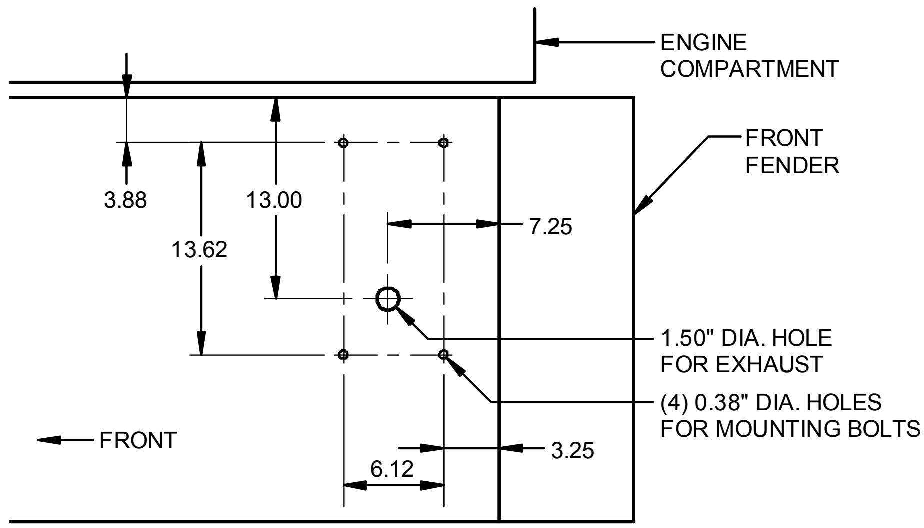


Figure J-12. Coolant Heater Installation Dimensions

c. Use a punch to create an indent in the center for each 0.38" (3/8") diameter hole (four places) and 1.5" diameter hole (one place).

d. Pre-drill 0.25" hole to be used as guide for drilling the one 1.5" diameter hole with a hole saw.

e. Using a 1.5" hole saw, drill the hole for the exhaust pipe of the coolant heater.

f. Drill the four 0.38" (3/8") diameter holes for the mounting bolts of the coolant heater.

g. Clean edges of all five holes using a round file.

h. Remove cover (1, Figure J-13) from the coolant heater (2) by removing the two 5/16"x1/2" bolts (3) securing cover to coolant heater.

WARNING

ASPHYXIATION HAZARD. Ensure that exhaust fumes cannot enter the cab. Failure to comply with this warning could result in personal injury or death from asphyxiation.

WARNING

The engine coolant heater exhaust is hot, ensure a minimum clearance of 2 inches (5 cm) from any heat sensitive material. Failure to follow this warning could result in personal injury and/or damage to the crane.

CAUTION

Ensure that the engine coolant heater exhaust outlet and pipe cannot be plugged by dirt, rainwater, or snow. Ensure that the exhaust outlet and pipe does not face the crane slipstream.

CAUTION

Ensure the engine coolant heater combustion air intake opening cannot be plugged by dirt, rainwater, or snow. Ensure that the combustion air intake opening does not face the crane slipstream.

i. Insert the end of the flexible exhaust hose (4) with the end cap through the 1.5” hole in fender. Route hose toward the lower right hand rear corner of the fender. Align with end cap of flexible exhaust hose (4) facing downward and extending 1-2” below the bottom of the fender. Leave a length of flexible exhaust hose long enough to connect to the exhaust outlet on the coolant heater and cut off excess hose at the coolant heater end.

NOTE

The exhaust outlet is on the lower part of the coolant heater and is the one closest to the water pump. The combustion air inlet is the one closest to the side of the boxed enclosure.

j. Determine a mounting location for the 34mm “C” exhaust hose clamp (5) and mark the location for the mounting hole.

k. Use a punch to create an indent for the center of the mounting hole and drill a 5/16” hole in the fender.

l. Insert 34mm “C” exhaust hose clamp (5) over the end of the flexible exhaust hose (4) and secure clamp to fender with a bolt (6), lockwasher (7), and hex nut (8) (not included in kit).

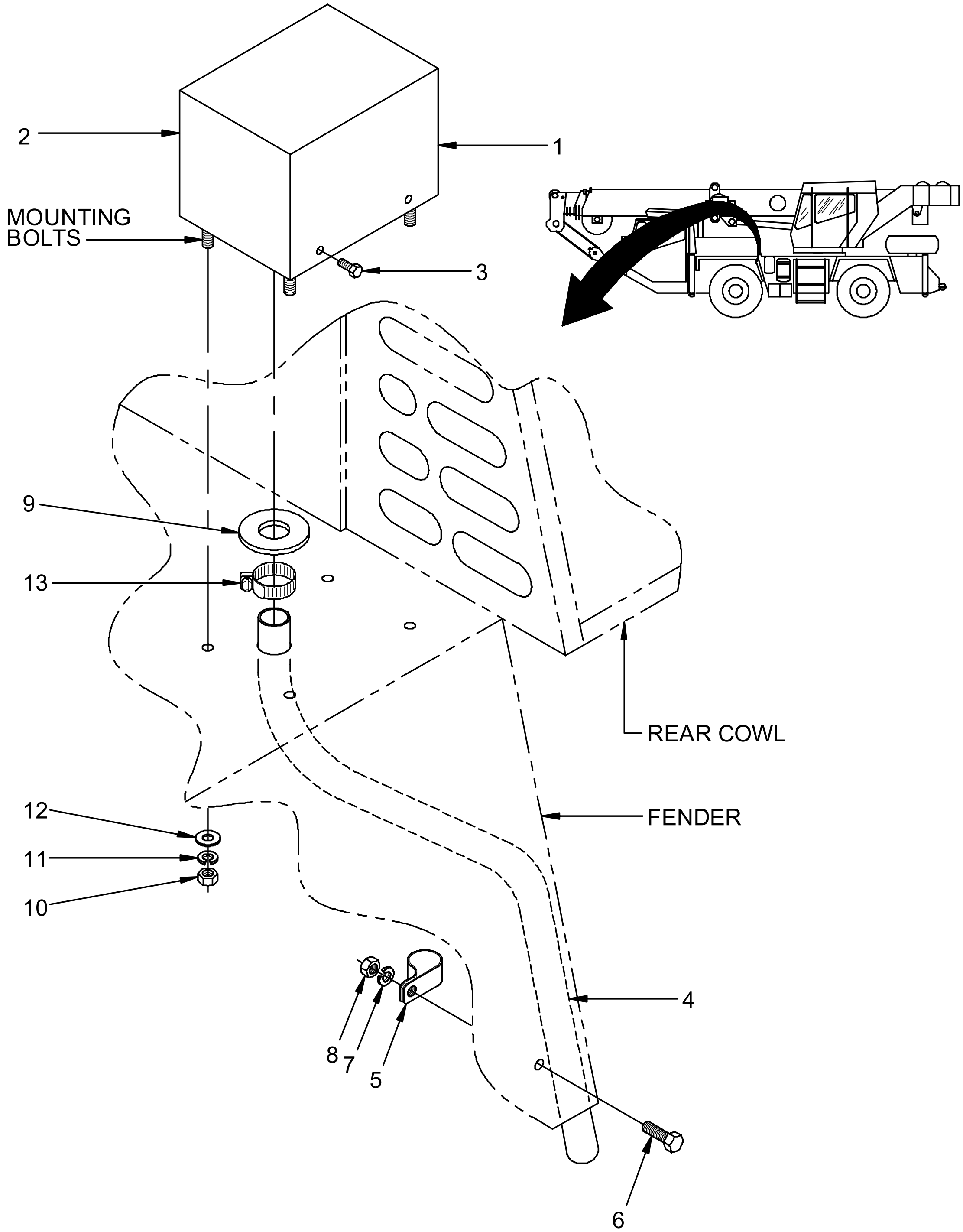
m. If not already installed, place silicon exhaust seal (9) in center hole in the bottom of boxed enclosure of the coolant heater (2).

n. If installed, remove four 8 mm hex nuts (10), spring washers (11), and 5/16”x1.25 fender washers (12) from the mounting bolts on the bottom of the coolant heater (2).

o. Insert the 30-33mm exhaust clamp (13) over end of flexible exhaust hose (4).

p. While feeding flexible exhaust hose (4) and 30-33mm exhaust clamp (13) through the silicon exhaust seal (9), install coolant heater (2) on left front fender and secure with four 8 mm hex nuts (10), spring washers (11), and 5/16”x1.25 fender washers (12).

q. Connect the flexible exhaust hose (4) to the exhaust outlet of coolant heater (2). Secure to exhaust outlet with 30-33mm exhaust clamp (13). Tighten clamp.



LEGEND

1. Boxed Enclosure Cover
2. Coolant Heater
3. 5/16”x1/2” Bolt
4. Flexible Exhaust Hose
5. 34mm “C” Exhaust Hose Clamp
6. Bolt
7. Lockwasher
8. Hex Nut
9. Silicon Exhaust Seal
10. 8 mm Hex Nut
11. Spring Washer
12. 5/16”x1.25 Fender Washer
13. 30-33mm Exhaust Clamp

Figure J-13. Coolant Heater Installation

Fuel Line Installation. (Refer To Figure J-19.) Install the fuel line from the fuel metering pump to the coolant heater as follows:

a. Connect a short section of 3.5 mm fuel hose (19) to the fuel inlet of coolant heater and secure with small No. 6 clamp (20).

b. Insert the plastic 2mm fuel line (18) through the grommet (21) located on the coolant fitting side of the coolant heater and connect to the other side of the short section of 3.5 mm fuel hose (19). Secure with small No. 6 clamp (17).

c. Route plastic 2mm fuel line from coolant heater, through vent opening of rear cowl on engine compartment hood, into engine compartment, and over transmission. Once on right hand side of transmission, route at a 90-degree angle towards rear of crane to circular opening in carrier deck for transmission dipstick. Route downward and to right over transmission mount. Route along hydraulic filter and lines toward fuel metering pump. Use tie wraps to secure in appropriate locations.

CAUTION

Ensure plastic 2mm fuel line (18) is secured to hydraulic lines and not to electrical wiring.

d. Cut plastic 2mm fuel line (18) to appropriate length.

e. Connect to the short section of 3.5 mm fuel hose (59) connected to the outlet of fuel metering pump (50) and secure with a small No. 6 clamp (60).

Electrical Connections – Battery and Fuel Metering Pump. (Refer To Figures J-11, J-14 and J-15.) Route and connect the battery and fuel metering pump wiring as follows:

CAUTION

The 15-amp in-line fuse must be installed in the battery wiring connecting the coolant heater to the crane's batteries. Failure to follow this caution could result in damage to the coolant heater due to a short circuit in the crane's electrical system.

a. Remove the battery box cover.

b. Locate the battery and fuel metering pump wiring cables and separate from the seven day timer wiring cable. Connect the ends together to assist in routing.

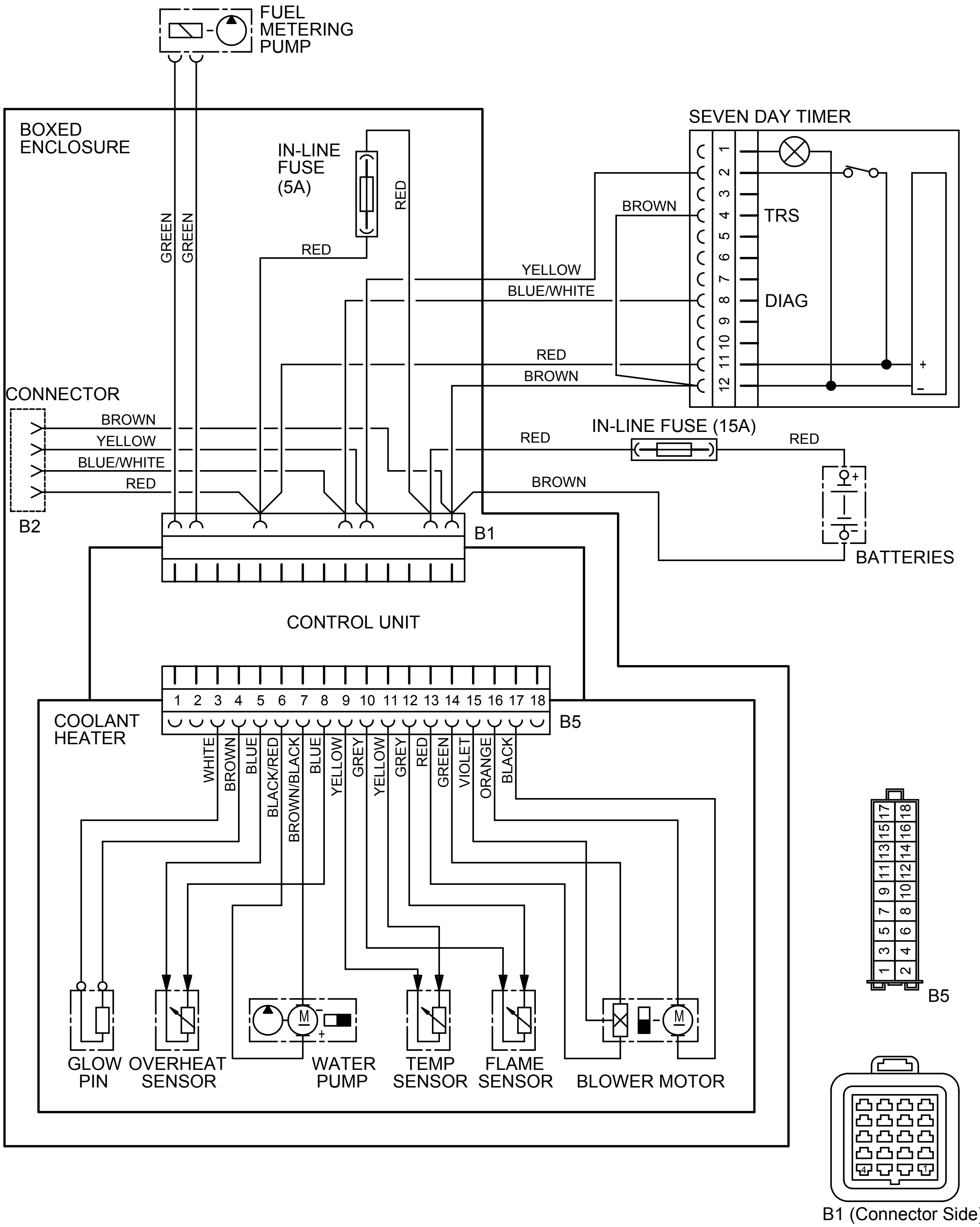


Figure J-14. Coolant Heater Wiring Diagram

c. Route the two cables from the coolant heater, through vent opening of rear cowl on engine compartment hood, into engine compartment, and over transmission. Once on right hand side of transmission, route at a 90-degree angle toward rear of crane to circular opening in carrier deck for transmission dipstick. Route downward and to right over transmission mount. Route battery wiring upward into left hand side of battery box. Route fuel metering pump wiring along electrical wiring near hydraulic filter and lines toward fuel metering pump. Use tie wraps to secure cabling in appropriate locations.

CAUTION

Ensure wiring is secured to crane electrical wiring and not to hydraulic lines and/or the plastic 2mm fuel line.

d. Cut fuel metering pump wiring (10, Figure J-11) to appropriate length and remove approximately 1” of outer insulation from the end of the wiring. Remove approximately 3/8” of insulation from the end of each green wire.

e. Insert wires (10) through rubber grommets (11) with flat end of grommet facing away from the end of the wire and crimp terminals (12) onto end of each wire.

f. Insert terminals into plastic connector body (13) with the terminal opening horizontal with the connector body (13).

NOTE

Specific terminal designations for the fuel metering connector body are not important.

g. Push rubber grommets (11) into end of connector body (13) and close end tab of connector body (13).

h. Put dielectric grease on connector terminals and connect to fuel metering pump (1) connector.

i. Remove hex nut (1, Figure J-15) from positive battery cable terminal on front right hand battery and hex nut (2) from negative battery cable terminal on rear right hand battery.

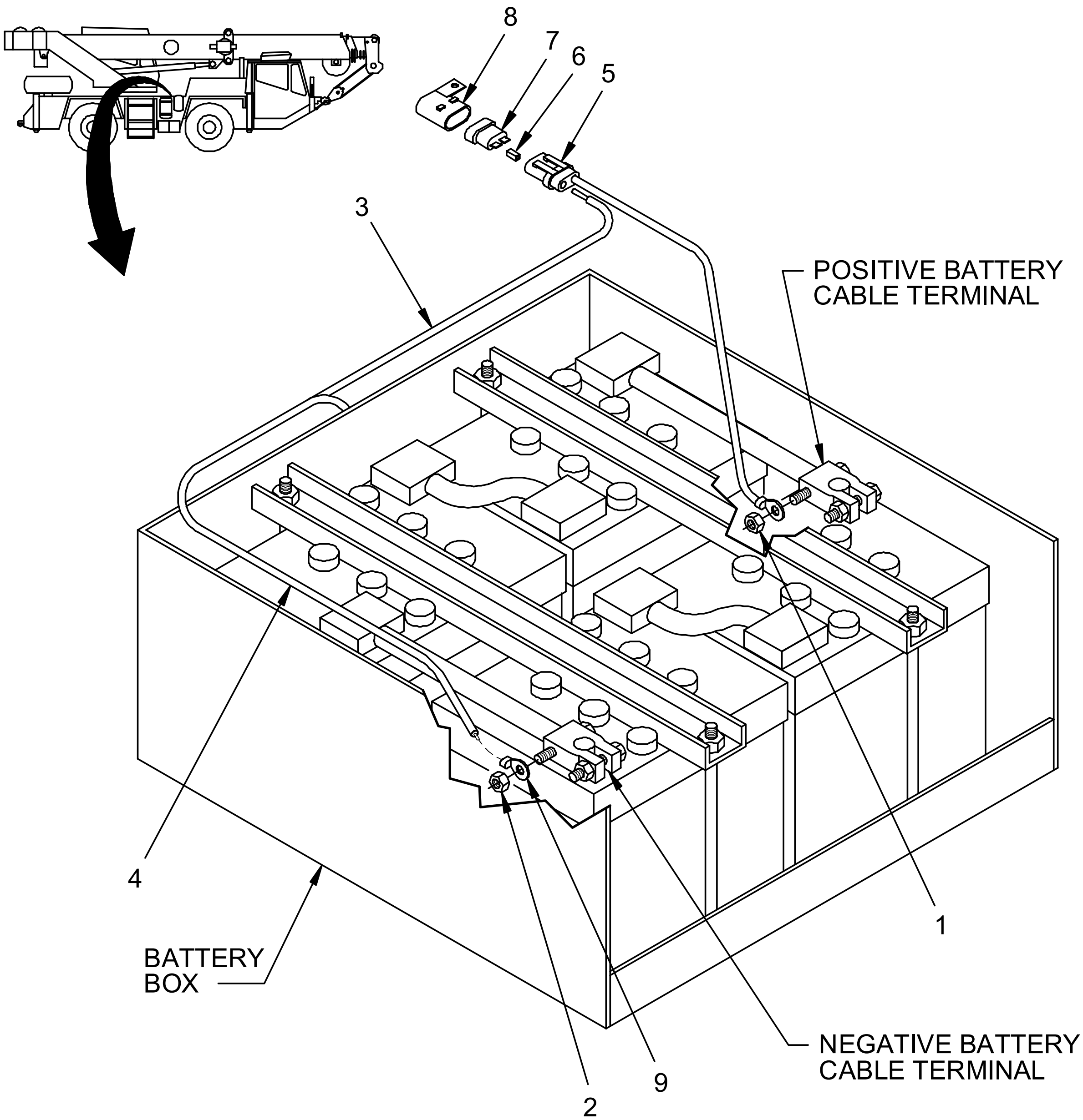
NOTE

Remove the hex nut from the portion that secures the cabling to the battery cable terminal and not the hex nut that tightens the battery cable terminal to the terminal posts on the battery.

j. Remove outer insulation from battery wiring cable to separate red and brown wires (3 and 4).

k. Route red wire (3) towards front of battery box and route brown wire (4) towards rear of battery box and the negative battery cable terminal. Use tie wraps to secure wires in the appropriate locations.

l. Connect spade terminal of 15A in-line fuse holder (5) to positive battery cable terminal and secure with hex nut (1).



LEGEND

1. Hex Nut
2. Hex Nut
3. Red Wire
4. Brown Wire
5. 15A In-Line Fuse Holder
6. Terminal
7. 15A Fuse
8. Fuse Holder Cover
9. Spade Terminal

Figure J-15. Battery Box Wiring Installation

m. Cut red wire (3) to appropriate length, remove approximately 3/8” of insulation from the end of wire, and feed wire through the empty terminal of the 15A in-line fuse holder (5).

n. Crimp terminal (6) onto end of red wire (3), push terminal (6) into 15A in-line fuse holder (5).

o. Put dielectric grease on connector terminals, insert 15A fuse (7) into terminals in fuse holder (5), and place cover (8) on fuse holder (5).

p. Cut brown wire (4) to appropriate length, remove approximately 3/8” of insulation from the end of wire, and crimp spade terminal (9) onto end of brown wire (4).

CAUTION

Do not connect the brown wire (4) to the negative battery cable terminal at this time. This should only be connected after all other connections have been made and installation is complete.

Electrical Connections – Seven Day Timer. (Refer To Figures J-10 and J-14.) Route and connect the seven day timer wiring as follows:

a. Locate the seven day timer wiring cable and route the cable from the coolant heater, through vent opening of rear cowl on engine compartment hood, into engine compartment, and downward along left hand side of transmission. Route along underside of frame toward front of crane. Route over top of front outrigger frame and through hole for other electrical cabling and heater hoses located at the center front of the outrigger frame (in between crane carrier tie-downs). Route cable toward cab wiring access hole located near the center front underside of crane, directly below right hand side of dash in the carrier cab. Insert cabling through the access hole into lower right hand corner of the carrier cab. Use tie wraps to secure cable in the appropriate locations.

b. Remove plastic plug from access hole in right hand side of the dash panel in the carrier cab.

c. Drill a 5/16” hole in the center of the plastic plug.

d. Route cable from floor up through dash, through access hole in right hand side of the dash panel, and through the hole in the plastic plug. Reinstall plastic plug in access hole.

e. Route cable (5, Figure J-10) to seven day timer (4) mounting location, cut cable (5) to appropriate length and remove approximately 1” of outer insulation from the end of the wiring. Remove approximately 3/8” of insulation from the end of the four wires.

f. Cut a piece of brown jumper wire (6) 2-3” in length from the excess cabling cut in Step e above and strip approximately 3/8” of insulation from both ends of the jumper wire (6).

g. Install a terminal (7) on one end of the jumper wire (6).

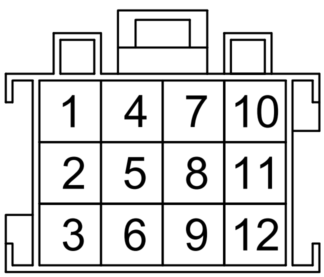
h. Twist the brown wire from the cable (5) and the other end of the jumper wire (6) together, install a terminal (7) on end, and crimp to secure.

i. Install terminals (7) on the red, blue/white, and yellow wires and crimp to secure.

j. Install terminals in appropriate terminal locations on plastic connector body (8) in accordance with the Table J-1.

k. Connect to the seven day timer (4) connector.

Table J-1. Seven Day Timer Connector Terminal Designations

Connector View - Cable input side (viewed from behind)	Term.	Designation	Wire Color
	1	-	-
	2	S+ Switch On Signal	Yellow Wire
	3	-	-
	4	TRS/TMD Mode Deactivation	Brown Jumper
	5	-	-
	6	-	-
	7	-	-
	8	Diagnosis	Blue/White Wire
	9	-	
	10	-	
	1	Terminal 30 (+) Supply 5A	Red Wire
	12	Terminal 31 (1) Supply	Brown Wire and Jumper

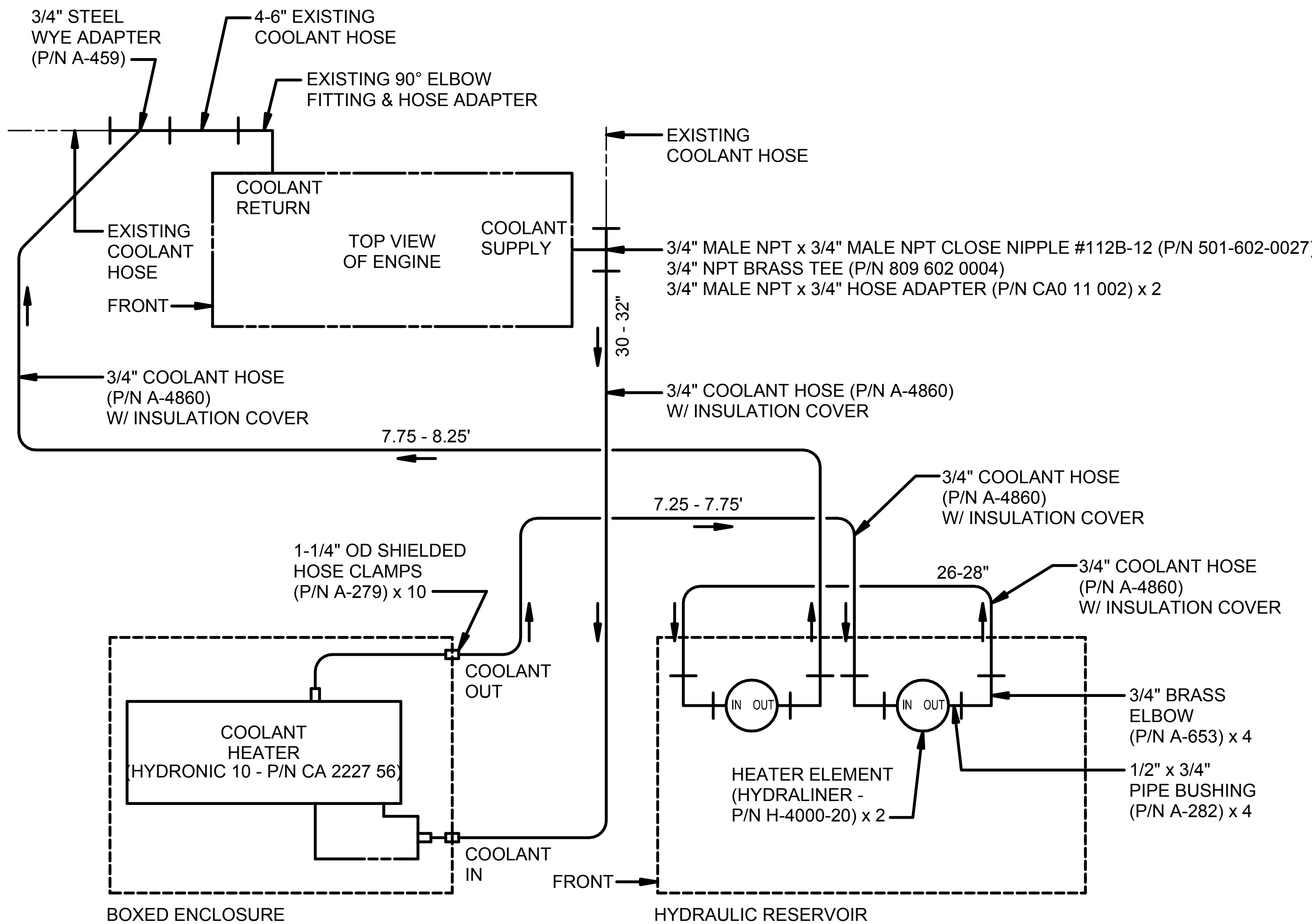


Figure J-16. Engine Coolant Flow Diagram

Engine Coolant Connections – Supply from Engine. (Refer To Figures J-16 and J-17.) Route and connect the supply from engine connections as follows:

a. Drain the engine coolant from the diesel engine in accordance with the Technical Manual, TM 5-3810-307-24-1-1.

b. Loosen the hose clamp securing the existing coolant supply hose to the existing hose fitting on the center rear of the diesel engine.

c. Remove the existing hose and 90-degree elbow fittings from the center rear of the diesel engine.

d. Place Loctite® 565 on both threads of the 0.75" male NPT X 0.5" male NPT close nipple #112B-12 - P/N 501-602-0027 (1, Figure J-17), install in the center rear of the diesel engine, and fully tighten.

e. Install 0.75" NPT brass tee - P/N 809 602-0004 (2) onto the 0.75" male NPT X 0.5" male NPT close nipple #112B-12 - P/N 501-602-0027 (1). Tighten until tee is perpendicular to carrier deck and outlets facing left and right.

f. Place Loctite® 565 on threads of the two 0.75" male NPT X 0.5" hose adapter - P/N CA0 11 002 (3), install in the 0.75" NPT brass tee - P/N 809 602-0004 (2), and fully tighten.

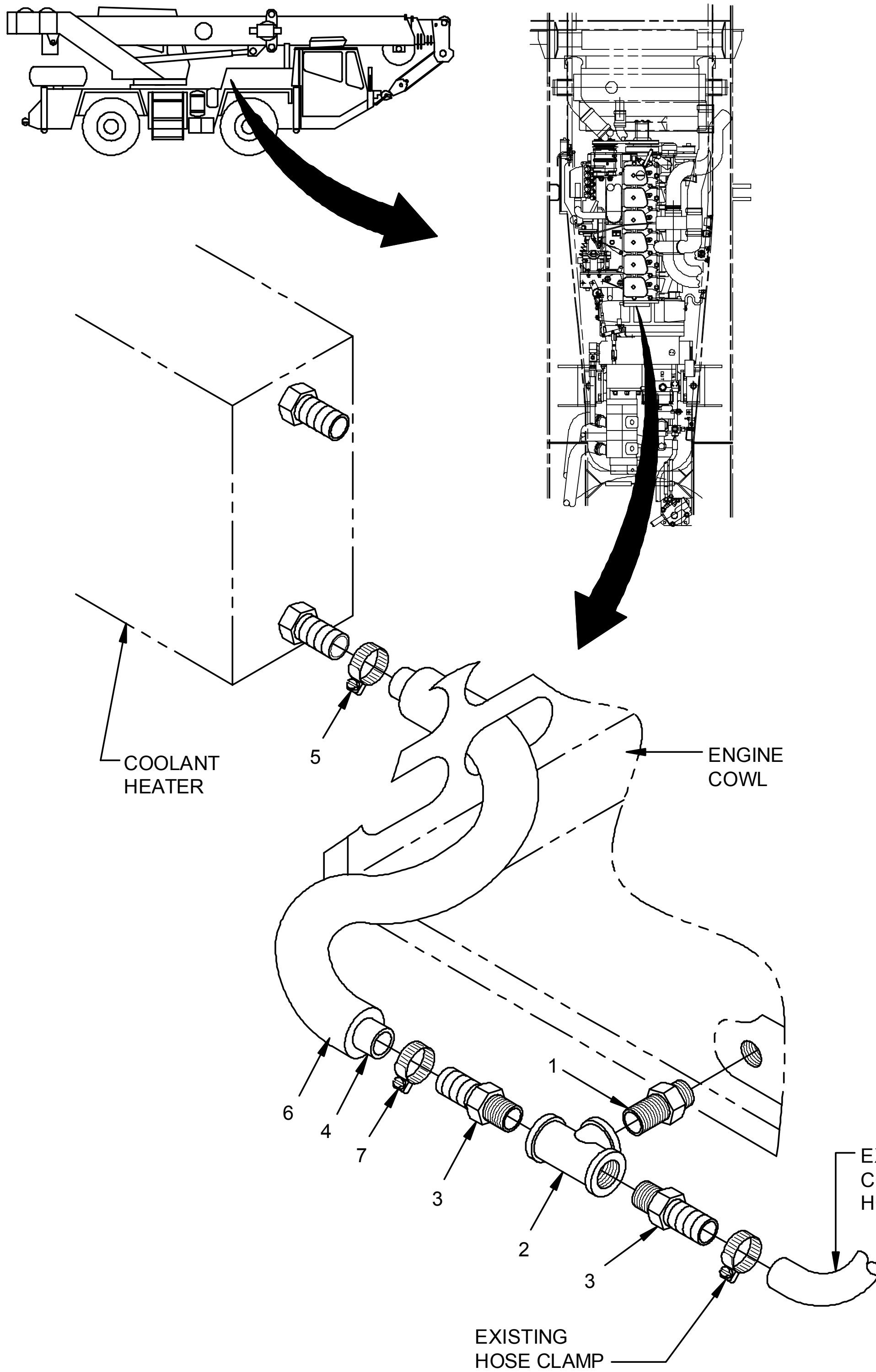
g. Reinstall existing coolant hose onto the right hand 0.75" male NPT X 0.5" hose adapter - P/N CA0 11 002 (3) and tighten using existing clamp.

h. Cut a section of new 0.75" coolant hose - P/N A-4860 (4) and insulation tubing (6) to a length of 30-32 " and slide insulation tubing over new coolant hose.

i. Connect one end of the new 0.75" coolant hose - P/N A-4860 (4) to the COOLANT IN fitting (lower) on the coolant heater and secure with hose clamp - P/N A-279 (5).

j. Insert other end of coolant hose (4) through vent opening of rear cowl on engine compartment hood, route to the 0.75" male NPT X 0.5" hose adapter - P/N CA0 11 002 (3), and cut new coolant hose to appropriate length.

k. Connect the other end of new coolant hose (4) to the 0.75" male NPT X 0.5" hose adapter - P/N CA0 11 002 (3) and secure with hose clamp - P/N A-279 (7).



LEGEND

1. 0.75” Male NPT X 0.5” Male NPT Close Nipple
2. 0.75” NPT Brass Tee
3. 0.75” Male NPT X 0.5” Hose Adapter
4. 0.75” Coolant Hose
5. Hose Clamp
6. Insulation Tubing
7. Hose Clamp

Figure J-17. Engine Coolant Supply from Engine Installation

Engine Coolant Connections – Return to Engine. (Refer To Figures J-16 and J-18.) Route and connect the return to engine coolant connections as follows:

a. Locate the existing coolant hose, hose adapter, and 90-degree elbow fitting for the engine coolant return located at the right hand front side of the diesel engine.

b. Cleanly cut existing coolant return hose approximately 4-6” from existing hose adapter and 90-degree elbow fitting on the engine.

c. Connect the two ends of the existing coolant return hose to the straight section of the 0.75” steel wye adapter - P/N A-459 (1, Figure J-18) with the angled connection on the wye adapter pointing downward and toward the left hand rear of the engine. Secure with two hose clamps - P/N A-279 (2).

d. Cut a section of new 0.75” coolant hose - P/N A-4860 (3) and insulation tubing (4) to a length of 10-11’ and slide insulation tubing over new coolant hose.

e. Connect one end of the new 0.75” coolant hose - P/N A-4860 (3) to the angled connection on the 0.75” steel wye adapter - P/N A-459 (1) and secure with hose clamp - P/N A-279 (5).

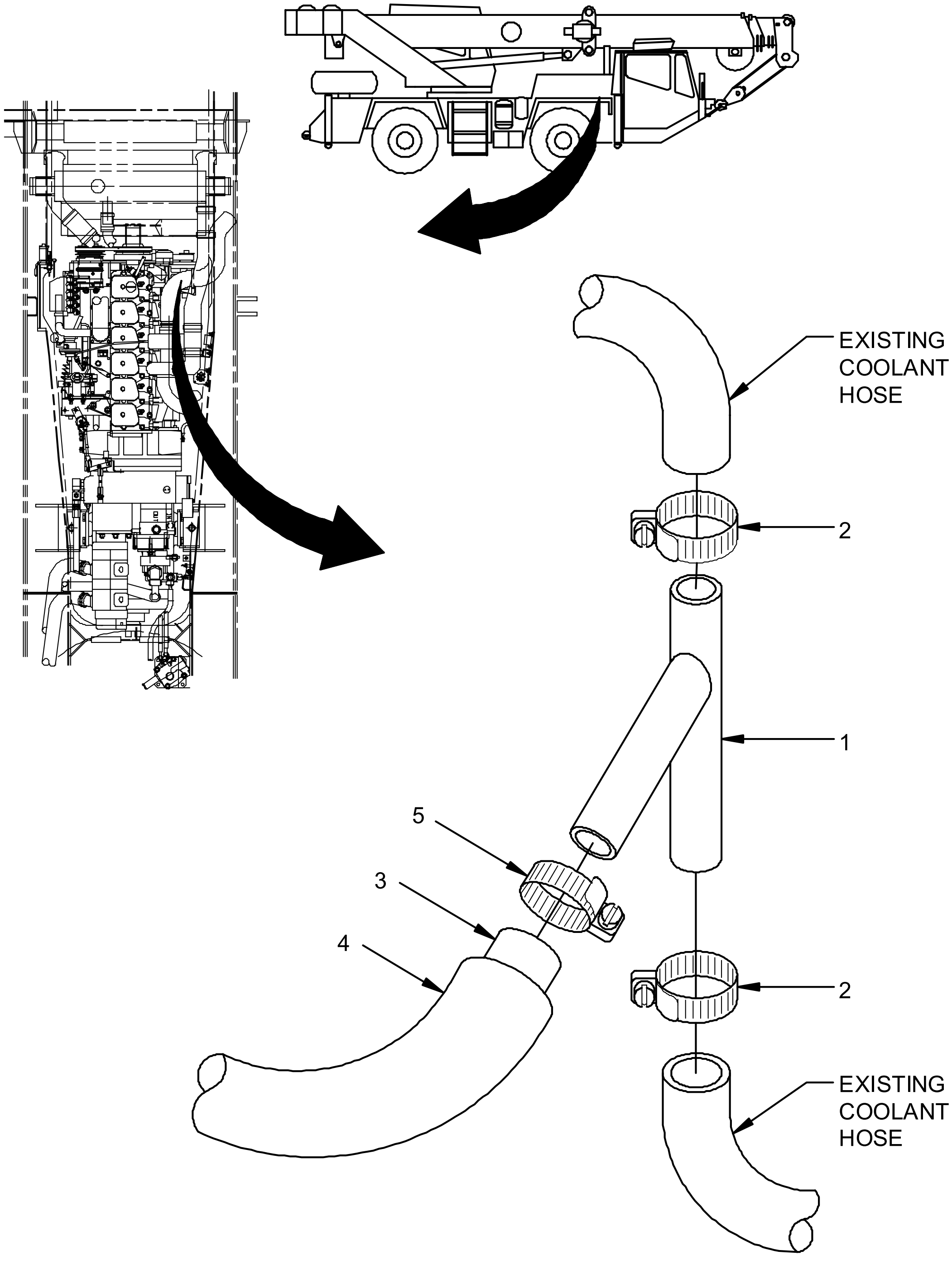
f. Route new coolant hose (3) toward the left hand side of the crane and the hydraulic hoses routed along the left hand side of the diesel engine. Route the coolant hose along the hydraulic hoses, toward the rear of the crane, and the hydraulic reservoir location. Tag and leave the end of the coolant hose hang freely at the hydraulic reservoir location for later connection to the hydraulic reservoir. Use tie wraps to secure new coolant hose in the appropriate locations.

Engine Coolant Connections – Coolant Out to Hydraulic Reservoir. (Refer To Figure J-16.) Route and connect the Coolant Out to hydraulic reservoir connections as follows:

a. Cut a section of new 0.75” coolant hose - P/N A-4860 and insulation tubing to a length of 9-10’ and slide insulation tubing over new coolant hose.

b. Connect one end of the new coolant hose to the COOLANT OUT fitting (upper) on the coolant heater and secure with hose clamp - P/N A-279.

c. Route the new coolant hose from the coolant heater, through vent opening of rear cowl on engine compartment hood, into engine compartment, and downwards along left hand side of transmission. Route the coolant hose along the hydraulic hoses, towards the rear of the crane, and the hydraulic reservoir location. Tag and leave the end of the coolant hose hang freely at the hydraulic reservoir location for later connection to the hydraulic reservoir. Use tie wraps to secure new coolant hose in the appropriate locations.



LEGEND

1. 0.75” Steel Wye Adapter
2. Hose Clamp
3. 0.75” Coolant Hose
4. Insulation Tubing
5. Hose Clamp

Figure J-18. Engine Coolant Return to Engine Installation

Engine Coolant Connections – Hydraulic Reservoir. (Refer To Figures J-8 and J-16.) Route and connect the Coolant Out to hydraulic reservoir connections as follows:

a. Cut a section of new 0.75” coolant hose - P/N A-4860 and insulation tubing to a length of 2-2.5’ and slide insulation tubing over new coolant hose.

b. Connect one end of the new coolant hose (4, Figure J-8) to the COOLANT IN fitting on the front heater element (1) in the hydraulic reservoir and secure with hose clamp - P/N A-279 (6).

c. Connect the other end of the new coolant hose (4, Figure J-8) to the COOLANT OUT fitting on the rear heater element (1) in the hydraulic reservoir and secure with hose clamp - P/N A-279 (6).

d. Locate the “return to engine” and “Coolant Out to hydraulic reservoir” coolant hoses tagged and hanging freely at the hydraulic reservoir location.

e. Route the “return to engine” coolant hose (4) to the COOLANT OUT fitting on the front heater element (1) and cut coolant hose and insulation tubing to appropriate length.

f. Connect the “return to engine” coolant hose (4) to the COOLANT OUT fitting on the front heater element (1) and secure with hose clamp - P/N A-279 (6).

g. Route the “Coolant Out to hydraulic reservoir” coolant hose (4) to the COOLANT IN fitting on the rear heater element (1) and cut coolant hose and insulation tubing to appropriate length.

h. Connect the “Coolant Out to hydraulic reservoir” coolant hose (4) to the COOLANT IN fitting on the rear heater element (1) and secure with hose clamp - P/N A-279 (6).

Final Checks/Pre-Initial Start Procedures

a. Check all fuel, engine coolant, hydraulic, and electrical connections.

b. Ensure hydraulic reservoir has been refilled and bled in accordance with the Technical Manual, TM 5-3810-307-24-1-1.

c. Refill the engine coolant system in accordance with the Technical Manual, TM 5-3810-307-24-1-1.

d. Bleed air from the engine coolant system by running the diesel engine and refill as needed.

NOTE

A lack of engine coolant, restriction, or poorly bled coolant system will result in overheating and a possible “overheat shutdown” of the coolant heater.

e. Replace the grill on the rear cowl of the diesel engine hood in accordance with the Technical Manual, TM-5-3810-307-24-1-1.

f. With battery disconnect switch in OFF position, connect spade terminal (9, Figure J-15) of the brown wire (4) in battery box to the negative battery cable terminal and secure with hex nut (1).

g. Replace battery box cover and turn battery disconnect switch to the ON position.

Initial Startup/Testing Procedures

NOTE

If the heater fails to start the first time it will automatically attempt a second start. If unsuccessful the heater will shut down completely.

NOTE

On initial startup the heater may require several start attempts to self prime the fuel system.

a. Turn on the engine coolant heater manually by pressing the "heater on" pushbutton on the seven day timer. The fuel line will be full and bled when the fuel delivery is uniform and bubble-free (after approximately 60 seconds).

b. Ensure proper operation of the coolant heater as described in the Theory of Operation Section of this Appendix.

NOTE

After running the diesel engine to bleed the coolant system, the coolant may still be warm during initial startup/testing. When the coolant heater is first turned on and only the water pump and combustion air blower are running, the warm coolant will cause warm air to be exhausted even though ignition has not yet occurred. When the coolant heater has ignited the exhaust can be clearly heard coming from the exhaust pipe along with hot exhaust air.

c. Replace cover (1, Figure J-13) on engine coolant heater boxed enclosure (2) and secure with two bolts (3).

TROUBLESHOOTING

NOTE

If the engine coolant heater fails, check the following before troubleshooting the heater.

- Check electrical connections and the fuses (in the battery box and engine coolant heater boxed enclosure). Ensure that the crane's batteries are charged.
- Check for interference between the combustion air and exhaust pipes.
- Check the fuel source.
- Check for coolant flow from the crane's engine coolant system.

NOTE

The engine coolant heater is equipped with self-diagnostic capability. When engine coolant heater faults occur, relevant fault codes will be automatically displayed on the seven day timer in place of the time of day display.

Timer Fault Retrieval. The Espar seven day timer displays fault codes generated by the heater control unit. This function is automatically activated when the heater is experiencing problems.

a. Fault codes appear on the LCD screen display of the seven day timer.

b. Fault codes can be interpreted from Table J-2, Fault Codes.

Retrieving Fault Codes

a. When a fault occurs, a fault code will automatically be displayed in place of the time of day display on the seven day timer located in the carrier cab, above the front console.

b. Refer to Table J-2 to interpret the displayed fault(s).

NOTE

There is a fault code retrieval device (Espar part number CA1 05 020) available for the engine coolant heater. The device has the capability to store and display up to five fault codes. If required, the device should be procured locally and can be ordered online at http://www.espar.com.

Instructions for using the fault code retrieval tool can be downloaded at: http://www.espar.com/pdfs/diagnosticinstruction.pdf.

Table J-2. Fault Codes

Fault Code	Fault Description	Cause/Corrective Action
000	Normal operation	-
001	Advanced warning – overvoltage	Verify that voltage between red and brown wires of control unit external connector B1 is greater than 30 VDC.
002	Advanced warning – undervoltage	Verify that voltage between red and brown wires of control unit external connector B1 is less than 20 VDC.
010	Overvoltage shutdown	Verify that voltage between red and brown wires of control unit external connector B1 is greater than 30 VDC. Check crane battery charging system.
011	Undervoltage shutdown	Verify that voltage between red and brown wires of control unit external connector B1 is less than 20 VDC. Check crane batteries and connections.
012	Overheating	Check for possible overheating causes. Check engine coolant flow. Coolant temperature at temperature sensor is greater than 240°F (115° C). Impedance at temperature sensor is < 400 ohms. Check difference at coolant heater control unit. Remove the control unit and disconnect the internal connector B5. Using multimeter set for ohms, measure impedance between pins 5 and 8 (blue wires) of B5. Overheat sensor values: 150K ohms at -13° F (-25° C), 10 kohms at 77°F (25° C).
013	Excessive temperature at flame sensor	Flame sensor signals temperature greater than 1292° F (700° C). Difference at flame sensor > 3400 ohms. Check difference at coolant heater control unit. Remove the control unit and disconnect the internal connector B5. Using multimeter set for ohms, measure impedance between pins 10 and 12 (grey wires) of B5. Flame sensor values: 900 ohms at -13° F (-25° C), 1100 ohms at 77°F (25° C).
014	Possible overheating detected	Difference of measured values at temperature sensor >158° F (70° C) (difference evaluation). Check temperature sensor and overheat sensor. Then check for coolant throughflow. Remove the control unit and disconnect the internal connector B5. Using multimeter set for ohms, measure impedance between pins 5 and 8 (blue wires) of B5. Overheat sensor values: 150K ohms at -13° F (-25° C), 10 kohms at 77°F (25° C).

Table J-2. Fault Codes (Continued)

Fault Code	Fault Description	Cause/Corrective Action
015	Too many overheats	The coolant heater control unit is interlocked after three consecutive overheating events (codes 012, 013, and 014). Correct the overheat fault. Cancel the control unit interlock and clear error memory by pressing both "L" buttons simultaneously on the Fault Code Retrieval Device.
020	Open circuit – glow pin	Check glow pin (nominal value: 2 ohms) and replace if necessary. Remove the control unit and disconnect the internal connector B5. Using multimeter set for ohms, check for continuity between pin 3 (white wire) and pin 4 (brown wire) on the coolant heater control unit internal connector B5. If OK, replace control unit.
021	Short circuit – glow pin	
033	Combustion air blower motor	Speed deviation for longer than 60 seconds. Nominal value: 5600 rpm (full load), 1850 rpm (part load). Check blower motor: Apply supply voltage to motor. Connect (+) to 1.5 black and (-) to 1.5 orange. If motor does not turn, replace the blower motor. Check blower motor sensor supply. Switch on coolant heater and using multimeter set for volts DC, measure voltage between output pin 13 (0.25 red) and pin 14 (0.25 green) at the control unit internal connector B5. Nominal value is 8 VDC. If voltage incorrect, replace control unit. Check blower motor sensor. Using multimeter set for volts DC, measure voltage between pin 15 (0.25 violet) and pin 14 (0.25 green) on internal connector B5 with blower motor running. Nominal value is 4 VDC (+ 0.3 volts) average value (8 VDC square-wave signal). If voltage is incorrect, replace blower motor. If OK, replace coolant heater control unit.
037	Water pump is not working	Check water pump for proper operation.
042	Water pump short circuit	Check water pump and electrical leads.
043	Short circuit external components	Using multimeter, check wiring to fuel metering pump and seven day timer for possible short circuit. Also check all connected components for evidence of short circuit (maximum current draw is 6 Amps). Replace defective components.
047	Short circuit – fuel metering pump	Using multimeter, check green wiring of coolant heater control unit connector B1 and leads to fuel metering pump for possible short circuit. Nominal value: approximately 20 ohms. If defective, replace fuel metering pump.
048	Open circuit – fuel metering pump	

Table J-2. Fault Codes (Continued)

Fault Code	Fault Description	Cause/Corrective Action
050	Too many no start attempts	The coolant heater control unit is interlocked after it has switched on ten times in succession (i.e., twenty failed starts) without flame detection (fault code 052). Check the fuel supply, glow pin, exhaust piping, combustion air piping, and flame sensor. Cancel the control unit interlock and clear error memory by pressing both “L” buttons simultaneously.
051	Faulty flame recognition	Flame sensor signals a temperature greater than 176° F (80° C) after four minutes of cooling air. Impedance at flame sensor is > 1300 ohms. If no combustion, using multimeter set for ohms, check the flame sensor. Flame sensor values: 900 ohms at -13° F (-25° C), 1100 ohms at 77°F (25° C).
052	No start safety time exceeded	No flame was detected during startup phase. Flame sensor value less that 194°F (90° C) – 1350 ohms. Check the fuel supply, glow pin, exhaust piping, combustion air piping, and flame sensor. Flame sensor values: 900 ohms at -13° F (-25° C), 1100 ohms at 77°F (25° C).
053	Flame cutout in boost mode	Coolant heater has started (flame detected) and indicates flame loss in a given power setting. Check fuel flow rate, combustion air blower speed, fuel supply, and exhaust/combustion air piping. If combustion OK, check flame sensor. Flame sensor values: 900 ohms at -13° F (-25° C), 1100 ohms at 77°F (25° C).
054	Flame cutout in high mode	
055	Flame cutout in medium mode	
056	Flame cutout in low mode	
059	Water temperature rises too quickly	Check coolant circulation (012) and temperature sensor (060/061).
060	Temperature control sensor interruption	Control sensor signals a temperature value outside of the measurement range. Check the connecting wiring to temperature sensor (0.35 yellow) as follows: Remove the control unit and disconnect the internal connector B5. Using multimeter set for ohms, measure impedance between pins 9 and 11 (yellow wires) of B5: greater than 10K ohms (fault code 060) and less than 100 ohms (fault code 061). Temperature sensor values: 650 ohms at -13° F (-25° C), 1000 ohms at 77°F (25° C).
061	Short circuit – temperature control	

Table J-2. Fault Codes (Continued)

Fault Code	Fault Description	Cause/Corrective Action
064	Open circuit – flame sensor	Flame sensor signals temperature value outside of the measurement range. Check the connecting wiring (0.35 grey) as follows: Remove the control unit and disconnect the internal connector B5. Using multimeter set for ohms, measure impedance between pins 10 and 12 (grey wires) of B5: greater than 50K ohms (fault code 064) and less than 100 ohms (fault code 065). Flame sensor values: 900 ohms at -13° F (-25° C), 1100 ohms at 77°F (25° C).
065	Short circuit – flame sensor	
071	Open circuit – overheat sensor	Overheat sensor signals temperature value outside of the measurement range. Check the connecting leads (0.35 blue) as follows: Remove the control unit and disconnect the internal connector B5. Using multimeter set for ohms, measure impedance between pins 5 and 8 (blue wires) of B5: greater than 700K ohms (fault code 071) and less than 100 ohms (fault code 072). Overheat sensor values: 150K ohms at -13° F (-25° C), 10k ohms at 77°F (25° C).
072	Short circuit – overheat sensor	
090	Control unit defective (internal fault)	Internal coolant heater control unit error in microprocessor/memory detected. Replace the control unit.
093	Control unit defective (RAM error)	
094	Control unit defective (EPROM error)	
097	Control unit defective (power failure)	

Fuel Quantity Test

The fuel quantity should be checked if the heater has difficulty starting or maintaining a flame.

NOTE

Measure the fuel quantity when the crane's batteries are properly charged. Supply voltage to the coolant heater should be between 22 and 26 VDC.

Test Preparation.

a. Disconnect the fuel supply line where it enters the engine coolant heater. Insert the end of the hose into a graduated, glass measuring container (size: 1.7 ounces or 50 cm^3).

b. Turn on the engine coolant heater manually by pressing the "heater on" pushbutton in the carrier cab. The fuel line will be full and bled when the fuel delivery is uniform and bubble-free (after approximately 60 seconds).

c. Press the "heater on" pushbutton to stop the fuel metering pump and empty the measuring container

Measurement.

a. Turn on the coolant heater manually by pressing the "heater on" pushbutton. Fuel delivery starts automatically after a 60-second delay and will shut off after approximately 105 seconds.

b. Wait for the coolant heater control unit to attempt a restart. The fuel delivery will restart automatically and will shutoff again after approximately 75 seconds.

c. Press the "heater on" pushbutton to stop the fuel metering pump.

d. Check the fuel level in the measuring container. The volume of fuel in the container should be between 0.6 and 0.7 ounces (17.1 and 20.9 ml).

e. Reconnect the fuel supply line where it enters the engine coolant heater.

MAINTENANCE

Engine Coolant Heater. (Refer to Figure J-19.)

NOTE

Also refer to Figure J-13, Coolant Heater Installation.

Removal.

a. Ensure battery disconnect switch is in the OFF position.

b. Drain engine coolant from diesel engine in accordance with the Technical Manual, TM 5-3810-307-24-1-1.

c. Remove two bolts (1, Figure J-19) and remove cover (2) from boxed enclosure (3) of the coolant heater (4).

d. Loosen hose clamps then tag and disconnect coolant hoses from COOLANT IN and OUT fittings (5) on boxed enclosure (3) of coolant heater (4).

e. Remove screw (9), washer (10), and nut (11) from 5A in-line fuse holder (12).

f. Disconnect control unit (internal) harness connector from control unit on coolant heater (4).

g. Slide wiring harness (15) and grommet (16) out of boxed enclosure (3).

h. Loosen No. 6 clamp (17) and disconnect 2mm plastic fuel line (18) from 3.5mm fuel hose (19).

i. Pull 2mm plastic fuel line (18) through grommet (21) and remove from boxed enclosure (3).

j. Loosen clamp (22) and disconnect flexible exhaust hose (23) from coolant heater (4).

k. Remove four hex nuts (30), spring washers (31), threaded washers (32), fender washers (33), and shock mounts (34) from four mounting bolts (37) and remove boxed enclosure and engine coolant heater (3 and 4).

Installation.

a. While feeding flexible exhaust hose (23, Figure J-19) and clamp (22) through the silicon exhaust seal (24), install boxed enclosure and coolant heater (3 and 4) on left front fender and install shock mounts (34), fender washers (33), and threaded washers (32) on four mounting bolts (37). Secure with four spring washers (31) and hex nuts (30).

b. Connect flexible exhaust hose (23) and tighten clamp (22).

c. Feed 2mm plastic fuel line (18) through grommet (21) in side of boxed enclosure (3).

d. Connect 2mm plastic fuel line (18) to 3.5mm fuel hose (19) and secure with No. 6 clamp (17).

e. Slide grommet (16) with wiring harness (15) and 5A in-line fuse holder (12) into boxed enclosure (3).

f. Connect the control unit (internal) harness connector to the control unit on the coolant heater (4).

g. Install 5A in-line fuse holder (12) on boxed enclosure (3) and secure with screw (9), washer (10), and nut (11).

h. Connect coolant hoses to COOLANT IN and OUT fittings (5) on boxed enclosure (3) as tagged and secure with hose clamps.

i. Replace cover (2) on boxed enclosure (3) and secure with two bolts (1).

j. Refill engine coolant and bleed air from the system in accordance with the Technical Manual, TM 5-3810-307-24-1-1.

Coolant Heater Control Unit. (Refer to Figures J-19 and J-20.)

Removal.

a. Ensure battery disconnect switch is in the OFF position.

b. Remove two bolts (1, Figure J-19) and remove cover (2) from boxed enclosure (3) of the coolant heater (4).

c. Disconnect control unit (internal) harness connector from control unit (2, Figure J-20).

d. Remove three fillister head bolts (1) securing control unit (2).

e. Carefully separate the control unit (2) and the burner assembly (4).

f. Remove and discard seal (3). Ensure all remnants of the seal are removed from the burner assembly (4). Use care to avoid damage to the sealing surface.

Installation.

a. If installing a new control unit (2, Figure J-20) proceed to step b. Otherwise, remove all remnants of the old seal (3) from the control unit (2). Use care to avoid damaging the sealing surface.

b. Ensure that both sealing surfaces are clean. Then apply liquid sealant (Form-a-Gasket®) to the sealing surface of the control unit (2).

c. Install a new seal (3) on the control unit (2). Then install the control unit (2) on the burner assembly (4). Secure the control unit with three fillister head bolts (1).

d. Connect control unit (internal) harness connector to the control unit (2).

e. Replace cover (2, Figure J-19) on boxed enclosure (3) and secure with two bolts (1).

Glow Pin. (Refer to Figures J-19 and J-20.)

Removal.

a. Ensure battery disconnect switch is in the OFF position.

b. Remove two bolts (1, Figure J-19) and remove cover (2) from boxed enclosure (3) of the coolant heater (4).

c. Remove the control unit (2, Figure J-20) as described above.

d. Remove nut and washer securing the glow pin harness (32) to glow pin (30). If necessary, cut tie wraps (23) and remove the glow pin harness (32).

e. Remove glow pin (30) and seal (31) from burner assembly (4). Discard seal (31).

Installation.

a. Install new seal (31, Figure J-20) and glow pin (30) into burner assembly (4).

b. If removed, route glow pin harness (32) as removed and secure with new tie wraps (23).

c. Connect glow pin harness (32) to glow pin (30) with nut and washer (part of glow pin).

d. Install coolant heater control unit (2) as described above.

e. Replace cover (2, Figure J-19) on boxed enclosure (3) and secure with two bolts (1).

Overheat Sensor. (Refer to Figures J-19 and J-20.)

Removal.

a. Ensure battery disconnect switch is in the OFF position.

b. Remove two bolts (1, Figure J-19) and remove cover (2) from boxed enclosure (3) of the coolant heater (4).

c. Cut tie wrap (23, Figure J-20). Then remove screws (6), lockwashers (8), and cover (9).

d. Tag and disconnect wiring from overheat sensor (12).

e. Remove screws (11), overheat sensor (12), and preformed packing (13). Discard preformed packing (13).

Installation.

a. Install overheat sensor (12, Figure J-20) with new preformed packing (13) into outer casing (15) of heat exchanger (20) and secure with screws (11).

b. Connect wiring from overheat sensor (12) as tagged. Remove tags.

c. Install cover (9), lockwashers (8), and screws (6). Install new tie wrap (23).

d. Replace cover (2, Figure J-19) on boxed enclosure (3) and secure with two bolts (1).

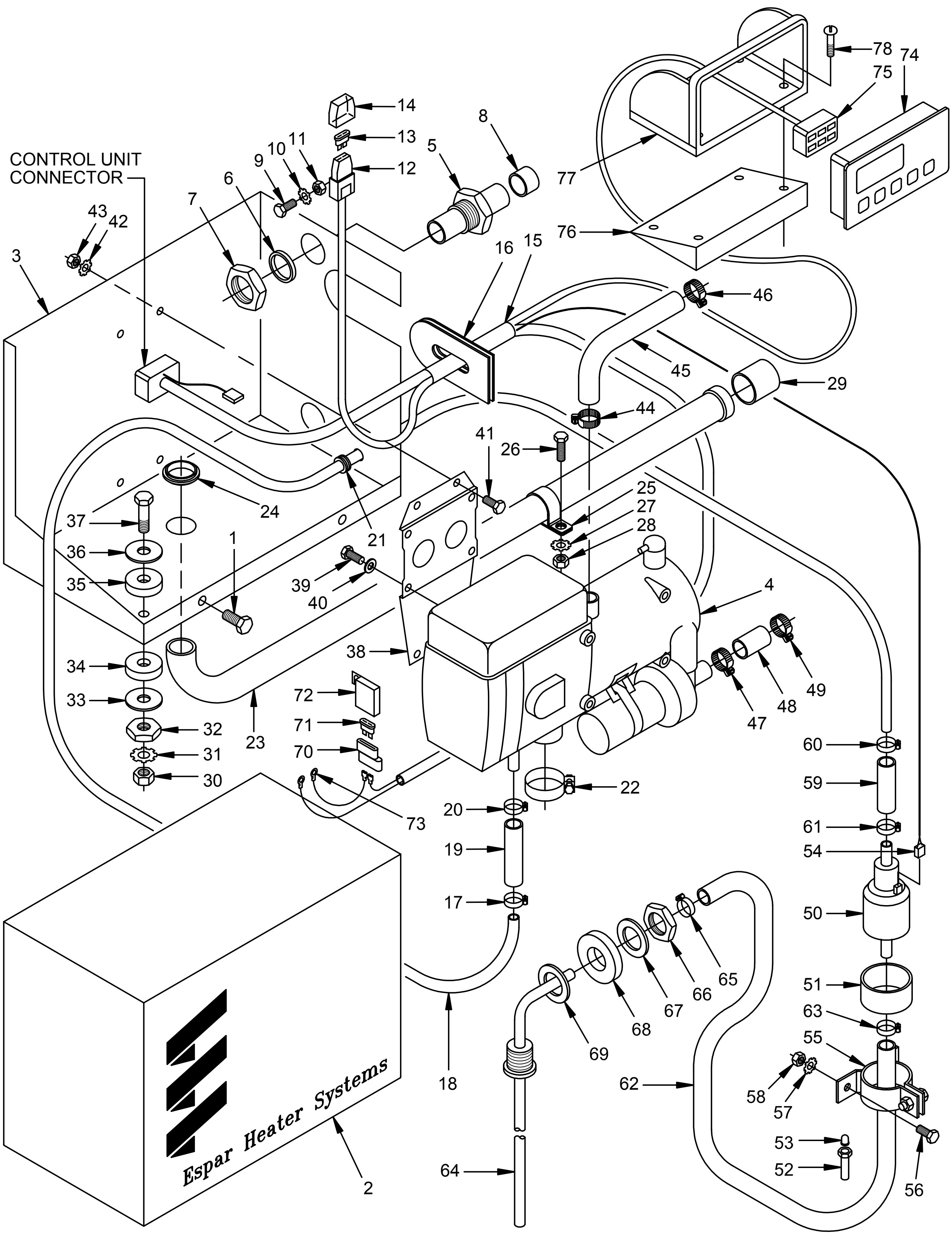


Figure J-19. Espar Coolant Heater Installation (Sheet 1 of 2)

LEGEND

1. Bolts, 5/16x1/2” #18 Stainless
2. Cover, Boxed Enclosure
3. Boxed Enclosure
4. Coolant Heater - Hydronic 10
5. Bulkhead Hose Connector, 3/4”
6. Washer, Bulkhead
7. Hex Nut
8. Dust Cap, Bulkhead Fitting
9. Screw, M3x30
10. Washer, 6mm
11. Hex Nut
12. Fuse Holder
13. Fuse Insert – 5 Amp
14. Fuse Holder Cover
15. Wiring Harness
16. Grommet
17. Clamp, 9mm
18. Plastic Fuel Line, 2mm
19. Fuel Hose, 3.5mm
20. Clamp, 9mm
21. Grommet
22. Exhaust Clamp, 30-33mm
23. Flexible Exhaust Hose w/ End Cap
24. Silicon Seal, Exhaust
25. Clamp, “C”, 34mm
26. Hex Bolt
27. Washer
28. Hex Nut
29. End Sleeve
30. Hex Nut, 8mm
31. Spring Washer, 8mm
32. Threaded Washer
33. Washer, Fender, 5/16x1.25”
34. Shock Mount, 8mm
35. Shock Mount, 8mm
36. Washer, Fender, 5/16x1.25”
37. Bolt, M8x50
38. Heater Mounting Bracket
39. Bolt
40. Washer
41. Bolt, M8x16
42. Washer, 8mm
43. Hex Nut, 8mm
44. Spring-loaded Clamp, 17-32mm
45. Molded Hose
46. Spring-loaded Clamp, 17-32mm
47. Spring-loaded Clamp, 17-32mm
48. Coolant Hose for Boxed Unit
49. Spring-loaded Clamp, 17-32mm
50. Fuel Metering Pump
51. FMP Rubber Ring
52. Fuel Connection Piece
53. Cup Sieve
54. Connector – Fuel Metering Pump
55. Fuel Metering Pump Holder
56. Hex Bolt, M6x12
57. Washer, 6mm
58. Hex Nut
59. Fuel Hose, 3.5mm
60. Clamp, 9mm
61. Clamp, 9mm
62. Fuel Hose
63. Clamp, 11mm
64. Fuel Pickup Tube
65. Clamp, 11mm
66. Nut
67. Flat Washer
68. Rubber Washer
69. Flat Washer
70. Fuse Holder Base
71. Fuse Insert – 15 Amp
72. Fuse Holder Cover
73. Ring Terminal, 3/8” awg 10-12
74. Seven Day Timer
75. Connector – Seven Day Timer
76. Wedge Bezel
77. Mounting Bracket
78. Screw, Self-tapping

Figure J-19. Espar Coolant Heater Installation (Sheet 2 of 2)

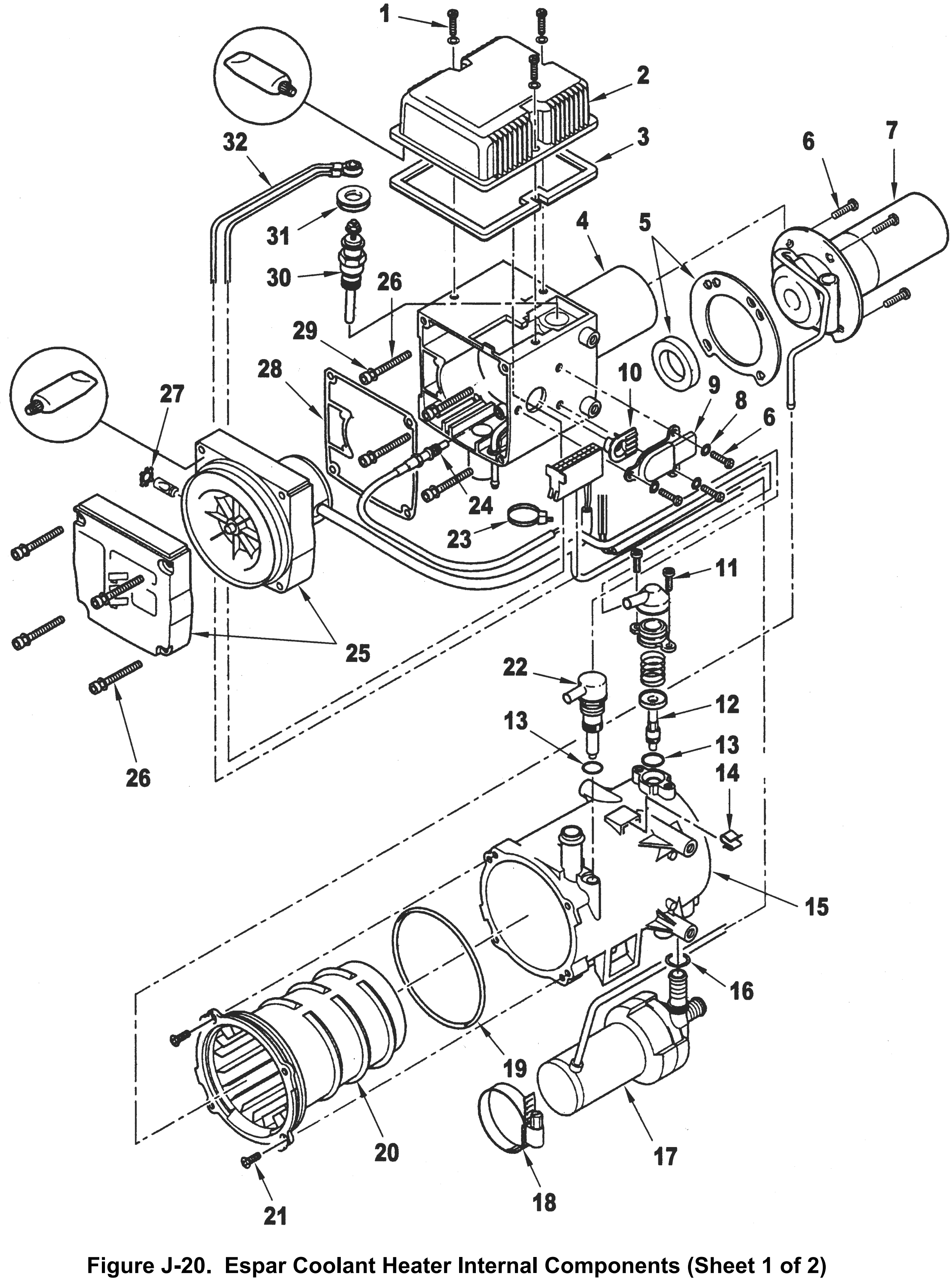


Figure J-20. Espar Coolant Heater Internal Components (Sheet 1 of 2)

LEGEND

1. Fillister Head Bolt
2. Control Unit
3. Seal
4. Burner Assembly
5. Seal
6. Taptite Screw
7. Flame Tube and Burner
8. Spring Washer
9. Cover
10. Sleeve
11. Taptite Screw
12. Overheat Sensor
13. Preformed Packing
14. Clip
15. Outer Casing
16. Preformed Packing
17. Water Pump
18. Clamp
19. Preformed Packing
20. Heat Exchanger
21. Taptite Screw
22. Temperature Sensor
23. Twist Tie
24. Flame Sensor
25. Combustion Air Blower with Cover
26. Screw
27. Hexagon Nut
28. Seal
29. Washer
30. Glow Pin
31. Seal
32. Glow Plug Cable

Figure J-20. Espar Coolant Heater Internal Components (Sheet 2 of 2)

Temperature Sensor. (Refer to Figures J-19 and J-20.)

Removal.

a. Ensure battery disconnect switch is in the OFF position.

b. Remove two bolts (1, Figure J-19) and remove cover (2) from boxed enclosure (3) of the coolant heater (4).

c. Cut tie wrap (23, Figure J-20). Then remove screws (6), lockwashers (8), and cover (9).

d. Tag and disconnect wiring from temperature sensor (22).

e. Remove temperature sensor (22) and preformed packing (13). Discard preformed packing (13).

Installation.

a. Install temperature sensor (22, Figure J-3) with new preformed packing (13) into outer casing (15) of heat exchanger (20).

b. Connect wiring from temperature sensor (22) as tagged. Remove tags.

c. Install cover (9), lockwashers (8), and screws (6). Install new tie wrap (23).

d. Replace cover (2, Figure J-19) on boxed enclosure (3) and secure with two bolts (1).

Combustion Air Blower Motor. (Refer to Figures J-19 and J-20.)

Removal.

a. Ensure battery disconnect switch is in the OFF position.

b. Remove two bolts (1, Figure J-19) and remove cover (2) from boxed enclosure (3) of the coolant heater (4).

c. Remove engine coolant heater (4) as described above.

d. Remove the control unit (2, Figure J-20) as described above.

e. Remove screws (26), combustion blower and cover (25), and seal (28). Discard seal (28). Ensure all remnants of the seal are removed from the burner assembly (4). Use care to avoid damage to the sealing surface.

f. Tag and disconnect wires from combustion blower motor and remove combustion blower and cover (25).

Installation.

a. Connect wires from combustion blower and cover (25, Figure J-20) as tagged. Remove tags.

b. If installing a new combustion blower and cover (25) proceed to step c. Otherwise, remove all remnants of the old seal (28) from the combustion blower (25). Use care to avoid damaging the sealing surface.

c. Ensure that all sealing surfaces are clean. Then apply liquid sealant (Form-a-Gasket ®) to the sealing surface between the combustion blower and its cover (25). Mate these two pieces together.

d. Install new seal (28) and combustion blower and cover (25) onto burner assembly (4) and secure with screws (26).

e. Install coolant heater control unit (2) as described above.

f. Install engine coolant heater (4, Figure J-19) as described above.

g. Replace cover (2) on boxed enclosure (3) and secure with two bolts (1).

Flame Sensor. (Refer to Figures J-19 and J-20.)

Removal.

a. Ensure battery disconnect switch is in the OFF position.

b. Remove two bolts (1, Figure J-19) and remove cover (2) from boxed enclosure (3) of the coolant heater (4).

c. Remove engine coolant heater (4) as described above.

d. Remove the control unit (2, Figure J-20) as described above.

e. Remove combustion blower and cover (25) as described above.

f. Tag and disconnect wires to flame sensor (24).

g. Remove flame sensor (24).

Installation.

a. Install flame sensor (24, Figure J-20).

b. Connect wires from flame sensor (24) as tagged. Remove tags.

c. Install combustion blower and cover (25) as described above.

d. Install control unit (2) as described above.

e. Install engine coolant heater (4, Figure J-19) as described above.

f. Replace cover (2) on boxed enclosure (3) and secure with two bolts (1).

Burner. (Refer to Figures J-19 and J-20.)

Removal.

a. Ensure battery disconnect switch is in the OFF position.

b. Remove two bolts (1, Figure J-19) and remove cover (2) from boxed enclosure (3) of the coolant heater (4).

c. Remove engine coolant heater (4) as described above.

d. Remove the control unit (2, Figure J-20) as described above.

e. Remove combustion blower and cover (25) as described above.

f. Remove the temperature sensor (22), overheat sensor (12), and flame sensor (24) as described above.

g. Remove four socket head capscrews (26) and washers (29) and separate the burner assembly (4) and outer casing (15) of heat exchanger (20).

h. If necessary, carefully separate the flame tube and burner (7) and the burner assembly (4) by removing four screws (6). Remove and discard seal (5).

Installation.

a. If separated, assemble flame tube and burner (7, Figure J-20), new seal (5), and burner assembly (4) with screws (6).

b. Assemble the burner assembly (4), outer casing (15) and heat exchanger (20) and secure with socket head capscrews (26) and washers (29).

c. Install the temperature sensor (22), overheat sensor (12), and flame sensor (24) as described above.

d. Install combustion blower and cover (25) as described above.

e. Install the control unit (2) as described above.

f. Install engine coolant heater (4, Figure J-19) as described above).

g. Replace cover (2) on boxed enclosure (3) and secure with two bolts (1).

Combustion Chamber. (Refer to Figures J-19 and J-20.)

Removal.

a. Ensure battery disconnect switch is in the OFF position.

b. Remove two bolts (1, Figure J-19) and remove cover (2) from boxed enclosure (3) of the coolant heater (4).

c. Remove engine coolant heater (4) as described above.

d. Remove the control unit (2, Figure J-20) as described above.

e. Remove combustion blower and cover (25) as described above.

f. Remove the temperature sensor (22), overheat sensor (12), and flame sensor (24) as described above.

g. Remove four socket head capscrews (26) and washers (29) and separate the burner assembly (4), outer casing (15), and heat exchanger (20).

h. Remove two screws (21) and separate the heat exchanger (20) and outer casing (15). Remove and discard preformed packing (19).

Installation.

a. Assemble the heat exchanger (20, Figure J-20) and outer casing (15) with a new preformed packing (19) and two screws (21).

b. Assemble the burner assembly (4), outer casing (15), and heat exchanger (20) and secure with socket head capscrews (26) and washers (29).

c. Install the temperature sensor (22), overheat sensor (12), and flame sensor (24) as described above.

d. Install combustion blower and cover (25) as described above.

e. Install the control unit (2) as described above.

f. Install engine coolant heater (4, Figure J-19) as described above.

g. Replace cover (2) on boxed enclosure (3) and secure with two bolts (1).

Water Pump. (Refer to Figures J-19 and J-20.)

Removal.

a. Ensure battery disconnect switch is in the OFF position.

b. Drain engine coolant from diesel engine in accordance with the Technical Manual, TM 5-3810-307-24-1-1.

c. Remove two bolts (1, Figure J-19) and remove cover (2) from boxed enclosure (3) of the coolant heater (4).

d. Loosen hose clamps then tag and disconnect coolant hoses from COOLANT IN and OUT fittings (5) on boxed enclosure (3) of coolant heater (4).

e. Loosen clamps (47 and 49) and disconnect coolant hose (48) at water pump (17, Figure J-20).

f. Cut tie wrap (23). Then remove screws (6), lockwashers (8), and cover (9).

g. Tag and disconnect wiring from water pump (17).

h. Remove clamp (18) and separate water pump (17) and outer casing (15). Discard preformed packing (16).

Installation.

a. Install water pump (17, Figure J-20) with new preformed packing (16). Secure water pump (17) to outer casing (15) with clamp (18).

b. Connect wiring from water pump (17) as tagged. Remove tags.

c. Install cover (9), lockwashers (8), and screws (6). Install new tie wrap (23).

d. Connect water hose (48, Figure J-19) and secure with clamps (47 and 49).

e. Connect coolant hoses to COOLANT IN and OUT fittings (5) on boxed enclosure (3) as tagged and secure with hose clamps.

f. Replace cover (2) on boxed enclosure (3) and secure with two bolts (1).

g. Refill engine coolant and bleed air from the system in accordance with the Technical Manual, TM 5-3810-307-24-1-1.

Fuel Metering Pump. (Refer to Figure J-19.)

NOTE

Also refer to Figure J-11, Fuel Metering Pump Installation.

Removal.

NOTE

It may be necessary to remove the oil sampling valve that is next to the bracket underneath the battery box in order to gain better access to the bracket.

a. Ensure battery disconnect switch is in the OFF position.

b. Disconnect electrical connector (54, Figure J-19) at fuel metering pump (50).

c. Loosen clamp (61) and disconnect fuel hose (59) at fuel metering pump (50).

d. Loosen clamp (63) and disconnect fuel hose (62) at fuel metering pump (50).

e. Remove two hex bolts (56), flat washers (57), and hex nuts (58) and remove fuel metering pump (50) and bracket (55) from battery disconnect bracket.

Installation.

a. Install the fuel metering pump and bracket (50 and 55, Figure J-19) on the inside of the battery disconnect bracket with the outlet facing upward and secure with two hex bolts (56), flat washers (57), and hex nuts (58).

NOTE

The outlet of the fuel metering pump (50) is smaller and on the side with the electrical connection.

b. Connect fuel hose (62) at fuel metering pump (50) and secure with clamp (63).

c. Connect fuel hose (59) at fuel metering pump (50) and secure with clamp (61).

d. Connect electrical connector (54) at fuel metering pump (50).

e. If removed, reinstall oil sampling valve.

Heating Elements. (Refer to Figure J-8.)

Removal.

a. Ensure battery disconnect switch is in the OFF position.

b. Drain engine coolant from diesel engine in accordance with the Technical Manual, TM 5-3810-307-24-1-1.

c. Drain hydraulic fluid from hydraulic reservoir in accordance with the Technical Manual, TM 5-3810-307-24-1-1.

d. Loosen hose clamps (6, Figure J-8) then tag and disconnect coolant hoses (4) from COOLANT IN and OUT fittings on heater elements (1).

e. Remove brass elbows (3) from pipe bushings (2).

f. Remove pipe bushings (2) from heater elements (1).

g. Unscrew heater element (1) from hydraulic reservoir.

Installation.

a. Place Loctite® 565 on threads of the heater element (1, Figure J-8) and install in 2.0" NPT coupler on hydraulic reservoir. Tighten until COOLANT IN or OUT points toward the lower RH corner of tank. Refer to the detail on Figure J-8.

b. Place Loctite® 565 on threads of pipe bushings (2), install in COOLANT IN and OUT of heater element (1), and tighten.

c. Place Loctite® 565 on threads of brass elbows (3), install in pipe bushing (2), and tighten.

d. Connect the coolant inlet and outlet hoses (4) to the COOLANT IN and OUT fittings on heater elements (1) and secure with hose clamps (6).

e. Refill hydraulic fluid and bleed air from the system in accordance with the Technical Manual, TM 5-3810-307-24-1-1.

f. Refill engine coolant and bleed air from the system in accordance with the Technical Manual, TM 5-3810-307-24-1-1.

Seven Day Timer. (Refer to Figure J-19.)

Removal.

a. Ensure battery disconnect switch is in the OFF position.

b. Remove connector (75, Figure J-19) from the back of the seven day timer (74).

c. Slide the seven day timer (74) out from the mounting bracket (77).

Installation.

a. Ensure the 24V bulb (green bulb casing) is installed in the seven day timer (74, Figure J-19) and slide the seven day timer (74) into the mounting bracket (77).

b. Connect the connector (75) into the back of the seven day timer (74).

APPENDIX K

BERMINGHAMMER PILE DRIVER SYSTEM
INSTRUCTIONS FOR MAINTENANCE, TROUBLESHOOTING, AND REPAIR

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SAFETY SUMMARY

WARNING

Remain clear when removing the impact block from the lower cylinder in the event the impact block falls from the sling.

WARNING

Installing the piston into the upper cylinder procedure presents several opportunities for pinching body parts between moving parts. Use care when lowering the piston into the upper cylinder.

WARNING

Ensure the pressure has been relieved on the remote throttle prior to disconnecting the remote throttle hydraulic line.

CAUTION

Do not use any starting fluids as a starting aid as they can cause excessive piston stroke and damage to the impact hammer.

CAUTION

When raising the impact hammer to a vertical position after performing repair procedures, it is imperative to raise the impact hammer very slowly. The piston and impact block must not be allowed to collide forcefully with the striker plate. A violent collision may cause damage.

CAUTION

Position a piece of plywood (or other protective material) on the floor beneath the impact block to prevent damage in the event any components fall to the floor during lifting of the impact block.

CAUTION

Be careful not to deform (oversize or stretch) the impact block compression rings during removal, open just enough to slide impact block compression rings over the diameter of the impact block.

CAUTION

Be careful not to deform (oversize or stretch) the piston compression rings during removal, open just enough to slide piston compression rings over the diameter of the piston.

CAUTION

Be careful not to damage any components while lowering the piston into the upper cylinder. Do not rest any weight of the piston on the piston compression rings.

Ensure the lifting pawl of the hammer trip assembly is disengaged, hanging vertically, and not going to strike the piston nose and/or piston compression rings when the piston is lowered into the upper cylinder.

CAUTION

Failure to finger tighten the two injector clamp capscrews prior to tightening to final torque value may result in a deformed fuel injector.

SYSTEM DESCRIPTION.

General Description (Refer To Figure K-1.)

The Pile Driver System is a sectional tower framework that contains a single-cylinder, diesel engine-driven impact hammer that pounds pilings (wood, steel H-beam, pre-cast concrete, or sheet pilings), into the soil to create foundations for buildings, bridges, docks, seawalls, and other structures required to maintain or support heavy loads. Standard pile lengths may be up to 25-feet (7.6 m) long but the system is capable of driving up to 40-foot (12.2 m) long piles without splicing.

The impact hammer drives the pilings by projecting a large steel mass (a “piston” or “ram”) upward through a cylinder until it free-falls back down, striking the top of the piling through a drive system, there-by driving the piling into the ground. The AT422T All-Terrain Crane (ATEC) is used to assemble, lift, position, stabilize, and operate the Pile Driver System.

The main Pile Driver System components include the lead tower, spotter, impact hammer, remote throttle, and accessory components. The Pile Driver System, including the lead tower, spotter, impact hammer, and all accessories, is housed in a reusable, weather-proof shipping/storage container. The general weight of the lead tower, spotter, and impact hammer is approximately 9,500 lbs (4,318 kg) (not including pile adapters). The weight of the shipping/storage container with all components stored inside is approximately 19,500 lbs (8,864 kg).

Specifications for the Pile Driver System are provided in Tables K-1 through K-4 at the end of this section.

Shipping/Storage Container

The shipping/storage container is a steel container used to house and transport the Pile Driver System. It consists of a steel base, with forklift pockets, that is used to secure all the components and a steel cover that is placed over the components and bolted to the base. A wrench, stored in a bracket on the outside of the steel cover, can be used to remove the bolts securing the steel cover to the base. Four lifting lugs are located on top of the steel cover and 1-1/4-inch (3.2 cm) shackles are permanently attached. Equipment tie-down straps prevent shifting of the components. A spotter storage support rests on the lead tower sections and provides a base for support of the spotter within the shipping/storage container.

Weight data is stenciled on the sides of the shipping/storage container.

Lead Tower (Refer To Figure K-1.)

The lead tower holds and allows vertical travel of the impact hammer, connected via four gibs (or brackets), along rails on the front of the lead tower. The lead tower is a single column, vertical travel (spud-type) style consisting of three identical 15 feet (4.6 m) sections joined together by removable nuts and bolts. The total length of the fully assembled lead is 45 feet (13.8 m) but expansion (60 feet (18.4 m)) is possible by adding one additional lead section.

The lead tower is attached to the top of the crane boom by two parallel boom adapter plates and the lead head adapter that enable vertical suspension of the lead tower. The lead head adapter is connected to the top of the lead tower by removable nuts and bolts and the boom adapter plates are connected to the lower boom nose shaft by locking collars. The lead head adapter and boom adapter plates are then bolted together. Weight, bolt storage location, and impact hammer orientation data is stenciled on the sides of the lead head adapter.

A foot roller is attached to the bottom lead section to assist in raising and lowering the assembled lead tower. A pile gate stop, installed in the foot roller, holds the pile gate in position on the lead tower. Two wheels can be attached to shafts on the foot roller to create a rough-terrain dolly.

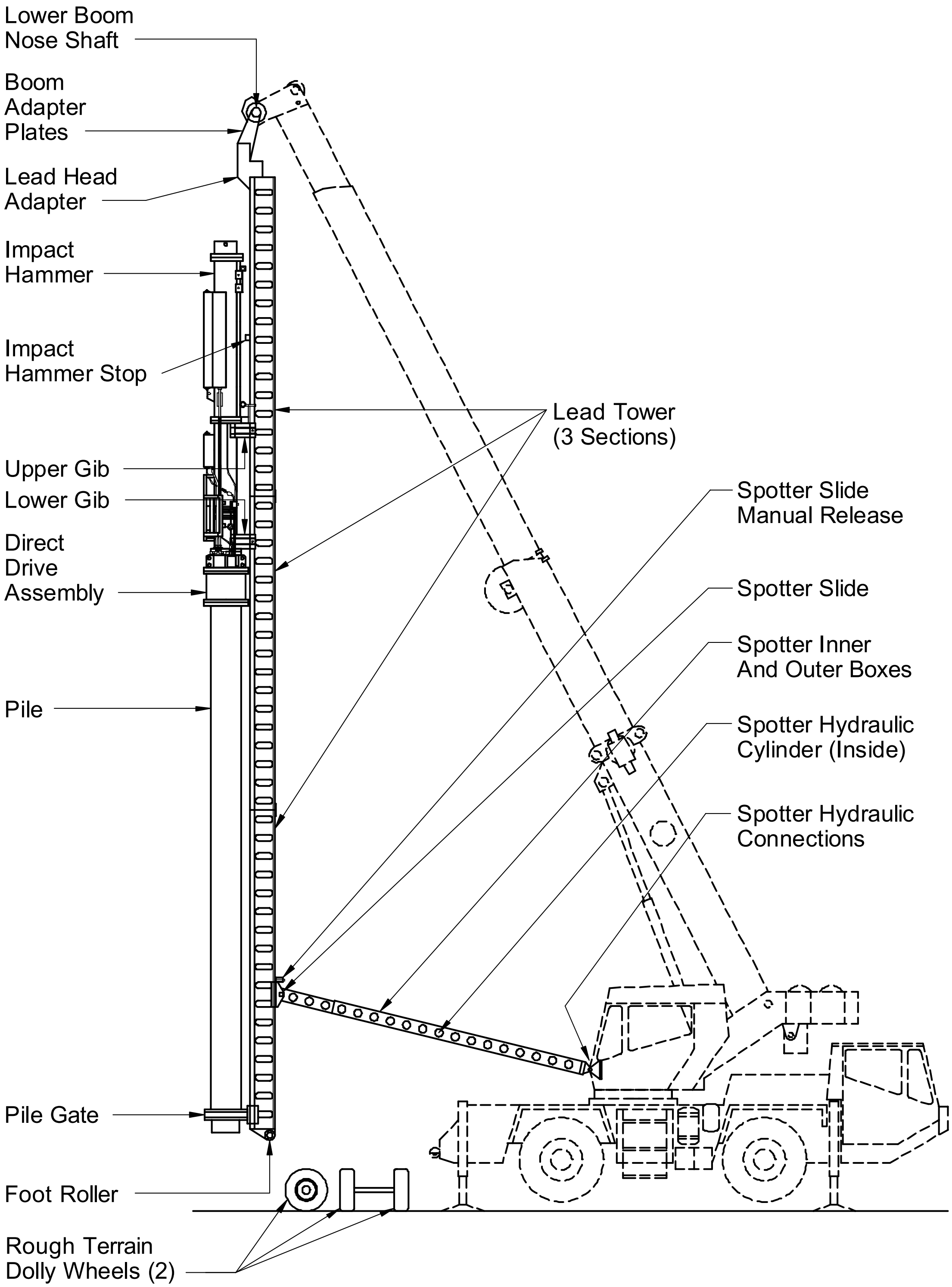


Figure K-1. Crane, Lead Tower, Spotter, and Impact Hammer

A pile gate, able to accommodate up to 18-inch (45.7 cm) diameter piles, is attached to the bottom lead section to assist in properly aligning the piles during operation. The pile gate consists of a pile gate frame, swing arm, and latch. Weight data is stenciled on the sides of the pile gate and warning and lift point location decals are also located on the pile gate.

An impact hammer stop, installed near the top of the lead tower by removable bolts, replaces the anti-two block function of the Load Moment Indicator (LMI) system for pile driving operations. The impact hammer stop physically prevents the impact hammer from colliding with the boom nose by limiting its vertical travel.

NOTE

The anti-two block function of the Load Moment Indicator (LMI) system is disabled and not used during pile driving operations.

Weight, impact hammer orientation (UP), and center-of-gravity location data is stenciled on the individual lead tower sections.

Spotter (Refer To Figure K-1.)

The spotter is a hydraulically-operated, adjustable, mechanical link attached to the bottom lead section and the crane superstructure to provide stability to and control the location and pitch of the lead tower. The spotter is attached to the bottom lead section via the spotter slide and to mounting lugs on the front of the crane superstructure via brackets and two support pins. The hydraulic connections are provided by the boom hose reel on the crane and connected to two hydraulic connections (spotter manifold) located on the right-hand side of the spotter base (at crane superstructure mounting bracket). A hydraulic hose retention chain, attached to the base of the spotter, is used to secure the hydraulic hose reel lines. The spotter is extended and retracted by the telescope/clamshell control pedal in the superstructure cab (when the TELE/CLAMSHELL selector switch is in the CLAMSHELL position).

The spotter consists of two telescoping inner and outer boxes with short and long wear pads on each, a hydraulic cylinder (3-inch (7.6 cm) diameter x 96-inch (2.4 m) stroke), and spotter slide.

The spotter slide, connected to rails on the rear of the lead tower, allows vertical adjustment of the spotter connection to the lead tower. A pin on the spotter slide engages holes on the rear of the lead tower to hold the spotter slide in place along the rails. A manual release on the spotter slide can be operated by a tag line and enables the pin to be disengaged to allow vertical movement of the spotter slide along the rails. A retainer pin can be used to hold the manual release (and spotter slide pin) in the disengaged position during height adjustment. Two lubrication fittings, located on each side of the spotter slide, enable lubrication of the spotter slide.

Warning and weight data is stenciled on top of the spotter. Warning, lubrication location, and lift point location decals are located on the spotter. In addition, a decal illustrating crane signals and additional pile driving hand signals is attached to the left-hand side of the spotter.

Impact Hammer (Refer To Figures K-2, K-3, K-4.)

The impact hammer is a self-contained, diesel engine-driven, direct drive-type pile driving hammer operating on compression/ignition, two-cycle operation. The impact hammer utilizes an air-activated, high pressure fuel injection system with a fuel tank and air-activated, pressurized lubrication system with attached oil tank. Startup of the impact hammer is controlled by an integrated hammer trip system with trip safety lock.

The main components of the impact hammer are the piston and impact block, upper and lower cylinders, hammer trip assembly (mechanical starting device), fuel injection system, lubrication system, and direct drive system that houses a recoil dampening system and striker plate (driving head).

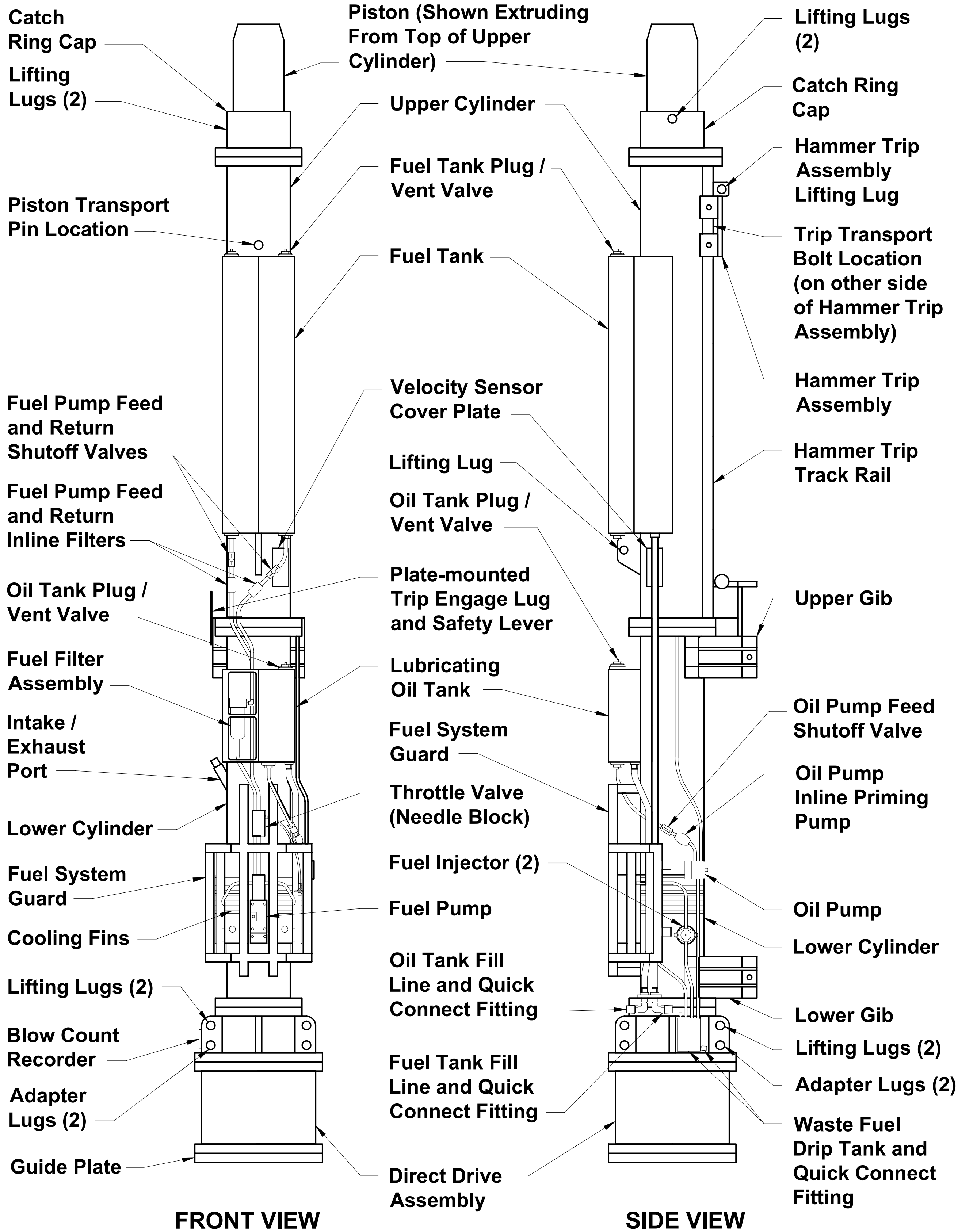
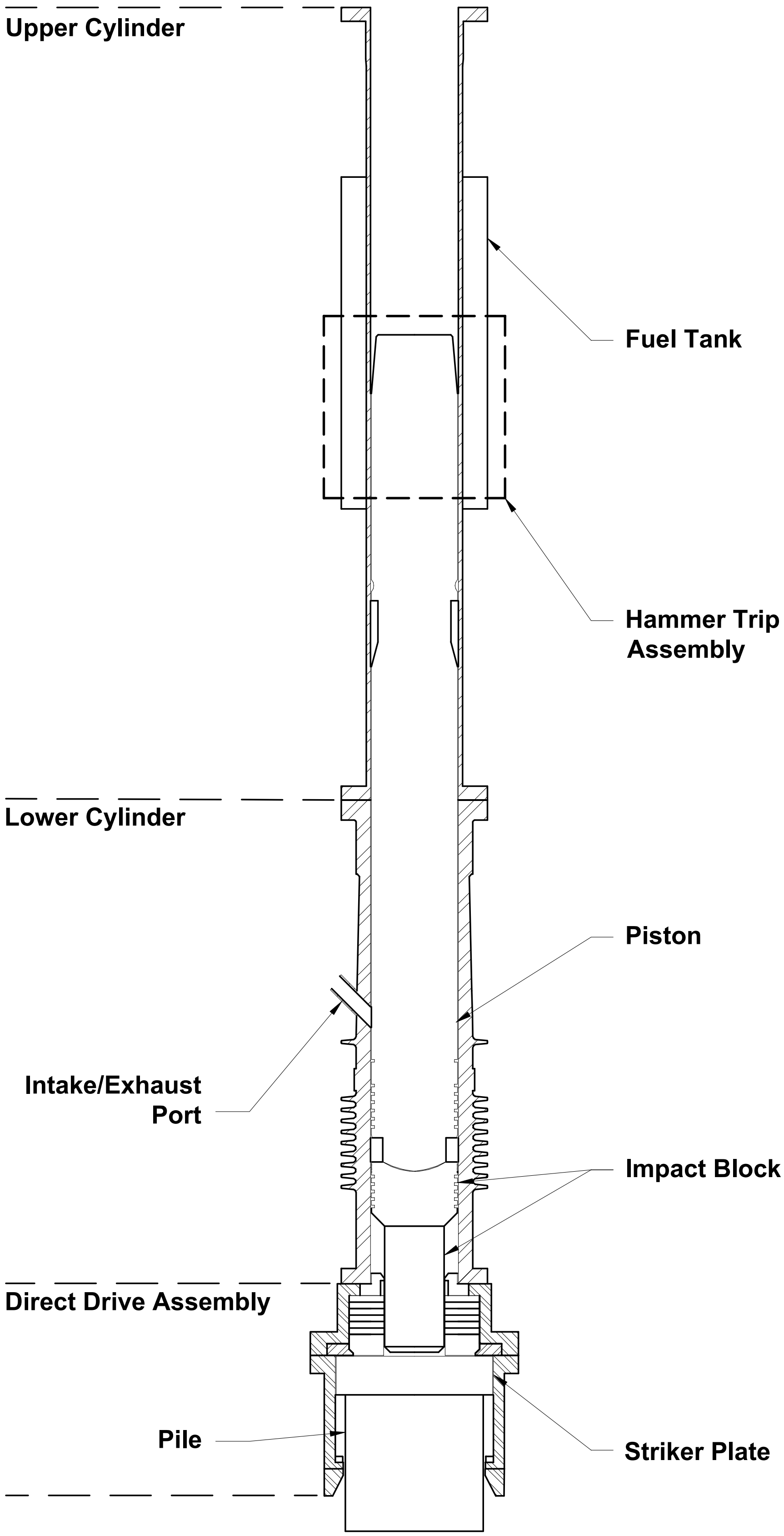


Figure K-2. Impact Hammer – Exterior View



WOOD PILE SHOWN

Figure K-3. Impact Hammer – Interior View

The piston is a free piston that provides the impact energy delivered to the pile. The impact block is located at the bottom of the lower cylinder and relays the energy from the piston to the pile via the direct drive assembly. Piston compression rings and impact block compression rings are installed to assist in compression and to prevent exhaust gases from entering the upper cylinder and escaping from the bottom of the lower cylinder.

The upper and lower cylinders are porous-chrome-lined and bolted together to form one cylinder that enclose the piston and impact block. An o-ring, installed between the upper and lower cylinders, provides an air-tight seal.

The upper cylinder contains the catch ring cap, fuel tank, and hammer trip system. Lifting lugs are located on the front of the upper cylinder. A red-colored piston transportation pin, normally housed in the tool box, can be installed in the top part of the upper cylinder to secure the piston for shipping/transportation purposes. A red-colored weather cap with securing strap, normally housed in the tool box, can be installed on the catch ring cap of the upper cylinder to keep out moisture and foreign objects.

The lower cylinder contains the four upper and lower gibs, intake/exhaust port, cooling fins, fuel injection system, fuel system guard, oil lubrication system, and lubricating oil tank. The lower cylinder also contains the internal combustion chamber that is created by the ring-shaped area on the nose of the piston and the cylinder walls. A cushion housing guide ring and cushion housing guide ring support are located in the bottom of the lower cylinder. A red-colored weather cap, normally housed in the tool box, can be installed on the intake/exhaust port to keep out moisture and foreign objects.

The hammer trip system consists of the hammer trip assembly, hammer trip track rails, trip disengage lug, trip safety lever and trip engage lug, trip safety lever cord, and trip transport bolt. The hammer trip assembly, sliding along the hammer trip track rails and hoisted up and down by the hammer line (main hoist) of the crane, contains a trip mechanism that is used to start the impact hammer by raising and automatically releasing the piston at a predetermined height. The trip mechanism of the hammer trip assembly consists of a lifting pawl, lever and shaft, connecting links, stop pin, and cam mounted in a housing and backplate. The trip engage lug, located on the trip safety lever in the lower portion of the upper cylinder, engages the trip mechanism in the hammer trip assembly when it is lowered to allow lifting of the piston. The trip disengage lug, located at the top of a slot in the upper cylinder and part of the upper cylinder, activates the trip mechanism and causes the piston to be released when the hammer trip assembly is raised to the predetermined height. The red-colored trip transport bolt, normally housed in the tool box, can be installed in the hammer trip assembly to secure the hammer trip assembly to the hammer trip track rails for shipping/transportation purposes.

The trip safety lever is used by ground personnel to engage the trip engage lug to allow the hammer line (main hoist) to raise the hammer trip assembly (and piston) in order to start the impact hammer. The trip safety lever cord, attached to the trip safety lever, is used to control the position of the trip safety lever. When in the normal position (trip safety lever cord not pulled), the trip safety lever locks out the hammer trip assembly allowing the hammer line (main hoist) to raise and lower the entire impact hammer.

The direct drive system transfers the driving energy developed by the piston and impact block in the lower cylinder to the pile being driven. This is provided by the direct drive assembly connected to the bottom of the lower cylinder that houses a recoil dampening system and striker plate (driving head). The direct drive assembly consists of the upper and lower drive housings and is capable of driving up to 18-inch (45.7 cm) piles. Lifting lugs and adapter holes (used to secure the square (concrete) and sheet pile adapters) are provided at the top of the direct drive assembly. A blow count recorder and waste fuel drip tank are also installed at the top of the direct drive assembly.

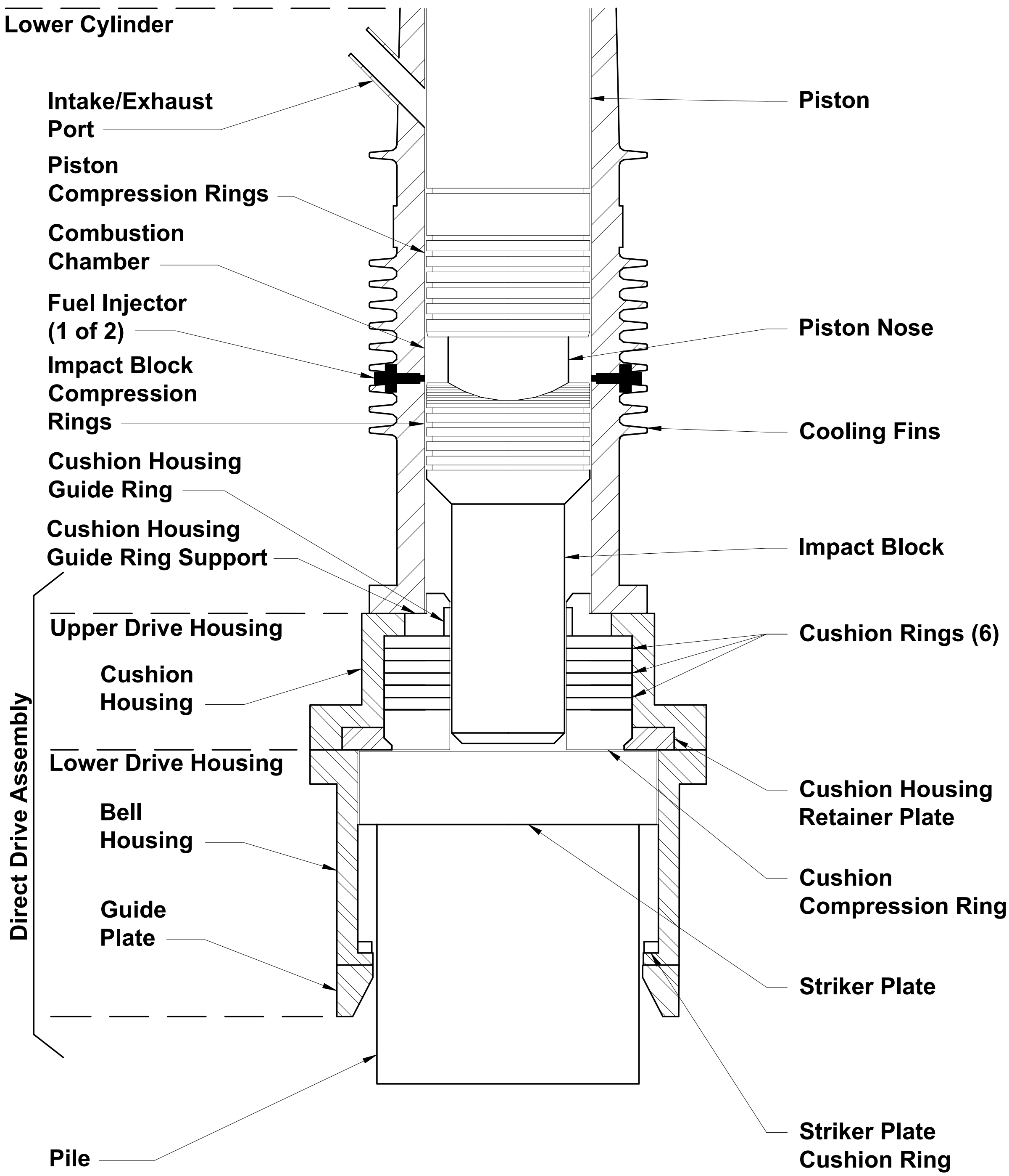


Figure K-4. Impact Hammer – Lower Cylinder and Direct Drive Assembly

The upper drive housing, bolted to the bottom of the lower cylinder, contains the recoil dampening system. The recoil dampening system consists of six cushion rings and the cushion compression ring secured in the cushion housing by the cushion housing retainer plate. A cushion shim ring can be installed in between the lower cushion ring and the cushion compression ring in order to give a 1/8-inch (3.175 mm) cushion ring stack preload.

The lower drive housing, bolted to the bottom of the upper drive housing, is used to hold the piles in place under the impact hammer during operation. It consists of a bell housing that contains the striker plate and an 18-inch (45.7 cm) guide plate is bolted onto the bottom of the bell housing. A striker plate cushion ring protects the bottom of the bell housing from damage caused by the striker plate.

The fuel injection system consists of a fuel tank, fuel tank fill line and quick connect fitting, two fuel tank suction strainers, fuel pump, two fuel injectors, throttle valve (needle block), fuel filter assembly, fuel pump feed inline filter, fuel return inline filter, fuel pump feed shutoff valve, fuel return shutoff valve, and associated lines and fittings.

The fuel tank, located on the side of the upper cylinder, provides fuel via gravity feed to the fuel pump located on the front of the lower cylinder. The in-tank suction strainers, located inside the fuel tank, filter the fuel prior to being delivered to and returned from the system. Two fuel tank plug/vent valves, located on top of the fuel tank, are used to vent the system during impact hammer operation.

The fuel tank is filled from the ground by connecting the quick connect fitting on the ground fueling hand pump to the fuel tank fill line and quick connect fitting located at the bottom of the lower cylinder and using the hand pump to pump fuel from an external JP-8 or No. 2 diesel fuel source to the fuel tank on the impact hammer. If the external fuel source has its own pump, it can be connected directly to the fuel tank fill line and quick connect fitting located at the bottom of the lower cylinder and the ground fueling hand pump need not be used. The fuel tank fill line and quick connect fitting on the impact hammer is identified by a red-colored “FUEL” label. In the absence of the ground fueling hand pump, the fuel tank can be filled manually by removing the fuel tank plug/vent valves.

The fuel pump, located on the front of the lower cylinder behind the fuel system guard, is an air-activated, single plunger-type pump that pressurizes and pumps the fuel to the fuel injectors. Inlet and outlet check valves on the fuel pump prevent fuel from flowing in a reverse direction.

The fuel injectors, located on each side of the lower cylinder, inject atomized fuel into the combustion chamber to initiate combustion.

The throttle valve (needle block), located on the front of the lower cylinder behind the fuel system guard, controls the stroke rate (blows per minute) by regulating the amount of fuel returned to the fuel tank. The throttle valve (needle block) is hydraulically-controlled by the remote throttle.

The fuel pump feed inline filter and fuel return inline filters, located behind the fuel system guard, filter the fuel delivered to the fuel pump and returned to the fuel tank respectively. The fuel pump feed shutoff and fuel return shutoff valves, also located behind the fuel system guard, are used to turn off the fuel supply in their respective lines.

The fuel filter assembly, mounted on the side of the lubricating oil tank on the lower cylinder, is a housing that contains a fuel filter element. The fuel filter assembly is downstream from the fuel pump feed inline filter and further filters the fuel being delivered to the fuel pump.

A waste fuel drip tank receives waste fuel and oil from the fuel injectors and oil pump. A quick connect fitting allows periodic draining of the waste fuel drip tank. The waste fuel drip tank vent valve, located on top of the tank, is used to vent the system during impact hammer operation.

The lubrication system provides lubricating oil to the lower cylinder and piston during operation. The system consists of the lubricating oil tank, oil tank fill line and quick connect fitting, oil pump, oil pump feed shutoff valve, oil pump inline priming pump, and associated lines and fittings.

The lubricating oil tank, located on the front of the upper cylinder, provides lubricating oil via gravity feed to the oil pump located on the rear of the lower cylinder. The in-tank suction strainer, located inside the lubricating oil tank, filters the oil prior to being delivered to the system. An oil tank plug/vent valve, located on top of the lubricating oil tank, is used to vent the system during impact hammer operation.

The lubricating oil tank is filled from the ground by connecting the hose and quick connect fitting to the ground oiling hand pump, placing the oiling hand pump container cover on an oil container filled with MIL-L-2104 15W40 oil, and installing the ground oiling hand pump in the container cover. Then connect the quick connect fitting on the ground oiling hand pump to the oil tank fill line and quick connect fitting located at the bottom of the lower cylinder and manually pump oil to the lubricating oil tank on the impact hammer. The oil tank fill line and quick connect fitting are identified by a yellow-colored “OIL” label. In the absence of the ground oiling hand pump, the lubricating oil tank can also be filled manually by removing the oil tank plug/vent valve. For temperatures below -20.0º F (-29º C), arctic-grade MIL-L-46167 0W40 oil should be used.

The oil pump is an air-activated, single plunger-type pump that pumps the lubricating oil to the lower cylinder via an oil line and fitting. Inlet and outlet check valves on the oil pump prevent oil from flowing in a reverse direction.

The oil pump feed shutoff valve is used to turn off the oil feed to the oil pump from the lubricating oil tank. The oil pump inline priming pump is used to prime the system for initial startup.

The impact hammer is equipped with a battery-powered blow count recorder located at the top of the direct drive assembly. The blow count recorder is an indicator that provides the operator with a running count of blows delivered. The blow count recorder and battery pack are protected by a foam cushion insert and housed in a weather-proof housing with a viewing window. The internal battery pack is designed to last for two years.

The impact hammer is equipped with a fitting for an optional velocity sensor located on the lower part of the upper cylinder, directly below the fuel tank. A velocity sensor cover plate is installed over the fitting.

The impact hammer has several major data and safety plates and decals. The Identification Plate, located on the top side of the direct drive assembly, specifies the name of the manufacturer, model number, National Stock Number, USA Registration Number, manufacture date, contract number, weight, and serial number. The Identification Bar Code Plate, located on the side of the fuel tank and readable by a hand-held scanner, provides comprehensive information about the impact hammer. “HOT AREA” warning and “LIFT POINT” location plates are located at the cooling fins and upper/lower cylinder lifting lugs respectively. Safety and hard hat warning decals are located on the side of the direct drive assembly. “PINCH POINT” warning decals are located at the upper and lower gibs.

Remote Throttle (Refer To Figure K-5.)

The remote throttle provides remote speed control and shutdown of the impact hammer diesel engine. The remote throttle can be installed in the superstructure cab if desired.

The remote throttle is a hydraulically-operated, bypass device that controls the stroke rate of the impact hammer by controlling the amount of fuel delivered to the fuel injectors by the fuel pump. It consists of a hydraulic reservoir and pump, a movable handle, pressure relief valve, pressure gauge, 70-foot (18 m) hydraulic hose, and associated fittings. The remote throttle is filled via a fill plug and utilizes automatic transmission fluid Dexron II/III or equivalent. A pressure relief valve is used to reduce remote throttle pressure in order to adjust the stroke rate or to remove remote throttle pressure (0 psi) in order to shut-down impact hammer operation.

The hydraulic hose is connected to the remote throttle via a quick connect fitting and is routed to the lower cylinder section of the impact hammer. The hydraulic hose is connected to the throttle valve whip line of the throttle valve (needle block) that is identified by a “THROTTLE CONNECTION” label. The pulley with 15-inch (38 cm) anchor bungee, normally stored in the toolboxes, can be attached to the hydraulic hose reel on the crane boom to ensure the hydraulic hose is kept out of the way during pile driving operations by holding a rope tied to the hydraulic hose.

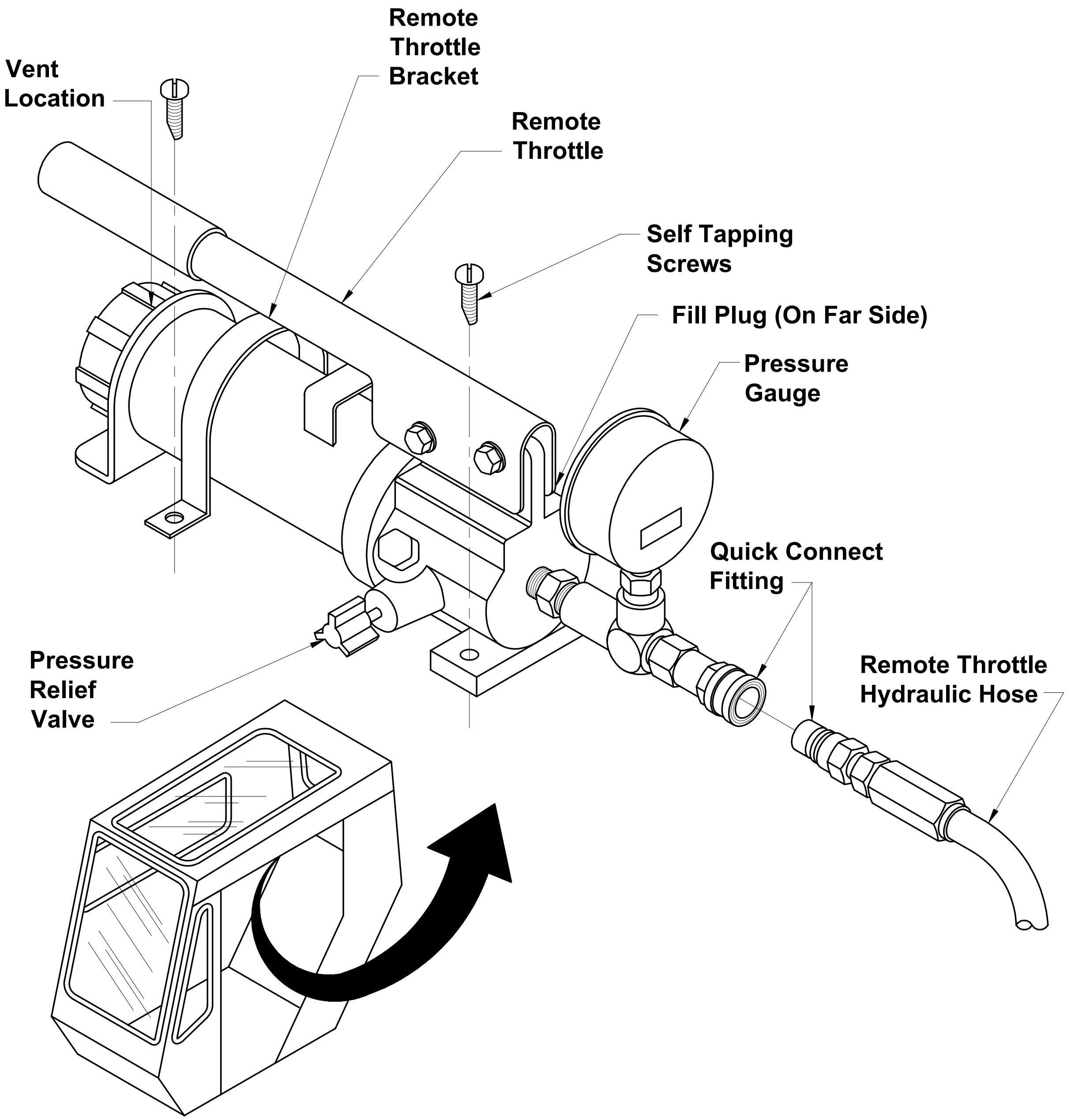


Figure K-5. Remote Throttle

Accessory Tools and Components

The accessory tools and components are initially provided with the Pile Driver System and located in two tool boxes that are housed in the shipping/storage container. Identification and weight data is stenciled on the sides of the tool boxes. The accessory tools and components include rigging and safety equipment, shipping/storage equipment, accessories and adapters, ground servicing tools, special tools, consumable materials such as lubricants, seal kits and spare filters, and miscellaneous spare parts.

The rigging and safety equipment include the following:

- One trip safety lever cord (3/8” x 100 ft (10 mm x 30.5 m))
- One piston lifting eyebolt
- Two 96-inch (2.44 m) wire rope lifting slings
- Two 89-inch (2.26 m) wire rope lifting slings
- Two 72-inch (1.8 m) wire rope lifting slings
- Two nylon lifting slings
- One H-type pile lifting sling (30-inch (76 cm))
- Two H-type pile chain lifting slings with hooks
- Two one-inch (2.5 cm) shackles
- Two 7/8-inch (2.2 cm) shackles
- Eight 3/4-inch (1.9 cm) shackles
- Two ground-release shackles
- One temporary hydraulic hose retainer chain (5/16 x 90-inch (0.8 x 229 cm))
- Four 4x4-inch (10 x 10 cm) wood blocks
- 1/2 x 48-inch (1.3 cm x 1.22 m) long wire cable
- 5/8 x 96-inch (1.6 cm x 2.44 m) long wire cable and 5/8-inch (1.6 cm) clamps for rigging the square (concrete) and sheet pile adapters

The shipping/storage equipment is red in color and used to protect and secure the impact hammer for storage and/or transportation. The equipment includes the catch ring weather cap and securing strap, intake/exhaust port weather cap, piston transportation pin and clip, and trip transport bolt.

The accessories and adapters are used to drive different size piles (wood other than 18-inch (45.7 cm and steel H-beam), pre-cast concrete, or sheet piles. The adapters include the following:

- 10-inch (25.4cm), 12-inch (30.5 cm), and 16-inch (40.6 cm) guide plates
- 18-inch (45.7 cm) square (concrete) pile adapter
- Sheet pile adapter
- Plywood template for the 18-inch (45.7 cm) square (concrete) pile adapter

The guide plates are bolted onto the lower drive housing of the direct drive assembly and replace the standard 18-inch (45.7 cm) guide plate. The size of the guide plate indicates the inside diameter. The square (concrete) pile adapter and sheet pile adapter are installed in the direct drive assembly and secured via cables and clamps to the adapter holes located at the bottom of the lower cylinder. The adapter holes are the lower holes directly below the impact hammer lifting lugs. Weight data is stenciled on the sides of the pile adapters. The plywood template for the 18-inch (45.7 cm) square (concrete) pile adapter can be used by operating personnel to fabricate a cushion to prevent damage to the square concrete piles during operation.

The ground servicing tools are used to add fuel and oil to the fuel and lubrication systems and to drain the waste fuel drip tank on the impact hammer. The ground fueling tools include a ground fueling hand pump and ground fueling hose and quick connect fitting. The ground oiling tools include a ground oiling hand pump and ground oiling hose and quick connect fitting. A waste fuel drip tank drain hose and quick connect fitting is also provided.

The special tools include the following:

- Various hex keys
- Grease gun with flex hose and fitting
- Oil gun
- Check valve extractor tool
- Ring compressor
- Piston ring pliers
- Wood pile tongs
- Crowbar
- Steel bar with hickey (5-foot (1.5 m))
- Cheater bar (36 x 2-inch (91 x 5 cm))
- Ten-pound (4.5 kg) sledge hammer
- Two-pound (0.9 kg) hammer
- Axe
- Vice grip
- 12-inch (30.5 cm) and 18-inch (46 cm) adjustable wrenches
- 1-5/16-inch combination wrench
- 1-1/8-inch combination wrench
- 1-5/16-inch box end wrench
- 1-1/8-inch box end wrench
- Two-inch (5 cm) wood level
- 100-foot (30.5 m) fiberglass measuring tape
- Pulley with 15-inch (38 cm) anchor bungee
- 36-inch (91 cm) peavey

The consumable materials include ten 14-oz. (400g) tubes of MIL-G-10924 grease, 1-quart (1 l) of MIL-L-2105 oil, 1/3-oz. (10 ml) of Loctite® 272, and Teflon® tape.

The seal kits include a fuel pump seal kit, throttle valve (needle block) seal kit, and oil pump seal kit. The spare filters include spare inline fuel filters, fuel filter element for the fuel filter assembly, and fuel/oil tank suction strainer assemblies.

Various spare parts are also included in the tool boxes. Refer to Component End Item Section at the end of Appendix H in the Operator's Manual TM 5-3810-307-10 for a complete listing of the spare parts.

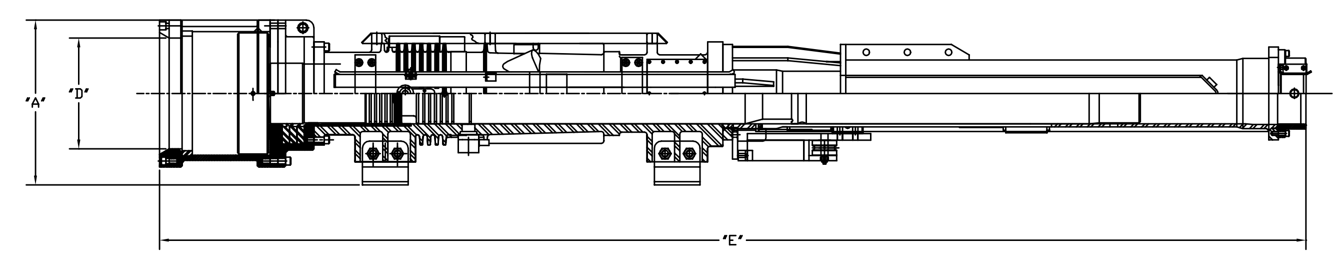
Table K-1. General Specifications – Loaded Shipping/Storage Container

Manufacturer	Berminghammer Foundation Equipment
Shipping/Storage Container	
Dimensions	247 in. (L) X 65 in. (W) X 68 in. (H)
	627.4 cm (L) X 165 cm (W) X 172.7 cm (H)
Weight (Fully Loaded Shipping/Storage Container)	19,500 lbs (8,864 kg)

Table K-2. General Specifications – Impact Hammer and Lead Tower

Model Number (Impact Hammer)	B-9M
Serial Number (Impact Hammer)	04-01-B9M
Performance	
Ram Weight x Maximum Stroke	20,000 ft•lb (27.1 kN•m)
Impact Energy	13,000 ft•lb (17.6 kN•m)
Maximum Ram Stroke	10.0 ft (3.05 m)
Ram Weight	2,000 lbs (900 kg)
Impact Block Weight/Mass	286 lb (130 kg)
Blows Per Minute (BPM)	38-54 BPM
Operating Weight	
Bare Impact Hammer Weight/Mass	4,480 lbs (2,032 kg)
Total Operating Weight/Mass of Impact Hammer	5,800 lbs (2,630 kg)
Weight of Tool Box – Spare Parts	115 lbs (52 kg)
Weight of Tool Box – Accessories	315 lbs (143 kg)
Weight of 18-inch Square (Concrete) Pile Adapter	1,240 lbs (564 kg)
Weight of Sheet Pile Adapter	890 lbs (405 kg)
Weight of Spotter Storage Support	340 lbs (154 kg)
Weight of Lead Section	740 lbs (336 kg)
Weight of Foot Roller	400 lbs (182 kg)
Weight of Spotter	815 lbs (370 kg)
Capacity	
Fuel Tank Capacity	15.0 US gallons (57.0 liters)
Fuel Consumption	0.6 gal./hr. (2.3 l/hr.)
Oil Tank Capacity	1.5 US gallons (6.0 liters)
Oil Consumption	0.16 gal./hr. (0.6 l/hr.)

Table K-3. Dimensional Specifications – Impact Hammer



Dimensions			
A	C - Minimum Box Lead	D	E
24.0 in (61 cm)	21.0 in (52.5 cm)	15.0 in (38.0 cm)	~ 220 in (5.34 m)

Table K-4. Lubricants Required

Fuel System	
Fuel Tank	No. 2 Diesel, JP-8
Lubrication System	
Lubricating Oil Tank	MIL-L-2104 (15W40)
Lubricating Oil Tank (Temperatures below -20.0º F (-29º C))	MIL-L-46167 (0W40)
Grease	
Lower Cylinder (Impact Block) Lubrication Fittings (four (4) locations)	MIL-G-10924
Impact Hammer Gibs (four (4) locations)	MIL-G-10924
Hammer Trip Assembly Gibs (four (4) locations)	MIL-G-10924
Spotter Slide (two (2) locations)	MIL-G-10924
Piston and Impact Block Compression Rings	MIL-L-2104
Oiling	
Fuel Pump Lubrication Fitting	MIL-L-2105
Oil Pump Lubrication Fitting	MIL-L-2105
Fuel Tank Preservative/Fog Oil Spray	Kleen-Flo Tumbler Industries (Stock #789)
Hydraulic Oil	
Remote Throttle	Automatic Transmission Fluid Dexron II/III or equivalent

THEORY OF OPERATION

Impact Hammer - General Operation (Refer To Figure K-6.)

There are five stages of operation for the impact hammer. To start the impact hammer, the hammer line (main hoist) of the crane is used to lift the hammer trip assembly, which raises the piston to a predetermined height. The hammer trip assembly then releases the piston, allowing it to free-fall in the cylinder. After initial start-up, the following sequence occurs:

1. Purge. The piston falls under the force of gravity and accelerates downward. As the piston falls, the air and/or gases in the cylinder are expelled through the intake/exhaust ports.

2. Compression. When the piston reaches the intake/exhaust port, the port is closed, compressing the air in the lower cylinder.

3. Combustion. As the piston nears the end of its downstroke a combustion chamber is created by the ring-shaped nose of the piston and the lower cylinder. The fuel pump, connected to the combustion chamber, amplifies the gas pressure compressed beneath the piston and delivers high pressure fuel to the fuel injectors. Just before the piston strikes the impact block, the fuel pressure overcomes the opening pressure of the fuel injectors, injecting atomized fuel into the combustion chamber. The fuel ignites (due to high compression temperatures) and the piston strikes the impact block, transferring its kinetic energy to the direct drive assembly. The combustion force drives the piston upward and the impact block further downward.

4. Exhaust. As the piston rises in the cylinder and passes the intake/exhaust port, the port is opened, allowing the exhaust gases to escape.

5. Intake. As the piston continues rising, fresh air is drawn into the lower cylinder via the intake/exhaust port. Under the force of gravity, the piston decelerates on the upward stroke until completely stopping at the top of the stroke. The piston then begins to fall, starting the five-stage cycle again. The fuel pump recharges and the cycle is repeated until the fuel supply is interrupted.

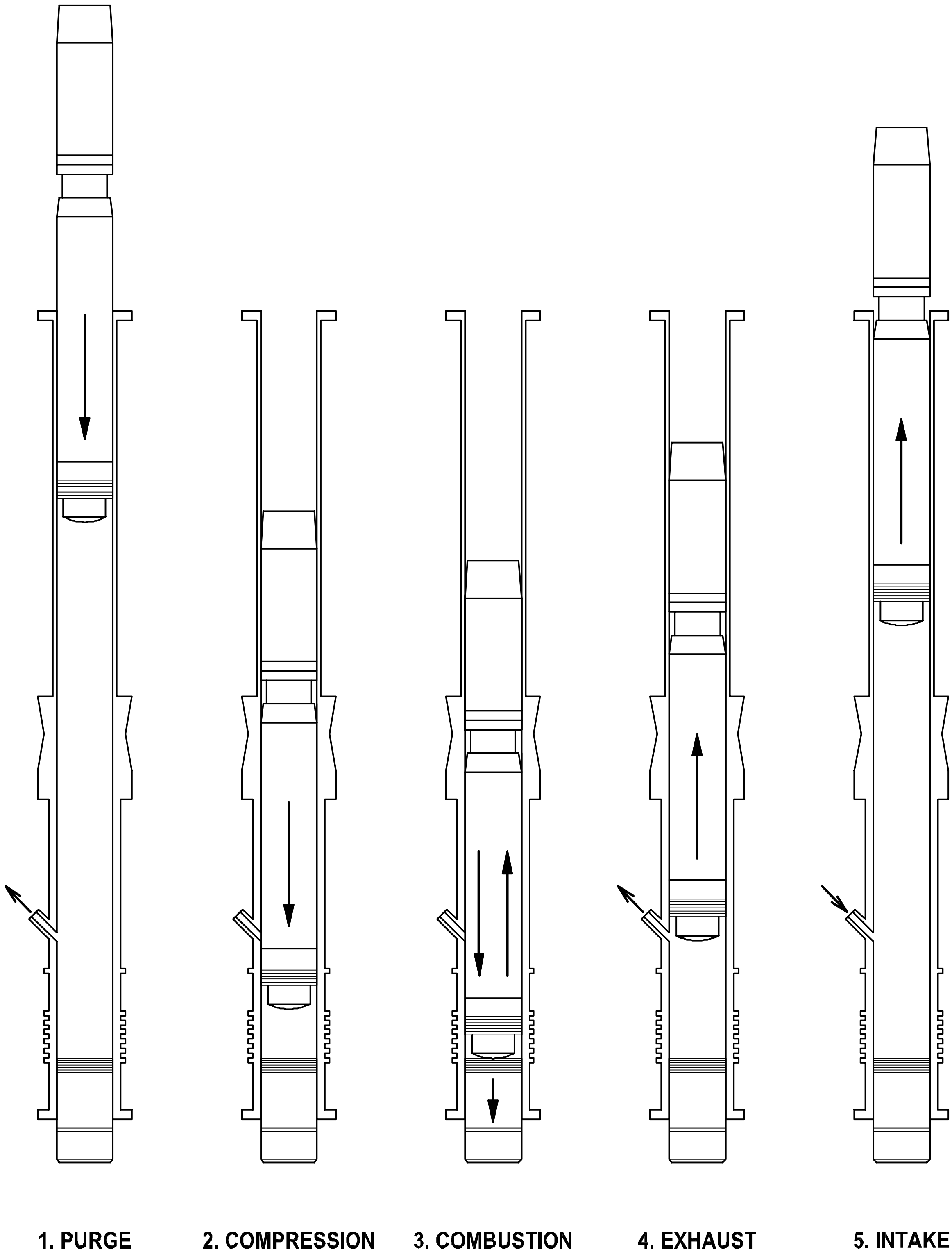


Figure K-6. Impact Hammer Stages of Operation

Impact Hammer - Hammer Trip System Operation (Refer To Figure K-7.)

There are four stages of operation for the hammer trip system. The hammer trip assembly, moving along the hammer trip track rails and controlled by the hammer line (main hoist) of the crane, is used to start the impact hammer by raising and automatically releasing the piston at a predetermined height The predetermined height is determined by the position of the trip disengage lug on the impact hammer. To start the impact hammer with the hammer trip assembly, the weight of the impact hammer must be fully on a pile, allowing the following sequence to occur:

1. With the trip safety lever cord (attached to the trip safety lever) pulled and held in place by ground personnel, the trip engage lug is engaged. The hammer trip assembly is then lowered by the crane operator, via the hammer line (main hoist) of the crane, along the hammer trip track rails. The lifting pawl is in the vertical disengaged position.

2. As the hammer trip assembly is lowered, the cam attached to the lever and shaft encounters the trip engage lug mounted at the bottom of the upper cylinder. The trip engage lug pushes the cam (and lever and shaft) upward, rotating the lifting pawl towards the horizontal, engaged position via the connecting links.

3. The hammer trip assembly is raised by the hammer line (main hoist). The lifting pawl is in the horizontal engaged position. The connecting links have passed “over-center” and rest against the stop pin. The leaf spring assists in rotating the connecting links over-center and retaining them in position. As the lifting pawl engages the lifting collar on the piston, the piston is lifted and the connecting links bear against the stop pin.

4. The crane operator continues raising the hammer trip assembly, via the hammer line (main hoist), until the lever and shaft encounters the trip disengage lug. The connecting links will rotate away from the over-center position and the stop pin, causing the lifting pawl to rotate to the vertical disengaged position. The piston falls freely.

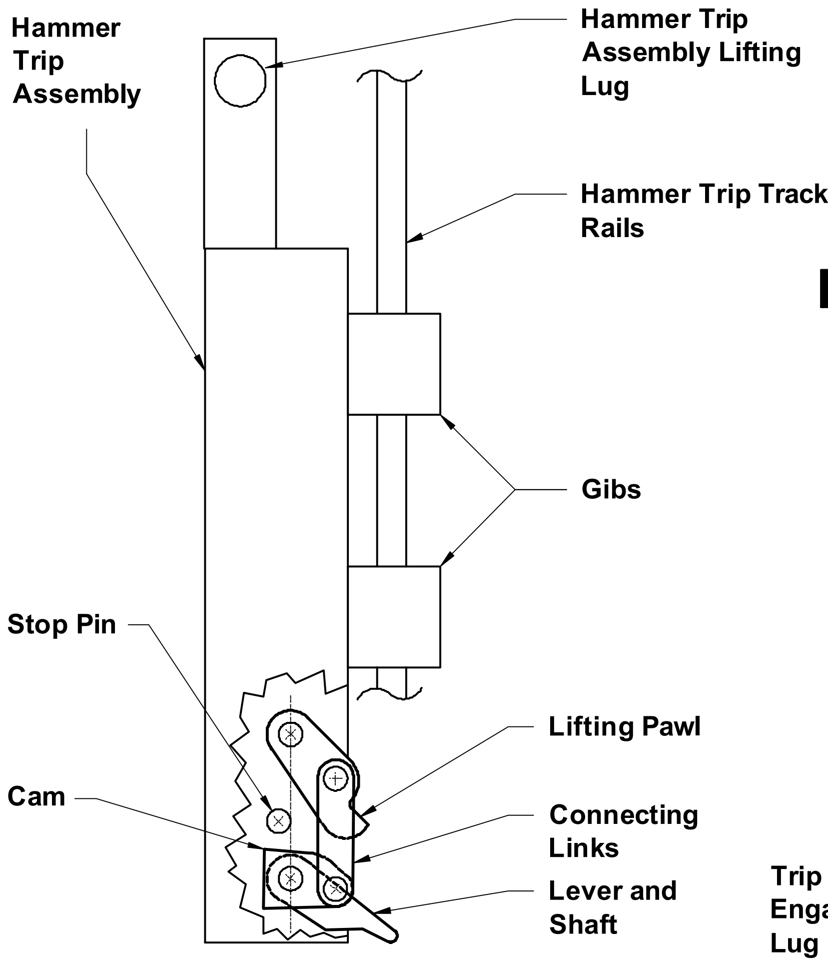
NOTE

The crane operator must cease hoisting the hammer trip assembly as soon as the piston falls.

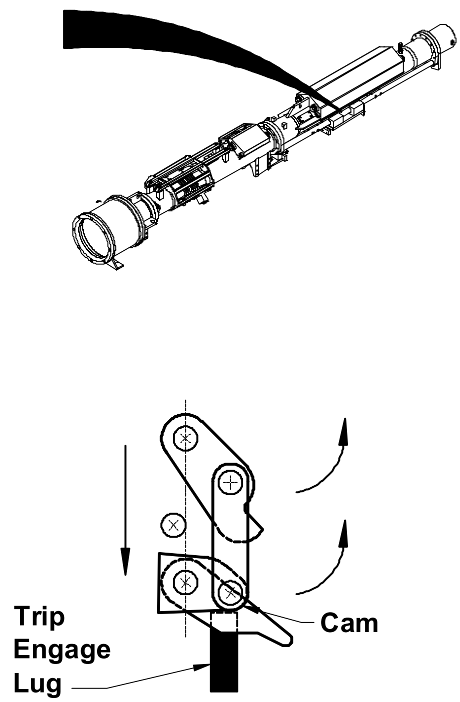
The normal position of the trip safety lever is used to lock out the hammer trip assembly in order to use the hammer line (main hoist) to raise and lower the entire impact hammer. The trip safety lever is held in its normal position by a spring (when the trip safety lever cord is not pulled) and maintains the trip engage lug in the disengaged position. The trip disengage lug is out of alignment with the hammer trip assembly and will not engage with the cam attached to the lever and shaft.

The trip safety lever is used to engage the trip engage lug to allow the hammer line (main hoist) to raise the hammer trip assembly (and piston) in order to start the impact hammer. This is accomplished by pulling and holding the trip safety lever cord attached to the trip safety lever. This will rotate the trip engage lug into position in order to engage with the cam attached to the lever and shaft of the hammer trip assembly when lowered.

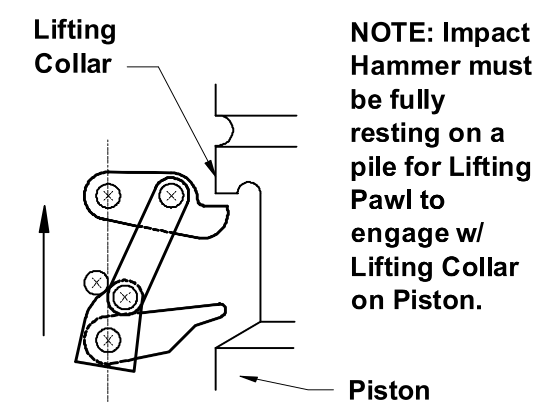
Rotating the lever and shaft with a wrench can manually disengage the hammer trip assembly.



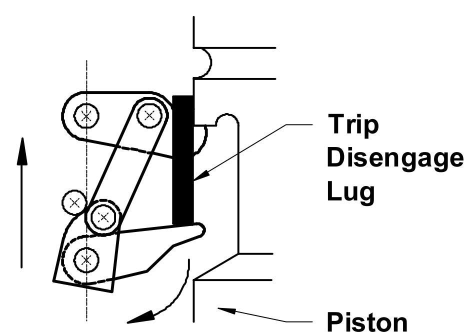
1. Lifting Pawl in Vertical Disengaged Position



2. Cam Encounters Trip Engage Lug



3. Lifting Pawl in Horizontal Engaged Position



4. Lever and Shaft Encounters Trip Disengage Lug

Figure K-7. Hammer Trip Assembly Operation

Impact Hammer - Fuel Injection System Operation (Refer To Figure K-8.)

The fuel injection system consistently delivers a precise amount of highly atomized fuel to the combustion chamber of the lower cylinder. The fuel injection system is both driven and timed by the pre-combustion pressure in the lower cylinder.

As the intake/exhaust port on the lower cylinder closes during the downward stroke, air in the lower cylinder combustion chamber begins to compress. As the air pressure increases, the increased force on the air piston in the fuel pump pushes the fuel plunger up into the fuel pump head. The fuel plunger, whose diameter is smaller than the air piston, produces a greater pressure in the fuel above the fuel plunger. As the fuel pressure increases, the inlet check valve closes and the outlet check valve opens, transferring high pressure fuel through the fuel injector lines to the two fuel injectors.

The fuel injectors contain an injector nozzle, needle, adjustable spring, and a small ring-shaped piston around the injector needle. Fuel is injected into the combustion chamber via two holes in the injector nozzle. The needle, held against its seat by the adjustable spring, blocks the flow of fuel when fuel is not required. As fuel enters the chamber behind the needle tip, it acts upon the needle in the opposite direction of the spring. When the fuel pressure is high enough, the pressure overcomes the spring and the needle is lifted off its seat, allowing fuel to pass through the nozzle.

NOTE

The fuel is injected into the ring-shaped area around the piston nose that forms the combustion chamber with the lower cylinder. It is not injected beneath the piston nose.

Fuel injection occurs one millisecond before the piston strikes the impact block. The instant one of the fuel injectors opens, the combustion process begins. The combustion of diesel fuel and air produces a rapid increase in the cylinder pressure, which is transmitted to the fuel pump where the fuel pressure will increase to approximately twice the opening pressure of the fuel injectors. The rapid increase in fuel pressure ensures that both fuel injectors deactivate within the same initial millisecond.

Fuel injection lasts for some five milliseconds and produces peak combustion pressure for ten milliseconds. Fuel injection continues until the air piston in the fuel pump reaches the end of its stroke. During the upward impact hammer piston stroke, the lower cylinder intake/exhaust ports open, relieving the cylinder pressure acting upon the fuel pump. The fuel plunger spring returns the fuel plunger and air piston to their original positions. As the fuel plunger retracts, the outlet check valve closes and the inlet check valve opens, refilling the fuel pump for the next cycle.

The remote throttle controls how much fuel pump output is transferred to the fuel injectors by controlling how much fuel is returned to the fuel tank via the return line. This controls the stroke rate (blows per minute) of the impact hammer operation. During fuel injection the throttle valve (needle block) allows a very small amount of fuel to return to the fuel tank. The throttle valve (needle block) is hydraulically-controlled by the remote throttle to vary the amount of fuel returned to the fuel tank. When the remote throttle is placed in the off position (no pressure), the throttle valve (needle block) is completely open and all of the fuel can return to the fuel tank before high pressures develop.

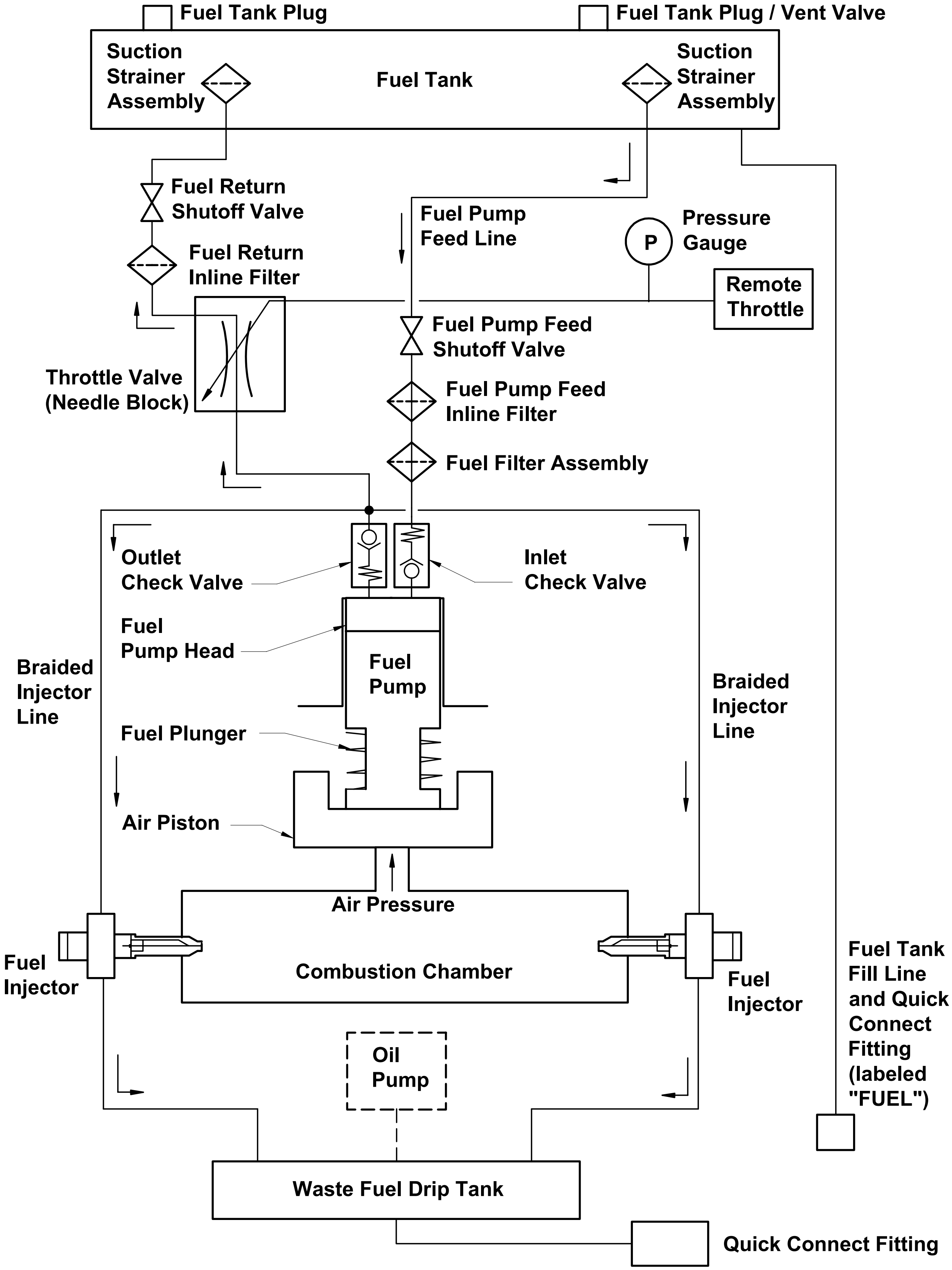


Figure K-8. Fuel Injection System Schematic

Impact Hammer - Lubrication System Operation (Refer To Figure K-9.)

The lubricating system delivers lubricating oil to the lower cylinder and is controlled by the air pressure in the lower cylinder.

Lubricating oil is supplied to the oil pump by gravity flow from the lubricating oil tank. It is then pumped by the oil pump to a fitting on the lower cylinder.

Operation of the oil pump is similar to the fuel pump operation. The plunger in the oil pump is operated by the change in air pressure in the lower cylinder during operation, forcing lubricating oil through the outlet check valve and into the lower cylinder via the lubrication fitting.

An indicator on the oil pump will pop in and out as the piston falls to indicate proper operation of the oil pump.

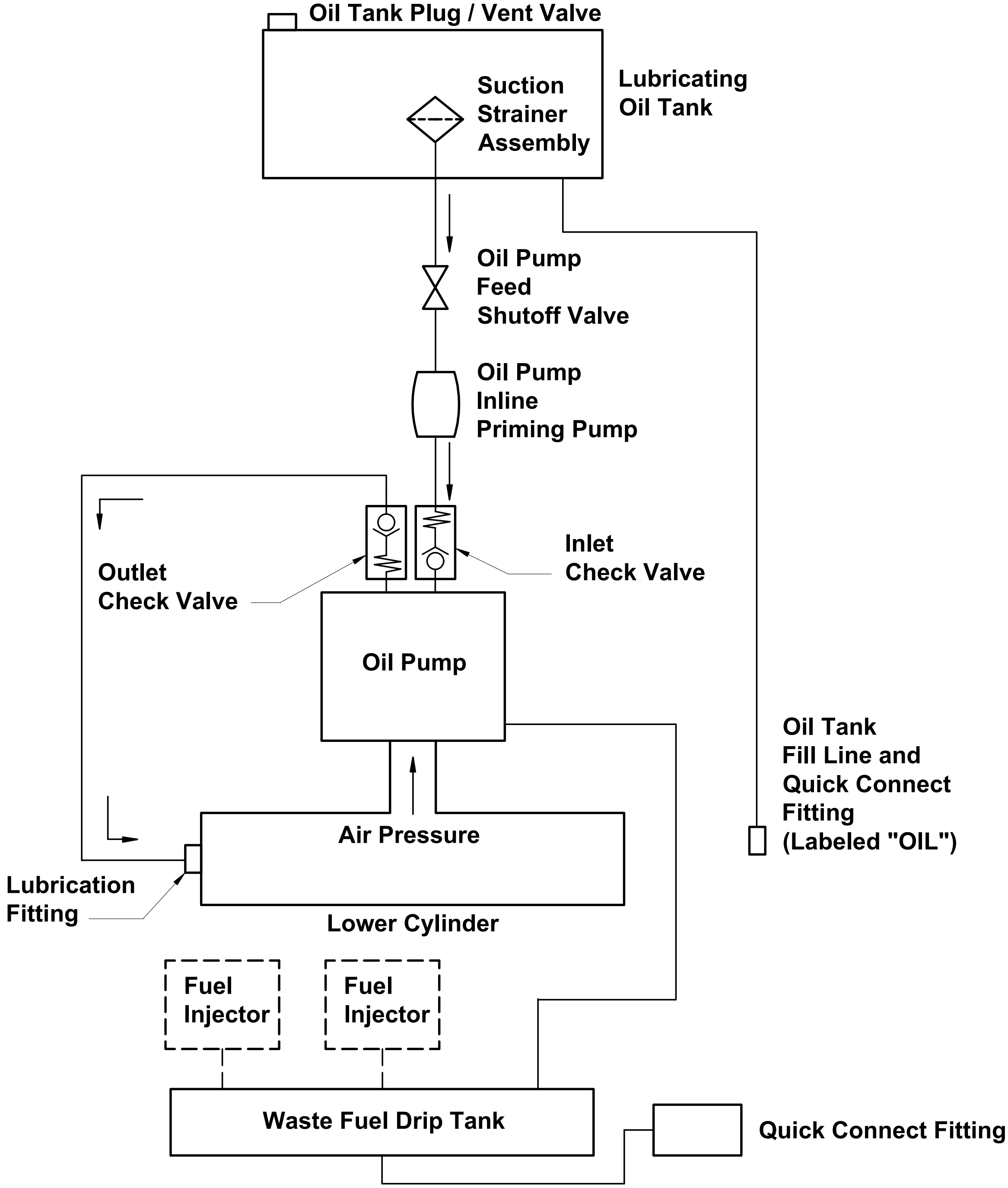


Figure K-9. Lubrication System Schematic

Impact Hammer - Direct Drive System Operation (Refer To Figure K-10.)

The direct drive system transfers the impact energy developed by the piston and impact block in the lower cylinder to the pile being driven. This is provided by the direct drive assembly connected to the bottom of the lower cylinder that houses the recoil dampening system and striker plate (driving head). During operation of the impact hammer the following sequence takes place.

1. At the bottom of the piston downstroke, the nose of the piston strikes the top of the impact block in the lower cylinder.

2. The impact block moves unimpeded and strikes the top of the striker plate in the direct drive assembly, transferring the impact energy from the impact block to the striker plate.

3. The impact energy from the striker plate is then delivered to the pile being driven by the striker plate. The striker plate evenly distributes and transfers the impact energy to the pile head to minimize mushrooming/splitting of the piling.

4. The pile is driven into the soil.

5. The recoil dampening system, consisting of the six cushion rings and cushion compression ring in the direct drive assembly, dissipates the rebound energy to allow up to 95% of the impact energy to be transmitted to the pile and only 5% of the rebound energy back to the impact hammer.

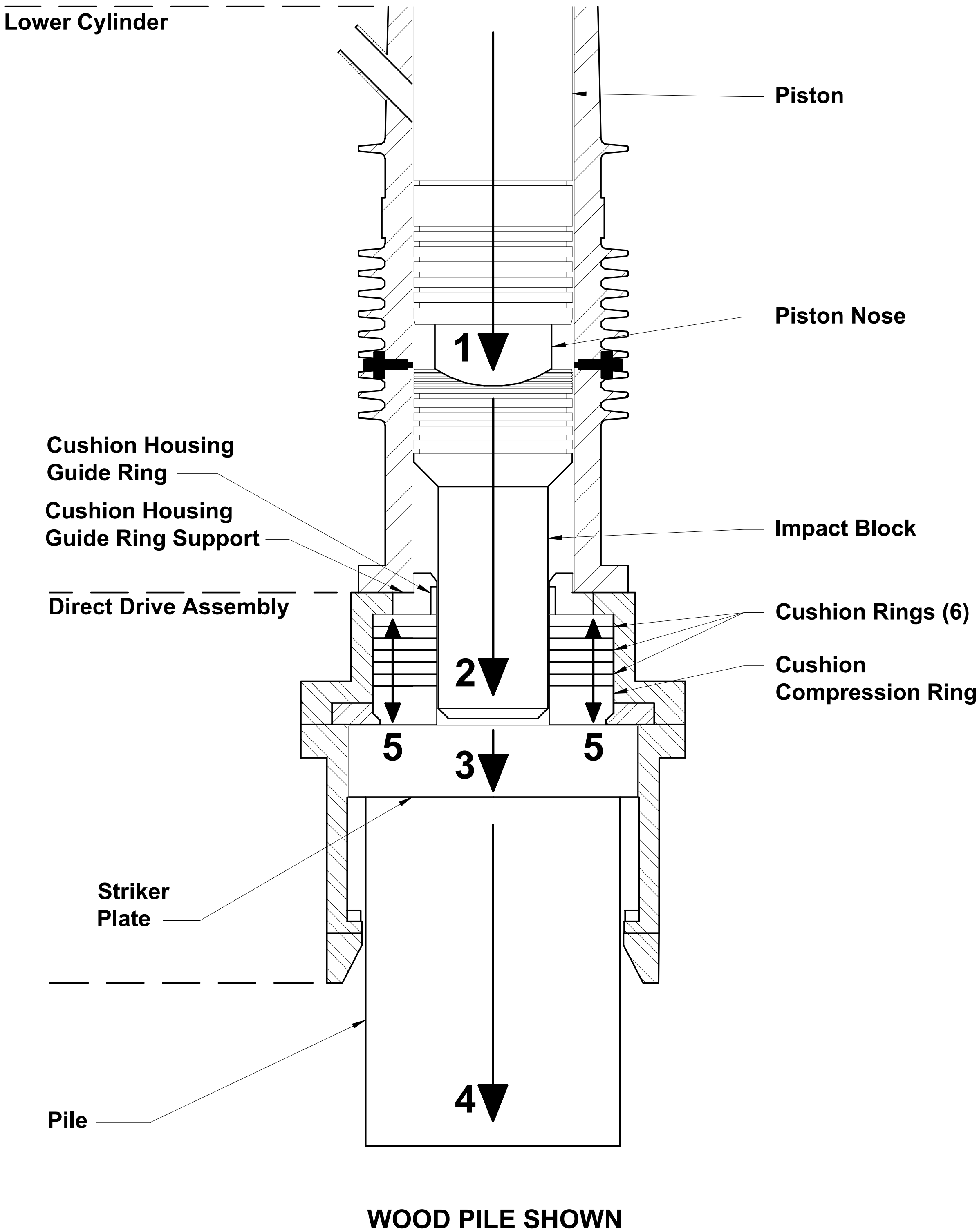


Figure K-10. Direct Drive System Operation

TROUBLESHOOTING

General (Refer To Figure K-11.)

The following troubleshooting flow chart (Figure K-11) is used to isolate problems with the impact hammer. The flow chart indicates the major source of problems likely to be encountered. The troubleshooting procedures for the impact hammer, as well as the spotter, are then listed in Table K-5. The four test procedures in the troubleshooting flow chart (Figure K-11) are provided after Table K-5.

CAUTION

Do not use any starting fluids as a starting aid as they can cause excessive piston stroke and damage to the impact hammer.

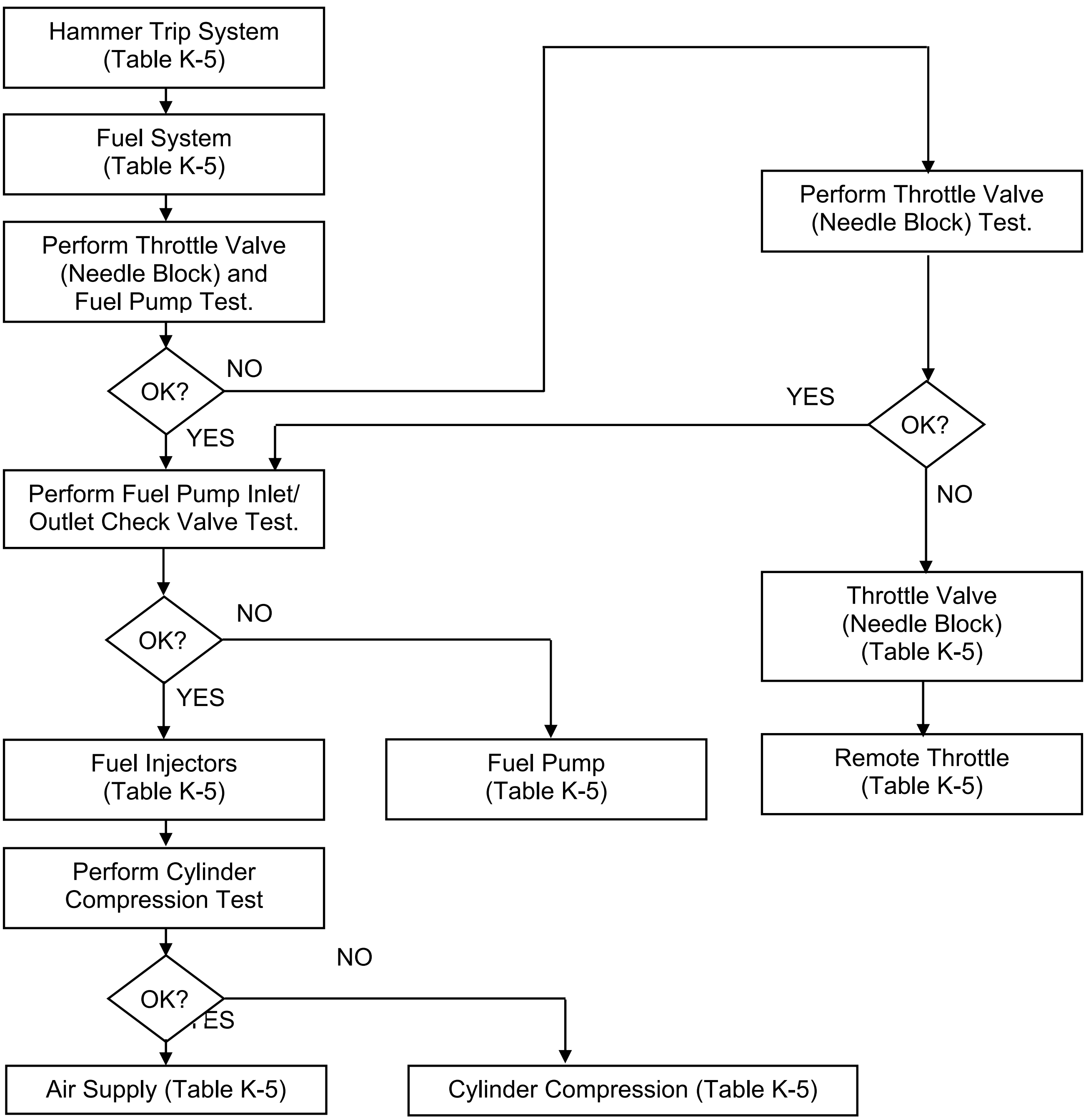


Figure K-11. Troubleshooting Flow Chart

Table K-5. Impact Hammer and Spotter Troubleshooting

Symptom	Probable Cause	Corrective Action
Hammer Trip System		
The hammer trip mechanism in the hammer trip assembly does not engage.	1. The impact hammer is not resting fully on the pile.	1a. Ensure impact hammer is resting fully on the pile.
		1b. Ensure striker plate is in up position, resting fully on pile, and not stuck in bell housing in an intermediate position.
	2. The hammer trip assembly will not descend fully.	2a. Ensure there are no obstructions.
		2b. Ensure that the trip safety lever and pin is pulled over spring tension.
	3. The cam (and lifting pawl) in the hammer trip assembly does not rise to a vertical position.	3. Check all mounting bolts and roll pins.
	4. The piston is not in the proper position for hammer trip engagement.	4a. Lower the piston so that it rests on the impact block. The lifting collar of the piston should be four inches (10 cm) above the cam in the hammer trip assembly when in the vertical position.
		4b. If the piston will not lower onto the impact block, check for any obstructions (i.e. broken compression ring wedged between the piston and the impact block or between the piston and the cylinder wall.)
	5. The lifting pawl in the hammer trip assembly does not engage the lifting collar of the piston.	5a. Check for worn lifting pawl in the hammer trip assembly.
		5b. Ensure the trip engage lug is properly engaging the cam in the hammer trip assembly.
	6. The leaf spring does not hold the cam of the hammer trip assembly in the over-center position.	6. Replace the leaf spring in the hammer trip assembly.
The hammer trip mechanism in the hammer trip assembly does not disengage.	1. The hammer trip track rails are worn or bent.	1. Replace worn or bent hammer trip track rails.
	2. The trip gibs on the hammer trip assembly are worn or mounting bolts may be loose.	2a. Tighten trip gib mounting bolts on hammer trip assembly.
		2b. Replace trip gibs on hammer trip assembly.
The piston releases prior to full hammer trip assembly height.	1. The hammer trip track rails are worn.	1. Replace worn hammer trip track rails.
	2. The trip gibs on the hammer trip assembly are worn or mounting bolts may be loose.	2a. Tighten trip gib mounting bolts on hammer trip assembly.
		2b. Replace trip gibs on hammer trip assembly.
Fuel System		
The impact hammer will not start.	1. The fuel tank is empty	1. Fill the fuel tank with the proper fuel.
	2. The fuel pump feed shutoff valve is not fully open.	2. Ensure the fuel pump feed shutoff valve is fully open (handle parallel to the lines). Also ensure the fuel return shutoff valve is fully open.
	3. The fuel plug/vent valves on the fuel tank are not open.	3. Ensure the fuel plug/vent valves on the fuel tank are fully open.

Table K-5. Impact Hammer Troubleshooting (Continued)

Symptom	Probable Cause	Corrective Action
Fuel System (Continued)		
The impact hammer will not start. (Continued)	4. There is no pressure on the remote throttle.	4. Increase the remote throttle pressure to 300 psi (20.6 bar).
	5. The remote throttle does not build up pressure.	5a. Ensure the reservoir of the remote throttle is full of hydraulic fluid.
		5b. Ensure the pressure relief valve on the remote throttle is closed.
		5c. Ensure the remote throttle hydraulic line is properly connected to the remote throttle and the throttle valve whip line on the impact hammer (connection labeled “THROTTLE CONNECTION”).
		5d. Ensure there are no leaks in the hydraulic line and associated fittings between the remote throttle and throttle valve (needle block) on the impact hammer. Tighten fittings or replace lines as necessary.
	6. The fuel pump feed inline filter is clogged.	6. Replace the fuel pump feed inline filter. **NOTE** Ensure fuel flows through the fuel filter before connecting the fuel line.
	7. The fuel filter assembly is clogged.	7. Replace the fuel filter assembly. **NOTE** Ensure fuel flows through the fuel filter before connecting the fuel line.
	8. The fuel return inline filter is clogged.	8. Replace the fuel return inline filter. **NOTE** Ensure fuel flows through the fuel filter before connecting the fuel line.
	9. The fuel injector(s) is/are clogged	9a. Replace the fuel injector(s).
		9b. Drain the fuel tank, flush the system, and refill with fresh fuel. Also replace the two fuel tank suction strainers, fuel pump feed inline filter, fuel return inline filter, and fuel filter element in fuel filter assembly.
	10. The fuel has become contaminated with foreign material or water.	10. Drain the fuel tank and refill with fresh fuel. Also replace the two fuel tank suction strainers, fuel pump feed inline filter, fuel return inline filter, and fuel filter element in fuel filter assembly.
	11. Fuel leaks appear in one or more fuel lines.	11. Check for fuel leaks throughout the fuel system. Replace any defective lines or fittings.
	12. Possible air-lock in fuel injector lines.	12. Set the remote throttle to zero pressure and remove the fuel injector line at the fuel injector. Allow fuel to flow freely for 15 seconds. When bubbles stop appearing, reconnect the fuel injector line and repeat the procedure for the other fuel injector. **NOTE** Do not perform procedure on both fuel injectors simultaneously.

Table K-5. Impact Hammer Troubleshooting (Continued)

Symptom	Probable Cause	Corrective Action
	Fuel Pump	
The fuel pump does not operate properly.	1. Possible air-lock in fuel pump.	1. Remove the inlet fuel line (flexible rubber hose) and insert a clean 1/8-inch (3 mm) rod into the passage to depress the inlet check valve (the inlet check valve operates by a very light spring). Fill the inlet with fuel and depress the check valve. Continue filling until no bubbles appear. Reconnect the inlet fuel line.
	2. The fuel plunger or the air piston of the fuel pump is leaking or seized.	2. Replace the fuel pump.
	Throttle Valve (Needle Block) **WARNING** Ensure the pressure has been relieved on the remote throttle prior to disconnecting the remote throttle hydraulic line.	
The throttle valve (needle block) does not operate properly.	1. Possible air-lock in throttle needle of the throttle valve (needle block).	1. Remove the 1/8-inch NPT hex head pipe plug (bleed screw) on the side of the throttle valve (needle block). Pressurize the remote throttle to pump air out.
	2. The remote throttle and/or hydraulic line to the throttle valve (needle block) is leaking hydraulic fluid.	2. Repair leaks in the hydraulic line and associated fittings between the remote throttle and throttle valve (needle block) on the impact hammer. Tighten fittings or replace lines as necessary.
	3. The throttle valve (needle block) is defective.	3. Replace the throttle valve (needle block).
	Remote Throttle	
The remote throttle does not function properly.	1. The remote throttle and/or hydraulic line to the throttle valve (needle block) is leaking hydraulic fluid.	1a. Repair leaks in the hydraulic line and associated fittings between the remote throttle and throttle valve (needle block) on the impact hammer. Tighten fittings or replace lines as necessary.
		1b. Replace the remote throttle.
	2. The remote throttle does not build up pressure.	2a. Remove the small NPT end plug from the top of the remote throttle. Close pressure relief valve and set remote throttle to pump, fill reservoir with MIL-2105 fluid, and connect a compressed air hose to reservoir filler. Pressurize with compressed air to bleed system. **NOTE** Do not allow reservoir to empty.
		2b. Replace the remote throttle.
	Fuel Injectors	
The fuel injector(s) do not function properly.	1. Defective fuel injector(s).	1. Replace the fuel injector(s). **CAUTION** Do not attempt to repair a fuel injector in the field.

Table K-5. Impact Hammer Troubleshooting (Continued)

Symptom	Probable Cause	Corrective Action
Cylinder Compression		
Both the fuel and oil pumps do not operate properly.	1. Low compression caused by worn piston compression rings and/or impact block compression rings.	1a. Inspect the piston compression rings and replace as necessary.
		1b. Inspect the impact block compression rings and replace as necessary.
	2. Low compression caused by worn lower cylinder.	2. Inspect the lower cylinder and repair or replace the lower cylinder as necessary. **NOTE** If damage is not too severe, it may be possible to re-chrome the combustion area of the lower cylinder.
Exhaust smoke (blow-by) is escaping out of the top of the lower and/or upper cylinder. Indicated by an area of black carbon on the piston (as opposed to a shiny, well-lubricated piston).	1. Worn piston compression rings.	1. Inspect the piston compression rings and replace as necessary.
	2. Worn lower cylinder.	2. Inspect the lower cylinder and repair or replace the lower cylinder as necessary. **NOTE** If damage is not too severe, it may be possible to re-chrome the combustion area of the lower cylinder.
Exhaust smoke (Blow by) is escaping out of the bottom of the lower cylinder.	1. Worn impact block compression rings.	1. Inspect the impact block compression rings and replace as necessary.
	2. Worn lower cylinder.	2. Inspect the lower cylinder and repair or replace the lower cylinder as necessary. **NOTE** If damage is not too severe, it may be possible to re-chrome the combustion area of the lower cylinder.
Air Supply		
Air supply is restricted.	1. The fuel plug vent/ valves on the fuel tank are not open.	1. Ensure the fuel plug vent/ valves on the fuel tank are fully open.
	2. The oil plug/vent valve on the lubricating oil tank is not open.	2. Ensure the oil plug/vent valve on lubricating oil tank is fully open.
	3. Obstruction in intake/exhaust ports on lower cylinder.	3. Remove obstruction from intake/exhaust ports on lower cylinder.
Spotter		
Spotter extends/retracts erratically.	1. Improper connection of the hydraulic hose reel lines to the hydraulic hose connections (spotter manifold) on the spotter.	1. Reconnect hydraulic hose reel lines properly.
	2. Clogged, broken, or loose hydraulic lines or fittings.	2. Clean, tighten, or replace hydraulic lines or fittings.
	3. Worn short or long wear pads on the inner or outer box.	3. Replace worn wear pads and properly lubricate.
	4. Damaged hydraulic cylinder.	4. Replace hydraulic cylinder.
	5. Distorted outer or inner box sections.	5. Replace outer or inner box section(s).

Table K-5. Impact Hammer Troubleshooting (Continued)

Symptom	Probable Cause	Corrective Action
Spotter (Continued)		
Spotter extends/retracts erratically. (Continued)	6. Hydraulic hose reel lines portion of the crane hydraulic system not functioning properly.	6. Troubleshoot crane hydraulic system in accordance with Section 5, Troubleshooting in Volume 1 of 2 of the Organizational, General Support, and Direct Support Maintenance Manual, TM 5-3810-307-24-1-1.
Spotter will not extend/retract	1. The TELE/CLAMSHELL selector switch, in the superstructure cab, is not in the CLAMSHELL position.	1. Place the TELE/CLAMSHELL selector switch, in the superstructure cab, in the CLAMSHELL position
	2. Improper connection of the hydraulic hose reel lines to the hydraulic hose connections (spotter manifold) on the spotter.	2. Reconnect hydraulic hose reel lines properly.
	3. Clogged, broken, or loose hydraulic lines or fittings.	3. Clean, tighten, or replace hydraulic lines or fittings.
	4. Damaged hydraulic cylinder.	4. Replace hydraulic cylinder.
	5. Bent outer or inner box sections.	5. Replace outer or inner box section(s).
	6. Hydraulic hose reel lines portion of the crane hydraulic system not functioning properly.	6. Troubleshoot crane hydraulic system in accordance with Section 5, Troubleshooting in Volume 1 of 2 of the Organizational, General Support, and Direct Support Maintenance Manual, TM 5-3810-307-24-1-1.

Throttle Valve (Needle Block) and Fuel Pump Test

The Throttle Valve (Needle Block) and Fuel Pump Test should be performed if the troubleshooting steps in the Hammer Trip and Fuel System sections of Table K-5 have not determined the problem.

Test Procedure.

a. With impact hammer standing upright, open the fuel tank plug/vent valves and the fuel pump feed and fuel return shutoff valves. Connect the hydraulic hose from the remote throttle to the throttle valve (needle block) whip line on the impact hammer (labeled “THROTTLE CONNECTION”).

b. Close the pressure relief valve on the remote throttle and pump the remote throttle to 550 psi (38 bar). This should cause the throttle valve (needle block) to close fully and prevent fuel from flowing, via gravity, in the fuel return line from the fuel tank to the fuel pump.

c. Disconnect either fuel injector line at the fuel injector and drain any remaining fuel. Use a suitable container to catch the fuel.

NOTE

Only a small amount of fuel should flow out.

d. Slowly decrease the remote throttle pressure. The needle in the throttle valve (needle block) should start to open allowing fuel to flow from the fuel tank, through the throttle valve (needle block), and out the removed fuel injector line. The fuel should flow freely with the remote throttle at zero pressure (0 psi).

e. Increase the throttle pressure again. The fuel should gradually diminish as remote throttle pressure increases and then completely shutoff at 550 psi (38 bar).

f. If the fuel system does not operate as described above, the problem is the throttle valve (needle block), remote throttle, fuel pump and/or fuel injectors. Perform the Throttle Valve (Needle Block) Test to isolate the problem.

g. If the fuel system operates as described above, the throttle valve (needle block) is OK and the problem is with the fuel pump and/or fuel injector(s). Perform the Fuel Pump Inlet/Outlet Check Valve Test to isolate the problem.

h. Reconnect the fuel injector line.

Throttle Valve (Needle Block) Test

The Throttle Valve (Needle Block) Test should be performed if the fuel system did not operate as described in the above Throttle Valve (Needle Block) and Fuel Pump Test.

Test Procedure.

a. Remove the throttle valve (needle block) from the lower cylinder of the impact hammer and the fuel tank return line. Leave the hydraulic line from the remote throttle connected.

b. Remove the outlet elbow fitting on the throttle valve (needle block).

c. The throttle needle stem is visible inside the fuel outlet port. It should move smoothly and seat completely at 550 psi (38 bar).

d. If the throttle valve (needle block) operates as described above, the problem is the fuel pump and/or fuel injectors. Perform the Fuel Pump Inlet/Outlet Check Valve Test to isolate the problem.

e. If the throttle valve (needle block) does not operate as described above, the problem is the throttle valve (needle block) and/or remote throttle. Perform the troubleshooting steps listed in the throttle valve (needle block) section and remote throttle Table K-7.

f. Place Loctite® 545 (purple) on the outlet elbow fitting. Reinstall the outlet elbow fitting in a functional throttle valve (needle block). Reinstall the throttle valve (needle block).

Fuel Pump Inlet/Outlet Check Valve Test

The Fuel Pump Inlet/Outlet Check Valve Test should be performed if the fuel system did operate as described in the Throttle Valve (Needle Block) and Fuel Pump Test.

Test Procedure.

a. Ensure the fuel injector line has been reconnected.

b. With impact hammer standing upright, ensure the fuel tank plug/vent valves and fuel return shutoff valve are open. Fully close the fuel pump feed shutoff valve. Also ensure the hydraulic hose from the remote throttle is connected to the throttle valve (needle block) whip line on the impact hammer (labeled “THROTTLE CONNECTION”).

c. Close the pressure relief valve on the remote throttle and pump the remote throttle to 550 psi (38 bar). This should cause the throttle valve (needle block) to close fully and prevent fuel from flowing, via gravity, in the fuel return line from the fuel tank to the fuel pump.

d. Disconnect the fuel line from the bottom of the fuel filter assembly (outlet) and drain any remaining fuel. Use a suitable container to catch the fuel.

NOTE

Only a small amount of fuel should flow out.

e. Release the remote throttle pressure (0 psi). The needle in the throttle valve (needle block) should be fully open allowing fuel to flow from the fuel tank, through the throttle valve (needle block), and to the outlet of the fuel pump.

f. If the inlet and outlet check valves of the fuel pump are operating correctly, there should not be any fuel flowing out of the disconnected fuel line.

g. If the fuel flows out of the disconnected fuel line, the problem is the fuel pump.

h. If the fuel does not flow out of the disconnected fuel line, the problem is the fuel injectors.

i. Reconnect the fuel line to the bottom of the fuel filter assembly (outlet).

Cylinder Compression Test

The Cylinder Compression Test should be performed if the troubleshooting steps in the Hammer Trip System, Fuel System, Fuel Pump, Throttle Valve (Needle Block), Remote Throttle, and Fuel Injector sections of Table K-5 have not determined the problem.

Test Procedure.

a. Ensure impact hammer is installed on lead tower and the weight of the impact hammer is resting fully on a pile (or pile adapter).

NOTE

The lifting pawl of the hammer trip assembly will not be able to engage with the lifting collar of piston unless the weight of the impact hammer is fully resting on a pile or pile adapter.

b. Open the pressure relief valve so the pressure on the remote throttle is 0 psi. This should cause the throttle valve (needle block) to open fully and allow all fuel to return to the fuel tank, thereby not allowing the impact hammer to start.

c. Simulate starting the impact hammer three times using the hammer trip assembly and measure the time elapsed from trip disengage until the piston stops bouncing, bottoms out, and rests fully on the impact block. View the lifting collar on the piston via slot in the rear of the impact hammer above the trip safety lever. A chalk line can be used to note the starting point of the lifting collar on the piston.

d. An impact hammer with adequate compression should take between 15 to 20 seconds to bottom out. A time of less than ten seconds indicates low compression.

MAINTENANCE

Spare Parts, Special Tools and Equipment

Spare parts, special tools and equipment are initially provided with the Pile Driver System and are located in the two tool boxes stored in the shipping/storage container. Table K-6 below lists the maintenance-related spare parts, special tools and equipment provided.

NOTE

Table K-6 is a list of the maintenance-related Spare Parts, Special Tools and Equipment and is not a comprehensive list of all components delivered with the system.

Table K-6. Spare Parts, Special Tools, and Equipment

No.	Qty.	Component Description	√
		Special Tools	
1.	1	Check valve extractor tool – fuel and oil pump	
2.	1	Ring compressor	
3.	1	Piston ring pliers	
4.	1	Grease gun with flex hose and coupler	
5.	1	Coupler for grease gun	
6.	1	Oil gun	
		Rigging and Safety Equipment	
7.	1	Piston lifting eyebolt	
		Seal Kits and Filters	
8.	1	Fuel pump seal kit	
9.	1	Throttle valve (needle block) seal kit	
10.	1	Oil pump seal kit	
11.	2	Fuel filter element for the Fuel Filter Assembly	
12.	6	In-line fuel filters	
13.	2	Fuel or oil tank suction strainer elements	
		Consumable Materials	
14.	10	14-oz. (400g) tube of MIL-G-10924 grease	
15.	1	1-quart (1 l) of MIL-L-2105 oil	
16.	1	1/3-oz. (10 ml) of Loctite® 272	
17.	1	Teflon® tape	
		Spare Parts	
18.	-	Refer to the Components of End Item – Table H-7 in Appendix H of the Operator's Manual, TM-3810-307-10 for a complete listing of the spare parts provided in the tool boxes.	

Field-level Preventive Maintenance Checks and Services (PMCS)

Table K-7 contains Preventive Maintenance Checks and Services (PMCS) which must be performed by maintenance personnel.

Table K-7. Field-level Preventive Maintenance Checks and Services (PMCS)

No.	Interval	Item to be Inspected	Procedure
1.	Every 25,000 blows or monthly (unless Pile Driver System is in storage)	Hammer Trip Assembly	Remove, disassemble, inspect, and lubricate with MIL-G-10924.
2.		Trip Safety Lever (Lubrication Fittings)	Lubricate with MIL-G-10924 and inspect.
3.	Every 250,000 blows or monthly (unless Pile Driver System is in storage)	Fuel pump feed and return inline filters	Replace.
4.		Fuel filter element in the fuel filter assembly	Replace.
5.	Every 800,000 blows or semi-annually (unless Pile Driver System is in storage)	Piston	Lubricate with MIL-L-2104 oil and inspect.
6.		Piston compression rings	Lubricate with MIL-L-2104 oil, inspect, and rotate. Replace as necessary.
7.		Impact Block	Lubricate with MIL-L-2104 oil and inspect.
8.		Impact Block compression rings	Lubricate with MIL-L-2104 oil, inspect, and rotate. Replace as necessary.
9.		Cushion rings (6) and cushion compression ring (in the drive upper housing of the direct drive assembly)	Inspect and replace as necessary.
10.		Striker plate and striker plate cushion ring (in drive lower housing of the direct drive assembly)	Inspect and replace as necessary.
11.		Spotter	Inspect the condition of the long and short wear pads on the spotter outer and inner boxes and replace as necessary.
12.	Every two (2) years	Blow Count Recorder	Replace the internal battery.

Lubrication

Lubricants required by the Pile Driver System are listed in Table K-4.

NOTE

The majority of lubrication for the Pile Driver System is performed by operating personnel before and during operation of the system.

Repair Instructions

To perform repair instructions on the impact hammer the impact hammer must be first removed from the lead tower. Lower the impact hammer onto blocks (of sufficient height to remove the various sub-assemblies). Ensure the piston is in the bottom position resting on the impact block. This can be verified by viewing the position of piston through the piston transportation pin hole. Unless removing the piston, install the piston transportation pin and clip.

After repair procedures are completed, the impact hammer can be raised to a vertical position.

CAUTION

When raising the impact hammer to a vertical position after performing repair procedures, it is imperative to raise the impact hammer very slowly. The piston and impact block must not be allowed to collide forcefully with the striker plate. A violent collision may cause damage.

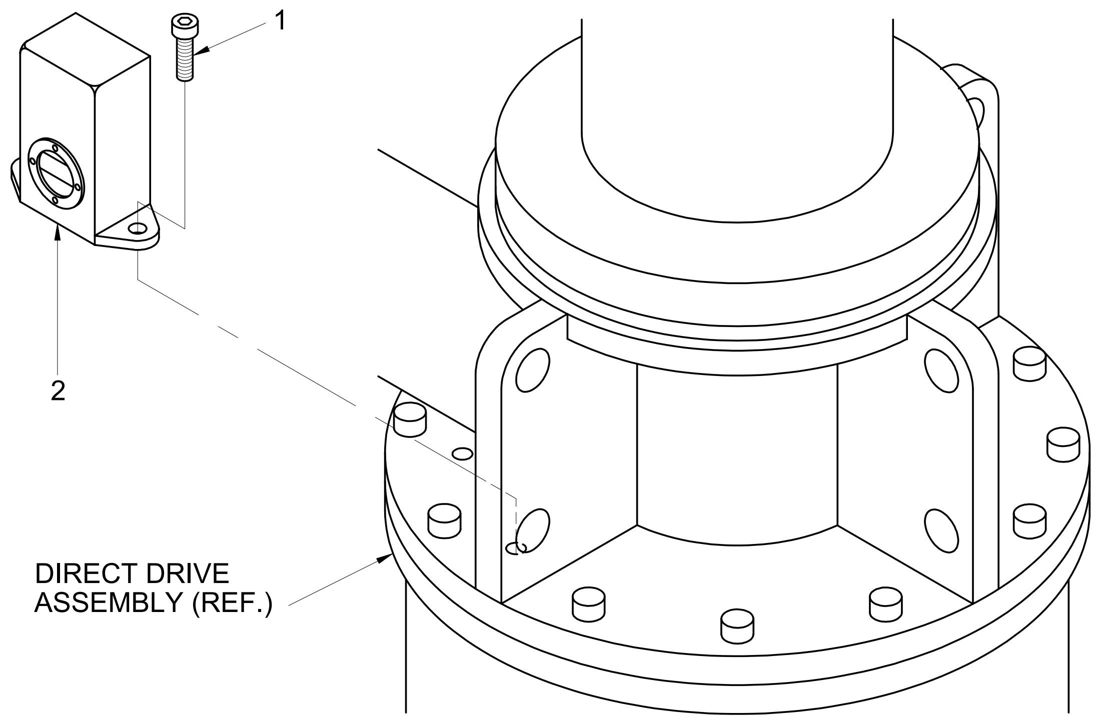
Blow Count Recorder. (Refer to Figures K-12 and K-13.)

The blow count recorder is normally removed to replace the battery pack, entire blow count recorder as an assembly, or to remove the lower gib.

Removal.

a. Remove the two blow count recorder mounting bolts (1, Figure K-12) securing the blow count recorder (2) to the direct drive assembly.

b. Remove the blow count recorder (2) from the direct drive assembly.



LEGEND

1. Blow Count Recorder Mounting Bolts, 1/2 x 1-3/4 NC SHCS
2. Blow Count Recorder

Figure K-12. Blow Count Recorder Installation

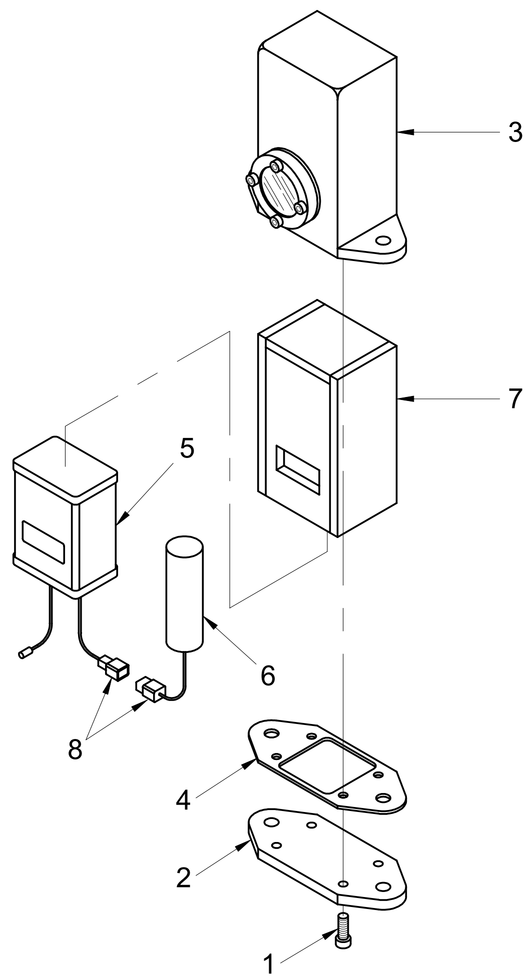
Disassembly

a. Remove the four base plate retaining screws (1, Figure K-13) securing the base plate (2) to the blow count recorder housing (3). Remove the base plate (2) and gasket (4) from the blow count recorder housing (3).

b. Pull on the free end of the screening to remove the blow count recorder (5) and battery pack (6), in their protective foam (7), from the blow count recorder housing (3).

c. Remove the blow count recorder (5) from the protective foam (7).

d. Disconnect the electrical connector (8) on the battery pack (6) from the blow count recorder (5) and remove the battery pack (6) from the protective foam (7).



LEGEND

1. Base Plate Retaining Screws, 1/4 x 3/4 NC SHCS
2. Base Plate
3. Blow Count Recorder Housing
4. Gasket
5. Blow Count Recorder
6. Battery Pack
7. Protective Foam
8. Electrical Connector

Figure K-13. Blow Count Recorder Disassembly

Reassembly.

a. Reconnect the electrical connector (8, Figure K-13) on the blow count recorder (5) to the replacement battery pack (6) and install the battery pack (6) in the protective foam (7). Ensure the count prior to removing the battery is displayed on the blow count recorder (5). Check electrical connections as necessary.

NOTE

When a new battery pack is connected to the blow count recorder, the count prior to removing the battery pack should be displayed.

b. Install the blow count recorder (5) into the protective foam (7).

NOTE

Ensure desiccant pack is also installed in protective foam (7).

c. Install the blow count recorder (5) and battery pack (6), in their protective foam (7), into the blow count recorder housing (3). Ensure the display is visible in the window of the blow count recorder housing (3).

d. Place Loctite® 242 (blue) on the four base plate retaining screws (1). Align the base plate (2) and gasket (4) with the mounting holes on the blow count recorder housing (3) and secure the base plate (2) to the blow count recorder housing (3) with the four base plate retaining screws (1).

Installation.

a. Align the blow count recorder (2, Figure K-12) with the mounting holes on the direct drive assembly.

b. Place Loctite® 272 (red) on the two blow count recorder mounting bolts (1). Secure the blow count recorder (2) to the direct drive assembly with the two blow count recorder mounting bolts (1). Tighten the bolts and torque to 150 ft•lb (203 N•m).

<u>Lower and Upper Gibs. (Refer to Figure K-14.)</u>

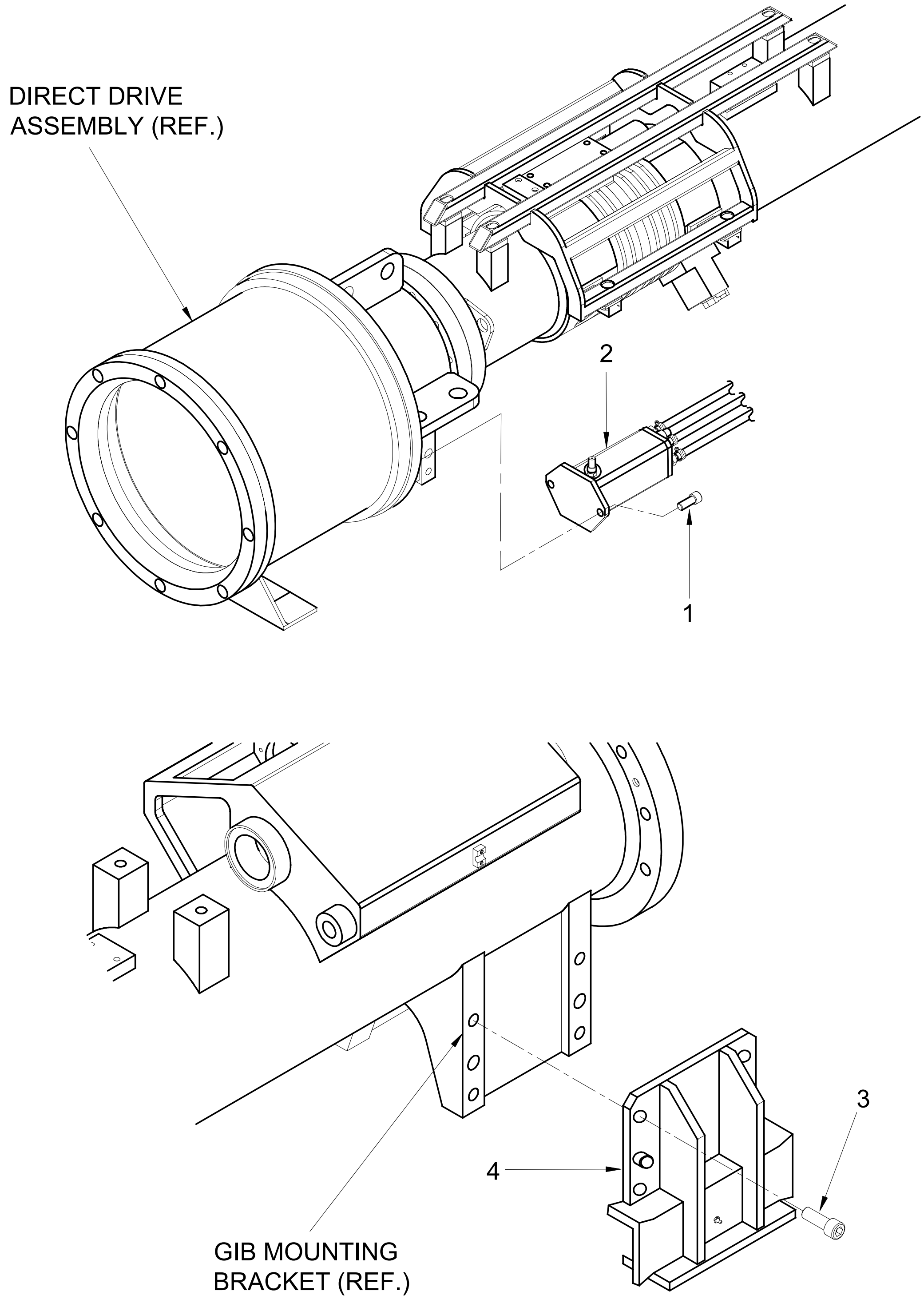
The lower gibs installed on the direct drive assembly are normally removed for replacement or to remove the lower drive housing, cushion rings, cushion compression rings, and/or direct drive assembly. The upper gibs installed on the lower cylinder are normally removed for replacement.

Removal.

a. If necessary to access the lower gib, remove the blow count recorder from the direct drive assembly (Page K-37).

b. If necessary to access the other lower gib, remove the two waste fuel drip tank mounting bolts (1, Figure K-14) securing the waste fuel drip tank (2) to the top of the direct drive assembly. Remove the waste fuel drip tank (2) from the direct drive assembly, leave the lines connected, and secure waste fuel drip tank (2) out of the way.

c. Remove the four gib mounting bolts (3) securing the gib (4) to the gib mounting bracket. Remove the gib (4).



LEGEND

1. Waste Fuel Drip Tank Mounting Bolt, 1/2-13 NC 1-1/4 LG SHCS
2. Waste Fuel Drip Tank
3. Gib Mounting Bolts, 3/4 x 1-1/2 – NC SHCS
4. Gib

Figure K-14. Lower and Upper Gib Installation (Upper Gib Shown; Lower Gib Similar)

Installation.

a. Align the gib (4, Figure K-14) with the mounting holes on the gib mounting bracket. Ensure the pins are aligned.

b. Place Loctite® 272 (red) on the four gib mounting bolts (3). Secure the gib (4) to the gib mounting bracket with the gib mounting bolts (3). Tighten the bolts and torque to 450 ft•lb (609 N•m).

c. If waste fuel drip tank (2) was removed, place Loctite® 272 (red) on the two waste fuel drip tank mounting bolts (1). Align the waste fuel drip tank (2) with the mounting holes on the top of the direct drive assembly and secure the waste fuel drip tank (2) to the direct drive assembly with the two waste fuel drip tank mounting bolts (1). Tighten the bolts and torque to 150 ft•lb (203 N•m).

d. If blow count recorder was removed, install the blow count recorder on the direct drive assembly (Page K-37).

Direct Drive System – Lower Drive Housing. (Refer to Figure K-15.)

The lower drive housing of the direct drive assembly is only removed to access the striker plate and striker plate cushion ring and/or the lower drive housing components. All other procedures require the direct drive assembly to be removed as an assembly.

Removal.

a. Remove the blow count recorder from the direct drive assembly (Page K-37).

b. Remove the two lower gibs from the direct drive assembly (Page K-39).

c. Secure and support the lower drive housing (1, Figure K-15) with a sling or chains.

d. Remove the twelve upper to lower drive housing bolts (2) securing the lower drive housing (1) to the upper drive housing (3).

e. Remove the lower drive housing (1) as an assembly (bell housing, guide plate, striker plate, and striker plate cushion ring).

Installation.

a. Secure and support the lower drive housing (1, Figure K-15) using a sling or chains.

NOTE

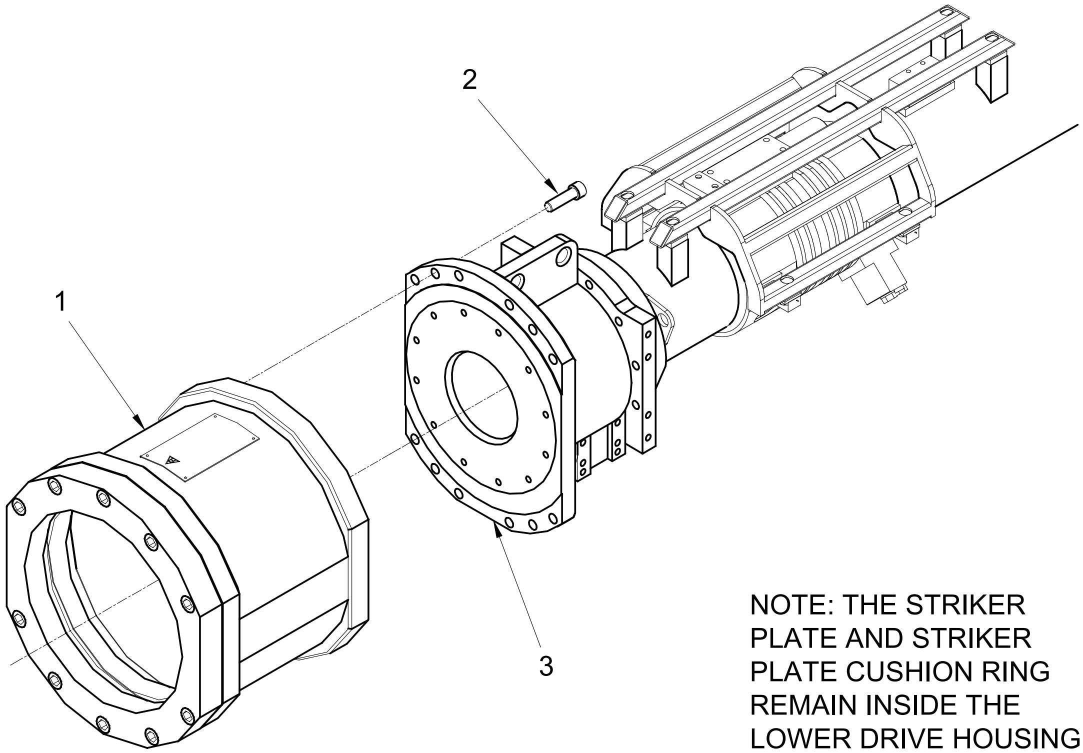
Ensure the striker plate and striker plate cushion ring are properly installed in the lower driver housing.

b. Align the lower drive housing (1) with the mounting holes on the upper drive housing (3).

c. Place Loctite® 272 (red) on the twelve upper to lower drive housing bolts (2). Secure the lower drive housing (1) to the upper drive housing (3) with the upper to lower drive housing bolts (1). Tighten the bolts in an even pattern to avoid binding and torque to 650-700 ft•lb (880-948 N•m).

d. Install the two lower gibs on the direct drive assembly (Page K-39).

e. Install the blow count recorder on the direct drive assembly (Page K-37).



LEGEND

1. Lower Drive Housing
2. Upper to Lower Drive Housing Bolts, 3/4-10 NC x 2 LG SHCS
3. Upper Drive Housing

Figure K-15. Lower Drive Housing Installation

Direct Drive System – Striker Plate and Striker Plate Cushion Ring. (Refer to Figure K-16.)

The striker plate and striker plate cushion ring are normally removed to inspect for wear and/or replacement.

Removal.

a. Remove the lower drive housing as an assembly from the upper drive housing and set upright with the guide plate side down and rest on wood blocks (Page K-41).

b. Remove the striker plate (1, Figure K-16) from the lower drive housing.

NOTE

A threaded hole in the side of the striker plate allows easy handling. The threaded hole can be easily accessed by lowering the lower drive housing onto wood blocks and raising the striker plate.

c. Remove the striker plate cushion ring (2) from the lower drive housing.

Inspection.

a. Check the striker plate (1, Figure K-16) and striker plate cushion ring (2) for wear such as gouging, loss of elasticity, damage to lips, or general wear.

Installation.

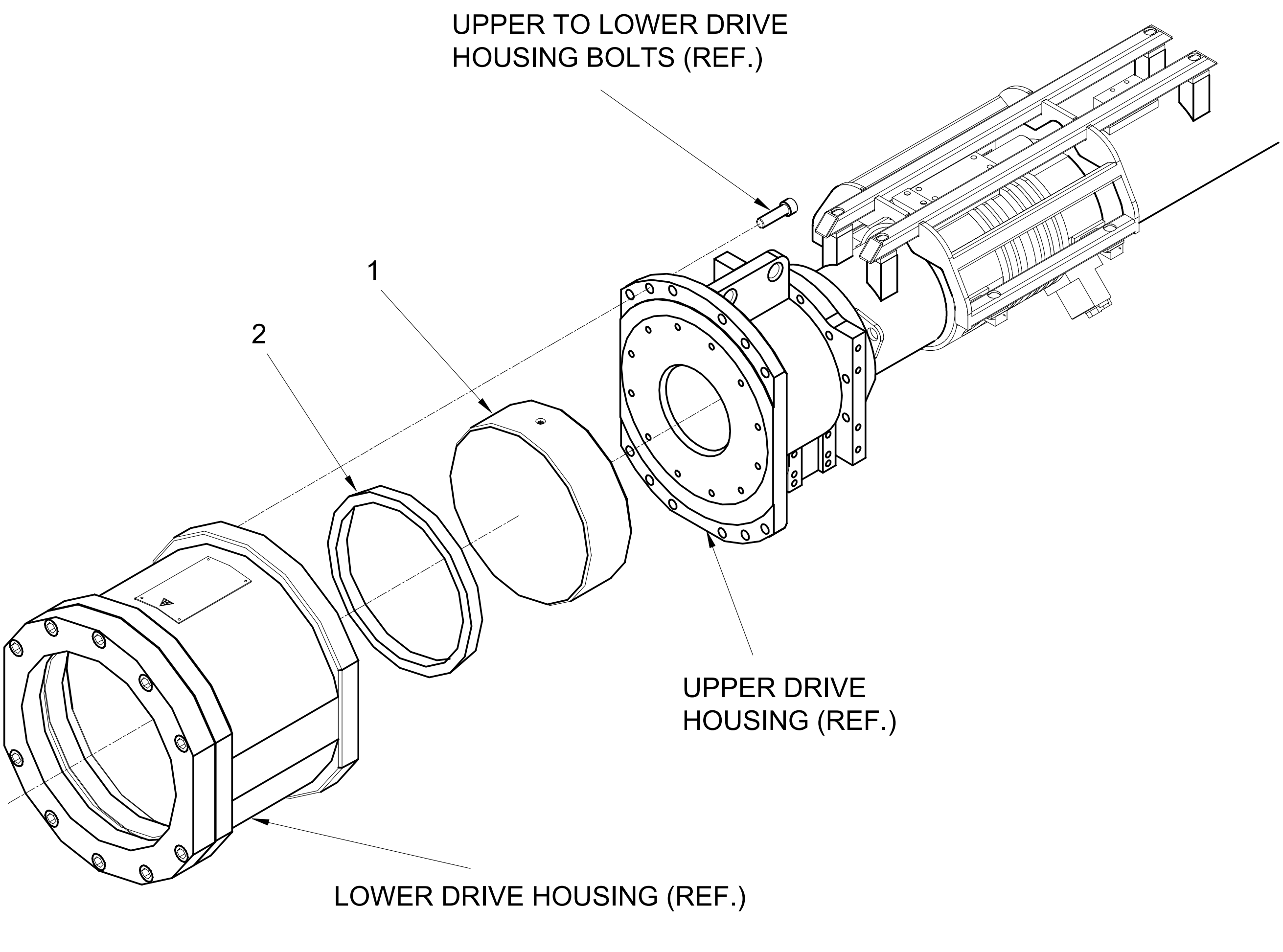
a. Install the striker plate cushion ring (2, Figure K-16) in the lower drive housing.

b. Install the striker plate (1) in the lower drive housing.

NOTE

A threaded hole in the side of the striker plate allows easy handling.

c. Install the lower drive housing on the upper drive housing (Page K-41).



LEGEND

1. Striker Plate
2. Striker Plate Cushion Ring

Figure K-16. Striker Plate and Striker Plate Cushion Ring Installation

Direct Drive System – Direct Drive Assembly from Lower Cylinder. (Refer to Figure K-17.)

The direct drive assembly is normally removed as an assembly in order to access the impact block in the lower cylinder and to remove the cushion rings, cushion compression ring, cushion housing guide ring support, and/or cushion housing guide ring.

Removal.

a. Remove the blow count recorder from the direct drive assembly (Page K-37).

b. Remove the two lower gibs from the direct drive assembly (Page K-39).

c. Secure and support the entire direct drive assembly (1, Figure K-17) with a sling or chains wrapped around the bell housing of the lower drive housing.

d. Remove the twelve lower cylinder to direct drive assembly bolts (2) securing the direct drive assembly (1) to the flange on the lower cylinder (3).

e. Remove the direct drive assembly (1) as an assembly (i.e. upper drive housing and lower drive housing still bolted together) by sliding away from the impact block. Support the impact block and prevent from falling out of the lower cylinder. Set the direct drive assembly upright with the guide plate side down and rest on wood blocks.

NOTE

The cushion housing guide ring and cushion housing guide ring support should remain in the top of the cushion housing of the direct drive assembly. IF NOT, CAREFULLY USE A PRY BAR TO SLIDE THE CUSHION HOUSING GUIDE RING AND CUSHION HOUSING GUIDE RING SUPPORT AWAY FROM THE FLANGE OF THE LOWER CYLINDER AND INTO THE TOP OF THE CUSHION HOUSING BEFORE REMOVING THE DIRECT DRIVE ASSEMBLY.

Installation.

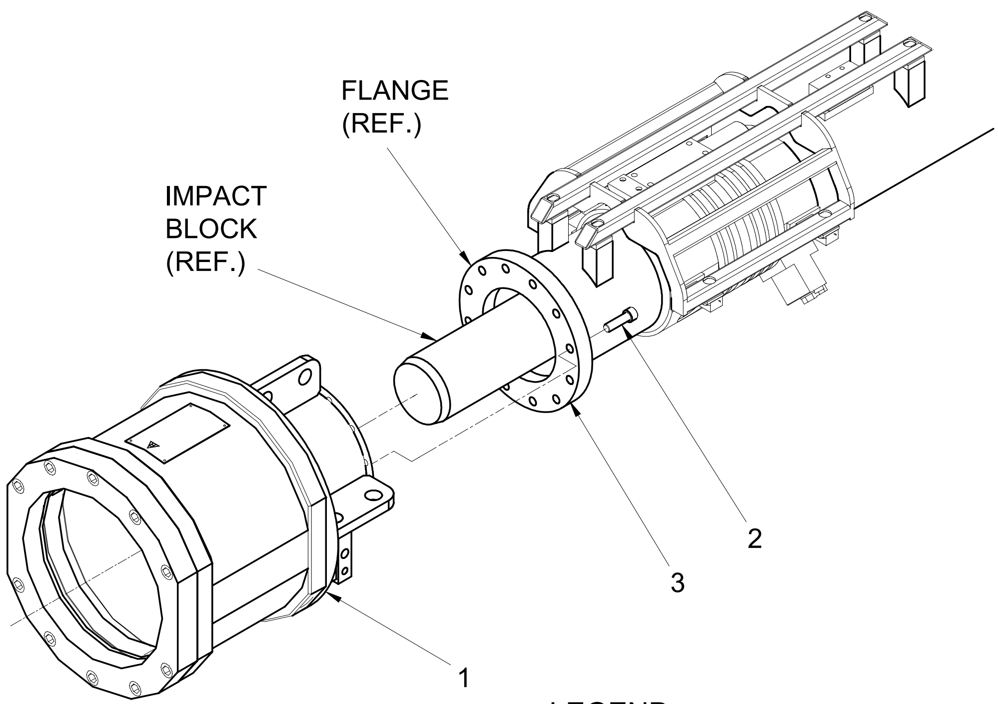
a. Secure and support the direct drive assembly (1, Figure K-17) using a sling or chains wrapped around the bell housing of the lower drive housing.

b. Slide the direct drive assembly (1) over the impact block and align with the mounting holes on the flange of the lower cylinder (3).

c. Place Loctite® 272 (red) on the twelve lower cylinder to direct drive assembly bolts (2). Secure the direct drive assembly (1) to the lower cylinder (3) with ten lower cylinder to direct drive assembly bolts (2). Tighten the bolts in an even pattern to avoid binding and torque to 500 ft•lb (677 N•m).

d. Install the two lower gibs on the direct drive assembly (Page K-39).

e. Install the blow count recorder on the direct drive assembly (Page K-37).



LEGEND

1. Direct Drive Assembly
2. Lower Cylinder to Direct Drive Assembly Bolts, 3/4-10 NC x 3 LG SHCS
3. Lower Cylinder

Figure K-17. Direct Drive Assembly Installation

Direct Drive System – Cushion Rings, Cushion Compression Ring, and Cushion Shim Ring. (Refer to Figures K-15 and K-18.)

The cushion rings, cushion compression ring, and cushion shim ring (if installed) are normally removed to inspect for wear and/or replacement.

Removal.

a. Remove the blow count recorder from the direct drive assembly (Page K-37).

b. Remove the two lower gibs from the direct drive assembly (Page K-39).

c. Loosen, but not remove, the twelve upper to lower drive housing bolts (2, Figure K-15) and the ten cushion housing retaining plate bolts (1, Figure K-18) on the upper drive housing (3, Figure K-15) of the direct drive assembly.

d. Remove the direct drive assembly as an assembly from the lower cylinder (Page K-44).

e. With the direct drive assembly standing upright, remove the twelve upper to lower drive housing bolts (2) securing the lower drive housing (1) to the upper drive housing (3).

f. Secure and support the upper drive housing (3) using a sling or chains attached to the lifting lugs.

g. Hoist and remove the upper drive housing (3) as an assembly (cushion housing, cushion housing retaining plate, cushion rings, and cushion compression ring) from the lower drive housing (1). Set upper drive housing (3) upright with the cushion housing retaining plate (3, Figure K-18) resting on wood blocks.

h. Remove the ten cushion housing retaining plate bolts (1) securing the cushion housing retaining plate (3) to the cushion housing (2).

i. Hoist and remove the cushion housing (2) from the stack of cushion rings (4), cushion shim ring (5), and cushion compression ring (6).

j. If installed, remove the cushion shim ring (5).

k. Remove the six cushion rings (4).

l. Remove the cushion compression ring (6) from the cushion housing retaining plate (3).

Inspection.

a. Check each cushion ring (4, Figure K-18) for wear such as gouging, loss of elasticity, damage to lips, or general wear.

Installation.

a. With the cushion housing retaining plate (3, Figure K-18) resting on wood blocks, install the cushion compression ring (6) in the cushion housing retaining plate (3).

b. Place the six cushion rings (4) in a stack on top of the cushion compression ring (6) with the flat sides down and the beveled sides facing upwards.

c. If required, install the cushion shim ring (5).

d. Secure and support the cushion housing (2) using a sling or chains attached to the lifting lugs.

e. Hoist and install the cushion housing (2) over the stack of cushion rings (4), cushion shim ring (5), and cushion compression ring (6). Ensure the cushion shim ring (5) and cushion rings (4) are lined up properly in the center of the cushion housing (2).

f. Place Loctite® 272 (red) on the ten cushion housing retaining plate bolts (1). Align the cushion housing (3) with the holes in the cushion housing retaining plate (2) and secure with the cushion housing retaining plate bolts (1). Tighten bolts but do not tighten to final torque value at this time.

g. Hoist and install the upper drive housing (3, Figure K-15) as an assembly (cushion housing, cushion housing retaining plate, cushion rings, and cushion compression ring) onto the lower drive housing (1).

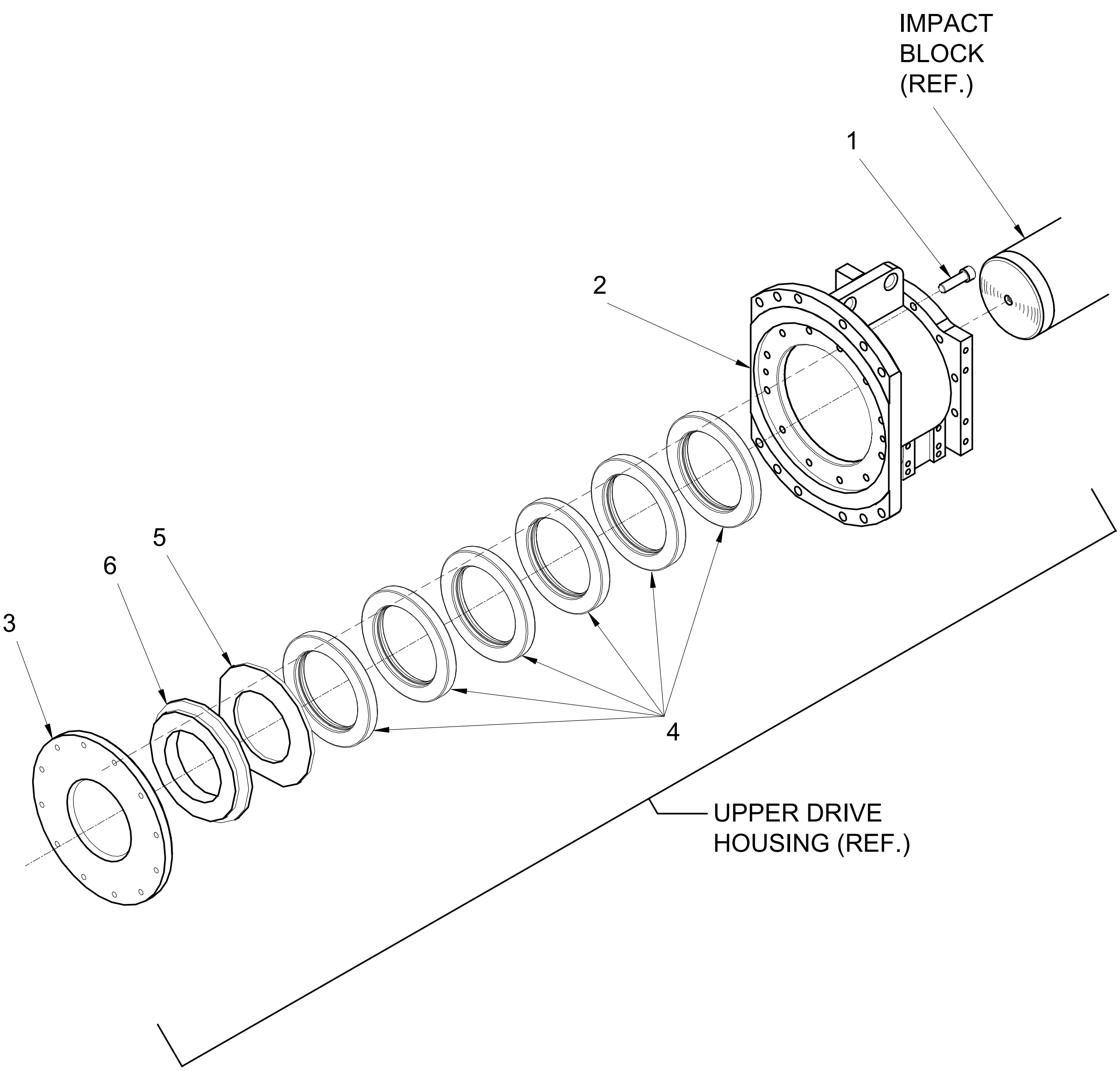
h. Place Loctite® 272 (red) on the twelve upper to lower drive housing bolts (2). Align the upper drive housing (3) with the holes in the lower drive housing (1) and secure the lower drive housing (1) to the upper drive housing (3) with the upper to lower drive housing bolts (2). Tighten the bolts in an even pattern to avoid binding and torque to 650-700 ft•lb (880-948 N•m).

i. Tighten the cushion housing retaining plate bolts (1, Figure K-18) in an even pattern to avoid binding and torque to 500 ft•lb (677 N•m).

j. Install the direct drive assembly on the lower cylinder (Page K-44).

k. Install the two lower gibs on the direct drive assembly (Page K-39).

l. Install the blow count recorder on the direct drive assembly (Page K-37).



LEGEND

1. Cushion Housing Retaining Plate Bolts, 3/4-10 NC x 1-3/4 LG SHCS
2. Cushion Housing
3. Cushion Housing Retaining Plate
4. Cushion Rings (6)
5. Cushion Shim Ring
6. Cushion Compression Ring

Figure K-18. Cushion Rings, Cushion Compression Ring, and Cushion Shim Ring Installation

Cushion Housing Guide Ring Support and Cushion Housing Guide Ring. (Refer to Figure K-19.)

The cushion housing guide ring support and cushion housing guide ring are normally removed for replacement.

Removal.

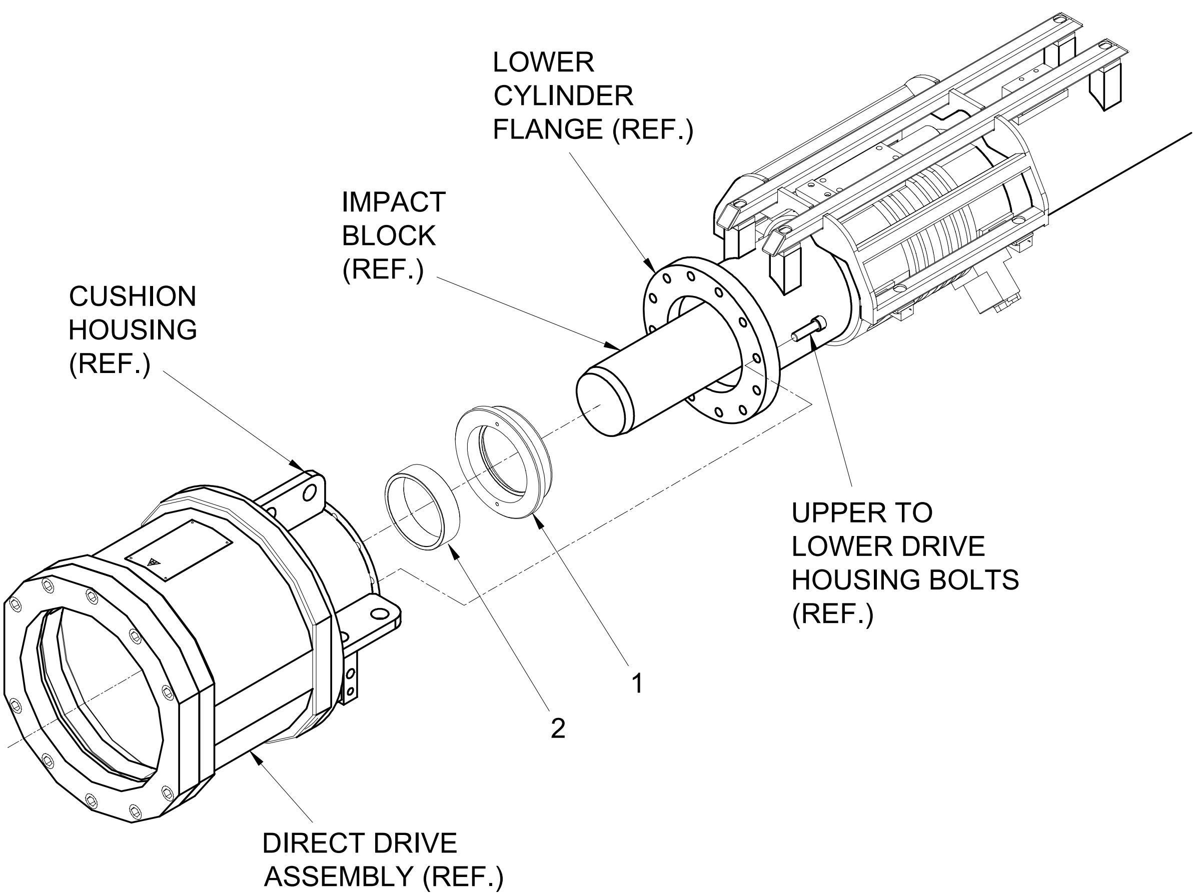
a. Remove the direct drive assembly as an assembly from the lower cylinder (Page K-44).

b. With the direct drive assembly standing upright, remove the cushion housing guide ring support (1, Figure K-19) and cushion housing guide ring (2) from the cushion housing of the direct drive assembly.

NOTE

The 3/8-16 UNC tapped holes in the cushion housing guide ring support (1) allow bolts or threaded rods to be used to pull the cushion housing guide ring support (1) and cushion housing guide ring (2) out of the cushion housing of the direct drive assembly.

c. Separate the cushion housing guide ring support (1) and cushion housing guide ring (2) from each other.



LEGEND

1. Cushion Housing Guide Ring Support
2. Cushion Housing Guide Ring

Figure K-19. Cushion Housing Guide Ring Support and Cushion Housing Guide Ring Installation

Inspection.

a. Inspect the cushion housing guide ring (2, Figure K-19) for scoring, wear, or other damage.

Installation.

a. Slide the cushion housing guide ring (2, Figure K-19) into the cushion housing guide ring support (1).

b. With the direct drive assembly standing upright, install the cushion housing guide ring support (1) and cushion housing guide ring (2) into the cushion housing of the direct drive assembly. Use a soft-face hammer or a wood block to help tap into place.

c. Install the direct drive assembly onto the lower cylinder (Page K-44).

Impact Block. (Refer to Figure K-20.)

The impact block is normally removed to inspect and to remove and inspect the impact block compression rings.

Removal.

a. Remove the direct drive assembly as an assembly from the lower cylinder and set aside (Page K-44).

b. Position a lifting device and sling approximately five inches (13 cm) behind the head of the impact block (1, Figure K-20).

CAUTION

Place a piece of plywood (or other protective material) on the floor beneath the impact block to prevent damage in the event any components fall to the floor during lifting of the impact block.

c. Raise the lifting device and sling slightly to carry the weight of the impact block (1).

WARNING

Remain clear when removing the impact block from the lower cylinder in the event the impact block falls from the sling.

d. Pull the impact block (1) clear of the lower cylinder (2).

e. Place the impact block (1) on a wood block with the compression ring (3) grooves down.

Inspection.

a. Inspect the impact block (1, Figure K-20) for pitting, mushrooming, or cracks.

b. Inspect the impact block (1) for evidence of exhaust smoke (blow-by) escaping as indicated by an area of black carbon on the impact block (as opposed to a shiny, well-lubricated impact block). This would indicate defective impact block compression rings (3).

Installation.

a. Raise the impact block (1, Figure K-20) with a lifting device and sling so that the impact block (1) hangs horizontally in the sling.

b. Ensure the impact block compression rings (3) are staggered.

NOTE

The impact block compression ring (3) gaps must be positioned such that no two gaps are directly in line. Each gap should be staggered 90 degrees from the adjacent gap.

c. Lubricate the impact block compression rings (3) and impact block (1) with MIL-L-2104 oil.

d. Push the impact block (1) into the lower cylinder (2). If necessary, use a ring compressor to compress the impact block compression rings (3). Push the impact block (1) fully into the lower cylinder (2).

e. Install the direct drive assembly onto the lower cylinder (Page K-44).

Impact Block Compression Rings. (Refer to Figure K-20.)

The impact block compression rings are normally removed to inspect, check the impact block compression ring gap, rotating, and/or replacement.

Removal.

a. Remove the direct drive assembly as an assembly from the lower cylinder and set aside (Page K-44).

b. Remove the impact block from the lower cylinder (Page K-49).

CAUTION

Be careful not to deform (oversize or stretch) the compression ring during removal, open just enough to slide compression ring over the diameter of the impact block.

c. Using the piston ring pliers stored in the tool box, remove the impact block compression rings (3, Figure K-20) from the impact block (1).

Inspection.

a. Inspect the impact block compression rings (3, Figure K-20) for seizure in the grooves, wear, and sharp edges or scoring marks.

b. Place the impact block compression rings (3) in the bore of the lower cylinder (2) and measure the impact block compression ring gap with feeler gauges (i.e. the gap between the ends). The impact block compression ring gap should be between 0.09 – 0.11 inches (2.29-2.79 mm).

NOTE

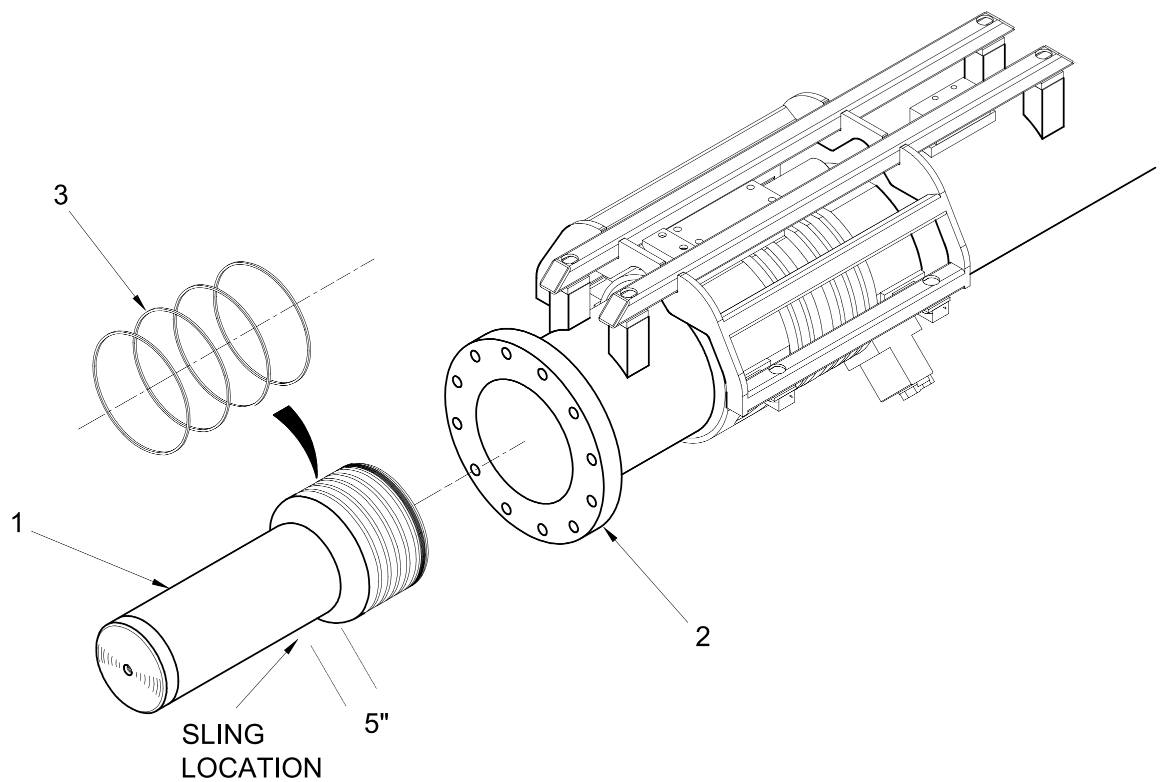
Under normal wear conditions, only the first two impact block compression rings closest to the end of the impact block require replacement.

Installation.

a. Install the impact block compression rings (3, Figure K-20) in the proper grooves on the impact block (1). Position the impact block compression rings (3) such that no two gaps are directly in line. Each gap should be staggered 90 degrees from the adjacent gap.

b. Install the impact block in the lower cylinder (Page K-49).

c. Install the direct drive assembly onto the lower cylinder (Page K-44).



LEGEND

1. Impact Block
2. Lower Cylinder
3. Impact Block Compression Rings

Figure K-20. Impact Block and Impact Block Compression Rings Installation

Catch Ring Cap. (Refer to Figure K-21.)

The catch ring cap is normally removed to remove the piston and/or the hammer trip track rails.

Removal.

a. Support the catch ring cap (1, Figure K-21) with a jack.

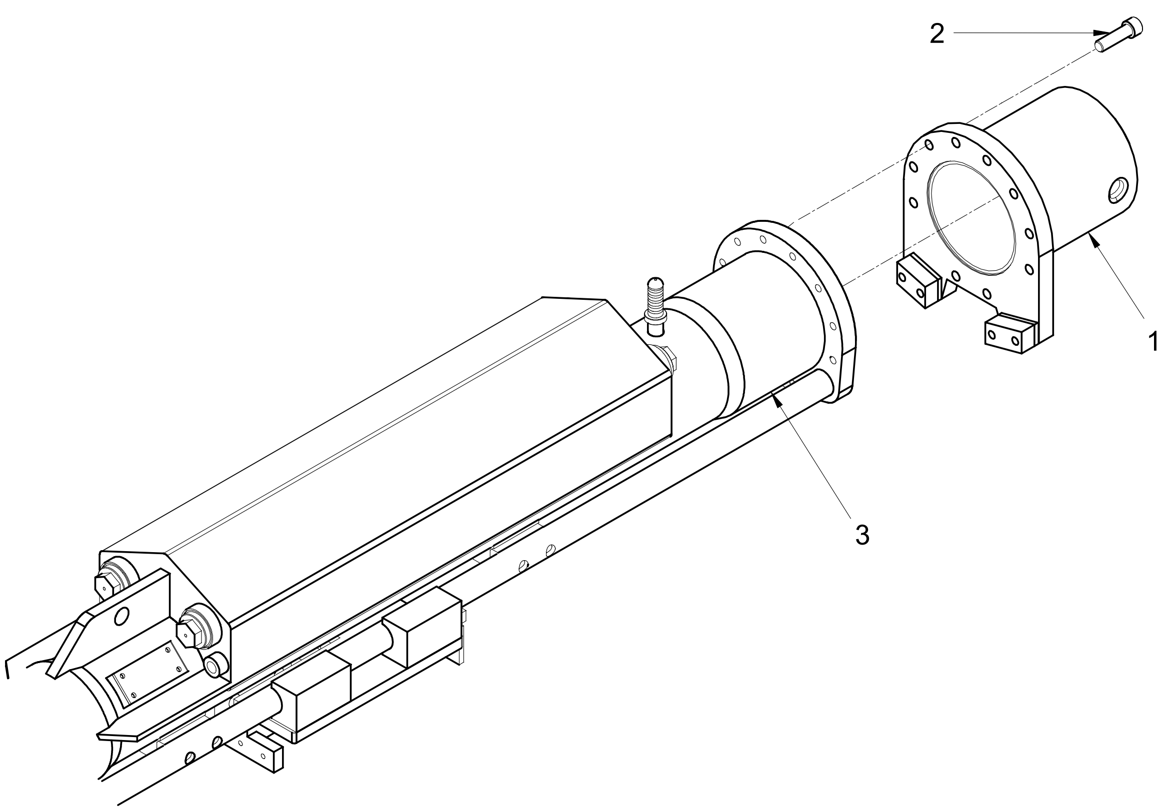
b. Remove the ten catch ring cap bolts (2, Figure K-17) securing the catch ring cap (1) to the top of the upper cylinder (3).

c. Remove the catch ring cap (1) and set aside.

Installation.

a. Align the catch ring cap (1, Figure K-21) with the mounting holes on the flange of the upper cylinder (3).

b. Place Loctite® 272 (red) on the ten catch ring cap bolts (2). Secure the catch ring cap (1) to the upper cylinder (3) with the ten catch ring cap bolts (2). Tighten the bolts and torque to 500 ft•lb (677 N•m).



LEGEND

1. Catch Ring Cap
2. Catch Ring Cap Bolts, 3/4-10 NC x 3 LG SHCS
3. Upper Cylinder

Figure K-21. Catch Ring Cap Installation

Piston. (Refer to Figure K-22.)

The piston is normally removed to inspect and to remove, inspect, rotate, and/or replace the piston compression rings.

Removal.

a. Remove the catch ring cap from the upper cylinder and set aside (Page K-52).

b. If necessary, remove the piston transportation pin (1, Figure K-22) and the intake/exhaust port weather cap (2). Install the trip transport bolt (3) in the hammer trip assembly to secure in position on the hammer trip track rails.

c. Remove the four lower cylinder (impact block) lubrication fittings (4) from the lower cylinder.

d. Screw the piston lifting eyebolt (5), stored in the tool box, into the top of the piston (6) to full thread depth and tighten lock nut (7) to piston surface.

e. With a lifting device and sling attached to the impact hammer, lift the impact hammer into a vertical position and support.

f. With a lifting device and sling attached to the piston lifting eyebolt (5), lift the piston (6) out of the upper cylinder so that the piston (6) is clear of the cylinder. Carefully lower piston (6) down to a horizontal position and place onto clean wood blocks. Maintain cleanliness of piston (6). Also use blocks to support piston (6) from any sideways movement.

CAUTION

Be careful not to deform (oversize or stretch) the compression rings during removal, open just enough to slide compression ring over the diameter of the piston.

g. Using the piston ring pliers stored in the tool box, remove the piston compression rings (8) from the piston (6).

Inspection.

a. Inspect the nose of the piston (6, Figure K-22) for excess pitting, mushrooming, or cracks.

b. Inspect the piston (6) for evidence of exhaust smoke (blow-by) escaping as indicated by an area of black carbon on the piston (as opposed to a shiny, well-lubricated piston). This would indicate defective piston compression rings (8).

c. Inspect the piston compression rings (8) for seizure in the grooves, wear, and sharp edges or scoring marks.

d. Place the piston compression rings (8) in the bore of the upper cylinder and measure the piston compression ring gap with feeler gauges (i.e. the gap between the ends). The piston compression ring gap should be between 0.09 – 0.11 inches (2.29-2.79 mm).

NOTE

Under normal wear conditions, only the first two piston compression rings closest to the end of the piston require replacement.

Installation.

a. Install the piston compression rings (8, Figure K-22) in the proper grooves on the piston (6). Ensure the piston compression ring (8) gaps are staggered.

NOTE

The piston compression ring gaps must be positioned such that no two gaps are directly in line. Each gap should be staggered 90 degrees from the adjacent gap.

b. Lubricate the piston compression rings (8) and piston (6) with MIL-L-2104 oil.

WARNING

Installing the piston into the upper cylinder procedure presents several opportunities for pinching body parts between moving parts. Use care when lowering the piston into the upper cylinder.

CAUTION

Be careful not to damage any components while lowering the piston into the upper cylinder. Do not rest any weight of the piston on the piston compression rings.

Ensure the lifting pawl of the hammer trip assembly is disengaged, hanging vertically, and not going to strike the piston nose and/or piston compression rings when the piston is lowered into the upper cylinder.

c. Raise the piston (6) with a lifting device and sling attached to the piston lifting eyebolt (5) so that the piston (6) hangs vertically in the sling. Lift the piston (6) into position directly above the upper cylinder. Align and then carefully lower the piston (6) into the cylinder. When all of the piston compression rings (8) are in the bore of the upper cylinder, lower the piston (6) until fully seated on the impact block.

NOTE

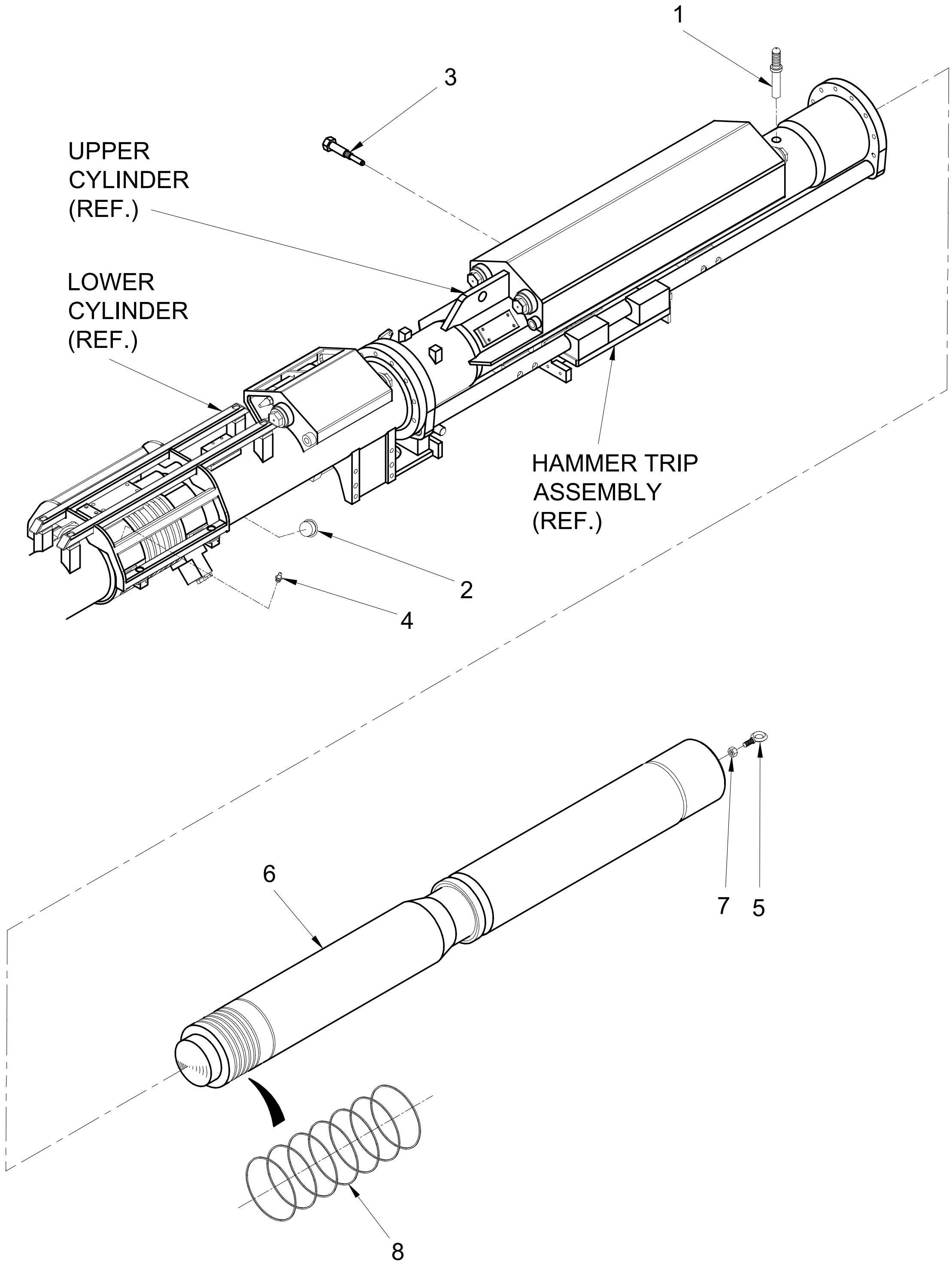
The top opening of the upper cylinder is tapered and will ease the entry of the piston compression rings into the upper cylinder.

d. Lower the impact hammer back down onto blocks.

e. Loosen the lock nut (7) and remove the piston lifting eyebolt (5) from the top of the piston (6).

f. Reinstall the four lower cylinder (impact block) lubrication fittings (4) on the lower cylinder.

g. Install the catch ring cap on the upper cylinder (Page K-52).



LEGEND

1. Piston Transportation Pin
2. Intake/Exhaust Port Weather Cap
3. Trip Transport Bolt
4. Lower Cylinder (Impact Block) Lubrication Fitting
5. Piston Lifting Eyebolt
6. Piston
7. Lock Nut
8. Piston Compression Rings

Figure K-22. Piston Installation

Fuel System – Fuel System Guard. (Refer to Figure K-23.)

The fuel system guard is normally removed to access the fuel pump and/or throttle valve (needle block).

Removal.

WARNING

Ensure the pressure has been relieved on the remote throttle prior to disconnecting the remote throttle hydraulic line.

a. Ensure the remote throttle hydraulic hose has been disconnected from the throttle connection on the impact hammer.

b. Using a suitable container to catch any hydraulic fluid, remove the male quick disconnect (1, Figure K-23) from the throttle valve whip line (2) at the throttle connection bracket on the fuel system guard (3).

c. Remove the eight fuel system guard bolts (4) and lockwashers (5) securing the fuel system guard (3) to the lower cylinder and four fuel system guard stabilizing brackets.

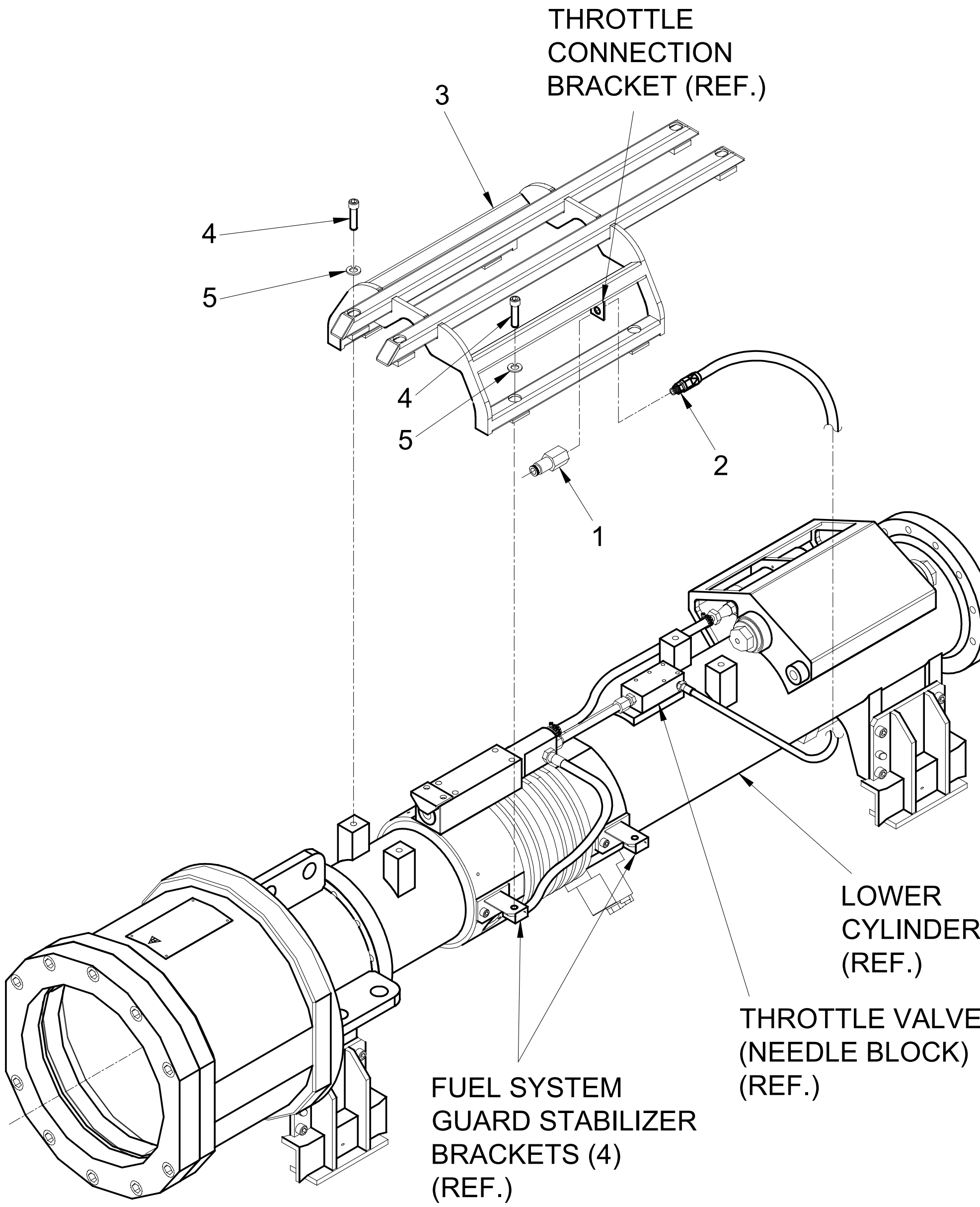
d. Remove the fuel system guard (3).

Installation.

a. Align the fuel system guard (3, Figure K-23) with the mounting holes on the lower cylinder and the four fuel system guard stabilizing brackets.

b. Place Loctite® 272 (red) on the eight fuel system guard bolts (4). Secure the fuel system guard (3) to the lower cylinder and four fuel system guard stabilizing brackets with the eight fuel system guard bolts (4) and lockwashers (5). Tighten the bolts and torque to 280 ft•lb (379 N•m).

c. Place Loctite® 545 (purple) on the threads of the throttle valve whip line (2). Insert the male quick disconnect (1) into the hole of the throttle connection bracket on the fuel system guard (3). Connect the throttle valve whip line (2) to the male quick disconnect (1) and tighten.



LEGEND

1. Male Quick Disconnect
2. Throttle Valve Whip Line
3. Fuel System Guard
4. Fuel System Guard Bolts, 5/8 x 1-1/4 LG NC SHCS
5. Lockwashers

Figure K-23. Fuel System Guard Installation

Fuel System – Fuel Pump. (Refer to Figure K-24.)

The fuel pump is normally removed for replacement.

Removal.

a. Remove the fuel system guard from the lower cylinder (Page K-57).

b. Close the fuel pump feed and return shutoff valves (handles perpendicular to the lines).

c. Using a suitable container to catch any fuel, disconnect the two braided fuel injector lines (1, Figure K-24) from the fuel injectors and then from the fuel pump (2).

d. Loosen the hose clamp (3) securing the rubber fuel line (4) to the fuel inlet fitting on the fuel pump (2) and disconnect the line from the fitting.

NOTE

The fuel inlet fitting on the fuel pump is a male, straight barbed fitting and the fuel outlet fitting is an adapter.

e. Remove the six fuel pump mounting bolts (6) and lockwashers (7) securing the fuel pump (2) to the lower cylinder. Retain the fuel pump adjusting screw keeper (8).

f. Disconnect the braided fuel line (5) from the fuel outlet fitting on the fuel pump (2).

g. Remove the fuel pump (2) from the lower cylinder and discard the fuel pump copper seal (9).

Installation.

a. Align the fuel pump (2, Figure K-24) and new fuel pump copper seal (9) with the mounting holes on the lower cylinder.

b. Connect the braided fuel line (5) to the fuel outlet fitting on the fuel pump (2).

c. Place Loctite® 272 (red) on the six fuel pump mounting bolts (6). Align the fuel pump adjusting screw keeper (8) with the mounting holes closest to the fuel pump adjusting screw (10) and secure the fuel pump (2) to the lower cylinder with the six fuel pump mounting bolts (6) and lockwashers (7). Tighten the bolts and torque to 150 ft•lb (203 N•m).

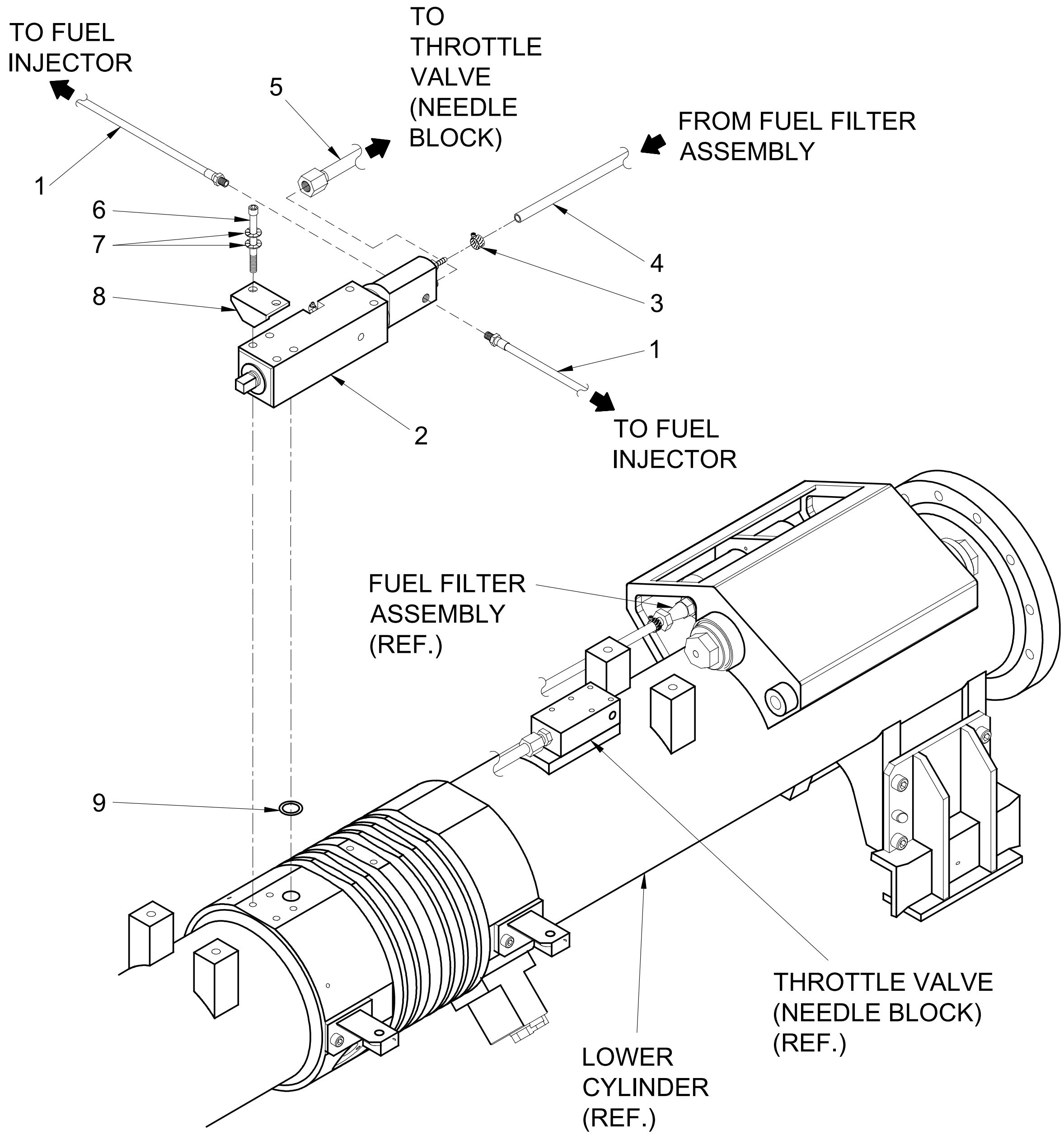
d. Connect the rubber fuel line (4) and hose clamp (3) to the fuel inlet fitting on the fuel pump (2). Tighten the hose clamp (3).

e. Place Teflon® tape on the threads of the two braided fuel injector lines (1) and connect the fuel injector lines (1) to the fuel pump (2). Connect the other end of each fuel injector line to the respective fuel injector.

f. Install the fuel system guard on the lower cylinder (Page K-57).

NOTE

Prior to starting the impact hammer, ensure fuel system has been bled by bleeding air from the fuel inlet line at each of the two fuel injectors in accordance with the Preventive Maintenance Checks and Services (PMCS) Table in Appendix H of the Operator's Manual, TM 5-3810-307-10.



LEGEND

1. Fuel Injector Line, Braided
2. Fuel Pump
3. Hose Clamp
4. Fuel Line, Rubber Hose
5. Fuel Line, Braided
6. Fuel Pump Mounting Bolts, (4) 1/2 x 3-3/4 NC SHCS, (2) 1/2 x 4 NC SHCS
7. Lockwasher, 1/2” Disc
8. Fuel Pump Adjusting Screw Keeper
9. Fuel Pump Copper Seal

Figure K-24. Fuel Pump Installation

Fuel System – Throttle Valve (Needle Block). (Refer to Figure K-25.)

The throttle valve (needle block) is normally removed for replacement.

Removal.

a. Remove the fuel system guard from the lower cylinder (Page K-57).

b. Close the fuel pump feed and return shutoff valves (handles perpendicular to the lines).

c. Using a suitable container to catch any hydraulic fluid, disconnect the hydraulic throttle valve whip line (1, Figure K-25) from the throttle valve (needle block) (2).

d. Using a suitable container to catch any fuel, loosen the hose clamp (3) securing the rubber fuel line (4) to the fuel outlet fitting on the throttle valve (needle block) (2) and disconnect the line from the fitting.

e. Remove the five throttle valve mounting bolts (6) and lockwashers (7) securing the throttle valve (needle block) (2) to the lower cylinder.

f. Disconnect the braided fuel line (5) from the fuel inlet fitting on the throttle valve (needle block) (2).

g. Remove the throttle valve (needle block) (2) from the lower cylinder.

Installation.

NOTE

The fuel outlet fitting and hex head pipe plug (bleed screw) are secured in the throttle valve (needle block) with Loctite® 545 (purple).

a. Align the throttle valve (needle block) (2, Figure K-25) with the mounting holes on the lower cylinder.

b. Connect the braided fuel line (5) to the fuel inlet fitting on the throttle valve (needle block) (2).

c. Place Loctite® 272 (red) on the five throttle valve mounting bolts (6). Secure the throttle valve (needle block) (2) to the lower cylinder with the five throttle valve mounting bolts (6) and lockwashers (7). Tighten the bolts and torque to 60 ft•lb (81 N•m).

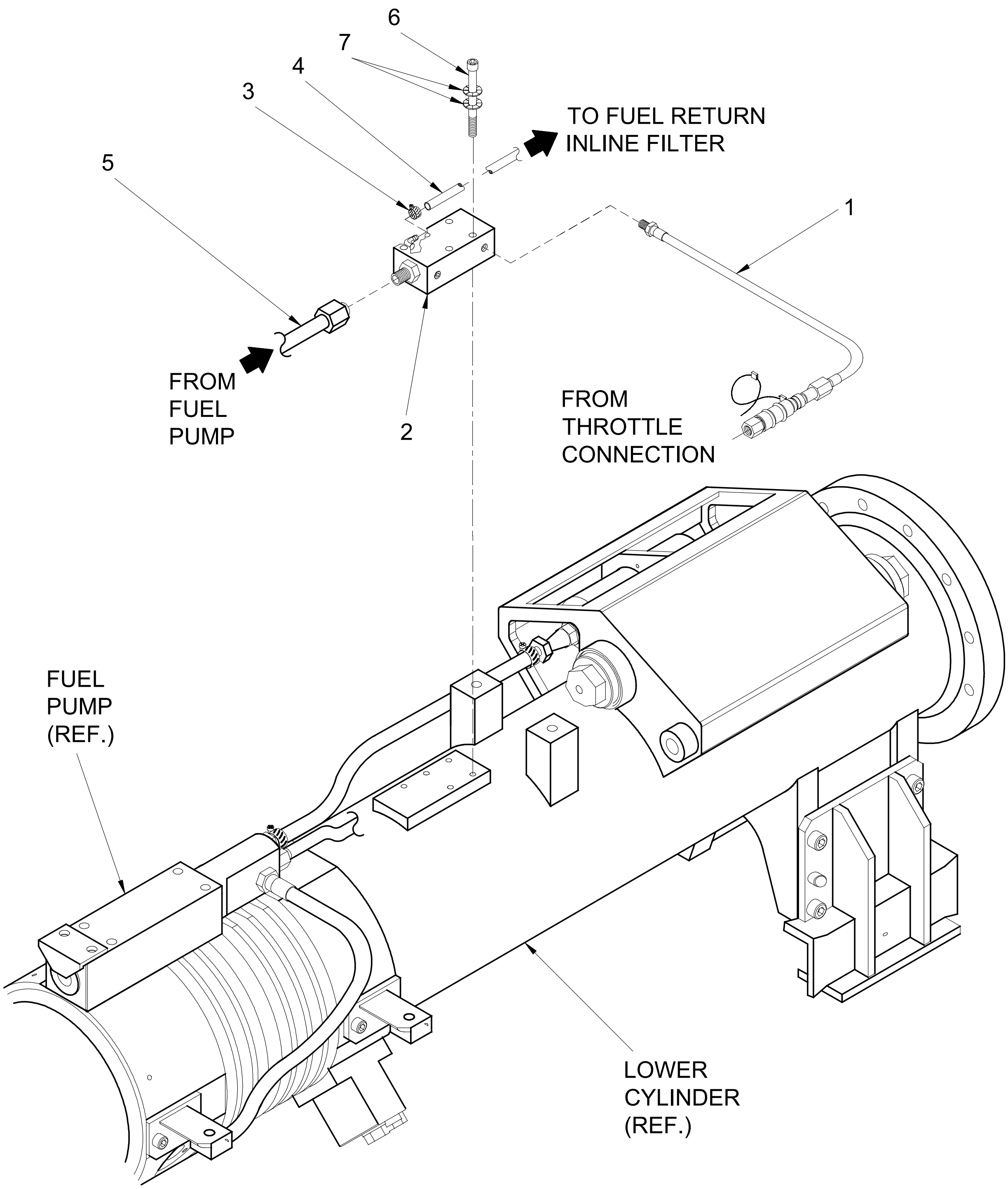
d. Connect the rubber fuel line (4) and hose clamp (3) to the fuel outlet fitting on the throttle valve (needle block) (2). Tighten the hose clamp (3).

e. Place Loctite® 545 (purple) on the threads of the hydraulic throttle valve whip line (1) and connect to the throttle valve (needle block) (2).

f. Install the fuel system guard on the lower cylinder (Page K-57).

NOTE

Prior to starting the impact hammer, ensure fuel system has been bled by bleeding air from the fuel inlet line at each of the two fuel injectors in accordance with the Preventive Maintenance Checks and Services (PMCS) Table in Appendix H of the Operator’s Manual, TM 5-3810-307-10.



LEGEND

1. Throttle Valve Whip Line
2. Throttle Valve (Needle Block)
3. Hose Clamp
4. Fuel Line, Rubber Hose
5. Fuel Line, Braided
6. Throttle Valve Mounting Bolt, 3/8 x 2-1/2 NC SHCS - Modified
7. Lockwasher, 3/8” Disc

Figure K-25. Throttle Valve (Needle Block) Installation

Fuel System – Fuel Injectors. (Refer to Figure K-26.)

The fuel injectors are normally removed for replacement.

Removal.

a. Close the fuel pump feed and return shutoff valves (handles perpendicular to the lines).

b. Using a suitable container to catch any fuel, disconnect the braided fuel injector line (1, Figure K-26) from the fuel injector (2).

c. Loosen the hose clamp (3) securing the rubber waste fuel line (4) to the waste fuel outlet fitting (5) on the fuel injector (2) and disconnect the line from the fitting (5).

d. Remove the waste fuel outlet fitting (5) from the fuel injector (2) and retain.

e. Remove the two injector clamp capscrews (6) securing the injector clamp (7) to the injector mounting base (carrier) (8). Remove the injector clamp (7).

f. Remove the injector (2) as an assembly and the brass washer (injector seal) (9) from the injector mounting base (carrier) (8).

NOTE

It is normally not required to remove the injector mounting base (carrier) (8) to replace the injector (2).

g. If replacement of the injector mounting base (carrier) (8) is necessary, remove the injector mounting base (carrier) (8) as follows:

1) Remove the three capscrews (10) securing the injector mounting base (carrier) (8) to the lower cylinder.

2) Remove the injector mounting base (carrier) (8) and the discard the bronze washer (injector carrier seal) (11) from the lower cylinder.

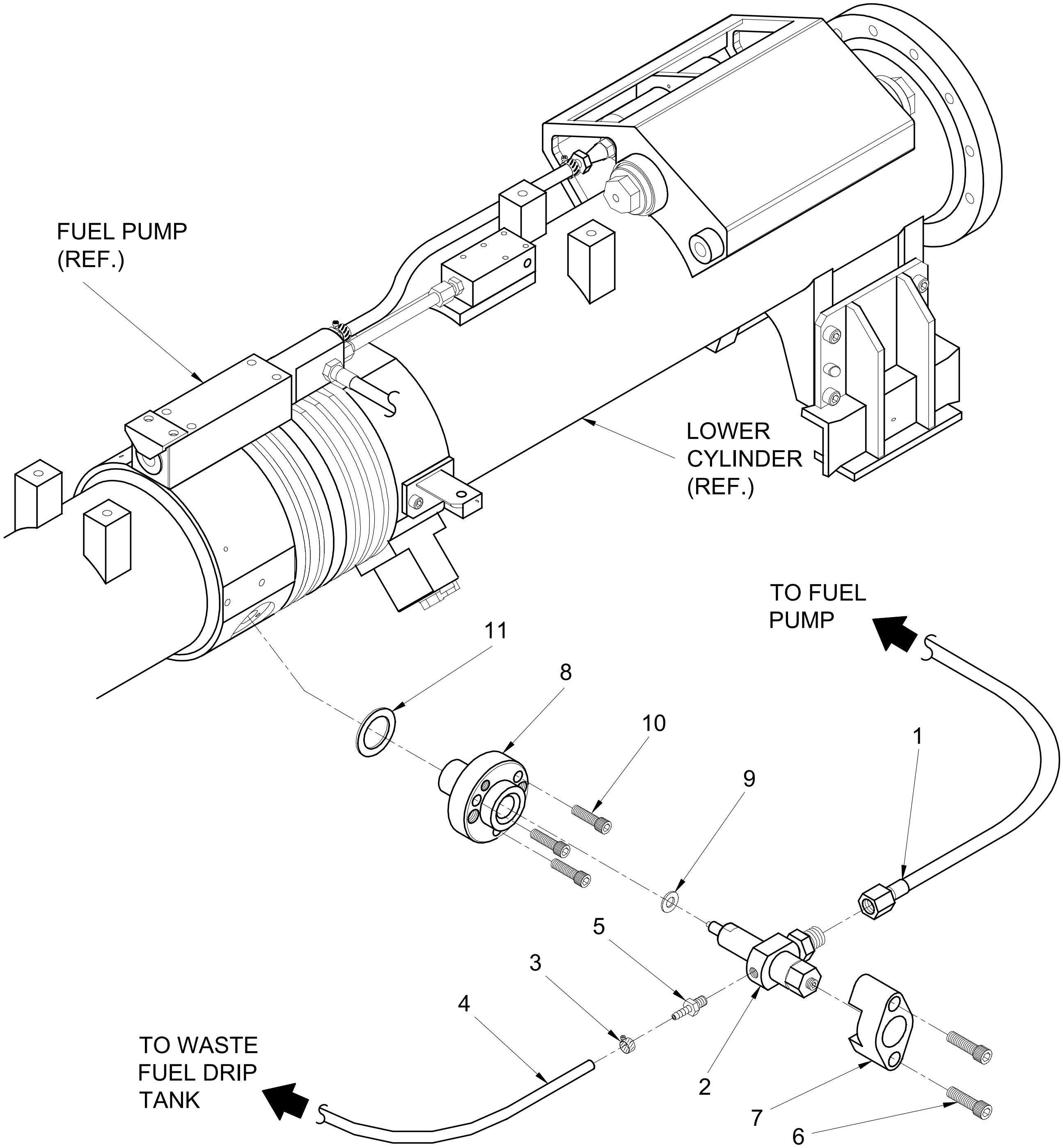
Installation.

a. If installation of the injector mounting base (carrier) (8, Figure K-26) is necessary, install the injector mounting base (carrier) (8) as follows:

1) Align the new bronze washer (injector carrier seal) (11) and injector mounting base (carrier) (8) with the mounting holes in the lower cylinder.

2) Place Loctite® 272 (red) on the three capscrews (10). Secure the injector mounting base (carrier) (8) and the bronze washer (injector carrier seal) (11) to the lower cylinder with the three capscrews (10). Tighten the capscrews and torque to 60 ft•lb (81 N•m).

b. Place the injector (2) assembly and the brass washer (injector seal) (9) in the injector mounting base (carrier) (8).



LEGEND

1. Fuel Injector Line, Braided
2. Injector
3. Hose Clamp
4. Waste Fuel Line, Rubber
5. Waste Fuel Outlet Fitting, Male 1/4 Barbed to 1/8 NPT
6. Injector Clamp Capscrew, 1/2 x 2-3/4 NC SHCS
7. Injector Clamp
8. Injector Mounting Base (Carrier)
9. Brass Washer (Injector Seal)
10. Capscrew, 3/8 x 1-1/2 NC SHCS
11. Bronze Washer (Injector Carrier Seal)

Figure K-26. Fuel Injector Installation

CAUTION

Failure to finger tighten the two injector clamp capscrews prior to tightening to final torque value may result in a deformed fuel injector.

c. Place Loctite® 272 (red) on the two injector clamp capscrews (6). Align the injector clamp (7) with the mounting holes on the injector mounting base (carrier) (8) and secure with the two injector clamp capscrews (6). Tighten both capscrews finger tight before tightening to final torque value of 50 ft•lb (68 N•m).

d. Place Loctite® 545 (purple) on the waste fuel outlet fitting (5) and install in the fuel injector (2).

e. Connect the rubber waste fuel line (4) and hose clamp (3) to the waste fuel outlet fitting (5) on the fuel injector (2). Tighten the hose clamp (3).

f. Connect the braided fuel injector line (1) to the fuel injector (2).

NOTE

Prior to starting the impact hammer, ensure fuel system has been bled by bleeding air from the fuel inlet line at each of the two fuel injectors in accordance with the Preventive Maintenance Checks and Services (PMCS) Table in Appendix H of the Operator's Manual, TM 5-3810-307-10.

Fuel System – Fuel Pump Feed and Fuel Return Inline Filters. (Refer to Figure K-27.)

The fuel pump feed and return inline filters are normally removed for replacement.

Removal.

a. Close the fuel pump feed and return shutoff valves (handles perpendicular to the lines).

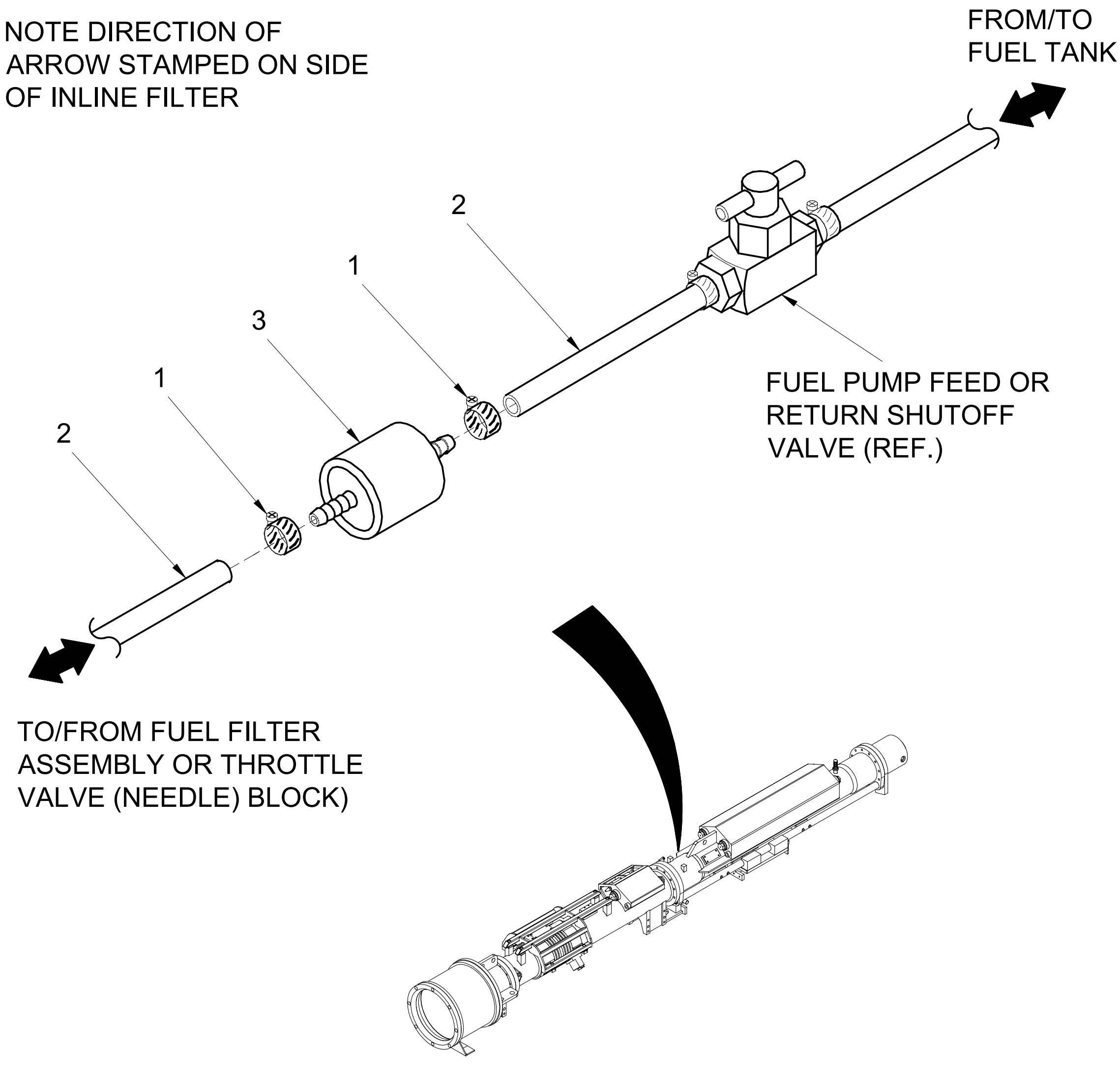
b. Using a suitable container to catch any fuel, loosen the two hose clamps (1, Figure K-27) securing the two rubber fuel lines (2) to the inline filter (3) and disconnect the lines. Note the direction of the arrow marked on the inline filter (3), remove the inline filter (3), and discard.

Installation.

a. Connect the two rubber fuel lines (2, Figure K-27) and hose clamps (1) to the proper fittings on the replacement inline filter (3) with the arrow marked on the side facing in the same direction noted during removal. Tighten the hose clamps (2).

NOTE

Prior to starting the impact hammer, ensure fuel system has been bled by bleeding air from the fuel inlet line at each of the two fuel injectors in accordance with the Preventive Maintenance Checks and Services (PMCS) Table in Appendix H of the Operator's Manual, TM 5-3810-307-10.



LEGEND

1. Hose Clamp
2. Fuel Line, Rubber
3. Fuel Pump Feed and Fuel Return Inline Filter

Figure K-27. Fuel Pump Feed and Fuel Return Inline Filter Installation

Fuel System – Fuel Filter Element in Fuel Filter Assembly. (Refer to Figure K-28.)

The fuel filter element in the fuel filter assembly is normally removed for replacement.

Removal.

a. Close the fuel pump feed and return shutoff valves (handles perpendicular to the lines).

b. Using a suitable container to catch any fuel, remove the four capscrews (1, Figure K-28) securing the end cap (2) to the fuel filter assembly (3).

c. Remove the end cap (2) and discard end cap o-ring (4).

d. Remove the fuel filter element (5) from the fuel filter assembly (3) by pulling on the ring.

e. Remove the plastic spacer (6) from the end of the fuel filter element (5). Retain the plastic spacer (6) and discard the fuel filter element (5).

Installation.

a. Place the plastic spacer (6, Figure K-28) on the end (without pull ring) of a replacement fuel filter element (5) and secure in place by aligning the tabs and turning.

b. Insert the fuel filter element (5) with plastic spacer (6) into the fuel filter assembly (3). Turn the fuel filter element (5) so that the pull ring will be aligned with the notches in the center ring of the end cap (2).

NOTE

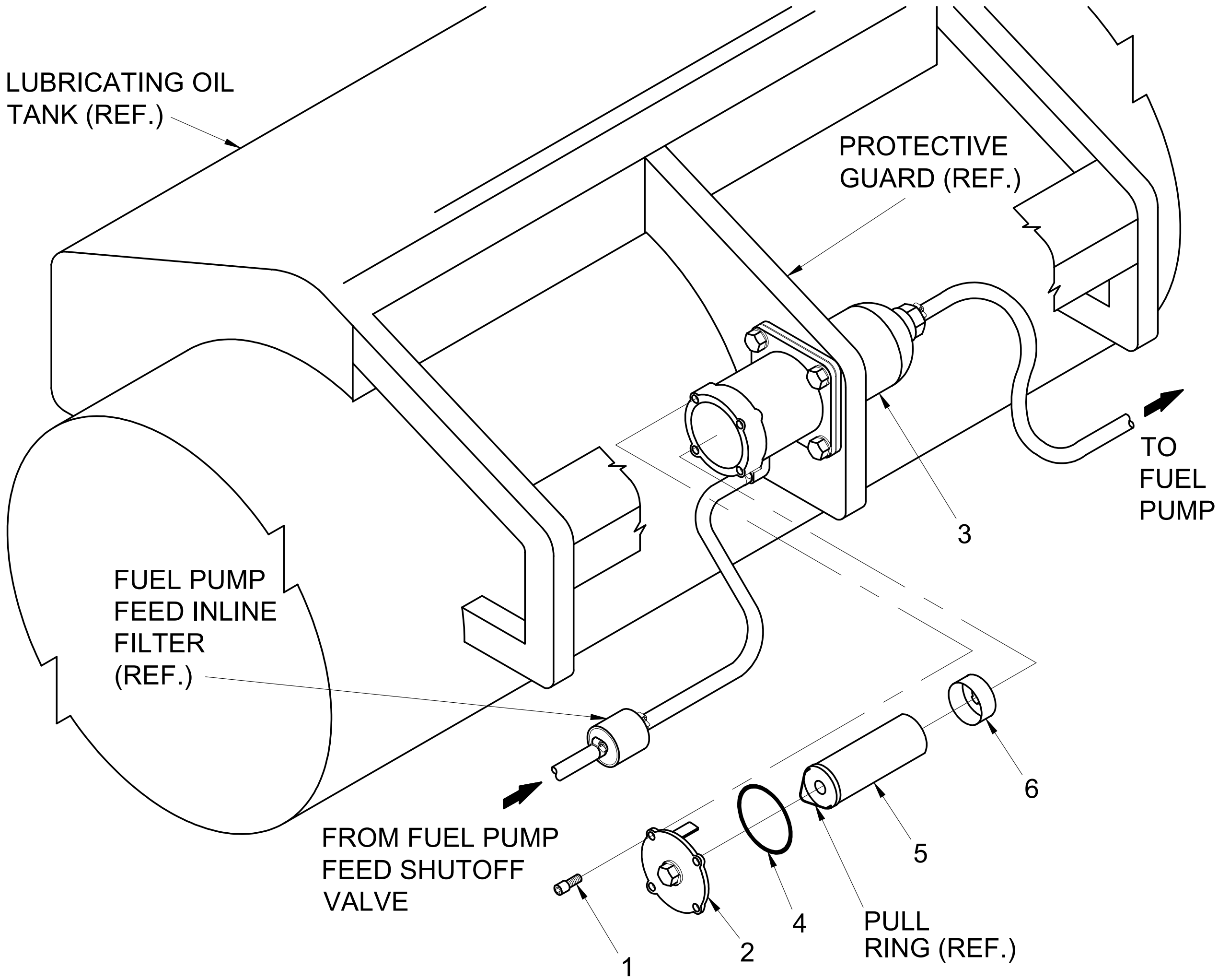
The tab on the end cap (2) also aligns with the body of the fuel filter assembly (3).

c. Place a new end cap o-ring (4) into the groove on the end cap (2) and align the end cap (2) with the holes on the fuel filter assembly (3).

d. Place Loctite® 272 (red) on the four capscrews (1). Secure the end cap (2) to the fuel filter assembly (3) with the four capscrews (1).

NOTE

Prior to starting the impact hammer, ensure fuel system has been bled by bleeding air from the fuel inlet line at each of the two fuel injectors in accordance with the Preventive Maintenance Checks and Services (PMCS) Table in Appendix H of the Operator's Manual, TM 5-3810-307-10.



LEGEND

1. Capscrews
2. End Cap
3. Fuel Filter Assembly
4. End Cap O-ring
5. Fuel Filter Element
6. Plastic Spacer

Figure K-28. Fuel Filter Element Installation

Fuel System – Fuel Filter Assembly. (Refer to Figure K-29.)

The fuel filter assembly is only removed as an assembly when replacement of the entire assembly is required.

Removal.

a. Close the fuel pump feed and return shutoff valves (handles perpendicular to the lines).

b. Using a suitable container to catch any fuel, loosen the hose clamp (1, Figure K-29) securing the rubber fuel line (2) to the outlet fitting (3) on the fuel filter assembly (4) and disconnect the line from the fitting (3).

NOTE

The fuel outlet fitting on the fuel filter assembly is a male, straight barbed fitting in the nose end of the fuel filter assembly and the fuel inlet fitting is a male, elbow barbed fitting in the side.

c. Loosen the hose clamp (5) securing the rubber fuel line (6) to the inlet fitting (7) on the fuel filter assembly (4) and disconnect the line from the fitting (7).

d. Remove the four fuel filter assembly mounting bolts (8) and flat washers (9) securing the fuel filter assembly (4) to the protective guard. Remove the fuel filter assembly (4) and rubber gasket (10). Discard the rubber gasket (10).

e. Remove the outlet fitting (3) from the NPT outlet adapter (11).

f. Remove the NPT outlet adapter (11) from the fuel filter assembly (4).

g. Remove the inlet fitting (7) from the fuel filter assembly (4).

Installation.

a. Place Loctite® 545 (purple) on the inlet fitting (7, Figure K-29) and install in the fuel filter assembly (4).

b. Place Loctite® 545 (purple) on the NPT outlet adapter (11) and install in the fuel filter assembly (4).

c. Place Loctite® 545 (purple) on the outlet fitting (3) and install in the NPT outlet adapter (11).

d. Slide the replacement fuel filter assembly (4) and the rubber gasket (10) behind the protective guard and align the mounting holes with the holes in the protective guard.

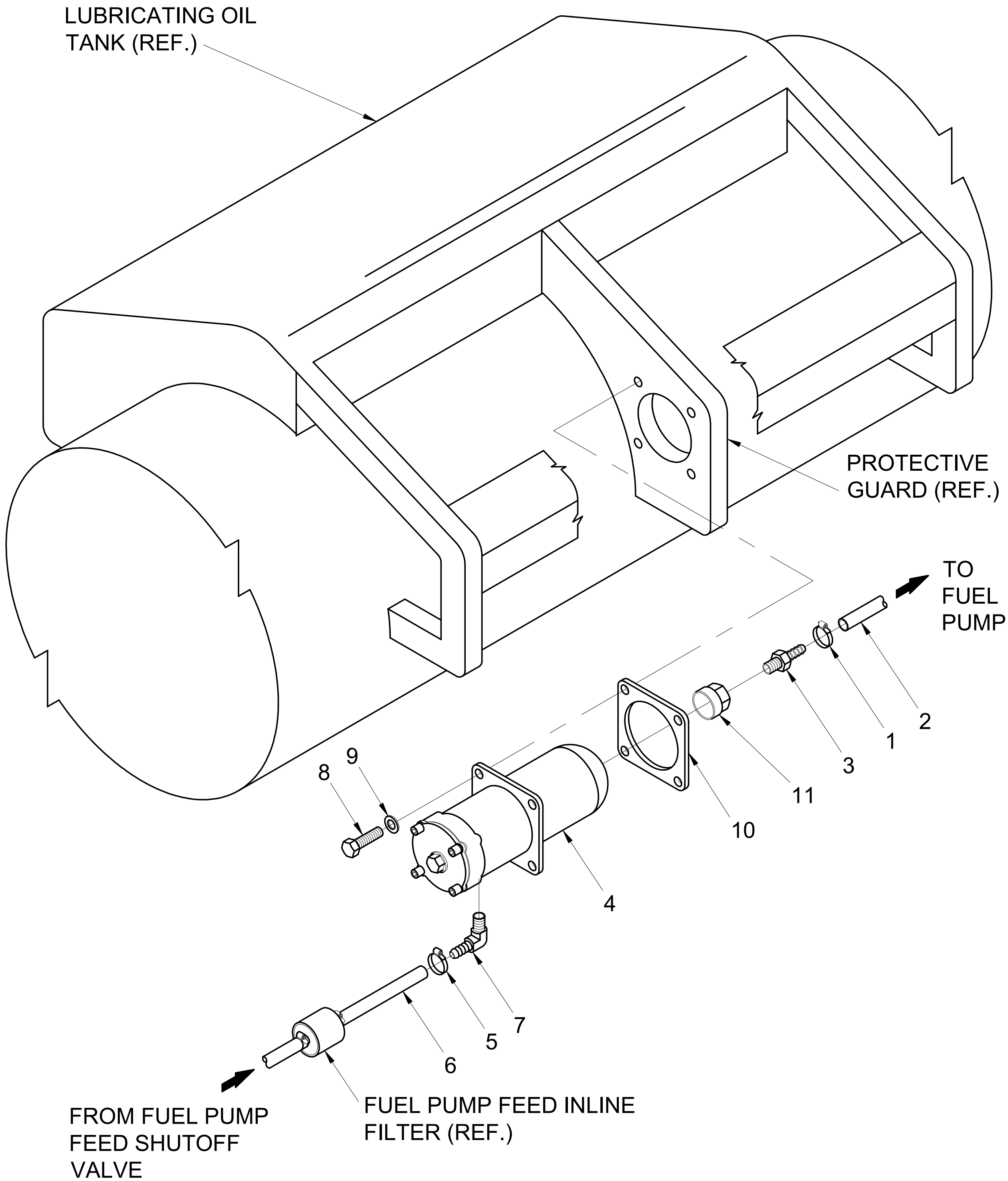
e. Place Loctite® 272 (red) on the four fuel filter assembly mounting bolts (8). Secure the fuel filter assembly (4) to the protective guard with the four fuel filter assembly mounting bolts (8) and flat washers (9).

f. Connect the rubber fuel line (6) and hose clamp (5) to the inlet fitting (7) on the fuel filter assembly (4). Tighten the hose clamp (5).

g. Connect the rubber fuel line (2) and hose clamp (1) to the outlet fitting (3) on the fuel filter assembly (4). Tighten the hose clamp (1).

NOTE

Prior to starting the impact hammer, ensure fuel system has been bled by bleeding air from the fuel inlet line at each of the two fuel injectors in accordance with the Preventive Maintenance Checks and Services (PMCS) Table in Appendix H of the Operator's Manual, TM 5-3810-307-10.



LEGEND

1. Hose Clamp
2. Fuel Line, Rubber
3. Outlet Fitting
4. Fuel Filter Element
5. Hose Clamp
6. Fuel Line, Rubber
7. Inlet Fitting
8. Fuel Filter Element Mounting Bolts, 1/4x 1 LG HHCS
9. Flat Washer
10. Rubber Gasket
11. NPT Outlet Adapter

Figure K-29. Fuel Filter Assembly Installation

Fuel System – Fuel Tank Suction Strainers. (Refer to Figure K-30)

The fuel tank suction strainers are normally removed for replacement.

Removal.

a. Completely drain the fuel tank. Close the fuel pump feed and return shutoff valves (handles perpendicular to the lines).

NOTE

A small amount of fuel will remain in the drained fuel tank because the suction strainers are higher than the bottom of the fuel tank. Use a suitable container to catch the remaining fuel.

b. Using a suitable container to catch any fuel, loosen the hose clamp (1, Figure K-30) securing the rubber fuel line (2) to the outlet fitting on the suction strainer mounting base (3) and disconnect the line from the fitting.

c. Slowly unscrew the suction strainer mounting base (3), with the suction strainer element (4) attached, from the fuel tank (5). Use a suitable container to catch the remaining fuel in the fuel tank (5). Remove the suction strainer mounting base (3), with the suction strainer element (4) attached, and the suction strainer mounting base o-ring (6). Discard the suction strainer mounting base o-ring (6).

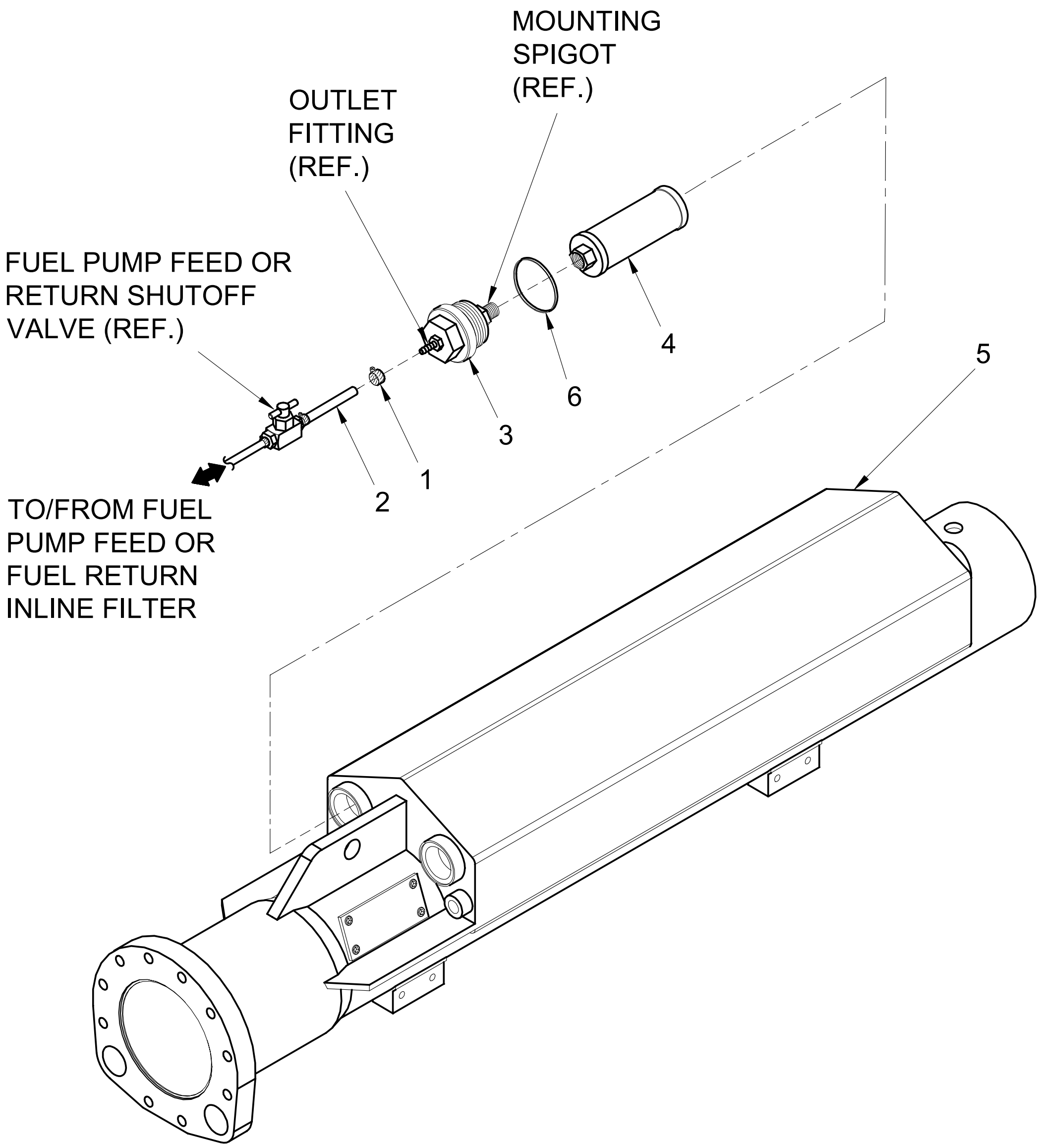
d. Unscrew the suction strainer element (4) from the mounting spigot on the suction strainer mounting base (3).

Installation.

a. Place Teflon® tape on the threads of the mounting spigot on the suction strainer mounting base (3, Figure K-30) and screw the replacement suction strainer element (4) into the mounting spigot.

b. Align a new suction strainer mounting base o-ring (6) on the suction strainer mounting base (3) and screw the mounting base, with the suction strainer element (4) attached, into the fuel tank (5).

c. Connect the rubber fuel line (2) and hose clamp (1) to the outlet fitting on the suction strainer mounting base (3). Tighten the hose clamp (1).



LEGEND

1. Hose Clamp
2. Fuel Line, Rubber
3. Suction Strainer Mounting Base
4. Suction Strainer Element
5. Fuel Tank
6. Suction Strainer Mounting Base O-ring

Figure K-30. Fuel Tank Suction Strainer Installation

Hammer Trip System – Hammer Trip Assembly. (Refer to Figures K-31 and K-32.)

The hammer trip assembly is normally removed to inspect or to remove the hammer trip track rails. The hammer trip assembly is normally disassembled for replacement of components.

Removal.

a. If removed, install the trip transport bolt (1, Figure K-31), and position the hammer trip assembly (2) in between the fuel tank and the upper cylinder to lower cylinder mounting flange.

b. Support the hammer trip assembly (2) with a jack.

c. Remove the two trip gib bolts (3) from the upper trip gib (4) on the left-hand side of the impact hammer. Remove the upper trip gib (4).

d. Remove the two trip gib bolts (3) from the lower trip gib (4) on the left-hand side of the impact hammer. Remove the lower trip gib (4).

e. Push the hammer trip assembly (2) slightly towards the right-hand side of the impact hammer, allowing the other two trip gibs (4) to clear the hammer trip track rail on the right-hand side of the impact hammer. Remove the hammer trip assembly (2) from the hammer trip track rails.

f. Remove the trip transport bolt (1) from the hammer trip assembly (2).

Disassembly.

a. Remove the four leaf spring bolts (1, Figure K-32) securing the leaf spring (2) to the hammer trip housing and backplate (3).

b. Move the cam (4) and drive out the roll pins (cam to shaft) (5) securing the lever and shaft (6) to the cam (4). Discard the roll pins (cam to shaft) (5).

c. Drive out the lever and shaft (6) from the cam (4).

d. Move the lifting pawl (7) and drive out the roll pins (8) securing the lifting pawl (7) to the stop pin (9). Discard the roll pins (8).

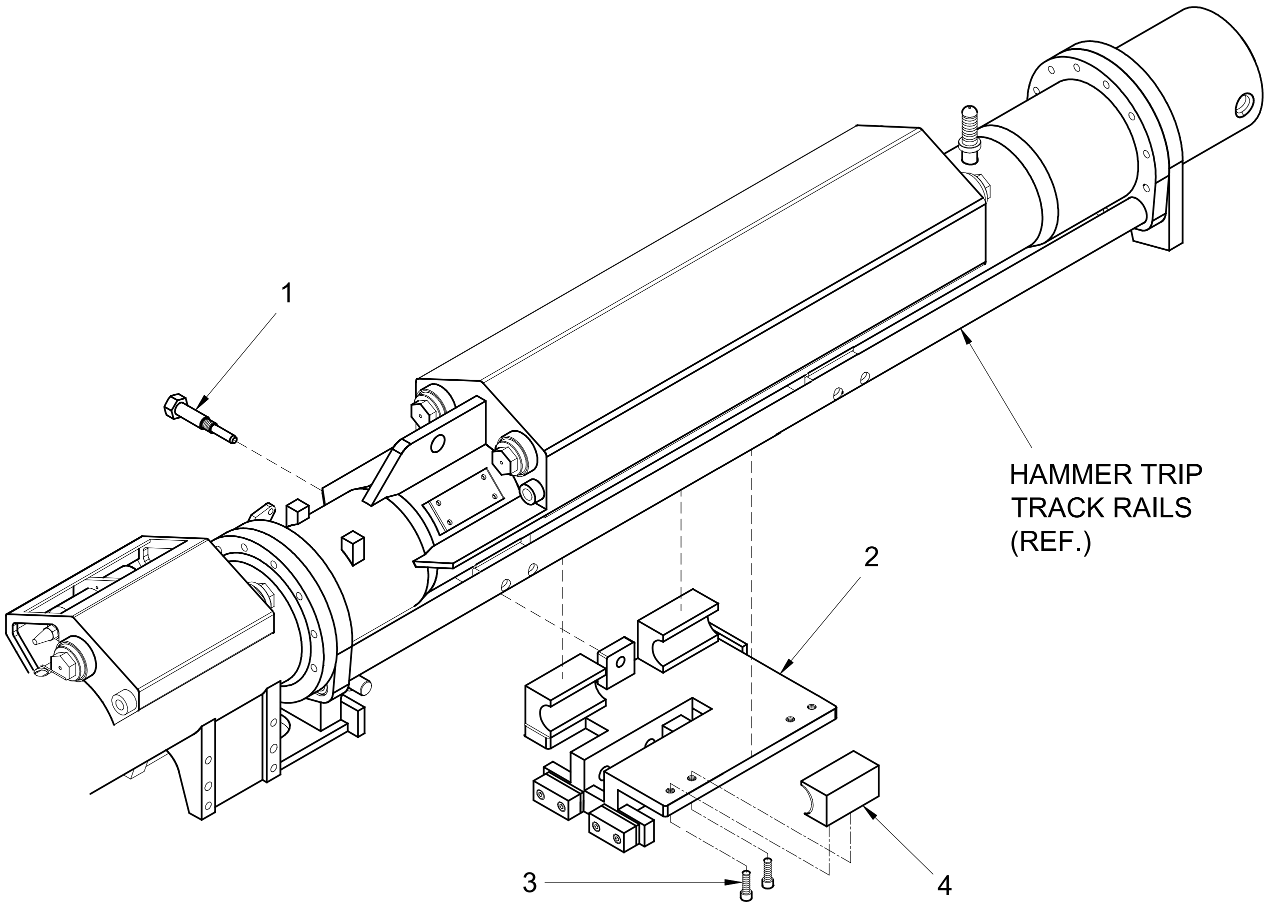
e. Drive out the stop pin (9) from the lifting pawl (7).

f. Remove the two link pins (10) securing the two connecting links (11) to the cam (4) and the lifting pawl (7). Retain the link pins (10).

g. Drive out the roll pins (12) securing the stop pin (13) to the hammer trip housing and backplate (3). Discard the roll pins (12).

h. Remove the two lower bumper mounting bolts (14) securing each lower bumper (15) to the hammer trip housing and backplate (3). Remove the two lower bumpers (15).

i. Remove the two trip gib bolts (16) securing the each trip gib (17) to the hammer trip housing and backplate (3). Remove the trip gibs (17).



LEGEND

1. Trip Transport Bolt
2. Hammer Trip Assembly
3. Trip Gib Bolts, 3/4-10 NC 2 LG SHCS
4. Trip Gib

Figure K-31. Hammer Trip Assembly Installation

Inspection.

a. Inspect all parts of the hammer trip assembly for wear, especially link pins (10, Figure K-32), cam (4), and lifting pawl (7). Replace any bent link pins (10).

b. Inspect each pin boss on the lifting pawl (7), cam (4), and connector links (11). Replace if any have gone out of round.

Reassembly.

NOTE

Replace all roll pins (5, 8, and 12, Figure K-32) when reassembling the hammer trip assembly. Also, use Loctite® 272 on all bolts.

a. Place Loctite® 272 (red) on the four trip gib bolts (16, Figure K-32). Align two trip gibs (17) with the mounting holes on one side of the hammer trip housing and backplate (3). Secure the trip gibs (17) to the hammer trip housing and backplate (3) with the two trip gib bolts (16). Tighten the bolts and torque to 500 ft•lb (677 N•m).

NOTE

Only install two trip gibs on one side of the hammer trip assembly in order to be able to install the hammer trip assembly on the hammer trip track rails.

b. Place Loctite® 272 (red) on the four lower bumper mounting bolts (14). Align the two lower bumpers (15) with the mounting holes in the hammer trip housing and backplate (3). Secure the lower bumpers (15) to the hammer trip housing and backplate (3) with the lower bumper mounting bolts (14). Tighten the bolts and torque to 150 ft•lb (203 N•m).

c. Install the stop pin (13) in the hammer trip housing and backplate (3) and secure with two new roll pins (12).

d. Install the two connecting links (11) on the lifting pawl (7) and secure with a link pin (10). Install the other side of the connecting links (11) on the cam (4) and secure with the second link pin (10).

e. Install the stop pin (9) in the lifting pawl (7). Secure the stop pin (9) in the lifting pawl (7) with two new roll pins (8).

f. Install the lever and shaft (6) in the cam (4) and secure with two new roll pins (cam to shaft) (5).

g. Place Loctite® 272 (red) on the four leaf spring bolts (1). Align the leaf spring (2) with the mounting holes in the hammer trip housing and backplate (3) and secure with four leaf spring bolts (1). Tighten to 45 ft•lb (91 N•m).

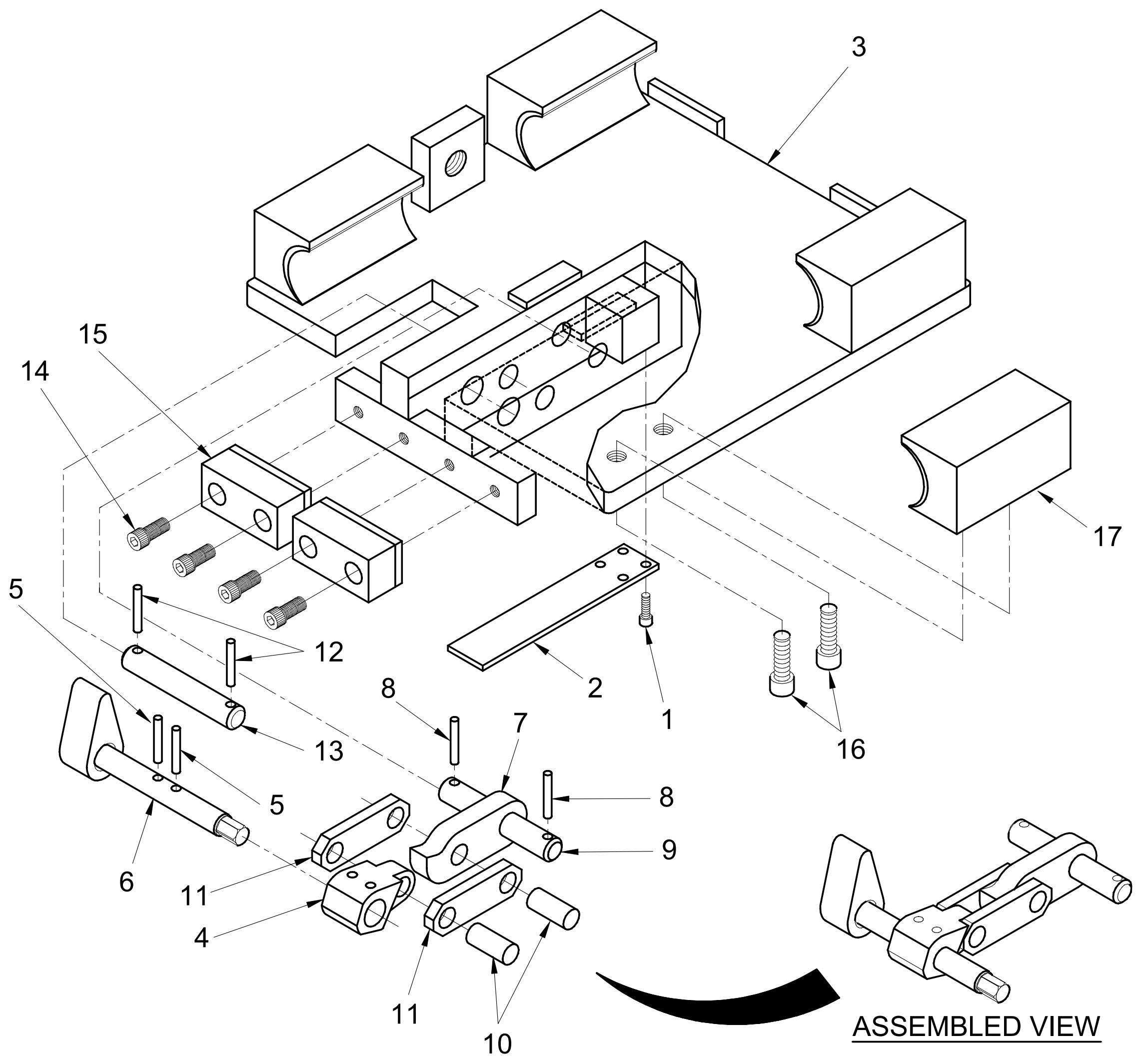
Installation.

a. Support the hammer trip assembly (2, Figure K-31) with a jack.

b. With two trip gibs (4) on one side of the hammer trip assembly (2) removed, raise the hammer trip assembly and slide the two installed trip gibs (4) over the hammer trip track rail.

c. Place Loctite® 272 (red) on the two trip gib bolts (3). Place the lower trip gib (4) over the hammer trip track rail and align with the mounting holes in the hammer trip assembly (2). Secure the lower trip gib (4) to the hammer trip assembly (2) with the two trip gib bolts (3). Tighten the bolts and torque to 500 ft•lb (677 N•m).

d. Place Loctite® 272 (red) on the two trip gib bolts (3). Place the upper trip gib (4) over the hammer trip track rail and align with the mounting holes in the hammer trip assembly (2). Secure the upper trip gib (4) to the hammer trip assembly (2) with the two trip gib bolts (3). Tighten the bolts and torque to 500 ft•lb (677 N•m).



LEGEND

1. Leaf Spring Bolt, 3/8-16 NC 1 LG SHCS
2. Leaf Spring
3. Hammer Trip Housing and Backplate
4. Cam
5. Roll Pin (Cam to Shaft), 3/8 x 2-inch
6. Lever and Shaft
7. Lifting Pawl
8. Roll Pin, 1/4 x 1-1/2-inch
9. Stop Pin
10. Link Pin
11. Connector Link
12. Roll Pin, 1/4 x 1-1/2-inch
13. Stop Pin
14. Lower Bumper Bolt, 1/2 x 3/4 NC SHCS
15. Lower Bumper
16. Trip Gib Bolt, 3/4 x 2 NC SHCS
17. Trip Gib

Figure K-32. Hammer Trip Assembly Disassembly

Hammer Trip System – Hammer Trip Track Rails. (Refer to Figure K-33.)

The hammer trip track rails are normally removed to inspect and/or for replacement.

Removal.

a. Remove the hammer trip assembly from the hammer trip track rails (Page K-72).

b. Remove the catch ring cap from the upper cylinder (Page K-52).

c. Remove the two trip track rail end caps (1, Figure K-33).

d. Remove the eight trip track rail spacer bolts (2) securing the four trip track rail spacers (3). Remove the four trip track rail spacers (3).

e. Slide the two trip track rails (4) out from the top of the impact hammer.

Inspection.

a. Inspect the two trip track rails (4, Figure K-33) for cracks and wear. Ensure trip track rails are straight.

NOTE

A new trip gib can be held against and slid along the trip track rails to inspect for bent trip track rails.

Installation.

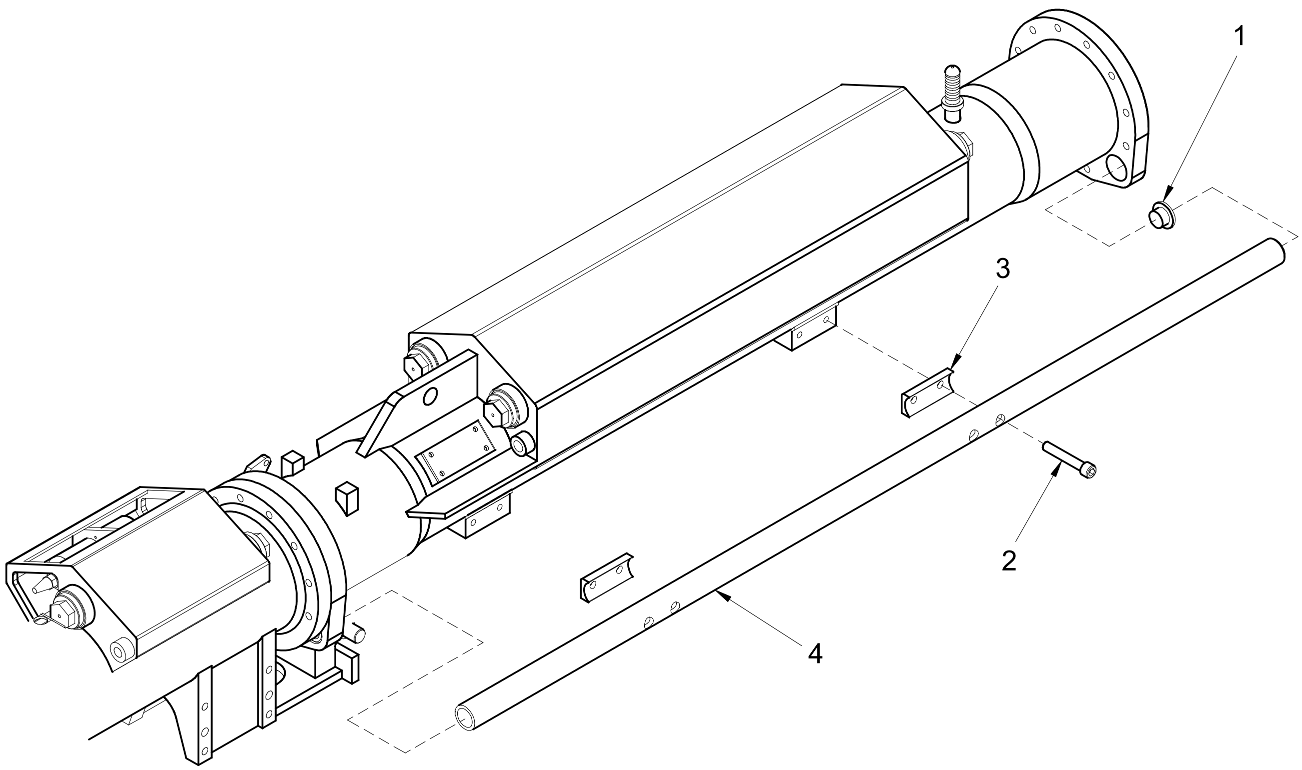
a. Slide the two trip track rails (4, Figure K-33) in from the top of the impact hammer.

b. Place Loctite® 272 (red) on the eight trip track rail spacer bolts (2). Align each trip track rail spacer (3) with the mounting holes. Secure the trip track rail spacers (3) with the trip track rail spacer bolts (2). Tighten the bolts and torque to 280 ft•lb (379 N•m).

c. Install the two trip track rail end caps (1).

d. Install the catch ring cap on the upper cylinder (Page K-52).

e. Install the hammer trip assembly on the hammer trip track rails (Page K-72).



LEGEND

1. Trip Track Rail End Caps
2. Trip Track Rail Spacer Bolts, 5/8-11 NC 1-1/2 LG SHCS
3. Trip Track Rail Spacer
4. Hammer Trip Track Rails

Figure K-33. Hammer Trip Track Rails Installation

Lubricating Oil System – Oil Pump. (Refer to Figure K-34.)

The oil pump is normally removed for replacement.

Removal.

a. Close the oil pump feed shutoff valve (handle perpendicular to the lines).

b. Using a suitable container to catch any oil, loosen the hose clamp (1, Figure K-34) securing the rubber oil line (2) to the oil inlet fitting on the oil pump (3) and disconnect the line from the fitting.

c. Loosen the hose clamp (4) securing the rubber oil line (5) to the oil outlet fitting on the oil pump (3) and disconnect the line from the fitting.

d. Loosen the hose clamp (6) securing the rubber oil line (7) to the waste oil outlet fitting on the oil pump (3) and disconnect the line from the fitting.

e. Remove the four oil pump mounting bolts (8) securing the oil pump (3) to the lower cylinder.

f. Remove the oil pump (3) from the lower cylinder.

Installation.

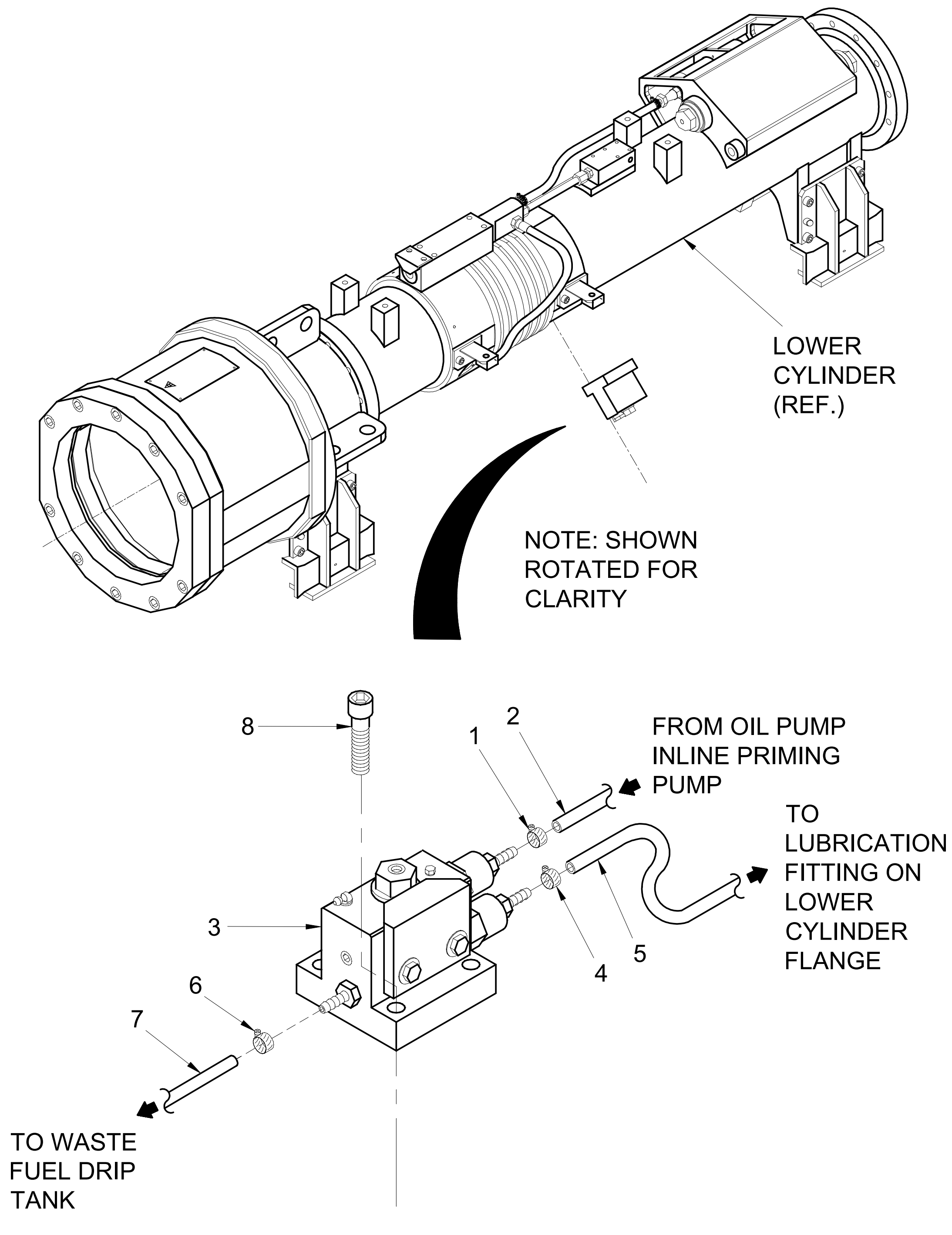
a. Align the oil pump (3, Figure K-34) with the mounting holes on the lower cylinder.

b. Place Loctite® 272 (red) on the four oil pump mounting bolts (8). Secure the oil pump (3) to the lower cylinder with the four oil pump mounting bolts (8). Tighten the bolts and torque to 150 ft•lb (203 N•m).

c. Connect the rubber waste oil line (7) and hose clamp (6) to the waste oil outlet fitting on the oil pump (3). Tighten the hose clamp (6).

d. Connect the rubber oil line (5) and hose clamp (4) to the oil outlet fitting on the oil pump (3). Tighten the hose clamp (4).

e. Connect the rubber oil line (2) and hose clamp (1) to the oil inlet fitting on the oil pump (3). Tighten the hose clamp (1).



LEGEND

1. Hose Clamp
2. Oil Line, Rubber
3. Oil Pump
4. Hose Clamp
5. Oil Line, Rubber
6. Hose Clamp
7. Waste Oil Line, Rubber
8. Oil Pump Mounting Bolts, 1/2 x 2-1/2 NC SHCS

Figure K-34. Oil Pump Installation

<u>Lubricating Oil System – Oil Tank Suction Strainers. (Refer to Figure K-35.)</u>

The oil tank suction strainers are normally removed for replacement.

Removal.

a. Remove the fuel system guard (page K-56).

b. Completely drain the lubricating oil tank. Close the oil pump feed shutoff valve (handle perpendicular to the lines).

NOTE

A small amount of oil will remain in the drained lubricating oil tank because the suction strainers are higher than the bottom of the lubricating oil tank. Use a suitable container to catch the remaining oil.

c. Using a suitable container to catch any oil, loosen the hose clamp (1, Figure K-35) securing the rubber oil line (2) to the outlet fitting on the suction strainer mounting base (3) and disconnect the line from the fitting.

d. Slowly unscrew the suction strainer mounting base (3), with the suction strainer element (4) attached, from the lubricating oil tank (5). Use a suitable container to catch the remaining oil in the lubricating oil tank (5). Remove the suction strainer mounting base (3), with the suction strainer element (4) attached, and the suction strainer mounting base o-ring (6). Discard the suction strainer mounting base o-ring (6).

e. Unscrew the suction strainer element (4) from the mounting spigot on the suction strainer mounting base (3).

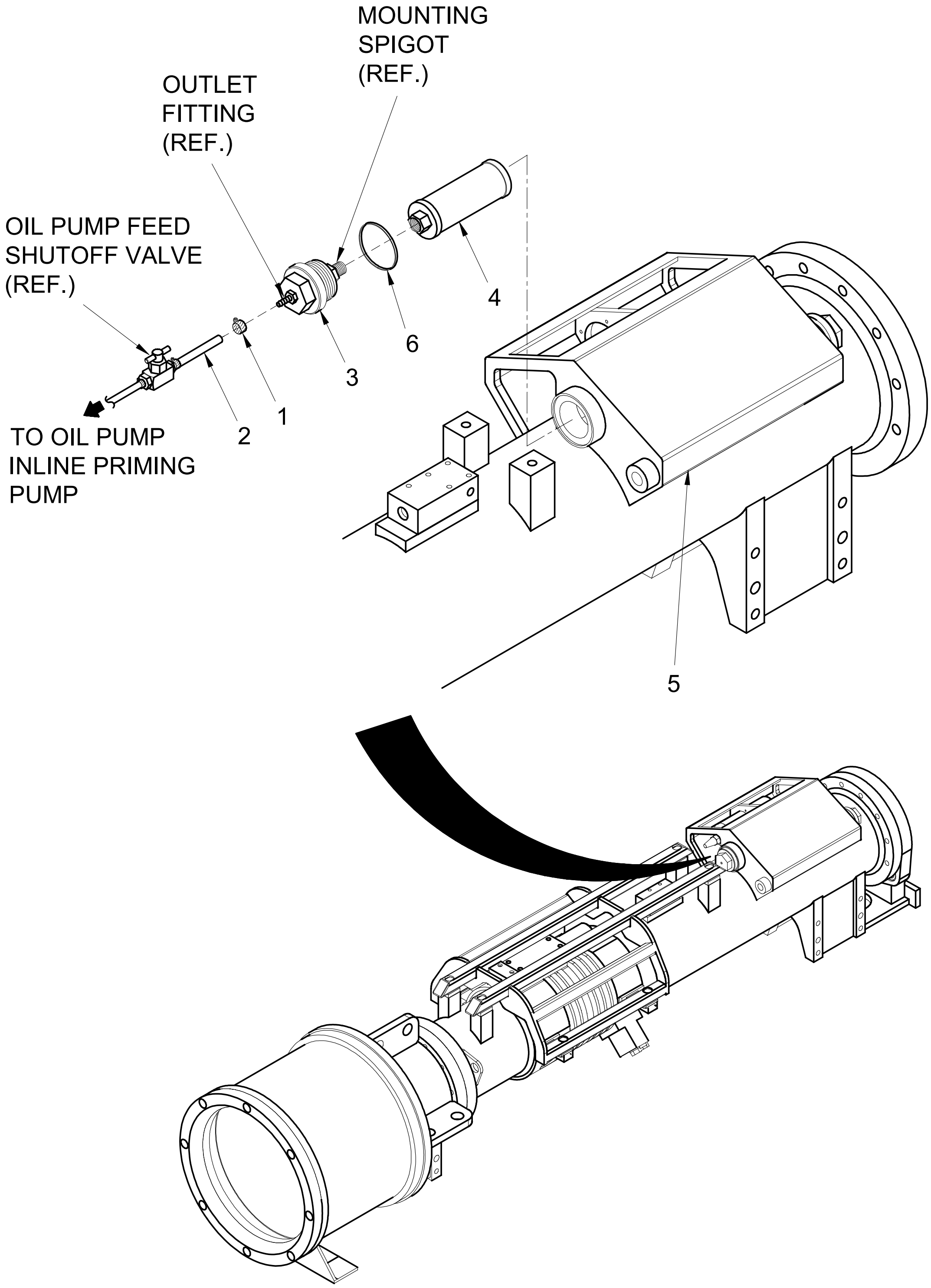
Installation.

a. Place Teflon® tape on the threads of the mounting spigot on the suction strainer mounting base (3, Figure K-35) and screw the replacement suction strainer element (4) into the mounting spigot.

b. Align a new suction strainer mounting base o-ring (6) on the suction strainer mounting base (3) and screw the mounting base, with the suction strainer element (4) attached, into the lubricating oil tank (5).

c. Connect the rubber oil line (2) and hose clamp (1) to the outlet fitting on the suction strainer mounting base (3). Tighten the hose clamp (1).

d. Install the fuel system guard (page K-56).



LEGEND

1. Hose Clamp
2. Oil Line, Rubber
3. Suction Strainer Mounting Base
4. Suction Strainer Element
5. Lubricating Oil Tank
6. Suction Strainer Mounting Base O-ring

Figure K-35. Lubricating Oil Tank Suction Strainer Installation

Waste Fuel Drip Tank. (Refer to Figure K-36.)

The waste fuel drip tank is normally removed for replacement.

Removal.

a. Completely drain the waste fuel drip tank.

b. Using a suitable container to catch any waste fuel or oil, loosen the two hose clamps (1, Figure K-36) securing the two rubber fuel lines (2) to the fuel inlet fittings (3) on the top of the waste fuel drip tank (4) and disconnect the lines from the fittings.

c. Loosen the hose clamp (5) securing the rubber oil line (6) to the oil inlet fitting (7) on the top of the waste fuel drip tank (4) and disconnect the line from the fitting.

d. Remove the two waste fuel drip tank mounting bolts (8) securing the waste fuel drip tank (4) to the direct drive assembly. Remove the waste fuel drip tank (4) from the direct drive assembly.

e. Remove the two fuel inlet fittings (3) from the top of the waste fuel drip tank (4) and retain.

f. Remove the one oil inlet fitting (7) from the top of the waste fuel drip tank (4) and retain.

g. Remove the waste fuel drip tank vent valve (9) from the top of the waste fuel drip tank (4) and retain.

h. Remove the waste fuel drip tank drain quick connect fitting (10) and the NPT fuel/oil outlet union (11) on the waste fuel drip tank (4) and retain.

Installation.

a. Place Loctite® 545 (purple) on the NPT fuel/oil outlet union (11, Figure K-36) and install in the waste fuel drip tank (4).

b. Install the waste fuel drip tank drain quick connect fitting (10) in the NPT fuel/oil outlet union (11) on the waste fuel drip tank (4).

c. Install the waste fuel drip tank vent valve (9) on the top of the waste fuel drip tank (4).

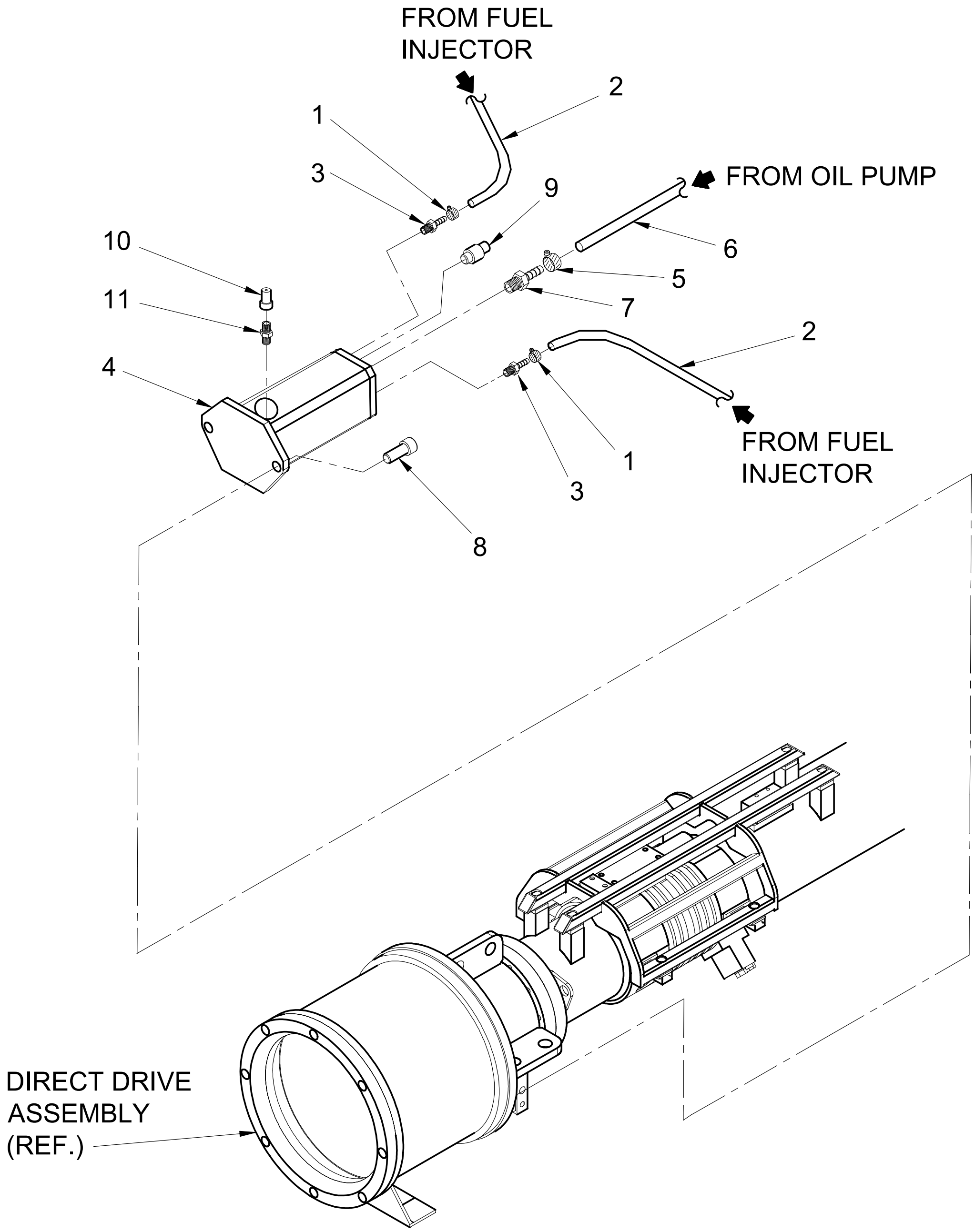
d. Place Loctite® 545 (purple) on the one oil inlet fitting (7) and install in the top of the waste fuel drip tank (4).

e. Place Loctite® 545 (purple) on the two fuel inlet fittings (3) and install in the top of the waste fuel drip tank (4).

f. Place Loctite® 272 (red) on the two waste fuel drip tank mounting bolts (8). Align the waste fuel drip tank (4) with the mounting holes on the direct drive assembly and secure the waste fuel drip tank (4) to the direct drive assembly with the two waste fuel drip tank mounting bolts (11). Tighten the bolts and torque to 150 ft•lb (203 N•m).

g. Connect the rubber oil line (6) and hose clamp (5) to the oil inlet fitting (7) on the top of the waste fuel drip tank (4). Tighten the hose clamp (5).

h. Connect the two rubber fuel lines (2) and hose clamps (1) to the two fuel inlet fittings (3) on the top of the waste fuel drip tank (4). Tighten the hose clamps (1).



LEGEND

1. Hose Clamp
2. Fuel Line, Rubber
3. Fuel Inlet Fitting
4. Waste Fuel Drip Tank
5. Hose Clamp
6. Oil Line, Rubber
7. Oil Inlet Fitting
8. Waste Fuel Drip Tank Mounting Bolt, 1/2-13 NC 1-1/4 LG SHCS
9. Waste Fuel Drip Tank Vent Valve
10. Waste Fuel Drip Tank Drain Quick Connect Fitting
11. NPT Fuel/Oil Outlet Union

Figure K-36. Waste Fuel Drip Tank Installation

Spotter Slide Manual Release. (Refer to Figure K-37.)

The spotter slide manual release is normally removed for replacement.

Removal.

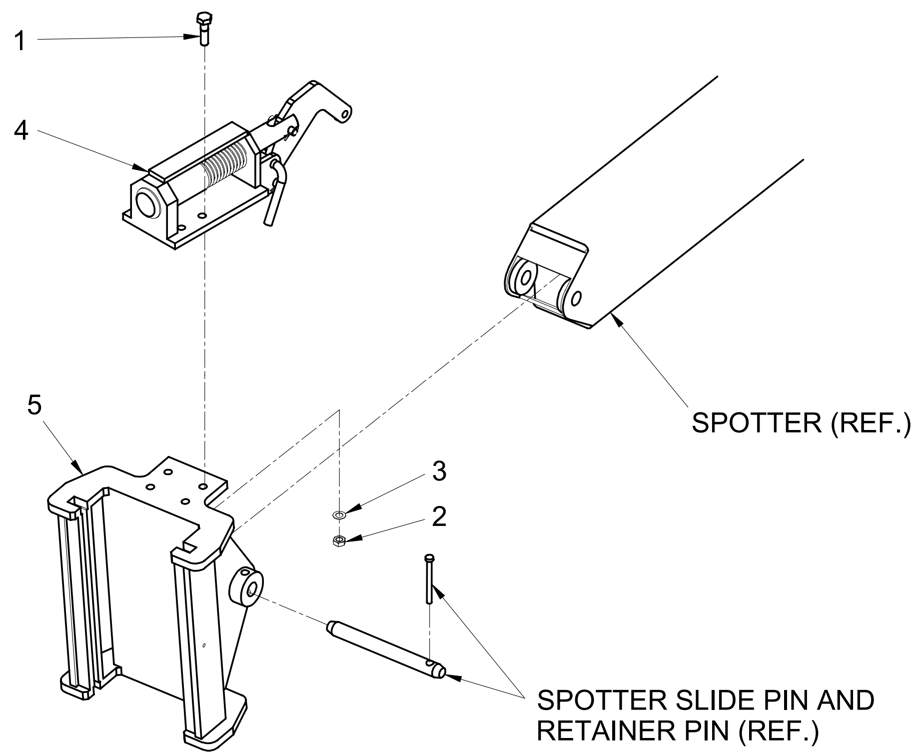
a. Remove the four spotter slide manual release mounting bolts (1, Figure K-37), hex nuts (2), and washers (3) securing the spotter slide manual release (4) to the top of the spotter slide (5).

b. Remove the spotter slide manual release (4) from the spotter slide (5).

Installation.

a. Align the spotter slide manual release (4, Figure K-37) with the mounting holes on the top of the spotter slide (5).

b. Place Loctite® 272 (red) on the four spotter slide manual release mounting bolts (1). Secure the spotter slide manual release (4) to the spotter slide (5) with the four spotter slide manual release mounting bolts (1), hex nuts (2), and washers (3). Tighten the bolts and torque to 150 ft•lb (203 N•m).



LEGEND

1. Spotter Slide Manual Release Mounting Bolts, 1/2 x 2 LG HHCS
2. Hex Nuts
3. Washers
4. Spotter Slide Manual Release
5. Spotter Slide

Figure K-37. Spotter Slide Manual Release Installation

Spotter. (Refer to Figure K-38.)

The spotter is normally disassembled to replace components or to inspect and remove the short wear pads, long wear pads, and spotter hydraulic cylinder.

Disassembly.

a. If necessary, remove the spotter slide from the end of the spotter inner box (1, Figure K-38) and set aside.

b. Tag and disconnect the hydraulic extension hose (2) from the fitting on the hydraulic manifold at the rear of the spotter outer box (3).

c. Tag and disconnect the hydraulic retraction hose (4) from the fitting on the hydraulic manifold at the rear of the spotter outer box (3).

d. Remove the cotter pin (5) securing the cylinder clevis pin (6) in the heel of the spotter outer box (3).

e. Remove the cylinder clevis pin (6), lower clevis pin spacer (7), and upper clevis pin spacer (8).

f. Push the spotter inner box (1) and spotter hydraulic cylinder (9), as an assembly, from the front and slide it until the rear of the spotter inner box (1) extends out the rear of the spotter outer box (3) exposing the rear of the hydraulic cylinder (9).

g. Pull the spotter inner box (1) and spotter hydraulic cylinder (9), as an assembly, out from the heel end of the spotter outer box (3). Support the spotter inner box (1) with a sling as it is pulled out of the spotter outer box (3).

NOTE

The wear pads (10 and 11) on the spotter inner box (1) prevent it from being removing by sliding out from the front of the spotter outer box (3).

Inspection.

a. Inspect the two short wears pads (10, Figure K-38) and two long wear pads (11) on the spotter inner box (1) for wear. Replace if worn.

b. Inspect the two short wears pads (12) and two long wear pads (13) on the spotter outer box (3) for wear. Replace if worn.

Reassembly.

a. Support the spotter inner box (1, Figure K-38) and spotter hydraulic cylinder (9), as an assembly, with a sling. Slide the front of the spotter inner box (1) into the heel end of the spotter outer box (3). Push forward until the clevis on the cylinder end of the spotter hydraulic cylinder (9) is aligned with the mounting location in the heel of the spotter outer box (3).

b. Secure the cylinder end of the spotter hydraulic cylinder (9) in the heel of the spotter outer box (3) by installing the upper clevis pin spacer (8), lower clevis pin spacer (7), and inserting the cylinder clevis pin (6).

c. Secure the cylinder clevis pin (6) in the heel of the spotter outer box (3) by installing the cotter pin (5).

d. Place Loctite® 545 (purple) on the threads of the hydraulic retraction hose (4) and connect the hydraulic retraction hose (4) to the appropriate fitting on the hydraulic manifold at the rear of the spotter outer box (3).

e. Place Loctite® 545 (purple) on the threads of the hydraulic extension hose (2) and connect the hydraulic extension hose (2) to the appropriate fitting on the hydraulic manifold at the rear of the spotter outer box (3).

Spotter Inner and Outer Boxes – Short and Long Wear Pads. (Refer to Figure K-38.)

The short and long wear pads on the spotter inner and outer boxes are normally removed for replacement.

Removal.

a. Disassemble the spotter to access the spotter inner (1, Figure K-38) and outer boxes (3) (Page K-85).

b. Remove the bearing pad screws (14) securing each of the two short wear pads (10) and long wear pads (11) on the end of the spotter inner box (2). Remove the wear pads (10 and 11).

c. Remove the two bearing pad screws (15) securing each of the two short wear pads (12) and long wear pads (13) on the end of the spotter outer box (4). Remove the wear pads (12 and 13).

Installation.

a. Place Loctite® 242 (blue) on the bearing pad screws (15, Figure K-38). Install replacement long wear pads (13) and short wear pads (12) on the end of the spotter outer box (4) and secure each wear pad with bearing pad screws (15 and 14).

b. Place Loctite® 242 (blue) on the bearing pad screws (14). Install replacement long wear pads (11) and short wear pads (10) on the end of the spotter inner box (2) and secure each wear pad with three bearing pad screws (14).

c. Reassemble the spotter (Page K-85).

LEGEND

1. Spotter Inner Box
2. Hydraulic Extension Hose, 1/2 x 30-inch
3. Spotter Outer Box
4. Hydraulic Retraction Hose, 1/2 x 128-inch
5. Cotter Pin, 1/2 x 5-inch
6. Cylinder Clevis Pin
7. Lower Clevis Pin Spacer
8. Upper Clevis Pin Spacer
9. Spotter Hydraulic Cylinder
10. Short Wears Pads – Inner Box
11. Long Wear Pads – Inner Box
12. Short Wears Pads – Outer Box
13. Long Wear Pads – Outer Box
14. Bearing Pad Screws – Inner Box, 5/16 x 1/2 FHCS
15. Bearing Pad Screws – Outer Box, 5/16 x 1/2 FHCS
16. Retaining Bolt, 1/2 x 2-1/2 NC HHCS
17. Locknut
18. Rod Clevis Pin
19. Fitting, 1/2 NPT (M) to 1/2 JIC (M)
20. Fitting, 1/2 NPT (M) to 1/2 JIC (M)

Figure K-38. Spotter Disassembly (Sheet 1 of 2)

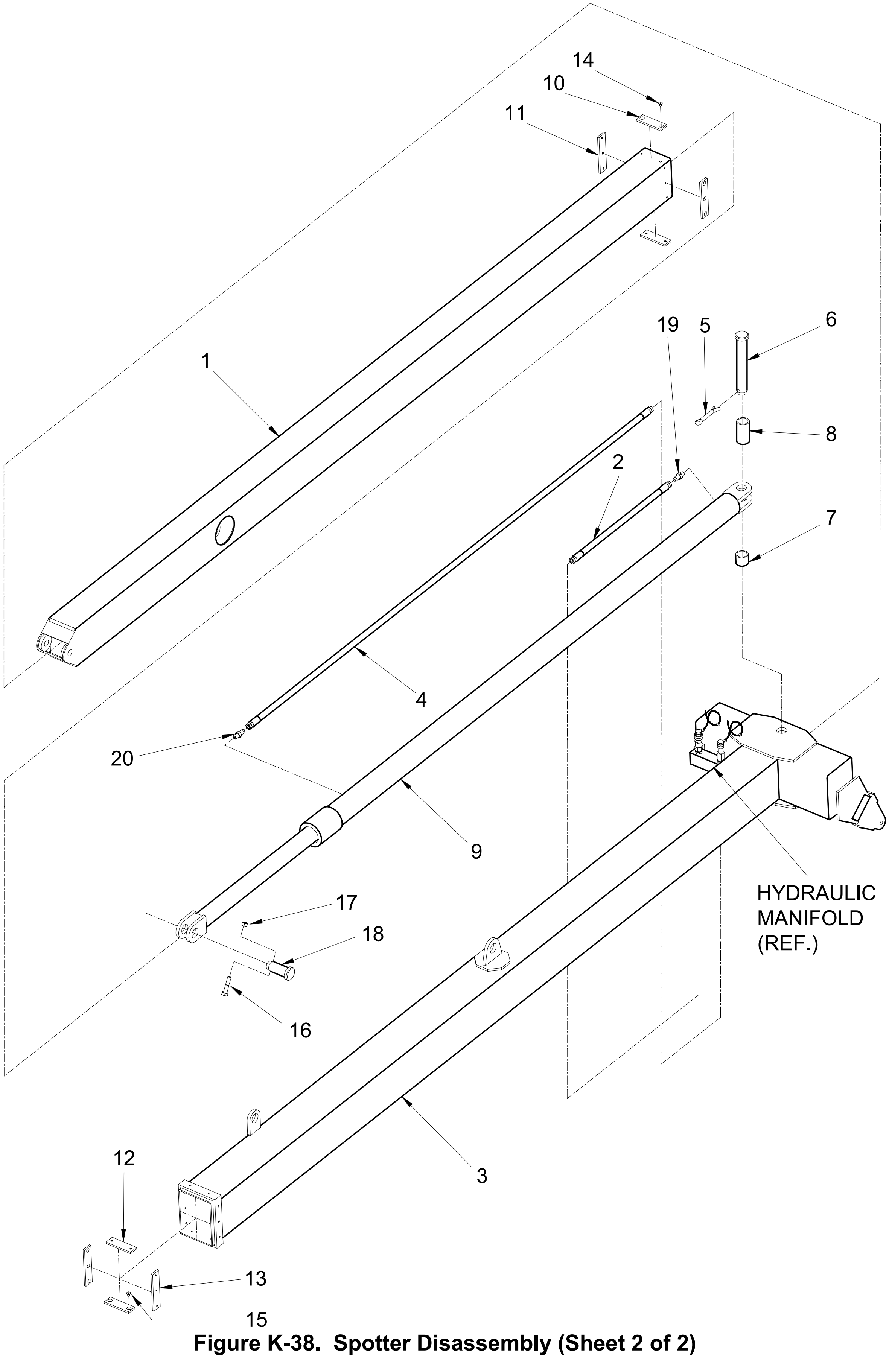


Figure K-38. Spotter Disassembly (Sheet 2 of 2)

Spotter Hydraulic Cylinder. (Refer to Figure K-38.)

The spotter hydraulic cylinder is normally removed for replacement.

Removal.

a. Disassemble the spotter to access the spotter hydraulic cylinder (9, Figure K-38) (Page K-85).

b. Remove the retaining bolt (16) and locknut (17) securing the rod clevis pin (18) in the front of the spotter inner box (1). Discard the locknut (17).

c. Remove the rod clevis pin (18) securing the spotter hydraulic cylinder (9) in the spotter inner box (1).

d. Remove the spotter hydraulic cylinder (9) from the spotter inner box (1).

e. Disconnect the hydraulic extension hose (2) from the fitting (19) on the spotter hydraulic cylinder (9).

f. Disconnect the hydraulic retraction hose (4) from the fitting (20) on the spotter hydraulic cylinder (9).

g. Remove the two fittings (19 and 20) from the spotter hydraulic cylinder (9) and retain.

Installation.

a. Place Loctite® 545 (purple) on the fittings (20 and 19, Figure K-38) and install in the appropriate locations on the spotter hydraulic cylinder (9).

b. Place Loctite® 545 (purple) on the fitting (20) on the rod side of the spotter hydraulic cylinder (9) and connect the hydraulic retraction hose (4) to the fitting (20).

c. Place Loctite® 545 (purple) on the fitting (19) on the cylinder side of the spotter hydraulic cylinder (9) and connect the hydraulic extension hose (3) to the fitting (19).

d. Slide the spotter hydraulic cylinder (9) into the spotter inner box (1) and align the clevis on the cylinder rod with the mounting hole on the inside of the spotter inner box (1).

e. Install the rod clevis pin (18).

f. Secure the rod clevis pin (18) in the front of the spotter inner box (1) with the retaining bolt (16) and new locknut (17).

g. Reassemble the spotter (Page K-85).

Pile Gate. (Refer to Figure K-39.)

The pile gate is normally disassembled for replacement of components.

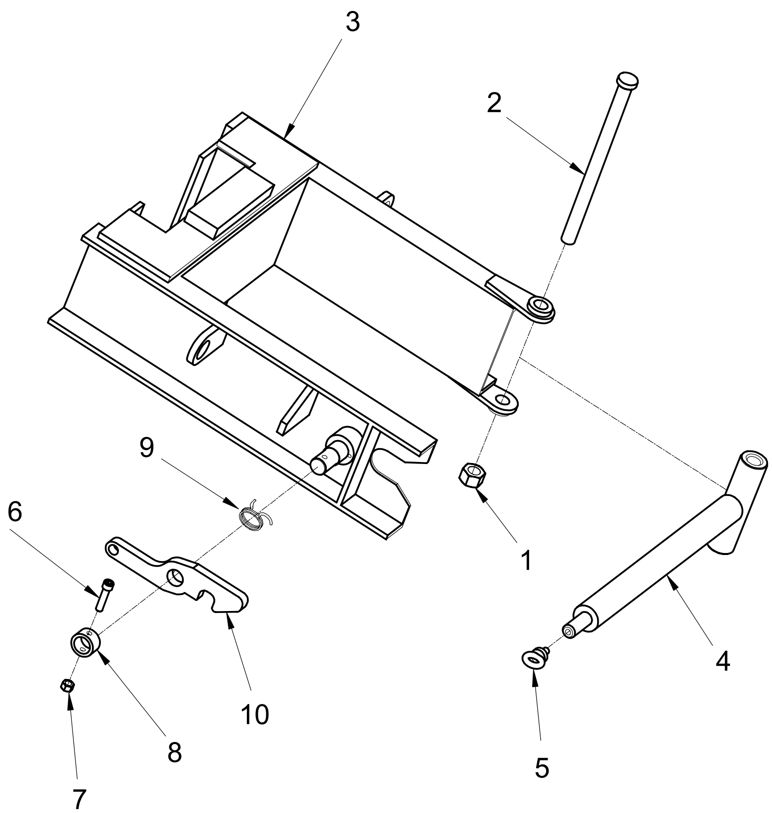
Disassembly.

a. Remove the pivot bolt locknut (1, Figure K-39) from the pivot bolt (2) and discard locknut. Remove the pivot bolt (2) from the pile gate frame (3) and remove the swing arm (4).

b. Remove the eyebolt (5) from the swing arm (4).

c. Remove the retaining bolt (6) and locknut (7) securing the latch spacer (8) to the pile gate frame (3) and discard locknut. Remove the latch spacer (8).

d. Note the positioning of the torsion spring (9) on the pile gate frame (3) and slide the latch (10) and torsion spring (9) off the pile gate frame (3).



LEGEND

1. Pivot Bolt Locknut
2. Pivot Bolt
3. Pile Gate Frame
4. Swing Arm
5. Eyebolt, 1/2
6. Retaining Bolt
7. Spotter Slide Manual Release
8. Latch Spacer
9. Torsion Spring
10. Latch

Figure K-39. Pile Gate Disassembly

Reassembly.

a. Slide the latch (10, Figure K-39) and torsion spring (9) onto the pile gate frame (3) and secure torsion spring (9) into the position noted during removal.

b. Slide the latch spacer (8) onto the pile gate frame (3) and install the retaining bolt (6). Secure the retaining bolt (6) to the pile gate frame (3) with a new locknut (7).

c. Install the eyebolt (5) onto the swing arm (4).

d. Install the swing arm (4) onto the pile gate frame (3) and install the pivot bolt (2). Secure the pivot bolt (2) to the pile gate frame (3) with a new pivot bolt locknut (1).

By Order of the Secretary of the Army:

ERIC K. SHINSEKI
General, United States Army
Chief of Staff

Official:

JOEL B. HUDSON
Administrative Assistant to the
Secretary of the Army

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